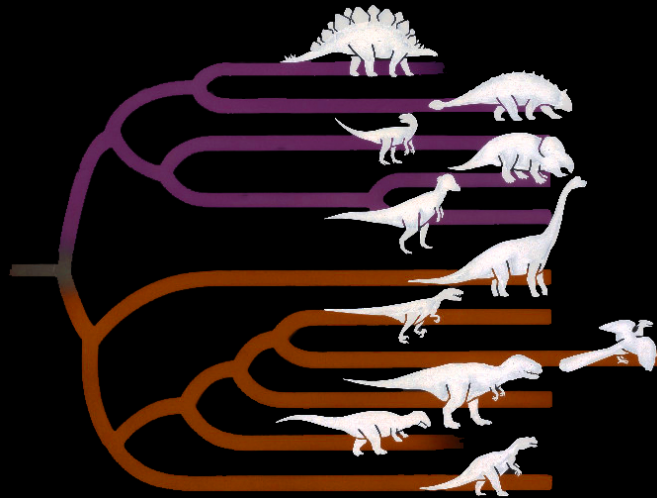


Classification & speciation



1

What is a species?

- A human-made construct to categorize variation. Species are difficult to define because of the amount of variation in nature.
- Most commonly, a species is an **interbreeding group** of animals or plants that are **reproductively isolated** through anatomy, ecology, behavior, or geographic distribution from all other such organisms.

2

Species concepts

- **Biological species concept**
 - Interbreeding populations, reproductively isolated from others
- **Phylogenetic species concept**
 - Smallest distinguishable cluster of ancestors & descendants
- **Evolutionary species concept**
 - Unique evolutionary lineages
- **Recognition species concept**
 - Unique traits/behaviors that allow identification of mates

3

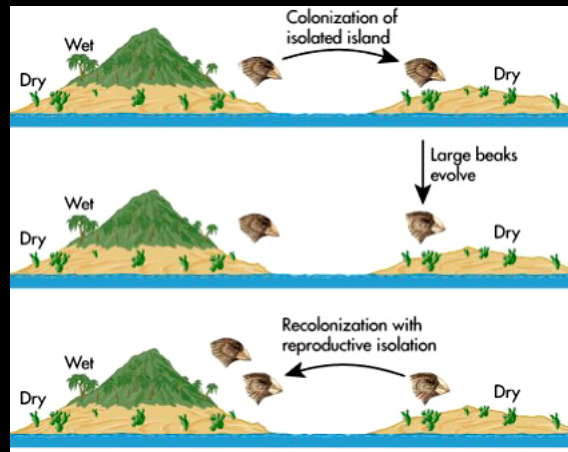
Reproductive isolating mechanisms

- **Habitat isolation** - species A & B occupy different habitats (e.g., arboreal vs. terrestrial)
- **Temporal isolation** - Species A & B breed in different months, or are active by day vs. night
- **Behavioral isolation** - Courtship behavior by males of species A does not elicit a response by females of species B
- **Mechanical incompatibility** - species A & B cannot mate successfully because of anatomical difference

4

Speciation

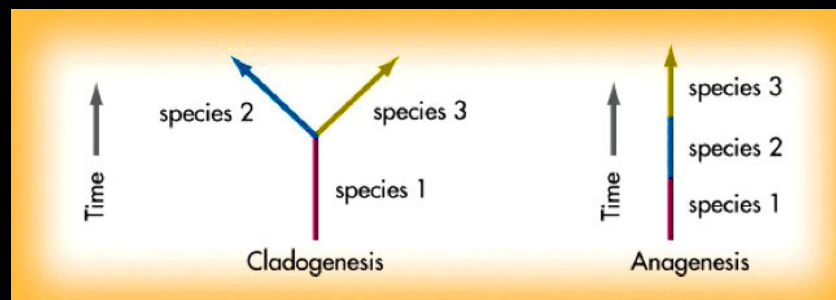
- **Allopatric speciation**
 - Speciation occurring via geographic isolation.



5

Modes of speciation

- **Speciation** is the formation of one or more species via (reproductive) isolation.



CLADOGENESIS:
Branching of a species
or lineage

ANAGENESIS:
Speciation within a
lineage

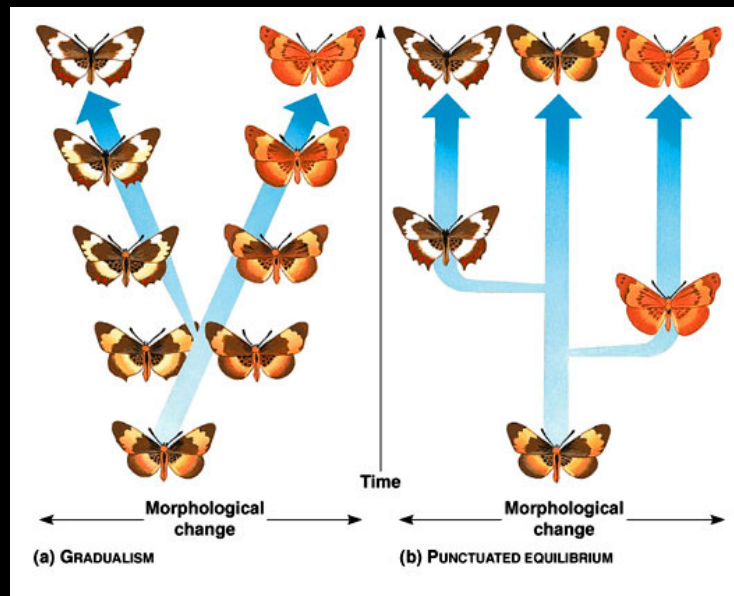
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Tempo of speciation

- **Phyletic gradualism (slow)**
 - Darwinian view of slow, incremental evolutionary change.
- **Punctuated equilibrium (fast)**
 - Model of evolution characterized by rapid bursts of change, followed by long periods of stasis.

