## The five-kingdom system reflected increased knowledge of life's diversity

- Traditionally, systematists (scientists that study classification) have considered ***kingdom*** as the highest taxonomic category.
- As a product of a long tradition, beginning with Linnaeus, organisms were divided into only two kingdoms of life - animal or plant.
    - Bacteria, with rigid cell walls, were placed with plants.
    - Even fungi, not photosynthetic and sharing little with green plants, were considered in the plant kingdom.
    - Photosynthetic, mobile microbes were claimed by both botanists (plants) and zoologists (animals).
- In 1969, R.H Whittaker argued for a five-kingdom system: Monera, Protista, Plantae, Fungi, and Animalia.
- The five-kingdom system recognizes that there are two fundamentally different types of cells: prokaryotic (the kingdom Monera) and eukaryotic (the other four kingdoms).
- Three kingdoms of multicellular eukaryotes were distinguished by nutrition, in part.
    - Plants are autotrophic, making organic food by photosynthesis.
    - Most fungi are decomposers with extracellular digestion.
    - Most animals digest food within specialized cavities.
- In Whittaker's system, the Protista consisted of all eukaryotes that did not fit the definition of plants, fungi, or animals.
    - Most protists are unicellular.
    - However, some multicellular organisms, such as seaweeds, were included in the Protista because of their relationships to specific unicellular protists.
    - The five-kingdom system prevailed in biology for over 20 years.

## Arranging the diversity of life into the highest taxa is a work in progress

- During the last three decades, systematists applying cladistic analysis, including the construction of cladograms based on molecular data, have been identifying problems with the five-kingdom system.
  - One challenge has been evidence that there are two distinct lineages of prokaryotes.
  - These data led to the **three-domain system**: Bacteria, Archaea, and Eukarya, as superkingdoms.
- Many microbiologists have divided the two prokaryotic domains into multiple kingdoms based on cladistic analysis of molecular data.
- Let's take a closer look at the three-domain system:
  - **Domain Archaea**
    - Prokaryotic
    - Lack peptidoglycan in cell wall
    - Several kinds of RNA polymerase
  - **Domain Bacteria**
    - Prokaryotic
    - Peptiodoglycan in cell wall
    - One kind of RNA polymerase
  - **Domain Eukarya**
    - Cell wall, if present, composed of cellulose or chitin
    - Several kinds of RNA polymerase
    - Four kingdoms:
      - ***Protista*** – unicellular or colonial eukaryotes
      - ***Fungi*** – multicellular heterotrophs with cell walls of chitin that absorb nutrients and cannot move
      - ***Plantae*** – multicellular autotrophs with cell walls of cellulose that cannot move
      - ***Animalia*** – multicelluar heterotrophs that ingest food, have no cell wall, and are usually mobile

- A second challenge to the five kingdom system comes from systematists who are sorting out the phylogeny of the former members of the kingdom Protista.
    - Molecular systematics and cladistics have shown that the Protista is not ***monophyletic.***
    - Some of these organisms have been split among five or more new kingdoms.
    - Others have been assigned to the Plantae, Fungi, or Animalia.
- Clearly, taxonomy at the highest level is a work in progress.
    - It may seem ironic that systematists are generally more confident in their groupings of species into lower taxa than they are about evolutionary relationships among the major groups of organisms.
    - Tracing phylogeny at the kingdom level takes us back to the evolutionary branching that occurred in Precambrian seas a billion or more years ago.
- There will be much more research before there is anything close to a new consensus for how the three domains of life are related and how many kingdoms there are.
    - New data will undoubtedly lead to further taxonomic modeling.
    - Keep in mind that phylogenetic trees and taxonomic groupings are ***hypotheses that fit the best available data.***