DOWNLOAD PDF THE STRUCTURE OF NEMATODES

Chapter 1 : Structure and Function of Nematodes

Overview. The structure of a nematode is intimately related to its function and its life cycle. Although there are common traits throughout the phylum there is also great diversity allowing each species to occupy a niche in which it may thrive.

Introduction Back to Top Nematodes are found in almost all habitats, but are often overlooked because most of them are microscopic in size. For instance, a square yard of woodland or agricultural habitat may contain several million nematodes. Many species are highly specialized parasites of vertebrates, including humans, or of insects and other invertebrates. Other kinds are plant parasites, some of which can cause economic damage to cultivated plants. Nematodes are particularly abundant in marine, freshwater, and soil habitats. One study in Colorado estimated that nematodes consumed about as much grass as a prairie dog colony. Diagram of a typical plant-parasitic nematode. Diagram from Florida Nematode Control Guide. Soil Nematodes Back to Top Soil is an excellent habitat for nematodes, and cc of soil may contain several thousand of them. Because of their importance to agriculture, much more is known about plant-parasitic nematodes than about the other kinds of nematodes which are present in soil. Most kinds of soil nematodes do not parasitize plants, but are beneficial in the decomposition of organic matter. These nematodes are often referred to as free-living nematodes. Juvenile or other stages of animal and insect parasites may also be found in soil. Although some plant parasites may live within plant roots, most nematodes inhabit the thin film of moisture around soil particles. The rhizosphere soil around small plant roots and root hairs is a particularly rich habitat for many kinds of nematodes. Various authorities distinguish among 16 to 20 different orders within this phylum. Only about 10 of these orders regularly occur in soil, and four orders Rhabditida, Tylenchida, Aphelenchida, and Dorylaimida are particularly common in soil. More than 15, species and 2, genera of nematodes had been described by the mids. Although the plant-parasitic nematodes are relatively well-known, most of the free-living nematodes have not been studied very much. Therefore there is a high probability that most soil habitats will contain undescribed species of free-living nematodes. Identification of these groups is extremely difficult, and there are only a few nematode taxonomists in the world who can formally describe new species of free-living nematodes to science. Therefore most nematode ecologists identify soil nematodes only to family or genus. Feeding Habits Back to Top Soil-inhabiting nematodes can also be classified according to their feeding habits. This classification is particularly useful to ecologists in understanding the positions of nematodes in soil food webs. Several important feeding groups of nematodes commonly occur in most soils. In addition, algivores feed on algae and various stages of insect and animal parasites occasionally are found in soil. The nematode feeding groups are called trophic groups by some authors. These are the plant parasites, which are relatively well known. This group includes many members of the order Tylenchida, as well as a few genera in the orders Aphelenchida and Dorylaimida. The mouthpart is a needlelike stylet which is used to puncture cells during feeding. Ectoparasites remain in the soil and feed at the root surface. Endoparasites enter roots and can live and feed within the root. Diagram of head regions of a herbivore left and nematode bacterivore right. In the herbivore, the mouthpart is modified into a stylet for puncturing plant cells. In the bacterivore, the mouth or stoma is a hollow tube. Many kinds of free-living nematodes feed only on bacteria, which are always extremely abundant in soil. In these nematodes, the "mouth", or stoma, is a hollow tube for ingestion of bacteria. This group includes many members of the order Rhabditida as well as several other orders which are encountered less often. These nematodes are beneficial in the decomposition of organic matter. This group of nematodes feeds on fungi and uses a stylet to puncture fungal hyphae. Many members of the order Aphelenchida are in this group. Like the bacterivores, fungivores are very important in decomposition. These nematodes feed on other soil nematodes and on other animals of comparable size. They feed indiscriminately on both plant parasitic and free-living nematodes. One order of nematodes, the Mononchida, is exclusively predacious, although a few predators are also found in the Dorylaimida and some other orders. Compared to the other groups of nematodes, predators are not common, but some of them can be found in most soils. The food habits of most nematodes in soil are relatively specific. For example, bacterivores feed only on bacteria and never on plant roots, and the opposite is true for plant parasites. A few kinds of nematodes may feed on more than one type of food material, and therefore are considered omnivores. For example, some nematodes may ingest fungal spores as well as bacteria. Some members of the order Dorylaimida may feed on fungi, algae, and other animals. Since free-living nematodes have not been studied very much, the food habits of some of them are unknown. The microscopic size of these animals presents additional difficulties. For example, it can be very difficult to distinguish whether a nematode is feeding on dead cells from a plant root or on fungi growing on the cell surface. Sometimes a nematode showing this feeding behavior may be classified simply as a root or plant associate. Community Composition Back to Top In one pasture in south-central Florida, herbivores comprised almost half of the soil nematode community, but bacterivores and fungivores were also well-represented. This habitat provided many fibrous roots as a food source for herbivores, but other nematode groups, particularly bacterivores, may predominate in other habitats. The composition of the soil nematode community depends on the vegetation present, as well as on soil type, season, soil moisture level, amount of soil organic matter, and many other factors. Because they are responsive to so many different factors, it is believed that nematodes may be useful bioindicators of the condition of the soil environment. Composition of nematode groups in a soil nematode community. Decomposition Back to Top Free-living nematodes are very important and beneficial in the decomposition of organic material and the recycling of nutrients in soil. Nematode bacterivores and fungivores do not feed directly on soil organic matter, but on the bacteria and fungi which decompose organic matter. The presence and feeding of these nematodes accelerate the decomposition process. Their feeding recycles minerals and other nutrients from bacteria, fungi, and other substrates and returns them to the soil where they are accessible to plant roots.

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Chapter 2 : Structure, Function and Evolution of The Nematode Genome

Cellular Structure of Nematodes. Polar (phospho) lipids as structural components of cell membranes. C20 PLFAs as nematode indicators.. Realignment of polar lipids in cell membranes at basal temperature thresholds (Lyons and Thomason).

