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CHAPTER NOTES

Patterns in Life: Diversity and Classification Class 9 Notes | CBSE Science Chapter 12

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Hi, I am **Ira**. I teach this syllabus all day, so **Patterns in Life: Diversity and Classification** is very much my home ground.

Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Patterns in Life: Diversity and Classification simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Patterns in Life: Diversity and Classification Class 9 Notes | CBSE Science Chapter 12

Patterns in Life: Diversity and Classification is Chapter 12 of CBSE Class 9 Science (2026-27). It starts with biodiversity, the immense variety of living organisms on the Earth, and explains endemic species and biodiversity hotspots such as the Western Ghats. It then shows how scientists group organisms using criteria such as cell type, cell structure, level of organisation and mode of nutrition, and traces how classification systems changed from Aristotle to Whittaker's five kingdoms and Carl Woese's three domains.

The core of the chapter is the five kingdom system: Monera, Protista, Fungi, Plantae and Animalia, then the five classes of plants (Thallophyta to Angiosperm) and the animal groups from Porifera to the vertebrates. It ends with the hierarchy from kingdom to species, binomial nomenclature, fossils and threats to biodiversity. School exams test this chapter through placing an unknown organism in the right group from its features, reasoning questions on why a group is separate, and rules for writing scientific names. Later biology classes build on the same classification ideas.

Quick Answer - Patterns in Life: Diversity and Classification

Biodiversity is the variety of life on the Earth. It includes the variety of organisms and their features. Whittaker (1969) proposed **five kingdoms** of life based on cell type (prokaryote vs eukaryote), cell wall, level of organisation and mode of nutrition. Monera are unicellular prokaryotes; Protista are unicellular eukaryotes; Fungi have cell walls and photosynthesise; Animalia are multicellular eukaryotes. Plants form five classes, animals split by the number of cells. The hierarchy of classification is Kingdom → Phylum → Class → Order → Family → Genus → Species. The scientific name of a tiger is *Panthera tigris*.



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All Key Terms at a Glance

Term	What it means	Example from the chapter
Biodiversity	The immense variety of living organisms on the Earth	Bacteria to giant trees, jellyfish to eagles
Endemic species	Species found naturally only in a particular region and nowhere else	Nilgiri tahr, Lion-tailed macaque, Neelakurinji
Biodiversity hotspot	Region with many endemic species that has undergone significant habitat loss	Western Ghats, Indo-Burma, Himalayas, Sundaland
Biological classification	The scientific system of grouping organisms by similarities and differences	Five kingdom system
Prokaryote	Cell without a membrane-bound (true) nucleus	Bacteria, cyanobacteria (Monera)
Eukaryote	Cell with a membrane-bound nucleus	
Five kingdoms	Monera, Protista, Fungi, Plantae, Animalia	
Notochord	Flexible rod-shaped structure found in chordates and some animals into non-chordates	
Hierarchy	Kingdom, Phylum, Class, Order, Genus, Species	
Binomial nomenclature	Two-part scientific naming system for species	
Three domains	Bacteria, Archaea, Eukarya	genetic data



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Key Concepts

1. Biodiversity, Hotspots and the Need for Classification

The Earth holds an enormous variety of life. Some organisms are microscopic and invisible to the naked eye; others are giant trees. Life exists in the snow-clad Himalayas and in the coral reefs of the Andaman Sea. This immense variety of living organisms is called **biodiversity**.

Every organism helps keep nature stable:

- Microscopic algae in the oceans release most of the oxygen we breathe.
- Fungi and bacteria decompose fallen leaves and convert waste into manure, which makes the soil fertile.
- Birds, bees and bats pollinate flowers.
- Plants capture sunlight to prepare food that supports nearly all life on the planet.

Humans depend on biodiversity for food, shelter, medicines and livelihoods. For centuries, farmers conserved many crop varieties with useful traits such as drought tolerance, pest resistance and the ability to grow in nutrient-poor soils. They realised that biodiversity strengthens food security.

India as a Biodiversity Hotspot

India has mountains in the north, desert in the west, rainforests in the south and long coastlines along the Arabian Sea and Bay of Bengal. It has many types and its own climate (temperature and rainfall) support many species.

Some species are restricted to particular regions and are found nowhere else. These are **endemic species**. Four examples are:

- Nilgiri tahr
- Lion-tailed macaque
- The Indian variety of the pitcher plant, *Nepenthes*
- Neelakurinji

A **biodiversity hotspot** is a region that supports many species that have undergone significant habitat loss. Both conditions are met by two hotspots named in the chapter: the Western Ghats and the Himalayas and Sundaland (including the Nicobar Islands). These hotspots support food webs and help ecosystems stay healthy.

How Biodiversity Evolved



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The biodiversity we see today was not always the same. Small differences among individuals affected their chances of survival and reproduction, because some differences helped them adapt to changed conditions. These differences built up over many generations and gave rise to new forms of life. Today's diversity is the outcome of continuous change over a vast span of time, shaped by interactions between organisms and their surroundings.

