Systematics

The science of determining relationships among organisms

Taxonomy

The science of naming organisms based on a systematic arrangement of relationships

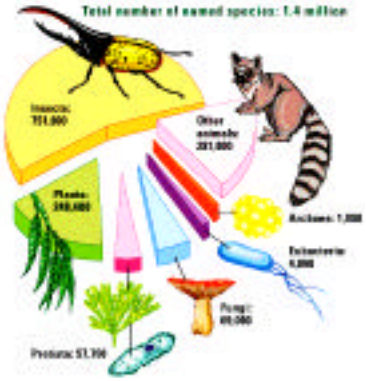
1.4 Million species

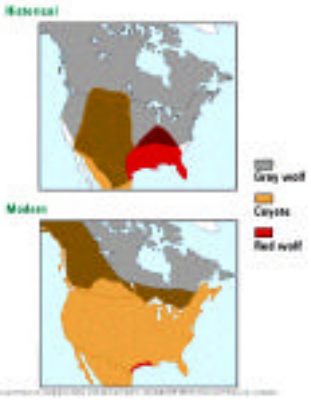
3 million?

10 million?

20 million?

100 million?





Binomial system

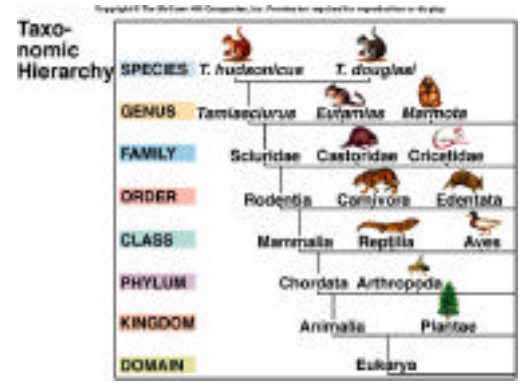
- ✓Two names (*Genus species*)
- ✓Require a type specimen
- ✓May be grouped into subspecies or varieties
- ✓Part of a broader taxonomic hierarchy

Unrelated robins

Sunflower's characteristics depend on water and light

Heirarchical classification

Taxon	Human	Barn owl	Box turtle	Maize
Domain	Eukarya	Eukarya	Eukarya	Eukarya
Kingdom	Animalia	Animalia	Animalia	Plantae
Phylum	Chordata	Chordata	Chordata	Anthophyta
Class	Mammalia	Aves	Reptilia	Monocotyledones
Order	Primates	Strigiformes	Chelonia	Commelinales
Family	Hominidae	Tytonidae	Emydidae	Poaceae
Genus	*Homo*	*Tyto*	*Terrapene*	*Zea*
Species	*Homo sapiens*	*Tyto alba*	*Terrapene carolina*	*Zea mays*



Some Major Distinguishing Features of the Three Domains of Life*

Characteristic	Bacteria	Archaea	Eukarya
Cell type	Prokaryotic	Prokaryotic	Eukaryotic
Nuclear envelope	Absent	Absent	Present
Number of chromosomes	1	1	More than 1
Chromosome configuration	Circular	Circular	Linear
Organelles (mitochondria and plastids)	Absent	Absent	Present (in all but a few)
Cytoskeleton	Absent	Absent	Present
Chlorophyll-based photosynthesis	Yes	No	Yes

*Note that some features listed apply to only certain representatives of a certain domain.

3 strategies in systematics

✓Orthodox or traditional
✓Phenetic (1960's - 70's)
✓Cladistics (current)

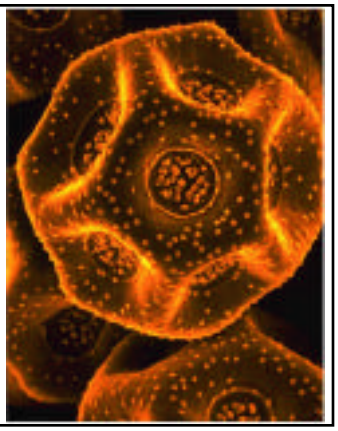
Orthodox or Traditional

✓Combines a number of traits
✓Does not look at one particular trait
✓Not all traits are given the same weight
- ✒Feathers may score higher
- ✒Birds are given their own group

Radula of a snail

Bristles on a marine worm

Pollen grains of plants - fossils and sediments



Phenetics

✓Numerical taxonomy

- ☞i.e. tassel, rows of kernels, weights, flowers, days to maturity, etc.