Structure[edit] The alae is formed by the hypodermal seam cells where a fibrous ribbon of a zona pellucida ZP domain protein is produced. The alae is a crease, that by the cross linking process causes radial shrinking of the seam cell secreted proteins. Function[edit] The function of the alae is not yet clear. It is generally given a function related to cuticle strength, nematode movement or fat storage. But the predominant structure of the C. Wherever ZP domains are found, they are found in definite or putative association with signal transduction accompanied by interaction with an external or hostile environment. Function based on genetic data of the H. Contortus dauer nematode[edit] In the parasitic nematode Haemonchus contortus a ZP domain protein of a dauer stage nematode has been genetically associated to a target molecule found in the environment that this nematode could be using for exiting the dauer stage. This was statistically related with a high degree of significance indicating that the alae may specifically function as a receptor site. In the case of H. During the dauer stage the mouth and anal openings are sealed and neural receptors around the head retracted. The alae is more pronounced than at any other stage and remains exposed to the external environment. Triggers for exiting the dauer state may be determined by the concentration of target molecules around the nematode. In order to measure concentrations accurately, a very large receptor area is necessary, hence a structure such as the alae may be required. Postulated function[edit] The alae appears to be a neural receptor responsive to just a handful of molecules particular to each species of nematode. Up to half a dozen types of receptors may be present at any one time on the alae and each type would be very numerous. The target molecules in the environment that stimulate each type of receptor may then be measured for their concentration and a threshold reached before an action is instigated. These actions may instigate entry into the dauer state L1 alae , exiting of the dauer state pheromone and or presence of an indicator for food availability , for sexual reproduction where the area around the vulva and gonads of the female and male use this family of receptors RAM-5 where the nematode is likely to identify that reproductive organs are in contact. Journal of Submicroscopic Cytology and Pathology. Archives of Biochemistry and Biophysics. Molecular and Biochemical Parasitology. Molecular and General Genetics. Biochemical and Biophysical Research Communications.

Chapter 3 : The Structure of Nematodes - Alan F. Bird, Jean Bird - Google Books

*It is aimed at all workers interested in nematodes irrespective of whether they do research on nematodes that are parasites on animals or plants or free-living in the soil. Highlights include * Up-to-date literature review of the structures of all types of nematodes, both free living and parasitic.*

Abstract As carbon and energy flow through the soil food web they are depleted by the metabolic and production functions of organisms. Disturbed soil food webs tend to be bottom heavy and recalcitrant to restoration due to the slow growth of upper predator populations, physical and chemical constraints of the soil matrix, biological imbalances, and the relatively low mobility and invasion potential of soil organisms. The functional roles of nematodes, determined by their metabolic and behavioral activities, may be categorized as ecosystem services, disservices or effect-neutral. Among the disservices attributable to nematodes are overgrazing, which diminishes services of prey organisms, and plant-damaging herbivory, which reduces carbon fixation and availability to other organisms in the food web. Unfortunately, management to ameliorate potential disservices of certain nematodes results in unintended but long-lasting diminution of the services of others. Beneficial roles of nematodes may be enhanced by environmental stewardship that fosters greater biodiversity and, consequently, complementarity and continuity of their services. Soil food webs, spatial patterns, functions, services, functional complementarity, functional continuity, feedback transitions The organisms of the soil food web derive carbon and energy through plant- bacterial- or fungal-feeding and through successive levels of parasitism or predation. Mainly, the resources originate through photosynthetic fixation of C by autotrophs. Carbon is immobilized in the body structure of organisms or mineralized and respired during liberation of the energy bound in complex carbohydrates. That energy drives metabolic and physiological processes Atkinson, ; Ingham et al. Consequently, C and energy dissipate during the course of successive exchanges and their availability affects the structure, dynamics and activities of the food web. Food webs driven by sparse resources, as in desert systems, or periodic pulses of resources, as in some agricultural systems, are likely to be short and dominated by opportunists at the entry level. Those with sustained energy supply may be longer, with greater abundance and biomass at higher trophic levels, provided the higher trophic organisms can thrive in the prevailing environmental conditions Ferris et al. Ecosystem functions are the activities and processes of the component organisms of the food web that impact on other organisms in the system or on the outputs and inputs of the system as a whole. Functions with positive impact are considered services; those with negative impact are disservices Table 1. Most of the functions are services, some are disservices, and some may transition between the two categories due to positive or negative feedback among the parties, often mediated by resource availability. Some functions realized at a local level have effects that permeate to the ecosystem level, others have effects that remain local. Table 1 Open in a separate window Some functions of nematodes in the soil food web. The relocation of organisms to new resources, facilitated by the size, body configuration and motility of nematodes, is an important service, particularly where the transported organisms provide other ecosystem services. Nematodes encumbered by propagules of fungal parasites may retain the ability to move in the soil matrix for some time, thus distributing their parasites to new locations Jaffee and Muldoon, Similarly, bacteria are distributed to new resources, either by survival of passage through the intestine or by external adherence Ingham et al. The bacteria transported to new resources generate additional food for their nematode transporters. Negative feedback causes the service to transition to a disservice when resources for the bacteria are depleted and the nematode predators consequently overgraze the limited prey Fu et al. Nematodes feeding on other organisms, including plants, fungi, bacteria, microarthropods and other nematodes, take in more N than they need for their body structure. Often there are differences in the C: The N associated with respired C is usually in excess of body needs Ferris et al. Excess N is mineralized as ammonia, excreted and available for uptake by plants and bacteria Ferris et al. In field plots in which sufficient N was fixed by a winter cover crop, the subsequent agronomic crop often exhibited N deficiency because the mineral was immobilized in the flush of microbial biomass that followed cover crop incorporation. When plots received additional organic matter and were irrigated during the dry post-harvest period of the previous year, the abundance of fungal- and bacterial-feeding nematodes and, by inference, the abundance of protozoa, was increased at the time of cover crop incorporation. Available mineral N was at higher levels in plots with abundant bacteria-grazing organisms, thus alleviating the N-deficiency Ferris et al. Nematode feeding that affects growth rates and fitness of higher plants may confer relatively greater fitness on their competitors with consequent effects on ecosystem succession Van der Putten, In natural systems, susceptible and less fit plant species are reduced in abundance or even eliminated from the plant community Yeates et al. In agricultural systems, reduction of vigor by nematode parasitism of the agronomic crop may reduce its competitiveness with weeds, which amplifies yield losses Alston et al. Higher predator nematodes specialist and generalist , and non-nematode components of that functional guild, feed on and regulate the abundance of opportunistic species. The transition of ecosystem functions between services and disservices can be explained by a generalized model of intensity of interactions among organisms or between organisms and their environment Fig. In phase 1, the service increases with the abundance of interacting organisms. In phase 2, the organisms are too abundant to be sustained by available resources and the function may become a disservice. The rate of transition and magnitude of the disservice depends on the intensity of interaction as indicated by the two scenarios in Fig. When feeding on plants at low population densities without causing evident damage to their hosts phase 1 , nematodes provide a resource that primes the beneficial services of other organisms in the food web, either by enhancing leakage of exudates or by serving as prey for parasites and predators. At higher population densities phase 2 , plant physiological processes are compromised, C fixation is restricted and resources for the food web are diminished. The herbivory function has transitioned to a disservice. Some nematodes are less damaging to plants than others and the consequent effects are portrayed by the differing trajectories of the disservices Fig. At one extreme, many of the known species of plant associate nematodes in the family Tylenchidae do not seem to cause measurable plant damage. In that case, the function of supplying resources that prime other activities of the food web may only transition to a disservice under extreme circumstances.

