Earthworm – *Lumbricus terrestris*

Earthworm Classification

Kingdom: Animalia
Phylum: Annelida (the segmented worms)
Class: Clitellata (clitellum forms cocoon)
Subclass: Oligochaeta (the earthworms)

Earthworm is the common name for the largest members of the Subclass Oligochaeta (Gr. *oligos*, few + *chaite* hair). Oligochaetes have setae, but fewer than found in polychaetes. Earthworms prefer moist rich soil that is neither too dry nor sandy. Found all over the world, earthworms are nocturnal and come out of their burrows at night to forage, hence the name "night crawlers." They are **detritivores,** feeding upon dead leaf litter. They consume very little soil. While earthworms are never dormant, they do retreat to permanent burrows which can be up to 2.5 meters deep. A single earthworm can live up to 6 years, maturing in 350 days.

While earthworms are **monoecious**, single individuals having both male and female reproductive organs, they reproduce sexually. The animals stick their heads up from their burrows on warm, humid nights when attracted by a neighboring worm's glandular secretions. Copulating earthworms overlap front ends ventrally and secrete copious amounts of mucus from their **clitellum** to form a slime tube around the pair. Each earthworm exchanges sperm with the other, storing its partner's sperm in its **seminal receptacles**. The **cocoon**, or egg case, is secreted by the clitellum. Long after the worms have separated, the clitellum produces a secretion that finally hardens over its outer surface, forming a ring around the worm. The worm then backs out of the ring, and as it does so, injects its own eggs and the other worm's sperm into it. As the worm slips out, the ends of the cocoon seal to form a vaguely lemon-shaped sac in which the embryonic worms develop. They emerge as small, but fully formed earthworms, lacking only sex structures. They can produce 38 cocoons annually, each cocoon having 1 to 20 eggs, depending on the species. This allows colonies to spread about 3-5 meters per year.

Earthworms have a limited ability to **regenerate** lost segments, but this ability varies between species and depends on the extent of the damage.

Copulating Earthworms

Earthworm Cocoons

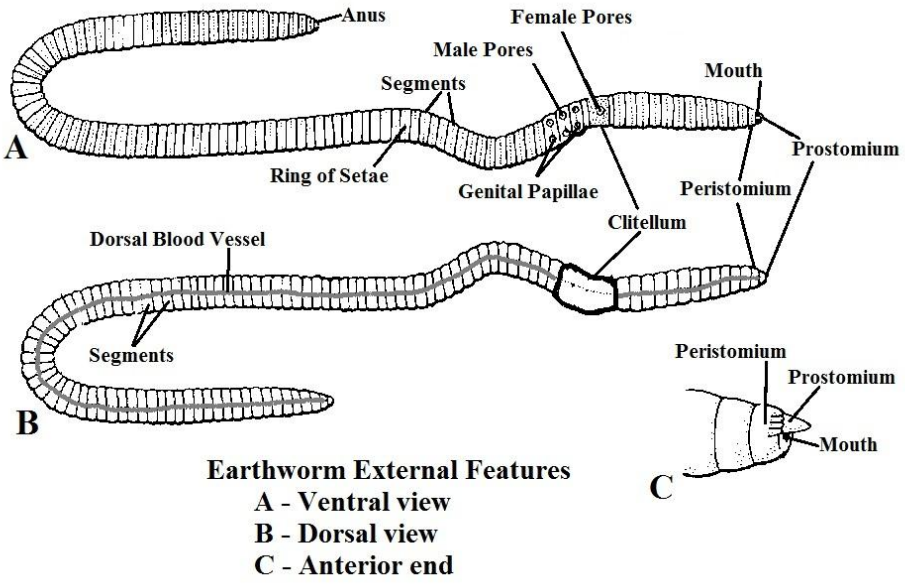
Photo source: wikipedia – earthworm

Basic Body Plan

The basic body plan of an earthworm is a tube, the digestive system, within a tube, the muscular slimy, moist outer body. Earthworms crawl and burrow by alternately contracting and relaxing their **longitudinal and circular muscles** in the body wall. These muscles compress against and pull on the **coelomic fluid**, which acts as a hydrostatic skeleton.

