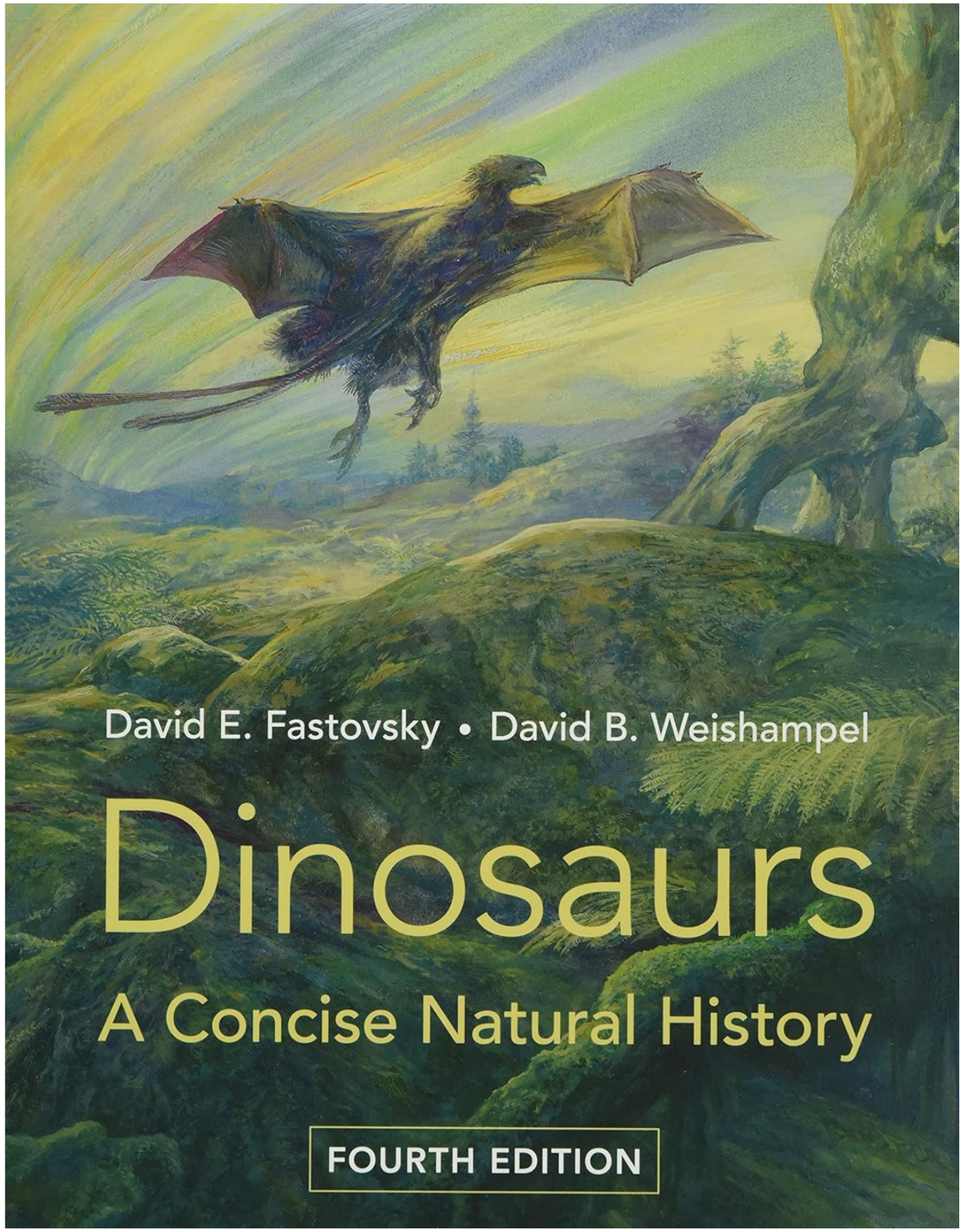


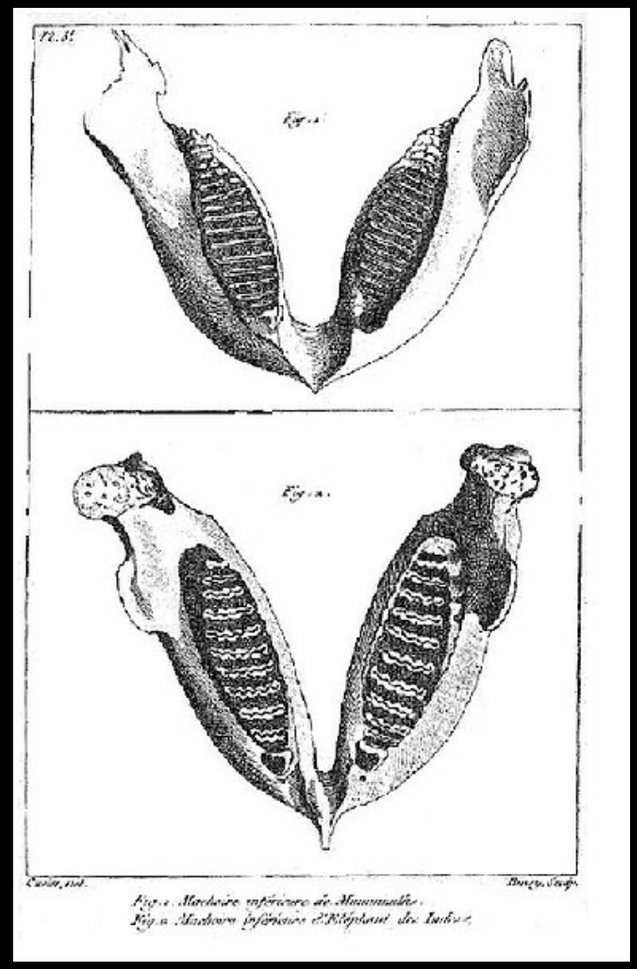
Reading for this week:
Fastovsky & Weishampel

Chapter 3: the key to the rest of the class

George Cuvier (1769-1832)

Father of modern paleontology
- Compared modern & fossil skeletons
Comparative Biology

- Believed that species were stable
No organic flux



Indian elephant

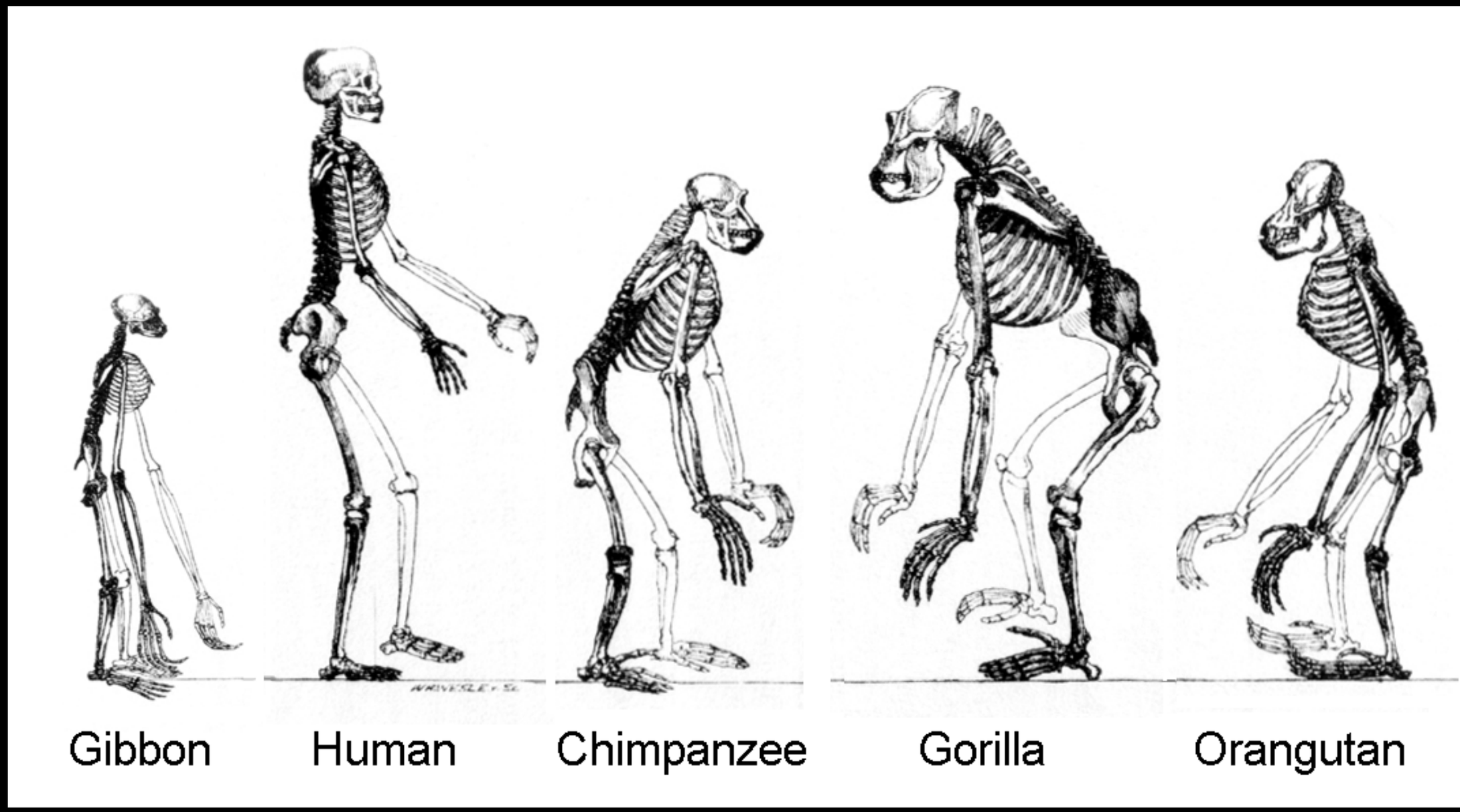
Mammoth

Catastrophism - Earth shaped by sudden violent events

(vs. Uniformitarianism)

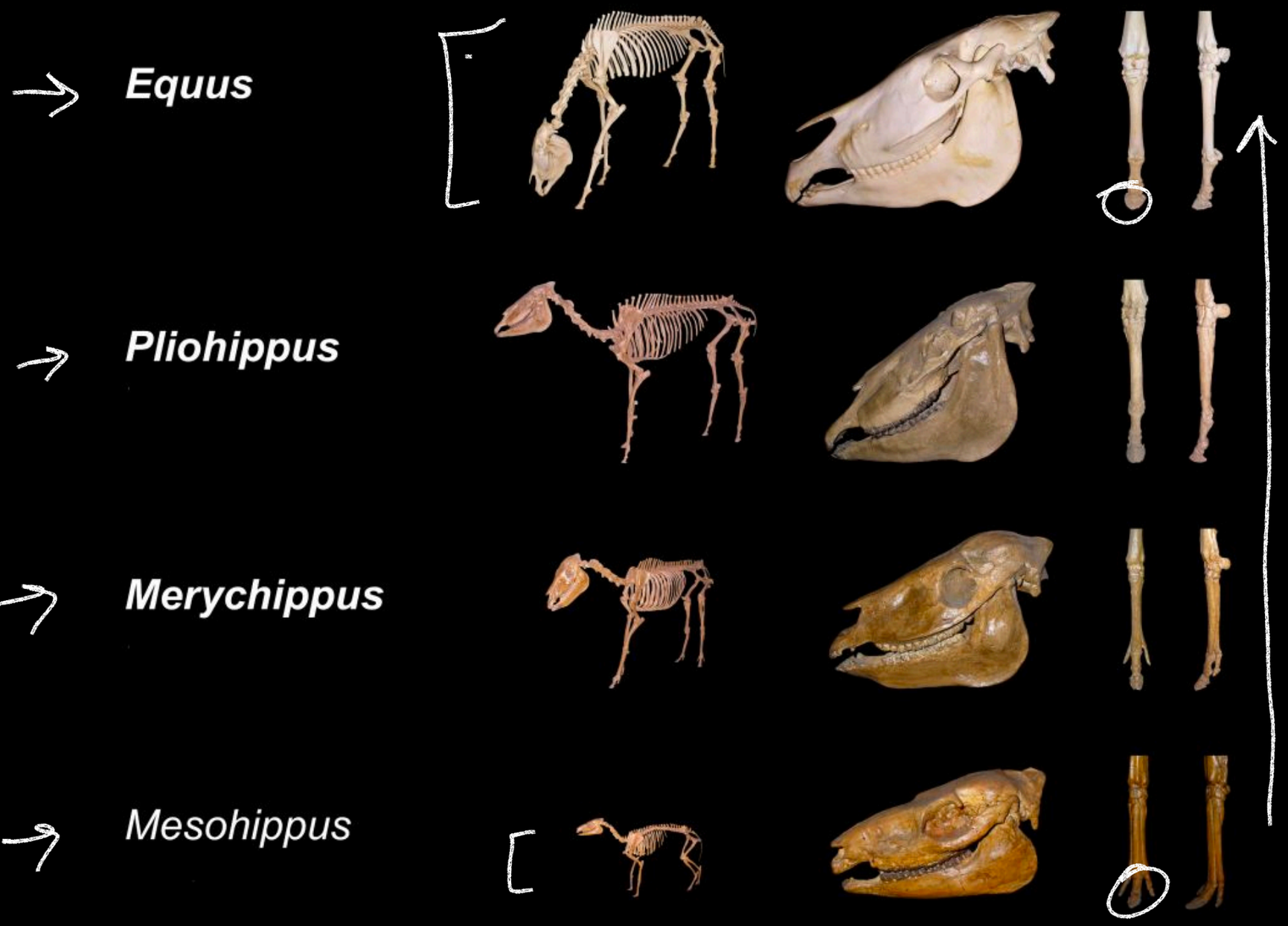
↳ Earth changed slowly/consistently

Similarity in form (comparative morphology)



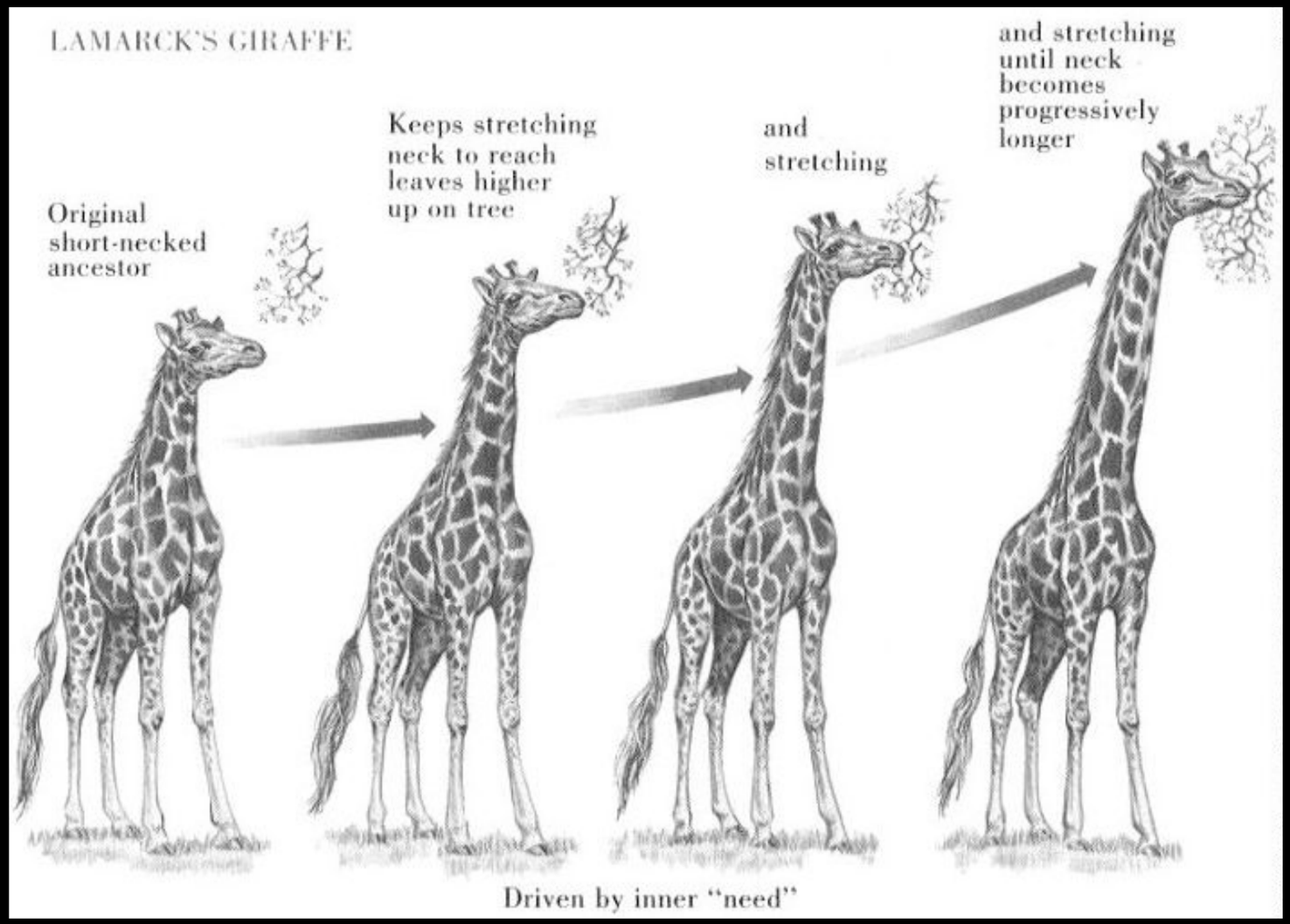
Gibbon Human Chimpanzee Gorilla Orangutan

Evolution
‘Change over time’



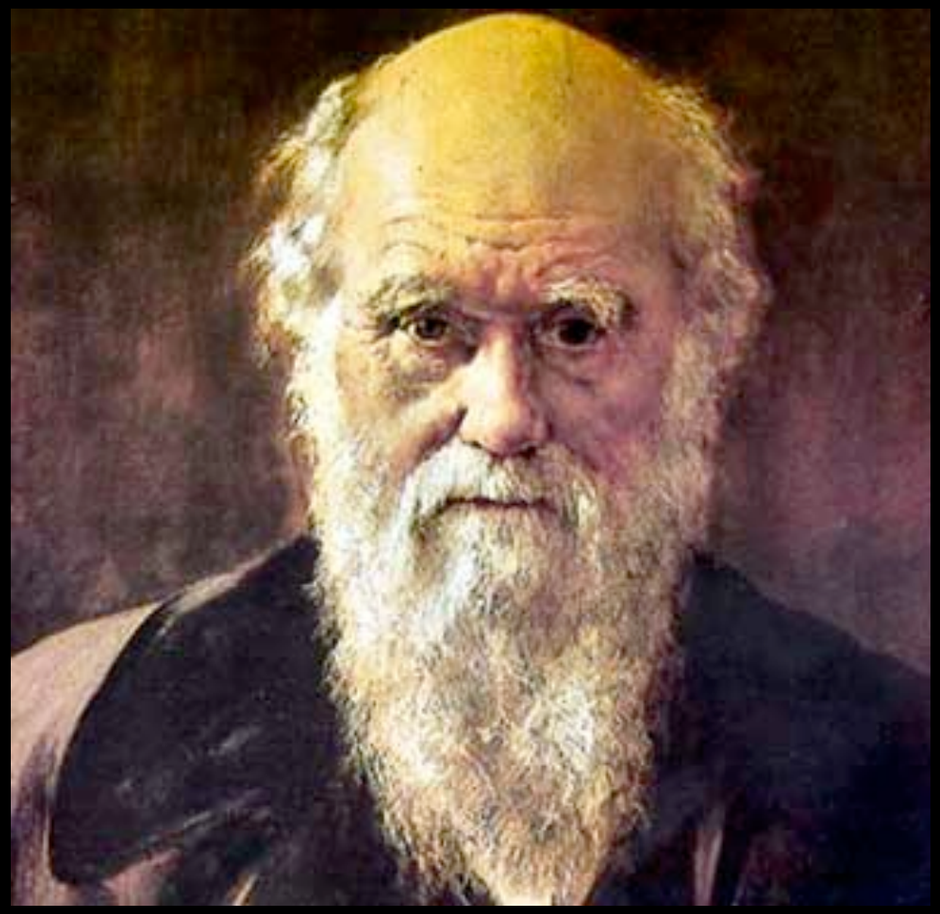
…but what is the process?