Why Classify at All

The chapter uses a library analogy. Picture thousands of books scattered on the floor of a huge library, and you want *On the Origin of Species* by Charles Darwin. Without arranging books by subject, author or section, finding it would be very hard. Millions of organisms need the same kind of order.

Case study: Pakke Tiger Reserve, Arunachal Pradesh. Scientists have recorded nearly 300 bird species here, while India as a whole has about 1,300. Pakke supports four hornbill species: the Rufous-necked Hornbill, the Oriental Pied Hornbill, the Great Hornbill and the Wreathed Hornbill. They nest only in large, old trees with suitable cavities and feed on specific fruits, so each species occupies the parts of the forest that match tree size and fruit availability. Classifying them lets scientists ask precise questions about how species are distributed. If the large, old trees disappeared, the hornbills would lose their nesting sites.

The scientific system of grouping living organisms is called **biological classification**. It helps us in six ways:

1. It makes the study of living organisms organised.
2. It helps us understand similarities and differences.
3. It shows how different organisms are related to each other.
4. It helps in identifying and naming newly discovered organisms.
5. It supports biodiversity conservation by identifying endangered species.
6. It lets scientists all over the world discuss organisms.

2. Criteria Used to Classify Organisms

In Activity 12.1 you group the animals of an ecosystem by when they are active (day, night or both), and by their "feathers" groups at once; an eagle, a tiger and a snake. This shows that **the same organism can fit into different groups**.

Scientists begin with broad, easily visible features. Table 12.1 lists seven characteristics:



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No.	Criterion	What is checked
1	External features	Visible characteristics such as shape, size and body organisation
2	Mode of nutrition	Autotrophic (makes its own food) or heterotrophic (depends on others)
3	Internal structures	Skeletal patterns, presence or absence of organs, types of tissues
4	Cell structure	Unicellular or multicellular; eukaryote or prokaryote; cell wall present or absent
5	Ecological role	Producer, consumer or decomposer
6	Reproduction	Asexual and/or sexual methods
7	Genetic similarity	Similarities in inherited features, studied in detail using DNA

Similar features in organisms suggest that they e

3. How Classification Systems Changed

Scientists built different systems over time, each chapter's timeline:



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Period	Scientist	System	Main idea
4th century BCE	Aristotle	Artificial system	Grouped animals by habitat (land, water, air) and by external appearance
1758	Carolus Linnaeus	Two kingdom	Plantae and Animalia
1866	Ernst Haeckel	Three kingdom	Added Protista for microscopic life
1938	Herbert F. Copeland	Four kingdom	Monera, Protista, Plantae, Animalia
1969	Robert H. Whittaker	Five kingdom	Monera, Protista, Fungi, Plantae, Animalia
1977	Carl Woese	Three domain	Bacteria, Archaea, Eukarya, based on genetic data

Why each change happened:

- **Aristotle's limit:** his system relied mainly on external appearance.
- **Two kingdoms:** Plantae were organisms that could photosynthesise and depend on others for food. This caused confusion as *Amoeba* and *Paramecium* move like animals but are unicellular. Animals are multicellular.
- **Three kingdoms:** Protista was added for unicellular organisms.
- **Four kingdoms:** better microscopes showed that fungi are different from plants while bacteria do not. Both are unicellular yet different. Added kingdom, Monera.
- **Five kingdoms:** fungi such as mushrooms do not photosynthesise (some are parasitic). So fungi got their own kingdom.
- **Three domains:** with better microscopes and DNA level. Organisms with similar DNA are closely related. Discovered that microscopic life is far more diverse than previously thought.

The Rigveda and the Brihat Samhita also classify organisms (based on land, water and aerial), behaviour patterns and ecological roles.



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Classification keeps changing as new tools, such as microscopes and staining techniques, reveal new organisms. It is an ongoing process of reasoning and change.

4. The Five Kingdoms

Whittaker's five kingdom system uses **four criteria**, applied in a fixed order in the chapter's concept map:

1. **Cell type:** prokaryote (no membrane-bound nucleus) or eukaryote (membrane-bound nucleus)
2. **Level of organisation:** unicellular or multicellular
3. **Cell structure:** presence or absence of a cell wall (and what it is made of)
4. **Mode of nutrition:** autotrophic or heterotrophic

The concept map in words. All living organisms first split by cell type. Prokaryotes form **Monera** (bacteria, archaea, cyanobacteria). Eukaryotes split by level of organisation. Unicellular eukaryotes form **Protista** (*Amoeba*, *Paramecium*, *Chlamydomonas*, *Euglena*), which may or may not have a cell wall. Multicellular eukaryotes split by cell structure. Those with a cell wall of **chitin** are heterotrophic decomposers: **Fungi** (mushroom, yeast, *Aspergillus*). Those with a cell wall of **cellulose** are autotrophic producers that photosynthesise: **Plantae** (mosses, grasses, ferns, pines, roses). Those **without a cell wall** are heterotrophic consumers:



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Kingdom Fungi: Multicellular, Heterotrophic Eukaryotes with a Cell Wall

Fungi are mostly multicellular eukaryotes with cell walls made of **chitin**. They do not make their own food. They absorb nutrients from dead or decaying matter through fine filaments, which together form a network called the **mycelium**. Most fungi are **saprophytes**, so they work as decomposers: they break down complex organic matter (fallen leaves, twigs, dead organisms) into simpler substances and make them available in soil as minerals. Some fungi form mutualistic (symbiotic) relationships with other organisms; others are parasites that cause disease in plants and animals. They reproduce both sexually and asexually, often by spores, and grow best in warm, moist conditions.