✒Susceptible to convergent (or parallel) evolution

Selected Characters Used in Analyzing the Phylogenetic Relationships of Four Plant Taxa

Taxon	Characters*			
	Xylem and Phloem	Wood	Seeds	Flowers
Mosses	–	–	–	–
Ferns	+	–	–	–
Pines	+	+	+	–
Oaks	+	+	+	+

*The character state "present" (+) is the derived condition; the character state "absent" (–) is the ancestral condition.

Cladistics

✓Determine the evolutionary relationships

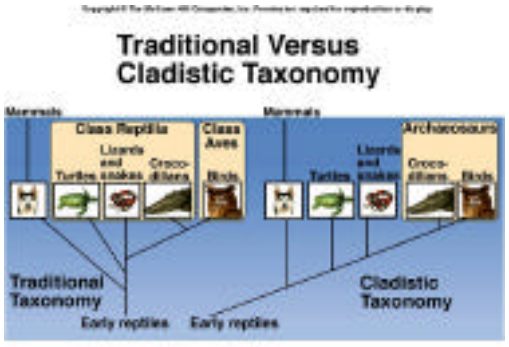
✒Single derived ancestor - monophyletic groups

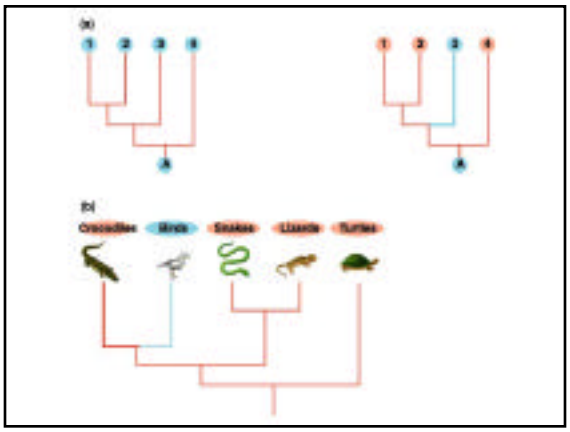
- ☞Groups terminating in adjacent nodes share a common ancestor

