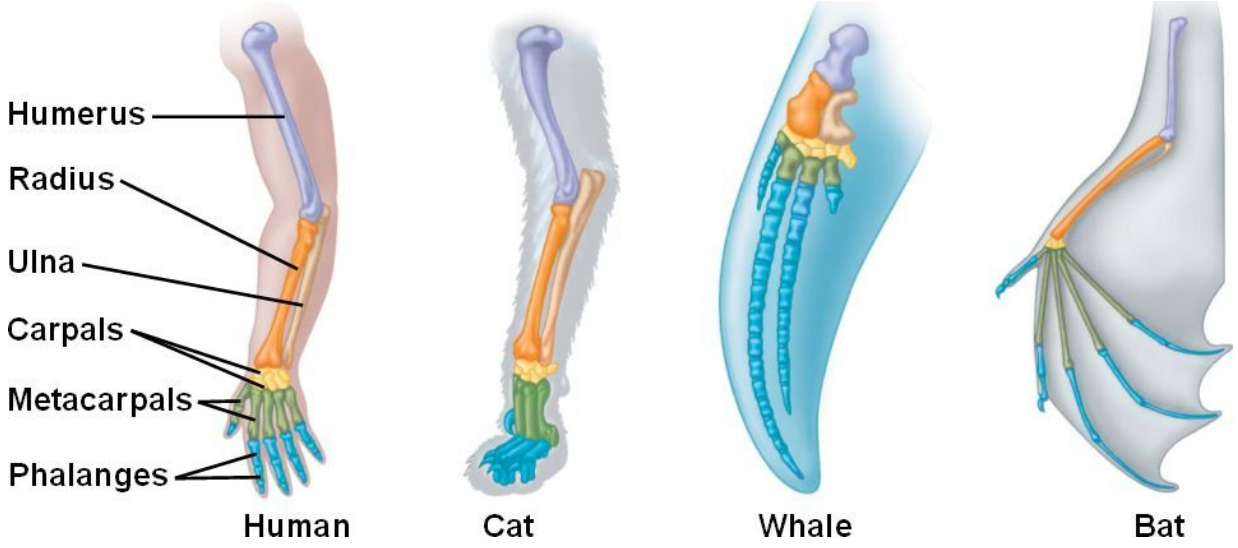
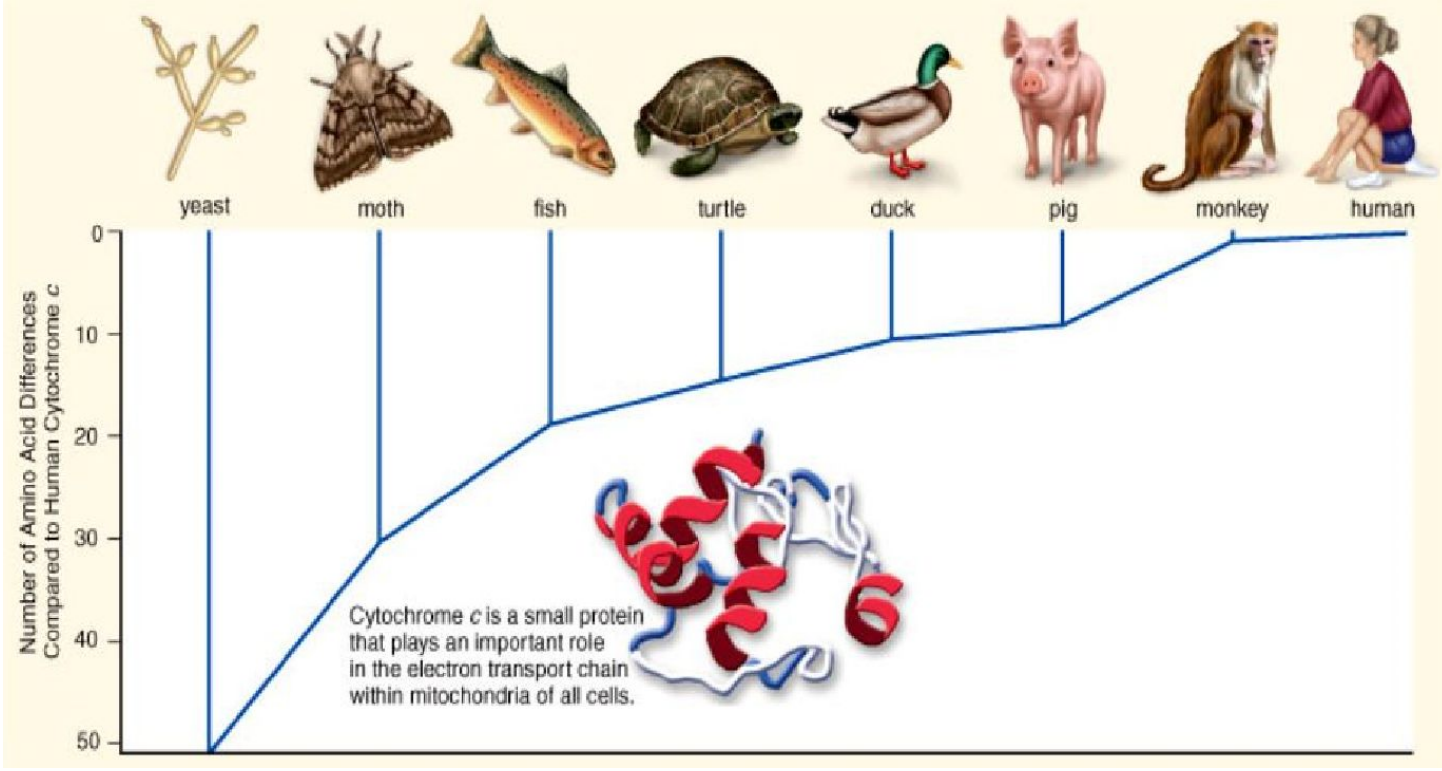

