MISSING LINKS or TRANSITIONAL FORMS?

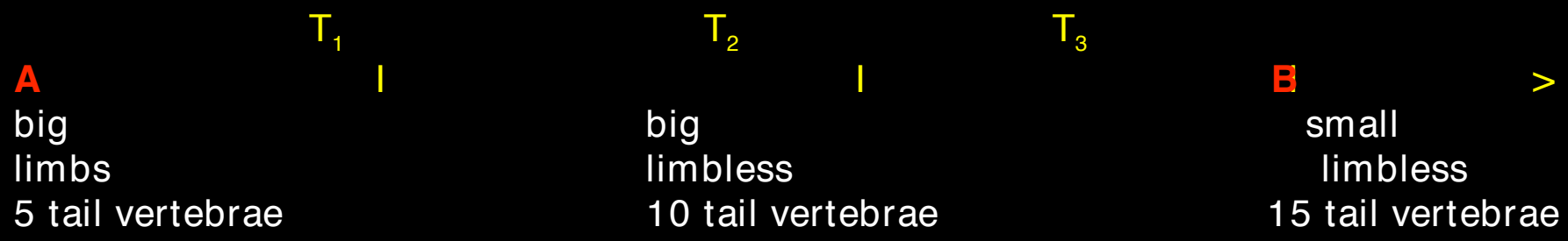
" Many believe that a missing link between different forms of life should be intermediate between the two in all aspects.

	T_1	T_2	T_3	
A	I	I		**B** >
big		medium		small
limbs		reduced limbs		limbless
5 tail vertebrae		10 tail vertebrae		15 tail vertebrae

MISSING LINKS or TRANSITIONAL FORMS?

" Many believe that a missing link between different forms of life should be intermediate between the two in all aspects.

" This is based on two misconceptions: first that all characters evolve at the same rate.



MISSING LINKS or TRANSITIONAL FORMS?

" Many believe that a missing link between different forms of life should be intermediate between the two in all aspects.

" This misconception is perpetuated by people who do not understand how evolution works.

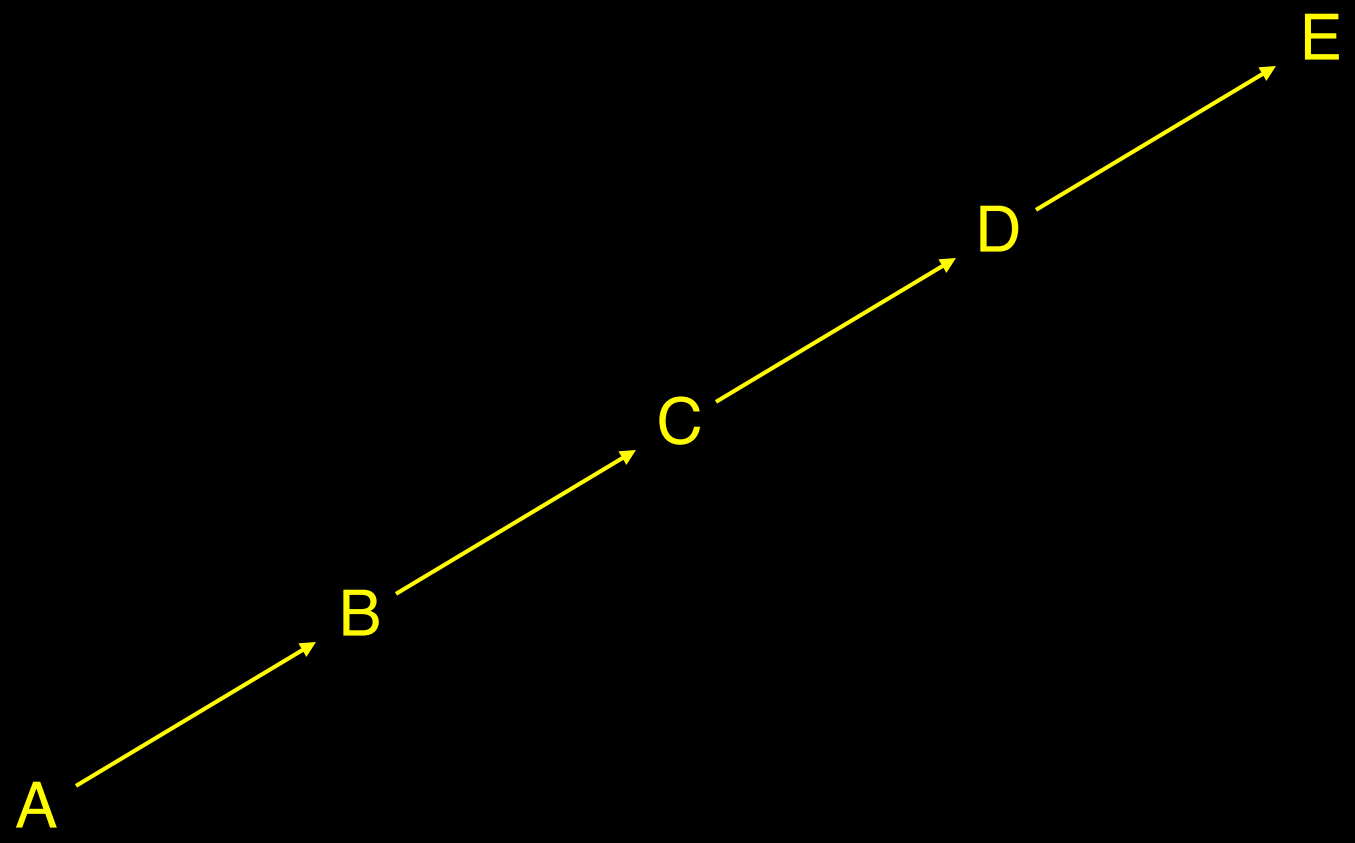
Dr. Duane Gish

MISSING LINKS or TRANSITIONAL FORMS?

Using their understanding we would perfect missing links or perfect intermediates between many forms of life.

MISSING LINKS or TRANSITIONAL FORMS?

This results from the second, fundamental misunderstanding in that they believe evolution proceeds through time in a ladder-like fashion where one species gives rise to another, which then gives rise to another, and so on.

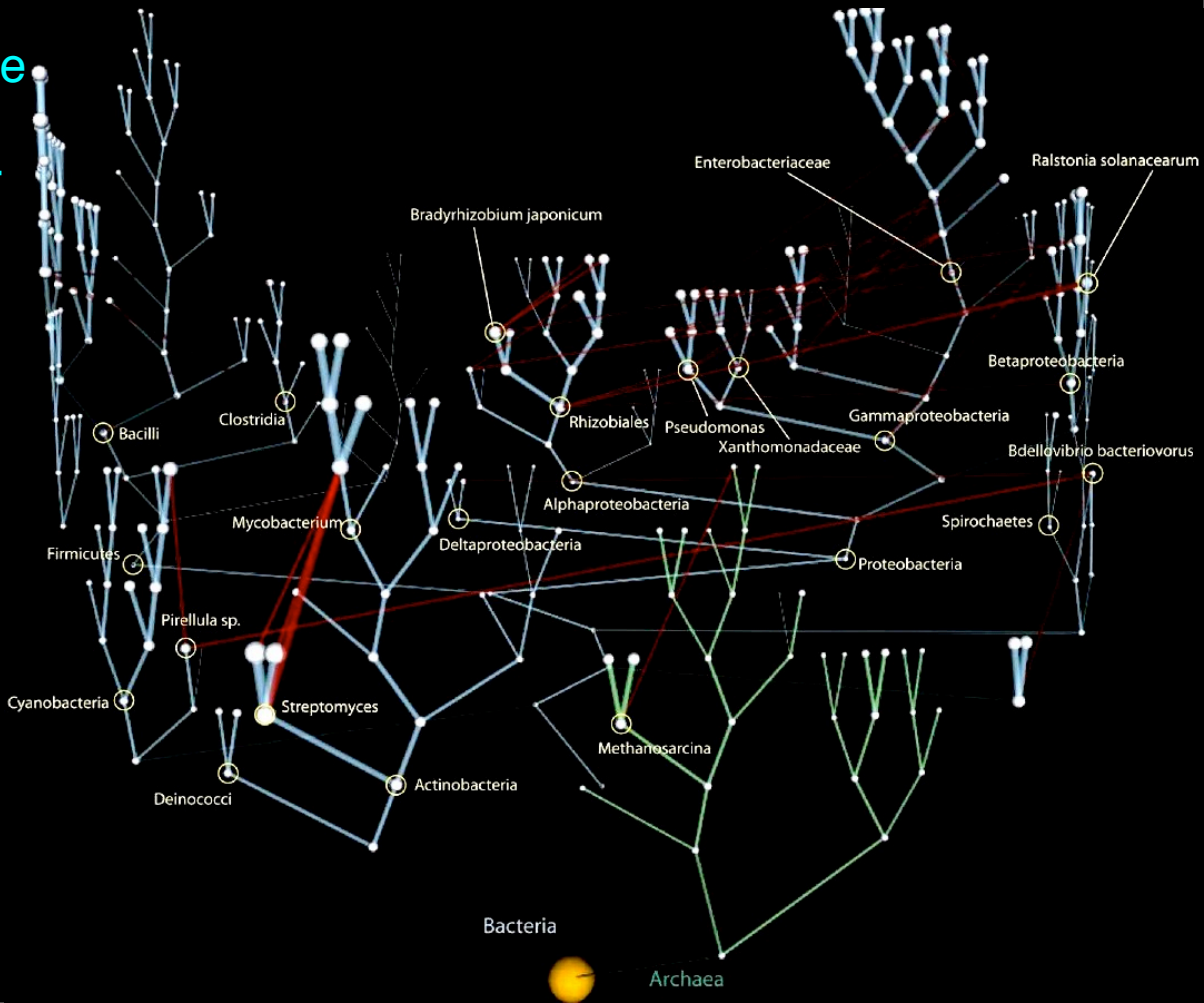


MISSING LINKS or TRANSITIONAL FORMS?

This results from the second, fundamental misunderstanding in that they believe evolution proceeds through time in a ladder- like fashion where one species gives rise to another, which then gives rise to another, and so on.

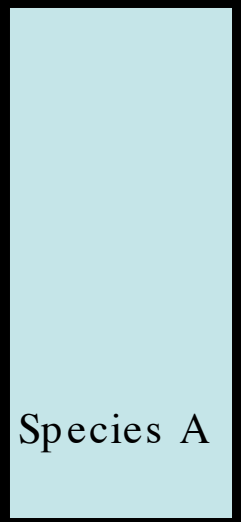
" However, evolution produces a tree not a ladder and it usually proceeds as a series

bifurcation events where one species gives rise to at least two others and the ancestor goes extinct in the process.



MISSING LINKS or TRANSITIONAL FORMS?

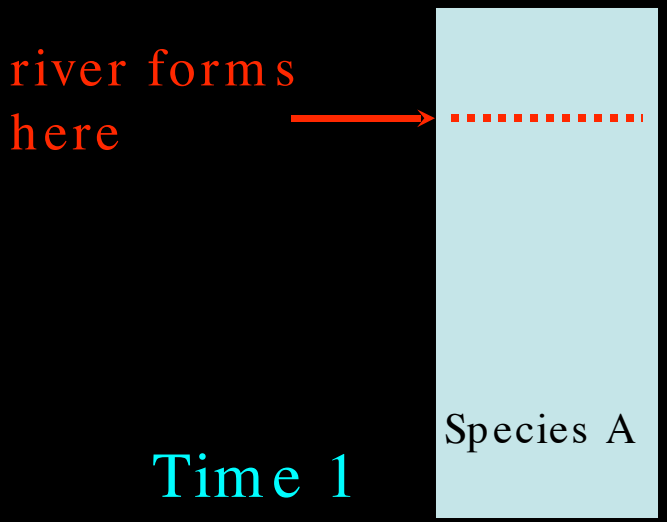
" Distribution of what will become an ancestral species.



Time 1

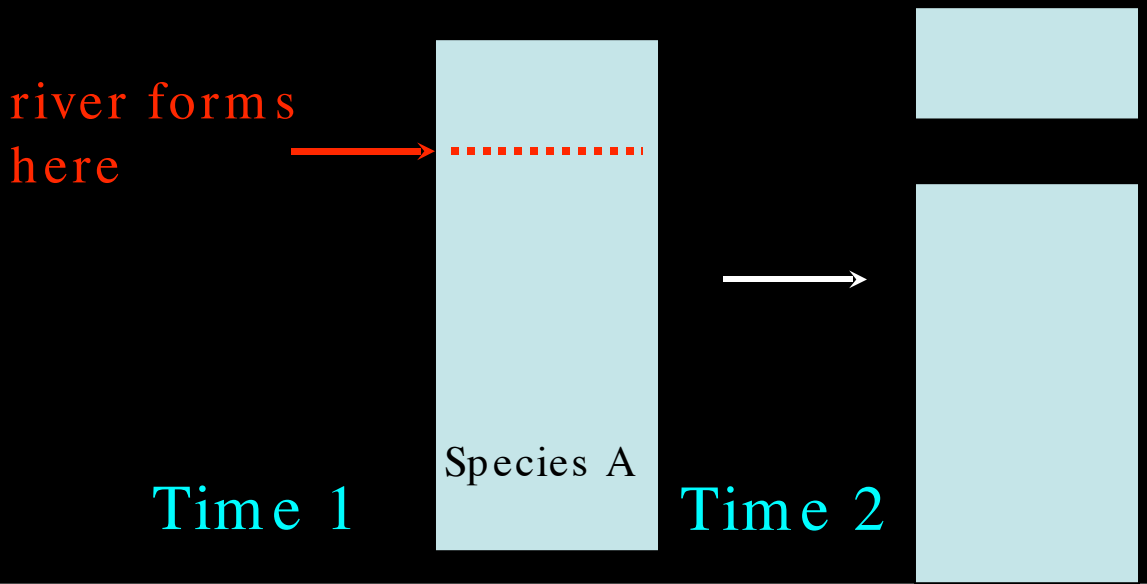
MISSING LINKS or TRANSITIONAL FORMS?

" Ancestral species becomes fragmented into isolated populations.



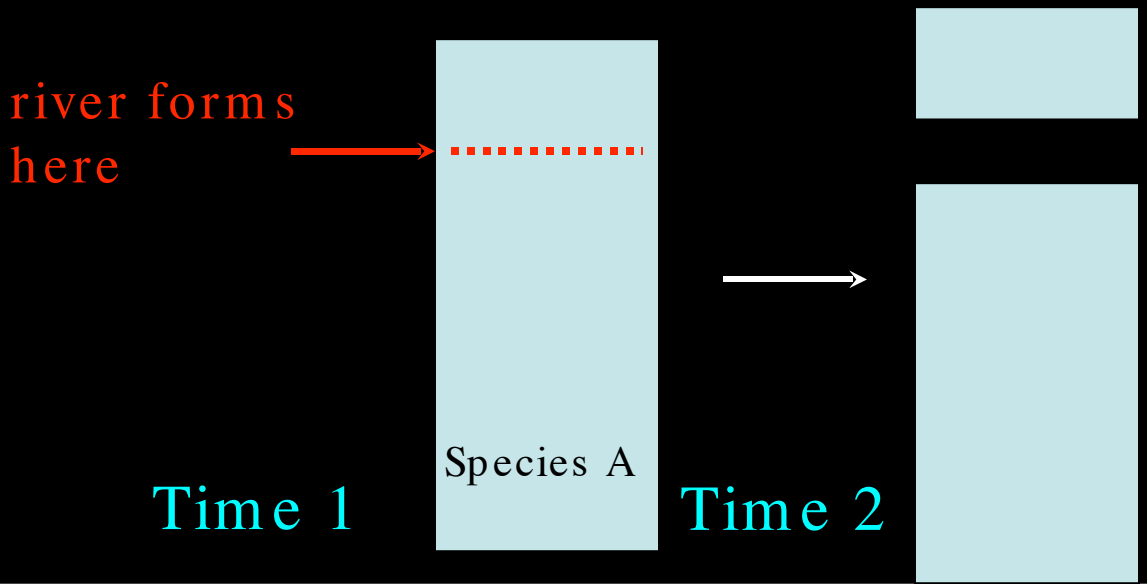
MISSING LINKS or TRANSITIONAL FORMS?

" Ancestral species becomes fragmented into isolated populations.
" Two populations in a different environment.



MISSING LINKS or TRANSITIONAL FORMS?

" Ancestral species becomes fragmented into several isolated populations.
" Two populations in a different environment.
" Populations change to adapt to their environments. (If not they go extinct).



MISSING LINKS or TRANSITIONAL FORMS?

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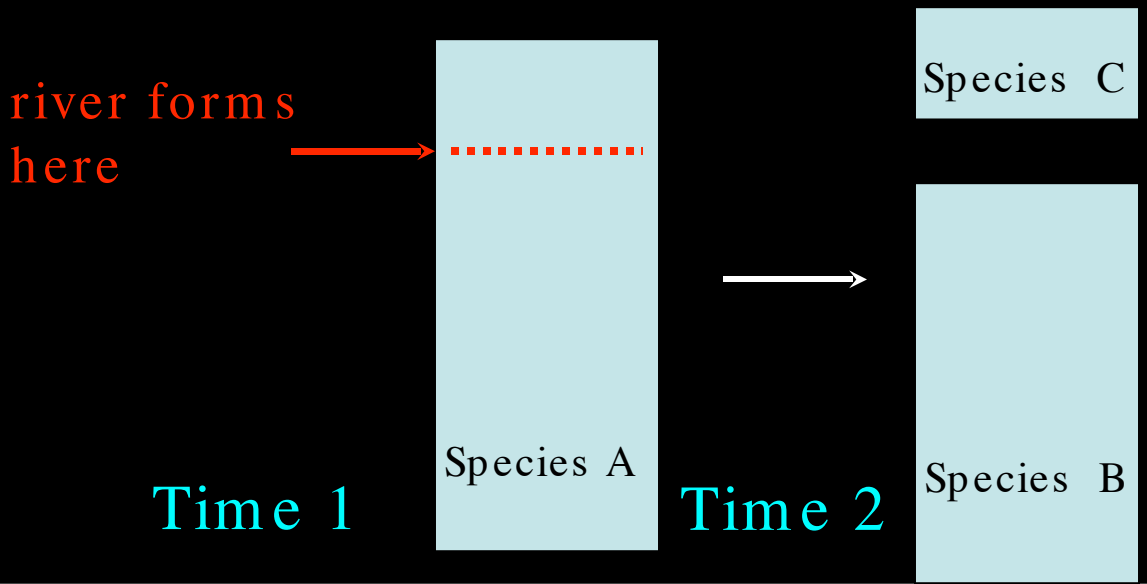
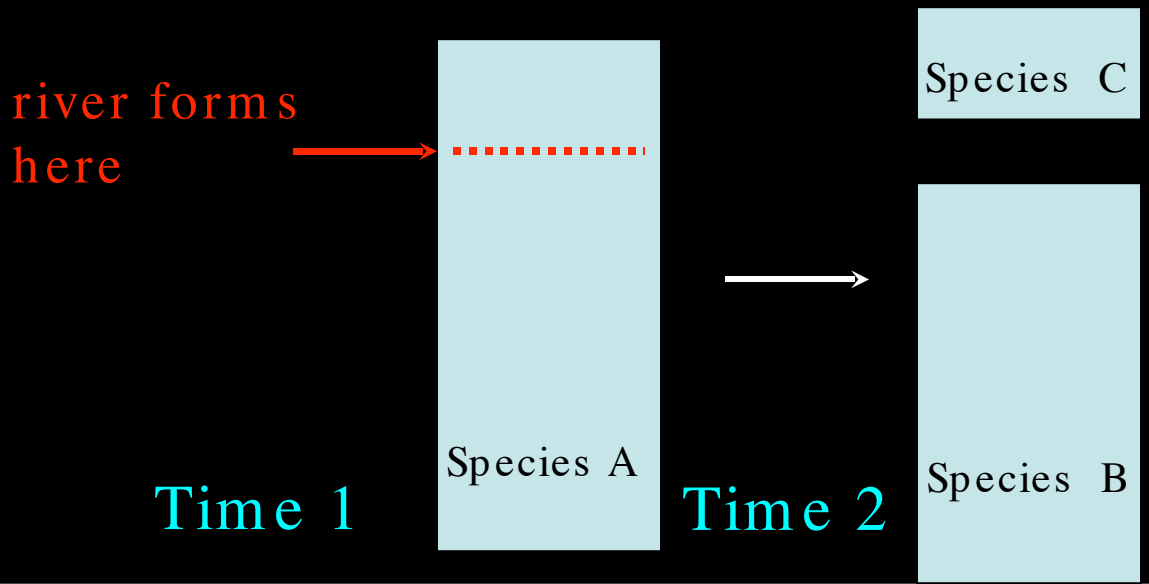
" Two populations in a different environment.
" Populations change to adapt to their environments. (If not they go extinct).
Become dissimilar enough via genetic drift to be recognized as different species



MISSING LINKS or TRANSITIONAL FORMS?

