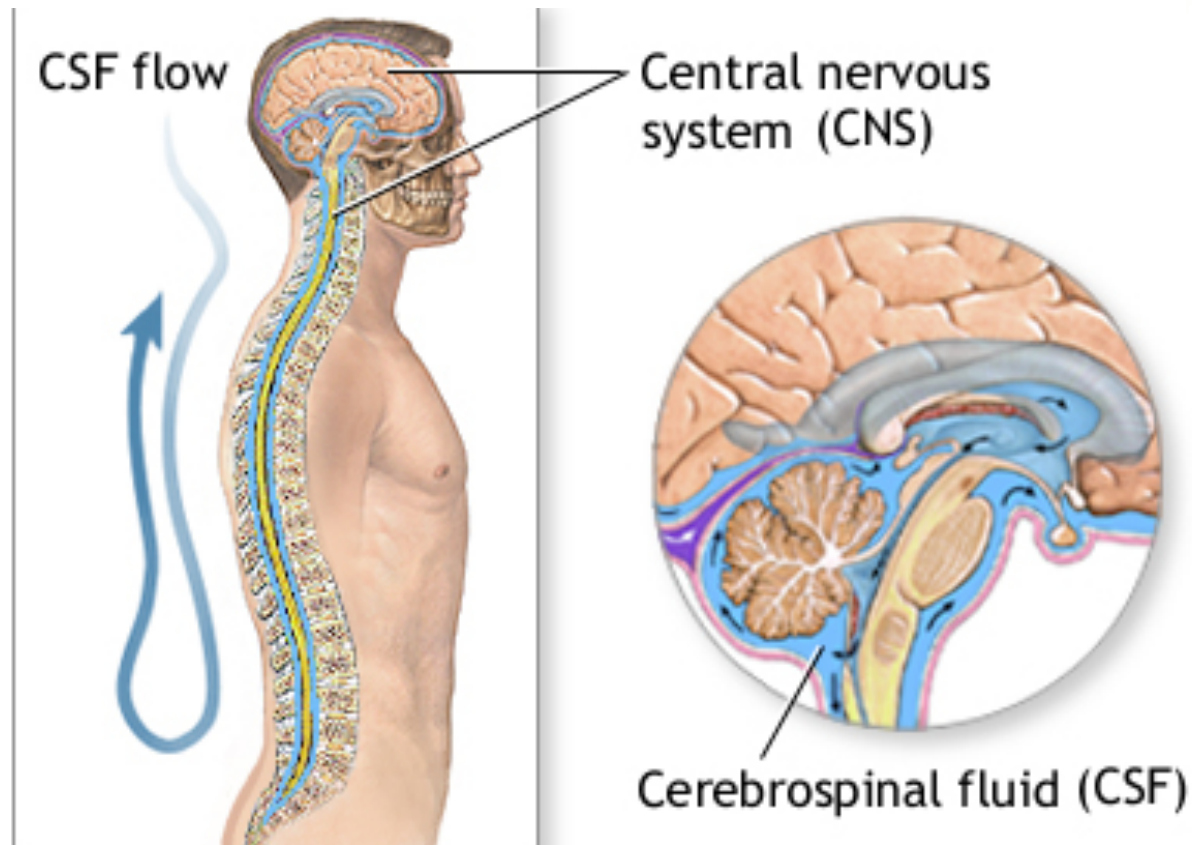


# 5<sup>th</sup> Lec. Body Fluid Analysis-II



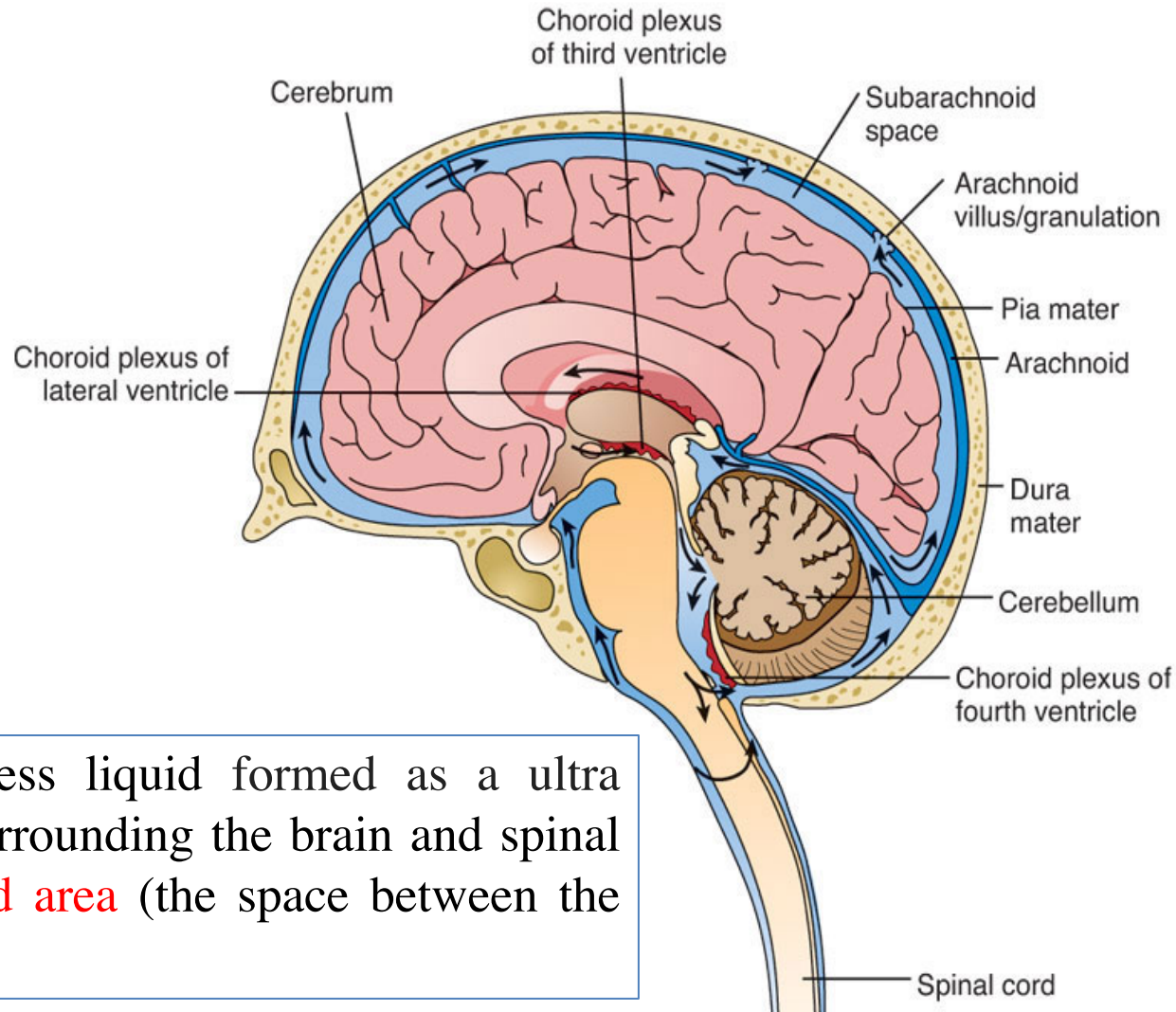
## Cerebrospinal Fluid Analysis (CSF)



