SURFING

NSW BIOLOGY 7&8

Module 7 Infectious Disease
Module 8 Non-Infectious Disease and Disorders

Kerri Humphreys

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Science Press
Bag 7023 Marrickville NSW 1475 Australia
Tel: (02) 9516 1122 Fax: (02) 9550 1915
sales@sciencepress.com.au
www.sciencepress.com.au

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Module 8 Non-Infectious Disease and Disorders

Introduction

This book covers the Biology content specified in the NSW Biology Stage 6 Syllabus. Sample data has been included for suggested experiments to give you practice to reinforce practical work in class.

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory parts of the syllabus, along with questions and answers.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions. These cover every aspect of the topic, and are useful for revision and exam practice.

Words To Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

SURFING

NSW BIOLOGY 7&8

Module 7

INFECTIOUS DISEASE

CONTENT FOCUS

In this module you will:

- Examine the treatment, prevention and control of infectious disease both locally and globally.
- Study the human immune system and its response to an infectious disease.
- Understand the value of learning about infectious disease and its cost to humans through losses in productivity and impact on overall health.
- Consider medical and agricultural applications that draw on the work of a variety of scientists.
- Engage with all the Working Scientifically skills for practical investigations involving the focus content to collect, process and analyse data and identify trends, patterns and relationships related to infectious disease.

1 Assumed Knowledge Module 7

QUESTIONS

1. (a) Distinguish between a prokaryote and a eukaryote.
   (b) Identify the groups of organisms that are prokaryotes and those that are eukaryotes.
2. The diagram shows a typical bacterial cell.

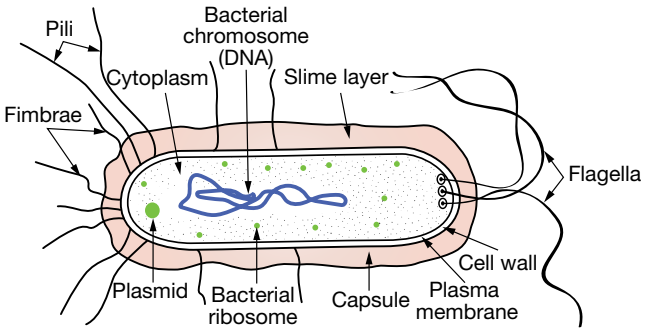


Figure 1.1 Typical bacterial cell.

Construct a table to summarise the function of the main parts of a bacterial cell.

3. The diagram shows a variety of viruses.

Table 1.1 A variety of viruses.

Examples of RNA viruses	Examples of DNA viruses
Lyssavirus (rabies virus)	*Orthopoxvirus* (vaccinia and smallpox virus
Influenzavirus (influenza viruses A and B)	*Simplexvirus* (herpes simplex virus 1 and 2)
Arenavirus (infect rodents)	*Mastadenovirus* (adenovirus)
Reovirus (Colorado tick fever virus)	*Rubivirus* (rubella virus)
Lentivirus (HIV)	*Hepadnavirus* (hepatitis B virus)
	T-even bacteriophage (phage T4)

Briefly describe viruses.

4. Define disease.
5. What is an infectious disease?
6. Define a pathogen.
7. Distinguish between macroparasites and microparasites.
8. What is an antibiotic?
9. How does penicillin prevent the growth of bacteria?
10. What is immunisation?
11. Define epidemiology.
12. The table shows cellular components of blood.

Table 1.2 Cellular components of blood.

Red blood cells	White blood cells	Platelets
	Monocyte, Basophil, Neutrophil, Lymphocyte	

Outline the function of each of these cellular components of blood.

13. What is phagocytosis?
14. The diagram shows a flow chart of the response of the body to a pathogen invading tissues.

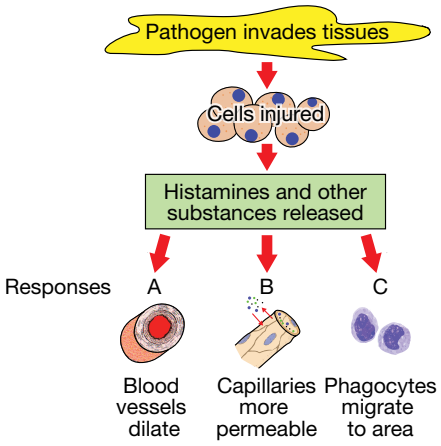


Figure 1.2 Body response to pathogen invading tissues.

Explain how responses A, B and C help protect the body.

15. What is an antigen?
16. What is an antibody?
17. The diagram shows a photograph of a gardenia plant.

Figure 1.3 Gardenia plant.

What evidence can be seen in the photograph of plant pests and/or pathogens?

18. Identify some diseases covered by the National Immunisation Program.

2 Infectious Disease

A disease is any condition that impairs or interferes with the normal functioning of the body. Infectious diseases differ from other diseases, e.g. genetic and lifestyle diseases in that they are caused by the invasion by a pathogen and can be transmitted from one host to another. Infectious diseases are also called communicable or transmissible diseases.

Infectious diseases have dramatically affected life on Earth acting as a selective pressure in the evolution of different populations. The history of human civilisations through the ages shows how natural immunity and the ability to combat infectious diseases has affected politics, economics and public works and health. During the middle ages in the 14th century nearly one third of the world's population died from bubonic plague – the Black Death which is an infectious disease caused by the bacteria *Yersinia pestis*.

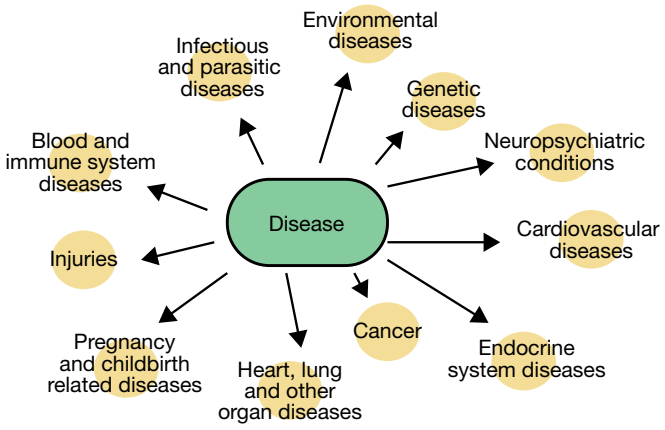


Figure 2.1 Types of disease.

Diseases can be classified in many ways, e.g. by the major categories of infectious disease and non-infectious disease or by the body part/system that is mainly affected, e.g. cardiovascular diseases, heart, lung and other organ diseases or endocrine system diseases or by the way the disease is acquired, e.g. genetic diseases, injuries and environmental diseases.

Technology and infectious disease

The invention of the light microscope and developments in its design to improve resolution and magnification enabled scientists to observe micro-organisms and then to link particular organisms to particular infectious diseases.

Anton van Leeuwenhoek was the first to describe 'little animals' in rainwater and his discovery led to many other scientists using the light microscope to look for micro-organisms in different substances.

Louis Pasteur carried out experiments using swan neck flasks that led to his germ theory of disease. Then in 1845-1846 he showed that a mystery disease that threatened the silkworm industry was caused by micro-organisms that were only visible under a microscope and only found in the tissues of diseased silkworms, moths and eggs. This work refuted the theory of spontaneous generation which had been a common belief that living organisms could arise from non-living matter.

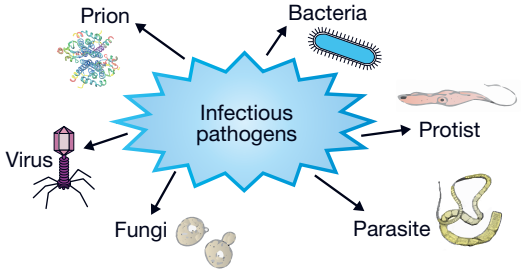


Figure 2.2 Types of pathogens.

