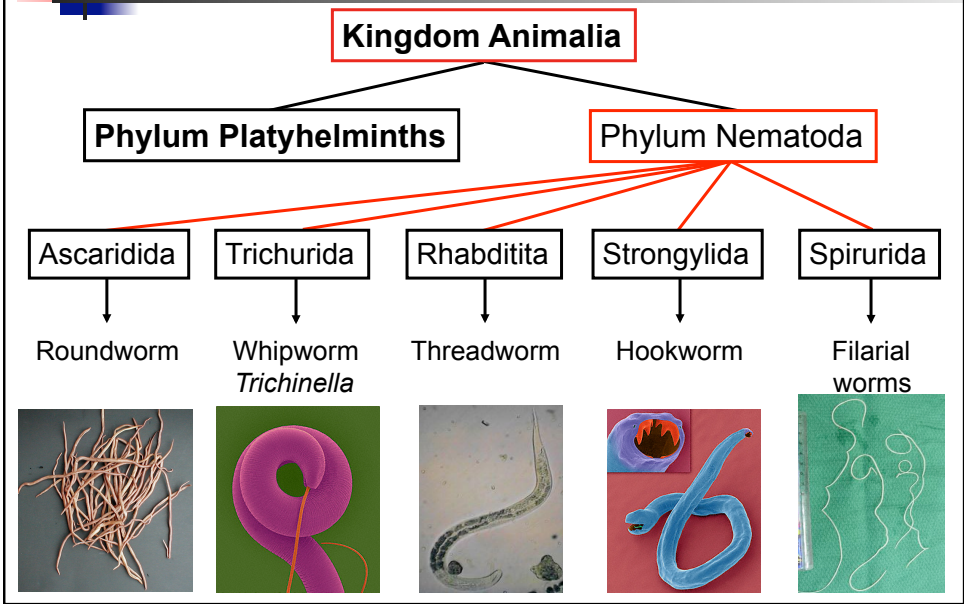
# Helminths (Parasitic worms)

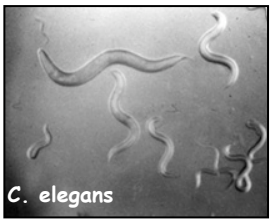



# Parasitic Nematodes of Humans

| | |
|---|---|
| ▪ Roundworm | *Ascaris* |
| ▪ Pinworm | *Enterobius* |
| ▪ Whipworm | *Trichuris* |
| ▪ Trichinella | |
| ▪ Toxocara | |
| ▪ Hookworms | *Necator & Ancylostoma* |
| ▪ Threadworm | *Strongyloides* |
| ▪ Filarial nematodes | *Wuchereria, Loa, Onchocerca* |
| ▪ Guinea worm | *Dracunculus* |

# Nematodes - General Properties

- Extremely abundant
  - Debate - more insects or nematodes?
    - 90,000 worms in a single rotting apple
    - ~9 billion in 1 acre of farmland
    - Major are small predators or saprophytes
    - Nearly every insect is parasitized by a nematode
    - Plant and animals nematode parasites
    - Parasitic infections can be enormous
  - Diverse habitats
    - Free-living marine, freshwater, soil species
    - Animal and plant tissue

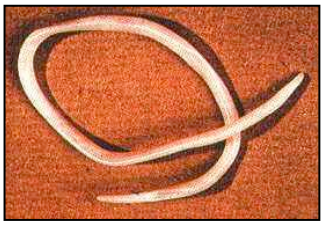



# Impact of Nematodes

- Human diseases
  - Debilitating diseases
- Livestock and other domesticated animal diseases
  - Impact on economic stability
  - Huge industry for anti-helminths for our pets
- Plant diseases
  - Turf grasses - big money (golf courses etc.)
- Model system for the study of development, aging, human diseases such as cancer

