Chapter 1: General Overview

1.1. Classification and Relative Importance of the Kingdoms

1.2. Learning Objectives

By the end of this session, students should be able to:

- Explain why it is necessary to classify living organisms;
- Retrace the historical evolution of the major classification systems (2 kingdoms → 5 kingdoms → 3 domains);
- Name and characterize the major kingdoms/domains of life currently recognized;
- Compare the relative importance of these kingdoms in terms of diversity, biomass, and ecological role.

1. Why Classify Living Organisms?

It is estimated today that several million living species exist (estimates range from 8 to more than 30 million depending on the groups considered), of which only about 1.8 to 2 million have been formally described by science. Faced with such diversity, biologists need an organized system to name, classify, and compare organisms.

> 📖 **Definition — Systematics (or Taxonomy)**
>
> The branch of biology concerned with the identification, description, naming, and classification of living organisms based on their similarities and evolutionary relationships.

Linnaeus's Binomial Nomenclature

Carl von Linnaeus (1707–1778) established, in the 18th century, the principle of the binomial name: each species receives a universal scientific name made up of two Latin words — the genus (capitalized) followed by the specific epithet (lowercase), both written in italics.

Example: Homo sapiens (the human species), Escherichia coli (an intestinal bacterium).

The Taxonomic Hierarchy

Each species is classified according to a nested hierarchy of categories, from the broadest to the most specific level:

Category	Example (Human)
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	Homo
Species	Homo sapiens

Classic mnemonic (English): "Kings Play Cards On Fine Green Silk" (Kingdom, Phylum, Class, Order, Family, Genus, Species).

2. History of Classification Systems

The number of recognized kingdoms has changed over time, as tools of observation (microscopy) and, later, molecular analysis (RNA sequencing) became more advanced.

a) Aristotle (4th century BC) — 2 kingdoms

The earliest known classification system, based on naturalist observation, simply distinguished two kingdoms according to a very simple macroscopic criterion: mobility.

- Regnum Animale (animals, capable of movement)
- Regnum Vegetabile (plants, fixed to the ground)

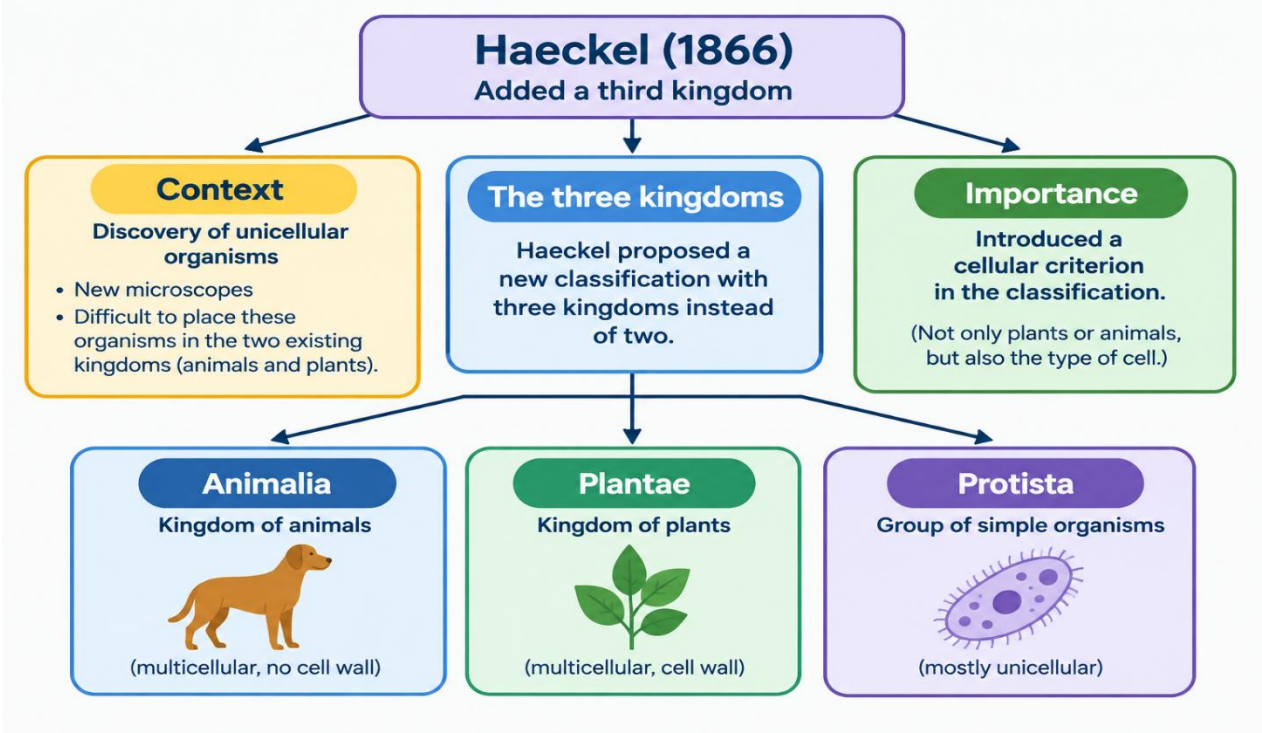
b) Linnaeus (18th century) — Systematization of the 2 kingdoms