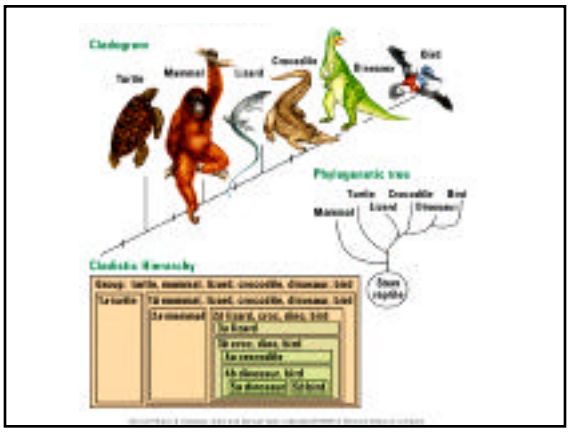
✒Shared derived characteristics

✒Equal weight to all traits

✒Birds are grouped with reptiles

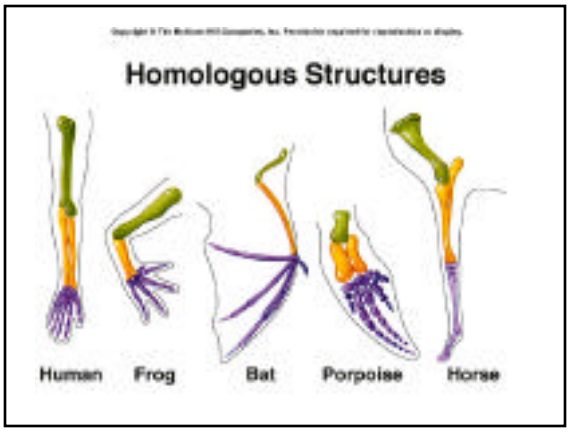






Phylogeny

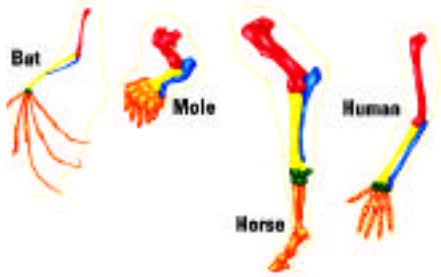
- ✓ Homologous -
  - ✒ traits with common anatomy (developmental pathway), but different shapes and function
- ✓ Analogous
  - ✒ Traits with similar shapes and functions, but different evolutionary orgins
- ✓ Ancestral
  - ✒ Commonly found in almost of descendants of a common ancestor - primative
- ✓ Shared derived
  - ✒ Newly developed traits found in some direct - line descendants, but not all descendants of a common ancestor
    - ⇨Lungs, jaws, amniotic egg, four chamber heart, fur, mammary glands



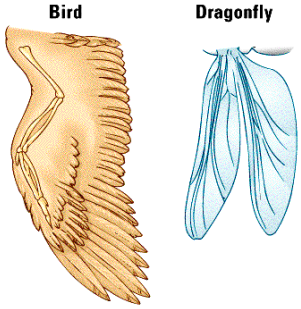
Comparative Anatomy

- ✓Homologous structures - Species descended from a common ancestor may evolve in different directions and yet retain some of the same characteristics.
  - ✒Forelimbs - humans, horses, bats, moles and whales - same bones -
- ✓Analogous structures - Species descended from different ancestral species may evolve to possess structures that serve the same function.
  - ✒Wings of bird and dragonfly

Homologous structures

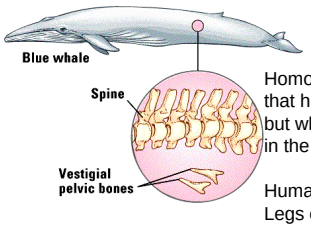


Analogous structures



Derive from different ancestral structures, but serve the same function.

Vestigial structures

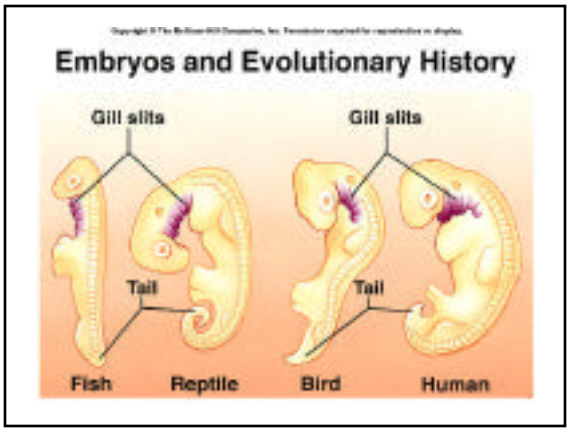


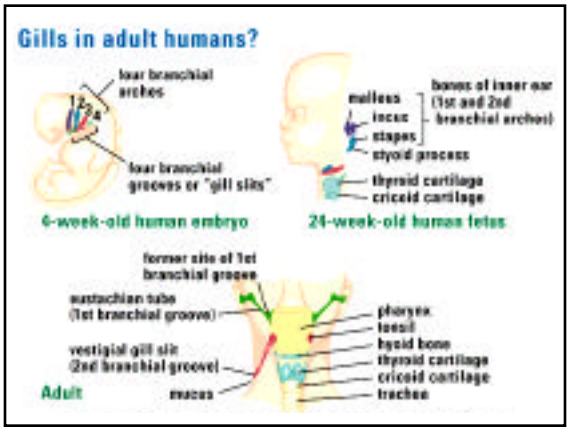
Homologous structures that have no apparent use, but which may have had use in the ancestral species.

