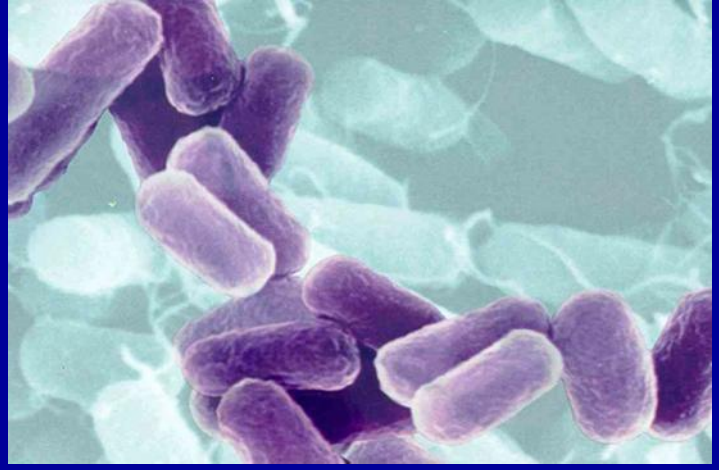


Chapter 18: Classification

KEY CONCEPT QUESTIONS:

- How are living things organized for study?
- What is binomial nomenclature?
- What is Linnaeus's system of classification?

The Classification Game!!

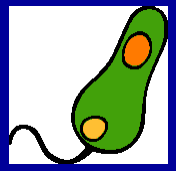
Divide into groups of 3 or 4

In the following few slides, you will find 14 different organisms, each of them labeled with a letter. In your groups, write down two main classification (example red/green). Then place the corresponding letters under the correct classification.

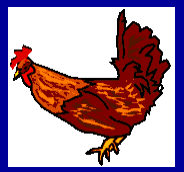
For Example

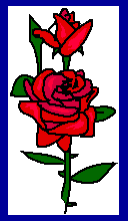
These organisms have been classified by their color.

Green



Red





ARE

YOU

READY!

A

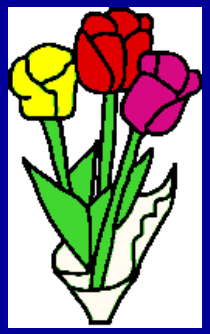
B

C

D

E

F



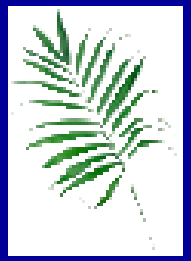
G

H

I

J

K



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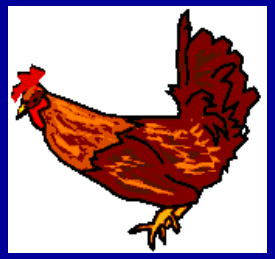
M

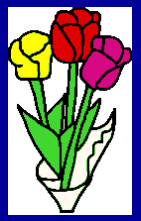


N

One Possible Solution

Plants


C


G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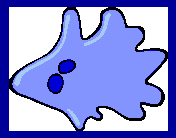
F


L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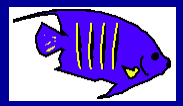
????

Animals

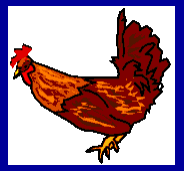

A


J


B


K


E


N


H

Did You Have Problems??

There were actually several different ways to go about classifying these 14 organisms. You might have done color, shape, size, number of legs… the possibilities are endless. You might have encountered one or two that really did not fit into either of your two classifications, what should you do when this happens? Make a new classification of course! And this is what scientist have done as well through the years.

18–1 Finding Order in Diversity

- Life on Earth has been changing for more than 3.5 billion years
- 1.5 million species named
- between 2 and 100 million additional species have yet to be discovered

Why Classify?

- Biologists want to better understand organisms so they **organize** them.
- One tool that they use to do this is classification—the grouping of objects or information based on **similarities.**
- **Taxonomy** is the branch of biology that groups and names organisms based on studies of their different characteristics.
- Biologists who study taxonomy are called taxonomists.

Assigning Scientific Names

- Common names are confusing and vary among languages or even regions
  - Ex: cougar, mountain lion, panther, puma
  - different species sometimes share a single common name
    - Ex: buzzard: hawk? Vulture?

Common names can be misleading

In the United Kingdom, BUZZARD refers to a hawk

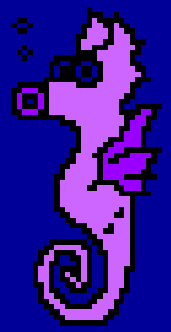
In the United States, BUZZARD refers to a vulture.

Common names vary

Chipmunk
Streifenhornchen (German)
Tamia (Italian)
Ardilla listada (Spanish)

Common names can be misleading

Ex:
A jellyFISH isn't a fish, but a seaHORSE is!



Sea cucumber sounds like a plant but… it's an animal!

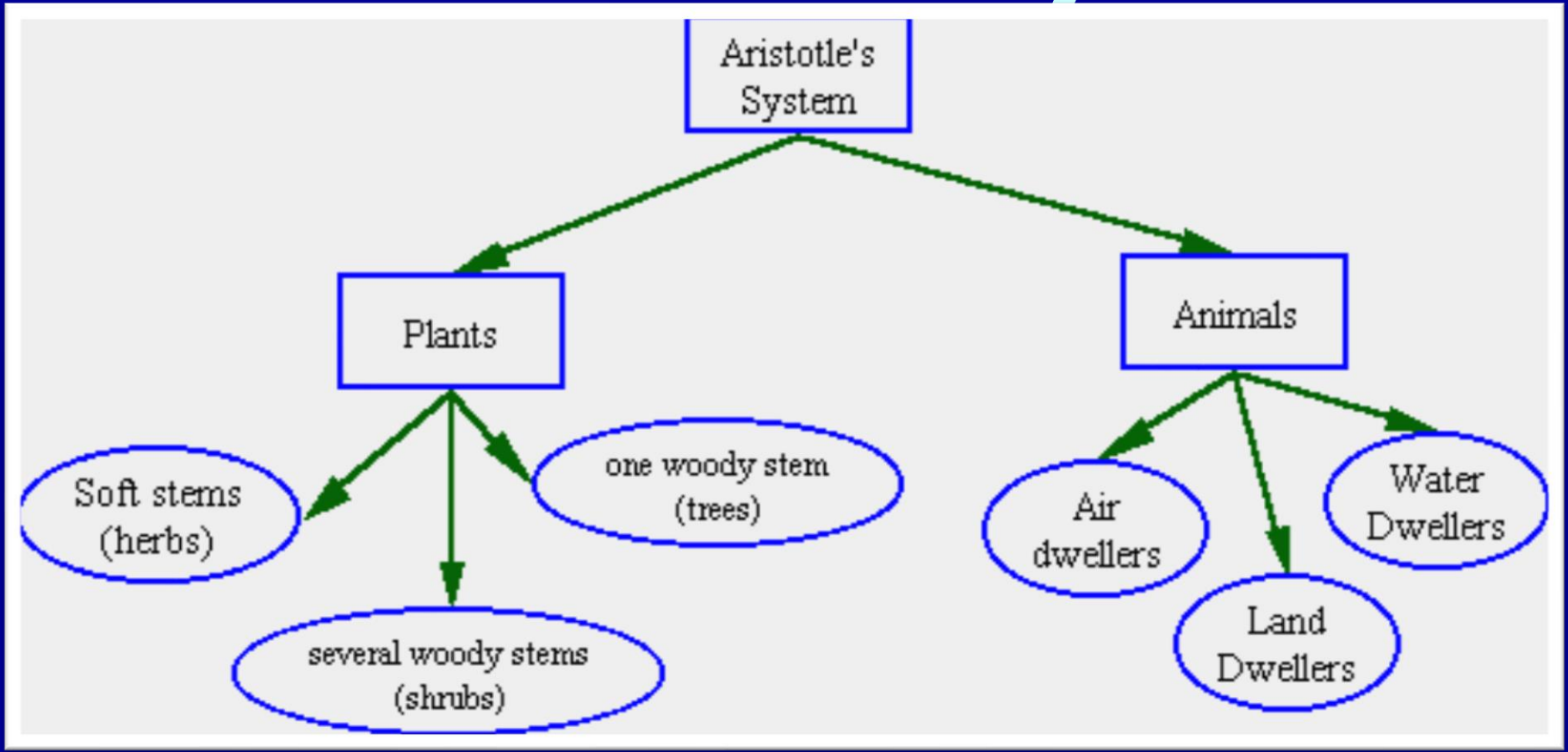
By mid 19th century, scientists recognized that using common names was confusing.

Scientists agreed to use Latin and Greek to give a single name to each species.

Aristotle's system

- The Greek philosopher Aristotle (384-322 B.C.) developed the first widely accepted system of biological classification.
- He classified all the organisms he knew into **two** groups: plants and animals.
- He grouped organisms according to their **physical** structures.
- As time passed, more organisms were discovered and some did **not** fit easily into Aristotle's groups, but many centuries passed before Aristotle's system was replaced.

Aristotle's system



PLANTS:
Based on size of stem

ANIMALS:
Based on where they lived

EXAMPLE: RED OAK

Quercus foliis obtuse-sinuatis setaceo-mucronatis

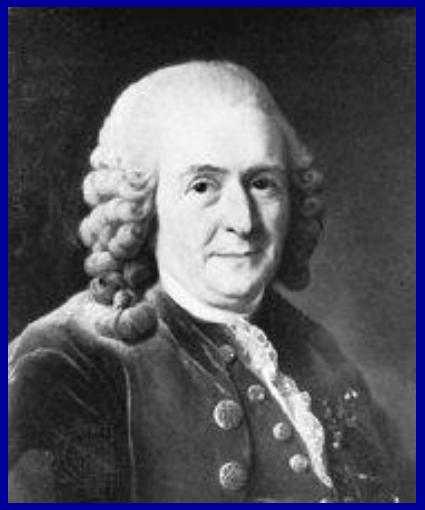
"oak with deeply divided leaves with deep blunt lobes bearing hair-like bristles"

PROBLEMS:

Names too hard and long to remember!

Different scientists described different characteristics.

Linnaeus's system of binomial nomenclature



- In the late eighteenth century, a Swedish botanist, Carolus Linnaeus (1707-1778), developed a method of grouping organisms that is the basis of modern classification systems.
  - Linnaeus's system was based on **physical** and structural similarities of organisms.
- Modern classification systems use a two-word naming system called **binomial nomenclature** that Linnaeus developed to identify species.
  - In this system, the first word identifies the **genus** of the organism.
    - A genus (plural, genera) consists of a group of similar species.

- The second word, which sometimes **describes** a characteristic of the organism, is called the specific epithet.
  - Thus, the scientific name for each species, referred to as the **species** name, is a combination of the genus name and specific epithet.
- *Homo sapiens*

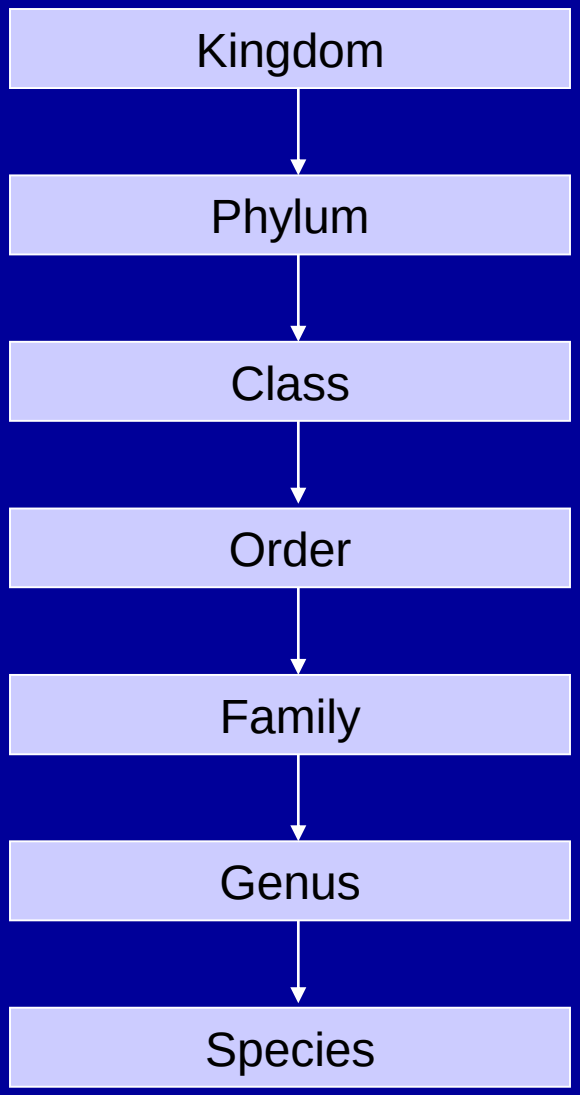
- Scientific names should be **italicized** in print and underlined when handwritten.
- The first letter of the genus name is uppercase, but the first letter of the specific epithet is **lowercase**.

Scientific and common names

- Many organisms have common names. However, a common name can be misleading. For example, a sea horse is a fish, not a horse.
- In addition, it is confusing when a species has more than one **common** name.

Linnaeus's System of Classification

- A group or level of organization is called a taxonomic category, or **taxon** (plural: taxa).
- Linnaeus's system of classification uses seven taxonomic categories.
- They are—from smallest to largest—species, genus, family, order, class, phylum, and kingdom.

