Station 1
The Nematodes – Phylum Nematoda

Nematodes (commonly referred to as roundworms) inhabit many places on the earth. Some free-living nematodes are found in hot springs, the soil, or even vinegar while others are important endoparasites of humans, animals and plants. The roundworms have tapered, cylindrical bodies and are bilaterally symmetrical pseudocoelomates with a complete digestive system. The outer body wall of a roundworm contains longitudinal muscle tissue, the epidermis and a protective outer cuticle. This cuticle, produced by the epidermal cells, is non-cellular and must be shed periodically as the roundworm grows. The roundworm nervous system consists of a brain and a system of dorsal, ventral and lateral nerves. Roundworms bodies are supported by a fluid-filled pseudocoelom (forming the hydrostatic skeleton) which also aids in the transport of materials through the roundworm’s body.

Most roundworms are dioecious. The parasitic forms often have complex life cycles involving multiple hosts. These parasites often have enormous amounts of reproductive tissues for production of large numbers of gametes.

Examples of Roundworms

Human pinworm (Enterobius vermicularis)
Pinworms inhabit the lower digestive tract of humans (colon and rectum). The males and females mate then the female crawls out of the rectum at night and deposits eggs on the perianal skin (surrounds anus). The mode of infection may be direct as the eggs hatch and larvae may enter the host’s body directly though the anus. However, a more common mode of infection involves the ingestion (through the mouth) of ripe eggs. When the female deposits her eggs, it may irritate the perianal skin (causing itching). The subsequent scratching may transfer the eggs to the bedding or fingers. These eggs are easily transferred to the mouth by unwashed hands. The eggs are tough and may be found in the soil (another mode of infection is children playing in sandboxes and not washing their hands afterwards). It is for this reason that so many humans are infected with estimates for US infection being as high as 16% of adults and 50% of children.

Observe the pinworm slide and in the space provided below.
Trichina worm (*Trichinella spiralis*)

*Trichinosis* is caused by the infection of trichina worms. Humans, swine (most common host in the US), bears, rats and many other mammals may serve as the host. The life cycle is simple and may involve a single host individual. The tiny worms live in the intestinal walls of the host. After mating, the eggs hatch and the larvae migrate to the circulatory system where the blood vessels carry them to muscle tissue. In the muscle tissue, the spiral-shaped larvae reside in calcareous cysts. Once the larvae complete their development, they leave the cysts and migrate to the intestinal wall. It is the consumption of these cysts in muscle tissue that allows the trichina worms to be passed from one host to another. It is for this reason that pork should always be cooked properly.

**Observe the slide of the trichina cysts in muscle tissue and label the image below.**

![Trichina cysts in muscle, 40X.](image)

Human intestinal roundworm or ascaroid (*Ascaris lumbricoides*)

Human ascaroids are widely-distributed in the world and are common in the southeastern US. Ascaroids live within the small intestines of their host forming a writhing mass of moving worms. This helps them remain in the intestinal lumen as they possess no adaptations for attachment (like tapeworms or flukes). Complications from intestinal blockage and malnutrition in the host are common symptoms of infection.

Ascaroids exhibit pronounced **sexual dimorphism** (variation in external appearance between males and females). The males are distinguished by a **ventrally curved tail** which forms a hook for **copulation** with female. **Sperm** produced in the single **testis** of the male travels through the **vas deferens** (larger in diameter) where the sperm are stored and mixed with fluids to aid in reproduction. During copulation the sperm move to the muscular **seminal vesicle** (largest in diameter) and are ejaculated through the **cloaca** (common area between the reproductive and digestive system) and into the female’s genital pore. The male reproductive organs occupy much of the pseudocoelom and wrap around the **flattened intestine**.

The “Y” shaped female reproductive system also occupies the majority of the pseudocoelom. The **genital pore** leads to the **vagina** where the sperm are collected and routed to the **seminal receptacles** (largest diameter). Sperm may be stored in the seminal receptacles for some time before they move to the **uterus** (larger diameter). **Eggs** from the **ovaries** (smallest diameter) pass through the **oviducts** and are fertilized. These fertilized eggs develop in the uterus and are passed out through the genital pore and into the host’s intestinal lumen.
From here, the host passes these eggs with feces. After an incubation period, infection of a new host occurs as the eggs are ingested. The eggs are very durable and may remain viable for some time (up to 20 years!). Once ingested, the larvae pass from the digestive system to the circulatory system and migrate to the lungs to continue their development. Eventually they rupture the alveoli (air sacs in lungs) and move up the respiratory tract where they can be coughed up and swallowed, relocating themselves to the digestive tract as adults.

Observe the ascaroid specimens and laminated sheets to label the drawings below.

