

Central Nervous System

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25.12.2025

Neuroglial Cell Types & Function

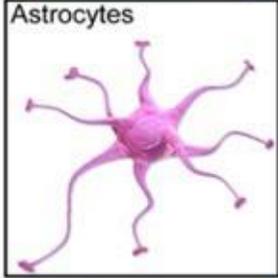


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Central Nervous system

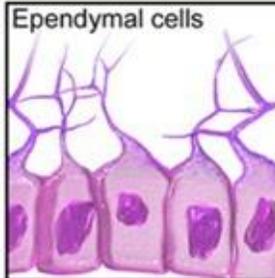
Peripheral Nervous system

Astrocytes



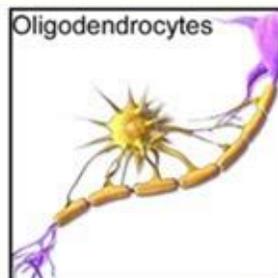
Maintain blood brain barrier
-controlling the levels of neurotransmitter around synapses,
-regulate ion, and providing metabolic support.

Ependymal cells



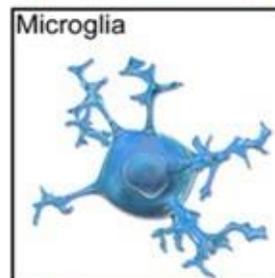
Line spinal cord & ventricles of the brain.
-involved in producing cerebrospinal fluid (CSF).

Oligodendrocytes



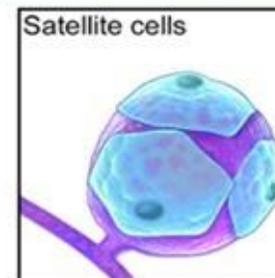
Myelinate CNS axons, provide structural framework

Microglia



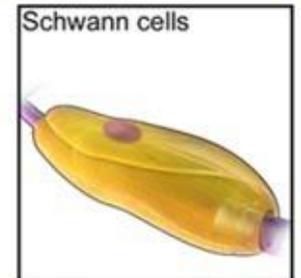
Brain's immune cells
-Remove dead cells and pathogens by phagocytosis

Satellite cells



Surround neuron cell bodies in ganglia. Regulate neurotransmitter levels

Schwann cells

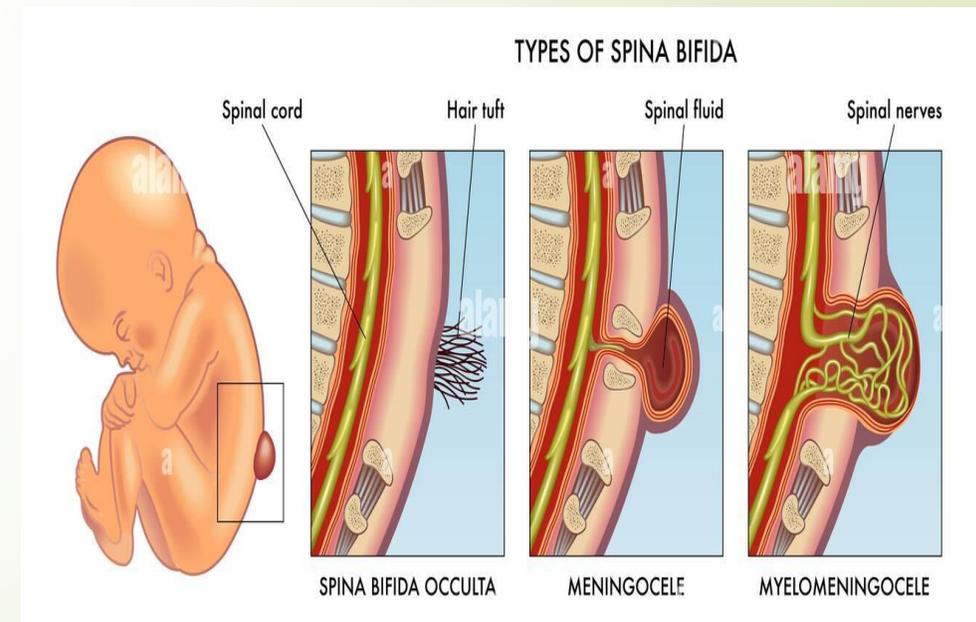
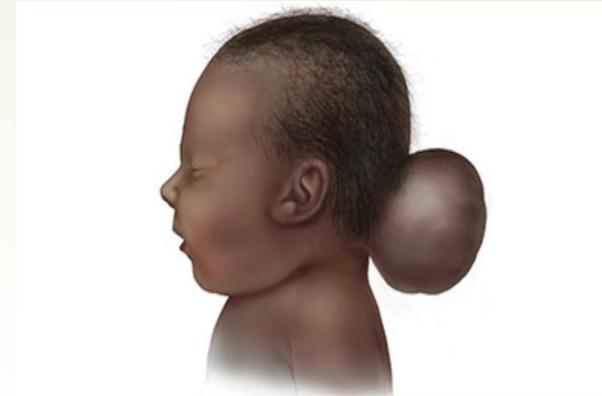


Myelinate neurons in PNS. maintenance and regeneration of neurons after injury

Congenital anomalies

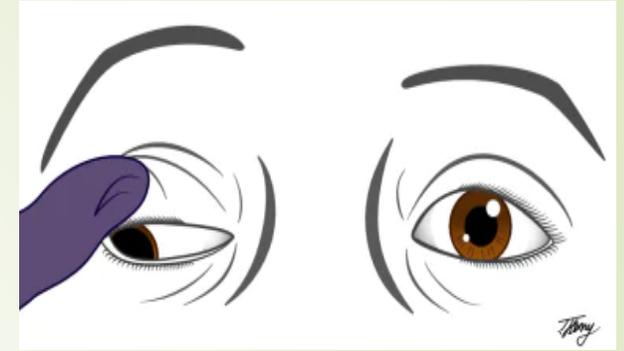
Neural tube defects:

- ❖ Anencephaly:
 - Absence of cranial vault.
- ❖ Encephalocele:
 - Herniation of brain tissue through defective cranium.
- ❖ Spina bifida occulta:
 - Incomplete closing of the vertebra and membranes around the spinal cord
- ❖ Meningocele:
 - Meninges protrudes through small opening
- ❖ Meningomyelocele:
 - Herniation of spinal cord and meningeal tissue through vertebral defect

