CHAPTER 11

Introduction to nutrition

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Before discussing the digestive system it is necessary to understand the body's nutritional needs, i.e. the dietary constituents and their functions. Food provides nutrients, some of which are broken down to provide energy while others are needed to maintain health, e.g. for growth and cellular metabolism. These substances are:

- carbohydrates
- proteins
- fats
- vitamins
- mineral salts, trace elements and water.

Many foods contain a combination of nutrients, e.g. potatoes and bread are mainly carbohydrate, but both also contain protein and some vitamins. *Fibre*, more correctly known as *non-starch polysaccharide* (NSP), consists of indigestible material. Although it is not a nutrient as it is neither a source of energy nor essential for cellular metabolism, NSP is important in the diet as it has many beneficial effects on the body.

The *diet* is the selection of foods eaten by an individual. A *balanced diet* is essential for health and provides appropriate amounts of all nutrients in the correct proportions to meet body requirements. An *essential nutrient* is a substance that cannot be made by the body and must therefore be eaten in the diet.

The first parts of this chapter explore the balanced diet and its constituents. Nutrition and its impact on older adults is discussed.

Many health problems arise as the result of poor diet. In developed countries obesity is increasingly common, while in other countries malnutrition is widespread; the final section considers some consequences of poor nutrition.

The balanced diet

Learning outcomes

After studying this section, you should be able to:

- list the constituent food groups of a balanced diet
- calculate body mass index from an individual's weight and height.

A balanced diet contains appropriate proportions of all nutrients required for health, which is normally achieved by eating a variety of foods, with the exception of breast milk, this is because no single food contains the correct proportions of the essential nutrients. If any nutrient is eaten in excess, or is deficient, health may be adversely affected. For example, a high-energy diet can lead to obesity, and an iron-deficient one to anaemia.

Box 11.1 Body mass index: WHO classification

Calculation of BMI

$$\text{Body mass index BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Interpretation of BMI

<16	Severely underweight
16–18.4	Underweight
18.5–24.9	Normal range
25–29.9	Overweight
30–39.9	Obese
>40	Severely obese

A balanced diet is important in maintaining a healthy body weight, which can be assessed by calculating body mass index (BMI) (Box 11.1).

Healthy eating, i.e. eating a balanced diet, requires some knowledge and planning. An important dietary consideration is the amount of energy required, which should meet individual requirements. Daily energy requirements depend on several factors including basal metabolic rate (p. 314), age, gender and activity levels. Dietary carbohydrates, fats and proteins are the principal energy sources and fat is the most concentrated form. Dietary energy is correctly expressed in joules or kilojoules (kJ) although the older terms calories and kilocalories (kcal or Cal) are also still used in the UK.

This section is based on the recommendations of the British Nutrition Foundation (2013). Recommendations for daily food intake sort foods of similar origins and nutritional values into food groups, and advise that from the age of two years a certain proportion from each group be eaten daily (Fig. 11.1). If this plan is followed, the resulting dietary intake is likely to be well balanced. The five food groups are:

- bread, rice, potatoes, pasta
- fruit and vegetables
- milk and dairy foods
- meat, fish, eggs, beans
- foods and drinks high in fat and/or sugar.

The first two groups above should form two-thirds of the diet with the other groups forming the remainder with only limited amounts of food and drinks high in fat and/or sugar.

Bread, rice, potatoes, pasta

The British Nutrition Foundation recommends that this group should make up one-third of the diet and that each meal should be based around one food from this group. Potatoes, yams, plantains and sweet potato are classified as 'starchy carbohydrates' and are, therefore, considered within this group rather than as fruit and vegetables. Other foods in this group include breakfast cereals, rice and

Figure 11.1 The eatwell plate. The main food groups and their recommended proportions within a balanced diet.

noodles. These foods are sources of carbohydrate and fibre that provide sustained energy release. Some also contain iron and B-group vitamins including folic acid (p. 279).

Fruit and vegetables

Foods in this group include fresh, frozen and canned products, 100% fruit or vegetable juices and pure fruit smoothies. These foods provide carbohydrate, fibre, vitamin C, folic acid and fibre. A minimum of five portions per day is recommended.

> One portion (80 g) = one piece of medium fruit, e.g. apple, orange, banana; three tablespoons of cooked vegetables, one bowl of mixed salad; 150 mL fruit juice or fruit smoothie

Milk and dairy foods

Foods in this group provide protein and minerals including calcium and zinc; some are also a source of vitamins A, B_2 and B_{12}. They include milk, cheese, fromage frais and yoghurt, and often contain considerable amounts of fat. Intake should therefore be limited to three servings per day.

> One serving = 200 mL milk, 150 g yoghurt or 30 g cheese

Meat, fish, eggs, beans

In addition to the food shown in Figure 11.1, this group includes meat products such as bacon, sausages, beefburgers, salami and paté. Moderate amounts are recommended because many have a high fat content. It is suggested that fish, including one portion of oily fish, e.g. salmon, trout, sardines or fresh tuna, is eaten twice weekly. This food group provides protein, iron, vitamins B and D and sometimes minerals. Vegetarian alternatives include tofu, nuts, beans and pulses, e.g. lentils. Beans and pulses are also a good source of fibre.

