NERVOUS SYSTEM OF NEMATODES

Lecture 2

Sense Organs

Caenorhabditis elegans

- Features
  - Free living, non parasitic
  - Transparent
  - Temperate soil environments
  - 1 mm in length
- Importance
  - Whole genome sequenced
  - Connectome (neuronal "wiring diagram") completed

Caenorhabditis elegans /ˌseɪnəræbˈdɪtɪs ˈɛlɛɡænz/ is a free-living (not parasitic), transparent nematode (roundworm), about 1 mm in length,[2] that lives in temperate soil environments.

C. elegans was the first multicellular organism to have its whole genome sequenced, and as of 2012, the only organism to have its connectome (neuronal "wiring diagram") completed. A connectome is a comprehensive map of neural connections in the brain, and may be thought of as its "wiring diagram". More broadly, a connectome would include the mapping of all neural connections within an organism's nervous system.

Sense Organs in C. *Elegans*

- How it Discovered?
  - Electron-micrographs of serial sections
  - Laser ablation
  - Lineage studies
  - Behavioural responses to mutations
- Complete anatomy> Nematode's nervous system
  - Head (Ward et al., 1975; Ware et al., 1975)
  - Pharynx (Albertson and Thomson, 1976)
  - Ventral cord (White et al., 1976)
  - Tail of the male (Sulston et al., 1980)

Over the past 20 years as a result of detailed work on reconstructions from electronmicrographs of serial sections coupled with laser ablation, lineage studies, and behavioral responses to mutations, more is now known about the nervous system of *Caenorhabditis elegans* than of any other animal.

By a process of reconstruction of the anatomy of *C. elegans* from serial sections viewed under the electron microscope (a tedious task involving some **15,000-20,000 sections per 1 mm of nematode**), White et al. (1986) described the complete anatomy of this nematode's nervous system.

The reconstructions presented by these workers show the connections of all the neurons of the *C. elegans* hermaphrodite nervous system, together with those previously described in the sensilla in the head (Ward et al., 1975; Ware et al., 1975), in the pharynx (Albertson and Thomson, 1976), in the ventral cord (White et al., 1976), and in the tail of the male (Sulston et al., 1980).

Neurons in C. *Elegans*

- Male C. *elegans*
  - 381 neurons and 92 glial and associated supporting cells
- Hermaphrodite C. *elegans*
  - 302 neurons and 56 glial and associated supporting cells

The male of *C. elegans* has a slightly more extensive nervous system, made up of 381 neurons and 92 glial and supporting cells, than the hermaphrodite, which has 302 neurons and 56 glial and associated supporting cells. This is largely due to the innervation of the male tail with its copulatory bursa.

Sensilla or Sense Organs

- Sensillum (Plural 'Sensilla')
- Definition
  - According to Webster's dictionary-
    - "Sensillum is a simple epithelial sense organ composed of one or a few cells with a nerve connection and usually taking the form of a spine, plate, rod, cone or peg."

