

HUMAN NUTRITION

SUBJECT GUIDE

Nominal Duration- 100 hours

Aim

To describe and explain food types and how the body uses them.

Course Content

There are nine lessons in this course, each requiring about 10 hours work by the student. Emphasis is placed on understanding the body, the food we eat and its effects, our mental, emotional health (state of mind), and physical health.

The content of each of the nine lessons is as outlined below:

1. Introduction to Nutrition
2. The Digestive System
3. Absorption & Enzymes
4. Energy Value and Foods
5. Carbohydrates and Fats
6. Proteins
7. Vitamins and Minerals
8. Water
9. Nutrient Disorders

REFERENCES

Information in this course has been compiled with reference to a large number of sources including:

- Human Nutrition Courses from Home Study College, South Africa (under licence)
- Principles of Anatomy and Physiology 7th ed, by Tortora & Gabowski, Harper Collins
- Human Anatomy and Physiology 2nd ed, by Marieb, Benjamin Cummings
- Food Facts by Briggs & Wahlqvost, Penguin
- Nutrition for Life, by Saxelby, Reed
- The Complete Book of Food & Nutrition, by Stanton, Simon & Schuster
- The Complete Idiot's Guide to Vitamins and Minerals. 2nd Ed. Pressman, A.H. and S. Buff. 2000. Alpha Books.
- The Complete Idiot's Guide to Nutrition. 3rd Ed. Bauer, J. 2003. Alpha.

INTRODUCTION TO NUTRITION

Aim

To understand and explain the role of different food types in human health.

Knowledge about nutrition can be looked at in many different ways. The emphasis in any consideration of human diet depends largely upon the context and situation which is being considered. Certain foods are deficient in the diets of certain groups of people. These must be emphasised when considering such people. Other foods might be eaten excessively in some situations and may need to be reduced significantly in a diet.

The food and drink that we consume each day have a direct bearing on our state of physical and mental health. As a general recommendation, it is good to have variety in our diet to ensure we have the whole range of substances we need to build and maintain our body and our health. Too much of one or two food types, even healthy foods, is not recommended for long term health. But every one of us is different from other people, and also the way we digest food and use food in our bodies. Each one of us needs a personal way of eating that may include more or less variety. In addition to being healthier, a varied diet can often be a lot more interesting for the taste buds. The extra time and thought needed to prepare good quality meals is easily rewarded in increased stamina and alertness, better resistance to illness and clear and healthy skin, eyes and hair. However, it is necessary to learn some basic principles so that the health benefits of what we eat are maximised.

IMPORTANT FACTORS IN NUTRITION



Initial Quality of Ingredients Used

Fresh food is superior to processed and packaged food. Fruit, vegetables, bread, meat and dairy products should be consumed when fresh. It is probably not always a good idea to buy the cheapest available produce, because you may only be getting half the nutritional benefit of a slightly more expensive product. In general, you do get what you pay for with foods. There has been some research into the advantages of 'organic' food over conventionally grown food. So far the findings have not found any difference in overall nutritional value, although flavour is usually reported to be better with organic produce and the possibility of chemical contamination is also greatly reduced.

Range of Ingredients Used

No one food (or even food group) can supply us with everything that we need for good health. An important principle is to eat a wide variety of foods daily. This gives our body the best chance of obtaining all the nutrients required. A diet dominated by bread will provide plenty of starch and other carbohydrates, but will be deficient in some vitamins. Eating too much meat will supply lots of protein, but again will be deficient in some vitamins. On the other hand, eating mainly vegetables and fruit may provide adequate levels of vitamins, but we will need to supply some fats from other vegetable sources and some proteins from concentrated sources, be it vegetal, like seeds and nuts, or animal, like eggs, dairy or meat. When we consider specific vitamins, minerals and other elements of the diet, the need for eating a wide range of

foods can be shown more clearly. For example, dietary zinc can be easily obtained from red meats, sunflower seeds and some shellfish, but vegetables are a poor source of zinc. For cobalt and molybdenum, it is the other way around; leafy greens have a high concentration, while meats do not.

It is not necessary to keep track of every vitamin, mineral, element, etc. which is consumed. It is much simpler to eat different foods. This will also be more appealing from a culinary point of view. But one word of caution: it is better to eat a simple meal, with only two or three foods together, and add variety in different meals (morning, midday and evening), than combining many different foods in the same plate.

This sort of meal will be more difficult to digest, and it is not recommended for people with digestive or immune problems.

Compatibility of Ingredients

While it is important to vary your diet, casually mixing in lots of different ingredients is not the best approach. Some foods should not be eaten together with certain other foods due to the different digestive processes in the stomach. An example of this is meat and milk or meat and starches. Fruits are often best eaten alone, as a separate course, particularly melon fruits. Starches and meats are slow to digest, so when combined together they make digestion even slower. For people with good and quick digestion, this will help them to keep hunger away, but for people with slow digestion, this combination makes things much worse, and in some cases it can provoke chronic health and immune system problems.

Some foods mutually improve each other when eaten together. This is true for plant proteins, where the balance of amino acids is more important than the actual quantity of protein consumed. While meat supplies all of the eight essential amino acids in adequate amounts, plants usually only have some of the essential amino acids. However different plants have different amino acids. By combining grains (eg. corn, wheat) with pulses or legumes (eg. beans, lentils) the nutrition of both foods is enhanced.

Cooking Methods Used

Food can be prepared cooked or uncooked, and it can be eaten raw or cooked. Some foods are best consumed raw; some foods have to be cooked before being ingested, otherwise they are too difficult to digest or they may even be toxic raw. An example is Taro, which should always be cooked before eating to deactivate its natural toxins.

Cooking food is useful because it softens hard ingredients, increases the availability of some nutrients (eg. Carotene and lycopene), releases and mixes flavours and makes some foods which are inedible when raw, palatable. While proper cooking may reduce in varying degrees the nutritional value of food, over-cooking should definitely be avoided. As a general rule, the longer you cook foods, the greater the nutrient loss. Boiling can leach (draw out of the food into the water) large amount of nutrients, although in the case of soups and stews this may not be a problem because the liquid is consumed anyway. Where the cooking water is not going to be consumed, (rice or lentils, for example) use the absorption method, rather than by boiling in water and then draining off the nutrient-rich excess water.

Frying, grilling, baking and barbecuing can produce toxic substances (such as acrylamides and benzopyrenes) that have been scientifically related to cancer in humans. This happens when fatty ingredients are heated at high temperatures or cooked for very long periods of time, like in chips. For that reason, the World Health Organization (WHO) recommends avoiding high temperature frying, grilling and barbecuing of animal and some vegetable foods (starches). While the occasional fried or barbecued meal is fine, consuming large amounts of food cooked in this manner, over an extended period should be avoided.

It is very important to include raw foods, such as fruits, vegetable and nuts in the diet. A platter of vegetable sticks and a couple of dips is a simple and healthy snack or meal. Uncooked salads, fruits and nuts, with their many vitamins and minerals intact, should be eaten every day for healthy maintenance of body systems. According to some nutrition schools, cooking any food over 42.5 °C (hand warm) deactivate some substances (enzymes) in the foods that may help with the digestion process.

The excessive use of fats and oils can be a problem in frying and baking. Dry frying, grilling or simply using a smaller amount of fat or oil, are alternatives. Use herbs and spices in preference to salt. Glass, stainless steel or enamel pots and pans should be used. Copper can interfere with the vitamins in food. The use of aluminium pots and pans is said to increase the amount of aluminium entering the body, which could lead to health problems such as muscle weakness, bone problems and Alzheimer's disease. Cooking with acidic foods (eg. vinegar, tomatoes and citrus fruits) can make the situation worse.

Some foods may need to be prepared before being eaten or cooked, for easier digestion. Seeds and nuts are produced by the plant and protected by different mechanisms to sprout only in the right conditions. Nutritionally, humans will be able to digest them and get their full nutritional value when this protection is lost. The most common way is soaking.

For seeds and nuts, like almonds, sunflower or pumpkin seeds, they can be soaked before consuming, or soaked for a few hours and air dried at low temperatures. In the case of pulses, like beans, lentils, fava beans, chick peas (garbanzo beans), etc, they need to be soaked overnight. Soaking also make the cooking times shorter and make legumes easier to digest as they loose some of their gas-producing substances in the soaking water. Always discard the soaking water, and if you can change it twice so much the better. Some beans, not all types, can be eaten as uncooked sprouts too, providing more easily digested carbohydrates, fibre, vitamins and minerals than their dried counterparts (lentils, mung beans).

Eating

After preparing food, the way it is eaten and the circumstances of the person eating can affect how well the nutrients are absorbed and used by the body. A relaxed state of mind and body is necessary, rather than eating 'on the run' while your mind is rushing about and your digestive system is being neglected at the expense of making your legs, arms and heart work full-time. Stress and tension can lead to poor digestion through poor chewing, unbalanced stomach acid release and bowel blockages. In a stressed state, your whole body is switched on to quick energy release in preparation for "fight or flight". In a relaxed state of mind, your body is in an absorbing and storing "mood", therefore making digestion the favoured process.

Chewing is the first stage in the digestion of food. Without going overboard, food should be chewed adequately in order to reduce the particle size, add moisture (saliva) for easier swallowing and to add a number of enzymes which will breakdown starches into sugars. Saliva, secreted from six glands within the mouth, contains the water and enzymes necessary for this stage of digestion. Once the food has been mashed and mixed with saliva, swallowing occurs. This involves the combined action of muscles in the mouth, tongue and throat pushing the **bolus** of food down into the pharynx. As the food goes down, the epiglottis stops it from entering the wind-pipe (larynx) by closing down over the top of it and sealing it off. The bolus will instead be routed to the oesophagus through which it passes into the stomach.

MAJOR FOOD GROUPS

Foodstuffs can usually be arranged into the following groups:

	Food	Composition
1.	Cereals	Mainly carbohydrate, with 7 - 12% protein. Oats have fat. Minerals, vitamins. Whole cereals have fibre.
2.	Meats, Poultry and Fish:	Protein source; fat content varies greatly, also some minerals.
3.	Dairy products except butter	Protein, vitamins, minerals and fats.
4.	Eggs	Protein, minerals and vitamins (fat in yolk).
5.	Legumes	Four times as much protein as leaf vegetables. Vitamins and minerals, fibre.
6.	Root Vegetables	Carbohydrates (starches), vitamins, minerals. Antioxidants.
7.	Other Vegetables, Leaf Vegetables	Carbohydrates and protein, minerals and vitamins, fibre; relatively little fat. Antioxidants.
8.	Fruits	Water soluble vitamins, minerals, sugars and starch. Antioxidants.
9.	Fats, Oils, Sugars & Butter	Direct intake of fats and sugar. Vitamins, minerals.
10.	Seeds and Nuts	Fats, protein, vitamins, minerals

FOOD ALLERGIES/INTOLERANCE

Common foods which some people have problems with mostly include proteins: wheat, sugar, chocolate, seafood, soy, eggs, dairy and peanuts. Chemicals in foods, such as preservatives and colourings, may also cause intolerance or allergic reactions. Monosodium glutamate (MSG) is an example of an allergen food chemical. Food intolerance and allergies may manifest with “mild” and often chronic symptoms, like poor digestion, belly bloating, irritable bowel syndrome (IBS), sinus, asthma, headaches and migraines, woolly head, irritability, depression and behaviour changes. They can also manifest in more sudden and dramatic symptoms, like diarrhoea, nausea, or anaphylactic shock that can require hospitalization and if untreated, or not treated promptly can result in death. It is important to note that some allergies to foods can be so severe that separate cooking utensils and pots must be used – an example being nut allergies.

Food Intolerance

This is the most common reaction to food. It is an adverse reaction to a food or component of food that does not involve the immune system. In some cases it is due to the body not being able to properly digest a proportion of the food because it lacks the right enzyme, like in dairy intolerance. In this case, the result is usually diarrhoea or nausea because the person lacks the enzyme in the bowel that digests lactose, the sugar found in dairy products. Many people manifest only mild symptoms throughout their lives, without realizing or connecting those symptoms with the foods they consume. In the long term impaired digestion can lead to chronic malnutrition that end up showing as chronic conditions or contributing significantly to them.

Allergies

Allergies (food hypersensitivity) involve an adverse immune response to a food. Allergens found in food are often proteins, and can stimulate the body to produce antibodies specific to that food. If an individual who has inherited a specific food allergy is first exposed to that food, their immune system produces IgE (immunoglobulin) antibodies. The antibodies reside in white blood cells and mast cells in the body, particularly in the skin, the respiratory tract and gastrointestinal tract, i.e. the parts of the body that come into contact with the air and the food that we eat. These cells also contain substances such as histamine that are released when the antibodies once again come into contact with the food allergen.

It is the histamine and the other chemicals that cause the allergic reaction resulting in such symptoms as swelling of the skin, itchiness, hives, and itchy eyes. The gastrointestinal tract may respond with vomiting, cramps, diarrhoea and nausea as attempts to remove the allergen. Symptoms in the respiratory tract may include runny nose, coughing, and sneezing. In severe cases anaphylactic shock and death may result. This is essentially a situation where the body's immune system goes completely overboard trying to save itself from the allergen and the side-effects of its efforts kill it instead..

Ninety percent of allergens found in food are proteins derived from milk, eggs, seafood, wheat, soy protein and nuts (particularly peanuts). Additives such as sulphites used as preservatives can also cause allergic reactions. It may be possible to self-diagnose and to avoid certain foods, though in more complex cases it may be necessary to consult a dietician, food allergist or physician to ensure that a proper diet is followed, avoiding deficiencies in protein, fat, vitamins and minerals.

TERMINOLOGY

Food has a language all of its own.

You must learn this language if you are to communicate in this field.

In some lessons you will be given several terms. These may or may not be new to you.

If the terms are new; you should try to find out their meaning using a dictionary or any other

means you have at hand. If you have difficulty still; you should ask for help; in which case the tutor will provide you with a definition to learn.

ASSIGNMENT

1. Provide a single or two sentence definition for the following:

- food
- nutrition
- diet.

2. The following 5 nutrients each have specific roles in the maintenance of good health. Give a one sentence definition for each, then, in no more than half a page, describe some ways each contributes to good health:

- Carbohydrates
- Proteins
- Fats
- Minerals
- Vitamins

THE DIGESTIVE SYSTEM

Aim

Understand and explain the anatomy of digestion.

The digestive system is basically a tube extending from the mouth to the anus. Its function is to take in food, grind it, digest it, absorb the nutrients and eliminate the waste products that result from the process. Digestion reduces the nutrients in food to compounds which are simple enough to be absorbed and used for energy and the building of tissues.

The digestive system can be divided into two main parts:

1. **The Alimentary Canal/Tract**
This is the tube through which food travels as it moves through the body.
(mouth, oesophagus, stomach, small intestine, large intestine, anus).
2. **Accessory Digestive Organs**
These are organs situated at different points along the alimentary canal, but which are not actually part of the structure of the canal
(eg. teeth, salivary glands, tongue, liver, gall bladder, pancreas).

THE ALIMENTARY CANAL

MOUTH

The mouth, also known as the oral cavity, is the region encompassed by the lips and the cheeks. It has several functions, serving to:

- *receive* food;
- *grind* food into small pieces
- *mix* food with saliva and mucus to form a slippery ball (called a **bolus**) that can be easily swallowed.

The mouth is lined by a **mucous membrane**. Mucous membrane is a layer of specialised epithelial tissue. The roof (top) of the mouth is called the palate. The palate has two parts: the soft palate (ie. soft tissue at the back) and the hard palate (ie. a hard area of skin over the top of a layer of bone at the front of the mouth). When food is swallowed, the soft palate rises to block off the nasal passage at the back of the mouth. The hard palate provides a solid surface which the tongue can squash food against when chewing. This process requires saliva, which is secreted from salivary glands located in pairs in different parts of the mouth. These will be discussed further in the section on accessory organs.

OESOPHAGUS

The oesophagus is a thick, muscular tube connecting the mouth to the stomach. It passes through the diaphragm (the partition between the chest and the abdomen). The tube is lined with mucous membrane and the walls are made up of involuntary muscle fibres.

Once a ball or bolus of food has been forced into the oesophagus from the mouth by the process of swallowing it is automatically pushed down the tube by an action known as peristalsis. Peristalsis works by the muscle behind the bolus contracting and narrowing the oesophagus but the muscle in front of the bolus becoming relaxed and widening the oesophagus. This squeezes the bolus forward into the area of relaxed muscle. This muscle

now contracts and propels the bolus further forward. The whole process is like a wave-like motion. Once the bolus is in the oesophagus, it must travel down to the stomach. There is no conscious control over this process, as the muscles are involuntarily controlled.

THE SIMPLE STOMACH

The stomach is a bag, the walls of which are made of involuntary muscle. The inside of the stomach is lined by a membrane of specialised cells. Food enters the stomach via the oesophagus. Once food has been processed it passes out of the stomach into the small intestine.

Both the entrance to the stomach (from the oesophagus) and the exit (the duodenum, the first part of the small intestine) are controlled by narrow rings of muscle called sphincters. These control the flow and passage of food into and out of the stomach. When the sphincter is contracted, it prevents the flow of food. When the sphincter is relaxed, food can pass through. The sphincter between the oesophagus and the stomach is the lower oesophageal sphincter. Between the stomach and the duodenum is the pyloric sphincter.

The lining of the inside of the stomach consists of numerous small folds which increase the surface area coming into contact with the food inside the stomach. In addition, the stomach lining contains many **gastric glands** (small pits). These glands are lined by three types of cells as follows:

- mucous cells: produce a thick, sticky fluid
- parietal cells: produce hydrochloric acid
- chief cells: produce enzymes.

All these substances help in the process of food digestion.

THE SMALL INTESTINE

The small intestine is a long, muscular tube leading from the stomach to the large intestine. Most of the digestion occurs here.

There are three sections to the small intestine:

1. *The Duodenum*

When food leaves the stomach, it moves through the pyloric sphincter (valve) and enters the duodenum. The duodenum is a c shaped tube and is the shortest part of the small intestine, commonly about 25 cm long. Hormones are secreted in the duodenum to control the release of digestive enzymes from the pancreas, and bile from the gall bladder. The chyme (food released from the stomach) is vigorously mixed here also. The majority of digestion in the small intestine occurs in this small region.

2. *The Jejunum*

This is about 2.5 metres long and is the middle section of the small intestine. The lining of the intestine changes here, to one specialised for the *absorption* of protein and carbohydrates from the chyme.

3. *The Ileum*

This is the lowest section of the small intestine, measuring approximately 3.6 metres long. The lining here is specialised for the absorption of water, fats and a component of bile, bile salts. At the end of this section, the ileocecal sphincter (valve) controls the passage of material into the large intestine.

Most of the absorption of food which occurs happens in the small intestine. Food comes into the small intestine through the pyloric sphincter in the stomach and is pushed along by

peristalsis. This is the same muscular action that pushes food down the oesophagus. Peristalsis is entirely involuntary so that a person has no control over it at all. In fact, if is unwell, the passage of foods can be either sped up, resulting in improper digestion and nutrient uptake, along with diarrhoea, due to inadequate fluid absorption, or conversely, if the process is slowed, a person will end up constipated. The lining of the small intestine contains many glands which produce mucous. The glands also produce enzymes that are required for the further digestion of food that has passed from the stomach.

In addition, the lining contains many small stalk-like projections called villi (singular = **villus**). Digested food passes through the villi on its way from the small intestine into the bloodstream. Digested carbohydrates and proteins pass into the bloodstream while digested fats pass through the villi into the lymphatic system.

THE LARGE INTESTINE

The large intestine is also known as the colon. It serves to move eliminated waste received from the small intestine (via the ileocecal sphincter) down to the rectum ready for elimination, while absorbing water. The diameter of the large intestine is much greater than the small intestine. There are four main parts:

1. The Caecum (sometimes spelt 'cecum')

In humans the caecum is a pouch about 6 cm long with a closed end. Its function in humans is mainly to absorb fluids and salts, while secreting a thick mucus and mixing it with the waste product it receives. Attached to the caecum is a coiled tube called the vermiform appendix. The mesentery of the appendix (i.e. mesoappendix) attaches to the lower part of the ileum.

2. The Colon

The open end of the caecum merges into the colon, which is divided into 4 parts:

- a. Ascending Colon
Ascends on right side of the body to the bottom of the liver.
- b. Transverse Colon
Runs from right to left side of body, horizontally.
- c. Descending Colon
Descends on left side of body to the point of the iliac crest.
- d. Sigmoid Colon
Starts near the left side of the iliac crest and runs towards the middle of the body finishing at the rectum.

The ascending and transverse colon continue the process of absorption of both water and salts. As this occurs, the waste becomes more solid and firm. The sigmoid colon has the special job of contracting to produce high pressure, which forces the solid waste products into the rectum. One of the effects of some infections and also laxative medicines is to prevent the absorption of water into the colon, causing people to pass a very watery fluid (diarrhoea). It is very important that humans have access to plenty of fresh, clean water so that it can replace lost fluids.

3. The Rectum

This is commonly about 20 cm long forming the final section of the alimentary canal. Its job is to store the solid waste until it is eliminated from the body, a process known as defecation.

4. The Anal Canal

This is 2 to 3 cm long. The opening of this canal is called the anus. There are two tight sphincters that control defecation. Signals received from this region are what give us the 'urge' to go to the toilet.

ACCESSORY DIGESTIVE ORGANS

TONGUE

The tongue is a muscular organ that is covered in a mucous membrane. The tongue helps in the grinding of food, the formation of the bolus, and in the swallowing of the bolus.

The surface of the tongue contains glands and taste buds which play an important part in the selection of food. The taste buds are sensitive to sweet, bitter, sour and salty tastes.

TEETH

People's teeth play an important part in the biting, tearing and grinding of food. There are three types of teeth:

Incisors - the sharp cutting teeth at the front of the mouth;

Canines - the conical, pointed teeth used for ripping; and

Molars & Premolars - the blunt, irregularly shaped teeth used for grinding food into small pieces.

SALIVARY GLANDS

Saliva is excreted into the mouth continuously, 24 hours a day. When a person is NOT eating, saliva is only excreted in very small quantities: just adequate to keep the mouth moist. When a person eats saliva increases. Saliva is 95% water and 5% solutes (dissolved particles) such as ions of sodium, chloride, bicarbonate, potassium and phosphate. Some dissolved gasses are also present. Also present are a range of organic compounds, the most significant being the enzyme "salivary amylase". Amylases break down carbohydrates.

There are three pairs of salivary glands:

- **The parotid gland:** this means "ear" - the parotid gland is situated in front of the ear;
- **The mandibular gland:** this means "jaw" - this gland is found in the lower jaw; and
- **The sub lingual gland:** this means "of the tongue" - this gland is found under the tongue.

The composition of the saliva from each of the pairs of glands is different to the other glands. The combination of the saliva from all three pairs of glands (mixed saliva) is important for digestion as it contains a unique enzyme called ptyalin. Saliva is also necessary for bolus formation and swallowing.

LIVER

This is the largest and heaviest gland in the body, commonly weighing around 1.4 kg in an adult. The liver serves many different purposes in the body, but only one digestive function, to produce and secrete bile into the duodenum. When digestion is not occurring bile is rerouted to the gall bladder for concentration (dehydration) and storage. Bile acts like a detergent, emulsifying fat which in turns makes the enzymatic breakdown of fats more efficient. The level of bile in the bile duct is regulated by a hormone called cholecystokinin (CCK).

The liver is covered by the serous membrane that lines the body cavity, known as the peritoneum.

It is made up of two main lobes, with the right being larger than the left. The two lobes are separated by falciform ligament. The lobes of the liver are divided into many functional units called lobules.

Lobules are made up of:

1. Hepatic (Liver) Cells - Also called hepatocytes; synthesise and secrete bile.
2. Central veins and branching capillaries

The common hepatic duct collects bile from a network of bile capillaries and ducts in the liver,

and takes the bile to the duodenum. The hepatic artery brings blood to the liver. This is a massive artery, and if it is damaged, such as in a car accident, a person will quickly bleed to death. In obese people, fat begins to be stored in the liver, resulting in fatty liver disease, which compromises the liver's function and can lead to cirrhosis, which requires a liver transplant.

