Nervous System

Msc. Lecture , No.8

5/13/2024

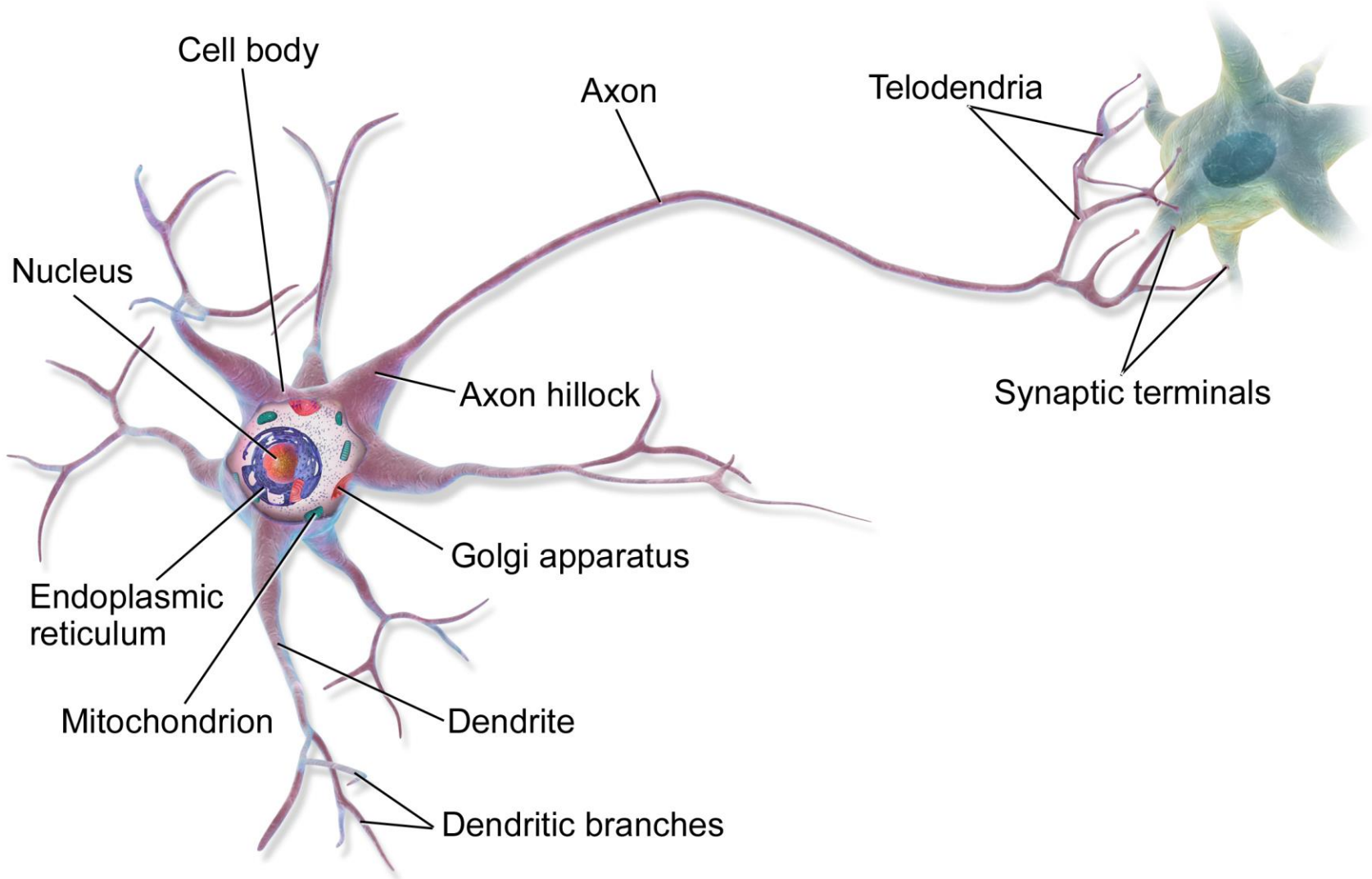
Monday

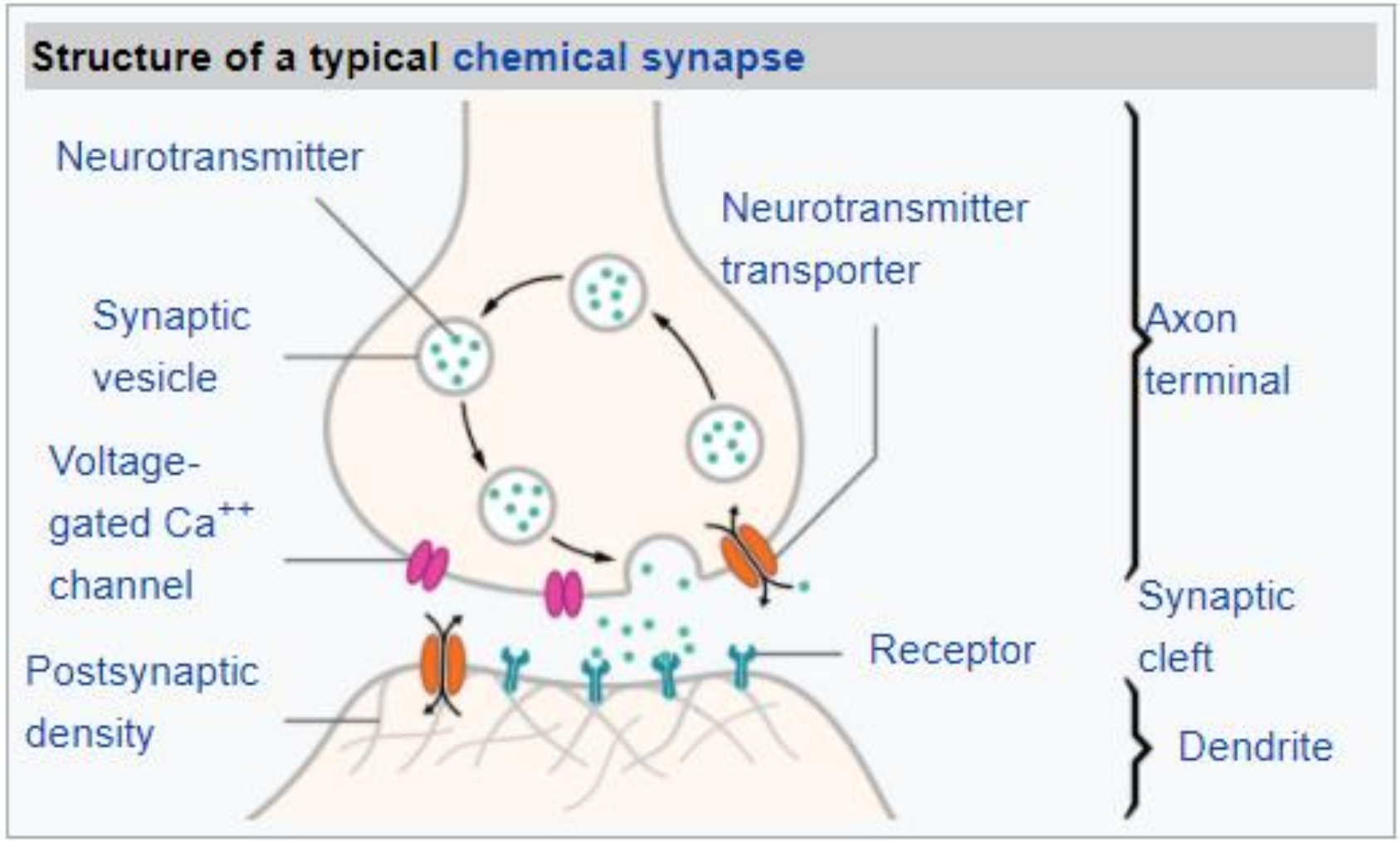
Structure of the Nervous system

Insects have a complex nervous system which incorporates a variety of internal physiological information as well as external sensory information. Like other animals the nervous system in insects serves to coordinate the activities of its various systems. The units of this system are elongated cells or neurons which carry information in the form of electrical impulses from external and internal sensilla (sensory cells) to appropriate effectors (e.g., glands, muscles) and special cells called glial cells which protect, support, and provide nutrition for the neurons.

Structure of the Nervous system

- The basic component in the nervous system is the nerve cell or neuron, composed of a cell body with two projections the dendrites that receive stimuli and the axon that transmits information, either to another neuron or to an effector organ such as a muscle
- Axon may have lateral branches called Collateral and terminal arborization and synapse
- Insect neurons release a variety of chemicals at synapses either to stimulate or to inhibit effector neurons or muscles
