

Characteristics and classification of living organisms

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What you need to know

This is the first topic in the course: what makes something alive, and how biologists sort living things into groups. The parts marked **Extended only** are tested on Papers 2 and 4 only. By the end of it you should be able to:

Characteristics of living organisms

1. **Describe the seven characteristics of living things**, each with its meaning: movement, respiration, sensitivity, growth, reproduction, excretion and nutrition.

Classification

2. **State that organisms are sorted into groups by the features they share.**
3. **Describe a species** as a group of organisms that can reproduce to produce fertile offspring.
4. **Describe the binomial system**: the naming system used all over the world, in which every species has a two-part scientific name, the genus followed by the species.
5. **Use and construct dichotomous keys** based on features you can see.
6. **Extended only**: explain that classification systems try to show evolutionary relationships (which groups share ancestors).
7. **Extended only**: explain that the sequence of bases in DNA is used to classify organisms, and that groups sharing a more recent ancestor (more closely related) have more similar base sequences than groups that share only a distant ancestor.

Features of organisms

8. **State the main features that place an organism in the animal kingdom or the plant kingdom.**
9. **State the main features of the five vertebrate groups** (mammals, birds, reptiles, amphibians, fish) and the **four arthropod groups** (myriapods, insects, arachnids, crustaceans), and use them to classify an organism.
10. **Extended only**: state the main features of all **five kingdoms**: animal, plant, fungus, prokaryote and protist, and use them to classify an organism.
11. **Extended only**: state the main features of **ferns** and **flowering plants**, and of the two groups of flowering plants, **dicotyledons** and **monocotyledons**, and use them to classify a plant.

12. **Extended only:** state the features of **viruses**: a protein coat and genetic material.

Understand it

What makes something alive

Every living organism, from a bacterium to an oak tree, carries out all seven of these processes. A handy way to remember them is **MRS GREN**:

Characteristic	What it means
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Movement	an action by the organism, or part of it, that changes its position or place
Respiration	the chemical reactions in cells that break down nutrient molecules and release energy for metabolism
Sensitivity	detecting changes inside or outside the body (stimuli) and responding to them
Growth	a permanent increase in size and dry mass
Reproduction	the processes that make more of the same kind of organism
Excretion	removing the waste products of metabolism, and substances that are in excess of what the body needs
Nutrition	taking in materials for energy, growth and development

Plants do all seven too. A plant **moves** when its leaves turn towards light or a Venus flytrap snaps shut, it **respires** in every living cell day and night, and it **excretes** oxygen made in photosynthesis and carbon dioxide made in respiration.

Some words look like characteristics but are **not** shared by all living things:

- **Breathing** is the muscle movement that moves air in and out of lungs. Plants, fungi and bacteria don't breathe, but they all **respire**.
- **Photosynthesis** happens only in plants (and some protocists and bacteria), and **transpiration** only in plants. Photosynthesis is one kind of **nutrition**.
- **Egestion** is getting rid of undigested food (faeces). That food was never part of the body's chemistry, so egestion is **not** excretion.
- **Digestion** and **ingestion** are parts of nutrition in animals only.

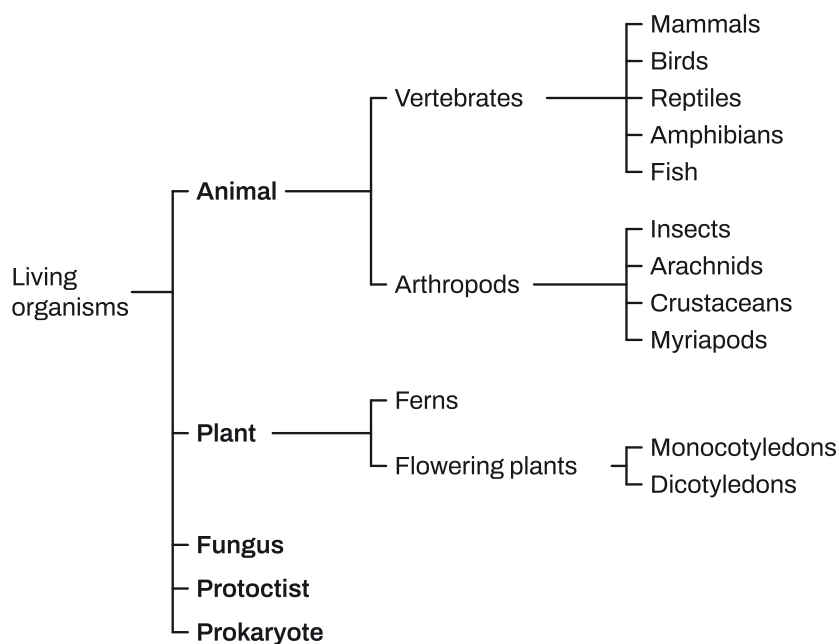
Exam questions often describe a scene and ask which characteristics it shows. Ask yourself what is happening:

- something detects a stimulus and reacts (light, touch, heat, a predator) → **sensitivity**, and if a part changes position, **movement** as well;
- dry mass goes up for good (a seed becoming a seedling, a plant getting bigger) → **growth**;
- energy is released from food, or yeast gives off carbon dioxide from sugar → **respiration**;

- carbon dioxide, urea or excess water or salts leave the body (including carbon dioxide breathed out of the lungs) → **excretion**;
- materials are taken in for building or energy (eating, a leaf taking in carbon dioxide and water for photosynthesis, food for tissue repair) → **nutrition**.

