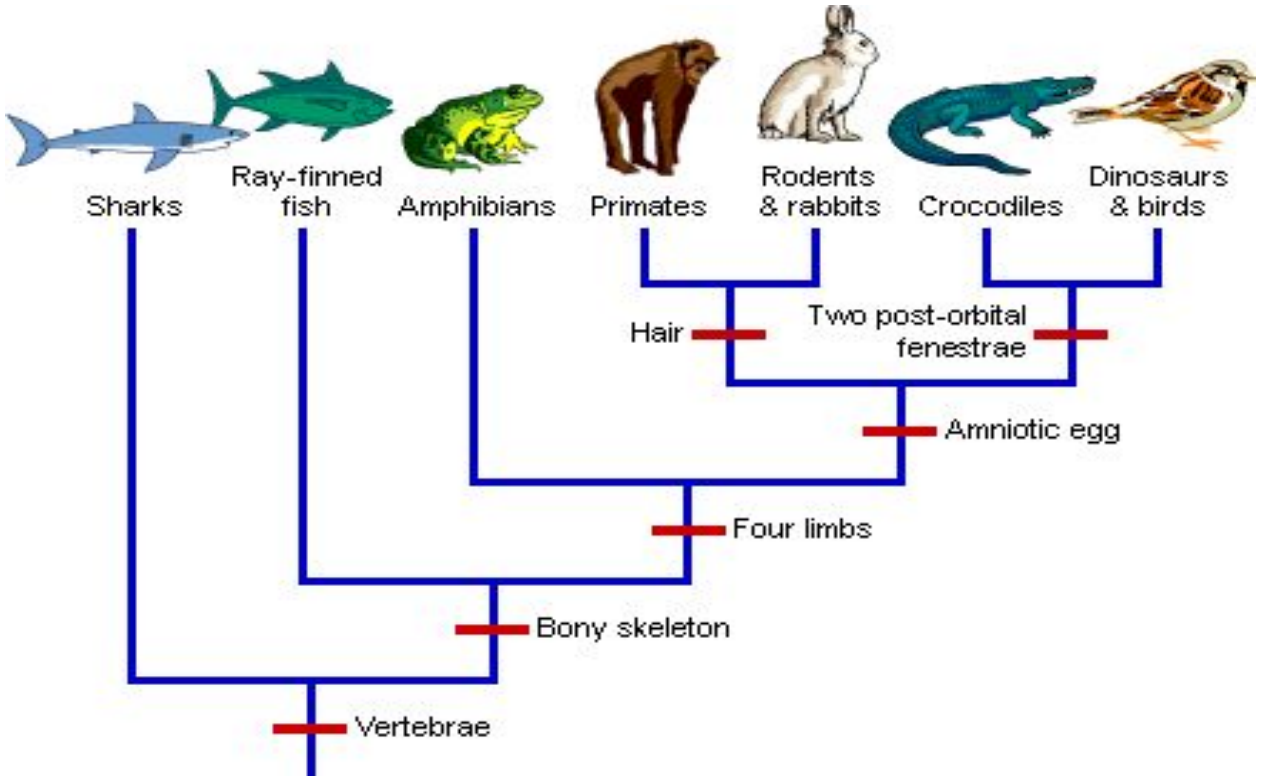
Evolutionary Trends



BIO 101

By

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Evolutionary trend

- **Evolutionary biology** is a subfield of **biology** concerned with the study of the **evolutionary** processes that produced the diversity of life on Earth.
- **Evolutionary biologists** study the descent of species, and the origin of new species.
- **Evolution** is a scientific theory proposed by Charles Darwin. It occurs at the population level, It is made possible by genetic variations
- EVIDENCES THAT SPECIES EVOLVE COMES FROM THREE LINES OF INVESTIGATION
  - Relationship were discerned among major groups of animals (Comparative anatomy)
  - Explorers discovered difference in the world distribution of species (Biogeography)
  - Geologist discovered apparent sequence of changing fossils in distinct layers of the earth

History of Life on Earth

- BILLIONS OF YEARS AGO EXPLOSION OF DYING STARS RIPPED THROUGH OUR GALAXY AND LEFT BEHIND A DENSE CLOUD OF DUST AND GAS
- AS THE CLOUD COOLED
- There are scientific evidence that earth and the other planets of the solar system formed about 4.6 billion years ago.
- Evidences have shown that conditions on early Earth made the origin of life possible e.g is the fossils of microorganisms that are about 3.5 billion years old.
- There are approximately two million species of animals and plants living today,
- How did this diversity of life come to exist?