- synapse is a structure that permits a neuron (or nerve cell) to pass an electrical or chemical signal to another neuron or to the target effector cell
- Acetylcholine and catecholamines such as dopamine are the important neurotransmitters involved in the impulse conduction


Cell body
Axon
Telodendria
Nucleus
Axon hillock
Synaptic terminals
Golgi apparatus
Endoplasmic reticulum
Mitochondrion
Dendrite
Dendritic branches

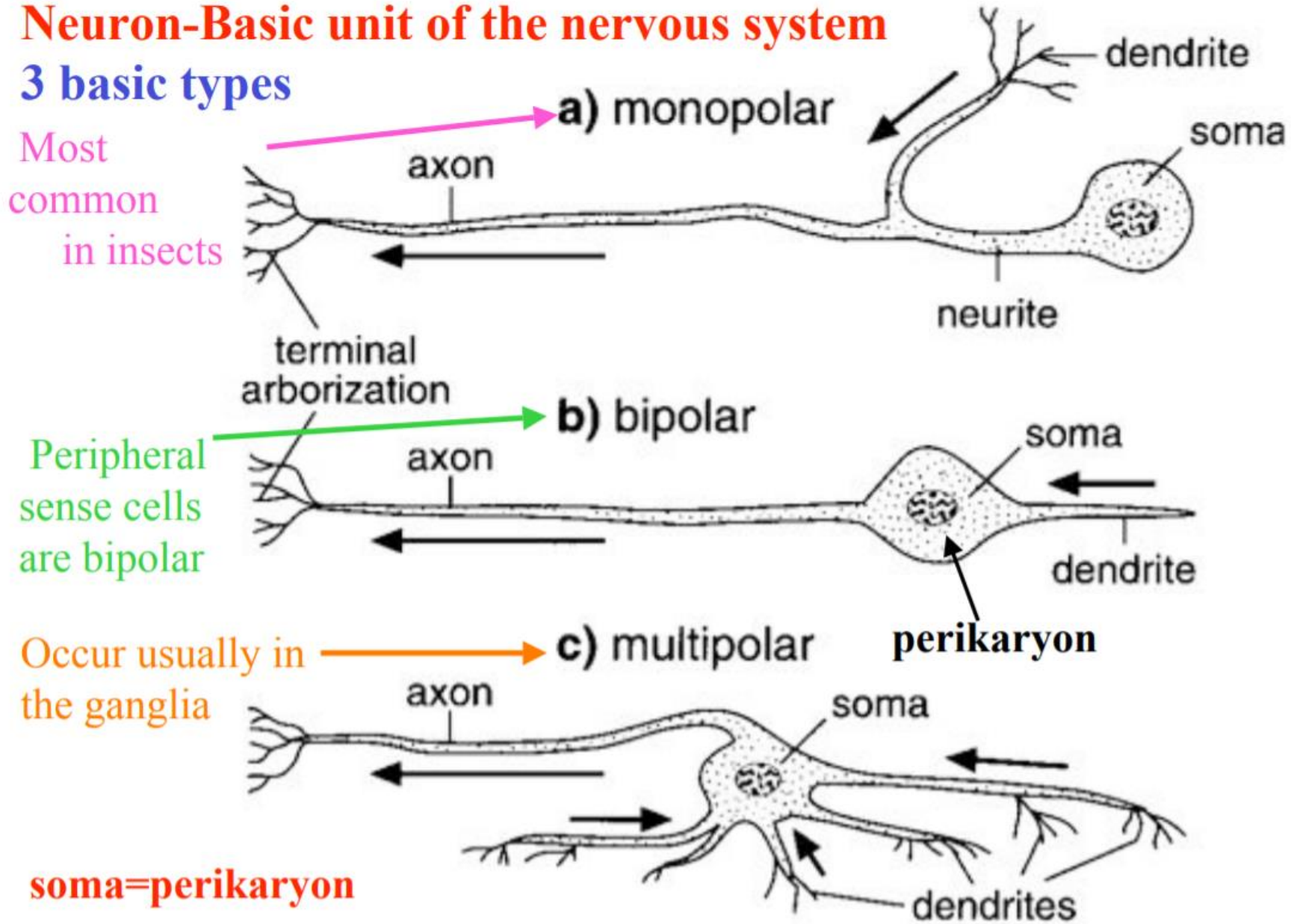

Structure of a typical chemical synapse
Neurotransmitter
Neurotransmitter transporter
Synaptic vesicle
Voltage-gated Ca++ channel
Postsynaptic density
Receptor
Axon terminal
Synaptic cleft
Dendrite

Neurons are of following types based on structure and function

- A. On structural basis
- i. Monopolar: neuron with a single axon
- ii. Bipolar: neuron with a proximal axon and a long distal dendrite
- iii. Multipolar: neuron with a proximal axon and many distal dendrites
- B. Functional basis
- i. Sensory neuron: It conducts impulse from sense organs to central nervous system (CNS).
- ii. Motor neuron: It conducts impulse from CNS to effector organs
- iii. Inter neuron (association neuron): It inter-links sensory and motor neurons. The cell bodies of inter neurons and motor neurons are aggregated with the fibers interconnecting all types of nerve cells to form nerve centers called ganglia.

