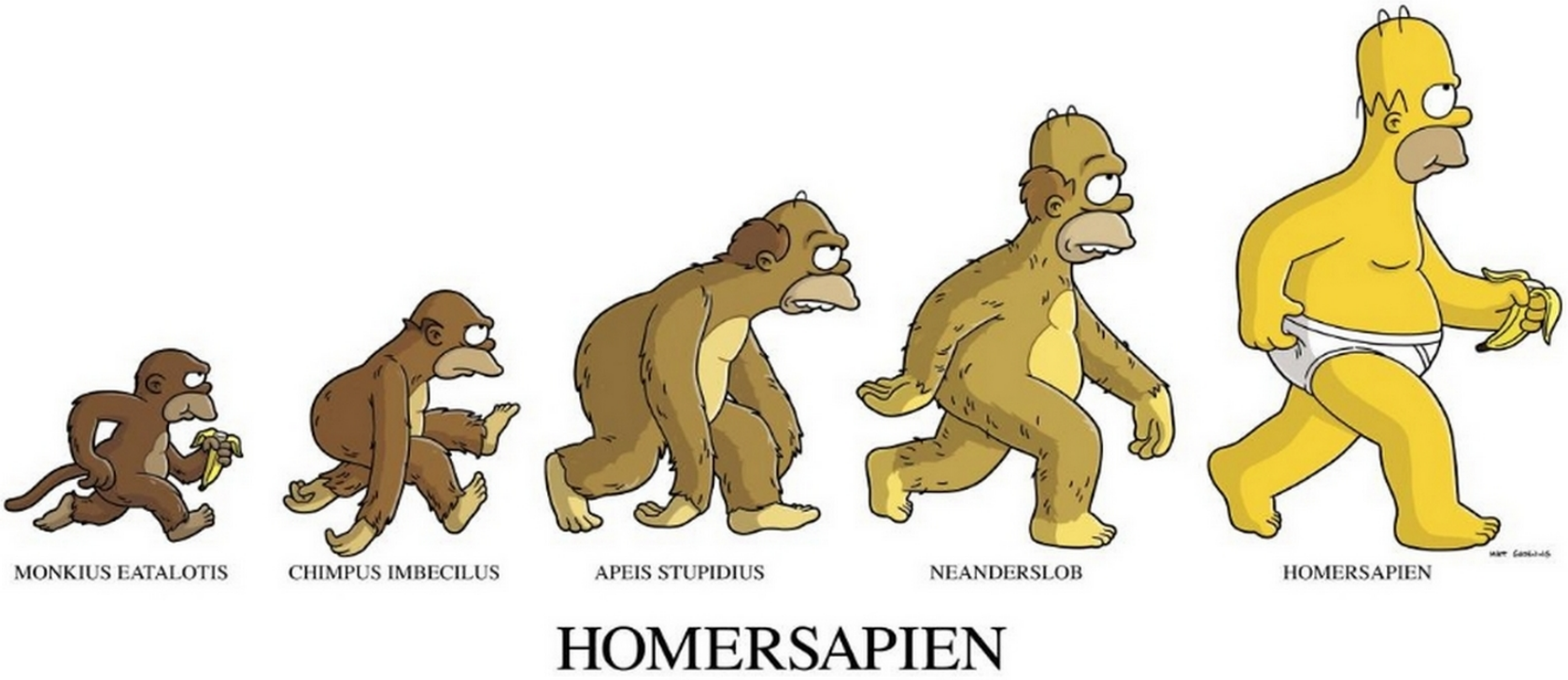
Biology
ES131

Module 3

Principles of Biology

Competition & Selection

Competition & Selection



Theory of Evolution

- **Evolution: The process of change over time**

  Specifically, a change in the frequency of a gene or allele in a population over time

Introduction

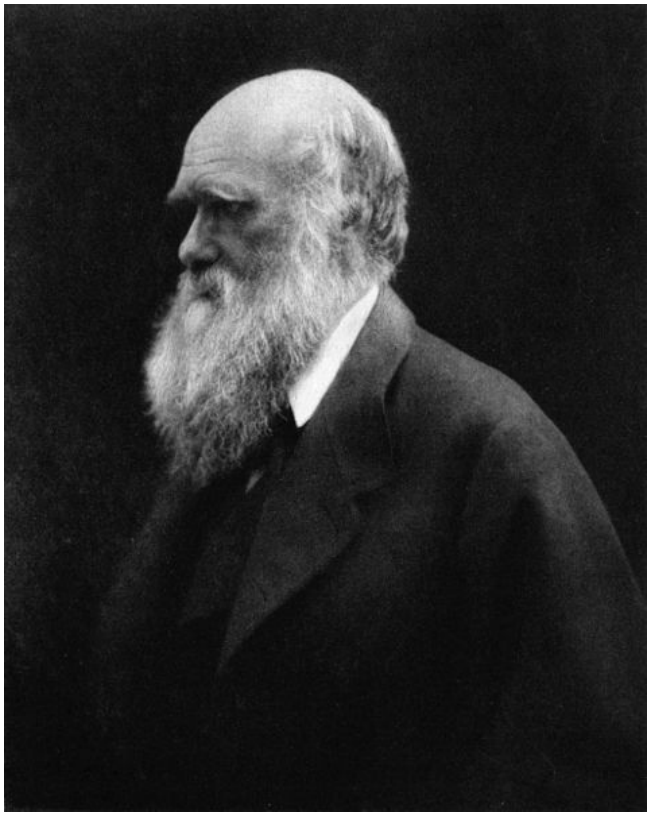
- **Evolution** – includes all of the changes in the characteristics and diversity of life that occur throughout time.
  - Evolution can occur on both large and small scales.
    - Microevolution
    - Macroevolution

Introduction

- The concept of **evolution**, that organisms may change over time, was not new in Darwin's time.
  - However, it was not a widely accepted concept because no one understood how it could work.
  - A **mechanism** was missing.

Natural Selection

- Darwin provided that mechanism with his theory of **Natural Selection**.



Natural Selection

- In any population of organisms there is natural variation.
- Some of these variations will allow the organisms possessing them to survive and reproduce better than those without these particular traits.

Natural Selection

- The successful traits will spread through the population.
- This change in the frequency of alleles in the population is **evolution**.

Natural Selection – High Reproductive Potential

- Darwin observed that organisms have the potential for very **high fertility**.
  - Organisms have the potential to produce, and often do produce large numbers of offspring.
  - Population size would quickly become unmanage offspring survived.

Natural Selection – Population Size Remains Constant

- Despite this high potential fertility, natural populations usually **remain constant in size**, except for small fluctuations.
  - Not all of the potential offspring survive.

Natural Selection – Limited Resources

- **Resources** that organisms need to survive are **limited**.
  - Food, water, shelter, nesting sites, etc.

Natural Selection – Competition

- If there are not enough resources for all of the individuals, there will be **competition** for those resources.
  - Survivors represent a small part of the individuals produced each generation.

Natural Selection – Populations Show Variation

- Which individuals will survive is often not a matter of luck.
- Populations show **variation** – individuals are not identical.
  - They differ in many different traits.

Natural Selection – Variation is Heritable

- Some of the variation between individuals in the population is **heritable**.
  - It can be passed down from one generation to the next.

Natural Selection – Some traits Enhance Survival

- Some of the traits found in the population enhance the survival and reproduction of the organisms possessing them.

Natural Selection – Adaptation

- The favored traits will spread through the population.
  - Over many generations, the species will become **adapted** to its environment.
  - Over time, these changes can lead to the formation of a new species.

Adaptation

- A species may become adapted to its environment in response to **environmental pressures**.
  - A trait may be favored due to enhanced survival or reproduction when faced with a particular aspect of the environment.

Adaptation

- When an environment changes, or when individuals move to a new environment, natural selection may result in adaptation to the new conditions.
  - Sometimes this results in a new species.

Populations Evolve

- Individuals do not evolve; populations evolve.
- Evolution is measured as changes in relative proportions of heritable variations in a population over several generations.

Natural Selection – Important Points

- Natural selection can only work on ***heritable*** traits.
  - Acquired traits are not heritable and are not subject to natural selection.

Natural Selection – Important Points

- Environmental factors are variable.
  - A trait that is beneficial in one place or time may be detrimental in another place or time.

Natural Selection – Important Points

- Natural selection is **not random**. It occurs in response to environmental pressures and results in adaptation.

Natural Selection – Important Points

- When natural selection is occurring, some individuals are having better reproductive success than others.
  - Alleles are being passed to the next generation in frequencies that are different from the current generation.
    - See the Tutorial on Microevolution!

Upsetting Genetic Equilibrium

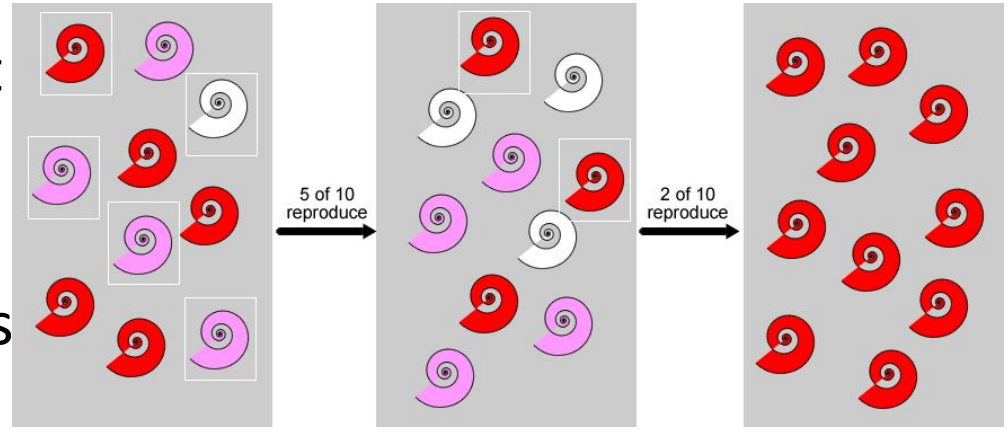
- **Natural selection** is not the only way that allele frequencies can change from one generation to the next.
  - Genetic Drift – a random loss of alleles.
  - Mutation – a new mutation can add alleles.
  - Nonrandom mating – inbreeding increases the number of homozygous traits.
  - Migration – shuffles alleles between populations; can prevent speciation.

Genetic Drift

- The smaller the sample, the greater the chance of deviation from expected results.
  - These **random** deviations from expected frequencies are called **genetic drift**.
  - Allele frequencies are more likely to deviate from the expected in **small** populations.

Genetic Drift

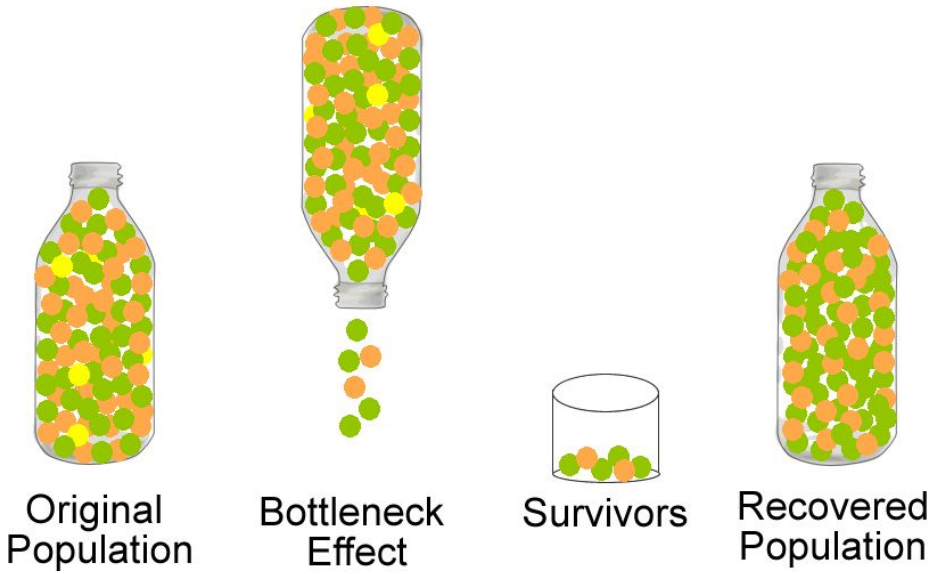
- Which allele gets lost is due to **random chance**.
- Over time, drift tends to reduce genetic variation through random loss of alleles.



