UNIT 8: EVOLUTION & CLASSIFICATION
TOPIC 3: CLASSIFICATION

TOPIC 3 LEARNING TARGETS

- Explain the development of the six kingdoms and three domain systems of classification of organisms.
- Contrast the characteristics of organisms found in each of the six kingdoms and three domains.
- Use a dichotomous key to identify an organism's classification and interpret a cladogram.

Why do scientists classify organisms?

ANIMAL CRACKERS CLASSIFICATION

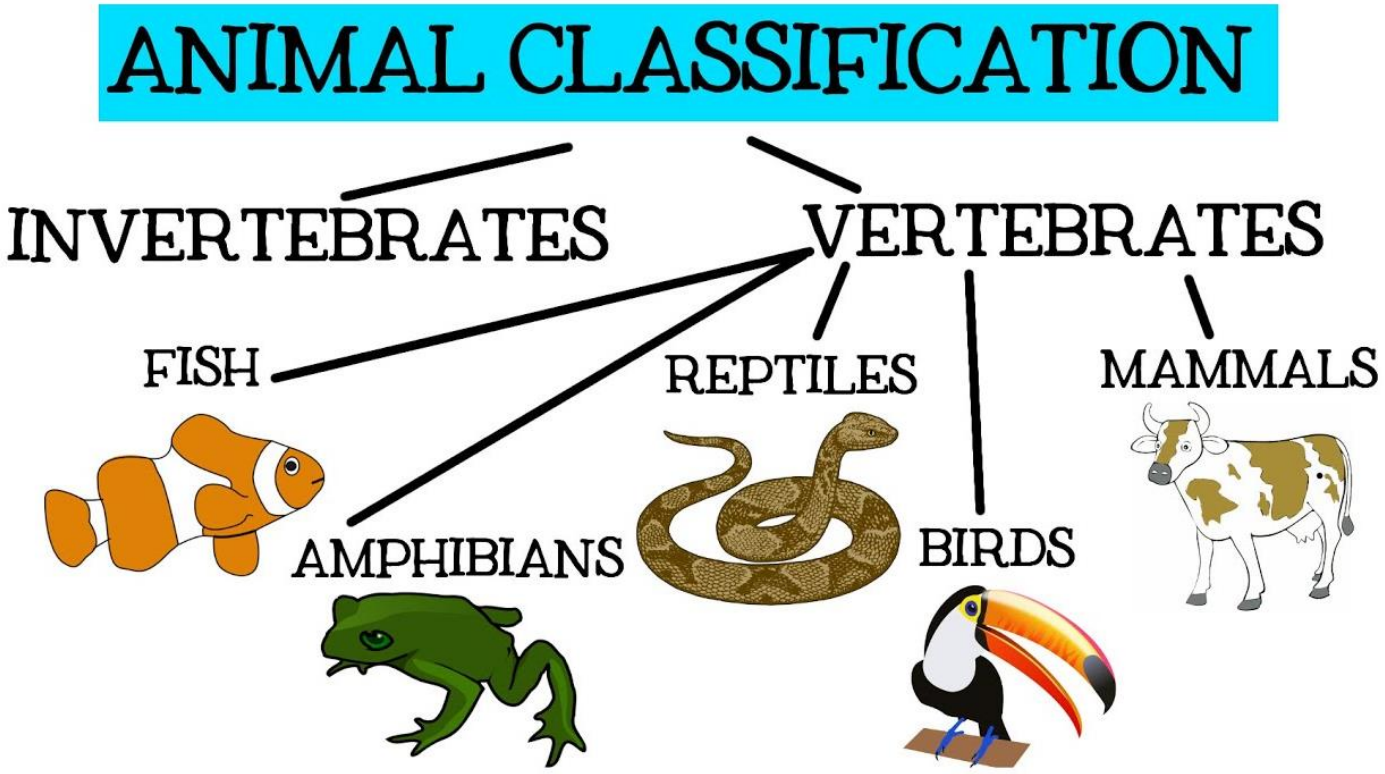
Working with a partner, sort the animal crackers within your bag into groups with similar characteristics.

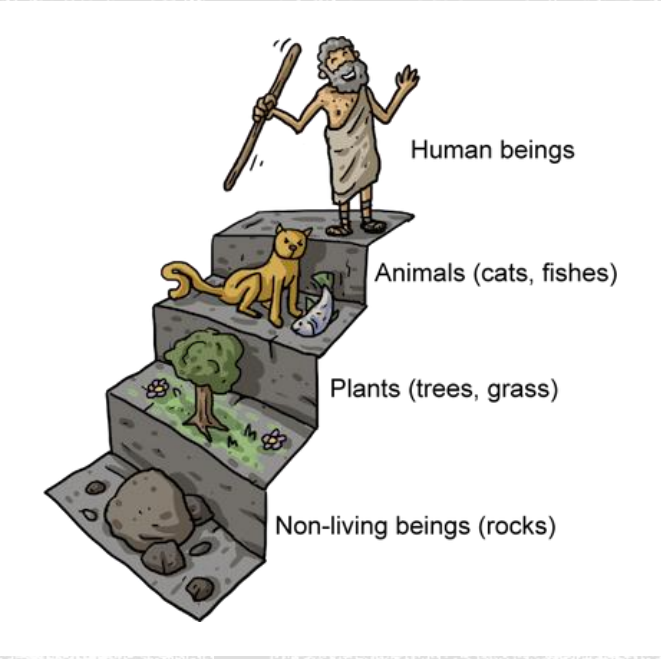
Use a blank sheet of paper and boxes or circles to organize the relationships between the similar characteristics.

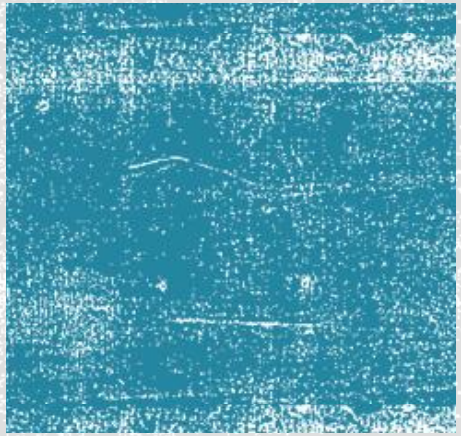
When completed, raise your hand to get your answer checked.

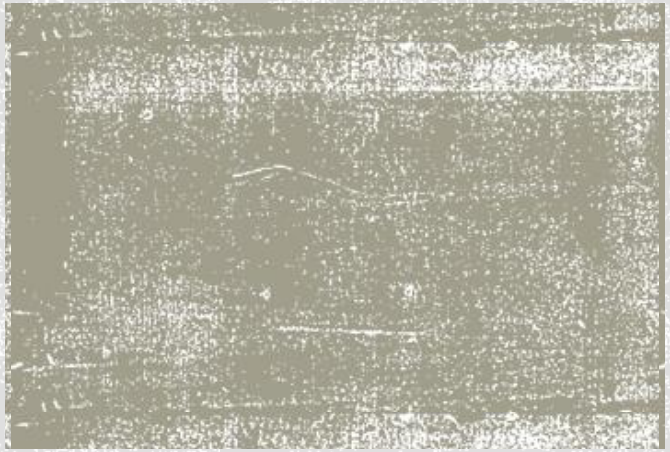
WHAT DOES CLASSIFICATION MEAN?

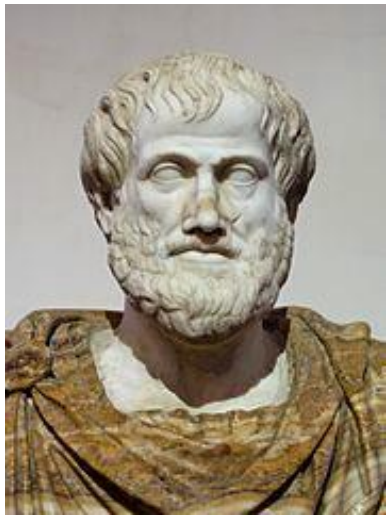
Grouping organisms based on their similarities









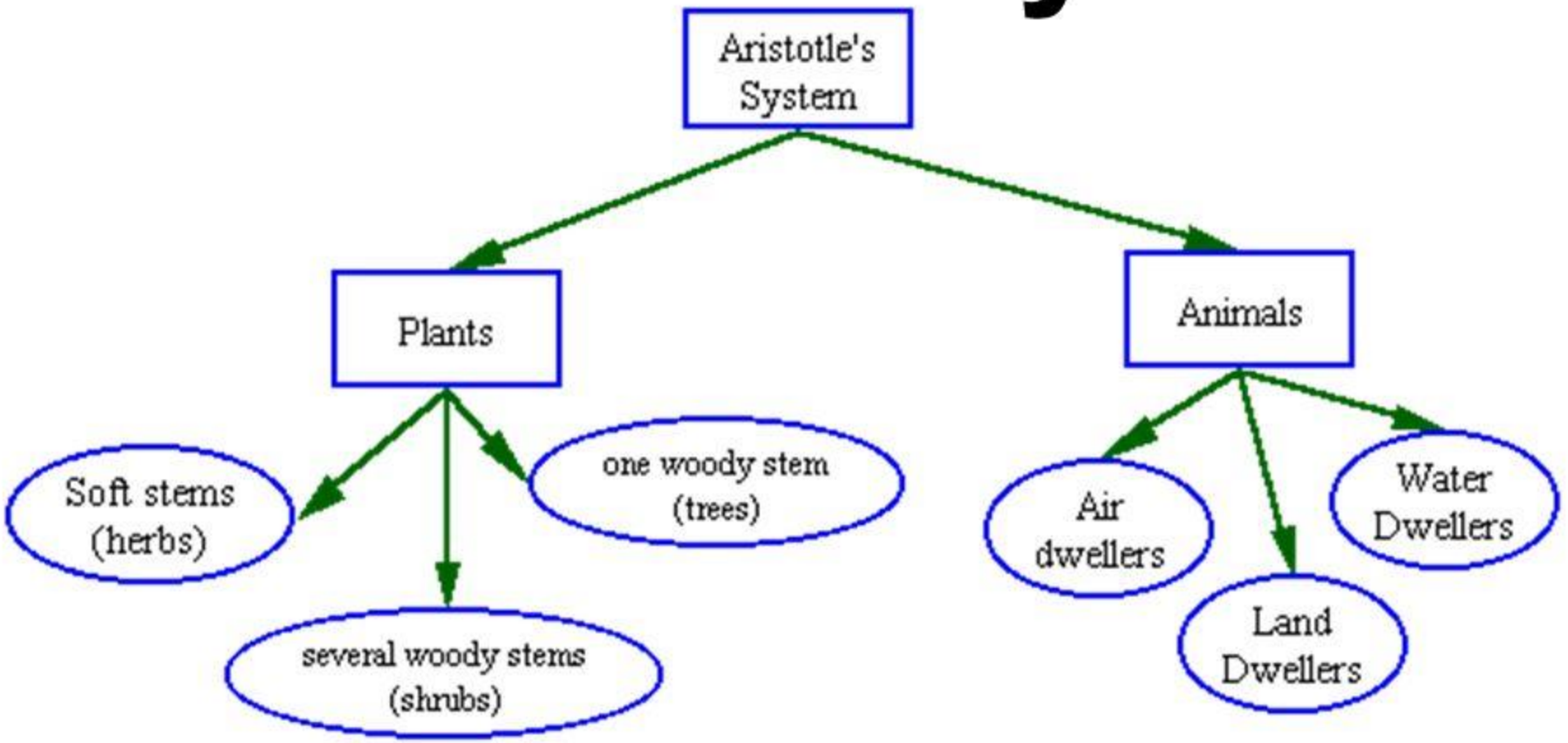


ARISTOTLE (2000 YEARS AGO)

- Aristotle developed the first known classification system – making him the first taxonomist
- Taxonomy is the science of classifying organisms
- He classified organism by:
  - Levels of complexity
  - Plant (stem characteristics) vs. animal (habitats characteristics: land, sea, or air)

By: Riedell

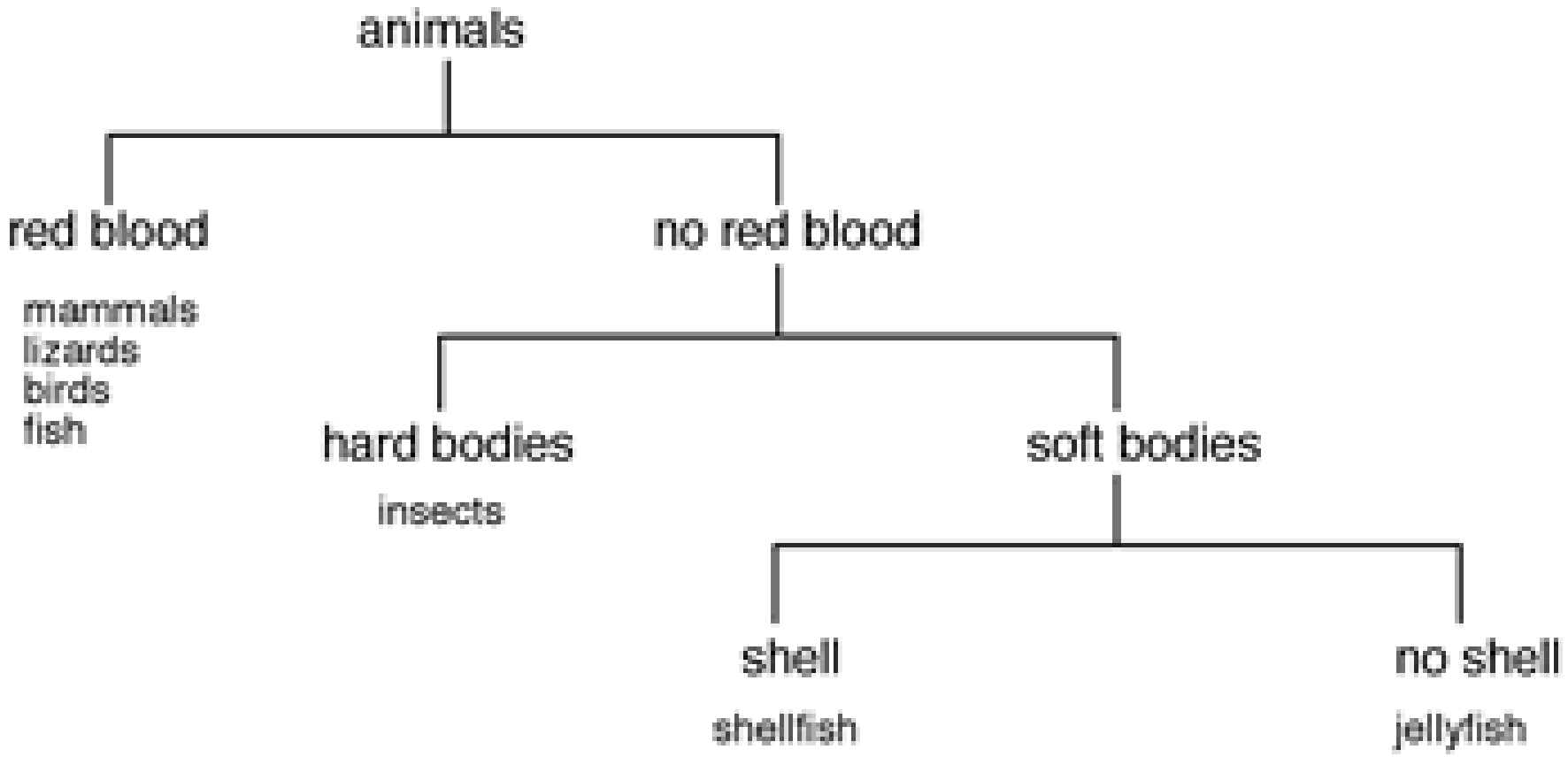
Aristotle's system

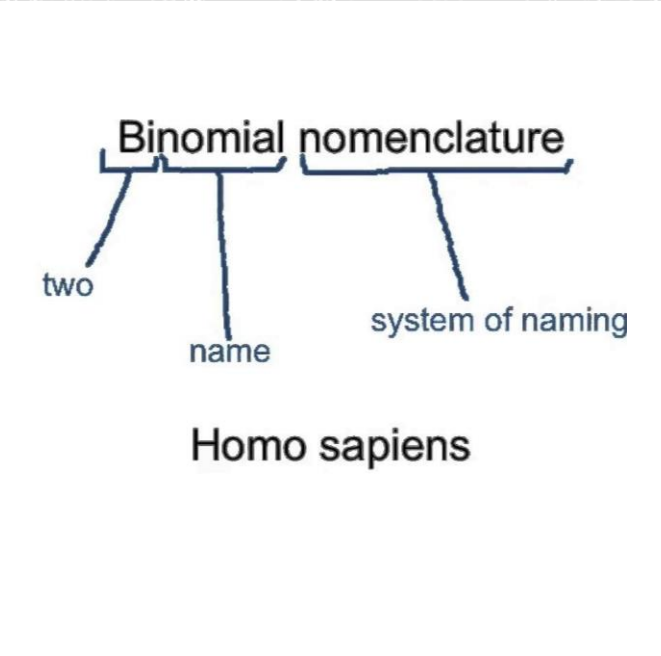


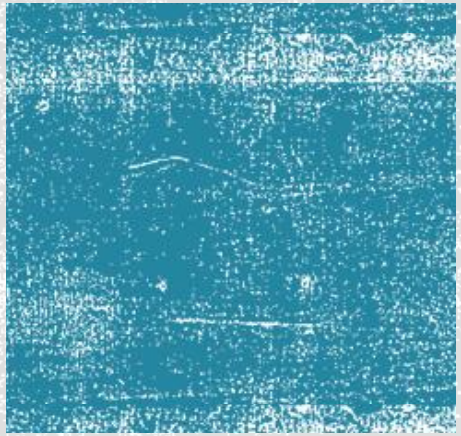
Based on size of stem

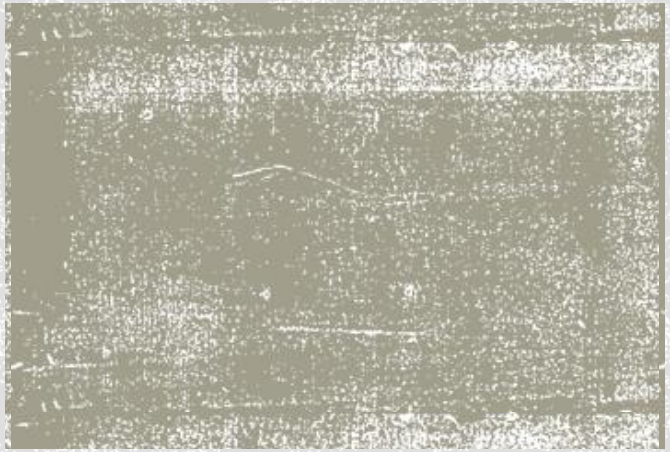
Based on where they lived

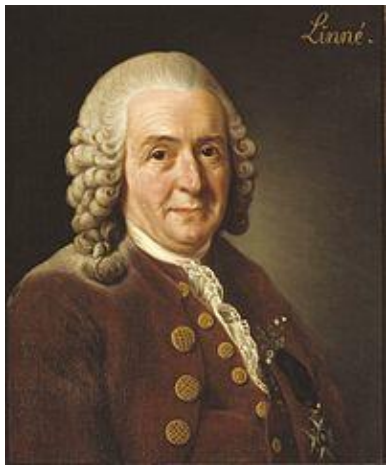
ARISTOTLE'S CLASSIFICATION OF ANIMALS











CAROLUS LINNAEUS (1707-1778)

The first scientist to use a more modern system of taxonomy (Father of Modern Taxonomy)

- In 1735, he published *Systema Naturae*, his classification of living things that organized species into taxa (groups) that formed a hierarchy or set of ordered ranks
- Linnaeus developed a two-word naming system called binomial nomenclature. In binomial nomenclature, each species is assigned a two-part scientific name.

