

# CHAPTER 1 THE DIGESTIVE SYSTEM – EVERYONE IS DIFFERENT

## NUTRITION & NUTRIENTS

*Nutrition can be defined as the science of food and it's relation to health.*

*It involves processes where all people (all living organisms) receive and process the nutrients essential for life.*

Nutrients themselves are defined as the chemical compounds from food that are found in a person's diet. Nutrients are essential to life; they play a variety of vital life roles such as in the provision of energy, the promotion of growth and development and in the regulation of bodily processes. There are six main classes of nutrients in food - proteins, lipids, carbohydrates, vitamins, minerals and water.

Foods have very different nutritional densities – this is the nutritional value of food relative to the number of kilojoules (energy) it supplies. In general terms, foods which have a high nutrient density are a good source of that nutrient relative to its contribution of energy. To explain, eggs or liver have high nutrient density as they contribute a great number of nutrients relevant to their kilojoule count, whereas fats and soft drinks provide energy, but have very low nutrient density as they contain few nutrients.

The most essential aspect of nutrition is the volume and variety of nutrients a person consumes in their diet. All people require the same nutrients during each stage in their life cycle although the volume of each nutrient necessary does vary. Here we will consider the differences of each life stage specifically and the major nutritional requirements during this time.

Please note the information herein is general and may not be directly applicable to every population/community group, chronological information is not absolute, but is based generally accepted standards. Additionally, the numerical data is given as approximates only – based on mean averages from a number of sources.

### Infancy

This life stage extends from birth to two years. This is a time of rapid growth and development with the average newborn (average birth weight 3.5 kg) doubling in weight in the first 4-5 months and tripling in weight over the first year. Babies also have high basal metabolic rates (BMR) - two times that an adult and these factors contribute to a comparatively high energy requirement of around 100 kcal\*/kilogram body weight.

**BMR stands for basal metabolic rate.  
It refers to the daily  
expenditure of energy during rest.**

*\* In the context of human nutrition we note the use of calorie (cal) and kilocalorie (kcal) are equivalent, therefore these are used interchangeably throughout the book.*

## NUTRITIONAL REQUIREMENTS DURING INFANCY:

In the first year of life, breast milk or infant formula milk is the main source of nutrition. Breast milk is considered to be the superior food for babies, containing the correct amounts of proteins, vitamins, minerals, fat and carbohydrates required for optimum growth and development. As well as providing nutrition, breast milk also has benefits for the immune system as it contains antibodies (specialised immune proteins) to provide protection against disease and infection from foreign microorganisms, thus reducing the chance of developing allergies, asthma and eczema, for example.



*Electric breast pump*

Mother's breast milk naturally changes over time to suit the baby's specific nutritional needs. The first milk produced is called colostrum. Colostrum contains protein, vitamins, minerals and hormones that encourage the growth of healthy gut flora ("good" bacteria in the intestine). Colostrum contains a high level of antibodies. It is yellow in colour due to its high level of proteins and nutrients. Colostrum is produced in relatively small quantities, to match the small size of the baby's stomach. After the first two weeks, the baby's requirements change, so the type of milk produced changes to suit their needs.

Mature milk produced is paler in colour and thinner in consistency. It has a high proportion of fats and lactose, the main source of carbohydrate, and is lower in proteins and minerals whilst still contains a high volume of antibodies. The first milk that comes during a feeding session is called foremilk. This is watery and satisfies the baby's thirst. After 5-10 minutes comes hindmilk, which is high in fat content and provides the baby with energy, allowing healthy growth and weight gain.

The additional benefits of breastfeeding, include strengthening of the bond between mother and child, helping the mother lose weight gained through pregnancy and decreasing the risk of some cancers and osteoporosis later in life.

There are a number of reasons a mother may not be able to breast feed. If this is the case, they can substitute infant formula for breast milk. Baby formulas have been developed to match breast milk as closely as possible to provide babies with their nutritional needs, however not all aspects

of breast milk can be artificially reproduced. Formulas are usually based on cow or soy milk. There are also special formulas for babies who cannot digest the formula properly.

