# 1: Characteristics of living organisms

The 7 characteristics that distinguish living things from non-living objects are: **Nutrition**, **Excretion**, **Respiration**, **Sensitivity**, **Reproduction**, **Growth** and **Movement**.

### 7 characteristics of living organisms

<table>
<thead>
<tr>
<th>#</th>
<th>Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nutrition</td>
<td>Take in, Absorb, Assimilate, Plants make their own food (Photosynthesis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Nutrients</strong> Organic substances, Mineral ions containing raw materials/energy for: Growth + Tissue repair</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Substance in Excess</strong> H₂O, CO₂, Light</td>
</tr>
<tr>
<td>2.</td>
<td>Excretion</td>
<td>Removal, Toxic Materials, Waste Products of metabolism in cells (respiration...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>By chemical reactions</strong></td>
</tr>
<tr>
<td>3.</td>
<td>Respiration</td>
<td>Break down, Food in cells, Release Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Stimuli</strong></td>
</tr>
<tr>
<td>4.</td>
<td>Sensitivity</td>
<td>Sense, Respond, Changes in the environment</td>
</tr>
<tr>
<td>5.</td>
<td>Reproduction</td>
<td>Produce, Offspring, Prevent extinction of species</td>
</tr>
<tr>
<td>6.</td>
<td>Growth</td>
<td>Increase, Size, Mass of an organism, By increasing cell number and/or cell size</td>
</tr>
<tr>
<td>7.</td>
<td>Movement</td>
<td>Change, Position or Place, of an organism or part of an organism</td>
</tr>
</tbody>
</table>

Ex: Parts of plants move very slowly to obtain more light for photosynthesis.
Credit: Painting Above All Else Guard Your Heart by Carmen Keys

Common misconceptions

- Don’t confuse **respiration** with **breathing**.

- Don’t use **faeces** or **defecation** as an example of **excretion** (faeces is indigested food - it has not been formed through metabolic processes).

- Some non-living things, such as a car, may appear to show some of the characteristics – but not all of them.

* Characteristics of living organisms Quiz*
# 2: Classification of living organisms

Classification: The scientific method of dividing organisms into smaller and larger groups, on basis of their similarities.

Swedish botanist Carolus Linnaeus is the Father of Systematic Biology. He believed he could:

- Put every organism into a group (the science of TAXONOMY)
- Give every organism a name (the science of NOMENCLATURE).

Carolus Linnaeus organized taxonomy (1735).

In his BINOMIAL SYSTEM, every living organism has a unique, two-part name:

- The first name is Genus, the second name is species.
- Names are written in Latin, printed in italics.
- The genus always has a capital letter, and the species always has a small letter.

For examples:

<table>
<thead>
<tr>
<th></th>
<th>Genus</th>
<th>Species</th>
<th>Abreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Homo</td>
<td>sapiens</td>
<td>H. sapiens</td>
</tr>
<tr>
<td>Lion</td>
<td>Panthera</td>
<td>leo</td>
<td>P. leo</td>
</tr>
<tr>
<td>Wolf</td>
<td>Canis</td>
<td>lupus</td>
<td>C. lupus</td>
</tr>
</tbody>
</table>
We still use this system today.

All life forms are categorized into a scheme that had 7 categorical terms. The biggest group are **Kingdom**, the smallest one is **Species**.

Each kingdom is divided into smaller group, which include genus and species. Organisms can exist in only one group at each level of classification. For example, an organism can only belong to one kingdom or one genus.
All living things are divided into 5 kingdoms. Each kingdom has certain characteristics that all members of that group shared. They are:

Animals, Plants, Fungi, Protoctists, Bacteria (Prokaryotes)

The characteristics that Linnaeus used to divide all organisms into one of the five groups included:

- How many cells made up their bodies, if their cells were very simple or had complex parts
- If they can move on their own
- If they could make their own food, or had to eat other creatures to survive ...