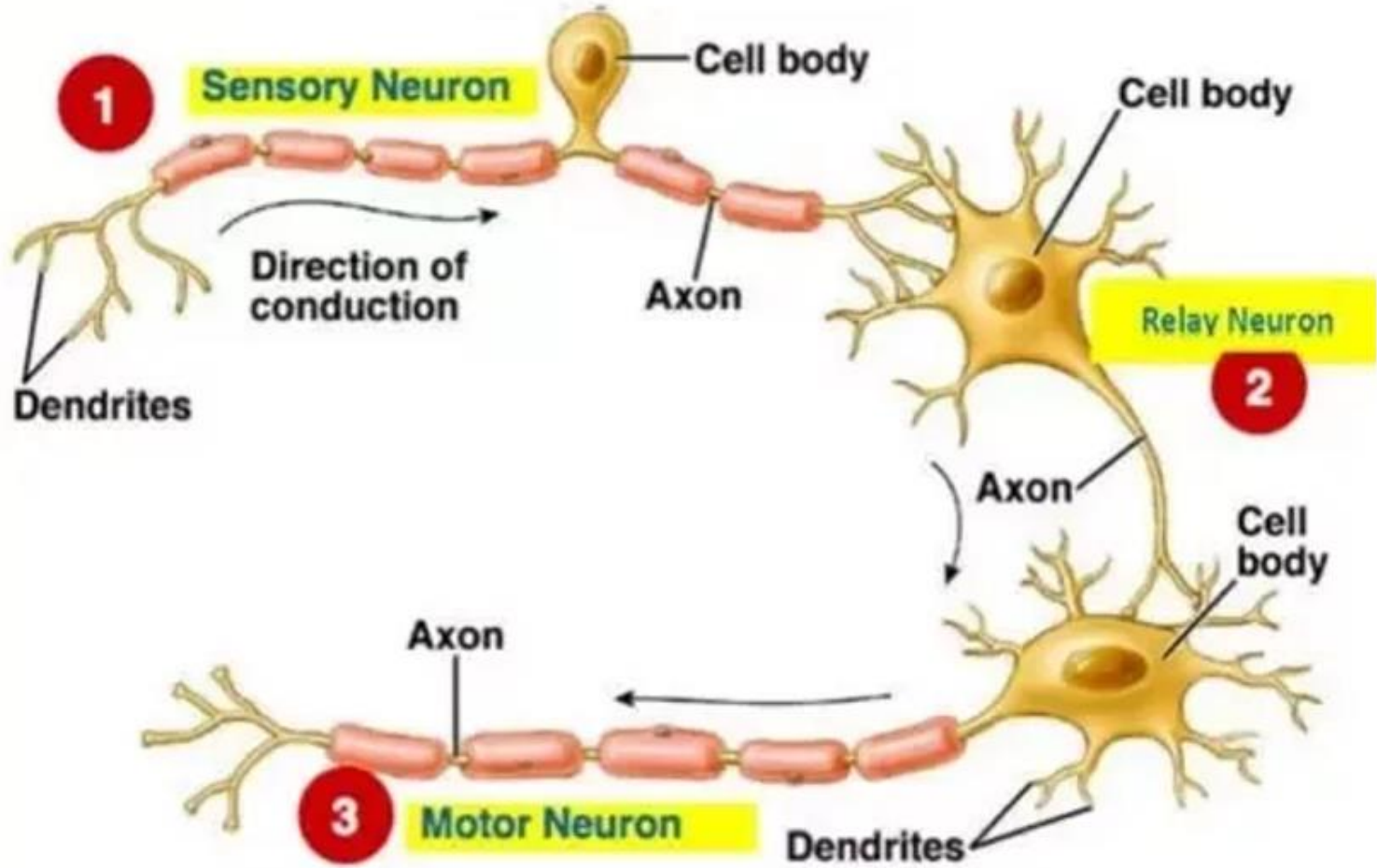
Neuron-Basic unit of the nervous system

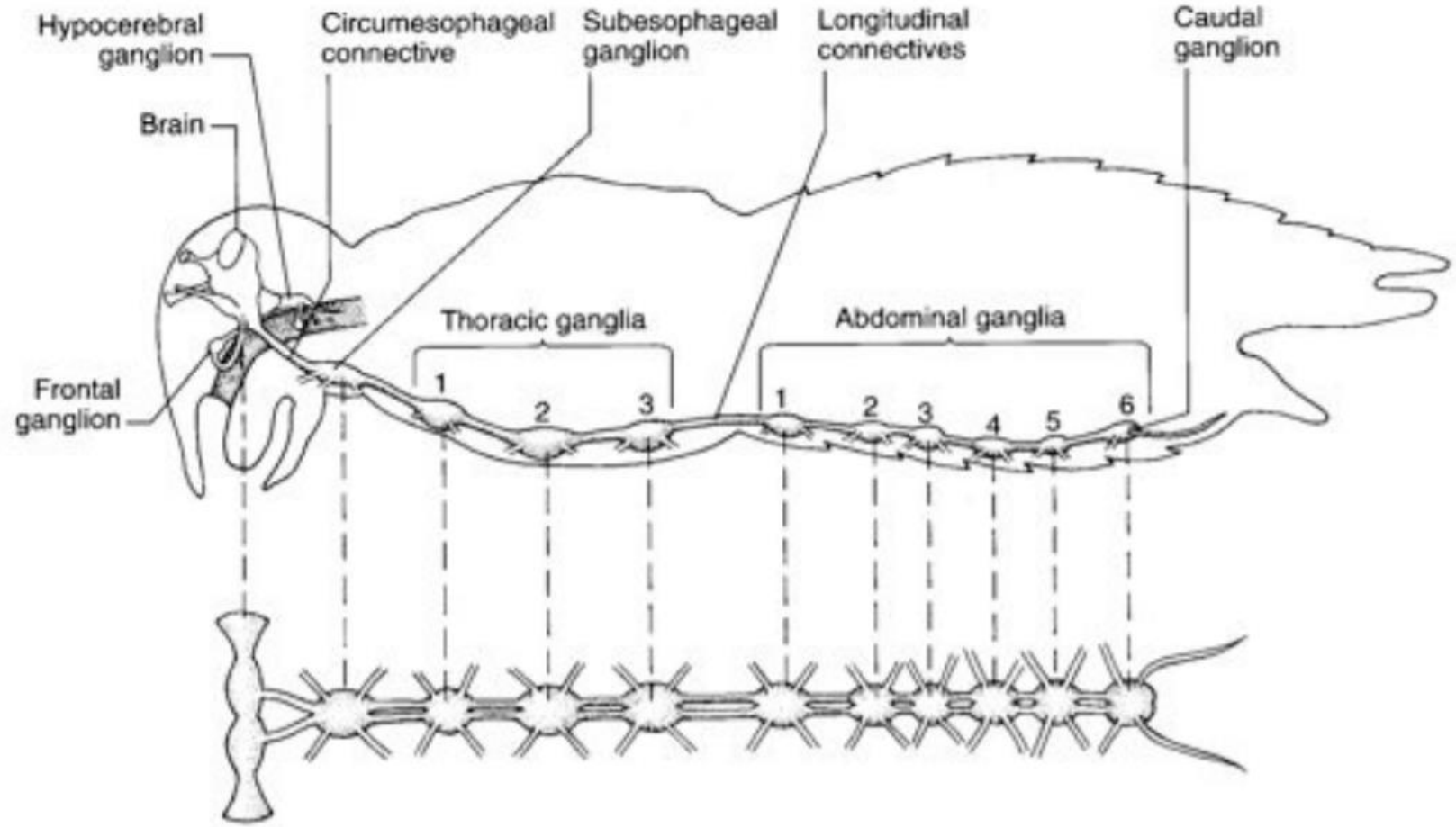
3 basic types



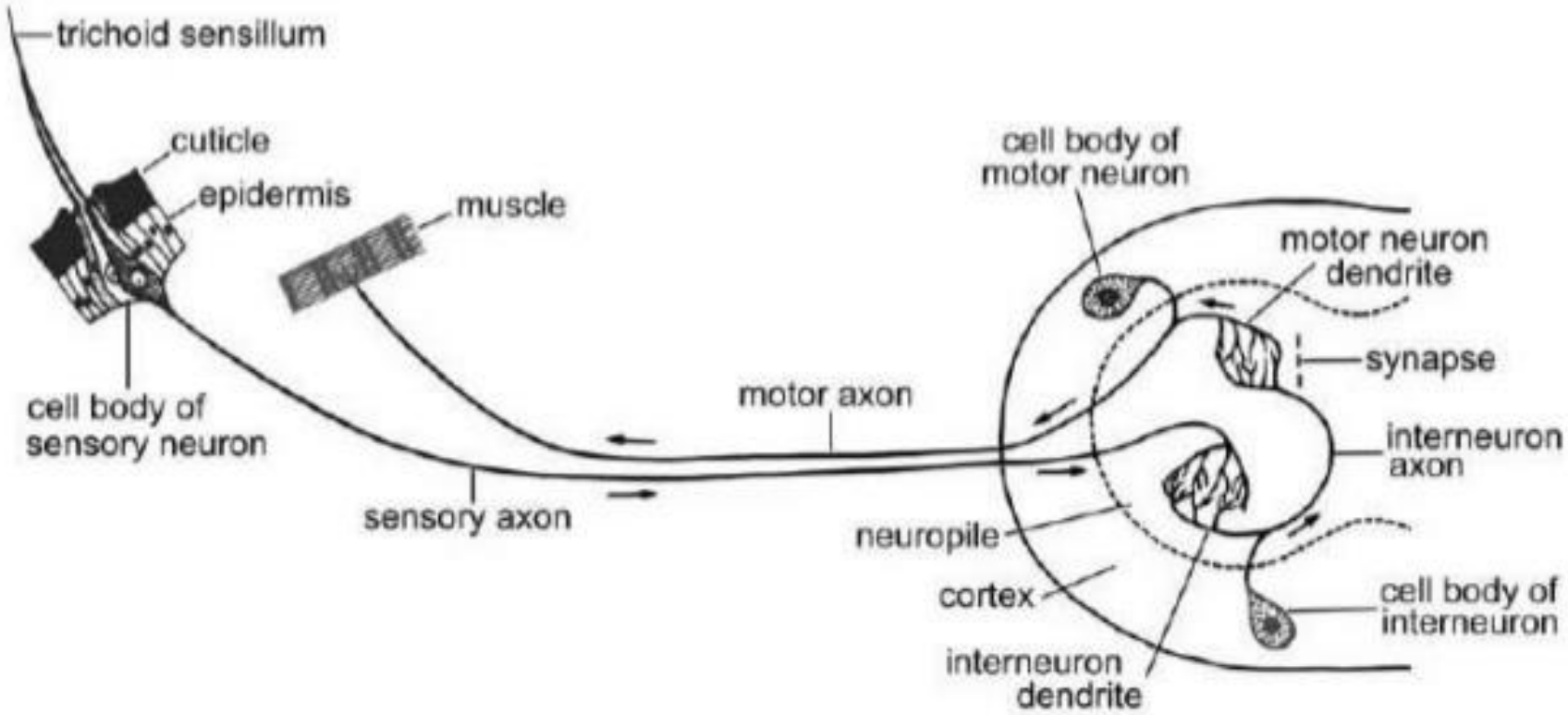
soma=perikaryon

Three Types of Neurons





Ganglion=a collection of neurons. Note the CNS is composed of a double chain of ganglia joined by lateral and longitudinal connectives. In many insects the ganglia have fused (e.g., the Diptera).


trichoid sensillum
cuticle
epidermis
muscle
cell body of motor neuron
motor neuron dendrite
synapse
cell body of sensory neuron
motor axon
interneuron axon
sensory axon
neuropile
cortex
cell body of interneuron
interneuron dendrite