Foods and drinks high in fat and/or sugar

These foods are illustrated in Figure 11.1 and also include oils, butter, margarine (including low-fat spreads), mayonnaise, fried food including chips, crisps, sweets, chocolate, cream, ice cream, puddings, jam, sugar and soft drinks, but not diet drinks. Fats are classified as saturated or unsaturated and the differences between these are explained on page 277. Foods in this group should only be used sparingly, if at all, as they are high in energy and have little other nutritional value.

Additional recommendations

The British Nutrition Foundation makes other specific recommendations about *salt* (p. 280) and *fluid intake* (1.5–2 L per day). This includes water, tea, coffee, squash and fruit juice. *Alcohol* intake should not exceed 3–4 units per day for men and 2–3 units per day for women.

> One unit of alcohol = 125 mL (small glass) wine; 300 mL (half pint) of standard strength beer, lager or cider; 25 mL of spirits

Groups of people with specific dietary requirements

Certain groups of people require a diet different from the principles outlined above. For example, pregnant and lactating women have higher energy requirements to support the growing baby and milk production. Menstruating women need more iron in their diet than non-menstruating women to compensate for blood loss during menstruation. Babies and growing children have higher energy requirements than adults because they have relatively higher growth and metabolic rates. In some gastrointestinal disorders there is intolerance of certain foods, which restricts dietary choices, e.g. coeliac disease (p. 331).

Digestion, absorption and use of nutrients are explained in Chapter 12. Structures of carbohydrates, proteins and fats are described in Chapter 2.

Nutrients

Learning outcomes

After studying this section, you should be able to:

- describe the functions of dietary carbohydrate, protein and fat.
- outline the sources and functions of fat- and water-soluble vitamins
- outline the sources and functions of minerals, trace elements and water.

Carbohydrates

Carbohydrates are mainly sugars and starches, which are found in a wide variety of foods, e.g. sugar, jam, cereals, bread, biscuits, pasta, convenience foods, fruit and vegetables. Chemically, they consist of carbon, hydrogen and oxygen, the hydrogen and oxygen being in the same proportion as in water. Carbohydrates are classified according to the complexity of the chemical substances from which they are formed.

Monosaccharides

Carbohydrates are digested in the alimentary canal and absorbed as monosaccharides. Examples include glucose (see Fig. 2.7, p. 26), fructose and galactose. These are, chemically, the simplest form of carbohydrates.

Disaccharides

These consist of two monosaccharide molecules chemically combined, e.g. sucrose (see Fig. 2.7, p. 26), maltose and lactose.

Polysaccharides

These are complex molecules made up of large numbers of monosaccharides in chemical combination, e.g. starches, glycogen and cellulose.

Not all polysaccharides can be digested by humans; e.g. cellulose and other substances present in vegetables, fruit and some cereals pass through the alimentary canal almost unchanged (see NSP, p. 281).

Functions of digestible carbohydrates

These include:

- provision of energy and heat; the breakdown of monosaccharides, preferably in the presence of oxygen, releases heat and chemical energy for metabolic work – glucose is the main fuel molecule used by body cells
- 'protein sparing'; i.e. when there is an adequate supply of carbohydrate in the diet, protein does not need to be used to provide energy and heat, and is used for its main purpose, i.e. building new and replacement body proteins
- providing energy stores when carbohydrate is eaten in excess of the body's needs as it is converted to:
  - glycogen – as a short-term energy store in the liver and skeletal muscles (see p. 315)
  - fat, that is stored in adipose tissue, e.g. under the skin.

Proteins (nitrogenous foods)

During digestion proteins are broken down into their constituent amino acids and it is in this form that they are absorbed into the bloodstream. A constant supply of amino acids is needed to build new proteins, e.g. structural proteins, enzymes and some hormones.

Amino acids (see Fig. 2.8)

These are composed of the elements carbon, hydrogen, oxygen and nitrogen. Some contain minerals such as iron, copper, zinc, iodine, sulphur and phosphate. Amino acids are divided into two categories: *essential* and *non-essential*.

Essential amino acids cannot be synthesised in the body, therefore they must be included in the diet. *Non-essential*

Box 11.2 Essential and non-essential amino acids

Essential amino acids	Non-essential amino acids
Histidine (in infants only)	Alanine
Isoleucine	Arginine
Leucine	Asparagine
Lysine	Aspartic acid
Methionine	Cysteine
Phenylalanine	Cystine
Threonine	Glutamic acid
Tryptophan	Glutamine
Valine	Glycine
	Hydroxyproline
	Proline
	Serine
	Tyrosine

amino acids are those that can be synthesised in the body. The essential and non-essential amino acids are shown in Box 11.2.

Nitrogen balance

Excess amino acids are broken down. The amino group ($\sim NH_2$) is converted to the nitrogenous waste product urea and excreted by the kidneys. The remainder of the molecule is converted to either glucose or a ketone body (see ketosis, Ch. 12), depending on the amino acid. *Negative nitrogen balance* occurs when amino acid supply does not meet body needs. This situation may arise either when dietary protein intake is inadequate, e.g. deficiency or absence of amino acids, or protein requirement is increased, e.g. during growth spurts and following injury or surgery.

