

Histology of CNS

↳ Highly complex + organized system containing around 10 billion neurons.

↓
The basic cell of the CNS

- each neuron processing 1000 connections

↓
2 neurons by connection of synapse form skeletal effector organ, neuron consist secretory glands, muscle

↳ Integrated communication system, starting with the receiving part, CNS is composed of basic circuits starting from the receiving part (reception of impulse).

analysis of the received info, interneuron

↳ Elementary circuits: circuits composed of receiving part to receive the impulse.

↳ Interneuron: analysis and integration of the signal and formation of the appropriate or adjusted response against continuously changing environment.

effluent neuron, effector neuron

may form higher orders: circuits
elements of old organization

coordination of various, fine co-ordination ← impulses through complex system and adjustment of response formation of the most appropriate response.

↳ Synapse: connection of the part of a neuron with other neurons.

Composed of: Presynaptic membrane, Intermembranous (=synaptic) space, postsynaptic space.

unconscious not reflexes
conscious reflexes

↳ Functionally, Nervous system is divided into: Somatic + Autonomous

↓
with consciousness

conscious + voluntary

From simple to complex responses.

(controlled by conscious mind)

↓
Involuntary

Control the functions of internal organs (as

CNS, Respiratory, digestive)

In cooperation with endocrine

system.

Can be divided into:

Sympathetic Parasympathetic enteric

GIT: colon

* Composition of nerve tissue:

- The basic cell is neuron, in addition to supporting cells = Neuroglial cells.

Central

↓

- Oligodendrocytes

- Astrocytes

- Microglia

- Ependymal cells

Enteric

(in GIT)

Peripheral

↓

- Schwann cells

- Satellite cells in the ganglia

* Functions of Neuroglial cells:

- Physical support mainly, neuron is a very fragile cell needs to be supported mechanically.
- Isolation: electrical impulse is an important part of nervous system function → electrical impulse لا يتأثر by isolation as it is a chemical signal and chemical signals are easily degraded.
- Repair of neurons when degenerated.
- Chemical adjustment and regulation of the nearby environment of the neuron (microenvironment) can be easily, delicate + sensitive cells لا يتأثر by degenerated.
- Clearance of the neurotransmitter. This is accomplished by transmission of unique chemical mediators (called neurotransmitter) maintain, postsynaptic of presynaptic the impulse to the following level.
- Metabolic exchange: neuroglial cells form a barrier between intravascular compartment and the neurons. waste products, metabolites of material لا يتأثر by neuroglial cells nutrients لا يتأثر by neuroglial cells
- Forming a unique functional and mechanical structure called Blood-Brain Barrier.

حتى تتكون الدم مخزلة واحدة على اتصال مباشر بال brain

* Neurons are heterogenous cells = different in shape, morphology and size.
حتى انهم يختلفون في شكلهم ، في عملية واحدة ، في شكلهم

لهم رغم انه هذا الاطلاق لكن بقدر اقل الى في حيوانات:

① Sensory neurons:

conduct the impulse from receptor sites (outer body surface) to the CNS through Afferent fibers.

fibers. تحيط به الإشارة من ال peripheral.
May be: Somatic or Visceral
تحت ال (مثل ال voluntary control)
على جانبي الجسم ، مثل (position of joints, body)

② Motor neurons:

= Effector neurons
على علاقة بال site أو ال organ أو ال tissue التي به يقوم بالانقباض ، في muscle contraction ال muscle فكون ال effector organ.
May be: Somatic or visceral.

③ Interneurons:

Integration, analysis of the data of the recieved impulse or stimulation of the appropriate response.
لها زلت درجة تدور الالان سون في عدد وتغيرات ال interneurons ، وداية ال level في الإنسان.
Interneurons constitute the vast majority of the neurons (99.9% of neurons).

Neurons consist of 3 parts:

① Cell Body (perikaryon)

nucleus = النواة

② Axon = cell process = plasmer membrane extension. perikaryon ال neuron أو ال effector organ.
ال neuron أي ال effector organ.

③ Dendrites: cell processes, shorter than axon, multiple, 1000 connections, recieve impulses.