- Lamarckian evolution



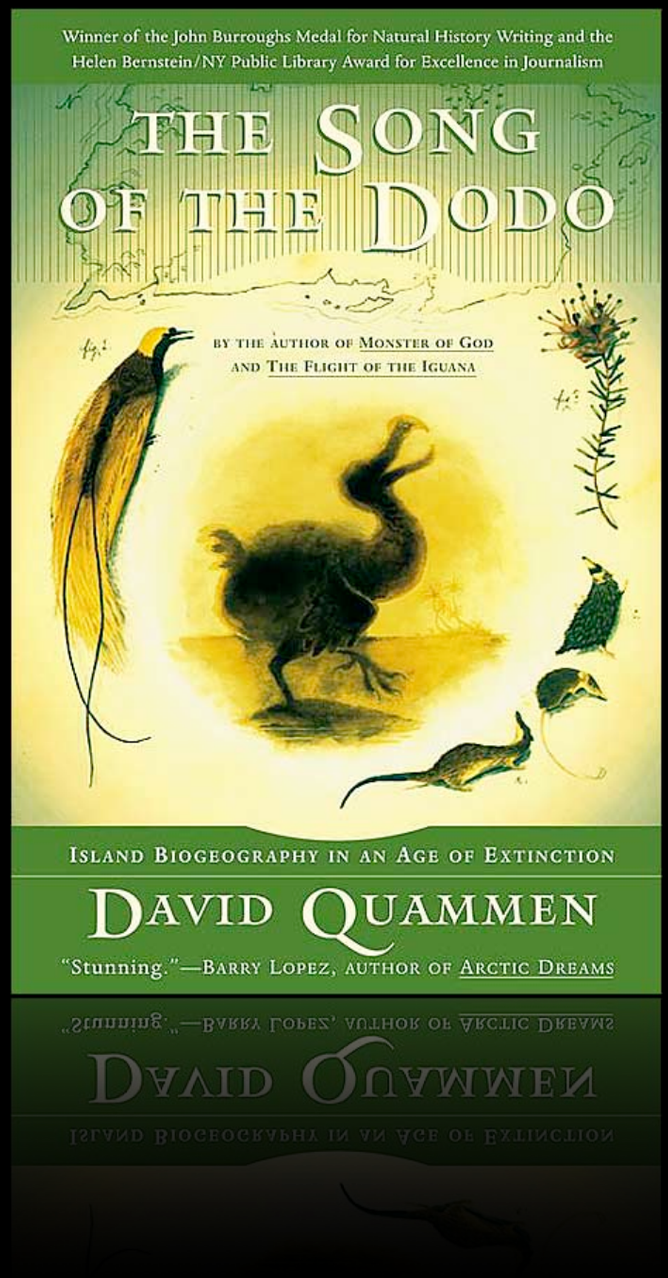
Jean-Baptiste Pierre Antoine de Monet Chevalier de la Marck

Evolution by Natural Selection



Charles Darwin

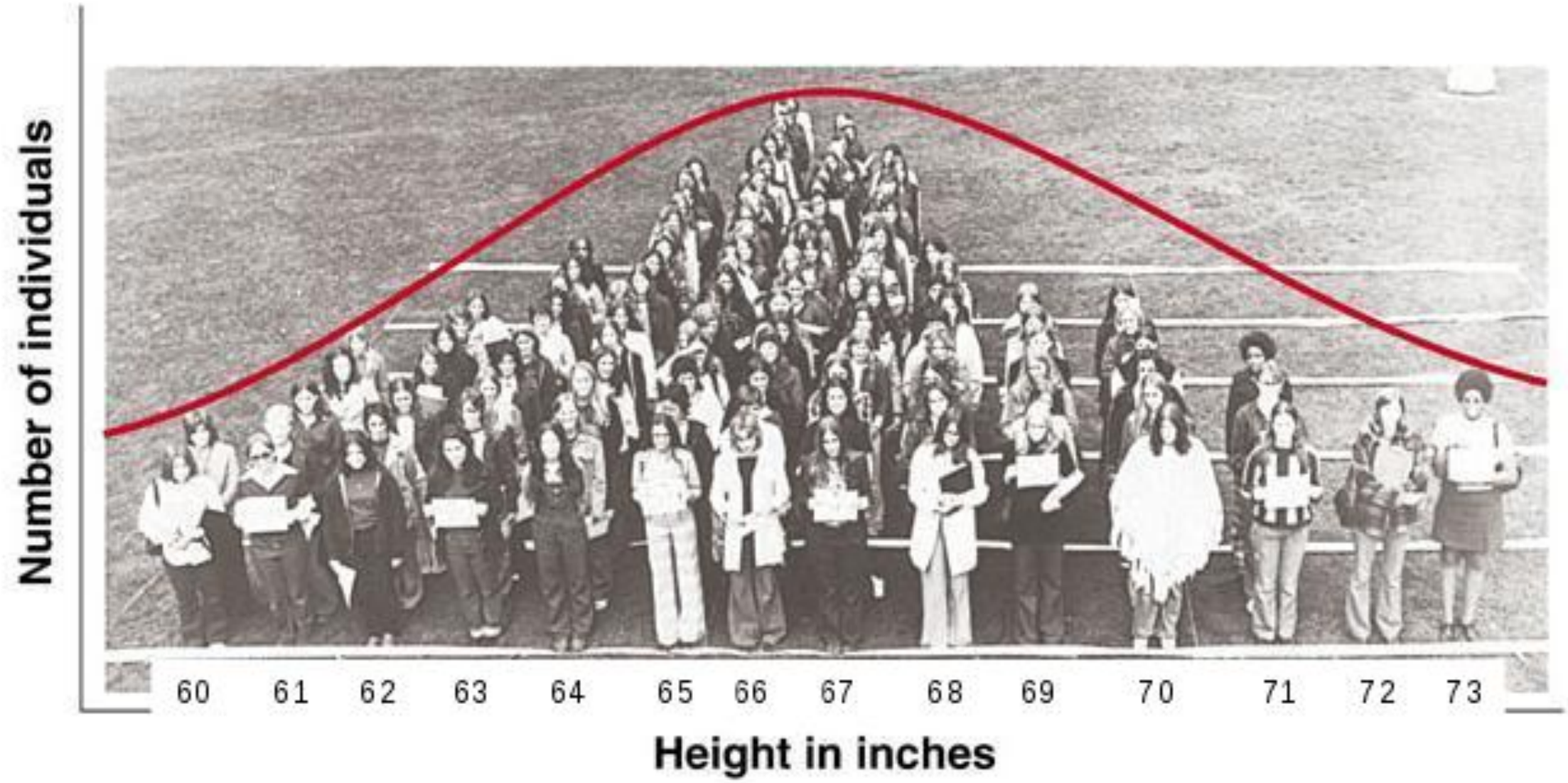
Alfred Russel Wallace



Observations forming Darwin's Inferences on Natural Selection

- **Observation #1:**
  - Trait variability!

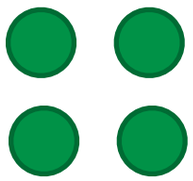
Individuals in this population of Asian ladybird beetles vary in color and spot pattern.



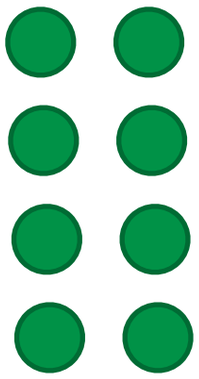
Exponential population growth

2^1 2

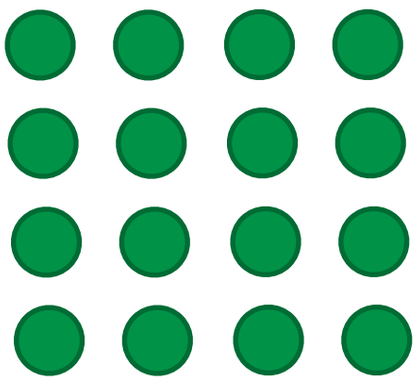
2^2 4



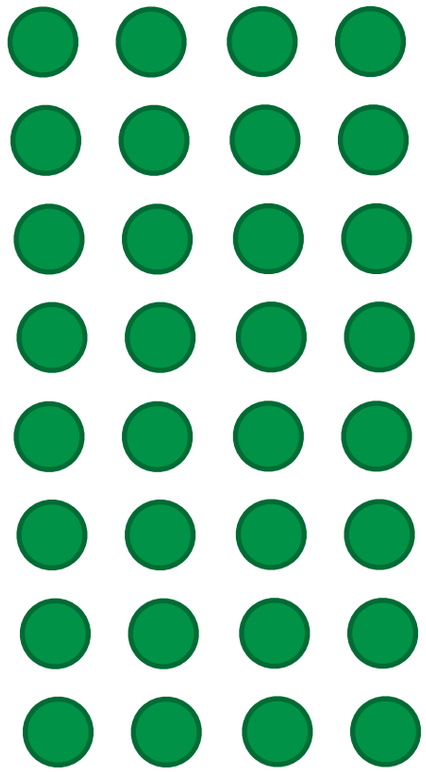
2^3 8



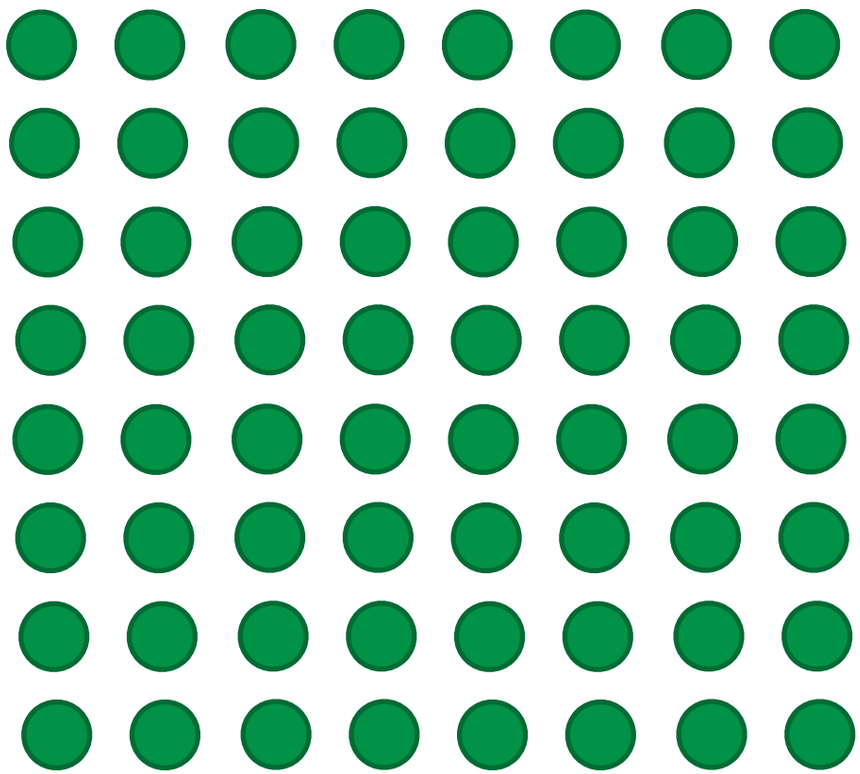
2^4 16

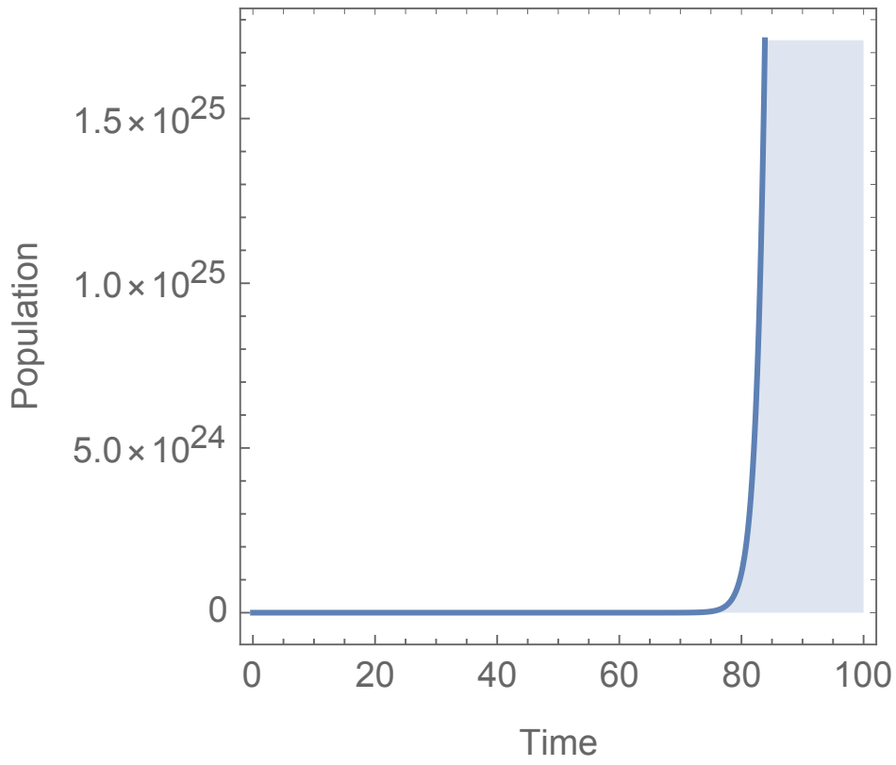


2^5 32



2^6 64





2^t

t=100?

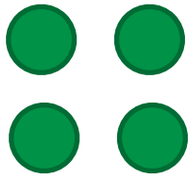
$N = 1.2x10^{30}$

Where is everybody?

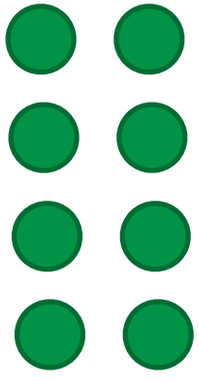
Exponential population growth

2^1
2

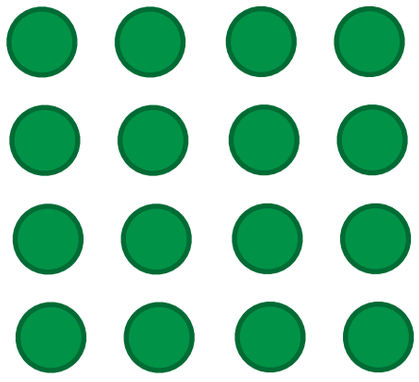
2^2
4



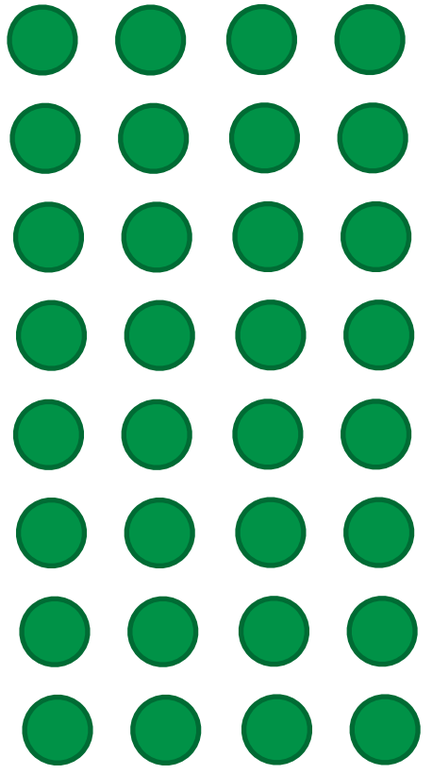
2^3
8



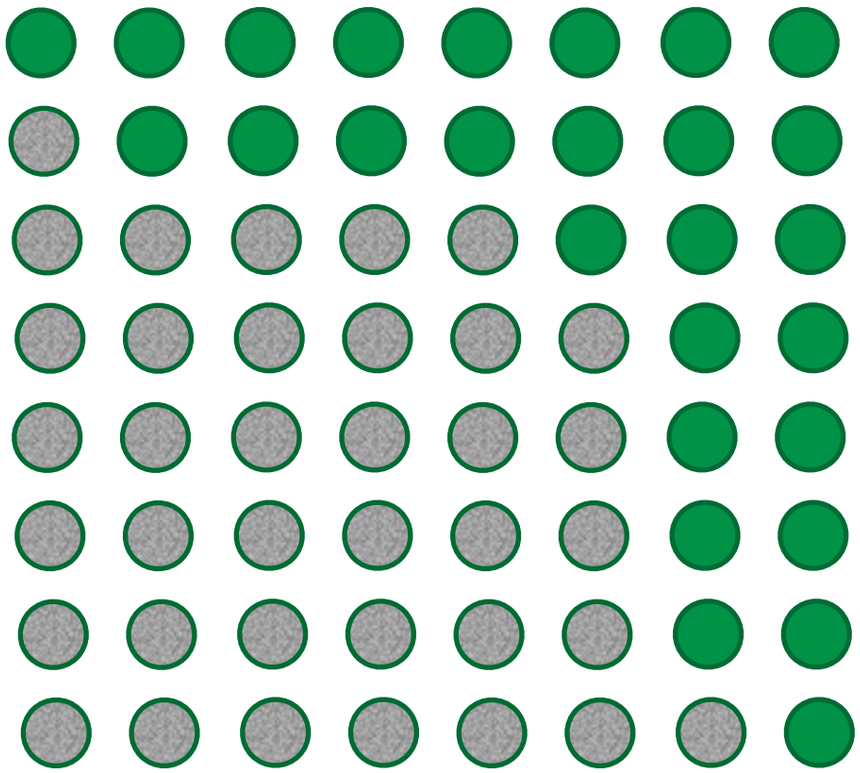
2^4
16



2^5
32



2^6
64

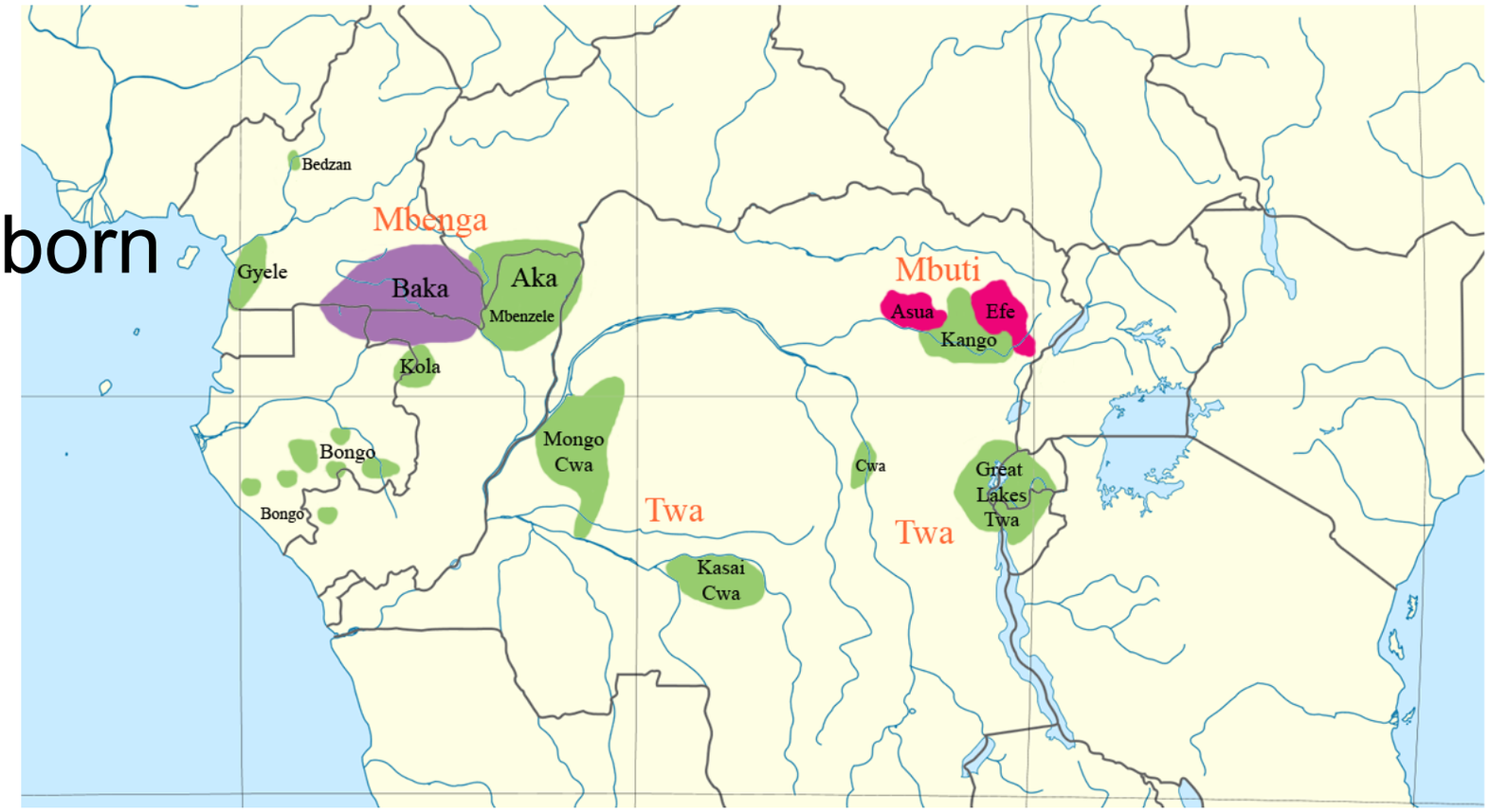


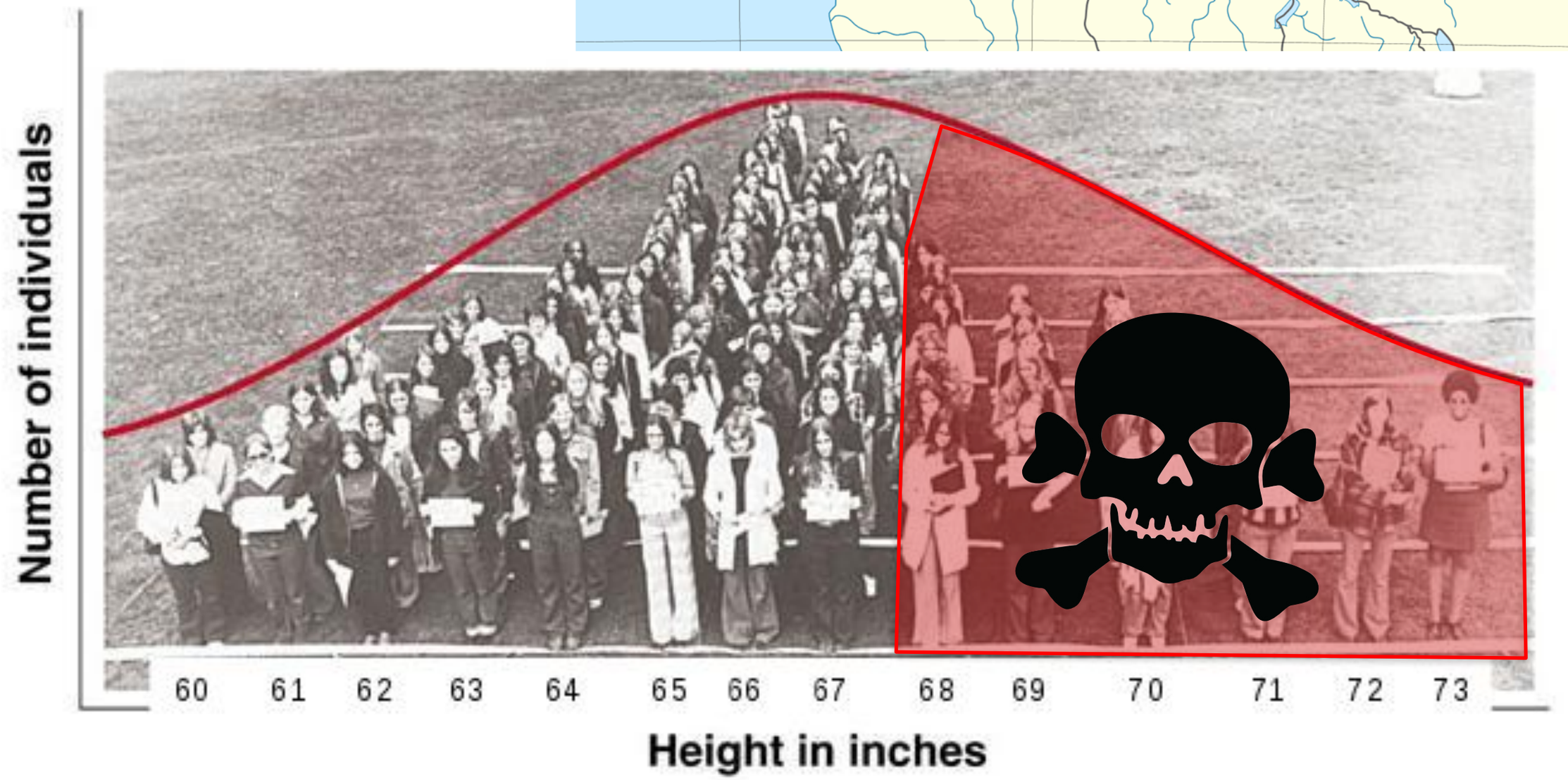
t=100?

