Chapter: 1 Characteristics and classification of living organisms

Book/PDF: Chapter-1-pdf.pdf

Pages: 1–52

Exam level: Cambridge IGCSE (0610)

1) Big-picture overview (100–150 words)

This chapter introduces the fundamental concepts of what it means to be alive and how scientists organise the vast diversity of life on Earth. It starts with the seven essential characteristics that all living things share, easily remembered by the mnemonic **MRS GREN**. You'll learn why a universal classification system is crucial, moving beyond simple groupings to a natural system based on shared features and evolutionary history. The chapter explains the **binomial system** for naming species, a key tool for scientists worldwide. It then dives into the major groups, or **kingdoms**, of life: Animals, Plants, Fungi, Protoctists, and Prokaryotes, detailing the key features of each. You'll explore the main classes within the animal kingdom (like arthropods and vertebrates) and plant kingdom (ferns and flowering plants), learning to identify them using their distinct characteristics.

2) Syllabus mapping

Outcome description (based on chapter content)	Where covered (page)
Define the characteristics of living organisms.	1-2
Define a species.	2, 3
State and explain the binomial system of naming species.	3, 4-5
Construct and use dichotomous keys.	6-9
Explain how classification systems can reflect evolutionary relationships.	10-15
Describe how DNA base sequences are used in classification.	16-17
List the main features of the five kingdoms: Animal, Plant, Fungus, Protoctist, and Prokaryote.	18, 36, 37, 43-46
List the main features of viruses, and explain why they are not classified as living organisms.	36, 47
List the main features of the phylum Arthropoda and its four main classes.	24-28
List the main features of the phylum Vertebrata and its five main classes.	28-35
List the main features of ferns.	38-41

Outcome description (based on chapter content)	Where covered (page)
List the main features of flowering plants and the differences between monocots and dicots.	41-42

3) Key terms and definitions

Term	One-sentence definition	First appears (page)	Example/application
Movement	An action by an organism or part of an organism causing a change of position or place.	2	A plant growing towards light; an animal running.
Respiration	The chemical reactions in cells that break down nutrient molecules and release energy.	2	Releasing energy from glucose for muscle contraction.
Sensitivity	The ability to detect and respond to changes in the internal or external environment.	2	A human pulling their hand away from a hot object.
Growth	A permanent increase in size and dry mass.	2	A seedling developing into a mature tree.
Reproduction	The processes that make more of the same kind of organism.	2	A bacterium dividing; a bird laying eggs.
Excretion	The removal of waste products of metabolism and substances in excess of requirements.	2	Humans releasing carbon dioxide when they breathe out.
Nutrition	The taking in of materials for energy, growth and development.	2	A plant photosynthesising; an animal eating food.
Species	A group of organisms that can reproduce to produce fertile offspring.	2	All domestic dogs belong to the species *Canis familiaris*.
Binomial system	An internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species.	3	The scientific name for humans is *Homo sapiens*.

Term	One-sentence definition	First appears (page)	Example/application
Dichotomous key	A tool used to identify unfamiliar organisms, made up of pairs of contrasting features.	6	Used to identify an unknown insect found in a garden.
Arthropods	A phylum of animals with jointed limbs and a hard, external skeleton (cuticle).	24	Insects, spiders, crabs, and centipedes.
Vertebrates	A phylum of animals which have a vertebral column (spine).	28	Fish, amphibians, reptiles, birds, and mammals.
Hyphae	Thread-like structures that make up the body of most fungi.	43	The network of hyphae forming a mycelium in a mould.
Virus	A non-cellular particle made of genetic material (DNA or RNA) surrounded by a protein coat.	36	Influenza virus, which causes the flu.
Monocotyledon	A flowering plant that has only one cotyledon (embryonic leaf) in its seeds.	41	Grasses, daffodils, and lilies.
Dicotyledon	A flowering plant that has two cotyledons in its seeds.	41	Oak trees, roses, and geraniums.

4) Core concepts explained

Characteristics of Living Organisms (p. 1)

All living things share seven key characteristics. A useful mnemonic to remember them is **MRS GREN**.

