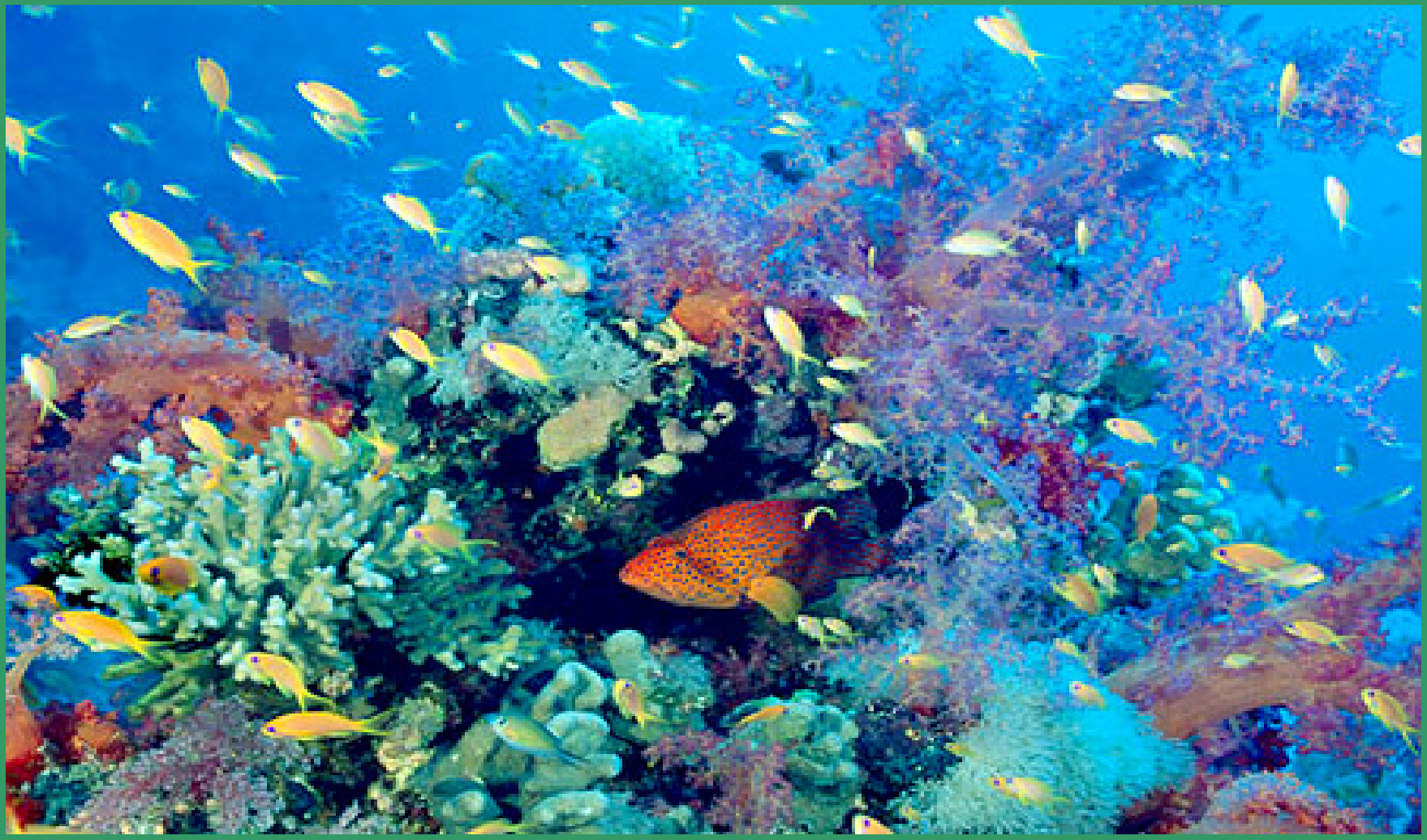
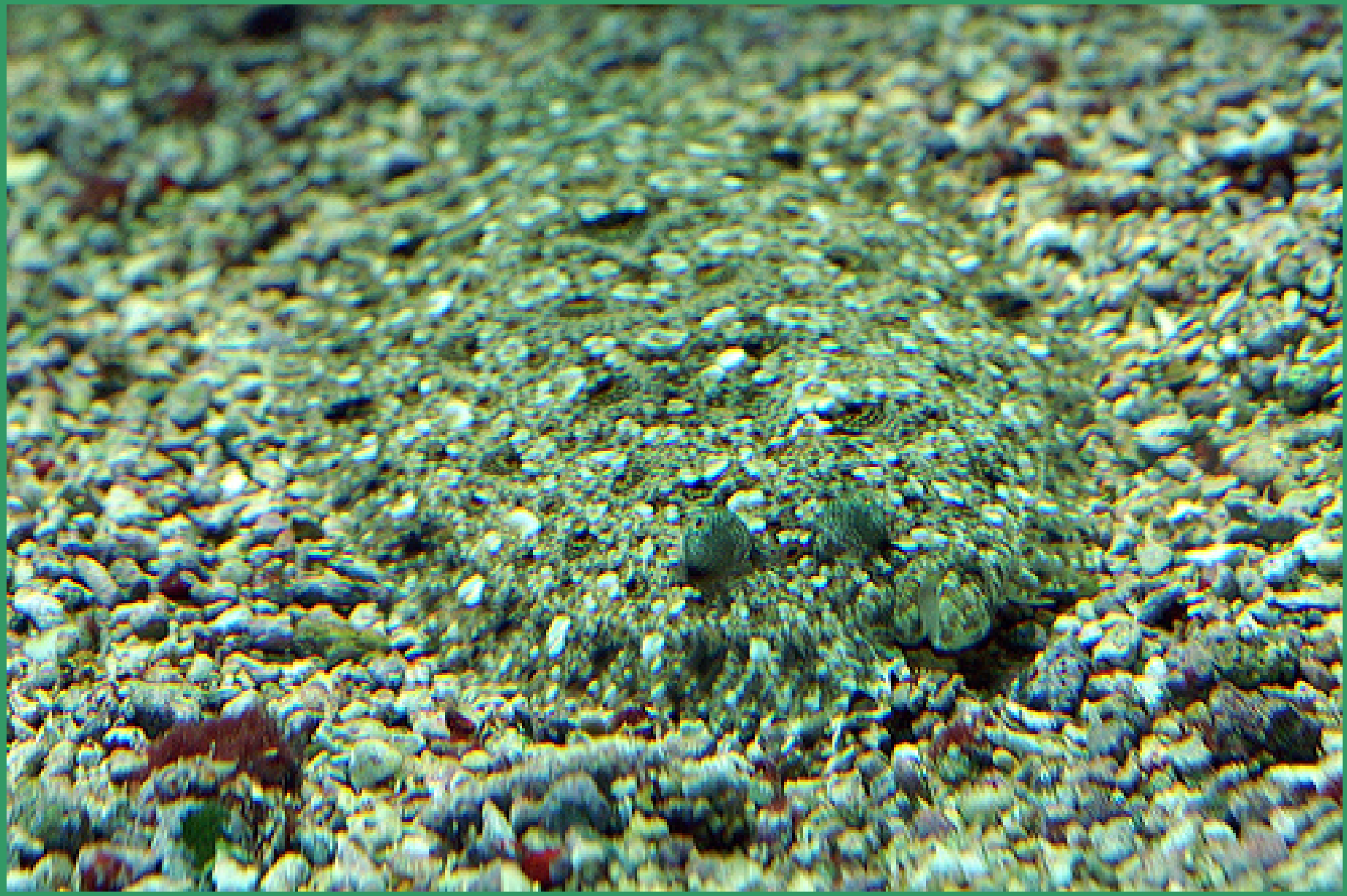
Evolution

The Unifying Theory



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What is a “Science”?

- Must be observable ~ “Empirical”
- Must have hard data ~ “Scientific Method”
- Must be supported by mathematical rationale
- Must start as a hypothesis ~ “A Prediction”
- Must be subject to “peer review”

A clarification on this Evolution discussion

What it is:

- A theory
- Testable
- Based on direct evidence
  - Fossils
  - Real-Time Living Organisms

What it isn't:

- A hypothesis or a law
- A discussion about the existence of a God
- A prediction of how life came into being on this planet
- Based on the writings of the Bible

What is a “theory”?

“It’s just a theory, right? It is not testable, it’s just a thought experiment. This can’t possibly be proven correct, can it?”

A definition of a theory:

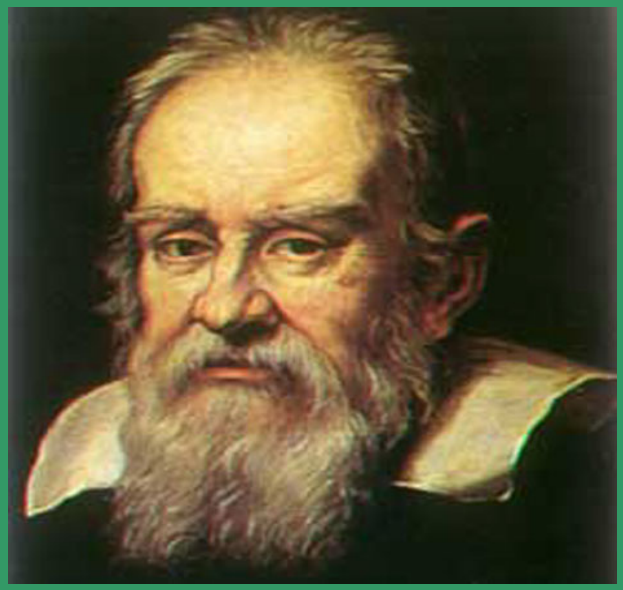
- An explanation or model based on observation, experimentation and reasoning…especially one that has been *tested and confirmed* as a general principle to help explain and predict a natural phenomena.

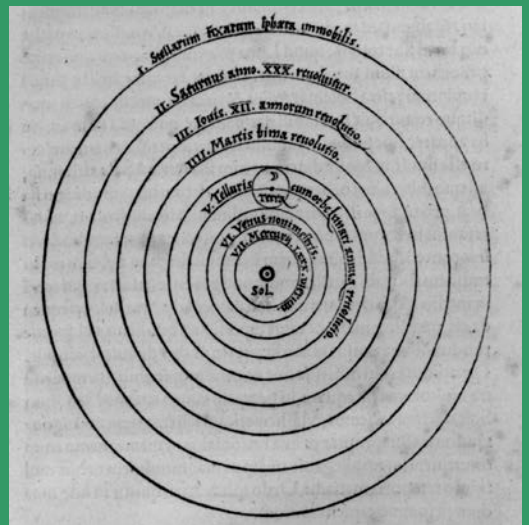
- The best we've got in science *at this time!*

Currently held theories in Science:

- Atomic
- Nuclear
- Gravitational
- Cell
- Germ
- Plate Tectonics
- Global Climate Change

Keep this in mind…are all new ideas readily accepted?



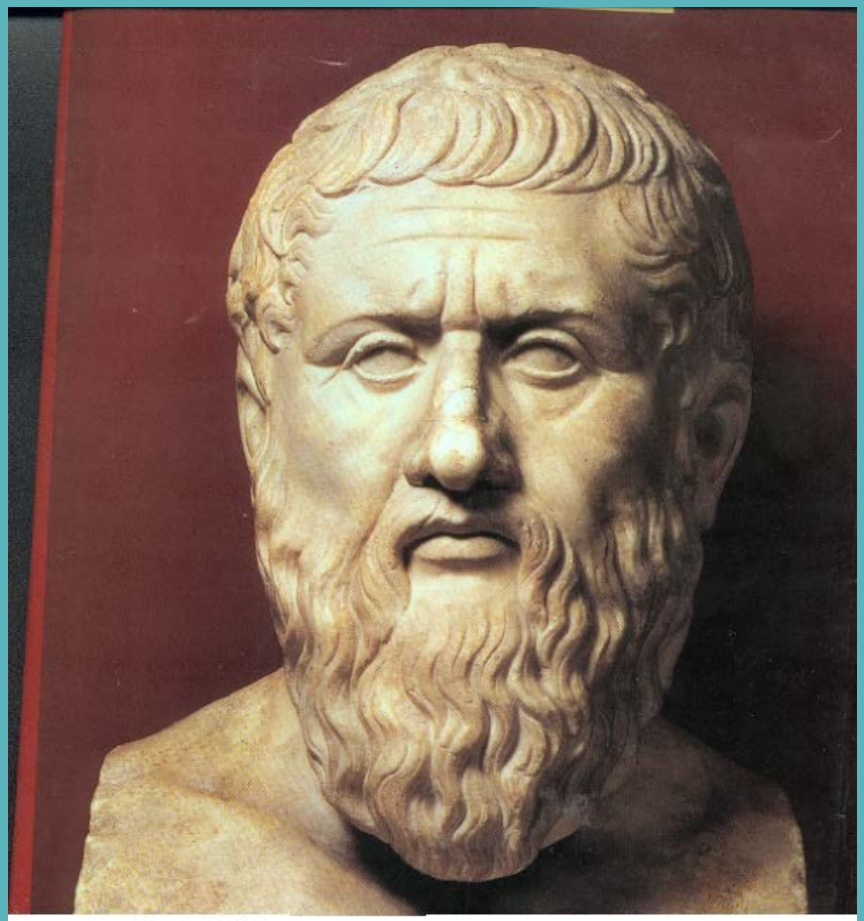


Evolution

A working definition:

- A progressive change of organisms over time.

