Biosystematics and Taxonomy

PRESENTED BY:
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MZOOCC – 208
SEMESTER – II
UNIT - 1

Biosystematics

- Systematic biology (hereafter called simply systematics) is the field that-

(a) provides scientific names for organisms,

(b) describes them,

(c) preserves collections of them,

(d) provides classifications for the organisms, keys for their identification, and data on their distributions,

(e) investigates their evolutionary histories, and

(f) considers their environmental adaptations.

The term biosystematics was coined by W. H. Camp and C. L. Gilly (1943).

- Blackwelder and Boyden (1952) gave a definition that “systematics is the entire field dealing with the kinds of animals, their distinction, classification and evolution”.

- C. G. Simpson (1961) considers that “Systematics is the scientific study of the kinds and diversity of organisms and of any and all relationships among them”.

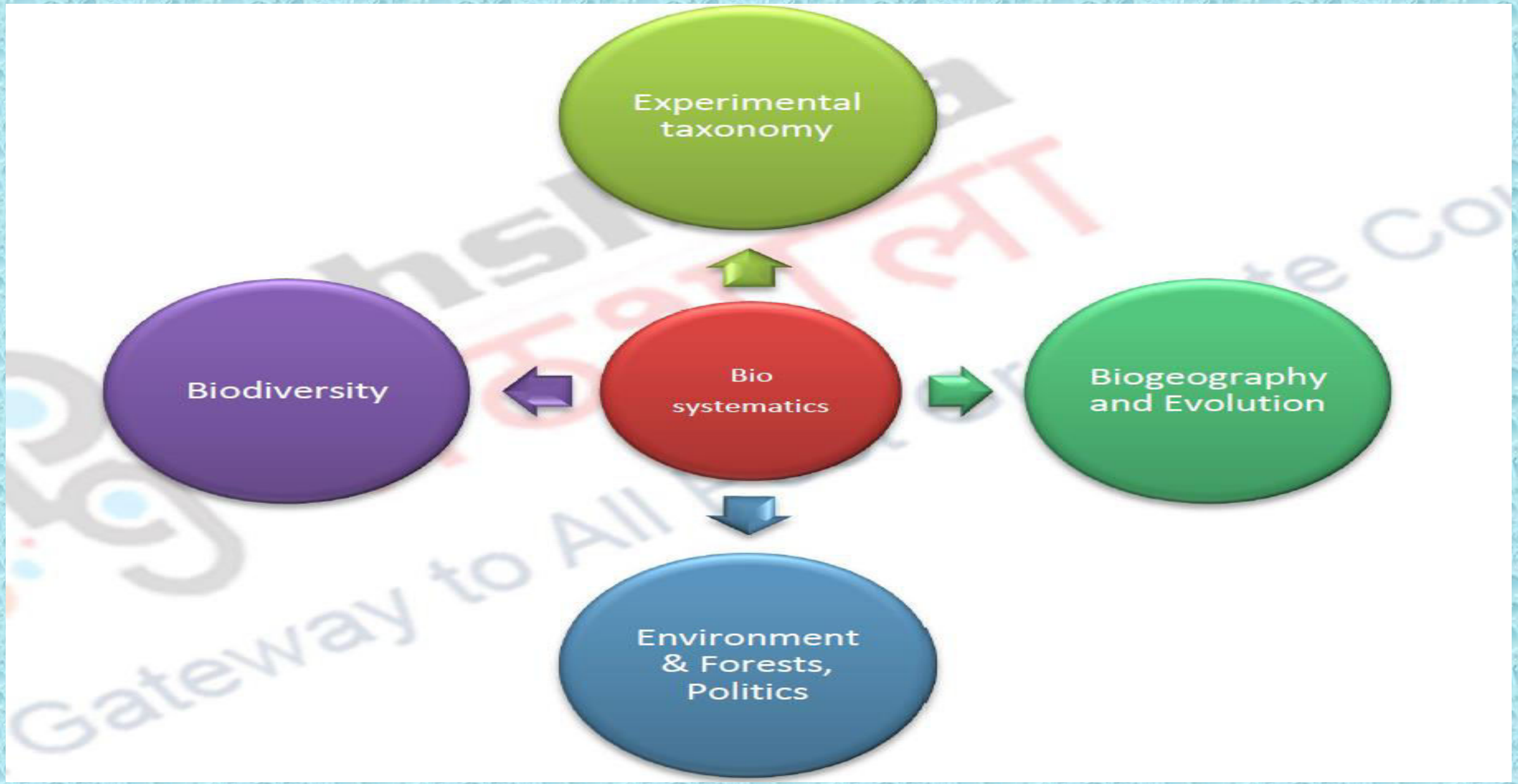
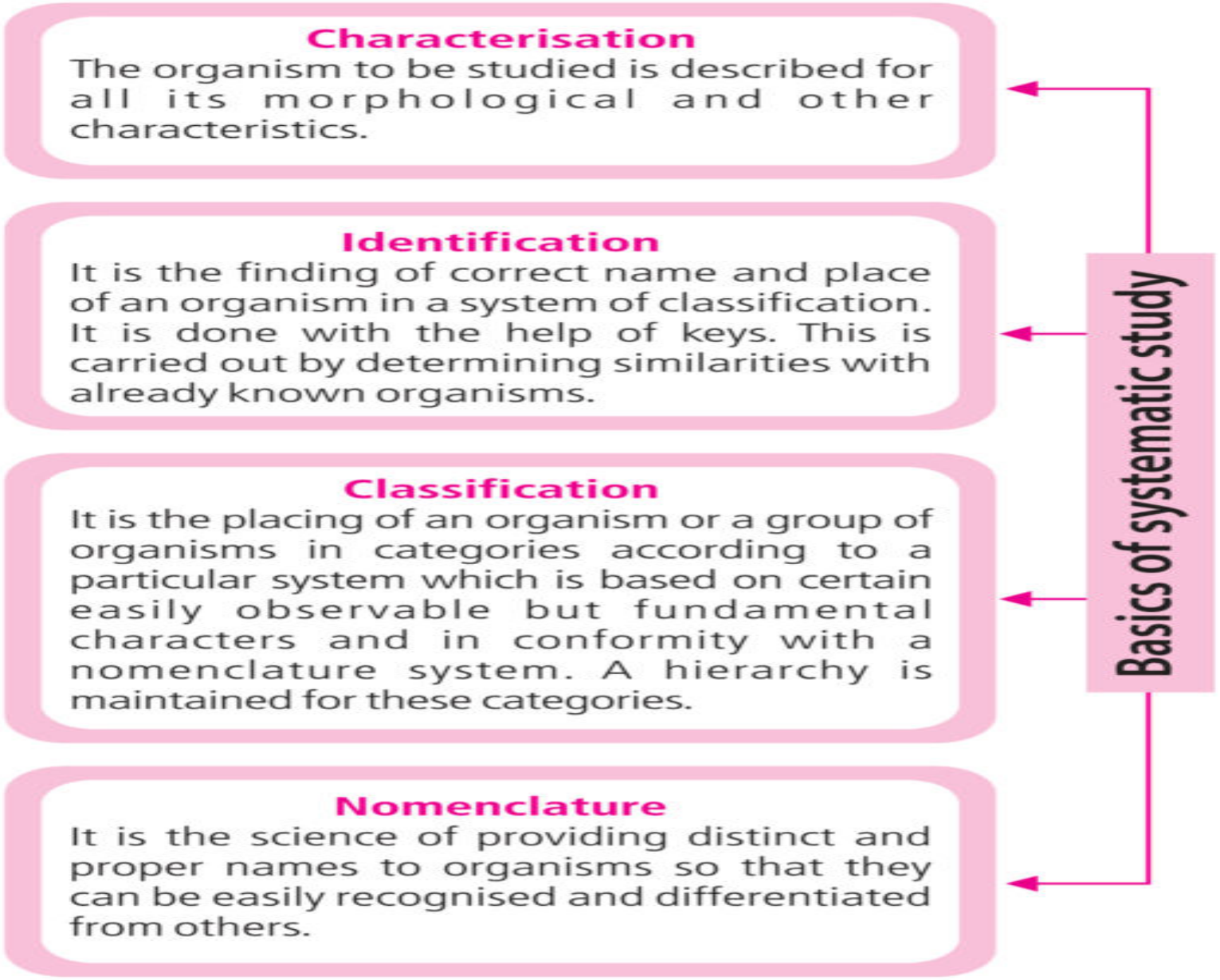


Fig. 1.The scope of Biosystematics in broader sense

APPLICATIONS OF BIOSYSTEMATICS

1. Studying the diversity of organisms and the differentiation between extinct and living creatures. Biologists study the well-understood relationships by making many different diagrams and "trees".
2. Including the scientific names of organisms, species descriptions and overviews, taxonomic orders, and classifications of evolutionary and organism histories.
3. Explaining the biodiversity of the planet and its organisms. The systematic study is that of conservation.
4. Manipulating and controlling the natural world. This includes the practice of 'biological control', the intentional introduction of natural predators and disease.


Characterisation
The organism to be studied is described for all its morphological and other characteristics.
Identification
It is the finding of correct name and place of an organism in a system of classification. It is done with the help of keys. This is carried out by determining similarities with already known organisms.
Classification
It is the placing of an organism or a group of organisms in categories according to a particular system which is based on certain easily observable but fundamental characters and in conformity with a nomenclature system. A hierarchy is maintained for these categories.
Nomenclature
It is the science of providing distinct and proper names to organisms so that they can be easily recognised and differentiated from others.
Basics of systematic study

Kingdom
Phylum
Class
Order
Family
Genus
Species

DEFINE TAXONOMY

- Discipline of classifying organisms and assigning each organism a universally accepted name.

TURKEY VULTURE (Cathartes aura)

Taxonomic Components

1. Classification

Animals are arranged into groups of similar characteristics. The groups are considered as categories or taxa and form the taxonomic system.

2. Identification

To identify and derive the name of an organism by referring to an existing classification.

3. Nomenclature

To provide a scientific name to an organism.

