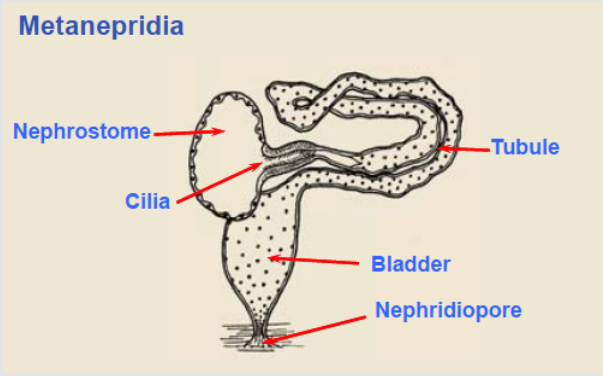
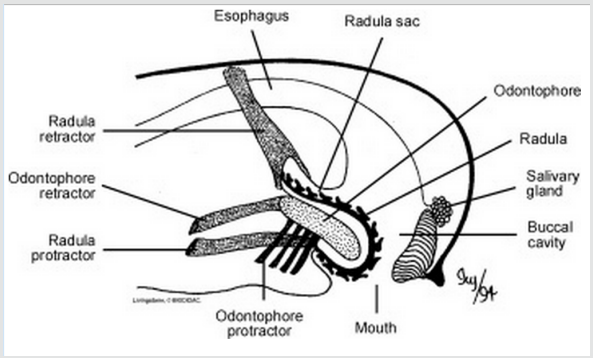
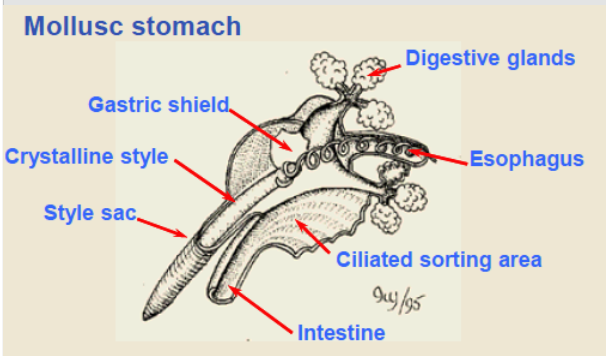
Keyword	Definition
———PHYLUM MOLLUSCA	**PHYLUM MOLLUSCA———**
Mollusca autapomorphies	• Radula • Dorsal mantle • Calcerous spicules or shells • Ventral ciliated muscular foot • Retractor muscles • Tetraneural nervous system • Veliger larva
Mollusca phylogeny	• Aplacophora • Polyplacophora • Monoplacophora • Gastropoda • Cephalopda • Scaphopoda • Bivalvia
Trochozoans	• The free-swimming ciliated larval stage found in a number of animal phyla including the Mollusca and Annelida • The larvae have a unique circle of pre-oral cilia around the middle of the body. • They have a complete gut (Mouth + Anus) • Apical tuft - Cilia at the top keep the organism properly oriented • Band of cilia that run around the body of the larva making a water current to bring water/food particulates to ingest • That cilia propels the organism in the water • Trochophores are often considered an ancestral characteristic of protostomes
Metanephridia 	• An excretory-osmoregulatory organ consisting of a ciliated funnel, the **nephrostome**, which is connected to **tubules** that lead to the **external nephridiopore**. The nephrostome collects coelomic fluid to produce the urine. • **Nephrostome** - Open-ciliated funnel of the metanephridium; moves coelomic fluid directly into the metanephridium without ultrafiltration • **Nephridiopore** - External openings to nephridia (protonephridia and metanephridia) in invertebrate excretory systems. • Usually associated with the circulatory system to return nutrients • The gonads release their sperm into the metanephridia so that it can be ejected out of the organism and into the water.

Keyword	Definition
Open circulatory system with a pericardial cavity	• Mollusks have an **open circulatory system**. In a **closed circulatory system**, exchange between the circulating blood and various tissues and organs occurs across capillaries. They're missing in an open circulatory system. Instead, blood pools in spaces or cavities, the **hemocoel**, and bathes the organs and tissues. • The **hemocoel** is the main body cavity of a mollusc and an important part of how molluscs move. There is a true coelom, but it is small, surrounding the heart. That's how it gets its name, the **pericardial cavity**. • Gonads are found on the wall of the pericardial cavity and the funnel-shaped opening **nephrostomes** of the **metanephridia** filters the coelomic fluid in the cavity to remove metabolic wastes. • The nephridiopore opens into the **excurrent flow** of the mantle cavity. With the exception of the cephalopods and their closed circulatory system, molluscs have an open circulatory system. • The heart lies inside the dorsal, pericardial cavity pumping blood that has passed from the **ctenidia**, ctenidia out aortas that carry blood to different parts of the body before emptying into the hemocoel. Oxygen-carrying capacity of mollusc **hemolymph** is enhanced by the use of the respiratory pigment **hemocyanin**.
Calcerous shell	• Molluscan shell is composed of three components: • Outer **periostracum -** Consists of chonchin, a protein that protects the underlying layers from damage. • Middle **prismatic layer** • Inner **nacreous laye**r - Consists of thin layers or calcium carbonate crystals (aragonite), continually produced by the mantle surface. It is very smooth because it is adjacent to living tissue. • A **pearl** is formed by a grain of sand that is in between the mantle and the shell. The mantle feels the abrasion and begins to secrete nacre and that nacre surrounds the sand particle until it is completely surrounded by it making a pearl.

Keyword	Definition
Mantle	• The shell originated as a defensive strategy by early molluscs to protect themselves using **calcareous spicules**, or spines, embedded in their outer epidermis. • Over time, the spicules became larger, forming plates that later fused with each other to create a solid shell covering the entire dorsal surface of the animal. The specialized epidermis and its gland cells that produced the shell are the **mantle**. • **Retractor muscles** attached to inner surface of the shell extended into the foot on the ventral side and when these muscles contracted the shell was pulled down against the substrate. The mollusc hid inside waiting for whatever danger lurked outside to go away. • The problem associated with gas exchange and diffusion which was reduced by the surface area of the shell was solved by extending the shell over the edge of the body, creating an open space underneath it-the mantle cavity and the increased surface area for gas exchange occurs as gills that developed inside the cavity. • The mantle epithelium is **tri-lobed**, one is sensory, one is adding more shell, and the other is a muscle component that connects everything together.
Tetraneural nervous system	• The mollusc body is often described as a ciliated visceral mass sitting atop a muscular foot, and this is reflected in the organization of the nervous system. • Most protostomes have a single pair of nerve cords that run the length of the body. • This is not the case in molluscs, where **a pair of nerves supplies the visceral mass and a second pair the foot**. • The result is that there are **four major nerve cords**, and this why the nervous system is referred to as **tetraneural**. • The apical brain and subesophageal ganglia have fused to form a ring around the esophagus, and the two pairs of nerve cords attach to the brain.

Keyword	Definition
Ctenidium	• Mollusc gills are called **ctenidia** and when the cilia that cover them beat, water is pulled into the mantle cavity, across the surface of the ctenidia, and out the cavity. The ctenidia are hollow and the spaces inside of them are part of the hemocoel. As blood flows through ctenidia, it is oxygenated by the water passing by the outer surface. • Once the water is past the ctenidia and on its way out, it goes by the openings of the metanephridia, gonad, and anus picking up gametes, if it's the reproductive season; metabolic wastes; and any undigested food from the alimentary tract, carrying it away from the mollusc.
Ciliated ventral muscular foot	• Two sets of muscles (four muscles); **dorsoventral muscles, transverse muscles**. • The two sets of muscles work in combination with the blood in the hemocoel, the third part, to form a hydrostatic skeleton. When the dorsoventral muscles contract, the transverse muscles contract at the same time, the result is that the box can only increase in length. • The edges of the raised space underneath the contracted dorsoventral muscles are sealed to the substrate by mucus, like a small suction cup. As the dorsoventral muscles at the back of the suction cup contract, lifting that end, the dorsoventral muscles at the front relax. • A wave of contractions moves toward the back of the animal as the animal moves forward, a **retrograde** wave. • Cephalopods, the muscular mantle forces water from the mantle cavity out the funnel to jet propel them through the water

Keyword	Definition
Radula 	• Molluscs were the first animals to scrape organic matter from the substrate using their unique **radula**, essentially a biological **file or scraper**. The scrapings are trapped in mucus and pass through the mouth to a stomach where digestion starts. • A tongue covered with teeth and works like a file to rasp food off of the substrate • As the radula grinds away at the substrate, the teeth on the end are worn down. They're replaced by new teeth added at the back of the radula, which, as it grows, moves forward on the surface of the **odontophore** • The usual solution for getting particulate food into the digestive tract is to trap it in mucus and then use cilia to propel the food-laden string of mucus into the mouth • The radula lies on top of the **odontophore** that is pulled in and out of the mouth as the snail feeds. In addition to the movement of the odontophore, **radular muscles** move the radula back and forth on the surface of the odontophore.
Digestion **DO NOT CONFUSE CILIARY SORTING FIELD WITH SETAL SORTING FIELD**	• Ingested food passes through the pharynx and esophagus to the stomach. In continuous feeding species, the crystalline style is present and releases digestive enzymes to initiate digestive processes completed in the digestive gland where suitably sized food particles enter after passing through ciliary sorting fields. • In carnivorous species that aren't continuous feeders, the crystalline style and style sac are missing, although the role of the digestive gland remains the same. • Final digestion is intracellular, and undigested food passes from the stomach to an intestine and anus.

Keyword	Definition
Crystalline style  **DO NOT CONFUSE CILIARY SORTING FIELD WITH SETAL SORTING FIELD**	• In many molluscs a **crystalline style** (A rodlike structure in some mollusc stomachs made of **enzymatic proteins** required for digestion. Cilia lining the stomach rotate the crystalline style, which grinds against the **gastric shield** to release the digestive enzymes) helps to wind the mucus string into the stomach where ci**liary sorting fields** in the stomach send only appropriately sized food particles into the digestive gland for final intracellular digestion. Larger particles pass to an intestine and an anus, which opens into the excurrent flow of the mantle cavity. • **Crystalline style** - A rodlike structure in some mollusc stomachs made of enzymatic proteins required for digestion. Cilia lining the stomach rotate the crystalline style, which grinds against the gastric shield to release the digestive enzymes. • **Style sac** - Houses the rotating crystalline style in the mollusc stomach. Cilia lining the style sac rotate the style that releases digestive enzymes into the stomach as it winds the mucus string of food into the stomach • **Gastric shield** - A thickening of the stomach wall in some mollusks for mixing the contents. • **Ciliated sorting fields** - They sort the food by size and send it into the intestine