# Nematodes - General Properties

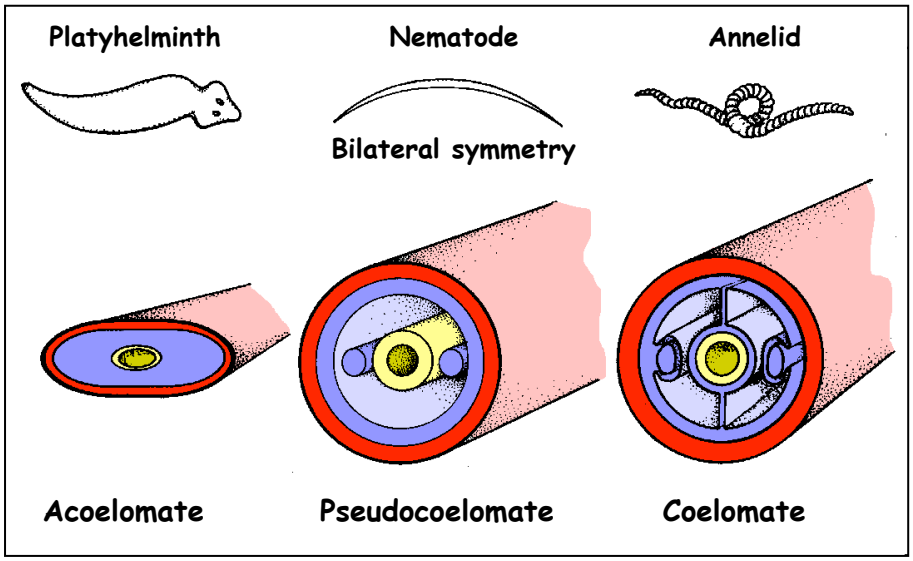
- "White worms"
  - Not segmented
  - Covered with a cuticle (non-cellular)
    - Hides the internal organs
    - Secreted by hypodermis (epidermis)
    - Grows as worm grows
    - Shed during each molt (new cuticle beneath)
- Sexes are separate
  - Find each other via pheromones
  - Male sperm lack flagellum
    - move by pseudopodia
- Most are slender with few distinguishing characteristics.
- Cause of some of the most debilitating the disfiguring diseases in humans



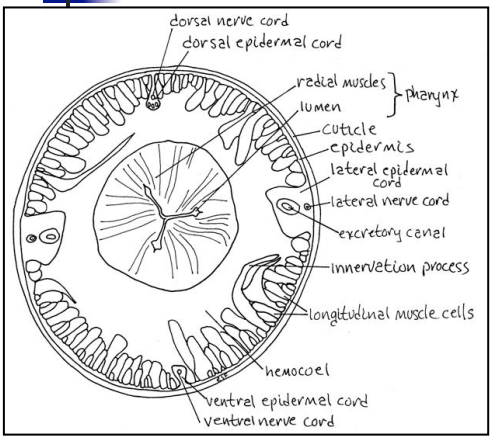
# Nematode General Properties

- Pseudocoel
  - Fluid-filled cavity that forms hydrostatic skeleton
- Simple nervous system
  - May include sensory organs called phasmids
- Complete digestive system
- Four larval stages which all look similar (molting)
  - Called L1, L2, L3, L4 or J1, J2, J3, J4
    - Most larval stages are free-living
  - L3 is usually the stage that gets into the definitive host

