Micro-organisms

Unit 1

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1.3 What are viruses?	• Describe the structure of a virus, draw and label it. • Explain the different forms of viruses and diagram them. • Classify viruses and give examples of RNA, DNA, and retroviruses. • Discuss the reproductive cycles of viruses and compare the lytic and lysogenic cycles of viral reproduction. • Draw and label a bacteriophage. • Compare viruses with free-living cells. • Draw, label and describe the structure of HIV, show the structure of glycoprotein-120 on its surface and tell that it is this protein that allows HIV to bind with CD4 lymphocytes. • Explain the life cycle of HIV, show how it replicates. • Explain how different anti-retroviral drugs work and tell why HAART is more effective than single drug treatment. • State the social and economic impacts of AIDS. • Demonstrate the life skills that lead to responsible sexual behaviour.

1.1 Bacteria

By the end of this section you should be able to:

- Name, describe and give examples of the different types of micro-organism.
- Describe the structure of a bacterial cell.
- Describe the shapes of different types of bacteria.
- Classify bacteria as Gram-positive and Gram-negative.

KEY WORDS

micro-organism *a very small organism, usually having just one cell*

fungus *(plural* **fungi***) a eukaryotic organism that obtains its nutrition using extracellular digestion. A fungus is neither a plant nor an animal*

unicellular *a unicellular organism has just one cell*

multicellular *a multicellular an organism has more than one cell*

yeast *a type of fungi used for brewing and baking*

What different types of micro-organisms are there?

Any **micro-organism** is just what its name suggests – a very small organism. Most micro-organisms are unicellular (the whole organism consists of just one cell), although some do contain more than one cell.

There are five main groups of micro-organisms, although each group can be subdivided. These groups are:

- protozoa
- some algae
- bacteria
- some **fungi**
- viruses

Protozoa, fungi and algae

Protozoa are **unicellular** organisms that lack a cell wall. Most of them are motile (able to move), and include organisms such as *Amoeba*, *Plasmodium* (the organism that causes malaria), and *Paramecium*.

(a) (b) (c)

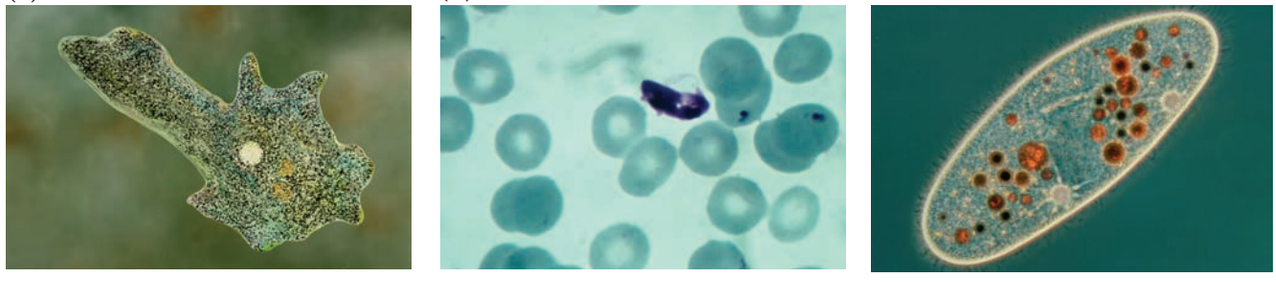

Figure 1.1 *Some protozoa. (a)* Amoeba*; (b)* Plasmodium *in blood cells; (c)* Parameciu

The only unicellular fungi are the **yeasts**. These include brewer's yeast and baker's yeast (*Saccharomyces*) as well as the yeast-like organism that causes thrush in humans (*Candida*).

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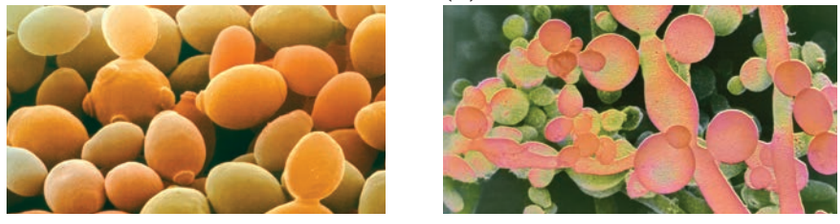


Figure 1.2 *Some yeasts. (a)* Saccharomyces*; (b)* Candida

KEY WORDS

mycelium *the collection of very fine strands that makes up a fungus. Each strand is called a hypha (plural hyphae). The hyphae are not 'compartmentalised' into cells; each is 'multinucleate' – the cytoplasm contains many nuclei*

alga (plural **algae**) *an alga is a single-celled organism that obtains its nutrition using photosynthesis.*

motile *an organism that is able to move on its own*

Although the yeasts are the only unicellular fungi, other fungi are also classed as micro-organisms. Many fungi produce a **mycelium** of microscopic strands called hyphae. They release enzymes from these strands that digest whatever the fungus is growing on. The products of digestion are then absorbed into the fungus to help with its growth and reproduction. Remember, fungi do not have true roots, stems and leaves. Some fungi live on or in living organisms, as parasites. Others live on dead material as saprobionts, organisms that digest their food externally and absorb the products.

Algae are an important group of organisms. Many are large (the seaweeds are all algae), but some algae are unicellular. The unicellular algae in figure 1.4 are part of the plankton, the collections of small microscopic plant and animal organisms that float or drift in large numbers in fresh or salt water, providing food for fish and other larger organisms. These unicellular algae in the oceans produce far more oxygen during photosynthesis than all the forests in the world together.

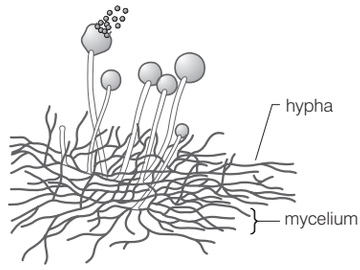


Figure 1.3 *Fungal hyphae*

Figure 1.4 *Unicellular algae are found in the ocean as plankton.*

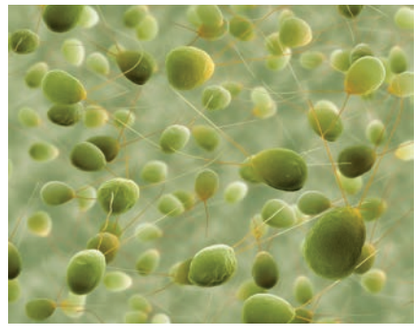


Figure 1.5 Chlamydomonas *moves using its two flagella.*

Some unicellular algae are **motile** – they can move. Figure 1.5 shows an alga called *Chlamydomonas*, which has two flagella at one end to propel it through the water.

Viruses are sometimes referred to as micro-organisms, although some biologists say that, strictly, they are not organisms at all.

Viruses cannot independently carry out any of the processes common to all living organisms. They can only reproduce inside other cells. So they are all parasites. Some parasitise bacteria, some parasitise plants and others parasitise animals. The basic virus is not even a cell – it has no nucleus and no cytoplasm – but it does have genetic material surrounded by a protein coat.

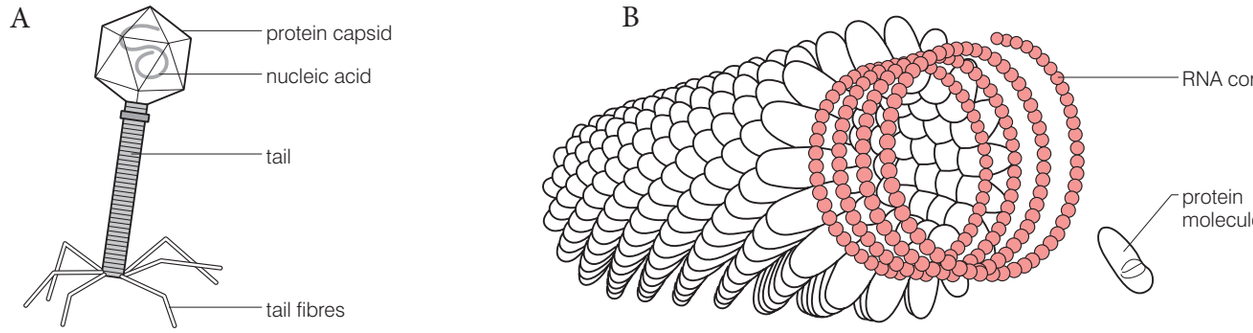


Figure 1.6 *Some viruses. A Bacteriophages are viruses that parasitise bacteria; B Tobacco mosaic virus parasitises tobacco plants.*

Activity 1.1: What micro-organisms do you know?

Try to find one species of each type of micro-organism (bacteria, protozoa, algae, fungi and viruses) that is useful, and one that is harmful. You may not be successful for all types in both cases. Explain why.

What are bacterial cells like?

You already know about the structure of plant and animal cells. Biologists call these **eukaryotic cells**. Fungi and protoctistans (algae and protozoa) also have eukaryotic cells.

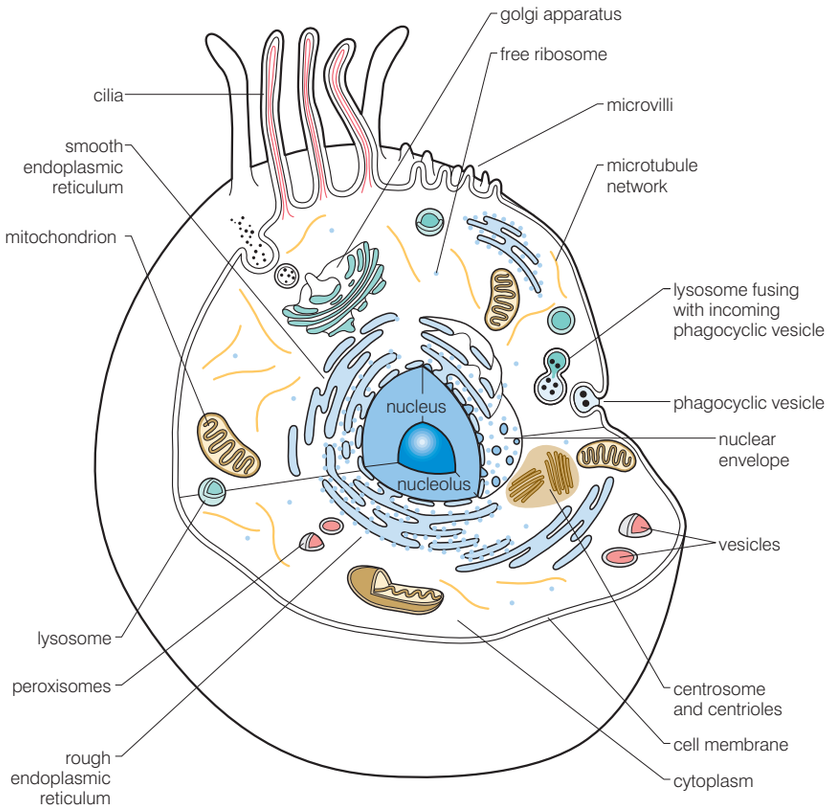


Figure 1.8 *The structure of a eukaryotic cell*

Bacteria, however, have **prokaryotic cells**. In prokaryotic cells there is no true nucleus separated from the rest of the cell by a membrane. Instead, the DNA of the bacterium forms a continuous loop that is intermingled with the cytoplasm.

Figure 1.9 shows the structure of a generalised **bacterial** cell. Not all bacteria have all the structures shown in the diagram. For example, not all bacteria have a capsule and many do not have a flagellum.

All bacteria do have a cell wall (but it is not made from cellulose like plant cell walls and instead is made from a substance called peptidoglycan, which makes it rigid), a cell membrane, cytoplasm, ribosomes and DNA.

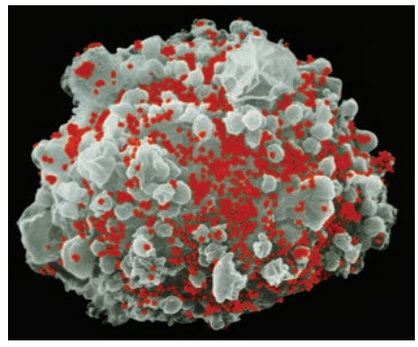


Figure 1.7 *HIV is a virus that parasitises human white blood cells, causing the symptoms of AIDS.*

KEY WORDS

eukaryotic cell *a type of cell that has a nucleus. The word eukaryotic is derived from Greek* eu *(true) and* karyos *(nuclear)*

prokaryotic cell *a type of cell that does not have a nucleus. Only bacteria have prokaryotic cells. The word* prokaryotic *is derived from Greek* pro *(before) and* karyos

bacterium (plural **bacteria**) *a micro-organism consisting of just one prokaryotic cell*

Activity 1.2

Work in small groups and brainstorm all the differences you can think of between eukaryotic and prokaryotic cells. Make a table comparing the two different types of cells and share your ideas with the rest of the class.

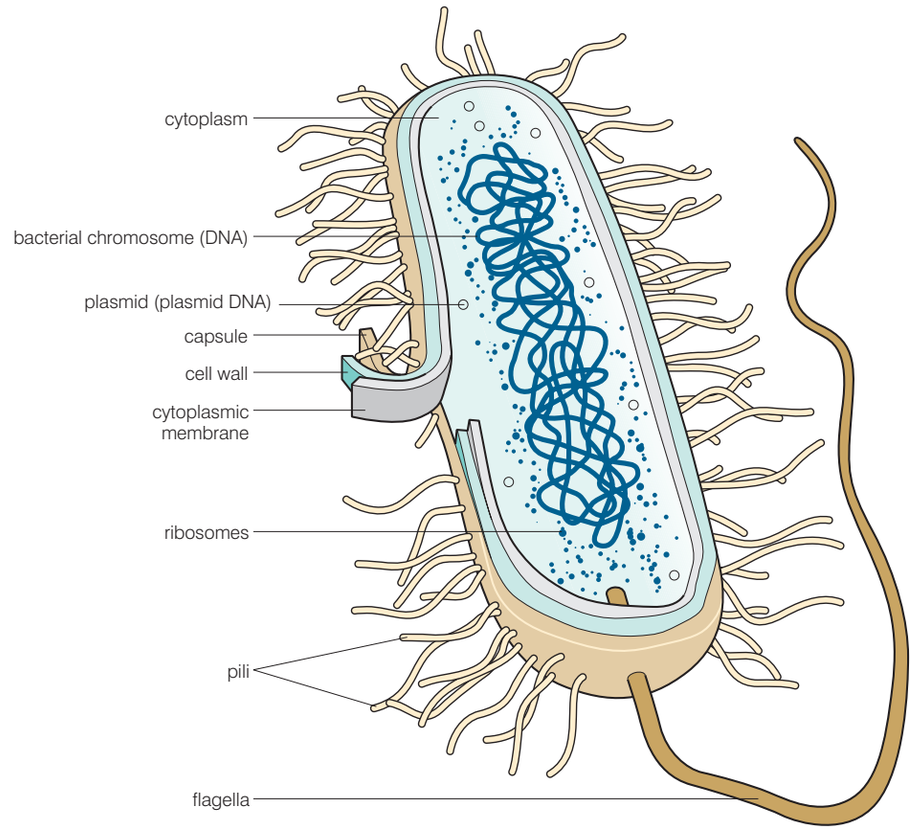


Figure 1.9 *The structure of a bacterial cell*

Although bacterial cells vary a great deal in size, they are usually much smaller than eukaryotic cells. Bacterial cells are usually between 1 and 10 µm long, whereas eukaryotic cells are between 10 and 100 µm long. (1 µm is 0.001 mm, one-thousandth of one millimetre.)

