

INTRODUCTION

Bio-sect is a learning system. Each study unit in this system is designed so that the student, with your help and support, can explore, understand, and integrate basic principles of anatomy and physiology among representatives of the animal kingdom.

This Study Unit Contains

- 12 earthworms preserved in Wardol
- 12 disposable styrofoam dissection trays
- 12 plastic storage bags
- 1 teacher's reference folder
- 1 container dissection pins
- 3 spirit masters
- 12 hand magnifying lenses

Students will also require

- 1 pair scissors
- 1 scalpel
- 1 sharp probe

Learning Objectives

1. **Recognize and identify** the major external and internal features and structures of the earthworm.
2. **Explain** the function of the various organs and organ systems in the earthworm.
3. **Interpret** how these features and structures relate to the biology of the animal—and to other animal forms.
4. **Develop** competency in the skills of dissection, including use of dissection instruments and the careful following of instructions.

Special Instructions

Disposable Dissection Tray: This tray is designed to be a firm moisture-proof surface on which the student can work. At the conclusion of the laboratory exercise, the student can simply discard the specimen, thus reducing cleanup time and mess. The dissection tray may be reused at your option.

Specimen Storage

All Bio-sect study specimens are treated in Wardol, which greatly minimizes student discomfort, especially eye irritation. Between study periods the specimen, pinned to the dissection tray, should be covered with a paper towel dampened in water or Wardol, and stored in one of the plastic bags provided. Students should fold over the open end of the bag twice and secure with staples or paper clips. The student's name can be written directly on the dissecting tray or plastic bag with a felt-tip marking pen.

Dissection Tips

A false notion about dissecting is that all you do is cut and slice. An animal specimen is a marvelously assembled and intricate set of structures held together by connective tissue. Dissection is making careful incisions to expose parts, then using a probe to separate organs and other structures from their coverings. In a sense, one's intent is to carefully unwrap the animal's structures without damage. **Except for major incisions, don't cut—dissect!**

NOTE: Adequate precautions and supervision should be given to students using scalpels. **Never let them use a scalpel for blade.**

Anatomical Orientation Terminology

- Dorsal — Back or upper part
- Ventral — Abdominal or lower side
- Anterior — Forward or front part
- Posterior — Hind or rear part
- Median — Towards the middle

Biology of the Earthworm

Among the most familiar invertebrate animals are the earthworms, members of the phylum Annelida. This word means "ringed" and refers to a series of rings or segments that compose the bodies of the members of this phylum.

There are over 170 earthworm species found the world over, except in arid and arctic regions. These animals range in size from one inch to the 11-foot giant worms of the tropics. Some earthworms are pallid in color, many are reddish-brown to purple, and one Philippine species is bright blue! The commonest species of earthworm is the common earthworm, *Lumbricus terrestris*, which attains a length of up to 30 cm (12 inches). It lives in a variety of soil types, but has a preference for chalky soil.

Earthworms swallow earth and digest out the organic substances (which have been broken down by other animals and bacteria), excreting inorganic parts as feces. This action aerates the soil, with subsequent increase of the soil bacteria populations, which accelerates the rate of organic decomposition and release of inorganic substances needed by plants. The earthworm's activity is therefore a basic necessity for fertile land.

The earthworm constructs its burrow by forcing its anterior ("head") end through crevices and by swallowing soil. The egested material and mucus are plastered against the burrow wall, forming a lining. During dry seasons or winter, earthworms migrate to deeper levels of the soil, down to 10 feet.

After moving to deeper levels, the earthworm undergoes a period of **quiescence** (resting), losing as much as 70% of its water and rolling up into a ball, for a period of up to 2 months.

Lumbricus mates continually during the spring and fall. In a few days, a cocoon, containing an egg and sperm deposited and stored at mating, is released. A new worm will hatch in 3 to 4 weeks. The life span of the earthworm is 4 to 5 years.

