

Branches on the Tree of Life

Annelids

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INTRODUCTION

When people think of worms, they often think about earthworms, or perhaps intestinal parasites – those creepy things we’d rather not imagine living inside us. Unless they have spent time sampling ponds and mud flats, or scuba diving on coral reefs, few people realize that one group of worms, the annelids, is one of the great branches of animal life with many thousands of species. ***Branches on the Tree of Life: Annelids*** shows the classification of Phylum Annelida into three main branches, summarizing the diversity of segmented worms and providing insights into their behavior, physiology, and evolution.

Six hundred million years ago, during the early evolution of animals, there were three primary (habitable) habitats for animal life – the open sea, the surface of the sea floor, and the soft muddy substrate there. Some of the earliest animals burrowed in the soft sea-floor mud. They were segmented worms, as shown by fossil worm tunnelling tracks, dated to Ediacaran times (540-650 mya). Descendants of these earliest worms can be found today living in the muddy substrate of quiet bays -- members of Phylum Annelida. ‘Annelid’ means ringed, or segmented – a characteristic that separates these worms from other animal phyla. Inside, the body shows repetition of organs and body parts, with the intestine and main blood vessels passing through the segments.



Polychaete worms live in high densities in mud flats, creating a large biomass.



Polychaete worms are an important source of food for shorebirds, and are critical in their long migrations.

CLASS POLYCHAETA

Most segmented worms found in marine environments represent a major evolutionary branch of annelids--Class Polychaeta. The name means “many bristles.” The bristles, or setae, proj-

ect from side flaps called “parapods.” Parapods have a variety of shapes – adaptations for different habitats and life-styles. Species living in rocky environments have leg-like parapods used in walking. In burrowing species, parapods function as digging paddles. In some worms the parapods are short and combine with peristaltic contractions to move the worm through the mud. In others, the parapods contract following their power stroke, streamlining the worm for passage through the mud.

Filled with blood vessels, parapods increase the worm’s surface area for gas exchange. Also, finger-like projections on some parapods function as gills to greatly increase gas exchange. The circulatory systems of many polychaetes contain hemoglobin, the same oxygen-hungry compound found in our own blood cells. Dissolved directly in the blood, hemoglobin allows the worms to live in stagnant mud where food is plentiful but oxygen is scarce.



The nereid worm, *Neanthes*, has jaws hidden in an eversible pharynx, below the distinctive chemical-sensing palps.



Calcereous tube worms have an elaborate fan of tentacles used to capture plankton and detritus food.

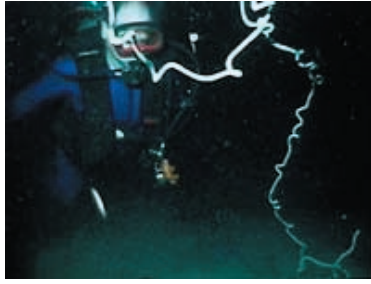
Polychaete feeding styles vary from eating organic material that settles on the surface of the muddy substrate (detritus feeding), to filtering plankton and detritus from the water using feathery feeding tentacles (suspension feeding), to eating their neighbors (predation). As early fossil tracks show, and modern lawns and gardens confirm, many annelids are superb burrowing organisms, taking in mud or earth, passing it through the intestine to extract its nutrients, and ejecting it in the form of worm castings. Many dozens of burrowing, mud-processing, polychaete species will be found in a typical bay mudflat. Examples include the lug worm (*Abarenecola*) and the bamboo worm.

On hard substrates such as rocks or corals, species of polychaete worms build temporary or permanent tubes, where they lead stationary lives by filtering the water for suspended food. The tube provides a place to retreat should danger threaten. Many tube dwellers are sensitive to sudden changes in light, jerking back into their tubes in response to a shadow.

Many species of polychaetes are predators. A typical example of this type is the “mussel worm”, *Nereis*. To capture a prey, it inflates an eversible proboscis out of the mouth that is armed with piercing hooks. A few polychaete species, such as scale worms, have taken up a symbiotic lifestyle, living in association with sea stars and limpets or other marine animals.

Polychaetes reproduction usually involves the dispersal of gametes directly into the sea. After fertilization, the eggs develop into ciliated larvae called trochophores. These larvae live in the

plankton, feeding on suspended algae, until they develop into juvenile worms that will settle down to become adults.



Female epitoke of the palolo worm – size relation to diver.



Female and male epitokes of the palolo worm. Explosive spawning is just starting.

