Chapter 16
The Theory of Evolution

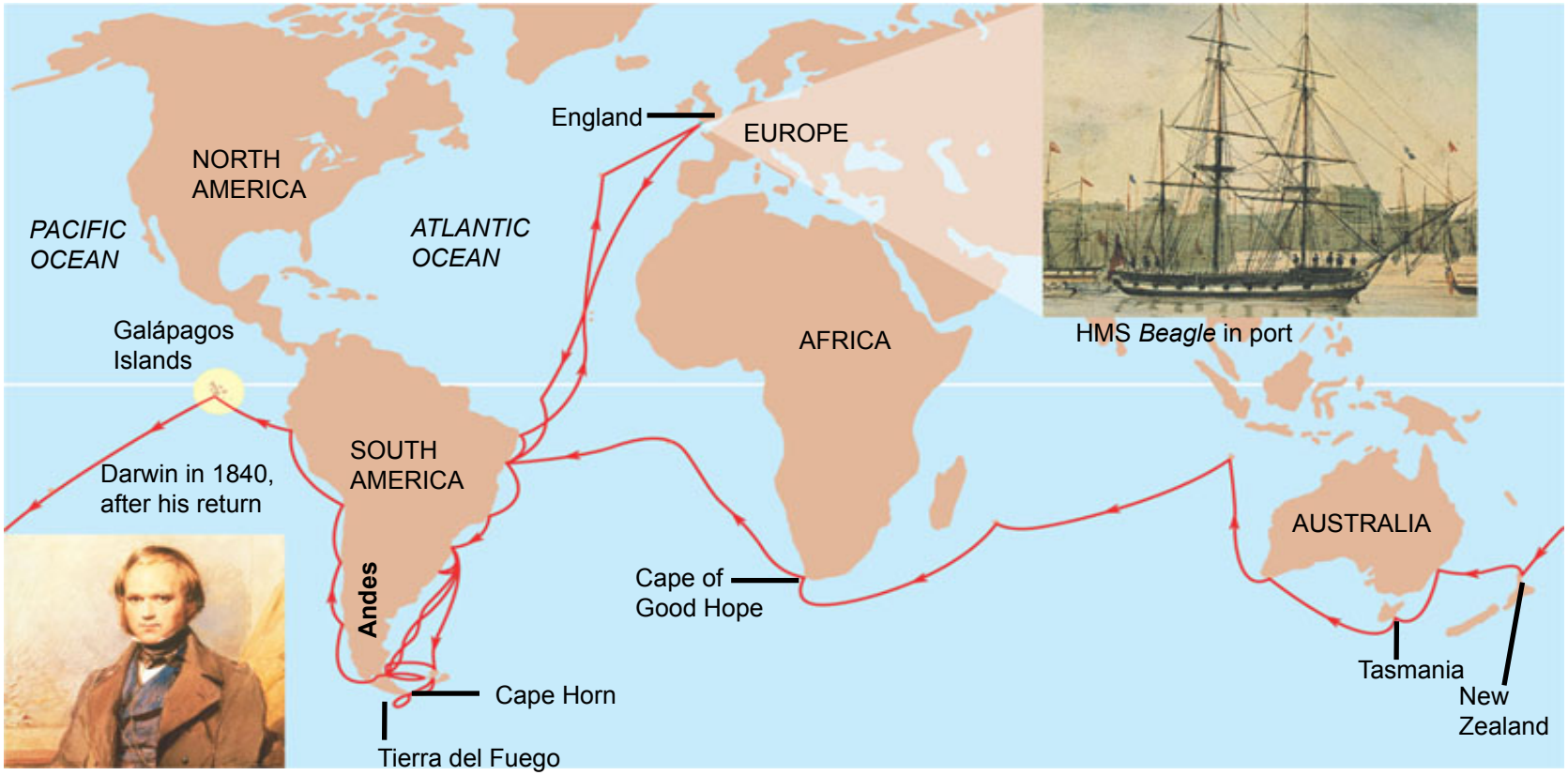
16-1 Darwin's Theory

- Life evolving 1st proposed by a Roman named Lucretius
- His idea was opposed by all scientists
- Darwin's theory in 1859 changed their thinking

Development of Theory

- Darwin was the naturalist on the HMS Beagle from 1831-1836
- Darwin's observations led to the development of his theory

Charles Darwin (1809-1882) served as Ship's Naturalist on the HMS Beagle's circumnavigation of the globe (1831-1836)



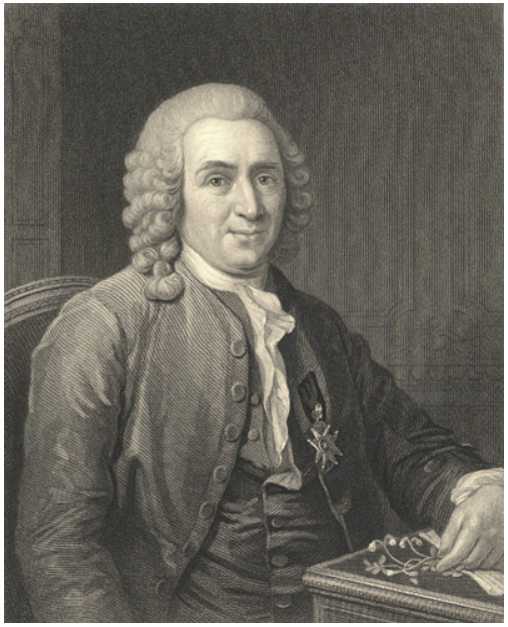
Before Darwin

- Most scientists believed that life was a divine creation
- By the time of his voyage, many were realizing that creation could not explain all they saw

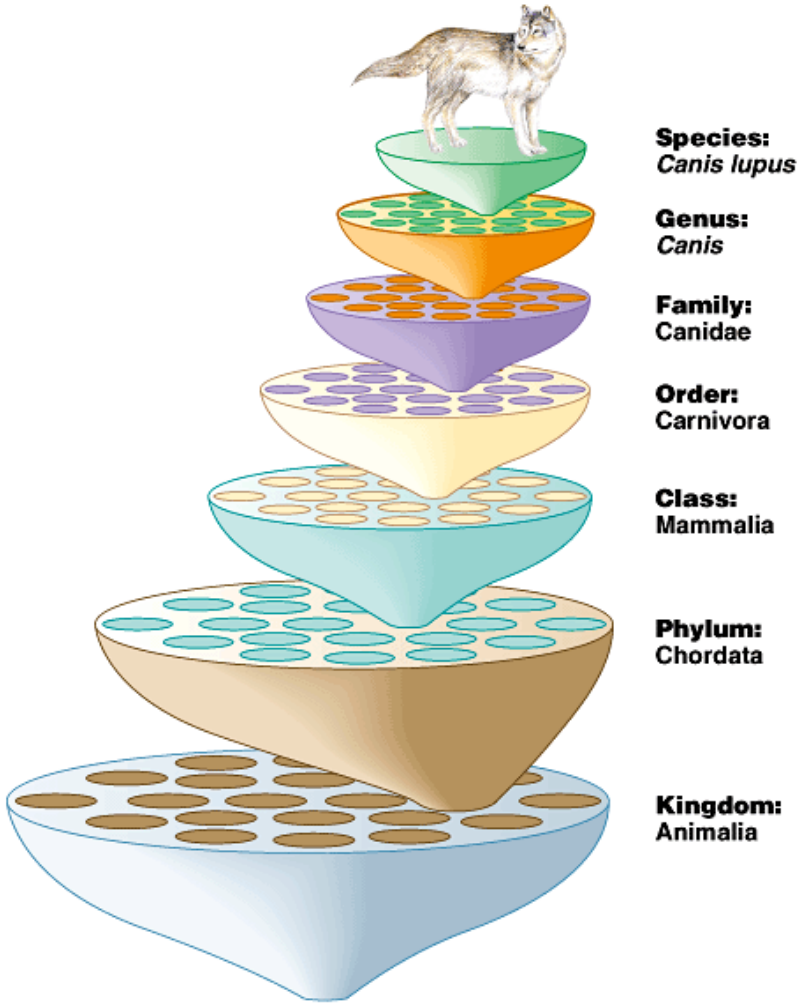
Carolus Linnaeus (1707-1778)

Swedish physician & botanist whose passion was taxonomy

Developed a hierarchical classification scheme & binomial nomenclature



Carolus Linnaeus (1707-1778)



Canis **= genus**
lupus **= specific epithet that refers to one species in the genus *Canis***

The binomial is always italicized or underlined, the genus name is always capitalized, and the specific epithet is always lower case

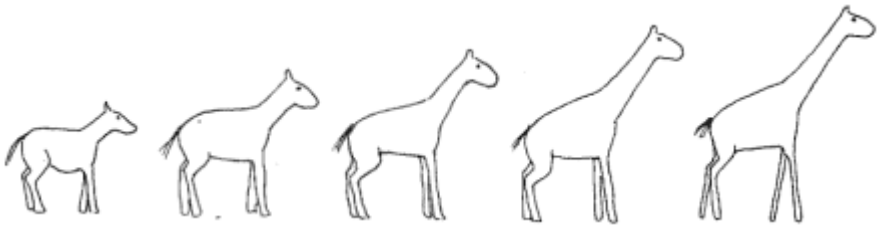
Jean Baptiste Lamarck (1744-1829)

