What is meant by metamerism

This article includes a list of general references, but it remains largely unverified because it lacks sufficient corresponding inline citations. Please help to improve this article by introducing more precise citations. (October 2013) (Learn how and when to remove this template message) Earthworms are a classic example of biological homonymous metamery – the property of repeating body segments with distinct regions In biology, metamerism is the phenomenon of having a linear series of body segments fundamentally similar in structure, though not all such structures are entirely alike in any single life form because some of them perform special functions.[1] In animals, metameric segments are referred to as somites or metameres. In plants, they are referred to as metamers or, more concretely, phytomers. In animals In animals, zoologists define metamery as a mesodermal event resulting in serial repetition of unit subdivisions of ectoderm and mesoderm products.[1] Endoderm is not involved in metamery. Segmentation is not the same concept as metamerism: segmentation can be confined only to ectodermally derived tissue, e.g., in the Cestoda tapeworms. Metamerism is far more important biologically since it results in metameres - also called somites - that play a critical role in advanced locomotion. One can divide metamerism into two main categories: homonomous metamery is a strict serial succession of metameres. It can be grouped into two more classifications known as pseudometamerism and true metamerism. An example of pseudometamerism is in the class Cestoda. The tapeworm is composed of many repeating segments - primarily for reproduction and basic nutrient exchange. Each segment acts independently from the others, which is why it is not considered true metamerism. Another worm, the earthworm in phylum Annelida, can exemplify true metamerism. In each segment of the worm, a repetition of organs and muscle tissue can be found. What differentiates the Annelids from Cestoda is that the segments in the earthworm all work together for the whole organism. It is believed that segmentation evolved for many reasons, including a higher degree of motion. Taking the earthworm, for example: the segmentation of the muscular tissue allows the worm to move in an inching pattern. The circular muscles work to allow the segments to elongate one by one, and the longitudinal muscles then work to shorten the elongated segments. This pattern continues down the entirety of the worm, allowing it to inch along a surface. Each segment is allowed to work independently, but towards the movement of the whole worm.[2] heteronomous metamery is the condition where metameres have grouped together to perform similar tasks. The extreme example of this is the insect head (5 metameres), thorax (3 metameres), and abdomen (11 metameres, not all discernible in all insects). The process that results in the grouping of metameres is called "tagmatization", and each grouping is called a tagma (plural: tagmata). In organisms with highly derived tagmata, such as the insects, much of the metamerism within a tagma may not be trivially distinguishable. It may have to be sought in structures that do not necessarily reflect the grouped metameric function (eg. the ladder nerve system or somites do not reflect the unitary structure of a thorax). Segments of a crayfish exhibit metamerism In addition, an animal may be classified as "pseudometameric", meaning that it has clear internal metamerism but no corresponding external metamerism - as is seen, for example, in Monoplacophora. Humans and other chordates are conspicuous examples of organisms that have metameres intimately grouped into tagmata. In the Chordata the metameres of each tagma are fused to such an extent that few repetitive features are directly visible. Intensive investigation is necessary to discern the metamerism in the tagmata of such organisms. Examples of detectable evidence of vestigially metameric structures include branchial arches and cranial nerves. Some schemes regard the concept of metamerism as one of the four principles of construction of the human body, common to many animals, along with general bilateral symmetry (or zygomorphism), pachymerism (or tubulation), and stratification.[3] More recent schemes also include three other concepts: segmentation (conceived as different from metamerism), polarity and endocrinosity.[4] In plants A metamer is one of several segments that share in the construction of a shoot, or into which a shoot may be conceptually (at least) resolved.