$N = 1.2 \times 10^{30}$

Where is everybody?

- **Observation #2:**
  - More offspring are born than survive!





Observations forming Darwin's Inferences on Natural Selection

- **Observation #1:**
  - Trait variability!

Individuals in this population of Asian ladybird beetles vary in color and spot pattern.

- **Observation #2:**
  - More offspring are born than survive!

A single puffball fungus can produce billions of spores that give rise to offspring.

If all of these offspring and their descendants survived to maturity, they would carpet the surrounding land.

Alfred Russell Wallace's Fever Dream

Natural Selection from thoughts on overpopulation

"It then occurred to me that these causes or their equivalents are continually acting in the case of animals also; and as animals usually breed much more quickly than does mankind, the destruction every year from these causes must be enormous in order to keep down the numbers of each species, since evidently they do not increase regularly from year to year, as otherwise the world would long ago have been crowded with those that breed most quickly. Vaguely thinking over the enormous and constant destruction which this implied, it occurred to me to ask the question, why do some die and some live? And the answer was clearly, on the whole the best fitted live ... and considering the amount of individual variation that my experience as a collector had shown me to exist, then it followed that all the changes necessary for the adaptation of the species to the changing conditions would be brought about ... In this way every part of an animals organization could be modified exactly as required, and in the very process of this modification the unmodified would die out, and thus the definite characters and the clear isolation of each new species would be explained." -ARW

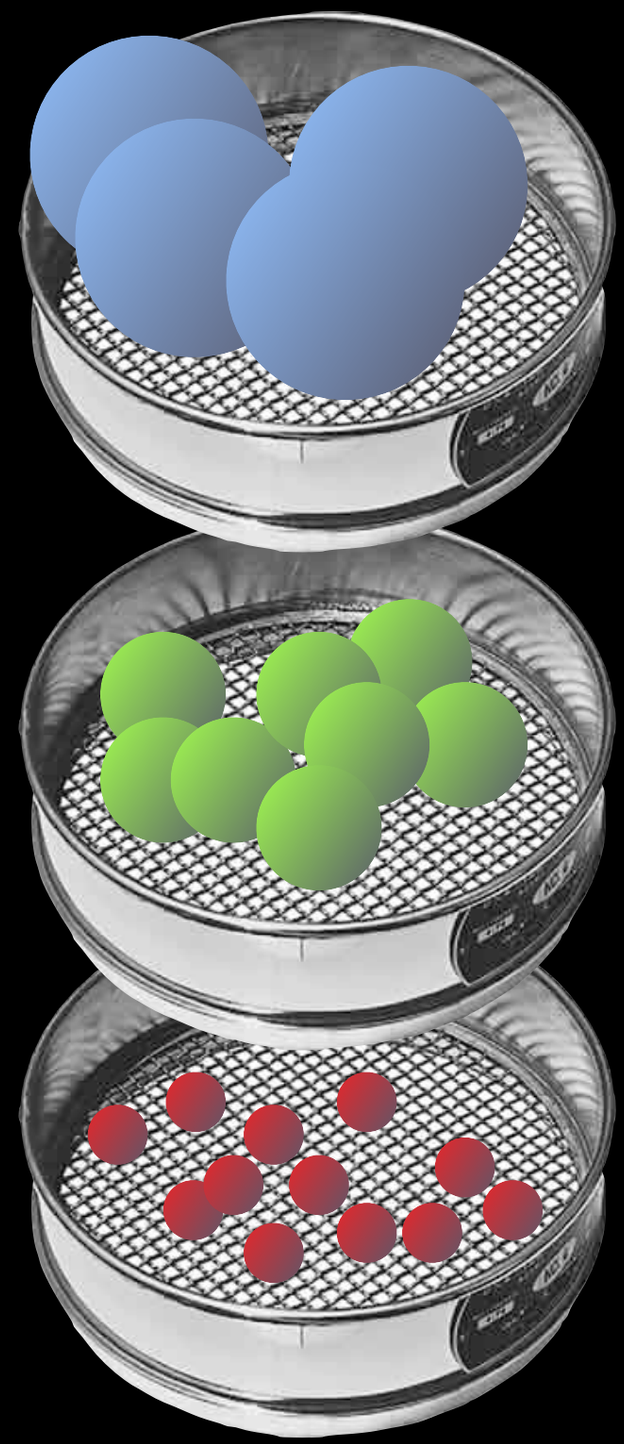
Evolution by Natural Selection!

✓1. Inheritance of trait
✓2. Variation in trait
✓3. Selective 'force'
Trait variants don't have equal reproductive success

Fitness

= survivorship
+ reproduction

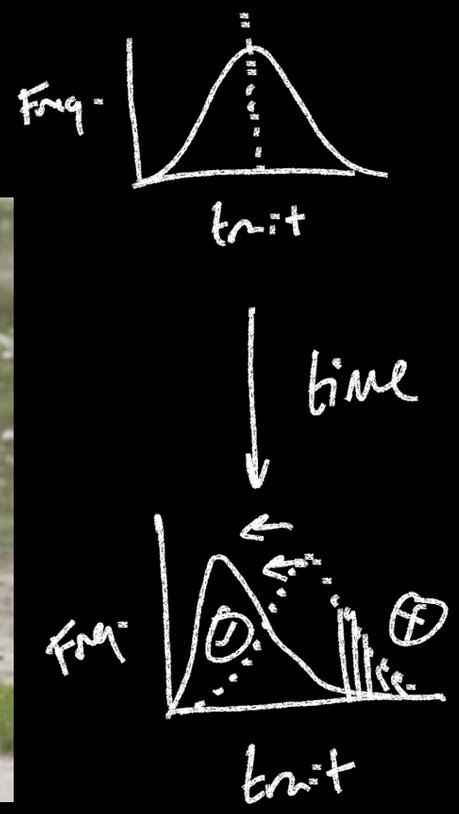
time



Individuals vs. Populations

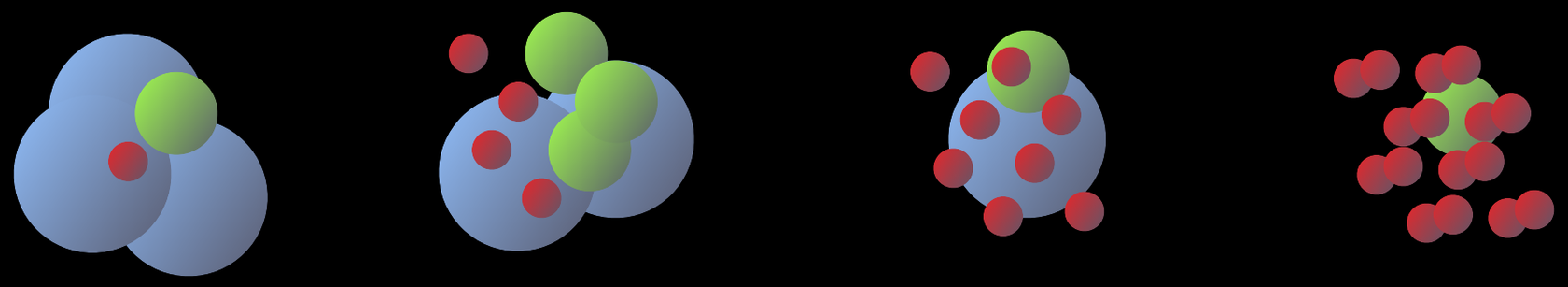
Individuals

NATURAL SELECTION

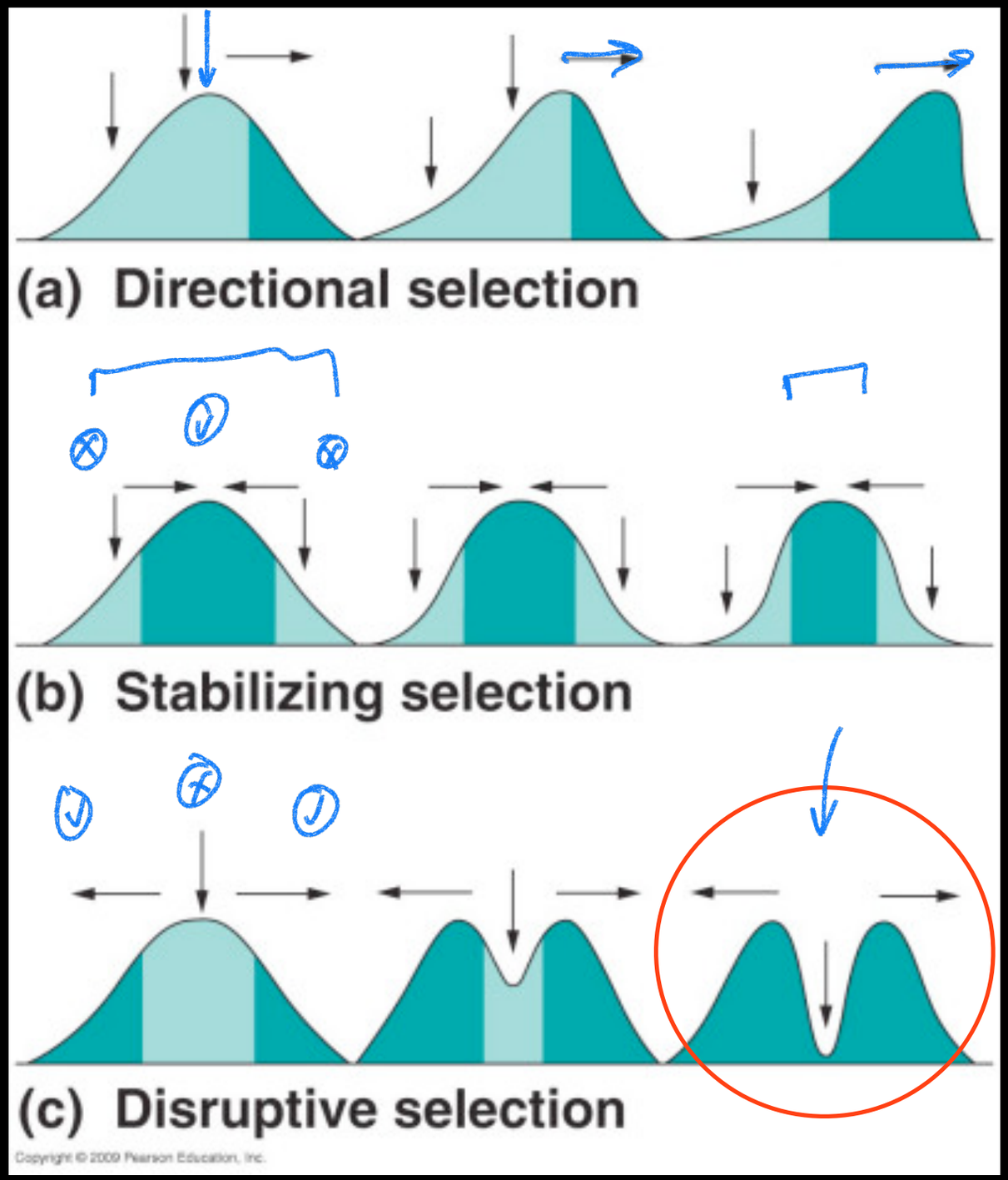


Populations

EVOLUTION



Modes of Selection



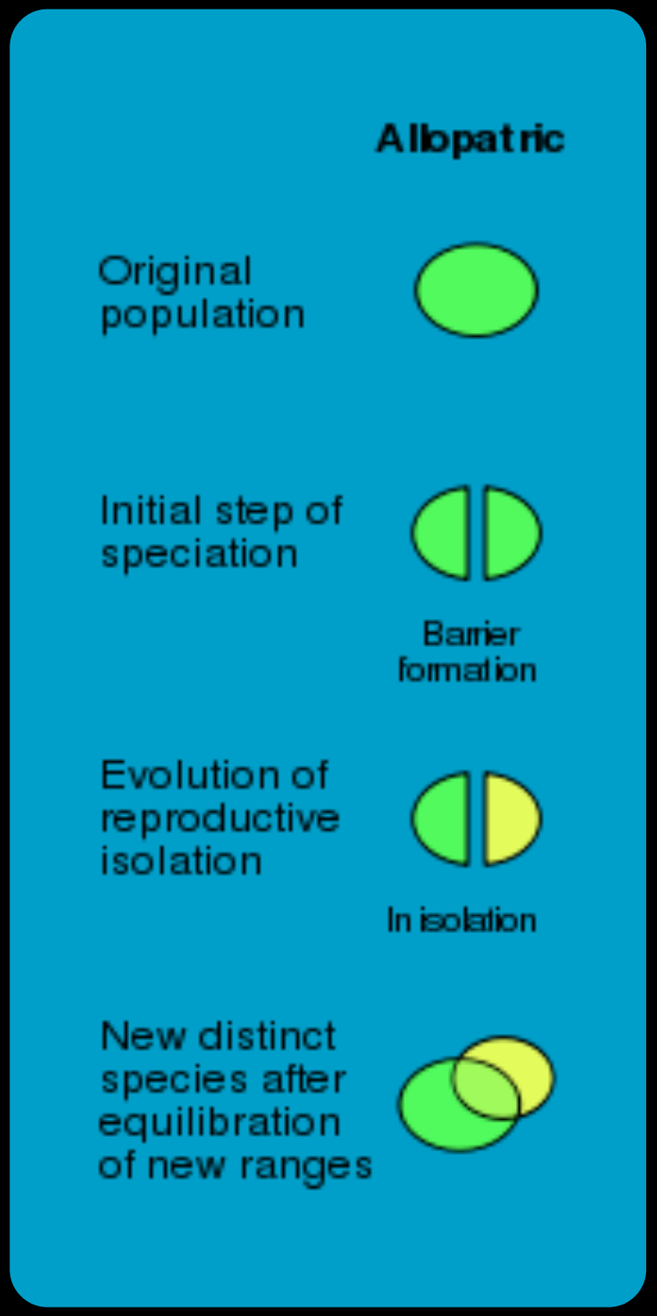
e.g. human height

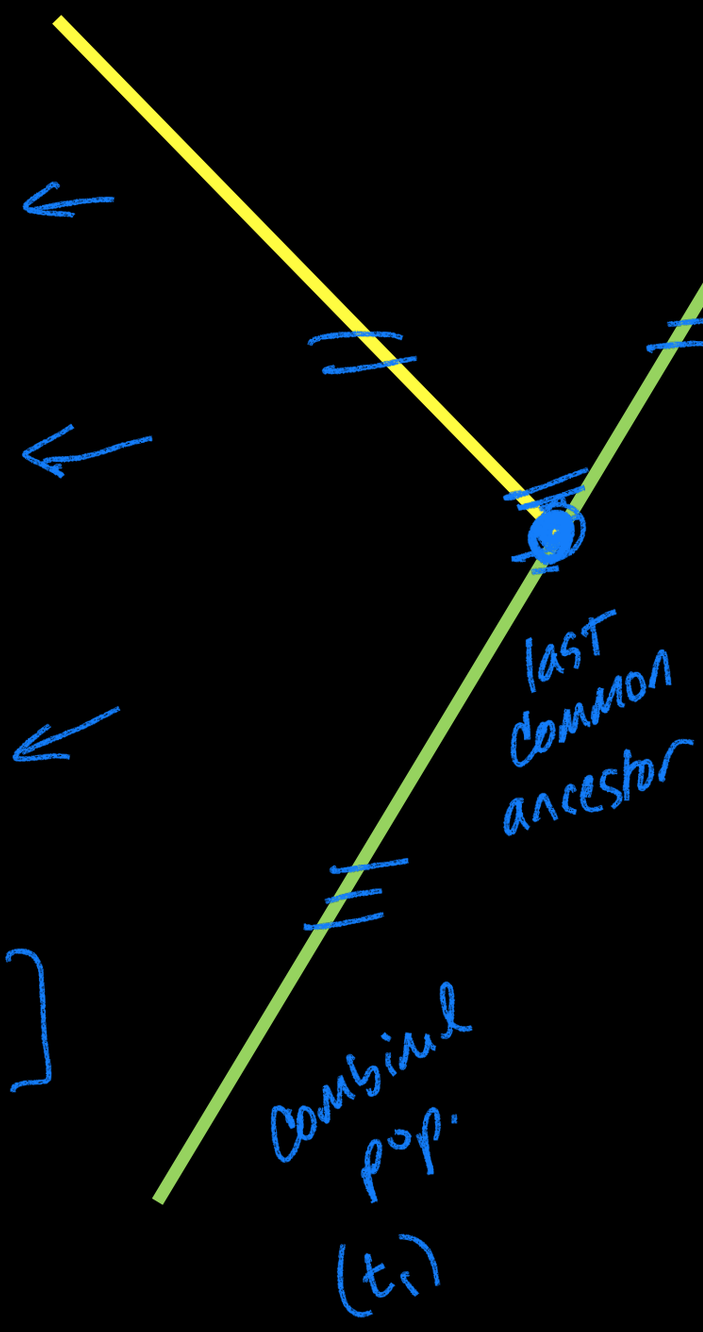
e.g. birth weight in humans

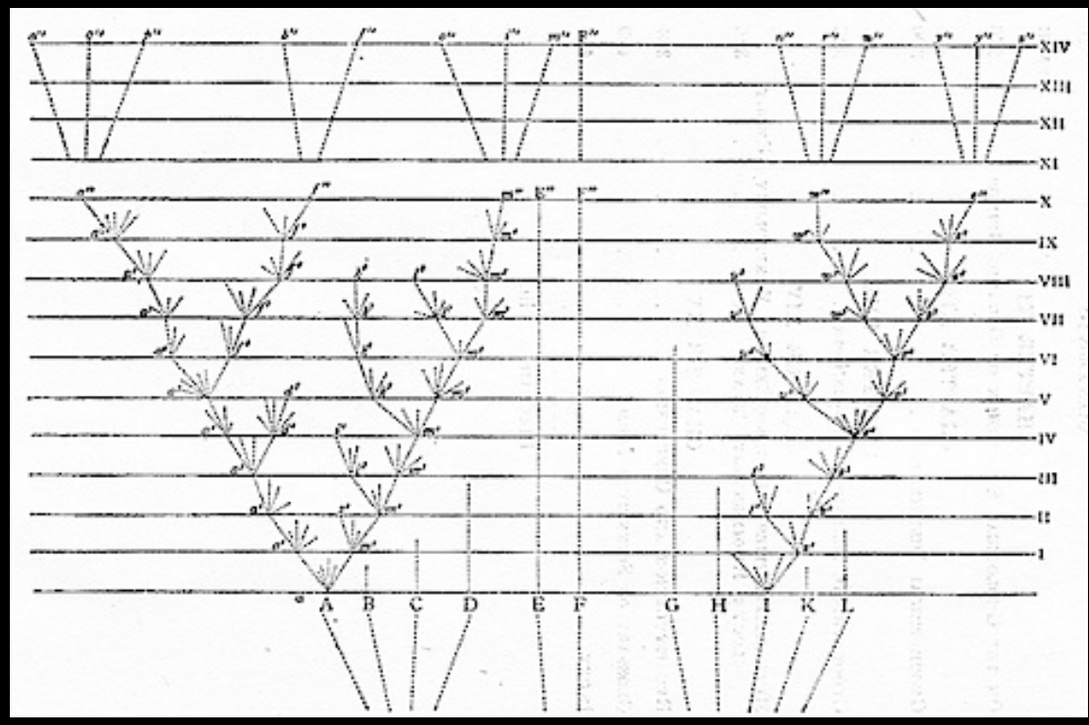
~speciation
(this is what we will be focusing on)

t_1 t_2 t_3

Speciation: Evolution by Natural Selection

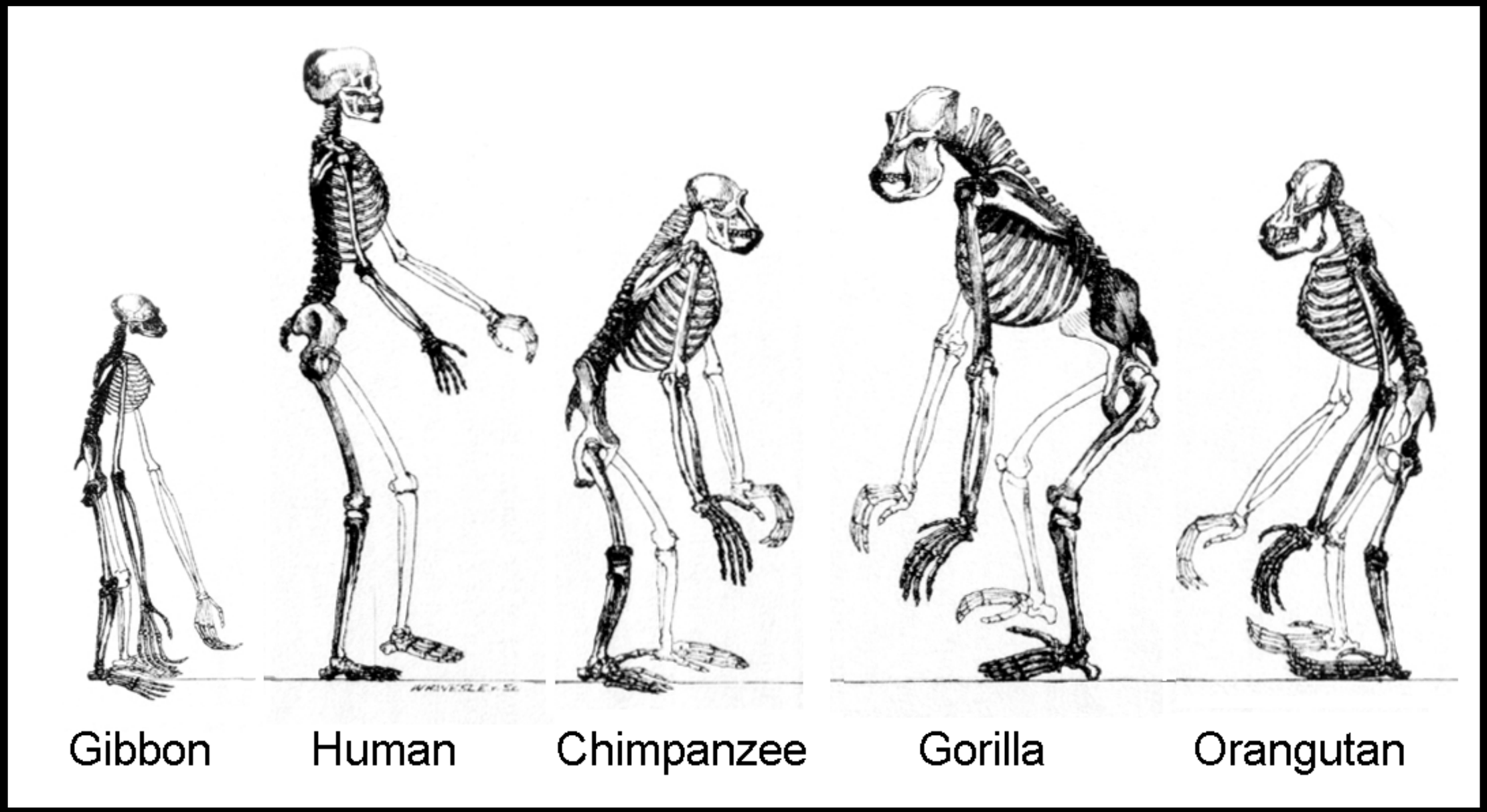


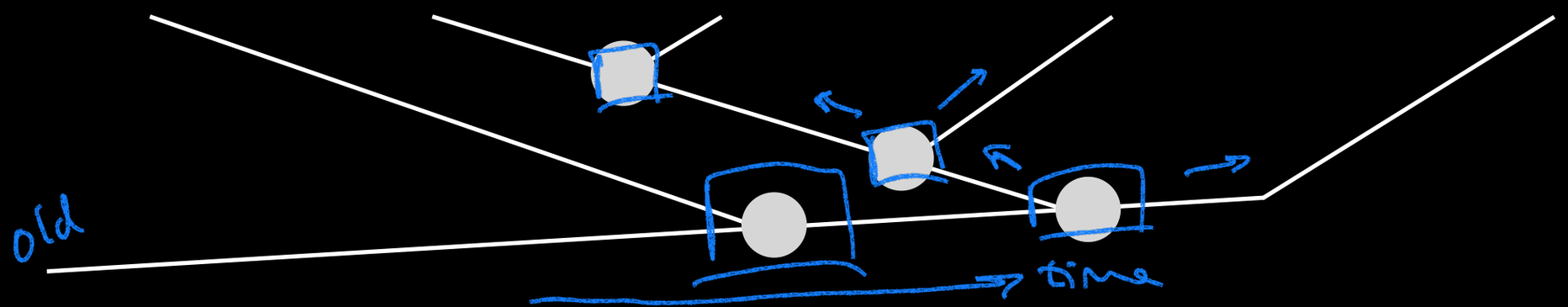




That is the theory... so what is the evidence?

