# Bacteria and Evolution

## Junior Science

# Micro-organisms

**Micro-organisms** (or microbes) are very small organisms, which are usually only visible with the aid of a microscope. Sometimes a colony of micro-organisms can be seen with the naked eye.

Micro-organisms which have single cells are **unicellular**. Those made of many cells are **multicellular**. Some have no cells at all – viruses.

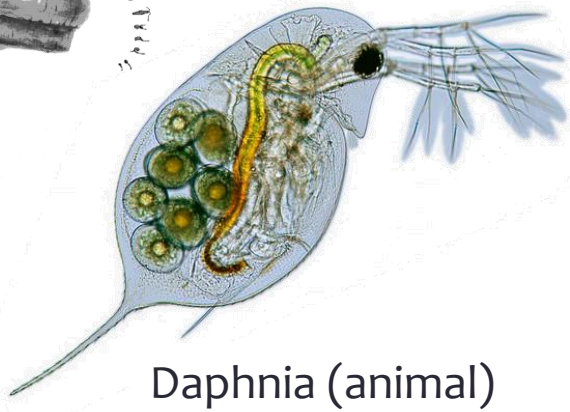
# Types of Micro-organisms

## Living

Yeast (fungi)

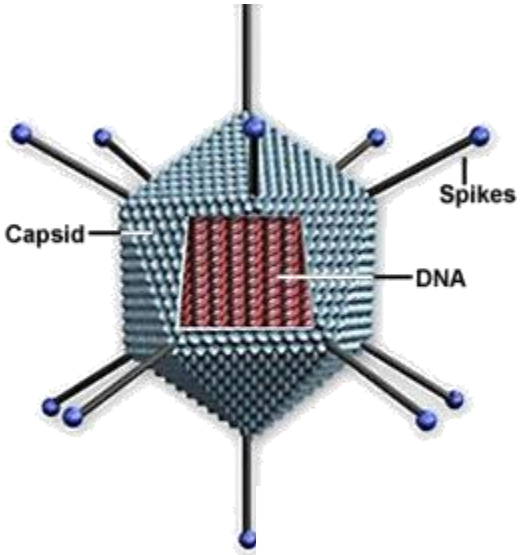
Bacteria

Protista



Daphnia (animal)

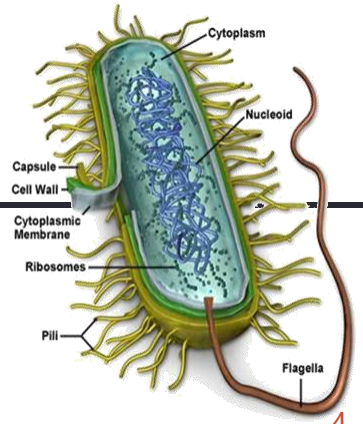
## Non-living

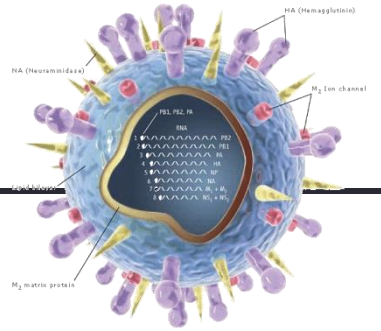



Viruses

# All living organisms are made of cells

| Fungi | Bacteria | Virus |
|---|---|---|
| Similar to the animal cell, <u>but</u> has a cell wall made of chitin (the same material insect exoskeletons are made of). Does not have chloroplasts as it **can not** photosynthesis.<br>Eukaryote cell. | Does not have nucleus or organelles (except ribosomes).<br>Prokaryote cell | **Not considered living** or consisting of cells but contains genetic material (RNA/DNA) similar to all other living things. |



# 8a Bacteria

Bacteria are different enough to be classified within their own group, separate from the plants, fungi, protists and animals. Bacteria have a large variety of different lifestyles and survival methods.

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Bacteria are microscopic, single-celled prokaryotes.

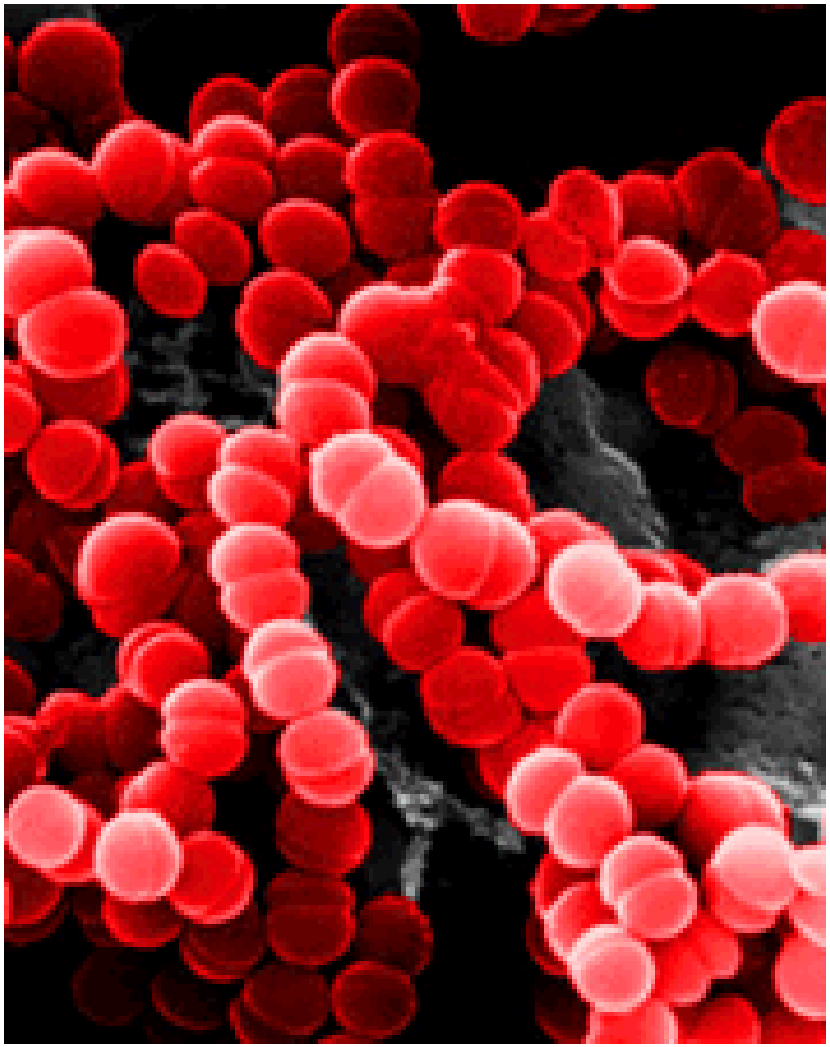
Many bacteria are classified by their shape, such as round, long & thin, or spiral shaped bacteria.

Bacteria need food and warmth (although the temperature range varies between species) to grow and they use enzymes to digest food.

Bacteria can survive in aerobic (with oxygen) or anaerobic (with no oxygen) environments depending on the species.

