Introduction to Clinical Nutrition

Human nutrition: describes the processes whereby the human body obtain and use necessary substances from foods (nutrients) to maintain structural and functional integrity.

Clinical nutrition focuses on the nutritional management of individual patients or groups of patients with established disease. **Public health nutrition**: focuses on health promotion and disease prevention in the general population.

Nutrients: chemical substances obtained from food and used in the body to provide energy, structural materials, and regulating agents to support growth, maintenance, and repair of the body's tissues. Nutrients may also reduce the risks of some diseases.

Essential nutrients: nutrients a person must obtain from food because the body cannot make them for itself in sufficient quantity to meet physiological needs; also called indispensable nutrients.

Classification of nutrients

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

- **Macronutrients** are required in large amounts by the body, usually measured in tens of grams.
- **Micronutrients** are substances required in very small amounts by the body, generally measured in milligrams or micrograms.

Macronutrients

- The macronutrients found in the diet are carbohydrates, fats and proteins.

- Carbohydrates and fats are the major providers of energy, although protein can also provide energy.
- They all have a structural role, the most important in this respect being proteins.
- All contain carbon, hydrogen and oxygen; in addition, proteins contain nitrogen and some contain sulphur.

1. Carbohydrates

These are saccharides, combined in various degrees of complexity to form the simple sugars, and larger units such as oligosaccharides and polysaccharides. Their main function is to act as a source of energy, in the form of glucose. Some resist digestion (termed nonglycemic), and comprise the non-starch polysaccharides (NSP), which are part of 'dietary fibre' and have a role in bowel function.

2. Fats

Fats comprise a diverse group of lipid-soluble substances, the majority being triglycerides or triacylglycerols (TAGs). Derived products such as phospholipids and sterols (most notably cholesterol) are included in this group.

TAGs are broken down to yield energy, and form the major energy reserve in the body, in adipose tissue. Specific fatty acids found in TAGs are important in cell membrane structure and function, and must be supplied in the diet. These are termed essential fatty acids.

3. Proteins

Proteins consist of chains of individual amino acids, combined to form a large variety of proteins. On digestion, individual amino acids are used for the synthesis of other amino acids and proteins required by the body, involving considerable recycling of the components.

There are eight 'essential amino acids' (more in children), which must be supplied by the diet. In addition, some may become 'conditionally' essential in particular 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, and the nitrogen part excreted as urea.

Micronutrients

1. Minerals

These are inorganic substances needed in small amounts, generally as part of the structure of other molecules (e.g. iron as part of haemoglobin), or as essential cofactors for the activity of enzymes (e.g. selenium in glutathione peroxidase).

Uptake of some minerals from the diet must be carefully regulated as there is limited 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 uptake of another (e.g. zinc and iron, or iron and calcium).

2. Vitamins

These share the common feature of being organic substances, required by the body in small amounts for its normal functioning. The vitamins are sub-classified, into water-soluble (vitamin C and B vitamins) and fat-soluble (vitamins A, D, E and K) groups. It is now recognised that vitamin D is synthesised in the skin by the action of ultraviolet light on a precursor, and could strictly be termed a hormone rather than a vitamin. Further, niacin can be made in the body from the amino acid tryptophan, so a separate supply may not be needed if protein intakes are adequate. However, in both of these cases, there are situations where synthesis is insufficient, and so a dietary need remains.

Water

Water provides the basic medium in which all the body's reactions occur. An inadequate level of fluid intake will quickly compromise the metabolic functions of the body and disturb the homeostatic mechanisms that operate.

Nutritional requirements

A certain amount of every nutrient is used by the body every day. This amount must therefore be replaced, either from the diet or from body stores. A **requirement** is defined as the amount of a specific nutrient required by an individual to prevent clinical signs of deficiency.

Using the results of thousands of research studies, nutrition experts have produced a set of standards that define the amounts of energy, nutrients, other dietary components, and physical activity that best support health. These recommendations are called Dietary Reference Intakes (DRI). These DRI apply to healthy people and may not be appropriate for people with diseases. Patients with certain diseases may require increase or decrease in nutrient needs.