GALL BLADDER

This is a small sac commonly around 10 cm long. It is located underneath the liver. The gall bladder stores bile, concentrates it, and then releases it when needed during digestion. The cystic duct takes juices from the gall bladder and merges with the common hepatic duct to form the common bile duct, which opens into the duodenum.

PANCREAS

The pancreas lies beneath the stomach and empties its contents into the duodenum. It is composed of two types of glands, endocrine (make up the bulk of the organ) and exocrine glands. The hormones made by the endocrine glands, insulin and glucagon, are secreted directly into the blood stream. Here insulin lowers blood sugar levels by directing the storage of glucose in the liver. When blood sugar levels are low, glucagon will elevate them, by directing the release of stored glucose back into the circulation. The loss of congenital absence of the endocrine cells results in type 1 (Juvenile) diabetes which in most cases requires the person to inject themselves with insulin and alter their diet to avoid eating foods that are quickly converted into glucose (high GI) and maintaining as stable a blood sugar level as possible, using foods that are slowly broken down into glucose (low GI).

The pancreas also releases digestive hormones via the pancreatic duct into the duodenum. These enzymes (trypsin, chymotrypsin, carboxypeptidase, lipases and amylases) break down complex nutrients such as fats and starches into the simple sugar glucose. If they are absent or not being produced, a person can starve. The pancreatic duct enters the duodenum in close proximity to the bile ducts, and this allows the liver and pancreatic enzymes and secretions to work together with each other.

The pancreas is commonly 12.5 cm long and approximately 2.5 cm thick, it is divided into 3 sections:

1. Head

A larger section near the "C" shaped duodenum.

2. Tail

At the opposite end to the head, and a tapering oval shaped end.

3. Body

It is the central section. A main duct runs through the tail and body. This is called the "Pancreatic Duct" (also called the "Duct of Wirsung"). In most people this duct joins the duct from the liver before emptying into the duodenum. A smaller duct called the accessory duct (also called the duct of Santorini) empties directly into the pancreas.

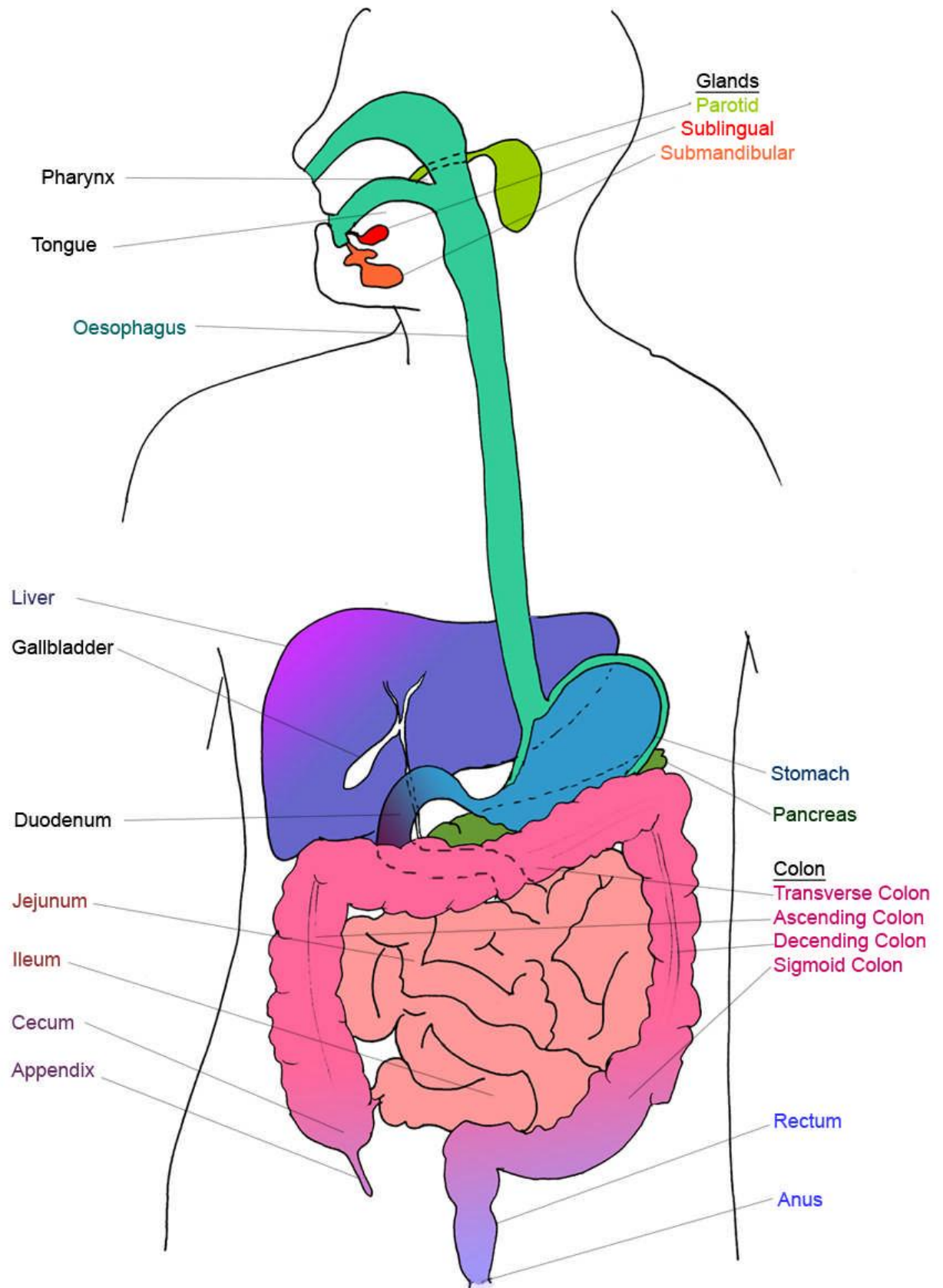


Figure 1. Diagram of the Human digestive system and organs.

DIGESTIVE TRACT LININGS

The wall of the digestive tract has the same basic structure in most parts; with the exception of the mouth. There are generally four layers to this tissue: the mucosa, submucosa, muscularis and serosa. See figure 2 below.

MUCOSA

This is the layer that lines the inside of the digestive tract tubes. (ie. the layer in direct contact with food moving through the canal). The mucosa has three layers:

- *Epithelium*: The outer lining in direct contact with food which functions to both secrete substances to aid digestion and also to absorb nutrients..
- *Lamina Propria*: A layer of connective tissue directly below the epithelium
- *Muscularis mucosae*: Thin layer of muscle connected to the epithelium by the lamina propria.

SUBMUCOSA

This is below mucosa, the next closest layer to the food in the alimentary canal. It is a connective tissue layer that serves mainly to cement the mucosa and muscularis layers together. It also is highly vascular (i.e. contains a lot of blood), and it contains nerves that help signal to and between the mucosa and muscularis layers.

MUSCULARIS

This is the next layer out from the canal, between the submucosa and the serosa. This is basically muscle tissue. In the mouth, pharynx and upper oesophagus, this is skeletal muscle causing voluntary swallowing. In the external sphincter, it is also skeletal muscle, which causes voluntary excretion from the anus. Throughout the remainder of the alimentary canal, this is involuntary smooth muscle and we have no conscious control over it.

SEROSA

This is the outer layer, most distant from the food moving through the canal. This outer layer consists of connective tissue and a multilayered epithelium that forms a protective outer membrane, known as the serous membrane around the digestive tract.

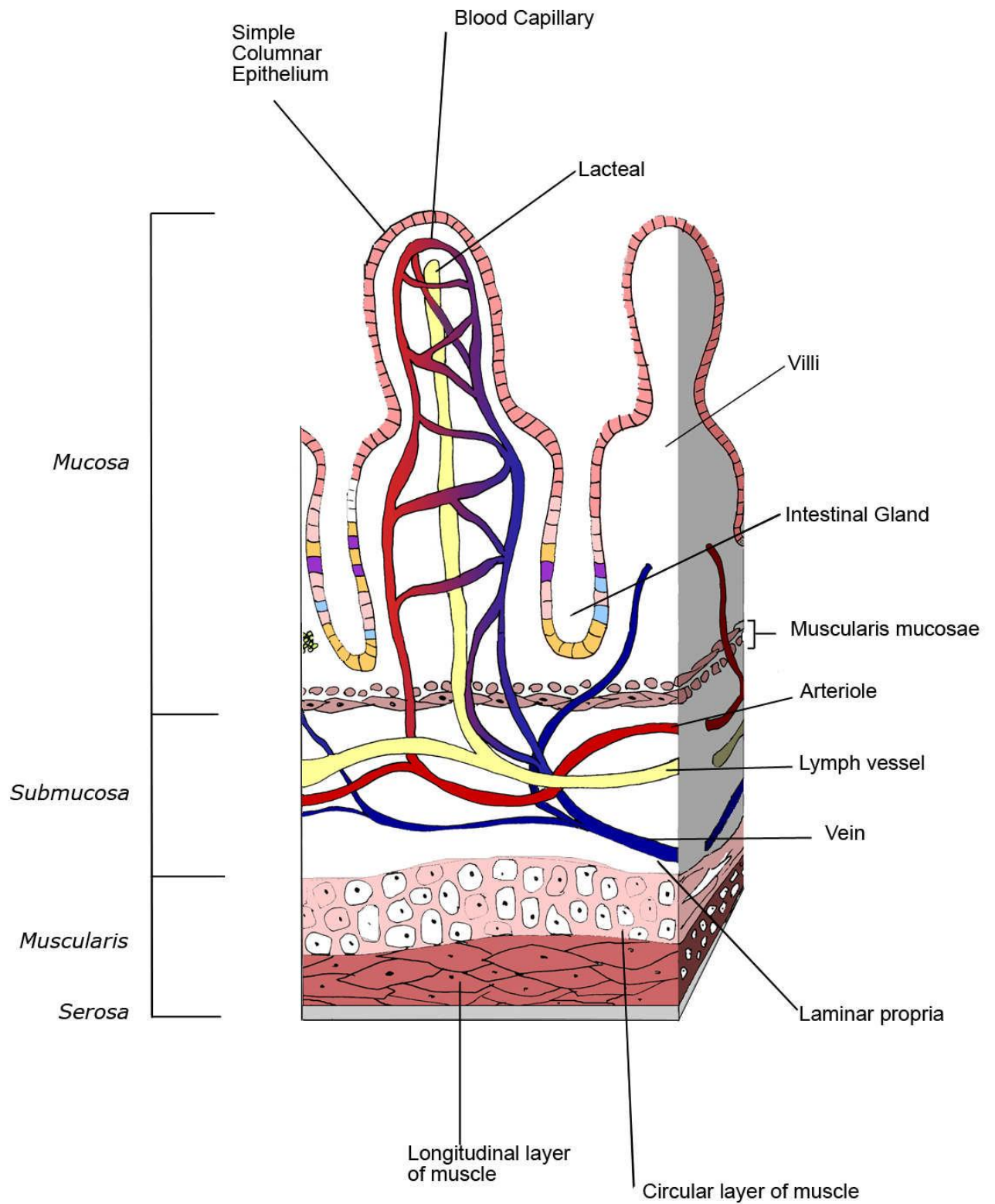


Figure 2: Diagram of the intestinal Wall.

ABSORPTION & ENZYMES

Aim

Explain the physiology (function) of digestive processes.

We have discussed the anatomy of digestion. However, as well as a complex array of organs and ducts, the digestive process also involves a complex series of biochemical reactions, which we will now cover.

There are two basic and important concepts to remember about digestion:

- Humans and other animals can only use nutrients that are in solution (i.e. have been dissolved in water/body fluids) either in the form of **ions** (very small particles carrying an electrical charge) or of **molecules** (a group of atoms/ions joined together).
- The digestive tract is a long tube stretching from the mouth to the anus. Various ducts and pockets along its length allow substances to be added to the tract and the substances within the tract vigorously mixed. However, there is no ducts for the contents of the digestive tract to enter the body cavity itself. In fact if an injury causes the rupture of the digestive tract, and contents do enter the body cavity it is a life-threatening situation.

This means that all the nutrients used by the animal have to pass through the wall of the digestive tract and into the circulation or lymph system. There is no other way they can reach the rest of the body.

The breaking down process of digestion takes place in three ways:

- physical or mechanical means (chewing, peristalsis)
- biochemical breakdown (enzymatic breakdown)
- biological (the activity of micro-organisms, such as E.coli in the colon).

We will consider each of these actions in turn under those headings.

PHYSICAL OR MECHANICAL BREAKDOWN

Physical breakdown begins in the mouth with the chewing and grinding action of the teeth to break down the food into smaller pieces. It is continued as the food is pounded against the palate to form the bolus. Physical breakdown continues as a side effect of the peristaltic muscle contractions that moves the foodstuffs along the oesophagus to the stomach. Within the stomach and small intestine the food is vigorously churned under the control of involuntary muscles, breaking the food down further as well as mixing it with digestive enzymes.

BIOCHEMICAL BREAKDOWN

In a biological setting, enzymes are proteins that catalyse biochemical reactions. Enzymes have three key properties:

- They can bring about chemical change in other substances without themselves being changed in the process (ie they are catalysts)
- They can also achieve those changes inside the body in conditions of mild heat and comparatively mild acidity or alkalinity. In a laboratory, such changes would require conditions of great heat and the use of strong acids or alkalis

- It takes only a very small amount of an enzyme to achieve big changes because the enzyme can be reused.

Enzymes are, therefore, very powerful chemicals indeed and they each have very effects, depending on the reaction they are catalysing. Some enzymes can break down only some carbohydrates while others only act on protein.

Enzyme action starts in the mouth with the action of the salivary enzyme **ptyalin**. This enzyme acts on the starch in the food, converting it into the simpler carbohydrates such as the sugar **maltose**. The process is continued in the stomach, by two enzymes, **pepsin** and **rennin**, and one chemical compound, **hydrochloric acid** (chemical formula is HCl). HCl is a strong mineral acid and is produced by the glands in the stomach wall.

When mixed together, the enzymes and hydrochloric acid form **gastric juice** whose pH (the level of acidity or alkalinity) is between 1.5 and 2 which is very acidic! (Gastric juice is almost as acidic as battery acid, if you have heartburn the burning sensation is due to the gastric juices burning your oesophagus). The stomach lining is protected from the gastric acid by a thick layer of mucous. The function of the acid in the stomach is to further breakdown the food and to prevent rotting (or putrefaction) of the mixture of undigested and partly digested food.

The enzyme **Pepsin** acts on proteins in the food, breaking them down into simpler compounds. Rennin functions to coagulate milk (it is found in many dairy products we eat, particularly cheeses). Coagulation of milk is necessary, as if it remained liquid it would simply flow straight through the digestive tract and be excreted without the body being able to extract the nutrients from it.

By the time all these actions have taken place, the food is no longer recognisable as such but is now semi-fluid with a paste like consistency and known as **chyme**. The chyme now passes slowly through the sphincter from the stomach into the small intestine in a series of spurts. **An important point to remember is that no food is absorbed in the stomach.** The only things which are absorbed through the wall of the stomach are alcohol and some drugs. When a prescription tells you to eat before taking a medication it is to help prevent loss of the medicine by absorption in the stomach.

The stomach acts as a container or a reservoir which holds up the passage of food for some time so that it can be collected and acted upon by the gastric juice. Once the chyme enters the small intestine, it is moved along continuously by the muscular contractions of the wall of the intestine. This action is called peristalsis and is the same as the action which moves the food bolus down the oesophagus.

In the small intestine, the chyme is acted upon by the following juices which are added to it as it passes along the length of the intestine:

- **Intestinal juice** (also known as succuss entericus)
- **Pancreatic juice**
- **Bile** (from the liver, stored in the gallbladder)

Almost all digestion takes place in the small intestine, predominantly the very first section, the duodenum. The chyme that enters the duodenum contains partially digested carbohydrates and proteins, and fats that are essentially untouched.

Succuss entericus is produced by glands in the lining of the intestine and it is made up of enzymes such as:

- Maltase (breaks down the disaccharide maltose, found in malted cereals, sprouting grains and beer into the monosaccharide glucose)
- Sucrase (breaks down disaccharide sucrose from cane sugar into glucose)
- Lactase (breaks down the milk and dairy disaccharide lactose into glucose)
- Peptidase (continues protein digestion)

Pancreatic juice contains one enzyme, amylase, which breaks down any remaining complex carbohydrates into simple sugars. Another three enzymes in pancreatic juice (chymotrypsin, peptidase and trypsin) continue protein degradation. Lipases begin the breakdown of fats which have been emulsified by bile. The fate of the glucose is controlled by the levels of the two pancreatic hormones, **insulin** and **glucagon**.

Bile released from the liver acts on the fats in the chyme to emulsify them. The result is very fine droplets suspended within the watery chyme. This type of fat/water mixture is called an emulsion. By isolating the fat into tiny droplets, the area exposed to the lipases is dramatically increased, making fat digestion much more efficient and the result is fatty acids.

The other function of bile is to reduce the acidity of the chyme which has come from the stomach making it alkaline so it doesn't damage the intestinal lining.

From the small intestine, the chyme passes into the colon which, together with the caecum, makes up the large intestine. At this stage, the original food has been broken down completely in the following way:

- Carbohydrates → glucose
- Proteins → amino acids
- Fats → glycerol and fatty acids.

Most of these products have been absorbed through the wall of the small intestine. What is left passes into the rectum and out through the anus. The main function performed in the colon is the removal of water from the chyme - this water is absorbed into the body and reused by the human or animal. This is a most important function. Without it, the human or animal would have to consume vast quantities of water, most of which would be wasted by passing straight through the body. No digestion occurs in the large intestine.

BIOLOGICAL BREAKDOWN

Some digestion also occurs through the activity of micro organisms living inside the body, in the digestive system. These micro organisms are often called the body's "microflora". Medical treatments (eg. antibiotics) can kill these important micro organisms and interfere with digestive processes. Extracts of these micro-organisms can be purchased from health food shops, and ingested to replenish flora if needed. Also, while taking antibiotics, an extract of yeast made up of *Saccharomyces boulardii* can be taken to avoid the growth of *Candida* and other harmful yeast in the body, while the normal intestinal flora is recovering. Because these micro-organisms are beneficial to the body, they are known as symbiotes. Examples of the over 400 different symbiotic micro-organisms in the human digestive tract are: *E.coli* (present in the intestine, but if ingested causes food poisoning) and *Lactobacillus acidophilus* (found in the small intestine). Different organisms can synthesise vitamins from our waste products, or enzymes (such as lactase). Some metabolise heavy metals.

SUMMARY OF FOOD PATHWAYS

FOOD TYPE	MADE OF:	FUNCTION
Carbohydrate	Glucose	Excess will be converted into body fat Stored as Glycogen (liver) Used as Immediate Energy
Fats	Glycerol & fatty acids	Stored as Body fat (energy reservoir) Broken down into glucose to be used as energy
Protein	Amino acids	Used to form muscle Used to make Enzymes & Hormones Absolute last resort energy source Excreted as Urea

DIGESTIVE HORMONES

HORMONE SOURCE	HORMONE NAME	HORMONE ACTIVITY
Mainly stomach	Gastrin	Promotes secretion of gastric juice, increases pepsin levels, promotes growth of gastric mucosa to protect stomach lining from gastric juice
Intestine	Gastric inhibitory peptide (GIP)	Stimulates insulin secretion, restricts pepsin secretion, slows emptying of stomach.
Intestine	Secretin	Stimulates release of bile and pancreatic juices, particularly those rich in alkalis; hence controls pH.
Intestine, brain	Cholecystokinin	Stimulates pancreatic juices rich in digestive enzymes, controls release of bile from gall bladder by stimulating valve to open.

DIGESTIVE ENZYMES

ENZYME SOURCE	ENZYME NAME	AFFECTED FOOD	DIGESTED PRODUCT
Mouth-Salivary Glands	Salivary amylase	Polysaccharides (Starches)	Maltose (disaccharide) Maltotriose (trisaccharide) & Alpha dextrins
Mouth -Tongue Glands	Ligule lipase	Lipids	Fatty acids & monoglycerides
Stomach	Pepsin	Proteins	Peptides
Pancreas	Pancreatic amylase	Starches	Maltose (disaccharide) Maltotriose (trisaccharide) & Alpha dextrins
Pancreas	Trypsin	Proteins	Peptides

Pancreas	Chymotrypsin	Proteins	Peptides
Pancreas	Carboxypeptidase	Peptides	Peptides & Amino acids
Pancreas	Pancreatic Lipase	Triglycerides already emulsified by bile	Fatty acids & monoglycerides
Pancreas	Nucleases	Nucleic Acids (ie. RNA & DNA)	Nucleotides
Small Intestine	Maltase	Maltose	Glucose
Small Intestine	Sucrase	Sucrose	Glucose & Fructose
Small Intestine	Lactase	Lactose	Glucose & Galactose
Small Intestine	Peptidases	Peptides	Peptides & Amino Acids
Small Intestine	Nucleosidases	Nucleotides	Phosphates, Pentoses & Nitrogenous alkalis
Small Intestine	Phosphatases	Nucleotides	Phosphates, Pentoses & Nitrogenous alkalis

ABSORPTION

Absorption is the process by which nutrients and water transfer from food in the digestive system into blood or lymph in the circulatory system. About 90% of absorption occurs in the small intestine. The remaining 10% of absorption occurs in the stomach and large intestine.

ANATOMICAL ADAPTATIONS FOR ABSORPTION

The small intestine has many adaptations to aid absorption of nutrients including the following:

1. LENGTH

Being very long increases the surface area which food is exposed to, hence increasing the surface area which nutrients can be absorbed through.

2. PLICAE CIRCULARES

These are circular deep folds in the mucosa and submucosa. The inside surface of the small intestine thus has fleshy projections of flesh into the canal. This structure forces the food (ie. chyme) to spiral continually as it moves through the intestine; and that action mixes digestive juices more thoroughly with the food.

3. VILLI

These are finger like projections of mucosa (NB: no submucosa) more than 1 mm high made up of absorptive cells. Food is absorbed through these cells into networks of both blood and lymphatic capillaries.

4. MICROVILLI

These are very small projections of plasma membrane of individual mucosa cells that make the surface of the mucosa bumpy or fuzzy, further increasing surface and absorptive area.

It has been estimated that the absorptive surface area of the small intestine is commonly around 200 square metres.

ABSORPTION OF THE DIFFERENT NUTRIENTS

Carbohydrates

Complex carbohydrates need to be broken down into monosaccharides for absorption. As monosaccharides they will move through the apical surface of the mucosa cells (the surface that touches the chyme) by either:

- **Facilitated Diffusion**
Nutrients that are water soluble (not lipid soluble) require a protein complex in the cell's membrane to 'carry' them through the lipid plasma membrane and into the cell.
- **Active Transport**
Active transport is where substances move through a membrane against a concentration gradient (i.e. against osmotic pressure). This process requires the expenditure of energy (ATP)

Monosaccharides move from the epithelial cells by facilitated diffusion to then enter the capillaries (tiny blood vessels) in the villi.

Proteins

Most proteins are broken down into amino acids, and then absorbed by active transport, mainly in the duodenum and jejunum.

Fats

Fatty acids and monoglycerides are lipid soluble, and this means they can passively diffuse across the plasma membrane of the mucosa cells without the help of carrier proteins of concentration gradients. Inside the cells they are converted into triglycerides and packed into chylomicrons with cholesterol. Unlike glucose, the triglycerides do not directly enter the bloodstream, instead they enter the lymph system, via the villi which then drains into the circulation.