Robert Koch built on the work of Pasteur developing improved ways to study micro-organisms. He solidified liquids using gelatine and agar to produce suitable mediums on which to grow bacteria. His assistant **Julius Petri** invented the Petri dish to aid the growth of pure cultures. Improved staining techniques meant that Koch was able to identify the causative bacteria for tuberculosis and cholera. This work led Koch to outline a systematic way, known as Koch's postulates, which identifies the causative pathogen for a particular disease.

New molecular technologies and computer assisted analysis are now speeding up the diagnosis process for infectious diseases which means specific treatments can be started earlier which hastens recovery times. New electronic tools and computer processing also assist in drug dosing and prescribing to improve the quality and efficiency of treatment procedures.

QUESTIONS

1. Define disease.
2. How are infectious diseases different from other diseases?
3. Use an example to show how infectious disease has affected human populations in the past.
4. How can diseases be classified?
5. How did the invention of the microscope increase scientific knowledge about infectious disease?
6. Construct a table to show at least *three* ways technology has helped aid our understanding of infectious disease.
7. Who was the first to describe 'little animals' under a microscope?
   (A) Van Leeuwenhoek. (B) Louis Pasteur.
   (C) Robert Brown. (D) Robert Koch.

3 Prion Pathogens

The term prion was first used in 1982 by Stanley Prusiner as a combination from *protein* and *infection*. He discovered and identified prions as a class of infectious self-reproducing pathogens that are only made of protein and won the Nobel Prize in Physiology or Medicine in 1997 for 'the discovery of Prions – a new biological principle of infection'.

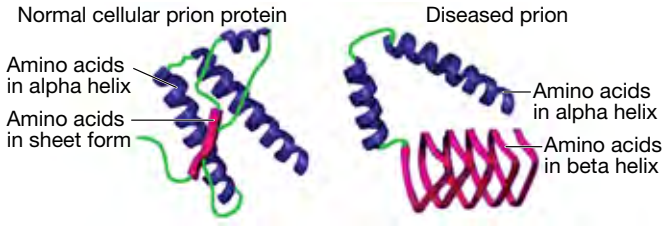


Figure 3.1 Normal protein and diseased prion.

Prions are infective proteins and do not have a nucleic acid genome.

The **normal form** of the protein is called the cellular prion protein (PrP^C). The **prion** is a misfolded version of the normal cellular protein.

The prions increase in number by converting correctly folded versions of the protein to more prions with the altered abnormal shape.

Comparisons of the normal protein and the prion protein show that normal prion proteins consist of about 40% alpha helices while prion proteins are about 55% beta pleated sheets and 20% alpha helices. It is believed that the pathogenic features of the misfolded prion proteins relate to the high amounts of beta pleated sheets.

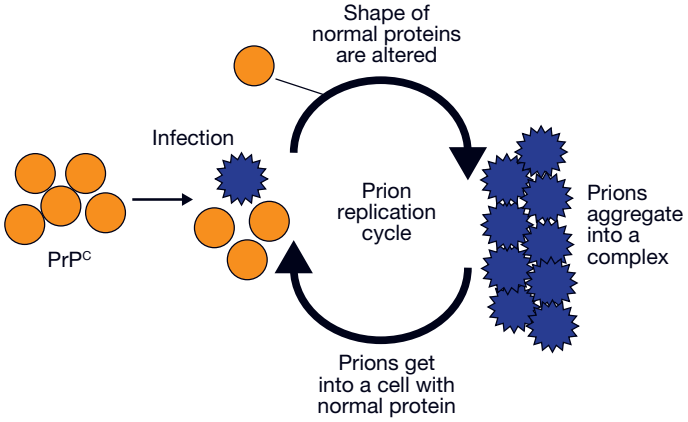


Figure 3.2 Prion replication.

The cellular prion proteins are mainly located on the surface of cells in the central nervous system but can occur in other body tissues in mammals.

Transmissable spongiform encephalopathies (TSEs)

TSEs are a group of progressive conditions that affect the brain and nervous system of many animals. When prions accumulate in tissues they cause large vacuoles so that the tissue begins to resemble a sponge. Tissues commonly affected are the cortex and cerebellum of the brain with degeneration of brain tissue. All prion diseases show a severe loss of neurons. This causes loss of full control of bodily movements and changes in behaviour. In humans the symptoms can involve personality changes, psychiatric problems, insomnia, progressive loss of intellectual capacity and the loss of the ability to move or speak.

TSEs in sheep and goats cause scrapie, in humans it causes CJD (Creutzfeldt-Jakob disease), FFI (fatal familial insomnia) and kuru; in cattle it causes BSE (bovine spongiform encephalopathy or mad cow disease) and in cats, pumas and cheetahs causes feline spongiform encephalopathy.

Infection

Humans may be infected in three ways: acquired infection, for example through food or medical procedures; or through apparent hereditary transmission or sporadically due to a spontaneous change into the infectious form of the protein which begins a chain reaction altering other proteins in the cell. This means that prion diseases are unusual as they can occur as *both* infectious and hereditary diseases.

Many prion diseases have a very long incubation period, e.g. at least ten years and at first act very slowly. The long incubation period means that sources of infection may not be identified until long after the first cases appear which means there may have been many infections from the original source or from later infected individuals.

After the long incubation there is often a very aggressive growth phase which causes fatal loss of brain and nervous functionality.

Many priors are not affected by many measures taken to destroy pathogens, e.g. the prions are not destroyed or deactivated by normal cooking temperatures or by normal sterilisation techniques such as boiling or irradiation.

Treatment

Prion diseases are always fatal. When there is rapid development death can occur within a few months to a few years. Most treatments are aimed at alleviating symptoms to make the patient as comfortable as possible.

There are several research projects, e.g. some researchers are developing therapeutic strategies against the diseased prion protein while others are trialling stem cell transplants to restore lost tissue and recolonise damaged areas.

Mad cow disease epidemic

The first confirmed death of an animal due to BSE occurred in 1986 in the United Kingdom. It is believed, but not proven that a scrapie agent jumped species when cattle were fed sheep offal as a protein supplement. The epidemic peaked in the early 1990s with 1000 cases of infected cattle being reported each week in 1993.

In 1996 the British Health Secretary announced to the British House of Commons that mad cow disease is the 'most likely explanation at present' for '10 cases of CJD in people under 42'. There has been over 160 cases of the new human TSE named variant Creutzfeldt-Jakob disease (vCJD) since 1995.

After the announcement in the British parliament about 4.5 million cattle were destroyed and many countries banned the importation of UK beef and beef products. The export ban on British beef was lifted in 1999 but a cow born in 2000 in the UK was diagnosed with BSE. In 2003 a cow born in Washington State, USA and a cow born in Canada tested positive for BSE.

Australia has a national monitoring program checking cattle and sheep populations for evidence of TSE.

There is also a complete ban on the importation of live cattle from all countries that have reported cases of BSE. The Ruminant Feed Ban prohibits the feeding to ruminant (animals that chew cud) of any material, tissue or blood taken from an animal.

QUESTIONS

1. How was the word 'prion' invented?
2. How was Stanley Prusiner rewarded for his work on prions?
3. What is a prion?

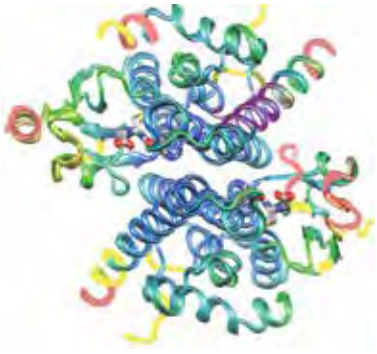


Figure 3.3 Prion.