" Ancestral species becomes fragmented into several isolated populations.
" Two populations in a different environment.
" Populations change to adapt to their environments. (If not they go extinct).
" Become dissimilar enough via genetic drift to be recognized as different species.
" So new species arises from ancestral forms by adapting to different environments.



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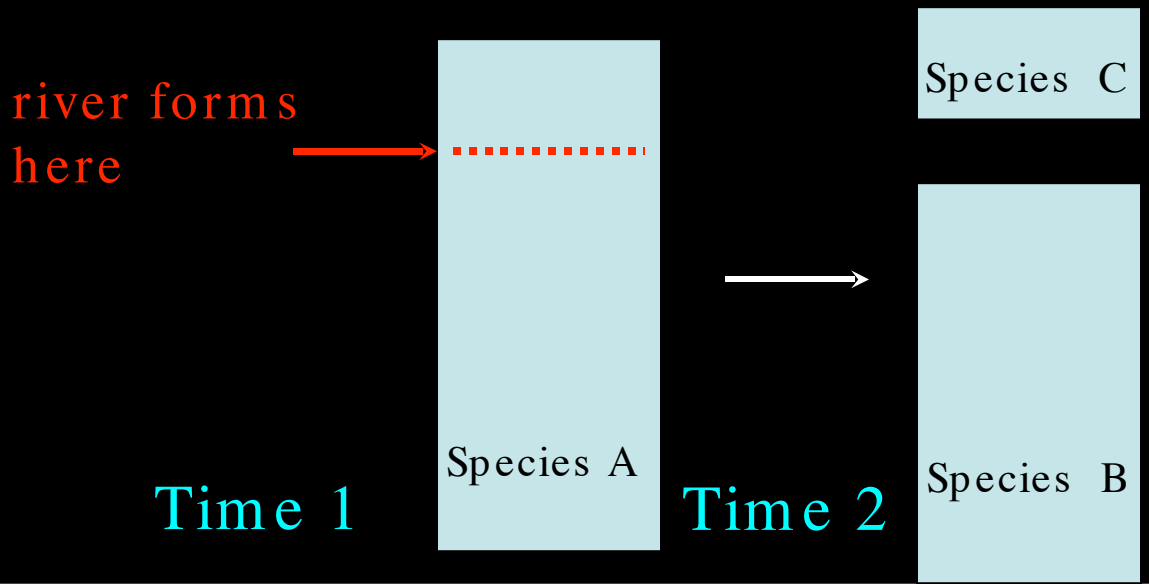

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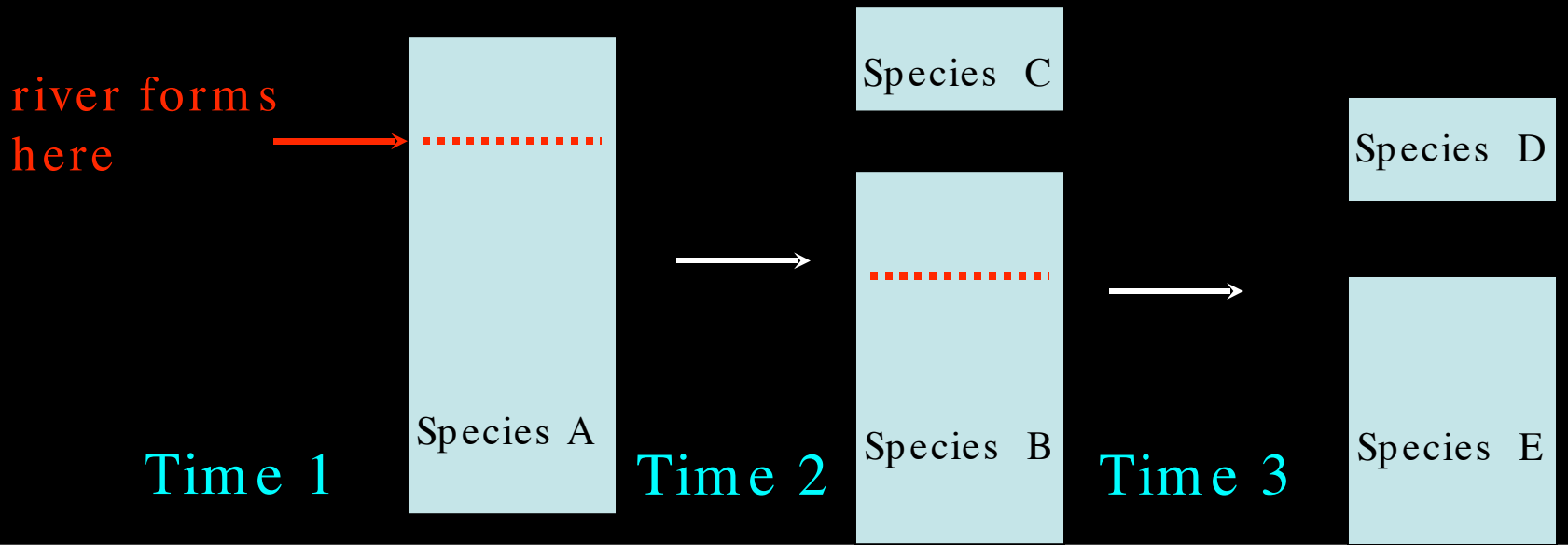
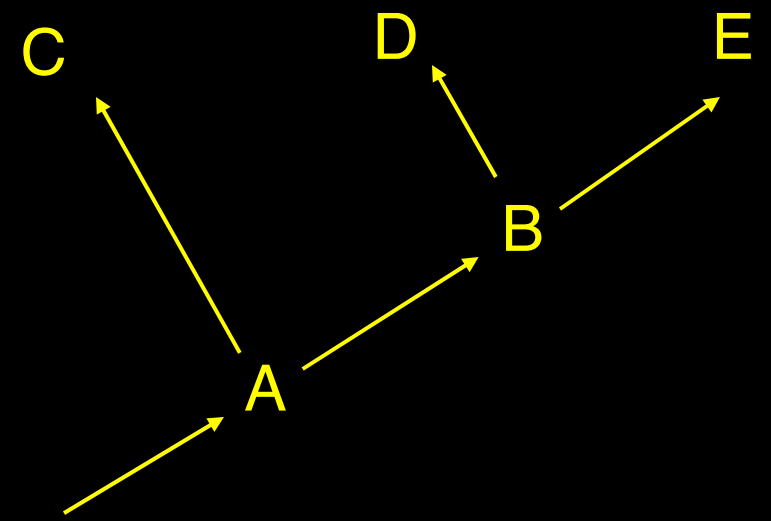
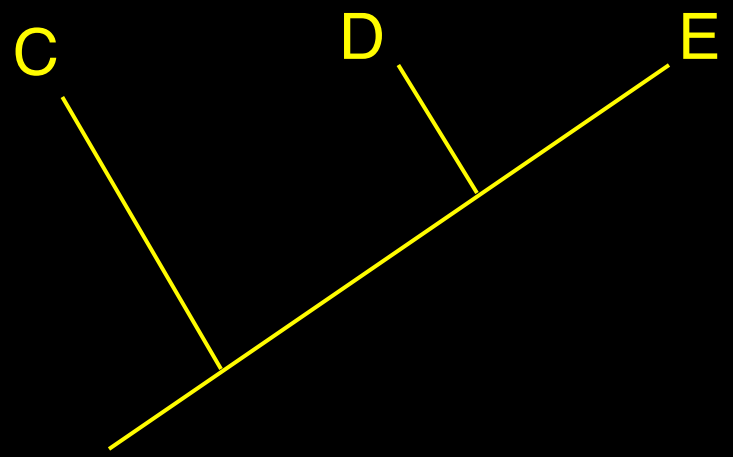
" Populations change to adapt to their environments. (If not they go extinct).
" Become dissimilar enough via genetic drift to be recognized as different species.
" So new species arises from ancestral forms by adapting to different environments.
" Ancestral species goes extinct by default.
" And this keeps happening as time continues.

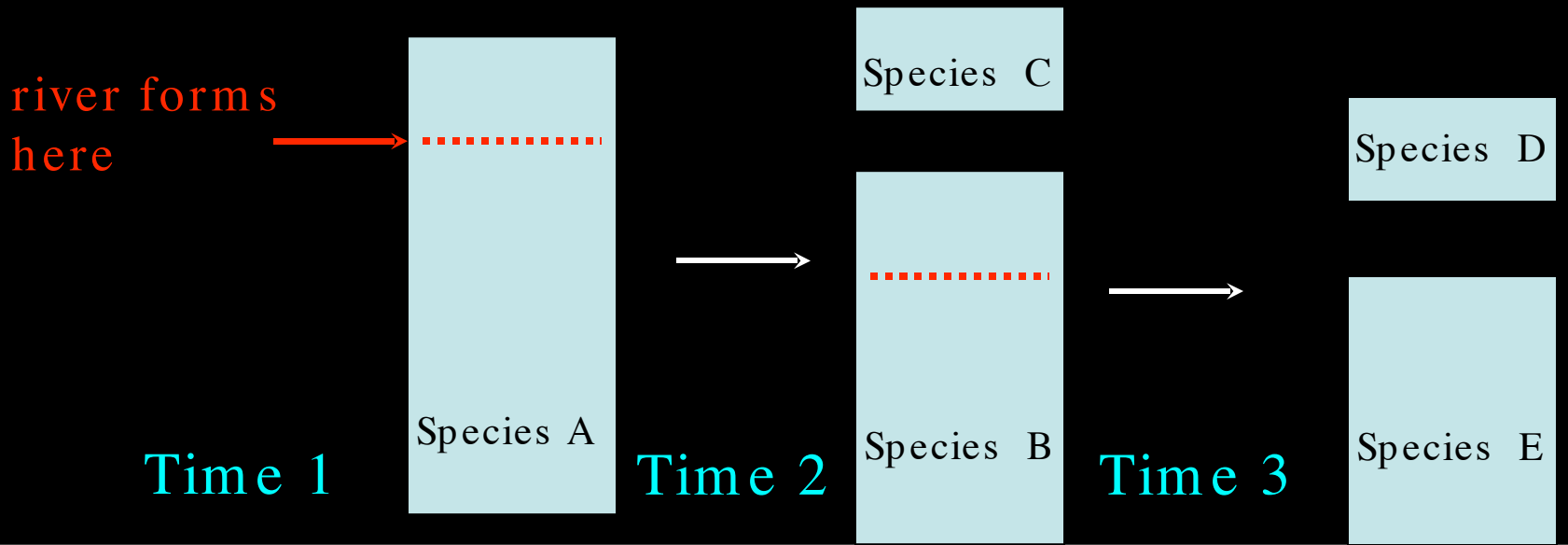


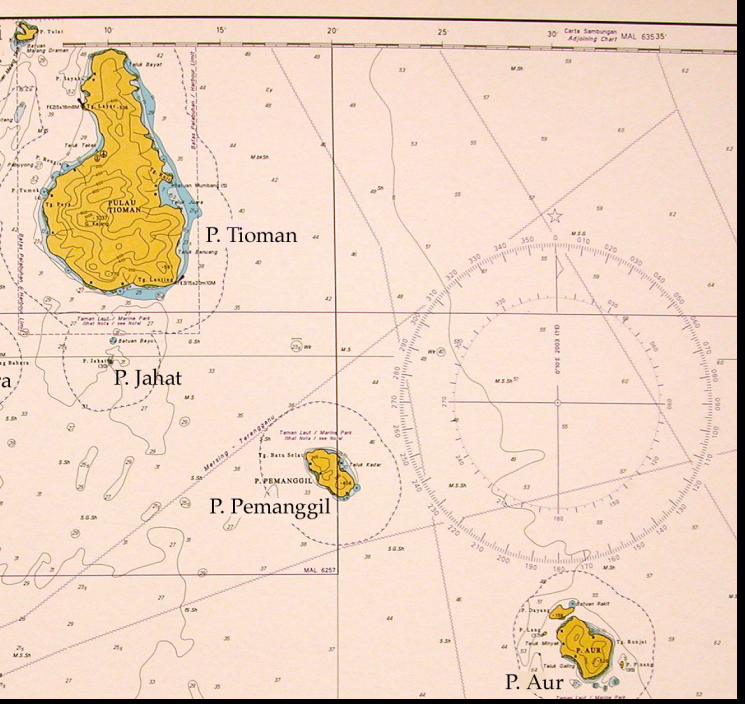
MISSING LINKS or TRANSITIONAL FORMS?

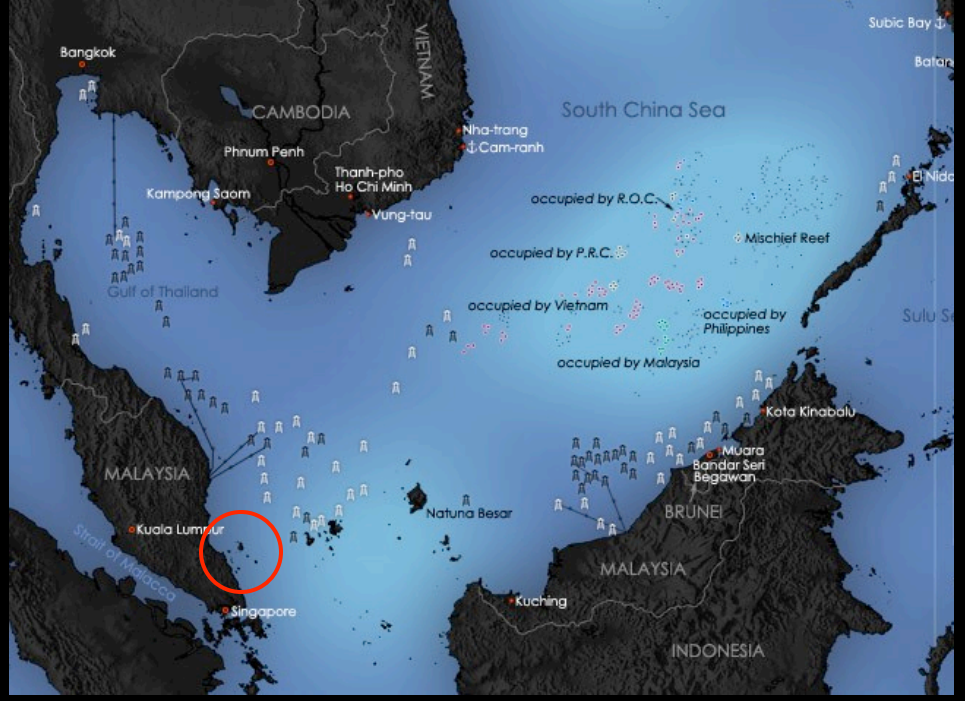
" These are the relationships that result from these sequential allopatric speciation events over time.











mountain

Tioman

Tioman

Cnemaspis tiomanensis

mountain

Pemanggil

Cnemaspis pemanggilensis

Aur

Cnemaspis baueri

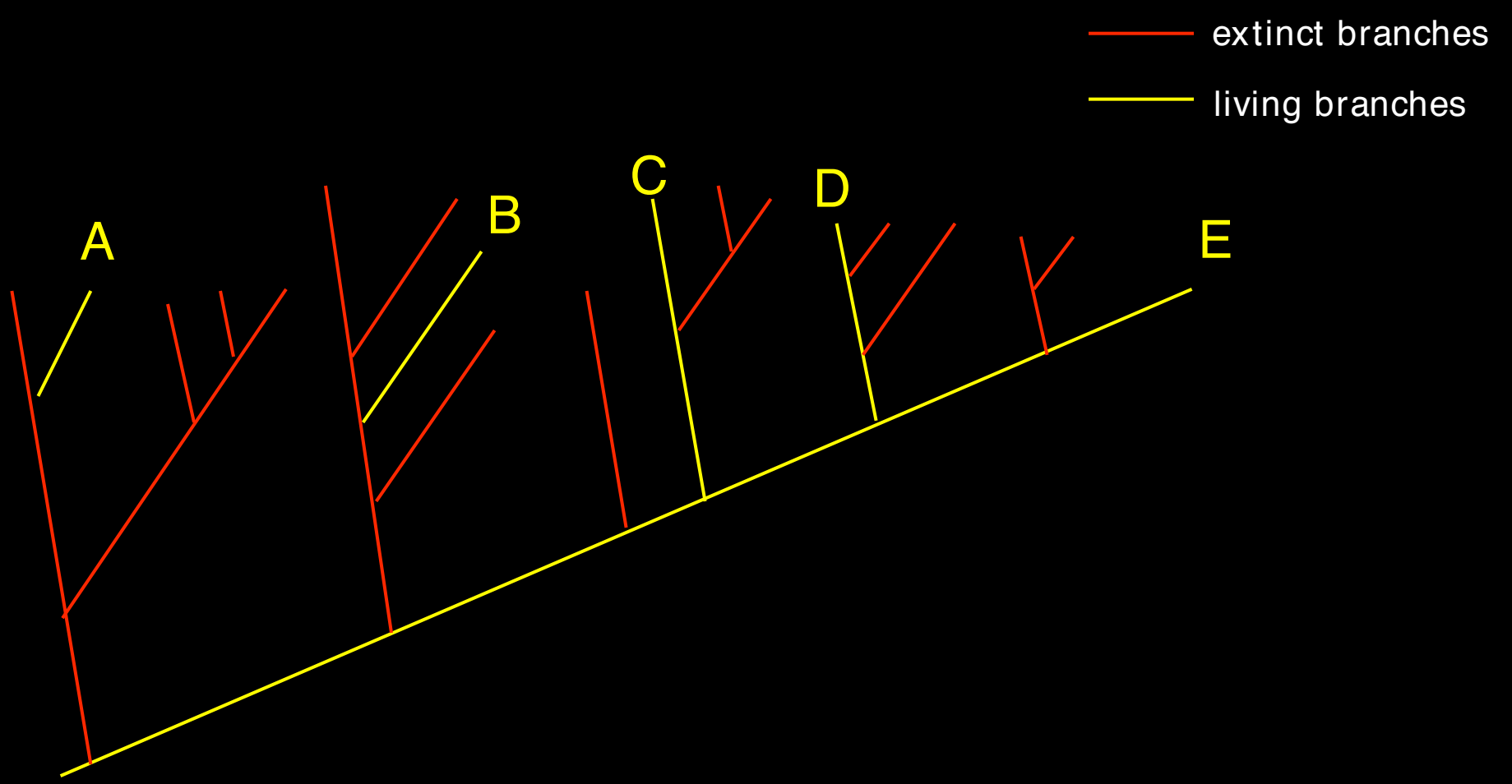
Cnemaspis baueri

Cnemaspis limi

Cnemaspis pemanggilensis

MISSING LINKS or TRANSITIONAL FORMS?