4. Description

To describe the characteristics of a taxon e.g. a family.

Kingdom
Phylum
Class
Order
Family
Genus
Species

WHY CLASSIFY?

1. How do biologists use a classification system to study the diversity of life?

to name organisms and group them in a logical manner.

Kingdom
Phylum
Class
Order
Family
Genus
Species

WHY CLASSIFY?

2. How do taxonomists group organisms when they classify them?

Into groups that have biological significance.

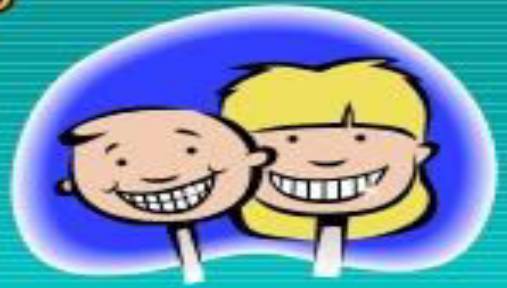
Kingdom
Phylum
Class
Order
Family
Genus
Species

WHY CLASSIFY?

3. How does classification make life easier?

grouping things makes them easier to find and work with

3a. What are some things we classify?



Taxonomic Characters

Morphological	Anatomical	Embryological	Paleontological	Molecular	Biochemical	Ecological-geographic
Similarities and differences in shape, structure, color, size, etc.	Anatomical similarities and differences	Similarities during the embryonic development	Documentation of the evolution of living organisms through fossils	Similarities based on genes	Different organisms have different chemical composition	Organisms that occupy the same area share a recent common ancestor

- Taxonomic characters are the taxonomic attributes that can be used to provide the evidence from which relationships (the phylogeny) between taxa are inferred.

- Kinds of taxonomic characters include:

1. Morphological characters

- General external morphology
- Special structures (e.g. genitalia)
- Internal morphology (anatomy)
- Embryology
- Karyology and other cytological factors

2. Physiological characters

- Metabolic factors
- Body secretions
- Genic sterility factors

3. Molecular characters

- Immunological distance
- Electrophoretic differences
- Amino acid sequences of proteins
- DNA hybridization
- DNA and RNA sequences
- Restriction endonuclease analyses
- Other molecular differences

4. Behavioural characters

- Courtship and other ethological isolating mechanisms
- Other behaviour patterns

5. Ecological characters

- Habit and habitats
- Food
- Seasonal variations
- Parasites and hosts

6. Geographic characters

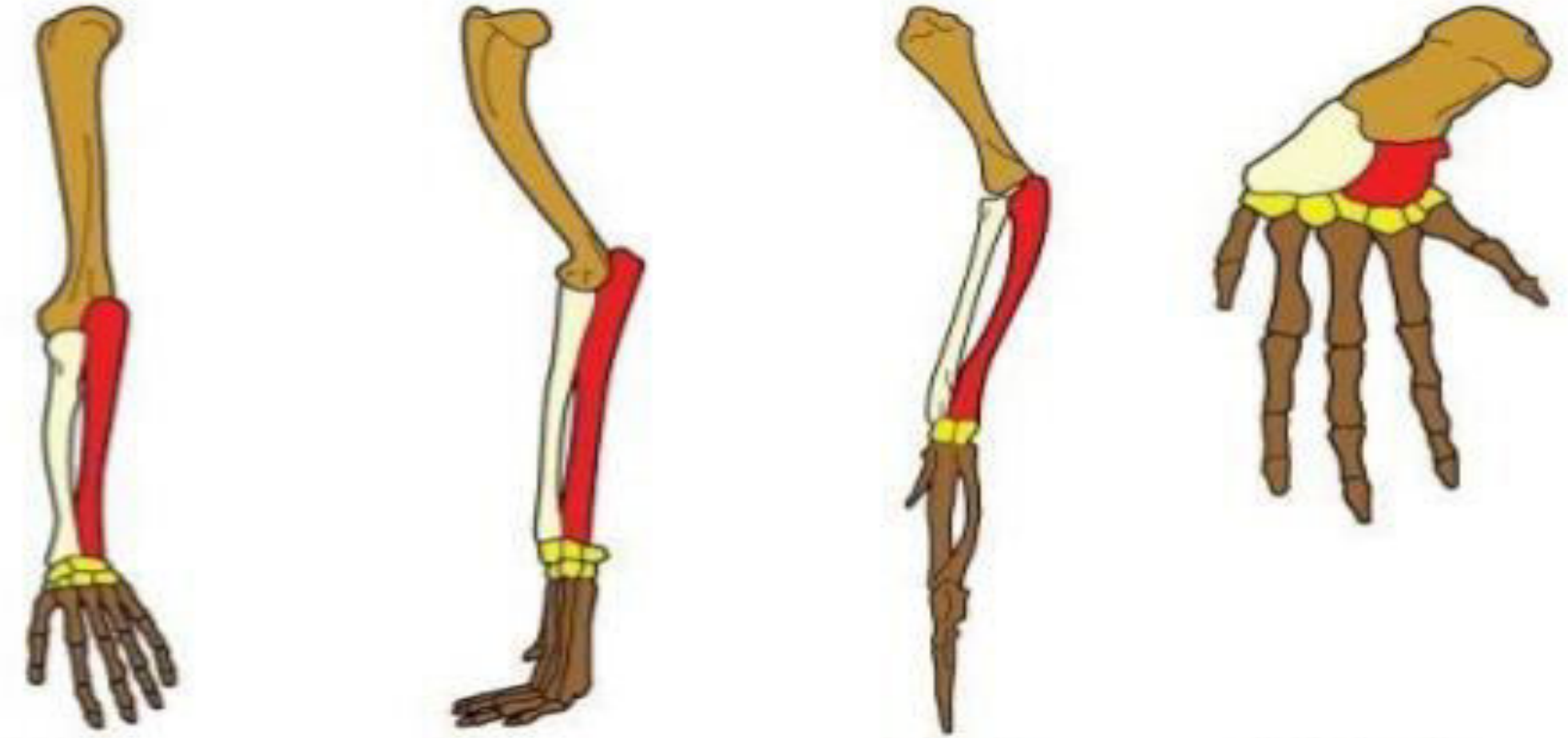
- General biogeographic distribution patterns
- Sympatric-allopatric relationship of populations

Morphological

Similarities and differences in shape, structure, color, size, etc.

