Achievement Standard 90927

Demonstrate understanding of biological ideas relating to micro-organisms

BIOLOGY

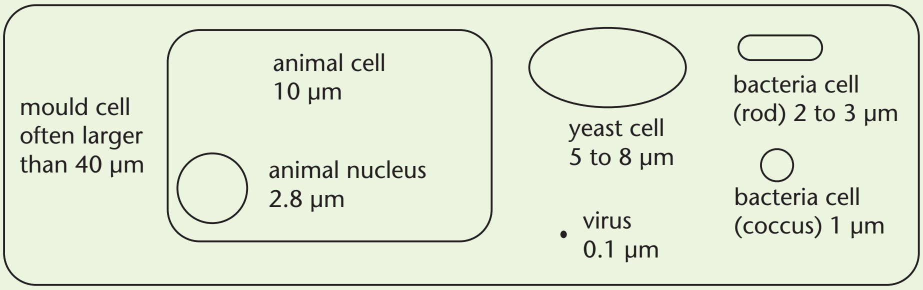
1.3

Externally assessed 4 credits

Micro-organisms

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

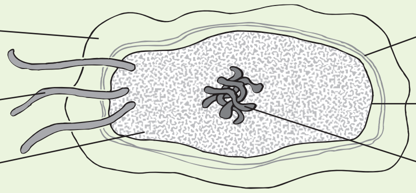
Comparative sizes of micro-organisms



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).



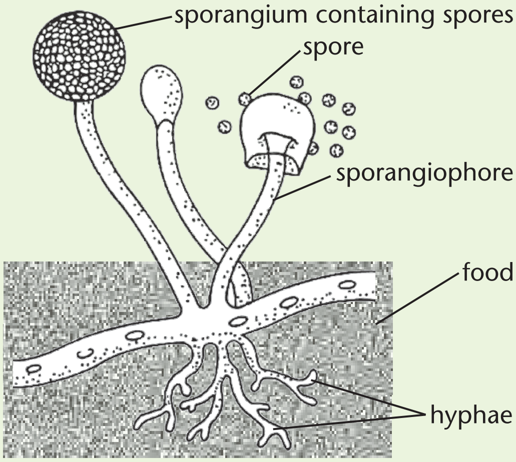
Reproduce by **binary fission** (splitting in two). In good conditions they can reproduce every 20 minutes. Growth rates can be slowed down by lack of food or space, unsuitable temperatures, or a build-up of **toxins** excreted by the bacteria.

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.

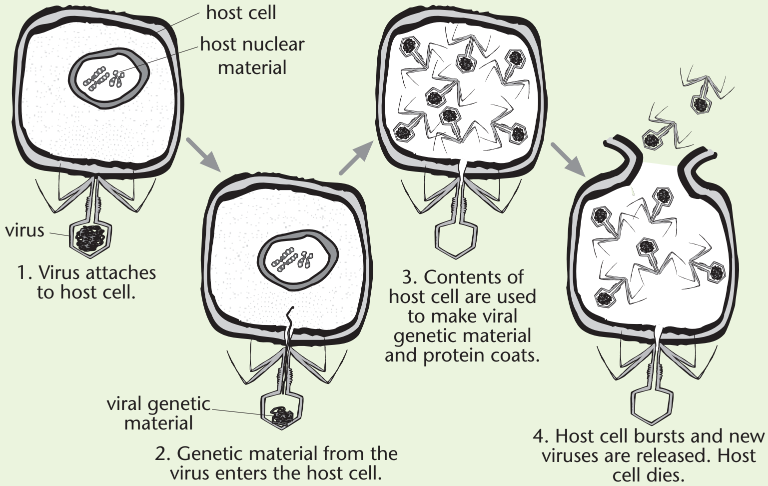


- Fungi require **food, moisture** and **warmth** to grow and reproduce. Some are **aerobic** while others are **anaerobic**.
- The body of a fungus consists of **hyphae** – fine thread-like structures that spread through the substance that the fungus is living on.
- Fungi produce **spores**, which grow 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