Why we classify

There are millions of species. Biologists sort them into groups by the **features they share**, so that similar organisms sit together and a new organism can be placed quickly. The biggest groups are **kingdoms**. Each kingdom is split again and again into smaller groups, ending with the **genus** and then the **species**.



Species

A **species** is a group of organisms that can reproduce with each other to produce **fertile offspring** (young that can themselves breed).

Two different species can sometimes mate. A horse and a donkey, for example, can produce a mule, but the mule is **infertile**. Because the offspring can't breed, the horse and the donkey are separate species, and the mule is not a species at all. Members of one species do **not** have to look identical: dogs of different breeds are one species because they can breed together and their puppies are fertile.

The binomial system

Common names change from language to language ("wolf", "lobo", "loup"), so scientists use one scientific name everywhere. In the **binomial system** (bi = two, nomial = name), every species has a two-part name:

- the first word is the **genus**, and it starts with a capital letter;
- the second word is the **species**, all in small letters.

In print the name is in *italics*; when you write it by hand, underline it. For the grey wolf, *Canis lupus*, the genus is *Canis* and the species is *lupus*. The coyote, *Canis latrans*, is in the **same genus** (both start *Canis*) but is a **different species**. Species in the same genus are closely related. Sharing the second word means nothing: *Canis lupus* and a plant called *Lupinus lupus* would be completely unrelated, so always compare the **first** word.

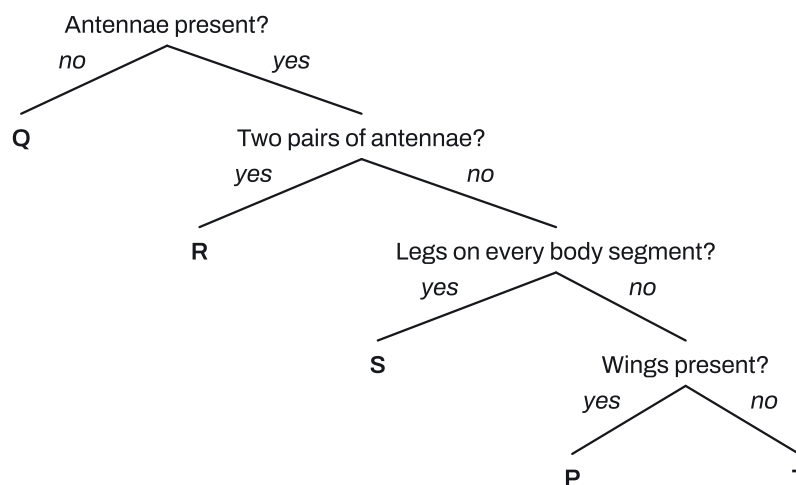
Dichotomous keys

A **dichotomous key** identifies an organism by a series of choices, each between **two** statements about a feature you can see ("dichotomous" means dividing into two). Each choice either names the organism or sends you to another step.

Keys come in two layouts:

- a **numbered key**: pairs of statements, 1(a) and 1(b), 2(a) and 2(b) and so on, each ending in a name or "go to ...";
- a **branching key**: a diagram of yes/no questions that split like a tree.

The diagram shows a branching key for the five arthropods P to T in Worked example 2.



To **construct** a key, pick a feature that splits the group into two, then keep splitting each smaller group until every organism is on its own. Good features are ones you can see and count (number of legs, wings present or not, shape of the leaf), not size, colour that varies, or behaviour.

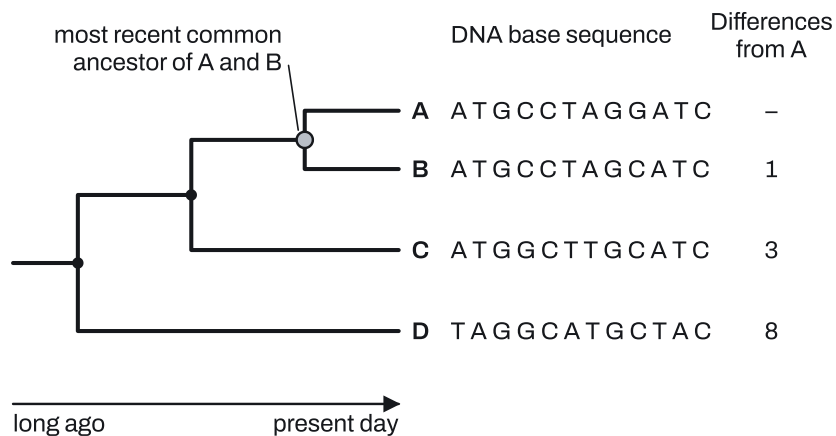
Classification and evolution (Extended only)

Extended only: classification tries to reflect **evolutionary relationships**: organisms in the same group should share a common ancestor. Grouping by appearance alone can mislead, because unrelated organisms can look alike (a whale looks like a fish, but it is a mammal).