7

Tempo of speciation



8

Classification

- What is your favorite living species? Look up its binomial name and the following:

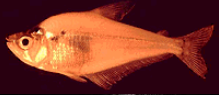
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Caviidae
Genus	<i>Cavia</i>
Species	<i>Cavia porcellus</i>



11

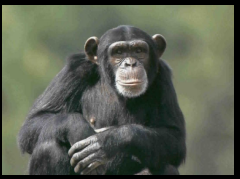










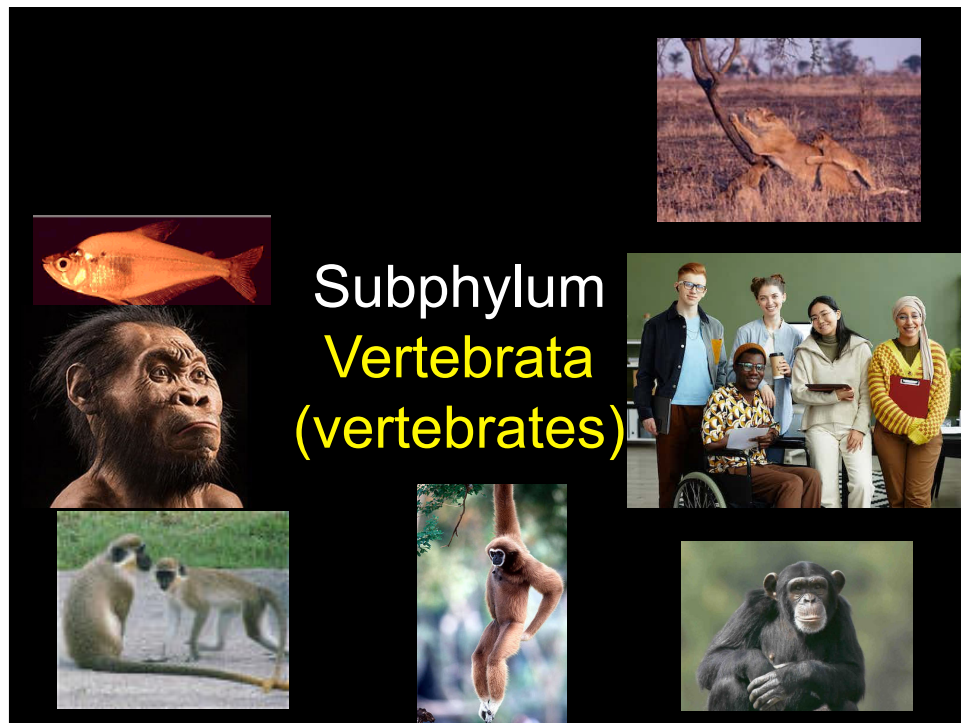


Kingdom
Animalia
(animals)