The palolo worm, an inhabitant of tropical seas, takes egg production to extremes. Once a year, timed to the November full moon, chains of gamete-filled segments break away from the worm's head section and swarm toward the surface. The female chains (epitokes) are often over a meter in length! The male epitokes are small by comparison. As they swim up to the surface they are triggered by light from the full moon to literally explode, releasing the gametes into the ocean.

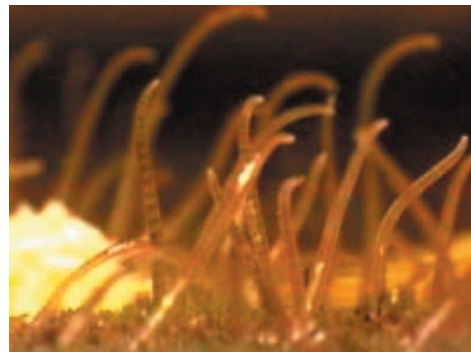
CLASS OLIGOCHAETA

A second class of annelids is most common in fresh water or on land. The oligochaetes, members of Class Oligochaeta, usually have few setae on each segment. The name means "few bristles". Also, they differ from most polychaetes in that they completely lack parapods.

Common freshwater oligochaetes shown in this program include: *Stylaria*, with its proboscis used as an early warning system; *Chaetogaster*, showing feeding by gulping in water fleas; *Dero* with its finger-like gills; *Aeolosoma*, with its ciliated mouth; and *Tubifex*, often found in clumps with heads buried in the muck, tails waving above. Students can often find these worms in pond water samples, where they can study these organisms in detail. This program presents observations on freshwater oligochaetes demonstrating: feeding, asexual reproduction through breaking apart followed by regeneration of missing parts, oxygen exchange and circulation, and the function of hemoglobin in low-oxygen environments.



Chaetogaster crawls along a water plant.

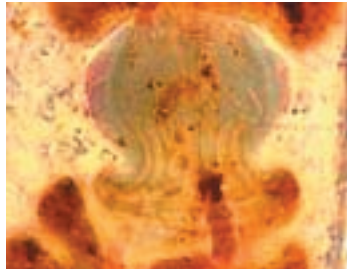


Tubifex lives head down in the mud.

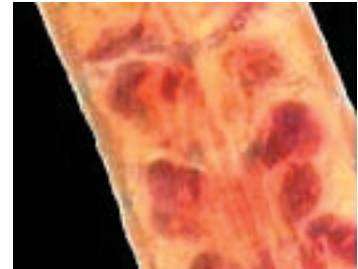
Earthworms are classic subjects for studying annelid anatomy. Instead of dissecting a preserved earthworm, this program shows how to observe the internal organs of a small living earth worm using a microscope. This technique shows many details of annelid functional biology: food being moved along the intestine by peristaltic contractions; the circulatory system including capillary beds where oxygen is picked up (worms breath through their skins); and excretory organs that act as miniature kidneys to remove urea.



A small earthworm between glass plates allows detailed observation of anatomy.



Earthworm gizzard



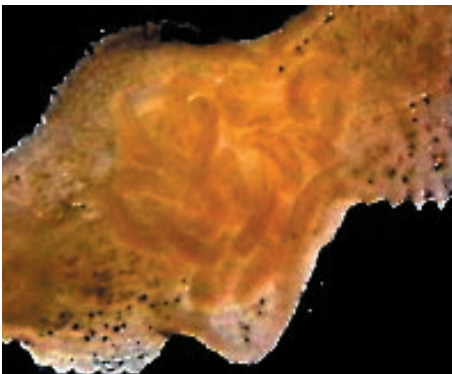
Pairs of hearts in a live earthworm.

The engulfment of soil by earthworms cultivates and aerates the soil creating conditions suitable for plants to germinate and grow. Earthworms are hermaphroditic - both sexes in one individual. During mating, the male parts of one transfer sperm to the female parts of the other. The eggs are shed in a cocoon from which the baby earthworms escape to take up their independent lives.

CLASS HIRUDINEA

The classification of leeches and crayfish worms as Class Hirudinea is controversial. Recent molecular phylogeny studies place the leeches and crayfish worms as possibly within the Class Oligochaeta, but the jury is still out on the best view of evolutionary relationships in these groups. In this program, we have stuck with the traditional view of leeches and crayfish worms as constituting Class Hirudinea, with the understanding that both groups are clearly close to the Oligochaetes.

Leeches have a bad name – their reputation as blood-sucking animals often interferes with an unbiased look at their biology. Leeches are flattened dorso-ventrally and they have two suction discs, one at each end. Leeches do not crawl or burrow as other annelids do, but



A leech brooding its young.

