

evolution

*a journey into where we're from  
and where we're going*

# Evidence of Evolution by Natural Selection





**Evolution is "so overwhelmingly established that it has become irrational to call it a theory."**

**-- Ernst Mayr  
What Evolution Is**

**2001**

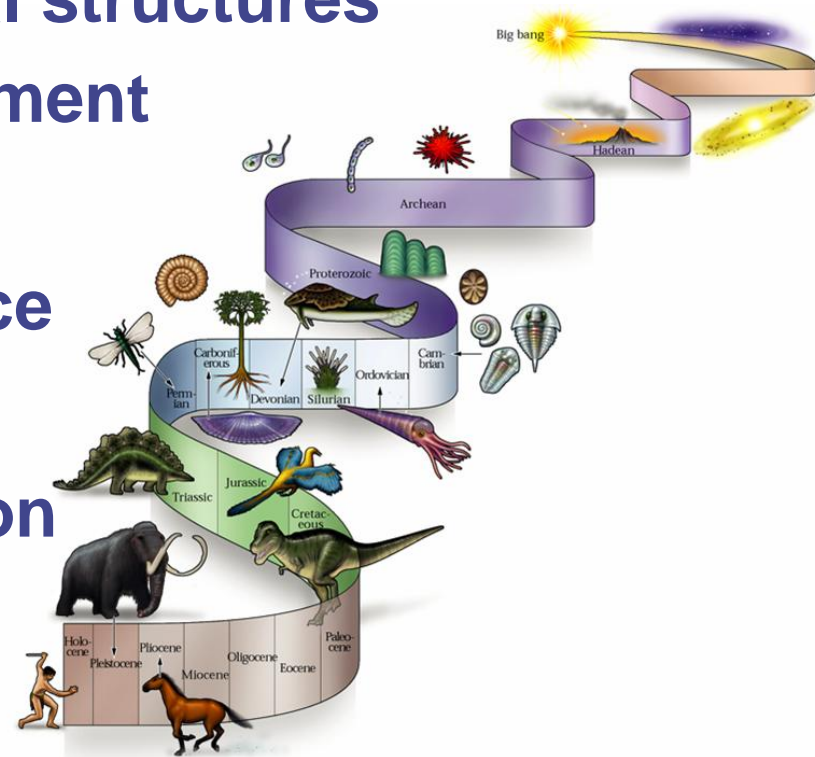
**Professor Emeritus, Evolutionary Biology  
Harvard University  
(1904-2005)**

**2007-2008**



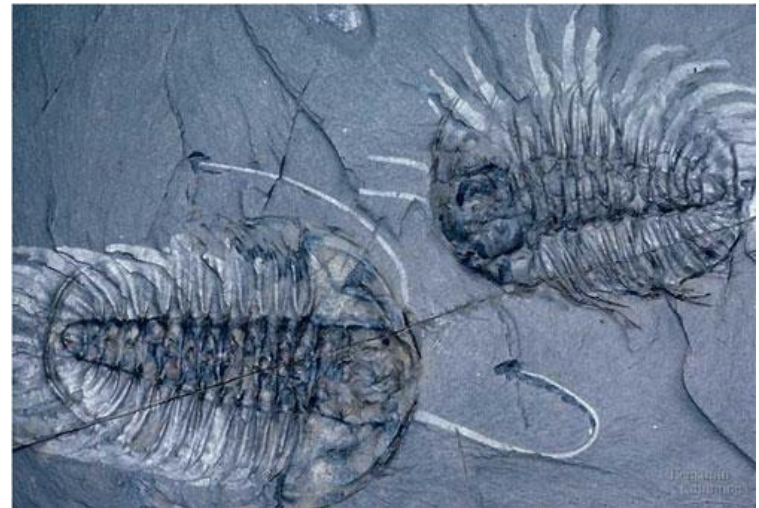
# Evidence supporting evolution

- **Fossil record**
  - ◆ transition species
- **Anatomical record**
  - ◆ homologous & vestigial structures
  - ◆ embryology & development
- **Molecular record**
  - ◆ protein & DNA sequence
- **Artificial selection**
  - ◆ human-caused evolution



# Fossil record

- **Layers of sedimentary rock contain fossils**
  - ◆ new layers cover older ones, creating a record over time
  - ◆ fossils within layers show that a succession of organisms have populated Earth throughout a long period of time