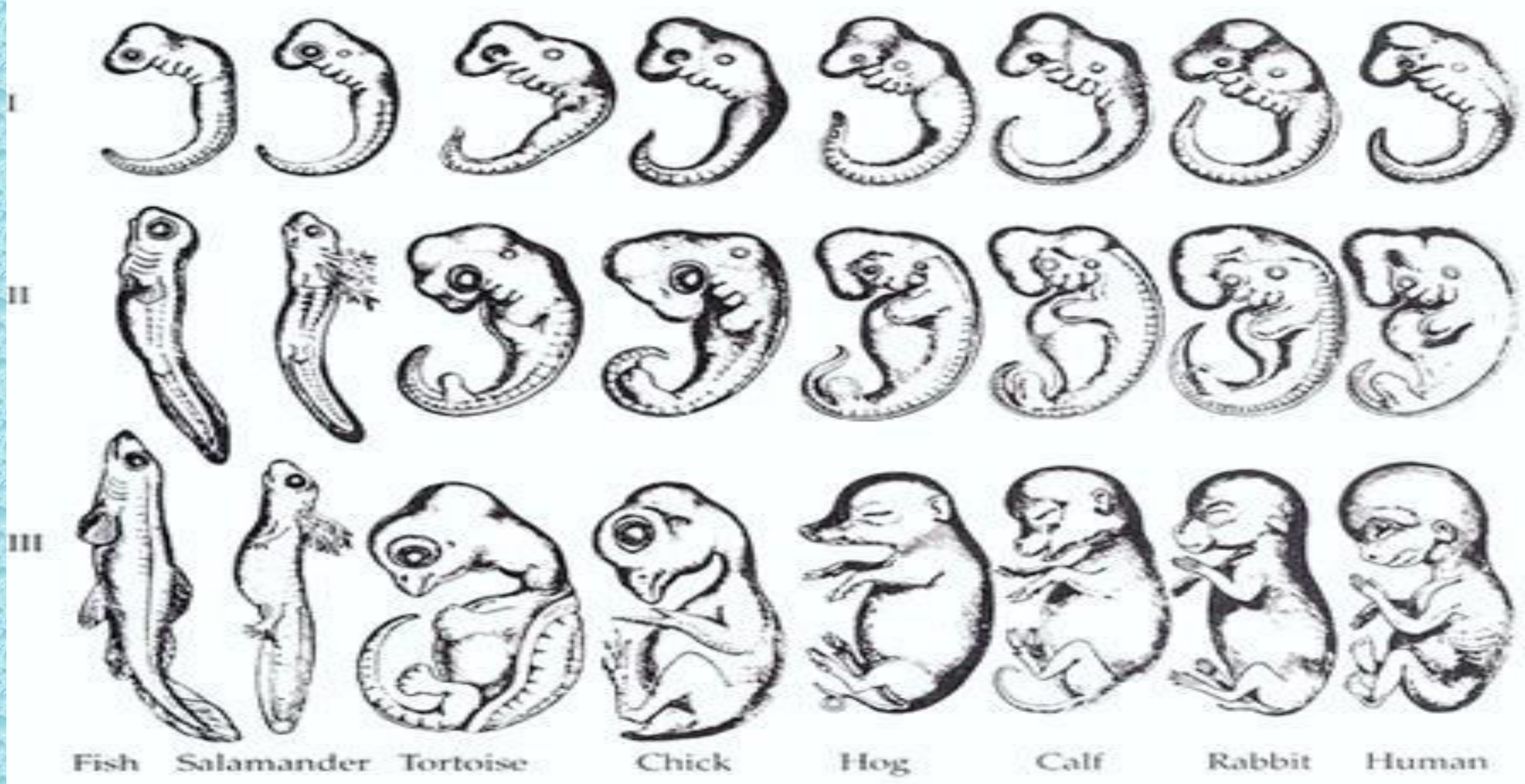
Anatomical

Anatomical similarities and differences



Embryological

Similarities during the embryonic development

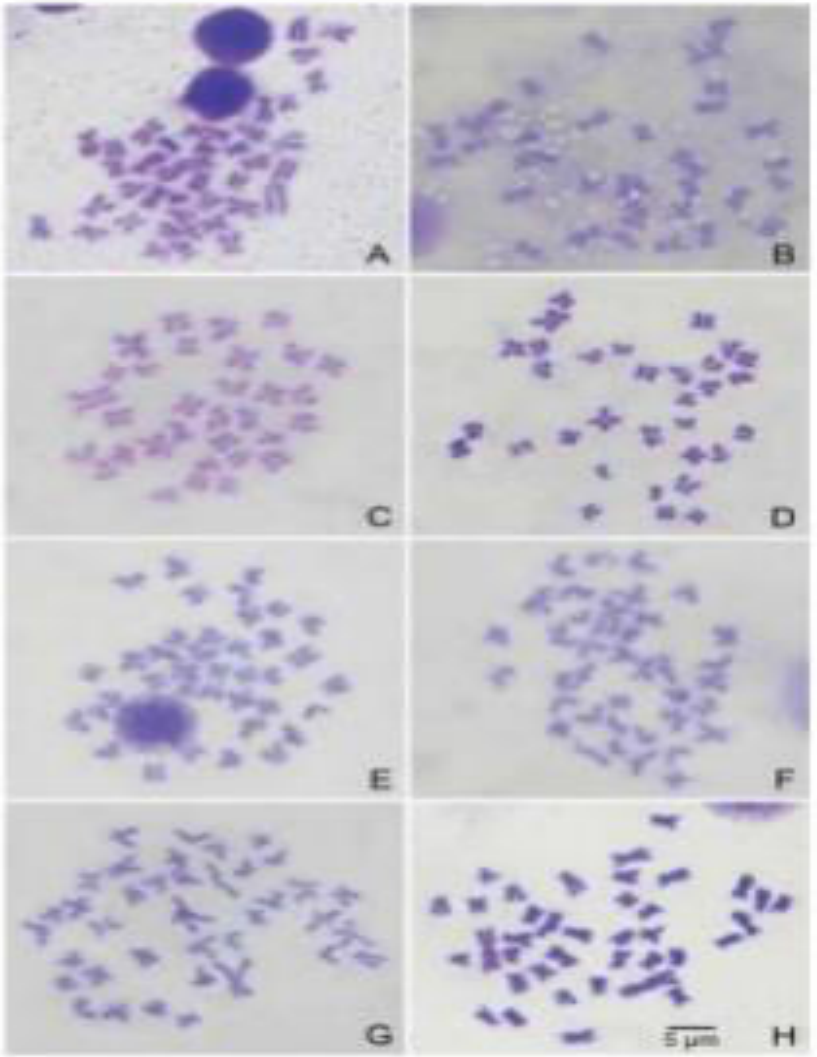

I
II
III
Fish
Salamander
Tortoise
Chick
Hog
Calf
Rabbit
Human

Paleontological

Documentation of the evolution of living organisms through fossils

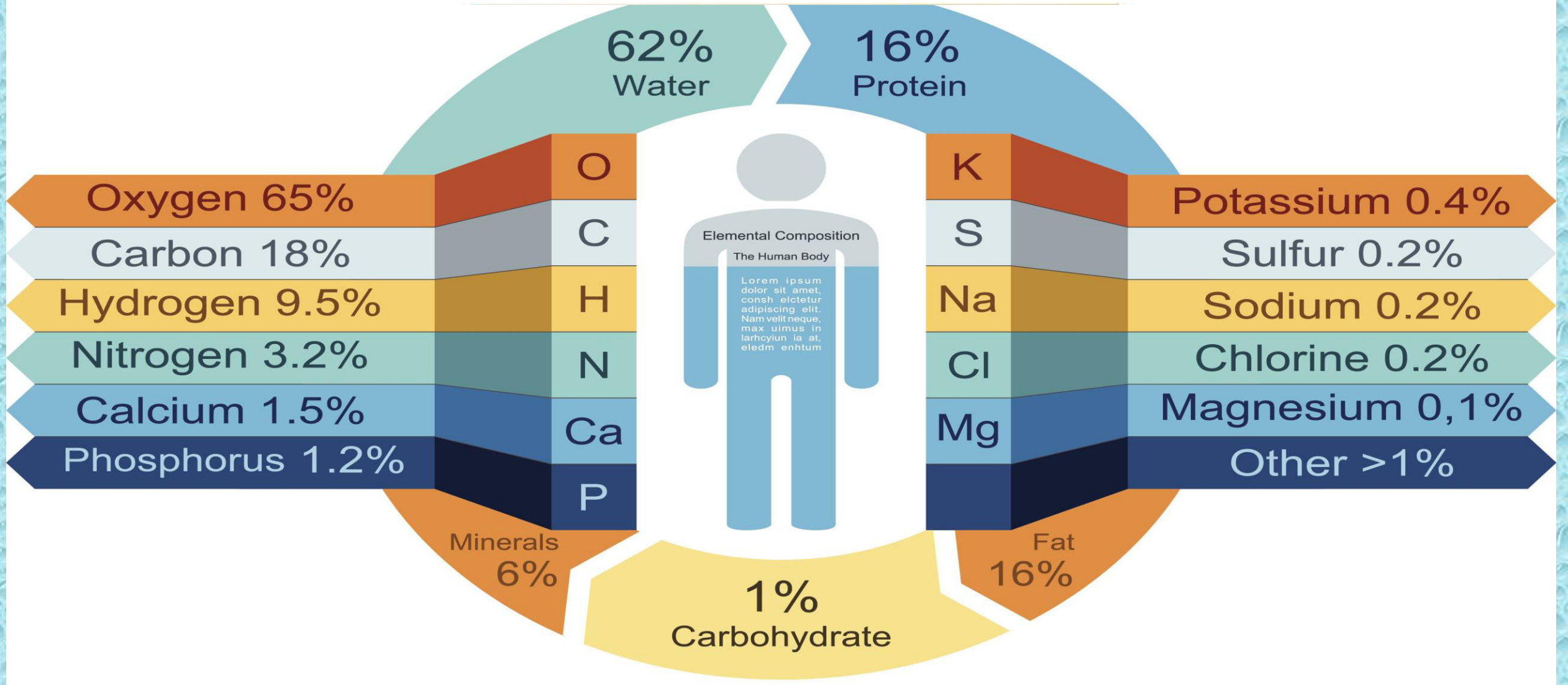
Molecular

Similarities based on genes



Biochemical

Different organisms have different chemical composition



Kingdom
Phylum
Class
Order
Family
Genus
Species

C. ASSIGNING SCIENTIFIC NAMES

1. Many organisms may have several different common names.

1a. The cougar is also known as the mountain lion, catamount, or puma …thus the need for a scientific name.

Felis concolor

Photo courtesy Texas Parks and Wildlife Department © 2004

Kingdom
Phylum
Class
Order
Family
Genus
Species

ASSIGNING SCIENTIFIC NAMES

2. A Swedish botanist named Carolus Linnaeus developed **Binomial Nomenclature**, a two-word naming system for naming all species on earth.

What do **Zoologist** study?

Kingdom
Phylum
Class
Order
Family
Genus
Species

ASSIGNING SCIENTIFIC NAMES

2a. The first part of the scientific name is the genus.

This word is always written first and capitalized.

It appears in italics or is underlined.

Homo sapien

Ursus arctos horribilis

Kingdom
Phylum
Class
Order
Family
Genus
Species

ASSIGNING SCIENTIFIC NAMES

2b. The second part of the scientific name is the species name.

This word is always written second and is not capitalized.

It appears in italics or is underlined.

Homo ***sapien***

Ursus ***arctos*** *horribilis*

Classification of Animals

- Aristotle classified organisms over 2000 years ago.
- When Carolus Linnaeus developed his system of classification, he had only 2 kingdoms, Plants and Animals, but the microscope led to the discovery of new organisms and the identification of differences in cells.
- A 2-kingdom system was no longer useful we now use 6 kingdoms.

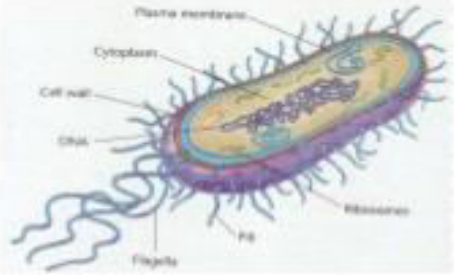
THE SIX KINGDOMS

PLANTAE
(Multicellular, eukaryotic)

ANIMALIA
(Multicellular, eukaryotic)

FUNGI
(Multicellular, eukaryotic)

