Balanced and unbalanced diets

We need to eat a balanced diet that is related to our needs, as listed in the table below.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficient energy for our needs</td>
<td>Provided by the macronutrients (carbohydrates, fats and proteins); energy intake by the body should equal energy expenditure</td>
</tr>
<tr>
<td>Essential amino acids</td>
<td>Our metabolism cannot make these amino acids from anything else – they have to be in the protein we eat</td>
</tr>
<tr>
<td>Essential fatty acids (linolenic acid and linoleic acid)</td>
<td>Our metabolism cannot make these either – they have to be in foods containing fat or oil</td>
</tr>
<tr>
<td>Micronutrients – vitamins and minerals</td>
<td>Required for a wide variety of functions: many B-group vitamins are used to make coenzymes; some minerals (e.g. Zn and Cu) are cofactors (see page 57)</td>
</tr>
<tr>
<td>Water to replace that lost in urine, sweat, breath, faeces</td>
<td>Water has many functions in the body (e.g. as a solvent, a reactant and a coolant); cytoplasm is about 70% water</td>
</tr>
<tr>
<td>Fibre</td>
<td>Prevents constipation; helps reduce risk of heart disease and bowel cancer</td>
</tr>
</tbody>
</table>

If you read through pages 38 to 57 you will find out how the components of our diet are used in our metabolism. For example:

- fats are used to make phospholipids and cholesterol for cell membranes
- carbohydrate is stored as glycogen in liver and muscles
- proteins in the diet are hydrolysed to give amino acids, which are then used to make our own proteins, such as haemoglobin, collagen and all our enzymes.

**Malnutrition**

Malnutrition means eating much less – or much more – than needed.

- People who are starving do not have sufficient energy or nutrients, and often show symptoms of protein–energy malnutrition. Deficiencies of specific nutrients impair health; for example, a lack of vitamin D leads to rickets.
- Eating more than is needed can lead to obesity, which is associated with many risks to health such as cancer, type 2 diabetes and coronary heart disease (CHD). A person who is very overweight is obese.

**Body mass index** (BMI) is a way of determining whether a person is overweight. This is calculated as:

\[
\text{BMI} = \frac{\text{body mass in kg}}{\text{height in m}^2}
\]

<table>
<thead>
<tr>
<th>BMI</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 18.5</td>
<td>Underweight</td>
</tr>
<tr>
<td>18.5–24.9</td>
<td>Acceptable</td>
</tr>
<tr>
<td>25–29.9</td>
<td>Overweight</td>
</tr>
<tr>
<td>30–34.9</td>
<td>Obese (class 1)</td>
</tr>
<tr>
<td>35–35.9</td>
<td>Obese (class 2)</td>
</tr>
<tr>
<td>Over 40</td>
<td>Severely obese (class 3)</td>
</tr>
</tbody>
</table>

**Examiner tip**

Be careful here about mass and weight. People talk about units of kilograms (or stones and pounds) as weight, when in scientific terms they should say mass.
The prevalence of obesity is increasing in affluent countries as people eat far more food than they need and take less exercise.

**Diet and coronary heart disease**
Many factors, such as diet, lack of exercise, obesity and heredity, contribute to the development of CHD. The prevalence of CHD is high in some countries, for example Scotland, where people consume large quantities of animal fats rich in saturated fatty acids. Countries where people have low consumption of animal fat, such as Japan, have a very low prevalence of CHD. People with high blood pressure (hypertension) are at high risk of developing CHD. Hypertension is related to a high intake of salt that lowers the water potential of blood. Water is retained in the blood, so increasing blood volume, which may lead to hypertension. This puts a strain on arteries in the brain, leading to a stroke. The extra work that is done by the heart may put it under strain and contribute to developing heart disease. Eating highly refined foods with high sugar content and not enough fibre are also risk factors for CHD.

