Micro-organisms

Unit 1

Learning competencies for Unit 1

By the end of this unit students 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.
- 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 as vectors.
- 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.

This unit should fill approximately **30 periods** of teaching time.

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This section should fill approximately **5 periods** of teaching time.

1.1 Bacteria

Learning competencies

By the end of this section students 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.

Starting off

Begin by reminding students that the terms micro-organism and bacteria are not synonymous. There are many different types of micro-organism. Stress that even in the microscopic world, there is huge variety in form and function.

It is also worth spending some time explaining the difficulty of classifying some types of micro-organism. Most bacteria have enough features in common to form a recognisable group. The same is true of fungi and viruses. These, however, are kingdoms; although protozoa have many features in common, they do not constitute a kingdom. How can it be that organisms with many animal-like features, such as *Amoeba* and *Paramecium*, are placed in the same kingdom (Protoctista) as the algae, which have so many plant-like features?

Teaching notes

Students could start by making a display of the different types of micro-organism, giving examples of each group (other than those given in the Students' Book) and listing three or four features that members of each group share. This will be an informative exercise for many students.

All the different groups of micro-organisms (with the exception of viruses) can be cultured easily and students can examine them. Cultures of several protozoans can be easily obtained at low cost and grown on in the laboratory. Alternatively, if safe to do so, water samples can be collected and the protozoa cultured in culture media. Details of these media are given in the appendix on page 33 of this book.

Regular observations of the culture can provide a valuable lesson in population dynamics. The best microscope to use is a compound microscope with 10×, 40× and 400× objective lenses. You can use cavity slides at the two lower powers, but use a plain slide with coverslip at 400×.

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Fungi can be cultured easily by leaving bread or milk exposed to the air. Species of *Mucor* and *Penicillium* and several others will readily colonise these and can be examined easily to show the mycelial habit of some fungi.

Bacteria can be cultured from many sources – including the air – in basic agar-based culture media in Petri dishes, to show the growth of colonies. Alternatively, bacterial cells can be seen in cultures of yoghurt. They can be stained for microscopic observation using small amounts of methylene blue or crystal violet, but little detail will be seen, even under the 400× objective lens.

Studying the structure of bacterial cells reinforces the differences between the prokaryotic cells of bacteria and the eukaryotic cells of other organisms.

It is recommended that, in describing the structure of these cells, the terms nucleoid and bacterial chromosome are avoided. The DNA in bacteria is not in a nucleus – there is no nuclear envelope enclosing the DNA. Similarly, chromosomes are made from linear DNA associated with histone proteins; neither of these is true of the bacterial DNA. It is best not to use terms that might imply the presence of these structures, as this can confuse the students.

It is worth stressing to the students that, even though bacterial cells do not have mitochondria, they can still carry out aerobic respiration. Similarly, without chloroplasts, some bacteria can still photosynthesise. Both these processes take place on the cell membranes of the bacteria.

Introduce students to the different shapes and arrangements of bacterial cells:

- coccus = sphere
- bacillus = rod
- spirochaete = spiral

They should be aware that the cocci and bacilli in particular may be arranged in pairs (prefix diplo-), groups (prefix staphylo-) or chains (prefix strepto-). Diplococci are bacteria in which a pair of spherical cells are associated. *Streptobacillus* is a bacterium in which several rod-shaped bacteria form a chain.

Students should appreciate that Gram's stain is a differential stain that stains bacteria according to the thickness of the peptidoglycan layer in the bacterial cell wall. Bacteria can be either Gram-positive or Gram-negative. They should appreciate that this is of considerable importance in medical diagnosis. Gram-negative bacteria are more likely to be serious pathogens because of the more dangerous endotoxins they produce; also because of the inflammation induced by these bacteria.

Students should be able to combine the two ways of classifying bacteria by describing them as (for example) Gram-positive cocci, or Gram-negative bacilli.

