16. NUTRITION, HEALTH AND DISEASE

16.1 INTRODUCING NUTRITION, HEALTH AND DISEASE

This chapter deals with nutrition, health and disease, topics that are important for everybody. First you should review Modules 12.3 (The digestive system) and 13.11 (Carbon – the element of life).

Nutrition. The first part of this chapter is about nutrition. Nutrition refers to the benefits that we get from eating food. Everybody needs food for (i) energy, (ii) growing and renewing tissues, and (iii) maintaining all the internal chemical processes that keep us healthy. These three needs can be used to define three food groups. The first group are the energy foods, carbohydrates (starches and sugars) and lipids (oils and fats). These are the nutrients that we need for the energy to move our muscles and keep all our bodily processes going. The second group are the growth foods, proteins. These are the nutrients that we need for growing and renewing all our cells, tissues and organs. The third food group are the health foods, vitamins and minerals. These are the special nutrients that we need in small amounts to keep us healthy. We will discuss each of these three food groups in some detail and explain how they can be combined to provide us with the balanced diet that is essential for a healthy life. And although water and fibre are not regarded as nutrients, we will discuss why these are also an essential part of our diet. After that, we will look at malnutrition and the health problems that arise when people can not obtain enough good food. Mothers and infants have special nutritional needs and we examine these carefully before concluding this section by looking at the health problems that go with overeating!

Health and disease. In the pictures above, the two little girls are well nourished. They are obviously much healthier and happier than the two malnourished little boys. Our health depends partly on good nourishment but it also depends on curing or avoiding diseases. In the second part of this chapter, we will consider the viruses, bacteria and other organisms that cause most human diseases. We will look at how diseases are spread, how our bodies are adapted to protect us from them, and what we can do to prevent and cure them. At the end of the chapter you will find information about a number of the most common diseases, including basic information about how to avoid them and how to treat them. The picture on the right shows three Asian children who are being successfully treated for a serious disease.
### 16.2 CARBOHYDRATES – ENERGY FOODS

Carbohydrates, produced by plants as a result of photosynthesis, provide our main energy foods in the form of starches and sugars.

**Carbohydrates as energy foods.**
The starches and sugars produced by plants provide our main sources of energy. Our digestive systems convert all starches and sugars (see box right) into glucose. Our blood carries the glucose to every cell in the body where energy is released by respiration.

\[
\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 6\text{CO}_2 + \text{energy}
\]

About 15% of this energy can be converted into mechanical energy as movements in muscles, and the rest appears as heat which helps to maintain the temperature of the body. Everything we do, from playing sports to thinking, requires energy and that energy comes from the food we eat.

The SI unit of energy is the joule (J), named after English physicist, James Prescott Joule (1818 – 1889). A joule is the energy required to move 1 metre against a force of 1 newton (see Module 10.2). 1N is about the weight of a 100 g mass, or the weight of a medium sized tomato. So 1J is the energy required to lift a tomato, against the force of gravity, a vertical distance of 1 metre. The joule is a small unit so we usually measure energy in kilojoules (kJ); 1 kilojoule = 1000 joules.

<table>
<thead>
<tr>
<th>Group of people</th>
<th>Energy needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male outdoor workers</td>
<td>14 500 kJ/day</td>
</tr>
<tr>
<td>Female office workers</td>
<td>8 500 kJ/day</td>
</tr>
<tr>
<td>Teenagers (boys 16)</td>
<td>12 000 kJ/day</td>
</tr>
<tr>
<td>Teenagers (girls 16)</td>
<td>10 000 kJ/day</td>
</tr>
<tr>
<td>Children (8 years)</td>
<td>8 500 kJ/day</td>
</tr>
</tbody>
</table>

The energy we need every day depends on our age, weight and gender; also on how active we are. In general, larger people need more energy from their food than smaller people, but children and teens (who are still growing) need more for their size than adults. People who are active need more energy food than those who are not, and males need a little more than females. The table shows typical daily energy needs.

**Sources of carbohydrates.** Many foods contain carbohydrates, but the main sources are starchy and sugary foods. Our main starchy foods, the staple foods of different countries, are:

- Seeds including grains or cereals such as rice, corn and wheat and a few legumes such as lentils and beans; foods made from grains include flour, meal, porridge, breakfast cereals, noodles, pasta, bread, and cakes.
- Root vegetables including yam, taro, cassava (manioc, tapioca), potatoes, beets and carrots.

In some countries another staple food is plantain, a starchy fruit like a banana. Many packaged foods show the energy value of the food on the package. A 100 gram serving (dry weight) of most staple foods will provide about 1400 to 1700 kJ of energy.

Sugary foods include sugar itself and foods that contain a lot of it such as sweets, ice cream, cakes and soft drinks. We also obtain sugar from fruits and some vegetables. 100 grams of sugar will provide about 1700 kJ of energy.

- 1. What is a staple food? List the staple foods in your region.
- 2. About how much starchy food should a teenager eat in a day?
- 3. What are: (i) a carbohydrate, (ii) glucose, (iii) energy, (iv) a joule, (v) a kilojoule, (vi) food grains, (vii) root vegetables?
16.3 LIPIDS AND PROTEINS – ENERGY AND GROWTH

Lipids are the natural oils (liquids) and fats (solids) found in living organisms. They are good energy foods and can be stored in the body. Proteins are the main components of living cells and we find them in all living organisms. We need proteins for the growth and renewal of our tissues.

**Lipids for energy and storage.** Lipids are more difficult for us to digest than carbohydrates (see Module 12.3) but they are very good energy foods! A 100 gram serving of a lipid will provide about 3800 kJ of energy, more than twice as much as the same mass of carbohydrate. Excess lipids are stored as fat under the skin and can be used as an extra source of energy when we do not get enough food. Lipids are also needed to build the cell membranes around every cell in our bodies.

Lipids are compounds of carbon, hydrogen and oxygen; they usually contain three long chains of carbon atoms, all joined onto another radical at one end. Lipids can be classified as:

- **saturated** - lipids in which all the bonds between the carbon atoms in the long chains are single bonds. Most animal fats are saturated lipids and so are coconut oil and palm oil.
- **unsaturated** - lipids in which there is at least one double bond between two carbon atoms in each long chain; if there is one double bond in each long chain the lipid is **mono-unsaturated**, if there is more than one it is **polyunsaturated**. Most oils from plants and fish are unsaturated lipids.

**Sources of lipids.** Most of the oils in our food come from plant products such as cooking oils, margarine, avocados, and nuts and seeds such as coconuts and peanuts. Fish and seafood are another valuable source of oils. The fats in our food come from animal products including fatty meat, and dairy products such as milk, butter and cheese. All fried foods contain oils or fats and so do baked products such as biscuits and pastries.

**Proteins for growth and renewal.** Proteins are the main components of our cells and we need proteins in our food for the growth and renewal of our tissues. The average adult needs about 50 g of protein every day to renew the complex chemicals inside every cell, and to replace the millions of cells that die every day. Pregnant women and growing children need relatively more protein than other people.

When we digest proteins, they are broken down into many different amino acids (see Modules 12.3 and 13.11). The amino acids are carried by the blood to every cell in the body. In the cells, the amino acids are combined together in different ways to make the many different proteins that we need. If we eat more protein than we need, our liver will convert the excess amino acids into carbohydrates (which can be used as a source of energy) and urea (which is excreted in urine – see Module 12.5).