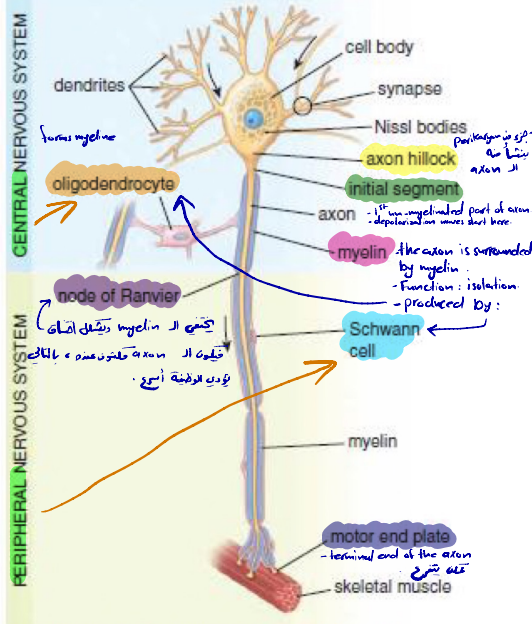


FIGURE 12.1 ▲ **Diagram of a motor neuron.** The nerve cell body, dendrites, and proximal part of the axon are within the CNS. The axon leaves the CNS and, while in the PNS, is part of a nerve (not shown) as it courses to its effectors (striated muscle). In the CNS, the myelin for the axon is produced by, and is part of, an oligodendrocyte; in the PNS, the myelin is produced by, and is part of, a Schwann cell.

Perikaryon

directly surrounding the nucleus
cytoplasm

- Nucleus of neuron is characterized by evenly dispersed chromatin, mostly composed of euchromatin (= can undergo transcription continuously)
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- Intermediate proteins, various elements, neurotransmitters
- Filaments
- Protein synthesizing cells
- Active chromatin, nucleus
- Prominent nucleolus (ribosome)
- Inside cytoplasm, rich in rough ER + large well-developed Golgi apparatus (which packages + finishes protein synthesis).
- Rough ER or polyribosomes may form aggregates inside cytoplasm. By light microscope I see it as granules or bodies called **Nissl Bodies**.

Dendrites

cell processes
multiple points of synapses coming from different neurons

Nissl bodies: granules in the cytoplasm (mostly ribosomes) of nerve cell bodies that are strongly stained by basic dyes and appear as basophilic clumps on light microscopy.

- **Axon hillock:** a specialized part of the cell body (or soma) of a neuron that connects to the axon/ where the summation of signals occur.
- **Axonal transport:** transport material to the terminal bulb.
- **Neural stem cells:** in limited areas.

effector organ
axon
axon

Neurons could also be:

1. Multipolar:

- characterized by many dendrites that can originate from different regions of a perikaryon.
- Motor neurons and interneurons.

2. Bipolar:

- One single axon and one single dendrite.
- Rare.
- Associated with receptor of special senses.

3. Pseudounipolar:

- One process.
- The majority are sensory neurons.
- Located close to the CNS.
- Cell bodies in the dorsal root and cranial nerve ganglia.
- In spinal ganglia of peripheral NS.

ما نظام تلك حبيبات
الخلايا

- Majority are sensory neurons.
- Located close to the central nervous system (close to spinal cord).

- rare
- associated with receptors of special senses (vision in retina + inner ear)

- single cell process
- cell process (dendrite) for reception (reception) + axon
- In spinal ganglia.