# Example of a Bacteria species

extra info



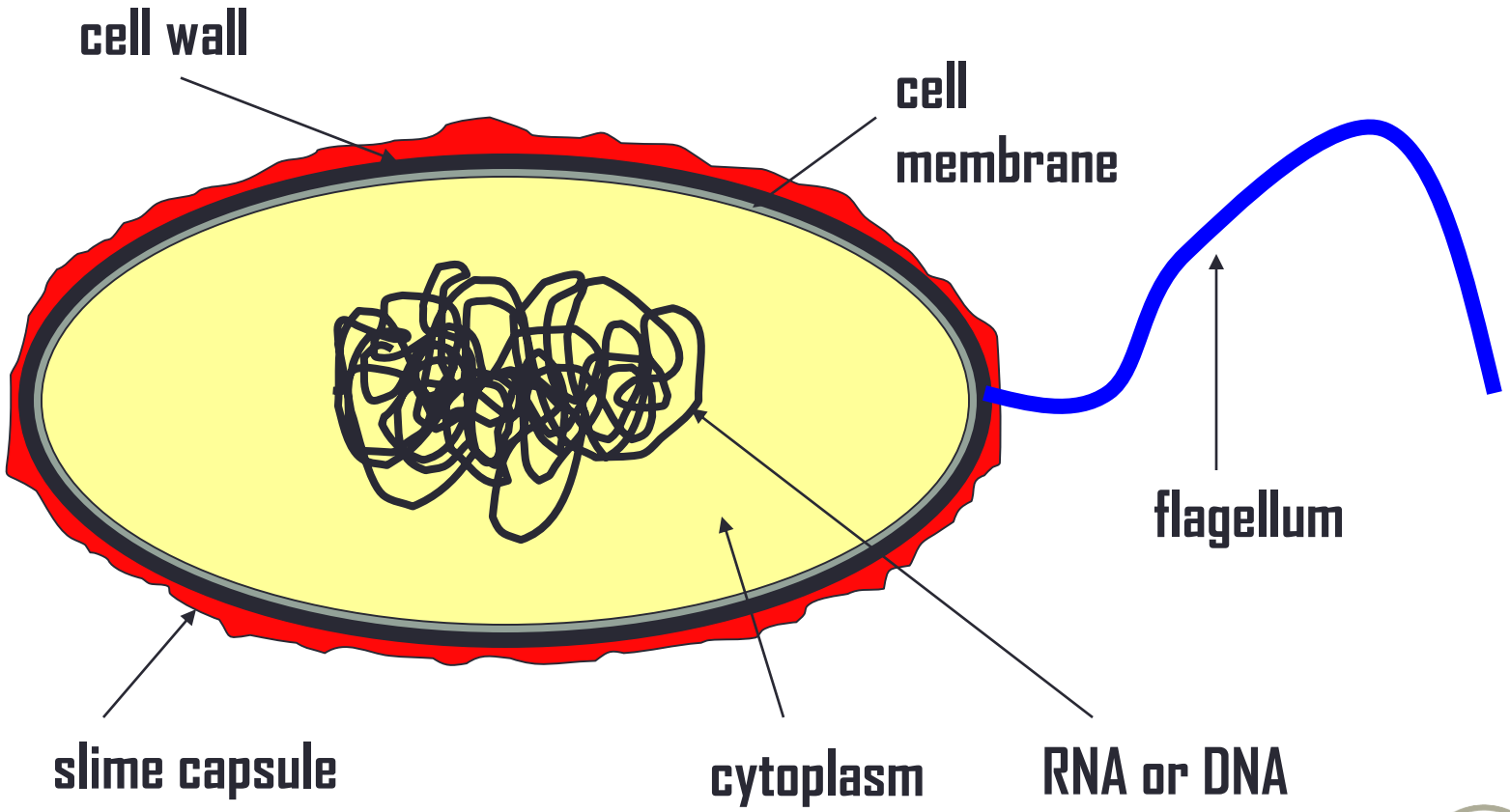
*Streptococcus pyogenes*

These spherical bacteria are common inhabitants of the throat. Sometimes they can cause strep throat or even more serious disease like necrotizing fasciitis (commonly called flesh-eating bacteria)

Humans have both beneficial bacteria species inside them, which help with digestion and many other processes, as well as harmful bacteria species called **pathogens** – that can make us sick or even kill us.

# 8a Bacterial Cell structure

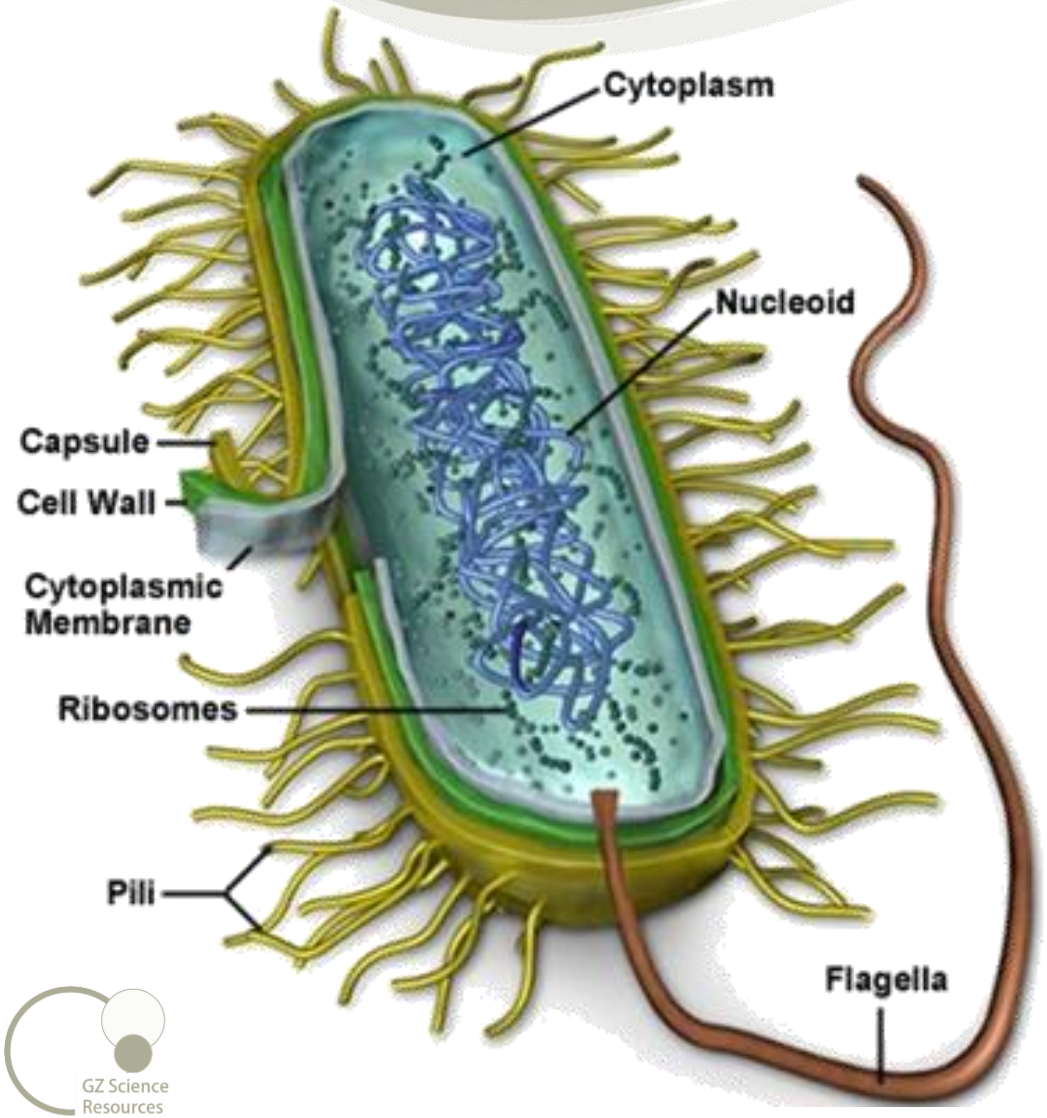
All bacteria are prokaryotes. They have no nucleus membrane, just an area that the DNA/RNA occupies.



8a

# Bacterial Cell

extra info




Bacterial cells have no mitochondria and the cell membrane is the site of energy release instead.

The DNA / RNA is in a single loop rather than chromosomes.

Outside the cell membrane is a cell wall and often bacteria have a slime capsule for protection.

There may be a flagellum to help the bacterium move, and smaller cilia/pili.

Bacterial cells are much smaller than plant or animal cells (usually).