DID YOU KNOW?

The nucleus, mitochondria and chloroplasts found in eukaryotic cells are all surrounded by a double membrane. They are sometimes called 'membrane-bound organelles'. So, biologists sometimes say that prokaryotic cells do not contain membrane-bound organelles. Because of this, photosynthesis and respiration are carried out differently in bacterial cells. Photosynthesis takes place in the plasma membrane or membranes in the cytoplasm. Many of the reactions of respiration take place in the cytoplasm, with some also occurring on the plasma membrane.

Are all bacteria the same shape?

No – there are several shapes, sizes and arrangements. Bacterial cells come in three main shapes:

- cocci (singular, coccus) – spherical bacteria
- bacilli (singular, bacillus) – rod-shaped bacteria
- spirochaetes – spiral or corkscrew-shaped bacteria

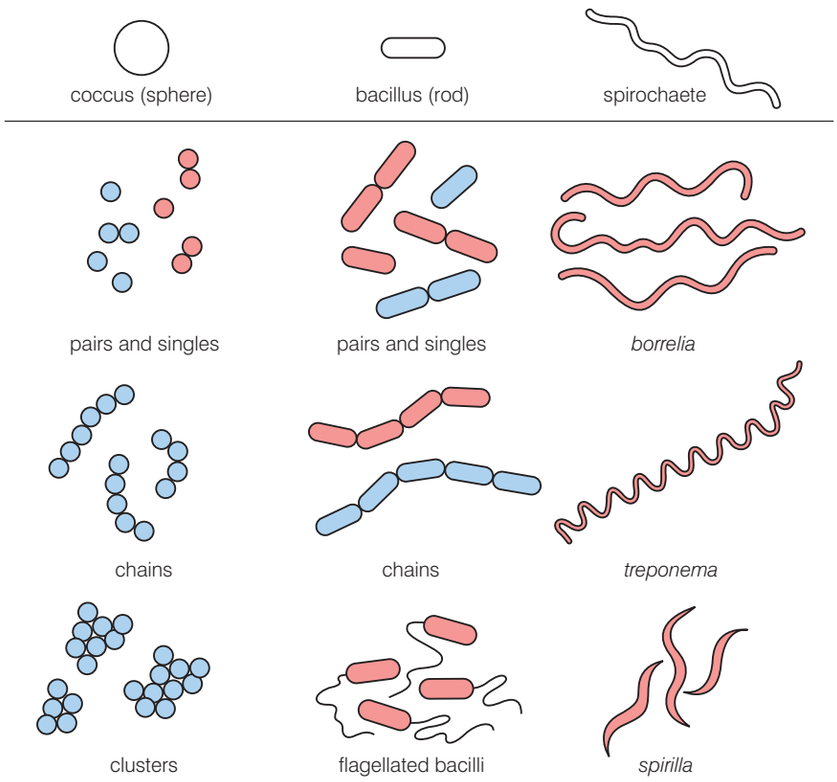


Figure 1.10 *Bacterial cells come in three main shapes.*

Whatever their shape, bacterial cells are sometimes found singly; sometimes two cells are stuck together; and sometimes the cells exist in chains.

Activity 1.3: Finding out more about bacteria

Streptococcus and *Lactobacillus* are two well-researched types of bacteria. Carry out a library search to find out what shapes these two bacteria have, and why they are so important to us. Also, try to find two diseases caused by spiral-shaped bacteria.

Are there other ways of classifying bacteria?

Bacteria can be classified in other ways, besides their shape. One of these ways is whether or not they are coloured by Gram's stain. This test gives two categories:

- **Gram-positive** – these bacteria are stained purple by **Gram's stain**
- **Gram-negative** – these bacteria are stained pink by Gram's stain

Because Gram's stain produces different results with different types of bacteria, it is called a **differential stain**.

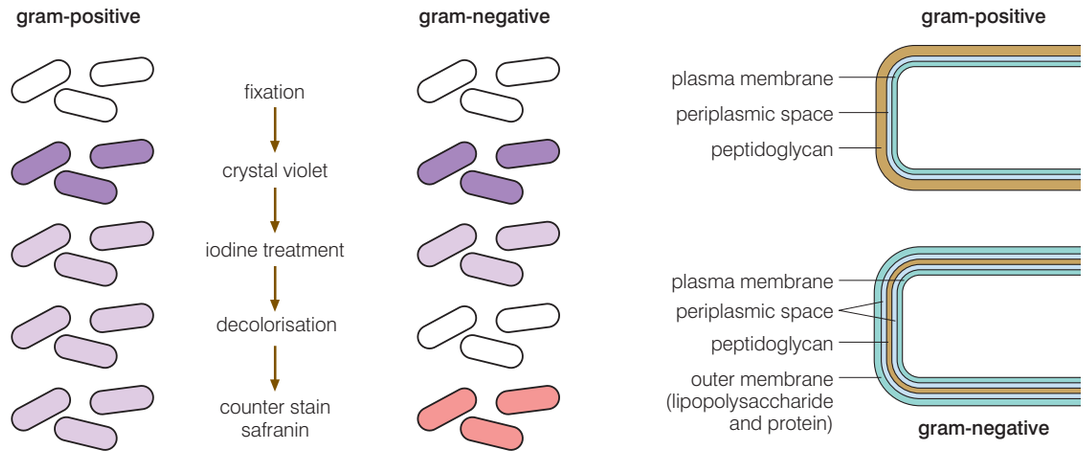


***Figure 1.11** Gram staining*

KEY WORDS

Gram's staining *a test for classifying bacteria (named after Hans Christian Gram, who developed the technique in 1884)*

differential stain *a test that uses staining to classify organisms or organic material*

peptidoglycan *a complex molecule made from sugars and amino acids. It has a mesh-like structure and is found in bacterial cell walls*

endotoxins *toxins found in some bacteria*

The difference is due to the structure of the cell wall of the different bacteria. Gram-negative bacteria have much less **peptidoglycan** in their cell walls. This is the part of the wall that absorbs the stain. They also have a membrane outside the peptidoglycan cell wall, which Gram-positive bacteria do not have. This outer membrane secretes **endotoxins** (a type of toxin that is a structural component of these bacteria) and is also quite resistant to many antibiotics. This makes diseases caused by Gram-negative bacteria more difficult to treat. Gram-negative bacteria, on the whole, cause more serious diseases, although there are exceptions – the bacterium that causes tuberculosis is a Gram-positive bacterium.

Gram staining is used much less than it was in diagnosing disease, as more advanced and more reliable biochemical techniques have become available.

Activity 1.4: Looking at bacteria in yoghurt

You will need:

- a microscope
- a slide and coverslip
- yoghurt
- water
- a dropping pipette

Method

1. Take a small sample of yoghurt using the pipette, and place it on a slide.
2. If the sample seems too thick, dilute it with a drop of water.
3. Lower a coverslip onto the yoghurt, taking care not to produce air bubbles.
4. First, observe the bacteria at low power (×100) to find a good place to start looking. The diaphragm setting should be very low (small) because these bacteria are almost transparent.
5. Switch to the highest power to identify the bacteria according to the shape of cells and arrangement of the cells (pairs, clusters, chains, etc.).
6. Make a drawing of the different bacteria you can see.

Review questions

Choose the correct answer from A to D.

1. Protozoa are:
   - A multicellular organisms
   - B one-celled animals
   - C members of the group protoctista
   - D unicellular plants
2. Micro-organisms include:
   - A bacteria and some fungi
   - B viruses
   - C protozoa
   - D all of the above
3. Viruses are sometimes not considered as living organisms because:
   - A they do not have any of the organelles found in cells
   - B they are incapable of independent reproduction
   - C they cannot carry out any metabolic processes
   - D all of the above

4. Gram's stain is called a differential stain because:
   - A it stains bacterial cells, but not fungi
   - B it stains some bacteria purple and others pink
   - C it stains viruses, but no other organisms
   - D it stains some fungal cells purple and others pink
5. Bacterial cells are different from animal cells because the bacterial cells:
   - A are larger than animal cells
   - B have no nucleus
   - C have no DNA
   - D have no cytoplasm
6. The three main shapes of bacterial cell are:
   - A diplococci, staphylococci and bacilli
   - B diplococci, streptococci and bacilli
   - C diplococci, streptococci and staphylococci
   - D cocci, bacilli and spirochaetes
7. Compared with Gram-positive bacteria, Gram-negative bacteria:
   - A have an extra membrane outside the cell wall
   - B are more resistant to antibiotics
   - C produce more dangerous endotoxins
   - D all of the above
8. Viruses can parasitise:
   - A only animal cells
   - B only plant cells
   - C only bacterial cells
   - D animal cells, plant cells and bacterial cells
9. It is true to say of bacterial cells that:
   - A none can photosynthesise
   - B only some can respire
   - C none contain ribosomes
   - D none contain chloroplasts
10. Membrane-bound organelles include:
    - A the nucleus
    - B chloroplasts
    - C mitochondria
    - D all of the above

1.2 The ecology and uses of bacteria

By the end of this section you should be able to:

- Appreciate that bacteria are found in many diverse locations.
- Explain that bacteria are important disease-causing agents; are used in industrial processes and give examples of industrial processes that use bacteria; and are involved in the cycling of mineral elements such as carbon and sulphur.
- Describe the main groups of micro-organisms.
- Explain the roles of reservoirs of infection in the transmission of infectious diseases caused by bacteria.
- Explain the roles that bacteria play in every ecosystem.
- Explain how bacteria produce disease.
- Compare infectious disease with functional disease and state the germ theory.
- State the role of bacteria in recombinant DNA work.
- Define cloning and illustrate how foreign genes are inserted in bacterial plasmids, and how bacteria are used vectors in the genetic engineering of plants.

Where are bacteria found?

Bacteria are found in every ecosystem – they are pretty well everywhere around you – and everywhere inside you as well! There are ten bacterial cells inside you for every one of your own cells. Most of these are found in the large intestine.

Bacteria are important because they:

- cause diseases
- are used in many industrial processes
- recycle mineral elements such as carbon, nitrogen and sulphur through ecosystems

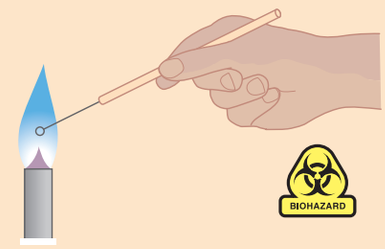
KEY WORDS

germ theory *says that infectious diseases are caused by micro-organisms*

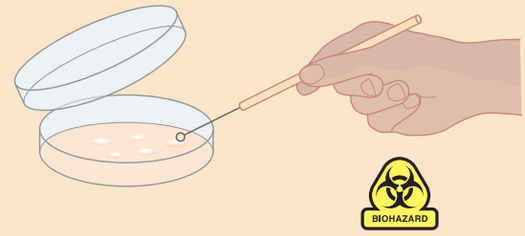
pathogen *the term describes any organism that causes disease*

infectious disease *an infectious disease is caused by a living organism entering or infecting another living organism. They are sometimes called communicable diseases because they can be transmitted or communicated from one person to another*

Activity 1.5: Culturing micro-organisms from the environment



1 A wire loop is placed in a hot Bunsen burner flame for a few seconds, until it glows red-hot. This sterilises the loop. It is then allowed to cool in the air.



2 The lid of the Petri dish containing the mixture of colonies is lifted to an angle of about 45°, just enough to allow the wire loop to be used to collect a sample of the bacterium of interest. The lid is then replaced.

Figure 1.12 *Culturing micro-organisms.*

What is the role of bacteria and other microorganisms in infectious diseases?

As we have already learned, the theory that some diseases are caused by the invasion of the body by micro-organisms was put forward by the French chemist and microbiologist Louis Pasteur. The English surgeon Joseph Lister and the German physician Robert Koch were also involved in the development of this theory. In the mid-19th century, Pasteur showed that micro-organisms in the air caused wine to go 'sour'. In the 1860s, Lister showed that carbolic acid (phenol) acted as a disinfectant, and prevented disease in bones following surgery. In 1880, Robert Koch identified the micro-organisms that cause tuberculosis and cholera.

The theory that disease can be caused by micro-organisms is called the **germ theory**. Organisms that cause disease are called **pathogens**. A disease that is caused by a micro-organism infecting the body is an **infectious disease**.

Koch's postulates

After considerable work on micro-organisms as the cause of disease, Robert Koch put forward the following ideas (or 'postulates') that should always apply if a certain micro-organism causes a disease.

- The micro-organism must always be present when the disease is present, and should not be present if the disease is not present.
- The micro-organism can be isolated from an infected person and then grown in culture.
- Introducing such cultured micro-organisms into a healthy host should result in the disease developing.
- It should then be possible to isolate the micro-organism from this newly diseased host and grow it in culture.

The first postulate establishes a link between the micro-organism and the disease. The following three postulates prove that the metabolism of a specific living micro-organism, when transferred into a healthy host, causes the disease.

Different micro-organisms cause disease in different ways, as shown in table 1.1.