**Mnemonic**

Bacteria
Protoctists
Fungi
Plants
Animals mnemonic:
Bees Prefer Finding
Poohbear Alive
The animal kingdom contains many phyla. Some of them are:

**Vertebrates, Arthropods, Annelids, Molluscs, Nematodes.**

It is not always easy to recognise an animal. For a very long time, people thought that ‘sea anemones were plants, because they tend to stay in one place and their tentacles look rather kike petals. Now we know that they are animals.
One of the best way to tell if an organism is an animal is to look at its cells under the microscope. **Animal cells never have cell walls.**

Animals are classified into many phyla. Here are just some of these phyla:

**Classes** in two of these phyla:

Details of each phylum and class are given in the next topics.
Vertebrates are animals with backbones. They are divided into 5 groups called classes:

**Fish, Amphibians, Reptiles, Birds and Mammals.**

Details of each group are given in the table below. You only need to be able to describe visible external features, but other details can be helpful.
## VERTEBRATES (ANIMALS WITH BACKBONES)

<table>
<thead>
<tr>
<th>CLASS</th>
<th>EXTERNAL FEATURES</th>
<th>OTHER FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish (all aquatic)</td>
<td>Scales</td>
<td>Jelly-covered eggs; usually use external fertilisation</td>
</tr>
<tr>
<td></td>
<td>Fins</td>
<td>Ectothermic</td>
</tr>
<tr>
<td></td>
<td>Eyes and lateral line</td>
<td>Gills for gas exchange</td>
</tr>
<tr>
<td>Amphibians (always breed in water)</td>
<td>Moist skin</td>
<td>Jelly-covered eggs; external fertilisation</td>
</tr>
<tr>
<td></td>
<td>Four limbs</td>
<td>Ectothermic</td>
</tr>
<tr>
<td></td>
<td>Eyes and ears</td>
<td>lungs/skin for gas exchange</td>
</tr>
<tr>
<td>Reptiles (lay eggs on land)</td>
<td>Dry, scaly skin</td>
<td>Soft-shelled eggs; internal fertilisation</td>
</tr>
<tr>
<td></td>
<td>Four limbs (not in snakes)</td>
<td>Ectothermic</td>
</tr>
<tr>
<td></td>
<td>Eyes and ears</td>
<td>lungs for gas exchange</td>
</tr>
<tr>
<td>Birds (very few are aquatic)</td>
<td>Feathers (scales on legs)</td>
<td>Hard-shelled eggs; internal fertilisation</td>
</tr>
<tr>
<td></td>
<td>Two wings, two legs</td>
<td>Endothermic</td>
</tr>
<tr>
<td></td>
<td>Eyes and ears</td>
<td>lungs for gas exchange</td>
</tr>
<tr>
<td>Mammals (very few are aquatic)</td>
<td>Fur or hair</td>
<td>Live young (a few lay eggs)</td>
</tr>
<tr>
<td></td>
<td>Four limbs</td>
<td>Endothermic</td>
</tr>
<tr>
<td></td>
<td>Eyes and ears</td>
<td>lungs for gas exchange</td>
</tr>
<tr>
<td></td>
<td>Nipples</td>
<td>Feed young with milk from mammary glands</td>
</tr>
</tbody>
</table>

You could be asked to directly describe these in exam questions.

You could use these features in questions on other topics.
Classification of vertebrates

Vertebrates are animals with backbones (part of an internal skeleton). Vertebrates are divided into five groups called classes. Details of each group are given in the table below.