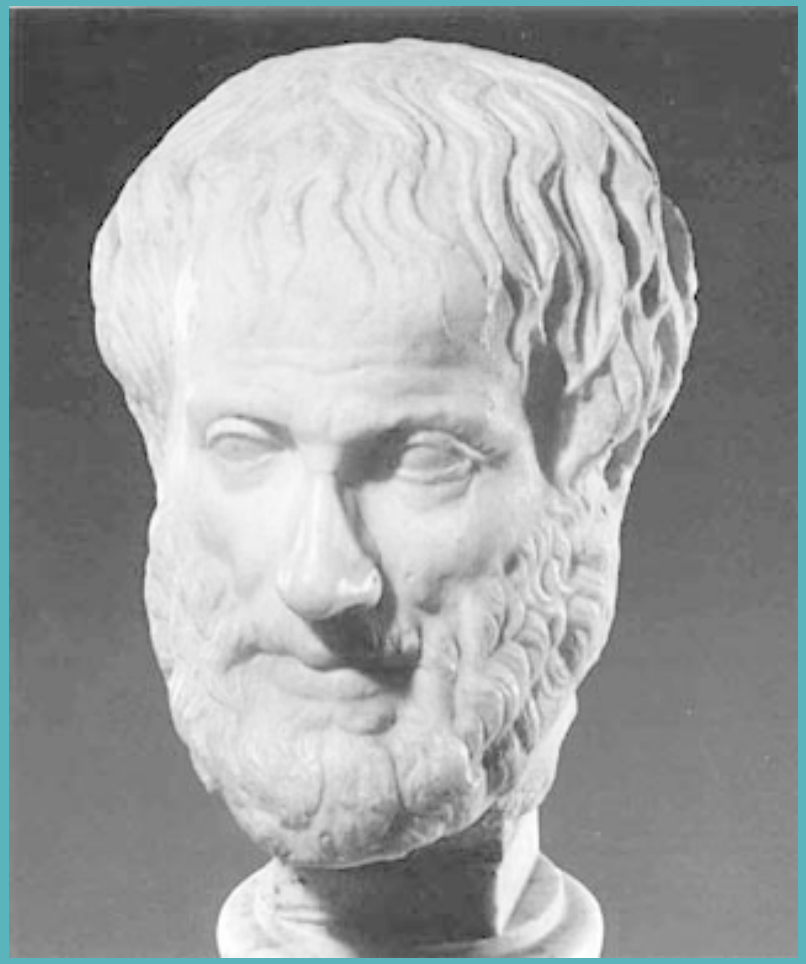
Darwin wasn't the first to consider the idea of evolution…



Bust of Plato

- Plato, Greek Philosopher (427-347 BC)
- Theory of Forms
- Two worlds: Perfect world of Forms and Imperfect World we experience
- Variation was considered "Imperfect"

Aristotle, Greek Philosopher (384-322 BC)

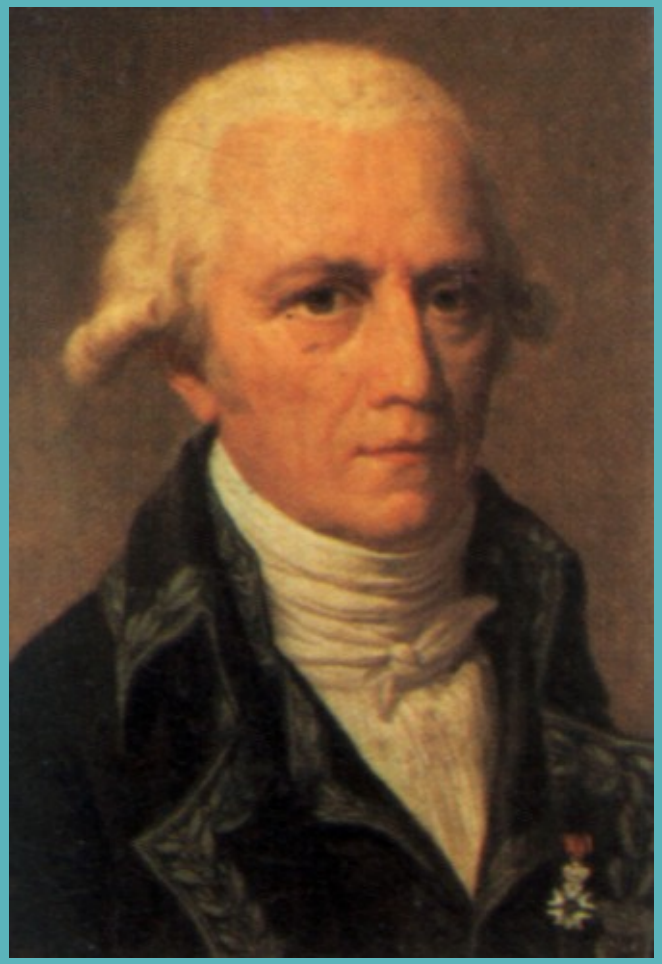


- Theory of Types
- Species reflect existence of unchanging, ideal form, the ***"universal"***
- Variation represents an imperfect organism

Geoffroy Saint-Hillaire (1772-1844)

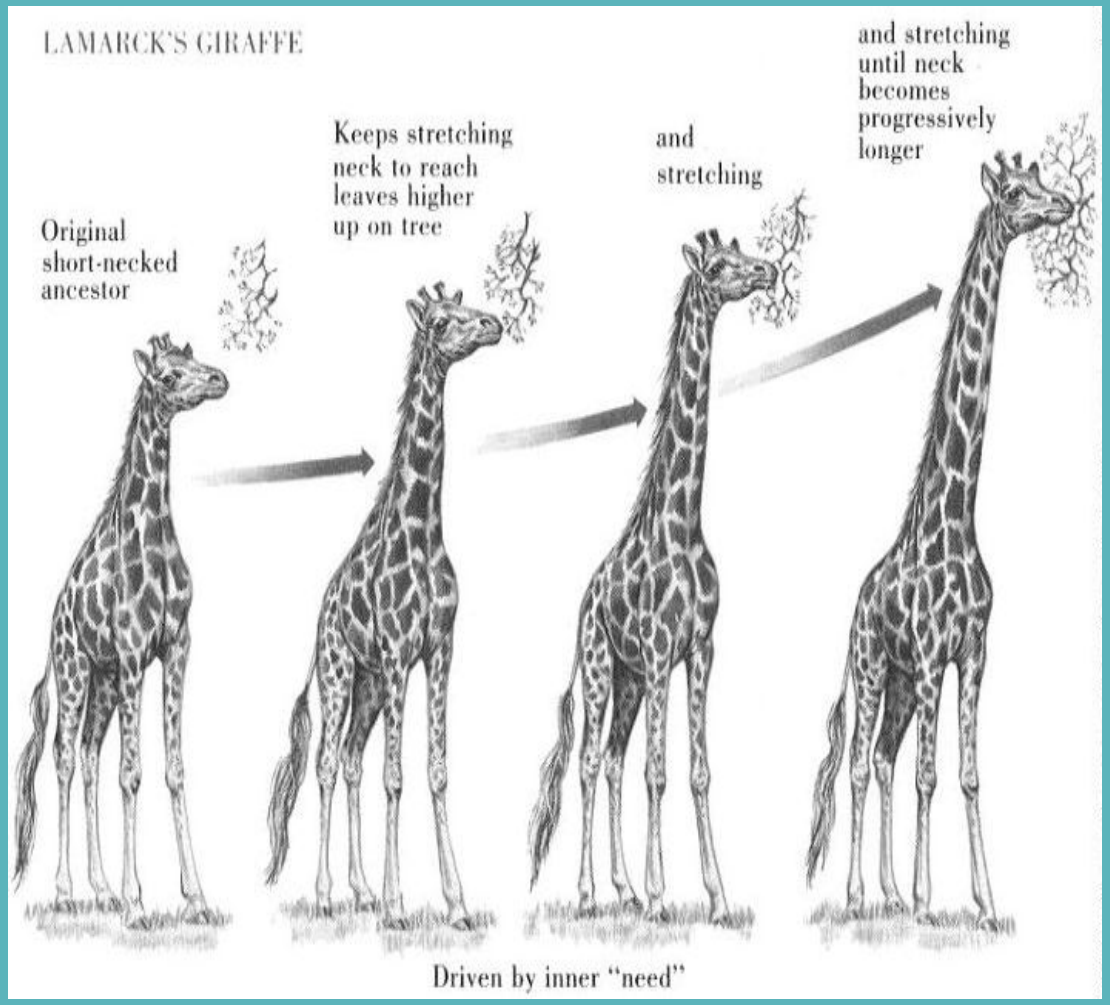
- All adaptations are directly induced by environment and passed on to offspring

Jean Baptiste de Lamarck (1744-1829)



- 1809: His *Philosophie Zoologique* presented theory of evolution
- Species progressed up escalator from spontaneous generation to pinnacle with man at top

Lamarck's Key Idea



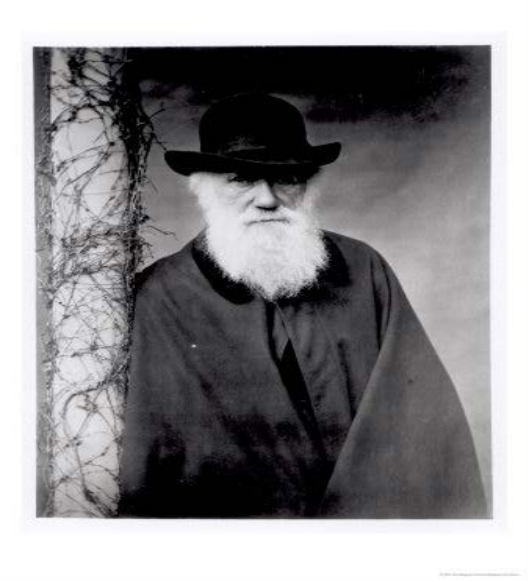
- Adaptations originated through the use of an organ
- Acquired traits were passed on to offspring

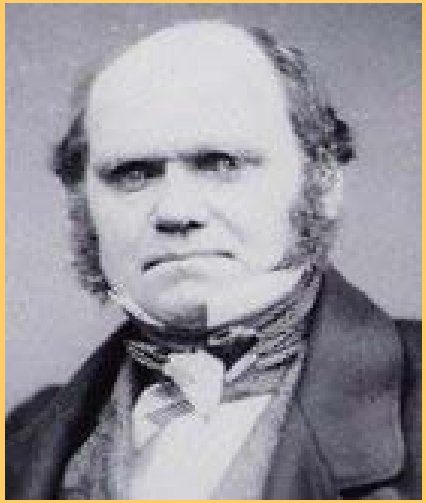
Previously held views about Earth and Life on it.

- Earth is about 6,000 years old.
- Everything we see on the surface was created in one catastrophic divine moment.
- All species were created as a direct result of “the creator.”
- All species have “been fixed in time.”*
- All species were specially created and unchangeable. (Literal Bible interpretation)

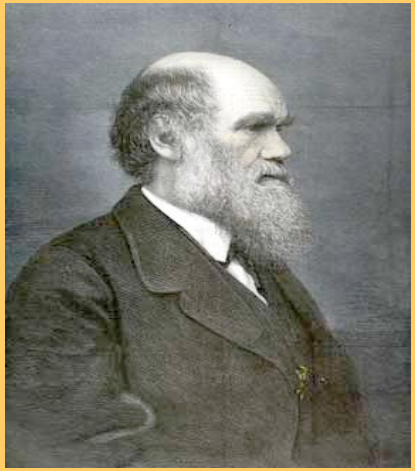
Charles Darwin
(1809 – 1882)

- Born to a moderately wealthy family in Shrewsbury, England
- Father was a very successful doctor
- Started university at 16 in Edinburgh, Scotland as a medical student





Being a Doctor was *not* his idea!



- Hated the brutality of “modern” surgical techniques
- Quit Medical School after two years
- Father sent him to Cambridge to study Theology and become a Priest

Not too excited about *this* major either!

Graduated in 1831 with a Theology Degree

- Was clearly more excited about biology and “Natural History” than theology
- Loved sea creatures…barnacles
- Well-read, but at this time did *not* think evolution was possible

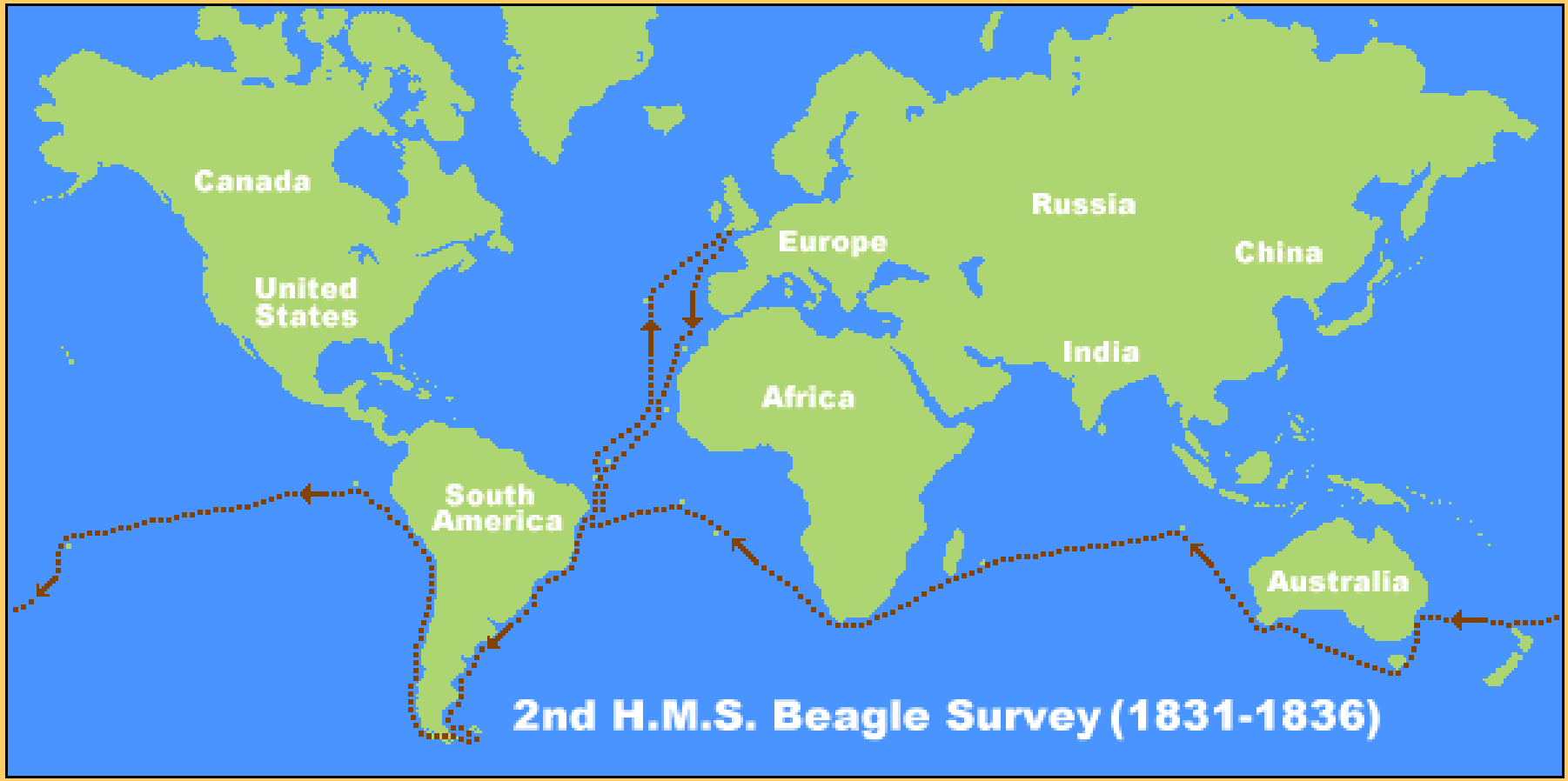
Summer of 1831, a break

- Went home to ponder his future
- Often took hikes to make observations of local flora and fauna
- Loved hunting, fishing, collecting geologic samples
- Basic taxidermy of local birds and mammals
- Botany Professor, John Henslow had a proposal

Naturalist on the HMS Beagle

- British Navy mapping expedition of South American coastline
- Darwin was only 22 years old at the time.
- 90 foot long ship with a crew of 74
- Thought to be a two year trip…ended up being five years.

