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Online Lecture, Semester I

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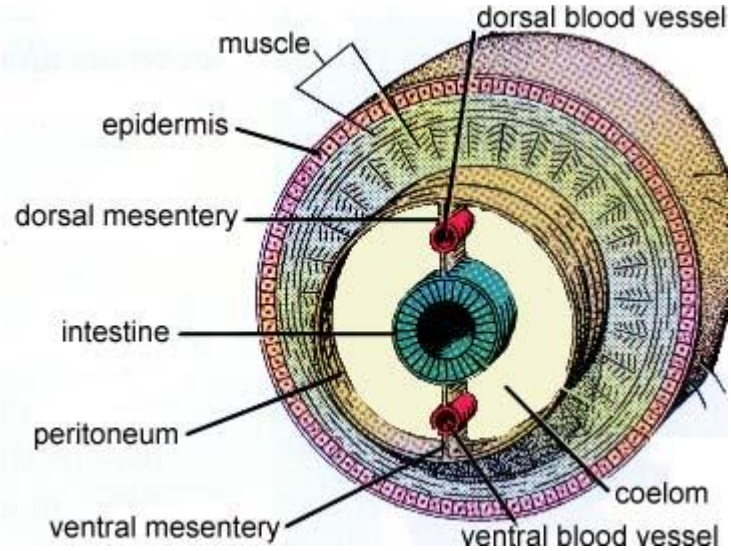
METAMERISM

Definition: Metameric segmentation or metamerism is an architectural body plan in some animals in which the similar body segments called metameres or somites are serially repeated one after another.

- The animals which exhibit such features called metamerically segmented.
- Structurally each meta-mere or somite is constructed on the basis of some fundamental plan and are identical in structure. The individual is formed by repetition of segments which are similar both externally and internally.
- This repetition may be sometimes interrupted by simplification, by coalescence of segments or by differentiation between the segments.



First evidence of Metamerism: Metamerism is first observed in annelids in animal kingdom. Each segment usually contains appendages, muscles, nerves, blood vessels, excretory organs and a pair of coelomic sacs.

- It is also seen in kinorhynchs. Apart from this it is also found in phylum Arthropoda and vertebrata. One group of Mollusca (Monoplacophora) also exhibits metamerism.

- Tape worms show pseudometamerism or strobilization, which is not true metameric segmentation.

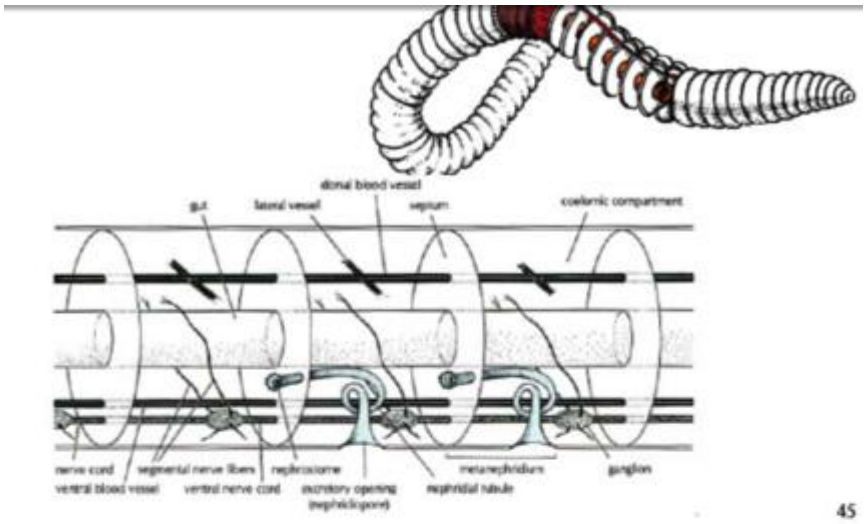
Characteristic Features of Metamerism:

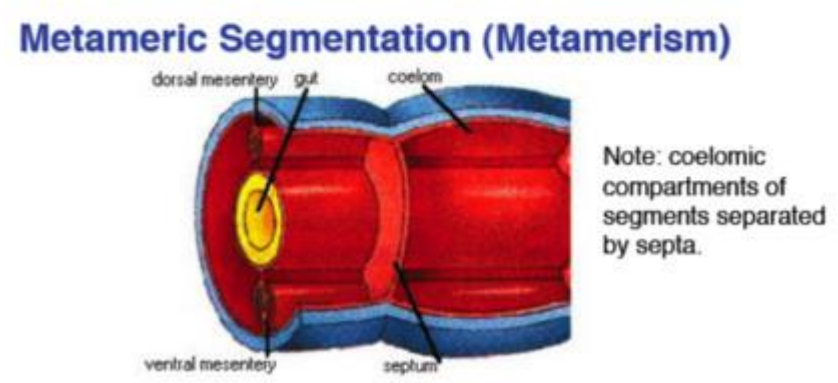
1. Metamerism is not found in the anterior head segment(acron) and a posterior telson(pygidium) and is usually confined to the intermediate (trunk) segments.