Structure of a typical Sensillum

(A) Sensory neuron

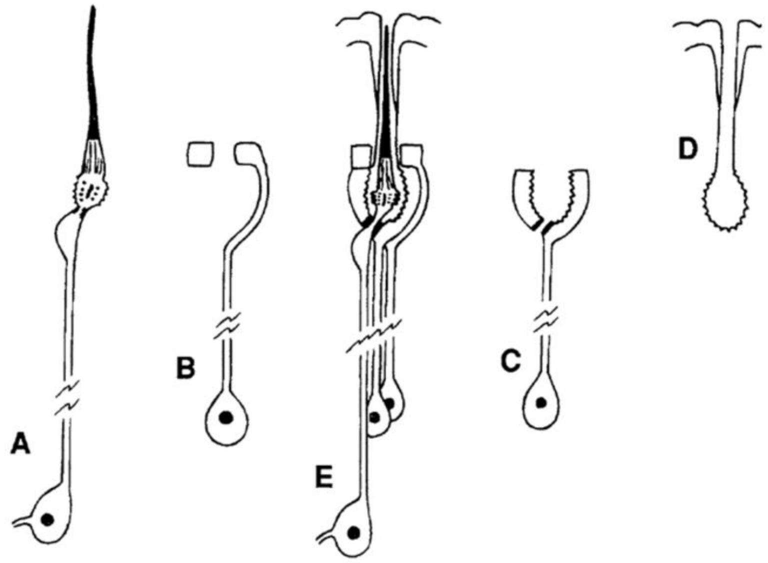
(B) Socket cell

(C) Sheath cell

(D) Sensillum canal

(E) Entire sensillum

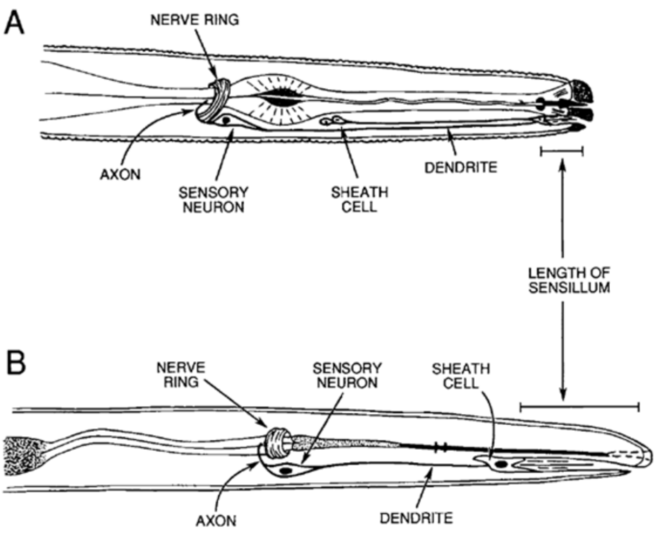
From Coomans and De Grisse (1981)



Each nematode sensillum has the same general structure and consists of one or more **bipolar neurons (Fig. A)** surrounded by a channel formed by **a socket cell (Fig. B) and a sheath cell (Fig. C).** The socket cell, which surrounds the distal end of a sensillar pouch, is thought to function as a supporting cell, which at times may secrete the cuticular lining of the sensillar pouch. The sheath cell forms a sheath around the **sensillar lumen** just behind the socket cell, the whole structure forming the **sensillar pouch (Fig. B+C+D)**. The sheath cell in some forms may have lamellae that project into the lumen of the sensillar pouch.

Diagram of Head Ends

(A) A secernentean plant parasitic nematode (tylench) and (B) an adenophorean plant parasitic nematode (dorylaim), illustrating differences in sensilla in these two groups. Note that the sheath cell body is located more anteriorly in the dorylaim and that the sensillum in this nematode is much larger than it is in the tylench. From Coomans and De Grisse (1981); Wright (1983).



In the tylenchids the **cell bodies** of the **non-neuronal socket and sheath cells** lie some distance back from the tip of the head and are connected by means of long extensions of their body cells to their distal parts, which wrap around the sensory neuron (Fig.). The dendrite of the sensory neuron runs from the ciliary receptor to a sensory neuron cell body just anterior to the nerve ring (Fig.) in most instances, whereas those of the amphids and a few other sensilla lie behind the nerve ring (Ward et al, 1975; Ware et al, 1975). From here axonal processes enter the nerve ring.

The **cell body**, also called the soma, is the spherical part of the **neuron** that contains the nucleus. The **cell body** connects to the dendrites, which bring information to the **neuron**, and the axon, which sends information to other **neurons**.