Extended only: a better method compares the **sequence of bases in DNA** (the order of A, T, C and G). DNA is copied from parent to offspring, and small changes build up over time. Two species that split from a **recent** common ancestor have had little time to change, so their base sequences are **very similar**. Species whose

common ancestor lived long ago have **more differences**. Every kingdom uses the same genetic code, which is why DNA can be compared across all living things. What matters is the **sequence** (order) of bases, not the number of bases or which four bases are present.

Extended only: a branching diagram like the one below shows these relationships. Each branch point is a common ancestor. The later (closer to the tips) two species join, the more recent their shared ancestor and the more alike their DNA.



The kingdoms

The animal and plant kingdoms (Core):

Kingdom Main features

Animal	multicellular; cells have no cell wall and no chloroplasts ; feed on organic substances made by other organisms; usually able to move the whole body
Plant	multicellular; cells contain chloroplasts with chlorophyll and photosynthesise ; cells have a cellulose cell wall and usually a large permanent vacuole

So a question asking for "structures in plant cells but not animal cells" wants **chloroplasts**, a **cellulose cell wall** and a **large permanent vacuole**.

Extended only: all living organisms fit into one of **five kingdoms**:

Kingdom	Main features	Examples
Animal	as above	insects, fish, humans
Plant	as above	ferns, grasses, trees
Fungus	usually multicellular, made of thread-like hyphae (yeast is single-celled); cell walls not made of cellulose (they are chitin); no chloroplasts ; feed by releasing digestive enzymes onto food outside the body and absorbing the products; reproduce by spores	mushrooms, moulds such as <i>Penicillium</i> , yeast

Kingdom	Main features	Examples
Protoctist	mostly single-celled with a nucleus ; some are like plant cells (with chloroplasts), some like animal cells; some are multicellular, like seaweeds	<i>Amoeba</i> , <i>Chlorella</i> , <i>Plasmodium</i>
Prokaryote	single-celled; no nucleus : DNA is a single circular loop free in the cytoplasm, often with extra small rings called plasmids ; cell wall not made of cellulose; no mitochondria or chloroplasts	bacteria

Extended only: to classify an organism from its cells, work through these questions in order:

1. **Is there a nucleus?** No → prokaryote.
2. **Is it single-celled?** Yes (with a nucleus) → protoctist (unless it is yeast, which is a fungus).
3. **Chloroplasts and a cellulose cell wall?** → plant.
4. **A wall that is not cellulose, no chloroplasts, feeds by releasing enzymes and absorbing?** → fungus.
5. **No cell wall and no chloroplasts, eats other organisms?** → animal.

"Bacteria" is a group inside the prokaryote kingdom, so when asked for the **kingdom**, write **prokaryote**.

Vertebrates

Vertebrates are animals with a **backbone** (vertebral column) made of small bones called vertebrae, inside an internal skeleton that also includes a skull and ribs round the chest. There are five groups:

Group	Skin or covering	Other main features	Eggs
Mammals	hair or fur	mammary glands that make milk; external ears (pinnae); different types of teeth (incisors, canines, molars); whiskers	most give birth to live young
Birds	feathers	a beak ; front limbs are wings ; two legs with scales	hard shells
Reptiles	dry skin with scales	lungs; four legs (snakes have none)	soft, leathery shells, laid on land
Amphibians	moist skin, no scales	young (tadpoles) live in water and use gills; adults live on land and in water and use lungs and skin	soft, laid in water, covered in jelly
Fish	scales	fins ; gills (covered by a bony flap); a lateral line along the side	soft, laid in water

Choose a feature **only that group has**. Feathers identify a bird; "lays eggs", "has wings" or "has two legs" do not (reptiles lay eggs, insects and bats have wings). Hair or fur identifies a mammal; mammary glands do too, but you can't see them in a photograph.

Arthropods

Arthropods are animals without a backbone that have **jointed legs**, a hard outer covering (an **exoskeleton**) and a **segmented body**. There are four groups; count legs, antennae and body parts to tell them apart.

