ORGANIC EVOLUTION

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POPULATION GENETICS AND EVOLUTION

LECTURE III

ORGANIC EVOLUTION

- The slow process of change from simple to complex is known as evolution.
- Evolution assumes that all living things are interrelated.
- According to Darwin, evolution is descent with modification.
- The term 'evolution' was coined by the British philosopher, Herbert Spencer.

ORGANIC EVOLUTION CONT`D

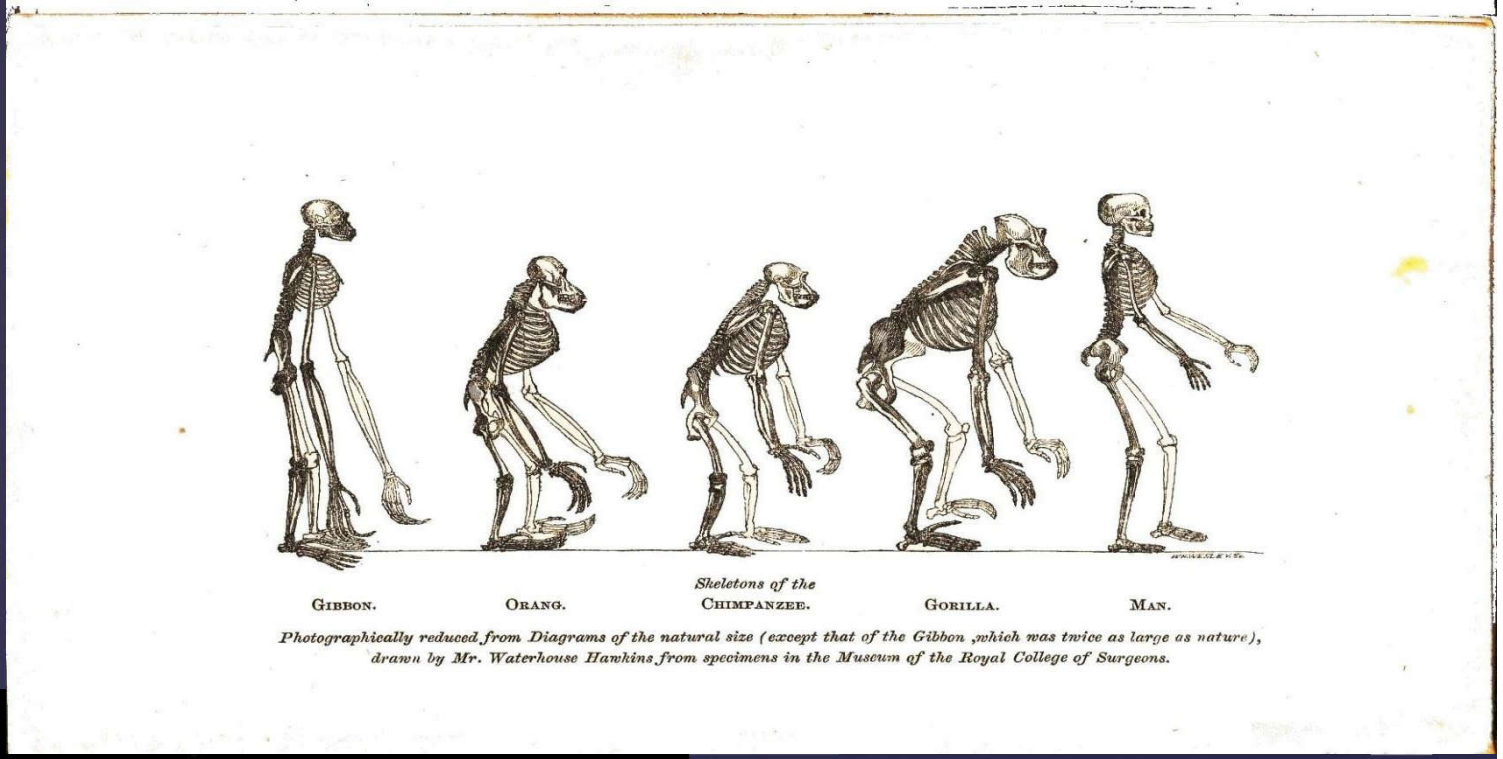
- According to Dobzhansky (1973) 'Nothing in biology makes sense except in the light of evolution'.
- Organic evolution is the change in the characteristics of a population of organisms over the course of generations, resulting in forms that are more complex from pre-existing simpler forms.

ORGANIC EVOLUTION CONT`D

- There are several evidences in favour of organic evolution.

I. Evidences from Comparative Anatomy

- Comparative anatomy is the study of the different internal organs of different animals.
- The study of different systems of organisms like digestive, circulatory, respiratory, muscular, skeletal, etc., in various animals shows similarities in their structure and functions.

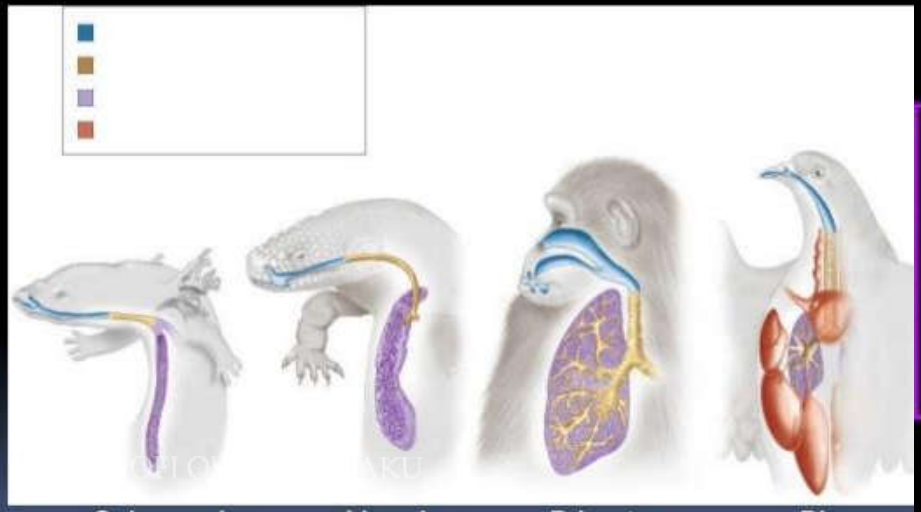


Skeletons of the

GIBBON. ORANG. CHIMPANZEE. GORILLA. MAN.

Photographically reduced from Diagrams of the natural size (except that of the Gibbon, which was twice as large as nature), drawn by Mr. Waterhouse Hawkins from specimens in the Museum of the Royal College of Surgeons.