BINOMIAL NOMENCLATURE

When writing the scientific name of an organism, both words must be underlined or *italicized*.

- The genus is **always capitalized**
- The species always begins with a **lower case letter**.

Examples

- *Homo sapiens* = human beings
- *Ursus arctos* = grizzly bear
- Felis domesticus = domestic cat
- Ursus americanus = black bear

BINOMIAL NOMENCLATURE

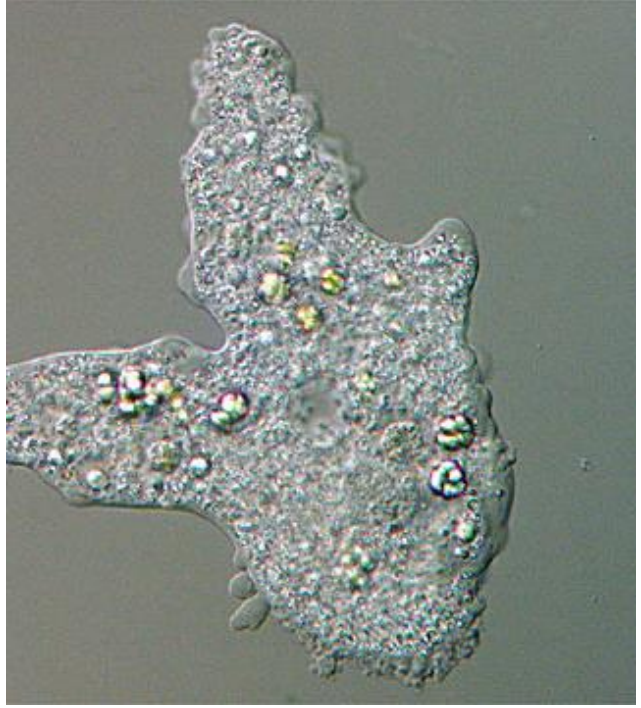
Scientific names are always written in Latin or ancient Greek so that they have the same name everywhere!

Genus is a group of similar species and can be abbreviated with one letter.

Examples

- *H. sapiens* = human beings
- *U. arctos* = grizzly bear
- F. domesticus = domestic cat
- U. americanus = black bear

How did we define a species in our evolution notes?



BINOMIAL NOMENCLATURE

Scientific names may describe the organism (Ex: *Chaos chaos)*

They may also honor a person or suggest the habitat of the organism ((*Linnaea borealis*)

Accurately and uniformly name organisms while preventing misnomers such as starfish and jellyfish that aren't really fish


UNE MOUFFETTE
EIN STINKTIER
SKUNK
UN ZORRILLO
CHECHE


Mephitis mephitis!
Mephitis
mephitis

Which of two are more closely related?

Giant Panda
Ailuropoda melanoleuca

Polar Bear
Ursus maritimus

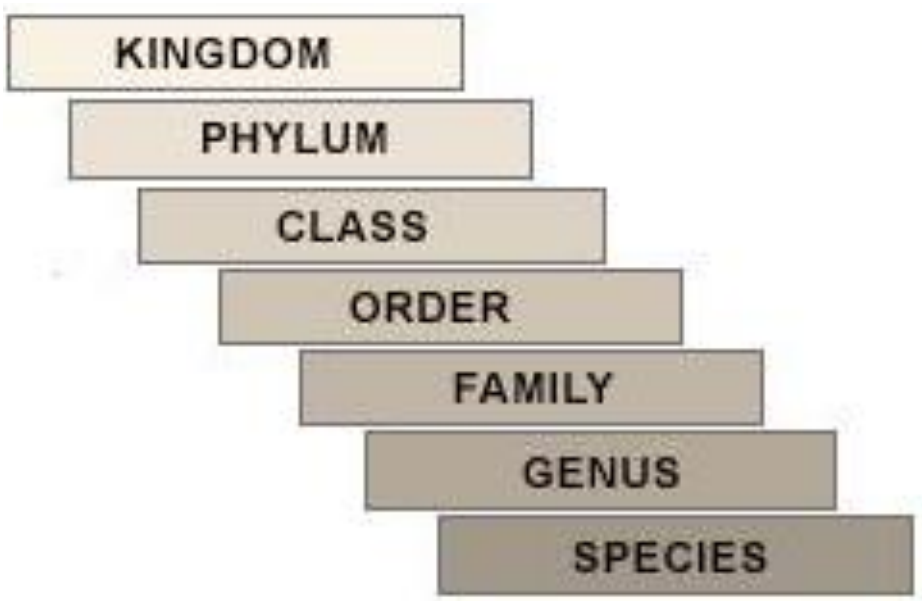
Grizzly Bear
Ursus arctos

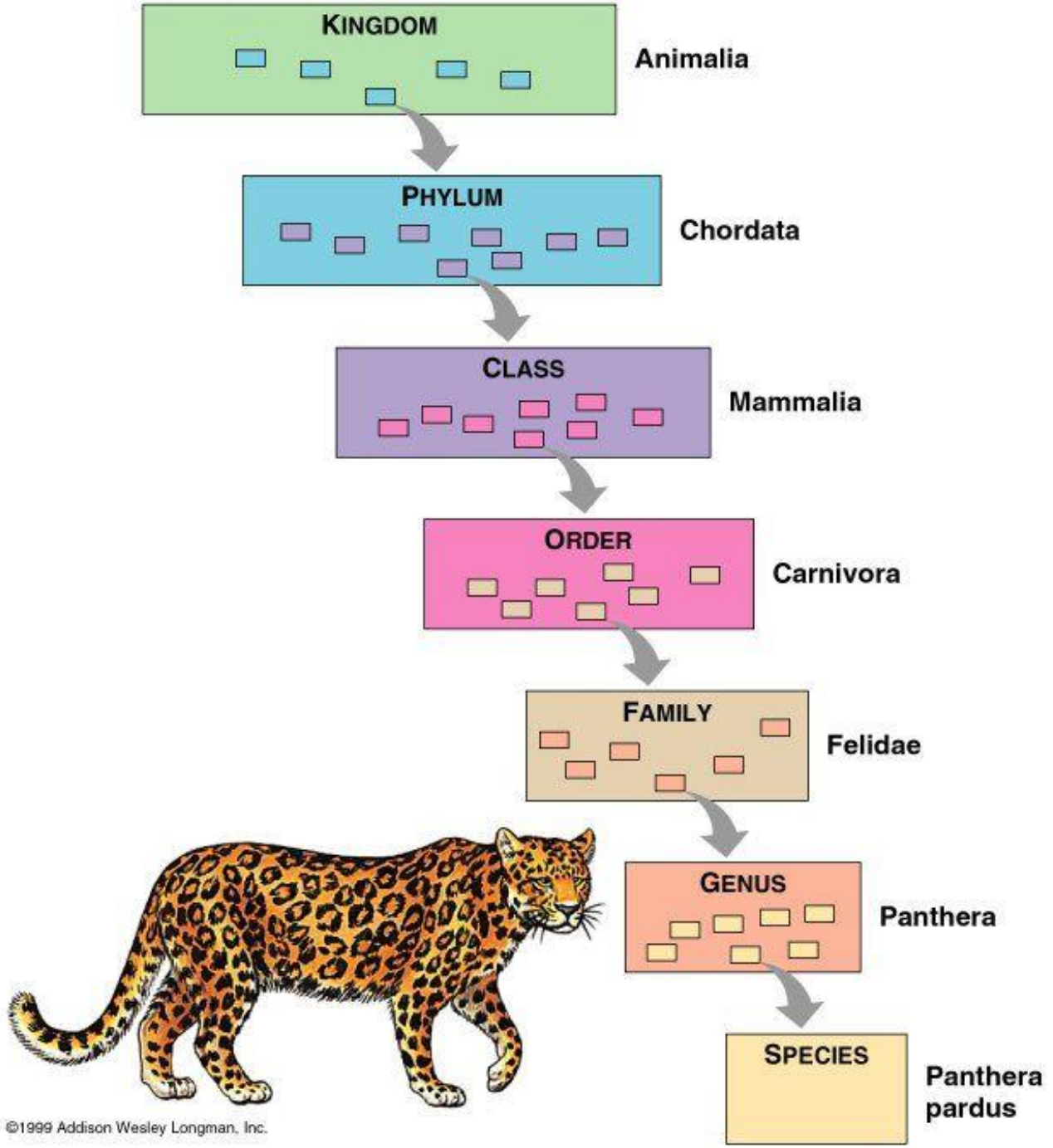
THE LINNAEAN CLASSIFICATION SYSTEM

His original system had <u>four levels</u> (kingdom, order, genus, species)

- Grouping species according to anatomical (structural) similarities and differences
- Similar to Aristotle's classification system, he had two kingdoms: Animalia and Plantae

Over time, Linnaeus's original classification system expanded to include <u>seven hierarchical taxa</u>: kingdom, phylum, class, order, family, genus, species




KINGDOM
Animalia
PHYLUM
Chordata
CLASS
Mammalia
ORDER
Carnivora
FAMILY
Felidae
GENUS
Panthera
SPECIES
Panthera pardus
©1999 Addison Wesley Longman, Inc.

grizzly bear | black bear | giant panda | red fox | squirrel | snake | sea star

Kingdom Animalia

Phylum Chordata

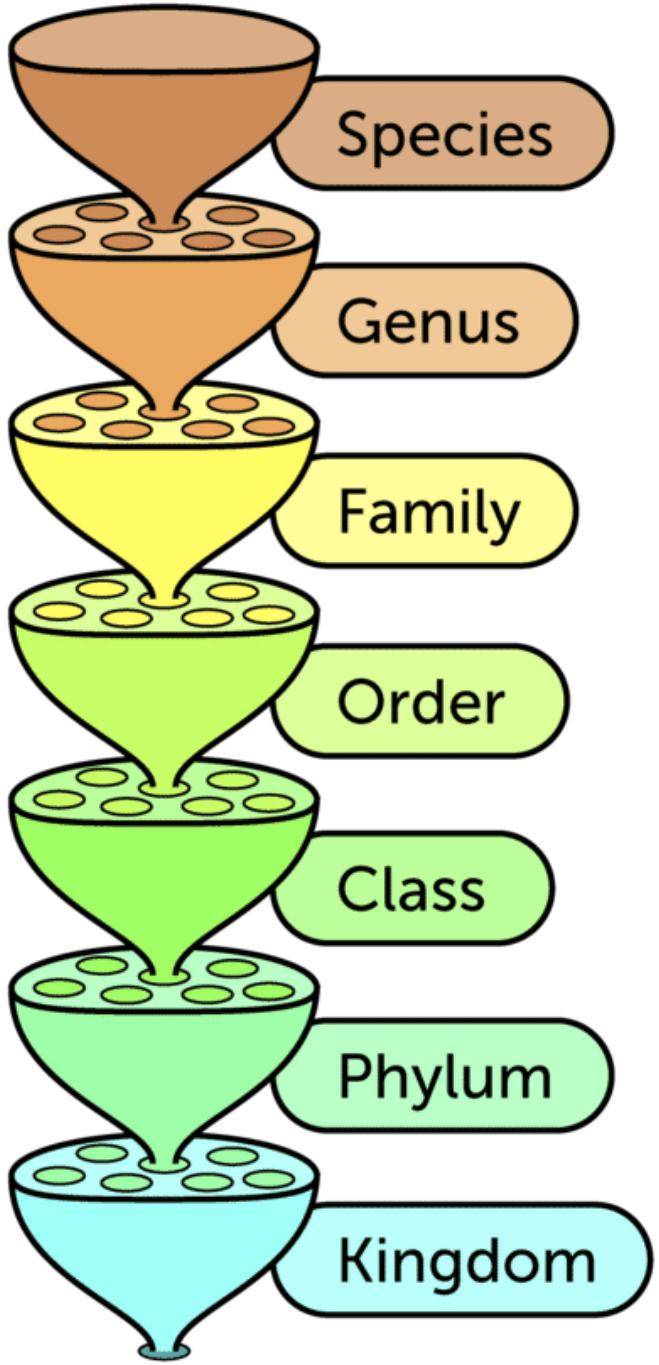
Class Mammals

Order Carnivora

Family Ursidae

Genus *Ursus*

Species *ursus arctos*



Homo sapiens

Members of the genus Homo with a high forehead and thin skull bones.

Homo

Hominids with upright posture and large brains.

Hominids

Primates with relatively flat faces and three-dimensional vision.

Primates

Mammals with collar bones and grasping fingers.

Mammals

Chordates with fur or hair and milk glands.

Chordates

Animals with a backbone.

Animals

Organisms able to move on their own.

MODERN CLASSIFICATION SYSTEM

Today, scientists continue to use the Linnaean system of binomial nomenclature

- **Each kingdom (plant and animal) was divided into a phylum* (division for plants)**
- **Each phylum into 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.**

Kingdom

Phylum

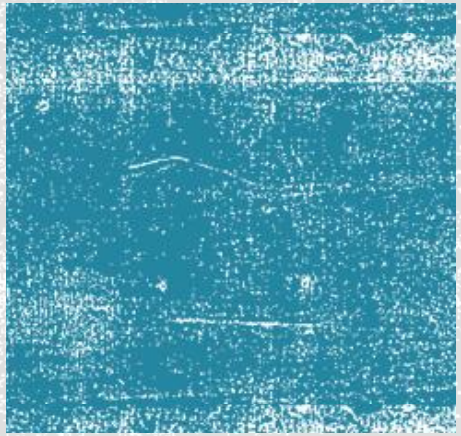
Class

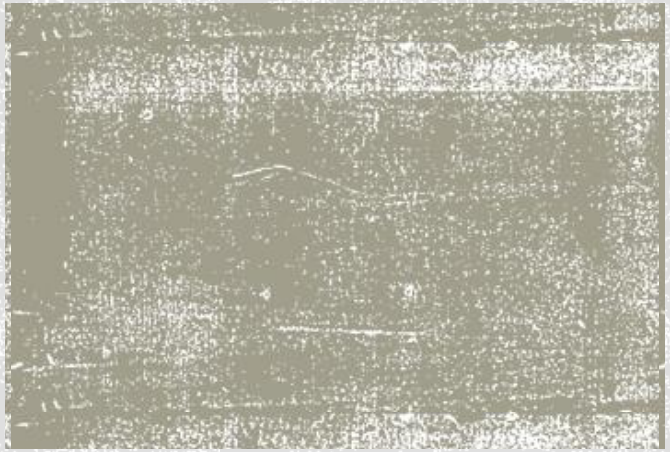
Order

Family

Genus

species





TAXONOMIC MNEMONICS

Kingdom

Phylum

Class

Order

Family

Genus

Species

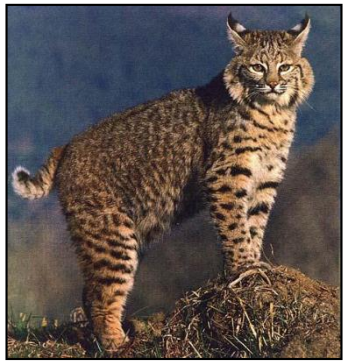
King **P**hilip **C**an **O**rder **F**ive **G**ood **S**oups

Katy **P**erry **C**ame **O**ver **F**or **G**rape **S**oda

Dirty **K**rabby **P**atties **C**rawl **O**n **F**rightened **G**randpa **S**quidward

At which taxonomic level do bobcats and humans begin to differ?

At which taxonomic level do lions and bobcats begin to differ?

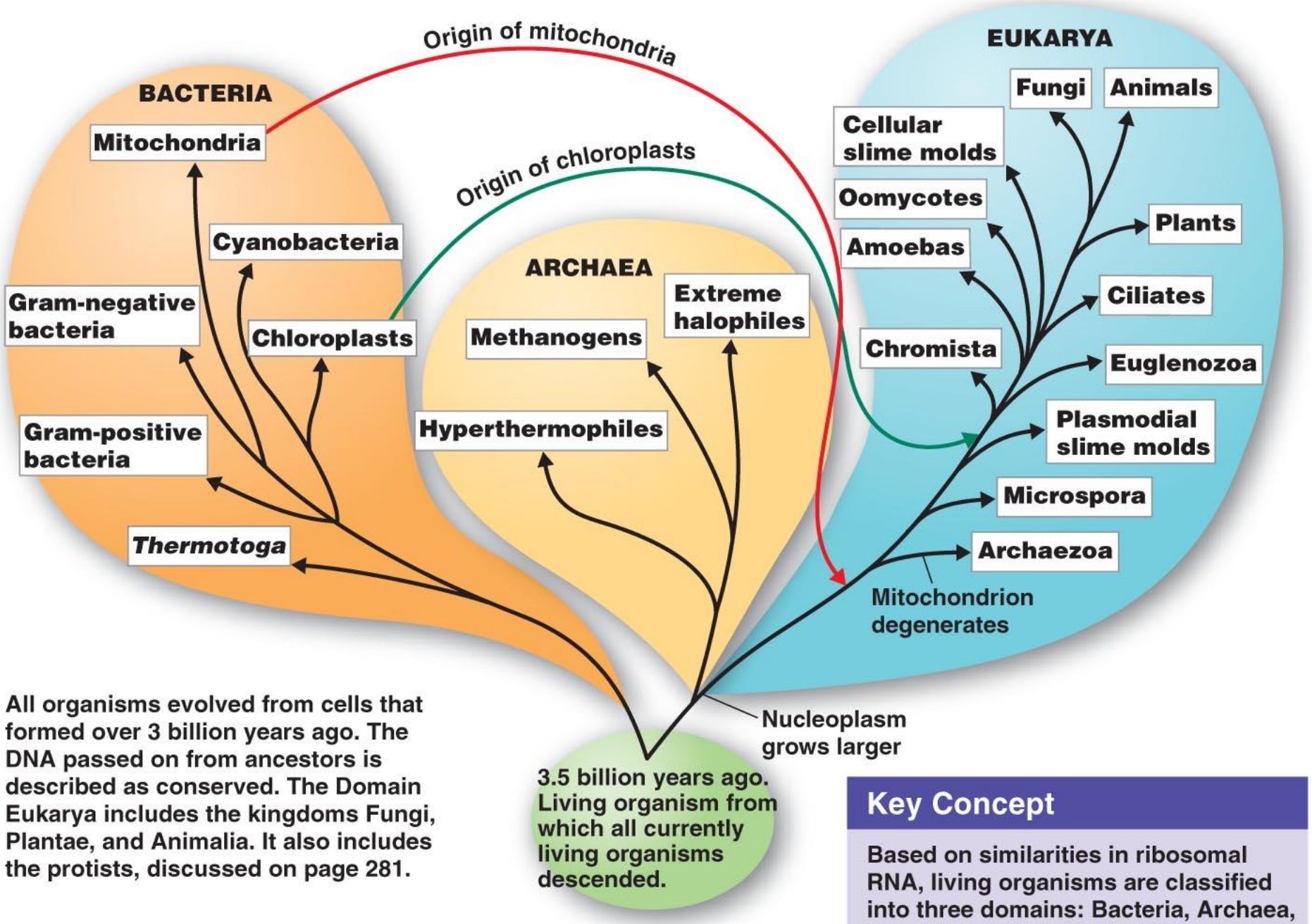


	Bobcat	Lion	Human
Kingdom	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata
Class	Mammalia	Mammalia	Mammalia
Order	Carnivora	Carnivora	Primata
Family	Felidae	Felidae	Hominidae
Genus	*Lynx*	*Panthera*	*Homo*
Species	*Lynx rufus*	*Panthera leo*	*Homo sapien*