Chapter 4 : Alae (nematode anatomy) - Wikipedia

Nematodes breathe across their entire body surface. This gas exchange strategy is adequate because of the small size of the worms, which means they have a high ratio of surface area to volume. The majority of nematodes are dioecious ; that is, the sexes are separate.

Introduction to the Nematoda the roundworms There are thousands of nematodes. Not only are there more than 15, known species of roundworms, but there are many thousands of individual nematodes in even a single handful of garden soil. And they keep coming! Some species of roundworm may contain more than 27 million eggs at one time and lay more than , of them in a single day. Some scientists have estimated that there may be as many as half a million more unkown species of roundworm yet to be discovered, an estimate based on the fact that many new species are still being discovered, that relatively few people are looking for more species, and that most roundworms look pretty much alike. If the estimated number of species is anywhere close to correct, it would mean that roundworms are the second most diverse group of animals, trailing behind only the arthropods. Nematodes were once classified with a very large and heterogeneous cluster of animals grouped together on the basis of their overall worm-like appearance, simple structure of an internal body cavity called a pseudocoelom, and the lack of features such as cilia and a well-defined head that are found in most animals. This group, variously known as Aschelminths or Pseudocoelomata, is today no longer recognized as a natural one. It is quite likely that the simple body plan of these organisms has resulted from reduction and simplification from more than one group of ancestral organisms, and so the pseudocoelom is neither a uniquely derived nor useful character. Current studies indicate that nematodes are actually related to the arthropods and priapulids in a newly recognized group, the Ecdysozoa. The image at left shows a living microscopic roundworm as viewed with an Environmental SEM. The worm is approximately one millimeter long. At right, a diagrammatic view of the internal anatomy of a roundworm, showing the simplicity of its organization. See text below for discussion. Click on either of the pictures above for a larger image. The word "nematode" comes from a Greek word nema that means "thread". The epidermis skin of a nematode is highly unusual; it is not composed of cells like other animals, but instead is a mass of cellular material and nuclei without separate membranes. This epidermis secretes a thick outer cuticle which is both tough and flexible. The cuticle is a feature shared with arthropods and other ecdysozoans. As in those other groups, the cuticle is periodically shed during the life of a nematode as it grows, usually four times before reaching the adult stage. The cuticle is the closest thing a roundworm has to a skeleton, and in fact the worm uses its cuticle as a support and leverage point for movement. Long muscles lie just underneath the epidermis. These muscles are all aligned longitudinally along the inside of the body, so the nematode can only bend its body from side to side, not crawl or lift itself. A free-swimming roundworm thus looks rather like it is thrashing about aimlessly. The muscles are activated by two nerves that run the length of the nematode on both the dorsal back and ventral belly side. The ventral nerve has a series of nerve centers along its length, and both nerves connect to a nerve ring and additional nerve centers located near the head. The head of a nematode has a few tiny sense organs, and a mouth opening into a muscular pharynx throat where food is pulled in and crushed. This leads into a long simple gut cavity lacking any muscles, and then to an anus near the tip of the body. Food digested in the gut is not distributed by any specialized vascular system, and neither is there a respiratory system for the uptake or distribution of oxygen. Rather, nutrients and waste are distributed in the body cavity, whose contents are regulated by an excretory canal along each side of the body. Many nematodes are able to suspend their life processes completely when conditions become unfavorable; in these resistant states they can survive extreme drying, heat, or cold, and then return to life when favorable conditions return. This is known as cryptobiosis, and is a feature nematodes share with rotifers and tardigrades. Fossil nematodes have been found in rocks from as early as the Carboniferous. Most living roundworms are microscopic, meaning that their discovery as fossils is likely to be difficult. On the other hand, one species of parasitic nematode can reach 13 meters in length -- it parasitizes the sperm whale. Nematodes also lack any substantial hard parts, again resulting in a spotty chance for fossilization. Despite these problems, fossil nematodes are occasionally found in amber fossilized tree resin from the Cenozoic. Because many of their relatives have left fossils dating from the Cambrian , it is likely that the nematodes have been around at least that long in some form. That statement goes triple for nematodes, who live not only in almost every geographic location on Earth, but live in such extreme habitats as ice and hot springs, as well as living on or in almost every other kind of animal and plant alive today. Free-living nematodes are extremely abundant in soils and sediments, where they feed on bacteria and detritus. Other nematodes are plant parasites and may cause disease in economically important crops. Still others parasitize animals including humans ; well-known parasitic nematodes include hookworms, pinworms, Guinea worm genus Dracunculus , and intestinal roundworms genus Ascaris. For more information about nematodes: For information about current research using nematodes as model organisms, try the Caenorhabditis elegans WWW Server , with links to an enormous array of scientific sites, databases, and image collections. Visit Worm Land , with information about nematodes and other worm-like critters. Or join the Society of Nematologists. The World Health Organization has information on infectious diseases , including those caused by intestinal nematodes. See the Nematoda page on the Tree of Life for information about nematode relationships. Micrograph of nematode prepared by B. Evidence for a clade of nematodes, arthropods and other moulting animals. University of Chicago Press. General Zoology, 6th edition. A cladistic analysis of pseudocoelomate aschelminth morphology. Invertebrate Biology 2:

Chapter 5 : External structures

It is aimed at all workers interested in nematodes irrespective of whether they do research on nematodes that are parasites on animals or plants or free-living in the soil. Key Features Up-to-date literature review of the structures of all types of nematodes, both free living and parasitic.

