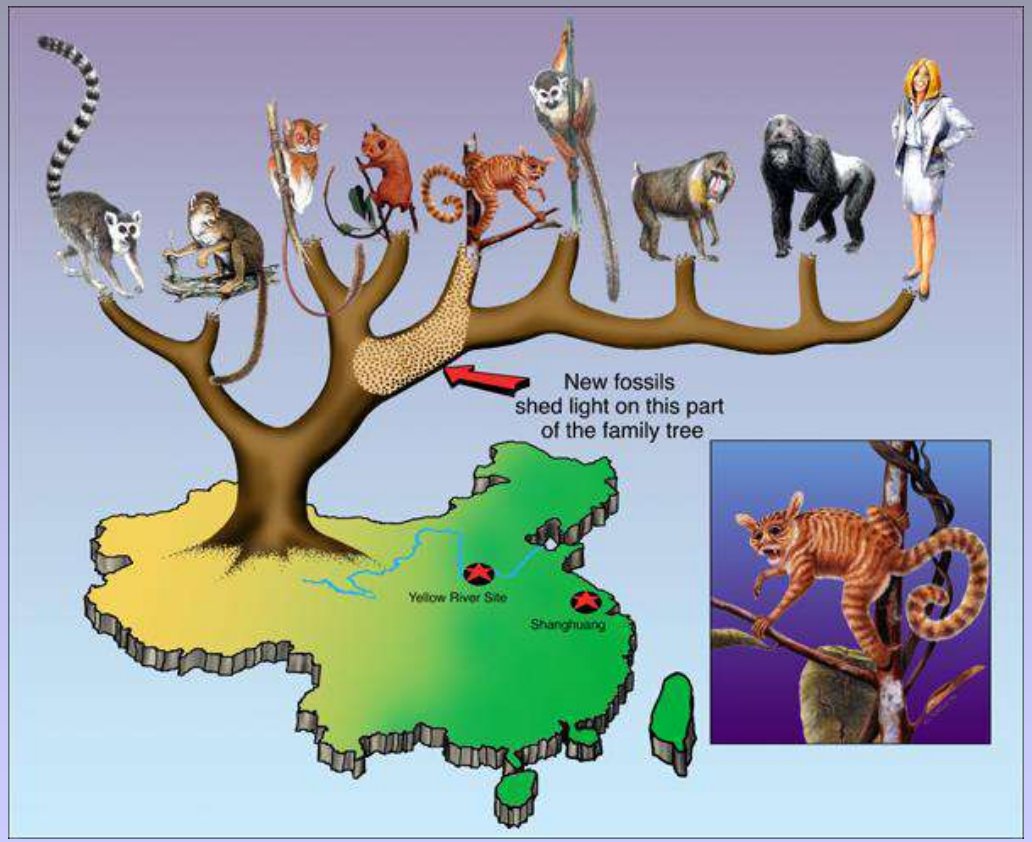
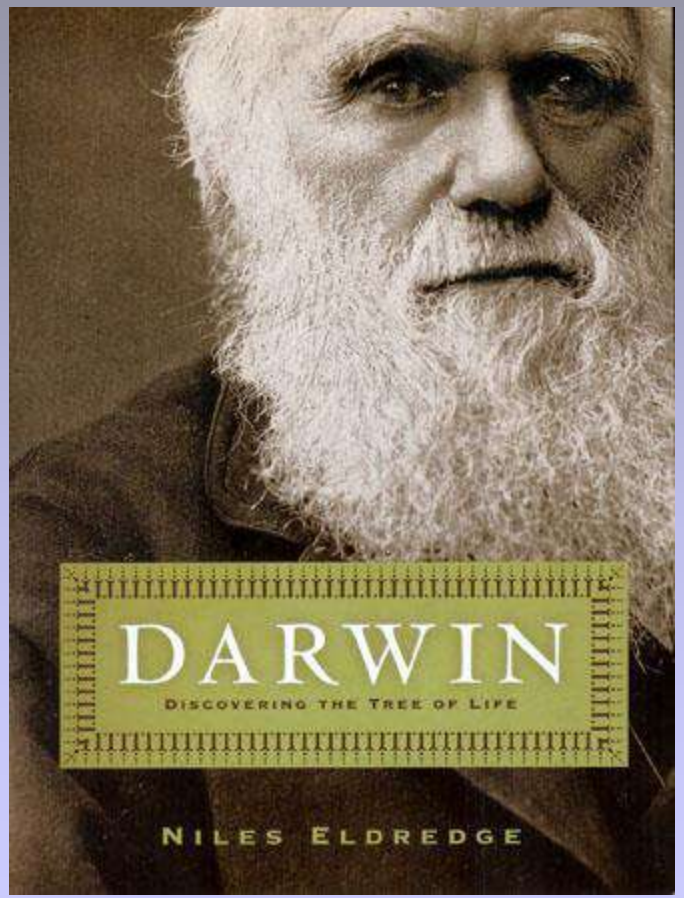
NOTES: CH 22 – Descent With Modification –

A Darwinian View of Life

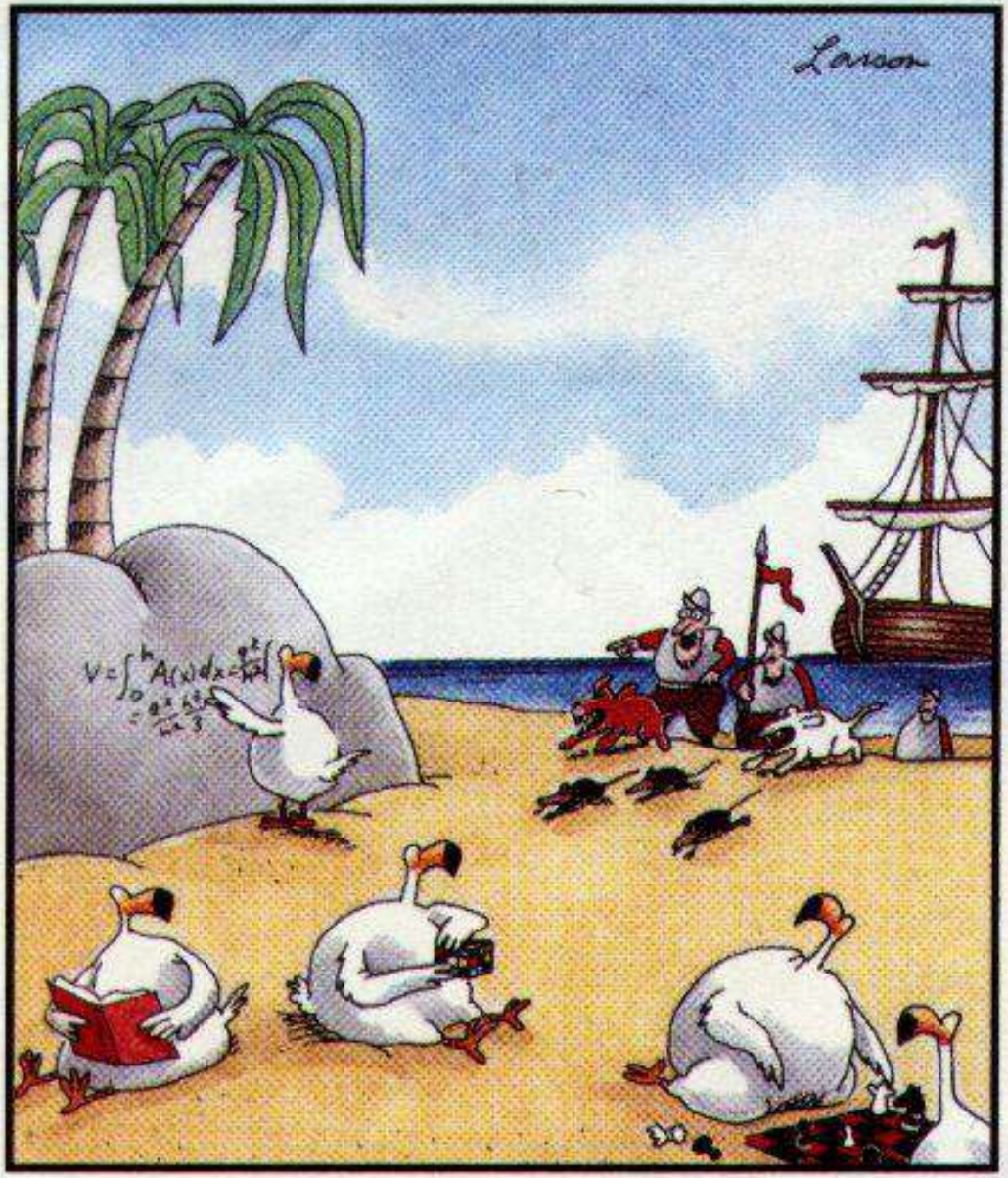




- Our planet is home to a huge variety of organisms

(Scientists estimate <u>5-20 million species</u> of organisms alive today!)

- Even more amazing is evidence of organisms that <u>once</u> lived on earth, but are now **<u>EXTINCT</u>**



Unbeknownst to most ornithologists, the dodo was actually a very advanced species, living alone quite peacefully until, in the 17th century, it was annihilated by men, rats, and dogs. As usual.

- Several <u>hundred million</u> species have come and gone during 4.5 billion years life is believed to have existed on earth

- So…where have they gone…why have they disappeared?

Laughing owl, extinct 1914

Bourbon crested starling, extinct 1850-60

Tasmanian Wolf, extinct 1936. AMNH transparency #5522

TERMS TO KNOW!!

- **EVOLUTION**: the process by which modern organisms have descended from ancient organisms.

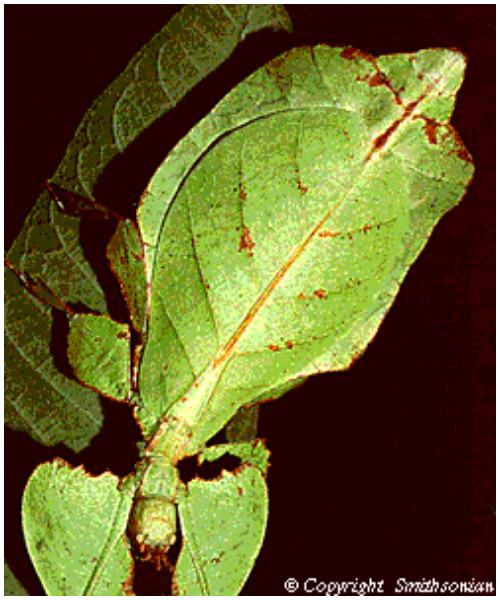
("CHANGE OVER TIME")

- **Central Idea:** organisms alive today have been produced by a long process of **change over time**.
- **FITNESS:** refers to traits and behaviors of organisms that enable them to survive and reproduce

- **COMMON DESCENT:** species share common ancestors
- **ADAPTATION:** any inherited characteristic that enhances an organism's ability to ***survive and reproduce***

~based on **variations**

that are **randomly inherited**



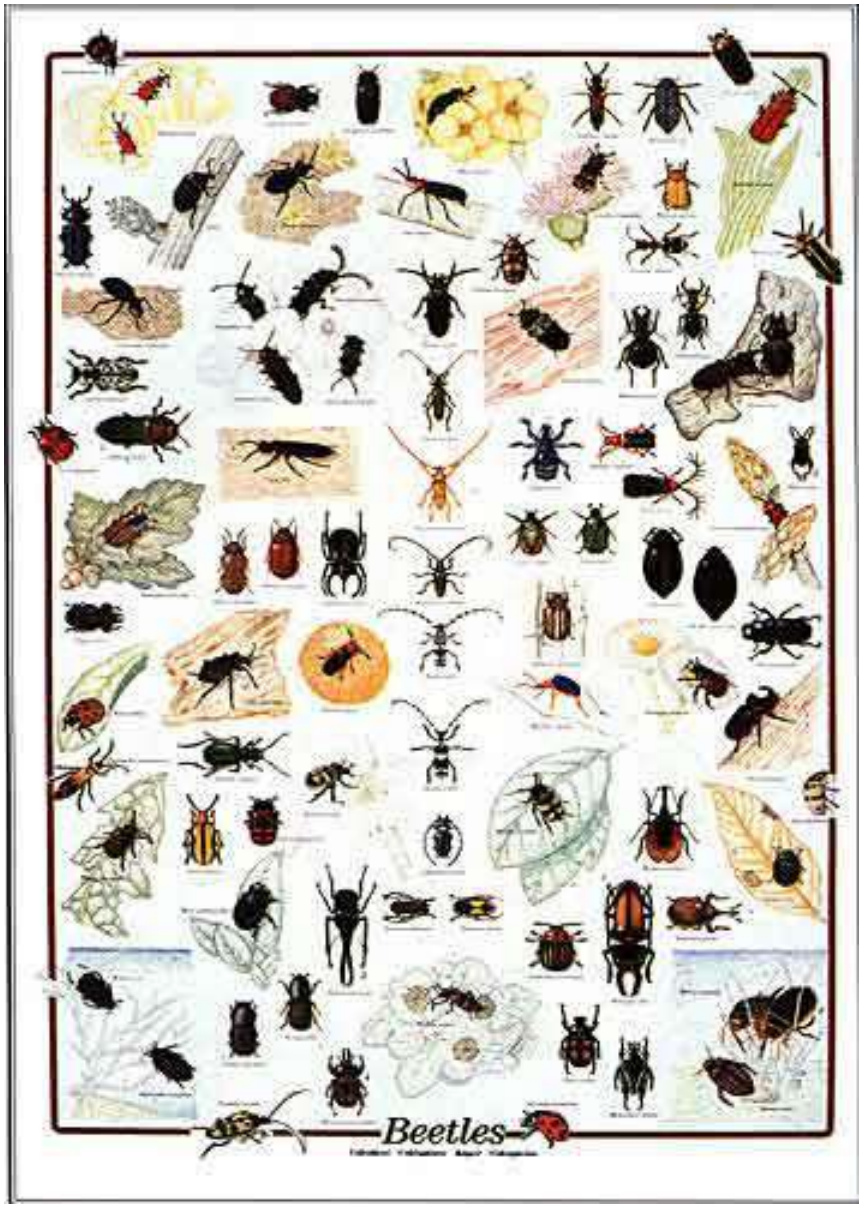
HOW DO WE KNOW THAT EVOLUTION HAS OCCURRED

(and is still happening!!!)???

Lines of Evidence:

1) **So many species!**

-at least 5 million species (250,000 beetles!)