# 8b Bacteria reproduction – Binary fission

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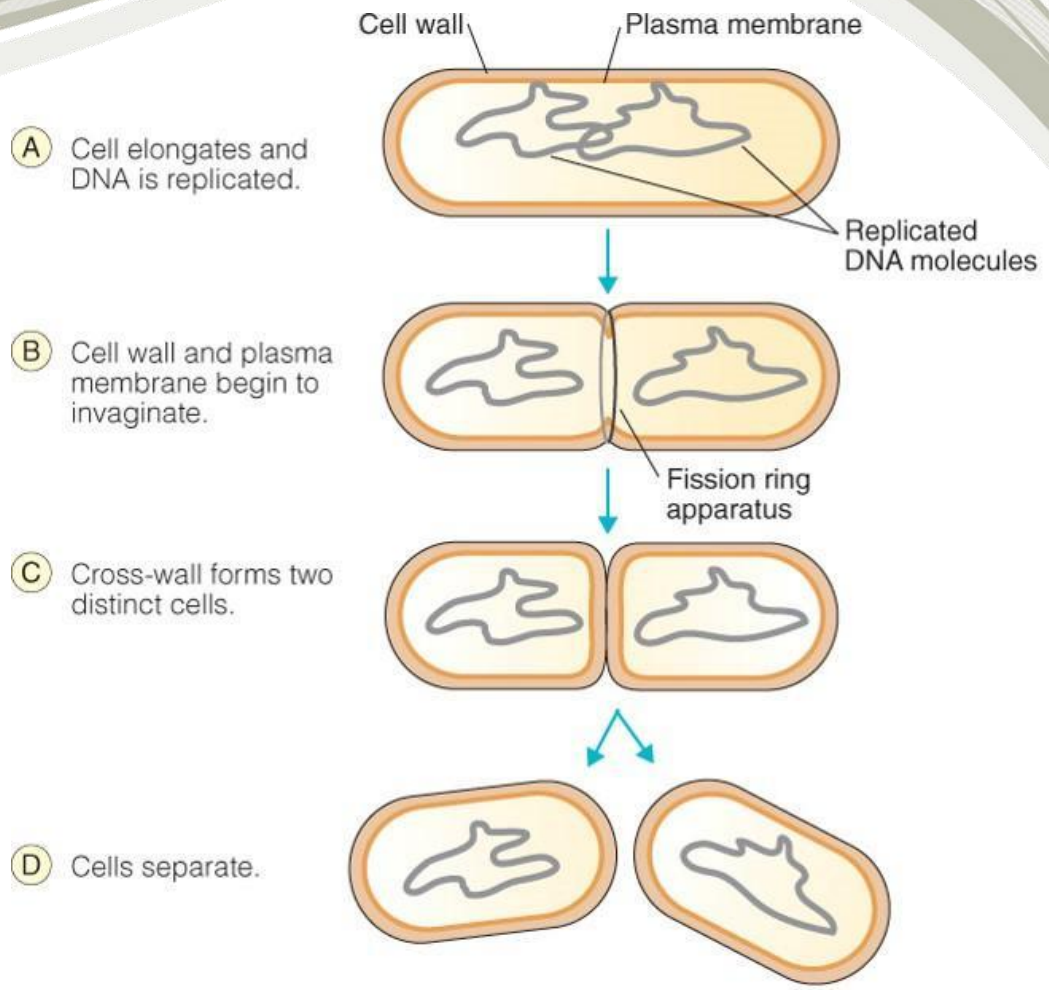
Bacteria reproduce **asexually** by **binary fission**. This happens when one bacteria cell reaches its maximum size and divides into two identical cells when the environmental conditions are right.

Some bacteria can divide every fifteen minutes. It is similar to mitosis but bacteria do not have chromosomes.




This type of reproduction means that bacteria can quickly make use of an available food source.
Bacteria can also **remain dormant** until the conditions are right.

# 8c Bacterial conditions for Growth

Bacteria need the following conditions for growth:

**Energy** – in the form of food (in humans this is their cells or food they have eaten)

**Moisture –** enough water for their metabolism

**Warmth** – cooling bacteria reduces their growth rate, but does not usually kill them. Refrigerators and freezers preserve food by slowing down the growth of bacteria.

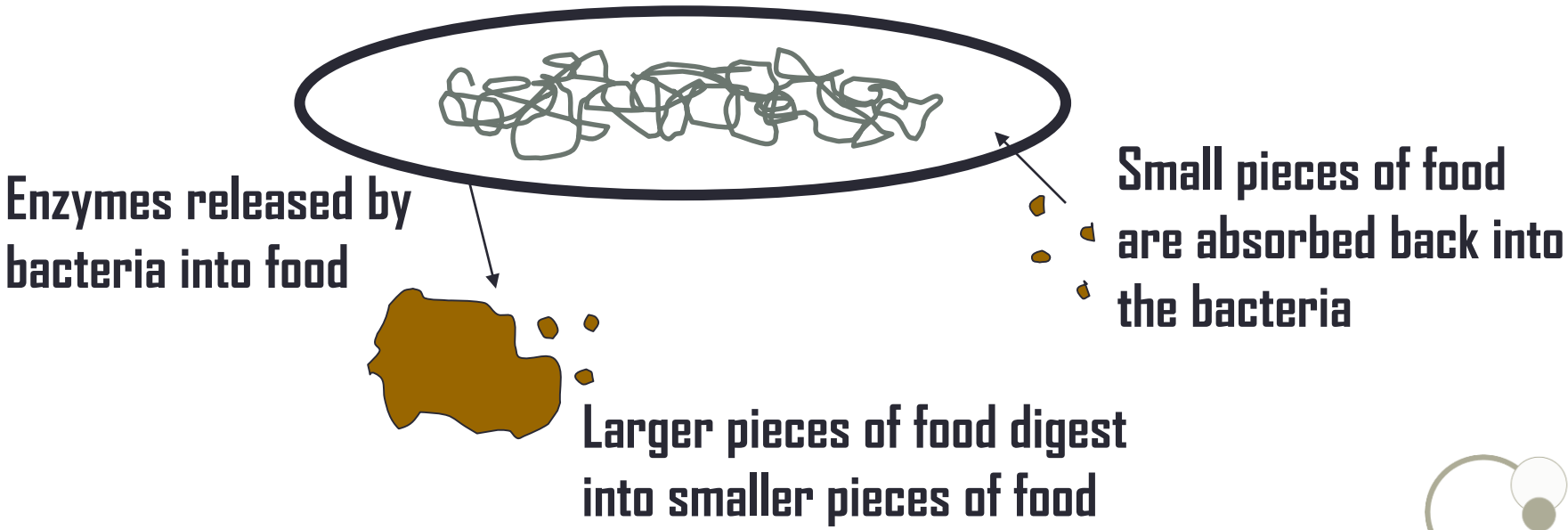
**Oxygen** – For aerobic bacteria only. Oxygen may kill anaerobic bacteria.

**pH** – bacteria grow better under the right conditions of pH (acidity or alkalinity). Bacteria grow well on the human skin, as it is slightly acidic.

# Bacteria nutrition – Extra-cellular digestion

extra info

Bacteria need to obtain food in order to grow and reproduce. Some bacteria can produce their own food through photosynthesis but many need to obtain nutrition from another source. Bacteria may be parasitic (feeding off other living organisms) or saprophytic (feeding off dead or decaying organisms). Bacteria feed by **extra-cellular digestion**, because the digestion (where larger pieces of food break into smaller pieces) takes place outside the cell. They secrete enzymes outside of their cell membrane and cell wall. The enzymes digest the food into small particles that can be absorbed through the cell membrane.



# 8d Useful and harmful bacteria

Some bacteria can be useful to humans and other can be harmful. Bacteria can respire in two main ways and so can be broken into 2 main groups. Respiration is the process of obtaining energy by chemically breaking down food, In animals and plants, oxygen is needed to break down the food into carbon dioxide, water and energy. This is called aerobic respiration. Most bacteria respire aerobically, while others do not need oxygen (and may even be killed by it). This type of respiration is called anaerobic respiration.