By

**Asst Prof Dr. Hastyar Hama Rashid**

- CSF is composed of about 99% water and solutes.
- **Anatomy:** The brain and spinal cord are lined by the **meninges**, which consists of three layers: the **dura mater**, **arachnoid**, and **pia mater**.



**CSF definition::** The colorless liquid formed as a ultra filtrate of plasma, which is surrounding the brain and spinal cord. It flows in **subarachnoid area** (the space between the arachnoid & pia matter).

## **Mechanism of formation and circulation:**

1. Selective *ultrafiltration* of plasma.
2. Active secretion by epithelial membranes

## **FUNCTIONS OF CSF**

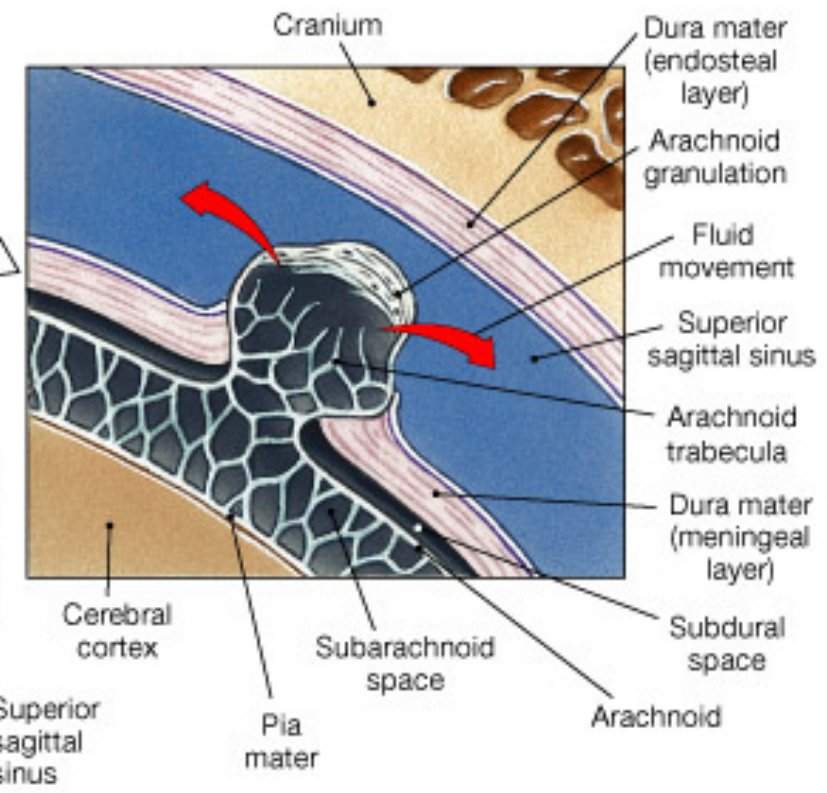
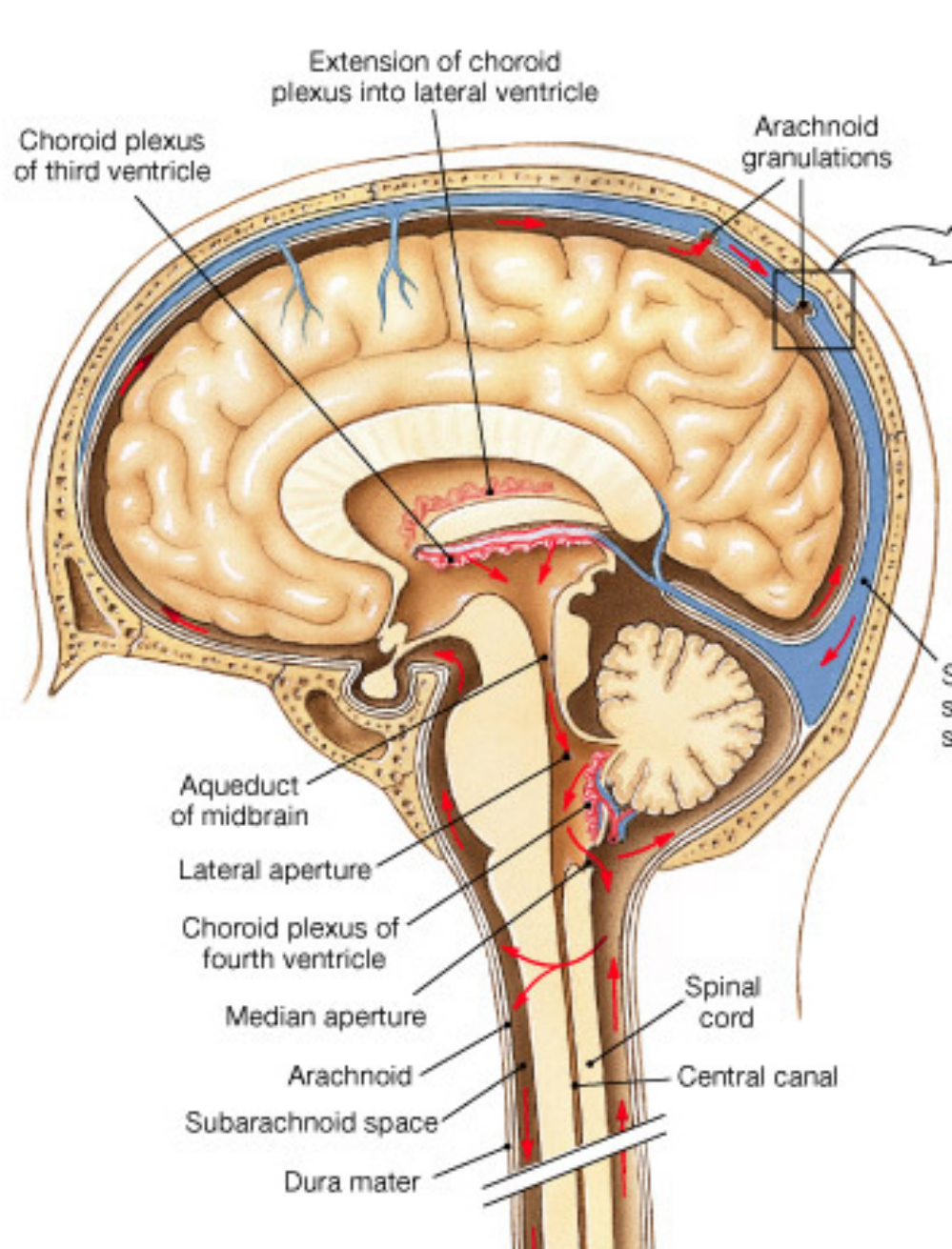
1. A shock absorber
2. A mechanical buffer or mechanical barrier
3. Act as cushion (pillow) between the brain and cranium
4. Act as a reservoir and regulates the contents and pressure of the cranium
5. Supplies nutrients to nervous tissues and removes metabolic wastes.
6. Transport hormones and hormone releasing factors such as amino acids, neurotransmitters.
7. provides a basic **mechanical** and **immunological** protection to the brain.