Evidence for evolution – 2) ADAPTATIONS

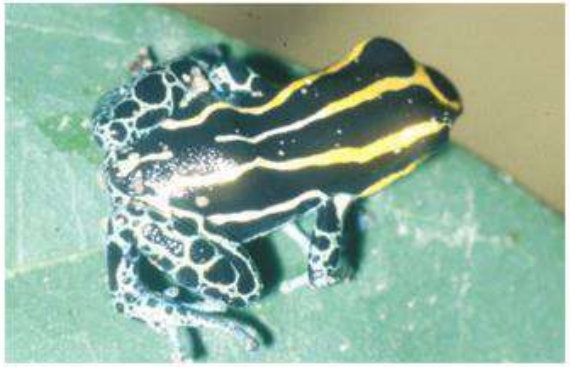
- Structural adaptations

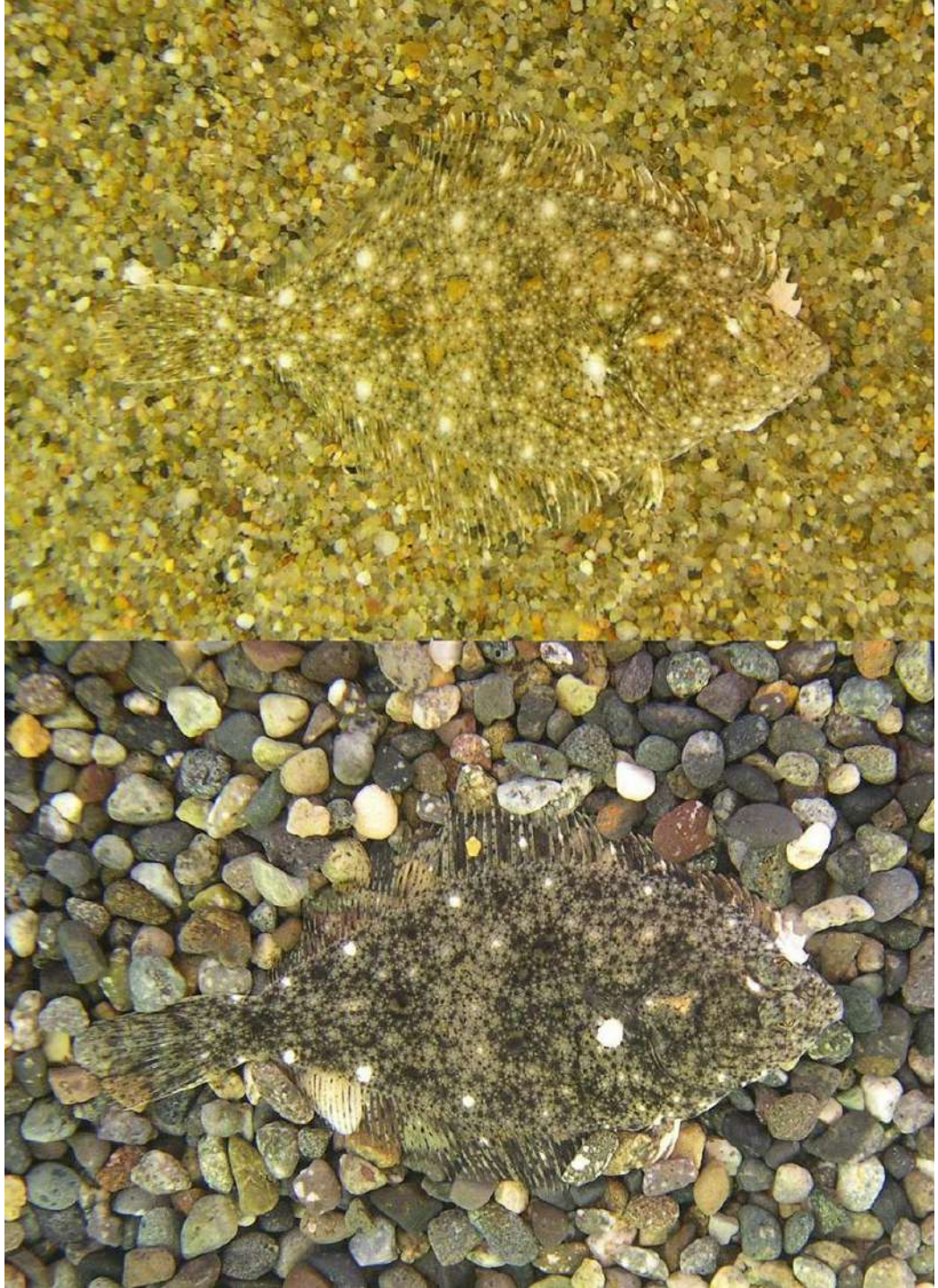
  -Mimicry

  -Camouflage





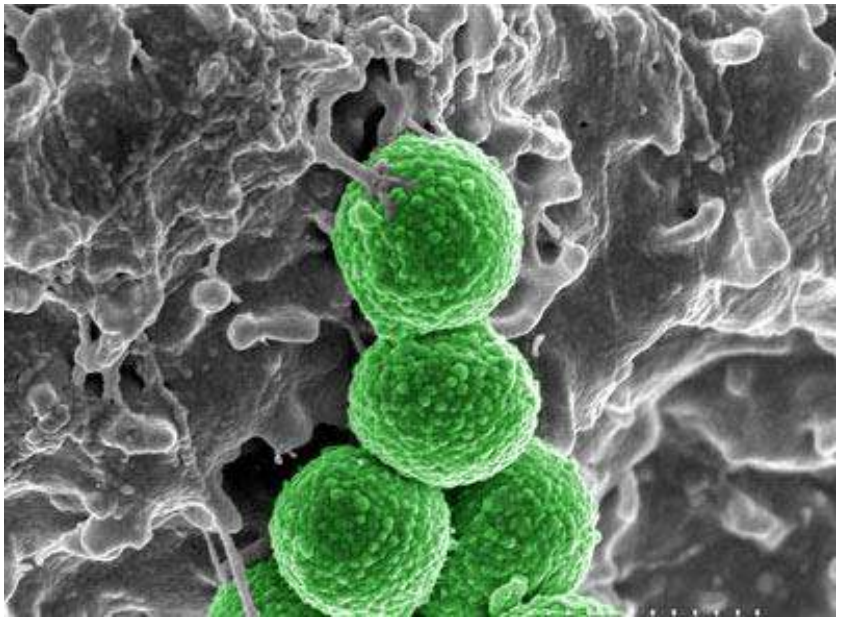


Evidence for evolution – 2) ADAPTATIONS

- Physiological adaptations

  -change in metabolic processes

  -resistance to certain toxins



H. pylori

Normal
(produces enzyme)

Antibiotic applied

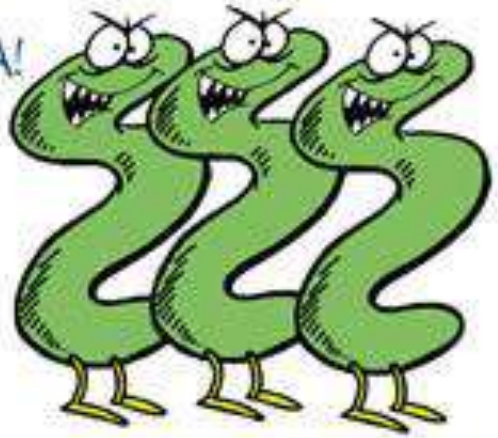
death

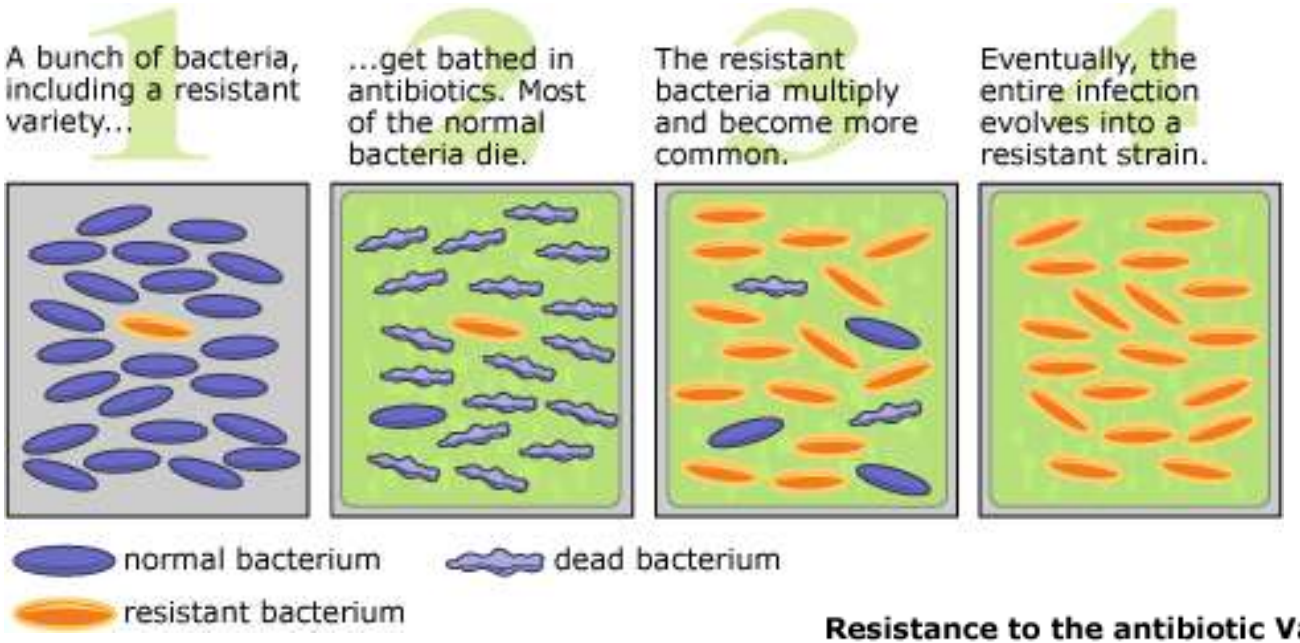
Continues to reproduce and produce offspring that resist antibiotics used to treat it.

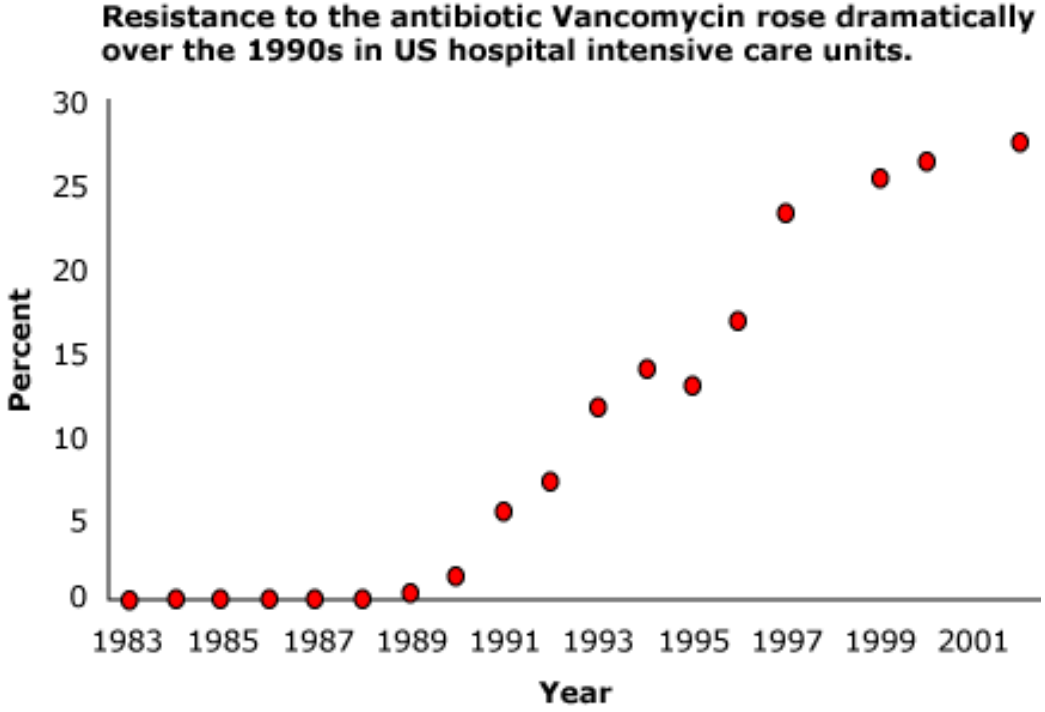
Mutant
(produces NO enzyme)

survives

HA HA HA HA!




1
A bunch of bacteria, including a resistant variety...
2
...get bathed in antibiotics. Most of the normal bacteria die.
3
The resistant bacteria multiply and become more common.
4
Eventually, the entire infection evolves into a resistant strain.
normal bacterium
dead bacterium
resistant bacterium


Resistance to the antibiotic Vancomycin rose dramatically over the 1990s in US hospital intensive care units.
Percent
0
5
10
15
20
25
30
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Year

