Animal Diversity II

Phylum Annelida and Phylum Arthropoda

Today we will study the annelids, the segmented worms, and the arthropods, a huge group that contains insects, spiders, and crustaceans. Three tissue layers are present in both of these groups. Also, they share with molluscs the presence of a true coelom. Annelids and arthropods are also protostomes, that is, the embryonic blastopore develops into the mouth. What type of symmetry do annelids and arthropods have?

A distinguishing characteristic shared by annelids and arthropods is their body segmentation. At some point in development, segmented animals possess a body plan with repeating segments of identical or similar structures. Later in development, some segments may form more specialized structures.

Today you will examine many different adaptations in segmented animals. How does organizing the body into segments influence function and life history? How do different modifications of segments make segmented animals, particularly the arthropods, the most diverse group of animals?

PHYLUM ANNELIDA (segmented worms)

The name "Annelida" means "little ring", which refers to the segments that make up their bodies. As in molluscs, a fluid-filled body cavity, the **coelom**, is present. Earthworms, leeches, and an assortment of segmented marine worms belong to this phylum.

The major subgroups of annelids are:

Polychaeta:	mostly marine, "many bristles", or chaeta, found on each segment
Oligochaeta:	terrestrial or freshwater, "few bristles"; earthworms are in this group
Hirudinea:	leeches, sucking mouth parts, no chaeta

Exercise 1 – Polychaeta

Observe examples of living and preserved polychaetes.

Exercise 2 - Oligochaeta, *Lumbricus terrestris* (earthworm)

Lumbricus, the common earthworm, is a terrestrial oligochaete. Obtain a living specimen and place it on a piece of moist paper towel. Observe the worm as it moves forward. Each segment of the body has its own circular and longitudinal muscles; hence the worm moves by alternate contraction and elongation of segments. Identify the anterior and posterior ends and the dorsal and ventral surfaces. Rub your finger over the ventral surface to feel the setae. What do you think is the role of the setae in locomotion? When you are finished, return the worm to the container.

Exercise 4 - *Lumbricus* external structures

You will need to use a dissecting microscope for parts of this exercise.

Obtain a preserved earthworm and place it on a dissecting pan. The mouth is located at the anterior, more pointed end of the body and is bounded by the first segment. Find the clitellum, a swollen region of five or six segments. This region contains glands that secrete the mucous in which the eggs are deposited. The anus is a vertical slit in the last segment. This end of the body may be more flattened. Observe the chaete. How many do you see in each segment?

Make a simple sketch of the whole worm and label the mouth, anus, clitellum, and chaete, **based on what you actually see.** How many segments does your worm have?

Exercise 5 - *Lumbricus* internal structures

With fine tip scissors or a scalpel, make a longitudinal incision along the dorsal midline extending from about ten segments posterior to the clitellum forward to the mouth. When cutting the body wall, be careful not to cut all the way through the body cavity. Pin the worm open. Note that the coelom is not continuous but is divided into compartments. Carefully cut the tissue separating the segments, called septa (singular septum), and pin down the body wall, exposing internal organs (refer to figure next page). Add a few drops of water to float the internal organs so they will be easier to see.

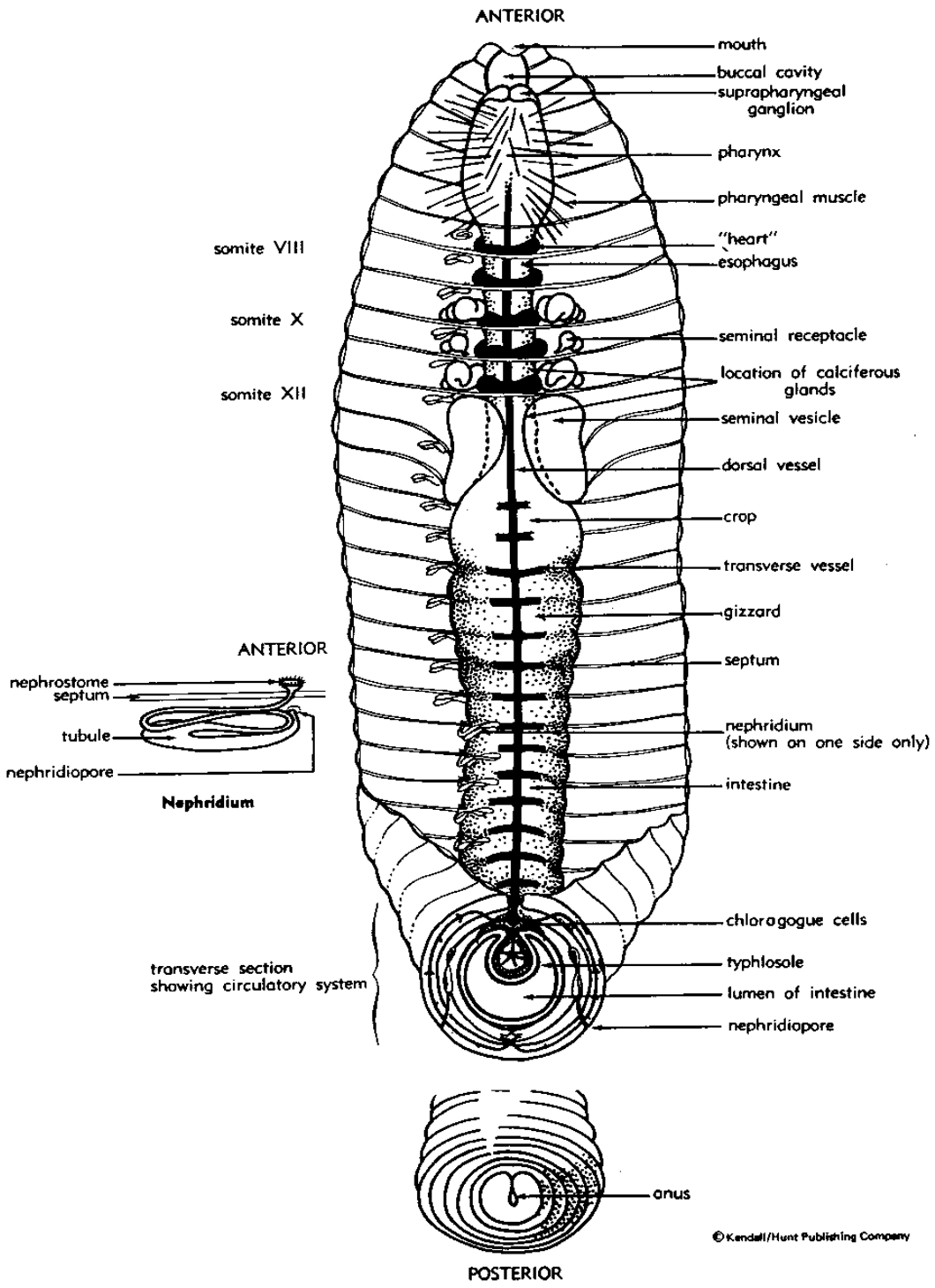
1. Digestive System - The alimentary tract is a tube extending from the mouth to the anus. It is surrounded by an inner circular and an outer longitudinal layer of muscle. After passing through the mouth, food enters the muscular pharynx. The pharynx leads into the long esophagus. Posterior to the esophagus is an enlarged temporary storage region, the crop, from which food next passes into the gizzard where it is ground up. Extending from the gizzard to the anus is the narrow thin-walled intestine where the absorption of food occurs. The unabsorbed solid waste is released from the anus.