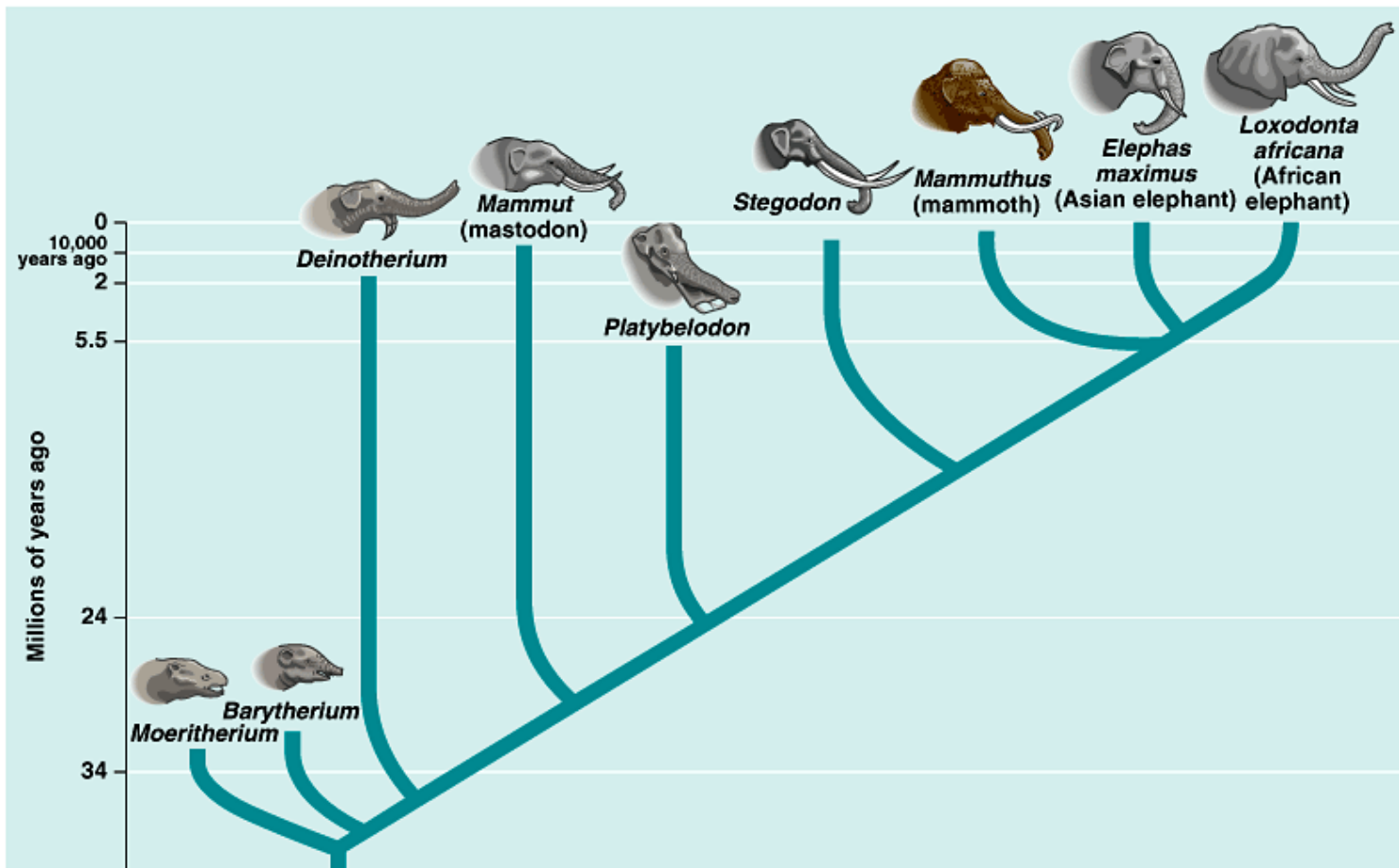


# Fossil Record

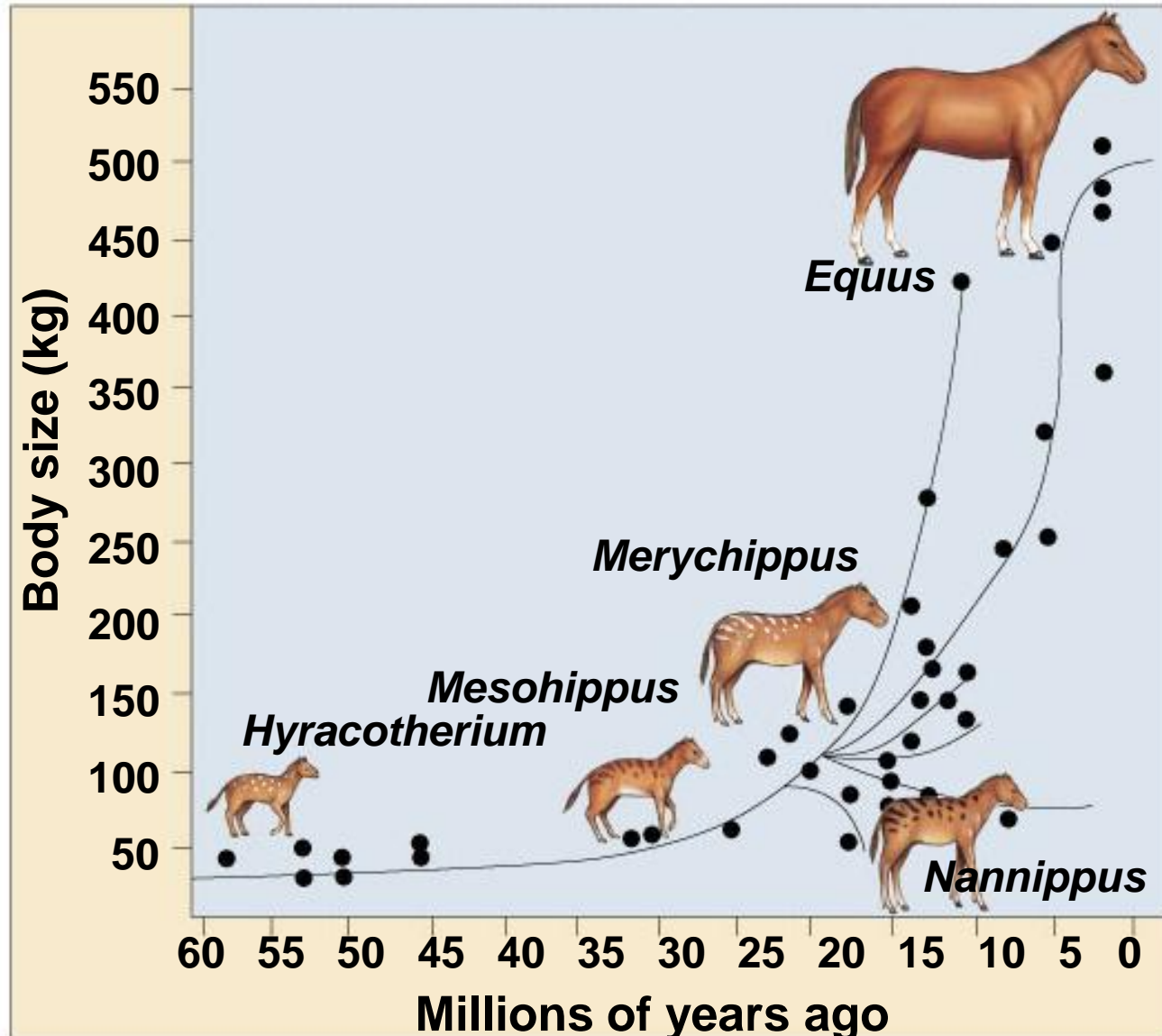


# Fossil record

- A record showing us that today's organisms descended from ancestral species



# Evolutionary change in horses



# Evolution of birds

## ■ *Archaeopteryx*

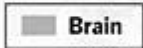
- ◆ lived about 150 mya
- ◆ links reptiles & birds



### Theory takes flight

A computer analysis of skull specimens from the bird-like dinosaur archaeopteryx indicates the creature was a skillful flier, according to a study in the journal Nature.