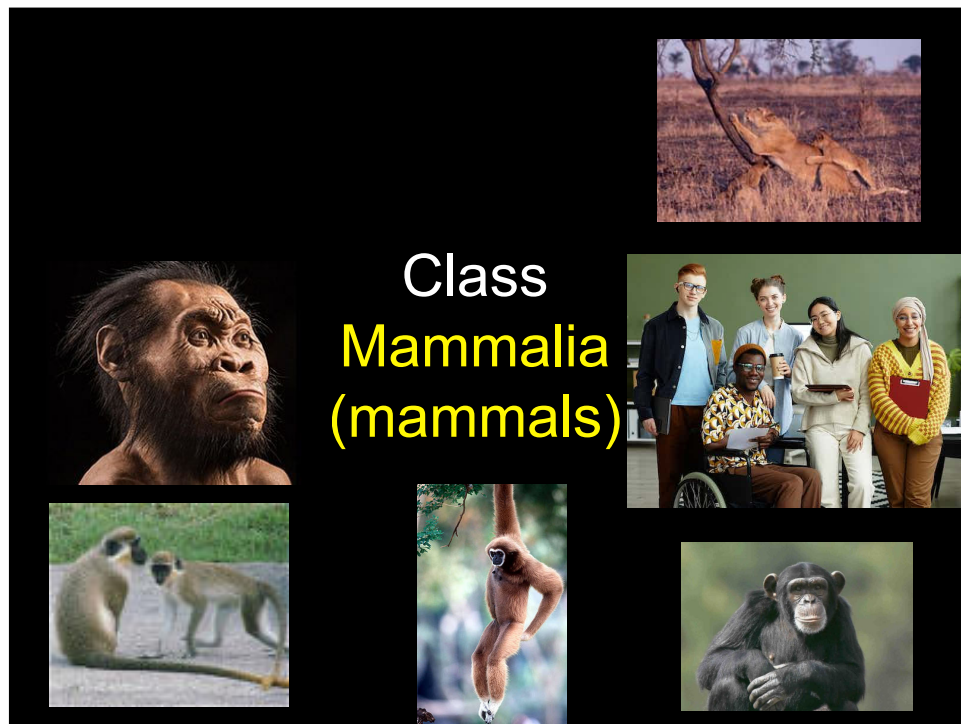
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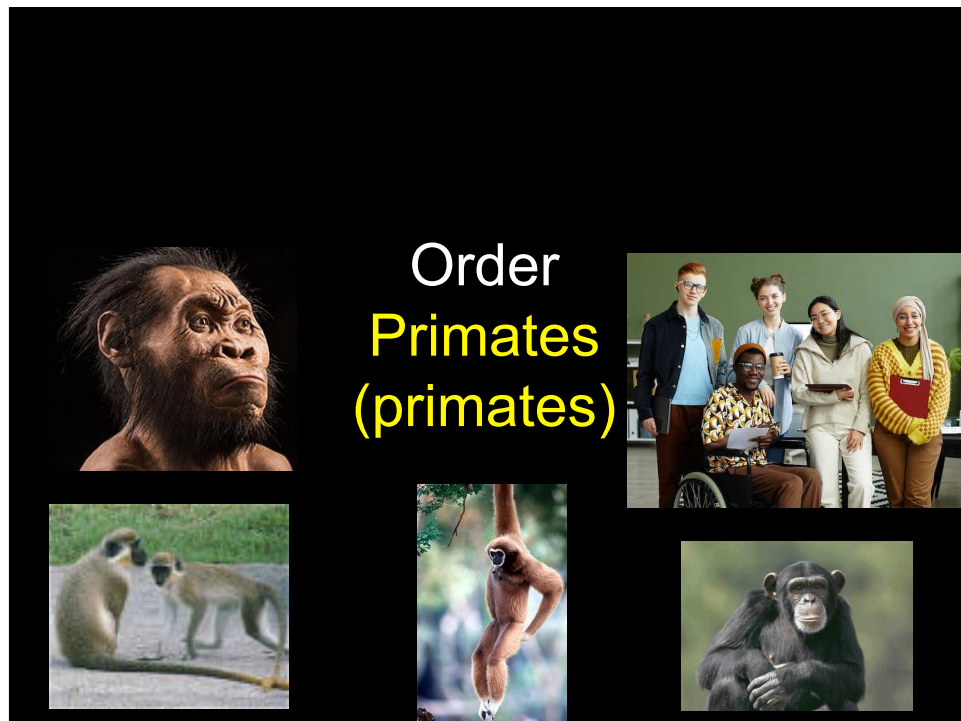
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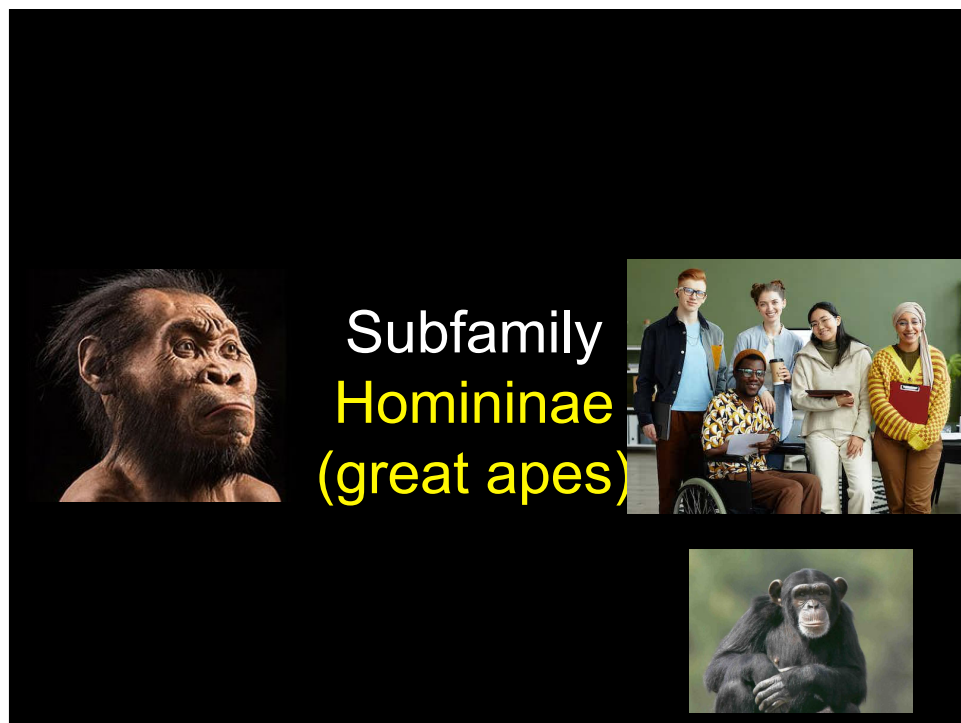
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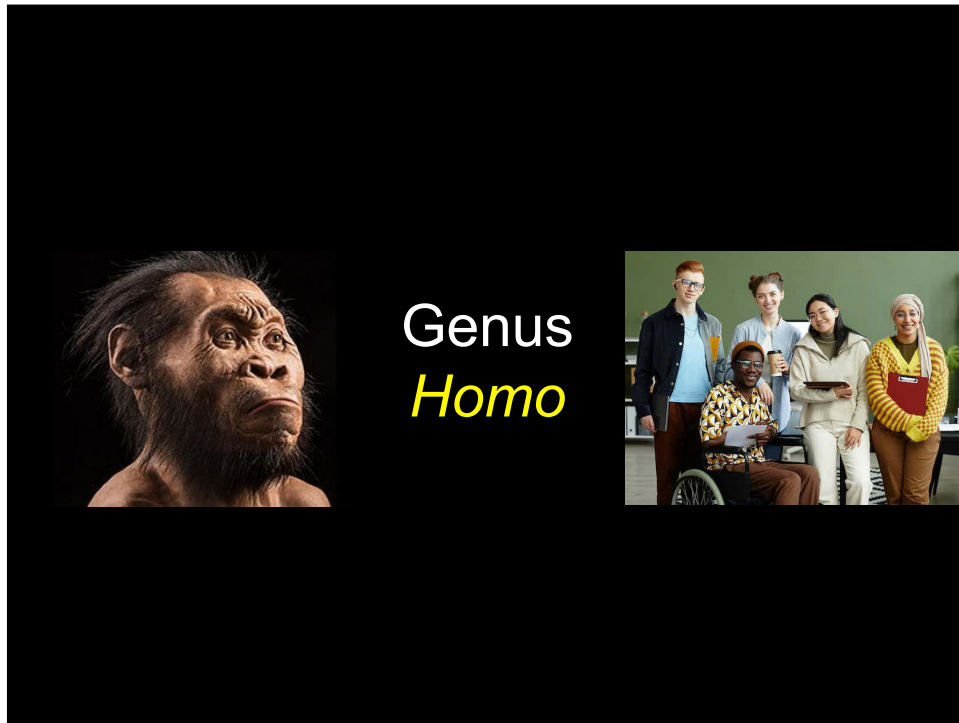
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19