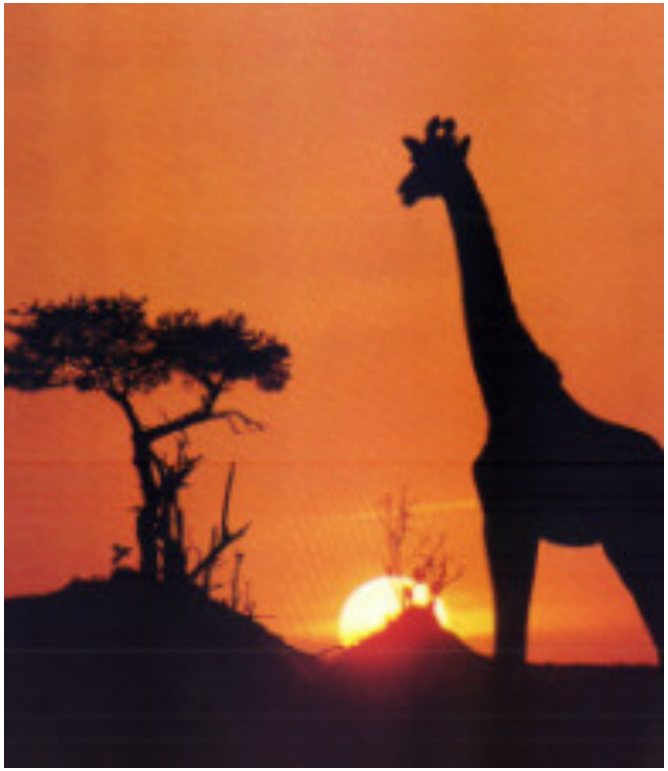
Invertebrate Curator of the Natural History Museum in Paris

One of the 18th & 19th centuries' biologists who hypothesized that traits of species are not immutable, *i.e.*, they can evolve

Jean Baptiste Lamarck (1744-1829)

Hypothesized mechanism of evolution: Use & disuse alters traits; inheritance of acquired characters results in adaptations to environmental conditions





Galapagos Islands, Ecuador

What He Observed

- Observed 13 different types of finches
- All were located on different islands
- Very similar except they had different beaks
- Also observed giant tortoises that were located on different islands
- Also slightly different

Galapagos Islands, Ecuador

Galapagos Islands, Ecuador

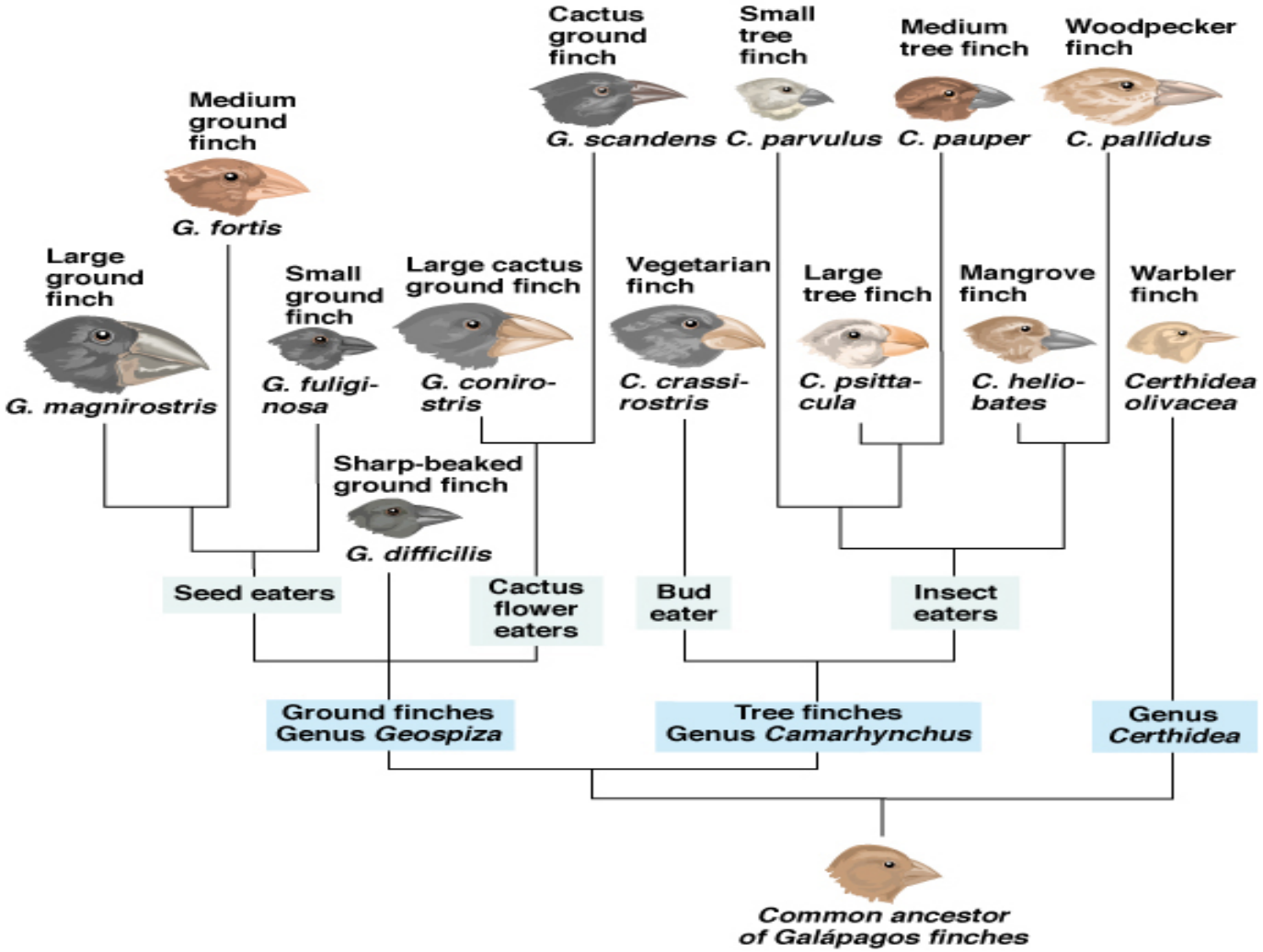
(a) large ground finch, beak suited to large seeds

(b) small ground finch, beak suited to small seeds

(c) warbler finch, beak suited to insects

(d) vegetarian tree finch, beak suited to leaves

Darwin was a good observer of both wild and domesticated organisms (*e.g.*, birds)

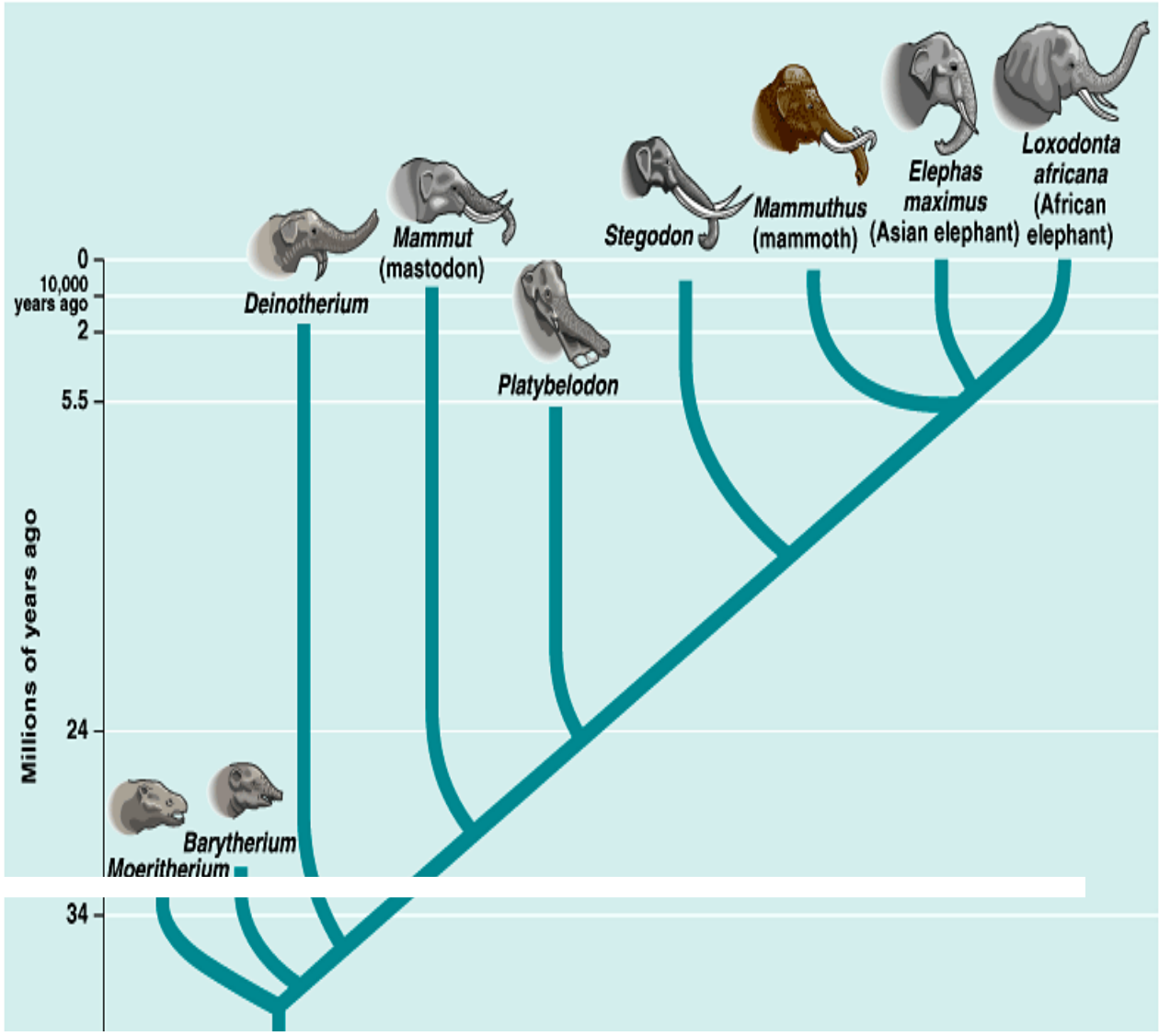


- Thought that island organisms resembled the animals of the main land
- Maybe they migrated from South America and changed?
- Called it descent with modification