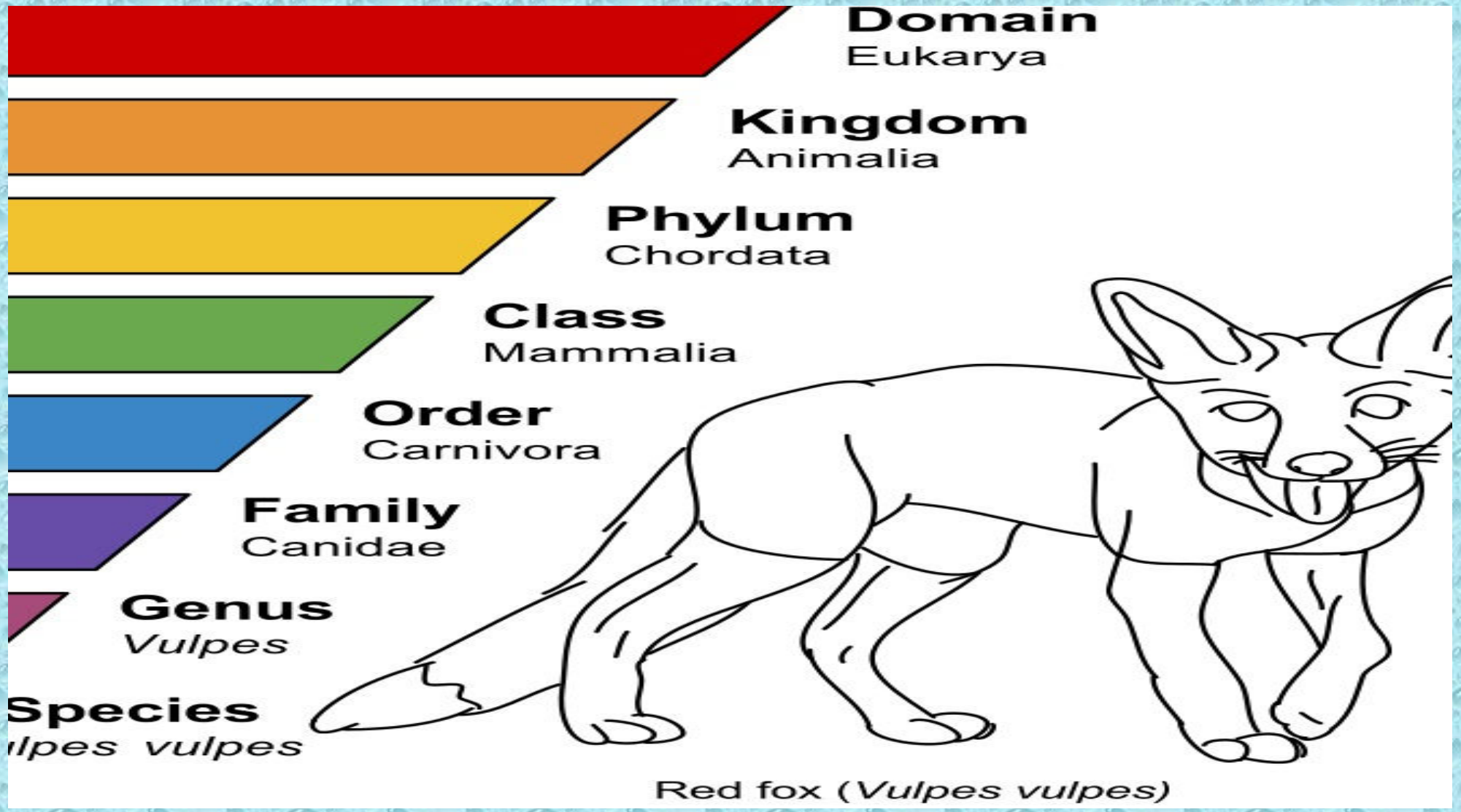
PROTISTA
(Eukaryotic, unicellular and multicellular)



EUBACTERIA
(Unicellular, prokaryotic)

ARCHAEBACTERIA
(Unicellular, prokaryotic)

Hierarchy of Categories



Kingdom
Phylum
Class
Order
Family
Genus
Species

LINNAEUS'S SYSTEM OF CLASSIFICATION

1. Linnaeus' hierarchical system of classification includes seven levels called taxa.

They are, from largest to smallest, **Kingdom, Phylum, Class, Order, Family, Genus, Species.**

Kingdom
Phylum
Class
Order
Family
Genus
Species

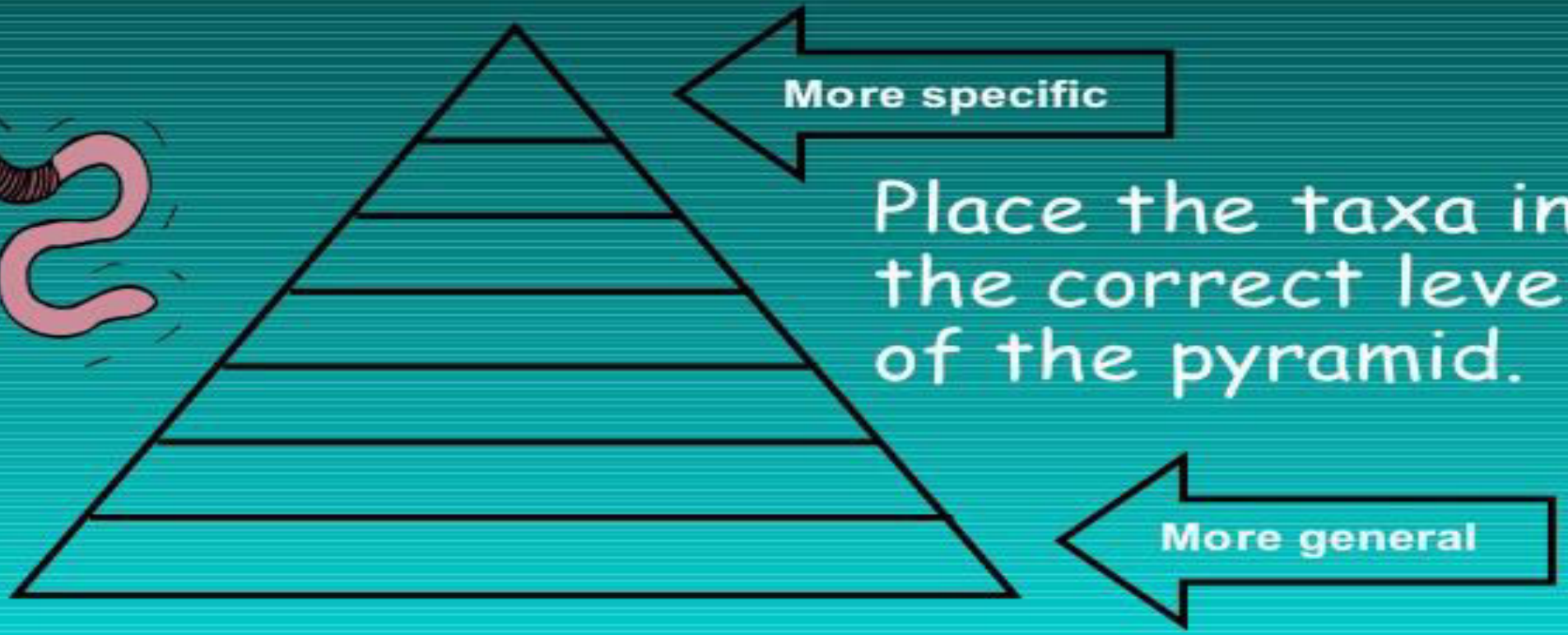
LINNAEUS'S SYSTEM OF CLASSIFICATION

2. The Kingdom is the largest and most inclusive (includes) of the taxonomic categories.
3. Species is the smallest and least inclusive of the taxonomic categories.

Kingdom
Phylum
Class
Order
Family
Genus
Species

LINNAEUS'S SYSTEM OF CLASSIFICATION

Kingdom, Phylum, Class, Order, Family, Genus, Species.



Place the taxa in the correct level of the pyramid.

Kingdom
Phylum
Class
Order
Family
Genus
Species

LINNAEUS'S SYSTEM OF CLASSIFICATION

4. The more taxonomic levels that two organisms share, the more closely related they are considered to be.

Kingdom
Phylum
Class
Order
Family
Genus
Species

THINKING CRITICALLY

Organism	Cat	Wolf	Fly
Kingdom	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Arthropoda
Class	Mammalia	Mammalia	Insecta
Order	Carnivora	Carnivora	Diptera
Family	Felidae	Canidae	Muscidae
Genus	*Felis*	*Canis*	*Musca*
Species	*F. domesticus*	*C. lupus*	*M. domestica*

Kingdom
Phylum
Class
Order
Family
Genus
Species

THINKING CRITICALLY

1. What type of animal is *Musca domestica*?

Animal; insect

2. From the table, which 2 animals are most closely related?

Cat and Wolf

3. At what classification level does the evolutionary relationship between cats and wolves diverge (become different)?

Family Level

Kingdom
Phylum
Class
Order
Family
Genus
Species

E. EVOLUTIONARY CLASSIFICATION

1. Biologists group organisms into categories that represent lines of evolutionary descent, or phylogeny, not just physical similarities.
2. Define Phylogeny: The study of evolutionary relationships among organisms.

Kingdom
Phylum
Class
Order
Family
Genus
Species

E. EVOLUTIONARY CLASSIFICATION

3. Classification using Cladograms

a. Cladograms are diagrams that show the evolutionary relationships among a group of organisms.

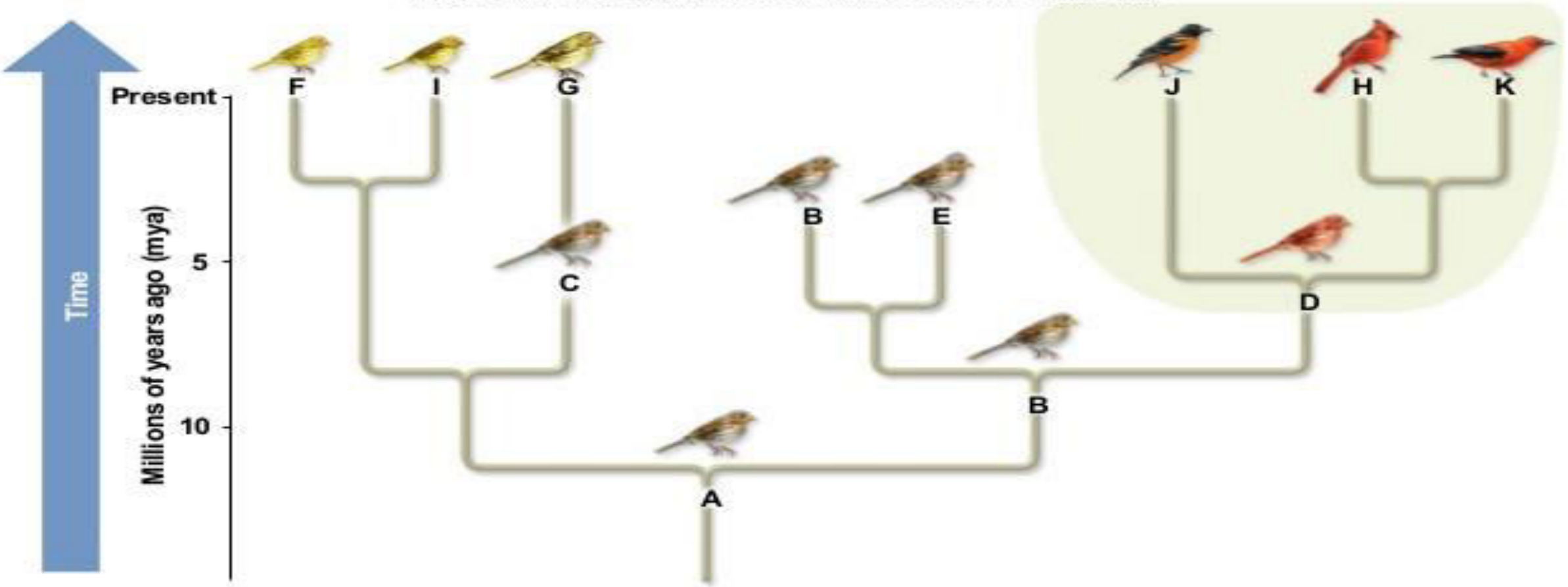
b. A phylogenic tree is a specific type of cladogram.