LABORATORY LESSON I

EXTERNAL ANATOMY OF THE EARTHWORM

Body Shape

The earthworm, an invertebrate (animal without a backbone), has a tubular shape which is divided into a series of repetitive ringed segments called **metameres**. This condition, termed **metamerism**, is present in all vertebrate and most higher invertebrate animals. The most easily observable examples of metamerism are in animals like the earthworm (phylum Annelida) and in the insects (phylum Arthropoda), but can also be seen in animals such as the perch (phylum Chordata) with its repetitive body musculature. These three groups

of animals (annelids, insects and chordates) constitute a large section of the animal population of the world, amounting to over 500,000 species, while the rest of the animal kingdom includes only about 100,000 species.

The earthworm lacks a distinct "head" and body appendages. Position of internal and external body structures is referred to by **segment number** beginning anteriorly. There are over 100 segments in an adult earthworm.

Dissection Instructions

Place the earthworm on the dissection tray. With the aid of the magnifying lens provided, locate and identify the external features of the earthworm by referring to figures and **Terms for Recognition and Learning**. It is suggested that students be given a list of terms prior to beginning the lesson, and that they mark and label each of these on the Spirit Master copies. Do not pin the worm to the dissection tray, as frequent handling must be done to identify structures.

NOTE The dorsal side of the animal has a darker coloration than the ventral side.

TERMS FOR RECOGNITION AND LEARNING (FIGURES 1 & 2)

prostomium (pro-sto-me-yum) — Located on segment 1, it is a small fleshy probe extending over the mouth and is used as a muscular probe in burrowing. Analogous to the "head".

peristomium (per-e-sto-me-yum) — Located on segment 1; it surrounds the *mouth* and lies beneath the prostomium (Figures 1 and 2).

segment — One in a linear series of body parts.

mouth Located ventrally on segment 1, directly under the prostomium.

setae — Carefully draw the animal between your fingers and note the presence of a "sand paper feel" along the animal's ventral surface. This sensation is caused by setae which are hair-like projections or appendages. There are 8 setae in four pairs on each segment (except the first and the last); they aid the animal in locomotion and as a holdfast in burrowing. (Note location in Figures 1 and 2.)

septum — Wall separating each body segment.

female genital pore — Pair of extremely small openings near the mid-ventral line of segment 14. These openings are external pores for the **oviducts** through which eggs pass.

male genital pores — Located laterally from the mid ventral line on segment 15, these structures are larger than the female counterparts. The pores themselves are very tiny but there is a distinct swelling around each (Refer to Figure 1).

openings of seminal receptacles — Located, laterally on the septa (ventral surface) of segments 9, 10, and 11. In these structures sperm is stored following mating. **These openings are difficult to see.**

clitellum (kli-'tel-lum) — A swelling of the body surface, which is prominent in sexually mature worms. This structure covers segments 32 to 37, and is responsible for the formation of a **cocoon** or **egg capsule**. Secretion by large gland cells in the body wall of the clitellum produces the cocoon.

LABORATORY LESSON II

INTERNAL ANATOMY OF THE EARTHWORM

1. Place a paper towel in the bottom of the dissection tray and moisten it with water.
2. Extend the worm full length, ventral surface down, and fasten it to the tray by placing pins through the tip of the first (prostomium) and last segment.
3. Add water to the tray so that the worm is **completely covered**. All dissection must be done with the worm submerged to prevent drying out and to allow structures to float freely for better observation.

Dissection Instructions

1. Using a scalpel and scissors, make a **shallow** mid-body dorsal incision beginning at segment 1 and continuing through the anterior third of the body. **Be careful!**
2. About halfway along the cut, start to turn the skin aside, and pin it to the dissection tray using dissection pins. Work posteriorly, continuing to pin the body wall laterally. As you proceed, carefully separate each septum from the central tube by cutting with scissors.
3. It is suggested that a magnifying lens be used to help locate and identify internal body structures.

Earthworm Body Plan

Between the body wall and the digestive tract is a space termed the **coelom** which is divided into ringlike cavities by a thin muscular **septum** between segments. Each cavity is lined with a membrane (peritoneum). A type of peritoneum, termed **mesenteries**, supports internal body organs.