Darwinian Theory of Evolution

Descent implies common ancestry

Modification to better suite the environment = adaptation



After The Voyage

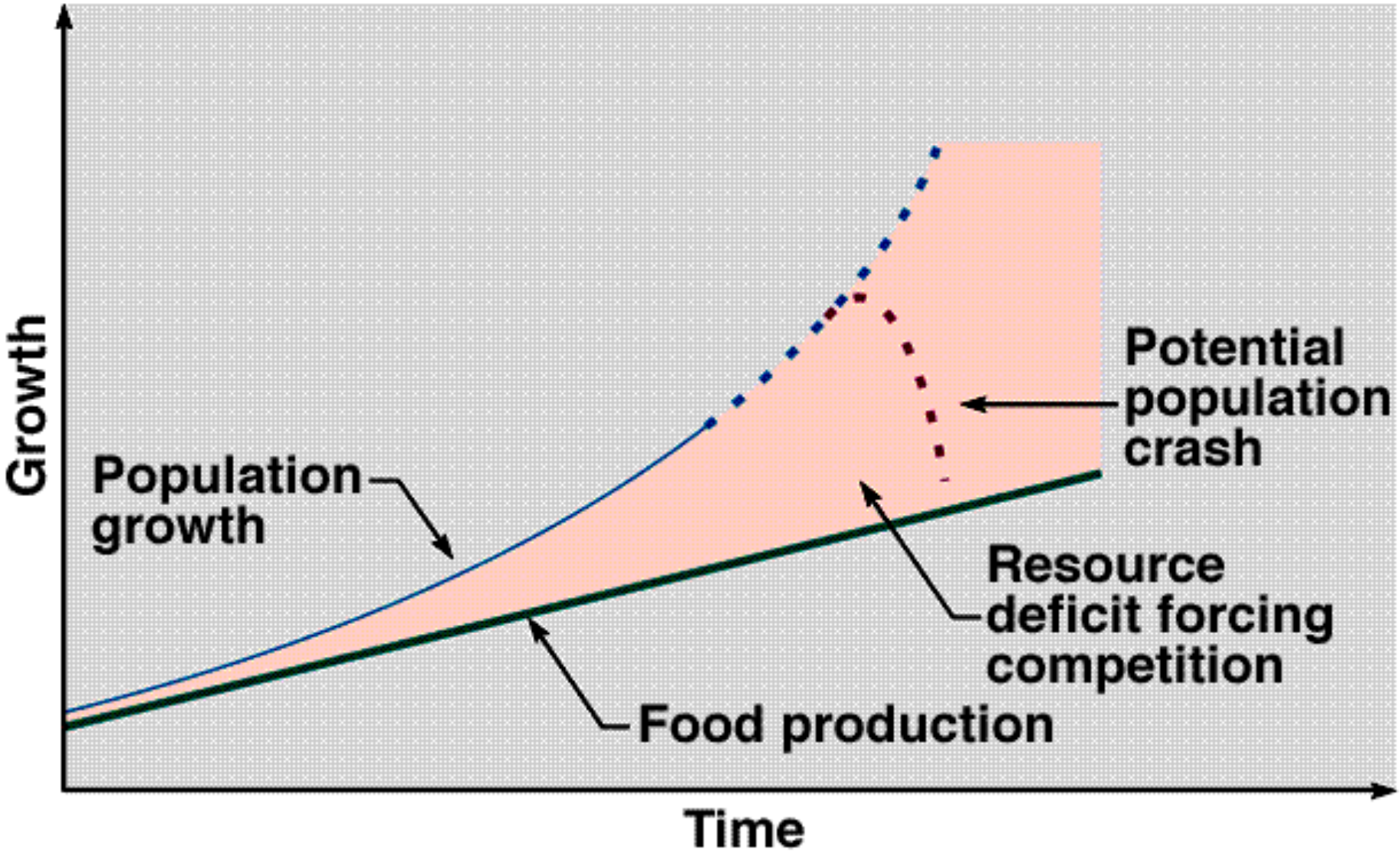
- Continued his study of the natural world
- Heavily influenced by Thomas Malthus

Thomas Malthus (1766-1834)

English demographer

Hypothesis: Plants and animals are capable of producing far more offspring than resources can support; the "struggle for existence" (*e.g.*, famine, war) is an inescapable consequence

Predictions of Malthus which Led to Darwin's Theory of Natural Selection



- Population-all the individuals of a species that live together in one place at one time
- Helped create idea of natural selection
- Natural Selection-individuals that have physical or behavioral traits that better suit their environment are more likely to survive and reproduce

Observations that lead to the principle of Natural Selection

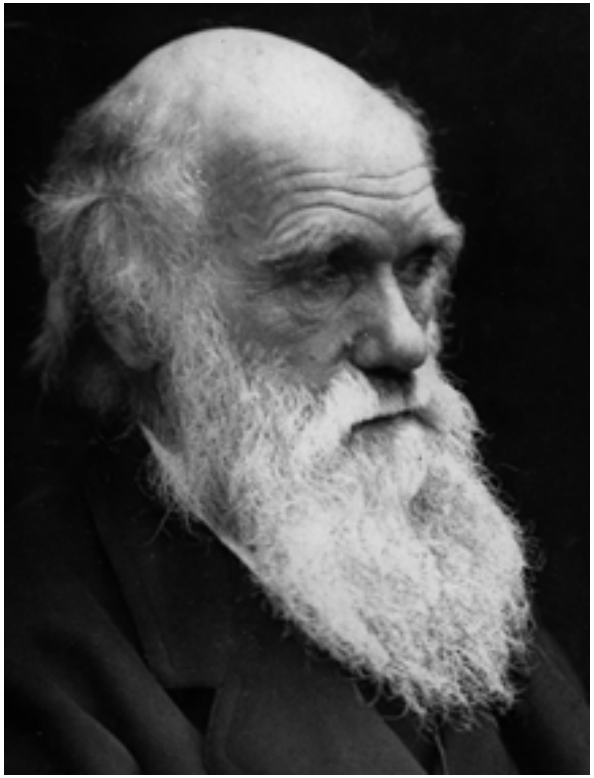
1. Variation of traits within a population
2. Overproduction of individuals
3. Limits on population growth: struggle for existence and competition for available resources
4. Differential reproductive success: survival and reproduction of the fittest

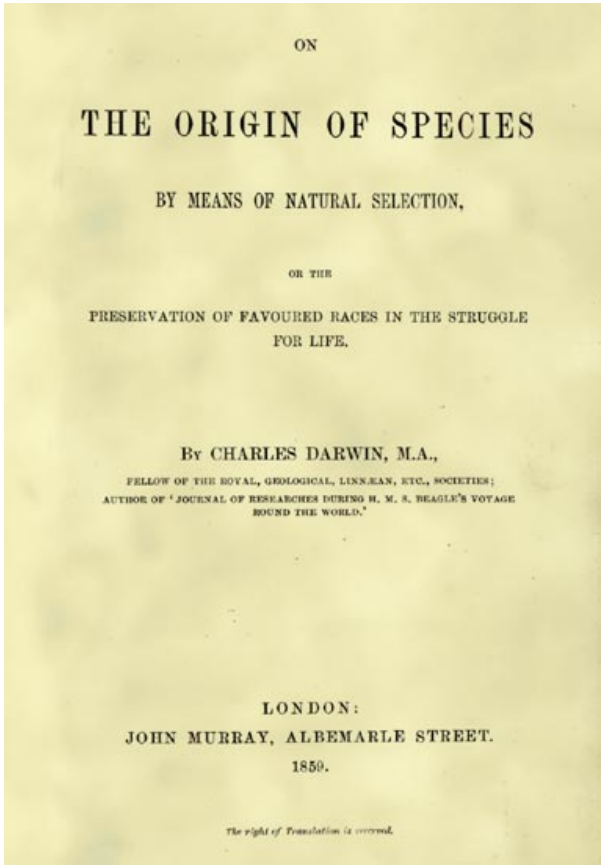
Publishing His Ideas

- Alfred Wallace developed his own hypothesis of natural selection in 1858
- Darwin Freaked Out!
- Finished his theory and published his book *On the Origin of Species by Means of Natural Selection* in 1859

Charles Darwin (1809-1882)

The Origin of Species (1859)





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.