20

Taxonomy & systematics

- **Taxonomy**: theory & practice of naming & classifying biological organisms.
- **Systematics**: branch of biology that describes patterns of organismal variation & relationships.
- **Binomial nomenclature**
 - *Genus species* like *Homo sapiens*

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Phylogeny & classification

- **Classification** should reflect the evolutionary history of life (phylogeny).
- Phylogenies are the **evolutionary histories** of groups of related organisms.
 - trace adaptations from common ancestors
 - show relationships & the time scale of splitting between ancestors & descendants (usually in the form of a **phylogenetic tree**)
- The 'Tree of Life' is very bushy, with different groups evolving new adaptations.

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Reconstructing phylogeny

Q: How do we trace ancestry back millions of years?

A: Look at living & fossil groups, try to identify features that related groups share.

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Establishing evolutionary history

- The **genotype** & **phenotype** of living animals (generally only phenotype for extinct animals) is the primary evidence for classification.
- A species' genotype/phenotype is viewed as a suite of characters/traits.
 - **Characters** are discrete, variable features that differ across groups (species, genera, orders, etc.)

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Character examples

- Number of teeth.
- Number of vertebrae.
- Alleles at a locus.
- Feathers vs. fur vs. scales.
- Bony morphology of the cranium.
- Type of reproductive system.

Can be morphological, behavioral or genetic.

25

Character value depends on context

- The value of a character (whether it is phylogenetically informative or not) cannot be determined without a context.
- A character which is not informative in one context may be pivotal in another.
- Characters often apply at particular levels in classification.

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What makes an informative character?

- Variable *between* groups, but not *within* groups.
- Shared by more than one group.
(Provides information about grouping, unlike unique characters)

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Shared character examples

- Among primates, some monkeys of the Americas have *prehensile tails*.



- Among mammals, dogs & cats have *carnassial teeth*.



28

Unique character examples

- Among mammals, only bats have wings.



- Among primates, only humans are bipedal.



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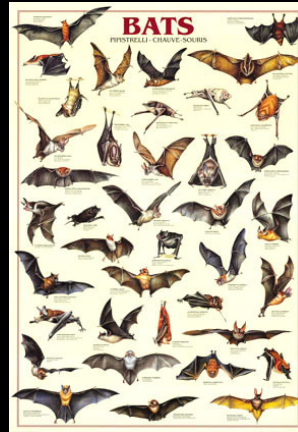
Unique vs. shared is generally easily discernible

- If you have access to all of the information about your study group, it should be relatively easy to determine if characters are unique

30

Unique vs. shared examples

- **RELATIVE:** Among mammals, bats are unique in having wings, but within bats there are many species - all of which have wings.



31

Early approaches: phenetics

- Method of classification that groups organisms based on **overall similarity** (can be molecular, phenotypic or anatomical).
- Phenetics assumes that all similarities imply relatedness.
- But, do all similarities imply relatedness?

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Different types of similarities

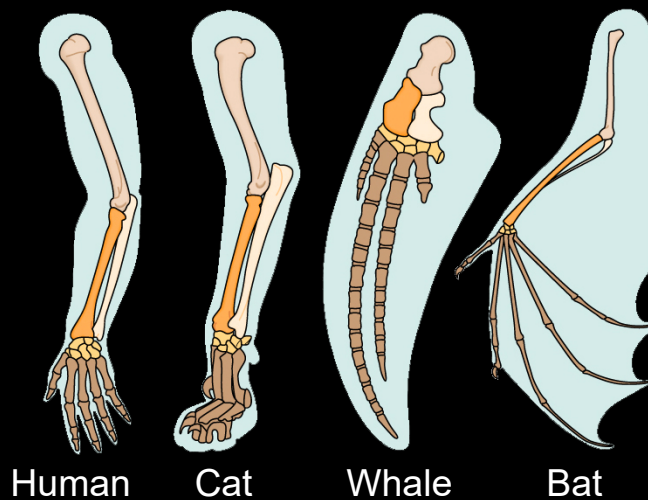
- Homology vs. analogy
- Homology
 - similarities due to common ancestry
 - imply shared descent (common ancestry)
- Analogy
 - similarities due to common function
 - does not imply shared descent or common ancestry