Although there are common traits throughout the phylum there is also great diversity allowing each species to occupy a niche in which it may thrive. Body Structure The nematode body is cylindrical, elongated and smooth with no limbs protruding, such as is seen in the common garden worm though generally on a smaller scale. The body is contained within a tough elastic cuticle which in many species forms elaborate structures useful for identification. The presence of a cuticle is similar to the structure of arthropods , however unlike them the nematode cuticle is not chitinous but is comprised mainly of collagens. The cuticle is non-living, produced by cells of the epidermis in most of the worm, allowing it to grown between moults of the worm without the need for shedding, although this does occur a number of times during the development of most worms. It is permeable to allow ions and water to pass through and therefore plays a key role in maintaining the hydrostatic pressure, which in most nematodes is relatively high inside the worm. The cuticle also acts as an anchoring point during locomotion as a skeleton does in mammalian species. Morphological differences in the cuticle are regularly used to identify different species of nematodes, though the functions of these are not all completely understood. Alae or wings - Projections of the outer cuticle layer. Can appear either just at the anterior or posterior or along the entire length of the worm. In bursate males posterior alae for part of the copulatory bursa. Spines - Protrusions of the cuticle on the surface of the nematode. Function unknown, could be in self defense or attachment to host. Inflations - Vesicle like swellings of the cuticle function unknown. Found in Oesophagostomum species. They are attached to the hypodermis and separated into four sections by hypodermal cords. They are obliquely striated unlike mammalian muscles and have dense bodies as opposed to Z disks. Two types of muscle arrangement occur in nematodes, platymyarian in small worms and coelomyarian in larger worms. During locomotion the muscles are used to apply pressure laterally to the cuticle, this pressure is opposed by the high hydrostatic pressure of the coelom and causes dorso-ventral bending. Nervous System Knowledge of the nervous system employed by nematodes has enabled the development of many anti-parasitic drugs as they work to disrupt this system. There is a neural ring around the pharynx of the nematode containing 4 ganglia, sensory and motor neurones extend to the anterior of the worm to innervate the pharynx. One ventral and one dorsal nerve cord extend distally from the neural ring run down the length of the worm with the hypodermal cord, these are responsible for innervating body wall muscles. The muscles involved in feeding respond to a range of neurotransmitters that can either be excitatory or inhibitory. The 5-HT neurotransmitter, also known as serotonin, stimulates rhythmical contractions of pharyngeal muscles required to generate the pharyngeal pumping action. The rate of pumping in the pharynx is regulated by the neurotransmitter Acetylcholine ACh. The pharyngeal muscles are inhibited by the actions of Glutamate and GABA which bind to post synaptic receptors and cause hyperpolarisation of the post synaptic membrane. The hyperpolarisation results in inhibition of the muscle actions as a greater stimulatory effect is required to overcome this and depolarise the cell. In locomotion both inhibitory and excitatory neurones play an important role in contracting and relaxing muscles to allow sinusoidal movement. Acetylcholine is responsible for excitation of muscles, leading to contraction. Contraction of the ventral body wall muscles causes bending of a section of the nematode dorsally, to allow this the muscles on the dorsal wall opposite must be relaxed. Relaxation of body wall muscles is brought about by the release of GABA from the pre-synaptic membrane, this prevent contraction and allows the body wall to bend. In this way the two neurotransmitters work as an antagonistic pair to bring about sinusoidal locomotion. Feeding and Digestion Diagram showing cross-section of a nematode at the level of the pharynx - BIODIDAC The pharynx is situated at the anterior end of the nematode and is used in feeding, often being embedded into the epidermis or blood vessels of the worms predilection site. There are a number of different mechanisms by which nematodes feed. One of the most damaging ways in which nematodes feed is by burying deep into the mucosa and feeding directly on the hosts blood. The pharynx may be specialized depending on the predeliction site and food type that the nematode requires, many blood feeders have teeth or plates used for attachment. The pharynx has a radial muscle that is used in pumping food into the intestines. The food enters the buccal capsule the size and shape of which is characteristic in some species of nematode. Due to the high pressure levels in the nematode body cavity there is a one way valve between the oesophagus and intestines and food is pushed through this by peristaltic action of radial oesophageal muscles. The intestines of nematodes are simple tubes, only a single cell thick. The cells are lined with microvilli, similarly to those in the mammalian gut, which are used to provide surface area for the absorption of nutrients. Digestion occurs rapidly and faeces is expelled under pressure from the posterior of the nematode. Reproduction Diagram showing nematode copulation - BIODIDAC The reproductive systems are major organs of the nematodes and can occupy a large portion of the body cavity in males and females. There are many morphological and physiological differences between the species and so they are separated here. Males Males are either monorchic most secernentea or diorchic most Adenophera , with regards to the number of testis present. The testis are tubular structures lined with epithelium and glandular tissue, sperm are produced at the end and mature as they migrate towards the shared opening of the cloaca. Many males have paired chitinous protrusion from the cloaca known as spicules, these are used for attaching to a female during copulation. The spicules are easily seen under a microscope due to their chitinous structure and their position and shape may be used as an identifying feature. Sperm are ejaculated from the cloaca around the spicule, rather than through it. The sperm produced by nematodes is amoeboid and is very motile, employing the same locomotion mechanism as seen in amoeboid species. One of the most distinctive features of some male nematodes is the presence of a copulatory bursa, seen in nematodes of the order Strongylida. Nematodes with a copulatory bursa are known as Bursate , whilst those without are non-bursate. This bursa is at the posterior end of the nematode and is formed from alae with laeral rays that are used for grasping onto the body of the female during copulation. Females Cross section of a female nematode showing the position of the uterus - I. Livingsotne - BIODIDAC Female nematodes usually have a single genital pore through which sperm may enter the uterus and oviduct, this pore is also referred to as a vulva and may be covered by a vulval flap. The uterus may take many forms form being short and straight, long with a single bend or a coiled form. Eggs produced in the ovaries populate the oviducts and uterus and may be released as embryonated or non embroynated eggs once fertilisation has occured. A small muscular organ exists at the vulval opening of some species known as the ovijector, this organ aids in the expulsion of eggs from the vulva. Unlike in male nematodes the end of the female is usually blunt ended with the anus being positioned proximally on the body wall.