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<table>
<tr><td colspan="2">SA = starter activity MA = main activity CA = concluding activity</td></tr>
<tr><td colspan="2">What kinds of micro-organisms are there?</td></tr>
<tr><td>SA</td><td>Students say what they understand by the term micro-organism. Students write down the names of five different micro-organisms.</td></tr>
<tr><td>MA</td><td>Help the Students list the five different types of micro-organisms (bacteria, viruses, protozoa, some algae, some fungi). Students make a table to describe the types of micro-organisms, with an example of each.
<table>
<tr><th>Micro-organism</th><th>Description</th><th>Example</th></tr>
<tr><td>Protozoa</td><td></td><td></td></tr>
<tr><td>Fungi</td><td></td><td></td></tr>
<tr><td>Algae</td><td></td><td></td></tr>
<tr><td>Viruses</td><td></td><td></td></tr>
<tr><td>Bacteria</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>CA</td><td>Students carry out activity 1.1.</td></tr>
<tr><td colspan="2">What are bacterial cells like?</td></tr>
<tr><td>SA</td><td>Students revise the structure of prokaryotic and eukaryotic cells from grade 11. Help them to remember that bacteria have prokaryotic cells.</td></tr>
<tr><td>MA</td><td>Students use figure 1.9 to discuss with the teacher the structure of a typical bacterial cell and outline the functions of the parts. Give students an unlabelled drawing that they can label and include as part of their notes. Students discuss the differences between this cell and a eukaryotic cell. Students discuss the three main shapes of bacterial cells (cocci, rods and spirochaetes). Students make notes on this, with an example of each type.</td></tr>
<tr><td>CA</td><td>Students carry out activity 1.2 and make notes on Gram staining.</td></tr>
<tr><td colspan="2">Culturing micro-organisms (1)</td></tr>
<tr><td>SA</td><td>Students examine the safety issues associated with culturing micro-organisms.</td></tr>
<tr><td>MA</td><td>Activity 1.4: help Students set up cultures of:
• protozoa • bacteria • fungi
using the culture media/techniques explained later in this book. Discuss with the students the conditions under which the cultures will be maintained.</td></tr>
<tr><td>CA</td><td>Students carry out activity 1.4 and write up their observations. Two types of bacteria should be visible.</td></tr>
<tr><td colspan="2">Culturing micro-organisms (2)</td></tr>
<tr><td>SA</td><td>Students recall how they set up their cultures and how they were maintained.</td></tr>
<tr><td>MA</td><td>Students remember safety issues.
Students observe their cultures and make notes/drawings to record their observations.</td></tr>
<tr><td>CA</td><td>Students discuss with the teacher the range of shapes and sizes of micro-organisms they have observed.</td></tr>
<tr><td colspan="2">What are micro-organisms?</td></tr>
<tr><td>SA</td><td>Students review what they have discovered about different aspects of micro-organisms.</td></tr>
<tr><td>MA</td><td>Students make a display about micro-organisms. Different groups could focus on:
• the structure of bacterial cells • the shapes of bacterial cells
• fungi and algae • protozoa
• viruses • how to culture micro-organisms.</td></tr>
<tr><td>CA</td><td>Help the Students review the display of other groups/all groups.</td></tr>
</table>

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Answers to review questions

1. C
2. D
3. D
4. B
5. B
6. D
7. D
8. D
9. D
10. D

1.2 The ecology and uses of bacteria

This section should fill approximately **10 periods** of teaching time.

Learning competencies

By the end of this section students 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 bacteria plasmids, and how bacteria are used on vectors.

Starting off

Students should be aware of the landmark work of Pasteur, Koch and Lister in establishing the germ theory of disease. Pasteur's work has already been described in some detail in grade 11 (The Nature of Science) but could be usefully revisited.

Teaching notes

Students could carry out a library search to find out more about the work of Lister in developing and using antiseptics in surgery, and Koch in identifying the organisms associated with some diseases, including the tuberculosis bacillus and the cholera vibrio. Koch's postulates should be discussed with the students to ensure they appreciate the logic of these in ensuring that a particular micro-organism causes a particular disease. The micro-organism should be:

- found in all cases of the disease examined
- capable of being prepared from the diseased organism and maintained in a pure culture

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- capable of producing the original infection, even after several generations in culture
- retrievable from an inoculated animal and cultured again.

Students should appreciate that the way in which micro-organisms cause disease is linked to their ability to infect organisms. Bacteria cannot usually enter cells, and so most bacterial diseases result from endotoxins they produce and/or tissue damage their reproduction causes.

Viruses can enter cells and so cause disease as a result of modifying cell function. The few human diseases caused by fungi are often a result of the physical damage caused by mycelial growth.

Students associate disease with micro-organisms, and to most, disease is almost synonymous with infectious disease. To persuade them to modify this viewpoint, a discussion about 'what is health' can be productive. The WHO definition is given in the Students' Book. From this a broader definition of disease is possible. One is suggested in the Students' Book.