Table 1.1 *How micro-organisms cause disease*

Type of micro-organism	How the micro-organism causes disease	Examples of diseases caused
Bacteria	Bacteria release toxins as they multiply. These toxins affect cells in the region of the infection, and sometimes in other regions of the body as well. Bacterial diseases can be treated with antibiotics, as each bacterium is a true cell with its own metabolic systems, and is capable of cell division. Some bacteria invade and grow in the tissues of organs, causing physical damage.	Pneumonia, cholera, pulmonary tuberculosis (TB)
Viruses	Viruses enter living cells and disrupt the metabolic systems of the cell. The genetic material of the virus becomes incorporated with that of the cell and instructs the cell to produce more viruses. Viruses cannot be treated with antibiotics as they are not true cells and are only active inside cells, which antibiotics cannot enter.	Influenza ('flu), AIDS, measles, common cold
Fungi	When fungi grow in or on living organisms, their hyphae secrete enzymes. These digest substances in the tissues, and the substances produced are absorbed. Growth of hyphae also physically damages the tissue. Some fungi also secrete toxins. Others can cause an allergic reaction (e.g. farmer's lung).	Athlete's foot, farmer's lung
Protozoa	Protozoa cause disease in many different ways.	Malaria, sleeping sickness

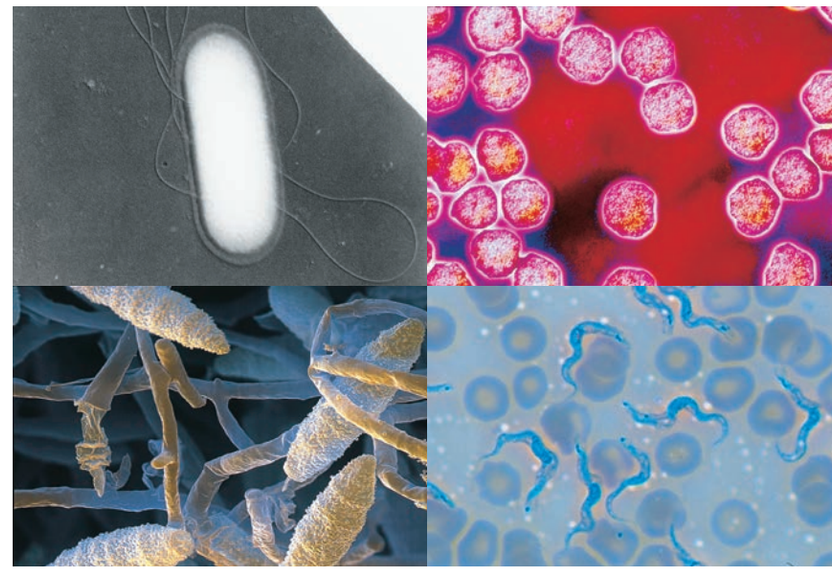


Figure 1.13 *Types of disease-causing organism*

How are disease-causing micro-organisms transmitted?

KEY WORD

reservoir of infection *this is any person, animal, plant, soil or substance in which an infectious agent normally lives and multiplies. The reservoir typically harbours the infectious agent without showing symptoms of the disease and serves as a source from which other individuals can be infected. People acting as the reservoir of infection are sometimes called carriers of the disease*

Table 1.1 looked at how bacteria cause disease. There must clearly be a source of infection. The origin of micro-organisms that infect other people is called the **reservoir of infection**. This is the principal habitat from which an infectious agent may spread to cause disease. Reservoirs of infection include:

- human beings – the reservoir for many diseases, including the common cold, diphtheria and others
- other animals – for example: chickens, the reservoir for salmonella infections; mosquito, the reservoir for malaria
- soil – the reservoir for tetanus and many other pathogens
- water – the reservoir for Legionnaire's disease, amoeba, cholera, etc.
- food – the reservoir for many diseases including typhoid
- contaminated objects – contact infections such as HIV/AIDS and trachoma
- air – the reservoir for pneumonia, tuberculosis, etc.

Figure 1.14 *Airborne droplet infection*

Because there are different reservoirs of disease-causing organisms, there are several different ways in which diseases can be transmitted, as shown in table 1.2.

***Table 1.2** How diseases can be transmitted*

Method of transmission	How the transmission route works	Examples of diseases
Droplet infection	Many of these diseases are 'respiratory diseases' – diseases affecting the airways of the lungs. The organisms are carried in tiny droplets through the air when an infected person coughs or sneezes. They are inhaled by other people.	Common cold, 'flu, pneumonia
Drinking contaminated water	The micro-organisms transmitted in this way often infect regions of the gut. When unclean water containing the organisms is drunk, they colonise a suitable area of the gut and reproduce. They are passed out with faeces and find their way back into the water.	Cholera, typhoid fever
Eating contaminated food	Most food poisoning is bacterial, but some viruses are transmitted this way. The organisms initially infect a region of the gut.	Salmonellosis, typhoid fever, listeriosis, botulism
Direct contact	Many skin infections, such as athlete's foot, are spread by direct contact with an infected person or contact with a surface carrying the organism.	Athlete's foot, ringworm
Sexual intercourse	Organisms infecting the sex organs can be passed from one sexual partner to another during intercourse. Some are transmitted by direct body contact, such as the fungus that causes candidiasis (thrush). Others are transmitted in semen or vaginal secretions, such as the AIDS virus. Some can be transmitted in saliva, such as syphilis.	Candidiasis, syphilis, AIDS, gonorrhoea
Blood-to-blood contact	Many of the sexually transmitted diseases can also be transmitted by blood-to-blood contact. Drug users sharing an infected needle can transmit AIDS.	AIDS, hepatitis B
Animal vectors	Many diseases are spread through the bites of insects. Mosquitoes spread malaria and tsetse flies spread sleeping sickness. In both cases, the disease-causing organism is transmitted when the insect bites humans in order to suck blood. Flies can carry micro-organisms from faeces onto food.	Malaria, sleeping sickness

Activity 1.6: Identifying sources of infection

For each of the methods of transmission given in table 1.2, identify the reservoir of infection.

DID YOU KNOW?

Eating too much food can result in obesity, which is regarded as a disease condition in itself, and can also lead to other diseases such as coronary heart disease.

What other types of disease are there?

Before we answer that question, we should really define what we mean by 'disease'.

The World Health Organization's definition of health is 'a state of complete physical, mental and social well-being'. But disease is less easy to define. It doesn't mean just the absence of perfect health. If we are less fit than we might be, or if we are feeling depressed at the thought of too much schoolwork, that doesn't necessarily mean we have a disease.

A useful definition of disease might be 'a condition with a specific cause in which part or all of a body is made to function in a non-normal and less efficient manner'. This definition could include diseases of all organisms – including plants. It could also include physical, mental and social aspects of disease in humans.

Infectious disease is just one type of disease. Disease can be caused by a number of other factors.

- A person's lifestyle and working conditions may result in **human-induced diseases**. Examples include many cancers, together with some forms of heart disease and fibrosis.
- Degenerative processes are often the result of ageing. Arthritis and atherosclerosis are examples of **degenerative diseases**.
- Our genes may lead to disease. Haemophilia and sickle-cell disease are examples of **genetic diseases**.
- Lack of nutrients in our diet may lead to **deficiency diseases**, including scurvy (caused by a lack of vitamin C) and kwashiorkor (caused by a lack of protein).
- Social activities can lead to disease. **Social diseases**, including alcoholism and drug addiction, may result in dependency on the drug, isolation, clinical depression and various levels of antisocial behaviour.

KEY WORDS

Human induced diseases *are diseases that arise as a result of a person's lifestyle*

Degenerative diseases *often result from the ageing process during which the affected tissues deteriorate over time due to simple 'wear and tear'*

Genetic diseases *are diseases that result from the action of mutated genes*

Deficiency diseases *are diseases that result from a lack of a nutrient in our diet.*

Social diseases *are conditions that result from social activities and may lead to socially unacceptable behaviour*

Multifactorial *describes a condition that is affected by the interaction of many factors*

Categorising diseases

In many cases, it is an oversimplification to place a disease in just one category. For example, atherosclerosis (laying down fatty substances in arteries) increases as we age, so it can be classified as a degenerative disease. But our diet influences this process. If we eat more saturated fat, more fatty substances are laid down in our arteries. There is also a genetic component – some people are at increased risk of this disease because of genes inherited from their parents. Stress and high blood pressure increase the rate at which atherosclerosis develops, and these can be the result of our lifestyle. Clearly, atherosclerosis does not fit neatly into any one category. It is best to consider such conditions as **multifactorial**.

Functional diseases
In some cases, there is an obvious 'malfunction' of an organ or system, without there being any obvious damage or physical sign of disease in the organ. Because of the malfunction, these diseases are called functional diseases, for example, heart disease.

Several intestinal conditions fall into this category. In many forms of Irritable Bowel Syndrome (IBS), there is no sign of damage or disease in the large intestine, yet the large intestine does not function normally.

Myalgic Encephalopathy (ME or Chronic Fatigue Syndrome) is another functional disease. In this condition, for no apparent reason, the sufferer is drained of all energy and the simplest task can be an extreme effort.

However, some biologists believe that there must be some kind of abnormality in the organs involved in functional diseases. For example, there is some evidence to suggest that, in ME, many of the mitochondria (which release energy in respiration) are abnormal. If this is true, then it may be that functional diseases are really just like other forms of disease, but the precise cause is yet to be discovered.

The role of bacteria in an ecosystem

The role of bacteria in recycling minerals through ecosystems

Many bacteria are decomposers. When organisms die, these bacteria break down the complex molecules that are found in the bodies of the dead organisms into much simpler molecules. The bacteria use some of these for their own metabolism, but in the process they release some minerals, in various forms, into the environment. Many elements are recycled in this way, including:

- carbon
- nitrogen
- sulphur
- phosphorus

Here we will look at how nitrogen and sulphur are recycled.

The nitrogen cycle

The element nitrogen is found in many important organic molecules in all living organisms. These include:

- proteins
- DNA
- RNA
- ATP

and many others.

It is important that once organisms die, the nitrogen they contain is made available again to other organisms. Several different types of bacteria are involved in this recycling of nitrogen.

DID YOU KNOW?

We describe the conversion of ammonium ions to nitrate ions as oxidation because in the process oxygen is gained and hydrogen ions are lost.

Activity 1.7

Plan a presentation which you can give to younger students explaining the different ways they can catch infectious diseases, and suggesting ways to avoid the spread of disease.

The nitrogen cycle will be treated in detail in Unit 2, but table 1.3 below shows the main bacteria involved and the roles they play.

Table 1.3 *The role of bacteria in the nitrogen cycle*

Micro-organism	Process
Nitrogen-fixing bacteria, e.g. *Rhizobium*	Nitrogen gas is fixed into forms other organisms can use (e.g. ammonium).
Ammonifying bacteria (decomposers)	The decomposers break down proteins in dead organisms and animal waste releasing ammonium ions, which can be converted to nitrates.
Nitrifying bacteria, e.g. *Nitrosomonas* and *Nitrobacter*	Nitrification is a two-step process. Ammonia or ammonium ions are oxidised first to nitrites (*Nitrosomonas*) and then to nitrates (*Nitrobacter*) which is the form most usable by plants.
Denitrifying bacteria, e.g. *Pseudomonas*	Nitrates are reduced to nitrogen gas, returning nitrogen to the air and reducing the amount of nitrogen in the soil.

Figure 1.15 *Root nodules*

The sulphur cycle

Sulphur is found in fewer types of organic molecule than nitrogen, but it is found in many proteins. The sulphur cycle will will be covered in detail in Unit 2, but table 1.4 below shows the bacteria involved in the cycle and the roles they play.

Table 1.4 *The role of bacteria in the sulphur cycle*

Reaction	Bacteria involved	Conditions needed	Process
Decomposition	*Desulphovibrio*	Anaerobic	Sulphur is released from proteins of dead matter as hydrogen sulphide (giving the 'rotten eggs' smell).
Oxidation of hydrogen sulphide	Photosynthetic sulphur bacteria	Anaerobic	Hydrogen sulphide is oxidised to release sulphur.
Oxidation of sulphur	Non-photosynthetic sulphur bacteria	Aerobic	Sulphur is oxidised to sulphate ions.

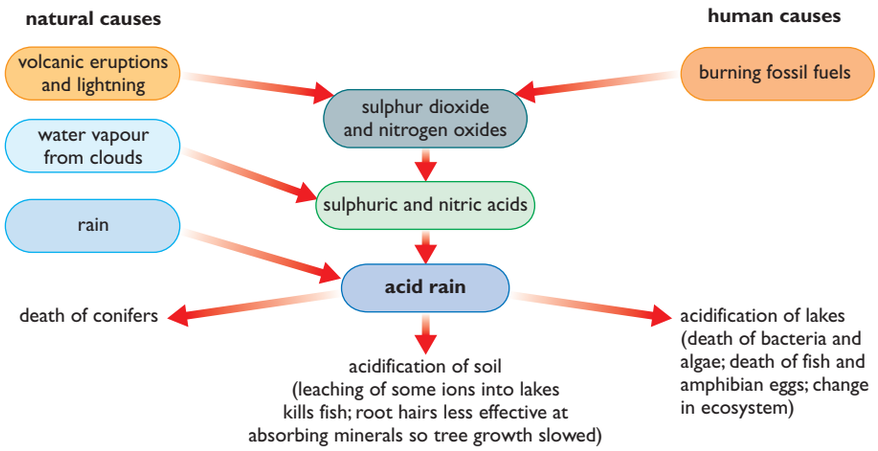


Figure 1.16 *Acid rain has many serious effects on living organisms, and can also corrode stone and metal over a long period.*

If the populations of bacteria that are involved in the nitrogen cycle and the sulphur cycle were reduced, then the cycling of these elements could not occur, and all life would be impossible as a result. It is worth thinking about. We are made from atoms and molecules that have been in many other bodies before they were in ours. The micro-organisms that recycle carbon, nitrogen, sulphur and all the other minerals make them available again … and again … and again …

Activity 1.8

Investigate the negative effects of acid rain and ways in which it can be prevented or the effects on the environment reduced.

How are bacteria used in industrial processes?

Food and beverage fermentation

Bacteria and other micro-organisms have been used in manufacturing processes for thousands of years. They have been used to make:

- bread
- alcohol
- irgo or yoghurt
- vinegar

as well as many other products.

They have also been used in key processes such as sewage treatment.

DID YOU KNOW?

Acetobacter gets its name from the old name for ethanoic acid, which used to be called acetic acid.

