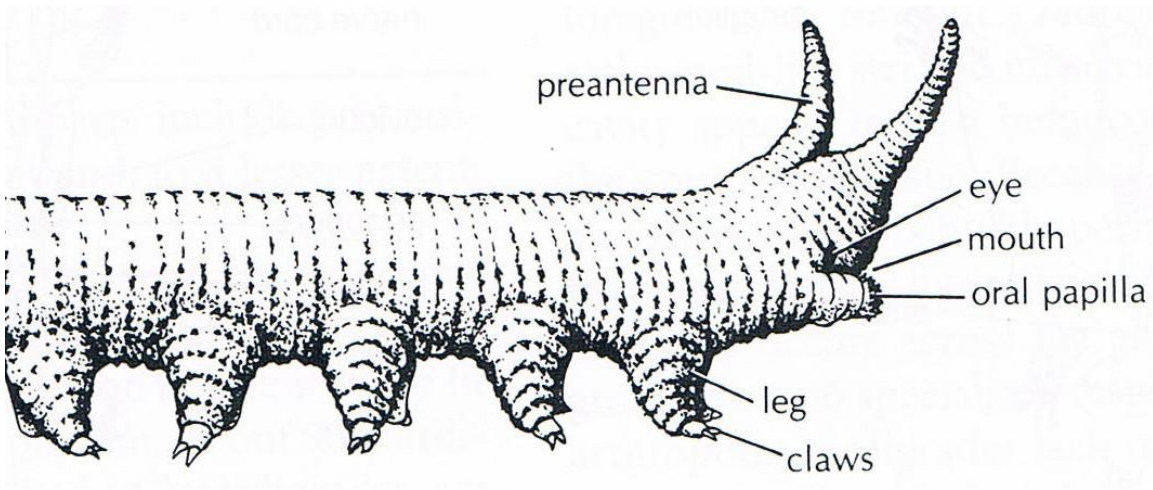
Onychophora



Introduction

- **The velvet worms (Onychophora — literally "claw bearers", also known as Protracheata) are a minor phylum with ~180 species.**
- **These obscurely segmented organisms have tiny eyes ,antennae, multiple pairs of legs and slime glands.**
- **Most common in tropical regions of the Southern Hemisphere**
- **they prey on smaller animals such as insects , which they catch by an adhesive mucus.**
- **In modern zoology , they are particularly renowned for their curious mating behaviour and for bearing live young.**
- **The two extant families of velvet worms are Peripatidae and Peripatopsidae .**
- **They show a peculiar distribution, with the peripatids being predominantly equatorial and tropical, while the peripatopsids are all found in what used to be Gondwana .**

Anatomy

- Velvet worms are segmented creatures with a flattened cylindrical body cross-section and rows of unstructured body appendages known as lobopods (informally: stub feet).
- The animals grow to between 0.5 and 20 cm (.25 to 8 in), with the average being about 5 cm (2 in), and have between 13 and 43 pairs of legs.
- Their skin consists of numerous, fine transverse rings and is often inconspicuously coloured orange, red or brown, but sometimes also bright green, blue, gold or white, and occasionally patterned with other colours
- Segmenting—is identifiable only in the regular spacing of the pairs of legs ,is visible in the regular arrangement of skin pores, excretion organs and concentrations of nerve cells.
- The individual body sections are largely unspecialised even the head develops only a little differently from any abdominal segment

Body appendages

- The stub feet that characterise the velvet worms are conical, baggy appendages of the body, which are internally hollow and exhibit no joints.
- Although the number of feet can vary considerably between species, their structure is basically very similar.
- Rigidity is provided by the hydrostatic pressure of their fluid contents, and movement is usually obtained passively by stretching and contraction of the animal's entire body.
- However, each leg can also be shortened and bent by internal muscles ,due to the lack of joints, this bending can take place at any point along the sides of the leg.