DETOXIFICATION MECHANISMS IN THE BODY

Eating and digestion produces some waste products that our body cannot use. We also eat or inhale or drink some substances that our body doesn't need or cannot use, like pesticides and other chemicals in food, heavy metals in our water, and environmental pollutants in the air. These substances must be expelled from our body for us to stay healthy. When we accumulate toxins, we become ill, developing health conditions that in the long term decrease our quality of life, and can lead to premature death. Examples of conditions related to accumulation of toxins and unneeded substances are obesity, some arterial diseases, allergies, Chronic Fatigue Syndrome, some forms of arthritis, and many other modern diseases, some of the unexplainable. In fact the most common cancer in the western world is bowel cancer, which affects approximately 1:15 people. There are several mechanisms that the body can use to eliminate toxins, which are not part of the digestive system. The two most important ones are the Urinary system and through the skin.

THE URINARY SYSTEM

Anatomy of the Urinary System

The urinary system is used to get rid of urea and other waste products from the lymph and blood from the body. These are carried to the urinary system by the bloodstream, filtered out and excreted as urine. It is a very important system because it is the only way that these waste products can be removed from the body.

The urinary system comprises:

- two kidneys
- two ureters (tubes that connect the kidneys to the bladder)
- the bladder
- the urethra (tube that leads from the bladder to the outside of the body)

The Kidneys

These are located in the abdominal cavity, about two thirds of the way down the back. There is one on each side of the spine, with an adrenal gland located on the top of each. They are each approximately 10cm long, 5.5cm wide and 3cm thick and are shaped much like a jellybean. The kidney is divided into the cortex on the outside and the medulla on the inside.

Kidneys are well supplied with blood vessels; blood being carried to the kidneys by the renal artery and away by the renal vein. Both the renal artery and renal vein break down into a large number of very tiny capillaries. The blood flows through the inside of the kidneys via these capillaries and any toxins or wastes are removed and transferred to a complex system of tubes called nephrons. Water diffuses into and out of the nephrons as well, and the fluid inside the nephrons is known as urine. Nephrons lead into collecting ducts which empty into the kidney pelvis which in turn joins the ureter.

The Ureters

These are thin tubes, about 30cm in length with very strong, contractile muscle walls. They function to carry the urine from the kidneys to the bladder. They move the urine using the same peristaltic method as the oesophagus and intestine. There are no valves to prevent the

backflow of urine from the bladder, instead the pressure of the filling bladder itself prevents this.

The Bladder and Urethra

This is a hollow organ with muscular walls. It can expand or contract depending on how much urine it holds. It is fed by the two ureters leading from the kidneys and acts as a reservoir for urine. When it is full, the urine is released through the urethra which leads to the penis in males and the vagina in females. Because of the anatomical differences between the genders in this region, the male urethra is much longer than the female. The passage of urine out of the body (urination) can be voluntarily controlled via the band of voluntary smooth muscle that surrounds the urethra. When contracted, the urethra is closed and urine cannot pass through it, when it is relaxed there is a clear passage for urine.

THE PHYSIOLOGY OF THE URINARY SYSTEM

The filtering out of waste products from the blood, the formation of urine and the re-absorption of water takes place in the nephrons of the kidneys. Small arteries leading from the renal artery divide up to form a tuft of capillaries called a glomerulus.

This is surrounded by a capsule known as Bowman's Capsule which is hollow and leads into a winding tube called the convoluted tubule. (Convoluted means "coiled" or "twisting"). This tubule, in turn, connects up with a "U"-shaped tube called the Loop of Henle. The Loop of Henle leads to another set of convoluted tubules and into a collecting duct connecting up to the ureter.

Blood coming into the glomerulus capillaries is under a high pressure and is also carrying the waste products from the rest of the bloodstream. Because of the high pressure, the waste products are forced from the blood into the hollow tubes of Bowman's Capsule. This is done by hydrostatic pressure.

This liquid, known as filtrate, then passes through the convoluted tubules, around the Loop of Henle, through the other set of convoluted tubules and into the collecting duct. Once it enters the collecting duct it has become urine. However, during the passage of the filtrate through the various tubes, anything still required by the body is re-absorbed back into the bloodstream. Glucose and some salts are commonly re-absorbed and so is water. This re-absorption is mainly done by osmosis.

In humans, about 180 litres of fluid is filtered into Bowman's capsule every day but, under normal circumstances, a person will pass only one litre of fluid as urine per day. About 99 % of the fluid forced back into the tube system is forced back into the tube system as it passes the Loop of Henle.

Waste products are not re-absorbed and, as the filtrate travels around the system, it becomes more and more concentrated until it is classed as urine. Urine carries all the waste nitrogen from the body as well as some waste salt. The amount of water re-absorbed back into the blood is controlled by the hormone anti-diuretic hormone or A.D.H. If the blood becomes too loaded with salts and glucose, A.D.H. is released and this increases the amount of water passing from the filtrate into the blood. This continues until the concentration of salts in the blood has reached the right level. Because of the extra water, the production of A.D.H. then ceases.

THE SKIN

The skin is the largest organ in the body. It protects us from external pathogens and extremes of temperature while detecting and transmitting sensations from the world around us. The detoxification processes in the skin are carried out mainly by sweating or perspiring.

SWEAT (SUDORIFEROUS) GLANDS

Humans have over 2.5 million sweat glands covering almost the whole body. Sweat glands do not occur on lips, nipples and parts of the external genitalia. Sweating is regulated by the sympathetic nervous system; therefore we do not have much control over this process. The most important function of sweating is its role in thermoregulation and preventing the body from overheating. Sweating due to heat begins on the forehead and spreads down over the rest of the body, whereas sweating due to emotions ('cold sweat' from anxiety, fear, and embarrassment) begins at the palms, soles and armpits and spreads from there.

There are two types of sweat glands, (a) eccrine and (b) apocrine.

Eccrine Glands

These are the most common type, occurring abundantly on the palms, soles of feet and forehead. They are tubular, with a pore opening at the skin's surface. The material secreted by these glands (commonly known as sweat) is made up of 99% water, salts (mostly sodium chloride), antibodies, traces of metabolic wastes (urea, uric acid, ammonia), lactic acid and vitamin C. The exact proportions vary between people and their diets. Sweat is usually acidic, with a pH of between 4 and 6.

Apocrine Glands

These are much less common in the human body, occurring mainly in the auxiliary and anogenital areas. They are larger than eccrine glands, with the duct going to hair follicles. The secretion contains similar components as true sweat as well as fatty substances and proteins, and is quite viscous and sometimes a milky or yellowish colour. Initially it is odourless, but it is broken down by bacteria living on the skin to products which give off an unpleasant odour. These glands begin to function at puberty, and are activated by hormones and by sympathetic nerves. Activity occurs during pain and stress, sexual foreplay and within the menstrual cycle of women, but their precise function is not known.

ASSIGNMENT

1. What is the difference between digestion and absorption of food? Explain briefly in one paragraph.
2. List 3 different physiological processes involved in absorption.
3. Describe how these different hormones control digestive process, in 2-3 sentences each:
 - Gastrin
 - Gastric Inhibitory Peptide
 - Secretin
 - Cholecystokinin
4. Research digestive enzymes and find three not listed in your lesson. Add them to the table below and indicate what sort of food they act on and the digested product. (Ptyalin is given as an example)

Enzyme name	Affected food	Digested product
Ptyalin	Starch	Simple carbohydrates such as maltose

ENERGY VALUE OF FOODS

In the past, food, or the lack of it, has influenced human destiny. A Dr. Lind helped Nelson to victory over Napoleon by introducing a small ration of oranges to the sailors. The fighting strength was not reduced by illness. On the other hand, Captain Scott's expedition to the south pole was thwarted by the lack of fresh fruit and vegetables. Not only must people eat to live, but what they eat will affect their ability to keep well, to work efficiently, to enjoy life in general and even their life expectancy.

The relatively new science of nutrition has developed in two steps. Firstly the discovery of nutrients and why people needed them. As a result the deficiency diseases that were prevalent at the turn of the century have been able to be prevented, or recognised early enough to treat, simply by understanding their nutritional cause. While this discovery stage has provided great insights into human nutrition and health, it is not yet over and there are likely still more discoveries to be made. In 1955 chromium was shown to be beneficial to the elderly; in 1961 zinc was shown to be essential for humans and only in 1960 was vitamin E shown to be necessary for humans - 40 years after its' discovery.

The present phase is much more complex. As research progresses, nutrients can no longer be considered in isolation. Their interaction with each other must also be considered. No longer are we concerned with the total carbohydrate content of the diet but with the types of carbohydrate included in the total. Where once we were suffering from diseases of deficiency, the west is now burdened by diseases of affluence, the most obvious being obesity. Massive amounts of money are now being directed at combating these new diseases.

THE SCIENCE OF NUTRITION



Nutrition is the science of providing adequately for the various body processes. It involves the study of foods and their use to the body and in case of human nutrition, how foods may be used to satisfy the nutritional needs of humans.

Food is defined as any substance, solid or liquid, which provides materials for:

1. Growth and repair (maintenance) of the body
2. Energy production
3. Regulation of the body processes.

The materials or chemical components of food which have these functions are called **NUTRIENTS**.

Almost no food contains only one nutrient, most are very complex substances and in order to maintain health, a person needs to be eating foods that provide sufficient variety of foods to obtain adequate amounts of all the necessary nutrients. A food rich in one particular nutrient may not be as important a source of that nutrient as another food containing less but eaten in larger quantities or more frequently.

The following types of nutrients may be found in foods and are considered in more detail later:

1. Carbohydrates provide energy and excess may be converted into body fat.

2. Fats provide energy and form body fat.
3. Proteins provide material for growth and repair of the body tissues and can also provide energy.
4. Mineral elements provide substances for growth and maintenance and the regulation of body processes.
5. Vitamins regulate the body processes.
6. Water by some people, not considered a nutrient; however, it does form a large part (62% by weight) of the body and is the medium in which all chemical changes take place within the body.

Nutrients are of critical importance to us from conception to the time of death. A new-born baby weighs on average between 6-9 lb and the materials for their growth come from the mother's food. For some years after birth the child increases their size and weight dramatically and the food they eat has a considerable effect their physical and mental development. While growth is never as rapid after childhood/adolescence throughout life changes are continually taking place within the body's cells. Cells may be replaced, or need to be repaired, and require regular maintenance. Nutritional needs change, to meet these new requirements and this is why recommended intakes of many vitamins, minerals and other nutrients are quite different between adults and children.

During the complicated processes of growth and maintenance of the body's cells, energy is constantly being used. It is required for every physiological and physical activity of the body, and if weight is to be maintained there must be a balance between total energy expended and that obtained from the food which is eaten. The energy needs of the body take precedence over the other needs in the use of nutrients. In addition to providing materials for the processes already mentioned, food provides materials for the regulation or control of these processes. Food is, therefore, needed for the growth, maintenance and energy production processes in the body and for the control of these processes.

DIET

A diet is the amount of foods actually eaten, usually in a day, and a balanced diet is one which provides adequate amounts of all the nutrients. Not everyone has the same requirement for each nutrient because there are, for example, periods of extra growth and of greater energy expenditure and general differences in metabolic rate; but everyone must have a satisfactory food intake to provide the appropriate amounts of all nutrients.

An unsatisfactory food intake over a period of time resulting in a shortage or excess of a particular nutrient can lead to malnutrition. Deficiency diseases such as rickets, scurvy and some anaemias are all forms of malnutrition caused by a diet lacking in a particular nutrient. Obesity, due to too great a food intake, or an unbalanced intake of fatty foods over other foods is another example of malnutrition.

Although the body has considerable power to adapt to reduced food intake, e.g. by reduced physical activity, insufficient food intake over an extended period will lead to malnutrition and eventual death by starvation. In the earlier years of this century many people in the U.K. had too little to eat and signs of malnutrition were obvious. Today no one has to go hungry, for not only has the total quality of food available increased but it is more fairly shared. This is however, not the case in developing countries, where people are still dying of deficiency diseases at an alarming rate.

People's intake of food, either qualitatively or quantitatively, is subject to a number of determining factors, such as their appetite, likes and dislikes, economic restraints, geographic conditions, religious and national customs, any one of which may impede or improve his well-being to some extent. However, there are generally so many different ways to obtain a healthy

diet, that most restrictions, whether due to taste, culture or religion should not result in malnutrition. That is, the food comprising one person's diet may be very different from someone else's, but both diets may be balanced.

It is a remarkable fact that no matter what foods are eaten the composition of the body - bones, flesh, blood - changes very little and that, within a few hours of the food being eaten, food materials are being used for growth and maintenance, energy production and the regulation of body processes. This transformation can, however, only take place after the foods have been broken down mechanically and chemically into simple soluble substances. This is achieved by the processes that make up digestion that we have already discussed in some detail. Following digestion, the simple substances are then absorbed through the intestinal wall and carried via the circulation to the various parts of the body where their use is required. Every single cell in the body has access to the blood and the nutrients (and toxins!) contained within it.

Metabolism is the name given to the complex chemical changes which occur in the body following absorption. The components of foods that are not nutritionally useful are excreted as faeces. While the waste products produced by the metabolism occurring in individual cells as well as any toxins in the blood are filtered out by the kidneys and excreted as urine.

An individual's required food intake is directly related to their energy requirements and under normal circumstances the appetite is a guide to the quantity of food needed. Most people eat sufficient food to satisfy their hunger and this provides energy by the oxidation or 'burning' of the three major nutrients carbohydrates, fats and proteins, in that order of preference. If an individual's weight remains constant then energy from their food intake - their diet - is equal energy that is being expended. When food is eaten in excess of energy expenditure there is a gain in weight, as the excess glucose is converted into lipid and along with excess dietary lipid is stored in cells called 'lipocytes' which together make up fat tissue or 'adipose tissue'. In contrast too little food will result in weight loss as the stored fat in the adipose tissue is converted to glucose and used as energy, and later, muscle wasting as the body retrieves protein to breakdown as a final attempt to generate energy.

Energy Value in Foods

For many years physiologists and nutritionists have expressed the energy value of foods in kilocalories or 'Calories' (with a capital 'C').

1 Calorie is the heat required to raise the temperature of 1 kilogram of water by 1 degree Celsius.

More recently SI (Système Internationale in French) units have been introduced, and in this case the unit of energy is the 'joule'

1 Calorie = 4,200 joules = 4.2 kilojoules (KJ)

1KJ = 1000 joules

1000 KJ = 1 Megajoule (MJ) = 240 Cals

1000 Cals = 4.2 MJ

The joule is being used in many textbooks and journals but the Calorie (kilocalorie) is still being used in many practical situations, including hospitals. In these studies both will be used.

The energy value of a food may be determined directly by measuring the energy produced (calculated as heat) when 1 gram (g) of the substance is completely oxidised by igniting it in a piece of equipment known as the bomb calorimeter. In this way the heat produced from pure

carbohydrate, protein and fat may be determined, and if the composition of a food is known the caloric value of the food may be calculated because:

Nutrient	Kilojoules per gram	Calories per gram
Carbohydrate	17	4
Fat	37	9
Protein	17	4

Alcohol also produces heat when it is oxidised, 1g yields 7 Cals (29 KJ).

Food tables give the composition of foods expressed either as the quantity of nutrients in a given weight or volume of the food or as a percentage, (you can convert between the two – if a food is 9% carbohydrate this means it has 9g carbohydrate per 100g of the food) and so the energy value of the foods can be calculated with the aid of the tables. Such tables do have limitations because there are wide variations in the composition of similar types of foods; e.g. the same cuts of meat may be lean or fat, the composition of milk varies with the breed of the cow, the time of milking, etc., and the composition of vegetables depends on the soil on which they are grown. The tables can therefore provide only average figures, suitable for general guidance.

Nutrients

To understand better how the body is nourished a more detailed study of the nutrients is necessary. The three major nutrients are Carbohydrates (complex sugars), Fats (lipids) and Proteins and nearly all the weight of a food is made up of one or more of these and water. As it has already been mentioned, all three can be sources of energy within the body. We will now examine each of these in detail.

ENERGY PRODUCTION

Foods contain chemical energy which can be converted into energy forms that the body can use. All three major nutrients can provide energy, however protein is the least preferred energy source, given the body's critical requirement on proteins and their individual component molecules, amino acids for muscle growth and maintenance, enzyme production, the generation of nucleic acids and a variety of other processes. Carbohydrates are ideal for immediate energy needs. Fats provide the most concentrated source of energy. Foods rich in fat will have the highest energy value because fat is a more concentrated form of energy than either carbohydrates or proteins. Most foods are a mixture of nutrients, and so the total energy value of a food will be the sum of energy from its carbohydrates, proteins and fats.

Watery foods will have little energy value because there will be less carbohydrate, fat and protein present. Food tables give the average composition of foods, and so the energy value of a food may then be calculated.

The body requires energy for:

- Involuntary activities which are needed for body maintenance: e.g. growth, breathing, heartbeat, maintenance of body temperature.
- Voluntary activities: e.g. Standing, eating, walking, dressing, play, work etc.

The least amount of energy expended by the body is when it is at complete rest, and without food (after the last meal has been digested and absorbed). The biochemical activities occurring within the body will at this point be simply to keep it alive, and these are known as "basal metabolism". The rate at which the body uses energy for basal metabolism is called the **basic metabolic rate** (BMR). An individual's BMR can be calculated by measuring the

amount of oxygen used, or the carbon dioxide produced from the body, when at complete rest and without food.

From BMR calculations on a wide range of individuals, it has been determined that the average BMR for different demographic groups is as follows:

Demographic Group	Weight (in kg)	Accepted BMR per day
Infant, 1 year old	10	2.1 mJ (500 Cals) <i>(ie. A 10kg child metabolises 500cals in a day)</i>
Child, 8 years old	25	4.2 mJ (1000 Cals)
Adult, woman	55	5.4 mJ (1300 Cals)
Adult, man	65	6.7 mJ (1600 Cals)

Basal metabolic rates vary from person to person because there are factors which affect an individuals BMR.

FACTORS AFFECTING INDIVIDUAL BMR

1. GROWTH RATE

During periods of growth, there is much involuntary activity taking place, and so the BMR in a growing child is higher in relation to body weight, than what it is in an adult. A baby of 1 year requires approximately one third more energy **per unit of lean body mass** than an adult of 25 years. BMR falls rapidly in the first 12 years of life, and then more slowly to the adult level.

Though a baby uses fewer calories than adult it does use more calories per kg of body weight!

2. BODY SIZE

After adolescence, BMR is proportional to the amount of lean tissue in the body, and as women generally have a higher ratio of fat to lean body mass than men, their BMR is normally lower. The rate is lower in the elderly and during starvation, because of the reduction of lean tissue (muscle). As age increases there is a fall of about 5% in the BMR for every decade, and the energy needed for basal metabolism at 75 years of age may be only two thirds of that needed at 25 years.

3. FOOD INTAKE

An increase metabolic rate is seen after about 10 minutes of eating food, and reaches its maximum in about 3 hours. This is the specific dynamic action of food, and is greater in the case of protein foods than with carbohydrate or fat foods.

The increase in metabolic rate is required to supply the energy required for the digestive processes (involuntary muscle contraction in peristalsis, chewing, hormone and enzyme production and secretion for example)

4. THYROID GLAND

The thyroid gland produces thyroxine, an iodine containing hormone, which controls BMR. An overactive gland will increase BMR, and an under active gland will decrease BMR; with the possibility of a corresponding decrease or increase in weight.

Energy needs above BMR are for physical activity, the voluntary movements of the body. The heavier the person is, the energy he will use, and of course, strenuous activities will require more energy than less heavy ones.

Some values for total energy expenditure (i.e. including BMR) for an average 25 year old man, weighing 65 kg, during various activities are:

Average Energy Expenditure

Everyday Activities	Cals/min	KJ/min
Washing, dressing	3.5	15
Sitting	1.4	6
Standing	1.7	7
Walking slowly	3	13
Walking -moderately	5	21
Walking up or down stairs	9	38
Light work (cooking)	2.5-4.9	10-20
Medium work (gardening, housework)	5.0-7.4	21-30
Cycling -up to 20 km/hr	6-7	23-28
Heavy work (Construction work, sport)	7.5 +	over 30

Using tables like these, it is possible to estimate an individual's daily energy expenditure. Combined with tables of the caloric intake from his diet, his energy input can be determined and the two compared. Where they are equal, body weight should remain constant, however too lower expenditure will lead to an increase in body weight, while lower intake will result in weight loss. It is important to keep in mind that there are considerable variations in the amount of energy expended by people doing the same work; some people make unnecessary movements, even fidget, and not all jobs are exactly the same.

The body is very efficient in controlling energy input to correspond to energy output. This may not occur daily, but any fluctuations in energy expenditure will, over a week or so, result in an altered energy intake to match output. To appreciate how skilfully the body does this, one only has to think that very many people in the course of 25 years will only have a variation in body weight of some 1 to 2 kg. During this period, their expenditure will have fluctuated, and some 12 tonnes of foods eaten.

An individuals correct calorie intake is one in which he can maintain his desirable weight.

If an individual eats or drinks foods which provide more energy than he expends, some carbohydrate, fat, protein or alcohol is converted into fat, and weight is gained. Any food can be fattening, but some are more concentrated sources of energy than others. Fat is the most concentrated source of energy, and the only nutrient that sugar contains is carbohydrate. Nearly all the weight of a food is made up of carbohydrate, protein, fat and water; so foods with a high water content have a low energy value. Fruits and vegetables have a high content of both water and cellulose, and are consequently useful when trying to reduce the energy value of a diet.

The energy values of some foods per 100 gm edible portion:

Foods	Kcal	KJ
Bread-white	233	991
Bread-wholemeal	216	918
Butter	740	3041
Sugar	394	1680
Potatoes -old boiled	80	343
Cabbage -spring boiled	7	32
Apples -eating	46	193
Dates -dried	248	1056

Sirloin -roast	284	1182
Bacon -back, fried	465	1926
Beer -draught bitter	32	132
White wine -dry	66	275
Spirits 70% proof	222	919
Sherry -sweet	136	568

(From: McCance & Widdowsons "The Chemical Composition of Foods", by Paul & Southgate Publ, 4th revised ed., 1978)

Weight may be lost by decreasing the energy value of a diet, or by increasing physical activity; or by both. The loss due to changes in the amount of exercise alone is small as can be seen from the following list of activities. Foods which are equivalent in energy value, approx. 300 calories (1.25 MJ) are shown in the bottom 4 rows.

Activity	Time
Walking fast	1.5hour
Gardening	2 hours
Tennis	1 hour
Cycling	0.75 hour
Food	Approx. amount
Beer	2 large glasses
Sugar	18 lumps
Milk	0.5 litre
Bread	5 slices

From the above table, it will be appreciated that to lose weight, food intake has to be curtailed, and weight loss simply cannot be achieved by increasing exercise alone. Regular exercise however, should not be neglected. Walking to the local pub instead of using the car may still not be enough to compensate for the energy intake of a 'pint' of beer (unless the pub is 10 km away and you fidget...a lot!).

ASSIGNMENT

1. Complete the following sentence:
Basal metabolic rate (BMR) is.....
2. Describe how any two different food groups of your choosing affect metabolic rate.
 - You may define food groups however you wish meat/fruit or carbohydrate/fat for example
 - Keep your answers to about 100 words each, or less
 - You only need to give a simple description, not a complex explanation.
3. Select two factors other than food intake that can affect digestion. Describe in single sentence dot points how each affects digestion. Use no more than 5 points for each factor.
4. List five negative consequences of mismatching calorie intake with physical activity.

CARBOHYDRATES & FATS

Aim

Recommend appropriate carbohydrate intake and recommend appropriate fat intake for a specific person.

CARBOHYDRATES



Carbohydrates are found in all plants. There are two forms in nature, sugars and starch. Both are made of the same molecules linked up in short or long chains much like beads in a necklace. Short chains are called simple sugars, and they are easily digested. Long chains are called starches or complex carbohydrates, and it takes a bit more time to digest them as the long chains have to be broken down more times, and this takes longer. Fibre is also a complex carbohydrate; in this case the chains are longer and even more difficult to break down. Carbohydrates are the main source of energy for most people. If you are using a lot of energy, as in sports training, then you should be eating more carbohydrate. There can be serious problems if you eat more carbohydrate than what you need for the energy you are using! One gram of carbohydrate yields 4 calories of energy.