KEY WORD

antibiotic *a drug that kills bacteria*

Production of vinegar

Vinegar is a dilute solution of ethanoic acid in water. It also contains other substances that give the vinegar its flavour. Vinegar is used in two main ways:

- to flavour foods
- to preserve foods

Vinegar is too acidic for most micro-organisms to grow and multiply, so keeping foods in vinegar is a good way of preserving them. We call this method of preserving food pickling.

Vinegar is produced by fermenting beer, wine or cider for a second time. A culture of a special bacterium called *Acetobacter* is used. The alcohol in the beer, wine or cider is oxidised to ethanoic acid.

This takes place in a special fermenter. The fermenter is filled with wood shavings and the alcohol source is sprayed in from the top. It trickles down through the wood shavings, which are covered with *Acetobacter* bacteria. As the liquid flows past them, the bacteria oxidise the alcohol to ethanoic acid. Air is blown in at the bottom to supply the oxygen the bacteria need. The vinegar drips out at the bottom of the wood shavings and is tapped off.

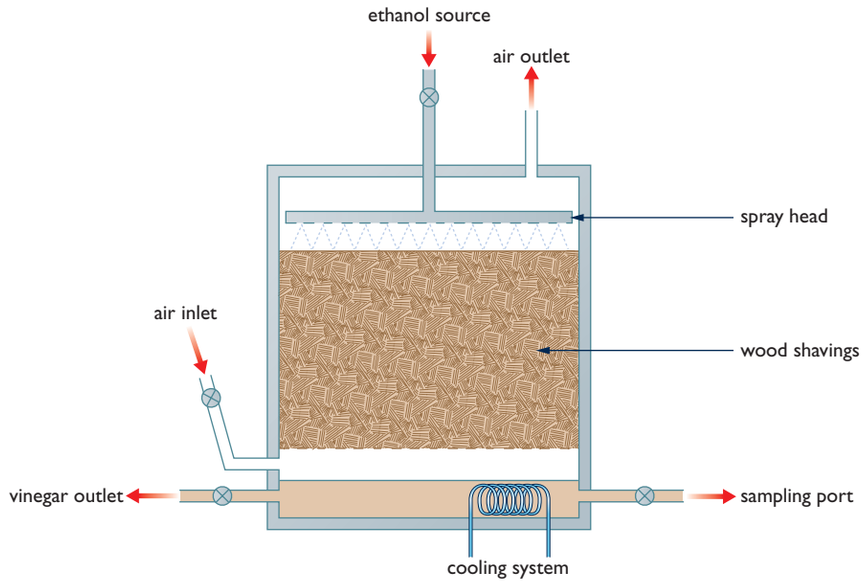


Figure 1.17 *Vinegar production*

This type of production is called continuous production, as alcohol is continuously being fed in and ethanoic acid is continuously dripping out at the bottom of the fermenter.

Producing antibiotics

The first **antibiotics** all came from fungi. Today, they are increasingly being made using genetically modified bacteria in huge fermenters. The stages in the process are shown in figure 1.18 overleaf.

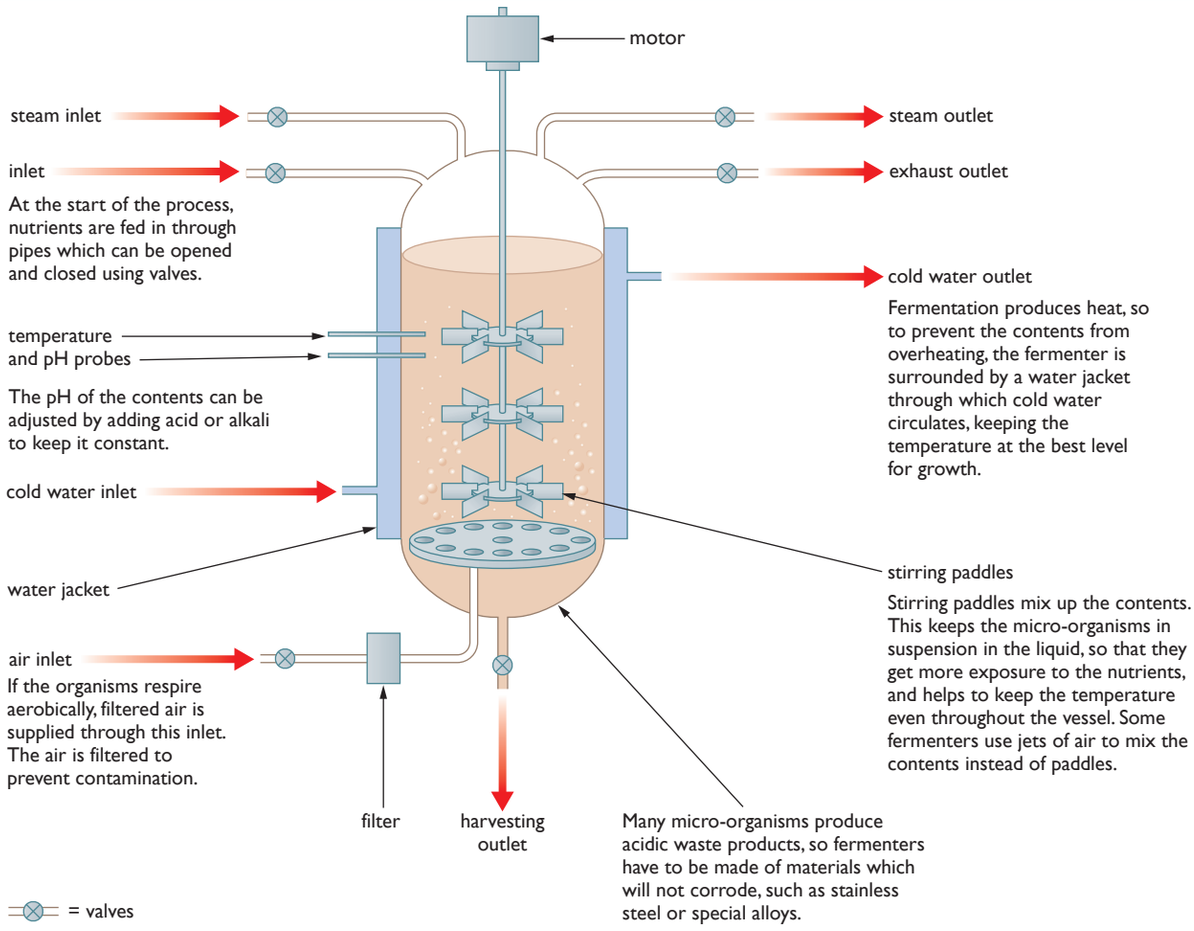


***Figure 1.18** Production of antibiotics*

Genetically modified bacteria are also used to produce:

- insulin
- human growth hormone
- antibiotics
- enzymes for washing powders
- human vaccines, such as the vaccine against hepatitis B

Sewage treatment

All types of sewage treatment rely on the action of a range of micro-organisms to oxidise the organic matter present in sewage. There are two main methods:

- the percolating filter method
- the activated sludge method

In the percolating filter method:

- sewage is screened to remove large pieces of debris
- it stands in a large settlement tank to allow suspended matter to settle out
- it is then allowed to trickle through a bed of stones, each of which is covered in a layer of micro-organisms (bacteria, fungi and protozoa)
- as the sewage trickles through the filter bed, the micro-organisms digest the organic matter and absorb the products
- by the time the liquid reaches the bottom of the filter bed, the polluting organic matter has all been removed

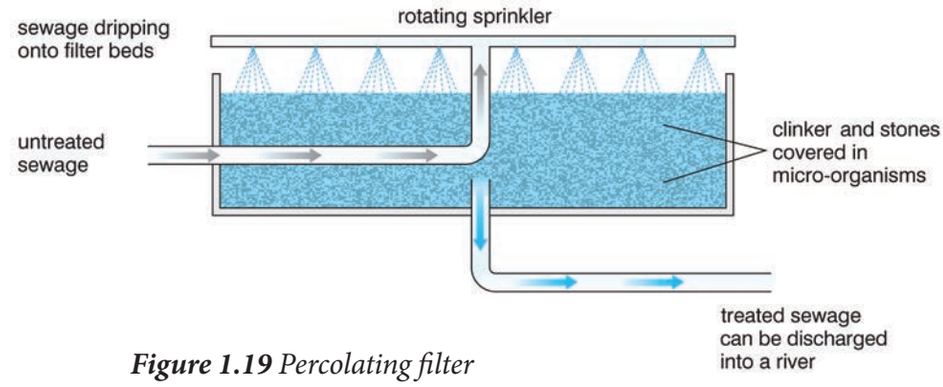


Figure 1.19 *Percolating filter*

In the activated sludge method:

- sewage is screened and allowed to stand in settlement tanks, as in the percolating filter method
- it is then pumped into treatment tanks, where:
  - activated sludge, rich in micro-organisms, is added
  - oxygen is blown through the mixture
- in the oxygenated mixture, the micro-organisms from the added activated sludge oxidise the polluting organic matter, reproducing as they do so
- some of the sludge formed is recycled to 'seed' new tanks.

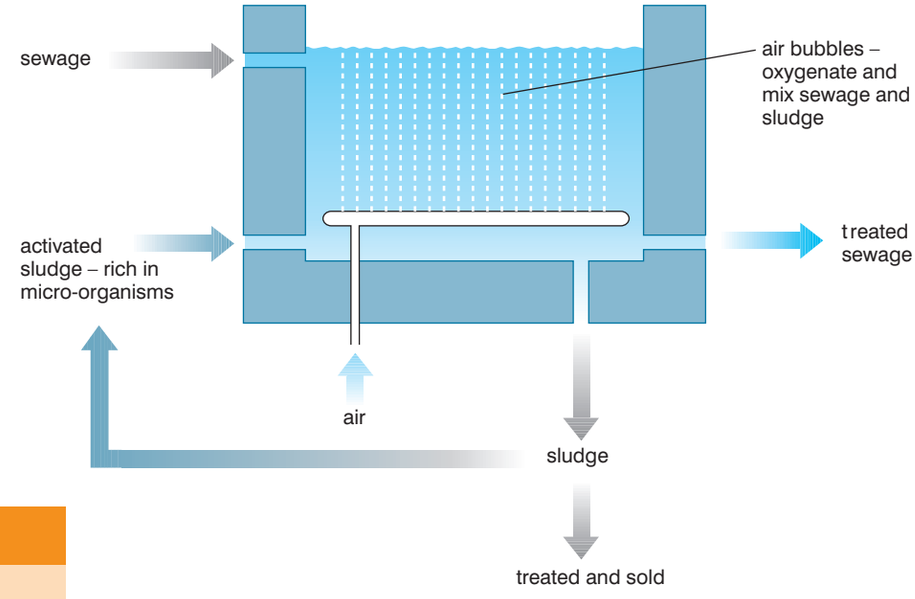


Figure 1.20 *The activated sludge method*

Activity 1.9

We use bacteria in many different ways in industry. Make a poster to show as many of these different industrial uses of bacteria as you can. Make your poster clear and colourful so people enjoy learning from it.

How are bacteria genetically modified?

You have already been introduced to **genetic engineering**.

Genes are sections of the DNA of an organism that code for a particular protein. So if a gene can be transferred successfully from one organism into a bacterium, the genetically modified bacterium will now make the protein that its 'new gene' codes for.

The development of three main techniques made genetic engineering possible.

- The discovery that genes can be 'cut' out of a DNA molecule using enzymes called restriction endonucleases.
- The discovery that genes can be inserted ('tied') into another DNA molecule using a ligase enzyme.
- Genes can be transferred into other cells using **vectors**. These are usually either plasmids (small pieces of circular DNA found in bacteria), or viruses.

Once the gene has been inserted into the new bacterium, the bacterium becomes a genetically modified or transgenic organism.

KEY WORDS

genetic engineering *the practice of transferring genes from one organism to another organism (either belonging to the same species or belonging to a different species). This is done by taking DNA from the first organism and transferring it to the second organism. Genetic engineering has only been practised since 1980*

vector *a means of transferring something. In genetic engineering, viruses are used as vectors to transfer genetic information between different organisms*

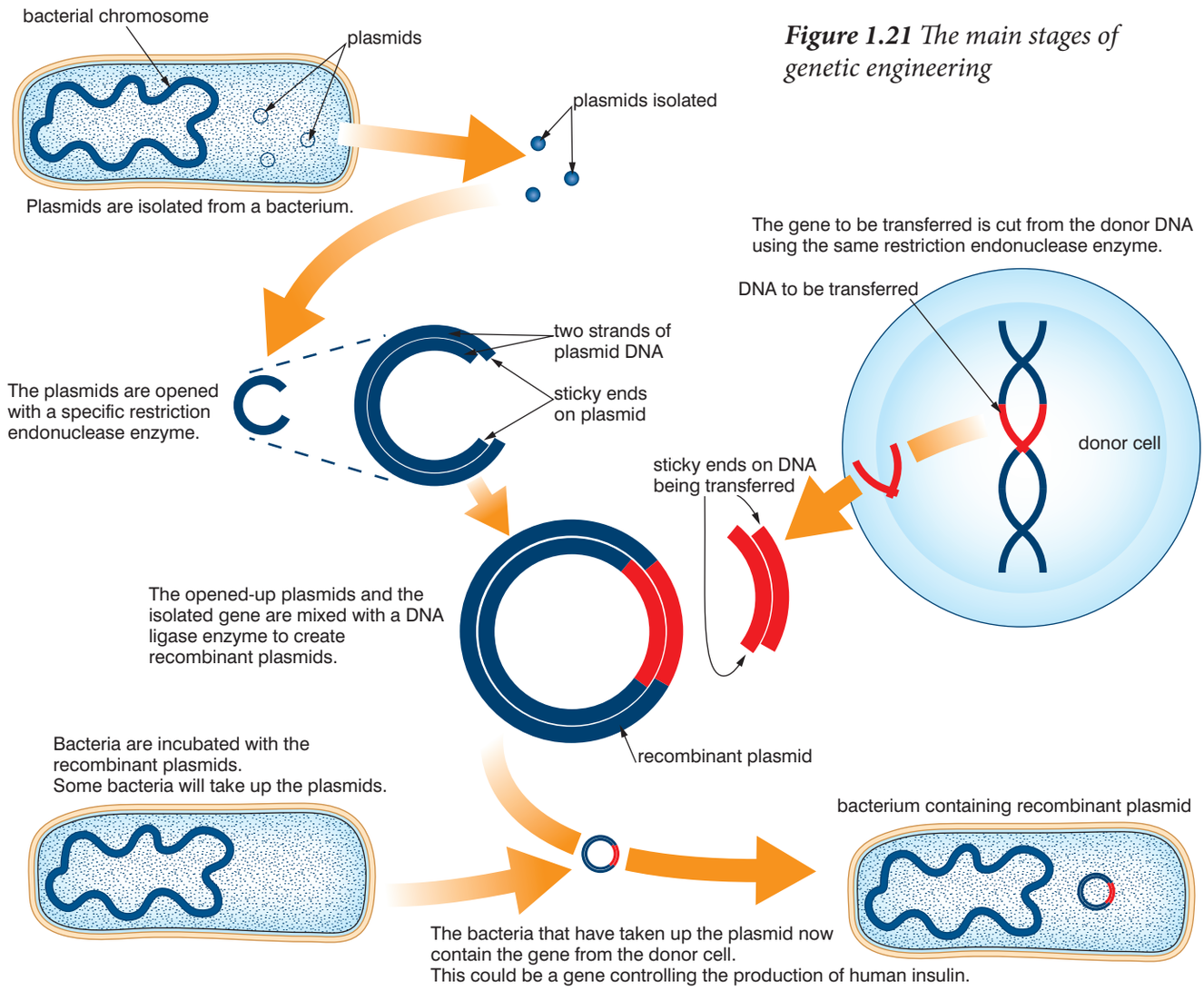


Figure 1.21 *The main stages of genetic engineering*

Bacteria aren't the only organisms that have been genetically modified. Many crop plants have also had foreign genes inserted into them. These give the plants new properties, such as:

- resistance to infectious disease
- resistance to animal pests
- a longer shelf-life before decaying

Genetic engineering of plants posed problems for biologists, as plant cells will not accept plasmids in the same way as bacterial cells do. However, they discovered that one particular bacterium, called *Agrobacterium tumefaciens*, regularly infects plant cells. This bacterium can act as a vector to carry genes that have been inserted into a genetically modified *Agrobacterium* into plants. Figure 1.22 shows how this is done.