Similarity in form (comparative morphology)

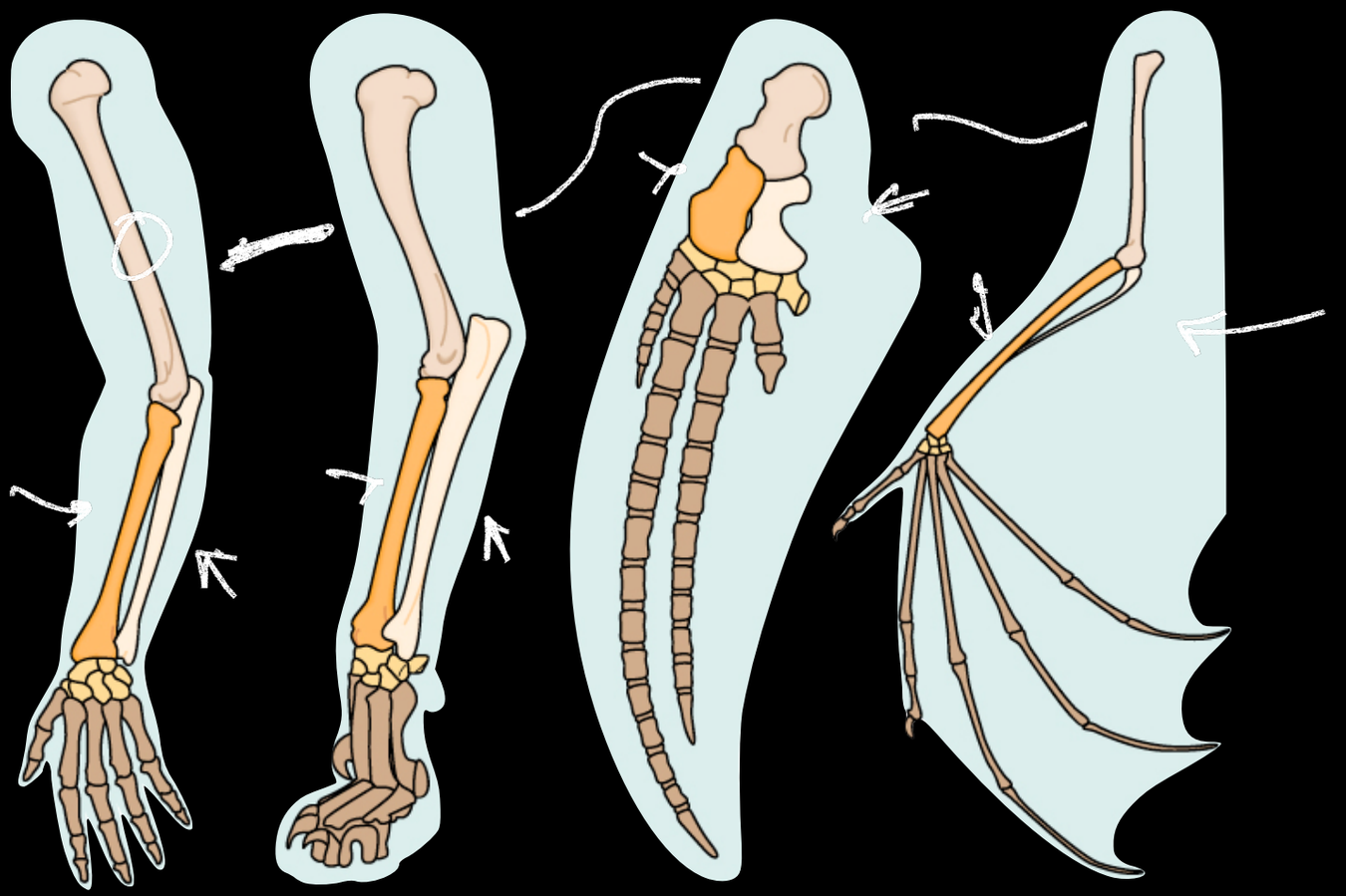




Evidence for Evolution

1. Homologous characteristics

- related individuals share traits
~ variations on the same theme

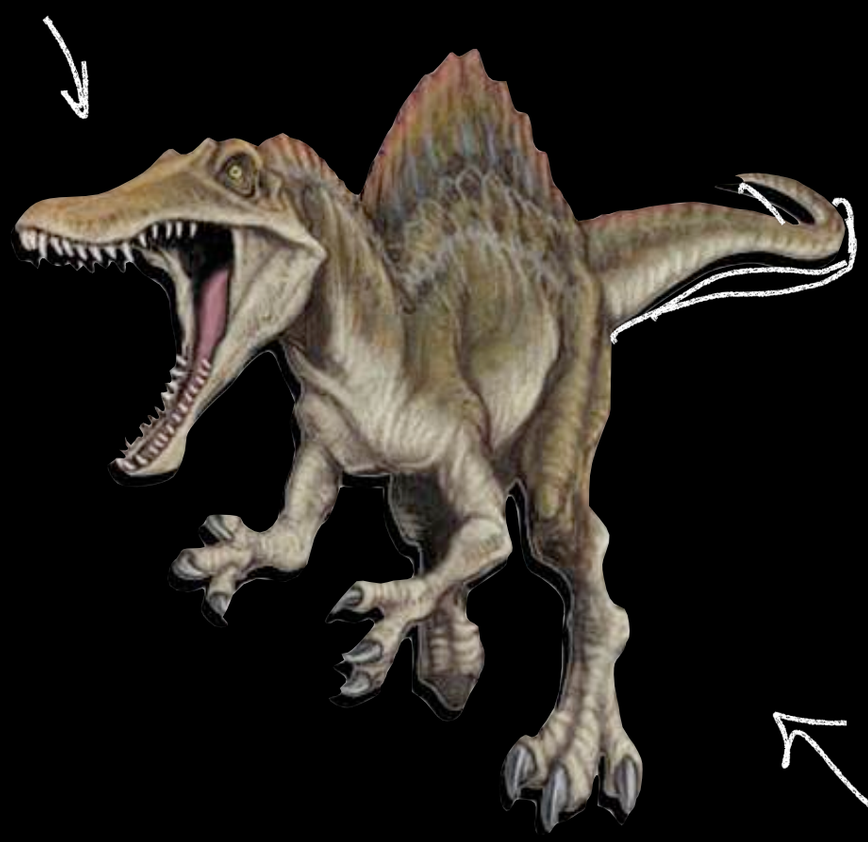


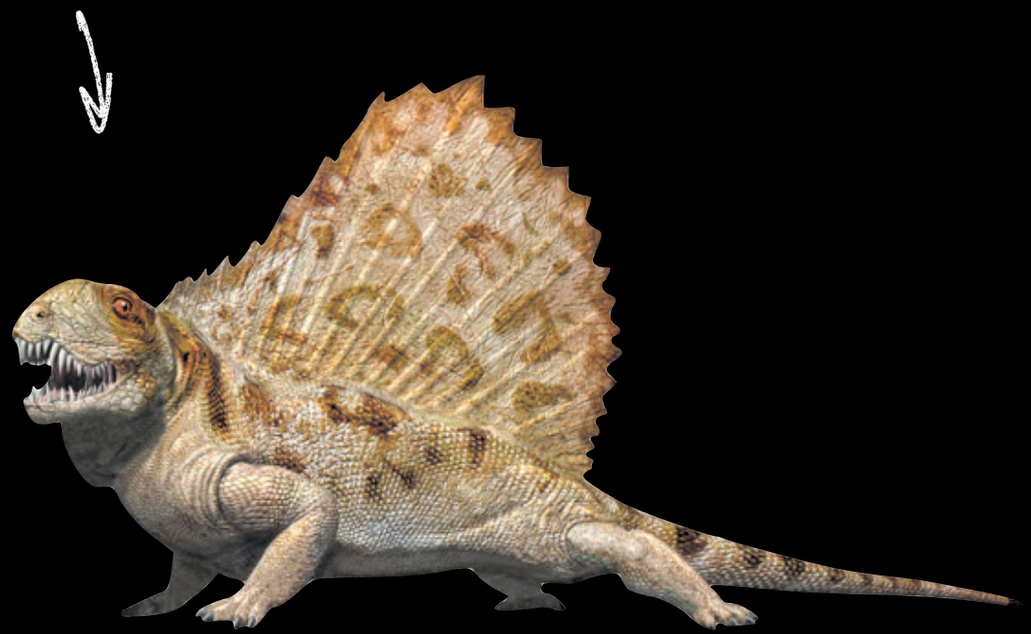
Human Cat Whale Bat

Traits that emerged from the Tetrapod Body Plan

* Share an evolutionary origin!

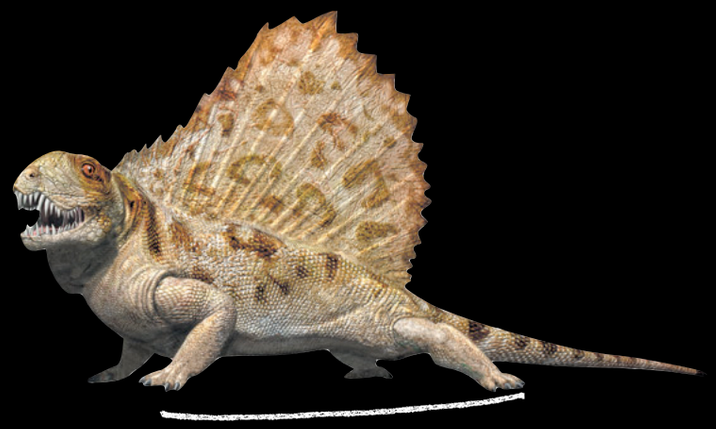
Evidence for Evolution

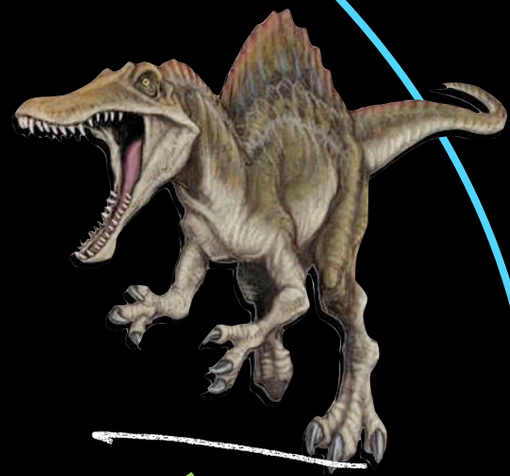


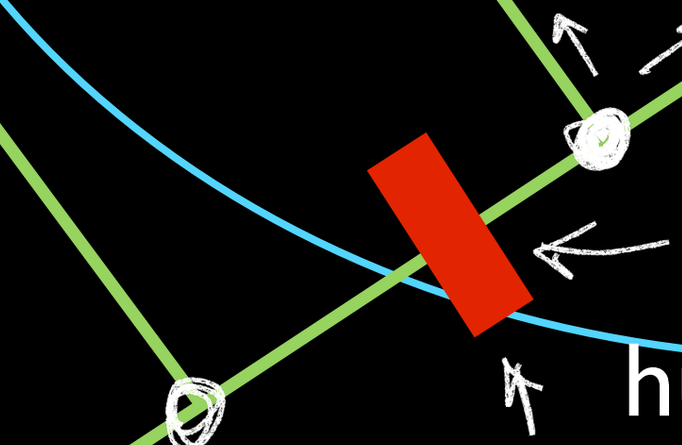


Evidence for Evolution

Homologous



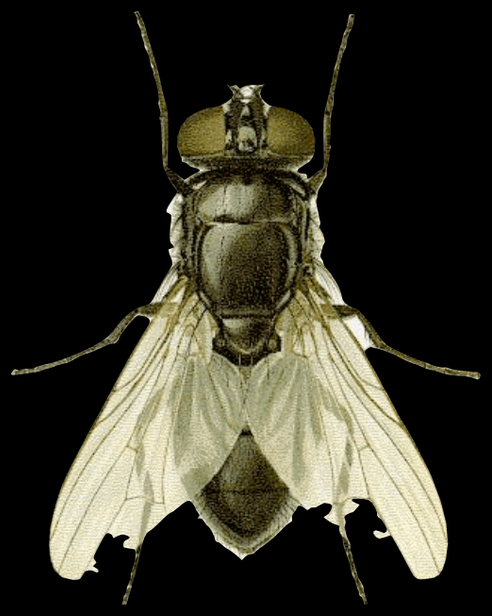




human limbs ~ dino limbs

{The Tetrapod body plan}

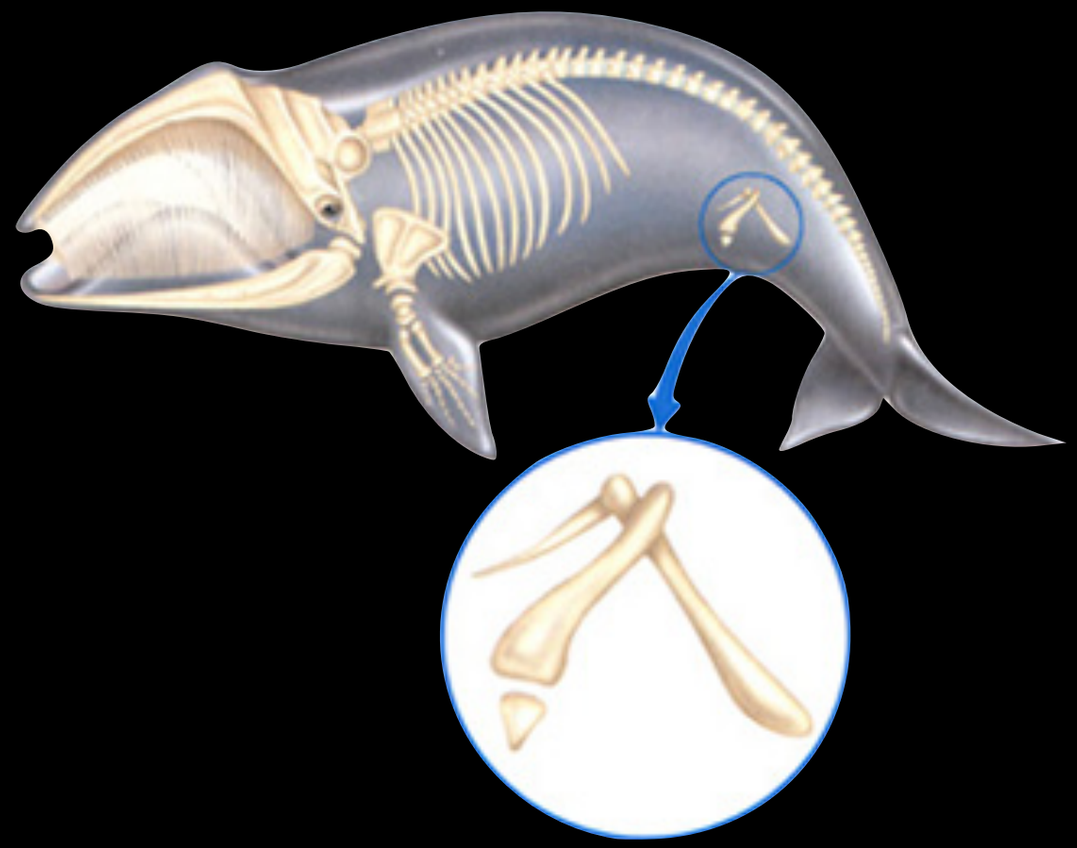
Analogous



Convergent Evolution
- Similar traits evolve independently
- Do not share an evolutionary origin

fly wings ≠ pterosaur wings

2. Vestigial Traits

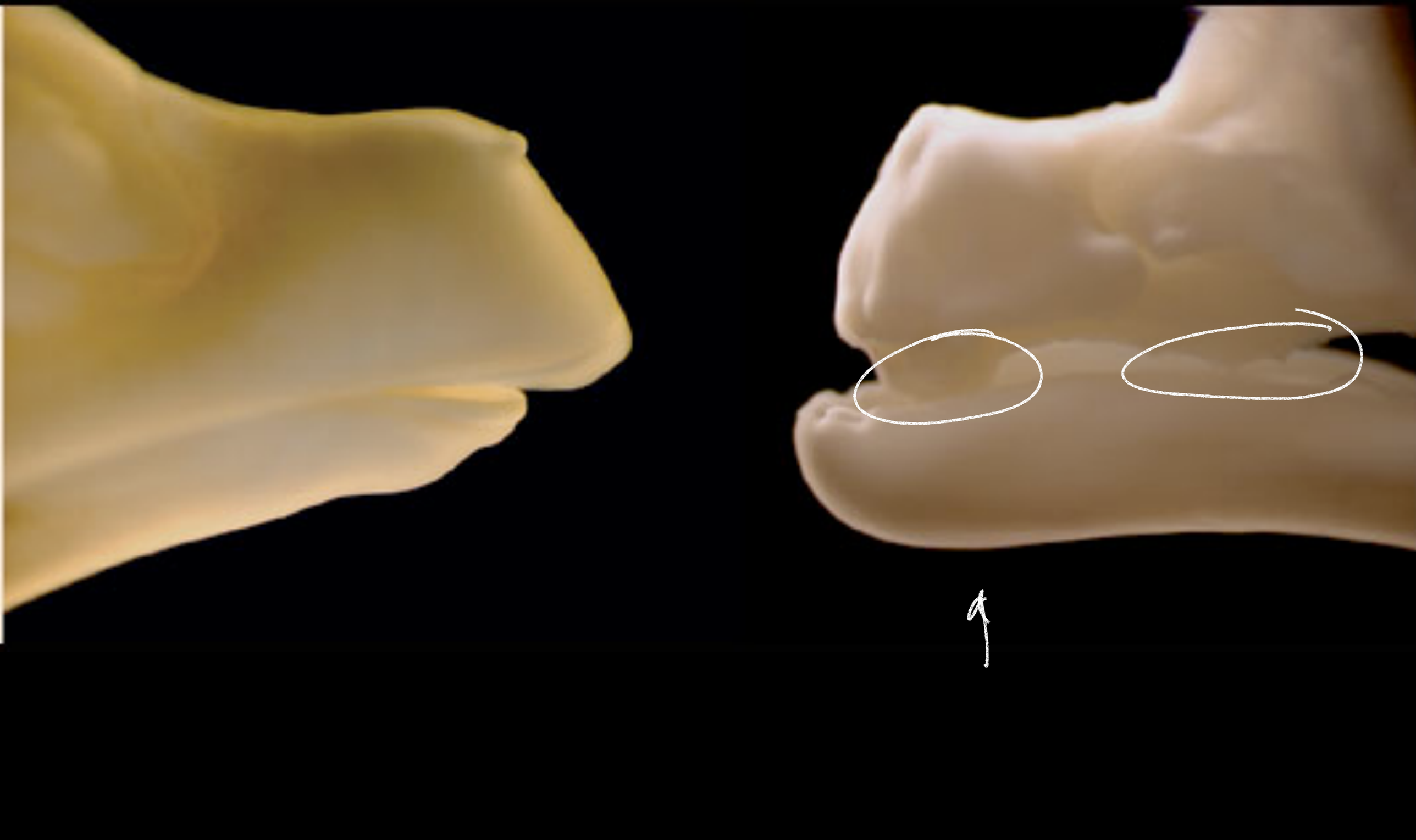


Can we think of some vestigial human traits?