- **M**ovement: Changing position or place.
- **R**espiration: Releasing energy from food.
- **S**ensitivity: Detecting and responding to stimuli.
- **G**rowth: Permanently increasing in size.
- **R**eproduction: Producing more of the same kind of organism.
- **E**xcretion: Removing metabolic waste.
- **N**utrition: Taking in materials for energy and growth.

Classification and Naming (pp. 3-5)

- **Why Classify?** With millions of species, classification brings a meaningful order to the diversity of life (p. 3).
- **Natural vs. Artificial Systems:** Biologists use **natural systems** based on important shared features that reflect evolutionary relationships (e.g., all birds have feathers). **Artificial systems**, like grouping animals by colour, are not meaningful because they don't reflect ancestry (p. 3).
- **Hierarchy:** The smallest natural group is the **species**. Closely related species are grouped into a **genus** (p. 4).
- **Binomial System:** This is the universal method for naming species, developed to avoid the confusion of common names (p. 4).
  - It uses two Latin words: The first is the **Genus** (always capitalised), and the second is the **species** (always lowercase).
  - Example: The Indian robin is *Copsychus fulicatus*, while the British robin is *Erithacus rubecula*. Using these names avoids confusion between the two different species (p. 4).

Using Dichotomous Keys (pp. 6-9)

- **Purpose:** Dichotomous keys are tools used to identify unknown organisms (p. 6).
- **Structure:** "Dichotomous" means 'two branches'. The key consists of a series of paired, contrasting statements or questions.
- **How to Use:** At each step, you choose the statement that best describes the organism. This choice leads you to the next pair of statements, or to the identification of the organism.

Classification, Anatomy and DNA (pp. 10-17)

- **Evolutionary Relationships:** Modern classification aims to reflect evolutionary history. Organisms with a more recent common ancestor are grouped more closely together (p. 14).
- **Anatomical Evidence:** A key piece of evidence is the **homologous structure**, such as the **pentadactyl limb** found in vertebrates (human, lizard, bird, whale, bat) (p. 12-13). Although the limbs perform different functions (e.g., flying, swimming), they share the same basic bone pattern, suggesting they all evolved from a common ancestor.
- **DNA Evidence:** Comparing the sequence of bases in the DNA of different organisms is a powerful tool for classification (p. 16).
  - The more similar the DNA base sequences are between two species, the more closely related they are (i.e., they share a more recent common ancestor) (p. 16).
  - For example, DNA analysis shows humans are more closely related to chimpanzees (1.2% genome difference) than to orangutans (3.1% difference) (p. 16).

The Five Kingdoms of Life (pp. 18, 36-47)

Biologists often use a five-kingdom scheme to classify all living organisms.

Feature	Animal	Plant	Fungus	Protoctist	Prokaryote
Cell type	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Prokaryotic
Number of cells	Multicellular	Multicellular	Mostly multicellular (hyphae)	Mostly unicellular	Unicellular
Cell wall	No	Yes (cellulose)	Yes (chitin)	Some have walls	Yes (not cellulose)
Nutrition	Heterotrophic (ingestion)	Autotrophic (photosynthesis)	Heterotrophic (saprotrophic)	Autotrophic or Heterotrophic	Various modes
Nucleus	Yes	Yes	Yes	Yes	No (nucleoid region)
Example	Mammal, Insect	Fern, Flowering plant	Mushroom, Yeast	*Amoeba*, *Euglena*	Bacteria
Exam Note	Viruses are not in any kingdom as they are not true cells and cannot perform life processes on their own (p. 36). They are composed of genetic material (DNA or RNA) inside a protein coat (p. 47).				

The Animal Kingdom: Arthropods vs. Vertebrates (pp. 24-35)

This chapter focuses on two major animal phyla:

Feature	Arthropods	Vertebrates	Exam Note
Skeleton	External (exoskeleton)	Internal (endoskeleton)	The term 'invertebrate' is a convenience for all animals without a backbone, not a formal group (p. 23).
Key feature	Jointed limbs	Vertebral column (spine)	
Examples	Insects, Spiders, Crabs	Fish, Birds, Mammals	

Classes of Arthropods (p. 28)