The role of bacteria in recycling minerals through ecosystems can be introduced by telling the students that their bodies are all at least 'second-hand'. The molecules that make them have all been in other bodies before – many times. Ask them to think of any famous person from history and work out how some of the carbon atoms in the carbon dioxide they breathed out with their dying breath could now be in the students' bodies.

With the idea of recycling firmly in their minds, the role of bacteria in this process can be introduced. Students first need the general idea of bacteria as decomposers – organisms that decay dead bodies – before the process of recycling mineral ions can be discussed in detail.

The nitrogen cycle and sulphur cycle are both described in Units 1 and 2 of the Students' Book in appropriate detail. It is important that the students realise that nitrogen and sulphur are absorbed by plants in an oxidised state – as nitrates or sulphates. Bacteria are important in transforming the reduced forms of the elements that are released by the decomposers into these oxidised forms. It is important that students do not fall into the trap of thinking that bacteria carry out these oxidations 'so that the plants can take up the nitrates/sulphates'. They should realise that the bacteria carry out these reactions as they release energy that can be used by the bacteria.

The Students' Book describes several examples of the way in which micro-organisms are used in producing a range of substances, and generally there is little to add to this. It is important, however, that students are made aware of the scale of some of these processes. The fermenters that are used to produce antibiotics, for example, have capacities of thousands of litres. Also, besides the obvious control over the environmental conditions in these fermenters, students should also be aware that the micro-organisms themselves are also controlled, with genes controlling growth and the production of the antibiotic being switched on and off as required.

Sewage treatment depends on bacteria and other micro-organisms (usually protozoa) oxidising the polluting organic matter in the sewage. The Students' Book shows two ways in which this is achieved – the percolating filter method and the activated sludge method.

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Students could carry out a library search to find out about how waste stabilisation ponds perform the same function.

Students should be made aware of the essential stages in the genetic modification of bacteria and of the overall aim. Bacteria are easily manipulated and, as seen already, can be used in culture to make large quantities of useful products. Transferring the gene for a desirable product (for example, production of insulin) into a bacterium opens up the possibility that this product will be able to be produced on a large scale in fermenters.

The Students' Book describes the essential stages of genetic engineering, but students may wish to carry out a library search to find out more about:

- gene banks
- different products that are now made by genetically modified bacteria.

The relative ease of creating transgenic bacteria is contrasted with the difficulty of creating transgenic plants and the ways in which this has been overcome. Genetically modified (GM) crops can raise strong emotions in some people, and the students could carry out a library search on this issue and make a display or a presentation to the rest of the class.

SA = starter activity MA = main activity CA = concluding activity	
Where are bacteria found?	
SA	Students discuss with the teacher where they think bacteria will be found.
MA	If safety requirements can be met see activity 1.5, Students set up cultures to see if bacteria are present: • in the air • in milk • on skin • on hair • on clothes • in food and/or any other easily testable source. Help students examine some of the reasons why bacteria are so important; include their role in: • infectious disease • recycling nutrients in ecosystems • industrial processes.
CA	Students research the role of some of the bacteria in the human gut.
The role of bacteria in infectious disease	
SA	Students examine cultures from previous lesson. Students make notes/drawings to record their observations. Students discuss with the teacher how the fact that bacteria are found in so many places is linked with transmission routes for pathogenic bacteria.
MA	Introduce the 'germ theory' and outline how Pasteur, Koch and Lister contributed to this theory. Students discuss Koch's postulates that link a specific micro-organism to a disease. Students discuss the ways in which different micro-organisms cause disease. Students make notes on the above.
CA	Students research the work of Koch and Lister.

