

BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS

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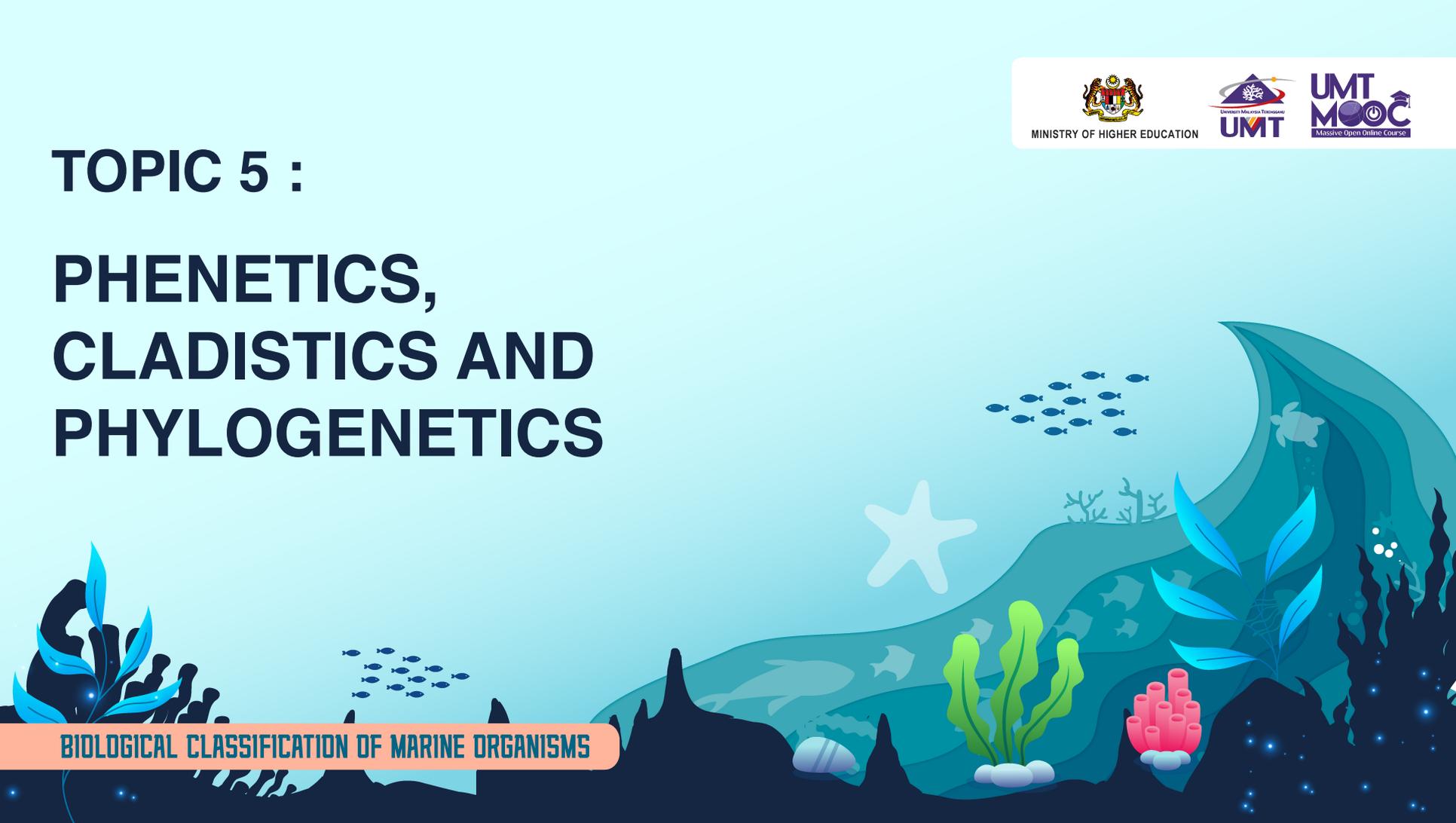
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TOPIC 5 :

PHENETICS, CLADISTICS AND PHYLOGENETICS

BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS





OBJECTIVES



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- Definitions
- Phylogenetic trees
- Cladistics
- Cladogram
- Construction of cladogram

BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS

Taxonomy

- The branch of biology concerned with naming and classifying diverse forms of life.

Phylogeny

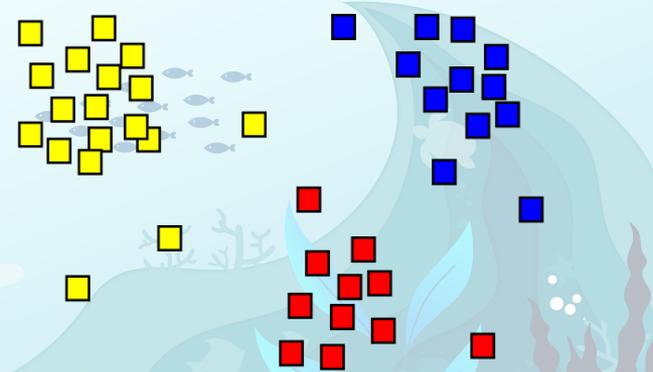
- *Greek phylon, tribe & genesis, origin*
- *The evolutionary history of a species or group of related species.*

Systematics

- The study of biological diversity in an evolutionary context.
- Reconstruct phylogeny.
- Name and classify species.