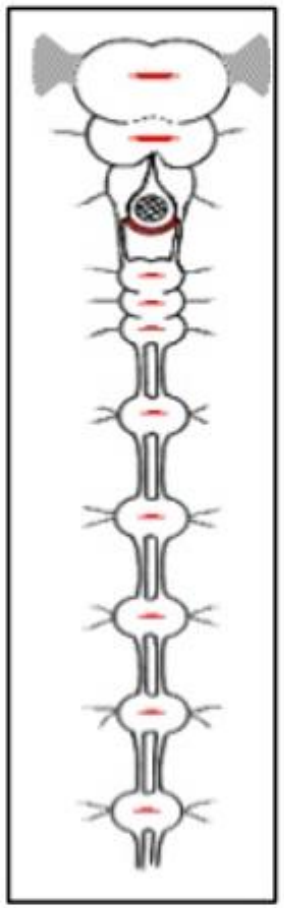
The nervous system can be divided into three major sub-systems as

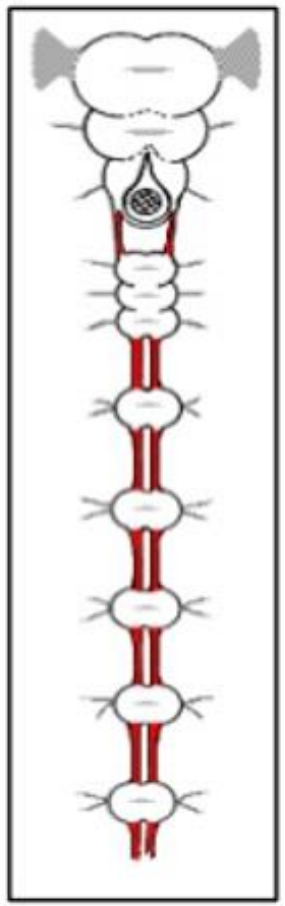
- Central nervous system (CNS)
- Sympathetic nervous system
- Peripheral nervous system (PNS)

- **Central nervous system (CNS)**
- It consists of anterior brain and ventral nerve cord bearing the segmental ganglion
- The CNS consists of a series of ganglion which are joined together by means of a longitudinal and transverse strands of nerve fibers

- Ganglia within each segment are linked to one another by a short medial nerve (commissure) and also joined by intersegmental connectives to ganglia in adjacent body segments.