Group	Legs	Antennae	Body	Other features	Examples
Insects	3 pairs (6)	1 pair	3 parts: head, thorax, abdomen	usually wings (1 or 2 pairs); compound eyes	flies, beetles, ants, butterflies
Arachnids	4 pairs (8)	none	2 parts	may have small feeler-like pedipalps near the mouth (not legs)	spiders, scorpions, ticks, mites
Crustaceans	more than 4 pairs (usually 5 pairs or more)	2 pairs	head and thorax often joined under a shell	mostly live in water; often a pair of pincers; gills	crabs, lobsters, shrimps, woodlice
Myriapods	many: a pair (or two pairs) on every segment	1 pair	many similar segments , no separate thorax	long, thin body	centipedes (one pair per segment), millipedes (two pairs per segment)

Woodlice live on land, but they are crustaceans: count seven pairs of legs and two pairs of antennae.

Plants: ferns and flowering plants (Extended only)

Extended only: the plant kingdom has two groups you need:

- **Ferns** have leaves called **fronds** (often divided into many small leaflets), **no flowers** and **no seeds**; they reproduce with **spores**, made in small brown patches on the underside of the fronds.
- **Flowering plants** reproduce with **flowers**, and make **seeds** inside fruits.

Extended only: flowering plants are either **monocotyledons** or **dicotyledons**:

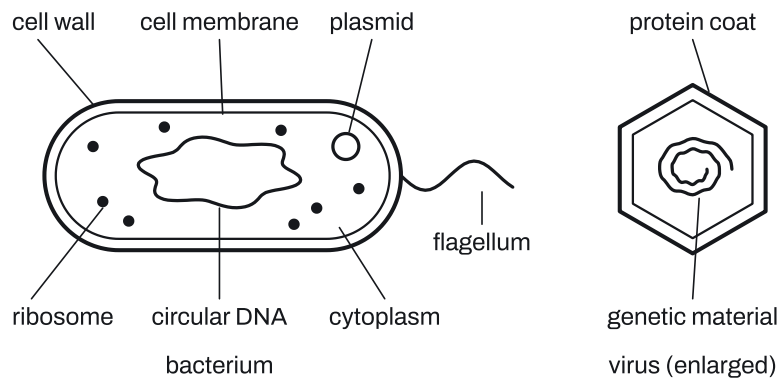
Feature	Monocotyledons	Dicotyledons
Seed leaves (cotyledons) in the seed	one	two
Leaf shape	long and narrow (strap-like)	usually broad
Leaf veins	parallel	branching (a network)
Flower parts (petals and others)	in threes (3, 6, 9 ...)	in fours or fives (4, 5, 8, 10 ...)
Vascular bundles in the stem	scattered	in a ring
Examples	grasses, maize, lilies, onions	beans, roses, oak trees

Viruses (Extended only)

Extended only: a virus is **not made of a cell** and is not in any kingdom. All you need is its two parts:

- a **protein coat** on the outside;
- **genetic material** (DNA or RNA) inside.

A virus has **no** cell wall, cell membrane, cytoplasm, ribosomes, nucleus or mitochondria. It can only reproduce inside a living cell of another organism. A bacterium, by contrast, is a complete (prokaryotic) cell.



Key facts and formulas

This topic has no formulas or given data. Everything below must be learnt.

Formula	Status
MRS GREN: movement, respiration, sensitivity, growth, reproduction, excretion, nutrition	Learn it
Growth = a permanent increase in size and dry mass	Learn it
Excretion = removal of the waste products of metabolism and substances in excess of requirements	Learn it
Species = a group of organisms that can reproduce to produce fertile offspring	Learn it
Scientific name = <i>Genus species</i> ; genus first, with a capital letter	Learn it
Insects: 3 pairs of legs, 1 pair of antennae, 3 body parts	Learn it
Arachnids: 4 pairs of legs, no antennae, 2 body parts	Learn it

Formula	Status
Crustaceans: more than 4 pairs of legs, 2 pairs of antennae	Learn it
Myriapods: legs on every segment, 1 pair of antennae	Learn it
Extended: prokaryote = no nucleus; fungus = non-cellulose wall, no chloroplasts, feeds by releasing enzymes and absorbing; protoctist = mostly single-celled with a nucleus	Learn it
Extended: monocot = parallel veins, parts in 3s; dicot = branching veins, parts in 4s or 5s	Learn it
Extended: virus = protein coat + genetic material	Learn it
Extended: more recent common ancestor → more similar DNA base sequences	Learn it

How to do it

In the questions we have tagged for this topic (248 questions, 2021–2025, on Papers 1–4), the types came up this often. 31 of the 248 questions mix types, so the counts add up to more than 248.

Question type	Questions
Recognise or name the characteristics of living organisms	79
Use the binomial system	45
Identify an arthropod group from its features	42
Identify a vertebrate group or state its features	30
Define species or apply "fertile offspring"	25
Identify or name kingdoms from cell features	22
Use a dichotomous key to identify organisms	21
Judge relatedness from DNA base sequences or a branching diagram (Extended)	13
Name structures of bacteria and viruses (Extended)	10
Distinguish ferns, flowering plants, monocots and dicots (Extended)	7

On Papers 3 and 4, key questions are worth the most marks per part (3 to 5 marks each), so practise them even though they are fewer.