The first four segments of the earthworm make up the head region. At the anterior tip of the worm, the first segment, bearing the mouth, is the **peristomium**. The mouth is overhung by a lobe, the **prostomium**. The last segment bears the **anus.** On the body dorsum, between body segments 30-40, one finds the saddlelike **clitellum.** The clitellum secretes mucus during copulation and received the egg capsules into which they lay their eggs. The clitellum will then form the **coccoon**.

There are multiple external body openings besides the mouth and anus. **Male pores** are the large openings of the sperm ducts on the ventral surface of somite 15. From here, the earthworms discharge sperm during copulation. Between segments 9 and 10 and 10 and 11, pairs of **seminal receptacles** receive a partner's sperm during copulation. The **female pores**, on the ventral surface of segment 14, are so small that a hand lens is required to see them. On the lateroventral surface of each segment (except the first 3 and the last) are paired excretory openings, the **nephridiopores**. Many earthworms eject a foul-smelling coelomic fluid from their **dorsal pore** in response to mechanical or chemical irritation.



Earthworm External Features
A - Ventral view
B - Dorsal view
C - Anterior end

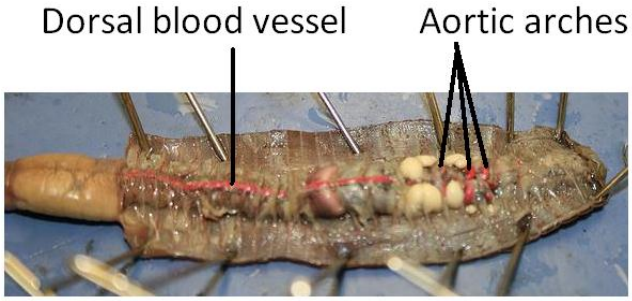
Image modified from: tutornext.com

The Circulatory System

The earthworm has a **closed** circulatory system in which the blood is confined to vessels throughout its circuit. However, compared to ours, the earthworms have a simple circulatory system. There are two main blood vessels that extend through the length of their body: a ventral blood vessel and a dorsal blood vessel. The **ventral blood vessel** (located beneath the digestive tract) propels blood to the posterior end of

the worm. Blood is distributed from the ventral vessel into capillaries on the body wall and other organs. The blood then accumulates in a **vascular sinus** in the gut wall, where gases and nutrients are exchanged.

The **dorsal blood vessel** is contractile and pumps blood anteriorly until it reaches a series of "hearts" (**aortic arches**), where it is pumped into the ventral vessel. Although the number of hearts varies by species, typically lumbricids have 5 aortic arches. The dorsal blood vessel is the chief pumping organ while the arches maintain a steady flow of blood into the ventral vessel.



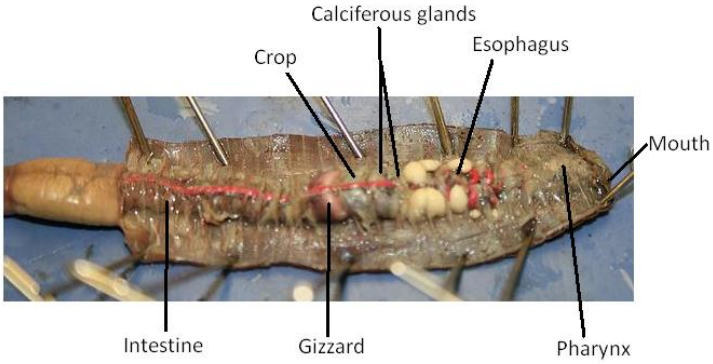
Dorsal View: dissection image modified from: http://farm3.static.flickr.com/2698/4344184028_6ce0c05e23_z.jpg

The Digestive System

Although much simpler than our digestive system, the digestive system of an earthworm is similar to ours in many ways. It is helpful to imagine the animal eating leaf detritus and then following that food through its passage in the digestive system.

The food is consumed through the **mouth**. Internal to the mouth is the sucking **pharynx** (throat). The pharynx is attached to the body by dilator muscles which are torn by the dissection process, giving the pharynx a hairy appearance. The food then passes into the slender **esophagus** in somites 6 to 13. The esophagus is hidden by the aortic arches and seminal vesicles. Food then passes into the thin-walled **crop** (segments 15 and 16) where it is stored for further processing. Food will then be passed at a steady rate into the muscular **gizzard** where it is ground into smaller particles. Food then passes into the long **intestine** where it is digested by enzymes and the resulting nutrition is absorbed into the circulatory system.