Biological value of protein

The nutritional value of a protein, its *biological value,* is measured by how well it meets the nutritional needs of the body. Protein of high biological value is usually of animal origin, easily digested and contains all essential amino acids in the proportions required by the body.

A balanced diet, containing all the amino acids required, may also be achieved by eating a range of foods containing proteins of lower biological values, provided that deficiencies in amino acid content of any one of the constituent proteins of the diet is supplied by another. A balanced vegetarian diet consists primarily of proteins with lower biological values, e.g. vegetables, cereals and pulses. When proteins from different plant sources are combined, they complement each other providing higher biological values than a single plant source. Through this complementary action the biological value of vegetarian diets can be similar to those based on animal protein.

Functions of proteins

Amino acids are used for:

- growth and repair of body cells and tissues
- synthesis of enzymes, plasma proteins, antibodies (immunoglobulins) and some hormones
- provision of energy. Normally a secondary function, this becomes important only when there is not enough carbohydrate in the diet and fat stores are depleted.

When protein is eaten in excess of the body's needs, the nitrogenous amino group is detached, i.e. it is deaminated, and excreted by the kidneys. The remainder is converted to fat for storage in the fat depots, e.g. in the fat cells of adipose tissue (p. 41).

Fats

Fats consist of carbon, hydrogen and oxygen, but they differ from carbohydrates in that the hydrogen and oxygen are not in the same proportions as in water. There are several groups of fats and lipids important in nutrition.

Fats (triglycerides)

Commonly known as 'fats', a triglyceride molecule consists of three fatty acids liked to a glycerol molecule (see Fig. 2.9, p. 27). Depending on the type and relative amounts of fatty acids they contain, fats are classified as *saturated* or *unsaturated*. In general, saturated fats are solid at room temperature and originate from animal sources, while unsaturated fats are oils, usually derived from vegetables or plants. A high intake of saturated fat can predispose to coronary heart disease (Ch. 5).

Linoleic, linolenic and arachadonic acids are *essential fatty acids*, which cannot be synthesised by the body in significant amounts, but are needed for synthesis of prostaglandins, phospholipids and leukotrienes. These fatty acids are found in oily fish.

Cholesterol

Unlike other lipids whose molecules are composed of chains of atoms, this molecule contains four rings, which give it the characteristic steroid structure. It can be synthesised by the body (around 20%) with the remainder coming from saturated fats in the diet as a constituent of full-fat dairy products, fatty meat and egg yolk. Cholesterol is needed for synthesis of steroid hormones, e.g. glucocorticoids and mineralocorticoids (Ch. 9) and is an important constituent of cell membranes.

Cholesterol is transported in the blood combined with proteins, forming *lipoproteins*. Two examples are:

- *low-density lipoprotein* (LDL): this carries cholesterol from the liver to the body cells. Excessive blood LDL levels are harmful to health as LDL can build up in arterial walls, leading to atherosclerosis. LDL is sometimes known as 'bad cholesterol'

- *high-density lipoprotein* (HDL): this carries cholesterol back from body cells to the liver, where it is either broken down or excreted. This may be referred to as 'good cholesterol' and raised HDL levels are cardioprotective.

High blood cholesterol levels are associated with an increased risk of atherosclerosis (p. 122), hypertension (high blood pressure, p. 131) and diabetes mellitus (p. 236).

Functions of fats

These include:

- provision of the most concentrated source of chemical energy and heat
- support of some organs, e.g. the kidneys, the eyes
- transport and storage of the fat-soluble vitamins: A, D, E, K
- constituent of myelin sheaths (p. 146) and of sebum (p. 365)
- formation of steroid hormones from cholesterol
- storage of energy as fat in adipose tissue under the skin and in the mesentery, especially when eaten in excess of requirements
- insulation – as a subcutaneous layer it reduces heat loss through the skin
- *satiety value* – the emptying time of the stomach is prolonged after eating food that is high in fat, postponing the return of hunger.

As the body stores excess fat, it is important not to eat too much as this will lead to weight gain and becoming overweight or obese (p. 283).

Vitamins

Vitamins are chemicals required in very small quantities for essential metabolic processes. As most cannot be made by the body, they are an essential part of the diet and insufficiency may lead to a deficiency disease. They are in found a wide range of foods and are divided into two groups:

- fat-soluble vitamins: A, D, E and K
- water-soluble vitamins: B complex and C.

Daily vitamin requirements for adults are shown on page 480.

Fat-soluble vitamins

Bile is needed for absorption of these vitamins from the small intestine. The presence of mineral oils in the intestine and malabsorption impair their absorption.

Vitamin A (retinol)

This vitamin is found in such foods as cream, egg yolk, liver, fish oil, milk, cheese and butter. It is absent from vegetable fats and oils but is added to margarine during manufacture. In addition, Vitamin A can be formed in the body from certain carotenes, the main dietary sources of which are green vegetables, orange-coloured fruit (e.g. mangoes, apricots) and carrots. The main roles of vitamin A in the body are:

- generation of the light-sensitive pigment rhodopsin (visual purple) in the retina of the eye (Ch. 8)
- cell growth and differentiation; this is especially important in fast-growing cells, such as the epithelial cells covering both internal and external body surfaces
- promotion of immunity and defence against infection
- promotion of growth, e.g. in bones.

