Achievement Standard 90927

Demonstrate understanding of biological ideas relating to micro-organisms

BIOLOGY

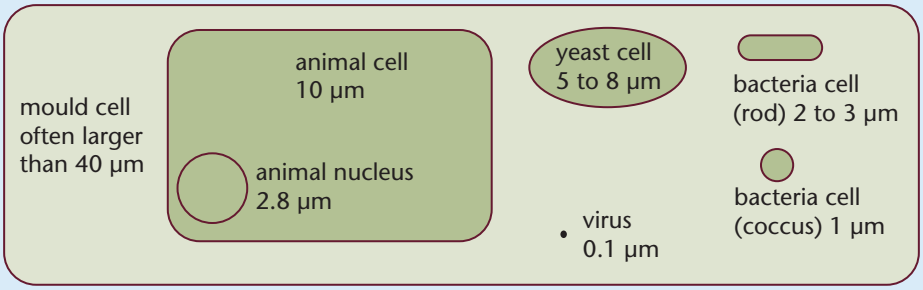
1.3

Externally assessed 4 credits

Micro-organisms

Bacteria, fungi (yeasts and moulds) and viruses are all micro-organisms.

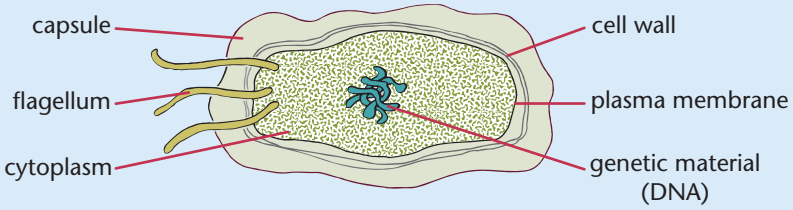
Comparative sizes of micro-organisms



Bacteria

Very small, **single-celled** organisms. Found in air, water, soil and food, as well as inside and outside all living organisms.

Require moisture, food and warmth (different bacteria are suited to different temperatures). Some are **aerobic** (require oxygen), while others are **anaerobic** (do not require oxygen).



Reproduce by **binary fission** (splitting in two). In good conditions they can reproduce every 20 minutes. Growth rates can be slowed down by lack of food or space, unsuitable temperatures, or a build-up of **toxins** excreted by the bacteria.

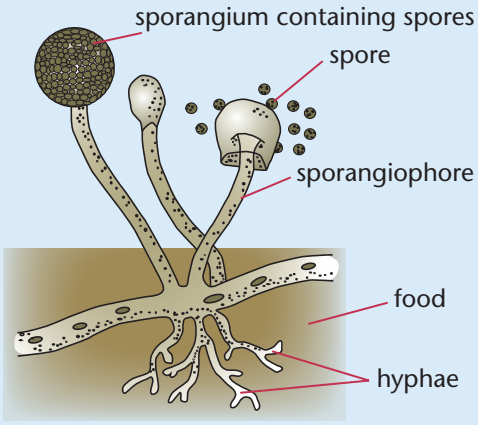
Saprotrophic/saprophytic bacteria are **decomposers** that feed on dead organisms and wastes (urine and faeces). **Pathogenic** bacteria are **parasites** that feed on a living host causing a disease.

Helpful bacteria	Harmful bacteria
Bacteria are used to: • produce foods such as cheese and yoghurt • release vitamin K in our intestines • recycle nutrients like nitrogen in the environment • produce drugs – some antibiotics are from bacteria (others are from fungi).	Bacteria can make food inedible. Many illnesses are caused by bacteria, including: • meningitis • food poisoning • tetanus • tuberculosis • whooping cough.

Fungi

Yeast, mould and mushrooms are all fungi.