**Blood cholesterol**
Lipoproteins are small particles made in the liver to transport cholesterol. Each lipoprotein is coated with protein to make it water-soluble, and contains a core of cholesterol and other lipids. Cells with appropriate receptors can absorb lipoproteins by endocytosis. There are two groups of lipoprotein:
- low-density lipoprotein (LDL)
- high-density lipoprotein (HDL).

LDLS deliver cholesterol to tissues; HDLS remove cholesterol from tissues and return it to the liver.

If the endothelial lining of an artery is damaged, LDLS tend to deposit cholesterol, which accumulates along with fatty acids, calcium salts and fibrous tissue. This fatty material forms plaques (atherosclerosis) inside the artery walls. Atherosclerosis is the progressive build-up of plaque. Plaque enlarges the wall so that there is less space for blood to flow. It also roughens the lining of arteries, so increasing the chances of blood clots forming.

Oxygenated blood flows from the aorta into the coronary arteries, which supply the muscle in the atria and ventricles of the heart. If these arteries are narrowed with plaques, the heart muscle may be deprived of oxygen and become fatigued. This means that people with this condition find even mild exercise difficult and have chest pains that disappear when they stop exercising. This form of CHD is angina. If a blood clot forms in a coronary artery it may reduce blood flow so much that heart muscle dies, thus causing a heart attack that may be fatal.

The risk of heart disease is increased if there is:
- a concentration of cholesterol in the blood greater than 5 mmol dm⁻³
- a high concentration of LDLS (> 3 mmol dm⁻³)
- a low concentration of HDLS (< 1 mmol dm⁻³)
- a low ratio of HDLS to LDLS. The ideal ratio is 4:1.

**Quick Check Questions**
1. Explain the term malnutrition.
2. Describe how to determine whether someone is obese.
3. Explain why cholesterol is transported in the form of lipoprotein.
Food production and preservation

**Food chains**

Producers form the first trophic level of food chains. Producers are autotrophs – they use an external energy source and simple inorganic molecules to make complex organic molecules. All the other organisms in the food chain are heterotrophs – organisms that take in complex organic molecules (such as carbohydrates, proteins and lipids) to act as a source of energy and to use in their metabolism.

Your diet depends on plants. Many foods, such as bread, are processed plant material. Vegetables and fruits are parts of plants. Animals and animal products, such as milk, cheese and eggs, come from the second trophic level of food chains. Some foods, mostly fish and fish products, come from the third or even fourth trophic level (food chains in the sea tend to be longer than those on land because the producers are tiny).

**Selective breeding**

Domesticated animals have been subjected to artificial selection. Breeders choose the feature or features they wish to improve. Individuals that show the desired features are selected and bred together. The offspring that show an improvement are selected to breed the next generation. Changes occur over many generations, giving varieties very different in appearance from the original stock, and with much improved productivity.

A plant breeder may breed a high-yielding variety susceptible to a fungal disease with a low-yielding variety resistant to the disease by transferring pollen. Seed is collected and sown in the next growing season. The offspring are tested, and if they are disease-resistant they are crossed with the high-yielding variety to maximise the contribution of that variety. This may continue for up to 10 years.

Some achievements of selective breeding of crops and livestock are shown on the left.

**Environment matters too**

Only so much can be achieved by breeding for improvement. Productivity has increased because farmers have improved the environments of their livestock and crop plants. When crops are harvested, only part of the plant is left to decompose and return nutrients to the ground. Yields decrease with time if soil fertility is not restored with fertilisers. Organic fertilisers are the wastes of animals and composted plants; artificial fertilisers contain the chemicals crop plants need as nutrients in the correct proportions:

- the element nitrogen, as nitrate or ammonium ions, to make amino acids
- magnesium ions to make chlorophyll
- potassium ions as enzyme cofactors and for guard cells to open stomata
- phosphate ions to make DNA, RNA, and coenzymes such as NADP.

Numerous pests and diseases consume crop plants, and weeds compete with crops for light, water and nutrients. Farmers can use various pesticides.

