Unit 25 · Earthworm

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Faunal Diversity (Units 22–26 together): 19 of 75 marks, 1 MCQ, 2 short and 1 long; in one group with Evolutionary Biology, Units 18–21 (28 marks)
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:**
  - short, OR (2 + 2 + 1): copulation; cocoon formation; **with a diagram**
  - long (1 + 4 + 3): excretion; septal nephridia; **a labeled diagram**
- **MCQ (1 mark)**
  - porphyrin; peristomium; metameric segments; ventral surfaces in mating
  - cocoon; seminal vesicles (11–12); nerve ring (3–4)
  - gizzard; omnivorous, detritivorous; setae
  - exonephric (integumentary); forest of nephridia (clitellum); yellow (chloragogen) cells
  - dorsal pores; nephridia with a nephrostome (septal)
- **Short and long (in parts)**
  - habit and habitat; external features
  - **draw** T.S. through the setae; through the **pharynx**; through the **gizzard**; the **body wall**
  - digestion; typhlosolar vs post-typhlosolar region
  - central nervous system; name parts of a figure
  - septal vs pharyngeal nephridia; the most advanced nephridium, **with a diagram**
  - male vs female organs; why protandrous; self-fertilization (no)
  - coelom and coelomic fluid; economic importance

Key terms

Metameric segmentation: segments alike outside and in, each with the same organs.

Peristomium: first segment, with the mouth; **prostomium**: lobe over it, boring and touch, not a segment.

Clitellum: gland band on segments **14–16**; makes the cocoon.

Perichaetine: setae in a complete ring round each segment.

Hydrostatic skeleton: coelomic fluid that the muscles push against.

Cutaneous respiration: breathing through the moist skin.

Enteronephric: nephridia emptying into the gut; **exonephric**: to the outside.

Nephrostome: ciliated funnel open to the coelom (septal nephridia only).

Protandrous: male organs ripen first, so it can't fertilize itself.

Detritivorous: eats decaying organic matter.

Pheretima posthuma

- Animalia · Annelida · **Oligochaeta** · *Pheretima* · *posthuma*
- newer name *Metaphire posthuma* (1972); write *Pheretima* in exams
- Nepal: 24 species recorded; *M. posthuma* used in labs, not yet found wild
- **Darwin** (1881): his last book, on earthworms

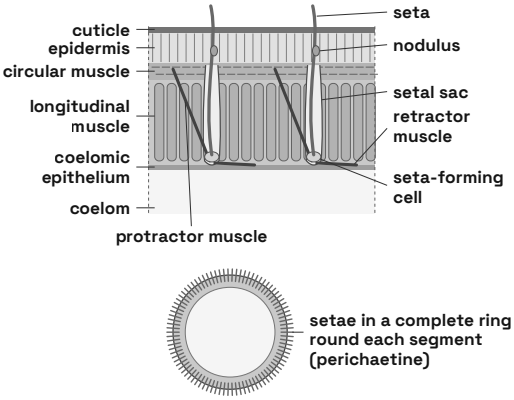
Habit and habitat

- **terrestrial**: burrows in moist soil rich in decaying matter (fields, gardens)
- **nocturnal**; up after heavy rain (burrows flood; breeding season)
- burrows by **eating** through soil → **worm castings**
- **omnivorous**, **detritivorous**; **cutaneous respiration** (mucus keeps skin moist)
- **hermaphrodite** but mates; fertilization **external** (in cocoon); development **direct**
- **farmer's friend**
- cut in two: regenerates lost segments, but doesn't make two worms

External features

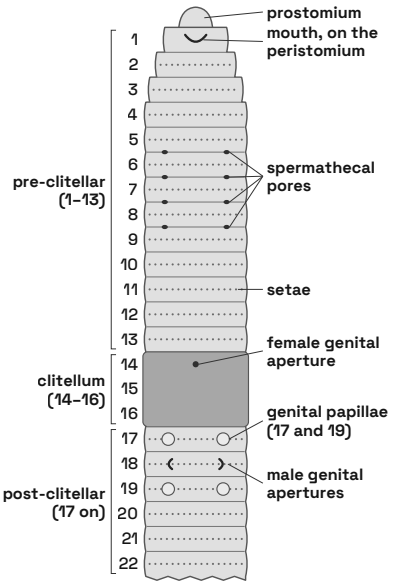
- **vermiform**, cylindrical, bilateral; pointed front, blunt back
- **~15 cm** × 3–5 mm
- dark brown: **porphyrin** (shields from UV); dorsal darker; **dorsal blood vessel** shows as a line

- **100–120** segments (metameres); **intersegmental grooves**; **septa** inside
- no head: **peristomium** (mouth) + **prostomium** (boring, touch)
- **clitellum** (cingulum), segments **14–16**: mucus, albumen and cocoon-forming cells
  - pre-clitellar 1–13 · clitellar 14–16 · post-clitellar 17 on
- **setae**: chitin, S-shaped, **nodulus**; in a **setal sac**; **protractor** pushes out, **retractor** pulls in
  - on every segment except the **first, last, clitellum**; 80–120 a ring (**perichaetine**)
- crawling: **circular** muscles → thin, long, setae in; **longitudinal** → short, fat, setae grip; waves front to back



T.S. through two setae (setal sac, protractor, retractor); below, the ring of setae.