Commissure nerves in red





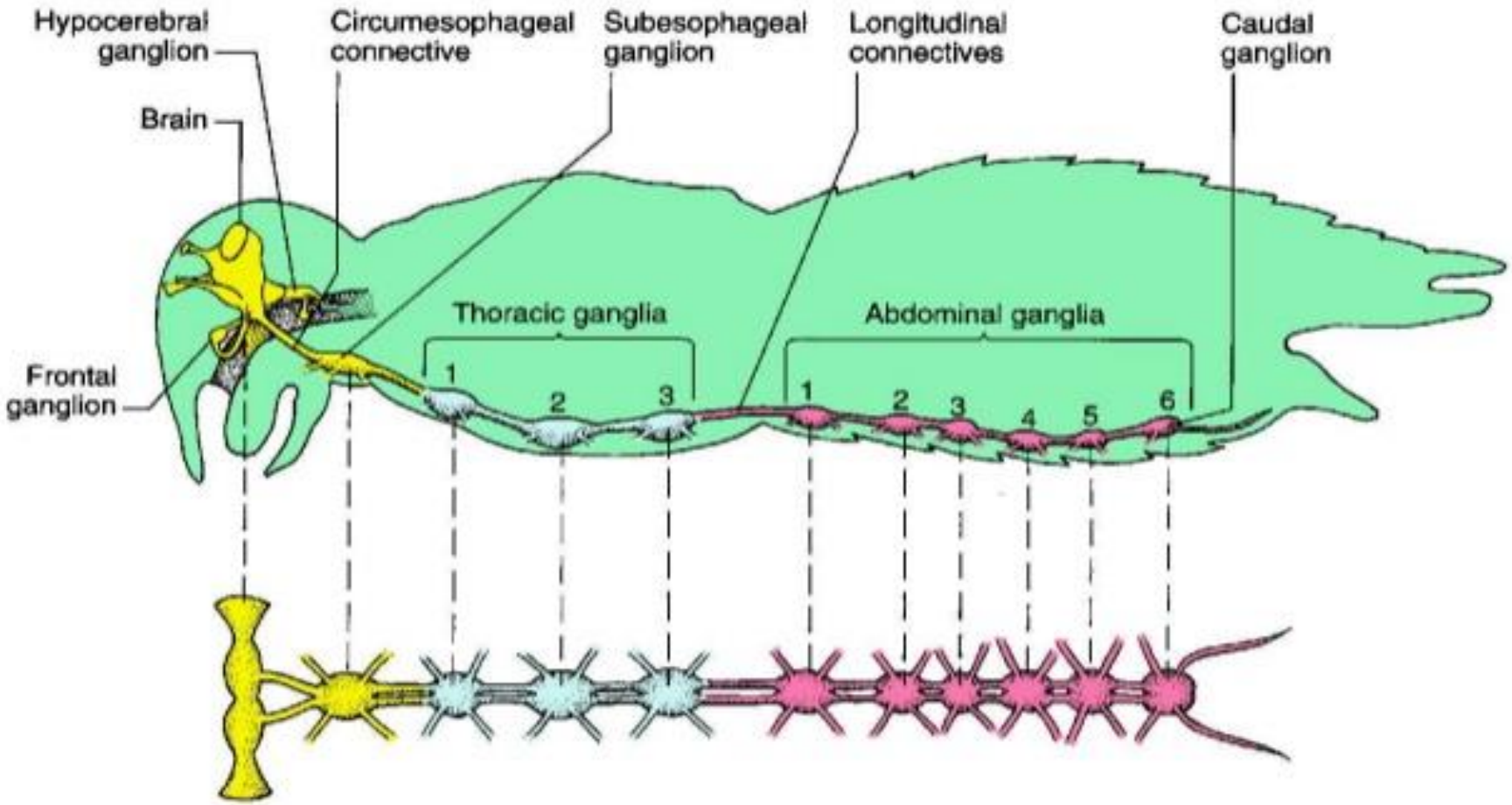
Intersegmental connectives

- The longitudinal cord are termed connectives, and they serve to join a pair of ganglia with those which preceed and succeed it
- The transverse fibers or commissures unite the ganglion of a pair. Typically, there is a pair of ganglion in each segment of the body but the numbers of the pair are so closely united that they appear as a single ganglion
- In many cases the ganglia of the adjacent segments combine to form ganglionic centers within the ganglia the neurons are grouped peripherally the centers of the ganglia are occupied by the neuropile
- The neuropile consists of a mass of axons and their terminal arborizations

The CNS is divided into –

- **The brain or cerebral ganglion**
- **The sub-oesophageal ganglion**
- **The ventral nerve cord**

- **The brain**
- The insect brain represents the supra-oesophageal ganglion, and it lies above the oesophagus in the oculo-frontal region of the head
- It is a bilobed structure both the lobes are well differentiated from each other by a distinct furrow


Hypocerebral ganglion
Circumesophageal connective
Subesophageal ganglion
Longitudinal connectives
Caudal ganglion
Brain
Thoracic ganglia
Abdominal ganglia
Frontal ganglion
1
2
3
1
2
3
4
5
6

The insect brain is divided into 3 dorso-ventral regions

- The forebrain or protocerebrum
- The midbrain or deutocerebrum
- The hind brain or tritocerebrum