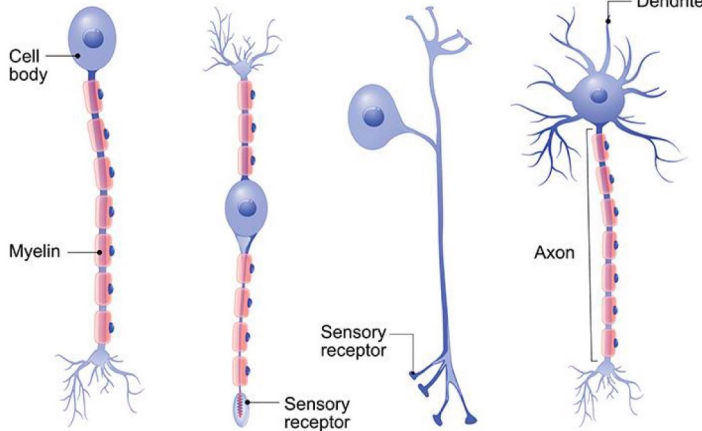
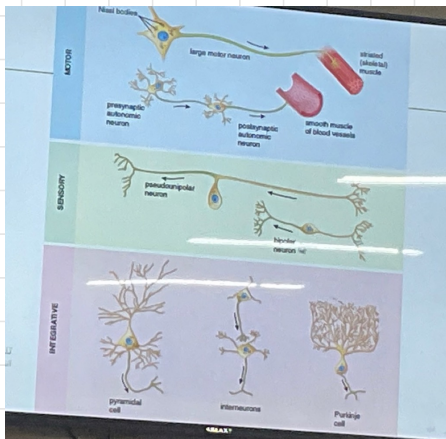
- Motor neurons and interneurons.
- More than 2 cell processes.

Unipolar

Bipolar

Pseudounipolar

Multipolar



Dendrites:

- Greater diameter than axons.
- unmyelinated. (axon myelinated)
- usually tapered. (usually tapered)
- Extensive arborization (dendritic tree).
- Similar cytoplasmic composition with the perikaryon (with the exception of Golgi).

لم يتفرع في البداية، بل perikaryon، كما توجد في dendrites.
• Golgi apparatus

Axons:

- Only one (mostly).
- May be extremely long.
- Branching at the end (near the effector organ).
- In the initial segment where the depolarization wave starts, the axon can give a branch after a short distance, this branch synapses with the same perikaryon for feedback function.

- Originate from the axon hillock.
- No large organelles.
- The initial segment.

Periaxoplasmic plaques: aggregation of proteins in the dendrites and axons thought to have a connection with memory and learning especially the ones in the dendrites called dendritic spikes. The proteins change their configuration when they receive signals.

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Synapses

- **Axodendritic:** between axon and dendrite.
- **Axosomatic:** axon on cell body (perikaryon).
- **Axoaaxonic:** synapse between 2 axons.

اسم الـ morphology : الـ axon يعالج synapse ، وهو يمر
 عبر طول الخلية (perikaryon) ، في هذه الأثناء يعمل عدد
 من الـ synapses على الـ dendrites أو الـ cell bodies .
 هذا يستلزم في فأطوه اسم فرنسي يعني Boutons en passant
 معناها buttons in passing بعد العمل contact أثناء حركته
 على سطح الخلية .

- terminal = Bouton terminal أو العنبر - end bulb = bouton
- perikaryon أو جسم الخلية - synapses أو اتصالات

Chemical synapses

للمفاصل Vertebrates = الحيوانات الفقارية
Chemically through neurons الالاتيم كيميائياً
secretion of neurotransmitter في إفراز الناقل العصبي

Electrical synapses

communication in invertebrates
(+ ion transmission) through gap junctions.
- also called *nexus* or *desmosomes*.
cardiac muscle in GIT
gap junctions in smooth muscle in GIT
muscle should work by close communication, junctions
as one single unit

Neuroglial cells

↳ Supporting cells

- central or peripheral



→ Schwann cells

- Satellite cells

- Others :

- terminal neuroglia (teroglia)

- enteric neuroglia

- müller's cells (in retina)

حوالين ال axon وتكون Schwann cells →

It is an unmyelinated cell, a myelinated cell just a neural crest. It is embryology. It is situated beneath the neural tube, induced by a special transcription factor (SOX-10).

- Producing myelin sheath.

- In both myelinated and unmyelinated axons.

- Rapped concentrically around the axon, plasma membrane ال غشاء البلازما

الخلايا ما بين Schwann cell تنقسم وتكون خلايا جديدة

Node of Ranvier

١٦ action potential نتي في صوره $\uparrow$ والاتي .

ganglion (عصب) → Satellite cells

(group of cell bodies = accumulation of perikaryons

دائره ۱۱ ganglion ۽ supporting neuroglial cells ۽ Satellite cells

- Isolating the perikaryon from the surrounding structures.

- Processes penetrate between them.

- Electrical insulation and controlled microenvironment.