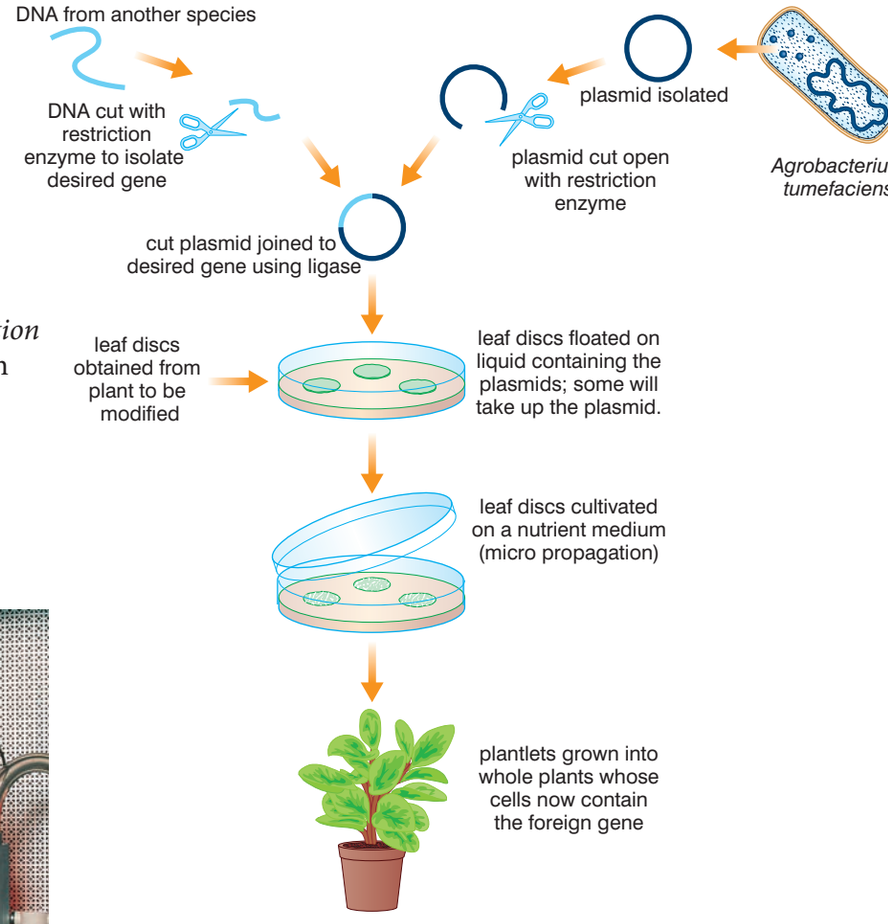


Figure 1.22 *Genetic modification of plants using* Agrobacterium

Figure 1.23 *A scientist working with a gene gun*

However, *Agrobacterium* can't be used to genetically modify all types of plant. It will not infect cereals such as maize, for example. To solve this problem, biologists developed the gene gun. This literally shoots the genes into cells of plants, using as 'bullets' tiny pellets of gold that are covered in DNA. You could think of it as the 'golden gun'.

The gene gun has made it possible to genetically modify plants such as maize, tobacco, carrots, soybean and apple. For example, maize has had genes inserted into it that cause it to:

- produce a pesticide that makes it resistant to some insect pests
- be resistant to some fungal diseases

Review questions

Choose the correct answer from A to D.

1. Sources of infectious organisms that spread to infect others are called:
   A hosts of infection
   B sources of infection
   C reservoirs of infection
   D sites of infection
2. Disease-causing bacteria can be transmitted by:
   A sexual intercourse
   B droplet infection
   C eating contaminated food
   D all of the above
3. Which of the following is *not* an infectious disease?
   A tuberculosis
   B AIDS
   C coronary heart disease
   D the common cold
4. Which if the following statements are NOT true about nitrogen-fixing bacteria?
   A They are often found in nodules on the roots of legumes
   B They convert nitrogen gas into ammonium ions
   C They break down nitrate ions into ammonium ions
   D They play a vital role in the nitrogen cycle in nature
5. In the sulphur cycle, the main source of sulphur for plants is:
   A sulphur in rocks
   B sulphates in the air
   C sulphur in water
   D sulphates in soil
6. In the percolating filter method of sewage treatment:
   A the sewage is screened to remove large pieces of waste
   B the sewage trickles through stones covered in micro-organisms
   C the micro-organisms oxidise the organic matter in the sewage
   D all of the above
7. DNA can be transferred into maize using:
   A plasmids
   B the gene gun
   C *Agrobacterium*
   D viruses

8. In genetic engineering, a section of DNA is removed from a DNA molecule using:
   A ligase enzymes
   B plasmids
   C restriction enzymes
   D polymerase enzymes
9. Which of the following is NOT a term used to describe organisms that have had foreign genes added to them?
   A transgenic organisms
   B genetically modified organisms
   C pathogenic organisms
   D genetically engineered organisms
10. Which of the following were important in developing the germ theory of disease?
   A Louis Pasteur, showing that excluding micro-organisms from wine prevented it from going sour
   B Joseph Lister, showing that using carbolic acid, which killed bacteria, reduced infection during surgery
   C Robert Koch, identifying specific micro-organisms associated with specific diseases
   D all of the above

1.3 What are viruses?

By the end of this section you should be able to:

- Describe the structure of a virus, draw and label it.
- Explain the different forms of viruses and diagram them.
- Classify viruses and give examples of RNA, DNA, and retroviruses.
- Discuss the reproductive cycles of viruses and compare the lytic and lysogenic cycles of viral reproduction.
- Draw and label a bacteriophage.
- Compare viruses with free-living cells.
- Draw, label and describe the structure of HIV, show the structure of glycoprotein-120 on its surface and tell that it is this protein that allows HIV to bind with CD4 lymphocytes.
- Explain the life cycle of HIV, show how it replicates.

- Explain how different anti-retroviral drugs work and tell why HAART is more effective than single drug treatment.
- State the social and economic impacts of AIDS.
- Demonstrate the life skills that lead to responsible sexual behaviour.

KEY WORD

virus *some genetic material contained in a protein coat. It is not usually regarded as a living organism*

Introducing viruses

We have already looked a little at **viruses** and we have seen that there are reasons to consider them not to be living organisms – a virus particle (sometimes called a virion) is nothing like either a prokaryotic cell or a eukaryotic cell.

Viruses are much smaller than even the smallest bacterium. Most are between 0.01 and 0.1 µm in length or diameter. This makes them at least 1000 times smaller than the smallest bacterium and 1 000 000 times smaller than most human cells.

The characteristics of viruses are shown in table 1.5.

Table 1.5 *Characteristics of viruses*

Feature	Virion (virus particle)
Size	0.01–0.1 µm
Nucleus	Absent
DNA	Tiny amount of linear DNA in some; others contain RNA but no chromosomes
Other cell organelles	Absent

Because they do not have the major organelles that are present in living cells, virus particles can't carry out any of the normal metabolic processes of cells, such as:

- respiration
- protein synthesis
- DNA replication
- photosynthesis
- active transport
- facilitated diffusion
- any other process requiring control by enzymes or the presence of proteins

DID YOU KNOW?

The particle of a virus is called a virion. All virions contain at least two components:

- a protein shell or capsid
- DNA or RNA as the genetic material

Some also have:

- a membrane made from lipids and proteins outside the capsid
- other proteins and enzymes inside the capsid

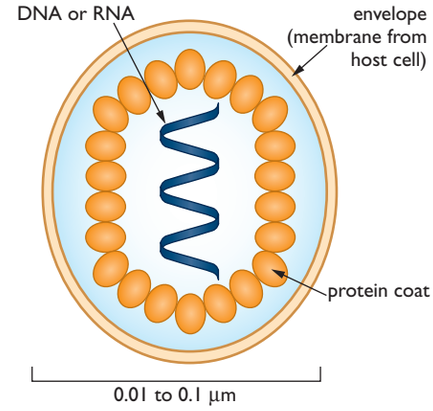


Figure 1.24 *The structure of a typical virus*

As a result, all viruses are parasites. The only way they can reproduce is to invade cells, 'hijack' the normal metabolic processes of those cells, and make the cells produce more virus. Once produced, the viruses escape from the cell and infect other cells. Figure 1.25 shows how this happens in two different types of viruses. Other viruses adopt different strategies.

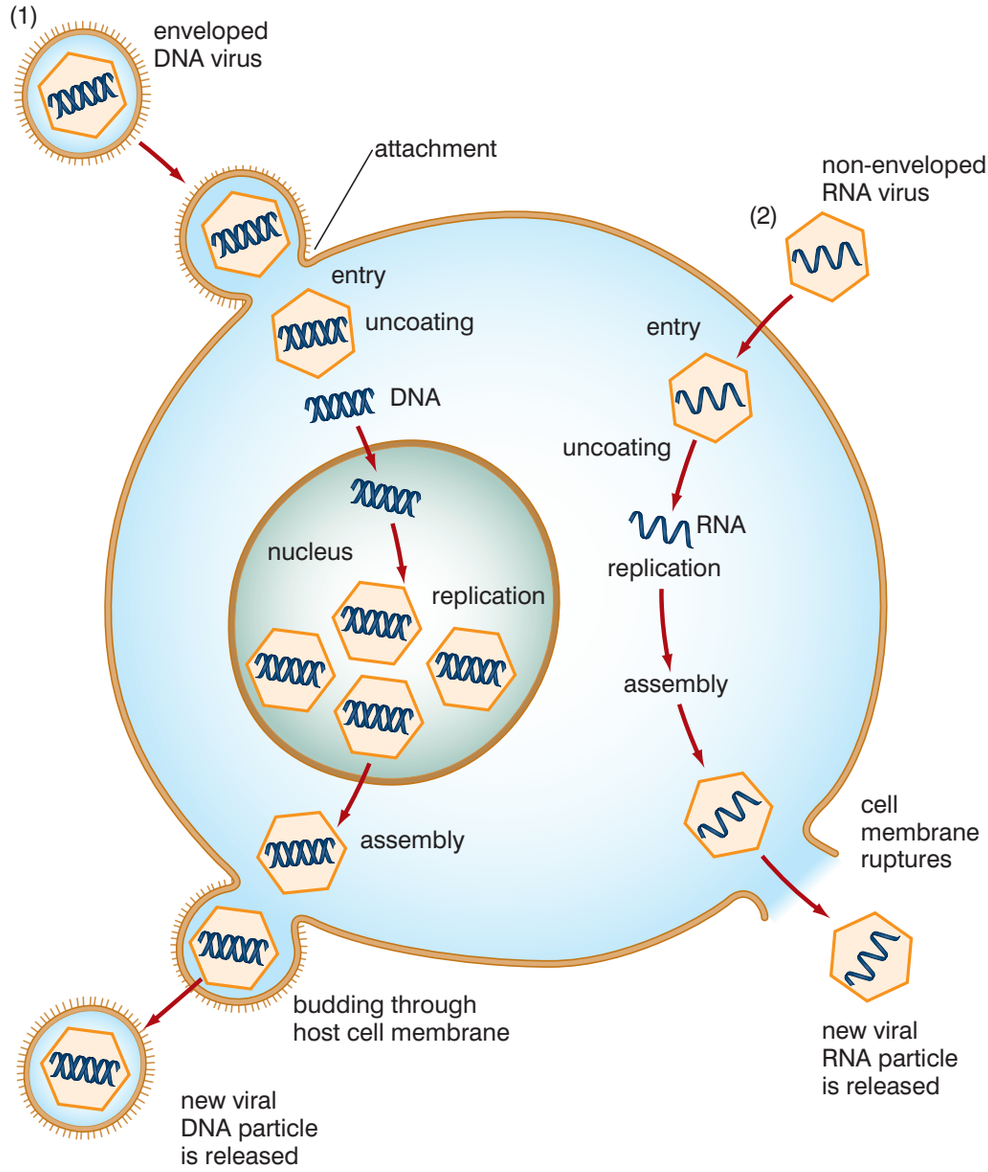


Figure 1.25 *Stages of virus infection of cells.*

Classifying viruses

It is difficult to classify viruses because, even though they have a basic structure, there is a great deal of variation in their shape and the way in which they infect cells. However, they can be classified into three main groups, based on the nature of their genetic material and the way in which it is expressed. These groups are:

- **DNA viruses** – for example, Herpes simplex (causes cold sores)
- **RNA viruses** – for example, H1N1 virus (causes swine flu)
- **retroviruses** – for example, HIV (causes AIDS)

DNA viruses

When a DNA virus infects a cell, the viral DNA can replicate itself and can also control the synthesis of virus proteins, so that the new DNA and new protein can be assembled into new virus particles.