4. What is PrP^C?
5. Identify one of the main differences between the structure of the normal form of the protein and the form of the prion protein.
6. Where are most cellular prion proteins located?
7. Suggest why many prion diseases are classified as spongiform encephalopathies.
8. Outline the effects of prion diseases.
9. Name a prion disease found in:
   (a) Goats and sheep.
   (b) Humans.
   (c) Cattle.
   (d) Cats.
10. Construct a table to summarise the three ways human TSEs can occur.
11. Explain why the transmission of prions is different to the transmission of other pathogens.
12. Discuss why prion diseases can become widely spread before they are detected.
13. Discuss the resilience of the prion protein.
14. What is the mortality rate for prion diseases?
15. How are researchers trying to overcome prion diseases?
16. (a) What is the believed cause of the outbreak of BSE in the United Kingdom in 1986?
    (b) Explain why many countries were concerned when there was an outbreak of BSE in the United Kingdom in 1986.
    (c) What measures have been introduced in Australia to prevent the spread of BSE?
17. The diagram shows three structures.

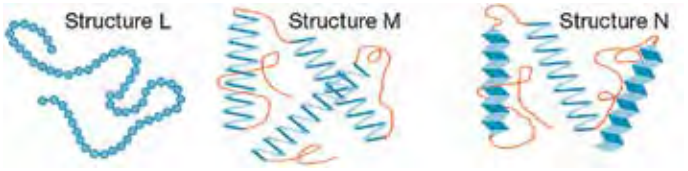


Figure 3.4 Three structures.

Which of the following correctly identifies the normal prion protein and the diseased prion protein?

	Normal cellular prion protein	Diseased prion protein
(A)	Structure L	Structure M
(B)	Structure L	Structure N
(C)	Structure N	Structure M
(D)	Structure M	Structure N

18. Which group lists diseases caused by prions?
    (A) AIDS, influenza, poliomyelitis.
    (B) Scrapie, kuru, Creutzfeldt-Jakob disease.
    (C) Creutzfeldt-Jakob disease, BSE, AIDS.
    (D) Fatal familial insomnia, CJD, malaria.
19. What is a prion?
    (A) Type of nucleic acid which can reproduce in brain tissue.
    (B) Protein particle that causes brain degeneration.
    (C) Lipid which can modify nucleic acids.
    (D) Amino acid which can transmit an infectious disease.

4 Case Study – Creutzfeldt-Jakob Disease

Creutzfeldt-Jakob disease (CJD) is a rapidly progressive degenerative brain disorder that is a transmissible spongiform encephalopathy (TSE). It is called spongiform as the infected tissue resembles a sponge due to the disintegration of the tissue by the misfolded prions. An encephalopathy is a disease that affects the functioning of the brain due to some agent or condition. CJD causes brain deterioration and dementia.

There are several variants of the disease, e.g. vCJD was first found in the United Kingdom. It affects younger individuals who show psychiatric symptoms and it has a longer duration from onset of symptoms to death.

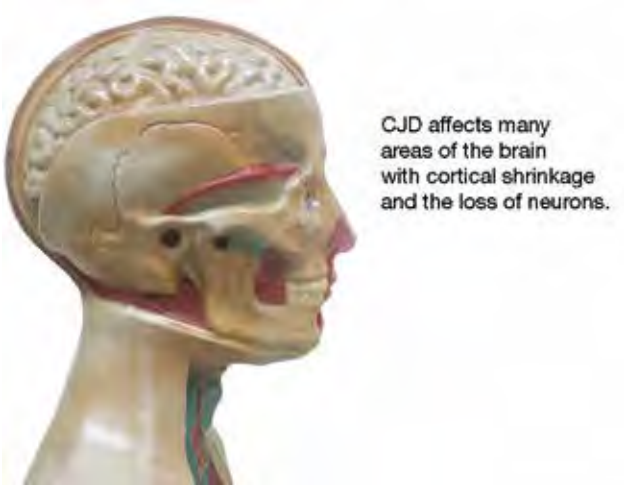


Figure 4.1 Creutzfeldt-Jakob disease.

Transmission and cause of disease

CJD is a prion disease. Once the prion is present it alters other normal cellular prion proteins to take on the misshaped form of the prion protein. The abnormal prion proteins aggregate into a clump that leads to the loss of neurons and brain damage.

Like other TSEs CJD can be caused by the following.

- Sporadic appearance even though the person has no risk factors for the disease. This spontaneous change into the infectious form of the protein begins a chain reaction altering other proteins in the cell. Sporadic CJD accounts for more than 85% of cases of CJD.
- Hereditary transmission where there is a family history of the disease and/or the genetic mutation is identified in the person's genome. Hereditary CJD accounts for 5% to 10% of cases of CJD.
- Acquired infection, for example through food or medical procedures. Acquired CJD accounts for less than 1% of cases of CJD.

CJD is often difficult to diagnose as the early symptoms are vague and similar to other brain disorders.

Symptoms of disease

The symptoms usually begin to show around the age of 60 and most people die within one year from the onset of symptoms.

Symptoms can include the following.

- Confusion, disorientation and failing memory which develops into dementia.
- Personality changes with impaired judgement and thinking.
- Behavioural changes.
- Weakness or loss of balance and muscle control causing problems with coordination and movement.
- Muscle spasms and paralysis.
- Vision problems, e.g. double vision or blindness.
- Coma.
- Incontinence.
- Other infections can occur, e.g. pneumonia which can lead to death.

Treatment of disease

There is no cure for CJD. Medical treatments try to ease the symptoms and aid the patient with the difficulties they have in coping with day to day activities. There are several research projects that are investigating prions, their nature and behaviour and details of their mode of transmission. Increased knowledge of prions will aid the development of new treatments for CJD.

QUESTIONS

1. What is CJD and what causes CJD?
2. What is the most common form of CJD?
3. What is vCJD?
4. How do prion diseases act in the body?
5. Why is CJD classified as a transmissible spongiform encephalopathy (TSE)?
6. (a) Outline the three ways CJD can be transmitted.
   (b) Give the approximate percentages for infection by the three different ways of transmission of CJD.
7. Why is CJD difficult to diagnose?
8. Identify some symptoms of CJD.
9. When do symptoms usually begin for CJD?
10. How is CJD cured and treated?
11. Which of the following diseases has a similar cause and transmission to CJD?
    (A) Measles. (B) Malaria.
    (C) Pneumonia. (D) Kuru.

5 Virus Pathogens

Viruses are very small (approximately 30 to 300 nm) and reproduce by taking over a host cell. They are infectious particles with either the DNA or RNA genome surrounded by a protein coat called a **capsid**.

A **phage** (bacteriophage) is a virus that infects bacteria. Phages are used as antibacterial agents.

A **viroid** is a plant pathogen consisting of a molecule of naked circular RNA with only a few hundred nucleotides.

Virus infections have been known since ancient times. One of the first written records of a virus infection is a hieroglyph from Memphis, the capital of ancient Egypt dated about 3700 BCE which shows typical paralytic poliomyelitis.

Living or non-living?

There has been debate as to whether they are living or non-living – they are not cellular and hence do not comply with the cell theory that states that all living things consist of cells. They also cannot metabolise or reproduce on their own. But viruses contain nucleic acid (either DNA or RNA) which is a requirement for life. Viruses can be crystallised.

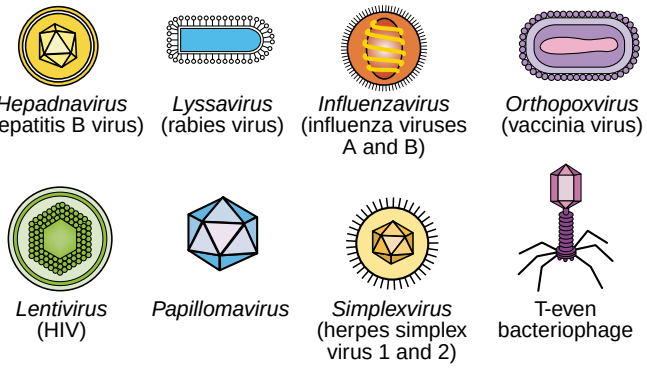


Figure 5.1 Viruses.