**Formation:** It is continuously being secreted by the **choroid plexus** at a constant rate inside the **ventricles of the brain** and circulates **in the subarachnoid space** of the brain and spinal cord through CSF pathways.

- CSF is produced at a rate of 0.2–0.7 mL per minute or 500–700 mL per day.
- Total volume in Adult: 90-150 mL
- Total volume in Neonate: 10-60 mL

### **Mechanism of excretion (absorption):**

- The circulating fluid is reabsorbed back into the blood capillaries in **the arachnoid granulations** at a rate equal to its production.
- Excretion volume = production volume → constant CSF volume



# Cerebrospinal Fluid (CSF)

- **Blood Brain Barrier (BBB)**
  - CSF composition is unlike blood? Because tight fitting endothelial cells that prevent filtration of larger molecules.
  - What are the importance of (BBB)?
    - Essential to protect the brain.
    - Blocks chemicals, harmful substances.
    - Antibodies and medications also blocked
    - Tests for those substances normally blocked can indicate level of disruption by diseases: ie **meningitis** and **multiple sclerosis**.

# Normal composition of CSF

<b>Appearance</b>	<b>Clear , Colorless</b>
<b>Lymphocytes</b>	<b>&lt;5/mm<sup>3</sup> Upto 30 in neonates</b>
<b>Polymorphs</b>	<b>Nil</b>
<b>pH</b>	<b>7.4</b>
<b>Total Volume</b>	<b>90 - 150 ml</b>
<b>Daily Secretion</b>	<b>500 - 700 ml</b>
<b>Specific Gravity</b>	<b>1.006 - 1.007</b>
<b>CSF Protein</b>	<b>15 – 45 mg/L</b>
<b>CSF Glucose</b>	<b>50 - 80 mg/dL 2/3 of plasma level)</b>
<b>CSF Lactate</b>	<b>1 - 3 mmol/L</b>
<b>Magnesium</b>	<b>1.2 - 1.5 mmol/L</b>
<b>Potassium</b>	<b>2.6 - 3.0 mmol/L</b>
<b>Chloride</b>	<b>115 - 130 mmol /L</b>
<b>Miroorganism</b>	<b>Should be zero</b>

