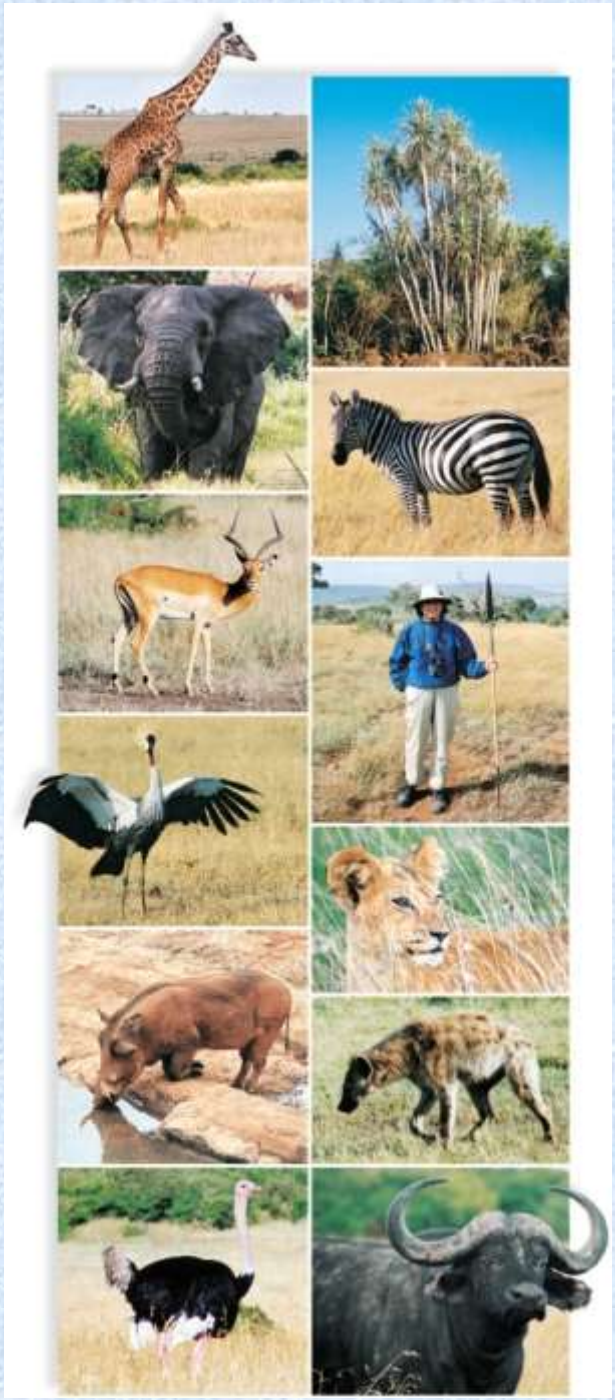
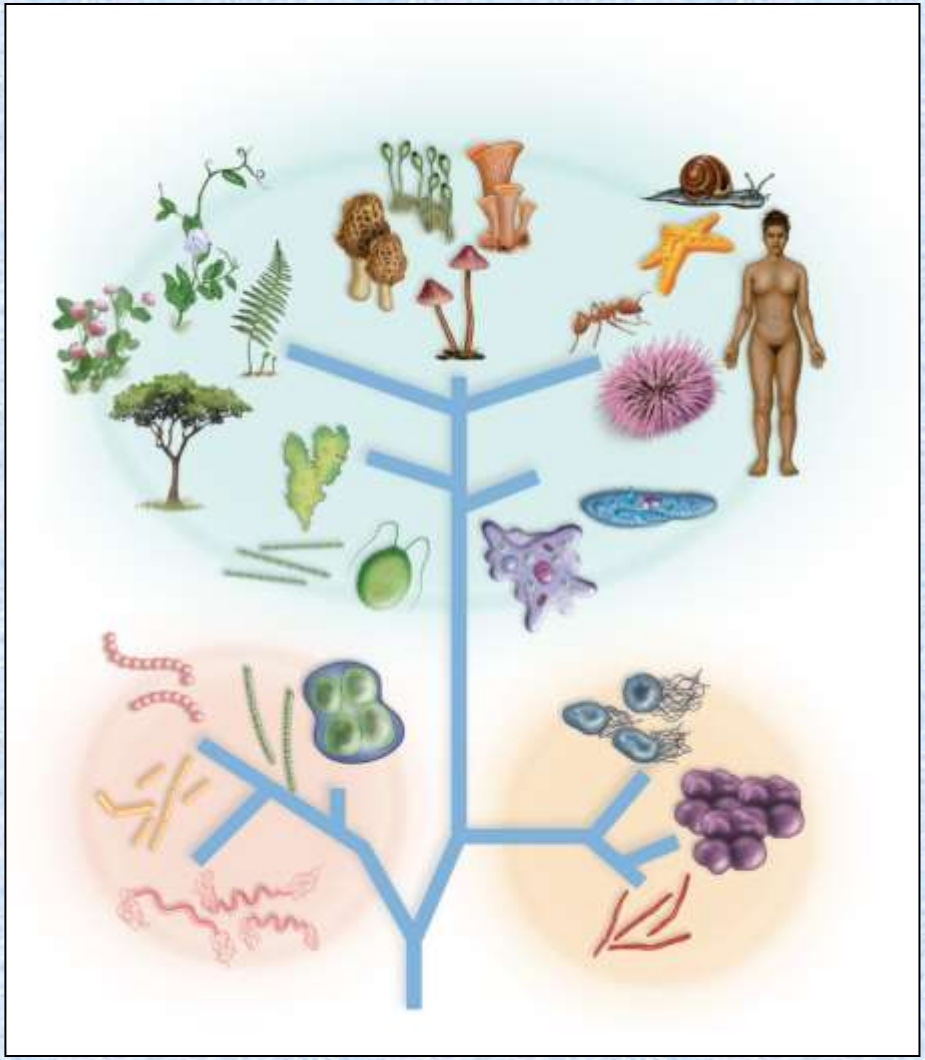


Taxonomy, Systematics, and Phylogeny



- **Taxonomy** – the orderly classification of organisms and other objects
- **Systematics** – scientific study of the diversity of organisms
  - Classification – arrangement into groups
  - Nomenclature – scientific names
  - Phylogenetics – evolutionary history
    - **Cladistics** – study of relationships of groups of organisms depicted by evolutionary trees

Where do plant and animal names come from?

Prehistory - Bushmen?

San women gathering for food. Ghanzi, Botswana.

The Bible – Adam?

"And out of the ground the Lord God formed every beast of the field and every fowl of the air and brought them unto Adam to see what he would name them, and whatsoever Adam called every living creature, that was the name thereof."
--Genesis 2:19

Cave Paintings – Lascaux, France – Cro-Magnon - 17,300 years old

Naming Plants and Animals

- Ancient people needed to communicate about which plants were edible, poisonous or could be used medicinally
- They needed to identify plants to be used for food, medicine, fiber, or for shelter
- Names varied from region to region and among different languages and cultures

Confusing because one organism could have many names

Modern Scientific Names

- Biologists use scientific names to precisely identify organisms (so we can talk about them and look up information)

- Each organism has only one scientific name
  - Avoids confusion of many common names

Modern Scientific Names

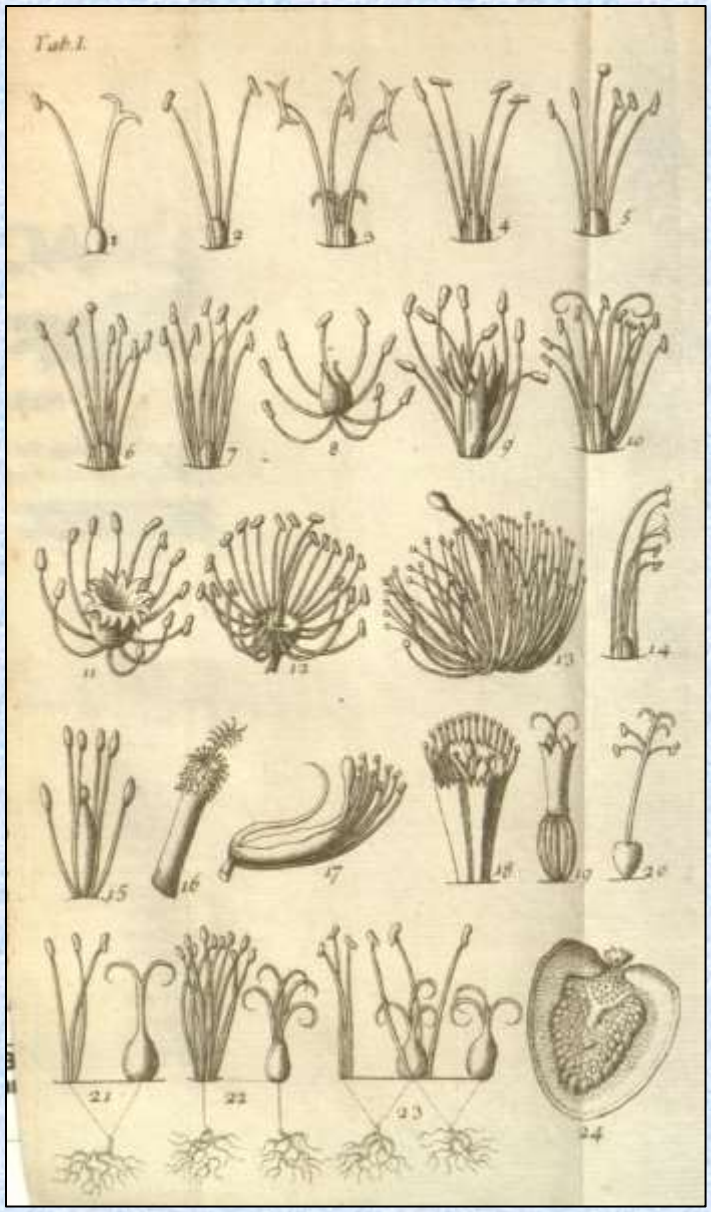
- Naming and identifying organisms began with the Greeks and Romans.
  Aristotle classified organisms into groups such as horses, birds, and oaks.
- In the Middle Ages, organisms were described using Latin names.

Carolus Linnaeus

1707 - 1778

- Religious man, Creationist
- Tried to name and classify all organisms
- Binomial nomenclature for Species
  - *Species Plantarum* - 1753
- Hierarchical System of Classification
- "Sexual System" – artificial classification by counting sexual organs
  - Classes - number of stamens
  - Orders - number of pistils

“Sexual System” of Linnaeus



A View of the Twenty-four Classes of the SEXUAL SYSTEM *of* LINNÆUS, *with their Names and Characters; also the Number and Explanation of Orders contained in each.*

Number of the Classes.	Their Names and Characters.	Number of Orders in each.	Their Names, expressive of the Number of Female Parts or Styles.	Number.
1.	MONANDRIA. One fertile stamen, i. e. having the *Anthera*.	2	1. Monogynia,	1
			2. Digynia,	2
2.	DIANDRIA. Two fruitful *Stamina* or male parts.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
3.	TRIANDRIA. Three ditto.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
4.	TETRANDRIA. Four ditto, all of equal length, by which it is distinguished from the fourteenth class.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
5.	PENTANDRIA. Five ditto.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Triginia,	3
			4. Tetragynia,	4
			5. Pentagynia,	5
			6. Polygynia,	many
6.	HEXANDRIA. Six ditto, all of equal length, by which this is distinguished from the sixteenth class.	5	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
			5. Polygynia,	many
7.	HEPTANDRIA. Seven ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
			4. Heptagynia,	7
8.	OCTANDRIA. Eight ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
9.	ENNEANDRIA. Nine ditto.	3	1. Monogynia,	1
			2. Trigynia,	3
			3. Hexagynia,	6

10. DECAN-

6. Aloë foliis ovato-lanceolatis carnosis apice triquetris: angulis inerme dentatis. *Hort. cliff.* 131. *Hort. upſ.* 86. *Roy. lugdb.* 24.
Aloë africana minima atroviridis, ſpinis herbaceis numeroſis ornata. *Boerh. lugdb.* 2. *p.* 131. *t.* 131.
Habitat in Æthiopiæ *campeſtribus.* ♄
Flores *in hoc genere ſpecierum certiſſimi indices conjungunt* (Margaritiferam & Arachnoideam.

9. ALOE floribus ſeſſilibus reflexis imbricatis priſmaticis. *Uvaria.*
Aloë foliis linearibus radicalibus membranaceis. *Hort. cliff.* 133. *Roy. lugdb.* 23.
Aloë africana folio triangulari longiſſimo & anguſtiſſimo, floribus luteis fœtidis. *Comm. hort.* 2, *p.* 29. *t.* 15. *Seb. theſ.* 1. *p.* 29. *t.* 19. *f.* 3.
Habitat ad Cap. b. Spei. ♄

AGAVE.

1. AGAVE foliis dentato-ſpinoſis, ſcapo ramoſo. *Gen. americana, nov.* 1102.
Agave foliis ſpinoſo-dentatis mucronatisque. *Hort. upſ.* 81.
Aloë foliis lanceolatis dentatis ſpina terminatis radicalibus. *Hort. cliff.* 130. *Roy. lugdb.* 22.
Aloë folio in oblongum mucronem abeunte. *Bauh. pin.* 286.
Habitat in America *calidiore.* ♄

2. AGAVE foliis dentatis, ſtaminibus corollam æquantibus. *vivipara.*
Aloë americana polygona. *Comm. rar.* 65. *t.* 65.
Habitat in America.
Confer. Aloe americana ſoboliferà. *Herm. lugdb.* 16. *t.* 17.

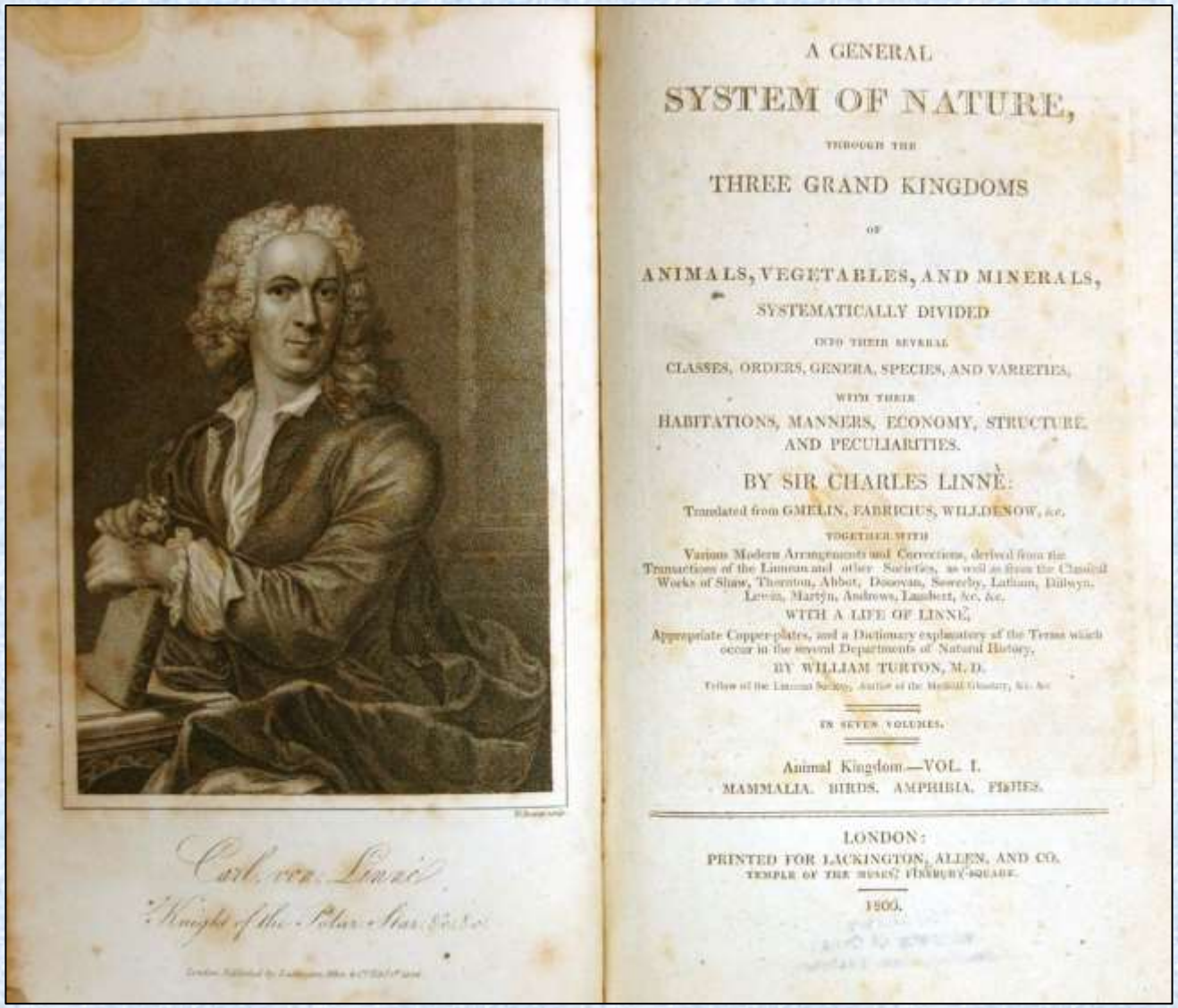
3. AGAVE foliis dentato-ſpinoſis, ſcapo ſimpliciſſimo. *virginica. Gen. nov.* 1102.
Aloe foliis lanceolatis ſpina cartilaginea terminatis, floribus alternis ſeſſilibus. *Gron. virg.* 152.
Habitat in Virginia. ♄

4. AGAVE foliis integerrimis. *Gen. nov.* 1102. *fœtida.*
Aloe foliis integerrimis patentiuſculis aculeo-terminatis, radice caulescente. *Hort. cliff.* 132.
Aloe americana, viridi rigiditimo & fœtido folio, Piet dicta indigenis. *Comm. hort.* 2. *p.* 35. *t.* 18.

Carolus Linnaeus also developed the system of **binomial nomenclature.**

- First word is the genus name.
- Second word is the **specific epithet.**
  It refers to one species (of potentially many) within its genus.
  Example: *Lilium bulbiferum* and *Lilium canadense* are different species of lily.
- A species is referred to by the full binomial name (Genus species).
- Genus name can be used alone to refer to a group of related species.
- Each species can have only one scientific name. Priority of names – oldest valid name.

The tenth edition of Systema Naturae (1758) was (and is) the most important, because Linnaeus first employed the binomial system of nomenclature throughout the book.



Carl von Linné
Knight of the Polar Star &c &c

A GENERAL

SYSTEM OF NATURE,

THROUGH THE

THREE GRAND KINGDOMS

OF

ANIMALS, VEGETABLES, AND MINERALS,

SYSTEMATICALLY DIVIDED

INTO THEIR SEVERAL

CLASSES, ORDERS, GENERA, SPECIES, AND VARIETIES,

WITH THEIR

HABITATIONS, MANNERS, ECONOMY, STRUCTURE,
AND PECULIARITIES.

BY SIR CHARLES LINNÈ.

Translated from GMELIN, FABRICIUS, WILLDENOW, &c.

TOGETHER WITH

Various Modern Arrangements and Corrections, derived from the Transactions of the Linnean and other Societies, as well as from the Classical Works of Shaw, Thornton, Abbot, Donovan, Sowerby, Latham, Dilwyn, Lewin, Martyn, Andrews, Lambert, &c. &c.

WITH A LIFE OF LINNÉ,

Appropriate Copper-plates, and a Dictionary explanatory of the Terms which occur in the several Departments of Natural History,

BY WILLIAM TURTON, M.D.

Fellow of the Linnean Society, Author of the Medical Glossary, &c. &c.

IN SEVEN VOLUMES.

Animal Kingdom.—VOL. I.

MAMMALIA. BIRDS. AMPHIBIA. FISHES.

LONDON:

PRINTED FOR LACKINGTON, ALLEN, AND CO.
TEMPLE OF THE MUSES; FINSBURY-SQUARE.

1806.

Scientific Names – Binomial Nomenclature

Species names ("scientific names") are Latin binomials

***Lewisia rediviva* Pursh.**

- Genus (pl. genera)
- Always capitalized
- Abbreviated on 2nd use (*L. rediviva*)

- Specific epithet
- Not capitalized
- Often a descriptive adjective
- Not abbreviated

- Authority

➢ Always *italicize* or underline species names (genus + specific epithet)

Hierarchical Classification

- Organisms are classified into a hierarchical classification that groups closely related organisms and progressively includes more and more organisms.
- Modern **taxonomists** use the following classification:
  - **Species**
  - **Genus** – one or more species
  - **Family** – one or more genera
  - **Order** – one or more families
  - **Class** – one or more orders
  - **Phylum** – one or more classes
  - **Kingdom** – one or more phyla
  - **Domain** – one or more kingdoms

LEVELS OF CLASSIFICATION

Category	Human	Corn
Domain	Eukarya	Eukarya
Kingdom	Animalia	Plantae
Phylum	Chordata	Anthophyta
Class	Mammalia	Liliopsida
Order	Primates	Commelinales
Family	Hominidae	Poaceae
Genus	*Homo*	*Zea*
*Species**	*H. sapiens*	*Z. mays*

* To specify an organism, you must use the full binomial name, such as *Homo sapiens*.