1. Recognise or name the characteristics of living organisms (79 questions)

1. **Recall MRS GREN** and each meaning from the table in "Understand it".

2. **"Which is a characteristic of all living things?"** Cross out anything only some organisms do: breathing, photosynthesis, transpiration, egestion, digestion, ingestion, tropism, sexual reproduction. What is left (usually excretion, respiration, sensitivity, growth, reproduction, movement or nutrition) is the answer.
3. **A scene or experiment** (a shoot bending to light, a leaf folding on an insect, woodlice moving to the damp end): name what is happening using the list under "What makes something alive". Detecting and responding is sensitivity; a part changing position is movement; a permanent rise in dry mass is growth.
4. **A definition** ("removing toxic materials and substances in excess"): match it to the word.

Variations you will meet:

- **Carbon dioxide leaving the body** (breathed out, or leaving a leaf at night) is **excretion**; carbon dioxide going **into** a leaf for photosynthesis is **nutrition**.
- **"State two other characteristics"** on Paper 3: write any two of the seven words. "Breathing" and "feeding" don't score; write "respiration" and "nutrition".
- **Growth** needs **dry mass**. A seed that swells with water has not grown; a seedling that has made new cells and material has.

2. Use the binomial system (45 questions)

1. **Genus** = the first word, with a capital letter. **Species** = the second word.
2. **"State the genus"**: write only the first word (for *Aquila chrysaetos*, write *Aquila*). Not the common name, not both words.
3. **"Which organisms are in the same genus?"** Look only at the **first** words and find two that match. A matching second word means nothing.
4. **"Which is a binomial name?"** It is the one with two Latin-style words, the first capitalised, such as *Vulpes vulpes*, not a common name like "red fox".

Variations you will meet:

- **Fill in the blanks**: organisms are classified by the **features** they share; the international naming system is the **binomial** system; a scientific name is made of the **genus** and the **species**.
- **"What must be added to a genus to make a scientific name?"** The species name.
- **Same genus, different species**: two rats named *Rattus norvegicus* and *Rattus rattus* share a genus, so they are closely related, but they are different species and can't produce fertile offspring together.

3. Identify an arthropod group from its features (42 questions)

1. **Confirm it is an arthropod**: jointed legs, exoskeleton, segmented body.
2. **Count the legs in pairs**. 3 pairs → insect; 4 pairs → arachnid; more than 4 pairs → crustacean or myriapod.
3. **Count the antennae**. None → arachnid; 1 pair → insect or myriapod; 2 pairs → crustacean.
4. **Look at the body**. 3 parts with wings → insect; 2 parts → arachnid; many similar segments with legs on each → myriapod.

Variations you will meet:

- **"State one feature, visible in the photograph, that shows it is an insect"**: three pairs of legs, three body parts, one pair of antennae, or wings. Give a feature you can **see**.
- **Pedipalps** near a spider's mouth are not legs or antennae; still count 4 pairs of legs → arachnid.
- **Two pairs of legs on each segment** is a myriapod (a millipede), not a crustacean.
- **Order by number of legs**: myriapods (most), crustaceans, arachnids, insects (fewest).
- **Features of all arthropods** (jointed legs, exoskeleton, segmented body) versus features of one group only. "Eight legs" is not true of all arthropods.
- **Matching images to groups**: count the legs and antennae in each picture before drawing lines.

4. Identify a vertebrate group or state its features (30 questions)

1. **Backbone present** → vertebrate. Name the kingdom as **animal** and the group as **vertebrates**.
2. **Look at the covering**: hair or fur → mammal; feathers → bird; dry scales → reptile; moist skin without scales → amphibian; scales with fins and gills → fish.
3. **"State two features of mammals"**: hair or fur, mammary glands (milk), external ears (pinnae), different types of teeth.

Variations you will meet:

- **A feature visible in a picture or skeleton**: fins or fin bones and gill covers for a fish; feathers, a beak or wings for a bird; fur, whiskers or ear flaps for a mammal. A curved bone round the chest in a skeleton is a **rib**; the chain of small bones along the back is the **backbone** (vertebral column).
- **Tell two groups apart**: reptiles have dry, scaly skin but amphibians have moist skin without scales; fish have scales and fins but amphibians don't.
- **A sea mammal** such as a dolphin or whale has lungs (not gills) and makes milk, even though it lives in water and has a fish-like shape.
- **Tables of features** (hair, scales, wings, gills): pick the row that fits every feature of the group, for example a mammal has hair but no gills or scales.

5. Define species or apply "fertile offspring" (25 questions)

1. **Definition** (2 marks): "a group of organisms that can reproduce (with each other) to produce **fertile offspring**". One mark is for "a group of organisms", the other for "fertile offspring".
2. **Applying it**: if two organisms breed and their offspring are **infertile** (a mule, a zedonk), the parents are **different species**.