DIGESTIVE SYSTEM

Function Composed of a **digestive tract** and related **digestive glands**, this system functions to both mechanically and chemically break down food into simple components that can be easily absorbed by the blood and passed throughout the body to provide body cells with nourishment.

TERMS FOR RECOGNITION AND LEARNING — DIGESTIVE TRACT (FIGURES 2 and 3).

mouth — Located under the prostomium.

pharynx — Segments 1 to 6. A bulbous organ that is attached to the body wall by numerous **radiating muscles**. When these muscles contract, the cavity of the pharynx is suddenly enlarged, producing suction at the mouth.

esophagus — Segments 6 to 13. A tubular passage between the pharynx and crop.

crop — Segments 13 to 15. An expanded chamber behind the esophagus, it functions to store food temporarily.

gizzard — Segments 16 to 18. A muscular organ that mills food into a fine pulp with the aid of soil fragments, before passing it on to the intestine where it is digested.

intestine — Begins at segment 18 and continues posteriorly. Digestion and absorption of food take place here. The intestine terminates in a short **rectum** and **anus**. Before discarding the worm, have the students cut out a section of the anterior and terminal portions of the intestine. Observe the presence of a **typhlosole**, a tube within the intestine. Its function is to increase the

absorptive surface area in the anterior portion of the intestine. Note that the terminal portion of the intestine lacks the typhlosole - for absorption of water and nutrients does not occur in that area. (See Figure 4.)

TERMS FOR RECOGNITION AND LEARNING — DIGESTIVE GLANDS (FIGURES 3 and 4).

digestive pouch — An expansion of the esophagus between the 4th and 5th aortic loops or "hearts". Cells in this pouch are believed to secrete digestive enzymes.

caliciferous glands — Two pairs of glands located posterior to the digestive pouch along the sides of the esophagus. These glands function to neutralize the acid foods.

CIRCULATORY SYSTEM

Function The transport system of the body, it supplies oxygen and nourishment to body cells. The circulatory system consists of a **pump** (5 aortic loops or "hearts"), **circulatory fluids** (blood), a network of **vessels** (**ventral** and **dorsal blood vessel**, analogous to arteries and veins respectively), and various **capillary beds**.

TERMS FOR RECOGNITION AND LEARNING (FIGURE 3)

"hearts" — In segments 7 through 11 are five pairs of aortic loops ("hearts") which extend dorso-ventrally around the esophagus.

dorsal blood vessel — Major blood collecting vessel of the body; it is located on the dorsal surface of the digestive tract.

ventral blood vessel — Major blood distribution vessel of the body; it is located on the ventral surface of the digestive tract.

capillary beds — There are three major capillary beds which are located in the:

- Intestinal Region** here blood picks up nutrients.
- Skin Region** here blood is oxygenated.
- Glandular Regions of the nephridia** (excretory structures); here blood is cleansed of waste products.

Waves of contractions force blood around the "hearts" (aortic loops) through the ventral blood vessel, to the various capillary beds, to the dorsal blood vessel, then back to the hearts.

EXCRETORY SYSTEM

Function — To remove metabolic waste products from the blood.

TERMS FOR RECOGNITION AND LEARNING (FIGURES 3 and 4)

nephridia (ne-'frid-e-a) — The excretory organs of the earthworm and of other similar invertebrates. One pair of nephridia, appearing as white fibers, is located on each body segment (except the first three and last) along the mid-dorsal body wall. Nephridia are analogous to the kidney of higher animals. Examine the posterior segments for nephridia, where there are less structures to confuse the dissector.

REPRODUCTIVE SYSTEM

Function Responsible for the production of sex cells (**eggs** or **sperm**) and their delivery to produce offspring. Unlike many animals, each earthworm contains both male and female sex organs. To produce offspring, earthworms must mate. There is no contact between egg cells and sperm cells within a single earthworm. Sperm cells are not discharged unless mating occurs.