- C^RC^R = red
- C^RC^W = pink
- C^WC^W = white

The Bottleneck Effect

- Sometimes a catastrophic event can severely reduce the size of a population.
  - The random assortment of survivors may have different allele frequencies.
  - This is a type of genetic drift called the **bottleneck effect.**

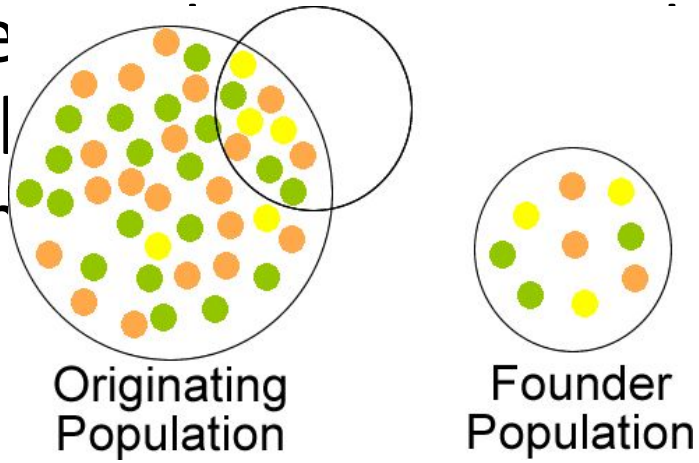


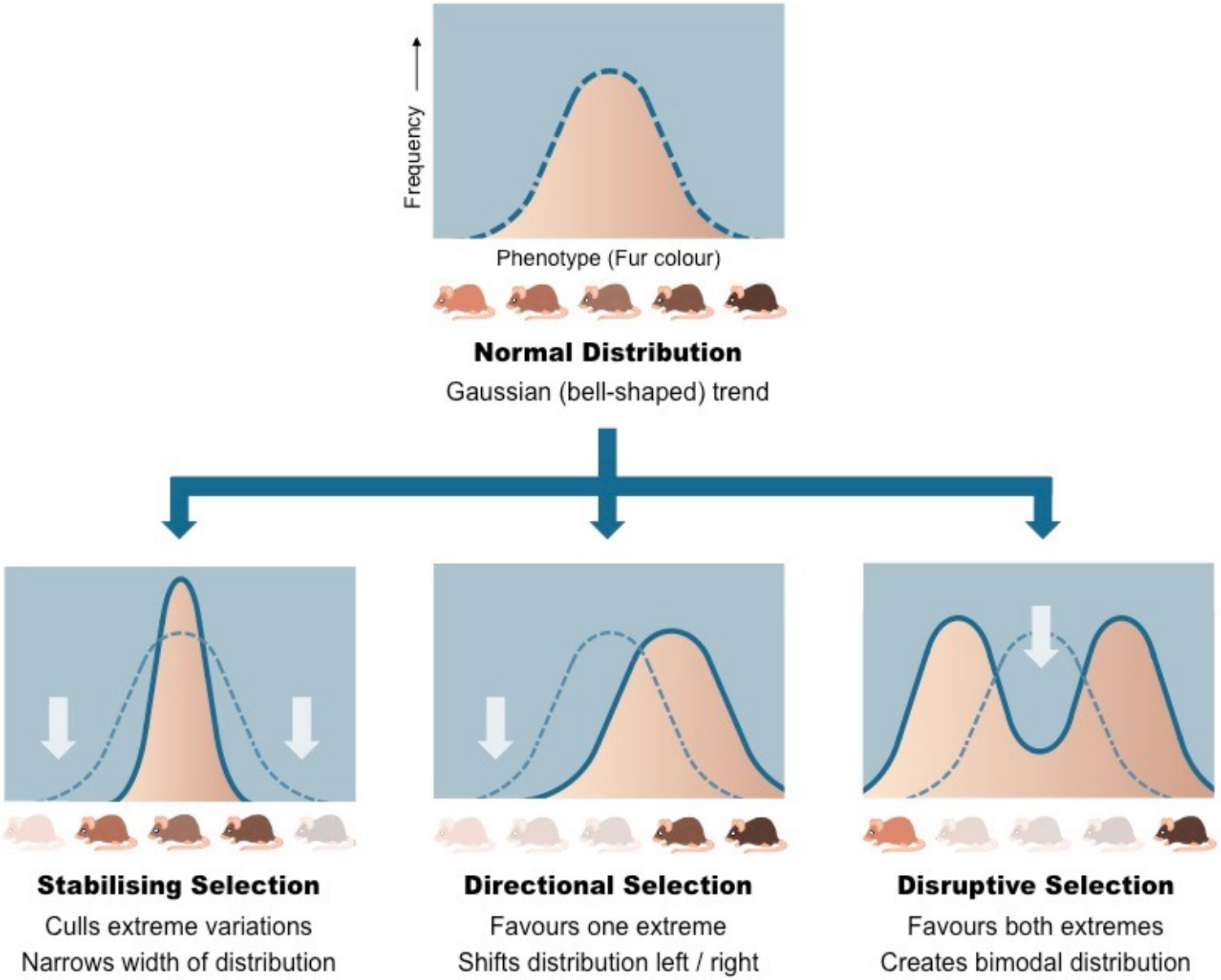
The Bottleneck Effect

- The actions of people sometimes cause bottlenecks in other species.
  - N. California elephant seal population reduced to 20-100 individuals in the 1890s.
  - Current population > 30,000.
  - Variation *drastically* reduced – 24 genes with 1 allele.

The Founder Effect

- **Founder effect** – Another type of genetic drift occurs when a small group of individuals becomes separated from the population and form a new population. The allele frequencie may be different t
  popultion





Natural selection can act in a number of directions

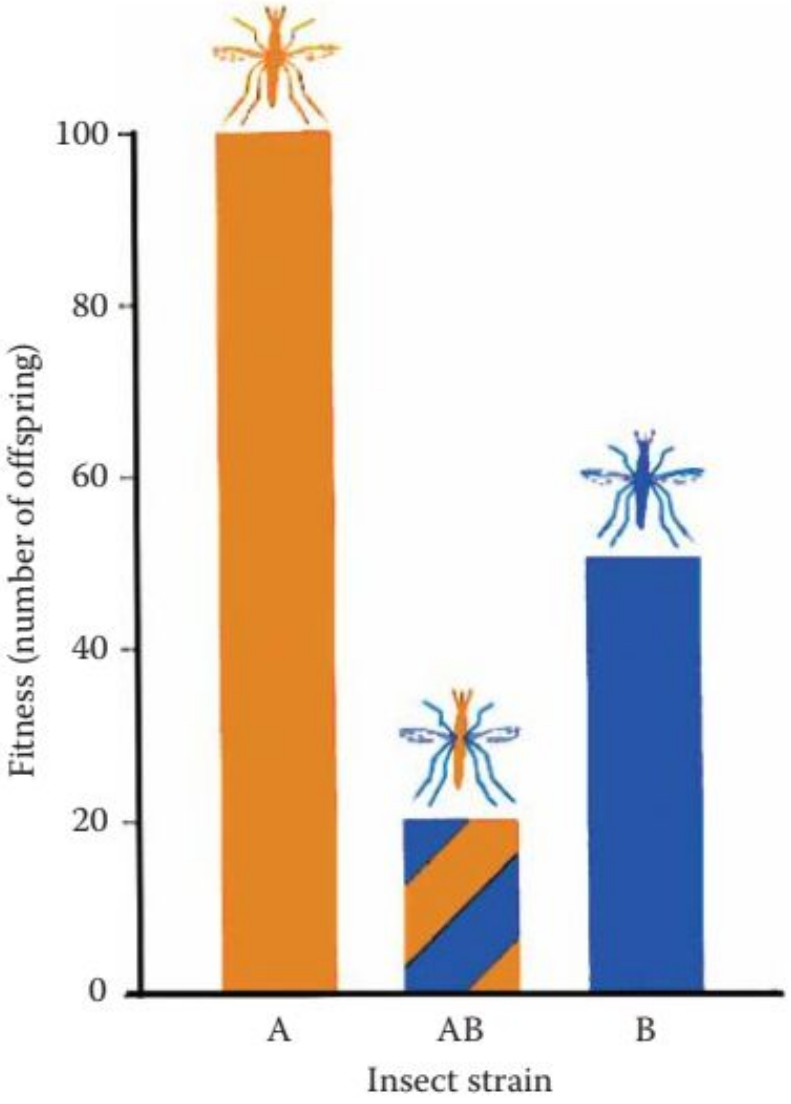
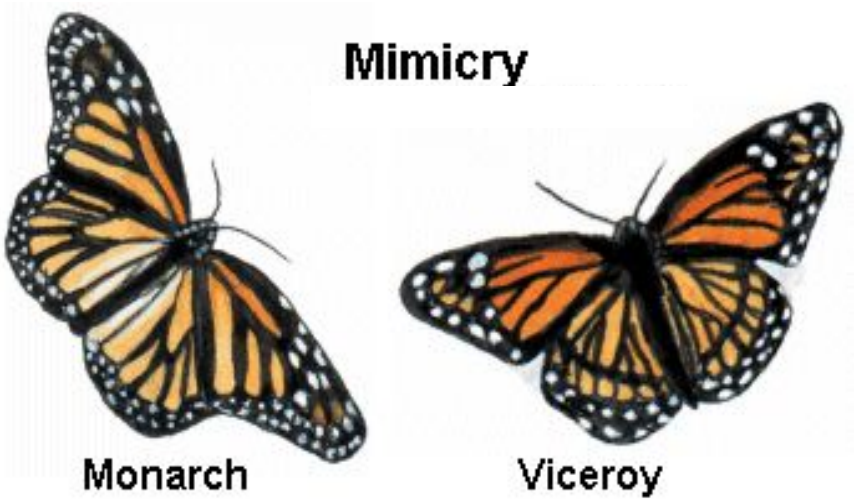


FIGURE 5.4.1 Underdominance describes a condition when a mating between two strains (A and B) results in offspring (AB) less fit than either parent. This mechanism has been proposed as a means to eliminate malaria-carrying mosquitoes from the environment. (From Gould, F. et al., *Am. Sci.*, 94, 238, 2006. With permission.)

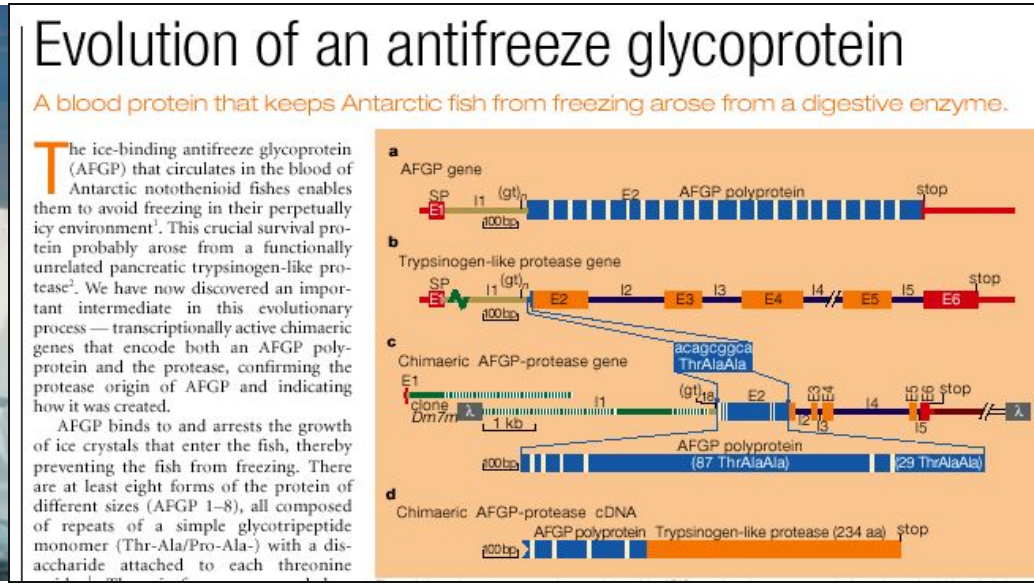
Natural Selection can take several forms

- Predation Selection
  - camouflage (mimicry)
  - speed
  - behaviors & habits
  - defenses (physical & chemical)



Natural Selection can take several forms

- **Physiological Selection**
  - fitness (food-gathering)
  - physiology efficiency (oxygen, food, water)
  - disease resistance
  - protection from injury
  - biochemical versatility



Evolution of an antifreeze glycoprotein

A blood protein that keeps Antarctic fish from freezing arose from a digestive enzyme.

The ice-binding antifreeze glycoprotein (AFGP) that circulates in the blood of Antarctic notothenioid fishes enables them to avoid freezing in their perpetually icy environment[1]. This crucial survival protein probably arose from a functionally unrelated pancreatic trypsinogen-like protease[2]. We have now discovered an important intermediate in this evolutionary process — transcriptionally active chimaeric genes that encode both an AFGP polyprotein and the protease, confirming the protease origin of AFGP and indicating how it was created.

AFGP binds to and arrests the growth of ice crystals that enter the fish, thereby preventing the fish from freezing. There are at least eight forms of the protein of different sizes (AFGP 1–8), all composed of repeats of a simple glycotripeptide monomer (Thr-Ala/Pro-Ala-) with a disaccharide attached to each threonine

Natural Selection can take several forms

- **Sexual Selection**
  - attractiveness to potential mate
  - fertility of gametes
  - ultimately, differential reproductive success

"survival" doesn't matter if you don't reproduce! ***(meaning: attract mate & breed)***

- Sexual selection acts in all sexually-reproducing species
  - it influences morphology & behavior
  - it acts on both males and females

Taeniopygia guttata

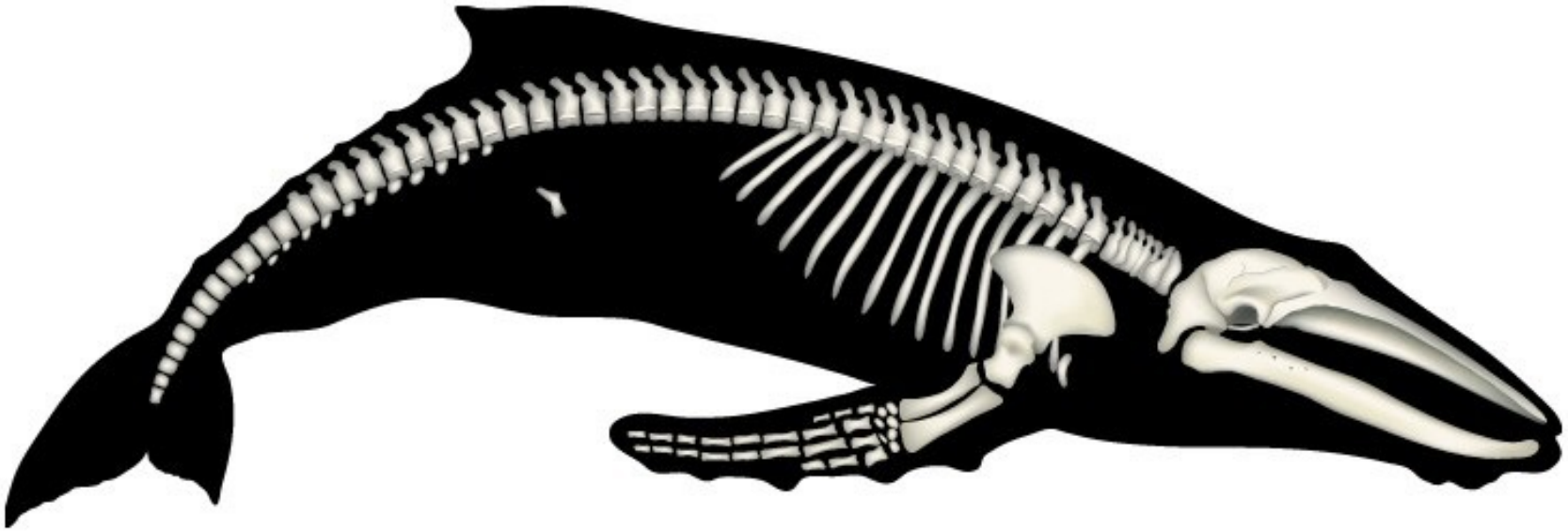
Descent with Modification

- **Descent with Modification – each living species has descended, with changes, from other species over time.**

