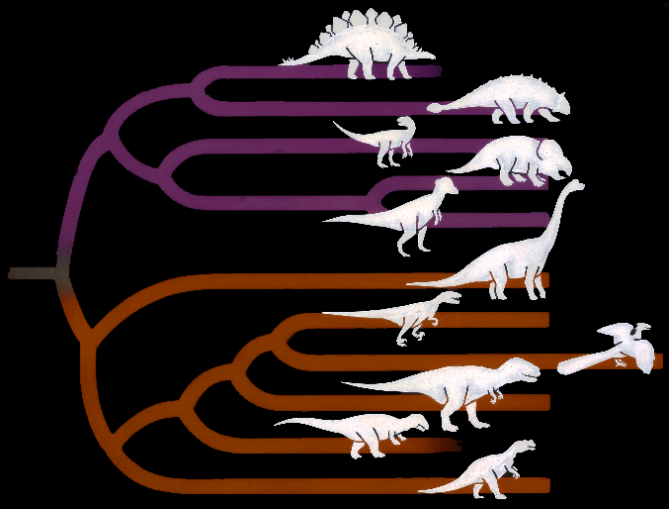
Classification & speciation



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.

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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

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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

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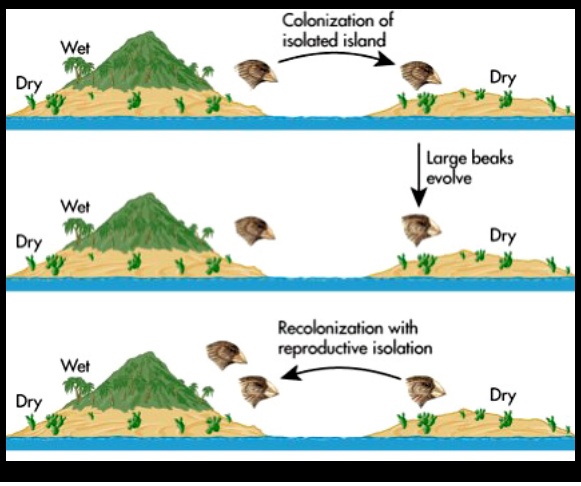
Speciation

- Allopatric speciation
  - Speciation occurring via geographic isolation.



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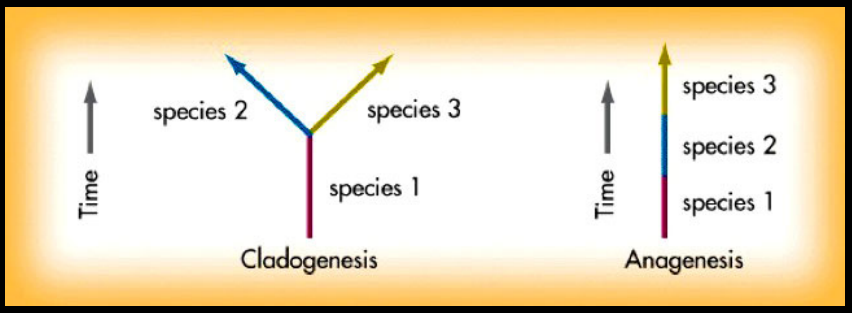
Modes of speciation

- 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.

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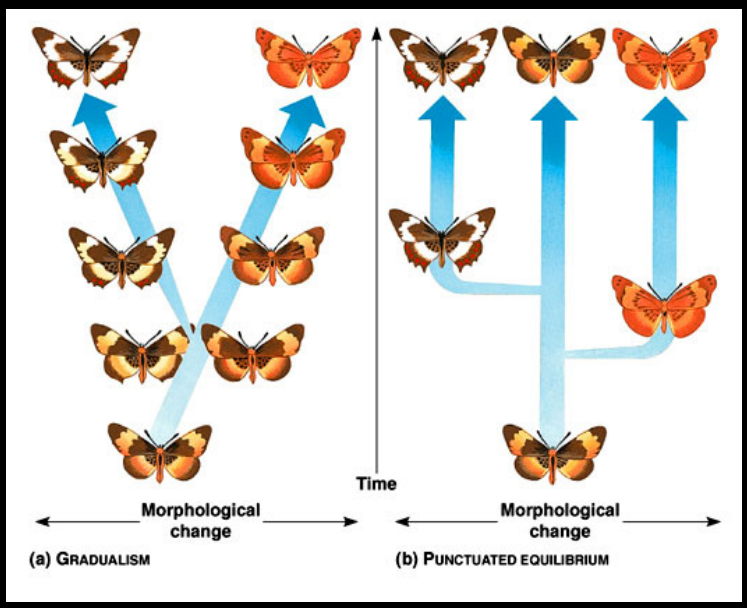
Tempo of speciation