Phenetics

- also known as taximetrics
- an attempt to classify **organisms based on overall similarity, usually in morphology or other observable traits**
- regardless of their phylogeny or evolutionary relation.
- It is closely related to **numerical taxonomy**
 - taxonomy using **numeric algorithms like cluster analysis** rather than using subjective evaluation of their properties.



KEY POINTS FOR PHYLOGENETICS

- A **phylogenetic tree** is a diagram that **represents evolutionary** relationships among organisms.
 - Phylogenetic trees are hypotheses, not definitive facts.
- The **pattern of branching** in a phylogenetic tree reflects **how species or other groups evolved** from a series of common ancestors.
- In trees, two species are **more related** if they have a **more recent common ancestor** and **less related** if they have a less recent common ancestor.
- Phylogenetic trees can be drawn in various equivalent styles.
 - Rotating a tree about its branch points doesn't change the information it carries.

RE-CAP FOR TAXONOMY

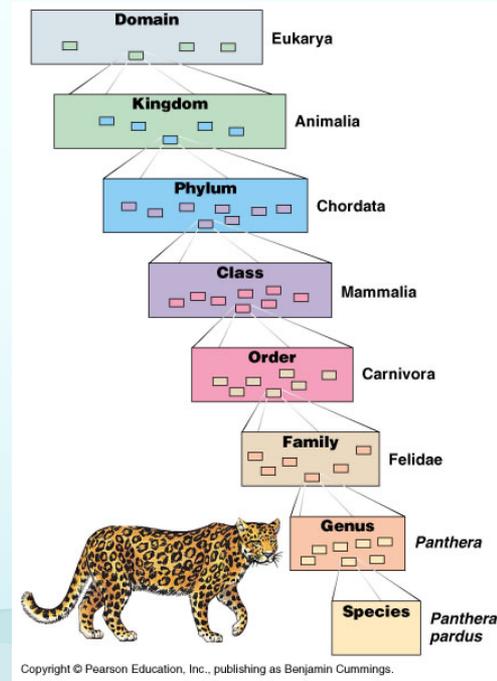
- Developed by Linnaeus in the 18th century
- It is a hierarchical system placing species into broader and broader groups of organisms.
- The groups include (from broad to specific)
 - **Kingdom** (keep)
 - **Phylum** (pots)
 - **Class** (clean)
 - **Order** (or)
 - **Family** (family)
 - **Genus** (gets)
 - **Species** (sick)



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- Linnaeus also developed a system of binomial nomenclature
- All organisms are given two-part latinized name
- The genus is the first name and is capitalized
- The species is the second name
- The names are italicized
- For example: *Canis lupis*



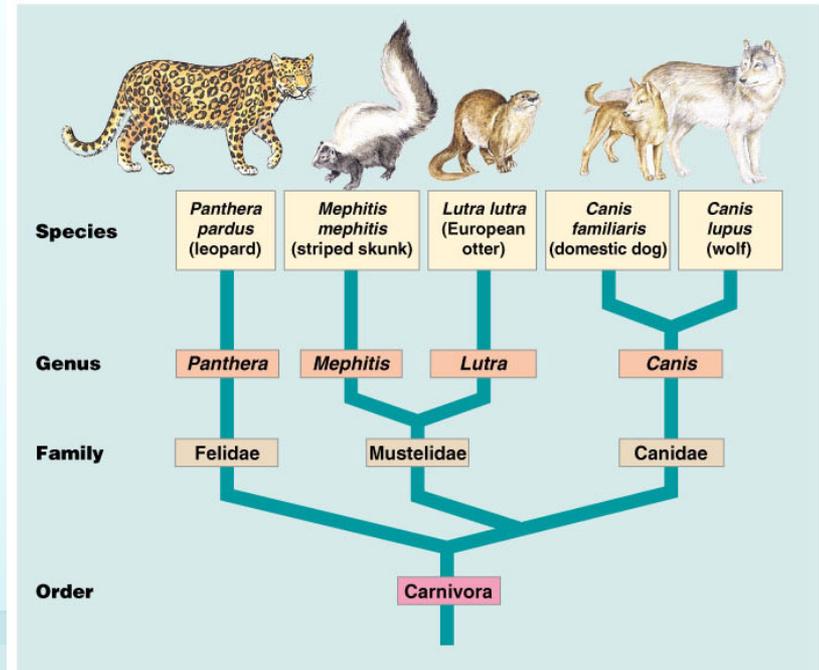
PHYLOGENETIC TREES



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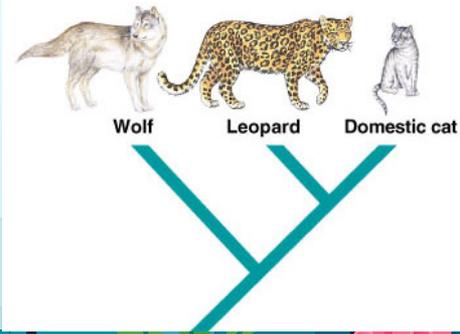
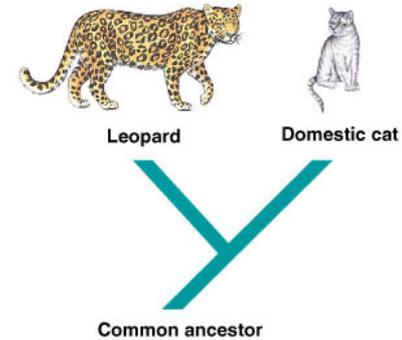