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<table>
<tr><td colspan="2">How are disease-causing micro-organisms transmitted?</td></tr>
<tr><td>SA</td><td>Students recall where they found bacteria when they set up cultures and review the methods by which different micro-organisms cause disease.</td></tr>
<tr><td>MA</td><td>Introduce the concept of a ‘reservoir of infection’. Students discuss with the teacher likely reservoirs of infection for certain diseases.
Lead the discussion into transmission routes/methods and help students examine that these link reservoirs of infection to hosts (humans).</td></tr>
<tr><td>CA</td><td>Students make a display of infection pathways.</td></tr>
<tr><td colspan="2">What kinds of diseases are there?</td></tr>
<tr><td>SA</td><td>Students discuss with the teacher the meaning of the term disease. The WHO definition of health is a useful starting point.</td></tr>
<tr><td>MA</td><td>Give the students a list of diseases, some caused by micro-organisms and others lifestyle or deficiency diseases.
Students identify the diseases caused by micro-organisms.
Students examine that these are infectious diseases and discuss with the teacher other ways in which disease can be caused.
Students summarise the information in a table, such as the one below.
<table>
<tr><th>Type of disease</th><th>Example</th><th>Description of disease</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>CA</td><td>Class discussion about the problem of categorising diseases and show how some diseases are multifactorial.</td></tr>
<tr><td colspan="2">The role of bacteria in an ecosystem</td></tr>
<tr><td>SA</td><td>Students say what they know of the role of bacteria in recycling minerals. Establish the principle that bacteria decompose organic materials to release the mineral ions ‘locked away’ in them.</td></tr>
<tr><td>MA</td><td>Students examine the role of bacteria in the main events of the nitrogen cycle. The students must distinguish between processes that:
• recycle the nitrogen
• add nitrogen to the biological cycle
• remove nitrogen from the biological cycle
Similarly, students examine the role of bacteria in the main processes of the sulphur cycle.</td></tr>
<tr><td>CA</td><td>As an extension, students could consider the effect of releasing sulphur by burning fossil fuels and the impact of the acid rain formed as a result of this.</td></tr>
<tr><td colspan="2">What is the role of bacteria in industrial processes? (1)</td></tr>
<tr><td>SA</td><td>Students discuss with the teacher the role of bacteria and other micro-organisms in traditional industries.</td></tr>
<tr><td>MA</td><td>Students discuss with the teacher the role of bacteria in:
• the production of vinegar
• the production of antibiotics
• sewage treatment</td></tr>
<tr><td>CA</td><td>Students, in groups, begin to research these (or other) processes for a presentation to the class.</td></tr>
</table>

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What is the role of bacteria in industrial processes? (2)	
SA	Students complete the work on their presentations.
MA	Students give presentations to the class.
CA	Teacher reviews presentations.
How are bacteria genetically modified?	
SA	Students say what they understand by the term 'genetic engineering'. Students examine that a gene is transferred from one organism to another (usually of a different species) and that the organism receiving the gene becomes a transgenic organism.
MA	Students begin by reviewing the structure of a bacterial cell, understanding the presence of DNA as: • the main non-linear strand (sometimes called the bacterial chromosome) • plasmids Students appreciate that plasmids can be moved from one bacterium to another and serve as vectors for genes. Students discuss with the teacher the main stages involved in transferring a gene into a bacterium. Give students an unlabelled diagram of the process for them to use as the basis of their notes.
CA	Students research the topic and find more examples of products that are made by genetically engineered bacteria.
How are genes transferred into plants?	
SA	Students discuss with the teacher some of the benefits of genetically engineering crop plants.
MA	Students study the methods of transferring genes into crop plants including using: • *Agrobacterium* • the gene gun Students make notes on these processes.
CA	Brief class discussion about some of the concerns about exploitation by companies who develop genetically modified crop plants. Students research this more deeply for the next lesson.
Do companies who develop genetically engineered crop plants exploit developing nations?	
SA	Students review the issues.
MA	Students collaborate to make a display.
CA	Class discuss the outcome and balance the advantages against the risks.

Answers to review questions

1. C
2. D
3. C
4. C
5. D
6. D
7. B
8. C
9. C
10. D

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This section should fill approximately **15 periods** of teaching time.

1.3 What are viruses?

Learning competencies

By the end of this section students 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.

Starting off

First make students aware of the general structure of a typical virus and the ways in which this structure differs from both prokaryotic and eukaryotic cells. Establish that, because of the much-reduced structure of viruses, some biologists consider them to be non-living structures, rather than living micro-organisms.

After considering the structure of a virus and the consequence of the lack of organelles, students could construct a table listing points in favour of considering viruses as living organisms and points against.

Teaching notes

Students should understand that viruses, because they contain genetic information in the form of DNA or RNA, have the potential to produce more viruses, but that this can happen only when viruses infect cells.

They should appreciate that the way in which new viruses are made is essentially the same, in that the viral genetic information directs the host cell to make more genetic information and protein and eventually to assemble more viruses. However, the differences between the lytic and lysogenic life cycles need careful explaining. Students should realise that both cycles result in the viral genetic material being reproduced and passed on. However, in the lysogenic cycle, the genetic material remains incorporated in the host cell DNA for many generations of cells. Students could compare this with Richard Dawkins' concept of 'the selfish gene', which views bodies purely as vehicles that allow genes to be propagated.