[5] In the metameristic model, a plant consists of a series of 'phytons' or phytomers, each consisting of an internode and its upper node with the attached leaf. As Asa Gray (1850) wrote:[6] The branch, or simple stem itself, is manifestly an assemblage of similar parts, placed one above another in a continuous series, developed one from another in successive generations. Each one of these joints of stem, bearing its leaf at the apex, is a plant element; or as we term it a phyton,—a potential plant, having all the organs of vegetation, namely, stem, leaf, and in its downward development even a root, or its equivalent. This view of the composition of the plant, though by no means a new one, has not been duly appreciated. I deem it essential to a correct philosophical understanding of the plant. Some plants, particularly grasses, demonstrate a rather clear metameric construction, but many others either lack discrete modules or their presence is more arguable.[5] Phyton theory has been criticized as an over-ingenious, academic conception which bears little relation to reality.[7] Eames (1961) concluded that "concepts of the shoot as consisting of a series of structural units have been obscured by the dominance of the stem- and leaf-theory. Anatomical units like these do not exist: the shoot is the basic unit."[8] Even so, others still consider comparative study along the length of the metameric organism to be a fundamental aspect of plant morphology.[9] Metameric conceptions generally segment the vegetative axis into repeating units along its length, but constructs based on other divisions are possible.[5] The pipe model theory conceives of the plant (especially trees) as made up of unit pipes ('metamers'), each supporting a unit amount of photosynthetic tissue.[10] Vertical metamers are also suggested in some desert shrubs in which the stem is modified into isolated strips of xylem, each having continuity from root to shoot.[5] This may enable the plant to abscise a large part of its shoot system in response to drought, without damaging the remaining part. In vascular plants, the shoot system differs fundamentally from the root system in that the former shows a metameric construction (repeated units of organs; stem, leaf, and inflorescence), while the latter does not. The plant embryo represents the first metamer of the shoot in spermatophytes or seed plants. Plants (especially trees) are considered to have a 'modular construction,' a module being an axis in which the entire sequence of aerial differentiation is carried out from the initiation of the meristem to the onset of sexuality (e.g. flower or cone development) which completes its development.[5] These modules are considered to be developmental units, not necessarily structural. See also Look up metamerism in Wiktionary, the free dictionary. Metamerism (disambiguation) (for other meanings) Segmentation Phytomer References ^ a b Shull, Franklin; George Roger Larue; Alexander Grant Ruthven (1920). Principles of Animal Biology. McGraw-Hill book company. p. 108. ^ Chandra, Dr. Girish. "Metamerism". ^ DiDio, L.J.A. Synopsis of Anatomy. Saint Louis, C.V.Mosby, 1970. ^ DiDio, L.J.A. (1989). Anatomico-surgical segmentation as a principle of construction of the human body and its clinical applications. Anat. Anz. (Suppl.) 164:737–743. ^ a b c d e White, J. 1979. The plant as a metapopulation. Annual Review of Ecology and Systematics 10:109–145. ^ Gray, A. 1850. On the composition of the plant by phytons, and some applications of phyllotaxis. Proceedings of the American Association for the Advancement of Science 2:438–444. ^ Arber, A. 1930. Root and shoot in the angiosperms: a study of morphological categories. New Phytologist 29(5):297–315. ^ Eames, A.J.Chutiya 1961. Morphology of the Angiosperms. McGraw-Hill, New York. ^ Kaplan, D.R. 2001. The science of plant morphology: Definition, history, and role in modern biology. American Journal of Botany 88(10):1711–1741. ^ Shinozaki, I., Yoda, K. Hozumi, K., and Kira, T. 1964. A quantitative analysis of plant form —the pipe model theory. I. basic analyses. Japanese Journal of Ecology 14:97–105. Retrieved from " Metamerism n., plural: metamerisms [mɪˈtæməˌrɪzəm] Definition: a linear series of body segments Metamerism is the repetition of homologous body segments. This type of development can be seen in the Annelids, which include earthworms, leeches, tubeworms, and their relatives. It is also seen in a more advanced form in the Arthropods, such as crustaceans, insects, and their relatives. What is metamerism? Metarism is a biological phenomenon in which growth occurs by formation of linear and fundamentally similar structures, however all the structures (also known as segments) are not exactly similar. The difference in structures is due to the function they perform such as digestion or breathing etc. In plants and animals, metameric segments are called metamers. More precisely, animal that has a segmented body, each segment is called somites and in plants, they are also known as