Variations you will meet:

- **Wrong options to reject**: "organisms living in the same area" (that is a population), "genetically identical organisms", "organisms that look the same", "animals that can mate".
- **Which organism can breed with this one to give fertile young?** Only one with the **same full scientific name** (genus and species).

- **Don't define genus** when asked for species. Read the word carefully.

6. Identify or name kingdoms from cell features (22 questions)

1. **Core: animal or plant.** Chloroplasts, cellulose cell wall, large vacuole → plant; none of these → animal. Arthropods and vertebrates are all in the **animal** kingdom.
2. **Extended: use the five-question order** in "Understand it": nucleus? single-celled? chloroplasts and cellulose? enzymes released and absorbed?
3. **"Name another kingdom":** animal, plant, fungus, protocist, prokaryote. Don't give a group inside a kingdom (vertebrates, insects, bacteria).

Variations you will meet:

- **Features of plants** (2 marks): multicellular; chloroplasts or chlorophyll to photosynthesise; cellulose cell walls.
- **A new organism described in words**, for example "multicellular, cell walls not made of cellulose, feeds by releasing enzymes and absorbing the products" → **fungus**. "Single cell with a nucleus, chloroplasts and a cell wall" → **protocist**. "No nucleus" → **prokaryote**.
- **Pictures of three cells**: thread-like hyphae → fungus; a tiny cell with no nucleus → prokaryote; a single cell with a nucleus → protocist.
- **Telling fungi from plants**: fungi have no chloroplasts and their walls are not cellulose.

7. Use a dichotomous key to identify organisms (21 questions)

1. **Take one organism at a time.** Start at step 1 for every organism.
2. **Read both statements** in the pair and decide which one is true, looking carefully at the drawing (count legs, check for hairs, spots, shape).
3. **Follow the instruction**: either the organism's name, or "go to" another step. Repeat until you reach a name.
4. **Write the letter in the box** beside that name. Each letter is used once, so if two organisms land on the same name, go back and check.

Variations you will meet:

- **Branching (yes/no) keys**: follow the arrows the same way.
- **"State the name of this type of key"**: a **dichotomous** key.
- **Read features back from a key**: to say what features an organism has, trace the path from its name back to the start.
- **Construct a key**: split the group into two by one visible feature, write it as a pair of opposite statements ("wings present" / "wings absent"), and keep splitting until each organism is alone. A group of n organisms needs $n - 1$ pairs of statements.

8. Judge relatedness from DNA base sequences or a branching diagram (Extended, 13 questions)

1. **Line up the sequences** and count the positions where the bases differ.
2. **Fewest differences = most closely related** = most recent common ancestor.
3. **Explain** in two steps: they have the most similar base sequences, **so** they share the most recent common ancestor.

Variations you will meet:

- **"What is used to classify organisms?"**: the **sequence** of bases in DNA, not the number of bases, the types of bases, or the shape of DNA.
- **"What is the most accurate method?"**: comparing DNA base sequences, rather than comparing bones or external appearance.
- **Branching diagrams**: the two species that join at the branch point nearest the tips are the most closely related.
- **"How could a scientist find out if two crops are closely related?"**: sequence (compare) their DNA or genes; closely related species will have more similar base sequences.
- **Identical amino acid sequences in a protein** suggest the two species share a recent common ancestor.

9. Name structures of bacteria and viruses (Extended, 10 questions)

1. **Virus labels**: the outer layer is the **protein coat**; the inside is the **genetic material** (DNA or RNA).
2. **Bacterium labels**: cell wall, cell membrane, cytoplasm, ribosomes, circular DNA, plasmid, and often a flagellum.
3. **"State two structures in bacteria that are absent from viruses"**: any two of cell wall, cell membrane, cytoplasm, ribosomes, plasmids.

Variations you will meet:

- **Kingdom of bacteria**: prokaryote. A virus is in **no** kingdom.
- **A feature that shows a cell is a prokaryote**: no nucleus, or circular DNA, or plasmids.
- **Which feature do viruses have?**: a protein coat (not a cell wall, mitochondria or nucleus).

10. Distinguish ferns, flowering plants, monocots and dicots (Extended, 7 questions)

1. **Fern or flowering plant?** Fronds with spores underneath and no flowers → fern; flowers or seeds → flowering plant.
2. **Monocot or dicot?** Look at the veins and count flower parts: parallel veins and parts in threes → monocot; branching veins and parts in fours or fives → dicot.
3. **"Explain your answer"**: give the **visible** features that led you there, one mark each.

Variations you will meet:

- **Complete a classification diagram:** plants → ferns and flowering plants; flowering plants → monocotyledons and dicotyledons.
- **Pick the monocot flower** from drawings: count the petals; 3 or 6 means monocot.
- **Vascular bundles in a stem:** a ring in a dicot, scattered in a monocot.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **B1** mark for a correct result on its own, with no method needed.

Example 1

Four species of cat are listed.