33

Homology

Traits that are the same in different organisms because they were inherited from a common ancestor

e.g., arm bones in amphibians, reptiles, birds & mammals



34

Analogy (homoplasy)

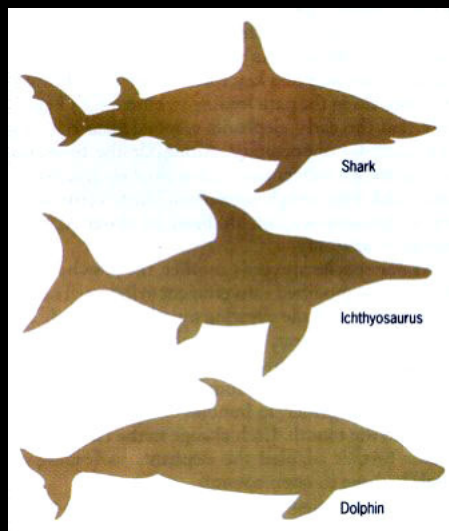


- common function, NOT common ancestry
- **convergent (parallel) evolution**
- e.g., wing structure of insects, birds, bats

35

Analogy (homoplasy)

Similarities due to **common function**, NOT ancestry



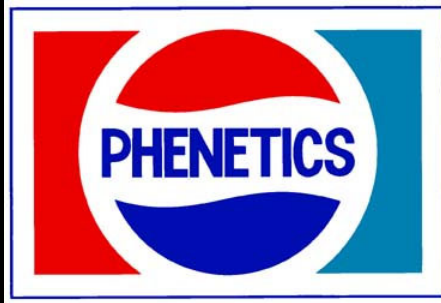
Fish

Reptile

Mammal

36

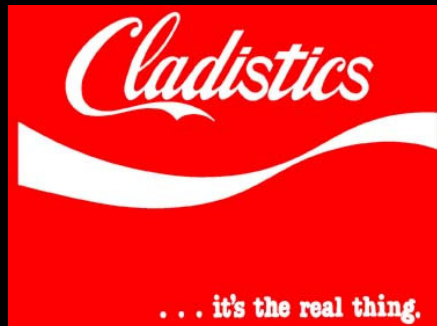
- Groups organisms based on **overall similarity**. Does NOT distinguish between similarity due to **homology** (common ancestry) or **analogy** (common function).



- Can lead to incorrect classifications.

37

- Method of classification using **shared, derived characters** to link taxa together in **nested groups**.



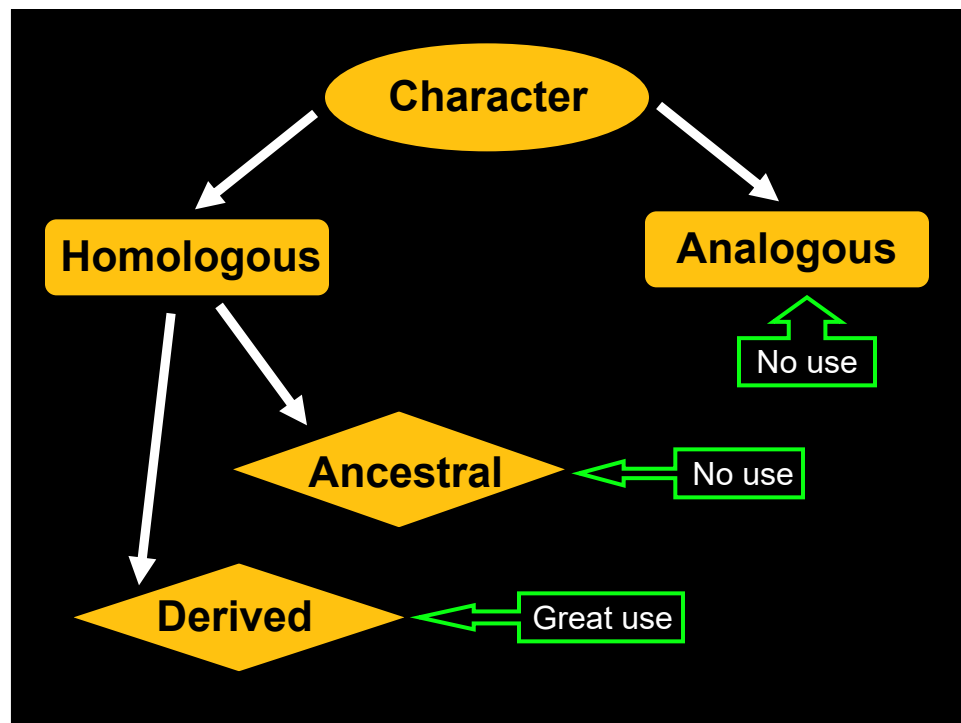
- Shared, derived characters** are more informative as they provide grouping information. **Ancestral** (primitive) characteristics do not.