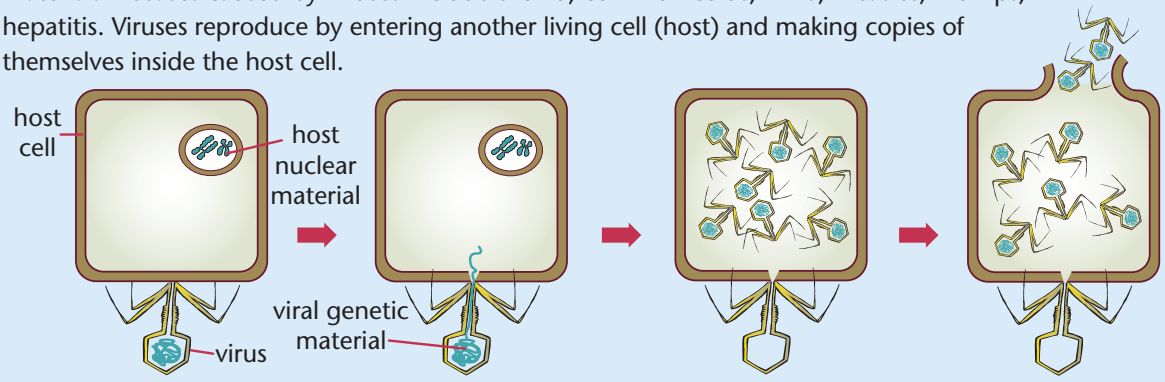
- Fungi require **food, moisture** and **warmth** to grow and reproduce. Some are **aerobic** while others are **anaerobic**.
- The body of a fungus consists of **hyphae** – fine thread-like structures that spread through the substance that the fungus is living on.
- Fungi produce **spores**, which grow in a spore head or **sporangium**. Mature sporangia burst, releasing large numbers of spores into the air. Spores settle and grow.
- **Saprotrophic/saprophytic** fungi live and feed on dead organisms. **Pathogenic** fungi are **parasites** that feed on living organisms and cause disease.



Viruses

Viruses are micro-organisms that cannot survive without a living host. They are always pathogenic (cause disease). Viruses are often thought to be nonliving, because they reproduce but do not grow, feed, respire or excrete wastes.

Viruses come in a variety of shapes, but they all have a protein case that holds genetic material. Diseases caused by viruses include the flu, common colds, AIDS, measles, mumps, hepatitis. Viruses reproduce by entering another living cell (host) and making copies of themselves inside the host cell.



1. Virus attaches to host cell.
2. Genetic material from the virus enters the host cell.
3. Contents of host cell are used to make viral genetic material and protein coats.
4. Host cell bursts and new viruses are released. Host cell dies.

Extracellular digestion

Both bacteria and fungi feed by **extracellular digestion** – this means that digestion occurs outside the cell.

Culturing micro-organisms

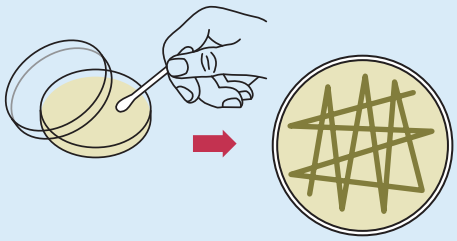
Some bacteria and fungi can be grown, that is 'cultured', on agar plates. Bacterial **colonies** can be seen as small, different coloured shiny spots. By the time a colony can be seen by the eye, it contains at least 1 million cells.

Fungi can be seen as a furry mass of fine white threads that can later turn grey as the fungi start to reproduce.

The following steps are taken when culturing bacteria and fungi at school. The first two steps may be carried out for you.

1. Sterilise Petri dishes and other equipment.
2. Mix agar with water and boil. Pour cooled agar into a Petri dish in a way that reduces the chance of bacteria and fungi in the air from falling on the agar surface.