- **Phylogenetic trees** reflect the hierarchical classification of taxonomic groups nested within more inclusive groups



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- Creating a phylogenetic tree based on:
 - Each branch point represents the **divergence of two** species from a common ancestor
 - **Anatomical traits** that appear as **dichotomies**, or two-way branching points



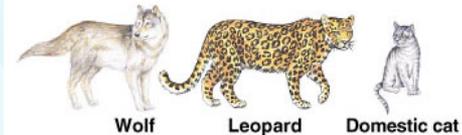
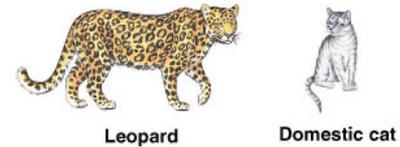
CLADOGRAM



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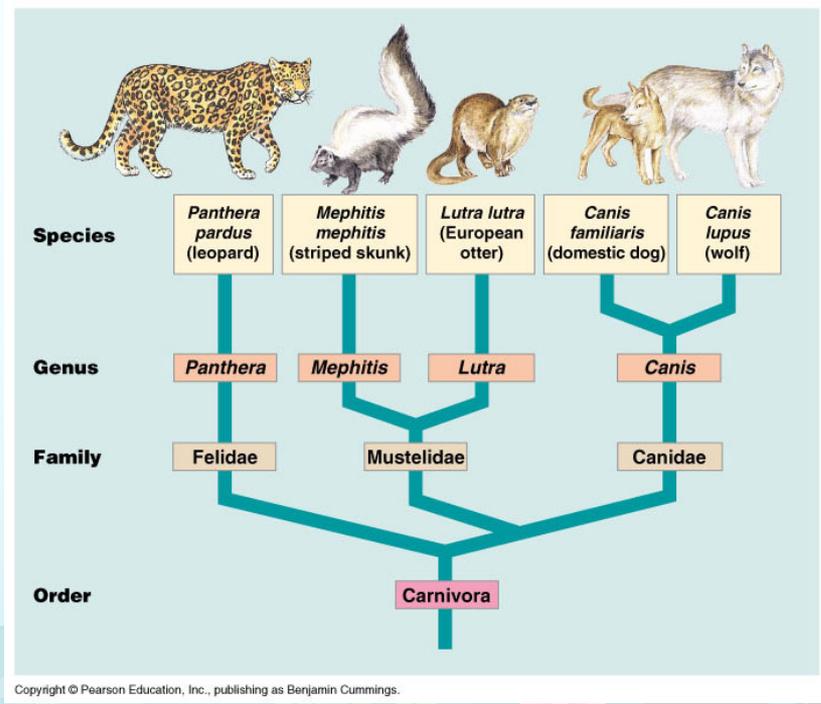


- A “tree” constructed from a series of dichotomies, or 2-way branch points that **represent divergence** of an animal from a common ancestor
 - the “deeper” the branch to greater the divergence
- The sequence symbolizes historical chronology



CLADOGRAM

- The sequence symbolizes historical chronology
- Clades
 - each branch in a cladogram; ancestral species and all of its descendents



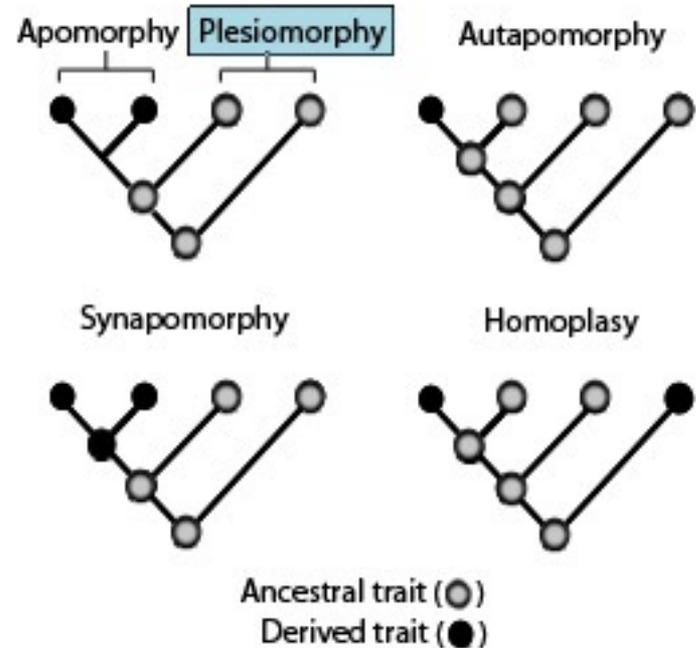
CLADISTICS



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- **Plesiomorphies**: a primitive or ancestral character state
- **Symplesiomorphies**: shared primitive characters
- **Synapomorphies**: shared derived characters
- **Autapomorphy**: derived character not shared with other species
- **Homoplasies**: convergent characters (analogous)