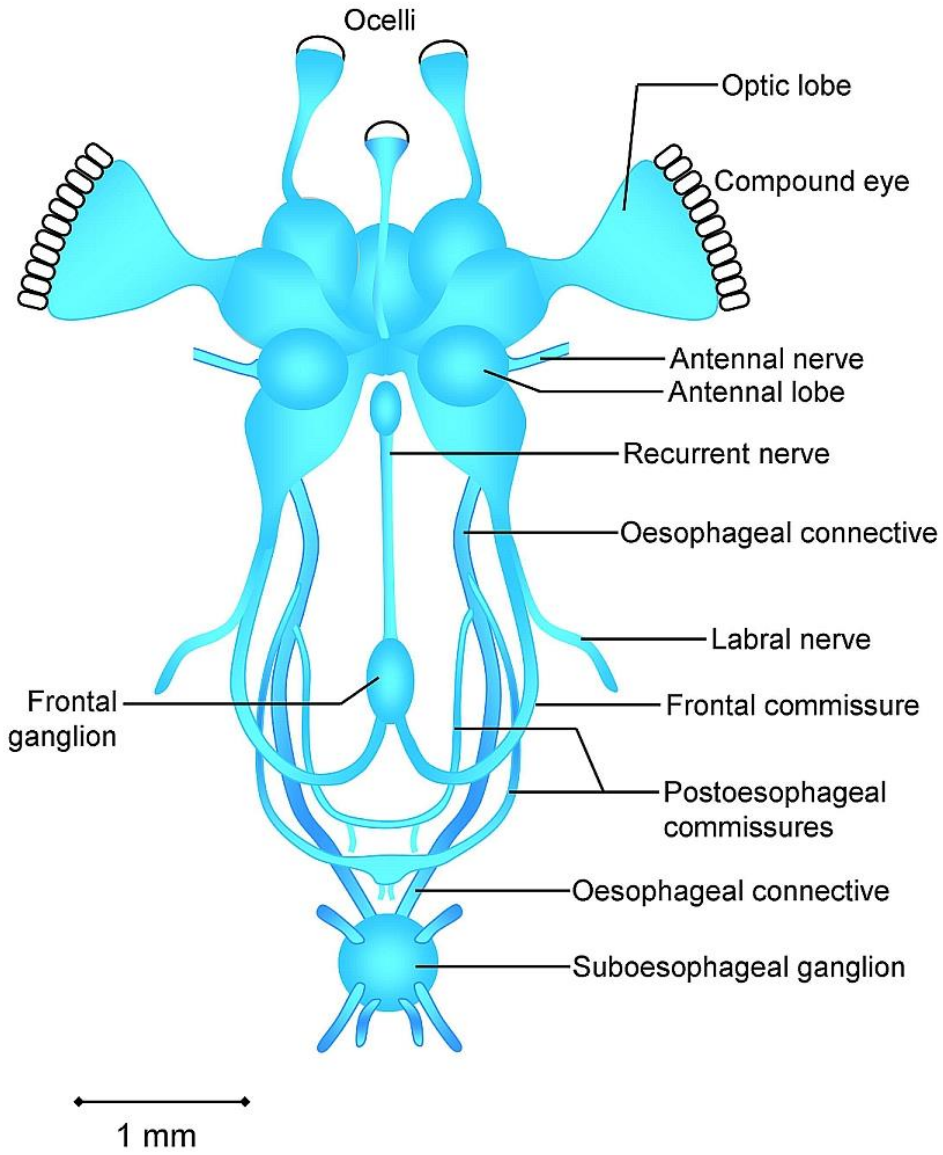
The protocerebrum – It is the antero-dorsal large region of the brain representing the fused paired pre-antennal ganglion

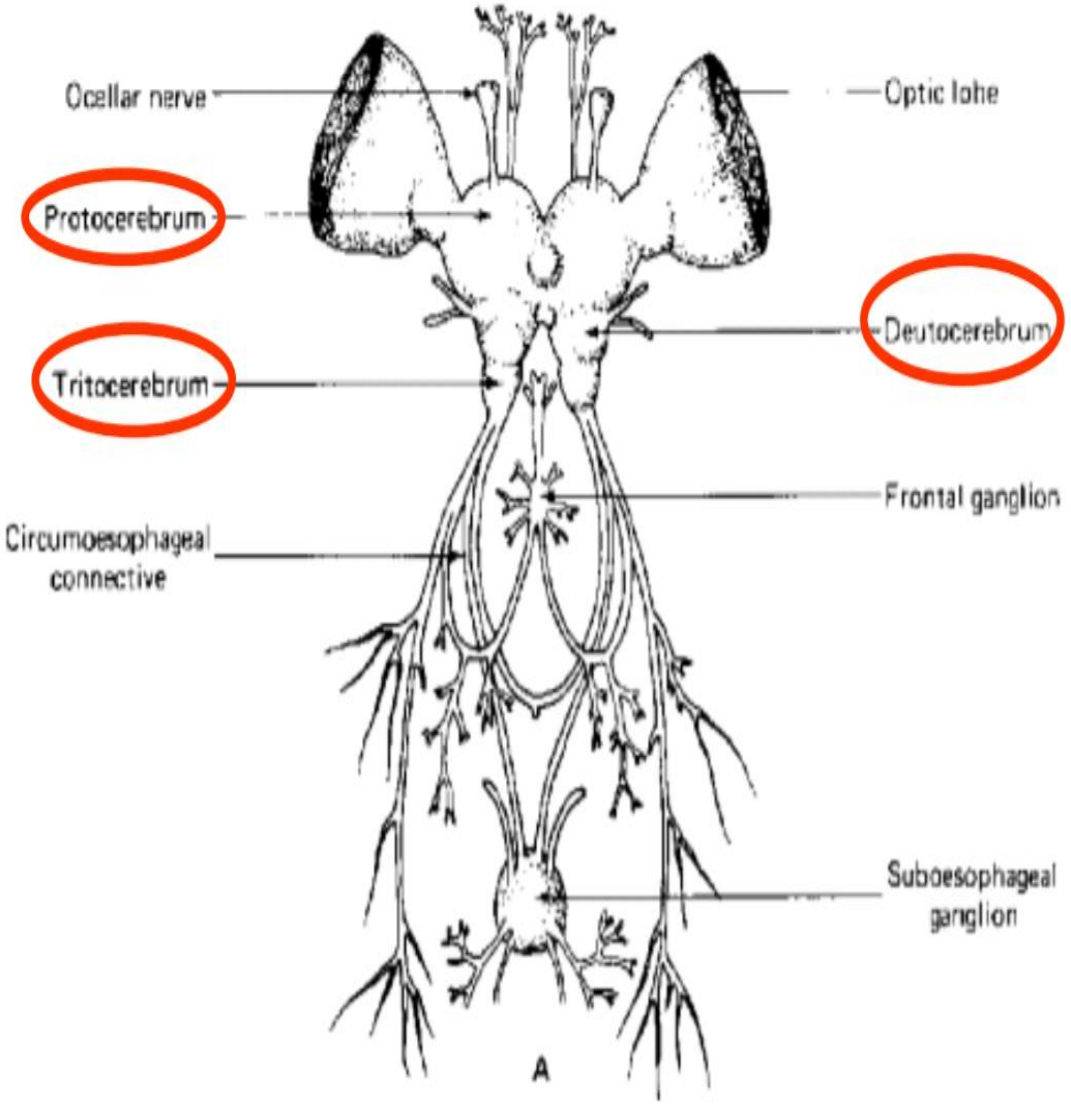
It bears on each lateral side the optic lobes and received the optic nerves from the optic lobes, the ocellar nerves from the median and lateral ocelli.