**Sources of proteins.** The best sources of protein are animal products such as lean red meat, chicken, fish (all about 25% protein), eggs (12%) and milk (3.5%). The best plant sources of protein are legumes including beans, peas, peanuts, lentils, tofu and soy products (10 to 30% protein). Other plant products with useful amounts of protein include grains (cereals) such as rice, and grain products such as bread; also some vegetables and fruits. We can get all the amino acids we need from any animal protein, or from a good mixture of plant proteins.

- 1. What are: (i) lipids, (ii) proteins, (iii) amino acids, (iv) legumes, (v) urea?
- 2. Can we get all the lipids and proteins we need from plants? What happens if we eat too much (i) lipid, (ii) protein?
Vitamins are complex organic substances that we need in small amounts for important chemical processes in our bodies. A normal, varied diet contains all the vitamins we need. Vitamins were discovered because of certain diseases that occurred in people on restricted diets. For example, in the days of sailing ships, sailors who got no fresh foods for several months, suffered from unusual diseases such as scurvy (with bleeding gums and joints, and wounds that would not heal), and beriberi (with loss of feeling in the hands and feet, loss of muscle function, and mental confusion). Many sailors died of these and other strange diseases during long voyages. After many years, doctors discovered that each of these deficiency diseases was caused by the lack of a particular vitamin. The table below lists the main vitamins and the foods that contain them.

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Food sources</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Dairy foods, margarine, eggs, green leaves, carrots, red peppers, palm oil.</td>
<td>Loss of vitamin A reduces resistance to diseases and causes damage to the eye and blindness.</td>
</tr>
<tr>
<td>B1,2,3</td>
<td>Most fresh foods including dairy foods, eggs, meat, yeast, fish, beans, green leaves and whole grain foods.</td>
<td>Lack of B vitamins leads to beriberi and skin and nervous problems; destroyed by processing in foods like white rice and flour; pregnant women on a poor diet often need extra B9 (folic acid).</td>
</tr>
<tr>
<td>B8,9,12</td>
<td>Most fresh foods including dairy foods, eggs, meat, yeast, fish, beans, green leaves and whole grain foods.</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Fresh fruit and vegetables: oranges, guava, paw paw (papaya), mango, tomato, dark green vegetables.</td>
<td>Lack of vitamin C leads to scurvy and low resistance to diseases. Vitamin C is destroyed by processing or overcooking.</td>
</tr>
<tr>
<td>D</td>
<td>Dairy foods, eggs, liver, fish-liver oil; also formed in our skin by sunlight.</td>
<td>Lack of vitamin D leads to rickets in which the bones become soft and bend.</td>
</tr>
</tbody>
</table>

Minerals (in food) are the chemical elements (apart from C, H, O and N) that the human body needs in small amounts. Na, K and Cl ions are needed for the basic chemistry of our blood and of every cell. Ca, Mg and P are also needed for many purposes, but especially for the making and maintaining of our bones and teeth. A normal, varied diet is likely to contain adequate amounts of these and all the other minerals that we need. However, highly processed foods are often deficient in minerals as well as vitamins. In some countries, calcium carbonate has to be added to white flour to avoid the danger of calcium deficiency in children. Iron, that we need to make the haemoglobin that carries oxygen in our red blood cells, may be deficient in some diets but this can be corrected by eating eggs, meat, liver or green leaves. Iodine is needed in tiny amounts by the thyroid gland for making growth hormones (Module 12.8). In a few places there is no iodine in the soil, and people who live there may not get enough iodine in their food. This can lead to goitre which is the swelling of the thyroid gland in the neck. The picture shows a severe case of goitre. In places where this occurs, a little iodide can be added to table salt to prevent the disease.

Water is about 70% of most living organisms including ourselves. It is the solvent in every cell, in our blood, in our stomach and intestine to digest food, in our urine to eliminate wastes, and in our sweat to control body temperature. All the food we eat contains water, but we also need to drink two to three litres a day to keep healthy. Pregnant women and nursing mothers may need more, and we all need more when we sweat a lot. We may survive for weeks with no food, but not even one day with no water.

Fibre is an important part of a healthy diet. It consists of cellulose from the cell walls of the plants we eat. We cannot digest fibre and we eliminate it in our faeces, but it adds bulk to our food and this helps the muscles around our intestines to push the food along by peristalsis (Module 12.3). As the fibre passes through, it stimulates the wall of the intestine and this may reduce the risk of bowel cancer. The best sources of fibre are unprocessed plant foods including whole grain foods, fruit and vegetables.

1. What are (i) vitamins, (ii) minerals, (iii) fibre, (iv) diary foods, (v) whole grain food? Give examples.
2. What are (i) rickets, (ii) calcium deficiency, and (iii) goitre? How can each of these be avoided?
A balanced diet contains the correct balance of foods from all the three main food groups, together with sufficient fibre and water. The table shows the recommended daily intake (RDI) for each of the main food groups, and also for fibre and water. The RDI is the daily intake of each kind of food as recommended by the authorities in many countries for a balanced 8400 kJ diet.

<table>
<thead>
<tr>
<th>Food type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>300 g</td>
</tr>
<tr>
<td>Lipids (including saturated fats maximum)</td>
<td>65 g (20 g)</td>
</tr>
<tr>
<td>Proteins</td>
<td>50 g</td>
</tr>
<tr>
<td>Fibre</td>
<td>25 g</td>
</tr>
<tr>
<td>Water</td>
<td>2.5 litres</td>
</tr>
</tbody>
</table>

Nutrition labels on packaged foods are compulsory in many countries. They show the amount of carbohydrate, fat (lipid), protein, fibre, vitamins and minerals in a 100 g serving. They may also show the RDI for each food and the percentage of the RDI that is provided in a serving.

Fatty foods provide lipids and sugary foods provide quick energy, but intake of both should be limited (Module 16.7).

Malnutrition is the result of a diet that lacks one or more essential foods. Acute forms of malnutrition are associated with war, famine and starvation. They are caused by an inadequate intake of energy foods and proteins, and they are usually made worse by deficiencies of vitamins and minerals (see Module 16.4). When we do not eat enough energy foods, the body converts fat stored under the skin into glucose and ‘burns’ the glucose to obtain the energy it needs to keep going. When there is no more fat, the body starts to convert protein from the muscles into glucose. The muscles waste away and the person becomes thin and listless, with less and less energy. The girl in the picture, and the boys in the picture in Module 16.1, are all suffering from severe malnutrition because of war in their countries.

- 1. What are a balanced diet and RDI? Find out why the RDI for saturated fats is limited.
- 2. How does the body obtain the energy to stay alive when there is not enough food?
Before you go on, review Modules 12.13/14 about pregnancy, birth and the growth of infants.

**Pregnant women** have to eat for two; for themselves and the baby growing inside them! During the first trimester a good healthy balanced diet is sufficient. However, a pregnant woman needs an extra 1500 kJ of energy foods a day during the second semester (weeks 13 – 28) and an extra 2000 kJ a day during the final trimester (week 29 onwards). During this time, a baby develops fast and it also needs extra protein and vitamin B9 (folate or folic acid) for growing new cells, extra calcium for making new bones, and extra iron for making new blood. To cover all these needs, the diet of a pregnant woman must be varied and should include low-fat dairy products, meat and/or eggs and/or legumes, whole grain products, and fresh fruit and vegetables.