<table>
<thead>
<tr>
<th>Vertebrate class</th>
<th>Body covering</th>
<th>Movement</th>
<th>Reproduction</th>
<th>Sense organs</th>
<th>Other details</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>Scales</td>
<td>Fins (also used for balance)</td>
<td>Usually produces jelly-covered eggs in water</td>
<td>Eyes but no ears, lateral line along body for detecting vibrations in water</td>
<td>Cold-blooded, gills for breathing</td>
<td>Herring, perch, shark</td>
</tr>
<tr>
<td>Amphibians</td>
<td>Moist skin</td>
<td>Four limbs, back feet often webbed to make swimming more efficient</td>
<td>Produces jelly-covered eggs in water</td>
<td>Eyes and ears</td>
<td>Cold-blooded, lungs and skin for breathing</td>
<td>Frog, toad, salamander</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Dry, with scales</td>
<td>Four legs (apart from snakes)</td>
<td>Eggs with rubbery, waterproof shell – laid on land</td>
<td>Eyes and ears</td>
<td>Cold-blooded, lungs for breathing</td>
<td>Crocodile, python</td>
</tr>
<tr>
<td>Birds</td>
<td>Feathers, scales on legs</td>
<td>Wings, two legs</td>
<td>Eggs with hard shell</td>
<td>Eyes and ears</td>
<td>Warm-blooded, lungs for breathing, beak</td>
<td>Flamingo, pigeon</td>
</tr>
<tr>
<td>Mammals</td>
<td>Fur</td>
<td>Four limbs</td>
<td>Live young</td>
<td>Eyes, ears with pinna (external flap)</td>
<td>Warm-blooded, lungs for breathing, females have mammary glands to produce milk to feed young, four types of teeth</td>
<td>Elephant, mouse</td>
</tr>
</tbody>
</table>

1. Fish

Scales - Fins - Eyes & lateral Lines - Gills.
2. Amphibians

Moist scaleless skin - Eye & Ears - 4 limbs.

3. Reptiles

Dry scaly skin - Eyes & Ears - 4 legs (apart from snakes).

4. Birds
Beak - Feathers - Scales on legs - Wings - 2 legs.

5. Mammals

Fur - 4 limbs.
There are more arthropods than any other group of animals, so they are divided into classes:

**Insects, Crustaceans, Arachnids and Myriapods.**

**Special features of Arthropods:**

- Invertebrates (no backbone)
- Waterproof Exoskeleton —> Exist in very dry places, not confined to water or moist places like most invertebrates.
- Segmented body
- Jointed legs (exoskeleton prevents movement)

**4 classes of Arthropods**

1. **Insects**

Insects are a very successful group, due to their exoskeleton and tracheae, which are very good at stopping water from evaporating from insects’s body, so they can live in very dry places.
2. Crustaceans

These are the crabs, lobsters and woodlice. They breath through gills, so most of them live in wet places and many are aquatic.

3. Arachnids

These are spiders, ticks and scorpions. They are land-dwelling organisms.
Key features of Arachnids

- 4 pairs of legs
- no wings
- 2 body parts: Cephalothorax, Abdomen
- several pairs of simple eyes
- all have piercing jaws since all are predator
- chelicerae (pointed mouthparts) for biting and poisoning prey
4. Myriapods

These are the centipedes and millipedes.

Key features of Myriapods

- long, thin body with many segments for moving easily through soil and leaf litter
- no obvious thorax and abdomen
- each segment has jointed legs (>9 pairs)
- 1 pair of antennae as sense organs in dark habitats
- simple eyes
# 7 Other groups of invertebrates

Details about some more phyla of invertebrates:

**Annelids, Nematodes, Molluscs.**

1. Phylum Annelids

Annelids are worms, with bodies made up of ring-like segments. Most of them live in water, some like the earthworm live in moist soil.

2. Phylum Nematodes

Nematodes are worms, but unlike annelids their bodies are not divided into segments. They are usually white, long and thin. They live in many different habitats. Many nematodes live in the soil.
3. Phylum Molluscs

Molluscs are soft-bodied animals, sometimes with a shell (snails) or without (slugs).
Key features of Molluscs

- **soft, unsegmented body**
- **muscular foot** for movement or burrowing
- most have a **shelf** made of calcium carbonate (protection from predators/drying out)
- often have **eyes** on retractable tentacles

Common misconceptions

Students are often confused by the different **numbers of legs** in **insects**, **arachnids** and **crustaceans**.