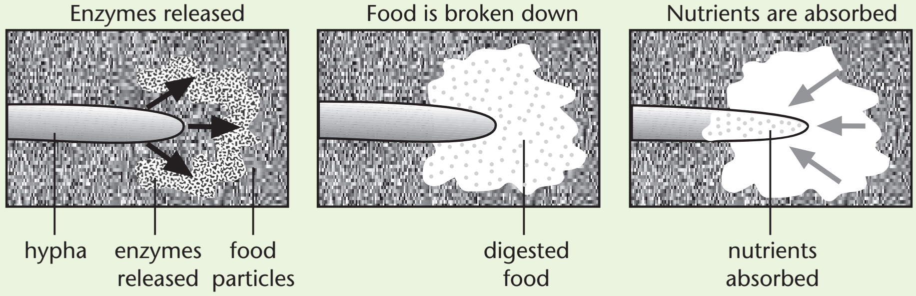
Viruses are micro-organisms that cannot survive without a living host. They are always pathogenic (cause disease). Viruses are often thought to be nonliving, because they reproduce but do not grow, feed, respire or excrete wastes.

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.



Extracellular digestion

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



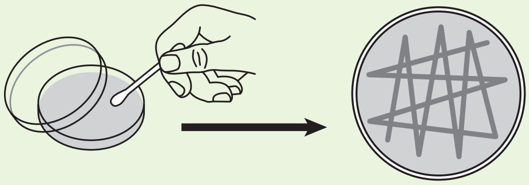
Culturing micro-organisms

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.

Essential exam notes

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 + oxyge n → 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.

NCEA practice

Questions
Micro-organisms

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.

Question One: Digestion and reproduction processes

Year 2013
Ans. p. 121

1. Describe the processes of digestion and reproduction in bacteria and in fungi.

   You may use labelled diagrams.

   a. Process of digestion in bacteria:

   b. Process of digestion in fungi:

c. Process of reproduction in bacteria:

d. Process of reproduction in fungi:

2. Compare and contrast the processes of digestion and reproduction in bacteria and in fungi. In your answer:
   - explain the process of digestion in bacteria and in fungi
   - explain the process of reproduction in bacteria and in fungi
   - discuss the similarities and differences between digestion and reproduction in bacteria and in fungi, making links between the structures of the organisms and the processes.

Achievement Standard 90948

Demonstrate understanding of biological ideas relating to genetic variation

SCIENCE

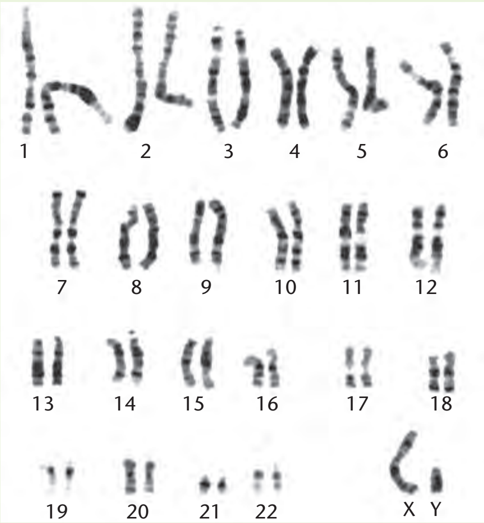
1.9

Externally assessed   4 credits

Chromosomes, DNA, genes, alleles

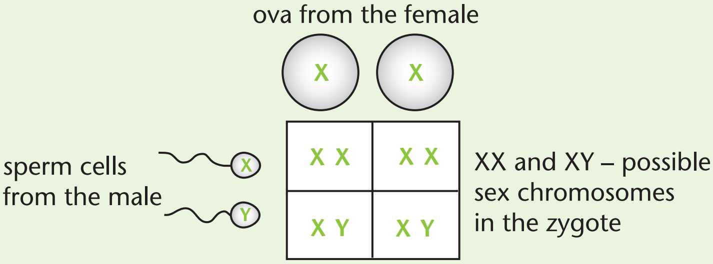
Genetics is the study of **inheritance** – the way in which genetic information is passed from one generation to another.