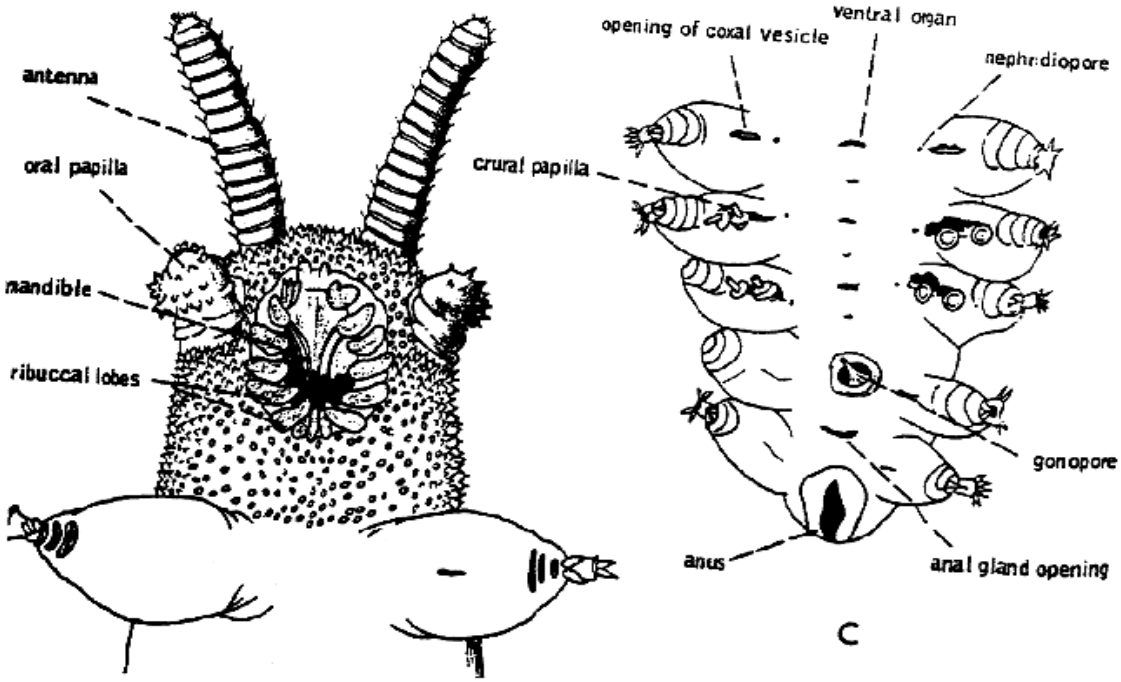


Figure 4

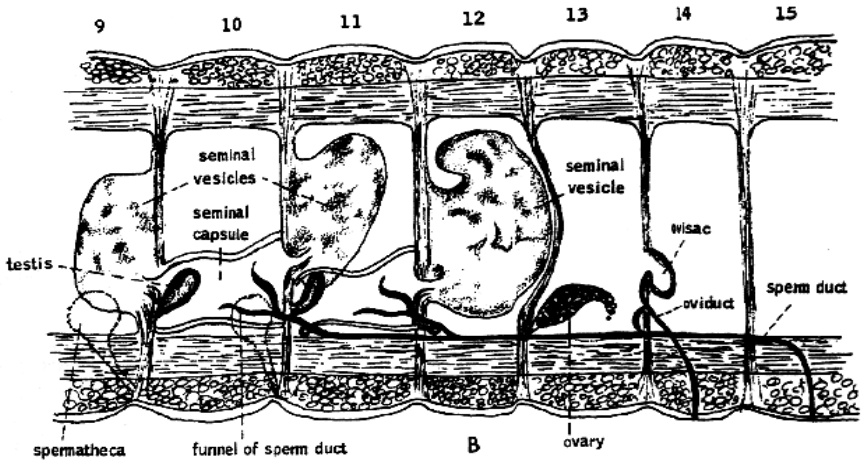
In some species, two different organs are found within the feet:

- Crural glands are situated at the shoulder of the legs, extending into the body cavity.
- They open outwards at the crural papillae -wart-like bumps on the ventral side of the leg—and secrete chemical messenger materials called pheromones . Their name comes from the Latin *cruralis* meaning "of the legs".
- Coxal vesicles are pouches located on the ventral side of the leg, which probably serve in water absorption. They are only found within the family Peripatidae and are named from *coxa*, the Latin word for “hip".
- On each foot is a pair of retractable, hardened (sclerotised) chitin claws, which give the taxon its scientific name: Onychophora is derived from the Greek *onyches*, "claws"; and *pherein*, "to carry".