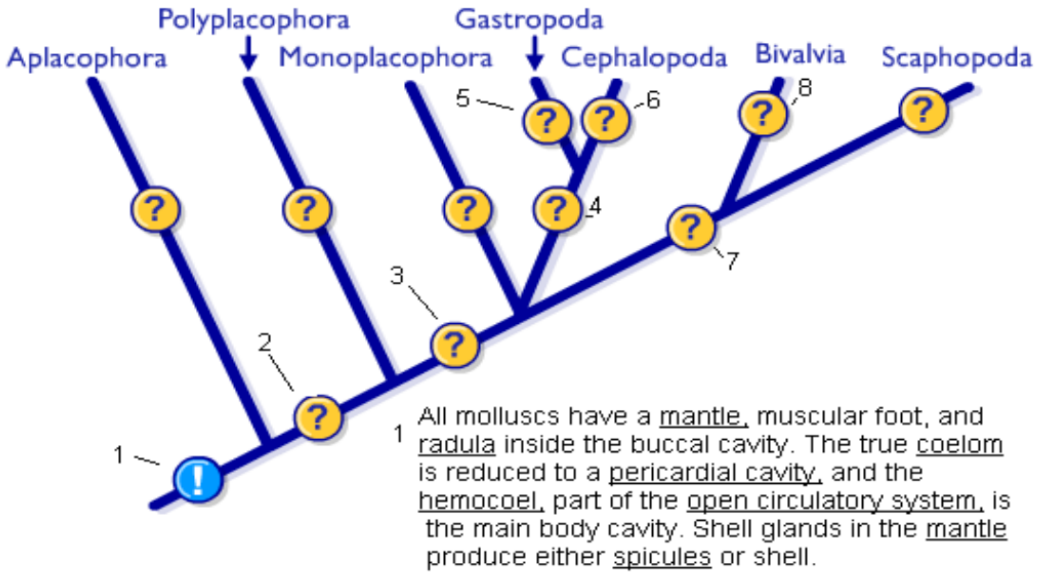
Keyword	Definition
Torsion	• During development, the visceral mass that sits on top of the foot **undergoes a 180-degree rotation**, and the mantle cavity that originally opened behind the animal now opens to the front and on top of the head. • At first glance it might seem like a good idea to have the mantle cavity and its sensory structures facing front and sampling the water where the animal is going rather than where it had been. But there's also a disadvantage. • However, in its new position, wastes from the excretory system and fecal material from the anus **drop right on top of the head** and where the animal is feeding. • Two conflicting hypotheses are used to explain why. One is that torsion was an **advantage for the larval stage** in that the animal could quickly retract its head into the shell for protection. The other is that it was advantageous for the adult, so that it could sample water from in front rather than behind. • ***Whichever is the case, much of the diversity in the shapes and forms of gastropods have resulted from overcoming torsion's disadvantages by repositioning the anus, **detorsion**, and changing water flow through the mantle cavity. *** • One of the consequences of torsion is that gastropods are **asymmetric**.
Veliger larva	• Modified trochophore larval stage • The general structure of the veliger includes a shell that surrounds the visceral organs of the larva and a ciliated velum that extends beyond the shell as a single or multi-lobed structure used for swimming and particulate food collection.

Keyword	Definition
Reproduction	• Most gastropods are **dioecious**, and the single gonad releases gametes into the coelomic fluid and out through the metanephridia. • This ancestral pattern is extensively modified in different gastropods, and some species are monoecious. • Fertilization may be external or internal. When it is internal, the eggs are laid in egg masses. Terrestrial species lay individual yolky eggs, and some are viviparous. • In marine species, eggs develop into a **veliger larva** before undergoing metamorphosis into an adult. In terrestrial species, development is direct. • **Ovotestis** - A gonad with both testicular and ovarian aspects. • **Dart Sac** - A sac connected with the reproductive organs of land snails, which contains a dart • **Dart** - When both snails meet they try to poke a dart into the other snail. love dart is used by the male component to manipulate the female component's sperm collection, increasing paternity
***Cephalopoda Autapomorphies ***	• Closed circulatory system • Ink sac • Modifications of the foot • Beak-like jaw • Cartilaginous brain case
Cephalopoda	• Cephalopods are the most complex of the molluscs and include squids, octopods, cuttlefish, and nautiloids • Ancestral cephalopods had heavy, chambered shells and lived in only the last chamber; today only the nautiloids have shells. • In other cephalopods, the shell is either reduced, internalized, or has **disappeared**. • Loss, or reduction, of the shell was essential if cephalopods were to be the agile rapid predators they have become. • The mantle is now muscular and surrounds the visceral mass. Expansion of the mantle **pulls water into the mantle cavity**, and **contraction forces it out the funnel** and jet propels the animal forward. • Paired ctenidia are suspended in the mantle cavity but lack the cilia usually found on the surface of mollusc gills, a modification made possible by the mantle pumping water and not the cilia.

Keyword	Definition
Squid tentacles	• The foot, which **forms the funnel**, is adjacent to a head surrounded by arms or tentacles, a modified part of the head used to capture prey.
Squid Digestion	• Squids evolved into having a bi-lobed digestive system. • One lobe is the stomach which breaks down the food • One lobe is the cecum and it's for absorption • At the center of the arms is a **chitinous beak** that crushes and tears apart prey; the radula is still present inside the **buccal cavity**. A muscular esophagus leads to the stomach connected to a large **cecum** where food mixed with digestive enzymes is stored. • The **digestive gland** is enlarged, and part of the gland forms the spongy "pancreas" that produces digestive enzymes while another part forms the larger "liver" where extracellular digestion and absorption of nutrients occurs. • Many cephalopods have an **ink sac** that also opens near the anus.
Squid gas exchange and circulatory system	• Unlike other mollusc, cephalopods have a **closed circulatory system** which includes three hearts; **paired branchial hearts** (push blood to gills and then to single systematic heart) and one **systematic heart** (pushes blood through entire body). • Blood flows to the heart, it passes through the renal sac and metabolic wastes diffuse from the blood to the fluid in the sac that is then filtered by metanephridia that open into the sac.
Squid Reproduction	• Most cephalopods are **dioecious**, and the gonads are located at the posterior end of the body and open into the mantle cavity. • Sperm in the males is packaged in a **spermatophore** and passed to the female using the ****hectocotylus arm***** inserted in the female's mantle cavity. • The spermatophore opens releasing the sperm into the mantle cavity where it fertilizes the yolky eggs as they leave the oviduct. Fertilized eggs are often laid in a protective gelatinous covering or in strings. There are no larval stages; a miniature adult hatches from the egg. • **Nidemental glands** - Involved in the secretion of egg cases or the gelatinous substance comprising egg masses.

Keyword	Definition
Squid color production	• Cephalopods are also masters of disguise, capable of changing their color to match their surroundings. • To do this, they use **elastic capsule chromatophores** that cover their bodies. • In addition to changing colors, many cephalopods, especially those that live in the deeper parts of the ocean, use **bioluminescence**. • **Chromatophore** - Specialized pigmented cells on the surface of cephalopods that, by changing their shape, expose differing amounts of pigment changing the color and appearance of the cephalopod • **Bioluminescence -** Uses flashing light to communicate
Bivalvia Autapomorphies	• Loss of radula • Lateral compression of the body • Ctenidia and mantle cavity specialized for filter feeding
Bivalve structure	• The oldest part of the shell is the **umbo**, and concentric growth rings surrounding the umbo result from new shell added by the secretory lobe of the mantle located under the shell's edge. • The two shell halves, or valves, are connected along the dorsal surface by an **elastic hinge ligament** and are the origin of the name Bivalvia-two shelled. • The bivalves have two **adductor** muscle. When the adductor muscles are relaxed, the elasticity of the hinge opens the shell; contraction of the muscles closes it. • To prevent dirt or debris from getting between the mantle tissue and the inner surface of the shell, the mantle's edge is held tight to the shell along the pallial line. If anything does get in, it's covered in nacreous material to prevent any damage to the delicate mantle; that is how a pearl is formed. • Water flows into the mantle cavity through a ventral incurrent channel and out the dorsal excurrent channel, both formed when the two sides of the posterior mantle come together. In some species, permanent siphons separate the incurrent and excurrent flows.

Keyword	Definition
Bivalve locomotion	• The foot is laterally compressed and is used for **burrowing**. The hemocoel inside the foot acts as a **hydrostatic skeleton** and works in combination with pedal protractor muscles. • Hydrostatic pressure extends the food into the substrate followed by a swelling of the tip to anchor it in place. The pedal protractor muscles contract while the shell opens and closes and digs as the muscles pull the bivalve deeper into the substrate.
Bivalve circulatory system/Nervous	• **Open circulatory system.** • Nephrostomes of a pair of metanephridia open into the pericardial cavity and filter its fluid, eliminating their wastes through a nephridiopore that opens in the excurrent flow of the mantle cavity. • The nervous system consists of a nerve ring that surrounds the esophagus, and two nerve cords extend into the foot and to the visceral mass.
Bivalve Ctenidia	• The gills have evolved into becoming a feeding structure
Bivalve reproduction	• Most bivalves are **dioecious** with their gonads embedded in the foot and release their gametes into the pericardial cavity and out the nephridiopores. • In most, **fertilization is external**; cleavage is spiral, which results in a trochophore larva, and then a veliger that ultimately forms a small bivalve that sinks to the bottom. • In freshwater forms, eggs are brooded inside the demibranchs and are fertilized by sperm in the water flowing through ctenidia. • ***In some freshwater bivalves, the veliger stage is replaced by an ectoparasitic **glochidium** larva that attaches to the gill surface of a fish before forming a new small bivalve that settles to the bottom.*** • **Glochidium -** This larva form has hooks, which enable it to attach itself to fish (for example to the gills of a fish host species) for a period before it detaches and falls to the substrate and takes on the typical form of a juvenile mussel. Since a fish is active and free-swimming, this process helps distribute the mussel species to potential areas of habitat that it could not reach any other way



(2) **Shell glands** are concentrated in specific locations in the **mantle** and produce a **solid shell**. The mantle forms a fold, or cavity, around at least part of the body. The gut is more complex and includes **digestive glands** and unique musculature for moving the **radula**. The large muscular foot moves by ripples of contractions that run down its length.

(3) The shells are all **univalved**, **folded** in **bivalves**, constructed of three layers: **periostracum**, **prismatic**, and **nacreous layers**. The **mantle margin** has three folds, and a **crystalline style** is found in the alimentary tract.

(4) The body is lengthened along the dorsal-ventral axis and the enlarged **dorsal visceral mass** is inside a coiled shell. The head is well defined, and the **mantle cavity** is found only in the **anal area**.

(5) **Torsion** results in a whole series of anatomical changes, and there is further concentration of the body organs in the dorsal visceral mass. **Asymmetric** body plan.

(6) **Closed circulatory system**; **ink sac**; and modification of the foot into arms, **tentacles**, and a **funnel**. **Septate shells**, beak-like **jaw**, and a **brain** contained in the **cartilaginous** case.

(7) Shared characters associated with a sedentary existence include **reduction** of the **head** and a **decentralized nervous system**. The foot has become modified for digging and anchoring the animal, and the mantle is folded to create a mantle cavity that surrounds the body.

(8) **Radula** is **lost**, and the body is laterally compressed with the result of folding the univalve into the **hinged bivalve** shape. **Ctenidia** and mantle cavity modified for **filter-feeding**.