- The composition of the CSF and its pressure is maintained relatively constant by various mechanisms. However in disease conditions the **composition and pressure of CSF can be altered**.
- CSF analysis usually consists of **biochemical analysis, cytology, biomarkers assay**, and **microbiological** evaluation. In some clinical conditions, lumbar puncture and drainage of can be a **therapeutic measure also**.
- **Under normal conditions**, the composition of CSF remains constant.
- **In Abnormal condition**: In various neurological disease especially in **acute conditions**, the composition, quantity and its pressure can be altered. By measuring the levels of various CSF components using relevant techniques, **diagnosis, severity and prognostication** of neurological conditions like **infections, subarachnoid hemorrhage, demyelinating conditions, tumor like conditions**, etc. can be done.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6707491/>



# Indications for lumbar puncture

## **A. Diagnostic:**

1. Central Nervous System (CNS) infections
2. Autoimmune CNS diseases like Guillain Barre syndrome
3. Malignant cells in metastasis

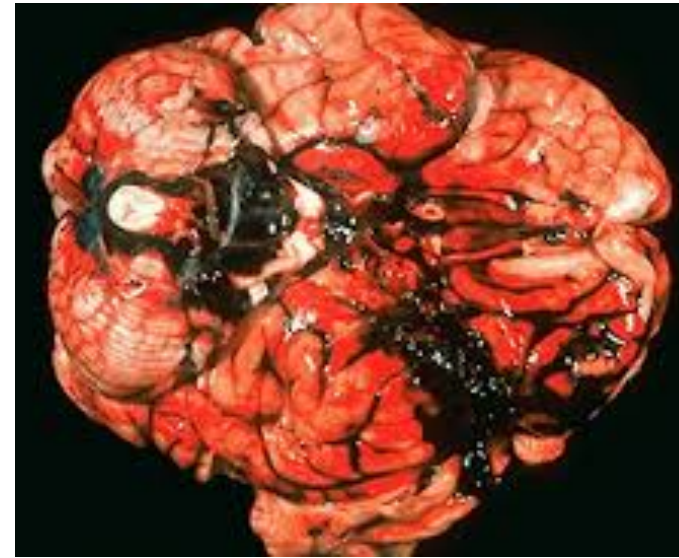
## **B. Therapeutic:**

1. Benign intracranial hypertension.
2. Acute communicating hydrocephalus
3. Cryptococcal meningitis in HIV infections
4. Delivery of antibiotics, antineoplastic drugs

# Indications of CSF analysis in Acute Brain and Spinal cord Conditions:

## 1. CSF in Subarachnoid Hemorrhage (SAH)

The causes for SAH can be due to rupture of intracranial aneurysms (balloon like), traumatic.



## 2. CSF Analysis in Meningitis/ Meningoencephalitis

Is one of the major indication for LP and CSF study. Meningitis can be community acquired or hospital acquired and caused by Various micro organisms ranging from **bacteria, virus, fungus, protozoa**, etc.

**Aseptic meningitis** is a condition that needs to be distinguished from other forms of meningitis that need a CSF analysis.

## Examples of Microorganisms

### Newborns

*Escherichia coli* & group B *Streptococci*.

### Children

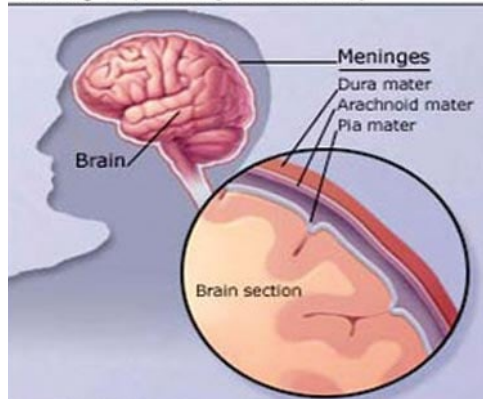
- *Streptococcus pneumoniae*
- *Hemophilus influenzae*
- *Neisseria meningitidis*

### Adults

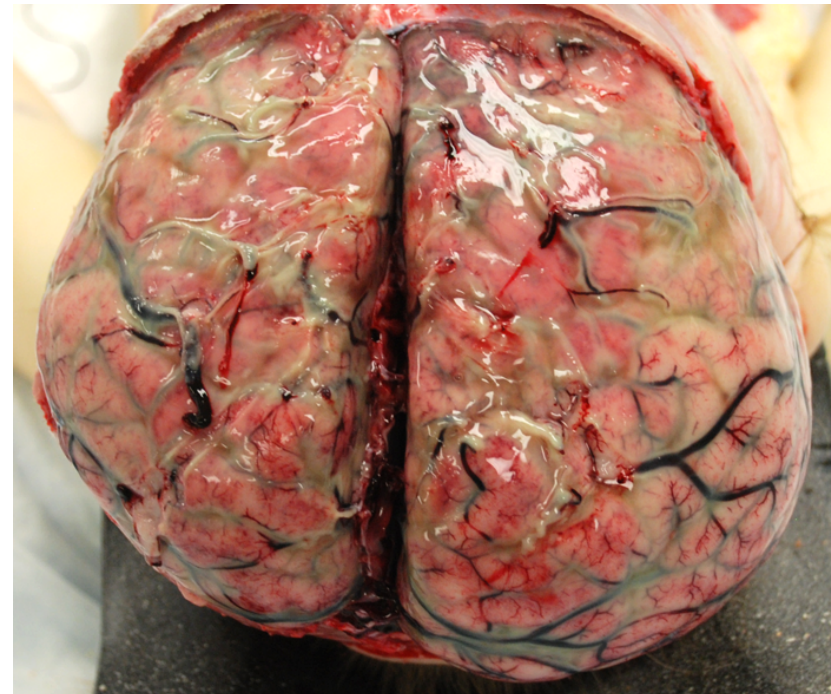
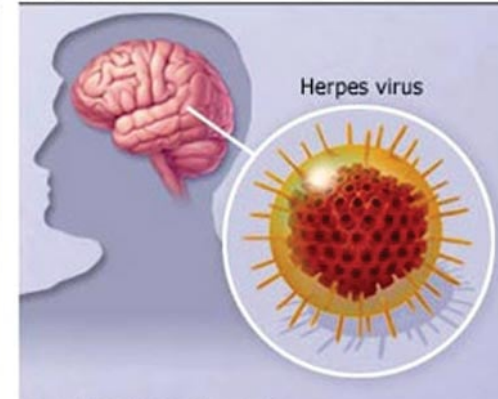
- *Neisseria meningitidis*
- *Streptococcus pneumoniae*
- *Staph. aureus* (if a shunt is present)
- Immunocompromised
  - *Cryptococcus neoformans*,
  - *Candida albicans*, *Coccidioides*, or  
– any opportunistic organism