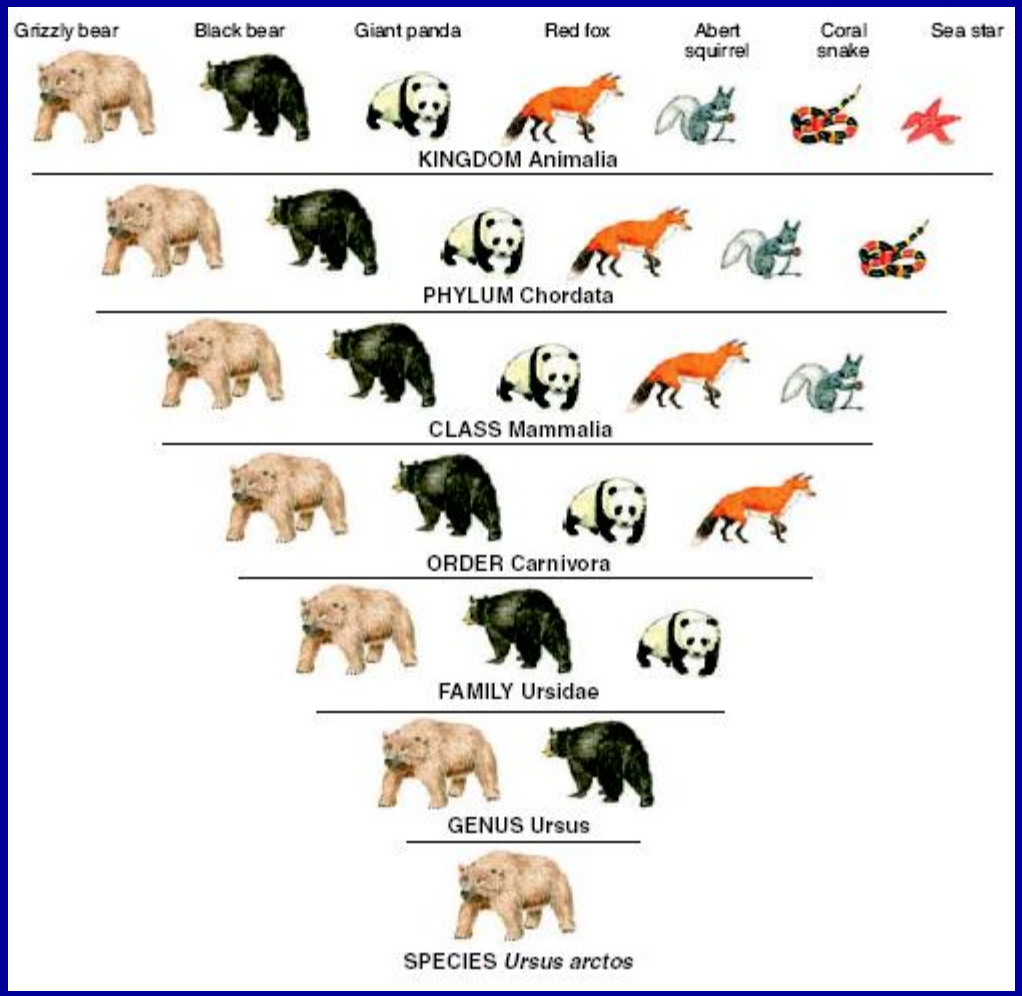


Modern System a Nested Hierarchy- Seven Levels of Organization

- **Modern System:**
  - **Each kingdom (plant and animal) was divided into a phylum* (division for plants)**
  - **Each phylum into a smaller groups called class.**
  - **Each class was divided into an order.**
  - **Each order was divided into family (families).**
  - **Each family was divided into a genus (plural- genera)**
  - **Each genus was divided into a species. (scientific name)**

***Note: Phyla and family were not in Linnaeus's classification system but were added by modern scientists.**

Classification of the Grizzly Bear



- **Linnaeus's system of classification uses seven taxonomic categories.**
- **This illustration shows how a grizzly bear, *Ursus arctos*, is grouped within each taxonomic category.**
- **Only some representative species are illustrated for each category above the species level.**

Scientific Names

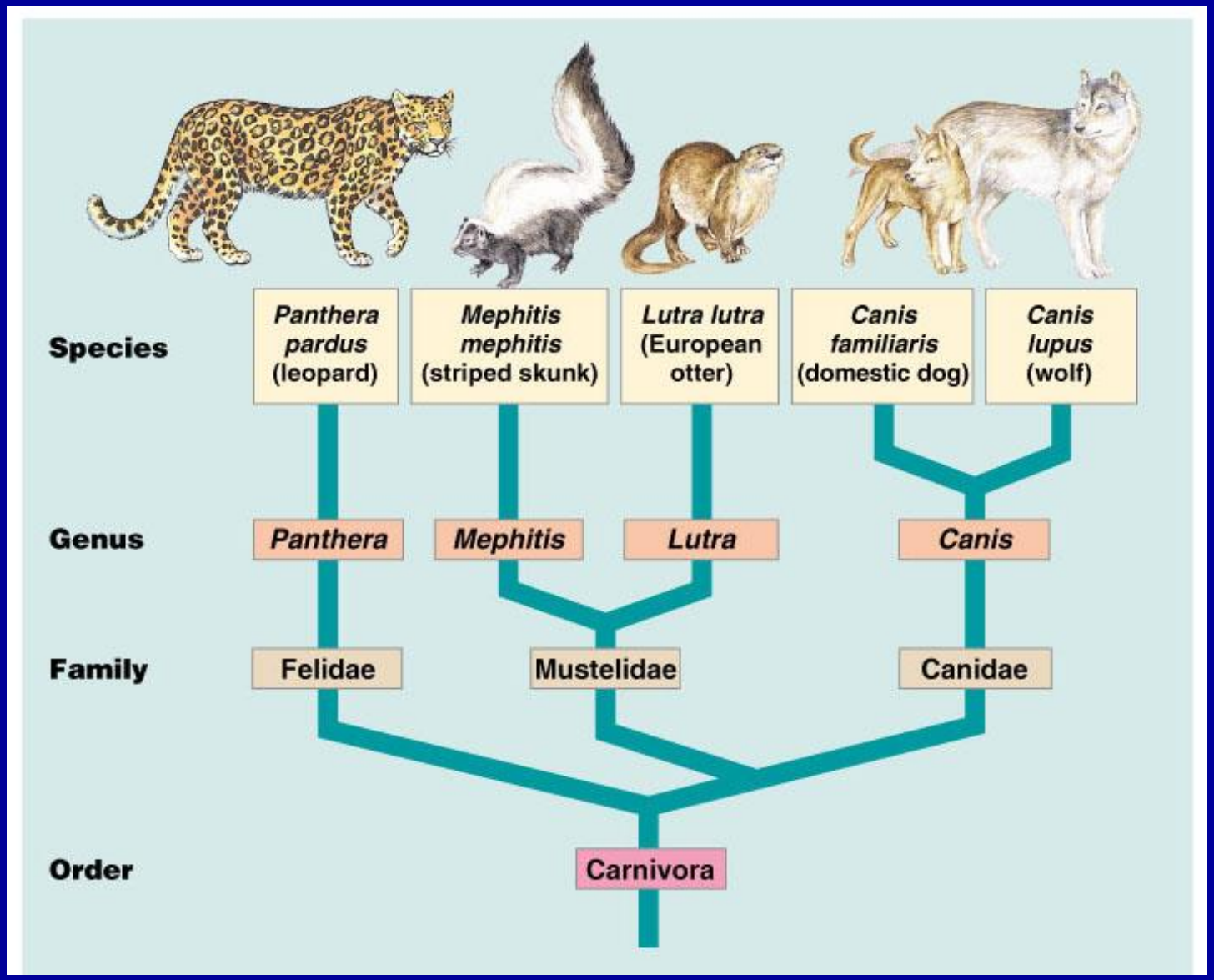
- grizzly bear is called *Ursus arctos*
  - *Ursus* — is the genus
    - Genus = group of closely related species
  - *arctos* – is the species
    - unique to each species within the genus
    - Often a Latinized description of some important trait of the organism or an indication of where the organism lives
  - *Ursus maritimus,* the polar bear
    - *maritimus,* referring to the sea

Humans

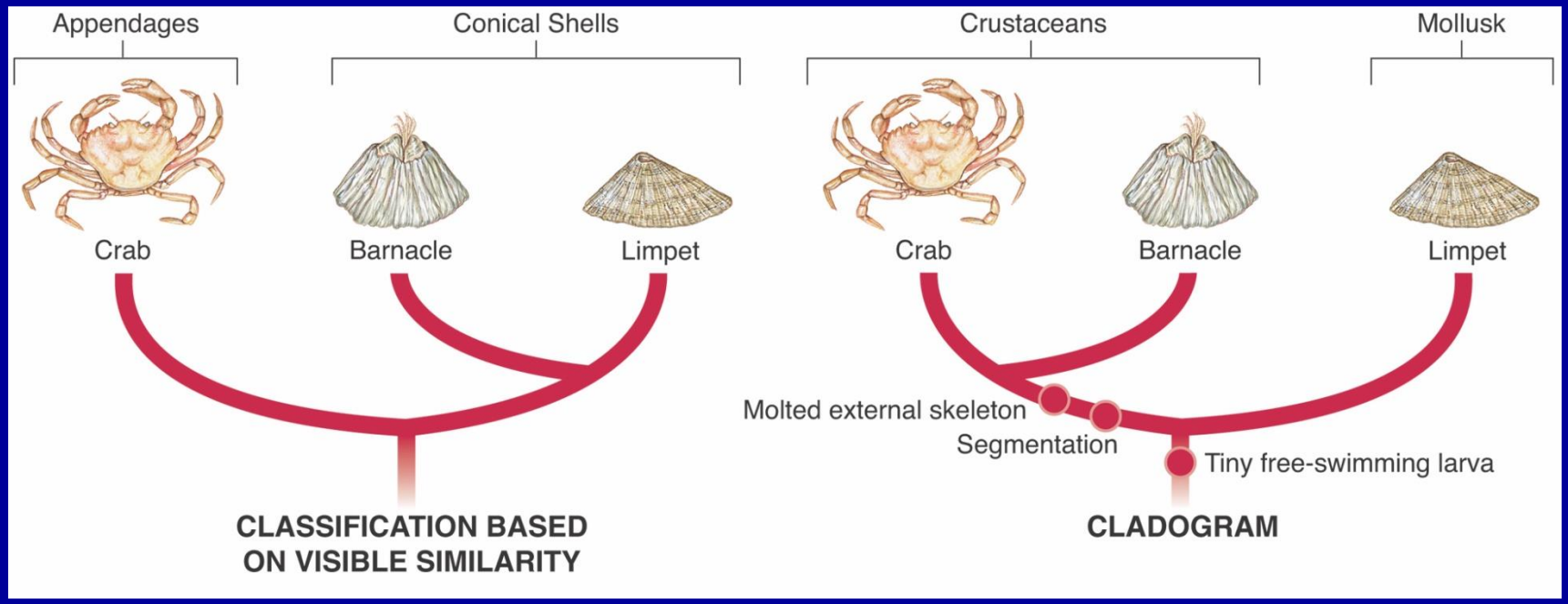
- Kingdom = Animalia
- Phylum (Division for plants) = Chordata
- Class = Mammalia
- Order = Primates
- Family = Hominidae
- *Genus* = *Homo*
- *species* = *sapiens*

Domain	Eukarya
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Family	Felidae
Genus	*Lynx*
Species	*Lynx rufus* *Lynx canadensis*
	Bobcat *Lynx*

Orders & families



18-2 Modern Evolutionary Classification



KEY CONCEPT QUESTIONS:

- How are evolutionary relationships important in classification?
- How can DNA and RNA help scientists determine evolutionary relationships?

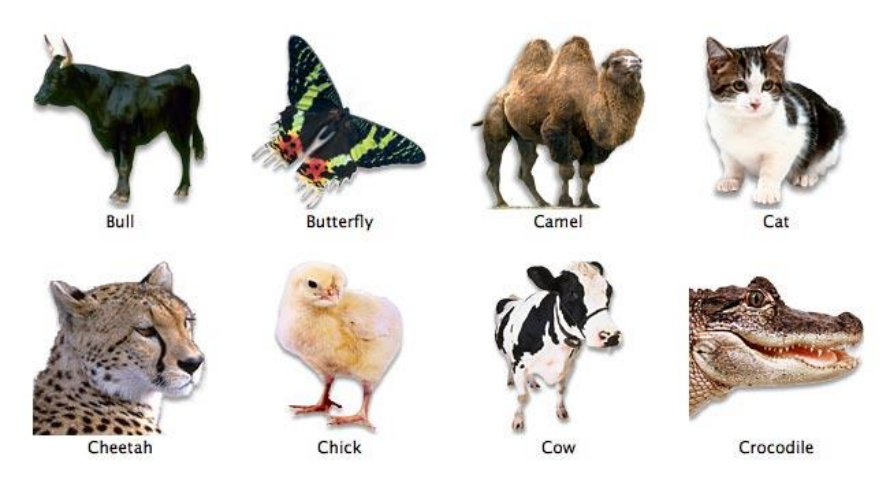
- Darwin's ideas about descent with modification have given rise to the study of PHYLOGENY, or evolutionary relationships among organisms.
  - evolutionary history of a species
  - based on common ancestries inferred from
    - fossil record
    - morphological & biochemical resemblances
    - molecular evidence

In a way, organisms determine who belongs to their species by choosing with whom they will _MATE_!

Taxonomic groups are "invented" by scientists to group organisms with similar _characteristics_.

BUT. . .

which characteristics are MOST IMPORTANT?



Should a dolphin be grouped with fish because it has fins and lives in water?

OR with mammals because it breathes air and makes milk for its young?

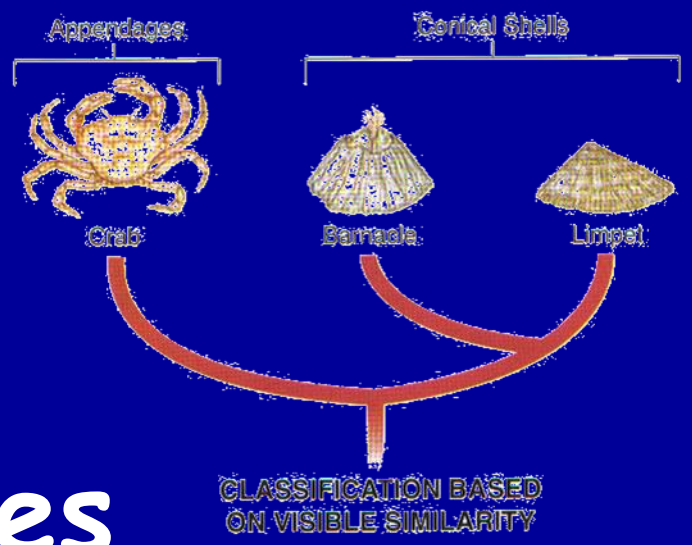
Look at these 3 organisms:

CRAB

BARNACLE

LIMPET

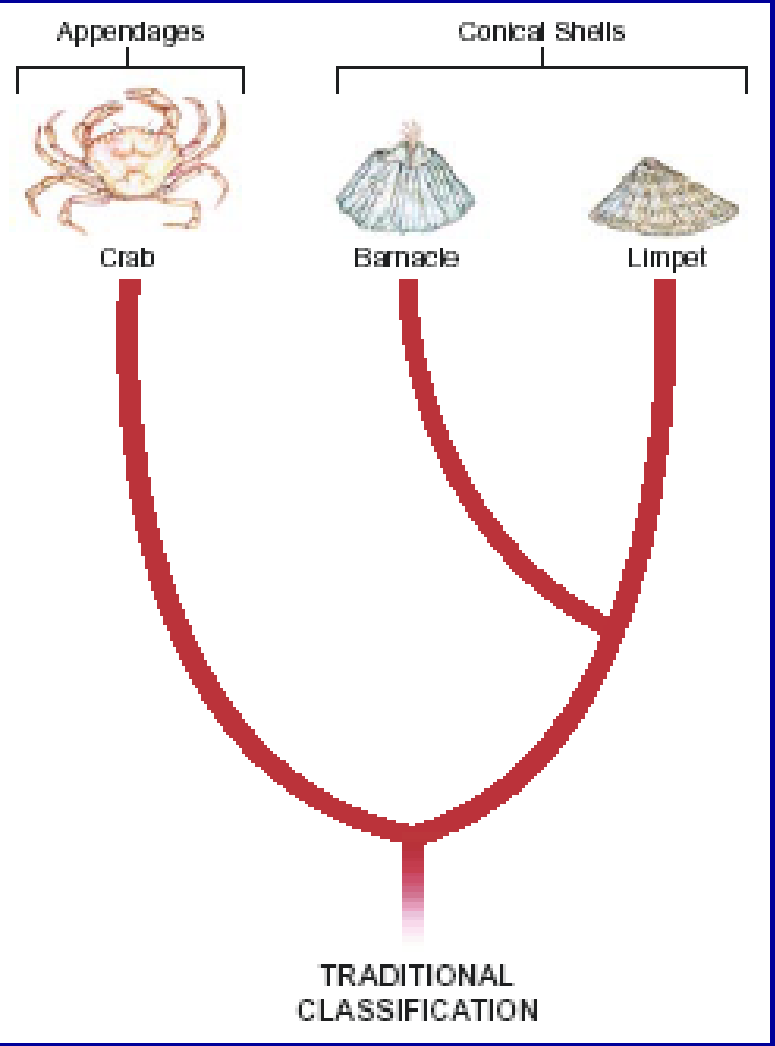
Judging by appearances you would probably put limpets and barnacles together in a group and crabs in a different group.