Linnaean Hierarchy

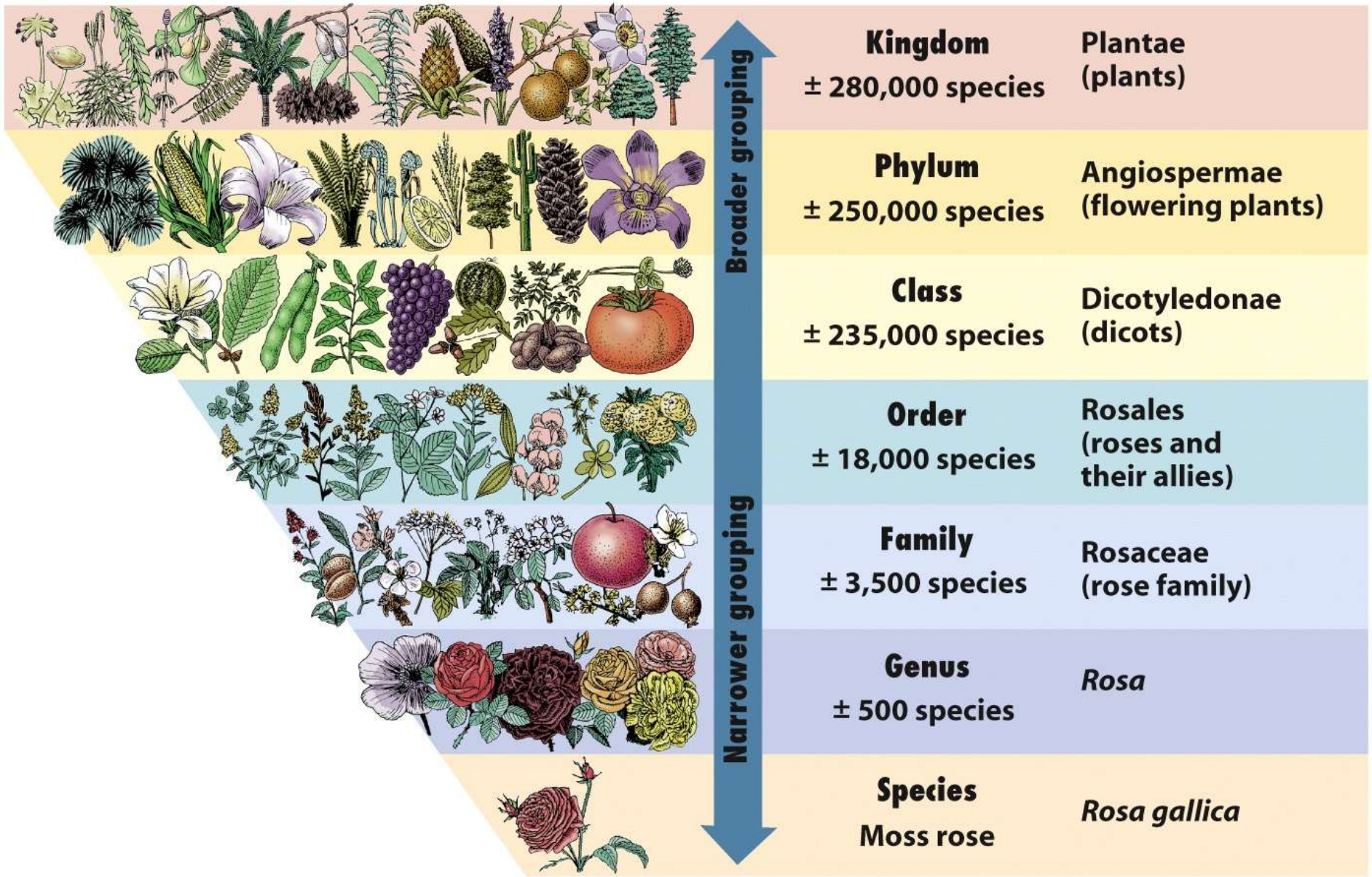
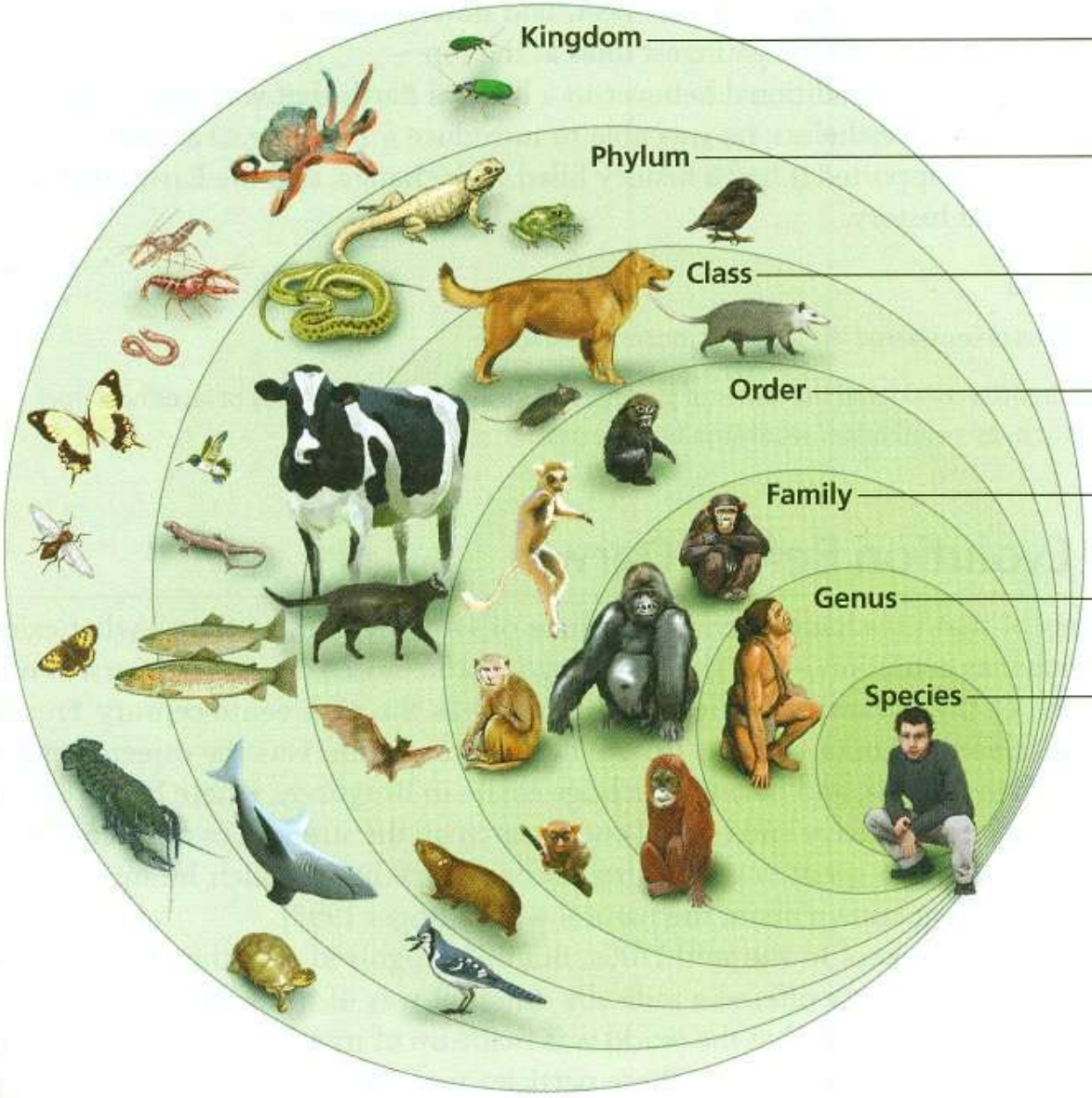


Figure 2-6 Discover Biology 3/e

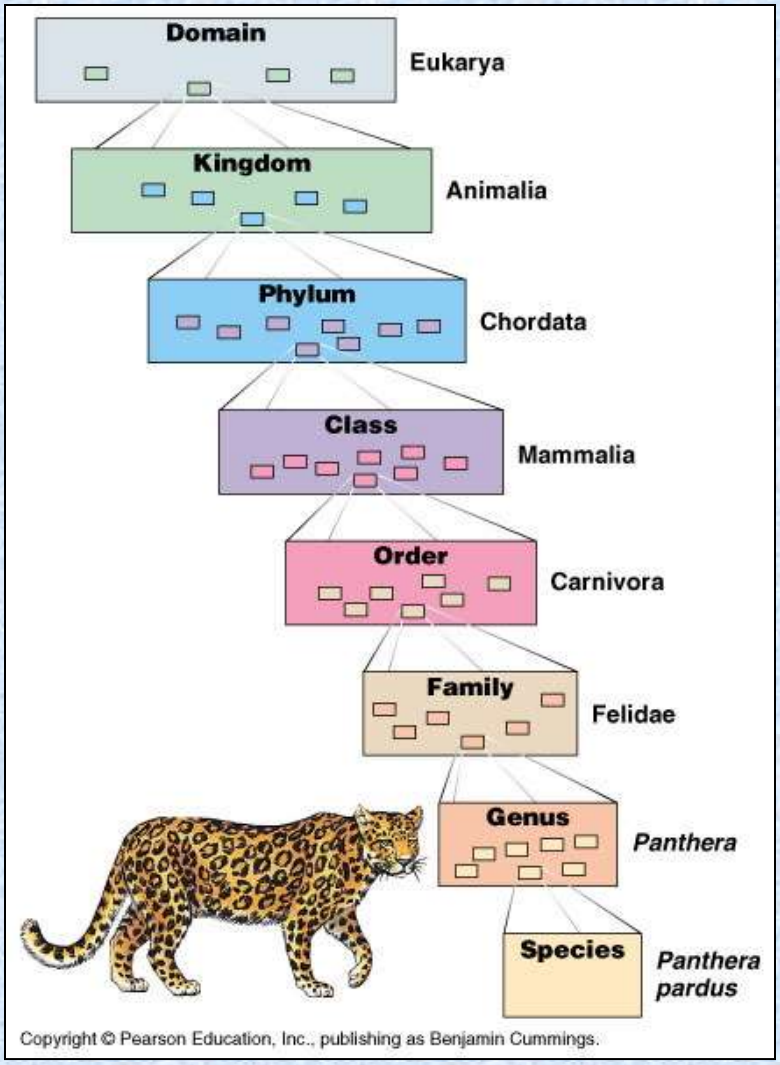
Linnaean Hierarchy of Humans

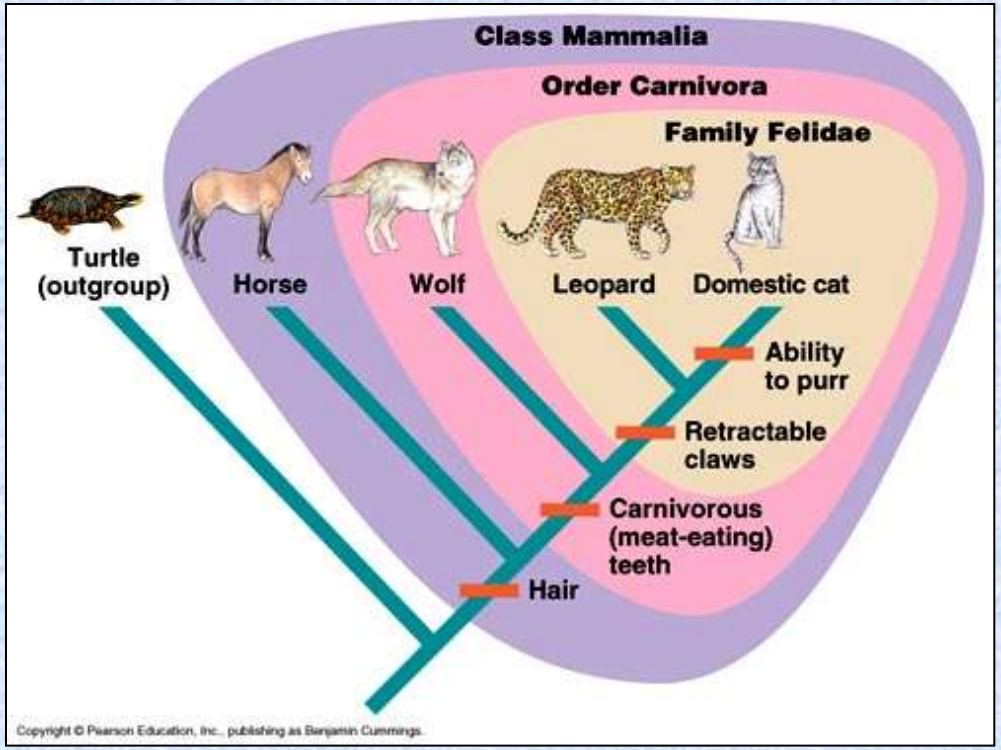


- **Animalia**
- **Chordata**
  (subphylum Vertebrata)
  Fish, amphibians, reptiles, birds, mammals
- **Mammalia**
- **Primates**
  Includes all prosimians (such as lemurs, tarsiers) and simians (monkeys, apes, humans)
- **Hominidae**
  Humans and great apes
- ***Homo***
  Modern and archaic humans
- ***Homo sapiens***
  Modern humans

Figure 2.3 The nested nature of biological classification.

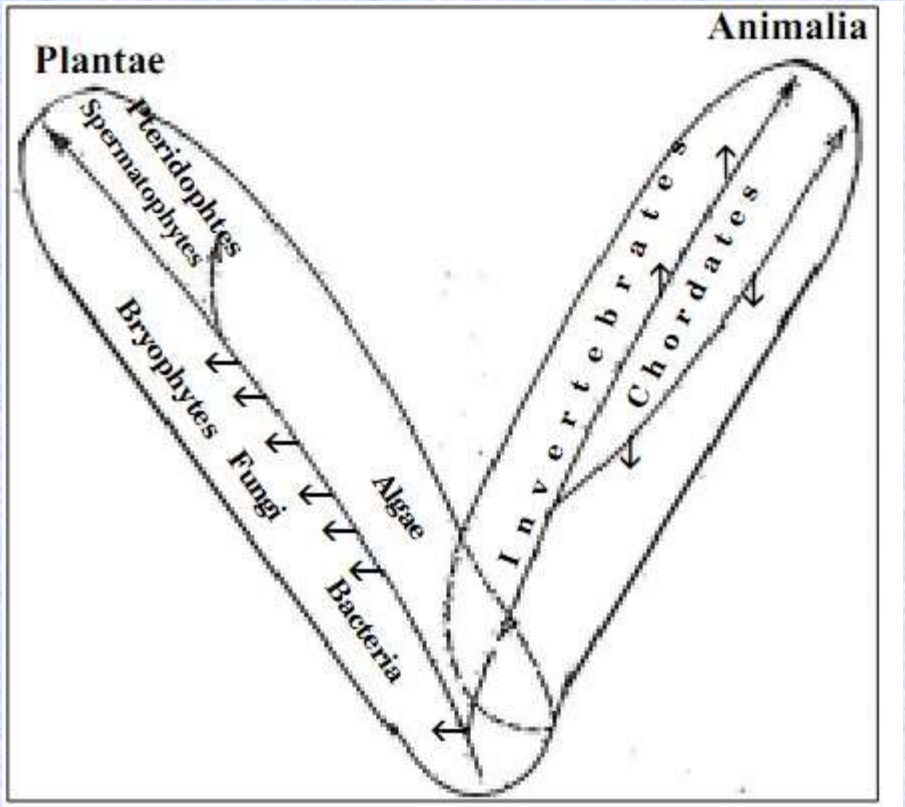
Nested box-within-box hierarchy is consistent with descent from a common ancestor, used as evidence by Darwin.



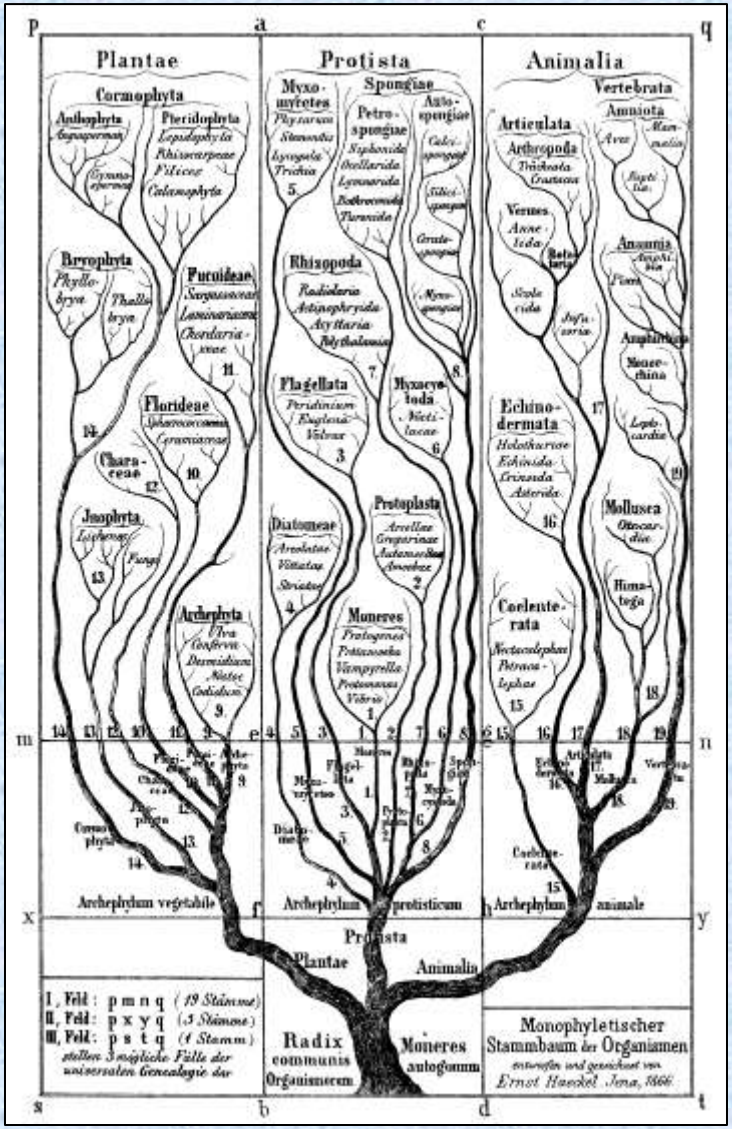


The Big Picture

Changing Kingdom Classification Schemes



Linnaeus 2-Kingdoms
(actually goes back to Greeks)