Genetic information (**genetic code**), contained in the molecule **DNA** (deoxyribose nucleic acid), is found in **chromosomes**. Chromosomes occur in cell nucleus and are *paired* (**homologous pairs**). Humans have 46 chromosomes or 23 pairs – one of each pair provided from the male parent and one from the female parent. 22 pairs are homologous, providing information for general body characteristics; remaining (23rd) pair are the **sex chromosomes**, **X** and **Y**. Females are XX; males XY.



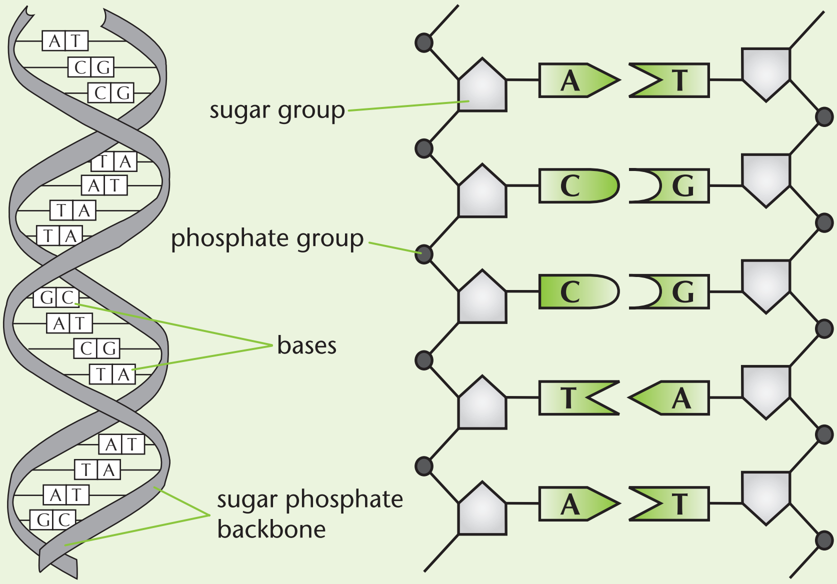
Human karyotype showing 22 homologous chromosomes plus X and Y sex chromosomes

A female ovum (egg) only has an X chromosome; a sperm may be either X or Y. Whether a child is male or female is determined at the moment of fertilisation by the sperm (and therefore the father).



Punnett square showing possible combinations of sex chromosomes in zygote; there is an equal chance of a female (XX) or male (XY) being formed – 50% female, 50% male

The DNA molecule is twisted into a double **helix**. The sides of the helix are made up of alternating **sugar** (deoxyribose) and **phosphate** groups. The sides are connected by pairs of (nitrogen) **bases** which bond to the sugar groups. Four different bases occur in DNA: Adenine (A), Thymine (T), Cytosine (C), Guanine (G). Adenine pairs with Thymine, Cytosine pairs with Guanine (the *base pairing rule*: A–T, C–G). The *sequence* (order) *of bases* in the DNA forms the genetic code.