BUT LOOKS can be deceiving!

Problems with Classifying

- Classifying species based on their **anatomy** sometimes posed problems for taxonomists.
- Scientists debated which of these three organisms were more closely related—crabs (top left), barnacles (bottom left), and limpets (right).



Look more closely!

LIMPET

BARNACLE

CRAB

Limpet and barnacle larvae are very different.

Barnacles have jointed limbs.
Limpets DON'T !

Barnacles have a segmented body
Limpets DON'T !

Barnacles have an exoskeleton that molts.
Limpets DON'T !

Look more closely!

CRAB

BARNACLE

LIMPET

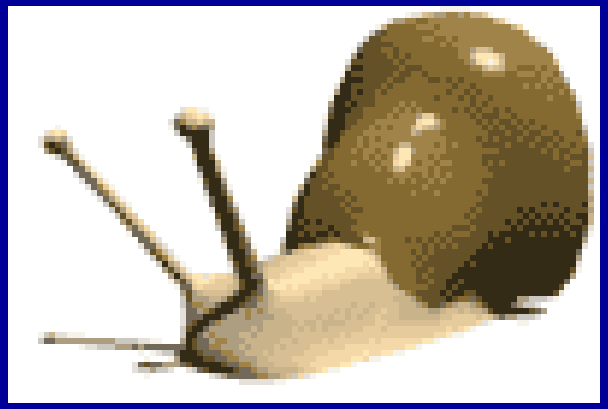
Crab and barnacle larvae are very similar

Barnacles have jointed limbs.
So do CRABS !

Barnacles have a segmented body
So do CRABS !

Barnacles have an exoskeleton that molts.
So do CRABS !

LIMPET



SNAIL

Limpets have an internal anatomy more like snails, which are MOLLUSKS.

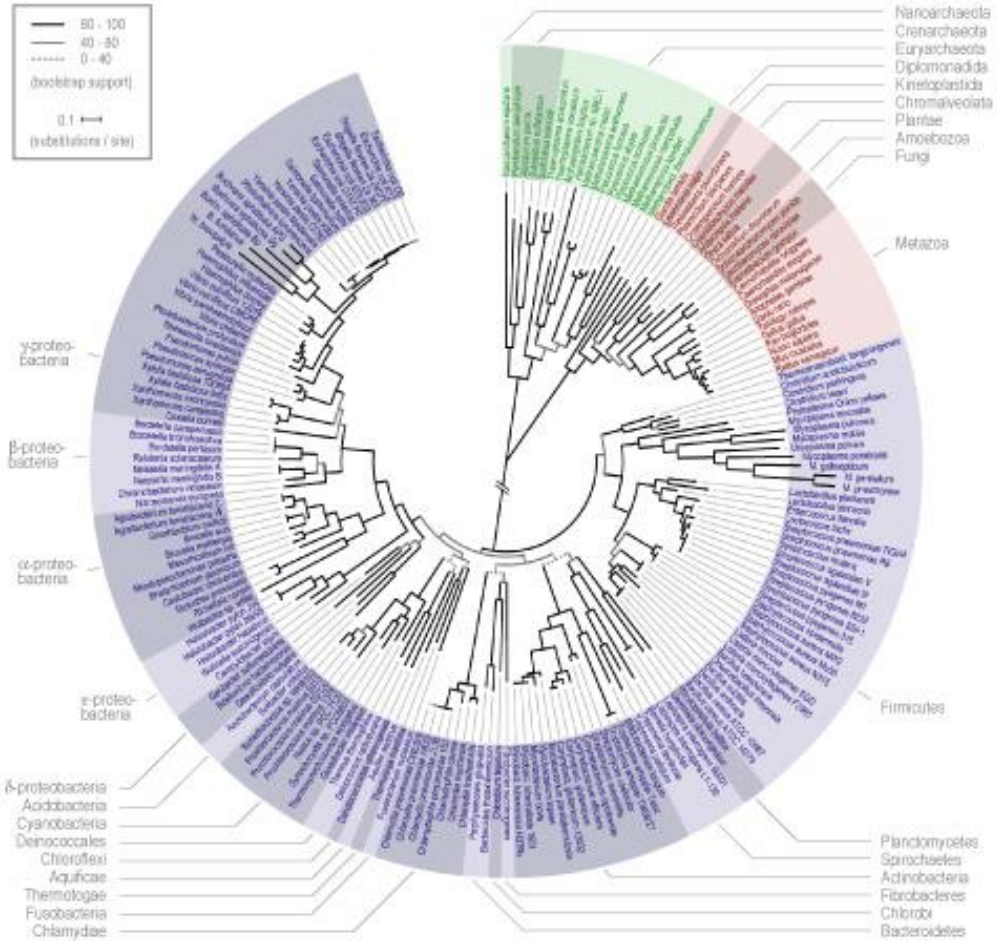
Because of these characteristics, scientists have concluded that barnacles are more closely related to crabs than to MOLLUSKS

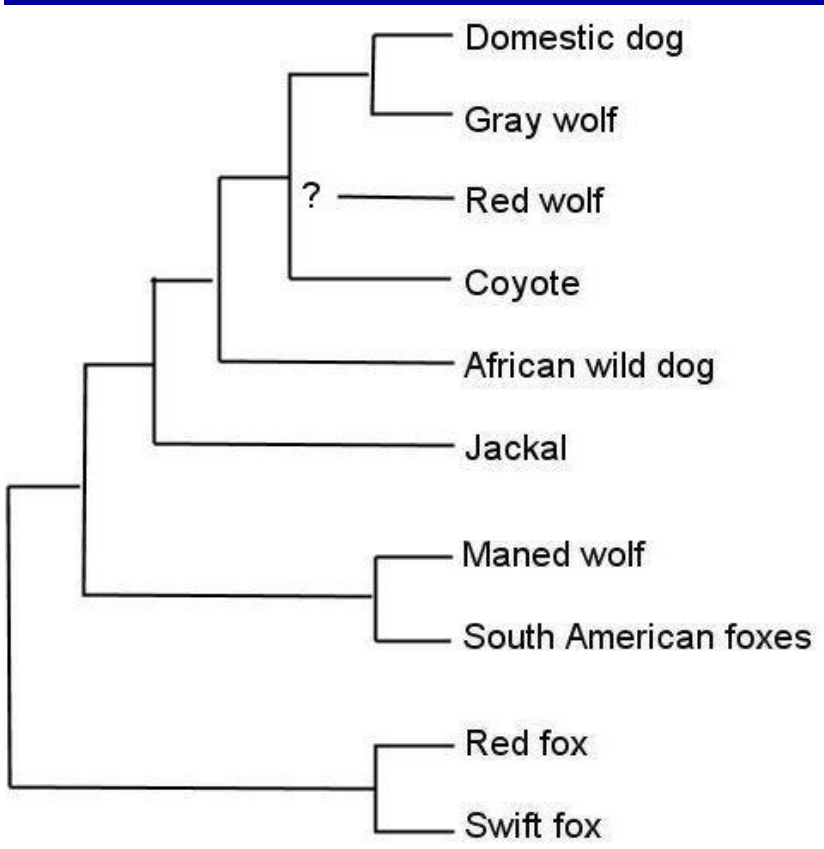
Systematics

- **<u>Systematics</u> is a system that organizes the tremendous diversity of organisms into a <u>phylogenetic</u> tree.**
  - **A phylogenetic tree is a family tree that's shows the evolutionary relationships thought to exist between organisms.**
  - **It represents a hypothesis that is based on lines of evidence such a the fossil record, morphology, embryological patterns of development, and chromosomes and macromolecules.**

Evolutionary Classification

Phylogeny is the study of evolutionary relationships among organisms.

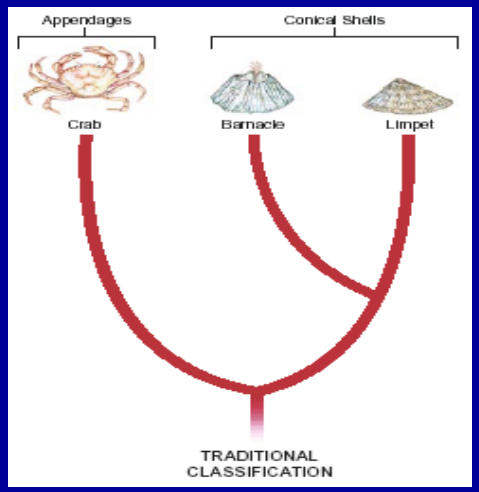


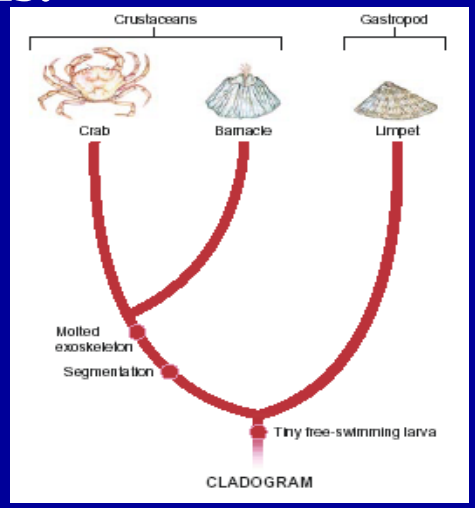


Redrawn from Wayne, 1993. Molecular evolution of the dog family

Modern Evolutionary Classification

- Biologists now group organisms into categories that represent lines of evolutionary descent, **not** just physical similarities.
- The strategy of grouping organisms is based on evolutionary history and is called evolutionary classification.
- Until about 150 years ago, barnacles and limpets were grouped together because both had conical shells.

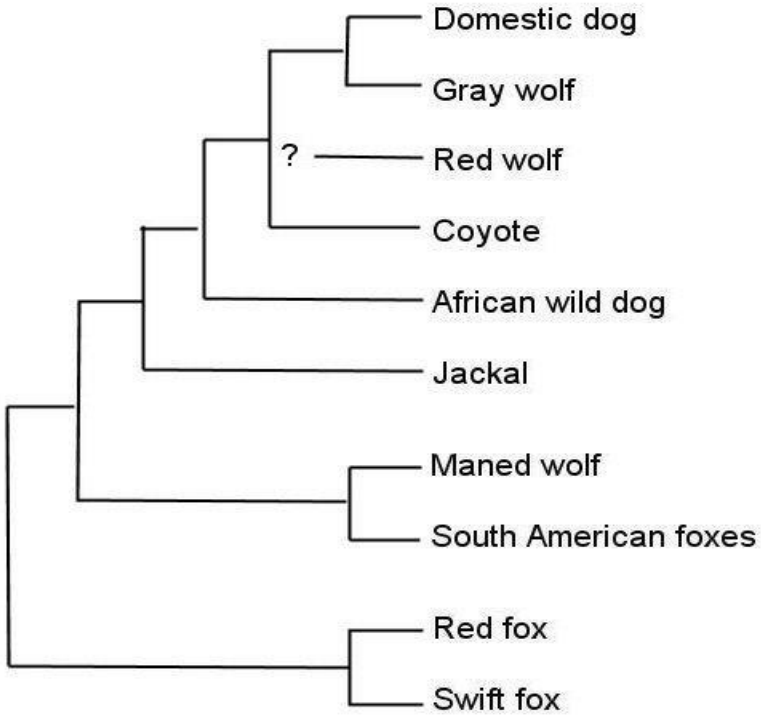




- In the cladogram, crabs and barnacles are grouped together because they **share** important evolutionary characteristics, such as a **segmented** body and an exoskeleton that the organism molts. Limpets do not share these characteristics.

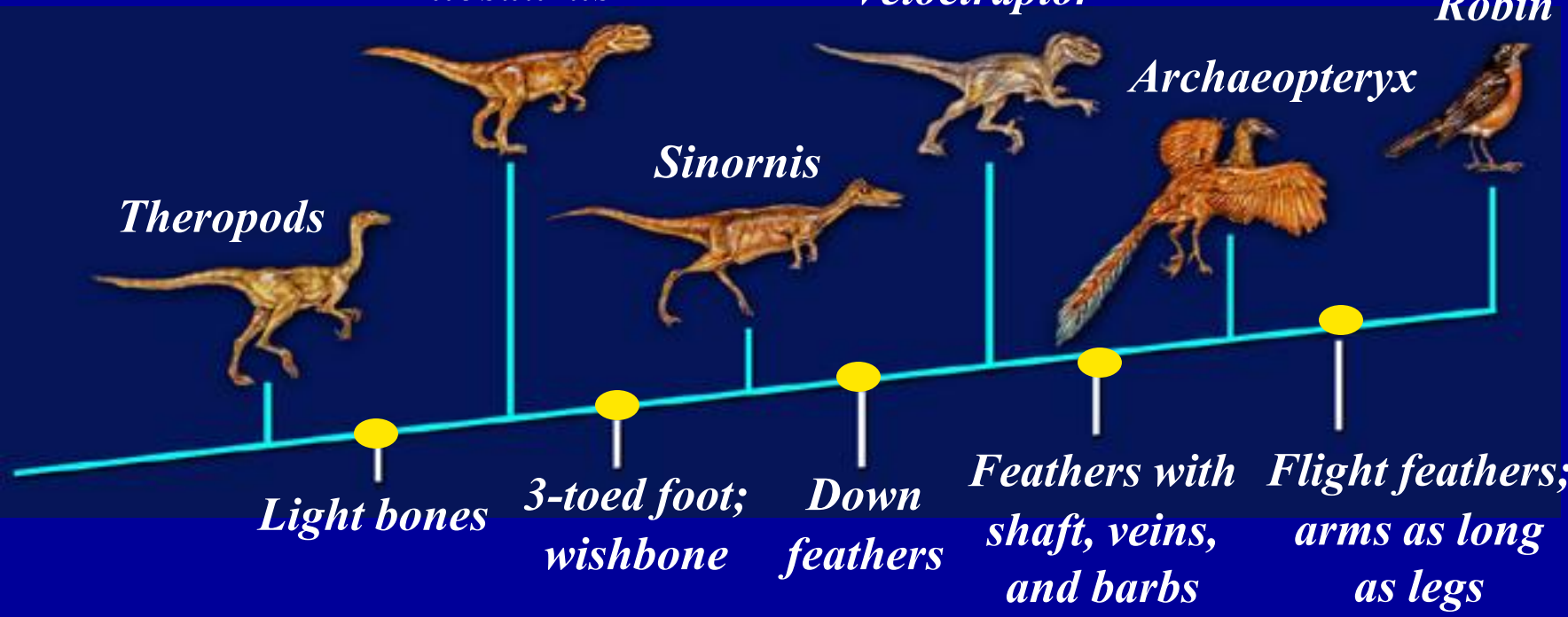
The higher the level of the taxon, the further back in time is the common ancestor of all the organisms in the taxon.

