

VII. Nematoda = Roundworms (Chapters 22-30) 2009 (Pages numbers refer to 8th edition of Roberts & Janovy text)

A. Characteristics

1. Slender worms pointed at both ends
2. Pseudocoelmates with spicules
3. Parthenogenesis occurs in some orders
4. Grow by molting, = shed cuticle

B. Anatomy

1. Cuticle assists in circumventing host's immune system
2. Digestive system complete (= mouth & anus)
3. NERVE RING surrounds esophagus
4. Sexual dimorphism (Fig. 22.2, p. 371)
 - a. Males
 - (1) CLOACA
 - (a) Cavity
 - (b) Reproductive and digestive tracts open into it
 - (2) COPULATORY BURSA
 - (a) Flared hood-like structure
 - (b) Helps male hold onto female.
 - b. Females
 - (1) Without the above 2 structures
 - (2) VULVA
 - (a) Genital opening
 - (b) On anterior half of body

Picture Slide #1: Morphology of a typical nematode male and female, Fig. 22.2, p. 371

C. Life cycles

1. Fixed number of stages (molts)
 - a. Egg
 - b. Three larval stages J₁, J₂ & J₃ or L₁, L₂ & L₃
 - c. Adult
2. One species may have more than one possible life-cycle, example = *Strongyloides*
3. DEVELOPMENT ARREST or HYPOBIOSIS commonly occurs (pp. 389-390)
 - a. DAUER JUVENILES (p. 389)
 - (1) Specialized J₃ (Not produced under favorable conditions)
 - (2) Do not become adults when environment is harsh, but postpone maturation until environment becomes favorable again
 - b. PARATENESIS
 - (1) Passage of an infective parasitic larva by a TRANSPORT or PARATENIC HOST to a definitive host
 - (2) Occurs when an intermediate host is eaten by a predator that is not the normal definitive host

- (3) Parasite larva does not develop into an adult in the paratenic host, but it remains alive and infective
- (4) Paratenic host neither favors (= parasite does not advance to next stage of life-cycle) nor hinders (= parasite is not killed by host's immune system) development of the parasite
- (5) Paratenic host may be harmed by parasite
- (6) Examples of paratenesis
 - (a) CUTANEOUS LARVA MIGRANS
 - 1) J₃ larvae of dog and cat hookworms burrow into and then migrate through human skin
 - 2) Irritant
 - (b) VISCERAL LARVA MIGRANS
 - 1) J₃ migrate through human organs and damage liver, eye & brain
 - 2) Can be fatal
 - 3) Locally important examples
 - a) *Toxocara canis* (dog)
 - b) *Baylisascaris* (raccoon)

Picture Slide #2: Life Cycle of *Baylisascaris*

D. Important orders and species of nematodes

- 1. Order Mermithida (p. 381)
 - a. Juveniles
 - (1) Parasitize invertebrates
 - (2) Fill body cavity
 - (3) Kill host when emerge
 - (a) Ecologically similar to parasitoids
 - (b) Biological control agents
 - b. Adults
 - (1) Free-living
 - (2) Do not feed

Picture Slide #3: Some Insect Hosts of Mermithid Nematodes

Picture Slide #4: Life Cycle of *Romanomermis culicivorax*

Picture Slide #5: Mermithid Emerging from an Adult Caddisfly

- 2. Order Trichurida (Chapter 23)
 - a. *Trichuris trichiura* (pp. 399-400)
 - (1) "Whipworm" (Fig. 23.1; p 400)
 - (a) Characteristic shape
 - (b) Anterior 60% of body is a thin flagellum-like structure

Picture Slide #6: Male *Trichiuris* with slender anterior and stout posterior; Fig. 23.1

- (2) Distribution
 - (a) World-wide
 - (b) Found in a 450 year old mummy of an Inca girl

Picture Slide #7: Prevalence of *Trichiuris trichiura* & Other Parasites in Migrant Farmworkers in North Carolina 1987 & 1988

- (3) Life cycle

- (a) Direct
- (b) Ingested eggs hatch in small intestine
- (c) Burrow into villi
- (d) After a few days, they leave small intestine and enter large intestine
- (e) Mature worms in large intestine produce eggs
- (f) Eggs have a characteristic barrel shape