The Voyage of the Beagle

- Charles Darwin (1809-1882)
- He went on a voyage from England with the aim of drawing a chart of the South American coastline
- But while on the journey, he observed and collected samples of South American plants and animals.
- He noted their adaptive characteristics to their environment.
- They had a stop at the Galapagos , a group of Islands located close to the equator about 900km west of South America.
- There he observed some unusual animals.
- e.g Birds with different beak sizes and different species, some were unique to individual islands while others lives on two or more adjacent island

Darwin and the theory of Evolution

Darwin developed two main ideas from four observations

- Observations

  1: Members of a population vary greatly in their traits

  2; Traits are inherited from parents to offspring

  3: All species are capable of producing more offspring than their environment can support

  4: Owing to lack of food or other resources, many of these offspring do not survive

- Ideas
  - **That descent with modification explains life's unity and diversity**
  - **That natural selection brings about the match between organisms and their environment**

Darwin and the theory of Evolution

- Darwin conclusion therefore means that Animals and Plants have arisen by a process of slow and gradual change over successive generations.
- This gradual change is brought about by NATURAL SELECTION

We can therefore infer that

i. Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals

ii. This unequal ability of individuals to survive and reproduce will lead to accumulation of favorable traits in the population over generations

Fossils

- Fossils are the remains of animals and plants that died a very long time ago and became preserved in rocks. These remains are our ‘window to the past’ .
- In general, it takes at least 10,000 years but usually millions, for fossils to form.
- Fossil evidences shows that past organisms were very different from those now alive.
- .

LEVELS OF EVOLUTION

- There are two levels of evolution
  - Microevolution
  - Macroevolution

- Microevolution- changes in allele frequencies in a population over generations, it occurs at the genetic level. Small scale changes.
  - What causes allele frequency to change
    - Natural selection
    - Genetic drift – chance events that alters allele frequencies
    - Gene flow – the transfer of alleles between populations.

    Only natural selection can cause ADAPTIVE RADIATION

LEVELS OF EVOLUTION

- Macroevolution-Larger changes, such as when a new species is formed. It includes the idea that all life forms is connected and can be traced back to one common ancestor.
- Macroevolution is cumulative microevolution
- The sweeping changes in life on Earth revealed by fossils illustrates MACROEVOLUTION

- The process of evolution can be summarized in three sentences:
  - Genes mutate.
  - Individuals are selected.
  - Populations evolve.
- Note: individuals do not evolve but populations evolve e.g *Biston betularia* (English moth), *Geospiza fortis*.

Evolution

- Evolution can be viewed in two related but different ways
  - As a pattern
  - As a process

One way to assess whether natural selection or other factors are causing evolution at a particular locus is to determine what the genetic makeup of a population would be if it were not evolving at that locus, and then compare with the real scenario. If there are no difference we can conclude that the real population is not evolving.

Hardy-Weinberg EQUILIBRUM

- This principle allows us to know if evolution is occurring in a population
  - *The frequencies of alleles and genotypes in a population will remain constant from generation to generation, provided there are no disruptive influences such as mutation and selection*
  - *i.e Genetic equilibrium is maintained.*
- Godfrey H, Hardy and Wilhelm Weinberg (1908)

  $p^2 + 2pq^2 + q^2 = 1$
- The equation can be used to calculate the proportion of

The Hardy-Weinberg Theorem

- Assumptions
  - Size must be extremely large (frequency will not change by chance)
  - Random Mating
  - No Migration / No gene flow
  - No Mutation
  - No natural selection

- If they are met, they EVOLUTION will not occur.