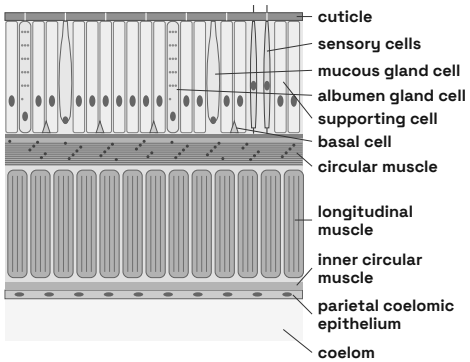
Opening	Where
mouth (crescent)	segment 1, ventral
spermathecal pores (4 pairs)	grooves **5/6–8/9**
female aperture (1)	**14**, mid-ventral
male apertures (1 pair)	**18**
genital papillae (2 pairs)	**17** and **19**
dorsal pores	mid-dorsal, from **12/13**
nephridiopores	all except segments 1–2
anus (vertical slit)	last segment (**pygidium**)



Segments 1–22, ventral view: the openings.

Body wall (outside in)

1. **cuticle**: non-living, collagen, secreted by epidermis; pores
2. **epidermis**: one layer on a basement membrane
   - **supporting cells** (secrete cuticle)
   - **gland cells**: mucous, albumen (moist, cement burrow)
   - **basal cells** (replacing)
   - **sensory cells** (light, chemicals, touch)
3. **muscle**: thin **circular** (porphyrin), thick **longitudinal** in bundles, thin inner circular
4. **parietal coelomic epithelium**: flat (squamous) cells



T.S. of the body wall.

Coelom

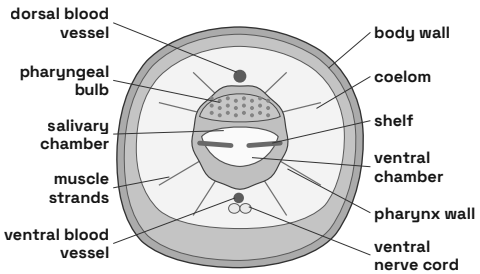
- true coelom, **schizocoel**; chambers divided by **septa**
- no septa in segments 1–4; one septum for 8–10 (gizzard)
- septa 4/5–13/14 without holes; 14/15 on with **sphincters**
- fluid: milky, **alkaline**; corpuscles:
  - **phagocytes** (amoebocytes): largest, most numerous; eat bacteria
  - **mucocytes**

- **circular nucleated cells**
- **chloragogen** (**yellow**) cells: ammonia → **urea**; store glycogen, fat; like a **liver**

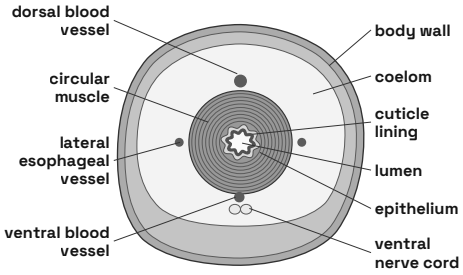
- functions: **hydrostatic skeleton**; oozes from dorsal pores (moist skin); fights infection

Digestive system

Part	Segments	Notes
mouth, **buccal chamber**	1–3	can be everted to grip food
pharynx	3–4	pear-shaped; **pharyngeal bulb** (salivary glands); shelves: **salivary chamber** above, **ventral conducting chamber** below; muscles suck and pump
esophagus	5–7	no glands; peristalsis
gizzard	8 (8–9)	thick **circular muscle**, cuticle lining; **grinds**
stomach	9–14	sphincters; **calciferous glands**: $CaCO_3$ neutralizes **humic acids**
intestine	15 on	beaded
· pre-typhlosolar	15–26	**villi**; **ceca** in **26** (to 23), **amylase**
· typhlosolar	27 on	**typhlosole**: more surface, most **absorption**
· post-typhlosolar (rectum)	last 23–25	no typhlosole, villi or glands
anus	last	castings



T.S. through the pharynx.