They often lose the mark by stating that insects have **3 legs** instead of **3 pairs of legs**.
Plants are multicellular organisms, with cell wall made of **cellulose**. They include small organisms such as mosses, ferns and flowering plants.

At least some parts of a plant are green, thanks to pigment **chlorophyll**. Chlorophyll absorbs **energy** from sunlight for plant to make **glucose**, using **CO₂** and **H₂O** from environment. This is called **photosynthesis**.
They are divided into 2 groups, depending on number of seed leaves (Cotyledon):

1. **Monocotyledonous** (Monocots)
2. **Dicotyledonous** (Dicots)
### Differences between Monocot and Dicot leaves

<table>
<thead>
<tr>
<th>Feature</th>
<th>Monocot</th>
<th>Dicot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf shape</td>
<td>long, thin</td>
<td>broad</td>
</tr>
<tr>
<td>Leaf veins</td>
<td>parallel</td>
<td>branching (network of veins)</td>
</tr>
<tr>
<td>Seed leaf</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Example</td>
<td>Grasses</td>
<td>Trees</td>
</tr>
</tbody>
</table>

![Monocot and Dicot leaves comparison](image)
Viruses are not true living things. They are not considered to be alive, because on their own they can do nothing until they enter a living cell.

Viruses are complicated assemblies of molecules including proteins, nucleic acids, lipids, carbohydrates...

When viruses encounter a cell, they take over cell’s machinery. A series of chemical reactions occur that lead to the production of new viruses. These new viruses burst out of the cell and invade others, where the process is repeated. The host cell is usually killed when this happens.

These steps are completely passive, that is, they are predefined by the nature of the molecules that comprise the virus particle. Viruses don’t actually ‘do’ anything. **Without cells, viruses would not be able to multiply.**
Scientists do not classify a virus as a living thing. This is because:

- it does not show all seven processes for life
- when it enters a cell it changes the way a cell works so it can make copies of the virus.

**Key features of Viruses**

- very **small** (100 times smaller than bacteria)
- **no typical cell structure**
- contain a strand of **DNA** or **RNA**
- surrounded by a protein coat called a **capsid**
- the only life process they show is **reproduction** (inside host cell)
#10: Bacteria Kingdom

Bacteria cells are very different from the cells of all other organisms: they do **not have a nucleus**.

Some bacteria can carry out photosynthesis. The oldest fossils belong to this kingdom, so we think that they were the first kinds of organisms to evolve.

**Bacterial cell structure**
For a very long time, fungi were classified as plants. However, they are very different from plants and belong to their own kingdom. Fungi do not have chlorophyll and do not photosynthesize.

They feed saprophytically, or parasitically, on organic material like faeces, human foods and dead plants or animals.
A fungus is made of **hyphae**, which are long tubes, collectively they are called **mycellium** and form branches that can cover many acres.

The hypha is a long tube and effectively one cell with many nuclei. It could be divided into compartments by **septa**; The tip is tapered, this is where it is growing outwards and is known as the extension zone.
Fungi grow specialised areas for reproduction called **fruits**. These can grow very large and be visible to the naked eye where they are known as **mushrooms**. It is from these that spores are produced.
The identification of biological organisms can be greatly simplified using tools such as **dichotomous keys**. It is a written set of **choices**, each involving **two statements**, that leads to the **name** of an organism. Scientists use these to identify unknown organisms.

Consider the following animals. They are all related, but each is a separate species. Use the dichotomous key below to determine the species of each.
As seen above:

- the keys are **mutually exclusive characteristics** of biological organisms.
- they often begin with **general** characteristics and lead to more **specific** characteristics.
- you simply compare the characteristics of an unknown organism against an appropriate dichotomous key.
- if the organism falls into one category, you go to the next indicated couplet.

By following the key and making the correct choices, you should be able to identify your specimen to the indicated taxonomic level.
Try this

Figure above shows single leaves from six different trees. Use the key below to identify which tree each leaf comes from.