# Body Plan - roundworms

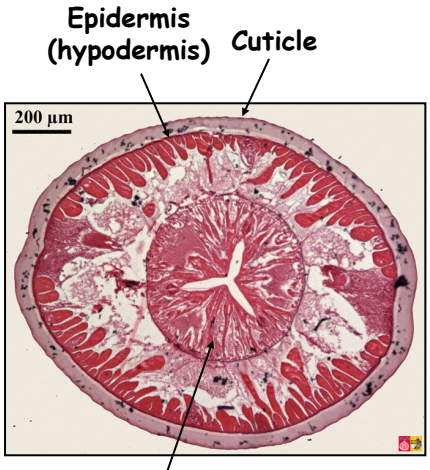



# Body Plan




**Hemocoel - filled with fluid**
**Exceptionally high hydrostatic pressure**

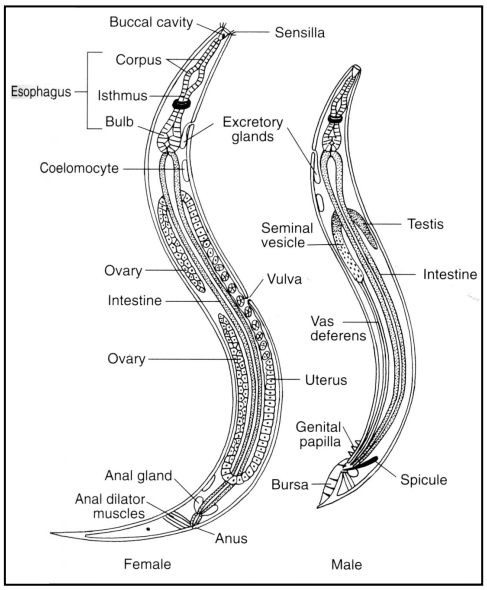
**Tube within a tube**



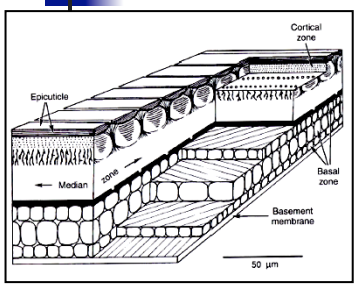

**Triradiate pharynx (esophagus)**

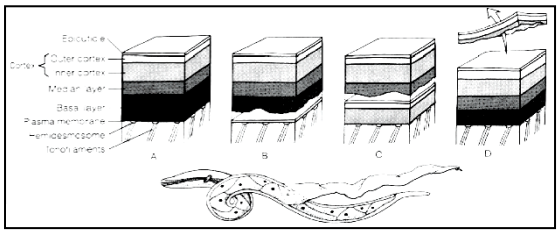
# Nematode Anatomy

- Tapered body shape
- Unsegmented
- Separate sexes
  - Females are typically larger
- Anterior mouth opening
- Posterior anus



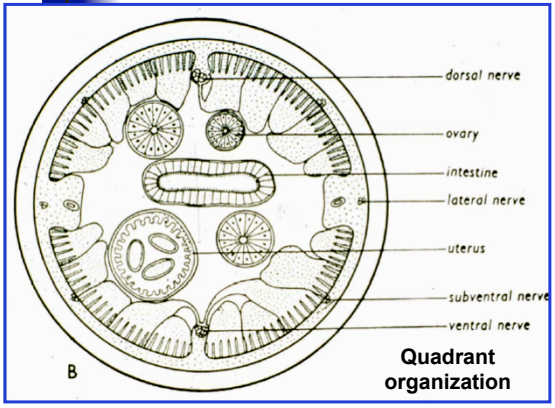

# Cuticle - complex outer covering

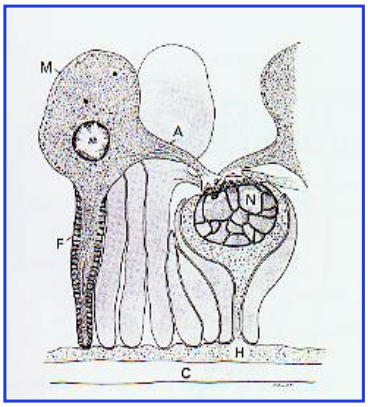



- Epicuticle - thin layer of lipid and proteins
- Cortex - cross-linked cuticilin proteins and collagen
- Basal layer - closest to the hypodermis
  - Basal layers are put down at angles to form a lattice structure
- Hypodermis secretes the cuticle (starting with the epicuticle - B)
- The old cuticle separates from the newly synthesized one

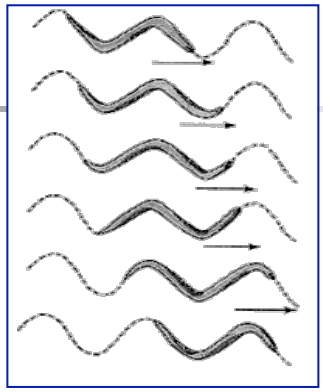
# Neuromusculature



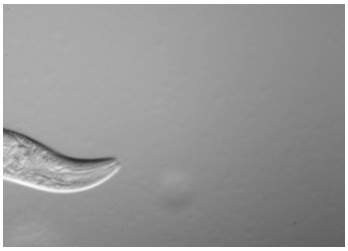




- Possess only longitudinal muscles - no circular muscles
- Musculature is tightly attached to hypodermis (and therefore cuticle)
- Muscle cell extends out to the hypodermis and to the neuron.

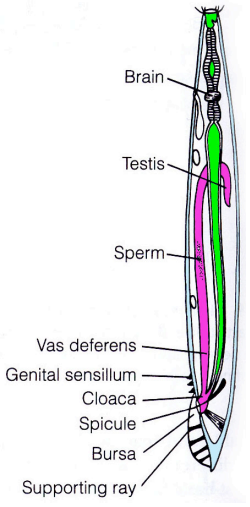
# Nematode Locomotion



- Turgid body - high pressure in pseudocoel
  - Contributes to muscle contractions - work against high pressure
- Undulating motion - wave-like
- The body's contractions are according to dorsal/ventral contractions of the body