MODERN CLASSIFICATION SYSTEM

The groups within each taxa are constantly changing as we discover new relationships between organisms

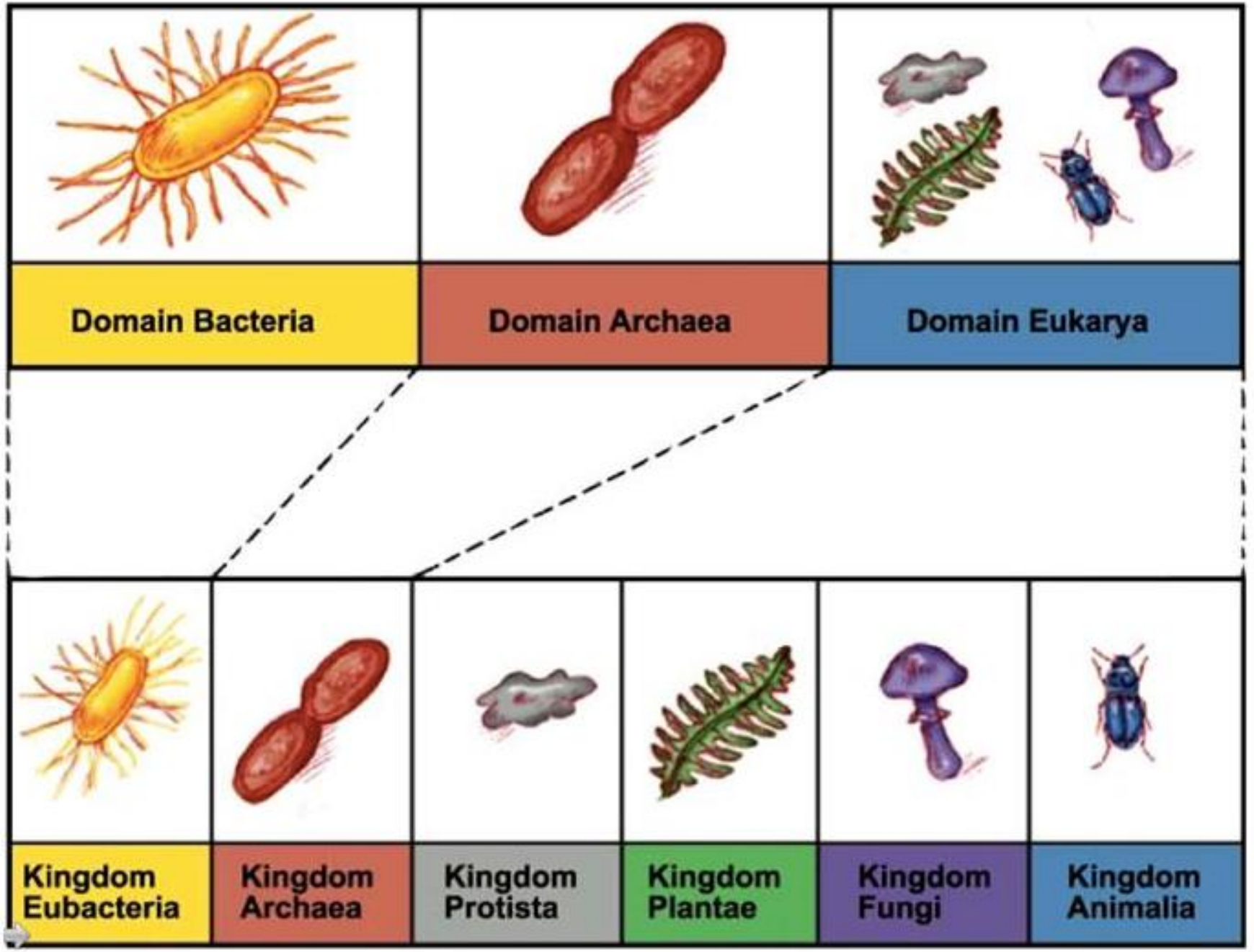
<table>
<tr><td>1735
Linnaeus</td><td>1866
Haeckel</td><td>1925
Chatton</td><td>1938
Copeland</td><td>1969
Whittaker</td><td>1990
Woese</td></tr>
<tr><td>2 Kingdoms</td><td>3 Kingdoms</td><td>2 Empires</td><td>4 Kingdoms</td><td>5 Kingdoms</td><td>3 Domains</td></tr>
<tr><td rowspan="3">Plant</td><td rowspan="2">Protist</td><td rowspan="2">Prokaryote</td><td rowspan="2">Monera</td><td rowspan="2">Monera</td><td>Eubacteria</td></tr>
<tr><td>Archaea</td></tr>
<tr><td rowspan="3">Eukaryote</td><td>Protist</td><td>Protist</td><td rowspan="3">Eukaryote</td></tr>
<tr><td rowspan="2">Plant</td><td rowspan="2">Plant</td><td>Fungi</td></tr>
<tr><td>Plant</td></tr>
<tr><td>Animal</td><td>Animal</td><td>Animal</td><td>Animal</td></tr>
</table>

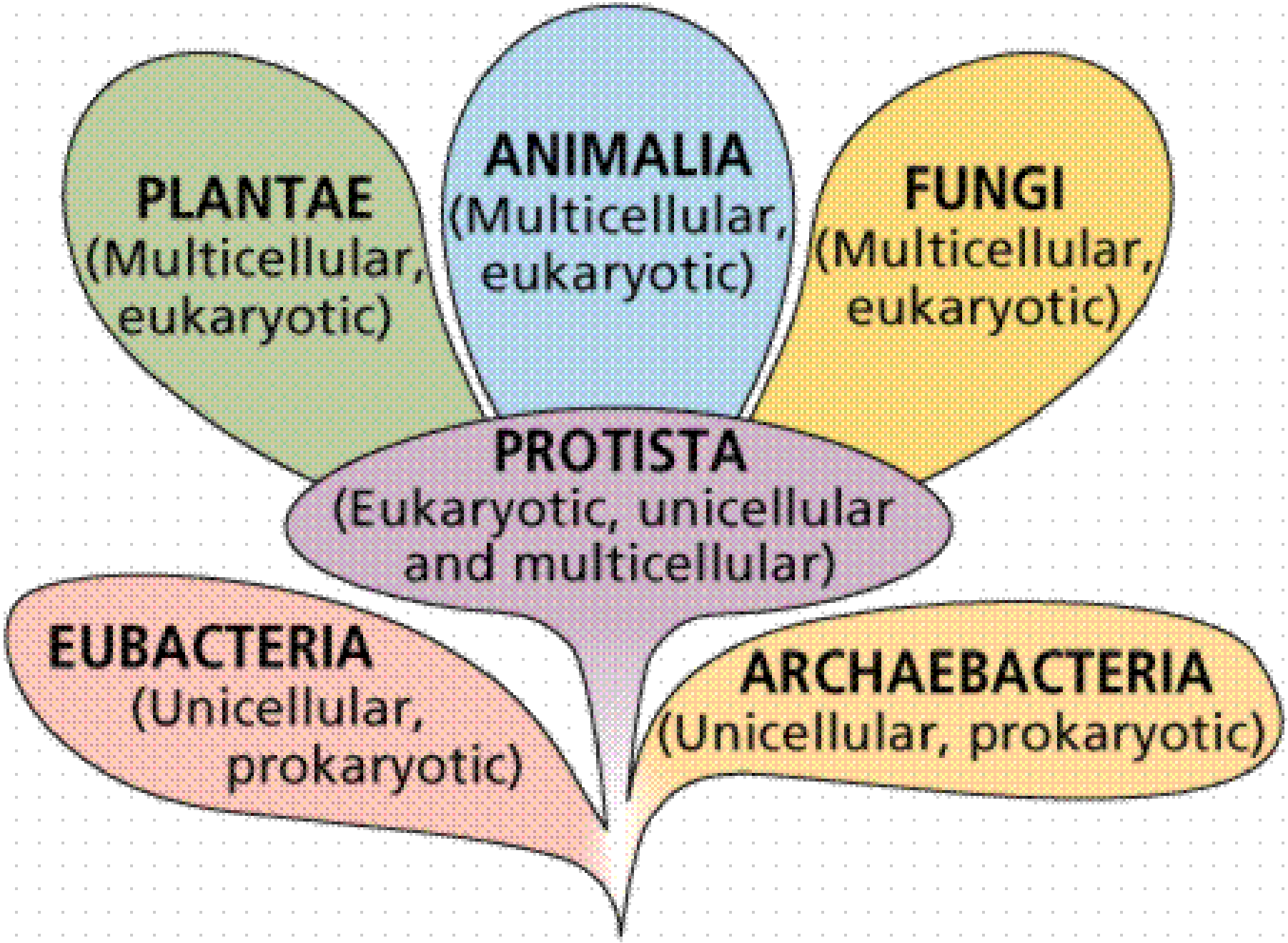


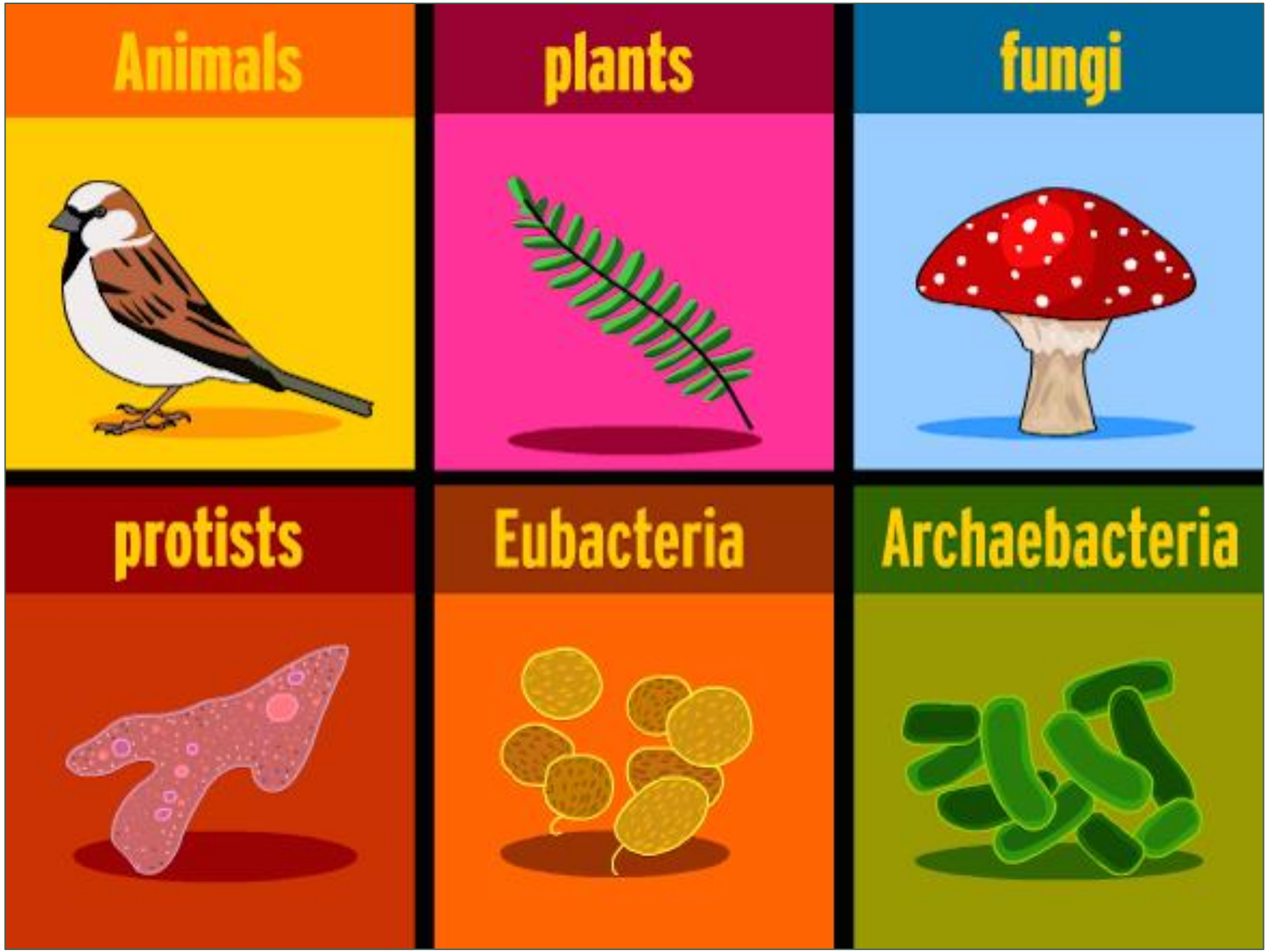
All organisms evolved from cells that formed over 3 billion years ago. The DNA passed on from ancestors is described as conserved. The Domain Eukarya includes the kingdoms Fungi, Plantae, and Animalia. It also includes the protists, discussed on page 281.

Key Concept

Based on similarities in ribosomal RNA, living organisms are classified into three domains: Bacteria, Archaea, and Eukarya.


Domain Bacteria
Domain Archaea
Domain Eukarya
Kingdom Eubacteria
Kingdom Archaea
Kingdom Protista
Kingdom Plantae
Kingdom Fungi
Kingdom Animalia


PLANTAE
(Multicellular, eukaryotic)
ANIMALIA
(Multicellular, eukaryotic)
FUNGI
(Multicellular, eukaryotic)
PROTISTA
(Eukaryotic, unicellular and multicellular)
EUBACTERIA
(Unicellular, prokaryotic)
ARCHAEBACTERIA
(Unicellular, prokaryotic)


Animals
plants
fungi
protists
Eubacteria
Archaebacteria

Domain
Eukarya

Kingdom
Animalia

Phylum
Chordata

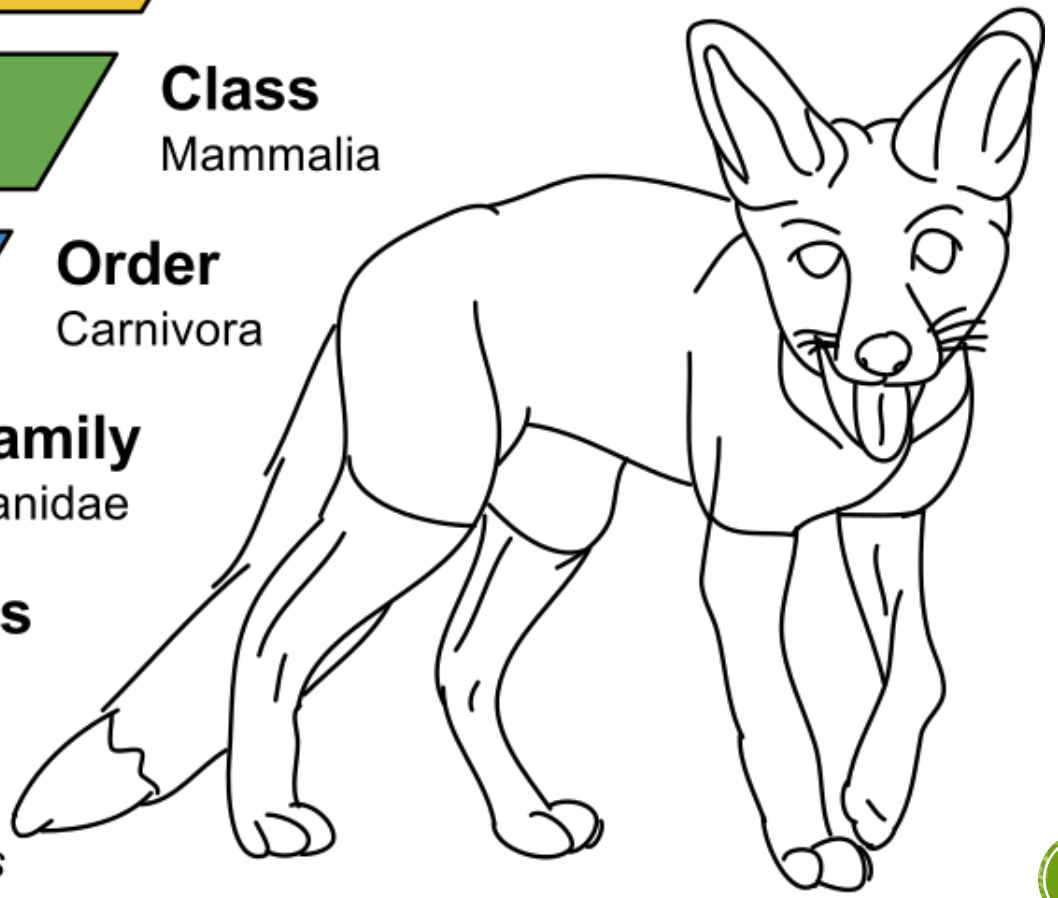
Class
Mammalia

Order
Carnivora

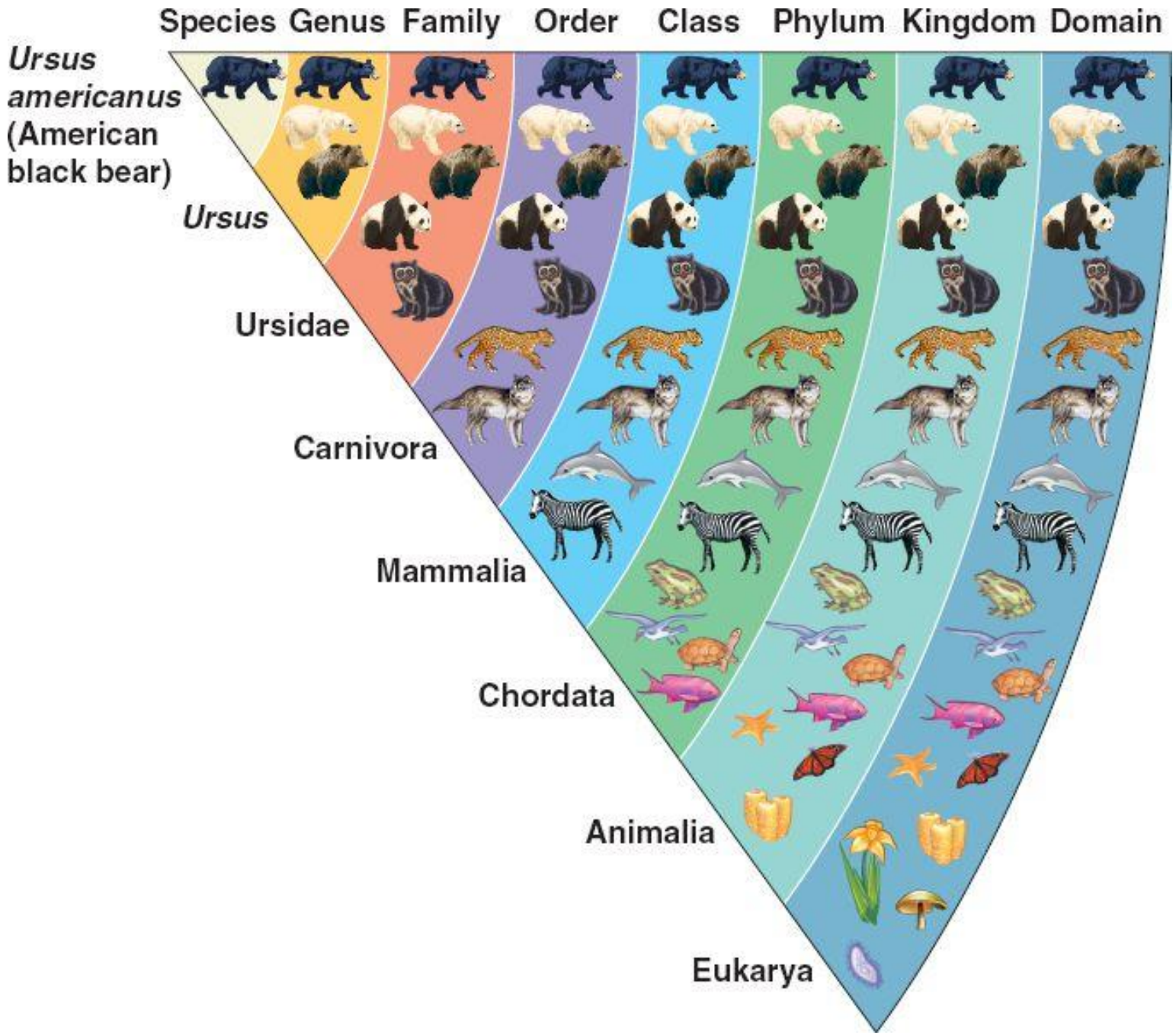
Family
Canidae

Genus
Vulpes

Species
Vulpes vulpes



Red fox (*Vulpes vulpes*)