FACTORS THAT BRING ABOUT EVOLUTION

- Violations of the conditions in the Hardy-Weinberg equilibrium can bring about EVOLUTION
- New mutations brings about alteration in allele frequencies , but mutations are rare.
- Non random mating can affect frequency of homozygous and heterozygous genotypes but these may have no effect on allele frequencies in the gene pool.
- The three mechanisms that alter allele frequencies directly and cause most evolutionary change are natural selection, genetic drift and gene flow.
- These three mechanisms cause decrease in genetic variation.

GENETIC VARIATION

- Variation is the range of differences that there are between individual organisms.
- Variation in traits has a heritable basis

Variation can be *within* species

(Think of all the differences between individual humans)

These are different varieties of the same species Or *between* species:

- **Natural Selection** is defined as differential reproductive success of pre- existing classes of genetic variants in the gene pool.
- **This is the process by which biological evolutionary changes take place. It is based on the following concepts**
  1. **Individuals in a population have different traits which can be inherited**
  2. **These individuals produce more young than the environment can support**
  3. **The individuals best suited to their environment will leave more offspring's, resulting in a change in the genetic make up of that population.**
- The most common action of natural selection is to remove unfit variants as they arise via mutation. In other words, natural selection usually prevents new alleles from increasing in frequency.

- Natural selection can maintain or deplete genetic variation depending on how it acts
- Mechanisms that increase genetic variation are mutation, recombination and gene flow.

Example

- *Fruit fly (Drosophila melanogaster) has an allele that confers resistance to several insecticides. The allele has a frequency of 0% in flies collected in the wild in early 1930's , before the introduction of DDT. However, strains of flies collected after 1960 , the allele frequency is 37%.*
- *This type of evolution is called ADAPTIVE EVOLUTION*

GENETIC DRIFT

- Chance events can cause allele frequencies to fluctuate unpredictably from one generation to the next, especially in small populations .
- This process is called GENETIC DRIFT.
- Certain circumstances can result in genetic drift having a significant impact on a population. Two examples are the founder effect and the bottleneck effect.

The founder effect

- Founder effect occur when a few individuals become isolated from a larger population, this smaller group may establish a new population whose gene pool may establish a new population whose gene pool differ from the source population.
- This can occur when storm indiscriminately transports some individuals (and their alleles) but not others, from the source population.
- Now, lets look at some examples

- British colonist founded a settlement (Tristan de Cunha). One of the colonists carried a recessive allele for retinitis pigmentosa, a progressive form of blindness that afflicts homozygous individuals. Of the 240 descendants of the founders, 4 had retinitis pigmentosa.
- The frequency of the allele that causes this disease is ten times higher on Tristan de Cunha than in the population in which the founders came.

The bottleneck effect

- A sudden change in the environment e.g. drought , fire or flood may drastically reduce the size of a population.
- A severe drop in population size can cause BOTTLENECK EFFECT.
- By chance, certain alleles may be overrepresented , underrepresented or totally absent.
- Even if a population that has passed through a bottleneck ultimately recovers in size, it may have low levels of genetic variation for a long period of time.

Summary of effects of genetic drift

- Genetic drift is significant in small populations
- It can cause allele frequencies to change at random over time
- It can lead to a loss of genetic variation within populations
- It can cause harmful alleles to become fixed

GENE FLOW

- This is the transfer of alleles into or out of a population due to the movement of fertile individuals or their gametes

MECHANISM OF MACROEVOLUTION

- Speciation -- Increasing Biological Diversity
- Extinction – reducing Biological Diversity
- Speciation is the process of a single species becoming two or more species.

ORIGIN OF SPECIES: Mode of Speciation

- A species is a group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring
- There are two types of speciation: allopatric and sympatric speciation.
- The two differ in geographical distribution of the populations in question.
- Allopatric speciation is the most common form of speciation. It occurs when a population is split into two (or more) geographically isolated subdivisions that organisms cannot bridge. Eventually, the two populations' gene pools change independently until they could not interbreed even if they were brought back together. In other words, they have speciated.
- .