Class	Body parts	Legs	Antennae	Example
Insects	Head, thorax, abdomen	3 pairs (6)	1 pair	Wasp, Butterfly
Arachnids	Cephalothorax, abdomen	4 pairs (8)	None	Spider, Mite
Crustaceans	Cephalothorax, abdomen	5+ pairs	2 pairs	Crab, Woodlouse
Myriapods	Head, segmented body	10+ pairs	1 pair	Centipede, Millipede

Classes of Vertebrates (p. 35)

Class	Body covering	Gas exchange	Reproduction	Temperature Regulation	Example
Fish	Wet scales	Gills	External fertilisation (in water)	Cold-blooded	Trout
Amphibians	Moist, smooth skin	Lungs and skin	External fertilisation (in water)	Cold-blooded	Frog
Reptiles	Dry, scaly skin	Lungs	Internal fertilisation (shelled eggs on land)	Cold-blooded	Lizard
Birds	Feathers (scales on legs)	Lungs	Internal fertilisation (hard-shelled eggs)	Warm-blooded	Sparrow
Mammals	Hair / Fur	Lungs	Internal fertilisation (live birth), feed young with milk	Warm-blooded	Mouse, Human

The Plant Kingdom: Ferns vs. Flowering Plants (pp. 37-42)

Feature	Ferns	Flowering Plants	Exam Note
Key structures	Have roots, stems, and leaves	Have roots, stems, leaves, and flowers	
Reproduction	By spores (found on the underside of leaves)	By seeds (produced in flowers, enclosed in an ovary)	Ferns are non-seed-bearing plants.

Types of Flowering Plants (p. 42)

Feature	Monocotyledons (Monocots)	Dicotyledons (Dicots)
Cotyledons	One	Two
Leaf shape	Long and narrow	Broad
Leaf veins	Parallel	Branching network
Flower parts	In multiples of 3	In multiples of 4 or 5
Example	Grass, Daffodil	Geranium, Oak Tree

5) Diagrams and micrographs (figures)

- **Pentadactyl Limb (Figure 1.9, p. 12-13)**
  - **What it shows:** The limb skeletons of five different vertebrates (human, lizard, bird, whale, bat), illustrating a homologous structure.
  - **Labels:** Humerus (one upper arm bone), Radius and Ulna (two forearm bones), Carpals (wrist bones), Metacarpals and Phalanges (five groups of hand/finger bones).
  - **To redraw:** Draw a single bone connected by a hinge joint to two parallel bones. These connect to a block of small wrist bones, which then branch out into five "finger" bones.
- **External Features of an Insect (Figure 1.16, p. 26)**
  - **What it shows:** A typical insect body plan (greenbottle fly).
  - **Labels:** Head (with one pair of antennae, compound eyes), Thorax (with three pairs of legs, wings attached), Abdomen (segmented).
- **Leaf Types in Flowering Plants (Figure 1.30, p. 42)**
  - **What it shows:** The difference in leaf venation between monocots and dicots.
  - **Labels (Monocot):** Parallel veins running the length of a narrow leaf.
  - **Labels (Dicot):** Main vein with a branching network of smaller veins in a broad leaf.
- **Generalised Structure of a Virus (Figure 1.36, p. 47)**
  - **What it shows:** The basic components of a non-cellular virus particle.
  - **Labels:** Central core of genetic material (labelled as an RNA strand), surrounded by a protein coat (capsid). Viruses have no nucleus, cytoplasm, or organelles.

6) Processes and cycles

Using a Dichotomous Key (p. 6)

- **Step 1:** Start at the first pair of statements (couplet 1).
- **Step 2:** Observe the unknown organism and decide which of the two statements best describes it.
- **Step 3:** Follow the instruction at the end of that statement. It will either identify the organism or direct you to another couplet.

- **Step 4:** Repeat the process until the organism is identified.
- **Inputs → Outputs:** Input is an unknown organism; output is its identification.
- **Common Error:** Misinterpreting a feature or choosing the wrong statement. Always read both options carefully before deciding.