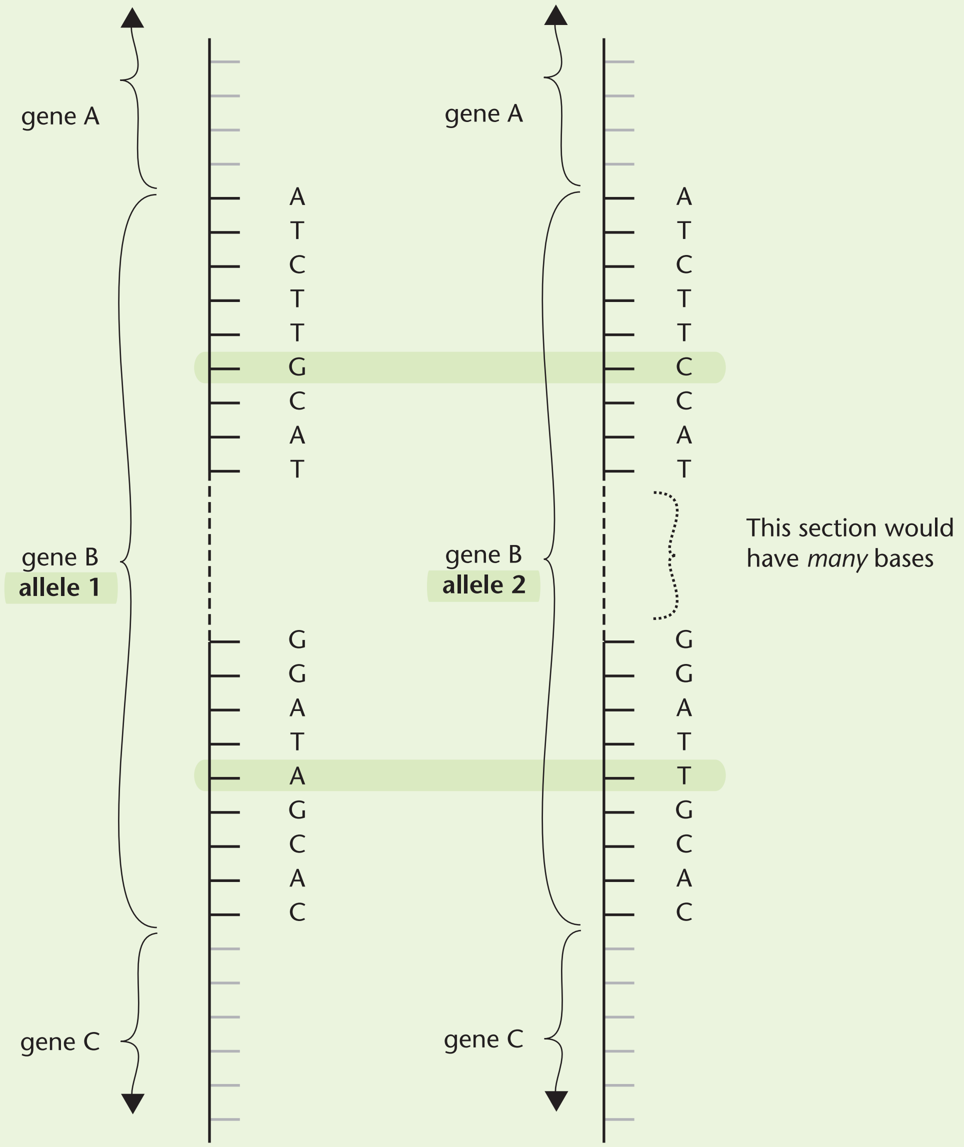
A simple representation of DNA

Part of a DNA helix untwisted – base pairs joined by bonds; 'sides' are sugar and phosphate groups

A sequence of three bases (a triplet) codes for an *amino acid*; amino acids make up **proteins**, the 'building blocks' of all living things. A **gene** is that length of DNA that codes for a particular protein, which in turn determines a particular *characteristic* (e.g. eye colour, hair colour) in an individual. The average human gene has 3 000 bases, but the number varies widely. Alternative forms of a gene are called **alleles**. Alleles code for the same characteristic (e.g. eye colour) but have a *slightly different order of bases*, so they code for a particular *trait* (e.g. brown hair or blonde hair).

The diagram shows two alleles for gene B.

Only one strand of DNA is shown (untwisted) for each allele. The alleles have a slightly different base sequence – differences are highlighted.



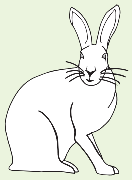
DNA *replicates* prior to cell division (mitosis and meiosis). Errors in replication may cause changes in the base sequence – a **mutation**. Mutations that occur in the formation of **gametes** (sex cells – sperm and ova) during meiosis *may be inherited*; mutations that occur in body cells (e.g. skin) are *not* inherited. Mutations produce *new alleles* for a characteristic (e.g. the alleles for blue and green eyes in humans are believed to be caused by mutations in the allele for brown eyes). *Mutations produce new variations.*

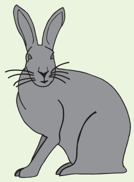
Mutations increase genetic variation in a population, because genetic variation in a population is determined by the *number* of *different alleles* in the population.

The information on a pair of alleles is the genotype, e.g. **Rr**. The outward appearance / visible expression of the genotype is the phenotype, e.g. red flowers.