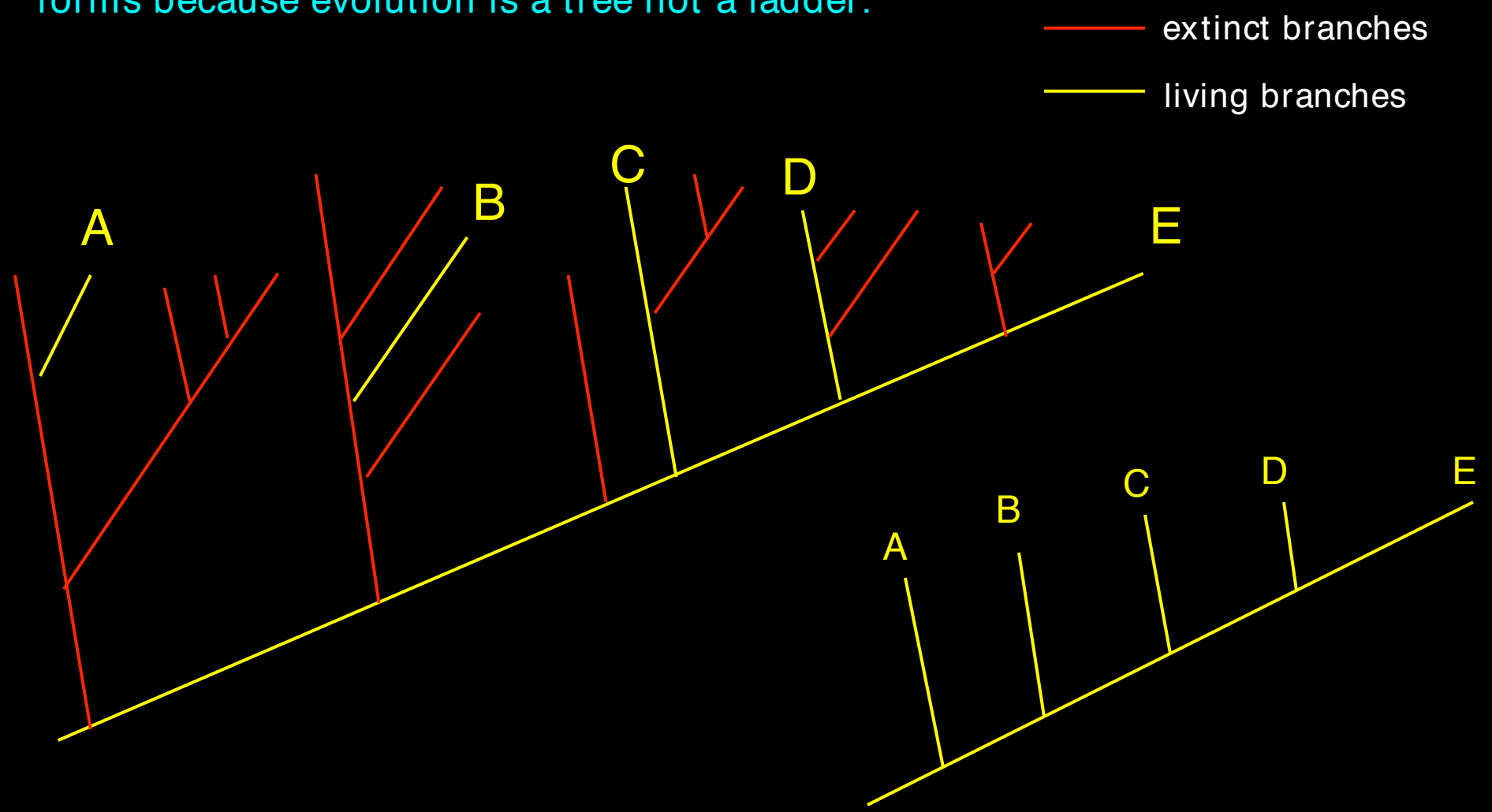
" Most species on evolutionary trees are extinct and all we see currently are few living twigs of an old, highly branched tree.



MISSING LINKS or TRANSITIONAL FORMS?

" Most species on evolutionary trees are extinct and all we see currently are few living twigs of an old, highly branched tree.

" There can be no missing links between the living species only transitional forms because evolution is a tree not a ladder.



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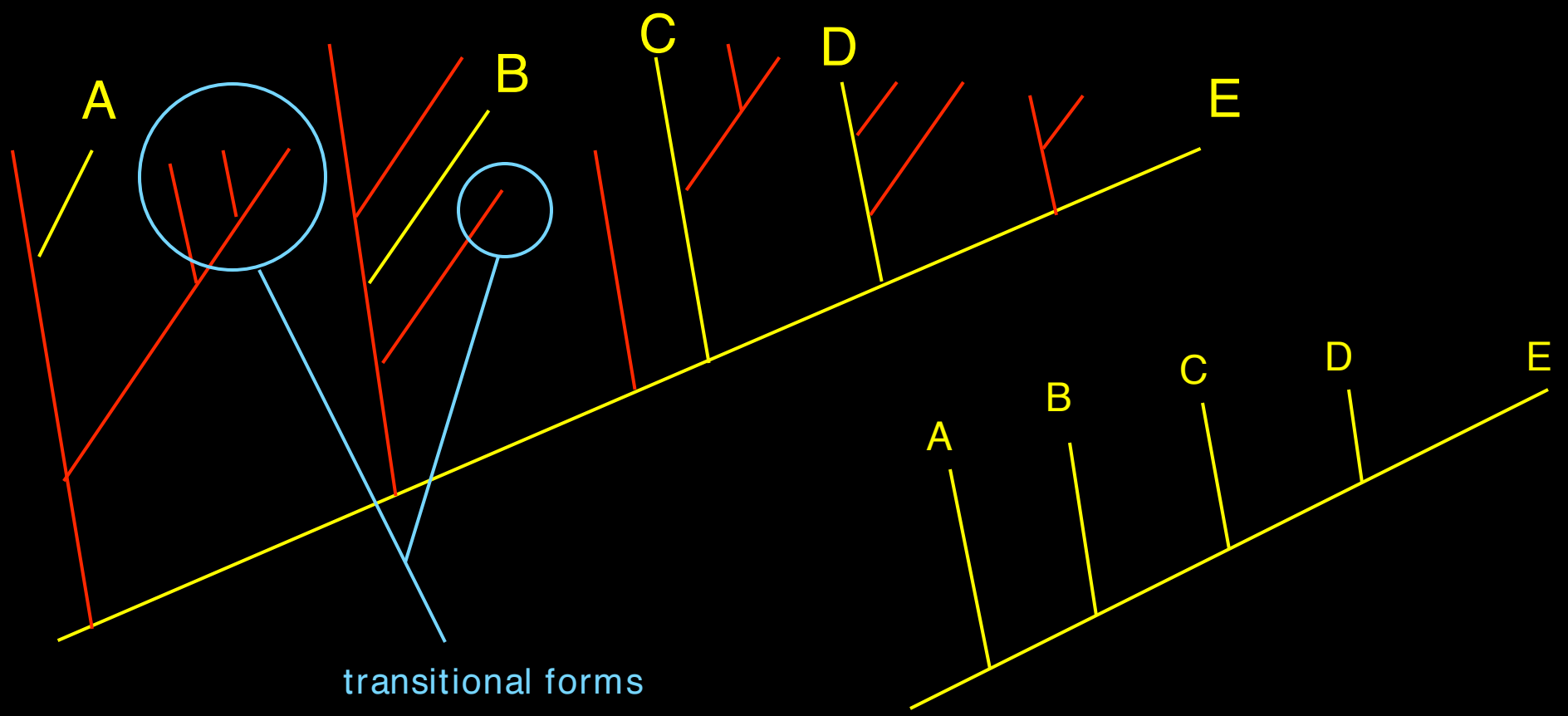
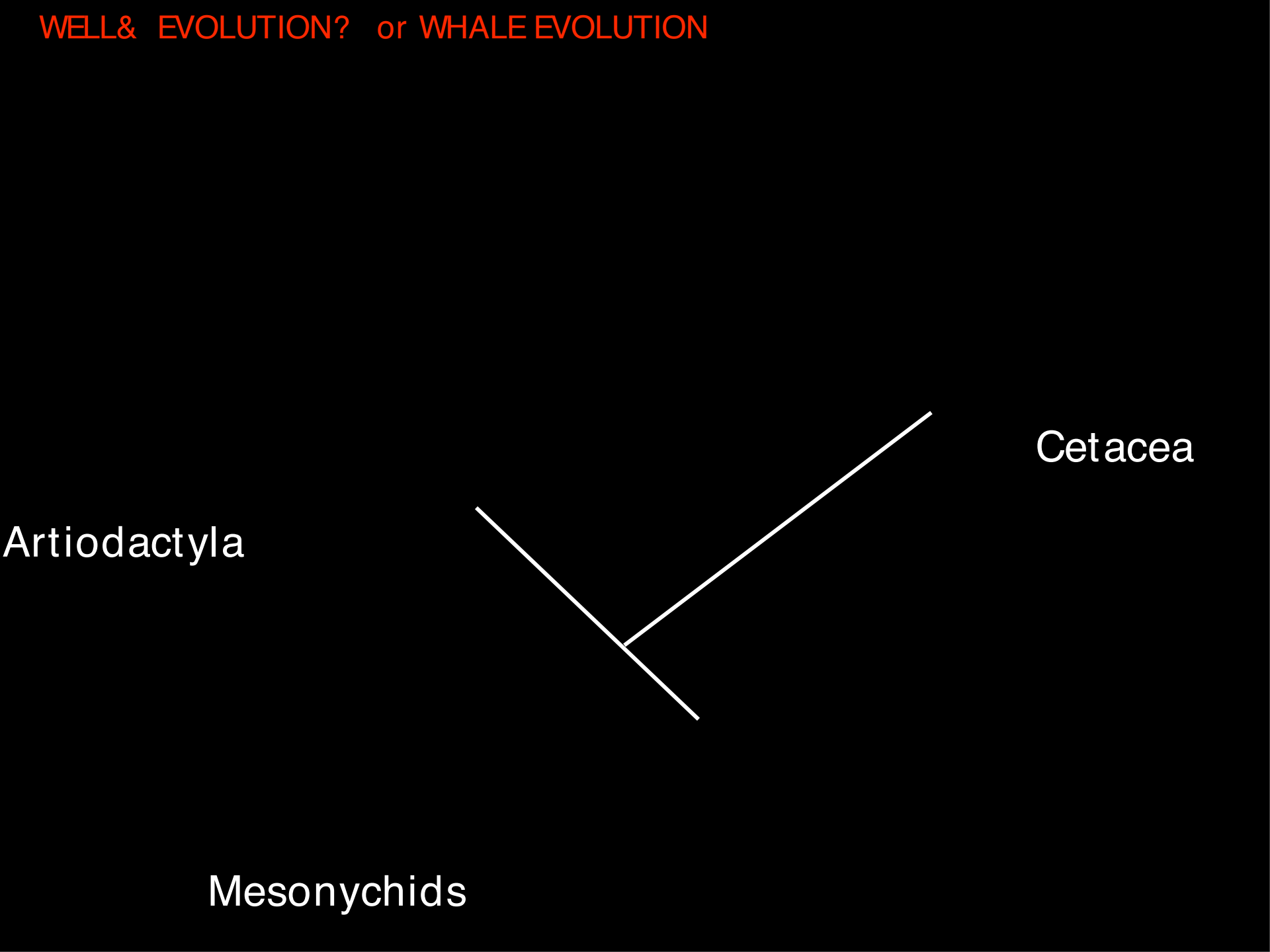


WELL& EVOLUTION? or WHALE EVOLUTION



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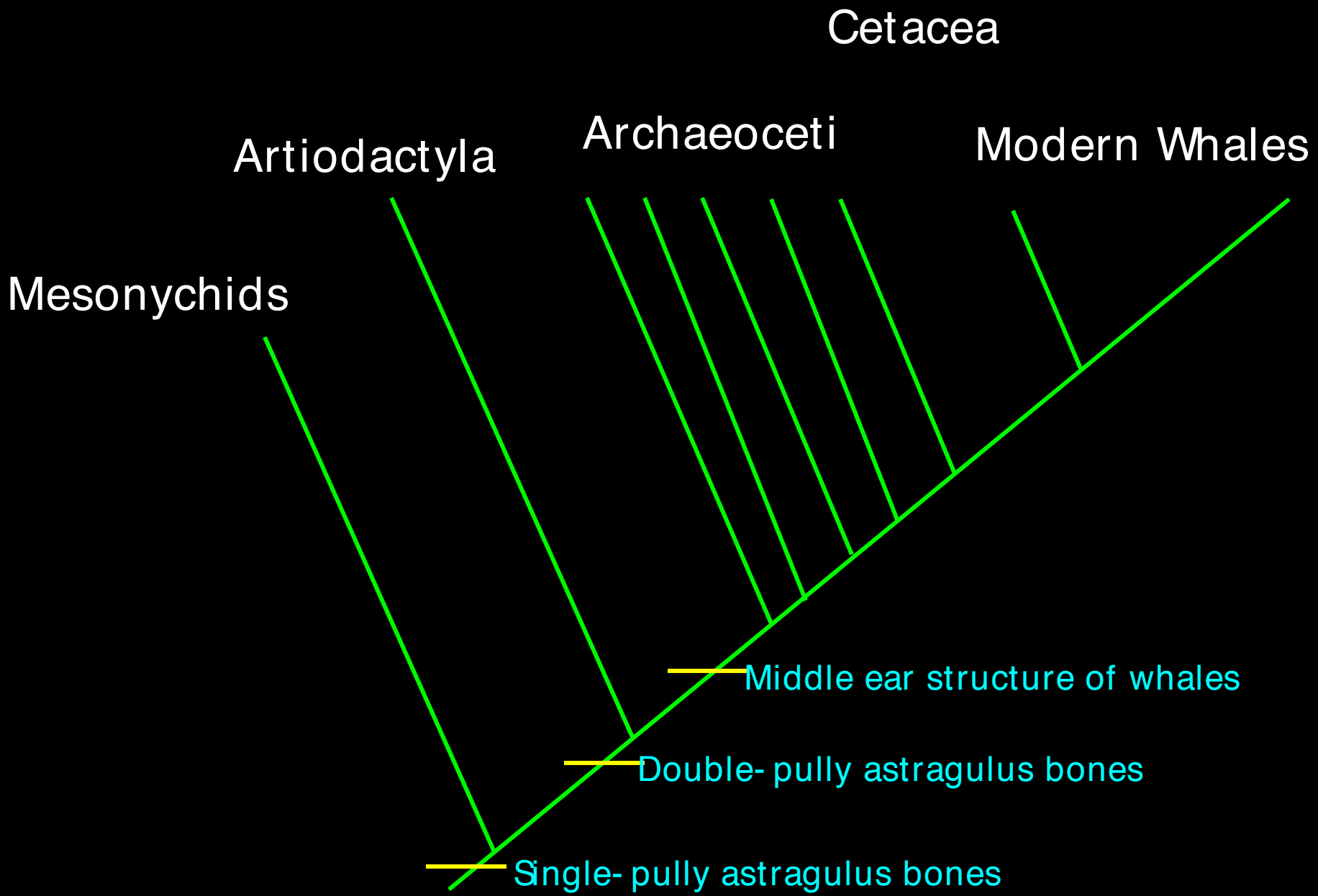


