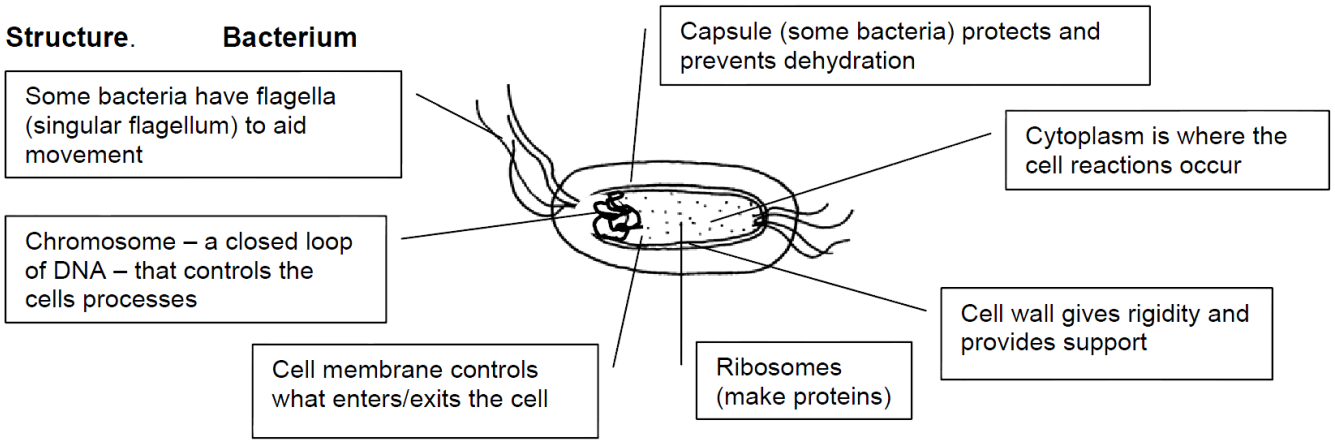
● BIOLOGY

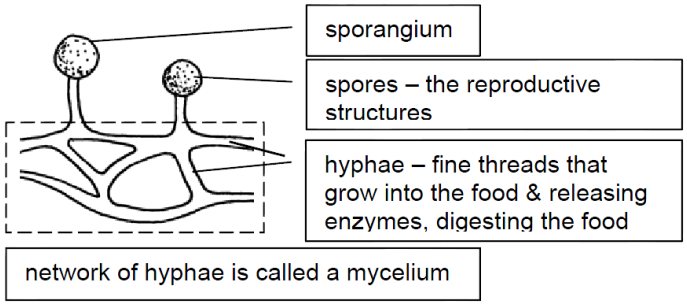
Demonstrate understanding of biological ideas relating to microorganisms

Structure. **Bacterium**

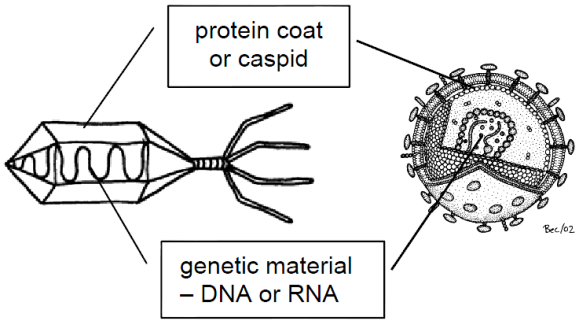


Shapes of bacteria include bacillus (rod), coccus (spherical), vibrio (comma shaped) and spirillum (spiral shaped).

Fungus – eg bread mould, *Mucor*



Viruses (two different ones shown here)

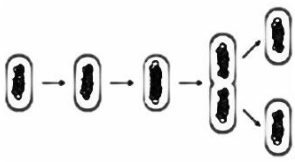


Life Processes.

Feeding. Both bacteria and fungi feed by extra cellular digestion (extra cellular = takes place outside the cell). ❶ secrete enzymes onto food ❷ the released enzymes break down (digest) the food into smaller molecules ❸ nutrients are reabsorbed into the bacterium / hyphae of fungi. Ideal conditions for feeding and growth are warmth, moisture and plenty of food. Some bacteria need O_2 (aerobic bacteria), others do not need O_2 (anaerobic bacteria) to release the energy from their food in the process called respiration.