Humerus
Radius
Ulna
Carpals
Metacarpals
Phalanges
Human
Cat
Whale
Bat


shark
lizard
chicken
pig
human
© 2006 Encyclopædia Britannica, Inc.


yeast
moth
fish
turtle
duck
pig
monkey
human
Number of Amino Acid Differences Compared to Human Cytochrome c
0
10
20
30
40
50
Cytochrome c is a small protein that plays an important role in the electron transport chain within mitochondria of all cells.

The evidence for evolution

learning Objective

- analyze the evidence for evolution

Success criteria

1. Name at least three examples which are evolution evidences and comment two examples against reliability.
2. Carry out research and analysis of results and make report on the performed work.

Terminology

- Microevolution, macroevolution, population, **fossil record, comparative anatomy, comparative embryology, comparative biochemistry, molecular embryology, biogeography**, ***homologous structures, analogous structures, vestigial structures,*** paleontology, protein sequence data, variations in heamoglobin molecules, cytochrome c, immunological, mitochondrial DNA, continental drift, Drug-Resistant Bacteria, evolutionary tree, convergent evolution.

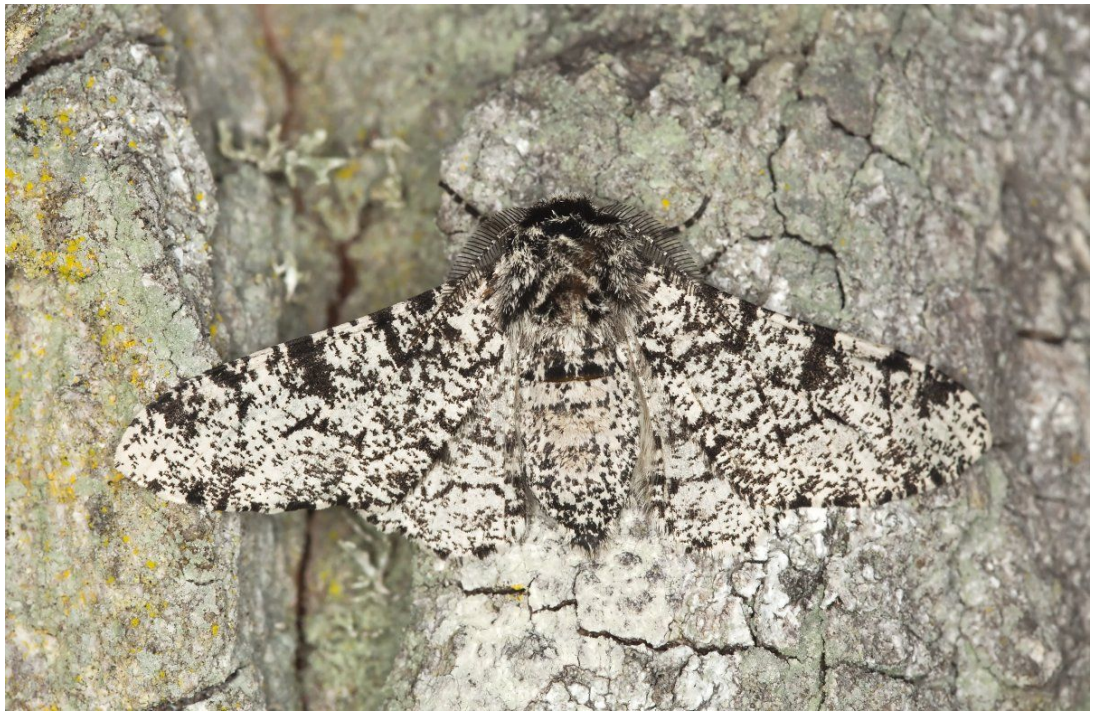
Evolution …

- In biology, evolution is the **change in the characteristics of a species over several generations** and **relies on the process of natural selection.**
- The theory of evolution is **based on the idea that all species are related and gradually change over time.**
- Evolution relies on there being **genetic variation in a population** which **affects the physical characteristics (phenotype) of an organism**.

What is natural selection?