Figure 33-10: Vertebrate Lungs



I. Evidences from Comparative Anatomy cont`d

- These similarities in the structure and functions of different organs in different animals indicate that they have originated from a common ancestor.
- Evidences from comparative anatomy are as follows:

I. Evidences from Comparative Anatomy cont`d

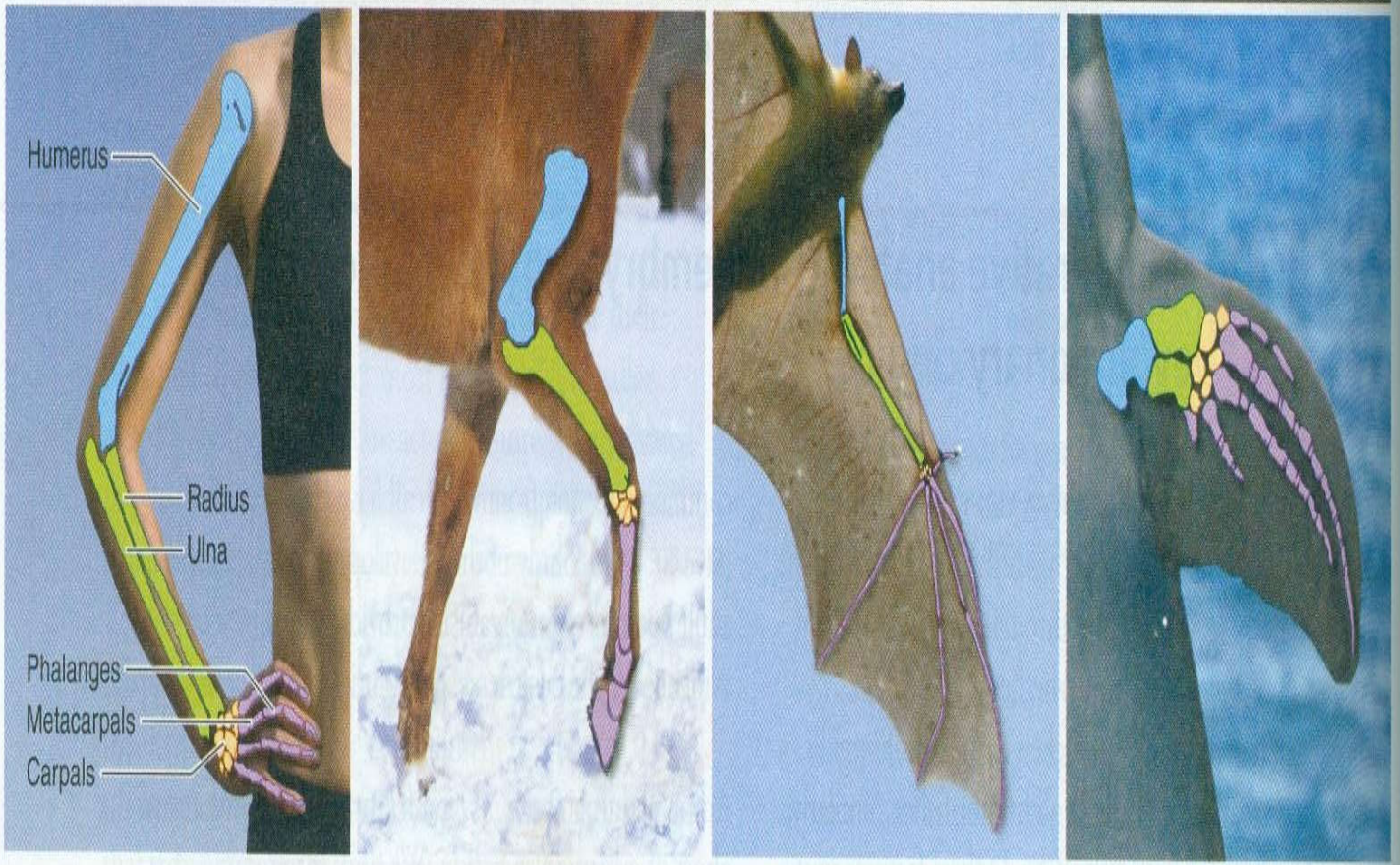
- Homologous Organs - Organs having similar basic structure but different functions are known as homologous organs. Homologous organs of different animals provide evidence for evolution.

(a) The forelimbs of frogs, birds and humans are built on the same basic design of bones, but perform different functions.

Homology – similarities across species
especially when similar form is modified for different function

Structural homology

HOMOLOGOUS BONE STRUCTURES



Human Horse Bat Porpoise

FIGURE 8-39 Evidence for evolution: comparative anatomy. Homologous bone structures among some mammals.

The similarities in the bone structure of the forelimbs of mammals demonstrate common ancestry.

Homologous structures

- Are features that often have different functions but are structurally similar because of common ancestry