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Modern Version of Darwin's Theory

- Natural Selection increases or decreases the frequency of certain alleles in a population over time
- Isolation leads to species formation
- Extinction leads to species replacement

16-2 Evidence For Evolution

- Theory is supported by virtually all scientists
- Scientists agree on 3 major points

- The Earth is 4.6 Billion Years Old
- Organisms have lived on the planet for most of its history
- All organisms alive today evolved from earlier, simpler life forms

Fossil Evidence of Evolution

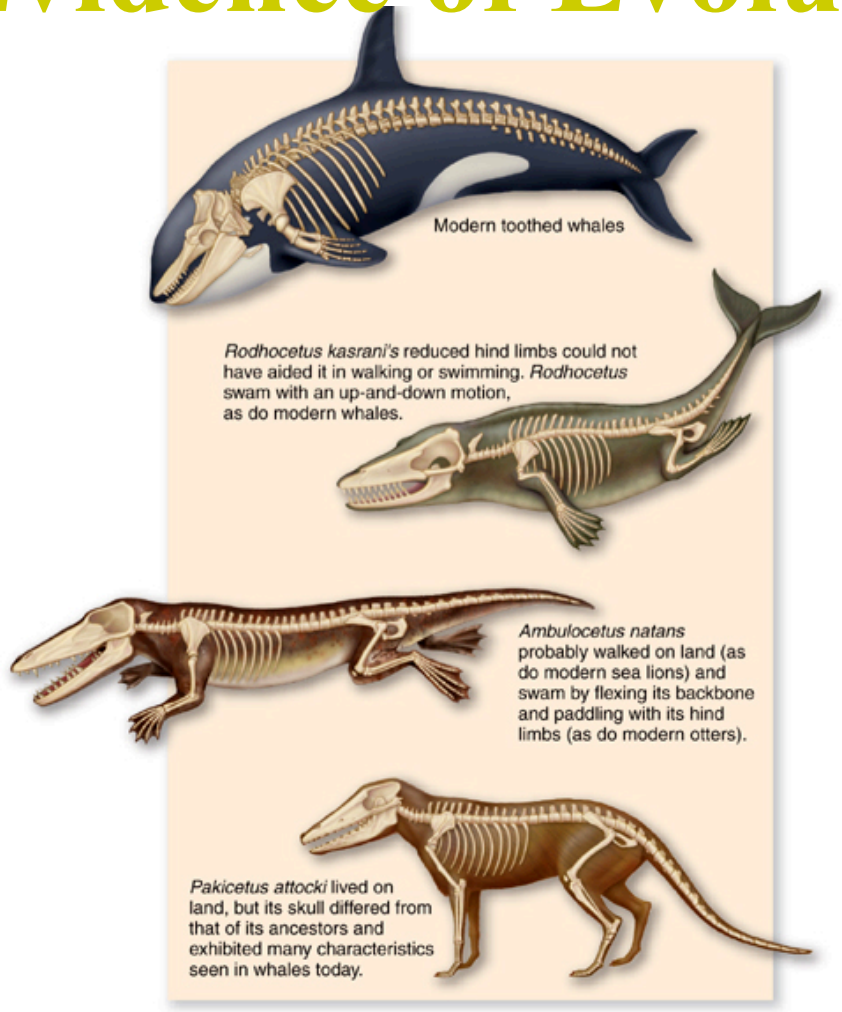
Fossil of *Archaeopteryx*

Fossil Evidence of Evolution

Recent discoveries

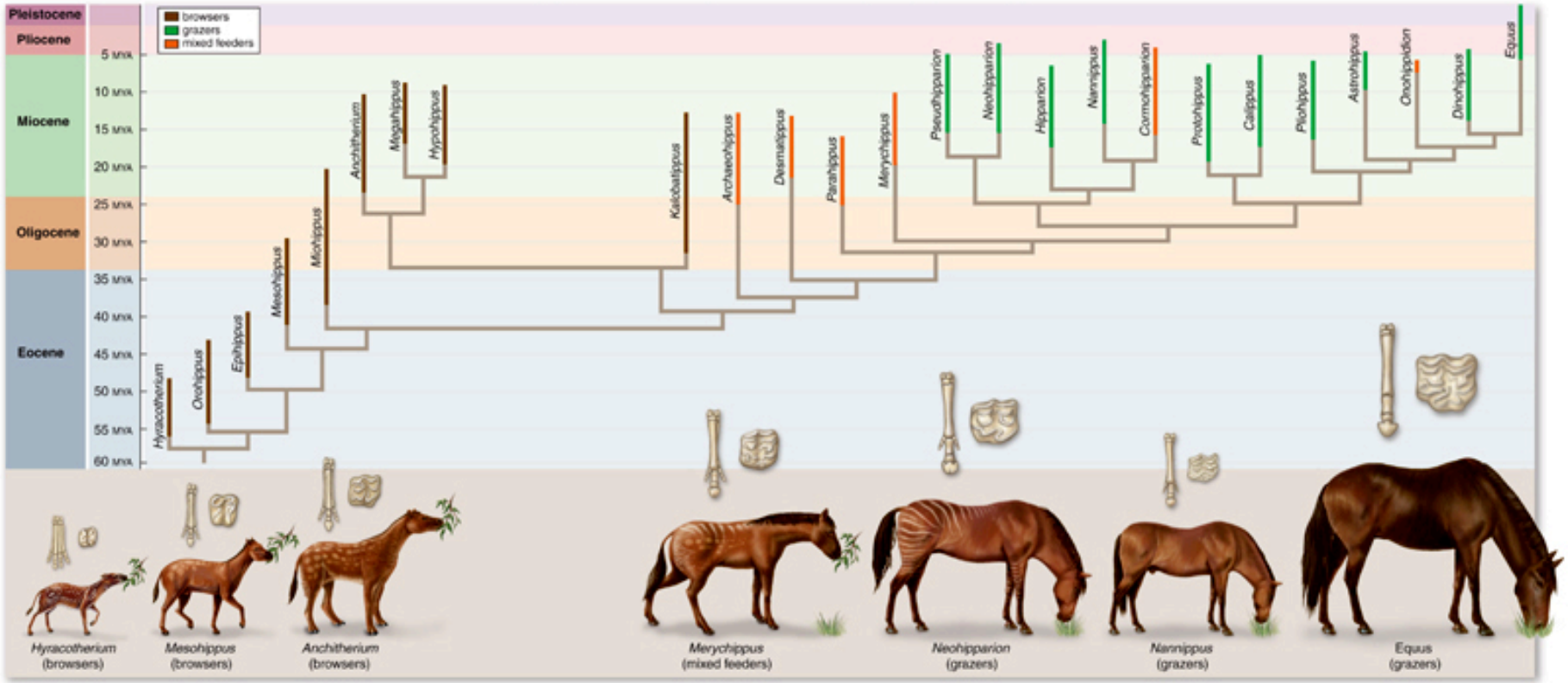
- Four-legged aquatic mammal
  - Important link in the evolution of whales and dolphins from land-dwelling, hoofed ancestors
- Fossil snake with legs
- *Tiktaalik*: a species that bridged the gap between fish and the first amphibian

Fossil Evidence of Evolution



Whale "missing links"

Fossil Evidence of Evolution

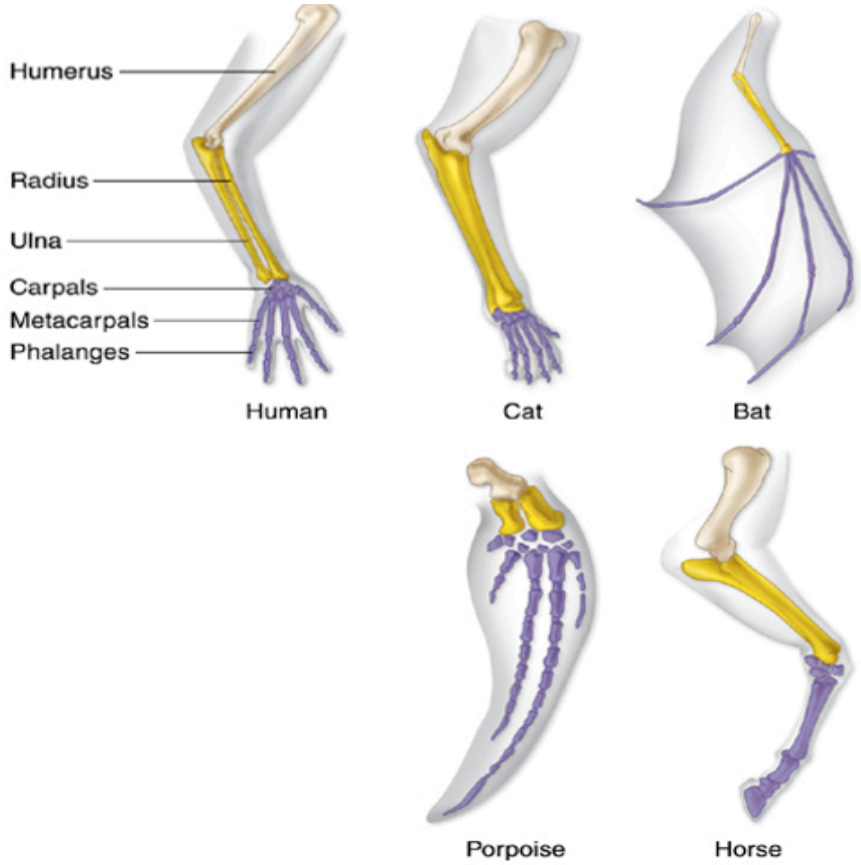


Evolutionary change in body size and toe reduction of horses

Anatomical Evidence for Evolution

- **Homologous structures**: structures with different appearances and functions that all derived from the same body part in a common ancestor
- The bones in the forelimb of mammals are homologous structures
- Different functions, same ancestor structure