**Nursing mothers** who are breast-feeding their babies have similar needs to a pregnant woman in her third trimester. They are still eating for two! They need an extra 2000 kJ of energy foods a day, with extra protein, calcium and iron. They also need extra water and should drink at least 3 litres a day.

### Breast feeding vs. Bottle feeding

<table>
<thead>
<tr>
<th>Breast-milk has natural antibodies to fight disease</th>
<th>Bottle-milk has no antibodies to fight disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean (hygienic)</td>
<td>Not always clean; may cause diarrhoea etc</td>
</tr>
<tr>
<td>Perfectly balanced food</td>
<td>Well balanced food (but only if made up properly)</td>
</tr>
<tr>
<td>Correct temperature</td>
<td>Temperature is variable</td>
</tr>
<tr>
<td>Easy and no cost</td>
<td>Difficult and expensive</td>
</tr>
<tr>
<td>Best for mother/child bond</td>
<td>Second best for bonding</td>
</tr>
</tbody>
</table>

**Babies and growing children.** A baby is usually breast-fed for the first six months. The reasons why ‘breast is best’ are summarised in the table. Breast milk is a perfectly balanced, hygienic food that contains all the nutrients a baby needs. It also contains natural antibodies to fight disease (see Module 16.10), it is always at the right temperature, and it is the easiest and cheapest way. Almost all women can breast-feed their babies but a few need help to get started, like the girls in the photo above who are attending a breast-feeding clinic. If a mother cannot breast-feed her baby, she should ask a health worker to teach her to use a bottle and a proper baby-milk formula with the proper nutrients. The milk must be hygienically prepared using good drinking water at the right temperature, and the bottles and teats must be well washed, and sterilised, between feeds.

Until a baby is 6 months old, it cannot properly digest any food except human milk. Between about 6 and 9 months a baby is weaned onto solids, starting with soft foods like mashed fruit and vegetables, and cereal (grain) products mashed with milk. One reason for weaning is that breast milk does not contain much iron. Babies have plenty of stored iron when they are born but this needs to be supplemented from ordinary food after 6 to 9 months. Babies and infants should not be given sugar, salt or caffeine (a stimulant in tea, coffee and cola).

Children need the same balanced diet as adults, but they are still growing so they need more-food-for-their-size than adults. Proteins, vitamins and minerals are very important for growing children, especially calcium and vitamin D which are needed for the growth of healthy bones. The child on the left has rickets (deformed bones) due to vitamin D deficiency. A child should be weighed at a clinic every month in the first year, then every three months. Typical weights are: at birth 2 – 4 kg, 6 months 6 - 9 kg, 1 year 7.5 – 11.5 kg, 2 years 9.5 - 14 kg. If a child’s weight does not increase steadily, parents should get advice from a health worker.

- 1. List the special food needs of a pregnant woman.
- 2. What should a mother do if she has difficulty breast-feeding? What foods should be avoided when weaning?
- 3. How often should a baby be weighed at the clinic?
16.7 OVEREATING

There is an old saying that you can have too much of a good thing. This is certainly true of food. If we regularly eat a lot more than we need, we are likely to get fat! Eating too much carbohydrate or lipid or protein can all lead to overweight or obesity and associated health issues. The box on the right describes how to work out your body mass index (BMI) which is a measure of how slim or fat you are. For adults, a BMI of 18.5 to 25 is normal. For 16-year-olds the normal range is about 17 to 23.5 and slightly less for younger teens.

What happens when we eat too much? Our bodies process excess food of all kinds in similar ways. If we eat more carbohydrate than we need, the body converts a limited amount of this into a special form, a polymer of glucose called glycogen which is stored in the liver. The rest is converted into fat and stored in a layer under the skin. If we eat more protein that we need, the nitrogen it contains is converted to urea and excreted in our urine. At the same time, a limited amount of the protein is converted into glycogen and stored in the liver, and the rest is converted into fat and stored under the skin. Finally, if we eat more oils and fats than we need, the body cannot convert them into glycogen so they are all stored in the fatty layer under the skin.

In the natural world, the glycogen and fat have survival value. If we cannot get enough food, glycogen can be converted into glucose quickly and carried to all our cells to provide the fuel they need. When the glycogen runs out, the fat can be converted into glucose too, but this takes longer. In places where famine occurs regularly, it makes sense that we can store up energy in the good times so that we will not starve in the bad times. For most of us, however, there are no really bad times and storing a lot of fat leads to overweight and obesity as shown by the man in the picture. Overweight and obesity are often associated with poor general health, unfitness, heart disease, diabetes and a shortening of life.

Overweight and obesity are often caused by junk foods; especially sugary food like sweets, cakes, pastries and soft drinks, and fatty food like chips and fried ‘fast foods’. Sweet foods are nice for a treat, and ‘fast food’ is sometimes convenient, but the healthy choices are whole grain and dairy foods, fresh fruit and vegetables, and meat, fish or eggs cooked with only a little fat.

Vitamins and minerals are foods we need in tiny amounts, but some of them are poisons if we eat too much of them! If we eat enough fresh food, we will not need vitamin and mineral tablets!

<table>
<thead>
<tr>
<th>BMI</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 18.5</td>
<td>underweight</td>
</tr>
<tr>
<td>18.5 - 25</td>
<td>normal</td>
</tr>
<tr>
<td>25 - 30</td>
<td>overweight</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>obese</td>
</tr>
</tbody>
</table>

1. What are (i) BMI, (ii) obesity, (iii) glycogen, (iv) junk food?
2. Find out what is diabetes.
3. Why is it not healthy to eat too much (i) sugar, (ii) lipids?
4. List as many reasons as you can for eating a variety of fresh fruit and vegetables regularly.
16.8 INFECTIVE AGENTS 1 – BACTERIA AND VIRUSES

An illness or disease is an unhealthy condition of the systems, organs or tissues of the body that prevents it from functioning properly. The systems, organs or tissues may be defective from birth, or may become damaged later. Infectious diseases occur when we are infected with parasitic organisms that damage our cells and/or make poisons called toxins. Most infective agents are micro-organisms; so small we need a powerful microscope to see them. Micro-organisms that cause disease are often called germs and they are classified as bacteria, viruses, fungi and protozoa.

Bacteria are the oldest, smallest and most numerous living organisms on Earth. They are single celled organisms and their cells have a cell membrane but no nucleus. Geologists have found fossils of bacteria 3.85 billion years old, so they have been around almost as long as the Earth. They have various shapes and sizes but most are just a few microns long. Some common shapes are shown in the diagram; cocci are spherical, bacilli are rod shaped and spirochetes are twisted. Thousands of species of bacteria have been identified but there are thousands more waiting to be discovered. There are billions of bacteria everywhere and, although they are tiny, the total mass of all the bacteria on Earth is greater than the total mass of all the animals and plants. Bacteria play a vital part in our environment, for example, without them nothing would ever rot away! Billions of bacteria live on our skin and billions more inside our bodies. Someone calculated that, if we could get rid of them all, the average person would weigh about 4 kg less!