- Herbicides are applied before the crop germinates to kill weeds that compete with freshly germinated crop plants.
- Fungicides are applied if weather conditions make it likely that the crop will be infected by fungi.
- Insecticides are applied when insect pests reach a level that will cause economic loss.

Organic farmers do not use pesticides; instead they use methods such as crop rotation and natural predators of pests (biological control).
Antibiotics are used to treat livestock that become ill. They can also be added to animal feed to reduce the activity of gut bacteria so more food is available to the animals – a practice now banned in the EU, although it continues in the USA.

Foods from microorganisms

Some bacteria and fungi were ‘domesticated’ by humans thousands of years ago. These microorganisms make foods using biological processes that we now understand and can modify.

- Bacteria are used to make yoghurt.
- Bacteria and fungi are used in cheese-making.
- Yeasts (single-celled fungi) ferment sugar to make alcohol in brewing and wine-making.
- Yeasts ferment to produce carbon dioxide that makes dough rise for bread-making.

Mycoprotein is a new food that uses microorganisms in its production. *Fusarium venenatum* strain PTA-2684, a soil mould fungus, was discovered in a field in Buckinghamshire in 1967. Since 1985 it has been used on an industrial scale to make a meat substitute marketed as Quorn™. Microorganisms are also used to make food additives, such as vitamins and the flavour enhancer monosodium glutamate.

The advantages and disadvantages of using microorganisms in foods are listed on the right.

Food spoilage

Our foods can be contaminated by microorganisms that feed as decomposers. The damage done by food-spoilage organisms ranges from mould growing on bread to large silos of grain being affected by the fungus *Aspergillus*, which produces carcinogenic toxins called aflatoxins. Food-spoilage organisms make food appear ‘off’, taste awful and smell bad, and may be harmful to our health. In order to grow, they need organic material (our food), water, a suitable temperature, oxygen (usually) and a suitable pH.

Food preservation techniques remove one or several of these conditions. Many methods to preserve foods have been used for thousands of years; several new methods have been developed in the past 100 years or so. The table shows some of these methods and the biological principles behind them.

<table>
<thead>
<tr>
<th>Food preservation method</th>
<th>Example</th>
<th>Biological principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salting</td>
<td>Salted cod</td>
<td>Salt removes water from organisms by osmosis; using sugar for preservation uses the same principle</td>
</tr>
<tr>
<td>Pickling</td>
<td>Sauerkraut (pickled cabbage)</td>
<td>Ethanoic acid (vinegar) gives a low pH (&lt;4.0) so that enzymes in spoilage organisms are denatured</td>
</tr>
</tbody>
</table>
| Heat treatment           | Milk, wine        | • Heated to 71.7°C for 15 seconds (pasteurisation), so killing potential pathogens but not all bacteria. Flavour is preserved  
                        |                   | • Heated to at least 135°C for at least one second so killing all bacteria (UHT). This changes the flavour |
| Freezing                 | Meat              | Water is frozen, so is not available to organisms. Enzymes are inactive               |
| Irradiation              | Fruit, prawns     | X-rays/gamma-rays kill bacteria and moulds by breaking bonds in proteins and DNA |

**Quick check 2**

1. Describe the principle of selective breeding.
2. Name five foods made by microorganisms.
3. Explain the term *food spoilage* and describe how food may be prevented from going ‘off’.