3. Collect samples from surfaces using Sellotape, cotton buds, or sterile inoculating loop. Avoid surfaces that are possible sources of harmful bacteria, e.g. toilets.
4. Lift one side of a Petri dish lid just high enough to **inoculate** the plate by placing the Sellotape on the agar surface for a couple of seconds *or* by rubbing the cotton bud or inoculating loop in an 'S' shape pattern across the agar surface – gently to avoid damaging the agar surface. Turn the dish 90 degrees, and make another 'S' shaped pattern across the first one.



5. Close the lid and seal the dish with tape.
6. On the bottom of the dish record information about how the plate was inoculated.
7. Place the dish upside down in an incubator set at 25 °C for 3 to 5 days. The plate is placed upside down to reduce the chance of water dropping on the agar and spreading the bacteria in the colonies so they cannot be seen.
8. Wash hands in soap and water, and burn any used Sellotape or cotton buds to destroy micro-organisms.

Viruses are cultured in **cell cultures** where *living cells* are used as host cells in which the virus can reproduce. Mammal, plant, fungal or bacterial cells are used depending on what type of cell the virus can use as a host.

Effects of environmental factors

Environmental factors such as temperature, availability of oxygen, water and nutrients, and the presence or absence of various chemicals, affect the rate of growth and reproduction of micro-organisms.

Temperature

Different micro-organisms have different optimum temperatures at which they grow and reproduce most quickly. For example, bacterial species that are parasites of humans have an optimum temperature around 37 °C, because this matches the temperature of the human body in which they grow.

Saprotrophs grow best in temperatures around 30 °C, but can grow in temperatures between 5 °C and 45 °C – this is an advantage to them because saprotrophs are likely to be growing on material that is continually changing temperature – e.g. night and day temperatures in garden waste. Growth and reproduction are slower in temperatures above and below the optimum because of the effect of temperature on processes such as enzyme activity and diffusion.

Oxygen availability

Aerobic micro-organisms require oxygen in their environment. The amount of oxygen required varies with different species – some require a significant amount and others very little. For example, *Helicobacter pylori* and *Campylobacter* are two types of bacteria that require very little oxygen in their environment, so they can survive inside the human digestive system.

Aerobic respiration equation: glucose + oxygen → carbon dioxide + water + lots of ATP

Anaerobic micro-organisms do not require oxygen – some anaerobic species are even harmed by the presence of oxygen. Lactic acid bacteria are anaerobic. They produce useable energy, in the form of ATP, by the process of fermentation.

Anaerobic respiration equation for lactic acid bacteria: glucose → lactic acid + 2ATP

Yeast can respire both aerobically and anaerobically. Aerobic respiration produces more energy, but if all the oxygen is used up, yeast can still produce some energy anaerobically by the process of **fermentation**. During anaerobic respiration, or fermentation, ethanol (alcohol) is produced. If anaerobic respiration is carried on for too long the ethanol concentration becomes very high, killing the yeast.

Anaerobic respiration equation for yeast: glucose → ethanol + carbon dioxide + 2ATP

Increasing the amount of oxygen in the environment increases the growth rate of aerobic micro-organisms up to a certain point, after which some other factor will begin limiting their growth.

Nutrients and moisture

Different micro-organisms have different nutrient requirements but all require an energy source, moisture (water), vitamins and minerals. The presence of suitable nutrients in a food source determines if a micro-organism can grow in the food source or not. Milk and other dairy products are rich in nutrients so provide an ideal growth environment for many different types of micro-organisms.

Water is essential for all living cells as the medium in which chemical reactions take place and materials are transported. If there is no water, micro-organisms cannot grow and reproduce.

Chemicals

pH – different species of micro-organisms have a different optimum pH and preferred pH range in which they can live. For example, most grow best when the pH is between 6 and 8, but lactic acid bacteria can grow and reproduce when the pH is much lower – which means they can outcompete other bacteria in materials containing large amounts of lactic acid.

The rate of growth of micro-organisms reduces very quickly as pH moves above or below the optimum. This is because of the sensitivity of enzymes to pH.