T.S. through the gizzard.

Digestion

- no digestion in the buccal chamber
- **pharynx**: saliva: mucus + **proteolytic** enzymes (proteins → proteoses, peptones)
- **gizzard**: grinds (with sand) to a paste
- **stomach**: protein digestion goes on
- **intestine**:

Enzyme	Acts on	Gives
amylase	starch	sugars
protease	proteins, peptones	amino acids
lipase	fats	fatty acids, glycerol
chitinase	chitin	sugars
cellulase	cellulose	glucose

- absorbed through villi and the **typhlosole** into blood; rest out as **castings**
- gut microbes do much of the leaf digestion

Typhlosolar	Post-typhlosolar
segment 27 on	last 23–25 segments
typhlosole, villi, glands	none; lengthwise folds
digestion, absorption	holds feces

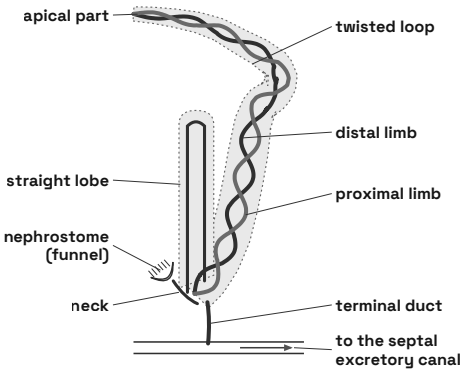
Excretory system

- **ammonotelic** and **ureotelic**: ~40% ammonia, 50% urea, 0.6% amino acids; well fed → more ammonia, starving → more urea
- **micronephridia** (*Pheretima*) vs **meganephridia** (*Nereis*, leech)

	Pharyngeal	Integumentary	Septal
where	**4, 5, 6** (3 pairs of tufts)	body wall, all but 1–2	septa from **15/16**
size	—	smallest, V-shaped	**largest**
number	hundreds a tuft	200–250 a segment; **2,000–2,500** in clitellum (**forest**)	40–50 a face, 80–100 a septum
nephrostome	no (closed)	no (closed)	**yes** (open)
wastes from	blood	blood	**coelomic fluid** and blood
empty into	pharynx (4, 5), buccal chamber (6)	outside, by **nephridiopores**	**intestine**
type	enteronephric	**exonephric**	enteronephric

Septal nephridium (most advanced: only one with a nephrostome)

- **nephrostome**: ciliated funnel; upper lip ~8 marginal cells round a central cell, lower lip ~4; draws in coelomic fluid
- **neck** (ciliated) → **body**: **straight lobe + twisted loop** (proximal and distal limbs, **9–13 twists**, apical part)
- **terminal duct → septal excretory canal**
- channels in the tube: 4 in straight lobe, 3 in each limb, 2 in apical part, 1 in neck and duct
- route: septal nephridia → terminal ducts → septal excretory canals → **supra-intestinal excretory ducts** (from 15) → intestine → anus
- emptying into the gut **saves water** (Bahl, 1919)

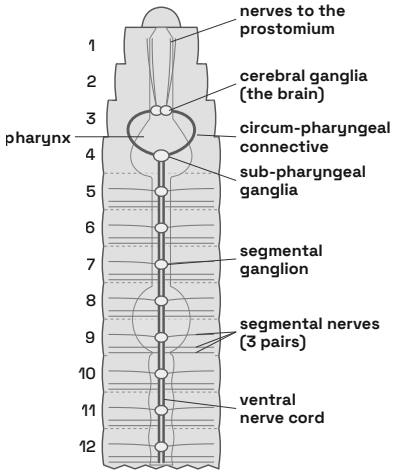


A septal nephridium (after Bahl, 1919).

Nervous system

Central

- **nerve ring** round the pharynx, segments **3–4**:
  - **supra-pharyngeal (cerebral) ganglia**: brain, dorsal, segment **3**
  - **circum-pharyngeal connectives**
  - **sub-pharyngeal ganglia**: ventral, segment **4**
- **ventral nerve cord**: solid, mid-ventral; **double** (two fused cords); a **segmental ganglion** in each segment
  - three **giant fibers** (fast; escape reflex, ~30 m/s)
  - sheath: visceral peritoneum, longitudinal muscle, **epineurium**



Nerve ring and ventral nerve cord, from above.

