Chaetognatha: A Phylum of Uncertain Affinity

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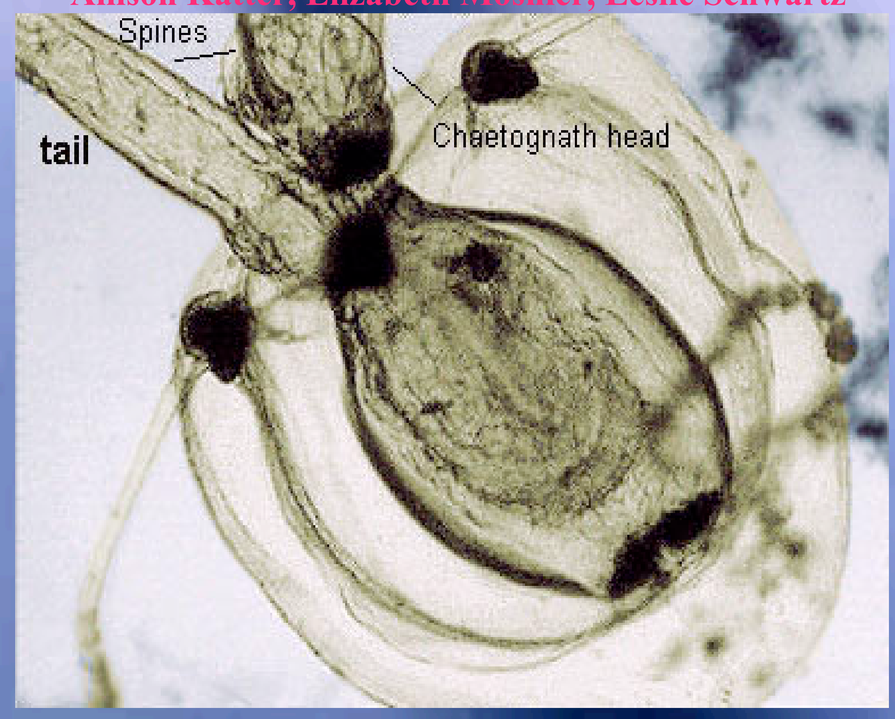
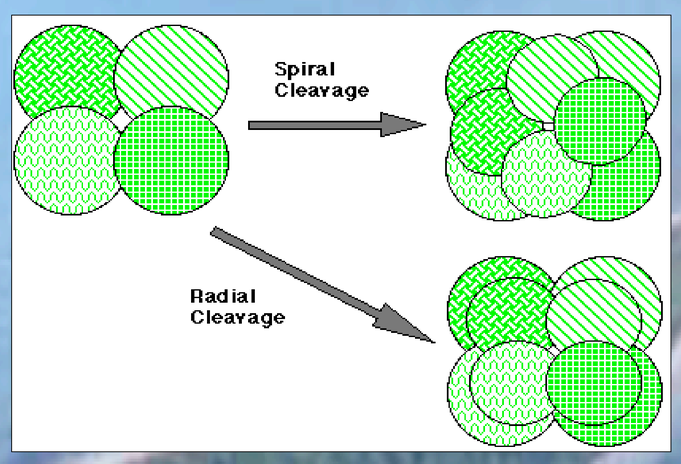
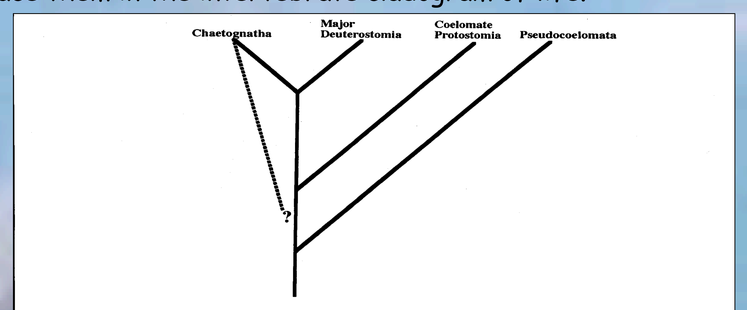


What are Chaetognaths? Chaetognaths are in a separate Phylum by themselves (~100 species). They are carnivorous marine invertebrates ranging in size from 2-120 mm. There are also known as "Arrow worms," "Glass worms," and "Tigers of the zooplankton." Characterized by a slender transparent body, relatively large caudal fins, and anterior spines on either side of the mouth, these voracious meat-eaters catch large numbers of copepods, swallowing them whole. Their torpedo-like body shape allows them to move quickly through the water, and the large spines around their mouth helps them grab and restrain their prey. Chaetognaths alternate between swimming and floating. The fins along their body are not used to swim, but rather to help them float.

A Phylogenetic mystery: The affinities of the chaetognaths have long been debated, and present day workers are far from reaching any consensus of opinion. Problems arise because of the lack of morphological and physiological diversity within the group. In addition, no unambiguous chaetognaths are preserved as fossils, so nothing about this groups evolutionary origins can be learned from the fossil record. During the past 100 years, many attempts have been made to ally the arrow worms to a bewildering variety of taxa. Proposed relatives have included nematodes, mollusks, various arthropods, rotifers, and chordates. Our objective is to analyze the current views regarding "arrow worm" phylogeny and best place them in the invertebrate cladogram of life.