Toxins – are poisonous wastes produced by micro-organisms. High concentrations of toxins kill the micro-organisms themselves.

Antibiotics – are chemicals that kill bacteria or slow their growth. Antibiotics can be produced by micro-organisms – for example the group of antibiotics called 'penicillins' are produced by *Penicillium* fungi. Many of the antibiotics used in medicines are made using synthetic or semi-synthetic processes.

Disinfectants – are chemicals that kill and break down micro-organisms. Examples of disinfectants are chlorine bleach, alcohols, ammonium compounds, and peroxides. Disinfectants act by joining on to chemical receptors on the micro-organism's cell wall and entering the cell, where they interfere with essential structures such as the phospholipid cell membrane and DNA molecules; and life processes such as the transport of materials.

Antiseptics – are disinfectant chemicals that are safe to use on skin. For example, a 6% hydrogen peroxide solution is used for cleaning wounds, while a solution stronger than 30% is used as an industrial disinfectant. Once inside a micro-organism's cell, part of the hydrogen peroxide molecule joins on to enzymes and other proteins destroying their structure – *denaturing* them so they stop functioning.

Competition

Micro-organisms make and secrete chemicals that help them out-compete other micro-organisms. For example, some fungi produce antibiotics that kill bacteria, resulting in reduced competition between the fungi and bacteria for nutrients and space. Lactic acid bacteria produce chemicals that kill other bacteria, thus reducing competition for resources.

Host species

Viruses and pathogenic bacteria and fungi require a host cell in which to live and grow. If there are few host cells available, the growth and reproduction of pathogens is reduced.

Assessment specifications

The Assessment specifications have given the following information to help clarify what could be included in the examination. This Achievement Standard assesses biological ideas that relate to micro-organisms selected from bacteria, fungi and viruses.

- Factors that affect the life processes of micro-organisms include water, temperature, oxygen availability, presence of suitable nutrients and host species, competitors related to antibiotic action and resistance.
- Why viruses cannot be considered living (only reproduce using host cells and do not grow, feed, produce energy or excrete).
- Basic practical work relating to micro-organisms.

Questions: Micro-organisms

Question One: Sooty mould

Year 2017
Ans. p. 107

Sooty mould is a common fungus that grows on beech/tawai trees in New Zealand. It feeds on honeydew, which is an energy-rich substance made by insects that also live on the trees.

Sooty mould growing on the trunk of a beech/tawai tree

Sooty mould hyphae as seen under a microscope

One environmental factor that affects the growth of sooty mould is humidity (amount of water in the air). A student collected some data to investigate the effect of humidity on sooty mould growth. Her results are in the table below:

Humidity (amount of water in the air)	Percentage cover of sooty mould on beech/tawai trees
High humidity	Average of 90% of trunks covered
Medium humidity	Average of 50% of trunks covered
Low humidity	Average of 20% of trunks covered

Discuss how environmental factors, life processes and the structure and function of a fungus such as sooty mould, work together to allow it to live successfully on New Zealand's beech / tawai trees.

In your answer:

- describe the structure and function of a fungus such as sooty mould
- explain the environmental factors required for a fungus such as sooty mould to live successfully
- explain how a fungus such as sooty mould feeds, grows, and reproduces
- discuss how the life processes of sooty mould are affected by humidity and other environmental factors such as temperature, oxygen availability, nutrients, moisture and competition.

Question Two: Fungi as plant pathogens

Loss of crops or food spoilage due to fungal diseases caused by fungal pathogens can have a large impact on human food supplies. Some fungal pathogens include **a.** green mould on fruit, and **b.** stem rust on wheat.

Year 2016
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a.

b.

Discuss how fungi feed, grow, and reproduce as pathogens on plants, and how damage to crops or food spoilage from fungal pathogens can be minimised. Your answer should:

- define the term pathogen
- explain how fungi feed, grow, and reproduce on plants
- explain how environmental factors allow fungi to grow quickly on plants
- explain how crop damage or food spoilage from fungal growth could be minimised
- compare the links between the methods used to control fungi and the expected changes to fungal growth and reproduction.