Wingspan: **19.6 inches**  
Weight: **12 ounces**



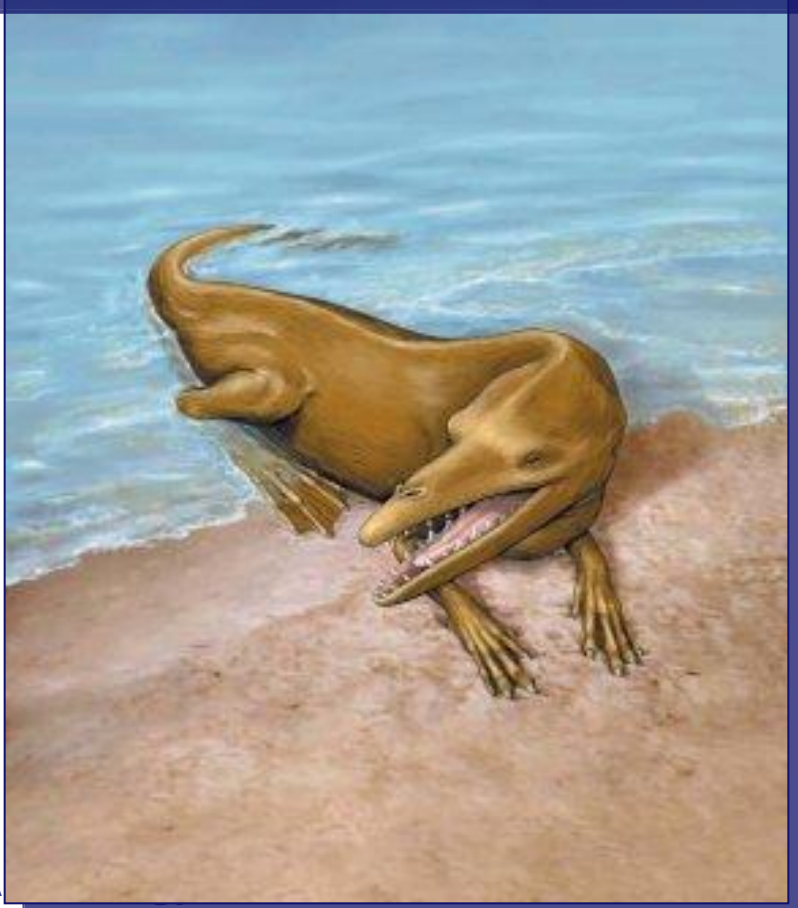
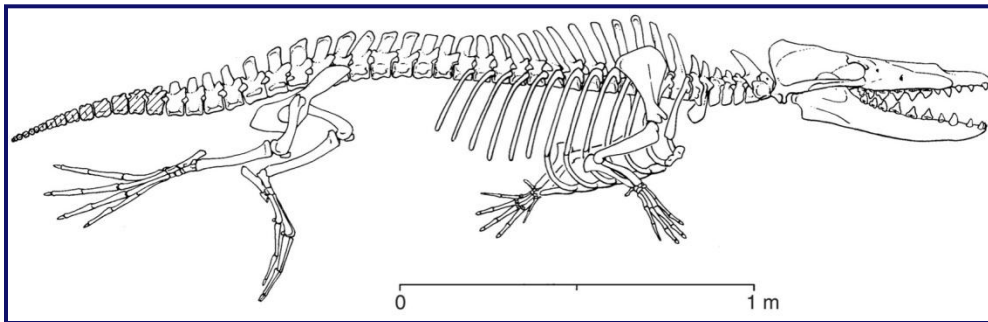
Modern flying bird

archaeopteryx



► The scientists point to similarities in the brain lobes responsible for vision, balance and flight coordination.



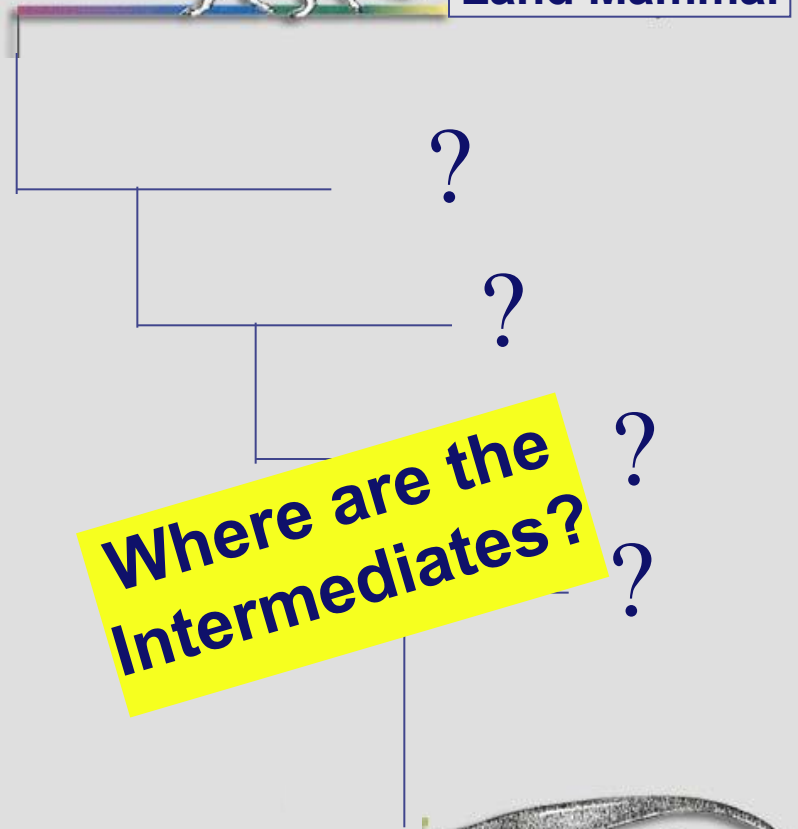


A

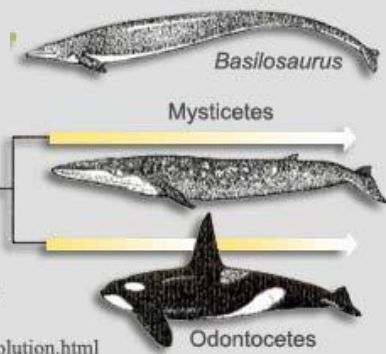
65 60 55 50 45 40 35 30 million years ago



Land Mammal



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*Evolution: The Triumph of an Idea*,  
 by Carl Zimmer.  
 New York: Harper Collins Publishers, 2001.  
 Source: Art by Deborah Perugi,  
 adapted from Carl Buell's  
 cladogram from *At the Water's Edge*,  
 by Carl Zimmer, Free Press, 1998.  
 file source:  
*Cetacean Evolution (Whales, Porpoises, Dolphins)*  
 by Edward T. Babinski  
[http://www.edwardtbabinski.us/babinski/whale\\_evolution.html](http://www.edwardtbabinski.us/babinski/whale_evolution.html)



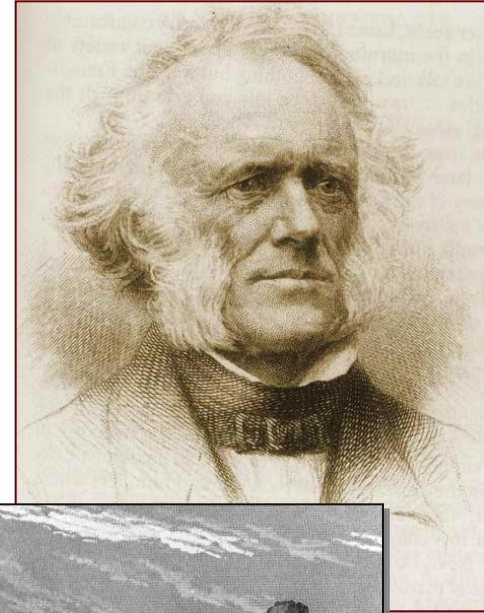
# 2006 Fossil Discovery of Early Tetrapod

