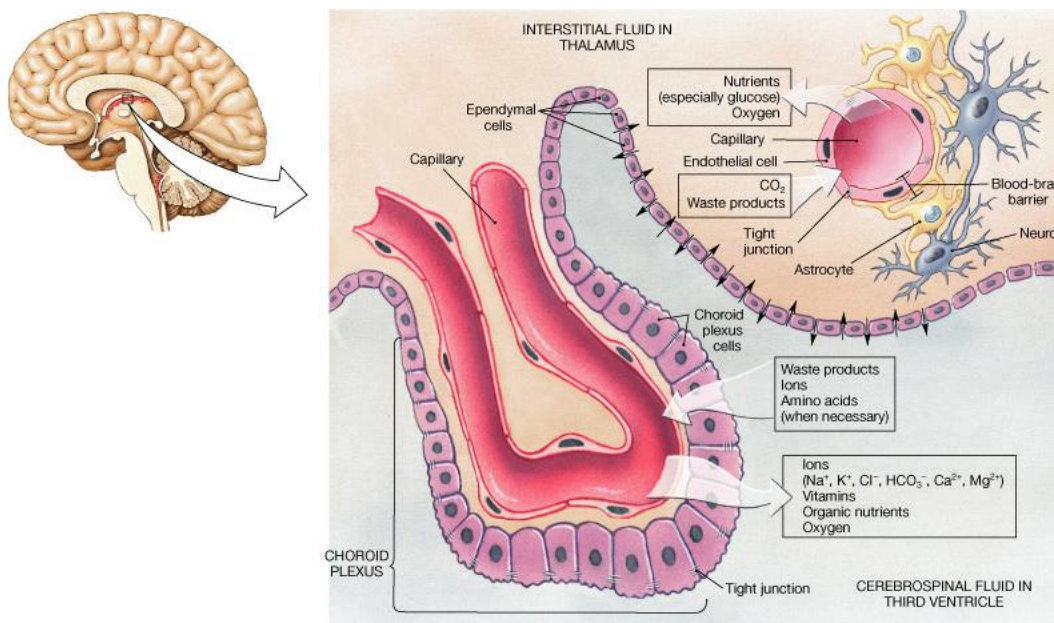


## Lab #5

### CSF production:

- CSF is produced by the choroid plexus (modified capillary).
  - Ventricles are lined by columnar epithelium-like cells called ependymal cells.
  - These ependymal cells and the capillaries (endothelium covered by basal lamina) form what is so called the choroid plexus.
  - Ependymal cells are the main players in producing CSF because they have a transport mechanism (from the capillaries to CSF and vice versa).
  - A comparison between the concentrations of some elements in the CSF and their concentrations in the blood are mentioned in the hand out.
  - CSF is in equilibrium with the interstitial fluid of the brain (this interstitial fluid is produced by the capillaries that form the blood brain barrier)
    - CSF and interstitial fluid are separated by the pia mater that does not interfere with this equilibrium.
  - Choroid plexus is absent in the posterior horn of the lateral ventricle (because it is narrow) and in the anterior horn of the lateral ventricle (to avoid obstructing the inter-ventricular foramen).
    - But it is present in the body and the inferior horn of the lateral ventricle and in the fourth ventricle.
  - CSF does not have direct contact with neurons because they are separated by Pia mater.



## Blood Brain Barrier (BBB):

- Is a capillary with reduced permeability (prevents large molecules from reaching the brain).
- Factors that reduce its permeability:
  - Tight junctions between the endothelial cells.
  - Very thick basal lamina.
  - These capillaries are covered by processes from the neighboring astrocytes.
- BBB is absent in some regions of the brain.
  - BBB absence does not mean that there are no capillaries in that region. It means that the capillaries in that region are more permeable (have less tight junctions, a thinner basal lamina, and are covered by fewer astrocyte processes).
  - These "leaky" capillaries have developed in regions of the brain that have to be in direct contact with the blood components.
  - Some of these regions:
    - Hypothalamus:
      - The hypothalamus is responsible for the regulation of the osmolarity. So, it has to be in direct contact with the blood to determine its osmolarity.
    - Area postrema (present in the posterior part of the medulla):
      - Induce vomiting if any toxins in the blood are detected.
    - Posterior pituitary.
- Premature babies have a higher tendency to develop neurological problems.
  - After birth there's an event of physiological lyses of RBCs that produces large amounts of bilirubin which circulates in the blood (physiological jaundice). In the premature babies BBB is immature, this will allow bilirubin to accumulate in brain (kernicterus).
    - Kernicterus: bilirubin-induced brain dysfunction.