Haeckel 3-Kingdoms, late 1800s

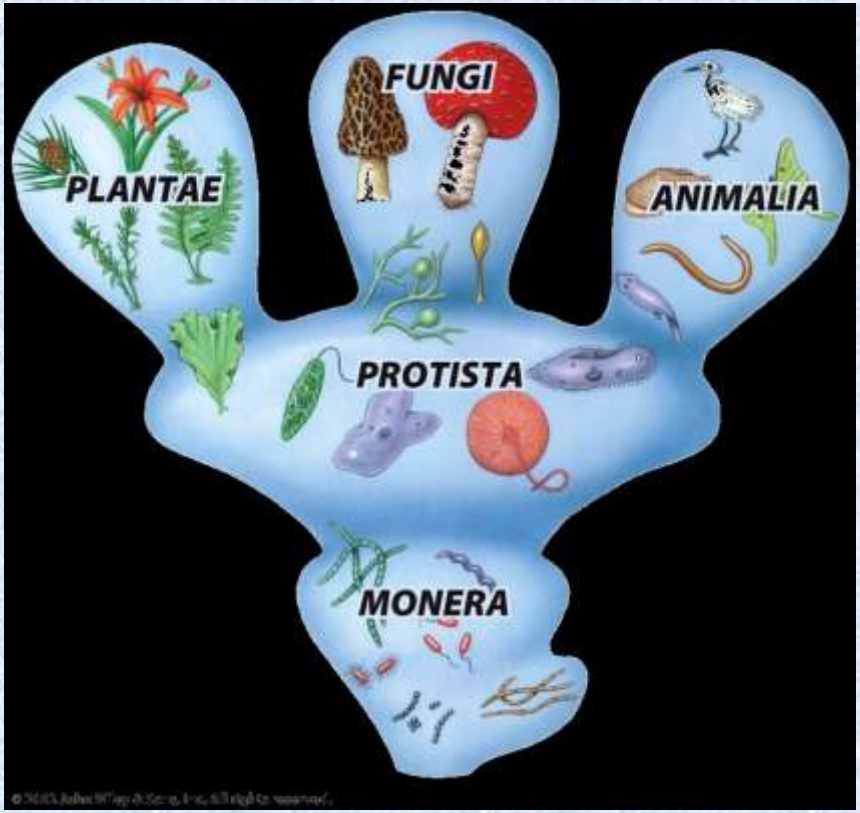
Four Kingdom Sysytem - 1950s

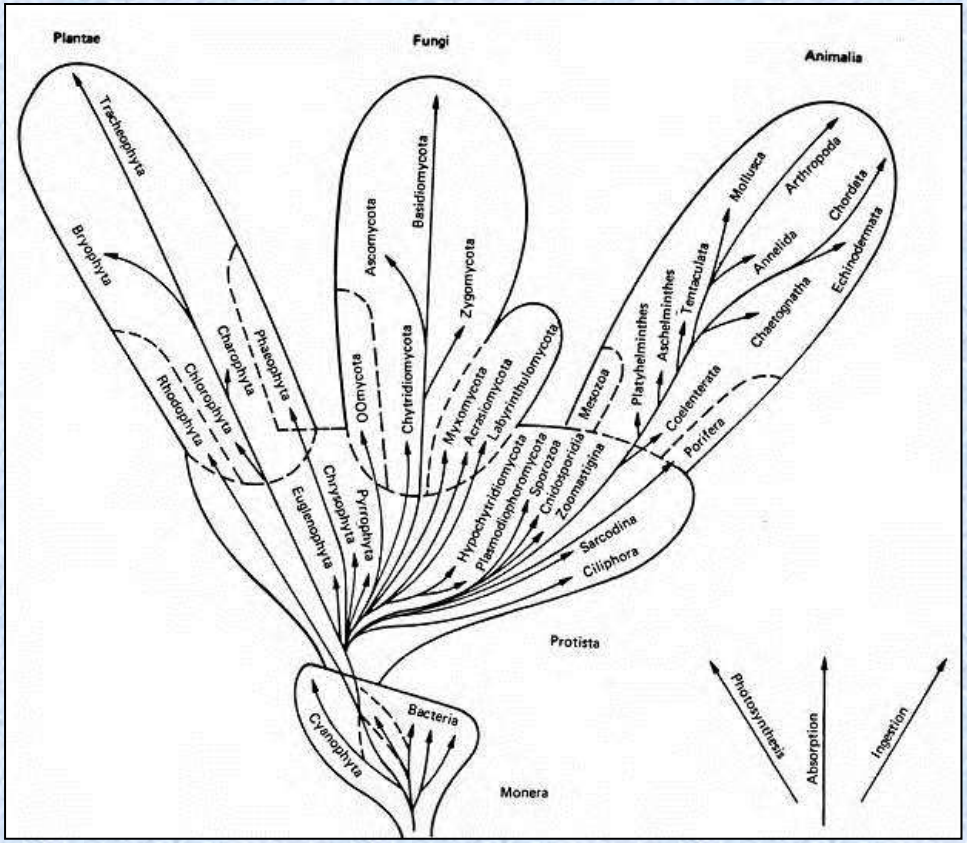
Protista lacking nuclei placed in separate kingdom, the Monera (bacteria)

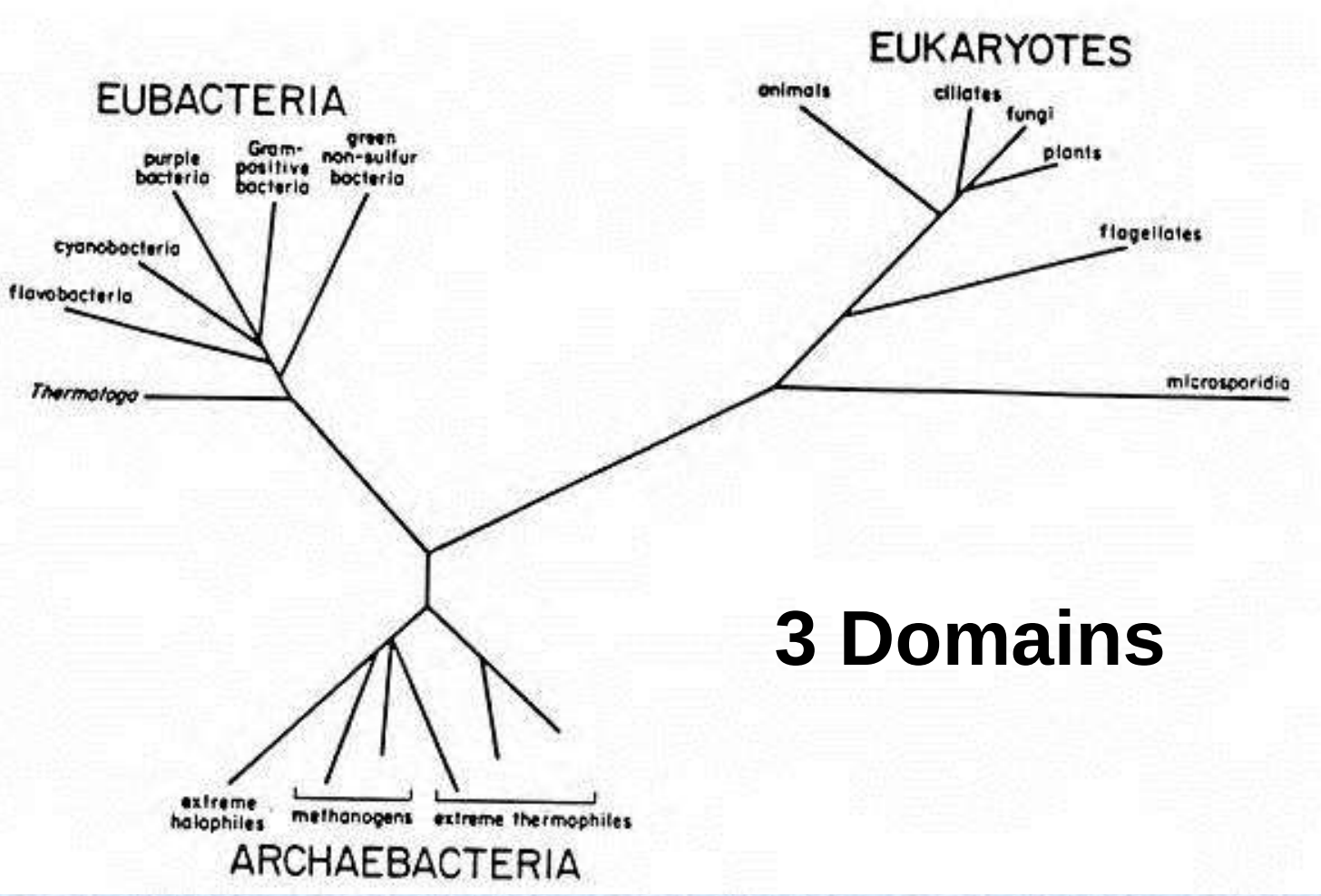
Five Kingdom System - Whittaker's Tree of Life, 1967

Stresses mode of nutrition

Fungi recognized as separate kingdom, separate from plants



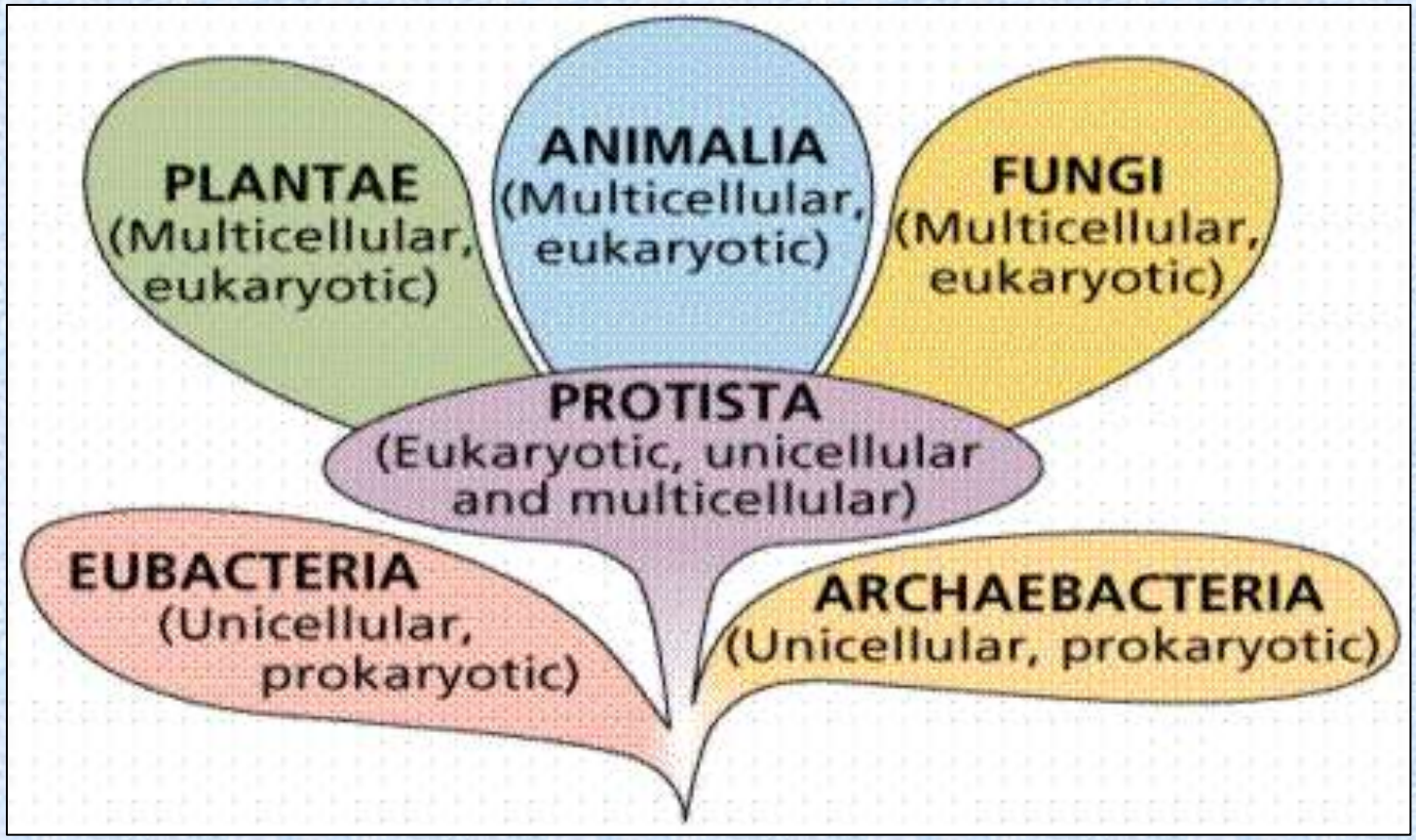




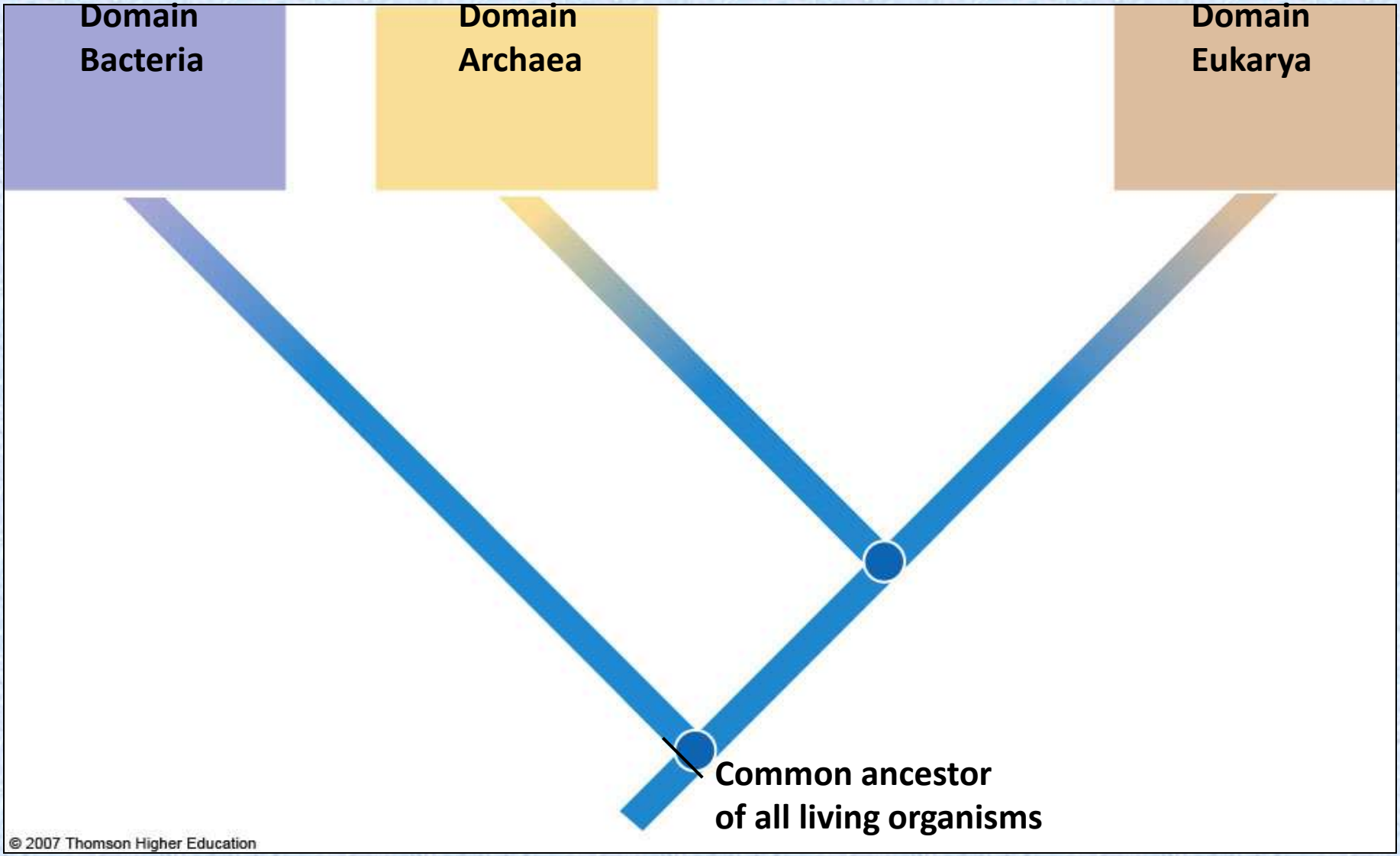
3 Domains

Carl Woese
1980s
ssRNA Sequences

Six Kingdoms?



3 Domains


Domain Bacteria
Domain Archaea
Domain Eukarya
Common ancestor of all living organisms
© 2007 Thomson Higher Education

Major Distinctions Among the Three Domains of Life

Table 19.1 Major Distinctions Among the Three Domains of Life

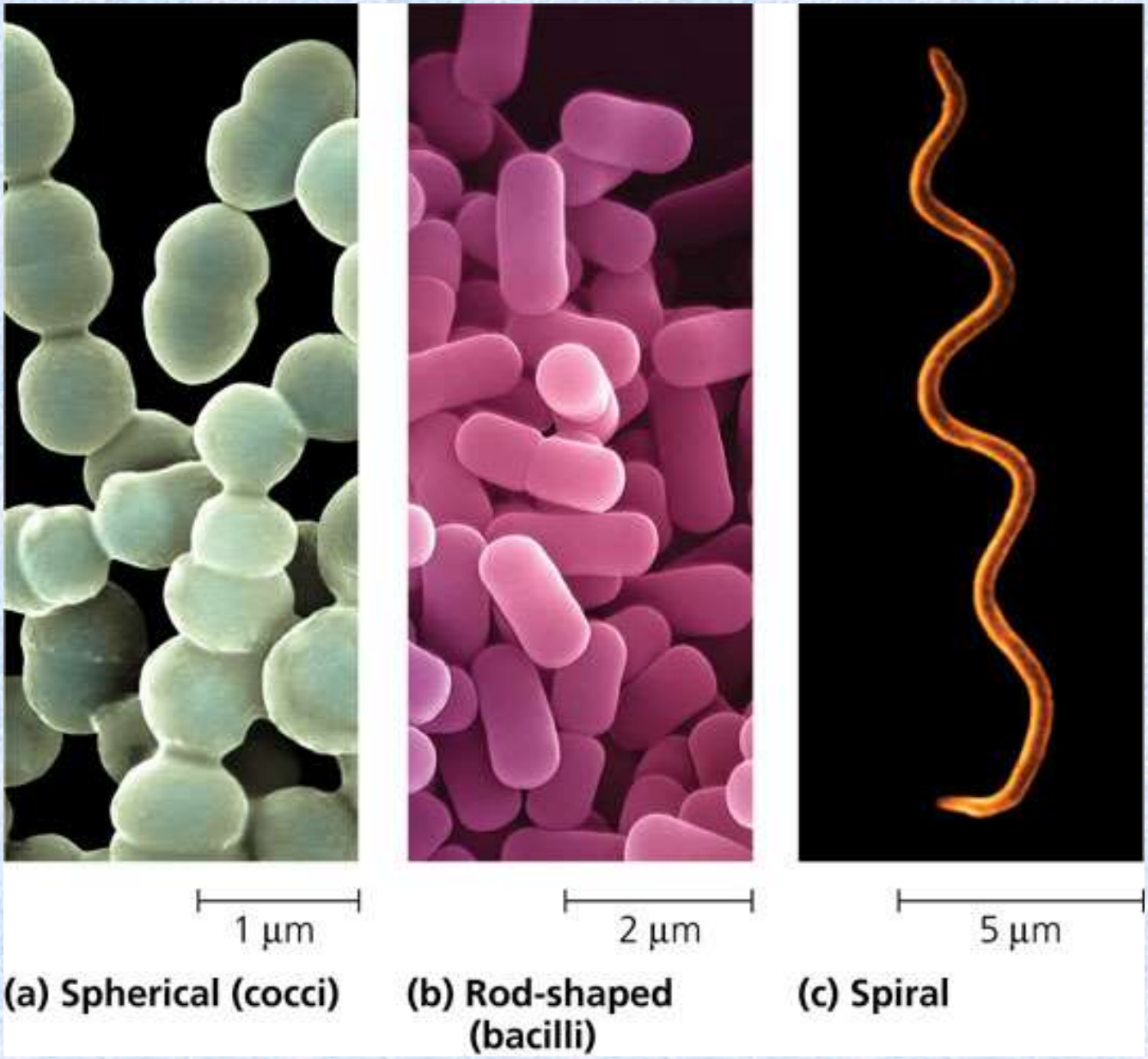
	Bacteria	*Archaea*	*Eukarya*
Unicellularity	Yes	Yes	Some, many multicellular
Membrane lipids	Phospholipids, unbranched	Varied branched lipids	Phospholipids, unbranched
Cell wall	Yes (contains peptidoglycan)	Yes (no peptidoglycan)	Some yes, some no
Nuclear envelope	No	No	Yes
Membrane-bounded organelles	No	No	Yes
Ribosomes	Yes	Yes	Yes
Introns	No	Some	Yes

Domains Bacteria and Archaea

- Domain Bacteria
- Domain Archaea

- The domains Bacteria and Archaea are both prokaryotes (they have no nucleus and the DNA is not arranged in chromosomes). Prokaryote derived from the Greek *Pro* meaning before and *karyon* meaning a kernel [i.e. a nucleus]

Domain Bacteria



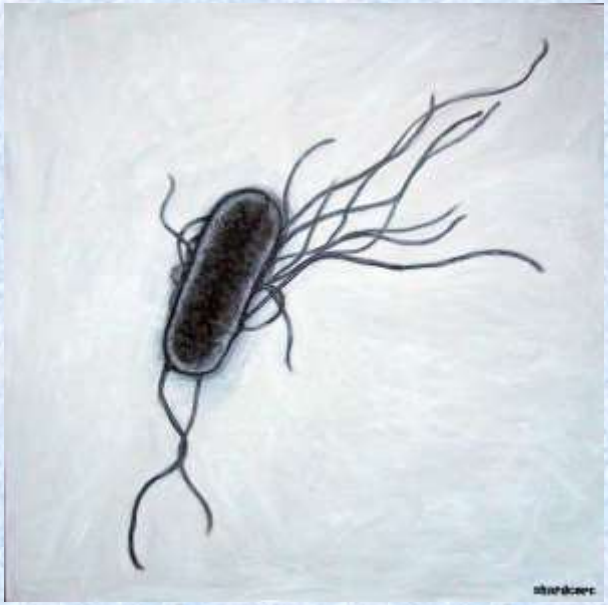
Domain Bacteria

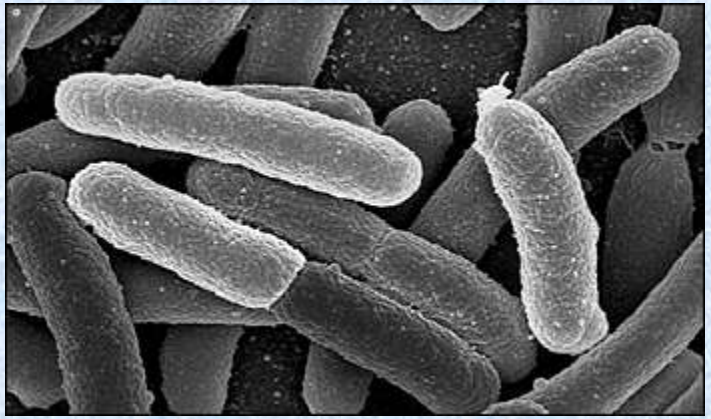
Includes bacteria people are familiar with:

- *Escherichia coli*
- *Staphylococcus*
- *Salmonella*
- *Vibrio cholerae (*causes cholera)
- *Borrelia burgdorferi* (Lyme disease)
- Many more

Domain Bacteria

- Bacteria play a major role in decomposition and many live symbiotically with other organisms including humans helping to break down or synthesize foods needed by the host.