The Trip from 1831 - 1836



Tierra del Fuego

Keep this in mind

- Darwin did not have a favorable opinion of evolution prior to his departure. Why?
  - **The lack of a real imperative** (Was such a theory really needed?)
  - **Insufficient time** to accomplish significant change (6000 year-old Earth)
  - **Lack of any real mechanism** that might drive evolutionary change

Plenty of time to work and read

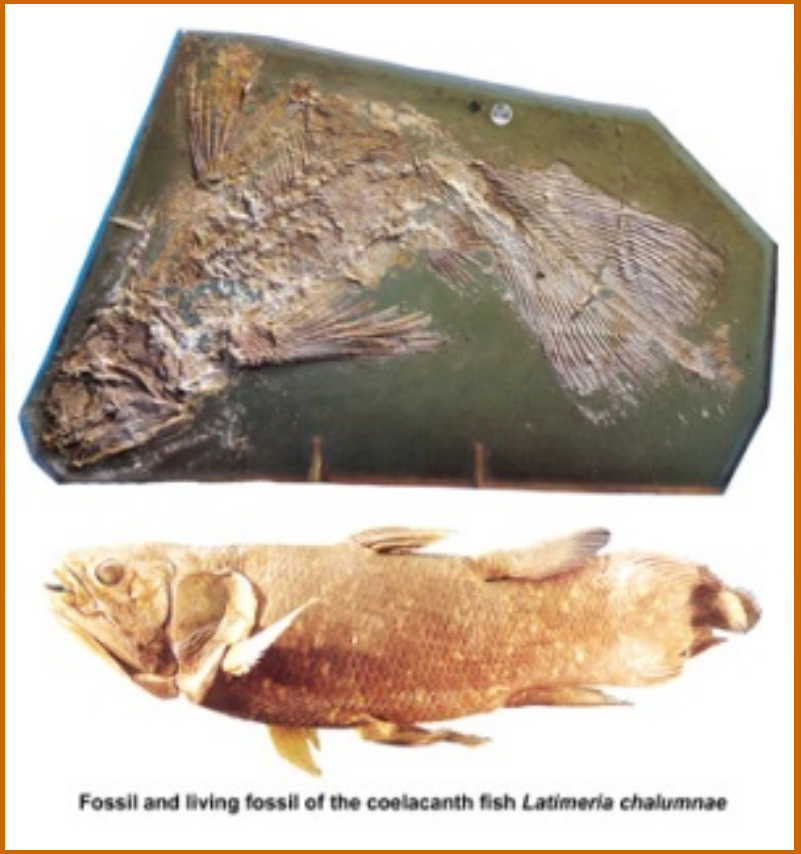
- Visited many new lands where he collected, catalogued and described dozens of new species of plants, animals and notable geologic formations
- Read ***Principles of Geology*** by Charles Lyell
- Lyell is considered the “father of modern geology.”
- Old-earth hypothesis

Darwin's Biological Data

- Plants and animals in temperate regions of S. America closely resembled organisms from the tropics of S. America…yet different.
- Island organisms were similar to, yet different from mainland organisms.

Darwin's Geologic Data

- Experienced an earthquake firsthand and noted that the shoreline had risen several feet
- Collected fossils of sea organisms high up in the Andes, nowhere near the coastline

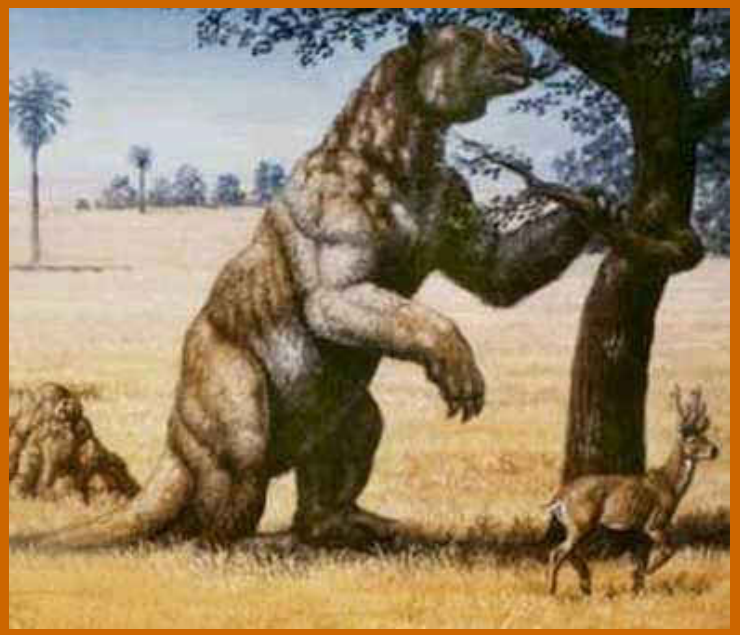


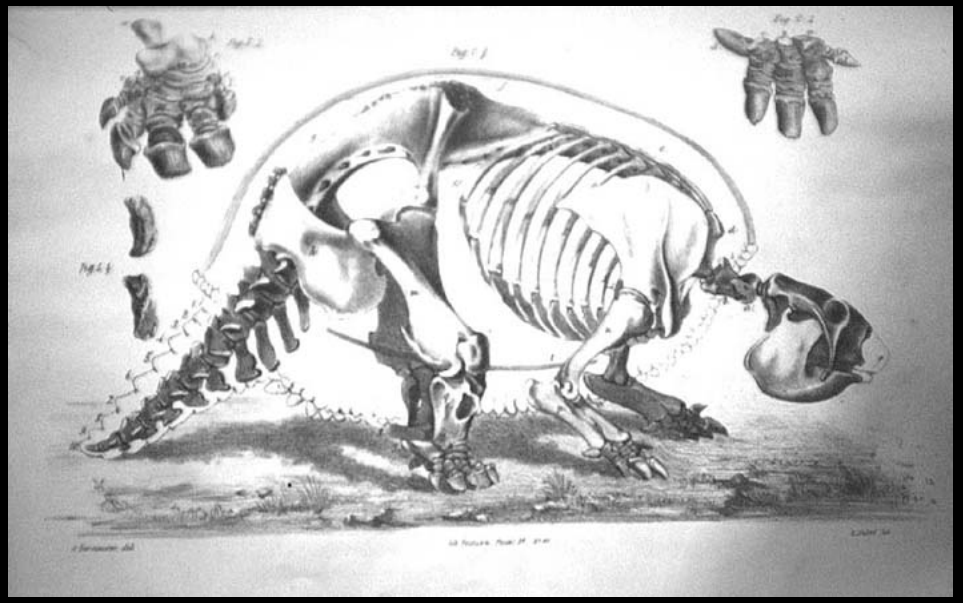
Fossil and living fossil of the coelacanth fish *Latimeria chalumnae*

Other fossils were impressive!

- Extinct Giant Sloth fossils were found.

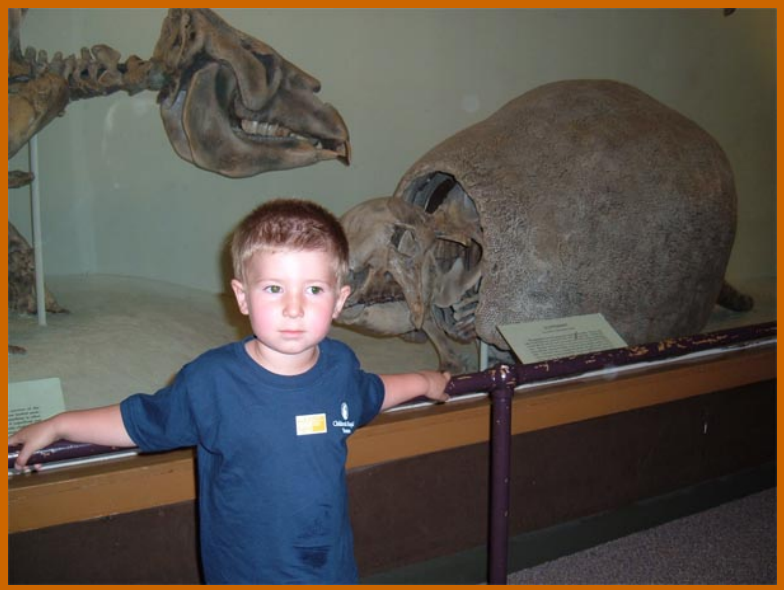
- Sort of resembled (but not entirely like) the modern version of a three-toed sloth

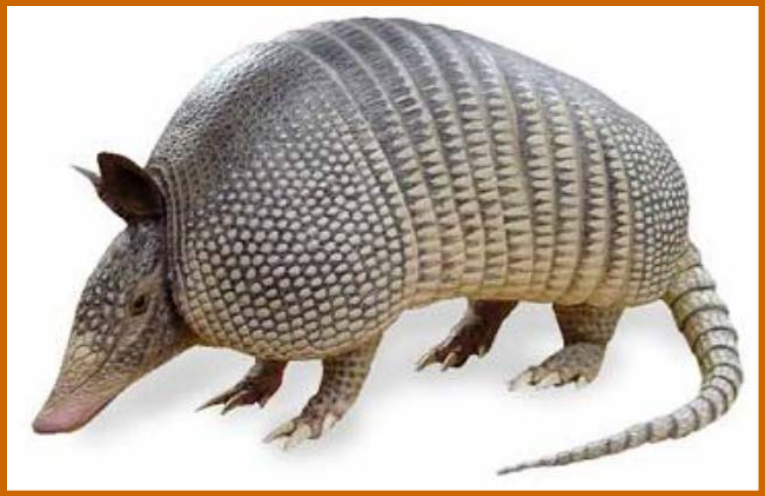




Giant Armadillo, *Glyptodont*

- Again, the extinct version was much larger than today's modern armadillo.





Lyell's book had a great influence on Darwin's thinking.

- Started to question the widely held belief that the earth was a *static*, *unchanging* system both *geologically* and *biologically*.

Five week stay on the Galapagos Islands

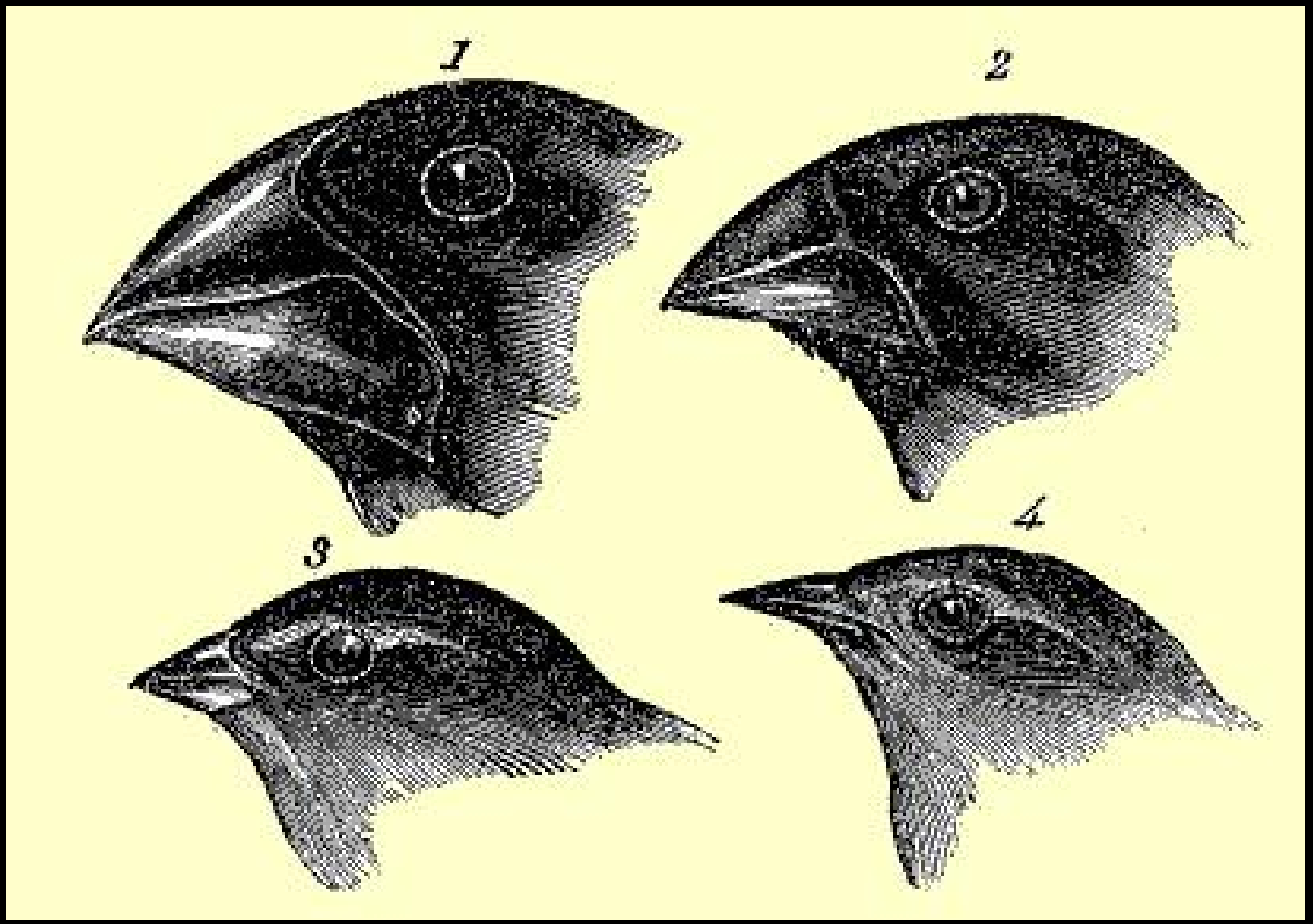
Great interest in Island "Biogeography"

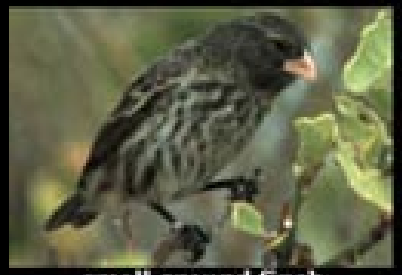
- Volcanic archipelago
- Relatively young in geologic age
- No known predators
- Simple biological systems without a lot of human intervention
- Observed many new species of plants and animals
- Giant tortoises!

Finches

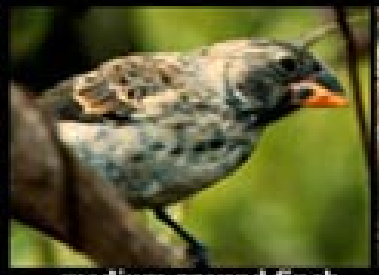
- Finch species varied with each island, depending on the available food source.