7) Formulae and calculations

Quantity	Formula	Units	Worked example (from p. 51)
Percentage of a subgroup	$\left(\frac{\text{Number in subgroup}}{\text{Total number in main group}}\right) \times 100$	%	**Calculate what percentage of arthropods are arachnids.** 1. **Find total arthropods:** 4.5% (arachnids) + 56.3% (insects) + 2.4% (crustaceans) + 1.2% (other arthropods) = 64.4% of all species. 2. **Use the formula:** $\left(\frac{4.5}{64.4}\right) \times 100 = 6.987\ldots$ 3. **Answer:** Arachnids make up approximately **7.0%** of all

Quantity	Formula	Units	Worked example (from p. 51)
			arthropods (to 2 sig. figs.).

8) Required practicals / experiments

Not covered in this chapter.

9) Data handling and graphing

- **Comparison Tables:** The chapter uses tables extensively to compare the features of different groups (e.g., Arthropod classes, p. 28; Vertebrate classes, p. 35; Monocots vs. Dicots, p. 42). Exam questions may ask you to extract data from such tables or to create one.
- **Dichotomous Keys:** These are a form of data sorting. You need to be able to use a provided key to identify an organism and construct your own simple key for a given set of organisms.
- **Evolutionary Trees (Phylogenetic Trees):** Figure 1.12 (p. 17) is an evolutionary tree for primates.
  - **How to read it:** The vertical axis represents time (past at the bottom, present at the top). Branching points represent a common ancestor. Organisms on branches that split more recently are more closely related.
  - **Exam prompt:** "Which two species share the most recent common ancestor?" Look for the two species whose branches join closest to the top of the diagram. In Fig 1.12, this is the chimpanzee and bonobo.

10) Common misconceptions and exam tips

- **Misconception:** Viruses are a type of simple, living cell.
  - **Correct Understanding:** Viruses are not cells and are not considered truly living (p. 36). They lack cytoplasm, organelles, and cannot reproduce without a host cell.
  - **Quick Tip:** Remember, "No cell, no life."
- **Misconception:** "Cold-blooded" means an animal's blood is always cold.
  - **Correct Understanding:** It means the animal's body temperature is variable and depends on the external environment. They are more accurately called poikilotherms (p. 29).
  - **Quick Tip:** Cold-blooded = variable temperature; Warm-blooded = constant temperature.
- **Misconception:** Spiders, crabs, and centipedes are all insects.
  - **Correct Understanding:** They are all arthropods, but belong to different classes. Insects are defined by having 6 legs and 3 body parts (p. 28).
  - **Quick Tip:** Count the legs! 6 = Insect, 8 = Arachnid, 10+ = Crustacean/Myriapod.
- **Misconception:** The binomial name can be written in any case (e.g., homo Sapiens).

- - **Correct Understanding:** The format is strict: *Genus* (capitalised) *species* (lowercase) (p. 5).
  - **Quick Tip:** First name is a capital, second is small. Genus gets the "capital treatment."

11) Exam-style practice

Multiple Choice Questions

1. Which characteristic of living organisms describes the release of energy from nutrient molecules?
   A. Excretion
   B. Nutrition
   C. Respiration
   D. Sensitivity
2. The scientific name for the tiger is *Panthera tigris*. What does *Panthera* represent?
   A. Species
   B. Kingdom
   C. Class
   D. Genus
3. Which of these is a feature of all arthropods?
   A. Six legs
   B. Wings
   C. Jointed limbs
   D. Two pairs of antennae
4. A vertebrate is found with moist skin and lays jelly-covered eggs in water. To which class does it belong?
   A. Reptilia
   B. Amphibia
   C. Pisces (Fish)
   D. Mammalia
5. Which feature is characteristic of a dicotyledonous plant but not a monocotyledonous plant?
   A. Produces flowers
   B. Has leaves with parallel veins
   C. Contains chloroplasts
   D. Has leaves with a branching network of veins
6. Why are viruses not classified into any of the five kingdoms?
   A. They are unicellular
   B. They do not contain genetic material
   C. They cannot reproduce without a host cell
   D. They have a cell wall made of chitin
7. An animal has 8 legs and its body is divided into a cephalothorax and abdomen. It is a(n)...
   A. Insect
   B. Crustacean
   C. Myriapod
   D. Arachnid

8. DNA sequence analysis shows that species X and Y have 98% similarity, while species X and Z have 92% similarity. What can be concluded?