Organisms that appear very similar may not share a recent common ancestor.



Redrawn from Wayne, 1993. Molecular evolution of the dog family

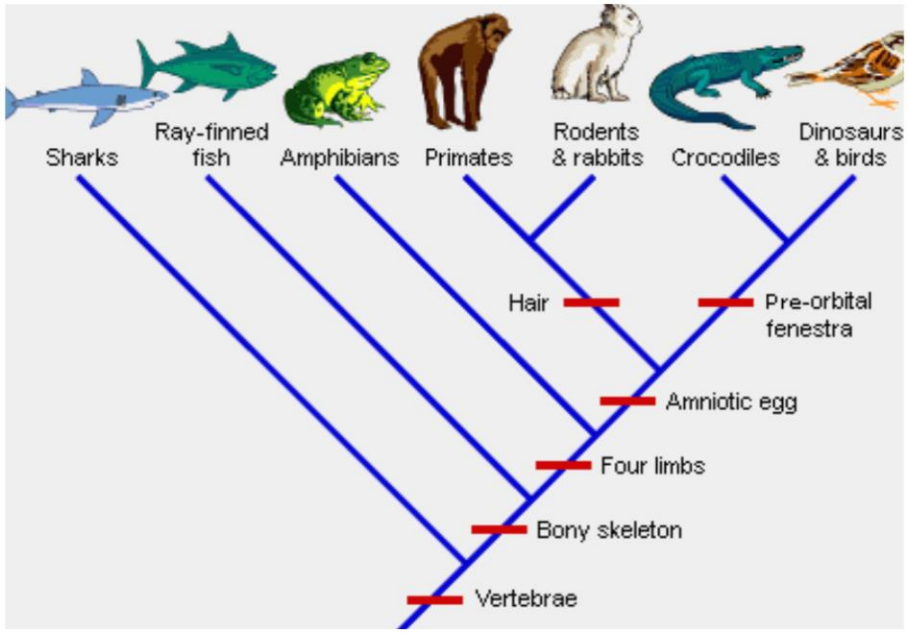
Classification Using Cladograms

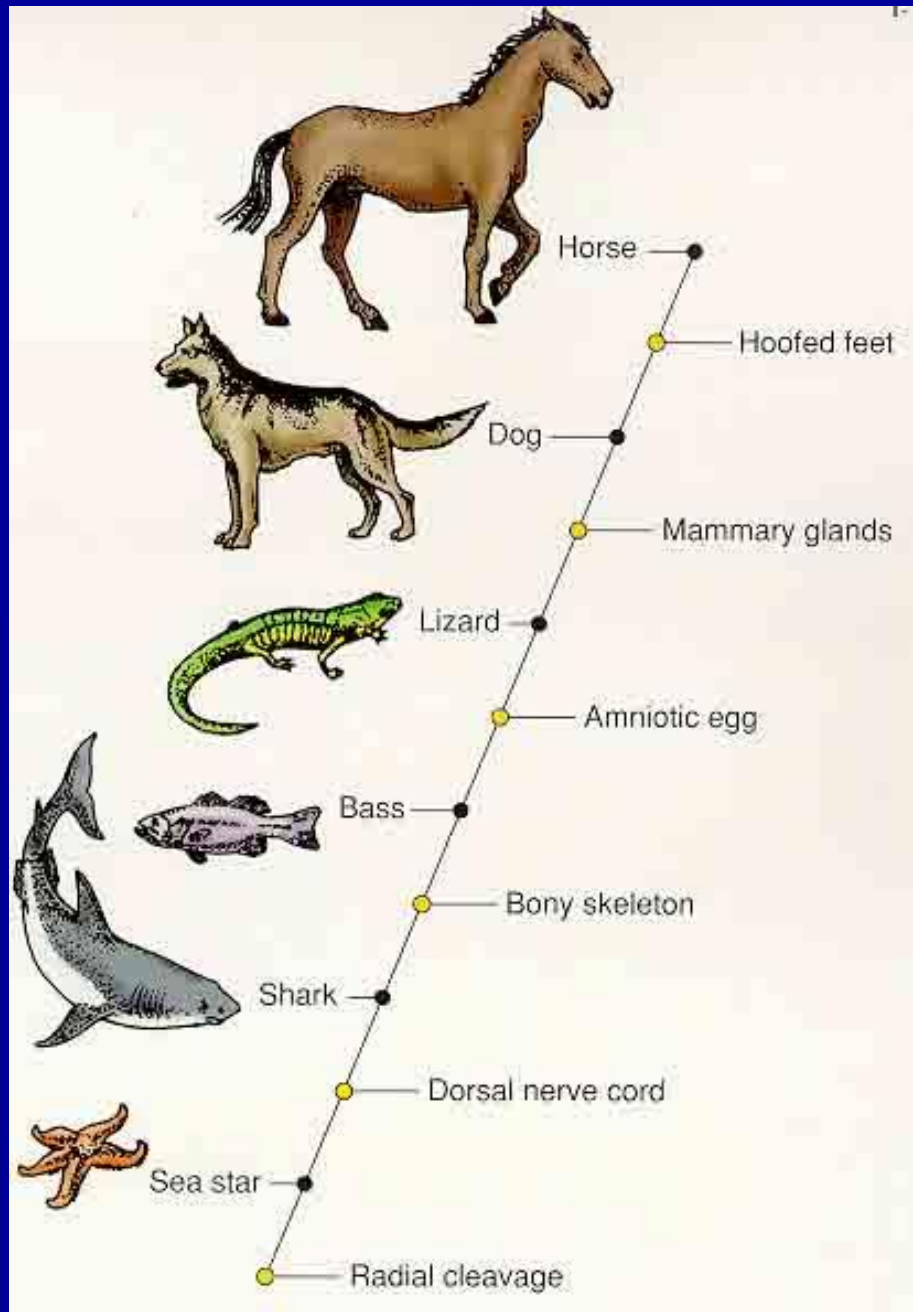


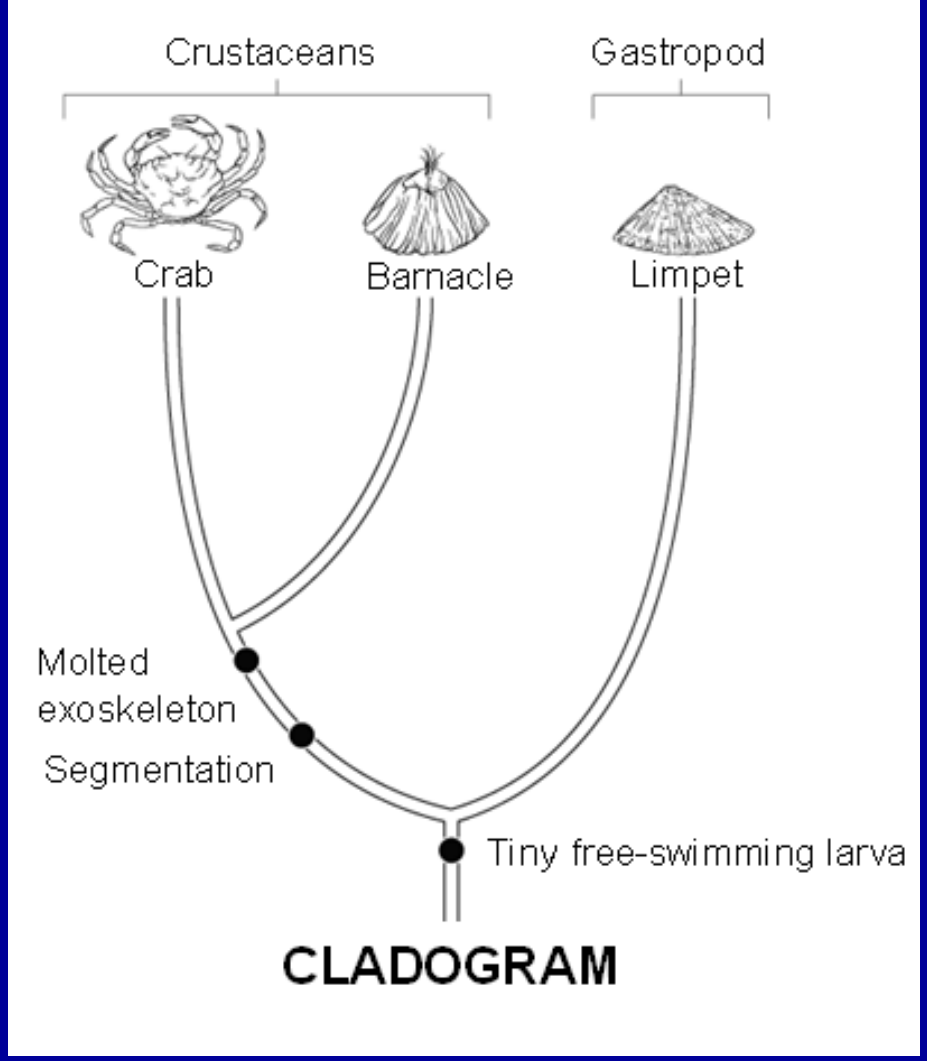
- One biological system of classification that is based on phylogeny is cladistics.
- **Phylogeny** is the evolutionary development or history of an organism.
- Cladograms show a probable evolution of a group of organisms from ancestral groups.
- Characteristics that appear in recent parts of a lineage but not in its older members are called **derived** characters.
- The dots represent the points at which these characteristics first arose.

Classification Using Cladograms

Derived characters can be used to construct a **cladogram**, a diagram that shows the evolutionary relationships among a group of organisms.



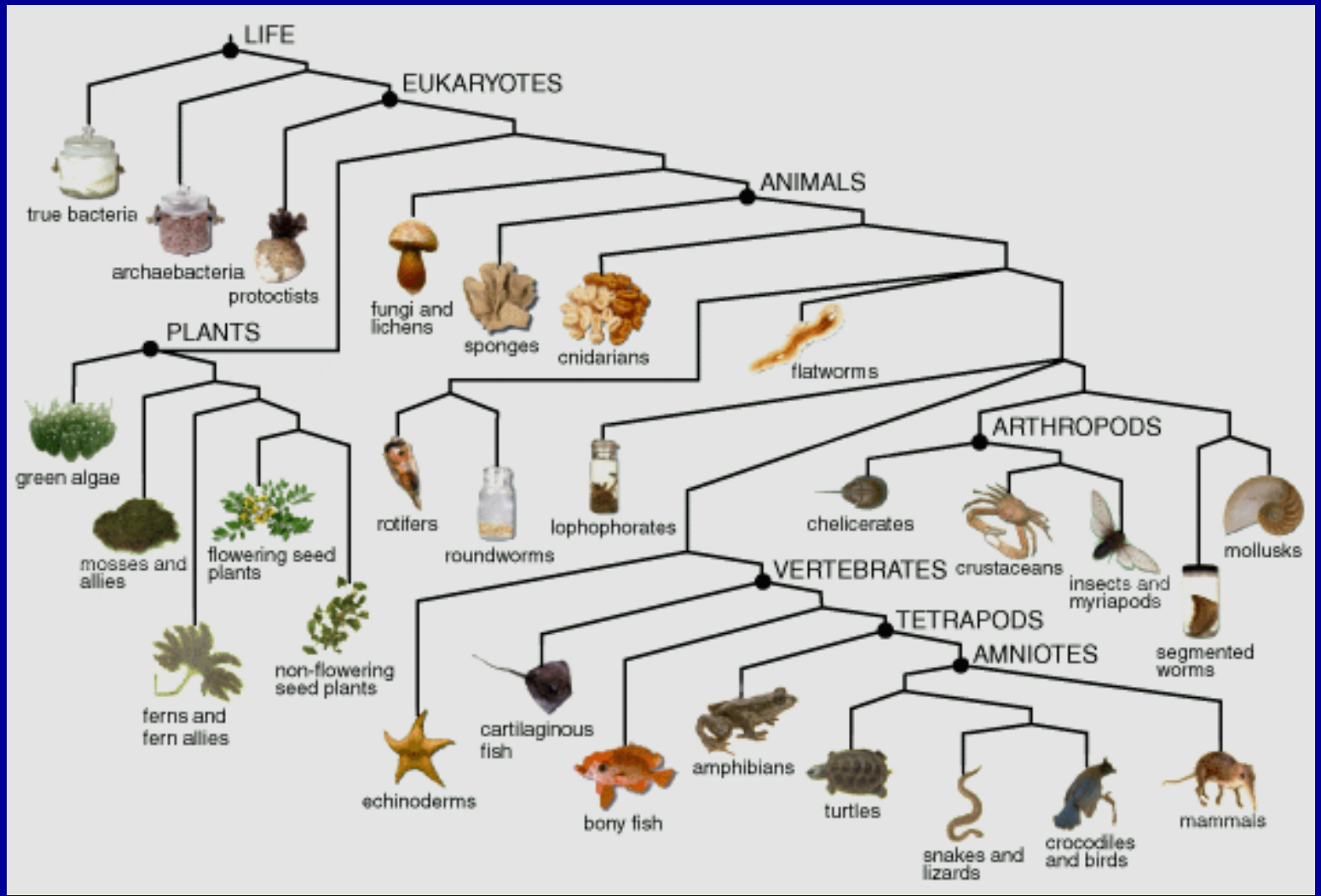


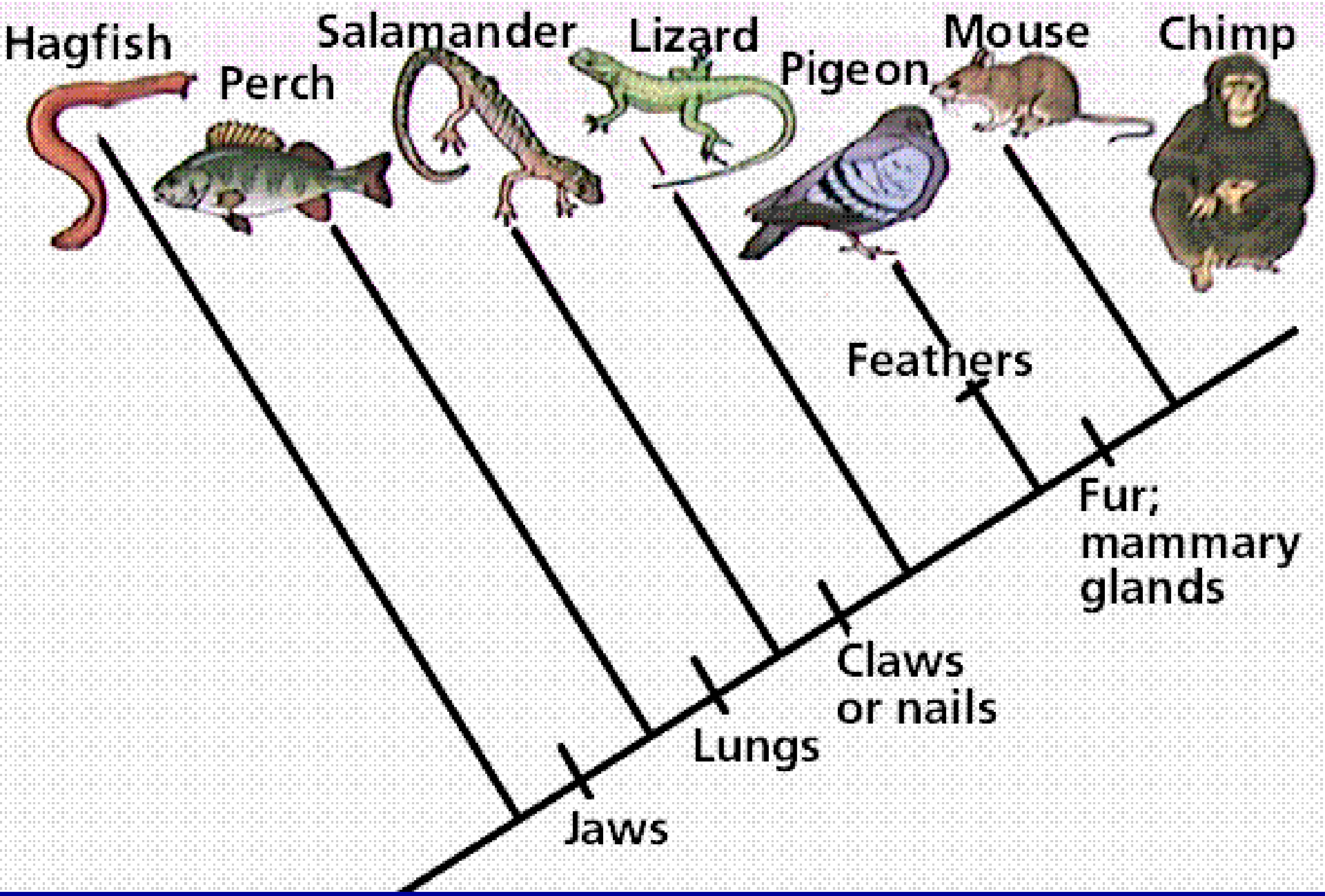


Derived characters appear at branches of the cladogram showing where they first arose.