Domain Archaea

- The Archaea include many extremophiles, organisms that live in extreme environments.

- Includes **thermophiles** which tolerate extreme heat (e.g. live in geysers and hot springs where temps may reach 90 degrees celsius); thermoacidophiles that like high temperature and high acidity; and **halophiles** (salt lovers, which live in very saline environments (e.g. Great Salt Lake, Dead Sea)

Domain Archaea

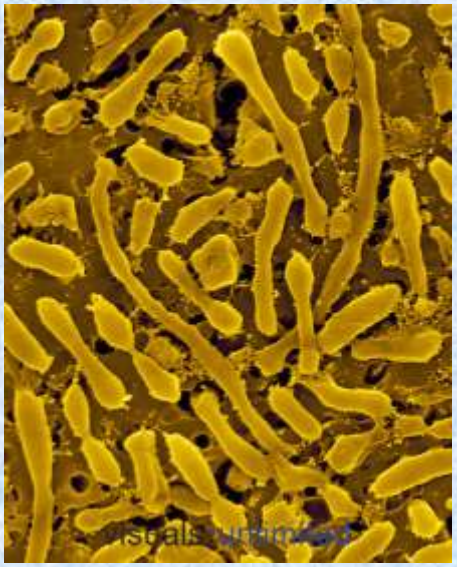
Thermophilic Archaea in hot springs

Domain Archaea

- Look like bacteria
- Very different RNA and DNA, and habitat preferences

Methanococcus

Methanosarcina

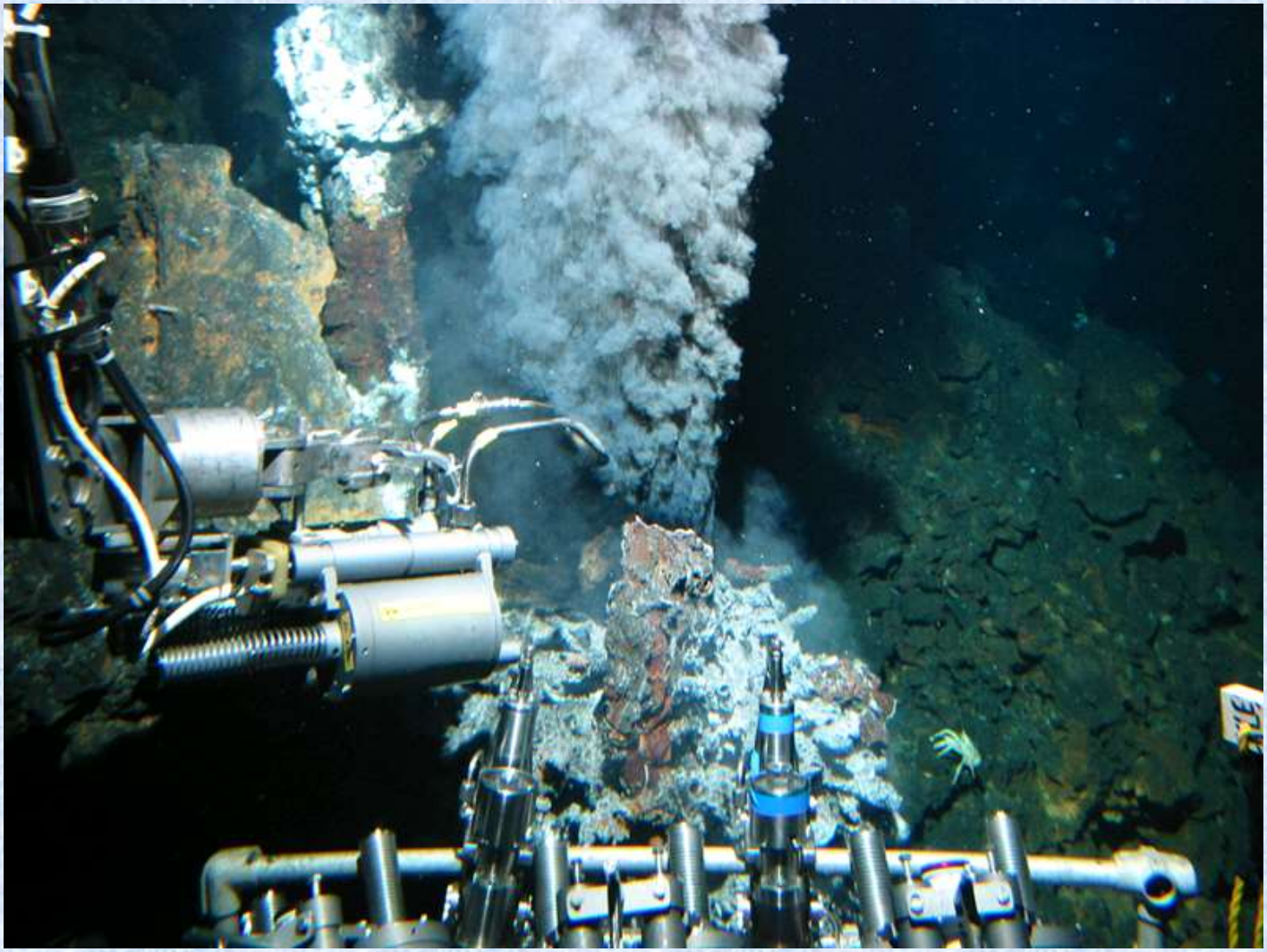


Halophilic bacterium

Where do you find Archaea?

Domain Archaea

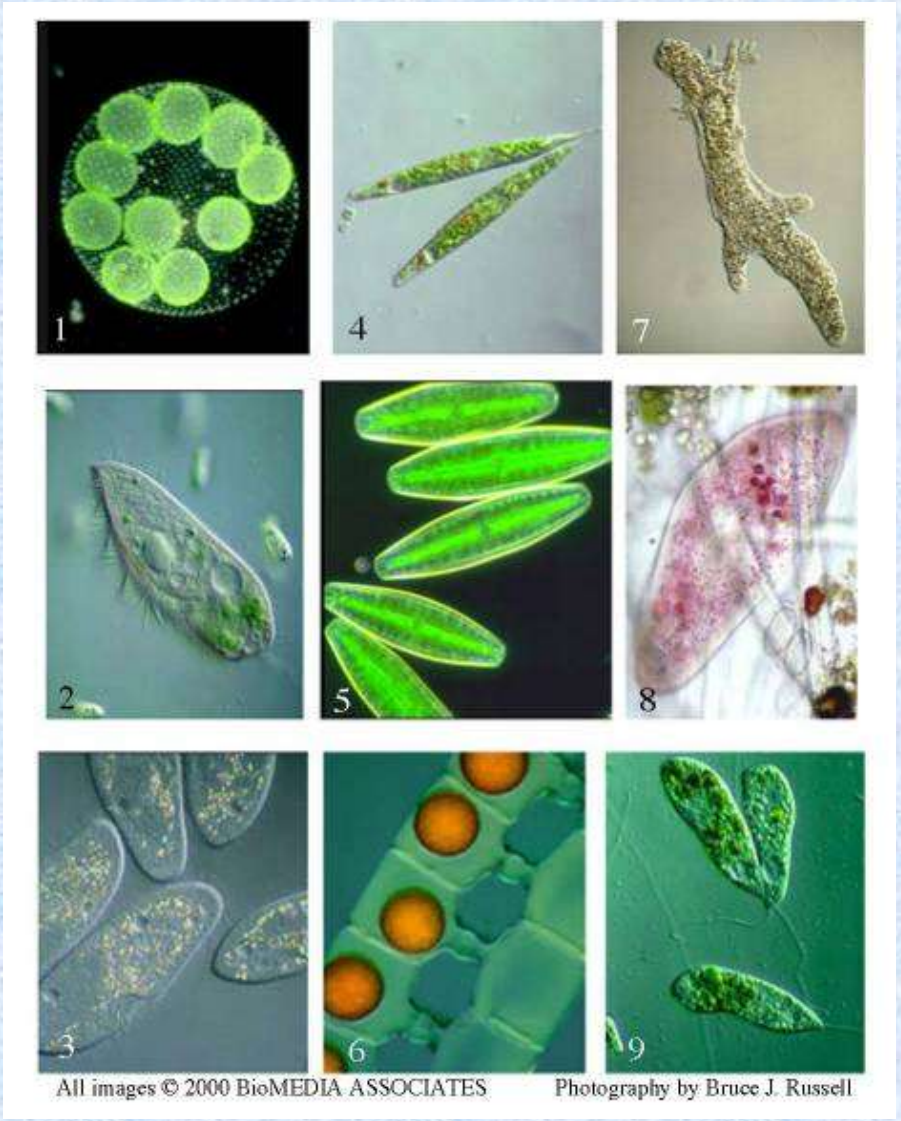
Thermophilic Archaea in deepsea hydrothermal vent



Domain Eukarya

- Domain Eukarya eukaryotic, has nucleus, and DNA arranged in chromosomes.
- Eukaryotic cells are much larger and complex than prokaryotic cells and contain organelles such as mitochondria, chloroplasts, and lysosomes
- includes three kingdoms the Plantae, Fungi and Animalia.
- Unicellular eukaryotes grouped in the Protista, very diverse, may form other kingdoms.

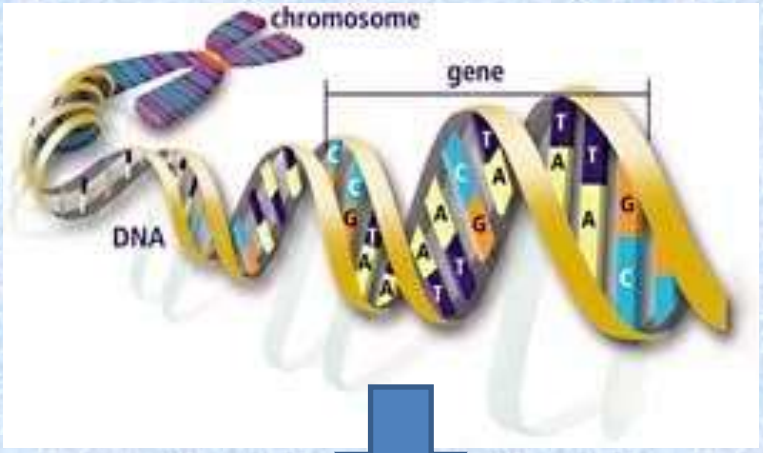
Domain Eukarya



Domain Eukarya

- Protists are unicellular
- Plantae, Fungi and Animalia are mostly multicellular, but
- Plants are autotrophic (produce their own food by photosynthesis) whereas the
- Fungi and animals are heterotrophic (consume other organisms)

Goal of DNA Barcoding: Identify species from DNA alone



ATGTTGAATCTGTGTCATGCTCTTCGAGGCGTAC
AAAGTGAAATGTGCGTCATGTTCCATAAAACTAC
TATTATACGAAGCCAAAAAGTCTACCCGACTCAA
AAGTATTTGCTATTCAGTCAAGACATACAGCTCT
GACCTCAAAACCAAAAGAGATTTACTATTGAGAG
CTTCATCATAACAATTATAACCCGGAAGAGTTTC
AACTACGTCCCCAGAGGCTCAAATGTTATGCATA
CATTTAGACCCCAATGTTTTGAAACGAAATGATT

Family, Genus, Species

DNA Barcoding: Basic Steps….

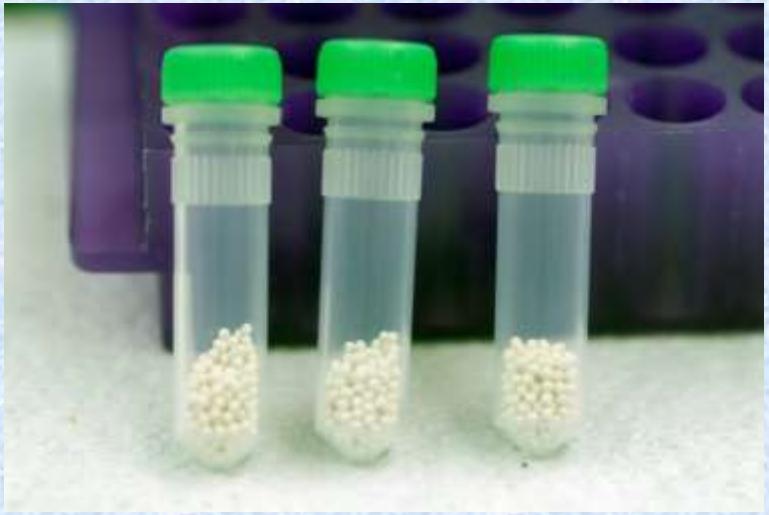
1. Establish a **reference library** of barcodes from identified specimens.
   - Expert identification needed
   - Voucher specimens required

2. Identify unknowns by **searching against reference sequences** to look for matches.
   - BOLD Database
   - GenBank

Collecting the Specimen
Pressing the Plant for Voucher

Livingstone Nganga, UMSL Undergraduate
2012 REU

Extracting DNA from Leaf Samples

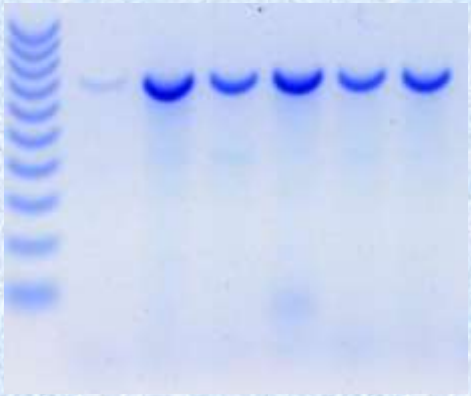


FastPrep DNA Extraction Kit

Livingstone Nganga

DNA Barcode Amplification: PCR

Kelsey Huisman, 2013 REU



PCR Product Gel Electrophoresis – check size

Sequencing Facility

DNA Barcoding Animals with CO1

Food Fraud - Counterfeit Meat

Fraudulent seafood
20-48% of the fish purchased in restaurants, grocery stores and markets in New York and Massachusetts was mislabeled
Boston Globe, 2011

"Bushmeat"

Horsemeat found in beefburgers on sale in UK and Ireland

Horse DNA has been found in some beefburgers being sold in UK and Irish supermarkets, the Republic of Ireland's food safety authority (FSAI) has said.

The FSAI said the meat came from two processing plants in Ireland, Liffey Meats and Silvercrest Foods, and the Dalepak Hambleton plant in Yorkshire.

It said there was no risk to health.

The FSAI said the affected supermarkets had withdrawn the products from sale

The burgers were on sale in Tesco and Iceland in the UK and Ireland. In the Republic of Ireland they were on sale in Dunnes Stores, Lidl and Aldi.

The FSAI said the retailers stated that they were removing all implicated batches of the burgers.

A total of 27 products were analysed, with 10 of them containing horse DNA and 23 containing pig DNA.

'Unacceptable'

Horsemeat accounted for approximately 29% of the meat content in one sample from Tesco.

Related Stories

Horsemeat in burgers poses 'no risk'

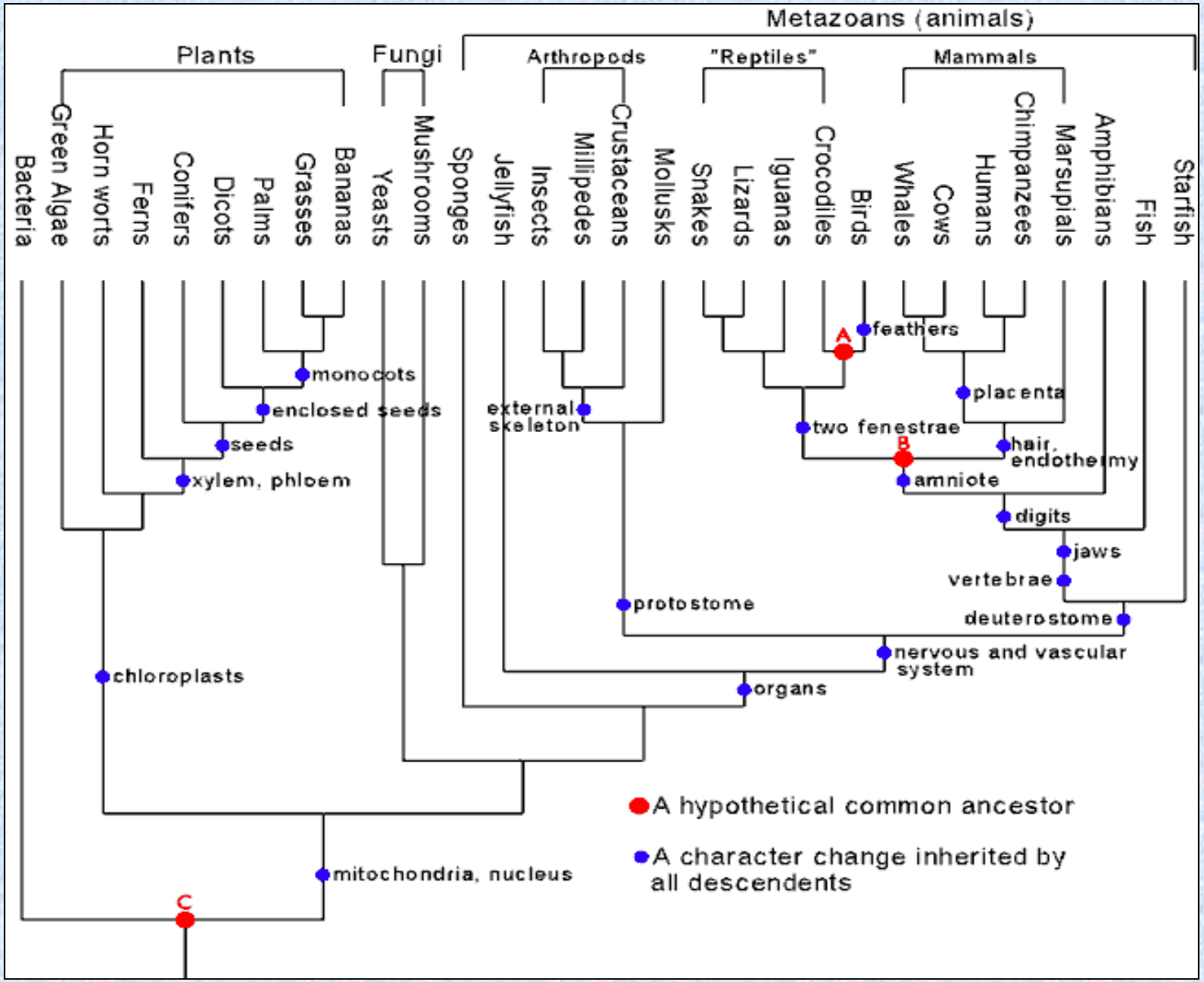
In Ireland, it is not in our culture to eat