further body appendages

- there are three further body appendages, which are at the head and comprise three segments :
- On the first head segment is a pair of slender antennae, which serve in sensory perception.
- They probably do not correspond directly to the antennae of the Arthropoda, but perhaps rather with their "lips" or labrum .
- At their base is found a pair of simple eyes, except in a few blind species.
- In front of these, in many Australian species, are various dimples, the function of which is not yet clear.
- It appears that in at least some species, these serve in the transfer of sperm-cell packages (spermatophores) .

- On the ventral side of the second head segment is the labrum, a mouth opening surrounded by sensitive "lips".
- In the velvet worms, this structure is a muscular outgrowth of the throat, so, despite its name, it is probably not homologous to the labrum of the Arthropoda.
- Deep within the oral cavity lie the sharp, "jaws", or mandibles, which are strongly hardened and resemble the claws of the feet, with which they are probably homologous.
- The jaws are divided into internal and external mandibles and are covered with fine toothlets.
- They move backward and forward in a longitudinal direction, tearing apart the prey.
- On the third head segment, to the left and right of the mouth, are two openings designated "oral papillae".
- Within these are a pair of large, heavily internally branched slime glands.
- These lie roughly in the centre of the body and secrete a sort of milky-white slime, which is used to catch prey and for defensive purposes.
- Sometimes the connecting "slime conductor" is broadened into a reservoir, which can buffer pre-produced slime.
- The slime glands themselves are probably modified crural glands.
- All three structures correspond to an evolutionary origin in the leg pairs of the other segments