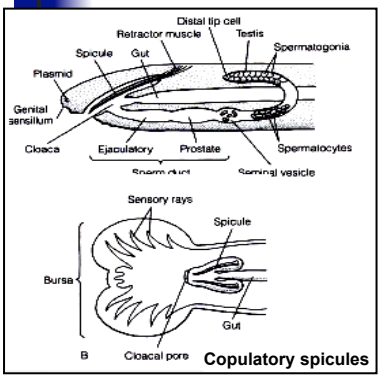


# Reproduction

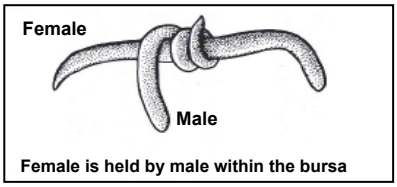



- **Most nematodes are dioecious (meaning they have two sexes, male and female), but hermaphrodites occur as well**
- **Males often have additional external features at the posterior end of the worm**
- **Partners are attracted to each other by pheromones**
- **The male inserts two sclerotized copulatory spicules**
- **The sperm duct is muscular and sperm is transferred to the female against the pseudcoel pressure**
- **Male cement glands can close vulva in some species**

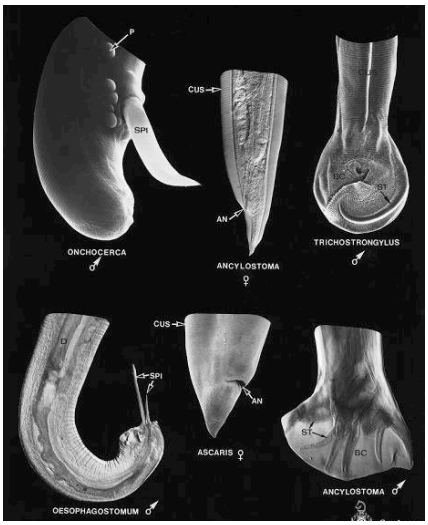
# Reproduction




**Copulatory spicules**



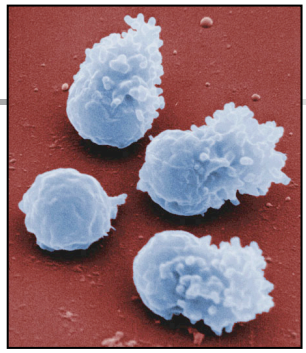

**Female is held by male within the bursa**

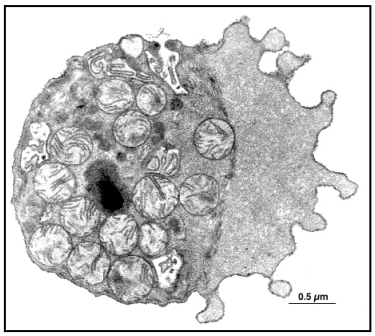



**Bursa size and shape are diagnostic**

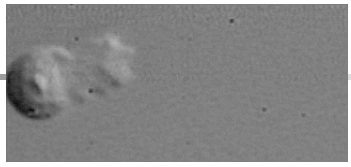
# Amoeboid Sperm

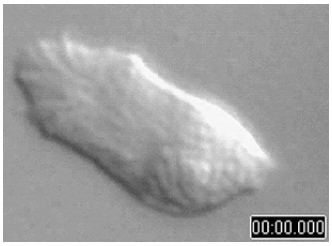
- All nematode sperm lack flagella
- Sperm actually crawl into uterus of the female
- In many species the amoeboid sperm are highly sensitive to oxygen
  - In vitro, sperm will die quickly when exposed to oxygen
- Non-actin based motility!!!
- Major sperm protein (MSP)
  - ~16% of total protein in sperm
  - Mainly localized to pseudopodia