RNA viruses

When an RNA virus infects a cell, its RNA can be used to synthesise more viral proteins, including an enzyme that controls the synthesis of more RNA. The new RNA and new proteins can be assembled into new virus particles.

With the exception of the RNA viruses, all organisms store their permanent information in DNA, using RNA only as a temporary messenger for information. DNA is quite a stable molecule, is not very reactive with other molecules, and replicates very accurately. In contrast, RNA is quite unstable and makes frequent mistakes during copying.

But these very properties make RNA ideal for the storage of viral information. Once the host's immune system has learned to recognise an infecting virus and create antibodies against it, it can quickly destroy it, and the virus needs to change its nature so that the host's immune system will no longer recognise it – it must mutate. The unstable nature of RNA allows RNA viruses to evolve far more rapidly than DNA viruses, frequently changing their surface structure.

Retroviruses

Retroviruses also contain RNA, but replicate in a different way. When they infect cells, they release into the cells their RNA and an enzyme that causes it to be 'reverse-transcribed' into DNA. This then controls the formation of more viral protein and RNA that can be assembled into new virus particles.

Viruses can also be classified by the type of organism they infect:

- animal-infecting viruses
- plant-infecting viruses
- bacteria-infecting viruses – these are called **bacteriophages**

Bacteriophages have a really unusual shape – they look rather like a lunar landing module!

KEY WORDS

DNA virus *contains genetic information stored in the form of DNA*

RNA virus *contains genetic information stored in the form of RNA*

retrovirus *an RNA virus that converts its genetic information from RNA into DNA after it has infected a host*

bacteriophage *a virus that uses a bacteria to replicate its genetic information*

DID YOU KNOW?

We say that the RNA is reverse-transcribed because, in cells, DNA is normally transcribed into RNA as part of the process of protein synthesis. Carrying out the process in the opposite direction is reverse transcription.

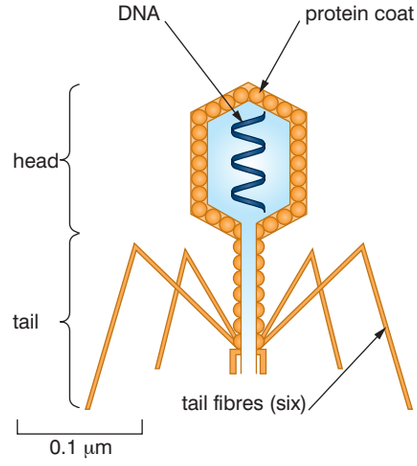


Figure 1.26 *Structure of a bacteriophage*

Virus multiplication

Much of our knowledge about how viruses are reproduced comes from work on bacteriophages. One bacteriophage in particular, called T4, has been studied more than any other. Its reproductive cycle is shown in figure 1.27.

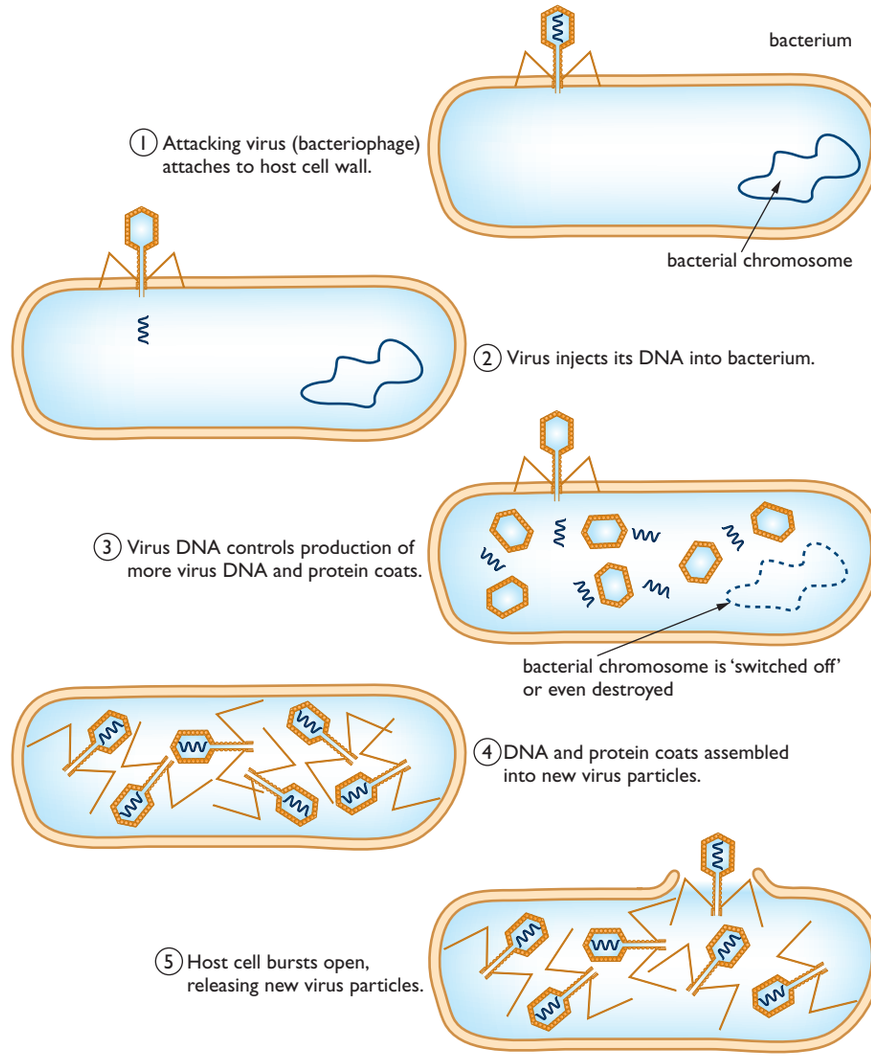


Figure 1.27 *The reproductive cycle of bacteriophage T4*

This type of life cycle is called a **lytic cycle** because it causes the rupture (lysis) of the host cell.

From research on bacteriophages, we know that this is not the only type of reproductive cycle in viruses. Sometimes, instead of causing the cell to burst and release the viruses all at once, a few at a time are released by exocytosis through the plasma membrane. This type of life cycle is called a **chronic release cycle**, because release of new viruses is ongoing (chronic).

In other cycles, the virus's DNA becomes incorporated into the DNA of the host cell. Each time the cell divides, the DNA is replicated, and each daughter cell gets a copy of the cell's DNA, which now includes the virus DNA. This can continue for many generations until some factor in the environment triggers the

virus DNA to start producing virus proteins. Then whole viruses are assembled, which then leave the cell either by causing cell lysis (splitting), or by chronic (ongoing) exocytosis from the plasma membrane. This type of life cycle is called a **lysogenic cycle**.

These different reproductive strategies are summarised in figure 1.28.

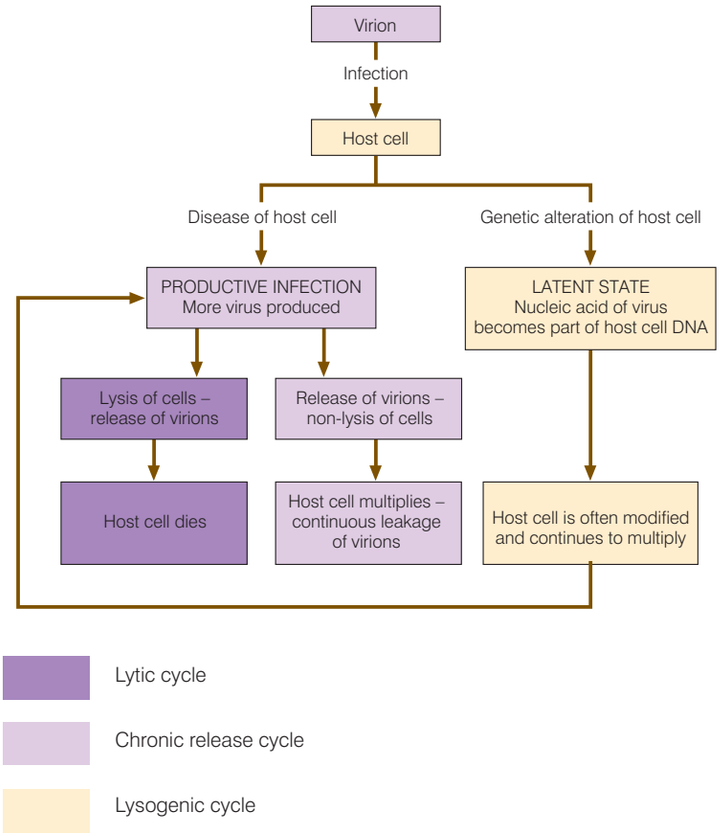


Figure 1.28 *Reproductive strategies of viruses: lytic cycle, chronic release cycle and lysogenic cycle*

Activity 1.10

You have now studied viruses and bacteria as well as plant and animal cells. Brainstorm the similarities and differences between them and then produce a large, clear table comparing viruses, bacteria, plants and animals.

Modes of virus transmission

As well as having different reproductive strategies inside the host cell, different viruses also enter cells in different ways.

- The bacteriophage injects just its DNA; the rest of the virus remains outside the cell.
- Many (but not all) animal viruses manage to get the whole virus inside the cell. This is done by tricking the cell into bringing the virus into the cell in the same way as it would with any large protein molecule – using the process of endocytosis.

HIV and AIDS

What is HIV like?

Human Immunodeficiency Virus or **HIV** is one of the retroviruses. It has RNA as its genetic material. This is transcribed to DNA by the enzyme reverse transcriptase, which HIV contains together with the RNA.

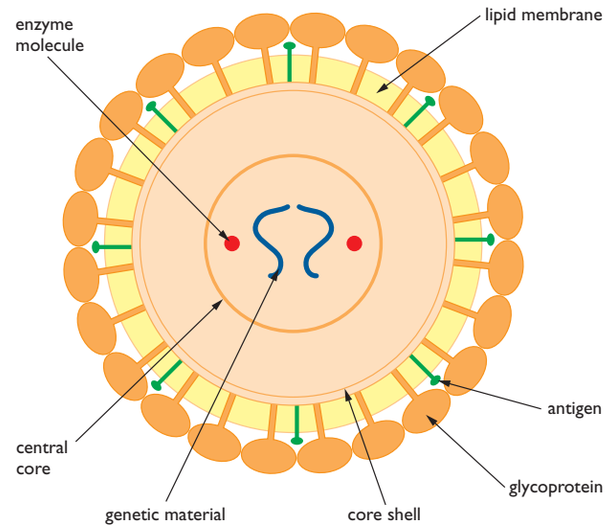


Figure 1.29 *The structure of HIV*

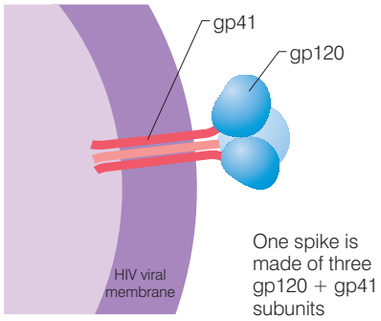


Figure 1.30 *The spikes on the surface of HIV are made from three gp120 glycoprotein molecules attached to another molecule called gp41. The shape of these spikes allows them to bind with CD4 receptors on the T-helper cells. Because they have this particular receptor on their surface, they are called CD4 lymphocytes.*

HIV targets cells that form part of the immune system. Its main target is a type of cell called a CD4 T-lymphocyte. These cells are also called T-helper cells, because they 'help' other cells in the immune system to mount an immune response to pathogens in the body. Without this response, pathogenic micro-organisms can multiply in the body and cause disease.

HIV has spikes on its surface, the heads of which are made from the glycoprotein known as gp120. This binds with CD4, a protein that protrudes from various types of human cell. A gp120 sticking out of an HIV virus particle connects with a CD4 sticking out of a cell like an egg fitting into an egg cup. Once the virus has attached to a cell, it can go on to the next stage and merge with the host cell.

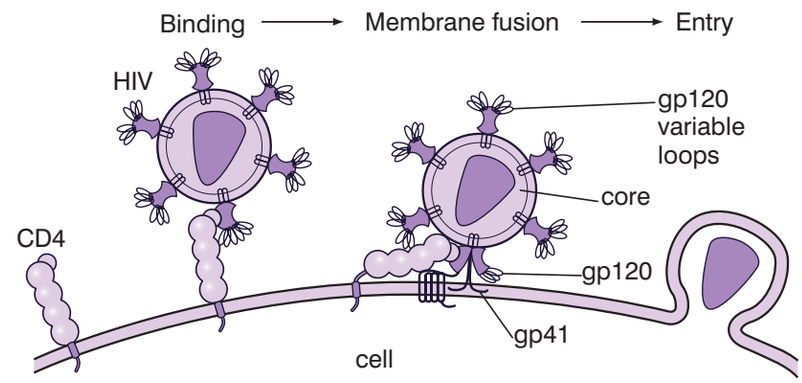


Figure 1.31 *HIV infection of CD4*

Besides the T-helper cells, there are other types of cell that carry CD4 on their surface – such as **macrophages** and some natural killer cells. T-helper cells are the most important, though, because they are co-ordinators of the immune system. If their activity is impaired, it can have serious effects on the body's response to infections by other organisms.

How does HIV reproduce and cause AIDS?

After HIV has bound to the CD4 receptors on the surface of the T-helper cell, the following events occur:

1. It fuses with the plasma membrane and then releases its RNA and reverse transcriptase enzyme into the cell.
2. The reverse transcriptase converts the RNA into DNA using building blocks called nucleotides, which are provided by the cell.
3. The viral DNA becomes incorporated into the cell's own DNA.
4. The viral DNA is transcribed to viral RNA, which starts producing viral proteins, including the enzyme reverse transcriptase.
5. The RNA, proteins and reverse transcriptase molecules are assembled by the cell into new HIV particles that escape by 'budding' from the cell membrane – this is an example of chronic release.
6. The viruses then infect other T-helper cells.

Some HIV proteins remain on the surface of the infected CD4 cell and are recognised by the immune system – these cells are destroyed. The cycle of infection, reproduction and destruction of infected cells repeats itself for as long as the body can keep replacing the CD4 lymphocytes.