Thirteen different species with varying beak types





small ground finch

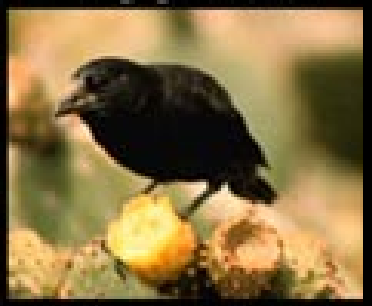


medium ground finch

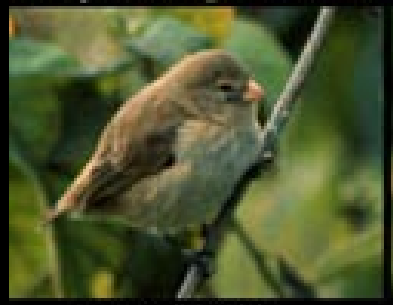
large ground finch

sharp-beaked ground finch

cactus finch



large cactus finch



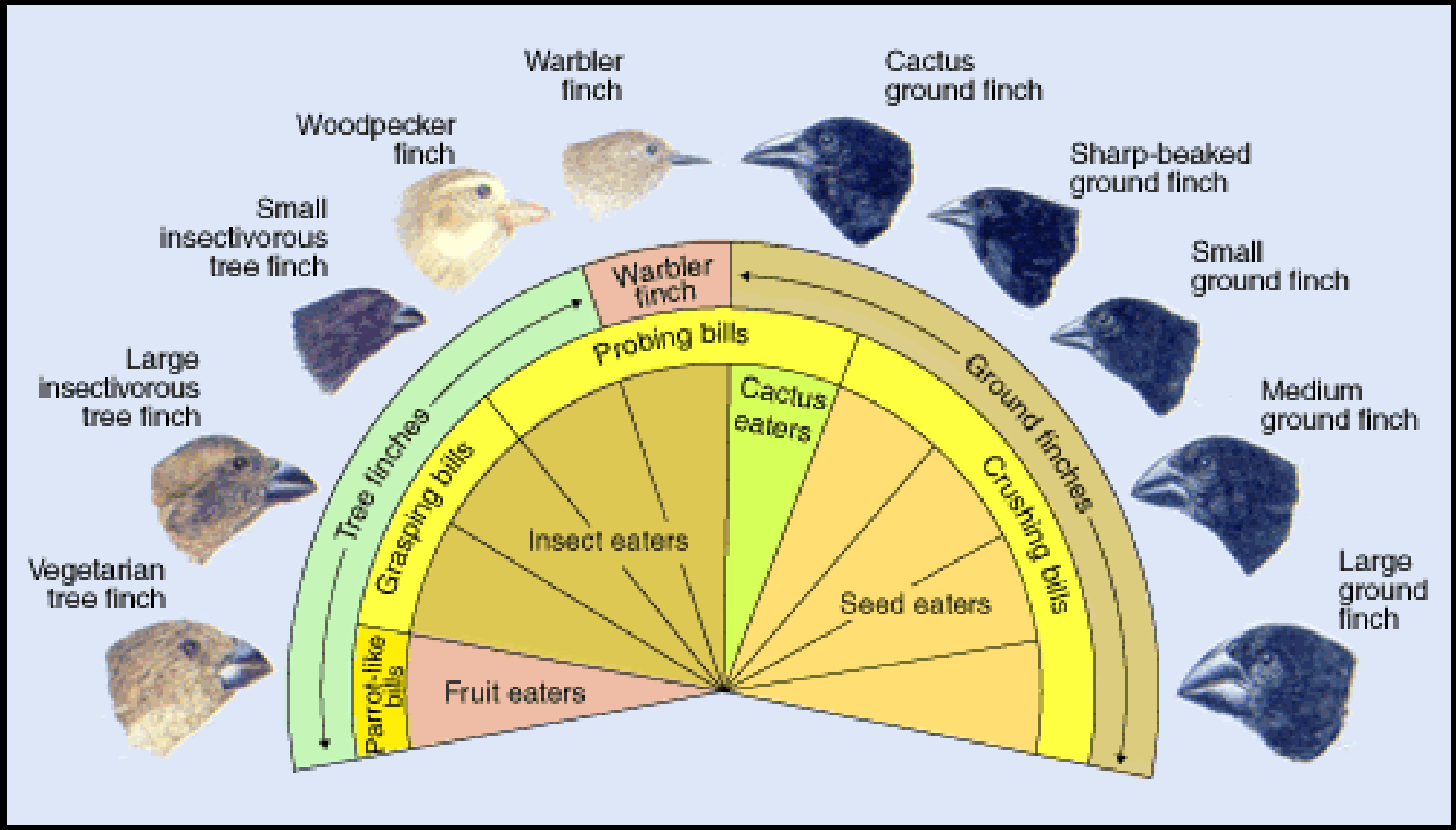
small tree finch

large tree finch?

vegetarian finch

woodpecker finch

warbler finch


Warbler finch
Cactus ground finch
Woodpecker finch
Sharp-beaked ground finch
Small insectivorous tree finch
Small ground finch
Large insectivorous tree finch
Medium ground finch
Vegetarian tree finch
Large ground finch
Warbler finch
Probing bills
Cactus eaters
Tree finches
Grasping bills
Ground finches
Crushing bills
Insect eaters
Seed eaters
Parrot-like bills
Fruit eaters

Return to England in 1836

- Darwin's findings and specimens were curious.
- He was sought after at conferences to explain his findings and trip.
- A bit of a "scientific celebrity" within certain academic circles
- Settled in rural London
- Began cataloging his data and writing volumes on the early ideas of evolution as they were formulating in his head
- Remained essentially silent on a large part of his thinking…for nearly two decades

Artificial Selection

- Long standing agricultural practice of selectively breeding an organism with desired phenotypic characteristics

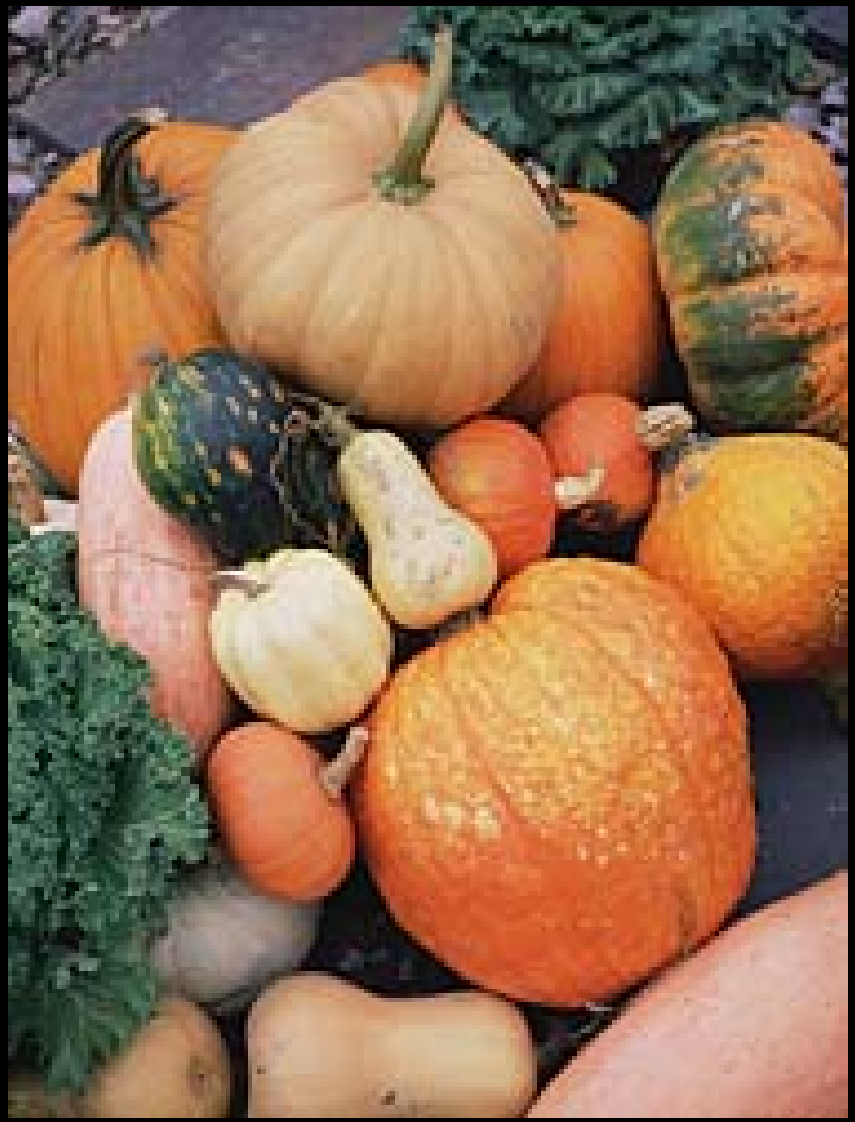

KENTUCKY HORSE PARK
EQUUS

Dwarf characteristics

Selective Breeding has been utilized on numerous agricultural crops for desired characteristics

Tomatoes

Pumpkins



Beans

Dogs..
Cats..
Chickens?

American shorthair

Manx

Maine coon

Siamese

Abyssinian

Persian

Artificial selection for size

Thomas Malthus (1766-1834)

- Malthus was a political economist.
- Concerned about what he saw as the decline of living conditions in nineteenth century England

Malthus was a radical “writer”

He blamed this decline on three elements:

1. The overproduction of young
2. The inability of resources to keep up with the rising human population
3. The irresponsibility of the lower classes

Malthus' *Essay on the Principle of Population* (1798)

Key points:

- In nature plants and animals produce far more offspring than can survive.
- Competition for food or space was a constant force keeping population in check.
- Darwin immediately saw how the idea could be applied to the natural world.

Alfred Russel Wallace (1823 – 1913)

- Young British Naturalist
- Friend of Darwin's
- Collecting and observing in East Indies
- Formulating a similar idea on Evolution
- Writes a brief manuscript that he wanted Darwin to comment on…!


Yangon
THAILAND
Mekong
Bangkok
CAMBODIA
Phnom Penh
VIETNAM
DAMAN SEA
INDIA
Gulf of Thailand
Manila
PHILIPPINE SEA
10057 m
Spratly Islands (disputed)
MICRONESI
8527 m
PHILIPPINES
MINDANAO
Koror
SOUTH CHINA SEA
Bandar Seri Begawan
BORNEO
SULAWESI SEA
PACIFIC OCEAN
Medan
Kuala Lumpur
Singapore
MALAYSIA
Manado
Pekanbaru
Pontianak
Samarinda
Padang
Jambi
Palangkaraya
Palembang
Banjarmasin
Sorong
Jayapura
JAVA SEA
Ujung Pandang
Ambon
NEW GUINE
Tanjungkarang-Telukbetung
Jakarta
BANDA SEA
Surabaia
Semarang
JAVA
I N D O N E S I A
Denpasar
Kupang
The Settlement
Darwin
Surabaia
Probolinggo
WESTERN AUSTRALIA
NORTHERN TERRITORY
AUSTRALIA
Jakarta
Cirebon
Cianjur
Semarang
Surakarta

Summer of 1858

- Darwin realizes that his ideas that he has been formulating for years might get scooped by Wallace…
- In a flash of about three weeks, quickly writes down the working outline of *The Origin of Species*, after years of gathering data and evidence.

“Descent with modification”

- Never used the word “evolution” until the closing pages of the book
- *Never* suggested that man evolved from a monkey
- Made four key points based on his travels, *observations*, *readings*, and *current biological knowledge*

Darwin's Key Points as presented in *The Origin of Species*

1. **Nature produces too many young**

   i.e. Frogs: 2000 – 5000 eggs

   Fish: 2000 – 5000 eggs

   Fertilization rate @ +/- 10%= 5000 X .10 = 500

   Development to fry @ +/- 10%= 500 X .10 = 50

   Development to minnow @ +/- 10%= 50 X .10 = 5

   Of those 5 minnows-> 2 – 3 make it to adult

   *About 1 or 2 of those adults make it to reproduction!


7
8
9
14
15
3
4
5
6

Key points continued:

2. Struggle for survival

All organisms struggle for basic necessities everyday for their entire life:

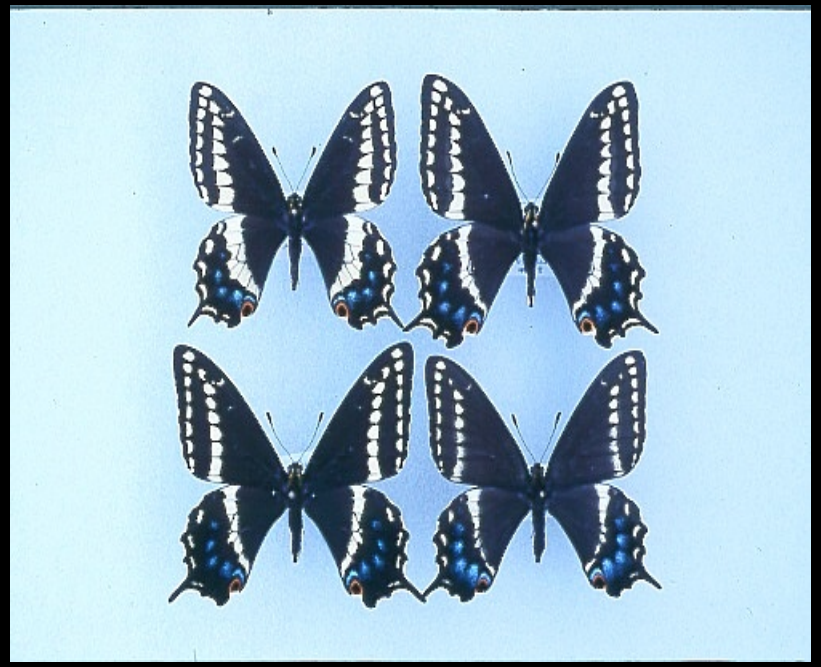
* Food
* Water
* Space
* Light
* Mates (Later to be called "sexual selection")

Key Points:

3. **Variations in a population are naturally present.**

Genetic probability due to

* crossing over @ meiosis
* random mutations



Key point

This is Darwin's pivotal and brilliant observation. This is new and significant since **it is the *first time* that a mechanism is proposed for evolution to occur.**

4. **Nature *selects the best fit organisms* for the environment.**

   "Natural Selection" (Struggle for survival)

   "Sexual Selection" (Struggle for mate(s))

Snowshoe Hare

Ptarmigan

Sexual Selection

Superb Bird of Paradise

Common Nighthawk

Evolution

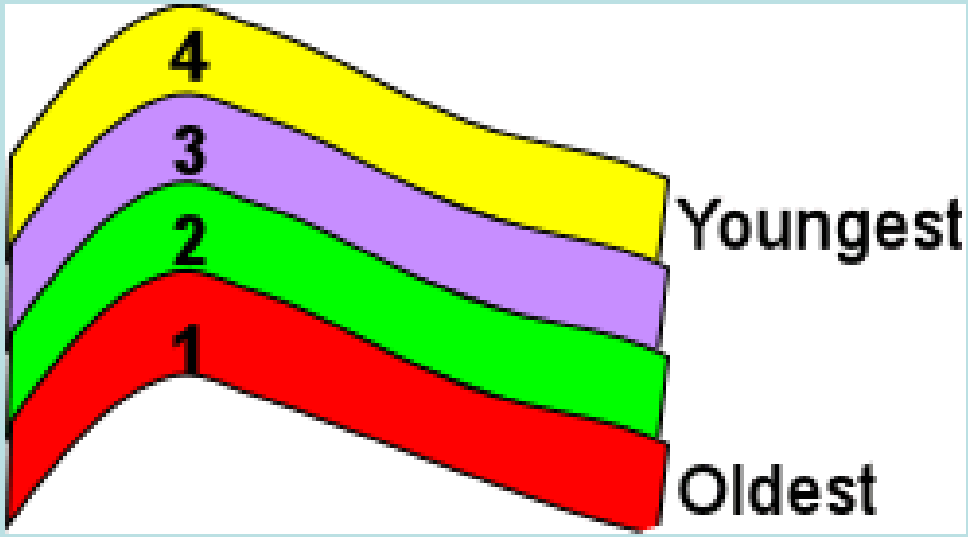
A progressive change of organisms over time.