ORIGIN OF SPECIES

- Sympatric speciation occurs when two subpopulations become reproductively isolated without first becoming geographically isolated.
- Insects that live on a single host plant provide a model for sympatric speciation. If a group of insects switched host plants they would not breed with other members of their species still living on their former host plant. The two subpopulations could diverge and speciate.
- . Agricultural records show that a strain of the apple maggot fly *Rhagolettis pomenella* began infesting apples in the 1860's. Formerly it had only infested hawthorn fruit.

ORIGIN OF SPECIES

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- Speciation has been observed. In the plant genus *Tragopogon*, two new species have evolved within the past 50-60 years. They are *T. mirus* and *T. miscellus*. The new species were formed when one diploid species fertilized a different diploid species and produced a tetraploid offspring. This tetraploid offspring could not fertilize or be fertilized by either of its two parent species types. It is reproductively isolated, the definition of a species.

- Factors that promote sympatric speciation
- 1. Polyploidy
- 2. Habitat differentiation
- 3. Sexual selection

Extinction

- Extinction is the ultimate fate of all species.
- The reasons for extinction are numerous.
- A species can be competitively excluded by a closely related species, the habitat a species lives in can disappear and/or the organisms that the species exploits could come up with an unbeatable defense.

HISTORY OF EARTH

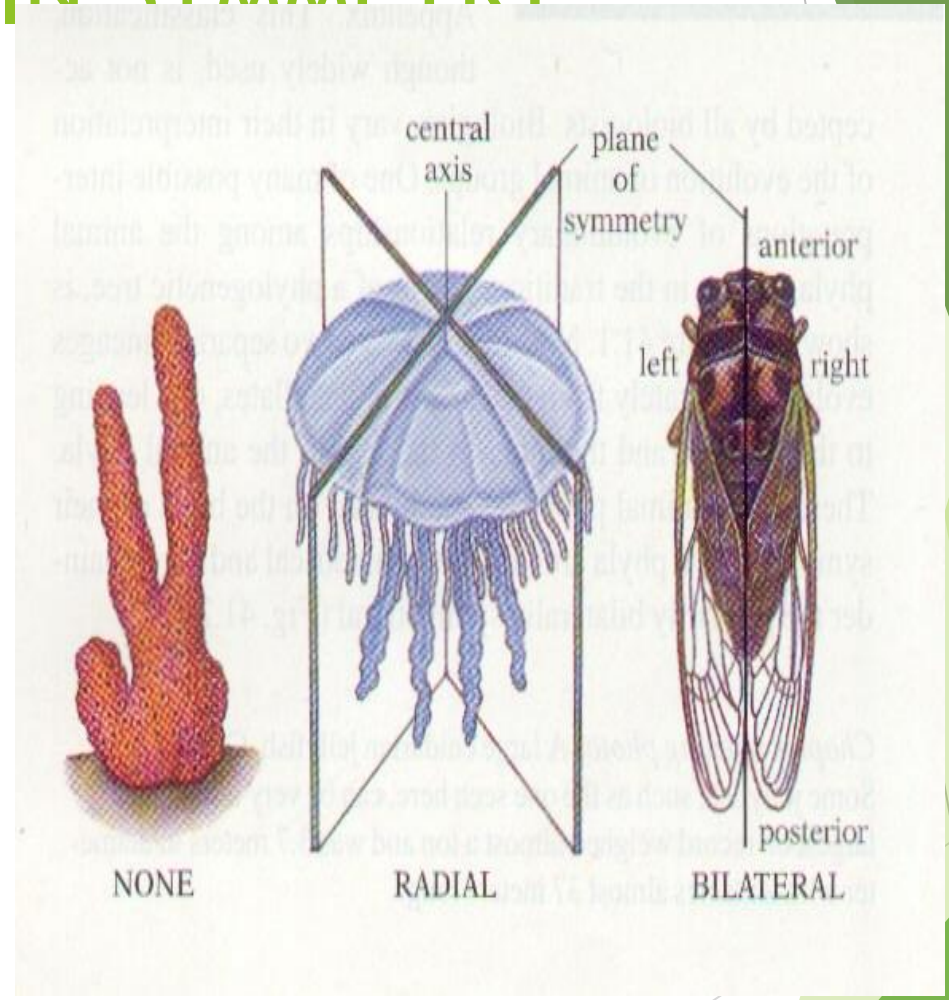
- Geologic records has told us that Earths time can be divided into three Eons,
- The first two Eons – the Archean and Protoezoic together lasted approximately 4 billion years. The Phanerozoic eon, the last half billion years ago encompasses most of the time that animals have existed on earth.
- It is divided into three Eras : the Paleozoic, Mesozoic and Cenozoic.
- Each era represents a distinct age in history of Earth and its life.
- The first evidence of life dates back to 3.5 billion yaers ago and the record comes from fossilized stromatolites, formed by Prokayotes

