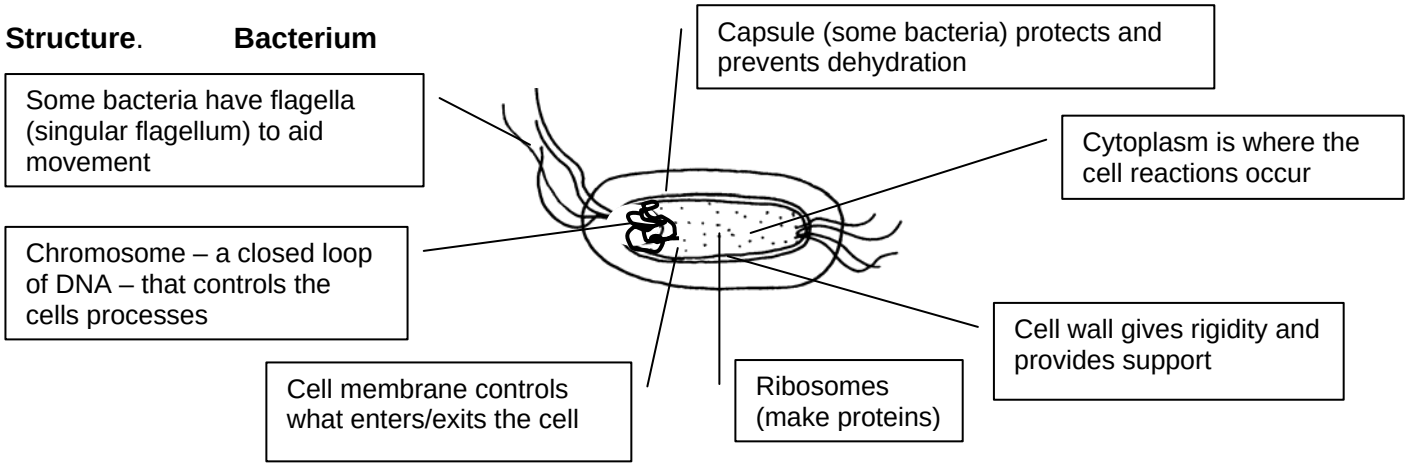
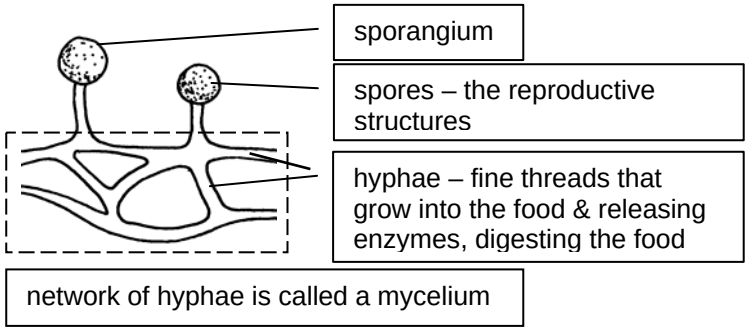
BIOLOGY 18978
Demonstrate knowledge of biotechnology
Level 1, 2 Credits

Structure. **Bacterium**

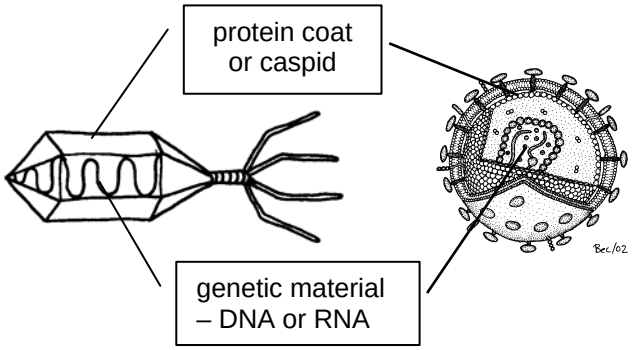


Shapes of bacteria include bacillus (rod), coccus (spherical), vibrio (comma shaped) and spirillum (spiral shaped).