- **Yeast** is unicellular, yet it is placed in Fungi because its cell wall is made of chitin.
- **Mushrooms** are macroscopic fungi that reproduce by spores.
- **Aspergillus and Penicillium** are used to make enzymes and antibiotics.

Without fungi, the decay of dead plants and animals would slow down greatly, which would harm soil fertility and ecological balance.

5. Classes of Kingdom Plantae

Kingdom Plantae is divided into five classes: **Thallophyta**, **Bryophyta**, **Pteridophyta**, **Gymnosperms** and **Angiosperm**.

Thallophyta (algae): Primitive Plants

The name comes from *thallos* (undifferentiated body). They are the simplest plants and are mostly found in water or moist places that allows direct exchange of gases, nutrients and wastes. They are well adapted to water but cannot live on land.

Lichens are the white-green patches seen on trees and rocks. They are associations of an autotrophic alga and a heterotrophic fungus. The alga photosynthesises and provides food. Lichens change the environment and are **bioindicators** of air quality. Some are used as species for correct identification matters.

Bryophyta: First Steps on Land, Still Need Water

From *bryon* (moss) and *phyton* (plant). Examples are mosses and liverworts. They grow on damp rocks, old walls and soil, especially in the shade. They are more advanced than thallophytes. They have root-like structures called rhizoids, leaf-like structures called leaf-like structures, but no true roots, stems or leaves. They reproduce because male reproductive cells must be near water. They are called the '**amphibians**' of the plant kingdom.

Pteridophyta: Land Plants with a Transport System



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From *pteron* (feather) and *phyton* (plant). Example: ferns. Pteridophytes have **true roots, stems and leaves** and **vascular tissues**: xylem carries water and phloem carries food throughout the plant. A cross-section of a fern stem under the microscope shows these tissues. Pteridophytes still need water for reproduction and **do not produce seeds**.

Gymnosperms: Reproduction Without Water

From *gymnos* (naked) and *spermos* (seed). Examples: pines and cycads. They are adapted to cold and dry regions; their needle-like or scale-like leaves reduce water loss. They produce **seeds**, which protect the developing embryo and store food. They do not need water for fertilisation. Their seeds are **not enclosed in fruits** and are often exposed on cones, hence "naked seed".

Angiosperms: Flowers, Fruits and Efficient Seed Dispersal

From *angeion* (vessel) and *spermos* (seed). Angiosperms are the flowering plants, with the most complex body organisation. Flowers attract pollinators, which makes reproduction more efficient. Fruits enclose the seeds and help spread them to new places through insects, birds, animals, wind or water. So angiosperms occupy the widest range of environments and are the **most diverse plant group on the Earth**. Example: Gulmohar. Their leaves can be grouped as monocots or dicots by shape and venation (Activity 12.8).

Plant Classes Compared

Class	Body	Vascular tissue
Thallophyta	Thallus, undifferentiated	Absent
Bryophyta	Slightly differentiated; rhizoids, no true root, stem, leaf	Absent
Pteridophyta	True roots, stems, leaves	Xylem and phloem
Gymnosperm	Needle-like or scale-like leaves	Present
Angiosperm	Well-developed roots, stems, leaves; flowers	Present



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Early plants relied on water for support and reproduction. Plant groups gradually evolved transport tissues, then seeds, then flowers.

6. Groups of Kingdom Animalia

Most animals show locomotion, rapid response to stimuli and coordinated behaviour, which lets them search for food, avoid predators and interact with their surroundings. A major criterion for classifying animals is the presence or absence of a **notochord**, a flexible rod-shaped structure.

- No notochord: **non-chordata (invertebrata)**
- Notochord present: **chordata**, further divided into **protochordata** and **vertebrata**. In some chordates the notochord is a precursor for the development of the vertebral column.

The Eight Invertebrate Phyla

From sponges to echinoderms, body organisation grows more complex; each new feature improves feeding, movement or protection and often brings a new challenge.

Porifera (pore-bearers): multicellularity without tissues. Sponges are one of the simplest animal body plans. They are multicellular but lack tissues. Water flows through the body, bringing food particles and oxygen away. They stay fixed in one place in water (marine sponges filter up to 1000 litres of sea water per day).