A micron (micrometre, symbol μm), is a millionth of a metre or 10^−6 m (μ is a Greek letter ‘mu’). A full stop measures ~ 100 μm. 1000 μm = 1 mm

Growing bacteria. Agar plates contain a jelly with nutrients dissolved in it. If you have some agar plates you can try this. Lift the lid off a plate and leave it open to the air for 5 minutes; close the lid and label it AIR. Open a new plate, rub your finger on the jelly, close the lid and label it FINGER. Cough onto another plate, or rub the jelly with a comb, then label it. Keep one plate closed and label it CONTROL.

Leaf the plates in a safe, dark, warm place so any bacteria can grow and multiply. Look at the plates every day for 4 days. Do not open them. You should see patches growing on all the plates except the control. These are colonies of bacteria (and/or fungi). Growing micro-organisms like this is called culturing. Destroy all used agar plates in a hot fire.

Most bacteria do not affect us but some are useful; for example some, on our skin, break down the millions of dead cells that we shed every day; others, in our intestines, help us digest our food. Fortunately, only a few species of bacteria are parasites that cause disease. Disease bacteria include Staphylococcus aureus (which causes pimples and boils on the skin and pneumonia in the lungs), and Streptococcus sp. (which causes some kinds of sore throats and tooth decay). Other well known diseases that are caused by bacteria are tuberculosis, tetanus, cholera, plague and leprosy.

Viruses are weird! They do not move, feed, grow, respire or excrete, so they are not normal living organisms. They are about 100 times smaller than bacteria and we can see them only with a special kind of microscope called an electron microscope. Viruses consist of complex organic molecules that are surrounded by a layer of protein and the main thing they do is reproduce! Viruses are everywhere and if a virus meets the right kind of cell, it can inject itself into the cell and turn the cell into a virus factory to make millions of copies of itself. This damages or destroys the cell (see diagram) and that is why viruses can cause diseases in most animals and plants. Viral diseases include colds, influenza, measles, chicken pox, dengue fever and AIDS.

- 1. Are the bacteria that live on, and inside, our bodies examples of mutualism, commensalism or parasitism? (Module 15.6). Explain why.
- 2. In the experiment on culturing bacteria, what is the ‘control’ plate for?
- 3. Viruses show 2 of the 7 characteristics of living things. Which two?
16.9 INFECTIVE AGENTS 2 – FUNGI, PROTOZOA AND LARGER PARASITES

**Fungi** feed by breaking down the cells of other organisms. Most fungi are decomposers that live on dead organic matter, but some cause disease by attacking living cells in plants and animals.

Fungi of the genus *Tinea* can attack the outer layers of our skin and cause intense itching. An itchy infection between the toes is called *athletes foot* (picture left), round itchy patches on the head which may cause the hair to fall out, are called *ringworm* (it's not a worm, it’s a fungus!) and an itchy infection in the groin is called *dhobi's itch*. *Tinea* or similar fungi are responsible for all these conditions. *Tinea* is highly infectious (easily passed from one person to another) but can be avoided by good hygiene (see Module 16.11). Medicines in the form of creams or powders can be used to kill the fungi.

Members of the genus *Candida* (part of the yeast family) live on the warm, moist linings of the mouth, throat, intestines, vagina and penis. Mostly they cause no problems, but if they get out of control they can cause a disease called *thrush*. Thrush causes inflammation and soreness in the parts affected and the *Candida* can often be seen as a white coating that smells of yeast, for example on the tongue or throat. Pills and creams are available to cure *Candida* infections.

**Protozoa** are unicellular animals of the protista kingdom. Their cells have membranes and nuclei and they are larger than bacteria; about 10 to 50 microns, but a few are larger. Three protozoa that cause diseases in humans are shown in the diagram (left). *Entamoeba* may occur on contaminated food; it causes dysentery and bloody diarrhoea. *Plasmodium* may be injected in the bites of certain mosquitoes; it causes malaria. *Trypanosoma* may be injected in the bites of tsetse flies; it causes sleeping sickness. There are other protozoa that cause other diseases.

**Larger parasites** may be external (living on the skin) or internal (living inside the body). *External parasites* include insects such as fleas and lice, and arachnids such as ticks and mites. They drink our blood and irritate our skin and they may infect us with other diseases. One of the most unpleasant is the mite which causes *scabies*. It tunnels under the skin causing intense itching and a rash. The tunnels made by the mites can be seen as streaks in the rash which may also become infected with *Staphylococci*. External parasites are passed on by close personal contact and by sharing clothes, bed linen, towels or combs. They can be avoided by good hygiene (Module 16.11) and killed by using creams or soaps that contain insecticides.

**Internal parasites** include bacteria, viruses and protozoa. They also include larger organisms such as worms which are adapted to living inside our bodies. Some parasitic worms are only 1 or 2 cm long, for example *bilharzia worms* that live in the veins around the bladder or intestine, and *hook worms* that live in the small intestine and lungs. Others are much larger, like the *tape worms* that live in the intestine and may be 10 m long! *Nematode worms* up to 30 cm long are common in the intestines of children. The notorious *guinea worm* (being extracted from a man’s foot in the picture by twisting it around a match) is now rare. Worms weaken us by drinking our blood and damaging our tissues. Those in our intestines may also absorb our food. We can become infected with worms by walking barefoot on contaminated ground, by bathing in, or drinking, dirty water, or by eating contaminated meat and fish that are not well cooked. Worms can be avoided by good hygiene and killed by various medicines.

1. What parasites cause (i) malaria, (ii) scabies, (iii) athletes foot, (iv) thrush?
2. A person has a sore throat and a white coating on the tongue. What is wrong?
3. What is meant by (i) good hygiene, (ii) contaminated ground, or water or food?
16.10 THE TRANSMISSION OF INFECTIONS

Certain bacteria, viruses, fungi and protozoa can infect human beings and cause diseases. Because they are so tiny, these micro-organisms (germs) can spread easily and invisibly with the help of air, water, food and animals. They reproduce very quickly; if only a small number infect us they can soon become a huge number (see text box). The symptoms of the disease – the signs that tell us we are sick, such as fever, headache, vomiting or a rash – occur because millions of disease organisms are damaging our cells, or releasing poisons called toxins, or both. In this module, we will focus on the different ways in which germs are transmitted (passed on) to us.

Disease organisms reproduce fast

When they find food and warmth, some disease organisms reproduce very fast. Some bacteria can reproduce by binary fission every 20 minutes. In one hour, a single bacterium will become 8; after three hours there will be 512; and after 12 hours there will be 68719476736. Check it for yourself!

Air-borne diseases. Many germs are spread by the air. When people cough or sneeze or spit, millions of bacteria and viruses are sprayed into the air in tiny droplets of water and mucus. The germs may land on food or float in the air for hours for other people to breathe in. This is how diseases spread in crowded places like schools, buses and meetings. Diseases that are spread in this way include colds, influenza, and tuberculosis. The poster is reminding soldiers to cover their mouth and nose when they cough or sneeze!

Water-borne diseases. Many germs are spread by contaminated water. This often occurs after disasters like earthquakes and floods when drinking water becomes contaminated with sewage, including decaying matter and faeces. Diseases that are spread in this way mostly affect the digestive system; they include polio, typhoid, cholera and other diseases that lead to severe diarrhoea. Bilharzia worms can infect us through our skin if we wash or swim in contaminated water.