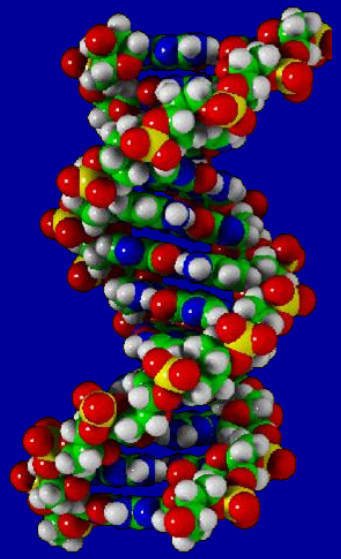
Cladograms help scientists understand how one lineage branched from another

- Cladogram = diagram that shows the evolutionary relationships among a group of organisms




Hagfish
Perch
Salamander
Lizard
Pigeon
Mouse
Chimp
Feathers
Fur; mammary glands
Claws or nails
Lungs
Jaws

All of the classification methods discussed so far are based on physical similarities and differences.

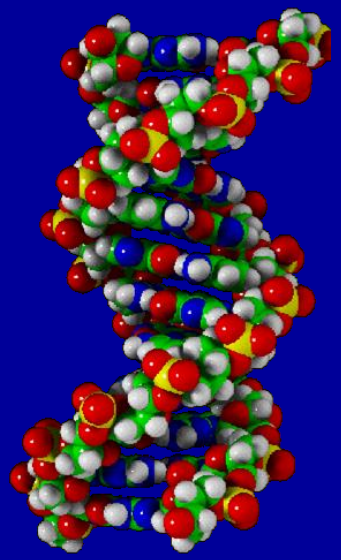


Even organisms with very different anatomies can share common traits.

EX: All living things use <u>DNA and RNA</u> to pass on information and control growth.

GENES of many organisms show important similarity at the molecular level.

Similarities in DNA can be used to help determine classification and evolutionary relationships between organisms.



Similarities in DNA and Proteins

- <u>Biochemistry</u> - determine similarities in DNA sequences and types of proteins produced
  - many differences between DNA sequences = very distant common ancestor
  - differences between amino acid sequences of the cytochrome c molecule (found in the mitochondrial membranes) in different organisms is used to determine how closely related two organisms are

- <u>Cytochrome c</u> protein has 104 amino acids
- - human & dog differ in 13 a.a.
- - human & rattle snake = 20
- - human & tuna = 31
- - human & rhesus monkey = 1
- - human & chimp = 0

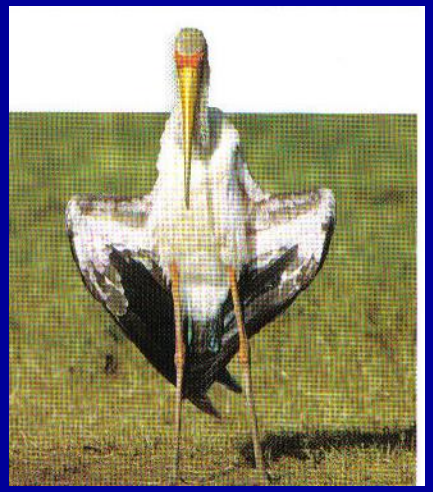
TABLE 16.1 SEQUENCE OF AMINO ACIDS IN CYTOCHROME C PROTEIN

ORGANISM	SEQUENCE OF FIRST 25 AMINO ACIDS
Dog	G D V E K G K K I F V Q K C A Q C H T V E K G G K
Tuna	G D V A K G K K T F V Q K C A Q C H T V E N G G K
Moth	G N A D N G K K I F V Q R C A Q C H T V E A G G K
Wheat	G N P D A G A K I F K T K C A Q C H T V D A G A G

Similarities in DNA can be used to help show evolutionary relationships and how species have changed.

African vulture

American vulture



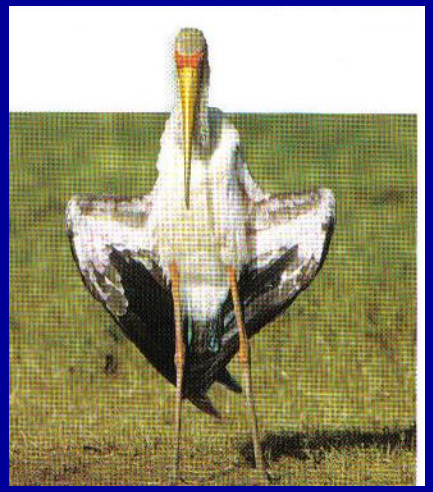
Stork

Traditionally these first two were classified together in falcon family. Storks were put in a separate family.

American vultures have a peculiar behavior. When they get overheated, they urinate on their legs to cool off

African vulture

American vulture



Stork

The only other bird that does this is the STORK.

DNA comparisons showed more similarities between American vulture and stork DNA than DNA from the two kinds of vultures suggesting a more recent common ancestor between storks and American vultures


African vulture


American vulture


Stork

DNA Evidence

The more similar the DNA of two species, the more recently they shared a common ancestor, and the more closely they are related in evolutionary terms.

```
                    1                                                  50
    Ovis aries X    CCCTTCCAGC CCCAGTCCAT CCAGCCGCAG CCTCACCAGC CCCTGCAGCC
Cervus elaphus X    CCCTTCCAGC CCCAGTCCAT CCAGCCGCAG CCTCACCAGC CCCTGCAGCC
    Ovis aries Y    CCCTTCCAGC CCCAGCCCAT CCAGCCACAG CCTCACCAGC CCCTACAGCC
Cervus elaphus Y    CTC....AGG CCCAGCCCAT CCAGCCACAG CCTCACCAAC CCCTACAGCC

                    51                                                100
    Ovis aries X    CCTGCAGCCC CTGCAGCCCT TGCAGCCCCT GCAGCCCCTG CAGCCCCAGT
Cervus elaphus X    CCTGCAGCCC CTGCAGCCCT TGCAGCCCCT GCAGCCCCTG CAGCCCCAGC
    Ovis aries Y    CCATGTCAGC CTG....... .......... .......... ..........
Cervus elaphus Y    CCAGTAGCAC CTG....... .......... .......... ..........

                    101                                               150
    Ovis aries X    CACCCG..TG CACCCCATCC AGCCCCTTGC CGCCGCAGCC ACCTCTGCCT
Cervus elaphus X    CGCCCAGTTG CACCCCATCC AGCCCCTTGC CGCCACAGCC ACCTCTGCCT
    Ovis aries Y    ........TG CACCCCATCC AGCCCTT... .......GCC ACCTCTGCCT
Cervus elaphus Y    ........TG CACCCCATCC AGCCCTT... .......GCC ACCTCTGCCT

                    151                                               200
    Ovis aries X    CCGATATTCC CCATGCAGCC TTTGCCCCCC .ATGCTTCCT GACCTGCCT
Cervus elaphus X    CCTATATTCC CCATGCAGCC TTTGCCCCCC .ATGCTTCCT GACCTGCCT
    Ovis aries Y    CCGATATTCC CCATGCAGCC TTTGCCCCCC TGTGCTTCCT GAGCTGCCT
Cervus elaphus Y    CCGATATTCC CCATGCAGCC TTTGCCCCCT .GTGCTTCCT GACCTGCCT
```

DNA sequence comparison of the X and Y amelogenin gene fragments of sheep and European red deer.

Pfeiffer and Brenig *BMC Genetics* 2005 **6**:16 doi:10.1186/1471-2156-6-16

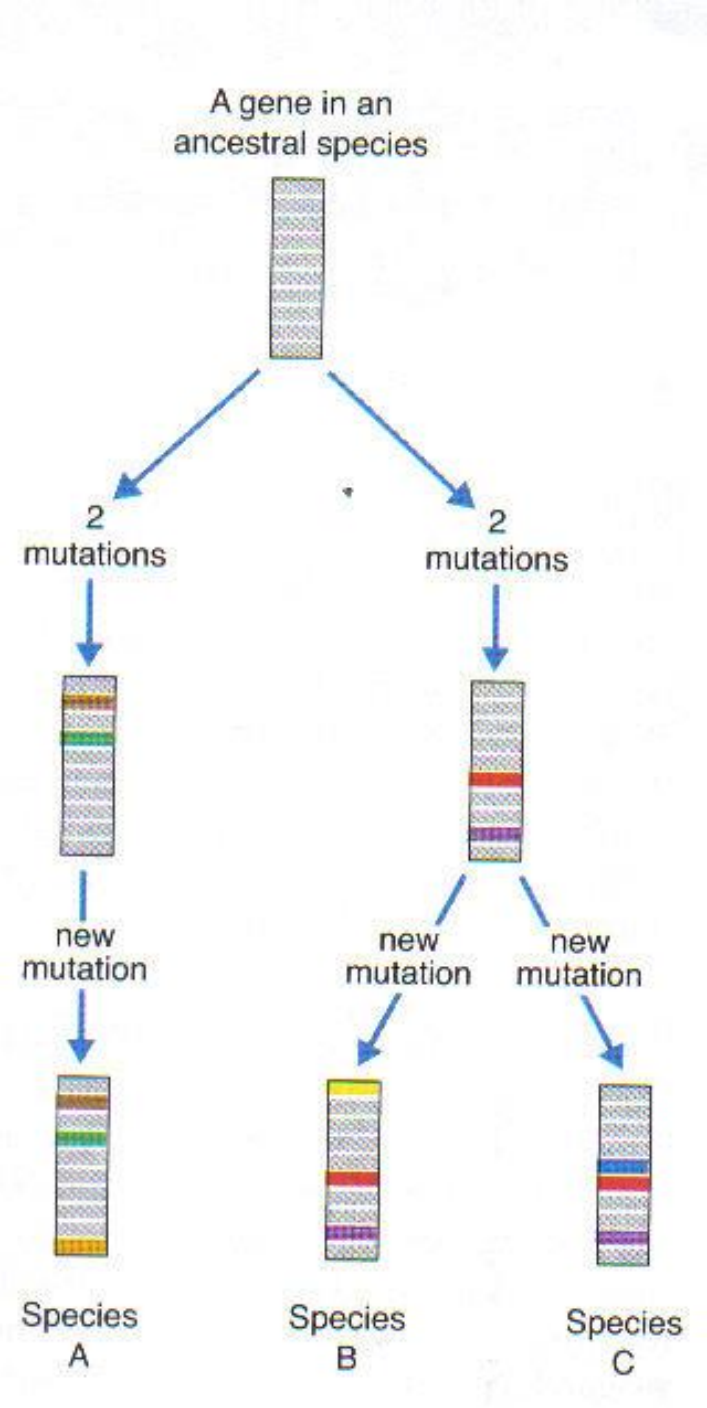
Comparisons of DNA can also be used to mark the passage of evolutionary time

A model that uses DNA comparisons to estimate the length of time that two species have been evolving independently

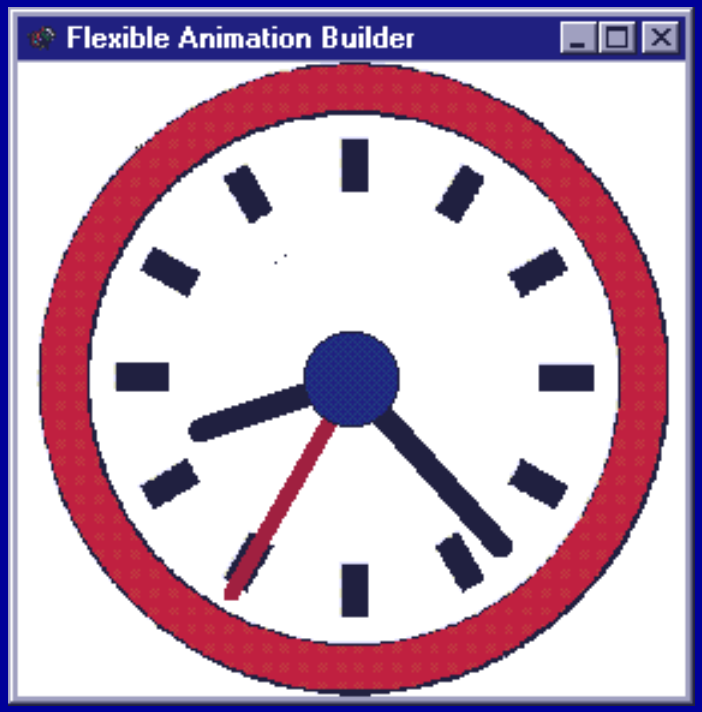
= MOLECULAR CLOCK

Mutations occur all the time and cause slight changes to the DNA code.

Degree of dissimilarity is an indication of how long ago two species shared a common ancestor



Different genes accumulate mutations at different rates so there are many molecular clocks "ticking".



Allows scientists to time different kinds of evolutionary events, like using different hands on a clock.

Dichotomous Key

- One tool used to identify **unfamiliar** organisms is a dichotomous key.
- A dichotomous key is a series of **paired** statements that describe physical characteristics of different organisms.
- A **key** is made up of sets of numbered statements.
- Each set deals with a **single** characteristic of an organism, such as leaf shape or arrangement.