Phylogenetic trees

- Phylogeny – evolutionary history of a species or group of species
- To propose a phylogeny, biologists use the tools of systematics
- Trees are usually based on morphological or genetic data

Phylogenetic tree

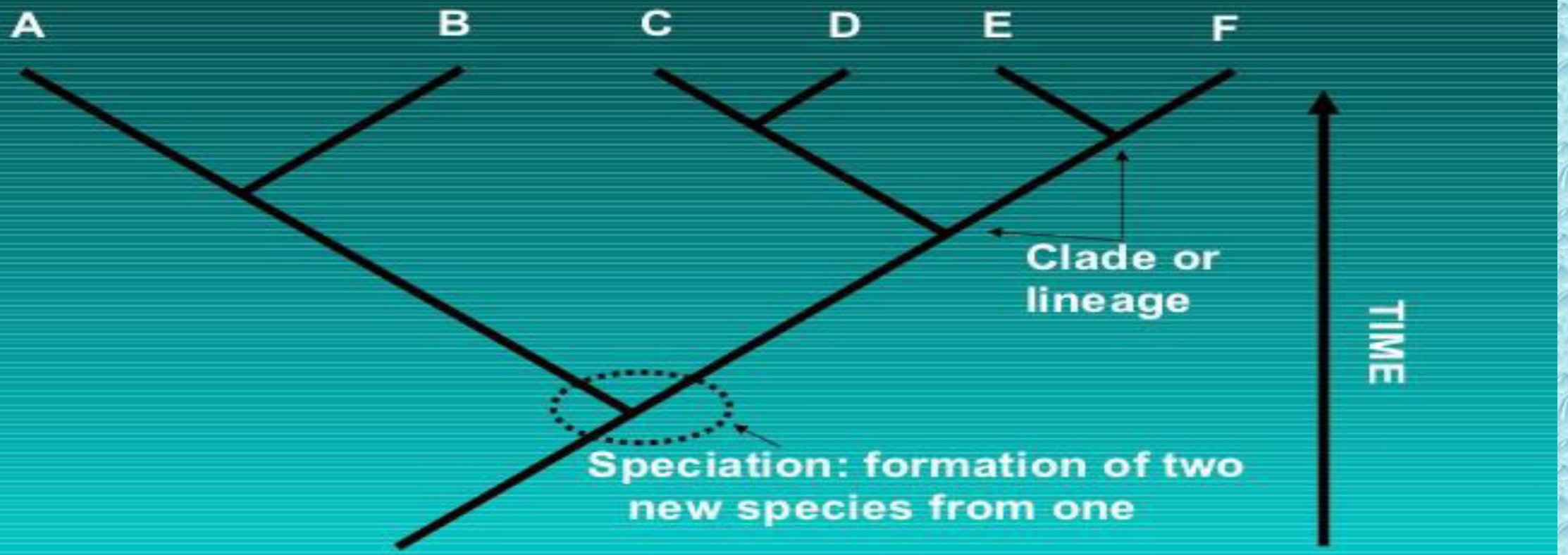
- Diagram that describes phylogeny
- A hypothesis of evolutionary relationships among various species
- Based on available information
- New species can be formed by
  - Anagenesis – single species evolves into a different species
  - Cladogenesis – a species diverges into 2 or more species



Kingdom
Phylum
Class
Order
Family
Genus
Species

E. EVOLUTIONARY CLASSIFICATION

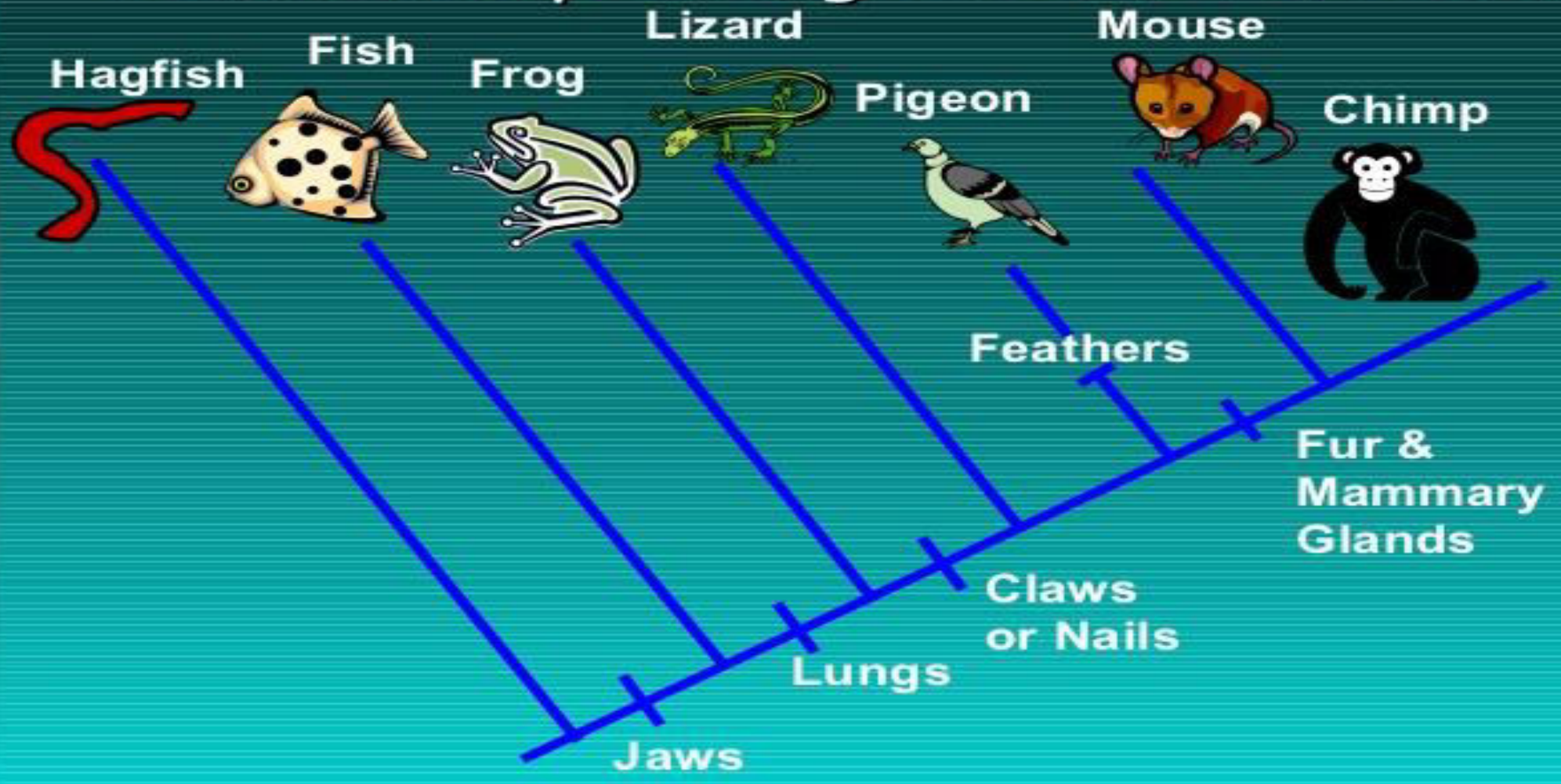
Example of a phylogenic tree.