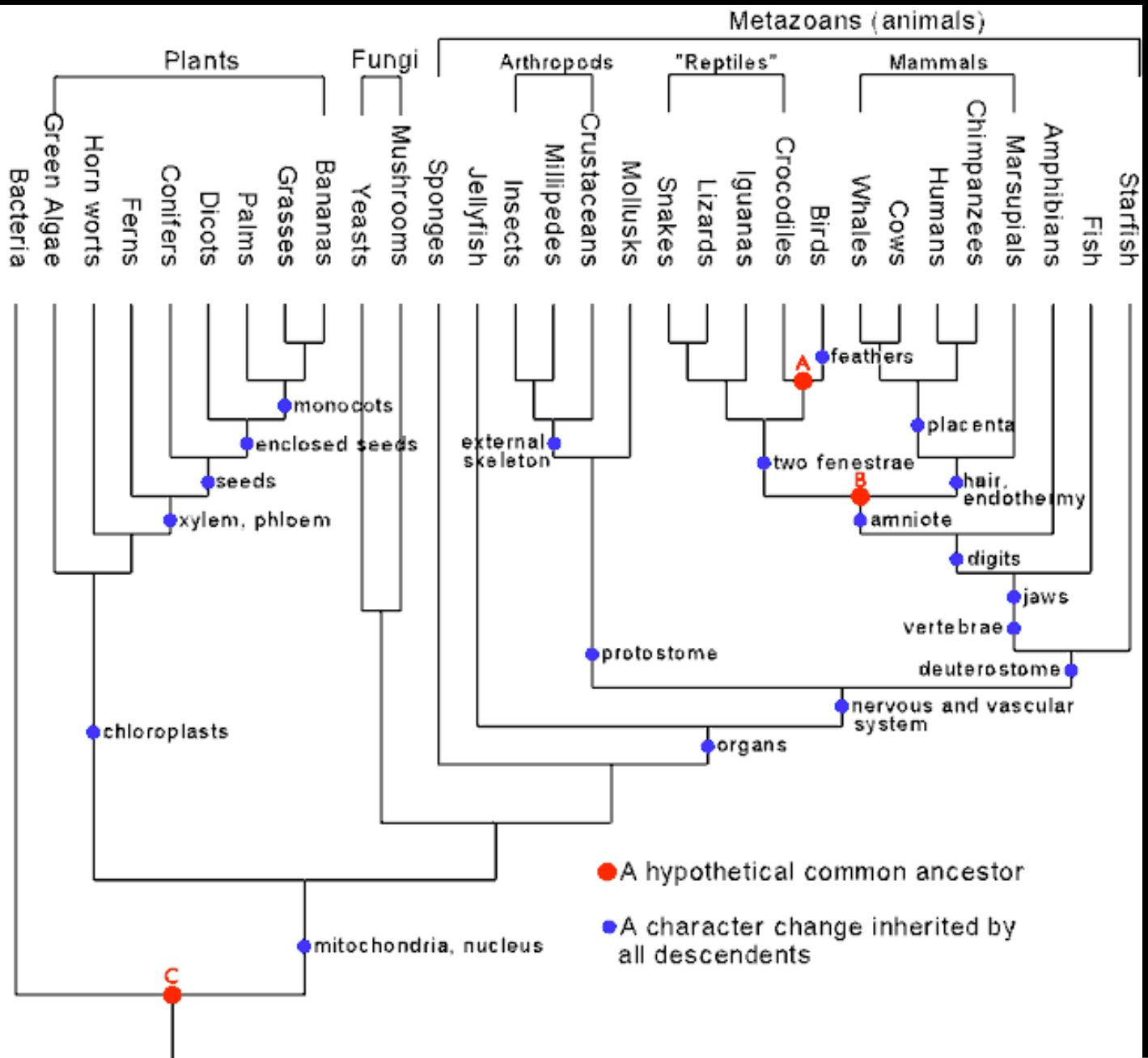
WELL& EVOLUTION? or WHALE EVOLUTION

Artiocetus

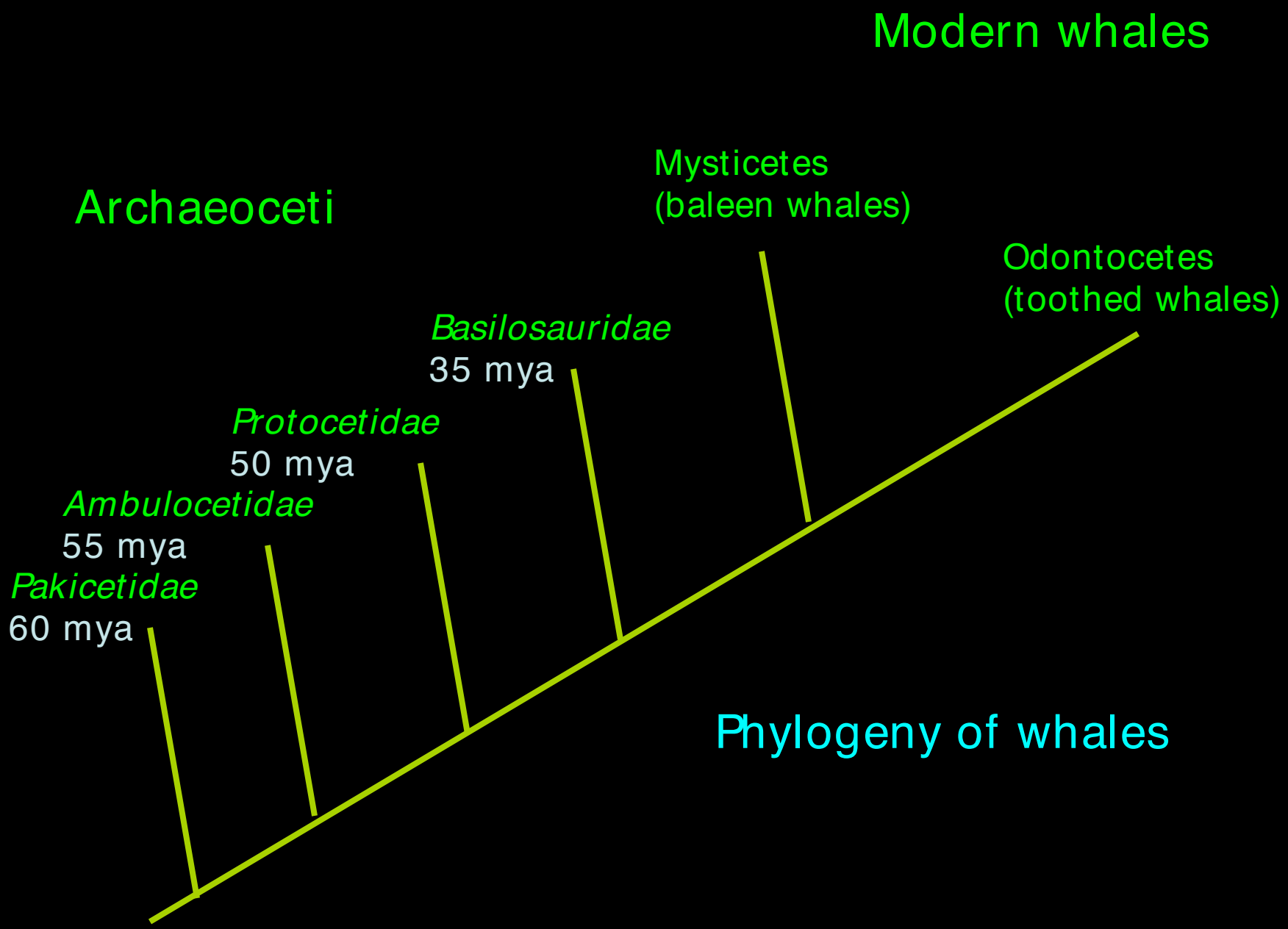
Pronghorn Antelope

Rodhocetus

WELL& EVOLUTION? or WHALE EVOLUTION



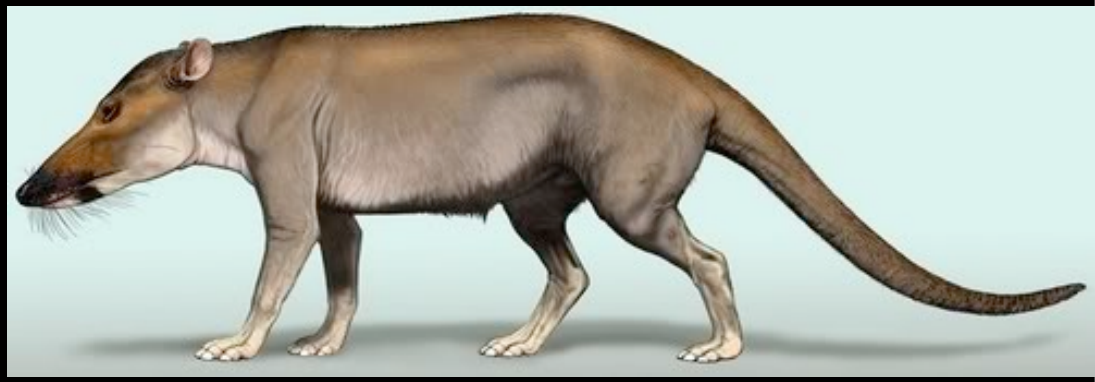
WELL& EVOLUTION? or WHALE EVOLUTION



WELL& EVOLUTION? or WHALE EVOLUTION

Pakicetidae 60 mya

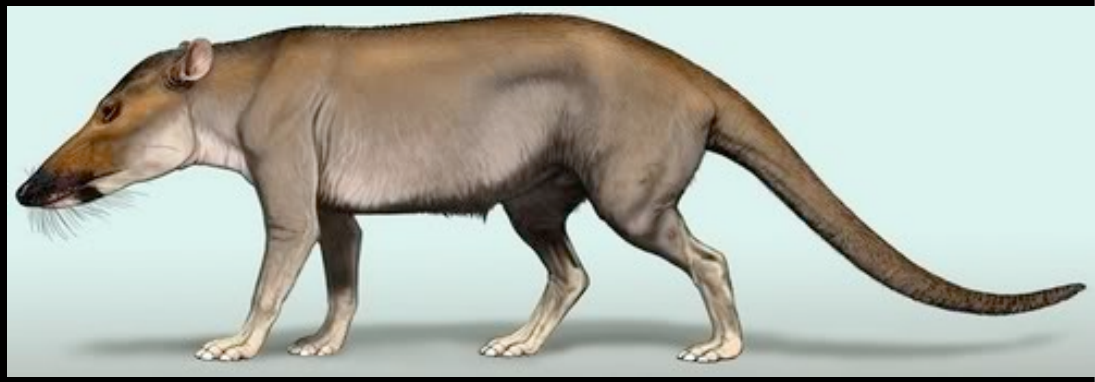
" Small terrestrial carnivore
that lived and foraged on
the edges of bodies of water.



WELL& EVOLUTION? or WHALE EVOLUTION

Pakicetidae 60 mya

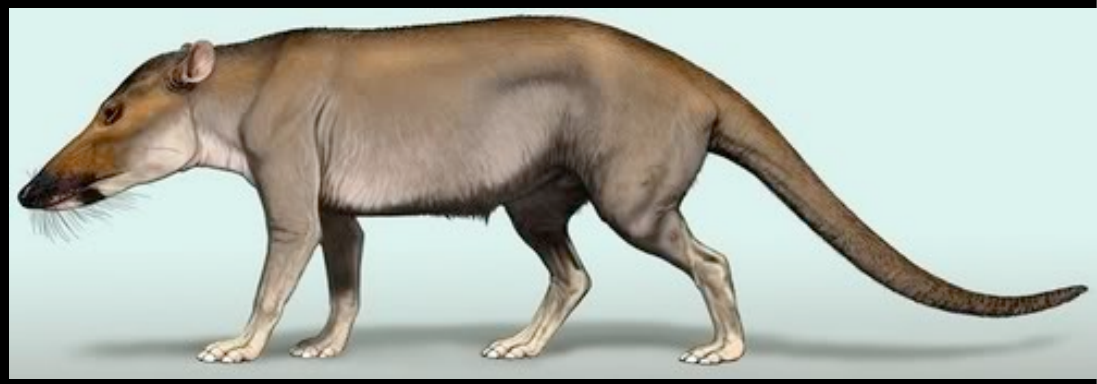
- Small terrestrial carnivore that lived and foraged on the edges of bodies of water.
- Ears not adapted for under-water hearing.



WELL& EVOLUTION? or WHALE EVOLUTION

Pakicetidae 60 mya

- Small terrestrial carnivore that lived and foraged on the edges of bodies of water.
- Ears not adapted for under-water hearing.
- Nostrils at tip of snout.



WELL& EVOLUTION? or WHALE EVOLUTION

Pakicetidae 60 mya

- Small terrestrial carnivore that lived and foraged on the edges of bodies of water.
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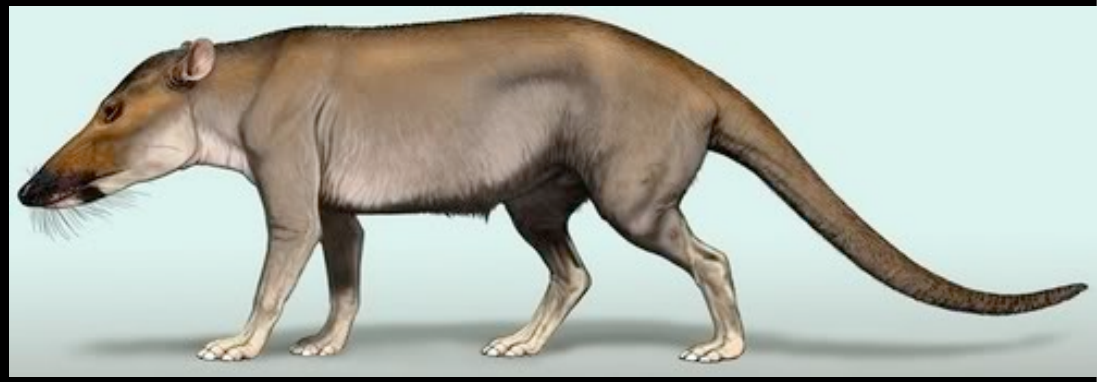
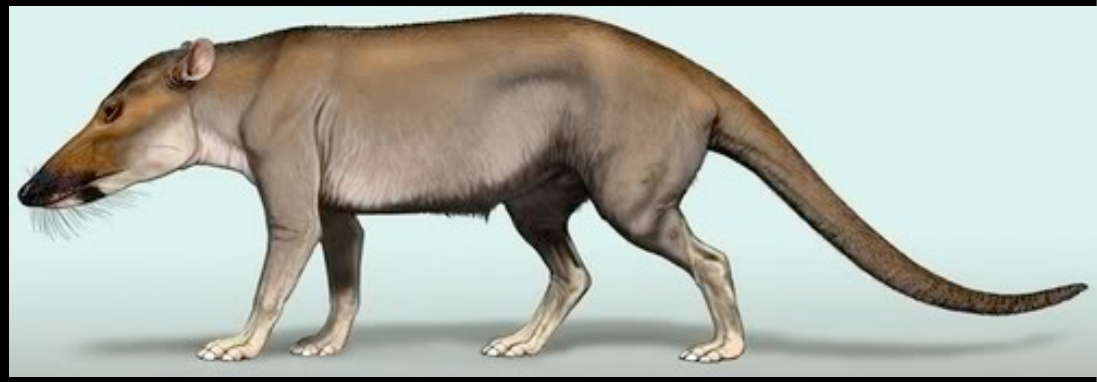
- Nostrils at tip of snout.
- Limbs well- developed.



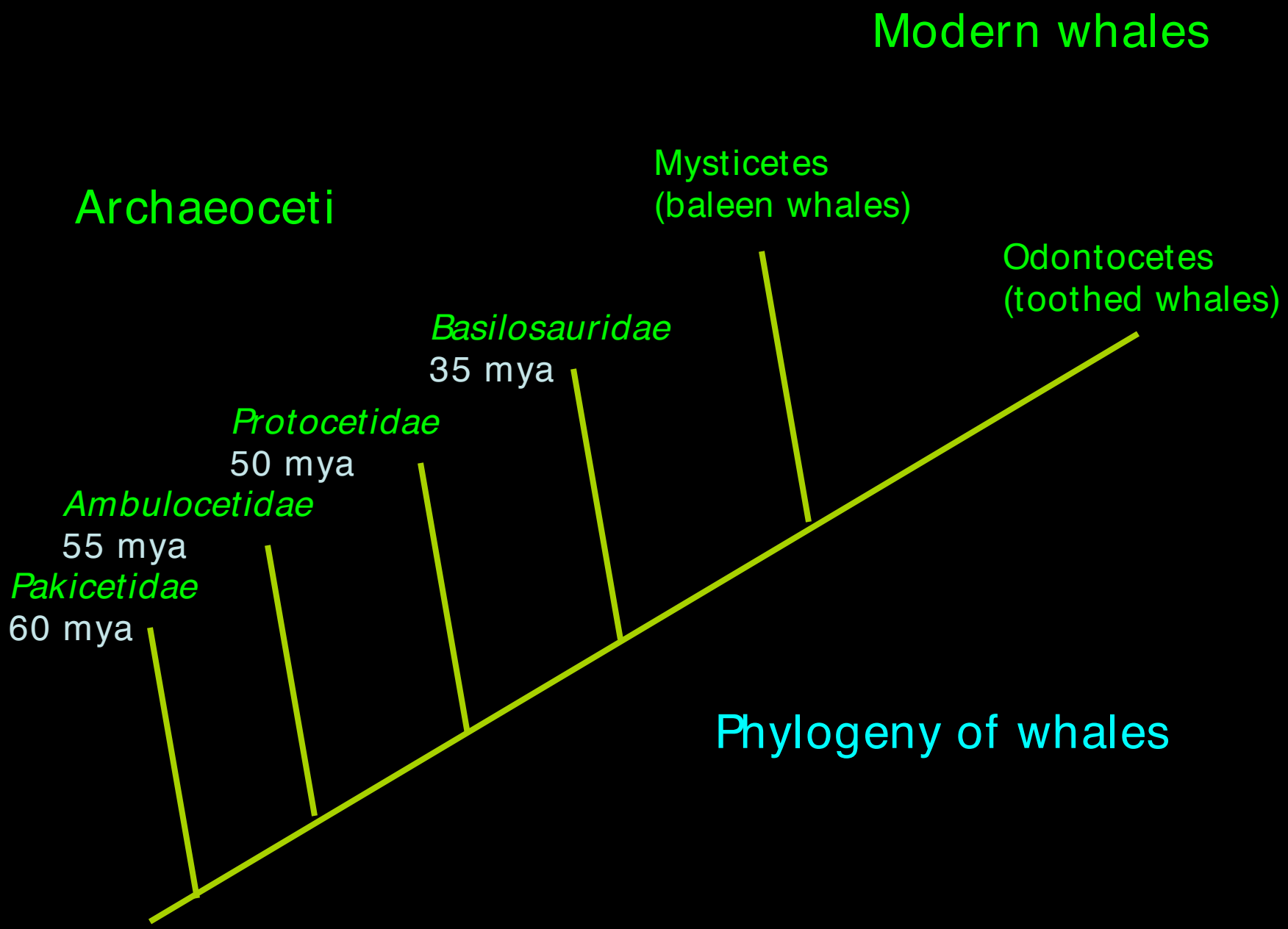
WELL& EVOLUTION? or WHALE EVOLUTION

Pakicetidae 60 mya

- Small terrestrial carnivore that lived and foraged on the edges of bodies of water.
- Ears not adapted for under-water hearing.
- Nostrils at tip of snout.
- Limbs well- developed.
- Whale middle ear bone.



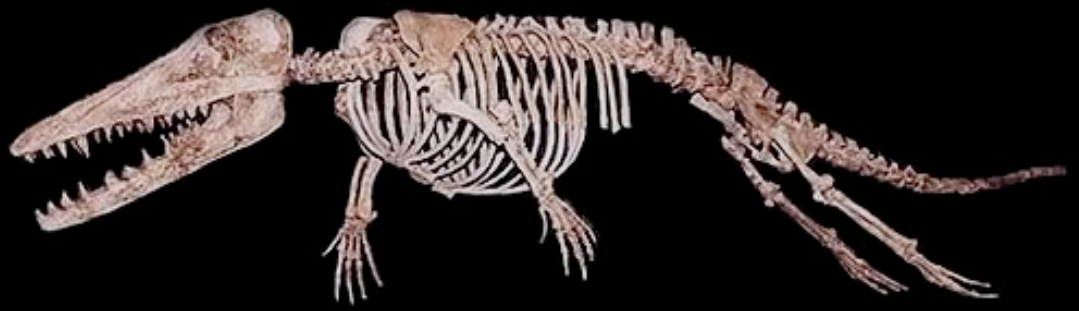
WELL& EVOLUTION? or WHALE EVOLUTION



WELL& EVOLUTION? or WHALE EVOLUTION

Ambulocetidae 55 mya

" Semi- aquatic carnivore carnivore.



WELL& EVOLUTION? or WHALE EVOLUTION

Ambulocetidae 55 mya

" Semi- aquatic carnivore carnivore.
" Ears beginning to be adapted for under-water hearing.

WELL& EVOLUTION? or WHALE EVOLUTION

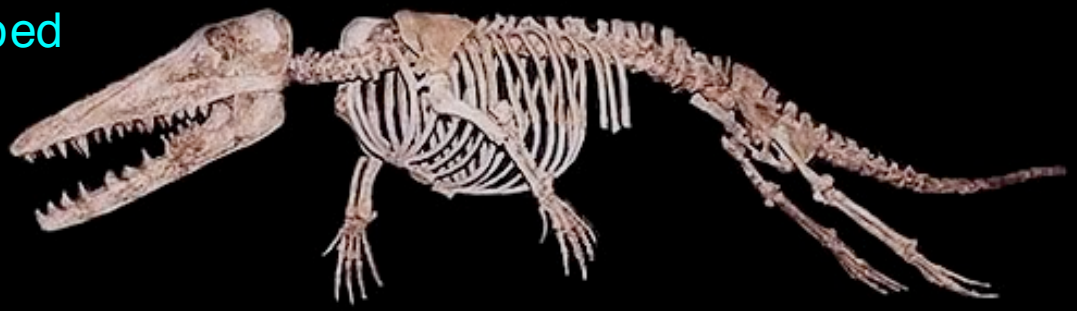
Ambulocetidae 55 mya

- Semi- aquatic carnivore carnivore.
- Ears beginning to be adapted for under-water hearing.
- Nostrils at tip of snout.

WELL& EVOLUTION? or WHALE EVOLUTION

Ambulocetidae 55 mya

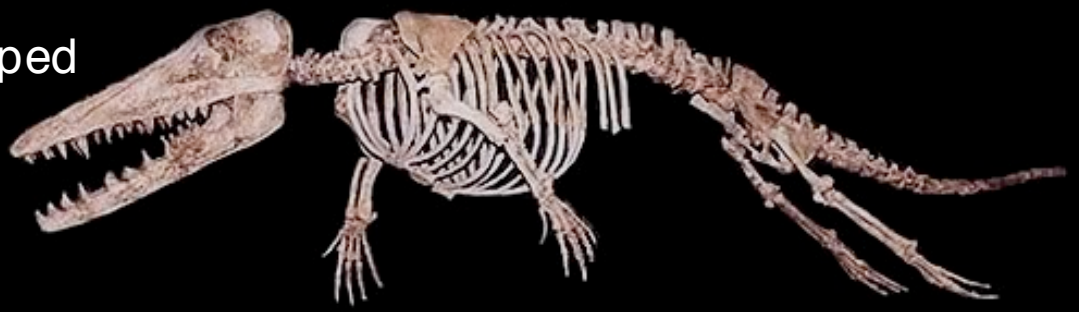
- Semi-aquatic carnivore carnivore.
- Ears beginning to be adapted for under-water hearing.
- Nostrils at tip of snout.
- Limbs shortened but well-developed with functional flippers.



WELL& EVOLUTION? or WHALE EVOLUTION

Ambulocetidae 55 mya

- Semi-aquatic carnivore carnivore.
- Ears beginning to be adapted for under-water hearing.
- Nostrils at tip of snout.
- Limbs shortened but well-developed with functional flippers.
- Skull more elongate.



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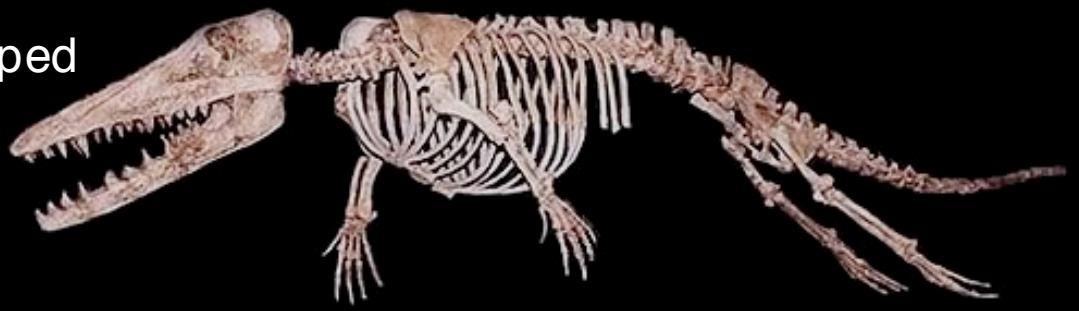
- Nostrils at tip of snout.
- Limbs shortened but well-developed with functional flippers.
- Skull more elongate.
- Crocodile-like life style.