A. Species X is more closely related to Z than to Y.

B. Species X is more closely related to Y than to Z.

C. All three species are equally related.

D. Species Y and Z are the most closely related.

9. Which statement about a dichotomous key is correct?

A. It can only be used to identify plants.

B. It consists of pairs of contrasting statements.

C. It groups organisms based on their colour.

D. Each step provides three or more choices.

10. Which row correctly matches the vertebrate class with its features?

	Class	Body Covering	Temperature Regulation
A	Bird	Feathers	Cold-blooded
B	Mammal	Fur / Hair	Warm-blooded
C	Reptile	Moist skin	Warm-blooded
D	Fish	Dry scales	Cold-blooded

MCQ Answers:

1. **C** (Respiration is the chemical process of releasing energy from food, p. 2).
2. **D** (The first part of a binomial name is the genus, p. 5).
3. **C** (The name arthropod means 'jointed limbs', a feature common to all, p. 24).
4. **B** (Amphibians have moist skin and return to water to lay eggs, p. 30).
5. **D** (Dicots have broad leaves with branching veins, while monocots have parallel veins, p. 42).
6. **C** (Viruses are considered non-living because they are dependent on a host for all metabolic processes, including reproduction, p. 36).
7. **D** (Arachnids are defined by 4 pairs of legs (8 total) and a cephalothorax, p. 28).
8. **B** (Greater similarity in DNA sequence indicates a more recent common ancestor and thus closer relation, p. 16).
9. **B** (A dichotomous key is based on pairs of contrasting features, p. 6).
10. **B** (Mammals have fur/hair and are warm-blooded. Birds are warm-blooded, reptiles have dry scales, and fish have wet scales, p. 35).

Short-Answer Questions

1. **State the seven characteristics of living organisms.**
   - Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion, Nutrition. [3 marks]
2. **Explain two reasons why the binomial system is important for scientists.**
   - It is an internationally agreed system, so it overcomes language barriers. [1]

- It avoids the confusion caused by common names, where one name might refer to multiple species or one species might have multiple names. [1]

3. **State three features that distinguish insects from arachnids.**
   - Insects have 3 pairs of legs (6 total), while arachnids have 4 pairs (8 total). [1]
   - Insects have one pair of antennae, while arachnids have none. [1]
   - The insect body is divided into head, thorax, and abdomen, while the arachnid body is divided into cephalothorax and abdomen. [1]

4. **A student classifies a fungus as a plant. State two reasons why this classification is incorrect.**
   - Fungi do not have chloroplasts and cannot carry out photosynthesis. [1]
   - Fungal cell walls are made of chitin, not cellulose like plants. / Fungi are mostly made of hyphae, not cells with a fixed structure like plants. [1]

5. **Distinguish between ferns and flowering plants in terms of their reproduction.**
   - Ferns reproduce using spores. [1]
   - Flowering plants reproduce using seeds, which are produced inside flowers. [1]

Structured Questions

1. The diagram shows five classes of vertebrates.
[Image showing a fish, a frog, a lizard, a bird, and a mouse]
a) **Construct** a simple dichotomous key that could be used to identify the class of each vertebrate shown. [5]
b) **State** one visible feature, other than body covering, that is unique to mammals among the vertebrates. [1]

Marking Points:
a)

1. Animal is warm-blooded -> go to 2
   Animal is cold-blooded -> go to 3 [1]
2. Animal has feathers -> Bird
   Animal has fur/hair -> Mammal [1]
3. Animal has gills and fins -> Fish
   Animal has lungs and limbs -> go to 4 [1]
4. Animal has dry, scaly skin -> Reptile [1]
   Animal has moist, smooth skin -> Amphibian [1]

b)

- Presence of external ears (pinnae) / females have mammary glands. [1]

2. DNA sequencing is a modern tool used in classification.
a) **Define** the term species. [2]
b) **Explain** how the sequence of bases in DNA can be used to show how closely related different species are. [3]
c) Traditional classification placed humans in their own family, separate from apes like chimpanzees and gorillas.
Describe how DNA evidence has changed this view. [2]

Marking Points:

a)

- A group of organisms that can reproduce [1]
- to produce fertile offspring. [1]

b)