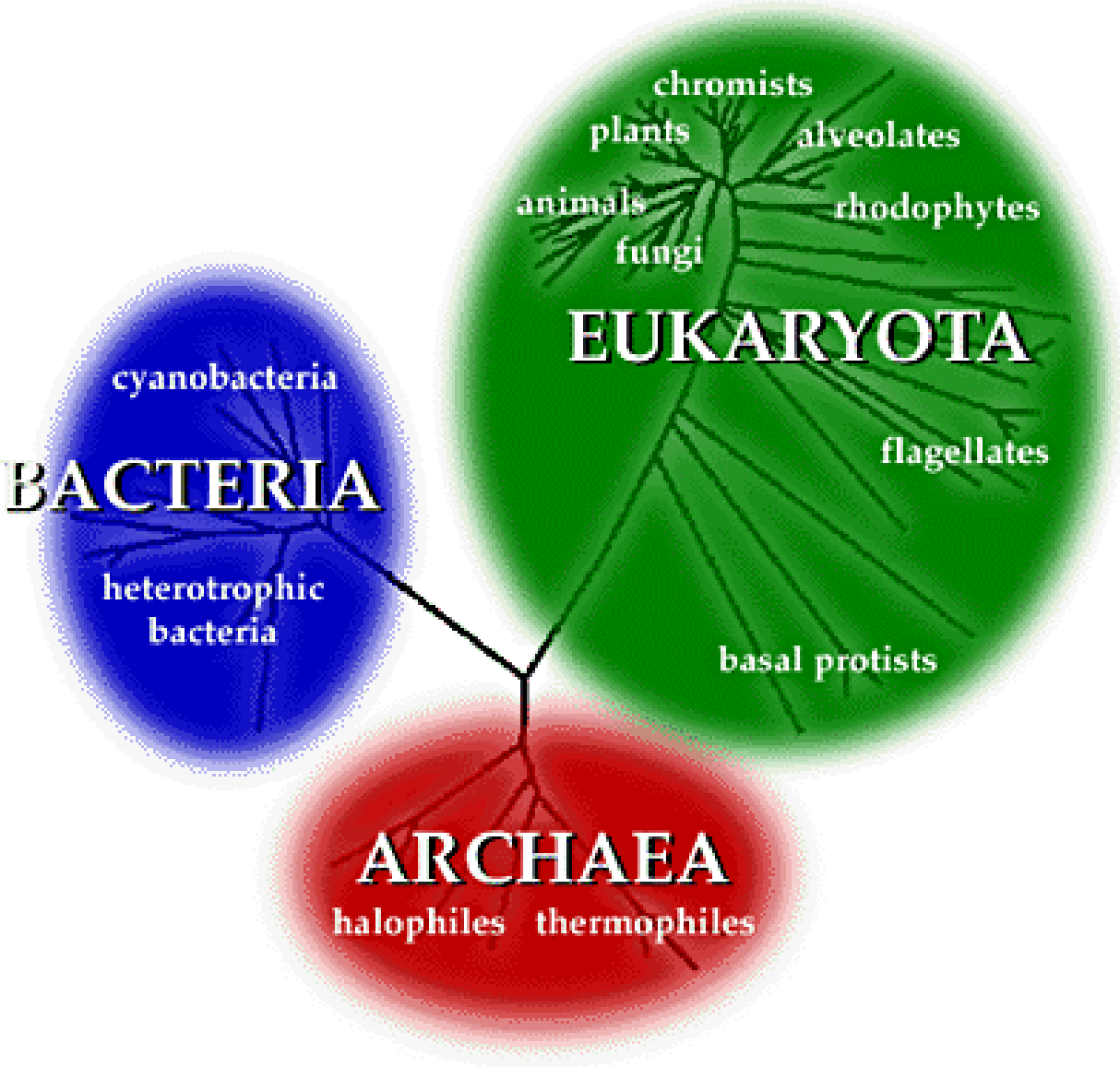

Species
Genus
Family
Order
Class
Phylum
Kingdom
Domain
Ursus americanus (American black bear)
Ursus
Ursidae
Carnivora
Mammalia
Chordata
Animalia
Eukarya

TOPIC 3 LEARNING TARGETS

- ✓Explain the development of the six kingdoms and three domain systems of classification of organisms.

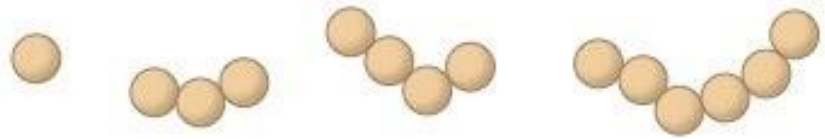
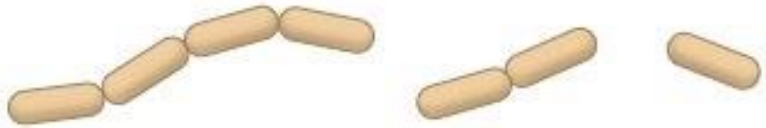
- Contrast the characteristics of organisms found in each of the six kingdoms and three domains.

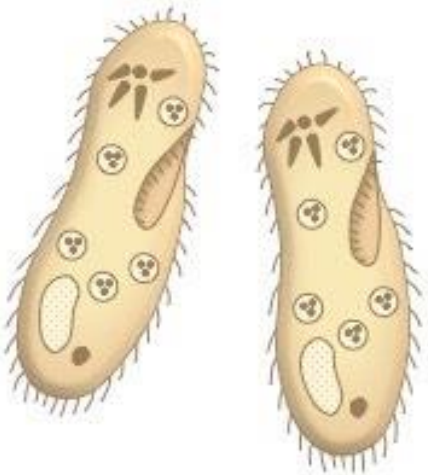
- Use a dichotomous key to identify an organism's classification and interpret a cladogram.



THE THREE DOMAINS

- Broadest, most inclusive taxon
- Three domains
  1. **Archaea**: unicellular prokaryotes (no nucleus or membrane-bound organelles)
  2. **Bacteria**: unicellular prokaryotes (no nucleus or membrane-bound organelles)
  3. **Eukarya (Eukaryota)**: More complex with nucleus and membrane-bound organelles

BACTERIA	ARCHAEA
	

EUKARYA			
Protista	Plantae	Fungi	Animalia
			

Characteristic	Archaea	Bacteria	Eukarya
Membrane lipids with branched hydrocarbons	✔		
Chromosomes are circular	✔	✔	
Lacks nuclear envelopes	✔	✔	
Lacks membrane bound organelles	✔	✔	
Methionine is the initiator amino acid for protein synthesis	✔		✔
Lack peptidoglycan in the cell wall	✔		✔
Growth not inhibited by streptomycin and chloramphenicol	✔		✔
Histones are associated with DNA	✔		✔
Contains several types of RNA polymerase	✔		✔

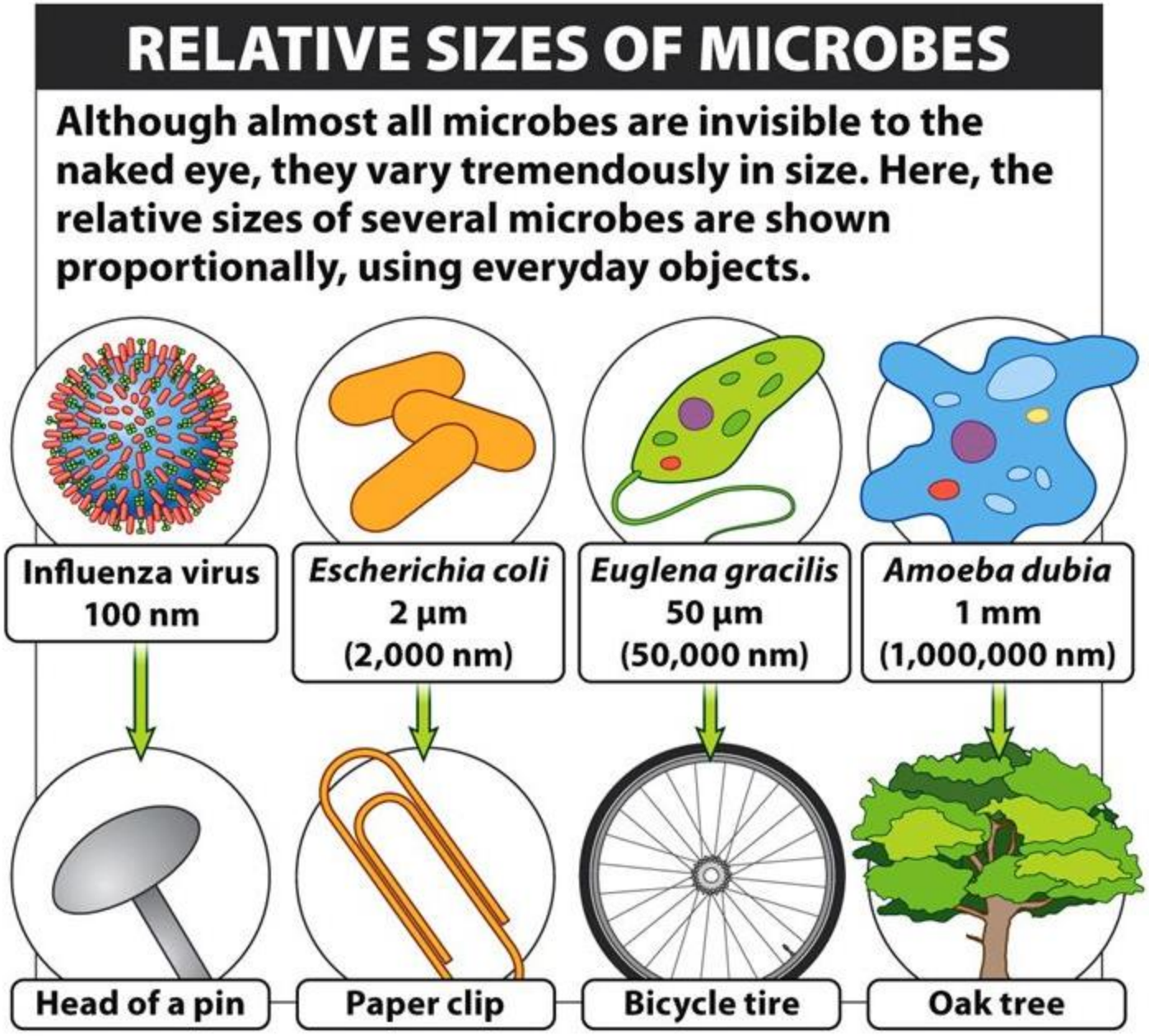


Figure 13-1
What Is Life? A Guide To Biology

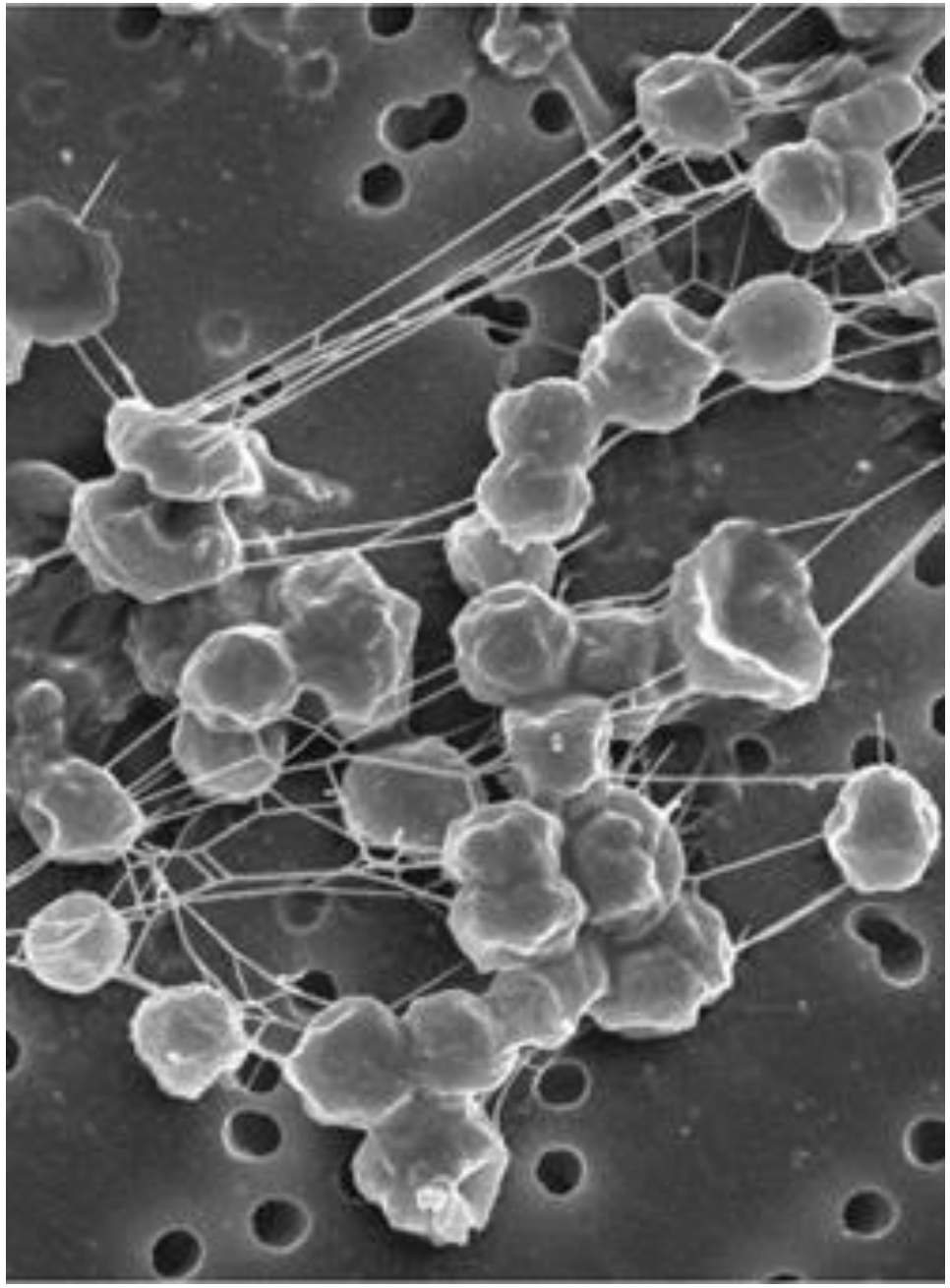
ARCHAEA AND BACTERIA

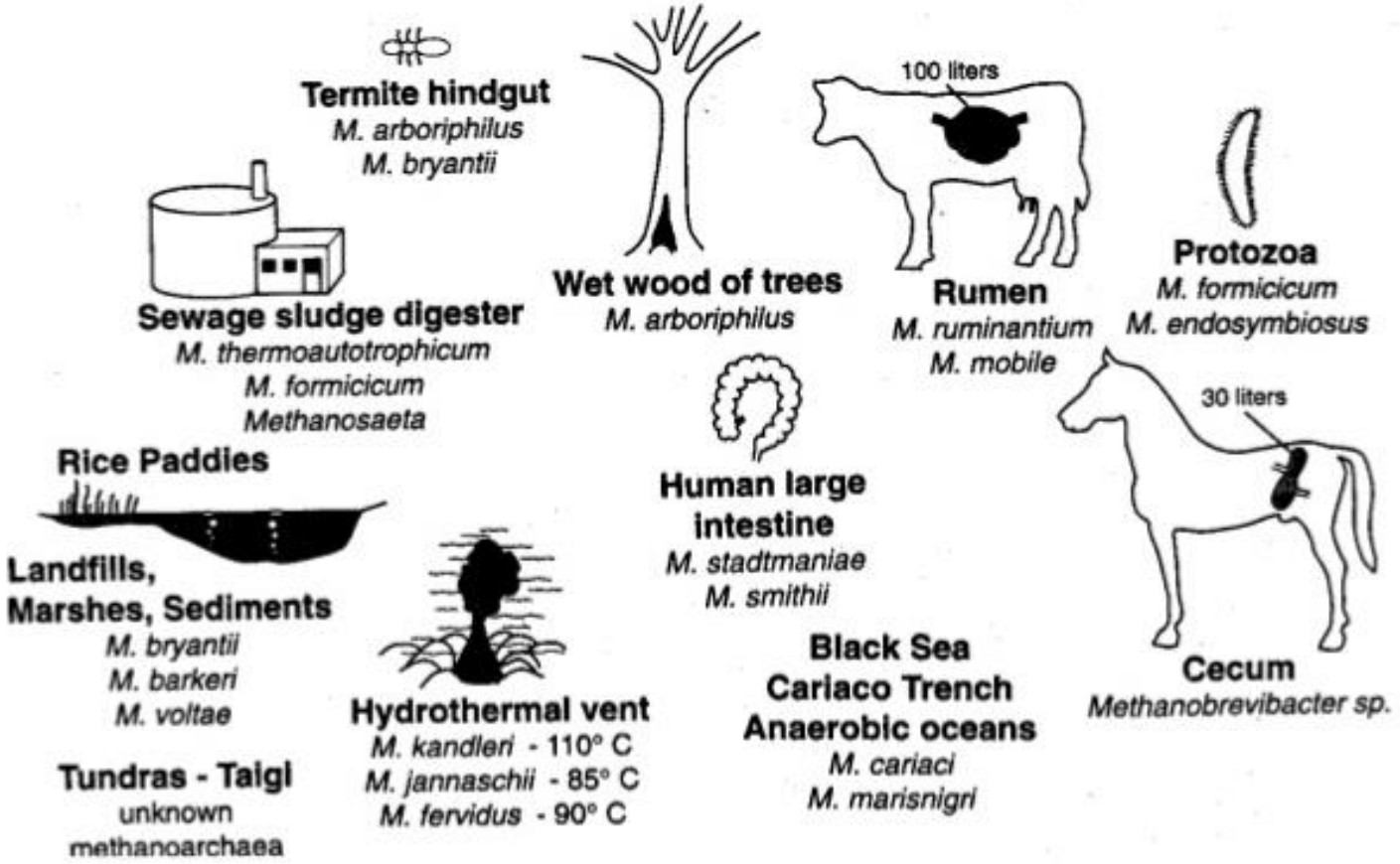
- Combined have the greatest number of organisms on Earth
- All of the prokaryotes are in these two kingdoms
- Both reproduce by binary fission, but they do have some ways to recombine genes, allowing evolution to occur