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Different types of similarity

- There are 2 types of homologies:
 - **Ancestral or primitive** (plesiomorphy)
 - **Derived** (apomorphy)
- Thus there are 4 possible character types:
 - **shared ancestral** (symplesiomorphies)
 - **shared derived** (synapomorphies)
 - **uniquely derived** (autapomorphies)
 - **Independently derived** (analogies / homoplasies)

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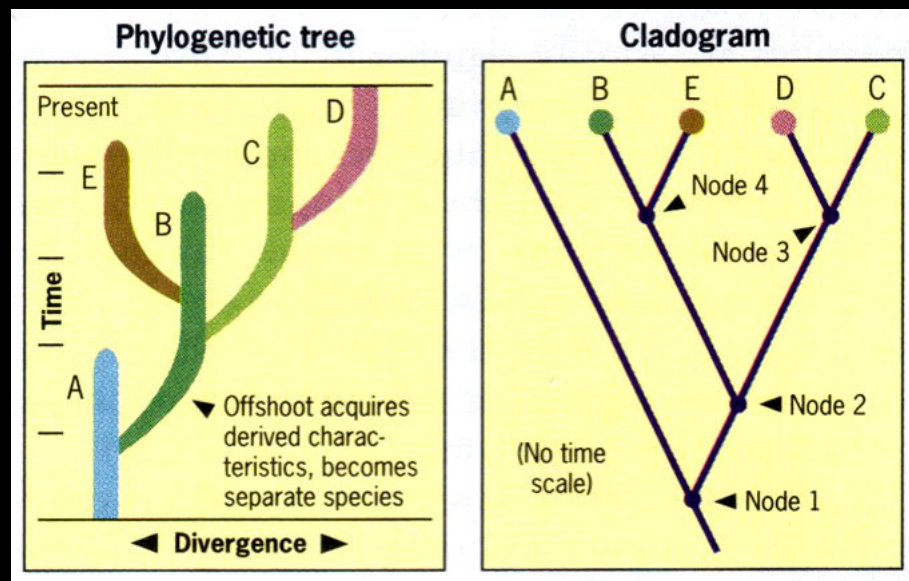


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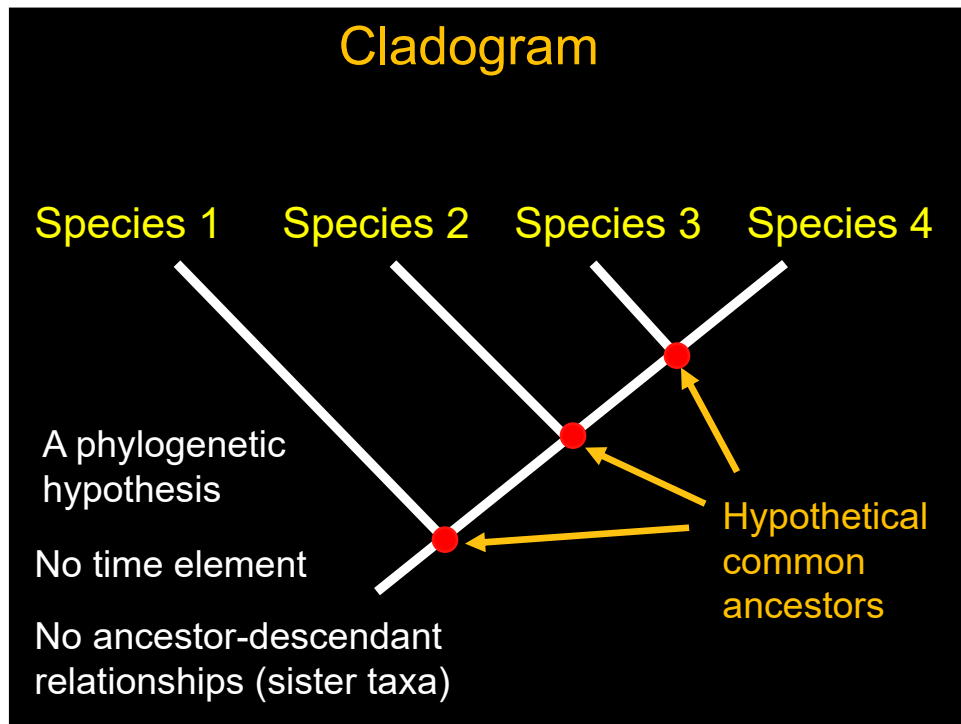
Trees

- **Cladogram**
 - strictly a branching tree
 - shows the sequence of character evolution
 - does not show ancestor-descendant relationships
- **Phylogenetic tree**
 - branch lengths indicate time & ancestor-descendant relationships can be represented