Cnidaria: true tissues and active feeding. *Hydra* has specialised cells do specific jobs. Tentacles catch food from water currents to bring food in. But they have a **single** opening for food and waste. This chapter asks you to think about the limits this plan

Platyhelminthes (flatworms): bilateral symmetry. *Planaria* is divided into two halves along one plane (**bilateral** symmetry). This allows better coordination and is the first step towards more complex organisation. Some are free-living, some are parasites and have hooks and suckers to attach to a host.

Nematoda (roundworms): two openings. *Ascaris* is elongated and lives in water or host tissue. The body has **two openings** for food and waste. It has a more complex organisation (digestive system). Male and female have separate openings.

Annelida (segmented worms): segmentation and coelom. *Pheretima* is divided into **segments**. Segmentation gives greater flexibility and coordination.



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They have organ system level organisation, muscles for locomotion, a nerve cord for control and coordination, and a **body cavity**. Habitat: moist soil or water. No skeleton.

Arthropoda: jointed appendages and an external skeleton. Insects, crabs and spiders have segmented bodies with segments specialised for different jobs, and jointed appendages. Their defining feature is a hard **external skeleton (exoskeleton)**. It gives protection, reduces water loss and supports powerful muscles, which lets arthropods survive in dry and exposed places. Habitat: land or water.

Mollusca: organ system level organisation with soft bodies. Snails, squids and octopuses have soft bodies with a distinct head, a muscular foot and a hump. In many molluscs a shell protects the soft body. The group shows how one basic body plan can be modified in different directions. Habitat: water or moist land.

Echinodermata: internal support without a notochord. From *echinos* (spiny) and *derma* (skin). Starfish and sea urchins have a hard **internal skeleton made of calcium carbonate**, which gives protection and controlled movement even though they lack a notochord. Habitat: marine water.



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Phylum	Example	Habitat	Level of organisation	Skeleton	Key new feature
Porifera	Sponge	Water (marine)	Cellular	None	Pores, water flow
Cnidaria	<i>Hydra</i> , jellyfish, coral	Water (fresh and marine)	Tissue	None	Tissues, tentacles; one opening
Platyhelminthes	Flatworms	Water, inside host	Organ	None	Bilateral symmetry; one opening
Nematoda	Roundworms	Soil, water, inside host	Organ system	None	Two openings (mouth and anus)
Annelida	Earthworm	Moist soil, water			
Arthropoda	Insects, crab, spider	Land, water			
Mollusca	Snail, squid, octopus	Water, moist land			
Echinodermata	Starfish, sea urchin	Marine water			

Protochordates and Vertebrates

Protochordates (like *Amphioxus*) have a notochord support without restricting movement. They are intermediate between invertebrates to vertebrates.



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Vertebrates have a vertebral column (backbone), an internal skeleton that supports the body and protects vital organs such as the brain and spinal cord. This framework allows larger body size, efficient movement and complex organ systems, along with advanced senses and coordinated behaviour. Vertebrates are classified into five groups, **fish, amphibians, reptiles, birds and mammals**, based on broad patterns of habitat use, body covering and reproduction.

Group	Structural features that support survival
Fish	Fins and gills let fish move and breathe in water
Amphibians	Live both in water and on land; young stages breathe in water (like the frog, and the Purple Frog of the Western Ghats)
Reptiles	Mainly land animals with a dry, scaly body covering (snakes, lizards)
Birds	Feathers and hollow bones make flight possible
Mammals	Mammary glands feed the young and improve their survival; thick fur (polar bear) and fat storage (camel) help in extreme conditions

The fish, bird and mammal features come from **structural change**. The chapter does not describe standard school-level features used to tell them

7. Hierarchy of Classification and Binomial Nomenclature

Classification follows a step-by-step order from

Kingdom → Phylum → Class → Order → Family

At each lower level, organisms share more common features with the group above it. It works like a house address, let's say, 100, 1000, 10000, etc.



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Level	Tiger	Pea
Kingdom	Animalia	Plantae
Phylum	Chordata (sub-phylum Vertebrata)	Magnoliophyta
Class	Mammalia	Magnoliopsida
Order	Carnivora	Fabales
Family	Felidae	Fabaceae
Genus	<i>Panthera</i>	<i>Pisum</i>
Species	<i>P. tigris</i>	<i>P. sativum</i>

Binomial Nomenclature

A tiger is *bagh* in Hindi, *puli* in Tamil, tiger in English and *tigre* in French. People from different regions may get confused. So scientists use a universal system of naming organisms, known as binomial nomenclature, introduced by **Carolus Linnaeus** in the 18th century. The name of an organism has two parts, written in Latin or a Latinised form.

Common name	Scientific name
Tiger	<i>Panthera tigris</i>
Lion	<i>Panthera leo</i>
Mango	<i>Mangifera indica</i>
Purple Frog	<i>Nasikabatrachus sahyadrensis</i>

A **genus** groups closely related species with common characteristics. For example, *Panthera*, the roaring cats, which can roar and have similar individuals capable of interbreeding and have a unique name used worldwide.