Dissection Instructions

Carefully snip the dorsal portions of each segment septum, and move the digestive tract to one side as illustrated in Figure 3. This will afford a better view of the reproductive and nervous systems.

TERMS FOR RECOGNITION AND LEARNING (FIGURES 3 and 4)

testis — Segments 10 and 11 each contain a pair of testes which produce **sperm** in isolated median cavities of the coelom, the testis sacs.

seminal vesicle — Three pairs of light-colored prominent lateral pouches that extend into the 9th, 10th, and 11th segments. Sperm produced in the testes are shed into both the testis sacs and seminal vesicles, where they mature and are stored.

sperm funnel — Located mid-ventrally near the base of the middle vesicle. This paired structure collects sperm and passes posteriorly through a pair of **sperm ducts** (vas deferens) to the **male genital pores** on the ventral side of the 15th segment.

ovary — These minute paired structures are located in the forepart of segment 13. The ovaries produce **eggs**. Eggs are set free in the coelomic cavity and are collected by **ovarian funnels**, which pass the eggs through oviducts to ventral **female genital pores** on the 14th segment.

seminal receptacles — Two spherical organ pairs, located under the seminal vesicles in segments 9 and 10. In these structures sperm is stored **after** mating (Figure 2).

clitellum — A swollen glandular region of the skin located at segments 32 to 37 in a sexually mature animal. During mating, two worms face in opposite directions, press their ventral surfaces together, so that the clitellum of one is opposite segment 10 of the other (openings of the seminal receptacles). They are held in this embrace by thick mucous secretions of the clitellum and skin. Sperm extruded on the 15th segment, at the male genital pore, will pass posteriorly along a **sperm groove** (Figure 1) to enter the seminal receptacles of the **other** worm. The worms then separate.

Soon after mating, the clitellum secretes a membranous **cocoon**. The cocoon slips forward along the body, and as it passes over the female genital pore, eggs are laid directly into it. The cocoon again moves forward and the eggs are fertilized by the sperm of the **other** worm as it passes over the seminal receptacles. Finally the cocoon is slipped off the worm, and the openings in it constrict to produce a spindle-shaped capsule. Although many eggs are deposited in the cocoon, only one will develop into a worm which later emerges.

NERVOUS AND SENSORY SYSTEMS

Function - To integrate and control body processes. Locomotion (movement) and all other activities are coordinated locally by a series of **ventral ganglia**. A series of reflexes coordinates movements so that what happens in one segment will occur a moment later in the next.

Dissection Instructions

1. Remove the pin holding the 1st segment in position.
2. Use a sharp probe, or needle, to locate structures.

TERMS FOR RECOGNITION AND LEARNING (FIGURE 3)

pharyngeal ganglion (brain) Paired, small, whitish masses located around the anterior portion of the pharynx (segment 2). The brain, along with the sub-pharyngeal ganglion, governs the nervous system, initiating and controlling body activities. If the brain is removed from a living animal, the worm becomes **more**

active. This means that the pharyngeal ganglion has an inhibitory function.

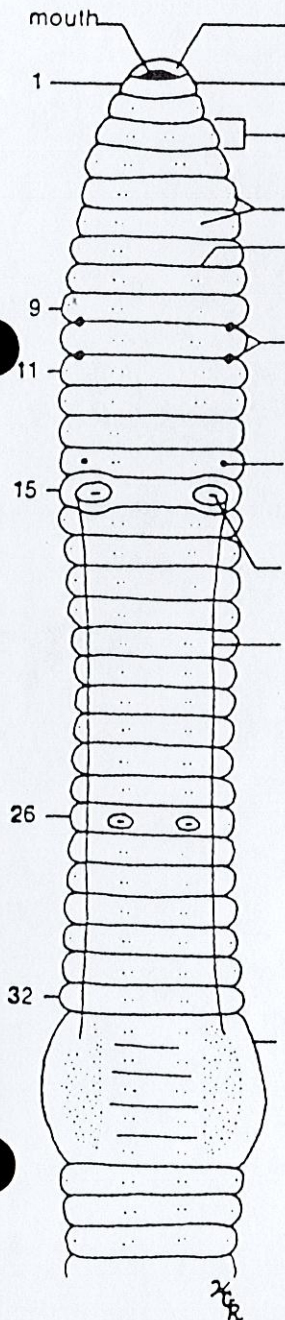
subpharyngeal ganglion — Located at the anterior portion of the pharynx where the two pharyngeal ganglia join; it is a small white structure. If this ganglion is destroyed, all spontaneous activity ceases, and the worm moves momentarily only if touched; thus the ganglion is responsible for such activity.