Food-borne diseases. Many air-borne and water-born germs get into our food. Food becomes contaminated when it is prepared in a dirty place, or with dirty containers and tools. Germs also get into food if it is prepared by someone who has not washed their hands properly (especially after using the toilet) or when flies land on the food after feeding on decaying matter or faeces. If warm food is left out for long, bacteria can contaminate and grow in it very quickly. Such food may look and smell good but if it has been contaminated by bacteria such as Salmonella, the germs, and the toxins they make, will cause food poisoning. Hot food that is not eaten at once should be covered and kept in a refrigerator.

Contact diseases. Some germs are spread by contact with an infected person or with something they have been touching like pillows, bed sheets, towels or combs. The fungi that cause ring worm and athletes foot are spread in this way and so is the bacterium that causes red eye. Some germs are spread mainly, or exclusively, by sexual contact. These include the virus that causes AIDS and the micro-organisms that cause other sexually transmitted diseases (STDs).

Vectors. A vector is an animal that carries and transmits germs. Vectors for human diseases include the rats and their fleas that spread plague and the flies that carry bacteria onto our food. Biting insects that carry particular germs can actually inject the germs into us. Tsetse flies inject the Trypanosoma that cause sleeping sickness, Anopheles mosquitoes inject the Plasmodia that cause malaria, and Aedes mosquitoes inject the viruses that cause dengue fever.

- 1. What are (i) germs, (ii) binary fission (iii) symptoms, (iv) sewage, (v) Salmonella, (vi) STDs, (vii) vectors?
- 2. Look at the photo of the people in the river. Why is water-borne disease a danger here? Give examples.
16.11 OUR DEFENCES AGAINST INFECTION

Our best defence against germs is to prevent them from entering the body. The most important barrier is the dead cells on the epidermis, or outer layer, of our skin (Module 12.9). The skin also protects us with an antiseptic oil called sebum which comes from glands in the dermis, or inner layer. The delicate surface of the eye, the cornea, is protected by our eyelids (Module 7.12). Every time we blink, we wipe the cornea with a mild antiseptic liquid from our tear ducts and this keeps germs away from our eyes.

Airborne germs enter the body through our nose and mouth when we breathe. We are protected from most of these by a thick fluid called mucus which is secreted by glands in the walls lining the air passages in the nose and lungs. The mucus traps the germs and tiny hairs called cilia, on the cells that line these passages, move the mucus towards the throat where it is coughed up or swallowed (see the diagram right and Module 12.2). Germs in the mucus that we swallow go straight to the stomach. There they join any food-borne or water-borne germs that we have taken in with our food and drink. In the stomach, most of these germs are killed by the strong hydrochloric acid there which has a pH of between 1 and 2 (Modules 12.3 and 13.8). Only a few germs can survive this and pass through into our intestines where they can infect us.

The role of blood is important in our defence against infection. Blood circulates to every cell in the body (Modules 8.4/5) and its main components are summarised in the table.

<table>
<thead>
<tr>
<th>Component</th>
<th>Where made</th>
<th>No. in 1 mm³</th>
<th>Size in μm</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>carries salt, glucose, amino acids, carbon dioxide, urea, proteins, hormones and more.</td>
</tr>
<tr>
<td>Red cells</td>
<td>Bone marrow</td>
<td>5500000</td>
<td>6 to 8</td>
<td>carry oxygen.</td>
</tr>
<tr>
<td>White cells</td>
<td>Bone marrow, lymph nodes and spleen</td>
<td>4000 to 11000</td>
<td>7 to 21</td>
<td>protect us against disease by ingesting (eating) germs and by making antibodies.</td>
</tr>
<tr>
<td>Platelets</td>
<td>Bone marrow</td>
<td>400 000</td>
<td>2 to 3</td>
<td>enable blood to form clots and scabs.</td>
</tr>
</tbody>
</table>

The components of blood

The diagram (left) shows what happens if something breaks the skin. Blood escapes from damaged capillaries in the dermis and platelets in the blood are attracted to the damaged cells. The platelets are tiny bits of broken cells and they clump together around the wound. They produce a substance that changes a protein in the blood into tiny fibres called fibrin. The fibrin forms a network that traps the platelets and red blood cells and forms a solid blood clot to seal the wound. The clot contracts as it dries, pulling the edges of the wound together and becoming a scab that keeps out germs. Meanwhile, large white cells (which can move around on their own by changing shape) squeeze out through the walls of the capillaries and destroy any bacteria or viruses they find by flowing around them and digesting them. Any germs that get into a capillary are soon gobbled up (ingested) by white cells too. If the wound is badly infected, a white or yellowish fluid called pus may form. Pus is mainly a mixture of dead white cells and plasma (lymph). As the wound heals the pus drains away. Pussies spots and boils on the skin occur when hair roots or blocked pores become infected by bacteria, usually Staphylococci.

There are several different kinds of white cells and, in addition to ingesting bacteria and viruses, they also defend us by producing chemicals called antibodies. Some antibodies kill the germs and others neutralise the toxins (poisons) that the germs produce. You will learn more about antibodies in Module 16.13.

- 1. What are (i) antiseptics, (ii) sebum, (iii) mucus glands, (iv) cilia, (v) platelets, (vi) fibrin, (vii) blood clots, (viii) pus, (ix) lymph, (x) toxins, (xi) antibodies?
- 2. (i) How does the size of white cells compare with the size of bacteria? (ii) How does the number of white cells in the blood vary? Why do you think it does this?
16.12 THE PREVENTION OF DISEASE 1 – HYGIENE

Germs thrive and multiply in dirty places, so one of the best and easiest ways we can protect ourselves against disease is to keep ourselves and our surroundings clean. Keeping things clean, and as free from dangerous germs as possible, is called hygiene.

**Personal hygiene** means keeping ourselves clean. In addition to dirt from other sources, our sweat glands excrete waste products and our oil glands secrete oily sebum through pores in the skin. If the skin is not cleaned regularly, millions of bacteria feed on these materials, rotting them, making an unpleasant smell, and blocking the pores which may become infected and develop into pussy spots. We should wash well with soap and water every day giving special attention to the groin, the armpits and the face and head. To avoid the danger of infecting our own or other peoples' food, we should also wash our hands several times a day – when we get up, after we use the toilet, before we prepare food, and before we eat.

Our clothes, towels, bed linen and combs all collect germs (and possibly other parasites) from our bodies. They must all be washed regularly and we should change our underclothes every day.

Personal hygiene includes the obligation to avoid infecting others. To avoid spreading air-borne diseases, we should keep away from others when we are sick or have a cold, cover our nose and mouth when we cough or sneeze, and we should never spit. Human faeces are a common source of water-borne and vector-borne infections so we should always use a proper toilet if we can. If we have to defecate in the open, we should keep well away from water sources and we should bury the faeces so that vectors such as flies, rats and domestic animals cannot pick up germs from them. In areas where people may defecate on the ground, we should wear shoes to protect us from hook worm larvae which can enter the body through the foot. And of course we must leave shoes at the door when we enter anyone’s home.

**Food hygiene** plays a vital part in preventing disease. Surfaces on which food is prepared must always be clean and should be wiped regularly with a suitable disinfectant such as Dettol, Jeyes Fluid or bleach to kill germs. All plates, containers and tools used with food must be clean too and people preparing food should wash their hands frequently, especially after using the toilet or after touching anything that has been on the floor. Food that has been on the floor should never be eaten. Some important food contamination issues include the following.