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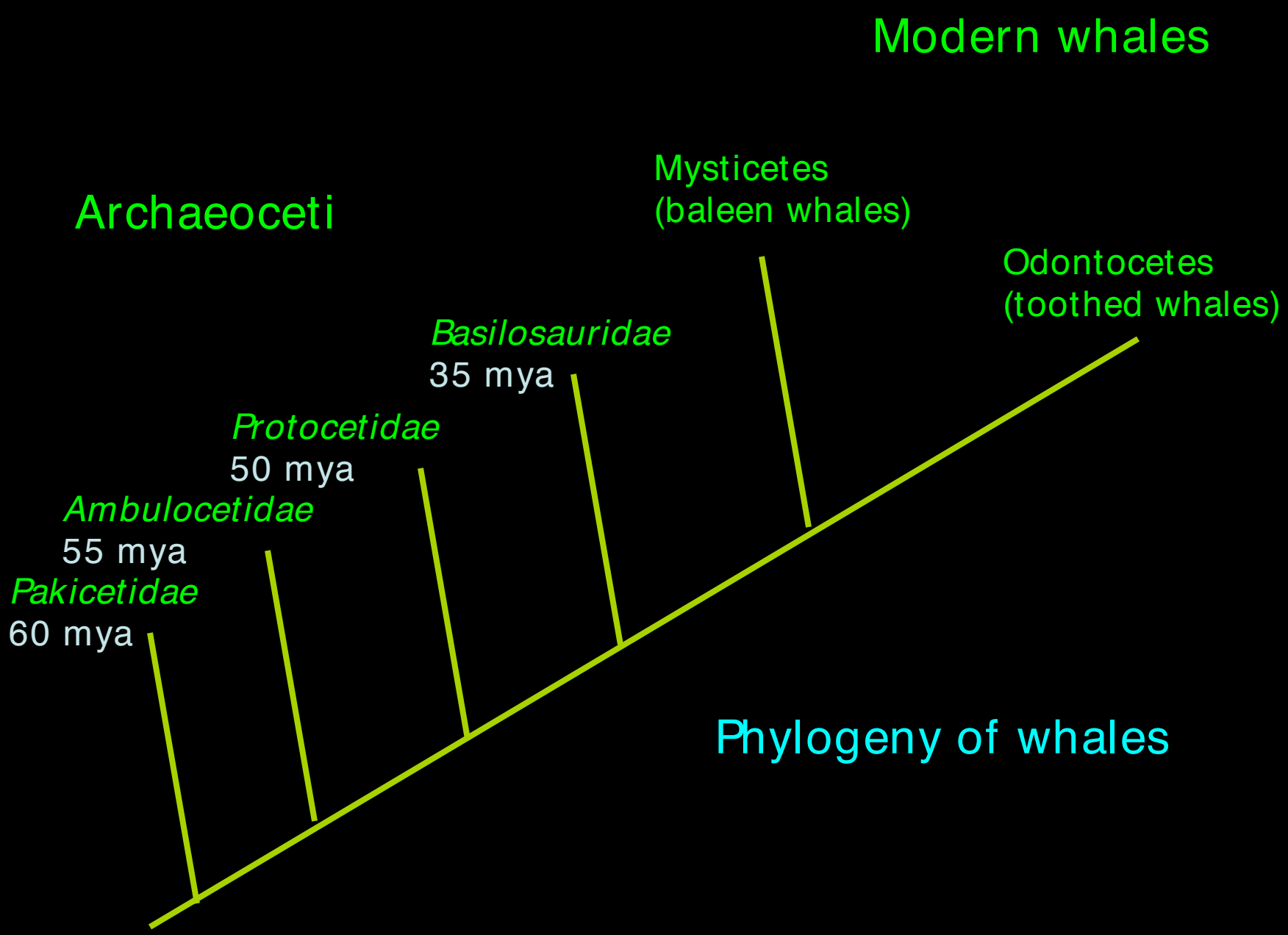
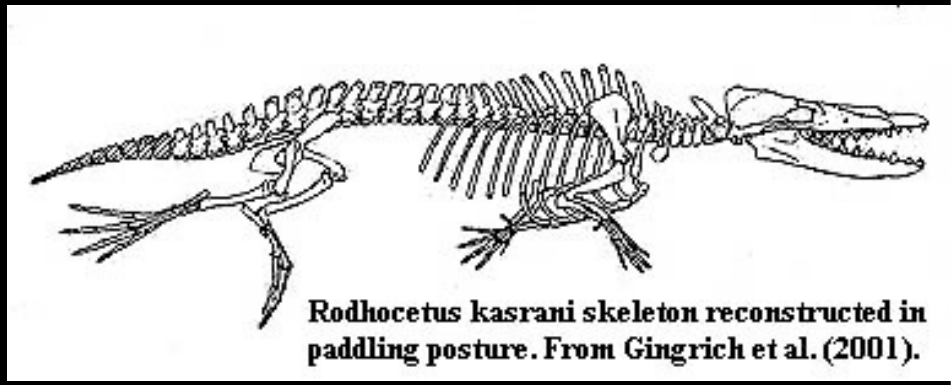


WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.

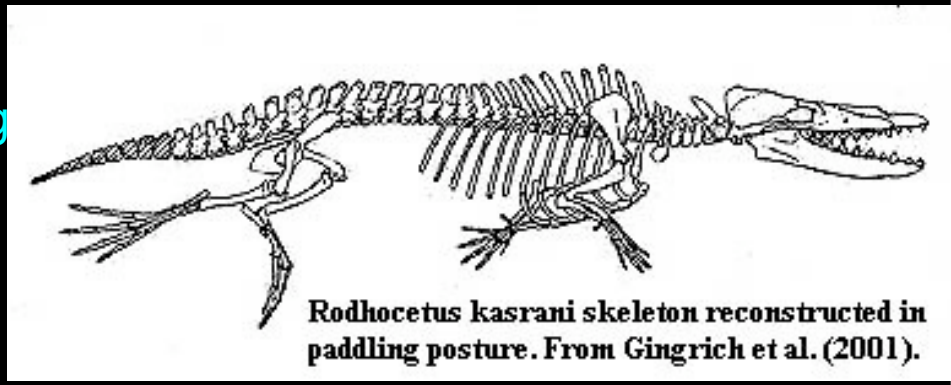


Rodhocetus kasrani skeleton reconstructed in paddling posture. From Gingrich et al. (2001).

WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.
" Ears well adapted for underwater hearing

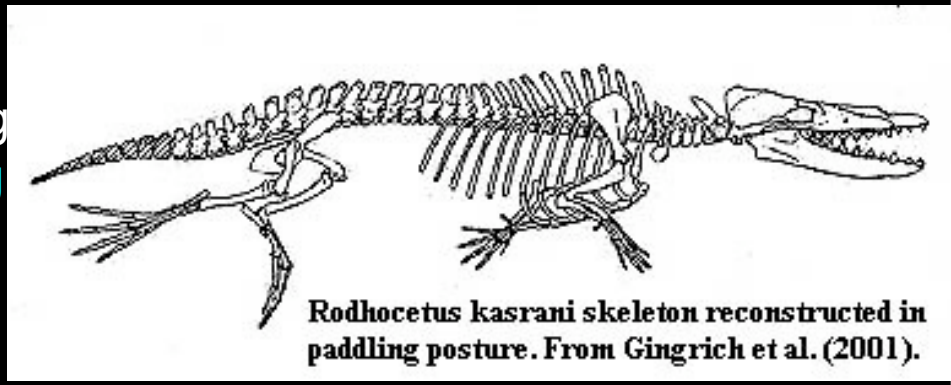


Rodhocetus kasrani skeleton reconstructed in paddling posture. From Gingrich et al. (2001).

WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.
" Ears well adapted for underwater hearing
" Limbs shortened and used for swimming



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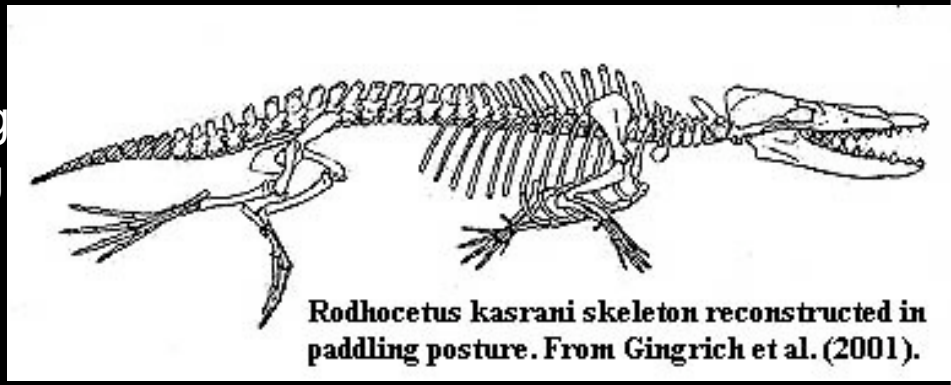
WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.
" Ears well adapted for underwater hearing
" Limbs shortened and used for swimming
" Skull flattened and more elongate.



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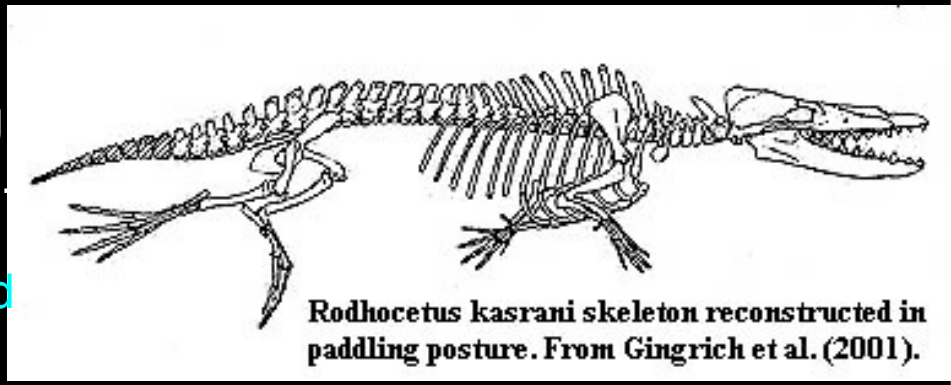
WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.
" Ears well adapted for underwater hearing
" Limbs shortened and used for swimming.
" Skull flattened and more elongate.
" Nostrils midway between tip of snout and top of head.

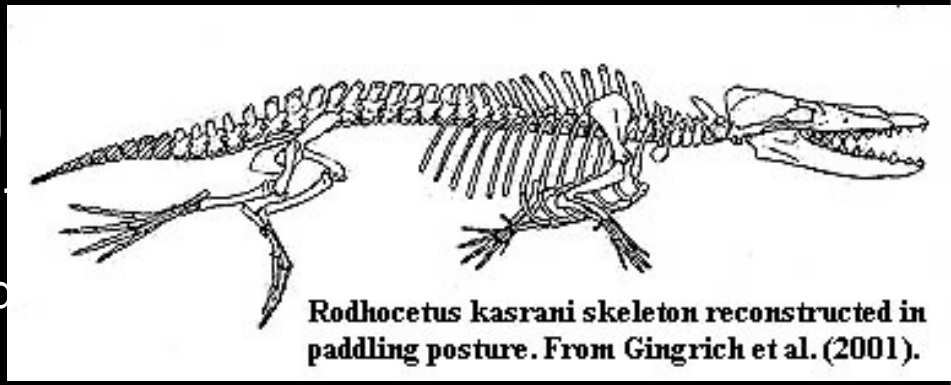


Rodhocetus kasrani skeleton reconstructed in paddling posture. From Gingrich et al. (2001).

WELL& EVOLUTION? or WHALE EVOLUTION

Protocetidae 50 mya

" Aquatic carnivore.
" Ears well adapted for underwater hearing
" Limbs shortened and used for swimming.
" Skull flattened and more elongate.
" Nostrils midway between tip of snout and top of head.
" Sacral vertebrae begin to lose their firm connection with the vertebral column.



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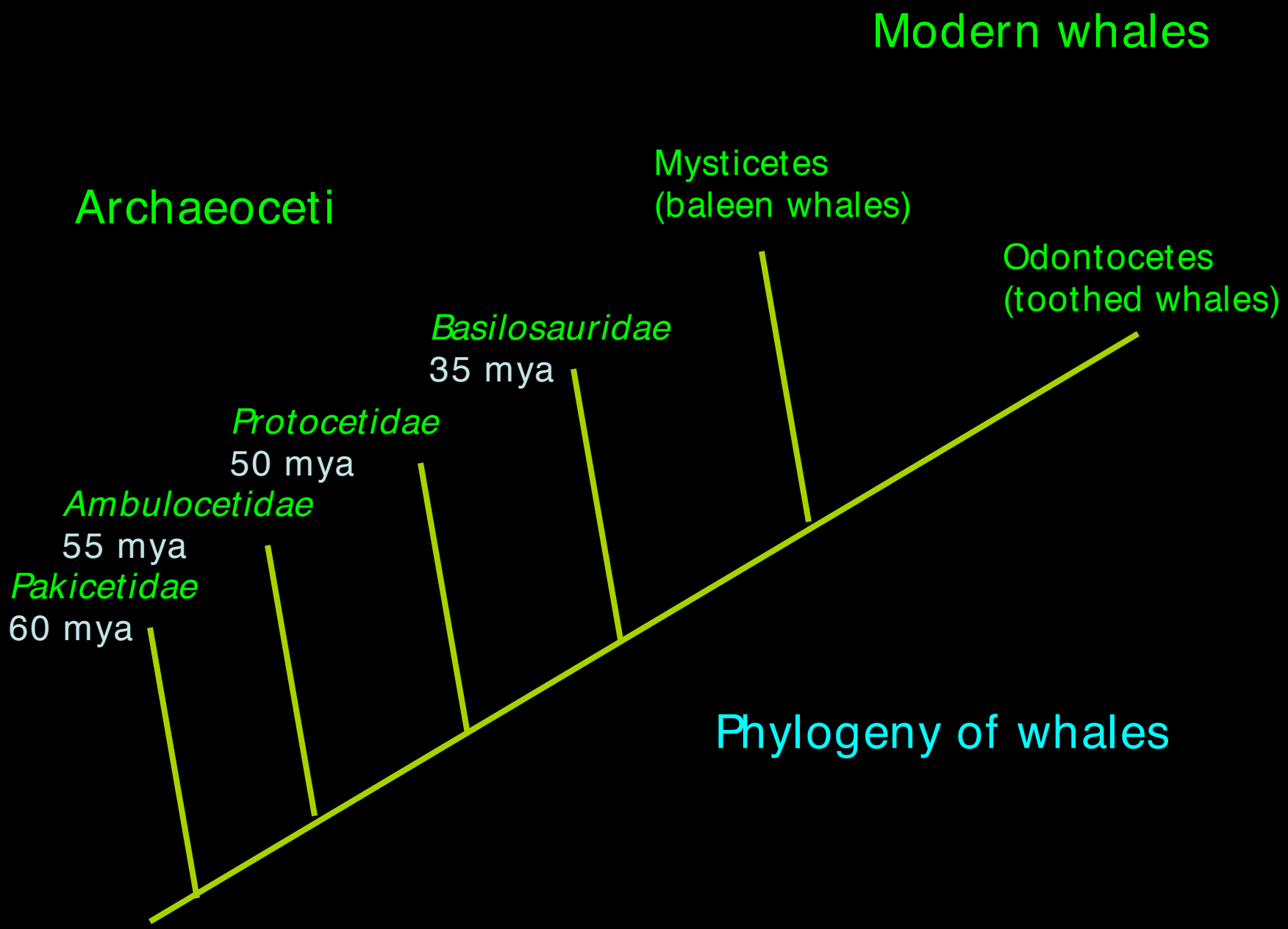


WELL& EVOLUTION? or WHALE EVOLUTION

Basilosauridae 35 mya

" Large aquatic carnivores (up to 24 meters).

WELL& EVOLUTION? or WHALE EVOLUTION

Basilosauridae 35 mya

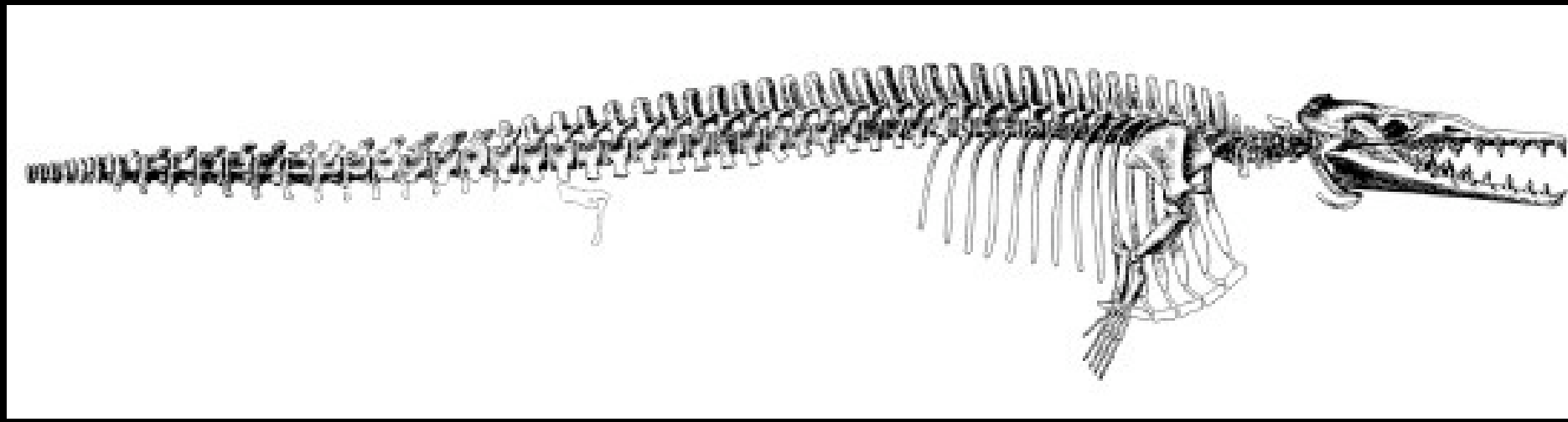
" Large aquatic carnivores (up to 24 meters).

" Entered adapted for underwater hearing but not echolocation.

WELL& EVOLUTION? or WHALE EVOLUTION

Basilosauridae 35 mya

" Large aquatic carnivores (up to 24 meters).
" Ears well adapted for underwater hearing but not echolocation.
" Nostrils at middle of snout.



WELL& EVOLUTION? or WHALE EVOLUTION

Basilosauridae 35 mya

" Large aquatic carnivores (up to 24 meters).
" Ears well adapted for underwater hearing but not echolocation.
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" Forelimbs shortened and flipper- like; hind limbs vestigial and external.

WELL& EVOLUTION? or WHALE EVOLUTION

Basilosauridae 35 mya

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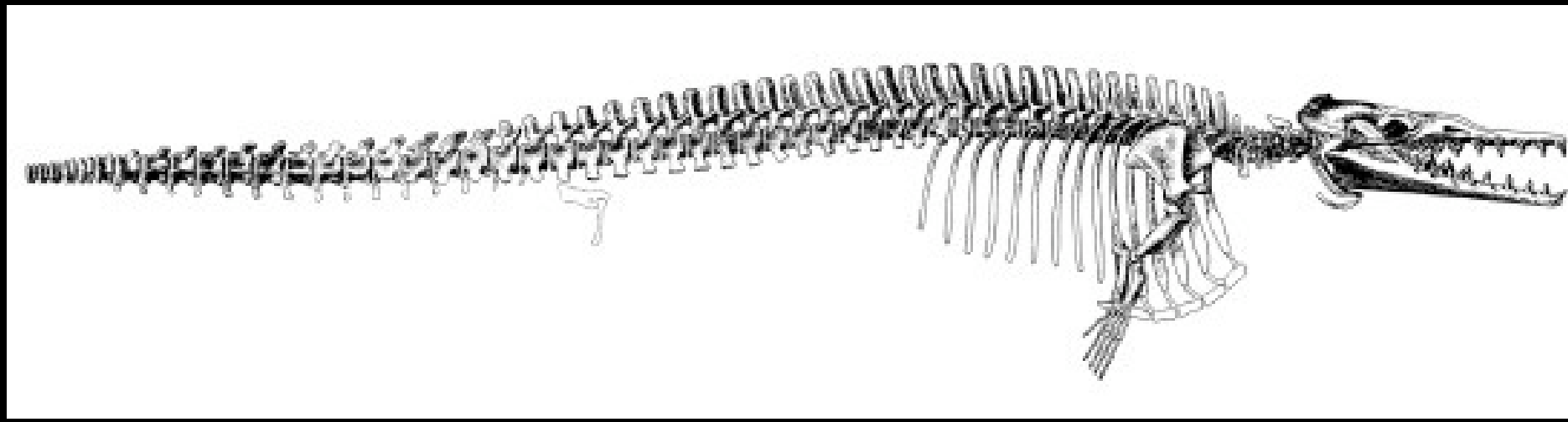

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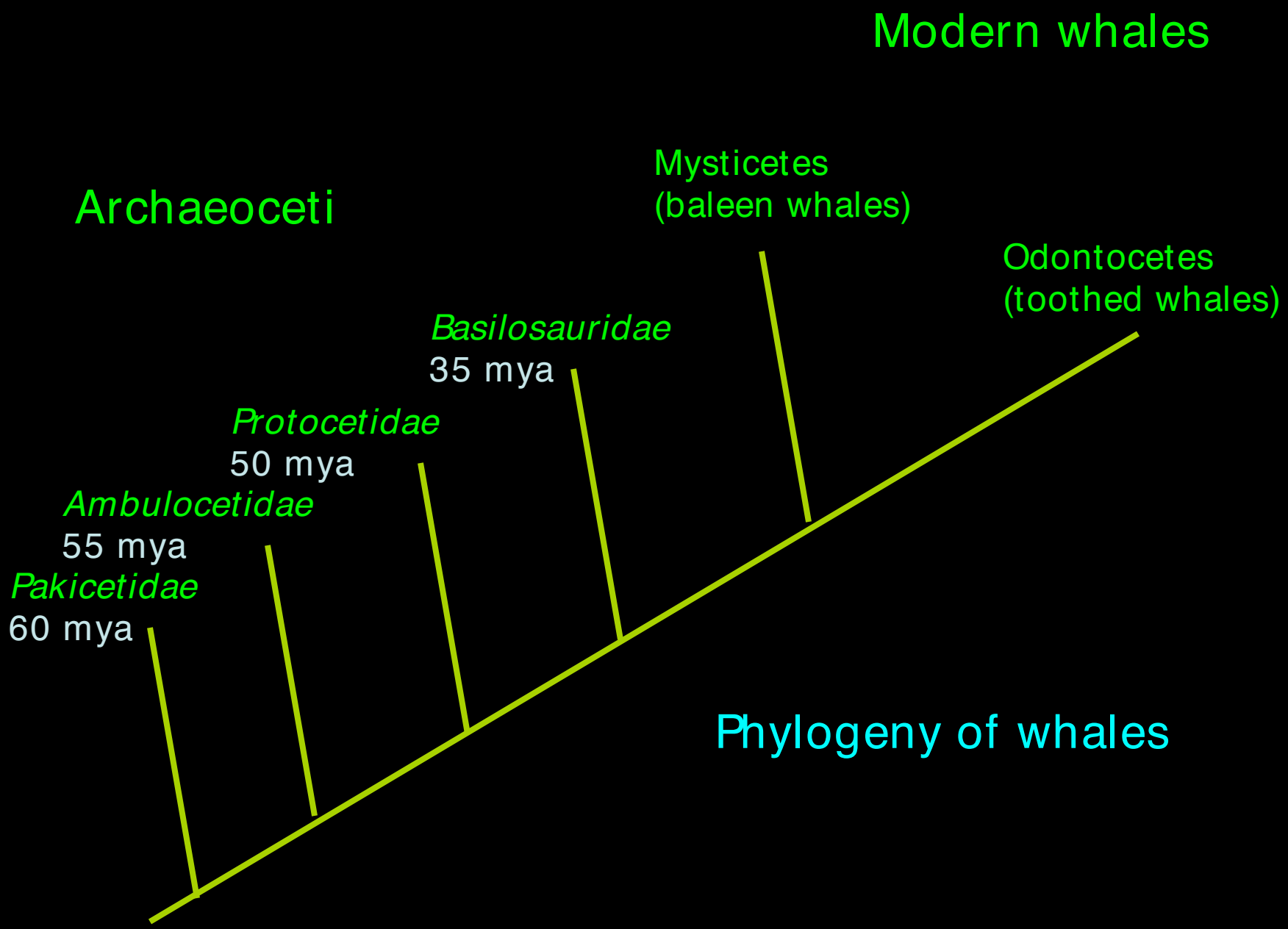

Modern Whales: Mystectes

" Large aquatic filter feeders with balleen.