Rules for writing scientific names:

1. The name has two parts: genus and species.
2. The genus name comes first and begins with a capital letter (upper-case) and the species name (lower-case) letters.



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3. The name is printed in italics, or underlined when handwritten.

The Three Domain System, Fossils and Threats to Biodiversity

The five kingdom system was more complete than earlier systems but still could not fully explain the diversity of life. Every living cell contains DNA, which carries instructions for growth and function. Using genetic data, **Carl Woese (1977)** proposed three domains: **Bacteria, Archaea and Eukarya**.

Fossils are preserved remains of plants and animals found in layers of rock, sand and mud. Generally, older layers contain simpler organisms and newer layers show more complex forms, so fossils are natural records of how life changed over millions of years. **Birbal Sahni** studied fossil plants and founded the BSIP in Lucknow.

Biodiversity under threat: pollution, deforestation, overuse of resources and climate change are reducing biodiversity. When one species disappears, others that depend on it may also decline and eventually disappear. Diverse forests also act as barriers: villages with more mangroves suffered less damage in the 1999 Orissa super cyclone. The **Sangai**, the dancing deer endemic to Manipur, lives on the floating grasslands called **phumdis** in Loktak lake (Keibul Lamjao National Park). It was declared extinct in 1951, rediscovered in 1953, and is now listed in the IUCN Red Data list as its phumdi habitat degenerates.



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Key Terms Sheet

Term or name	Meaning	Remember it by
Five kingdom criteria	Cell type, level of organisation, cell structure (cell wall), mode of nutrition	Nucleus, number of cells, wall, food
Monera	Unicellular prokaryotes	No true nucleus
Protista	Unicellular eukaryotes, no wall or cellulose wall	<i>Amoeba, Paramecium, Euglena</i>
Fungi	Chitin cell wall, absorptive heterotrophs	Decomposers; yeast is the unicellular exception
Plantae	Cellulose cell wall, autotrophic	Producers
Animalia	No cell wall, heterotrophic	Consumers
Thallophyta	Thallus body, water-dwelling	
Bryophyta	Rhizoids, no vascular tissue	
Pteridophyta	True root, stem, leaf; xylem and phloem; seeds	
Gymnosperm	Naked seeds on cones	
Angiosperm	Flowers; seeds enclosed in fruit	
Invertebrate order	Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Echinodermata	
Vertebrate groups	Fish, amphibians, reptiles, birds, mammals	
Hierarchy	Kingdom, Phylum, Class, Order, Family, Genus, Species	
Three domains	Bacteria, Archaea, Eukarya	



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Important Definitions

Term	Definition
Biodiversity	The immense variety of living organisms found on the Earth
Endemic species	Species restricted to a particular region of the world and not found naturally anywhere else
Biodiversity hotspot	A region that supports a large number of endemic species and has undergone significant habitat loss
Biological classification	The scientific system of grouping living organisms on the basis of their similarities and/or differences
Prokaryote	An organism whose cell has no membrane-bound nucleus
Eukaryote	An organism whose cells have a true, membrane-bound nucleus
Saprophyte	An organism that feeds on dead organic matter
Mycelium	The network formed by the hyphae of a fungus that absorbs nutrients
Thallus	A simple, undifferentiated body that absorbs water directly with the surface
Rhizoids	Root-like structures of some organisms that anchor them and absorb water
Vascular tissue	Transport tissue: xylem and phloem
Notochord	A flexible rod-shaped structure that is present in chordates and some non-chordates
Bilateral symmetry	A body that can be divided into two equal halves by a single plane
Genus	A group of closely related species
Species	A group of similar individuals that can interbreed and produce fertile offspring



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Term	Definition
Binomial nomenclature	The universal system of naming organisms with two parts, genus and species, introduced by Carolus Linnaeus

Solved Examples (NCERT-Based)

Example 1: Insect or earthworm (Revise, Reflect, Refine Q1)

Meena and Hari observed an animal in their garden. Hari called it an insect while Meena said it was an earthworm. Choose the correct option which confirms that it is an insect. (i) Bilateral symmetrical body (ii) Body with jointed legs (iii) Cylindrical body (iv) Body with little segmentation

Solution: Insects are arthropods, and the defining feature of Arthropoda is jointed appendages with a hard exoskeleton. Bilateral symmetry is shared by many phyla, including annelids, so it cannot separate the two. A cylindrical body and segmentation both fit the earthworm. Answer: **(ii) Body with jointed legs.**

Example 2: A slide with a nucleus and cilia

You find an unlabelled slide of a single-celled organism with a well-defined nucleus and cilia. Which group would it most likely belong to?

Solution: Step 1, cell type: a well-defined nucleus. Step 2, mode of organisation: single-celled. Unicellular eukaryotes with cilia, like *Paramecium*, which the chapter lists.

Example 3: Class or genus (Q12)

In the classification hierarchy, which group, class or genus, is more common? Explain your answer.