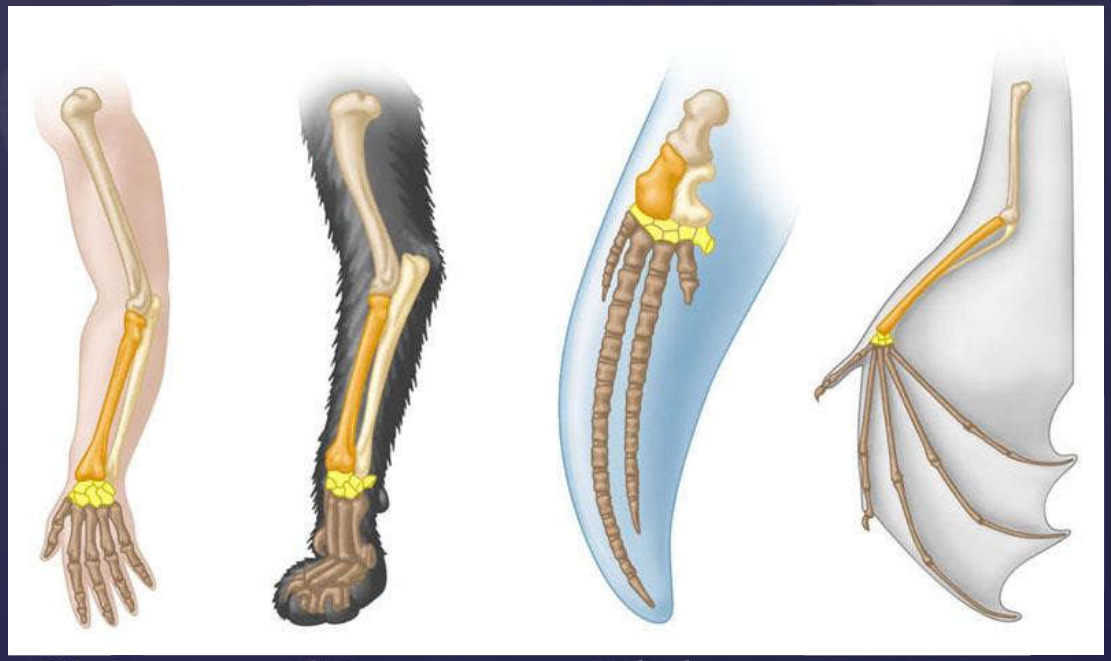


Figure 13.4A

I. Evidences from Comparative Anatomy cont`d

- (b) The presence of homologous forelimbs in frogs, birds and humans indicate that all these forelimbs have evolved from a common ancestor and during the course of evolution they became adapted for different functions.
- (c) Thus, it can be concluded that frogs, birds and humans have evolved from a common ancestor.

2. Analogous Organs

- Organs having a different basic structure but similar appearance and functions are known as analogous organs.

similarity in form can reveal similarity in funct

The wings of insects and birds have a different structural plan, but perform the same function of flying.

2. Analogous Organs cont`d

- (b) The development of analogous organs in animals of unrelated groups to become adapted for performing the same function for their survival under hostile environmental conditions is known as convergent evolution.

3. Vestigial Organs

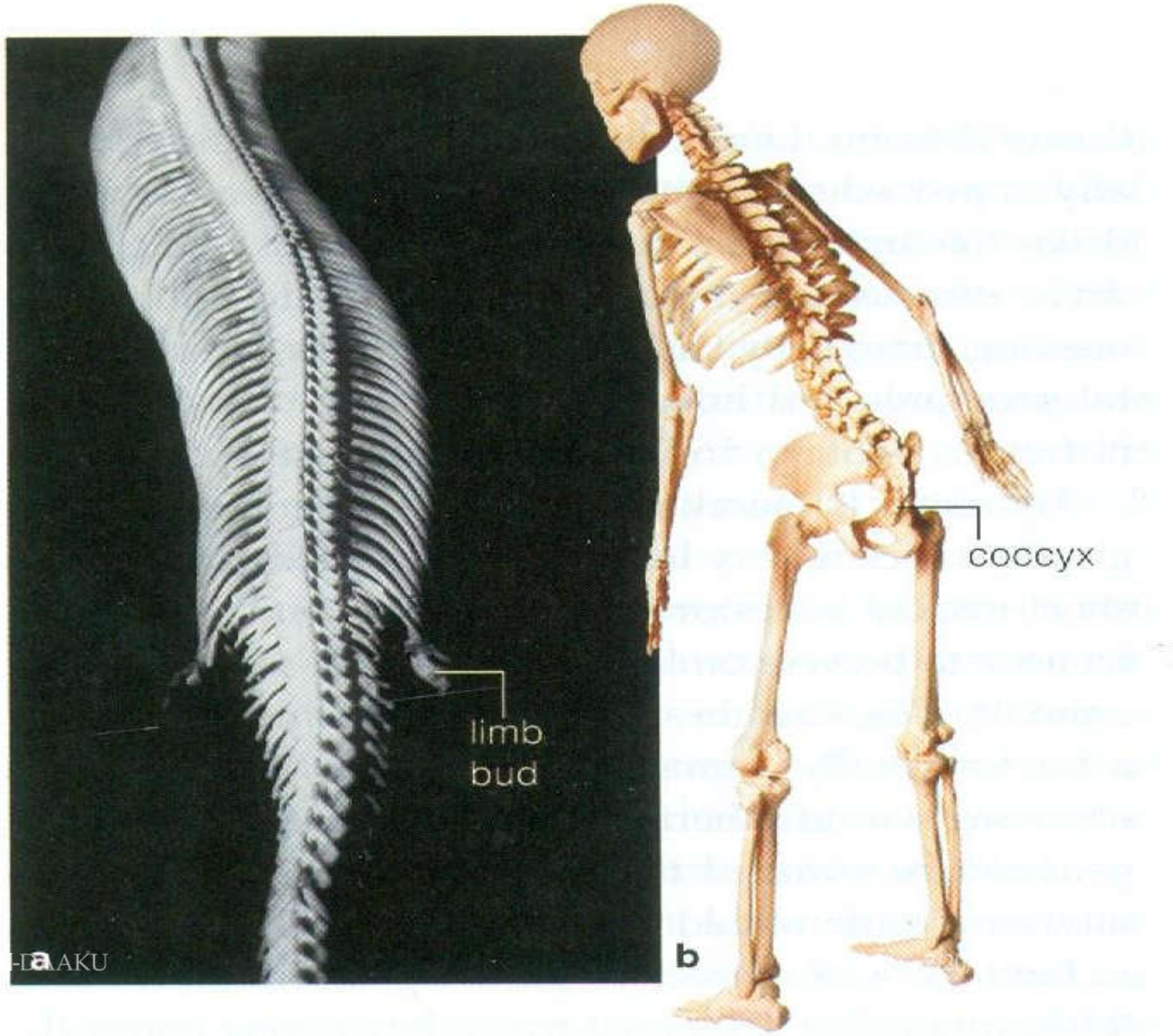
- Vestigial organs are those organs of living beings, which are functionless and useless now (but used to function in their ancestors).
- (a) Vestigial organs are believed to be well developed and functional in ancestral forms but due to changed modes of life, are gradually disappearing in living forms.

3. Vestigial Organs cont`d

- (b) The nictitating membrane is functionless in humans but is still functioning in birds and provides protection. Thus, it indicates that human beings have evolved from those ancestors that had a functioning nictitating membrane.

3. Vestigial Organs

- (c) The coccyx present at the end of vertebral column in humans is formed by the fusion of a few caudal vertebrae, indicating that the ancestors of humans were tailed.


limb
bud
coccyx
a
b

- Similarities in the anatomy and development of different groups of organisms and in the their physical appearance can reveal common evolutionary origins.

3. Vestigial Organs cont`d

- d) The vermiform appendix in the large intestine in human beings has no function but it is still functioning in herbivorous ruminant mammals and helps in the digestion of cellulose.

3. Vestigial Organs cont`d

- The presence of the vestigial form of vermiform appendix in humans suggests that human beings evolved from mammals that were herbivorous. During the course of evolution, when humans changed their food, i.e., became omnivorous from herbivorous, it gradually reduced in size and became functionless.