- Missing link from sea to land animals



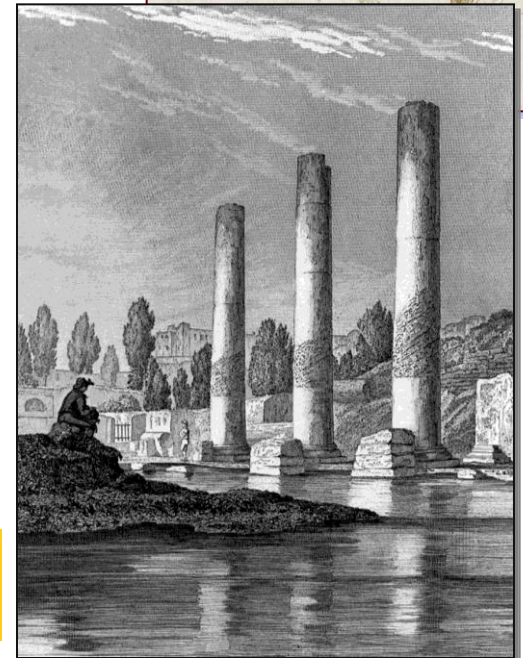
# Geologist give us time for evolution

- Charles Lyell (1797-1875)
  - ◆ studied the Temple of Scrapis (Sicily)
  - ◆ built on land & used until 200 AD
  - ◆ high tide now above temple floor
  - ◆ erosion in columns well above high tide



## Meaning:

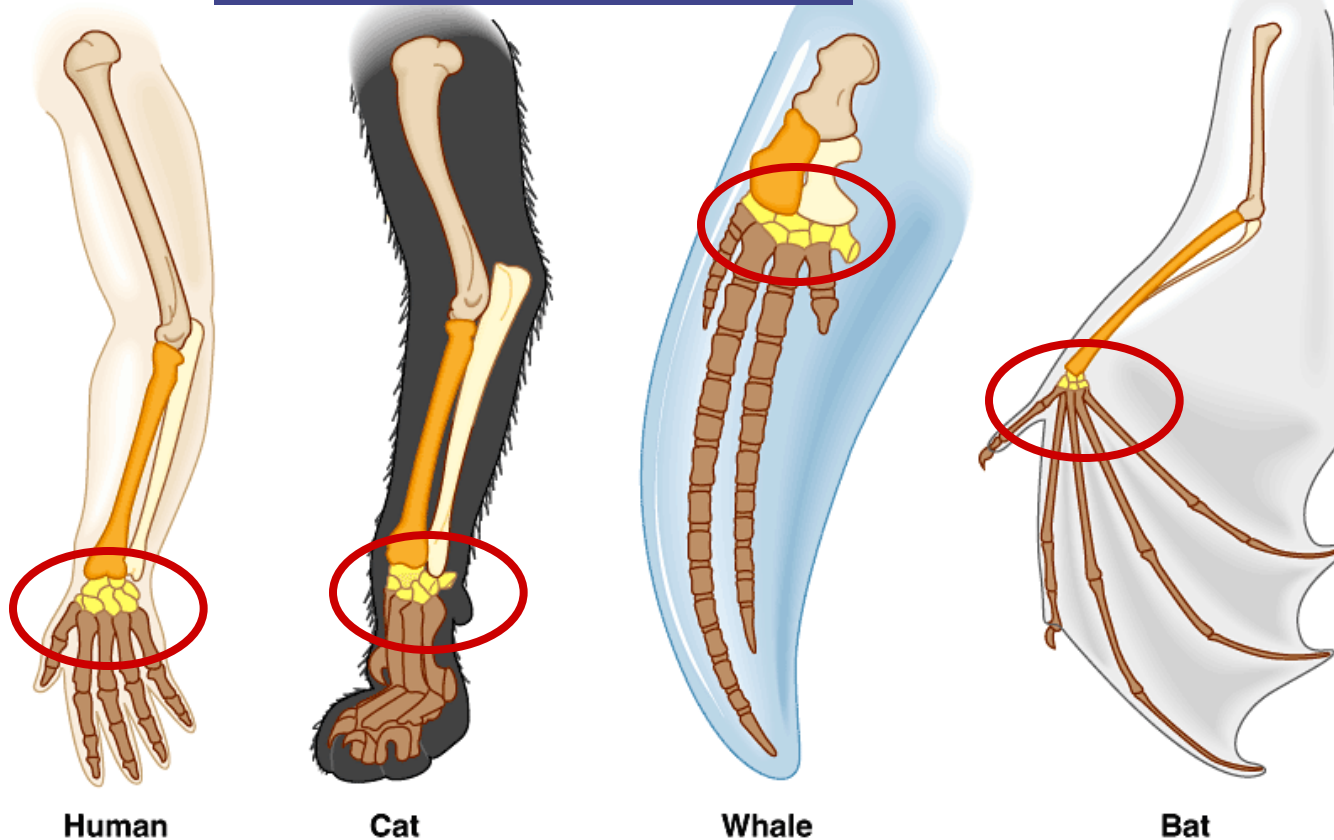
In less than 2000 years, temple sunk well below sea level, and then was raised up again — natural processes and immense periods of time could produce great changes.



**“the present is the key to the past”**

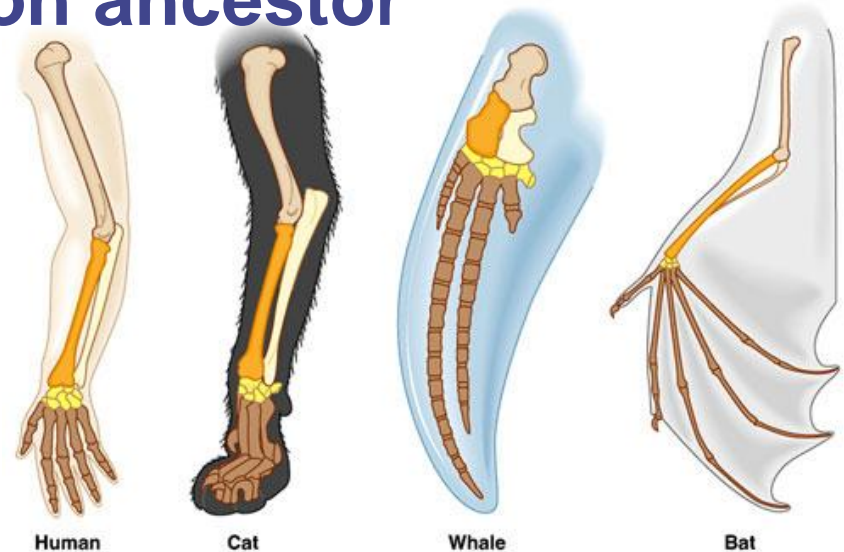
# Anatomical record

- **Homologous structures**
  - ◆ similarities in characteristics resulting from common ancestry