Question Three: Microbes and illness

Two students, Manaaki and Angela, were sick and went to the doctor on the same day.

Manaaki was told that he had the common cold, which is caused by a viral infection, and was advised to stay home and rest.

Angela had a sore throat, which is caused by a bacterial infection, and was prescribed a 10-day course of antibiotics.

Year 2015 Ans. p. 108

1. Draw a labelled diagram of a virus and of a bacterium.

Virus	Bacterium

2. The symptoms developed very differently for Manaaki and Angela before they saw the doctor. Manaaki's symptoms (caused by a virus) had become worse suddenly in the morning, while Angela's symptoms (caused by bacteria) became worse gradually throughout the day.

Explain why Manaaki developed the symptoms more quickly than Angela. In your answer you should:

- explain how the reproduction of viruses and bacteria affected how quickly Manaaki and Angela developed the symptoms
- compare and contrast the way viruses and bacteria reproduce, including their requirements for energy.

Answers and explanations

The 'Achievement' (A), 'Merit' (M) and 'Excellence' (E) ratings given with answers supplied are based on professional judgements made by the author.

Words/phrases like 'this means', 'therefore', 'however' show the linking of ideas and they are what makes a piece of text an explanation (M) or discussion (E) rather than a description (A). It takes several ideas linked together to make a discussion.

(A, M, E) – an answer containing mostly descriptions would be graded A, an answer with descriptions linked together into explanations would be graded M and a comprehensive answer containing descriptions and explanations linked together would be graded E.

Achievement Standard 90927 (Biology 1.3): Demonstrate understanding of biological ideas relating to micro-organisms

Micro-organisms

Question One: Sooty mould

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Check that your answer has the following important points.

- Structure – mycelium of many thread-like hyphae.
- Function – saprophyte.
- Environmental factors – warm temperatures, moisture / humidity, oxygen if aerobic, food (honeydew); *see last bullet point for explanations*.
- Feeding – extracellular digestion, enzymes released into food source/honeydew, enzymes digest food, nutrients from digested food absorbed into hyphae.
- Growth – hyphae grow longer by cell division/mitosis.
- Reproduction – produce spores, spores dispersed, germinate and hyphae grow.
- Effect of humidity – high humidity, higher growth.
- Effect of other environmental factors – for example: (1) temperature – increased temperature faster life process reactions up to optimum rate when further increase in temperature denatures enzymes; (2) oxygen – aerobic only, increased oxygen availability faster respiration up to optimum when another factor limits; (3) nutrients – increased nutrient availability faster growth up to optimum when another factor limits; (4) moisture/humidity – water for diffusion/enzyme reactions, increased moisture availability faster growth up to optimum when another factor limits; (5) competition – limits growth as individuals of the same fungus compete for the same resources, to reduce competition some fungi release chemicals that limited the growth of other micro-organisms.

Possible answer

The structure of the body of a sooty fungus is a mycelium made up of many thread-like hyphae which grow as a saprophyte on the trunks of tawai trees. The fungus feeds on the honeydew by extracellular digestion. The cells in the hyphae release enzymes into the honeydew. The enzymes digest the honeydew and the nutrients from the digested food are absorbed into hyphae. Some nutrients are used in respiration to provide energy for life processes, and other nutrients are used as building-block molecules for growth. When growing, the cells in hyphae divide by mitosis then grow bigger which makes the hyphae get longer.

Some nutrients are used for reproduction when spores are produced. The (light) spores are dispersed away from the parent. If they land on a food source, the spores germinate and hyphae grow.

Humidity is an environmental factor that affects growth – the results show that high humidity results in higher percentage cover of sooty mould on trees. This is because humidity provides water so that materials can diffuse into and out of cells and enzymes are able to make reactions go faster. Increased moisture results in increased growth up to an optimum, when another factor limits the growth of the fungus.