Kingdom
Phylum
Class
Order
Family
Genus
Species

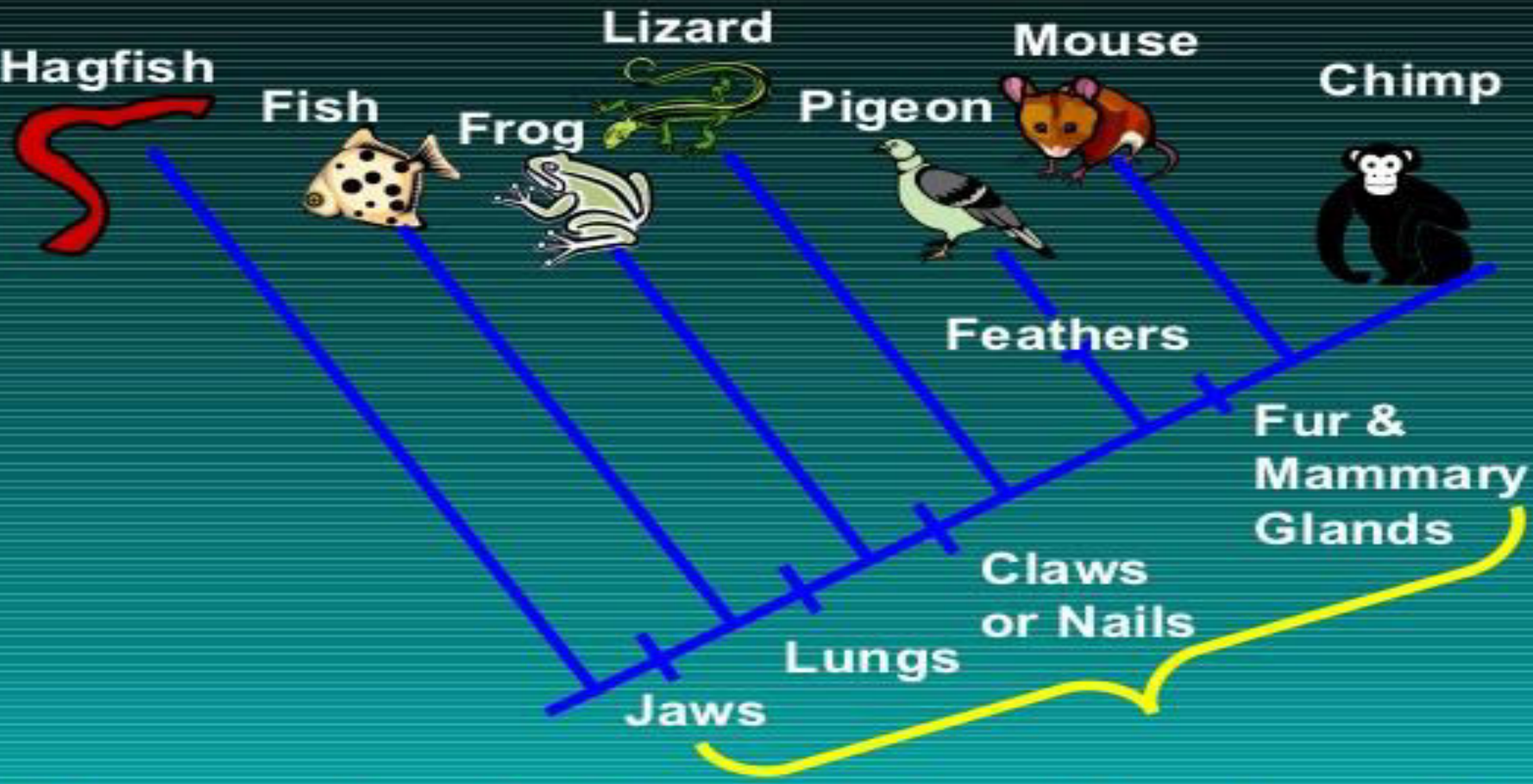
3. CLADOGRAMS

c. This cladogram shows the evolutionary relationship among several vertebrates.



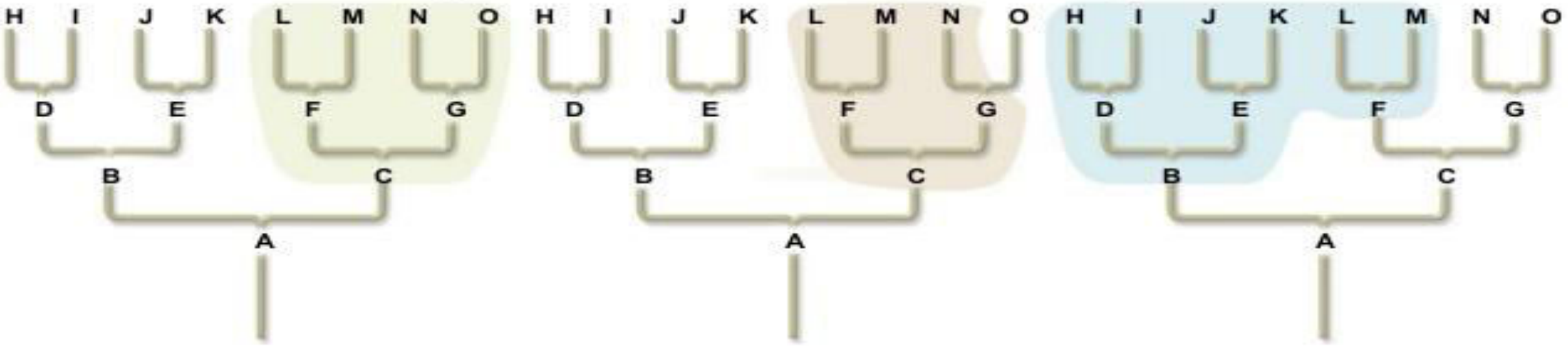
Kingdom
Phylum
Class
Order
Family
Genus
Species

3. CLADOGRAM



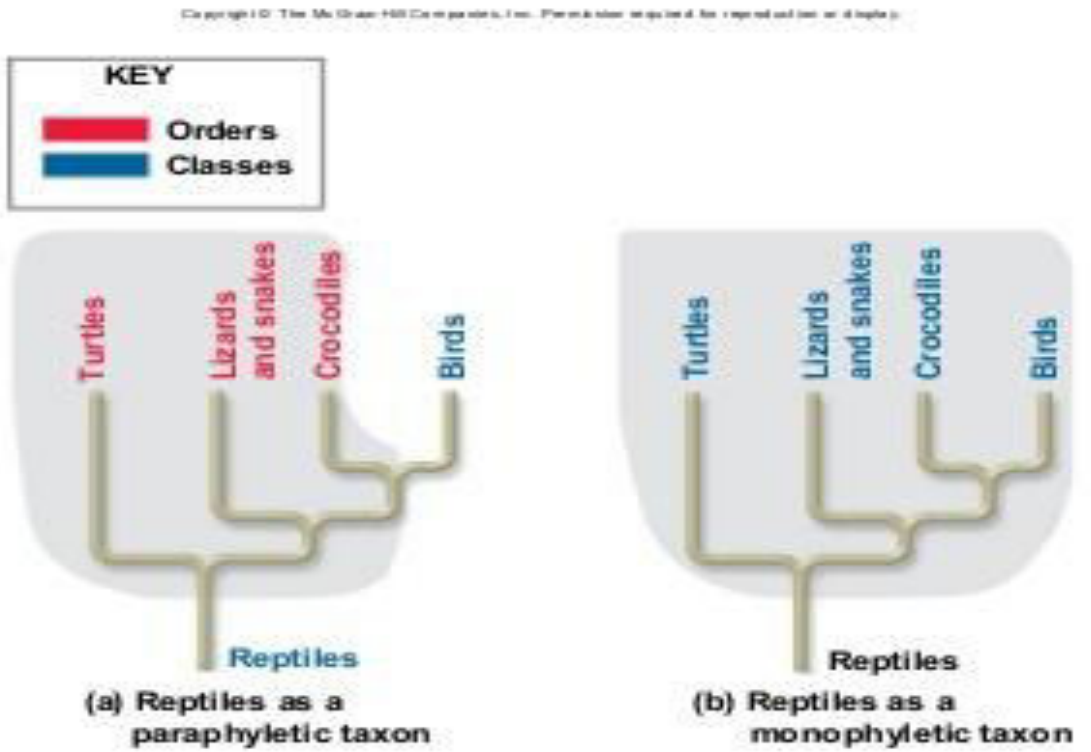
d. Characteristics listed below the line are called derived characters (traits).

- Monophyletic group or clade
  - Group of species, taxon, consisting of the most recent common ancestor and all of its ancestors
- Smaller and more recent clades are nested within larger clades that have older common ancestors
- Paraphyletic group
  - Contains a common ancestor and some, but not all, of its descendents



(a) Monophyletic (b) Paraphyletic (c) Polyphyletic

- Over time, taxonomic groups will be reorganized so only monophyletic groups are recognized
- Reptiles were a paraphyletic groups because birds were excluded