The first sign of vitamin A deficiency is night blindness due to formation of abnormal retinal pigment. Other consequences include xerophthalmia, which is drying and thickening of the conjunctiva and, ultimately, ulceration and destruction of the conjunctiva. This is a common cause of blindness in developing countries. Atrophy and keratinisation of other epithelial tissues leads to increased incidence of infections of the ear and the respiratory, genitourinary and alimentary tracts. Immunity is compromised and bone development may be abnormal and delayed.

Vitamin D

Vitamin D is found mainly in animal fats such as eggs, butter, cheese, fish liver oils. Humans can synthesise this vitamin by the action of the ultraviolet rays in sunlight on a form of cholesterol (7-dehydrocholesterol) in the skin.

Vitamin D increases calcium and phosphate absorption from the gut and stimulates their retention by the kidneys. It therefore promotes the calcification of bones and teeth.

Deficiency causes *rickets* in children and *osteomalacia* in adults (p. 431), due to impaired absorption and use of calcium and phosphate. Stores in fat and muscle are such that deficiency may not be apparent for several years.

Vitamin E

Also known as *tocopherol*, this is found in nuts, egg yolk, wheat germ, whole cereal, milk and butter.

Vitamin E is an antioxidant, which means that it protects body constituents such as membrane lipids from being destroyed in oxidative reactions caused by free radicals. Recently, vitamin E has been shown to protect against coronary heart disease.

Deficiency is rare, because this vitamin is present in many foods, and is usually seen only in premature babies and in conditions associated with impaired fat absorption, e.g. cystic fibrosis.

Vitamin K

The sources of vitamin K are liver, some vegetable oils and leafy green vegetables. It is also synthesised by bacteria in the large intestine and significant amounts are absorbed. A small amount is stored in the liver. Vitamin K is required by the liver for the production of prothrombin and factors VII, IX and X, all essential for blood clotting (p. 70). Deficiency therefore prevents normal blood coagulation. It may occur in adults when there is obstruction to the flow of bile, severe liver damage and in malabsorption, e.g. coeliac disease. Premature babies may be given vitamin K to prevent haemorrhagic disease of the newborn (p. 78). This is because their intestines are sterile and require several weeks to become colonised with vitamin K-producing bacteria allowing normal blood clotting.

Water-soluble vitamins

Water soluble vitamins are lost in the urine, so body stores are usually limited.

Vitamin B complex

This is a group of water-soluble vitamins that promote activity of enzymes involved in the chemical breakdown (catabolism) of nutrients to release energy.

Vitamin B_1 (thiamin). This is present in nuts, yeast, egg yolk, liver, legumes, meat and the germ of cereals. It is rapidly destroyed by heat. Thiamin is essential for the complete aerobic release of energy from carbohydrate. Absence or deficiency causes accumulation of lactic and pyruvic acids, which may lead to accumulation of tissue fluid (oedema) and heart failure. Thiamin is also important for nervous system function because of the dependency of these tissues on glucose for fuel.

Deficiency causes *beriberi*, which mainly occurs in countries where polished rice is the chief constituent of the diet. In beriberi there is:

- severe muscle wasting
- delayed growth in children
- polyneuritis, causing degeneration of motor, sensory and some autonomic nerves
- susceptibility to infections.

If untreated, death from cardiac failure or severe microbial infection may occur.

The main cause of thiamin deficiency in developed countries is alcoholism, where the diet is usually poor. This affects the central nervous system causing neurological symptoms, which are usually irreversible. These include memory loss, ataxia and visual disturbances known as Wernicke-Korsakoff syndrome.

Vitamin B_2 (riboflavin). Riboflavin is found in yeast, green vegetables, milk, liver, eggs, cheese and fish roe. Only small amounts are stored in the body and it is destroyed by light and alkalis. It is involved in carbohydrate and protein metabolism, especially in the eyes and skin. Deficiency leads to cracking of the skin, commonly around the mouth (angular stomatitis), and inflammation of the tongue (glossitis).

Vitamin B_3 (niacin). This is present in liver, cheese, yeast, whole cereals, eggs and dairy products; in addition, the body can synthesise it from the amino acid tryptophan. It is central to energy release from carbohydrates in cells. In fat metabolism it inhibits the production of cholesterol and assists in fat breakdown. Deficiency is rare and occurs mainly in areas where maize is the chief constituent of the diet because niacin in maize is in an unusable form. *Pellagra* develops within 6 to 8 weeks of severe deficiency. It is characterised by:

- dermatitis – sunburn-like skin sensitivity affecting areas exposed to sunlight
- delirium and dementia.

Vitamin B_6 (pyridoxine). This stable vitamin is found in egg yolk, peas, beans, soya beans, yeast, poultry, white fish and peanuts. Dietary deficiency is very rare. Vitamin B_6 is associated with amino acid metabolism, including the synthesis of non-essential amino acids and important molecules such as haem and nucleic acids.