- Tail bone
- Wisdom Teeth
- Appendix ~ vestige of the cecum
  - └ digesting cellulose

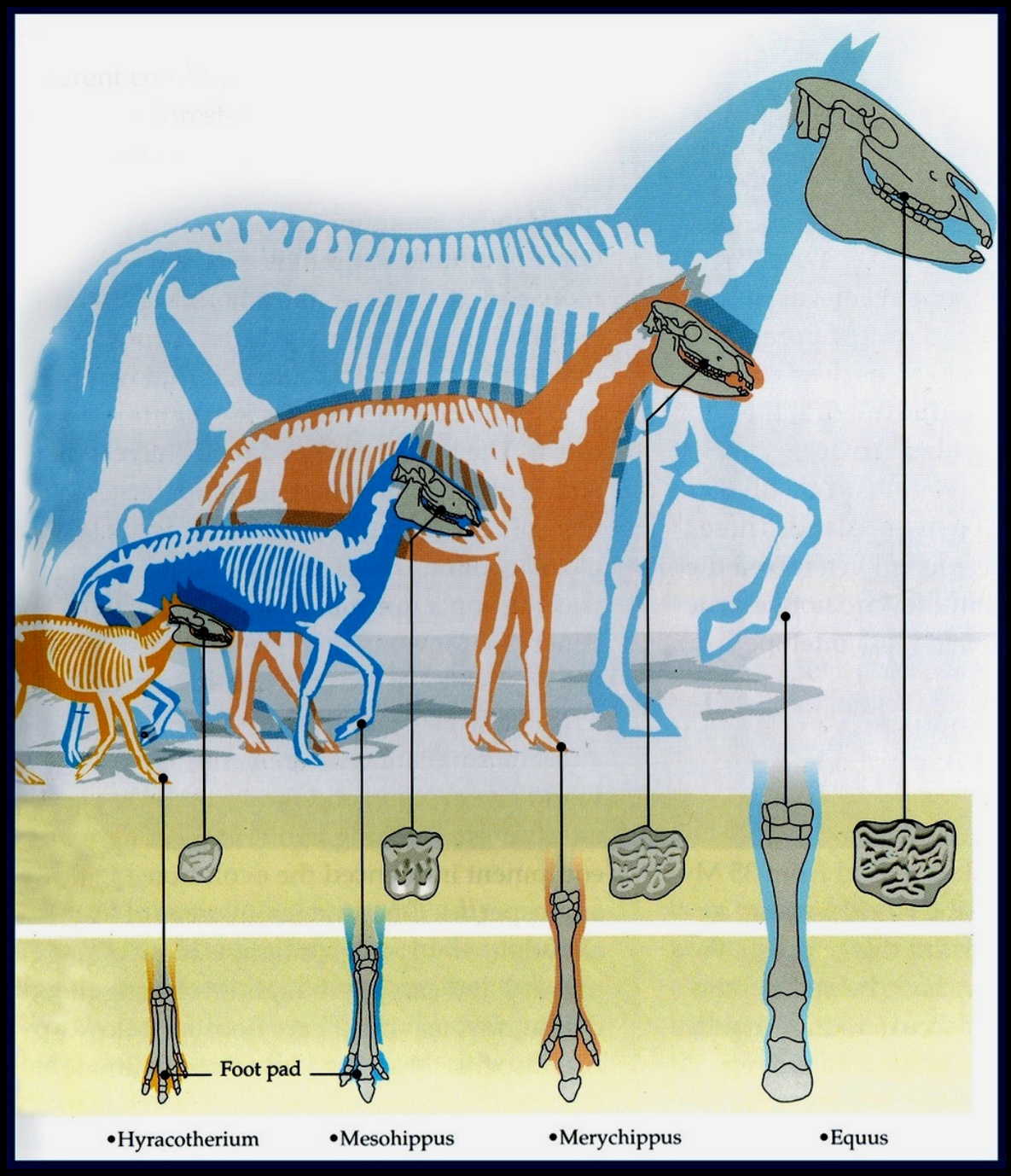
Evidence for Evolution

Vestigial Traits

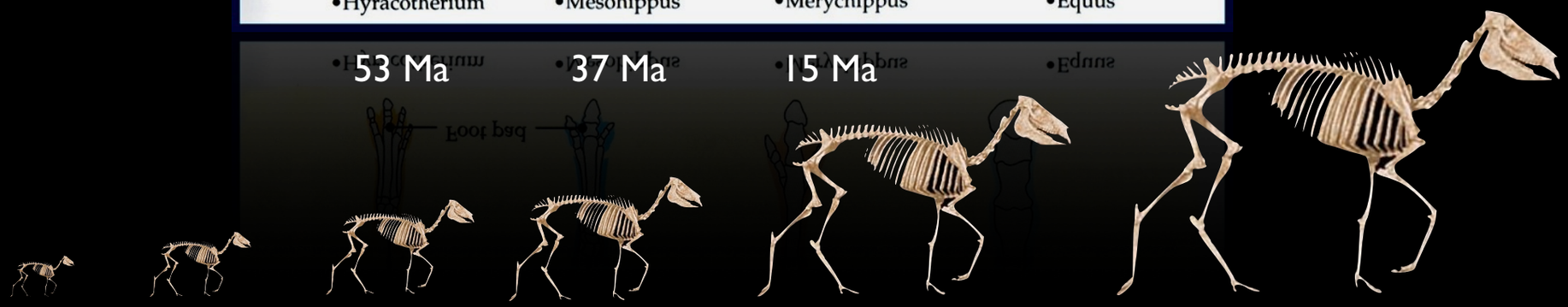


Evidence for Evolution

3. The Fossil Record



53 Ma 37 Ma 15 Ma

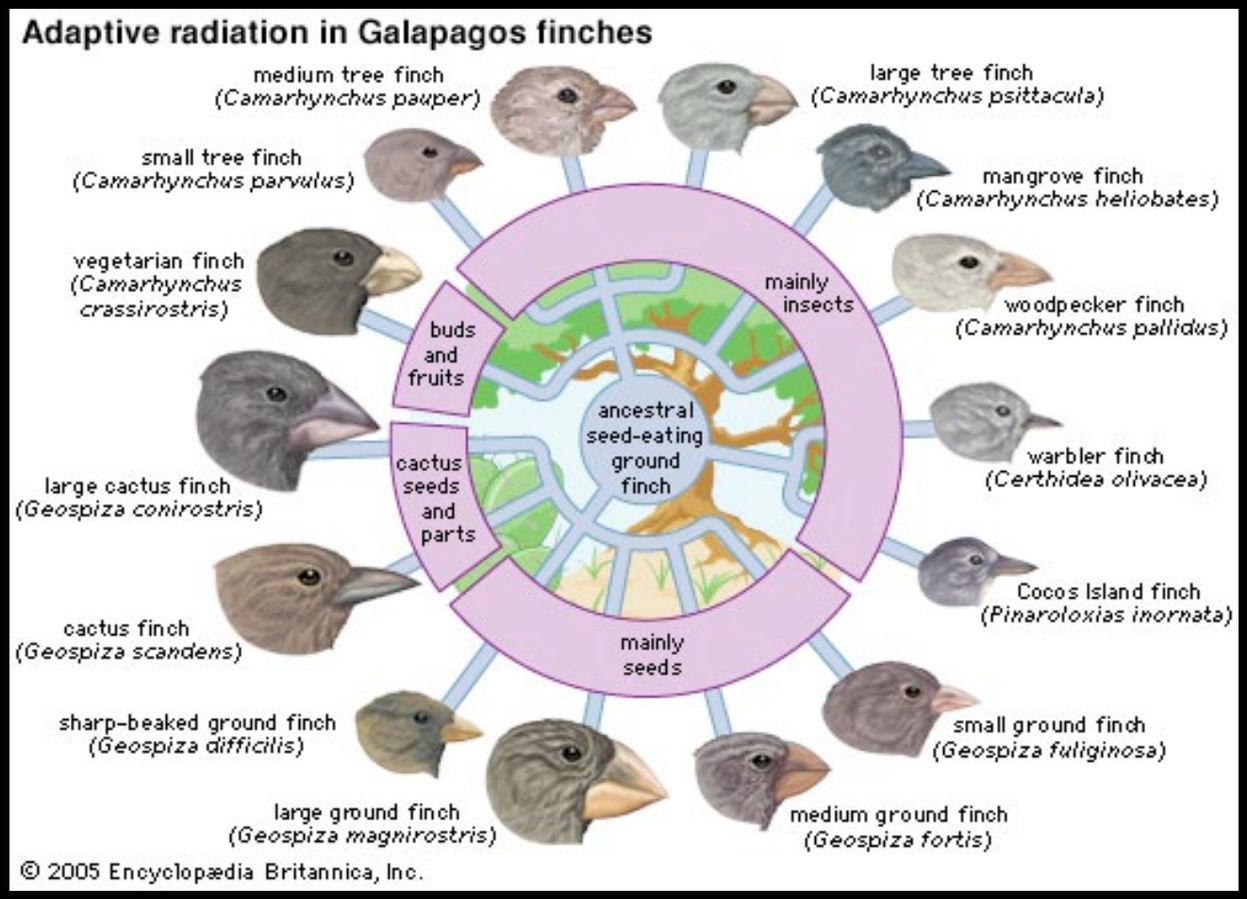


Evidence for Evolution
by Natural Selection

3. Modern Evolutionary Events

Evolution can occur on much smaller timescales than once thought

Finch Radiation



Islands: Natural Laboratories

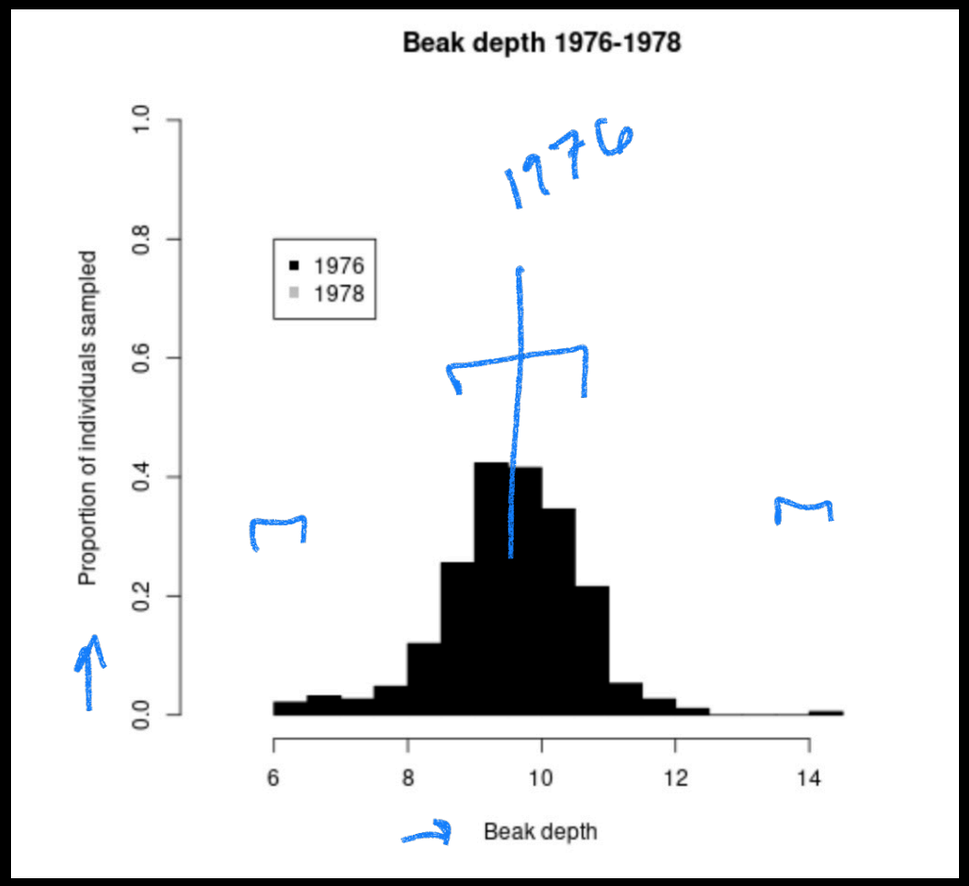
1. Inherited traits (beak size)
2. Variation in trait

Evidence for Evolution
by Natural Selection

3. Modern Evolutionary Events

Evolution can occur on much smaller timescales than once thought

Finch Radiation



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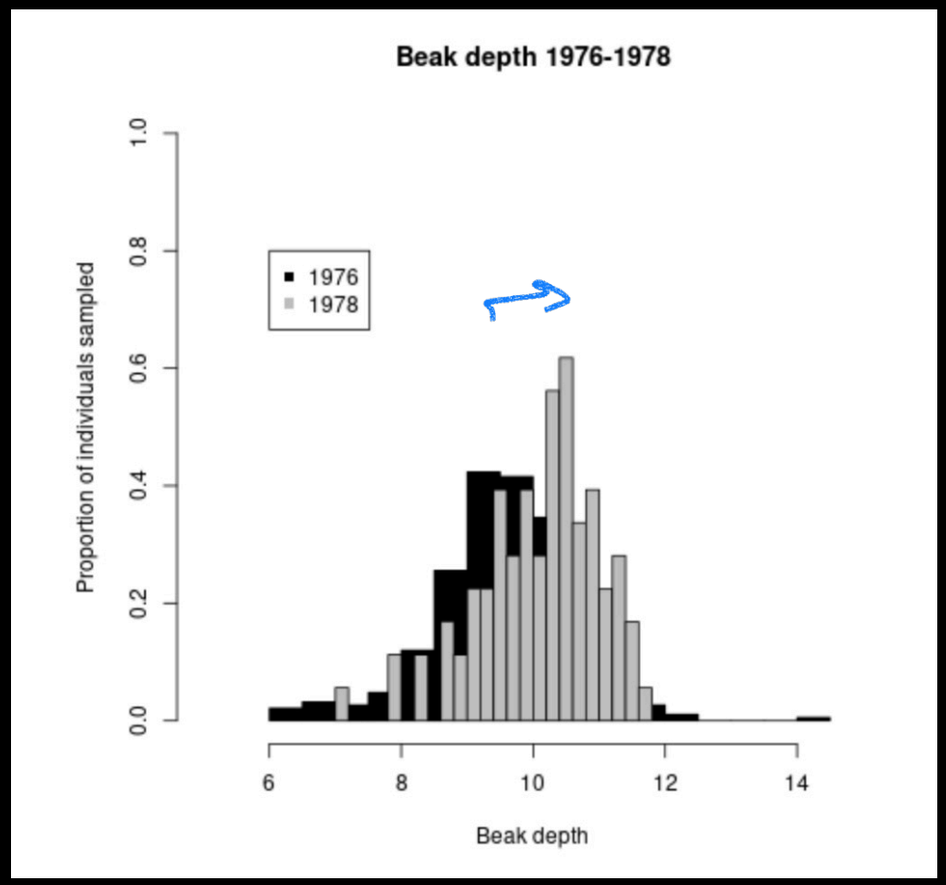
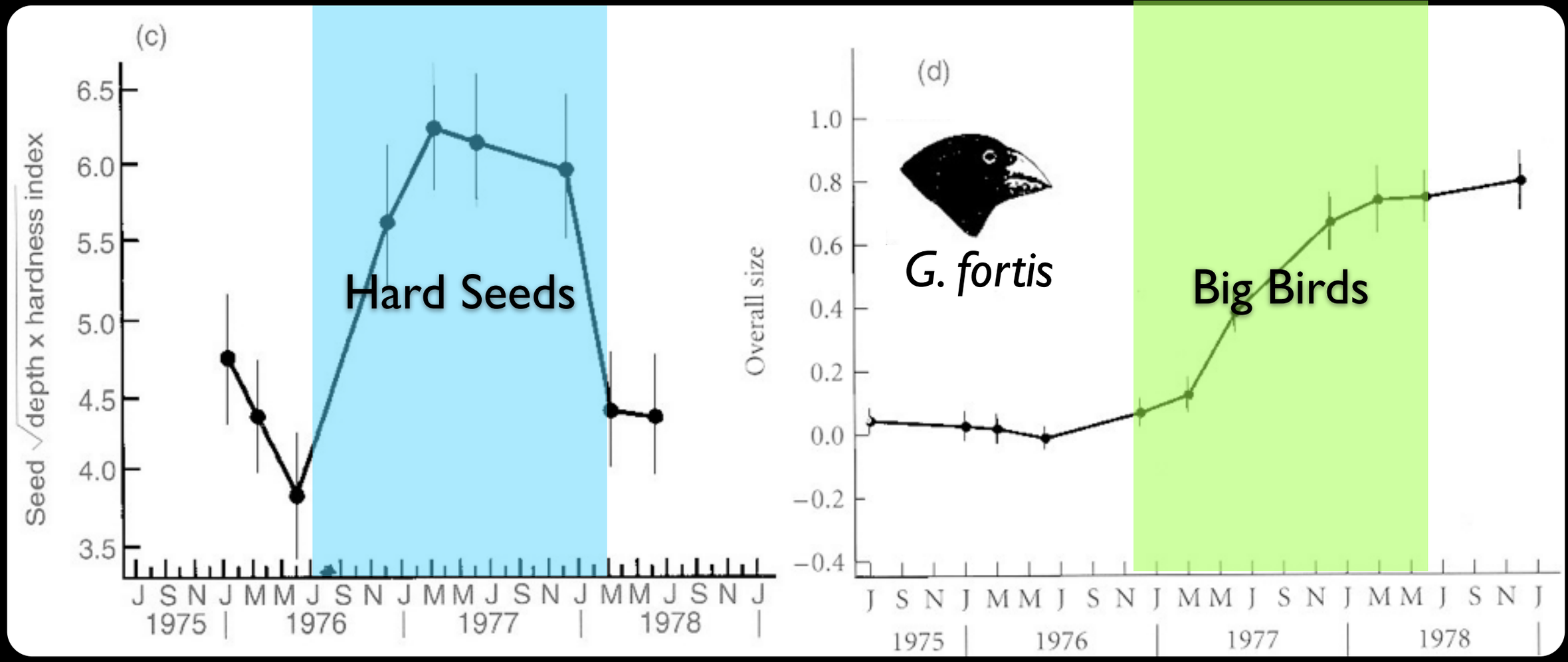


Islands: Natural Laboratories

1. Inherited traits (beak size)
2. Variation in trait

Evidence for Evolution
by Natural Selection

Selection on Galapagos finches

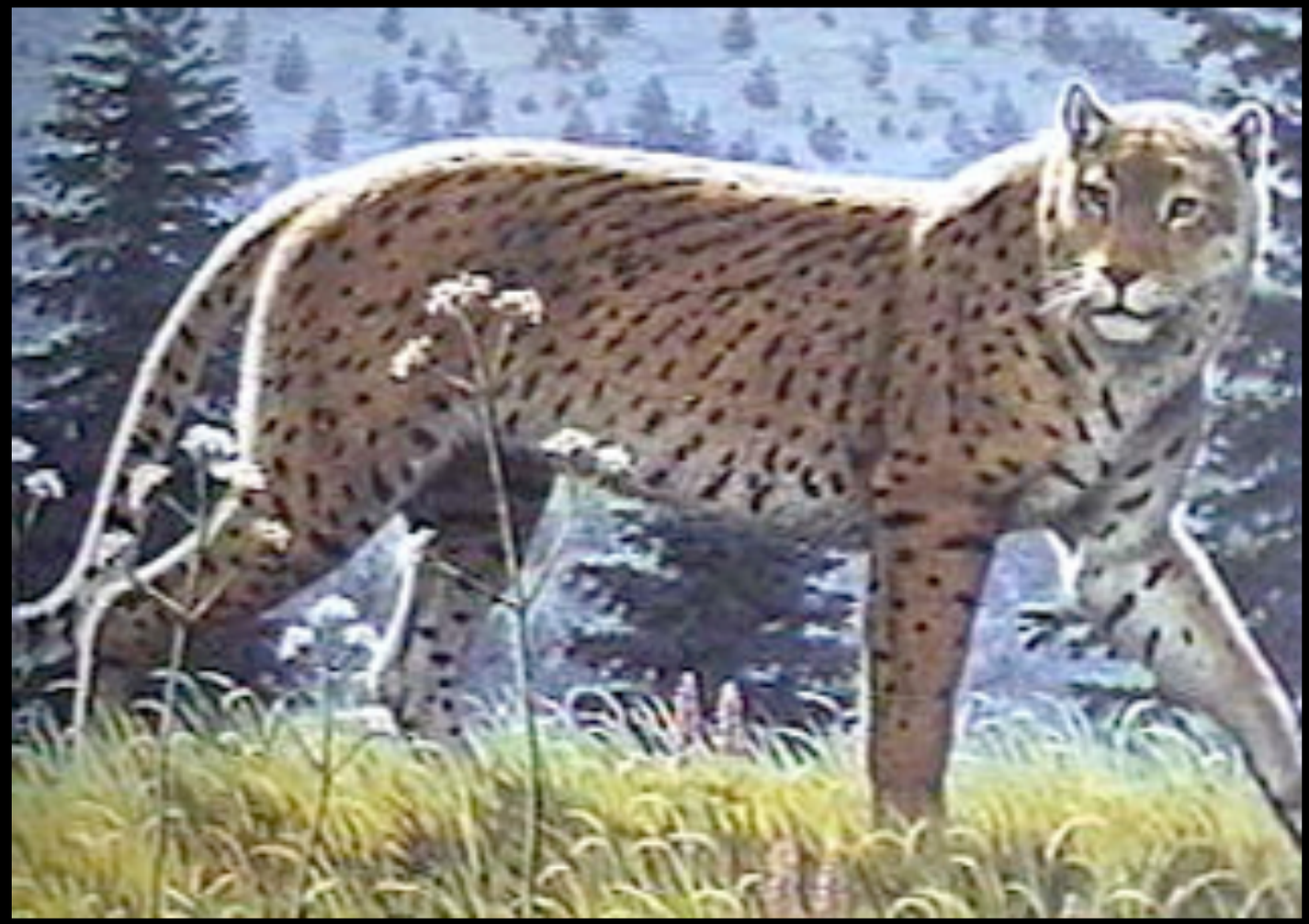


Major Drought

Selection

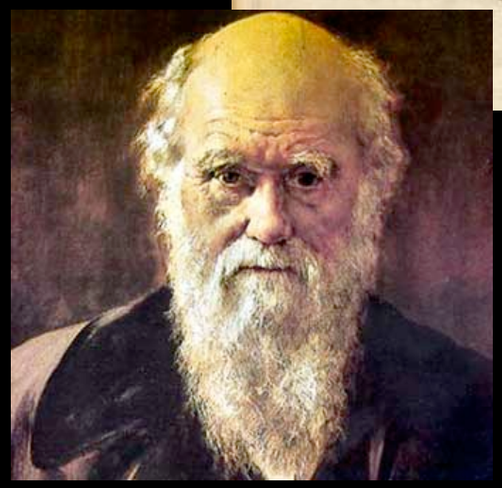
1. Inherited traits (beak size)
2. Variation in trait
3. Selection based on fitness (survival)

Coevolution



Coevolution

"I have just received such a Box full from Mr Bateman with the astounding *Angræcum sesquipedalia* with a nectary a foot long - Good Heavens what insect can suck it?"