Types of viruses

There are four main types of viruses – icosahedral (capsid has 20 flat sides giving it a special shape), helical, (capsid is rod shaped), enveloped (capsid is encased in a baggy membrane) and complex (no capsid).

Features of viruses

Features include the following.

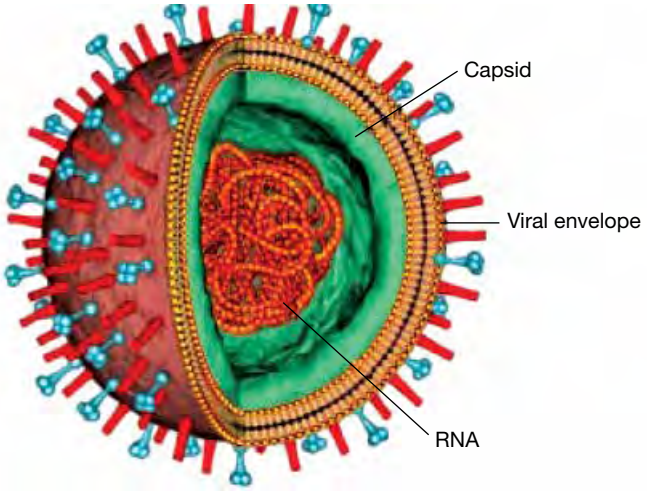
- Genome can be DNA or RNA as single linear or circular molecule.
- Capsid is a protein shell with the shape dependent on the type of virus, e.g. rod shape, polyhedral or more complex.
- Viral envelope occurs in some viruses and is derived from the host cell phosopholipids and membrane proteins.
- Viruses can be crystallised and remain viable and infectious.
- They lack metabolic enzymes and ribosomes for making proteins but can express their genes and do chemical synthesis when they are inside a living host cell using the host cell's metabolic equipment and chemical pathways to make more virus proteins and nucleic acid.
- Host range is the limited number of host species that each particular virus can infect. The host specificity is due to a 'lock and key' fit between viral surface proteins and specific receptor molecules on the outside of host cells.

Viral diseases

At present there are no cures for viral diseases but vaccination reduces their incidence.

Viral diseases include measles, mumps, poliomyelitis, chickenpox, AIDS, influenza and glandular fever. Some viruses are used to control pest populations, for example myxomatosis in the control of rabbits.

Influenza A virus – H1N1



Causes influenza in birds and some mammals. There are many variants and subtypes and are RNA viruses with a viral envelope. Strains of H1N1 cause flu in humans, pigs and birds. It has caused pandemics, e.g. 1918 Spanish flu and 2009 swine flu and epidemics, e.g. 1978 Russian flu.

Figure 5.2 Influenza A virus – H1N1.

Viral vaccines

The first viral vaccines were based on attenuated or weaker viruses, e.g. smallpox vaccine used coxpox virus.

Vaccines using live attenuated viruses include measles, mumps, rubella and chickenpox.

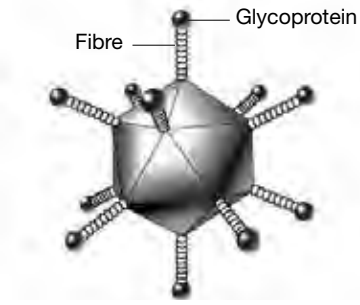
Vaccines using inactivated or killed viruses include polio and hepatitis A. A vaccine that uses segments or conjugates include hepatitis B and the influenza vaccine.

Some viruses keep mutating from one person to the next and vaccination is difficult for these viruses as the virus has already changed its format by the time the vaccine is developed, e.g. common cold.

QUESTIONS

1. What is a virus?
2. Distinguish between a phage and a viroid.
3. Explain why some people consider viruses to be living while others consider them to be non-living.
4. Identify the four main types of viruses.
5. What is a capsid?
6. Describe a viral envelope.
7. Explain why a virus can only metabolise inside a host cell.
8. Outline how viruses cause disease.
9. Outline the disease caused by H1N1 virus and why the disease is closely monitored.
10. The box of information provides data about viral conjunctivitis.

Viral conjunctivitis



Caused by an adenovirus with no viral envelope. The capsid has an icosahedral shape with a glycoprotein spike at each vertex. It is highly contagious and if eyes are touched can be transmitted by shaking hands, sharing towels, contaminated swimming pools.

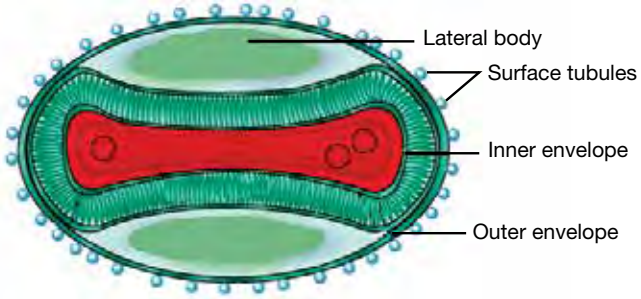
Figure 5.3 Viral conjunctivitis.

(a) How is viral conjunctivitis spread from person to person?
(b) Describe the conjunctivitis virus.

11. What was used in the first viral vaccines?
12. Explain why it is difficult to produce a long term vaccine against some viruses.
13. The vaccine for hepatitis B has been available in Australia since 1982 and the hepatitis B vaccination program started in 1988. Hepatitis B is a life threatening liver infection caused by the hepatitis B virus (HBV) and spread through contact with blood or other body fluids. HBV can survive outside the body for at least 7 days. Suggest why the World Health Organisation recommends vaccination for hepatitis B in the first day of life.

The box of information provides data about smallpox. Use this information for the next TWO questions.

Variola virus and smallpox



Variola virus is a double stranded DNA virus with two envelopes with the outer envelope only present in the extracellular state. The core has a dumbbell shape with two lateral bodies. It is transmitted by direct contact or airborne droplets.

Figure 5.4 Smallpox.

14. Smallpox is a highly contagious disease. WHO certified the eradication of smallpox in 1979. Which of the following could be used as a vaccine for smallpox?
    (A) Cowpox virus.
    (B) H1N1 influenza virus.
    (C) *Salmonella* bacteria.
    (D) Human immunodeficiency virus.
15. What is the variola virus?
    (A) Single stranded DNA virus.
    (B) Double stranded RNA virus.
    (C) Single stranded DNA virus.
    (D) Double stranded DNA virus.
16. In 1892, Dmitri Iwanowsky discovered that the disease which caused the leaves of tobacco plants to become mottled and wrinkled was caused by an agent that was so small it could pass through a porcelain filter and could not be seen under the microscope. In 1935, WM Stanley isolated and crystallised the agent for this disease. When the crystals were injected into healthy tobacco plants, mould appeared. These experiments show that the tobacco plant disease is caused by a:
    (A) Prion. (B) Virus.
    (C) Bacterium. (D) Fungus.

6 Case Study – Human Immunodeficiency Virus

Human immunodeficiency virus (HIV) is a type of retrovirus that causes acquired immunodeficiency syndrome (AIDS). HIV weakens the immune system allowing other infections and cancers to affect the host.

HIV has a roughly spherical shape about 120 nm in diameter with two copies of single stranded RNA that contains its genetic information. The RNA is enclosed in a conical shaped capsid made of protein. Necessary enzymes, e.g. reverse transcriptase bond to the RNA inside the capsid.