- Before and after it is prepared, we should protect food from vector and air-borne germs by using fly screens and containers with lids. A refrigerator is the best place for perishable food that has to be stored for some time; the low temperature slows the growth of bacteria.
- Raw meat and fish often contain a lot of bacteria and sometimes the eggs or larvae of parasitic worms. They must be well cooked to kill any contaminating organisms. Surfaces on which raw meat has been prepared must be disinfected before other food is prepared there.
- Salad vegetables must be well washed in clean drinking water; fruit should also be washed or freshly peeled.

**Water hygiene** is essential for a healthy community. This is not usually a problem in places with piped water. Piped water will come from a clean source or will have been treated with chlorine to kill germs. In other places, water for drinking should be boiled and communities should make sure that water sources do not become contaminated, especially with human faeces. The most reliable way to achieve this is by providing water closet toilets or properly constructed latrines.

**Environmental hygiene** means keeping our surroundings clean and healthy. Domestic rubbish looks and smells bad and it encourages disease vectors such as rats, flies and mosquitoes. Metal, paper, cardboard and plastic rubbish should be recycled if possible and food scraps should be composted and turned into soil. Alternatively, most rubbish can be buried or burned.

1. Why should we (i) not undercook meat, (ii) leave shoes outside, (iii) use toothpaste, (iv) recycle rubbish?

2. Describe and explain the dangers to community health when people defecate on the ground.
16.13 THE PREVENTION OF DISEASE 2 – IMMUNITY AND VACCINATION

A person may become immune to a particular disease naturally or by vaccination (see also Modules 16.15/16). To understand how immunity and vaccination work, we need to think about what happens when disease organisms invade our bodies.

Particular germs tend to infect particular tissues or organs, for example tuberculosis bacteria usually attack the lungs and hepatitis viruses attack the liver. As germs multiply inside us, they damage or destroy our cells and tissues and they may also release poisons called toxins. Our immune system responds to the cell damage and the toxins and we experience symptoms that tell us we are sick. These symptoms may include pain, fever, rashes, coughs, sneezes, vomiting and diarrhoea. They are part of our attempt to fight the invasion. For example, most germs are sensitive to heat so the immune system allows our temperature to rise a few degrees. This kills or slows down some of the germs but it also causes us to feel unwell and experience fever. In the same way, coughing, sneezing, vomiting and diarrhoea are all ways to get rid of the germs and their toxins. Unfortunately they also help to spread the germs! However, our immune system relies mainly on several different kinds of white blood cells that recognise and attack germs. The blood carries the white cells to the site of the infection and ‘killer’ cells exit the capillaries and start to ingest the invaders. Other white cells ‘identify’ the germs and start to make substances called antibodies that will kill these particular germs and neutralise their toxins. They also release chemicals that stimulate the body to produce more white cells in the bone marrow, spleen and lymph nodes. In a few hours, or days, the number of white cells can increase from about 4000 cells per mm$^3$ to over 10000 per mm$^3$. If the patient is well-nourished and fit, the white cells usually win the battle and the patient recovers. However if the patient is malnourished or unfit, or if the germs are unusually virulent (strong), the germs may win and the patient may die.

**Acquired immunity.** After a person has recovered from a disease, the antibodies against that disease remain in the blood for some time. This protects the person from getting the disease again. Even after the antibodies have gone, the white cells ‘remember’ the germs. If the same germs invade the body again, the white cells produce the antibodies to kill them off very quickly, before they do any damage. Because of this, we say the person has got acquired immunity to the disease. For example, if a person has measles once, they are unlikely to get it again, even if they are exposed to the measles virus. For some diseases such as measles, acquired immunity lasts for life. For other diseases, including influenza and the common cold, it lasts only a few weeks!

**Vaccination** (immunisation) gives immunity to a particular disease by injecting the body with dead or weakened germs of the disease, or a harmless form of the toxin they produce. The white cells respond by producing antibodies, just as they would against the real disease, so we develop acquired immunity. If we are infected with the real germs later, the white cells ‘remember’ them and quickly produce the antibodies to kill them. In most countries, every child is protected against deadly childhood diseases by vaccination. The commonest vaccines are measles, polio, BCG (for tuberculosis), and DPT (for diphtheria, whooping cough and tetanus, all in one injection). To provide full immunity, most vaccinations require one or two follow-up or booster injections spread out over a few months or years. To monitor these, parents and health workers must keep careful records of every child’s vaccinations. Details of common diseases will be found in later Modules.

Vaccination provides protection for communities as well as individuals. The diseases mentioned above used to kill thousands of children every year. Now that most children are vaccinated against them, some of these diseases are starting to die out so the whole community is safer. Smallpox used to kill, blind or disfigure millions, but it was finally wiped out by vaccination in 1979. Now polio, which used to be widespread, occurs regularly in only four countries. This may be the next disease to be wiped out. However, if parents become complacent and fail to vaccinate their children, many serious diseases could become common again.

In addition to protecting children and communities, vaccination is used to protect travellers who go to places where dangerous diseases are common. It is also used to protect people when there are epidemics. For example, epidemics of the deadly water-borne disease cholera often occur after natural disasters such as earthquakes, cyclones and floods. Injecting everyone with cholera vaccine provides only 6 months immunity but that is enough to save many lives.

- 1. What are (i) the immune system, (ii) vaccination, (iii) acquired immunity, (iv) an epidemic, (v) BCG and DPT?
- 2. How does vaccinating children benefit the community as well as the child? What are vaccination records for?
Diagnosis is the process that doctors or health workers go through to decide what is wrong with a patient. They consider the patient’s symptoms (pain, rash, fever, swellings, vomiting, coughing and so on) and they also carry out tests such as taking the patient’s temperature, pulse or blood pressure, or taking samples of urine or blood for analysis in a laboratory. When they have identified the problem, they write a prescription for a suitable medicine or treatment. Any person, especially a child, who has severe symptoms, or mild symptoms that persist for several days, needs to see a doctor.

Minor problems like small cuts, grazes, pimples and boils are usually treated by ‘first aid’ at home. The area is cleaned well with soap and water to remove dirt and germs, and then treated with a suitable antiseptic (a medicine for killing germs on the skin). The area can be covered with a plaster to keep it clean, but the plaster must be changed every day. Minor fungal infections, like athletes foot and ring worm, are first cleaned then treated with a fungicide. With home medicines of this kind, it is important to follow the instructions on the bottle or tube. Iodine solution (often sold as ‘Betadine’) is an effective antiseptic and fungicide. Larger wounds or skin infections, and any condition that does not heal quickly, must be treated by a qualified health worker.

Viral diseases include measles, dengue fever, the common cold and influenza. At present there are no medicines that kill viruses; all we can do is treat the symptoms and help the natural defences of the body to defeat the invaders. Medicines that are often used include paracetamol (‘Panadol’) which is the safest one for reducing pain, temperature and swellings, cough mixtures to ease coughing and so on. The common cold is usually treated in this way at home, but more serious diseases need to be treated by a qualified health worker.