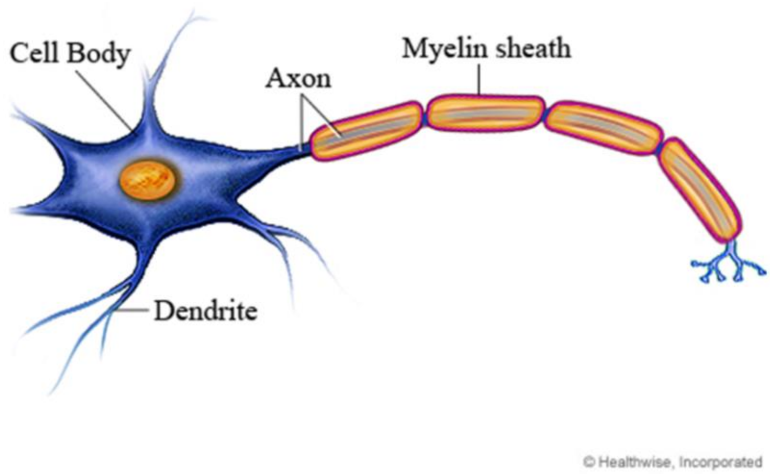
A Typical Neuron

<u>Focus On:</u>

Cell Body

Dendrite

Axon



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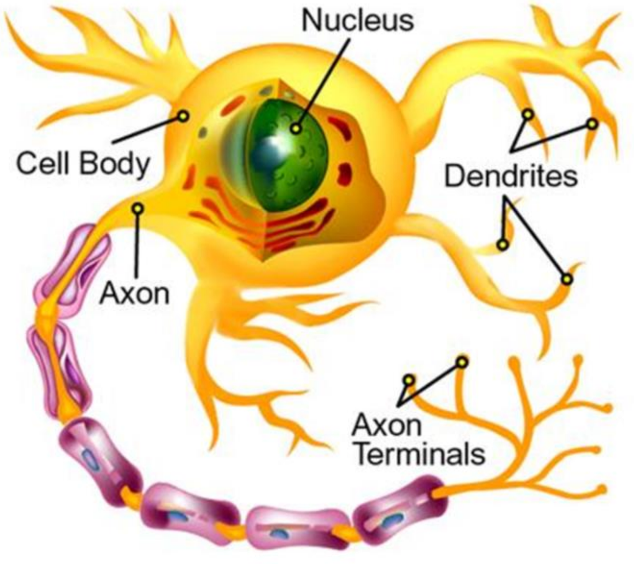
A Typical Neuron

Focus On:

Cell Body

Dendrite

Axon



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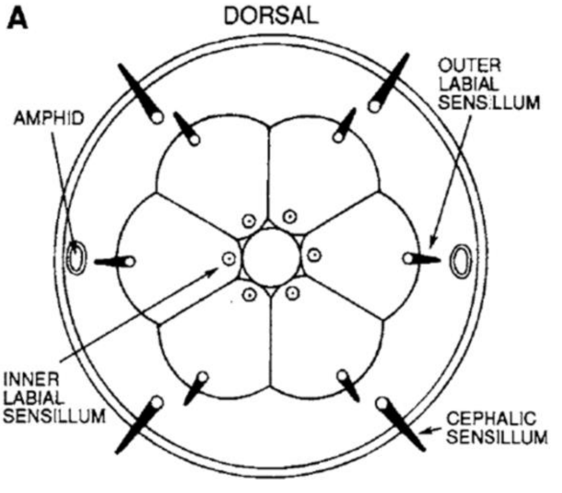
Arrangements of Sensilla



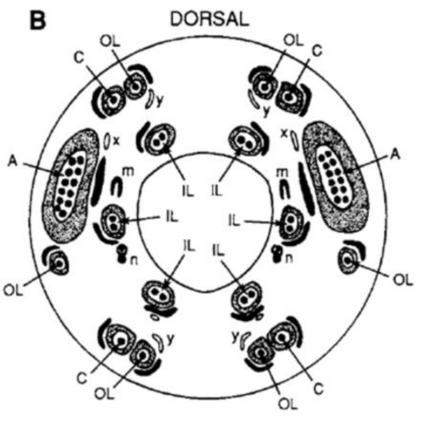
The anterior sensory organs of nematodes consist of circles of structures arranged in a hexaradiate pattern (De Coninck, 1942; Coomans, 1979). This pattern comprises a head with six lips containing **12 labial sensilla**, **4 cephalic sensilla**, and **2 amphids**. These are arranged in three circles consisting of an outer circle of four cephalic sensilla, a middle circle of six outer labial sensilla, and an inner circle of six inner labial sensilla (Fig. 39A). All these sensilla are associated with the cuticle and are called cuticular sense organs (Wright, 1980) or peripheral sense organs (Coomans and De Grisse, 1981).