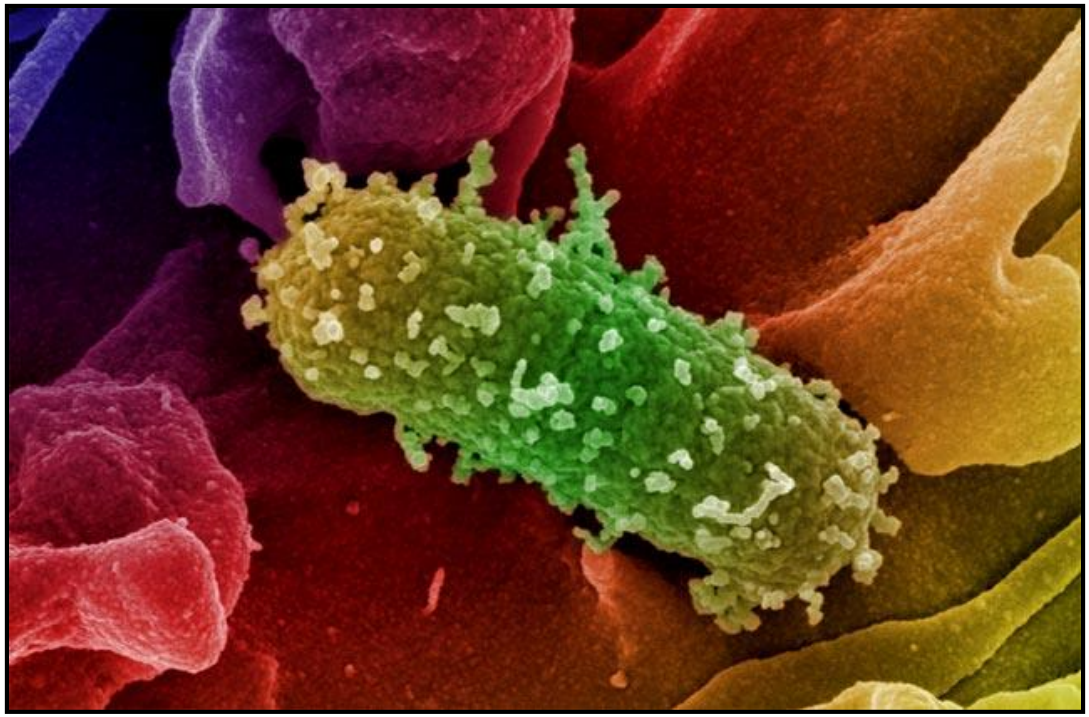
| Anaerobic respiration | |
|---|---|
| Harmful to humans | Useful to humans |
| >Gangrene - foul-smelling discharge, dead tissue, and gas formation within the tissue | >yoghurt production<br>>production of biogas<br>>waste processing<br>>electricity generation |

| Aerobic respiration | |
|---|---|
| Harmful to humans | Useful to humans |
| >Food rotting – sour milk | >Nitrogen fixing bacteria<br>>Cheese production<br>>GE insulin production |

# Bacteria excretion

extra info

Bacteria excrete waste products. Sometimes these are harmful and are known as **toxins**. The toxins can lead to vomiting and diarrhoea in humans, or even death.  A disease-causing bacterium is called a pathogen.



# 9a An investigation is used to collect data for evidence

Scientists ask questions to help work out what is occurring in the natural world around them. They then create testable ideas which they think may answer the question.
Scientists test their ideas by predicting what they would expect to observe if their idea were true (called a **hypothesis**) and then seeing if that prediction is correct.
Scientists look for patterns in their observations and data.
Analysis of data usually involves putting data into a more easily accessible format (graphs, tables, or by using statistical calculations).

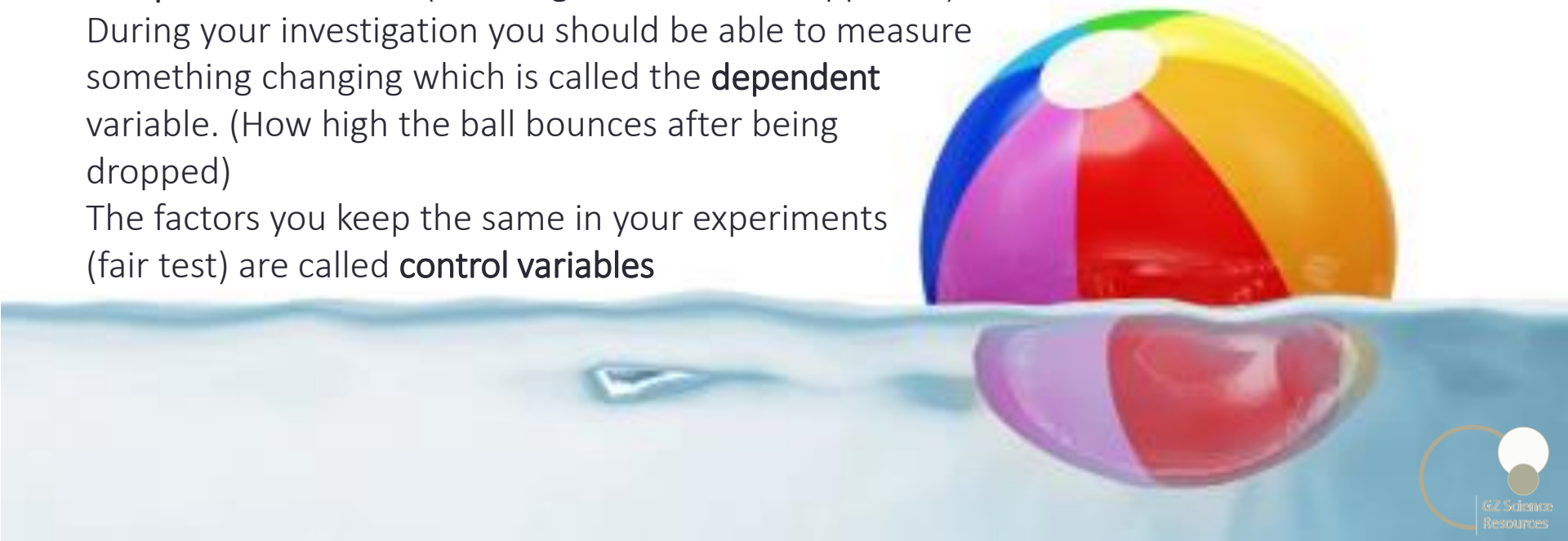
The process of creating a question, developing a hypothesis and carrying out a test to collect data which is then analysed to see if their hypothesis is proved or disproved is called a **scientific investigation**.

# 9a

## A 'fair test' is one in which you only change one thing (variable).

**Variables** are all the things that could change during an investigation.
In a bouncing ball investigation, where the height a ball bounces to is measured after it is dropped at different heights, many things could affect the results from one experiment to the next such as using a different ball, a different drop height or a different surface which the ball is dropped on.

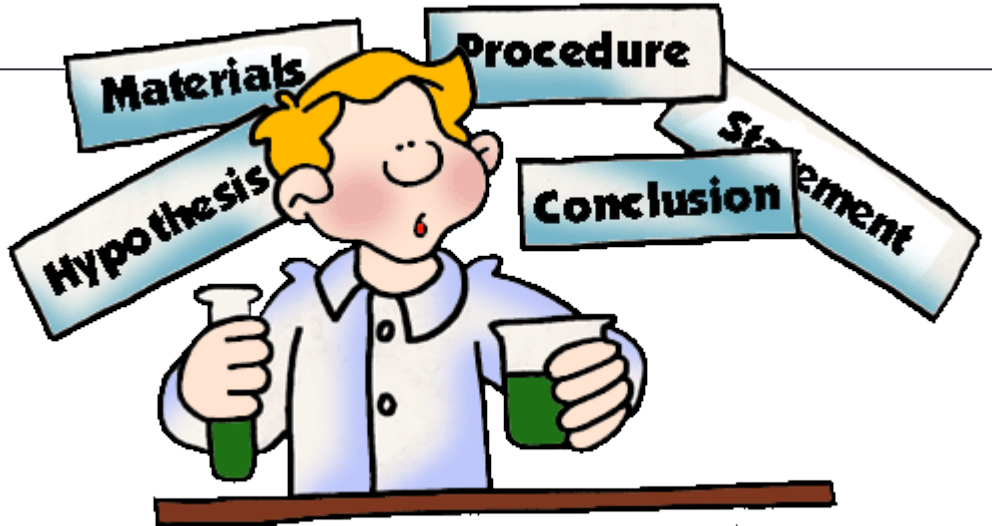
You should only change one thing at a time in your investigation. This called the **independent variable**.(The height the ball is dropped at)
During your investigation you should be able to measure something changing which is called the **dependent** variable. (How high the ball bounces after being dropped)
The factors you keep the same in your experiments (fair test) are called **control variables**



# 9a The typical way that scientists work is called the Scientific method.

Scientific investigations are typically written up in a standard way under the following headings:

**Aim (focus question):** what you are trying to find out or prove by doing the investigation
**Hypothesis:** what you think will occur when an investigation is carried out
**Equipment (or materials):** the things that you need to do the investigation
**Method :** A simple, clear statement of what you will do – and can be repeated by another person
**Results :** data, tables and graphs collected from investigation
**Conclusion :** what your results tell you – linked back to the aim and hypothesis
**Discussion :** Science ideas to explain your results, possible improvements to the investigation, how you managed to control the other variables.