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Students should understand something of the consequence of containing genetic material in the form of DNA or RNA. DNA viruses can transcribe their DNA on entry into the cell and produce viral RNA that will instruct the synthesis of viral proteins, including enzymes. Some of these enzymes catalyse the replication of the viral DNA.

When RNA viruses enter the cell, their RNA directs the host cell to synthesise viral proteins, including enzymes that cause the replication of the viral RNA, before assembling new virus particles.

Although retroviruses contain RNA, it is in a different form to that of RNA viruses and so must be first converted to DNA. This then directs the synthesis of viral proteins and viral RNA.

From the generalised structure of a 'typical' virus, look at the structure of one specific virus – HIV. In particular, students should appreciate that the shape of the gp120 glycoprotein on the surface of the virus is key to binding with and infecting the CD4 lymphocyte. They should understand that the shapes of the gp120 and the CD4 receptor are complementary. The idea of an egg cup fitting an egg is a useful idea in explaining this concept.

Students should appreciate the stages in the life cycle of HIV and the importance of each in synthesising the new viral particles. They should also appreciate that each stage is essential to the reproductive cycle of HIV. If any stage is blocked completely, the virus will not be able to reproduce itself. Different anti-retroviral drugs act by blocking different stages, as shown in the Students' Book. Students should understand that HIV mutates regularly and an infected person may have several different strains of HIV in their bodies. Some of these mutations confer a resistance to one or more of the anti-retroviral drugs. However, no strain is completely resistant to all drugs, so using a 'cocktail' of anti-retrovirals, as in HAART, is likely to have more success.

The last section concerns the social and economic impact of AIDS. This is, naturally, a massive topic and only the basics can be covered in a Biology textbook.

Students will have first-hand or second-hand experience of families affected by AIDS and a discussion of their experiences will throw up all the main ways in which AIDS affects families. They may be less aware of the impact on the country and need instruction on how the same things that impact on families affect the economic output of companies and the country as a whole. Reduction in the workforce and increased medical costs to the Government exactly mirror loss of income and increased costs to a family in which one or more 'breadwinner' is infected.

Life skill instruction is, again, a separate, large topic in its own right, but Biology can contribute to this by helping to develop:

- A thorough understanding of the nature of the disease and its impact, together with a way in which this and other diseases are transmitted.
- A sense of self-confidence in their ability to solve problems and make informed decisions, particularly concerning their sexual attitudes.
- Good relationships and the ability to resolve conflict.

Role play of situations in families and companies where a person is infected can help to promote understanding of what needs to be done.

Typing 'Ask the expert fighting the virus role play' into an internet search engine will give a well-structured role play idea to teach about the transmission of AIDS.

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<table>
<tr><td colspan="2">SA = starter activity MA = main activity CA = concluding activity</td></tr>
<tr><td colspan="2">Introducing viruses</td></tr>
<tr><td>SA</td><td>Students write down:
• as many features of viruses as they can
• as many differences as they can between bacteria and viruses.</td></tr>
<tr><td>MA</td><td>Show the students a picture or micrograph of a ‘typical’ virus. Students examine the total lack of organelles.
Students discuss the consequences of having no organelles:
• cannot carry out normal cellular processes
• must therefore be parasitic.
Students learn how viruses use the organelles of the host cell to manufacture more viruses.</td></tr>
<tr><td>CA</td><td>Students make notes on a ‘typical’ virus life cycle.</td></tr>
<tr><td colspan="2">Classifying viruses</td></tr>
<tr><td>SA</td><td>Students discuss different ways of classifying viruses, e.g.:
• according to what they infect (plant, animal, bacterium)
• shape of the virus particle
• nature of the genetic material.
An excellent account of the classification of viruses can be found at:
http://www.mcb.uct.ac.za/tutorial/classif.htm.</td></tr>
<tr><td>MA</td><td>Class to discuss the classification of viruses based on the type and expression of their genetic material. Students examine how each type of virus expresses the genetic material it carries.</td></tr>
<tr><td>CA</td><td>Students produce a table to summarise the genetic classification of viruses like the one below. They should carry out research to find an example of each type.
<table>
<tr><th>Type of virus</th><th>How the genetic material is expressed</th><th>Example</th></tr>
<tr><td>DNA virus</td><td></td><td></td></tr>
<tr><td>RNA virus</td><td></td><td></td></tr>
<tr><td>Retrovirus</td><td></td><td></td></tr>
</table></td></tr>
<tr><td colspan="2">How do viruses multiply (1)?</td></tr>
<tr><td>SA</td><td>Students examine the nature of bacteriophages and that much of our knowledge of virus life cycles comes from work on bacteriophages.
Students make a labelled drawing of a bacteriophage.</td></tr>
<tr><td>MA</td><td>Students remember that in their life cycle, viruses must:
• replicate and express their genetic material
• assemble the new virus proteins and replicated genetic material into virus particles
Students study how this happens in a typical bacteriophage life cycle.
Students make a labelled diagram to show the life cycle of a bacteriophage.
Students examine that the cycle discussed is a lytic cycle (and revise the term lysis meaning splitting) and that there are other types of cycles.
Students examine the chronic release and lysogenic cycles of some viruses.</td></tr>
<tr><td>CA</td><td>Students discuss the different methods of infection and make notes</td></tr>
</table>