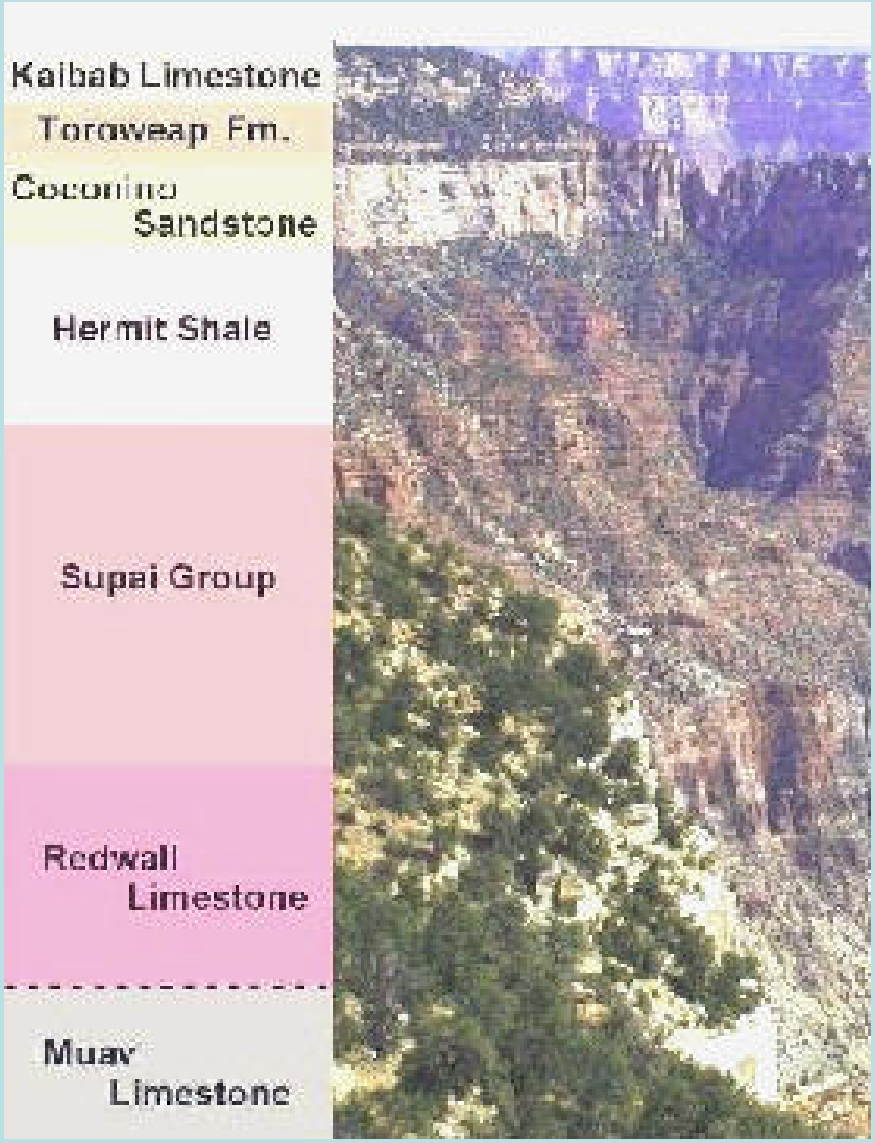
Evidence for the Theory of Evolution has been collected for the past 150 years

- Hundreds of thousands of biologists, geologists, ecologists, bacteriologists and other specialty scientists test, observe, and measure the theory on a regular basis

Fossil Record

- Law of Superposition


4
3
2
1
Youngest
Oldest


Kaibab Limestone
Toroweap Fm.
Coconino Sandstone
Hermit Shale
Supai Group
Redwall Limestone
Muav Limestone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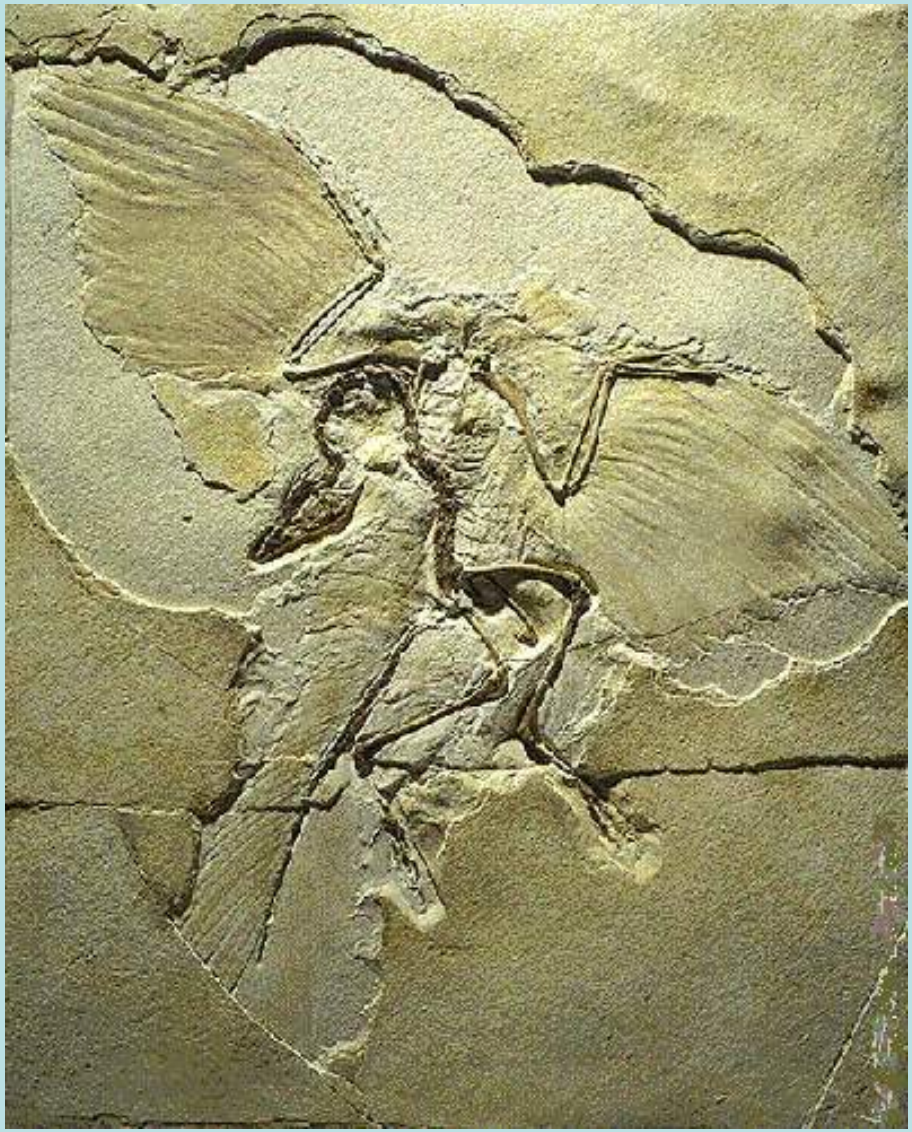
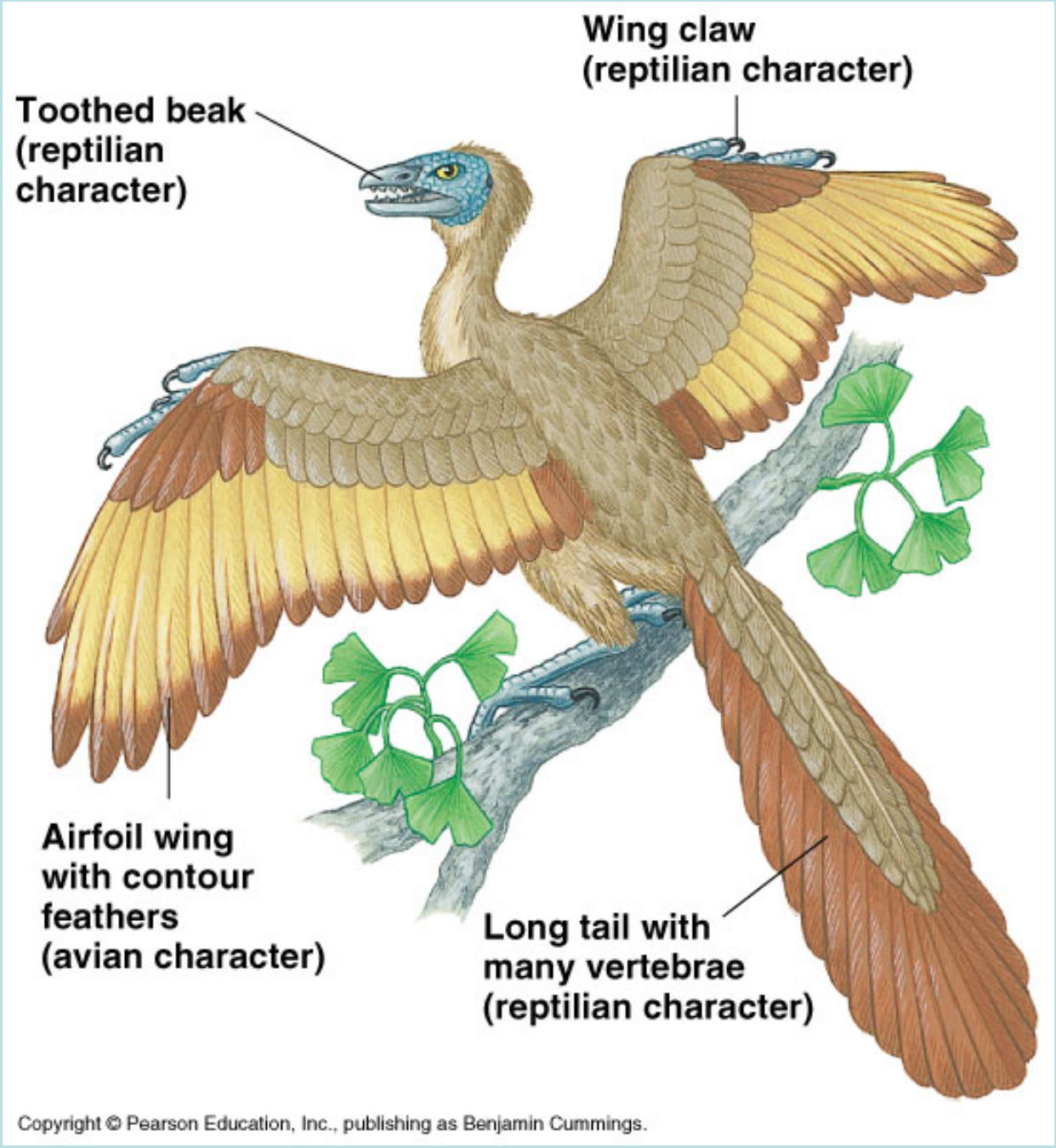
Transitional Fossils

- Show anatomical connections between groups of organisms and individual species

Archaeopteryx

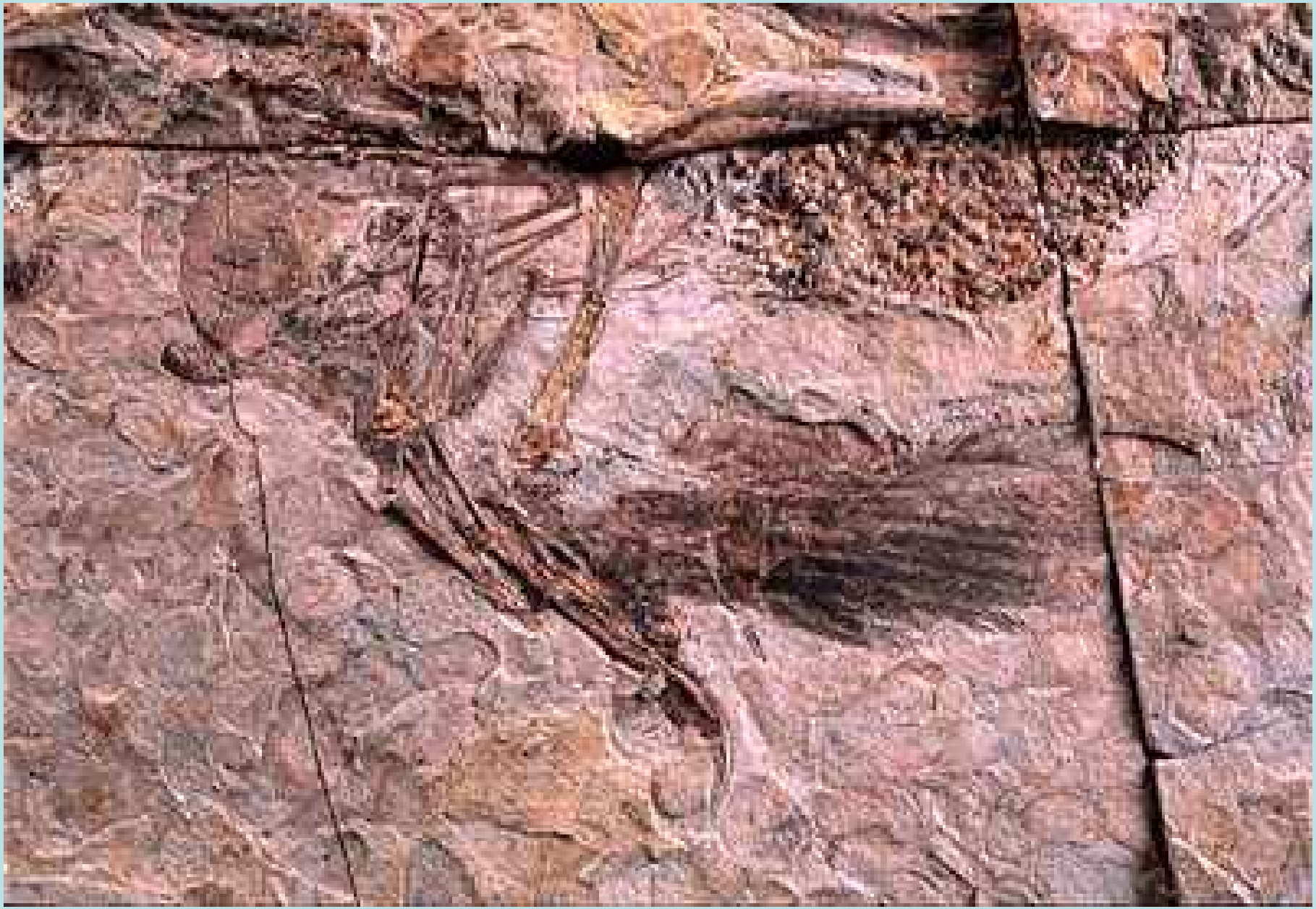




First Bird/Reptile Link

- **Meaning** - Archaeopteryx means "ancient wing“
- **Named By** - Hermann von Meyer 1861
- **Length** - 1 foot beak to tail
- **Wingspan** - 1.5 feet
- **Weight** - 11 to 18 ounces
- **WHEN IT LIVED:** about 150 million years ago