Respiration is the release of energy from food. (Don't say "need air/don't need air). Some bacteria can make own food – autotrophs e.g. photosynthetic bacteria. Others are saprophytes - feed on dead organic matter, and are decomposers. Yeast can respire without oxygen (anaerobic respiration), producing carbon dioxide and ethanol (alcohol). This is called fermentation. In the presence of oxygen yeast carries out aerobic respiration and produces carbon dioxide and water. Aerobic respiration provides more energy and is necessary for the yeast to grow and reproduce. Viruses do NOT feed, grow, respire, excrete, move and not sensitive.

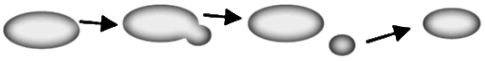
Growth. Bacteria and fungi both need warmth, water, a food source, oxygen (unless anaerobic bacteria), space and a suitable pH. They feed on nutrients and grow bigger.



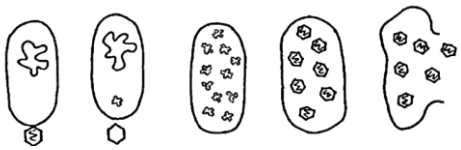
Reproduction. Bacteria – reproduce by binary fission (cell division – mitosis - splitting into two). ❶ the chromosome/DNA replicates (copies itself) ❷ cell membrane pinches the cytoplasm in half ❸ bacterium divides into two, each with a chromosome. Bacteria numbers increase rapidly when conditions are ideal – (warm, moist and plenty of food) and some can reproduce every 20 minutes. This doubling of population (called exponential growth) can't go on indefinitely because; the food is used up; bacteria produce wastes or toxins that accumulate & reach a level where they interfere with or poison the bacteria; the bacteria can run out of room; if aerobic bacteria they can run out of O_2. Some bacteria form spores when unfavourable conditions arise. These spores are resistant to low temperature, high temperature, change in pH, desiccation (drying out) and the effect of chemicals, and that they can grow into new bacterial cells if favourable conditions return.

Fungi – reproduce by producing spores. ❶ certain hyphae grow upwards and produce swellings at their tips – sporangium (plural sporangia) ❷ a large number of spores (small, tough coated reproductive cells) form in the sporangia ❸ sporangia burst releasing spores into the air (they are light and are carried by wind) ❹ those landing on moist food germinate and grow new hyphae - hyphae are threads used for feeding/growth/spreading.

Yeast, a single-celled organism, is a fungi. The cells have a nucleus, cytoplasm and a membrane surrounded by a cell wall. Yeast reproduces by budding.



Viruses – exist ONLY to reproduce and are totally dependent on a living host cell as viruses they cannot reproduce alone as they have no chemical processes of their own. For this reason they are not usually regarded as "living". (E.g. raw materials, energy and enzymes are supplied by host cell.) ❶ virus attaches to host cell ❷ injects its DNA ❸ virus DNA instructs cell DNA and cell machinery to produce copies of the virus DNA ❹ virus DVA and also newly made protein coats are assembled into new viruses ❺ host cell ruptures releasing many viruses which can infect other cells. Viruses can't be grown on agar plates because agar jelly is not a living medium.



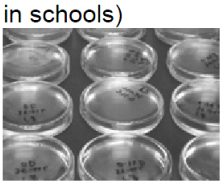
The type of virus that uses a bacterium (shown opposite) is called a bacteriophage. Viruses can only be cultured (grown) in living cells. Fertilised chickens' eggs can be used.

Culturing microbes. Bacteria and fungi can be cultured (grown) on nutrient agar in Petri dishes. Petri dishes and culture media must be sterilised before use to kill unwanted micro-organisms. ❶ Inoculation. Collected microbes are wiped on the agar surface. E.g. stroke table and then the agar with a sterile cotton bud or a sterile inoculating loop (sterilised in a hot flame & allowed to cool), replacing the lid rapidly to avoid allowing airborne microbes to contaminate the agar ❷ Seal the dish with 2 pieces of tape - top to bottom so the lid won't fall off but don't seal "all around" which would make it air tight and would encourage growth of the generally more harmful anaerobic bacteria, once all the O_2 in the dish had been used up. ❸ Incubation. (Growth). The sealed agar place is placed upside down in a warm place for 2-4 days. Upside down avoids the condensation in the dishes dripping on the growing microbes (which would "spread and mix them" on the agar, and a drop of water on bacteria could also make an "anaerobic" environment). In school, cultures are incubated a temperature of 25°C to prevent the growth of pathogens that might be harmful to humans, rather than 35-40oC - nearer to human body temperature. ❹ Disposal – incinerate (burn at high temperature), or drop into very strong disinfectant/bleach solution.