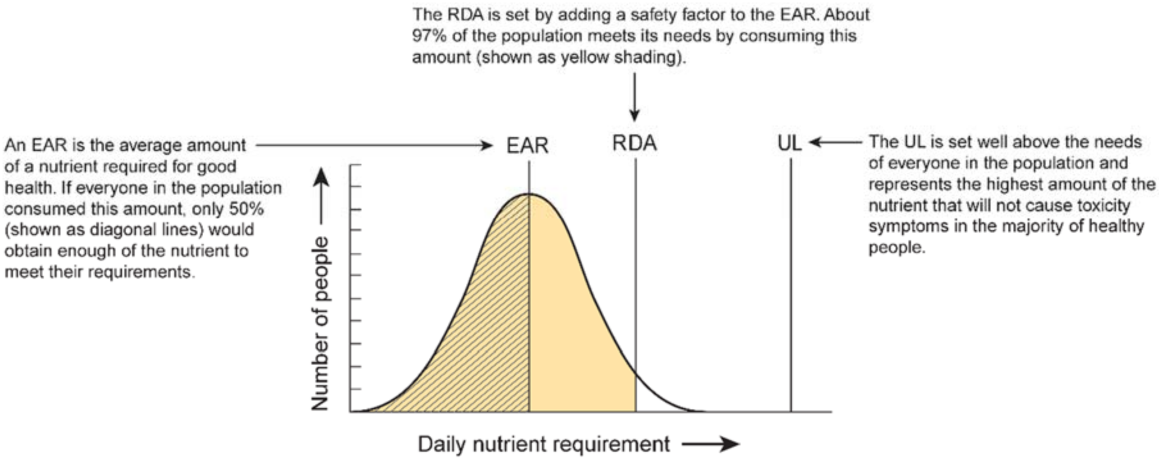
Dietary Reference Intakes (DRIs) A set of four types of nutrient intake reference standards used to assess and plan dietary intake; these include the Estimated Average Requirements (EARs), Recommended Dietary Allowances (RDAs), Adequate Intake levels (AIs), and the Tolerable Upper Intake Levels (ULs).

Estimated Average Requirement (EAR) The amount of a nutrient that meets the physiological requirements of half the healthy population in a specified life stage and gender group.

Recommended Dietary Allowance (RDA) The average intake of a nutrient thought to meet the nutrient requirements of nearly all (97%) healthy people in a specified life stage and gender group.

Adequate Intake (AI) level Nutrient intake of healthy populations that appears to support adequate nutritional status; established when RDAs cannot be determined.

Tolerable Upper Intake Level (UL) The highest level of chronic intake of a nutrient thought to be not detrimental to health.



<u>Energy from foods</u>

The amount of energy a food provides depends on how much carbohydrate, fat, and protein it contains. When completely broken down in the body, a gram of carbohydrate yields about 4 kcalories of energy; a gram of protein also yields 4 kcalories; and a gram of fat yields 9 kcalories. Because fat provides more energy per gram, it has a greater energy density than either carbohydrate or protein.

Calories: units by which energy is measured. Food energy is measured in kilocalories (1000 calories equal 1 kilocalorie), abbreviated kcalories or kcal. One kcalorie is the amount of heat necessary to raise the temperature of 1 kilogram of water by 1°C. The scientific use of the term kcalorie is the same as the popular use of the term calorie. However, the international unit for measuring food energy is the joule, a measure of work energy. One joule is the energy used when a mass of 1 kilogram is moved through 1 meter by using a force of 1 newton. To convert kcalories to kilojoules, multiply by 4.2; to convert kilojoules to kcalories, multiply by 0.24.

To calculate the energy available from a food, multiply the number of grams of carbohydrate, protein, and fat by 4, 4, and 9, respectively. Then add the results together. For example, 1 slice of bread with 1 tablespoon of peanut butter on it contains 16 grams carbohydrate, 7 grams protein, and 9 grams fat:

- 16 g carbohydrate × 4 kcal/g = 64 kcal
- 7 g protein × 4 kcal/g = 28 kcal
- 9 g fat × 9 kcal/g = 81 kcal
- Total = 173 kcal

Energy in the body: The body uses the energy-yielding nutrients to fuel all its activities. When the body uses carbohydrate, fat, or protein for energy, the bonds between the nutrient's atoms break. As the bonds break, they release energy. Some of this energy is released as heat, but some is used to send electrical impulses through the brain and nerves, to synthesize body compounds, and to move muscles.

If the body does not use these nutrients to fuel its current activities, it converts them into storage compounds (such as body fat) to be used between meals and overnight when fresh energy supplies run low. If more energy is consumed than expended, the result is an increase in energy stores and weight gain. Similarly, if less energy is consumed than expended, the result is a decrease in energy stores and weight loss.

Energy requirements

Estimated Energy Requirement (EER): the average dietary energy intake that maintains energy balance and good health in a person of a given age, gender, weight, height, and level of physical activity. There are two approaches to assessing energy requirements for subjects who are weight-stable and close to energy balance:

1. **Assessment of energy intake:** Energy intake can be estimated from dietary surveys and, in the past, this has been used to decide daily energy requirements. However, measurement of energy expenditure gives a more accurate assessment of requirements.
2. **Assessment of total energy expenditure:** Daily energy expenditure is the sum of:

a. **The basal metabolic rate (BMR):** is the minimum amount of energy expended that is compatible with life. An individual's BMR reflects the amount of energy used during 24 hours while physically and mentally at rest in a thermoneutral environment that prevents the activation of heat-generating processes, such as shivering.