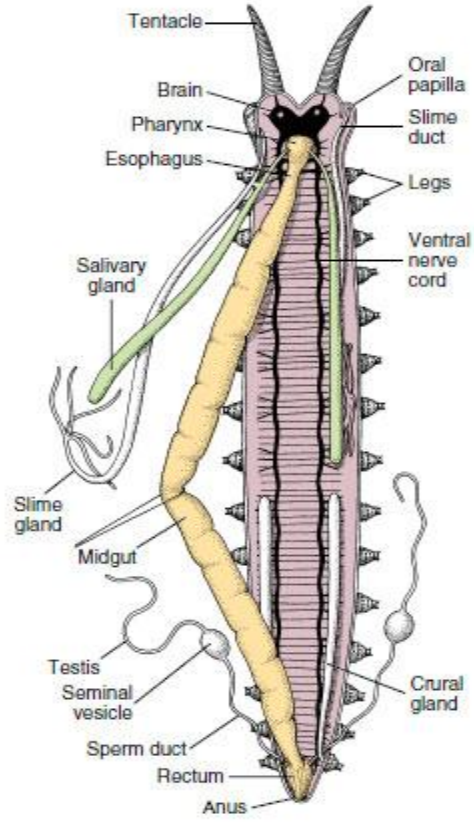
- Figure 2

Skin and musculature

- Unlike the arthropods, velvet worms do not possess a rigid exoskeleton.
- Instead, their fluid-filled body cavity acts as a hydrostatic skeleton, similarly to many unrelated soft-bodied animals that are cylindrically shaped, for example sea anemones and various worms .
- Pressure of their incompressible internal bodily fluid on the body wall provides rigidity, and muscles are able to act against it.
- The body wall consists of a non-cellular outer skin, the cuticula ; a single layer of epidermis cells forming an internal skin; and beneath this, usually three layers of muscle, which are embedded in connective tissues
- The cuticula is about a micrometer thick and covered with fine villi.
- In composition and structure, it resembles the cuticula of the arthropods, consisting of α-chitin and various proteins, although not containing collagen .
- It can be divided into an external epicuticula and an internal procuticula, which themselves consist of exo- and endo-cuticula.
- This multi-level structure is responsible for the high flexibility of the outer skin, which enables the velvet worm to squeeze itself into the narrowest crevices.
- Although outwardly water-repellent, the cuticula is not able to prevent water loss by respiration, and, as a result, velvet worms can only live in microclimates with high humidity to avoid desiccation.
- The surface of the cuticula is scattered with numerous fine papillae, the larger of which carry visible villi-like sensitive bristles.
- The papillae themselves are covered with tiny scales, lending the skin a velvety appearance (from which the common name is likely derived).
- It also feels like dry velvet to the touch, for which its water-repellent nature is responsible. Moulting of the skin (ecdysis) takes place regularly, sometimes every 14 days, induced by the hormone ecdysone.
- At each moult, the shed skin is replaced by the epidermis, which lies immediately beneath it; unlike the cuticula, this consists of living cells. Beneath this lies a thick layer of connective tissue, which is composed primarily of collagen fibres aligned either parallel or perpendicular to the body's longitudinal axis. Within the connective tissue lie three continuous layers of unspecialised smooth muscular tissue. The relatively thick

outer layer is composed of annular (sphincter) muscles, and the similarly voluminous inner layer of longitudinal muscles.

- Between them lie thin diagonal muscles that wind backward and forward along the body axis in a spiral.
- Between the annular and diagonal muscles exist fine blood vessels, which lie below the superficially recognisable transverse rings of the skin and are responsible for the pseudo-segmented markings.
- Beneath the internal muscle layer lies the body cavity.
- In cross-section, this is divided into three regions by so-called dorso-ventral muscles, which run from the middle of the underbelly through to the edges of the upper side: a central midsection and on the left and right, two side regions that also include the legs.
- The colouration of Onychophora is generated by a range of pigments . Clarification needed .[] The solubility of these pigments is a useful diagnostic character: in all arthropods and tardigrades, the body pigment is soluble in ethanol.
- This is also true for the Peripatidae, but in the case of the Peripatopsidae, the body pigment is insoluble in ethanol



Haemocoel and circulation

- The body cavity is known as a "pseudocoel", or haemocoel. Unlike a true coelom, a pseudocoel is not fully enclosed by a cell layer derived from the embryonic mesoderm.
- A coelom is, however, formed around the gonads and nephridia.
- As the name *haemocoel* suggests, the body cavity is filled with a blood -like liquid, in which all the organs are embedded; in this way, they can be easily supplied with nutrients circulating in the blood. This liquid is colourless as it does not contain pigments; for this reason, it only serves a limited role in oxygen transport.
- Two different types of blood cells (or haemocytes) circulate in the fluid: amoebocytes and nephrocytes.
- The amoebocytes probably function in protection from bacteria and other foreign bodies; in some species, they also play a role in reproduction.
- Nephrocytes absorb toxins or convert them into a form suitable for elimination by the nephridia.

aemocoel and circulation

- The haemocoel is divided by a horizontal partition, the diaphragm, into two parts: the pericardial sinus along the back and the perivisceral sinus along the belly.
- The former encloses the tube-like heart, and the latter, the other organs.
- The diaphragm is perforated in many places, enabling the exchange of fluids between the two cavities.
- The heart itself is a tube of muscles consisting of epithelial tissues, with two lateral openings (ostia) per segment.
- While it is not known whether the rear end is open or closed, from the front, it opens directly into the body cavity.
- Since there are no blood vessels, apart from the fine vessels running between the muscle layers of the body wall and a pair of arteries that supply the antennae, this is referred to as an open circulation

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- The pumping procedure can be divided into two parts: diastole and systole.
- During diastole, blood flows through the ostia from the pericardial sinus (the cavity containing the heart) into the heart.
- When the systole begins, the ostia close and the heart muscles contract inwards, reducing the volume of the heart.
- This pumps the blood from the front end of the heart into the perivisceral sinus containing the organs.
- In this way, the various organs are supplied with nutrients before the blood finally returns to the pericardial sinus via the hole in the diaphragm.
- In addition to the pumping action of the heart, body movements also have an influence on circulation.