Each bacterium grows and reproduces many times to form a colony. Colonies of bacteria appear as greasy, glistening spots (shiny/smooth/oily/greasy) (although they have a range of colours and textures).

The bacterial colonies increase in size because the bacteria feed on the nutrient agar and grow bigger. The big bacteria then divide (reproduction) into two (binary fission), and the two daughter cells begin to grow again and increase the numbers in the colony. Fungi (hyphae) appear as fuzzy, furry, fluffy or thread like growth.

Sterile: free of micro organisms
Nutrient agar: jelly material containing food
Petri dish: dish and lid (usually Plastic in schools)



Pathogens. Microbes that cause diseases are called pathogens. Pathogenic bacteria (eg salmonella, TB & meningitis or fungi (eg fungi causing thrush, athlete's foot & ringworm) enter an organism and feed, respire, excrete and reproduce. These processes break down cells and/or produce toxins that poison cells. Viruses (eg flu, cold, measles, mumps, chicken pox, tetanus, HIV / AIDS) are ALWAYS pathogens as the host cell is destroyed by the virus. Pathogens are spread in various ways: in water or food, in air, by contact, by body fluids and by animals.

Food production

- Yoghurt: A starter culture of bacteria is added to warm (30°C) milk. The bacteria ferment the milk sugar/lactose, producing lactic acid. This causes the milk protein to form a solid material.
- Cheese manufacture: A starter culture of bacteria (different from that used in yoghurt production) is added to warm milk; curds are produced that are more solid than yoghurt; these curds are separated from the remaining liquid part of the milk (whey); bacteria and moulds are added to the curds to slowly ripen the cheese to produce the distinctive colour and taste of blue cheeses.

- Baking: a mixture of yeast, sugar and flour is left in a warm place. The yeast respires, producing carbon dioxide. The CO_2 gas bubbles cause the dough to rise. The bubbles of gas in the dough expand when the bread is baked making the bread light. The alcohol also evaporates.
- Beer/wine: a mixture of yeast and sugar solution is left in a warm place. The yeast respires, producing CO_2 and ethanol (alcohol). Glucose → ethanol + carbon dioxide
- Ginger beer: mix ginger, sugar and water and add yeast and seal in a (plastic) bottle. Put in a warm place for several days to ferment. CO_2 is produced by the respiring yeast and will make it fizzy. Glucose → ethanol + carbon dioxide.

How the "life processes of yeast" make it useful in making baking and brewing:
Yeast makes CO_2 and alcohol (ethanol) when they carry out feeding or respiration/ fermentation or excretion. The yeast feed on the sugar, they release energy from the sugar in the process called respiration / fermentation. Excretion by the yeast releases the waste products, CO_2 and alcohol. CO_2 makes the dough rise. CO_2 can make beer fizzy or bubbly wine (if fermentation occurs in a sealed container) and the ethanol makes the beer or wine alcoholic.

Preventing food spoilage ("going off")

Pasteurisation. Milk is very vulnerable to microbial contamination during collection and storage and once contaminated it provides an excellent medium for growth and reproduction of a considerable range of microorganisms. Pasteurisation extends the keeping time of milk to several days if it is refrigerated. The process is called 'Flash pasteurisation'. ❶ Milk heated to 72^{o}C for 15 seconds (Heating kills many pathogenic organisms and spoilage organisms). ❷ Cooled rapidly to 3^{o}C. (Rapid cooling prevents organisms that survive the heat treatment from dividing rapidly). Spore-forming pathogens do not normally occur in milk. The limited heat treatment does not adversely affect either the flavour or the nutritional value of milk.
Food Preservation. Food may be preserved by a number of methods eg Freezing: microorganisms cannot reproduce at cold temperatures (but they are NOT killed).
Freeze drying: The water is drawn out of micro-organisms which kills them.
Salting: The water is drawn out of micro-organisms if they are surrounded by salt which kills the microorganism.
Pickling: Micro-organisms are killed by Vinegar (too acidic).
Canning/bottling/vacuum sealing: Micro-organisms are killed when food is boiled/heated. The food is then sealed in a tin/can/bottle/vacuum pack to keep out the air (there are micro-organisms in the air).