Factors affecting BMR include: Age (higher in younger), gender (higher in males), body composition (higher in leaner [muscular] individuals), body size (higher in larger people), food intake (higher with caffeine or nicotine intake).

b. **The diet-induced thermogenesis**: is the increase in energy expenditure associated with the consumption, digestion, and absorption of food. This represent about 10% of total energy expenditure.

c. **Physical activity:** this encompasses all types of activity, including sports and leisure, work-related activities, general activities of daily living, and fidgeting. The metabolic rate of physical activity is determined by the amount or duration of activity (i.e., time), the type of physical activity (e.g., walking, running, typing), and the intensity at which the particular activity is performed. The contribution of physical activity is the most variable component of total energy expenditure, which may be as low as 100 kcal/day in sedentary people or as high as 3000 kcal/day in athletes.

Non-exercise activity thermogenesis (NEAT): represents the energy expended during the workday and during leisure-type activities (e.g., shopping, fidgeting, even gum chewing), which may account for vast differences in energy costs among people.

The ratio of total energy expenditure to BMR provide a rough index of physical activity referred to as physical activity level (PAL). If the person is sedentary, the PAL coefficient is 1.0. If the person is somewhat active, the PAL coefficient is 1.12. If the person is active, the PAL coefficient is 1.27. If the person is very active, the PAL coefficient is 1.45.

Regulation of food intake and energy expenditure

Hunger can be defined as a demand for energy (e.g. after starvation), while appetite refers to a demand for a particular food. Satiety refers to the inhibition of further intake of food or meal after eating has ended. There are both short- and long-term mechanisms for regulating food intake and energy expenditure so as to maintain energy balance.

Short-term signals regulating food intake: The distention of the stomach wall in response to the presence of food, called gastric stretching, provides a powerful satiety signal. The GI tract has specialized receptors (mechano-receptors) that are responsive to this type of stretching.

The concentration of certain nutrients in the blood can also influence hunger and satiety. For example, the brain is very sensitive to changes in blood glucose and amino acids levels. When blood glucose and amino acids increase following a meal, the brain responds by releasing neurotransmitters that stimulate satiety, providing a signal to stop eating.

The presence of food in the stomach and small intestine can trigger the release of several GI hormones, the majority of which promote satiety (table below).

TABLE 8.1 Gastrointestinal Hormones and Effect on Food Intake

Gastrointestinal Hormone	Stimulus for Release	Site of Production	Effect on Food Intake
Cholecystokinin (CCK)	Protein and fatty acids	Small intestine	↓
Glucagon-like peptide 1 (GLP-1)	Nutritional signals and neural/hormonal signals from the gastrointestinal tract	Small and large intestine	↓
Ghrelin	Empty stomach	Stomach	↑
Enterostatin	Fatty acids	Stomach and small intestine	↓
Peptide YY (PYY)	Food in the GI tract	Small and large intestine	↓

Long-term signals regulating food intake and energy homeostasis: Insulin and leptin are the two most important long-term regulators of food intake and energy balance. Both insulin and leptin act in the CNS to inhibit food intake and to increase energy expenditure, most likely by activating the sympathetic nervous system (SNS).

Insulin is secreted from beta cells in the endocrine pancreas in response to circulating nutrients (glucose and amino acids) and to the incretin hormones, glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-1 (GLP-1), which are released during meal ingestion and absorption.

Leptin is mainly secreted by the adipose tissue and its main function is to regulate long-term food intake and energy expenditure in response to the state of fat reserves. The gastric hormone ghrelin increases food intake and decreases fat oxidation in rodents and may have an anabolic role in long-term food intake regulation

Appetite Effects on Energy Intake

Two important responses that help maintain a healthy body weight are eating when you hungry and stopping when you are full. However, sometimes we eat for reasons other than hunger, and at times we eat past satiety. The stimuli that override hunger and satiety tend to be more psychological than physiological.

Whereas appetite is the psychological longing or desire for food, a food aversion is a strong psychological dislike of a particular food or foods. Sometimes, even the thought or smell of certain foods can trigger an adverse physical response. Our appetite can be an important determinant of what and when we eat. When the desire for a specific food is especially compelling, it is often referred to as a food craving.

Estimation of energy requirement

$$\text{Males: kcal/: day} = 10\,(\text{wt}) + 6.25\,(\text{ht}) - 5\,(\text{age}) + 5$$
$$\text{Females: kcal/ day} = 10\,(\text{wt}) + 6.25\,(\text{ht}) - 5\,(\text{age}) - 161$$
$$\text{Weight} = \text{actual body weight in kilograms}$$
$$\text{Height} = \text{centimeters; age} = \text{years}$$

×

PAL