© UCMP



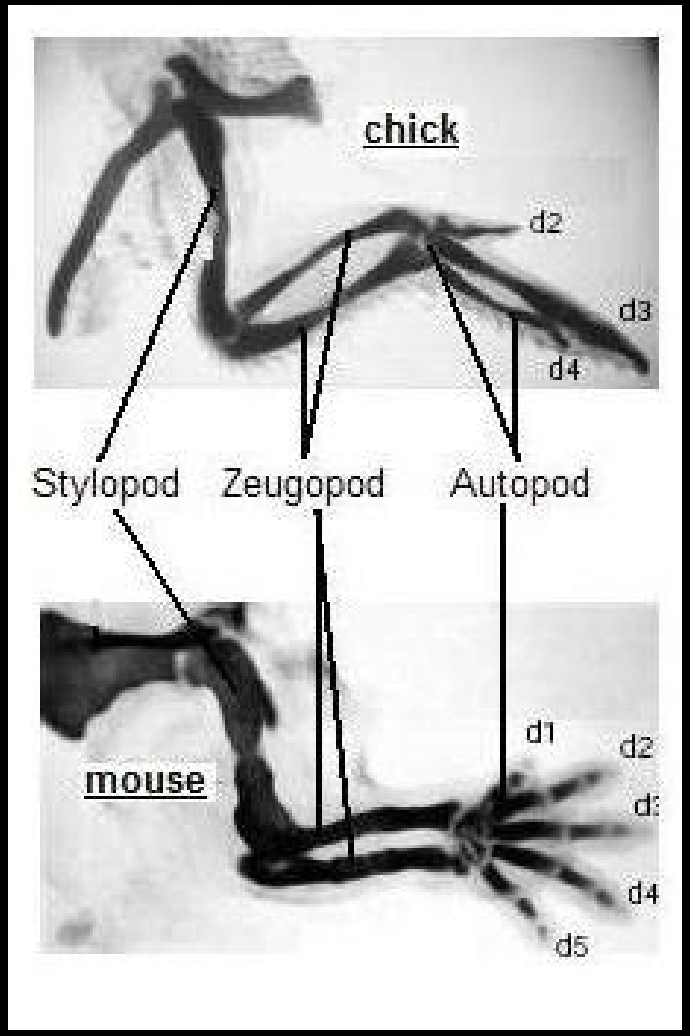
Embryology

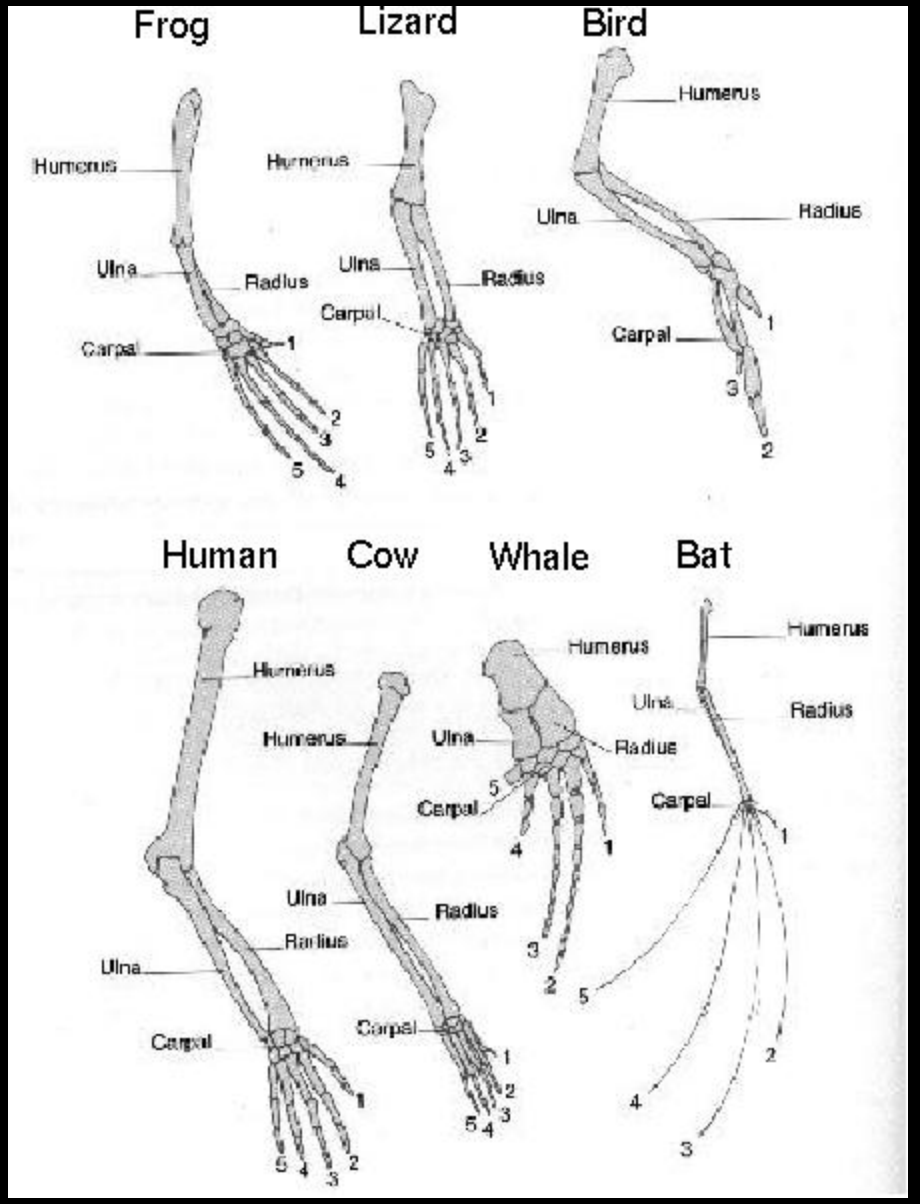
- Embryos of vertebrates share numerous common structures
- Mouse Embryo

Human Embryo


I
II
III
Fish
Salamander
Tortoise
Chick
Hog
Calf
Rabbit
Human

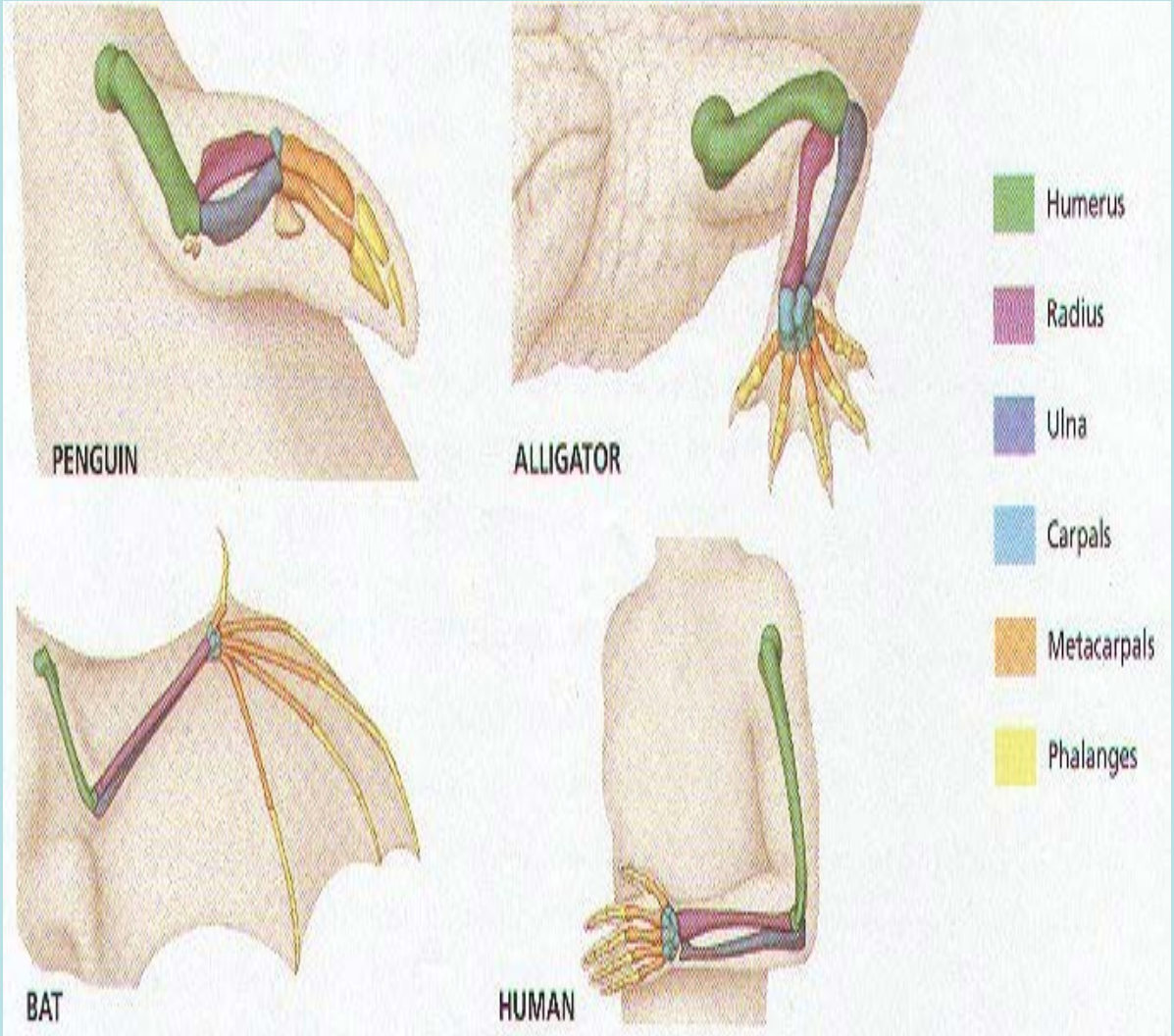
Homologous Structures





Adaptive radiation - the progressive modification of a structure to serve many different purposes

- Comparative anatomy where similar bones have a common descent but now have been modified for different purposes
- Swimming, flying, walking, grasping

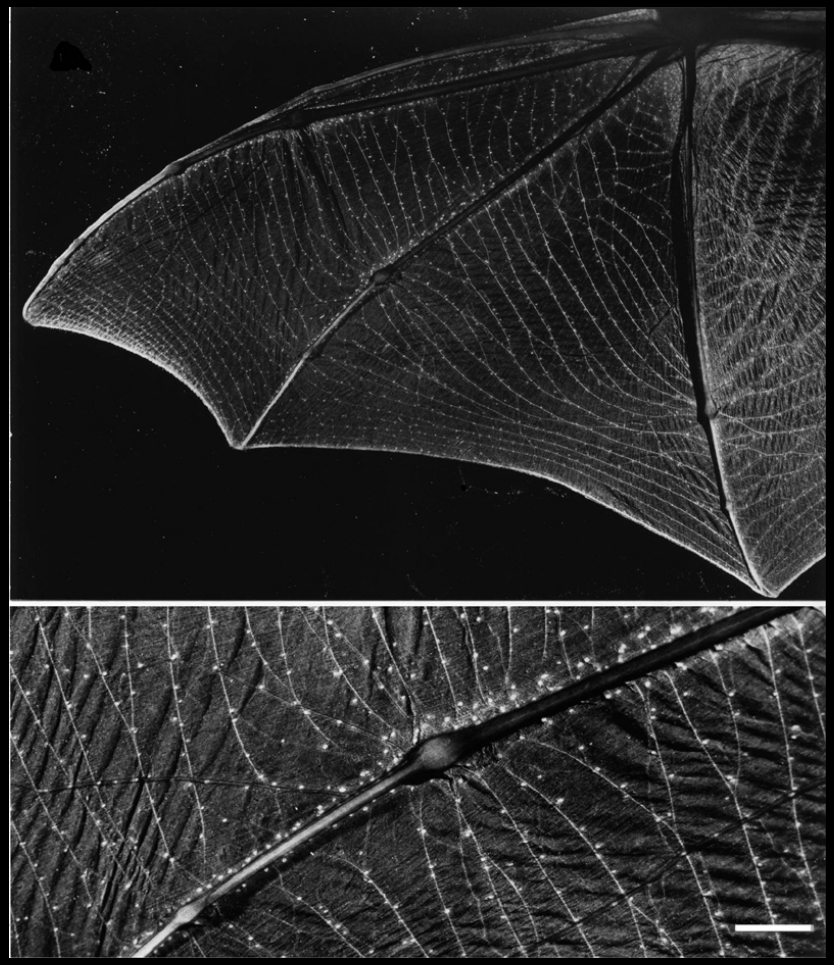


Analogous Structures

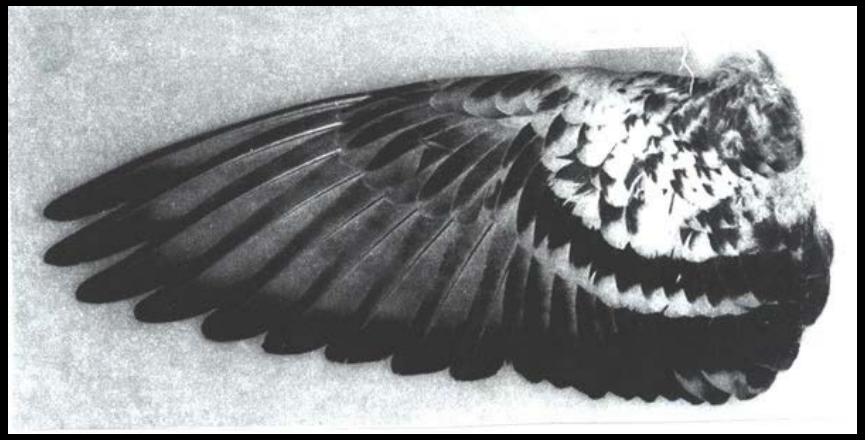
Analogous Structures

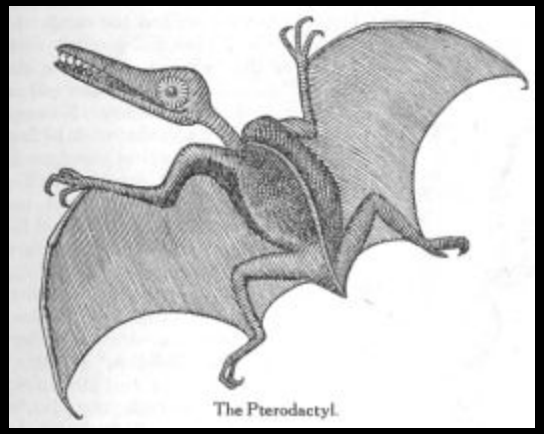
- Vertebrate eyes have an origin in brain cells; cephalopod eyes have an origin in skin cells.
- Wings have developed separately in insects, birds, bats, and reptiles.