- **Common Descent – all living organisms are related to one another**

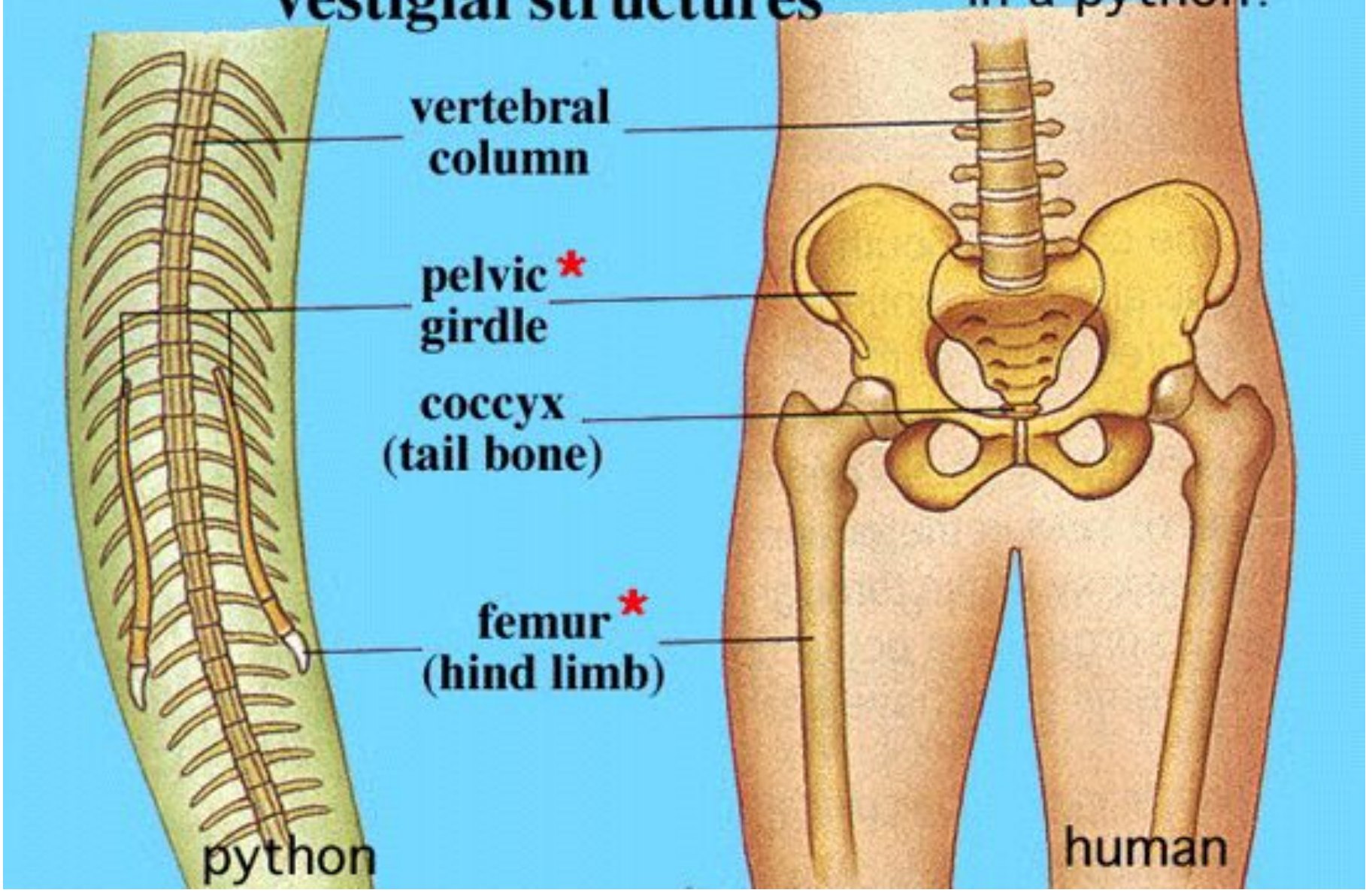
Vestigial Organs

Vestigial Organs: “leftover” traces of evolution that serve no purpose



How do you explain the presence of these bones

vestigial structures* in a python?



A researcher studying the evolution of flight in birds is focusing on:

- Microevolution
- Macroevolution
- The bottleneck effect

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

What was the mechanism of evolution that Darwin proposed?

- Natural Selection
- Macroevolution
- Genetic drift
- Chromosomal basis of inheritance

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

In every population there is variation. It is important that this variation

- Involves a variety of colors
- Is heritable
- Is not noticeable
- Is acquired during an organisms lifetime

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

During natural selection, some organisms will survive & reproduce better than others. This is due to:

- Random chance
- Humans choosing which animals to breed
- Environmental pressures resulting in organisms with certain traits having the best reproductive success
- Luck

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

Which statement about adaptation is NOT true?

- A species may become adapted to its environment in response to environmental pressures.
- A species is perfectly adapted to its environment from the beginning.
- As favored traits spread through the population, a species will become adapted to its environment.
- When an environment changes, or when individuals move to a new environment, natural selection may result in adaptation to the new conditions, sometimes this results in a new species.

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

How can allele frequencies change from one generation to the next?

- Genetic drift
- Natural selection
- Mutation
- Migration
- All of the above

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

Which of the following is NOT due to random chance?

- Genetic drift
- The bottleneck effect
- Natural selection
- The founder effect

Sorry!

- That is incorrect.
- Try again!

Congratulations!

- You are correct!

After a catastrophe reduces the size of a population, the survivors may have a different set of allele frequencies. This is called

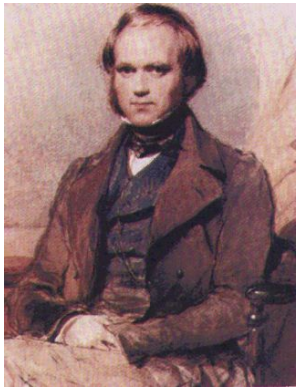
- The bottleneck effect
- Natural selection
- The founder effect
- All of the above

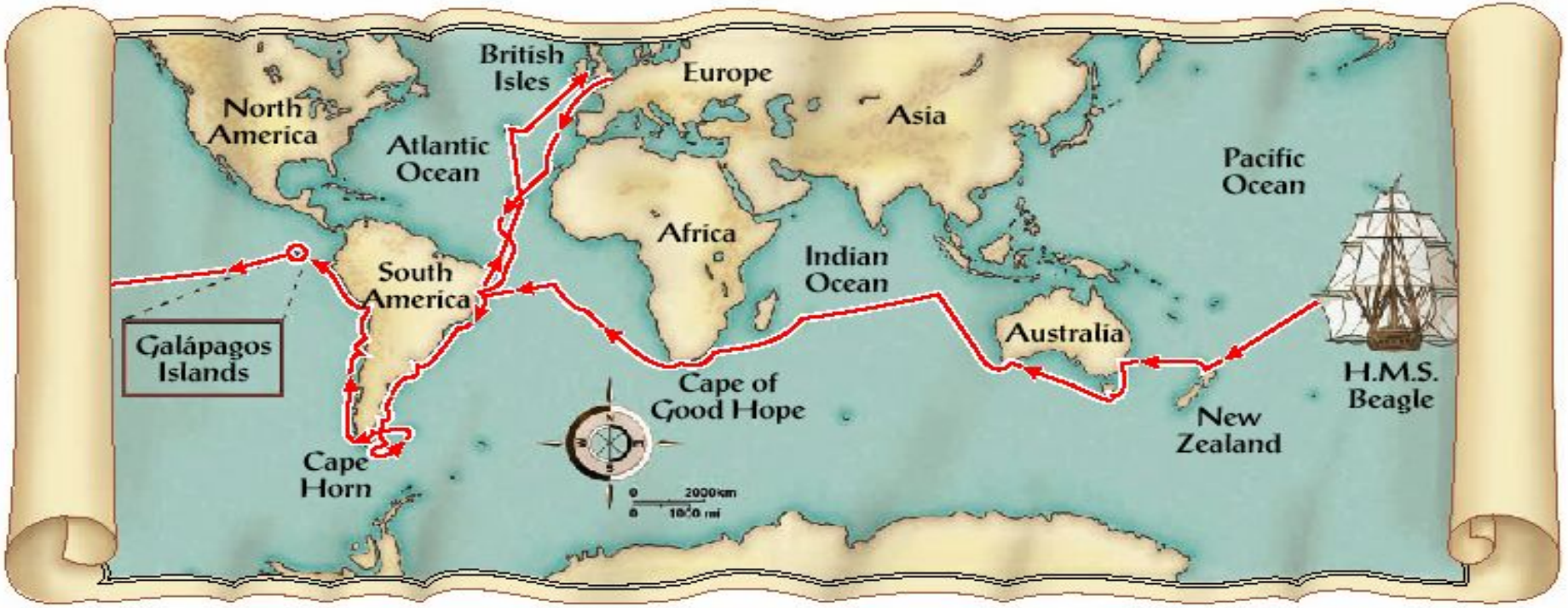
Sorry!

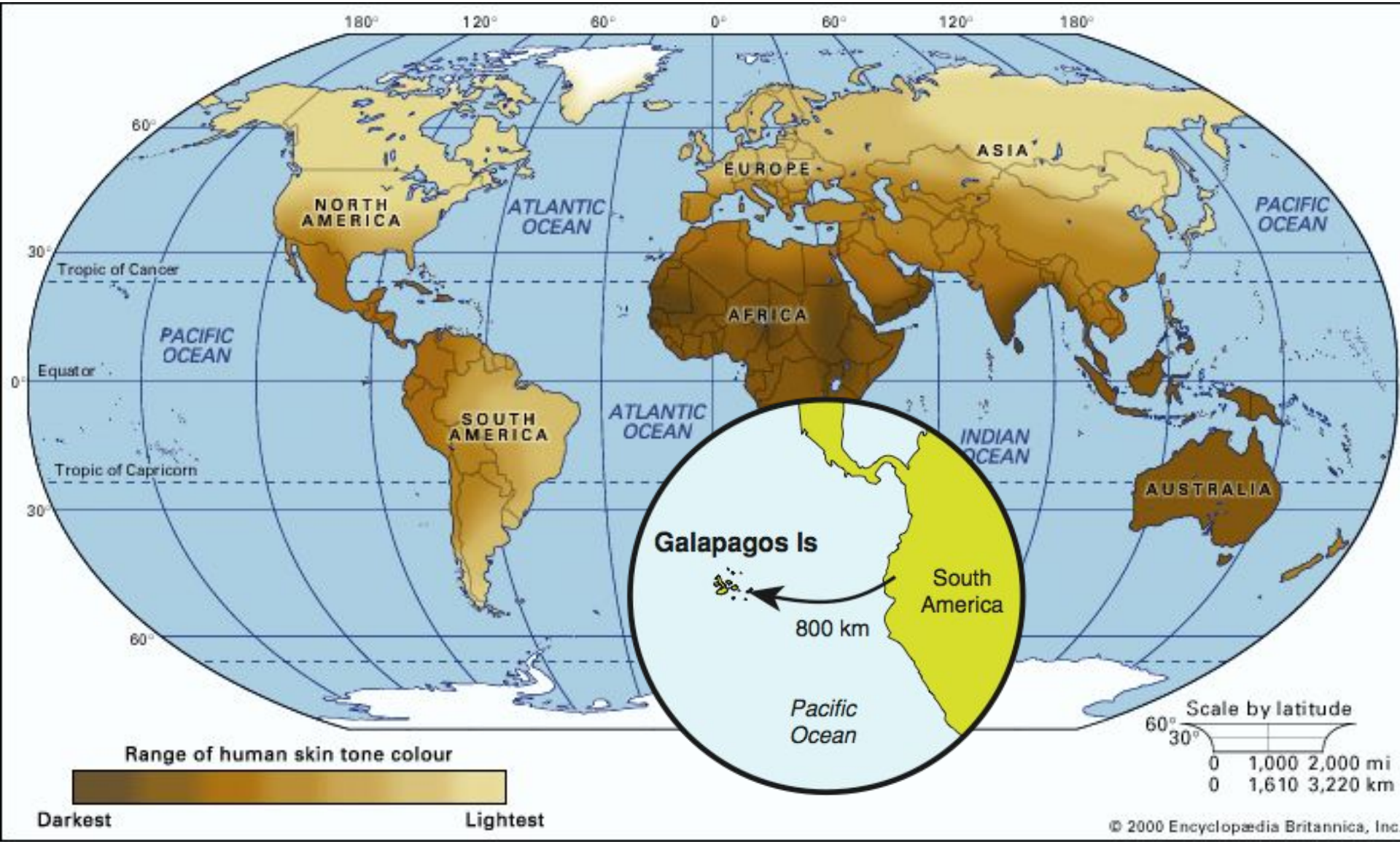
- That is incorrect.
- Try again!

Congratulations!