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<table>
<tr><td colspan="2">How do viruses multiply (2)?</td></tr>
<tr><td>SA</td><td>Students discuss in pairs the features of virus life cycles and make brief notes from their memory of the last lesson.</td></tr>
<tr><td>MA</td><td>Students construct a table to summarise the three types of cycle like the one below. They write ‘yes’, ‘no’ or ‘sometimes’ in the boxes.
<table>
<tr><th rowspan="2">Feature of cycle</th><th colspan="3">Type of cycle</th></tr>
<tr><th>Lytic</th><th>Lysogenic</th><th>Chronic release</th></tr>
<tr><td>Lysis of host cell</td><td></td><td></td><td></td></tr>
<tr><td>Death of host cell</td><td></td><td></td><td></td></tr>
<tr><td>Disease of host cell</td><td></td><td></td><td></td></tr>
<tr><td>Genetic alteration of host cell</td><td></td><td></td><td></td></tr>
<tr><td>Continual release of viruses</td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>CA</td><td>Students choose a virus life cycle and draw a diagram showing its key features for display in the classroom; you may have to supervise the choice of cycles to ensure an even distribution.</td></tr>
<tr><td colspan="2">HIV and AIDS – What is HIV like?</td></tr>
<tr><td>SA</td><td>Students revise that HIV is a virus and AIDS is the disease resulting from infection.
Students examine that HIV is a retrovirus and recap the properties of retroviruses.</td></tr>
<tr><td>MA</td><td>Students discuss the structure of HIV. If possible give students an unlabelled diagram to label and include in their notes.
Class discussion of the roles of:
• the RNA molecule
• the reverse transcriptase molecule
• the gp120 and gp41 glycoproteins.</td></tr>
<tr><td>CA</td><td>Students make diagrams and notes to explain the function of these main components of HIV.</td></tr>
<tr><td colspan="2">How does HIV reproduce and cause AIDS?</td></tr>
<tr><td>SA</td><td>Students research the role of CD4 cells in the immune system. A brief but adequate account is given by about.com at:
http://aids.about.com/od/newlydiagnosed/qt/cd4.htm
Students remember that the gp120 glycoproteins can bind with the CD4 receptors on these cells.</td></tr>
<tr><td>MA</td><td>Students discuss with the teacher the main stages in HIV infecting a cell and replicating more virus particles.</td></tr>
<tr><td>CA</td><td>Students make an illustrated flow chart to show the stages, using figure 1.32.</td></tr>
<tr><td colspan="2">Can AIDS be treated?</td></tr>
<tr><td>SA</td><td>Class discussion of the difference between using drugs to treat AIDS and a vaccine to prevent it.
Students make a poster to show what impact a vaccine would have in Ethiopia.</td></tr>
</table>