Whilst milk should be the main source of nutrients for the first year of a baby's life, they can start being introduced to solids from 6 months to fulfill their needs for extra kilojoules and nutrients. The digestive system is not developed enough to deal with solids until after 6 months. It is thought that introduction of solids earlier than 6 months may trigger the development of food allergies. It is often recommended that babies should continue receiving milk until at least 12 months old, whilst slowly introducing solid foods (initially pureed).

## Childhood

2 years to approximately 11 years. Children have relatively high energy needs and dietary guidelines designed for an adult are not appropriate. Under the age of 5, nutrition and energy requirements are high relative to the small capacity of the child. Increased physical activity has an effect on nutritional consumption. Gender related differences in physical features are not so apparent. Children tend to reflect the growth patterns of their biological parents, thus small parents have small children, and tall parents have tall children and so on.



Child trying a new taste

## NUTRITIONAL REQUIREMENTS DURING CHILDHOOD

With reference to early childhood, toddlers growth rates slow down, compared to infancy, and their nutritional requirements change accordingly. In this stage they will stop drinking breast milk and diversify the range of foods that they eat. It is important to foster healthy eating habits at this stage of their lives, as this will encourage a preference for healthier options throughout their life. They will go through periods of growth where they will have increased appetites, and periods of slower growth and be less interested in foods. A toddler's stomach is still relatively small and the child's appetite may be the best guide as to how much they need to eat in a meal. Checking growth regularly can help to ensure the toddler is receiving sufficient nutrition.

Children can become "fussy eaters" through the period of early childhood, so it can help to offer a selection of nutritious food and allow them some choice. Ideally the meal will be well-balanced and include food from a variety

of food groups. Encourage drinking water, rather than fruit juices or similar. Cow's milk is another healthier alternative.

For optimum health and development it is important for children to eat a wide range of nutritious food. Maintaining an appropriate rate of physical growth requires a balanced intake of nutrients and energy. Although the growth rate in this stage is decreased compared with infancy, children still require proportionally nutrients and energy for their body weight than adults. It is useful to continue to monitor children's growth rate, as an indicator of good nutrition.

To achieve adequate daily intake, children generally need to eat 3-4 meals per day and at least one snack. It is important to ensure snacks are healthy, low sodium and low sugar, as they can significantly contribute to daily intake. When children start school they are exposed to food influences from outside the home and will often be drawn to snack foods such as chips, sweets, biscuits and other food that is high in energy value but low in nutritional density.

## Late childhood (adolescence)

12 -18 years. Gender related differences create a variation in the distribution of body fat and muscle tissue during this phase - as a result nutritional requirements change considerably now and become somewhat gender based.

Studies interpret the distribution of fat in females during puberty as the preparation of energy reserves by the body for reproductive demands. The process of the development of lean body mass in males utilises fat reserves from childhood at this time. The age at the onset of puberty has fallen over recent years, this often attributed to improved nutrition.

## NUTRITIONAL REQUIREMENTS DURING LATE CHILDHOOD

Growth spurts takes place during this time, often there is a period of rapid growth between 12-15 years and a second period of (less rapid) growth during the later teenage years. During the first main growth spurt girls gain on average 16cms in height and 16kg in weight, and boys 20cm in height and 20kg in weight. This increased growth has a corresponding requirement for an increase in energy and nutritional needs. Up until this stage male and female body mass in terms of fat and muscle is the same, however through puberty the proportion of muscle mass in males increases compared to in females. During this time of rapid growth, their calcium requirements increase, to ensure strong bones and teeth. If there is not sufficient calcium taken in at this time there may be an increased chance of osteoporosis later in life. Dairy products are the most efficient food source of calcium. Calcium can also be found in foods such as leafy greens and almonds, the active form of Vitamin D is required to enable calcium to be absorbed from the intestine to the bones. It is also important during this time for females to get adequate iron. Because they start to menstruate they lose blood monthly so their iron needs increase. To get adequate iron in the diet, eat red meat at least once a week, and lots of iron-rich legumes and vegetables. It is also good to eat vitamin C with the meal as vitamin C helps with the absorption of iron.