*Ascaris lumbricoides* – label mouth, anus, intestine, male, female, cloaca, seminal vesicle, vas deferens, testis, ovary, uterus, oviduct, seminal receptacle, vagina, genital pore, pseudocoelom
Review Questions:

1. Complete the table below contrasting nematodes with the previously covered phyla.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Porifera</th>
<th>Cnidaria</th>
<th>Platyhelminthes</th>
<th>Nematoda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of organization</td>
<td></td>
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<tr>
<td># Germ layers</td>
<td></td>
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<tr>
<td>Symmetry</td>
<td></td>
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<tr>
<td>Body cavity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestive tract</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Incomplete/complete</td>
<td></td>
<td></td>
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</tbody>
</table>

2. Describe the general shape of a nematode.

3. How does an organism become infected with *Trichinella spiralis*?

4. Which of the parasites examined today are most likely to occur in areas with poor sanitation and sewage disposal? Why?

5. The scientific name for the trichina worm is *Trichinella spiralis*. Explain the species name.

6. Why is the infection percentage higher in children for pinworm infections?

7. What type of structures primarily fill the body cavity of an ascaroid? How is this important to a parasitic lifestyle?

8. Explain the sexual dimorphism seen in ascaroids.

9. Why is *Ascaris* not digested within a host’s digestive tract?
Station 2

The Mollusks - Phylum Mollusca

Mollusks are soft-bodied invertebrates that occupy aquatic, marine and terrestrial environs. There is huge variation in this phylum with some mollusks being sessile filter feeders, others function as locomotive herbivores, and yet others as active predators with advanced body systems.

Mollusks are coelomate protostomes with a complete digestive system. There are three basic parts to the mollusk body: the foot, mantle and visceral mass. The ventral foot is a muscular organ used for locomotion. The foot of many mollusks is adapted to a particular style of locomotion (swimming, digging, etc…). The broad mantle secretes the dorsally located shell if present. The visceral mass is covered by the mantle and includes the internal organs of the mollusk as well as the coelomic cavity.

Most mollusks have an open circulatory system with a muscular heart. The heart pumps the blood across sinuses (open cavities) in the internal organs. Gas exchange occurs in the comb-like gills which are often highly branched or folded to increase surface area. The complete digestive system of a mollusk exhibits good regional specialization with well-developed organs (esophagus, stomach, intestine, etc..). The mouth often contains a coarse, rasping organ called a radula for masticating food. Interestingly, despite these well developed organ systems, cephalization ranges from highly advanced to seemingly absent in the various mollusk groups.

Examples of Mollusks

Chitons (the “coat-of-mail” mollusks)
The primitive-looking chitons are adapted to life along the tidal zones of marine environments. Their body is protected by a dorsal shell consisting of eight overlapping plates (like a suit of armor). Their muscular foot is used for locomotion and allows the chiton to adhere firmly to rocks or shells of other animals in the tidal zone. There may be tremendous turbulence in the tidal zone as waves crash to and fro. By using the girdle portion of the mantle (on the periphery of the eight plates) and the muscular, ventral foot, the chiton creates suction and the overlapping nature of the plates allows the chiton’s body to conform to irregular shapes yet remain protected. As herbivores, chitons use their radula in the large mouth to scrape algae from the substrate. Their ventral gills are used for gas exchange as the movements of the girdle provide a constant current from anterior to posterior. Chitons have a reduced cephalization.

Observe the chiton specimen and label the figure below.
Gastropods (snails and slugs)
Gastropods are an extremely diverse group of mollusks inhabiting many aquatic, marine and terrestrial habitats. The body of all gastropods exhibits torsion during development. Torsion is a 180° rotation of the visceral mass with respect to the location of the foot. It is thought that the ancestral gastropod evolved a heavy shell and this torsion helped to relocate the center of gravity to aid in locomotion.

The muscular foot is often covered with ciliated epidermal tissues and secrets mucus to aid locomotion. Cephalization is somewhat more pronounced and sense organs, like the eyes, are often located on retractable tentacles.

Many living gastropods (i.e. snails) have a coiled dorsal shell secreted by the mantle. This shell offers protection from predators and dehydration in terrestrial forms. Many snails are herbivores consuming plant material using their radula for mastication. Other snails are carnivorous (i.e. cone snails) or are scavenging detritivores.

Slugs have lost the dorsal shell through the evolutionary process and have a large number of secretory cells associated with the epidermis which secrete mucus to maintain their hydration.

Observe the gastropod specimens provided and label the diagram below.

Terrestrial slug and snail. Label foot, dorsal shell, eye on retractable tentacle

Cephalopods (advanced mollusks; squid, octopus, nautilus)
The predatory, marine cephalopods are the most advanced mollusks. They have a well-developed central nervous system, large central brain, and exhibit more complex behaviors. They have a high degree of cephalization with large well-developed eyes and a closed circulatory system which is more efficient at the delivery of materials to the tissues than an open system. The epidermis also contains chromatophores (pigmented cells) which can change colors rapidly. These color changes allow the cephalopod to camouflage itself in its environment or disorient its potential predators. It is thought that some species may even communicate using these color changes.

The foot of cephalopods is divided (modified) into tentacles which have a host of muscular suckers which are used for grabbing the substrate, potential predators or prey. The mantle of a cephalopod is modified to include a muscular funnel. Water taken into the mantle cavity may be forced out through this funnel to provide jet-propulsion locomotion. The movement of this water in and out of the mantle cavity also carries
water across the gills. In most cephalopods, the dorsal shell has been lost and replaced with an internal shell.