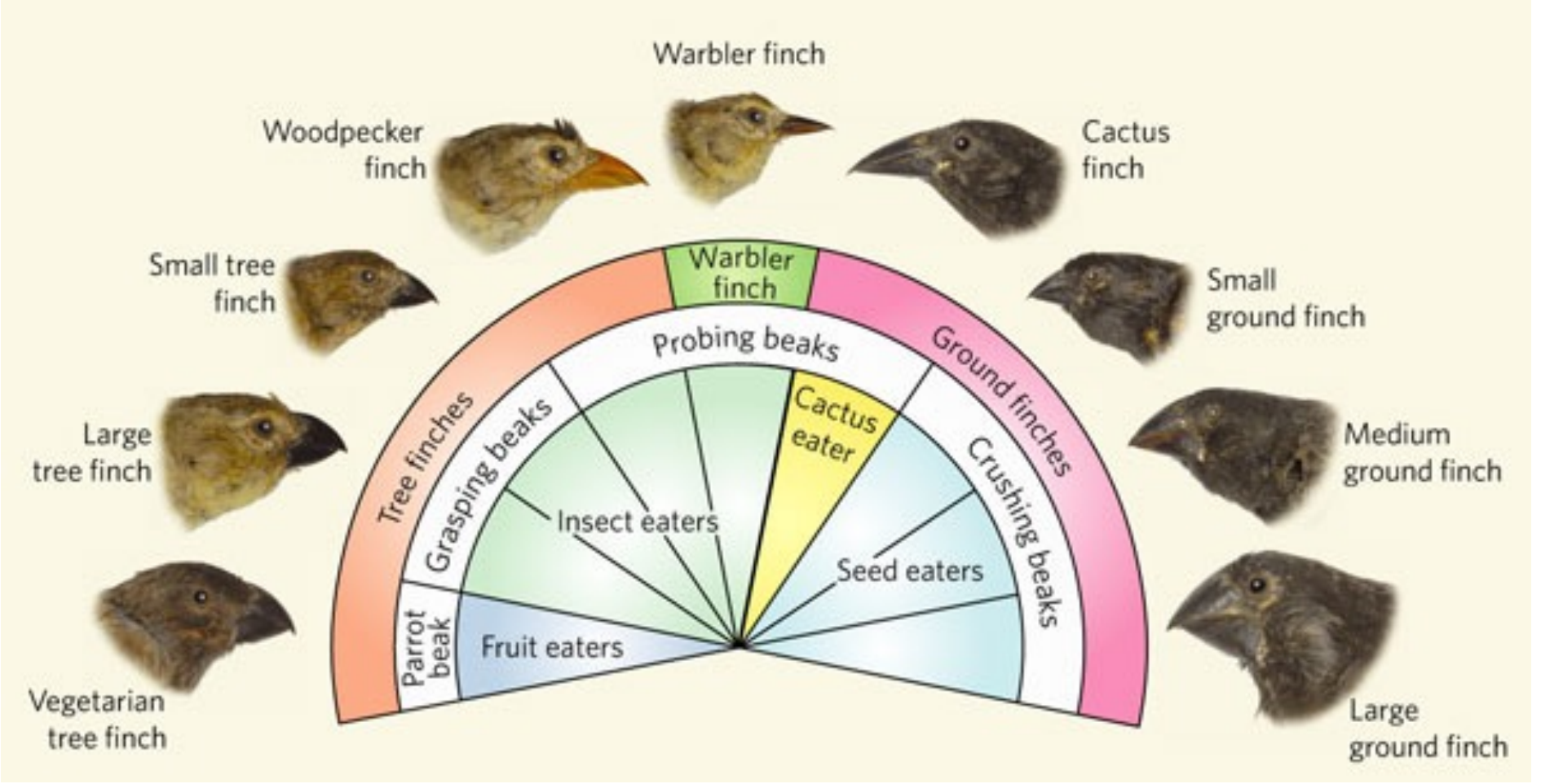
- You are correct!



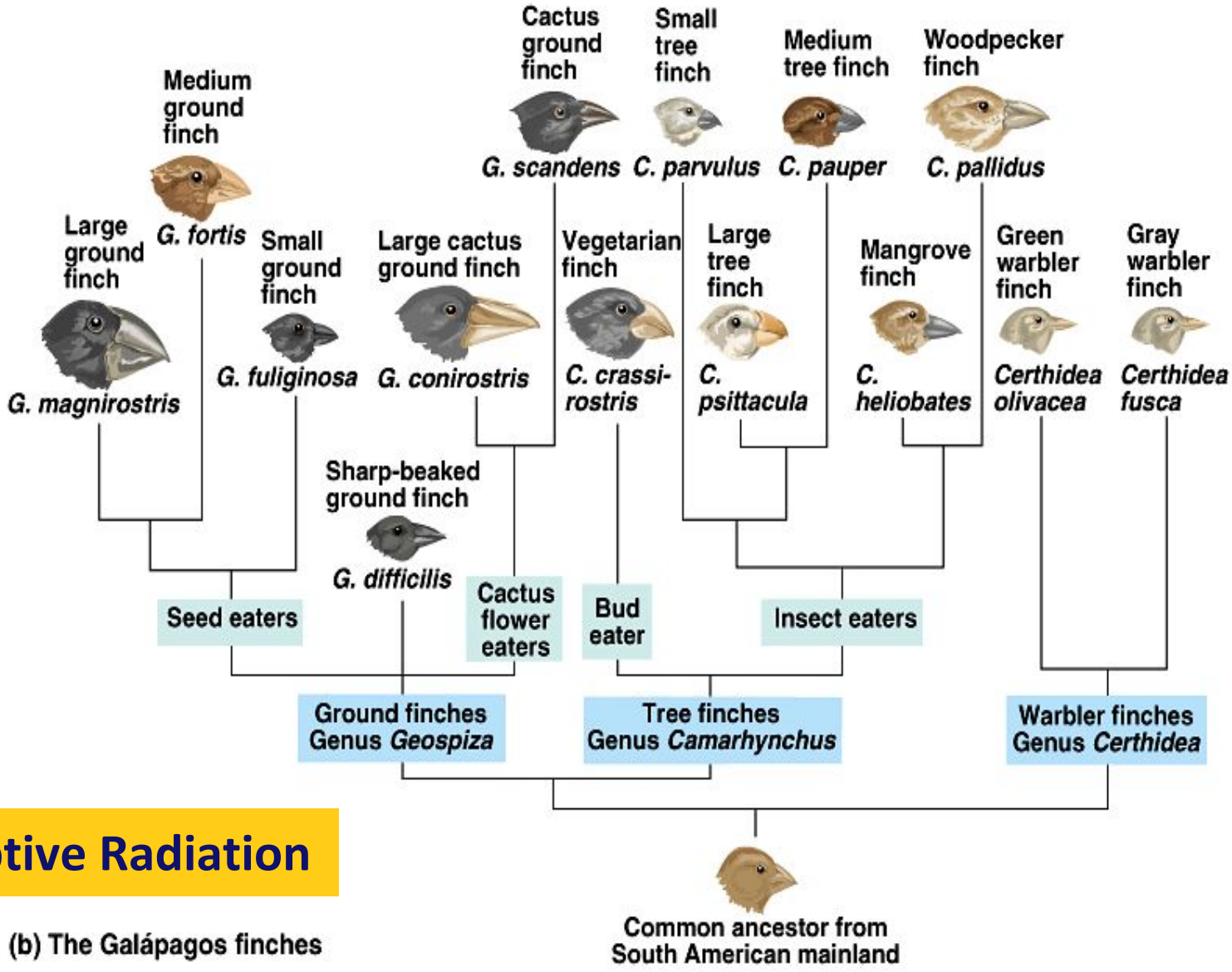

British Isles
Europe
North America
Asia
Atlantic Ocean
Pacific Ocean
Africa
Indian Ocean
South America
Galápagos Islands
Australia
H.M.S. Beagle
Cape of Good Hope
New Zealand
Cape Horn
2000km



Darwin's Finches



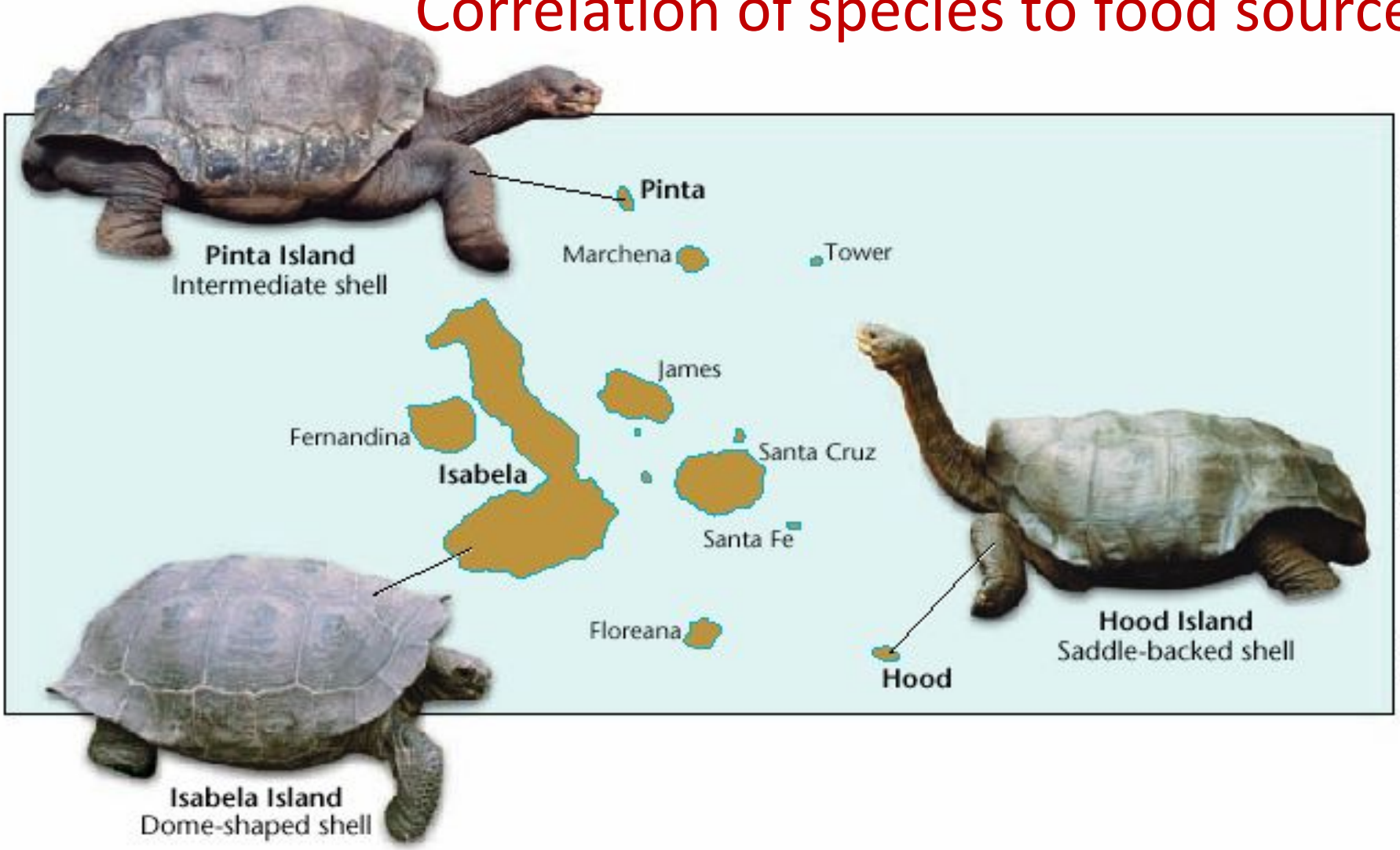
Correlation of Species to Food Source



(b) The Galápagos finches

Adaptive Radiation

Correlation of species to food source

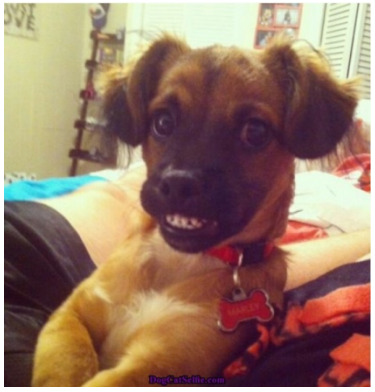


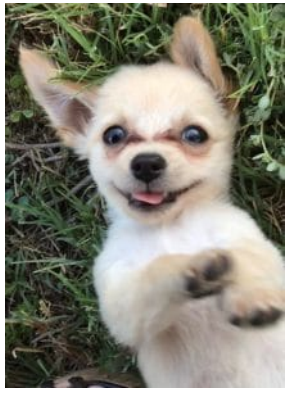
Variation Among Tortoises Darwin observed that the characteristics of many animals and plants varied noticeably among the different Galápagos Islands. Among the tortoises, the shape of the shell corresponds to different habitats. The Hood Island tortoise (right) has a long neck and a shell that is curved and open around the neck and legs, allowing the tortoise to reach the sparse vegetation on Hood Island. The tortoise from Isabela Island (lower left) has a dome-shaped shell and a shorter neck. Vegetation on this island is more abundant and closer to the ground. The tortoise from Pinta Island has a shell that is intermediate between these two forms.

Natural Selection

- **<u>Natural Selection:</u> Organisms that are best adapted to an environment <u>*survive*</u> and <u>*reproduce*</u> more than others**
- **Darwin's Theory of Natural Selection occurs in four steps:**
  Overproduction
  Variation
  Competition
  Selection

Artificial Selection





Natural Selection

1. Overproduction

- **Each species produces more offspring that can survive**

Natural Selection
2. Variation

- **Each individual has a unique combination of inherited traits.**

  - **Adaptation: an inherited trait that increases an organism's chances of survival**


Cummings

Why is Variation Important?