Microorganisms

**Advantages**
- Microorganisms grow quickly, giving high yields and fast production
- Factories use less land than traditional agriculture, and can be set up anywhere
- Can use waste material as substrate
- Selection and genetic engineering are easier than with animals and plants
- No ethical issues (as with keeping livestock)
- Low-fat or no-fat foods

**Disadvantages**
- Microorganisms are subject to infections (e.g. by viruses), with loss of production
- Production vessels (fermenters) can be contaminated by competitors (e.g. bacteria), with loss of production
- Customer resistance to new foods
- Fungi, yeasts and bacteria must have substrates, such as sugar or starch, produced by plants
- Purification before entering the human food chain may be expensive, for example removal of nucleic acids
The World Health Organization (WHO) defines **health** as a state of complete physical, mental and social wellbeing, which is more than just the absence of disease. **Disease** may be defined as an absence of health, but we tend to use the word to refer to specific states of bad health that give certain symptoms that we experience. We report these symptoms to doctors, who look for certain clinical signs to decide which disease we have.

We are afflicted by numerous diseases that can be catalogued into different groups: inherited and non-inherited; chronic and acute; infectious and non-infectious, and so on. This spread is concerned with infectious diseases caused by **parasites** with which we do not live in harmony. Our bodies are hosts to many organisms – countless numbers of bacteria live on our skin, inside our mouth and inside our guts. Most of these are not harmful, although those that cause teeth decay certainly are. We may also be the host for larger organisms, such as lice, ticks and fleas. Parasites are organisms that live in or on a host and obtain their nourishment from their host.

Some of the bacteria described above provide us with some useful services, such as producing substances we need (e.g. vitamin K) and successfully competing with harmful bacteria so they do not infect us. **Pathogens** are parasites that invade the body, multiply in tissues or inside cells and cause disease. **Disease transmission** is the transfer of a pathogen from infected to uninfected people.

- Malaria and tuberculosis (TB) are caused by pathogens that invade our cells and then spread through the tissues.
- Human immunodeficiency virus (HIV) infection can lie dormant in T lymphocytes (see page 66) in the body for a long time, but eventually weakens the immune system so that people become susceptible to **opportunistic infections**, such as pneumonia, and certain cancers. The collection of these diseases is known as AIDS (acquired immune deficiency syndrome).

### Causative organisms and means of transmission

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causative organism (pathogen)</th>
<th>Main methods of transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Protoctist: several species of <em>Plasmodium</em></td>
<td>Insect vector: female <em>Anopheles</em> mosquito</td>
</tr>
<tr>
<td>TB</td>
<td>Bacterium: <em>Mycobacterium tuberculosis</em>, <em>Mycobacterium bovis</em></td>
<td>Airborne droplets of water <em>M. bovis</em> in milk and meat from infected cattle</td>
</tr>
</tbody>
</table>
| HIV/AIDS  | Virus: human immunodeficiency virus                     | • During unprotected sexual intercourse  
• Infected blood and blood products  
• Sharing or re-using hypodermic needles  
• Across placenta from mother to fetus  
• Blood-to-blood contact from mother to baby at birth |
Global impact of infectious diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Global distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Widely distributed throughout the tropics and sub-tropics</td>
</tr>
<tr>
<td>TB</td>
<td>Worldwide – throughout developing world, Russia and Central Asia; among homeless and poor in inner cities in developed world, especially among immigrants from developing countries</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>Worldwide: highest prevalence in sub-Saharan Africa and South-east Asia</td>
</tr>
</tbody>
</table>