Solution: Genus is three levels below class. At each level, there are more common features, and each lower group is part of the group above it. Example: class Mammalia includes only the roaring cats, such as the tiger and lion, which can roar.

Example 4: Unicellular organism in Fun

A researcher identified a unicellular eukaryotic organism. Suggest according to the five kingdom classification to keep a unicellular organism in the Kingdom



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Fungi?

Solution: A unicellular eukaryote would normally go to Protista. The key to move it into Fungi is the **cell wall made of chitin**, together with heterotrophic nutrition by absorption. Protists either lack a cell wall or have one of cellulose. Yeast is the chapter's example: it is unicellular, but since its cell wall is made of chitin, it is placed under fungi. Suggested key: eukaryotic? yes → cell wall present? yes → wall of chitin? yes → absorbs food, no chlorophyll? yes → Fungi.

Example 5: Bryophytes versus pteridophytes (Q11)

Both pteridophytes and bryophytes lack flowers and seeds, yet they are placed in different groups. Explain this classification using their key features.

Solution:

Feature	Bryophyta	Pteridophyta
Body	Slightly differentiated; rhizoids, stem-like and leaf-like structures	True roots, stems and leaves
Vascular tissue	Absent	
Water for reproduction	Needed	
Example	<i>Marchantia</i> , moss	

The absence of flowers and seeds is shared, so true organs and vascular tissue, which pteridoph

Example 6: Cellular organisation versus

How would a scientist justify choosing cellular or

the basis of classification rather than the presen

Solution: Cellular organisation (prokaryotic or eu

every living organism, so it can be used to comp

only in some plants (pteridophytes, gymnosperm

bacteria, protists, fungi or animals, and even am

bryophytes. That is why cell type is the first split



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Example 7: Viruses and the five kingdoms (Q10)

Viruses contain genetic material like living organisms but lack cellular organisation. Which features prevent them from fitting into the five kingdom system? What does this tell us about the limitations of classification systems?

Solution: All four criteria of the five kingdom system are cell-based: cell type, level of organisation, cell structure and mode of nutrition. A virus is acellular, so none of these questions can be answered for it. It also remains inactive outside a host cell. So it cannot be placed in any kingdom. Classification systems therefore have limits and must be revised as knowledge grows, as the move from two kingdoms to five and then to three domains shows.

Example 8: Placing organisms P to T (Q15, parts i to v)

Students recorded features of organisms from a pond, damp soil near decaying logs and the digestive tract of animals:

Organism	Key observations
P	Microscopic; no true nucleus; rigid body; survives extreme temperature
Q	Multicellular; filamentous body; grows on decaying organic matter
R	Unicellular; true nucleus; contracts and expands; performs photosynthesis in light but heterotrophic in dark
S	Multicellular; well-differentiated body; grows during early life stage
T	Acellular; contains genetic material; survives extreme temperature

(i) Identify one organism that clearly belongs to the Kingdom Fungi. Organism Q has a cell wall, lacks chlorophyll and grows on decaying organic matter, showing the decomposer lifestyle of fungi.

(ii) Which organism would be placed in the Kingdom Monera (prokaryote)? Organism P (prokaryote). Surviving extreme salinity and temperature shows its adaptability to extreme environments.

(iii) Organisms R and Q are both eukaryotic, yet they differ in many criteria that separate them. Level of organisation

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photosynthesise, Q cannot and absorbs food from dead matter. R is a protist (like *Euglena*); Q is a fungus.

(iv) Explain why organism S cannot be classified using the mode of nutrition alone. Heterotrophic nutrition is shared by animals, fungi, many protists and many bacteria. Nutrition alone would lump S with Q. S needs other criteria: multicellular, no cell wall, differentiated tissues and a backbone place it in Animalia, among vertebrates; aquatic breathing in early life points to an amphibian.

(v) Organism T does not fit into any of the five kingdoms. Which fundamental characteristic used in classification does it lack and what does this reveal about the limitations of classification systems? Cellular organisation. T is acellular (a virus). It shows that classification systems are limited by their criteria and must keep evolving.

Example 9: A new multicellular absorber (Q15 part vii)

Imagine scientists discover a new organism that is multicellular, eukaryotic, lacks chlorophyll and absorbs nutrients from a host externally. Should it be placed under fungi or animalia? Justify your reasoning using classification criteria.

Solution: Fungi. Obtaining nutrients by absorption notes that some fungi live as parasites and cause and lack a cell wall. The final check is the cell wall



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Competency-Based Question

1. Case-based: Lichens on the village wall

Villagers see white-green patches on tree trunks. Researchers read the colour of these patches to

(a) What are these patches? Lichens, a symbiotic heterotrophic fungus.

(b) What does each partner contribute? The fungus provides shelter and provides food.

(c) Why must lichens be classified and identified? Lichens are used as a spice (*patthar ke phool*), medicine or dye, while ensuring safe use.