3) **Biogeography:**

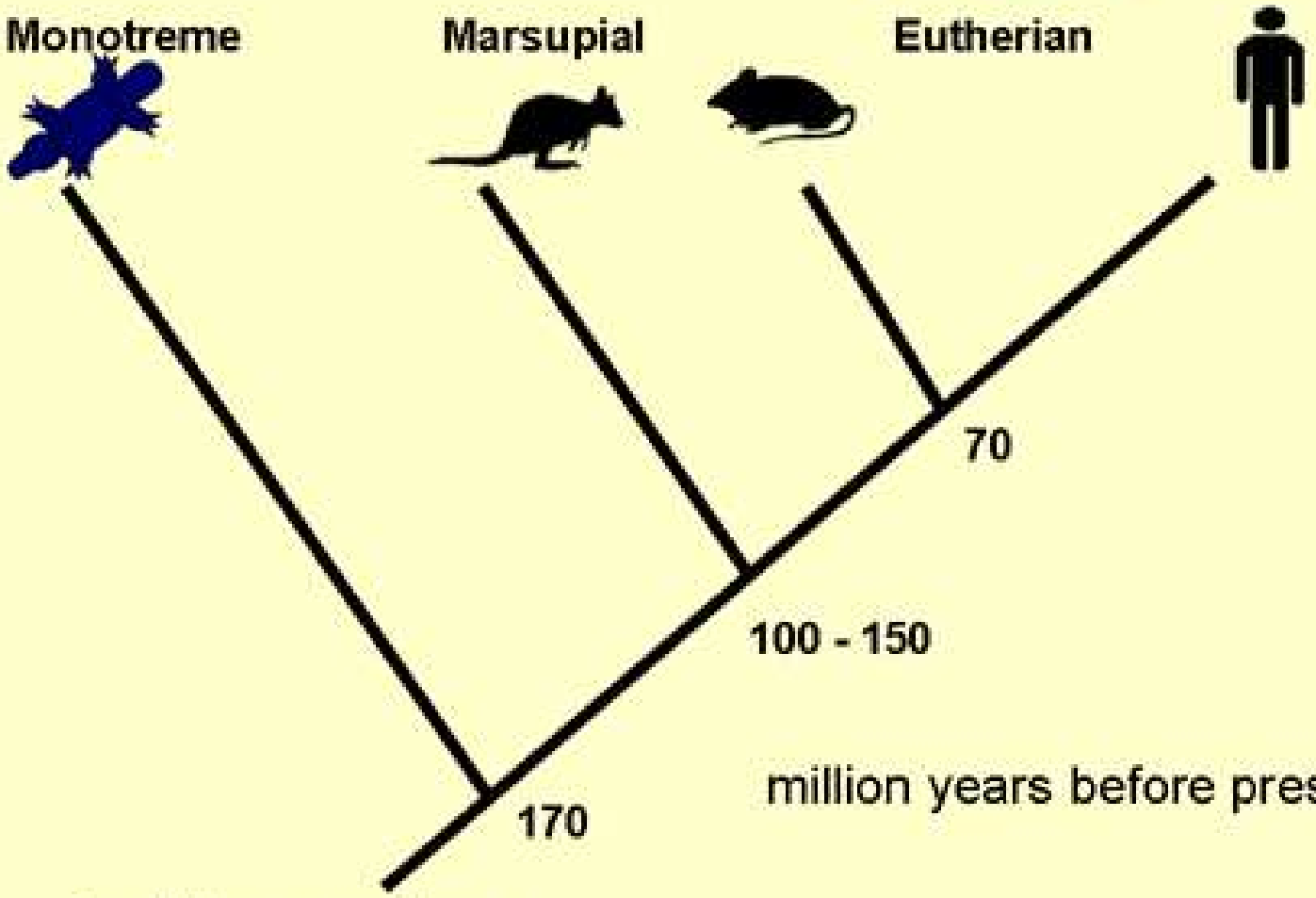
-Distribution of plants and animals

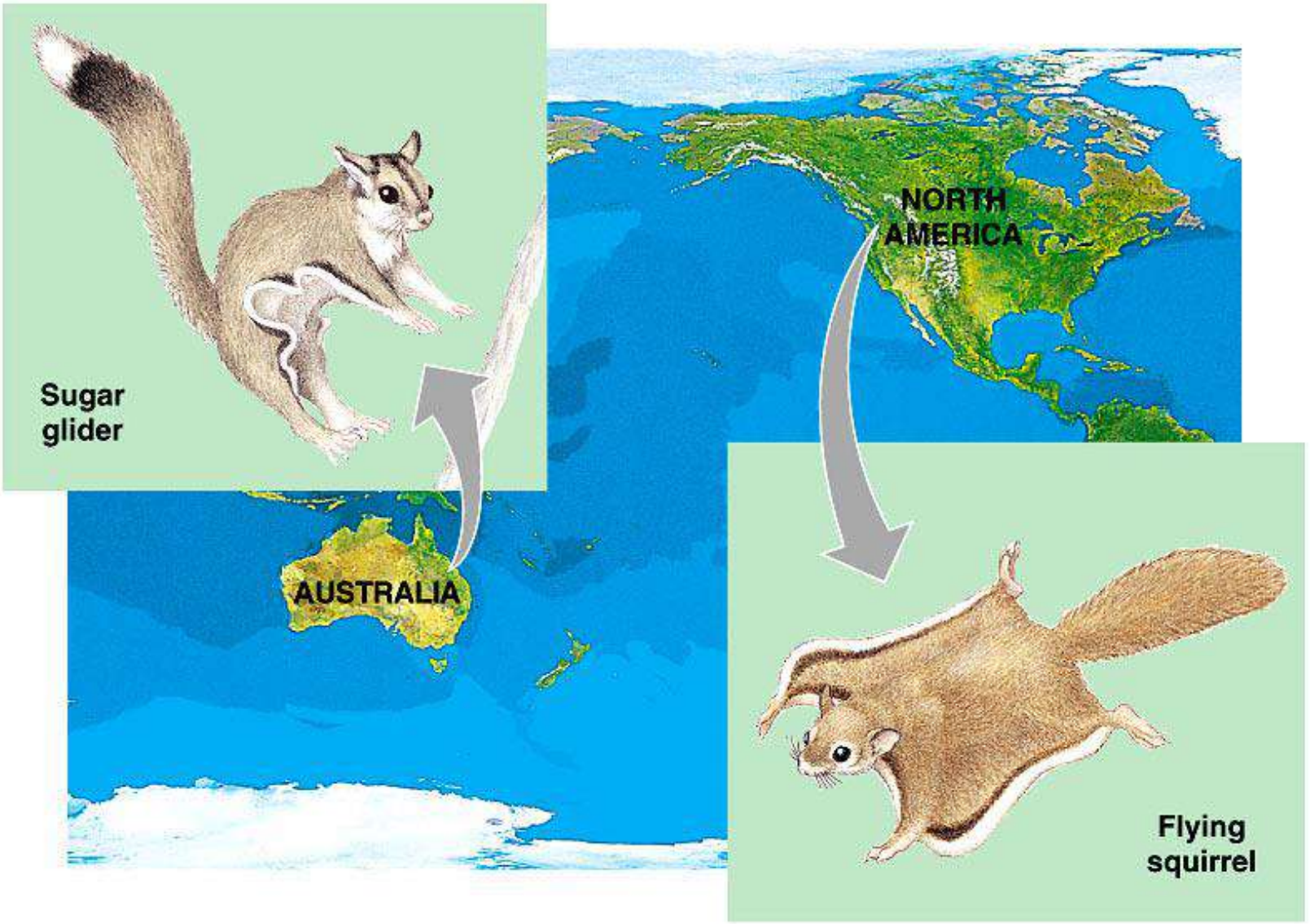
-**Isolation** and **evolution**

-Examples: 13 species of finches on the 13 Galapagos Islands

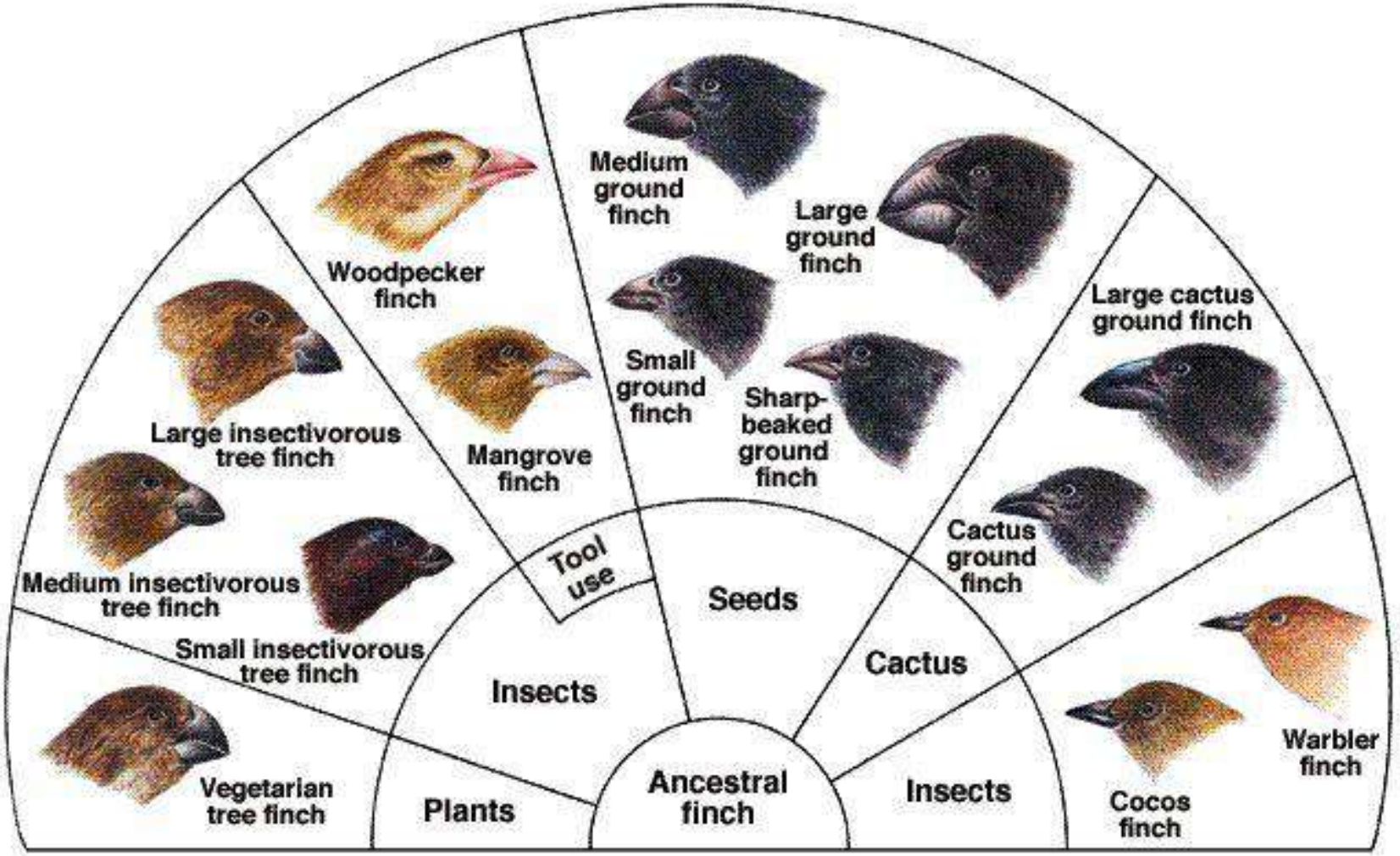
-57 species of Kangaroos…all in Australia

Mammalian Phylogeny





Darwin's Theory of Finches on the Galápagos Islands

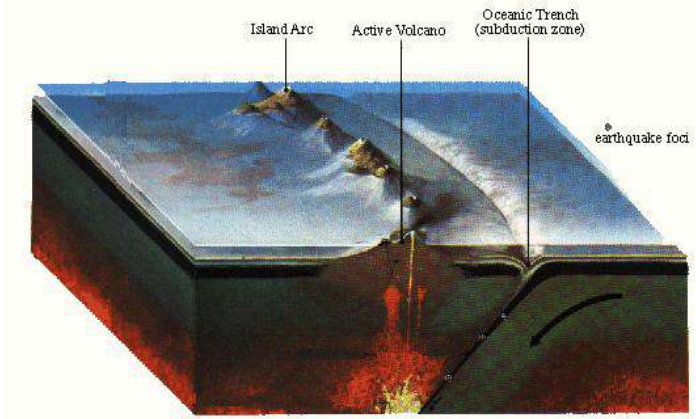


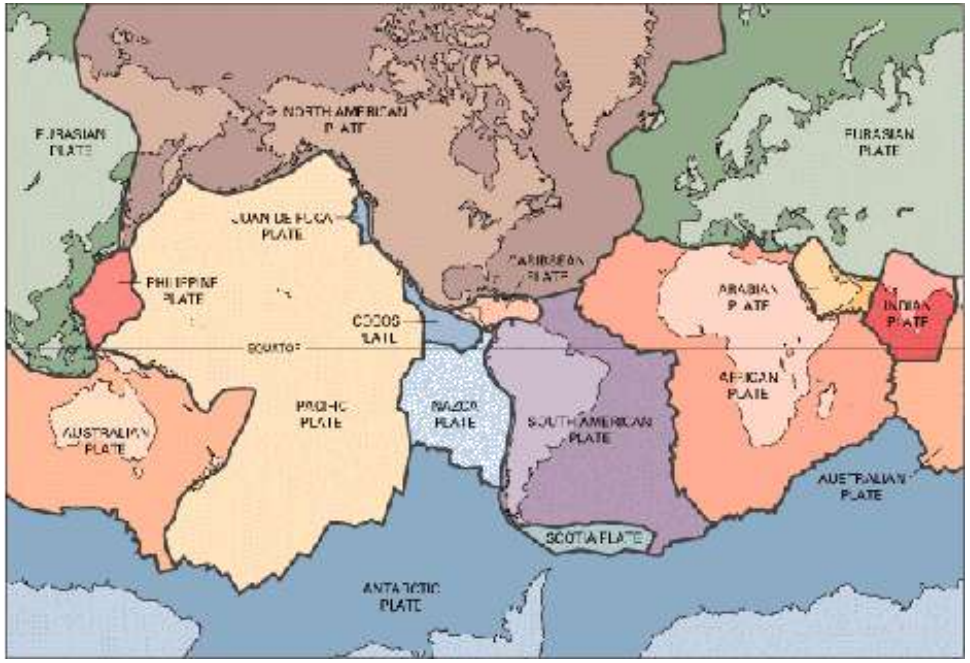
Lines of Evidence: (cont.)

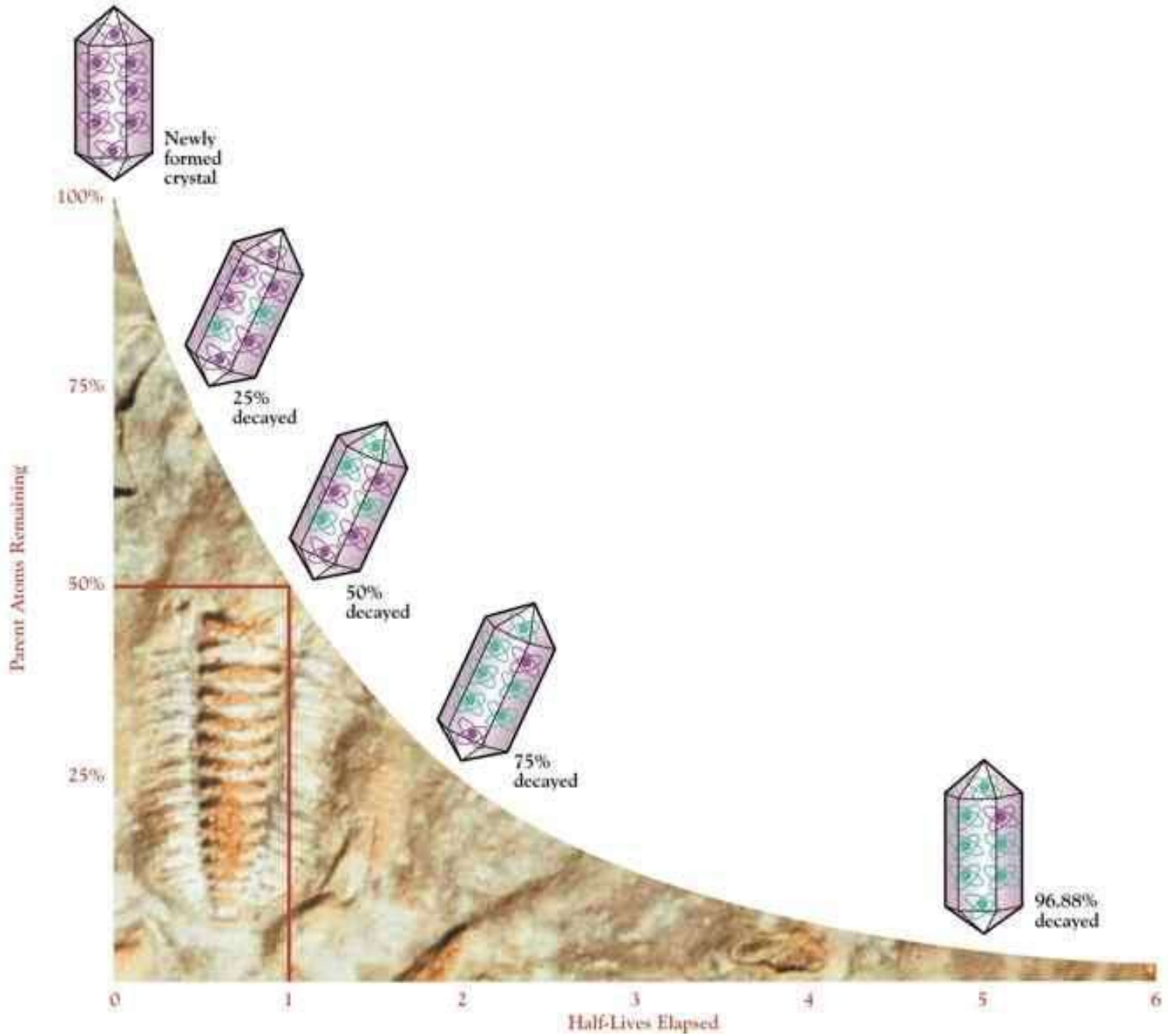
4) **Age of Earth:**

-Rates of motion of tectonic plates

-Radioactive dating



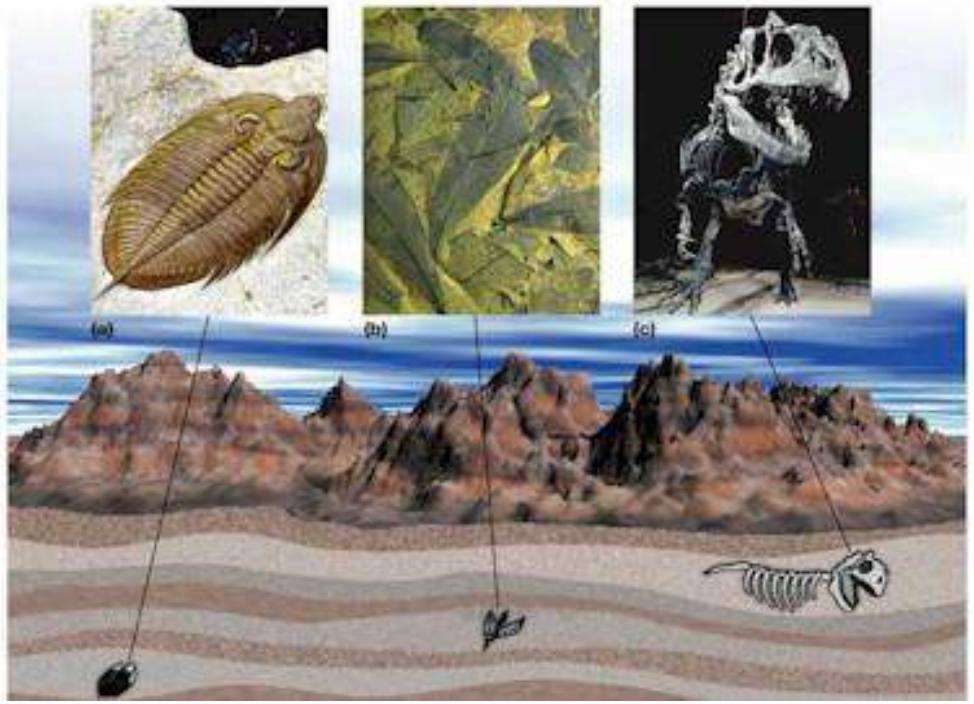



Newly formed crystal
100%
75%
25% decayed
50%
50% decayed
25%
75% decayed
96.88% decayed
Parent Atoms Remaining
0
1
2
3
4
5
6
Half-Lives Elapsed

5) **FOSSILS:**

-Evidence of once-living things (shells, casts, bones, teeth, imprints)