Keyword	Definition
———PHYLUM ANNELIDA	**PHYLUM ANNELIDA ———**
Annelida Autapomorphies	• Metamerisim of mesodermal structures • Four bundles of setae formed from beta-chitin
Symplesiomorphies	• Schizocoel, and metanephridia filtering coelomic fluid • Dorsal heart and pericardial cavity
Different classes	• **Marine Worms** (Class **Polychaetes**) • **Earthworms** (Class **Oligochaeta**) • **Leeches** (Class **Hirudinea**).
Nitrogenous waste	• Openings to the **metanephridia** collect coelomic fluid from the body cavity and filter it, removing nitrogenous wastes. • **Urea** in terrestrial species • **Ammonia** in aquatic worms.
Metamerization	• To become larger animals, annelids have repeated coelomic units, end to end, adding the new segments in front of the anus. • **Serially homologous** segments that repeat down the length of the animal. • Each segment is a **metamere** and gives annelids their segmented look. Each metamere is seperated by a **septa** • The segments grow inbetween the **peristomium** and **pygidium**. • **Prostomium** - The most anterior part of an annelid found just in front of the mouth it. - Not a true segment • **Peristomium** - The part of the body behind the prostomium in annelids that contains the oral opening. - Not a true segment and has no setal hairs • **Pygidium** - The most posterior part of a segmented animal that houses the anal opening. The pygidium is not a true segment • Ancestrally each one of these metameres were identical to the one next to it. • Each segment as a complete independent organism with its own excretory system, circular and longitudinal muscles to work the fluid-filled coelomic fluid as a hydrostatic skeleton, and a ganglion to coordinate events in the metamere. • There were also paired metanephridia to filter coelomic fluid and remove metabolic wastes, as well as paired gonads on the septal wall of each metamere.

Keyword	Definition
Setae formed from Beta-Chitin	• There are two types of chitin: • **Beta** - Chitin - The fibers/molecules of chitin are arranged in the same direction. The weaker one of the two types of chitin. - Characteristic of everything that isn't an Arthropod. • **Alpha** - Chitin - The fibers/molecules of chitin are Arranged in opposite directions. This is a much stronger because the ends of the fiber strands interlock together making it very robust. - Characteristic of Arthropods.
Body wall - Earthworm	• The body wall of the earthworm is made up of the: • Epithelium, circular muscle, inner longitudinal muscle, a coelomic space and **4 sets of setae** poking out of the space in between each segment.
Locomotion - Earthworm	• The earthworm uses it circular and longitudinal muscles like a hydrostatic skeleton to move. • Individual **metameres** can be lengthened, with the associated decrease in diameter, or shortened, with an increase in length, without affecting the shape of the adjacent segment. • However, simply using the muscles to move wasn't very efficient because it would only slide on the substrate when it really needed to move and maneuver itself. • The earthworm uses setae to anchor itself into the substrate and push itself away from the anchor. • Basically the worm would anchor itself into the ground and then it can either stretch itself forward —>anchor itself again —> retract the setae at the back—> pull itself forward —> rinse and repeat • The metameres and setae are key to the success of the group because they could get into a new food source that no other organism has tapped into before.

Keyword	Definition
Digestive system - Earthworm	• The digestive system consists of the **pharynx**, the **esophagus**, the **crop**, the **intestine** and the **gizzard** • The earthworm is a burrower. Because it is not strong enough to push soil out of the way it ingests it and puts it into its digestive tract. • This allowed the earthworm to tap into a new food source that no other organism has fed on before. • Food such as soil enters the earthworm's mouth where it is swallowed by the pharynx. • Then the soil passes through the esophagus, which has **calciferous glands** that release calcium carbonate to rid the earthworm's body of excess calcium. • After it passes through the esophagus, the food moves into the **crop** where **it is stored** and then eventually moves into the gizzard. • The **gizzard** uses stones that the earthworm eats to grind the food completely. • The food moves into the intestines as gland cells in the intestine release fluids to aid in the digestive process. The intestinal wall contains blood vessels where the digested food is absorbed and transported to the rest of the body. • **Chlorogogue tissue** - Involved in intermediary metabolism and the deamination of amino acids. Comparable to the liver in humans. • **Typhlosole** - It is a dorsal flap of the intestine that runs along most of its length, effectively forming a tube within a tube, and increasing the absorption area by that of its inner surface. Its function is to increase intestine surface area for more efficient absorption of digested nutrients.
Metanephridia - Earthworm	• They are arranged segmentally along the worm. • The metanephrida filters the coelomic fluid and then the fluid is secreted out of the nephridiopore to keep the skin moist so that the earthworm can breathe. • The nutrients are filtered out of the coelomic fluid before it is secreted out of the nephridiopore. • They package their nitrogenous waste as urea, and that fluid covers their bodies.

Keyword	Definition
Circulatory system - Earthworm	• Gas exchange occurs across the body wall, modified into gills in some species. • Large annelids use respiratory pigments to increase the oxygen carrying capacity of blood that flows in a **closed circulatory system**. • A contractile **dorsal vessel** pushes blood forward, and a **ventral vessel** moves it toward the back. • Connecting the two major blood vessels are capillary beds: in the body wall, where it's oxygenated; in the gut wall, where it picks up nutrients; and surrounding the **metanephridium**, where it recovers essential components from the coelomic fluid inside. • **Aortic arches** - There are five pairs of aortic arches, which have the responsibility of pumping blood into the dorsal and ventral blood vessels. • **Dorsal vessel** - Moves blood towards the front of the worm • **Ventral vessel** - Moves blood towards the back end of the worm. • The **aortic arches** distribute blood to the reproductive structures and then follows the usual path it would follow in the body. • Connecting the two major blood vessels are capillary beds: in the body wall, where it's oxygenated; in the gut wall, where it picks up nutrients; and surrounding the **metanephridium**, where it recovers essential components from the coelomic fluid inside
Nervous system - Earthworm	• The nervous system is well developed with a paired ventral nerve chord and an anterior brain that lies on top of the pharynx. Sensory structures, eyes, and tentacles are found on the heads of swimming and predatory annelids. • There is a ganglion in each segment. It everything that is going on in that segment like controlling all the muscle movements. • **Suprapharyngeal ganglion** - Above the pharynx • **Subpharyngeal ganglion** - Below the pharynx • **Ventral nerve cord** - A nerve cord that runs down the worm • **Giant axon** - There are a series of these giant axons in the nerve cords. It causes all of the longitudinal muscles to contract. It allows worms to contract rapidly back into their burrow to escape predators. IT IS AN ESCAPE MECHANISM.

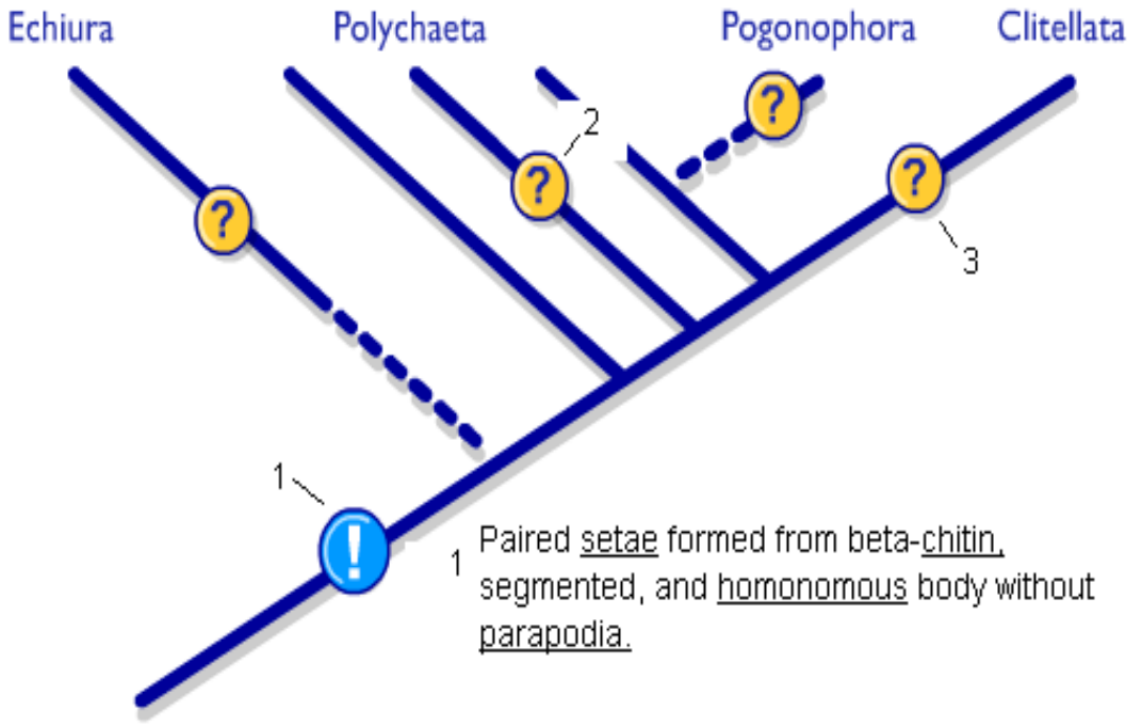
Keyword	Definition
Reproductive system - Earthworm	• Earthworms are hermaphroditic • These are monoecious worms that mutually cross-fertilize, have a secretory **clitellum**, and place their eggs inside **protective cocoons** where they develop directly into small worms rather than ciliated larva. • **Clitellum** - A thickened glandular and non-segmented section of the body wall near the head in earthworms and leeches, that secretes a viscid sac in which the eggs are deposited - Its main function is to store the eggs of the worm. • **Cocoon formation** - Copulation and reproduction are separate processes in earthworms. The mating pair overlap front ends ventrally and each exchanges sperm with the other. The clitellum becomes very reddish to pinkish in color. Some time after copulation, long after the worms have separated, the clitellum (behind the spermathecae) secretes material which forms a ring around the worm. The worm then backs out of the ring, and as it does so, it injects its own eggs and the other worm's sperm into it. As the worm slips out of the ring, the ends of the cocoon seal to form a vaguely lemon-shaped incubator (cocoon) in which the embryonic worms develop. They emerge as small, but fully formed earthworms
Nereid (Polychaeta) - Movement	• **Errent** Polychaeta - A free living worm (Crawls along the substrate and sometimes it swims) • **Nereid Movement:** • Each segment contains a pair of bilobed **parapodia** with bundles of setae on each. • Parapodia increase the body surface available for gas exchange and are highly vascularized. • **Notopodium -** Upper lobe of parapodia • **Neuropodium -** Bottom lobe of the parapodia • The parapodia are moved by means of **oblique muscles**. • They have 4 muscle bands. 2 on the top and 2 on the bottom. • When the Nereid wants to move it will contract a pair of muscle bands on one side and alternate these contractions —> Making an “S” type of movement. This movement is also incorporated with the anchoring of the parapodia. • It “sticks and pivot around the parapodia”

Keyword	Definition
Nereid (Polychaeta) - Head	• The polychaetes anterior head is filled with sensory structures. It has tentacles, palp and eye cups that are all tactile and chemoreceptive • If something crawls in-front of a Nereid and stimulates the eye cups, its jaws will shoot out and eat the prey. The pharynx is lined with teeth so that the prey cannot escape.
Nereid (Polychaeta) - Circulation	• There is a ventral and dorsal vessel to carry blood • However, there is a capillary system that runs through the parapodia. The parapodia are essential for gas exchange.
Nereid (Polychaeta) - Reproduction	• Only when the polychaetes is in its reproductive cycle will the gonads appear in each septal wall. They will fill the coelomic space with eggs or sperm, which will be released through the nephridiopores. • Some polychaetes that grow specific segments which they will fill with sperm or eggs depending on if they are male or female. The segment is broken off which is free swimming and rises in the water column and then burst and release sperm and eggs into the water.
Leeches (Hirudinea) — Body wall and locomotion	• The former annelid classes of Oligochaeta, and Hirudinea, have been combined into one class named the **Clitellata**. • Burrowing has **streamlined the body** of the oligocheate, and sensory structures are placed in pits and are referred to as **epithelial sense organs**. • Eyes aren't of much use to a burrowing annelid but are important for the leeches **trying to find a meal**. • They have surrendered the large coelomic space that defined the phylum annelida • They are similar to flatworms because they have **circular**, **longitudinal** and **dorsoventral muscles**. Allowing them to create wave like undulations • They have 2 suckers at their anterior and posterior end allowing them to move. • The body cavity has been reduced down to a series of spaces or sinuses • All of the organs and structures of the leech have a layer of the body cavity around them. • Everything is “shrink wrapped” down. • Taken coelomic space and **reallocated** the space to enlarge the gut.