- **Because the environment changes**

- **The more variation within a species, the more likely it will survive**
  - **EX: If everyone is the same, they are all vulnerable to the same environmental changes or diseases**

- **The more variation of types of species in an habitat, the more likely at least some will survive**
  - **EX: Dinosaurs replaced by mammals**

Natural Selection

3. Competition

- **Individuals COMPETE for limited resources:**
  - **Food, water, space, mates**

- **Natural selection occurs through "Survival of the fittest"**
  - **Fitness: the ability to survive and reproduce**

- **Not all individuals survive to adulthood**

Natural Selection
4. Selection

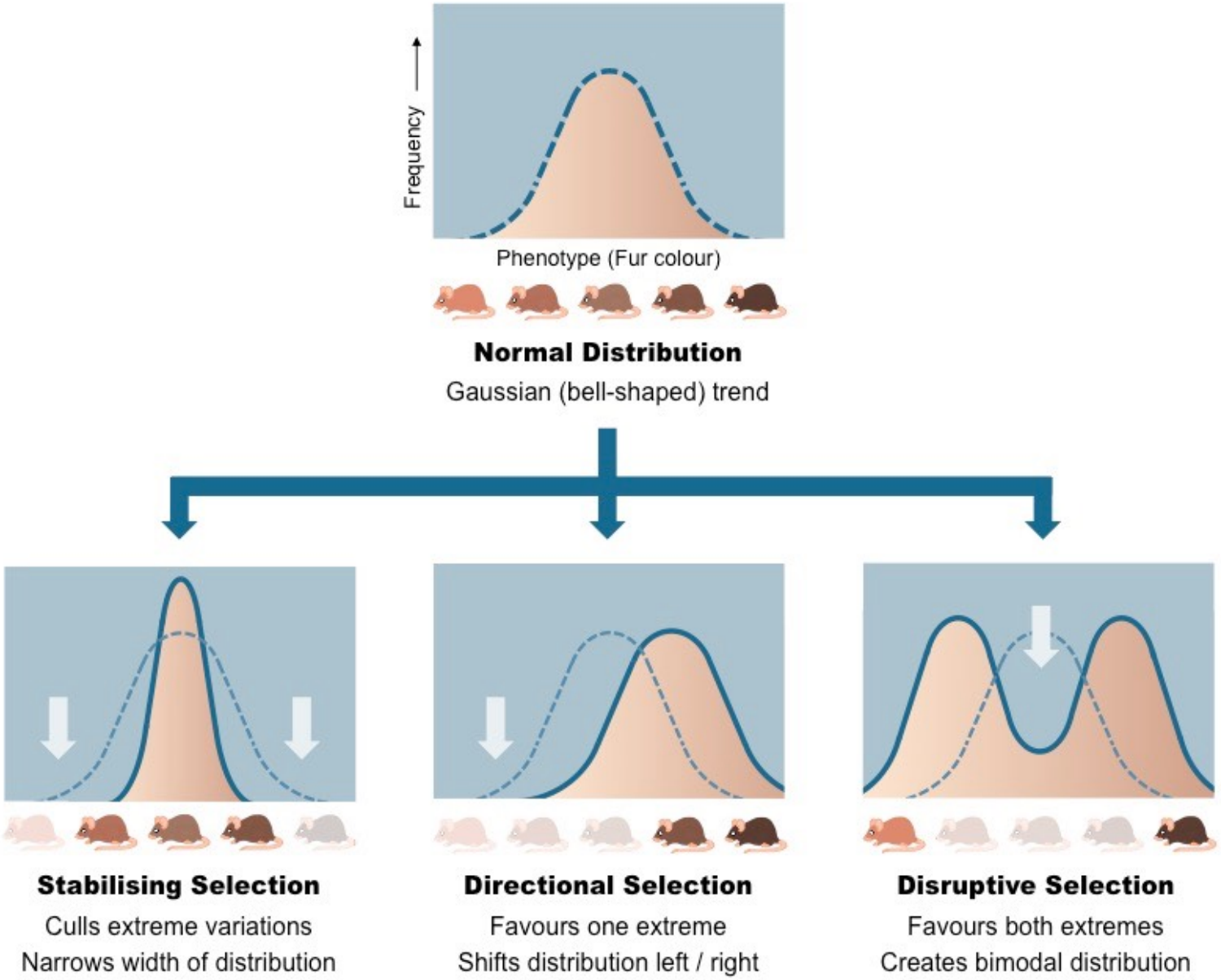
- **The individuals with the best traits / adaptations will survive and have the opportunity to pass on it's traits to offspring.**

  - **Natural selection acts on the phenotype (physical appearance), not the genotype (genetic makeup)**

  - **Ex: When a predator finds its prey, it is due to the prey's physical characteristics, like color or slow speed, not the alleles (BB, Bb)**

Peppered Moth

- Which moth will the bird catch?



Natural selection can act in a number of directions

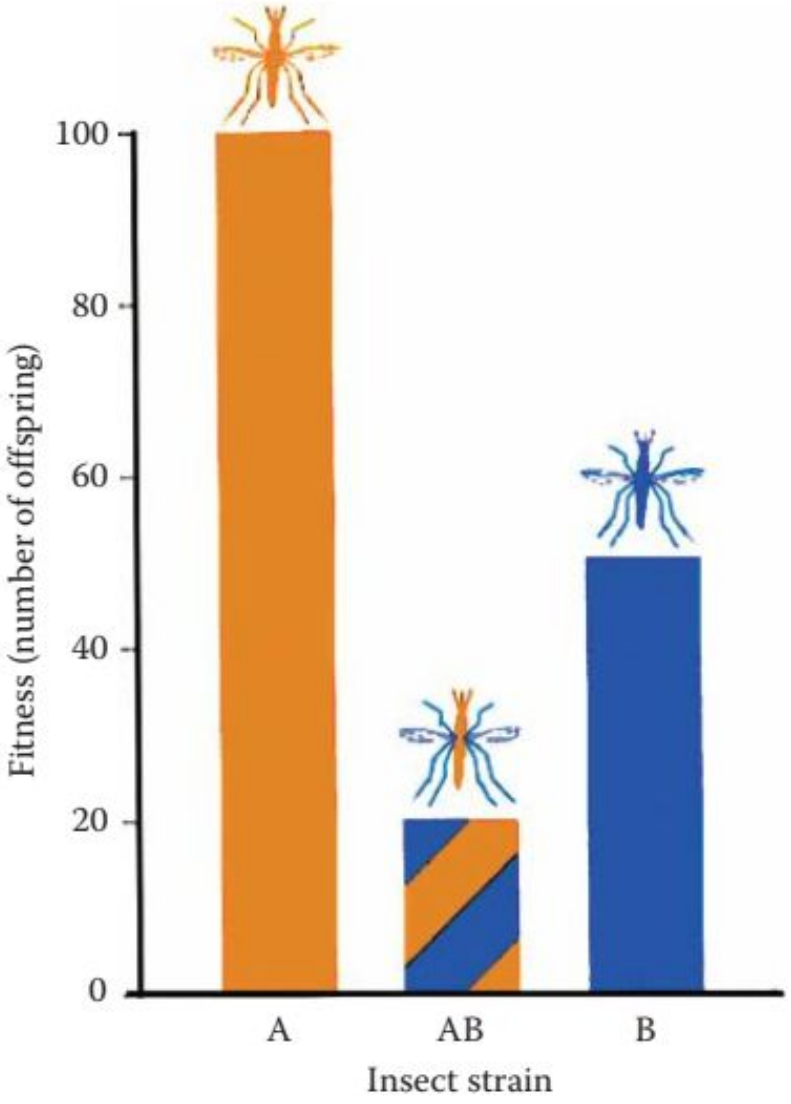
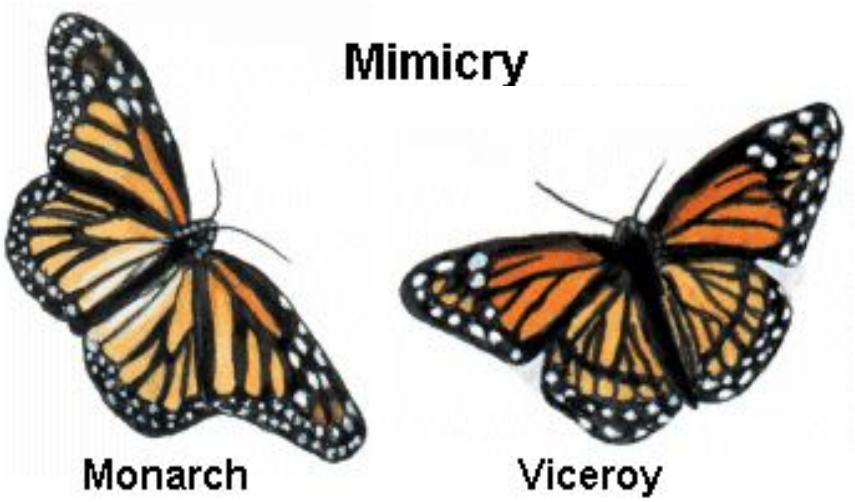


FIGURE 5.4.1 Underdominance describes a condition when a mating between two strains (A and B) results in offspring (AB) less fit than either parent. This mechanism has been proposed as a means to eliminate malaria-carrying mosquitoes from the environment. (From Gould, F. et al., *Am. Sci.*, 94, 238, 2006. With permission.)

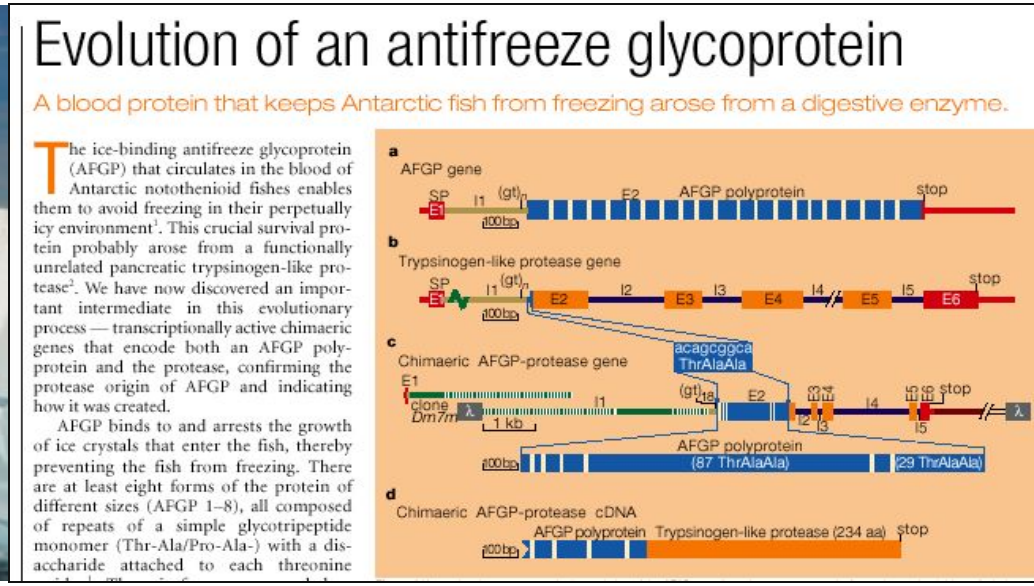
Natural Selection can take several forms

- Predation Selection
  - camouflage (mimicry)
  - speed
  - behaviors & habits
  - defenses (physical & chemical)



Natural Selection can take several forms

- **Physiological Selection**
  - fitness (food-gathering)
  - physiology efficiency (oxygen, food, water)
  - disease resistance
  - protection from injury
  - biochemical versatility



Evolution of an antifreeze glycoprotein

A blood protein that keeps Antarctic fish from freezing arose from a digestive enzyme.

The ice-binding antifreeze glycoprotein (AFGP) that circulates in the blood of Antarctic notothenioid fishes enables them to avoid freezing in their perpetually icy environment[1]. This crucial survival protein probably arose from a functionally unrelated pancreatic trypsinogen-like protease[2]. We have now discovered an important intermediate in this evolutionary process — transcriptionally active chimaeric genes that encode both an AFGP polyprotein and the protease, confirming the protease origin of AFGP and indicating how it was created.

AFGP binds to and arrests the growth of ice crystals that enter the fish, thereby preventing the fish from freezing. There are at least eight forms of the protein of different sizes (AFGP 1–8), all composed of repeats of a simple glycotripeptide monomer (Thr-Ala/Pro-Ala-) with a disaccharide attached to each threonine

Natural Selection can take several forms

- **Sexual Selection**
  - attractiveness to potential mate
  - fertility of gametes
  - ultimately, differential reproductive success

"survival" doesn't matter if you don't reproduce! ***(meaning: attract mate & breed)***

- Sexual selection acts in all sexually-reproducing species
  - it influences morphology & behavior
  - it acts on both males and females

Taeniopygia guttata

Thus, when a BU dies as a result of competition, not only does that BU fail to survive, but all potential future generations also fail to survive. This has enormous consequences. It means that

- Those BU that are best adapted to their environment will stand the best chance of populating that environment.
- Future generations will be well adapted to that environment because those less well adapted will be crowded out.
- Competition among all future BU will become even stronger.
- Genetic material contained by BU that do not survive will be forever lost.

SELFISH GENES

According to Dawkins (1976), genes are impersonal replicators, dedicated to multiplying as widely as possible. This idea considers the organism as the means to pass genes from one generation to the next. Aggression and selfishness are natural attributes of genes locked in a competition to dominate. Altruism, love, and generosity would only be expected to be shown toward those other individuals who share the same genes, and the closer the relationship, the more care and attention would be lavished on the relative. Parents and their offspring share 50% of their unique genetic material; grandparents and grandchildren share 25%; siblings share, on average, 50%. This is an interesting idea and seems to have some merit in the animal kingdom.