-Show a succession of forms through a vast span of time



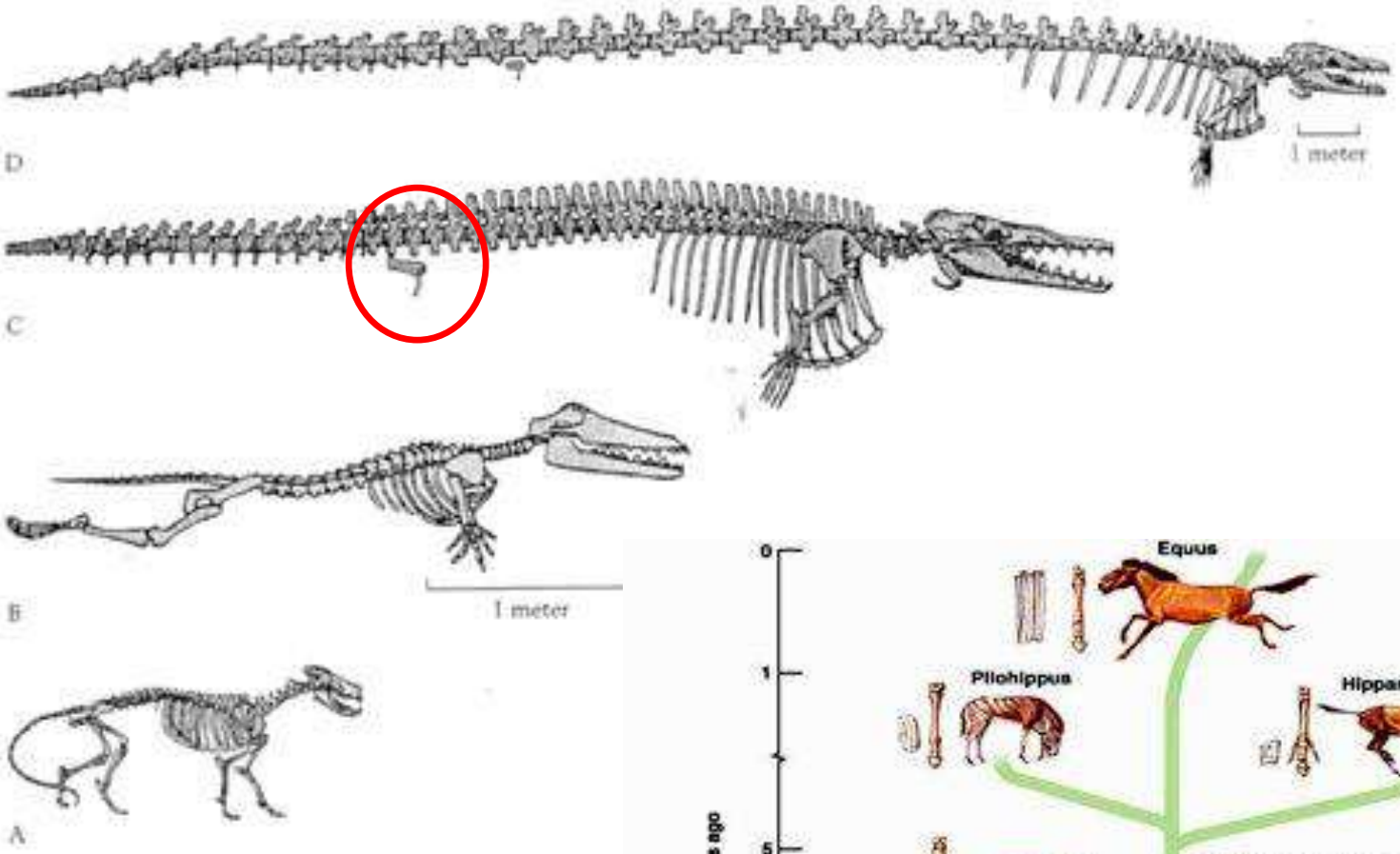
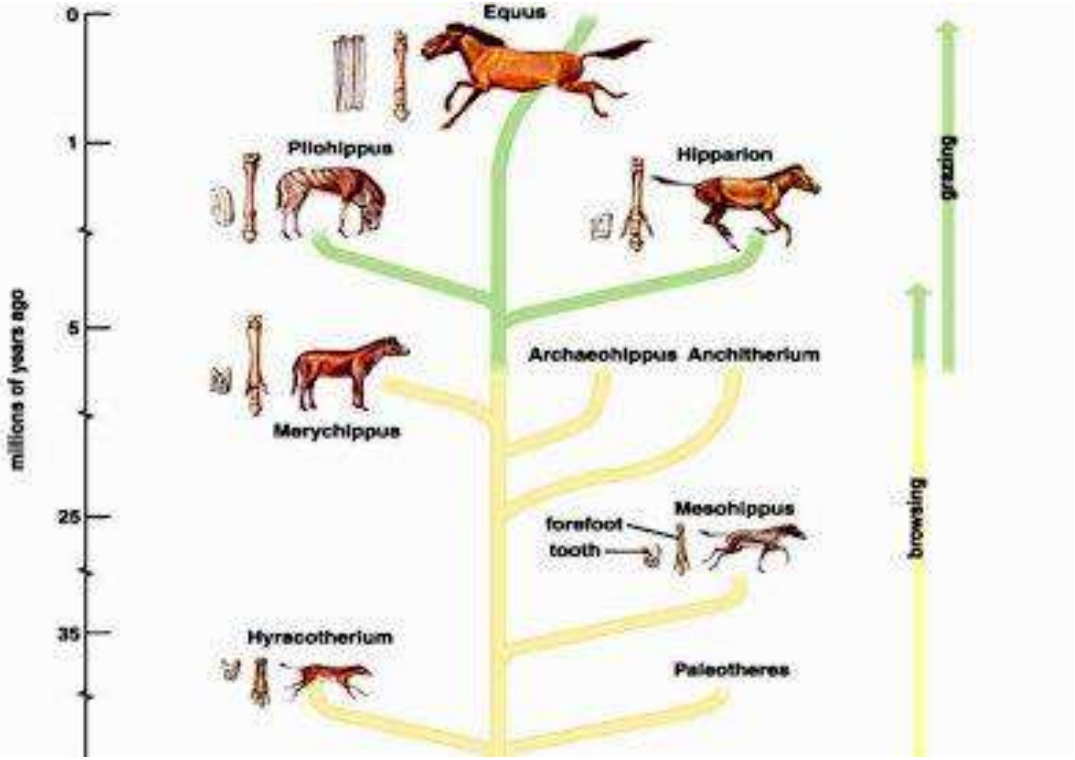


Figure 7-15 Stages in the evolution of whales. *A*. A member of the mesonychid group of terrestrial mamm from which whales evolved. *B*. *Ambulocetus*, an early whale that lived about 50 million years ago and probal spent some time on land at the water's edge. *C* and *D*

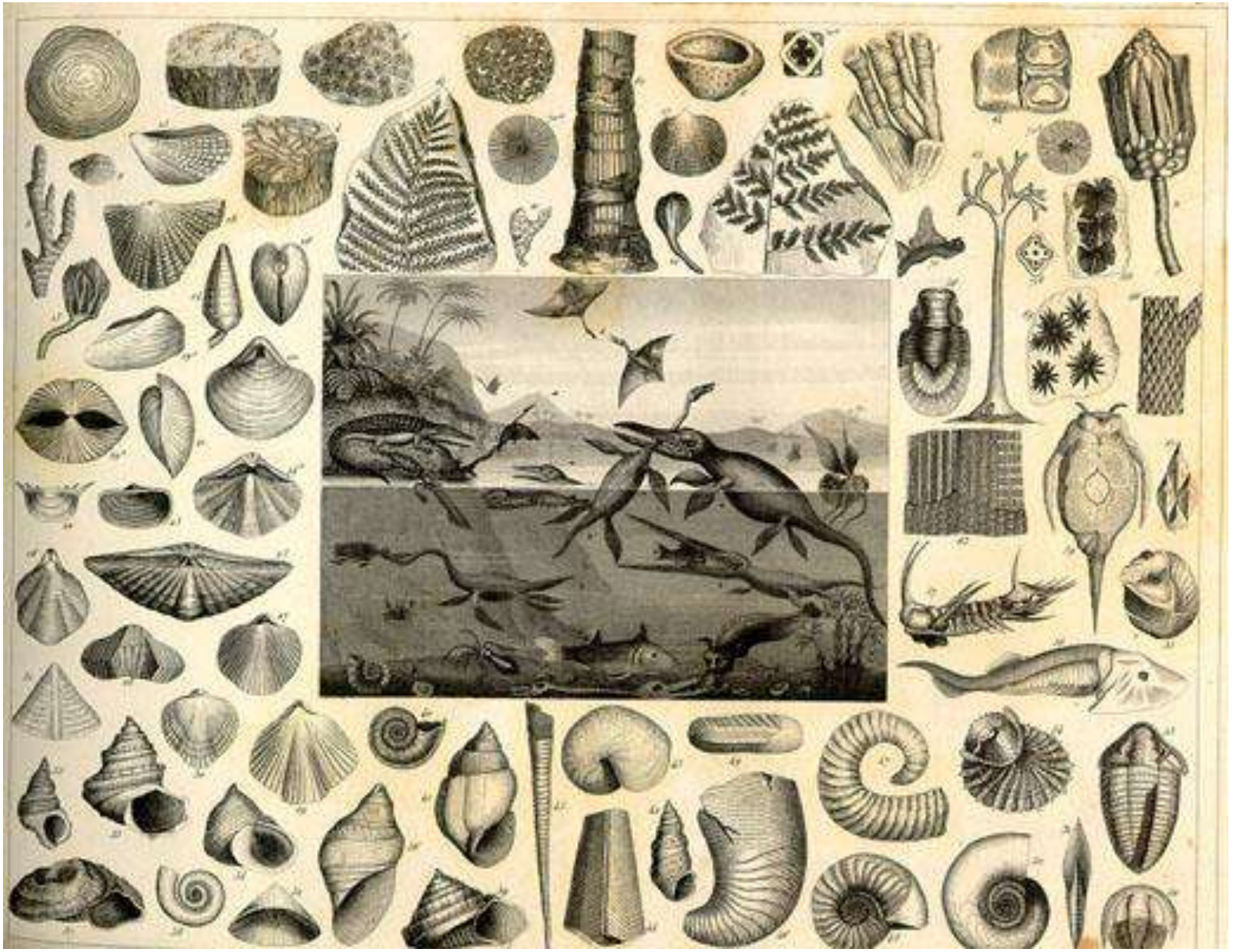


Lines of Evidence (cont.):

-We see progressive changes based on the order they were buried in sedimentary rock:

*Few → *many fossils / species*

*Simple → *complex organisms*



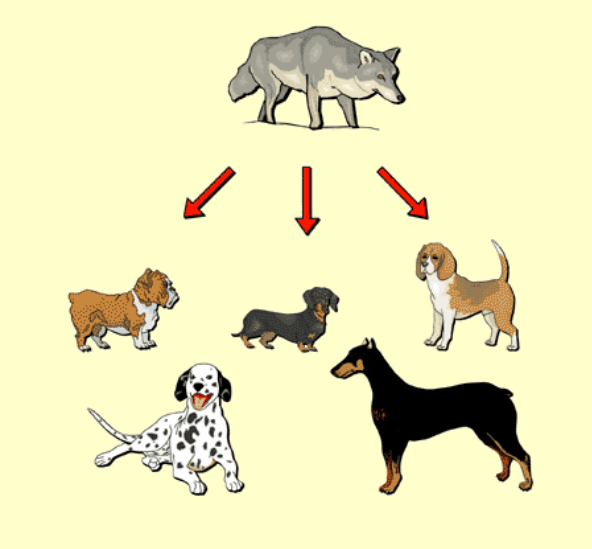
Lines of Evidence (cont.):

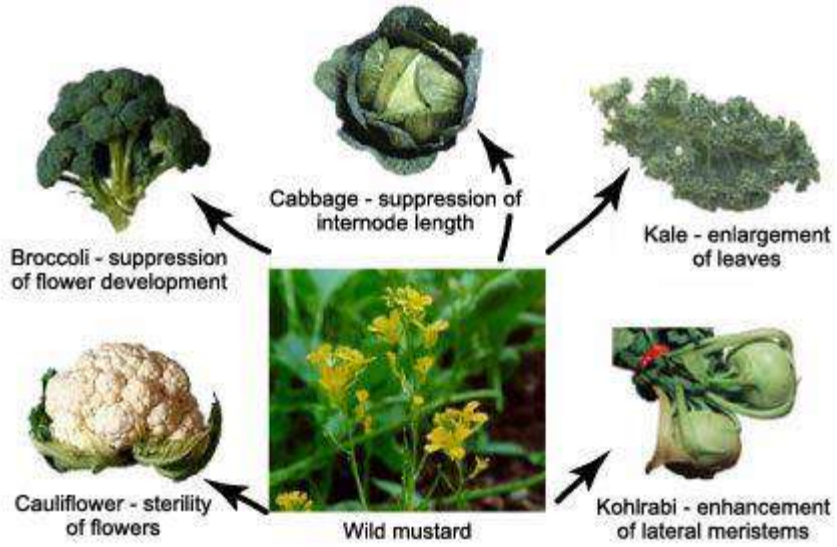
6) **Applied Genetics: "Artificial Selection"**

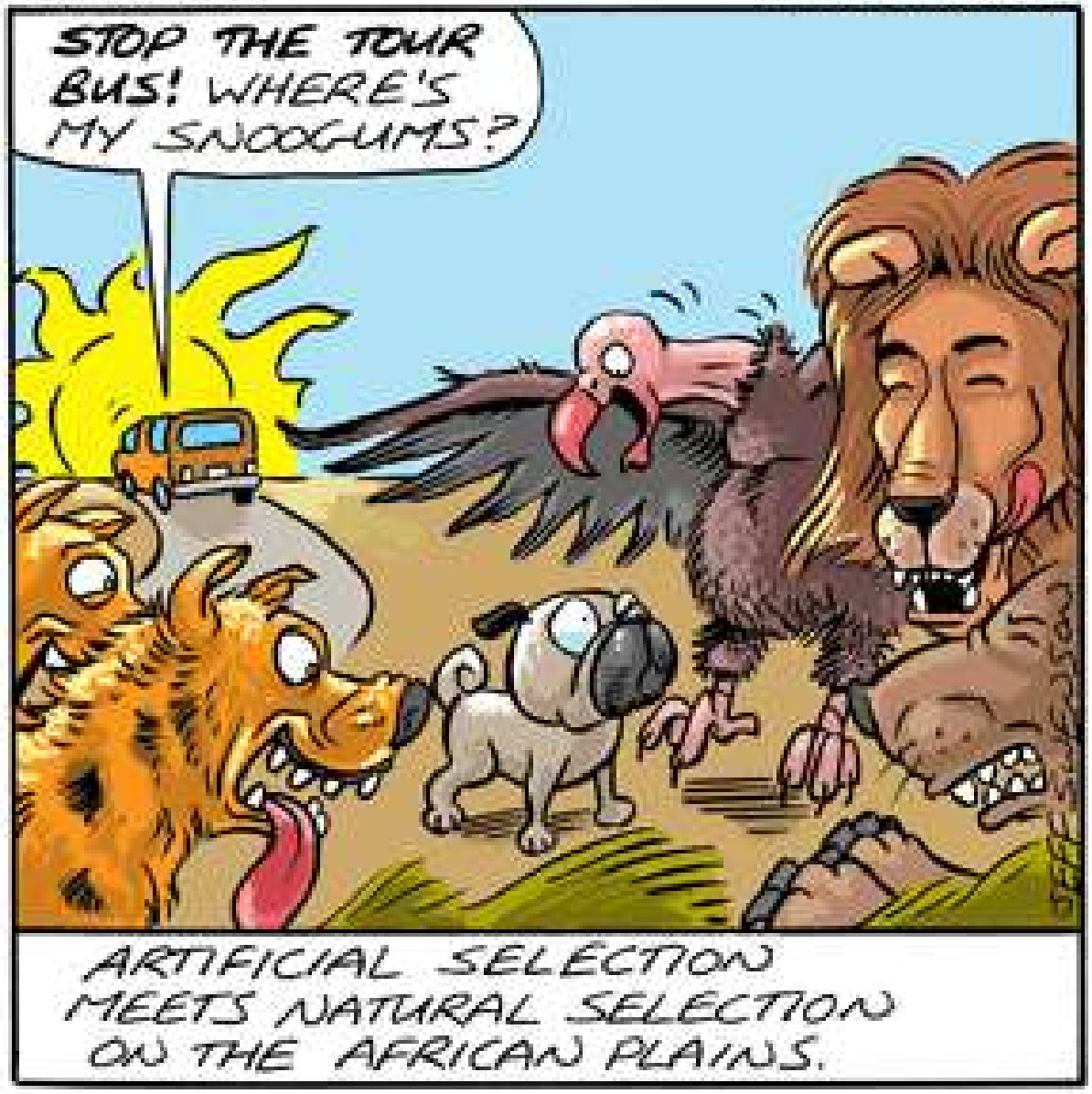
-animal breeds (cattle, dogs, cats)

-insecticide-resistant insects

-special food crops






STOP THE TOUR BUS! WHERE'S MY SNOOGUMS?
ARTIFICIAL SELECTION MEETS NATURAL SELECTION ON THE AFRICAN PLAINS.