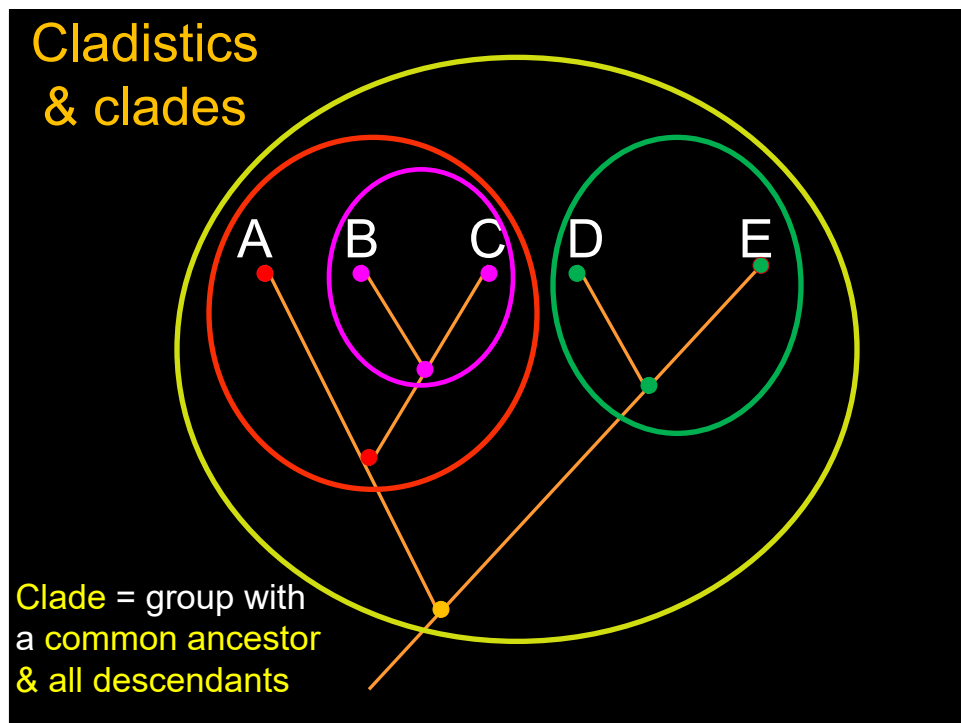
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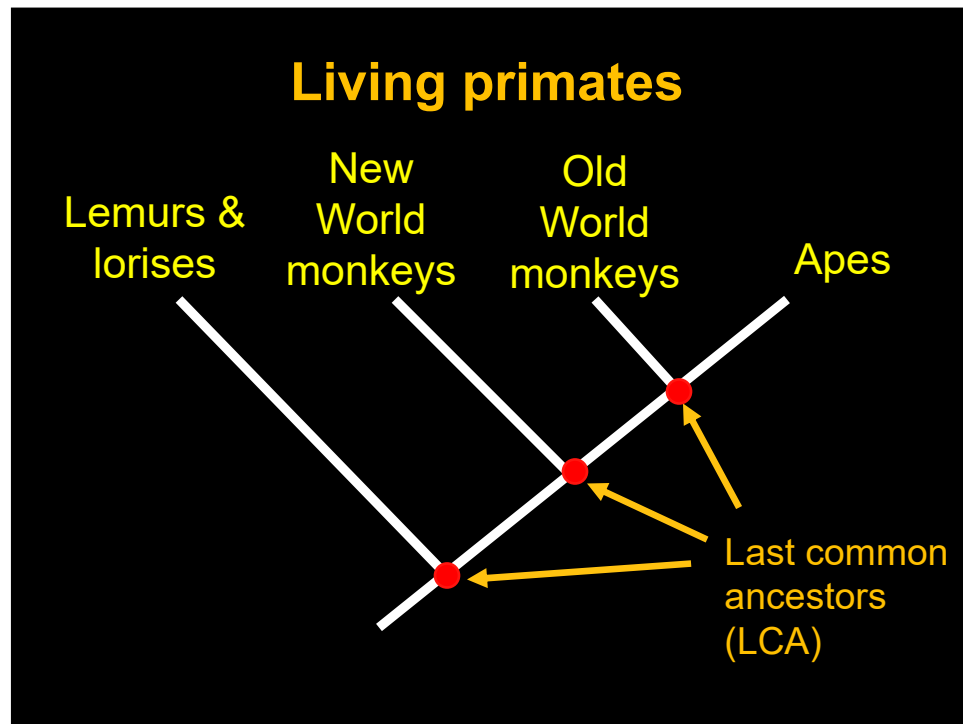
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44



45

Constructing relationships

We can examine relationships between primates by exploring their physical traits.

- **Shared trait** - present in more than one taxon.
- **Ancestral trait** - expressed in an **ancestor** and the **descendant**; this may be **shared** across multiple taxa. Also known as a primitive trait.
- **Derived trait** – trait expressed in **descendants** but not expressed in an **ancestor**. These features may be shared across taxa or unique to an individual taxon.

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Constructing relationships

- There is no end point of evolution!
 - No species is more evolved than any other species. Taxa CANNOT be primitive, only traits can.
- Traits are ancestral or derived **relative to other taxa**.
- Traits can develop in a mosaic fashion.
 - Most taxa have derived AND ancestral traits.

47

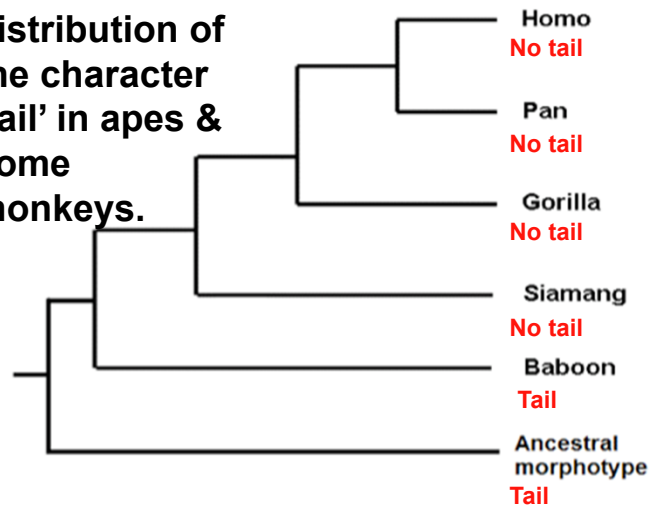
Example

- Some primates have tails, some do not.



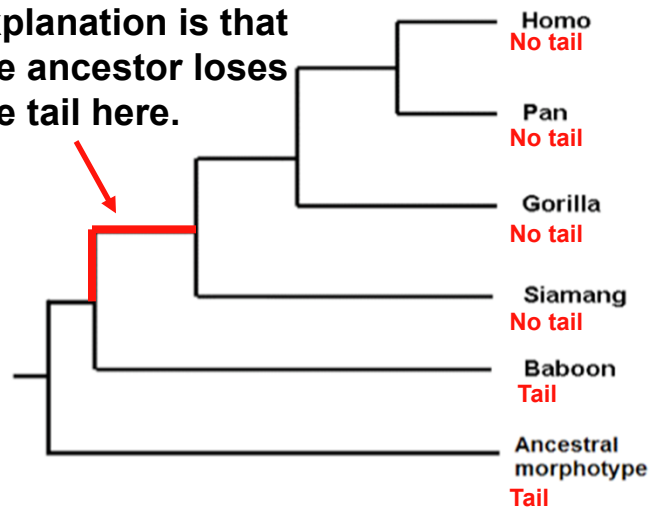
48

The distribution of the character 'tail' in apes & some monkeys.