ARCHAEA

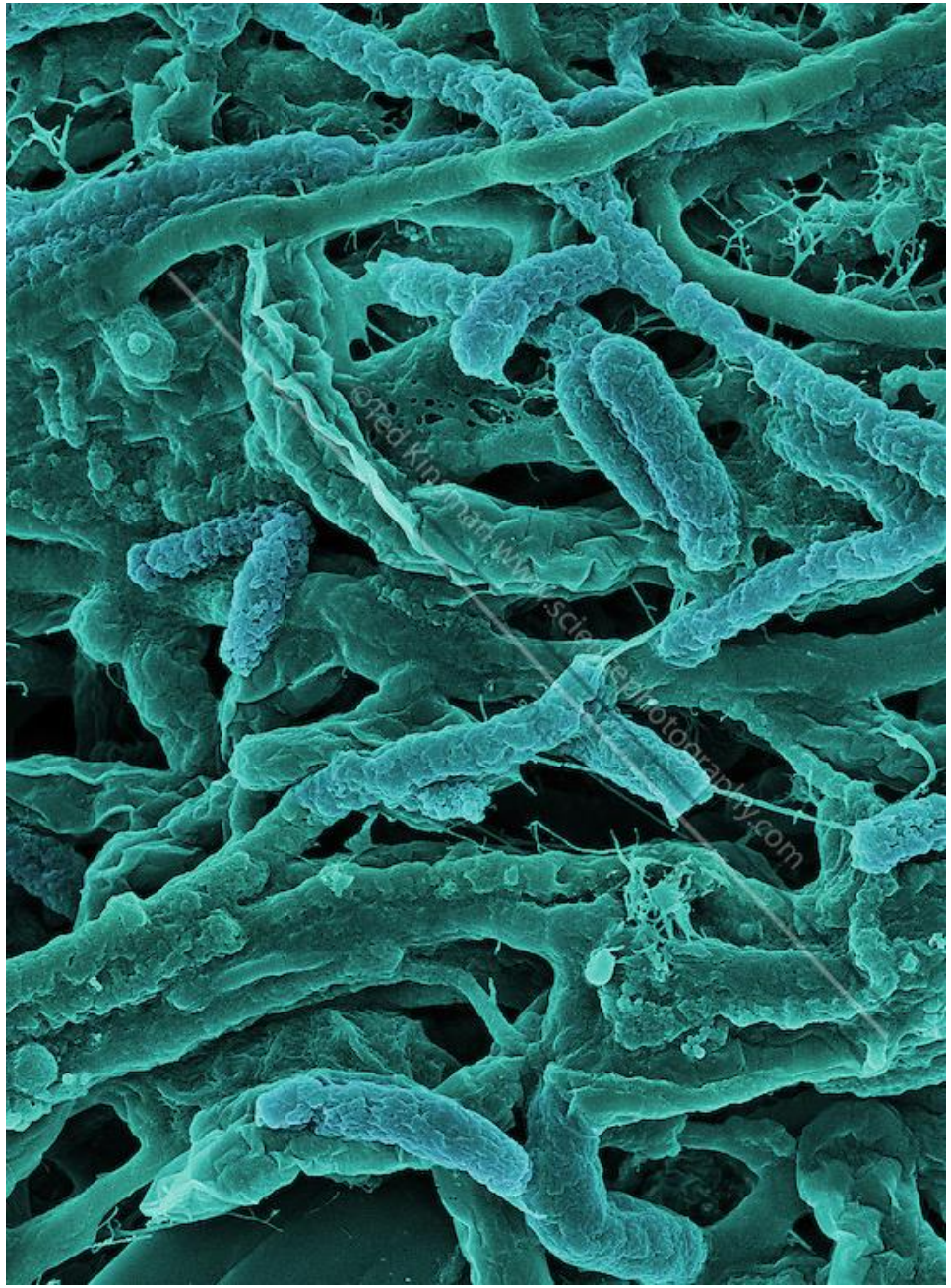
Kingdom: Archaebacteria

- Most likely to be first cells to evolve
- Often called "extremophiles" because they live in harsh environments
- Three major types:
  1. Methanogens: Methane producers; areas with low concentrations of oxygen (Sewage treatment plants, bogs, intestinal tract of ruminants)
  2. Thermophiles: Areas with high exposure to heat (Volcanic vents, geysers, hot springs)
  3. Halophiles: Areas with high concentrations of salt (Dead Sea, Great Salt Lakes)

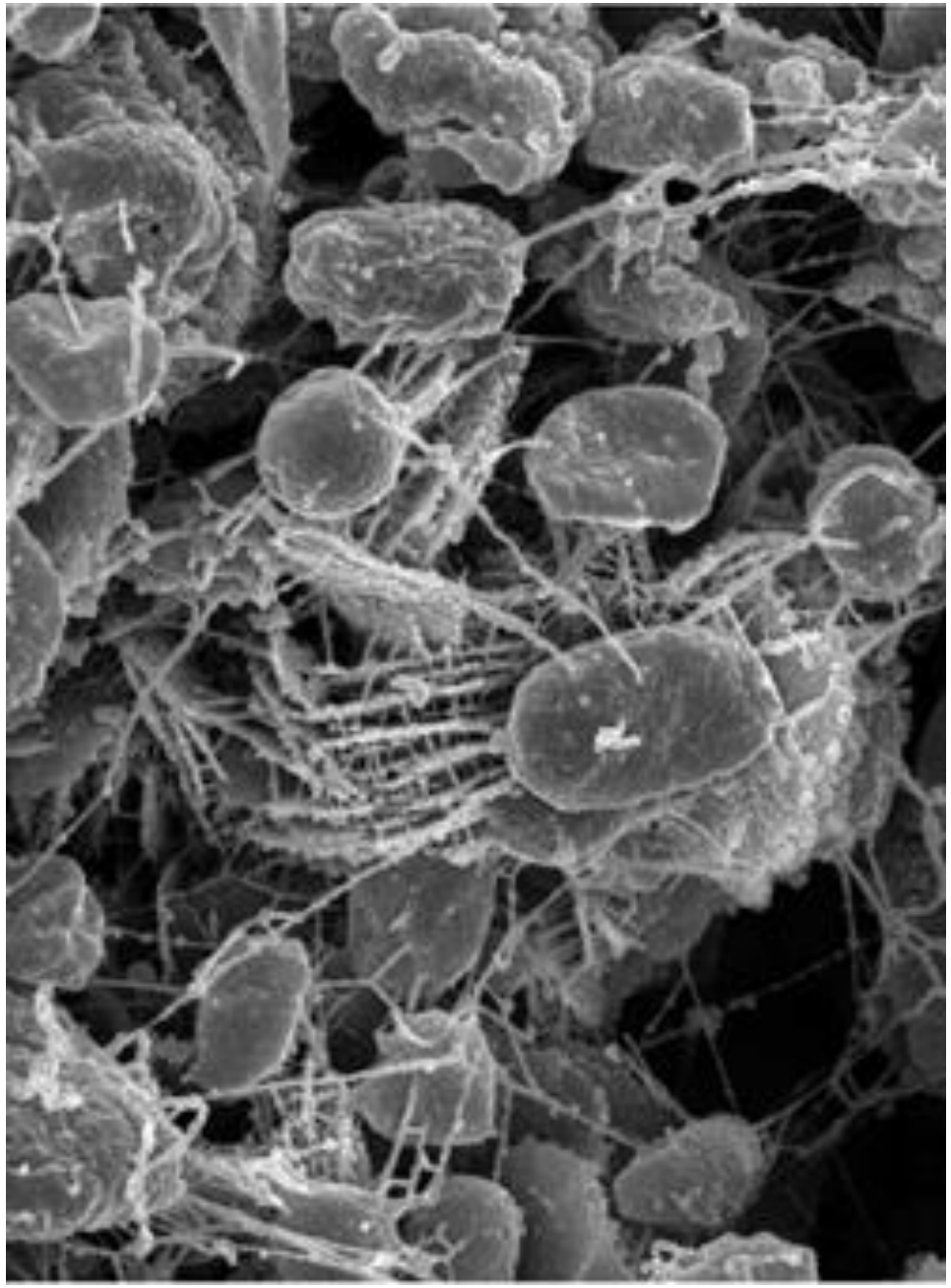




METHANOGENS



THERMOPHILES



HALOPHILES

BACTERIA

Kingdom: Eubacteria

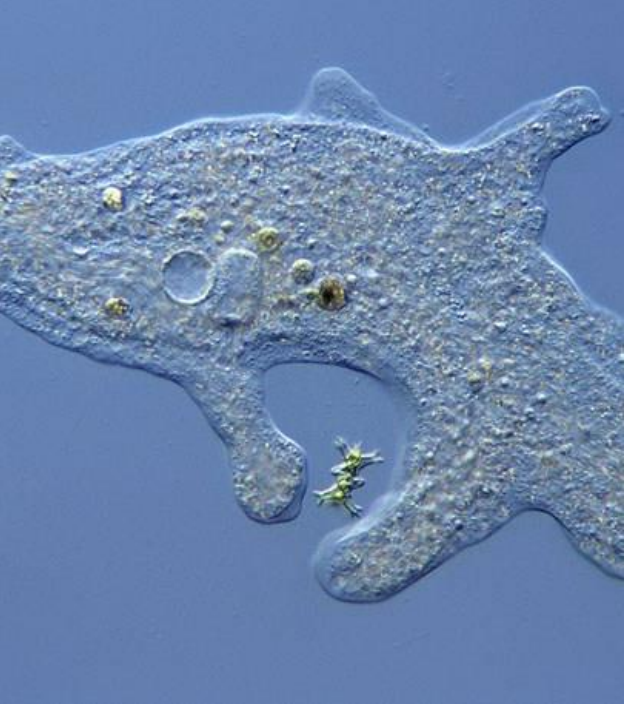
- Pathogenic (disease-causing) or probiotic
- Found in all habitats because they can be either auto- and heterotrophic
- Important decomposers for the environment
- Commercially important in making cottage cheese, yogurt, buttermilk, etc.

Escherichia coli, a bacterium

EUKARYA

Four Kingdoms

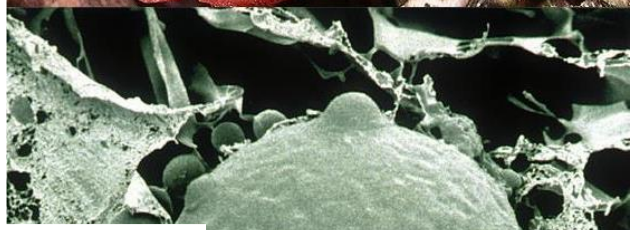
1. Protista (protozoans, algae…)
2. Fungi (mushrooms, yeasts…)
3. Plantae (multicellular plants)
4. Animalia (multicellular animals)

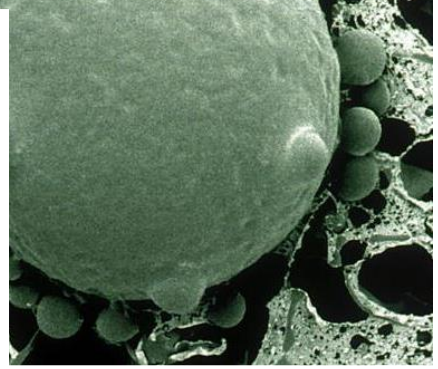


PROTISTA

- Most are unicellular or some are multicellular
- Autotrophic or heterotrophic

In what environment might these organisms be found?





FUNGI

- Multicellular, except yeast
- Absorptive heterotrophs (digest food outside their body and then absorb it)
  1. Obtain their nutrients by releasing digestive enzymes into a food source
  2. Absorb their food after it has been digested by the enzyme
- Cell walls <u>made of chitin</u>

PLANTAE

- Multicellular, autotrophic
- Use photosynthesis to make glucose
- Cell walls made of cellulose
- Two major groups

1. Nonvascular plants: Mosses
2. Vascular plants: ferns, gymnosperms (cone-bearing plants), and angiosperms (flowering plants)

Bryophyte

Sphagnum Moss

Filicinophyte

Tassle Fern

Coniferophyte

Pine Tree

Angiospermophyte

Sunflower

	Structures	Vascularisation	Reproduction	Other Features	Examples
Bryophyta	No 'true' leaves, roots or stems	None	Spores	Anchored by rhizoids	Mosses
Filicinophyta	Have leaves, roots and stems	Present	Spores	Leaves are pinnate	Ferns
Coniferophyta	Have leaves, roots and stems	Present	Seeds (in cones)	Woody stems	Conifers
Angiospermophyta	Have leaves, roots and stems	Present	Seeds (in fruits)	Have flowers & fruits	Flowers

ANIMALIA

- Multicellular, ingestive heterotrophs (consume food and digest it inside their bodies)
- Feed on plants or animals
- Most members of the Animal Kingdom can move from place to place.
- Some are permanently attached to surfaces such as sponges and barnacles.
- Major groups
  - Invertebrates: Sponges, jellyfish, worms, sea stars, and insects.
  - Vertebrates: Fish, Birds, Reptiles, Amphibians, and mammals-including humans

Porifera

Sea sponge

Cnidaria

Sea anemone

Platyhelmintha

Flatworm

Annelida

Earthworm

Mollusca

Octopus

Arthropoda

Spider

	Symmetry	Body Cavity	Segmentation	Other Features	Examples
Porifera	Asymmetrical	None (have pores)	None	Spicules for support	Sea sponge
Cnidaria	Radial	Mouth but no anus	None	Stinging cells (cnidocytes)	Jellyfish, coral, sea anemone
Platyhelmintha	Bilateral	Mouth but no anus	None	Flattened body (↑ SA:Vol ratio)	Tapeworm, planaria
Annelida	Bilateral	Mouth and anus	Segmented	Move via peristalsis	Earthworm, leech
Mollusca	Bilateral	Mouth and anus	Non-visible (mantle & foot)	May have a shell (made by mantle)	Snail, octopus, squid, bivalves
Arthropoda	Bilateral	Mouth and anus	Segmented	Exoskeleton (chitin)	Insects, spiders, crustaceans

Fish

Zebrafish

Amphibian

Frog

Reptile

Lizard

Bird

Sparrow

Mammal

Elephant

	Body covering	Reproduction	Breathing	Temperature	Other Features
Fish	Scales made out of bony plates	External	Gills	Ectothermic	Have a swim bladder
Amphibian	Moist skin	External	Simple lungs (and via skin)	Ectothermic	Larval state in water, adult state on land
Reptile	Scales made out of keratin	Internal (lays soft eggs)	Lungs with extensive folding	Ectothermic	Simple teeth with no living tissue
Bird	Feathers	Internal (lays hard eggs)	Lungs with bronchial tubes	Endothermic	Have wings and beaks with no teeth
Mammal	Hair	Internal – live births (except monotremes)	Lungs with alveoli	Endothermic	Feed young with milk from mammary gland

Kingdom	Organization	Type of Nutrition	Representative Organisms				
Protista	Complex single cell, some multicellular	Absorb, photo-synthesize, or ingest food	 paramecium	 euglenoid	 slime mold	 dino-flagellate	Protozoans, algae, water molds, and slime mold
Fungi	Some unicellular, most multicellular filamentous forms with specialized complex cells	Absorb food	 black bread mold	 yeast	 mushroom	 bracket fungus	Molds, yeast, and mushrooms
Plantae	Multi-cellular form with specialized complex cells	Photo-synthesize food	 moss	 fern	 pine tree	 nonwoody flowering plant	Mosses, ferns, nonwoody and woody flowering plants
Animalia	Multi-cellular form with specialized complex cells	Ingest food	 coral	 earthworm	 blue jay	 squirrel	Invertebr-ates, fishes, reptiles, amphibians, birds, and mammals

c. Domain Eukarya
Eukaryotes, structurally diverse and organized into the four kingdoms depicted here.

CREATE A GRAPHIC ORGANIZER

Create a graphic organizer that shows:

- The six different kingdoms
- Their organization levels
- Their types of nutrients
- Examples of organisms from each group

TOPIC 3 LEARNING TARGETS

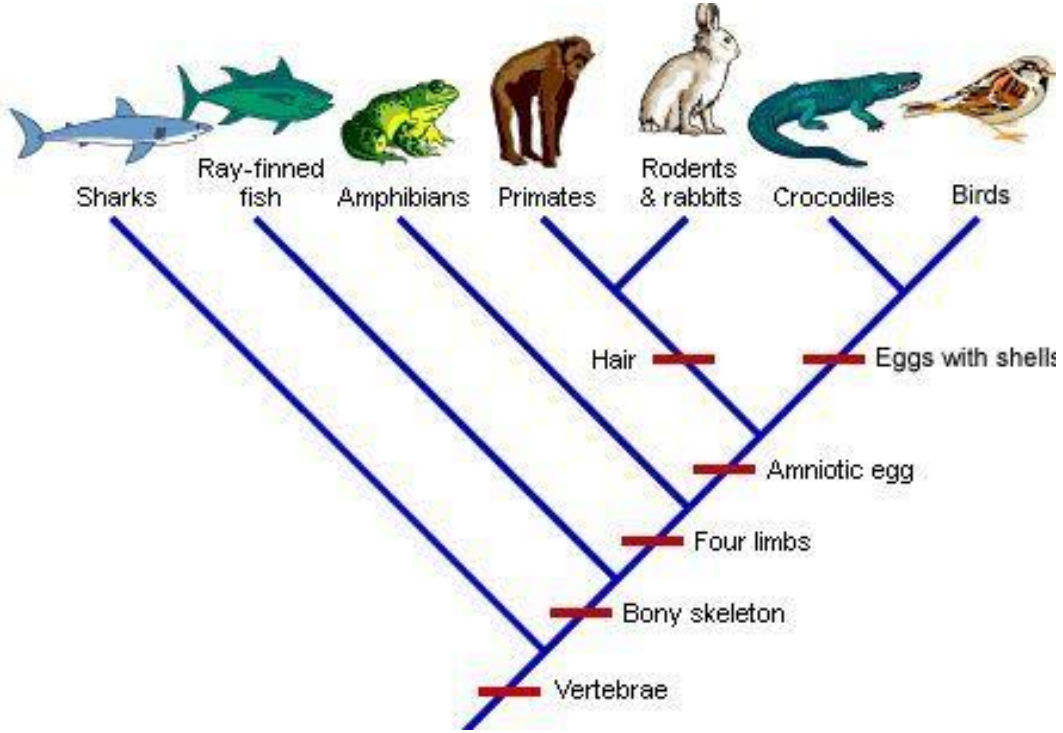
- ✓Explain the development of the six kingdoms and three domain systems of classification of organisms.

- ✓Contrast the characteristics of organisms found in each of the six kingdoms and three domains.