9b

# Focus Question / Aim

Your Aim or focus question must include both variables.
For example: If I change (independent variable) how will it affect (dependant variable)

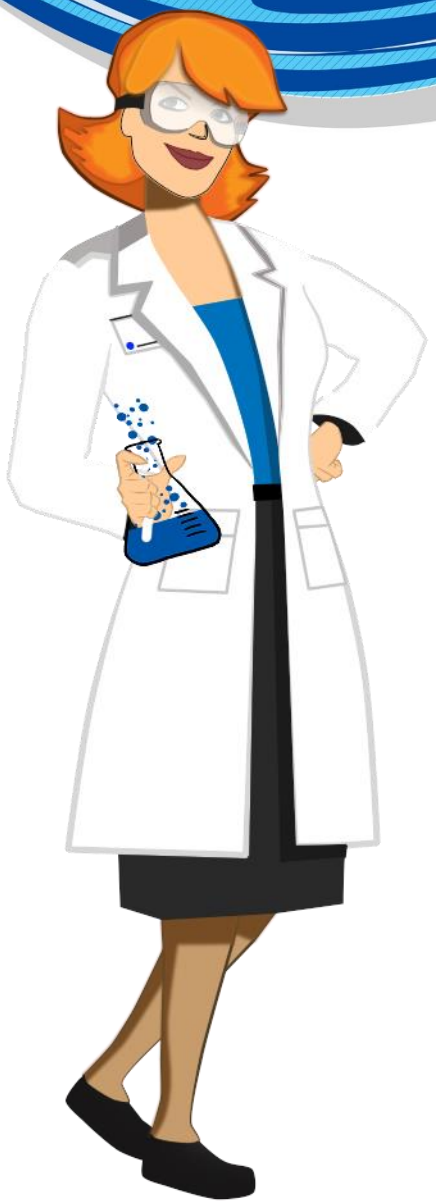
Such as: If I change the temperature of the water (independent) how will it affect how much sugar I can dissolve into the water (dependant)

**Independent variable** – amount of light a plant receives
**Dependant variable** - height that plant grows

**Focus Question:** How does the amount of light a plant receives affect the height it grows to

9b

# Writing the Method



A method must be written so that an investigation is **repeatable** by another person.

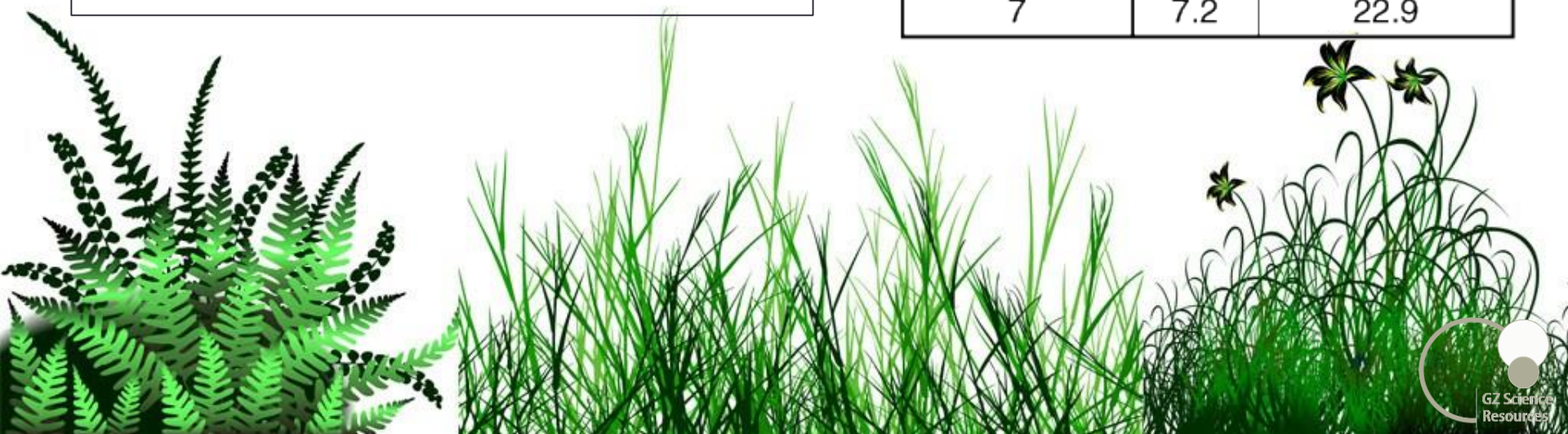
In order for results from an investigation to be **reliable** an investigation must be able to be repeated exactly the same way following the method. The results gained from each repeat must show the same pattern each time for the conclusion to be valid (or if not an explanation or fault in following the method given)

# 9c Collecting Data

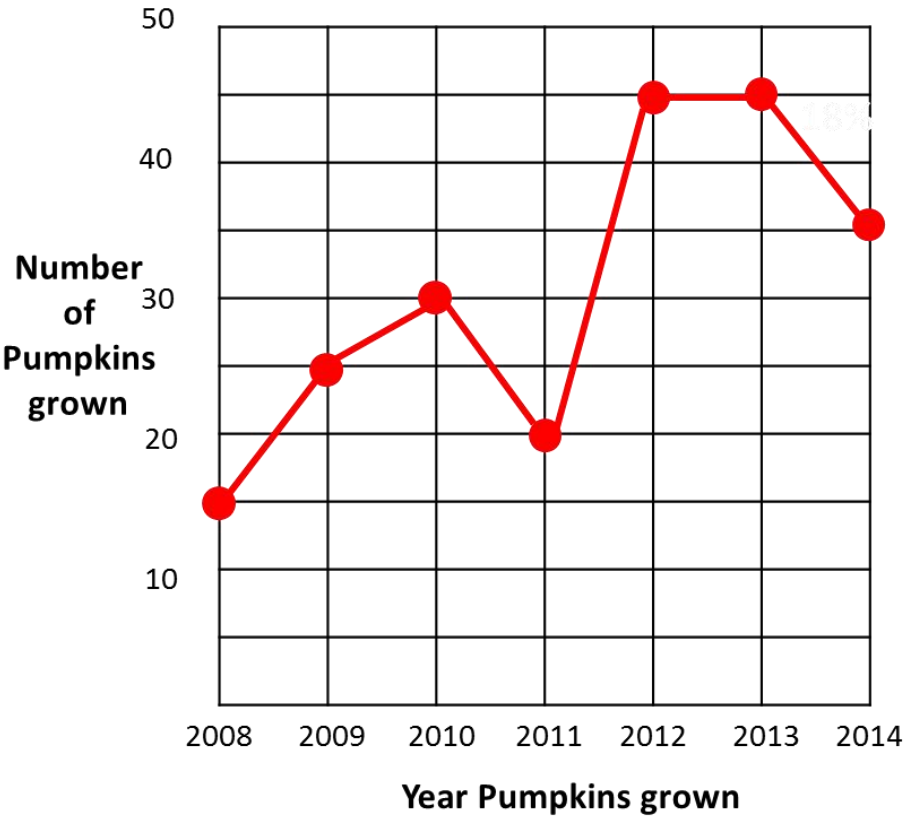
Data that is collected from an investigation can be analysed easier if placed into a clearly labelled and laid out **data table**.
The table must have:
A heading linked to the aim/hypothesis
Labelled quantities, units and symbols
Values (often numerical) of data collected
Data tables can also contain processed data such as results from multiple trials that have been averaged to give a more reliable value.