Measures can be taken to control and prevent the spread of disease. This is done by breaking the transmission from infected to uninfected people.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Global impact</th>
<th>Control measures</th>
</tr>
</thead>
</table>
| Malaria | • 40% of world population live in malarial areas  
• More than 500 million people become ill with malaria each year  
• More than 1 million people die of malaria each year – mostly infants and children in Africa  
• Mosquitoes are resistant to insecticides  
• Plasmodium is resistant to drugs (such as chloroquine) that are used to kill it | • Prevent mosquitoes biting at night by using sleeping nets (most effective when nets are soaked in insecticide)  
• Use drugs that prevent Plasmodium spreading through the body  
• Reduce mosquito populations by spraying insecticide or putting fish in ponds, streams, irrigation ditches |
| TB      | • One-third of human population carry the bacterium although in many it is inactive  
• 8.8 million new cases and 1.5 million deaths each year  
• Disease is more likely to spread in poverty-stricken and overcrowded conditions  
• Spread of MDR-TB (multiple drug resistant) and XDR-TB (extensively drug resistant). XDR-TB is resistant to 2 of the 3 ‘first-line’ drugs and 2 of the ‘second-line’ drugs used when the ‘first-line’ drugs have failed | • Cured by long course of antibiotics, but some people do not finish the course  
• Directly observed treatment, short course (DOTS) is a WHO strategy against TB (volunteer supervises patient to make sure antibiotics are taken daily and the course is completed)  
• BCG vaccine against TB is not very effective – routine use discontinued in UK in 2005 |
| HIV/AIDS| • 39.5 million people living with HIV/AIDS (25 million in sub-Saharan Africa); 4.9 million new HIV infections in 2006 with 2.9 million deaths from AIDS  
• A disease both of poverty and affluence – all social groups affected  
• TB is an opportunistic disease associated with HIV | • Using condoms or femidoms during sexual intercourse  
• Health education about safer sex  
• Contact-tracing to find people likely to be infected  
• Blood donations screened for HIV (although false negatives may be a problem)  
• Blood donations and blood products heat-treated to kill viruses  
• Needle exchange schemes |
The immune system

Before and shortly after we are born, our developing immune system gains the ability to distinguish between ‘self’ (our own cells) and ‘non-self’ (anything foreign including pathogens and the toxins they produce). The immune system defends the body against infectious diseases. The primary defences prevent pathogens from entering tissues. They are:

- the epidermis, layers of dead skin cells containing the fibrous protein keratin
- mucus secreted by the epithelial lining of the airways, digestive system and reproductive system to trap bacteria and other particles; the airways also contain ciliated cells to move the mucus to the mouth, where it is swallowed
- hydrochloric acid secreted by the stomach lining to kill most organisms we ingest (mucus protects the stomach lining from the acid).

Pathogens that pass these barriers can feed, grow and divide. They may spread beyond the original site of infection through the blood or lymphatic system. The next line of defence is formed by the five groups of cells shown in the table.

<table>
<thead>
<tr>
<th>Cell type</th>
<th>Distribution</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutrophil</td>
<td>Blood and tissues</td>
<td>Phagocytosis</td>
</tr>
<tr>
<td>Macrophage</td>
<td>Tissues (e.g. lungs)</td>
<td>Phagocytosis</td>
</tr>
<tr>
<td>B lymphocyte (B cell)</td>
<td>Blood and lymph nodes</td>
<td>Production of antibodies</td>
</tr>
<tr>
<td>T helper lymphocyte (Th cell)</td>
<td>Blood and lymph nodes</td>
<td>Stimulate B lymphocytes to divide and to produce antibodies; stimulate phagocytosis</td>
</tr>
<tr>
<td>T killer lymphocyte (Tk cell)</td>
<td>Blood and lymph nodes</td>
<td>Destroy cells infected with viruses</td>
</tr>
</tbody>
</table>

The immune response

Phagocytes, such as neutrophils and macrophages, are not very successful alone. Alongside lymphocytes in an immune response they are much more effective. The body contains many millions of B and T lymphocytes, especially in lymph nodes and in the spleen, bone marrow and thymus. These cells have glycoproteins on their surfaces that each recognise a different antigen (usually a protein or glycoprotein) on the surface of a specific pathogen. When a pathogen enters the body, its antigens bind to the B and T lymphocytes that have glycoproteins of complementary shape, stimulating an immune response. These B and T lymphocytes divide by mitosis to form many identical cells. Some become effector cells; others become memory cells. B lymphocytes that become effector cells (plasma cells) make and release lots of antibodies.