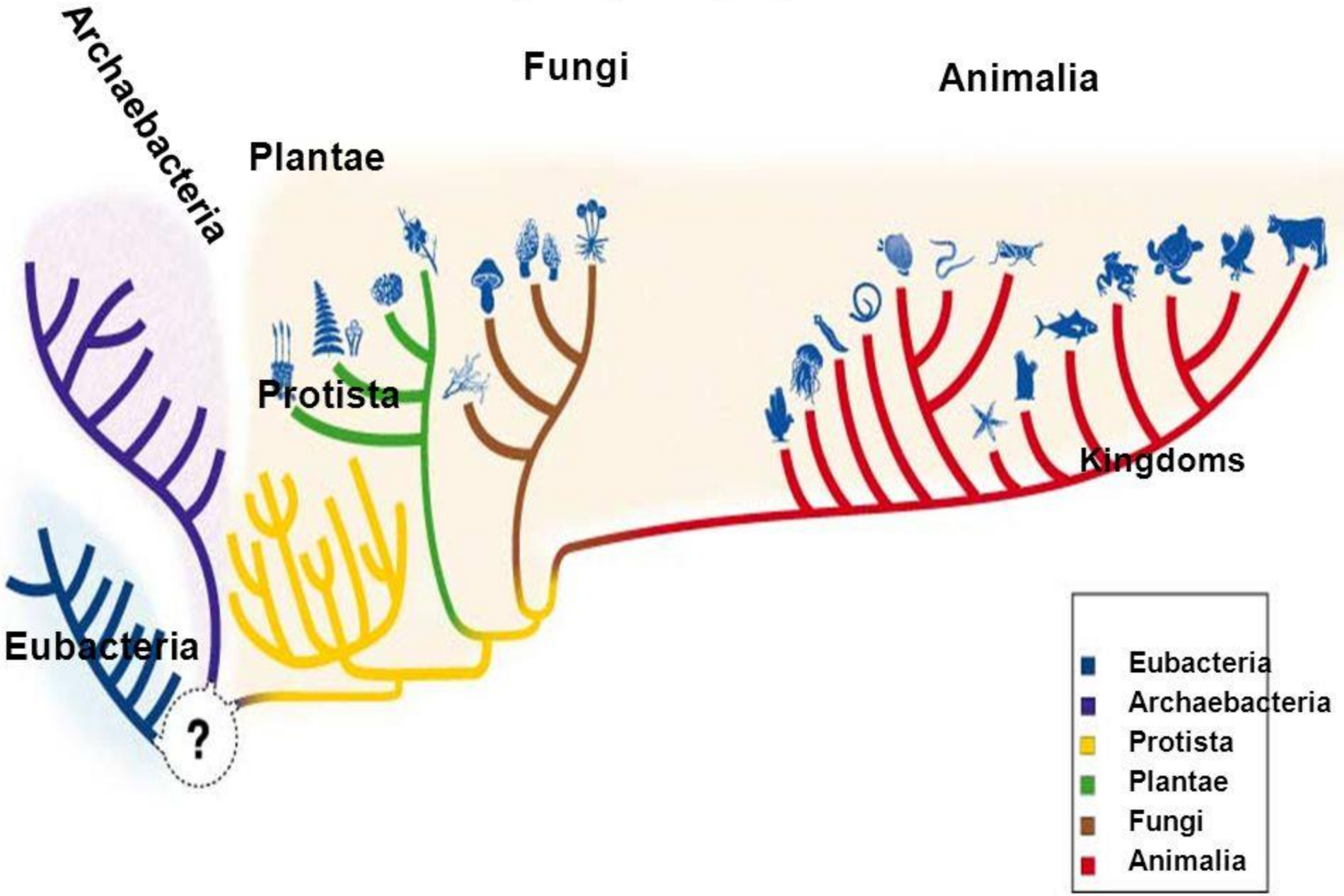
- Use a dichotomous key to identify an organism's classification and interpret a cladogram.

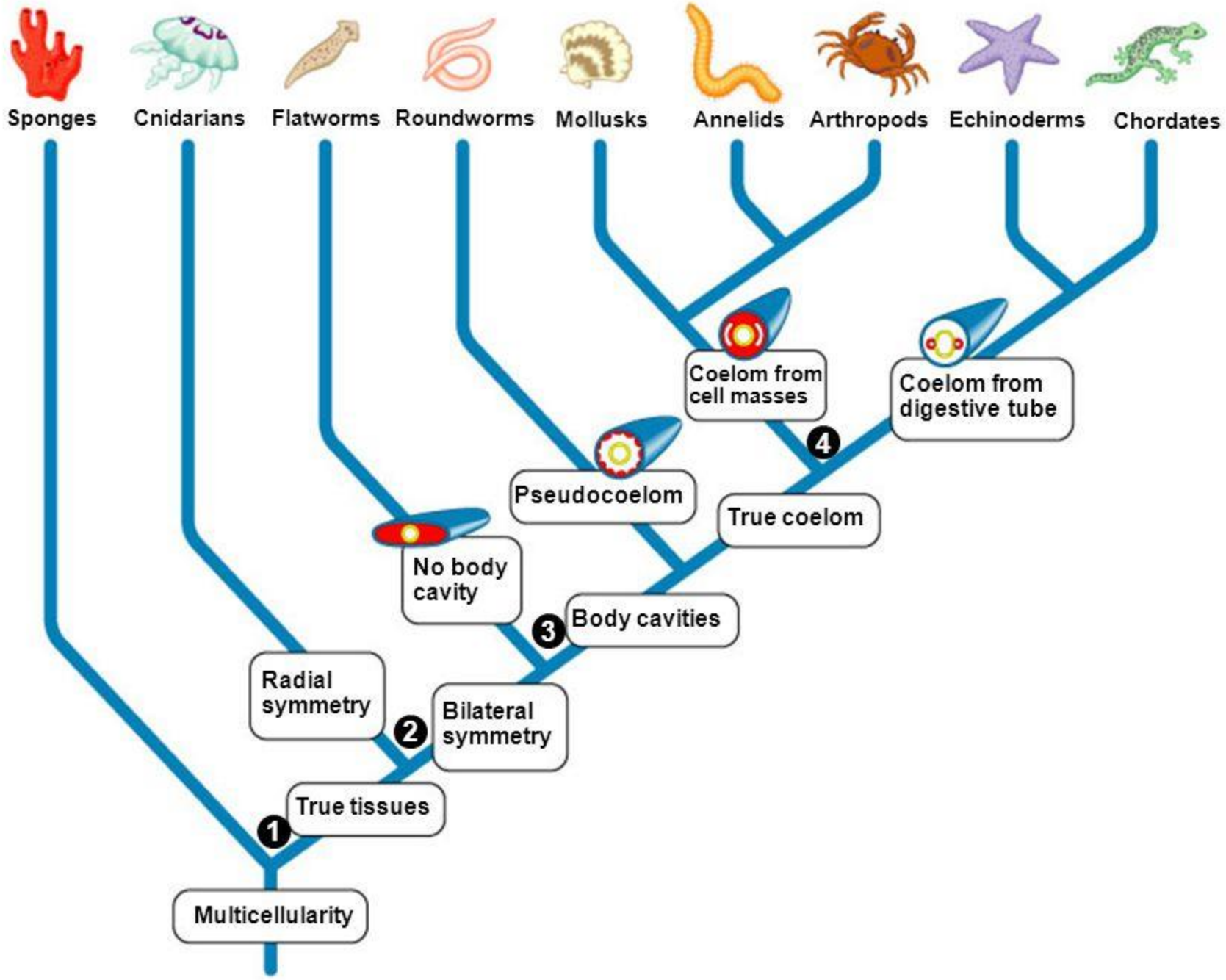
WHAT IS A CLADOGRAM?

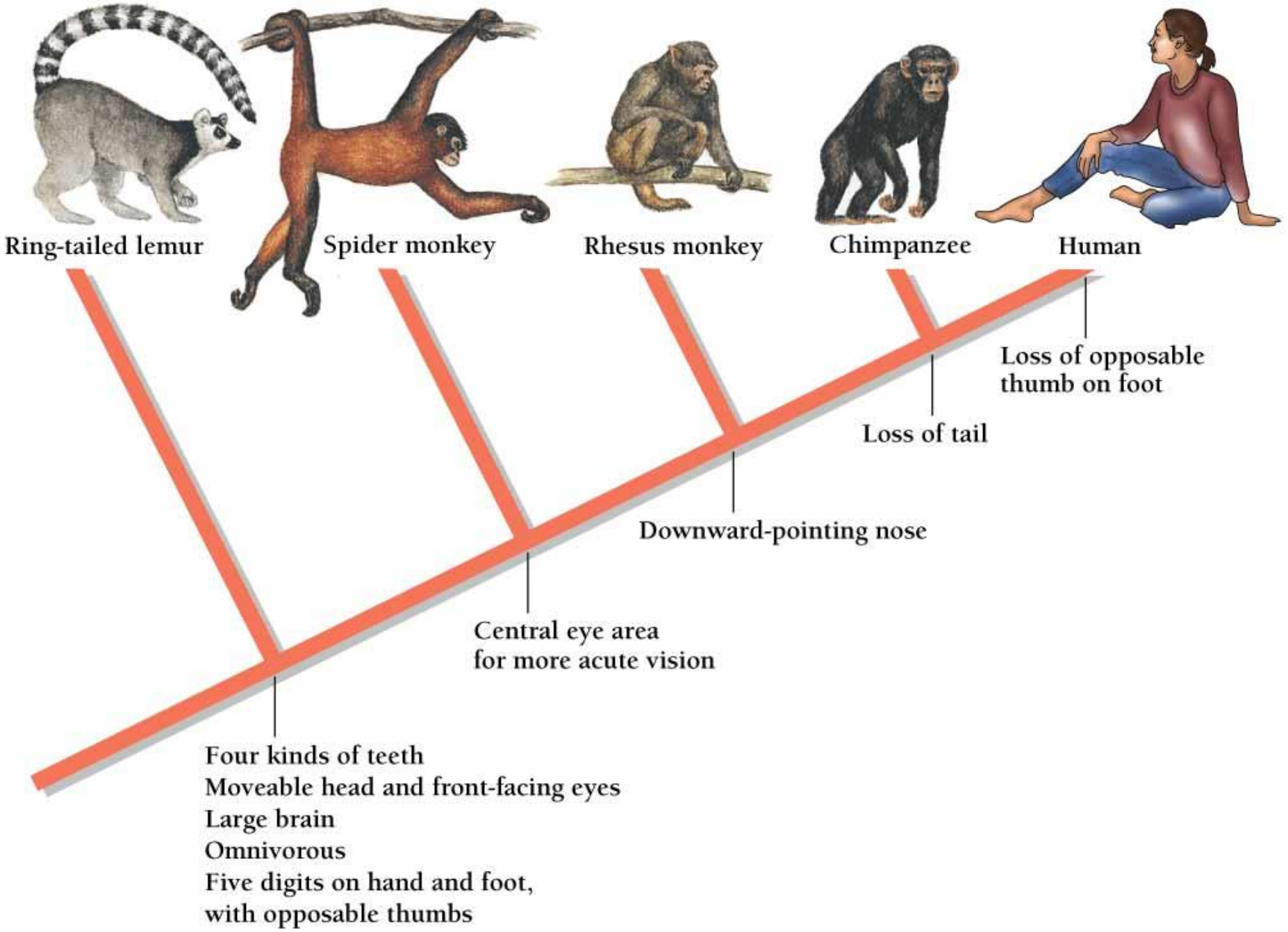
A diagram showing how organisms are related based on shared, derived characteristics such as feathers, hair, or scales

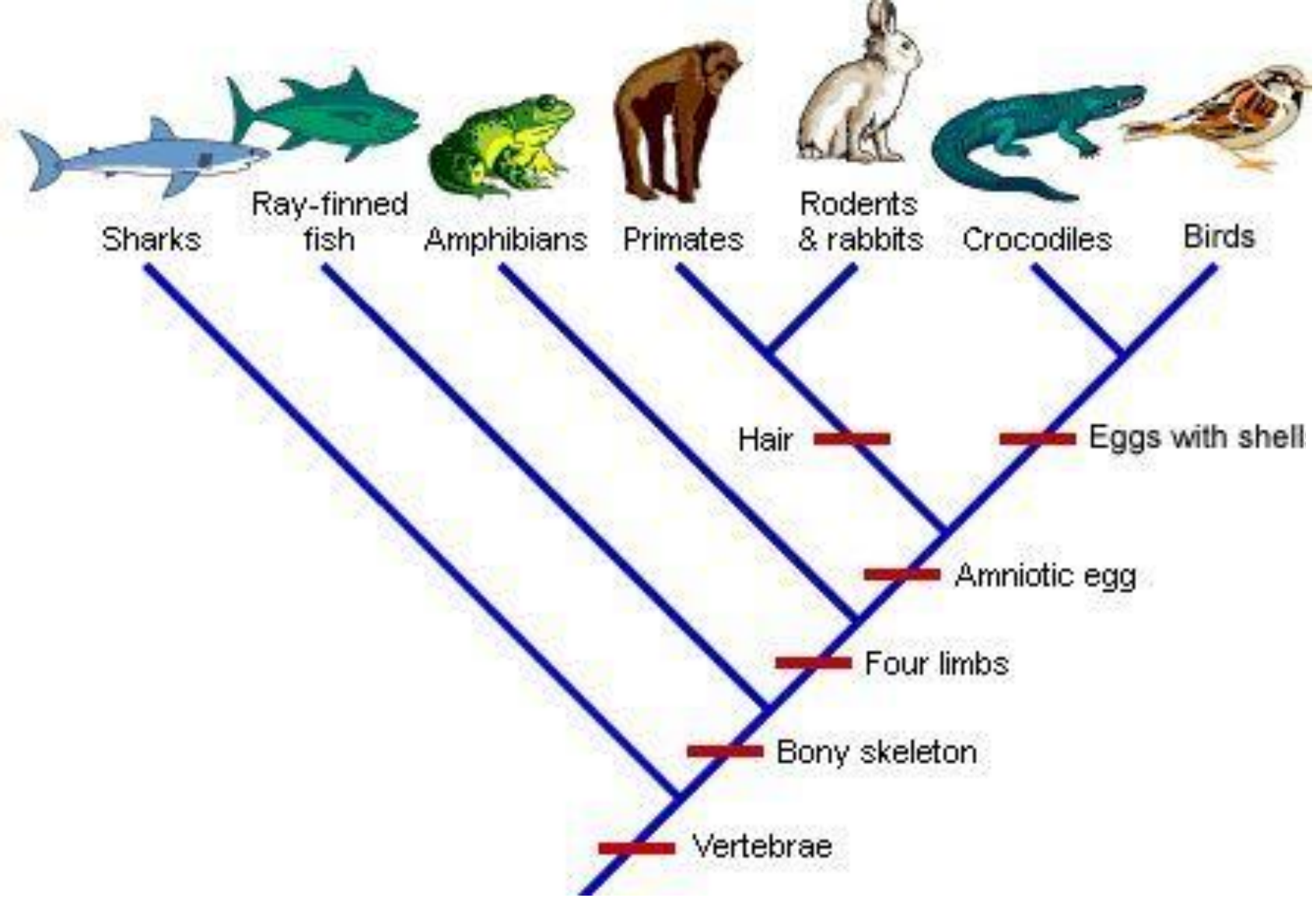


KINGDOMS OF LIFE




Sponges
Cnidarians
Flatworms
Roundworms
Mollusks
Annelids
Arthropods
Echinoderms
Chordates
Coelom from cell masses
Coelom from digestive tube
4
Pseudocoelom
True coelom
No body cavity
3
Body cavities
Radial symmetry
2
Bilateral symmetry
True tissues
1
Multicellularity





1. **Does a cladogram show divergent or convergent evolution?**

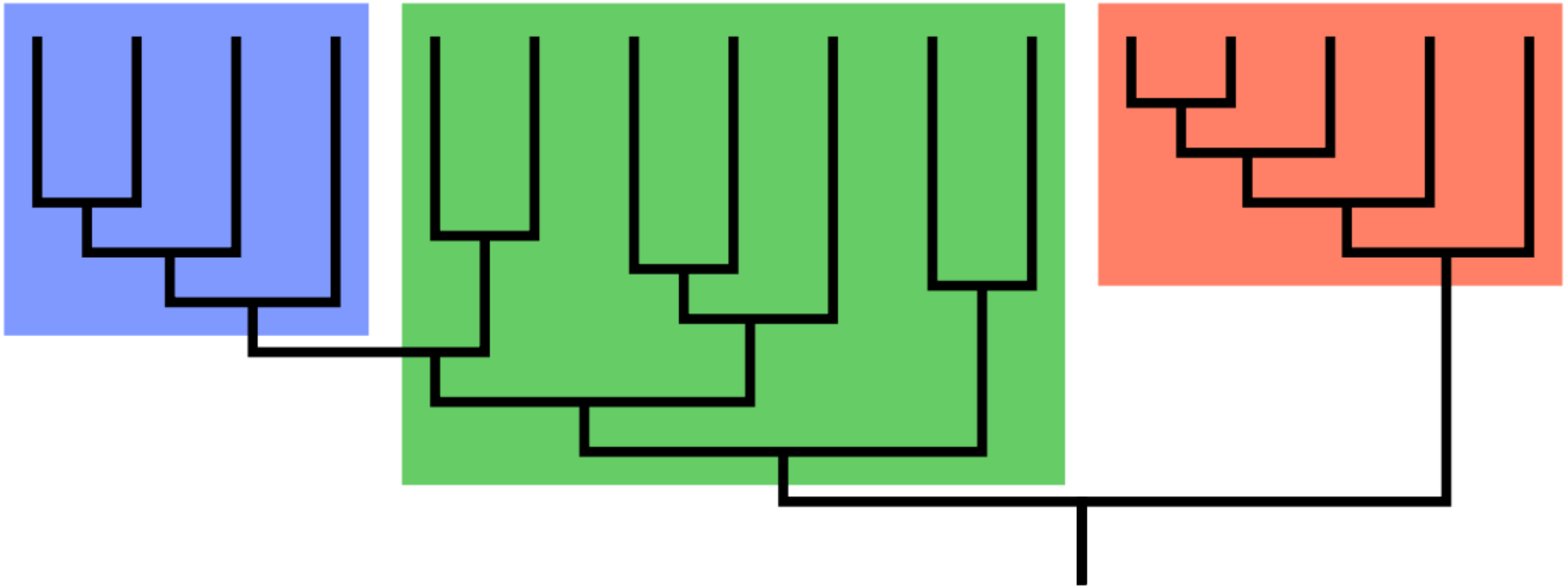
2. **Where is the common ancestor between amphibians are birds?**

3. **Where is the common ancestor between primates and rodents?**

4. **Where is the common ancestor between crocodiles and sharks?**

WHAT IS A CLADE?