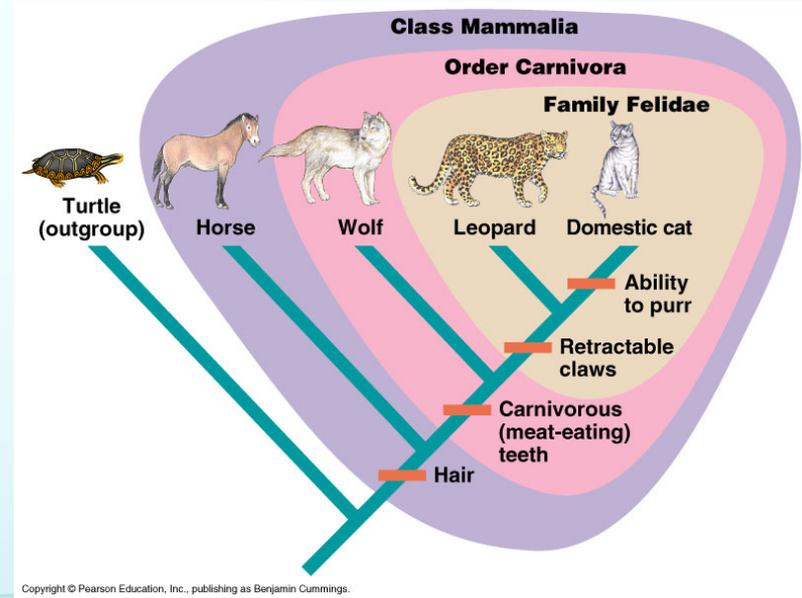
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CONSTRUCTION OF A CLADOGRAM



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• Homology

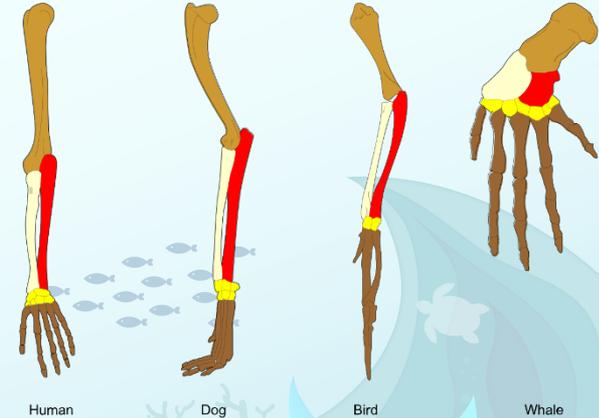
- likeness attributed to shared ancestry; all forelimbs of mammals are homologous

• Analogous

- Not all likeness qualifies as homology; represent adaptive features

• Convergent Evolution

- Species from different evolutionary branches may come to resemble one another if they have similar ecological roles and natural selection has shaped analogous adaptation. Similarity due to convergence is called analogy.
- Example – the wings of a bird, bat, and bee.



CONSTRUCTION OF A CLADOGRAM

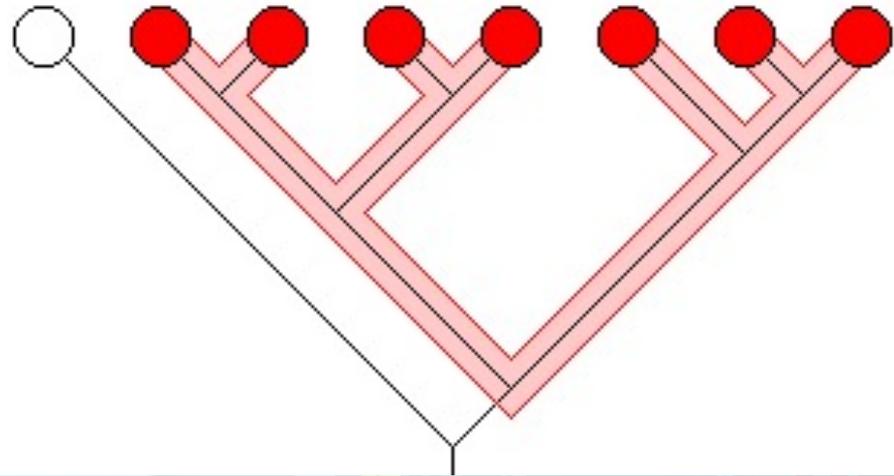


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- Monophyletic taxon
 - A group composed of **a collection of organisms**, including the **most recent common ancestor** of all those organisms and **all the descendants** of that most recent common ancestor.
 - A monophyletic taxon is also **called a clade**.
 - Examples : Mammalia, Aves (birds), angiosperms, insects, etc.

Monophyletic taxon (clade) :



CONSTRUCTION OF A CLADOGRAM



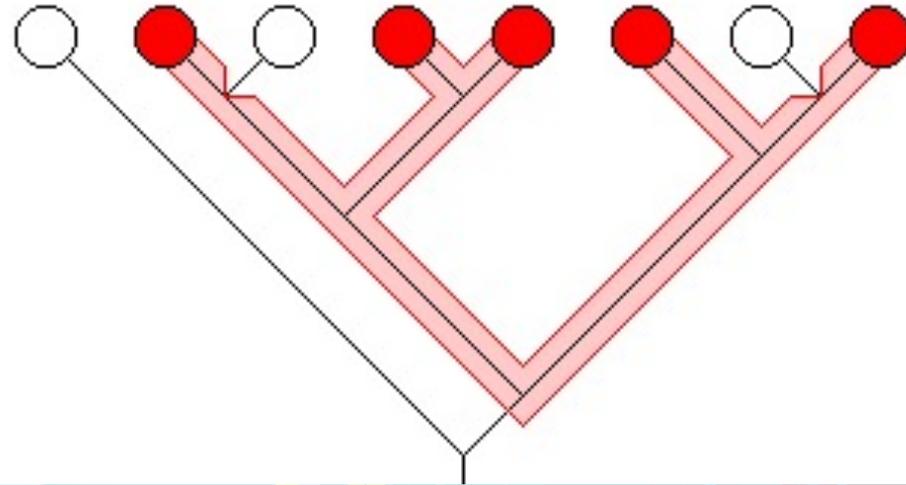
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• Paraphyletic taxon