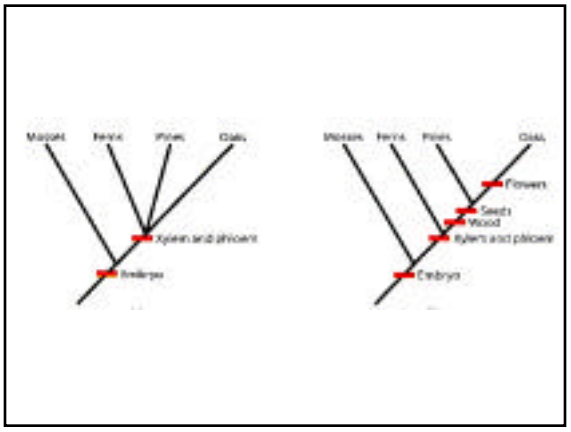
Human tailbones
Legs on a snake

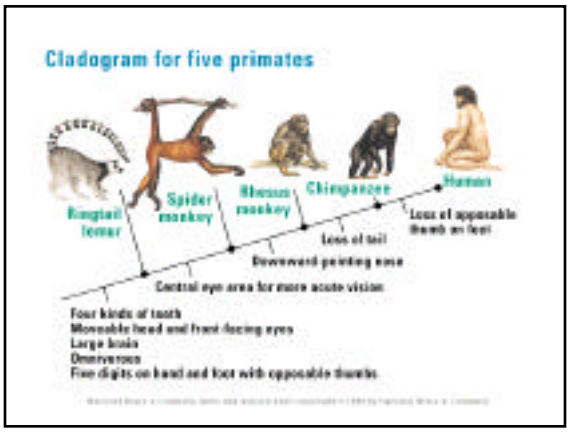
Comparative Embryology

- ✓The early embryos of mammals resemble the embryos of birds, reptiles, amphibians and fishes.
- ✓All vertebrate embryos have tails and gill slits.





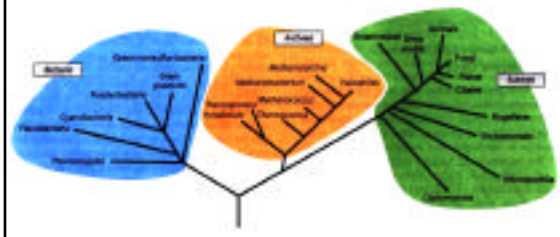


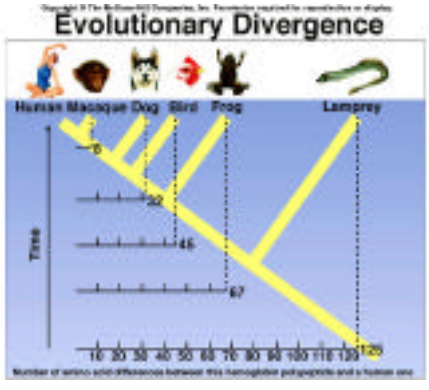


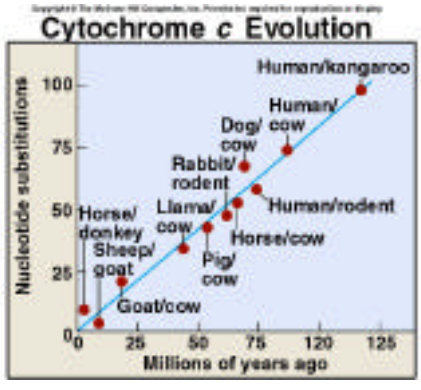
Molecular systematics

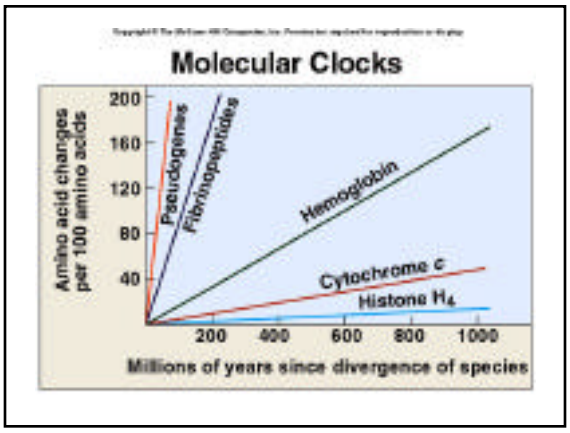
✓Sequence of amino acids in proteins, nucleotides in nucleic acids.