A group of organisms believed to have evolved from a common ancestor, according to the principles of cladistics

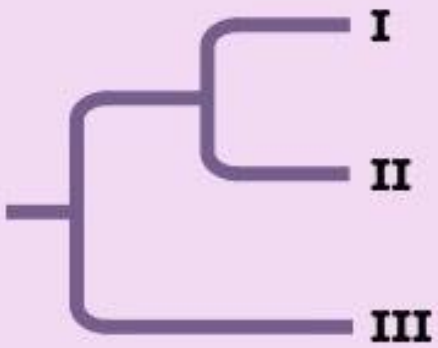


Species I

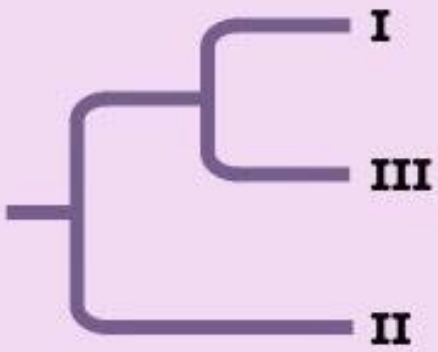
Species II

Species III

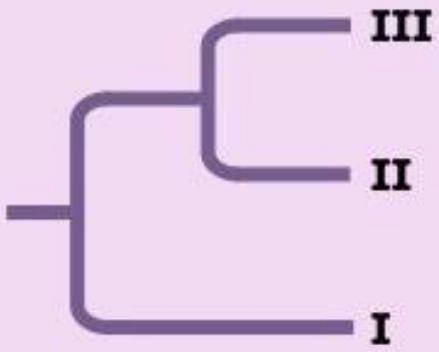
Three phylogenetic possibilities:



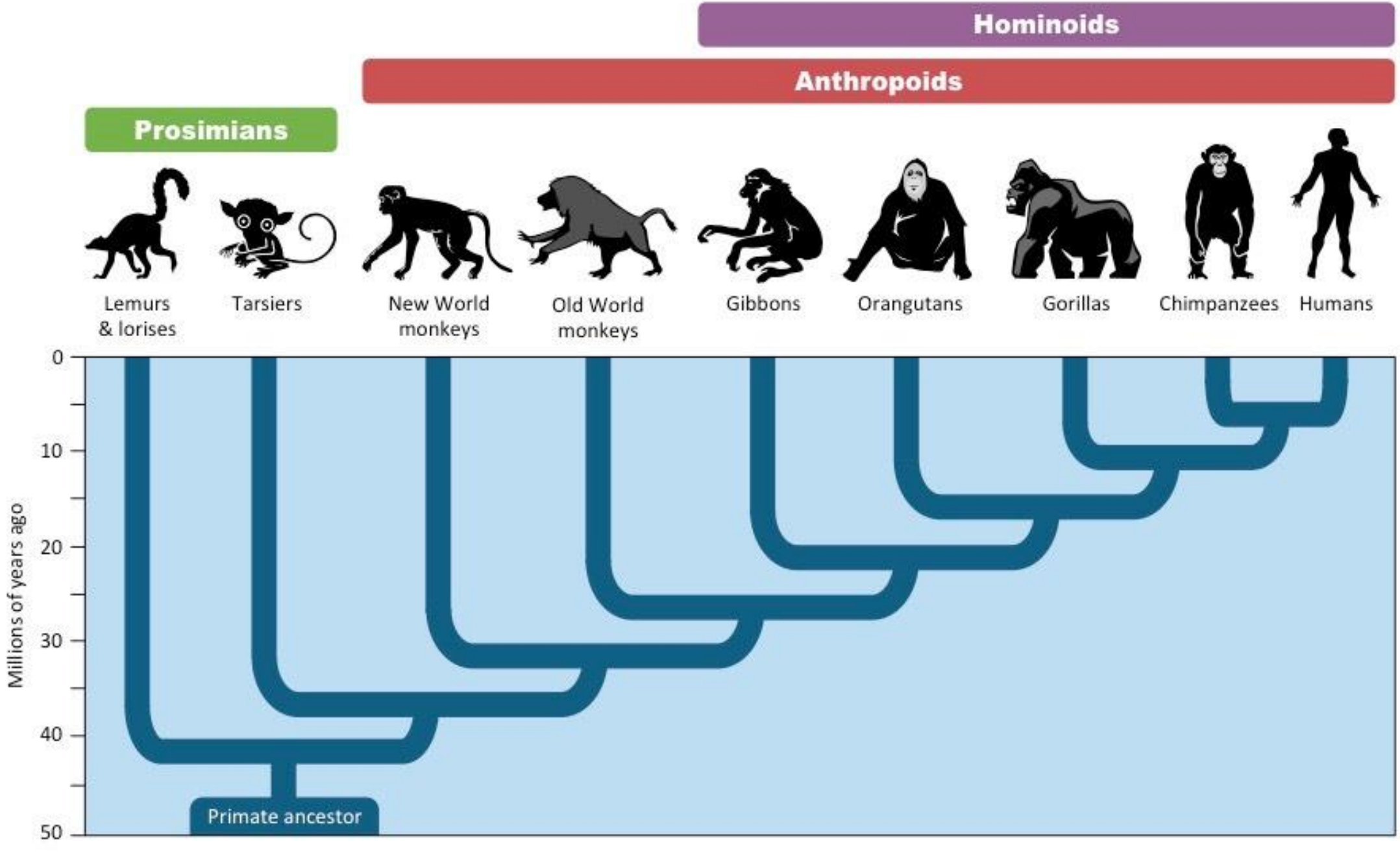
Species I and II
most closely related

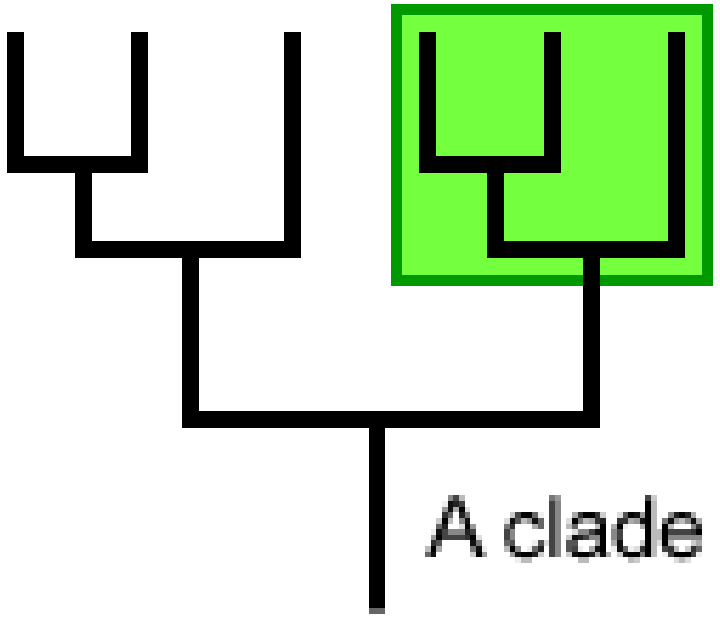


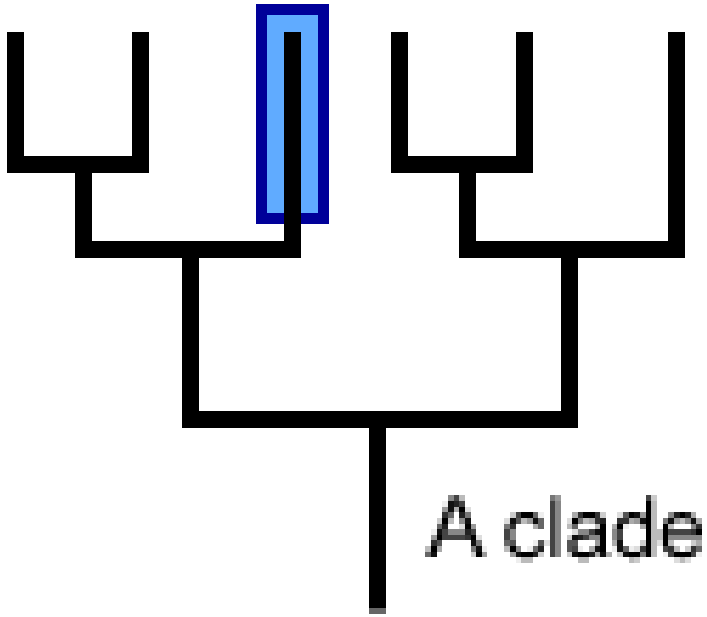
Species I and III
most closely related

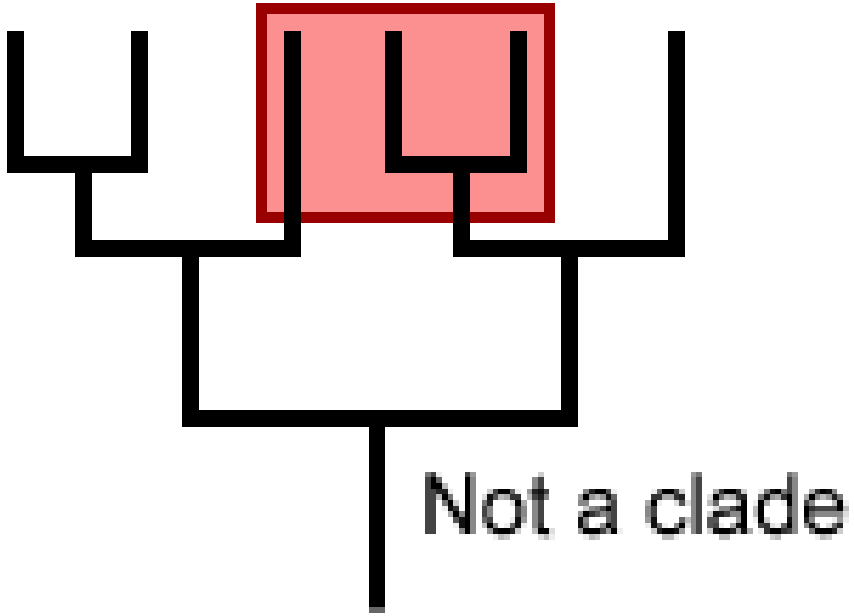


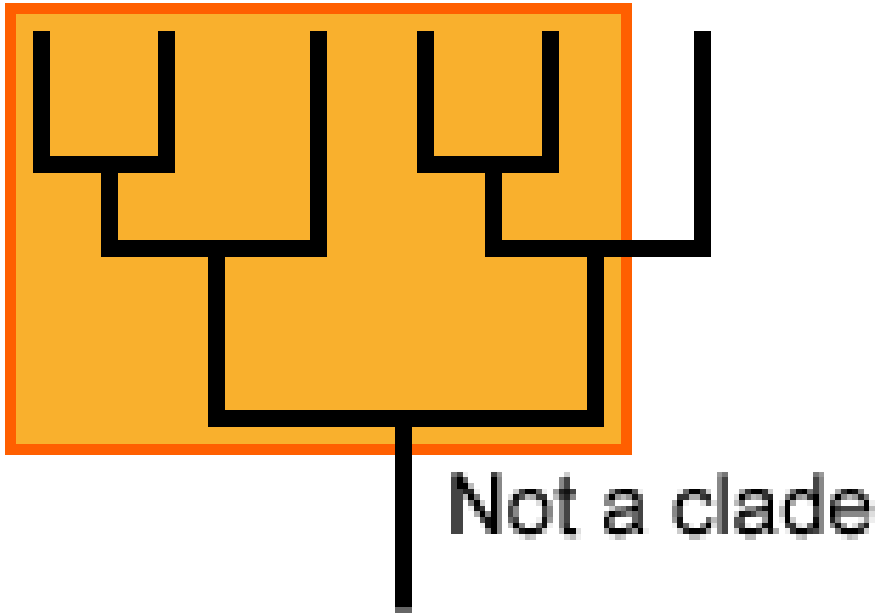
Species II and III
most closely related

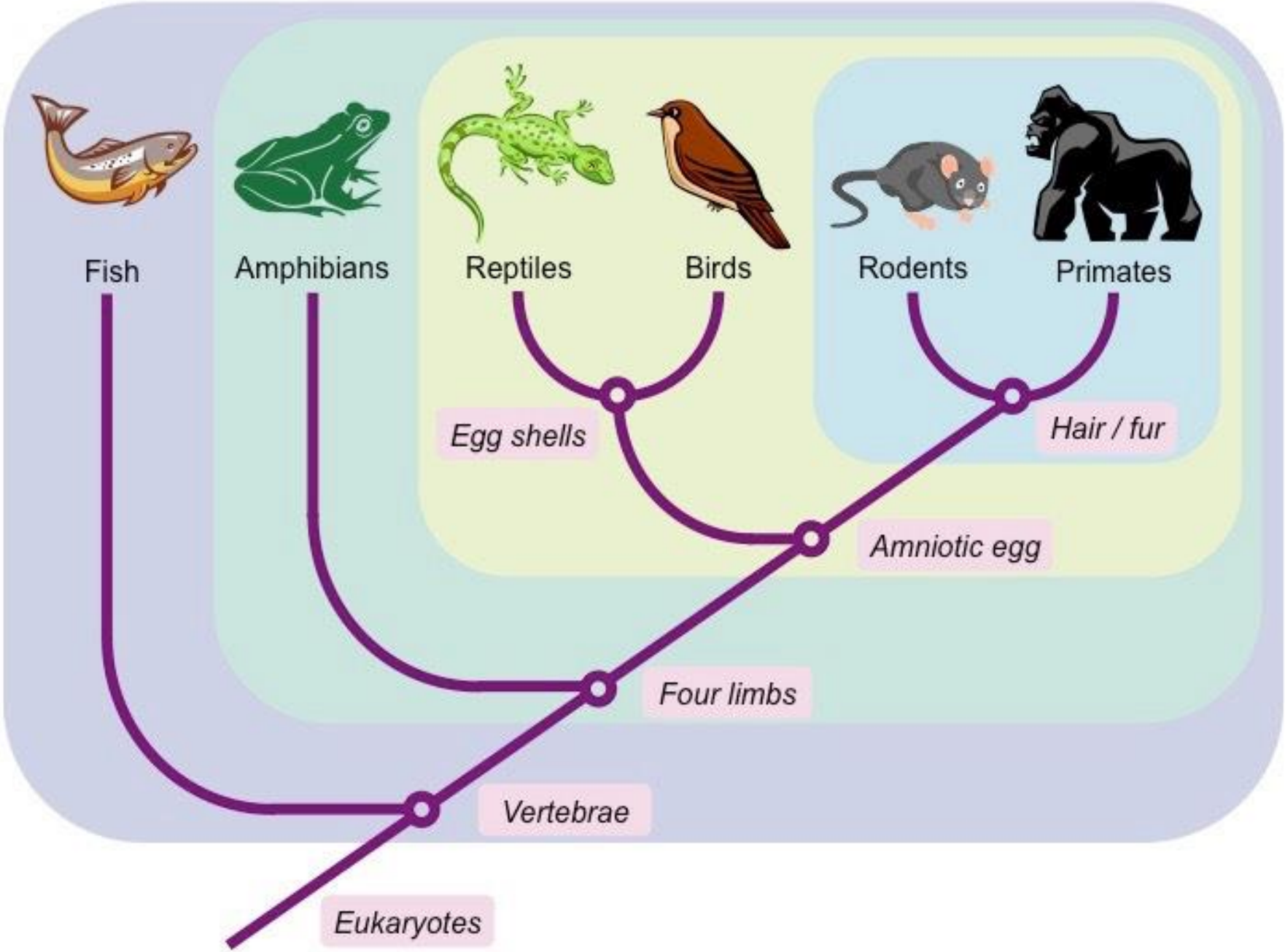

Hominoids
Anthropoids
Prosimians
Lemurs & lorises
Tarsiers
New World monkeys
Old World monkeys
Gibbons
Orangutans
Gorillas
Chimpanzees
Humans
Millions of years ago
0
10
20
30
40
50
Primate ancestor

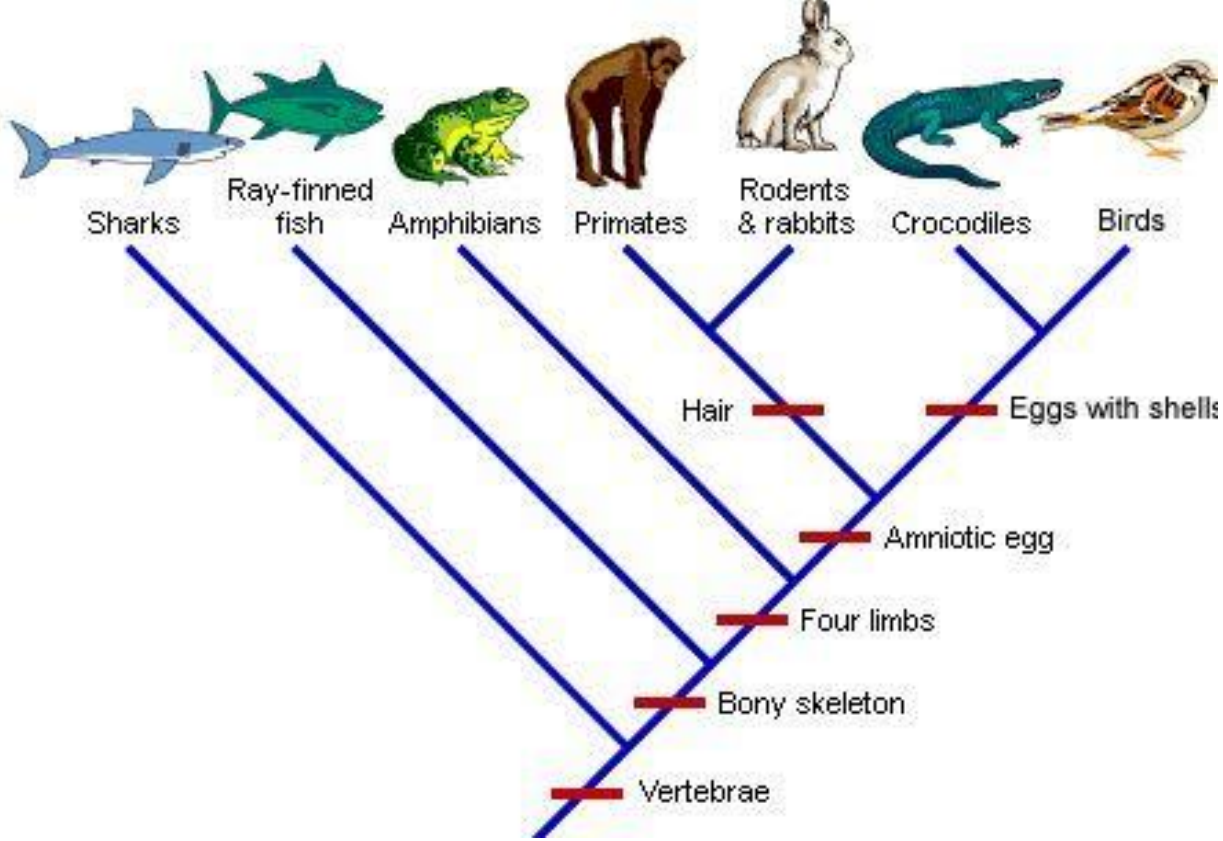

A clade

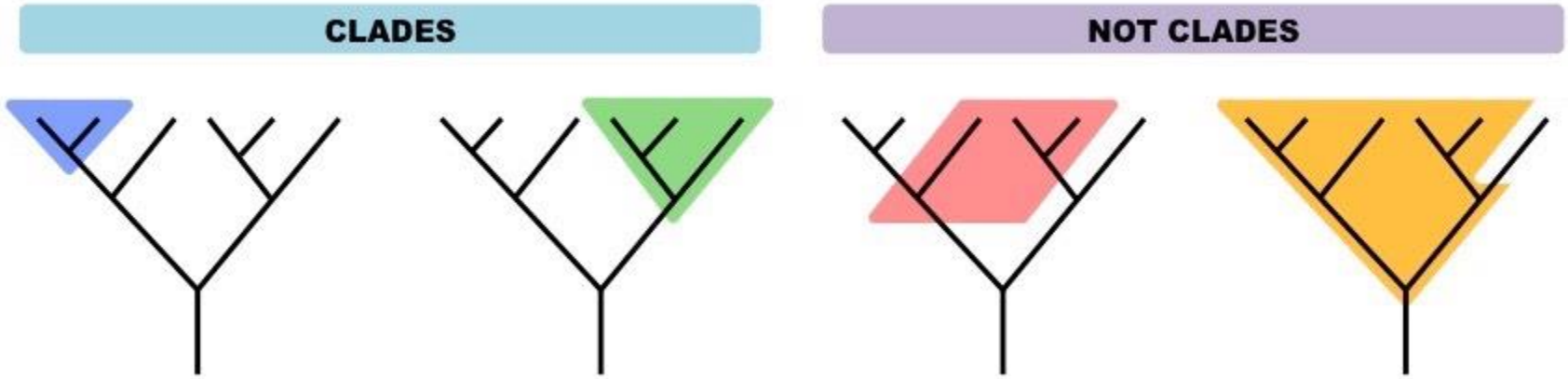

A clade


Not a clade


Not a clade


Fish
Amphibians
Reptiles
Birds
Rodents
Primates
Egg shells
Hair / fur
Amniotic egg
Four limbs
Vertebrae
Eukaryotes


Sharks
Ray-finned fish
Amphibians
Primates
Rodents & rabbits
Crocodiles
Birds
Hair
Eggs with shells
Amniotic egg
Four limbs
Bony skeleton
Vertebrae


CLADES
NOT CLADES

ANIMAL CRACKERS CLADOGRAM

Working with a partner, sort the animal crackers within your bag into groups with similar characteristics.