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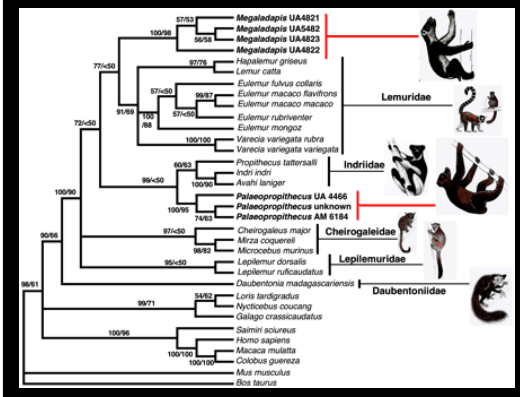
Adaptive radiation

- a rapid speciation of a species to fill many ecological niches
  - lemurs on Madagascar



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Classification

- Linnaean hierarchy:
  - Kingdom
  - Phylum
  - Class
  - Order
  - Family
  - Tribe
  - Genus
  - Species

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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	*Cavia*
Species	*Cavia porcellus*

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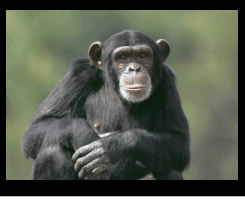
Kingdom Animalia (animals)



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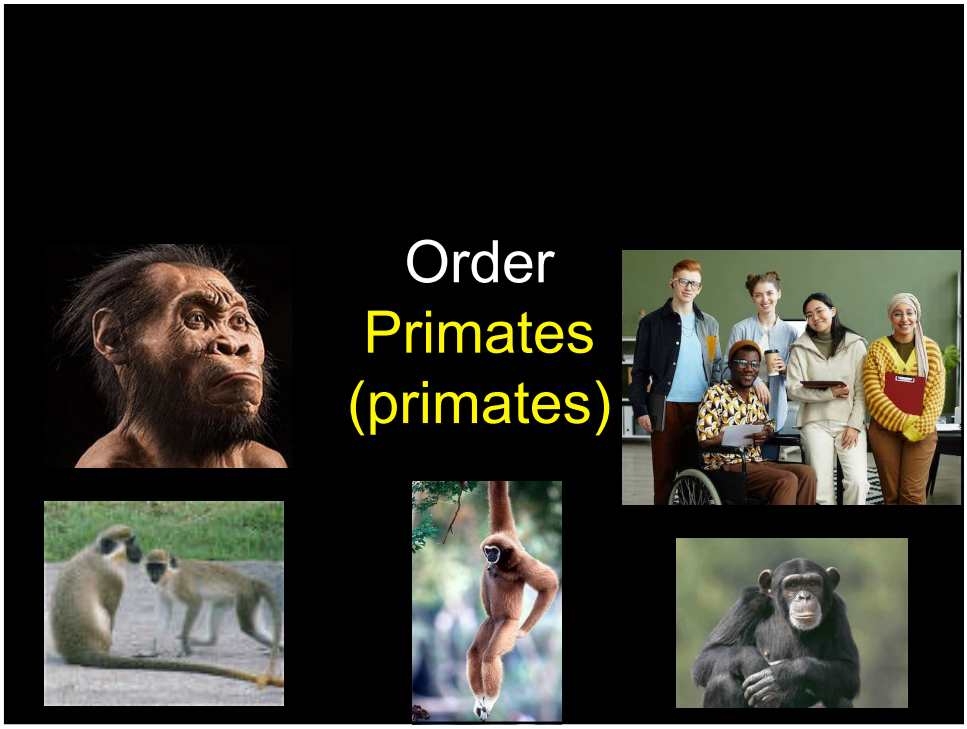
Phylum
Chordata
(chordates)

13


Subphylum
Vertebrata
(vertebrates)

14

15



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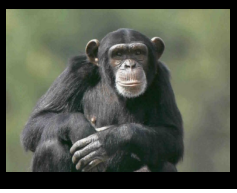
Family
Hominidae
(apes)



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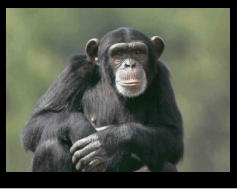
Subfamily
Homininae
(great apes)



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Genus
Homo

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Species
Homo
sapiens

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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.

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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.

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Unique character examples

- Among mammals, bats have wings.

- Among primates, 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.