Increased temperature results in faster life-process reactions up to an optimum rate when further increase in temperature denatures enzymes. Oxygen is an important factor for aerobic fungi, but not for anaerobic ones. Fungi that carry out aerobic respiration require oxygen to complete the process:
glucose + oxygen → carbon dioxide + water + lots of ATP

Increased oxygen availability results in faster respiration up to an optimum, when another factor limits. This is the same with nutrients. If honeydew is in short supply the fungi will not be able to grow as quickly or reproduce as often.

Competition limits growth, as individuals of the same fungus compete for the same resources – so, when resources are limited (e.g. not much moisture), the fungi grow at a slower rate. To reduce competition, the cells of some fungi release chemicals that limit the growth of other micro-organisms such as bacteria. This means more resources are available for the fungus.

(**A** – describes three out of: structure, function, feeding, growth, reproduction, effect of environmental factors;

M – explains two out of: feeding, growth, reproduction, effect of an environmental factor, effect of a second environmental factor;

E – discusses how fungus is able to live successfully by linking environmental factors to life processes)

Question Two: Fungi as plant pathogens

p. 7

Check that your answer contains the following important points.

- Pathogen – a disease-causing organism
- Feed – extracellular digestion: enzymes released onto plant (food source), food digested, molecules of digested food absorbed into fungal cells
- Growth – hyphae cells divide by mitosis, grow through food source
- Reproduce – sporangia grow, produce spores, sporangia burst releasing spores into air
- Environmental factors that allow quick growth – moisture, food, warmth, oxygen

- How damage minimised – store in cool temperatures, remove infected fruit/plant/leaf, spray with fungicide
- Control methods and expected change to growth and reproduction – cold temperatures slow the rate of growth and reproduction, removing infected fruit stops the spores from the infected fruit being released into the air and germinating, spraying with a fungicide kills the fungi or the spores so stops growth and reproduction, cooking during canning kills fungi and then the can prevents further infection, drying removes moisture so fungi cannot grow and reproduce.

Possible answer

Fungi that cause disease are called pathogens. Fungi require moisture, food and warmth to grow. Plants and fruit contain food and moisture so when conditions are warm, fungi can grow quickly on or in them and cause disease. The body of the fungus, called the mycelium, is made up of many thin threads, called hyphae, which divide by mitosis and grow into the plant or fruit, to get to a new food source for the fungus. Fungi feed by releasing enzymes onto the plant or fruit, and the enzymes digest the food so that the molecules are small enough to be absorbed into the fungal cells.

Fungi reproduce by growing sporangia that produce reproductive spores. Once the sporangia are ripe they burst, releasing spores into the air. Spores that land on a food source, e.g. the next grape in the bunch, can germinate and grow into new individual fungi.

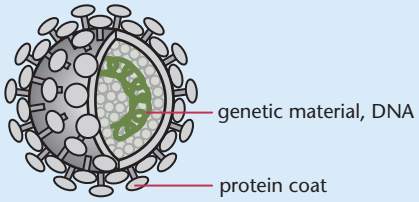
Crop damage and food spoilage can be minimised by keeping plants and fruit in cool temperatures such as in a fridge or freezer, which slows the rate of growth and reproduction of the fungus, because cell division occurs more slowly and enzyme activity is reduced in cooler temperatures. It is also important to remove infected plants and fruit to stop spores from the infected plant or fruit being released into the air and landing on other plants and fruit. Some diseases, e.g. stem rust, can be controlled by spraying with a fungicide, which kills the fungi or the spores and so prevents growth and reproduction. Some foods, e.g. pears, are heated to kill any fungi and then stored in sealed cans, which prevents any more fungi from growing on that food.