Hygiene and food. Food can become contaminated both during preparation and storage.
Preparation: Dirty hands, knives, utensils, cutting boards, bench tops, work surfaces, cloths & tea-towels, storage containers or fridges. Using same cutting boards for raw and cooked food. Sick people preparing food. Cooking unthawed food, or under cooked food (eg pink chicken). Foods reheated more than once or not reheated right through to the middle.
Storage: Storing cooked and raw food together. Storing raw meat above other food. Warm storage temperatures. Broken seals/exposure to air. The contamination can be avoided by: Eg Washing hands, knives etc. Wearing gloves or hair nets/hats. Using different cutting boards, & storage containers. Keeping sick people out of the kitchen. Cooking food thoroughly. Thawing food completely. Keeping food cold. Serving hot food hot or cold food cold.

Sewage treatment .
Sewage consists of domestic and industrial waste and sometimes drainage from rainfall. First the sewage passes through screens to removal the larger solids, and passes into a settlement tank. After this the liquid component and sludge are treated separately. Aerobic bacteria digest, breakdown and oxidise organic components of the liquid component in oxidation ponds (liquid trickled from a rotating arm over stones with bacteria on them) OR an activated sludge tank (air bubbled through bacteria and sludge).
This is because these bacteria need oxygen for respiration / metabolism to break down the sludge efficiently. The digestion of more solid sludge is carried out by anaerobic bacteria in tanks, producing a mixture of carbon dioxide and methane. The digested sludge may be used as compost / fertiliser to grow plants. The methane can be used as fuel source at the sewage treatment plant to heat the plant or to produce electricity. Sewage treatment reduces the organic content and suspended material to a level that does not harm a river receiving the effluent.

Food poisoning. Caused by various pathogens including *Salmonella*. Poultry farming is a common source (chicken meat and eggs) as well as unpasteurised milk. *Salmonella* bacteria in meat and eggs reproduce quickly in warm storage conditions and produce toxins which have harmful effects in the human gut. Methods of avoiding food poisoning by

Salmonella including improved animal rearing, suitable food storage and cooking techniques. If infected eg by bacteria, you don't get ill immediately. It takes some time 24-48 hours after ingestion for enough toxins to be produced by the bacteria before a person shows symptoms. Cooked chicken should be stored at temperatures below 4oC because at these low temperatures growth of the bacteria are slow, there is slow reproduction, and less toxins are produced.

Nutrient cycles. Living things remove materials from the environment for growth and other processes.
These materials are returned to the environment either in waste materials or when living things die and decay.
Materials decay because they are broken down (digested) by micro-organisms. Micro-organisms digest materials faster in warm, moist conditions. Many micro-organisms are also more active when there is plenty of oxygen. Extra cellular digestion by the microbes releases enzymes to break down the organic/dead/waste material and nutrients are recycled and grass/plants can use the nutrients to produce new growth.
The constant cycling of carbon is called the carbon cycle. In the carbon cycle: when plants and animals die, micro-organisms (called decomposers) feed on their bodies; carbon is released into the atmosphere as carbon dioxide when these organisms respire. In the Nitrogen cycle, nitrogen fixing bacteria in legume (clover, pea) roots convert N_2 from the air into nitrates (needed by the plants to make protein).

Compost heaps. Saprophytic bacteria (feed on/decompose/break down dead material) break down waste plant materials. To encourage microbe activity in a compost heap: keep moist – water to avoid dehydrating the microbes; keep aerated – build compost heap with layers of stems between layers of leafy matter and turn the pile regularly to supply adequate O_2 to the aerobic bacteria; avoid too acidic pH – lime can be added if the compost pile is too acidic. Compost heaps get warm because respiration by the decomposers breaks down the "food" to release CO_2, water and heat. food $\rightarrow$ CO_2 + H_2O + heat.