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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

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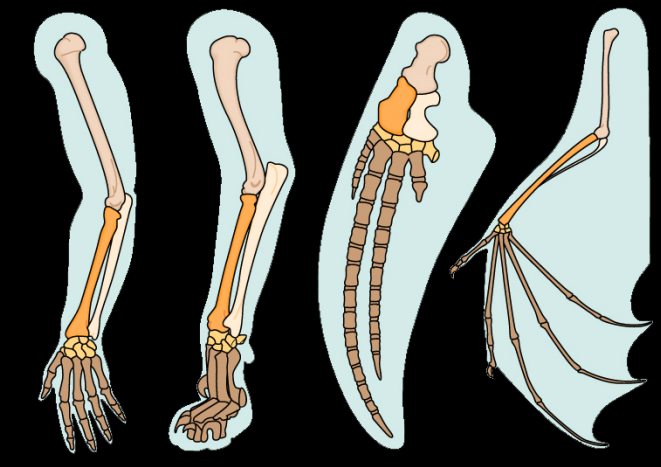
Homology

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



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Analogy (homoplasy)


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

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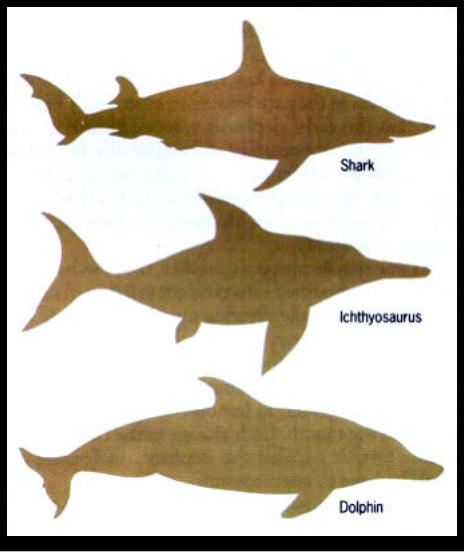
Analogy (homoplasy)

Similarities due to common function, NOT ancestry



Fish

Reptile

Mammal

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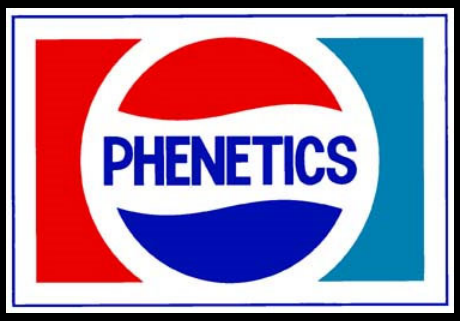
- Groups organisms based on overall similarity. Does NOT distinguish between similarity due to homology (common ancestry) or analogy (common function).



  - Can lead to incorrect classifications.

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- 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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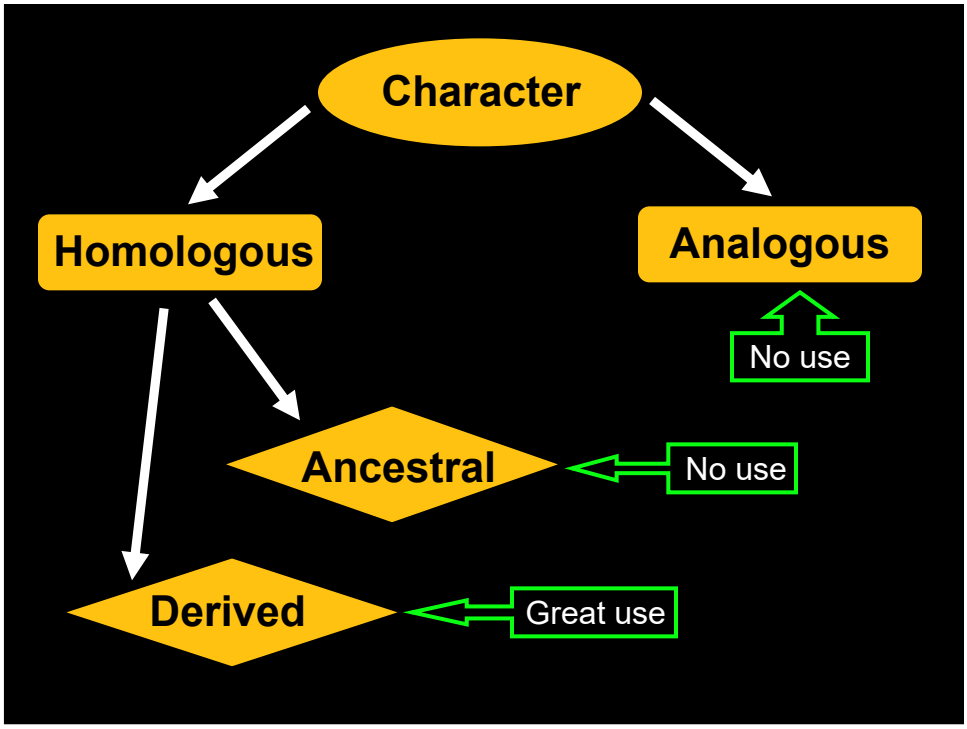