The immune response is coordinated by local hormones known as cytokines. The main cell type involved is the T helper lymphocyte, which releases cytokines to stimulate B lymphocytes to divide. This is an example of cell signalling (see page 10). The events shown in the diagram occur during the first (primary) immune response to an invasion by a pathogen. If a pathogen with the same antigens invades again, the secondary response is much faster, because this time there are memory cells that can divide and become effector cells quickly. The pathogen is destroyed before it can cause disease.
Module 2

Describe the mode of action of B lymphocytes and T lymphocytes.

Describe the structure of an antibody molecule and explain how it is specific to an antigen.

Draw a graph to show what you predict will happen to the antibody concentration in an infant’s blood following the first vaccination for polio at 2 months, and following boosters at 3 and 4 months.

People are immune to a disease when they can mount a fast, effective defence against the pathogen so no symptoms develop. Immunity arises in one of two ways.

- **Active immunity**: the immune system develops antibodies directed against the specific pathogen. It is usually long-term, as memory cells are produced.
- **Passive immunity**: antibodies are transferred from another source. The immune system does not produce its own antibodies or memory cells, so the immunity lasts only weeks, or months at most, as the foreign antibodies are destroyed.

Both types of immunity can be natural or artificial. The table shows how these four forms of immunity are gained, and their advantages and disadvantages.

### Antibodies

During an immune response B lymphocytes develop into plasma cells, which make glycoproteins called antibodies. Antibodies consist of four polypeptides and have two or more antigen-binding sites. These variable regions are different shapes in different antibodies to complement the particular antigen for which an antibody is specific. The constant region is the same shape in all antibodies of the type shown in the diagram.

Antibodies work by neutralisation and agglutination, as shown in the diagram. Neutralisation means that antibodies combine with viruses, to stop them entering cells, or with toxins released by some pathogens, to make them harmless. Bacteria are agglutinated into clumps that phagocytes can recognise.

### Quick check 2

1. **Bacteria secrete toxin**
2. Antibodies combine with (neutralise) toxin
3. Host cells protected from toxin

Antibodies link bacteria in clumps that can be found and engulfed by phagocytes (agglutination)

How antibodies act by neutralisation and agglutination

### Quick check 3

1. Describe the mode of action of B lymphocytes and T lymphocytes.
2. Describe the structure of an antibody molecule and explain how it is specific to an antigen.
3. Draw a graph to show what you predict will happen to the antibody concentration in an infant’s blood following the first vaccination for polio at 2 months, and following boosters at 3 and 4 months.
Vaccines and other medicines

We saw on page 67 that active immunity may be gained artificially by vaccination. A vaccine is a preparation of an antigen or many antigens for a specific infectious disease, and is injected or given by mouth.

Some vaccines contain live, but weakened, forms of the pathogen.
- The vaccine for measles, mumps and rubella (MMR) contains attenuated (weakened) viruses that can infect cells, but are harmless.
- The BCG vaccine against TB is an attenuated form of *Mycobacterium bovis*, the pathogen that causes the disease in cattle and can be caught by humans.

A vaccine stimulates a primary immune response (see primary and secondary responses in the graph on page 67), so it takes time to gain immunity. The response is good if the vaccine is a 'live' vaccine containing living organisms. This is possibly because the weakened form of the pathogen remains in the body and may multiply, so there is a longer exposure to the immune system, giving a better response. To improve the response to vaccines, boosters are given to stimulate secondary responses and the development of larger clones of lymphocyte memory cells specialised to act against the pathogen concerned.

Vaccination success stories

Smallpox was the first disease to be eradicated from the world. It is likely that polio will be the next. Since 1988, WHO has coordinated mass immunisation programmes against polio, making this the largest public health initiative to date.

This form of immunisation is known as herd immunity. It is effective because if anyone is infected by the virus, develops symptoms and becomes infectious, there is nowhere for the virus to go, as nearly everyone is immune. With time, polio has become restricted to India, Pakistan and Nigeria, and vaccination programmes are concentrated on those areas. Occasionally, cases of polio occur elsewhere – possibly because someone has travelled from an area where the disease still exists, or sometimes because the live (attenuated) vaccine regains virulence. In these cases, ring vaccination is used: everyone in the surrounding area is vaccinated to prevent transmission.