Linnaeus formalized and systematized this classification into 2 kingdoms (Animalia, Vegetabilia) through binomial nomenclature, though the basic principle (animal/plant) remained unchanged.

c) Haeckel (1866) — 3 kingdoms

The invention of the microscope revealed the existence of unicellular organisms that could not be classified as either animals or plants. Ernst Haeckel then proposed adding a third kingdom:

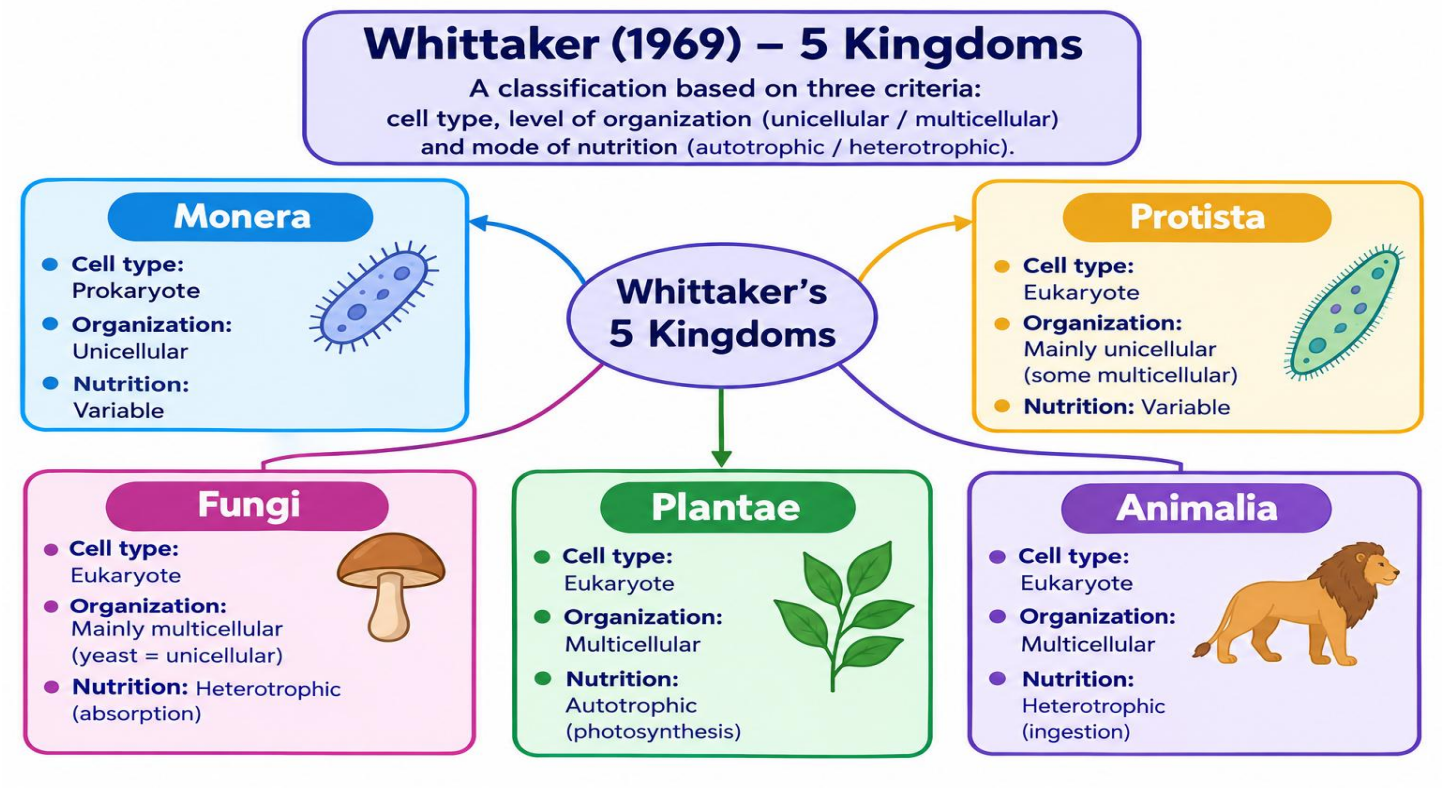
- Animalia, Plantae, and Protista (unicellular organisms, eukaryotic or not, grouped together by default).



d) Whittaker (1969) — 5 kingdoms

Robert Whittaker proposed a classification into 5 kingdoms, based on three combined criteria: cell type (prokaryote/eukaryote), level of organization (unicellular/multicellular), and mode of nutrition (autotrophic/heterotrophic).