- lion, *Panthera leo*
- tiger, *Panthera tigris*
- cheetah, *Acinonyx jubatus*
- wildcat, *Felis silvestris*

(a) State the genus of the tiger. **[1]**

(b) Which two of these species are most closely related? Explain your answer. **[2]**

(c) Describe what is meant by the term *species*. **[2]**

(d) In a zoo, a lion and a tiger bred and produced an animal called a liger. Ligers are usually infertile. Explain why this shows that lions and tigers are different species. **[2]**

(a) *Panthera*. B1 (The first word only; "tiger" or *Panthera tigris* would not score.)

(b) The lion and the tiger. B1 They are in the same genus, *Panthera*, and species in the same genus share a recent common ancestor. **B1**

(c) A group of organisms B1 that can reproduce to produce fertile offspring. B1

(d) The liger cannot reproduce, so the lion and the tiger have not produced fertile offspring. B1 Members of one species produce fertile offspring, so the lion and tiger cannot be one species. **B1**

Example 2

The table describes five arthropods, P to T.

Arthropod	Pairs of legs	Pairs of antennae	Body parts	Wings
P	3	1	3	2 pairs
Q	4	0	2	none
R	5	2	2	none
S	1 pair on each of 30 segments	1	many segments	none
T	3	1	3	none

(a) Name the arthropod group of P, Q, R and S. **[4]**

(b) State **two** features shared by all five arthropods that are not shown in the table. **[2]**

(c) Construct a dichotomous key to identify P to T, using only features in the table. **[4]**

(a) P: insect (3 pairs of legs and wings). **B1** Q: arachnid (4 pairs of legs, no antennae). **B1** R: crustacean (2 pairs of antennae). **B1** S: myriapod (legs on every segment). **B1**

(b) Any two of: an exoskeleton, jointed legs, a segmented body. **B1 B1**

(c) Five organisms need four pairs of statements, one feature per pair. **B1** for each correct pair, up to **4**:

Step	Statement	Go to
1(a)	antennae present	2
1(b)	antennae absent	Q
2(a)	two pairs of antennae	R
2(b)	one pair of antennae	3
3(a)	legs on every body segment	S
3(b)	legs not on every body segment	4
4(a)	wings present	P
4(b)	wings absent	T

The branching key in "Understand it" is the same key drawn as a diagram. P and T are both insects: an insect doesn't have to have wings.

Example 3 (Extended)

The table shows the same section of DNA from four species, A to D.

Species	Base sequence
A	ATGCCTAGGATC
B	ATGCCTAGCATC

Species	Base sequence
C	A T G G C T T G C A T C
D	T A G G C A T G C T A C

(a) Count the number of bases that are different between species A and each of species B, C and D. **[2]**

(b) State which species is most closely related to species A. Explain your answer. **[2]**

(c) Explain why comparing DNA base sequences gives a more reliable classification than comparing appearance. **[2]**

(a) Compare A with each species position by position:

- A and B: only the 9th base differs (G, C): **1** difference;
- A and C: the 4th, 7th and 9th bases differ: **3** differences;
- A and D: the 1st, 2nd, 4th, 6th, 7th, 9th, 10th and 11th bases differ: **8** differences.

B2 for all three counts correct (**B1** for two).

(b) Species B. **B1** Its base sequence is the most similar to A's (only 1 difference), so A and B share the most recent common ancestor. **B1**

(c) Unrelated organisms can look similar, and related ones can look different. **B1** DNA is passed from ancestors to descendants, so how similar the base sequences are shows how recently two species shared an ancestor, which is what classification aims to reflect. **B1**

The third diagram in "Understand it" shows these four species on a branching diagram.

Example 4 (Extended)

The table gives some features of four organisms.

Organism	Nucleus	Number of cells	Cell wall	Chloroplasts	How it feeds
W	absent	one	present, not cellulose	absent	absorbs food from its surroundings
X	present	one	present	present	photosynthesis
Y	present	many, as thin threads	present, not cellulose	absent	releases enzymes onto food and absorbs the products
Z	present	many	cellulose	present	photosynthesis

(a) Name the kingdom that each organism belongs to. **[4]**

(b) A virus is found infecting organism W. State the two features of a virus. **[2]**

(c) State **two** structures present in W that are not present in a virus. [2]

(a) W: prokaryote (no nucleus). **B1** X: protist (one cell with a nucleus). **B1** Y: fungus (non-cellulose walls, no chloroplasts, feeds by releasing enzymes). **B1** Z: plant (many cells, cellulose walls, chloroplasts). **B1**

(b) A protein coat **B1** and genetic material (DNA or RNA). **B1**

(c) Any two of: cell wall, cell membrane, cytoplasm, ribosomes, plasmids. **B1 B1**