Plant Growth in Soils with Different pH Values

| Plant Group | pH of Soil | Average Plant Growth (cm) |
|---|---|---|
| 1 | 6.0 | 25.4 |
| 2 | 6.2 | 33.0 |
| 3 | 6.4 | 50.8 |
| 4 | 6.6 | 53.3 |
| 5 | 6.8 | 53.3 |
| 6 | 7.0 | 30.5 |
| 7 | 7.2 | 22.9 |



# 9c Looking for patterns in results - Graphs

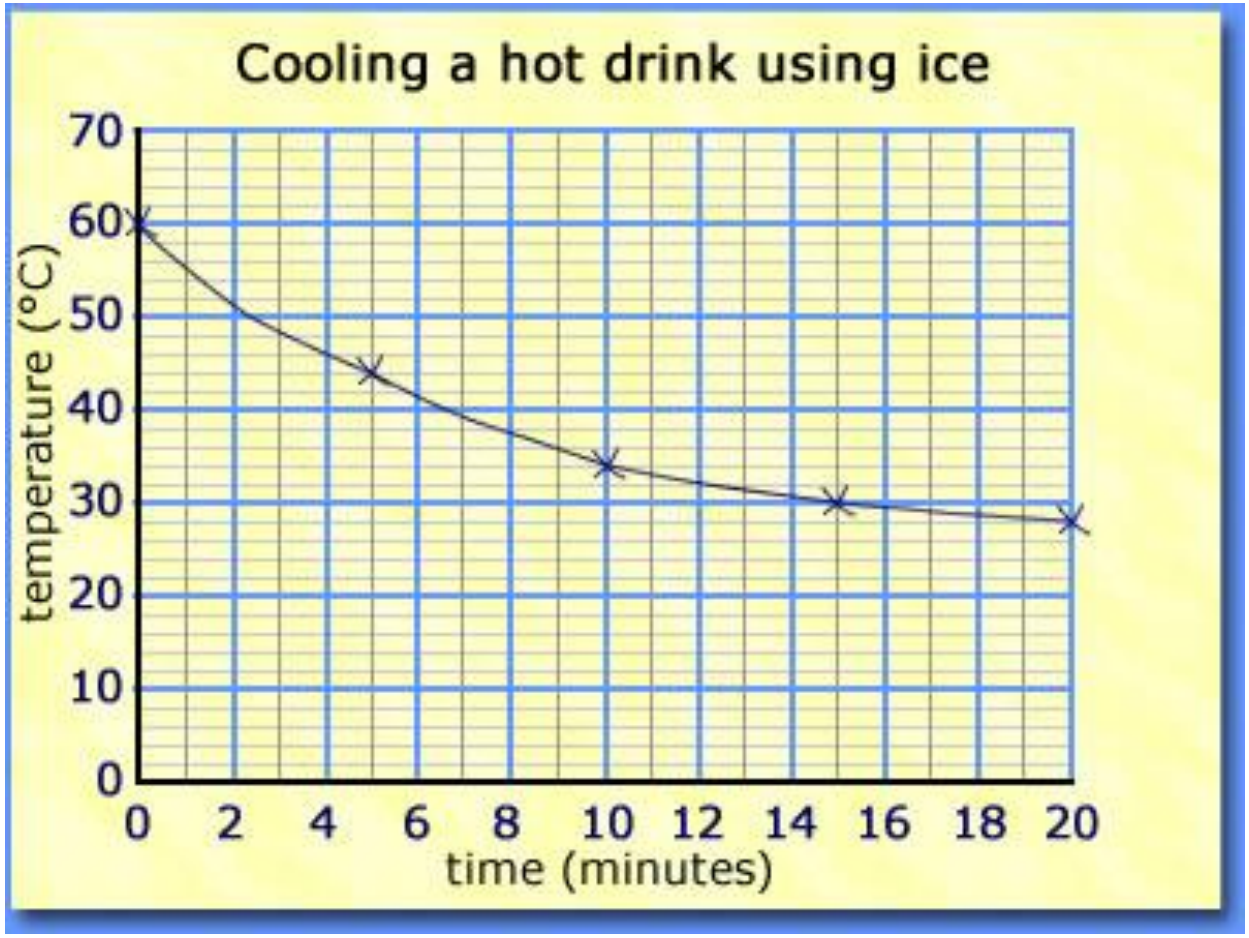



## Line Graph

A line graph is used to show changes in a variable. It could graph **discrete variables** - such as the number of pumpkins each year: 1 or 2 etc but not 2.5. It can also graph **continuous variables** – such as the weight of pumpkins grown: any value between a minimum and maximum.

More than one set of data can be graphed to make comparisons.

# 9c Drawing a line Graph




A well drawn line graph must have the following features:

A suitable heading

Evenly spaced numbered axes

Labels with units

Correctly plotted line

# 9d Writing a conclusion

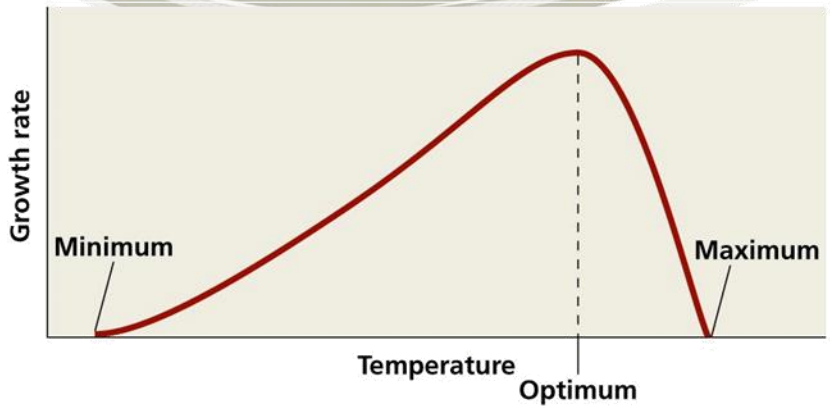
A conclusion looks for patterns in collected data from an investigation and uses it to agree or disagree with the hypothesis.
Both the variable that is changed (independent) and the variable that is measured (dependant) must be included in the conclusion statement.
The data is used as evidence in the conclusion.
The conclusion can also be used to answer the original Aim (focus question)

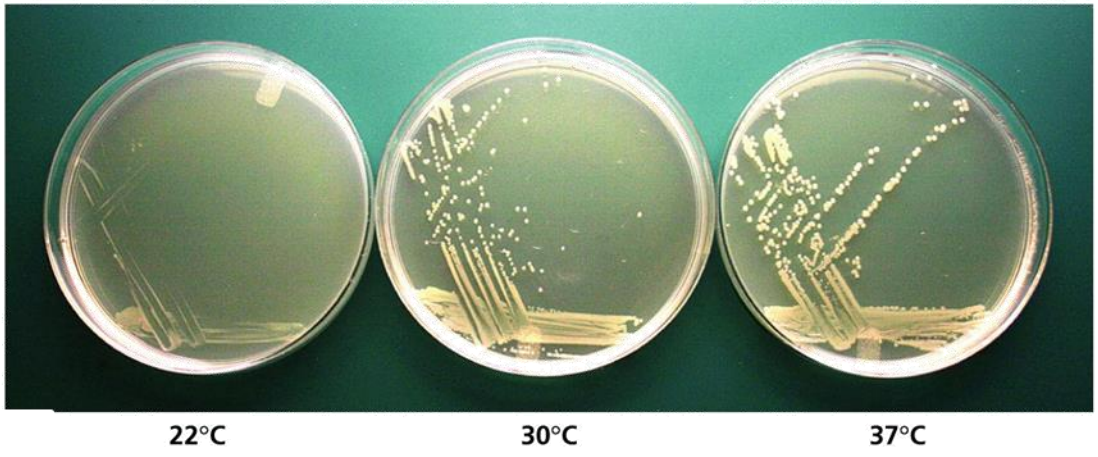
## 6-sentence Conclusion

1. Rewrite the hypothesis
   My hypothesis stated _____.
2. Support/reject the hypothesis according to the data
   The data I collected (supports or rejects) my hypothesis.
3. Explain your data (use numbers)
   My data showed _____.
4. Draw a conclusion
   I conclude _____.
5. Ask a new question
   I now wonder _____.
6. Explain ways to improve the experiment
   If I were to conduct this experiment again, I would try _____.