- A group composed of a collection of organisms, including the most recent common ancestor of all those organisms.
- Unlike a monophyletic group, a **paraphyletic taxon does not include all the descendants of the most recent common ancestor.**
- **Examples :** Traditionally defined Dinosauria, fish, gymnosperms, invertebrates, protists, etc.

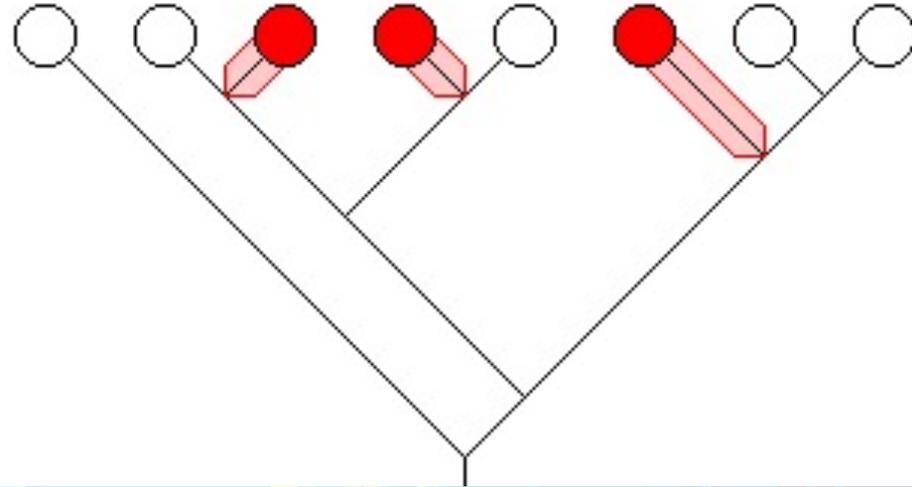
Paraphyletic taxon :



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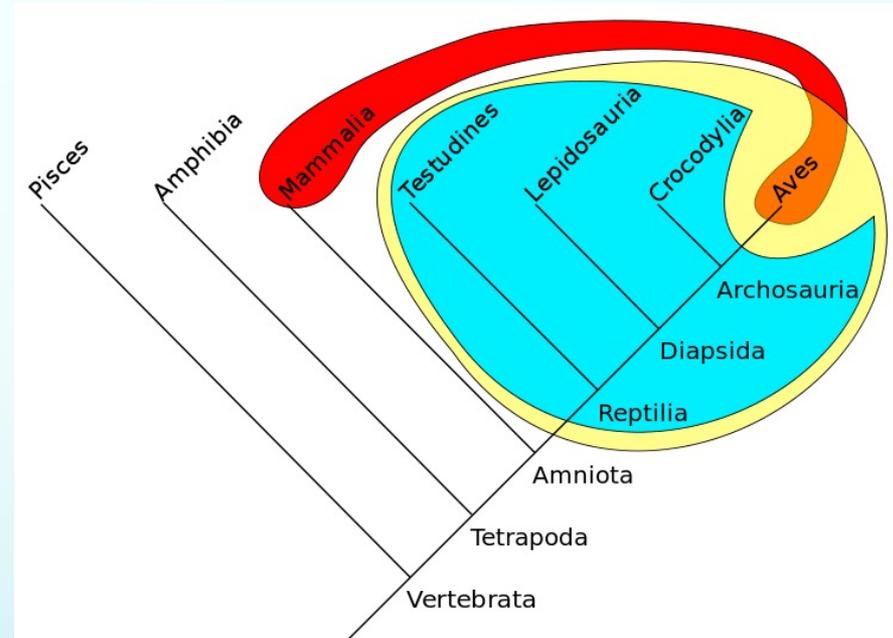
- Polyphyletic taxon
 - A group composed of a collection of organisms in **which the most recent common ancestor of all the included organisms is not included, usually because the common ancestor lacks the characteristics of the group.**
 - Polyphyletic taxa are considered "unnatural", and usually are reclassified once they are discovered to be polyphyletic.
 - Usually reflect **convergent evolution**
 - **Examples :** marine mammals, bipedal mammals, flying vertebrates, trees, algae, etc.