Common mistakes

- **Writing "breathing" as a characteristic of living things.** Plants and bacteria don't breathe. The characteristic is **respiration**, the chemical release of energy in cells.
- **Mixing up excretion and egestion.** Excretion removes waste made **by the body's own reactions** (carbon dioxide, urea); egestion removes undigested food. Removing carbon dioxide is excretion.
- **Leaving "dry mass" out of growth.** "An increase in size" alone isn't enough; say "a permanent increase in size and dry mass".
- **Giving the wrong part of a scientific name.** The **first** word is the genus. Examiners often see the second word, the full name or the common name given when only the genus was asked for.
- **Thinking a hybrid like a mule is fertile, or a species.** It is infertile, which is exactly why its parents are different species.
- **Defining genus when the question says species,** or leaving out "fertile" in the species definition.
- **Calling a myriapod with two pairs of legs per segment a crustacean,** or a spider-like animal with pedipalps an insect. Count pairs of legs and antennae carefully.
- **Naming a group when the question asks for a kingdom.** "Arthropod", "crustacean", "vertebrate" or "bacteria" are not kingdoms; "animal" and "prokaryote" are.
- **Giving a feature you can't see** when the question says "visible in the photograph", such as mammary glands on a photo of a mammal. Use fur, ear flaps or whiskers.
- **Using "lays eggs" or "has wings" to identify a bird.** Other groups lay eggs or have wings; feathers are unique to birds.
- **Saying the number or type of bases in DNA is used for classification.** It is the **sequence** of bases. Say which sequence (DNA or genes), not just "genes".

How to get the marks

- **Learn the syllabus definitions in your own words but keep the key terms:** growth needs "dry mass"; excretion needs "waste products of metabolism" and "in excess of requirements"; species needs "fertile offspring". Each is usually one mark per key idea.
- **"State"** wants a short answer: one word or phrase, no explanation. **"Describe"** a term (like species) wants the full definition. **"Explain"** wants a reason linked to the answer, often with "so" or "because".

- **"Visible in Fig. ..."** means give a feature you can see in the picture, never one you know about but can't see.
- **Keys on Papers 3 and 4 score on a sliding scale:** every correct letter adds to your total, so do every organism, even if you're unsure of one. Use each letter once.
- **"Identify the group ... Explain your answer":** name the group, then give **each** visible feature that shows it (one mark per feature, up to the marks shown).
- **Scientific names:** write the genus with a capital letter and the species in small letters. Spelling needs to be recognisable, so copy names from the question.
- **Kingdom questions:** give the kingdom's name exactly: animal, plant, fungus, protoctist or prokaryote.
- **Extended relatedness answers:** mention **base sequences** (or DNA sequences) and the idea of **more similar** sequences meaning a **more recent common ancestor**.
- **Multiple choice:** cross out options that are only true for some organisms, or that use a common name where a scientific one is needed.

Quick check

1. Name the characteristic of living things shown by each: (a) a snail pulls in its eye stalks when touched; (b) the kidneys remove urea from the blood; (c) a caterpillar eats a leaf to get materials for building new cells; (d) the dry mass of a bean seedling increases over two weeks.
2. The scientific names of four trees are *Quercus robur*, *Fagus sylvatica*, *Quercus alba* and *Acer rubrum*. (a) Which two trees are in the same genus? (b) What is the species name of *Fagus sylvatica*?
3. Name the arthropod group of each animal: (a) 2 body parts, 4 pairs of legs, no antennae; (b) about 100 segments, two pairs of legs on most segments, one pair of antennae; (c) 3 body parts, 3 pairs of legs, 1 pair of antennae, 1 pair of wings.
4. A vertebrate has moist skin without scales and lays its eggs in water. (a) Name its group. (b) State one visible feature that would tell a reptile apart from it.
5. **Extended only:** part of a gene was sequenced in four species. P: GCATTAGCTA; Q: GCTTTAGCAA; R: CCATTACCTA; S: GCATTAGCTT. Which species is most closely related to P? Explain your answer.

Answers

1. (a) Sensitivity (and movement of the eye stalks). (b) Excretion. (c) Nutrition. (d) Growth.
2. (a) *Quercus robur* and *Quercus alba*: they share the first word, the genus *Quercus*. (b) *sylvatica*.
3. (a) Arachnid. (b) Myriapod (a millipede). (c) Insect.
4. (a) Amphibian. (b) A reptile has dry skin covered in scales.
5. Compared with P, Q differs at 2 positions (3rd and 9th), R at 2 positions (1st and 7th), and S at only 1 (the last base). S has the most similar base sequence to P, so S shares the most recent common ancestor with P and is its closest relative.

Past questions to try

- [0610/31/O/N/25 Q1](#): binomial blanks, a key to six crustaceans, and matching arthropods to groups.
- [0610/32/O/N/25 Q1](#): vertebrate skeletons, mammal features and the species definition.
- [0610/43/O/N/25 Q1](#): kingdoms, ferns and monocots from photographs, and relatedness from DNA.
- [0610/22/O/N/25 Q2](#): naming the kingdoms of three cells from their structure.