Make a table similar to the one below and put a tick in the correct box to show how you identify each leaf. Give the name of the tree. Leaf A has been identified for you as an example.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Name of tree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td><strong>a</strong></td>
<td>Leaf with smooth outline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>go to <strong>2</strong></td>
<td></td>
<td></td>
<td>Cydonia</td>
</tr>
<tr>
<td></td>
<td><strong>b</strong></td>
<td>Leaf with jagged outline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>go to <strong>3</strong></td>
<td></td>
<td></td>
<td>Magnolia</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td><strong>a</strong></td>
<td>Leaf about the same length as width</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cydonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>b</strong></td>
<td>Leaf about twice as long as it is wide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Magnolia</td>
<td>go to <strong>4</strong></td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>a</strong></td>
<td>Leaf divided into more than two distinct parts</td>
<td>go to <strong>4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>b</strong></td>
<td>Leaf not divide into more than two distinct parts</td>
<td>go to <strong>5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td><strong>a</strong></td>
<td>Leaf divided into five parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aesculus</td>
<td>go to <strong>5</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>b</strong></td>
<td>Leaf divided into ten or more parts</td>
<td>Fraxinus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td><strong>a</strong></td>
<td>Leaf with pointed spines along its edge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ilex</td>
<td>go to <strong>5</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>B</strong></td>
<td>Leaf with rounded lobes along its edge</td>
<td>Quercus</td>
<td>go to <strong>5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[4 marks]
## Answers

<table>
<thead>
<tr>
<th>Leaf</th>
<th>1a</th>
<th>1b</th>
<th>2a</th>
<th>2b</th>
<th>3a</th>
<th>3b</th>
<th>4a</th>
<th>4b</th>
<th>5a</th>
<th>5b</th>
<th>Name of tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Quercus</td>
</tr>
<tr>
<td>C</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>Ilex</td>
</tr>
<tr>
<td>D</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Fraxinus</td>
</tr>
<tr>
<td>E</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aesculus</td>
</tr>
<tr>
<td>F</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Magnolia</td>
</tr>
</tbody>
</table>

Additional sources:

http://www.biologycorner.com/bio1/notes_taxonomy.html
http://biology.clemson.edu/bpc/bp/Lab/104/Labmanual/LabEx/09Keys.pdf
http://www.biologyjunction.com/dichotomous_keying.htm
#13 Summary of Classification of Living things

- All living things have **7 characteristics**: Nutrition, Respiration, Growth, Excretion, Movement, Reproduction and Sensitivity.

- Living organisms are classified into groups according to how closely related they are. Each species of organism is given a unique two-word Latin name called a **binomial**. The first word of the binomial is the **genus** and the second word is the **species**.

- **Vertebrates** are classified into **5 classes**: fish, amphibians, reptiles, birds and mammals. They each have their own distinctive set of features. E.g. amphibians have a smooth skin, fish and reptiles have scales, birds have feathers and scales, and mammals have hair.

- **Arthropods** are invertebrates with joined legs and segmented bodies. They can be further classified into insects, arachnids, crustaceans and myriapods.

- **Annelids** are worm with **segmented** bodies but no legs.

- **Nematodes** are worms with **unsegmented** bodies.

- **Molluscs** have unsegmented bodies, and often have a **shell**.

- **Bacteria** are single-celled organisms whose cells do not have nuclei.

- **Fungi** include moulds, mushrooms and toadstools. They have cells with **cell walls** but do not photosynthesise.

- **Viruses** are not generally considered to be alive at all. They are not made of cells and cannot carry out any of the characteristics of living things on their own.

- **Flowering plants** can be classified in to **monocotyledonous** plants and **dicotyledonous** plants. **Monocots** have seeds with one cotyledon, and their leaves often have parallel veins. **Dicots** have seeds with two cotyledons, and their leaves generally have branching veins.

- A **dichotomous key** is a set of paired contrasting descriptions which lead you through to the identification of an unknown organism.