3. Vestigial Organs cont`d

- (e) Third molars are regarded as wisdom teeth in humans. These do not erupt in all humans, but in other primates they are well developed and fully functional, and erupt early. This indicates that humans have descended from some primates.

3. Vestigial Organs cont`d

(f) The presence of vestigial hind limbs in the python and boa suggests that snakes have descended from ancestors that had well-developed limbs.

II. Evidences from Connecting Links

- Connecting links are those organisms that possess characteristics of two different groups. These organisms provide continuity in the series of organisms by proving that one group has evolved from the other.
- *Peripatus* is a connecting link between Annelida and Arthropoda.

II. Evidences from Connecting Links

- Its Annelidan characters are as follows:
- (a) Worm-like body with soft cuticle and continuous muscle layers in the body wall
- (b) Unjointed legs and simple eyes
- (c) Excretory organs are nephridia

II. Evidences from Connecting Links

- Its Arthropodan characters are as follows:
- (a) Presence of antennae
- (b) Presence of tubular heart
- (c) Presence of trachea as respiratory organ

(d) Presence of haemocoel.

II. Evidences from Connecting Links

- *Neoplina* is a connecting link between Annelida and Mollusca.
- Its Annelidan characters are as follows:
  (a) Presence of metamerism
- (b) Presence of segmentally arranged gills
  (c) Presence of nephridia
- (d) Spiral cleavage
- (e) Larva trochophore

II. Evidences from Connecting Links

- Its Molluscan characters are as follows:

(a) Presence of shell

(b) Soft and flat body

(c) Presence of mantle

(d) Presence of foot

- Some other examples of connecting links are given below.

Table 2

	Organisms	*Connecting link between*
(a)	Viruses	Living and nonliving
(b)	*Euglena*	Plants and animals
(c)	*Proterospongia*	Protozoa and Porifera
(d)	*Balanoglossus*	Nonchordata and Chordata
(e)	*Chimera*	Cartilaginous and bony fish
(f)	Dipnoi	Fishes and amphibians
(g)	*Archaeopteryx*	Reptiles and birds
(h)	Prototheria	Reptiles and mammals

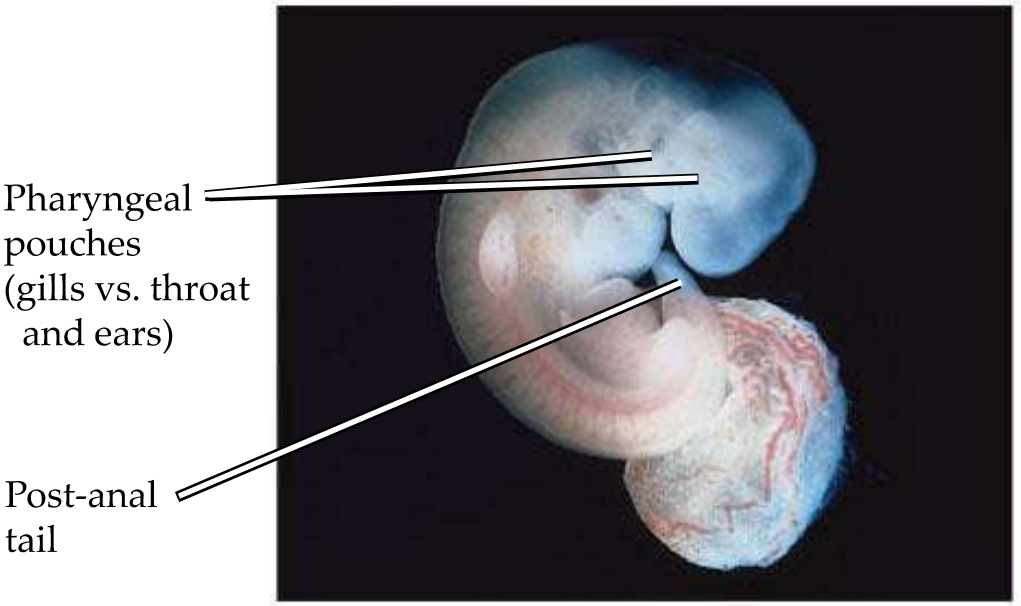
III. Evidences from Embryology

- The developing embryos of animals exhibit striking similarities in their structure.
- The embryos of vertebrates are so similar in their structure in their early stages of development that it is very difficult to differentiate one from another.

III. Evidences from Embryology cont`d

- The early embryos of vertebrates like fish, salamander, tortoise, chicks and humans look similar. It indicates that all these animals have evolved from a common ancestor.