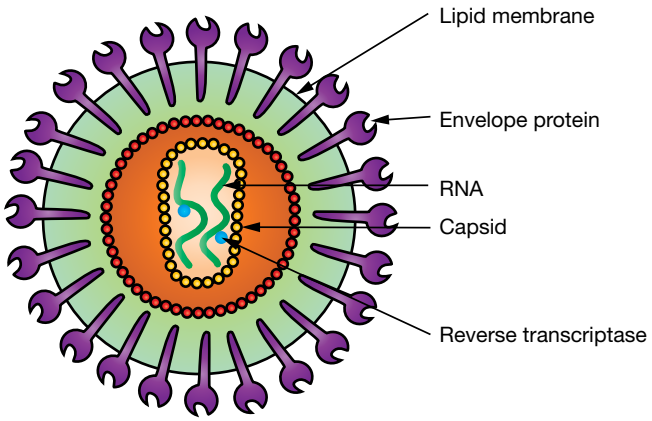


Figure 6.1 Human immunodeficiency virus.

A person becomes HIV positive when they have been infected with the virus and an infected person may develop acquired immunodeficiency syndrome (AIDS) when the virus causes progressive failure of their immune system.

AIDS is a syndrome which means it is diagnosed from a set of symptoms and is not inheritable.

Transmission and cause of disease

HIV can have a long incubation period as the viral genome upon entry into a host cell is converted into a double stranded DNA by the reverse transcriptase.

The viral DNA then moves into the cell nucleus of the host and integrates itself into the host DNA.

Once part of the host DNA the virus can stay latent and undetected by the host immune system or it can cause gene expression to produce new RNA genomes and viral proteins that are released from the cell as new virus particles.

HIV targets and infects helper T cell (CD4 cells), macrophages and dendritic cells. CD4 is a naturally occurring protein found on the surface of helper T cells. When the HIV virus is taken into the cell it begins replicating. Helper T cells are an important part of the immune response. They secrete cytokines that influence other cells, e.g. they secrete gamma interferon which activates macrophages and interleukins that activate antibody production.

There are several ways that HIV can be transmitted.

- **Sexual contact** – is the most common transmission of HIV, e.g. sexual contact with an infected partner. The virus can enter through the lining of the vagina, vulva, penis, rectum or mouth during sex.
- **Contaminated equipment** can transmit HIV, e.g. when sharing contaminated syringes or needles, e.g. drug users, tattoos, piercings.
- **Mother to child** when HIV crosses the placenta during pregnancy or the child is infected during birth or when drinking infected breast milk.
- **Blood** – at one stage HIV was transmitted through blood transfusions or blood products that used infected blood. However, there is now blood screening for evidence of HIV infection and treatments to destroy HIV in blood products.

Symptoms of disease

The symptoms of AIDS can be the same as the symptoms for other diseases, e.g. flu-like symptoms, extreme tiredness, fevers, chills and night sweats, swollen lymph glands, skin blemishes or bumps, a dry cough and white spots or unusual marks in the mouth.

Blood tests can determine the presence of HIV antibodies which are detectable between 6 to 12 weeks after infection.

The destruction of the CD4 cells means that the body cannot fight other infections which leads to the final stage of HIV infection which is AIDS. HIV infection can be classified into three categories.

Category A – mild symptoms similar to glandular fever with swollen lymph nodes mainly on the neck, headaches, fever and dry cough. At this stage the amount of virus in the blood can be high and there is greater chance of transmission than in the later stages of infection. After the initial reaction many people feel better and do not show other symptoms for several years.

Category B – advanced symptoms with persistent generalised lymphadenopathy – swelling of lymph nodes, weight loss, diarrhoea, fatigue, fever, unexplained bleeding and memory loss. Many people get thrush – oral yeast infections or shingles (herpes infections) at this stage.

Category C – final stage with severe symptoms and AIDS when other serious diseases develop such as pneumonia, cancer and brain disorders.

Without treatment an HIV infection will progress to AIDS in about 10 years.

Treatment of disease

At present there is no cure for AIDS.

There are several medications that help control the virus and slow the progression of the disease and also help the person maintain their health for a longer period of time.

Antiretroviral medications used in antiretroviral therapy (ART) target different stages of the virus replication life cycle. However, the medications do not work well for all people and the virus can become resistant to the medication.

There are several treatments that reduce AIDS-related illnesses to help maintain the quality of life for the affected person and those who care for them.

There is pre-test counselling for those who request an HIV test and there is also post-test counselling for people, regardless of the outcome of the test.

Control and management of disease

The main control is safe sex practices, e.g. using a condom during sexual intercourse. Other control measures include not sharing needles, syringes and other injecting equipment.

In Australia there were 1236 newly diagnosed cases of HIV infection in 2013 with about 70% new diagnoses occurring due to sexual contact between men.

Ethical issues

Worldwide issue – AIDS is a pandemic that has killed more than 39 million people since 1981 It is estimated that 1.5 million people died of AIDS in 2013 which is 22% fewer than in 2009 and 35% fewer than the number in 2005. About 35 million people were living with HIV at the end of 2013. The global nature of HIV infection means everyone needs to be aware of how HIV is transmitted and take precautions against infection.

Uneven regional distribution – at the end of 2013, of the 35 million living with HIV/AIDS, about 69% were living in Sub-Saharan Africa.

Economic productivity – young people with HIV/AIDS may be unable to work, their health care may be expensive and families lose their primary income person or child care person. The country loses skilled labour and there is a collapse in the economy and social structure. If both parents die, society needs to care for the children now orphaned.

Discrimination – there are many ways different groups in society can discriminate against people living with HIV/AIDS, e.g. ostracism, loss of previous social network, work restrictions, travel restrictions, denial of hospital facilities or the subject of violence.

Social stigma – the forms of transmission can lead to prejudices and people living with HIV/AIDS have issues with loss of reputation, feelings of worthlessness, withdrawal from society, e.g. some people associate AIDS with other areas they consider a stigma – homosexuality, promiscuity, prostitution, intravenous drug use.

Education programs can help reduce the incidence of HIV/AIDS and reduce the negative social implications.

QUESTIONS

1. Distinguish between HIV and AIDS.
2. Describe HIV.
3. Explain why HIV can evade the immune system.
4. Which cells are infected by HIV?
5. Identify some ways in which HIV can be transmitted.
6. What are some initial symptoms of HIV infection?
7. Describe the three categories of HIV infection.
8. Outline the cure and treatment for patients that are HIV positive.
9. The diagram shows part of the life cycle of HIV.

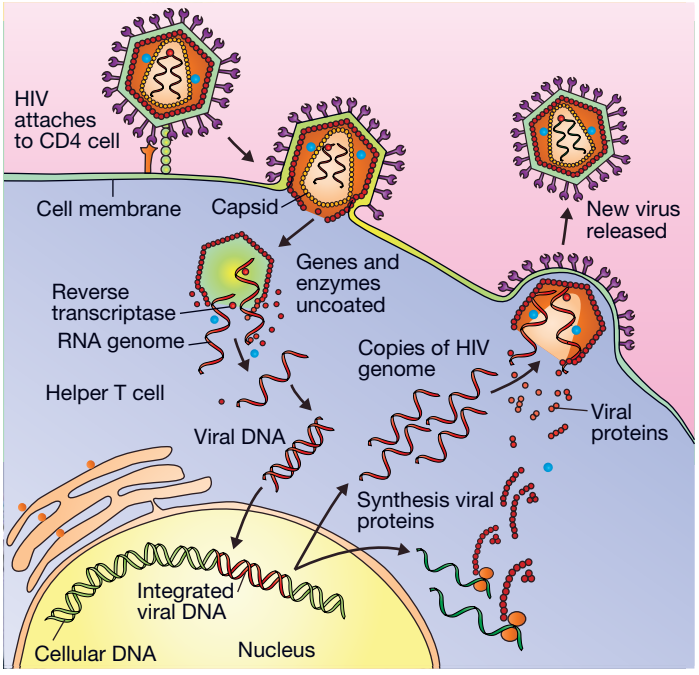


Figure 6.2 Part of HIV life cycle.