2. Each metamere represents a mirror image of the other.

3. Segmental structures within metameres are interdependent.

4. They are integrated into a single functional unit working in coordination.





Types of Metamerism:

A. Homonomous & Heteronomous metamerism: In annelida the body is divided into a number of similar segments. If all the metameres are similar throughout the body it is called **Homonomous metamerism.**

However in some groups like arthropoda and chordata the anterior segments will show clear cephalisation. They are modified into head bearing specific sense organs. Such metamerism is called **Heteronomous metamerism.**

B. Complete and incomplete metamerism: **Complete type** of metamerism practically affects all the body systems. In this type the metameres are homonomous and each metamere has segmental blood vessels, nerves, coelomoducts and nephridia.

   Metamerism in Arthropods and other higher animals is **incomplete** because of division of Labour. Consequently, metameres of different regions of body vary considerably. The larval and embryonic stages of arthropods and other vertebrates show complete metamerism with uniform metameres. But these metameres become unclear in the adults succeeding specialization.

C. External and internal metamerism: In most of the Annelids, metamerism is conspicuously visible **both externally and internally**. Example, Pheretima posthuma, it has numerous body segments and all body being repeated segmentally. Moreover even the coelom is segmentally divided into compartments by intersegmental transverse mesenteries called septa. Only the digestive tract escapes this metamerism and it extends through every segment.

In Arthropods, metamerism is chiefly **external**. Humans and other vertebrates show internal metamerism of nerves, blood vessels etc.

D. True and pseudometamerism: **True** segments in Annelids are developed during the embryonic stages whereas the **pseudo** segments present in tape worms are superficial which are formed as a result of strobilization. The proglottids of tapeworms are not true segments but rather they are complete reproductive individuals.

Significance of metamerism:

- The coordinated contraction of the metameres along the body generates efficient body undulating movement providing an **effective locomotory mechanism.**
- Fluid filled coelomic compartments provide **hydro static skeletons for burrowing.** Accurate movements can take place by differential turgor pressures affected by flow of coelomic fluid from one part of the body to the other.
- Different segments can be specialized for different functions leading to the **development of high grade of organization**. It is not clearly marked in annelids, but well developed in arthropods. Example spermatheca, clitellum are involved with reproduction, thus regional specification of the body with proper division of Labour.

Origin of metameric segmentation:

Several theories have been put forward to explain the development of metamerism, though its origin is not certain.

1. Fission theory:

a. This theory, which was further improved by Perrier proposes annelids might have developed from Platyhelminthes.
b. Metamerism is derived from non-segmented ancestor, which might have under gone transverse fissions repeatedly to develop metamerism.

Drawbacks:

a. Fission gives rise to separate individuals but they will not unite together to form a metameric individual.
b. Generally, reproduction by fission occurs in sessile animals but not in free moving organisms.

2. Pseudometamerism theory:

This theory was proposed by Hyman & Goodrich, which states that the body parts like coelom, blood vessels, nephridia muscles etc. will be repeatedly formed with septa in between them. This in turn led to the development of metamerism which can be seen in some larval forms and adults of some annelids.

3. Embryological theory:

In the embryonic stage by some stress in the mesoderm caused fragmentation that developed into metameres.

4. Locomotory theory:

This theory is based on combination of pseudometamerism theory and embryological theory which states that metamerism is derived as an adaptation to locomotion:

a. In annelids the segmentation is developed as an adoptation for burrowing.
b. In chordates the metamerism is developed as an adoptation for swimming, undulatory movements.

Long coelomate organisms, developed septa which provided their fluid skeletons strength and localised muscles function making it advantageous for burrowing. Later the nervous system, excretory system etc. are also undergone segmental-organization.

In chordates the metameric segmentation of body wall and musculature allow alternate waves of contraction which helps them in swimming. Thus it was inferred that locomotion might have triggered metamerisation of segments in these animals.

METAMERISM IN ANNELIDA

R.B. Clark in 1964 advocated the LOCOMOTION THEORY to explain the origin of metamerism in annelids. In annelids, for evolution of peristaltic locomotion and burrowing, metamerism became necessary.