Kingdom	Cell Type	Organization	Nutrition
Monera	Prokaryote	Unicellular	Variable
Protista	Eukaryote	Mostly unicellular	Variable
Fungi	Eukaryote	Multicellular	Heterotrophic (absorption)
Plantae	Eukaryote	Multicellular	Autotrophic (photosynthesis)
Animalia	Eukaryote	Multicellular	Heterotrophic (ingestion)

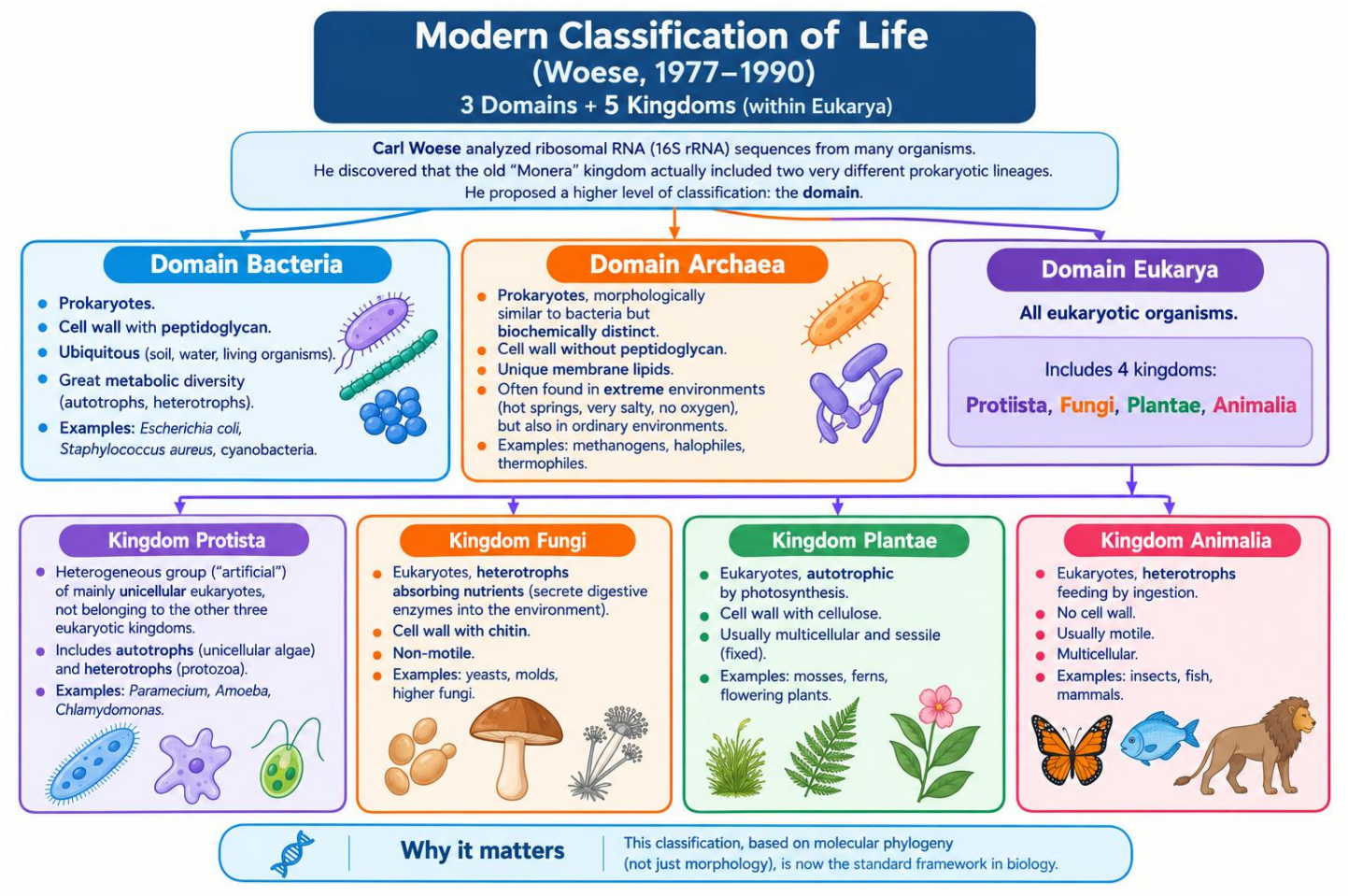


e) Woese (1977–1990) — 3 domains

Carl Woese revolutionized classification by comparing ribosomal RNA sequences (16S rRNA) across a very large number of organisms. He discovered that the kingdom Monera actually grouped together two prokaryotic lineages as different from each other as from eukaryotes: Bacteria and Archaea. He proposed a level of classification above the kingdom, called the domain:

- Domain Bacteria ("true" bacteria)
- Domain Archaea (often associated with extreme environments)
- Domain Eukarya (all eukaryotic organisms: Protista, Fungi, Plantae, Animalia)

This system, based on molecular phylogeny rather than morphology alone, is today the reference framework in biology.