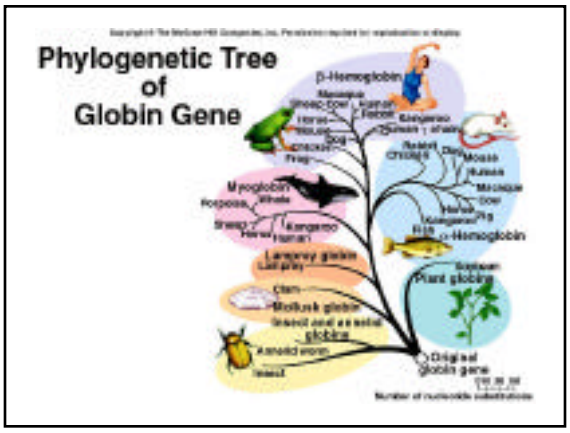
Phylogenetic relationship

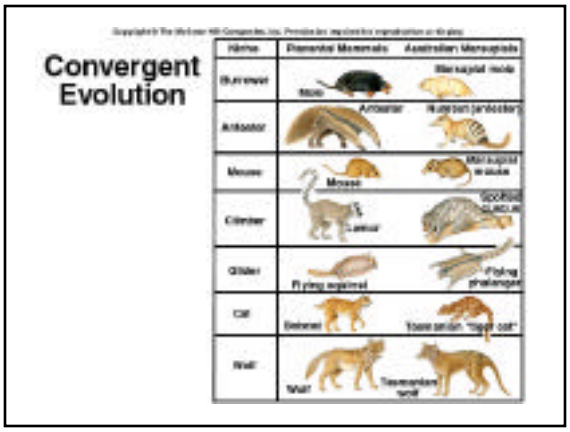


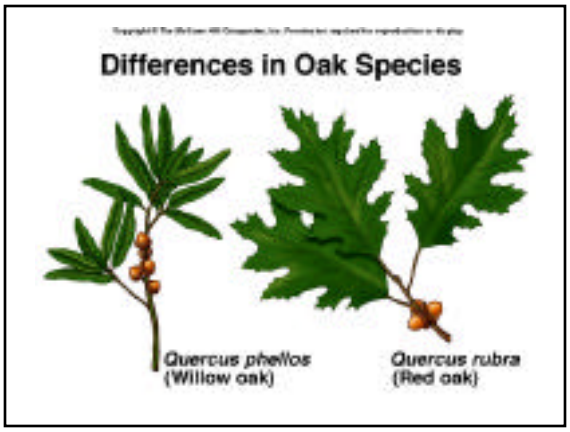


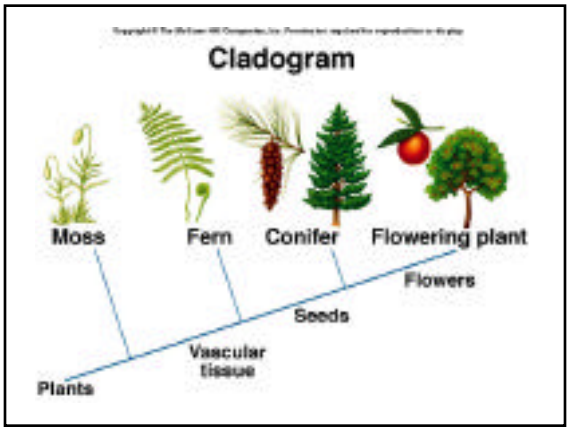


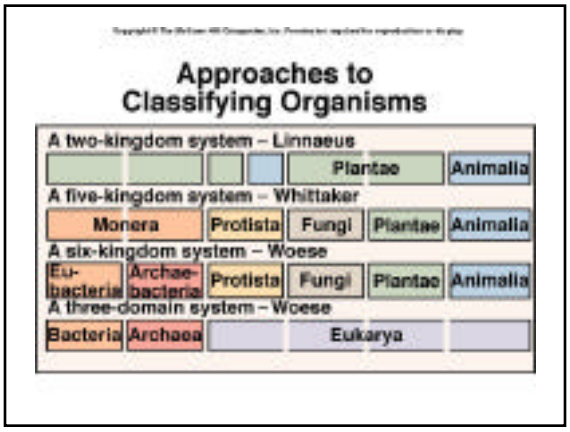

Molecular Clocks
Amino acid changes per 100 amino acids
200
160
120
80
40
Pseudogenes
Fibrinopeptides
Hemoglobin
Cytochrome c
Histone H4
200
400
600
800
1000
Millions of years since divergence of species