## Meningitis and Encephalitis Differences

Meninges (Coverings of the Brain)



Encephalitis



## Bacterial meningitis

Neonates

- *E. coli*
- Group B strep
- *Listeria*

< 5 yr

- *N. meningitidis*  
(*H. influenzae*)

Young adult

- *N. meningitidis*

Older

- *S. pneumoniae*
- *Listeria*

Immunosuppressed

- *M. tuberculosis*
- *Cryptococcus*

Shunt

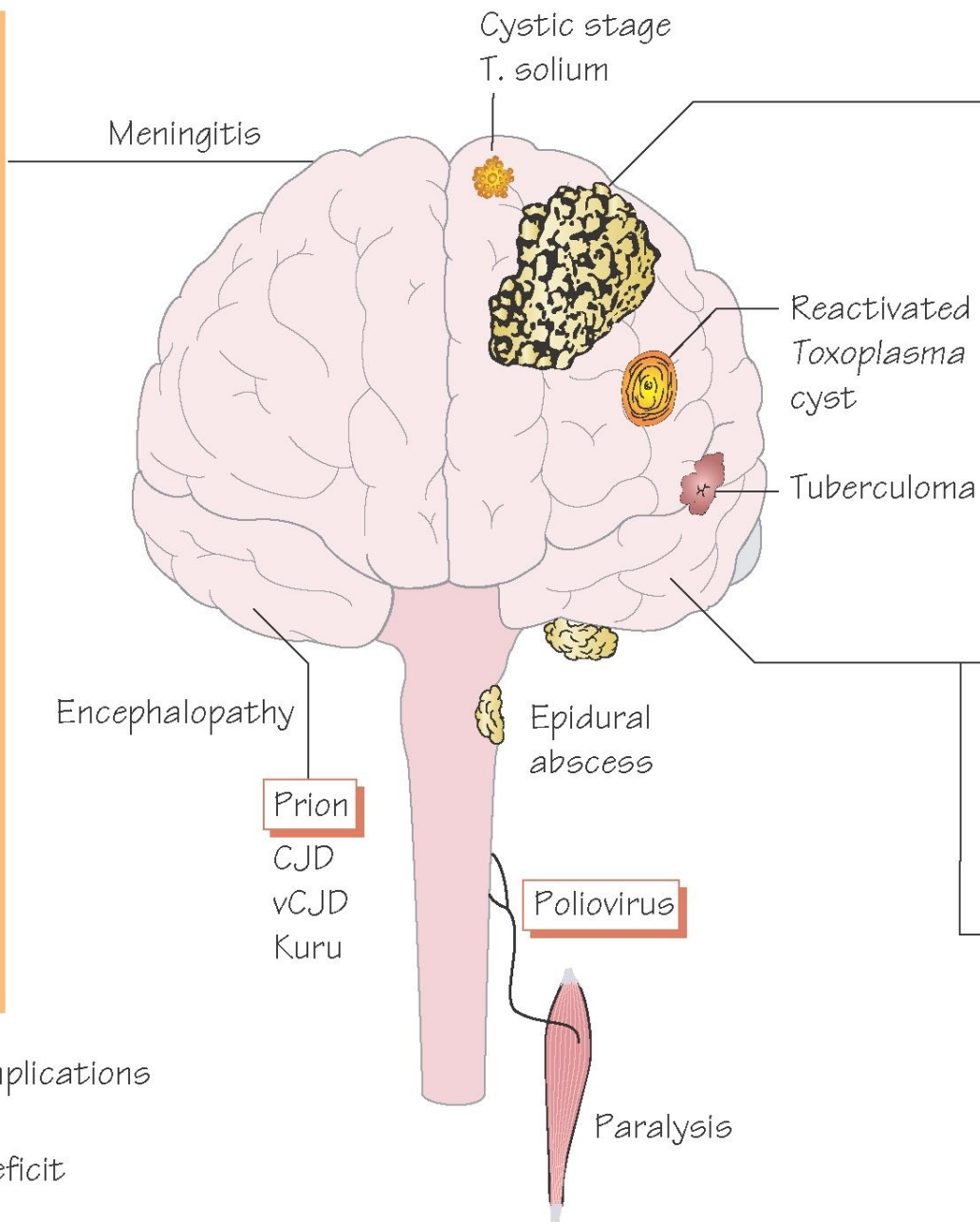
- Staphylococci

CSF findings

- Glucose low
- Protein raised
- Polymorphs raised

Bacterial meningitis complications

- Septicaemia
- Intellectual deficit
- Deafness
- Arthritis
- Skin necrosis



## Brain abscess

Route

- Haematogenous
- Local spread
- Foreign body

Organisms

- Anaerobic strep.
- *Bacteroides*
- Staphylococci
- Gram negatives

## Viral encephalitis

- Herpes simplex
- Arboviruses
- Mumps
- Measles

## Viral meningitis

- Enterovirus
- Mumps
- Herpes simplex
- Arboviruses

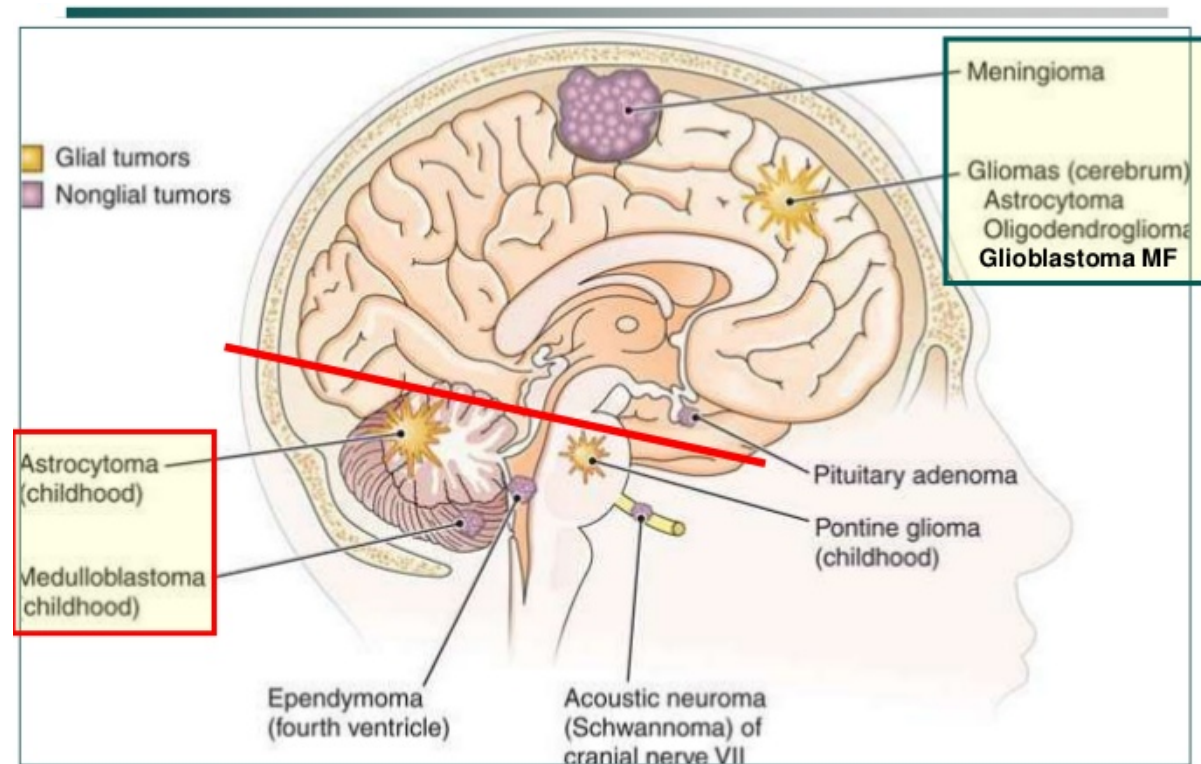
CSF findings

- Glucose normal
- Protein raised
- Lymphocytes raised

### 3. Brain and Spinal Cord Neoplasms

Neoplasms of CNS in which CSF analysis are helpful is usually due to primary CNS lymphoma.

Radiological investigations will help in making the diagnosis. However at times, it may be **difficult to distinguish between secondaries and primary tumors or infections** like abscess. A CSF analysis may help. After the initial CT scan brain or MRI, centrifuged CSF can be used for presence or absence of malignant cells and various tumor markers like colon, lung, prostate etc.