(*continued*)

SELFISH GENES (continued)

Humankind, however, does not always act this way. There is care and concern for even total strangers. There is even care and concern for other species, especially those kept as pets. This is a cultural attribute.

Perhaps the paradigm for selfish genes are genes called *transposons*, or "jumping genes." The transposon encodes a protein that cuts the transposon DNA free of its place in the chromosome and then reinserts it in another unrelated place in the genome. DNA repair mechanisms of the cell then mend the hole at the original transposon position by recreating the transposon nucleic acid sequence. After this, the cell has two copies of the transposon rather than one. This is an example of competition even among different genes within the same cell (Gould et al., 2006). Transposons make up about 50% of the human genome (Burt and Trivers, 2006), and make up a large part of the so-called "junk DNA" that appears to have no purpose except to replicate itself.

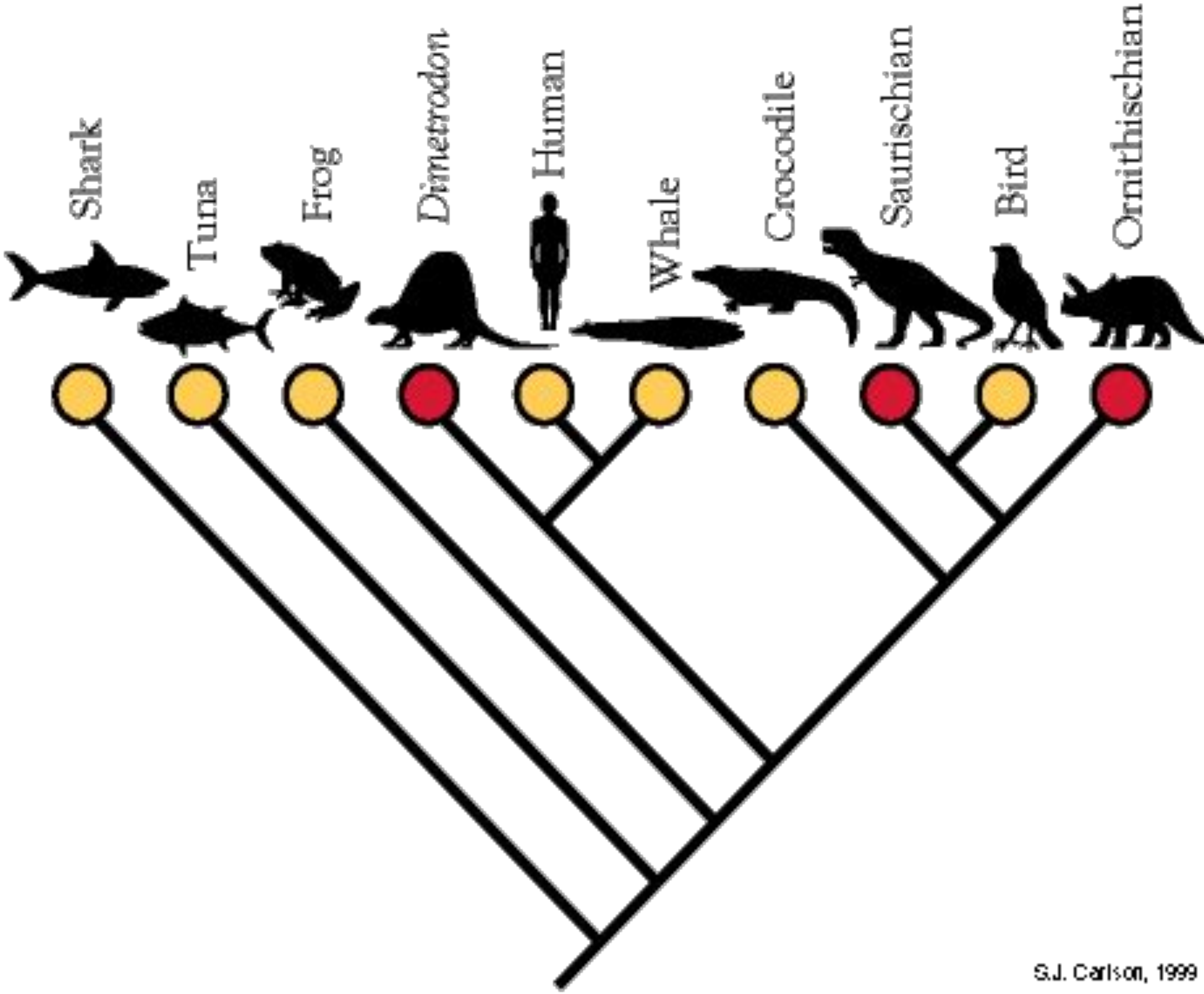
The conflict among genetic elements is sharpened by the existence of *gamete killer* genes in certain fungi. The gamete killers are a series of tightly linked genes (genes that nearly always are replicated together, just as certain sex-linked genes are tightly linked) that code for a toxin that is formed or deposited in all spores produced by the fungus. In the spores that contain the gamete killers, an antitoxin is made. Thus, spores that contain the gamete killer genes survive but spores without the genes are extirpated. The result is that gamete killers end up in 100% of the viable spores.

All is not clearly one-sided, however, because there are other genes that confer resistance to gamete killer genes. The tide of battle turns around when these genes enter the gene pool.

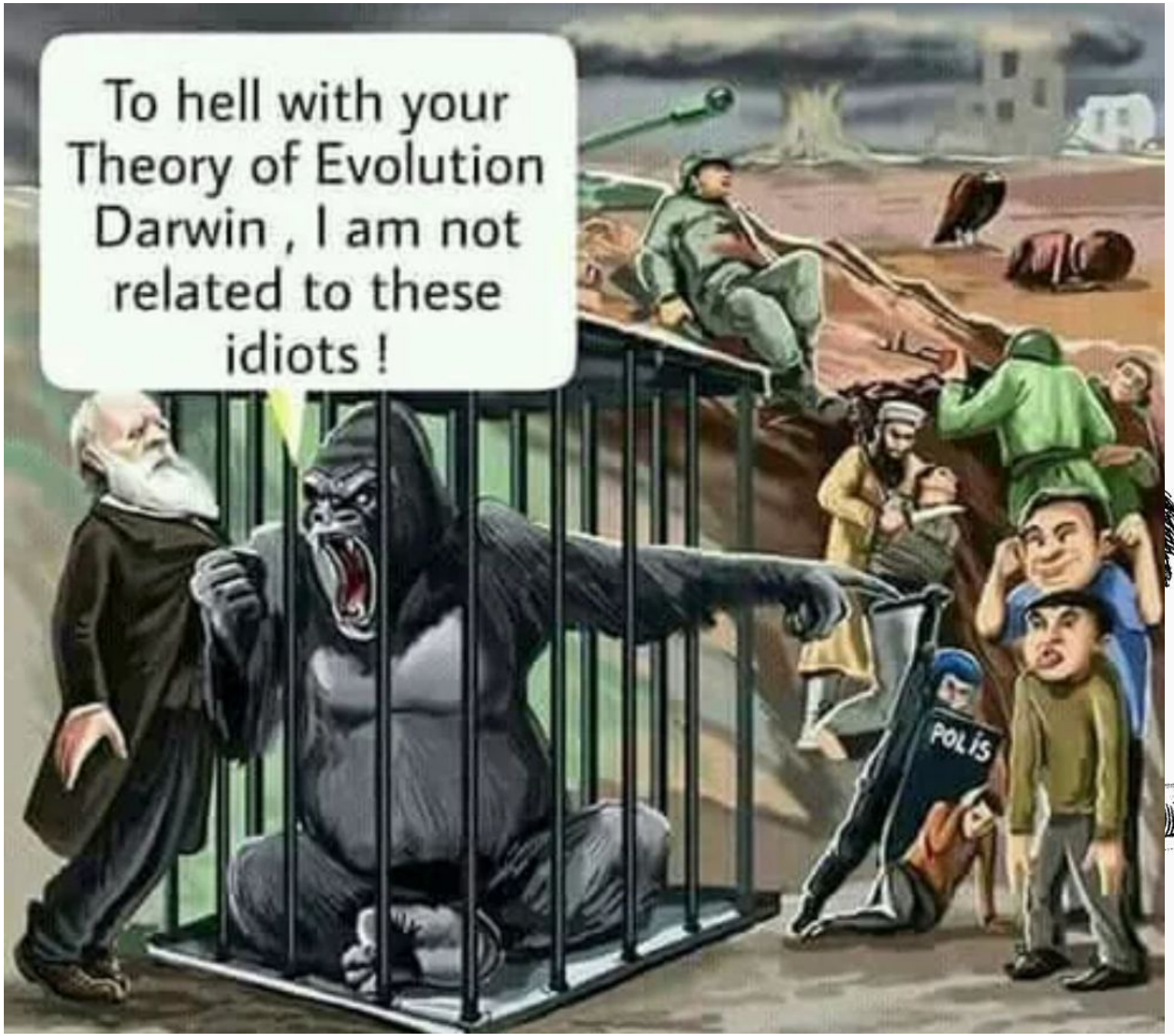
Descent with Modification

- **Descent with Modification – each living species has descended, with changes, from other species over time.**

- **Common Descent – all living organisms are related to one another**



Shark
Tuna
Frog
Dimetrodon
Human
Whale
Crocodile
Saurischian
Bird
Ornithischian
S.J. Carlson, 1999

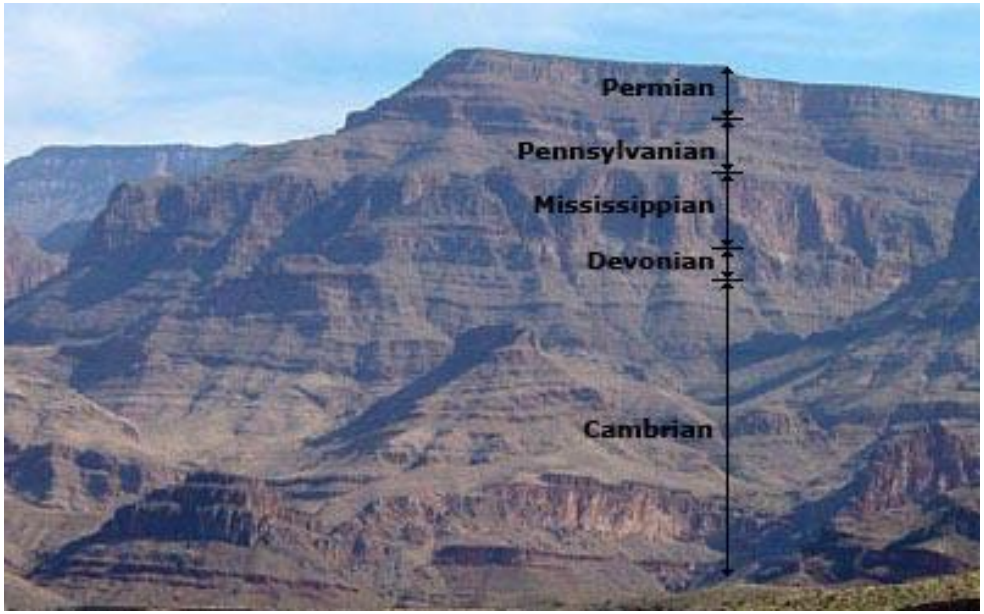

To hell with your Theory of Evolution Darwin , I am not related to these idiots !
POLIS

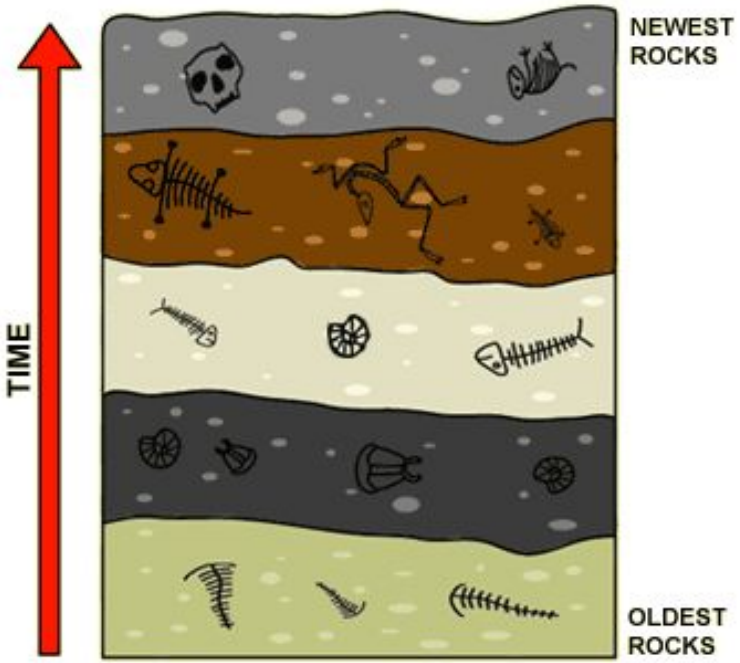
Evidence for Evolution:

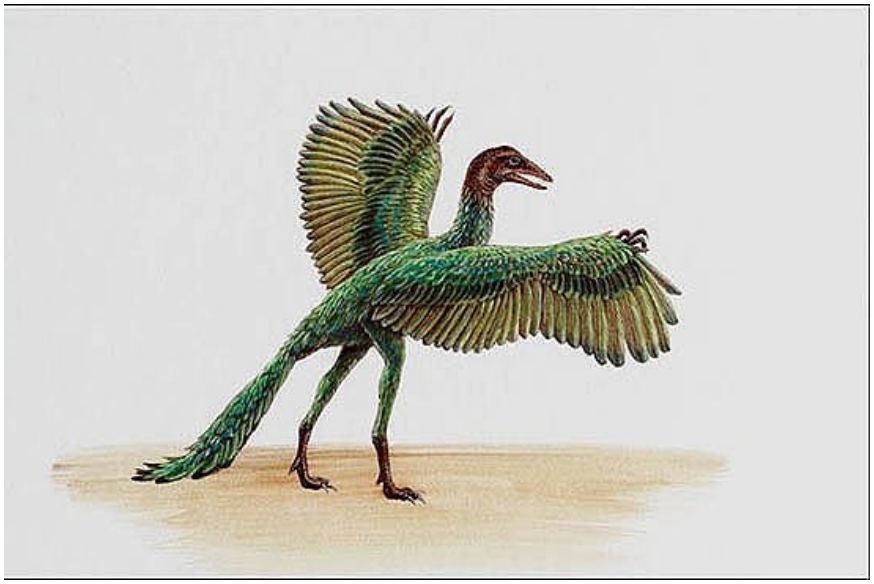
- Fossil Record
- Homologous Body Structures
- Vestigial Organs
- Embryology
- Biochemical Evidence