Diseases caused by bacteria, fungi, protozoa and larger parasites can all be cured by killing the organisms that cause them. Antibiotics such as penicillin are medicines that kill bacteria and fungi. Quinine, chloroquine and similar medicines kill the plasmodia that cause malaria and a number of different medicines are used to kill other internal and external parasites. Medicines that only treat the symptoms, such as paracetamol and cough mixtures, are also useful. It is important that patients take ALL of the antibiotic or other germ-killing medicine prescribed. If they stop taking the medicine as soon as they feel a bit better, the disease may come back and the germs may start to develop drug resistance with serious results for the community (see text box).
Basic information about some common viral diseases is provided below. Symptoms and treatments can vary. If you believe that you may have any disease you should consult a doctor.

**The common cold** is caused by air-borne viruses; they can also be transmitted by direct contact. The virus attacks the upper respiratory system causing symptoms that include a runny nose, sore throat, coughing and mild fever. There is no cure but the symptoms can be treated with paracetamol, gargling and cough mixtures. A cold usually lasts from about 1 to 3 weeks.

**Influenza** is caused by air-borne viruses; they can also be transmitted by direct contact. The virus attacks the respiratory system and symptoms are similar to those of the common cold but more severe; sore throat, coughing, fever, headache, muscle pains and general weakness. There is no cure but symptoms can be treated with paracetamol, gargling, cough mixtures, bed rest and plenty to drink (not alcohol). New strains of the virus often develop in birds and domestic animals by natural selection. If these viruses infect humans, we sometimes get dangerous epidemics like ‘bird flu’ and ‘swine flu’. Such epidemics often kill a lot of people, especially young children, the elderly and those with poor nutrition. Influenza can be prevented by regular vaccination.

**Measles** is a highly infectious disease caused by an air-borne virus; it is also spread by direct contact. The virus attacks the respiratory system but also spreads throughout the body. It is very dangerous for young children and on average more than 400 children die from measles every day, mainly in developing countries. The first symptoms are often fever with a runny nose, a cough and red eyes, followed by a rash on the face which spreads down the body. There is no cure but symptoms can be treated with paracetamol and cough mixtures. Measles can be prevented by vaccination which is advised for all children. The first of three injections should be given at six months.

**Mumps** is a viral disease spread by air-borne droplets and direct contact. The virus attacks the salivary glands causing painful swelling of the neck on one or both sides; it occasionally attacks other glands including the testes in males. Other symptoms include fever and headache. There is no cure but symptoms can be treated with paracetamol. Mumps can be prevented by vaccination which is sometimes included in childhood vaccination programs.

**Rubella** (or German measles) is a viral, air-borne infection. Symptoms are often mild but are similar to ‘flu with a rash like measles. The disease is important because it can damage the developing foetus in a pregnant woman causing stillbirth or birth defects. In some countries, a vaccine to prevent rubella is available for teenage girls and young women.

**Chicken pox** is an infectious viral disease spread by air-borne droplets and direct contact. Symptoms include coughing, headache and fever, with a spotty rash mainly affecting the body and head. The spots are itchy and, if scratched, they can become infected and leave scars. There is no cure but paracetamol can be used for the headache and fever, with soothing creams and antiseptics for the spots. Gloves can be used to discourage scratching. Chicken pox can be prevented by vaccination.

**Polio** is a viral disease spread by food contaminated from human spit or faeces by vectors such as flies and unwashed hands. Often there are no symptoms, but occasionally the virus attacks motor neurons (Module 12.7) resulting in permanent paralysis of one or more parts of the body. Up to the middle of the last century polio crippled thousands every year, but vaccination has now wiped out the disease in most countries. Normal childhood vaccinations still include polio.

**Dengue fever** (break-bone fever) is a vector-borne viral disease that is spread by the bite of the *Aedes* mosquito. The symptoms include fever, headache, a rash similar to measles, and pain in the muscles and joints. As with all viral diseases, there is no cure but if symptoms are severe they can be treated in hospital. No vaccine is available and prevention depends on suppressing mosquitoes and avoiding their bites.

1. List all the things you can do to avoid getting (i) ‘flu, (iii) dengue, (iii) chicken pox, (iv) polio, (v) mumps.
2. How should you treat (i) ‘flu, (ii) chicken pox?
3. Why might teenagers fear rubella and mumps?
16.16 COMMON BACTERIAL DISEASES

Basic information about some common bacterial diseases is provided below. Symptoms and treatments can vary. If you believe that you may have any disease you should consult a doctor.

**Tuberculosis (TB)** is a serious bacterial disease. It is caused by a bacillus that is transmitted by the air, especially by sneezing, coughing and spitting. It usually attacks the lungs and symptoms start with a dry cough. If not treated, the cough becomes worse with spitting of blood, wasting (becoming thin) and death. The disease can also affect other organs and about two million people die from TB every year. To diagnose TB, health workers may use skin tests and X-ray photographs of the chest. TB can be cured with antibiotics that kill the bacteria, but if the disease is well established the treatment takes a long time. TB can be prevented by vaccinating infants with the BCG vaccine soon after birth; unfortunately the vaccine is less effective with adults. The spread of this deadly disease can best be controlled by good personal hygiene; covering the nose and mouth when sneezing and coughing, not spitting and washing the hands frequently.

**Tetanus** (or lock jaw) is caused by a bacterium that may be present with soil in deep wounds, especially ‘puncture’ wounds caused by sharp objects that penetrate deeply. The bacterium is killed by oxygen so tetanus is not an issue with ordinary wounds. Symptoms, which may be slow to develop, include muscular spasms and convulsions. Once the symptoms start, the disease is usually fatal. There is no treatment, but many people are immune to tetanus because they received the DPT vaccine when they were children. Anyone who has not been vaccinated, and who gets a puncture wound or a deep wound that may be contaminated with soil, should be vaccinated immediately. People at risk can get a booster dose every 10 years.

**Whooping cough** (or pertussis) is a highly infectious, air-borne bacterial disease which attacks the respiratory system. It starts with a runny nose and mild sneezing and coughing, but develops into severe fits of coughing. Typically, five or ten forceful coughs are followed by vomiting and the disease lasts between one and two months. There is no effective treatment so the emphasis is on prevention using the DPT vaccine (for diphtheria, pertussis and tetanus). This vaccine is given to infants and young children in most countries. Whooping cough is increasing in some places where poorly educated parents have stopped vaccinating their children.

**Diphtheria** is a bacterial infection of the upper respiratory system, spread by the air and by direct contact. Symptoms include a sore throat and fever, with swelling of the throat that often makes it hard for the patient to breathe. Diphtheria used to be common but has largely been wiped out in many countries by vaccinating all children with the DPT vaccine.

**Cholera and typhoid** are unrelated bacterial diseases of the intestine; both are transmitted by water or by food contaminated from human faeces by human hands or insect vectors. Typhoid bacteria can be carried by people called carriers who have no symptoms but who infect others without knowing it. ‘Typhoid Mary’ was a carrier who infected more than 50 people in the USA; three of them died. Both diseases can occur as epidemics. Cholera kills thousands of people when sewage systems and hygiene break down after natural disasters such as earthquakes and floods. Cholera causes profuse watery diarrhoea and vomiting which can lead to dehydration and death within hours. Typhoid causes high fever, headache, delirium, abdominal pain and evil-smelling diarrhoea. Antibiotics shorten both diseases, but the best treatment for all diarrhoeal diseases is **oral rehydration**. A lot of water is needed to replace the fluids lost in diarrhoea (and vomiting and sweating). Use salted rice water, or drinking water with 6 teaspoons of sugar and ½ a teaspoon of salt dissolved in one litre. This saves the lives of millions of children every year. Cholera and typhoid vaccines protect people who travel to places where these diseases occur.