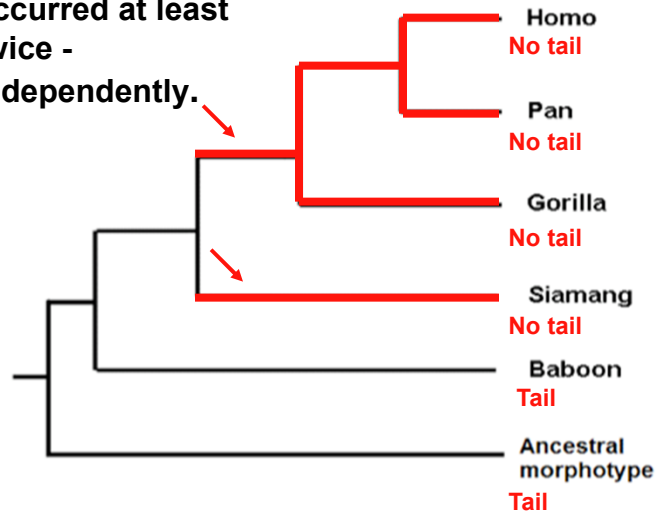
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Most parsimonious explanation is that the ancestor loses the tail here.



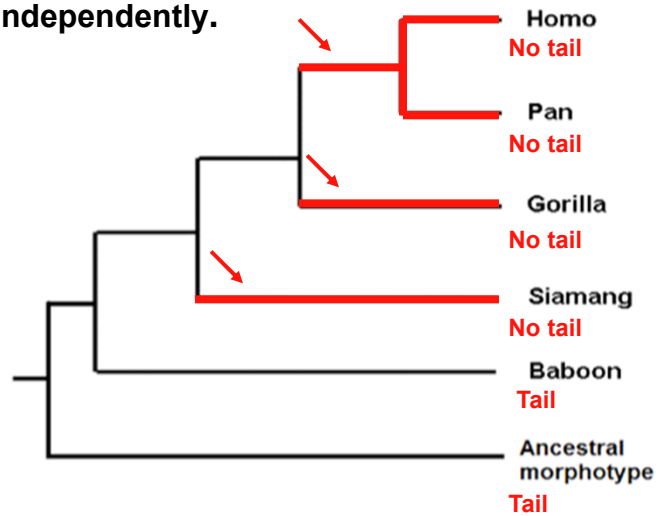
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Otherwise tail loss
occurred at least
twice -
independently.



51

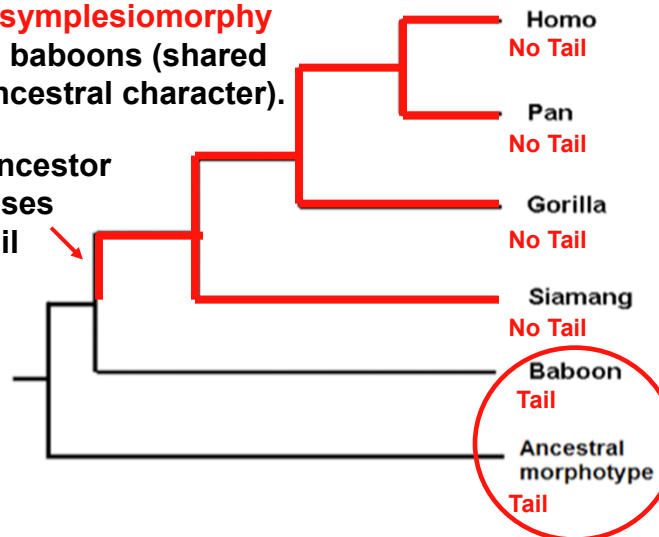
Or more than twice
- independently.



52

Presence of a tail is a **symplesiomorphy** in baboons (shared ancestral character).

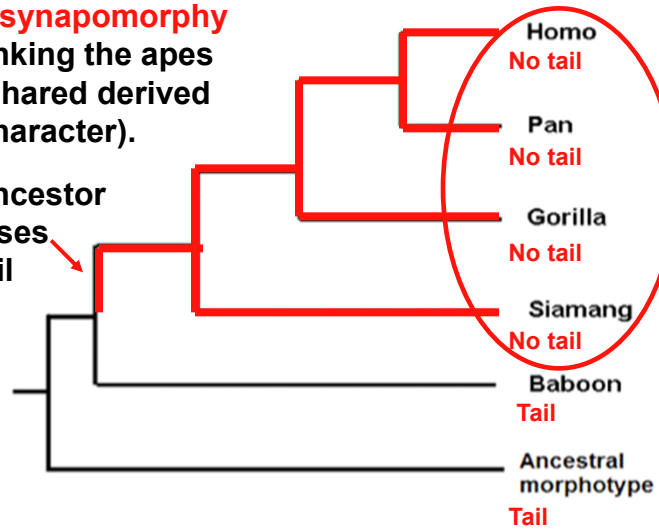
Ancestor loses tail



53

Absence of a tail is a **synapomorphy** linking the apes (shared derived character).

Ancestor loses tail



54