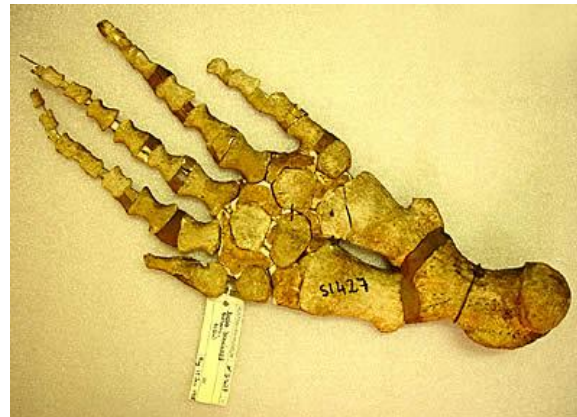
# Homologous structures

- Forelimbs of human, cats, whales, & bats share same skeletal structures
  - ◆ similar structure
  - ◆ similar embryological development
  - ◆ different functions
  - ◆ evidence of common ancestor
    - branched off from common 4-limbed ancestor



# Homologous structures

- Similar structure
- Similar development
- Different functions
- Evidence of close evolutionary relationship
  - ◆ recent common ancestor

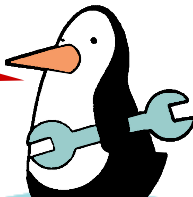


# Analogous structures

- **Separate evolution of structures**
  - ◆ similar functions
  - ◆ similar external form
  - ◆ different internal structure & development
  - ◆ different origin
  - ◆ **no evolutionary relationship**



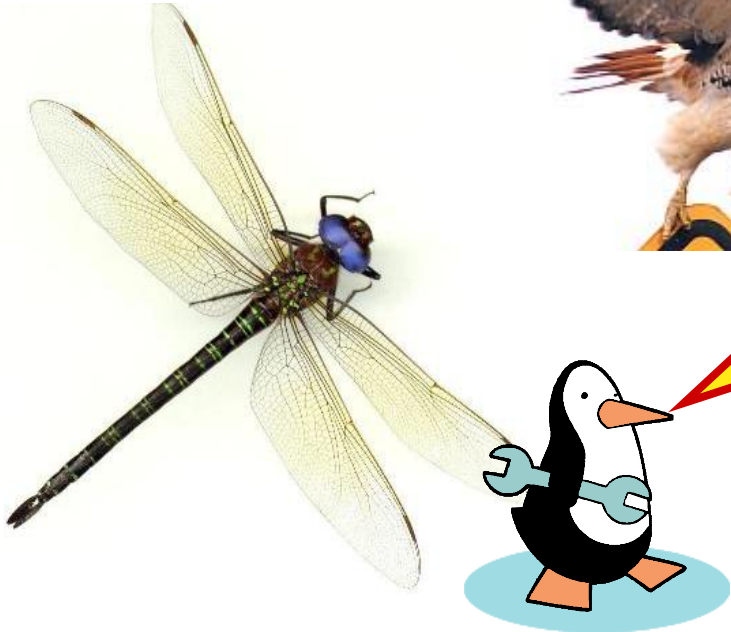
Don't be fooled  
by their looks!



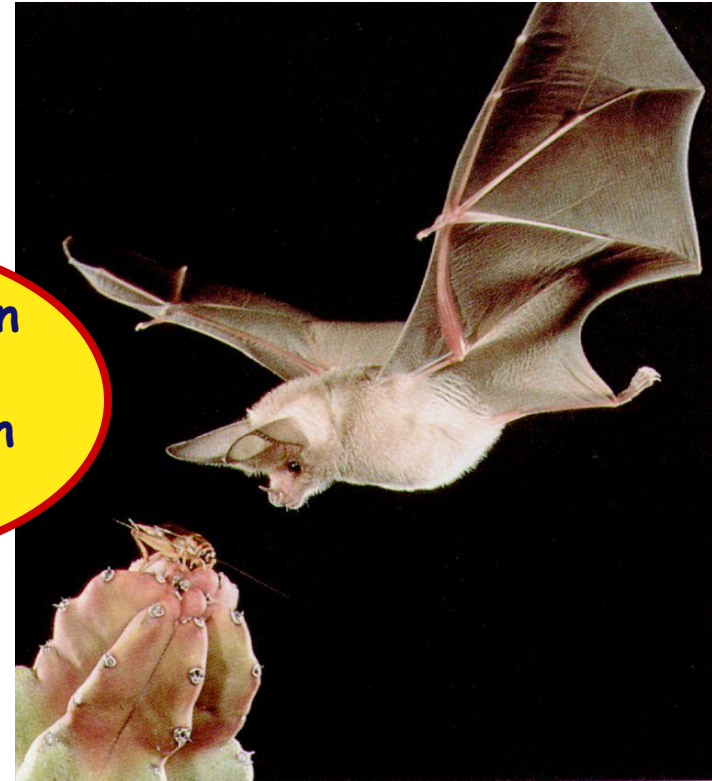
**Solving a similar problem with a similar solution**

# Convergent evolution

- Flight evolved in 3 separate animal groups
  - evolved similar “solution” to similar “problems”
  - analogous structures



Does this mean they have a recent common ancestor?

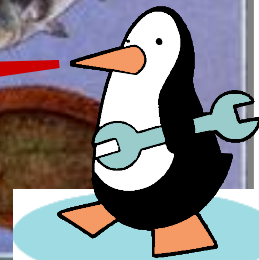


# Convergent evolution

- Fish: aquatic vertebrates
- Dolphins: aquatic mammals
  - ◆ similar adaptations to life in the sea
  - ◆ not closely related



Those fins & tails  
& sleek bodies are  
analogous structures!