Keyword	Definition
Leeches (Hirudinea) — Feeding	• The clitellate gut is divided into specialized regions that include all of the following: • A pharynx— to suck food in (includes teeth in leeches) • **Crop** - Stores the food. It also has multiple cecum on either side of it • **Intestine** - Absorbs the nutrients from the food. It also has multiple cecum intestinal cecum on either side. • The space that used to simply fill up the coelom with mesenchyme can now be used to increase the surface area of the digestive system (**Primarily the cecum**) ———————————————————— • In blood-sucking leeches, salivary glands secrete **anticoagulants** of medical importance. • The anticoagulant is a blood thinner which enhances the circulation of blood. • The medical leech prefers venus blood that is pooling on its way back to the heart.
Leeches (Hirudinea) — Reproduction	• These are **monoecious** worms that mutually cross-fertilize, have a secretory clitellum, and place their eggs inside protective cocoons where they develop directly into small worms rather than ciliated larva.

Keyword	Definition

Annelid phylogeny



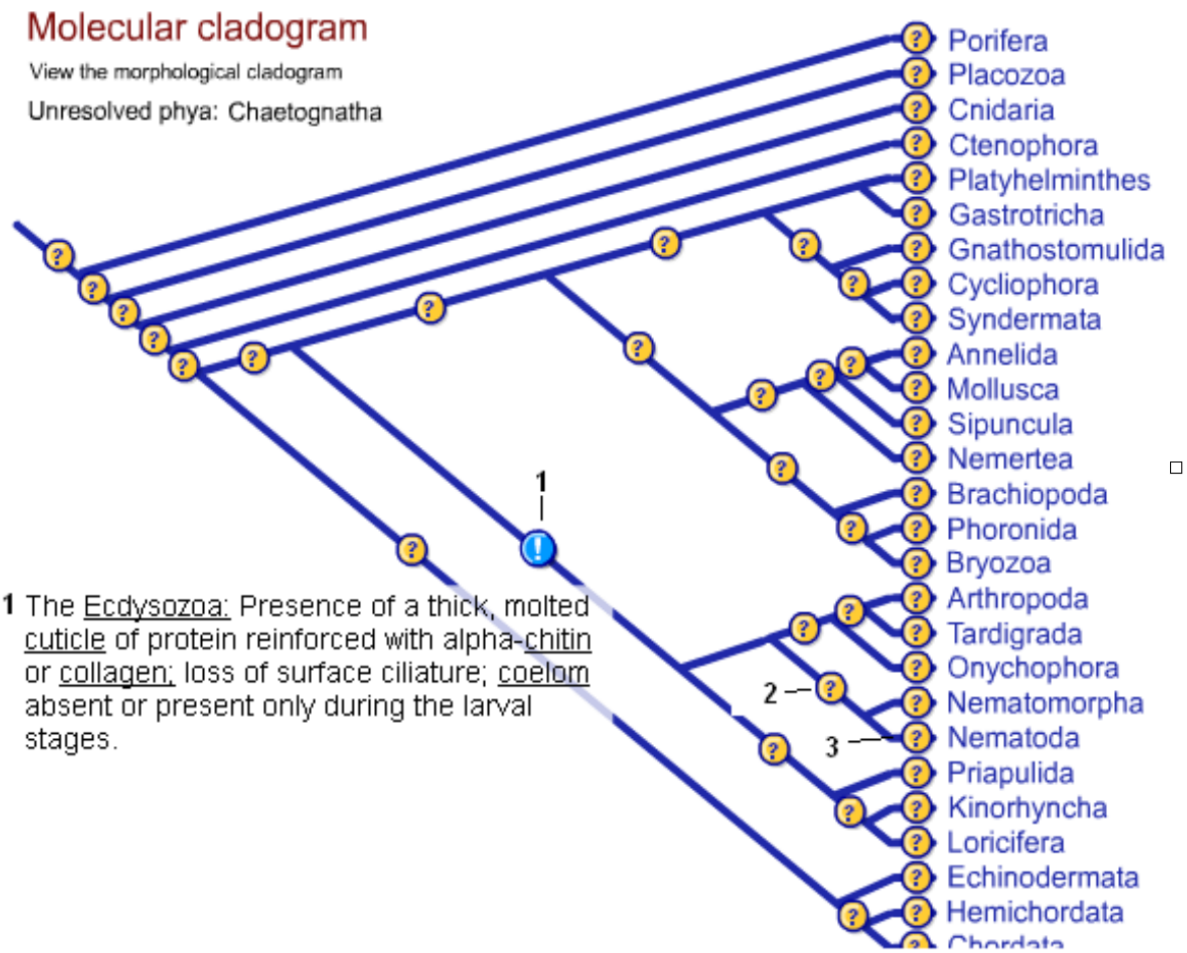
(2) Polychaetes probably aren't monophyletic but the following characteristics are often used to describe the taxon: parapodia, nuchal organs, absence of permanent gonads that form on the septal walls, and a complex prostomium.

(3) Terrestrial, permanent gonads restricted to a few segments, direct development, monoecious, clitellum, and eggs in cocoons.

Keyword	Definition
———PHYLUM NEMATODA	**PHYLUM NEMATODA———**
Nematoda (Autapomorphies)	• Pair of ampids • Epitheliomuscular pharynx • Three circumoral rings with 6,6,4 sensilla in the rings
Ecdysozoa (Autapomorphies)	• Moulted protein cuticle reinforced with alpha - chitin or collagen • No surface cilia • Loss of the coelom
Symplesiomorphies	• Collagenous cuticle without microvilli • Longitudinal but **no circular muscles**
Nematoda - General Information	• They are **psuedocoelomates** (They have mesoderm around the outside but no mesoderm around their gut) • They are **bilaterally** symmetric • The body is covered with a **collagenous cuticle** produced by an underlying epidermis, syncytial (This creates a multinucleate cellular appearance for a tissue that appears to lack cell boundaries) in some species.
Nematoda - Body Wall	• Consist of a cuticle lining the outside • Gas exchange occurs across the cuticle, which in parasitic forms is also important for absorbing nutrients from their host. • Gut with no mesoderm surrounding it • Nematodes have **only longitudinal muscles**, and with a single fluid-filled **pseudocoel** acting as a hydrostatic skeleton, any contraction of the musculature alters the shape of the whole animal • **Renette cells** - They run down the nematode on both sides. Unique cells found in nematodes believed to be involved in osmoregulation and elimination of metabolic wastes
Nematoda - Nervous system	• Every single muscle cell has a cytoplasmic extension of itself that it takes directly to the nerve cord. • A nerve ring surrounding the pharynx is connected to four or more nerve cords that run the length of the animal. In an unusual twist rarely seen in animals, in nematodes, instead of having nerves that connect the nerve cord to muscles, the muscles extend their own arms, cytoplasmic extensions, to connect with the nervous system.

Keyword	Definition
Amphids	• The arrangement of the sensory papillae in two rings of six on the lips and an outer ring of four on the head is unique to nematodes. • The papillae are small bumps on the cuticle surface and the presence of pores on the innermost ring of papillae suggests they are chemosensory; the other papilla don't have a pore and are assumed to be mechanoreceptors. In addition to the papillae, a single pair of amphids is located on the sides of the head and at the base of the lips. • The **amphid** consists of indentation of cuticle forming a small pocket at the base of which there are chemosensory cells. • **Amphid** structure is controversial and they appear to be modified cilia; the controversy arises because ecdysozoans are supposed to have lost all their ciliated structures.
Epitheliomuscular Pharynx	• Because of the constant hydrostatic pressure on the pseudocoelom, nematodes have a system of circular muscles forming valves in the pharynx so they can swallow food. • When the **posterior valve closes**, the **anterior opens** and the pharynx sucks in food. • When the **anterior valve closes**, the **posterior opens** and the pharynx contracts pushing food into the intestine. • With only one valve, as soon as its musculature relaxed the hydrostatic pressure on the intestinal wall would squeeze the food in the gut out the mouth. The pharynx has a triradiate arrangement of muscles
Nematoda - Reproduction	• The sexes are separate and show dimorphism. • In the males the genital opening is at the posterior tip • In the females, which are larger than the males, the opening is midway down the body. • Fertilization is internal and copulatory spicules hold the male in place as he passes his unusual **amoeboid sperm** to the female. • In both sexes the gonads are tubular and threadlike with males having one or two testes. • The females' reproductive system is always paired. Cell divisions in the developing embryo fit neither the spiral cleavage nor radial cleavage patterns. • Nematodes demonstrate **eutely** and **don't have a larval stage**. • Miniature adults emerge from the egg and molt four times before becoming mature adults.

Keyword	Definition

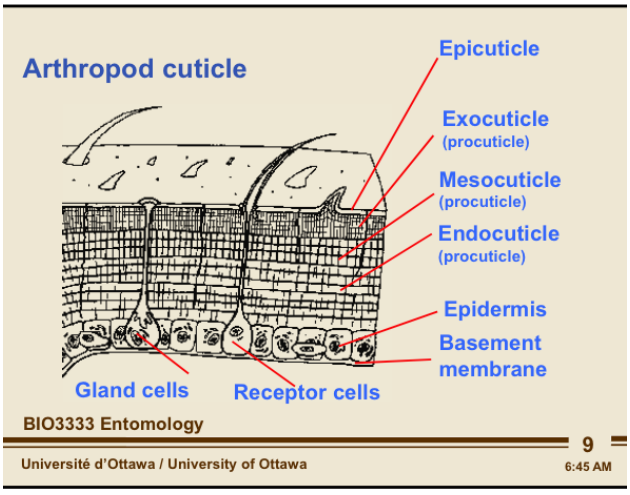


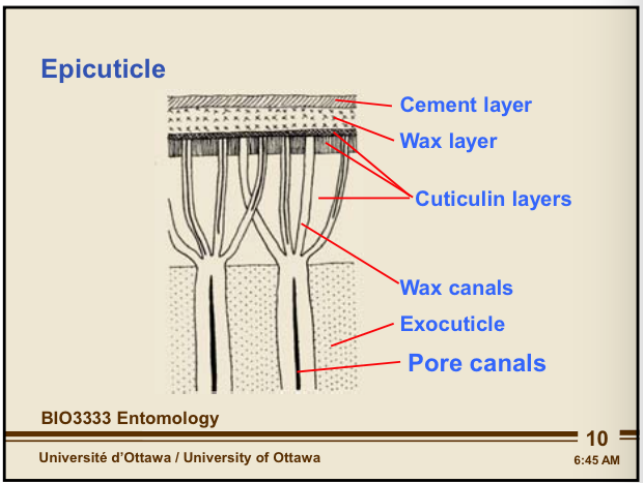
(2) Collagenouscuticle without microville; longitudinal but no circular muscles.

(3) Three circumoral rings with 6,6,4 sensilla in the rings; pair of amphids; epitheliomuscular pharynx.