Earthworms have 2 or 3 pairs of **calciferous glands** that lie on either side of the esophagus. These glands remove excess calcium and carbonate ions that are consumed from the soil. If these ions were not removed, they would impact muscle contraction and result in the animal's death.



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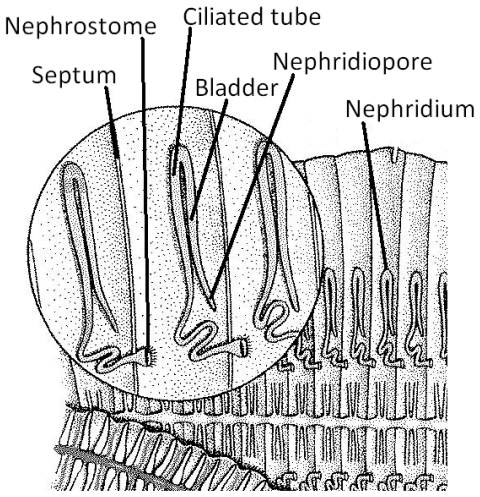
The Excretory System

The excretory organs of annelids, like many other invertebrates, are called **nephridia**. A pair of tubular nephridia lies in each somite except the first 3 and the last one. Each nephridium begins with a ciliated, funnel-shaped **nephrostome**. Coelomic fluid is drawn by ciliary activity (produced by a tuft of flagella) into the nephrostome and then flows through the tubule where ions (especially sodium and chloride) are reabsorbed. The remaining fluid, urine, containing the waste products collects in the bladder. The bladders empty to the outside of body via the **nephridiopores**.

Annelids excrete ammonia, which diffuses readily into the water. Therefore, most nitrogen excretion probably occurs across the body wall. The function of the excretory organs is most likely more involved in regulating water and ion balances.



Dorsal View: image modified from: Hickman, Cleveland P. Jr. And Lee B. Kats. *Laboratory Studies in Animal Diversity, 4th ed.* Boston: McGraw Hill Higher Education, 2007.

The Integumentary System

The integumentary system consists of the **epidermis** which secretes a protective, nonliving **cuticle**. The bristle-like hairs on the epidermis are the **setae** which facilitate burrowing. The segmental arrangement of the body parts is known as **metamerism**. The body segments (known as **somites**) are apparent due to the depressions in the body wall known as **annuli**. The segmentation can be seen internally as **septa** (partitions between the metameres). The skin is moist to allow for gas exchange through simple diffusion (earthworms have no lungs or gills).

Earthworms don't have eyes, but they do have **light-sensitive cells** scattered in their outer skin. These cells don't enable earthworms to see images, or forms, but they do give their skin the capacity to detect light and changes in light intensity. The worm's skin cells are also sensitive to touch and chemicals

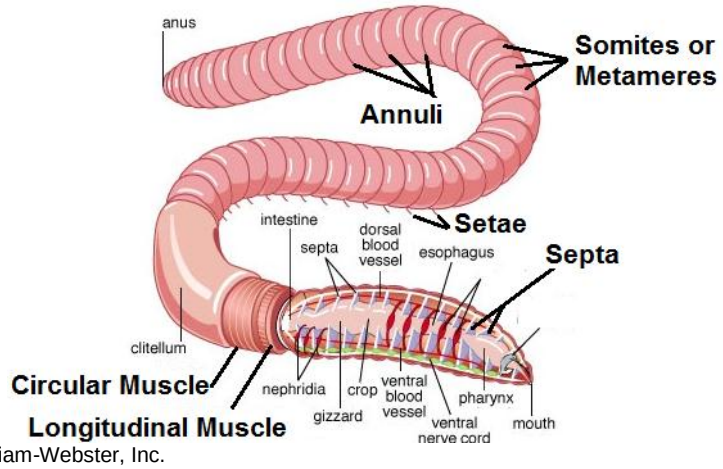


Image modified from: Merriam-Webster, Inc.

The Muscular System

The earthworm has two types of muscles: longitudinal and circular. The **longitudinal muscles**, the inner muscle layer, run the length of the animal and immediately surround the **coelom**. When the longitudinal muscles of a segment contract, the circular muscles relax, and because of the incompressibility of the coelomic fluid, the segment becomes shorter and fatter. The **circular muscles** surround the longitudinal muscles. Contraction of the circular muscles reduces the diameter of the body, making the worm long and thin.