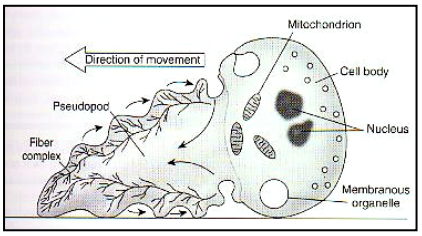


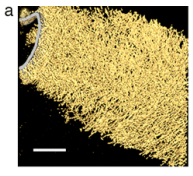


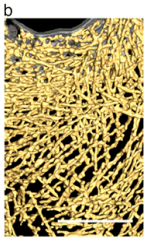

# Sperm Motility

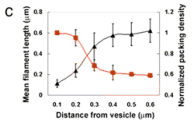


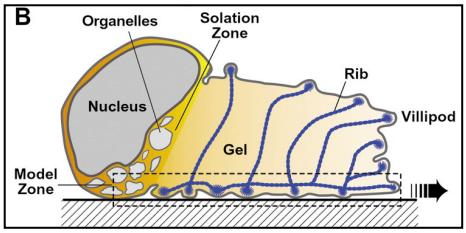


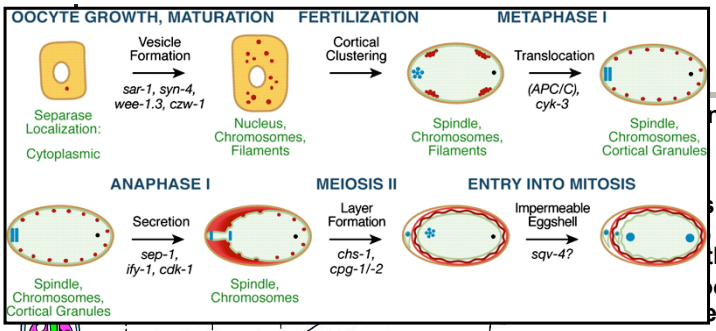



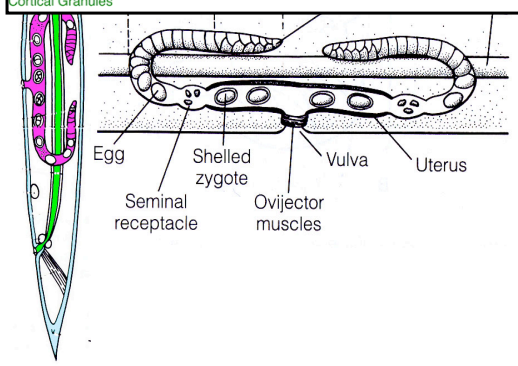






**nematodes have**

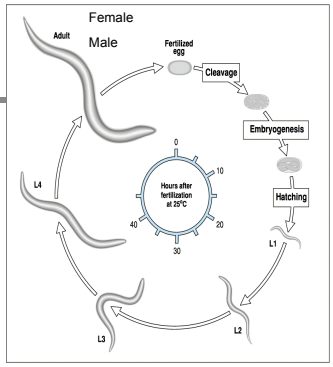
**similar to the linear oogonia are the distal end oocytes while they e growth zone**

- **As the oocytes enter the oviduct they are fertilized by sperm stored in the receptacle**
- **Fertilization triggers the completion of meiosis**

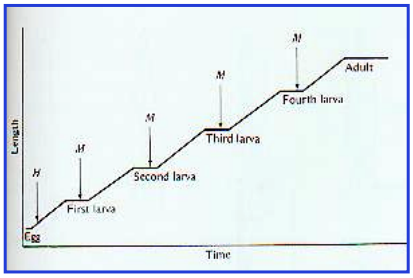
**Development 134, 3837-3848 (2007)**

# Development

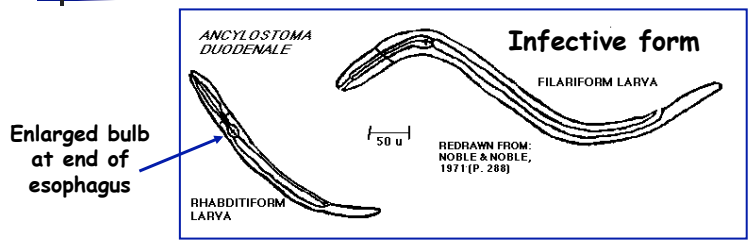
- 6 life cycle stages
  - Egg
  - 4 larval stages
  - Adults (dioecious)
- Free-living and parasitic nematode undergo molts
  - Increasing in size with each molt
- Usually the L3 larvae are infectious stage
  - Infective stage can vary among the nematodes