- Many vertebrates
  - Have common embryonic structures



Chick embryo

Figure 13.4B

Human embryo

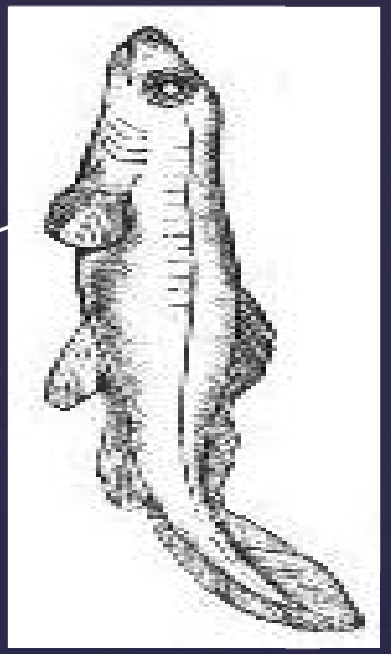
Match the embryo with the animal

chick embryo

fish embryo

human embyro

rat embryo



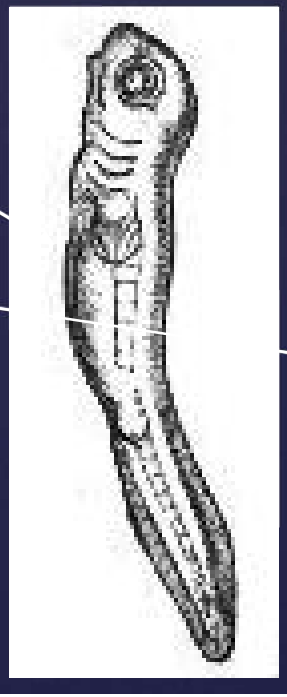
Match the embryo with the animal

chick embryo

fish embryo

human embyro

rat embryo



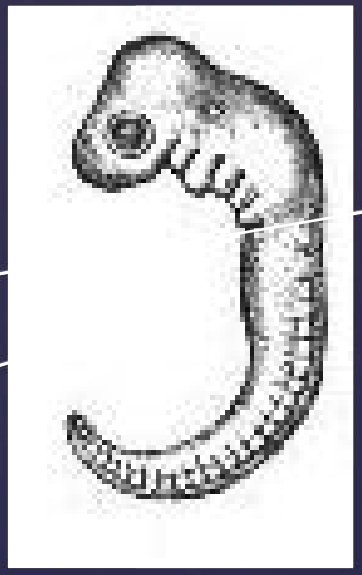
Match the embryo with the animal

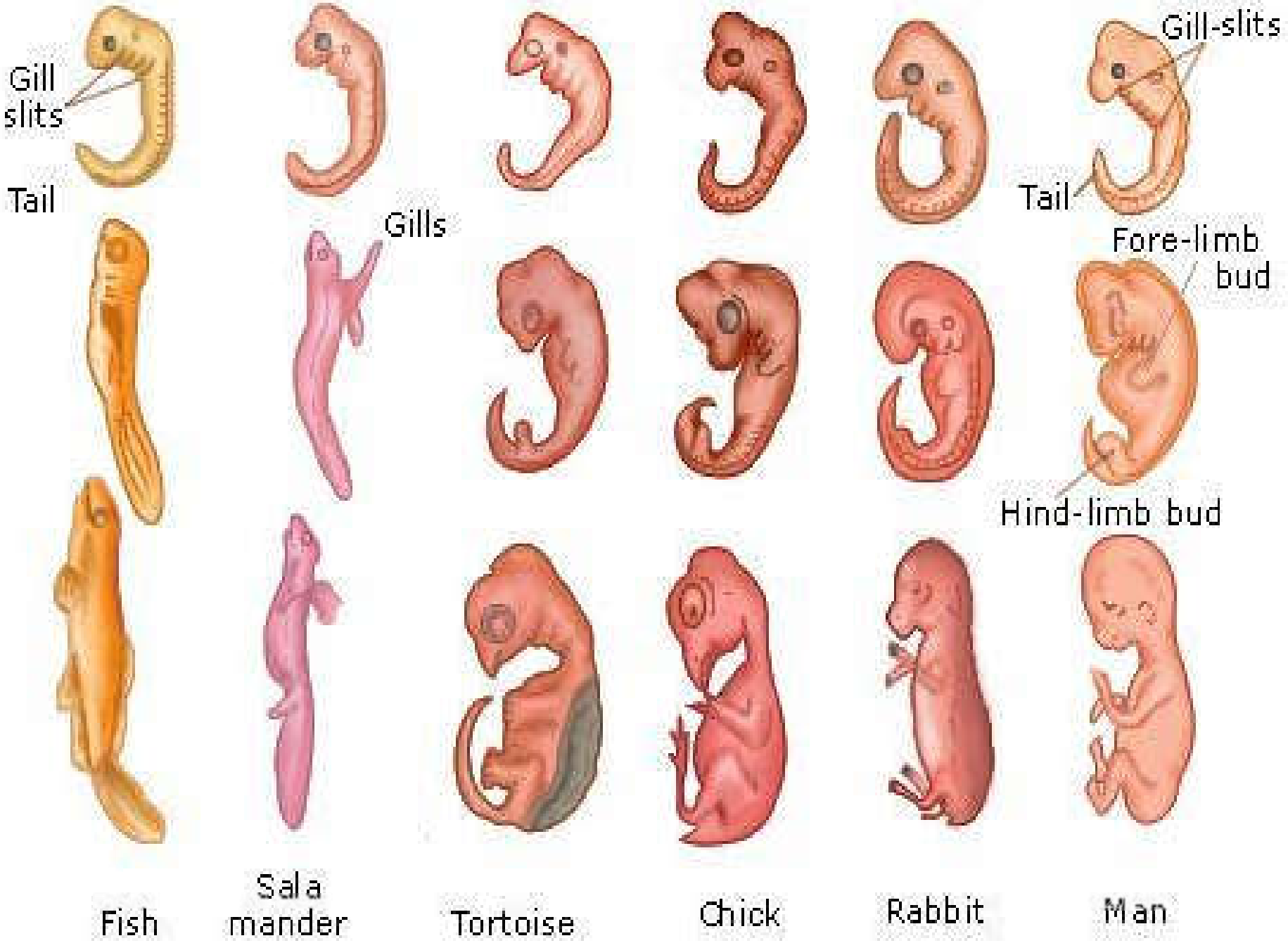
chick embryo

fish embryo

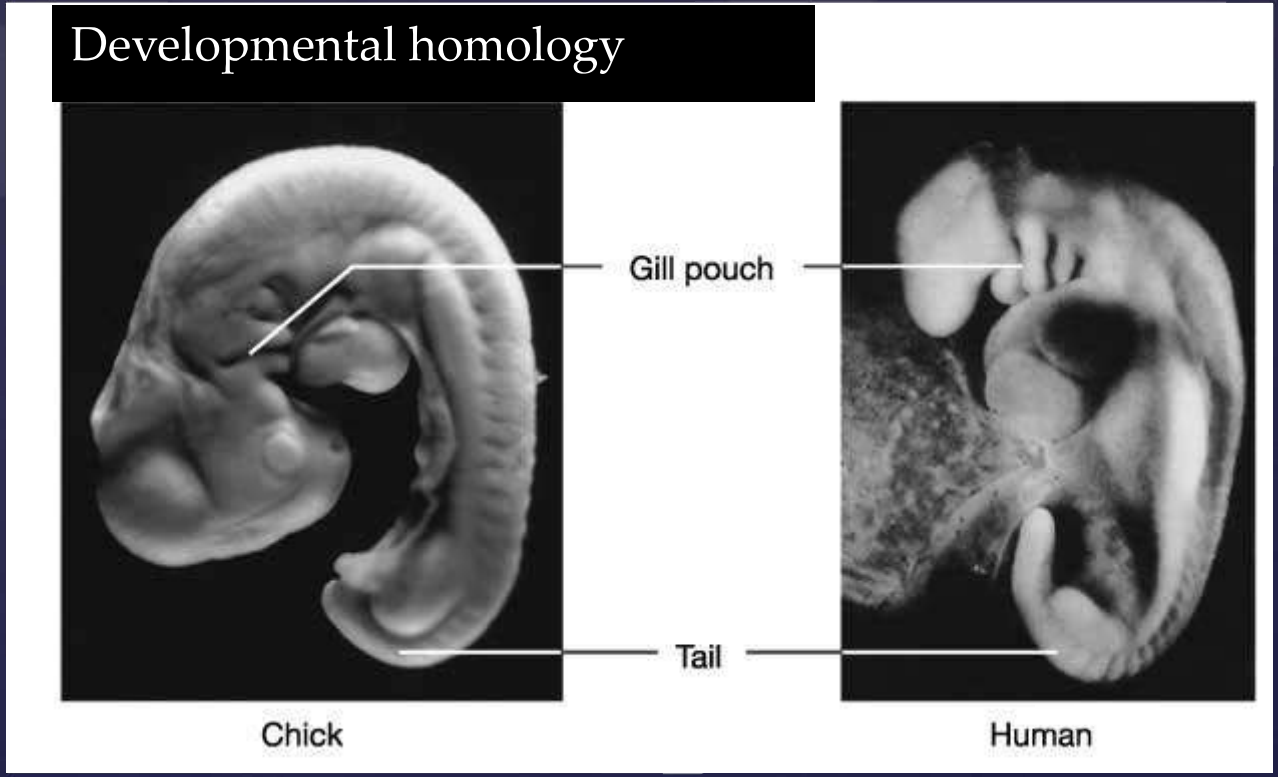
human embyro

rat embryo




Gill slits
Tail
Gills
Gill-slits
Tail
Fore-limb bud
Hind-limb bud
Fish
Sala mander
Tortoise
Chick
Rabbit
Man

Homology – similarities across species
especially when similar form is modified for different function



III. Evidences from Embryology cont`d

- Based on these similarities, the developmental pattern in the embryos of vertebrates, Ernst Haeckel proposed the Biogenetic Law, which states that 'ontogeny recapitulates phylogeny, i.e., during the development of the embryo of any organism, its complete history is repeated'. For example, embryonic forms of human beings are similar to fishes, amphibians, reptiles and birds.

III. Evidences from Embryology cont`d

- Thus, on the basis of similarities in embryos of different vertebrates, it can be concluded that vertebrate animals have evolved from a common ancestor.

IV. Evidences from Palaeontology