KEY WORDS

HIV *HIV (human immuno-deficiency virus) is the virus now known to cause AIDS*

AIDS *(acquired immune deficiency syndrome) is a disease that causes its victim's immune system to degenerate leaving them vulnerable to infectious diseases and some types of tumour*

macrophage *(also called a* **white blood cell***) is a cell that surrounds and destroys pathogens*

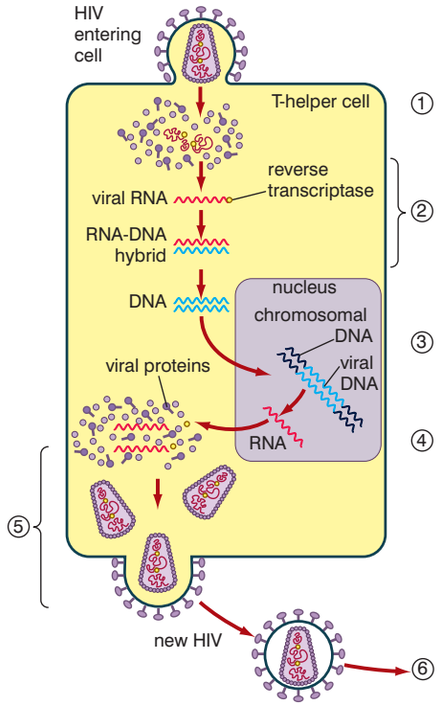


Figure 1.32 *The reproductive cycle of HIV.*

Activity 1.11

It is important for people to know as much as possible about HIV/AIDS, including how to prevent the virus spreading and how to support those affected by the virus. Plan an HIV/AIDS awareness campaign to be used in your community.

Eventually, the body will not be able to replace these cells, and the number of free viruses in the blood will increase dramatically – HIV may infect other areas of the body, including the brain.

Because of the drastic reduction in the number of T-helper cells, the immune function is severely reduced and many opportunistic infections may occur (including pneumonia and tuberculosis), together with rare cancers like Kaposi's sarcoma.

Figure 1.33 summarises these changes.

DID YOU KNOW?

As well as infected cells being destroyed by natural killer cells, other lymphocytes make antibodies that target any free HIV in the blood. The presence of these antibodies can be detected, and the person is diagnosed as being HIV-positive.

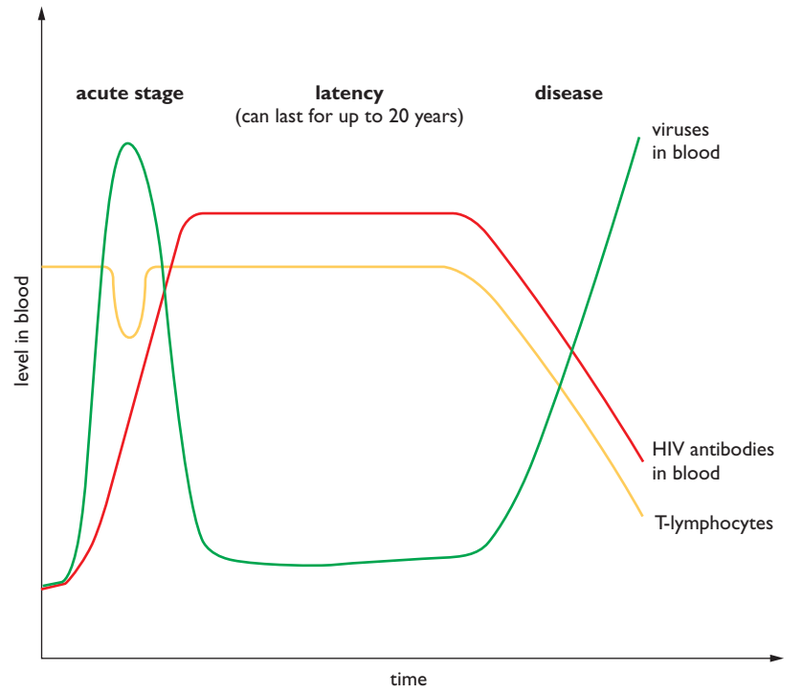


Figure 1.33 *Changes in blood caused by HIV infection over time*

The period when the body keeps replacing the CD4 lymphocytes as fast as they are destroyed is called the **latency period** and can last for many years.

Can AIDS be treated?

Although there is no cure for AIDS and, as yet, no vaccine to give immunity against infection, there are a number of drugs – called anti-retroviral drugs – that can be effective in slowing down the progression to AIDS. These drugs work by blocking the reproduction of the virus in the CD4 lymphocytes. There are several different drugs that act in different ways at different stages of the cycle of reproduction.

Because the drugs act on different stages of the HIV life cycle, the most effective treatment is obtained when they are used together. This is called **H**igh **A**ctivity **A**nti-**R**etroviral **T**reatment (HAART). Although it is effective against HIV, it does have unpleasant side-effects.

Activity 1.12: Avoiding AIDS

Avoiding AIDS is about respect

- You respect your body – you refuse to expose it to HIV
- You respect your future – you refrain from sexual intercourse or always use condoms correctly

Work in pairs and think of five more 'respects' that will help a person to avoid AIDS. For each write a short paragraph explaining how respecting each item will help you to avoid AIDS and incorporate the paragraphs into a poster.

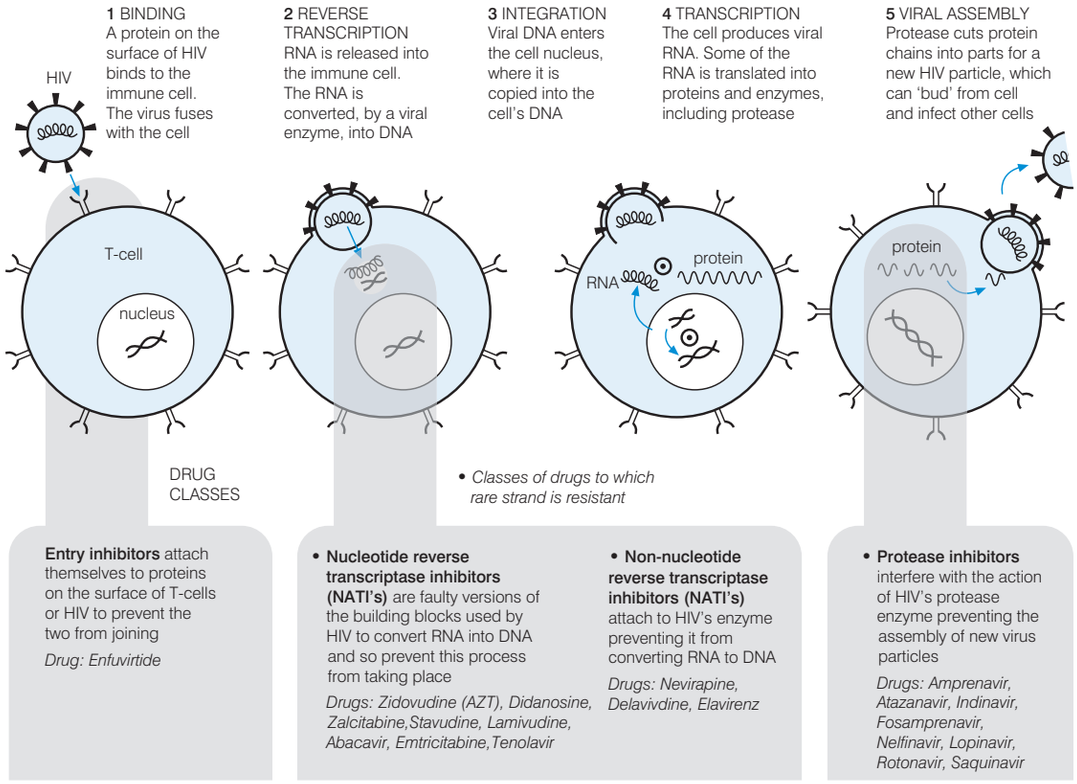


Figure 1.34 *The effects of different anti-retroviral drugs*

What is the social and economic impact of AIDS?

Within families, the infection of family members is often not a subject for discussion. This is because of:

- shame associated with admitting to being infected (which is connected with the taboo on speaking about sexuality)
- fear of being isolated (or putting the family under pressure)
- fear of losing a job, etc.

In many cases, infected individuals have to deal with their infection alone. This puts immense emotional pressure on them. For a growing number of infected people, suicide is a way out of this situation. Traditional coping strategies and the extended family can no longer manage the situation.

Many affected families find themselves in a vicious circle:

- an increasing amount of money is needed for medical treatment and burials, but
- the number of breadwinners is decreasing.

The need to deal with the increasing number of orphans leads to more children dropping out of school to work in the household or in agriculture.

Nationally, AIDS has a serious economic impact in two main areas:

- labour supply – the loss of young adults in their most productive years will affect overall economic output

A VACCINE FOR AIDS?

Despite nearly 100 clinical trials there is no effective AIDS vaccine. Why not?

- the virus mutates (changes) regularly and so a vaccine against one strain would be ineffective against a new strain
- it infects the immune system itself
- live attenuated (harmless) virus particles cannot be used because of the danger they will re-acquire their virulence
- AIDS is a retrovirus and once RNA is converted to DNA, it can remain hidden in the host cell DNA for many years
- the only effective vaccine is likely to be one that prevents the initial infection by HIV; this is very difficult to achieve

- costs:
  - direct costs including expenditure for medical care, drugs and funeral expenses
  - indirect costs including lost time due to illness, recruitment and training costs to replace workers, and for care of orphans
  - if costs are financed out of savings, then the reduction in investment could lead to a significant reduction in economic growth

The spread of AIDS can be limited by:

- responsible sexual behaviour
  - limiting the number of sexual partners
  - using condoms
- male circumcision (this reduces the risk of males acquiring the disease)

Activity 1.13: The agree/disagree game

Activity

1. Your teacher will place signs reading AGREE, DISAGREE and DO NOT KNOW around the room.
2. Your teacher will then read aloud a statement from the list below to the class.
3. You should respond to the statement by standing next to the sign that best represents your opinion about the statement.
4. The people by each sign should explain why they agree, disagree, or don't know.

Statements

- There are more serious health problems than AIDS such as malaria and malnutrition.
- All people with HIV should be forced to carry an identity card.
- People with HIV/AIDS can contribute much to society.
- People at risk of HIV infection should be made to take a test.
- People with HIV and AIDS should be isolated.
- If you stick to one partner, you will not become infected by HIV.
- All people suffering from AIDS should be cared for in a hospital.
- I would feel embarrassed talking about condoms.
- It is natural for young men to experiment with several sexual partners.
- The main reason to have sex is for pleasure.
- AIDS is a punishment from God.
- We all die sometime, so if I die from AIDS, that's just how I'll go.
- I am not the kind of person to get HIV/AIDS.
- Condoms prevent you from getting HIV.

Activity 1.14: A case study

Read the following case study.

Almaz is seventeen and has only ever had one boyfriend who she wants to marry. She told him that she wants to wait until they get married before having sex. Her boyfriend's friends teased him for still being a virgin and so he found another girlfriend in a different township who will have sex with him. He says he uses condoms with the other girlfriend because he does not want her to get pregnant.

Imagine you could hear Almaz talking to her boyfriend about the situation. What do you think each might say to the other? Write a short dialogue between them, making it clear who is saying what.

You could start it in the following way:

Almaz: So you have a new girlfriend who has sex with you?

Boyfriend: Yes, but I always use a condom, and you know it's you I really want to be with.

Almaz: Do I?

Boyfriend: You must do, I only left because …

Almaz: I wouldn't have sex with you – is that right?

Things you could consider are:

- What does Almaz feel about the situation?
- Does she still believe her decision to wait until she is married to have sex is the right one? (Why or why not?)
- What might her boyfriend say about being teased about being a virgin? What could Almaz do about this?
- Were the boys who were doing the teasing also virgins?
- If Almaz would decide to have sex with her boyfriend, how can she know that he *has* used condoms with the other girlfriend?

Review questions

Choose the correct answer from A to D.

1. Compared with bacterial cells, viruses are:
   - A smaller, with more organelles
   - B smaller, with fewer organelles
   - C larger, with fewer organelles
   - D larger, with more organelles
2. When bacteriophages infect bacteria:
   - A they inject only the DNA
   - B the whole virus enters by exocytosis
   - C the DNA enters by endocytosis
   - D none of the above
3. In the lysogenic cycle of virus reproduction:
   - A the viral DNA becomes incorporated into the host cell's DNA
   - B when the host cell divides, copies of the viral DNA are passed to the daughter cells
   - C eventually the viral DNA becomes activated and causes the production of viral proteins
   - D all of the above

Activity 1.15: Debate

Some people believe that viruses are not living organisms at all. Others believe that they are highly specialised microorganisms. In this activity you will debate this issue.