- Annelids exhibit peristaltic locomotion which involves alternating shortening and lengthening of body by circular and longitudinal muscles. Septal demarcation was needed in the coelomic compartment which is filled with coelomic fluid to facilitate peristaltic movement such that high pressure produced by contraction of muscles can be confined to a particular region and it does not affect the whole body. By having metamerism Thus with emergence of metameric segmentation, annelids can save energy by keeping high pressure areas in selected regions and regulate locomotory movements in different directions.
- Thus, hydraulic skeleton is formed in annelids with the help of coelomic fluid and intersegmental septa that aids their burrowing habits.

SEGMENTATION IN DIFFERENT GROUP OF ANNELIDA

Polychaeta

These annelids bear highly distinguished internal & external segmentation; each body segment bearing a pair of appendages or parapodia.

(i) **Sarantia**

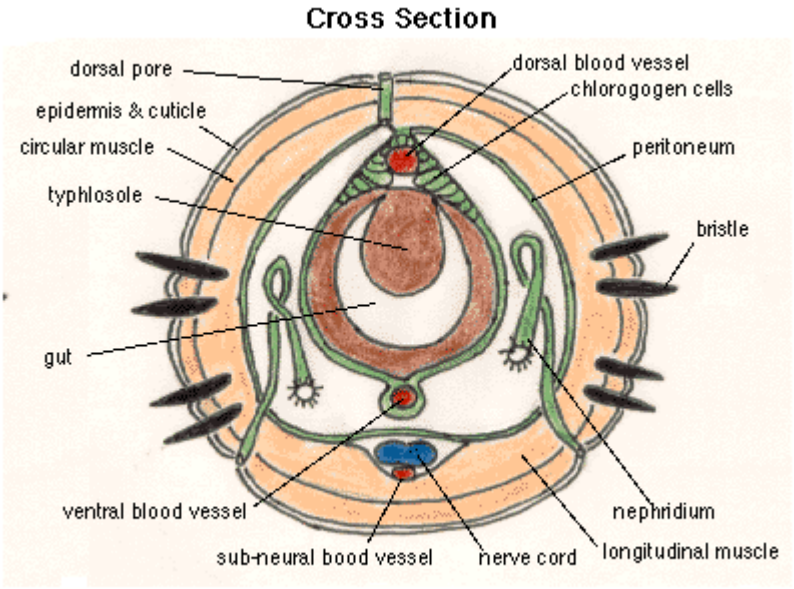
Polychaetes with numerous usually similar segments except for the head and anal segments.

(ii) **Sedentaria**

Body generally divided into two or more distinct regions with dissimilar segments and parapodia.

Oligochaeta

These annelids have a well –marked external & internal segmentation, usually segmentally arranged throughout the greater part of the body, but not parapodia setae present in each segment.

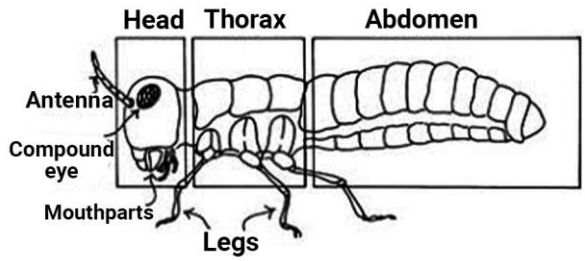


Hirudinea

These annelids, have limited and definite number of segments which is marked externally by secondary ring and annuli. The anterior end of the body is suctorial, and several of the hindmost segments are fused into a powerful posterior sucker.

METAMERISM IN ARTHROPODS

Arthropods inherited metamerism from annelids in which body organs and appendages were serially repeated in each segment. According to Williston's rule of serial homology, arthropods used this feature to specialise body organs and compaction of the body segments. As a result, arthropods specialised segmented body into tagma, such as cephalothorax and abdomen in crustaceans or into head, thorax and abdomen in insects. Appendages were modified to produce antennae, mouth parts, walking and swimming appendages, wings etc. Such specialization of body segments in arthropods is called tagmatization or tagmosis. This process of tagmatization led to rapid evolution and diversification of arthropods.



METAMERISM IN CHORDATES

CLARK'S LOCOMOTION THEORY

R.B. Clark's (1964) theory states that metamerism evolved independently in chordates also for advancement of locomotory abilities which was carried out by lateral undulation of body in primitive aquatic vertebrates. Metamerism allowed myotomes or muscle bundles and nerves to be arranged segmentally for better co-ordination of undulatory movement of body.

CYCLOMERISM THEORY

This theory, proposed by Sedgwick in 1884, postulates that metamerism in chordates evolved for better arrangement of organs in coelom. True coelom or enterocoel evolves by outpouching of coelenteron in three places to produce protocoel, mesoscoel and metacoele, which further partitioned later to produce somites. This provided septa and compartments in coelom in which organs could be arranged in more efficient manner.