↳ Enteric neuroglial cells → morphologically and functionally identical to astrocytes.

(in Meissner submucosa, intermuscular = Auerparks).

Astrocytes

↳ The largest neuroglial cell.

- Mechanical support.
- control of metabolism + chemical environment around the neuron
- modulation of function + activity of neurons.
- scaffolding during embryology, الخلايا الجذعية embryology الخلايا الجذعية neuron
- processes from vessel to neuron = B.V. neuron $\text{Blood-brain barrier}$

Types :

- **Protoplasmic** → more common in the grey matter.
 - where cell bodies are located
 - White : cell processes + their extensions.
- numerous short branching processes.
- **Fibrous** → common in white matter.
 - Relatively straight with fewer number of cell processes.

↳ Astrocytes are characterized by intermediate filaments, called **Glial fibrillary acidic protein (GFAP)**

neoplasms $\text{intermediate filaments}$ tumor marker GFAP $\text{immunohistochemical study}$

✓ Astrocyte ← positive !

- Maintain the BBB.
- Covering for Ranvier nodes and synapses.
- NT (neurotransmitter) removal. → after releasing of the neurotransmitter.
- Glia limitans (impermeable).
 - Pia $\text{single layer of astrocytes}$ Glia limitans matter

Oligodendrocyte

↳ neuroglial cells forming myelene inside the CNS (Schwann cell in the peripheral).

↳ Few processes.

↳ No supporting cells around unmyelinated axons (peripheral axons).

↳ No Basal lamina.

Microglia

macrophages cells

- originated from monocyte.
- phagocytic function
- 5% of glial cells.
- higher in inflammation.
- elongated nucleus, less process.

Ependymal cells

↳ lines the ventricles and the central canal.

↳ morphology of fluid transporting cells :

- basal plasma membrane has foldings.
- apical surfaces may have extensions as microvilli.
- rich in mitochondria.

↳ Production + secretion of CSF.

↳ tightly bound by junctional complexes at the apical surfaces.

↳ Lack external lamina (or basement membrane)

↳ Directly attached to the nervous system tissue.

Types of ependymal cells

- * **Tanycytes** :
- mainly in the floor of 3rd ventricle.
 - no cilia.
 - its surface is in close contact with the CSF.
 - $\text{نخاع دماغ في قاع البطين الثالث}$ - CSF

* Choroid plexus :

- part of the ependymal layer (in ventricles).
- may modify to produce and secrete the CSF in association with rich network of capillary structures.

Peripheral nerves

↳ Nerve fibers are held together by connective tissue.

- ① **Epineurium** : the outermost CT surrounding the entire nerve. ($\text{الغلاف الخارجى للصبغة}$)
- dense irregular CT.
 - may contain fat (in large nerves).
 - B.V.s أوعية دموية

② Perineurium :

- the nerve is composed of various fascicles (of axons).
- $\text{الغلاف المحيى للصبغة}$ fascicle $\text{في$ perineurium الصبغة
- metabolically active diffusion barrier.
- contribute to the formation of blood-brain barrier.
- no lymphocytes or plasma cells.

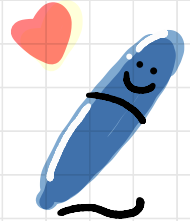
③ Endoneurium :

- loose CT surrounding each 1 single axon.
- formed and secreted by schwann cells.
- mast cells + macrophages may be seen.

> Anatomy <



- outer cortex
- 6 main layers (from outside):
 - ① Molecular → contains small neurons.
 - ② External granular.
 - ③ ~ Pyramidal.
 - ④ Internal granular.
 - ⑤ ~ Pyramidal.
 - ⑥ Multiform (pleomorphic) cell layer.



* Cerebellum 3 layers :

- Molecular
- Purkinje
- Granular

* Spinal cord (مخاع)

Gray → inner
White → outer

Meninges

1. Dura matter:

- Dense connective tissue.
- Continuous with the periosteum in the skull.
- Separated from the spinal canal by the epidural space.
- Sinuses for draining venous blood.

2. Arachnoid:

- Arachnoid trabeculae of loose CT.
- Subarachnoid space/CSF.

3. Pia matter:

- Loose CT.
- Continuous with the perivascular connective tissue.