## Meningiomas

- Originate from meninges
- The most common tumor in adult
- Three categories:
  - benign (WHO grade I)
  - atypical (WHO grade II)
  - anaplastic (WHO grade III)



**Tumor mouse models:**  
Syngeneic models and  
GEMMs



**Xenografts:**  
CLX and PDOX



**Brain organoids:**  
PDO

## Gliomas

- Large family of brain tumors
- Two wide categories:
  - low-grade gliomas (LGG), WHO grade I and II
  - high-grade gliomas (HGG), WHO grade III and IV



**Tumor mouse models:**  
Syngeneic models and  
GEMMs



**Tumor like Drosophila  
models**



**Brain organoids:**  
PDO, GEBO, GLICO and  
Bioprinted



**Xenografts:**  
CLX, PDX and PDOX



**Tumor like Zebrafish  
models**

## Ependymomas

- Originate from brain or spinal cord
- Cell of origin: ependymal cell
- Four histological groups:
  - subependymomas (WHO grade I)
  - myxopapillary (WHO grade II)
  - classic (WHO grade II)
  - anaplastic (WHO grade III)



**Tumor mouse models:**  
GEMMs



**Xenografts:**  
PDOX

## Medulloblastomas

- The most common pediatric brain tumors
- Originate from cerebellum
- Four molecular subgroups:
  - WNT, SHH, Group 3 and Group 4