- The sequence of bases in DNA is unique to each species. [1]
- The more similar the base sequences are between two species, the more closely related they are. [1]
- This is because they share a more recent common ancestor and have had less time for mutations to cause differences. [1]

c)

- DNA evidence shows humans are very closely related to chimpanzees and gorillas. [1]
- Humans are more closely related to chimpanzees than chimpanzees are to gorillas, so humans are now classified within the great ape family. [1]

12) Quick revision checklist

- ☐ Can you list and define the 7 characteristics of living things (MRS GREN)?
- ☐ Do you know that a species can reproduce to create fertile offspring?
- ☐ Can you explain the rules of the binomial system (*Genus species*)?
- ☐ Can you use a dichotomous key to identify an organism?
- ☐ Can you explain that classification reflects evolutionary relationships shown by DNA and anatomy (e.g., pentadactyl limb)?
- ☐ Do you know the five kingdoms: Animal, Plant, Fungus, Protoctist, Prokaryote?
- ☐ Can you state the key difference between an arthropod (exoskeleton) and a vertebrate (spine)?
- ☐ Can you list the 4 classes of arthropods and one defining feature for each (e.g., insects have 6 legs)?
- ☐ Can you list the 5 classes of vertebrates and one defining feature for each (e.g., birds have feathers)?
- ☐ Do you know that fish, amphibians, and reptiles are "cold-blooded" (variable temperature)?
- ☐ Can you state two main differences between fungi and plants (nutrition, cell wall)?
- ☐ Can you explain why viruses are not considered living?
- ☐ Can you list two key differences between monocots and dicots (leaf veins, number of cotyledons)?

13) Flashcards (ready-to-use)

Question (Front)	Answer (Back)
What does MRS GREN stand for?	Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion, Nutrition.

Question (Front)	Answer (Back)
What is a species?	A group of organisms that can reproduce to produce fertile offspring.
What are the two parts of a scientific name?	Genus (capitalised) and species (lowercase).
What is a dichotomous key?	A tool with paired, contrasting statements used to identify organisms.
What is the pentadactyl limb?	A five-fingered limb structure found in all vertebrates, providing evidence for a common ancestor.
How does DNA show relatedness?	The more similar the DNA base sequence, the more closely related the species.
What is the main feature of an arthropod?	An exoskeleton and jointed legs.
What is the main feature of a vertebrate?	A vertebral column (backbone).
How many legs do insects have?	6 (three pairs).
How many legs do arachnids have?	8 (four pairs).
What is the body covering of a reptile?	Dry, scaly skin.
What is the body covering of an amphibian?	Moist, smooth skin.
What is a key feature of mammals?	Have fur/hair and feed their young with milk.
What is a key feature of birds?	Have feathers and a beak.
Why is a fungus not a plant?	It is a heterotroph (not photosynthetic) and its cell walls are made of chitin (not cellulose).
What are the two main groups of flowering plants?	Monocotyledons and Dicotyledons.
What is the difference in leaf veins between monocots and dicots?	Monocots have parallel veins; Dicots have a branching network of veins.
How do ferns reproduce?	Using spores, not seeds.
What are viruses made of?	Genetic material (DNA or RNA) inside a protein coat.
Are viruses living?	No, because they cannot perform life processes (e.g., reproduce) without a host cell.

14) 60-second recap

This chapter covers the seven characteristics of life, remembered as MRS GREN. All life is organised into groups based on shared features and evolutionary history. We name organisms using the two-part binomial system: *Genus species*. We can identify them using dichotomous keys. Classification reflects evolution, with anatomical evidence like the pentadactyl limb and molecular evidence from DNA showing how closely species are related. Life is divided into five kingdoms. Animals are multicellular heterotrophs, including arthropods (insects, arachnids) and vertebrates (fish, amphibians, reptiles, birds, mammals). Plants are multicellular autotrophs, including ferns (spores) and flowering plants (seeds), which are split into monocots and dicots. Fungi are decomposers with chitin cell walls. Protoctists are mostly unicellular eukaryotes, and Prokaryotes are unicellular without a nucleus. Viruses are non-cellular particles, not classified as living.

15) References to pages