phytomers. Figure 1: Metameric segment. The earthworm is an example of an annelid showing true metamerism. Notice how the organs and muscle tissues are repeated in every segment. Source: Maria Victoria Gonzaga of Biology Online. Metamerism (biology definition): the condition of possessing or forming a linear series of body segments. Examples: the metameres of earthworms and the metamerism exhibited by vertebrates at embryonic stage. Etymology: from μετά (metá), meaning "among" and "μερισμός" (merismós), meaning "rationing". Synonym: metameric segmentation. Metamerism has a significant biological importance when it leads to metamers, which can also be defined as somites. They are significant because they perform a vital role in advanced locomotion. There are two main categories of metamerism: homonomous and heteronomous. Homonomous metamery In homonomous metamery, there is strict serial succession of body parts, i.e. metamerism. It can be classified into two major categories, which are known as "true metamerism" and "pseudo-metamerism". The explanation of these two categories are given below: True Metamerism Pseudo-Metamerism Definition In true metamerism, the parts of the bodywork collectively work for the entire organism. In pseudo-metamerism, the repeated part of the body may perform the independent task from each other. Coordination In true metamerism, the segmented body parts are well coordinated. In pseudo-metamerism, there is zero coordination between the fragments. Examples Earthworms (annelids) Tapeworms (Cestoda) In the annelids such as earthworms, all the body segments work together but such coordination does not happen in the tapeworms (Cestoda). It is said that one of the main reasons for segmentation is locomotion. For Example: in the earthworm, muscular tissue segmentation causes the movement in the worm in an inching way. The circular muscles elongate while there is a shortening in longitudinal muscles. This pattern continues and thus assists in the movement on the surface. Although each segment works independently, the ultimate goal is the movement of the worm. In heteronomous metamerism, the metameres are combined to perform the same task. In insects, 5, 3, and 11 metamers are in its head, thorax, and abdomen, respectively, and this is a pure example of heteronomous metamerism. The process in which all the groups of metamers are combined is known as tagmatization. The single group is called tagma (plural: tagmata). In some organisms like insects, which have highly derived tagmata, most of the metamerism in tagma might not be distinguished easily. It is in such a structural form that does not show group metameric function. For Example: Somites or the nervous system does not replicate the unitary structure of the thorax. Figure 2: The diagram shows the crustacean body as an example of an animal that has a heteronomous segmentation. Credit: Bjoertvedt, CC BY-SA 4.0. In this, in the body of an animal, there is the repetition of tissues and organs in a regular interval. The body is thus divided into identical segments in a linear series. These segments are called metameres. It is most commonly found in Annelida. It is an internal and mesodermal. The main segmental divisions are body musculature and coelom. There is an internal segmentation of excretory organs, nerves, and blood vessels. The external segmentation is visible in some metameric animals, but in most animals like Chordata, external segmentation cannot be seen. In the embryo stage, the internal segmentation is remarkably visible. It is thought that metameric segmentation comes as an adaptation for effective locomotion. Chordata segmentation In chordates, segmentation is carried through the process of somitogenesis. In this, there is the development of a pair of somites on each side of the midline. Clock and Wavefront Model is used to describe the segmentation in chordates. This "clock" is considered as the episodic oscillation of defined genes like Her1, a hairy/Enhancer of split-gene. Its expression initiates at the posterior side of the embryo and travels at the anterior side. The site where the somites matured is considered as "wavefront". It is the gradient of FGF and at the lower end of the gradient, somites develop. A metamer is referred to as one of the numerous segments that take part in the construction of a shoot or into which a shoot may be resolved. In the metamerism model of the plant, there are many "phytomers" or "phytons". Each phyton comprises an internode at its upper margin with the leaf. Plants like grass have a clear and visible metameric construction. In other plants no discrete modules were found and they are also under research. In vascular plants, the shoot system shows metameric construction but not the root system. In the shoot system, there are