Peristalsis, the coordinated contraction of the worm's muscles, results in body movements. Peristalsis passes down the animal in a wave of contracting and relaxing muscles, a few segments at a time. This movement is controlled by separate segmental nerves branching off the large ventral nerve cord. During locomotion the septal sphincter muscles remain closed and the septa act as bulkheads to keep the coelomic fluid within each segment constant.

Burrowing is achieved by protruding the setae (to anchor the worm) as the longitudinal muscles contract. The longitudinal muscles relax and the setae are withdrawn as the circular muscles contract. The circular muscles compress the coelomic fluid and stretch the longitudinal muscles, pushing the head forward. The posterior of the worm is anchored by protracted setae embedded in the burrow wall.

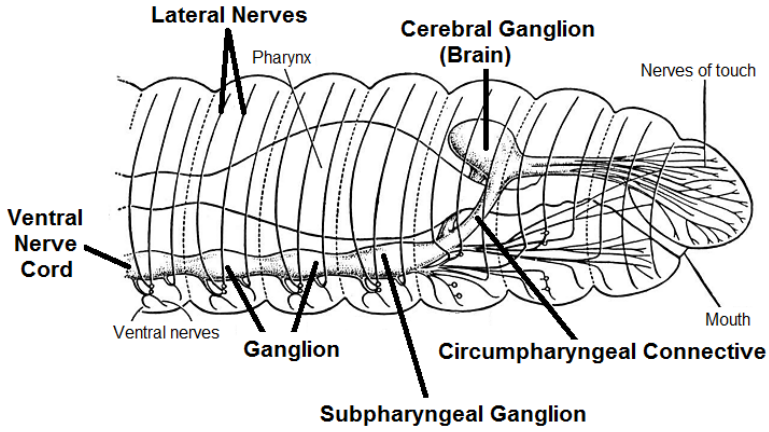
Most zoologists believe that the coelom evolved as an adaptation for burrowing. The coelom is known as the **hydrostatic skeleton** because the muscles contract and pull upon it, resulting in movement.

The Nervous System

Earthworms have **simple brains** which specialize in directing body movement in response to light, and not much else. Even if an earthworm's brain is removed, the resulting changes in its general behavior are hardly noticeable.

The brain consists of a pair of white **cerebral ganglia** that lie on the anterior end of the pharynx and are partially hidden by the dilator muscles. There are a pair of circumpharyngeal connectives that extend from the ganglia, encircle the pharynx, and reach the **subpharyngeal ganglia** under the pharynx. A **ventral nerve cord** extends

posteriorly from the subpharyngeal ganglia down the entire length of the animal. This can be seen if the digestive tract is moved laterally. Using a hand lens, one can see in each body segment the slightly enlarged **ganglion** and **lateral nerves**.

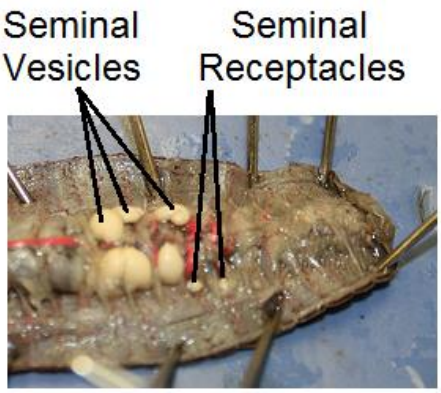


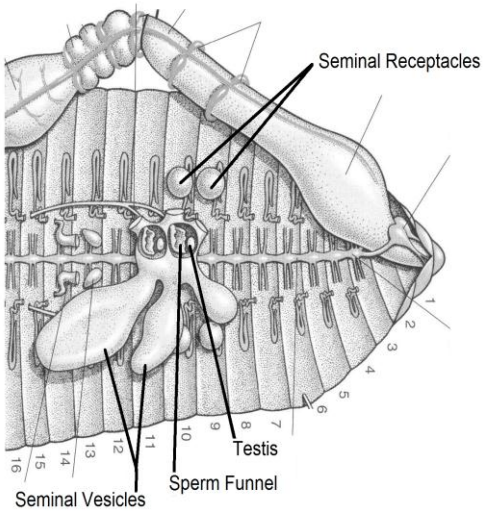
Lateral View: image modified from: http://shs.westport.k12.ct.us/mjvl/biology/dissect/earthworm.htm