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MA	Students recall the HAART treatment outlined in grade 11. Students discuss with the teacher the modes of action of the different types of anti-retroviral drugs, specifically: • entry inhibitors • nucleotide reverse transcriptase inhibitors • non-nucleotide reverse transcriptase inhibitors • protease inhibitors.
CA	Students prepare an illustrated flow chart to show how the numbers of HIV are reduced by each type of drug. Give the students the flow chart below and ask them to illustrate each stage. Entry inhibitors stop many viruses entering the CD4 cells ↓ Of those that enter, many are prevented from transcribing their RNA to DNA by the reverse transcriptase inhibitors ↓ Of the few that transcribe their RNA to DNA, most cannot synthesise any viral proteins because of the protease inhibitors
What is the social and economic impact of AIDS? (1) – Some basic ideas	
SA	Students examine that they will be considering the impact that AIDS has on their personal lives and therefore on the economy of the country. Ensure that they understand the link.
MA	Students discuss with the teacher the issues discussed in the textbook.
CA	Students can make posters individually or in groups about some of these issues.
What is the social and economic impact of AIDS? (2) – A visiting speaker	
SA	Brief the students about the speaker's area of expertise and what he/she will talk about.
MA	Speaker delivers talk and answers students' questions. Students make notes throughout.
CA	Students write up their notes.
What is the social and economic impact of AIDS? (3) – Avoiding AIDS	
SA	Brief the students about the activity and how it will be carried out. Divide the group into pairs.
MA	Students carry out the activity 'Avoiding AIDS'.
CA	Students produce posters and incorporate into a display.
What is the social and economic impact of AIDS? (4): Activity 14	
SA	Brief the students that the activity is a case study of a 17-year-old Ethiopian girl. The aim is to encourage the Students to be assertive in preventing the spread of HIV. Divide the group into pairs – one boy and one girl where possible.
MA	Students carry out the activity 'A case study'.
CA	Plenary in which the students discuss the social and sexual pressures on teenagers and how they might resist them.
What is the social and economic impact of AIDS? (5) – The agree/disagree game	
SA	Activity 1.13: brief the students about the rules of the game. The aim is to encourage open discussion of HIV/AIDS.

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MA	Students carry out the activity 'Agree/disagree'. Teacher records the results for each statement.
CA	Teacher and class review the opinions that the class has displayed.
AIDS awareness campaign (1)	
SA	Students determine most significant effects HIV/AIDS has on community relations, drawing on their experience in previous lessons.
MA	Students complete the planning stage of activity 1.11.
CA	The class discusses together the different plans formulated and decides on the best one.
AIDS awareness campaign (2)	
SA	Students decide what actions they need to take to get their chosen campaign up and running.
MA	With your help, students make the resources they need to run their campaign and make relevant contacts in the community to ensure they can carry it out.
CA	Students assign team roles for the campaign and are ready to carry it out outside of school time. Students agree a method of evaluating the success of their campaign.
Are viruses living organisms?	
SA	Class to review the discussion from the 'Introducing viruses' lesson. Explain activity 1.15 and divide the students into the three groups.
MA	Students in all groups research the issues. Students carry out activity 1.15.
CA	Teacher reviews the outcome of the debate. The students should understand that viruses are an example of life that does not have all the characteristics of living organisms but is an important part of the study of biology.

Answers to review questions

1. B 3. D 5. A 7. A 9. D
2. A 4. C 6. A 8. C 10. C

Answers to end of unit questions

1.

Type of micro-organism	Example
Bacteria	*Streptococcus*/*Lactobacillus*/*Staphylococcus*/*Vibrio*/any suitable example
Protozoa	*Amoeba*/*Plasmodium*/*Paramecium*/any suitable example
Fungi	Yeast/*Penicillium*/*Mucor*/*Candida*/any suitable example
Viruses	HIV/cold virus/'flu virus/hepatitis virus/any suitable example

2. a) The bacterial cell is smaller than the animal cell and has:
   - no nucleus
   - no mitochondria
   - smaller ribosomes
   - 'circular' DNA/DNA in a loop.

   b) The bacterial cell is bigger than the virus and has:
   - more DNA

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- plasmids
- a cell wall
- ribosomes
- a cell membrane.

3. a) To sterilise the equipment/kill all the micro-organisms/bacteria so that any that appeared later must have entered from outside.

   b)

Tube	Appearance	Reason
1	Cloudy	Broth is exposed to air; bacteria can enter
2	Clear	Cotton wool prevents bacteria from entering
3	Cloudy	Bacteria can enter through glass tube
4	Clear	Bacteria cannot enter – are caught at bottom of S-shaped tube

4. a) i) Restriction enzyme

   ii) Ligase

   b) The plasmid is a vector, which carries gene into the host cell.

   c) A plasmid cannot enter plant cells.

   d) Gene gun, which fires golden pellets coated with DNA into cells.