Respiration

- Oxygen uptake occurs via simple diffusion through the entire body surface, with the coxal vesicles on the legs possibly being involved in some species.
- However, of most importance is gas exchange via fine unbranched tubes, the tracheae, which draw oxygen from the surface deep into the various organs, particularly the heart.
- The walls of these structures, which are less than three micrometers thick in their entirety, consist only of an extremely thin membrane through which oxygen can easily diffuse.
- The tracheae originate at tiny openings, the spiracles, which themselves are clustered together in dent-like recesses of the outer skin, the atria.
- The number of "tracheae bundles" thus formed is on average around 75 per body segment; they accumulate most densely on the back of the organism.
- Unlike the arthropods, the velvet worms are unable to control the openings of their tracheae; the tracheae are always open, entailing considerable water loss in arid conditions.
- For this reason, velvet worms are dependent upon habitats with high air humidity.

Digestive system

- The digestive tract begins slightly behind the head, the mouth lying on the underside a little way from the frontmost point of the body.
- Here, prey can be mechanically dismembered by the mandibles with their covering of fine toothlets.
- Two salivary glands discharge via a common conductor into the subsequent "throat", which makes up the first part of the front intestine .
- The saliva that they produce contains mucus and hydrolytic enzymes, which initiate digestion both within and outside the mouth.
- Historically, the salivary glands probably evolved from the waste-elimination organs known as nephridia, which are found homologously in the other body segments.

- The throat itself is very muscular, serving to absorb the partially liquified food and to pump it, via the oesophagus, which forms the rear part of the front intestine, into the central intestine. Unlike the front intestine, this is not lined with a cuticula but instead consists only of a single layer of epithelial tissue, which does not exhibit conspicuous indentation as is found in other animals.
- On entering the central intestine, food particles are coated with a mucus-based peritrophic membrane, which serves to protect the lining of the intestine from damage by sharp-edged particles.
- The intestinal epithelium secretes further digestive enzymes and absorbs the released nutrients, although the majority of digestion has already taken place externally or in the mouth.
- Indigestible remnants arrive in the rear intestine, or rectum, which is once again lined with a cuticula and which opens at the anus, located on the underside near to the rear end

Excretory organs :

- In almost every segment is a pair of excretory organs called nephridia, which are derived from coelom tissue.
- Each consists of a small pouch that is connected, via a flgellated conductor called a nephridioduct, to an opening at the base of the nearest leg known as a nephridiopore.
- The pouch is occupied by special cells called podocytes, which facilitate ultrafiltration of the blood through the partition between haemocoelom and nephridium.
- The composition of the urinary solution is modified in the nephridioduct by selective recovery of nutrients and water and by isolation of poison and waste materials, before it is excreted to the outside world via the nephridiopore.
- The most important nitrogenous excretion product is the water-insoluble uric acid; this can be excreted in solid state, with very little water.
- This so-called uricotelic excretory mode represents an adjustment to life on land and the associated necessity of dealing economically with water.
- A pair of former nephridia in the head were converted secondarily into the salivary glands, while another pair in the final segment of male specimens now serve as glands that apparently play a role in reproduction.

Sensory organs :

- The entire body—including the stub feet—is littered with numerous papillae: warty protrusions that carry a mchanoreceptive bristle (responsive to mechanical stimuli) at the tip, each of which is also connected to further sensory nerve cells lying beneath.
- The mouth papillae, the exits of the slime glands, probably also have a function in sensory perception. Sensory cells known as "sensills" on the "lips" or labrum respond to chemical stimuli and are known as chemoreceptors.
- These are also found on the two antennae, which can be regarded as the velvet worm's most important sensory organs.
- Except in a few (typically subterranean) species, one simply constructed eye (ocellus) lies laterally, just underneath the head, behind each antenna.
- This consists of a chitinous ball lens, a cornea and a retina and is connected to the centre of the brain via an optic nerve.
- The retina comprises numerous pigment cells and photoreceptors; the latter are easily modified flagellated cells, whose flagellum membranes carry a photosensitive pigment on their surface.
- The rhabdomeric eyes of the Onychophora are thought to be homologous with the median ocelli of arthropods; this would imply that the last common ancestor of arthropods bore only median ocelli.
- However, the innervation shows that the homology is limited: the eyes of Onychophora form behind the antenna, whereas the opposite is true in arthropods.