2. Circulatory System - The circulatory system of the earthworm is closed, meaning that blood flows through enclosed vessels and tubes. The main vessels of the system lie above and below the digestive tract. These are called the longitudinal dorsal and ventral vessels. These vessels are connected by transverse vessels that encircle the digestive tract. Five of the transverse vessels are larger and more muscular. They function as contractile "hearts."

3. Excretory System - Each segment, except the first three or four and the last one, has its own pair of excretory organs, the nephridia, that function to remove nitrogenous waste from the circulatory system. This liquid waste is excreted to the outside through the pores in the body wall. The nephridia are the thin, coiled tubules lying to the left and right of the digestive tract.

4. Nervous System - The nervous system of the earthworm consists of a bi-lobed pair of suprapharyngeal ganglia ("brain") located on the dorsal surface of the pharynx in segment 3. A pair of nerves passes around the pharynx and joins with the subpharyngeal ganglion and a ventral nerve cord. There is also a ganglion in each segment.

5. Reproductive System - Earthworms, like other oligochaetes, are hermaphrodites, that is, each individual has both male (testis) and female (ovary) reproductive organs. Earthworms mate by lying head to tail with other worms and exchanging sperm. Later each worm excretes mucous into which they deposit their own eggs and the sperm of another individual for fertilization. The reproductive structures of the earthworm are often difficult to identify in a gross dissection, but with some care a few of the parts may be located. Cut the intestine near the clitellum and carefully lift and pull forward. Examine segments 10 and 11 for two tri-lobed, white structures, the seminal vesicles. These contain spermatocytes in various stages of development that have been produced by the testes. Leading from the seminal vesicles to the male genital pores in the 15th segment are the two vas deferens or sperm ducts. The two pairs of seminal receptacles lie just anterior to the seminal vesicles. Tiny ovaries are located on the anterior septum in segment 13 near the ventral midline. On the posterior septum of segment 13 are the two oviducts leading to the female genital pores in segment 14 where eggs are released.



Lumbricus - Internal Structure

Exercise 6 - Prepared slide of *Lumbricus*, cross section

Obtain a prepared slide of a cross section of an earthworm. Examine the body wall under low power. The body wall is covered with a cuticle secreted by the underlying cells of the epidermis. Beneath the epidermis is a thin layer of connective tissue, then a layer of circular muscles, then feather-like longitudinal muscles, and finally the peritoneum that lines the coelom. Also find the ventral and dorsal blood vessels of the circulatory system and the ventral nerve cord. Next, examine the intestine. The wall of the intestine consists of an inner layer of circular muscle and an outer layer of longitudinal muscle. Outside the muscle layers is a layer of specialized cells that aid in digestion. The wall of the intestine has folds that increase surface area for absorption. In favorable slides, you may see sections of nephridia and setae in the body wall.

Draw a sketch of this cross sectional view and label as many of the structures listed above as you can **based on what you actually see on the slide:**

Exercise 7 – Hirudinia, leeches

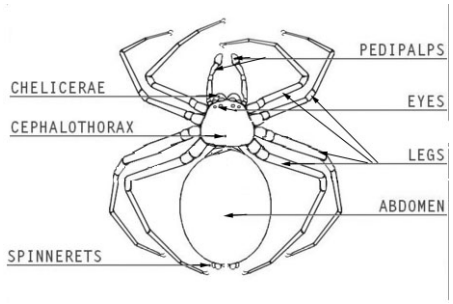
Examine the preserved leeches on demonstration. What differences in external anatomy do you notice between the earthworms you just studied and the leeches? In particular, what do you notice regarding their mouth? What adaptations do leeches have for their particular mode of nutrition?

PHYLUM ARTHROPODA

There are more species of arthropods than in all other animal phyla combined. Species occupy water, land, and air; they are herbivores, carnivores, and parasites. This vast array divides into three extant groups: **chelicerates**, **crustaceans**, and **uniramians**, and one extinct group, the **trilobites.** One major difference between arthropods and annelids is that arthropods have a protective **exoskeleton** formed of chitin. Another difference is arthropods have an **open circulatory system**.

CHELICERATA

Chelicerates lack antennae and mandibles. They possess six pairs of appendages. The first pair of appendages, called chelicera, may be modified as pincers (e.g. scorpions) or fangs (e.g. spiders). The second pair of appendages, called pedipalps, are modified for sensory, food manipulation, or for copulation. The remaining four pairs of appendages are walking legs. Chelicerates respire by means of specialized gills. Arachnids are the largest group of chelicerates and include spiders, ticks, mites, and scorpions. We will be studying an unusual marine member of the chelicerates, the horseshoe crab.