Anatomical Evidence for Evolution



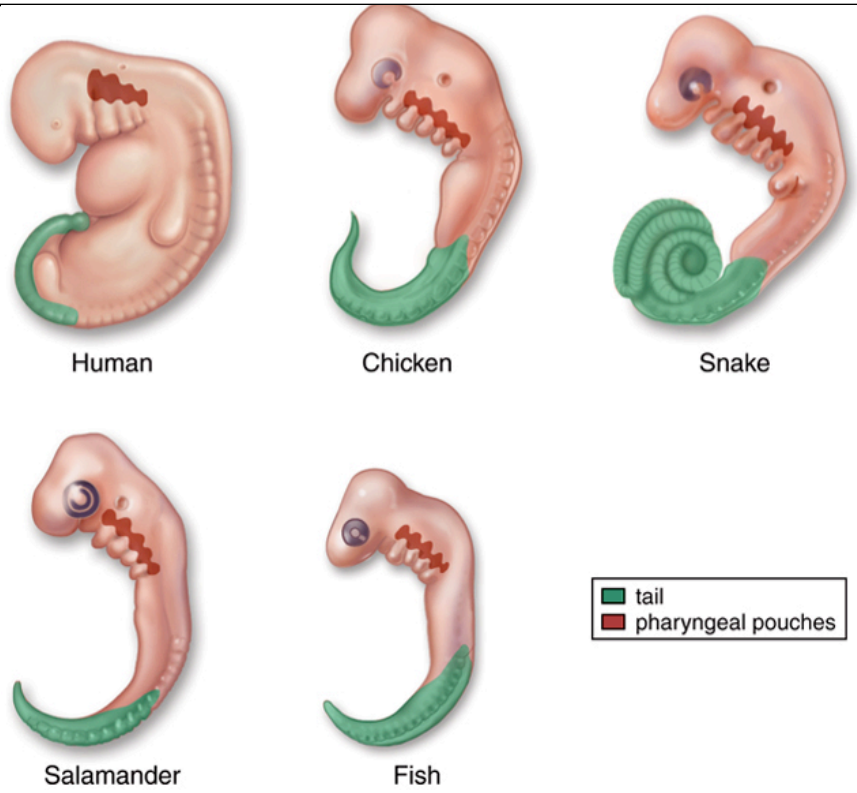
Homology of the bones of the forelimb of mammals

Skull Homologies

Anatomical Evidence for Evolution

- Strongest anatomical evidence supporting evolution comes from comparisons of how organisms develop.
- Early vertebrate embryos possess pharyngeal pouches that develop into:
  - **In humans: glands and ducts**
  - **In fish: gill slits**

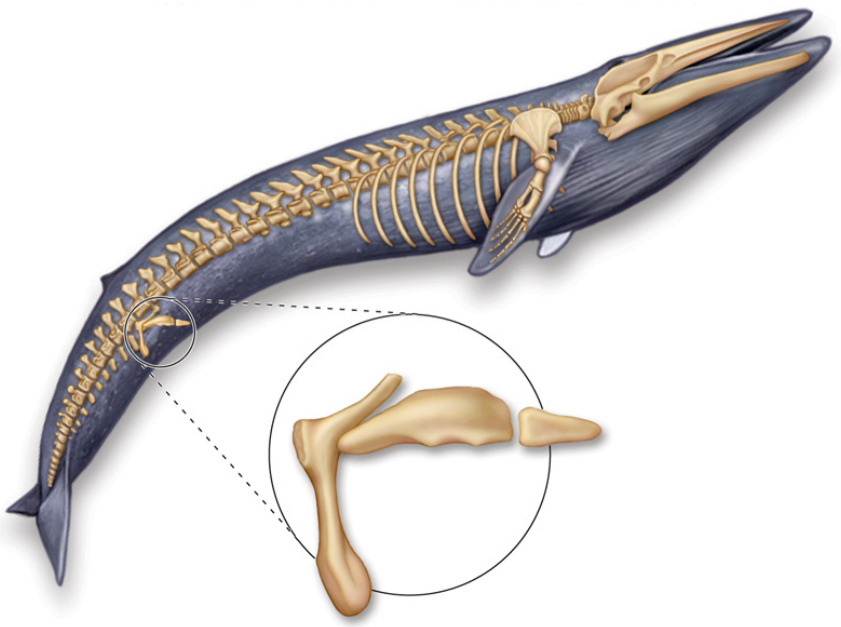
Anatomical Evidence for Evolution



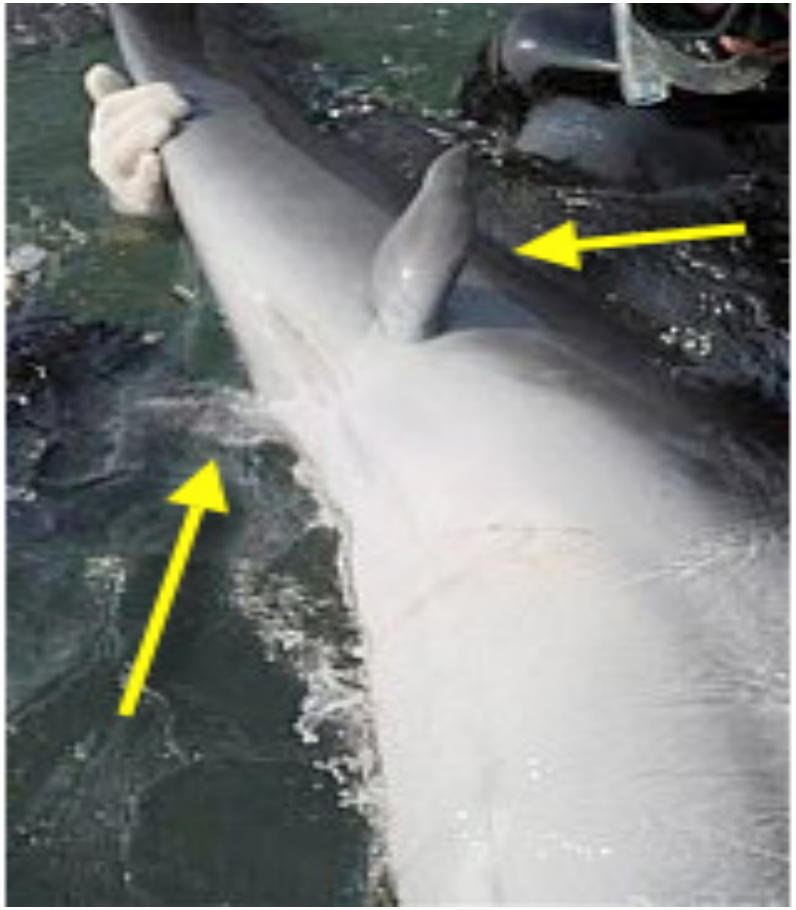
Developmental similarities reflect descent from a common ancestor

Anatomical Evidence for Evolution

- **Vestigial structure** have no apparent function, but resemble structures their ancestors possessed



Vestigial structures of a whale



Anatomical Evidence for Evolution

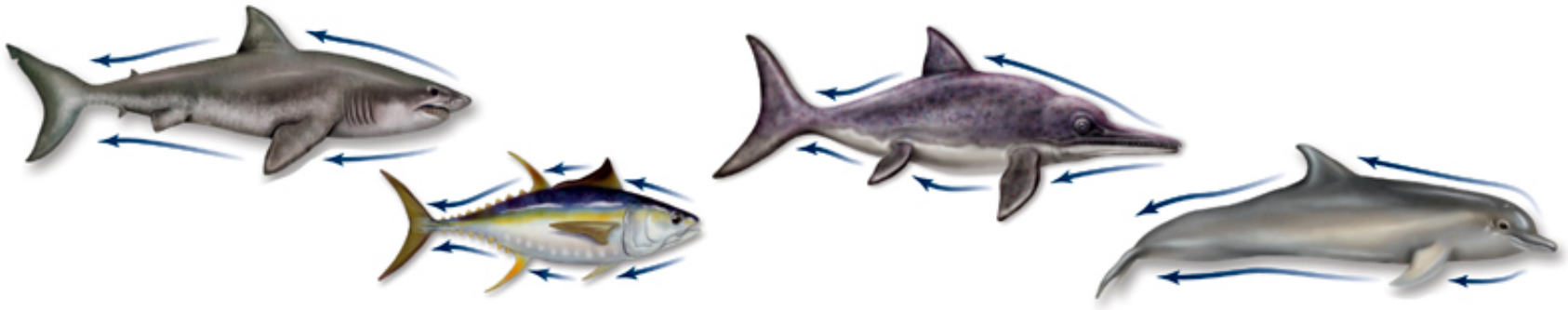
- Humans
  - Muscles for wiggling ears
- Boa constrictors
  - Hip bones and rudimentary hind legs
- Manatees
  - Fingernails on their fins
- Blind cave fish
  - Nonfunctional eyes