The Fossil Record

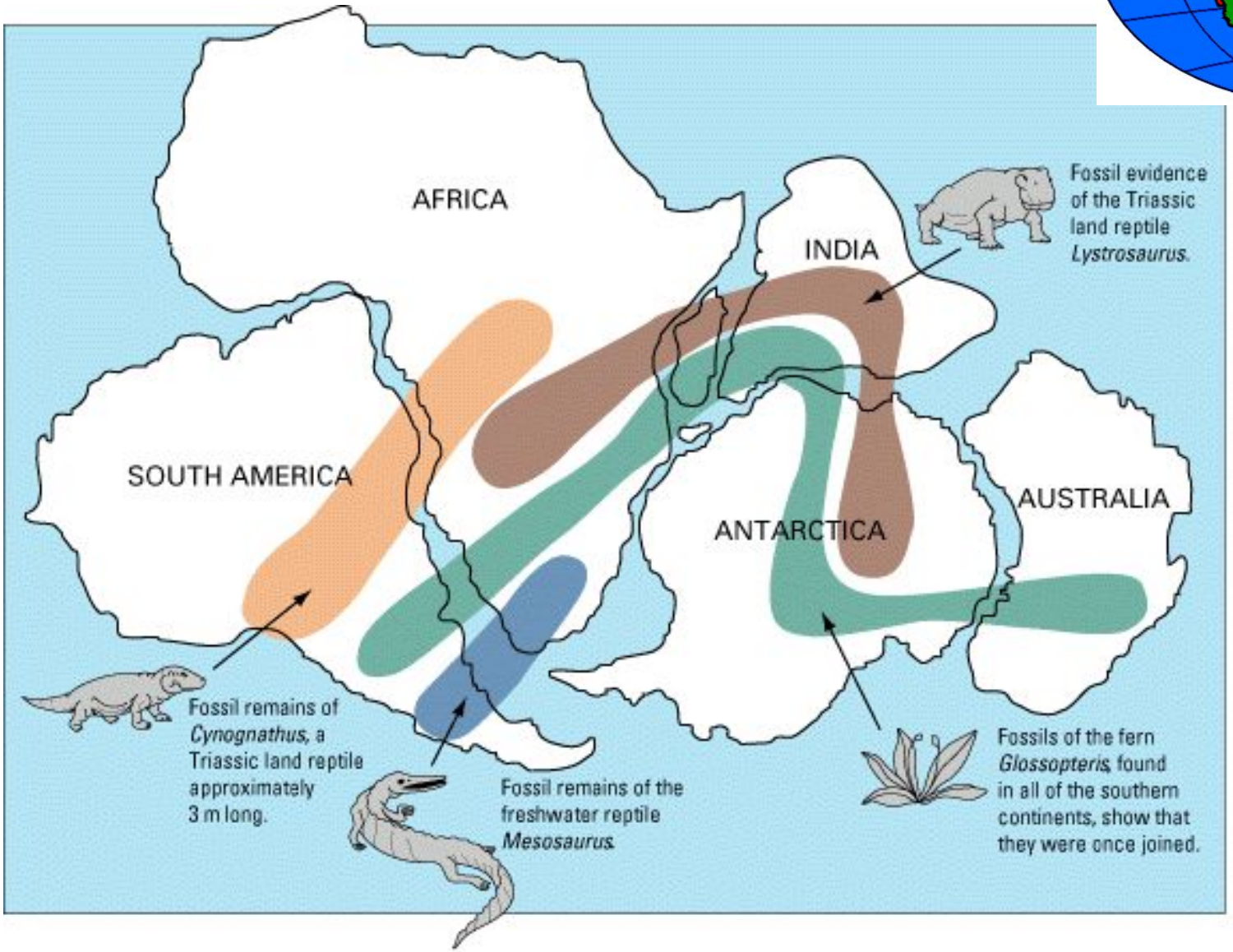
- **Fossils: a record of the history of life on Earth**





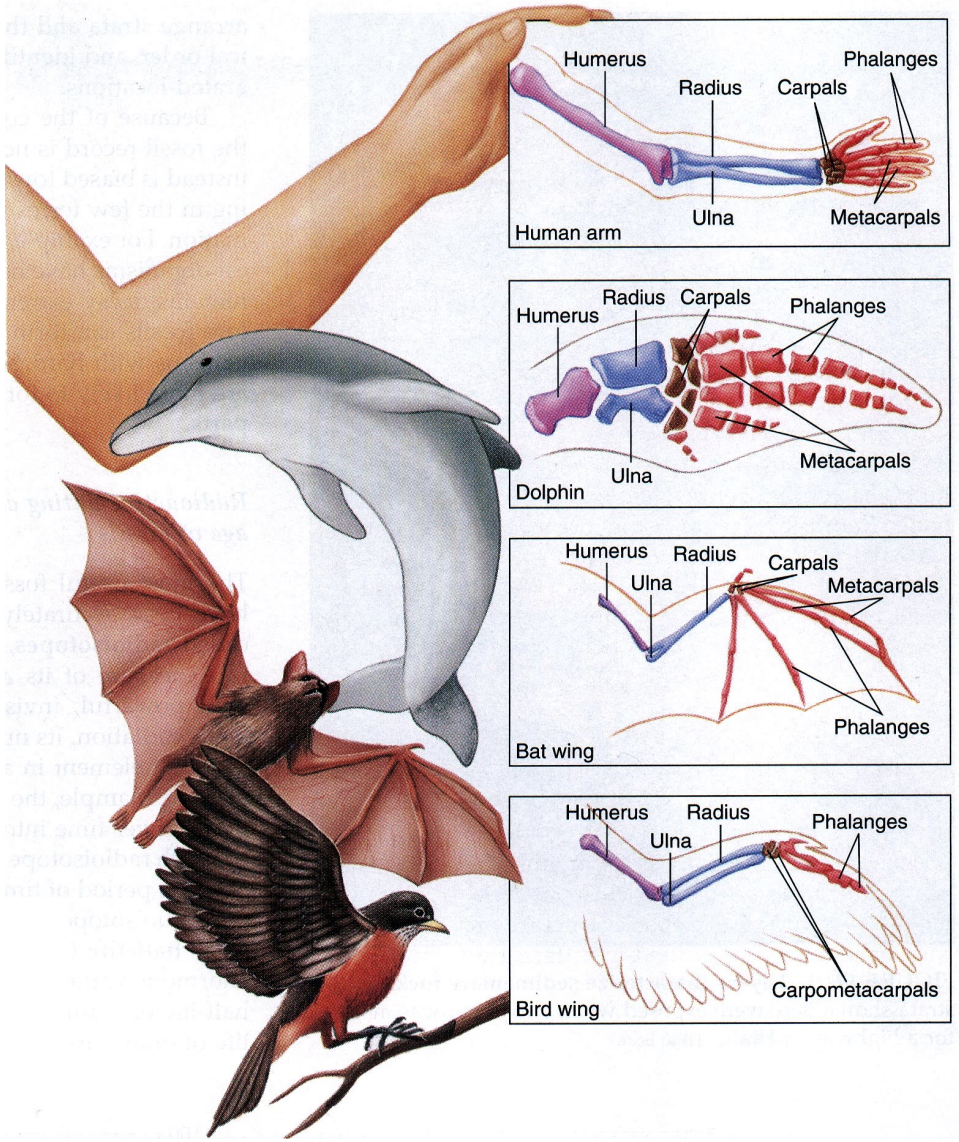



N
Eurasia
North America
Africa
South America
India
Australia
Antarctica


AFRICA
INDIA
SOUTH AMERICA
ANTARCTICA
AUSTRALIA
Fossil evidence of the Triassic land reptile *Lystrosaurus*.
Fossil remains of *Cynognathus*, a Triassic land reptile approximately 3 m long.
Fossil remains of the freshwater reptile *Mesosaurus*.
Fossils of the fern *Glossopteris*, found in all of the southern continents, show that they were once joined.

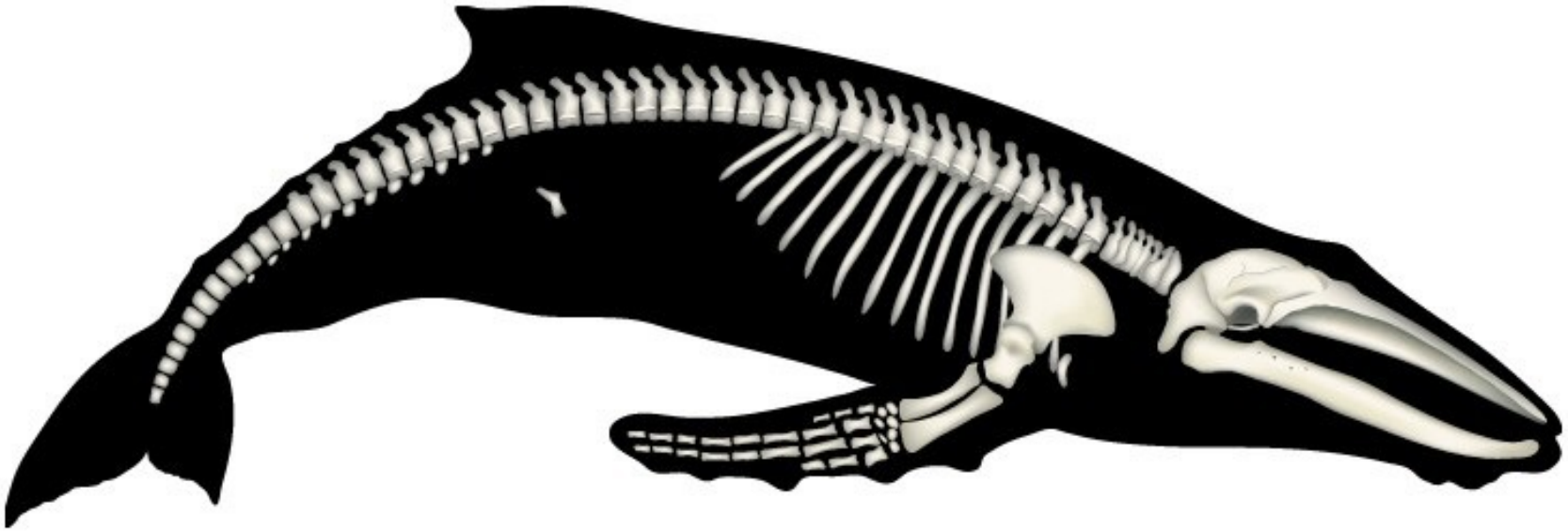
Homologous Body Structures

- **Homologous Body Structures: similar anatomy in different types of animals because of common ancestor**