10a

# Providing the environmental conditions are that favourable to bacteria result in them reproducing rapidly



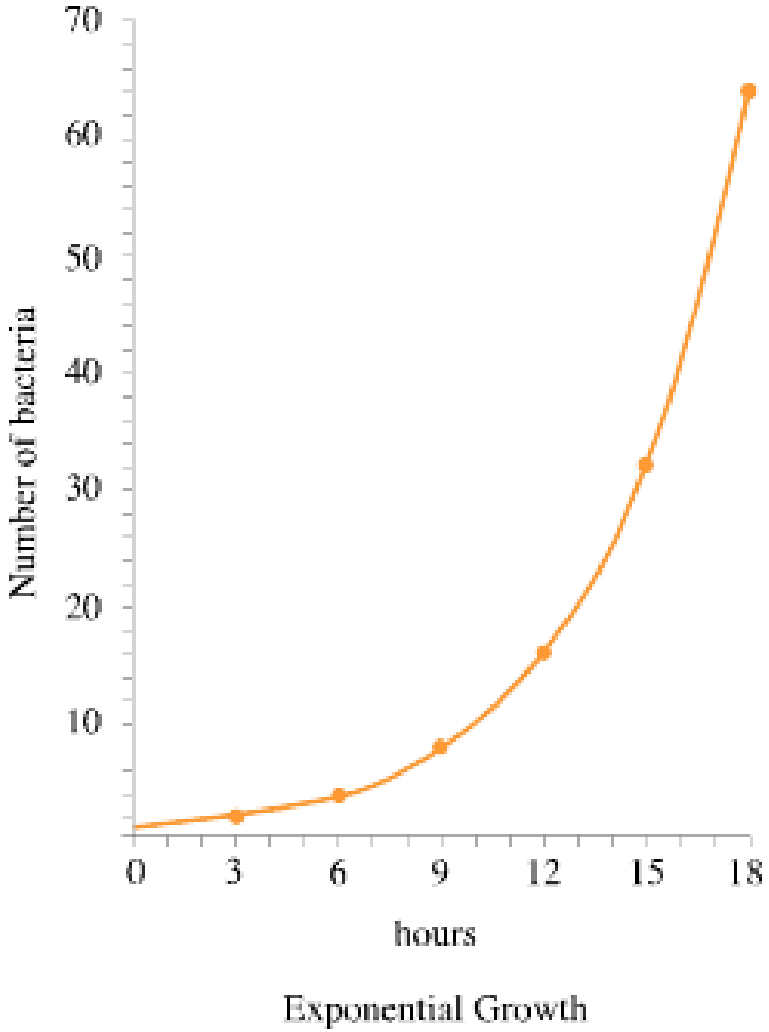

Different species of bacteria have **optimum** ranges for any environmental condition. Either side of the optimum the bacteria grows more slowly.

Each time bacteria reproduce they divide into two new bacteria. Those bacteria then divide again. This type of growth is known as exponential growth.

If a suitable food source is available along with the preferred environmental conditions such as light, pH and temperature are provided then the bacteria will continue exponential growth at the maximum possible rate.

# 10a

## Providing the environmental conditions are that favourable to bacteria result in them reproducing rapidly




Exponential Growth

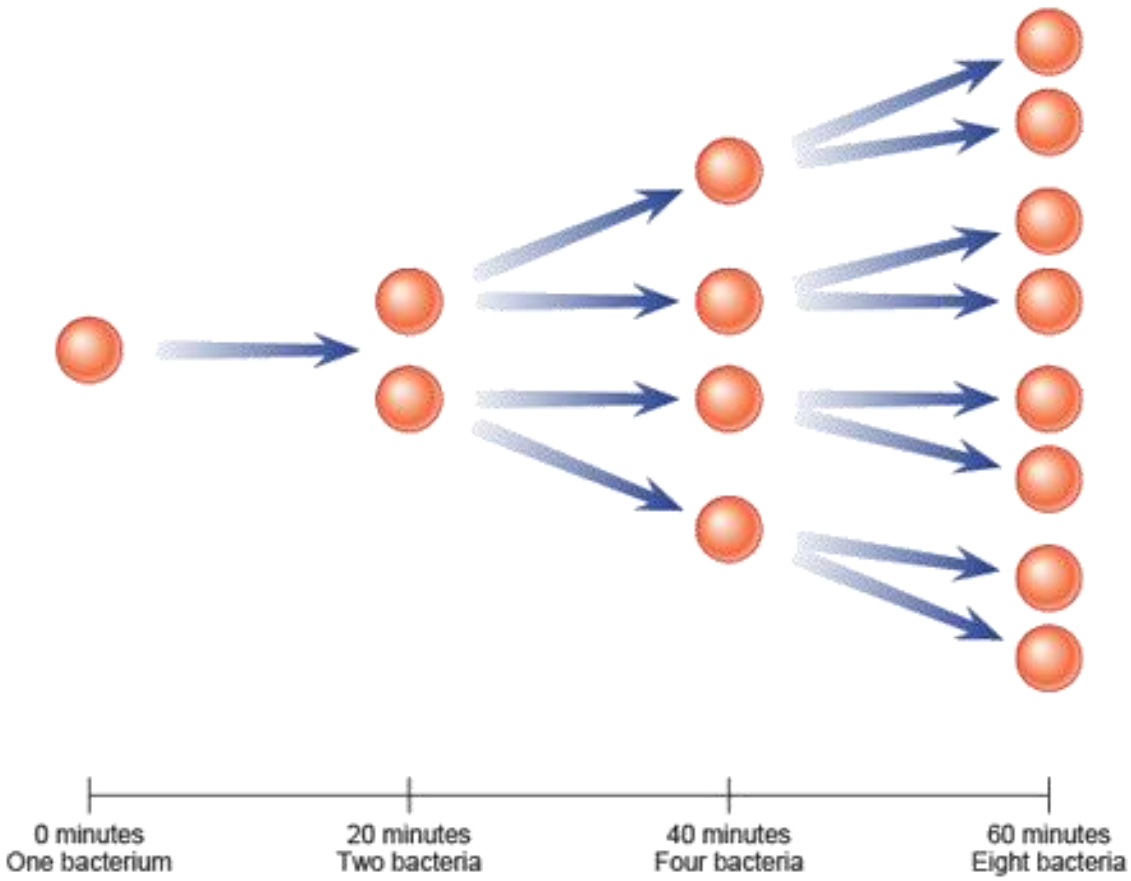
Bacteria can growth from a few hundred individuals to many millions in just a few hours.

In useful bacteria the environmental conditions are adjusted so the bacteria can work quickly, such as providing warmth to make yogurt bacteria turn milk into yogurt overnight.

Harmful bacteria, such as that on left out food that give us food poisoning can cause a lot of harm. Our bodies can protect us from a few bacteria on fresh food, and food that has been refrigerated to slow growth but not from many millions of bacteria that have been produced at room temperature that provides the ideal environmental conditions for growth.