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Trees

- 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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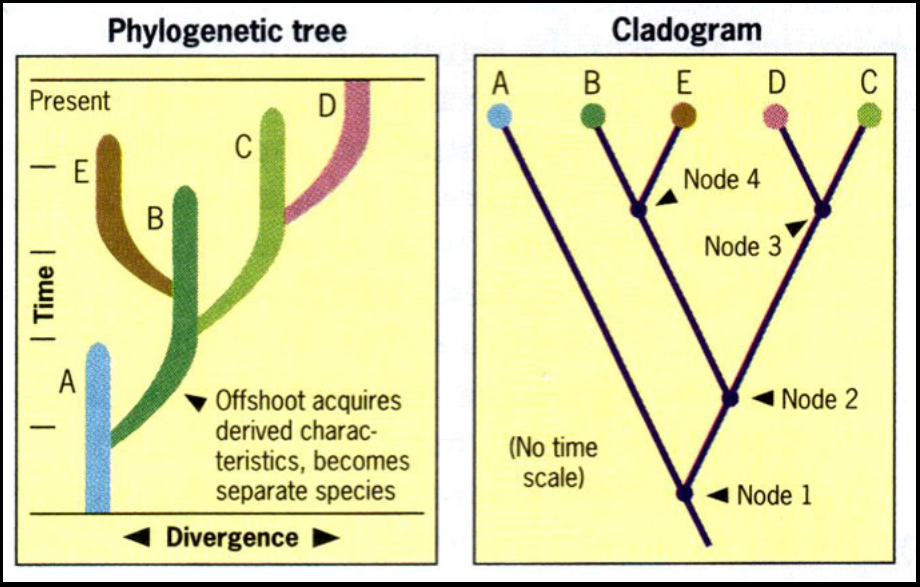

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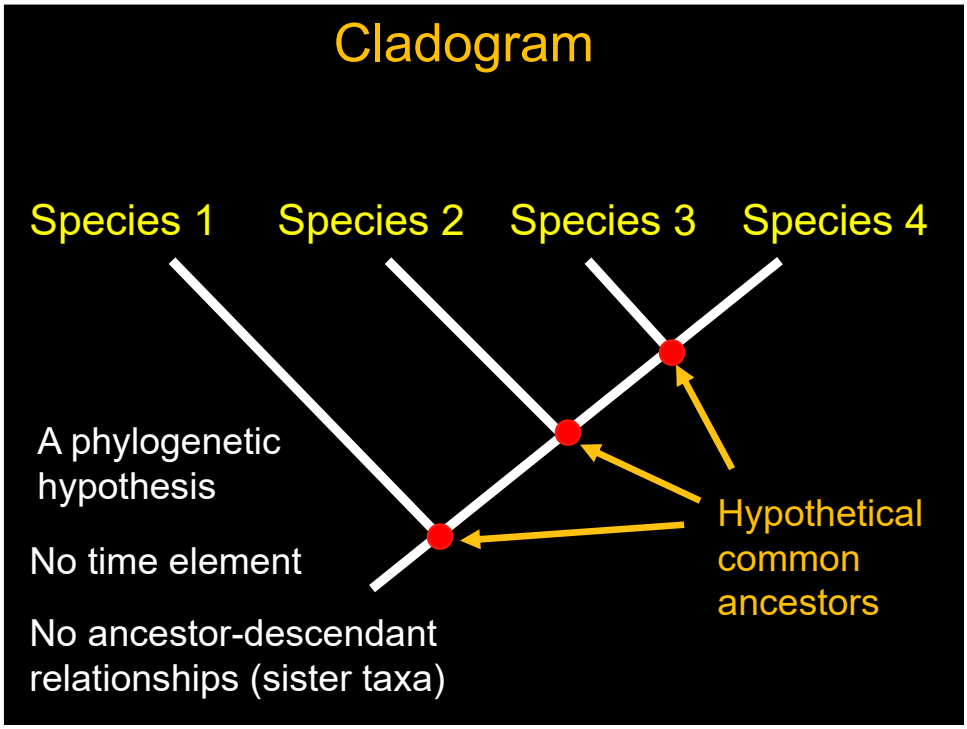
Cladogram
Species 1
Species 2
Species 3
Species 4
A phylogenetic hypothesis
No time element
No ancestor-descendant relationships (sister taxa)
Hypothetical common ancestors