Exercise 1 - *Limulus*

Limulus, the horseshoe crab, is considered a "living fossil" because these animals have not changed in appearance from fossils dated to hundreds of millions of years ago. Examine a preserved specimen. Try to find the different pairs of modified appendages found in all chelicerates.

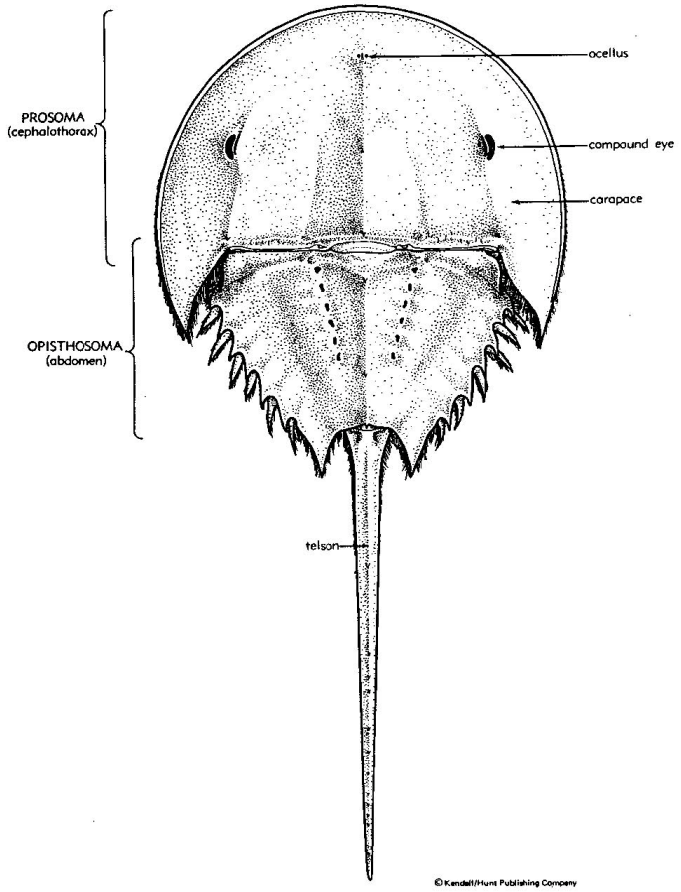


Figure 11-3, *Limulus* (horseshoe crab), dorsal view

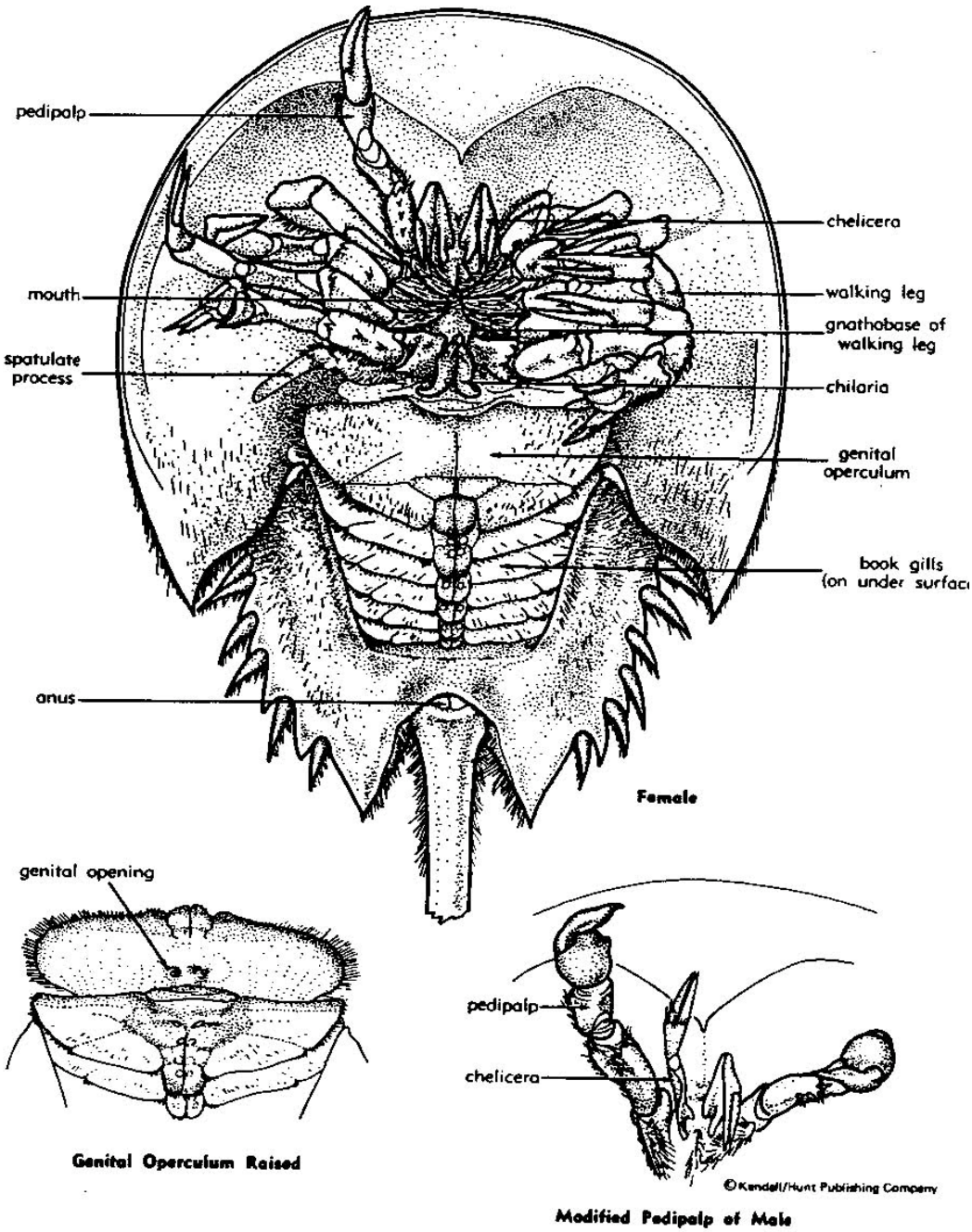


Figure 11-3, *Limulus* (horseshoe crab), ventral view

TRILOBITA

Exercise 2 - Trilobites

Trilobites are an extinct group of the arthropods that flourished in the Cambrian seas (500-550 millions of years ago) for hundreds of millions of years. They became extinct about 245 million years ago. Study the fossils of trilobites. Note the variation in size of different species of trilobites. What characteristics of arthropods can you see in the fossils?