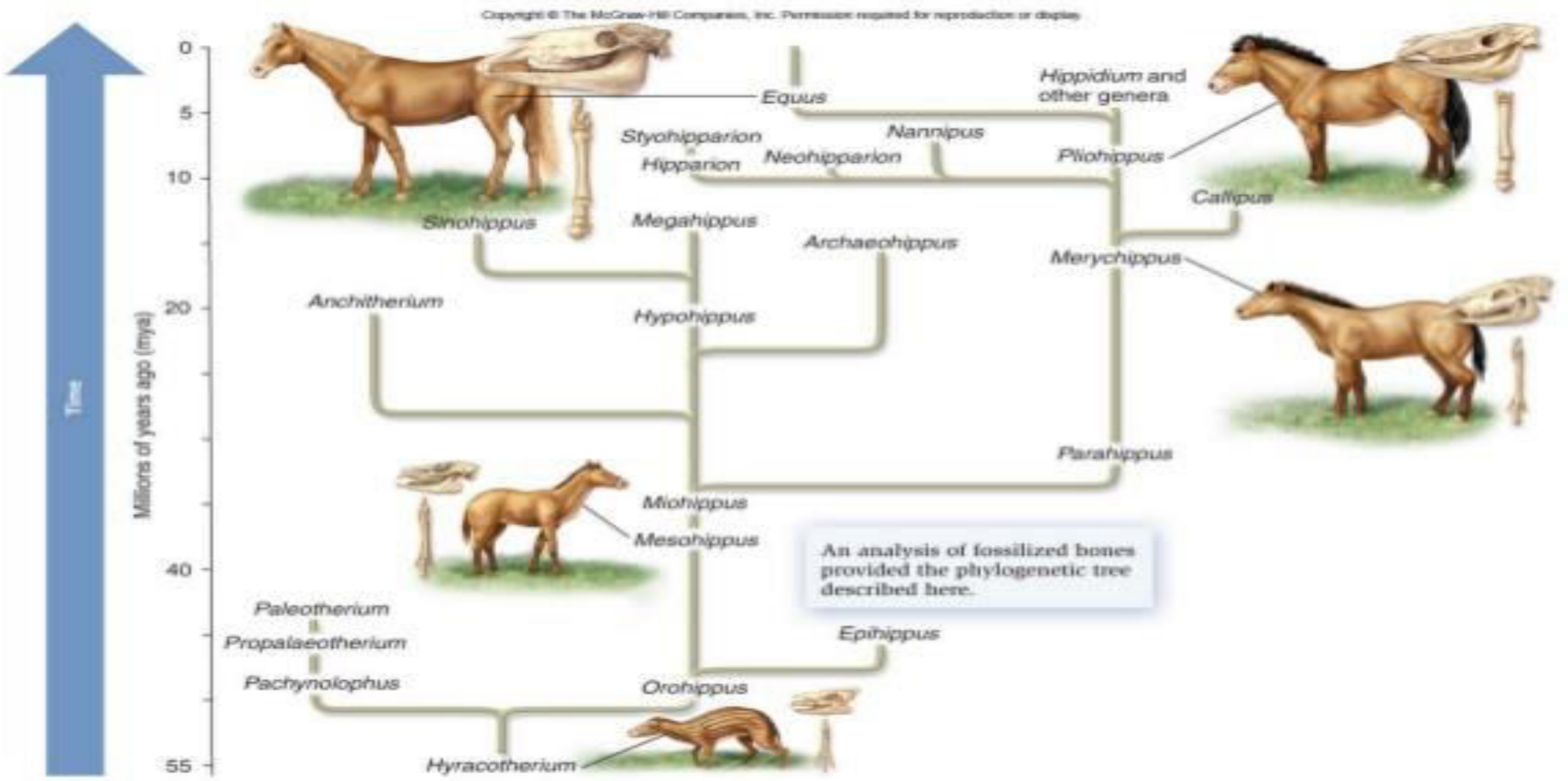


Homology

- Similarities among various species that occur because they are derived from a common ancestor
- Bat wing, human arm and cat front leg
- Genes can also be homologous if they are derived from the same ancestral gene

Morphological analysis

- First systematic studies focused on morphological features of extinct and modern species
- Convergent evolution (traits arise independently due to adaptations to similar environments) can cause problems

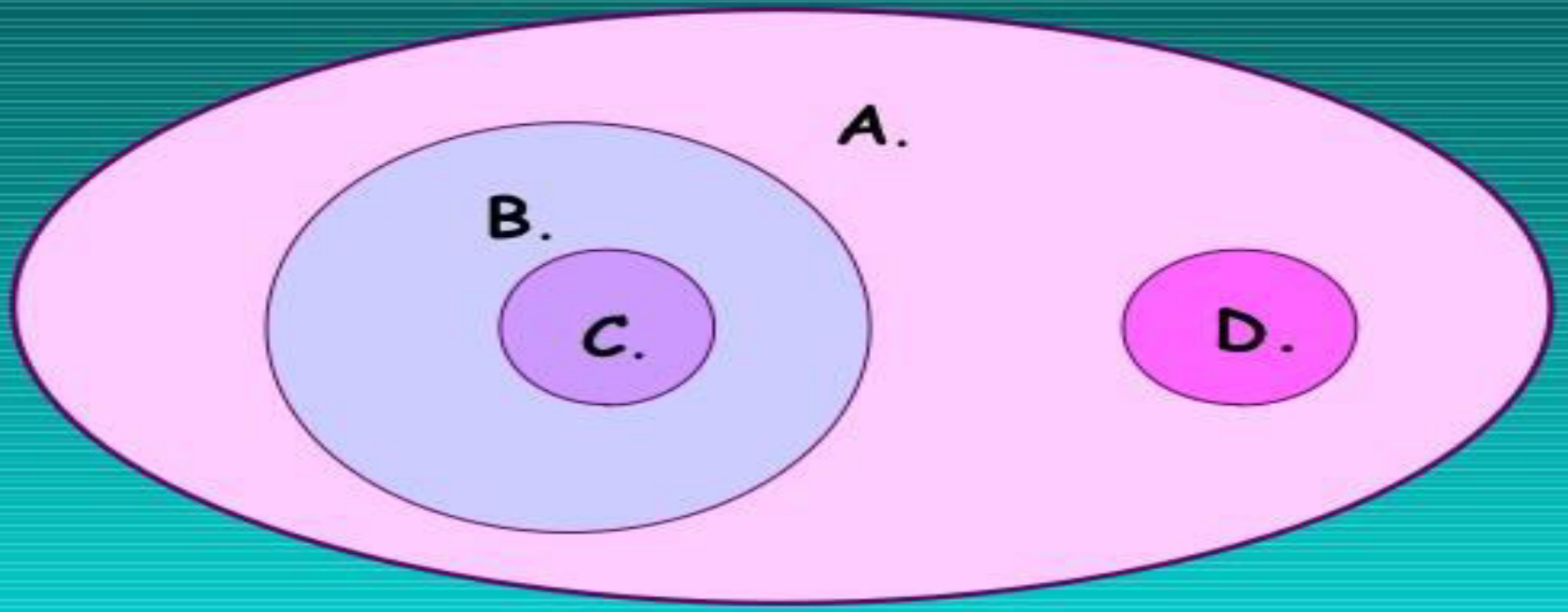

Time
Millions of years ago (mya)
0
5
10
20
40
55
Equus
Hippidium and other genera
Nannipus
Styohipparion
Hipparion
Neohipparion
Pliohippus
Calippus
Sinohippus
Megahippus
Archaeohippus
Merychippus
Anchitherium
Hypohippus
Parahippus
Miohippus
Mesohippus
An analysis of fossilized bones provided the phylogenetic tree described here.
Paleotherium
Propalaeotherium
Pachynolophus
Epihippus
Orohippus
Hyracotherium

Kingdom
Phylum
Class
Order
Family
Genus
Species

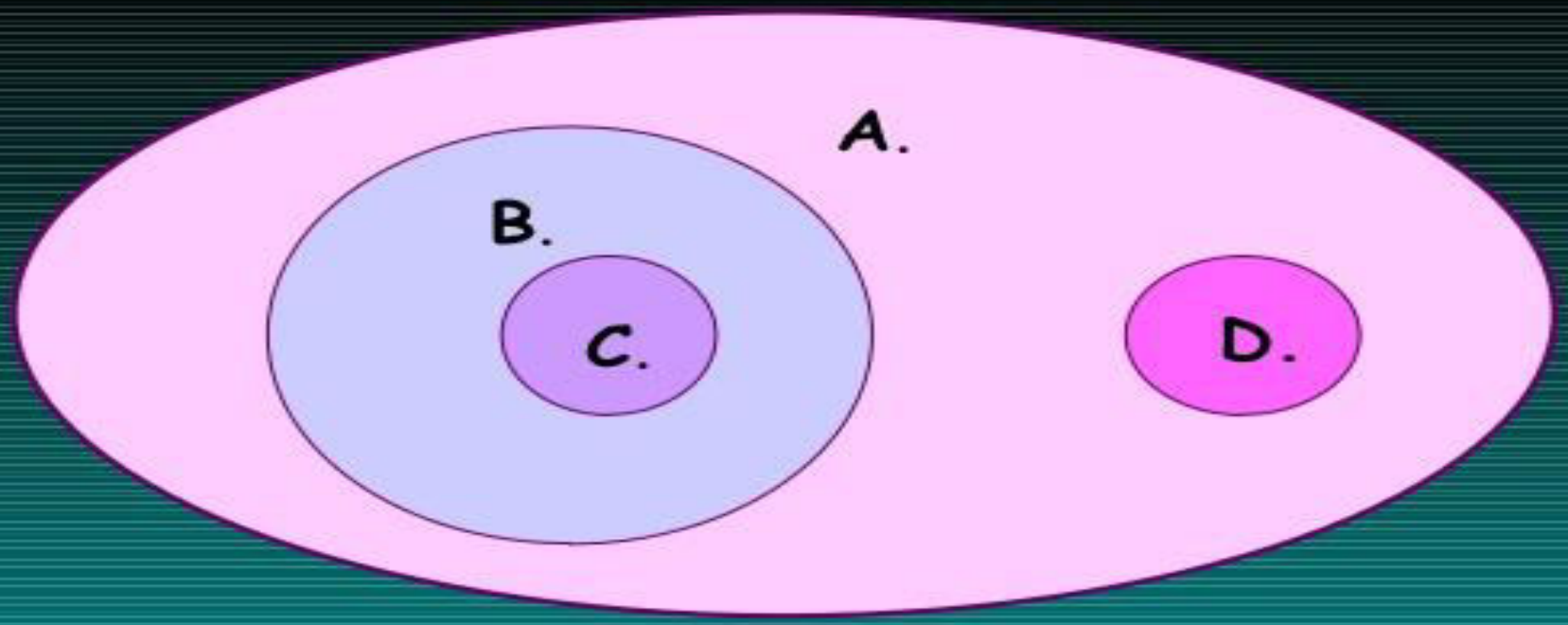
4. VENN DIAGRAMS

Venn Diagrams can be used to make models of a classification scheme.

- Venn diagrams show hierarchy and grouping relationships of organisms.