The cylindrical _squid_ are fast moving predators. They capture their prey with their tentacles and consume it by tearing bits of flesh with a hardened _beak_ and a rasping _radula_. Squid are adept swimmers and can make rapid movements with burst from their funnel. As a secondary line of defense they may also release _ink clouds_ into the water and seek escape behind these screens.

_Octopi_ have eight large arms with many suckers and are bottom-dwelling cephalopods. Locomotion may include the use of arms to “walk”, undulation of the arms to “swim” through the water or the use of the funnel to “jet” through the water. Octopi also can produce an ink screen to avoid predators. Octopi are predators and may deliver powerful bites with their beaks. Some species are also known to be venomous.

The _nautilus_ is the only cephalopod with an external shell. The shell of a nautilus is chambered. As the nautilus grows, the _body chamber_ (where the body resides) is replaced. The old body chamber walls (called _septa_ ) are connected by a duct that allows gases to be passed into the older, smaller chambers. The addition or removal of gases from these chambers allows the nautilus to regulate its _buoyancy_.

**Observe the cephalopod specimens and compare them to the figures below.**

![Nautilus shells; inner above, external below](Image)

![Squid, ventral view showing funnel](Image)

![Octopus, lateral view](Image)
**Review questions:**

1. Describe the molluskan body plan.

2. Describe how the foot is adapted for locomotion in a:
   - Snail-
   - Chiton –
   - Octopus-

3. What is a radula used for?

4. What are chromatophores?

5. Which group of mollusks has a closed circulatory system?

6. What is torsion?

7. How do squid and octopi use ink?

8. Describe the feeding of a chiton.

9. How does a chiton remain attached to a rock?
Station 3

Bivalves (clams, mussels, scallops and oysters)

Bivalves get their namesake from having a two-part hinged shell (each shell is known as a valve). The sheet-like mantle secretes the valves, which form growth rings as the shells increase in size over time. The valves are hinged dorsally and open ventrally. Each valve has an umbo, or beak, which is oriented just anterior to the hinge. The anterior and posterior adductor muscles are responsible for the closing of the valves. Located along the hinge, the hinge ligament provides elastic antagonistic resistance to allow the valves to open when the adductor muscles relax.

Cephalization is highly reduced in bivalves. Most bivalves have limited locomotive abilities and use their ventral, muscular foot for burrowing.

Most bivalves are filter-feeders. Water flows into and out of the bivalve through a pair of posteriorly positioned siphons (formed from folds of mantle tissue). Water enters through the ventral incurrent siphon and flows toward the anterior across the comb-like gills. A pair of labial palps is located around the mouth and assist with the ingestion of suspended nutrients.

Nutrients pass into the stomach where enzymes secreted from the digestive gland break them down chemically. Digested particles are taken to the coiled intestine where absorption occurs and waste is formed. These digestive wastes are passed through the anus and are swept from the body with water flowing out of the dorsal excurrent siphon. The gonads are also located in the visceral mass and surround the intestine. Gametes will also be released as water passes out of the excurrent siphon. The open circulatory system includes a muscular heart which surrounds the intestine as it passes through the coelom.

Use the model and the laminated sheets to label the figure below.
**Review Questions:**

1. Name the muscles which are responsible for closing the shell of a clam.

2. Name the structure in a clam that produces the hinged shell.

3. Which structure is responsible for providing the movement which opens the shell of a clam?

4. What is the function of a labial palp?

5. Describe the circulatory system of a bivalve.

6. Digestive enzymes are secreted into the stomach from which structure?

7. The intestine is the longest digestive organ, why?

8. Which structures are responsible for the flow of water into and out of the bivalve?
**Class activity:**

**Dissection of freshwater mussel**

Obtain a freshwater mussel and place it in the dissection pan provided. Examine the external anatomy using the laminated sheets as a guide. Examine the growth rings on each valve. These rings grow concentrically and the ‘youngest rings’ are towards the edge of each valve. Notice the umbo is oriented towards the anterior of the clam and the valves hinge dorsally and open ventrally. The hinge is covered by the hard hinge ligament.

Your preserved mussel is in a relaxed state, so the valves should be open slightly. Carefully use a scalpel to cut each adductor muscle with a transverse incision. When you have completed these two incisions, you should feel the valves ‘relax” and you may simply pry open the valves to expose the internal anatomy.

Observe the sheet-like mantle which is loosely attached to each valve and covers the visceral mass and the foot. Carefully look for the incurrent and excurrent siphons which appear as folds of mantle tissue. Locate the paired gills which are used for gas exchange cover the muscular foot. A pair of labial palps is located near the mouth opening.

If you wish after you observe these structures and label the drawings below, you may make an incision in the visceral mass to expose the stomach, heart and other internal organs.

External anatomy – label umbo hinge ligament, growth rings, dorsal, ventral, anterior, posterior

Internal anatomy – label posterior and anterior adductor muscles, foot, gills, labial palps, mantle, mouth, incurrent and excurrent siphon