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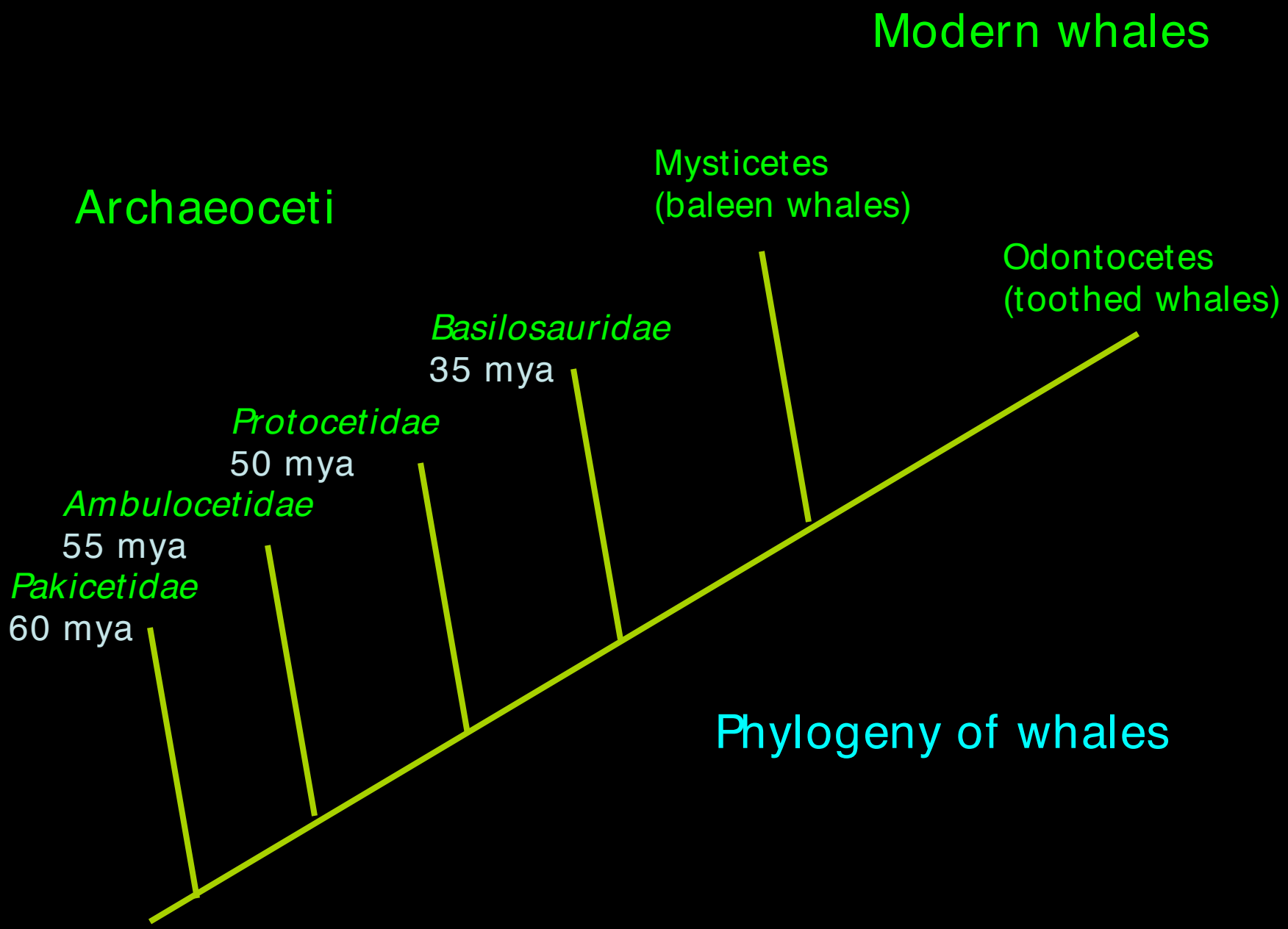

WELL& EVOLUTION? or WHALE EVOLUTION

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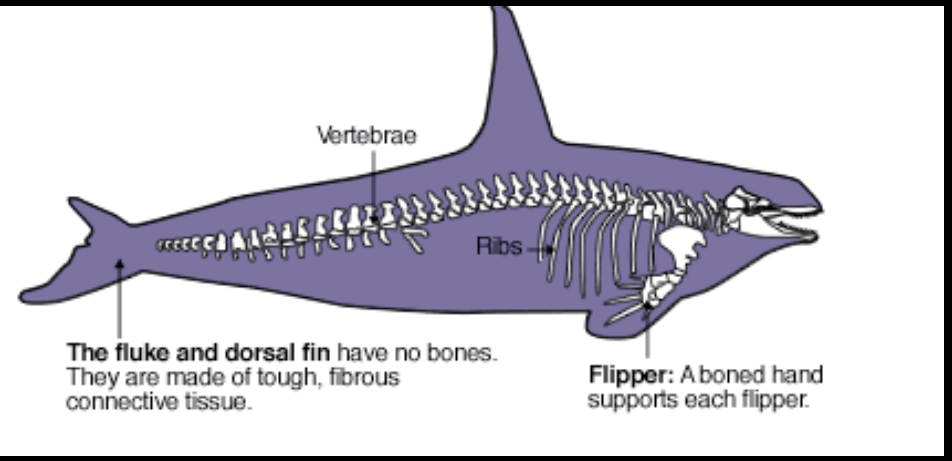

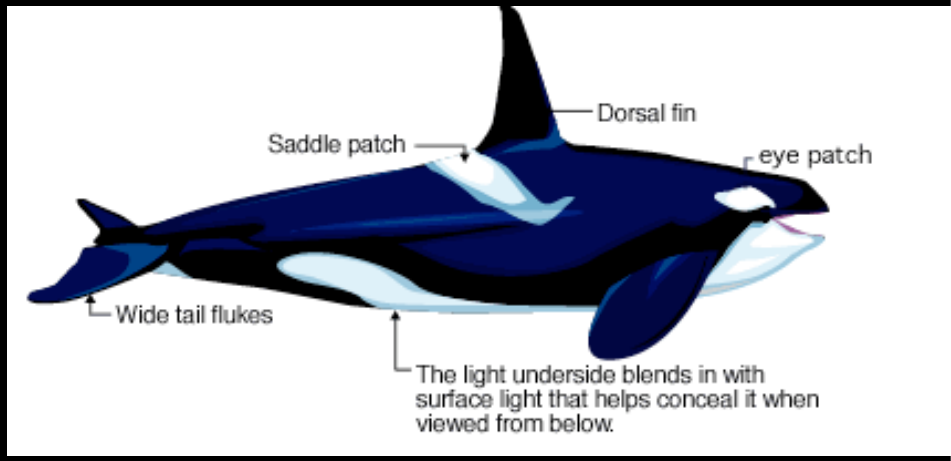

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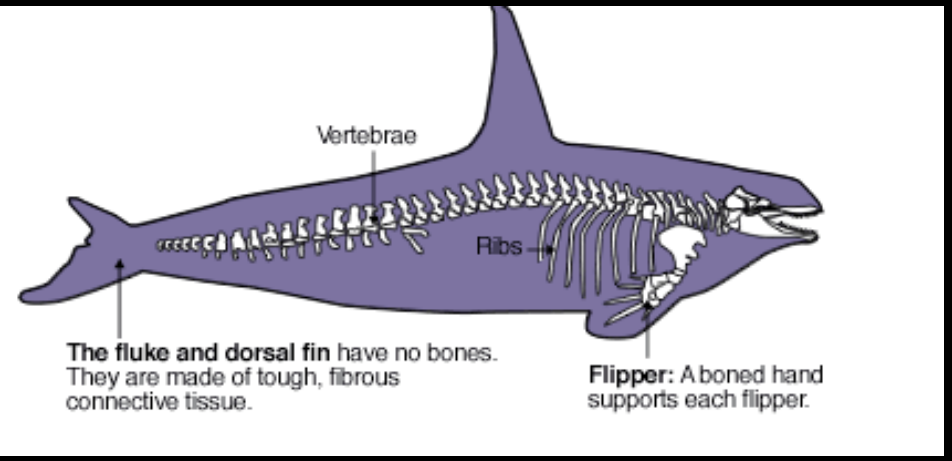

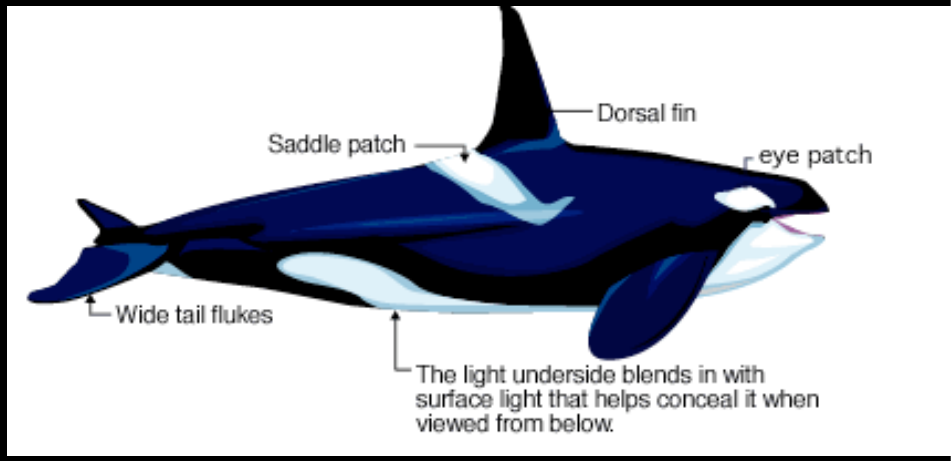

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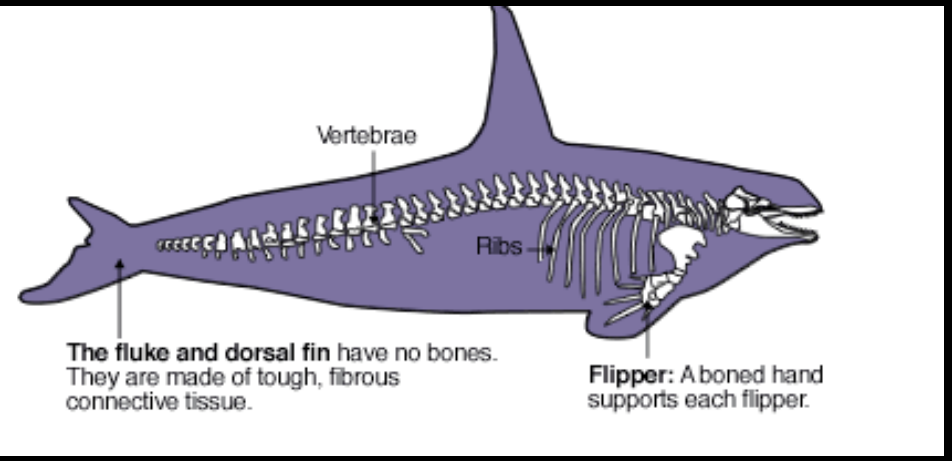

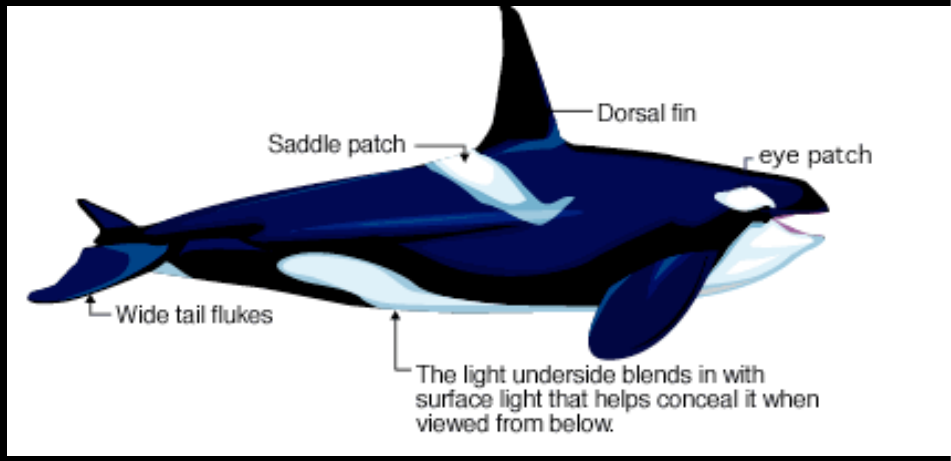

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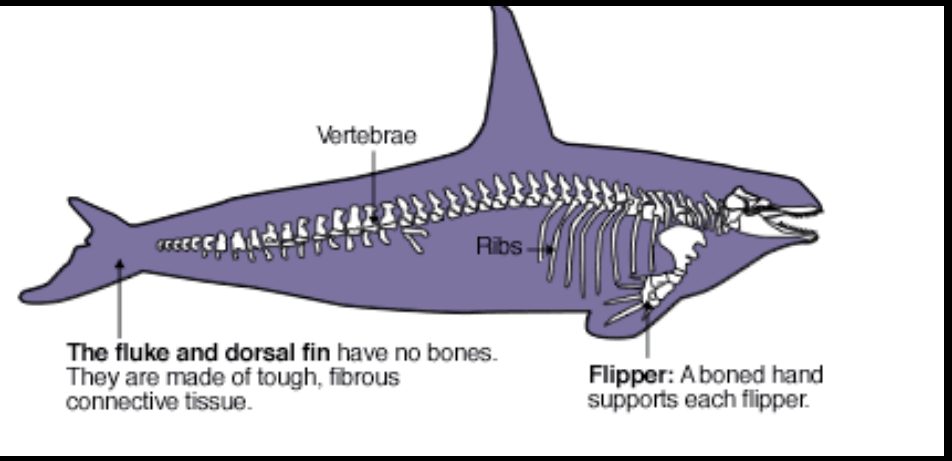

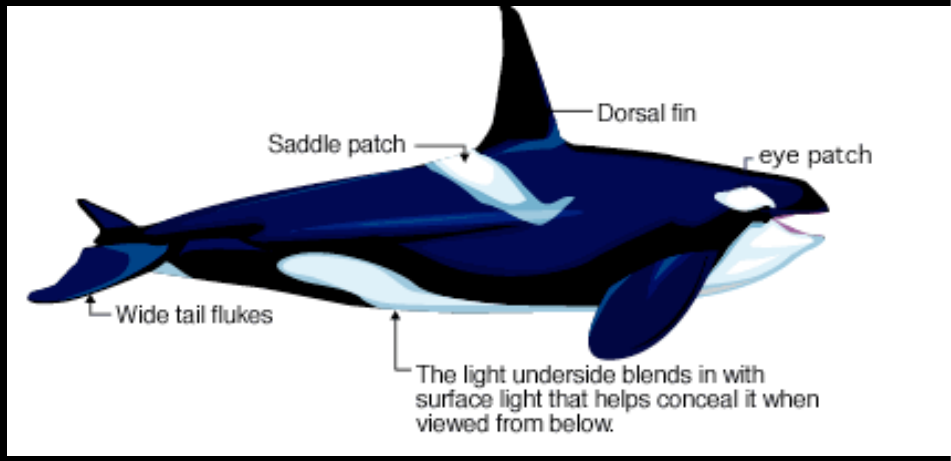

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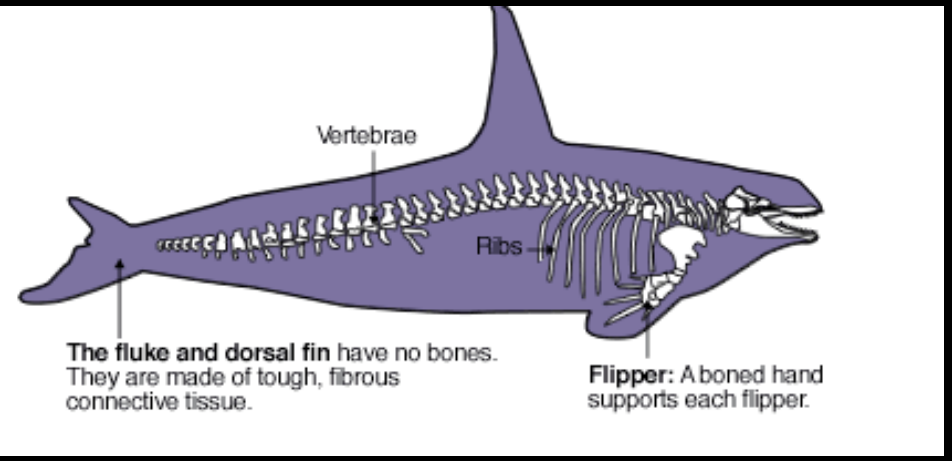

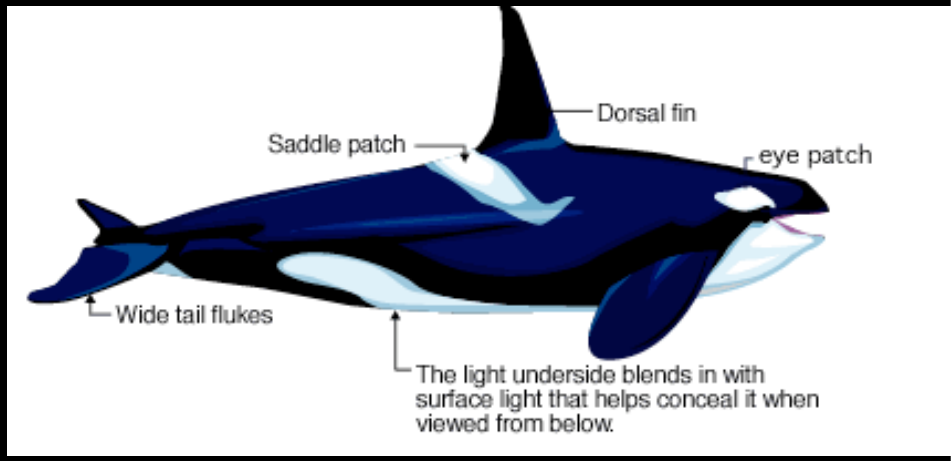

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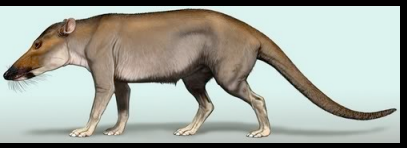