- The remains of dead plants and animals that lived in the past are called fossils and the study of fossils is called palaeontology. Fossils help to trace evolution of a particular animal as they fill the gap between two animals.
- Fossils provide evidence in favour of evolution. For example, *Archaeopteryx* is a fossil bird and is a connecting link between reptiles and birds.

IV. Evidences from Palaeontology

- It had a skeleton, beak with teeth, a tail like reptiles but wings with feathers and furcula like birds. Thus, it suggests birds too have evolved from reptiles.

V. Evidences from Geographical Distribution of Animals

- Animals are distributed throughout the entire earth, which has been divided into six different regions.
- Different regions of the world have different animals and plants. Different geographical regions, at various places, are separated or isolated from others due to geographical barriers.

BIOGEOGRAPHY: AUSTRALIAN MARSUPIALS AND THEIR PLACENTAL COUNTERPARTS

AUSTRALIAN MARSUPIALS

Sugar glider

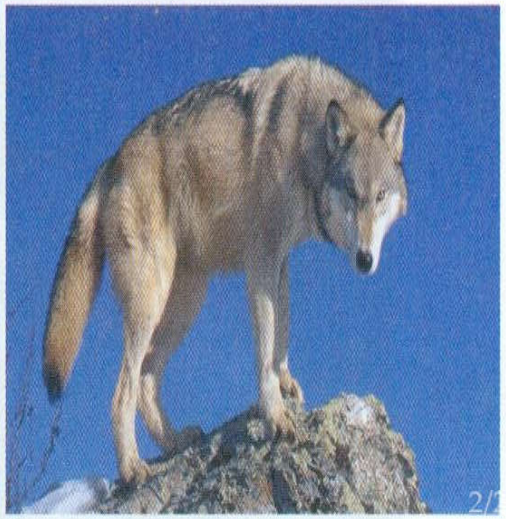
Numbat

Tasmanian wolf

PLACENTAL COUNTERPARTS

Flying squirrel

Giant anteater



Gray wolf

V. Evidences from Geographical Distribution of Animals

- Due to different environmental and climatic conditions, the separated regions gave rise to different animals and plants.
- Prototheria and metatheria are found only on the Australian continent, which was separated from the Asian continent before the appearance of eutherians.

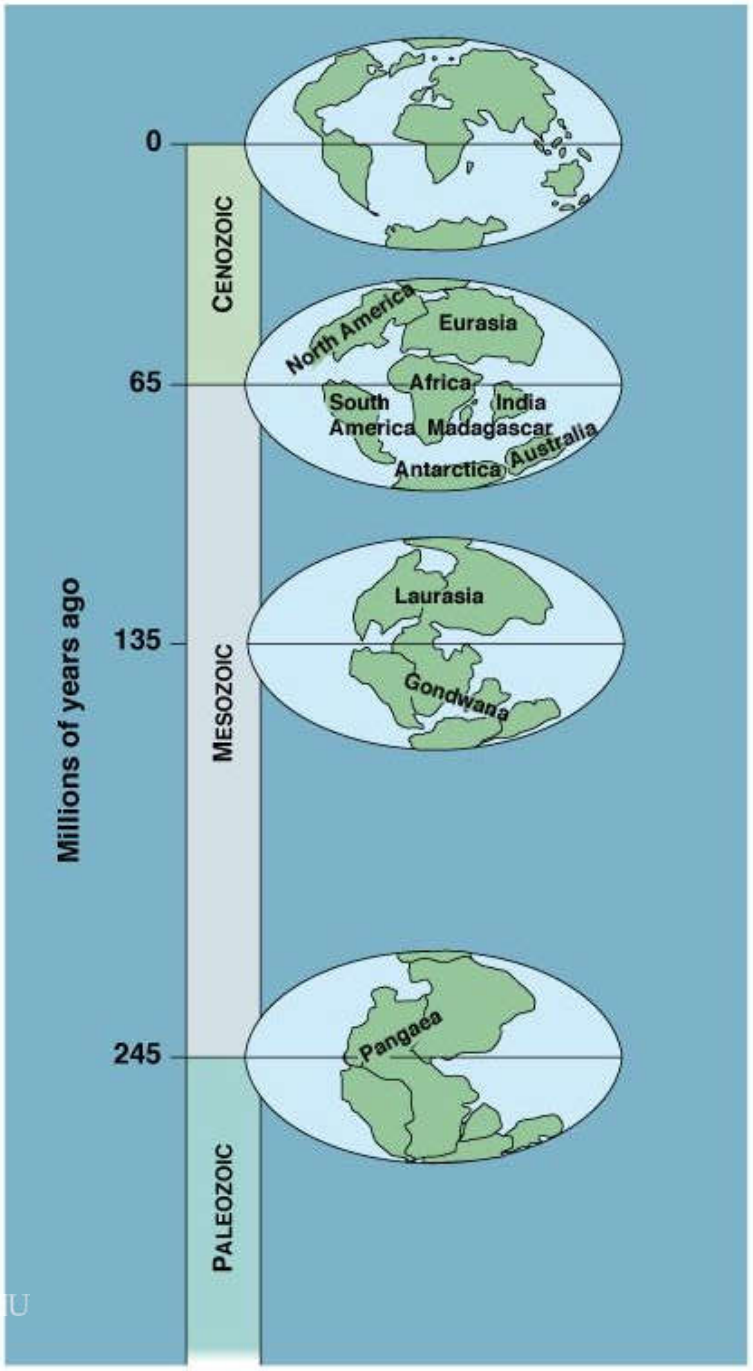
V. Evidences from Geographical Distribution of Animals