Use the diagram to draw a flow chart to show how HIV uses the host cell for replication.

10. Explain why HIV/AIDS is a worldwide issue.
11. Outline why HIV infection can lead to discrimination.
12. What is the best description of HIV?
    (A) Retrovirus with RNA genome.
    (B) Retrovirus with DNA genome.
    (C) Single stranded DNA virus.
    (D) Double stranded DNA virus.

7 Bacteria Pathogens

Bacteria are prokaryotes (no membrane bound organelles or nucleus) ranging in size from 0.5 to 5.0 μm, with a single strand of DNA. Bacteria are present in the soil, air and water and in many human body parts such as skin, throat, mouth, nose and digestive tract. Human armpits have over a million bacteria per square centimetre, although many do not cause disease.

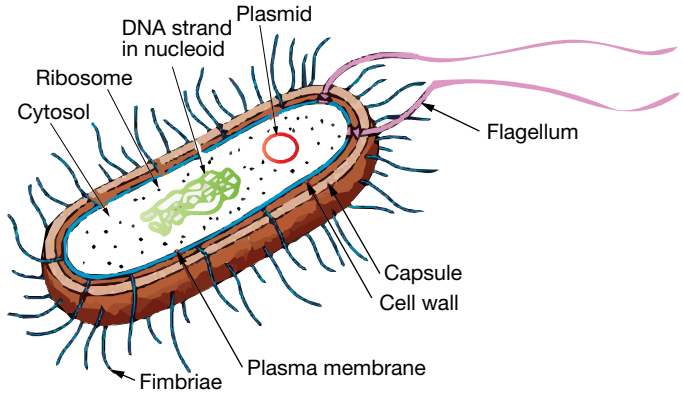


Figure 7.1 Generalised bacterium.

Features of bacteria

Structural features of bacteria are include the following.

- A **cell wall** is a rigid structure which can be surrounded by a capsule. It is a protective layer outside the cell membrane.
- The **capsule** is a sticky layer of polysaccharide or protein and if less well organised is called a slime layer. It is a virulence factor as it aids the disease causing ability and protects against phagocytosis by macrophages.
- **Fimbriae** are hairlike appendages that help the bacteria stick to their substrate or to one another.
- **Flagella** may be concentrated at one or both ends or can be scattered over the entire surface. They are used for locomotion.
- **Nucleoid** region where the bacterial double stranded circular DNA chromosome is located.
- **Plasmids** are small rings of independently replicating DNA with only a few genes. The genes in the plasmids often provided genetic advantages, e.g. antibiotic resistance.
- **Endospores** – in harsh conditions the bacterium surrounds a copy of its chromosome with a tough multilayered structure forming an endospore and metabolism stops. The original cell lyses and releases the endospores. Endospores can survive boiling and high pressure and can lie dormant for long periods of time.

Bacterial reproduction

Bacteria reproduce asexually by binary fission so that within a short time the host can contain thousands of bacteria. Bacteria produce toxins, often as waste products, which harm the host.

A bacterium can also directly transfer DNA to another bacterium by **conjugation** when two cells are temporarily joined.

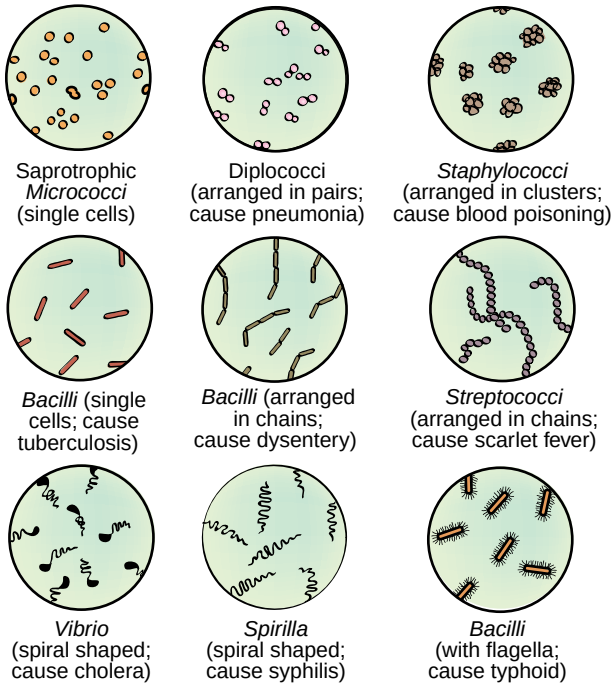


Figure 7.2 Bacteria are classified by their shape.

Bacterial classification

Bacteria can be classified and named by shape, e.g. cocci, bacilli, spirilla, vibrio, rickettsiae and others as shown in the diagram.

Bacteria are also subdivided on Gram staining. Gram staining distinguishes bacteria on the properties of their cell wall. Gram positive bacteria keep the crystal violet dye colour identifying the peptidoglycan in the cell wall while gram negative stain red or pink. The Gram stain is usually the first step in bacteria identification.

Bacterial diseases

Bacteria cause about half of all human diseases. Bacterial diseases include bubonic plague, diphtheria, gonorrhoea, leprosy, scarlet fever, syphilis, tetanus, tonsillitis, typhoid and whooping cough.

Cholera is caused by an exotoxin secreted by the bacterium *Vibrio cholerae*. The exotoxin causes the intestinal cells to release chloride ions into the gut and water follows by osmosis. This leads to severe diarrhoea, dehydration and an electrolyte imbalance.

In plants, bacteria are found in the conducting and leaf tissues. They cause some leaf spot diseases, bacterial canker on tomatoes, bacterial soft rot of lettuce and carrots and some rot diseases such as stem rot of potatoes, although most plant diseases are caused by fungi. Since many bacteria can survive in the soil, crop debris, seeds, plant parts and in weeds they can remain dormant until suitable conditions allow them to multiply. Favourable conditions include high humidity, crowding, poor air circulation and warm, wet weather.

Bacteria and antibiotics

Antibiotics are chemicals that kill or inhibit the growth of bacteria and are used to treat bacterial infections. Antibiotics are produced by soil bacteria and fungi. Antibiotics can inhibit cell wall synthesis, inhibit protein synthesis (e.g. translation), alter the cell membrane and its permeability or inhibit nucleic acid synthesis. For example, penicillins affect cell wall synthesis and the tetracyclines are protein synthesis inhibitors.

Bacterial vaccines and toxoids

A bacterial **exotoxin** is a toxin, e.g. protein secreted by bacteria and released outside the cell. They are produced by both gram negative and gram positive bacteria. There are many types of exotoxins based on structure and function. Exotoxins may be secreted or like endotoxins are released during lysis of the cell.

Bacterial **endotoxins** are part of the outer membrane of the cell wall of gram negative bacteria. They are lipopolysaccharides and are only one type of endotoxin.

Vaccines contain killed or attenuated bacteria that activate the immune system. Antibodies are created against that particular bacteria, e.g. whooping cough vaccine has killed bacteria while measles vaccine has living, attenuated bacteria.

Toxoids are modified toxins that have the antigen but it cannot destroy tissues, e.g. toxoids for tetanus and diphtheria. Booster injections for vaccines and toxoids increase the number of antibodies and the number of circulating memory cells to sustain immunity.

QUESTIONS

1. Define a prokaryote.
2. How large are bacteria?
3. Where are bacteria found?
4. Construct a table to summarise the function of different parts of a bacterium.
5. How do bacteria reproduce?
6. Distinguish between cocci, bacilli and spirilla bacteria.
7. How is the Gram stain used in bacteria identification?
8. (a) Outline the cause of cholera.
   (b) Identify some symptoms of cholera.
9. The diagram shows a generalised bacterium.