Sources for complex carbohydrates:

(Starches): rice, nuts, potatoes and other root vegetables, leafy vegetables, other vegetables bread, cereal, biscuits, flour, pasta. Root vegetables, legumes and whole grains are vital for fibre intake.

Sources for simple carbohydrates:

(Sugars): sugar, honey, fruit, ice cream, immature (sweet) vegetables, soft drinks, dairy (eg. coca cola)

Sources of both simple and complex carbohydrates:

Pies, cakes, biscuits

Symptoms of carbohydrate deficiency include metabolic acidosis from increased use of fat deposits and in extreme cases, tissue wasting. Symptoms of carbohydrate toxicity/excess include nutritional deficits, over weight, digestive tract irritation and higher levels of triglycerides (ie. a type of fat) in plasma.

Recommended daily intake of carbohydrate for an average adult = 125 to 175 grams and 55-60% of total calories ingested.

Carbohydrates are a class of chemical compound of made up of a backbone of carbon, hydrogen and oxygen atoms. Plants are able in sunlight to build up (synthesise) carbohydrates from the carbon dioxide and water surrounding them, this process of photosynthesis is a complicated one, but the result is that:

- (a) Part of the carbohydrate provides energy for the growth of the plant,
- (b) Part is stored for energy needs of the plant when there is no photosynthesis (this part is stored as sugars and starches), and

- (c) Part is used for the supporting structures of the plant (this is the fibre or wood of the plant and is composed largely of cellulose)

Humans and animals cannot photosynthesise their carbohydrates.

TYPES OF CARBOHYDRATE

Humans obtain carbohydrates from plant foods in the form of sugars, starches and indigestible cellulose and related materials. The different carbohydrates fall into three categories, based on their size:

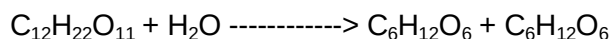
1. Monosaccharides

These are simple sugars which under reasonably mild conditions can be hydrolysed into smaller compounds. They comprise glucose, fructose, galactose, mannose and several others. These are the simplest carbohydrate molecules (hexoses, $C_6H_{12}O_5$) and form the units from which the more complex carbohydrates are built. They require no digestion and are readily absorbed into the blood stream.

- Glucose occurs naturally in fruits and vegetables and is found in the blood of animals. It is the form into which other carbohydrates are converted for transport in the blood and utilisation by the tissues of the body.
- Fructose is associated with glucose in many fruits and plant foods, especially in honey. It is the sweetest of all sugars.
- Galactose is not found free in nature but is derived from a larger saccharide, lactose, which it is digested.

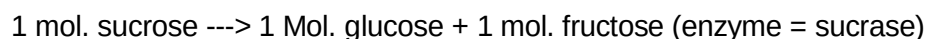
2. Oligosaccharides

These are compound sugars which when hydrolysed will yield two to six molecules of monosaccharides. (Disaccharides are oligosaccharides which yield two monosaccharide molecules when they hydrolyse, trisaccharides will yield three monosaccharides as so on). Disaccharides may be split into two simple sugars by hydrolysis or in the body by specific enzymes in the digestive tract:

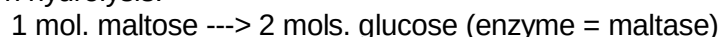


Sucrose is ordinary cane or beet sugar and is about twice as sweet as glucose.

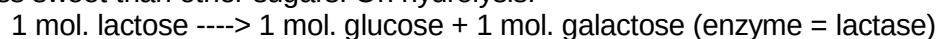
On hydrolysis:



Maltose is formed by the breakdown of starch during digestion and during the manufacture of malt liquors. On hydrolysis:



Lactose occurs in milk and is the only one of the common sugars not found in plants. It is less soluble and less sweet than other sugars. On hydrolysis:



3. Polysaccharides

These consist of a large number of monosaccharide units which may be alike (all glucose for example) or different (some glucose, some fructose for example). Therefore they yield a large number of monosaccharides when they are digested. Starches and fibre (cellulose) are examples of those.

- (a) Starch is insoluble and a stable and efficient store of potential energy in plants. It is found in roots, seeds and stems of plants and is a mixture of two polysaccharides, amylose and amylopectin. These contain a large number of glucose units (amylose 70-350 and amylopectin 20-30) and the exact number depends on the particular plant from which the starch comes. On hydrolysis, glucose is the only monosaccharide

produced.

- (b) Glycogen is the only starch found in humans. It consists of a number of glucose units and is deposited in the liver as a reserve store of carbohydrate and in muscle as a more immediate source of fuel for energy. These stores are only temporary and are used between meals and at night.
- (c) Cellulose is the chief structural carbohydrate of plants. With other materials, it provides the rigid and fibrous structure of fruits, vegetables and cereal grains, including the plant cell walls. Cellulose cannot be digested by humans and so the component monosaccharides are not available to the body, meaning cellulose has no nutritional value in terms of energy or nutrients.

Nonetheless these indigestible polysaccharides, which are collectively known as dietary fibre or roughage, greatly aid the passage of food along the digestive tract and add bulk to the faeces. Dietary fibre has been shown to tie up excess cholesterol from animal sources and thus help relieving conditions related to high cholesterol, heart and arterial diseases in humans. The better elimination of faeces with higher fibre foods has also been related with the prevention of colon cancer, in addition to alleviating chronic constipation. Care should be taken though with patients with highly irritated bowels already, such as chronic Candida patients, IBS sufferers and Crohn's Disease sufferers. In their case dietary fibre should only be supplied when consuming fresh vegetables and fruits, and not added to foods from external sources such as bran. In diabetics, cereal bran has chromium, zinc, manganese and silicon, which may contribute to stabilise blood sugar levels in diabetics, and in the case of silicon, to provide support for pancreatic function, and skin, nails and hair maintenance.

- (d) Pectin is another complex carbohydrate, found mainly in fruits. It is responsible for the formation of gels in jam and jelly making. It is a component of many plant cell walls and is another source of dietary fibre.

Carbohydrates in the Diet

Carbohydrates in the form of sugars and starches provide most of the energy derived from human diets. In the diets of people in developing countries (particularly in the tropics), or those in low socio-economic brackets as much as 90% of energy average energy intake is carbohydrate. (bread, rice, potatoes, yam). In more affluent societies where more fat is eaten some people will obtain less than 50% of energy comes from carbohydrates. Ideally, 55-60% of energy intake should be in the form of carbohydrate. Athletes and those working in heavy manual labour industries will require more.

Starch is the major energy reserve in plants and so forms a major source of energy for humans. Sugars as simple carbohydrates occur naturally in fruits and vegetables. This should be the major source of simple sugar for humans. However, in cases, refined or purified sugars, in powder form or liquid as molasses or syrups is the main source of sugars, as people snack on processed foods such as cakes, biscuits, pastries and tinned fruits. During the last century the consumption of sugar has increased considerably and a much larger proportion of carbohydrate intake in the world now consists of sucrose. As a result conditions related to weight maintenance and blood sugar regulation such as diabetes and obesity are increasing at alarming rates in developed countries, and some experts consider these ailments to be epidemic within western society.

While energy requirements can be satisfied by the intake of either sugar or starch, there are dangers associated with excessive intake of sugar, e.g. dental caries, overeating due to lack of appetite suppression (sugars are rapidly digested and do not make a person feel 'full' even

when they have ingested a high number of calories.

A diet low in carbohydrates is not recommended for people in otherwise good health as carbohydrates can spare the wasteful use of proteins as a source of energy and enable them to be used for other vital functions that carbohydrates and fats cannot fulfil. This has been termed the 'sparing action' of carbohydrates, and the best use of protein is made when carbohydrate and protein foods are eaten in the same meal. Many traditional combinations of foods are based on sound physiological principles, e.g. bread and cheese, rice and curried meat, beef and Yorkshire pudding, and for those with slow digestion, fish and salad, meat and vegetables, or other easier to digest combinations. Dairy is not the best combination with meat, as lactose requires more digestion (to maltose and then to its monosaccharide components) than fructose or sucrose in other carbohydrate sources.

As stated earlier, polysaccharides contribute to the fibre content of the diet. The process of refining cereals, to remove the 'rough' exterior and improve the colour results in a dramatic reduction in the fibre content of the food source. The resulting lack of fibre in many people's diets has been attributed to the high incidence of bowel cancer, along with a variety of other illnesses and diseases of the intestines.

Carbohydrate Content of Some Foods, g. per 100g (available carbohydrates as monosaccharide)

Food	Carbohydrates (g/100 g)	Food	Carbohydrates (g/100 g)
Sugar, white	105.3*	Apples	11.9
Syrup	79.0	Bananas	19.2
Jam	69.2	Oranges	8.5
Bread - Brown	44.7	Pears	10.6
- White	49.7	Dates, dried	63.9
Crispbread - Rye	70.6	Sultanas	64.7
Flour - White	80.1	Beans - broad	9.5
Cornflakes	85.1	- runner	3.9
Custard Powder	92.0	Carrots, old	19.7
Potatoes, boiled	19.7		

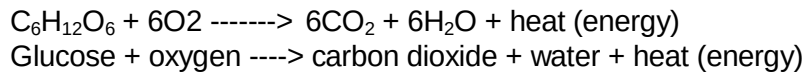
*Equivalent to 100g. sucrose

1 g. disaccharide = 1.05 g. monosaccharide.

A detailed account of digestion was given before describing how digestible carbohydrates are broken down into monosaccharides and these are then absorbed through the villi of the small intestine into the blood stream. Refer to your notes from the previous chapters if you need to refresh your memory.

Carbohydrates in the Body

Following the absorption of monosaccharides into the blood stream they are carried directly to the body's cells which will take them for their own use if they need to. The remaining glucose is collected from the bloodstream by the liver. A small amount of sugar (normally 0.08 - 0.14%) always circulates in the blood and is carried to the tissue cells where it is an immediate source of energy. The release of energy from glucose is brought about by a series of complicated chemical changes which can be represented very simply by:



Glucose not required for immediate use in the production of energy is converted into glycogen in the liver and the muscles as a temporary store of carbohydrate. At night or when insufficient food is eaten this store is drawn on and the glycogen reconverted to glucose. In this way the amount of glucose in the blood is kept reasonably constant.

When the liver and muscles can accommodate no more glycogen the surplus glucose is converted into fat and stored in the various fat deposits of the body, subcutaneous (under the skin) and omental (in the body cavity). In extreme cases, fat will be stored in the liver, which is a serious problem. As energy expenditure is continuous and food is only eaten intermittently this store can be drawn on if needed as a source of energy. However, if the body's energy needs are smaller than the intake, then there will be an increase in weight.

This complex series of chemical changes involved in the metabolism of carbohydrates is controlled by a number of hormones. When there is a sudden and dramatic intake of sugar-rich foods, such as in sweets, cakes, puddings and other foods abundant in simple sugars (high Glycemic Index – GI- foods, such as potatoes), then the pancreas releases enough insulin to stop the new glucose becoming too concentrated in the blood. It does this by directing the conversion of glucose into glycogen and the storage of the glycogen in the liver. In between meals, or other times when the brain detects that its major nutrient, glucose, is low, it starts sending signals, and it is then we might experience these sudden urges to eat, especially sweets. If we do not, secondary symptoms, including irritability and loss of concentration (due to the brain prioritising the limited glucose it has) and general lethargy/sleepiness occur.

The consequences of having high blood sugar levels or too low sugar levels can be very serious for health.

Consistently high blood sugar levels can cause major problems with the kidneys, as they have to work continuously to decrease the sugar in blood. It can also cause nervous system problems (deterioration of peripheral nerves especially in the hands and feet), with symptoms like tingling, pain and lack of coordination. In the more extreme cases, very high blood glucose levels can lead to diabetic ketoacidosis, or a "diabetic coma." When blood sugar levels drop too low, it is called hypoglycaemia. This can have symptoms such as dizziness, mental confusion, and irritability.

In diabetes insufficient or no insulin is secreted by the pancreas gland or cells in the body become insensitive to insulin. The glucose in the blood increases as it is not taken up by the liver and muscles for conversion to glycogen or used for oxidation, and there comes a point when the excess sugar is excreted via the kidneys in the urine.

Alcohol

A molecule of alcohol consists of carbon, hydrogen and oxygen. It does not hydrolyse to simple sugars and therefore is not a carbohydrate. Alcohol can only be oxidised by the liver, as this is the only place that has the necessary enzymes. Oxidation occurs at a limited rate, drinking coffee or sleeping for example, will not increase the oxidation of alcohol. Alcohol provides 7 cal or 29 Kilojoules per g. When large amounts are taken, about 5% is excreted in the breath and urine, the remainder begins to enter the bloodstream, circulating to the tissues and cells and impairing their function while waiting to eventually be oxidised by the liver.

Alcohol is only a problem when taken in excess, and is high concentration in the blood stream affecting the brain and nervous tissues. The liver can also be affected, which will cause the body to be unable to process other toxins out of the body as well. The result of chronic alcoholism is alcoholic fatty liver disease, and if alcohol intake is not curbed, cirrhosis will develop and a transplant will be required.

Remember that alcohol provides the body with energy and may lead to excess energy intake without adequate vitamin and mineral intake, resulting in malnutrition.

FATS



'Fat' is the general term used to include oils and fats. Both are more correctly called "LIPIDS". They all have a characteristic 'greasy' appearance whether solid or liquid. Solid lipids are actually fats, while liquid lipids are oils.

Lipids contain carbon, hydrogen and oxygen, but in different proportions to carbohydrates. Fats are an important source of energy to some people, and some types of fats are essential in the diet. They provide materials for the replenishment of cell membranes (a double layer membrane composed of phospholipids), hormone balance, brain function and nervous system balance. Fat also helps to insulate our body and a small amount is needed around the major organs to protect them against damage resulting from movement or external force. Fat-soluble vitamins such as vitamins A, D, E and K, tend to be found in foods with a high fat content, like fatty fish (salmon, mackerel, sardines). If a person's fat intake is very low, there intake of these vitamins will also be low. One gram of fat yields 9 calories. Some types of fats (i.e.: animal fats) are a significant heart disease risk when eaten in excess.

There are different types of lipids, however the most common type in most diets are *triglycerides* (also known as triglycerol). These are saturated fatty acids found in vegetable oils and meat fats and while they have important roles in the body, high dietary intake can increase a persons risk of heart disease and other serious illnesses. Cholesterol is another type of fat that is found in food from animals (egg yolks, shellfish, meats, dairy) and not plants. Cholesterol is needed for proper cell membrane maintenance, and to synthesise some hormones and because it is so important for health, it is synthesized in the body too, by the liver. Essential fatty acids (EFA's) are those lipids that we have to consume in the diet as we cannot synthesize them.

Linoleic acid (omega 3's) and alpha-linolenic acid (omega 6's) fatty acids are essential fatty acids.

Fats (not including cholesterol) are changed to fatty acids and monoglycerides through digestion. They are then converted into triglycerides and transported in the lymphatic system. The liver is very efficient at converting fatty acids from one type into another type. It can't synthesize linoleic acid however. This fatty acid must be ingested. Research has indicated that alpha-linolenic acid must also need to be ingested. Both of these fatty acids occur in most nuts, seeds, fish and their oils, and both are needed (precursors) for the synthesis of prostaglandins, which are very important to regulate the immune system and control inflammation, specially in inflammatory diseases.

Lipids can be found in the following groups:

1. Animal Sources of Lipids: meat, poultry, eggs, milk, milk products, lard.
2. Plant Sources of Lipids: sunflower seeds/oil, olive oil, coconut and coconut oil, nuts, chocolate beans (fruits) corn, soy beans,
3. Sources of Essential Fatty Acids (EFA's): flax seed, nuts, seeds, avocado, corn, soy oil, wheat germ, fish and fish oil.
4. Sources of Cholesterol: liver, kidneys, brains, egg yolk, fish roe, fatty meats, cream, cheese, milk.

Recommended fat intake (from American Heart Foundation):

Fat intake should be no greater than 30% of total calorie intake.

Saturated fats should be no greater than 10% of total fat intake.

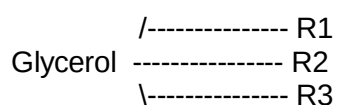
Daily cholesterol should not exceed 250 mg (i.e. the amount in one egg yolk).

The National Heart Foundation in Australia similarly produces recommendations in Australia.

Fat Biochemistry

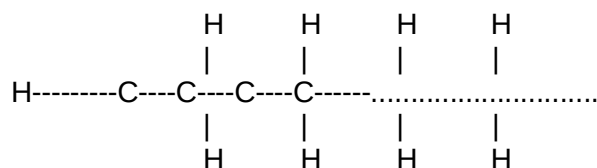
Fats are also compounds of carbon, hydrogen and oxygen but contain less oxygen than carbohydrates. It has already been mentioned that excess carbohydrate is converted into fat and so fats (and oils, which are liquid at normal temperatures) are the forms in which animals and some seeds store their energy. Fats are found in foods as visible fats, e.g. in butter, margarine, oils and the fat on meat as well as invisible fats in milk, nuts, lean meat, some fish etc.

Chemically, fats are mixtures of triglycerides. Each triglyceride is a combination of three fatty acid molecules (called here 'R' from residue) with one of glycerol.



R1, R2 and R3 may be the same or different fatty acids and it is the type or types of fatty acids in the fat which give the fat its flavour, texture, melting point and other characteristics.

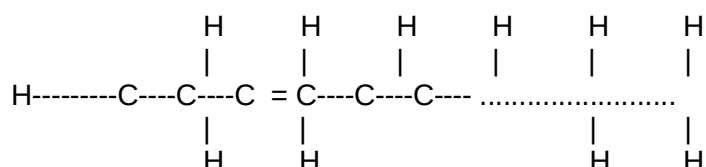
The chemical basis of every fatty acid is a long string of linked carbon atoms, the length of which varies with the fatty acid. In some fatty acids each carbon atom in the chain has its full complement of hydrogen atoms:



When carbon atoms are linked by single bonds they are called 'saturated' fatty acids and fats formed mainly of saturated fatty acids are usually (though not always) solid at room temperature. Butter fat, lard and coconut oil have a high percentage of saturated fatty acids.

In unsaturated fatty acids one or more of the carbon atoms does not have the full complement of hydrogen atoms and so there is a double bond. Where there is only one double bond, a fat is said to be 'monounsaturated'.

Two or more double bonds and the fat is termed 'polyunsaturated'.



Most fats contain both saturated and unsaturated fatty acids but in widely varying proportions, e.g.

Butter	60%	saturated	35%	unsaturated fatty acids by weight
Soft margarine	31%	--"	66%	--"
Cheddar Cheese	60%	--"	35%	--"
Olive oil	14%	--"	81%	--"
Lamb (average)	48%	--"	43%	--"

Fats with a high percentage of unsaturated fatty acids are usually liquid at room temperature (oils). Under controlled conditions unsaturated fatty acids can be converted to saturated fatty acids, a process known as hydrogenation and use is made of the process during the manufacture of margarine. The liquid oils are hardened as a result of the hydrogenation. Hydrogenation also eliminates omega 3 and omega 6 fatty acids in the oils. Hydrogenation has been shown to create trans-fatty acids, which have been related in research studies to an increase risk of cancer, diabetes and cardiovascular diseases. Due to that, they are being banned in Europe in the food industry and the American Food and Drug Administration is enforcing the inclusion of the amount of trans-fatty acids in manufactured food labels. Trans-fatty acids can be found in margarines and vegetable shortenings, and in manufactured baked foods like cookies, cakes and breads.

Fat is required for the palatability of many foods. To achieve a palatable diet and to feed well, at least 20-25% of total calories should come in the form of fat. High fat diets however are high in energy, and will, except for physically active people, lead to obesity. Fats slow down the emptying of the stomach and give a sense of satisfaction and satiety after a meal, delaying the feeling of hunger. Most animal fats provide the fat soluble vitamins A and D.

In plants, the fat is made from carbohydrates; as seeds ripen the amount of starch decreases, and the fat content increases. This provides a useful amount of oil in sunflower, cotton and soy

bean seeds. Soy bean oil is used in many types of cooking oil. The fat content of cereal grains is small as it is in fruits and vegetables (exceptions are nuts, olives and avocados).

Fatty fish (herrings, mackerel, salmon, tuna etc) have fat in the flesh, and the proportion varies with the seasons. This fat is a useful source of fat soluble vitamins A and D. White fish contains little oil except in the liver (cod liver oil or halibut liver oil). The fat content of animal derived foods is especially variable.

Fish oils differ from vegetable and animal oils in that they contain a much greater proportion of highly unsaturated fatty acids. The ratio of polyunsaturated to saturated fatty acids in the whole diet is normally about 0.2 :1, but would be increased if less beef, lamb and dairy foods, and more poultry, fish and vegetable oils were eaten. According to Complementary Medicine sources, a good healthy diet should tend to have a ratio of 20:1 unsaturated to saturated fats, which means eating 20 times more unsaturated than saturated fats. This is quite uncommon nowadays as the food industry tends to use saturated fats in their products because they resist oxidation longer, and thus product shelf-life is extended.

About 40% of the total fat in the diet comes from visible fats (eg. butter, margarine and cooking fats or oils), and much of the rest comes from protein foods (eg. milk, cheese, meat, bacon and fatty fish).

The choice of fat containing foods however, is very individual, and the figures can only be an approximation. Where the intake of fat is low, there may well be a low intake of protein and other important nutrients.

Average fat content in some foods:

Foods	Grams of fat per 100 gms of food
Milk	3.8
Cheddar cheese	33.5
Butter	82.0
Eggs	10.9
Lard	99.0
Fresh Peanuts	49.0
Vegetable Oils	99.9
Chicken (dark) boiled	9.9
Beef (stewed)	11.0
Pork roast (lean)	6.9
Cod (baked)	1.2
Herring (grilled)	13.0

Butter, margarine, cooking fats and oils contribute approximately 40% of the total fat intake. Milk, cheese and egg can be expected to contribute some 15%; meat, bacon, poultry and fish 30%. As expected, cereal products contain little fat, contributing only about 5%. The remaining 10% comes from miscellaneous sources.

NOTE: Oils which are true fats must not be confused with mineral oils derived from petroleum. The latter, paraffin oil, etc, are completely indigestible in the body, and inhibit the absorption of fat soluble vitamins. They have been banned from foods in Great Britain since 1945. During digestion, fats are first broken down into smaller particles (emulsified), and then fatty acids are

split off from the fat molecule so that there is a mixture of free fatty acids, and mono- and di-glycerides. As hydrolysis is not complete, there is little glycerol produced.

FATS IN THE BODY

After absorption, most fat is carried to fat deposits of the body, and is not used immediately to produce energy (ie. it is not oxidised immediately). This occurs even when the body is in urgent need of energy. This means the fat deposits in the body are not static, and fats are constantly being broken down into fatty acids and glycerol, and resynthesized. When the body requires energy from fats, the fatty acids and glycerol undergo a series of chemical changes in part similar to carbohydrates; that is they are oxidised to produce carbon dioxide, water and heat (energy).

If energy is not required immediately, molecules of fatty acids and glycerol recombine, and the synthesised fat is again deposited in the body fat deposits.

If diets contain too much fat, and too little carbohydrate; substances known as ketones accumulate in the blood giving rise to ketosis. This condition also occurs in starvation, when fats are metabolised at an abnormally fast rate and in condition such as diabetes.

ASSIGNMENT

1. List 5 foods which are common sources of carbohydrate and 5 foods in *your* diet which are poor sources of carbohydrate.

2. In 1-2 sentences distinguish between monosaccharides and disaccharides.

3. Select any 5 of the different sources of carbohydrates listed below and rank them in order of their carbohydrate value, with 1 being the highest, 5 the lowest. Give a short explanation of why you ranked them in the order you did. (2-3 sentences is sufficient)

- Steamed Potatoes
- White Bread
- French Fries
- Chocolate
- Boiled lollies
- Milk
- Honey
- Apples
- Cakes
- Fruit Salad
- Corn flakes
- Wholemeal Bread

4. Select any 3 factors which affect the bodies demand for carbohydrate and give a single sentence description of how they do so.