Polyphyletic taxon :



A cladogram of the vertebrates

- **A monophyletic taxon (in yellow):** the group of "reptiles and birds", contains its most recent common ancestor and all descendants of that ancestor.
- **A paraphyletic taxon (in cyan):** the group of reptiles, contains its most recent common ancestor, but does not contain all the descendants (namely Aves) of that ancestor.
- **A polyphyletic "group" (in red):** the group of all warm-blooded animals (Aves and Mammalia), does not contain the most recent common ancestor of all its members



Yellow Monophyly
Cyan Paraphyly
Red Polyphyly

CONSTRUCTION OF A CLADOGRAM



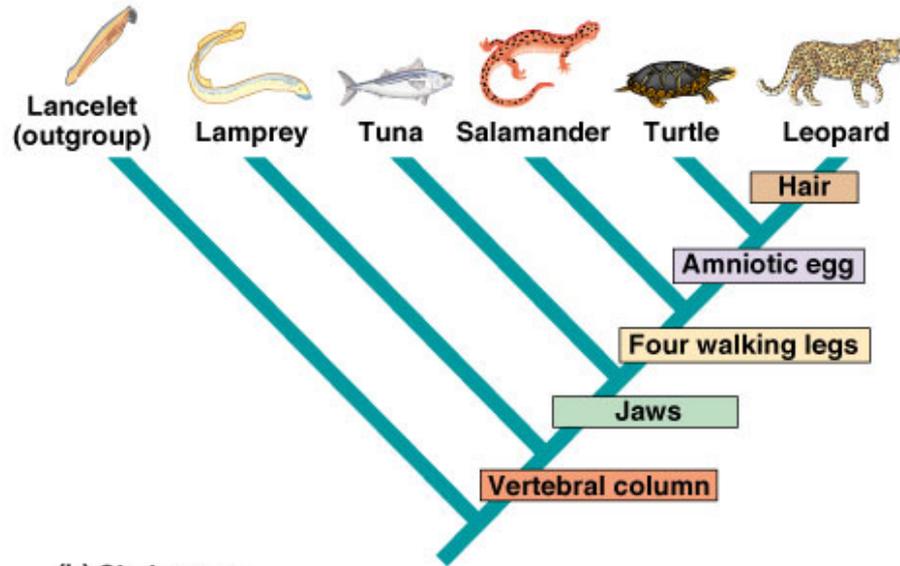
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CHARACTERS	TAXA					
	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking legs	0	0	0	1	1	1
Jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1

(a) Character table

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(b) Cladogram

•convergent evolution

- different species possess **common characteristics** because they have similar ecological roles and natural selection pressures.
- Some organisms have **analogous structures/ adaptations**
 - i.e. wings of butterfly/wings of a bird are analogous flight equipment.

CASE STUDY 1



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A long-beaked echidna (*Zaglossus bartoni*) an endangered species is pictured.

PHOTO BY TIM LAMAN



Aardvark walking

PHOTO BY BEVERLY JOUBERT



Giant anteater

Myrmecophaga tridactyla

PHOTO BY DARLYNE A. MURAWSKI

CASE STUDY 2



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Colugo

PHOTO BY TIM LAMAN



Dimorphodon in flight

IMAGE COURTESY ATLANTIC PRODUCTIONS /
ZOO



Northern Flying Squirrel,

Glaucomys sabrinus,
gliding

CASE STUDY 3



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Bird

PHOTO BY RICH REID



Dimorphodon in flight

IMAGE COURTESY ATLANTIC PRODUCTIONS /
ZOO



Bat

PHOTO BY MATTIAS KLUM

1. Molecular changes

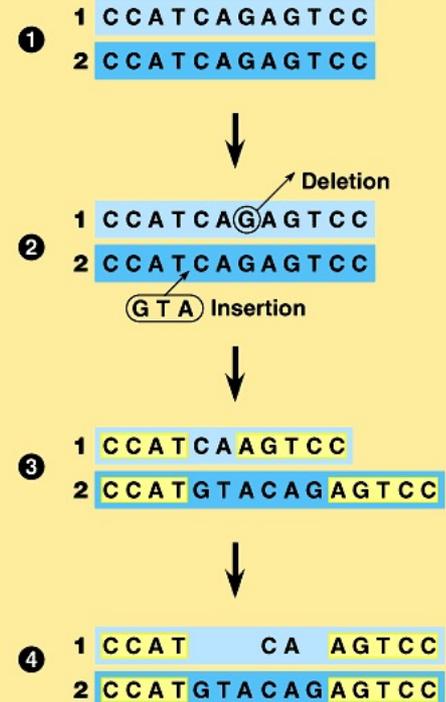
- Many organisms share **similar sequences of DNA and amino acids (polypeptides)**
- Mutations- **insertions/deletions** occur over time
- Databases & computer programs are used to assess phylogenetic relationships that cannot be measured by comparative anatomy or other methods



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Aligning segments of DNA

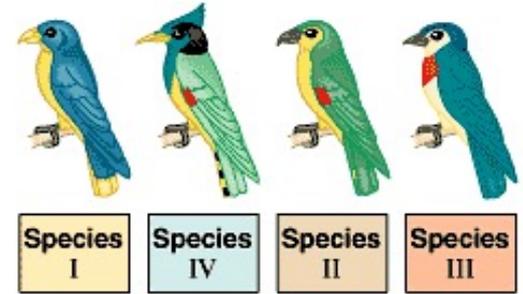
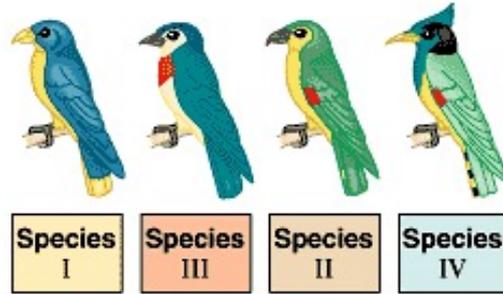
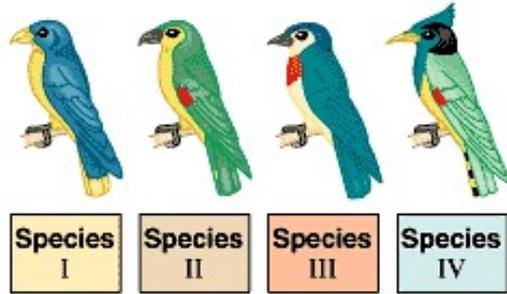