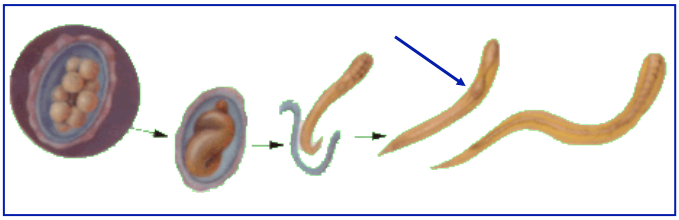
# Larval forms



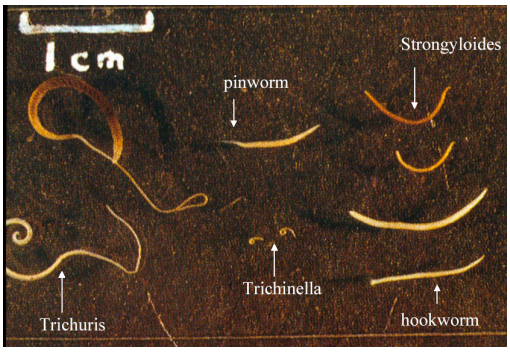

Enlarged bulb at end of esophagus

Feeding form

Non-feeding form



# Parasitic Nematode Diversity



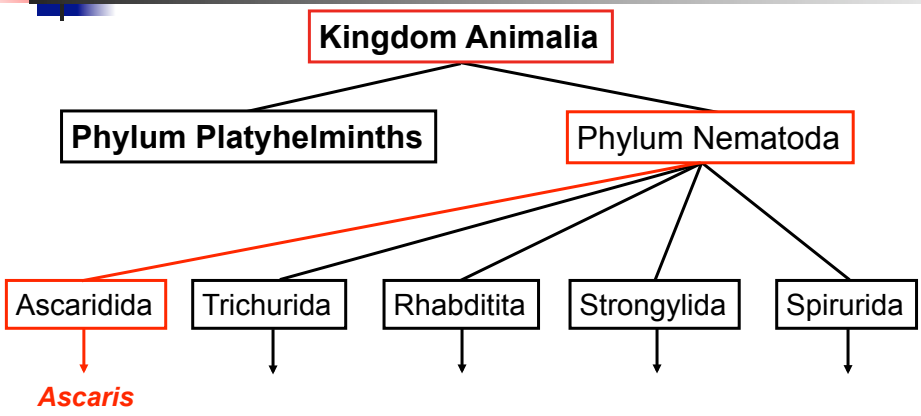

| Size of Nematodes | |
|---|---|
| Ascaris | 12-40 cm |
| Trichuris | 3-5 cm |
| Ancylostoma | 10-14 mm |
| Enterobius | 8-13 mm |
| hookworm | 5-13 mm |
| Trichostrongylus | 4-8 mm |
| Capillaria philippinensis | 2-4 mm |
| Strongyloides | 2 mm |
| Caenorhabditis | 1 mm |

# Helminth Lifespan

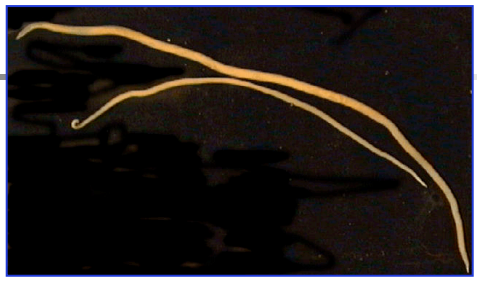
Maximum survival of helminths in Human Host

| | years |
|---|---|
| ascaris | ~ 1 |
| hookworm | » 6 |
| trichuris | ~ 3 |
| liver fluke | » 20 |
| lung fluke | » 20 |
| schistosoma | » 40 |
| taenia | » 35 |
| strongyloides | » 70 |