5. Give any 3 questions you might ask someone when you are trying to determine their specific carbohydrate requirements.

6. List 5 foods which are a common source of fats.

7. Select any person you know and in a table distinguish between saturated and unsaturated fats in their diet. Indicate the persons age, sex and occupational status.
8. Explain the relative value of 5 alternative sources of fats selected from different products you saw in the supermarket/store which you visited.
9. Select any 3 factors which affect the bodies demand for fat and give a single sentence description of how they do so.
10. What is the role of fat in the body? Give a one paragraph answer including a simple description of 2 different physiological processes involving fat.
11. Develop a set of guidelines you might give to a friend with no education in nutrition, so they can determine their appropriate daily fat intake. Use no more than 300 words.

Lesson 6

PROTEINS

Aim

Recommend appropriate protein intake.



PROTEINS are very complex substances which like carbohydrates and fats contain hydrogen, oxygen and carbon. However they also contain a fourth element, nitrogen. Proteins are large molecules made up of different combinations of smaller units called amino acids. Different proteins are different combinations of different amino acids.

The body needs eight "essential" different amino acids throughout all stages of life. They are:

- Tryptophan
- Methionine
- Valine
- Threonine
- Phenylalanine
- Leucine
- Isoleucine
- Lysine

For infants, a ninth "essential" amino acid is also needed: Histidine.

Essential Amino acids cannot be stored in the body so they must be supplied in the diet. These are "essential" amino acid requirements. Recommended amino acid requirements will include a lot more than the essential 8 or 9 compounds (up to around 20).

As well as the standard four elements, many proteins also contain sulphur and some phosphorus. Every cell in the body is partly composed of proteins. Protein is a structural material required for growth and repair, and replacement of damaged tissues. Proteins are involved in the regulation of numerous cellular processes and are also the end product of many. They are crucial for vital processes such as glandular secretions, enzymes and hormones. Excess protein can be converted to glucose, and used for the production of energy. Because of their requirement in numerous vital functions, protein is the least favoured energy source and is only used as such when absolutely required.

Plants manufacture their own protein from their basic components, carbon, hydrogen, oxygen and nitrogen, but humans and other animals cannot do this. People and animals must obtain theirs from plant foods. Humans and other carnivorous animals can obtain their protein supply eating animals that in turn get their protein from plants (herbivorous).

Proteins consist of a chain of hundreds, or more, amino acid units. There are 20 different amino acids found in food and body proteins. By being linked together in different combinations and proportions, an almost endless variety of different proteins can be formed. Every species of plant or animal has its own characteristic proteins. Beef proteins are different to lamb proteins, and both are different to pea proteins, etc. In humans, the protein in bone is different from the protein in skeletal tissue, or heart, blood or skin, etc.

USES IN THE BODY

Proteins are needed in the body for:

1. Body growth and repair: building and maintenance muscles and other soft tissues
2. Regulation: proteins and amino acids are or are part of compounds that regulate or modulate the processes in the body, such as enzymes, hormones, antibodies and neurotransmitters.
3. Energy: To burn as fuel (ie. to provide a source of energy).

Proteins are found in all active tissues of the body (eg: muscle cells, the liver, glands, etc). Though one gram of protein can yield 4 calories, the most important functions of the protein are tissue building, and repair and provision of the ingredients for the formation of enzymes, hormones and antibodies.

Whether a protein is burnt to supply energy, or used in a more constructive way depends on the following:

The all or none rule

An appropriate amount of all necessary amino acids must be present to make a particular protein, or the protein will not be made. Any essential amino acids not used to make proteins will soon be oxidised for energy, or converted to produce carbohydrates or fats.

Calorie intake adequacy

If a diet doesn't contain adequate carbohydrates or fats for calories in energy production as ATP, tissue proteins are then used for energy. (NB: ATP is a chemical involved in the process of storage and release of energy, allowing work and movement to occur in the body).

Body nitrogen balance

In healthy adults, the rate at which proteins are synthesised should be the same as the rate at which they are being broken down in the body. This balance is reflected by the nitrogen balance in the body based on the fact that all protein average approximately 16% nitrogen.

The body is considered in balance when the amount of nitrogen ingested in protein is equal to the amount excreted in urine. Under physical or emotional stress, the protein breakdown can be affected and exceed by the amount of protein being synthesised: this is called a "negative nitrogen balance".

Hormone activity

Anabolic hormones can cause acceleration of protein synthesis and growth. The effect of these hormones may continually change (affected by things such as age, stress, growth rate etc), hence growth rates and protein synthesis rates can be continually changing.

RECOMMENDED PROTEIN INTAKE

As a general guide: approximately 0.8 to 1 gm per kilogram of body weight per day. Typically a small serve of fish and an egg would be adequate for an average person, per day. Protein needs vary much among different people, depending on their metabolism, physical activity and health conditions. A sports person will need to rebuild muscles more often than a sedentary one. They will also have higher metabolic rates. So their protein consumption will need to adapt to higher requirements, and can be as high as 1.2-1.4 gm of protein per kg of body weight. People with kidney stones will have to be careful about their nitrogen intake, as in concentrated proteins sources, as a high intake will tend to stress the kidney in an attempt to increase urea elimination. According to the theories behind Metabolic Typing, some people may require more proteins in their diet, as much as 55%, and others may require less protein and more carbohydrates, as much as 70 %. This is due to genetic differences in the way biochemistry cycles occur in our bodies, if people are fast or slow oxidisers.

Proteins sources are very varied, they can be supplied with plant or animal sources, and both of them lead to good health provided the essential amino acids are supplied and an adequate total quantity of protein is ingested. Too much protein is as bad too little. Moderation is the key. Too many proteins can lead to blood pH unbalances, which will put stress on other bodily systems in order to equilibrate the pH. Also, protein degradation will produce residues that will need to be eliminated from the body.

Animal sources of proteins are animal meats, poultry, fish, dairy and eggs.

Plant sources of proteins include seeds, nuts and beans, grains, leafy greens, other vegetables and fruits.

GRAIN

Grains are a good source of protein, complex carbohydrates, fibre and many different minerals and vitamins. Different grains have different food values. Typically they consist of 65-75% carbohydrates (sugars and starches), 7 to 12 % proteins, 2 to 6% lipids and the rest is water. Whole grains are generally better nutritionally than processed grains, particularly with respect to dietary fibre, minerals and vitamins. Grains are a staple component of many diets in many cultures around the world, including Western countries. They are a basic component of daily protein intake in Western and Asian vegetarian and vegan diets, together with beans, nuts and seeds.

Some values of protein for different grains are given in the table below:

GRAIN	PROTEIN (in % of dry weight)	CALORIES/100g (Raw dry grain)	GOOD SOURCE FOR:
Barley	Medium levels (11.0)	360	Slightly more nutritious rice substitute
Buckwheat	Medium to high	363	B group vitamins & minerals
Corn	Lacks some amino acids (9.8)	350-400	Vitamins & minerals
Oats	Higher than many grains (9.3)	400	Iron, potassium, zinc manganese, Vitamin E & more
Rice	Variable -wild rice is higher than brown rice (7.3)	360	Varies between types, many minerals & vitamins
Rye	High (8.7)	335	Many minerals & vitamins
Triticale	High content	360	Iron, potassium & B group vitamins
Spelt	High content		Iron, potassium & B group vitamins
Wheat	Wheat germ is high in protein (10.6)	300	E & B group vitamins

Triticale and spelt are related to wheat, but have some different properties that make them more suited to be consumed by people with wheat sensitivities.

VEGETABLES

Vegetables are also a source of proteins. Legumes are possibly the best source of protein amongst vegetables. Peas and all types of beans (dried or fresh) are high in protein, as are all

seeds.

The average root or leaf vegetables have been determined to contain 1 to 3% (approximately) of protein, whereas dried beans or peas may be as high as 20% protein. Soy contains as much as 40% proteins (dry weight) and 20% fat. Beans are also a good source of vitamin C, and provide a range of other minerals and vitamins. Bean sprouts have an increased amount of vitamin C (which is produced as they germinate). Dietary fibre is excellent in beans and even better in sprouted beans. Vegetable protein tends to be more easily digested, as much of it comes also as amino acids; therefore there is no need of high energy expenditure in its digestion to break long and complex protein molecules.

NUTS AND SEEDS

They are also a good source of proteins, vitamins and minerals, but due to their high fat content they have been considered unsuitable for many dietary programs, especially those designed for weight loss.

As an example almonds contain 17% protein (gm/100 gm), Brazil nuts 12%, cashews 17.2% and coconut fresh 3.2%. The highest protein content is found in pine nuts (31%), pumpkin seeds (29%), sesame seeds (26.4%) sunflower and peanuts (24%). They also contain calcium, phosphorous, potassium, iron, zinc, selenium and vitamins A, E and B₂.

MEAT, POULTRY AND FISH

Meat, poultry and fish are biologically and nutritionally classed as 'meats' or 'concentrated animal protein'. Their structure is similar, although their fat contents vary and the fat quality is different between fatty fish and other types of meat.

Fatty fish have greater content of omega 3 and omega 6 oils (unsaturated fats), that they get from the algae in their diet. On the contrary, white fish, poultry and meat have saturated fats as the main fats in their tissues. That is why to balance the unsaturated: saturated ration in the diet an increase in oily fish intake is recommended as a source of healthy fats and a decrease in meat intake as they are source of saturated fats.

The Structure of Meat

Meat is made up mostly of muscle but it does include some connective and fatty tissues as well as bone and skin. Connective tissue is closely associated with muscle and is found in the muscle itself or within the muscle sheath. The white connective tissue (collagen) can be broken down by cooking but the yellow elastic tissue (elastin) found in ligaments and tendons are not affected by heat. Fat is an important component of meat as it improves the tenderness, moisture content or juiciness and flavour of the meat. Fat is also a source of Vitamins A, D, E and K and prevents meat from becoming dry.

Dressing Out Percentage

After an animal is slaughtered, the head, hooves, intestines, liver, lungs and heart are removed from the carcass leaving only the lean and fatty meat (muscle). The term, **dressing out percentage**, is used to describe the amount of meat and bone that a farmer expects to obtain from a slaughtered animal. Cattle, for example, have a dressing out percentage of about 55%. In other words, a farmer could expect a healthy steer to produce a carcass that is 55% of its live weight. The following table shows the parts that form the carcass and the parts that are removed from a slaughtered animal.

The Composition of a Beef Animal (dressing out in %)

CARCASS	REMOVED
Bone..... 8 %	Blood 3%
Fat..... 10%	Offal 16 %
Meat..... 37%	Hide 6%
	Waste 20%
Total 55%	Total 45%

MEAT QUALITY

Meat quality is a broad term that can be broken down into three factors appearance, palatability (tenderness, juiciness and flavour) and nutritive value. Other factors that contribute to palatability are breed, sex, age, finish and cooking.

Tenderness

Collagen and elastin increase in content with age and work and result in tougher cuts. Muscle bundle size also increases with age up to four years and causes coarseness of meat. Tenderness is more than 60% heritable (passes on from parent to offspring) and this may be associated with the family trait of docility.

Rigor mortis becomes evident six hours after death and reaches a maximum stiffness by 24 hours. Anaerobic breakdown of muscle glycogen causes contraction of the muscle fibres and lactic acid is produced. Then the actin and myosin filaments fuse. To prevent the toughening of meat by shrinkage, the muscles are stretched by hanging the carcass during the process of rigor mortis. Immediate freezing does not prevent rigor mortis - it merely delays it until the carcass is thawed.

Excitement and stress affect tenderness by depleting the animal's glycogen content. To ensure animals are in a state of physiological balance at slaughter, they should be fed and watered as usual up to 12 hours before slaughter to restore the level of muscle glycogen.

Meat is tenderised by the natural process of **autolysis** (self digestion) due to certain enzymes present in the muscles. The muscle proteins become denatured and the bonds binding the molecules together are broken down. These actions are favoured by a slightly acidic pH and by elevated temperatures by temperatures above 5°C permit the multiplication of ever-present bacteria. Aging of carcasses up to 40 days increases tenderness but longer periods have an undesirable effect on palatability. Meat tenderisers are preparations of these enzymes or from fruit enzymes, as papain (from pawpaw) and bromelain (from pineapples).

Juiciness/Moisture

This depends on the water-holding capacity and the amount of fat embedded in the meat.

Flavour

Certain chemicals (amino acids and fatty acids) impart the characteristic flavour to meat. Age and muscle activity improve flavour due to the larger amounts of derivatives and aromatics (myo-globin and connective tissue). Meat with a low pH and with muscle glycogen has better flavour. Autolysis also improves flavour. Heating releases flavour but, in excess, can drive away or destroy substances.

EGGS AND DAIRY

Eggs and dairy are also good sources of protein, especially for vegetarian and other non- or low- animal protein diets (raw foodists, hunter-gatherer diets, etc). Vegans do not consume any animal products at all, including dairy and eggs. Most vegetarians do eat both. Eggs provide around 6 grams of protein per eggs (average weight 50-60 grams). They also provide some cholesterol (0.2 mg), and a host of vitamins and minerals. Dairy protein content depends of its processing. While milk provides around 3 grams per 100 gm, or 8-10 grams per glass, hard cheeses provide up to 25 gm of protein per 100 gm.

PROTEINS IN DIET

During digestion proteins are broken down, liberating the constituent amino acids. The value of protein food is assessed by considering the amounts and nature of various amino acids produced.

The body has limited powers of converting one amino acid into another as the need arises. There is however 8 amino acids which cannot be manufactured by the body in sufficient quantities, and these 8 are known as "essential amino acids". They **MUST** be provided in the diet of every adult human.

The essential amino acids for adults are:

- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine

In addition one other amino acid, **histidine**, is essential for growth in children.

Proteins which have all the essential amino acids in proportions needed by humans are described as being of high biological or food value. Proteins which do not provide all of these essential amino acids are of lesser biological value.

In general, proteins from animal foods, including meat, fish, milk, eggs, cheese, etc, have a higher biological value than plant proteins. The reason for this is that the animals have pre selected, with varying degrees of efficiency, the plant proteins. The animal proteins are therefore usually more like those of humans than the plant proteins.

Plant proteins are normally low in an essential amino acid (eg. wheat is comparatively low in lysine). Lysine is then known as the limiting amino acid; the one most below that is required in humans. The limiting amino acid in maize is tryptophan; and in peas and beans is methionine.

There are two exceptions to this general rule. Firstly, gelatine, the protein from the connective tissue in meat, is of low biological value and the limiting amino acid is tryptophan. Gelatine would not support life as the only source of amino acid. Secondly, the protein of soy beans is of high biological value.

In any diet a mixture of foods containing proteins is normally eaten and, as the important dietary requirement is that the total protein intake should supply all the amino acids in suitable proportions for our needs, the fact that one protein is of high or low biological value is of little matter.

Thus, a protein short of one essential amino acid can compliment or supplement another

protein which lacks the different amino acid, and the result can be of high biological value. In fact the biological value can be greater than when the two foods are eaten separately. For instance, pulses low in methionine but with good lysine can complement cereals which are poor in lysine. Even in countries short of animal protein, sufficient amino acids can be obtained from a variety of cereal and vegetable foods. This also happens in vegetarian diets.

In most diets, animal foods containing high quality protein are frequently combined with the less complete and less expensive plant protein foods.

eg. Rice and beans
 Macaroni and cheese
 Bread and cheese
 Meat and potatoes
 Breakfast cereal and milk.

For economical use of essential amino acids, protein foods of either origin, animal or plant, should be eaten at all three meals, and not concentrated in one. There is a strong argument that protein foods should also be eaten with carbohydrate foods so that protein is used for growth and maintenance, and not for energy at the expense of body building processes.

Animal protein foods, especially meat, are expensive and, on a world wide basis, in short supply. Because of this, processes have been developed to isolate protein from soy beans, which is of high biological value. The products are sometimes made to simulate meat, with the addition of important vitamins and mineral elements contained in meat, and they can be used instead of meat, or as a meat extender. These are known as textured vegetable proteins (TVP), and are acceptable to vegetarians. Traditional high-protein soy products which have been used for centuries throughout Asia include miso, tofu and tempeh (fermented soy).

Proteins can also be isolated from yeasts, fungi and other micro organisms, but as yet are being only used in animal feeds and to supplement vegetarian diets, as yeast extracts, yeast powders and spreads.

The recommended daily intake (RDI) of protein is 1 gram per kilogram of body weight, or roughly 10-15% of energy for the day should come from proteins. This figure allows for variation in the amount of physical activity undertaken and would be adequate even for people doing regular, vigorous exercise. In South Africa it is recommended that at least 10% of the energy requirement for adults be protein-derived. In the United Kingdom, normally one third comes from plant sources and two thirds from animal sources.

Average protein content of some foods: gm per 100 gm of food.

Food	Protein content (g/100 g)	Food	Protein content (g/100 g)
Milk, cows	3.3	Potatoes	2.1
Cheese, cheddar	26.0	Peas, frozen	5.7
Eggs	12.3	Bean, baked	5.1
Beef, average	17.1	Apples	0.3
Lamb, average	15.9	Bread, white	7.8
Pork, average	16.0	Bread, wholemeal	8.8
Cod	17.4	Cornflakes	8.6

A diet consisting of a daily protein intake of 60-75 grams for men and 40-60 grams for women is desirable.

It is unlikely that protein intake will be deficient if appetite is satisfied. In the U.K., approximately 30% of the dietary protein is obtained from flour, its products, and from other cereals. At the same time, these commodities provide 30% of the energy.

Special consideration should be given to protein intake in the following cases:

1. The Elderly

They do not require any more protein than other adults, in fact they require a little less, however, they may be subject to some risks due to reduced energy expenditure. (i.e. lower BMR and less physical activity). The fact that carbohydrate foods are cheap and easier to prepare often leads to elderly people eating too much of this type of food. As a result, protein intake can suffer.

2. Babies and Young Children

During these formative years there is extra growth taking place. The size of the stomach is small, and concentrated forms of protein foods are required. When a baby is being weaned, it is especially important to see that there is sufficient protein in the diet.

3. Convalescents

Infections, broken bones, operations and burns, all cause a loss of body protein. A broken femur for example, may cause a loss of 800 gm, and burns an even greater loss from the skin as it needs to recover and be rebuilt. This protein must be restored to a patient who often has a reduced appetite. Dry skimmed milk is of value in these situations, and there are certain protein rich proprietary foods (eg. Casein-milk, which can be used to supplement the diet).

PROTEINS IN THE BODY

Body proteins are involved in rapid and ceaseless change, being continually broken down into amino acids, which become part of the amino acid reservoir, along with amino acids derived from food.

Each part of the body selects, from the reservoir, amino acids it requires for resynthesizing the specific proteins it needs for growth, maintenance, repair, or the production of enzymes or hormones.

There is no permanent store of protein in the body, so amino acids surplus to the body's need for growth, repair, maintenance of its proteins, and manufacture of enzymes and hormones are held only transiently before being used as a source of energy. The resulting urea is excreted via the kidneys in the urine.

There is no need for more protein in more active adults, but there is obviously a need for more food. As most foods contribute some protein, a higher energy intake is accompanied by a higher protein. A diet in which 10% of the recommended energy is provided by protein is a safe target for food administrators in all countries, and nowhere should it be beyond reach. Should there be insufficient carbohydrate in the diet, protein will be used as a source of energy at the expense of its body building processes. It is therefore important that there is adequate other energy producing foods so that protein is not wasted.

ASSIGNMENT

1. List both 3 animal and 3 non-animal foods which are a good source of protein.
2. What is the role of protein in the body? Keep your answer to a paragraph and include examples of 2 physiological processes involving protein.
3. Select 5 foods and rank them in order of their relative protein value, with 1 being the highest and 5 the lowest. Give a brief reason as to why you ordered them the way you did (2-3 sentences only).
4. You are helping someone determine their appropriate protein intake (they can be real or made up). Write them a brief report of 200-300 words on what protein intake you recommend and why. Then, give a list of foods they should include in their diet to ensure they are getting their required amino acids. (1-2 foods per amino acid)

VITAMINS & MINERALS

Aim

Recommend appropriate intake of minerals. Recommend appropriate intake of vitamins.



Vitamins are complex organic substances which are essential for the satisfactory utilization of energy foods by the body. Many vitamins must be supplied by the diet, because the body is unable to make them. Vitamins which are manufactured within plants are much easier to digest than vitamins and minerals of animal origin. The presence of plant vitamins is dependant to some extent on the overall health and vigour of the plant, the plant variety and the conditions under which the plant is grown.

Minerals are inorganic (containing no carbon) chemical elements which are required for regulation of the body's metabolism and formation of the body's structure. They play an important role in the health of teeth, bones, hair, blood, skin and connective tissue. Minerals are also an important part of the enzymes, vitamins and hormones which are involved in many chemical processes in the body. Each mineral has specific functions, but are also dependant on the concentrations of other minerals in the body.

The eight major essential minerals are Sodium, Potassium, Calcium, Magnesium, Iron, Phosphorus, Sulphur and Chlorine. Recommended daily intake for minerals is usually quite low. For example, magnesium requirements are about 320 milligrams for men and 270 milligrams for women. Minor or trace elements have recently been recognised as also being essential to good health, in very small quantities though. The more important ones are Copper, Zinc, Iodine, Fluorine, Chromium, Manganese, Selenium and Cobalt.

A number of mineral deficiencies are common in Western diets. Iron, calcium and zinc are probably the most significant, with the first two being more common in women. They are largely due to an inadequate intake of the particular mineral or vitamins and minerals that improve their absorption, especially in the SAD diet (Standard American Diet), and vegetarian or vegan diets. Too much of any mineral can be toxic. Sources of overdose can be over-use of mineral supplements (eg. pills) or from environmental pollution. This can be a problem with the trace elements because they are usually only present only minute amounts.

The **Recommended Daily Allowance**, known as RDA, are recommendations for nutrients. They were developed by the Food and Nutrition Board of the National Academy of Sciences/National Research Council. The RDA state the amount of a nutrient that is needed for most people to stay healthy. They are different for children, adults, males, and females.

The **Dietary Reference Intake**, known as DRI, is an average that includes the following other nutrient measures: RDA, Adequate Intakes, known as AI, Estimated Average Intakes, known as EAR and Tolerable Upper Intakes, known as UL.

DRI is slowly becoming the more accepted form for nutrient recommendations. For some nutrients they are lower, for others they are higher. Experts expect that DRI will take the place of the RDA in time.

SUMMARY OF VITAMINS

A general rule is that water soluble vitamins are not stored in the body, so a daily intake is needed. On the contrary, fat soluble vitamins (vitamins A, D, E, K), are stored in the body so care should be taken to avoid high doses taken for long periods, as this can lead to excess accumulation and toxicity. Conversely, deficiencies are rare with fat soluble vitamins and more common in water soluble vitamins, especially when needed in higher doses (as in vitamin C).

VITAMIN A (Retinol)

A group of chemical compounds including retinol and retinal. They are stable to heat or changes in pH, but destroyed if exposed to light (eg. cutting a fruit). Normally large amounts of vitamin A is stored in the liver (sufficient for the body's needs for up to 12 months). Vitamin A is formed from "carotene" in the intestine.

Food Sources

Deep yellow and deep green leafy vegetables, egg yolk, liver, fish liver oils, milk, margarine. Alfalfa, dandelion, okra pods (a vegetable), paprika, parsley, watercress.

Significance to Body

Required for bone and teeth development, reproduction, integrity of skin and mucosae.

Needed to synthesize photoreceptor pigments of rods and cones (ie. pigments in the eye that detect light), therefore useful for night blindness and eye health.

Antioxidant: together with vitamin E, Vitamin A helps stabilising cell membranes thus avoiding cell and general ageing.

Toxicity

Caused by ingesting greater than 50,000 IU (International Units) per day for months.