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). ① <u>secrete enzymes</u> onto food ② the released <u>enzymes break down</u> (digest) the food into smaller molecules ③ <u>nutrients are reabsorbed</u> 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. (Don't say "need air/don't need air).<u>Respiration is the release of energy from food</u>**.** Some bacteria can make own food – <u>autotrophs</u> eg photosynthetic bacteria. Others are <u>saprophytes</u> - 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.

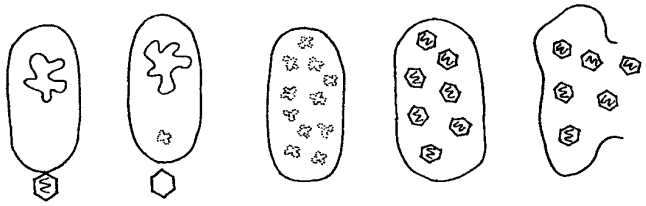
Reproduction. **Bacteria** – reproduce by binary fission (cell division – mitosis - splitting into two). ① the chromosome/DNA replicates (copies itself) ② cell membrane pinches the cytoplasm in half ③ bacterium divides into two, each with a chromosome. Bacteria numbers increase rapidly when conditions 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. ① certain hyphae grow upwards and produce swellings at their tips – sporangium (plural sporangia) ② a large number of spores (small, tough coated reproductive cells) form in the sporangia ③ sporangia burst releasing spores into the air (they are light and are carried by wind) ④ those landing on moist food germinate and grow new <u>hyphae</u> - 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.

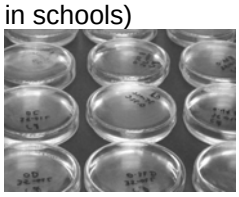
Viruses – exist ONLY to reproduce and are totally dependent on a living host cell as viruses they cannot reproduce alone as they have no chemical processes of their own. (Eg raw materials, energy and enzymes are supplied by host cell.) ① virus attaches to host cell ② injects its DNA ③ virus DNA instructs cell DNA and cell machinery to produce copies of the virus DNA ④ virus DVA and also newly made protein coats are assembled into new viruses ⑤ 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.

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



① <u>Inoculation</u>. Collected microbes are wiped on the agar surface. Eg 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 ② 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. ③ <u>Incubation</u>. (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 35-40^{o}C - nearer to human body temperature. ④ 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 <u>grow</u> bigger. The big bacteria then divide (<u>reproduction</u>) 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.

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. We often suffer more than once from viral diseases such as colds and flu. Viruses mutate frequently leading to different strains that 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.
Pathogens are spread in various ways: in water or food, in air, by contact, by body fluids and by animals.

Biotechnology

This is the application of biological organisms to manufacturing and service industries. We have made use of it for hundreds of years – wine making, beer brewing, baking of bread and the production of cheese depend upon yeasts, other fungi and bacteria or *enzymes* from these organisms.

Antibiotics such as penicillin are produced by mould fungi or bacteria. The production of industrial chemicals like citric and or lactic acid needs bacteria or fungi to bring about the essential chemical changes.

Sewage disposal depends upon bacteria in filter beds – digest the waste and purifies the effluent.

Food production

Yogurt
Made by the fermentation of milk by bacteria.

- Milk is pasteurized (heat treated to kill any pathogenic (potentially harmful) bacteria and other micro-organisms.
- A "starter culture" of bacteria is added warm (30^{o}C) milk to ferment the milk.
- The bacteria turn the milk sugar called lactose into lactic acid.
- The lactic acid coagulates the milk protein to produce the thick creamy yogurt (and the lactic acid gives the yogurt a slightly sour taste).
- The process works best @ 46^{o}C, and when complete cooling to 5^{o}C stops the process.

Cheese
The process is basically the same as for yogurt. A variety of bacteria cultures are used depending upon the type of cheese to be made.
As well as the starter culture of bacteria (different from those used in yoghurt production), a mixture of enzymes called rennet is added. Rennet coagulates the milk protein to form semi-solid "curds". The liquid "whey" is drained from the curds. The curds are partially dried and compressed. The cheese "ripens" as the enzymes in the bacteria act on the proteins and fats in the curd to give the cheese its characteristic flavour. To make varieties of "blue cheese" mould spores (fungi) are added at the fermentation stage.