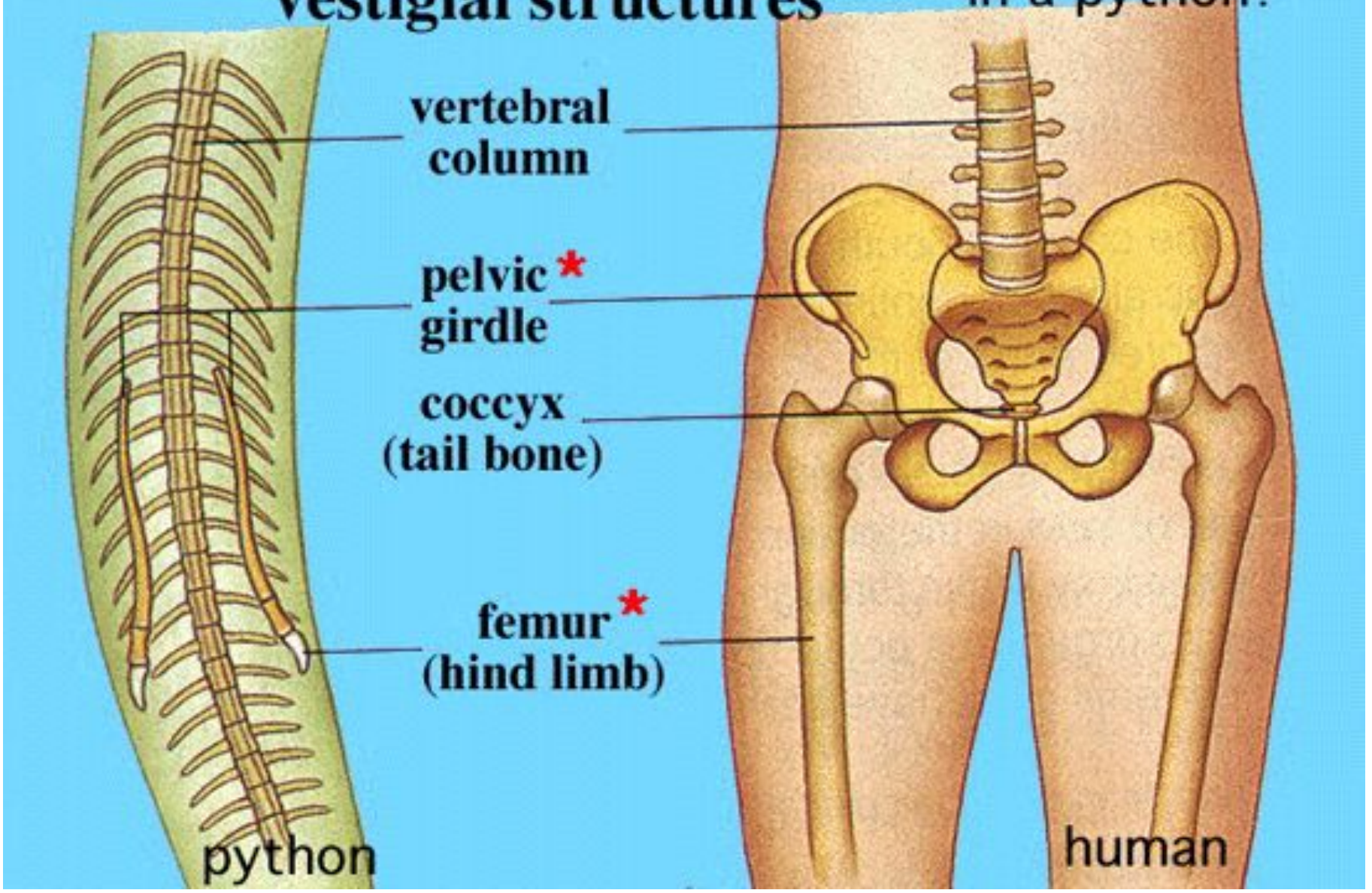
Vestigial Organs

Vestigial Organs: “leftover” traces of evolution that serve no purpose



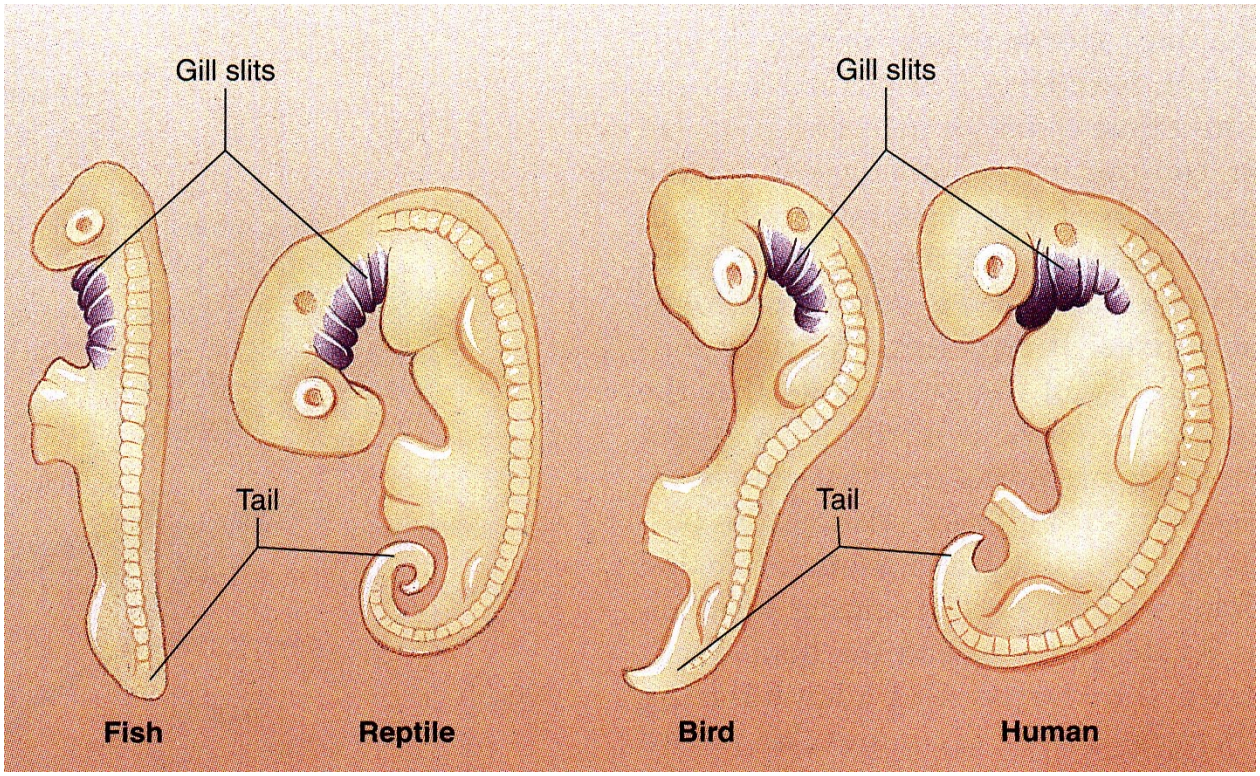
How do you explain the presence of these bones

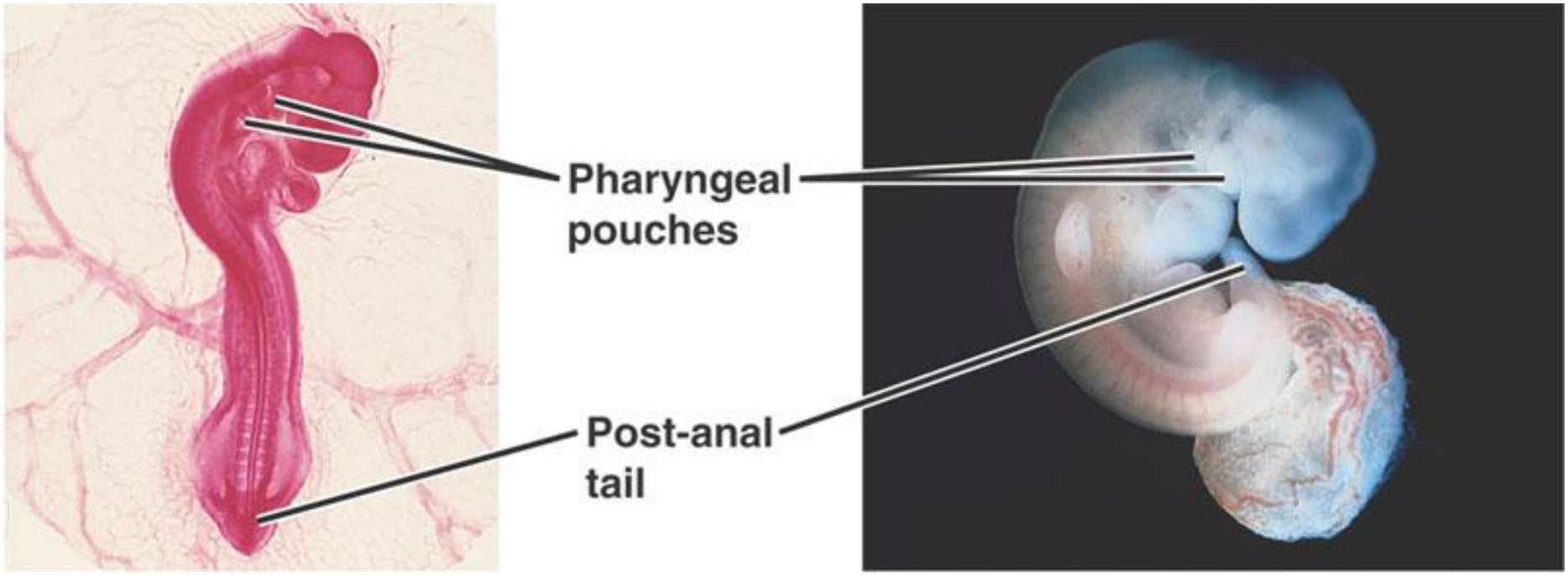
vestigial structures* in a python?

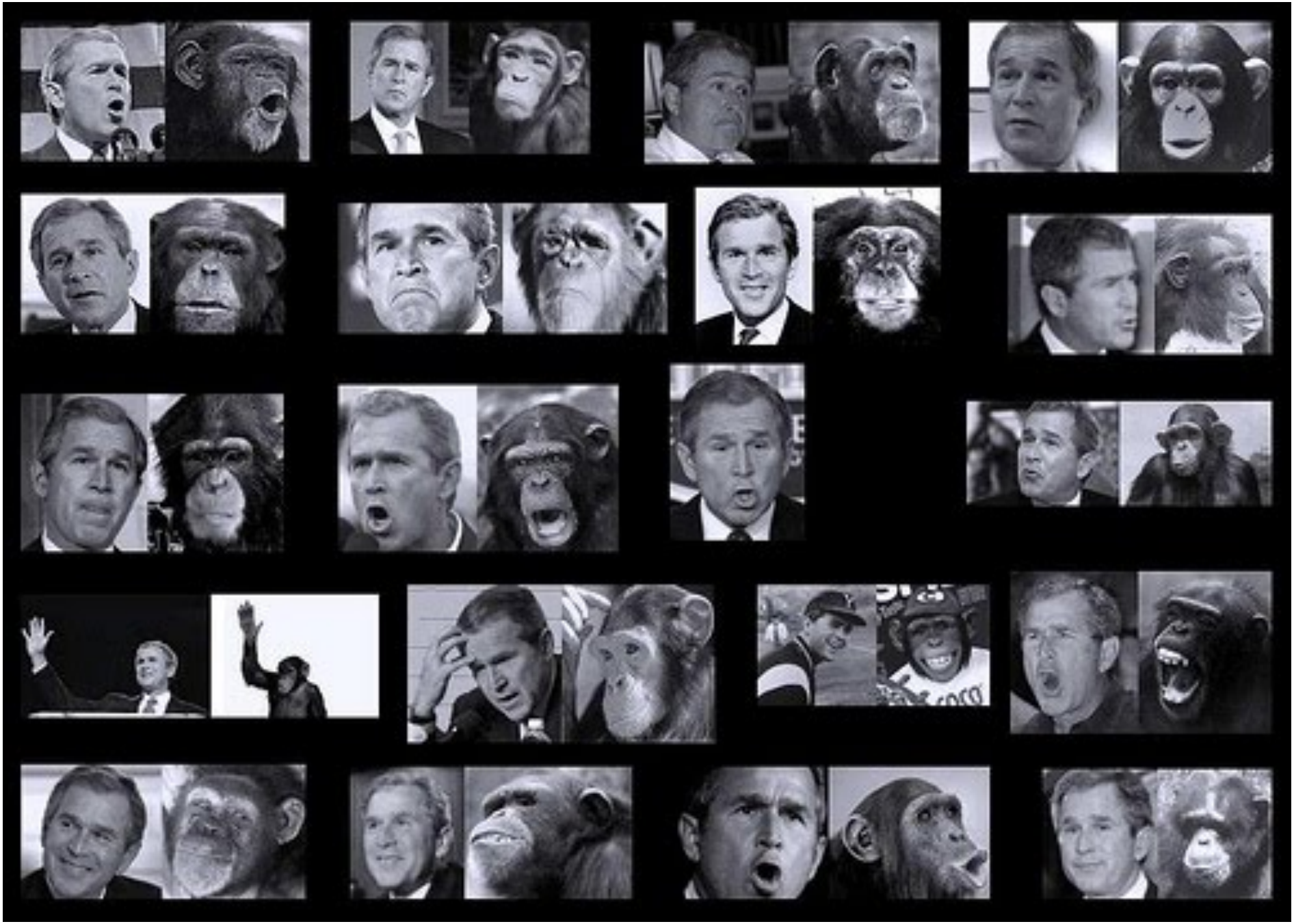


Embryology

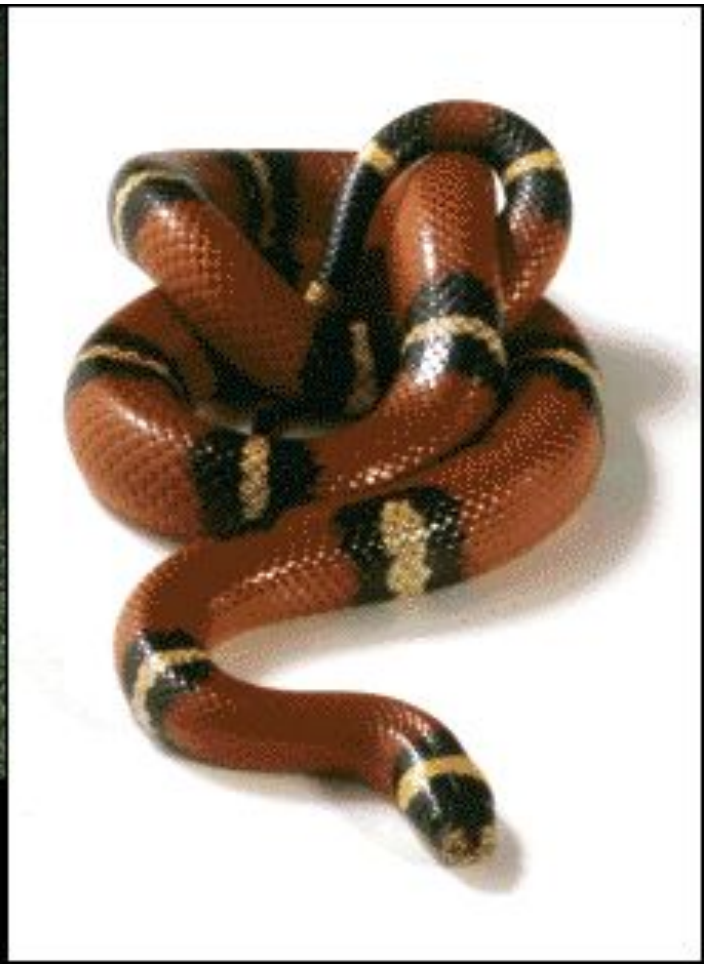
- **Embryology: embryos of all vertebrates are very similar early on**




Pharyngeal pouches
Post-anal tail
Chick embryo
Human embryo



Coral Snake (venomous)



Milk Snake (Non venomous)