Separation of inhibitory and stimulatory centers in the nervous system is typical in higher invertebrate and vertebrate animals.

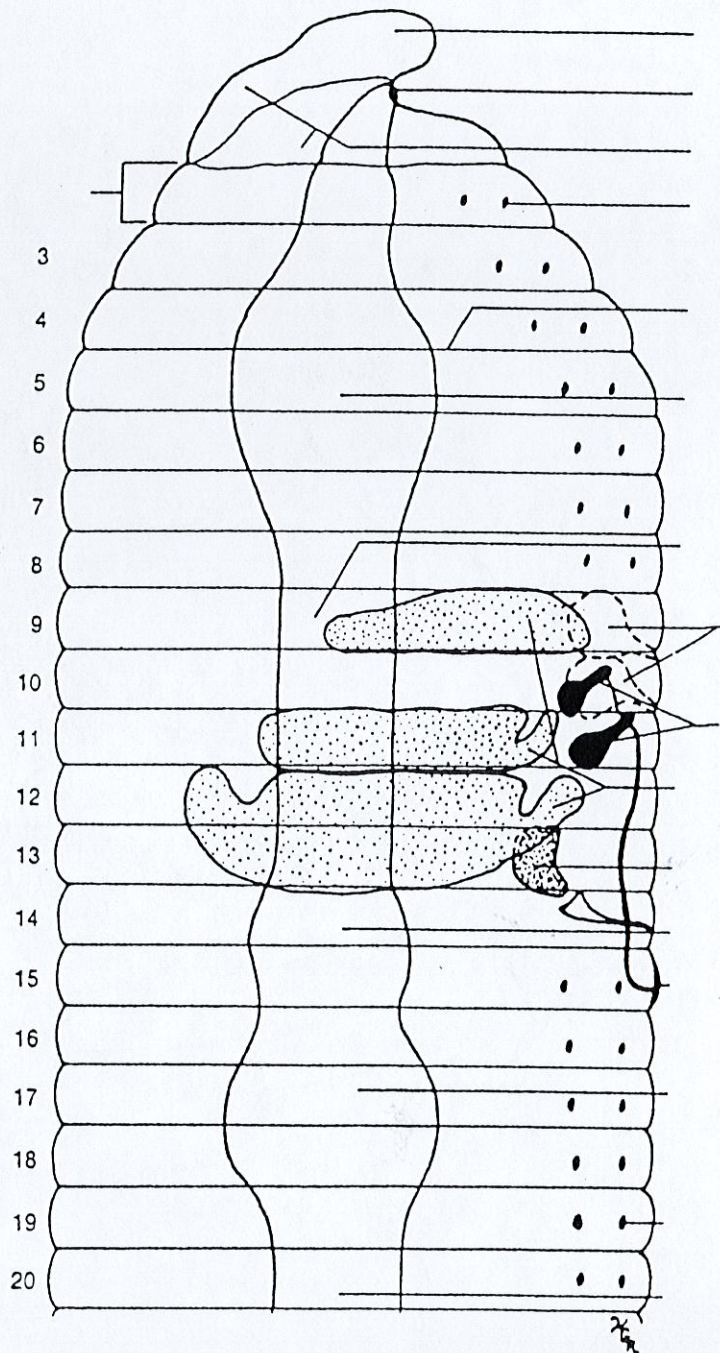
ventral nerve cord — Analagous to the vertebrate spinal cord, it extends down mid-ventrally through the entire worm. At each segment there is an enlargement, or **ganglion** (a mass of nervous tissue containing many nerve cells). Impulses sent by the brain and sub-pharyngeal ganglion travel down the nerve cord to effect movement and other responses.