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2. Source-based: The timeline of classification

Aristotle grouped animals by habitat. Linnaeus (1758) used two kingdoms. Haeckel (1866) added Protista. Copeland (1938) separated Monera. Whittaker (1969) separated Fungi.

(a) Which observation led to Monera? Better microscopes showed *Amoeba* has a membrane-bound nucleus while bacteria do not.

(b) Why were fungi removed from plants? Fungi do not make their own food; they absorb nutrients, many from dead and decaying matter.

(c) What general point about science does the timeline show? Science changes as new tools and knowledge appear; classification is an ongoing process of reasoning and change.

3. Assertion-Reason

Choose: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true but R is false. (d) A is false but R is true.

Assertion (A): Yeast is placed in Kingdom Fungi. **Reason (R):** Yeast is a multicellular organism.

Answer: (c). A is true. R is false: yeast is unicellular and has a cell wall made of chitin.

4. Assertion-Reason

Assertion (A): Bryophytes are called the amphibians of the plant kingdom because they grow on land but need water for reproduction.

Answer: (a). Male reproductive cells must swim to reach the egg, yet depend on moisture, just as amphibians live on land but need water to reproduce.

5. Assertion-Reason

Assertion (A): Arthropods can survive in dry and hot environments because they have a hard external skeleton that reduces water loss.

Answer: (a). The exoskeleton protects the body, reduces water loss, and provides support.

6. Assertion-Reason

Assertion (A): Echinoderms are chordates. **Reason (R):** Their shells are made of calcium carbonate.

Answer: (d). A is false: echinoderms lack a notochord. R is true: their shells are made of calcium carbonate.



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7. Data reasoning: Build the key

A student is given five organisms: a mushroom, *Euglena*, a bacterium, a fern and an earthworm. Using the four criteria of the five kingdom system, sort them.

Answer: No true nucleus: bacterium (Monera). True nucleus and unicellular: *Euglena* (Protista). Multicellular with chitin wall, absorbs food: mushroom (Fungi). Multicellular with cellulose wall, photosynthesises: fern (Plantae). Multicellular without a cell wall, heterotrophic: earthworm (Animalia).

8. Competency MCQ: Sponge cells (Q2)

Sponges represent one of the simplest animal body plans. Their bodies lack true tissues and organs. Which feature of sponge cells supports its classification under the animal kingdom? (i) Absence of mitochondria (ii) Ability to photosynthesise (iii) Presence of a cell membrane (iv) Presence of a cell wall

Answer: (iii). Every cell has a cell membrane, so the point is that in sponge cells the membrane is the outer boundary, with no cell wall around it, as in all animals. A cell wall (iv) would point to plants or fungi, and photosynthesis (ii) to plants. Option (i) is wrong: animal cells have mitochondria. Sponge cells take food from water flowing through the pores, which also fits heterotrophic animals.

Important Questions for Exa

1-Mark Questions

1. Name the scientist who proposed the five ki
2. What is the cell wall of fungi made of? Chitin
3. Which structure divides animals into chorda
4. Write the scientific name of mango correctly (handwritten).
5. Name two endemic species of India. Nilgiri ta
khasiana, Neelakurinji).

2-Mark Questions

1. What is a biodiversity hotspot? Name two in
number of endemic species and has undergone
Himalayas (also Indo-Burma, Sundaland).
2. Why are bryophytes called the amphibians of
water for reproduction, because male reprodu



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3. **Differentiate between gymnosperms and angiosperms.** Gymnosperms have naked seeds, not enclosed in fruits and often exposed on cones (pine). Angiosperms produce flowers, and their seeds are enclosed in fruits (Gulmohar).
4. **State the rules for writing a scientific name.** Two parts, genus then species; genus starts with a capital letter, species in small letters; printed in italics or underlined when handwritten.

3-Mark Questions

1. **List any three advantages of biological classification.** It makes the study of organisms organised and systematic; it shows how organisms are related and how they interact; it helps identify and name new organisms. (Also: supports conservation, provides a common system for scientists worldwide.)
2. **How do Cnidaria differ from Porifera and from Nematoda?** Porifera have only cellular organisation and depend on water currents through pores for food; Cnidaria have tissues and catch prey with tentacles. Cnidaria have a single opening for food and waste; Nematoda have two openings, mouth and anus.
3. **Explain why fungi were given a separate kingdom.** Fungi do not move and look plant-like, yet they are heterotrophic and cannot make food. They absorb nutrients, mostly from dead and decaying matter, and their cell walls are made of chitin, so they were placed in a separate kingdom.
4. **Write the classification of the tiger from kingdom to species.** (sub-phylum Vertebrata), Class Mammalia, Order Carnivora, Family Felidae, Genus *Panthera*, Species *P. tigris*.