Barcoding Applications

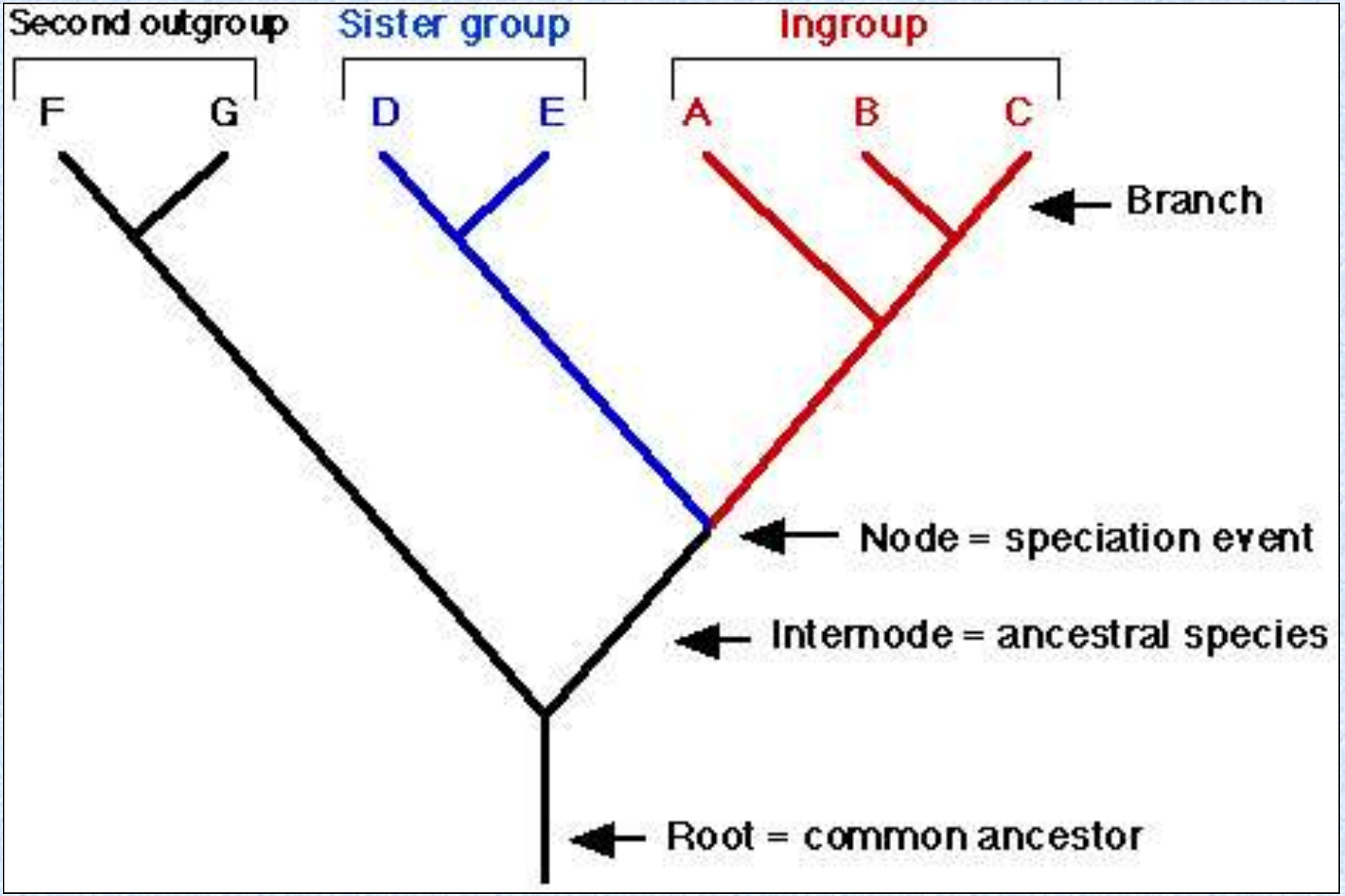
Phylogeny

- Systematic biology is a quantitative science that compares traits of living and fossil organisms to infer relationships over time.
  - Characters from the fossil record, comparative anatomy and development, and the sequence, structure, and function of RNA and DNA molecules are used to construct a phylogeny.
- A **phylogeny** is the evolutionary history of a group.
- Phylogeny is often represented as a phylogenetic tree.
  - A diagram indicating lines of descent
  - Each branching point:
    - Is a divergence from a **common ancestor**
    - Represents an organism that gives rise to two or more new groups

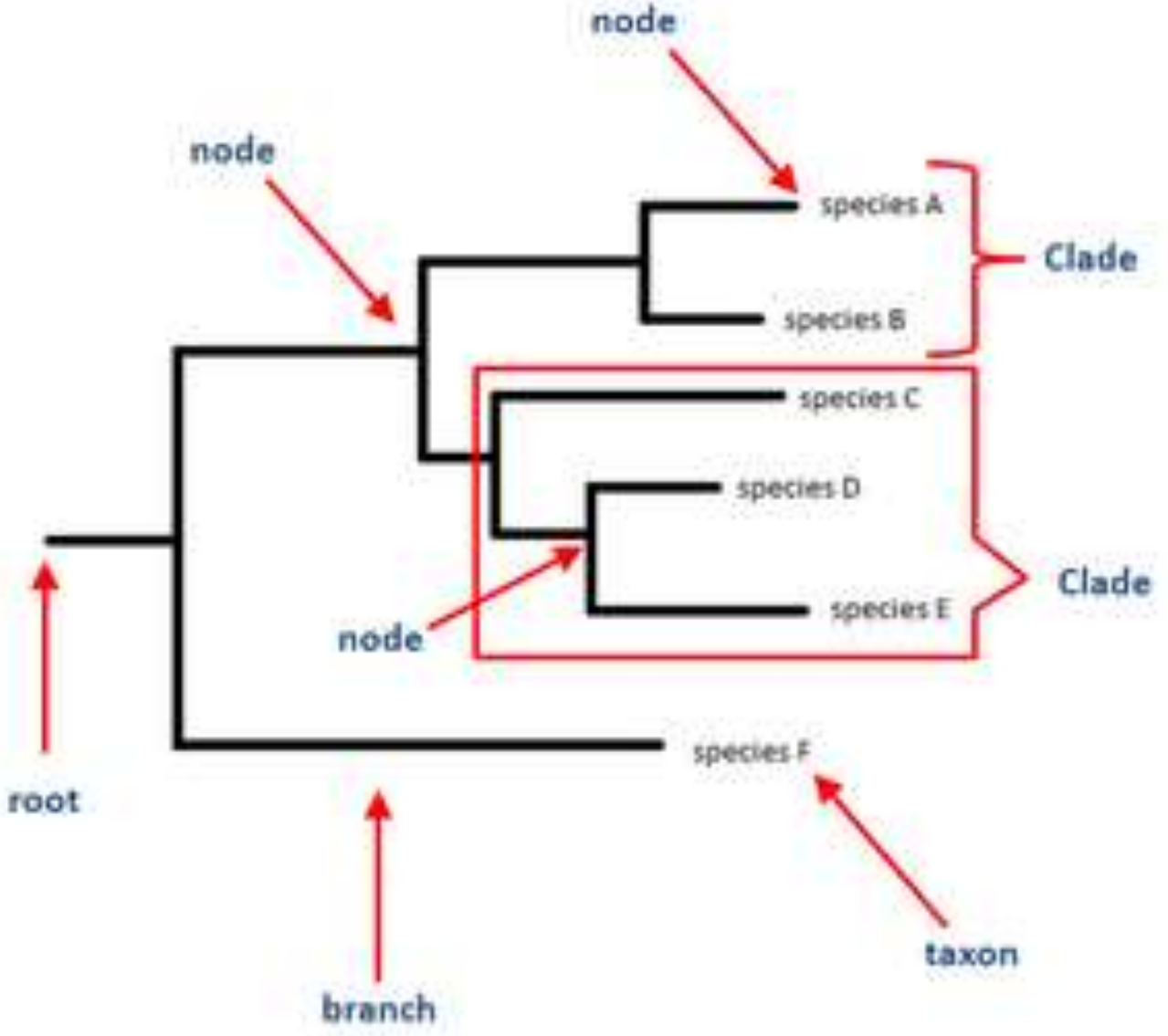
Simplified Tree of Life – branches supported by shared characters



Tree Terminology



Parts of a phylogenetic tree



Phylogeny

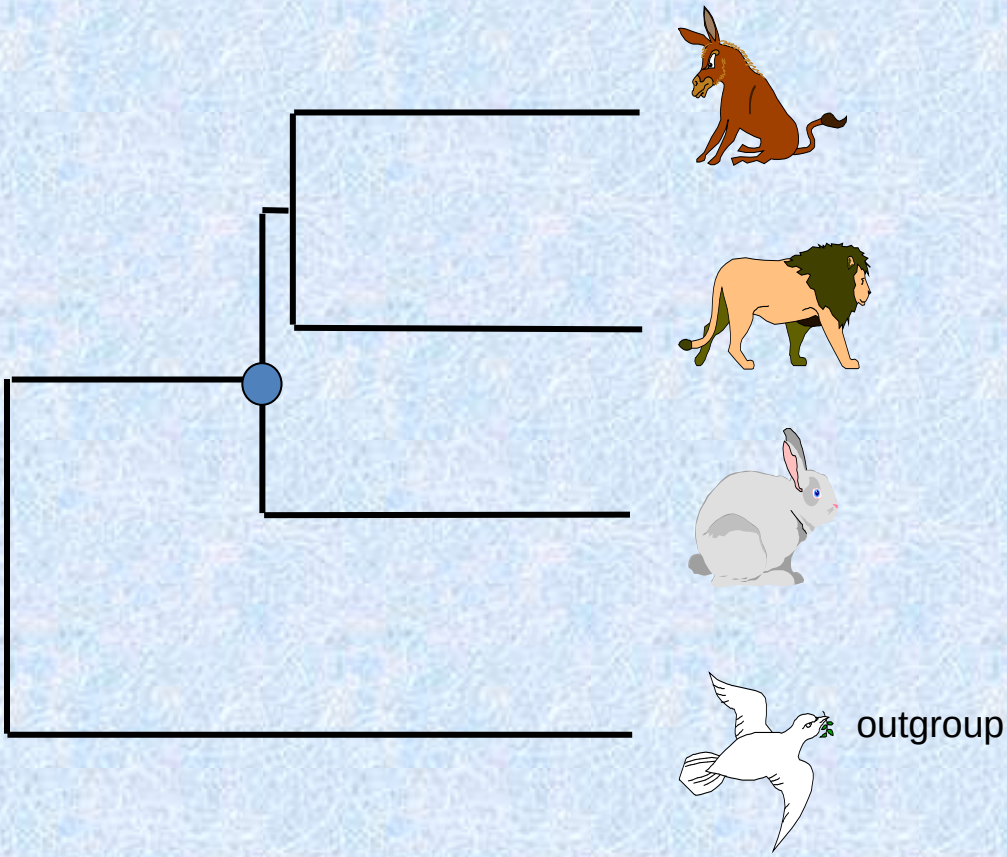
Ingroup — the group of organisms of primary interest.

Outgroup — species or group known to be closely related to, but phylogenetically outside, the group of interest.

Used to root the tree. Helps establish the direction of evolutionary change, the polarity of a character.

Rooting by outgroup

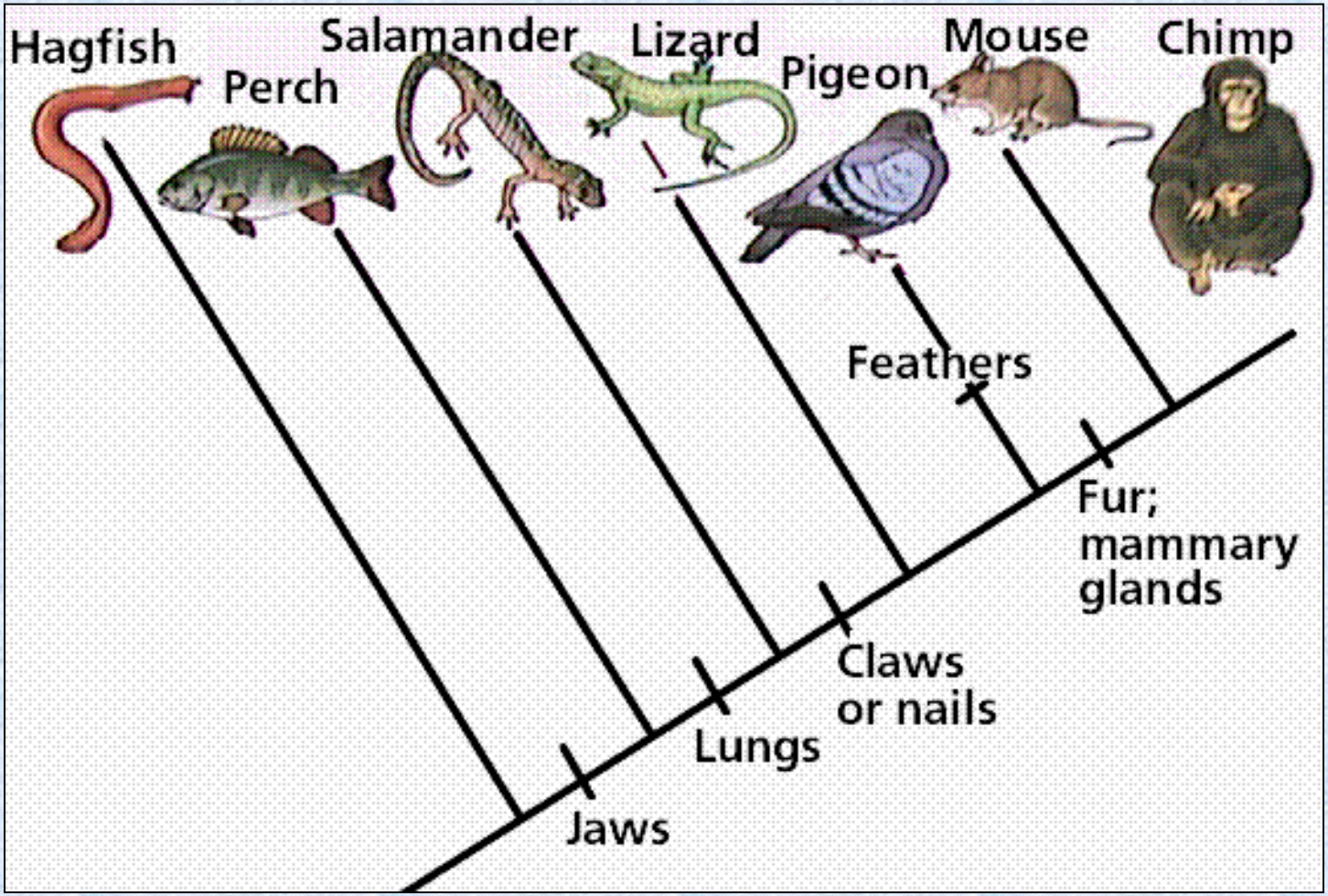
- Uses taxa (the “outgroup”) that are known to fall outside of the group of interest (the “ingroup”).
- Requires some prior knowledge about the relationships among the taxa.



Phylogeny

- **Cladistics** is method that uses shared, derived traits to develop a hypothesis of evolutionary history.
  - This evolutionary history of derived traits is interpreted into a type of phylogeny called a cladogram.
- A cladogram is a special type of phylogenetic tree.
  - A **clade** is an evolutionary branch that includes:
    - A common ancestor, together with
    - All its descendent species
  - It traces the evolutionary history of the group being studied.
  - A cladogram is a working hypothesis.
  - It may change when new traits are discovered and incorporated into the cladogram.
  - Cladistics is a hypothesis-based, quantitative science subject to testing.

Phylogenetic trees are based on character data

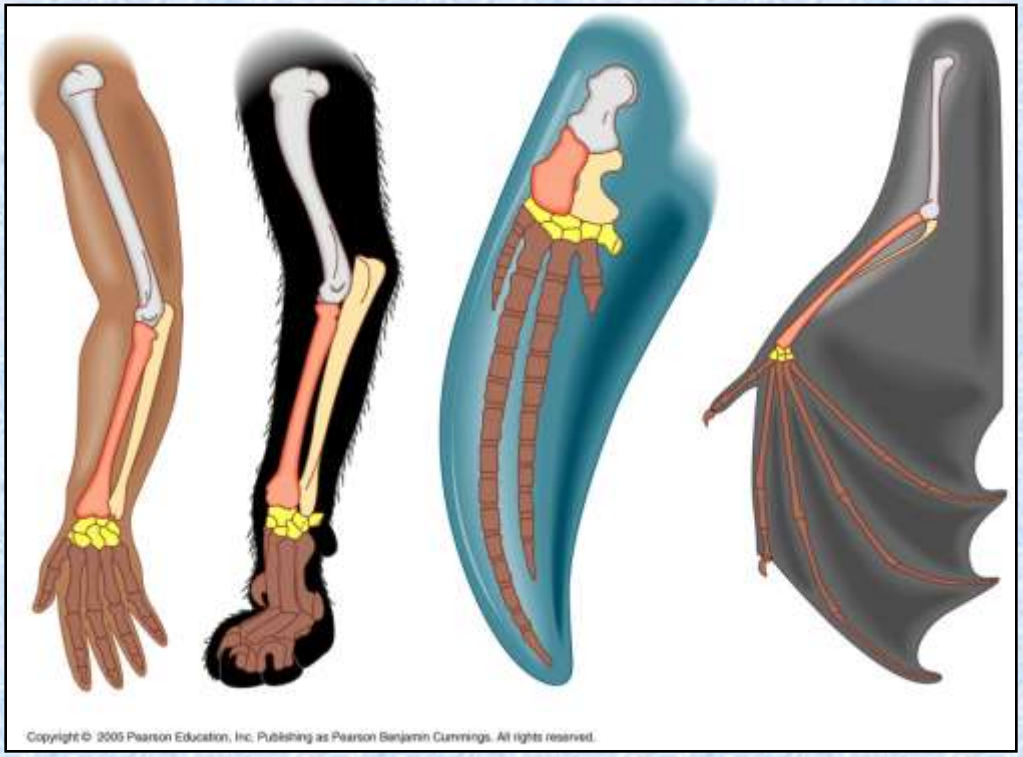


Phylogenetic trees describe the sequence of events that lead to a set of current day species.

Phylogenetic Methods

- What kinds of data do we use?
- Characters
  - Morphology
    - Must use homologous characters
  - Fossils
    - Often incomplete;
    - can be dated, calibrate molecular clock
  - Behavior
    - E.g. mating behavior, calls
  - Molecules (DNA)
    - Advantage of many DNA base pairs to use

Homologous Characters

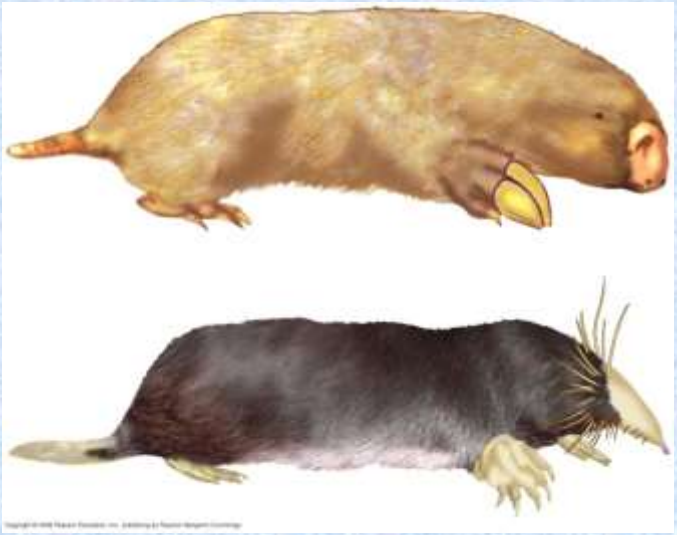


- Shared by two or more species
- Inherited from a common ancestor
- They can be any heritable traits, including DNA sequences, protein structures, anatomical structures, and behavior patterns.