Thrid Nipple piercing on
SPC Online www.bme.freeq.com/spc

Convergent Evolution

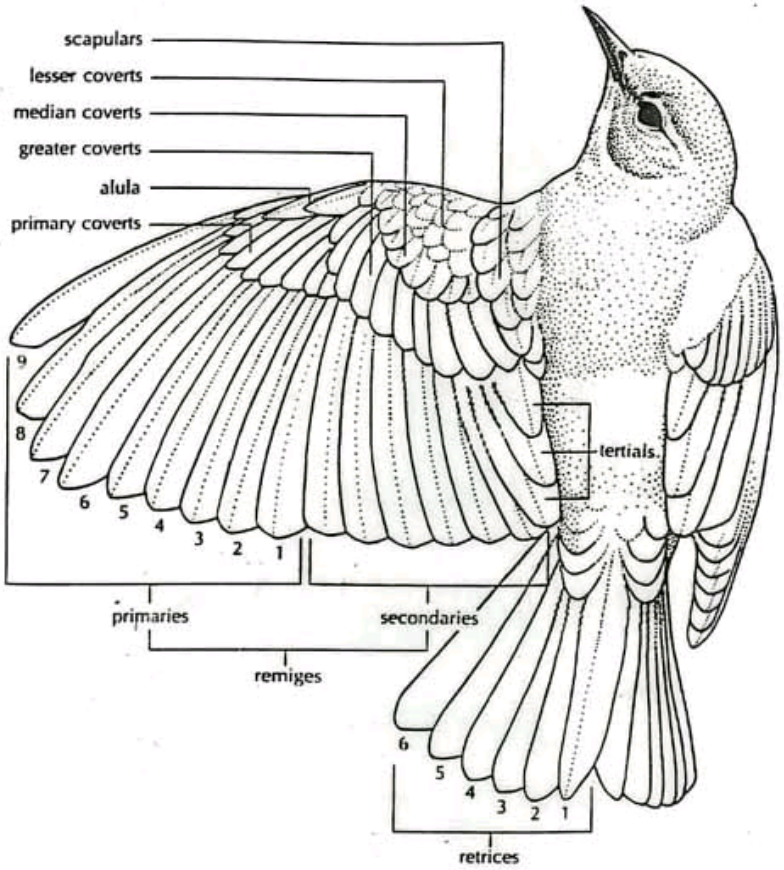
- **Convergent evolution**: the independent development of similar structures in organisms that are not directly related
- Convergent evolution is usually seen in animals and plants that live in similar environments

Convergent Evolution



Convergence among fast-swimming predators

- Leads to analogous structures
- Same function, different ancestry


scapulars
lesser coverts
median coverts
greater coverts
alula
primary coverts
9
8
7
6
5
4
3
2
1
tertials
primaries
secondaries
remiges
6
5
4
3
2
1
retrices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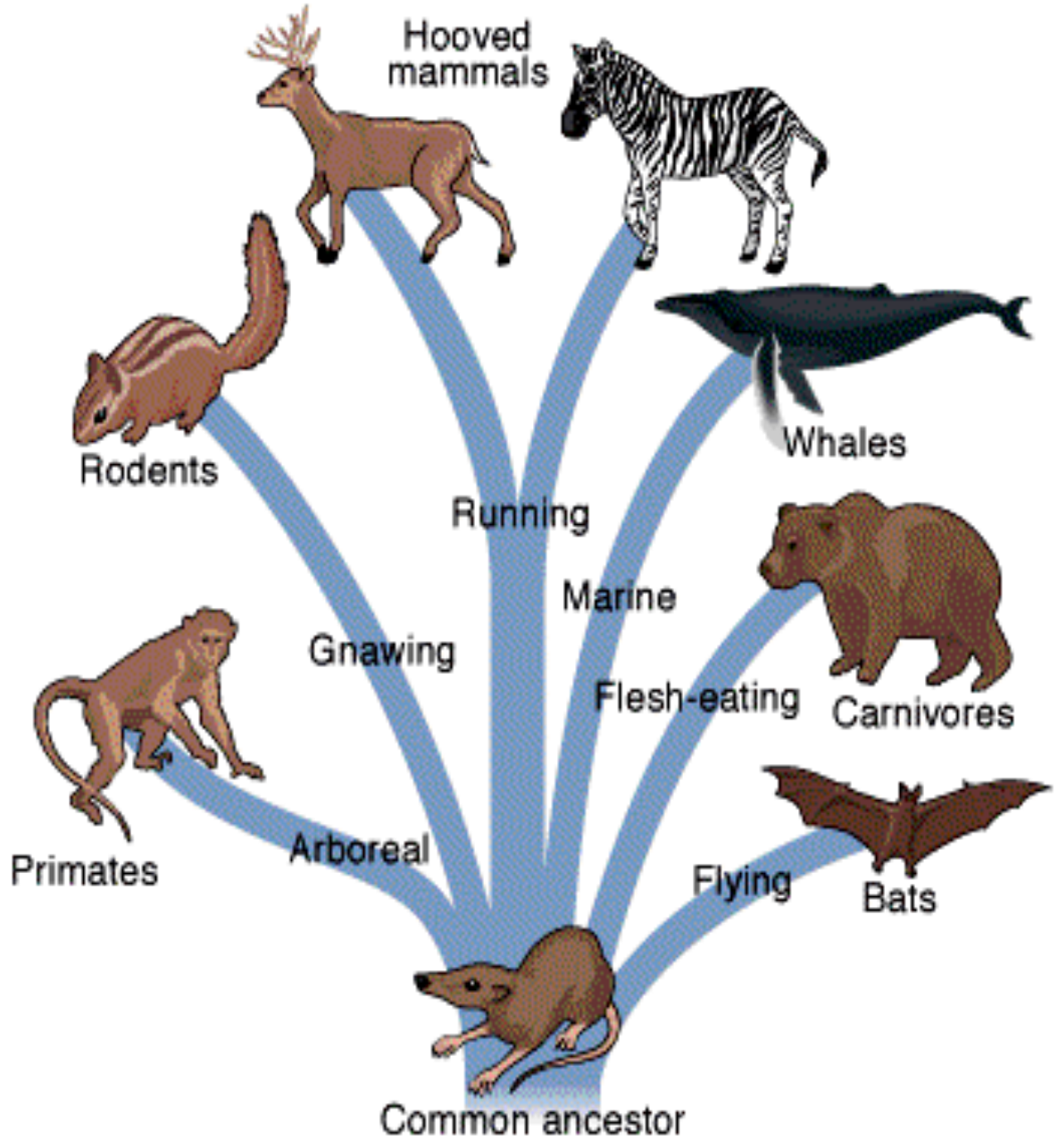
Divergent Evolution

- Different pressures cause species to look different externally, but are similar internally
- Adaptive Radiation-where one species may give rise to several species



Divergent Evolution

- Different pressures causes species to become more different
- appear different externally but are similar internally
- **Adaptive Radiation -** one species gives rise to many species

Molecular Evidence

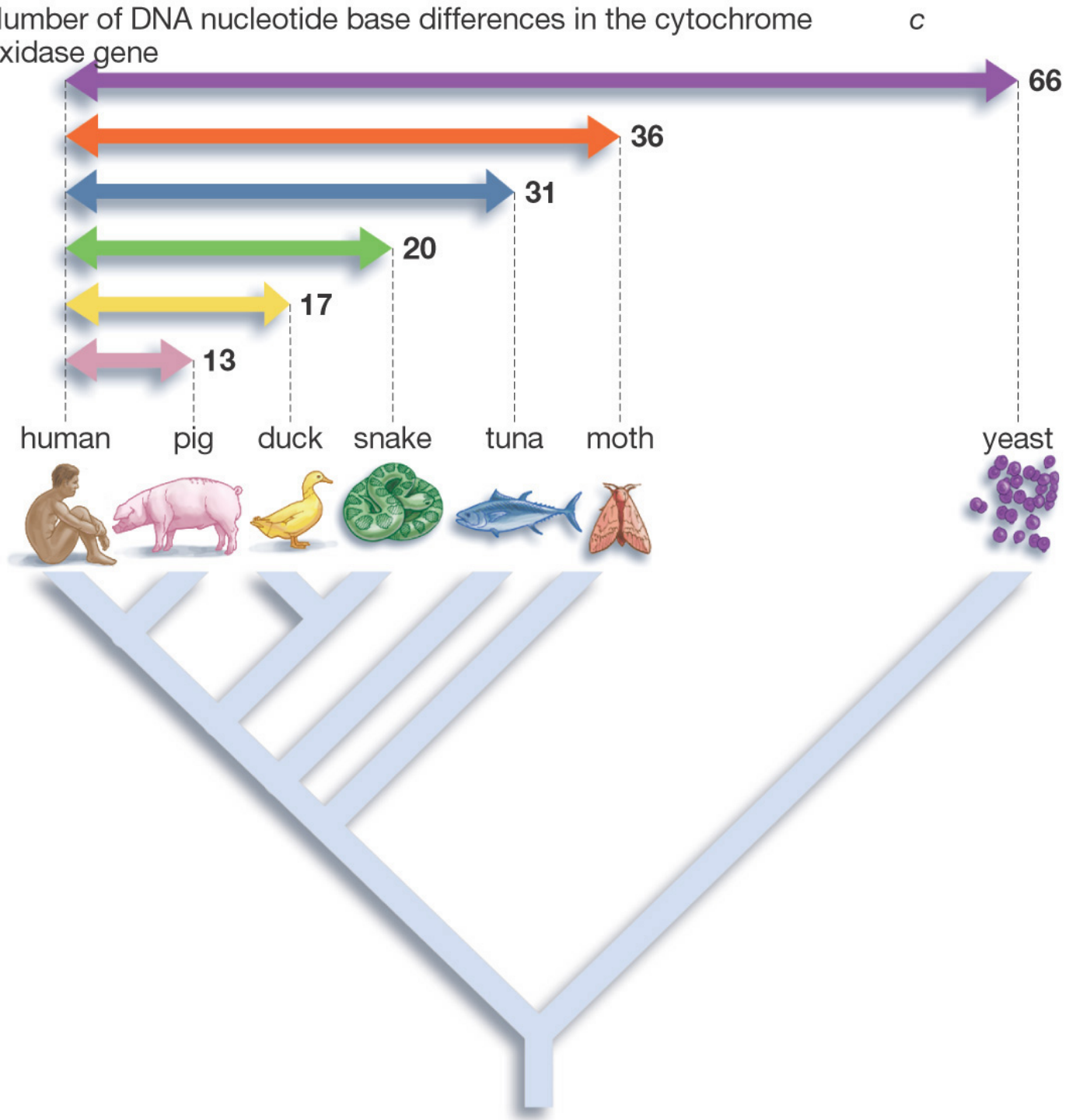
- Proteins-the fewer the amino acid differences in proteins, the closer related species are
- Nucleic Acids-Scientists can estimate the number of nucleotide changes that have taken place in a gene