Influenza

Influenza is a viral disease. The virus infects the lining of the airways and is associated with fever, sore throat, headache, muscle pains and weakness. In severe cases it can lead to pneumonia and may be fatal. There have been some very serious outbreaks of influenza, and it is a disease that WHO and national health authorities monitor very carefully. Thorough surveillance is carried out all the time to check for newly emerging strains of the virus. New strains often originate in East Asia, where people live in close proximity to domesticated animals such as pigs and chickens, which also harbour the virus.

The H5N1 strain of the virus that causes influenza in birds is an indication of what may happen when the influenza virus mutates into a new strain. As yet, H5N1 is not transmitted easily between people.

The virus that causes human influenza may 'cross-breed' with viruses that cause similar diseases in animals, or a strain that is pathogenic in animals may cross the species barrier and infect us. ‘Cross-breeding’ occurs when viruses of two strains infect the
same cell. As each new virus particle buds from the host cell it takes genes from both strains. Each year, WHO advises countries to vaccinate people at risk with specific vaccines against the three strains that are predicted to infect people that year. In the UK, all people over the age of 65 are offered influenza vaccination, as are young people with conditions such as asthma, and people in high-risk categories such as medical staff and carers. Herd immunity may become necessary if a new, dangerous strain emerges. However, it is unlikely that sufficient stocks of the required vaccine would be ready in time to vaccinate most of the population.

New medicines

Pharmaceutical companies are always developing new medicines. There are several reasons for this.

- Pathogens have become resistant to existing drugs, such as many antibiotics.
- New diseases have emerged over recent years, and there will be more in the future.
- Vaccines are needed for many diseases, and existing vaccines can be improved.

Various fungi and bacteria, such as Streptomyces, are the source of most antibiotics, although many are modified chemically before they are formulated and sold. Pharmaceutical companies invest in searches for potential new medicines. They search soil samples from all over the world in the hope of finding microorganisms that produce antimicrobial substances that could become antibiotics of the future. They screen compounds extracted from plants – especially those used in traditional medicines. Currently much interest is being shown in the plants used in traditional Chinese medicine. Plants have complex metabolisms that produce a very wide range of chemicals, some of which may have potential as a medicine. The table shows four such medicines.

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Plant source</th>
<th>Use</th>
<th>Biological action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxol®</td>
<td>Taxus spp., yew tree</td>
<td>Anticancer agent</td>
<td>Inhibits mitosis by interacting with microtubules</td>
</tr>
<tr>
<td>Vinblastine</td>
<td>Catharanthus roseus, Madagascan periwinkle</td>
<td>Anticancer agent</td>
<td>Inhibit mitosis by interacting with microtubules</td>
</tr>
<tr>
<td>Vincristine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artemisinin</td>
<td>Artemisia annua, sweet wormwood</td>
<td>Antimalarial drug</td>
<td>Attacks various stages of Plasmodium</td>
</tr>
</tbody>
</table>

These four drugs were originally found in plants, although they are now synthesised chemically. Without the plants, we would not have discovered them. It is therefore important that plant species do not become extinct (see page 85).

QUICK CHECK QUESTIONS

1. Explain what is meant by a vaccine.
2. Outline the ways in which vaccination is used to control the spread of disease.
3. Outline the ways in which health authorities control influenza.
4. In the context of the information in this spread, explain why it is important to preserve species from extinction.
Smoking and disease

The World Health Organization (WHO) considers smoking to be an epidemic. This is because smoking is the cause of numerous diseases, and a contributory factor to many more. The major effects are on the **gas exchange system** (trachea, bronchi and lungs) and the **cardiovascular system** (heart and blood vessels).