Picture Slide #8: Egg of *Trichiuris trichiura*, Fig. 23.2, p. 400

- b. *Trichinella spiralis* cause TRICHINOSIS (pp. 403-409)
 - (1) Acquired by humans by eating poorly cooked pork & meat from other predators/omnivores
 - (2) Same host serves as both intermediate & definitive host
 - (3) Life cycle
 - (a) Cysts found in striated muscle of mammals
 - (b) Larvae liberated from cysts in digestive tract of predator
 - (c) Females burrow into intestinal epithelial cells (= intracellular parasites)
 - (d) “Newborn” larvae leave female and burrow into lacteals (= lymphatic vessels in intestinal villi)
 - (e) These “newborn” larvae disperse through body in circulatory system
 - (f) Burrow into striated muscles
 - (g) Adjacent muscle cell of host changes into a “nurse cell” and supports development of larval worm inside the cyst. Fig. 23.12, p. 406

Picture Slide #9: *Trichinella spiralis* - Nurse Cell Complex with Network of Host Circulatory Vessels, Fig. 23.12, p. 407

- (4) Found in carnivores/omnivores throughout the world (Fig. 23.13, p. 407)
 - (a) Arctic polar bears
 - (b) African lions
 - (c) Temperate foxes, raccoons, mink, etc
 - (d) Pigs are important definitive hosts for humans
- (5) Death in humans attributed to massive invasions of heart muscle or the central nervous system

Picture Slide #10: Life Cycle of *Trichinella spiralis*, Fig. 23.13, p. 407

- (6) Trichinellid larvae share the following characteristics with viruses
 - (a) They invade host cells
 - (b) They cannot be cultured *in vitro*
 - (c) They produce substances that convert the metabolic activities of host cells to meet the metabolic requirements of the parasite
 - (d) The nuclei of infected host cells undergo metabolic, physiological and structural changes in response to substances secreted by the parasite.

3. Order Rhabditida

- a. Illustrate evolutionary opportunism
 - (1) Species common in soils/decaying materials, thus often become facultative parasites
 - (2) Bridge gap between parasites and free living modes of life
 - b. *Strongyloides stercoralis* (Fig. 24.3; p. 416, Chapter 24)
 - (1) Parasitizes humans and dogs
 - (2) Common in puppies from kennels with poor sanitation
 - (3) Usually hosts develop resistance although autoinfection occurs
 - (4) Immunosuppressed people at risk
 - (a) Organ recipients
 - (b) AIDS patients
 - (5) Life cycle
 - (a) Two types of larvae
 - 1) RHABDITIFORM (RHABD = rod)
 - a) Can be free living
 - b) Morphology
 - i) Short esophagus with bulb
 - ii) Short & thick body
 - 2) FILARIFORM (FILUM = thread)
 - a) Infective (J3)
 - b) Morphology
 - i) Elongated esophagus (no bulb)
 - ii) Slender
 - (b) AUTOINFECTION
 - 1) Eggs hatch in large intestine
 - 2) Rhabditiform larvae become filariform in large intestine and re-infect host
 - 3) A metazoan parasite that multiplies its numbers within the definitive host
 - (c) HETEROGONIC CYCLE: Free living generation I interspersed between parasitic generations
 - 1) Rhabditiforms leave host in feces
 - 2) Rhabditiforms become free living adults
 - 3) Next generation
 - a) Eggs hatch in soil
 - b) Free living rhabditiforms become infective filariforms
 - (d) HOMOGENIC CYCLE
 - 1) Rhabditiforms leave host in feces
 - 2) Become infective filariforms J3
4. Order Strongylida, Family Ancylostomidae (= hookworms) (Chapter 25)
 - a. Most important nematode parasites of humans (Fig. 25.3, p. 421)
 - b. *Necator americanus* (= American killer)
 - (1) Was a major problem in southern U.S. in early 20th century
 - (a) Distribution of sanitary latrines, shoes, & medicine helped to control it

- (b) 4-15% in a southeastern United States rural community in 1974
- (c) African Americans are more resistant than Caucasians
- (d) Contributed to the stereotype of the lazy, rural Southerner