A **dominant** allele is *always expressed in the phenotype* when it occurs in the genotype: it hides the presence of a recessive allele. A **recessive** allele is expressed in the phenotype *only* when *two* recessive alleles for the gene are present. Upper-case letters represent dominant alleles; lower-case letters represent recessive alleles.

In rabbits, brown-haired allele (B) is dominant to white-haired allele (b). Genotypes BB and Bb both produce brown hair; genotype bb produces white hair. When both alleles are the *same* (e.g. BB or bb), genotype is **homozygous.** Homozygous individuals are **pure breeding** as they *only* pass on one type of allele to their offspring (e.g. B from BB genotype or b from bb genotype). When both alleles in a pair are *different* (e.g. Bb), genotype is **heterozygous**. Heterozygous individuals are *not* pure breeders as they can pass on *either* type of allele (e.g. B *or* b from Bb genotype).



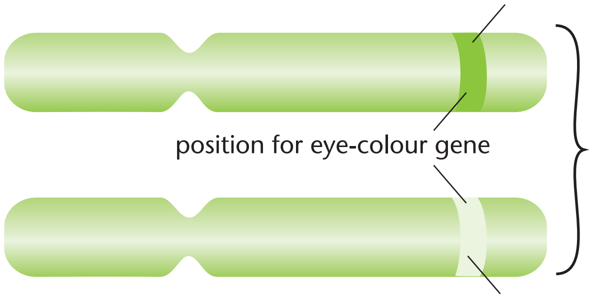


Questions
Chromosomes, DNA, genes, alleles

NCEA practice

Question One: The role of DNA in inheritance

Year 2013
Ans. p. 132



1. Use the previous diagram to help you explain the relationship between chromosomes, genes, alleles, phenotype, genotype, and the molecule DNA. A labelled diagram may help your explanation.

2. The allele for brown eyes (**B**) is dominant over the allele for blue eyes (**b**) in humans.

   Discuss how it is possible for a child to have blue eyes, even though both the child's parents have brown eyes. In your answer you should:
   - use labelled Punnett squares
   - link the genotypes and phenotypes of the child, parents, AND grandparents.

1.9

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

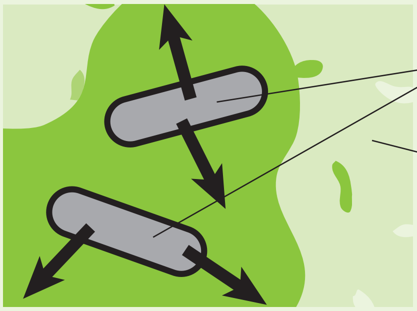
Micro-organisms

Question One: Digestion and reproduction processes

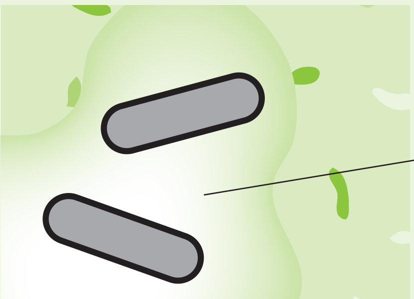
p. 5

1. a.

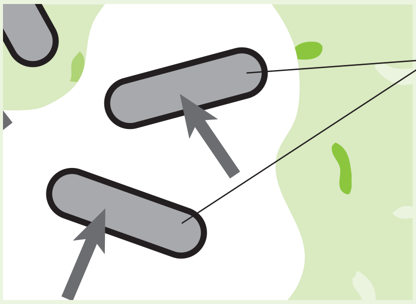
Enzyme released



Food is broken down



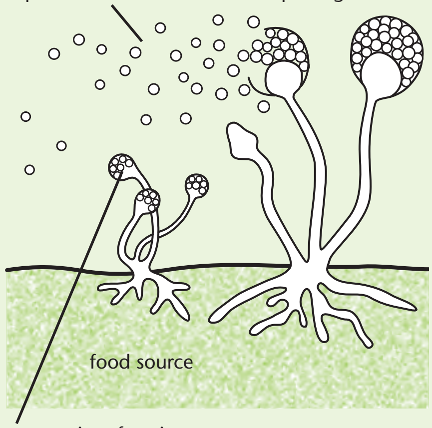
Digested food is absorbed



b. Fungal hyphae release enzymes, which digest the food. The digested food is absorbed into the cells in the hyphae.

c. The genetic material is copied and the cell divides into two cells – each cell with one copy of the genetic material and half the cytoplasm of the original cell.

d.