5-Mark Questions

1. **Describe the criteria of the five kingdom classification.** Criteria: cell type, level of organisation, mode of nutrition. Monera: unicellular prokaryotes, autotrophic or heterotrophic. Protista: unicellular eukaryotes with no wall or a cellulose wall, absorb food, mostly saprophytes, mushrooms. Plantae: multicellular, autotrophic, photosynthetic, fern. Animalia: multicellular, heterotrophic.
2. **Describe the five classes of Kingdom Plantae.** Thallophytes: thallus body, live in water (*Spirogyra*). Bryophytes: no vascular tissue, need water for reproduction. Pteridophytes: have xylem and phloem, but still need water and have sporophylls. Gymnosperms: have needle-like leaves, no water needed for fertilisation, needles. Angiosperms: flowers attract pollinators, fruits enclose and protect seeds. Sequence shows transport tissue, then seeds.



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Common Mistakes and Examiner Tips

1. **Defining a hotspot by richness alone.** A hotspot needs both a large number of endemic species and significant habitat loss. Write both parts.
2. **Putting yeast in Protista.** Yeast is unicellular, but its chitin cell wall places it in Fungi. Quote the chitin wall as the reason.
3. **Mixing up chitin and cellulose.** Chitin: fungal cell wall. Cellulose: plant cell wall and some protists. Animals have no cell wall.
4. **Calling cyanobacteria algae in the plant kingdom.** The name "blue-green algae" misleads. Cyanobacteria are prokaryotes and belong to Monera.
5. **Listing only three or five criteria for the five kingdoms.** There are four: cell type, level of organisation, cell structure (cell wall) and mode of nutrition. Keep these apart from the seven general criteria in Section 12.3.1.
6. **Saying bryophytes have roots.** They have rhizoids, which are root-like. True roots, stems and leaves first appear in pteridophytes.
7. **Saying pteridophytes have seeds.** Ferns have vascular tissue but no seeds. Seeds begin with gymnosperms.
8. **Writing that gymnosperm seeds are inside fruits.** They are exposed, often on cones. Fruits belong to angiosperms.
9. **Treating echinoderms as chordates because they have a notochord.** The notochord is internal, but they lack a notochord.
10. **Scientific name slips.** Writing "panthera Tigris". Genus capitalised, species lower case, underlined.
11. **Reversing the hierarchy.** Moving down from kingdom to species, the number of shared features decreases and the shared features increase.
12. **Forcing viruses into a kingdom.** Viruses are not in any of the five kingdoms. Explain it through the criteria.



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Quick Revision Points

- Endemic species occur naturally in one region. Examples: *Nelumbo*, *Neelakurinji*.
- Hotspot = many endemic species + significant habitat loss. Examples: Sundaland.
- Seven criteria: external features, nutrition, internal structure, mode of reproduction, genetic similarity.

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- Timeline: Aristotle (habitat) → Linnaeus 1758 (2) → Haeckel 1866 (3) → Copeland 1938 (4) → Whittaker 1969 (5) → Woese 1977 (3 domains).
- Five kingdom criteria: cell type, level of organisation, cell wall, mode of nutrition.
- Monera: prokaryotes; bacteria, cyanobacteria; *Lactobacillus*, *Rhizobium* are useful.
- Protista: unicellular eukaryotes; *Amoeba*, *Paramecium*, *Euglena*, *Chlamydomonas*.
- Fungi: chitin wall, mycelium, saprophytes; yeast unicellular; *Aspergillus* and *Penicillium* give enzymes and antibiotics.
- Thallophyta (thallus, *Spirogyra*) → Bryophyta (rhizoids, amphibians) → Pteridophyta (xylem, phloem, no seeds) → Gymnosperm (naked seeds) → Angiosperm (flowers, fruits).
- Notochord splits animals into non-chordata and chordata; chordata = protochordata + vertebrata.
- Invertebrates: Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca, Echinodermata.
- One opening: Cnidaria, Platyhelminthes. Two openings from Nematoda on.
- Protochordates (*Amphioxus*) have a notochord at least once in life.
- Vertebrates: fish, amphibians, reptiles, birds, mammals; backbone protects brain and spinal cord.
- Hierarchy: Kingdom, Phylum, Class, Order, Family, Genus, Species; shared features.
- Binomial nomenclature: Linnaeus; genus (capital), species (lowercase).
- Fossils: older layers simpler organisms, newer layers more complex organisms.

Weightage and Exam Pattern

Class 9 has no board exam. This chapter is assessed in annual exams, and your school decides its mark.

The chapter's own exercise, Revise, Reflect, Refine.



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Question style	What it looks like in this chapter
Multiple choice	Pick the feature that confirms an insect (jointed legs), or the sponge cell feature that places it in Animalia
Observation and reasoning	Distinguish two animals from your surroundings; justify cellular organisation as a basic criterion
Identify and justify	Place an unlabelled single-celled organism with a nucleus and cilia; build a key for a unicellular fungus
Compare and explain	Bryophytes versus pteridophytes; class versus genus
Case study	Organisms P to T from a pond, damp soil and an animal gut, with seven linked sub-questions
Open-ended	Should viruses get a new category; how diversity keeps an ecosystem stable



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