

Body chemicals

Chemical composition

In a human body of mass 70 kg, the following quantities of elements, chemically combined to form compounds, are found:

• oxygen	43 kg	• sulphur	0.14 kg	In smaller amounts (<0.0003 kg) in descending order: rubidium, strontium, bromine, lead, copper, aluminium, cadmium, boron, barium, tin, iodine, manganese, nickel, gold, molybdenum, chromium, caesium, cobalt, uranium, beryllium, radium
• carbon	16 kg	• potassium	0.14 kg	
• hydrogen	7 kg	• sodium	0.10 kg	
• nitrogen	1.8 kg	• chlorine	0.095 kg	
• calcium	1 kg	• magnesium	0.019 kg	
• phosphorus	0.78 kg	• silicon	0.018 kg	
		• iron	0.0042 kg	
		• fluorine	0.0026 kg	
		• zinc	0.0023 kg	

However, being present in small quantities does not mean an element is any less important for the functioning of a healthy body. Even in tiny amounts elements can have vital roles. Cobalt is an essential component of vitamin B₁₂.

Organic molecules

Carbon atoms can bond to one another to form chains, branching chains and rings. Complex and sophisticated large molecular structures can be synthesised.

Carbon compounds are classified as organic because it was once thought that they could come from living (or once-living) sources only and it was impossible to synthesise them artificially.

Note: The exceptions are carbon monoxide, carbon dioxide, carbonates and hydrogencarbonates. These are classified as inorganic.

Carbohydrates, lipids (including phospholipids), proteins, nucleotides and nucleic acids are important types of organic compounds in the body.

Carbohydrates

Carbohydrates are important sources of energy. They have the general formula (CH₂O)_n and include:

- Monosaccharides, including glucose which is the major carbohydrate in blood. Most of those in the body are pentoses, C₅H₁₀O₅, or hexoses, C₆H₁₂O₆.
- Disaccharides are formed by combining two monosaccharides in a condensation reaction forming a glycosidic bond and yielding water.
 - glucose + glucose makes maltose
 - glucose + fructose makes sucrose
 - glucose + galactose makes lactose

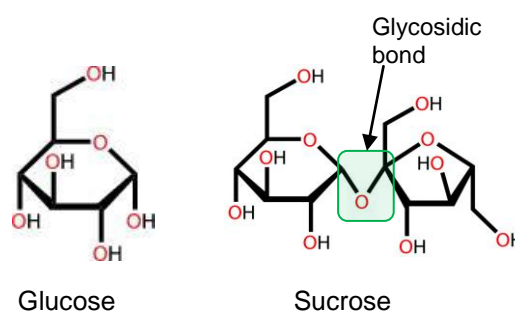


Figure 1 Small carbohydrates are soluble in water due to the presence of polar hydroxyl groups in their molecules.

- Polysaccharides are formed by combining many monosaccharides into long chains which may branch profusely. Glycogen (in animals) and starch (in plants) are insoluble in water and important stores of glucose.

Lipids and phospholipids

Lipids are an important energy store, adding less to body mass than glycogen would. They are made from atoms of carbon, hydrogen and oxygen. The proportion of oxygen atoms is very small so lipids are non-polar and insoluble in water.

Phospholipids are formed by the combination of glycerol to two carboxylic acids and a phosphate. The polar phosphate forms a hydrophilic 'head' with two hydrophobic 'tails'. These molecules are important in the formation of cell membranes.

Steroids are also classed as lipids, but have a different structure based on four interconnected carbon rings. They are insoluble in water and include cholesterol and sex hormones such as testosterone and oestrogen.

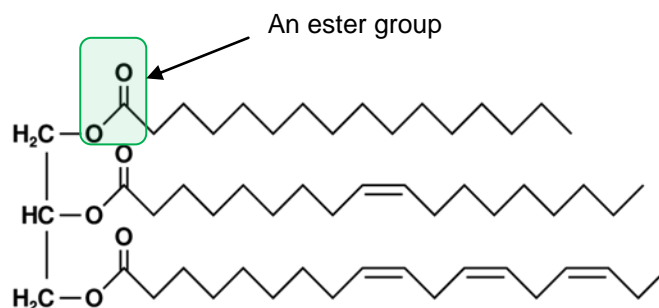


Figure 2 Most lipids in the body are triglycerides. Ester groups form from the hydroxyl groups on a glycerol molecule and three long chain carboxylic acid molecules (fatty acids).