Dichotomous Key for Leaves

1. Compound or simple leaf
   - 1a) Compound leaf (leaf divided into leaflets) .....go to step 2
   - 1b) Simple leaf (leaf not divided into leaflets) .....go to step 4
2. Arrangement of leaflets
   - 2a) Palmate arrangement of leaflets (leaflets all attached at one central point) .....*Aesculus* (buckeye)

Leaf Key

Dichotomous Key for Leaves

1. Compound or simple leaf
   - 1a) Compound leaf (leaf divided into leaflets) .....go to step 2
   - 1b) Simple leaf (leaf not divided into leaflets) .....go to step 4
2. Arrangement of leaflets
   - 2a) Palmate arrangement of leaflets (leaflets all attached at one central point) .....*Aesculus* (buckeye)
   - 2b) Pinnate arrangement of leaflets (leaflets attached at several points) ....go to step 3
3. Leaflet shape
   - 3a) Leaflets taper to pointed tips .....*Carya* (pecan)
   - 3b) Oval leaflets with rounded tips .....*Robinia* (locust)
4. Arrangement of leaf veins
   - 4a) Veins branch out from one central point .....go to step 5
   - 4b) Veins branch off main vein in the middle of the leaf .....go to step 6
5. Overall shape of leaf
   - 5a) Leaf is heart shaped.....*Cercis* (redbud)
   - 5b) Leaf is star shaped .....*Liquidambar* (sweet gum)
6. Appearance of leaf edge
   - 6a) Leaf has toothed (jagged) edge .....*Betula* (birch)
   - 6b) Leaf has untoothed (smooth) edge .....*Magnolia* (magnolia)

Dichotomous Key

- A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees, wildflowers, mammals, reptiles, rocks, and fish.
- Keys consist of a series of choices that lead the user to the correct name of a given item.
- "Dichotomous" means "divided into two parts". Therefore, dichotomous keys always give two choices in each step.

Dichotomous Key – Family: Candius

1a. Candy is chewy……..2
1b. Candy is hard……7

2a. Candy is wrapped……...3
2b. Candy is not wrapped……....Ursa gummius

3a. Candy is rounded……....4
3b. Candy is not rounded……..…5

4a. Wrapper is all white……....Saltus taffinia
4b. Wrapper is not all white...……..…5

5a. Wrapper is brown and white……..Tutus rollus
5b. Wrapper is not brown and white....6

6a. Wrapper is silver……....Chocolatus cyssan
6b. Wrapper varies in color……Stellaria explodus

7a. Candy is spherical (ball-shaped)....8
7b. Candy is not spherical……...9

8a. Candy is wrapped……11
8b. Candy is unwrapped……..…Mandibulus crackus

9a. Wrapper is transparent……...10
9b. Wrapper tells the flavor……Joyous rancheria

10a. Wrapper is clear……..…Mintus stripus
10b. Wrapper is yellow……...Ranunculus scotchus

11a. Candy is on a stick……..…Moronus moronus
11b. Candy is not on a stick……...Spherus combustus

18–3 Kingdoms and Domains

- There are now 6 Kingdoms – listed below.

Changing Number of Kingdoms						
First Introduced	Names of Kingdoms					
1700s	Plantae					Animalia
Late 1800s	Protista			Plantae		Animalia
1950s	Monera		Protista	Fungi	Plantae	Animalia
1990s	Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia

KEY CONCEPT QUESTIONS:

- What are the six kingdoms of life as they are now identified?
- What is the three-domain system of classification?

The Tree of Life Evolves

Systems of classification adapt to new discoveries.

- Linnaeus classified organisms into two kingdoms— plantae and animalia
- We then had 5 kingdoms
- We can also have 6 kingdoms

Five Kingdoms

Scientists realized there were enough differences among organisms to make 5 kingdoms:

- Monera
- Protista
- Fungi
- Plantae
- Animalia

Six Kingdoms

Recently, biologists recognized that Monera were composed of two distinct groups: **Eubacteria** and **Archaebacteria**.

The six-kingdom system of classification includes:

- **Eubacteria**
- **Archaebacteria**
- **Protista**
- **Fungi**
- **Plantae**
- **Animalia**

Changing Number of Kingdoms

- **This diagram shows some of the ways organisms have been classified into kingdoms over the years.**

Changing Number of Kingdoms						
First Introduced	Names of Kingdoms					
1700s	Plantae					Animalia
Late 1800s	Protista			Plantae		Animalia
1950s	Monera		Protista	Fungi	Plantae	Animalia
1990s	Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia

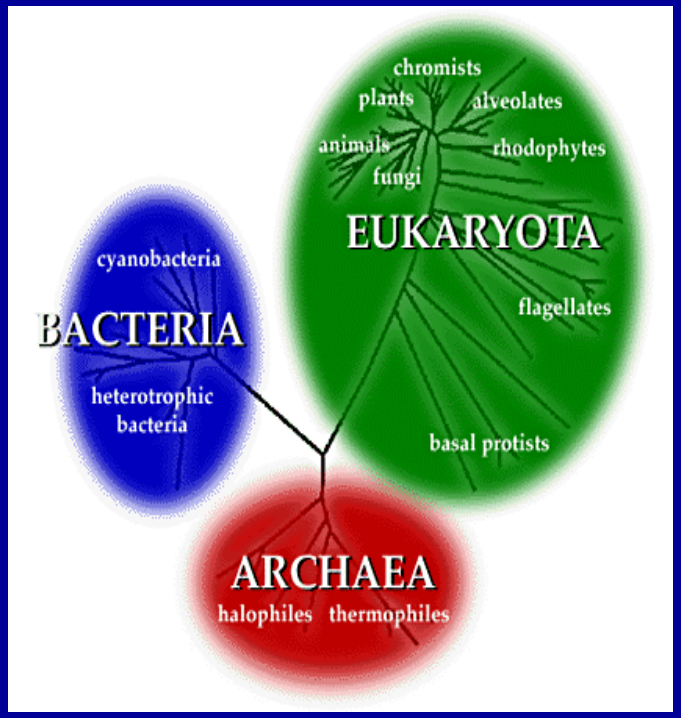
The Three-Domain System

Molecular analyses have given rise to a new taxonomic category that is now recognized by many scientists.

The **domain** is a more inclusive category than any other — **larger than a kingdom**.

There is also a level higher than kingdom called Domains

- The three domains are:
  - Bacteria
    - kingdom Eubacteria
  - Archaea
    - kingdom Archaebacteria
  - Eukarya
    - Kingdom protists, fungi, plants, and animals.



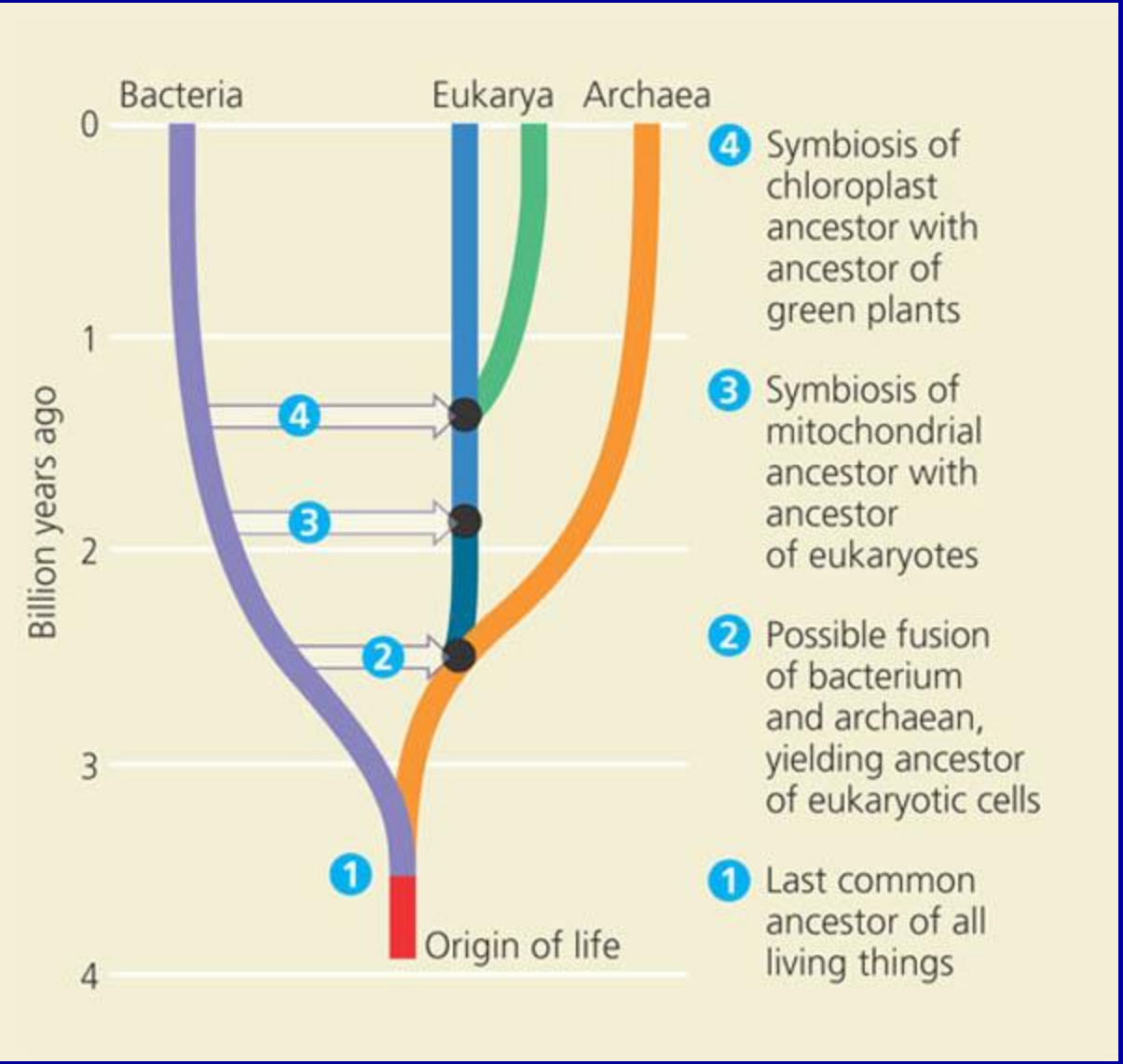
- Domain = most inclusive taxonomic category; larger than a kingdom

Classification of Living Things

DOMAIN	Bacteria	Archaea	Eukarya			
KINGDOM	Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus*, *Escherichia coli*	Methanogens, halophiles	*Amoeba*, *Paramecium*, slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals

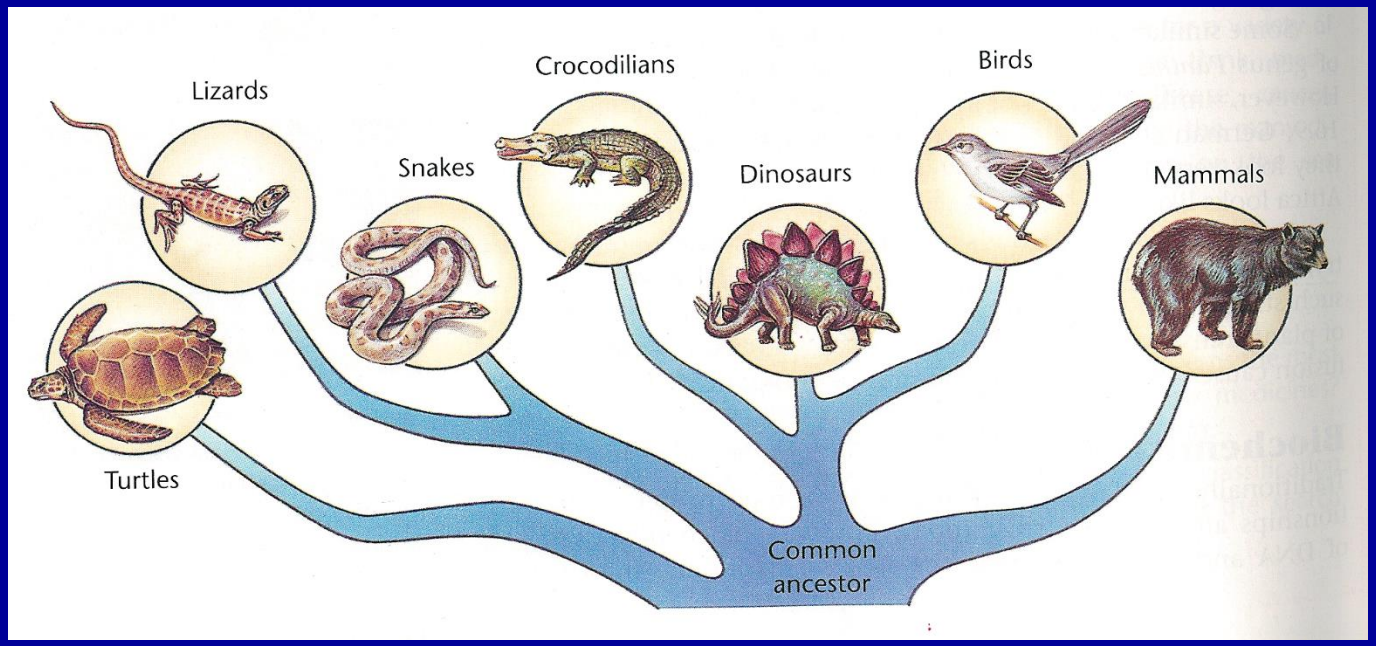
Universal Tree of Life

- 3 Domains
  - Bacteria
  - Eukarya
  - Archaea

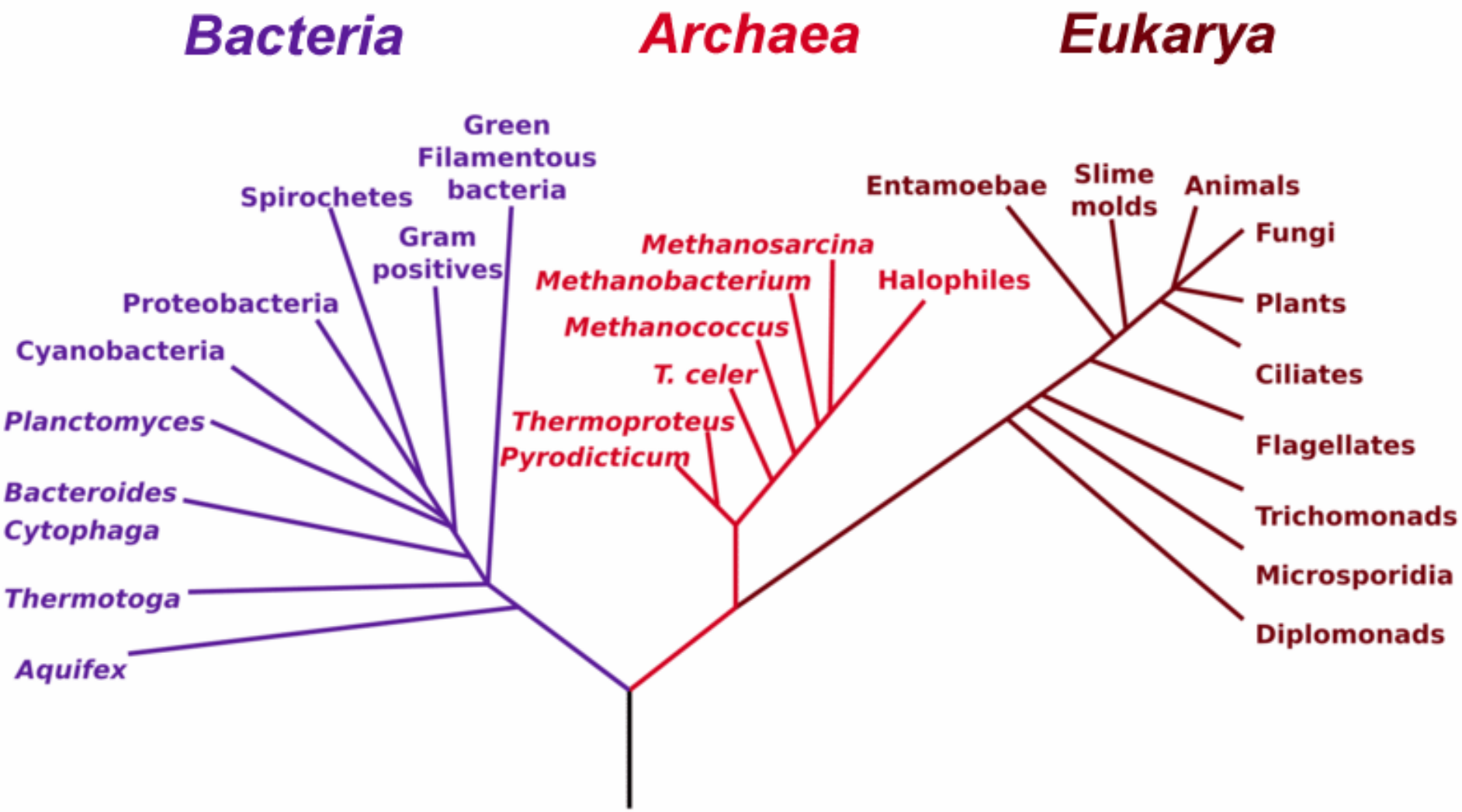


Phylogenetic trees

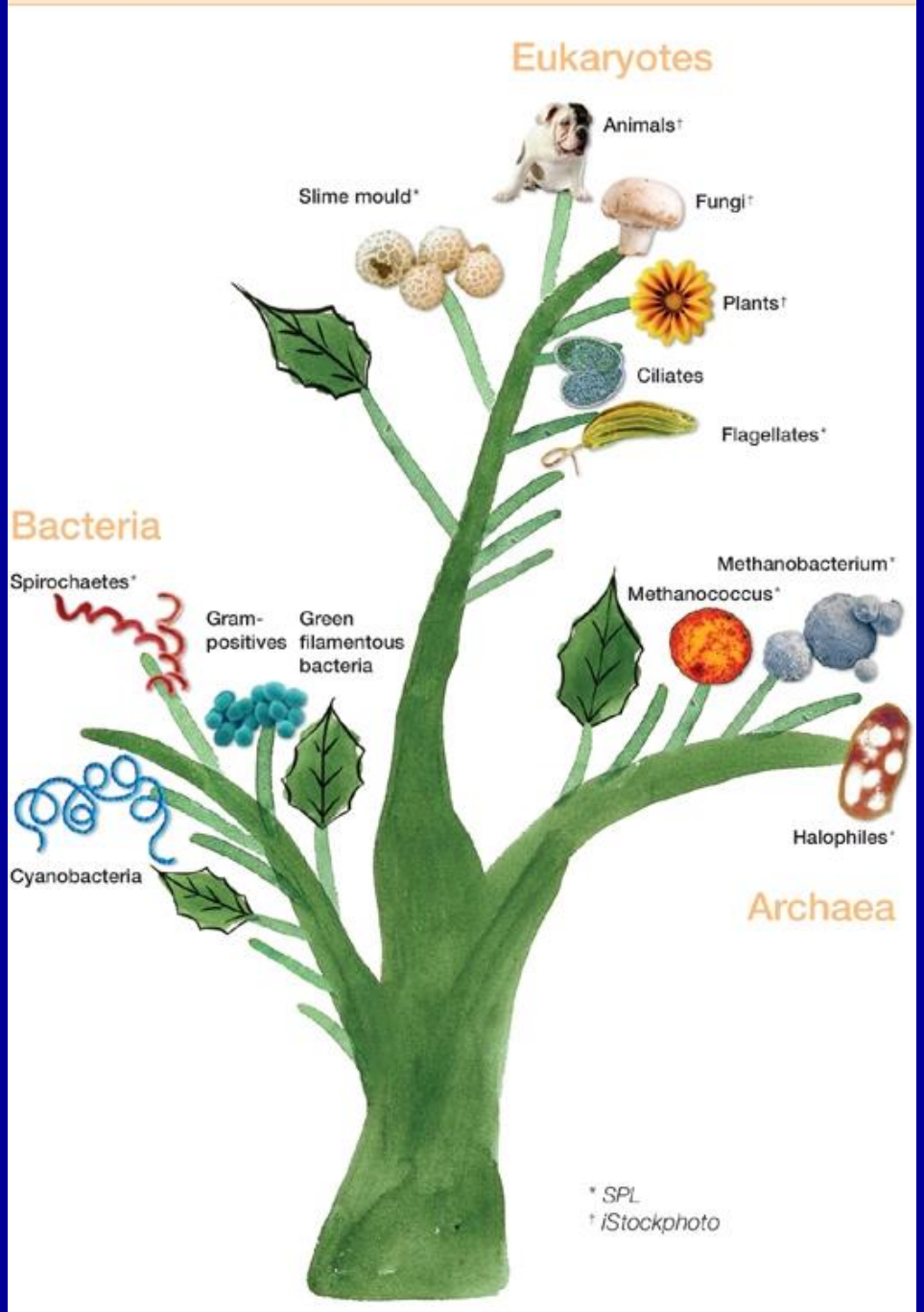
- shows relationships between organisms
  - tips of branches = modern organisms
  - branches = common ancestors
  - new divisions = emergence of new species



Phylogenetic Tree of Life

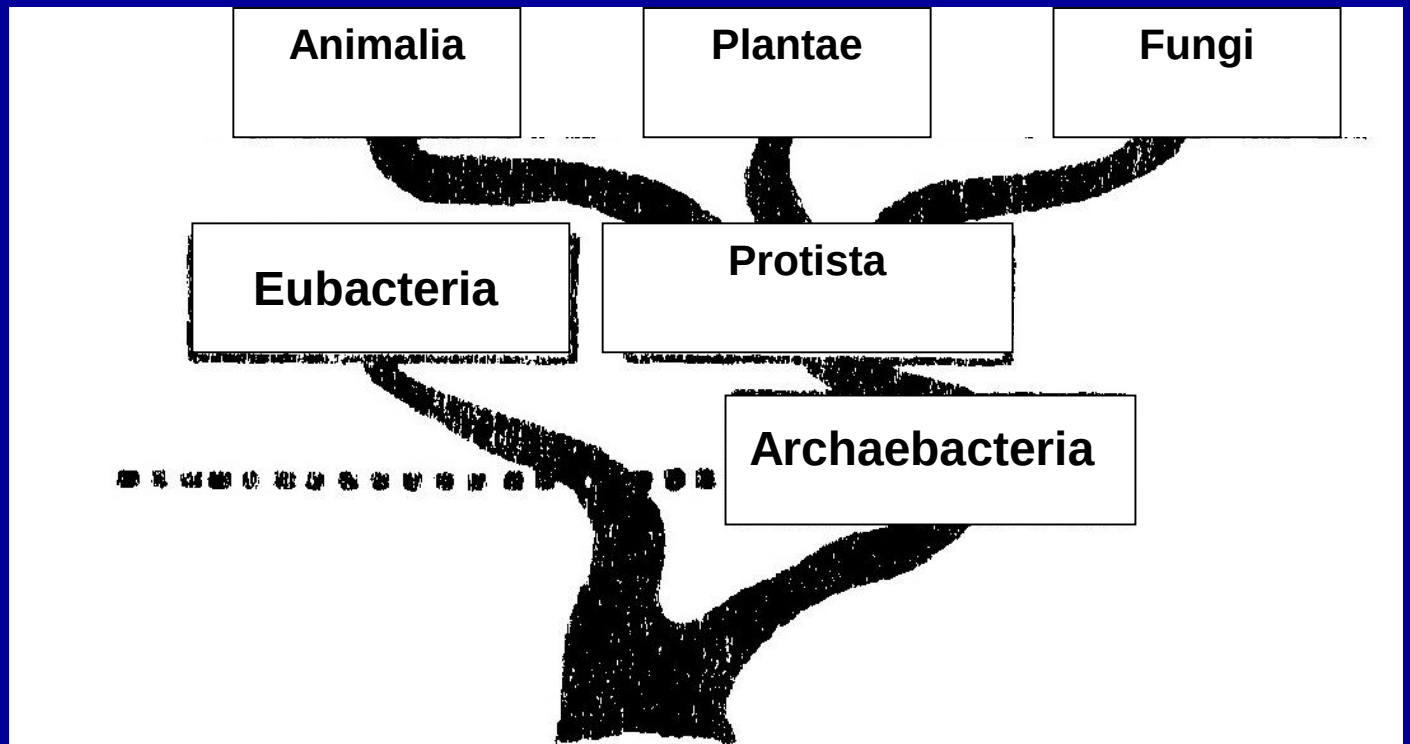


TREE OF LIFE


Eukaryotes
Animals†
Fungi†
Slime mould*
Plants†
Ciliates
Flagellates*
Bacteria
Spirochaetes*
Gram-positives
Green filamentous bacteria
Cyanobacteria
Methanobacterium*
Methanococcus*
Halophiles*
Archaea
* SPL
† iStockphoto

The Six Kingdoms of Organisms

- The six kingdoms of organisms are archaebacteria, eubacteria, protists, fungi, plants, and animals.
- In general, differences in cellular structures and methods of obtaining energy are the two main characteristics that distinguish among the members of the six kingdoms.



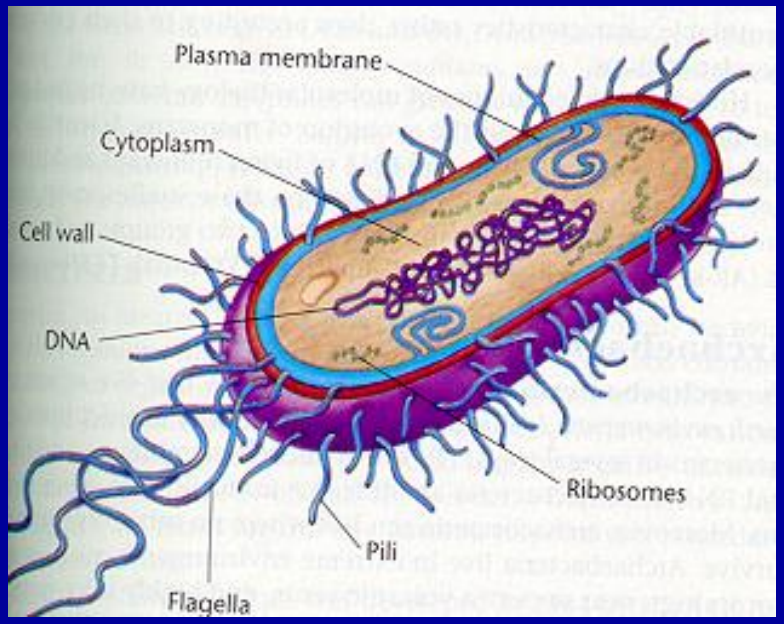
Domain Bacteria

Prokaryotes

- **The prokaryotes, organisms with cells that lack distinct nuclei bounded by a membrane, are microscopic and unicellular.**
- **Some are heterotrophs and some are autotrophs.**
- **In turn, some prokaryotic autotrophs are chemosynthetic, whereas others are photosynthetic.**
- **There are two kingdoms of prokaryotic organisms: Archaebacteria and Eubacteria.**

Eubacteria

- All of the other prokaryotes, about 5000 species of bacteria, are classified in Kingdom Eubacteria.
- Eubacteria have very strong cell walls (made of peptidoglycan) and a less complex genetic makeup than found in archaebacteria or eukaryotes.
- They live in most habitats except the extreme ones inhabited by the archaebacteria.
- Although some eubacteria cause diseases, such as strep throat and pneumonia, most bacteria are harmless and many are actually helpful.



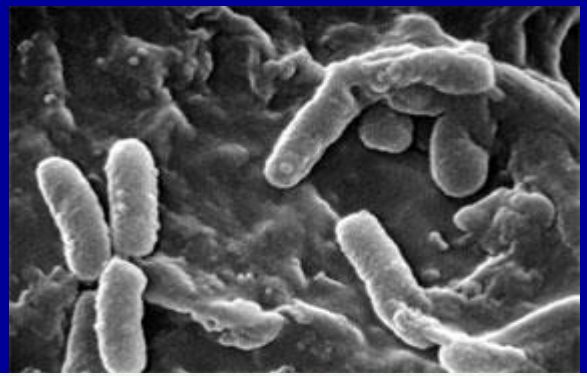
KINGDOM EUBACTERIA

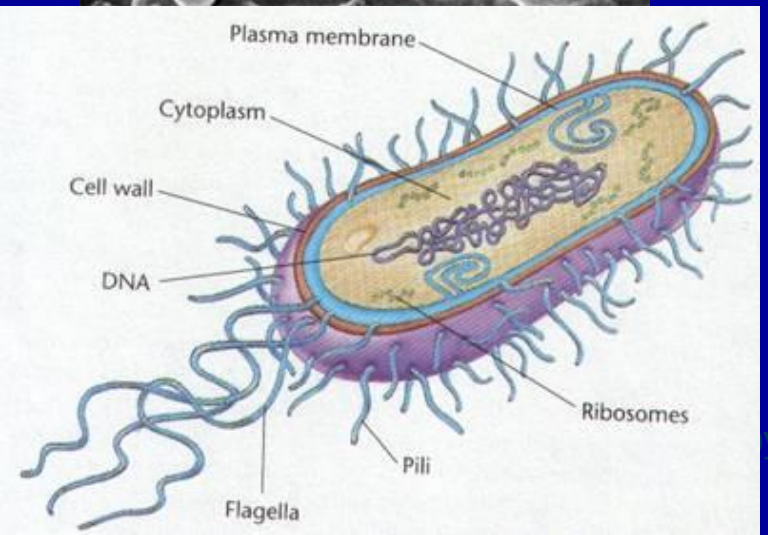
- They are UNICELLULAR PROKARYOTES. Most of the Bacteria (Germs) that affect your life are members of the Kingdom Eubacteria.
- Eubacteria are both autotrophic and heterotrophic.
- Includes the disease-causing bacteria such as tooth decay or food poisoning.
- The Combined Kingdoms, Archaebacteria and Eubacteria include the greatest number of living things on Earth.
- ALL OF THE PROKARYOTES ARE IN THESE TWO KINGDOMS.
- Both reproduce by binary fission, but they do have some ways to recombine genes, allowing evolution to occur.

E. coli

Staphylococcus

The domain Bacteria corresponds to the kingdom **Eubacteria**.