Trilobites and *Limulus* are monophyletic, i.e., they arose from a common ancestor. What common features can you identify between the fossil trilobites and the *Limulus*?

CRUSTACEA

Crustaceans are a very diverse group, represented by 40,000 species. Some familiar crustaceans include lobsters, shrimp, and crayfish. As you examine the following specimens, consider how modifications of appendages have allowed crustaceans to inhabit many different niches in mostly aquatic environments.

Exercise 3 - Crayfish

The lobster and crayfish are closely related crustaceans that live in different environments, the lobster in the sea and the crayfish in fresh water. Their bodies are very similar and a description of one also fits the other fairly well. Obtain a preserved crayfish for study of external anatomy. First note the different body regions: the **cephalothorax**, and **abdomen**.

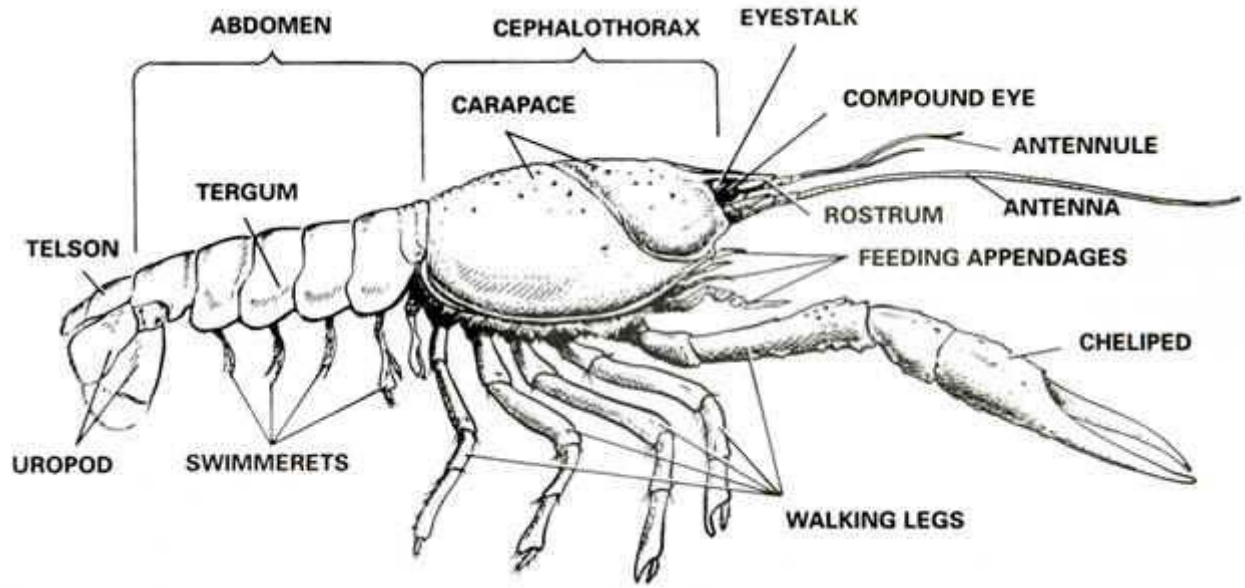
1. The first antenna has 2 branches, followed by the second antenna with a single branch. Both antennae have sensory function for touch and taste. Next is the mandible used for crushing food, then first maxilla for food handling, and second maxilla for food handling and water movement.

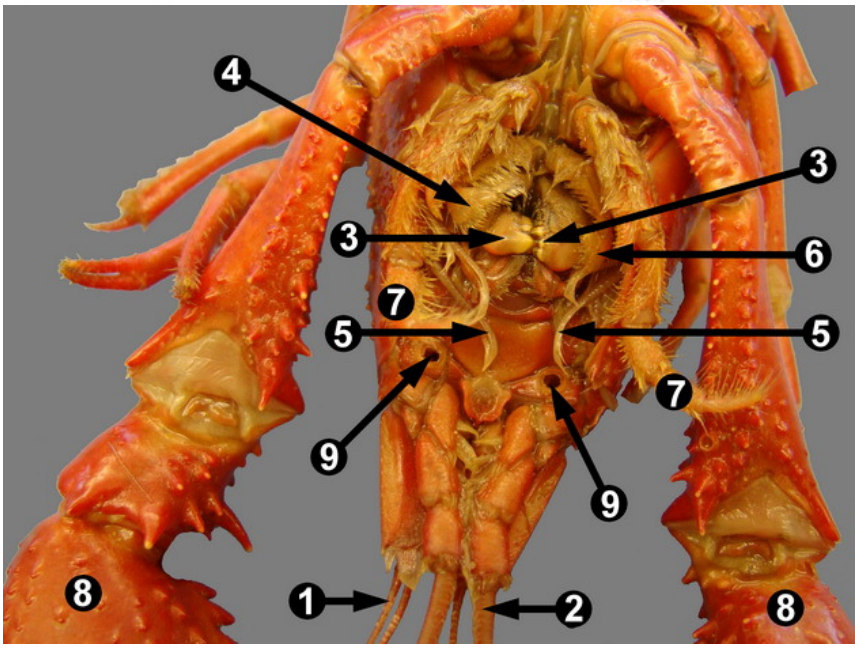
2. The most conspicuous appendage is the cheliped bearing the large grasping claw. Posterior to it are four segments each with walking legs. Anterior to the cheliped are three maxillipeds, which together are involved primarily in food handling. With forceps, grasp one of the walking legs near its base and pluck it from the body. Note the attached, soft gills, the primary site for gas exchange.