   Transgenic *Agrobacterium* bacteria carry the gene into plant cells.

5. a) Unprotected sexual intercourse, drug users sharing needles, from mother to child across the placenta.

   b) The phase when T-helper cells are replaced as fast as they are destroyed/infected; this can last for many years.

   c) They block enzymes involved in the entry phase, block reverse transcription, block protein synthesis, block assembly of virus particles (any two).

6. a) Decomposers/putrefying bacteria/ammonifying bacteria.

   b) Y – nitrate

   X – nitrite

   c) i) Nitrogen-fixing bacteria use nitrogen gas/nitrogen from the air, and convert it to ammonium ions/ammonia.

   ii) Denitrifying bacteria use nitrates, and convert them to nitrogen gas.

7. a) Essays should address some of the following ideas:

   Families:

   - Loss of income by families – increased costs because of medical/funeral expenses.
   - Children drop out of school to provide support in the home, to work in agriculture.
   - Families reduce expenditure on basics.
   - Increased demands on physical and mental health of carers, especially where these carers are untrained or unsupported.

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Country as a whole:

- Loss of economic output because of reduction of workforce due to time taken off work or due to deaths.
- Government income also falls as less revenue from taxes.

Life skills:

- Develop a good sense of personal identity leading to self-confidence.
- A thorough understanding of AIDS and of healthy living.
- Ability to think independently, critically and creatively.
- Ability to develop good relationships.
- Ability to communicate well.
- Problem solving.
- Conflict management skills.
- Ability to make informed and responsible decisions.
- Assertiveness and self-esteem in order to drive actions needed to solve problems.

Appendix

Collecting and culturing protozoans

Teachers must ensure that there is no health and safety issue in collecting the water.

Microscopic life can be found in ponds, lakes, streams, rivers and rain puddles that have been in existence for a few days. Water samples can be collected easily using wide-mouth glass jars with tight-fitting lids. The collection jars you use should be completely clean and detergent free.

Collections from one site could include surface or bottom samples. When sampling from the bottom, include some of the bottom solid material with your sample. When sampling from the surface, include any floating material.

Upon close microscopic examination you may well see very few living things, perhaps only one protozoan per drop. Cultures can set up a short food chain, enabling the protozoans to feed and reproduce. Six different solutions that can be made easily are listed below.

Solution A – hay infusion medium

Boil one litre of pond, spring or rain water. Add a small handful of hay and boil for 10 more minutes. Allow this mixture to stand for two days. Add 25–50 cm^3 of your water sample. Add a sample of this culture to a freshly prepared hay infusion every week.

Solution B – wheat infusion medium

Boil 100 cm^3 of pond or spring water for 10 minutes. Cool and add five grains of wheat. Let this mixture stand in open dishes for two days, then add one tablespoon of your sample.

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Solution C – rice infusion medium

Follow the instructions for Solution B, but use five grains of uncooked rice instead of the wheat.

Solution D – egg infusion medium

Hard boil an egg and grind a pinch (0.25 g) of the yolk in a bowl with a small amount of water to form a paste. Add the paste to one litre of boiled pond or spring water, allow to stand for two days before adding a tablespoon of your sample.

Solution E – powdered milk medium

Boil 250 cm^3 of pond or spring water for 10 minutes. Cool and add a pinch of powdered skimmed milk. Mix thoroughly and immediately add a tablespoon of your sample.

Solution F – yeast medium

Boil 250 cm^3 of pond or spring water for 10 minutes. Cool and add 2 g of dried yeast. Mix and stand in open containers for a few hours before adding a tablespoon of your sample.

Answers to end of unit crossword puzzle

Across

2 genetically modified
6 disease
9 nitrification
13 reservoir
14 protozoa
15 cocci
16 CD4

Down

1 viruses
2 Gram-positive
3 nitrogen fixation
4 lysogenic
5 prokaryotic
7 spirochaetes
8 human induced
10 genetic
11 bacilli
12 algae

Further resources

http://www.qedoc.net/qqp/jnlp/TZCED_009.jnlp – quiz modules on gram positive and negative bacteria

http://www.k12station.com/k12link_library.html?subject=NST&sub_cat=105355&final=105373 – links to animations and resources on the nitrogen, carbon, sulphur and water cycles

http://www.avert.org/aids-young-people.htm – teaching advice and resources on HIV/AIDS

http://www.who.int/topics/hiv_aids/en/ – data and resources on HIV/AIDS

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