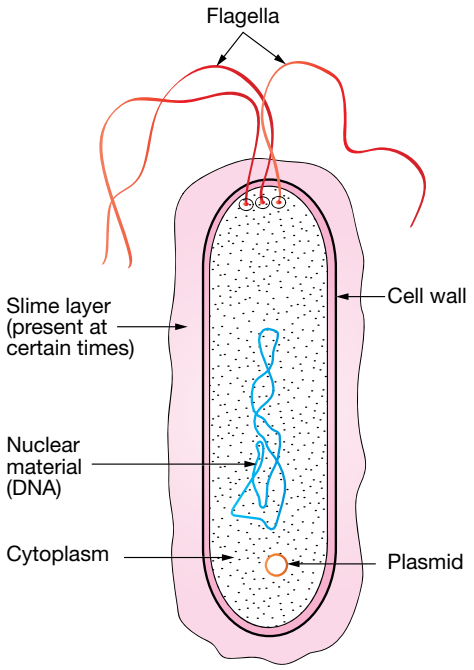


Figure 7.3 A bacterium.

Explain why numbers of a bacterial pathogen can rapidly increase.

10. Describe how many bacteria are named and classified.
11. Outline why bacteria cause disease.
12. Distinguish between an exotoxin and an endotoxin.
13. (a) What is an antibiotic?
    (b) How are antibiotics used?
    (c) Outline some ways in which antibiotics work.
    (d) Name an antibiotic and state how it works.
14. How do vaccines work against pathogenic bacteria?
15. What is a toxoid?
16. Why are booster injections needed in vaccination programs?
17. Which correctly matches the infectious disease, pathogen and classification of pathogen?

	Infectious disease	Pathogen	Classification of pathogen
(A)	AIDS	HIV	Virus
(B)	HIV	HIV	Bacteria
(C)	HIV	AIDS virus	Virus
(D)	AIDS	*Streptococcus* HIV	Bacteria

18. Which group lists diseases caused by bacteria?
    (A) AIDS, influenza, poliomyelitis.
    (B) Pneumonia, cholera, tetanus.
    (C) Ringworm, tinea, thrush.
    (D) Malaria, amoebic dysentery, sleeping sickness.

8 Case Study – Cholera

Cholera is caused by the vibrio bacteria – *Vibrio cholerae*. The bacterium has a direct life cycle; it is ingested in contaminated food or water, infecting the bowel of the human and is then egested with the faeces. Incubation may be a few hours to five days.

For at least 2000 years, cholera was endemic to the southern parts of India, spreading to the rest of the world along the trade routes. In 1854, John Snow established the link between cholera and its source – sewage-contaminated water. Also in 1854, Filippo Pacini first clearly described the cholera vibrio. *Vibrio cholerae* can live in both fresh and salt water and survives outside the human body with no need for an animal host or insect vector. Due to the severe diarrhoea it causes, anything fouled can transmit the disease, for example bedding, clothing and unprotected water sources. The European cholera epidemic of 1831-1832 claimed many lives.

In 2010 there was an outbreak of cholera in Haiti ten months after an earthquake hit the island. In 2012 during the rainy season the epidemic returned and it is estimated that more than 5% of the population were infected with over 7000 deaths.

Figure 8.1 *Vibrio cholerae.*

Major symptoms and host response

The bacteria produce a toxin which interrupts the sodium and potassium transport systems in the intestine. The bacteria attaches to the mucous lining of the microvilli, causing excessive secretion of fluids and electrolytes. The lining of the intestine is broken down by bacterial enzymes. Reabsorption of electrolytes, nutrients and fluid is prevented. Muscle cramps are experienced. The bowel becomes inflamed (enteritis), causing severe 'rice water stool' diarrhoea, and loss of water and salts results in dehydration; death can occur within 12 hours. Cholera victims can lose 10 litres of water a day. Victims develop cold, shrivelled skin and sunken eyes, blood pressure falls and the pulse becomes faint. The toxin causes antibodies to be produced. These antibodies provide resistance to the same strain of bacteria.

Treatment

It is essential to replace the fluids and salts. Antibiotics are effective only in the early stages and if given during the first day reduce the period of diarrhoea and the need for fluid replacement. If treated with the proper amount of glucose, cholera patients can still reabsorb fluid. Oral rehydration solution (ORS) containing sodium and potassium chloride and glucose and sodium bicarbonate prevents dehydration. A simple recipe for treatment is 1 litre of water to 1 teaspoon of salt and 8 teaspoons of sugar.

Control

The control of a disease can involve many factors, such as laws, infrastructure and economics, necessary to create an environment where the pathogen cannot survive or be transmitted. For cholera, it is important to prevent contaminated faeces infecting the water supply. Chlorination of water and an effective sewerage system can guard against this. Cholera is a notifiable disease and all outbreaks of cholera in cholera-free zones are reported to WHO which has established regulations to prevent travellers spreading the disease to other areas.

Prevention

Prevention is a type of control which prevents people from becoming infected. For example, travellers who wish to visit areas where cholera is found can have vaccines that are effective for six months. They should avoid drinking water or eating food that may be contaminated.

Cholera in Australia

The European epidemic of cholera in 1831 led the Bourke government to introduce Australia's first quarantine act in 1832. The area within a quarter mile of the high water mark of Spring Cove in Sydney Harbour was established as a quarantine area in 1833 and four years later the area was extended to the whole of the North Head peninsula.

QUESTIONS

1. Identify the cause and transmission of cholera.
2. Describe the host response to *Vibrio cholerae* infection.
3. Outline the major symptoms of cholera.
4. Describe oral rehydration therapy.
5. How can cholera be prevented?

6. On the diagram identify the point of entry for the pathogen, the site of colonisation and the point of exit from the body.
7. Distinguish between prevention and control.
8. How did the European cholera epidemic in 1831 affect Australia?
9. Cholera is a bacterial infectious disease common in tropical countries. Identify the most likely method of transmission.

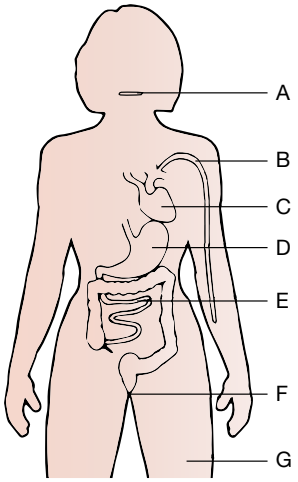


Figure 8.2 *Vibrio cholerae* in the body.

(A) Ingestion of contaminated food or water.
(B) Inhalation of airborne droplets.
(C) Direct contact.
(D) Vector.