The Reproductive System

Earthworms are hermaphrodites, having both male and female reproductive organs. Let us consider the male reproductive organs first. Upon opening up the worm, the 3 pairs of **seminal vesicles** (sperm sacs in which spermatozoa mature and are stored before copulation) are apparent. The seminal vesicles are attached to somites 9, 11, and 12. Inside the seminal vesicles are 2 pairs of small, branched **testes** which produce immature spermatozoa. These structures are internal and are so small that they are difficult to find. After maturation, spermatozoa will escape via the **sperm ducts** and **male pores** (somite 15) during copulation. During copulation, the earthworm will store a partner's sperm in its **seminal receptacles** (located in somites 9 & 10) to be used later to fertilize its own eggs.

The Male Reproductive Organs





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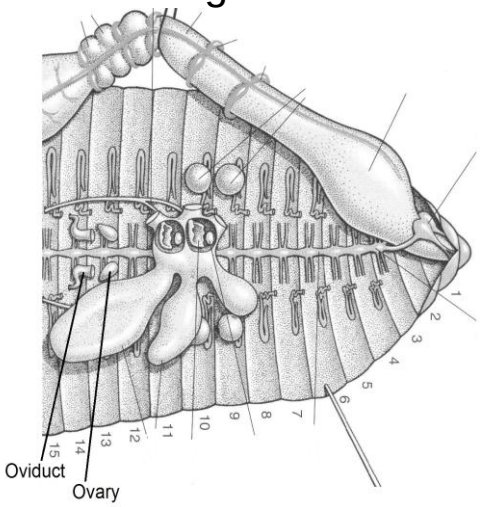
Hickman, Cleveland P. Jr. and Lee B. Kats. *Laboratory Studies in Animal Diversity, 4th ed.* Boston: McGraw Hill Higher Education, 2007.

The female reproductive organs are also small. One should be able to locate the paired **ovaries** (somite 13) which produce the eggs. The ovaries lie ventral to the third pair of seminal vesicles. They discharge their eggs into the **oviducts** in the next segments. The oviducts have ciliated funnels which carry the eggs to the female pores.

The Female Reproductive Organs



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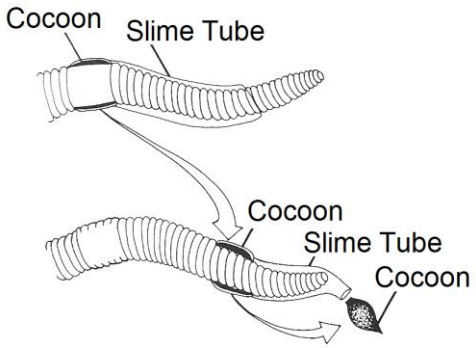