When dried tobacco leaves are burnt, they give off a large number of substances that are inhaled into the lungs. Some remain in the lungs; others are absorbed into the blood. This table shows some of these substances and their effects on the body.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Effects on the body</th>
</tr>
</thead>
</table>
| Tar       | • Accumulates in the airways (especially the bronchi)  
• Destroys cilia  
• Stimulates goblet cells to secrete more mucus  
• Causes chronic bronchitis and emphysema |
| Carcinogens | • Cause mutations to occur in bronchial epithelial cells, leading to formation of tumours (lung cancer) |
| Carbon monoxide | • Absorbed into blood  
• Combines with haemoglobin to form carboxyhaemoglobin  
• Reduces oxygen-carrying capacity of the blood and starves heart muscle of oxygen |
| Nicotine | • Absorbed into the blood  
• Increases heart rate and blood pressure, causing damage to artery walls  
• Stimulates decrease in blood flow to extremities  
• Increases chances of blood clots forming |

**Chronic obstructive pulmonary disease and lung cancer**

Chronic obstructive pulmonary disease (COPD) is a disease associated with smoking, and includes the conditions **chronic bronchitis** and **emphysema**, which are described in the table below.

But for smoking, lung cancer would be a very rare disease. Cancer-causing agents (**carcinogens**) in tobacco smoke cause mutations in the epithelial cells lining the bronchi that may eventually lead to the growth of a tumour.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Changes in the lungs</th>
<th>Symptoms</th>
</tr>
</thead>
</table>
| Chronic bronchitis | Bronchi become obstructed and narrow because:  
• lining is inflamed  
• smooth muscle layer thickens  
• goblet cells and mucous glands produce much mucus | Shortness of breath  
Wheezeing  
Persistent cough |
| Emphysema | • Alveoli become overstretched, lose elasticity and burst  
• Fewer elastic fibres  
• Large gaps in the lungs, giving smaller surface area for gaseous exchange | Shortness of breath  
Difficulty in breathing out  
In severe cases people need to breathe oxygen through a mask |
| Lung cancer | • Bronchi blocked by cancerous growths | Coughing up blood; persistent cough; weight loss |
Epidemiological evidence

**Epidemiology** is the study of patterns of disease. The link between cigarette smoking and lung cancer was first suggested in the 1950s by epidemiologists who collected data from patients with the disease. They found that almost all lung cancer patients were smokers. Many studies since then have shown that smoking is the major cause of lung cancer. Very few non-smokers develop the disease. Many smokers develop it and die from it. The table below summarises some of this epidemiological evidence.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung cancer was a rare disease before the twentieth century</td>
<td>Cigarettes were first made at the end of the nineteenth century; smoking became common early in the twentieth century</td>
</tr>
<tr>
<td>Cases of lung cancer increased from the 1930s onwards</td>
<td>Smoking became common during the First World War; it takes 20–30 years for symptoms to develop</td>
</tr>
<tr>
<td>More men than women suffer from lung cancer</td>
<td>For most of the twentieth century, more men than women smoked cigarettes</td>
</tr>
<tr>
<td>Most people who develop lung cancer are smokers</td>
<td>Tar from cigarette smoke contains carcinogens (other causes of lung cancer are very rare)</td>
</tr>
<tr>
<td>Death rates from lung cancer are highest among people who smoke more than 25 cigarettes a day</td>
<td>People who smoke many cigarettes in a day expose their lungs to more carcinogens, increasing the chance of cancer</td>
</tr>
</tbody>
</table>

**Experimental evidence**

There are two main lines of experimental evidence for the link between smoking and lung cancer:

- dogs that were exposed to cigarette smoke in the same way as humans developed cancerous growths in their lungs
- when substances extracted from tar in cigarette smoke were painted on the skin of mice, tumours started to develop.

These experiments show that cigarette smoke contains carcinogens that cause genes to mutate so that cells start to divide uncontrollably to give cancerous growths or tumours.