# Parallel Evolution

- Parallel, but separate, evolutionary paths
  - ◆ filling similar ecological roles in similar environments, so similar adaptations were selected
  - ◆ but are not closely related

**marsupial mammals**



Sugar glider

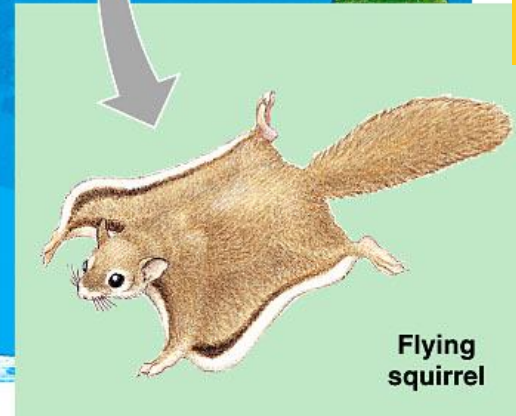


NORTH AMERICA

**placental mammals**

















AUSTRALIA



Flying squirrel

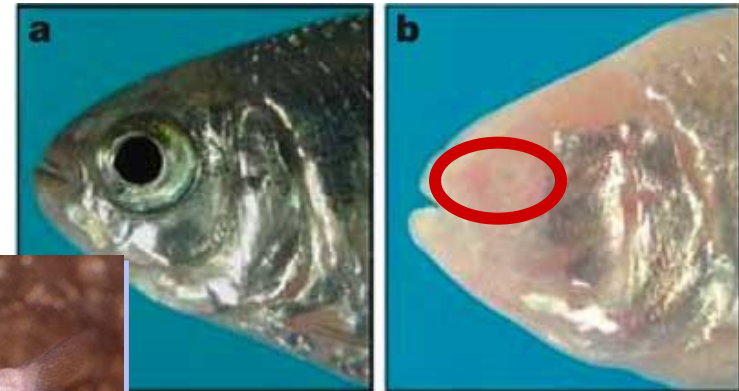


# Parallel Evolution

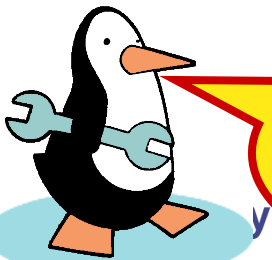
Niche	Placental Mammals	Australian Marsupials
Burrower	 Mole	 Marsupial mole
Anteater	 Anteater	 Numbat
Nocturnal insectivore	 Mouse	 Marsupial mouse
Climber	 Lemur	 Spotted cuscus
Glider	 Flying squirrel	 Sugar glider
Stalking predator	 Ocelot	 Tasmanian cat
Chasing predator	 Wolf	 Tasmanian "wolf"

# Vestigial organs

- Modern animals may have structures that serve little or no function
  - ◆ remnants of structures that were functional in ancestral species
  - ◆ evidence of change over time
    - some snakes & whales show remains of the pelvis & leg bones of walking ancestors
    - eyes on blind cave fish
    - human tail bone

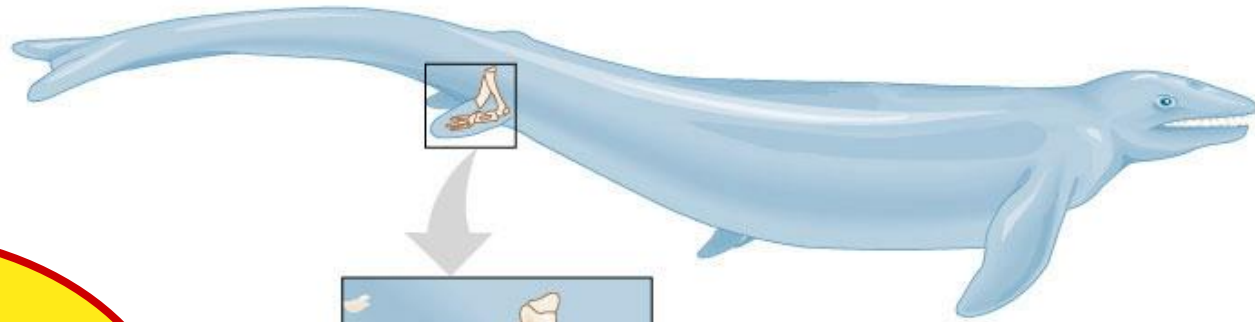


This is not LaMarck's loss from "disuse"!

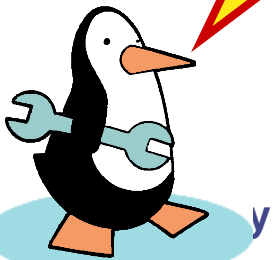


# Vestigial organs

- Hind leg bones on whale fossils

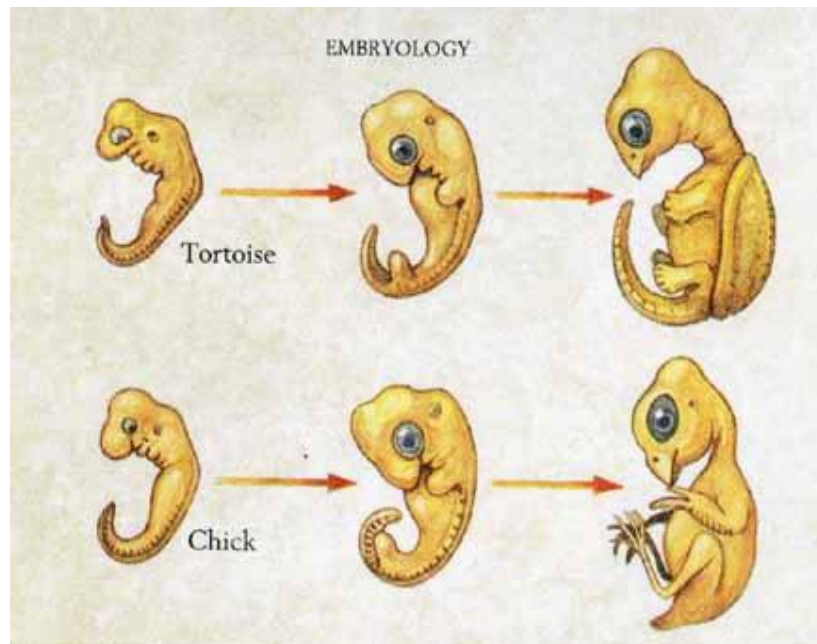


Why would whales have pelvis & leg bones if they were always sea creatures?

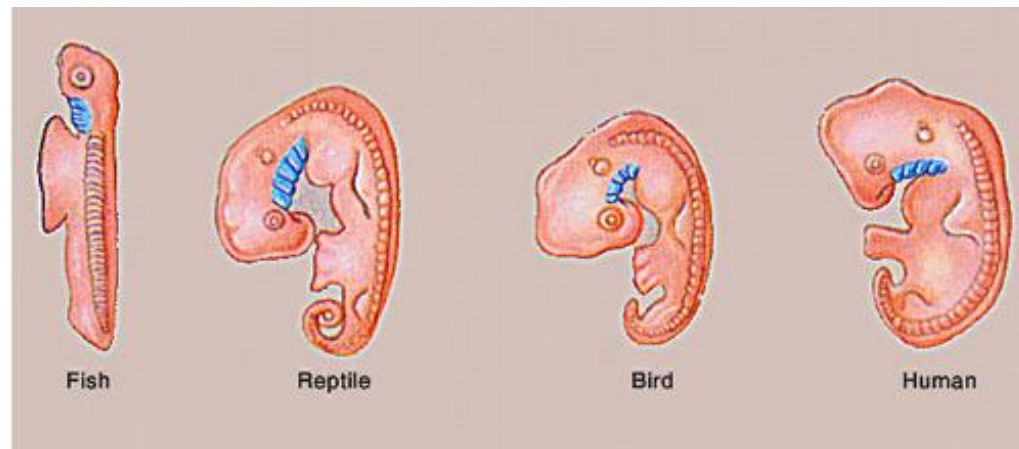


# Comparative embryology

- **Similar embryological development in closely related species**
  - ◆ all vertebrate embryos have similar structures at different stages of development



h, frog, snake, birds, human, etc.