10. The bacterium *Vibrio cholerae* infects the human intestine disrupting the salt and electrolyte transport in the lining of the intestine. The bacteria also produce an enzyme that damages the intestine. Identify the most likely effect on the human.
(A) Anaemia.
(B) Severe diarrhoea.
(C) Pink spots on the skin of the abdomen that become itchy.
(D) Fever with regular periodic shivering.
11. Drugs such as tetracycline and chloramphenicol can be used to treat cholera. Which of the following gives the most probable reason why drugs can be used against the spread of cholera?
(A) It is a genetic disease.
(B) It is a disease with a long incubation period.
(C) It is caused by a virus.
(D) It is caused by a bacteria.
12. Cholera was endemic in southern India for at least 2000 years before it gained world attention in 1817 when travellers reported the disease spreading along the trade routes. It had reached Moscow by 1831. People feared cholera as it claimed the lives of so many regardless of age, wealth, or fitness. Which of the following gives one of the reasons why cholera is such a threatening disease?
(A) A protozoan parasite has both a human host stage and an insect vector host stage.
(B) A bacterial parasite can be an intracellular parasite on other bacteria.
(C) Vibrio bacteria can survive outside the human body with no animal host or insect vector.
(D) Virus is easily transmitted by close contact with blood and vomit.
13. It has been suggested that the periodic outbreaks of cholera are related to the climatic conditions of southern India, where the disease is endemic. The vibrio bacteria survives and increases in numbers in water storage areas such as wells and cisterns. When the monsoon rains come, the bacteria is flushed out of these storage places and spread over wide areas causing an epidemic. Some parts of Australia have similar climatic conditions to southern India. Which of the following is a possible method to control the spread of cholera in Australia?
(A) Cover water storage areas to prevent the bacteria entering the water.
(B) Continually flush the water storage areas through the dry season with salt compounds.
(C) Prevent contaminated faeces infecting the water supply.
(D) Adjust the pH of water in storage areas so it lies within a range of pH 2.0 to pH 8.5.
14. In 1854, John Snow studied the spread of cholera through London districts, charting maps to show its occurrence. An analysis of his results convinced him that a common factor involved the water from the Broad Street pump. He persuaded the aldermen to remove the hand of the Broad Street pump. What link was established by the work of John Snow?
(A) The cause of cholera and the life cycle of the pathogen.
(B) A cholera epidemic and its source.
(C) Host response to cholera and bacterial toxins.
(D) The vector and the source of cholera.
15. The worldwide cholera epidemic of 1831 lead to Australia's first quarantine act being established by the Bourke government in 1832. Which of the following resulted from this act?
(A) The federal government assumed responsibility for quarantine.
(B) The establishment of a Board of Health.
(C) Statewide immunisation program against cholera.
(D) The establishment of a quarantine area at North Head peninsula.
16. Which of the following is the most suitable control to prevent the spread of cholera?
(A) Provide continual medication to the population of drugs such as tetracycline.
(B) Chlorination of the water supply.
(C) Rapid fluids and salt doses to people.
(D) Avoid sexual contact with infected people.

Answers

Module 7 Infectious Disease

1 Assumed Knowledge

1. (a) Prokaryotes do not have membrane bound organelles, e.g. nucleus, mitochondria while eukaryotes contain membrane-bound organelles including a nucleus.
   (b) Prokaryotes include bacteria and Archaea while eukaryotes include plants, animals, fungi and the protists.
2.

Component	Function
Bacterial chromosome	Contains genetic information that controls cell metabolism.
Cytoplasm	Entire contents of cell where most reactions occur.
Cell wall	Protects cell, gives cell shape.
Capsule	Capsule allows bacteria to attach to other cells, e.g. to form a colony or to adhere to a substrate or pathogens attach to host.
Plasma membrane	Controls substances in/out of cell.
Plasmid	Ring of accessory DNA with additional genes that aid survival.
Fimbrae	Assist attaching to surfaces and other cells. Some used for motility.
Pili	Sex pili used during conjugation and transfer of DNA.
Flagella	Used for motility and locomotion.
Slime layer	Unorganised layer for protection, e.g. against drying out.

3. Viruses are very small, not cellular, consist of nucleic acid (either RNA or DNA) and are enclosed in a protein coat.
4. Disease is any condition that impairs or interferes with the normal functioning of the body.
5. An infectious disease is caused by pathogens which invade the body. They are contagious diseases often able to be passed from one person to another.
6. A pathogen is an agent that causes disease.
7. Macroparasites can be seen with the naked eye, e.g. worms, ticks, while microparasites cannot be seen with the naked eye, e.g. bacteria.
8. An antibiotic is a chemical which inhibits or destroys micro-organisms such as bacteria.
9. Penicillin interferes with the formation of the bacterial cell wall which limits the survival ability of the bacterium.
10. Immunisation is a process which stimulates the immune system to produce lymphocytes or antibodies for a particular antigen.
11. Epidemiology is the study of disease and its prevalence in the community.
12. Red blood cells transport oxygen in the body to needy cells for respiration. Neutrophils are a type of white blood cells that are the first cells to migrate to a site of infection and are phagocytes. Monocytes are large white blood cells and differentiate into macrophages and are involved in adaptive immunity. Lymphocytes are white blood cells involved in the immune response and are B cells and T cells. Basophils are white blood cells involved in the inflammatory response and allergic symptoms. Platelets are cytoplasmic fragments involved in blood clotting.
13. Phagocytosis is a type of endocytosis where large, particulate substances are taken into a cell.
14. Response A is dilation of blood vessels which allows an increased flow of blood to the area bringing phagocytes, nutrients, antibodies, increased temperature and also makes the area appear red. Response B is an increase in permeability of the walls of the capillaries which allows the needed substances to move from the bloodstream into the tissues that have been invaded by the pathogen. Response C is the migration of phagocytes to the area which will engulf and destroy the pathogens by phagocytosis.
15. An antigen is a substance that causes an immune response by binding to receptors of B cells, antibodies or of T cells.
16. An antibody (or immunoglobulin) is a protein secreted by plasma B cells in response to a particular antigen.
17. The photograph shows leaves with holes and missing sections that indicate a plant pest, e.g. caterpillar has been eating the leaves and some of the leaves show leaf curl which could be due to insects laying eggs on the leaves or incorrect growing conditions of the soil.
18. Vaccination programs in the National Immunisation Program include: hepatitis B (at birth, 2, 4 and 6 months) the triple antigen (diphtheria, tetanus and whooping cough) at 2, 4, 6, and 18 months, poliomyelitis at 2, 4, and 6 months and 4 years, chickenpox at 10 to 15 years, human papillomavirus (HPV) at 10 to 15 years and measles at 12 and 18 months.

2 Infectious Disease

1. A disease is any condition that impairs or interferes with the normal functioning of the body.
2. Infectious diseases differ from other diseases, e.g. genetic and lifestyle diseases in that they are caused by the invasion by a pathogen and can be transmitted from one host to another.
3. In the past infectious diseases have affected human populations by causing the death of many individuals which can affect the politics and economics of an area, e.g. by the death of prominent citizens, leaders, insurgents. In the 14th century nearly one third of the world's population died from bubonic plague – the Black Death which is an infectious disease caused by the bacteria *Yersinia pestis*.
4. Diseases can be classified in many ways, e.g. by the major categories of infectious disease and non-infectious disease or by the body part/system that is mainly affected, e.g. cardiovascular diseases, heart, lung and other organ diseases or endocrine system diseases or by the way the disease is acquired, e.g. genetic diseases, injuries and environmental diseases.
5. The invention of the light microscope and developments in its design to improve resolution and magnification enabled scientists to observe micro-organisms and then to link particular organisms to particular infectious diseases. For example, in 1845-1846 Louis Pasteur showed that a mystery disease that threatened the silkworm industry was caused by micro-organisms that were only visible under a microscope and only found in the tissues of diseased silkworms, moths and eggs.
6.

Technology	Used by	Scientific understanding of infectious disease
Light microscope	Anton van Leeuwenhoek	Observed micro-organisms under the microscope which led to other scientists searching for microbes in different substances.
Swan neck flasks	Louis Pasteur	Showed microbes caused decay giving rise to the germ theory and refuting the theory of spontaneous generation.
Petri dish with agar jelly	Robert Koch	Identified the causative pathogens for tuberculosis and cholera and proposed a systematic method that will identify the pathogen causing a particular infectious disease.

7. A

3 Prion Pathogens

1. In 1982 Stanley Prusiner invented the word prion as a combination from *protein* and *infection*.
2. Stanley Prusiner won the Nobel Prize in Physiology or Medicine in 1997 for 'the discovery of Prions – a new biological principle of infection'.
3. Prions are infective proteins that have been altered to an abnormal shape.
4. PrP^{C} stands for cellular prion protein and is the normal form of the protein that will become a prion.
5. The normal prion proteins consist of about 40% alpha helices while prion proteins are about 55% beta pleated sheets and 20% alpha helices.