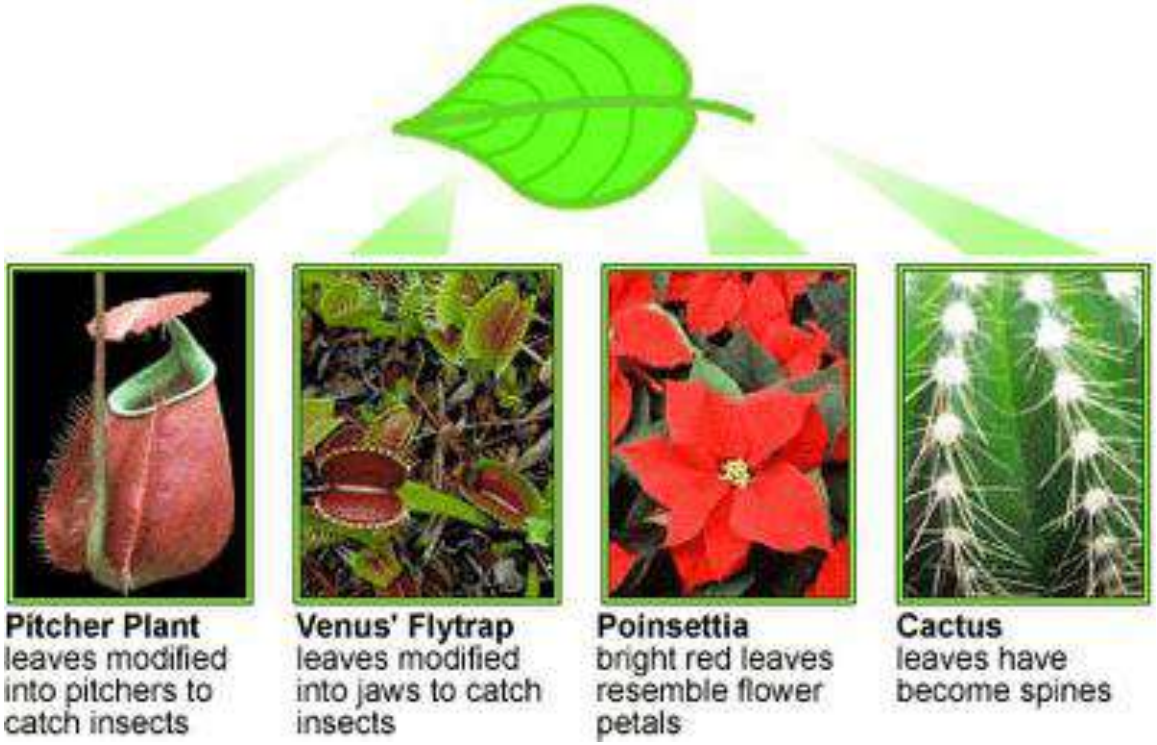




~10,000 years of evolution by artifical selection

LBR 10/2002

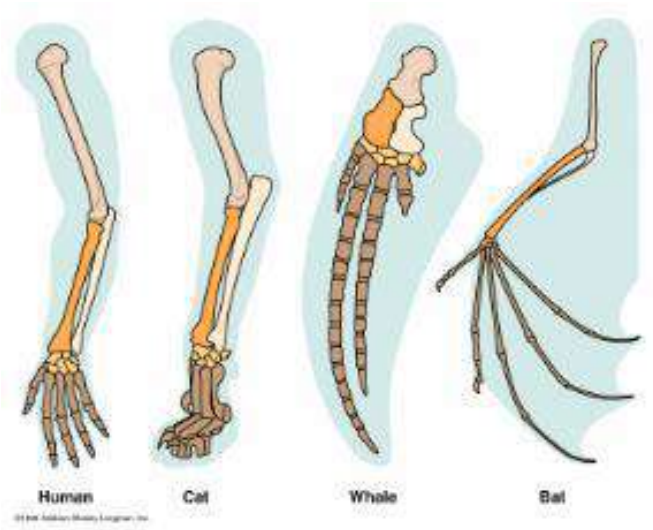
7) **Homologies:** similarities in characteristics resulting from common ancestry

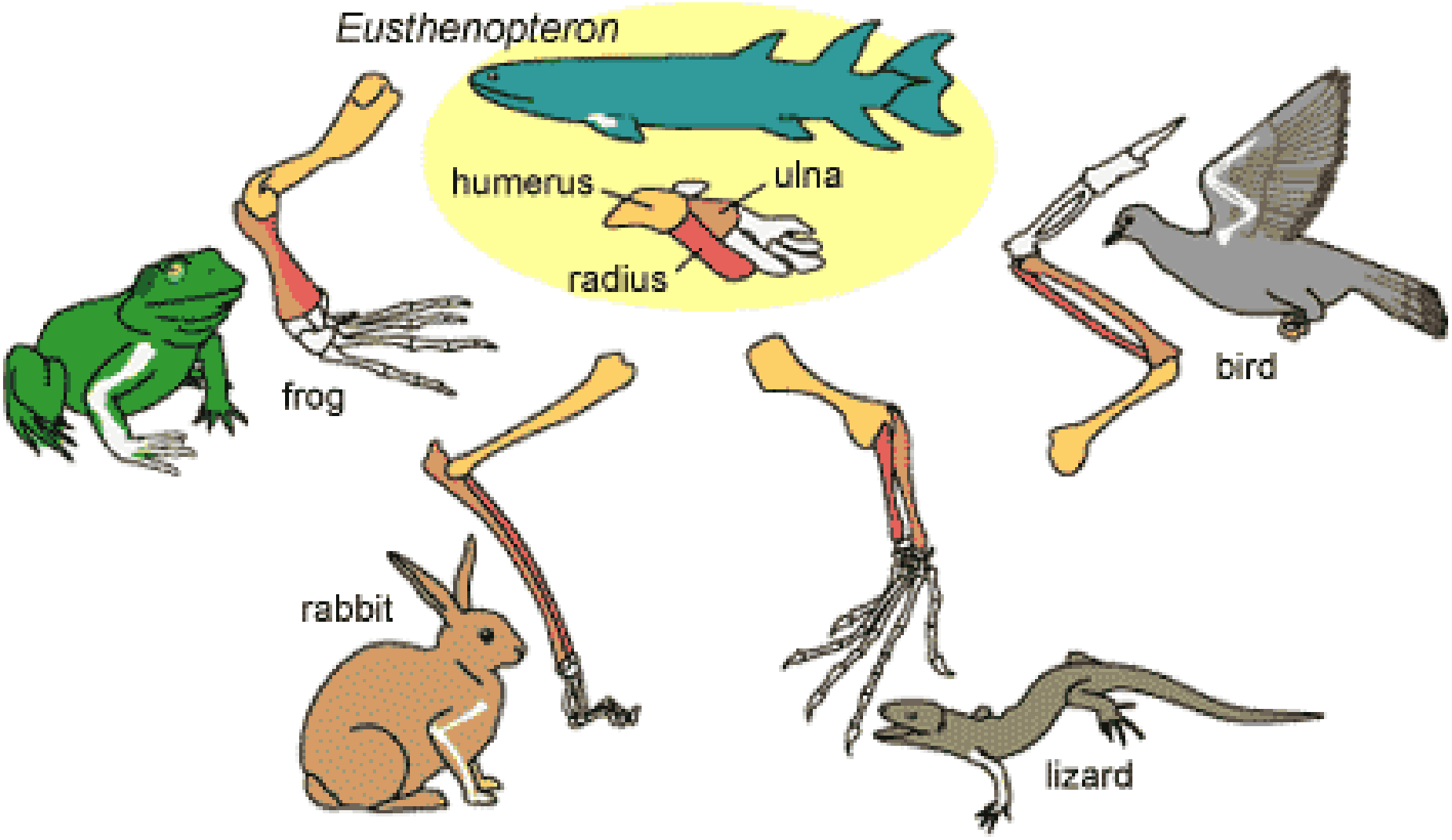


Anatomical Homologies:

- comparative anatomy reveals **HOMOLOGOUS STRUCTURES** (same underlying structures, different functions)

  -EX: forearm bones!

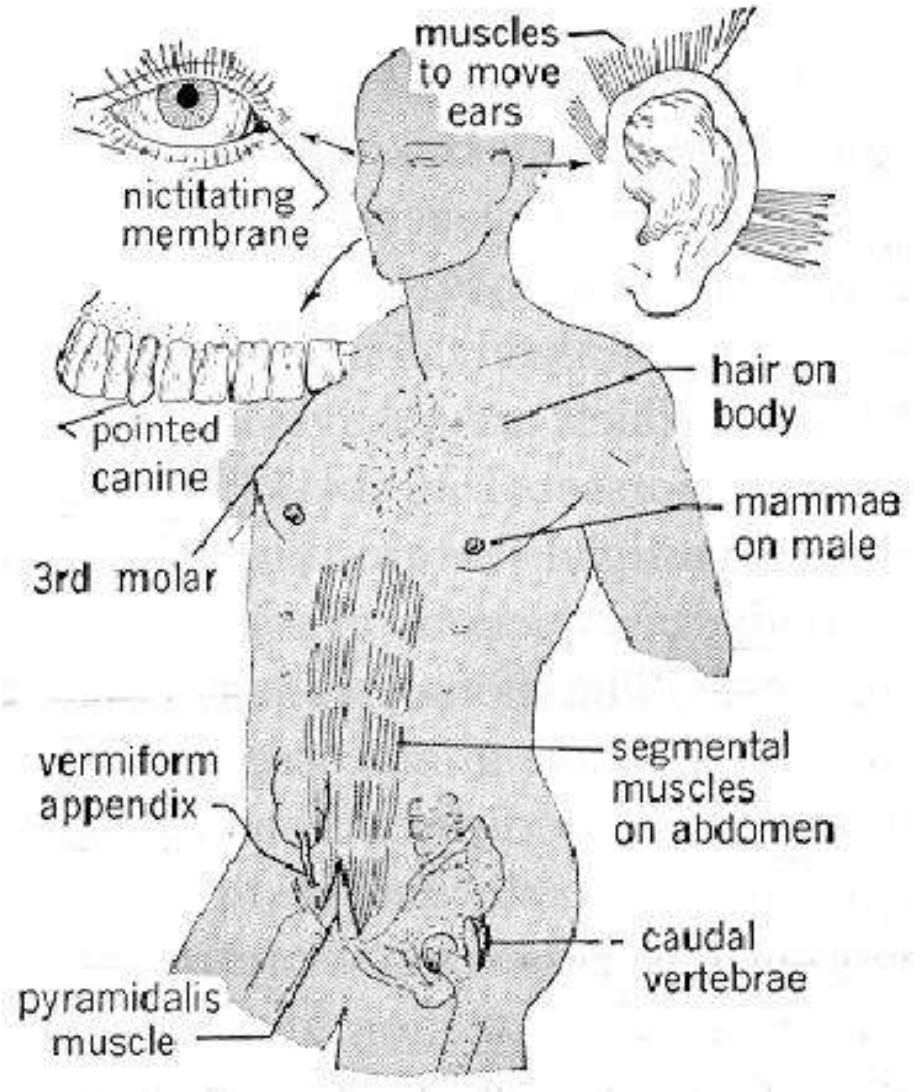


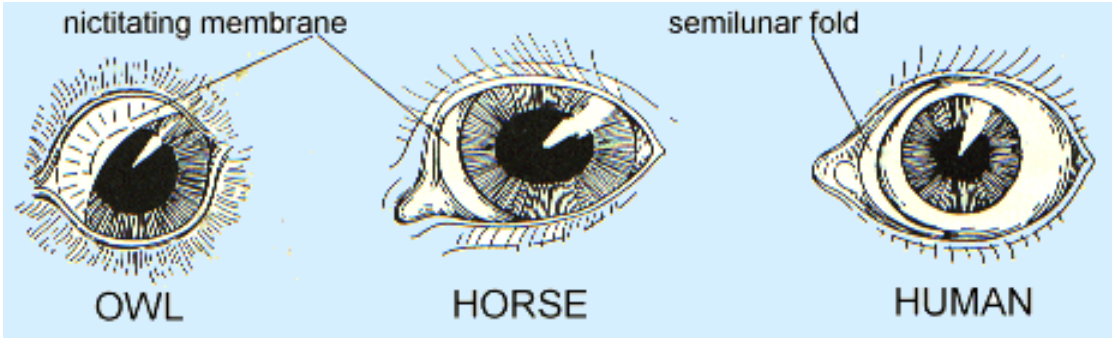

Eusthenopteron
humerus
ulna
radius
frog
bird
rabbit
lizard

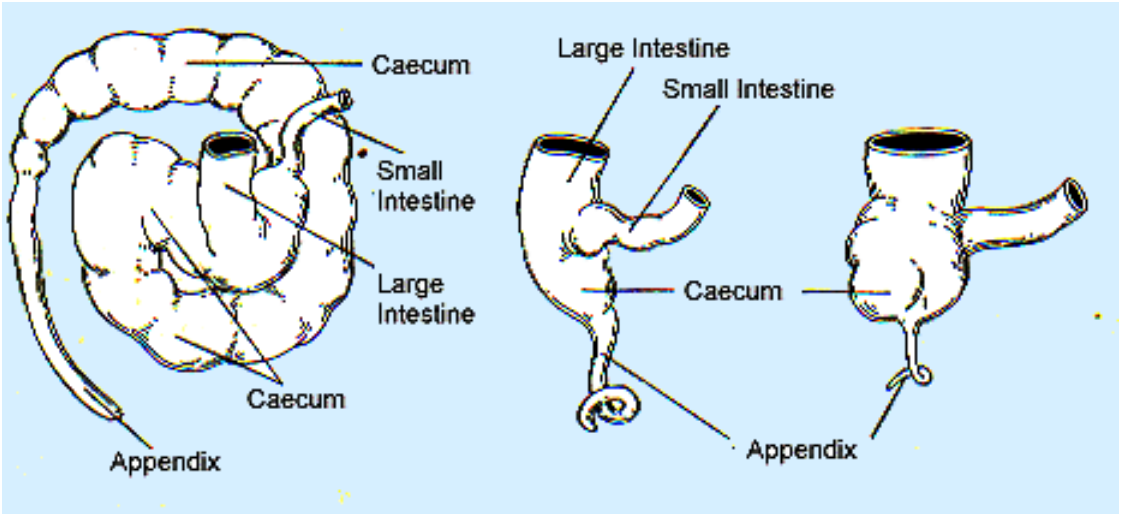
Vestigial Organs:

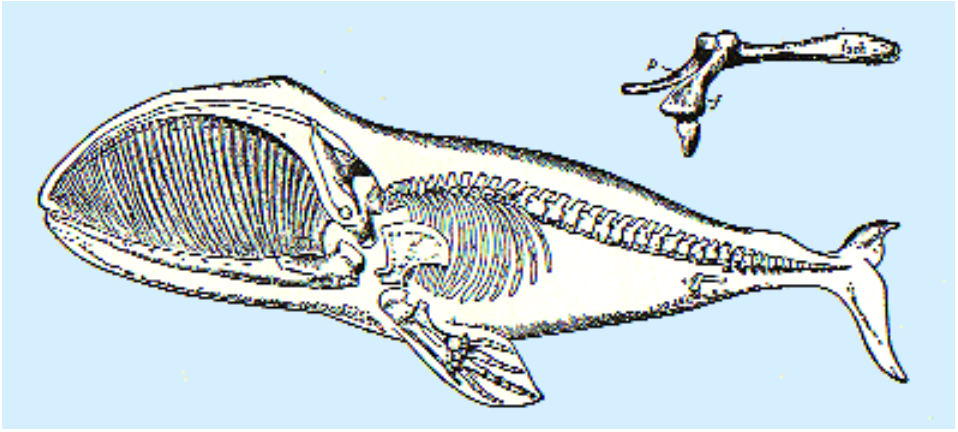
-“Leftovers” from the evolutionary past

-Structures that no longer serve their purpose



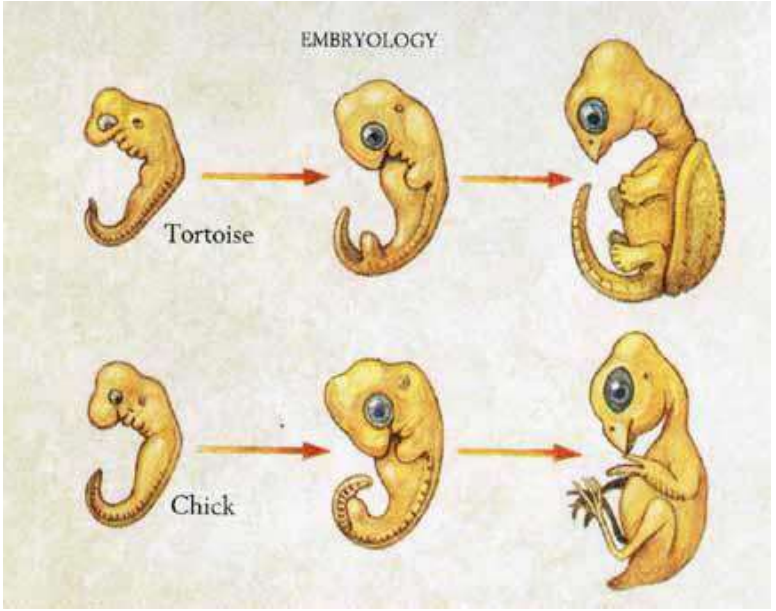

nictitating membrane
semilunar fold
OWL
HORSE
HUMAN

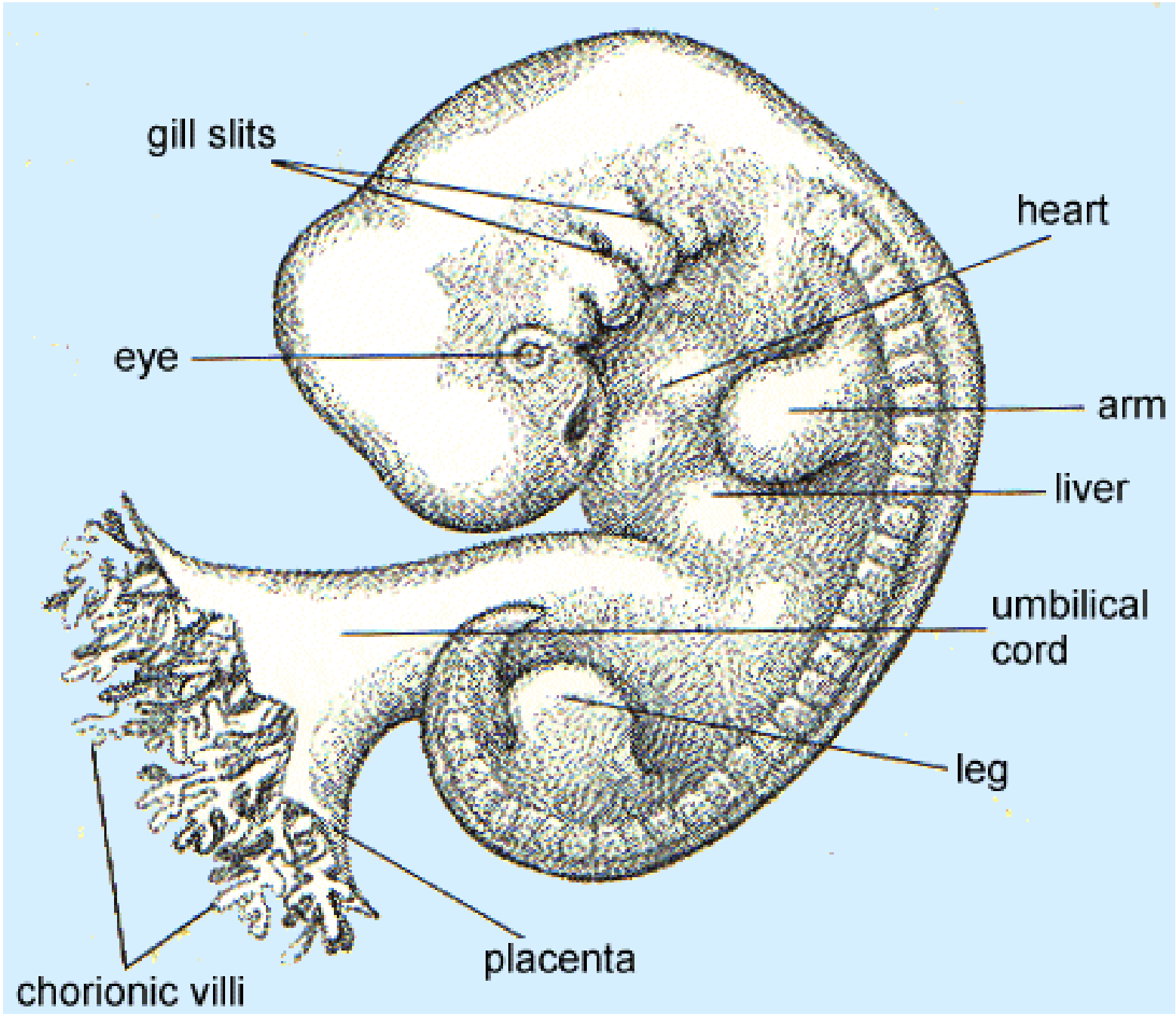

Caecum
Small Intestine
Large Intestine
Caecum
Appendix
Large Intestine
Small Intestine
Caecum
Appendix



Embryological Homologies:

- similarities evident in different stages of embryo development




gill slits
heart
eye
arm
liver
umbilical cord
leg
placenta
chorionic villi

Molecular/Biochemical Homologies:

- DNA is the “universal” genetic code or code of life
- Proteins (sequences of amino acids)

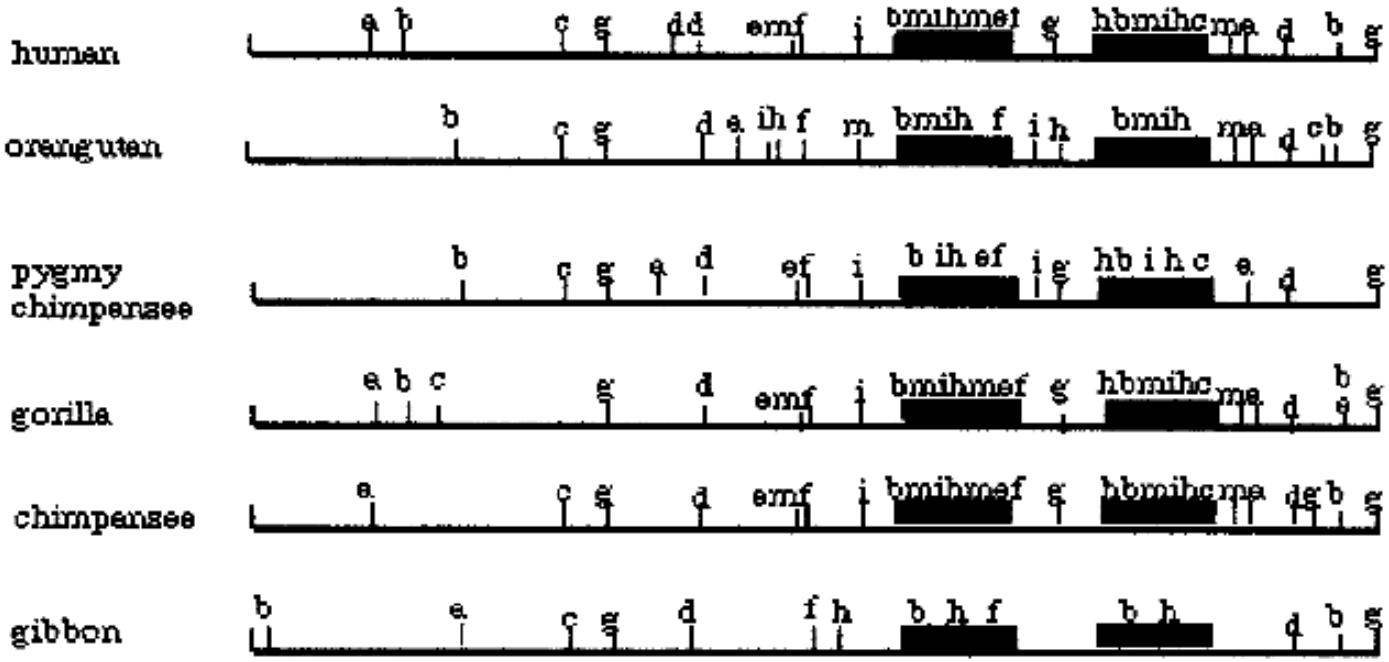
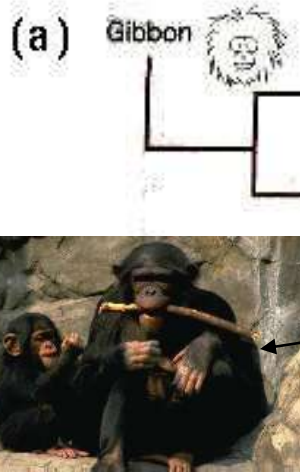
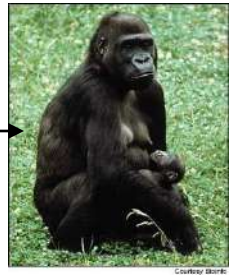
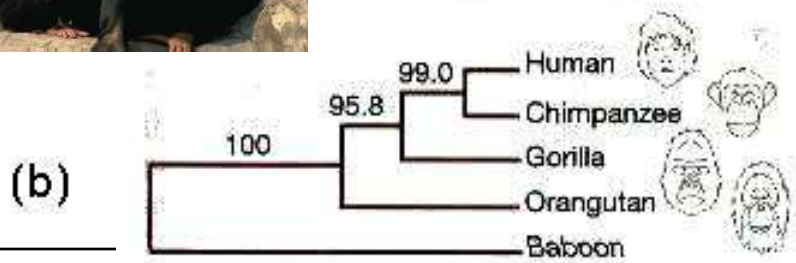


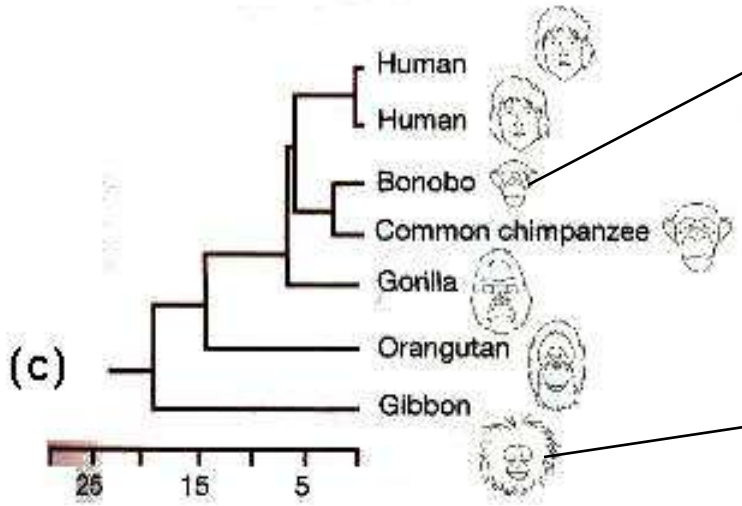
Table 22.1 Molecular Data and the Evolutionary Relationships of Vertebrates

Species	Number of Amino Acids That Differ from a Human Hemoglobin Polypeptide (Total Chain Length = 146 Amino Acids)
Human 	0
Rhesus monkey 	8
Mouse 	27
Chicken 	45
Frog 	67
Lamprey 	125

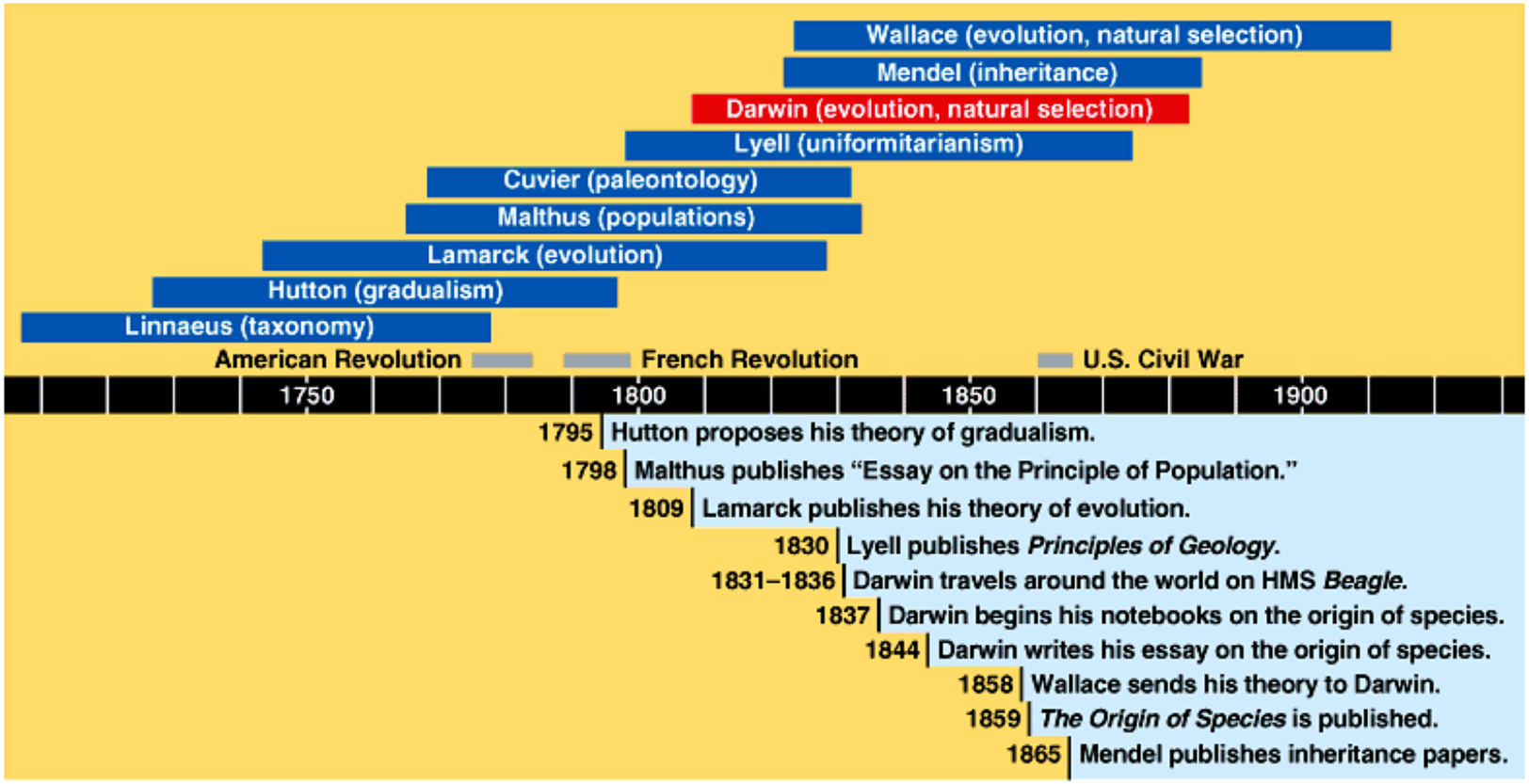

(a)
Gibbon
Orangutan
Gorilla
Human
Pygmy chimpanzee
Common chimpanzee




(b)
99.0
95.8
100
Human
Chimpanzee
Gorilla
Orangutan
Baboon

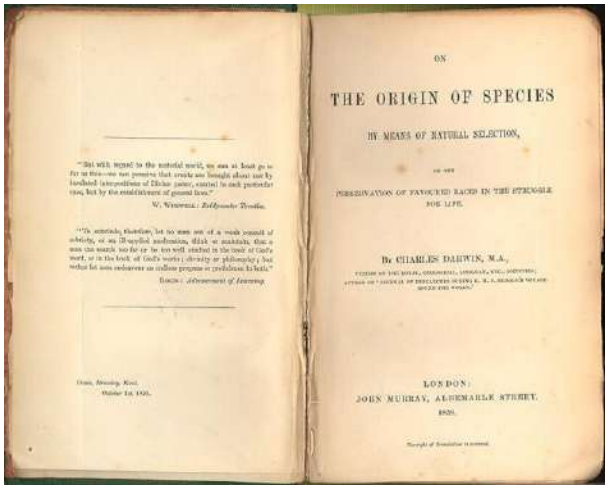

(c)
Human
Human
Bonobo
Common chimpanzee
Gorilla
Orangutan
Gibbon
25
15
5

Darwin & the Scientists of his time



Introduction to Darwin…

- On November 24, 1859, Charles Darwin published *On the Origin of Species by Means of Natural Selection*.
- Darwin's book drew a cohesive picture of life by connecting what had once seemed a bewildering array of unrelated facts.


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

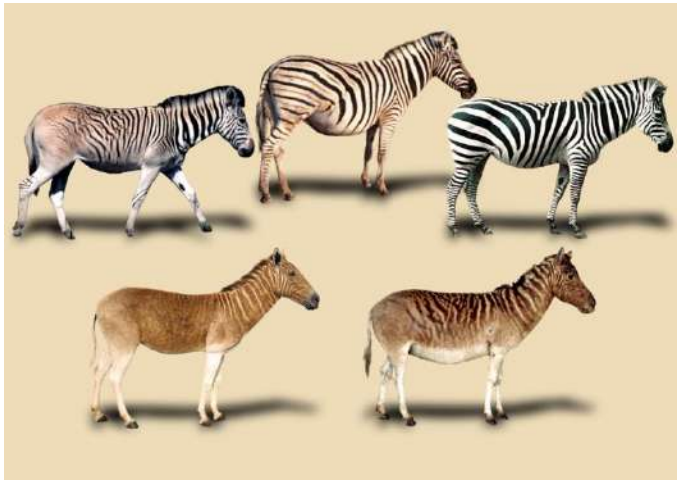
LONDON:
JOHN MURRAY, ALBEMARLE STREET.