# Helminths (Parasitic worms)



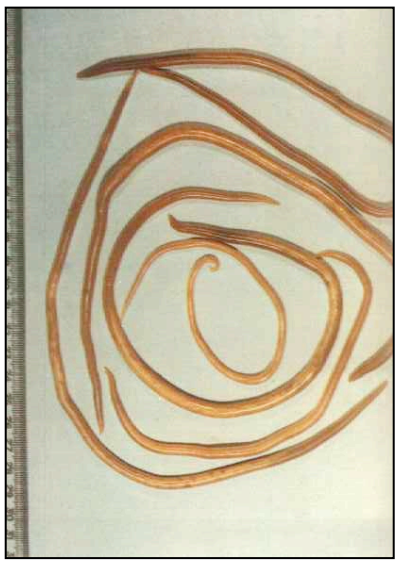
## Ascarids



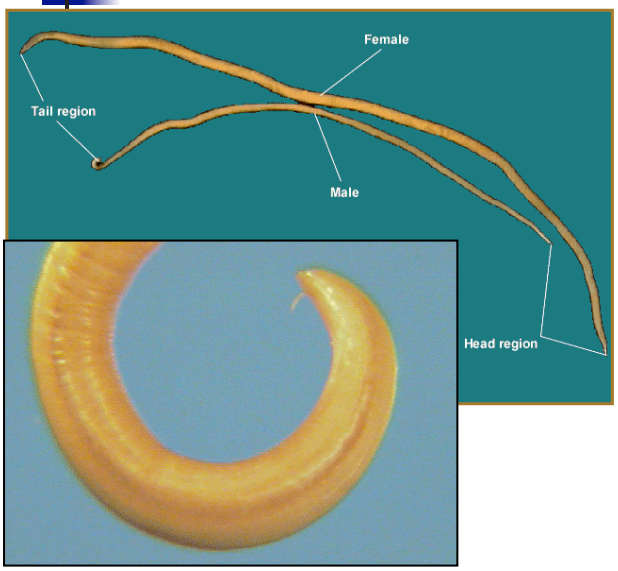
- Largest of the nematode parasites
  - Some are over a foot long
- Stout, big worms
- Mouth surrounded with large lips, usually 3
- Most are intestinal parasites
- Infections are usually very heavy

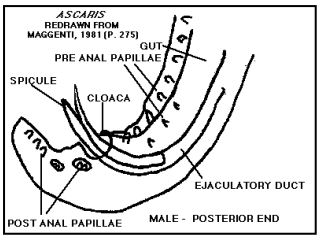
## *Ascaris lumbricoides*

- **Definitive Host:** Humans
- **Intermediate Host:** None
- **Geographic Distribution:** Cosmopolitan
  - 25% of world population is infected
  - Prevalence in southeastern U.S. can reach 60%
  - Has been known as human parasite for over 2000 years
    - Found in writing of ancient Greeks
- **Location:** small intestines



# *Ascaris lumbricoides, A. suum*



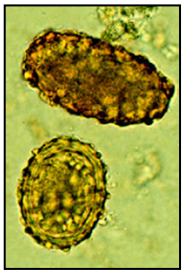



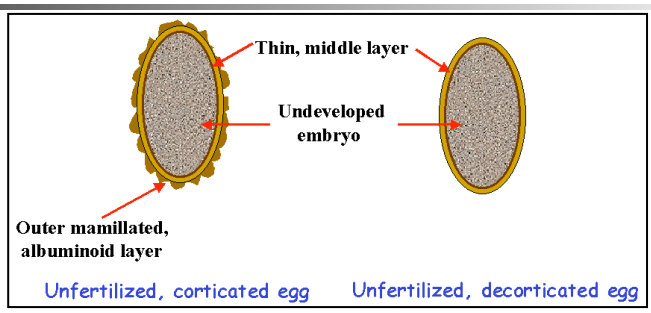

# *A. lumbricoides* transmission

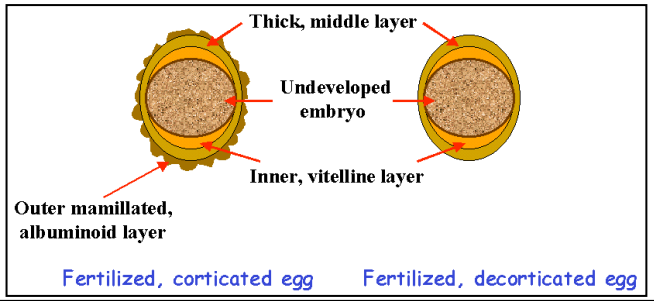
- Ingestion of eggs in contaminated food or water.
  - Use of night soils on crops increases transmission
- Require shade and mild temperatures
- Eggs are very resistant
  - Eggs can embryonate in very strong chemicals
    - 2% formalin
    - Potassium dichromate
    - 50% hydrochloric, nitric, acetic, and sulfuric acid
  - Very long life
    - At least 10-15 years