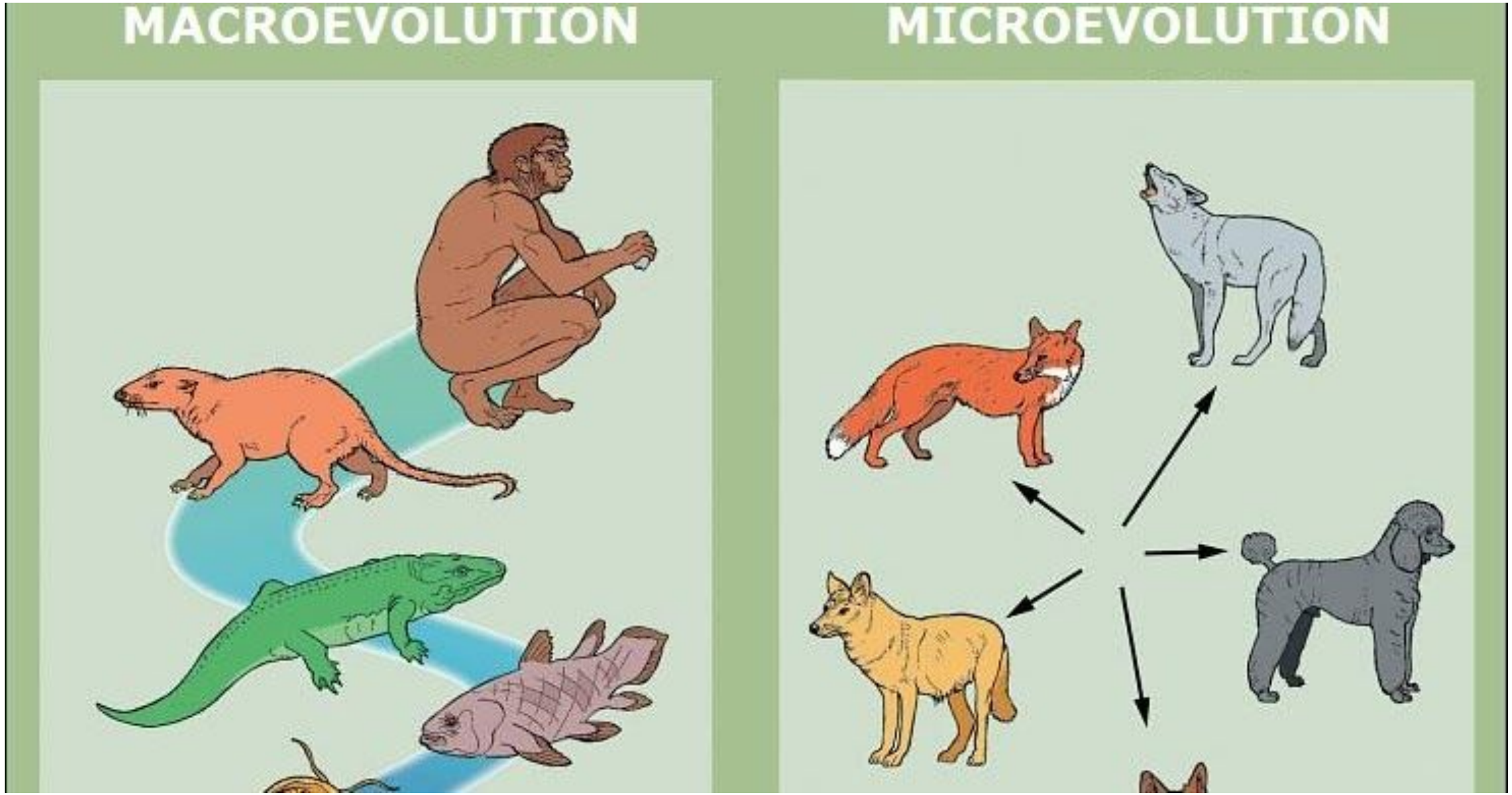
- **Individuals with characteristics best suited** to their **environment** are more likely to **survive, finding food, avoiding predators and resisting disease.** These individuals are more likely to **reproduce and pass their genes on to their children.**
- As a consequence those individuals most suited to their environment survive and, given enough time, the species will gradually evolve.

Natural selection in action: **the Peppered moth**



Evolution

- **Microevolution**
  - is the change in **allele frequencies** that occurs over time within a **population**.
  - mutation, selection (natural and artificial), gene flow and genetic drift.
- **Macroevolution**
  - refers to the **concept of large-scale evolution** that occurs **at the level of species and above**.
  - reproductive isolation.
  - can describe differences between that organisms belonging to **larger clades** of **organisms**, for example the different taxonomic groups within the primates.


MACROEVOLUTION
MICROEVOLUTION

Evidence of Evolution

- **fossil record,**
- **comparative anatomy,**
- **comparative embryology,**
- **comparative biochemistry,**
- **molecular biology,**
- **biogeography**

Evidence for Evolution

FAME summarizes the evidence that evolution has occurred:

- F – **fossil** evidence (remains of ancient organisms)
- A – **anatomical** structures (body parts)
- M – **molecular** evidence (DNA/RNA/ATP)
- E – **embryological** (embryos look similar from one species to the next)

What are the five categories of evidence for evolution?