# Molecular record

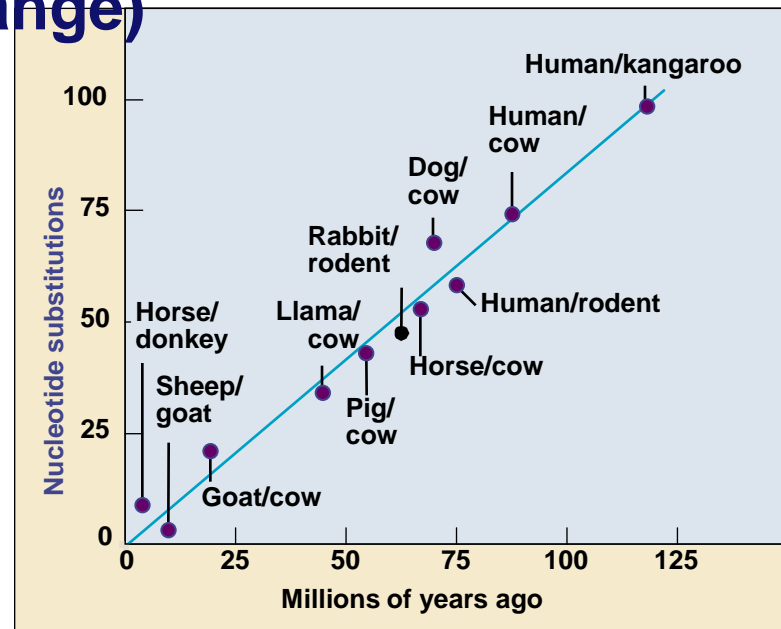
- **Comparing DNA & protein structure**
  - ◆ universal genetic code!
    - DNA & RNA
  - ◆ compare common genes
    - cytochrome C (respiration)
    - hemoglobin (gas exchange)



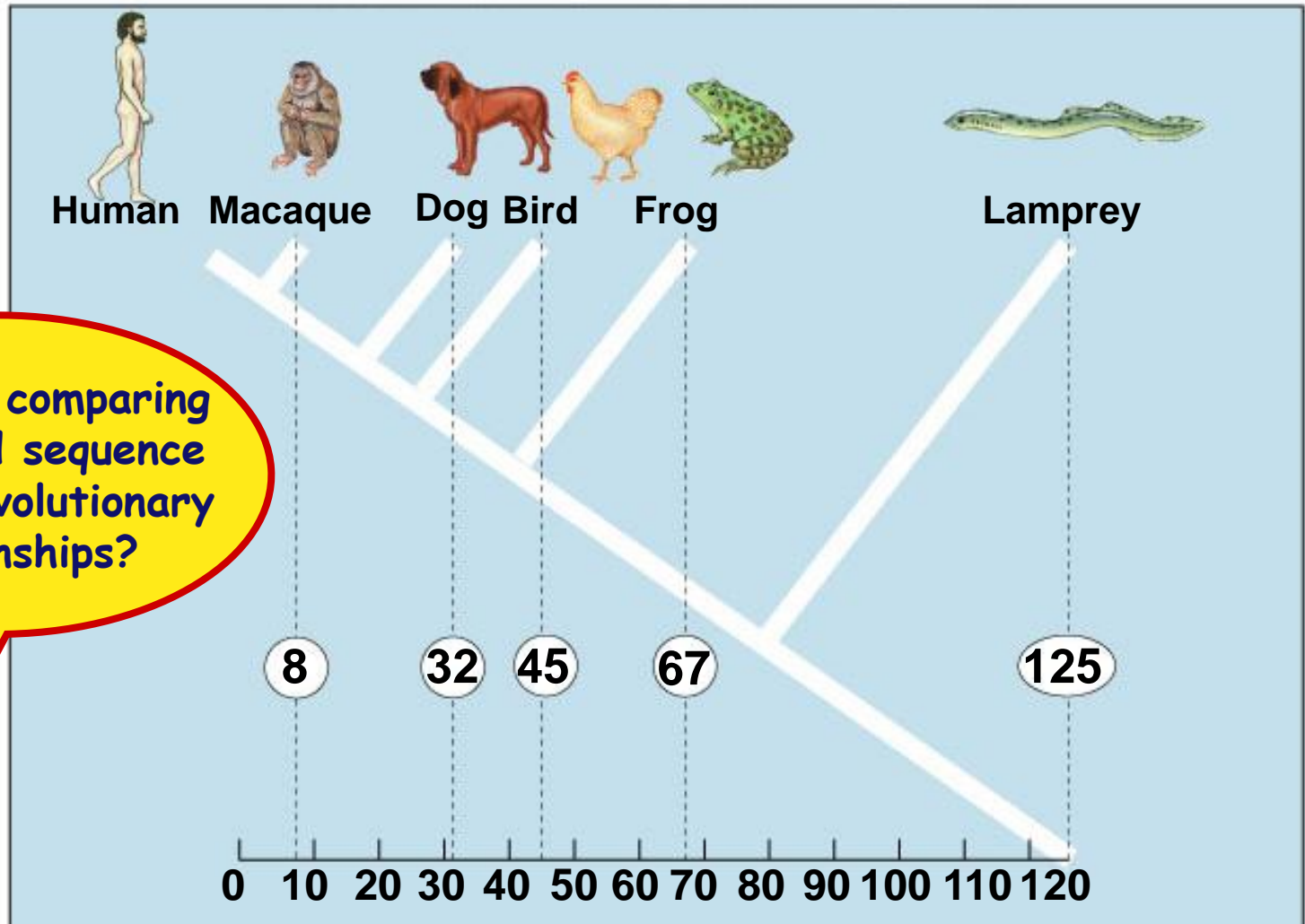
Why compare these genes?