Beer
Barley grains are soaked in water and allowed to germinate. The seeds are dried, crushed and added to water. Barley enzymes convert the starch in the grains into sugars. The sugary solution (called "wort') is filtered and boiled with hops to give it its bitter flavour. The yeast respires, producing carbon dioxide and ethanol (alcohol). Glucose → ethanol + carbon dioxide. Fermentation converts the sugar solution to alcohol

Wine
Grapes are crushed and the juice is treated with sulfur dioxide to kill bacteria and naturally occurring yeasts. A starter culture of yeast is added. The y east respires anaerobically and turns the glucose into carbon dioxide and alcohol. The alcohol rises to 10-15% concentration which eventually kills the yeast.

Bread
Flour, water, salt, oil and yeast are mixed to make a dough. The yeast respires and converts the sugar to alcohol and carbon dioxide in the process also known as fermentation. The only fermentation product needed this time is the carbon dioxide. The carbon dioxide makes the bubbles in the bread dough to make the bread 'light" in texture. A protein called gluten gives the dough its sticky plastic texture which traps and holds the bubbles of gas. When placed in the oven the bubbles expand even more and the yeast is killed, and the small amounts of alcohol produced evaporates before the dough turns to bread.

*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.

Helpful & Harmful Microbes. Some examples

	Bacteria	Fungi	Viruses
Helpful	To make food eg cheese and yoghurt. In sewage treatment works to break down sewage.	Yeast to make bread, wine, beer. Fungi in cheese making and ripening. To produce antibiotics.	Can be used to make vaccines against viral diseases.
Harmful	Bacteria may be pathogenic (disease causing) eg staphylococcus, or cause sickness eg food poisoning by salmonella.	They may cause diseases such as Athletes foot, thrush, & ringworm. They can cause food to spoil eg mouldy fruit & bread, or kill crops.	Viruses cause diseases eg HIV causes AIDS: Bird flu is caused by a virus. Viruses can damage food crops.

Enzymes

Enzymes are catalysts in living things, speeding up chemical reactions in living organisms. They are necessary since most cells work at relatively low temperatures and their chemical reactions would be too slow without the help of enzymes.
Enzymes are protein molecules. They speed up a reaction without being used up which means they can be used over and over again. A small amount of enzyme can bring about the change of a large amount of chemical.
Enzymes work best at particular temperatures. They can be denatured (destroyed) by temperatures above about 50°C because their shape is altered. At low temperatures they work too slowly to be of use.
Each type of enzyme works best at a particular limited range of pH and changing the pH outside this also denatures the enzyme. Eg the enzyme pepsin only works between pH 1 - pH 4 (acidic). The temperature or pH which makes an enzyme work at its very fastest is called the optimum (best) for that enzyme.
Enzymes are **specific** which means they control can usually only be the catalyst for a single reaction. For example, the enzyme maltase is the catalyst for changing the sugar called maltose into glucose, and cannot break down other sugars. Enzymes are NOT alive, and they cannot be "killed".

Key Words
- enzymes - biological catalysts which speed up chemical reactions, but remain unchanged themselves
- optimum - the conditions (usually temperature or pH) at which an enzyme works quickest
- product - the substance(s) which are produced by a reaction
- substrate - the substance which an enzyme works on
- specific - the term used to describe the fact that one enzyme can work on only one substrate

Some uses of enzymes
Proteases are used to pre-digest proteins in the manufacture of baby foods to make them easier to digest.
Lipases are used (with proteases) in biological washing powders to break down (digest) fats and other substances in food stains.
Carbohydrase enzymes turn cheap starch syrup into the more valuable sugar syrup used in sports drinks.
Isomerase converts glucose syrup into fructose syrup (a sweeter sugar can be used in smaller amounts in slimming foods)
Invertase enzyme is used to make soft centres in some chocolates.