- 1. Fossil Record
- 2. Anatomical features
  - Homologous structures
  - Vestigial structures
- 3. DNA and molecular sequences
- 4. Geography
- 5. Artificial selection and observed natural selection.

Fossil record

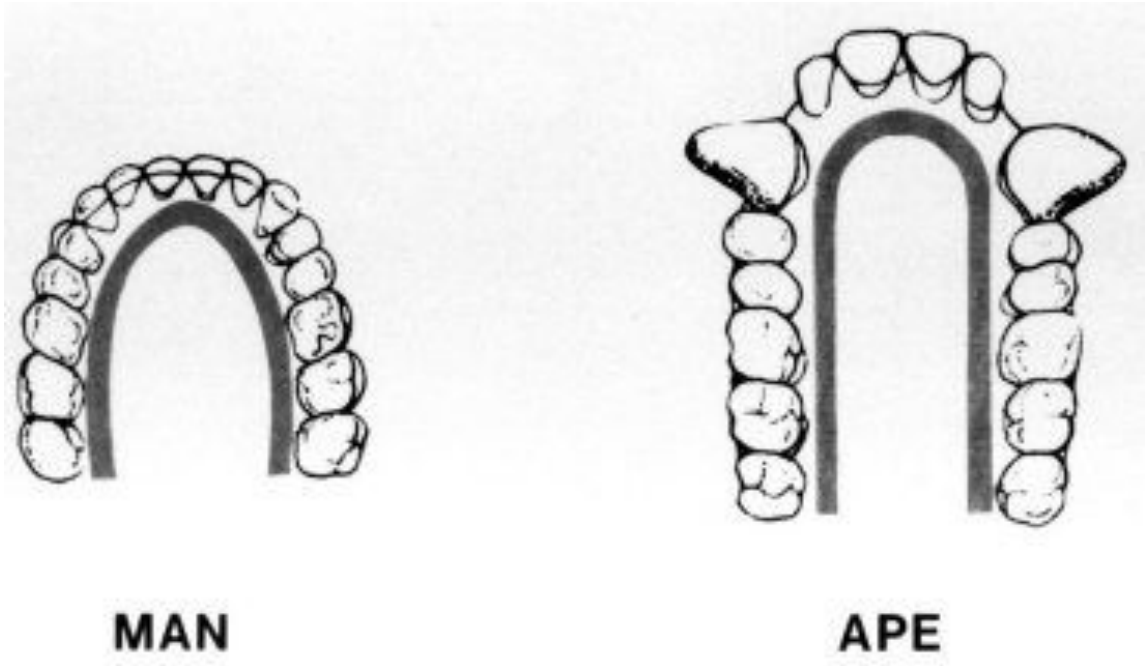
The fossil reveals the **existence of species that have become extinct or have evolved into other species.** The fossil record shows there important facts:

- 99% of all organisms now extinct.
- The radioactive dating and half-life, we know that Earth is about 4,6 billion years ago.
- Prokaryotic cells are the oldest fossils and the first organisms to develop on Earth.
- **Transitional fossils** that link older extinct fossils to modern species.