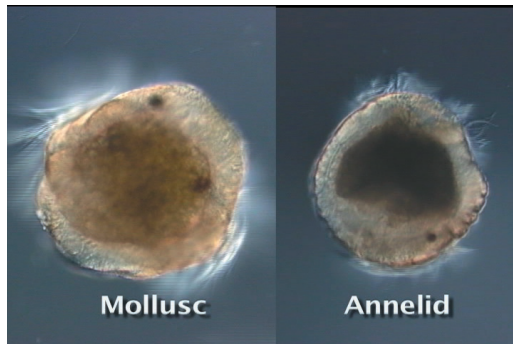
move with a looping motion, using the suction discs to grip the surface as the loop along. As viewed in the program, some leeches swim with a wavy ribbon-like motion. Most leeches are aquatic, but in wet tropical regions there are many leech species adapted to a terrestrial lifestyle.

Some leeches are scavengers. Other species prey on small water animals. Many leeches are ectoparasites on fish and a few are blood-sucking parasites of mammals. They lack bristles and their external rings do not correspond to the internal segmentation. Like earth-

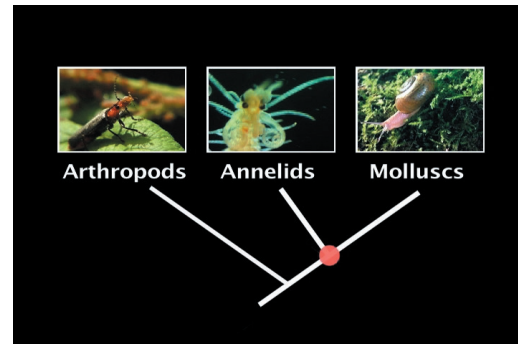
worms, leeches are hermaphroditic, although they are usually protandric – first males, and then later as their bodies become larger and can support the higher demands of producing eggs, they become females. Many freshwater leeches carry their developing young on their bodies.

Summary and Evolution

With well over 13,000 living species, the Phylum Annelida is a highly successful line of invertebrate life dating back over 540 million years. Their elongate, segmented body plan and other body features have allowed annelids to specialize at burrowing through substrates, and to radiate into other ecological niches.



Trochophore larvae from two different animal phyla as seen through the microscope.



An phylogeny of three major invertebrate phyla based on modern evidence.

The place of Phylum Annelida in the animal kingdom has received much study in recent years, with the advent of the tools of molecular phylogeny and developmental genetics. Traditionally, Annelids were thought to be a sister group to Phylum Arthropoda, with another group, Phylum Onychophora, the velvet-worms, thought to be an intermediate between annelids and arthropods. Modern research has effectively dispelled this idea. A variety of new evidence indicates that arthropods belong to a separate line of evolution consisting of animals that shed their outer exoskeleton as they grow – a process called ecdysis. The entire line of evolution is now called the ecdysozoans, and it includes nematodes, priapulids, and tardigrades, in addition to the arthropods. A different line of evolution led to the annelids and its sister groups of animal phyla. These phyla share a group of specific developmental (HOX) genes, and they share a common larval development that, in ‘primitive’ groups includes a trochophore larva. These phyla of animals are the lophotrochozoans, and include annelids, molluscs, bryozoans, brachiopods, phoronids, and several related groups. So the modern view of animal phylogeny clearly places arthropods on a distinct primary branch on the tree of life, and annelids and molluscs on a different major branch with a later common ancestor than either group had with arthropods.

Questions for research and discussion:

What advantages are offered by a segmented body. In thinking about this, contrast an annelid worm with a nematode worm. How might segmentation have originated? (Hint: Consider the genetic program for the development of a body plan, and how this program might be influenced by genes that control development.)

Describe at least two ecological roles played by annelids living in mudflats.

Describe the function of setae, the bristles projecting from the bodies of most annelid worms.

How are annelids adapted to live in the mud? on a rocky shore?

The palolo worm of tropical seas and most other marine polychaete worms, release eggs and sperm directly into the water. What factors might coordinate the males and females so that the chances of fertilization are improved?

Contrast the human digestive system with that of an earthworm. What are the similarities?

Hermaphroditic mating is the rule in oligochaetes such as earthworms. What are its advantages for these animals?

What advantages are presented by protandry - serial hermaphroditism in which the animal is first a male, and then turns into a female?

Describe some of the evidence that indicates evolutionary relationships between annelids and arthropods? What evidence indicates an evolutionary relationship between annelids and molluscs?