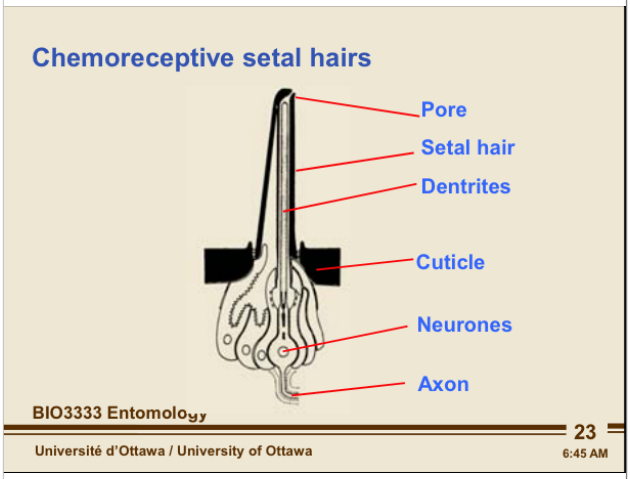
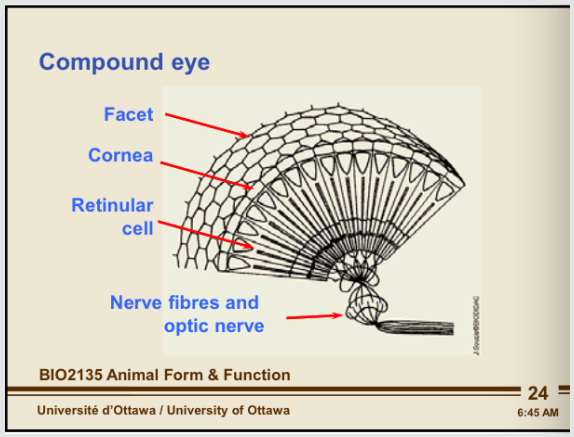
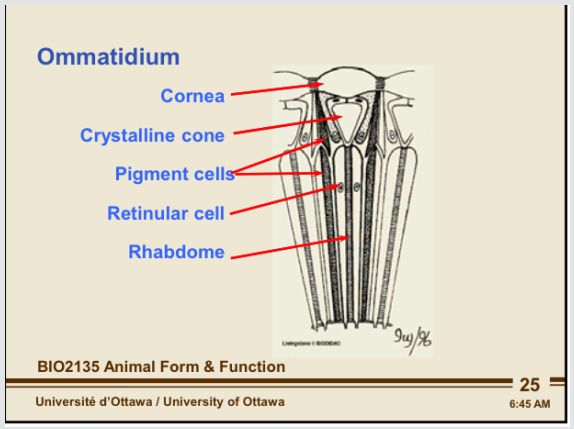
Keyword	Definition
——PHYLUM ARTHROPODA	**PHYLUM ARTHROPODA ——**
Arthropoda (Autapomorphies)	• Muscles arranged in bands • Compound eye • One pair of pre-oral antennae • Three pairs of post oral appendages
Symplesiomorphies	• Cuticle of alpha-chitin and noncollagenous protein • Haemocoel with dorsal tubular ostiate heart • Ecdysis • Food manipulated by limbs • Saccate metanephridia
Symplesiomorphies between classes	• Articulated limbs • Three segmented brain • Exoskeleton with articulated plates
Arthropoda Sub Phylums	• **Trilobita** - Fossil group of extinct marine arthropods. —WE DON'T LOOK AT THESE • **Crustacea** - Marine arthropods like lobsters, crayfish, shrimp and crabs. • **Chelicerata** - Spiders, scorpions, mites, and ticks. • **Atelocerata** - Insects, millipedes, and centipedes - They have 1 less pair of antennae than their crustaceans cousins.
Arthropod success	• Number of species • Distribution • Evolutionary history • Impact on humans
Chitin	• Arthropods moult an alpha chitin cuticle • **Beta** - Chitin - The fibers/molecules of chitin are arranged in the same direction. The weaker one of the two types of chitin. - Characteristic of everything that isn't an Arthropod. • **Alpha** - Chitin - The fibers/molecules of chitin are Arranged in opposite directions. This is a much stronger because the ends of the fiber strands interlock together making it very robust. - Characteristic of Arthropods.
Arthropod Cuticle -	• The **Ecdysozoa** have a cuticle made of a protein matrix reinforced with either **collagen** or **alpha-chitn fibres**; arthropods use **alpha-chitin**. • In addition to the **epidermal layer** and the **basement membrane** underneath, the cuticle has two main components, the **inner procuticle** and **outer epicuticle**. • In terrestrial arthropods epicuticular hardness is supplemented with a waxy waterproof layer.

Keyword	Definition
Arthropod Cuticle - Detailed	• **Epicuticle** - • The Epicuticle is a chemical barrier and it is waterproofed. • Made up of a **cement** layer, **wax** layer and a **cuticulin** layer. • These three layers prevent the cuticle from losing water. • Wax is a water impermeable membrane, however it is usually soft and is easy scratched or damaged so the cement layer protects it. • The water proofing becomes valuable when the arthropods move onto terrestrial environments • **Procuticle** - • **Alpha chitin** is found in the procuticle. • Differentiated into an **inner Endocuticle** and an **outer Exocuticle** in the crustacean we get another layer in between called the **mesocuticle** • The difference between the endocuticle and exocuticle is that in the exocuticle the proteins are covalently cross - linked with each other making the exocuticle “hardened”. • The Endocuticle hasn't been hardened because it has ionic bonds between the proteins and chitin.
Molting of the cuticle	• Arthropods shed their cuticle in order to grow which is referred to as molting or **ecdysis**. • Each time an arthropod molts it creates a new, larger suit of armor and grows into it • When an arthropod first molts out of its skin the cuticle is flexible and then they harden in. • Arthropods commit a huge metabolic effort to make the cuticle and they recycle the endocuticle when they molt

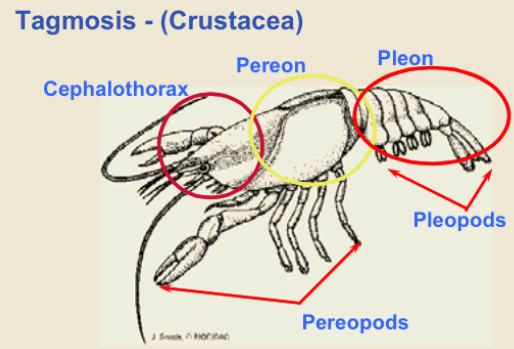
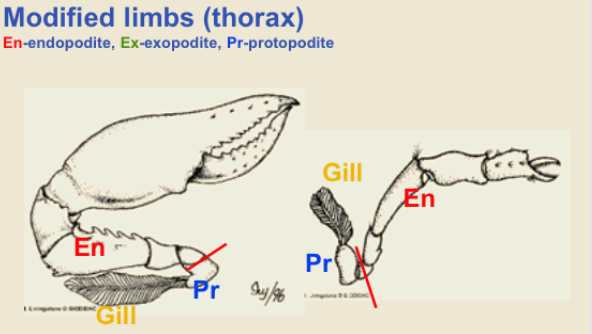
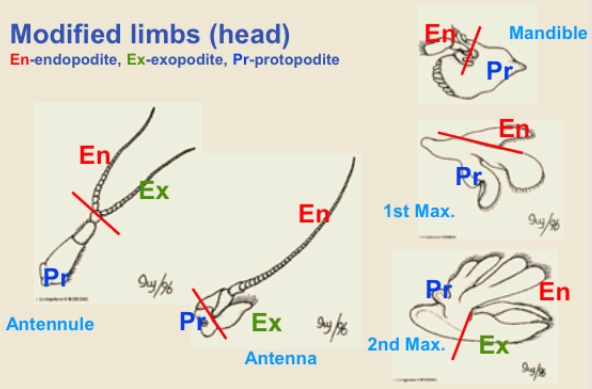




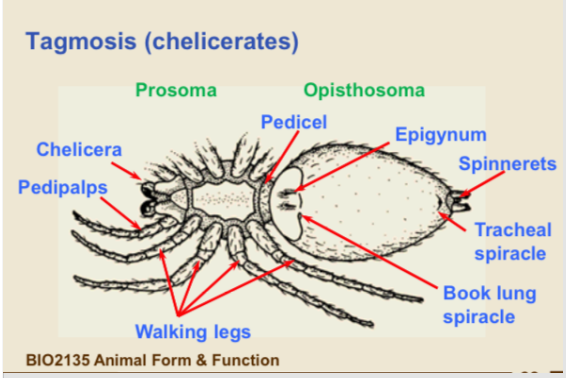
Keyword	Definition
Molting Process	• **Apolysis** - Hormone is released which triggers the usual dormant epidermal cells to turn on and begin to enlarge, which makes a space between themselves and the old cuticle • Into that space **two things** happen: • Cuticle digesting enzymes are released but are not active. • **Chitinases** breakdown the chitin and **proteinases** attack the proteins to regenerate **N-acetyl-glucosamine** and the amino acid subunits that help to build the new cuticle. • A protein matrix is secreted (**cuticulin**) — In this protein mesh the pores are so small that they only let small things go through. This is to prevent the enzymes from attacking the new cuticle which is being made underneath • As the chitinase and proteinases break down the old endocuticle the new cuticle is being made underneath. • However, when the enzymes reach the exocuticle they turn off because cross linked protein is extremely stable and undigestible. • At this point the arthropod begins to swallow air (terrestrial) and water (marine) in order to inflate themselves. • This causes a few lines of weakness on the exocuticle causing it to buckle. • The Arthropod then sends signals to make the areas where it needs exocuticle harden • The arthropod then deflates and gland cells from the cuticulin secrete wax and cement layer into the exocuticle.
Arthropod Articulating Limbs	• Each articulation in an arthropod limb can only articulate in one direction. • Each articulation point is at a 90 degree angle to each other • Similar to a suit and armor • The cuticle is thickened into rigid plates called **sclerites**, and these create a protective suit of armor for these animals. • The articular membrane allows the sclerites to move relative to each other which is important not only in the joints of the appendages but also in the body wall itself
Arthropoda Muscle Organization	• You can no longer have a hydrostatic skeleton when you are living in an exoskeleton. • Muscle is organized in bands. They are similar to cables connected to each articulating joint.

Keyword	Definition
Arthropod Mechanoreceptive Setal hairs 	• Because Arthropods live inside a cuticle they are unable of sensing their environment • **Setal hairs** made up of cuticle is embedded into a socket that has a nerve cell attached to the hair. (The hair is attached to the exocuticle) • When something brushes up against the setal hair the base of the hair also moves within the socket, that movement stretched the sensory cell causing it to depolarize causing an action potential and sending a signal down the nerve. ——————————————————— • These hairs are sometimes **chemoreceptive**. • There is a pore on the surface of the setal hair because the Arthropod doesn't want too many openings into its body so it doesn't lose water. • As the arthropod walks along the substrate the tip of the hair picks up chemical signals which help it identify food and other things.
Arthropod Compound Eye  	• The cuticle covers everything including the eye! • Consists of a series of optic units called **ommatidia** which is a light sensor. • Each ommatidium is made up of a **facet**, **cornea** and **retinular cells**. The whole structure is similar to a straw, hundreds of these ommatidium make up the compound eye of the Arthropods. • The epidermis makes the cuticle, setal hairs, and the camera eye. • When making the ommatidia the cornea sits on the top with a **crystalline cone** underneath it. • The crystalline cone acts like a lens, it focuses the light onto a single point. • The light is then shot down a structure called the **rhabdome** which is made up of **retinular cells.** • The rhabdome is essentially the sensory micro villi from all of the retinular cells. • All of these are loaded with **pigment cells** which will be stimulated for color. • Each of the rods (Ommatidia) will create a single dot of a whole image. When all of these dots are combined it is called the “**Mosaic model of insect vision**” • The more ommatidia we add to the eye the better the resolution becomes.