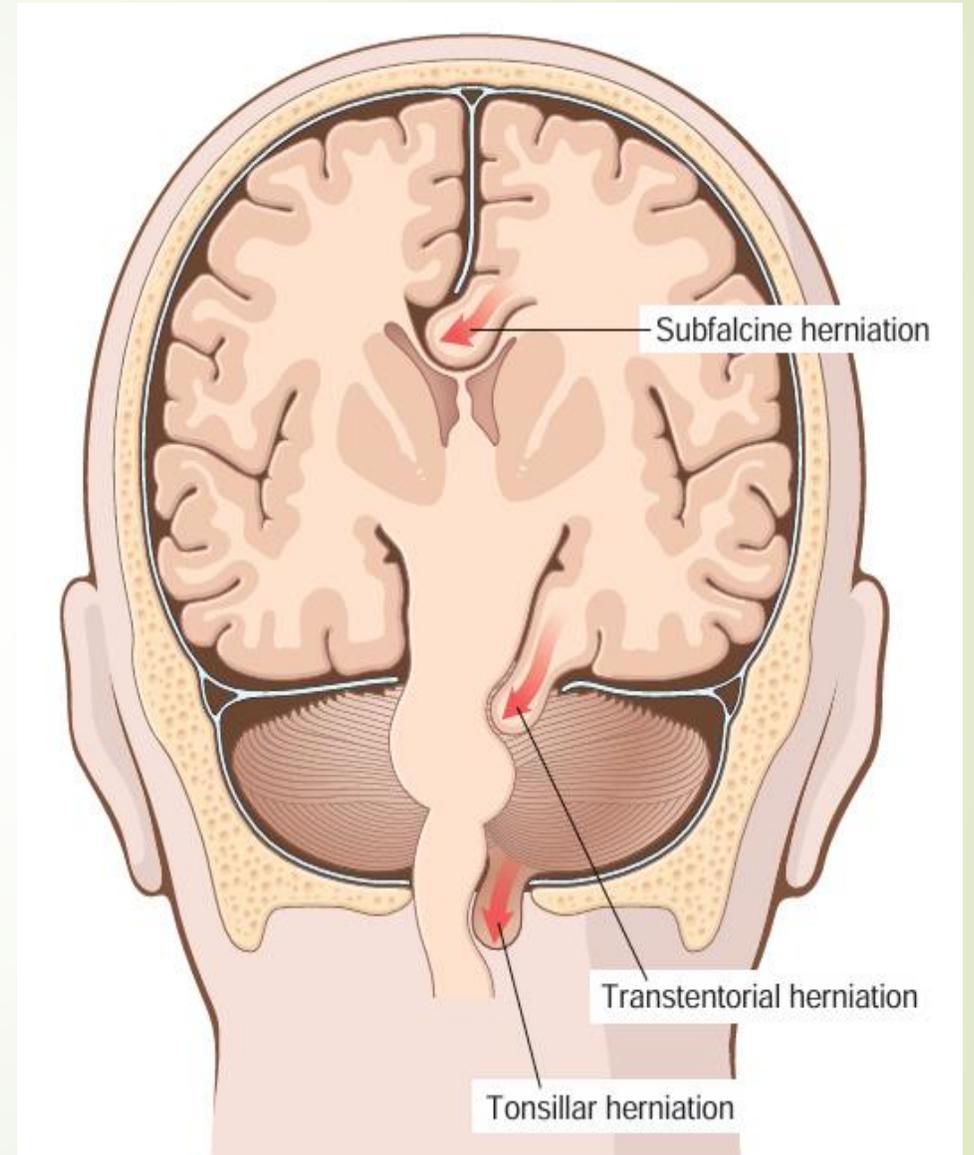
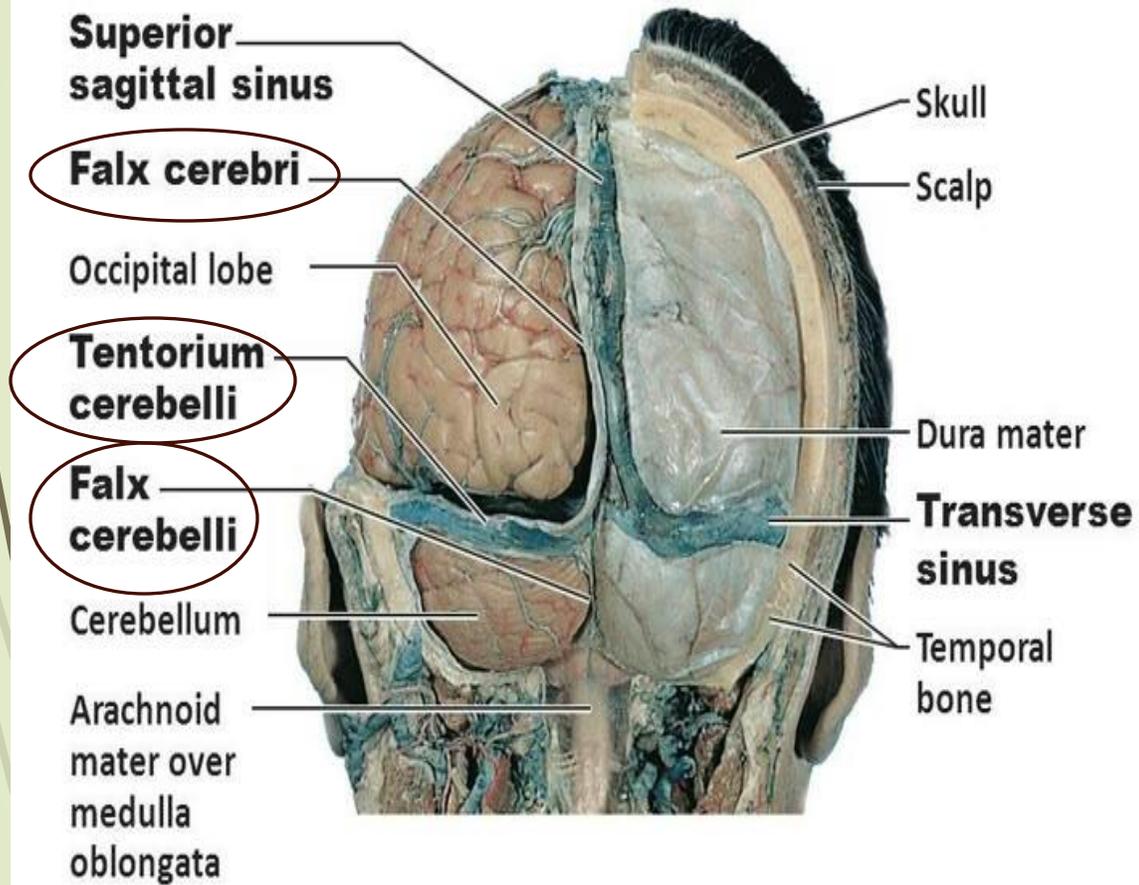


Cerebral herniation

- Definition: Herniation is the displacement of brain tissue past rigid dural folds (the falx and tentorium) or through openings in the skull because of increased intracranial pressure
- Causes: Brain herniation is mostly caused by mass effects, either diffuse (generalized brain edema) or focal (tumors, abscesses, or hemorrhages)
- Types:
 - ❖ 1) **Transtentorial:**
 - **The most common type**
 - From supratentorial to infratentorial.
 - Compress the third nerve and result in mydriasis and ophthalmoplegia
 - ❖ 2) **Subfalcine:**
 - Herniation of medial aspect of cerebral hemisphere under the falx
 - Compress the anterior cerebral artery

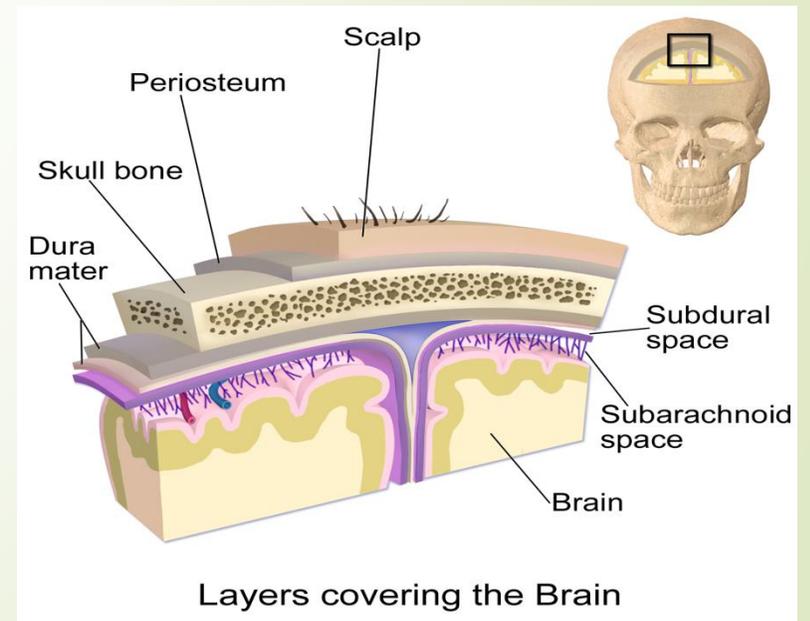


- ❖ 3) **Tonsillar:**
 - **The cerebellar tonsil herniate into foramen magnum**
 - **Compress the medulla and respiratory center, may lead to death.**



CNS Infections

- Meningitis is an inflammatory process of the leptomeninges and CSF within the subarachnoid space, usually caused by an infection
- Meningoencephalitis refers to inflammation of the meninges and brain parenchyma
- Based on the etiology and clinical evolution of the illness, infectious meningitis is broadly classified into:
 - 1) Acute pyogenic (usually bacterial),
 - 2) Aseptic (usually acute or subacute viral),
 - 3) Chronic (usually tuberculous, spirochetal, or cryptococcal)



➤ 1) Acute pyogenic (bacterial) meningitis:

➤ Organisms:

➤ In neonates: Escherichia coli and the group B streptococci

➤ In elderly: Streptococcus pneumoniae and Listeria monocytogenes

➤ In adolescents and young adults: Neisseria meningitidis.

➤ The introduction of immunization against Haemophilus influenzae has markedly reduced the incidence of this infection in the developed world, particularly among infants.

➤ Clinically:

➤ symptoms related to meningeal irritation and neurologic impairment, including headache, photophobia, irritability, clouding of consciousness, and neck stiffness.

➤ Untreated pyogenic meningitis can be fatal, while effective treatment with antibiotics markedly reduces mortality.

spinal tap yields cloudy CSF with increased neutrophils, increased protein concentration, and markedly reduced glucose content.

Spinal tap yields increased lymphocytic count, the protein elevation is only moderate, and the glucose content is nearly always normal

➤ 2) Acute Aseptic (Viral) Meningitis:

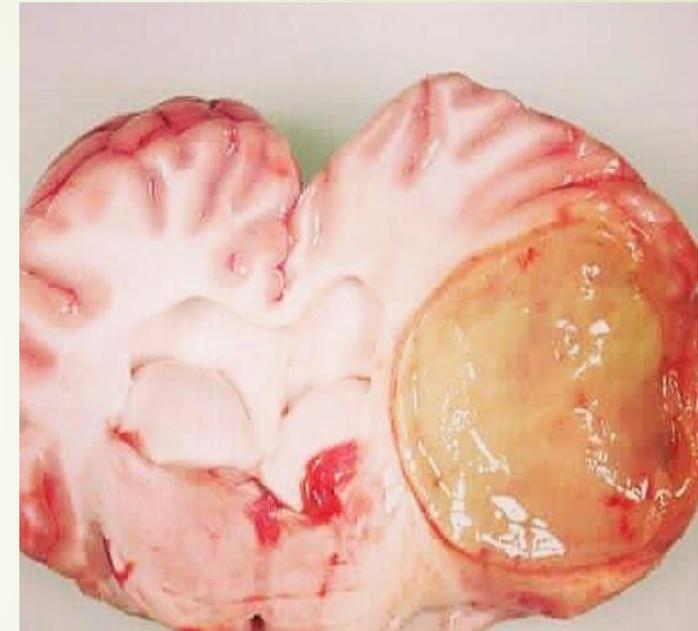
- Aseptic meningitis is a clinical term used for **an absence of organisms by bacterial culture** in a patient with manifestations of meningitis
- Same symptoms as in bacterial meningitis
- The viral aseptic meningitides are usually self-limited and are treated symptomatically

➤ 3) Chronic meningitis:

- long-lasting inflammation of the meninges (brain/spinal cord lining), lasting over four weeks, with gradual symptoms like headache, fever, confusion, and stiff neck
- Often from infections (TB, fungi), autoimmune issues, or cancer

Brain abscess

- ❖ Definition: localized focus of necrosis of brain tissue with accompanying inflammation, usually caused by a bacterial infection.
- ❖ Predisposing conditions include:
 - 1) Acute bacterial endocarditis, which may give rise to multiple brain abscesses
 - 2) Chronic pulmonary sepsis, as in bronchiectasis
 - 3) Systemic disease with immunosuppression.
- ❖ **Streptococci and staphylococci are the most common offending organisms identified in non-immunosuppressed patients**
- ❖ Clinically:
 - General: Fever, chills, severe headache, stiff neck, nausea, vomiting, confusion, personality changes, sleepiness.
 - Focal (depending on location): Weakness or numbness (often one-sided), seizures, vision problems, speech difficulties, balance issues
- ❖ Treatment: A medical emergency, usually starting with high-dose antibiotics or antifungals, sometimes followed by surgery (drainage or removal)



liquefactive center
with yellow pus
surrounded by a thin
wall

Trauma

- ❖ The magnitude and distribution of a traumatic brain lesion depends on: the shape of the object causing the trauma, the force of impact, and whether the head is in motion at the time of injury.
- ❖ A blow to the head may be penetrating or blunt; it may cause either an open or a closed injury
- ❖ Site and consequence:
 - Frontal lobe – Clinically silent
 - Spinal cord – Severely disabled
 - Brain stem – Fatal
- ❖ Types of injury:
 - Skull fracture
 - Parenchymal injury
 - Traumatic vascular injury
 - Spinal cord injury

► # Skull fracture:

- when an individual falls while awake (such as might occur when stepping off a ladder), the site of impact is often the occipital portion of the skull; in contrast, a fall that follows loss of consciousness (as might follow a syncopal attack) can result in either frontal or occipital impact.

► # Parenchymal injury:

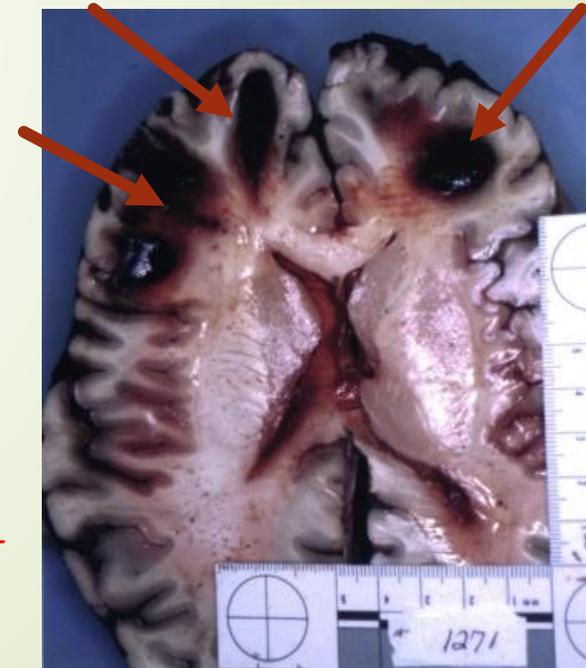
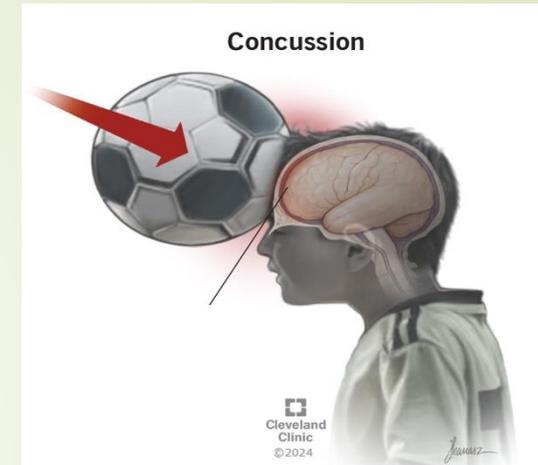
- 1) **Concussion**: altered consciousness secondary to head injury.

- from a blow to the head or body, causing the brain to shake inside the skull

- 2) **Contusion and laceration**: traumatic brain injuries from impacts, involving **bleeding/damage to brain tissue**, often at the frontal/temporal lobes where the brain hits the skull.

- **Contusion**: Bleeding/bruising of brain tissue, small blood vessels leaking into the brain.

- **Laceration**: A tear or cut in the brain tissue, often involving the dura mater (outer membrane).



Traumatic vascular injury:

❖ Classification according to the site:

1) Epidural Hemorrhage/ Hematoma:

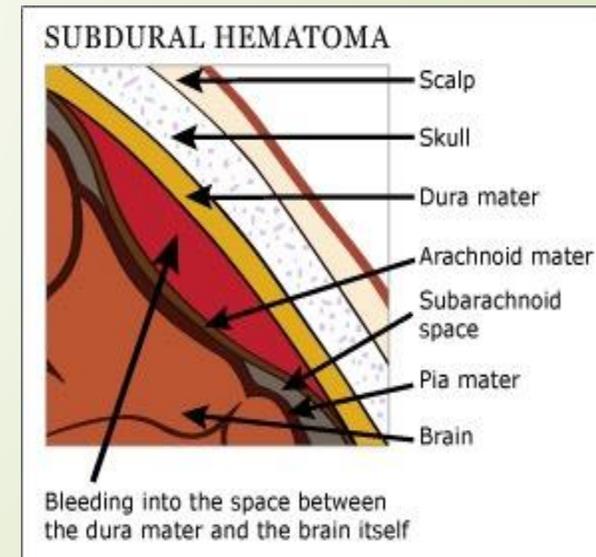
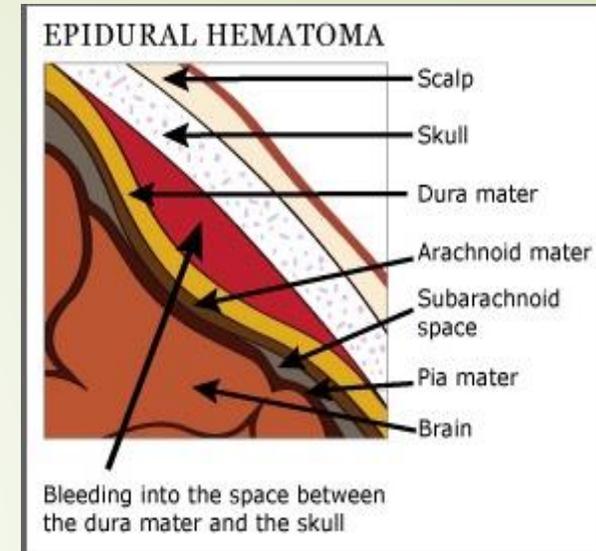
- Hemorrhage between the dura and the bone of skull. **By rupture of one of the meningeal arteries.**
- From severe trauma that causes skull fracture

2) Subdural Hemorrhage/ Hematoma:

- Collection of blood located in the potential space between the **dura mater** and the **arachnoid mater** of the meninges. **By rupture of a bridging vein.**

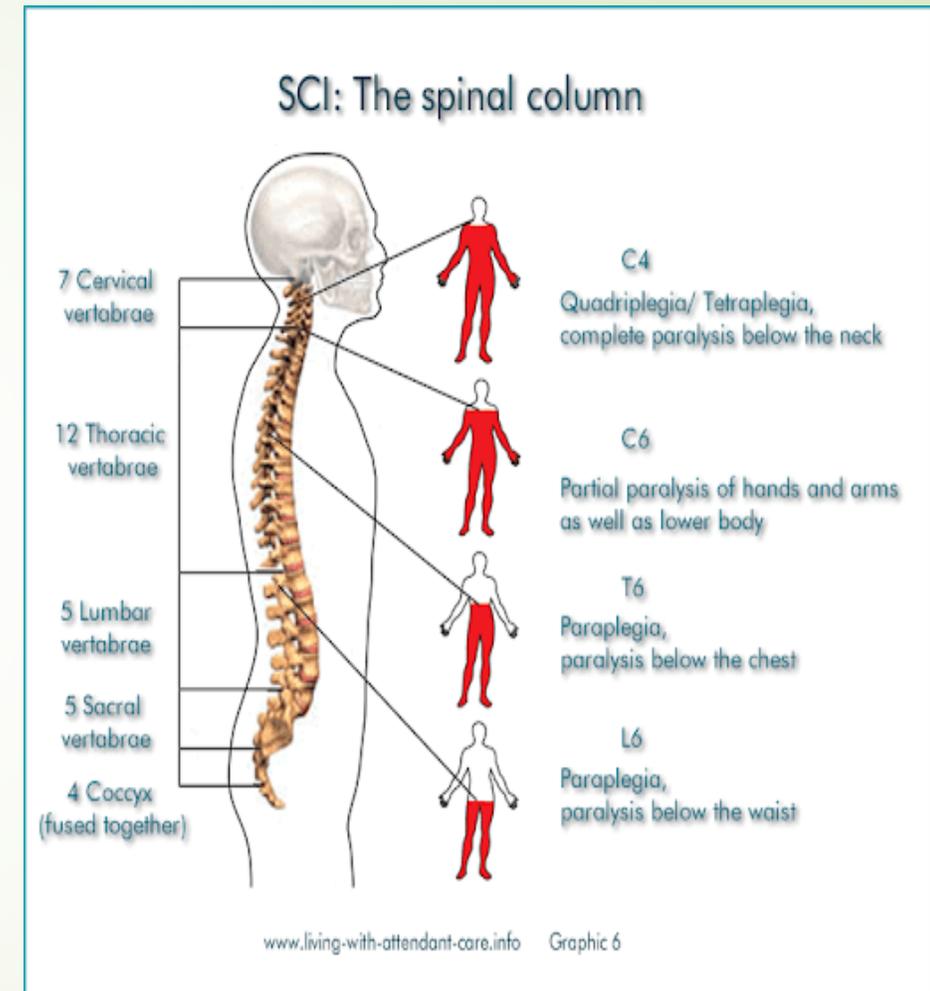
Intraparenchymal Hemorrhage (Non-traumatic hemorrhage)

- Rupture of a small intraparenchymal vessel
- **Hypertension is the major risk factor**, accounting for more than 50% of clinically significant hemorrhages and for roughly 15% of deaths among individuals with chronic hypertension



➤ # Spinal cord injury:

- Most injuries that damage the cord are associated with the transient or permanent displacement of the vertebral column.
- The level of cord injury determines the extent of the neurologic manifestations:
 - Thoracic vertebrae or below can lead to paraplegia
 - Cervical lesions result in quadriplegia
 - Those above C4 can, in addition, lead to respiratory compromise from paralysis of the diaphragm.



Hypoxia and ischemia to brain

- ▶ Although the brain accounts for only 1% to 2% of body weight, it receives approximately 15% of the resting cardiac output and accounts for 20% of the body's oxygen consumption.
- ▶ Brain may be deprived of oxygen by either: **hypoxemia** (low blood oxygen content) or **ischemia** (inadequate blood flow).
- ▶ Inadequate blood flow may result from a reduction in perfusion pressure (as in hypotension), small- or large-vessel obstruction, or both
- ▶ **Effect**: When blood flow to a portion of the brain is reduced, the survival of the tissue at risk depends on the presence of collateral circulation, the duration of ischemia, and the magnitude and rapidity of the reduction of flow.
- ❖ **Focal Cerebral Ischemia**: follows reduction or cessation of blood flow to a localized area of the brain due to partial or complete arterial obstruction.
- ▶ When the ischemia is sustained, infarction follows in the territory of the compromised vessel.

► # Brain infarct:

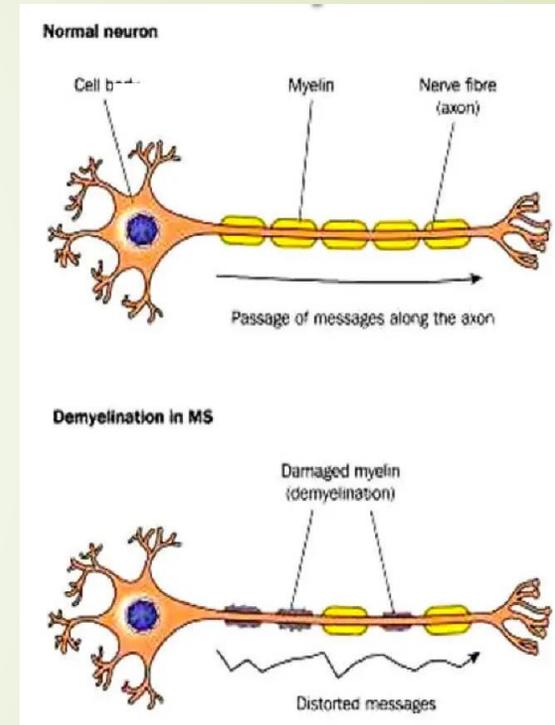
► Types:

- 1) Red infarcts: multiple, punctate hemorrhage, often associated with embolism.
- 2) Pale infarcts (non-hemorrhagic): associated with thrombosis



Demyelinating diseases

- Definition: they are acquired conditions characterized by preferential damage to myelin with relative preservation of axons.
- Effect: Slowing or stopping nerve signals
- ❖ Multiple Sclerosis
 - **Is the most common type of demyelinating diseases**, and the most common cause of non-trauma related neurologic disability in young adults
 - Can involve any site in the central nervous system (CNS) → **Optic chiasm and tract (nearly always involved)**
 - Mechanism: Cause of MS is unknown, though it is favored to be due to an autoimmune activation of lymphocytes.
 - Clinically: thy course is typically relapsing and remitting. Early findings include weakness of the lower extremities and visual abnormalities with retrobulbar pain.

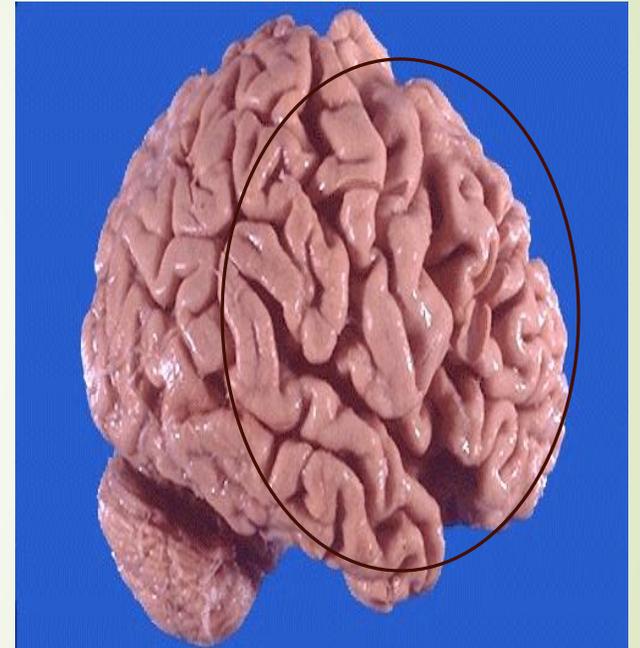


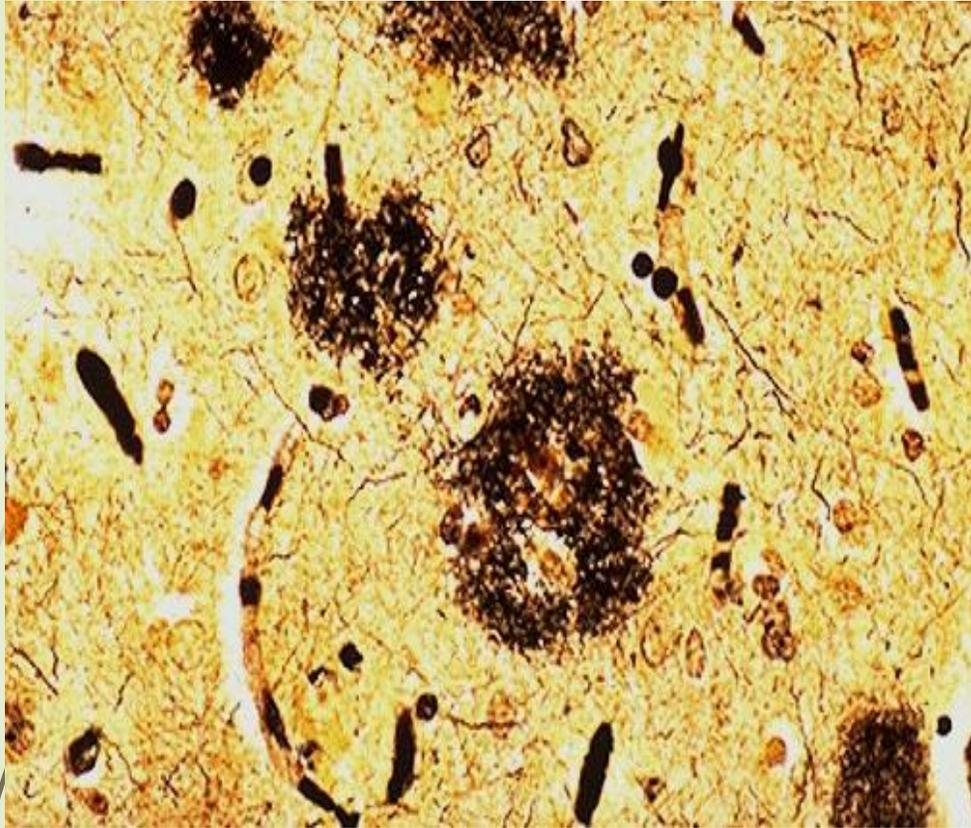
Neurodegenerative diseases

- Definition: they are disorders characterized by the progressive loss of particular groups of neurons, which often have shared functions.
- The pathologic process that is common across most of the neurodegenerative diseases is the accumulation of protein aggregates
- Protein aggregates may arise because of mutations that alter the affected protein's synthesis or disrupt the pathways that are involved in the processing or clearance of an otherwise normal protein
- **Diagnostic hallmark:** The protein aggregates are recognized histologically as inclusions.
- Of the most common types are: Parkinson disease and Alzheimer Disease.

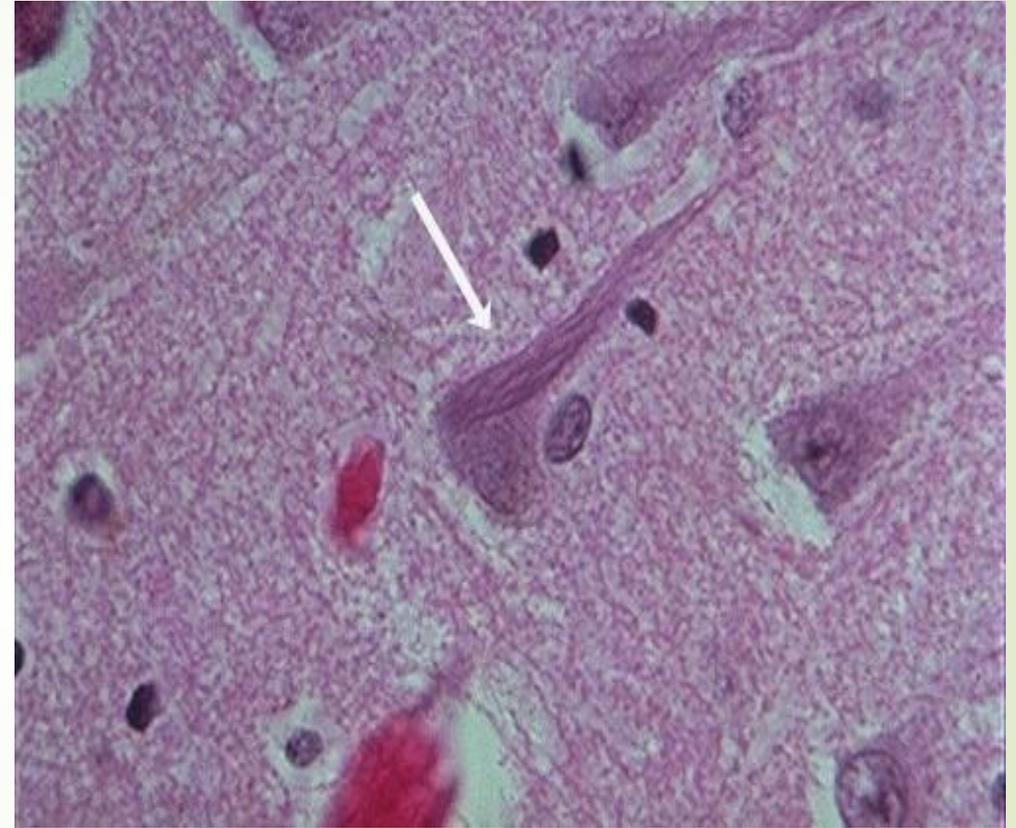
Alzheimer Disease (AD):

- AD is the most common neurodegenerative disease .
- The fundamental abnormality in AD is the accumulation of two proteins (**A β** and **tau**) in specific brain regions, likely as a result of excessive production and defective removal.
- **Morphology:**
 - **Grossly:** cerebral atrophy mainly in the frontal and parietal regions, characterized by narrowed gyri along with widened sulci.
 - Microscopically: The major microscopic abnormalities of AD are:
 - 1) **Neuritic plaques:** they are extracellular deposits of the amyloid beta-protein (A β)
 - 2) **Neurofibrillary tangles:** they are intracellular aggregates of the microtubule binding protein tau.
 - 3) **Clinically:** symptomatic course often running more than 10 years. Initial symptoms are forgetfulness and other memory disturbances; with progression, other symptoms emerge, including language deficits, loss of mathematical skills, and loss of learned motor skills. In the final stages, affected individuals may become incontinent, mute, and unable to walk.





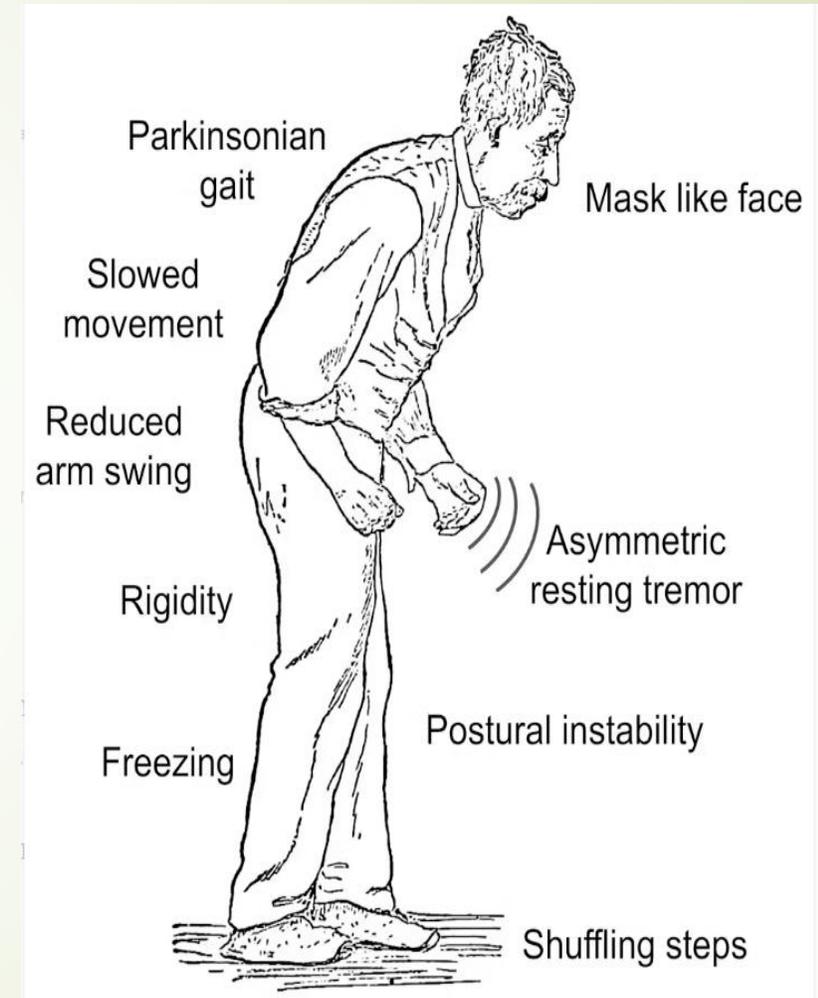
Silver stain of plaques



neurofibrillary tangle

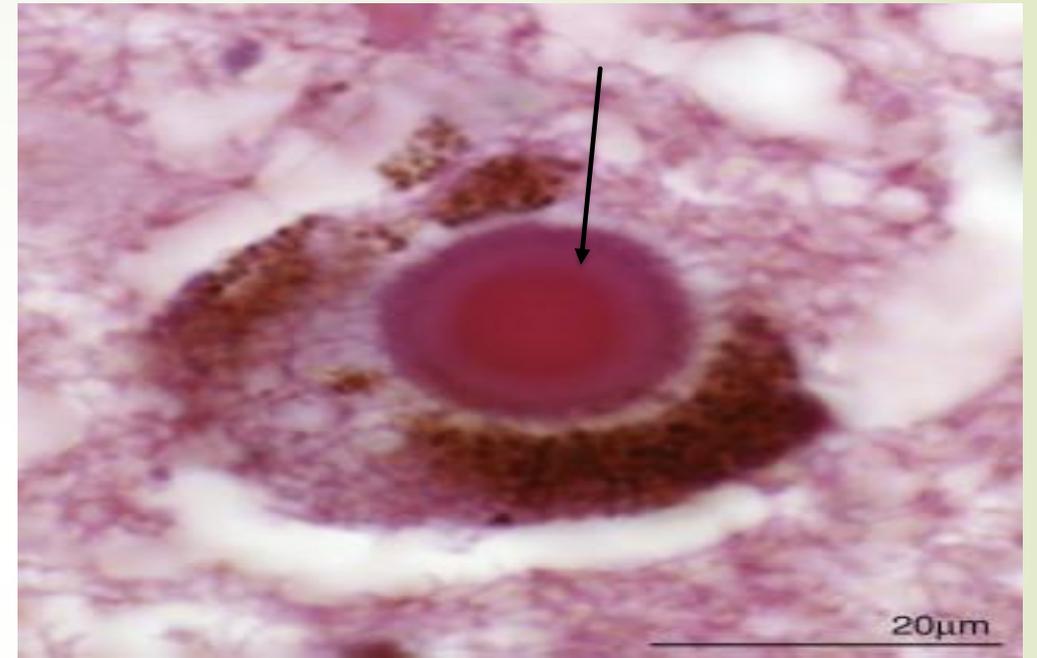
Parkinson disease (PD):

- The second most common neurodegenerative disease after Alzheimer's disease (AD)
- Mechanism: Loss of dopaminergic neurons from the substantia nigra.
- The pathological hallmark being intracellular aggregates of **α -synuclein**, in the form of Lewy bodies.
- Morphology:
 - Grossly: Loss of the darkly pigmented area in the substantia nigra. This pigmentation loss directly correlates with the death of dopaminergic (DA) neuromelanin-containing neurons
- Clinically: triad of parkinsonism (resting tremor, rigidity, and bradykinesia).





(A) Normal substantia nigra.
(B) Depigmented substantia nigra in Parkinson disease



Lewy body in a substantia nigra neuron, staining bright pink (arrow).

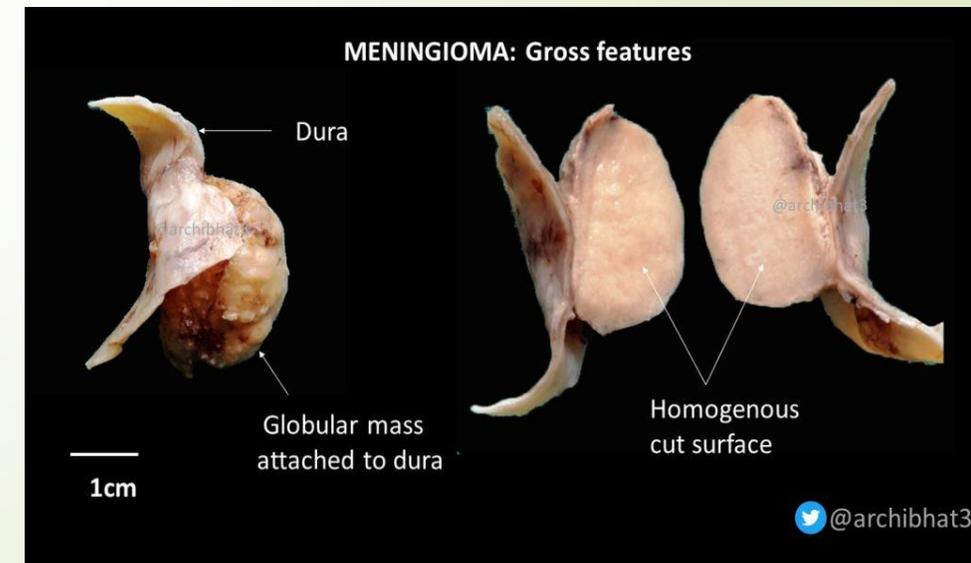
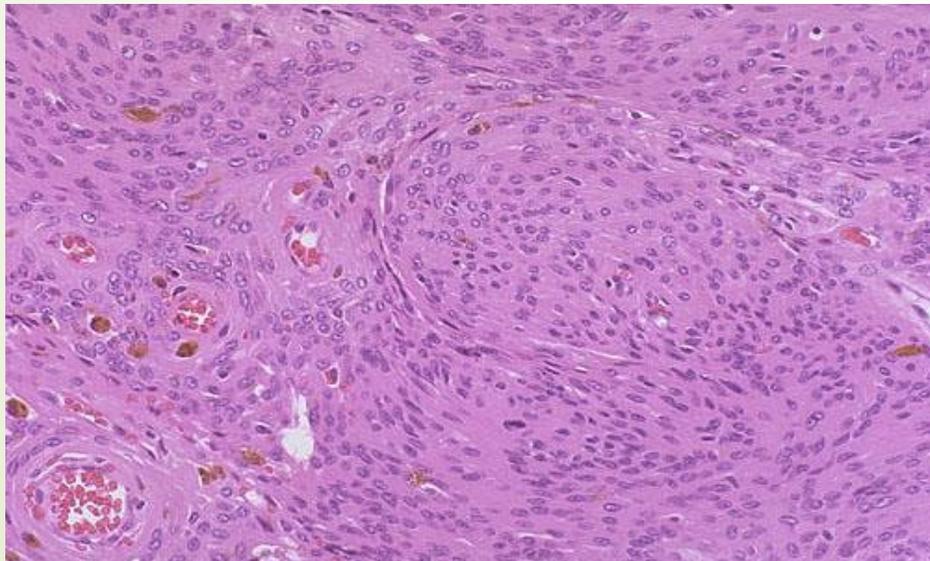
Tumors

Meningioma:

- ▶ Meningiomas are predominantly **benign** tumors of adults that arise from the **meningotheial cells of the arachnoid and are usually attached to the dura.**
- ▶ Site: **growing along external surface of brain, spinal cord or rarely, within the ventricular system**
- ▶ Clinically: common symptoms include headaches, seizures and focal neurological deficit due to tumor compression

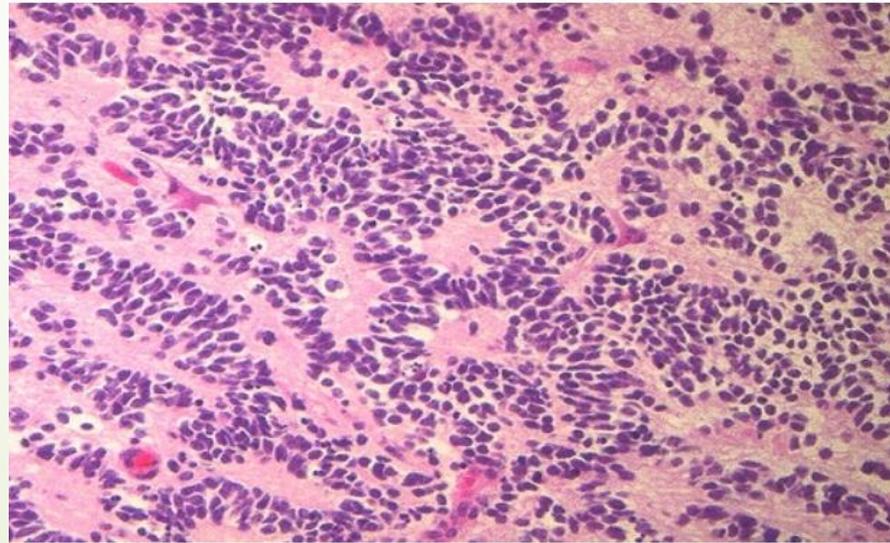


Microscopically: composed of whorled nests of cells. With rich vascularity

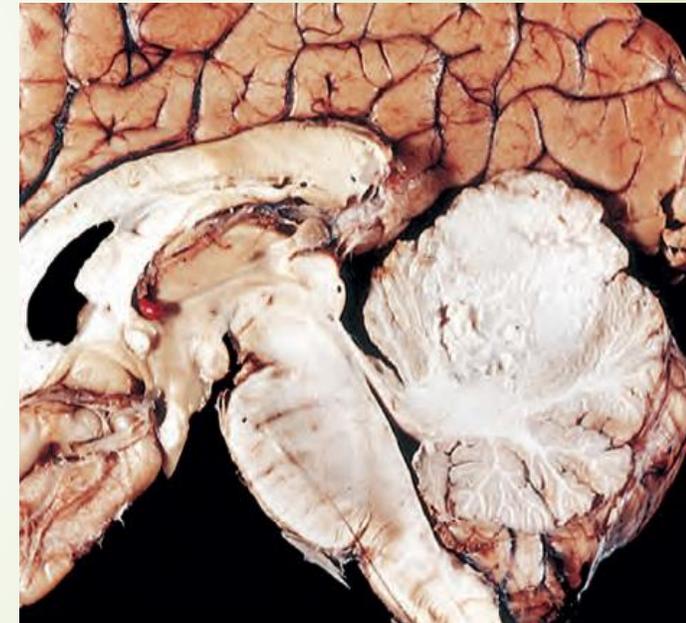


Medulloblastoma:

- This malignant embryonal tumor occurs predominantly in children and exclusively in the cerebellum (by definition).
- Clinically: Signs and symptoms of increased intracranial pressure (headache, nausea, vomiting)
- Microscopically: includes primitive appearing “small blue cells” that form sheets and Homer Wright-rosettes with central neuropil (pink material)
- **Medulloblastomas are highly malignant**, and the prognosis for untreated patients is dismal.



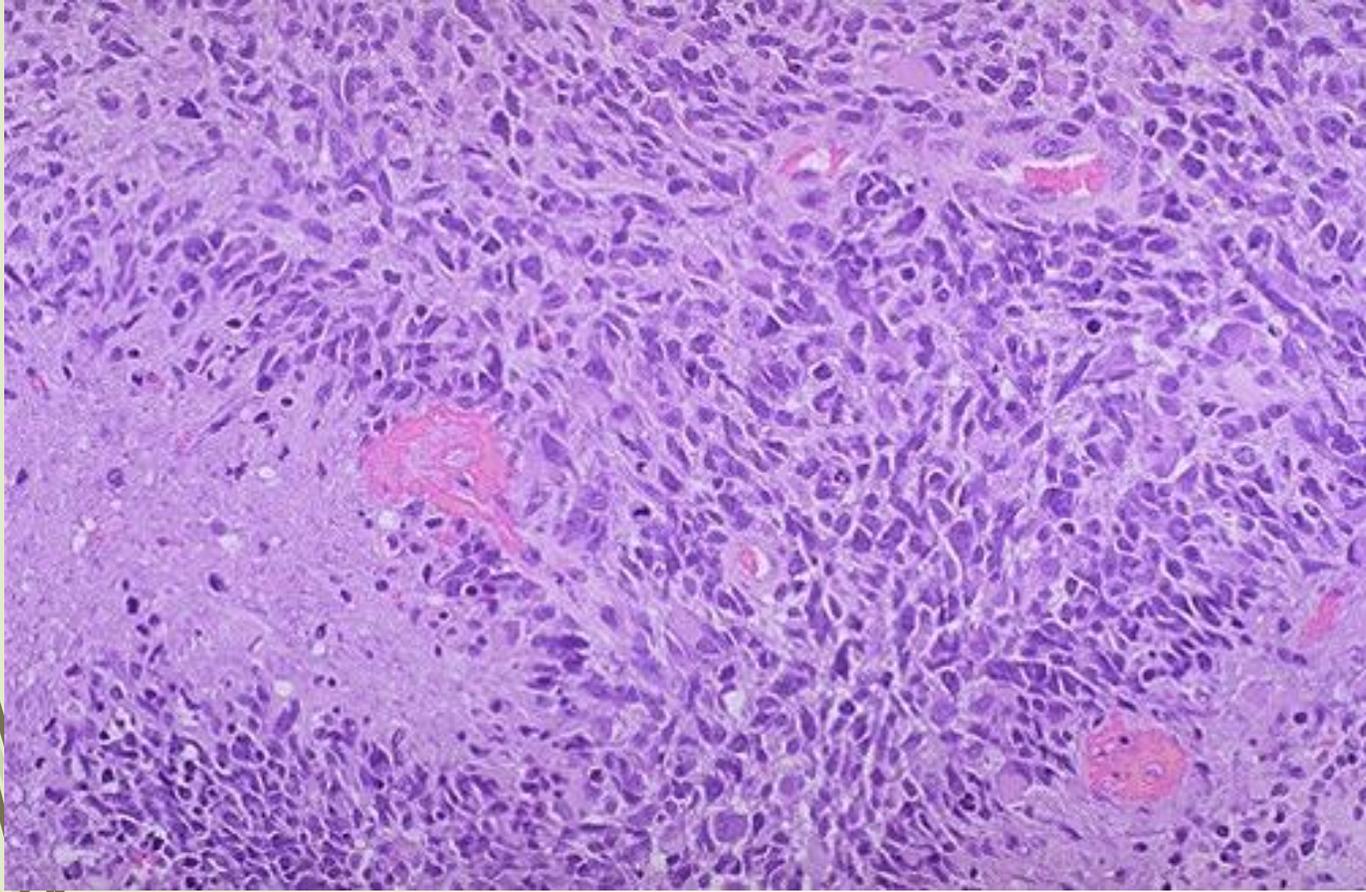
Embryonal,
meaning that
they appear
primitive or
undifferentiated,



Gliomas:

- ▶ The most common group of primary brain tumors with glial differentiation, include (astrocytomas, oligodendrogliomas, and ependymomas).
- ▶ Range in biologic aggressiveness from WHO grade 1 (benign) to WHO grade 4 (malignant)
- ▶ Simplified classification of adult type diffuse gliomas into 3 groups
 - Glioblastoma, IDH wildtype, WHO grade 4
 - Astrocytoma, IDH mutant, WHO grade 2 - 4
 - Oligodendroglioma, IDH mutant and 1p / 19q codeleted, WHO grade 2 – 3

- CNS WHO grade:
 - WHO grade 1: generally benign; potentially curable with resection
 - WHO grade 2 - 3: intermediate prognosis; survival generally many years with eventual tumor progression
 - WHO grade 4: malignant; survival limited to months
- Even low grade tumors can cause significant morbidity and mortality if located in delicate parts of the brain, such as the brainstem



Glioblastoma

- Marked cellularity, with marked hyperchromatism and pleomorphism.
- Prominent vascularity.



THANK YOU!