Fossil record -Transitional fossils

Comparative anatomy

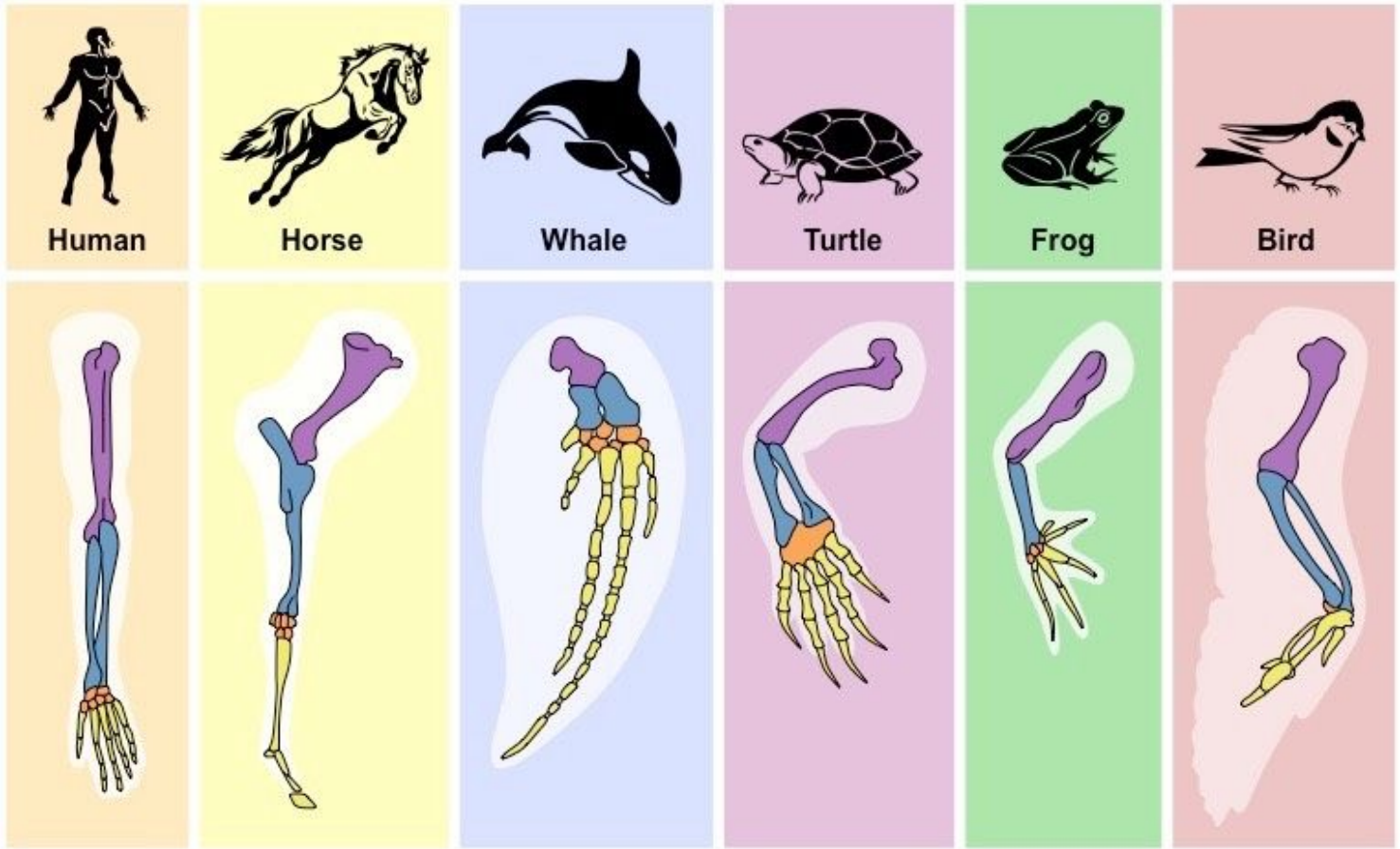
- Organisms that have **similar anatomical structures are related to each other and share a common ancestor**.
- Human and chimpanzees dental structure.