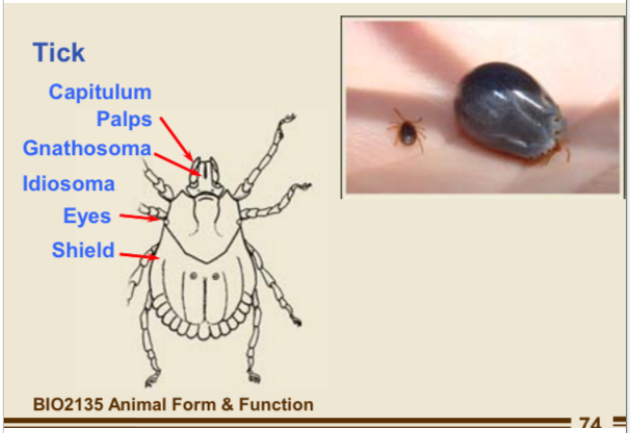
Keyword	Definition
Crustacea (Autapomorphies)	• Antennal and/or maxillary saccate metanephridia • Nauplius larval stage • Biramous appendages • Gnathobasic articulated mandible
Saccate metanephridium	• A type of nephridium consisting of a tubular structure lined with cilia which opens into the coelomic cavity. • In this case, it is sac-like. • In the arthropods, there is no coelom. What we have is the remnant of the ancient coelom as a membrane covering the end of the funnel that is suspended in the hemocoel. • As the cilia beat and propel fluids down the metanephridium, it will have an ultra filter. • Only fluids that can pass across the membrane can get through.
Nauplius larval stage	• A larval stage in the crustacean life cycle characterized by the single medial compound eye, the **naupliar eye**. • It consists of 3 appendages, 1st antenna, 2nd antenna and a appendage that will eventually become the mandible • As the nauplius larva matures it will grow more appendages
Biramous appendages	• Biramous appendages are branched and Y-shaped. • The appendages are anchored to the side of the body. • The basal segment which is connected to the body is called the **protopodite** it consists of two parts: **coxa** and **basis** • There are usually fleshy extensions on the base of the appendages. • The fleshy ones on the outside are called **exites** and if they're fleshy on the inside they're **endites.** • The biramous appendage has two branches called podites: • There is an **endopodite** which is the inner branch, and there is a **exopodite** which is the outer branch of the biramous appendage.
Crustacean limb and serial homology	• Every appendage has a role in all of the following: • **Locomotion** - Legs used for swimming • **Feeding** - legs used for filter feeding • **Respiration** - Gas exchange across the body • **Sensory** - Setal hairs on the outer cuticle

Keyword	Definition
Filter feeding	• Organisms that feed by capturing suspending particles from the water (Usually algae) • Water is pulled down the center line across the setal net trapping particulate food on the surface then squeezing the water and shooting it out the sides as a **propulsive force** to move it forward. • The **bases of the appendages** squeeze together during this whole process which **pushes the food** forward towards the mouth • The arthropod can move and feed at the same time.
Tagmosis (Crustacea)   	• Usual anatomy of an arthropod • **Head** - A head with 5 segments—> 2 antennae, a mandible and 2 pairs of maxillae • **Thorax** - Has all the locomotory structures • **Abdomen** - Usually has small or no appendages. Usually the main organs are found in the abdomen. ——————————————————— • In crustaceans tagmosis is as follows: • **Cephalothorax** —> Head + thorax are attached • The appendages found on the thorax become involved in feeding, and when this happens they are referred to as maxilliped. ——————————————————— • **Pereon** - Essentially the thorax —> • **Pereiopods** - Primarily walking legs and are also used for gathering food. • **Chelipeds** are the pereiopods that are armed with claws. • The pereiopods bear the sexual organs, which are the **third pereiopod** in the female and the **fifth pereiopod** in the male. • Each appendage from the second maxilla to the fifth pereiopod also bears a gill ——————————————————— • **Pleon** - Essentially the abdomen —> • At the end of the pleon is the tail fan, comprising a pair of biramous uropods and the telson, which bears the anus. • Together, they are used for steering while swimming. • **Pleopods -** (also called swimmerets) are primarily swimming legs, and are also used for brooding the eggs (except in prawns), catching food (then swept to the mouth), and can sometimes bear their own gills. • Teleson - The posterior-most division of the body of an arthropod

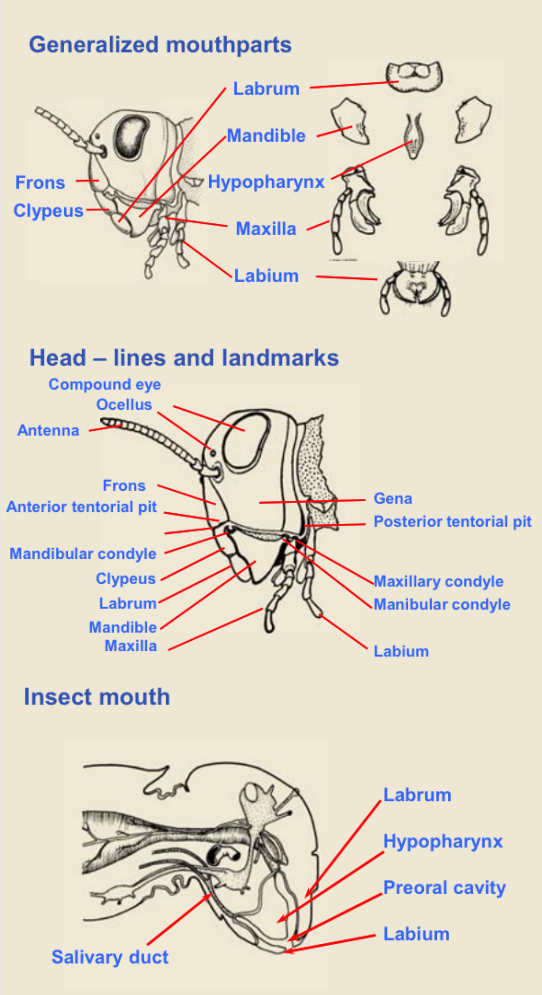
Keyword	Definition
Crustacean feeding and digestion **DO NOT CONFUSE CILIARY SORTING FIELD WITH SETAL SORTING FIELD**	• The stomach in crustaceans is called the **gastric mill** • It is a grinding apparatus consisting of chitinous plates in the stomach. • Inside the stomach differentiating the two stomach regions (Cardiac and pyloric stomach) there are three massive jaws. • The crustacean pulverizes the food in the gastric mill. Once it has been completely pulverized it is sent into the **pyloric stomach** where there is the **setal sorting field** so that it can sift the small particles from big particles. • Only the finest smallest particulates of food can pass through the setal sorting field and make their way into the digestive gland for final digestion and to be absorbed for nutrients. • Anything too large to go through the sorting field will pass through the intestine so it can extract organic material. • **Cardiac stomach** - Stores the ingested food • **Pyloric stomach** - Connected to the digestive gland
Crustacean Respiration	• The gills of the crayfish are attached to its legs. The base of the legs are heavily vascularized. • The maxilliped helps move the water through the **branchial chamber** to oxygenate the crustacean. • **Gill bailer** - A flat membranaceous expansion of the second maxilla in the crustaceans by which water is scooped out of the gill cavity
Crustacean Circulatory system	• Crustaceans have an open circulatory system • The heart sits in the pericardial on the dorsal side with three major arteries connected to it. • **Sternal artery** - Supplies blood to the organs of the **cephalothorax** • Anterior artery - Supplies blood to the head • Posterior artery - Supplies blood to the back • The heart has a valve called the **ostium**, when it is compressed the valve closes but when the heart is stretched back to the original shape the valve opens. • This valve is more or less passive because the motion of the heart it self determines if the valve is opened or closed.

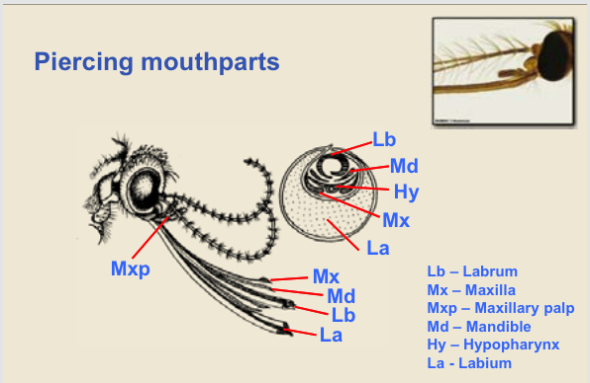
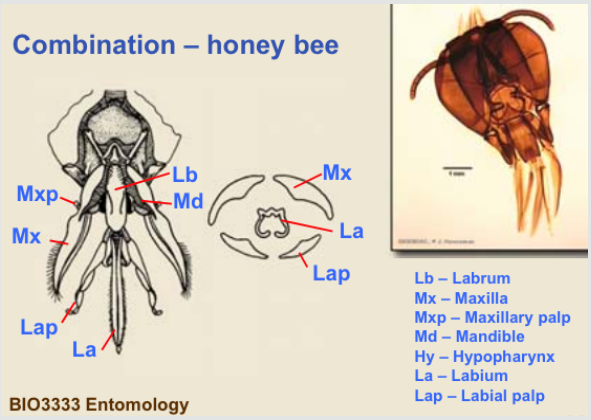
Keyword	Definition
Crustacean excretory system	• Two different excretory organs are found among crustaceans: the **antennal gland** and the **maxillary gland**. • Both have the same basic structure: an end sac and a convoluted duct that may expand into a bladder before opening to the outside. In most adult crustaceans only one or the other gland functions. The functional gland may change during the life cycle. • Antennal gland - Either of a pair of ducts (coelomoducts) found in the third segment of a crustacean and opening to the exterior at the base of the second antenna. • They function as osmoregulatory organs. For example, in the antennal gland of the freshwater crayfish (Astacus), fluid is filtered from the blood into an end sac and passes through a tubular labyrinth, where ions are reabsorbed, to produce a hypotonic urine that passes via a renal tubule to the bladder.
Chelicerata (Autapomorphies)	• Two tagma: prosoma and opisthosoma • Prosoma with six pairs of appendages • **Chelicera, first pair of appendages** • Loss of antenna and deuterocerebrum
Tagmosis (Chilicerata)  	• Chelicerates have six pairs of uniramous appendages, and **pedipalps** behind the **chelicera** are usually involved in feeding, locomotion, or sometimes reproduction and are followed by four pairs of walking legs. • A chelicerate's body consists of **two tagmata**, including an anterior **prosoma** (cephalothorax) with the six pairs of appendages and a posterior **opisthosoma** (abdomen) formed from the fusion of twelve or less segments. • **Chilcerae** - This is the mouth part of the Chilcerata • The opisthosoma may be divided into a **mesosoma** and **metasoma** or may have a terminal **telson** with the anus at its base. • **Epigynum** - The genital pore of female arachnids is found on its dorsal side of the opisthosoma • **Spinnerets** - Modified appendage on the posterior end of the opisthosoma of a spider that produces silk. • **Spiracles** - Openings on the surface, which usually lead to respiratory systems • There are **book lungs** and **tracheal spiracles**.