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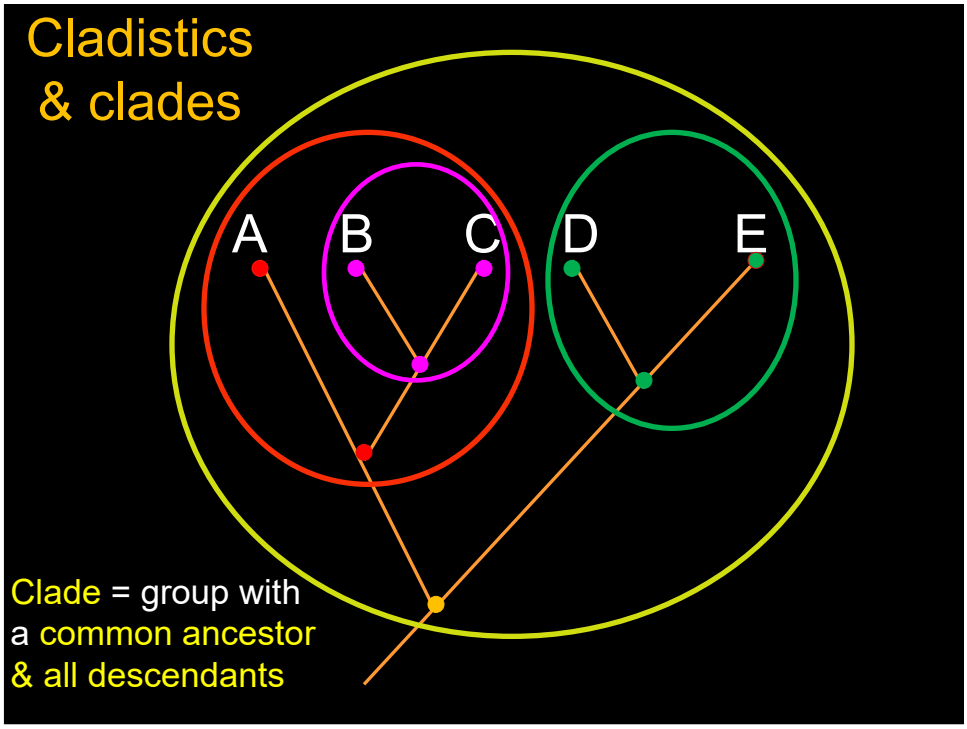
Cladistics & clades
A
B
C
D
E
Clade = group with a common ancestor & all descendants

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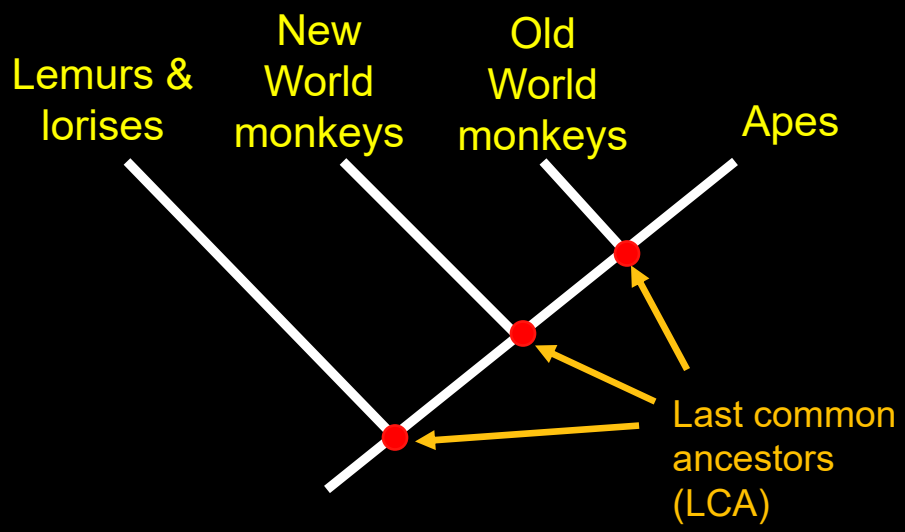
Living primates



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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.

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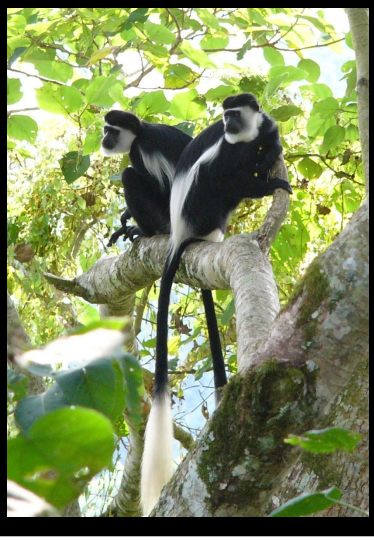
Example

- Some primates have tails, some do not.