Peripheral

- cerebral ganglia: 8–10 nerves each (prostomium, buccal chamber)
- connectives: 2 pairs (segment 1, buccal chamber)
- sub-pharyngeal: 3 pairs (segments 2–4)
- each segmental ganglion: **3 pairs** (1 in front, 2 behind); all **mixed**

Sympathetic: plexus under the epidermis and on the gut, joined to the connectives

Sense organs

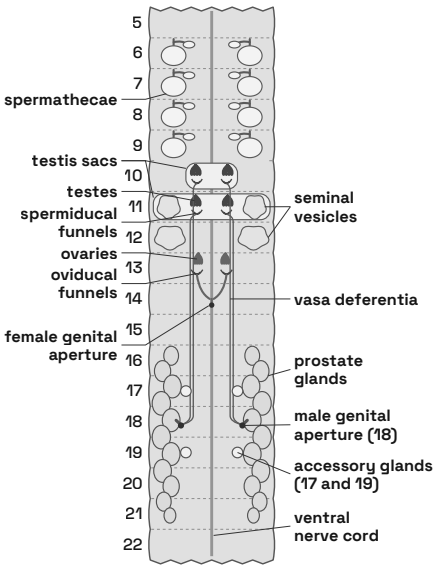
- **epidermal receptors**: touch, chemicals
- **buccal receptors**: taste, smell
- **photoreceptors**: dorsal, most on prostomium and peristomium; none on clitellum

Reproductive system

- **hermaphrodite** (monoecious) but **protandrous** → **cross-fertilization**

Male	Segments
2 pairs of **testes** (4–8 finger-like lobes)	**10, 11**
2 **testis sacs**	10, 11
2 pairs of **seminal vesicles** (sperm mature)	**11, 12**
2 pairs of **spermiducal funnels**	10, 11
vasa deferentia	to 18
prostate glands	**16–21**
common prostatic and spermatic duct → **male apertures**	**18**
2 pairs of **accessory glands** (on genital papillae)	**17, 19**

Female	Segments
1 pair of **ovaries** (ripest eggs at the tips)	**13**
oviducal funnels	13
oviducts → **common oviduct** → **female aperture**	**14**
4 pairs of **spermathecae** (ampulla, neck, **diverticulum** stores sperm)	**6–9**



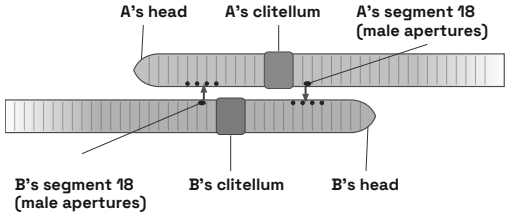
Reproductive organs of *Pheretima posthuma*.

Male system	Female system
testes in 10, 11	ovaries in 13
2 pairs of gonads	1 pair
seminal vesicles	spermathecae
prostate, accessory glands	none
1 pair of apertures on 18	1 aperture on 14

Copulation and cocoon formation

Copulation

- rainy season (July–October), at **night**, ~an hour
- **ventral surfaces** together, **heads opposite ways**
- male apertures (**18**) against the other's **spermathecal pores** (**6–9**)
- papilla round each male aperture acts as a copulatory organ
- sperm and prostatic fluid pass **both ways**; stored in spermathecae



Two earthworms mating: segment 18 of each against segments 6–9 of the other.

Cocoon formation

1. **cocoon-forming** glands → **membranous band** round the clitellum; **albumen** added
2. worm **backs out**: band slides **forwards**
3. at segment **14**: **eggs** laid into it
4. at segments **9–6**: **sperm** from spermathecae
5. slips off the front; ends close → **light yellow, oval cocoon**

- fertilization **inside the cocoon** (external)
- usually **one** young per cocoon; **holoblastic, unequal** cleavage; **direct**; hatches in **15–20 days**

Economic importance

Useful

- food for birds, frogs, fish; bait
- **better soil**: air, water, castings mix in nutrients
- **vermicompost** (by the red wiggler, *Eisenia fetida*; NAST, Khumaltar)
- traditional medicine (no good evidence)
- type animal for study

Harmful

- burrows let irrigation water **seep away**
- loose soil **washed** off slopes
- carry parasites (poultry tapeworm *Amoebotaenia*, gapeworm)
- some damage roots (**rice**, **betel vine**)

COMMON MISTAKES

✗ The earthworm fertilizes itself
✓ **protandrous**: two worms mate and exchange sperm.

✗ Fertilization is internal
✓ **external**, in the cocoon.

✗ Cutting a worm makes two worms
✓ only regeneration of lost segments.

✗ Integumentary nephridia have a nephrostome
✓ only **septal** ones do.

✗ Pharyngeal nephridia open outside
✓ into the **gut** (enteronephric).

✗ The cocoon slides backwards
✓ the worm backs out; the band slides **forwards**.

✗ Ovaries in 14
✓ ovaries in **13**; female aperture on 14.