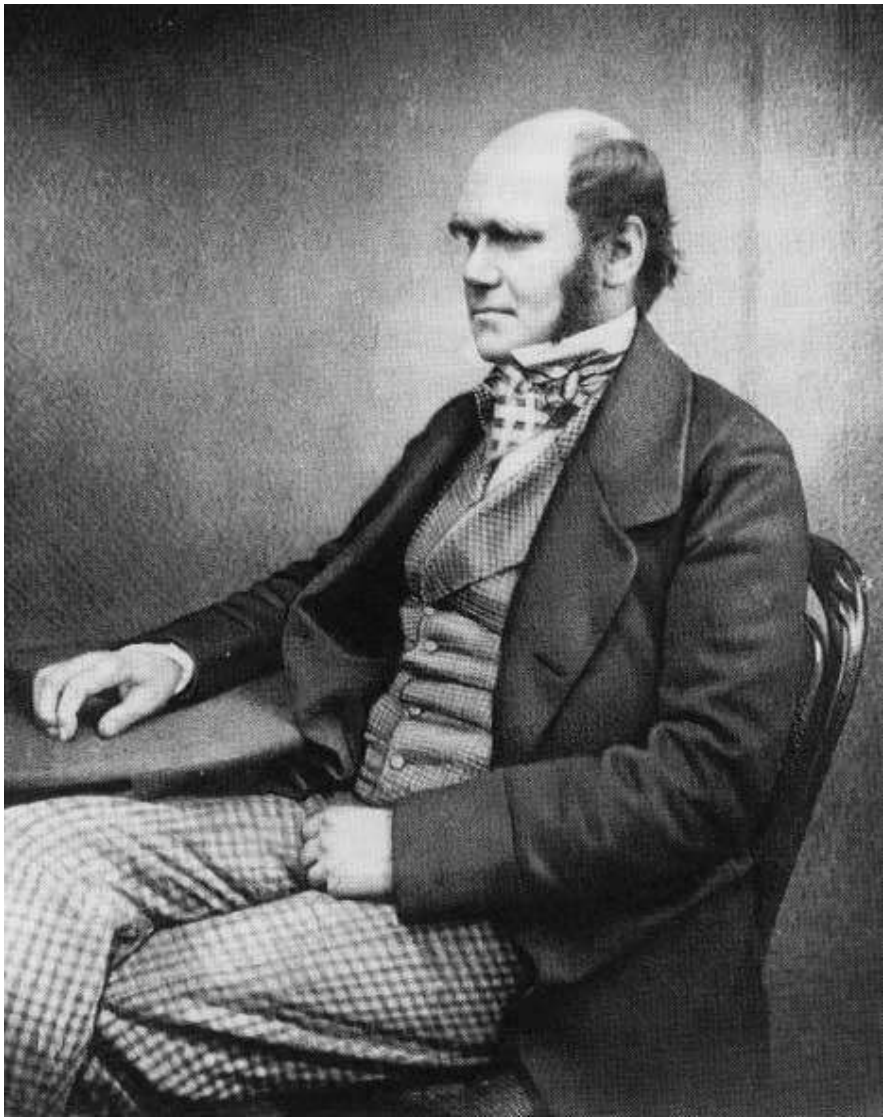
Introduction to Darwin…

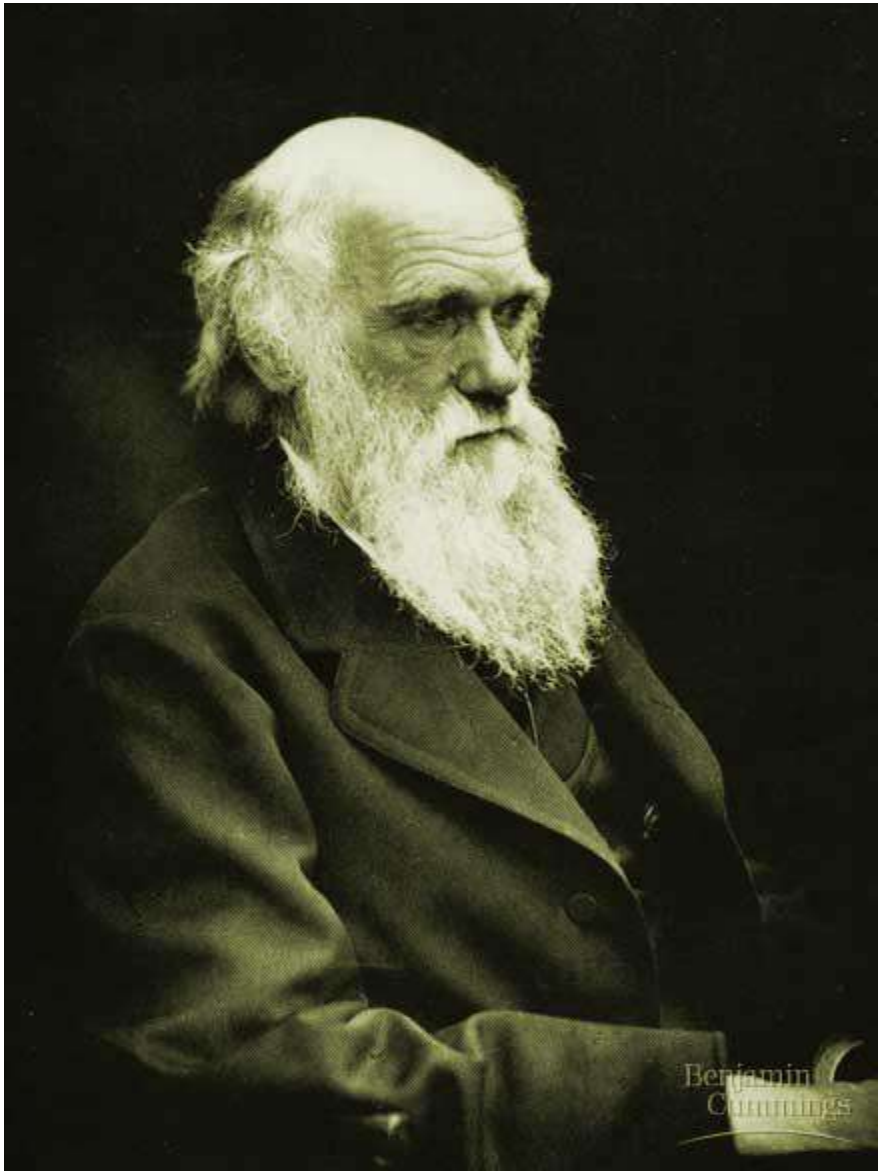
- Darwin made two points in *The Origin of Species*:

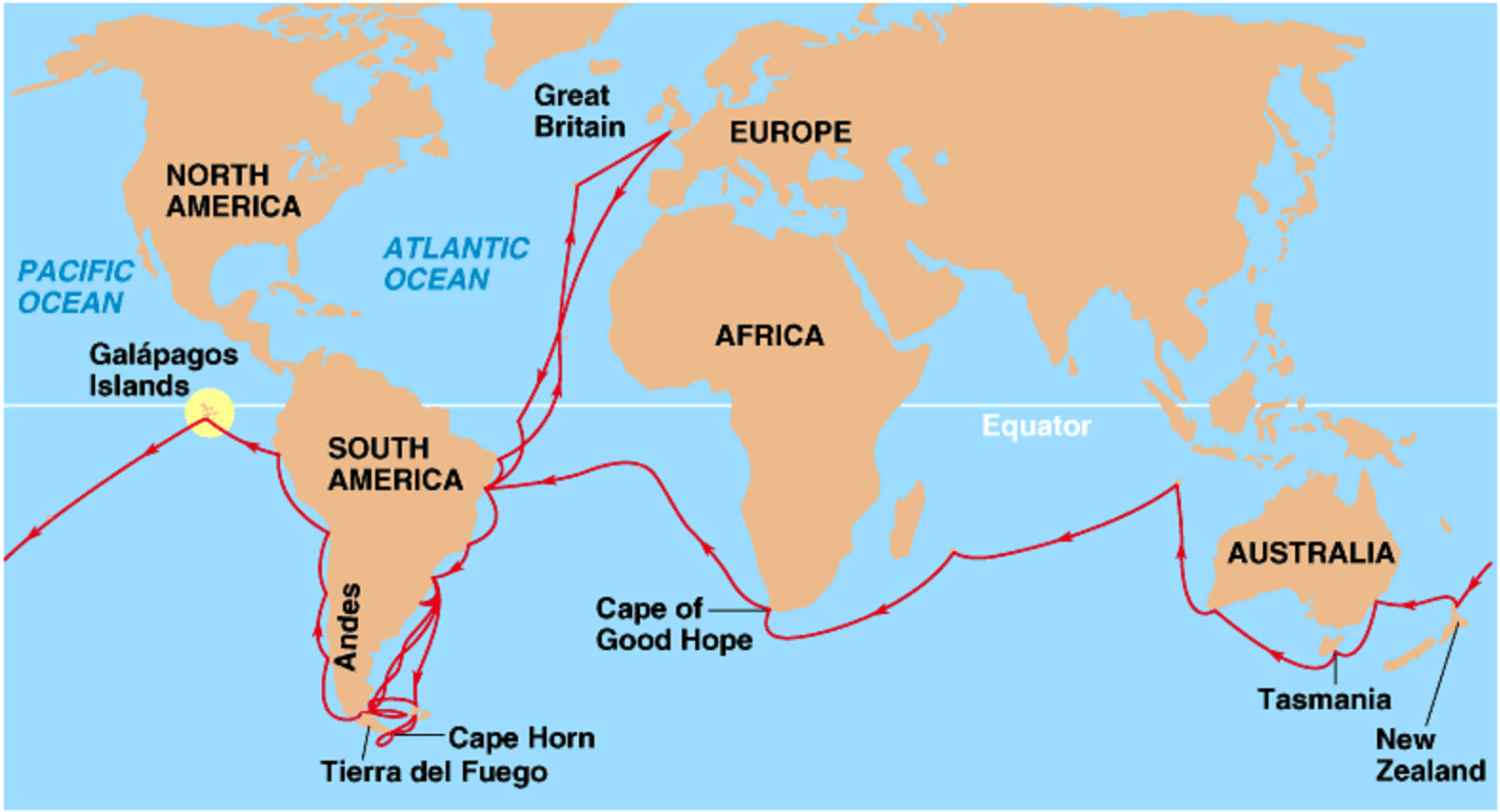
1) Today's organisms descended from ancestral species;

2) Natural selection provided a mechanism for evolutionary change in populations.






Benjamin
Cummings

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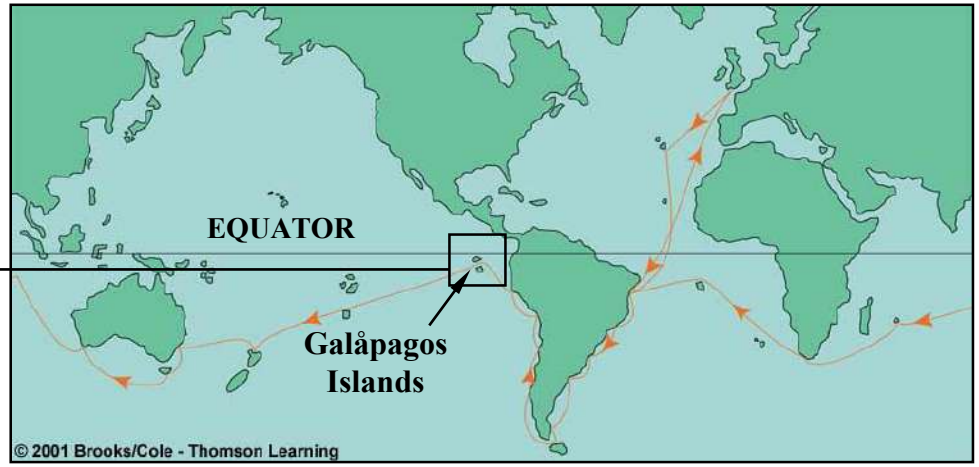
Darwin
Wolf
Pinta
Marchena
Genovesa
Santiago
Bartolomé
Seymour
Råbida
Baltra
Pin zon
Fernandia
Santa Cruz
Santa Fe
Tortuga
San Cristobal
Isabela
Española
Floreana
© 2001 Brooks/Cole - Thomson Learning


EQUATOR
Galåpagos
Islands
© 2001 Brooks/Cole - Thomson Learning

Alfred Wallace


© 2001 Brooks/Cole - Thomson Learning

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;

AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1859.

Darwin's Influences…
A Flurry of New Theories!

- **Cuvier -** Catastrophism
- **Jean Baptiste Lamarck -** Theory of Inheritance of Acquired Characteristics
- **Lyell -** Uniformitarianism
- **Hutton -** Gradualism

Georges Cuvier

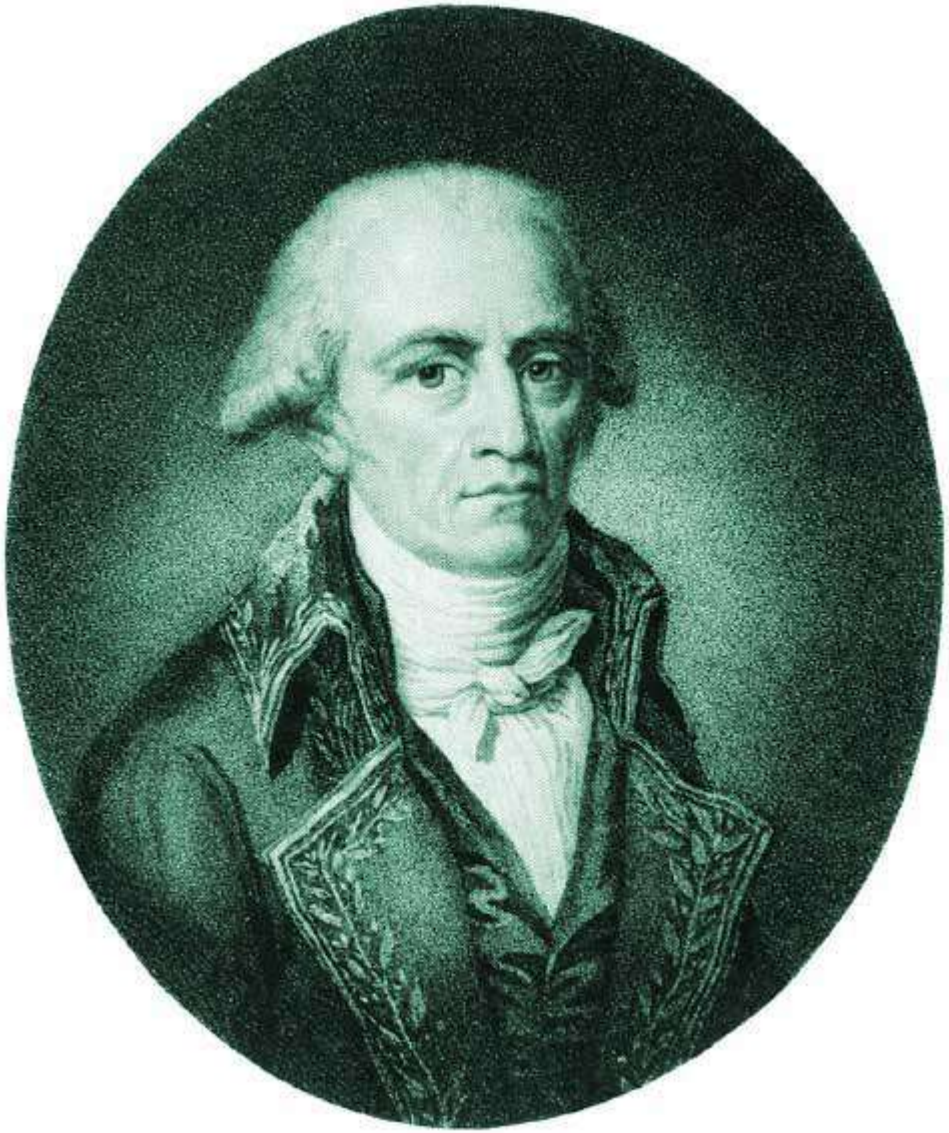
- **Paleontology**, the study of fossils, was largely developed by Georges Cuvier, a French anatomist.
- In particular, Cuvier documented the succession of fossil species in the Paris Basin.

  -Cuvier recognized that extinction had been a common occurrence in the history of life.

  -Instead of evolution, Cuvier advocated **catastrophism**, that boundaries between strata were due to local flood or drought that destroyed the species then present.

  -Later, this area would be repopulated by species immigrating from other unaffected areas.

Lamarck



Lamarck placed fossils in an evolutionary context

- In 1809, Jean Baptiste Lamarck published a theory of evolution based on his observations of fossil invertebrates in the Natural History Museum of Paris.

  -Lamarck thought that he saw what appeared to be several lines of descent in the collected fossils and current species.

  -Each was a chronological series of older to younger fossils leading to a modern species.

- Central to Lamarck's mechanism of evolution were the concepts of use and disuse of parts and of inheritance of acquired characteristics.

  -The former proposed that body parts used extensively to cope with the environment became larger and stronger, while those not used deteriorated.

  -The latter proposed that modifications acquired during the life of an organism could be passed to offspring.

  -**Example:** long neck of the giraffe (individuals could acquire longer necks by reaching for leaves on higher branches and would pass this characteristic to their offspring)

- Lamarck's theory was a visionary attempt to explain both the fossil record and the current diversity of life through its recognition of the great age of Earth and adaptation of organisms to the environment.
- However, there is NO evidence that acquired characteristics can be inherited.

  -Acquired traits (e.g., bigger biceps) do NOT change the genes transmitted by gametes to offspring.

LAMARCK's explanation on evolution

ASSUMPTION #1 → **Law of Use and Disuse:** an organism can change certain body parts during its lifetime and pass these changes on.

CRITICISM OF THIS ASSUMPTION → Implies that an organism can sense its needs and change to meet them.

LAMARCK continued…

ASSUMPTION #2 → **Inheritance of Acquired Characteristics:** acquired traits can be passed on to offspring → population changes.

CRITICISM OF THIS ASSUMPTION → Suggests that changes in body cells can be inherited.

Lyell

Theories of geologic gradualism helped clear the path for evolutionary biologists

- In contrast to Cuvier's catastrophism, James Hutton, a Scottish geologist, proposed that the diversity of landforms (e.g., canyons) could be explained by mechanisms *currently* operating.