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Respiratory System

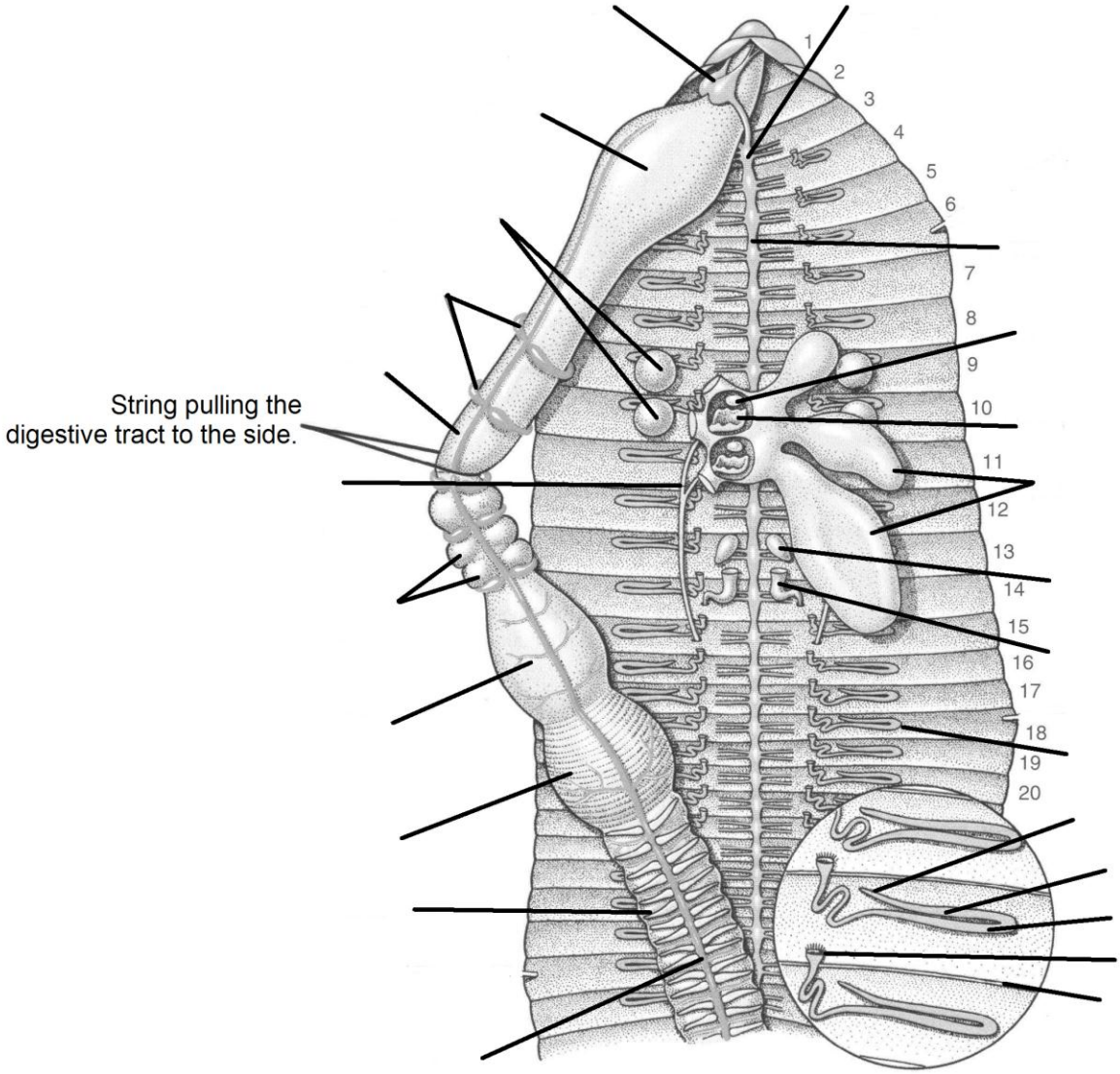
An earthworm has neither lungs nor gills but uses its body's great surface area to absorb oxygen from the soil. The oxygen is taken in by the dorsal blood vessel and travels to the five aortic arches (hearts) where it is pumped to the lower, ventral blood vessel. The ventral blood vessel pumps the blood to all segments and organs in need of oxygen. In each segment, there is a small blood vessel that sends the blood from the ventral blood vessel back to the dorsal blood vessel, thus completing the loop.

Dissection Instructions

1. Identify the dorsal surface (back side) of the earthworm. The dorsal side has the clitellum and you can see the faint line of the dorsal blood vessel.
2. Pin the animal in the dissection tray dorsal side up.
    a. Place the first pin through the worm's mouth.
    b. Place the second pin through the body, several somites below the clitellum.
3. Beginning just in front of the clitellum, use a razor blade to carefully slice through the cuticle and skin, just to the side of the dorsal blood vessel. Don't use downward force, as we only want to slice open the skin.
    a. Continue to cut upwards to the head of the animal.
4. Use a dissection pin to carefully break through the septa as you peel the skin from the sides of the animal. Pin the skin open using other dissection pins.
5. Identify the organs discussed in the exercise.
6. Label the diagram of the earthworm on the next page.
7. Clean up your work station.

On the next page is a diagram representing a dorsal view of the internal structures of an earthworm. Use the following terms above the diagram to identify the indicated structures.

Organ System	Structures to Identify
Circulatory	Aortic arches (“hearts”) & Dorsal blood vessel
Digestive	Calciferous glands, Crop, Esophagus, Gizzard, Intestine, & Pharynx
Excretory	Bladder, Ciliated tube, Nephridiopore, Nephridium, Nephrostome
Integumentary	Septum
Nervous	Cerebral ganglion, Subpharyngeal ganglion, & Nerve cord
Reproductive	Ovary, Oviduct, Seminal receptacles, Seminal vesicles, Sperm duct, Sperm funnel, Testis



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