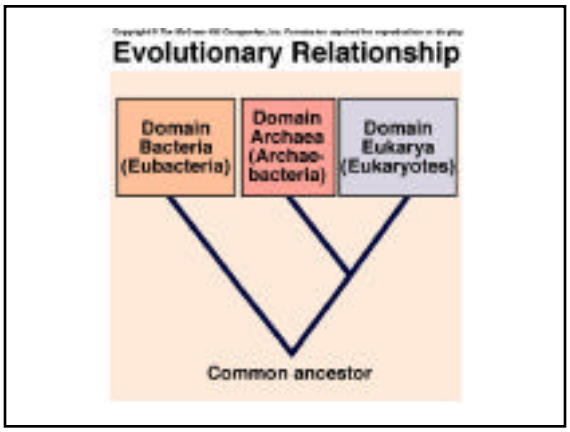

Phylogenetic Tree of Globin Gene
β-Hemoglobin
α-Hemoglobin
Myoglobin
Plant globins
Original globin gene

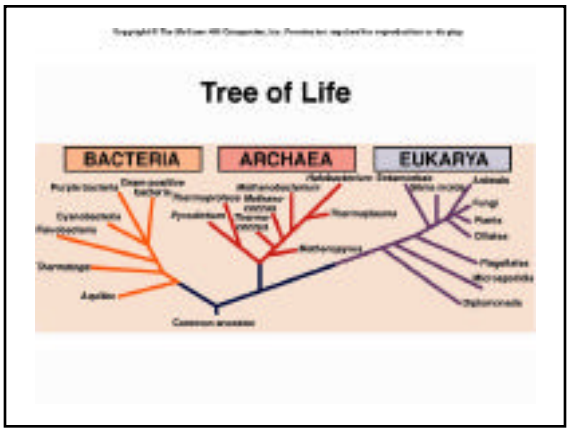

Convergent Evolution

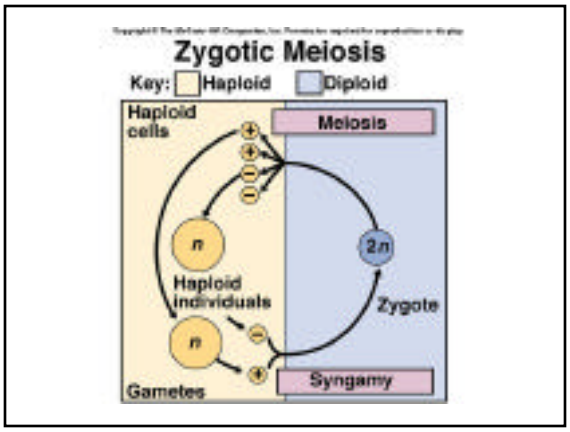

Differences in Oak Species
Quercus phellos
(Willow oak)
Quercus rubra
(Red oak)