2. Bacteria and fungi both live on their food source so the process of **digestion is similar** in bacteria and fungi. Neither has a digestive system so both carry out **extracellular digestion** in which **enzymes** are released through the **cell walls** to the outside of their cells. The food source is digested and the food nutrients are absorbed directly into the individual bacterial cells and **hyphae** of the fungi.

Fungi can reproduce by producing spores and bacteria reproduce by binary fission. In both, new individuals are produced by **asexual reproduction** so they are **genetically identical** to the parent cell.

A difference is that bacteria do not have specific structures related to binary fission. A copy of the DNA is made and then the cell wall, membrane and cytoplasm divide in half to produce bacterial cells with a complete copy of the DNA. In contrast, fungal hyphae develop **sporangia** – reproductive structures that grow above the food source and **produce spores** that are released into the air. When the spores land on a food source they **germinate and grow** into new individuals.

(**A** – Describes three of: extracellular digestion in bacteria, extracellular digestion in fungi, binary fission in bacteria, reproduction by spores in fungi. **M** – Explains the similarities of digestion OR differences of reproduction OR functions of structures (e.g. sporangia grow above food sources to disperse spores). **E** – Discusses similarities and differences in structures and processes for both digestion and reproduction.)

Question Two: Culturing microbes

p. 7

The words in **bold** are examples of key words important in possible answers to this question.

The conditions micro-organisms need in order to grow and reproduce on the plate include: **moisture**, **food** and **warmth**. When the plate was left open on the bench, **micro-organisms in the air landed on the plate** and began to grow and reproduce. Spores produced by fungi also travelled in the air and landed on the agar plate. The nutrient agar provided water and food and the incubator was set to keep the temperature at 25 °C, so the bacteria began to reproduce quickly by binary fission. The high rate of reproduction caused the growth of **colonies**, each containing so many individual organisms that the colony could be seen with the eye. The bacterial colonies appeared on the agar as **shiny dots** because of the slimy protective **capsule** around the outside of each bacterial cell.

On the plate, the fungi looked **furry** because fungi are made up of a **mycelium** of many fine threads, called **hyphae**, which grow through and feed on the nutrient agar. The darker areas are where the fungi are reproducing by growing **sporangia** containing **asexually** produced **spores**. Sporangia grow above the surface of the food supply so the **light** spores are carried easily in the air.

Both bacteria and fungi are **saprotrophs**, so they can survive and reproduce on the plates because they digest the nutrients in the agar through the process of extracellular digestion. Viruses have none of the characteristics of living things except reproduction. Viruses must have the living cell of a host to enable them to carry out reproduction. Since nutrient agar does not contain any living cells, viruses are unable to reproduce on the plate.

(**A** – Describes food, warmth, water as conditions required for reproduction, describes micro-organisms from air landing on opened plate, describes fungi as furry/threads/fuzzy and bacteria as shiny/various coloured colonies. **M** – Uses structures (e.g. hyphae, mycelium, sporangia, capsule, colonies) and functions (e.g. reproduction, protective, feeding) to explain why fungi appear furry and bacteria appear as shiny dots; explains that viruses need a living host to reproduce. **E** – Uses a range of biological terms (e.g. conditions, structures, functions) to describe and explain conditions, source of micro-organisms, appearance of micro-organisms and lack of viruses on plate.)

Question Three: Fungi

p. 9

Part B is a sporangium. Its function is to produce light spores (part A) for reproduction. The sporangium is held up above the fungus by the sporangiophore so that, when released, the light spores can travel in the wind. The spores can land on new food sources, germinate and grow so that the life cycle of the fungus can continue.