Vitamin B_{12} (cobalamin). This is a group of cobalt-containing compounds. It is found in almost all foods of animal origin, and is destroyed by heat.

Vitamin B_{12} is essential for DNA synthesis, and deficiency leads to megaloblastic anaemia (p. 74), which is correctable with supplements. However, vitamin B_{12} is also required for formation and maintenance of myelin, the fatty substance that surrounds and protects some nerves. Deficiency accordingly causes irreversible damage such as peripheral neuropathy and/or subacute spinal cord degeneration and usually affects older adults. The presence of intrinsic factor in the stomach is essential for vitamin B_{12} absorption, and deficiency is usually associated with insufficient intrinsic factor.

Folic acid (folate). This is found in liver, leafy green vegetables, brown rice, beans, nuts and milk. It is synthesised by bacteria in the large intestine, and significant amounts derived from this source are believed to be absorbed. It is destroyed by heat and moisture. As only a small amount is stored in the body, deficiency quickly becomes evident. Like vitamin B_{12}, folic acid is also essential for DNA synthesis, and when lacking mitosis (cell division) is impaired. This manifests particularly in rapidly dividing tissues such as blood, and folate deficiency therefore leads to megaloblastic anaemia (p. 74), which is reversible with folate supplements. It is involved in development of the embryonic neural tube, which later becomes the spinal cord and skull. Deficiency at conception and during early pregnancy is linked to spina bifida (p. 188).

Pantothenic acid. This is found in many foods and is associated with energy-yielding carbohydrate metabolism; no deficiency diseases have been identified. It is destroyed by excessive heat and freezing.

Biotin. This is found in a wide range of foods including yeast, egg yolk, liver, kidney and tomatoes and is synthesised by microbes in the intestine. It is associated with the metabolism of carbohydrates, lipids and some amino acids; deficiency is very rare.

Vitamin C (ascorbic acid)

This is found in fresh fruit, especially blackcurrants, oranges, grapefruit and lemons, and also in rosehips and green vegetables. The vitamin is very water soluble and is easily destroyed by heat, ageing, chopping, salting and drying. These processes may predispose to the development of *scurvy* (deficiency). Deficiency becomes apparent after 4–6 months.

Vitamin C is associated with protein metabolism, especially the laying down of collagen fibres in connective tissue. Vitamin C, like vitamin E, acts as an antioxidant, protecting body molecules from damaging oxidative reactions caused by free radicals. When scurvy affects collagen production there is fragility of blood vessels, delayed wound healing and poor bone repair. Gums become swollen and spongy and the teeth loosen in their sockets. Systemic affects include fatigue, weakness and aching joints and muscles.

Minerals, trace elements and water

Minerals and trace elements

Minerals are inorganic substances needed in small amounts for normal cellular functioning. Some minerals, e.g. calcium, phosphate, sodium and potassium are needed in larger amounts than others. Those required in only tiny quantities are known as trace elements or trace minerals, e.g. iron, iodine, zinc, copper, cobalt, selenium and fluoride. The main minerals and trace elements are outlined below.

Calcium

This is found in milk, cheese, eggs, green vegetables and some fish, e.g. sardines. An adequate supply should be obtained from a normal, well-balanced diet, although requirements are higher in pregnant women and growing children. The most abundant of the minerals, 99% of calcium (about 1 kg in adults) is found in the bones and teeth, where it is an essential structural component. Calcium is also involved in blood clotting, and nerve and muscle function. Deficiency of calcium causes *rickets* in children and *osteomalacia* in adults (p. 431).

Phosphate

Sources include milk and dairy products, red meat, fish, poultry, bread and rice. If there is sufficient calcium in the diet it is unlikely that there will be phosphate deficiency.

It is associated with calcium and vitamin D in the hardening of bones and teeth; 85% of body phosphate is found in these sites. Phosphates are an essential part of nucleic acids (DNA and RNA, see Ch. 17), cell membranes and energy storage molecules such as adenosine triphosphate (ATP, Fig. 2.10, p. 28).

Sodium

Sodium is found in most foods, especially fish, meat, eggs, milk and especially in processed foods. It is also frequently added during cooking or as table salt. Intake of sodium chloride usually exceeds recommendations and excess is normally excreted in the urine. High sodium intake is associated with hypertension (p. 131), which is a risk factor for ischaemic heart disease (p. 127) and stroke (p. 181). The recommended daily salt (sodium chloride) intake for adults should not exceed 6 g. In practice, food is usually labelled with sodium content, and to convert this to salt, the sodium content is multiplied by 2.5.

It is the most common *extracellular cation* and is essential for muscle contraction and transmission of nerve impulses.

Potassium

This is found widely distributed in all foods, especially fruit and vegetables, and intake usually exceeds requirements.

It is the most common *intracellular cation* and is involved in muscle contraction and transmission of nerve impulses.

Iron

Iron, as a soluble compound, is found in liver, red meat, pulses, nuts, eggs, dried fruit, wholemeal bread and leafy green vegetables. In normal adults about 1 mg of iron is lost from the body daily. The normal daily diet contains more, i.e. 9 to 15 mg, but only 5–15% of intake is absorbed. Iron is essential for the formation of haemoglobin in red blood cells. It is also necessary for carbohydrate metabolism and the synthesis of some hormones and neurotransmitters. Menstruating and pregnant women have increased iron requirements, as do young people experiencing growth spurts.