## Adulthood

*18 to 65 years. Good nutrition through adulthood is important in determining health later on in life as well as during the adult stage. By eating a wide variety of nutritious food and exercising regularly, you will experience a greater sense of wellbeing and be less likely to develop serious diseases.*

### NUTRITIONAL REQUIREMENTS DURING ADULTHOOD:

#### Men

As a result of their higher proportion of muscle mass, men generally have a higher metabolic rate than women, and therefore have a greater energy intake requirement than women. Men generally eat more food overall and have a higher requirement for protein and fibre. Other nutrients specifically important for men include lycopenes (may lower risk of prostate and lung cancer); vitamins B6, B12 and folate (may lower the risk of cardiovascular disease); selenium, vitamin C and vitamin E (necessary for normal fertility in men).

#### Women

Women generally require less energy intake than men (apart from when pregnant and breastfeeding). As in adolescence, women continue to have a greater need for iron, due to blood loss in menstruation. It is estimated women should consume twice the daily intake of iron – for those with heavy menstrual blood loss, up to 16mg of iron should be aimed for. Changes in monthly hormone levels also alter sodium levels. Sodium in the tissues leads to fluid/water retention overall. Controlled studies show the best cure for fluid retention is to drink more water thus flushing the sodium from the tissues. Calcium is another nutrient that is important for women to protect from developing osteoporosis.

#### Pregnancy

Folate is important before conception and in early pregnancy as it prevents some genetic diseases and birth defects in babies. Pregnant women have higher energy requirements to support the growth of their baby. A women will require on average an extra 1400kJ (333 calories) per day in the second trimester and an extra 1900 kJ (452 calories) per day in the third trimester. It is important that the diet is well-balanced and nutritious to support the health of the child. There are a number of conditions that can effect the dietary requirements of pregnant women, such as gestational diabetes, constipation, heartburn, indigestion, nausea and vomiting. The need for some vitamins and minerals is increased slightly (such as calcium, iron and folate).

After birth, whilst breast feeding, women have a need for increased energy intake. They will need to ensure they are

maintaining adequate levels of fluid (about 2 litres a day). They will also have an increased need for most nutrients, supplementation may be necessary. Some foods eaten by the mother can also be passed through her milk to the baby, which may cause an adverse reaction for the baby. Examples include dairy products, wheat, caffeine, garlic, cabbage.



*Pregnant women have specific nutritional needs*

Menopause occurs in women between the ages 45-60, during this time ovaries reduce their production of sex hormones, especially oestrogen. Eating nutrient dense foods may help reduce the symptoms of menopause and prevent post-menopausal problems such as osteoporosis. Nutrients that can help alleviate menopausal symptoms include omega-3 fatty acids, folate, vitamin D and E, iron and calcium.

#### Late adulthood (elderly)

*65 years plus. Cognitive and physical capabilities tend reduce during this stage. Life expectancy and functional age has increased over time, which means it is becoming later and later before people tend to become susceptible to disease and lose capabilities and function respectively. Good nutrition during this life stage is vital for maintaining optimal health.*

### NUTRITIONAL REQUIREMENTS DURING LATE ADULTHOOD:

The body goes through more changes during later life, which is again reflected in nutritional requirements. Body composition changes, so there is less muscle mass, increased fat and decreased total body water. As a result of the reduction in muscle mass, the basal metabolic rate also decreases, so the energy intake requirements decrease. To fill the energy requirements it is important to eat nutrient dense food to maintain good health. Eating food that is rich in antioxidants may help slow down the ageing process by fighting free radicals and slowing oxidative damage in our bodies. Some nutrients that older people may need to consider supplementing are vitamins B6, B12, D and folate and the mineral calcium.

## DIGESTION

We have discussed which nutrients are required by the human body, here we will focus on how nutrients are derived from the foods that we eat i.e. how does the body change basic food items such as cereals, meat, fruit and vegetables to nutrients that can be absorbed into the blood and carried to cells where they are used by the body. The process involved here is called digestion.

It is through the biochemical process of digestion that food is mixed up, moved along the digestive tract and chemically broken down into smaller molecules. The digestive process begins in the mouth as a person chews and swallows, while the majority of digestion takes place in the small intestine before the remaining mixture passes to the large intestine where water is absorbed and digestion is completed. The whole process can take around 24 hours – around 6-8 hours of which is taken up by digestion in the stomach and small intestine, with most of the remaining time spent in the large intestine.