Symptoms include vomiting, nausea, headaches, bone and joint pain, bones become fragile, liver and spleen can enlarge, hair loss and anorexia,

Deficiency

This is the most common vitamin deficiency throughout the world.

Symptoms include dry skin, dry hair, sores on skin, drying of conjunctiva, more respiratory, digestive and urogenital infections, clouding of cornea, night blindness

Recommended Daily Allowance: Males: 5000 IU, Females: 4000 IU

VITAMIN D (Antirachitic factor)

A group of distinct types of sterols (sterols are compounds containing a central ring structure of a steroid). They are stable to heat, light, pH changes and oxidation and can be synthesised in the skin when exposed to sunlight. It is stored in the liver and to a lesser degree in the spleen, kidneys and skin.

Food Sources

Egg yolk, fortified milk, fish liver oils

Plant sources: watercress, wheat germ, annatto seed.

Significance to Body

Functions as a hormone increasing calcium levels in the blood by encouraging absorption of

calcium and phosphorous. As such it mobilises calcium from bones so it can be used for different processes such as blood clotting and neuromuscular processes.

Toxicity

Children may show symptoms if taking more than 1800 IU/day; massive doses are required to cause toxicity in adults.

Symptoms may include diarrhoea, vomiting, weight loss, renal damage and calcification of soft tissues.

Deficiency

Symptoms can include rickets in children, osteomalacia in adults, restlessness and irritability, faulty mineralisation of bone and teeth, osteoporosis and poor muscle tone.

Recommended Daily Allowance: 400 IU

VITAMIN E (Antioxidant)

A group of compounds related to the sex hormones, called tocopherols. Resist heat, light and acids, but oxidise readily.

Food Sources

Nuts and seeds, vegetable oils, whole grains, dark green leafy vegetables, margarine.

Plant sources: alfalfa, dandelion leaves, kelp, linseed, sesame, watercress, wheat germ.

Significance to Body

An antioxidant that reacts with and eliminates harmful effects of free radicals, helping prevent destruction of cell membranes. As such is an anti-ageing vitamin. Helps reduce oxidation of vitamins A and C in the intestine. It can prevent heart disease and cancer, and boost immunity in the elderly.

Toxicity

Symptoms may include slow healing of wounds, hypertension and thrombophlebitis.

Deficiency

This is an extremely rare condition, and precise symptoms are not certain, however it may cause fragile capillaries, macrocytic anaemia and haemolysis of RBCs.

Recommended Daily Allowance: 22 IU for adults, 10 for children. Many doctors recommend a daily intake of 100 IU to 400 IU.

VITAMIN K (Coagulation vitamin)

Description

Includes several related compounds called quinones. Vitamin K is synthesized mostly by coliform bacteria in the large intestine. Not necessarily required in food if this synthesis is working properly.

Heat resistant, but destroyed by pH abnormalities, light and oxidation. Synthesis by bacteria is reduced by some antibiotics and anticoagulants.

Food Sources

Pork liver, beef liver, leafy vegetables, raw cabbage and raw cauliflower, turnip greens.

Other plant sources: alfalfa, chestnut leaves and shepherd's purse which is prescribed by some natural therapists for haemorrhage it is very potent.

Significance to Body

It is essential for blood clotting and liver proteins production. Also for osteoporosis prevention.

Toxicity

Toxicity does not appear to occur. This vitamin is not stored in any significant amounts.

Deficiency

Symptoms are a prolonged time for blood clotting -easy bruising and bleeding.

Recommended Daily Allowance: Males 70 micrograms; Females 55 micrograms

VITAMIN C (Ascorbic acid)

A simple 6 carbon compound derived from glucose. It is the main antioxidant and immune booster in your body. Destroyed rapidly by heat, light, alkalis and oxidation. Only around 1500 mg can be found in the body, and any excess is excreted by kidneys rapidly.

Food Sources

Found in fresh fruits and vegetables, particularly acerola berries, citrus, cantaloupe (rock melon), papaya, strawberries, tomatoes, fresh potatoes and leafy greens.

Other plant sources: burdock seed, capsicum, coltsfoot, elder citrus, berries, marigold, oregano, paprika, parsley, rose hips and rosehips oil (for topic use only), watercress.

Significance to Body

Vitamin C is an antioxidant that reacts with and eliminates harmful effects of free radicals. Helps protect vitamins A and E from oxidation, cells membranes, builds connective tissue, heal wounds and keep the immune system healthy. Vitamin C can help in diabetes, high blood pressure, high cholesterol, may help in cancer prevention and heart disease. It may also help prevent vision loss, premature births and gallstones.

Toxicity

It is nearly impossible to reach as it is readily eliminated through the kidneys. However symptoms of large doses include diarrhoea and stomach cramps. Doses should be increased slowly. Long term toxicity caused by repeated very large doses (eg. in excess of 2000 milligrams) and the symptoms include blood coagulation, mobilisation of bone minerals, kidney stones and gout.

Deficiency

Immune system failure symptoms, like increased susceptibility to disease and infection, recurrent colds and flu, increased allergies, and in severe and long term deficiencies, poor bone and tooth growth, joint pain and incorrect formation of intracellular cement (loose tissues). Smokers are more susceptible to deficiencies.

Recommended Daily Allowance: 90 milligrams for men, 75 for women. For smokers 100 milligrams. But most doctors and nutritionists recommend a dose of 250 to 500 mg of vitamin C daily.

VITAMIN B₁ (Thiamine)

Dietary thiamine is combined into a complex called thiamine pyrophosphate (TPP). TPP is an enzyme that is vital for the conversion of carbohydrates into energy. It is water soluble; therefore a very small amount is found in the body, with excess being eliminated in urine. Toxicity is therefore very rare. It is important to note that while small amounts of thiamine are found in complexes in the body fluids, it cannot be stored long term or for later use. It is rapidly destroyed by heat.

Food Sources

Wheat germ, sunflower seeds, whole grains and all nuts. Beans and peas. Oatmeal, oranges, raisins, asparagus, eggs, liver, lean meats and green leafy vegetables.

Plant sources: bladder wrack seaweed, dulse, fenugreek, kelp, okra.

Significance to Body

Part of a coenzyme which participates in carbohydrate metabolism, therefore important in the energy conversion from food. Also keeps brain and heart healthy. It is important in the oxidation of alcohol, therefore in its use or elimination from the body.

Toxicity

Unknown

Deficiency

Decreased appetite, gastrointestinal upset, cramping in calf muscles, numbness in feet, enlarged heart, beriberi, tachycardia.

Recommended Daily Allowance: 1.5 milligrams. A good varied diet provides most.

VITAMIN B₂ (Riboflavin)

Chemically similar to ribose sugar. It is required for the efficient conversion of food into energy, and many other functions in the body, including immune system support. It is rapidly broken down by UV and visible light, and by alkalis.

Food sources

Meat, poultry, fish, milk, legumes, liver, egg white, yeast.

Plant sources: bladder wrack seaweed, dulse, fenugreek, kelp, saffron.

Significance to Body

Riboflavin is part of two enzymes, FMN and FAD, which help producing energy from the carbohydrates and fats in food. They also provide support for the immune system and keep red blood cells healthy.

Toxicity

Unknown

Deficiency

It is one of the more common vitamin deficiencies. Symptoms include cracking of lips at corners, lips and tongue can become shiny and purple-red, dermatitis, light sensitivity, blurred vision.

Recommended Daily Allowance: 1.1 mg in women, 1.3 mg in men (adults). Under 2 mg per day is enough, or 0.6 mg per 1000 Calories ingested.

VITAMIN B₃- NIACIN (Nicotinamide)

These are simple and stable organic compounds. Only limited quantity is stored in the body, so a daily intake is desirable. Usually any good sources of protein will ensure adequate niacin, because the body easily converts a protein molecule into niacin.

Food Sources

Meat and dairy products, fish, poultry, liver, yeast, nuts and seeds, potatoes, leafy green vegetables.

Other plant sources: alfalfa, blueberry leaves, burdock seed, fenugreek, parsley, watercress, wheat germ.

Significance to Body

These are constituents of coenzymes involved in glycolysis, oxidative phosphorylation and fat breakdown (NAD and NADP), so they are needed, as the other B vitamins, for the proper production of energy in your body. They inhibit cholesterol synthesis, may help with PMS and with dizziness and tinnitus.

Toxicity

Only caused by megadoses. Possible liver damage, gout, hypoglycaemia, vasodilatation can cause flushing of skin, tingling sensation. It can be avoided by taking IHN (inositol hexaniacinate)

It should not be taken with drugs for high blood pressure, as this could make blood pressure too low!

Deficiency

Generally not a concern as most people get enough in the diet. Pellagra, a Niacin deficiency disease, can occur after months of deficiency with symptoms at first including listlessness, headaches, loss of weight, appetite loss. As the condition develops, symptoms can become increasingly severe. Pellagra is uncommon in developed countries.

Recommended Daily Allowance: 14 mg for women and 15 mg for adult men.

VITAMIN B₅-PANTOTHENIC ACID

As for the other B vitamins, pantothenic acid participates in the conversion of food into energy, and in the metabolism of carbohydrates and fats. Pantothenic acid is a very stable chemical, though heat can cause some breakdown during cooking. Some pantothenic acid is synthesised by bacteria in the digestive system.

Food Sources

Whole grains, organ meat, egg yolk, legumes, sweet potato and yeast.

Significance to Body

It is part of Coenzyme A (CoA) and acyl carrier protein (ACP), and as such, is involved in transfer of acetyl group in energy chemical reactions; also involved in synthesis of steroids, part of haemoglobin and vitamin D.

Toxicity

Unknown

Deficiency

Symptoms are usually vague including appetite loss, depression, muscle spasms and pain, muscle degeneration. This is thought to be related to alcoholism.

Recommended Daily Allowance: there is not a RDA as there are not reported deficiencies. There is an Adequate Daily Intake which is 5 milligrams for adults.

VITAMIN B₆ (Pyridoxine)

These chemicals are a group of three pyridines which occur both free and in phosphorylated forms.

They are stable to heat and acidic conditions, but are broken down by alkalis and light.

Food sources

Mainly: high quality protein like meat, poultry and fish, dairy products, eggs.

Also: avocados, bananas, mangoes, potatoes, sweet potatoes, spinach and tomatoes.

Significance to body

Pyridoxine is involved in amino acid metabolism, to convert amino acids into proteins, needed to convert tryptophan to niacin, to form haemoglobin, to form antibodies and for glycogenolysis (turning stored sugars into energy).

Toxicity

Numbness and depressed deep tendon reflexes.

Deficiency

In children: irritability, vomiting, convulsions, abdominal pain and anaemia.

In adults: seborrhoea lesions around eyes and mouth.

Recommended Daily Allowance: 1.5-1.7 milligrams

VITAMIN H (B₇)- BIOTIN

This is a derivative of urea, containing sulphur. Some biotin is synthesised by bacteria in the digestive system. It is stable to heat, light and acids.

Food Sources

Beef liver, egg yolk, legumes, nuts and whole grains.

Significance to Body

Acts as a coenzyme in carboxylation, decarboxylation and deamination reactions.

Essential in the Krebs cycle.

Toxicity

Unknown

Deficiency

Anorexia, nausea, fatigue, high blood cholesterol levels, muscle pain, scaly skin.

Recommended Daily Allowance: 0.3 milligrams

VITAMIN B₁₂ (Cyanocobalamin)

This is a very complex vitamin. It is stored mainly in the liver. It is not affected by heat, but inactivated by light or pH changes.

Food Sources

Liver, fish, meat, poultry, dairy foods (not butter though!), eggs.

Some say it is not found in plant foods, though some herbalists list plant sources: alfalfa, bladder wrack, dulse, kelp.

Significance to Body

Very important to the transport of chemicals across the membranes of the intestine. It is essential for proper functioning of the digestive system and bone marrow. It is required in the synthesis of DNA (your genetic material). It functions as a coenzyme to some degree in all cells.

Toxicity

Unknown

Deficiency

Usually deficiency is due to a lack of absorption rather than actual deficiency of supply except in cases of very restrictive diets such as veganism.

Symptoms may include: anaemia, fatigue, weakness, loss of appetite, constipation, weight loss, anorexia, dyspnea, neurological disturbances (tingling in arms and legs), and pernicious anaemia.

Recommended Daily Allowance: 2.4-3 micrograms (0.002 to 0.003 mg per day).

VITAMIN B₉-FOLIC ACID (Folacin)

It is stable to heat, but easily oxidised in light and acidic conditions. Synthesized by enteric bacteria of the intestine and stored mainly in the liver.

Food Sources

Dark green vegetables, whole grains, lean beef, yeast, eggs and veal.

Significance to Body

Important for protein metabolism, in the synthesis of methionine and other amino acids. Can help to prevent birth defects, heart disease and it has been reported to be useful in cancer prevention.

Toxicity

Unknown

Deficiency

Symptoms may include: gastrointestinal disturbances, diarrhoea, and anaemia

Recommended Daily Allowance: 0.4 milligrams, 0.6 in pregnant women.

There are other substances that are not vitamins, but are needed on a daily basis and as such they are recommended together with vitamins and minerals by doctors and health practitioners. These are:

- **CHOLINE**

Choline is a phospholipid that can be synthesized in the body. It is required to make neurotransmitters (Acetylcholine) and phosphatidylcholine which helps to keep cell membranes healthy. It is important for proper development of newborns.

An Adequate Daily Intake is 425 mg per day. This is quite easily achieved in most healthy diets. Choline is in all foods containing lecithin, so you can find it in eggs, meats, liver, caviar, cabbages, cauliflower, soy beans, chickpeas, lentils and rice. Choline is classified as BOTH an essential nutrient AND a member of the B-group vitamins.

- **INOSITOL**

It is necessary to make neurotransmitters, which ensure proper brain and nervous system function. Also helps to move fats out of your liver (which is good), together with choline. Most people get more than 1000 mg per day in their food. Good sources are citrus fruits, nuts, beans, whole grains and meats.

MORE ON VITAMINS

Vitamins are inorganic substances which the body requires in small quantities for its metabolism, yet cannot make for itself (at least in sufficient quantities) from carbohydrates, proteins and fats. Generally, they are not chemically related compounds, and each one differs in its physiological effect.

Research during the first half of the 20th century led to the isolation of a number of vitamins as pure chemical substances, and since the 1930s synthetic vitamins have become available. As a vitamin was discovered it was given a letter of the alphabet to distinguish it from the rest, but once isolated, and its chemical structure discovered, it was given a specific name.

Different vitamins vary greatly in their chemical structure, and in their ultimate functions in the body. They are found in varying amounts in different foods, and most foods contain a variety of vitamins. No one food however contains all vitamins in sufficient quantity to satisfy human needs.

Some vitamins (i.e. A, D, E and K) are fat soluble, and found in fatty foods. Other vitamins (eg. B group and C) are water soluble.

Fat soluble vitamins are absorbed with dietary fats, so any factors upsetting the absorption of fat will impair their absorption. They are stored in the body (liver) to some extent, so humans are not absolutely dependent on their daily supply in the diet.

Water soluble vitamins are less stable than fat soluble ones. They may be leached from foods during washing and cooking. Most are heat labile. Excess is normally excreted in the urine, and so there is little to no store in the body. A daily supply is necessary, to provide a temporary reservoir for immediate use and to avoid their depletion and consequent upset in the regulation and maintenance of body processes.

Diseases due to severe deficiency of vitamins (eg. rickets, scurvy, Berri-Berri etc), are virtually unknown in developed countries, but sub optimal nutrition can lead to a shortage of several vitamins, and poor health can result. Each vitamin has its own specific role to play in the body, but often two or more are concerned in one process (eg. A, C and D are all concerned with calcium and phosphorus in the growth and maintenance of the bony structure of the body).

FAT SOLUBLE VITAMINS

VITAMIN A

Vitamin A is also known as "retinol".

It is needed for all parts of the body throughout life, but its function in some parts is only known in general terms. It is necessary for:

1. Proper growth and development of bones.
2. Healthy moist surface tissues (eg. skin, cornea, lining membranes, digestive and urinary tracts). A shortage of "vitamin A" can cause these to become dry, to degenerate, and to become infected.
3. The ability to see in the dark (visual purple is necessary to see in dim light, and "vitamin A" is needed for its manufacture). An eye disease called "xerophthalmia" results from severe deficiency.

Vitamin A is fat soluble, and found in animal fats. Nearly all animal foods will show seasonal variations in vitamin A. Animals in summer, or in sunny climates fed on dark green pasture, provide cheese, milk, meat etc. which is higher in vitamin A than animals from, less sunny or colder conditions.

The body can convert carotenes found in green and yellow vegetables and fruits, into vitamin A. Beta carotene is the type of greatest dietary importance, and is known as pro-vitamin A, or a precursor to vitamin A.

The body is not very efficient at converting carotene to vitamin A, and the amount to be converted varies from one vegetable or fruit to another, but on average one sixth of carotene present is converted to vitamin A. In this way, pre formed vitamin A from animal fats is six times more valuable in the diet than the same amount of beta carotene.

Sources of Vitamin A

Cod liver oil	Butter
Halibut liver oil	Cheese
Fat fish	Milk
Liver	Eggs
Kidney	Margarine (vitamin added)

Sources of Beta Carotene

Dark green vegetables; spinach, watercress, cabbage etc.
Carrots
Tomatoes
Apricots

All margarine is required by law in the U.K. to contain approximately the same amount of Vitamin A as summer butter. Any deficiency is added as synthetic retinol and beta carotene. This is called "vitaminised" margarine.

Being fat soluble, retinol and beta carotene are not lost in washing or cooking water. They are stable to heat at ordinary cooking temperatures, but are destroyed by oxidation in strong light; so air (i.e. oxygen) should be excluded as much as possible in cooking, canning etc. Fruits and other foods that are dried in the sun will lose much of their vitamin A. potency. The body can store vitamin A in the liver and draw on those supplies when needed. Excessive amounts of vitamin A over a long period however can be harmful.

VITAMIN D

D₃ (Cholecalciferol) is the natural form of vitamin D found in animal fats as the result of ultraviolet light acting on 7-dehydrocholesterol in the fat.

D₂ (ergocalciferol) occurs rarely in nature. It is manufactured by exposing ergosterol, (found in fungi and yeasts) to ultra violet light.

For ordinary purposes it is not necessary to differentiate between different types of vitamin D.

Vitamin D is necessary for:

1. Absorption of calcium, and its deposition in bones and teeth.
2. Prevention of dental decay, rickets and osteomalacia
3. Aiding some abnormal skin conditions.

Vitamin D is fat soluble, and found in animal fats. As with vitamin A, there will be seasonal variations in the amount of vitamin D in some foods because of the need for ultra violet light.

The body manufactures vitamin D when the skin is exposed to sunlight.

Sources of vitamin D include:

Cod liver oil	Eggs
Halibut liver oil	Butter
Fat fish	Cheese
Liver	Margarine (vitaminised)

Compared with other vitamins, vitamin D is found in few foods, and in small quantities.

The amount of vitamin D required for adults is not usually specified. It is probably quite low, and sufficient is probably obtained with normal exposure to sunlight. People who have restricted exposure to sunlight however may require supplements. Children and lactating women also require more.

Too high an intake of vitamin D can be harmful because more calcium may be absorbed than can be excreted, leading to kidney damage. Vitamin D is fat soluble, and thus is not lost during normal washing or cooking of food.

VITAMIN E

Vitamin E (Tocopherol) is present in human tissue, and is a necessity for normal metabolism. It is fat soluble. Most foods contain traces of vitamin E, the richest sources being vegetable oils, cereal products and eggs. It is stored in the body, and a deficiency is unlikely. Vitamin E plays an important part in the diet, as an antioxidant. It helps prevent fats and fatty foods from going rancid. It helps prevent oxidation of vitamin A, carotene and vitamin C.

VITAMIN K

Vitamin K is fat soluble and necessary for the clotting of blood. It is widely distributed in foods, and there is no real likelihood of a deficiency under normal circumstances (but there can be a deficiency during disease). Green leafy vegetables, cereals and pigs liver are good sources of vitamin K. Vitamin K is also synthesised by bacteria in the large intestine.

WATER SOLUBLE VITAMINS

VITAMIN B COMPLEX (or Group)

At least 11 different substances have now been discovered in this group, of which one or two are of little importance in nutrition. Although these vitamins of the B group have different functions in the body, they do often occur in the same types of food (eg. liver).

Vitamin B₁ (thiamine or aneurin) is necessary for:

- a) Growth
- b) Prevention of a certain type of neuritis
- c) The oxidative processes which the body uses to obtain energy from carbohydrate as it forms part of one of the enzymes.

Beri-Beri is the deficiency disease associated with vitamin B₁.

Because vitamin B₁ is a catalyst for the release of energy, the body's requirement for this vitamin is proportional to the number of calories provided by nutrients other than fat. 0.06 mg of Thiamine is needed for every 100 cals from carbohydrate or protein; so foods providing more than 0.06 mg thiamine for each 100 cals are a real source of vitamin B₁ in the diet. (0.06 mg per 1000 non fat cals or 0.4 mg per 1000 total calories).

Sources (these are numerous, but few are rich sources):

- Yeast extract (eg. Marmite or Vegemite)
- Pork, bacon
- Oatmeal
- Peas, lentils, broad beans
- Liver
- Cornflakes (fortified).

All flour except wholemeal is fortified with thiamine to at least 0.24 mg per 100 gm, equivalent to 0.7 mg per 1000 cal. Bread, flour, potatoes, carrots, cabbage and milk make useful contributions to diet. Thiamine is synthesised by bacteria in the large intestine, but this is not a reliable source because the bacteria may be inactivated by drugs, or removed by purgatives, diarrhoea, etc.

Vitamin B₁ is water soluble and readily lost into washing and cooking waters. It is unstable at high temperatures, and thus may be lost in some cooking processes. It is destroyed by alkalis (eg. baking powder, bicarbonate of soda) and sulphites. The average loss of thiamine in cooking of an ordinary diet is likely to be about 25%. Modern processes of freezing, canning and dehydration of foods result in smaller losses. Thiamine cannot be stored in the body and different individuals require and absorb different amounts. Alcohol destroys the B vitamins in general, and adolescents, pregnant women, vegetarians and those people who are under stress, ill or who smoke are particularly at risk.

VITAMIN B₂ (Riboflavin) is necessary for:

- a) The release of energy from food
- b) Growth
- c) Good digestion

Minor signs of deficiency are common in many parts of the world, but they do not often progress to serious illness.

Sources:

Milk	Beef
Cheese	Vegemite
Eggs	Cornflakes
Liver	

It is present in beer, but relatively lacking in cereals (not added to low extract flour).

Riboflavin may be synthesised in the large intestine.

Vitamin B₂, is less soluble in water than vitamin B₁, but there still may be 15-20% loss into cooking water. It is fairly stable to heat, but sensitive to light. If milk is exposed to sunlight, larger losses occur. It is destroyed by alkalis. A well balanced diet containing a satisfactory supply of other necessary nutrients will generally provide sufficient riboflavin. Recommended intake is 1.7 mg daily for an adult man and 1.3 mg for an adult woman. More is required during pregnancy and lactation.

NIACIN

NIACIN or nicotinic acid is necessary for the chain of processes by which the body obtains energy, growth, normal digestion, and healthy skin.

Pellagra (with symptoms of dementia, dermatitis and diarrhoea) is the deficiency disease associated with niacin.

Sources include:

Liver	Lean Meat
Kidney	Fish
Whole grain cereals	

Niacin is widely distributed in plant and animal foods, but with the exception of the above, only in small amounts. Potatoes contribute to the niacin content of the diet because of the quantity eaten. All flour except wholemeal is fortified with niacin.

The body is not entirely dependant on dietary sources as it is capable of converting the essential amino acid, tryptophan, into niacin, but not very efficiently. 60 mg of tryptophan is needed to replace 1 mg of dietary niacin. Niacin is water soluble and in a mixed diet from 15-25% of niacin may be lost into the cooking waters, and the "drip" from meat. It is not easily destroyed by heat.