# 10b

## A fast reproductive cycle means that there are many generations of bacteria in a short period of time

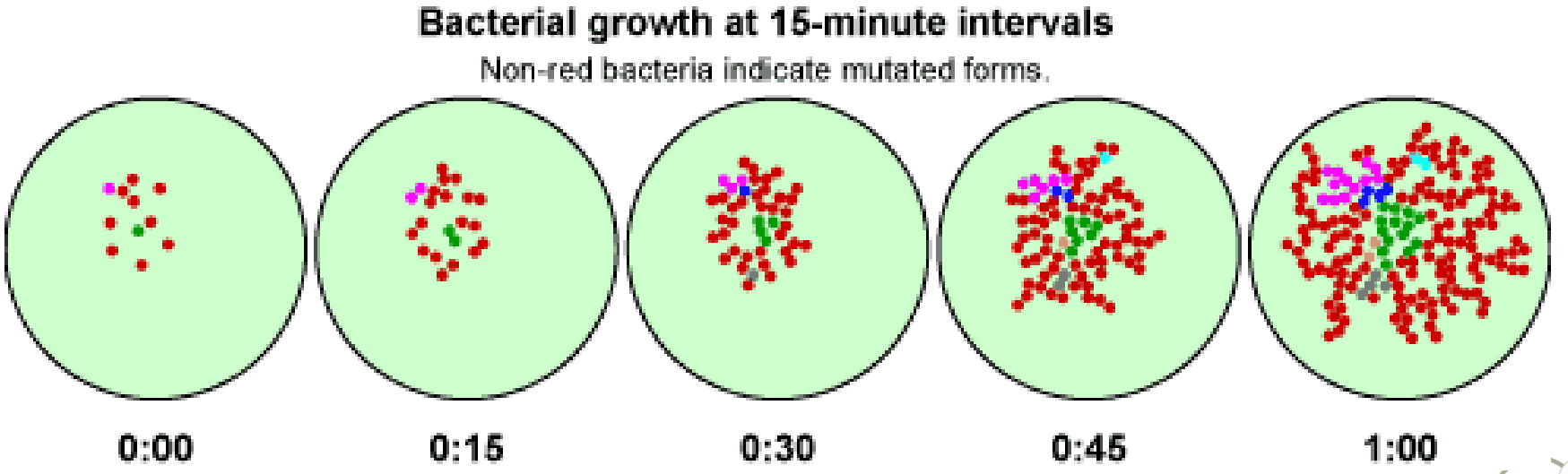



Short amounts of time between each new reproductive event means the bacteria can populate a new area quickly. The bacteria to the right reproduces every 20 minutes (if the environmental conditions are the most suitable) compared to many animals that can only reproduce every 1 or 2 years. In 60 minutes the bacteria have reproduced in 3 cycles and gone from 1 bacteria to 8. In 60 more minutes there will be 480 bacteria.

# 10c

## Evolutionary change in Bacteria

Bacteria have a fast reproductive cycle and this causes evolutionary change to be seen in bacterial species in a relatively short evolutionary time period.
Evolution occurs when there is a permanent change in the frequency of types of genes (alleles in a population. Different alleles are caused due to different bases making up a gene.
**Mutation** occurring during binary fission (reproduction in bacteria) can create new alleles.



# Disease

A **disease** is a pathological condition of body parts or tissues characterized by an identifiable group of signs and symptoms.

**Infectious disease** are diseases caused by an infectious agent such as a bacterium, virus, protozoan, or fungus that can be passed on to others.

An **infection** occurs when an infectious agent enters the body and begins to reproduce; may or may not lead to disease.

A **pathogen** is an infectious agent that causes disease and they affect a **Host**, which is an organism infected by another organism.

Diseases are classified by their **virulence**, which is the relative ability of an agent to cause rapid and severe disease in a host

# How Pathogens cause diseases

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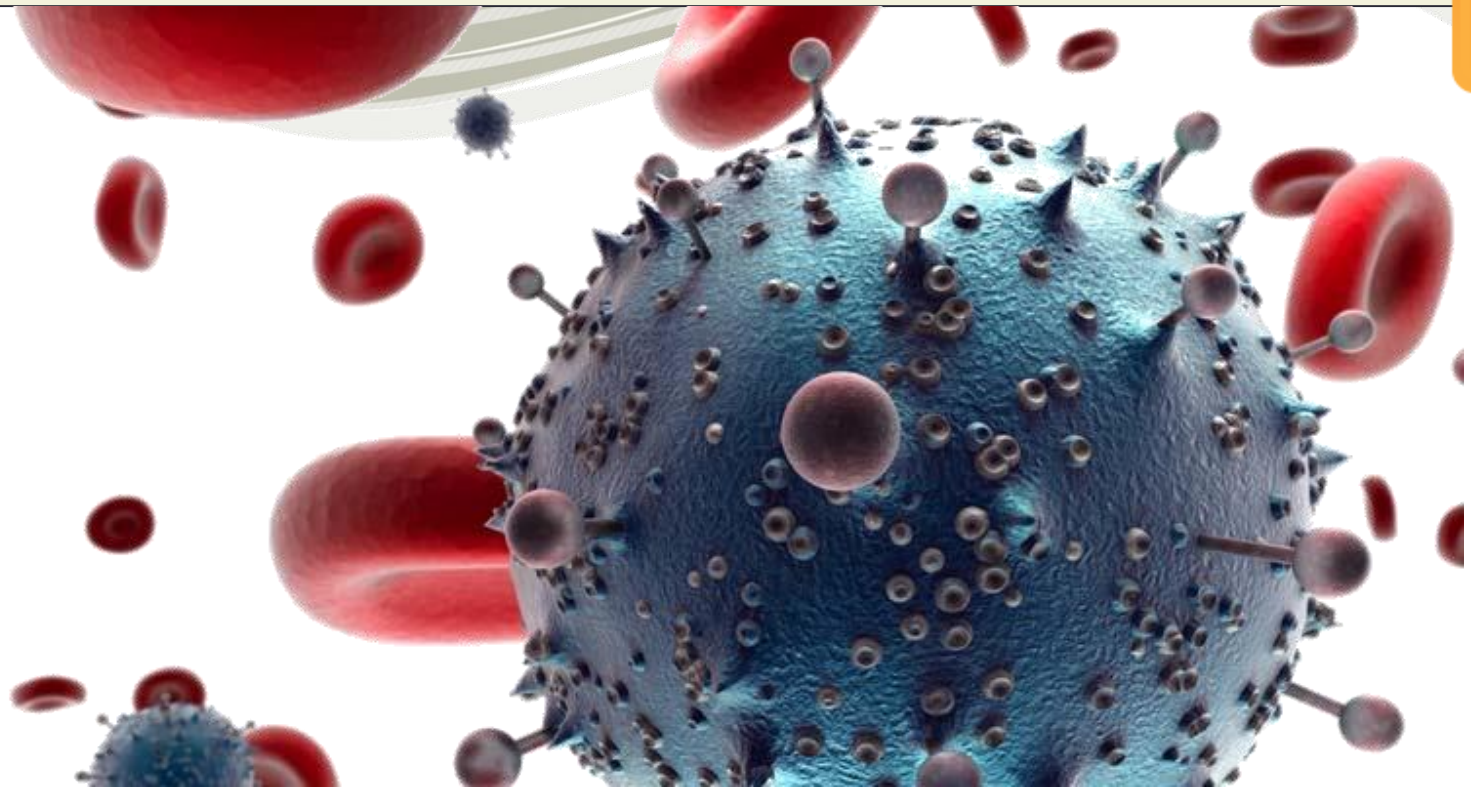
extra info



Many bacteria that are **pathogens** and infect humans produce of **poisons**, such as toxins and enzymes, that destroy cells and tissues. These poisons are created during the micro-organisms life processes during feeding, excretion or respiration. Pathogens can cause **triggering responses** from the host's immune system leading to disease signs and symptoms.

GZ Science Resources

# Treating bacterial infections with antibiotics


Antibiotics are chemicals, either produced by fungi or made by humans that kill the bacteria that have infected humans and other animals. Antibiotics are normally needed in large amounts over many days to kill all bacteria. Bacteria can mutate to resist bacteria.

# 10d

## Evolutionary change in Bacteria

Natural selection occurs in bacteria as well. Bacteria mutate during reproduction. If the alleles produced are favourable to survival – such as antibiotic resistance – then those bacteria with that allele will increase in numbers. If antibiotics are not taken for long enough the resistant bacteria will survive and grow in numbers.

Most Bacteria have a small, circular piece of DNA/RNA called a plasmid. Because prokaryotes only **have** one chromosome, so they generally only **have** one **allele** for a particular gene.