Basilosauridae
35 mya

Mysticetes
(baleen whales)

Odontocetes
(toothed whales)

Protocetidae
50 mya

Ambulocetidae
55 mya

Pakicetidae
60 mya

Phylogeny of whales

WELL& EVOLUTION? or WHALE EVOLUTION

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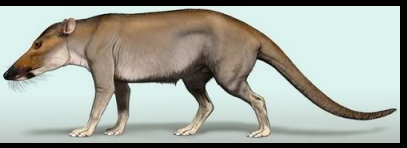

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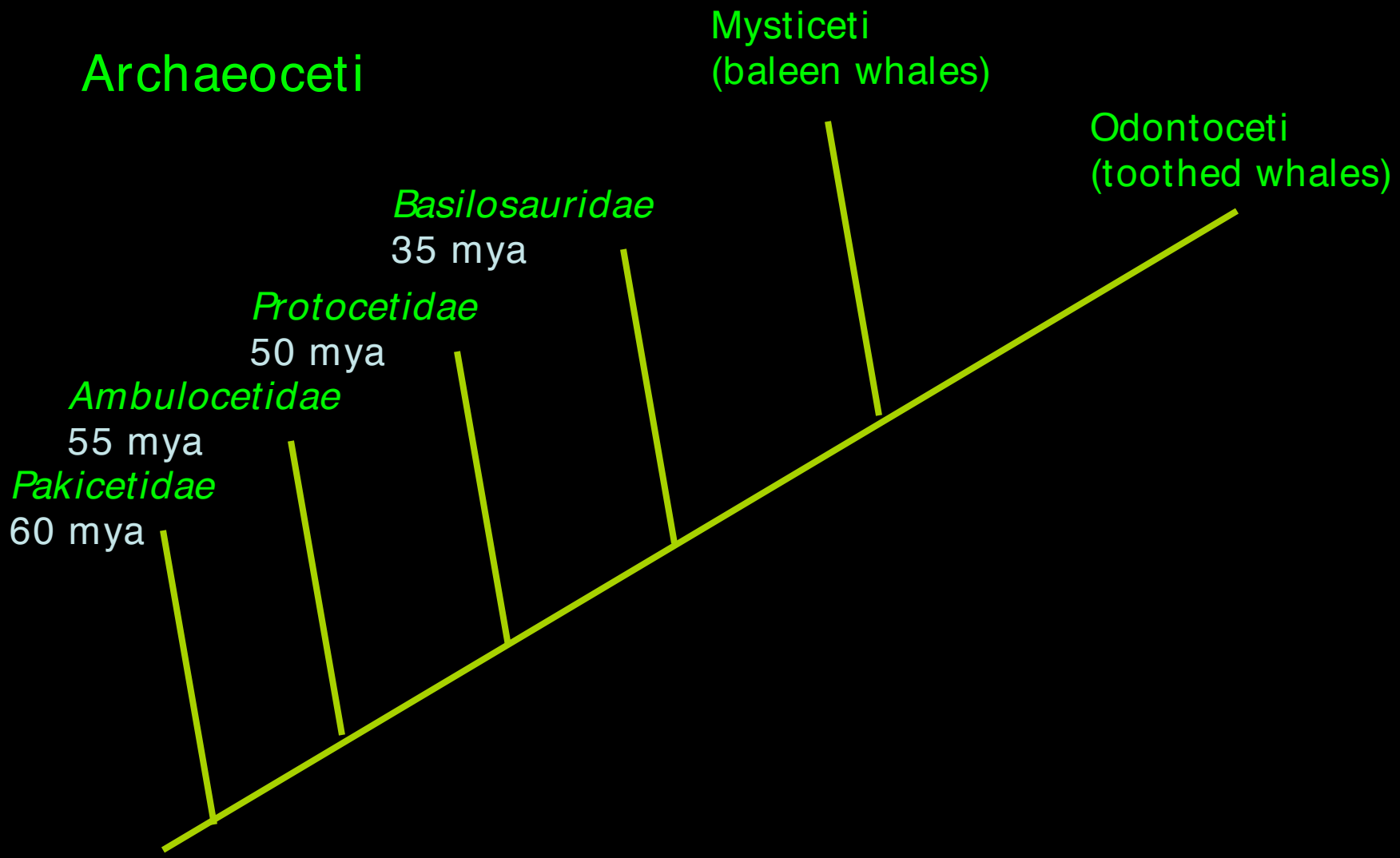
Which is the first whale?

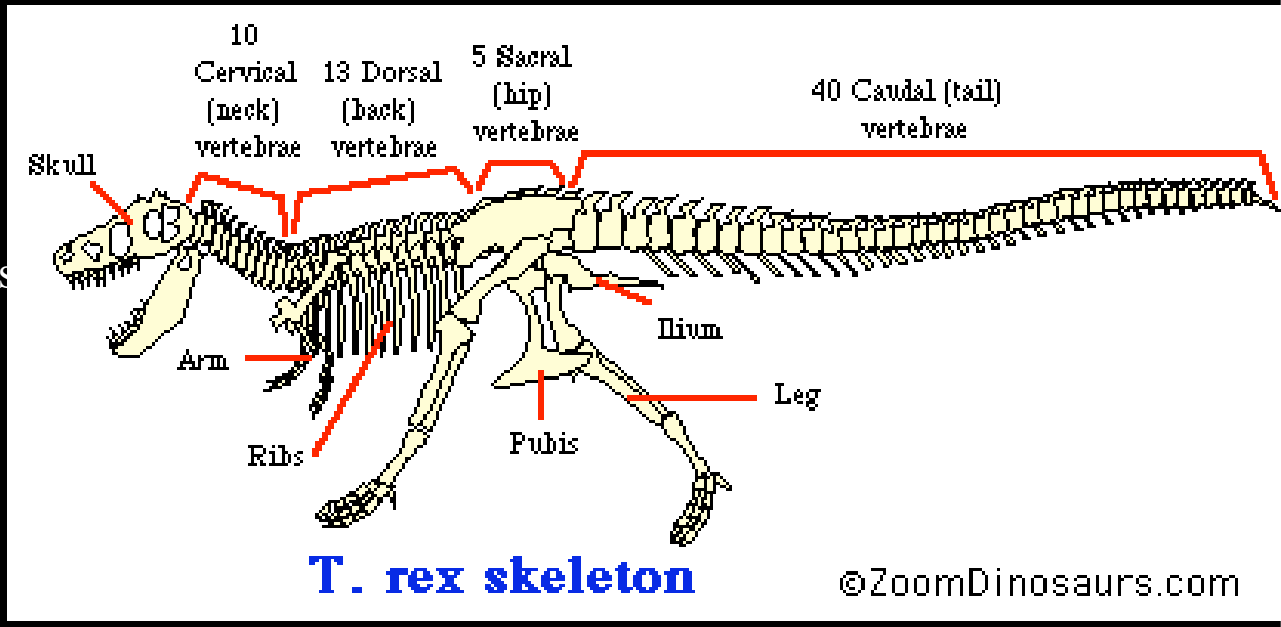
WELL& EVOLUTION? or WHALE EVOLUTION



MISSING LINKS

" Birds

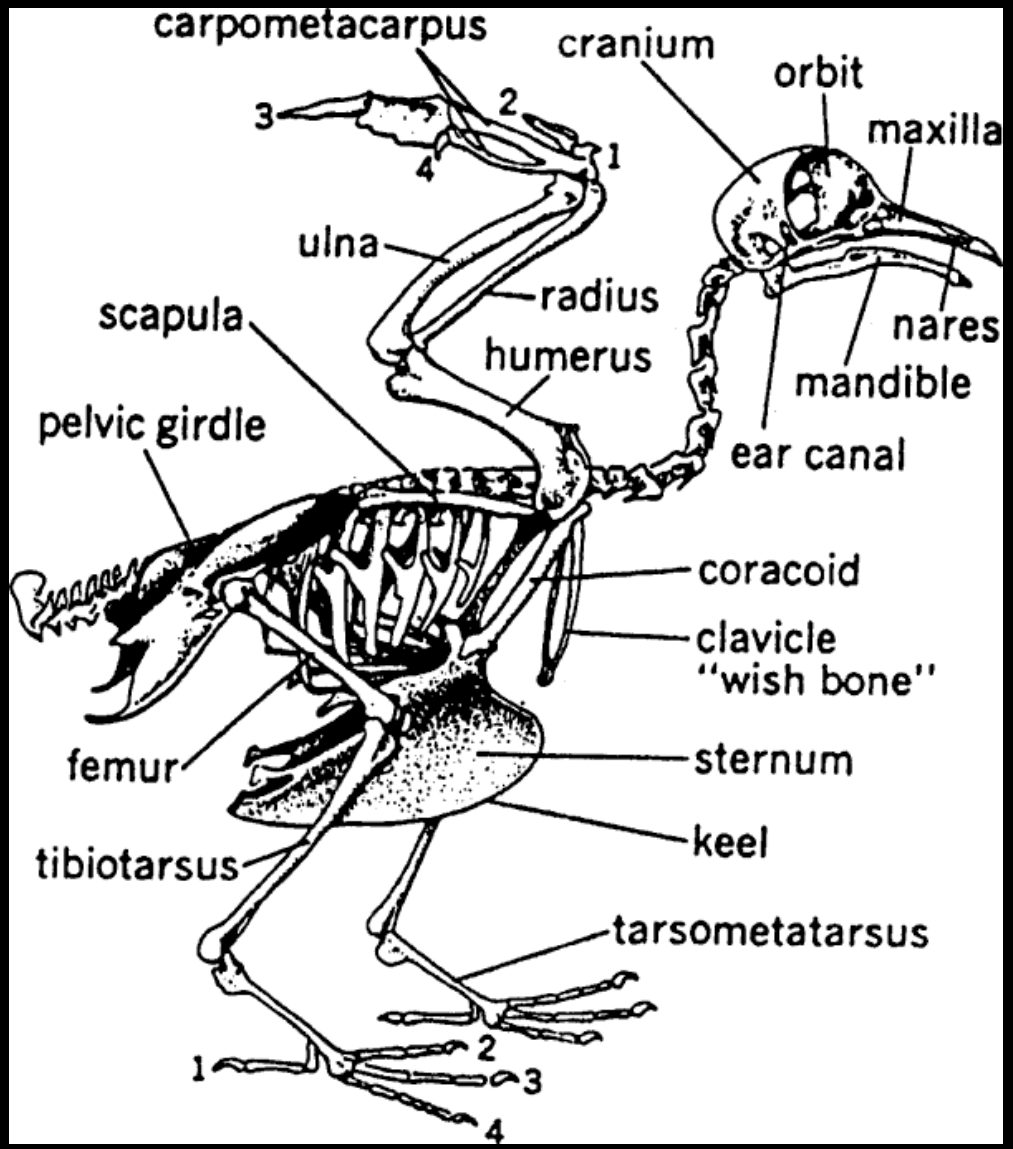
" Birds evolved from dinosaurs.
" In fact, birds are nothing more than an advanced theropod dinosaurs.
" Typical theropad dinosaur skeleton
  " Deep pelvis
  " 3 toes forward one backward
  " 4 sections in hind limb
  " Claws on forelimbs
  " Caudal vertebrae
  " Teeth
  " Two skull fenestrations (holes) between nostrils and orbits



MISSING LINKS

" Birds

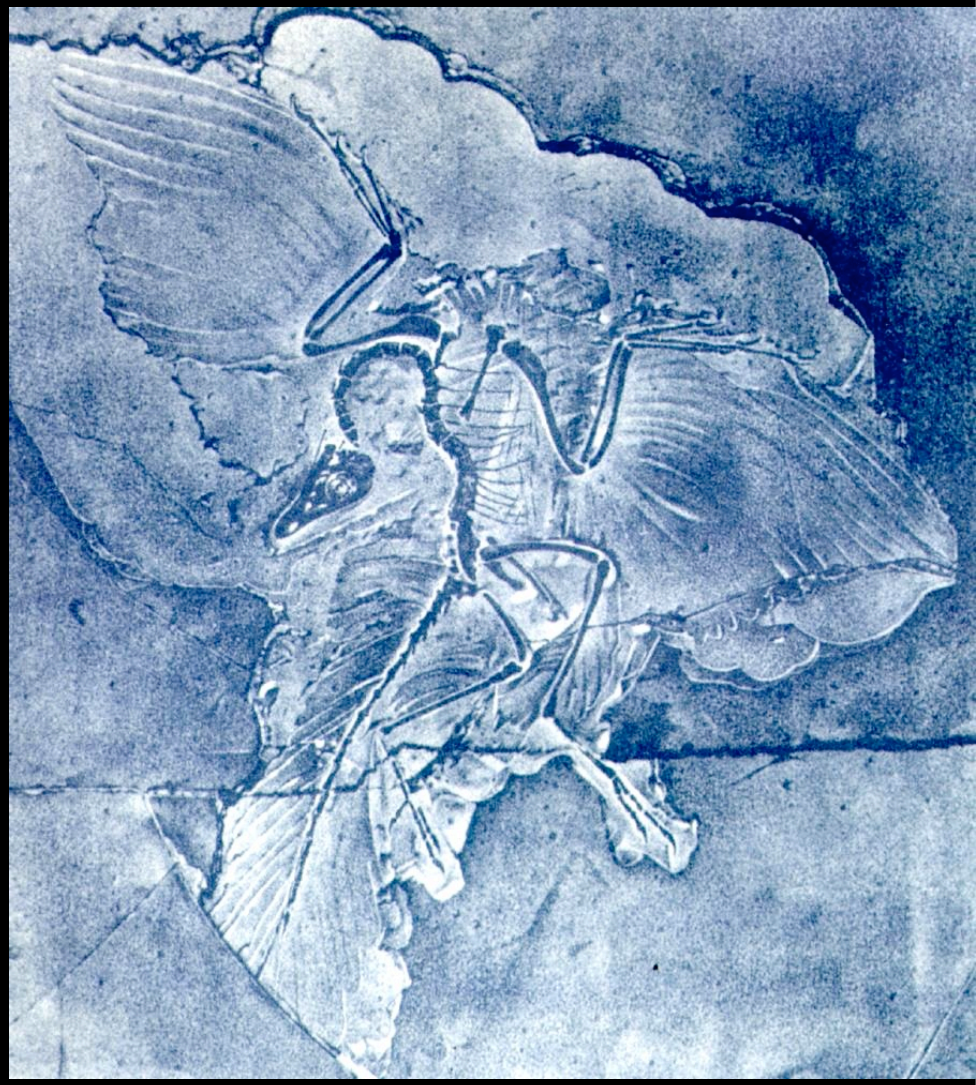
" Typical bird skeleton
- " Deep pelvis
- " 3 toes forward one back-ward
- " 4 sections in hind limbs
- " Two skull fenestrations (holes) between nostrils and orbits.
- " Highly modified forelimb
  - " Finger bones and wrist bones all fused.
  - " No claws
- " Feathers



MISSING LINKS

- Birds

- *Archeopteryx* skeleton
  - Deep pelvis
  - 3 toes forward one back-ward
  - 4 sections in hind limbs
  - Two skull fenestrations (holes) between nostrils and orbits.
  - Slightly modified forelimb
    - Finger bones and wrist bones partly fused.
    - Some claws present
  - Caudal vertebrae
  - Teeth
  - Feathers



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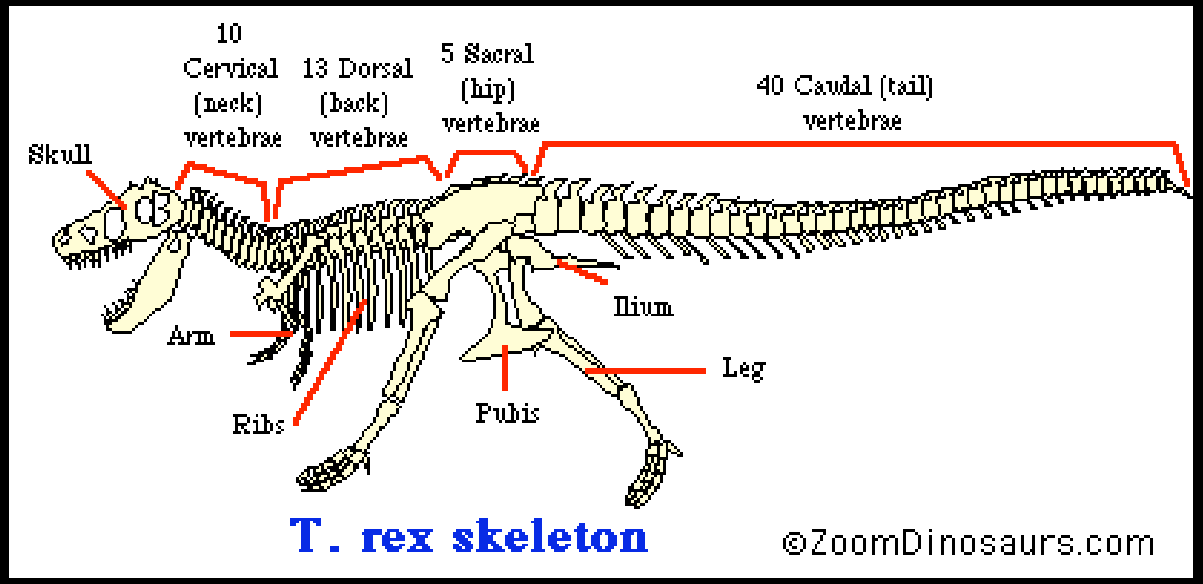
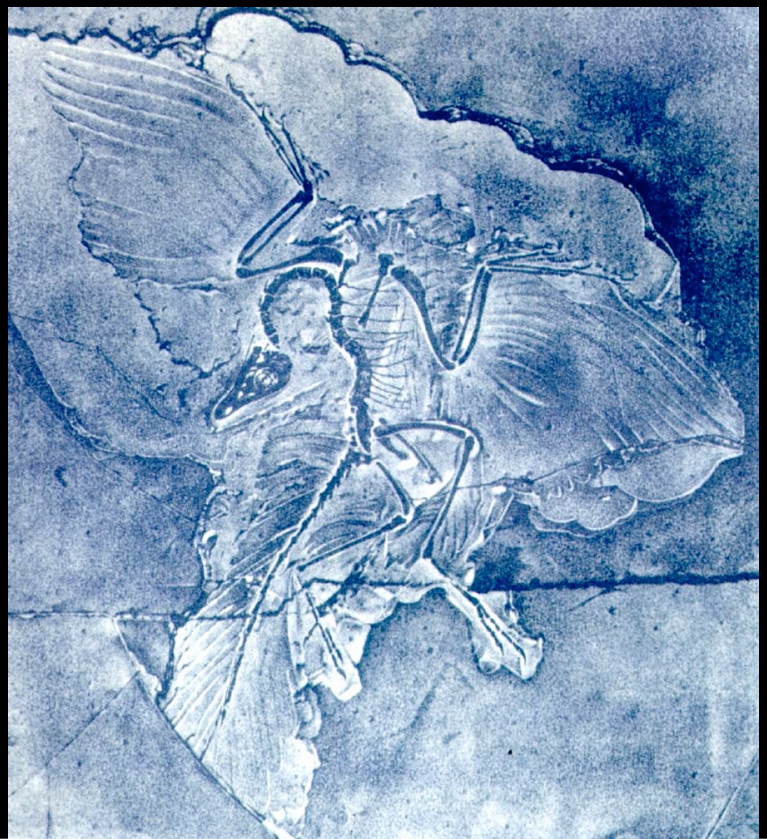
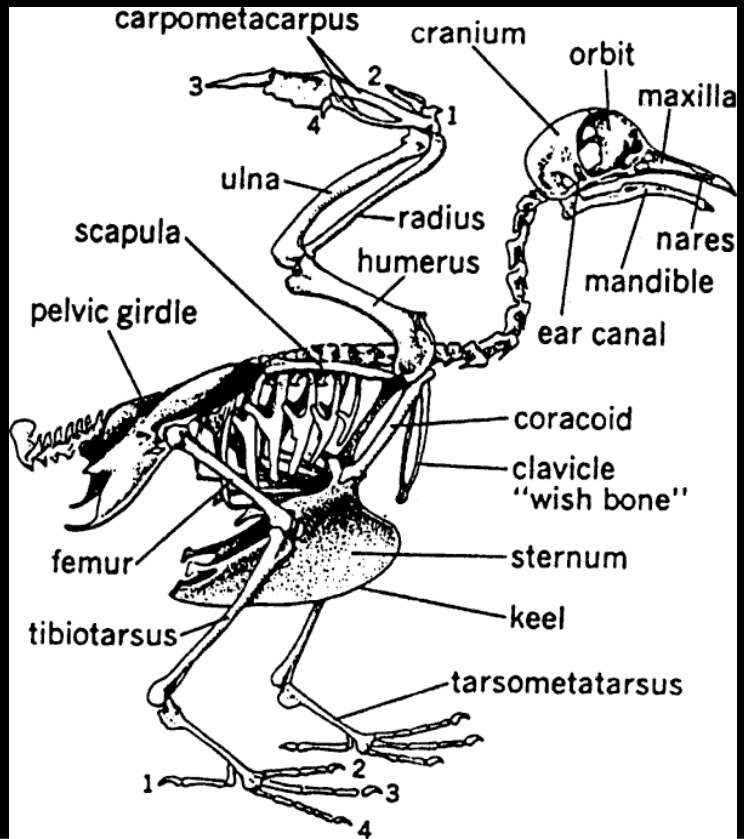