Molecular Record

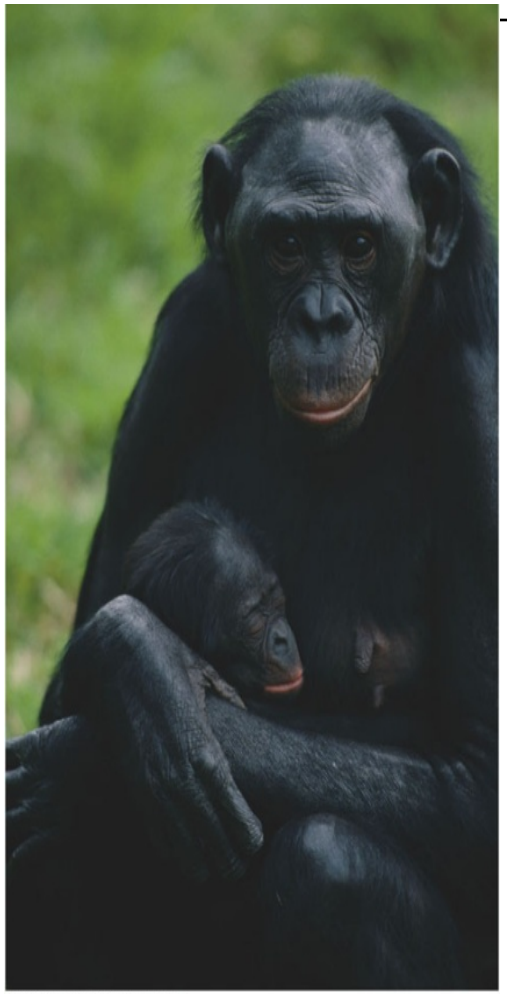
- Evolutionary theory allows evolutionary change involves substitution of new versions of old genes.
  - New alleles arise by mutation and come to predominate through favorable selection.

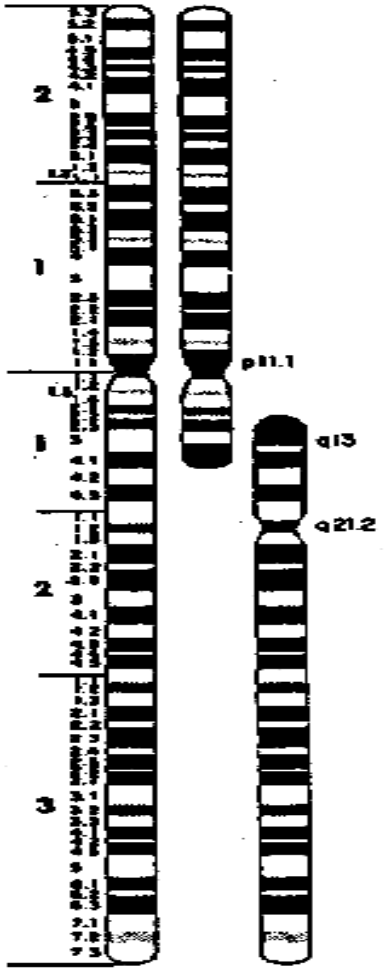
- Molecular Clocks
  - The longer the time since divergence, the greater the number of differences in nucleotide sequence of cytochrome C.
    - Changes accumulate at constant rate.

Evidence of


Number of DNA nucleotide base differences in the cytochrome c oxidase gene
66
36
31
20
17
13
human
pig
duck
snake
tuna
moth
yeast

Changes in chromosome number can lead to new species?





- Chimpanzees, Orangutans, and Gorillas all have 48 chromosomes
- Humans have 46
- Two medium sized chimpanzee chromosomes fused to form our chromosome #2

How Fast Does Evolution Happen?

- Gradualism is the theory that it happens at a slow and steady rate (many transitional fossils)
- Punctuated Equilibrium-periods of rapid change in species are separated by periods of little or no change

13-3 Examples of Evolution

- Industrial Melanism-the darkening of populations of organisms over time in response to industrial pollution
- Best known case involves the Peppered Moth in Europe
- Tested by Kettlewell

The melanic (black) variety and the original 'peppered' variety (below the right wing-tip of the melanic moth) on a light, lichen-covered tree trunk.

The same two varieties on a dark, soot-covered tree trunk.

Figure 5-5 (2) Biology Today, 3/e (© 2004 Garland Science)

Geographic variation in the frequency of melanic moths in the 1950s, which reached as high as 100% in polluted localities downwind from major industrial centers.