Evolutionary trends in ANIMALS

- 1. Trends in Symmetry
- 2. Trends in Digestive Tracts
- 3. Trends in Body Cavities
- 4. Trends in Cephalization
- 5. Trends in Segmentation
- 6. Trends in Skeletal modification

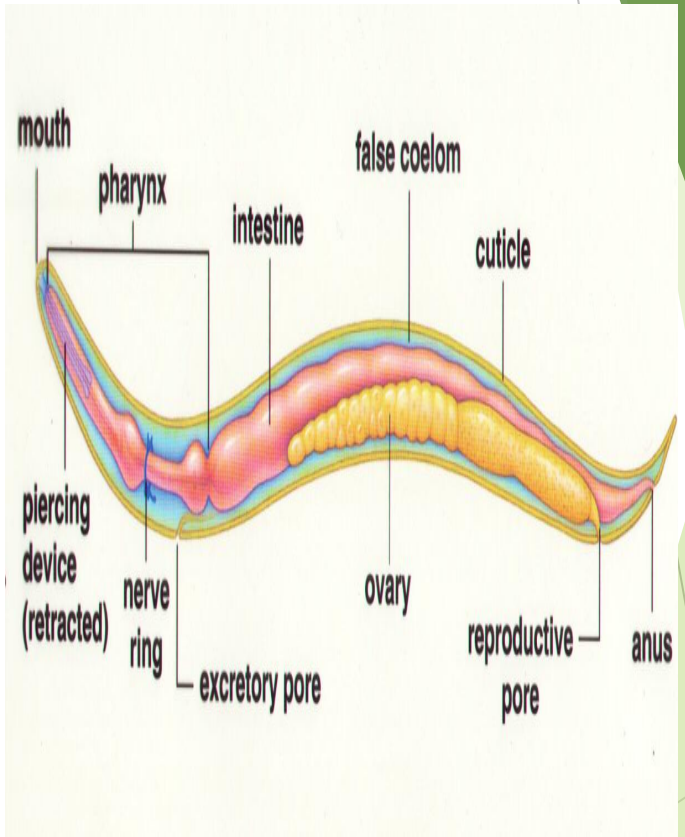
EVOLTUTIONARY TREND IN SYMMETRY

- Asymmetry (No Symmetry)
- Radial Symmetry
- Bilateral Symmetry



Digestive system complete

- Incomplete
- Complete



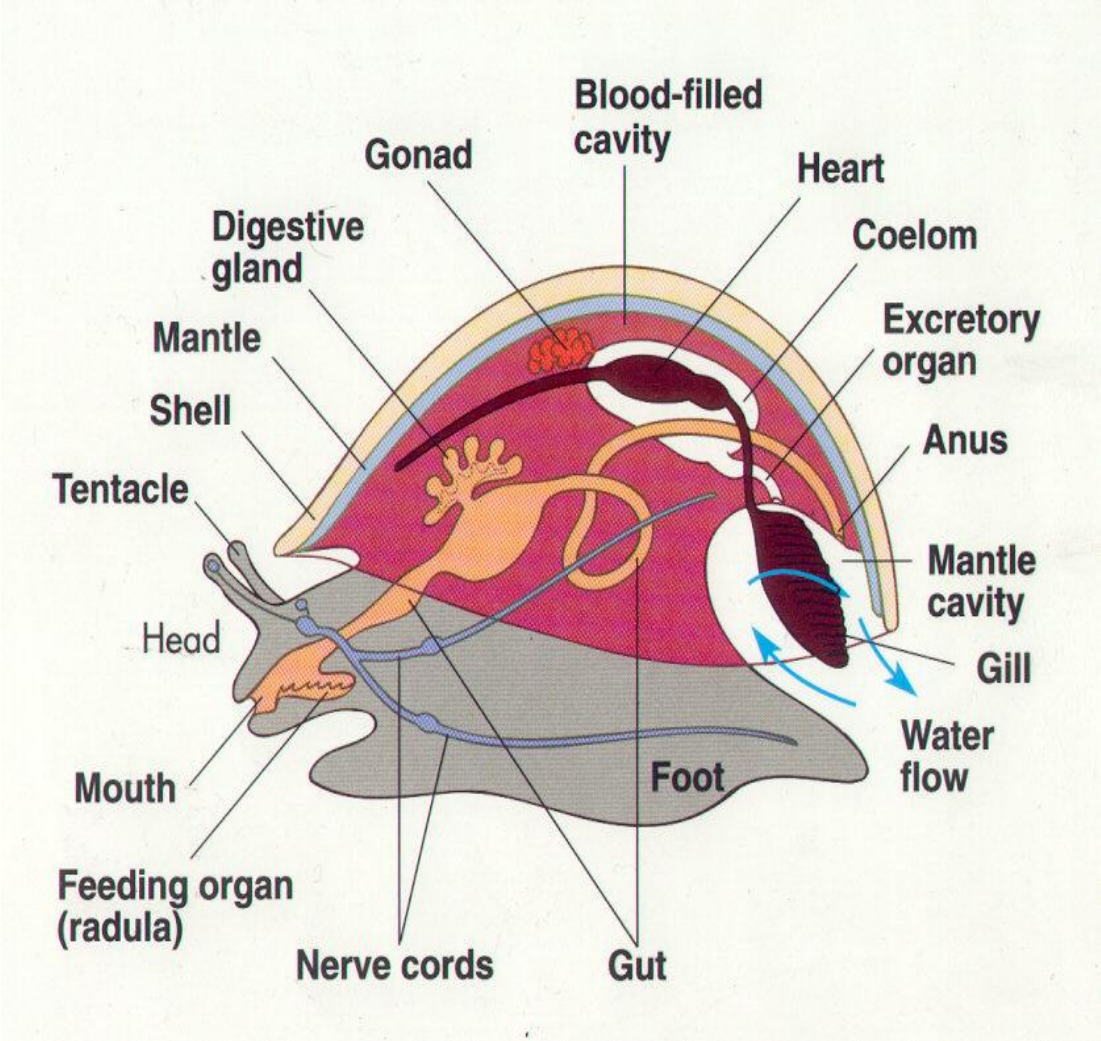