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Chapter 6 : Nematodes Parasites of Higher Plants Rev 10/

Some functions of nematodes in the soil food web. The relocation of organisms to new resources, facilitated by the size, body configuration and motility of nematodes, is an important service, particularly where the transported organisms provide other ecosystem services.

In this article we will discuss about Phylum Nematoda: Habit and Habitat of Phylum Nematoda 2. Structure of Phylum Nematoda 3. Respiratory and Circulatory Systems 8. Habit and Habitat of Phylum Nematoda: Great number of nematodes is free-living and extends from north to South Pole and at the same time there exists a formidable array of parasitic forms living both on plants and animals. In fact, every plant and metazoan animal has its quota of nematode parasites. The parasitic forms cause unimaginable damage to crop and domestic animals. So far as the absolute number of nematodes is concerned they are second to none than the insects and outnumber the insects in the variety of ecological nitches they occupy. Free-living nematodes are saprozoic and feed on plant and animal remains. Some feed on yeast and bacteria. Few members prey on small protozoa and rotifers. Parasitic forms are provided with spines or teeth around the mouth which are used in piercing. None of the nematodes can engulf large particles. And in all essentialities they are microphagus or juice feeder. Living nematodes have emerged from mosses which have been rewetted after keeping them dried for about 5 years. The shelled eggs are much more resistant and remain viable for years. Embryonic stages are usually less resistant. Structure of Phylum Nematoda: General shape of the body as the name implies is round, cylindrical and tapering at both ends. The length usually varies from 0. The largest of all nematodes is Placentonema gigantissima. The females of this species attain a length of 8. The females of all nematodes are generally larger than the male. Body Wall of Phylum Nematoda: On the outer surface of the body wall there is a cuticle which is hard and flexible. It is resistant to many solvents and gastric juices. Next to the cuticle lies the ectoderm. In some forms like ascaris the ectoderm is represented by a syncitial protoplasmic mass. Beneath the ectoderm only longitudinal muscles are found. The individual cells of the muscle fibres are very peculiar. They are elongated and may reach a length of 10 mm. One end of the cell is contractile while the other end which houses the nucleus is non- contractile. The non-contractile part keeps contact with a nerve fibre. Two of these bands are dorso-lateral while the other two are ventrolateral in position. In some free-living species the ectoderm bears unicellular glands. Body Cavity of Phylum Nematoda: Body cavity is not a true coelom because it is not lined by epithelial layer derived from mesoderm. According to them, the absence of mesenchyme in between the body wall and digestive tract has stood in a good way for the evolution of a more organised digestive system. Digestive System of Phylum Nematoda: Digestive tract is complete. The mouth is situated at the anterior end of the body and remains surrounded by lips. In the basic plan there are six lips. But as seen in Ascaris the number of lips is reduced to three due to fusion. In some forms there may be many lips due to splitting. The mouth leads to a buccal capsule. The capsule is cuticular and the inner wall of the capsule in some cases forms plates. The capsule may house three or more teeth. The buccal capsule leads to the pharynx. The pharynx, like the buccal capsule is also cuticular. The lumen of the pharynx is triangular. The pharyngeal wall is a syncytium of radial muscle fibres and the wall contains many one-celled glands. Pharynx leads to the intestine. Intestine is straight and is made up of a single layer of epithelium. Rectum is short and opens into the anus. The anal opening is on the ventral surface of the posterior end of the body. The anus is cuticular and in some forms like Ascaris it acts as a cloaca in males only. The intestine is much reduced in Mermis. Feeding habits of nematodes are variable. Free forms may be herbivorous, carnivorous or saprophagous. Excretory System of Phylum Nematoda: Excretory system of nematodes is very different from other animals as it does not show any phylogenetic relationship to the protonephridial system of platyhelminthes or to the excretory system of any other higher phylum. It is a glandular cell with a tubular neck. Respiratory and Circulatory Systems of Phylum Nematoda: There is no special organ or organ system for respiration and circulation. The cuticle serves as the respiratory surface. To send the end-products of digestion to the cells of the body wall and other parts, there is no special organ for circulation. End- products of digestion are absorbed by the intestinal epithelium and from there they are passed onto the fluid of the pseudocoelom. From the fluid of the pseudocoelom nutrient materials reach the cells of the body wall. Nervous System of Phylum Nematoda: The nerve ring is present round the pharynx and is formed by two lateral pairs of ganglia. From the ganglion a ventral nerve cord extends along the mid- ventral line and ends in a ganglion above the anus. Dorsal motor nerve and three pairs of lateral sensory nerves are also present. Reproductive System of Phylum Nematoda: In nematodes, sexes are separate. Adult males are smaller in size than the females, and in most males the posterior end of the body is curved. Male reproductive system consists of a single thread-like much coiled structure. The testis may be monorchic i. Inside the anus there is a pocket which contains a pair of eversible penial spicules. That means there is no male gonopore. The sperms are cone-shaped and have a broad base and a tapering apex. The sperms show amoeboid movement inside the body of the female. The two uteri unite to form a vagina which opens to the outside by a single female genital aperture situated on the ventral surface of the body. If there is one tract containing single ovary, oviduct and uterus called monodelphic but didelphic and polydelphic also occur. In Ascaris there are two tracts containing paired ovaries, oviducts and uteri. In Trichinella, the female reproductive structure is single. Development of Phylum Nematoda: Eggs are fertilized in the vagina of the female. In hook-worms the outermost layer is absent. Cleavage is of determinate type. Blastula is a coeloblastula. Epiboly is the usual mode of gastrulation. Segmentation starts outside the body and later on it becomes infective. In Enterobius the eggs leave the body of the mother and host in segmented condition. In Ancylostoma, the eggs leave the body of the mother and host in partially segmented condition.