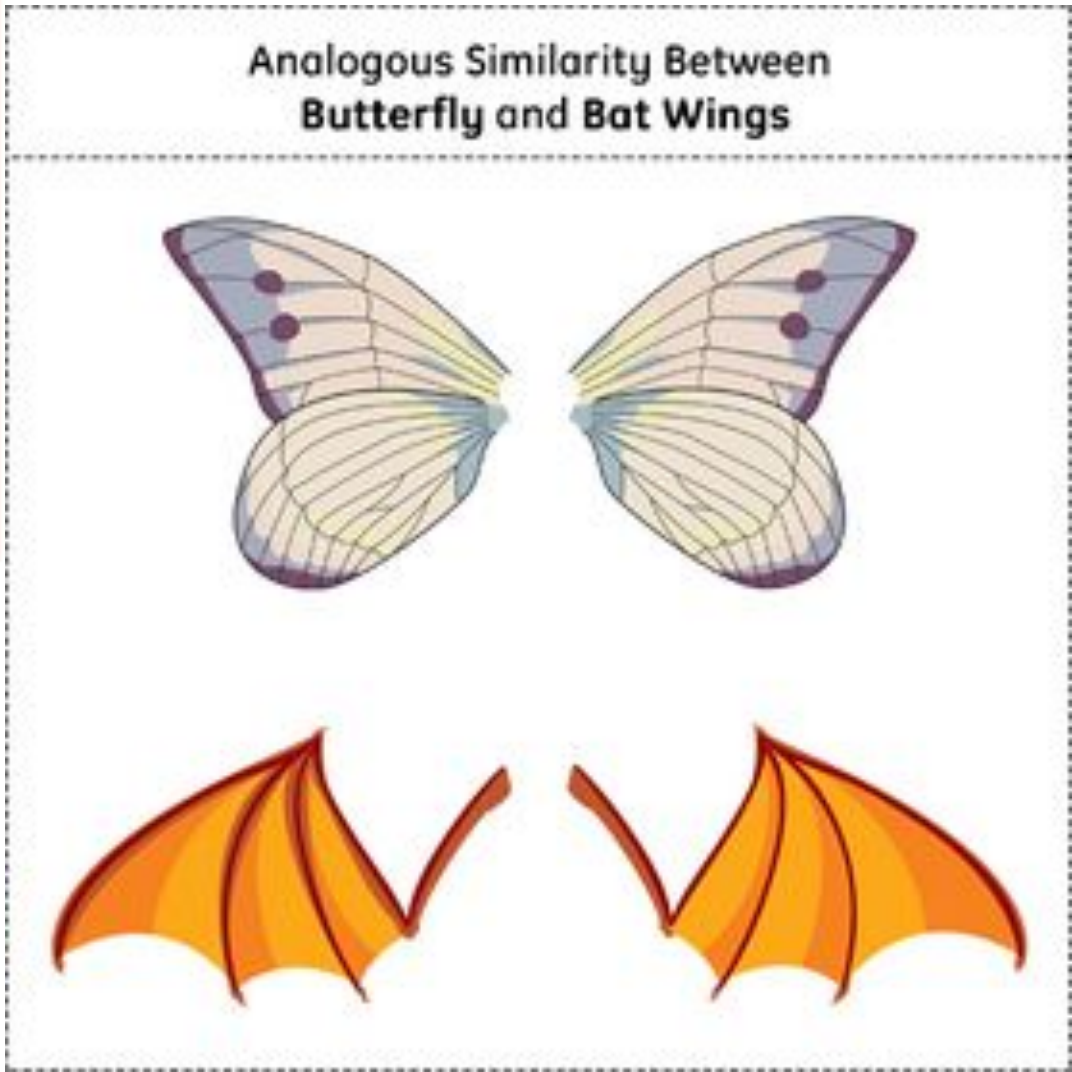
Comparative anatomy

- **Homologous structure**
  - **Bat wings, the lateral fin of the whale, human arm** and etc.
  - Although the **function** of each **varies**, they all have the **same internal bone structure**.
  - **Divergent** evolution.

- **Analogous structure**
  - **Bat's wings and a fly's wings,** have **same function** but **not** the **same** underlying **structure**.
  - **Convergent** evolution.