3. Abdomen – At the end of the abdomen is the telson and on either side of the telson is a three-part uropod. These together form a tail that can be flexed for swimming. The anus is located near the base of the tail. Paired swimmerets can be found segmentally arranged along the ventral edges of the abdomen. Swimmerets are used for gas exchange and movement. They also serve to hold eggs, thus the first few pairs of swimmerets differ between males and females.

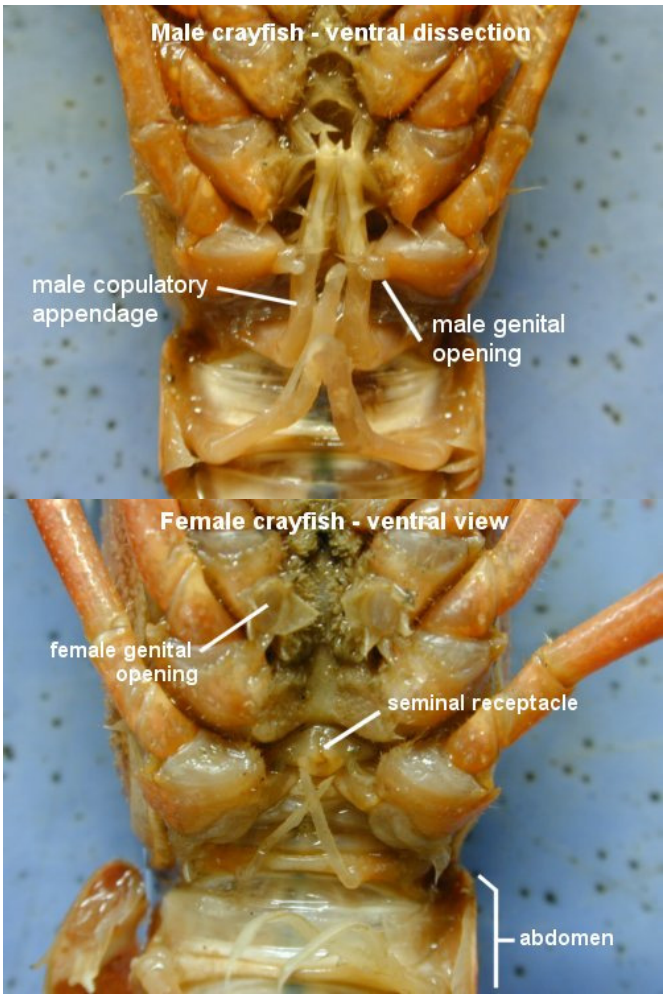
With forceps, grasp one of the more posterior swimmerets near its base and pull it free of the

abdomen. From the base (where you grasped it with forceps), two branches depart, giving a Y-shaped appearance. These two-branched, or **biramous** appendages are a distinguishing characteristic of this group. All other appendages are thought to be derived from this biramous shape, even if only a single branch remains.





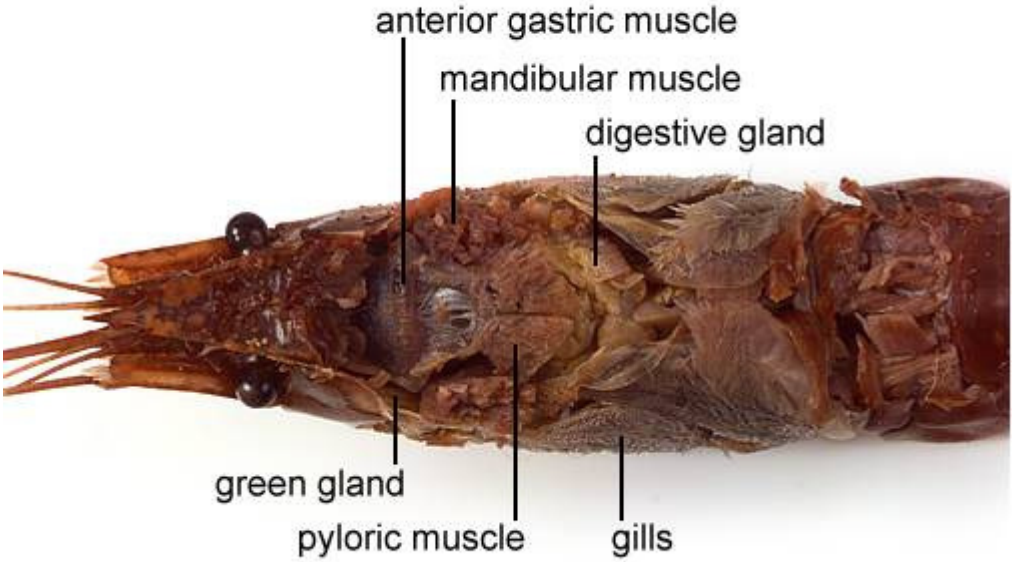
1. antennules 2. antennae 3. mandibles 4. maxillae 5. 6. 7. maxillipeds 8. chelipeds