Convergent Evolution

Similarity between species that is caused by a similar but evolutionarily independent response to similar selection pressures

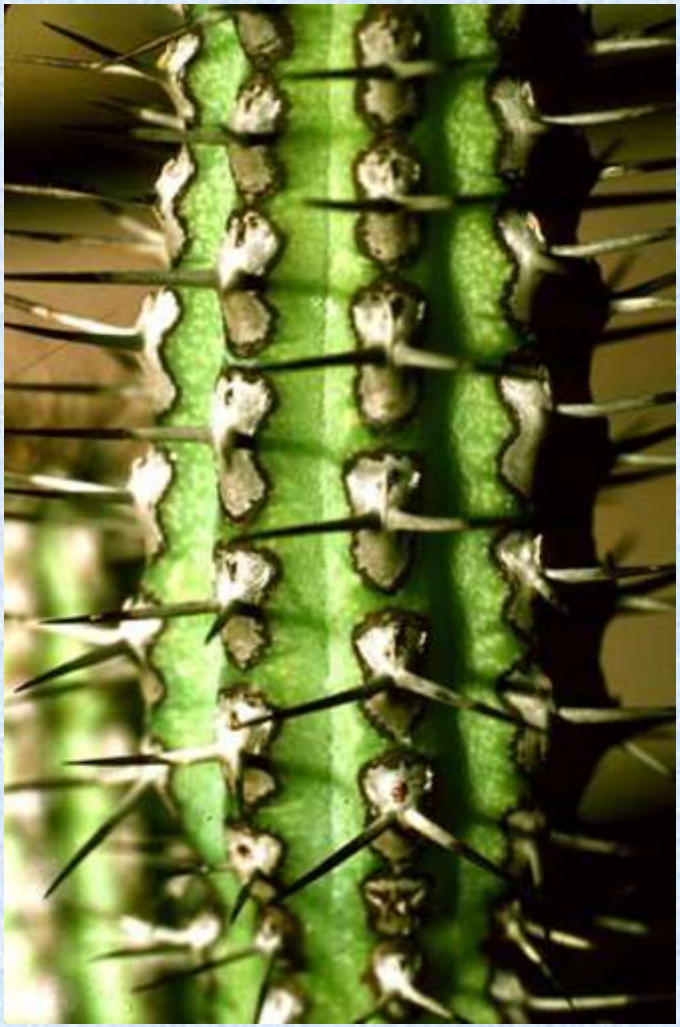
Ancestors are different in appearance, but the two descendants now look alike for that trait.



Convergent evolution: Australian “mole” and N. American “mole”

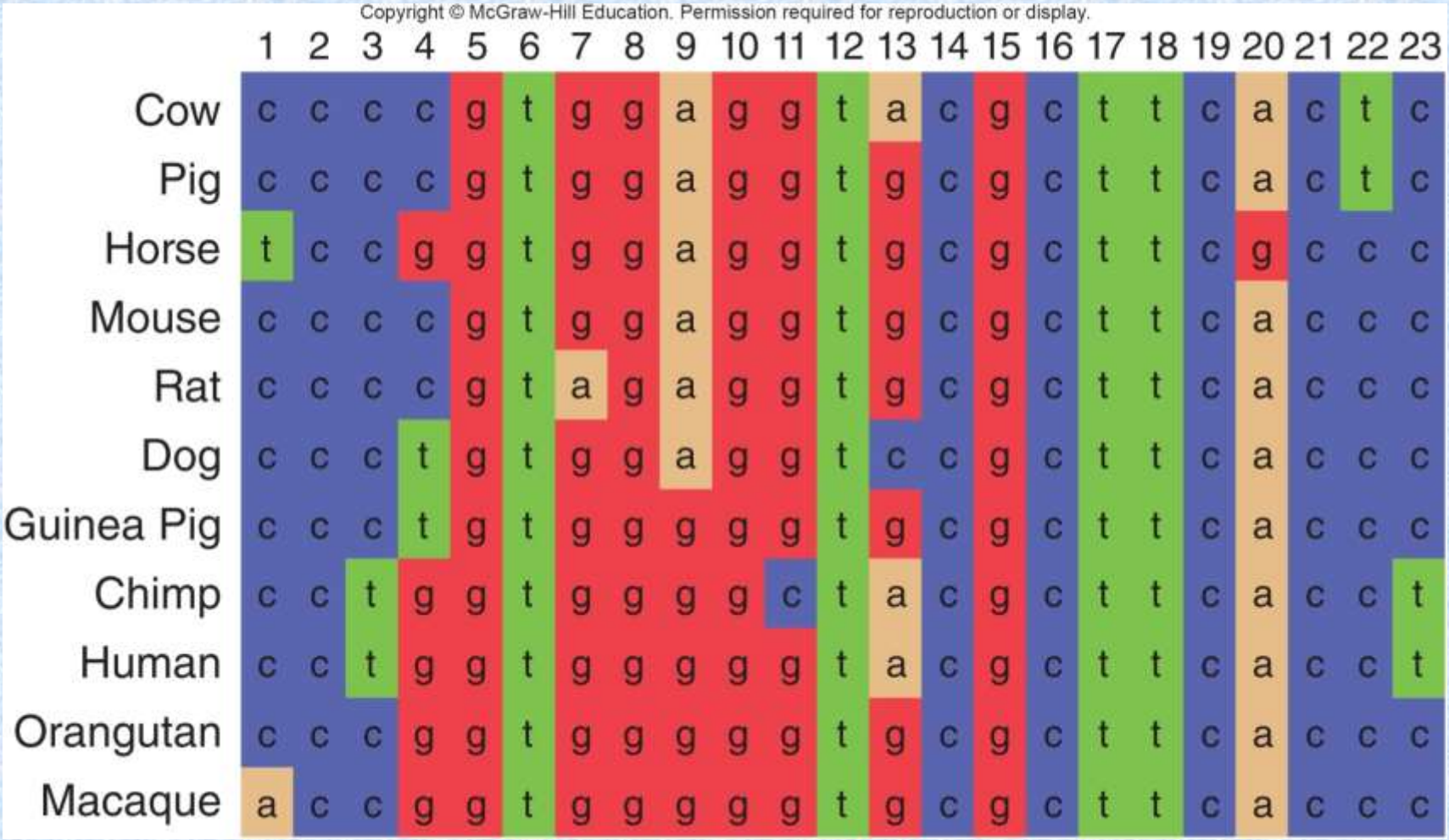
Convergent evolution:
spines of cacti and euphorbs

Cactus



Euphorb

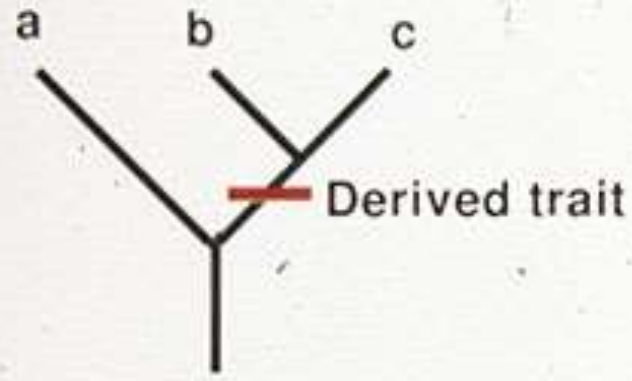
DNA Sequence Alignment

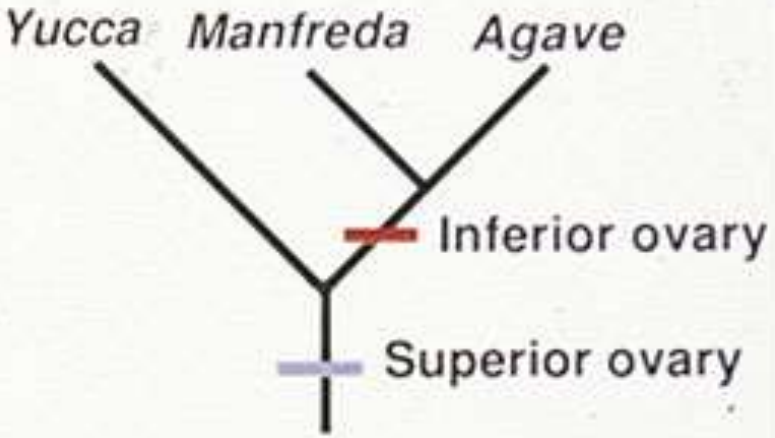


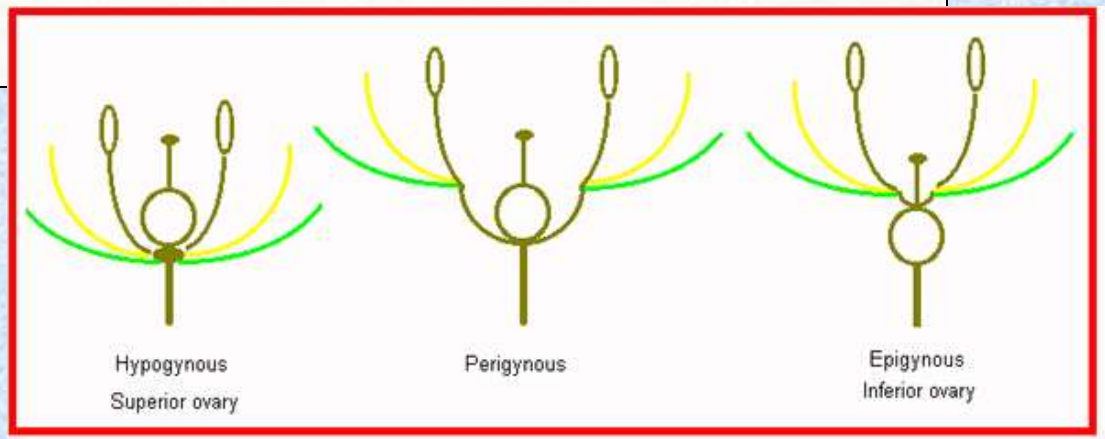
Cladistics

Phylogeny reconstruction

Shared derived characters







Phylogeny

- **Ancestral traits**:
  - Present in all members of a group, and
  - Present in the common ancestor
  - Are not useful for determining the evolutionary relationships of an ancestor's descendents
- **Derived traits**:
  - Present in some members of a group, but absent in the common ancestor
  - Are the most important traits for clarifying evolutionary relationships
    - An opposable thumb, not present in the common ancestor of all mammals, is an ancestral trait of primates.

Phylogenetic Systematics = "Cladistics"

Willi Hennig about 1970

Put forward his ideas in 1950,wrote in his German, so these were completely ignored until 1966 when an English translation of a manuscript was published under the title "Phylogenetic Systematics" (Hennig 1966).

Willi Hennig - 1913-1976

Germany, military entomologist, malaria prevention

Taxonomist, specialist in Dipterans (flies)

1950 - *Basic outline of a theory of phylogenetic systematics*

1. Relationships interpreted as sister-lineages (clades)
2. Synapomorphies determine common ancestry
3. Best tree determined by greatest amount of evidence
4. Taxonomy/classification should based on inferred pattern of historical relationships (monophyly)

*population genetics, natural selection and adaptation have little to do with the discovery of genealogical relationships

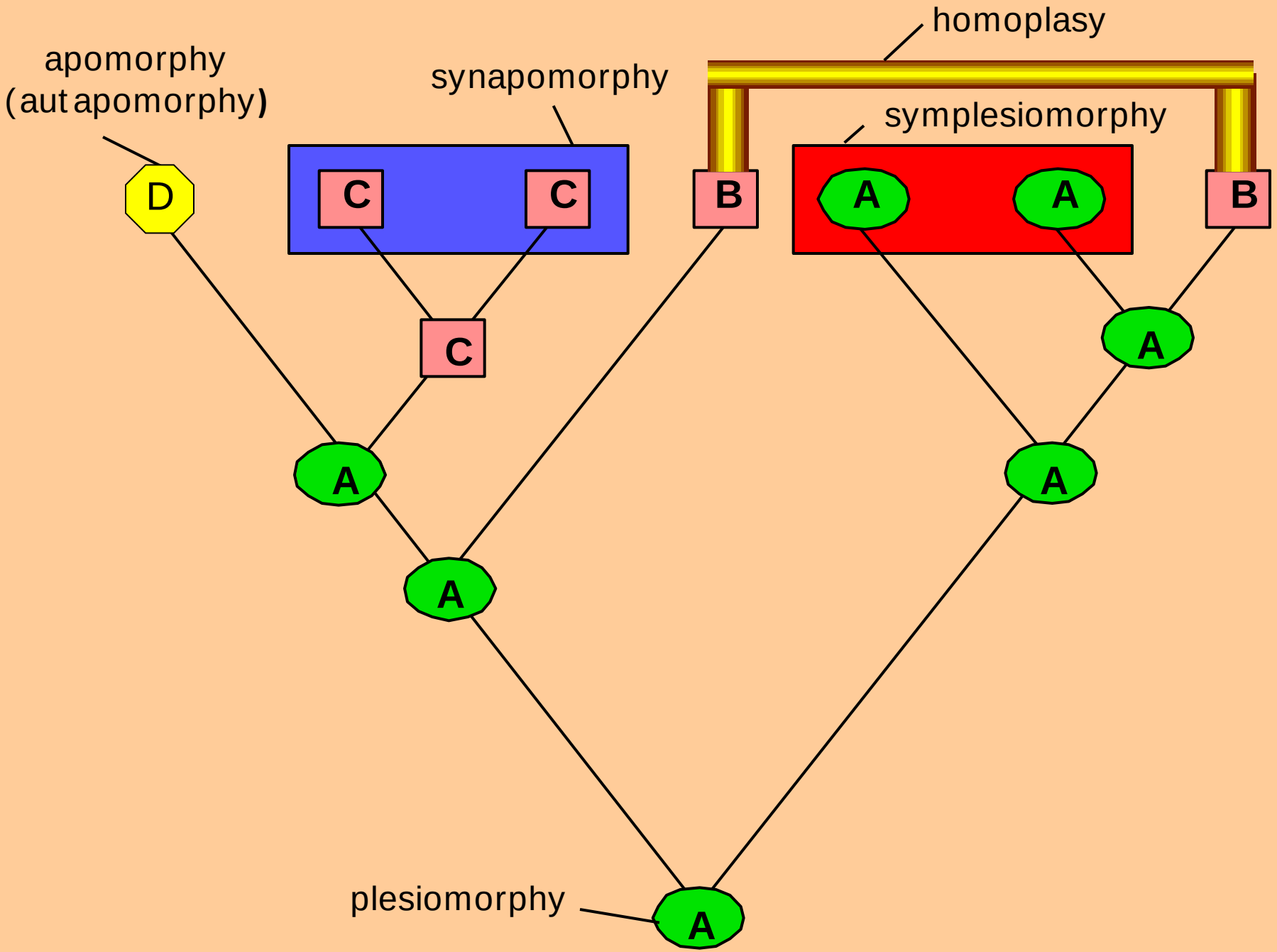
Terminology developed by Willi Hennig

Apomorphy - a **derived** feature or character; derived from and differing from an ancestral (plesiomorphic) condition

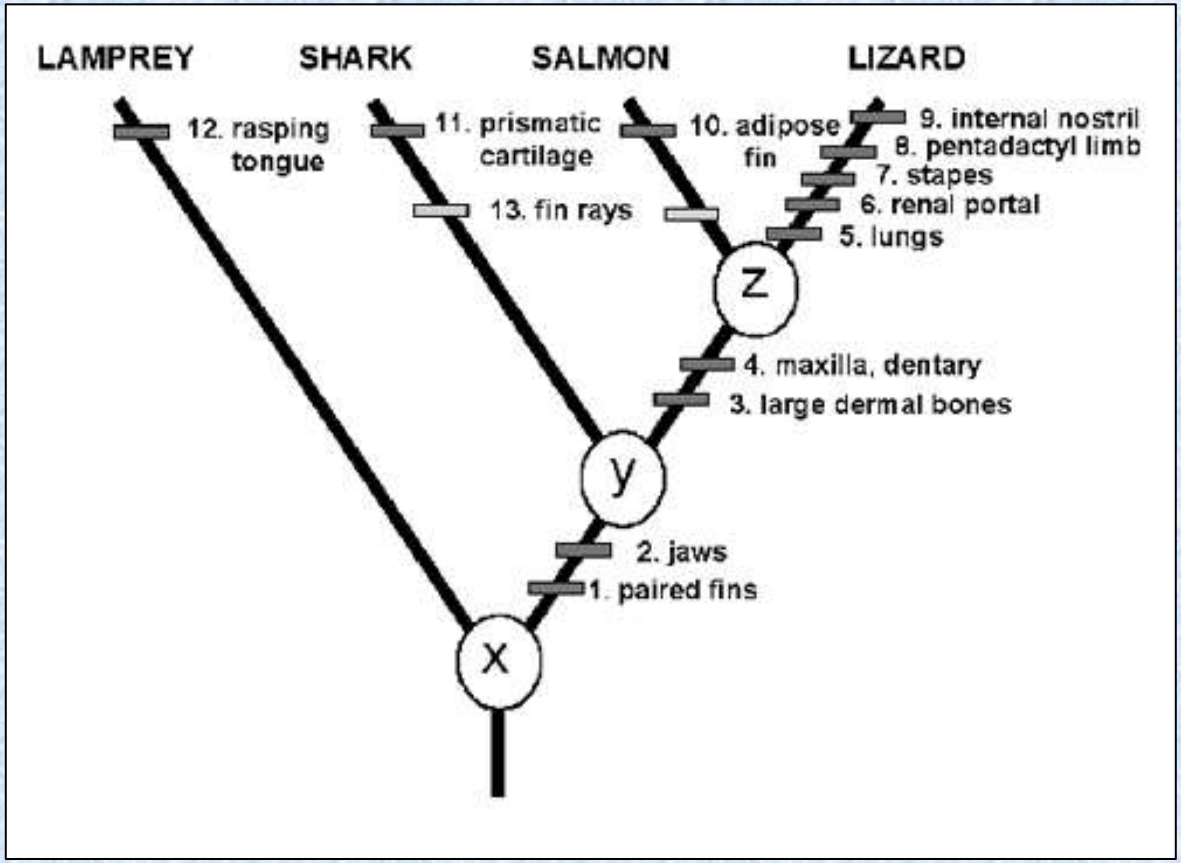
Synapomorphy - A shared, derived character (apomorphy) reflecting common ancestry used to group taxa. Hair is a synapomorphy of mammals

Plesiomoprphy - an ancestral or primitive character, often incorrectly used to group taxa

Autapomorphy – character unique to a single taxon


homoplasy
apomorphy
(autapomorphy)
synapomorphy
symplesiomorphy
D
C
C
B
A
A
B
C
A
A
A
A
plesiomorphy

Hennig's Method Phylogenetic Tree based on shared derived characters = "Cladogram"



An example of a phylogeny showing characters by which taxa are recognized. Characters 1 – 4 are synapomorphies, 5 – 12 are autapomorphies and 13 is an attribute seen in the salmon and the shark.