Similarity in structure based on adaptation for the *same* function, *not* common origin



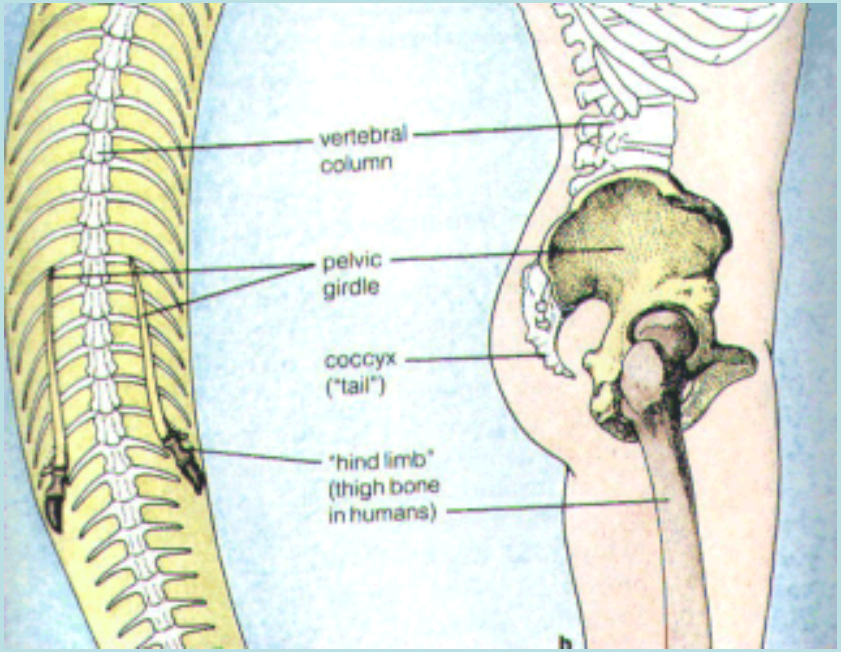
Flying is essential for many different organisms

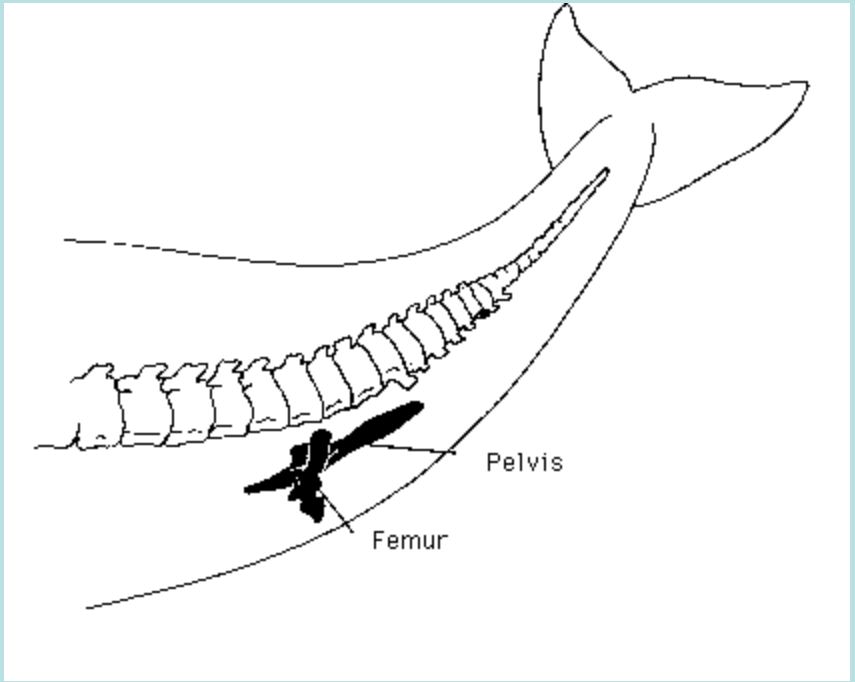




Body Shape

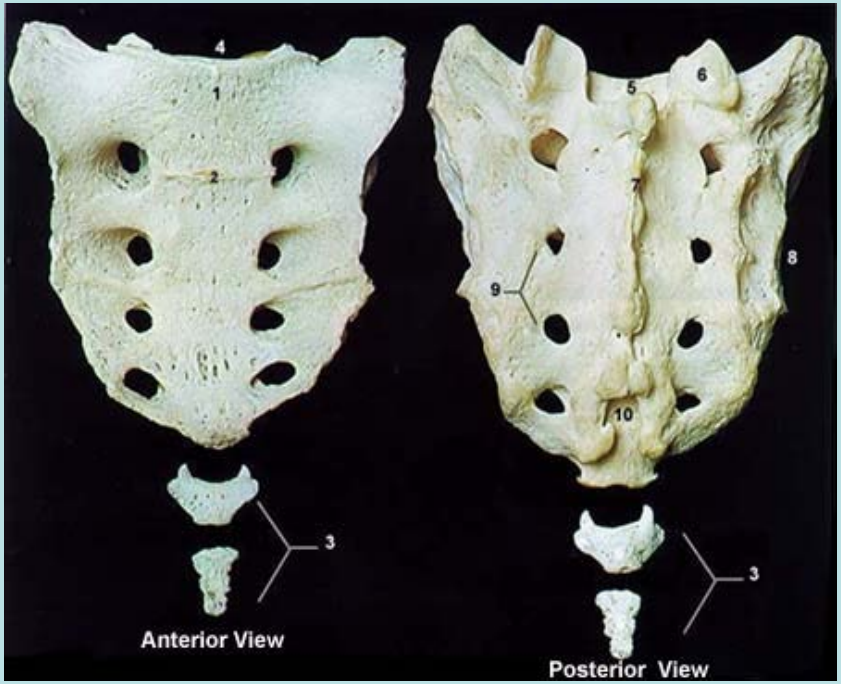
Vestigial Structures-if functional, perform relatively simple, minor, or unessential functions





Human Vestigial Structures

1. Human appendix useless yet in other mammals, including primates, it is necessary to aid in digestion of high cellulose diet
2. Human external ear muscles still present but useless
3. Humans have tailbones and some babies occasionally have tails
4. Human wisdom teeth vestigial compared to other primates


4
1
2
3
Anterior View
5
6
7
8
9
10
3
Posterior View

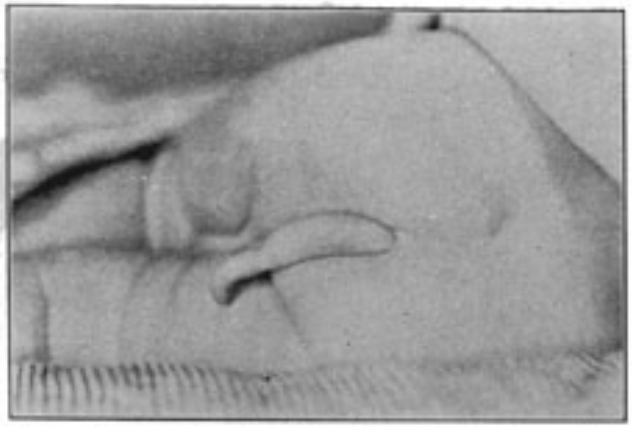


Fig.1 - Photograph showing tail in extended condition.

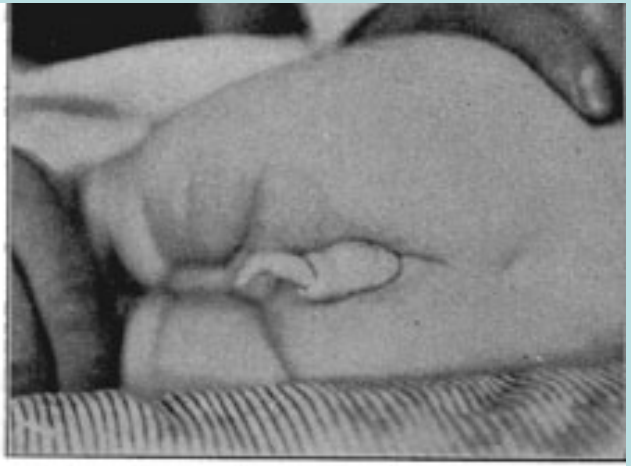
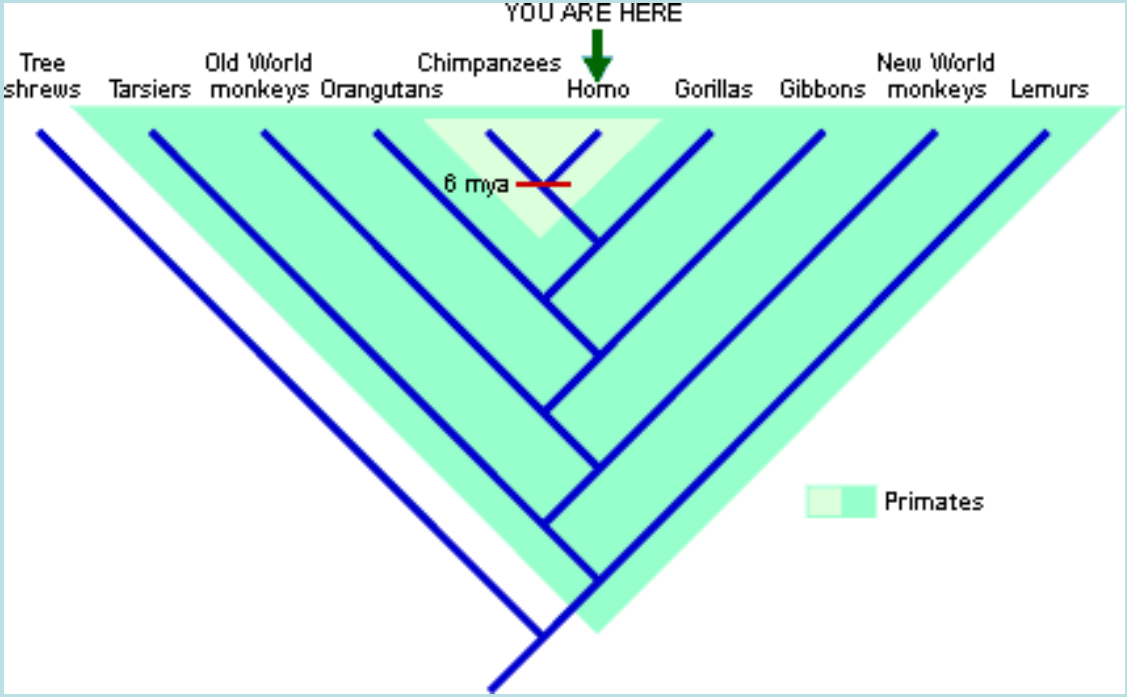
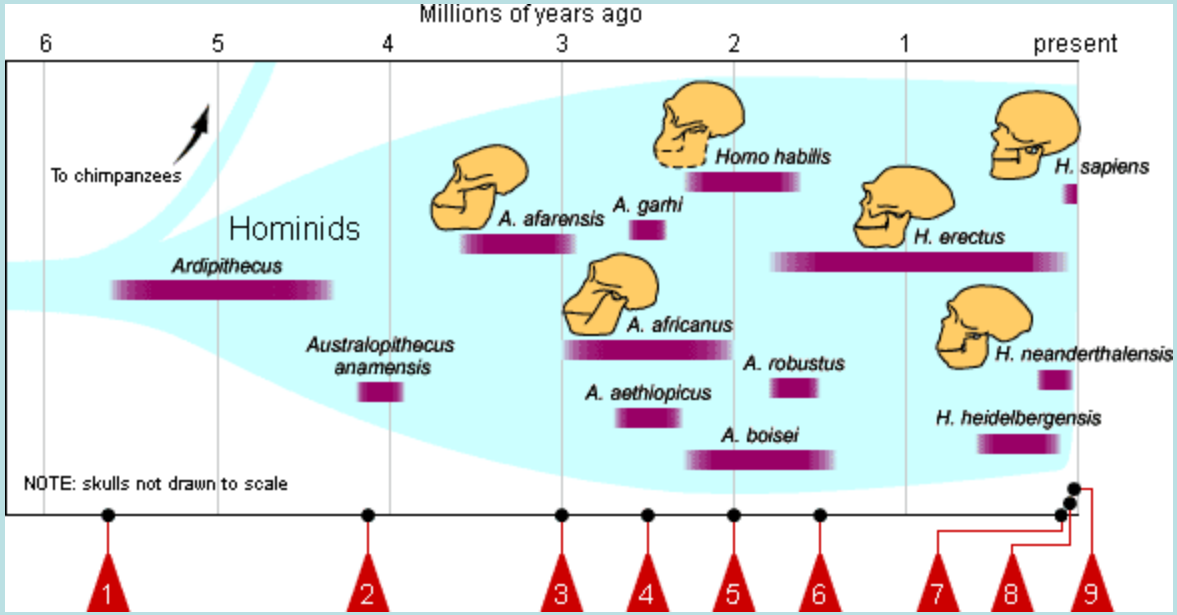
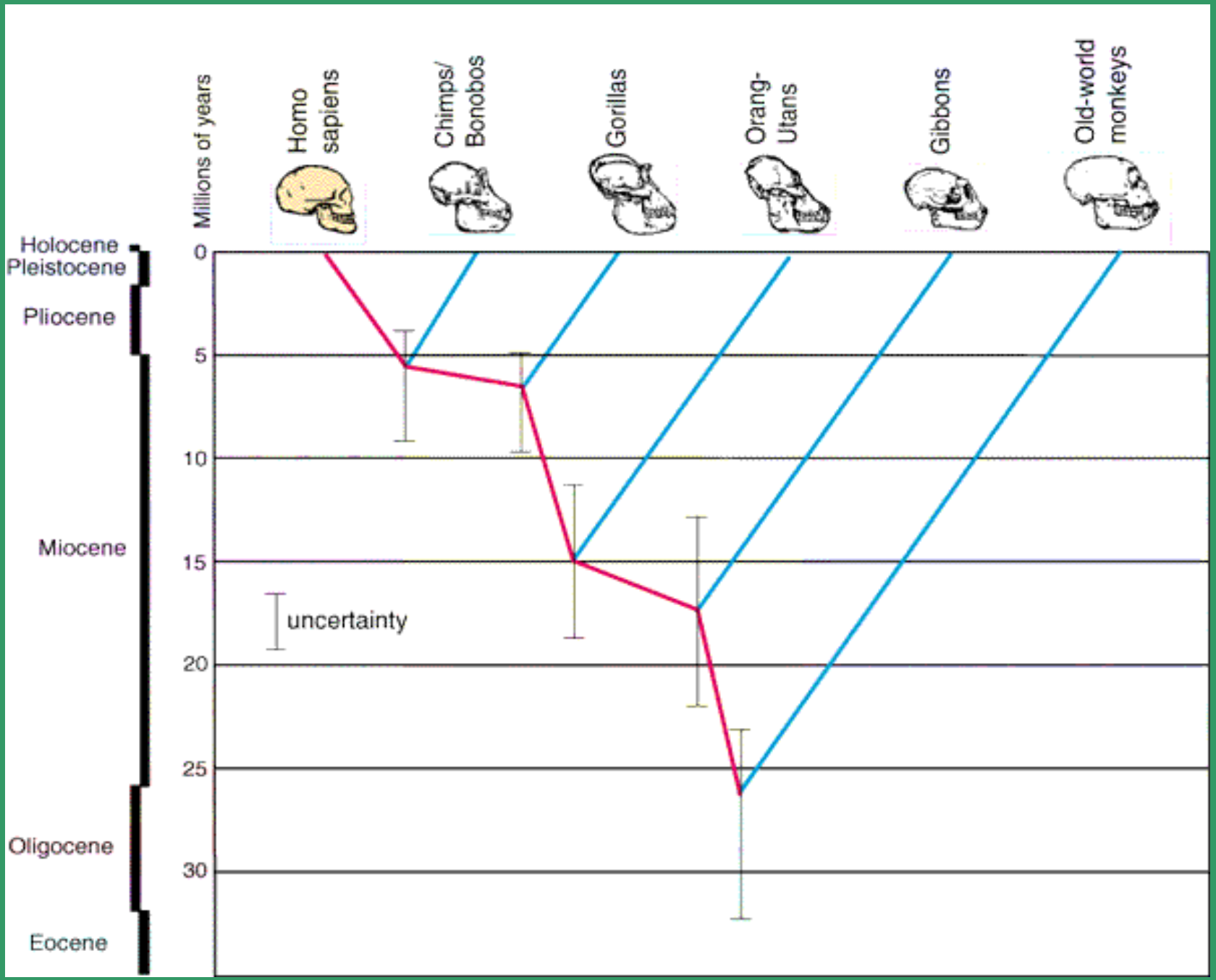