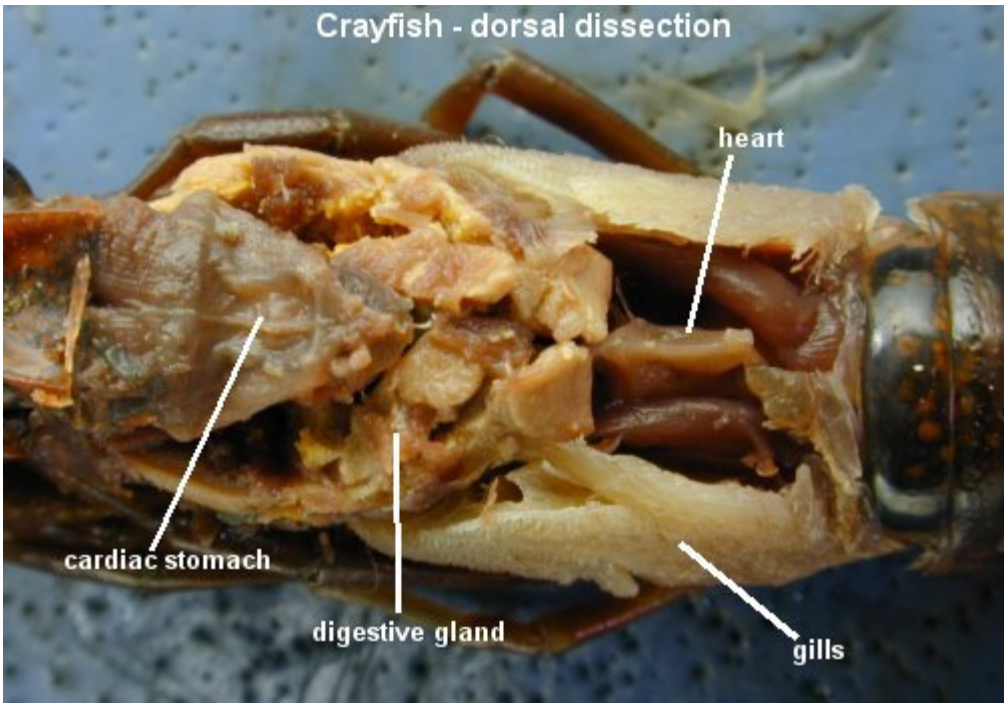


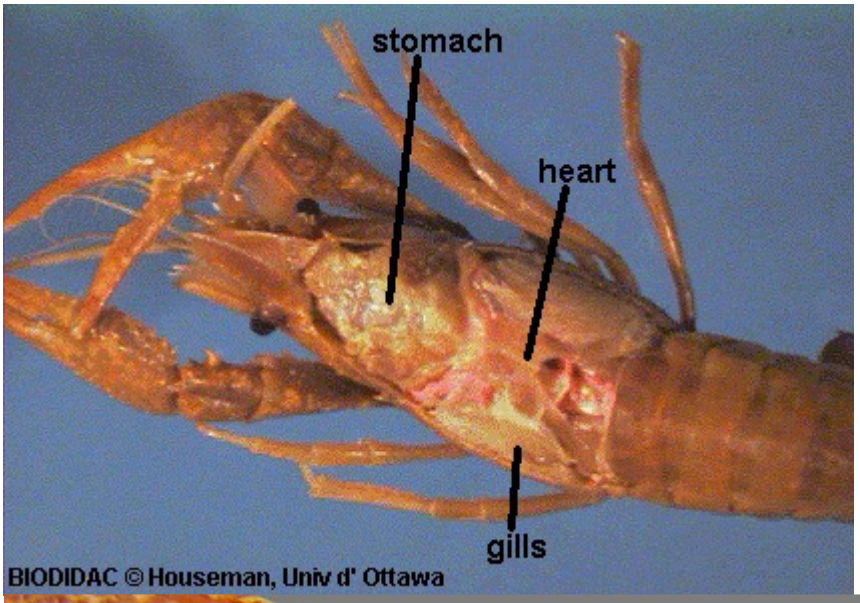
Determining the sex of the crayfish Behind the chelipeds are the four pairs of walking legs. You can use the walking legs as one way to determine the sex of your crayfish. Locate the base segment of each pair of walking legs. The base segment is where the leg attaches to the body. Use a magnifying glass to study the inside surface of the base segment of the THIRD PAIR of walking legs. If you observe a crescent-shaped slit, you have located the genital pore of a female. In a male, the sperm duct openings are on the base segment of the FOURTH PAIR of walking legs. These may be difficult to find, so if you cannot find them, you can still determine the sex of your crayfish by looking at the next group of appendages.

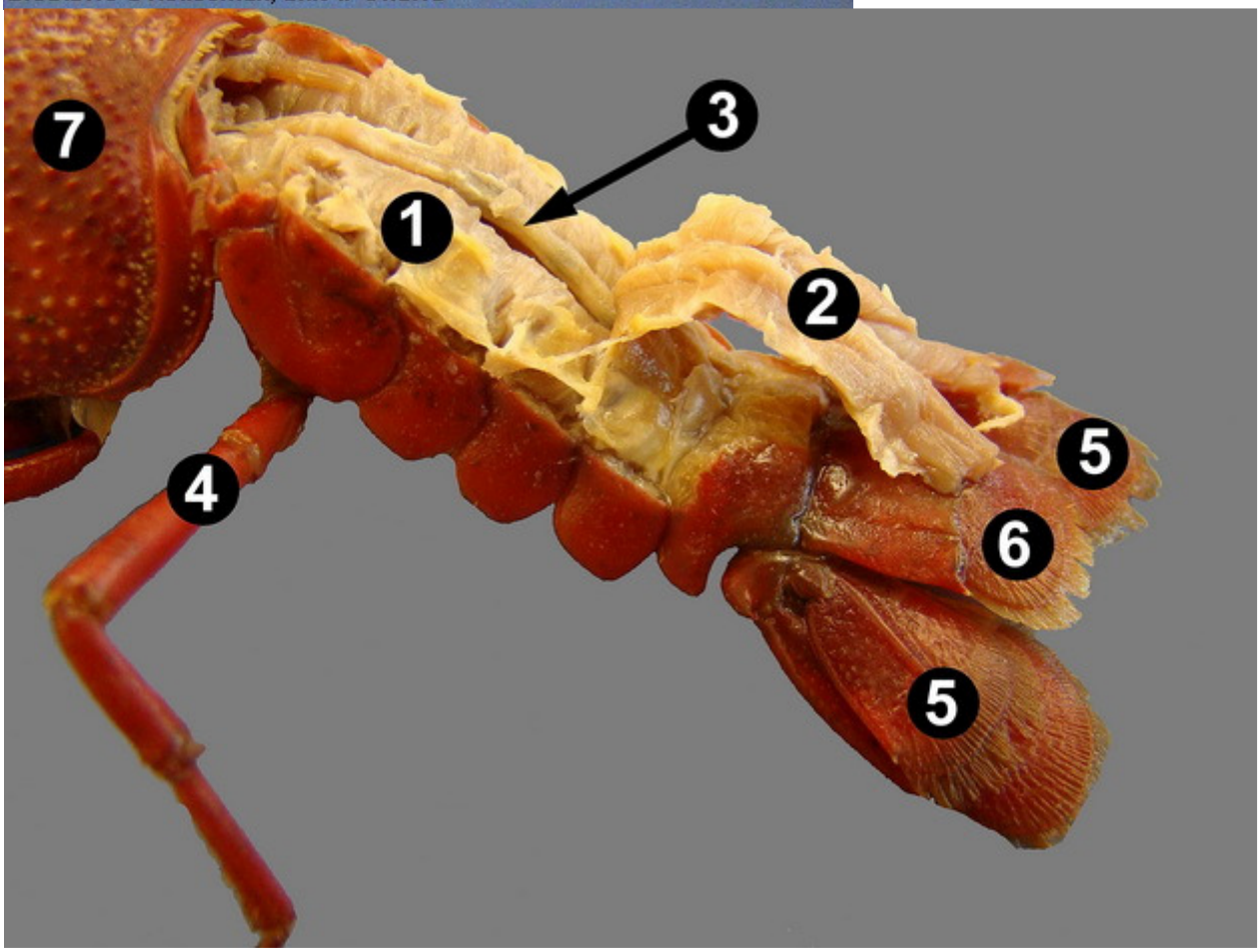
On the underside of the abdomen you will find the appendages known as the swimmerets. The FIRST TWO pair of swimmerets in the male are longer and are tucked up underneath and forward facing. The male uses these swimmerets to transfer sperm to the female. The female swimmerets are all rather small and dainty. She will use these swimmerets to hold the eggs underneath her abdomen until they hatch. When a female crayfish is holding her eggs, it somewhat resembles a bunch of "berries", so the term in berry refers to a female that is clutching her eggs under her abdomen.