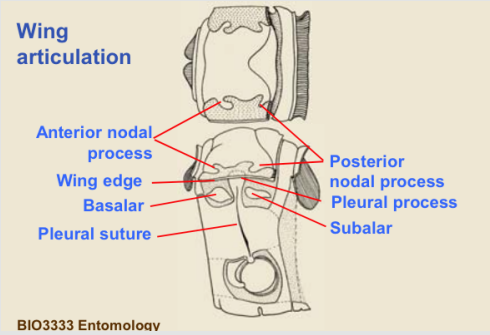
Keyword	Definition
Tagmosis (Chilicerata) Continued	• At the base of the Chilicerata we will find the feeding mouth parts • All chilceratates are **fluid feeders** - They pierce • They have fangs (**Chilcerae**) which inject venom into their prey to immobilize them and they inject fluids to digest the prey. • There is a grinding structure called the **Gnathobase** which sits right on top of the mouth. • Once a Chilcerates imobilizes its prey it uses the gnathobase to **squeeze out** any juices from its prey and sucks it up. • They never consume solid food they **ONLY** consume liquified food.
Chelicerata - Simple eyes	• There are always eight eyes on chelicerates • The eyes are positioned in a way so that the chelicerate can identify if things are moving around near them. They are not necessarily used for vision. • Spiders are picking up their environmental information from the web they're weaving. They pick up the vibration from the web and can determine how big or small the prey is ———————————————————— • Some Chelicerates have evolved into having **simple eyes** • The optic surface behind the lens rotates. This way the actual physical eye doesn't have to move. • Because they have eight eyes they are able to see 180 degrees. • Some chelicerate eyes can see light where others can see actual vision.
Chelicerata - Male spider Pedipalp	• The males in the Chelicerates have modified the pedipalp as a sperm containing organ • The tip of the pedipalp is designed to harvest and collect the sperm. The male then passes the sperm package into the females **Epigynum.** • The females are usually sitting in their web. They are essentially blind though and will interpret the vibrations of the male spider to be its next meal. So the female almost always eats the male after the sperm package has been received.

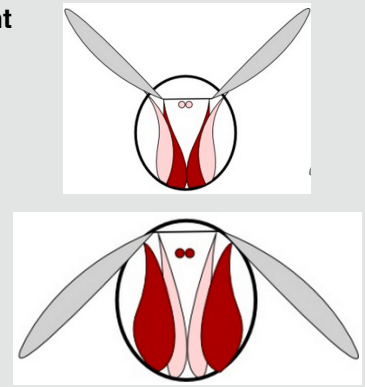
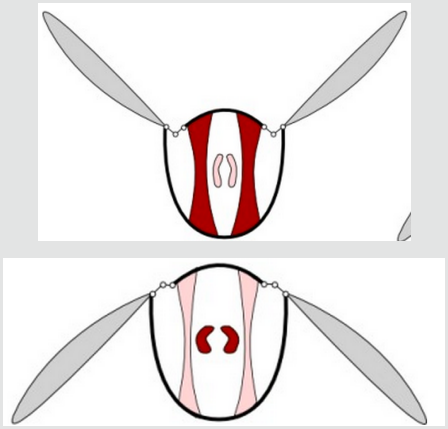
Keyword	Definition
Chelicerate - Silk and spider web	• The female spider creates an **orb web.** • It takes them about an hour to make a perfectly symmetrical and strong web. • Once it is finished the female sits in the middle waiting for prey. She then wraps the prey in a cocoon of silk and injects them with digestive enzymes that will break them down. • The inside of the insect will liquify and then she will drink the liquified food out of the outer cuticle of the insect like a slurpee. • **Spinneret** - Modified appendage on the posterior end of the opisthosoma of a spider that produces silk.
Chelicerate - Book lung	• **Book lung spiracle** - The respiratory structures found in some spiders. It consists of multiple folds of the cuticle that form sheets, or lamellae, across which air moves for gas exchange • Most chelicerates have book lungs and t**racheal spiracles**
Chelicerate - Ticks and mites	• **Ticks**: • They are the worlds smallest predators • They figured out how to drink the blood of invertebrates • **Mites:** • They enter the respiratory system of insects and feed on them from the inside
Chelicerate - Ticks 	• Ticks are smallest kind of Chelicerates • The ticks have evolved by removing the **prosoma** and changing the **opisthosoma.** • The tick is divided as follows: • It has the **Gnathosoma** and the **idiosoma**. • The Gnathosoma has the feeding structures on it called the **cupitulum** palps • The idiosoma is divided into two regions. A hardened region to support the rigidity of the legs. And a shield on the back that can expand because it is a fluid feeder. (Like a stomach expands)

Keyword	Definition
Atelocerata (autapomorphies)	• Loss of second pair of appendages on the head • Mandibles without articulation • Malpighian tubules • Paired segmental tracheal system
Reasons of insect success	• **Small size** - Doesn't need a vascular system • **Water proof exoskeleton** - Self explanatory… • **Metamorphosis** - A change in the form and often habits of an animal during normal development after the embryonic stage • **Reproductive potential** - Being able to be pesticide resistant because of how genes are past down from generation to generation. • **Co-evolution with plants** - Plants depend on insects for fertilization (Pollen) Insects at the same time get food • **Evolution of flight** (Not an ancestral character.)
Chilopoda Head	• **Centipede**: Its maxilliped has evolved into becoming a poison claw • It is carnivorous
Diplopod head	• **Millipede**: Its maxilliped has evolved into becoming a Gnathochilarium. • The lower lip of the millipede has fused with the maxillae which is called a gnathochilarium.
Atelocerata - Tagma	• Insects always have 3 tagma: • **Head** - Formed from 6 segments, and always have 3 feeding appendages • Used for sensory and food acquisition • **Thorax** - Formed from 3 segments, and always have 3 pairs of legs • Used for locomotion • **Abdomen** - Ancestrally there are 11 segments • Used for reproduction and general function. Designed for change in size after meals.

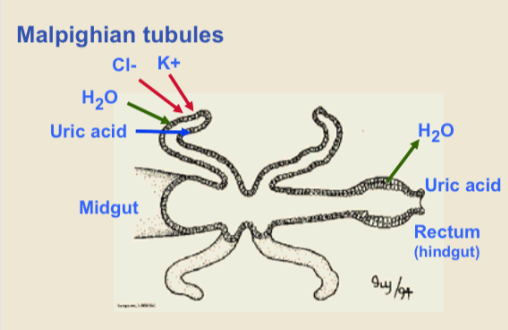
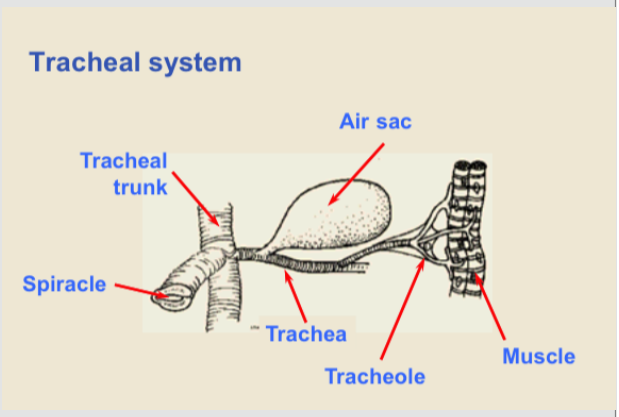
Keyword	Definition
Atelocerata - Head 	• The anatomy of the head of a Atelocerata Top to bottom: • The **labrum, mandible and labium** create an oral cavity. • **Labrum** - A lip or liplike structure, such as the one forming the roof of the mouth in insects • **Mandible** - Moving mouth organs of invertebrates used for seizing and biting food • **Hypopharynx** - A sensory, tonguelike structure on the floor of the mouth of many insects; sometimes modified for piercing. • The **hypopharynx** separates the oral cavity into a top and bottom. The bottom leads to the salivary duct. • **Maxilla** - Head appendage involved in feeding. They most commonly are involved in manipulating the food so that it can be crushed or chewed by the mandibles. • **Maxillary palp** - Sensory structure attached to the maxilla. • **Labium** - The second maxilla insects, often fused to form the lower portion of the buccal cavity. • **Labial palp** - Sensory structure attached to the labium. • These are all necessary for pre-processing the food before ingestion. ———————————————————— • That mandible is creating a lot of forces on the head. There are a series of lines on an insects head. These lines are important because they are reinforcing the structure of the head against the forces of the mandible • The cuticle folds in on itself making it stronger and in doing so creates the lines that we can see. • The insects have an endoskeleton made up of cuticle that bends inwards. This endoskeleton reinforces the head from the front to the back with a series of ridges and bars. • This internal skeleton is called the **tentorium**. • **Frons** - The frontal area of an insect's head. It covers the upper part of the face above the clypeus and below and between the antennae. It supports the pharyngeal dilator muscles and usually bears an ocellus (simple eye)

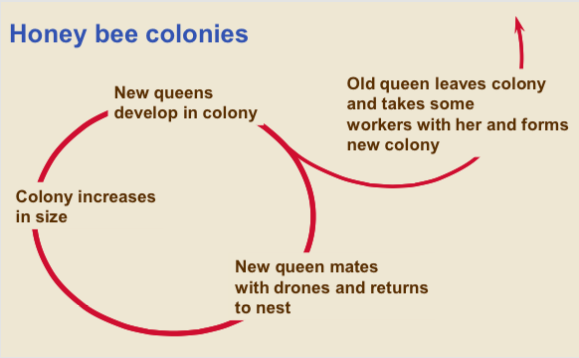
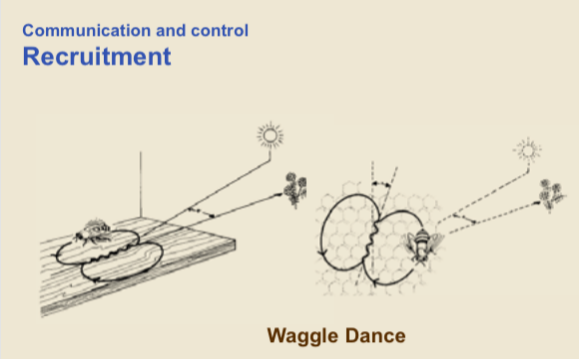
Keyword	Definition
Atelocerata - Piercing mouth parts   	• The mosquito mouth parts consist of a giant folded **labium**. And inside that labium we will find all of the other structures. • Inside we will find: A pair of **mandiblary needles**, the **maxillary needles,** and a **labrum** sitting on top closing it off. • When a mosquito is ready to feed it pushes the tip of the mouthparts against the skin and the muscles that are at the top of the head push the mandiblary needles and all of the other mouth parts into the skin piercing it. • As it is doing this it is anchoring itself, and as its mouth piece gets deeper it is looking for a capillary. • Once it finds a capillary it uses the maxillary, and mandiblary needles to piece the capillary but not allow the capillary to hemorrhage. • To prevent the blood from coagulating the hypopharynx is squeezing salivary secretions with anti coagulants so that the blood can be sucked up • It then pushes the straw made up of the labrum into the capillary to suck up blood. ———————————————————— • **Horseflys** do the same thing as mosquitos except instead of having needles it uses its mandible as a pair of scissors and fucks shit up (they're assholes) …then it sucks up all the blood. • **Butterflys** have maxilla that have joined together making interlocking straws with a core in the center. • The core in the center is the extension of the hemocoel. It squeezes blood down the mouth part to uncoil it and then it sticks it into the nectar at the bottom of the plant. • **Honey bees** the labrum is just a little flap on the top. However, the labium and its little palp have been elongated and they are structured together with the maxillary palp. • The labium is lined with cilia so that the nectar can stick to it like a wick. The maxillary and labial palps squeeze the liquid and nectar into the mouth part and into the digestive tract of the bee • The mandibles sit on the side of the bees mouth and it is used in the hive to manipulate the wax to make the honey comb.