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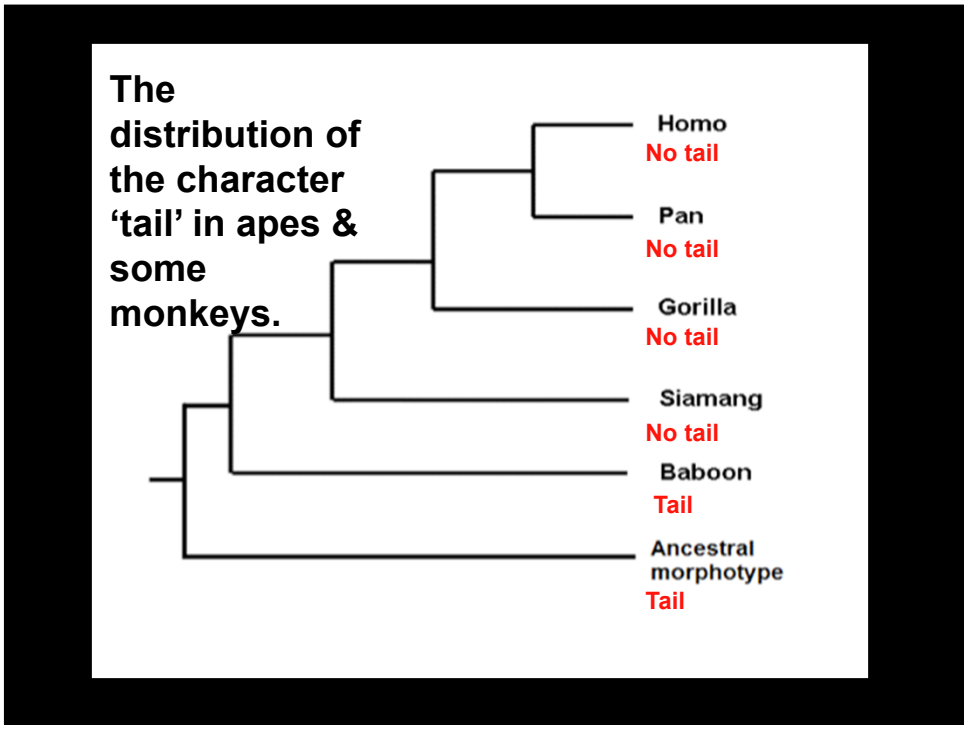
The distribution of the character 'tail' in apes & some monkeys.
Homo
No tail
Pan
No tail
Gorilla
No tail
Siamang
No tail
Baboon
Tail
Ancestral morphotype
Tail

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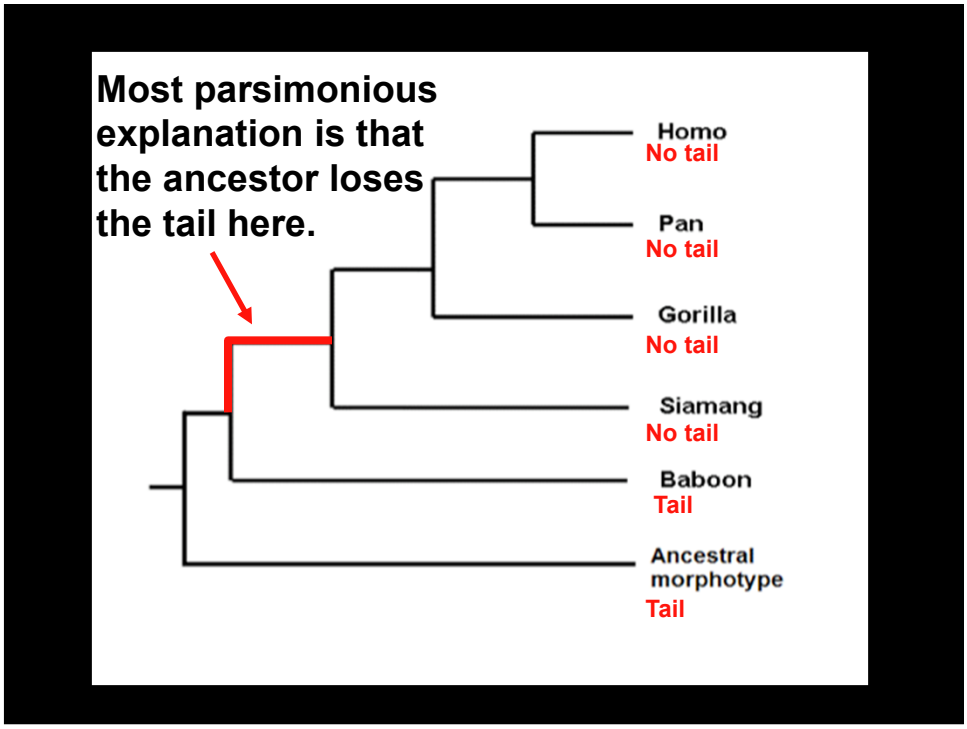
Most parsimonious explanation is that the ancestor loses the tail here.
Homo
No tail
Pan
No tail
Gorilla
No tail
Siamang
No tail
Baboon
Tail
Ancestral morphotype
Tail