The deutocerebrum

- It is the middle part of the brain representing The antennal ganglia. It gives out a pair of lateral antennal nervous innervating the antennae
- **The tritocerebrum**
- This is the smallest part of brain consisting of a pair of lobes beneath the deutocerebrum
- It is the third or the ventral part of the brain representing the ganglion of the intercalary segment

Anterior (frontal) view of the brain of the locust

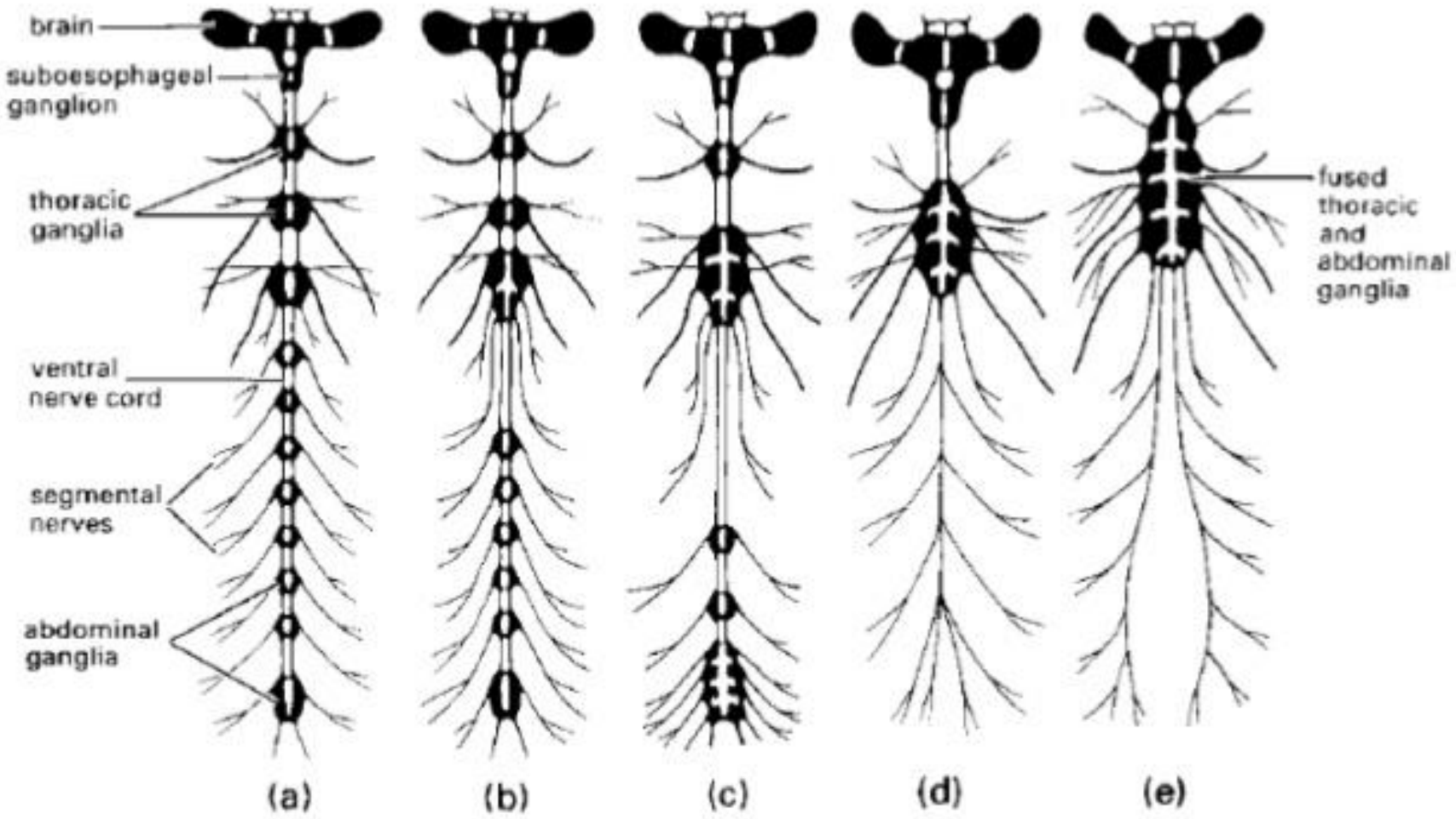




Histology of brain

- Histologically of the brain shows the following structures –
- A. brain sheath cerebral neurolemma
- It composed of two layers the outer neurolemma and the inner perineurium
- The neurolemma is non-Cellular while the perineurium is cellular layer
- The neural lamella provides mechanical support and protection to the ganglion as well as the nerve cord
- The perineurium is trophic in function and acts as a blood brain barrier
- B. the cortex
- It is the peripheral region of the brain and the outer ganglia
- It is filled with nonpolar, motor neuron and glial cells
- C. The medulla
- It is completely filled with the neuropile

- **The sub-oesophageal ganglion**
- The first ganglion in the ventral chain is the sub-oesophageal ganglion
- It is the ventral ganglionic center of the head and is formed by the fusion of the ganglia of the mandibular, maxillary and labial segments
- **The ventral nerve cord**
- It consists of a series of ganglia lying on the floor of the thorax and the abdomen.
- They are United into longitudinal chain by means of pair of connectives, The first three ganglia are situated on each of the thoracic segments and are known as thoracic ganglia.


brain
suboesophageal ganglion
thoracic ganglia
ventral nerve cord
segmental nerves
abdominal ganglia
fused thoracic and abdominal ganglia
(a)
(b)
(c)
(d)
(e)