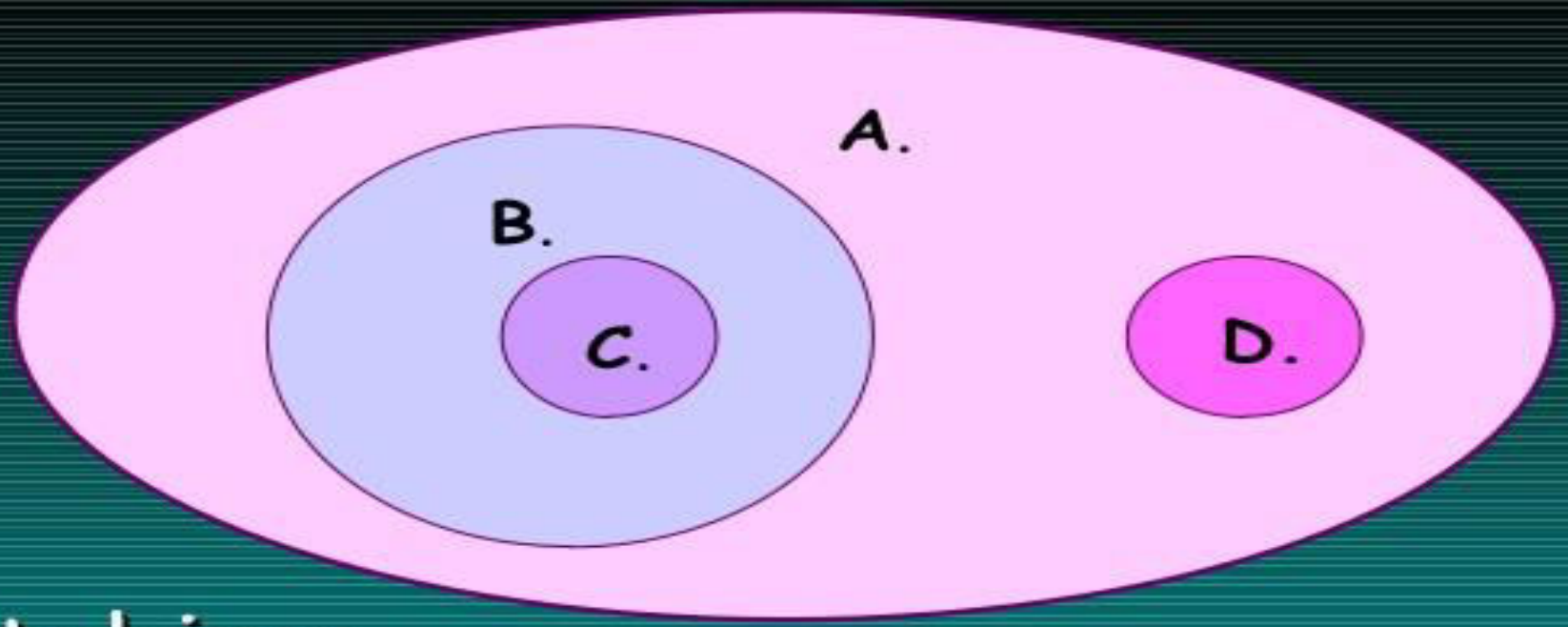


Kingdom
Phylum
Class
Order
Family
Genus
Species



- Four groups are represented by circular regions
- Each region represents different taxonomic levels.
- Regions that overlap, share common members.
- Regions that do not overlap do not have common members.

Kingdom
Phylum
Class
Order
Family
Genus
Species

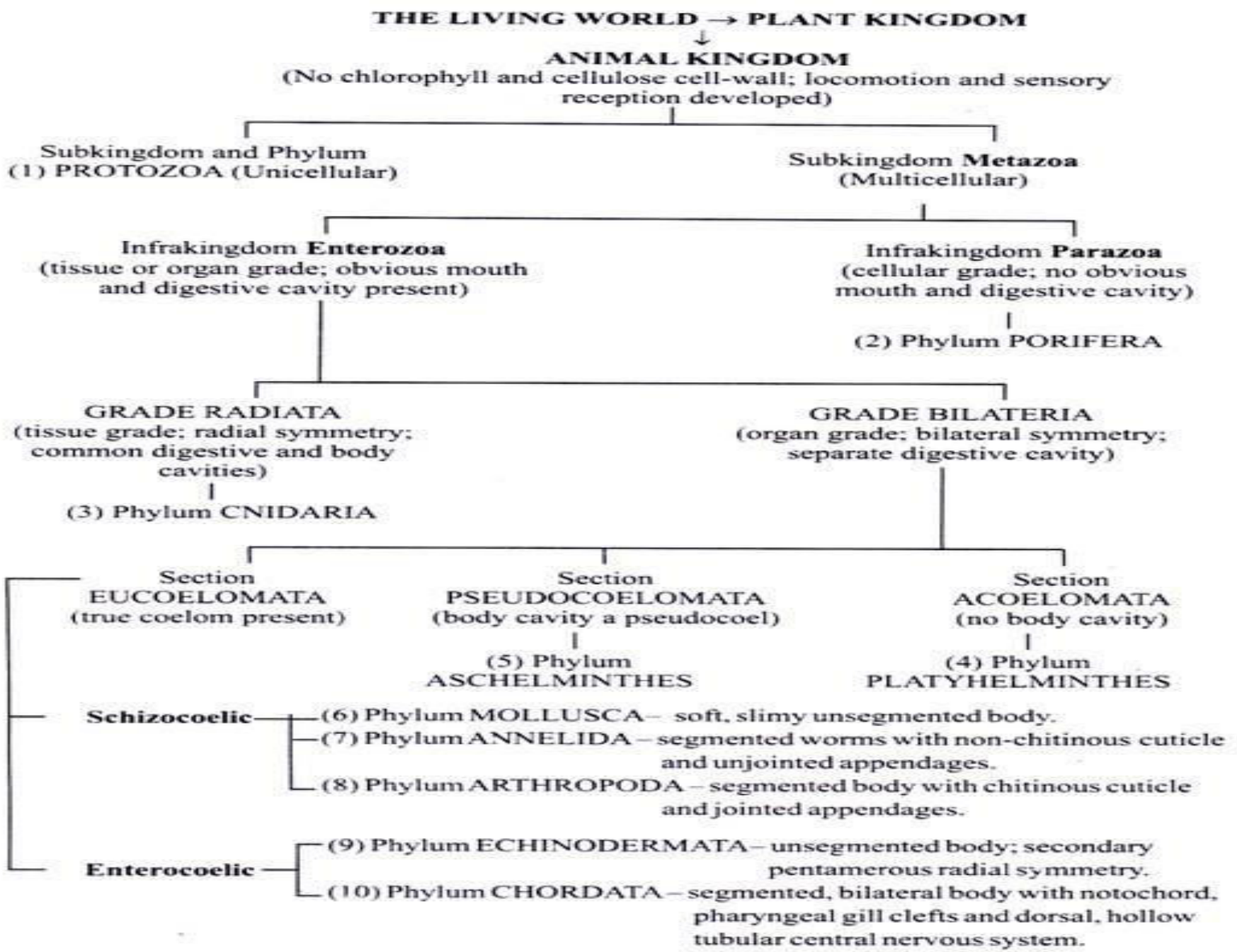


Matching:

- Mammals C
- Animals with backbones B
- Insects D
- All animals A

Important Criteria for Classifying Animals

- Symmetry
- Segmentation
- Appendages
- Skeleton
- Sex
- Embryonic development
- Larvae


THE LIVING WORLD → PLANT KINGDOM
ANIMAL KINGDOM
(No chlorophyll and cellulose cell-wall; locomotion and sensory reception developed)
Subkingdom and Phylum
(1) PROTOZOA (Unicellular)
Subkingdom Metazoa
(Multicellular)
Infrakingdom Enterozoa
(tissue or organ grade; obvious mouth and digestive cavity present)
Infrakingdom Parazoa
(cellular grade; no obvious mouth and digestive cavity)
(2) Phylum PORIFERA
GRADE RADIATA
(tissue grade; radial symmetry; common digestive and body cavities)
(3) Phylum CNIDARIA
GRADE BILATERIA
(organ grade; bilateral symmetry; separate digestive cavity)
Section
EUCOELOMATA
(true coelom present)
Section
PSEUDOCOELOMATA
(body cavity a pseudocoel)
(5) Phylum
ASCHELMINTHES
Section
ACOELOMATA
(no body cavity)
(4) Phylum
PLATYHELMINTHES
Schizocoelic
(6) Phylum MOLLUSCA – soft, slimy unsegmented body.
(7) Phylum ANNELIDA – segmented worms with non-chitinous cuticle and unjointed appendages.
(8) Phylum ARTHROPODA – segmented body with chitinous cuticle and jointed appendages.
Enterocoelic
(9) Phylum ECHINODERMATA – unsegmented body; secondary pentamerous radial symmetry.
(10) Phylum CHORDATA – segmented, bilateral body with notochord, pharyngeal gill clefts and dorsal, hollow tubular central nervous system.

CLASSIFICATION OF ANIMALS

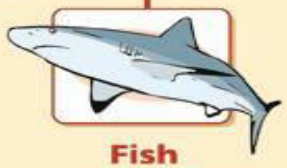
This is the grouping together of animals with similar characteristics. Animals can be classed as either vertebrates or invertebrates.

ANIMALS

VERTEBRATES

These are animals that have a backbone.

Reptiles
Have dry scaly skin.
Lay eggs on dry land.
Are cold blooded.
(Snake, Crocodile)



Fish
Have scales on their bodies.
Have gills for breathing.
Are cold blooded.
(Shark, Tuna)

Amphibians
Have moist slimy skin.
Lay eggs in water.
Are cold blooded.
(Frog, Newt)

Birds
Have feathers and wings.
Have beaks and lay eggs.
Are warm blooded.
(Wren, Swan)

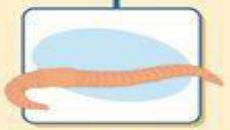
Mammals
Have fur or hair.
Feed young on milk.
Are warm blooded.
(Cow, Human)

INVERTEBRATES

These are animals that do not have a backbone.

Protozoa
Single cell organisms all microscopic.

Flatworms
Simple and soft bodied.
(Tape worm, Flukes)



Annelid Worms
Segmented bodies.
(Earthworm, Leech)

Echinoderms
Spiny sea creatures.
(Starfish, Sea urchin)

Coelenterates
Soft bodies, stinging cells.
(Jellyfish, Sea anemone)

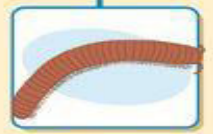
Arthropods
Hard external skeleton and jointed limbs.

Molluscs
Soft bodied, most have shells.
(Snails, Limpet)

Arachnids
Eight legs, two body parts, no antennae.
(Spider, Scorpion)

Crustaceans
Mostly sea creatures.
Many legs and two sets of antennae.
(Crab, Lobster)

Insects
Wings, six legs, three body parts, one pair of antennae.
(Bee, Ladybird)



Myriapods
Many legs and body segments.
(Centipede, Millipede)


Thank you
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