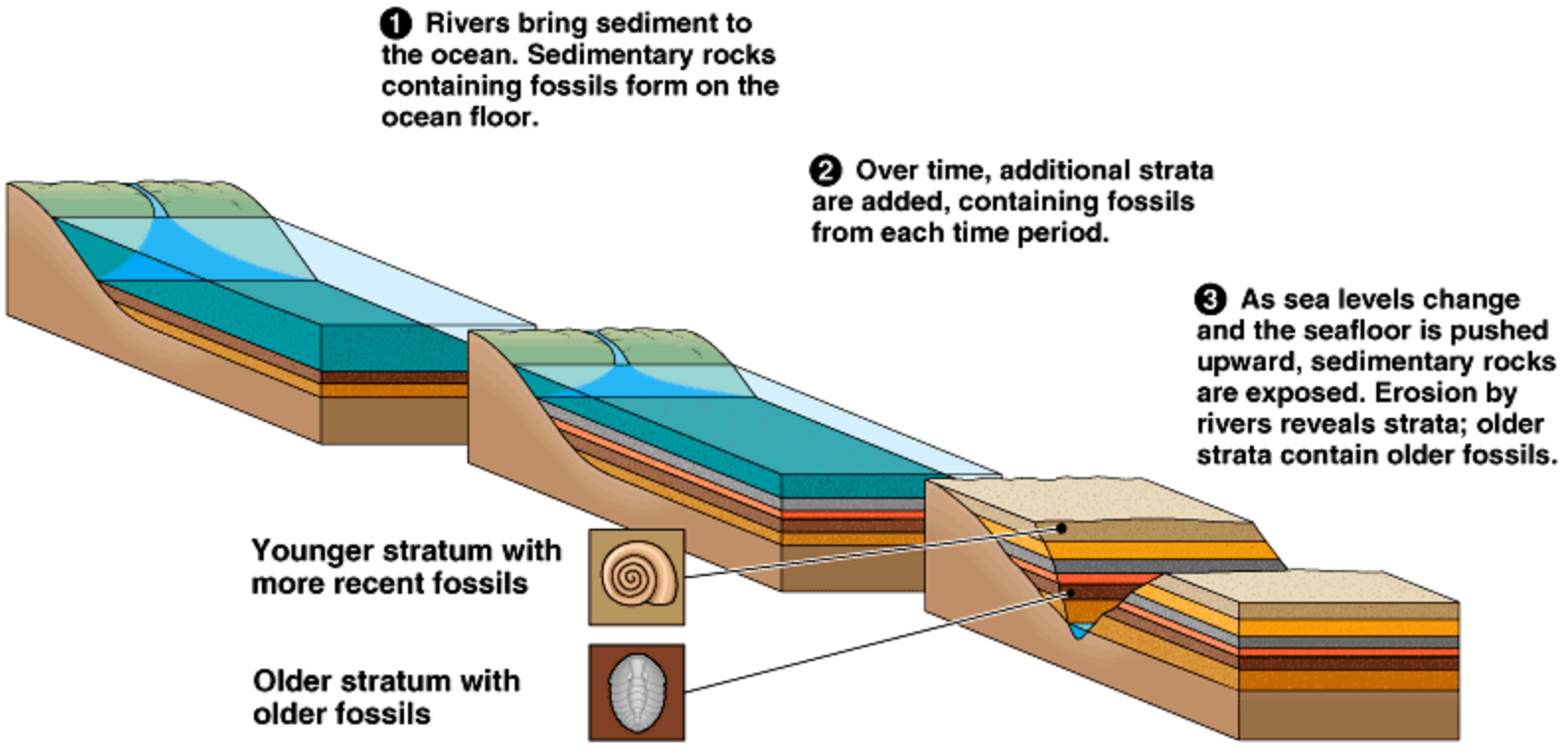
  -Hutton proposed a theory of **gradualism**, that profound change results from slow, continuous processes.

- Later, Charles Lyell proposed a theory of **uniformitarianism**, that geological processes had not changed throughout Earth's history.

- Hutton's and Lyell's observations and theories had a strong influence on Darwin.

  -First, if geologic changes result from slow, continuous processes, rather than sudden events, then the Earth must be far older than the 6,000 years assigned by theologians from biblical inference.

  -Second, slow and subtle processes persisting for long periods of time can add up to substantial change!



Darwin's Theory Takes Form:

- **Thomas Malthus:** Essay on Disease, Famine, and Population Size
- Populations produce more individuals than the environment can support
- Variations in traits affect the ability to acquire resources, survive, and reproduce
- Observation of finch species in Galapagos Islands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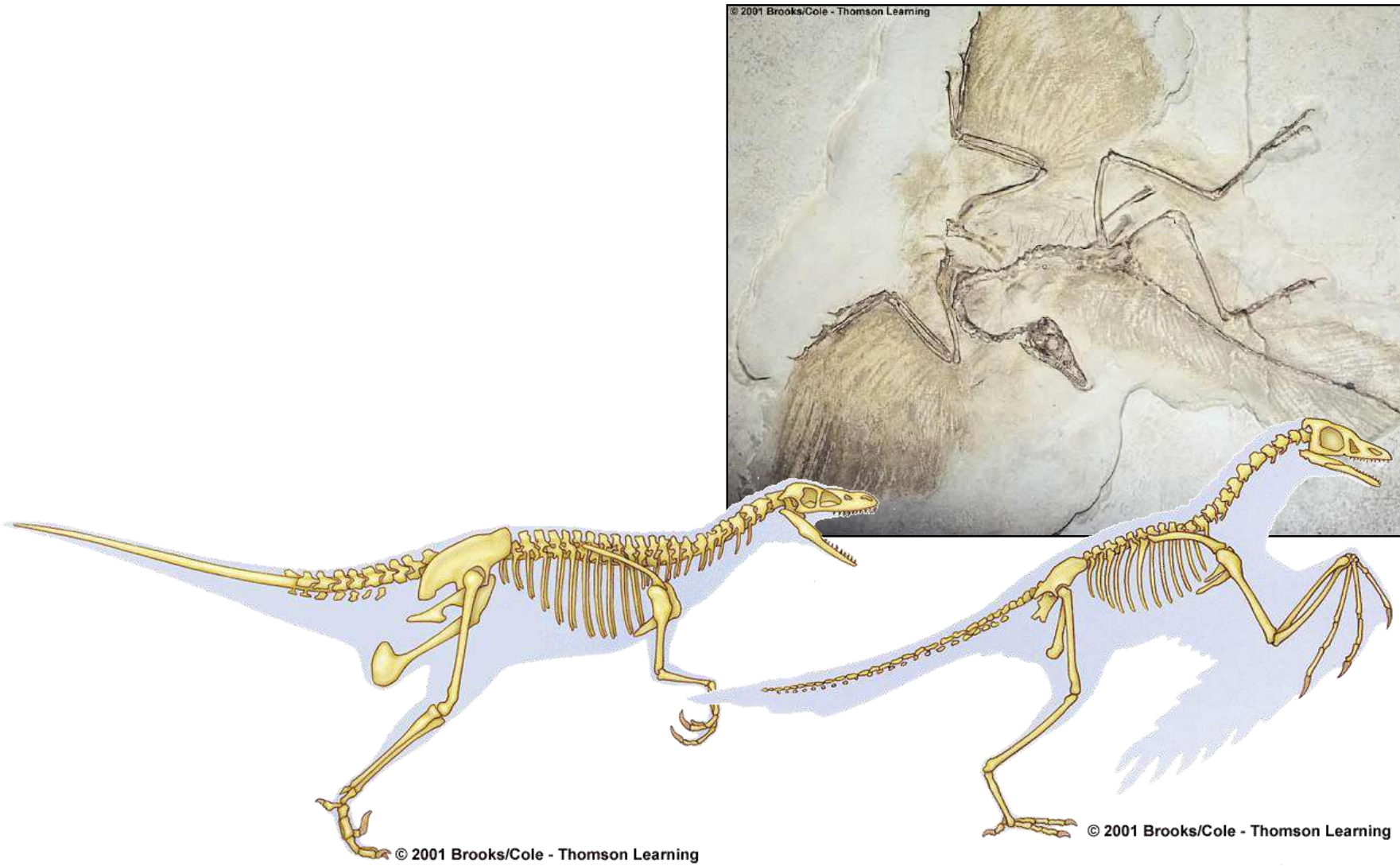


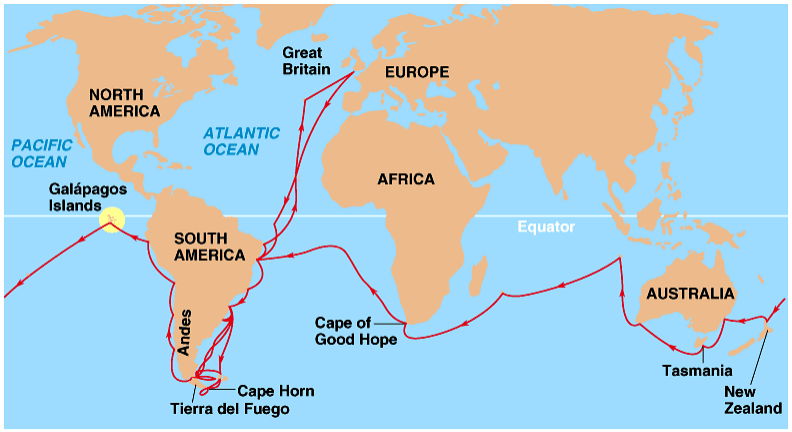
Dromaeosaurus

Archaeopteryx

Descent with Modification:

5 observations:

1) Exponential fertility
2) Stable population size
3) Limited resources
4) Individuals vary
5) Heritable variation



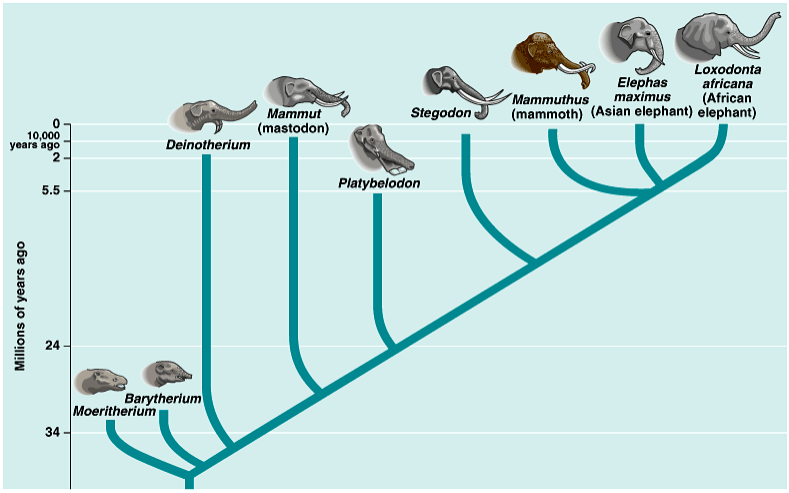
Descent with Modification:

3 Inferences:

1) **Struggle for existence**

2) **Non-random survival**

3) **Natural selection**
(differential success in reproduction)



In conclusion…

- The Theory of Evolution by Natural Selection states

  -More offspring are produced than the environment can support

  -Variant forms of a trait may be more or less adaptive under environmental conditions

  -An adaptive trait allows organisms to survive and reproduce more frequently; the frequency of that adaptive trait increases in a population

Charles **DARWIN**'s Explanation on Evolution (six major ideas of Darwin)

Overproduction occurs in nature → Not all organisms can survive

Variation occurs in all populations → Variations are inherited

Organisms with favorable variations survive and reproduce → Populations as a whole become FIT = **evolved!**

SUMMARY

LAMARCK:

Evolution acts on **individuals**

DARWIN:

Evolution acts on **populations**

DARWIN'S THEORY OF NATURAL SELECTION

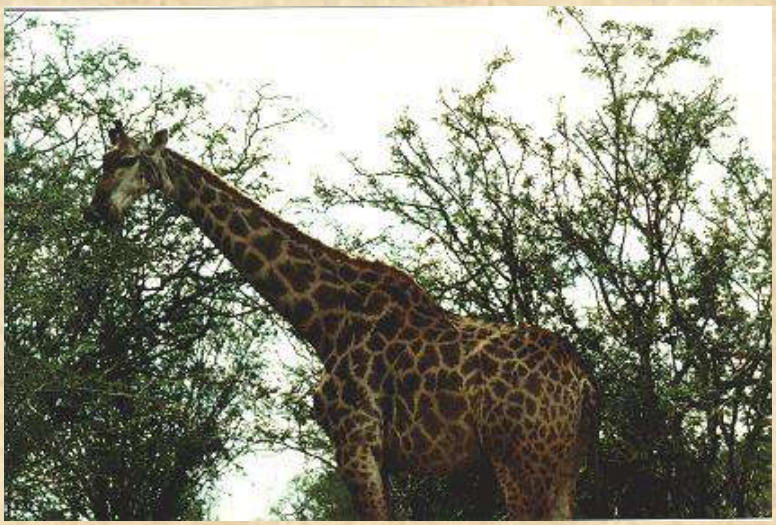
1. ORGANISMS HAVE MORE OFFSPRING THAN CAN SURVIVE AND…

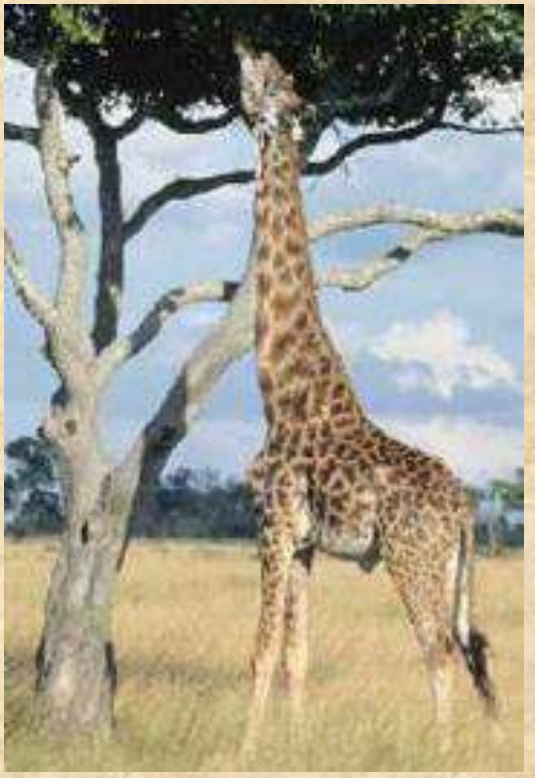
…a herd of giraffes would produce hundreds of descendents over several generations.

2. RANDOM, HERITABLE VARIATION EXISTS AMONG THESE ORGANISMS (EX. MUTATIONS), SO…

…by genetic "chance", some giraffes were born with longer necks.

3. BECAUSE THERE IS A STRUGGLE FOR EXISTENCE (COMPETITION), THEN…



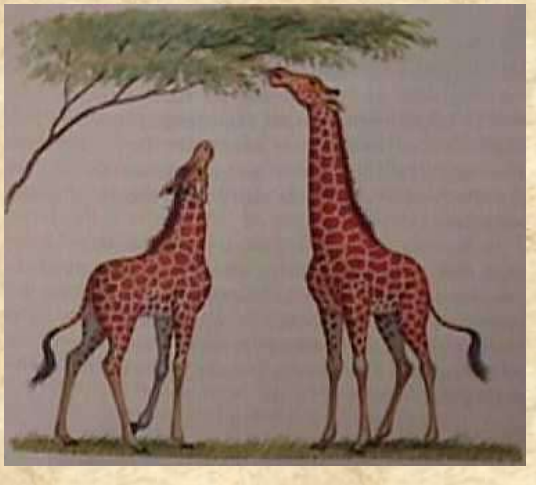


…giraffes were competing for food source (vegetation).

4. THE ORGANISMS WITH FAVORABLE VARIATIONS (THE "FITTEST") SURVIVE AND…

…a long neck enabled giraffes to reach an "untapped" food source…tree tops! (short-necked giraffes ran out of food and starved)

5. GENES FOR FAVORABLE FEATURES ARE PASSED TO OFFSPRING THROUGH REPRODUCTION, AND THEREFORE, THE **POPULATION EVOLVES!!!**



The giraffes with longer necks survive and pass their genes (for longer necks) on to their offspring…the process continues, and whole population **EVOLVES.**

AND, if populations are geographically isolated, changes will accumulate to the point of reproductive isolation

(===> NEW SPECIES!!)

EVOLUTIONARY CONCEPTS

- Mutations, genetic recombination, crossing over, etc. are “accidents” in the genes of organisms. They do not appear according to any purpose; they just happen.
- Mutations cause a large amount of variation among organisms in a population.
- There is room on Earth for only a fraction of organisms that are born or hatched. The individuals which happen to have the mutations giving them the best adaptations to the environment will be the ones that survive.

EVOLUTIONARY CONCEPTS

- The survivors will have their own offspring. The offspring will be subject to their own random mutations. Again, only the most advantageous mutations will result in the survival of the next generation of offspring, and hence be "passed down" to the next generation.
- Countless generations of mutations and natural selection result in organisms that have very different structures.