1. What are (i) a bacillus, (ii) an X-ray photograph, (iii) lock law, (iv) a puncture wound, (v) a typhoid carrier, (vi) a booster dose, (vii) oral rehydration?  
2. Why is it important for all infants and young children to be given BCG and DPT vaccinations?  
3. How do you treat (i) a puncture wound, (ii) cholera?
16.17 MALARIA

Malaria is a serious disease that is common in tropical and subtropical countries. About 250 million people suffer from malaria every year and about one million, mostly young children, die of the disease. Malaria is caused by mosquito-borne protozoa of the genus Plasmodium. The commonest species is Plasmodium vivax and the most dangerous is Plasmodium falciparum. The vector is a female mosquito of the genus Anopheles like the one shown on the right. She becomes infected with the plasmodium when she sucks the blood of a person who has malaria. Male mosquitoes feed on the nectar of plants and do not carry malaria. Inside the female mosquito, the plasmodium reproduces and develops, finishing up in the mosquito’s saliva. After that, the mosquito can transmit malaria to every person she bites.

When a person is infected, the blood carries the plasmodium to the liver. In the liver, it grows and reproduces before going on to invade the red blood cells. In the red blood cells, the plasmodium continues to grow and reproduce, periodically bursting open the infected cells and invading new ones. If malaria is not treated, the body’s natural defences usually defeat the disease after some time, but it often recurs. This may be due to re-infection, but some species of plasmodium can ‘hide’ in the liver and re-emerge months or years later. People who are infected several times, acquire some degree of immunity so that the attacks become progressively less severe.

Symptoms of malaria include fever with sweating and chills, headache, muscular and back pain, weakness and vomiting. The fever usually lasts for a few hours and recurs every two or three days, corresponding with the periodic bursting open of the red blood cells. Treatment of malaria used to rely mainly on a medicine called chloroquine which kills the plasmodia. Now, however, the plasmodia in some parts of the world have developed resistance to chloroquine, so new medicines are needed (see the text box about drug resistance in Module 16.14).

The prevention of malaria is very important for people who live in malarial areas. They try to avoid infection by killing the vector (the Anopheles mosquito) and by avoiding its bite. The mosquito can be killed by spraying suitable insecticides inside and around people’s homes, and by interrupting its life cycle (see diagram below). Mosquitoes need still water to lay their eggs on, and this can be restricted by good environmental hygiene. In particular, discarded containers, car tyres and anything that can trap water must be removed. Lying water that cannot be removed can be covered with oil. The bites of mosquitoes can be avoided by screening windows and doors, and by sleeping under a net. Anopheles start to bite around dusk, so wearing clothes that cover the arms and legs in the evening provides some protection. Visitors to malarial areas are advised to take prophylactics throughout their stay. Prophylactics are medicines similar to the cure for a disease. Malaria prophylactics prevent visitors from getting malaria by killing any plasmodia that enter the blood before they get to the liver and reproduce. Visitors can also protect themselves from bites by using insect repellents. Residents do not use such medicines because they may have bad side effects if they are used for too long. Prophylactics and repellents are also expensive.

1. What are (i) vectors, (ii) protozoa, (iii) prophylactics?
2. You have to visit a malarial area. List ALL the things you can do to make sure that you do not catch malaria.
16.18 SEXUALLY TRANSMITTED DISEASES AND AIDS

Before studying this module(6,7),(992,992), review Modules 12.11 and 12 about the human reproductive system. Sexually transmitted diseases (STDs) are diseases that are transmitted only or mainly during sexual intercourse. You are very unlikely to catch any of these diseases except by having ‘unprotected sex’ with an infected person. If a man covers his penis with a condom (a thin rubber sheath) during sexual intercourse, this protects the woman against becoming pregnant and it also protects both of them against the transmission of STDs. This protection is usually effective but it is not guaranteed. Sex workers, and people with many sexual partners, have a high risk of getting these diseases.

Three of the most common STDs are chlamydia, gonorrhoea and syphilis. All three are caused by bacteria and all three can be cured by antibiotics, although drug resistance is becoming a problem. These diseases are particularly dangerous for women because women may have fewer obvious symptoms than men. By the time a woman knows she is infected, the disease may already have caused permanent damage. It is accepted in most communities that anyone diagnosed with an STD has a moral obligation to inform his or her sexual partners so that they can be tested and treated if necessary. After having one of these diseases, immunity is short-lived so a person can catch them many times. The most serious of all STDs is AIDS which is caused by a virus. There is no cure for AIDS.

**Chlamydia and gonorrhoea** are very common bacterial STDs. In men, the bacteria attack the urethra and a common symptom is a pussy discharge from the penis. There may also be by an unpleasant smell and a burning sensation when urinating. Women may have similar symptoms affecting the urethra or vagina. Often they have no obvious symptoms but both diseases can easily be diagnosed by a doctor. If untreated, they may lead to pelvic inflammatory disease affecting a woman’s uterus and ovaries and causing both pain and infertility. Both these bacteria attack the eyes of babies born to infected mothers causing a red and swollen condition called conjunctivitis.

**Syphilis** is a serious STD caused by a spirochete bacterium. The first symptom is usually a painless, hard-edged, ulcer a few weeks after infection. This clears up on its own and may be followed by a general rash a few weeks later. Afterwards there are no symptoms for a long time while the spirochete spreads throughout the body. In time it will attack various organs, often including the heart and the nervous system, causing serious illness and death. Babies born to mothers with syphilis usually have severe birth defects. Syphilis can be diagnosed by blood tests and cured by antibiotics, but any damage that the spirochetes have already caused to internal organs will be permanent.

**AIDS** stands for Acquired Immune Deficiency Syndrome (set of symptoms). It is caused by the human immuno-deficiency virus (HIV) which can be transmitted in three ways: (i) sexually, (ii) from mother to child at birth, or (iii) by direct contact between body fluids such as blood. The latter occurs when people who inject themselves with drugs share needles; otherwise it is rare. Fortunately the AIDS virus is weak and cannot remain active for long outside the body. Normal hygiene gives good protection against HIV when people are tattooed or have their ears pierced. It is impossible to catch the virus by ordinary social contact with someone who has AIDS. In many countries, for example, children born with AIDS go to school with everyone else.

The HIV is a difficult virus to treat because it attacks the immune system by destroying some of the white blood cells. Once the virus has spread inside the body (which may take many years) those infected cannot properly fight off the germs they meet every day. Typical symptoms include fevers, sweating, swollen glands, weight loss and weakness. Patients become more and more sick and eventually die of a common disease which would not be serious for a healthy person. AIDS can be diagnosed by blood tests and antiretroviral drugs can slow down the progress of the disease and greatly prolong life. For many people, however, these drugs are not available or not affordable.

The World Health Organisation estimated that, in 2009, there were over 30 million people infected with AIDS, with about 2 million new infections and 2 million deaths every year.

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- **1. What are (i) a condom, (ii) ‘protected’ sex, (iii) pelvic inflammatory disease, (iv) conjunctivitis, (v) AIDS, (vi) spirochetes, (vii) antiretroviral drugs?**
- **2. Is it safe to: (i) have sex with someone you have just met? (ii) have your ears pierced by your friend?**
- **3. What should you do if you think you have an STD?**