Chapter 7 : Introduction to the Nematoda

The Structure of Nematodes attempts to connect the research on the fine structure of nematodes, as seen with the aid of the electron microscope, with the research on these animals done with the aid of the light microscope.

Figure Generalized life cycle of flukes. All cycles involve snails as intermediate hosts. Hermaphroditic flukes - Clonorchis sinensis, Fasiolopsis buski, Paragonimys westermani, and Heterophytes heterpphyes. Metacercaria are infective for humans. Flukes have a well-developed alimentary canal with a muscular pharynx and esophagus. The intestine is usually a branched tube secondary and tertiary branches may be present consisting of a single layer of epithelial cells. The main branches may end blindly or open into an excretory vesicle. The excretory vesicle also accepts the two main lateral collecting ducts of the excretory system, which is of a protonephridial type with flame cells. A flame cell is a hollow, terminal excretory cell that contains a beating flamelike group of cilia. These cells, anchored in the parenchyma, direct tissue filtrate through canals into the two main collecting ducts. Except for the blood flukes, trematodes are hermaphroditic, having both male and female reproductive organs in the same individual. The male organ consists usually of two testes with accessory glands and ducts leading to a cirrus, or penis equivalent, that extends into the common genital atrium. The female gonad consists of a single ovary with a seminal receptacle and vitellaria, or yolk glands, that connect with the oviduct as it expands into an ootype. The tubular uterus extends from the ootype and opens into the genital atrium. Both self- and cross-fertilization occur. The components of the egg are assembled in the ootype. Eggs pass through the uterus into the genital atrium and exit ventrally through the genital pore. Fluke eggs, except for those of schistosomes, are operculated have a lid. The blood flukes or schistosomes are the only bisexual flukes that infect humans Fig. Although the sexes are separate, the general body structure is the same as that of hermaphroditic flukes. Within the definitive host, the male and female worms inhabit the lumen of blood vessels and are found in close physical association. The female lies within a tegumental fold, the gynecophoral canal, on the ventral surface of the male. The medically important flukes belong to the taxonomic category Digenea. This group of flukes has a developmental cycle requiring at least two hosts, one being a snail intermediate host. Depending on the species, other intermediate hosts may be involved to perpetuate the larval form that infects the definitive human host. Flukes go through several larval stages, each with a specific name, before reaching adulthood. Taking into account variations among species see Fig. Eggs are passed in the feces, urine, or sputum of humans and reach an aquatic environment. The eggs hatch, releasing ciliated larvae, or miracidia, which either penetrate or are eaten by a snail intermediate host. In rare instances land snails may serve as intermediate hosts. A saclike sporocyst or redia stage develops from a miracidium within the tissues of the snail. The sporocyst gives rise either to rediae or to a daughter sporocyst stage. In turn, from the redia or daughter sporocyst, cercariae develop asexually and migrate out of the snail tissues to the external environment, which is usually aquatic. The cercariae, which may possess a tail for swimming, develop further in one of three ways. They either penetrate the definitive host and transform directly into adults, or penetrate a second intermediate host and develop as encysted metacercariae, or they encyst on a substrate, such as vegetation, and develop there as metacercariae. When a metacercarial cyst is ingested, digestion of the cyst liberates an immature fluke that migrates to a specific organ site and develops into an adult worm. Tapeworms Cestodes As members of the platyhelminths, the cestodes, or tapeworms, possess many basic structural characteristics of flukes, but also show striking differences. Figure shows the general features of the structure and development of tapeworms. Figure Structure of tapeworms. Atlas of Medical Helminthology and Protozoology. Churchill Livingstone, Edinburgh, , with permission. Whereas flukes are flattened and generally leaf-shaped, adult tapeworms are flattened, elongated, and consist of segments called proglottids. Tapeworms vary in length from 2 to 3 mm to 10 m, and may have three to several thousand segments. Anatomically, cestodes are divided into a scolex, or head, which bears the organs of attachment, a neck that is the region of segment proliferation, and a chain of proglottids called the strobila. The strobila elongates as new proglottids form in the neck region. The segments nearest the neck are immature sex organs not fully developed and those more posterior are mature. The terminal segments are gravid, with the egg-filled uterus as the most prominent feature. Externally, the scolex is characterized by holdfast organs. Depending on the species, these organs consist of a rostellum, bothria, or acetabula. A rostellum is a retractable, conelike structure that is located on the anterior end of the scolex, and in some species is armed with hooks. Bothria are long, narrow, weakly muscular grooves that are characteristic of the pseudophyllidean tapeworms. Acetabula suckers like those of digenetic trematodes are characteristic of cyclophyllidean tapeworms. Differential features of pseudophyllidean and cyclophyllidean tapeworms are listed in Table Most human tapeworms are cyclophyllideans. Table Differences between Pseudophyllidean and Cyclophyllidean Tapeworms. A characteristic feature of adult tapeworm is the absence of an alimentary canal, which is intriguing since all of these adult worms inhabit the small intestine. The lack of an alimentary tract means that substances enter the tapeworm across the tegument. This structure is well adapted for transport functions, since it is covered with numerous microvilli resembling those lining the lumen of the mammalian intestine. The excretory system is of the flame cell type. Cestodes are hermaphroditic, each proglottid possessing male and female reproductive systems similar to those of digenetic flukes. However, tapeworms differ from flukes in the mechanism of egg deposition. Eggs of pseudophyllidean tapeworms exit through a uterine pore in the center of the ventral surface rather than through a genital atrium, as in flukes. In cyclophyllidean tapeworms, the female system includes a uterus without a uterine pore Fig. Thus, the cyclophyllidean eggs are released only when the tapeworms shed gravid proglottids into the intestine. Some proglottids disintegrate, releasing eggs that are voided in the feces, whereas other proglottids are passed intact. The eggs of pseudophyllidean tapeworms are operculated, but those of cyclophyllidean species are not. Eggs of all tapeworms, however, contain at some stage of development an embryo or oncosphere. The oncosphere of pseudophyllidean tapeworms is ciliated externally and is called a coracidium. The coracidium develops into a procercoid stage in its micro-crustacean first immediate host and then into a plerocercoid larva in its next intermediate host which is a vertebrate. The plerocercoid larva develops into an adult worm in the definitive final host. The oncosphere of cyclophyllidean tapeworms, depending on the species, develops into a cysticercus larva, cysticercoid larva, coenurus larva, or hydatid larva cyst in specific intermediate hosts. These larvae, in turn, become adults in the definitive host. Figure illustrates these larval forms and representative life cycles. Generalized life cycle of tapeworms. Hymenolepsis nana, Hdiminuta, Taenia saginata, T solium, Diphyllobothrium latum, Dipylidium craninum. Cysticercus larva in cow and pig; procercoid larva in copepod, plerocercoid sparganum more Roundworms Nematodes Figure shows the structure of nematodes. In contrast to platyhelminths, nematodes are cylindrical rather than flattened; hence the common name roundworm. The body wall is composed of an outer cuticle that has a noncellular, chemically complex structure, a thin hypodermis, and musculature. The cuticle in some species has longitudinal ridges called alae. The bursa, a flaplike extension of the cuticle on the posterior end of some species of male nematodes, is used to grasp the female during copulation. Figure Structure of nematodes. Transverse sections through the midregion of the female worm C and through the esophageal region D. Modified from Lee DL: The Physiology of Nematodes. Oliver and Boyd, Edinburgh, , with permission. The cellular hypodermis bulges into the body cavity or pseudocoelom to form four longitudinal cordsâ€”a dorsal, a ventral, and two lateral cordsâ€”which may be seen on the surface as lateral lines. Nuclei of the hypodermis are located in the region of the cords. The somatic musculature lying beneath the hypodermis is a single layer of smooth muscle cells. When viewed in cross-section, this layer can be seen to be separated into four zones by the hypodermal cords. The musculature is innervated by extensions of muscle cells to nerve trunks running anteriorly and posteriorly from ganglion cells that ring the midportion of the esophagus. The space between the muscle layer and viscera is the pseudocoelom, which lacks a mesothelium lining. This cavity contains fluid and two to six fixed cells celomocytes which are usually associated with the longitudinal cords. The function of these cells is unknown. The alimentary canal of roundworms is complete, with both mouth and anus. The mouth is surrounded by lips bearing sensory papillae bristles. The esophagus, a conspicuous feature of nematodes, is a muscular structure that pumps food into the intestine; it differs in shape in different species. The intestine is a tubular structure composed of a single layer of columnar cells possessing prominent microvilli on their luminal surface. The excretory system of some nematodes consists of an excretory gland and a pore located ventrally in the mid-esophageal region.