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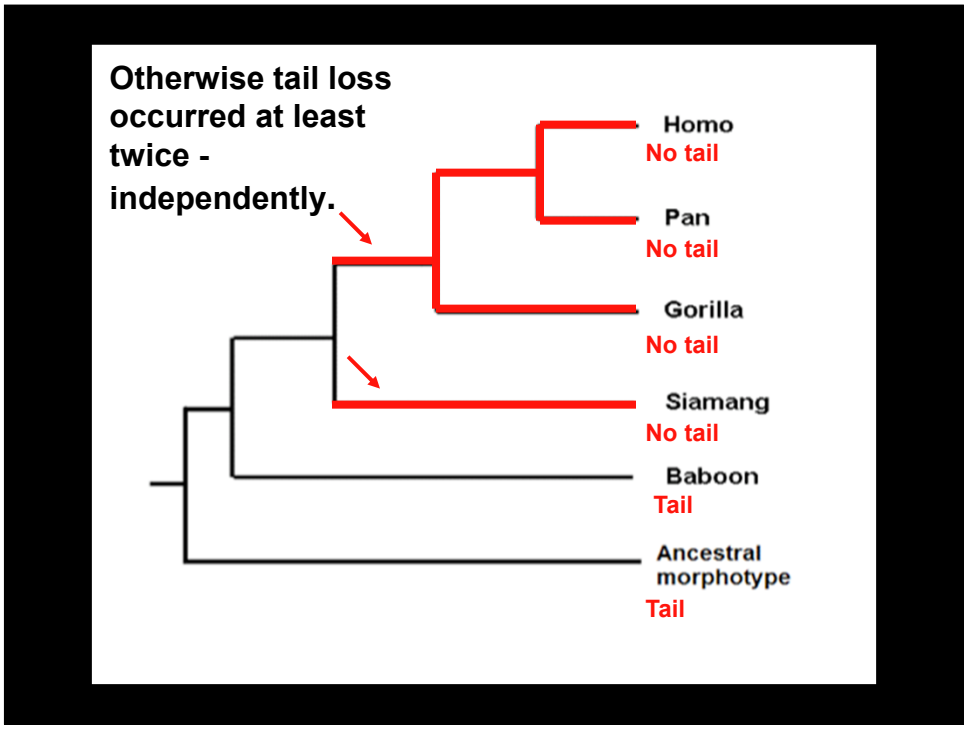
Otherwise tail loss occurred at least twice - independently.
Homo
No tail
Pan
No tail
Gorilla
No tail
Siamang
No tail
Baboon
Tail
Ancestral morphotype
Tail

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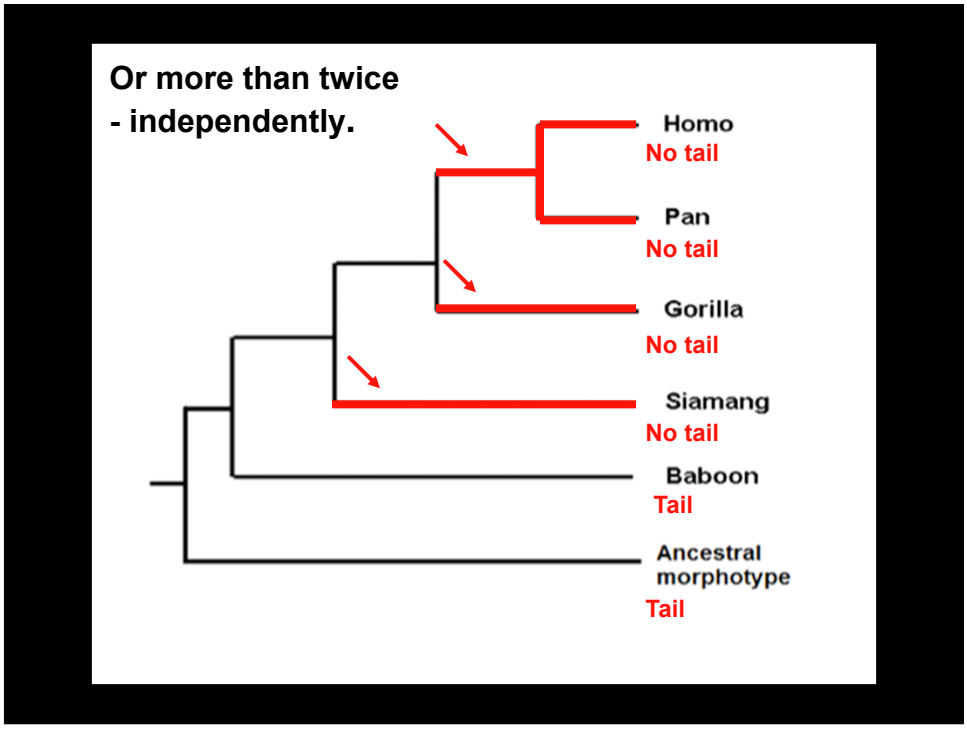
Or more than twice - independently.
Homo
No tail
Pan
No tail
Gorilla
No tail
Siamang
No tail
Baboon
Tail
Ancestral morphotype
Tail