3. Today's Major Kingdoms / Domains

Modern classification combines Woese's 3 domains with the classic kingdoms within the domain Eukarya.

Domain Bacteria

Prokaryotes, cell wall containing peptidoglycan, ubiquitous (soil, water, living organisms). Great metabolic diversity (autotrophic, heterotrophic). Examples: Escherichia coli, Staphylococcus aureus, cyanobacteria.

Domain Archaea

Prokaryotes morphologically similar to bacteria but biochemically distinct (cell wall without peptidoglycan, distinctive membrane lipids). Often associated with extreme environments (hot springs, highly saline environments, absence of oxygen), although also found in ordinary environments. Examples: methanogenic, halophilic, and thermophilic archaea.

Domain Eukarya — Kingdom Protista

A heterogeneous ("artificial") group of mostly unicellular eukaryotes that do not fit into any of the other three eukaryotic kingdoms. Includes autotrophic organisms (unicellular algae) and heterotrophic organisms (protozoa). Examples: Paramecium, Amoeba, Chlamydomonas.

Domain Eukarya — Kingdom Fungi

Heterotrophic eukaryotes that feed by absorption (secreting digestive enzymes into the external environment), cell wall containing chitin, non-motile. Examples: yeasts, molds, higher fungi.

Domain Eukarya — Kingdom Plantae

Autotrophic eukaryotes through photosynthesis, cellulose cell wall, generally multicellular and fixed. Examples: mosses, ferns, flowering plants.

Domain Eukarya — Kingdom Animalia

Heterotrophic eukaryotes that feed by ingestion, no cell wall, generally motile, multicellular. Examples: insects, fish, mammals.

4. Relative Importance of the Kingdoms

Comparing kingdoms according to different criteria nuances a purely hierarchical view of classification: "importance" does not mean the same thing depending on whether one is speaking of diversity, biomass, or ecological role.

By Number of Described Species

The kingdom Animalia dominates by far in number of described species (about 1.2 to 1.5 million, more than half of which are insects alone), followed by plants (≈ 400,000 species) and fungi (≈ 150,000 described species, out of several million estimated). The true diversity of bacteria and archaea remains largely underestimated, as the vast majority of microbial species have never been cultured or described.

By Biomass

The ranking changes radically when total biomass (total mass of living matter) is considered: plants alone account for about 80% of Earth's total biomass, far ahead of bacteria, fungi, and then animals (whose biomass is actually relatively small on a global scale).

By Ecological Role

- Primary producers: plants, algae, and cyanobacteria, at the base of nearly all food chains through photosynthesis.
- Decomposers: fungi and bacteria, essential for recycling organic matter and nutrients.
- Consumers: animals, which depend directly or indirectly on primary producers.

By Medical and Economic Importance

- Bacteria: infectious agents but also major biotechnological tools (production of insulin, antibiotics, food industry).

- Fungi: source of antibiotics (penicillin), used in the food industry (fermentation, breadmaking), but also pathogens and crop parasites.
- Plants: the basis of agriculture and many plant-derived medicines.
- Animals: livestock farming, biomedical research, pollination (insects).

Conclusion: no kingdom is objectively "more important" than another in absolute terms — their relative importance depends entirely on the criterion chosen (diversity, biomass, ecological function, economic or medical interest).

5. Summary — Key Takeaways

Key Point	Takeaway
Goal of classification	Name and organize the diversity of life according to evolutionary relationships (systematics, Linnaeus's binomial nomenclature).
Historical evolution	2 kingdoms (Aristotle/Linnaeus) → 3 kingdoms (Haeckel) → 5 kingdoms (Whittaker, 1969) → 3 domains (Woese, 1990), thanks to advances in microscopy and later molecular biology.
Current system	3 domains: Bacteria, Archaea, Eukarya. The domain Eukarya includes 4 kingdoms: Protista, Fungi, Plantae, Animalia.
Classification criteria	Cell type (prokaryote/eukaryote), organization (uni/multicellular), mode of nutrition (autotrophic/heterotrophic), and today molecular phylogeny.
Relative importance	Depends on the criterion: Animalia dominates in number of species, Plantae dominates in biomass, each kingdom has a specific and complementary ecological and economic role.

Transition to the Next Section

Whatever kingdom is considered, all living organisms share one fundamental trait: they are made up of one or more cells. This is what we will explore further in the next section: "1.2. The Cell and Cell Theory".

End of course material — Happy studying!