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Chapter 8 : Phylum Nematoda: Habitat, Structure and Development

Nematode species can be difficult to distinguish, The ventral nerve is the largest, and has a double structure forward of the excretory pore. The dorsal nerve is.

The suborders Spirurina and Tylenchina and the infraorders Rhabditomorpha , Panagrolaimomorpha , and Tylenchomorpha are paraphytic. The monophyly of the Ascaridomorph is uncertain. Anatomy[edit] Internal anatomy of a male C. The mouth has either three or six lips, which often bear a series of teeth on their inner edges. The cuticle is often of complex structure, and may have two or three distinct layers. Underneath the epidermis lies a layer of longitudinal muscle cells. The relatively rigid cuticle works with the muscles to create a hydroskeleton, as nematodes lack circumferential muscles. Projections run from the inner surface of muscle cells towards the nerve cords ; this is a unique arrangement in the animal kingdom, in which nerve cells normally extend fibres into the muscles rather than vice versa. The mouth often includes a sharp stylet , which the animal can thrust into its prey. In some species, the stylet is hollow, and can be used to suck liquids from plants or animals. Digestive glands are found in this region of the gut, producing enzymes that start to break down the food. In stylet-bearing species, these may even be injected into the prey. This produces further enzymes, and also absorbs nutrients through its single-cell-thick lining. The last portion of the intestine is lined by cuticle, forming a rectum , which expels waste through the anus just below and in front of the tip of the tail. Movement of food through the digestive system is the result of body movements of the worm. The intestine has valves or sphincters at either end to help control the movement of food through the body. However, the structures for excreting salt to maintain osmoregulation are typically more complex. In most other nematodes, these specialised cells have been replaced by an organ consisting of two parallel ducts connected by a single transverse duct. This transverse duct opens into a common canal that runs to the excretory pore. Muscle arms Four peripheral nerves run the length of the body on the dorsal, ventral, and lateral surfaces. Each nerve lies within a cord of connective tissue lying beneath the cuticle and between the muscle cells. The ventral nerve is the largest, and has a double structure forward of the excretory pore. The dorsal nerve is responsible for motor control, while the lateral nerves are sensory, and the ventral combines both functions. Smaller nerves run forward from the ring to supply the sensory organs of the head. These are well supplied with nerve cells, and are probably chemoreception organs. A few aquatic nematodes possess what appear to be pigmented eye-spots, but whether or not these are actually sensory in nature is unclear. Both sexes possess one or two tubular gonads. In males, the sperm are produced at the end of the gonad and migrate along its length as they mature. The testis opens into a relatively wide seminal vesicle and then during intercourse into a glandular and muscular ejaculatory duct associated with the vas deferens and cloaca. In females, the ovaries each open into an oviduct in hermaphrodites, the eggs enter a spermatheca first and then a glandular uterus. Males are usually smaller than females or hermaphrodites often much smaller and often have a characteristically bent or fan-shaped tail. During copulation , one or more chitinized spicules move out of the cloaca and are inserted into the genital pore of the female. Amoeboid sperm crawl along the spicule into the female worm. Nematode sperm is thought to be the only eukaryotic cell without the globular protein G-actin. Eggs may be embryonated or unembryonated when passed by the female, meaning their fertilized eggs may not yet be developed. A few species are known to be ovoviviparous. The eggs are protected by an outer shell, secreted by the uterus. In free-living roundworms, the eggs hatch into larvae , which appear essentially identical to the adults, except for an underdeveloped reproductive system; in parasitic roundworms, the lifecycle is often much more complicated. The juvenile nematodes then ingest the parent nematode. This process is significantly promoted in environments with a low food supply. The single genus Meloidogyne root-knot nematodes exhibits a range of reproductive modes, including sexual reproduction , facultative sexuality in which most, but not all, generations reproduce asexually , and both meiotic and mitotic parthenogenesis. The genus Mesorhabditis exhibits an unusual form of parthenogenesis, in which sperm-producing males copulate with females, but the sperm do not fuse with the ovum. Contact with the sperm is essential for the ovum to begin dividing, but because no fusion of the cells occurs, the male contributes no genetic material to the offspring, which are essentially clones of the female. Free-living marine nematodes are important and abundant members of the meiobenthos. They play an important role in the decomposition process, aid in recycling of nutrients in marine environments, and are sensitive to changes in the environment caused by pollution. One roundworm of note, C. Parasitic species[edit] Eggs mostly nematodes from stools of wild primates Nematodes commonly parasitic on humans include ascarids Ascaris , filarias , hookworms , pinworms Enterobius , and whipworms Trichuris trichiura. Baylisascaris usually infests wild animals, but can be deadly to humans, as well. Dirofilaria immitis is known for causing heartworm disease by inhabiting the hearts, arteries, and lungs of dogs and some cats. Haemonchus contortus is one of the most abundant infectious agents