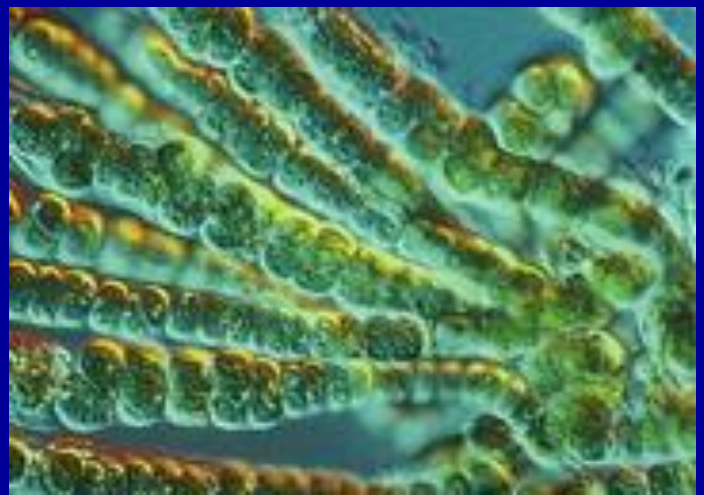




Classification of Living Things	
DOMAIN	Bacteria
KINGDOM	Eubacteria
CELL TYPE	Prokaryote
CELL STRUCTURES	Cell walls with peptidoglycan
NUMBER OF CELLS	Unicellular
MODE OF NUTRITION	Autotroph or heterotroph
EXAMPLES	*Streptococcus*, *Escherichia coli*

Domain Archaea

- Members of the domain **Archaea** are **unicellular prokaryotes**.
- Many live in extreme environments.
- Their cell walls lack peptidoglycan, and their cell membranes contain unusual lipids not found in any other organism.



Archaebacteria

- There are several hundred species of known archaebacteria and most of them live in extreme environments such as, deep-ocean hydrothermal vents, and seawater evaporating ponds, Sulfurous Hot Springs, very salty lakes, and in anaerobic environments, such as the intestines of mammals.
- Most of these environments are oxygen-free.
- Modern Archaebacteria MAY BE Directly descended from and very similar to the First Organisms on Earth.
- They Are UNICELLULAR PROKARYOTES with distinctive Cell Membranes as well as Biochemical and Genetic Properties that differ from ALL other kinds of life.
- Some are autotrophic, producing food by chemosynthesis. Includes Chemosynthetic Bacteria
- Most are heterotrophic.

The domain Archaea corresponds to the kingdom **Archaebacteria.**

Classification of Living Things	
DOMAIN	Archaea
KINGDOM	Archaebacteria
CELL TYPE	Prokaryote
CELL STRUCTURES	Cell walls without peptidoglycan
NUMBER OF CELLS	Unicellular
MODE OF NUTRITION	Autotroph or heterotroph
EXAMPLES	Methanogens, halophiles

Domain Eukarya

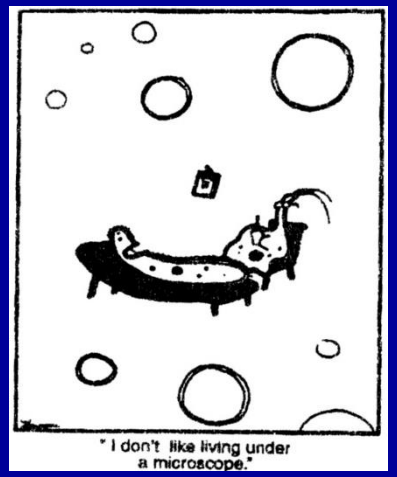
The domain **Eukarya** consists of organisms that have a nucleus.

This domain is organized into four kingdoms:

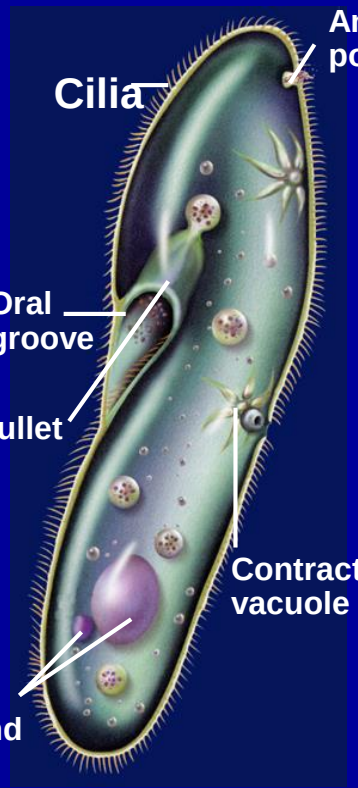
- **Protista**
- **Fungi**
- **Plantae**
- **Animalia**

Protists: A diverse group

- Kingdom Protista-organisms are placed here more because of What They Are Not than What They Are.
- A protist is a eukaryote that lacks complex organ systems and lives in moist environments.
- Although some protists are unicellular, others are multicellular. cells of multicellular protists are not specialized to perform specific functions in the organisms.



A Paramecium



Protists: A diverse group

- Some are plantlike autotrophs like algae and kelp that are photosynthetic. They have a cell wall, chloroplasts and make their own food.
- Some are animal-like heterotrophs like protozoans (paramecium and amoeba).
- Others are fungus-like heterotrophs that produce reproductive structures like those of fungi (slime-molds).
- Kingdom Protista contains all eukaryotes that are NOT Plants, Animal, or Fungi, more than 50,000 species in all. Kingdom Protista includes unicellular and a few simple multicellular EUKARYOTES.
- Eukaryotic cells have nuclei and organelles that are surrounded by membranes.

Euglena

Amoeba

Fungi: Earth's decomposers

- Organisms in Kingdom Fungi mostly multicellular are that do not move from place to place.
- They have a cell wall made of chitin (insect exoskeletons).
- Fungi are heterotrophic eukaryotes that absorbs nutrients by releasing digestive enzymes into a food source.
- They absorb their food after it has been digested by the enzymes. They are usually decomposers or parasites.
- Examples of fungi include molds, mildews, yeasts, mushrooms.
- There are more than 50,000 known species of fungi.

Plants: Multicellular oxygen producers

- All of the organisms in Kingdom Plantae are multicellular, photosynthetic (autotrophic) eukaryotes, that do **not** move from place to place.
- A plant's cells usually contain chloroplasts and have cell walls composed of the polysaccharide **cellulose**.
- Plant cells are specialized for different functions, such as photosynthesis, the transport of materials, and support.
- There are more than 250,000 known species of plants.
- Although you may be most familiar with flowering plants (angiosperms), there are many other types of plants, including mosses, ferns, and cone-bearing (gymnosperms).

Animals: Multicellular consumers

- Animals are multicellular heterotrophs, that do **not** have cell walls.
- Nearly all are able to **move** from place to place.
- Their cells are organized into tissues that, in turn, are organized into organs and complex organ **systems.**
- Some are permanently attached to surfaces such as sponges and barnacles.
- Types of Animals include sponges, jellyfish, insects, fish, birds, reptiles, amphibians, mammals, worms, sea stars etc.







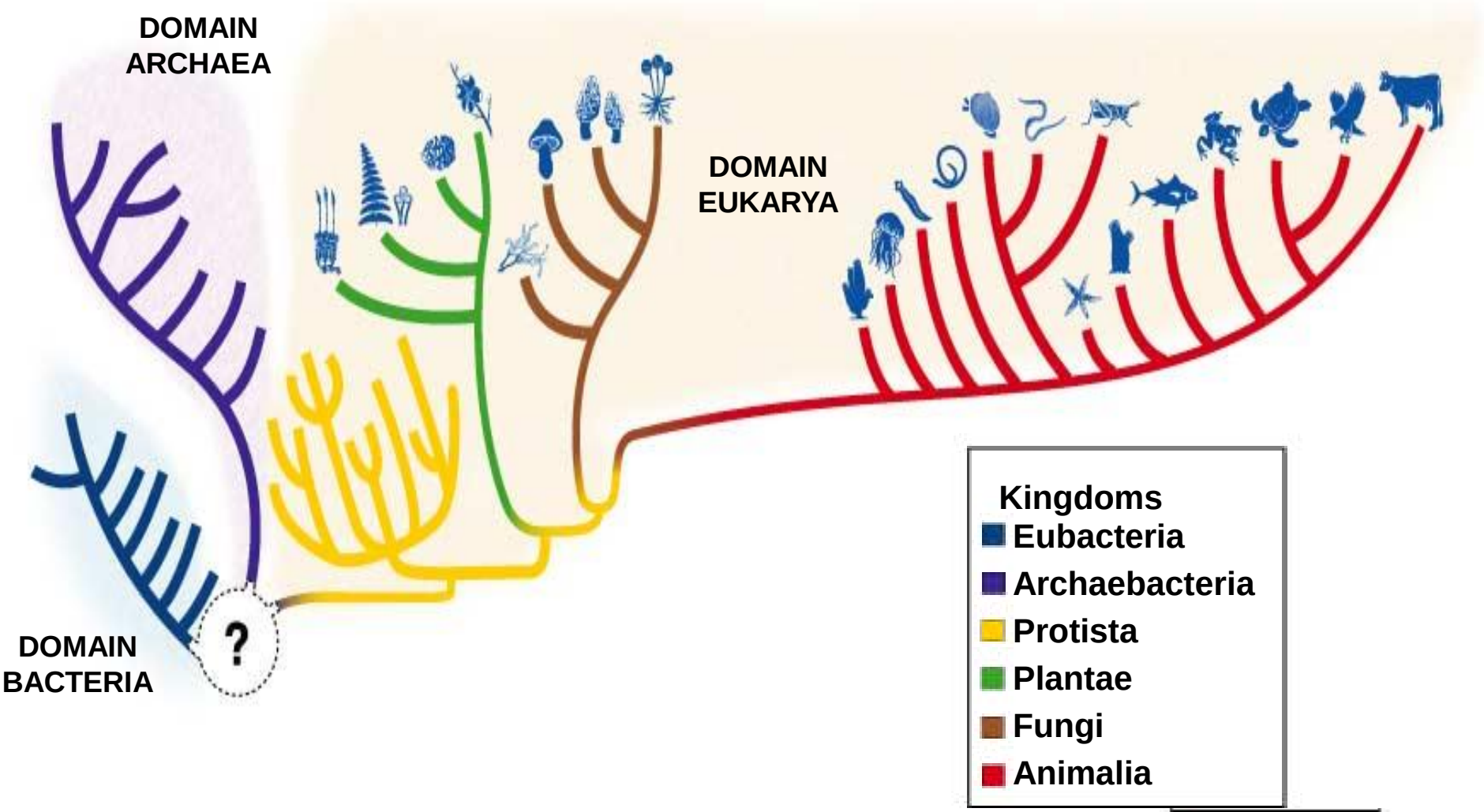




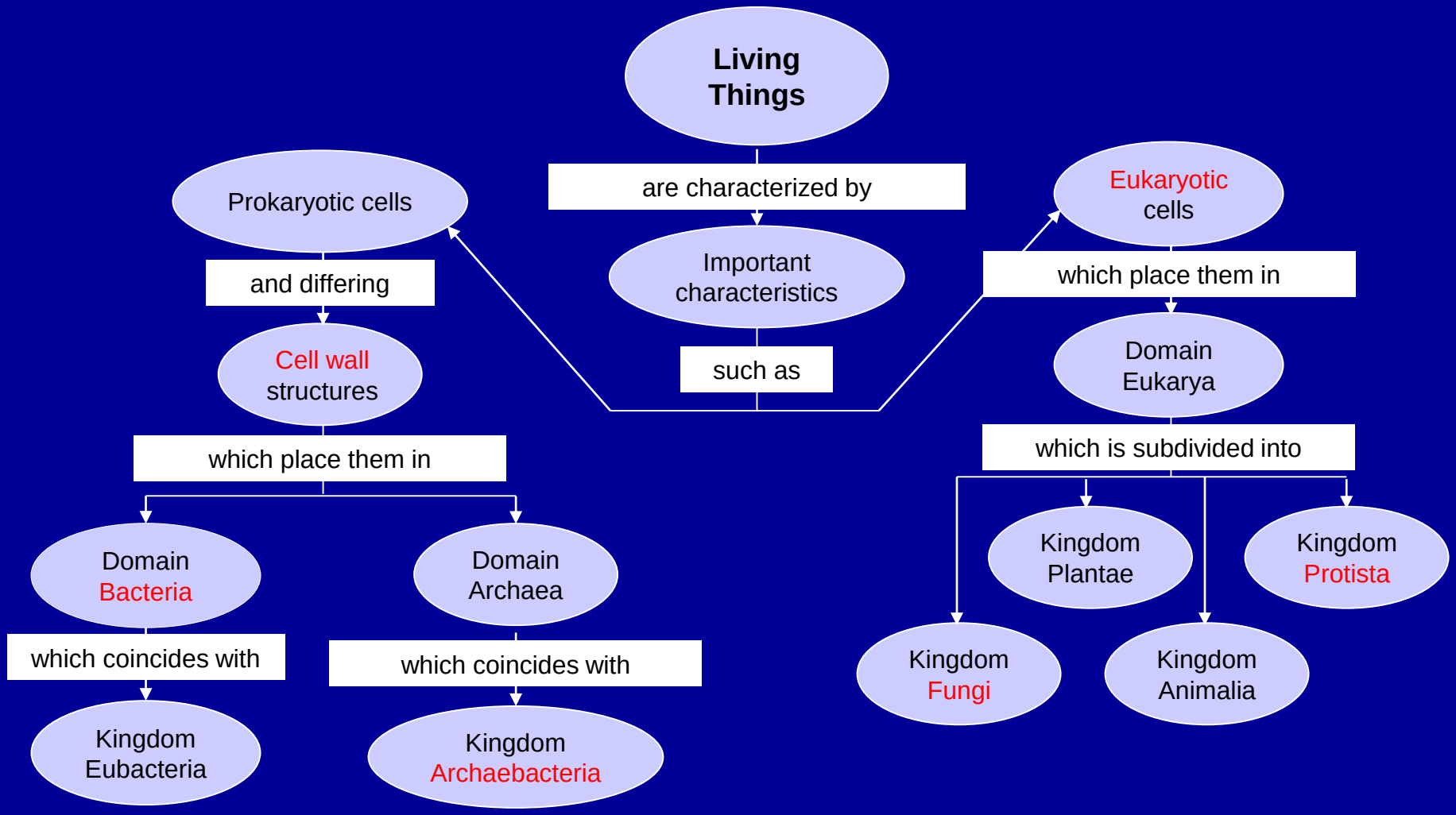
Classification of Living Things

Classification of Living Things						
DOMAIN	Bacteria	Archaea	Eukarya			
KINGDOM	Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus*, *Escherichia coli*	Methanogens, halophiles	*Amoeba*, *Paramecium*, slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals

The Domain System



Concept Map


Living Things
are characterized by
Important characteristics
such as
Prokaryotic cells
and differing
Cell wall structures
which place them in
Domain Bacteria
which coincides with
Kingdom Eubacteria
Domain Archaea
which coincides with
Kingdom Archaebacteria
Eukaryotic cells
which place them in
Domain Eukarya
which is subdivided into
Kingdom Plantae
Kingdom Protista
Kingdom Fungi
Kingdom Animalia