Crayfish - Internal Features (Dorsal View)









1. flexor muscles 2. extensor muscles 3. intestine 4. walking leg 5. uropods 6. telson 7. carapace

UNIRAMIA (insects, millipedes, centipedes)

The Uniramia derive their name from that fact that unlike chelicerates and crustaceans, they do not have branched appendages. Many characteristics set this group apart: uniramous appendages (single branch), a pair of antennae, three pairs of legs, and usually two sets of wings. Insects are the largest group of uniramians, and in fact outnumber all other animal groups combined. Most insects are capable of flight at some time during their life cycle, a feature usually cited as the basis for their extraordinary diversity. Built like other arthropods, on a segmented body plan with an exoskeleton, insects achieve great complexity through specialization of appendages and through the cooperation of appendages from adjacent segments. The grasshopper is useful in illustrating this, especially in its complex chewing mouthparts.

Exercise 4 - Grasshopper

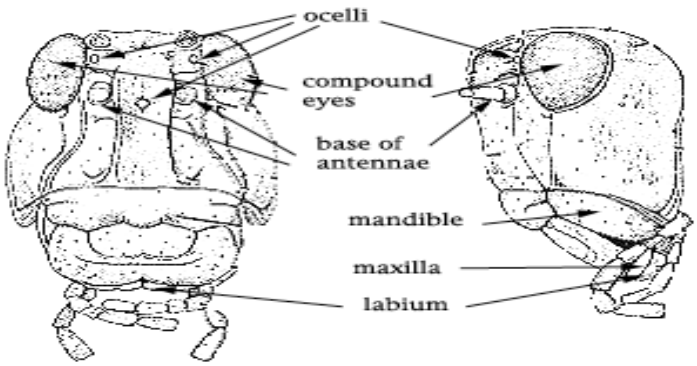
The grasshopper is an extremely common uniramian of the Insecta. Obtain a preserved grasshopper for external examination. Can you identify and name the three regions of the body?

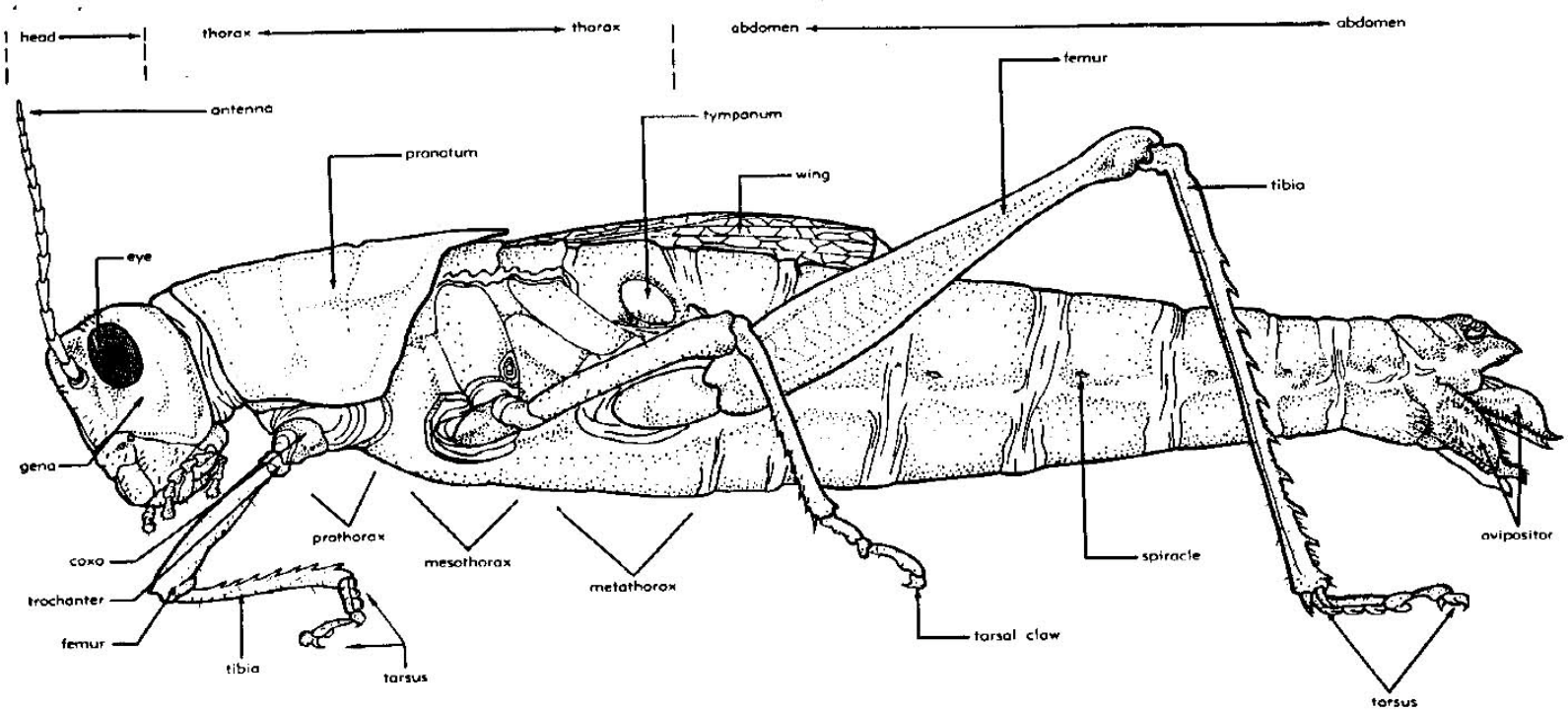
1. Head - The head of the grasshopper is a good example of **cephalization**, that is, concentration of sensory function in the head region. Find the paired sensory antennae, the large paired compound eyes, and the three ocelli, or simple eyes. Note the complex mouth parts are adapted for chewing plant materials. They include the upper lip or labrum, a pair of mandibles, a pair of maxillae, and a lower lip or labium (refer to figure). Note that the head is movable.