Incomplete

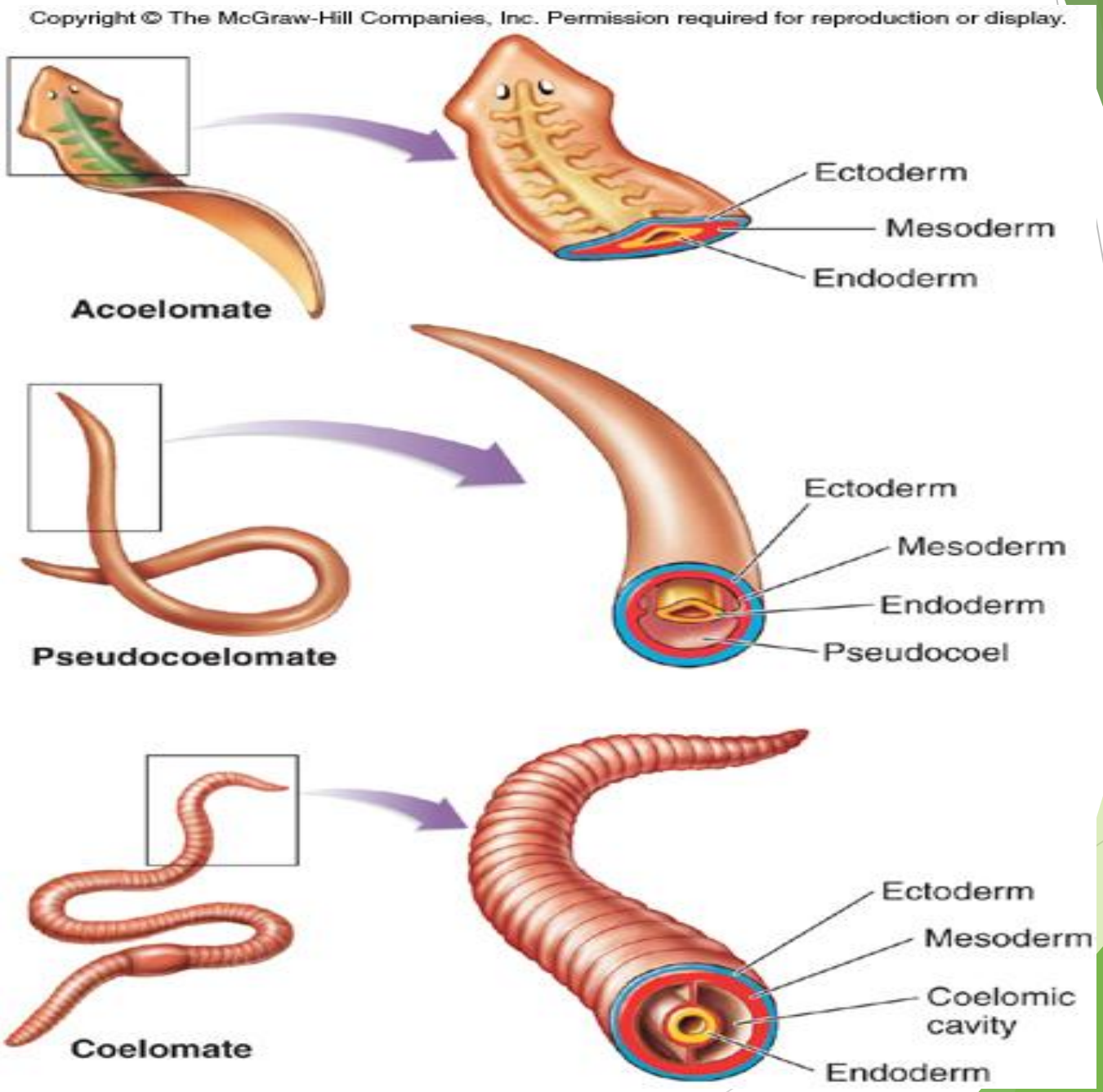
Evolutionary Trend in Body cavity

- Acoelom (No Coelom)e.g platyhelminthes Flatworms
- Pseudocoelom (False Body Cavity) e.g Round worm (Ascaris)
- Coelom (True Coelom) e.g Earthworm

Advantages of coelom and psuedocoelom

- The reproductive and digestive organs can evolve more complex shapes and functions.
- The gut tube and other organs are cushioned and thus better protected.
- Can act as hydroskeleton providing support and rigidity for the soft animal.
- The activities of the suspended gut can take place undisturbed by the activity of the animal's outer





EVOLUTIONARY TREND IN CEPHALIZATION

- **Cephalization** is considered an evolutionary trend, whereby nervous tissue, over many generations, becomes concentrated toward one end of an organism.
- This process eventually produces a head region with sensory organs.