Picture Slide #11: Parasites in Literature: Excerpt from *Letters from Earth* by Mark Twain

- (2) Pathogenicity
 - (a) Loss of blood results in iron deficiency and anemia
 - (b) Diarrhea due to protein loss in mucosal lining
- c. *Ancylostoma duodenale*
 - (1) Africa, southern Europe, & Asia
 - (2) Life cycle (Same as *N. americanus*)
 - (a) Eggs in feces
 - (b) Larvae hatch and undergo 2 molts before becoming infective
 - (c) Filariform larvae
 - 1) Infective
 - 2) Non-feeding
 - 3) When moist, they crawl to a high point (vegetation) and wait for host
 - (4) Burrow through skin of host's foot (between toes)
 - (a) Travels in blood to lungs where it bursts through and travels via phlegm to esophagus
 - (b) Reaches intestine and molts to adult

Word Slide: Cheap Thoughts by Jack O'Brien

- (3) Holds onto villi of host
 - (a) Feeds on mucosa and blood
 - (b) Most RBCs pass through nematode
- (4) Believed that it can be passed onto nursing children in mother's milk

Picture Slide #12: A 4,000 year old Chinchorro infant; A quarter of all Chinchorro children died before age of one year.

Picture Slide #13: Parasites and the Native American Migration to the New World

5. Order Ascaridida (Chapter 26)

- a. *Ascaris lumbricoides* Family Ascaridae
 - (1) Largest nematode that lives in human intestine
 - (2) World wide distribution
 - (3) Prevalence
 - (a) 25% of world's human population
 - (b) 15% in rural children in a South Carolina survey (1969)
 - (4) Generally mortality is low

Picture Slide #14: Male & female worms

Picture Slide #15: Typical worm burden

Picture Slide #16: Worms can obstruct intestine

- (5) Life cycle (Fig. 26.5, p. 436)
 - (a) Adult female lays about 200,000 eggs per day

- 1) Eggshell is resistant to desiccation
- 2) Eggs in 10% formalin remain viable and students should be careful when handling preserved specimens
- (b) Molting occurs within egg
- (c) Infected eggs ingested by humans
- (d) Larvae hatch in same part of small intestine occupied by adults, but migrate through body before maturation
 - 1) Burrow through intestinal wall entering blood circulation
 - 2) Leave blood circulation in lungs & move up trachea

Picture Slide #17: *Ascaris* larva in lung tissue

Picture Slide #18: Life-cycle of *Ascaris*

- (e) Swallowed in phlegm and return to small intestine where they become adults
- (6) Adult worms are wanderers
 - (a) May obstruct bile duct
 - (b) Emerge from nose or anus
- b. *Toxocara canis* (Fig. 26.7, p. 438)
 - (1) Dogs are definitive hosts
 - (2) Paratenic and definitive hosts can be infected by eating eggs
 - (3) Arrested infected larvae in tissues of resistant mother dog
 - (4) Virtually every (98%) puppy in United States is infected; therefore puppies should be “dewormed” after first few weeks of life
 - (a) When bitch becomes pregnant, larvae migrate across placenta & puppies are born with worms in gut
 - (b) Milk (from mammary gland) is also a vector
 - (5) Health risk for children
 - (a) Visceral larva migrans
 - 1) Larvae can fatally damage organs of paratenic host
 - 2) Make mice more susceptible to canine (definitive host) predation
 - 3) In humans, they can cause blindness
 - (b) Sandboxes in public parks where dog owners walk pets are frequently heavily contaminated with *Toxocara* eggs
- c. *Baylisascaris* (p. 440-41)
 - (1) Raccoon is definitive host
 - (2) Visceral larva migrans
 - (a) Occurs when another vertebrate eats eggs
 - (b) May be fatal in humans
 - 1) People put out food for wild raccoons
 - 2) Children play in defecation sites
 - (3) Present in Alabama