Iron deficiency anaemia (p. 73) is relatively common and occurs when iron stores become depleted. Iron deficiency anaemia may also occur arise from chronic bleeding, e.g. peptic ulcer disease.

Iodine

Iodine is found in seafoods and vegetables grown in soil rich in iodine. In parts of the world where iodine is deficient in soil, very small quantities are added to table salt to prevent *goitre* (p. 232).

It is essential for the formation of *thyroxine* and *triiodothyronine*, two hormones secreted by the thyroid gland (p. 222) which regulate metabolic rate, and physical and mental development.

Water

Water is the most abundant constituent of the human body, accounting for around 60% of the body weight in an adult (see Fig. 2.14, p. 30).

A large amount of water is lost each day in urine, sweat and faeces. This is normally balanced by intake in food and fluids, to satisfy thirst. Water requirements are increased following exercise and in high environmental temperatures. Dehydration, with serious consequences, may occur if intake does not balance loss. Water balance is finely regulated by the action of hormones on the kidney tubules (Ch. 13).

Functions of water

These include:

- providing the moist internal environment required by all living cells, e.g. for metabolic reactions
- moistening food for swallowing (see saliva, p. 295)
- regulation of body temperature – as a constituent of sweat, which is secreted onto the skin, it evaporates, cooling the body surface (Ch. 14)
- being the major constituent of blood and tissue fluid, it transports substances round the body and allows exchange between the blood, tissue fluid and body cells
- dilution of waste products and toxins in the body
- providing the medium for excretion of waste products, e.g. urine and faeces.

Non-starch polysaccharide (NSP)

Learning outcome

After studying this section, you should be able to:

- describe the sources and functions of non-starch polysaccharide.

Non-starch polysaccharide (NSP) is the correct term for dietary fibre although the latter term continues to be more commonly used in the UK. It is the indigestible part of the diet and consists of bran, cellulose and other polysaccharides found in fruit, vegetables and cereals. Dietary fibre is partly digested by microbes in the large intestine and is associated with gas (flatus) formation. The recommended daily intake is at least 18 g, at least 5 portions of fruit or vegetables ('5 a day').

Functions of NSP (dietary fibre)

Dietary fibre:

- provides bulk to the diet and helps to satisfy the appetite
- stimulates peristalsis (see p. 289) } prevents constipation
- attracts water, increasing faecal bulk } prevents constipation
- protects against some gastrointestinal disorders, e.g. colorectal cancer and diverticular disease (p. 328).

Nutrition and ageing

Learning outcome

After studying this section, you should be able to:

- describe the factors affecting diet and nutrition in older adults.

The importance of good nutrition to health and wellbeing at all stages of the lifespan is well established. The relationship between nutrition, diet and ageing is complex as many diseases arise from poor diet, e.g. atherosclerosis predisposes to coronary heart disease (p. 127). Good nutrition during early and middle life can significantly reduce the risk of problems in later life e.g. osteoporosis (p. 431) can be greatly reduced by an adequate intake of calcium, phosphate and vitamin D.

The senses of smell and taste decline with age (Ch. 8) which can reduce appetite and enjoyment of eating.

Basal metabolic rate (BMR, p. 314) gradually declines with age from the fourth or fifth decades of life. This is mainly due to a reduction in muscle mass and a corresponding increase in body fat; BMR is higher in those with more muscle as muscle is more metabolically active than adipose tissue (fat). Physical activity generally lessens with age, further reducing BMR in older adults.

UK dietary recommendations for older adults are the same as those for other adults although energy requirements gradually reduce as the BMR falls, especially when physical activity is limited. As for other age groups, it is important for older adults to eat a balanced diet with sufficient fibre and vitamins.

Nutritional disorders in older adults

Malnutrition and obesity are both prevalent in older adults as well as other conditions considered below. Malnutrition is more prevalent in those living in institutions, whereas being overweight or obese tends to be more common in people living at home.

Malnutrition

Being underweight (BMI < 18.5) predisposes to health problems e.g. development of pressure ulcers which take longer to heal in older adults. In the oldest adults, anorexia and weight loss become increasingly common and the incidence of protein-energy malnutrition (PEM, p. 283) increases. Malnutrition in healthcare settings is considered in the following section.

Obesity

It is common for body weight to increase between the ages of 40 and 65 ('middle age spread'). This is generally attributed to a reduction in physical activity and BMR rather than increased dietary energy intake. Overweight is defined as BMI above 25 and obesity when BMI is above 30 (Box 11.1). After 65 years, there is usually weight loss accompanied by a lower dietary intake, a decline in muscle mass and an increasing risk of malnutrition. Being overweight or obese at any age carries many health risks (see p. 284), for example, type 2 diabetes mellitus (p. 236). In older adults, obesity is associated with a decline in BMR (see above) and lessened secretion of and responsiveness to hormones which is often accompanied by a more sedentary lifestyle.