VITAMIN B₆ (Pyridoxine) is necessary for:

- a) The metabolism of amino acids and fatty acids, including the conversion of tryptophan to niacin.
- b) The formation of haemoglobin
- c) The absorption of zinc
- d) The utilisation of magnesium

Main sources include:

Whole grain cereals	Eggs
Meat	Some vegetables (eg. cabbage)
Fish.	

It is widely distributed in foods, especially the above. It is water soluble and sensitive to heat.

VITAMIN B₁₂ (Cyanocobalamin)

Vitamin B₁₂ is required for the production of red blood corpuscles, and many metabolic processes.

The "intrinsic factor" present in gastric juice is necessary for the absorption of vitamin B₁₂, and pernicious anaemia is caused by malabsorption of this vitamin.

Sources include:

Meats (especially liver)	Eggs
Fish	Milk
Yeast extracts	

Vegetarian diets that also limit the intake of dairy and eggs may be deficient in vitamin B₁₂. Some vegetarian experts recommend supplementing the diet with spirulina, sea vegetables, tempeh, and miso, but other sources point out that this type of vitamin B₁₂ might be an analogue rather than the active vitamin. Although dairy products and eggs contain vitamin B₁₂, some research indicates that lacto-ovo-vegetarians have low blood levels of vitamin B₁₂. It is advisable for vegans and lacto/ovo vegetarians to use of fortified foods or supplements.

FOLIC ACID is necessary for normal blood function with vitamin B₁₂.

Folic acid deficiency not only occurs because inadequate amounts are eaten (common in elderly), but also because of increased requirements during pregnancy, or decreased absorption as a characteristic of some diseases.

Sources include:

Offal	Green leafy Vegetables
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Bread

Pulses (legumes)

Folic Acid is water soluble and heat sensitive and severe losses may occur into washing and cooking waters; or through preservation processes such as canning. Vitamin C, a reducing agent, tends to protect folic acid.

PANTOTHENIC ACID takes part in the release of energy from carbohydrates and fats. It is widely distributed in foods.

Main Sources include:

Offal Cereals
Pulses (legume seeds)

It is water soluble and withstands the normal temperatures of cooking.

BIOTIN is necessary for the metabolism of fat. It is synthesised in the large intestine, and is unlikely to be in short supply in the diet except when large quantities of raw eggs are eaten. Raw egg contains avidin which renders biotin unavailable. Offal and cooked egg yolks are the best sources. Milk, cheese, cereals and vegetables also contain biotin.

INOSITOL and **CHOLINE** are other vitamins in the B group, and are found in similar foods, such as offal and whole grains.

Points to remember regarding the B group vitamins include:

1. Alcohol destroys vitamin B
2. Coffee and coca cola will increase the need for vitamin B.
3. Milk should be fresh and not left in the sun
4. Toasting bread destroys vitamin B.
5. Foods based on white flour or sugar, use up vitamin B.
6. Roast or grill meat to retain vitamin B, and use the "drip".
7. Cook vegetables quickly and in as little water as possible to minimise vitamin B loss.

VITAMIN C

Vitamin C (Ascorbic acid) is necessary for:

1. The maintenance of healthy connective tissues.
2. Healing of wounds
3. Absorption of iron
4. Calcification of bones
5. Growth
6. The metabolism of folic acid.

Severe deficiency results in scurvy which causes haemorrhages under the skin, joints become painful and swollen, there is muscular pain, and gums and other mucous membranes become inflamed and bleed. Sources are much more limited than for most vitamins; many being expensive, and vitamin C content varying with soil, climate, ripeness and storage (freshness):

Blackcurrants	Brussels sprouts
Strawberries	Green peppers
Gooseberries	Cauliflower
Citrus fruit	Cabbage
Tomatoes	Spinach
Watercress	Potatoes

Potatoes are an important source in the diet because they are eaten so regularly and widely; but vitamin C content can vary from 8-30 mg per 100 gm according to freshness. The amount in tomatoes is small compared with the others, but again these are probably more often eaten than many other sources.

Vitamin C is water soluble and found only in fruits and vegetables, except for a very small amount in milk and liver. It may well be in short supply in the diet because of the ease with which it is lost into washing and cooking waters, and during wasteful preparation. It is also heat liable and easily oxidised.

Oxidation takes place all the time in the air, hence the importance of fresh fruits and vegetables. It is increased by heat, especially under alkaline conditions (e.g. cooking with bicarbonate of soda); by the presence of traces of copper, and when enzymes, oxidases, are released from the plant cells.

The release of the enzymes occurs when the leaves or fruits are damaged by drying, bruising, crushing or cutting with a blunt knife. The rate of oxidation of vitamin C is diminished in weak acid solution and by storage in the cold. The loss of vitamin C in stored canned fruits and vegetables is increased with warmth. Vitamin C is partly protected by the presence of sulphur dioxide.

The recommended intake of vitamin C has been a subject of much controversy. The RDI in Australia is 30mg. In South Africa, the RDI for adults is 30 mg and 60 mg for pregnant and lactating women. In the USA it is 45 mg. There is no store of vitamin C in the body, so a regular supply is essential. Those at risk are infants who are fed on non-supplemented cows milk preparations, and people who for economic or other reasons, are living on a restricted diet (eg. elderly or ill people). Some loss of vitamin C is inevitable in cooking (hence the value of raw fruits and vegetables) but the loss can be minimised by careful and appropriate food preparation, and serving methods.

- e.g.
- Use fruits and vegetables as fresh as possible.
 - Store in a cool place
 - Avoid bruising and crushing
 - Avoid soaking whenever possible, and never soak for too long.

Shred vegetables and immediately place in a small quantity of already boiling water

Never use bicarbonate of soda in water for washing or cooking.

Boil with the lid on.

Serve immediately following cooking.

Use cooking waters for soups, gravies, stews etc.

Keeping vegetables hot for some time after cooking will destroy the ascorbic acid. In 15 minutes a quarter of the original amount is lost, and after 90 minutes, three quarters is lost. For example, the preparation of cabbage in an acute hospital kitchen started at 9am when the ascorbic acid content of raw cabbage was 96.7 mg/100 gm.

By the time a plate sample was taken at 12.20 pm, the ascorbic acid content was 19.0 mg/100 gm. At 9.45 am a sample of frozen peas contained 20.5 mg/100 gm. A plate sample at 12.10 pm contained 1.1 mg/100 gm.

MINERALS

CALCIUM (Ca)

This is the most abundant cation (positively charge atom) in the body. It is stored in salt form in the bones. It is absorbed from intestines with vitamin D. Excess is eliminated through the faeces.

Food Sources

Milk and milk products, leaf vegetables, egg yolk, shellfish.

Significance to Body

Makes bones and teeth hard. Important constituent of blood, essential for transmitting nerve impulses, blood clotting, heart rhythm and muscle contractions.

Toxicity

Symptoms may include kidney stones, calcium salts deposited in soft tissues, depressed neural function.

Deficiency

May include osteoporosis, osteomalacia and muscle tetany.
Symptoms in children may include retarded growth and rickets.

Dietary reference Index (DRI): 1200 milligrams; drops to 1000 milligrams between 25 years of age and rises again to 1200 mg daily for men and women over 50.

PHOSPHORUS (P)

Approx. 80% is found in bones and teeth, but also in muscle, nerves and blood.

About 33% of daily intake is excreted in faeces.

Food Sources

Milk, eggs, fish, meat, nuts, legumes and whole grains.

Significance to Body

A component of bones, teeth, proteins, nucleic acids (DNA), ATP, phosphates (buffers) of body fluids.

Important to energy transfer, muscle and nerve activity and cell permeability.

Toxicity

Symptoms are unknown

Deficiency

Symptoms may include rickets and poor growth.

Recommended Daily Allowance: 800 milligrams

MAGNESIUM (Mg)

Magnesium is an important constituent of many coenzymes. Every single cell in your body needs magnesium to produce energy, every muscle, including the heart, to be able to function properly, and to keep blood pressure at normal ranges. Magnesium is excreted mainly in urine.

Food Sources

Beans, nuts, dark green leaf vegetables, dairy products and whole grains.

Significance to Body

It is important for numerous processes in the body. Has an important role in the conversion of ATP to ADP (energy production in the cell). It is essential for normal muscle and nerve activity. Important for bone building and preventing osteoporosis.

Toxicity

Symptoms are diarrhoea.

Deficiency

Symptoms may include a range of renal disease and neuromuscular problems including tremors.

Recommended Daily Allowance: 300-350 milligrams

POTASSIUM (K)

A major intracellular cation, 97% within cells. Some potassium is bound to proteins. Mainly excreted in urine.

Food Sources

Meat, fish, poultry, cereals, avocados, dried apricots.

Significance to Body

Important to intracellular osmotic pressure, to nerve and muscle operation for protein synthesis and for glycogenesis.

Toxicity

Toxicity can be associated with alcoholism.

Symptoms can include severe dehydration, muscular weakness, cardiac problems and renal failure.

Deficiency

A rare condition

Symptoms may include vomiting, diarrhoea, nausea, muscular weakness, tachycardia paralysis and heart failure.

Recommended Daily Allowance: 2500 milligrams

SULPHUR (S)

An essential part of many proteins and some vitamins. Found widely particularly in hair skin and nails, excess excreted in urine.

Food Sources

Legumes, eggs, meat and milk.

Significance to Body

Present in cartilage, tendons and bone.

Toxicity

Symptoms are unknown.

Deficiency

Symptoms are unknown

Recommended Daily Allowance: Not known, but a diet with adequate protein intake will meet requirements.

SODIUM (Na)

An abundant cation in extracellular fluid. Excretion is mainly in urine.

Food Sources

Table salt, cheese, sauerkraut, cured meats (eg. ham).

Significance to Body

Important in maintaining osmotic pressure of extra cellular fluids and water balance. Important to pH balance of blood, normal neuromuscular function and part of the system which moves glucose and other nutrients in the body.

Toxicity

Symptoms may include hypertension and oedema.

Deficiency

A rare condition.

Symptoms may include diarrhoea, vomiting, sweating, convulsions and muscle cramping.

Recommended Daily Allowance: probably around 2500 milligrams.

CHLORINE (Cl)

It is the main anion (atom carrying a negative charge) in extra cellular fluid. Its highest concentrations are in gastrointestinal juice and in cerebrospinal fluid. A component atom of HCl, the acid found in the stomach.

Food Sources

Sea salt, vegetables and fruits.

Significance to Body

Along with sodium and potassium, helps maintain osmotic pressure and pH of extracellular fluid.

A component of hydrochloric acid in the stomach, helps transport of carbon dioxide in the blood and activates salivary amylase.

Toxicity

In western society, often this is ingested in greater quantity than required. Massive doses will cause vomiting.

Deficiency

Vomiting and diarrhoea can lead to chlorine loss and alkalosis. Deficiency symptoms can include muscle cramps and apathy

Recommended Daily Allowance: Not determined, an average daily diet contains 3-9 grams.

IRON (Fe)

Up to 70% is in haemoglobin in blood. Eliminated from body in urine, menstrual cycles, perspiration and other ways. Only 2-10% of dietary iron is absorbed!

Food Sources

Best sources are red meats, particularly liver (eg. pate). Also found in egg yolk, shellfish, dried fruit, molasses, nuts and legumes.

Significance to Body

Responsible for binding most of the oxygen by haemoglobin in the blood. A component of cytochromes which work in oxidative phosphorylation (energy producing systems).

Toxicity

Toxicity can cause damage to the liver pancreas and heart.

Deficiency

Symptoms may include anaemia, gastrointestinal problems, constipation, flatulence, pallor, anorexia and paresthesias.

Recommended Daily Allowance: Males -10 milligrams; Females: 15 milligrams.

IODINE (I)

Occurs in all tissues but high concentrations are in thyroid gland. Absorption is controlled according to levels of iodine in the blood.

Food Sources

Iodised salt, cod liver oil, shellfish, and vegetables grown in iodine rich soils.

Significance to Body

Essential for formation of some thyroid hormones; important in regulating metabolic rate.

Toxicity

The synthesis of thyroid hormones is depressed.

Deficiency

Causes hypothyroidism; in less severe cases: simple goitre (swelling of the thyroid gland which is located in the neck).

Recommended Daily Allowance: 0.15 milligrams

MANGANESE (Mn)

Mainly found in kidneys, spleen and liver.

Bone has the highest concentration.

Excreted mainly in faeces.

Food Sources

Legumes, whole grains, nuts, fruit and green leafy vegetables.

Significance to Body

Important in synthesis of fatty acids, cholesterol, urea and haemoglobin. Important to carbohydrate oxidation, protein hydrolysis, lactation and neurological functions.

Toxicity

Largely unknown

Reported toxicity in miners of magnesium oxide, who breath in the dust.

Deficiency

Unknown

Recommended Daily Allowance: 2.5-5 milligrams

COPPER (Cu)

Occurs mainly in brain, heart, liver and spleen. Excreted mainly in faeces.

Food Sources

Legumes, meat, liver, shellfish and whole grains.

Significance to Body

Needed to synthesise haemoglobin, melanin and myelin. Important in electron transport chain.

Toxicity

Rarely occurs.

Abnormal storage of copper can result in "Wilson's Disease".

Deficiency

Rare

Recommended Daily Allowance: 2-3 milligrams

ZINC (Zn)

Occurs mainly in brain, kidneys and liver. Excreted in faeces.

Food Sources

Meat, seafood, legumes, cereals, nuts, wheat germ and yeast.

Significance to Body

A component of several different enzymes. Important in carbon dioxide metabolism.

Essential for normal growth, wound healing, sperm production and operation of senses (ie. taste and smell).

Toxicity

Symptoms may include slurred speech, tremors, difficulty walking and abnormal facial expressions.

Deficiency

Symptoms may include growth retardation, loss of senses (eg. taste & smell), less disease resistance and learning difficulties.

Recommended Daily Allowance: 15 milligrams

COBALT (Co)

A constituent of vitamin B₁₂. Occurs in all cells but at higher levels in bone marrow.

Food Sources

Fish, lean meat, poultry, liver and milk.

Significance to Body

Important for red blood cells

Toxicity

Can cause heart disease, goitre and polycythemia.

Deficiency

Symptoms may include pernicious anaemia, anorexia, weight loss, neurological disturbances.

Recommended Daily Allowance: not determined.

FLUORINE (F) (Fluoride)

Found in bones, teeth and other body cells. Excreted in urine.

Food Sources

Fluoridated water

Significance to Body

Important in tooth structure. May help prevent osteoporosis and dental cavities.

Toxicity

Can cause mottling of teeth.

Deficiency

Symptoms are unknown

Recommended Daily Allowance: 1.5 to 4 milligrams

SELENIUM (Se)

Description

Stored in kidneys and liver, an essential component in some enzymes.

Food Sources

Seafood, meat and cereals, nuts, eggs. Highest levels generally in brazil nuts (soil dependant) as well as kidney, crab and lobster.

Significance to Body

A part of vitamin E, several enzymes, and an antioxidant. Cofactor for the reduction of antioxidant enzyme. Important for thyroid function.

Toxicity

Can cause nausea, vomiting, fatigue and irritability.

Deficiency

Unknown

Recommended Daily Allowance: 0.05-2 milligrams

CHROMIUM (Cr)

Found widely throughout the body.

Chromium levels in the body decline with age. An adult has probably no more than 6 mg in their body. Required by the body in trivalent form (Cr³⁺)

Food Sources

Meat, cheese, whole grains, yeast, wine and liver.

Significance to Body

Important for carbohydrate metabolism, may have a function in blood.

Aids in the binding of insulin to cell membranes, and so facilitates the action of insulin. Chromium therapy is used in case of diabetes.

Toxicity

Unknown

Deficiency

Rare outside developing countries. Fatigue, high blood cholesterol, faulty carbohydrate metabolism, plaque accumulation in the aorta, elevated blood pressure and slow healing.

Recommended Daily Allowance: 0.05-2 milligrams

MORE ON MINERALS AND INORGANIC ELEMENTS

The term "mineral elements" refers to elements other than carbon, hydrogen, oxygen and nitrogen. About 15 mineral elements are known to be essential to humans, and must be obtained from food.

Compared with carbohydrates, proteins & fats, mineral elements are only required in very small amounts, and compose only about 6.9% of the body by weight. Carbohydrates, protein and fats comprise 31.5%. Water comprises 61.6 %. All are equally essential to the body structure and function.

It is possible for mineral elements to be present in foods in a form which the body cannot absorb. They are then said to be unavailable (Calcium is present in spinach as calcium oxalate which is not absorbed). Theoretical calculations may show adequate intakes of minerals, but in fact the body is not able to make use of them all. It is therefore wise to have a variety of foods in the diet, so there will be several sources of any one mineral element, and if one is not available, another will be, at the risk that a shortage of the mineral element is lessened.

Fortunately most mineral elements are widely distributed in foods, and there is little risk of anything being in short supply; but calcium, iron and iodine perhaps require more consideration than some others.

CALCIUM

Bones and teeth consist mainly of calcium phosphate. The diet must therefore contain sufficient calcium and phosphorus to meet the body's needs, not only during periods of growth, but at all times. This is because the bones are not static: they continue to grow with old bone cells dying and being replaced. Bones also provide a reserve of calcium if it is needed for something else, like maintaining stable blood pH and maintaining proper nerve impulses transmission; so it is constantly being withdrawn from and replaced in blood. The level of

calcium in the blood is controlled by the parathyroid gland.

Calcium is needed for:

- Proper development and maintenance of bones and teeth.
- Normal clotting of blood.
- Normal functioning of nerves and muscles.
- Activity of several enzymes.

During pregnancy the foetus is assured of its supply of calcium because the mother's body always provides the calcium provided. If the mother's diet is deficient in calcium it is she who suffers as the calcium required for the foetus is drawn from her bones and teeth. Pregnant or lactating women require more than double the normal calcium intake required by adults.

Calcium Content of Some Foods (mg per 100 gm)

Food	Calcium content (mg per 100 gm):
Milk, liquid	120
Collard greens (raw)	250
Milk, dried	1020
Cheese, cheddar	800
Yoghurt, natural	180
Eggs	52
Cod, baked	22
Pilchards	300
Chicken, boiled	11
Beef, roast	10
Bread, white	100
Bread, wholemeal	23
Cabbage	57
Almonds	234
Dandelion greens	187
Figs (dried)	126
Kale (raw)	249
Kale (cooked)	187
Tofu	128
Sweet potatoes (baked)	40
Turnip greens (raw)	249
Oranges	43
Lettuce (dark green)	68
Chick peas (garbanzo)	150

Calcium can be found in dairy, but also in greens, nuts and seeds and beans, as can be seen in the table above. Hard water is also a source of calcium. Dried milk has high calcium content, but once reconstituted, its value becomes the same as fresh milk. Pilchards have a high content because their bones are eaten. This applies to other types of tinned fish such as salmon. The difference between white and wholemeal bread is that calcium carbonate is added to all but 100% extraction flour.

One pint of milk supplies 340 mg calcium and, provided milk is liked and can be tolerated, the daily recommended amount can easily be achieved. Milk, cheese, bread and flour (if fortified), and green vegetables, are the main sources of calcium in the diet.

In the past, rickets was the deficiency disease associated with calcium. Rickets is due to a deficiency of calcium, brought about by poor absorption due to a lack of vitamin D. Fortunately the incidence of rickets is now very low. It is characterised by curvature of bones and limbs or other improper bone formation.

Osteomalacia (decalcified bones) is sometimes seen both in women who have had repeated pregnancies, and in the elderly. Again, a more likely cause is lack of vitamin D. In some elderly people however, because of a restricted and unvarying diet, calcium intake may be inadequate. Osteoporosis (the loss of bone) in old people is sometimes thought to be due to a calcium deficiency, but in actual fact, the basic cause is unknown.

Normally only 20-30% of calcium intake is absorbed and factors concerning the absorption of calcium are still hotly debated. It is however known that certain substances assist the absorption of calcium, and others interfere with it.

ABSORPTION of Calcium is ASSISTED by:

- Vitamin D -derived from foods or sunlight, (essential)
- Magnesium – should be taken in a dose halving the calcium intake to obtain maximum intake of both minerals.
- Proteins -amino acids resulting from protein digestion form soluble calcium salts.
- Lactose

ABSORPTION of Calcium is INTERFERED with by:

- Oxalic Acid - present in some fruits and vegetables, like the Solanaceae family (potatoes, tomatoes, aubergine), rhubarb, spinach, strawberries. When oxalic acid is present in the diet, renders calcium unavailable.
- Phytic Acid - present in cereals and nuts. Forms insoluble compounds with calcium, and when in the diet renders the calcium unavailable. Phytic acid is inactivated and thus calcium absorption facilitated when cereals, nuts and seeds are soaked overnight, or in the case of cereals, cooked. To combat this loss due to phytic acid calcium carbonate was first added to flour (to all except wholemeal) during the Second World War. It is still added although it is now known that enzymes that are present in the flour break down phytic acid during bread making.
- Vegetarian diets have a higher phytic acid content than many others, when phytic acid is not properly inactivated by soaking and cooking, therefore an adequate calcium supply should be assured, be it with greens or other foods.
- Fats -large amounts of fat in the intestine interfere with calcium absorption because unabsorbed fatty acids form insoluble salts with calcium.

The 70-80% of calcium which is unabsorbed is excreted in the faeces.

Excretion of the absorbed calcium is via the kidneys. Adults on a mixed diet are normally in a state of equilibrium (ie. calcium absorbed = calcium lost). Pregnant and lactating women, and growing children must of course obtain more calcium.

The Calcium Debate

The standard orthodox nutritional guidelines have always recommended dairy products as the best calcium source available to humans, especially to avoid osteoporosis. But other nutrition experts, more akin to complementary and natural therapies, advocate for low dairy and higher green foods as the best sources of calcium. Arguments in favour of this last hypothesis is that Asian women with Asian diets, who consume no significant dairy throughout their lives and specially as adults, have much better bone health and much lower osteoporosis rates as a social group than women with Western diets (Caucasian or Asian), with diets rich in milk products and derivatives. Another argument is that foods rich in proteins and fats may unbalance the body pH making it more acid, therefore to compensate acidity the body will have to take calcium from diet and if that is not enough then from bones, to maintain the blood pH balanced (neutral). The whole process will mean that in the long term calcium will be lost from bones favouring osteoporosis. Some Western women that have been on diets without dairy due to lactose intolerance since early adulthood report having excellent bone health.

As an example of an alternative source of calcium, a cup of collard greens is equivalent in calcium amount to a glass of cow's milk, and it is also an alkaline food (non acid). For more alternatives, see table above.

PHOSPHORUS

The bones and teeth contain 80-85% of the body's phosphorus as calcium phosphate. Phosphorus is a constituent of all body cells and body fluids, and plays an important part in the release of energy. It is present in all natural foods, but the phosphorus content in refined or processed foods is often reduced greatly. However, phosphates are often added to processed foods. The best sources of phosphorus are those which contain calcium and protein, so if the levels of calcium and protein are adequate, the diet should contain enough phosphorus. Cheese, liver, eggs and milk are valuable sources. Cow's milk has a high ratio of phosphorus to calcium compared with human milk, and when fed to infants during the first few days of life, it may produce low levels of calcium in the blood resulting in muscular spasms.

IRON

About two thirds of the small amount of iron in the body (only about 4 gm) is in the haemoglobin in the blood. Haemoglobin carries oxygen to the tissues and carbon dioxide away, and if the body is deficient in iron, the circulating haemoglobin is reduced, resulting in anaemia. There are other types and causes of anaemia too, but this is the most common.

Iron is stored to some extent in the liver, and this is of great importance to infants because milk is deficient in iron. It is present in muscle protein - myoglobin, which stores oxygen for use when muscles contract. Iron is required for certain enzymes concerned in the release of energy. The loss of iron from the body is small, and an adult man only loses about 1 mg of iron a day. Red blood corpuscles have a life of about 4 months, but the iron involved in the formation of haemoglobin is reused. Bleeding accounts for the most loss of iron, and there will be extra demands during periods of growth, menstruation and pregnancy and the post-partum period.