Part C is feeding threads called hyphae. The hyphae are important for survival because they carry out extracellular digestion by releasing enzymes into the food the fungus is growing in. The enzymes digest the food and then the digested nutrients are absorbed back into the hyphae to be used for growth and reproduction. (**A**, **M**, **E**)

(**A** – Names the three parts and links them to reproduction or feeding: **A** = spores for reproduction, **B** = sporangium holds spores, **C** = hyphae for feeding (at least three correct). **M** – explains the function of each part (at least two of the three parts correct). **E** – Relates role of each part to reproduction and continuation of species or feeding for survival of the individual fungus (naming, function and role all required).)

Question Four: Culturing micro-organisms

p. 10

1. Sterile agar plates are made. Plates inoculated by placing the swab onto the plate for a few seconds then removing it again. Plates are labelled, sealed and turned upside down and placed in an incubator at 25 °C for 3 or 4 days. (**A**)
2. Fungi form irregular furry patches. Bacteria form shiny greasy spots. (**A** – Both required for **A**)
3. Bacteria and fungi are all around in air, water and on surfaces[1] therefore all equipment, including the agar plates, must be sterilised so that the only micro-organisms that grow on the plate are those on the swab.[3] A control is a plate that is not exposed to the swab – it is placed in the incubator with the inoculated plate.[2] If bacteria or fungi grow on the control plate it shows that the plates were not sterile to begin with, therefore the results are not valid.[4] Care is taken to ensure that the swab and all the plates used are clearly labelled so materials do not get mixed up with other samples.[5] Use of sterilisation and a control means that the results can be used to correctly identify the micro-organisms in the patient's throat.[5] (**A**, **M**, **E**)

(**A** – Describes contamination[1] OR use of control.[2] **M** – Explains why has to be sterile[3] OR why control is necessary.[4] **E** – Discusses why has to be sterile AND why control is necessary[3, 4] AND links back valid/reliable results.[5])

Question Five: Life processes

p. 11

Bacteria are living cells because they carry out all the life processes – MRSGREN. Viruses do not. Viruses reproduce but do not feed[5] or excrete wastes. Viruses are made up of DNA or RNA and a protein coat,[1] but bacteria are complete cells containing genetic material and cytoplasm surrounded by a cell membrane.[2] Bacteria feed by extracellular digestion where they secrete enzymes onto the food and then absorb the digested food molecules.[3] Bacteria reproduce by binary fission, in which one cell divides into two cells.[4] Numbers in bacterial populations can increase very quickly when conditions are warm and moist because binary fission can occur as quickly as every 20 minutes.[7]

In contrast, viruses require a living host cell in which to reproduce. The virus injects its genetic material into a host cell where the genetic material takes over the cell to make copies of the viral genetic material and protein coat. New virus particles are assembled and released from the cell.[6] The presence of many suitable host cells allows viruses to increase in number very quickly.[8] (**A**, **M**, **E**)

(**A** – Describes structure of viruses[1] OR bacteria.[2] **M** – Explains feeding[3] and reproduction[4] in bacteria OR feeding[5] and reproduction[6] in viruses. **E** – Discusses why bacteria are considered to be living cells but viruses are not[1, 2, 3, 4, 5, 6] and how warmth, moisture[7] and availability of host cells[8] influence population growth.)

Question Six: Bacterial growth

p. 12

Bacteria reproduce by binary fission. Once a bacterium reaches maximum size, the genetic material is copied and the cytoplasm is split in half by the growth of the cell wall through the middle of the cell, with one copy of the genetic material going into each half. Each new bacterial cell grows to maximum size and then splits in two. In optimal conditions for bacterial growth, such as plentiful food supply, moisture, and warmth, bacteria can reproduce as quickly as every 20 minutes.

At the start of the graph there is only a small number of bacteria. They are reproducing by binary fission so their numbers increase slowly – 2 to 4 to 8 to 16. However, since the number doubles each time binary fission takes place, as the number increases, so the number in the population of bacteria increases very quickly – 5 000 becomes 10 000. A fast rate of reproduction continues until a factor – such as lack of food, lack of space, build-up of toxins, lack of water, or a cooler temperature – begins to limit bacteria's ability to survive and reproduce, shown by the curve levelling off. The end of the curve shows a reduction in numbers because of the death of bacteria unable to survive in the conditions created by the limiting factor.