One initial point to grasp is that the digestive system consists of muscle (from mouth to anus) that enables the walls of the system to move. This movement, known as peristalsis, propels food and liquid through the hollow organs of the esophagus, stomach and intestine. The first muscular movement occurs as food is swallowed and this is the only movement which we actively control with all further movements being involuntary under the control of the nervous system.

### A MORE DETAILED LOOK AT STEPS OF DIGESTION

**Step 1:** Food enters the mouth. The grinding motion of teeth starts the mechanical breakdown of food. Chewing motion is known as mastication. Mastication encourages the major glands (parotid, submandibular, sublingual) under the tongue and at the back of the mouth to produce saliva. Saliva is 99.5% water and 0.5% solutes including potassium, sodium, chloride, bicarbonate and phosphates, some organic substances, a bacteriolytic enzyme (lysozyme) and amylase which is an enzyme responsible for the breakdown of starch. The chemical components of saliva work together to commence digestion; the food is also lubricated for swallowing (deglutition). Lingual lipase is an enzyme released from the tongue, but becomes active in the stomach where it digests triglycerides into fatty acids and monoglycerides.

**Step 2:** Food now referred to as a bolus, is passed along the esophagus. The esophagus lies behind the trachea and is about 24cm long in adults. The movement of food along the esophagus is controlled by peristaltic waves. The waves are a rhythmic, alternating contraction and relaxation of the circular and longitudinal muscles of the gastrointestinal tract.

**Step 3:** The bolus passes via the lower esophageal sphincter into the stomach. Several minutes after the bolus enters the stomach, strong muscular waves start to move to mix the food with secretions from the gastric glands. This mixing reduces food to a liquid form called chyme.

An enzyme, pepsin, begins to breakdown proteins here into smaller sub-units called amino acids. Proteins are the only nutrients digested by the stomach.

**Step 4:** From the stomach the partially digested chyme passes into the small intestine where most digestion and absorption of nutrients occurs. The small intestine is long muscular tube which is coiled up, thus increasing surface area, to allow for maximum absorption; in fact the small intestine can be up to 9 meters in length in an adult. It consists of three distinct parts - the duodenum, jejunum and ileum.

The surface area of the small intestine is further increased by the presence of finger-like projections called villi. Each villus contains blood vessels and fluid called lymph (contained within the lacteal). Fat soluble vitamins are absorbed into the lymph system while glucose, amino acids, water soluble vitamins and minerals are absorbed into the blood vessels for transportation to different parts of the body. The digestive capacity of the small intestine is the result of digestive enzymes being present.

Hormones play a role in digestion as most of these enzymes are secreted by the pancreas and enter the small intestine by the pancreatic duct under the control of a hormone known as cholecystokinin (CCK). CCK is produced by the small intestine in response to the presence of nutrients.

A second hormone called secretin also causes bicarbonate to be released which neutralizes any harmful acid coming from the stomach and also stimulates hepatic cells to secrete bile. A large amount of bile salts in the blood increases the rate of bile production after this.

**Step 5:** From the small intestine food passes into the large intestine (colon). The large intestine absorbs vitamins which are created by colonic bacteria such as vitamin K, vitamin B12 and thiamine. The colon also solidifies undigested material into faeces.

Step 6: The rectum stores the faeces until it can be excreted through the anus.

### HOW THE DIGESTIVE SYSTEM DIFFERS

With the basic explanation of digestion described above lets now consider how digestive systems can change during two particular times in a person's life.

#### Newborns

The digestive system of a newborn is immature and digestive problems are common place. Anatomical differences between a newborn's digestive system and that of an older child/adult can account for many of these problems. For example, a newborn has only a very small stomach which can hold around 60 to 90mls of fluid at one time rising to around 350mls at 1 year, this is in contrast to an adult's stomach which can hold between 2 and 3 litres. This means that newborns are only capable of tolerating small feeds at one time and it is important that they receive a diet with a high fat content (breast milk or formula milk) as fat has the highest energy content of all the nutrients helping to ensure energy requirements are met. Digestion also occurs more quickly in newborns than in adults so energy requirements are also met by ensuring a newborn feeds at frequent intervals.