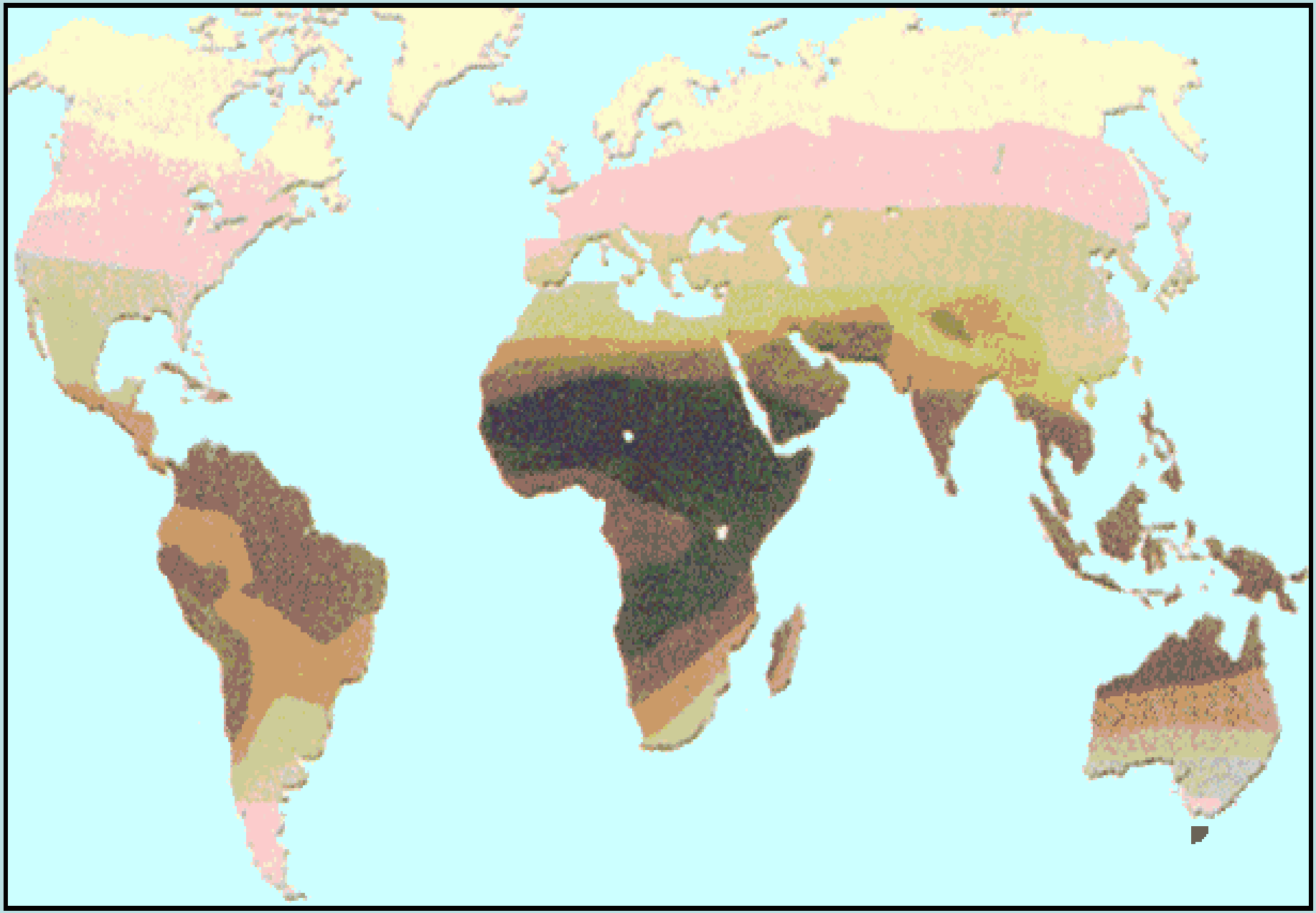
Fig. 2. - Photograph showing tail in state of contraction.


YOU ARE HERE
Tree shrews
Tarsiers
Old World monkeys
Orangutans
Chimpanzees
Homo
Gorillas
Gibbons
New World monkeys
Lemurs
6 mya
Primates


Millions of years ago
6
5
4
3
2
1
present
To chimpanzees
Hominids
Ardipithecus
A. afarensis
A. garhi
Homo habilis
H. sapiens
H. erectus
A. africanus
Australopithecus anamensis
A. robustus
A. aethiopicus
A. boisei
H. neanderthalensis
H. heidelbergensis
NOTE: skulls not drawn to scale
1
2
3
4
5
6
7
8
9


Old World monkeys
Gibbons
Siamang
Orang
Asian forms
Chimp
Gorilla
Human
Ardi-pithecus
African forms
X
Pliopithecus
X
Sivapithecus
Dryopithecus
Small-bodied hominoids
Afropithecus
? ?
Large-bodied hominoids
? ?
Proconsulids
MIOCENE
22.5 m. y.
OLIGOCENE
?
Aegyptopithecus
(Jurmain & Nelson, 1994)


Millions of years
Homo sapiens
Chimps/ Bonobos
Gorillas
Orang-Utans
Gibbons
Old-world monkeys
Holocene
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
0
5
10
15
20
25
30
uncertainty



DNA Analysis

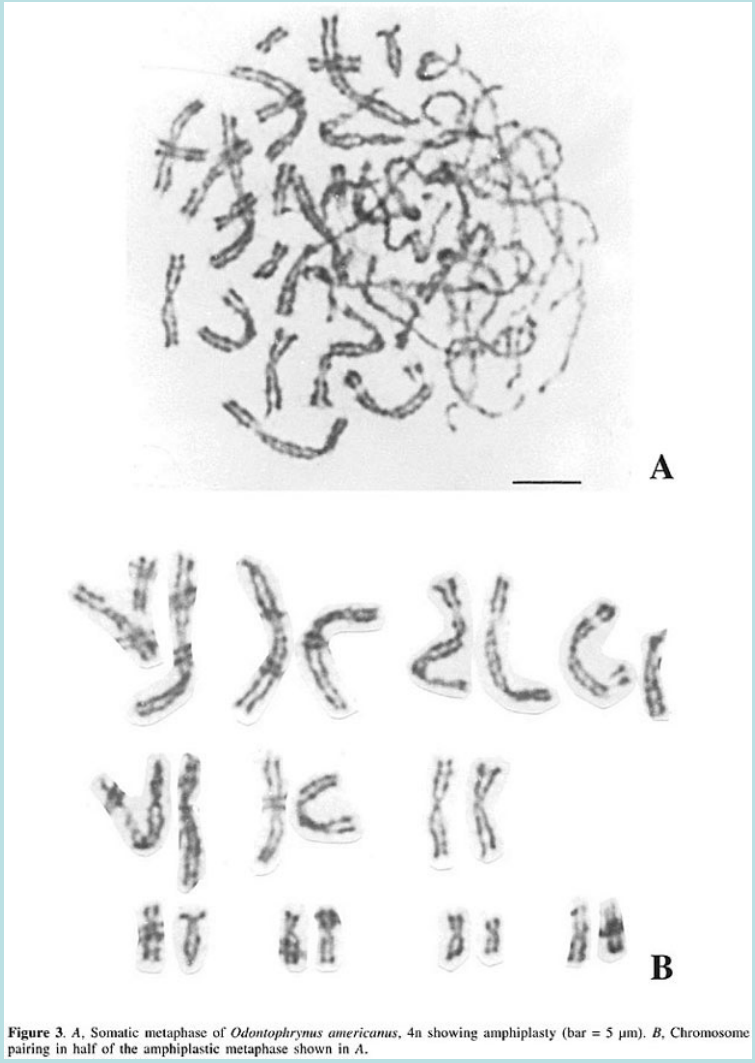
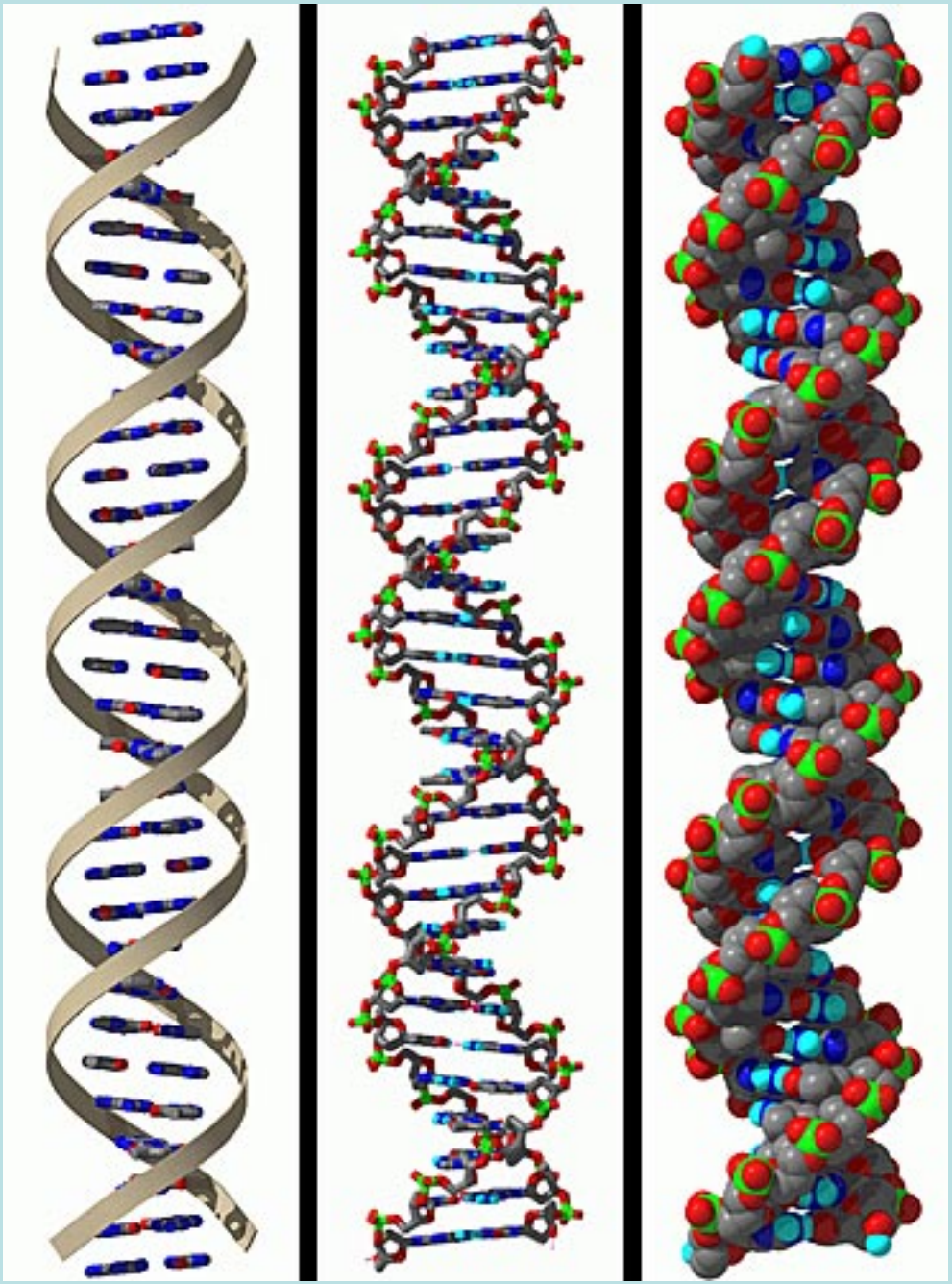


Figure 3. *A*, Somatic metaphase of *Odontophrynus americanus*, 4n showing amphiplasty (bar = 5 μm). *B*, Chromosome pairing in half of the amphiplastic metaphase shown in *A*.



Look for gene sequence similarities among organisms