MISSING LINKS

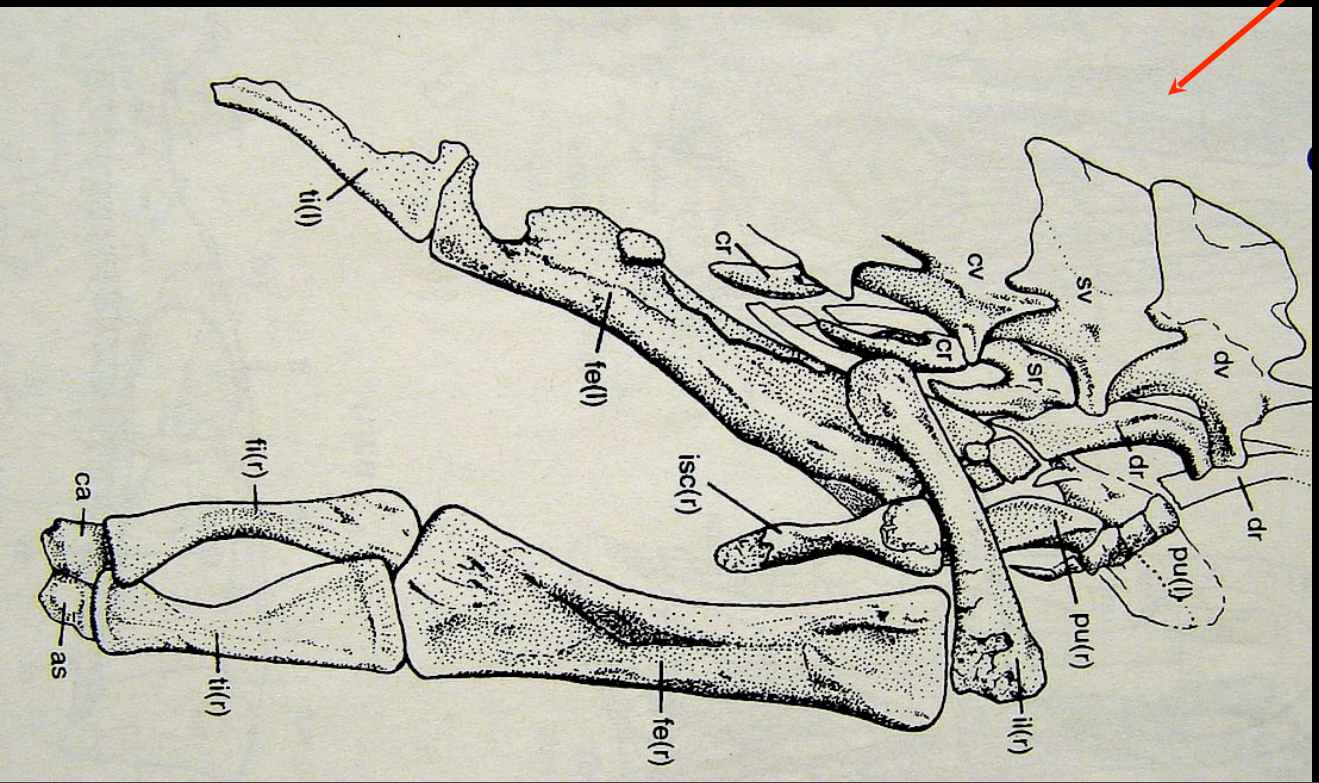
" Snakes

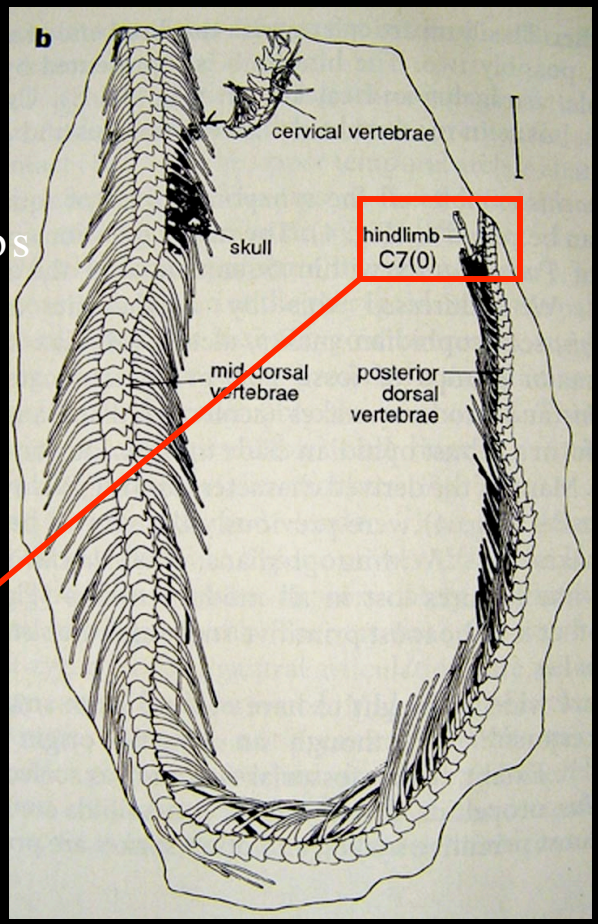
" Snakes are an extremely specialized group of vertebrates.
" They have many adaptations for being limbless predators.
" Very elongate necks and bodies.
" Highly developed sense of smell which involves the tongue.
" Snakes share a common ancestor with monitor lizards.
" A lot of snake- like behavior and anatomy exists in living monitors lizards.
  " Long necks and bodies
  " Active foragers using tongue to gain olfactory information about their environment.
  " Specialized teeth and tongue

MISSING LINKS

" Snakes

" 60 myo fossil snakes from Algeria with small hind limbs and a pelvic girdle.

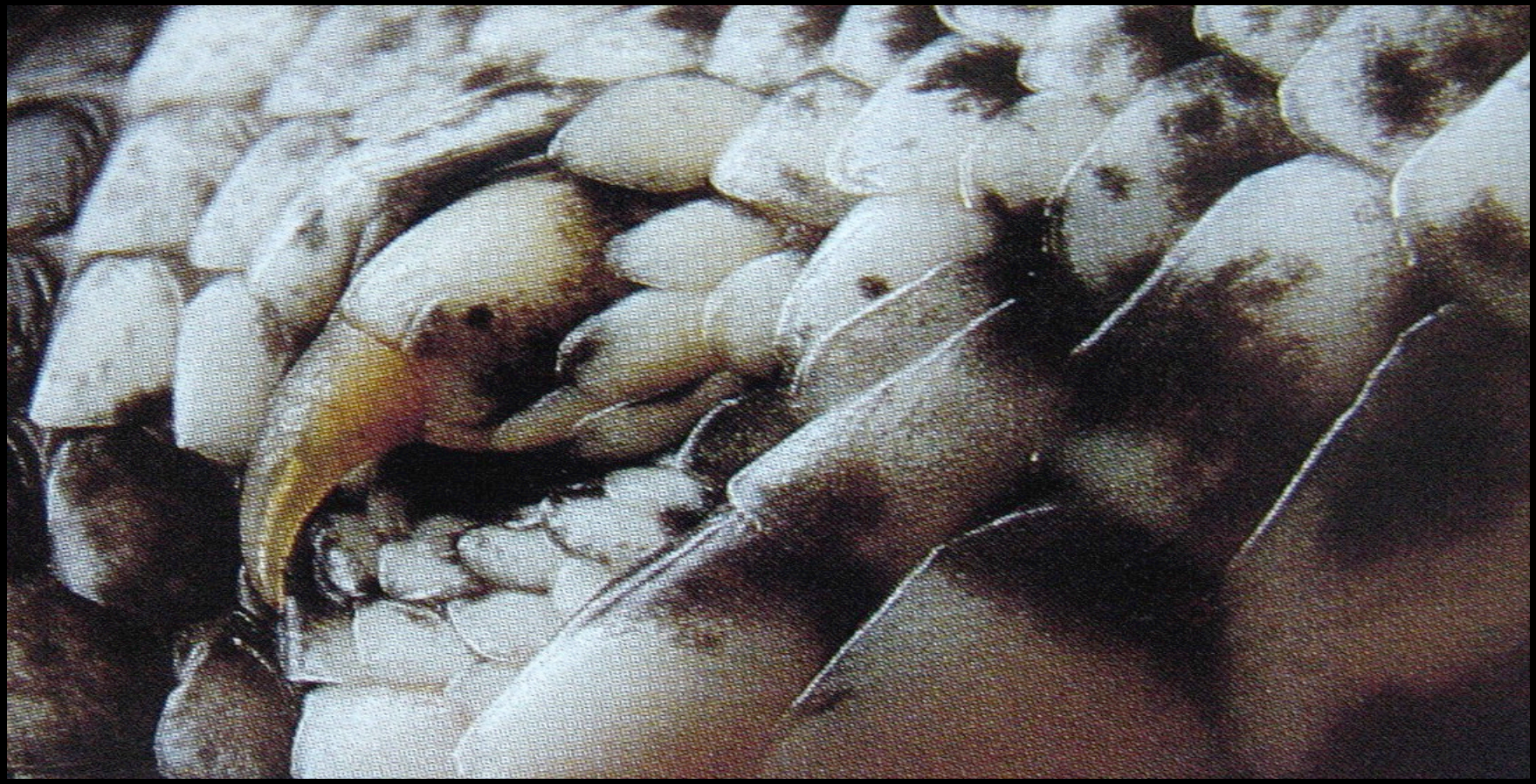




MISSING LINKS

" Snakes

" Primitive snakes such as boas and pythons still have vestigial hind limbs and pelvic girdles but lack all traces of forelimbs and pectoral girdles



MISSING LINKS

" Snakes

Modern snakes lack all traces of limbs.

MISSING LINKS

" Frogs

" Frogs are an extremely specialized group of vertebrates whose anatomical and behavioral adaptations revolve around a lifestyle of hopping.

" Frog skeletons are some of the most derived systems known to vertebrates.

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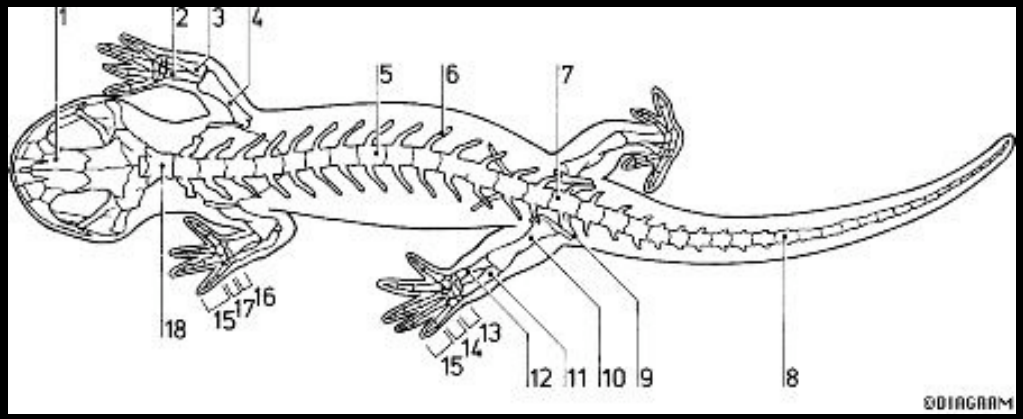
" Frogs

" Frogs are an extremely specialized group of vertebrates whose anatomical and behavioral adaptations revolve around a lifestyle of hopping.
" Frog skeletons are some of the most derived systems known to vertebrates.

" Primitive amphibian body plan.
" Lacks specializations



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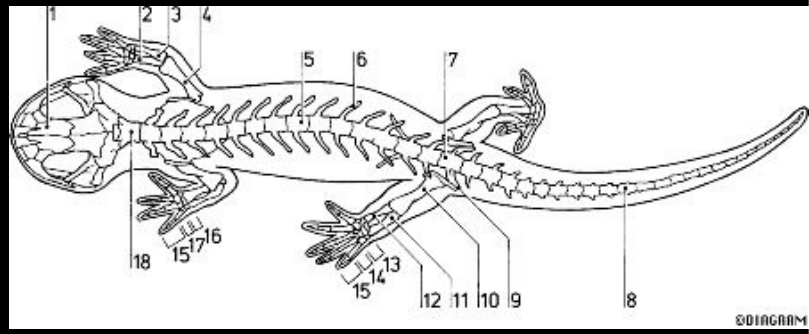
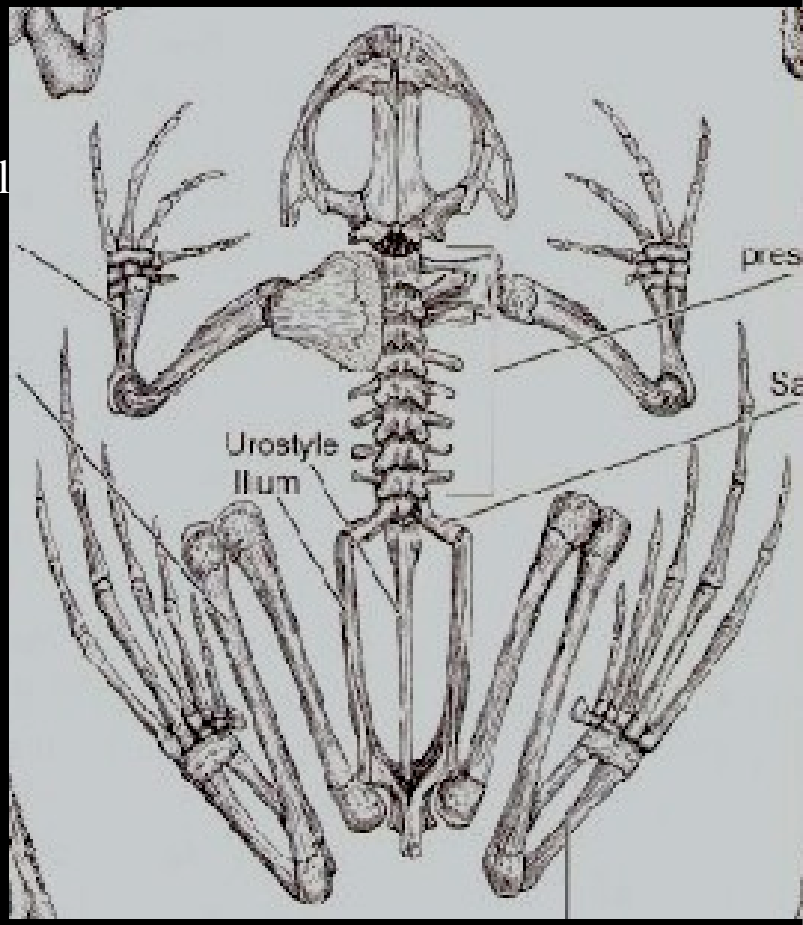


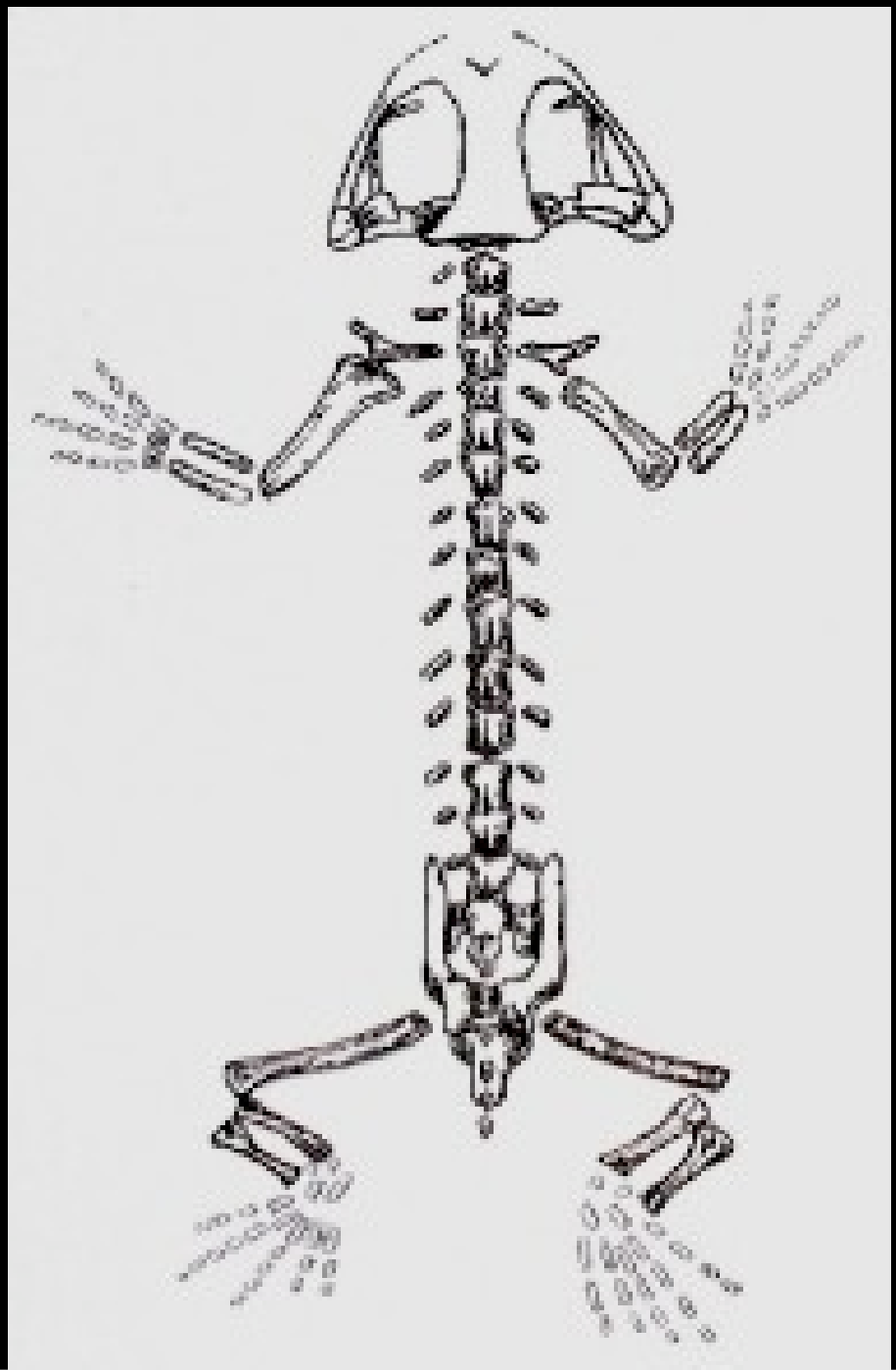
" Frogs have highly modified skeletons
  " Shortened vertebral column
  " Fused forearm and foreleg bones
  " Internal tail
  " Elongated pelvis
  " Elongated ankle bones adding an additional linkage component to the hind limb



MISSING LINKS

- Frogs

- *Triadobatrachus:* 225 myo proto-frog
  - Slightly shortened vertebral column
  - Forearm and foreleg bones not fused
  - No internal tail
  - Slightly elongated pelvis
  - No elongated ankle bones



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