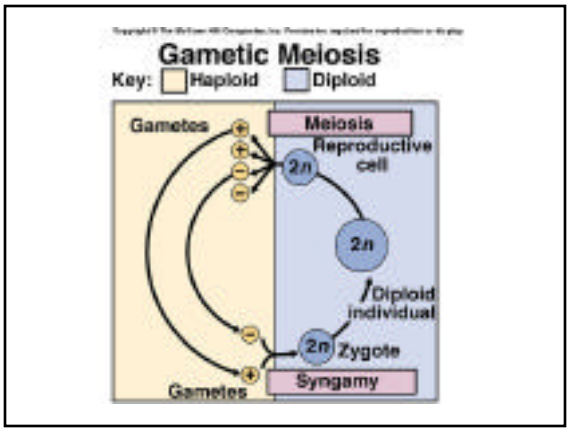

Cladogram
Moss
Fern
Conifer
Flowering plant
Flowers
Seeds
Vascular tissue
Plants

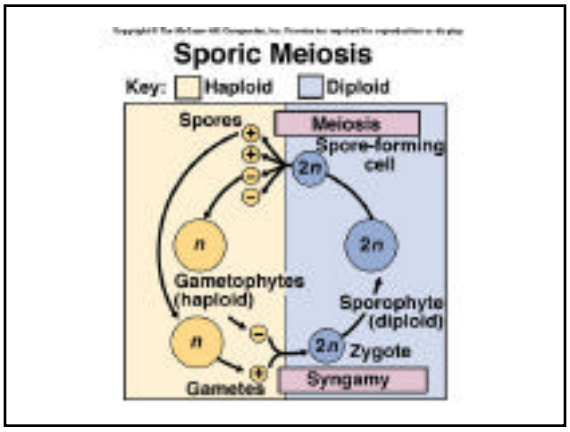

Approaches to Classifying Organisms
A two-kingdom system – Linnaeus
Plantae
Animalia
A five-kingdom system – Whittaker
Monera
Protista
Fungi
Plantae
Animalia
A six-kingdom system – Woese
Eu-bacteria
Archae-bacteria
Protista
Fungi
Plantae
Animalia
A three-domain system – Woese
Bacteria
Archaea
Eukarya

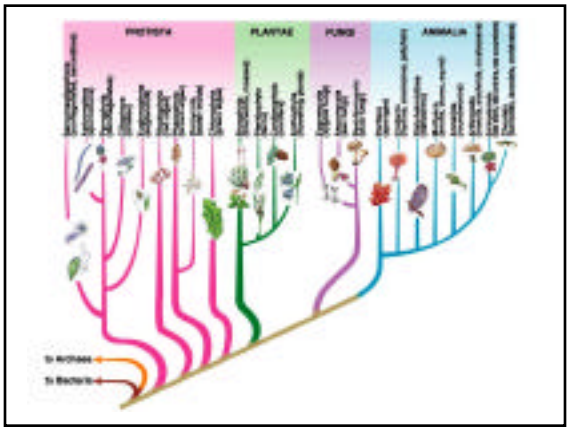

Evolutionary Relationship
Domain Bacteria (Eubacteria)
Domain Archaea (Archae-bacteria)
Domain Eukarya (Eukaryotes)
Common ancestor

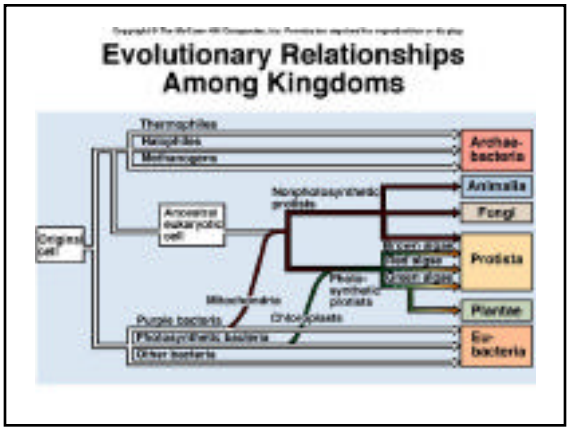

Tree of Life
BACTERIA
ARCHAEA
EUKARYA


Zygotic Meiosis
Key: Haploid Diploid
Haploid cells
Meiosis
n
2n
Haploid individuals
Zygote
n
Gametes
Syngamy