in sheep around the world, causing great economic damage to sheep. In contrast, entomopathogenic nematodes parasitize insects and are mostly considered beneficial by humans, but some attack beneficial insects. One form of nematode is entirely dependent upon fig wasps , which are the sole source of fig fertilization. A newly discovered parasitic tetradonematid nematode, Myrmeconema neotropicum , apparently induces fruit mimicry in the tropical ant Cephalotes atratus. Infected ants develop bright red gasters abdomens , tend to be more sluggish, and walk with their gasters in a conspicuous elevated position. These changes likely cause frugivorous birds to confuse the infected ants for berries, and eat them. Inside the female body, the nematode hinders ovarian development and renders the bee less active, thus less effective in pollen collection. The most common genera are Aphelenchoides foliar nematodes , Ditylenchus , Globodera potato cyst nematodes , Heterodera soybean cyst nematodes , Longidorus , Meloidogyne root-knot nematodes , Nacobbus , Pratylenchus lesion nematodes , Trichodorus , and Xiphinema dagger nematodes. Several phytoparasitic nematode species cause histological damages to roots, including the formation of visible galls e. Some nematode species transmit plant viruses through their feeding activity on roots. One of them is Xiphinema index , vector of grapevine fanleaf virus , an important disease of grapes, another one is Xiphinema diversicaudatum , vector of arabis mosaic virus. Other nematodes attack bark and forest trees. The most important representative of this group is Bursaphelenchus xylophilus , the pine wood nematode, present in Asia and America and recently discovered in Europe. Agriculture and horticulture[edit] Depending on the species, a nematode may be beneficial or detrimental to plant health. From agricultural and horticulture perspectives, the two categories of nematodes are the predatory ones, which kill garden pests such as cutworms and corn earworm moths , and the pest nematodes, such as the root-knot nematode, which attack plants, and those that act as vectors spreading plant viruses between crop plants. Rotations of plants with nematode-resistant species or varieties is one means of managing parasitic nematode infestations. For example, marigolds , grown over one or more seasons the effect is cumulative , can be used to control nematodes. Chitosan , a natural biocontrol, elicits plant defense responses to destroy parasitic cyst nematodes on roots of soybean , corn , sugar beet , potato , and tomato crops without harming beneficial nematodes in the soil. The golden nematode Globodera rostochiensis is a particularly harmful variety of nematode pest that has resulted in quarantines and crop failures worldwide. CSIRO has found a to fold reduction of nematode population densities in plots having Indian mustard Brassica juncea green manure or seed meal in the soil.

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Chapter 9 : Introduction to Plant-Parasitic Nematodes

The esophagus, a conspicuous feature of nematodes, is a muscular structure that pumps food into the intestine; it differs in shape in different species. The intestine is a tubular structure composed of a single layer of columnar cells possessing prominent microvilli on their luminal surface.

Although nematode genomes vary in size within an order of magnitude, compared with mammalian genomes, they are all very small. Nevertheless, nematodes possess only marginally fewer genes than mammals do. Nematode genomes are very compact and therefore form a highly attractive system for comparative studies of genome structure and evolution. One observes high rates of gene losses and gains, among them numerous examples of gene acquisition by horizontal gene transfer. Nematode genomes tend to be compact. Nematode genomes vary in their gene composition due to extensive gene gain and loss. Genes are lost through gene deletion or rapid evolutionary change beyond the point where they can be recognised as homologous to a gene in another species. Genes are acquired through gene duplication, de novo formation and horizontal gene transfer. Horizontal gene transfer allows nematode species to acquire new physiological properties. Phylogenetic relationship of the nematodes with published genome sequences. The phylogeny follows Blaxter et al. Roman numerals denote the clade. Evolution of orphan genes. The number of orphan ESTs increases linearly with the number of species suggesting that the nematode protein space is still undersampled. Error bars indicate standard deviations for different species permutations. Their Development and Transmission, 2nd edn. Andersson JO Lateral gene transfer in eukaryotes. Cellular and Molecular Life Sciences Blaxter M Symbiont genes in host genomes: Cell Host and Microbe 2: Trends in Genetics Molecular Biology and Evolution Katju V and Lynch M On the formation of novel genes by duplication in the Caenorhabditis elegans genome. BMC Evolutionary Biology 8: Lambshead PJ Recent developments in marine benthic biodiversity research. BMC Evolutionary Biology McCarter JP Nematology: Mitreva M, Smant G and Helder J Role of horizontal gene transfer in the evolution of plant parasitism among nematodes. Methods in Molecular Biology International Journal for Parasitology Poulin R Evolutionary Ecology of Parasites, 2nd edn. Cold Spring Harbor Laboratory Press. Nature Reviews Genetics Sommer RJ and Ogawa A Hormone signaling and phenotypic plasticity in nematode development and evolution. Wenk P and Renz A Parasitologie. Cutter AD Evolution of the C. Danchin EG What Nematode genomes tell us about the importance of horizontal gene transfers in the evolutionary history of animals. Mobile Genetic Elements 1: International Journal of Evolutionary Biology Annual Review of Genetics