Name _____ Date _____

Ventral view.
Figure 1



Lateral view showing location
of reproductive organs. *Figure 2*



Name _____ Date _____

Detailed dorsal view of
dissection of anterior end.

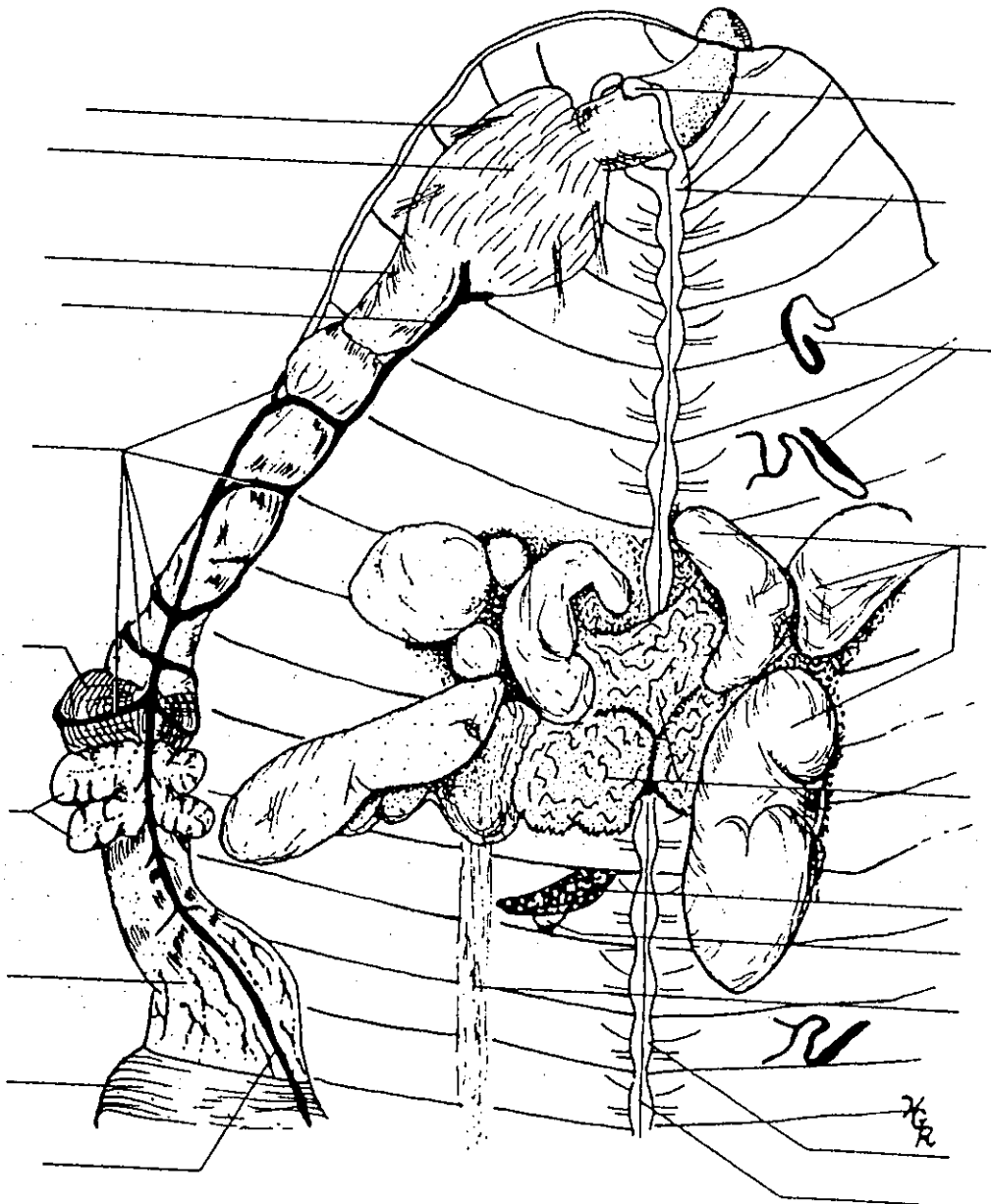
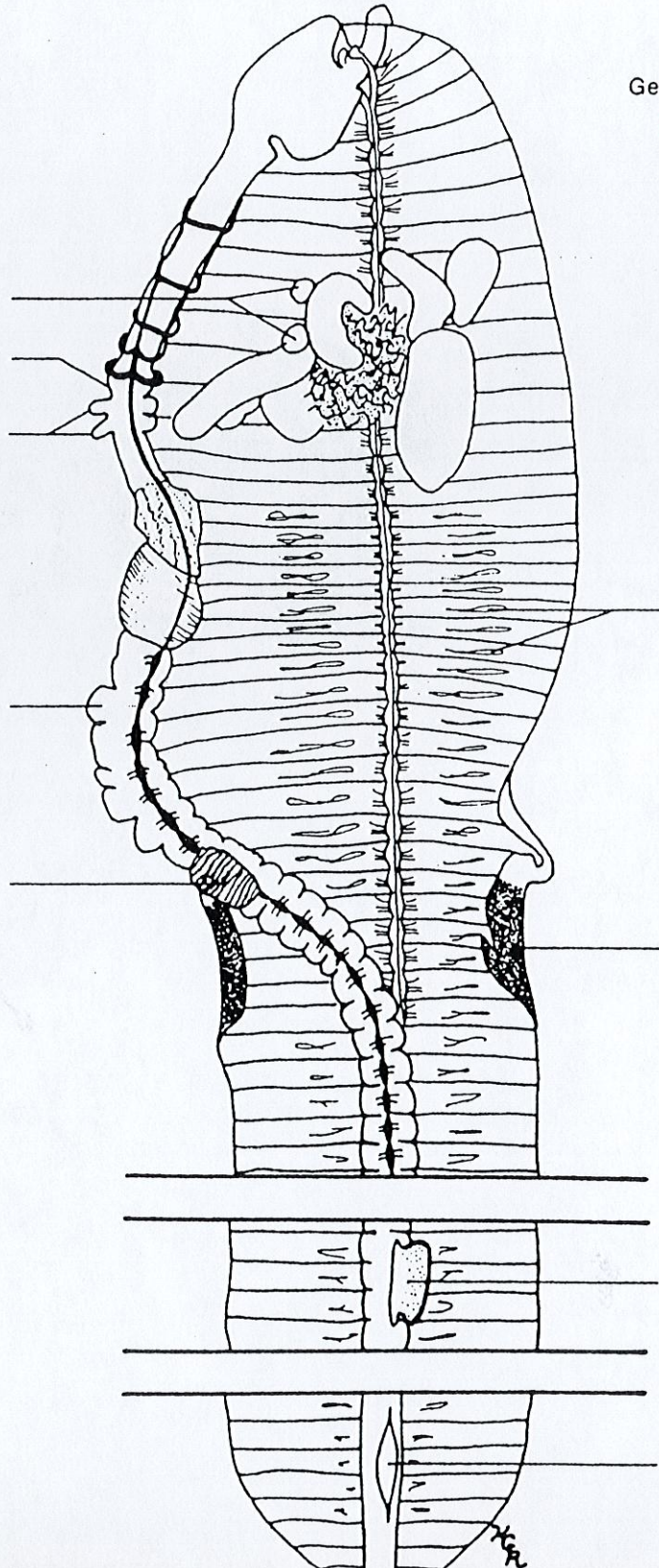


Figure 3

Name _____ Date _____



General dissection, dorsal view.

Figure 4