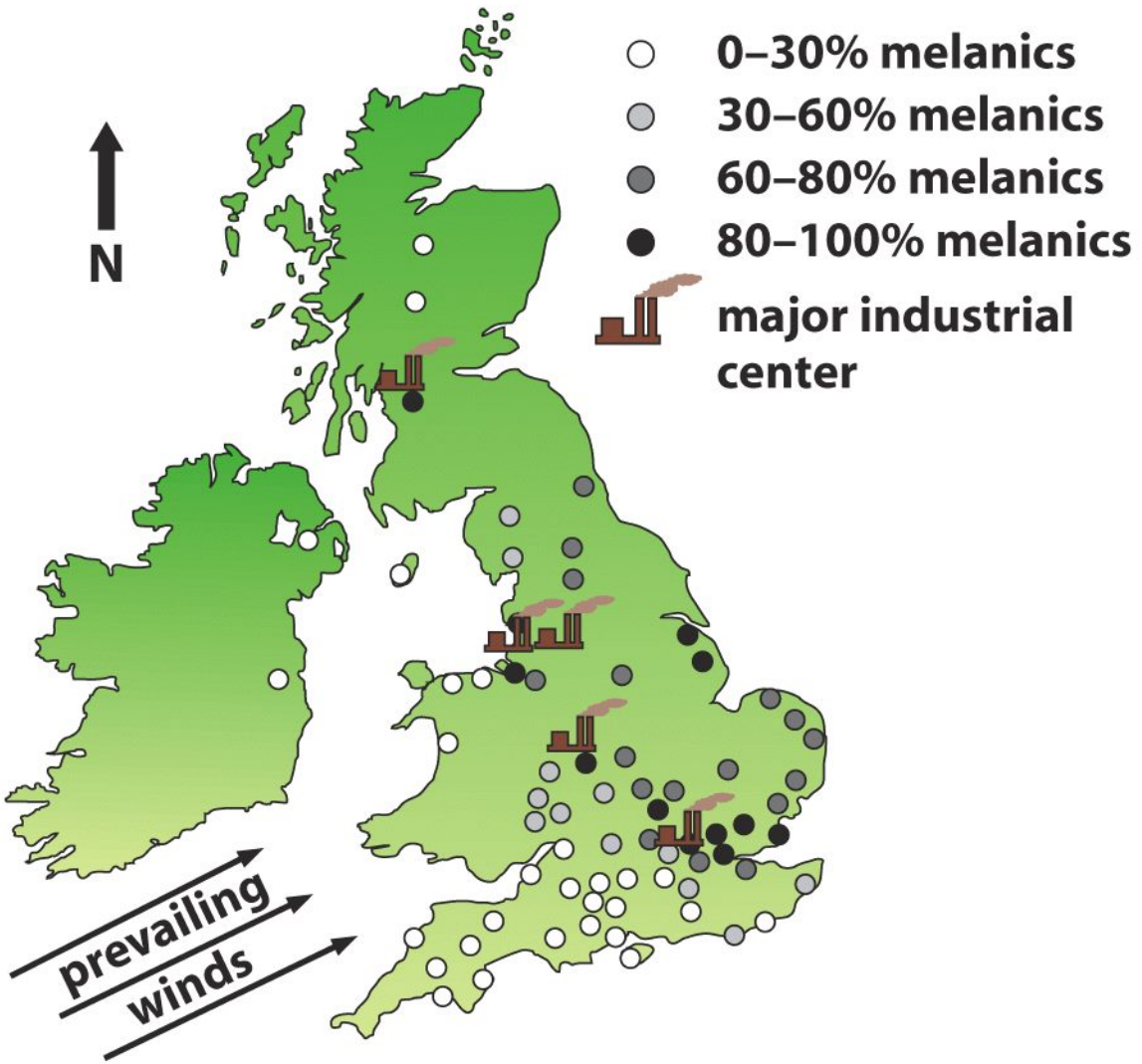
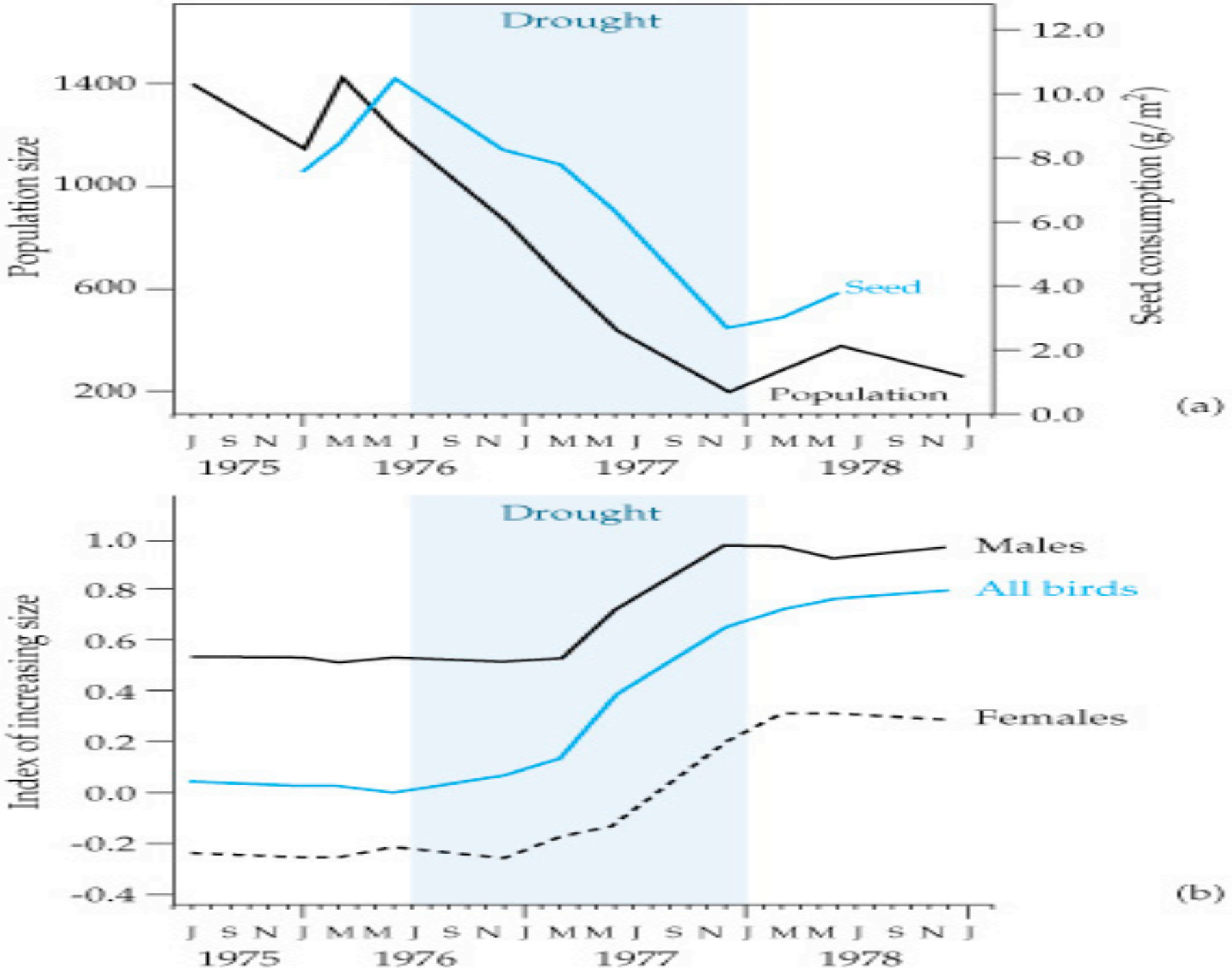


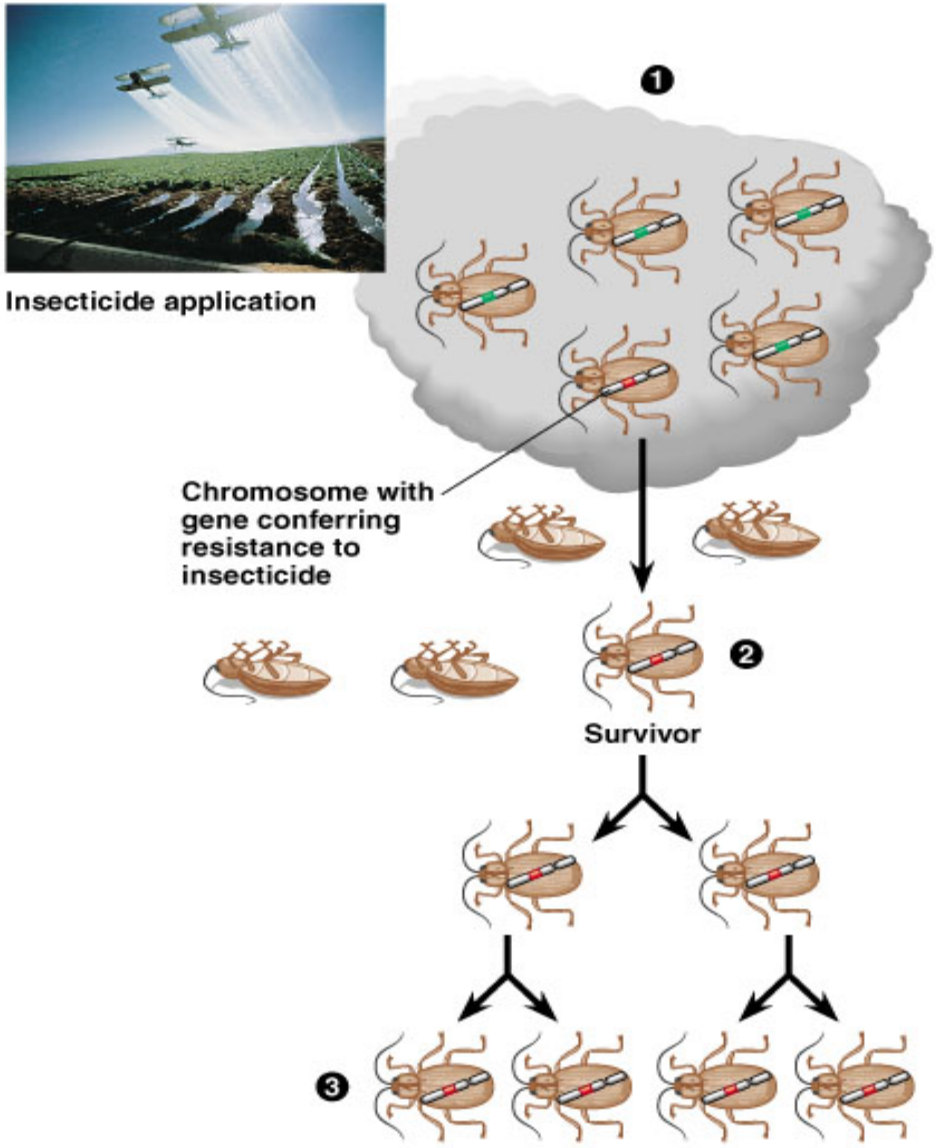
Figure 5-5 (1) Biology Today, 3/e (© 2004 Garland Science)

- http://www.biologycorner.com/worksheets/pepperedmoth.html

- Finch Evolution on the Galapagos
- Dry years allowed studies to show how allele frequency in a population changed over time
- Beak shape was determined by the environment


Drought
Population size
1400
1000
600
200
Seed consumption (g/m²)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Seed
Population
(a)
J S N J M M J S N J M M J S N J M M J S N J
1975
1976
1977
1978
Drought
Index of increasing size
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Males
All birds
Females
(b)
J S N J M M J S N J M M J S N J M M J S N J
1975
1976
1977
1978

Human-Induced selection



1) Natural pop'n with variation for insecticide resistance
2) Insecticide appl'n kills all but those with resistance
3) Surviving insects breed new generation of insecticide resistance population

Speciation

- Divergence-accumulation of differences between groups of organisms
- Speciation-process by which new species form

Gene Variation

- Macroevolution - Evolutionary change on a grand scale, encompassing novel designs, evolutionary trends and episodic mass extinction.

- Microevolution - Differential survival and reproduction due to natural selection. Gradually alters population to include more individuals with advantageous characteristics.

- Ecological Races - populations of the same species that differ genetically because of different adaptations to different living conditions
- Concept is becoming obsolete!

What keeps new species separate?

- Reproductive Isolation
- 2 kinds
- Prezygotic
- Postzygotic

Prezygotic Isolating Mechanisms

- Prevent formation of Zygote:
  - Geographic Isolation
  - Ecological Isolation
  - Behavioral Isolation
  - Temporal Isolation
  - Mechanical Isolation
  - Prevention of Gamete Fusion (Aquatic)

Postzygotic Isolating Mechanisms

- Prevent zygotes from developing into normal, functional offspring.
  - Improper development
    - Reduced fertility or sterility.