Reproductive organs :

- **Both sexes possess pairs of gonads ,opening via a channel called a gonoduct into a common genital opening, the gonopore, which is located on the rear ventral side. Both the gonads and the gonoduct are derived from true coelom tissue.**
- **In females, the two ovaries are joined in the middle and to the horizontal diaphragm.**
- **The gonoduct appears differently depending on whether the species is live-bearing or egg-laying. In the former, each exit channel divides into a slender oviduct and a roomy "womb", the uterus, in which the embryos develop**

- **. The single vagina, to which both uteri are connected, runs outward to the gonopore. In egg-laying species, whose gonoduct is uniformly constructed, the genital opening lies at the tip of a long egg-laying apparatus, the ovipositor.**
- **The females of many species also possess a sperm repository called the receptacle seminis, in which sperm cells from males can be stored temporarily or for longer periods.**
- **Males possess two separate testes, along with the corresponding sperm vesicle (the vesicula seminalis) and exit channel (the vasa efferentia).**
- **The two vasa efferentia unite to a common sperm duct, the vas deferens, which in turn widens through the ejaculatory channel to open at the gonopore.**
- **Directly beside or behind this lie two pairs of special glands, which probably serve an auxiliary reproductive function; the rearmost glands are also known as anal glands.**
- **A penis-like structure has so far only been found in males of the genus *Paraperipatus* but has not yet been observed in action.**
- **As previously mentioned, males of many Australian species exhibit special structures on the head, which apparently take over certain tasks in transferring sperm to the females. In the species *Euperipatoides rowelli*, sperm is collected by these structures, and, when a female is encountered, the worm inserts its head in the vagina**

Reproductive organs

- Almost all species of velvet worm reproduce sexually.
- The sole exception is *Epiperipatus imthurni*, of which no males have been observed; reproduction instead occurs by parthenogenesis.
- All species are in principle sexually distinct and bear, in many cases, a marked sexual dimorphism: the females are usually larger than the males and have, in species where the number of legs is variable, more legs.
- The females of many species are fertilized only once during their lives, which leads to copulation sometimes taking place before the reproductive organ of the females are fully developed.

- In such cases, for example at the age of three months in *Macroperipatus torquatus*, the transferred sperm cells are kept in a special reservoir, where they can remain viable for longer periods.
- Fertilization takes place internally, although the mode of sperm transmission varies widely.
- In most species, for example in the genus *Peripatus*, a package of sperm cells called the spermatophore is placed into the genital opening of the female. The detailed process by which this is achieved is in most cases still unknown, a true penis having only been observed in species of the genus *Paraperipatus*.
- Velvet worms are found in egg-laying (oviparous), egg-live-bearing (ovoviviparous) and live-bearing (viviparous) forms

Slime

- The slime of the Onychophora is forcefully squirted from a pair of slime glands (oral papillae) in defence against predators and to capture prey .
- The slime glands, positioned on the sides of the head below the antennae, are a pair of highly modified limbs and typically propel the slime around a centimetre
- The proteinaceous composition accounts for the slime's high tensile strength and stretchiness.Upon ejection, it forms a net of threads about 20 µm in diameter, with evenly spaced droplets of viscous adhesive fluid along their length.
- It subsequently dries, shrinking, losing its stickiness, and becoming brittle. Onychophora will eat and "reuse" any dried slime.
- The lipid and nonylphenol constituents may serve one of two purposes.
- They may line the ejection channel, stopping the slime from sticking to the organism when it is secreted; or they may slow the drying process long enough for the slime to reach its target

Classification

- Phylum Onychophora
  - Class Onychophorida
    - Order † Paronychophora (extinct)
      - Family † Onychodictyidae
        - » Genus † *Onychodictyon*
    - Order Euonychophora
      - Family Peripatidae
        - » Genera: ……
      - Family Peripatopsidae
        - » Genera: ……
      - Family † incertae sedis
        - » Genus † *Helenodora*