Adenophorea Vs. Secernentea

	Adenophorea	Secernentea
1.	The neuronal elements are more numerous	The neuronal elements are not that numerous
2.	Amphids are more prominent and contain more receptors, i.e. 10-46	Amphids are less prominent and contain 3-15 receptors
3.	Have two or more receptors in the inner labial sensilla	Have only one or two receptors in the inner labial sensilla
4.	Have several receptors in the outer labial sensilla	There are only one or two receptors in the outer labial sensilla
5.	Have two or three receptors in the cephalic sensilla	There are only one or two receptors in the cephalic sensilla
6.	Nearly all the sense organs in the Adenophorea appear to be chemoreceptive	The sense organs in the Secernentea, other than the amphids and phasmids, are mechanosensory
7.	Infoldings in the receptor regions appear to be absent in the Adenophorea	Sheath cells have characteristic infoldings in their receptor regions
8.	Pronounced cuticular patterns of the amphids are seen in the Adenophorea	Cuticular patterns of the amphids are less pronounced

There are some pronounced differences between the Secernentea and Adenophorea in the detailed structure of the sensilla. Examples are (1) the neuronal elements are more numerous in the Adenophorea than in the Secernentea, (2) the amphids are more prominent in the Adenophorea and contain more receptors (10-46) than do the Secernentea (3-15), (3) the Adenophorea have two or more receptors in the inner labial sensilla, whereas the Secernentea have one or two, (4) the Adenophorea have several receptors in the outer labial sensilla, whereas the Secernentea have only one, and (5) the Adenophorea have two or three receptors in the cephalic sensilla, whereas in the Secernentea there are only one or two. Thus there are major differences in the sensillar components of these two groups of the Nematoda. Furthermore, it seems that many of the sense organs in the Secernentea, other than the amphids and phasmids, are mechanosensory, whereas nearly all the sense organs in the Adenophorea appear to be chemoreceptive (Wright, 1980). Another marked difference is that in the Secernentea the sheath cells have characteristic infoldings in their receptor regions, and these appear to be absent in the Adenophorea. The most obvious differences, which are clearly visible to the light microscopist, are the pronounced cuticular patterns of the amphids in the Adenophorea (Riemann, 1972).

Arrangements of Neurons



Sensilla	Symmetry	Neurons
Inner Labial (IL)	Six	12
Accessory Nurons (m.n)	Two (l)	4
	Two (v)	2
Outer Labial (OL)	Six	6
Cephalic (C)	Four (d, v)	4
Amphids (A)	Two (l)	24
Not in Sensilla (x)	Two (d)	2
Not in Sensilla (y)	Four (d, v)	4
	Total	58

Numbers and symmetry of sensory nerve cells in the tip of the head. (1, lateral; v, subventral; d, subdorsal). From Ward et. al. (1975).

The detailed descriptions, involving electron microscopical reconstruction of the anterior sensory anatomy of *C. elegans* by Ward et al. (1975) and of the sensory input and motor output of the nerve ring in this nematode by Ware et al. (1975) have shown that there are 58 neurons in the tip of the head (Fig.). The anatomy of these structures does not appear to vary from specimen to specimen and that of the larvae is similar to that of the hermaphrodite adult. The adult male differs slightly in having an additional sensory process in the channel of each of the cephalic sensilla, which opens to the outside through a small papilla. The inner labial sensilla and the amphids open to the outside and are thought to be chemosensory, whereas the endings of the other sensilla (i.e., outer labial and cephalic) are embedded in the cuticle and for this reason are thought to be mechanosensory. One of the sensory neurons from each of the six inner labial sensilla makes a direct synapse on a muscle, and so these are sensory motor neurons.

Next

- Typical structures of the Anterior Sensilla
- Pharyngeal Sense Organs- Digestive System
- Somatic Sense Organs- Epidermis
- Genital Sense Organs- Reproductive System
- Caudal Sense Organs- Secretory-Excretory System

Thank You Very Much