Keyword	Definition
Atelocerata - Thorax	• The thorax is divided into three segments: • A **Prothorax**, **Mesothorax** and **Metathorax**. • All three segments have legs • However, **only the** Mesothorax and Metathorax are **associated with the wings**.
Atelocerata - Legs	• The insect leg is uniform all across the group. Every single insect has the same number of segments. • The leg articulates against the body wall with a **coxa**. • When the legs articulate against the body wall along the prothorax (doesn't have wings) there is a plate of cuticle on the dorsal side called the **Notum** and a plate of cuticle on the ventral side called the **Sternum**. With a **coxal cavity** surrounded by **pleurites** and **coxal articulation** points in between.
Atelocerata - Wings  	• The **mesothorax** and **metathorax** are associated with the wings. • These two segments merge to make a **Pterothorax**. • The pterothorax can be divided into the • **Tergum** (back) • **Pleura** (sides) • **Sternum** (belly) • Tergum parts are separated by internal skeletal folding, ridges, and sutures. • Tergum is composed of **notum**, and **postnotum**. • The **notum** can be further subdivided into the prescutum, scutum, and scutellum • During flight each part of tergum reacts to the contraction of muscles by moving in a specific direction or distorting in a particular way. • These complex elastic deformations cause wing movement • **The wing is elevated or depressed by deformation of the notum** • During flight the notum reacts to the contraction of muscles by moving in a specific direction or distorting in a particular way. • **Pleural wing process** - A process of the pleuron located at the upper end of the pleural suture that serves as a fulcrum for the wing. • If the notum moves up the **wing moves down**, and if the notum moves down the **wing moves up**. • The cuticle has bent inwards creating ridges to prevent the collapse of the box. • **Apodeme** - An internal ridge on an arthropod exoskeleton so that muscles can attach

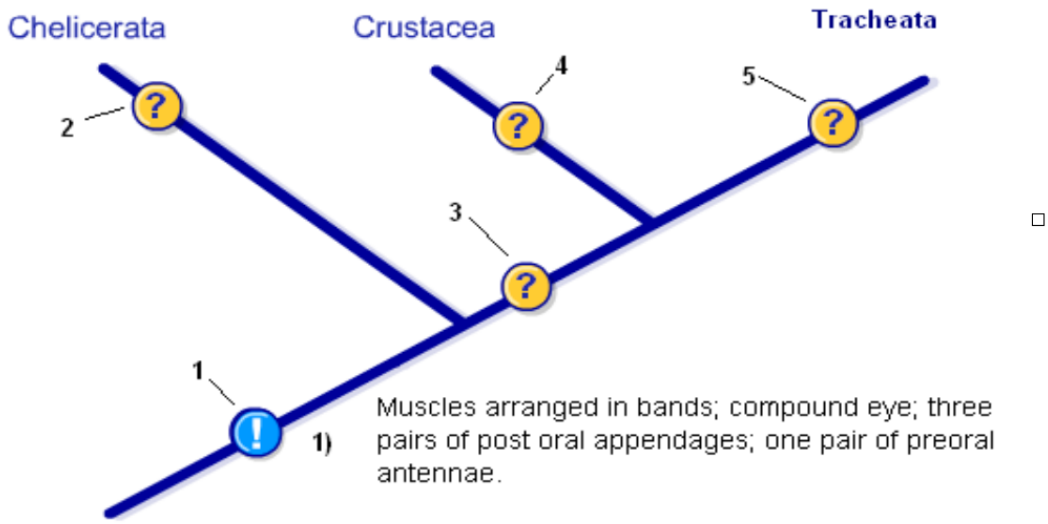
Keyword	Definition
Flight	• In both flight mechanisms we make the wing rise by contacting the **dorsol ventral muscles** and moving the **notum** down • There are 2 muscles that are attached to the **basalar** and **subalar** that move the wings up/ down. • The dorsal ventral muscles move the notum down so that the wing can go up.
Direct Flight 	• First type of flight mechanism in arthropods • We use the **dorsal ventral muscles** to move the wing up and then another set of muscles to pull the wings back down • The wings pivot up and down around a single pivot point. • The wings are raised by a contraction of muscles attached to the base of the wing inside (toward the middle of the insect) the pivot point • The wings are then brought down by a contraction of muscles that attach to the wing outside of the pivot point.
Indirect Flight 	• We now have longitudinal muscles attached to the top and bottom of the box. • The doors ventral muscles pull the notum down, and the new longitudinal muscles push the notum back up. • Indirect flight muscles are connected to the upper (tergum) and lower (sternum) surfaces of the insect thorax. • A second set of muscles attach to the front and back of the thorax. • The wings are raised by the muscles attached to the upper and lower surface of the thorax contracting. • This brings the top surface of the thorax down and, along with it, the base of the wings. As a result the wing tips pivot upwards. • The wings are then lowered by a contraction of the muscles attached to the front and rear of the thorax. • This forces the upper surface of the thorax to raise and the wings pivot downwards. • This is called the **click mechanism** • The contraction of the muscles compresses the scelerite to assist the rapid rise and fall of the wing. • These muscles are able to contract multiple times for each single nerve impulse, allowing the wings to beat faster than would ordinarily be possible.

Keyword	Definition
Asynchronous	• This can be found in dragonflies • A single nerve impulse causes a muscle fiber to contract multiple times; this allows the frequency of wing beats to exceed the rate at which the nervous system can send impulses. • This causes the 2 pairs of wings to move in asynchronous beats so that. • Because of this they cannot fold the wings up
Synchronous	• Both sets of wings move at the same time. • This isn't very aerodynamic
Atelocerata - Abdomen	• All of the major organ system are found in the abdomen • The abdomen is made up of two plates, one on the top called the **tergite** and another on the bottom called the **sternite** with a **pleural membrane** in the middle so that the abdomen can enlarge when food is eaten or in the females case for reproduction.
Atelocerata - Reproduction	**1. Female reproductive system:** • Inside the female there is a seminal vesicle called the **spermatheca** which is where the sperm is stores • **Ovarioles** - The tubular structural units of an insect ovary that each produce an egg • Ovarioles make up the ovary. Each ovary could have more than a hundred ovarioles which increases the reproductive potential. • **Spiracular openings** are located on each of the segments, and the terminal segments bear appendages involved in copulation and egg laying. • **Ovipositor** - A tubular structure, usually concealed but sometimes extending outside the abdomen, with which many female insects deposit eggs. • Female eggs are water proofed. However, there is an opening into the egg for which sperm can enter called the **Micropyle.** **2. Male reproductive system:** • Inside the male there are testis that have **follicles** • The follicles are comparable to the ovarioles in females. • They produce sperm which flows down the sperm duct and is stores inside the seminal vesicle • **Accessory gland** - The sperm needs to be packaged into a spermatophore and this gland does just that.

Keyword	Definition
Atelocerata - Excretory system 	• **Malpighian tubules**: Excretory structures found in insects. • The system is it is essentially driven by simple potassium pumps in the wall of the tubule and the rectum • Malpighian tubules are hollow extensions of the gut suspended in the hemocoel. They are found in between the mid gut and hind gut. • The epidermis in the Malpighian tubule pumps **potassium** into the lumen of the tube making the center of the tube positive. Which means a counter ion (**chloride**) will flow across the membrane making the inside of the Malpighian tubule salty • That means we now have an osmotic gradient because it is saltier in the tubule than it is in the hemolymph bathing the tubule. • As a consequence water will flow in to balance the osmotic gradient. • Dissolved in the water is the nitrogenous waste (**uric acid**) • This all passes into the rectum and all of the same things happens except the rectum is lined with cuticle. • So we recover the water and the uric acid cannot get through the cuticle.
Atelocerata - Respiratory system 	• Insects transport air directly to the active tissues through **spiracles** that open to the outside of the body and are connected to trachea. • The spiracles act like a valve to let air in. • **Tracheal system** - These tubes extend through the body and ultimately turn into **tracheoles** which are missing the waterproof layer • Gas exchange occurs across the surface of the tracheoles to the tissue immediately next to it. • That air is continuous because it is connected all the way up to respiratory system. • Once the spiracle opens and the air is at 21% (composition of oxygen + air) it diffuses really quickly in air. • The tracheoles have an unlimited supply of oxygen to supply the tissues in the insect • Atelocerata muscles never go into lactate mode because they have a continuous supply of oxygen supplied by air. • Evidence of this is the dragonfly during the carboniferous era had a wing span of 2 feet because of the 32% oxygen concentration.

Keyword	Definition
Metamorphosis	**1. Incomplete metamorphosis (Hemimetabolous)** • The juveniles look just like the adults, except only the adults can reproduce and have wings. **2. Complete metamorphosis (Holometabolous)** • There is a resting stage in between juvenile and adult • In the pupal stage a set of cells in clusters have been set aside to turn all of the living tissue into the adult form from the larva. • The caterpillar larvae feeds like crazy and puts away carbohydrate and protein reserves. • It then spins its case (cocoon) then liquifies its whole body. Then all of the cell packets will begin to differentiate into the new cuticle, wings, legs, new set of internal organs all fueled by the reserves preserved inside. • The benefit from all of this is that they can now live off two food sources in their lives.
Sociality in insects  	• **Queen** - Bad ass bitch that has a crazy orgy with all of the guys. Every egg she fertilizes turns into a female if the egg isn't fertilized it is turned into a male. • She has complete hormonal control over the hive and she makes sure that all of the other basic bitches (workers) are **NOT** reproductively capable. She regulates their reproductive ability and shuts that shit down ASAP. • **Worker** - Female bees, they go out and collect nectar and pollen and take care of the young workers in the hive. They're pretty much slave =(• **Drone** - Male bee. • The colony sometimes gets too big and they all switch up on the queen and throw that bitch out. • When everything goes to shit the queen recruits some workers and dips the fuck out. • Then some of the workers will be able to reproduce and at that point the colony will collapse R.I.P • Bees can also communicate using the "**waggle dance**" • They use angles and stuff to communicate where all mad dope pollen and nectar is at • This dance is done by the foraging bees after it comes back from collecting nectar • It tells the other bees where to find mad stacks of pollen and nectar • Seriously though why do we need to know this shit?

Cladograms
Arthropoda phylogeny



(2) Two tagma: **prosoma** with **six pairs of appendages** and **opisthosoma**. **Chelicera** represent first pair of appendages. **Loss** of **compound eye**, **deuterocerebrum** and **antennae**

(3) **Mandibulata**: Five pairs of appendages present. Three postnatal segments, mandibles, two pairs of maxilla, and ommatidia of compound eye with crystalline cone

(4) Loss of second pair of appendages on the head and mandibles without articulation. **Malpighian tubules** for excretion and **paired segmental tracheal system** for respiration.

(5) Unique **Nauplius larval stage**. Antennal and maxillary saccate metanephridia present. Biramous appendages and gnathobasic articulated mandible

Keyword	Definition