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CASE STUDY 1



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Sites in DNA sequence

		1	2	3	4	5	6	7
1	I	A	G	G	G	G	G	T
	II	G	G	G	A	G	G	G
	III	G	A	G	G	A	A	T
	IV	G	G	A	G	A	A	G

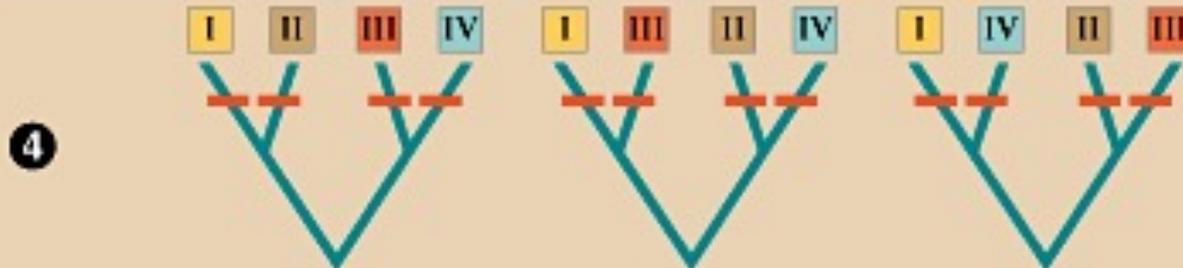
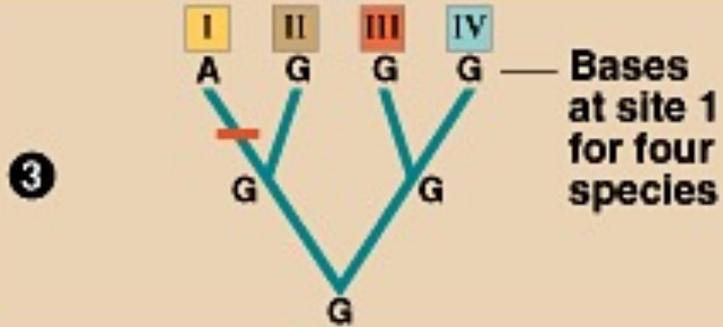
Species

2

Three phylogenetic hypotheses

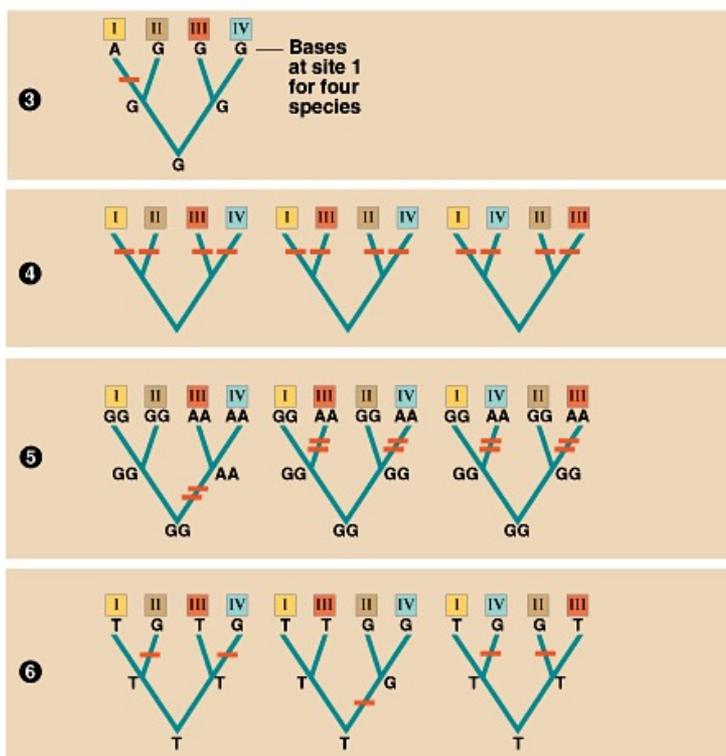
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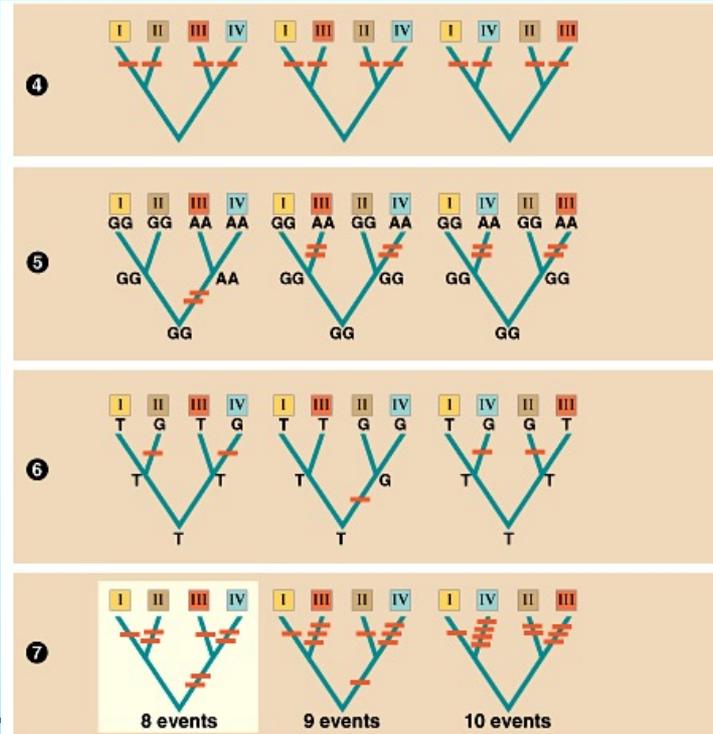