(**A** – Describes three out of: pathogen, feeding, growth, reproduction, environmental factors (two from moisture, food, warmth), control method (two from fridge, freezer, isolation, spraying, salting, acidification, drying, freeze-drying, canning); **M** – Explains two out of: how fungi feed, how fungi grow and reproduce, how environmental factors allow quick growth, how crop damage minimised, how food spoilage minimised; **E** – Discusses how fungi live as pathogens and how they can be controlled to minimise damage to crops and food spoilage.)

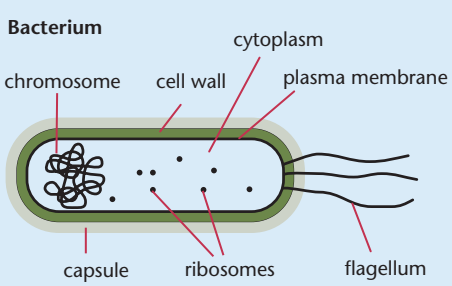
Question Three: Microbes and illness

p. 8

1. **Virus**



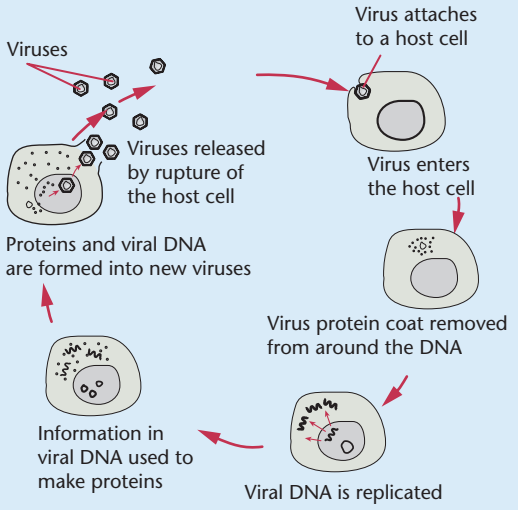
Bacterium



2. Check that your answer contains the following important points.
   - How quickly viruses cause symptoms: Symptoms caused by **damaged cells**, one virus infects cell and many viruses produced, **many cells then infected** so **symptoms felt quickly**.
   - How quickly bacteria cause symptoms: Symptoms caused by effects such as **toxins** and **extracellular digestion**, one bacterium divides into two by **binary fission**, as quickly as every 20 minutes, numbers of individuals goes 1-2-4-8-16-32-64 (or graph, see in possible answer), **takes time** for numbers of bacteria to increase and produce effects; e.g. toxins produced, so symptoms take longer to develop.
   - Energy requirements: When viruses reproduce they use the **components and energy in the cell** they infect, but each time bacteria reproduce they have to feed and **build up materials and energy** before they can reproduce again. Bacterial reproduction slows down or stops when resources become limited.
   - Compare and contrast viral and bacterial reproduction (see 'possible answer' for diagrams showing reproduction in bacteria and viruses). Viruses need a **living host cell**, bacteria reproduce on a **food source or surface**, one virus produces **many** offspring, one bacterium divides by binary fission to give **two**, viruses can infect a cell and reproduce immediately but **bacteria require time** before they can reproduce again, in good conditions some bacteria can reproduce every 20 minutes.

Possible answer

The symptoms developed much more quickly in Manaaki because when viruses reproduce they **infect a living cell** and **use the materials and structures already inside that cell** to produce many more viruses – **one virus can produce many viruses all at the same time**. These viruses then **infect more cells immediately** so the **symptoms occur quickly**.



Angela's symptoms became worse during the day because it takes **time for the numbers of bacteria to increase** to a level where their effects are felt – for example, a small number of bacteria producing toxins does not have much effect on the person but as the **numbers of bacteria increase more toxin is produced**, so the person feels the symptoms of the infection slowly develop. Bacteria divide into two by **binary fission** and in suitable conditions can divide **every 20 minutes**, but **numbers build up slowly** compared to virus

Answers