**Embryonated egg containing L1**

# *Ascaris* eggs

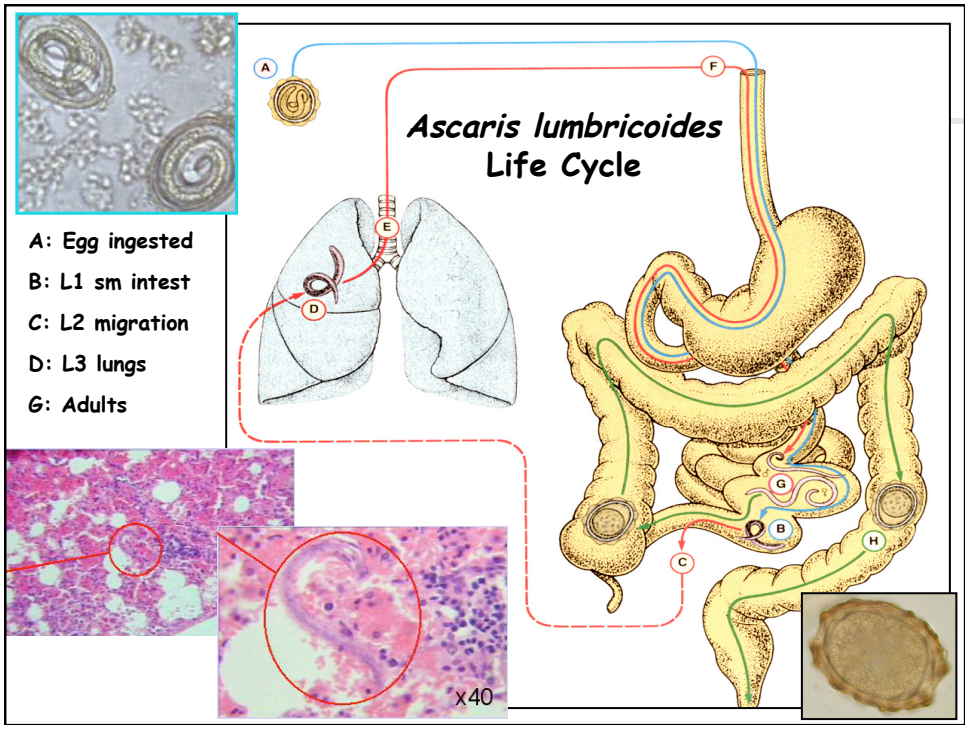




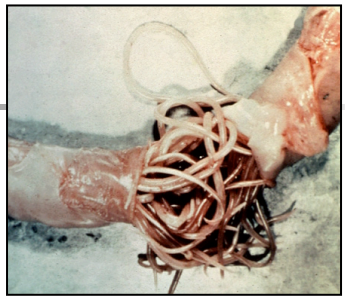




# *A. lumbricoides* transmission

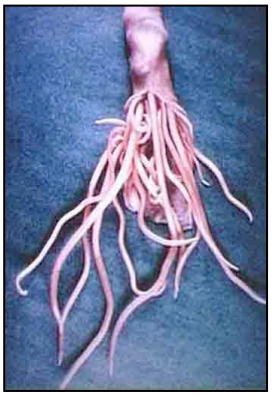
- Eggs can splash up onto vegetables
  - One strawberry patch was still infective after six years
- Eggs can be picked up and transported by cockroaches.
- Wind borne dust may carry the eggs
  - Trapped on mucus membranes then swallowed
- Eggs have been found on German bank notes!
- Children are infected much more frequently than adults
  - Dig in soil and put fingers in mouth




# *Ascaris* infestation



- Ascariasis
- Depends on the number of worms
- Worms subsist on liquid content of small intestines
  - Do not suck blood or graze on mucosa.
- Small to medium infections are usually asymptomatic



- May cause “sensitization phenomenon”
  - Allergic reaction to worm waste.
  - Rashes, eye pain, asthma, insomnia, restlessness

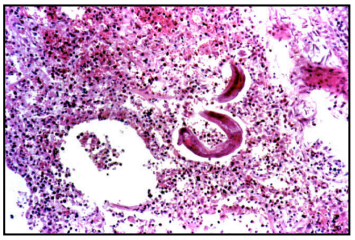
# Pathology

- Wandering adults are dangerous.
  - Overcrowding can lead to wandering
    - Upstream to pancreatic or bile ducts
      - May cause liver damage
      - If reaches stomach, causes vomiting of worm
    - Downstream to appendix or out anus
  - Females like to crawl through small spaces
    - Looking for curly tail of male
    - She may crawl through nose, ear, or any other opening
      - Image the surprise as a 1.5 foot worm crawls out the nose or ear!
    - Aspiration of worm can cause death

**Unfortunate migratory route**

# Diagnosis

- **Diagnosis:**
  - Eggs in feces
  - Juveniles in sputum
    - Difficult to identify to species.
  - Sticky Tape test
  - Dead adults may be found in feces



# Deworming

- **Treatment:** Mebendazole will kill the adults but not the migrating larvae
  - May need to repeat treatment
- Dead adults usually pass out through the anus