Proteins

Proteins are made from atoms of carbon, hydrogen, oxygen and nitrogen. For some proteins sulphur atoms are used to make them and, occasionally, atoms of other elements in small amounts.

Proteins form from amino acids by condensation reactions. The amine group in one amino acid molecule reacts with the carboxyl group and another amino acid molecule. A water molecule is eliminated and a peptide bond forms. Each reaction leaves an amine group at one end of the chain and a carboxyl group at the other.

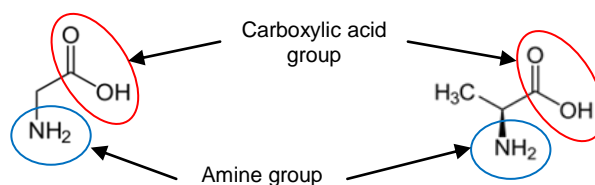


Figure 3 The two smallest amino acids.

- Two amino acids make a dipeptide.
- Three amino acids make a tripeptide.

Through repeated condensations, very long chains can form. Many amino acids make a polypeptide.

There are 20 commonly occurring amino acids in the proteins in the body. The primary structure of a protein is the order of the specific amino acids in the polypeptide chain.

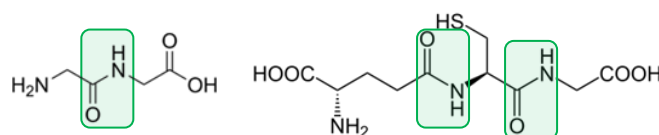


Figure 4 A dipeptide molecule (left) and a tripeptide molecule. The peptide links are highlighted.

Amino acids can rotate around their peptide bonds. Polypeptide chains are therefore able to bend and twist into a wide range of three dimensional shapes.

The shape of a protein molecule is determined by the bonds which can form between neighbouring amino acids. These may include hydrogen bonds, ionic bonds, van der Waals forces and covalent bonds. These primary structures can further twist and intermingle to give secondary structures (helices and pleated sheets) and tertiary structures.

The structure of each protein is highly specific and directly related to its function.

Nucleotides and nucleic acids

Nucleotides contain a base formed from a ring of four carbon and two nitrogen atoms, a pentose and a phosphate group. ATP (adenosine triphosphate), the primary energy carrier in cells has three phosphates.

Nucleic acids are formed from nucleotides. Phosphates and pentoses link through condensation reactions to form long chains.

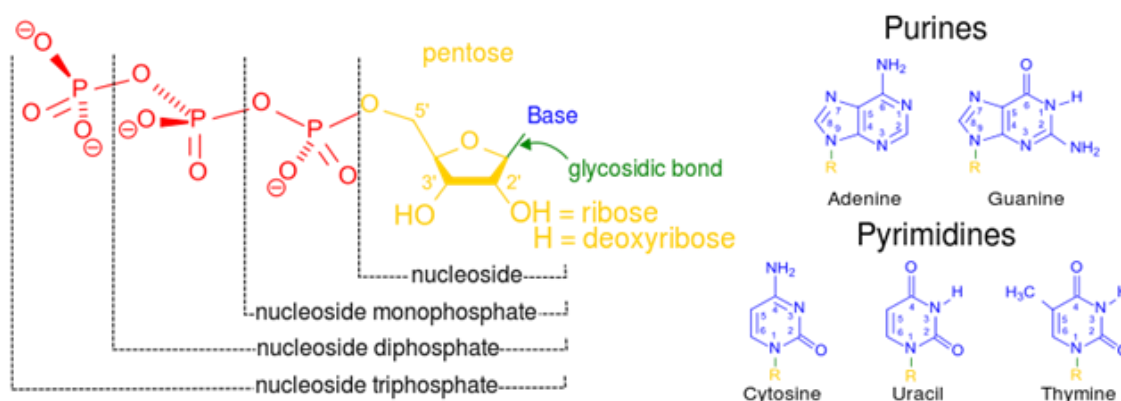


Figure 5 The make-up of the most common nucleotides.

DNA (deoxyribonucleic acid) stores the genetic code in the specific sequence of the nucleotides. It is formed from a double chain of nucleotides in which bases pair between the chains and link through hydrogen bonds to give a double helix in the form of a twisted ladder. RNA (ribonucleic acid) is a single chain of nucleotides able to transfer the code for individual genes to control protein synthesis.

Finding out

DNA contains the 'universal' genetic code used by all living organisms.

- How is DNA able to form identical copies of itself?
- How is DNA able to provide a code for protein synthesis?