A. sequipedale

Evidence for Evolution
by Natural Selection

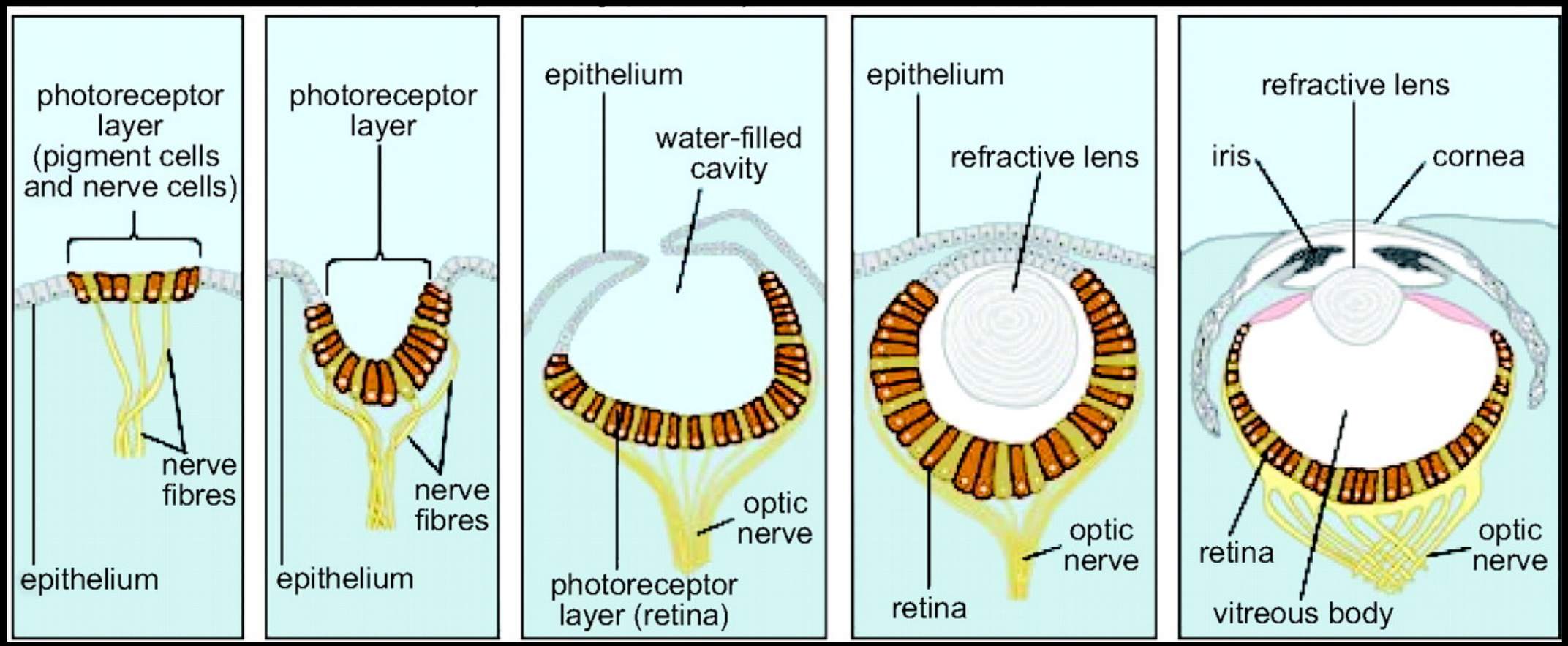
What is the method of inheritance?

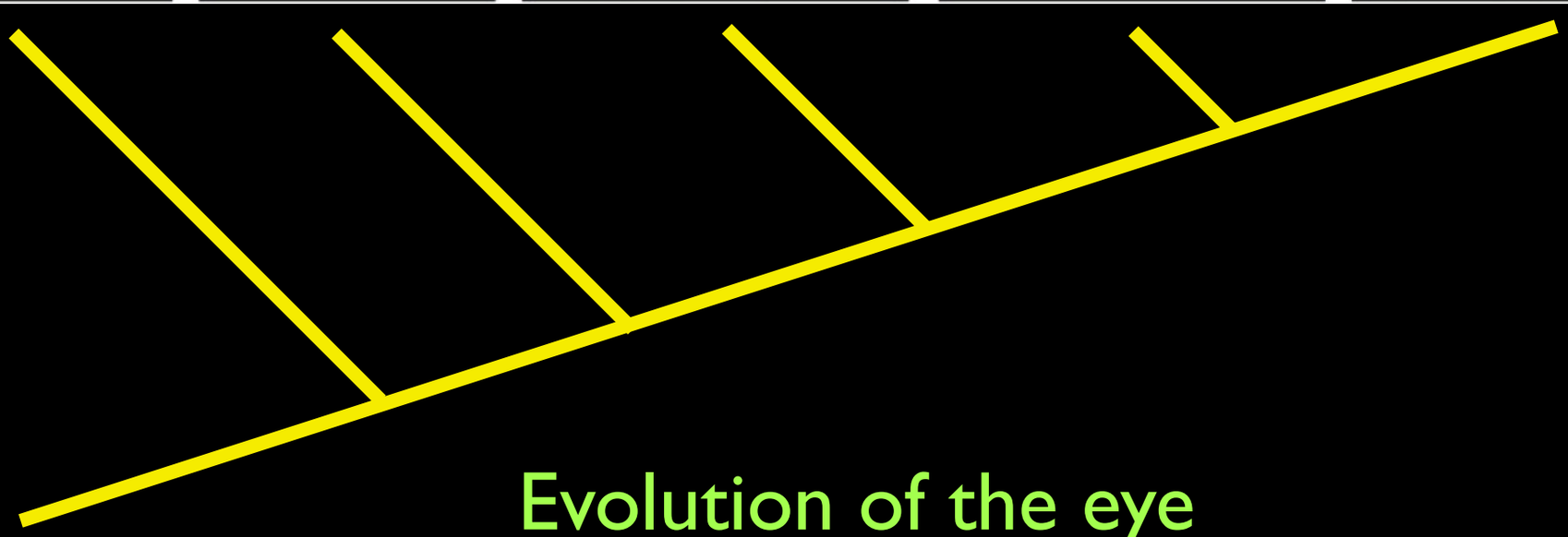
Evidence for Evolution
by Natural Selection

4. DNA

Evidence for Evolution
by Natural Selection

Evolution occurs in many small steps
Over a very long time...





Evolution of the eye

Cladograms

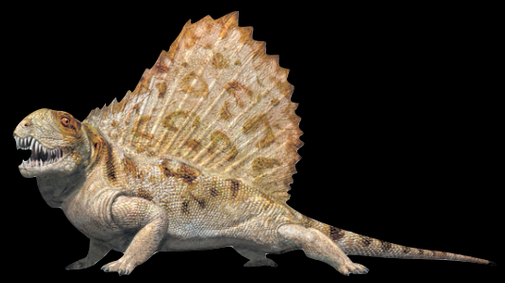
This is possibly the most important concept for the rest of the course...

- A cladogram is a hypothesis of evolutionary relationships
- No absolute time... just sequences of events
- Parsimony

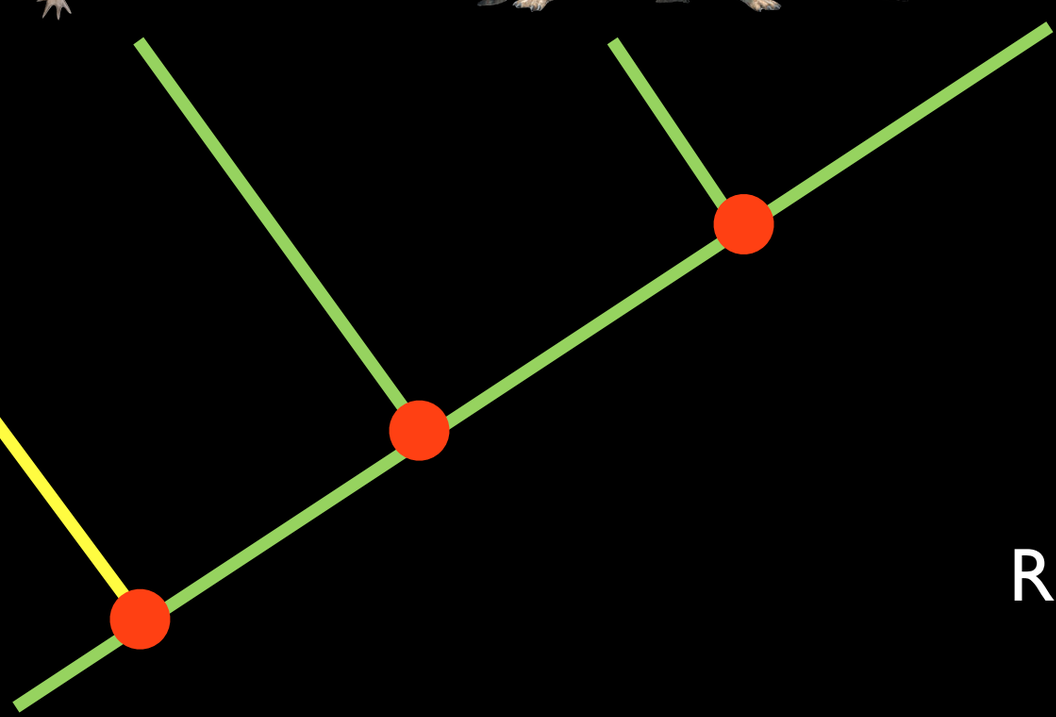
Cephalopods

Amphibians

Synapsids

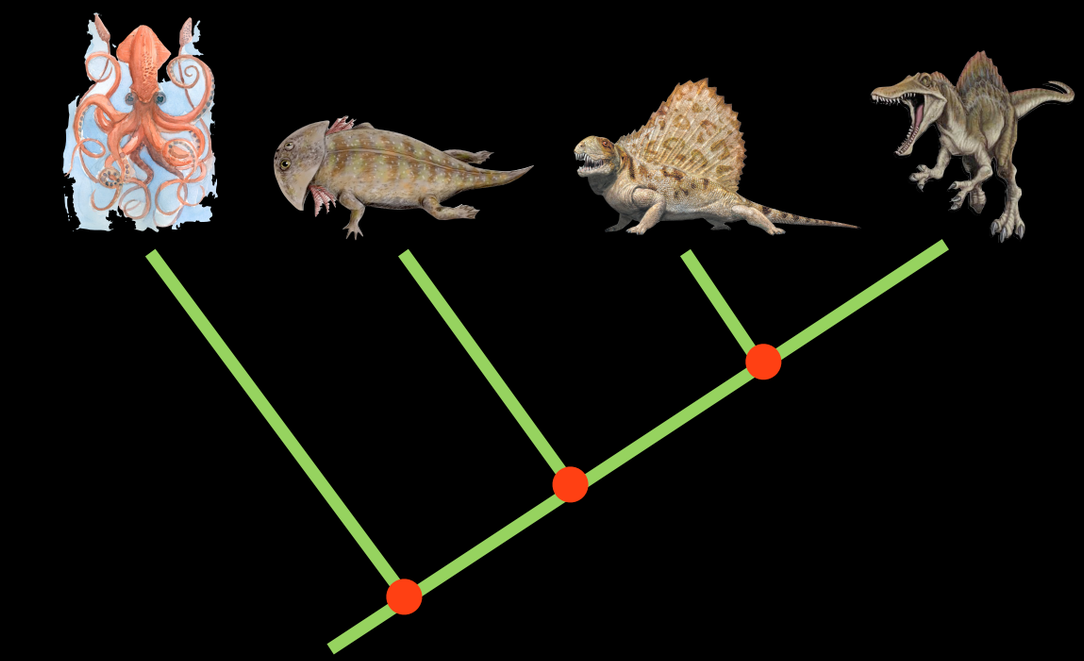


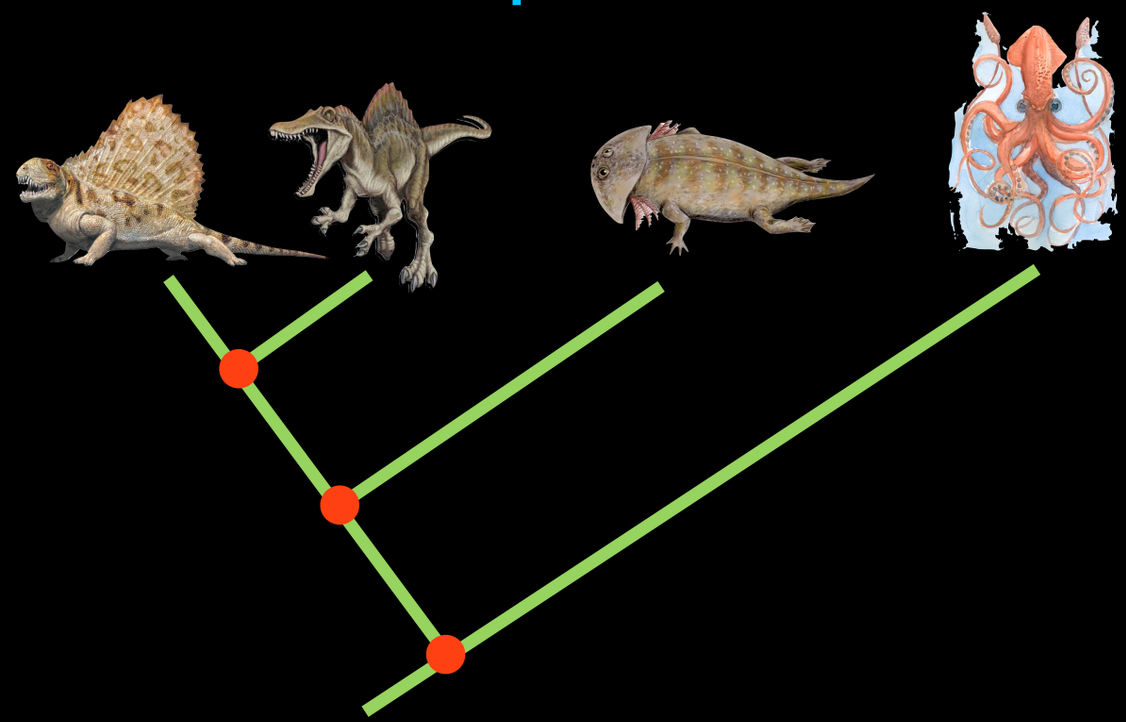
Therapsids



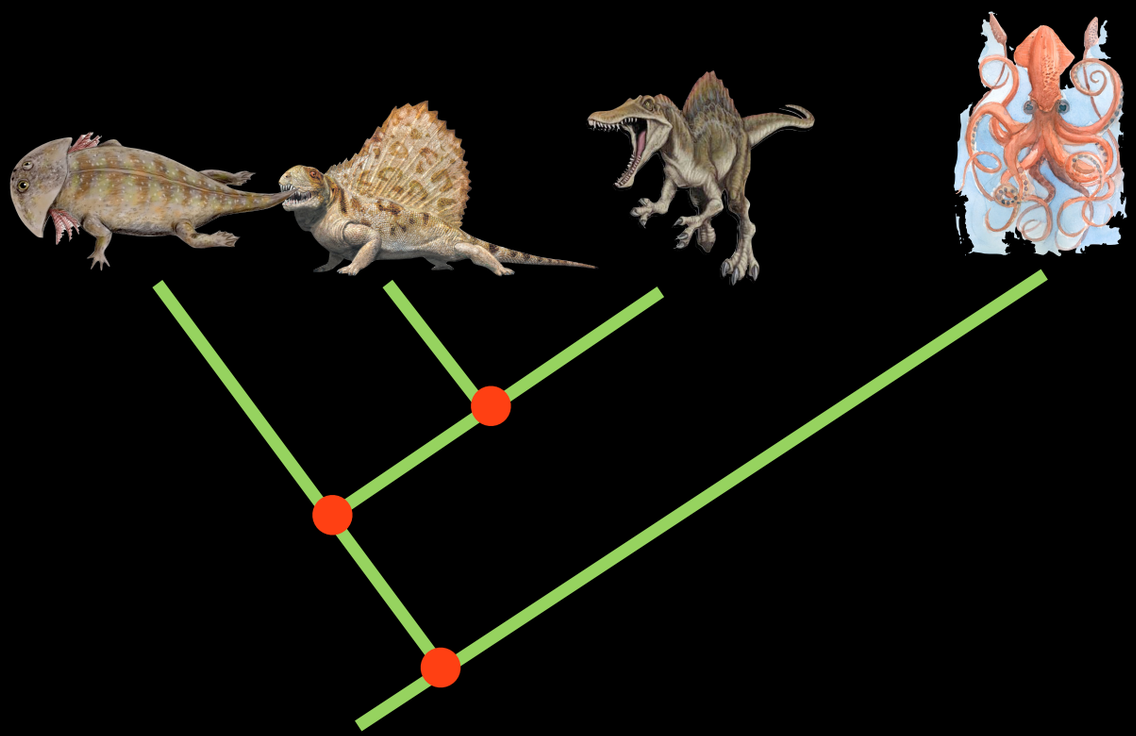
RELATIVE time

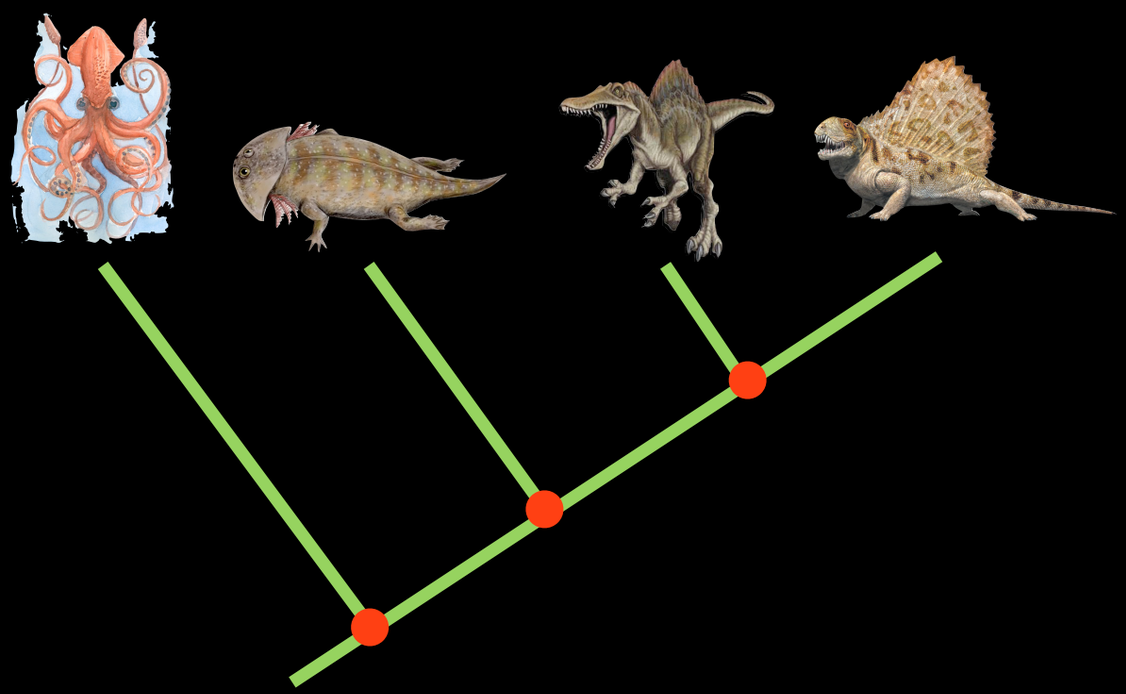
Different Hypotheses of Relationships?

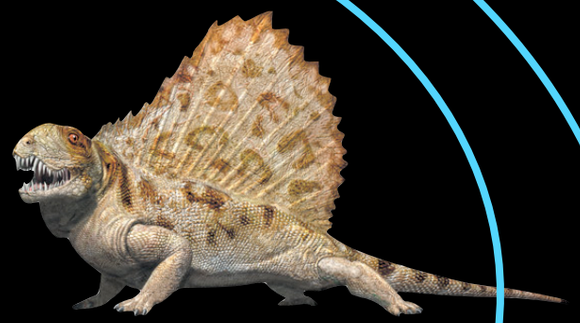




No! These are all the SAME!