Your teacher will divide the class into three groups:

- Group 1 – this group will present arguments to support the idea that viruses are not living organisms
- Group 2 – this group will present arguments to support the idea that viruses are highly specialised microorganisms
- Group 3 – this group will form the 'audience' who will:
- question the members of each of the other groups after their presentation
- vote to decide the outcome of the debate

The debate will follow the following procedure:

- Group 1 will present their case (2 minutes)
- Group 2 will present their case (2 minutes)
- Groups 1 and 2 can question the other group and try to disprove their ideas (2 minutes)
- Group 3 (the audience) can question any members of any group (4 minutes)
- Group 3 votes on the issue

4. Some biologists do not think viruses are living organisms because:
   A they reproduce inside the cells of other living organisms
   B they contain genetic material
   C the only function of living organisms that they carry out is reproduction
   D they are parasites
5. It is true to say that:
   A all viruses are parasites
   B all viruses contain DNA
   C all viruses contain RNA
   D all viruses have a lysogenic reproductive cycle
6. HIV is:
   A a retrovirus
   B an RNA virus
   C a DNA virus
   D a bacterium
7. gp120 is:
   A a glycoprotein on the surface of HIV
   B a glycoprotein on the surface of T-helper cells
   C a lipoprotein on the surface of HIV
   D a lipoprotein on the surface of T-helper cells
8. The period in the development of AIDS when the body replaces T-helper cells as fast as they are destroyed is called:
   A the acute phase
   B the binding and fusion phase
   C the latency phase
   D the escape phase
9. Being HIV-positive means that:
   A a person has AIDS
   B a person has been in contact with HIV
   C a person has other diseases as a result of HIV
   D a person has HIV antibodies in his or her blood
10. Which of the following is NOT a way in which AIDS can affect families?
    A it can increase the medical costs
    B it can reduce the family income
    C it can help people to find work
    D it can cause sadness and bereavement

Summary

In this unit you have learnt that:

- The five different groups of micro-organisms are:

Group	Comments	Example
Protozoa	Eukaryotic cells, unicellular, lack cell wall	*Amoeba, Plasmodium*
Fungi	Eukaryotic cells, non-cellulose cell wall Only yeasts are unicellular Most have hyphae which form a mycelium	*Yeast, Candida* *Mucor, Penicillium*
Algae	Eukaryotic cells, non-cellulose cell wall Unicellular algae are part of the plankton	*Chlamydomonas*
Bacteria	Prokaryotic cells, non-cellulose cell wall, all unicellular	*Streptococcus, Lactobacillus*
Viruses	Acellular, made only of nucleic acid and protein coat	HIV, influenza virus

- Eukaryotic and prokaryotic cells differ in a number of ways:

Feature	Prokaryotic cell	Eukaryotic cell
Size	1 µm to 10 µm	10 µm to 100 µm
Nucleus present	No	Yes
DNA	In a continuous loop, no chromosomes	Linear DNA in chromosomes
Mitochondria	Absent (but all can still respire)	Present
Chloroplasts	Absent (but some can photosynthesise)	Present in some
Ribosomes	Small (70S)	Large (80S)

- The main shapes of bacterial cells are cocci (spheres), bacilli (rods) and spirochaetes (spirals).
- Bacteria can be classified as Gram-positive or Gram-negative by their response to the Gram stain.
- Micro-organisms cause disease in different ways:
  - bacteria release toxins that affect cells as they multiply
  - viruses enter cells and take over the 'metabolic machinery' of these cells
  - fungi secrete enzymes that digest substances in the tissues where they grow
  - protozoa have no set pattern of causing disease
- The main methods of transmission of disease are:
  - droplet infection
  - drinking contaminated water and eating contaminated food
  - direct contact
  - sexual intercourse
  - blood-to-blood contact
  - animal vectors

- Diseases can be categorised into:
  - infectious diseases (caused by the entry of some organism into the body)
  - human-induced diseases (caused by lifestyle/working conditions, for example, heart disease)
  - degenerative diseases (often the result of ageing – for example, arthritis)
  - genetic diseases (mutant alleles sometimes cause a large malfunction, for example, haemophilia)
  - deficiency diseases (caused by lack of specific nutrients – for example, scurvy)
  - social diseases (result from social activities, for example, alcoholism)
- Bacteria are involved in cycling minerals through ecosystems; these include carbon, nitrogen and sulphur.
- Bacteria have been used to manufacture bread, alcohol, irgo/yoghurt and vinegar. They are also used in the production of antibiotics, sewage treatment and water purification as well as many other key processes.
- Bacteria can be genetically modified by transferring a gene from another organism; the newly formed transgenic bacterium is then able to carry out the process specified by its new gene.
- Viruses are different from other micro-organisms because they have no cellular organelles and so cannot carry out any metabolic processes; they must all enter other cells to reproduce.
- Viruses can be classified into DNA viruses, RNA viruses and retroviruses.
- There are three different life cycles in viruses:
  - lytic life cycle (infection causes the host cell to burst and release new viruses)
  - lysogenic life cycle (infection causes the virus to enter a latent state where its DNA is reproduced with the host DNA, but no new viruses are formed
  - chronic release life cycle (infection causes viruses to be released without killing the host cell)
- AIDS (Acquired Immune Deficiency Syndrome) is caused by HIV (Human Immunodeficiency Virus).
- The glycoprotein gp120 on HIV binds with the CD4 receptor on T-helper cells.
- AIDS reduces the body's immune response by reducing the number of T-helper cells; this can take a long time. When the body is replacing the helper cells as fast as they are destroyed, the person is said to be in the latency phase of infection.
- AIDS is often best treated by HAART (High Activity Anti-Retroviral Therapy) in which several anti-retroviral drugs are combined to target different stages of the HIV infection process.
- The spread of AIDS can be limited by responsible sexual behaviour, including the use of condoms and restricting the number of sexual partners.

End of unit questions

1. Name four different types of micro-organism. Give an example of each type you name.
2. Describe four ways in which a bacterial cell is different from:
   a) an animal cell
   b) a virus
3. A student carried out an experiment to try to repeat the work of Louis Pasteur. She used the apparatus shown in figure 1.35.

   She used a broth containing all the nutrients needed by micro-organisms in test tubes.

   She heated all the test tubes at 121°C for 20 minutes. She left them for a few days, then looked to see if the broth in any of the tubes had turned cloudy. This would have meant that micro-organisms were present.

   a) Why did she heat all the tubes to 121°C at the start of the experiment?
   b) Predict the results she would have found in each tube. Explain the reasoning behind your answers.

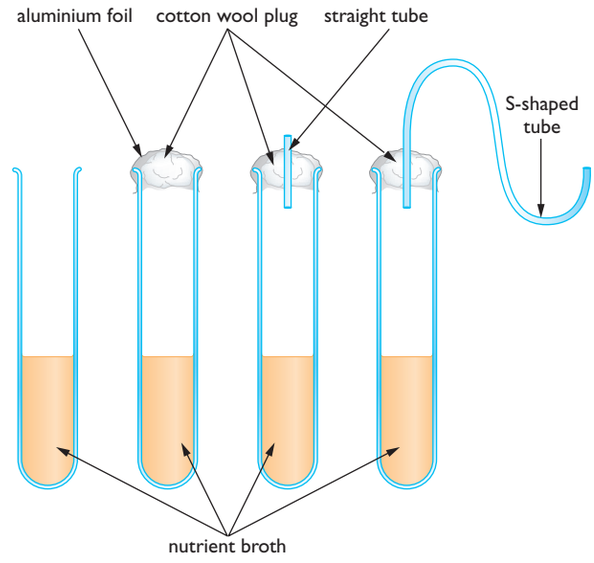


Figure 1.35

4. Figure 1.36 shows the main stages in transferring the gene for insulin production from a human cell to a bacterium.
   a) Name the enzyme used to:
      i) cut the gene from the DNA in the human cell
      ii) 'stitch' the gene into the plasmid
   b) What is the importance of the plasmid in this process?
   c) Why cannot plants be genetically engineered in this way?
   d) Describe *two* methods used to genetically modify plants.

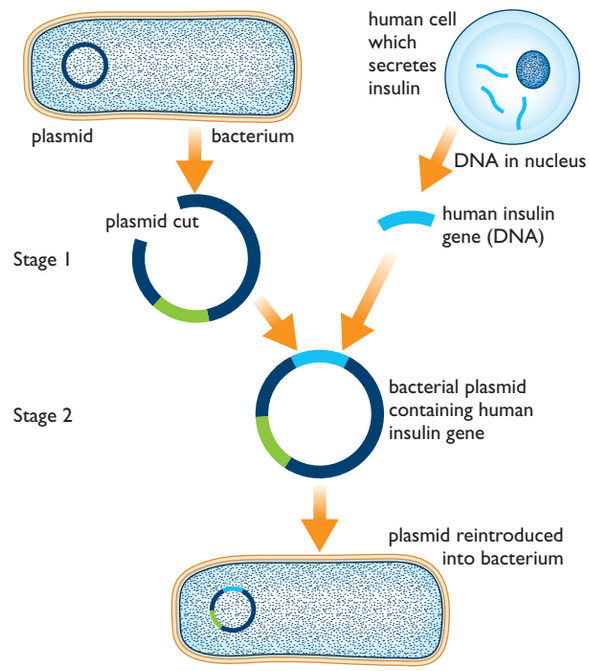


Figure 1.36

5. AIDS is caused by the Human Immunodeficiency Virus (HIV)
   a) Describe three ways in which HIV can be transmitted from one person to another.
   b) What is the 'latency' phase of AIDS?
   c) Describe *two* ways in which anti-retroviral drugs reduce the spread of HIV within a person.
6. Figure 1.37 shows the main stages of the nitrogen cycle.

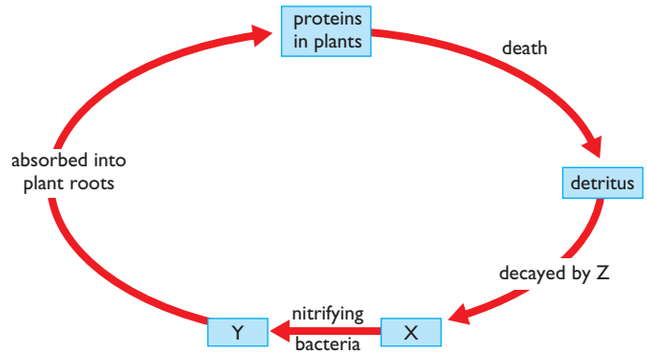
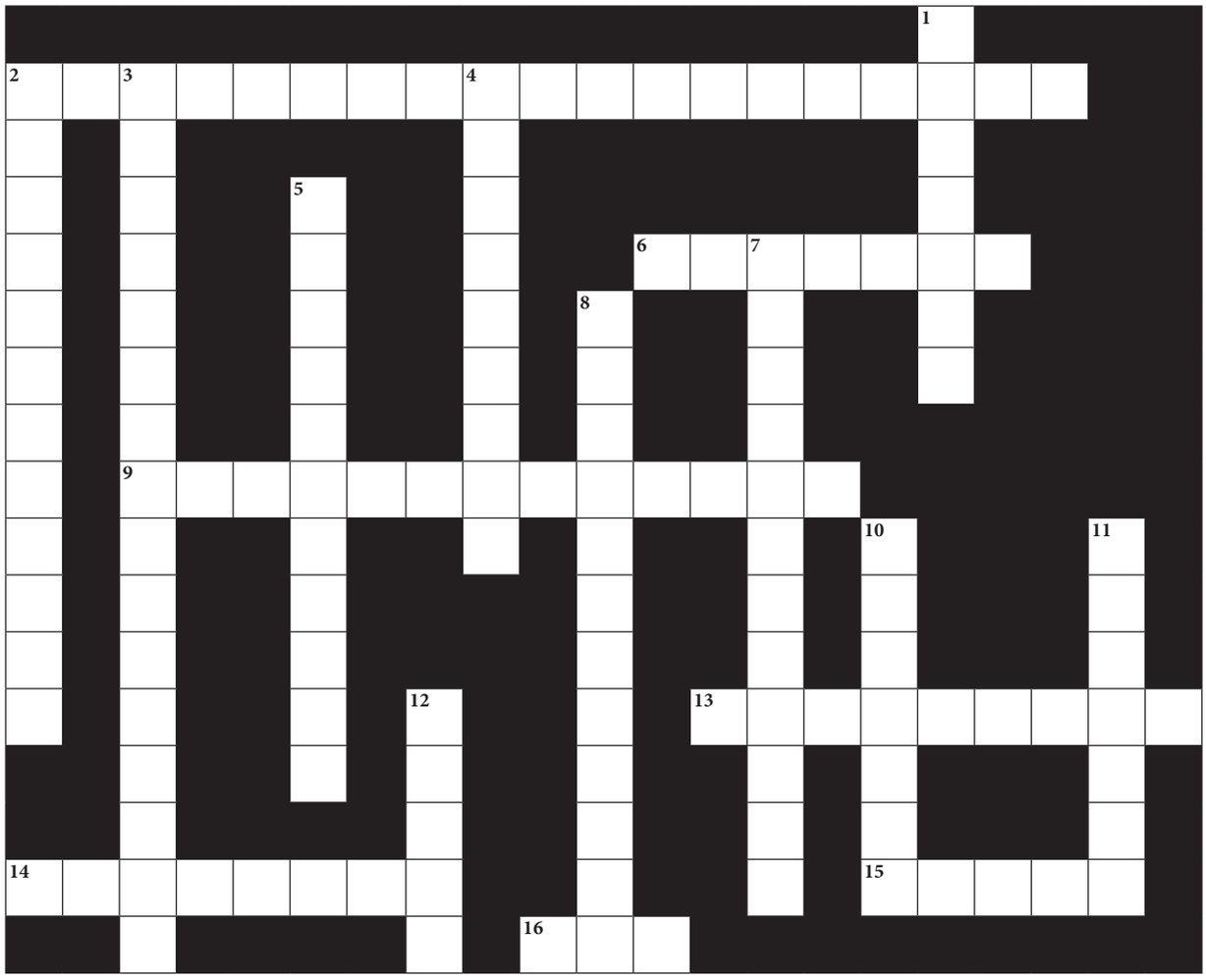


Figure 1.37

   a) What types of organism are represented by Z?
   b) What mineral ions are represented by Y and X?
   c) What are:
      i) nitrogen-fixing bacteria?
      ii) denitrifying bacteria?
7. Write an essay about the impact of AIDS. You should include the following ideas in your essay:
   - how AIDS affects families
   - how AIDS affects the country as a whole
   - the life skills that people need to cope with AIDS themselves or to care for people with AIDS
   - the life skills people need to adopt responsible sexual behaviour

Copy the crossword puzzle below into your exercise book (or your teacher may give you a photocopy) and solve the numbered clues to complete it.



Across

2. The bacteria that are used to produce antibiotics have had other genes put into them; they have been … (11, 8)
6. A condition with a specific cause in which part or all of a body is made to function in a non-normal and less efficient manner (7)
9. A process in the nitrogen cycle in which ammonium is converted into nitrate (13)
13. A source of disease-causing micro-organisms is a … of infection (9)
14. Unicellular organisms with no cell wall (8)
15. Spherical bacteria (5)
16. Gp120 molecules on HIV bind with this type of receptor on T-helper cells (3)

Down

1. Acellular micro-organisms (7)
2. Bacteria that stain purple with Gram's stain (4–8)
3. A process in the nitrogen cycle in which nitrogen gas is converted to ammonium (8, 8)
4. A type of viral life cycle in which, for a period, the infected cell keeps reproducing, copying the viral DNA without producing more viruses (9)
5. Bacteria have this type of cell (11)
7. Spiral or corkscrew-shaped bacteria (12)
8. Diseases caused by a person's lifestyle or working conditions are … (5, 7)

10 Diseases that are inherited are … diseases (7)

11. Rod-shaped bacteria (7)
12. Unicells of this group make up much of the plankton (5)