Hennig – Cladistics
Higher taxonomic groups determined by shared derived characters

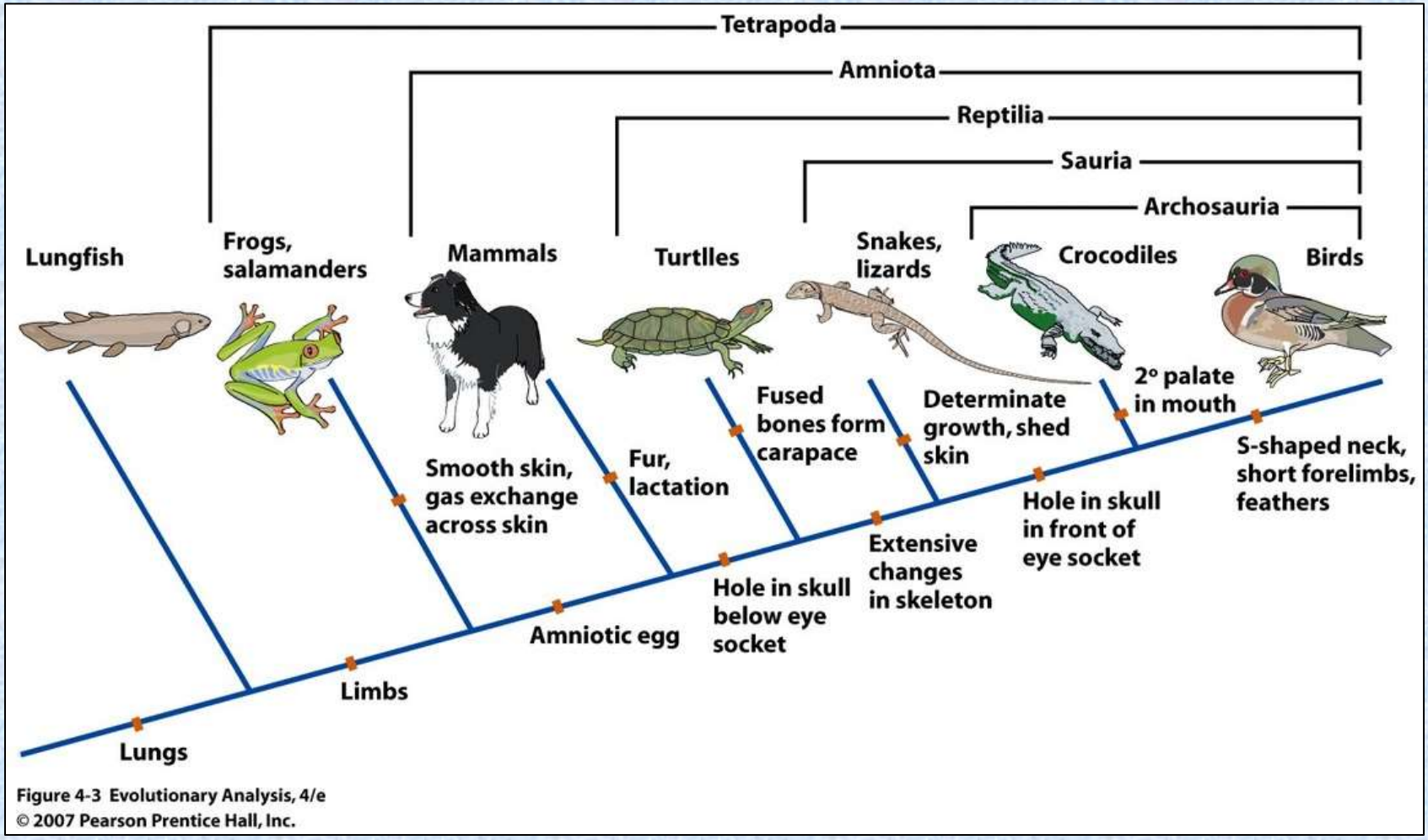
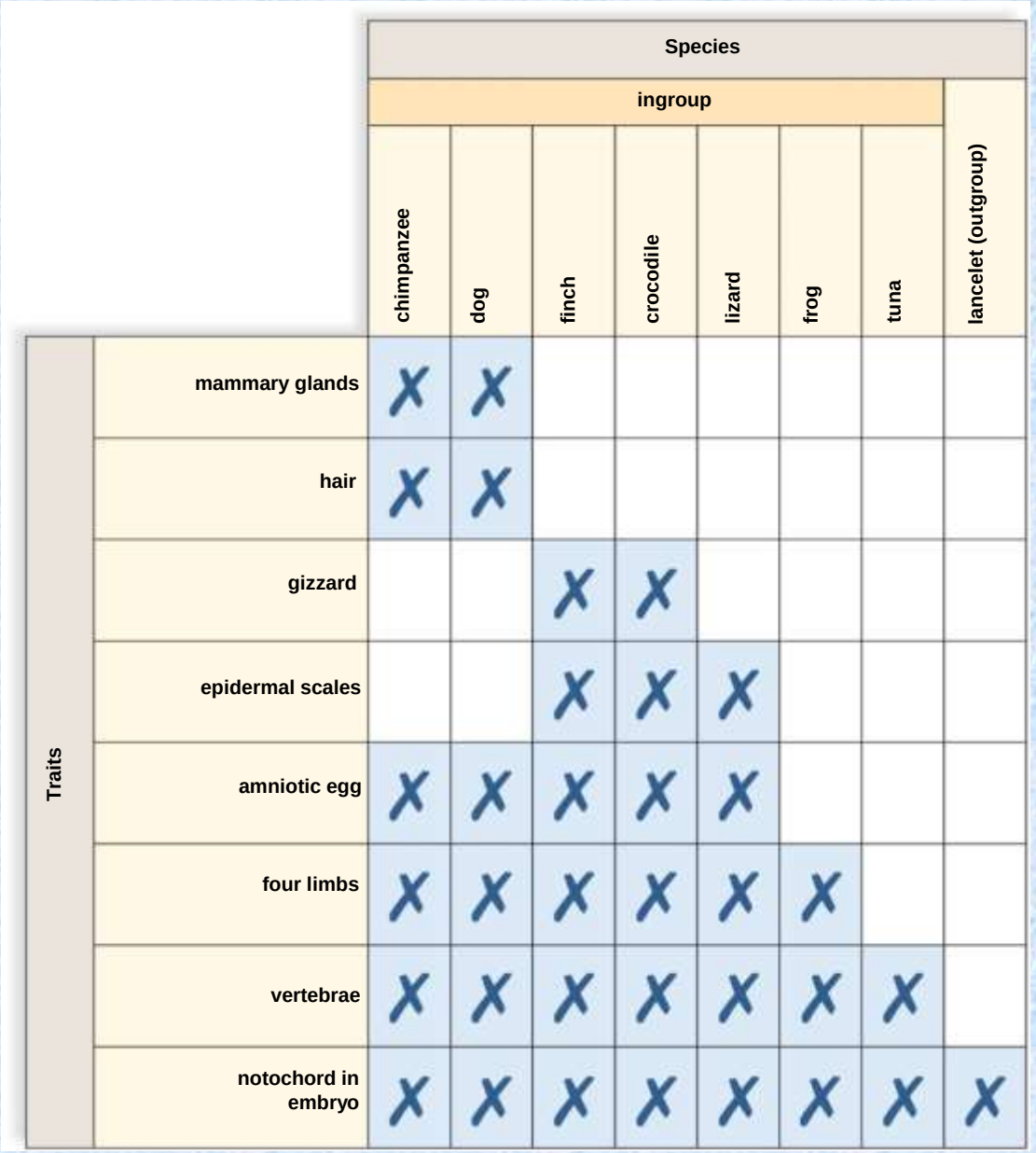


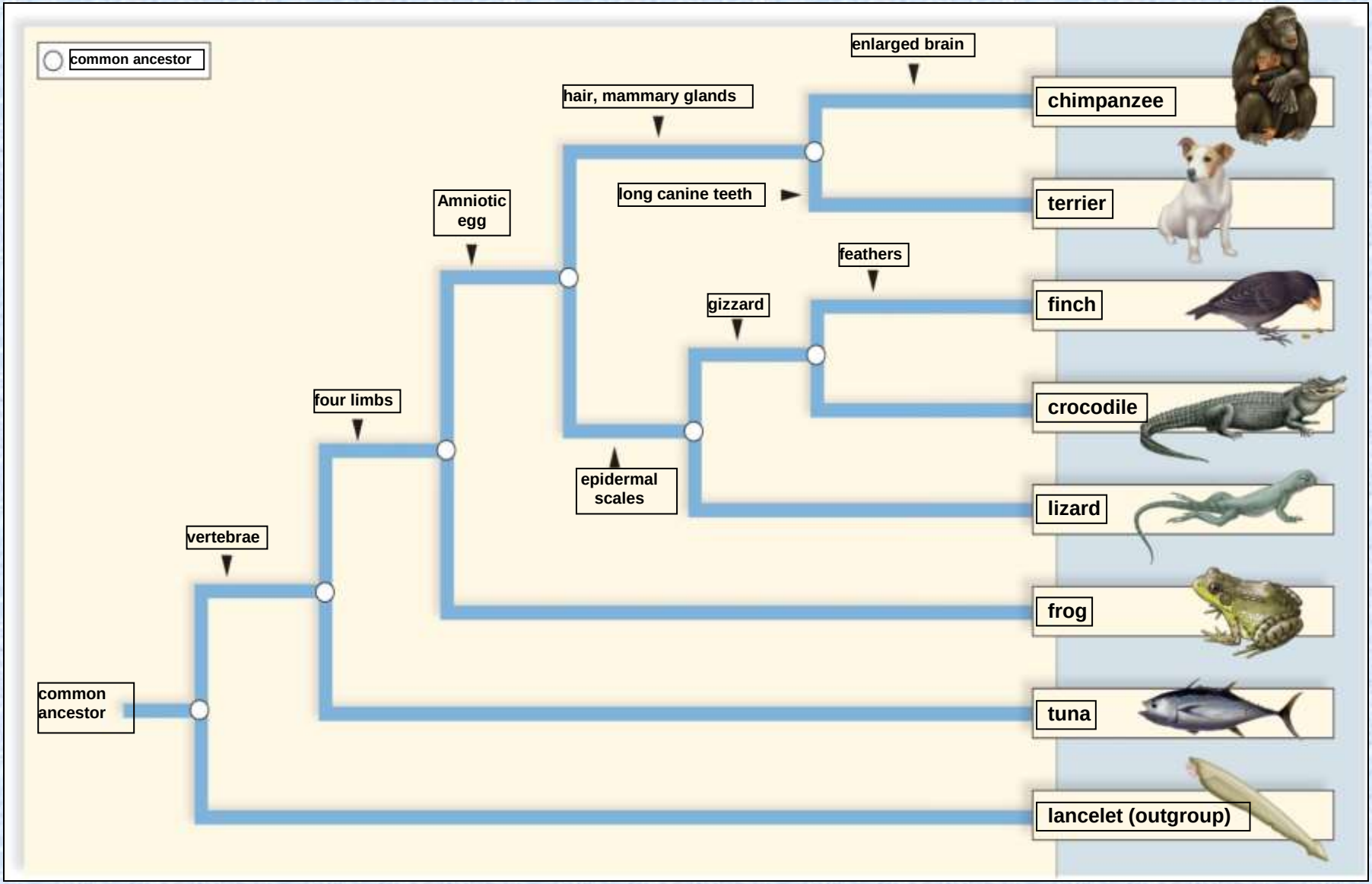
Figure 4-3 Evolutionary Analysis, 4/e

Constructing a Cladogram: The Data Matrix

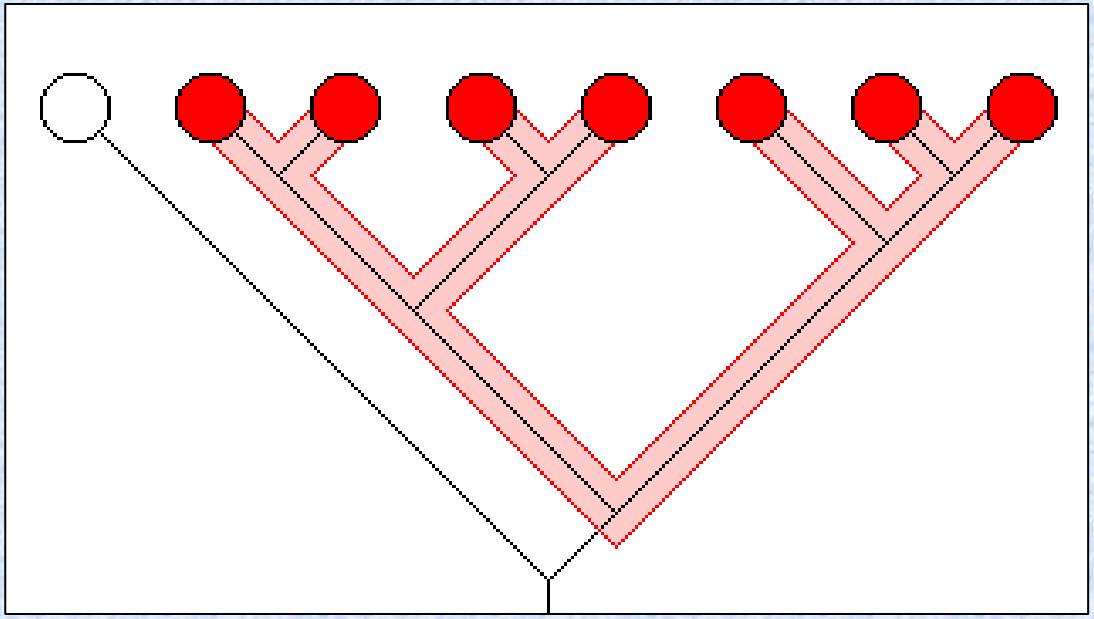


		Species							
		ingroup							lancelet (outgroup)
		chimpanzee	dog	finch	crocodile	lizard	frog	tuna	
Traits	mammary glands	✗	✗						
	hair	✗	✗						
	gizzard			✗	✗				
	epidermal scales			✗	✗	✗			
	amniotic egg	✗	✗	✗	✗	✗			
	four limbs	✗	✗	✗	✗	✗	✗		
	vertebrae	✗	✗	✗	✗	✗	✗	✗	
	notochord in embryo	✗	✗	✗	✗	✗	✗	✗	✗

Constructing a Cladogram: The Phylogenetic Tree



Monophyletic Taxon

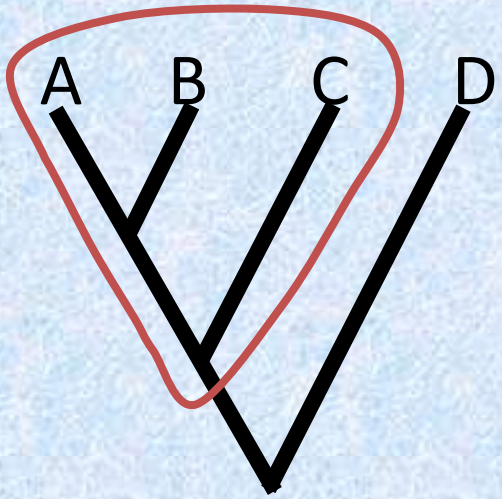


- Includes the most recent common ancestor of all those organisms and all the descendants of that common ancestor
- Cladistics acknowledges only monophyletic groupings as valid

Phylogeny and Classification

Monophyletic group

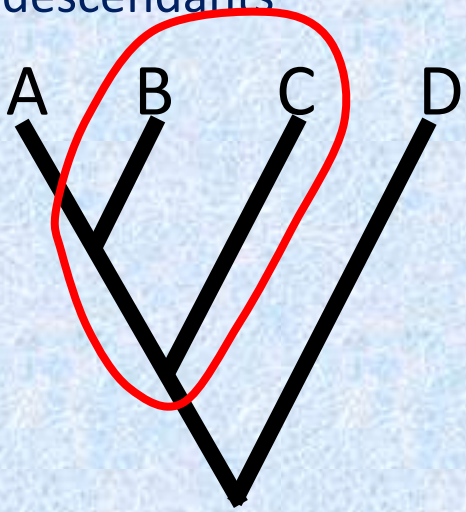
Includes an ancestor and all of its descendants



How could this happen?

Paraphyletic group

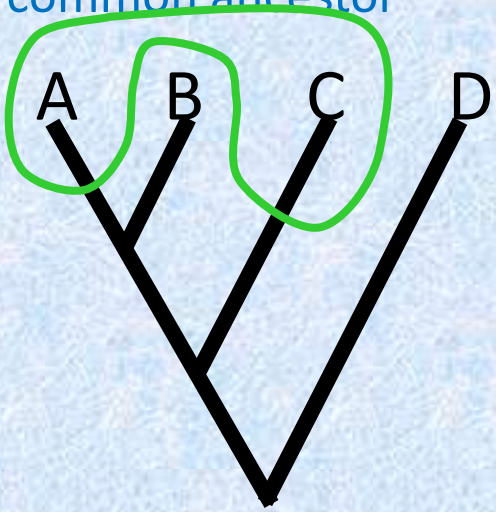
Includes ancestor and some, but not all of its descendants



Taxon A is highly derived and looks very different from B, C, and ancestor

Polyphyletic group

Includes two convergent descendants but not their common ancestor

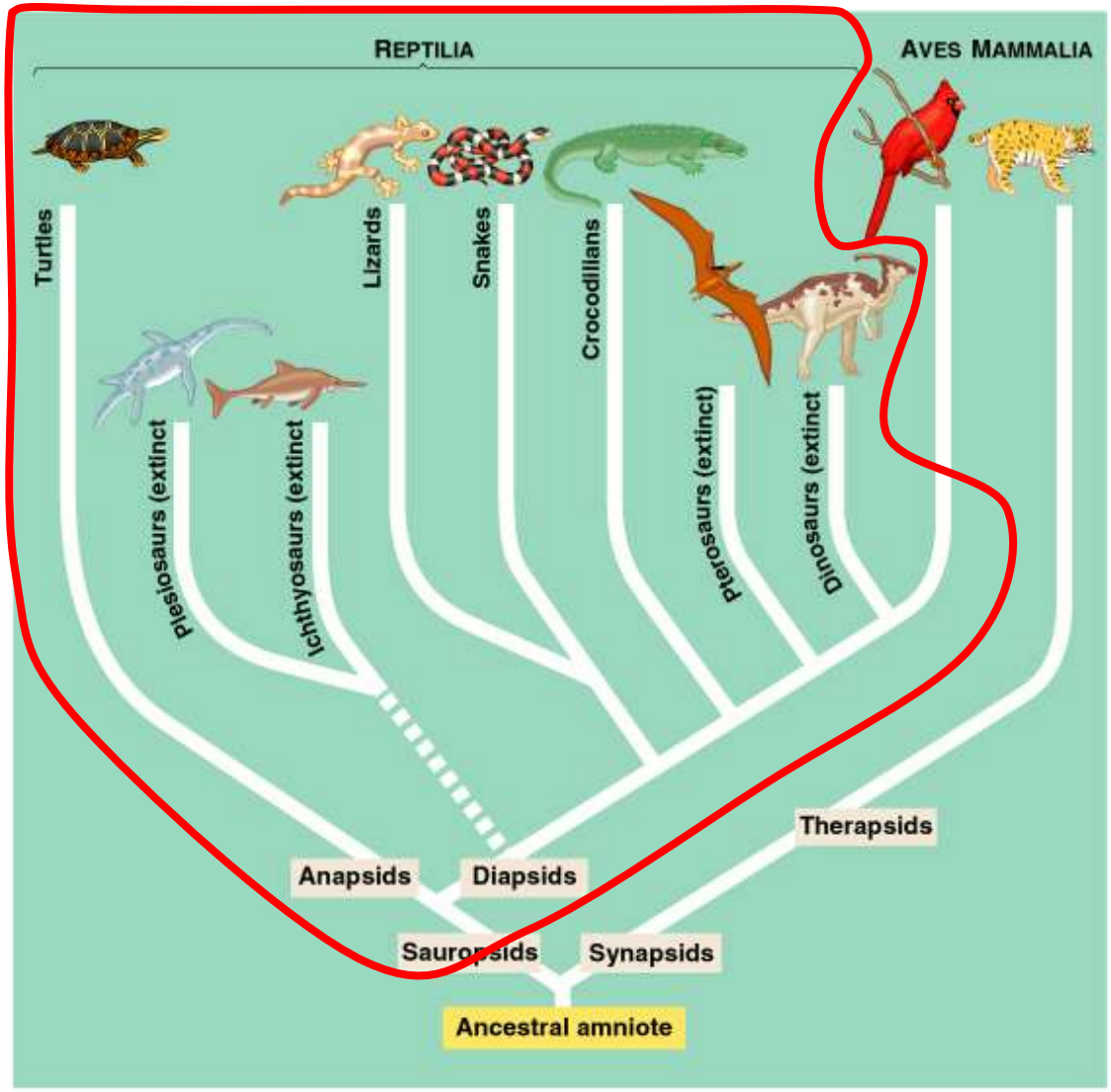


Taxon A and C share similar traits through convergent evolution

Only monophyletic groups (**clades**) are recognized in cladistic classification

Monophyly vs Paraphyly: Reptiles/Birds

Reptilia



Paraphyly

Birds are more closely related to crocodilians than to other extant vertebrates

Archosauria = Birds + Crocs

We think of reptiles as turtles, lizards, snakes, and crocodiles

But Reptilia is a paraphyletic group unless it includes Aves

Ockham's Razor – Parsimony Optimality Criterion

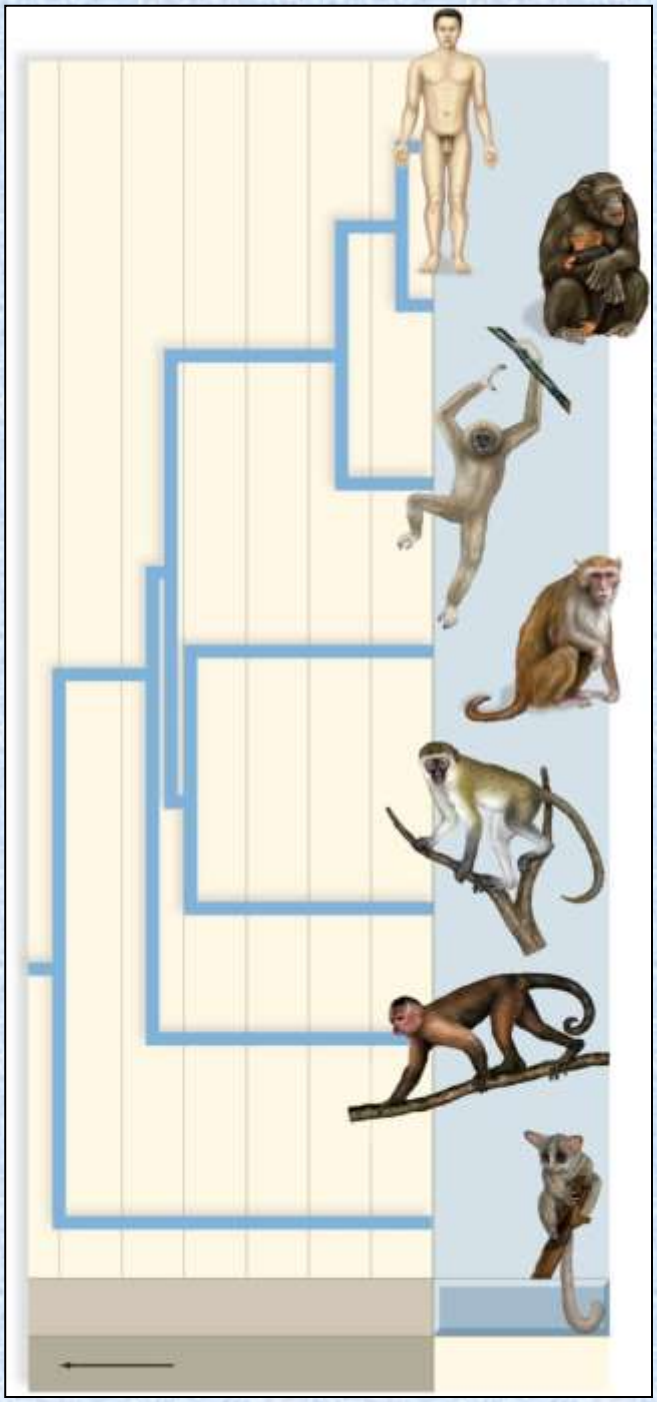
- The simplest explanation is the best
- Among competing hypotheses (trees), the one with the fewest assumptions (steps) should be selected.
- Other, more complicated solutions may ultimately prove correct, but—in the absence of certainty—the fewer assumptions that are made, the better

William of Ockham (c. 1287–1347).