The sympathetic nervous system

- The sympathetic nervous system can be divided into three parts :-

1- The somatogastric nervous system or stomodaeal nervous system

2- Ventral sympathetic nervous system

3- Caudal sympathetic nervous system

The sympathetic nervous system

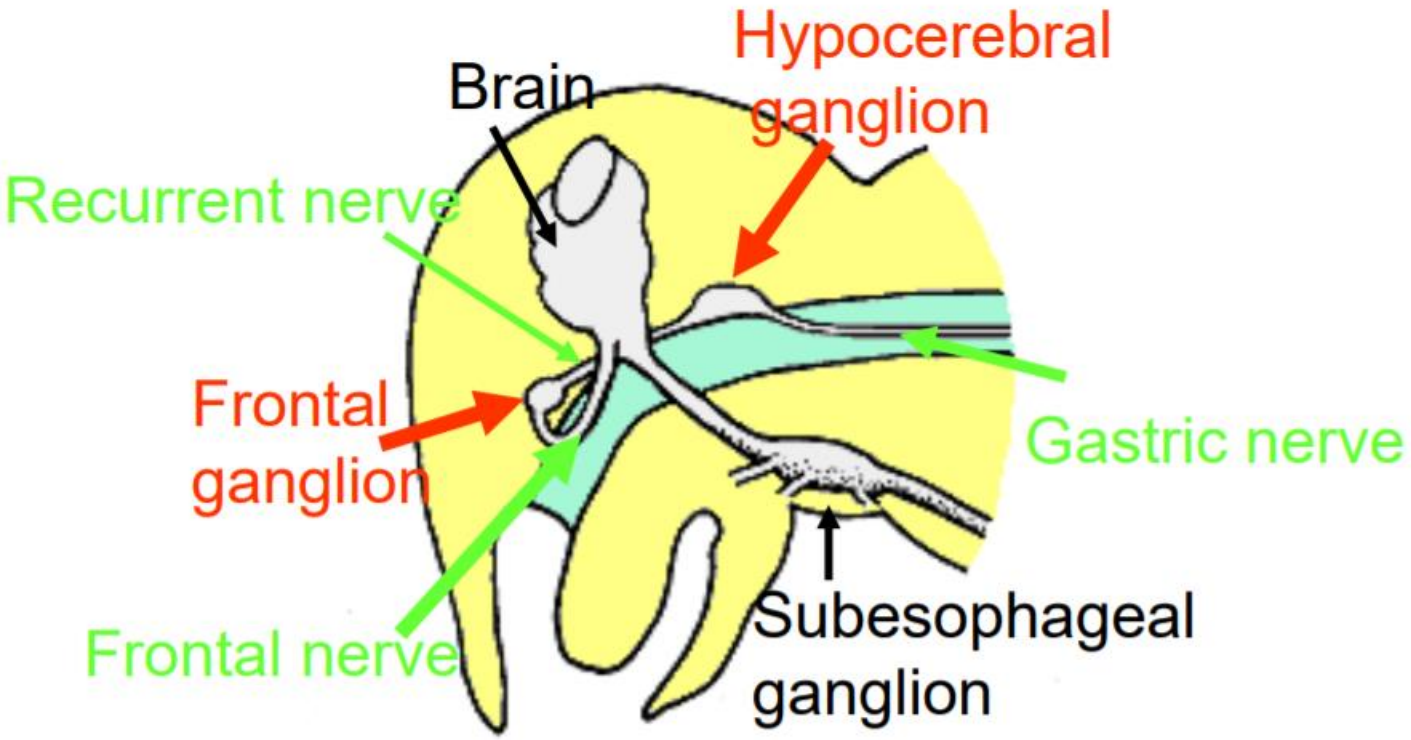
1- The somatogastric nervous system

It contains the frontal, hypo-cerebral and ventricular ganglia and a long median recurrent nerve and other fine nerves arising from these ganglia

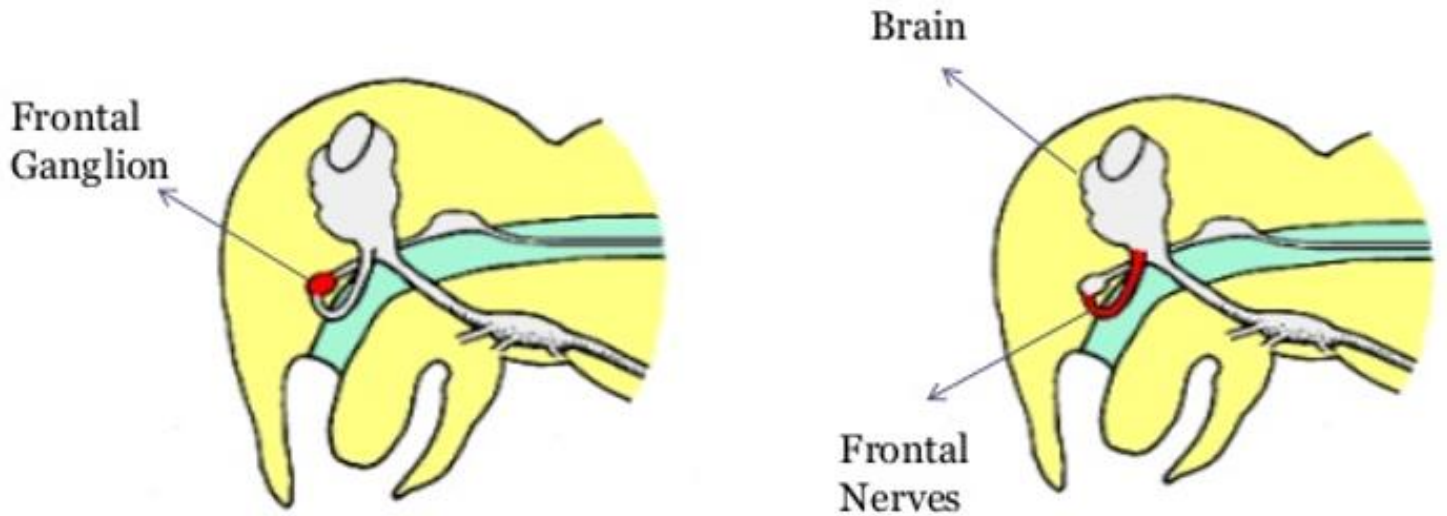
It innervates mainly the stomodeum and the dorsal vessel

The hypocerebral and the ventricular ganglia maybe lacking in some insects but the frontal ganglia of universal occurrence

The hypocerebral ganglia lies between the corpora cardiaca and in some insects the ganglion is connected with the corpora cardiaca by lateral nerves


Hypocerebral ganglion
Brain
Recurrent nerve
Frontal ganglion
Gastric nerve
Frontal nerve
Subesophageal ganglion

• A pair of frontal nerves arising near the base of the tritocerebrum link the brain with a frontal ganglion(unpaired).



• This ganglion innervates the pharynx and muscles associated with swallowing.

2- Ventral sympathetic nervous system

- From each ganglia of the ventral nerve cord arise posteriorly a fine unpaired or median nerve running in the anteroposterior direction
- The median nerve arising from the ganglia runs for a short distance and terminally gives a pair of transverse nerves
- these transverse nerves run laterally and innervate the spiracle, segmental and allery muscles of the region
- The median nerve gives out dilation at or behind the site of bifurcation of the transverse nerves

3-The caudal sympathetic nervous system

- The last abdominal ganglion gives of the caudal sympathetic nervous system the nerves innervate the reproductive system, hind gut, Malpighian tubules, and the caudal part of the dorsal vessel
- Some of the nerves are provided with peri-sympathetic organs for neurosecretory material released by the neurosecretory cells of The Last abdominal ganglion

The peripheral nervous system

- It consists of all the nerves radiating from the ganglia of the ventral and sympathetic system
- some bipolar and multipolar neuron from a complex network beneath the integument, above the segmental muscles and upon the surface of the gut
- Their distal processes divide enormously over the innovated structures and their centripetal processes are terminated into the ventral ganglia

Glial cells help support, connect, and protect the neurons of the central and peripheral nervous systems. They come in many shapes, sizes, and types, each performing specialized functions. In the CNS, glial cells regulate neurotransmission and help form the blood-brain barrier.

Neuropil (or "neuropile") is any area in the nervous system composed of mostly unmyelinated axons, dendrites and glial cell processes that forms a synaptically dense region containing a relatively low number of cell bodies.

Intercalary segment, an appendage-less segment in the segmental composition of the heads of insects and Myriapoda.