On the other side of your paper produce a cladogram that shows the relationships of the animal crackers.

Include taxonomic levels such as Order, Family, Genus, and species

When completed, raise your hand to get your answer checked.

WHAT IS A DICHOTOMOUS KEY?

A method of identification whereby groups of organisms are divided into two categories repeatedly

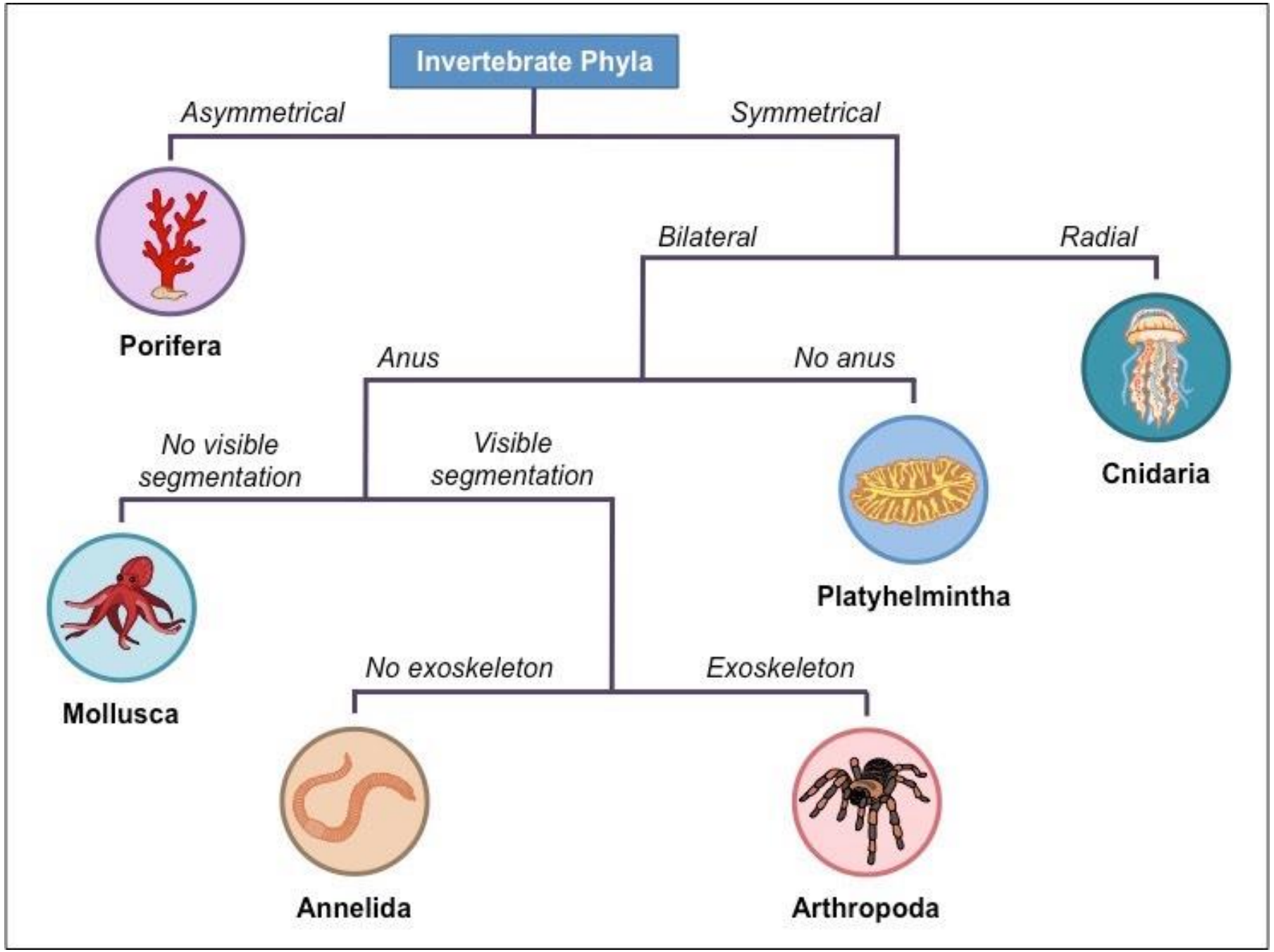
- With each sequential division, more information is revealed about the specific features of a particular organism
- When the organism no longer shares 100% of selected characteristics with any organisms, it has been identified

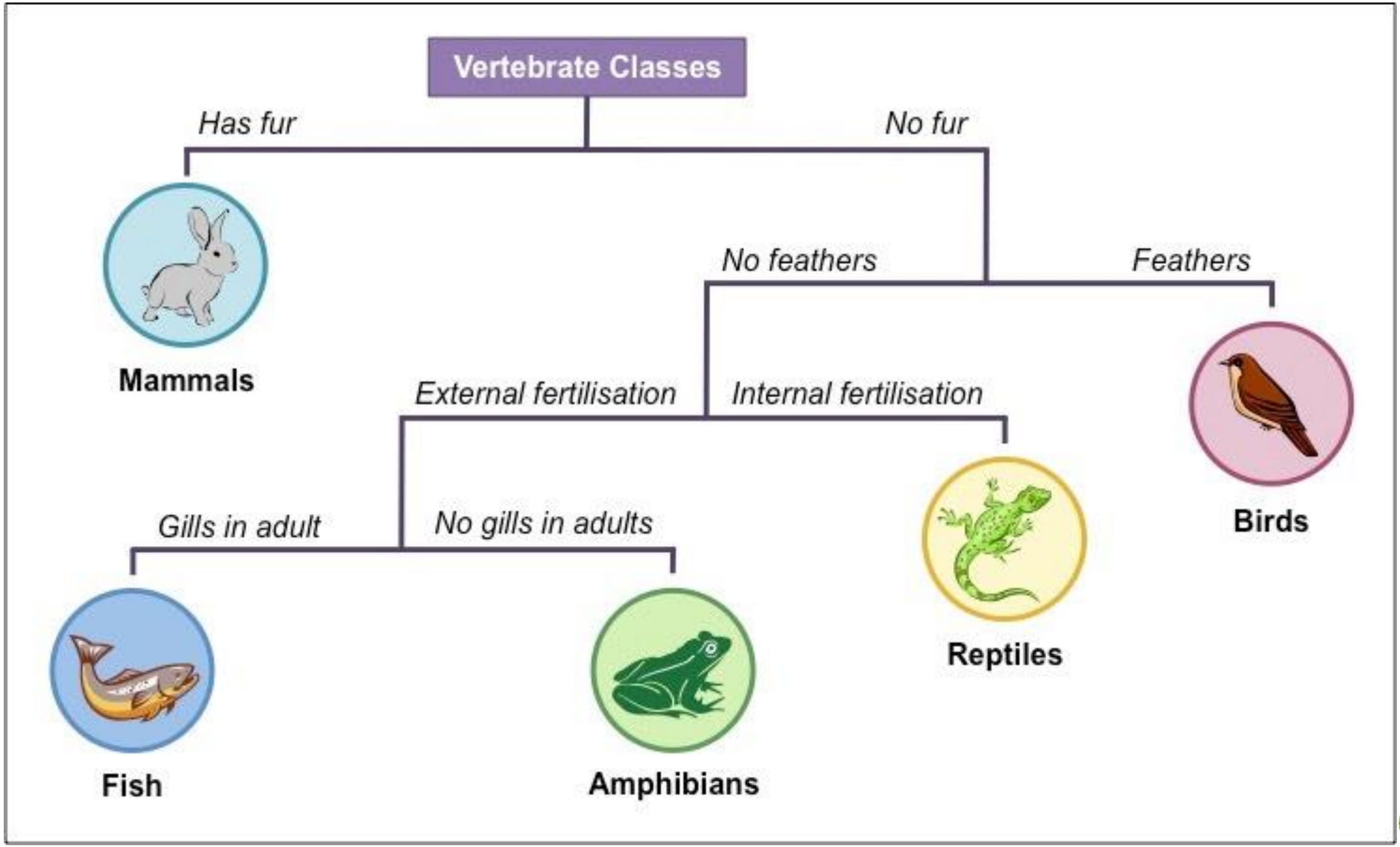
How to use a dichotomous key:

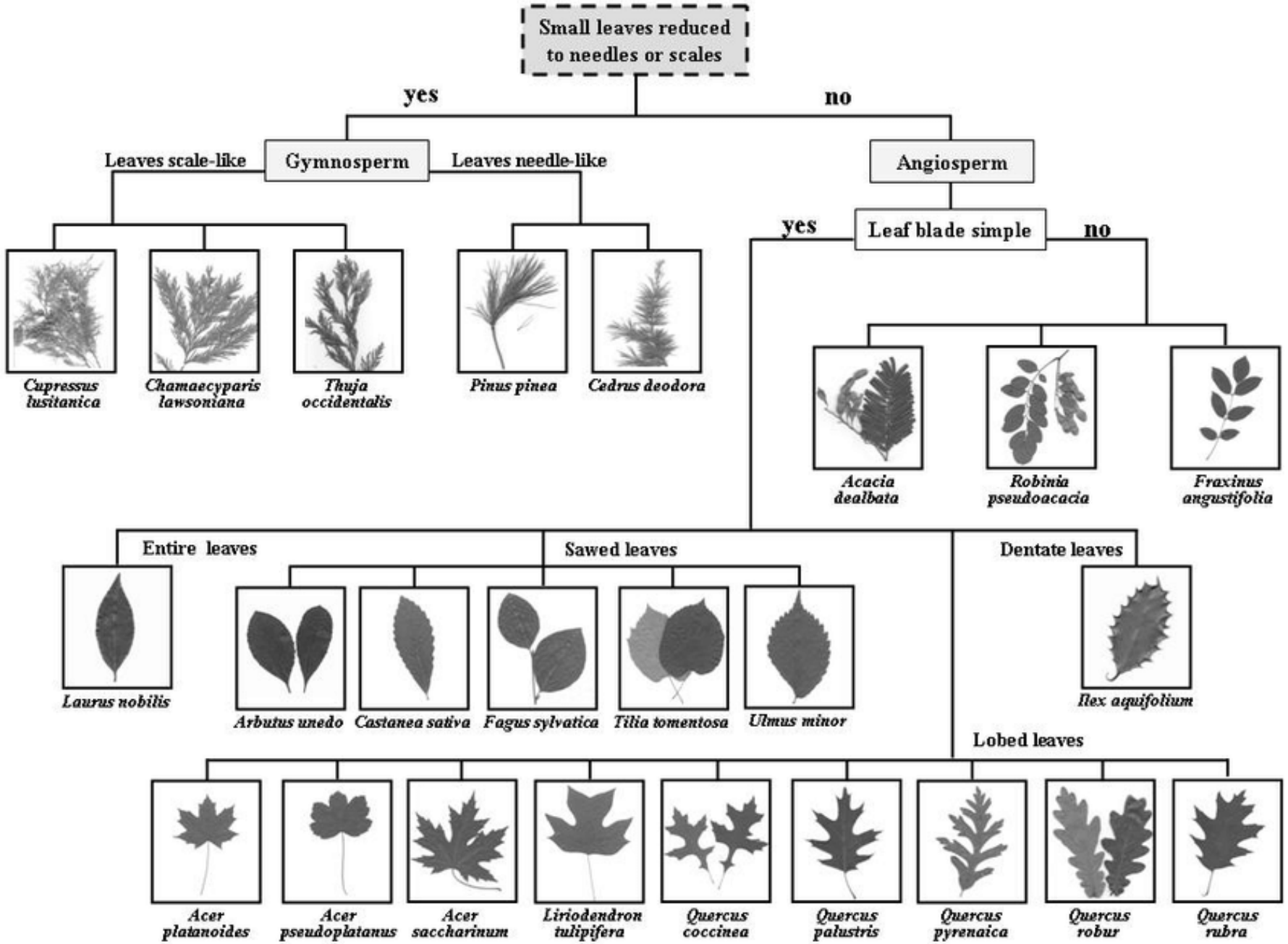
1. Read both statements laid out in a numbered sequence (descriptive representation)
2. Choose statement that better matches the organism
3. Go to next series of paired statements or identify the organism

1.	Has green colored body .....go to 2
	Has purple colored body ..... go to 4
2.	Has 4 legs .....go to 3
	Has 8 legs ..... *Deerus octagis*
3.	Has a tail ..... *Deerus pestis*
	Does not have a tail ..... *Deerus magnus*
4.	Has a pointy hump ..... *Deerus humpis*
	Does not have a pointy hump.....go to 5
5.	Has ears .....*Deerus purplinis*
	Does not have ears .....*Deerus deafus*

Step	Description of Leaves	Go to Step
1. a	Leaves are evergreen, thin, needle-like	2
b	Leaves are broad, deciduous	6
2. a	Needles are over 1 inch long, in clusters	3
b	Needles are $\frac{1}{2}$ inch long or less	4
3. a	Needles are in clusters of 3	Pitch pine
b	Needles are in clusters of 5	Eastern white pine
4. a	Needles are scale-like, sharp, cover twigs	Eastern red cedar
b	Needles protrude from twigs	5
5. a	Needles are flat, rounded tips, in 2 rows along twig	Eastern hemlock
b	Needles are in whorl around the stem	White spruce

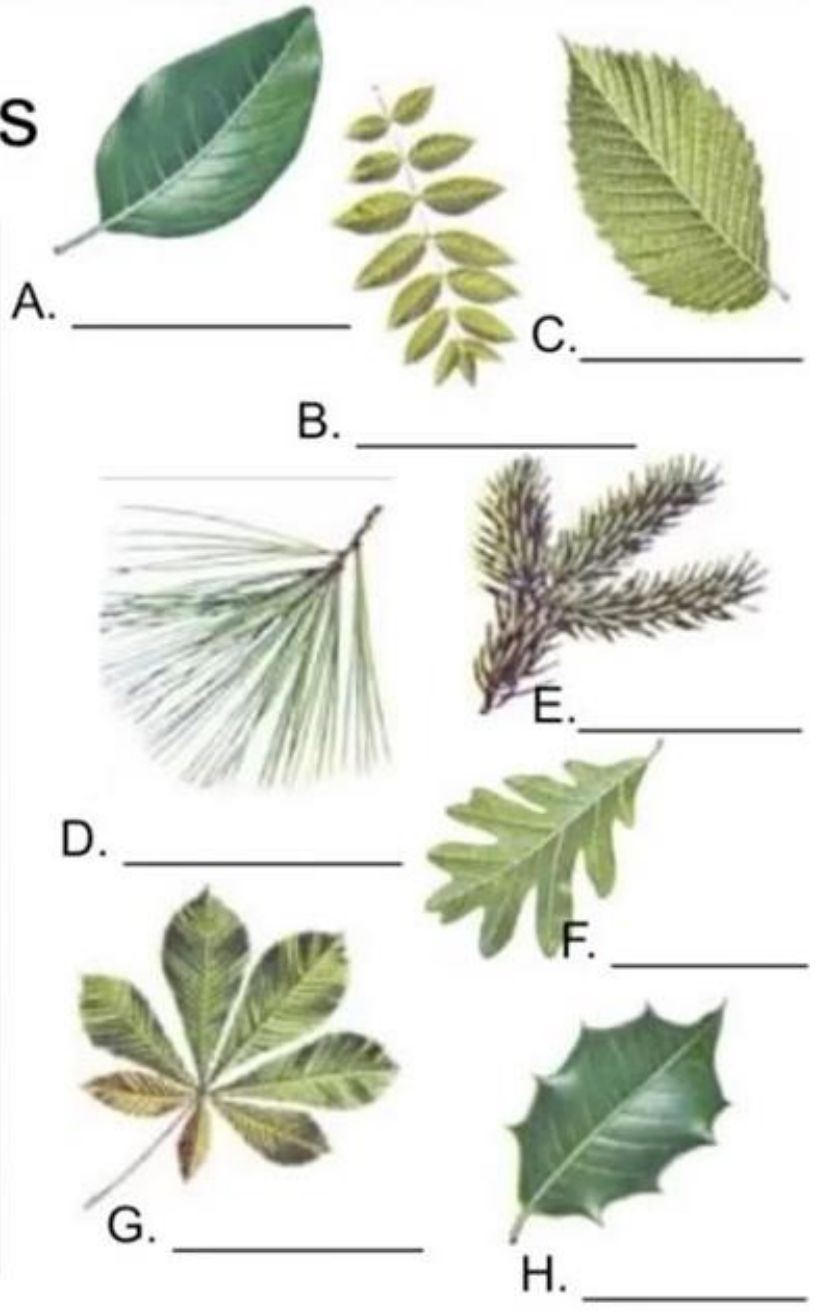

Invertebrate Phyla
Asymmetrical
Symmetrical
Porifera
Bilateral
Radial
Anus
No anus
Cnidaria
No visible segmentation
Visible segmentation
Platyhelmintha
Mollusca
No exoskeleton
Exoskeleton
Annelida
Arthropoda


Vertebrate Classes
Has fur
No fur
Mammals
No feathers
Feathers
Birds
External fertilisation
Internal fertilisation
Reptiles
Gills in adult
No gills in adults
Fish
Amphibians


Small leaves reduced to needles or scales
yes
no
Leaves scale-like
Gymnosperm
Leaves needle-like
Angiosperm
yes
Leaf blade simple
no
Cupressus lusitanica
Chamaecyparis lawsoniana
Thuja occidentalis
Pinus pinea
Cedrus deodora
Acacia dealbata
Robinia pseudoacacia
Fraxinus angustifolia
Entire leaves
Sawed leaves
Dentate leaves
Laurus nobilis
Arbutus unedo
Castanea sativa
Fagus sylvatica
Tilia tomentosa
Ulmus minor
Ilex aquifolium
Lobed leaves
Acer platanoides
Acer pseudoplatanus
Acer saccharinum
Liriodendron tulipifera
Quercus coccinea
Quercus palustris
Quercus pyrenaica
Quercus robur
Quercus rubra

Dichotomous Key For Leaves

1.	a. Needle leaves	go to 2
	b. Non-needle leaves	go to 3
2.	a. Needles are clustered	Pine
	b. Needles are in singlets	Spruce
3.	a. Simple leaves (single leaf)	go to 4
	b. Compound leaves (made of "leaflets")	go to 7
4.	a. Smooth edged	go to 5
	b. Jagged edge	go to 6
5.	a. Leaf edge is smooth	Magnolia
	b. Leaf edge is lobed	White Oak
6.	a. Leaf edge is small and tooth-like	Elm
	b. Leaf edge is large and thorny	Holly
7.	a. Leaflets attached at one single point	Chestnut
	b. Leaflets attached at multiple points	Walnut



TOPIC 3 LEARNING TARGETS

- ✓Explain the development of the six kingdoms and three domain systems of classification of organisms.
- ✓Contrast the characteristics of organisms found in each of the six kingdoms and three domains.
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