Picture Slide #19: Life Cycle of *Baylisascaris*

6. Order Oxyurida (Chapter 27)

- a. *Enterobius vermicularis* = pinworm

- b. Common in children
 - c. Diurnal migration
 - (1) Adult female in large intestine during day
 - (2) Females lay eggs outside host on perianal area at night
 - d. Methods of transmission
 - (1) Eggs adhere to perianal region in a “sticky” mucus
 - (a) Mucus induces itching when dries
 - (b) Eggs under fingernails after scratching
 - (2) Eggs get in clothes and dust
 - e. Not considered to be a dangerous parasite
7. Order Spirurida, Superfamily Filarioidea (Chapter 29)
- a. *Wuchereria bancrofti* and *Brugia malayi*
 - (1) Filarial nematodes causing ELEPHANTIASIS
 - (2) Worms live in lymphatic vessels of humans
 - (3) Life cycle
 - (a) Vectors are mosquitoes
 - 1) MICROFILARIAL stage in human blood is picked up by mosquito
 - 2) Larvae molt in mosquito
 - 3) Move to proboscis and will invade new host when mosquito feeds again
 - 4) Unlike malaria, there is NO sexual reproduction in mosquito
 - (b) Worms travel to lymphatic vessels where they mature
 - (4) Pathogenicity
 - (a) Vessels thicken when worms present
 - (b) Lymph does not flow well and back pressure develops causing swelling
 - (c) Host develops immune response
 - (d) Regular re-exposures in individuals with strong immune response can lead to extreme swelling of lymphatic vessels or elephantiasis
 - (e) Not every victim develops elephantiasis (Immigrants are more susceptible)

Picture Slide #20: Extreme Elephantiasis of All Four Limbs and Scrotum

- b. *Onchocerca volvulus*
 - (1) River blindness or ONCHOCERCIASIS
 - (2) Vectors are blackflies
 - (3) River areas of Africa, Central and South America
 - (4) Life cycle
 - (a) Adult worms live in a nodule of connective tissue in skin
 - (b) Females release microfilarial larvae which migrate through human host eventually arriving at the skin
 - (c) Microfilaria picked up by blackflies when biting people
 - (d) Molt and become infective J₃ in blackfly
 - (e) Migrate to proboscis and enter new hosts during feeding

Picture Slide #21: *Onchocerca* Nodules on Scalp of Central American Child

- (5) Pathogenicity
 - (a) Blindness
 - (b) Microfilariae get into eye causing damage

Picture Slide #22: Chain of Men Blinded by Onchocerciasis Led by Small Boys Not Yet Blinded by the Disease

- c. *Dirofilaria immitis*
 - (1) Dog heartworm
 - (2) Transmitted by mosquitoes
 - (3) Adult worms live in heart
 - (a) Obstruct blood flow
 - (b) Dead worms may be carried to lung blocking arteries
 - (4) Pathogenicity
 - (a) Victims tire easily
 - (b) Persistent cough

Picture Slide #23: Ventricle of a Dog's Heart Showing Heavy Infection with *Dirofilaria immitis*

d. Family Dracunculidae (Chapter 30)

- (1) *Dracunculus medinensis* = Guinea worm
- (2) Common in economically poor areas of Asia & Africa where water is supplied by open wells

Picture Slide #24: People Drawing Water under Conditions that Facilitate Transmission of *Dracunculus*, Figs. 30.4 & 30.5, p. 482

- (3) Life cycle
 - (a) Adult female worm (containing young worms) in blister on leg
 - (b) Larvae released when blister comes in contact with water
 - 1) Example of a parasitic worm influencing behavior of human host
 - 2) Itching caused by gravid female is relieved when human immerses blister in water
 - 3) Infected people go to and consciously immerse blister in water
 - (c) Larvae eaten by aquatic crustacean copepod, *Cyclops*
 - (d) Humans drink water containing infected *Cyclops*
 - (e) Worm burrows through intestinal wall to mature in connective tissue of skin
- (4) Gee Whiz Biology
 - (a) Traditionally removed by winding worm around a small stick (Symbol of medicine is a snake wrapped around a stick)
 - (b) Bible records that the Israelites encountered "fiery serpents" in their travels to the Promised Land (Numbers Chapter 21:6)

Picture Slide #25: *Dracunculus* Worm Being Removed with a Stick Suggestive of the Serpent and Staff Medical Symbol; Figs. 30.7 & 30.8, p. 484

Picture Slide #26: Periodicity of Microfilariae in Definitive Hosts Correlates with Feeding Time of Vector