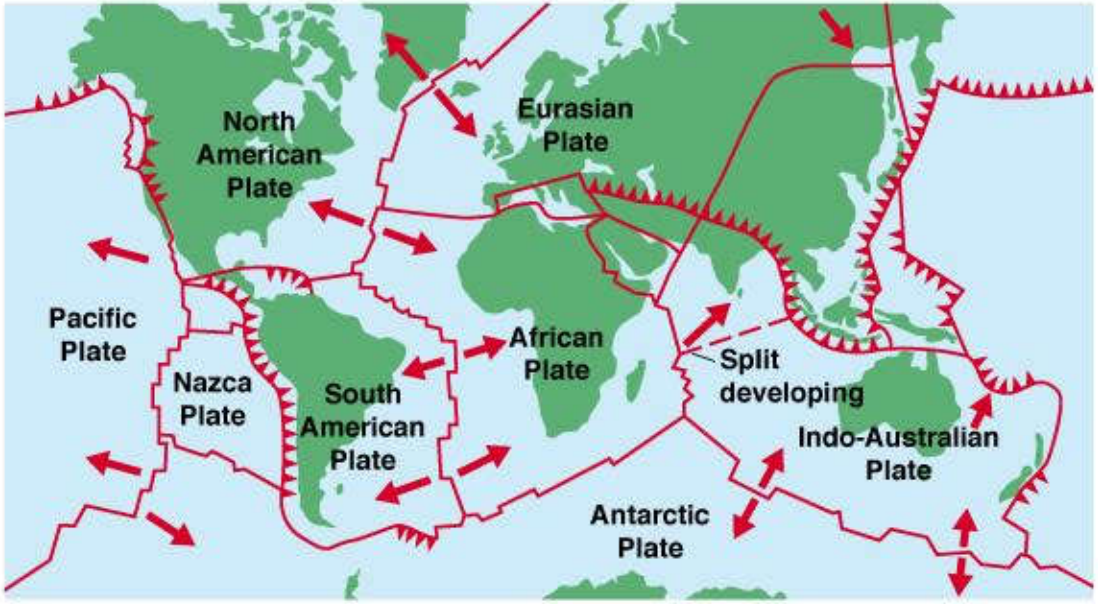
- Eutherian mammals, therefore, could not reach the Australian region.
- As a result of the evolution of eutherian mammals in the Asian continent, prototheria and metatheria disappeared from that region as eutherians were more efficient.

V. Evidences from Geographical Distribution of Animals

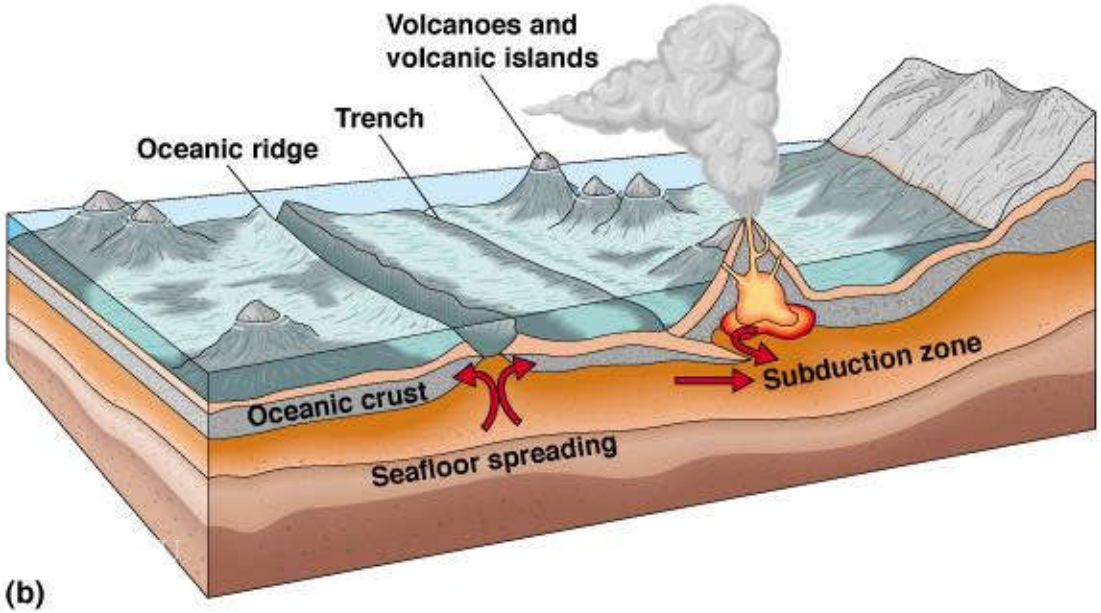
- On the other hand, in the absence of eutherian mammals in the Australian region, prototheria and metatheria had many opportunities to flourish.

- The camel and the llama are closely related and are found in Asia and South America, respectively. It suggests that Asia and South America were once a continuous landmass. Consequent to the separation of these two landmasses, the ancestors of the camel and the llama inhabiting Asia adapted themselves to desert life and evolved into the camel, while those that remained in South America underwent an evolutionary change to the llama, according to environmental conditions.


0
65
135
245
Millions of years ago
CENOZOIC
MESOZOIC
PALEOZOIC
North America
Eurasia
Africa
South America
India
Madagascar
Antarctica
Australia
Laurasia
Gondwana
Pangaea
©1999 Addison Wesley Longman, Inc.