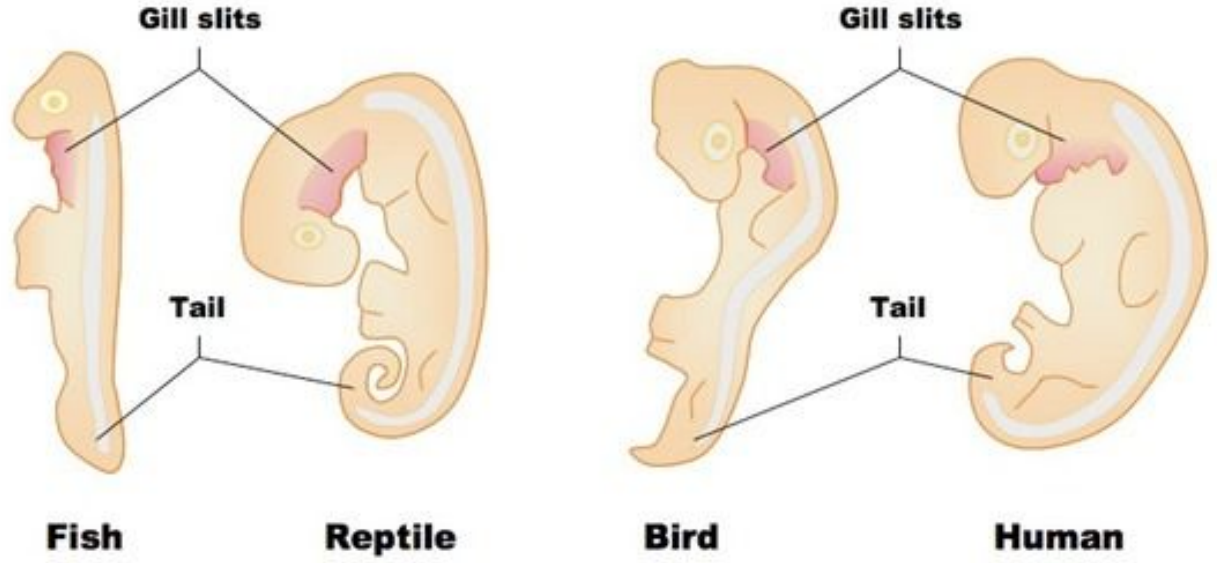


Homologous structure



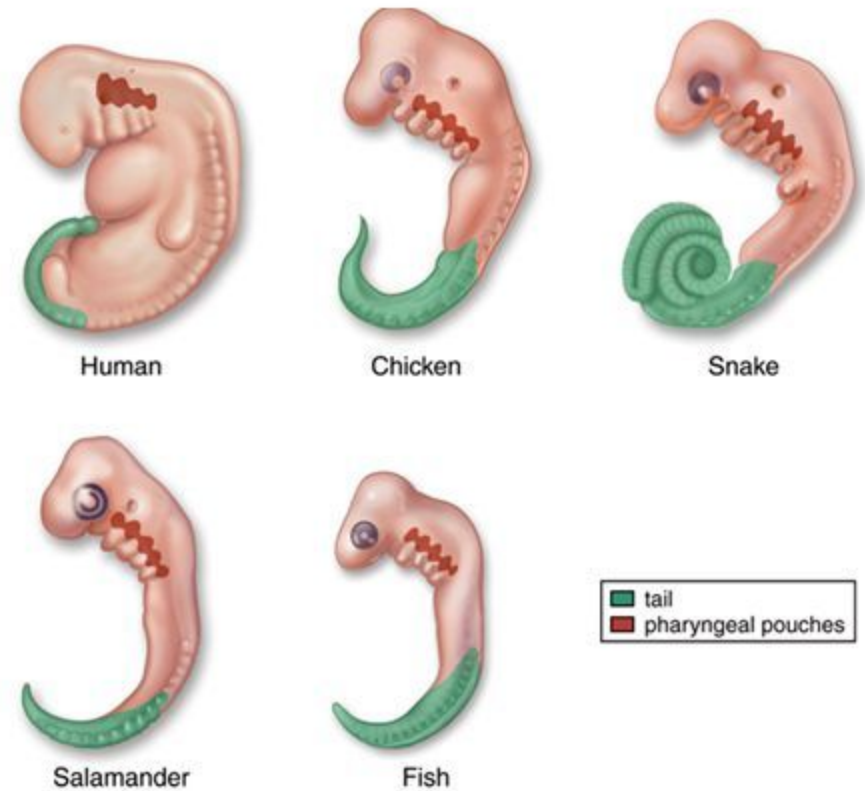
Comparative embryology

- Closely related organisms go through **similar stages in their embryonic development** because they **evolved from a common ancestor**.
- For examples: vertebrate embryos go through a stage in which they have gill pouches on the their throats.
- Unicellular
- Blastula – like medusa
- Fish



How do Comparative Embryology and Biochemistry supports evolution?

- Anatomical Evidence for Evolution



Developmental similarities reflect descent from a common ancestor

Molecular biology (DNA, protein and enzyme system)

- Since all aerobic organisms contain cells that carry out respiration and require ETC, they also all contain the necessary polypeptide, **cytochrome *c***.
- A comparison of the **amino acid sequence** of **cytochrome *c*** among **different organisms** shows which are **most closely related**.
- Number of **amino acid differences in β chain of heamoglobin**.

Species	Precipitation (%)	Difference from human (%)	Difference to common ancestor (half difference from human)	Postulated time since common ancestor (my) (*see below*)
human	100	–	–	–
chimpanzee	95	5	2.5	4
gorilla	95	5	2.5	4
orang-utan	85	15	7.5	13
gibbon	82	18	9	15
baboon	73	27	13.5	23
spider monkey	60	40	20	34
lemur	35	65	32.5	55
dog	25	75	37.5	64
kangaroo	8	92	46	79

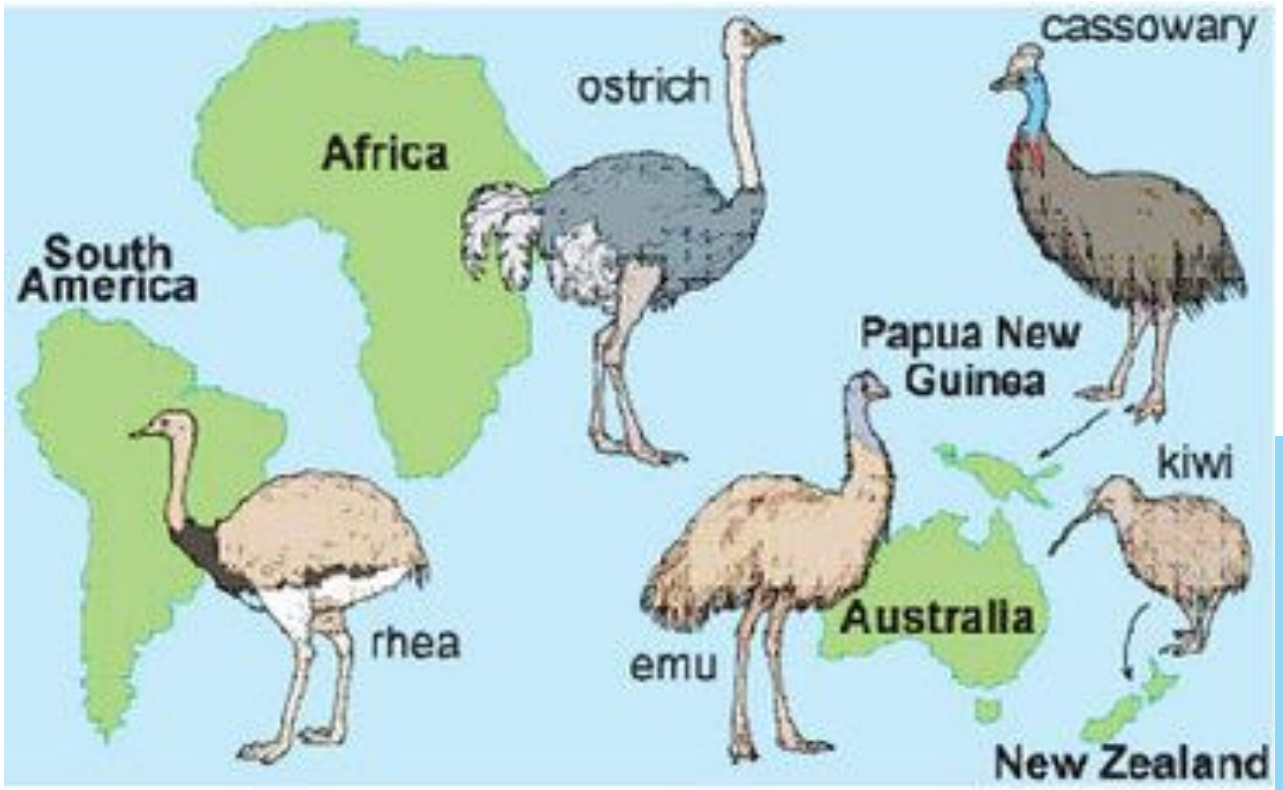
Number of amino acid differences in β chain of heamoglobin