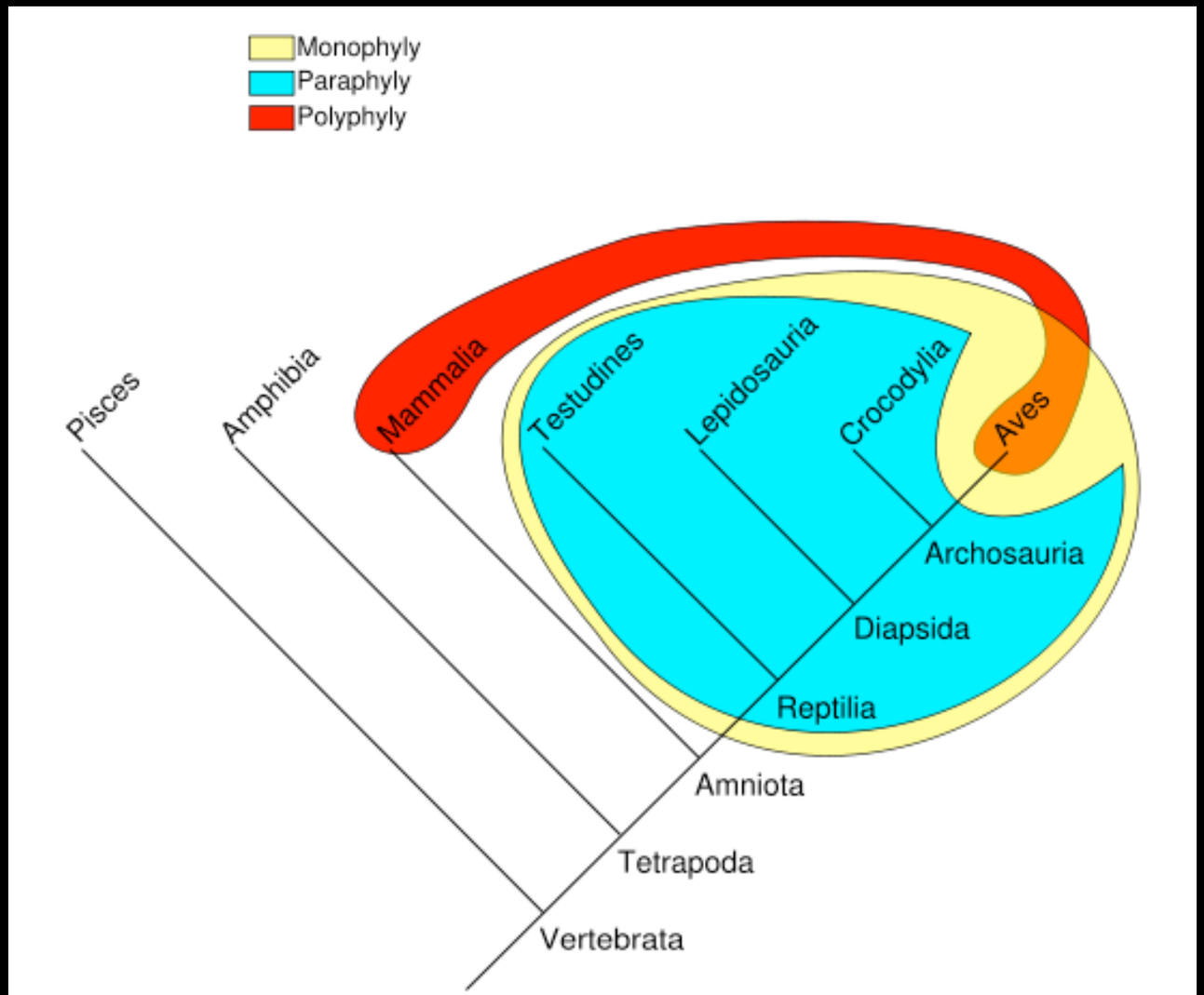






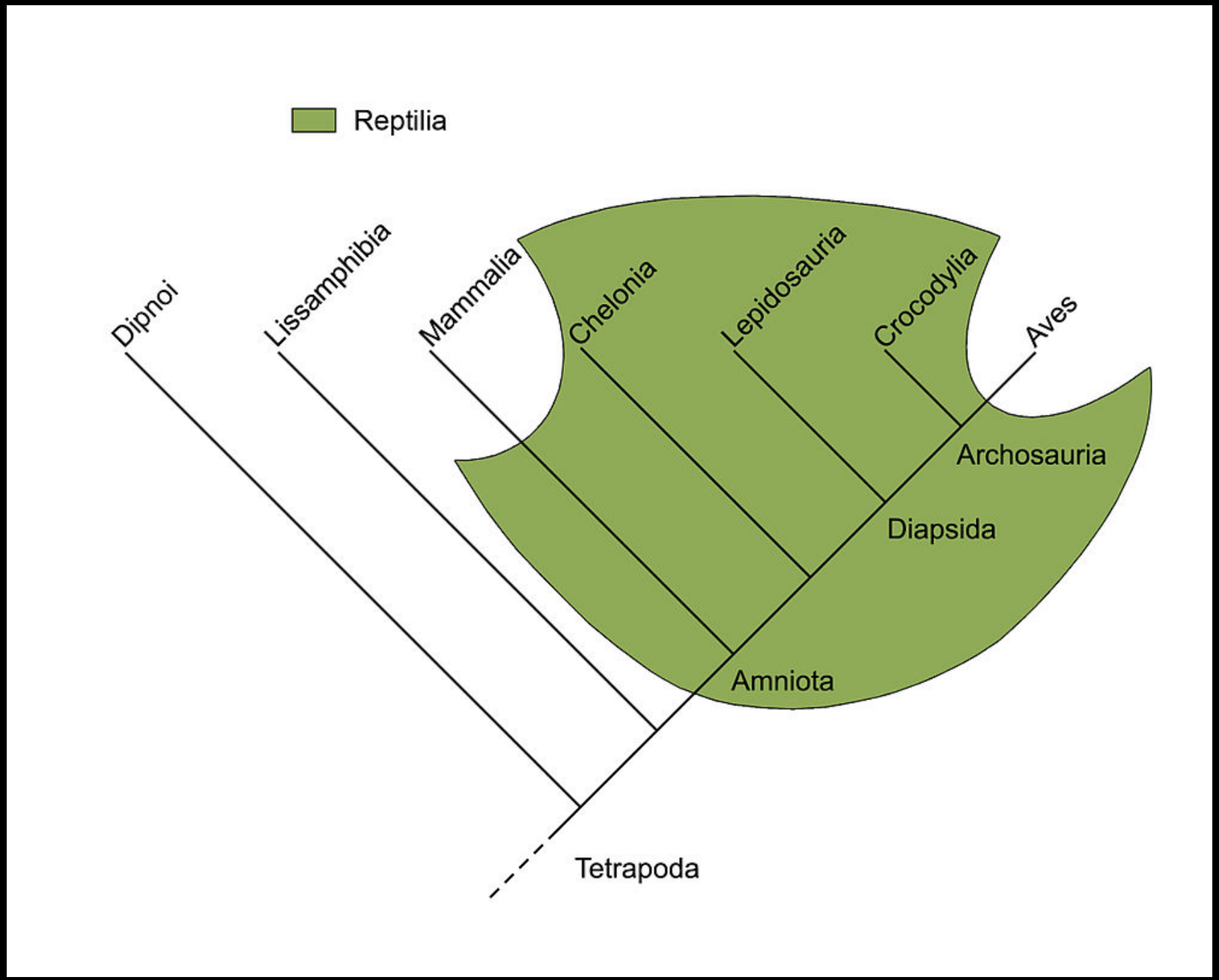
Most Recent Common Ancestor

Monophyletic Groups

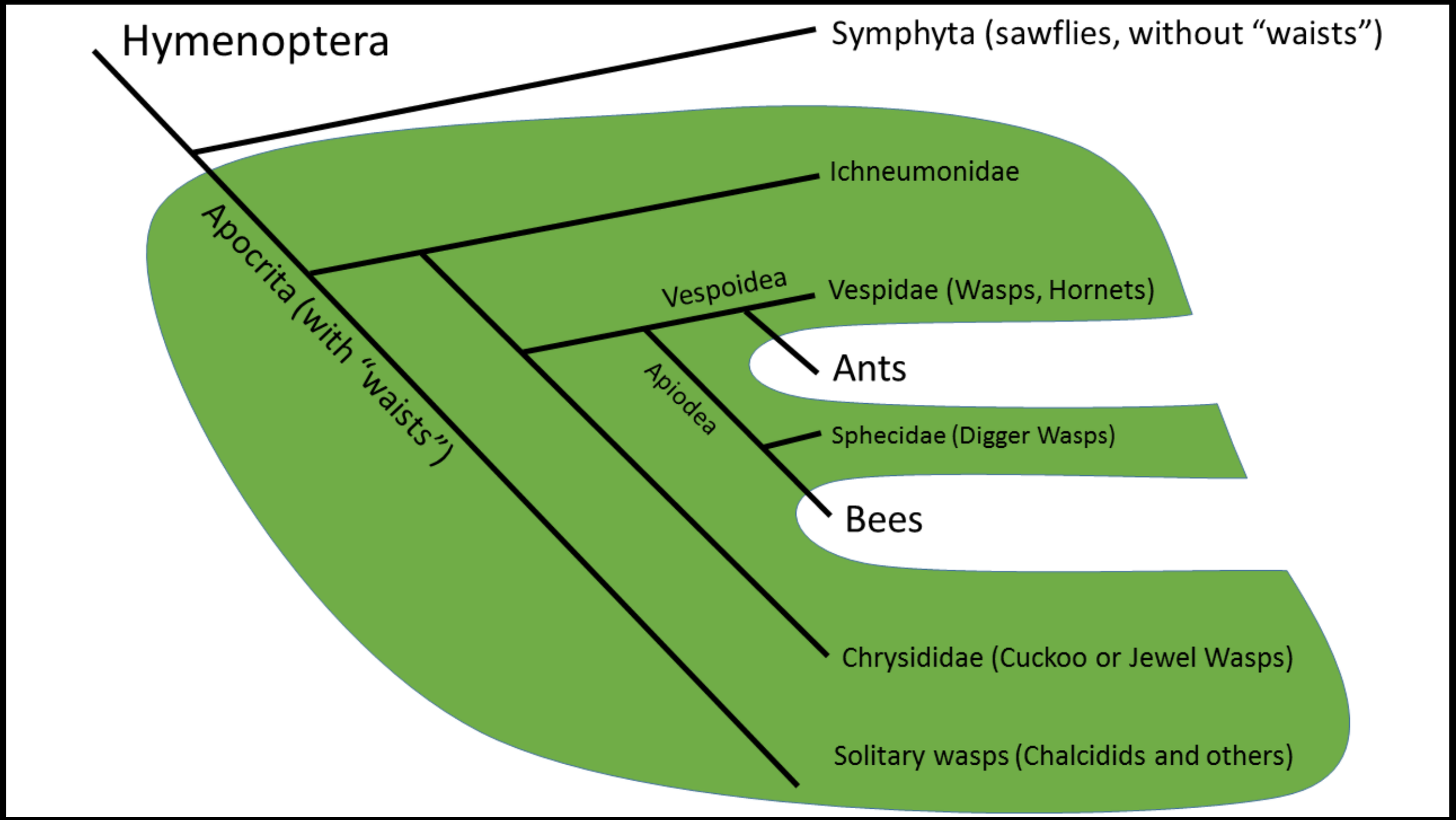


- Paraphyletic: A group that contains the most recent common ancestor of it's members, but not all of it's descendants
- Polyphyletic: A group that does NOT contain the common ancestor of it's members