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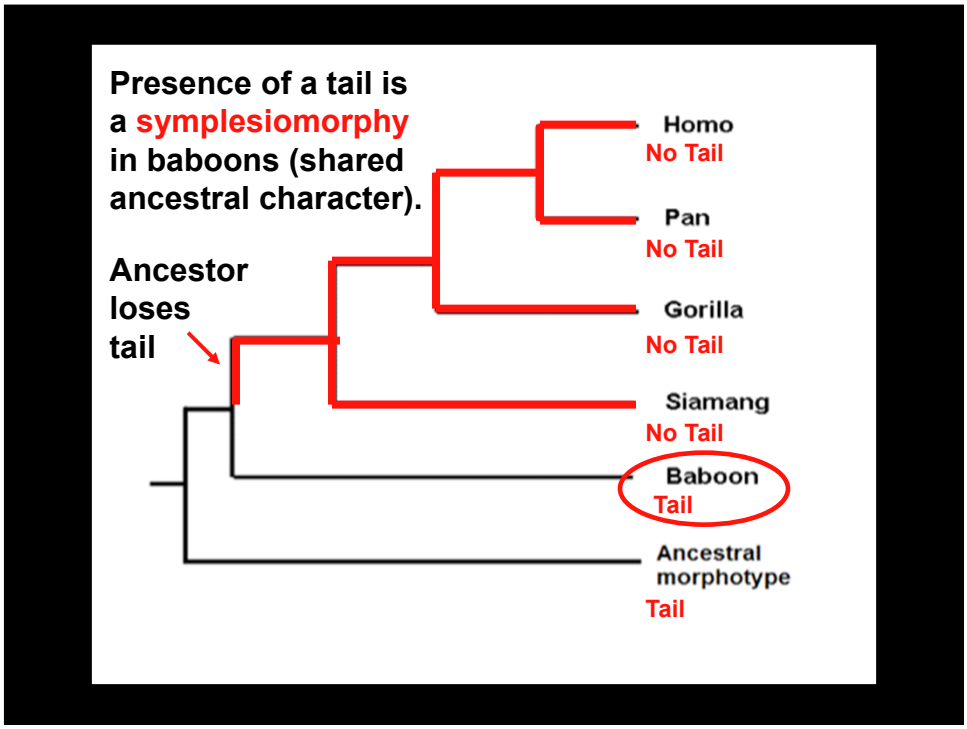
Presence of a tail is a symplesiomorphy in baboons (shared ancestral character).
Ancestor loses tail
Homo
No Tail
Pan
No Tail
Gorilla
No Tail
Siamang
No Tail
Baboon
Tail
Ancestral morphotype
Tail

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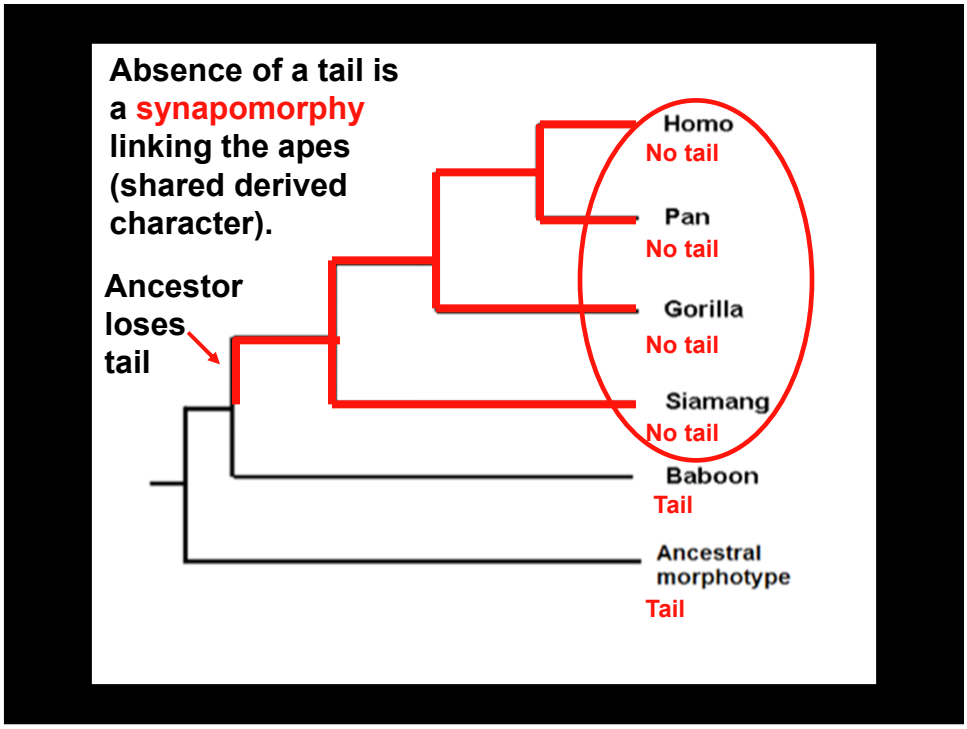
Absence of a tail is a synapomorphy linking the apes (shared derived character).
Ancestor loses tail
Homo
No tail
Pan
No tail
Gorilla
No tail
Siamang
No tail
Baboon
Tail
Ancestral morphotype
Tail

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