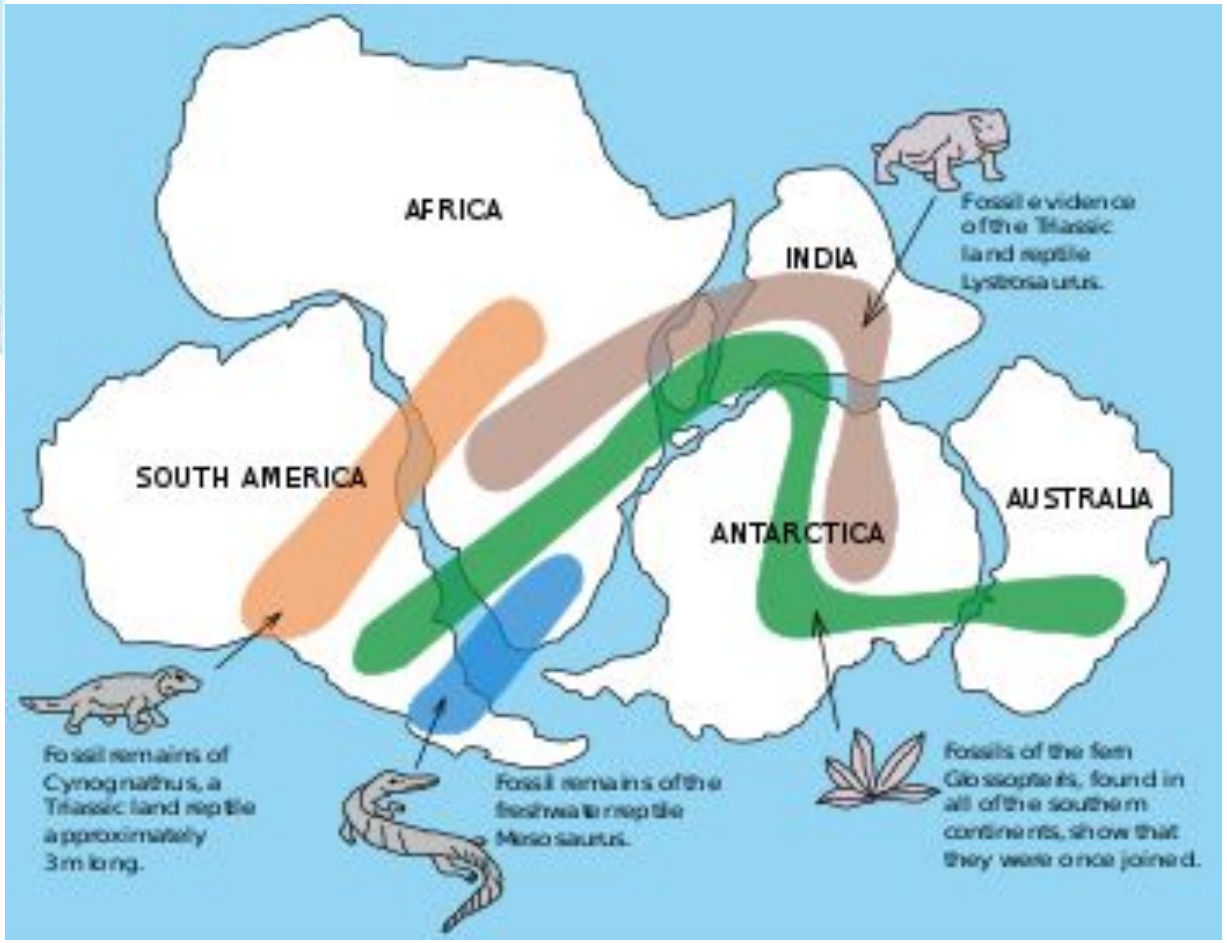
Comparative biochemistry

- Organisms that have a **common ancestor** will have **common biochemical pathway.**
- The more closely related organisms are to each other, the more similar their biochemistry is.
- For examples: human and mice are both mammals.
- **Immunological studies (reaction): serum and antibodyes.**

Biogeography

- The theory of **continental drift** (Pangaea).
- Supercontinent Pangaea slowly separated into 7 continents.
- **Isolation** (most of the workd's marsupials are isolated in Australia).
- **Endemic species** –The ring-tailed lemur in Madagascar.
- North America and Eurasia floras and faunas similar.


cassowary
ostrich
Africa
South America
Papua New Guinea
kiwi
Australia
rhea
emu
New Zealand


AFRICA
INDIA
Fossil evidence of the Triassic land reptile Lystrosaurus.
SOUTH AMERICA
AUSTRALIA
ANTARCTICA
Fossil remains of Cynognathus, a Triassic land reptile approximately 3m 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.