2. Thorax - The thorax consists of three segments. One pair of legs is attached to each thoracic segment. What functions are these legs adapted for? Each leg is composed of five parts or segments. The segment next to the body is the coxa. Below the coxa is another short segment, the trocanter. The next two segments, called the femur and tibia, are long, and the last segment is the tarsus. Two pairs of wings are attached on the dorsal surface of the second and third thoracic segments. The forewings are not used for flying but function as protective covers for the hindwings. The hindwings are fanlike, and fold when the grasshopper is not in flight.

3. Abdomen - The abdomen lacks paired appendages. On the side of the abdomen look for the spiracles. These are the openings to the tracheal system used for gas exchange.

Structures of the Head, grasshopper


ocelli
compound eyes
base of antennae
mandible
maxilla
labium



WINGS REMOVED ON ONE SIDE, FEMALE

Name:_____

PHYLUM ANNELIDA (segmented worms)

Exercise 4 – *Lumbricus*
Make a simple sketch of the whole worm and label the mouth, anus, clitellum, and chaetae, **based on what you actually see.** How many segments does your worm have? How many chaetae per segment?

Exercise 5 - *Lumbricus* internal structures – Sketch the internal anatomy of the earthworm. Label the following structures: heart(s), pharynx, gizzard, septa, blood vessels, nephridia, ventral nerve cord.

Exercise 6 - Prepared slide of *Lumbricus*, cross section

cuticle
epidermis
circular muscles
longitudinal muscles
peritoneum
coelom.
ventral and dorsal blood vessels
ventral nerve cord
intestine circular muscle and longitudinal muscle.
intestine folds
nephridia
setae in the body wall

Draw a sketch of this cross sectional view and label as many of the structures listed above as you can **based on what you actually see on the slide:**

Exercise 7 – Hirudinia, leeches

What differences in external anatomy do you notice between the earthworms you just studied and the leeches? In particular, what do you notice regarding their mouth? What adaptations do leeches have for their particular mode of nutrition?

PHYLUM ARTHROPODA

TRILOBITA

Exercise 2 - Trilobites
What characteristics of arthropods can you see in the fossils?

What common features can you identify between the fossil trilobites and the *Limulus*?

Exercise 3 - Crayfish

Identify and locate the following in your specimen. Optional mark with a dissecting pin. Be able to locate if interrogated by your TA.

cephalothorax
abdomen
antennules
antennae
mandibles
maxillae
maxillipeds
chelipeds
flexor muscles
extensor muscles
intestine
walking leg
uropods
telson
carapace
dorsal nerve cord
swimmerets
sex of your crayfish
cardiac stomach
digestive gland
heart
gills

Exercise 4 - Grasshopper

Can you identify and name the three regions of the body? Roughly what fraction of total body length is made up of each region?

Head - the large paired compound eyes, and the three ocelli, or simple eyes. Describe the difference between the grasshopper eye structure and the squid eye structure. What is the difference in size between the ocelli and the compound eyes?

Complex mouth parts. They include the upper lip or labrum, a pair of mandibles, a pair of maxillae, and a lower lip or labium. How would you expect these structures to differ in a predatory insect like the praying mantis? Is this a more or less complex structure than the squid beak? In what ways?

Thorax - What functions are different legs adapted for? Sketch a leg and label the five segments.

Creating a phylogenetic tree

Students often view the evolutionary relationships between organisms and the characteristics that are used to differentiate between taxa as "settled science" and fixed like the order of numbers in our numeric system (1, 2, 3…).

Actually these relationships are often subject to revision, can tell a story of how the present species came to be, and illustrate the importance of specific characteristics that differentiate taxonomic groups.

To facilitate an understanding of classification, this exercise will involve making a hypothetical tree but using an example that is non-biological:

There are many names that evolved from the name "Joseph". From the list below, make a hypothetical "evolutionary" tree of Joseph derived names starting with Joseph at the base of the tree. There is no wrong answer. Whenever there are branches, indicate what defines the branch (can be anything you choose i.e. spelling, gender, sound, nationality).

BETTY JO
BILLY JO
BOBBY JO
FIFI
GIOSETTA
GIUSEPPA
GIUSEPPE
GIUSEPPINA
JO
JOBETH
JODENE
JODI
JODIE
JODY
JOE
JOE BOB
JOEY
JOJO
JOLEEN
JOLENE
JOSÉ
JOSÉE
JOSEF
JOSEFINA
JOSEFINE
JOSEMARÍA
JOSEPHINE
JOSÉPHINE
JOSETTE
JOSIE
MARY JO

EXAMPLE