Disinfectants and Antiseptics.
Disinfectants kill or inhibit the growth of **harmful / pathogenic** micro-organisms especially bacteria. They reduce the chance of infection through food contamination or wounds. They can be used to clean items or areas that present a high risk of infection (eg kitchen work surface areas, sinks and toilets, door handles
etc). Antiseptics are chemicals applied to the skin to kill pathogens but not the cells.

Antibiotics: An "antibiotic" you take when you are ill is a chemical substance or drug//medicine that stops or controls the growth of bacteria. Antibiotics are produced naturally by some micro-organisms. Penicillins are a major group of antibiotics, produced by a number of genetically different strains of the fungus *Penicillium*. Today doctors have many other antibiotics at their disposal. Common ones include amoxicillin, streptomycin and erythromycin. Most antibiotics work by either killing the disease micro-organism or stopping them multiplying. Penicillin interferes with the cell walls of bacteria so the bacteria die but as human cells do not have cell walls, penicillin does not affect them. Other antibiotics may work by inhibiting protein synthesis by the bacteria or stopping DNA replication in the bacteria.

In 1928, a doctor named Alexander Fleming was working with a bacterium called Staphylococcus. He grew the bacteria on agar in glass dishes. Normally, the dishes were sealed with a glass lid. Some of the dishes were left without lids & became contaminated with a mould from the air. Fleming noticed that there were no bacteria growing near the mould. Fleming thought the mould was producing a substance that either killed the bacteria or inhibited their growth. To test his idea, he produced a pure culture of the mould.
He grew the mould in a broth. He added the broth to various types of bacterial cultures. The broth killed the bacteria even when diluted thousands of times. Fleming named the substance penicillin. Penicillin was found to be effective against many human diseases.

Limitations of antibiotics. They are ineffective against viruses; problems arising from their over-use are the rapid evolution of resistant strains of bacteria (eg MRSA) by mutation and natural selection.
Resistance: Within the population of bacteria mutations can cause variation in resistance. The more resistant bacteria can survive the antibiotics (particularly if a person doesn't take all their full course of prescribed antibiotics). The resistant strains of bacteria reproduce and pass on their resistance to their offspring. The particular antibiotic will no longer work against these bacteria, so scientists have to keep discovering or synthesising new antibiotics to kill the resistant bacteria.
Some food-producing animals are given antibiotic drugs to keep them healthy and to maximize their growth. These antibiotics can cause microbes to become resistant to drugs used to treat human illness.

Immune system: Intact skin forms a barrier against microbes. The body also defends itself by: blood clots to seal wounds, and by white cells in the blood that ingest microbes, or produce antibodies and antitoxins.
Immunisation can be used to protect humans from infectious disease. An antigen is a protein, foreign to an individual, which triggers a response by some white blood cells which secrete antibodies specific to the antigen that is present. Antibodies destroy the cells bearing the antigen. After an antigen has been encountered, memory cells remain in the body and antibodies are produced very quickly if the same antigen is encountered a second time. This memory provides immunity following a natural infection and after vaccination. The response is highly specific to the antigen involved. Vaccines may be produced against bacteria and viruses.
We often suffer more than once from viral diseases such as colds and flu. Viruses mutate frequently leading to different strains with different protein coats/antigens. These are not recognised by the white blood cells and antibodies of immune system and so we have to fight each one as if it was a new disease each time and the patient is likely to become ill.

Helpful & Harmful Microbes. Some examples

	Bacteria	Fungi	Viruses
Helpful	To make food e.g. cheese and yoghurt. As decomposers and in compost making to recycle the elements in dead plants. In sewage treatment works to break down sewage.	As a food or to make food. E.g. mushrooms, Yeast to make bread, wine, beer. Fungi in cheese making and ripening. To produce antibiotics. As decomposers to recycle elements in dead plants / animals.	Can be used to make vaccines against viral diseases. Calcivirus can be used to kill rabbits (pests). Viruses are used as vectors, tools for introducing new genes into a host cell in genetic engineering.
Harmful	Bacteria may be pathogenic (disease causing) e.g. Staphylococcus. They can cause sickness e.g. food poisoning by salmonella.	They may cause diseases such as Athletes foot, thrush, & ringworm. They can cause food to spoil e.g. mouldy fruit and bread, or kill crops e.g. potato blight fungus.	Viruses cause diseases e.g. HIV causes AIDS: Bird flu and swine flu are both caused by viruses. Viruses can damage food crops.

Additional notes: