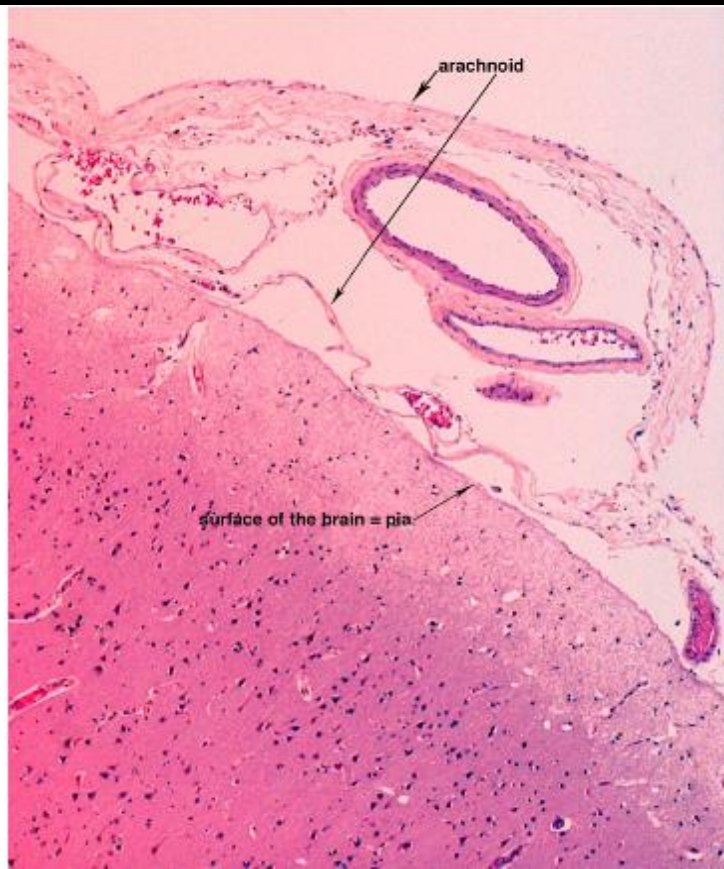
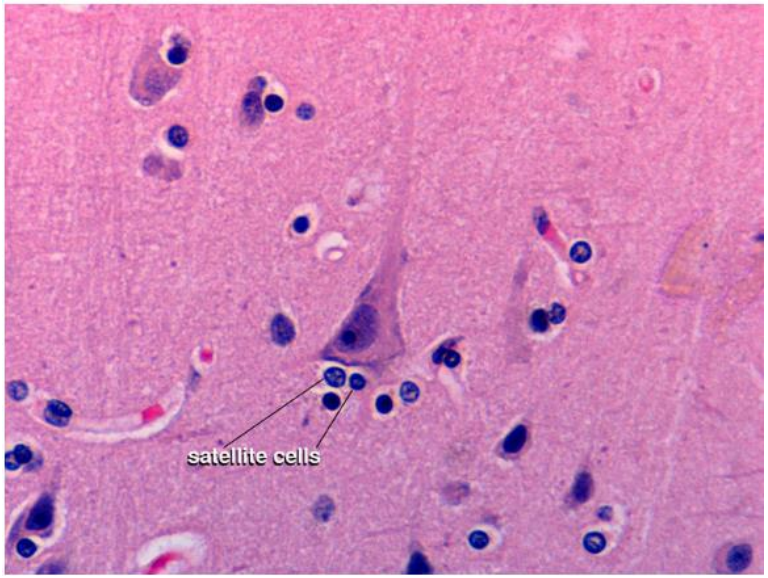
MJF COLLEGE OF VETERINARY AND ANIMAL SCIENCE, CHOMU, JAIPUR

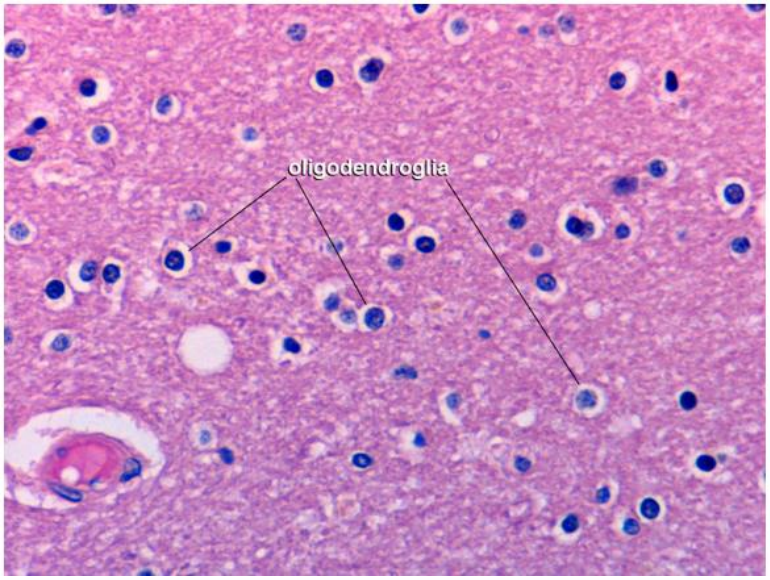
DEPARTMENT OF VETERINARY PATHOLOGY

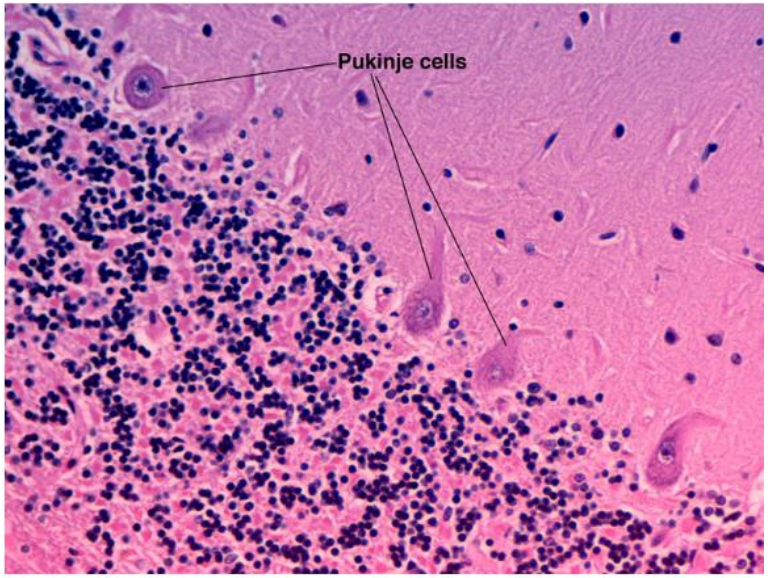
Nervous System

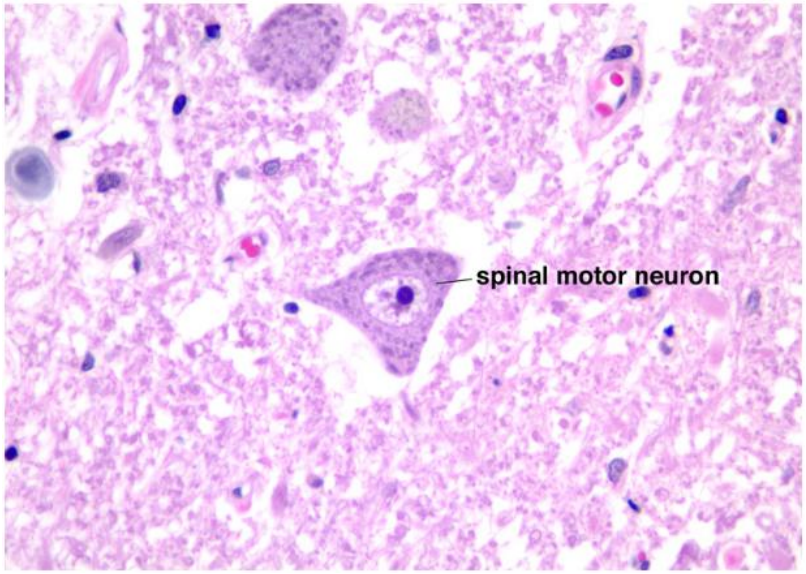
The meninges consist of three layers. The outermost is called the dura mater, also known as the *pachymeninx* (pachy = thick).
The potential space located between the dura and the bones of the cranium is known as the epidural space.
The arachnoid and the pia mater together form the leptomeninges (lepto = slender).
The pia is a delicate membrane that closely covers the brain surface,




satellite cells


oligodendroglia


Pukinje cells


spinal motor neuron

NEUROMUSCULAR DISTURBANCES

Spasms : **S**udden, violent involuntary muscles contractions.

- They may be continuous (tonic spasms) or intermittent (clonic spasms).

Tremor :

- When the spasms are mild and are confined to groups of muscles, they are called tremors .

Convulsions

- If the muscle spasms are widespread and involve the whole body, including the limbs, they are called convulsions.

Epilepsy

- When tonic and clonic spasms alternate, and are accompanied by loss of consciousness, they are termed epilepsy.

Paralysis

- There is complete immobility of a muscle

Paresis

- Paresis means incomplete loss of motion

Hemiplegia

- Hemiplegia is the paralysis arising in the brain cortex and in the peripheral nerves and is unilateral.

Paraplegia

- A bilateral paralysis of the posterior parts of the body and hind limbs resulting from injury to the spinal cord is called paraplegia.

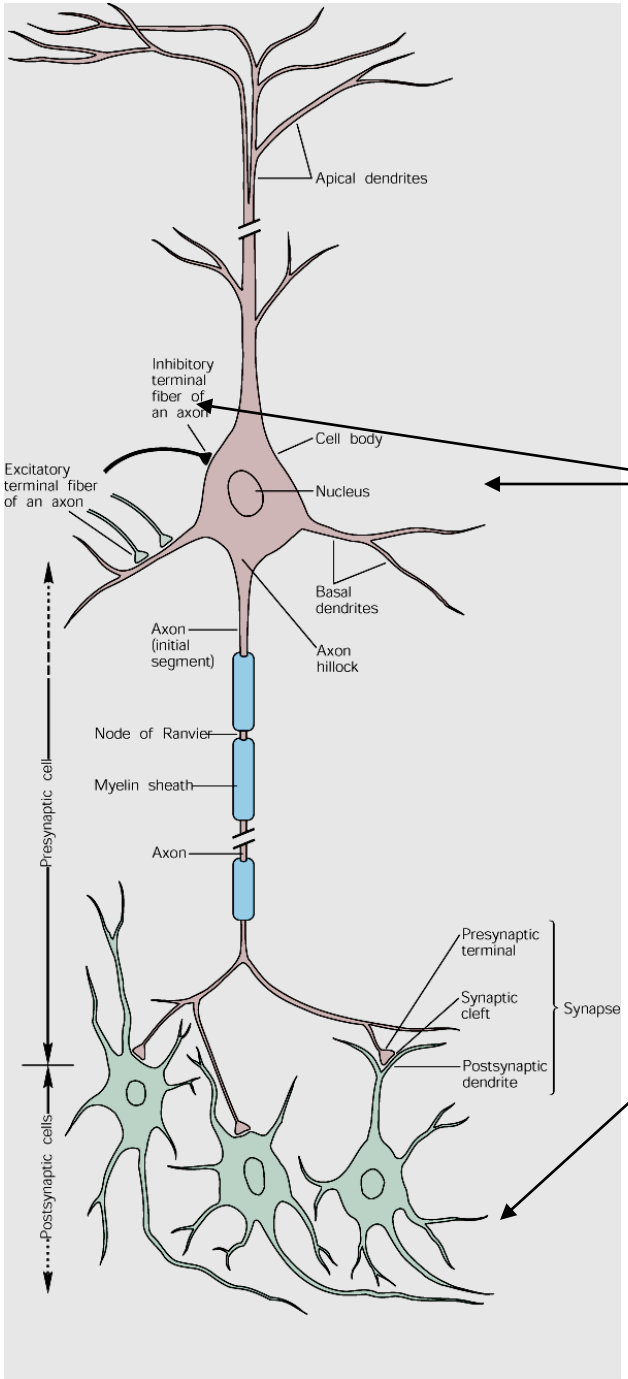
REACTION OF NERVOUS TISSUE TO INJURY

Etiology

- Easily susceptible to injury by hypoxia or toxic materials.
  - Inoroganic salts : lead, arsenic.
  - Organic : Anesthetic agents.
  - Metabolic: Toxic products of uremia.
  - Infectious agents : neurotropic viruses.
  - Nutritional deficiency: Deficiency of B1, Copper, Cobal
  - Vascular: Ischemia causing anoxia
  - Toxic agents

Concepts in Understanding Responses of the CNS to Injury

- susceptibility to injury === neurons> oligodendroglia > astrocytes > microglia> blood vessels.
- Neurons have only small energy stores - highest metabolic rate – Need high & continuous oxygen and nutrients, particularly glucose
- No regeneration of neurons
- Nerve :-
  - CNS – no or little regeneration of nerve fibers
  - PNS - regenerate under certain circumstances

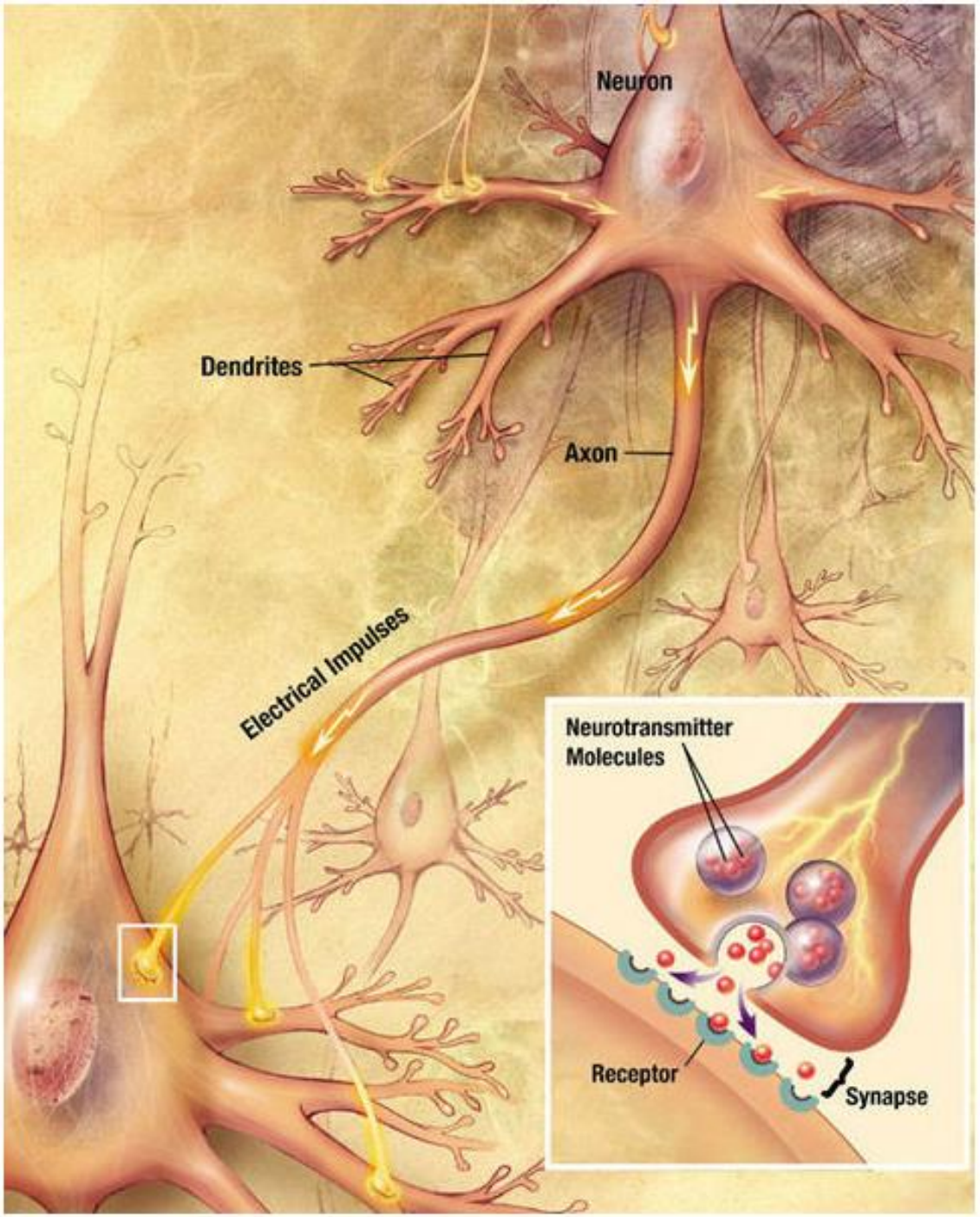


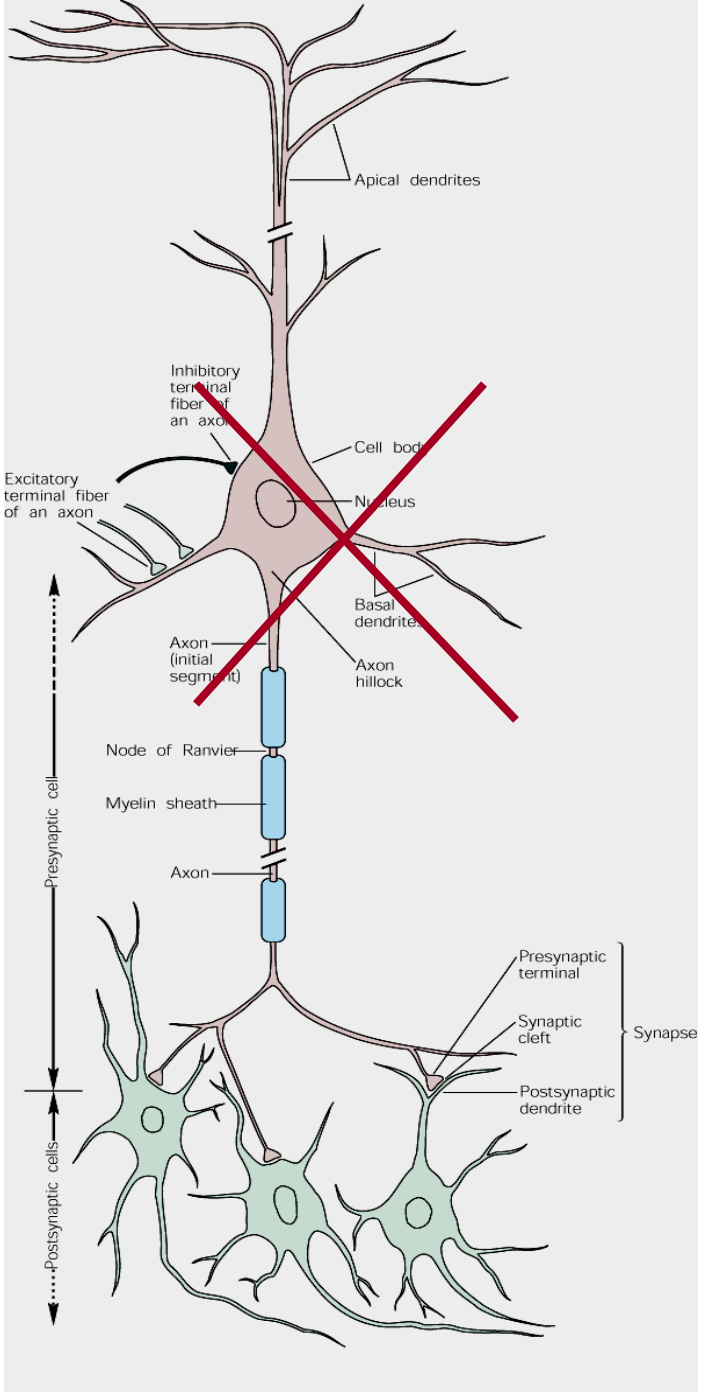
Cell biological reactions in the damaged neuron,

presynaptic

and

postsynaptic neurons

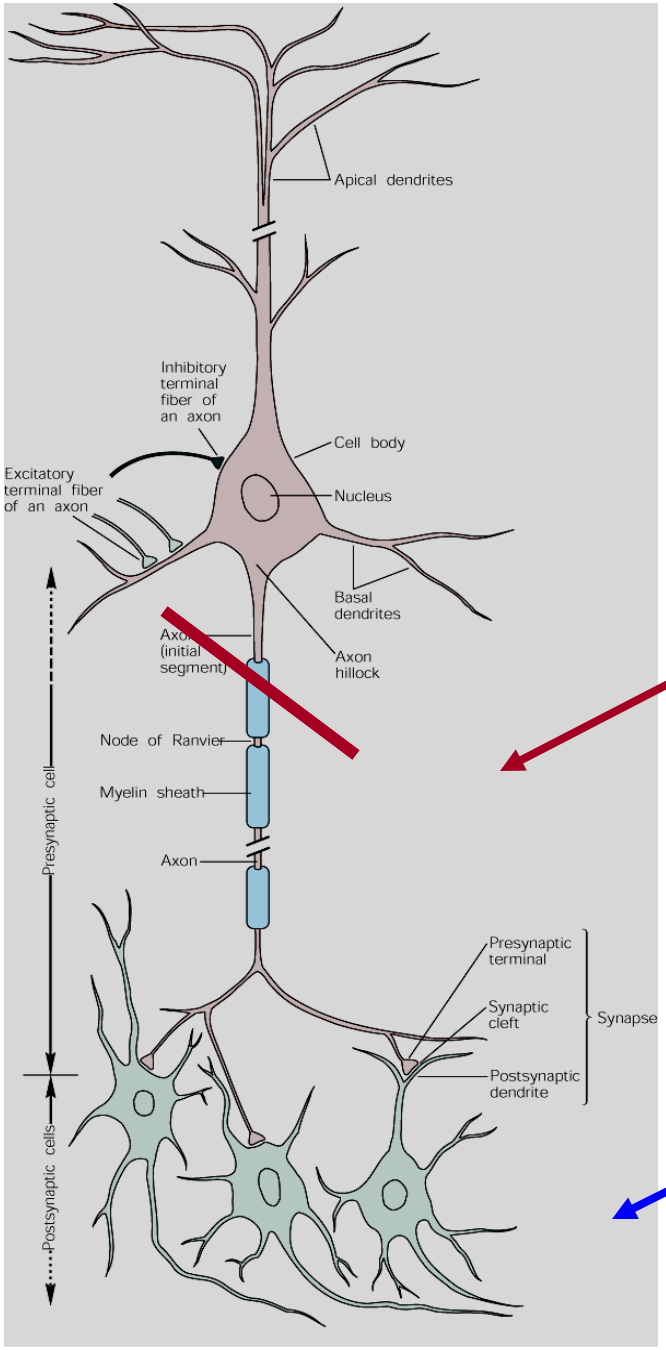

Neuron
Dendrites
Axon
Electrical Impulses
Neurotransmitter Molecules
Receptor
Synapse



If the cell body is damaged,

the neuron is lost;

there is no cell division in adult brain to replace the lost neuron.

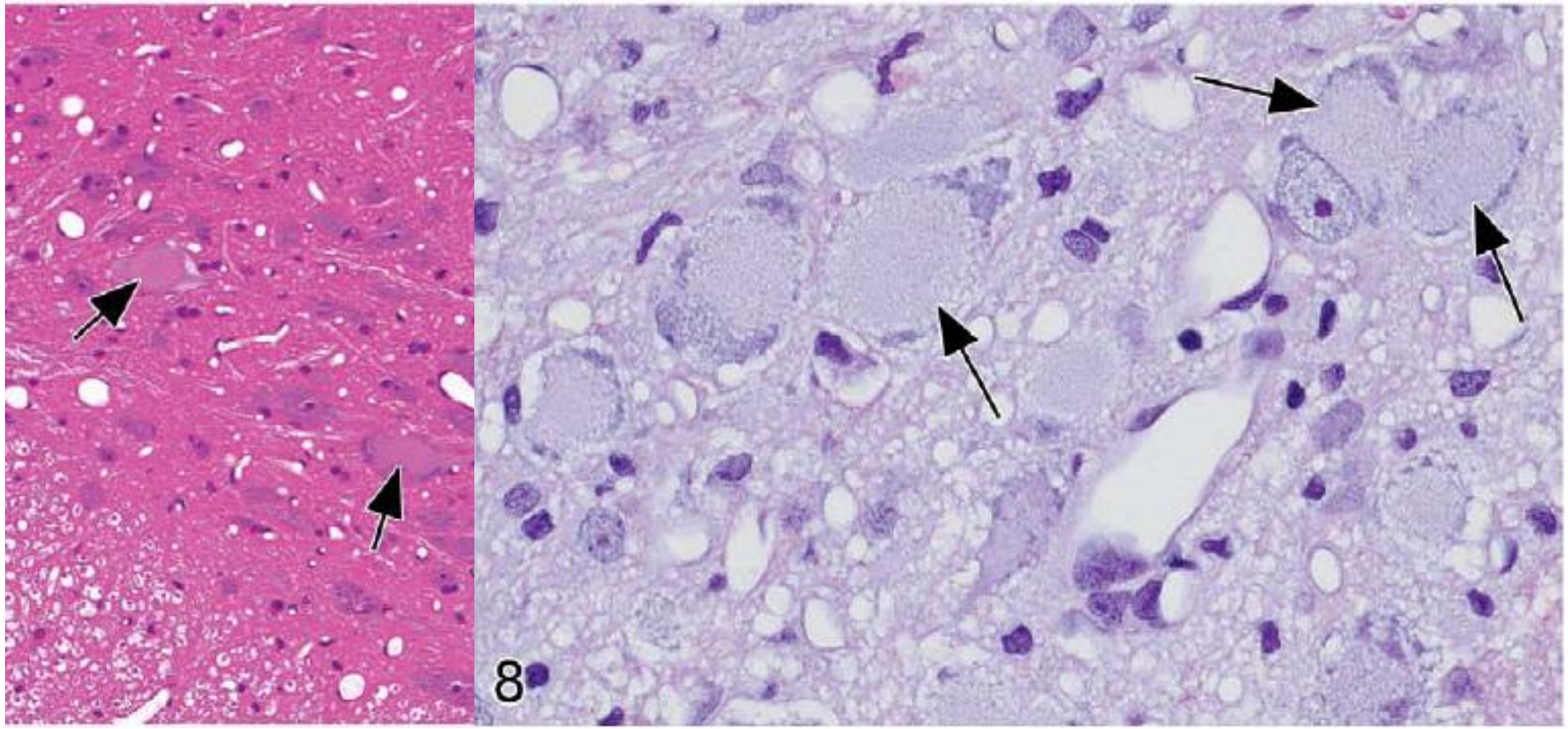


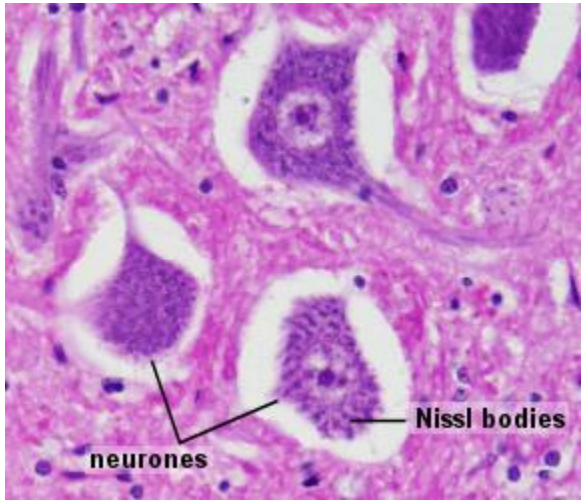
The cell body is lost if the axon is severed close to the cell body, but there is a chance that the axon will regenerate, even in the CNS.

The postsynaptic, (and the presynaptic), neurons are also affected and may degenerate

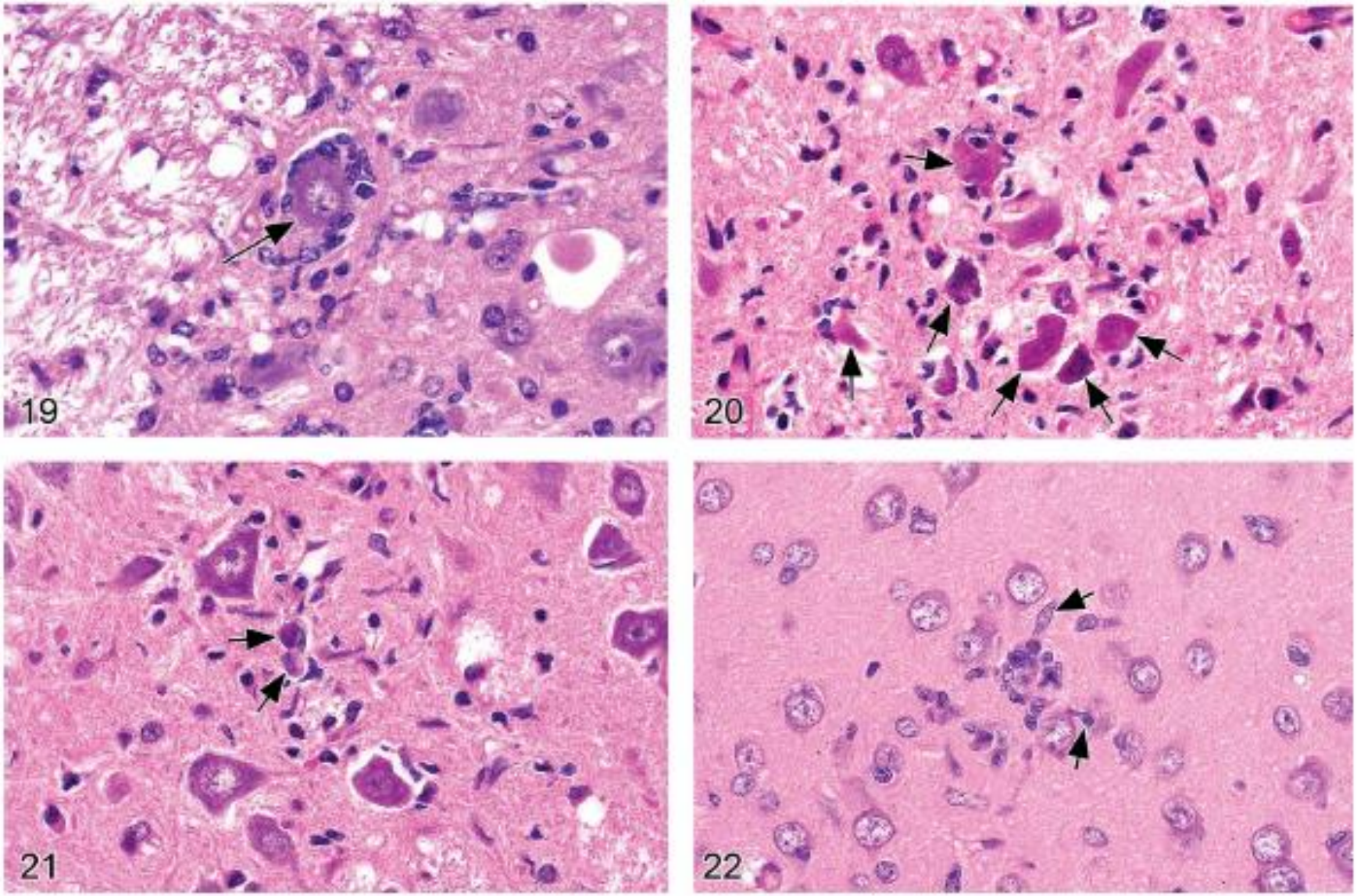
Reactive changes noticed in the neurons

- Apoptosis or Necrosis
- Swelling : cytoplasm stains very faintly and only the cell outline may be discerned with fragmentation of the processes.
- Vacuolation
- Chromatolysis: in this condition the Nissl substance becomes fine and dispersed and later may disappear. The nucleus may be eccentric. This change is seen in injury to the axon.
- Satellitosis: Whenever a neurone is damaged, oligodendroglia and microglia crowd around such cells, without actually invading them, and this phenomenon is known as “satellitosis”
- Neuronophagia-dying neuron surrounded by microglia.

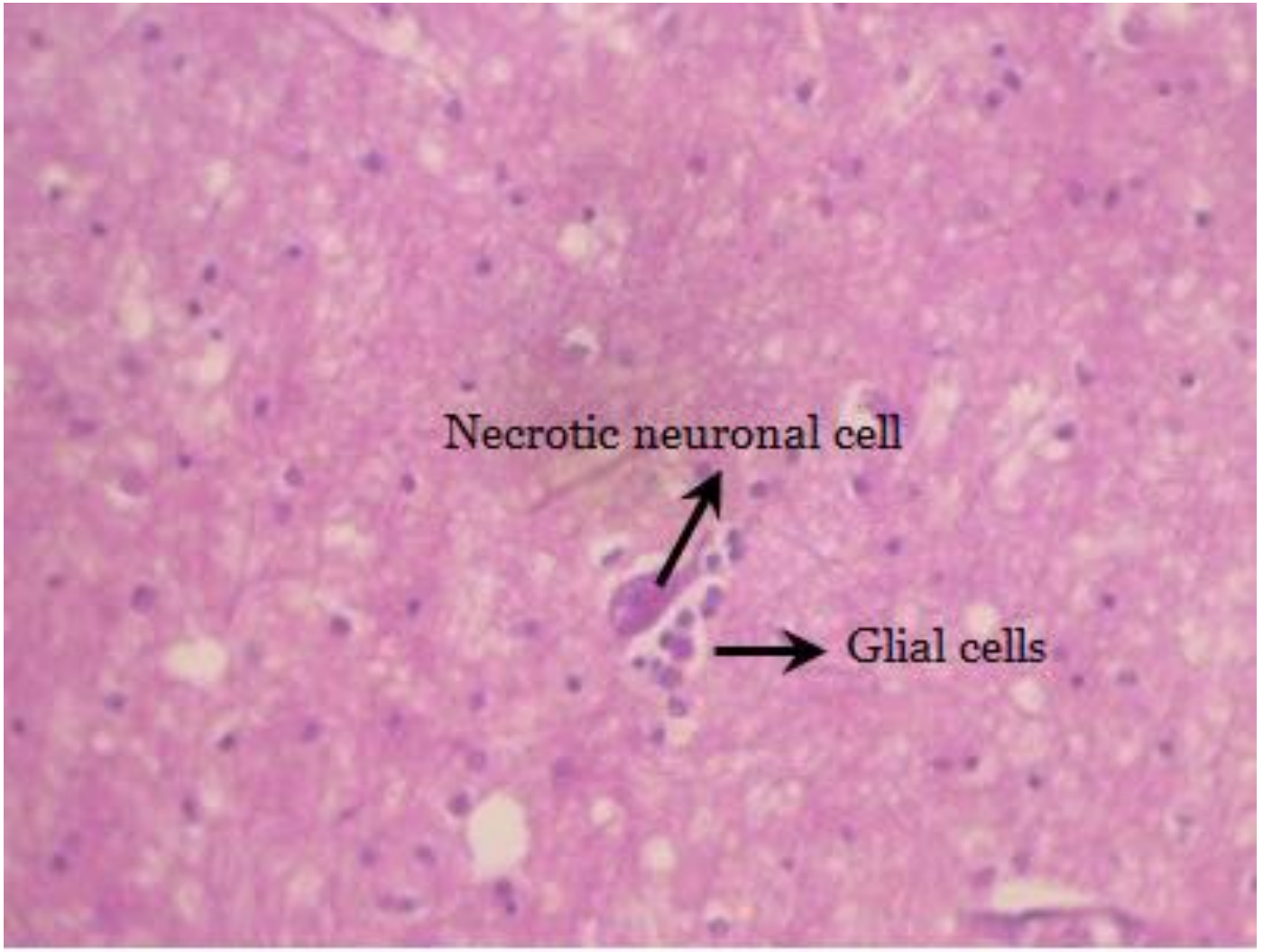




Chromatolysis



Neuronophagia



Satellitosis - Brain - Cow

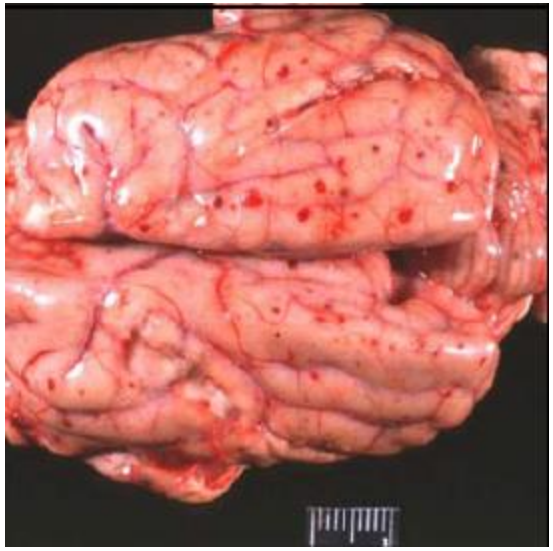
CONGENITAL ANOMALIES

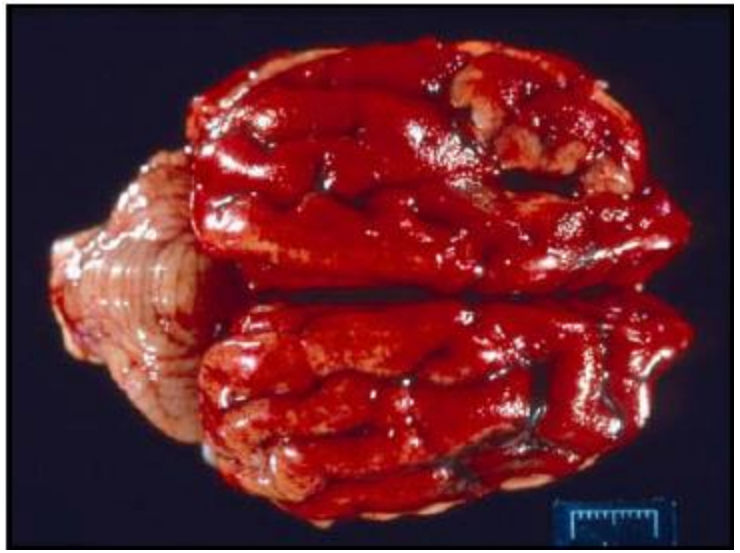
- **Anencephaly** is the absence of most part of the brain
- **Acrania** is the complete failure of cranial development
- **Amyelia** is the absence of spinal cord.
- **Encephalocele** is the protrusion of meninges, alone or with part of the brain through a defect in the cranium.
- **Microcephaly** is the presence of an abnormally small brain.
- **Meningocele** is hernia of the meninges, which protrude through an opening of the skull or spinal column.
- **Rachicele** is hernia of the spinal cord.

Meningocele is hernia of the meninges, which protrude through an opening of the skull or spinal column.

Disturbances of Circulation

- Hyperemia
- Anemia or ischemia
- Congestion of brain
- Hemorrhage
- Edema of brain
- Hydrocephalus





Hydrocephalus

Brain congestion - Heat stroke - Japanese quail

DISTURBANCES IN GROWTH

Aplasia : "Defective development or congenital absence of the brain and spinal cord

Hypoplasia : Cerebellar hypoplasia , At necropsy, cerebellum may be found to be rudimentary or even absent.

Hypertrophy or Hyperplasia

- This may result from increase in size/number of the glial cells, microglia showing the greatest degree of hypertrophy.
- The neuron does not increase in size/number.

Metaplasia

- This does not occur in the nervous tissue proper.
- It may occur in the connective tissue of the meninges and blood vessels, in which case cartilage and bone may be found.

Atrophy

- Atrophy of the cerebrum may occur in hydrocephalus.

DISTURBANCES IN CELL METABOLISM

Cloudy swelling : hypoxia

- The cells become larger, cellular outline more round and cellular structures indistinct.

Fatty degeneration

Hydropic degeneration

- It is a continuation of cloudy swelling. In this droplets of edematous fluid are observed in the cytoplasm of the neurons and glia.

Pigmentation

- In cattle and sheep, melanin is most frequently encountered in the pia mater of the anterior one-fourth of the brain.

Calcification

- This is most commonly found in meninges than in the brain and spinal cord proper.

NECROSIS

Coagulative necrosis

- hypoxia, chemical poisons, bacterial toxins and viruses.
- *Histopathology:* cells are swollen, pink cytoplasm, chromatolysis and shrinkage & satellitosis, neuronophagia.

Liquefactive necrosis

- Necrosis of the brain is almost always liquefactive in nature.
  - Infarction is one of the common causes
  - Pyogenic bacteria.
  - Encephalomalacia due to
    - Defeciency of Vitamin E in young chickens (crazy chick disease);
    - moludy corn poisoning in horses (cornstalk disease); Acute pancreatitis in all animals;
    - Antenatal copper deficiency in lambs (sway back);
    - cobalt deficiency (Enzootic marasmus);

- *Histopathology :* The lesions seen are thickening of blood vessels, endothelial hyperplasia and liquefaction of brain substance.

Caseous necrosis

- by *Mycobacterium tuberculosis*.
- dry, crumbly, yellowish-white mass, It may contain areas of calcification.
- *Histopathology*
  - The necrosed area is surrounded by a zone of inflammation.
  - Necrosis of nerve fibres of the peripheral nerves, the tracts and central nervous system is first indicated by fatty degeneration of the myelin sheaths of the nerve fibre affected. This change occurring in the brain and spinal cord is called demyelination. Ultimately the axon may disappear.

INFLAMMATION

- **Encephalitis** – is inflammation of the brain.
- **Myelitis** – is inflammation of the spinal cord.
- **Encephalomyelitis** – is inflammation of the brain and spinal cord.
- **Meningitis** – is inflammation of the meninges.
- **Pachymeningitis** - is inflammation of the dura matter.
- **Leptomeningitis** – is inflammation of the pia matter.
- **Meningoencephalomyelitis** – is inflammation of the meninges, brain and the spinal cord.
- **Poliomyelitis** – is inflammation of gray matter in the spinal cord.
- **Neuritis** is inflammation of the peripheral nerve

SPECIFIC INFLAMMATIONS OF BRAIN AND SPINAL CORD

- **lymphocytic meningoencephalomyelitis**.
- Rabies
- Pseudorabies
- Hog cholera (swine fever) encephalitis
- Canine distemper encephalitis
- Infectious viral equine encephalomyelitis
- Louping ill
- Ranikhet disease (Pneumoencephalitis of poultry)

Enterotoxaemia

- In enterotoxaemia of sheep, there is perivascular edema and haemorrhage.

Parasitic Encephalomyelitis

- *Hypoderma bovis*
- larvae of *Oestrus ovis*
- Cysts of *Multiceps multiceps*, *Taenia pisiformis* and *Tanenia echinococcus*.
- Gid or Sturdy **:-** larval stage of *Multiceps multiceps*, a dog tapeworm is known as coenurus cerebralis
- **Cerebrospinal nematodiasis (Neurofilariasis; Kumri, wobbles):-** In horses it is known as Kumri (“weakness of the loin”) in our country, whereas in sheep and goats it is known as “ lumbar paralysis ”. Caused by *Setaria digitata.*
- *Toxoplasma gondi*

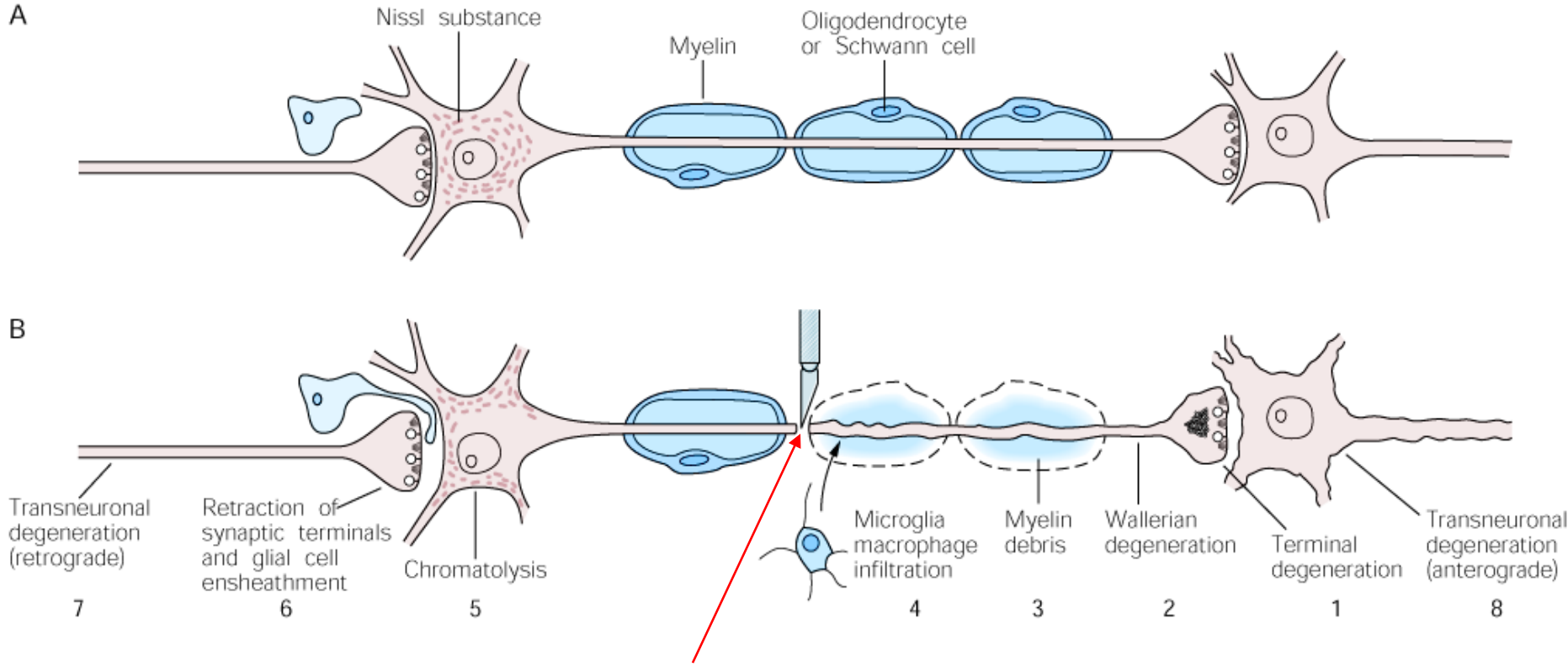
EPILEPSY

- Epilepsy is a sudden brief (petit mal) or prolonged (grand mal), loss of consciousness usually preceded by convulsions.

SWAYBACK OR ENZOOTIC ATAXIA

- Deficiency of copper.
- The ewes which are maintained on a copper deficient diet or grazed on lands with molybdenum-rich grasses may manifest anemia and produce “steely” wool. Lambs of such ewes show demyelination and suffer from “swayback”.

Reaction of Nerve to Injury



Appleton & Lange
Kandel/Schwartz/Jessell
Principles of Neural Science
Fig. 55.18

MINUTES after injury…
- synaptic transmission off / Paralysis of affected part
- cut ends swell
- Function distal to the axon cut is lost. (immediate)
- K+ leaks out of the cell and Na/Ca++ leaks into the cell.
- Proximal and distal segments of axon reseal slightly away from cut ends. (~2 hrs)
- Subsequent anterograde & retrograde effects

Anterograde Effects (Wallerian Degeneration)

- Mitochondria accumulate at nodes of Ranvier. (hrs)
- Axon swells. (within 12 hrs)
- Axolema and mitochondria begin to fragment. (within 3 days)
- Myelin not associated with a viable axon begins to fragment. (within 1 wk)
- Astrocytes or Schwann cells proliferate (within 1 wk), which can continue for over a month.
- Result in >10x the original number of cells.
- Microglia (macrophages) invade from the vasculature.
- Glia and microglia phagocytize debris. (1 month in PNS; >3 months in CNS)

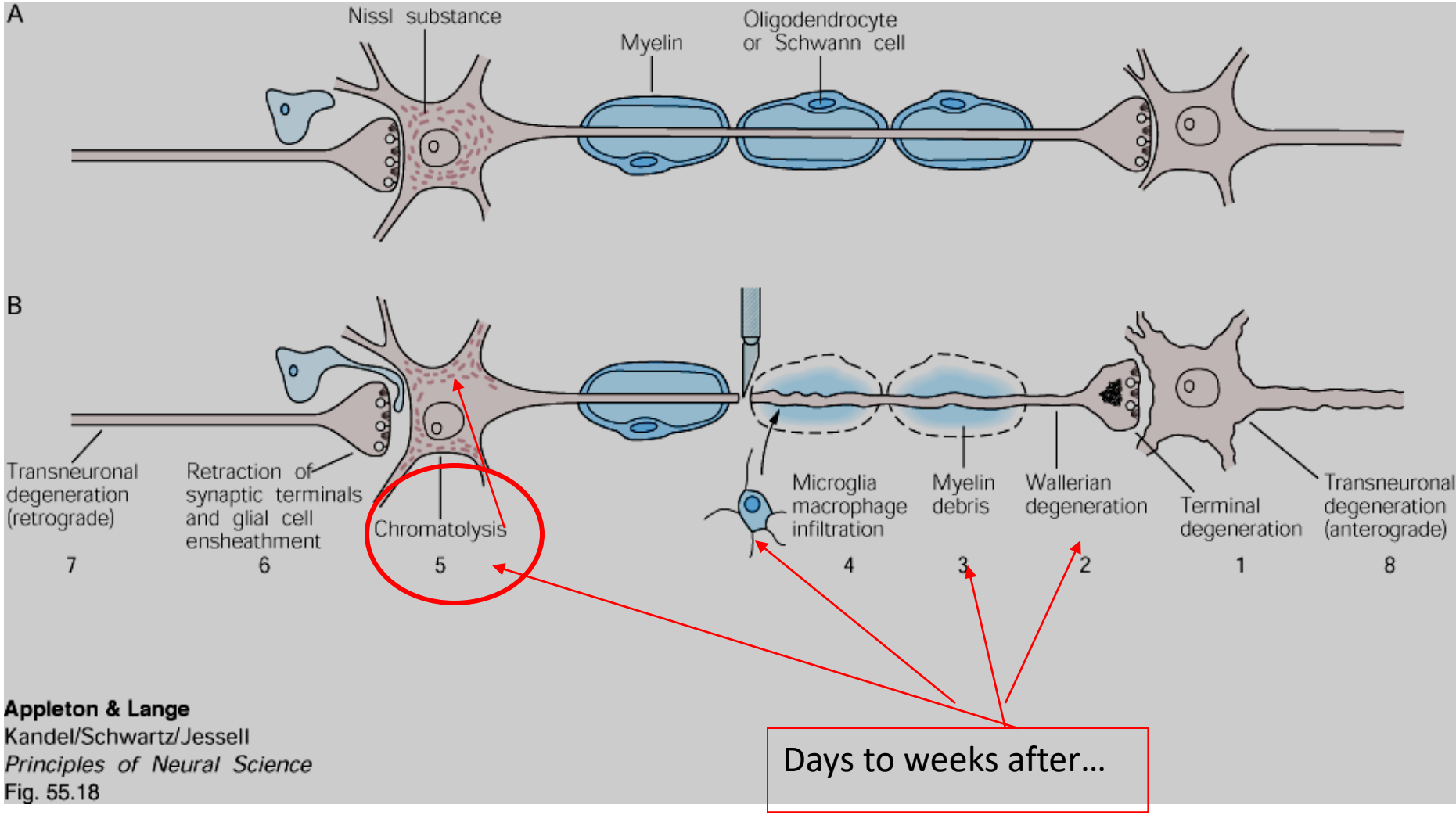


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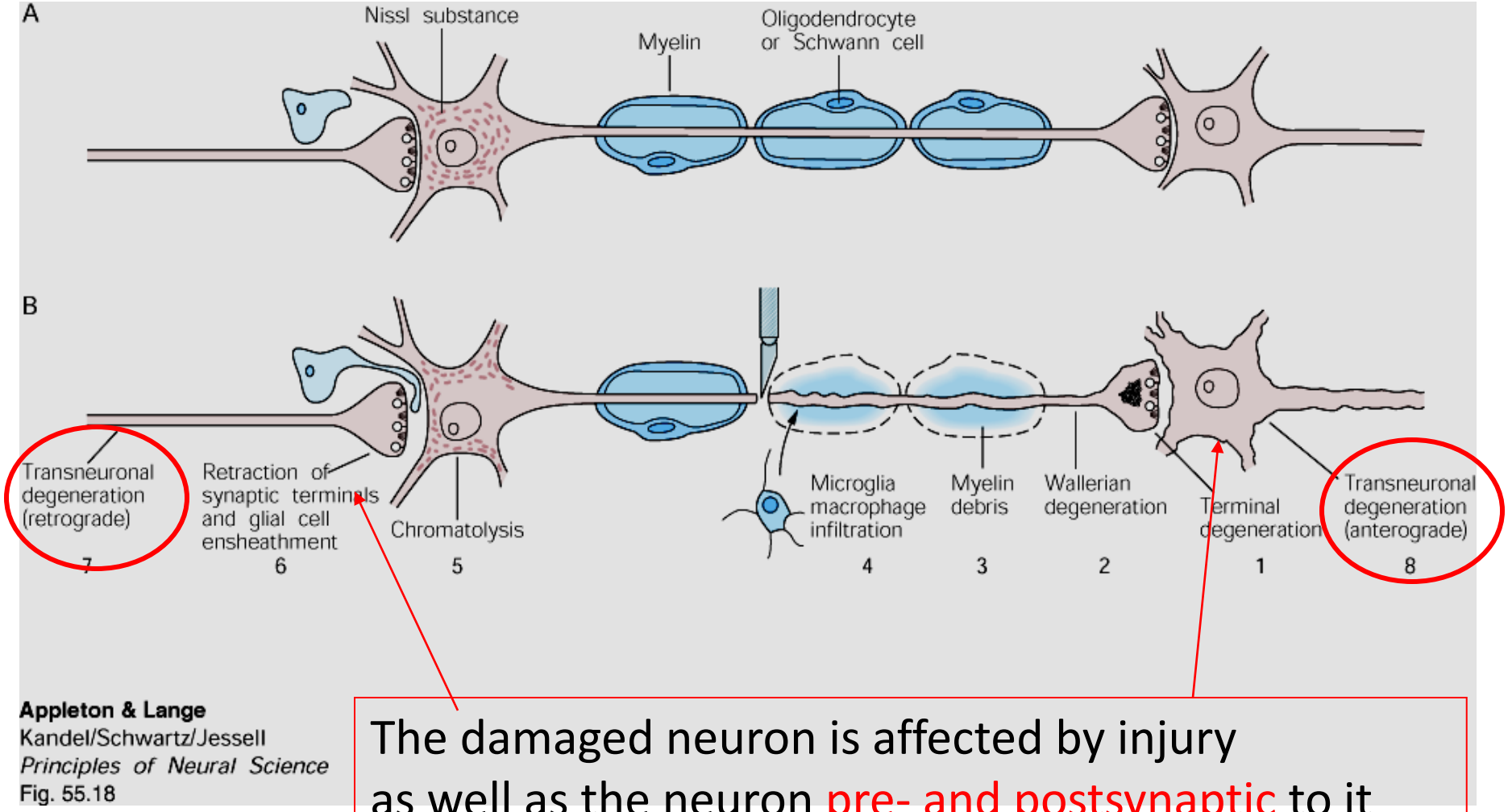
Fig. 55.18



Appleton & Lange
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Principles of Neural Science
Fig. 55.18

The damaged neuron is affected by injury
as well as the neuron pre- and postsynaptic to it

Retrograde Response

- Soma undergoes chromatolysis: loss of rER, soma swells, nucleus moves eccentric, nucleolus enlarges. (within 3 days)
- Cell down-regulates expression of molecules required for neuronal communication (e.g. neuro-transmitters) and up-regulates synthesis of molecules needed for axon growth
- Axon begins to regrow (regenerate) from its cut end. (1- 2 wks)

PATHOLOGY OF THE PERIPHERAL NERVES

- Degeneration
- *Types*
  - When a nerve cell undergoes degeneration it also affects the nerve fibre of that cell. This is known as descending degeneration .
  - Degeneration can also begin in the nerve fibre and progress towards the nerve cell (ascending degeneration).
- *Histopathology*
  - Loss of the myelin substance is called demyelination.
  - When a nerve fibre (axon gets severed from cell body, the distal part of the nerve fibre undergoes characteristic degenerative changes known as **Wallerian degeneration** .

Regeneration

Neurons in the PNS can regenerate their axons. HOW? (summary)

a. After degeneration of distal axon and myelin, macrophages clean up debris.

b. Macrophages release mitogens that induce Schwann cells to divide

c. The myelin-forming Schwann cells repopulate the nerve sheaths;

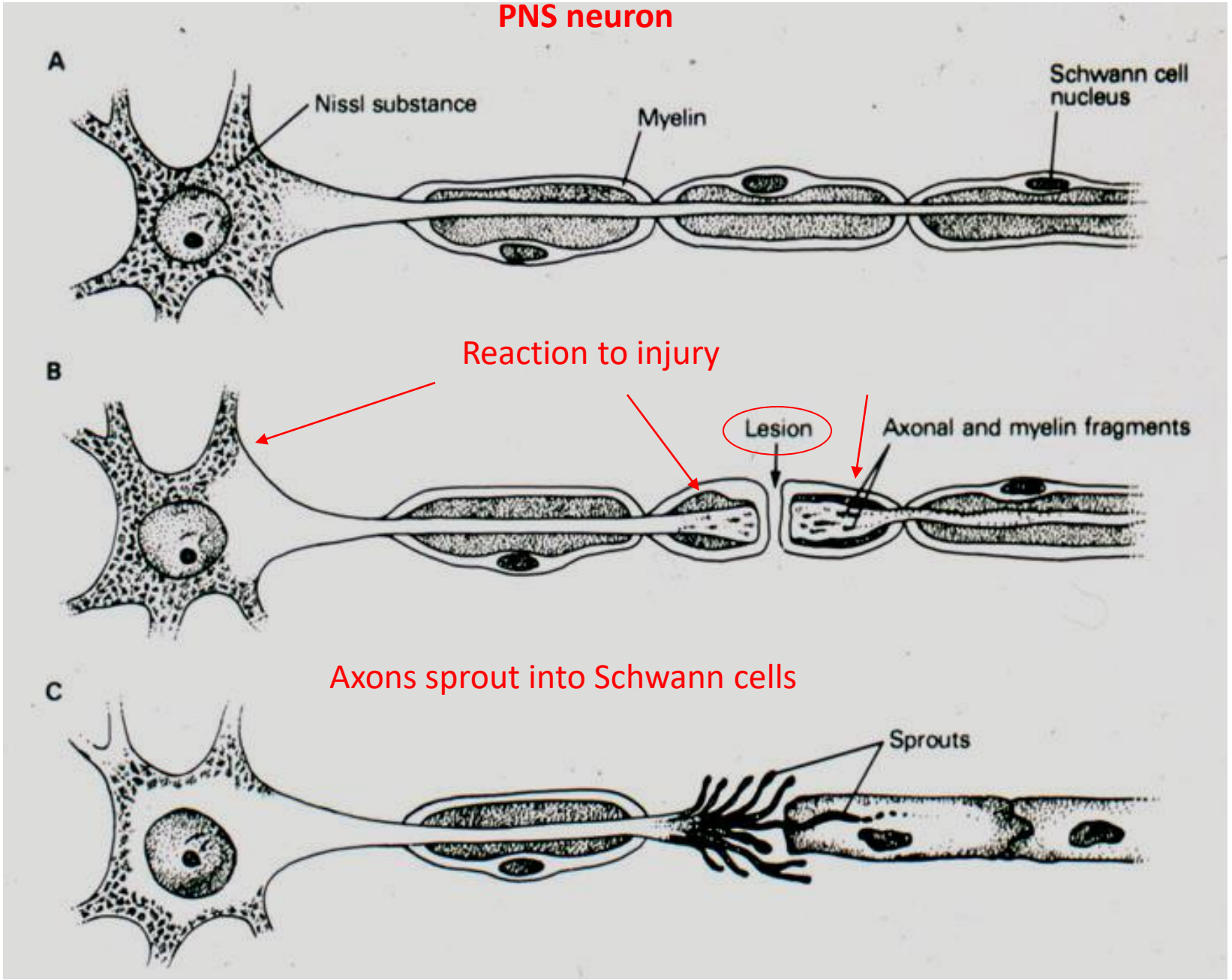
d. Schwann cells make laminin

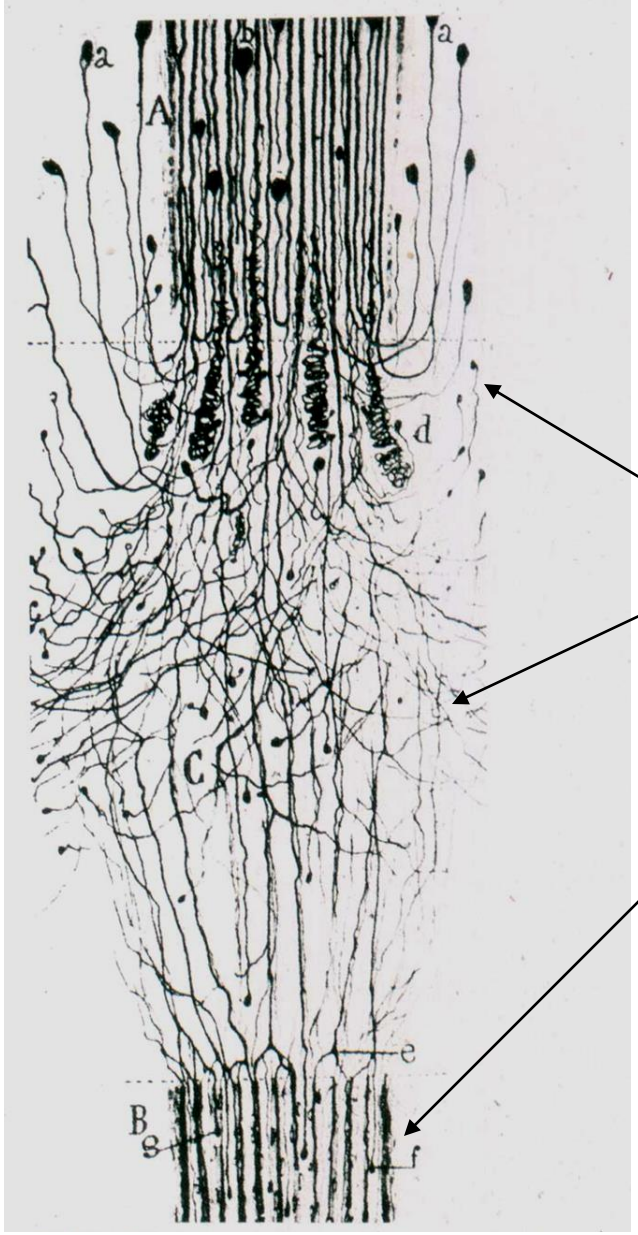
e. Macrophages make interleukin, which induces Schwann cells to make Nerve Growth Factor.

f. Axons sprout, and some sprouts enter new Schwann cell tubes

g. Axonal growth cones successfully grow

PNS neuron


A
Nissl substance
Myelin
Schwann cell nucleus
Reaction to injury
B
Lesion
Axonal and myelin fragments
Axons sprout into Schwann cells
C
Sprouts

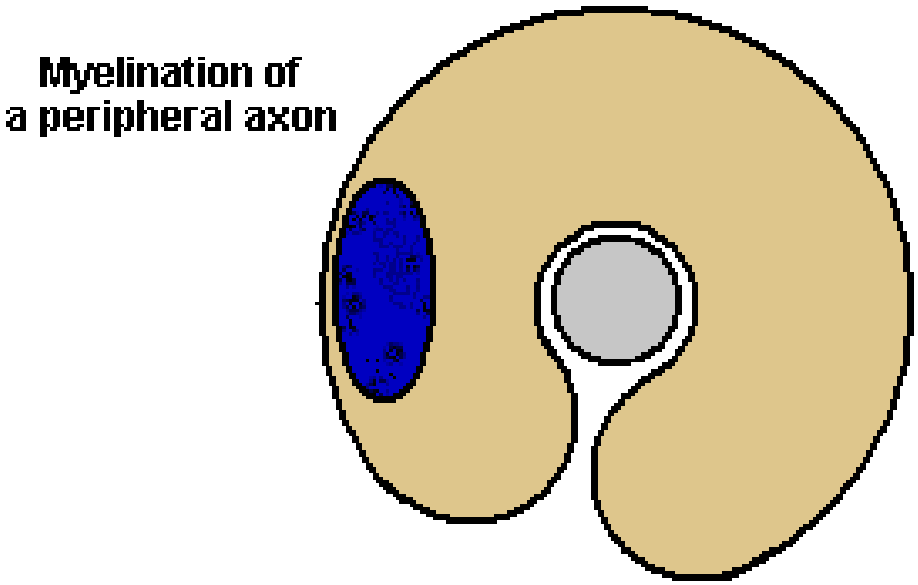


Regenerating axons form many sprouts, some of which find Schwann cell tubes

-Ramon y Cajal

Regeneration

- Nerve fibres in the CNS cannot regenerate as it is lacking a sheath of Schwann, but the peripheral nerves regenerate fairly rapidly.
- it requires 10 to 12 months for complete healing.
- Schwann cells play a leading role in the healing of nerves.



NEOPLASMS AFFECTING THE NERVOUS SYSTEM

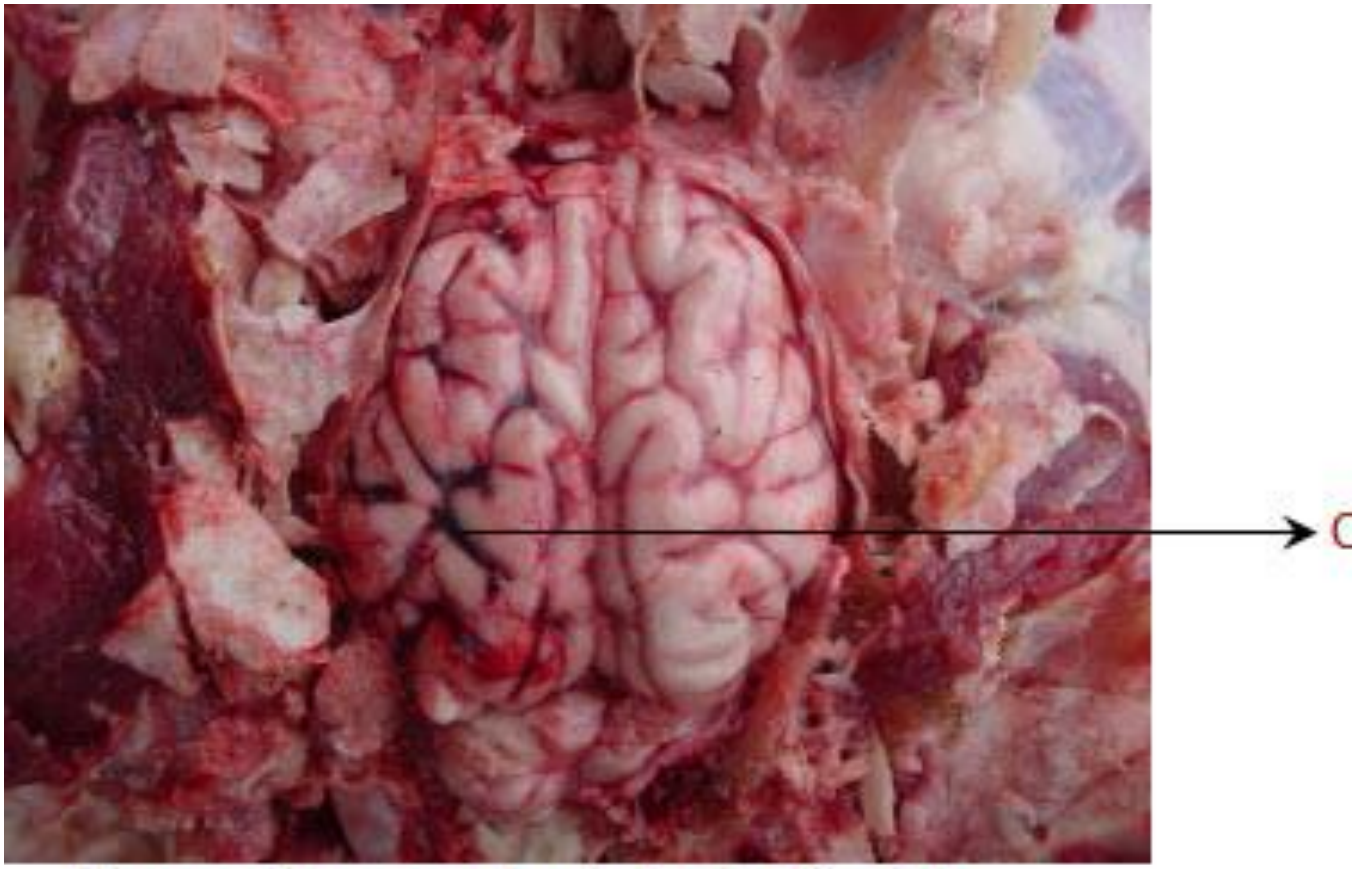
Primary tumors

- rare. However, common in dogs and least common in the pig and sheep.
- Primary tumors include those of the neuroglia (gliomas, astrocytoma, oligodendroglioma), nerve cell and fibres (neuromas), ganglion cells (ganglioneuroma), ependymal cells (ependymomas) and of meninges (meningiomas).

Secondary tumors

- Central nervous system is also prone to secondary tumors, which are metastatic, their primary sites being the lung or some other organ.

POSTMORTEN CHANGES IN THE BRAIN



Hypostatic congestion in brain of a piglet