Closely related species have sequences that are more similar than distantly related species

- DNA & proteins are a molecular record of evolutionary relationships

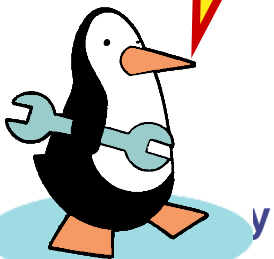


# Comparative hemoglobin structure



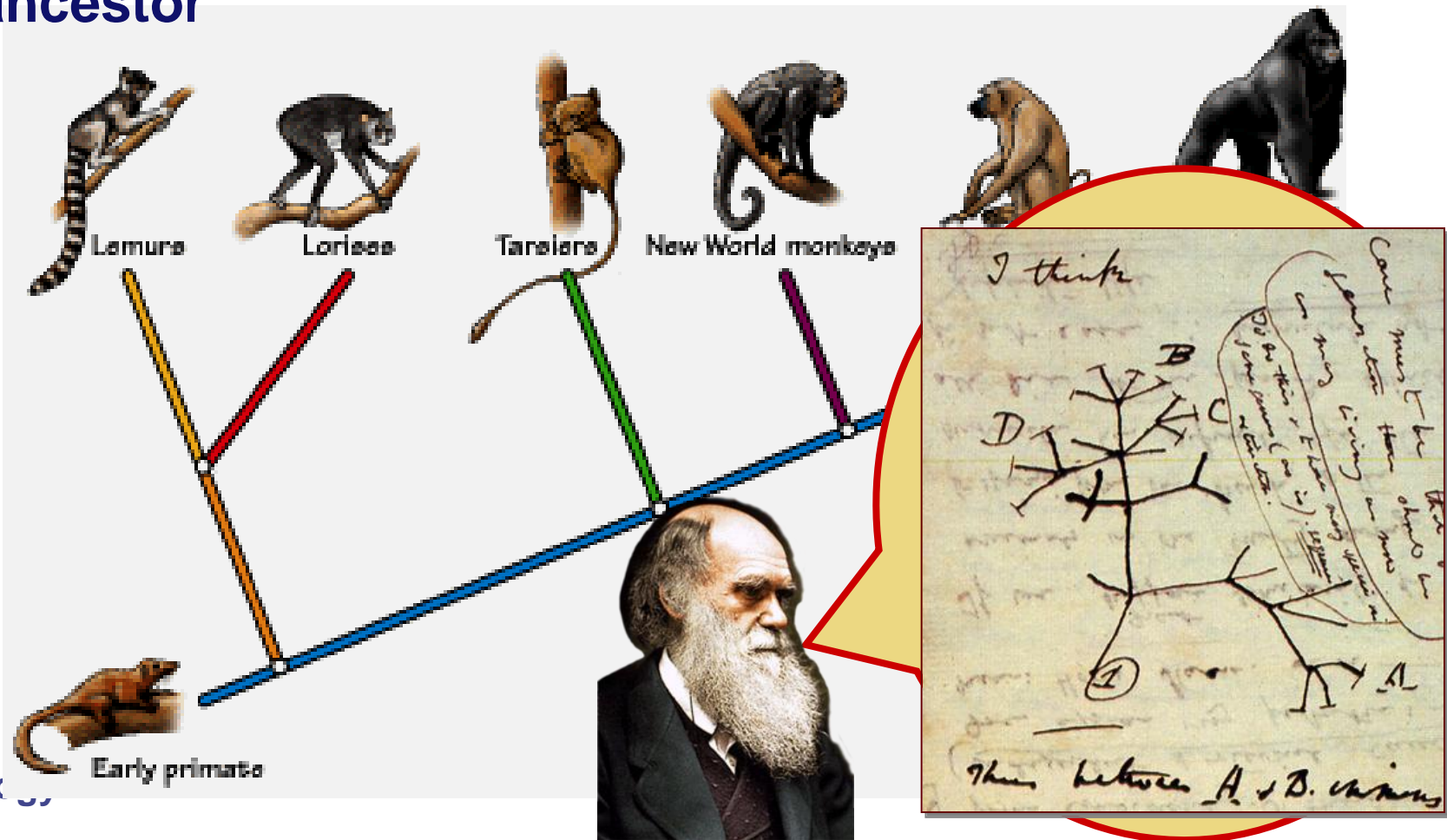
Why does comparing amino acid sequence measure evolutionary relationships?

Number of amino acid differences between hemoglobin (146 aa) of vertebrate species and that of humans



# Building “family” trees

Closely related species (branches) share same line of descent until their divergence from a common ancestor



# Artificial selection

- Artificial breeding can use variations in populations to create vastly different “breeds” & “varieties”



**“descendants” of wild mustard**

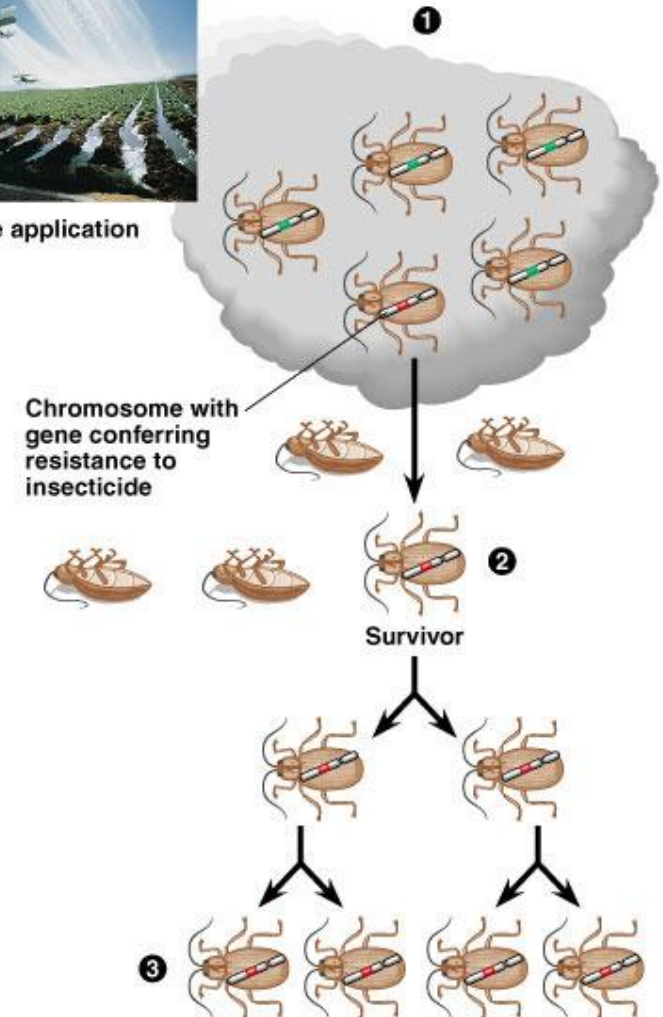
**“descendants” of the wolf**

# Natural selection in action

- Insecticide & drug resistance
  - ◆ insecticide didn't kill all individuals
  - ◆ resistant survivors reproduce
  - ◆ resistance is inherited
  - ◆ insecticide becomes less & less effective



Insecticide application



**Any Questions??**

