Introduction to the nutrients

Aims
1 To show how nutrients are classified and discuss their main roles
2 To describe how nutrients may interact to fulfil similar roles

Food is composed of a large variety of chemical substances, some of which are recognised as nutrients. Over the past century or so, scientists have identified the roles of these nutrients in the body and the consequences of insufficient intakes. Many other substances are present in foods of plant origin that help promote the plant's growth, protect it against predators or contribute to its appearance or smell to attract animals that will spread its seeds. Although these substances (phytochemicals) are not recognised as nutrients, some may be biologically active in humans and could have either beneficial or harmful effects.

Classification of nutrients
Traditionally, the major nutrients have been classified according to the amounts in which they are required by the body, their chemical nature and their functions. The principal distinction is between macronutrients and micronutrients:

1 Macronutrients are required in relatively large amounts, usually expressed in terms of grams per day.
2 Micronutrients are required in small amounts, usually expressed in terms of milligrams or micrograms per day.

Some classifications also include ultratrace nutrients. These are found in the diet in very small amounts (typically <1 µg/g of dry food). For many of these substances, their roles are, as yet, uncertain.

Water is an essential component of the diet, as an adequate intake of fluid is vital to sustain life.

Macronutrients
This category comprises carbohydrates, fats and proteins:

• Carbohydrates and fats are the major providers of energy, although proteins can also be used to provide energy.
• They all have a structural role in the body, the most important in this respect being proteins.
• All contain carbon, hydrogen and oxygen. In addition, all proteins contain nitrogen, while some amino acids (cysteine and methionine) that are found in proteins contain sulphur.

Carbohydrates
Carbohydrates are the most important source of food energy in the world. Carbohydrates occur in the diet in various degrees of complexity, ranging from simple sugars (mono- and disaccharides) to larger units such as oligosaccharides and polysaccharides. Simple sugars include the monosaccharides glucose, fructose and galactose and the disaccharides sucrose and lactose. Oligosaccharides include maltodextrins and fructo-oligosaccharides. Important polysaccharides include starch and glycogen.

The main function of carbohydrates is to act as a source of energy, in the form of glucose. However, some carbohydrates resist digestion and are termed 'non-glycaemic' (see Chapter 8). They comprise the non-starch polysaccharides (NSP), which are part of the category known as 'dietary fibre'. These carbohydrates play an important role in bowel function.

Fats
Fats are a diverse group of lipid-soluble substances, the majority of which are triacylglycerols (TAGs). Other lipid-soluble substances including phospholipids and sterols (e.g. cholesterol) are also included in this group.

TAGs are broken down to yield energy and are the body's richest source of energy, having over twice the caloric content of carbohydrates and proteins. They are also the body's major energy reserve, stored in the adipose tissue. Specific fatty acids found in TAGs (called essential fatty acids) are important for cell membrane structure and function. Since the body lacks the ability to manufacture essential fatty acids, they must be supplied in the diet.

Proteins
Proteins consist of chains of amino acids. Food proteins typically contain 20 different amino acids, but because these can be arranged in countless ways, there is enormous diversity between different proteins in the diet in terms of their amino acid sequences. On digestion, individual amino acids are used for the synthesis of other amino acids and proteins required by the body. This process involves considerable recycling of the components.

There are eight essential amino acids (more in children), which must be supplied by the diet. Certain other amino acids may become conditionally essential in situations of physiological stress. Only when there is no further need for amino acids are they broken down and used as a source of energy. During that process, the nitrogen part of the amino acid is excreted via the urine as urea.

Micronutrients
The micronutrients consist of the vitamins and minerals (see Table 1.1).

<table>
<thead>
<tr>
<th>Name</th>
<th>Main members of the group</th>
<th>Role(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat-soluble vitamins</td>
<td>Vitamins A, D, E, K</td>
<td>Structural role, cell integrity, homeostasis, antioxidant, nerve impulses</td>
</tr>
<tr>
<td>Water-soluble vitamins</td>
<td>B vitamins, vitamin C</td>
<td>Metabolism, cell division, antioxidant, cofactors for enzymes, synthesis of neurotransmitters</td>
</tr>
<tr>
<td>Minerals</td>
<td>Calcium, phosphorus, sodium, chloride, potassium, magnesium, iron, zinc, copper, manganese, iodine, selenium</td>
<td>Structural role, cofactors for enzymes, acid–base balance</td>
</tr>
</tbody>
</table>

Table 1.1 Classification of micronutrients by chemical properties.
Vitamins
Vitamins are organic substances that are required by the body in very small amounts for its normal functioning. They are classified into the fat-soluble vitamins (A, D, E and K) and the water-soluble vitamins (B-group vitamins and vitamin C).

The body does have the capacity to synthesise some vitamins. For example, vitamin D is synthesised in the skin by the action of ultraviolet light on a precursor molecule, 7-dehydrocholesterol. Vitamin B₃ (niacin) can also be made in the body, from the amino acid tryptophan, which means that a separate supply of niacin may not be needed if protein intake is adequate. However, in the case of both of these vitamins, there are situations where synthesis is insufficient, and so a dietary need remains.

Minerals
Minerals are inorganic substances required by the body in small amounts, generally to function as part of the structure of other molecules (e.g. calcium in the bone or iron in haemoglobin) or to act as essential cofactors for the activity of enzymes (e.g. selenium in glutathione peroxidase).

For some minerals (e.g. iron), uptake from the diet must be carefully regulated as there is only a very limited capacity for excretion, and potential toxicity may result if large amounts accumulate in storage organs.

In addition, some minerals compete with each other for absorption, so excessive intakes of one may hinder the uptake of another (e.g. zinc and iron, or iron and calcium).

Water
Water provides the basic medium in which all the body’s reactions occur. Inadequate fluid intakes will quickly compromise the metabolic functions of the body and disturb the homeostatic mechanisms that normally operate.

Alcohol
Alcohol is not considered a nutrient, but when ingested, it is broken down to provide energy. Some alcoholic beverages (e.g. beer) provide additional nutrients such as B vitamins, albeit in small amounts.

Grouping of nutrients by functional role
Many nutrients interact in carrying out their functional roles in the body, and this may also be used as a basis for classification:
- At the genetic level, nutrients are involved in regulating the transcription of genes, thus affecting the synthesis of proteins, including enzymes.
- At the cellular level, nutrients are involved as cofactors in controlling and regulating metabolic reactions and the release of energy. They are regulated by hormones and other chemical messengers, such as cytokines, which are also influenced by the nutrient environment.
- Immune and defence mechanisms function through the release of highly reactive molecules called free radicals, which must then be quenched by antioxidants, again supplied directly by the diet or indirectly as enzymes activated by dietary factors.

Interactions
When food is eaten, interactions may occur between nutrients and non-nutritional constituents at all stages of the processing and metabolism of the food. It is therefore unwise to study nutrients in isolation without considering some of the other factors that may influence their activity and how they may interact in whole body functioning.

Key characteristics of nutrients
In studying the nutrients, it is important to pay attention to:
- Their structure and chemical characteristics
- Which foods are major sources
- How they are digested, absorbed, transported and stored
- In what form they are used, what determines their use, how and in what circumstances they are mobilised and how surplus or metabolic end products are excreted
- What the physiological requirement for the nutrient is and how this can be translated into a recommended level of intake
- How the body responds to overconsumption and under-consumption
- How long it takes to develop a deficiency or a toxicity and what are the characteristic features
- Interaction between nutrients
- Which members of a population are vulnerable to deficiency
- Whether there are any therapeutic applications of the nutrient
- What are the gaps in knowledge requiring further study