Vitamin deficiency

Some vitamin deficiencies become more common in older adults. Vitamin D deficiency (p. 278) is linked to older adults who live in institutions, or are Asian, black or housebound. Those who habitually cover their skin are also vulnerable due to limited exposure to sunlight. The British Nutrition Foundation (2009) recommends that vitamin D intake is maintained by eating oily fish and fortified cereals regularly and that those over 65 years take supplements (10 μg per day). Vitamin B_{12} deficiency, perhaps due to decreased absorption of intrinsic factor, is also more common in older adults and may result in pernicious anaemia (p. 74).

Constipation

Constipation becomes more common as muscle tone and peristaltic activity of the colon lessens with age. This is exacerbated by a lower fluid and/or fibre intake, taking less exercise and reduced mobility. If there is difficulty with activities related to nutrition, e.g. mobility problems which prevent shopping, impaired cognitive function or loss of the manual dexterity required to prepare and eat food and drinks, this further predisposes to constipation.

Disorders of nutrition

Learning outcome

After studying this section, you should be able to:

- describe the main consequences of malnutrition and obesity.

The importance of nutrition is increasingly recognised as essential for health, and illness often alters nutritional requirements.

Protein-energy malnutrition (PEM)

This is the result of inadequate intake of protein, carbohydrate and fat. It occurs during periods of starvation and when dietary intake is insufficient to meet increased requirements, e.g. trauma, fever and illness. Malnutrition is relatively rare in developed countries except when there is an underlying condition, e.g. sepsis, trauma, surgery or a concurrent illness. Under-nutrition is seen where poverty is prevalent and is usually the result of a poor diet which is not adequately balanced. In the UK many older adults admitted to healthcare establishments (e.g. hospitals and care homes) have signs of undernutrition which often worsens during admission. Anorexia (loss of appetite) from any cause may lead to malnutrition. People with advanced cancer or some chronic illnesses can experience loss of appetite accompanied by profound weight loss and muscle wasting as a symptom of *cachexia* (p. 57).

If dietary intake is inadequate, it is not uncommon for vitamin deficiency to develop at the same time. Poor nutrition reduces the ability to combat other illness and infection. The degree of malnutrition can be assessed from measurement of body mass index (see Box 11.1).

Infants and young children are particularly susceptible as their nutritional requirements for normal growth and development are high. In developing countries where people experience long periods of near-total starvation the two conditions below are found in children under 5 years.

Kwashiorkor

This is malnutrition with oedema that typically occurs when breastfeeding stops and is often precipitated by infections such as measles or gastroenteritis. Severe liver damage significantly reduces the production of plasma proteins leading to ascites and oedema in the lower limbs that masks emaciation (Fig. 11.2A).

Growth stops and there is loss of weight and loss of pigmentation of skin and hair accompanied by listlessness, apathy and irritability. There is susceptibility to infection and recovery from injury and infection takes longer.

Marasmus

This malnutrition with severe muscle wasting is characterised by emaciation due to breakdown (catabolism) of muscle and fat (Fig. 11.2B). There is no oedema. Growth is retarded and the skin becomes wrinkled due to absence of subcutaneous fat; hair is lost.

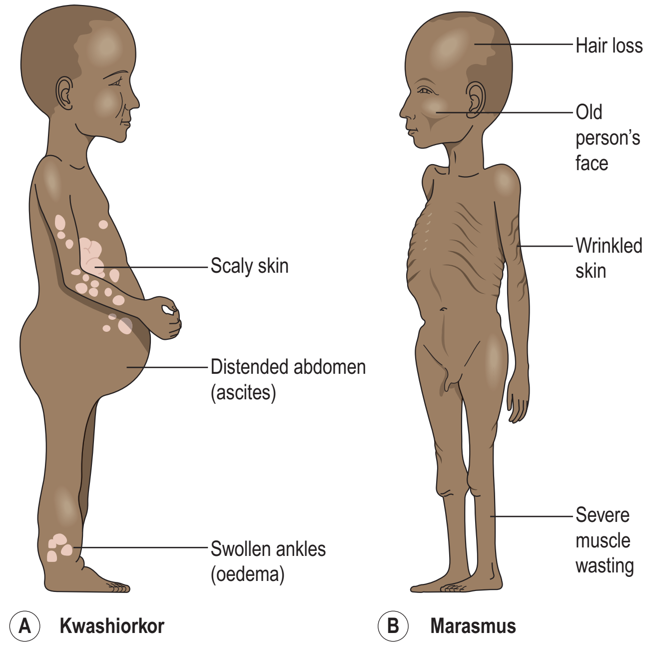

Figure 11.2 Features of protein-energy malnutrition.

Malabsorption

The causes of malabsorption vary widely, from short-term problems such as gastrointestinal infections (p. 325) to chronic conditions such as cystic fibrosis (p. 266). Malabsorption may be specific for one nutrient, e.g. vitamin B_{12} in pernicious anaemia (p. 74), or it may apply across a spectrum of nutrients, e.g. tropical sprue (p. 331).

Obesity

In developed countries, this is increasingly common although it is also prevalent in some developing countries. The WHO define obesity as a body mass index that exceeds 29.9 (Box 11.1). It occurs when energy intake exceeds energy expenditure, e.g. in inactive individuals whose food intake exceeds daily energy requirements.