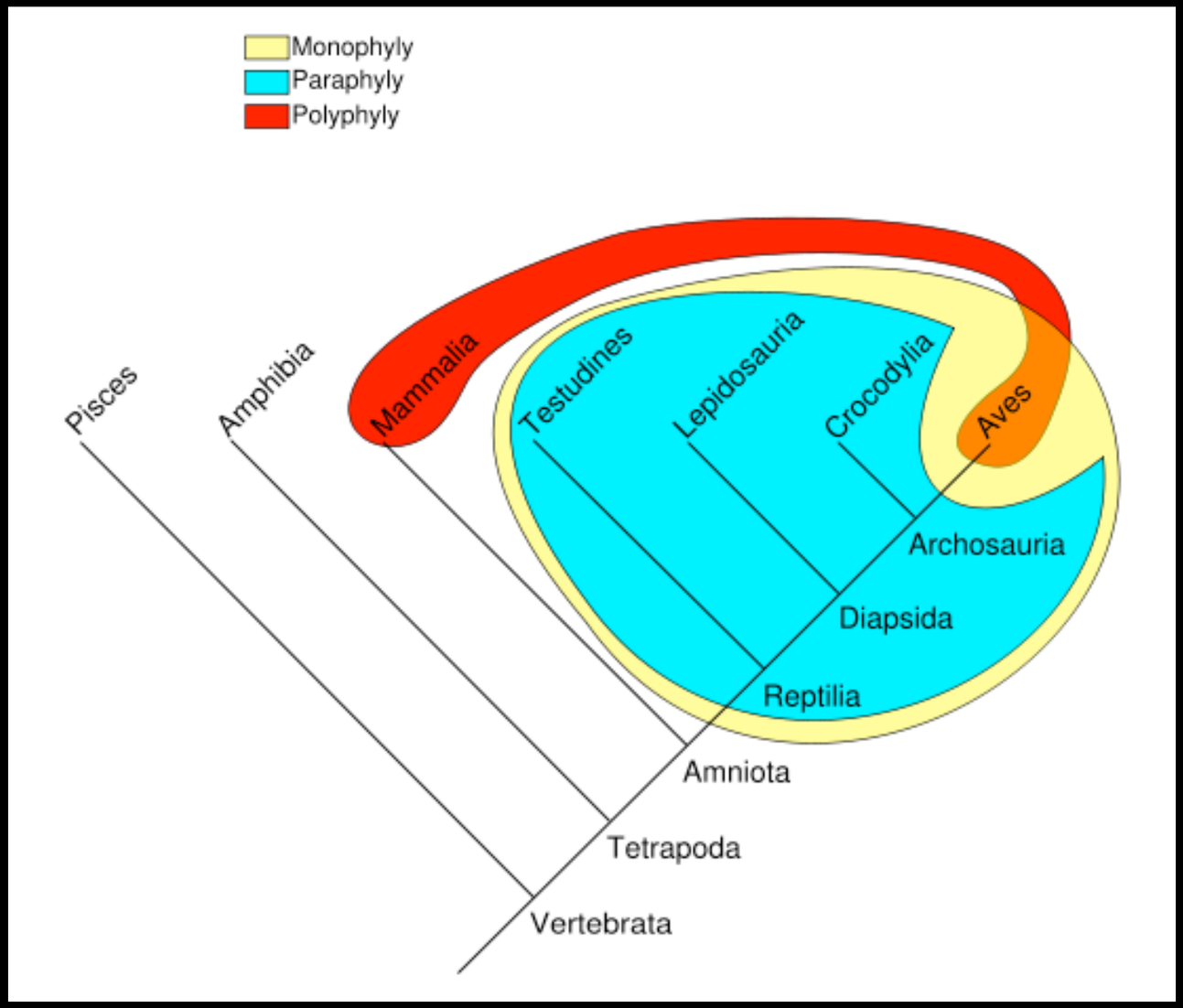
- Paraphyletic



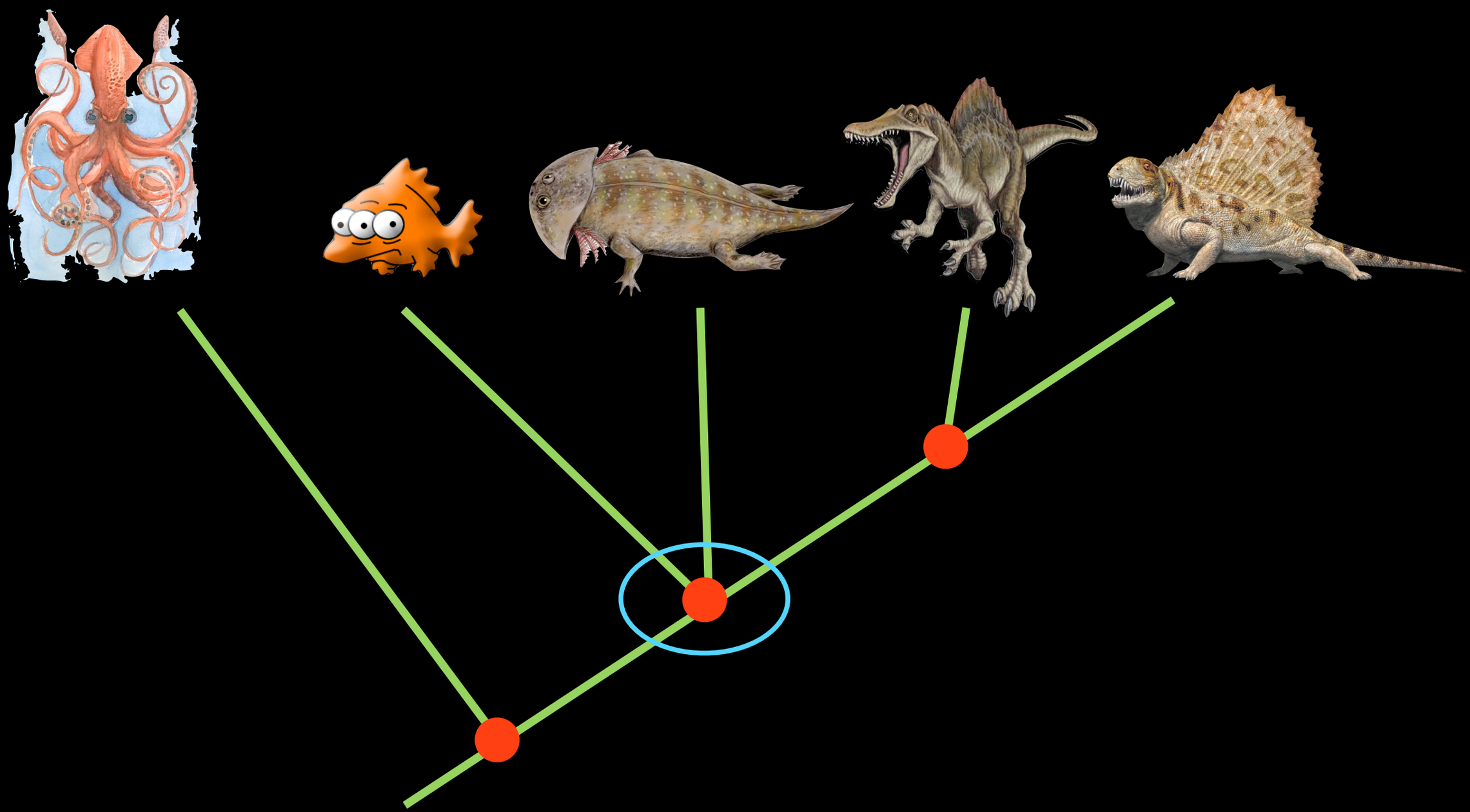
- Paraphyletic



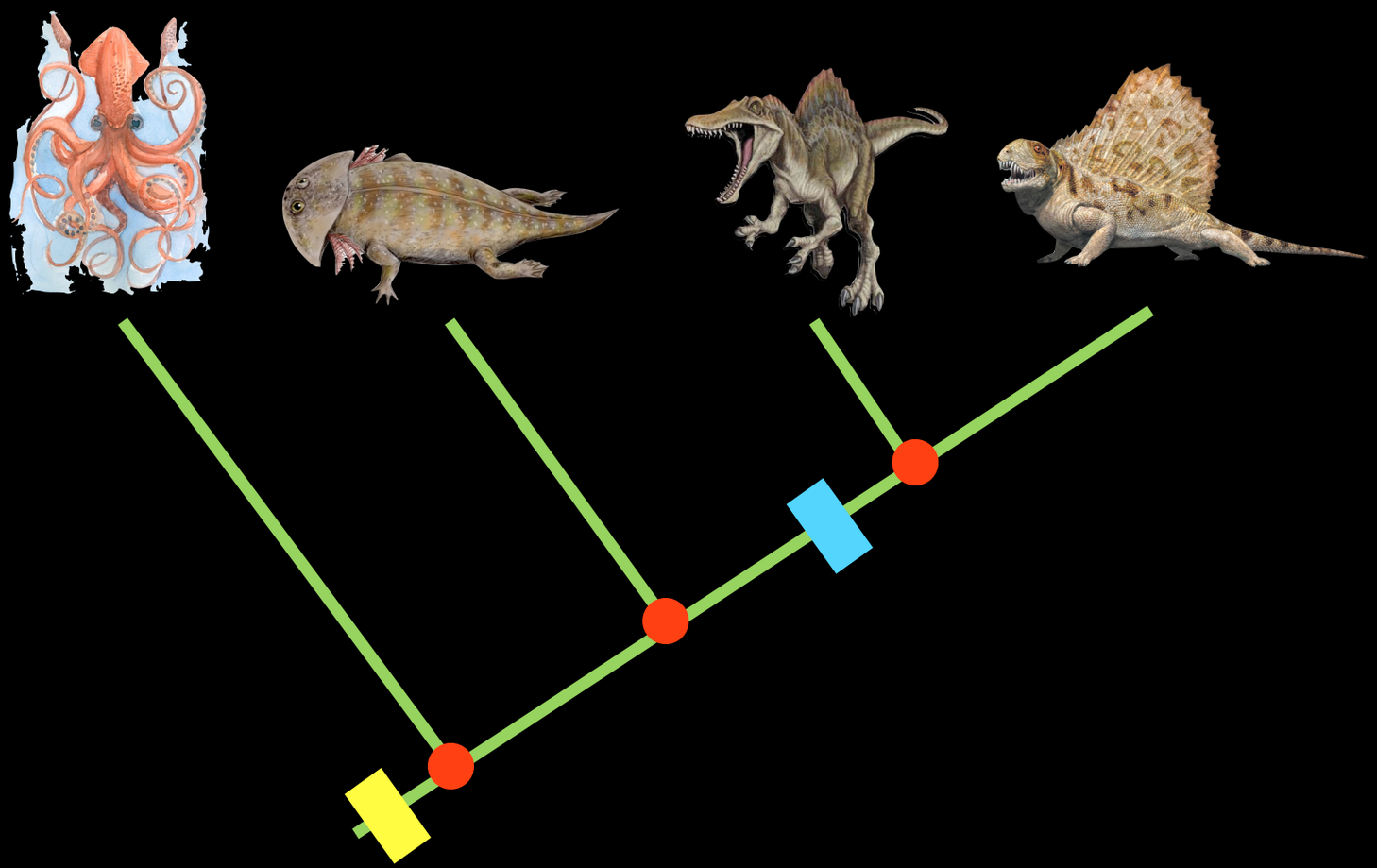
- Polyphyletic



Warm-blooded amniotes



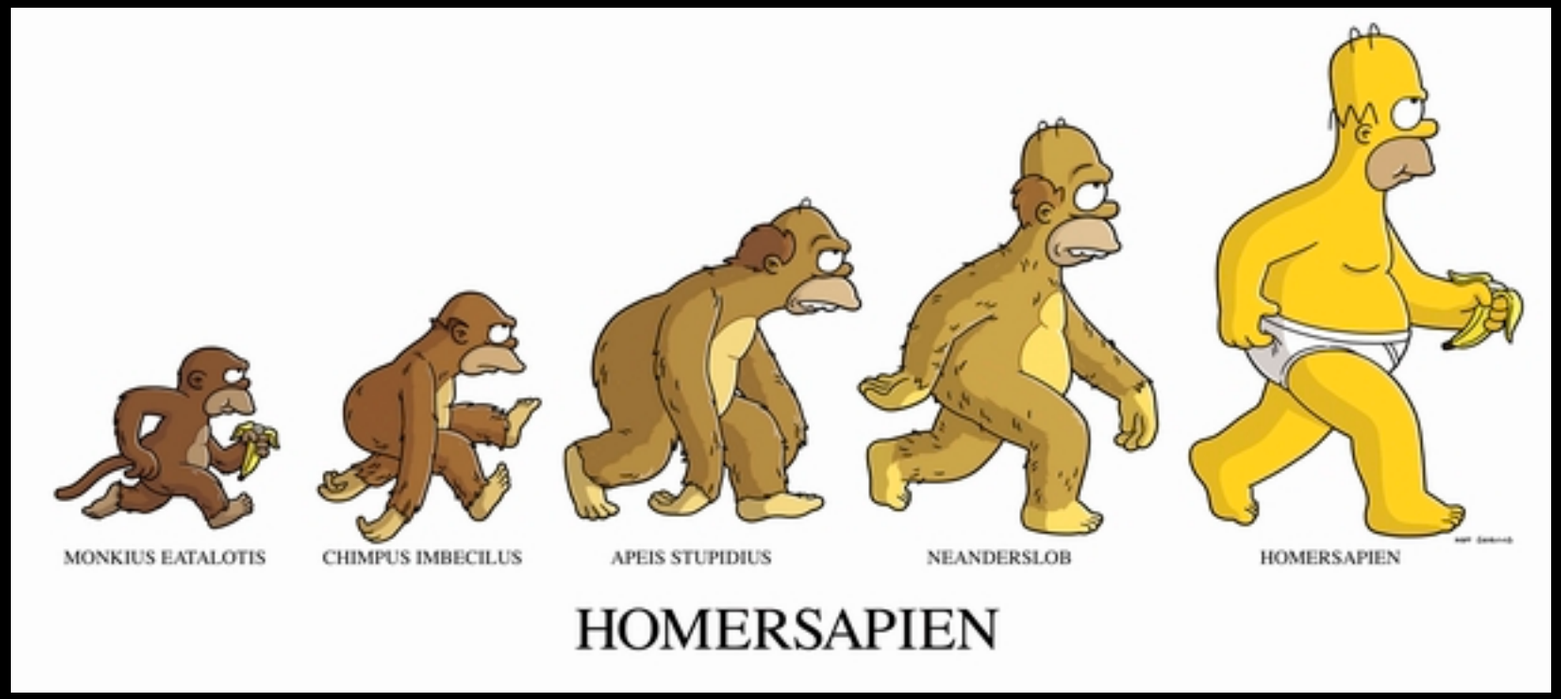
Polytomy ~ unresolved relationship

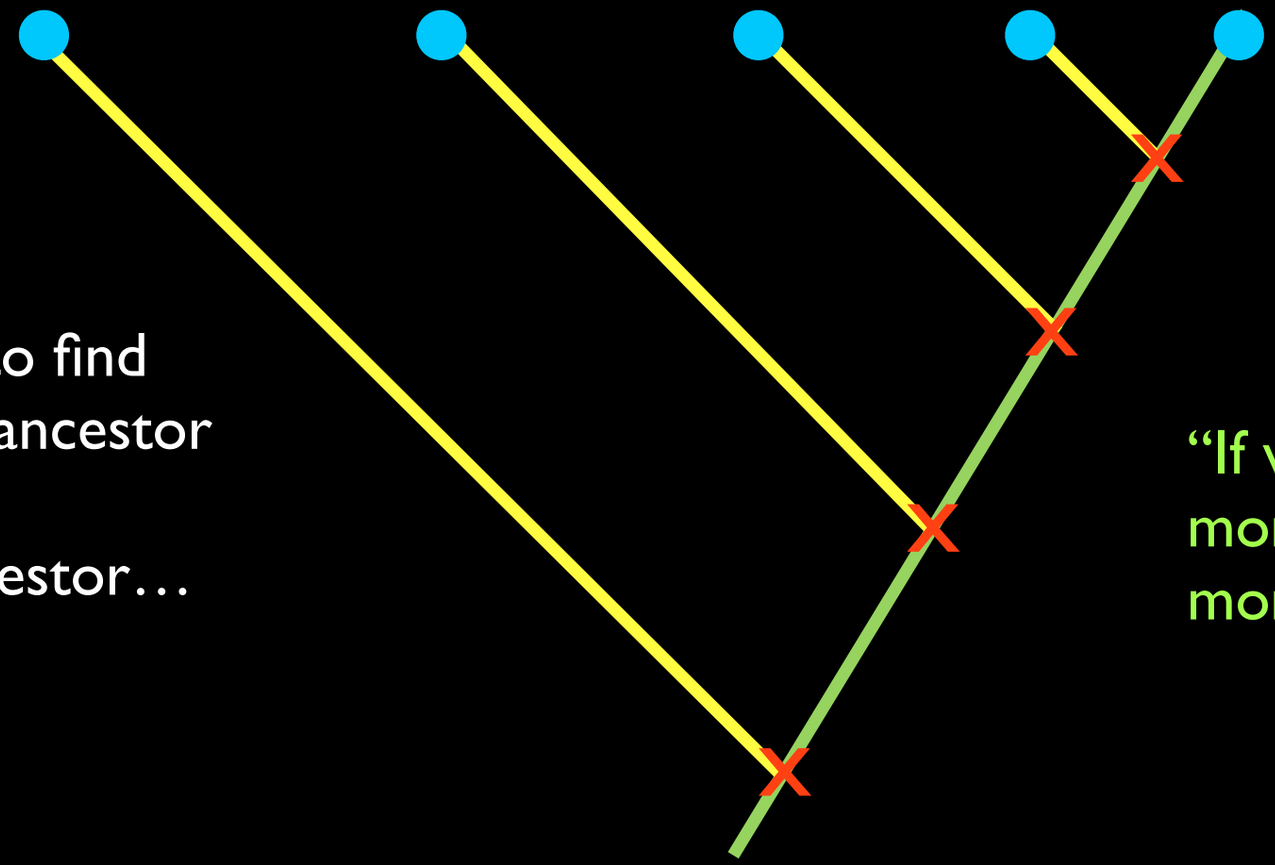


Some Terms

- Shared, derived characteristics = Synapomorphy
  - **Do** have splitting, or bifurcation, information
  - Derived, newly evolved

- Non-diagnostic ANCESTRAL traits of a CLADE = Plesiomorphy
  - Have no ‘splitting’, or bifurcation, information
  - Ancestral, ‘primitive’





- We never expect to find the true common ancestor
- No such thing as a primitive living ancestor…

"If we evolved from monkeys, why are there still monkeys?"

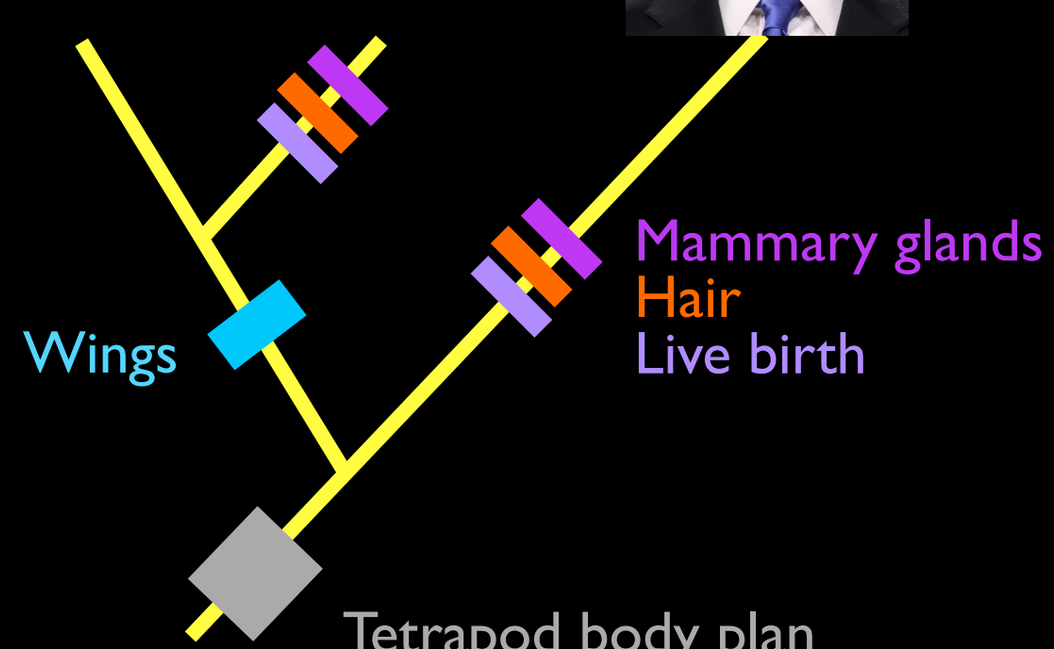
Not a progression... a 'tree'

Parsimony

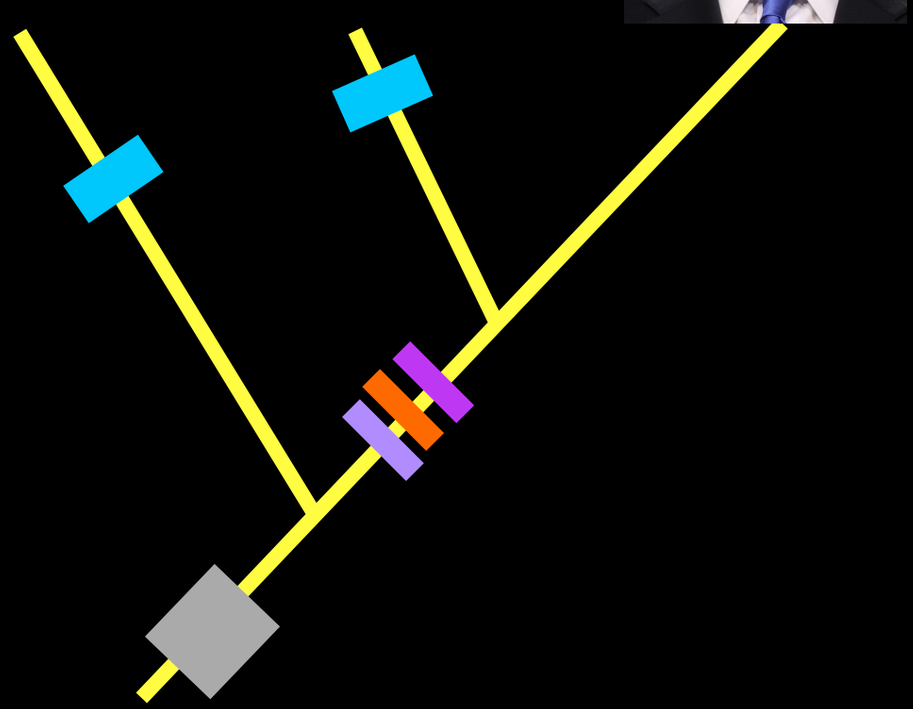
Parsimony

Most parsimonious

vs.

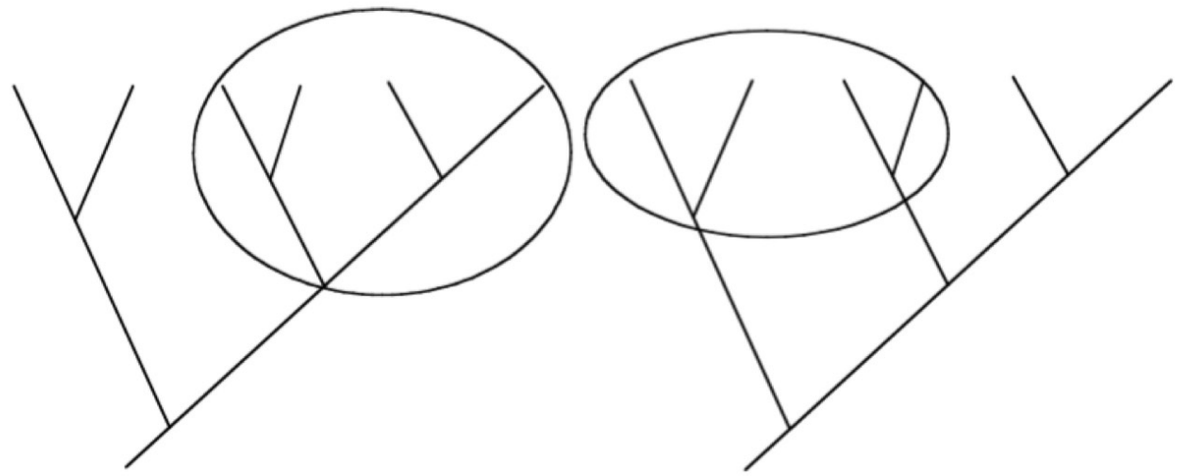


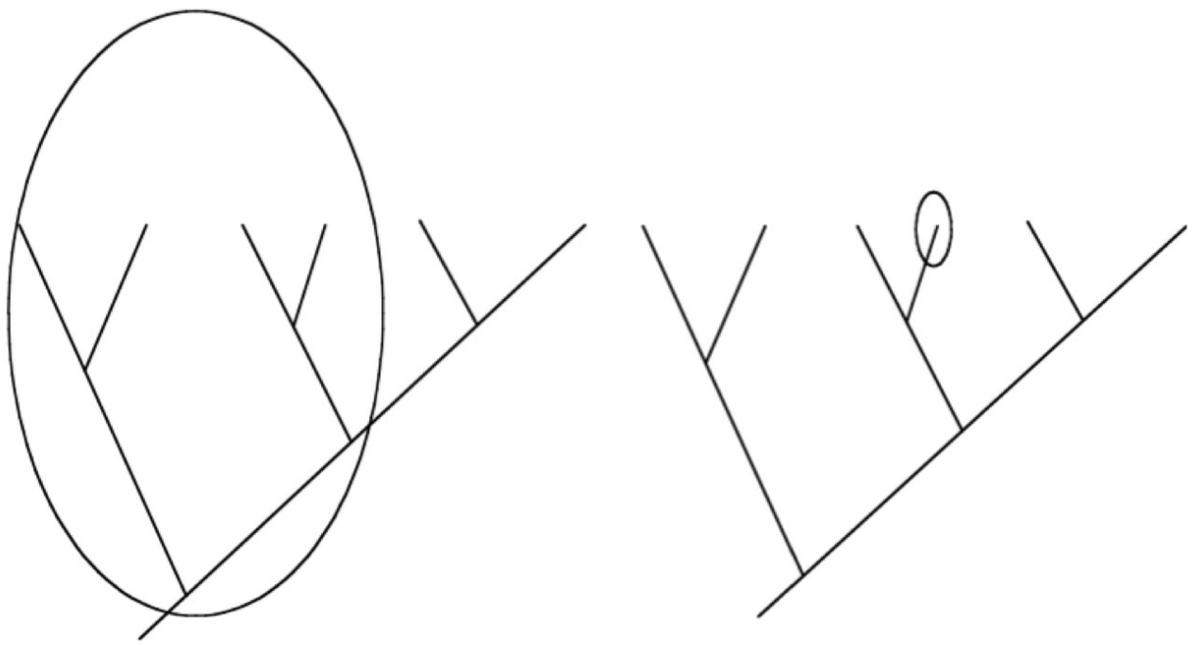
7 evolutionary events



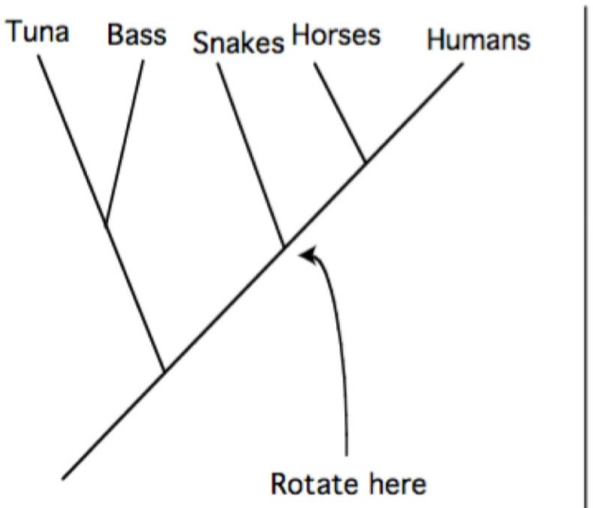
5 evolutionary events

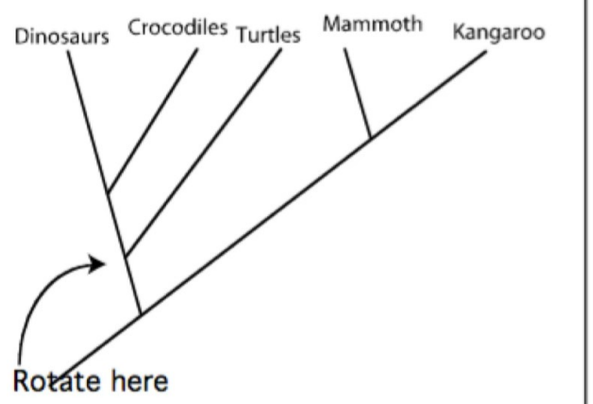
Decide if the group that is circled is monophyletic, paraphyletic, or polyphyletic

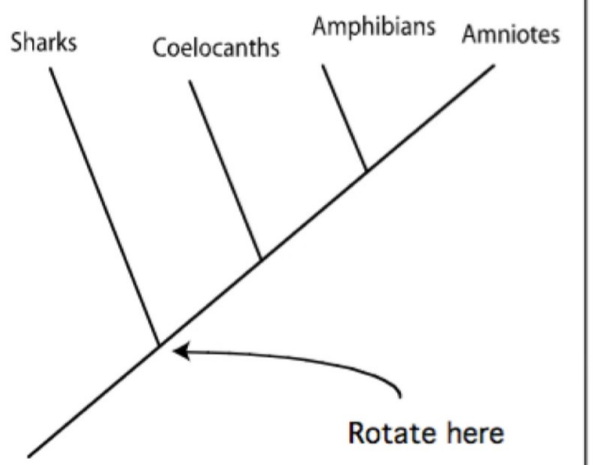




Rotate a node on each cladogram so that the diagram looks different, but retains the same relationships

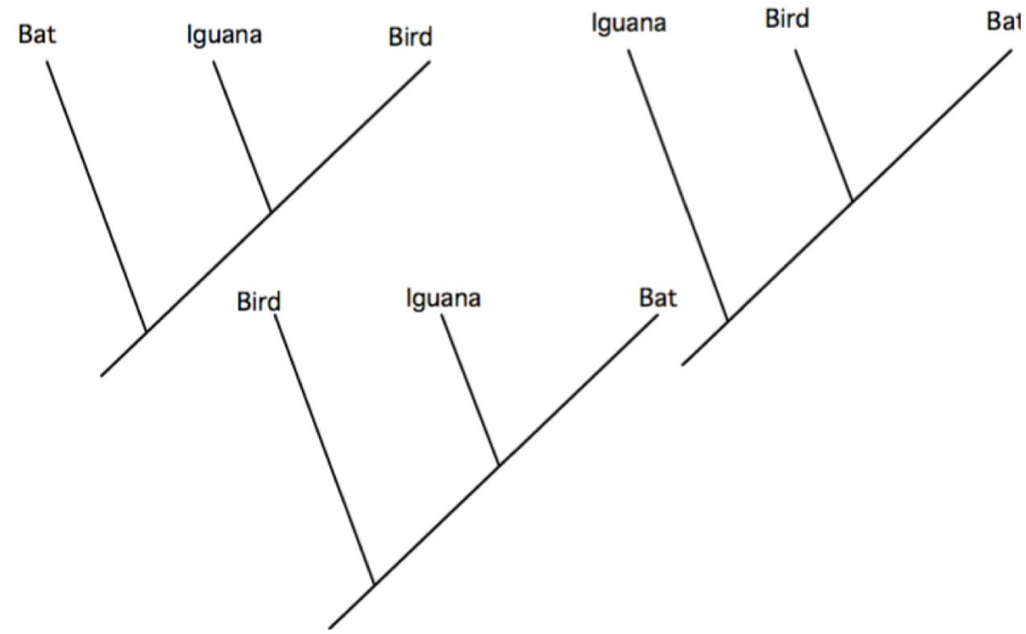






Place the characters from the table on the cladograms.

Then determine which is the most parsiomonious



Character Number	Character	Bat	Bird	Iguana
1	Feathers			
2	Wings			
3	Egg laying			
4	Warm-blooded			
5	Active in day			
6	Lungs			
7	Green			
8	Hair			
9	Mammary glands			
10	Scales			
11	Teeth			
12	Hemipenes			
13	Cloaca			

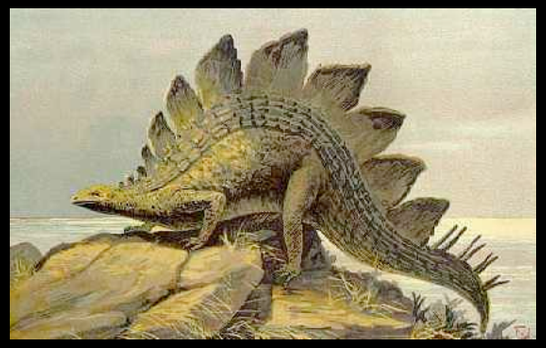
Okay, now put these animals and characters on a PARSIMONIOUS cladogram

Species

Bird

Bear

Shark



Stegosaurus

Deinonychus

Characters

Bird Bear Shark Stegosaurus Deinonychus

‘Bird-Hip’/
Ornithischian condition

Vertebral Column

Loss of Teeth

Tetrapod body plan

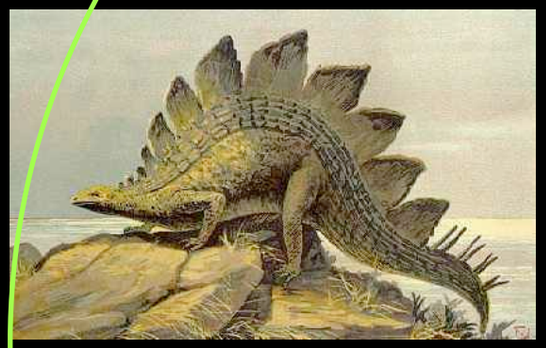
The Answer

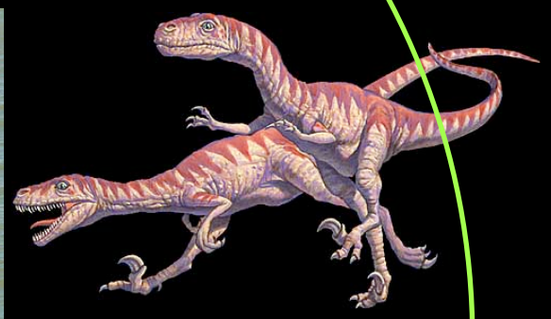
‘Bird-Hip’/
Ornithischian condition

Tetrapod body plan

Loss of Teeth

Vertebral Column





Stegosaurus

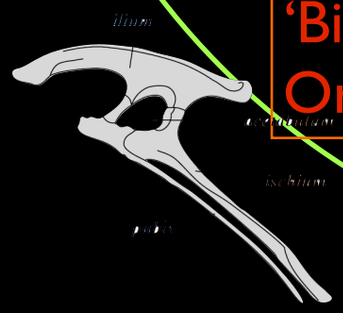
Bird

Deinonychus

Bear

Shark

Loss of Teeth



‘Bird-Hip’/
Ornithischian condition

Amniota

Tetrapod body plan

Vertebrata

Vertebral Column

DINOSAURIA