- Protostomes or “First Mouth Animals”

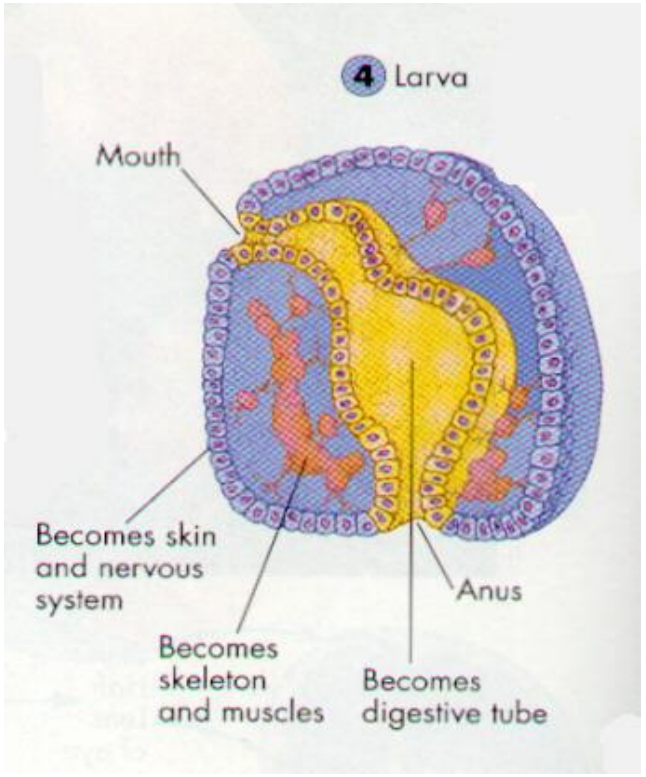
  During their embryonic development the mouth forms first and the anus second.

- Deuterostomes: “Second Mouth Animals”

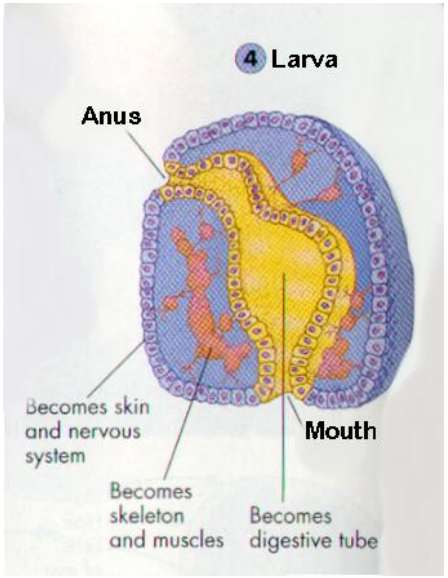
  During their embryonic development the anus forms first and the mouth second.

Larva

Deuterostome



Protostome



Evolutionary Trend in Segmentation

- **Segmentation** in biology refers to the division of some animal and plant body plans into a series of repetitive segments.
- i. this similar repeated units permit larger organisms
- ii. in annelids (segmented worms), segments are similar
- -- form fluid filled compartments that can be stretched or compressed separately-- worm locomotion
- iii. segmentation permits specialization of different segments

Evolutionary Trend in SKELETAL MODIFICATION

- TREND AMONG PRIMATE
- FROM LEGGED GAITS TO SPECIALIZED MODE OF LOCOMOTION E.G BIPEDALISM (TWO LEGGED GAIT)
  - CHANGES IN THE SHOULDERS, BACKBONE, PELVIC GIRDLE, LEGS AND
- CHANGE IN DENTITION
- MODIFICATION OF HANDS LEADING TO INCREASED MANIPULATIVE SKILLS
- LESS RELIANCE ON SENSE OF SMELL, MORE RELIANCE ON ENHANCED DAYTIME VISION
- FROM SPECIALIZED TO OMNVOROUS EATING HABITS
- BRAIN EXPANSION AND REORGANIZATION.- THIS TREND BEGAN WITHAMONG MAMMALS GENERALLY BUT ACCELERATED DURING HOMONID EVOLUTION

- TREND IN BEHAIVOURAL MODIFICATION
  - LONGER LIFE SPAN
  - LONGER PERIODS BETWEEN PREGNANCY
  - SINGLE BIRTHS RATHER THAN LITTERS
  - EXTENDED PERIOD OF INFANCY DEPENDENCY