Obesity (Fig. 11.3) is a growing public health challenge worldwide that affects people of all ages and predisposes to many other conditions (Box 11.3). Worldwide, around 33% of adults are obese and 10% are overweight (see definitions in Box 11.1). There are more than 40 million obese children aged under five worldwide, of whom 75% live in urban areas of developing countries (WHO, 2013). Childhood obesity is of particular concern, especially in developing countries (where malnutrition can also be widespread), because this preventable condition is likely to continue into and during adulthood with its associated health risks, especially diabetes and cardiovascular disease.

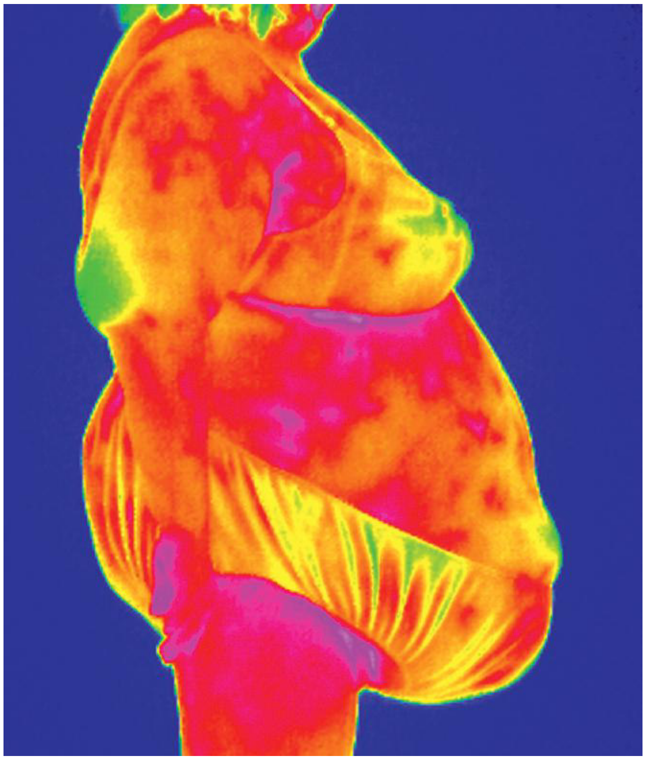

Figure 11.3 Obese woman (thermogram).

Box 11.3 Conditions with obesity as a predisposing factor

Cardiovascular diseases, e.g. hypertension (p. 131), ischaemic heart disease (p. 127)
Type 2 diabetes (p. 236)
Some cancers
Gallstones (p. 335)
Osteoarthritis (p. 434)
Varicose veins (p. 123)
Increased risk of postoperative complications

The hormone *leptin* is associated with obesity. It has several functions, one of which is control of appetite. After eating, this hormone is released by adipose tissue and acts on the hypothalamus resulting in a feeling of satiety, or fullness, which suppresses the appetite. In obesity, there are usually high blood levels of leptin and the negative feedback system, which usually suppresses the appetite, no longer operates normally.

Another function of leptin is involvement in the synthesis of GnRH and gonadotrophins at puberty (Ch. 18). Being secreted by fat tissue, levels are low in thin individuals which explains why:

- thin girls with little body fat reach puberty later than their peers of normal weight
- very thin women may have difficulty in conceiving
- menstruation stops in females with very little body fat.

Obesity predisposes to:

- cardiovascular diseases, e.g. ischaemic heart disease (p. 127), hypertension (p. 131)
- type 2 diabetes mellitus (p. 236)
- some cancers
- hernias (p. 329)
- gallstones (p. 335)
- varicose veins (p. 123)
- osteoarthritis (p. 434)
- increased incidence of postoperative complications.

Conditions with dietary implications

In addition to nutritional disorder there are many conditions where dietary modifications are needed. Some of these are listed in Box 11.4.

Box 11.4 Conditions that require dietary modification

Obesity	Phenylketonuria (p. 446)
Malnutrition	Acute renal failure (p. 352)
Diabetes mellitus (p. 236)	Chronic renal failure (p. 353)
Diverticular disease (p. 328)	Liver failure (p. 334)
Coeliac disease (p. 331)	Lactose intolerance

Further reading

British Nutrition Foundation. Nutrition science. Available online at: http://www.nutrition.org.uk/nutritionscience Accessed 31 March 2013

British Nutrition Foundation. The Eatwell plate. Available online at: http://www.food.gov.uk/multimedia/pdfs/publication/eatwellplate0210.pdf Accessed 31 March 2013

WHO 2009 Global database on body mass index. Available online at: http://www.who.int/bmi/index.jsp?introPage=intro_3.html Accessed 4 November 2013

WHO (2010) Global Strategy on Diet, Physical Activity and Health: childhood overweight and obesity. Available online at: http://www.who.int/dietphysicalactivity/childhood/en/ Accessed 31 March 2013

WHO (2013) Factsheet: Obesity and overweight. Available online at: http://www.who.int/mediacentre/factsheets/fs311/en/ Accessed 31 March 2013

For a range of self-assessment exercises on the topics in this chapter, visit Evolve online resources: https://evolve.elsevier.com/Waugh/anatomy/