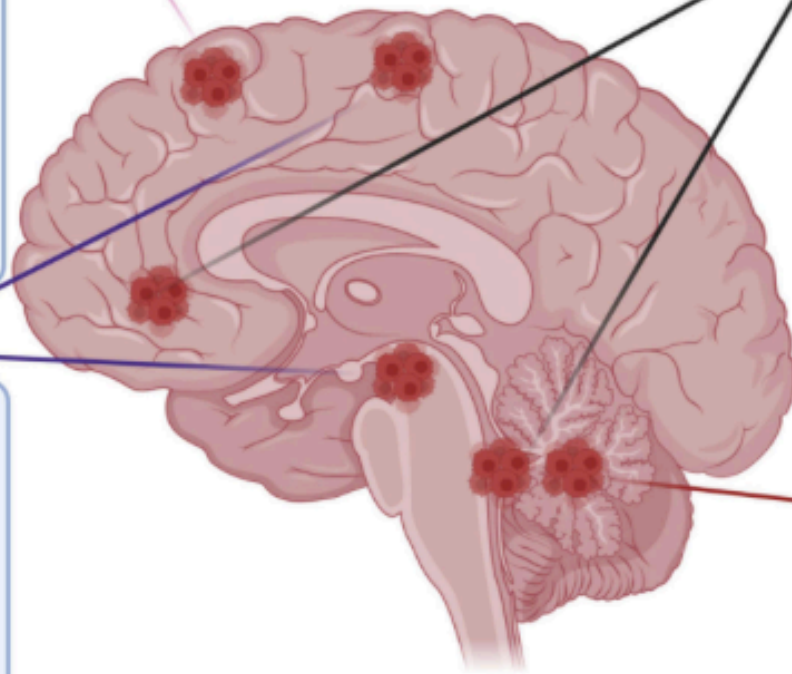
**Tumor mouse models:**  
GEMMs



**Brain Organoids:**  
cerebellar organoids

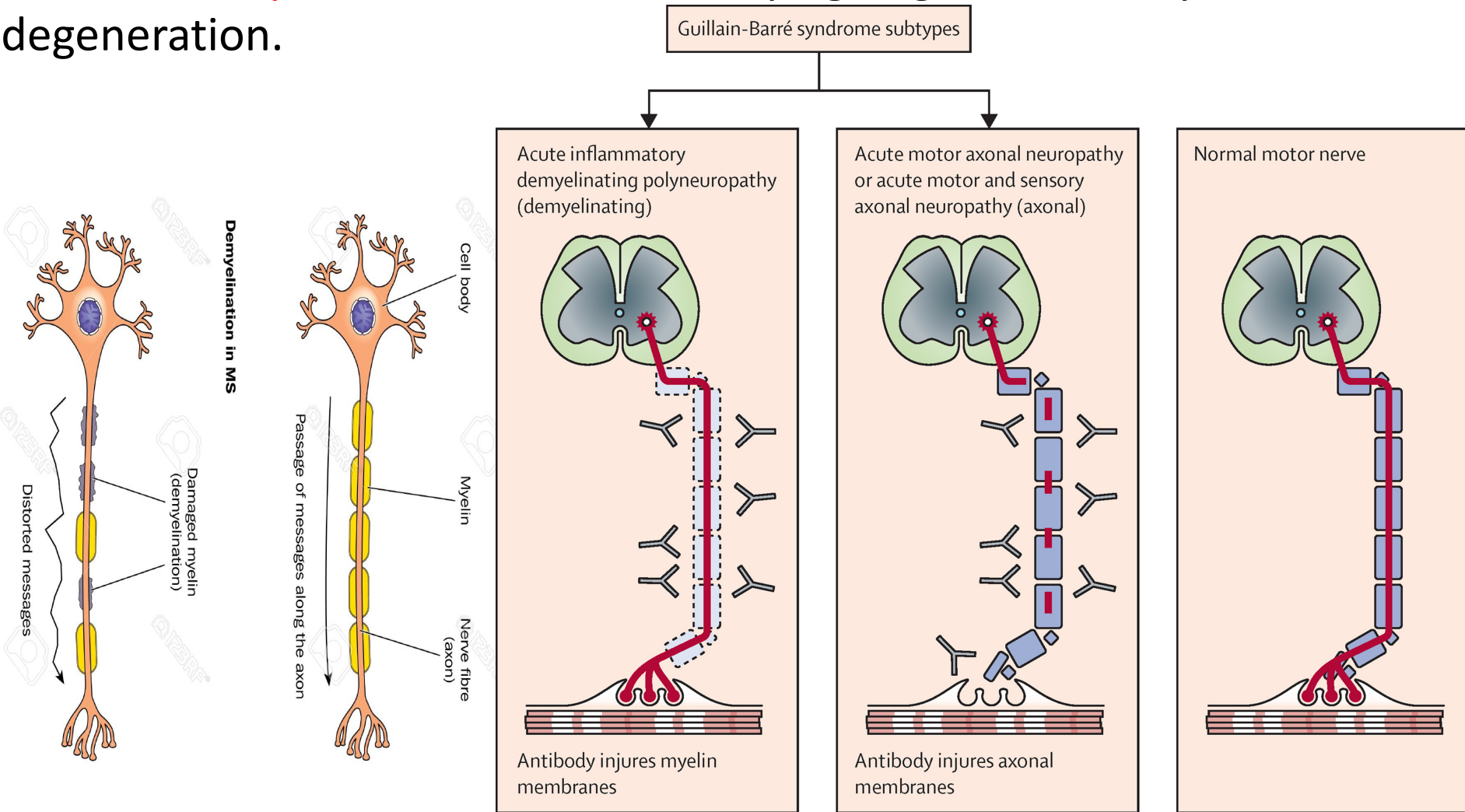


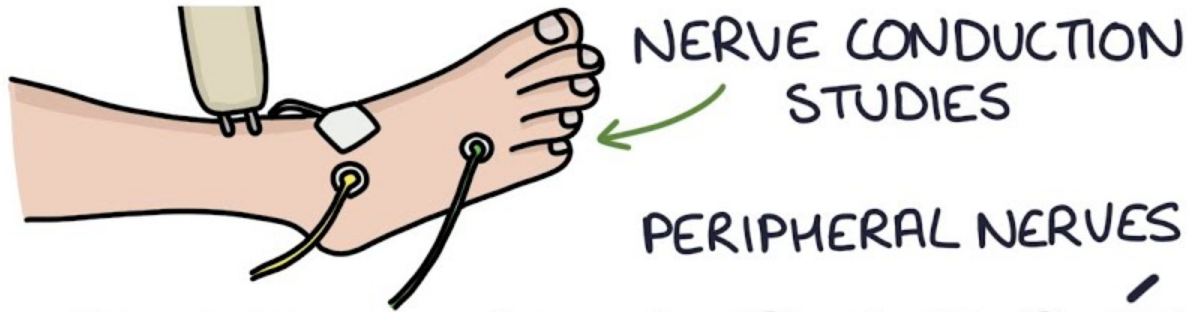
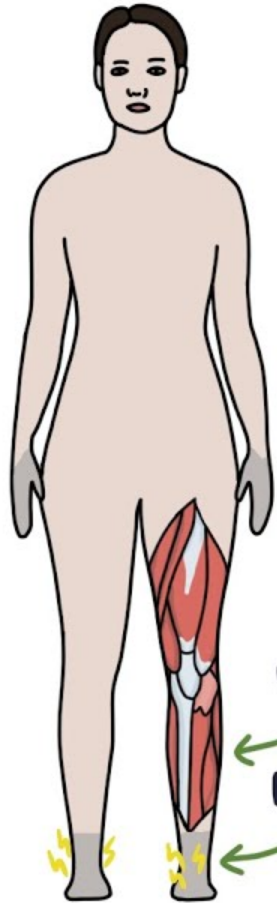
**Xenografts:**  
CLX and PDOX



# 4. CSF Analysis in Acute Demyelinating/Autoimmune Diseases:

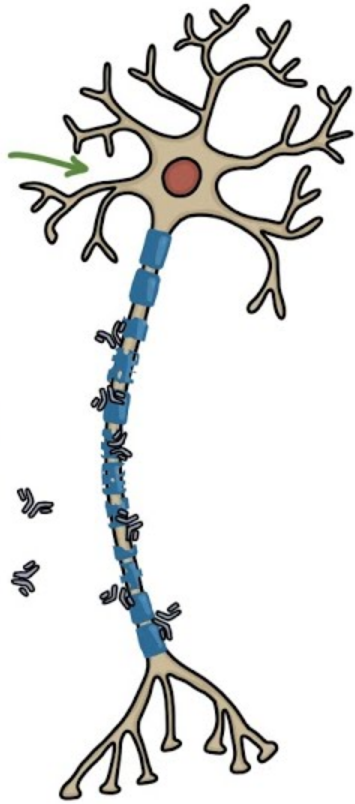
The demyelinating diseases include **multiple sclerosis**, **acute disseminated encephalomyelitis**, and **neuromyelitis optica (NMO)**. The autoimmune diseases such as **Guillain-Barré syndrome (GBS)**, **Transverse myelitis** can also cause varying degrees of demyelination and degeneration.





PERIPHERAL NERVES

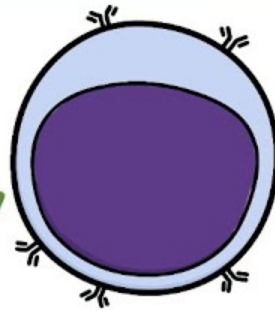
# GUILLAIN-BARRÉ SYNDROME



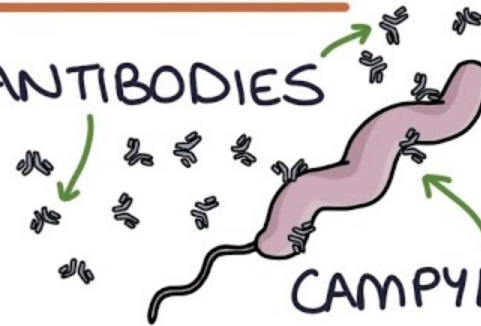
WEAKNESS

NEUROPATHY

B-CELLS



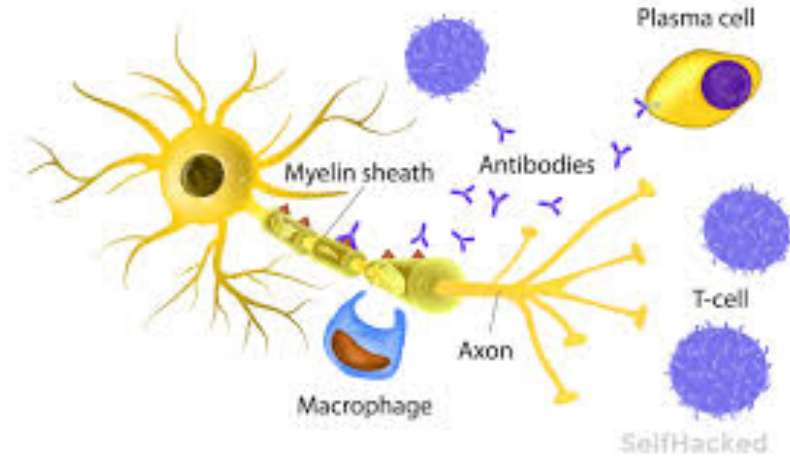
ANTIBODIES



CAMPYLOBACTER



# Autoimmune Attacks on Myelins



## Main symptoms of Multiple Sclerosis