Ockham chooses a razor

How do we determine the correct tree if there is more than one possible?

- Cladists are guided by the principle of **parsimony**—the minimum number of assumptions is most logical.
  - The best cladogram is one in which the fewest number of steps determined by shared derived characters; minimizes the number of assumed evolutionary changes.
- Reliability of cladograms is dependent on the knowledge and skill of an investigator.
- There are other methods to make trees



Molecular Phylogeny of Primates

- Based on several genes
- Length of branches corresponds to number of nucleotide differences.
- When matched to fossil evidence it suggests dates for divergence time for the other nodes.

Molecular Clock

- Assumes bases change at constant rate
- Used to create a timeline for evolutionary changes

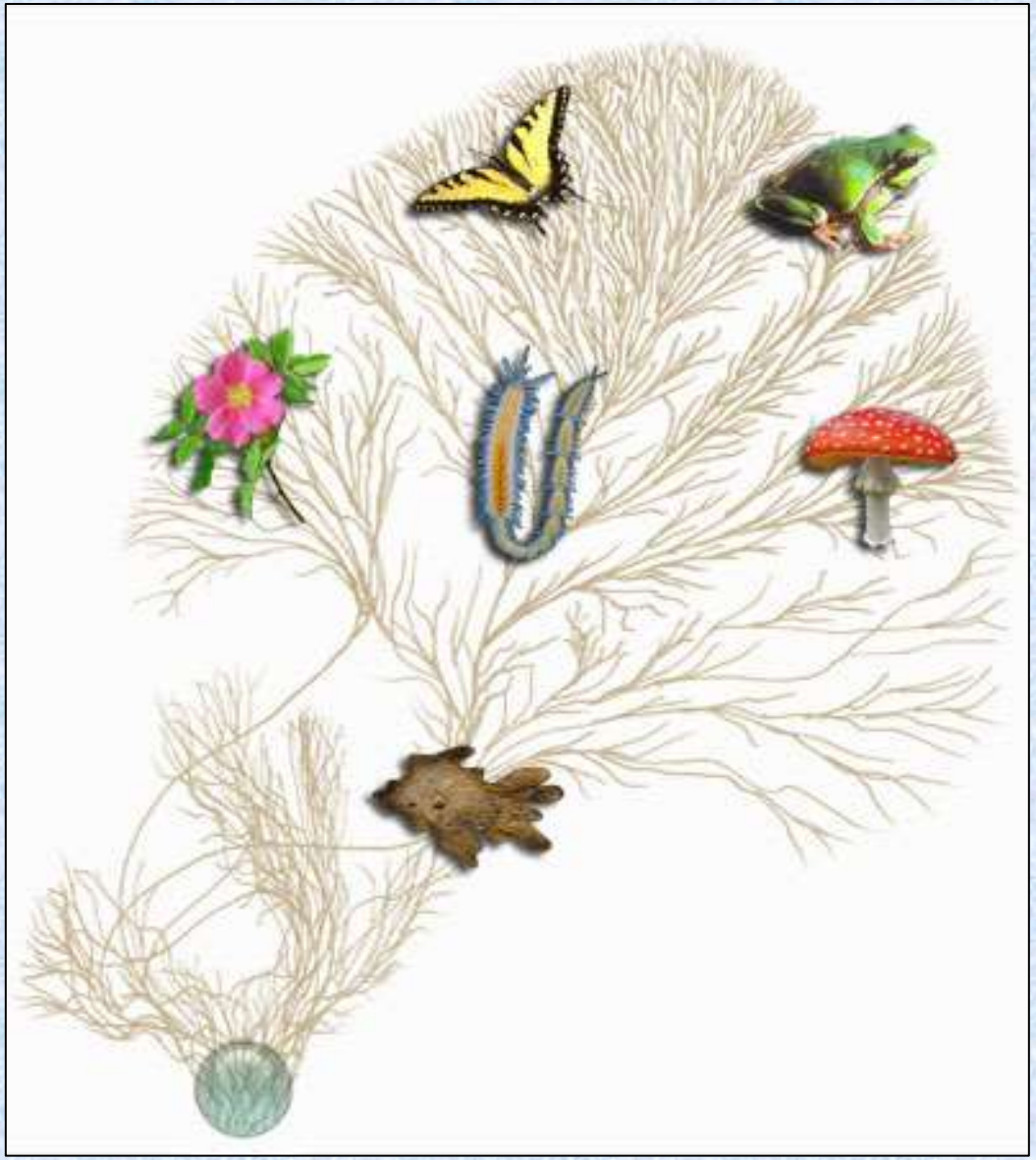
Phylogenetic Tree of Life

Why is phylogeny important?

Understanding and classifying the diversity of life on Earth

Testing evolutionary hypotheses:
- trait evolution
- coevolution
- mode and pattern of speciation
- correlated trait evolution
- biogeography
- geographic origins
- age of different taxa
- nature of molecular evolution
- disease epidemiology

…and many more applications!



End

Higher categories are defined by shared traits

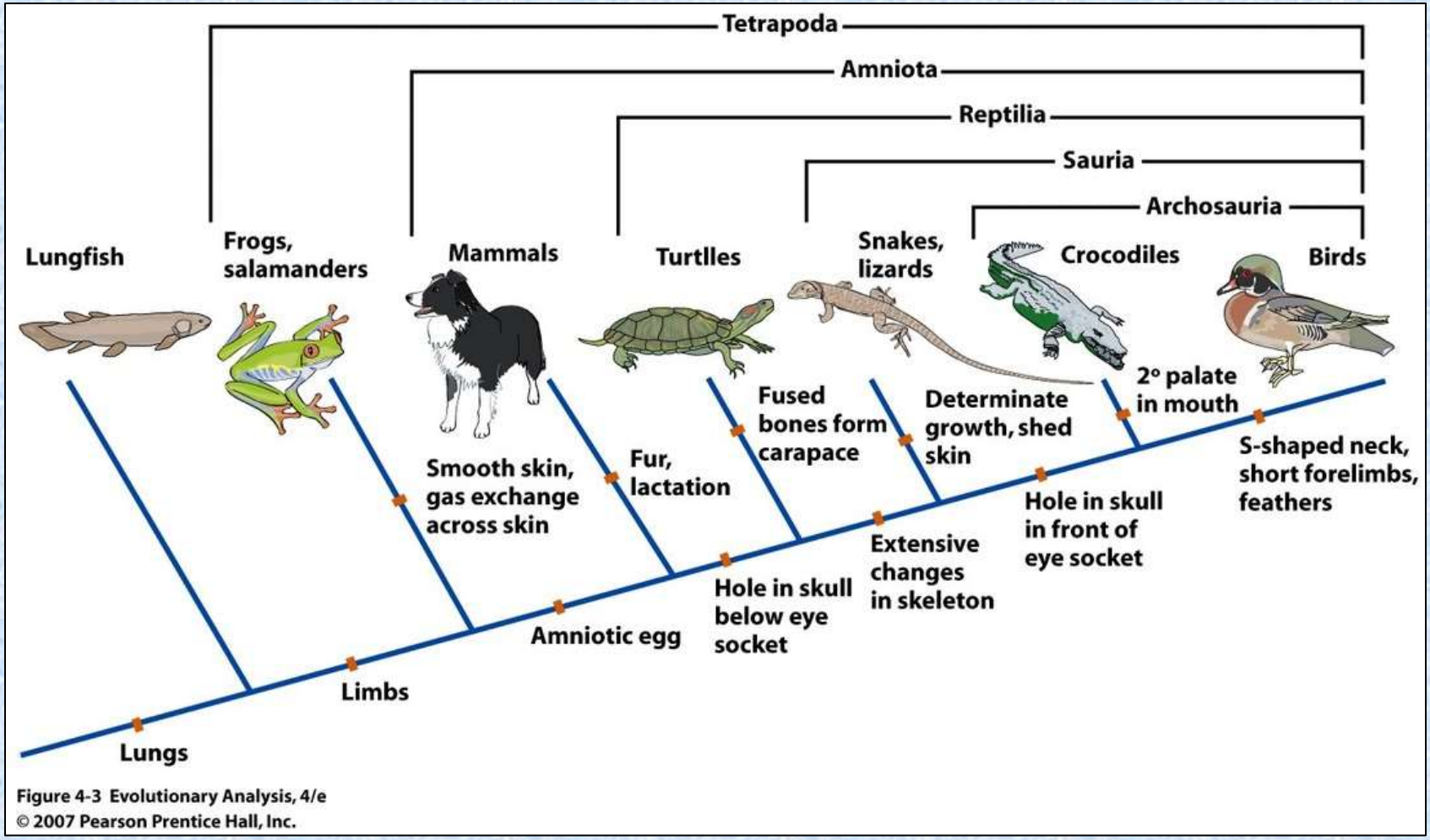


Figure 4-3 Evolutionary Analysis, 4/e

Methods

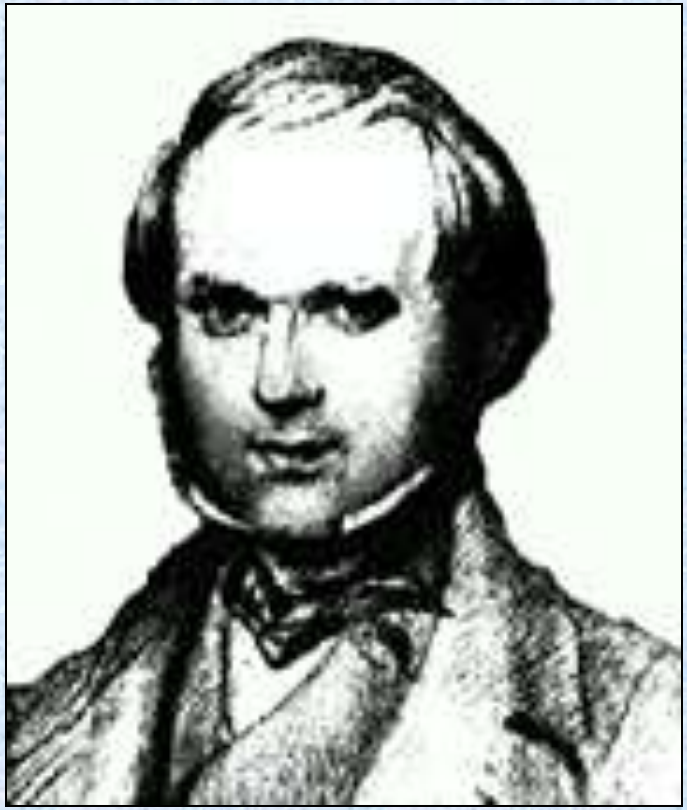
- What kinds of data do we use? Characters?
  - Morphology
  - Fossils
  - Behavior
  - Molecules (DNA)
- How do we make phylogenetic trees?
  - Similarity (distance, phenetics)
  - Cladistic methodology, Parsimony
  - Maximum Likelihood, Bayesian
- How do we decide among competing alternative trees?

Domain Eukarya

- Domain Eukarya contains the eukaryotic organisms (from Greek *eu* true and *karyon* a kernal) which have a true nucleus and DNA arranged in chromosomes.
- Eukaryotic cells are much larger and complex than prokaryotic cells and contain organelles such as mitochondria, chloroplasts, and lysosomes.

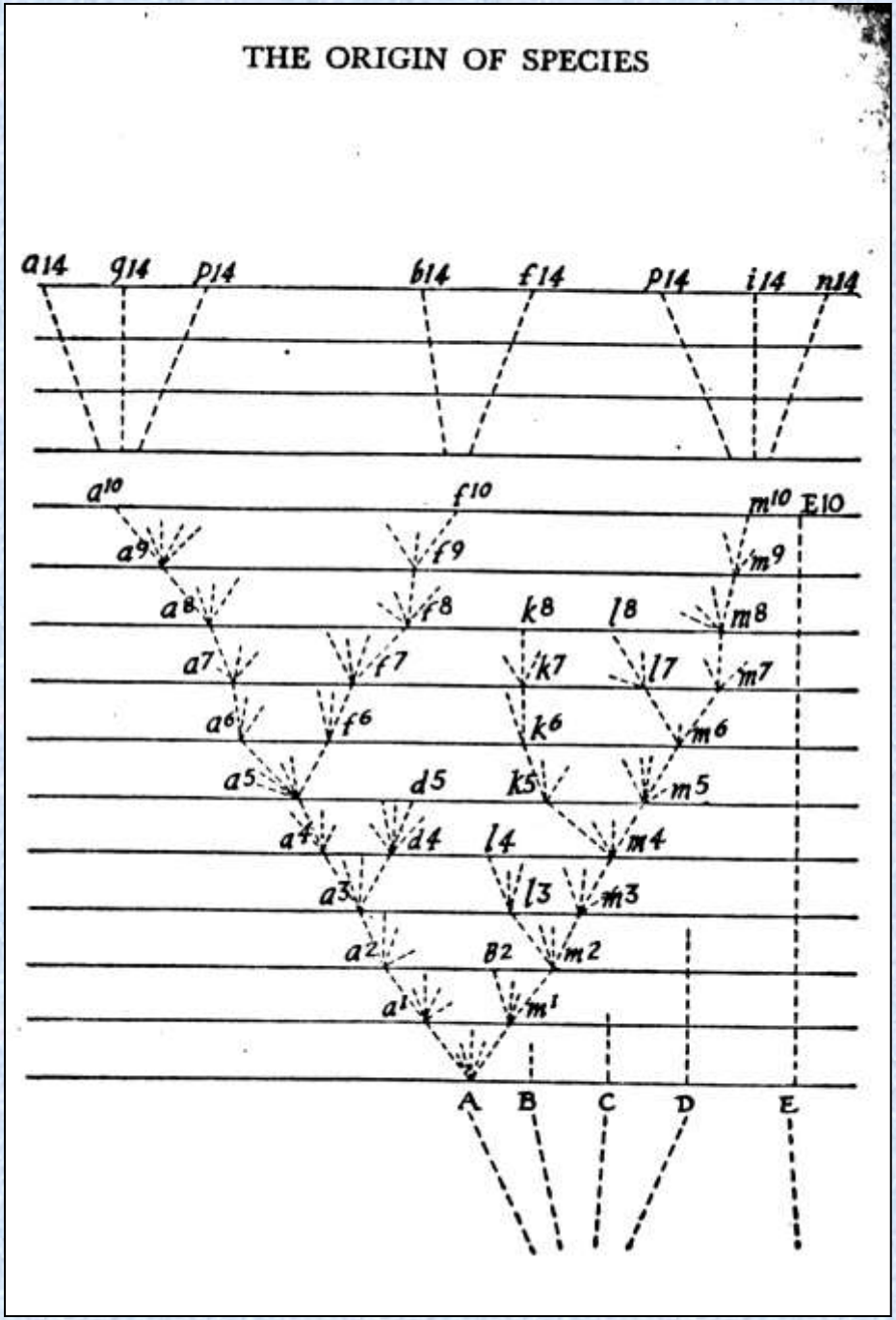
Domain Eukarya

- Domain Eukarya eukaryotic, has nucleus
- includes three kingdoms the Plantae, Fungi and Animalia.
- There are also a number of unicellular eukaryotes that may form as many as five other kingdoms. These were formerly grouped in the Protista.

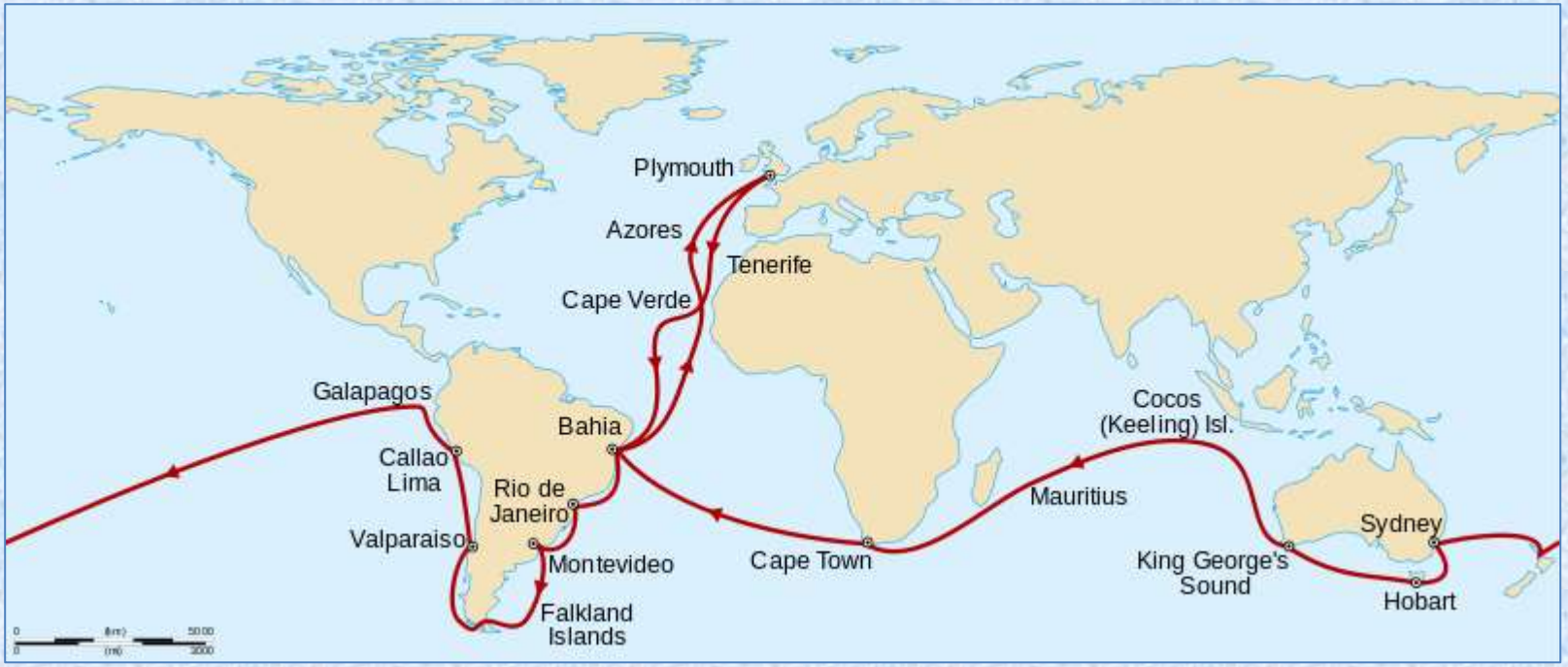


Charles Darwin 1859
Origin of Species by Natural Selection, or the Preservation of Favored Races in the Struggle for Life

Descent from Common Ancestor



As a young man, Darwin went on a 5-year voyage around the world….



What is the Mechanism of Evolution?

"Preservation of Favored Races in the Struggle for Life"
= Natural Selection

1. **Variation** - There is **variation** in function or behavior between individuals. Some traits are more **adaptive** than others. Traits are **heritable**.
2. **Overproduction** – More offspring are produced than can survive.
3. **Competition** – Individuals compete for limited resources. Struggle for existence.
4. **Survival** - Individuals that are more **adapted to the environment** live to reproduce or **reproduce more.**

Less adaptive traits become less common in populations.
The gene frequencies or proportions in the population change.

Classifying Biodiversity

- **Taxonomy** - the science of identifying classifying objects, including plants and animals.
- **Classification** - arrangement of objects and organisms into groups.
- **Systematics** - the scientific study of the diversity and relationship of organisms and how they are related in an evolutionary context.
- **Phylogeny -** is the branching evolutionary relationships among organisms.
- **Nomenclature** – system for naming objects

Tree of Life Showing the Three Domains