The amount of iron absorbed is regulated to a large extent by the needs of the body, but is only likely to be 10-20% of the iron in the diet. The total iron content of different foods gives no true value of the iron absorbed, as some is unavailable, and absorption also depends on the nature of foods eaten.

Absorption of iron is ASSISTED in the presence of :

- Vitamin C - the value of green vegetables as a source of iron may be partly due to their vitamin C content.
- Proteins

Absorption of iron is INTERFERED with by the presence of:

- Phytic Acid and Phosphates
- Oxalic Acid

The iron content of some foods in mg per 100 g is shown below:

Food	Iron content (mg/100g)	Food	Iron content (mg/100g)
Milk	0.1	Potatoes	0.5
Eggs	2.0	Cabbage	0.6
Beef	1.8	Watercress	1.6
Chicken	0.7	Bread, white	1.7
Liver	11.4	Bread, wholemeal	2.5
Kidney	6.0	Flour, white	2.4
Fish, white	0.3	Chocolate, plain	2.4
Dates, dried	1.6	Cocoa powder	10.5

Meat, bread, flour and other cereal products, potatoes and green vegetables are the main

sources of iron in the diet.

IODINE

Iodine is needed in minute amounts, but is essential to the proper functioning of the thyroid gland which controls the basal metabolic rate. Deficiency of iodine leads to an enlargement of the thyroid gland. At one time this was endemic in countries away from the sea, (eg. Switzerland). In the U.K it was sometimes known as Derbyshire neck.

The iodine content of plant and animal foods depend on the amount of iodine in the soil. Sea foods and vegetables grown near the sea have a higher content than other iodine foods. Milk and cereals are other foods which contain iodine, but the amount is very variable. Because the iodine content of food can vary so much, iodised salt (25 ppm) is available in some countries. According to thyroid specialists, people living near the sea or consuming sea salt don't need additional iodine in the diet. Iodised salt is only beneficial for people living in very continental areas, if they cannot get enough in the diet.

SODIUM

Sodium in the form of common salt is a major factor in maintaining the proper water balance in the body, and is found in extra cellular fluids. It is also required for normal muscular activity, and a deficiency may lead to painful muscle cramps. A shortage of sodium however, is unlikely unless there is excessive sweating with the constant loss of salt. About 4 gm per day is required, and many foods contain small quantities of sodium. Because larger quantities are often added to cooked or processed foods, it is not uncommon for people to take in several times their daily requirement.

POTASSIUM

Potassium behaves similarly to sodium, except that it is in the intracellular fluids. There is not likely to be any deficiency as it is found in a wide variety of foods.

MAGNESIUM

Magnesium is present in bones and teeth, and is necessary for some of the enzymes involved in the production of energy. It is widely distributed in foods, and a deficiency is unlikely.

The above, with the exception of iodine, might be considered as "major minerals". The remaining minerals are also essential, but are required in much smaller quantities. They are also known as "TRACE ELEMENTS" The exact role which these trace elements play in the body is not always fully known, as most of them are associated with several metabolic pathways and involved in with enzymes, hormones or vitamins.

FLUORINE is found in bones and teeth, and is beneficial in protecting teeth against decay (especially in children). Drinking water is the main source, but the amount in water varies considerably. Soft waters may contain no fluorine at all, and others may fall below the minimum 1 ppm. Other fluorine sources include sea fish where bones are eaten (eg. sardines) and tea.

COPPER is a component of many enzymes, and is required when iron is used in the synthesis of haemoglobin. Good sources include fish, nuts, liver and other meats.

COBALT is a constituent of vitamin B¹².

ASSIGNMENT

1. List 2 sources for each of 10 different minerals considered essential to human health.
2. Provide a 1-2 sentence description of the role of 10 different minerals in the body.
3. List the foods you have eaten on any one day in the past week. Look at the minerals you would get from these foods. In one to two paragraphs, discuss any minerals which may be supplied in inappropriate quantities and include any health issues you may develop if you maintained this diet long term. (Just list the problems, don't describe or explain them)
4. Describe symptoms of 5 different nutrient disorders. Keep your answers brief, no more than 3 sentences each.
5. Select 5 different mineral supplements and give a 2-3 sentence explanation of how they might be used in a specified human diet.
6. From the list of vitamins below, select 6 and provide 3 sources for each, noting the relative value of each source:
 - Vitamin D
 - Vitamin E
 - Vitamin K
 - Ascorbic acid
 - Thiamine
 - Riboflavin
 - Nicotinamide
 - Pyridoxine
 - Pantothenic acid
 - Biotin
 - Cyanocobalamin
 - Folacin
 - Retinol
7. Discuss the increasing use of vitamin supplements. Why do you think more people are using supplements? Are people currently using supplements now using more supplements? Do you think the increase in vitamin supplement use is a good thing or bad? Explain your opinion in 200-300 words.
8. A person is showing symptoms including anaemia, dental cavities, frequent colds (low disease resistance) and tremors. They also appear to have a small goitre. What minerals would you suggest this person increase in their diet? (Provide a list only and note what symptom/s the mineral would improve)

WATER

Aim

Recommend appropriate water intake in different situations.

Water is a fundamental part of our lives. It is easy to forget how completely we depend on it. Human survival is dependent on water. The average adult body is 75% water. Our brain is made up of 85% of water. *2/3 of your body weight* is water. A human embryo is more than 80% water. A newborn baby is 74% water. Everyday your body must replace 2 1/2 quarts (about 2L) of water. Since such a large percentage of our body is water, it plays a very important role in the body's functions. Water carries nutrients and oxygen to cells, thus keeps our cells alive and healthy. Water aids in digestion and absorption of food, water regulates body temperature and blood circulation and removes toxins and other wastes from cells and from our body. 'Body water' also cushions joints and protects tissues and organs, including the spinal cord, from shock and damage.

Chronic dehydration may cause certain problems for the body, including hypertension, asthma, allergies, and migraine headaches. An average person needs to drink about 8 glasses of water per day. By the time you feel thirst the body is already mildly dehydrated. Water is essential to life. Of our body water about two thirds is contained within the cells, and one third is extra cellular in body fluids. Much of the water in the body is used repeatedly, for example digestive juices, which are excreted by the glands into the digestive tract, and then reabsorbed to carry simple substances into blood and lymph.

Water is however lost from the body in urine, faeces, from the lungs (when breathing out), and from the skin (in perspiration). The kidney is the main organ for regulating the amount of water in the body, and output reflects intake. The kidney can deal with excess fluid but there is a minimum volume of urine which an individual on a good diet must excrete to eliminate waste products from tissues. This is approximately 1 litre per day, so the minimum intake of fluids is 0.75 L. A greater intake is highly desirable to allow for variations in the amount of water lost through the skin and lungs; so daily intake is best to be 1.5 L or more.

Fluid intake is largely determined by social custom and habit, and in most cases, if thirst is satisfied, the body's needs for water will be met. Water intake comes from various sources, including all types of drinks, AND some solid foods. This is called "metabolic water", being water which is resulting from the metabolising of foods. Vomiting and diarrhoea will result in water loss.

If salt is lost through excessive sweating (in tropics, some occupations etc), the thirst mechanism may not work adequately, and more water than is necessary to satisfy thirst should be drunk. The salt loss should also be made up as the electrolyte balance will be disturbed. Sodium and potassium are important in maintaining electrolyte and chemical balance between the tissue cells and blood:

- sodium remains outside the cell in the extracellular fluid
- potassium is located inside the cell wall
- these ions are in constant flux

When a muscle undergoes contractions, or an impulse travels along a nerve, there is a rapid exchange of these two elements across the cell membrane. The exchange creates an electrical impulse.

The water balance in the body is also important for acid-base equilibrium. Human life is only possible if the blood is kept within a narrow range of alkalinity. In health, the blood is maintained at a pH of 7.4. This level is maintained by two mechanisms, the excretion of carbonic acid ($\text{CO}_2 + \text{H}_2\text{O}$) through the lungs, and the excretion through the kidneys of urine, which is either acid or alkaline.

Water has three basic functions to perform in our bodies:

- to transport nutrients and oxygen to our cells
- to carry away toxic wastes from the cells
- to regulate our body temperature through hydration

The quality of drinking water, which has surface water as its source, is steadily deteriorating because of pollutants and acid rain. Our water is becoming acidic from all the pesticides and waste run offs as well. It is hard to find "pure water" today. Most "tap" water is treated with chlorine and fluoride both causing more acidity. For that reason, filtered water is today the best option to maintain basic health, together with a healthy diet.

"Pure water" has a pH reading of 7 and has a balanced number of H^+ and OH^- ions (a molecule of water has 2 H^+ atoms and 1 O^{2-} atom – H_2O with no overall charge). If there are more H^+ ions than OH^- ions present, the water is acidic and will have a reading less than 7. Water with less H^+ ions than OH^- ions is considered alkaline and will have a higher reading than 7.

Our body systems work to keep our blood and the fluids surrounding our cells slightly alkaline. The process of metabolism - the digestion and burning of our foods to produce energy - results in waste products. These waste products are acidic. If conditions were ideal, we'd get rid of our acidic wastes as fast as they formed through breathing and through the kidneys, bowels and skin. Unfortunately with our water also being more acidic these days, the body is having a tougher job of maintaining pH.

Alkaline water has many of the same "living qualities" of high altitude spring-fresh mountain water. Like mountain stream water which passes over rocks and through soil, picking up oxygen, ionized alkaline water is grouped together in smaller clusters of 5-6 water molecules instead of the 10-13 found in tap water. This makes it "micro-clustered", meaning it will be more quickly and easily absorbed, and will hydrate the tissues more effectively.

It is especially important to make sure that the water that is being put into your body is clean and free from chemicals and pollutants. There are different techniques and machines that can alkalize and filter the water you are drinking and help to restore health and hydration to the body. So the normal concentration of ions in body fluids is usually preserved by a balance between the intake of water and electrolytes in the diet, and the output of excretions.

WATER RETENTION

Oedema is the condition when fluid is retained in the body tissues. In such situations, a low salt or low sodium diet may be helpful. This will draw water back into the circulation by osmosis. Dehydration is the state when excessive amounts of fluid are lost from the body. Humans can live a lot longer without food than without water. Along with fluid loss, electrolyte balance will be disturbed and salt must be given as well as fluid.

ASSIGNMENT

1. Explain in 2-3 sentences each, the role of water in the body for 5 different physiological processes.
2. List 5 factors which affect the body's requirement for water.
3. In 200-300 words compare 3 different methods of purifying water, including two commercially available water purifiers. Consider how each method differs, and the advantages and disadvantages of each. Which one would you select to purify tap water in your house? Why?
4. Describe the symptoms of mild, severe and chronic dehydration, and how a lack of water might cause these symptoms to occur. Give your answer in 1-2 paragraphs
5. Discuss the effect of 5 different water impurities on human health. Allow 2-3 sentences for each one.

NUTRIENT DISORDERS

Aim

Recognise symptoms of the major nutrient disorders.

NUTRIENT/DIGESTION DISORDERS

Nutritional disorders may be anything from minor to very serious problems.

The result of nutritional disorders can result in the improper functioning of a part of the digestive system. This may be due to an anatomical or physiological peculiarity which a person possesses or it may be due to a disease or degeneration of part of the system

There are two main types of nutrient/digestive disorders:

- Deficiencies: inadequate supply of important vitamins and minerals to conduct the normal bodily processes.
- Sensitivities: Some people are sensitive or allergic to certain chemical compounds. Their body simply lacks the ability to deal with those chemicals and reacts badly. An example is intolerance to lactose, the sugar in milk. 70% of the adult Asian population, 60% of the Latin and around 40 to 60% of the western adult population lack naturally the enzyme lactase, needed for the conversion of lactose in simple sugars. Consequently they suffer from indigestion symptoms when ingesting dairy products, such as stomach cramps, bloating, sinuses, mucus conditions and generally poor health due to a malfunctioning immune system.

SELECTED DIGESTIVE SYSTEM DISORDERS

VOMITING

This is expulsion of stomach contents (and sometimes contents of the duodenum) through the mouth.

Vomiting is commonly and most strongly stimulated by the stomach being irritated or swollen. Other things can stimulate vomiting in some people, can include: nervousness/psychological upsets, dizziness and certain drugs or toxins (particularly if ingested). Nausea and vomiting can also be the result of hormonal changes and imbalances, such as morning sickness in pregnant women. Prolonged periods of vomiting can cause serious loss of gastric juices and result in serious disturbances in the balance of fluids & acid/base relations in the body. The loss of fluids can result in dehydration, and the expulsion of partially digested foods leaves a person at risk of nutrient deficiencies and weight loss due to inadequate calorie intake. The oesophagus, which is not anatomically designed to handle the highly acidic fluids of the stomach can also be affected, suffering mild chemical burns. If a person is vomiting constantly (such as pregnant women with hyperemesis) they should be hospitalised to avoid permanent oesophageal damage, and to receive hydration and nutrition via IV.

PEPTIC ULCER

Peptic ulcers can occur in either the stomach or duodenum and results in the erosion of their linings. It occurs when the stomach produces too much gastric acid, or when the protective mucosal lining of the stomach or duodenum is compromised. It can occur in people who drink excessively, or use large quantities of anti-inflammatory drugs. In many cases it is hereditary and a large number of cases are due to a bacterial infection (*Helicobacter pylori*). Symptoms include indigestion, pain in the upper abdomen which is often worse before or after eating, in the early hours of the morning (when the stomach is empty) and also very dark black faeces, the colour being due to blood. Drugs can be given to inhibit this acid secretion. Prior to the

late 1970s the condition was treated by surgery.

JAUNDICE

This is when eyes and skin develop a "yellowish" colouring. It results from a build up of bilirubin in the body. Bilirubin is formed from the breakdown of pigment in red blood cells. Bilirubin is absorbed into the liver from the blood and eventually excreted in bile. There are 3 types of jaundice:

1. Prehepatic Jaundice -caused by excess of bilirubin.
2. Hepatic Jaundice -caused by liver disease, and liver not working properly.
3. Extrahepatic Jaundice -caused by a blockage of bile, probably either gallstones or cancer.

It is important to seek medical advice if the skin and eyes become yellow, as it could indicate either a liver condition, or a condition affecting the blood or spleen. Jaundice also occurs in newborn babies, however it is easily treatable in most cases. Severe jaundice in a newborn suggests an underlying serious medical condition. Infants are treated by exposure to special 'bili lights' which emit high levels of coloured light, which break down the bilirubin.

LACTOSE INTOLERANCE

Occurs when the small intestine fails to produce the enzyme lactase. Bacterial fermentation of undigested lactose results in gas production leading to diarrhoea, bloating and cramps, after consuming dairy products. This can impair digestion and absorption of nutrients from other foods as well, as the intestines are continually irritated. When not recognized it can lead to a host of other nutritional problems such as vitamin and mineral deficiencies, which can in turn provoke immune system deficiency, followed by frequent colds and flu, allergies to other foods, etc.

Alternatives to cow's milk that are easier to digest are sheep's and goat's milk, which are good alternatives for children, and sheep's and goats milk derivatives such as yogurt and cheese. There are also dietary supplements with lactase, which can be taken with the milk, and low-lactose milk to which lactase has been added in manufacturing. Other problems with milk can be due to another milk protein, casein. In this case avoiding dairy products in the diet is the best solution. Alternatives include soy milk, rice milk and oat milk. Oat milk is also good for cholesterol and excess oestrogen control, as it has a good fibre content, which traps both.

HAEMORRHOIDS (PILES)

This occurs when veins in the rectum are put under pressure and swell up with blood. In severe cases, there can be blood loss. Bleeding and itching are common signs. The cause is usually constipation putting pressure on the rectal area. Low fibre diets often cause this problem. The solution is dietary changes with the inclusion of more high fibre content foods, such as fresh fruits and vegetables, which will add bulk and moisture to faeces and facilitate its transit.

CIRRHOSIS

Cirrhosis is a severe liver disease. It is generally the result of chronic liver diseases, such as alcoholic or non-alcoholic liver disease. It is characterised by fibrotic scar tissue in the liver and the gradual loss of liver function. It is most commonly seen in people suffering with alcoholism or Hepatitis C and can sometimes be caused by parasites. Symptoms can be jaundice, uncontrolled bleeding and heightened sensitivity to drugs. It is generally non-reversible and must be closely monitored, with many of the monitoring procedures being quite invasive. Alcohol consumption must be stopped, and stopping smoking is also advisable. Liver transplant is required in many cases.

ALLERGIES

A true allergy is an over-reaction of the immune system, causing the formation of antibodies in white blood cells. Food sensitivities or intolerances do not provoke true allergic responses, but they do cause particular symptoms and can be quite severe, especially in children. However, there are some people who suffer from true food allergies, the most common being nut and shellfish allergies. These can be extremely severe, and in recent times children have died from anaphylactic shock after accidentally consuming even tiny quantities of peanut butter. An undetected food intolerance or sensitivity can deplete the body of vitamins and minerals, even if the quantity of food ingested is sufficient. This can affect the functioning of the immune system, leading to chronic or recurrent health problems. Constant colds and flu are a very common indication of a run down immune system, therefore of undetected allergies or sensitivities.

Foods intolerances and sensitivities that are most common include proteins, such as dairy products, eggs, wheat (and other cereals containing gluten), seafood, chocolate, tomatoes, some fruits and some meats. Skin and blood tests are not reliable in diagnosing allergies. The elimination diet is the best method for diagnosis: all foods known to cause reactions are abstained from and gradually reintroduced into the diet one-by-one. Multiple allergies may go undetected. Keeping a diary of foods eaten, subsequent behaviour and reactions can be useful.

CHOLESTEROL/HEART DISEASE/ATHEROSCLEROSIS

Cholesterol is a fatty, waxy substance that is important in cell membranes, hormones and brain cells and making vitamin D and bile salts. The body is able to make its own cholesterol, so it is not really necessary to eat it. Excess cholesterol is a serious problem, as it builds up in arteries (with other substances) and causes poor blood flow and sites for blood clots to lodge. In response to the deposition of excess lipoproteins containing cholesterol on the artery walls, the walls themselves develop a chronic inflammation which over time results in their hardening. This hardening of the artery walls is known as atherosclerosis. Heart disease arises when the heart does not get a full supply of blood, and when atherosclerosis develops, the ability for blood to flow through the arteries is compromised due partially to the narrowing due to the accumulation of fatty deposits, and also due to the loss of muscular function of the arteries, as the walls are too stiff to allow it. A complete blockage of the arteries near the heart will result in a heart attack.

Heart disease is an umbrella term that is used to describe a number of related but distinct diseases affecting the heart. In relation to dietary cholesterol, and atherosclerosis, the important heart disease to be aware of is coronary heart disease. This is the direct result of the accumulation of fatty plaques on the artery walls. Cardiovascular disease, which can also be caused by elevated cholesterol levels in the blood, and the other forms of heart disease combine to be the leading cause of death in many Western Countries.

A diet high in saturated fats, found in animal fats as well as some vegetable oils (eg. coconut and palm oil), is usually the source of excess cholesterol. Eating oats, legumes and plenty of fruits and vegetables is effective in increasing the removal of cholesterol, as they have natural fibre which traps and carries away excess cholesterol, so ample intakes of these foods is important in addition to reducing the intake of cholesterol-rich foods.

HDL (high density lipoproteins) and LDL (low density lipoproteins) are compounds attached to cholesterol. HDL is considered 'GOOD' because it removes cholesterol from the artery walls, returning it to the liver, whereas LDL is considered 'BAD' because it deposits cholesterol in cells. Usually, most people with high overall levels of blood cholesterol have high levels of the bad LDL. Fatty deposits in the arteries (atherosclerosis) and hardening of the arteries (arteriosclerosis) are also involved in heart disease.

BOWEL CANCER

Cancer of the large bowel (colon and rectum) is very common in modern society. In fact, while breast cancer and prostate cancer are the most common cancers for each gender, bowel cancer, which affects both men and women is the most common cancer in Australia, affecting approximately 1:15 people. Although it tends to occur in people over 50 this is not always the case.

It is thought to be caused by the prevailing dietary habits which are high in fats and low in fibre, although the roles of the various factors are not completely understood. There is also a hereditary component. It is possible that diets with a lot of meat may be harmful, as vegetarians tend to have a lower incidence of bowel cancer. However whether high intake of meat is harmful, or vegetarians simply eat more dietary fibre than people who consume large amounts of red meat is not clear. Thus for colon cancer the best prevention method is a daily intake of fresh vegetables and fruits, which will supply the crucial fibre, as well as water, minerals and vitamins. Ensuring adequate hydration is also important to avoid constipation.

When detected early, this is a very treatable cancer, however, the symptoms can be embarrassing and unpleasant and people can find it difficult to approach their doctor. Colonoscopy (an endoscope inserted through the anus and used to visually inspect the intestinal linings) is used both for early detection (polyps can be removed during this procedure, stopping them developing into tumours) and for confirmation of diagnosis. In severe cases, sections of the bowel and/or rectum will need to be removed, and the remaining upper section of the intestines is re-routed through the abdominal wall to a new orifice created through the skin of the abdomen. All faeces are then collected into an attached bag. This is called a colostomy.

PROBLEMS WITH NUTRITION

Effects of inadequate nutrition.

There are many theories and much research into the link between diet and disease. Listed below are some commonly known effects of malnutrition.

1. The hair may become dull and brittle, or it may fall out or change colour.
2. Some headaches may be related to vitamin deficiency.
3. Night blindness may arise from lack of vitamin A.
4. The tongue may become inflamed as a result of a number of vitamin deficiencies.
5. Bleeding gums may be a sign of scurvy (vitamin C deficiency).
6. Enlargement of the thyroid gland (goitre) may be linked to iodine deficiency.
7. Rashes, itching, soreness, scaliness and cracking of the skin may be a sign of a number of vitamin deficiencies.
8. Obese people often experience breathing difficulties.
9. Backache may occur as a result of obesity.
10. Too much food, particularly fat and carbohydrates, will lead to obesity. Too little food will cause wasting of the tissues and ultimately starvation. Failure to thrive in children may be a sign of marasmus (too little energy intake) or kwashiorkor (too little protein and energy intake).
11. Heart disease can occur as a result of obesity, and heart failure may be a result of extreme anorexia nervosa as the balance of electrolytes is disturbed.
12. Softening of the bones may be a sign of rickets (lack of vitamin D).
13. Loss of motor function in the legs may be a sign of beriberi (lack of vitamin B₁, or thiamine).
14. Lesions in the spinal cord may be a sign of vitamin B₁₂ deficiency.

15. There are a number of conditions affecting the stomach and digestive system as a result of diet. Symptoms may include diarrhoea, nausea, vomiting, pain and cramps.
16. Stones may form in the kidneys as a result of insufficient fluid; obese people may be prone to kidney failure.
17. Adrenal glands may enlarge as a result of pantothenic salt deficiency (related to the B vitamins).
18. The formation of gallstones is associated with a fatty diet.
19. Too much alcohol may cause cirrhosis of the liver.
20. Insufficient iron will cause anaemia.
21. Constipation can be caused by lack of fibre in the diet.
22. Piles (haemorrhoids) may also be a result of lack of fibre.
23. Swelling and painful feet may be a sign of vitamin B₁₂ deficiency.
24. Numbness in the toes may be a sign of vitamin deficiency.

Attacks of gout are connected with overindulgence in rich food and alcohol.

ASSIGNMENT

1. Distinguish between the signs and symptoms of 10 common problems associated with nutritional disorders. Include examples of deficiencies, sensitivities and diseases. Use the table below to set out your answer.

Name of deficiency/sensitivity/disease	Signs	Symptoms
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

2. List 3 different techniques used by health practitioners for determining food/nutrition disorders. Describe each briefly in no more than 3 sentences.

3. In about half a page, explain why it is important to obtain a recommendation from a medical practitioner when a nutritional disorder is suspected. Also discuss the significance of obtaining a second opinion when diagnosing a nutrient disorder.