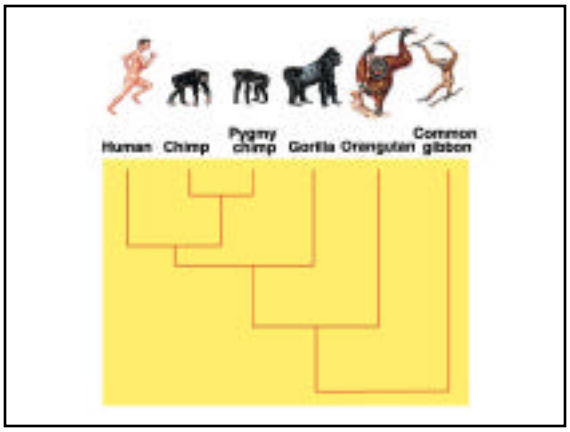

Gametic Meiosis
Key: Haploid Diploid
Gametes
Meiosis
Reproductive cell
2n
2n
Diploid individual
2n Zygote
Gametes
Syngamy


Sporic Meiosis
Key: Haploid Diploid
Spores
Meiosis
Spore-forming cell
2n
n
2n
Gametophytes (haploid)
Sporophyte (diploid)
n
2n Zygote
Gametes
Syngamy

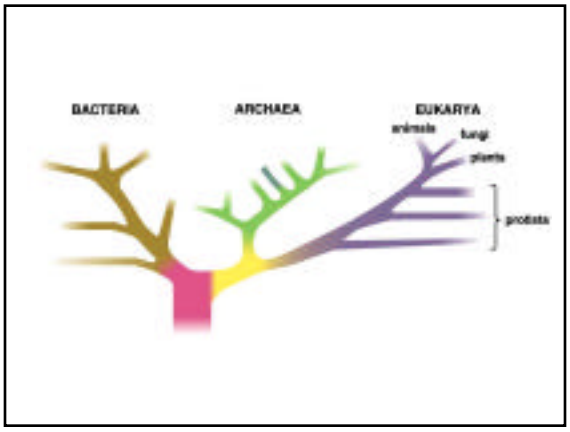

PROTISTA
PLANTAE
FUNGI
ANIMALIA



Human verses chimp chromosomes

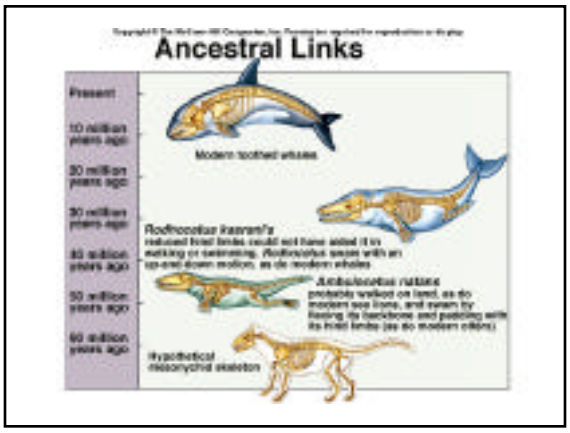


Two domains of prokaryotic organisms



T. Cavalier-Smith 8 Kingdom

	Cell type	Mt	Cp	Cell wall	Cell div.	Genetic recomb	nutrition	multi	nervous syst
Archaebacteria	Prok	No		not peptido-glycan	Bin. fission	transformation transduction conjugation	Chemolithotrophs heterotrophs	uni	-
Eubacteria	Prok	No		peptido-glycan	Bin. fission	transformation transduction conjugation	chemoautotrophs photosynthesis heterotrophs	uni	-
Archezoa	Euk	No		-	mitosisi	meiosis/ fert	heterotrophs	uni	-
Protozoa	Euk	yes	Yes/ no	yes/no	mitosisi	meiosis/ fert	photosynthsis and/or heterotrophs		prim
Chromista	Euk	yes	yes	cellulose	mitosisi	sporic	photosynthsis and/or heterotrophs	mult	
Plantae	Euk	yes	yes	cellulose	mitosisi	sporic	Photosynthesis	mult	
Fungi	Euk	yes	yes	chitin	mitosisi	zygospore	hetero - extracellular digestion/absorption	mult	
Animalia	Euk	yes	yes	-	mitosisi	gametic	hetro - injestion of food and digest	mult	yes


Ancestral Links
Present
10 million years ago
20 million years ago
30 million years ago
40 million years ago
50 million years ago
60 million years ago
Modern toothed whales
Rodhocetus kasrani's
Ambulocetus natans
Hypothetical mesonychid skeleton