repeated units of leaf, inflorescence, and stem. In seed plants or spermatophytes, the embryo of the plant shows the first metamer of the shoot. Characteristic Features of Metamerism Below are the features of metamerism: Except for the anterior acron and posterior telson, metamerism is always restricted to the intermediate segments. Every metamer shows an exact copy of the other. Segmental structures are inter-reliant on one another. They are combined as a single functional unit. All the body segments work in harmony and coordination. Apart from those discussed above, the other types of metamerism are as follows: external metamerism vs. internal metamerism External Metamerism: this form of metamerism is observed in arthropods. There is no partition in the internal segments. Internal Metamerism: there is internal metamerism in vertebrates. It is visible in the embryo and it is limited to the nervous, muscular and skeletal system. External and internal metamerism: metamerism in Annelids is clearly visible both externally and internally. Internally they are marked by separations (septa) on the body and externally a constriction mark represents external metamerism. complete metamerism vs. incomplete metamerism Complete Metamerism:when the segmentation is visible on all systems it is termed as complete metamerism. Example: annelids. Incomplete Metamerism: the metamerism is termed incomplete when it is not visible on all body organs. Examples: Chordates and Arthropods The strict serial succession of metameres is particularly called homonymous metametry. It can be further grouped into true metamerism and pseudometamerism. In true metamerism, the segments work together for the whole organism whereas in pseudometamerism each of the repeating segments may act independently from each other. An example of true metamerism is that of earthworms whereas an example of pseudometamerism is that of tapeworms. Conversely, the condition in which metameres are grouped together for a similar task is referred to as heteronomous metametry. Insects exhibit this type of metametry. Certain insects have discernible five metameres in its head portion, three metameres in the thorax, and eleven metameres in the abdomen. Why do some living things exhibit metamerism? Here are some of the theories that postulate the evolution of metamerism. The theory suggests that metamerism evolved secondarily to the repetition of body parts. It evolved from the unsegmented and acoelomate ancestors. They have several organs and systems which are spread along the entire body length. This is referred to as pseudo-segmentation. This hypothesis is explained by the example of turbellarians. Turbellarians had yolk glands, testes, and transverse connective tissues of two nerve cords. The cords are repetitive along the entire body length and septa cause the separation in organs. Cyclomerism theory In 1884, Sedgwick Adam (Sedgwick, 1884) presented this theory. In 1950 and 1963, it was supported by Remane A.. It was thought that from the gastric pouch of some ancestral anthozoan coelenterates, coelom originates. There is a separation between the gastric cavity and gastric pouches and the arrangement is linear. In protocoelomates, the pouches are converted into coelomic pouches. In ancestral medusoid coelenterates, four gastric pouches are formed. Additional separation of two pouches results in the formation of three pairs of coelomic cavities which are protocoel, mesocoel, and metacoel. This theory proposed that incomplete separation leads to metameric segmentation. This happens in two ways. First, when there are repetitive transverse separations in a non-segmented antecedent, and second is the formation of a chain of zooids or sub individuals from asexual reproduction. The zooids are combined from one end to the other. An example of this is platyhelminthes or scyphozoan strobilae. Locomotion theory To describe the origin of metamerism, R. B. Clark presented the locomotion theory (Clark, 1960). This theory states that in annelids metamerism comes as an adaptation for burrowing and for peristaltic locomotion. In peristaltic locomotion of annelids, there is lengthening and shortening of the body and longitudinal and circular muscles. The locomotion is carried out by the coelomic-filled fluid which acts as a hydrostatic skeleton. Peristaltic movement cannot become possible if the septa do not develop compartments. In chordates, metamerism is linked to strong serpentine, undulatory swimming. R. B. CLARK, M. E. CLARK; The Ligamentary System and the Segmental Musculature of Nephtys. J Cell Sci 1 June 1960; s3-101 (54): 149–176. doi: Sedgwick, A. (1884). On the origin of metameric segmentation and some other morphological questions. ©BiologyOnline.com. Content provided and moderated by Biology Online Editors.