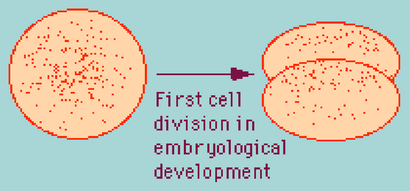
Phylogeny Based on Embryology and Ultrastructure





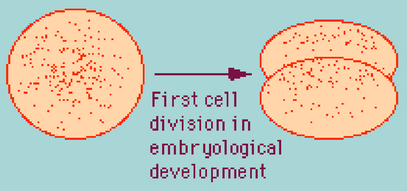
Hyman, Ducret, and Ghirardelli have concluded that the chaetognaths are distant relatives of deuterstome phyla. This view is based primarily on certain embryological features claimed to be shared derived characters linking the two groups. Emryological studies reveal that cleavage is radial and indeterminate, and the site of the blastopore gives rise to the anus; as in other deuterstome. In addition, the embryonic coelom arises from an archenteron, although, in detail, the method of coelom formation by chaetognaths differs significantly from basic deuterstome plan.

Indeterminate Cleavage:



If these cells are separated from each other, each has the potential to develop into an entire organism on its own.

Determinate Cleavage:

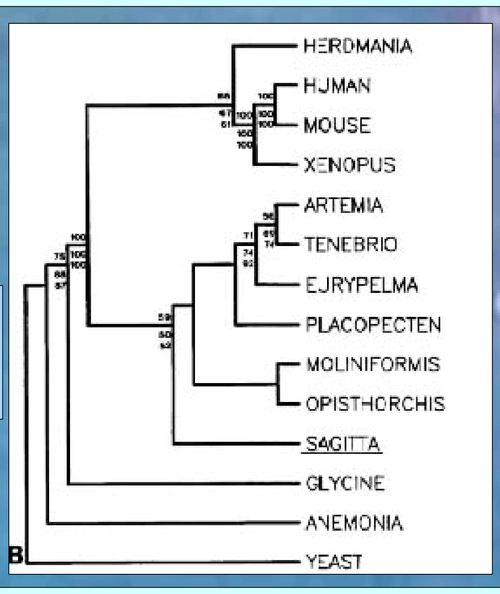


If these cells are separated from each other, they will **die**. Neither has the potential to develop into an organism on its own

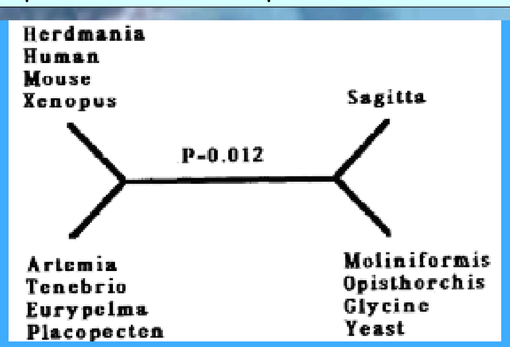
Casanova (1987) discusses the possibility that the chaetognaths are derived from within the mollusks. This conclusion in based on the similarity that circumoral palps found on several chaetognaths have to certain gymnosome mollusks. Nielsen (1985) links the chaetognaths to acanthocephalan worms and rotifers by the presence of an unusual cuticle structure.

Phylogeny Based on Molecular Data

This hypothesis is based on molecular sequence data. Chaetognath 18srDNA was isolated and cloned using PCR. Extensive Phylogenetic analyses were conducted using maximum parsimony, maximum likelihood, and evolutionary parsimony which suggested that the hypothesized relationship between arrow worms and deuterostomes is incorrect. In addition, the analyses gave little or no support to a molluscan or acanthocephalan link. In contrast, it is proposed that the lineage leading to the Chaetognaths arose prior to the advent of the coelomate metazoan or from a sister group to the coelomate protostomes.



Based on the 18S rDNA sequencing and the statistical analyses carried out, this is the most parsimonious tree placing *Sagitta* (a species of chaetognath) as a basal group to the coelomates.



Summary of Analyses of the position of the chaetognaths (*Sagitta*) by using evolutionary parsimony on a collected data set. The favored topology places the chaetognath as an outgroup to the coelomates.

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Pechenik, Jan Biology of the Invertebrates, 4th ed. McGraw Hill 2000

Casanova, JP, 1987

Neilsen C., 1985

Telford, M.J. 1993, UofChicago

Conclusion: The results from molecular analyses implies that several embryological features said to be derived features shared by chordates, hemichordates, echinoderms, and chaetognaths (i.e., radial cleavage, deuterostome mouth formation, and entercoelous coelom formation) are not synapomorphies. Instead, these features, if homologous, must be shared ancestral characteristics, or if not homologous must be convergent characters. The conclusion that they are not shared derived characters is not unreasonable because although cleavage in the chaetognath embryo is radial, this character is also found in nondeuterostome phyla such as priapulids (Lang 1953), and in gastrotrichs (Sacks 1955). In addition, although chaetognaths do seem to form coeloms during embryogenesis, and although these coeloms are not formed by schizocoely as in protostomes, neither are they formed by a process recognizable as a typical deuterstome enterocoely. The embryonic coelom closes later in embryogenesis, and a new coelom forms in the adult. The adult cavities may in fact be secondarily derived and pseudocoelomic in nature, possessing no peritoneum. In addition, 18S rDNA analyses are very controversial being that there are disagreements in how data is prepared and used, and in how results are interpreted. Molecular studies may be complex and precise, however, they are not entirely conclusive because of their inability to closely define divergences. In order to understand chaetognath phylogeny more clearly, more investigations need to be carried out employing a combination of molecular data and embryological and ultrastructural studies.