(a)



(b)

- Thus, every region of the world has its own specific plants and animals and such distribution provides proof in favour of organic evolution.

VI. Evidences from Biochemistry and Physiology

- Protoplasm is the physical basis of life and is made up of carbohydrate, protein and fat. Oxygen, hydrogen, nitrogen and carbon are its main components. The percentage of these components is found to be the same in the protoplasm of all living worlds. Thus, it suggests that all living beings have originated from a common ancestor.

- In animals, the same types of enzymes have similar reactions (e. g., trypsin acts on proteins in all animals). Thus, the occurrence of the same enzyme in different animals indicates their common origin.
- Blood protein test has revealed that humans are closer to apes (chimpanzees and gorillas) than monkeys.

VI. Evidences from Biochemistry and Physiology cont`d

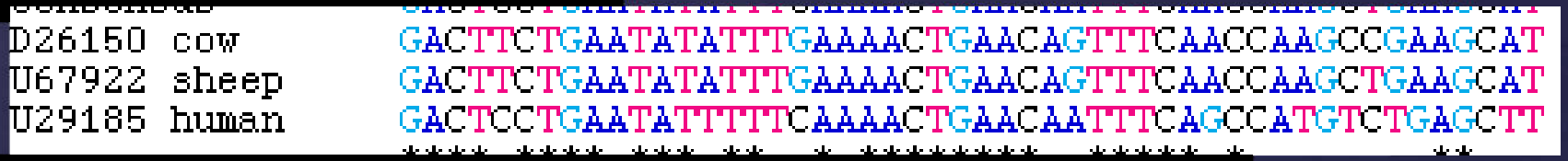
- Hormones of all vertebrates show similar a chemical nature and function.
- In the entire living world, the chromosome has the same biochemical organisation. The octamer of nucleosome has the same protein in all animals, indicating their common origin.

VI. Evidences from Biochemistry and Physiology cont`d

- All organisms utilise the same DNA triplet base and the same 20 amino acids in their proteins. Many organisms share the same introns and types of repeats. These similarities suggest descent from a common ancestor.

Homology – similarities across species
especially when similar form is modified for different function

Biochemical homology



also commonality of genetic code, amino acids

TABLE 13.4 COMPARISON OF A PROTEIN IN DIFFERENT SPECIES

Species	Percent of amino acids that are identical to the amino acids in a human hemoglobin polypeptide
Human	100%
Rhesus monkey	95%
Mouse	87%
Chicken	69%
Frog	54%
Lamprey	14%

Table 13.4

- All living organisms share the same genetic code. The degree of similarity in the DNA of different species can reveal how closely related they are and amount of time that has passed since they last shared a common ancestor.

VII. Evidences from Atavism

- The sudden reappearance of an ancestral characteristic is known as atavism or reversion. The reappearance of such features in newborns is suggestive of the fact that these features were present in their remote ancestors, but lost during the course of evolution to their present-day form.

Some common examples of atavism are as follows:

- (a) Appearance of tail in the newborns of human beings.
- (b) Occurrence of cervical fistula in some human bodies, which are the remnants of gill slits found in ancestors.
- (c) Occurrence of long and pointed canine and thick body hair in human babies (Lion's boy of Russia).

VIII. Evidences from Taxonomy

- Depending on the basis of similarities and differences, animals are grouped as phyla, classes, orders, families, genus and species.
- The similarities revealed their common ancestry, while differences among them are due to different environmental conditions that operate on them.

Patterns of Organic Evolution

- **Divergent Evolution**

(a) The pattern of evolution in which two closely related species gradually become increasingly dissimilar in different habitats of the same area is called divergent evolution.

(b) Divergent evolution is confirmed by DNA analysis in which the species that diverged is genetically similar to the form from which it diverged.

Divergent Evolution cont`d

(c) Adaptive radiation is an example of divergent evolution.

(d) Any genus of plants or animals can show divergent evolution.

(e) A good example of divergent evolution is Darwin's finches. Presently there are 80 species of Darwin's finches, which have diverged from a single finch.

Divergent Evolution cont`d

(f) A very common example of divergent evolution is the vertebrate limbs. Whale flippers, forelimbs of frogs and human arms perform different functions but share a common evolutionary origin.

(g) Divergent evolution results in speciation.

II. Convergent Evolution

- (a) The pattern of evolution in which two unrelated species become similar to each other due to favourable changes in morphology, living in the same area due to natural selection is known as convergent evolution.

CONVERGENT EVOLUTION

Different starting materials come to perform the same function through convergent evolution.

Convergent Evolution cont`d

- (b) Convergent evolution often results in analogous structures.
- (c) The striking similarity in hummingbird moths and hummingbirds is an example of convergent evolution.

Convergent Evolution cont`d

- (d) The evolution of functionally similar but distinct antifreeze proteins in divergent species of fishes (one group living near Antarctica and the other found in the Arctic) is an example of convergent evolution

III. Co-evolution

- (a) Combined changes in two or more species which are in close interaction, usually dependent upon each other, is known as co-evolution.

(b) A good example of co-evolution is shown by insects in which the shape and structures of the body as well as the size of proboscis is of different types, according to the structures of flowers.

(c) Plants and animals that pollinate them are a common example of co-evolution.

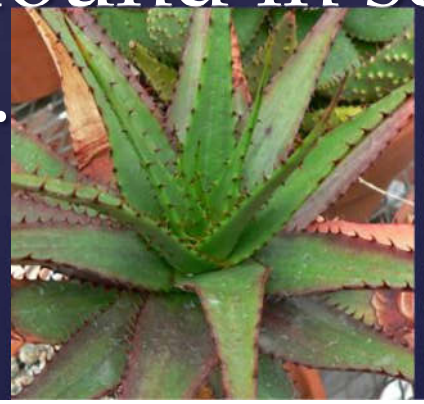
IV. Parallel Evolution

(a) The pattern of evolution in which independent development of similar characteristics in two groups of animals having common ancestry occurs due to similar environmental conditions is known as parallel evolution.

(b) Parallel evolution is more frequent between structures.

(c) In both parallel and convergent evolution, similar adaptations arise in different species. But in parallel evolution, the two species have a relatively recent common ancestor.

(d) The form of leaves in plants is a good example of parallel evolution. A similar pattern of leaves is found in separate genera and families.



(e) Several instances of parallel evolution are found in placental and marsupial mammals. Placental mammals like the anteater, house mouse, wolf, flying squirrel and groundhog are parallel in evolution to marsupials like the wombat, marsupial mouse, Tasmanian wolf, native cat, etc.