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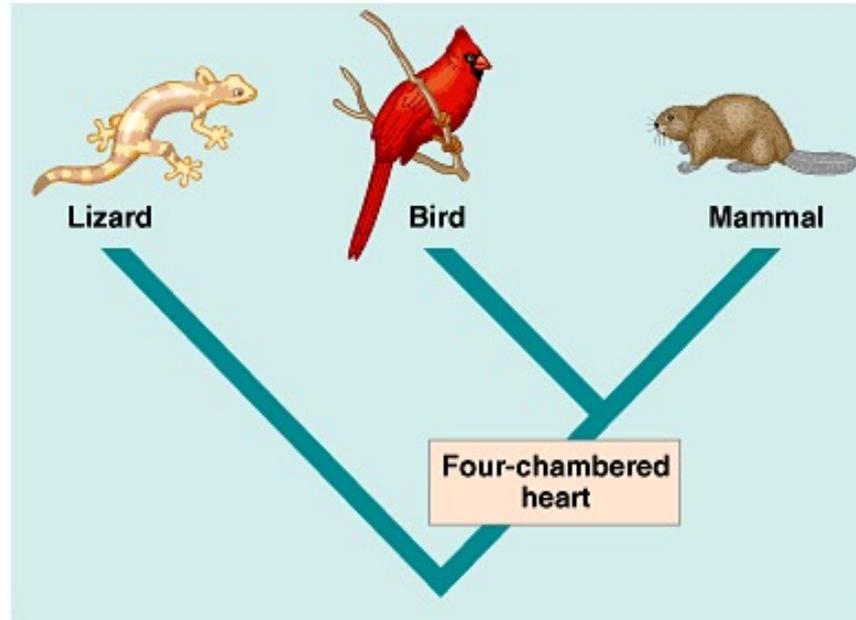




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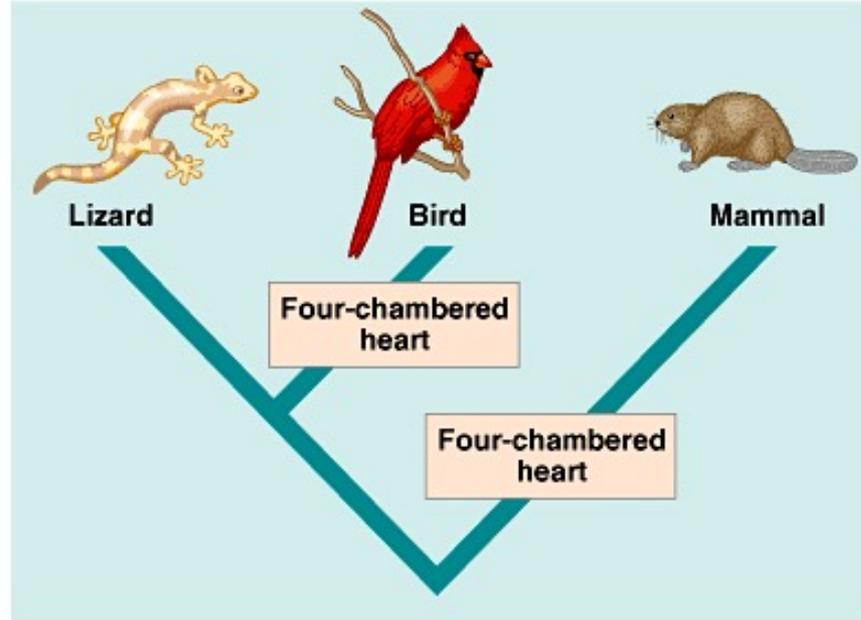


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(a) Mammal–bird clade

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(b) Lizard–bird clade

2. Molecular clock

- using differences in the sequence of DNA and in protein amino acid sequence to **place the origin of taxonomic groups in time.**
- Based on the observation that at least some regions of **genomes evolve at constant rates.**
- The **number of nucleotide and amino acid substitutions** is proportional to the time that has elapsed since the lineages branched.

- Phylogenetic trees (Khan Academy)

<https://www.khanacademy.org/science/biology/her/tree-of-life/a/phylogenetic-trees>

- How to understand evolutionary trees

• <https://www.youtube.com/watch?v=RVW8iIEfiZI>