## CSF drainage:

- CSF volume = 150 ml.
  - Secreted and drained 5 times each day.
  - If the volume of the CSF decreases, this will disturb the balance of the brain. Thus, the brain will stretch the meninges causing severe headache.
    - Remember, brain substance is insensitive to pain (headache results from stretching meninges, bone or blood vessels).
- From openings in the dura mater of the superior sagittal sinus, the arachnoid mater projects as finger-like projections (arachnoid villi) into the venous blood in the sinus.
  - A group of arachnoid Villi are called arachnoid granulation.
- Arachnoid granulation acts as unidirectional valve that allows CSF drainage from a high pressure system (subarachnoid space) to a low pressure system (venous system).
  - Increased venous pressure will interfere with CSF drainage process.

## Hydrocephalus:

- Abnormal accumulation of CSF in the ventricles of the brain.
  - Compresses the brain tissue over the skull leading to its damage.
  - In children, this condition will lead to progressive enlargement of the skull because the sutures of the skull have not fused yet.
- Causes:
  - Obstruction to the flow.
    - Stenosis of the interventricular foramen or the cerebral aqueduct.
  - Increased production of CSF.
  - Obstruction to the drainage.
- Treated by a shunt from the ventricles to the heart or the superior vena cava to prevent further increment in the intracranial pressure.

## Subarachnoid cisterns:

- Are dilatations of the subarachnoid space.
- Some major arachnoid cisterns:
  - Pontine cistern (anterior to the pons).
  - Cerebelleromedullary cistern (cisterna magna).
  - Interpeduncular cistern (anterior to the midbrain).
- They have a diagnostic importance.
  - If we noticed that their size is smaller than normal; that indicates the presence of a tumor compressing them.
- They used to sample CSF through the cistern puncture (to the cisterna magna). This is a dangerous procedure (could damage the cerebellum) and it has been totally replaced by the lumbar puncture.

## CSF cycle:

1. CSF is secreted from the two lateral ventricles.
2. Drained to the 3<sup>rd</sup> ventricle through the inter-ventricular foramina.
3. Drained to the 4<sup>th</sup> ventricle through cerebral aqueduct (the 4<sup>th</sup> ventricle receives the drained CSF and secretes it too).
4. Drained to the infra-tentorial subarachnoid space through 3 apertures in the roof of the forth ventricle:
  - Central aperture of magendie.
  - 2 lateral apertures of luschka.
5. CSF is pushed from the infra-tentorial subarachnoid space to the supra-tentorial subarachnoid space (to reach the superior sagittal sinus) using the arterial pulsation as a driving force.
  - CSF in the spinal subarachnoid space is pushed up using the vertebral movements as a driving force.

- Infra-tentorial space is narrower than the supra-tentorial space. So, tumors that arise from the infra-tentorial space raise the intracranial pressure earlier than those that arise in the supra-tentorial space.

## CSF and the eye:

- Sometimes, the optic nerve (that's going to supply the retina of the eye) is called the optic tract because it's covered by the 3 layers of meninges. Also, there's a subarachnoid space filled with CSF.
- Central artery and vein (that are going to supply the retina) pass through the dura, arachnoid and pia mater of the optic nerve and enter the substance of the optic nerve. After reaching the retina, within the substance of the optic nerve, through the optic disc, the central artery and vein start giving branches to supply the retina.
  - Obstruction of the central artery leads to sudden blindness.
- Increased intracranial pressure will collapse the central **vein** as it passes through the subarachnoid space to reach the substance of the optic nerve.
  - This collapse will lead to edema in the retina (papilledema); in the head of the optic nerve specifically.
  - We diagnose papilledema through a fundus examination using ophthalmoscope (requires pupil dilatation).
    - Normally, the optic disc appears pink.
    - In papilledema:
      - Optic disc elevation.
      - Venous engorgement.
- Optic disc depression is caused by optic nerve atrophy.
- The retina:
  - Is divided into temporal (lateral) part and nasal (medial) part.
  - Photoreceptors are cones and rods.
  - The optic disc (where the optic nerve and central vessels enter the retina) lack photoreceptors; it's called the blind spot.
- Photoreceptors are increased in an area of the retina called macula lutea.
  - In the center of the macula there's the fovea centralis (has the highest concentration of cones). Responsible for:
    - Sharp central vision.
    - Details of colored vision.
  - If the image is felt on different areas of the retinas, this will lead to double vision.
    - Caused by unconjugate movements of the eyes.
      - Multiple sclerosis damage to the Medial longitudinal fasciculus (MLF) will lead to unconjugate eye movements.

- Foster-Kennedy Syndrome:
  - A tumor that increases the intracranial pressure and compresses the optic nerve of one eye.
  - Manifestations:
    - Depression in the optic disc of the eye so that its optic nerve has been compressed (optic nerve atrophy).
    - Elevation of the optic disc in the other eye (papilledema).

### **Meningitis:**

- May cause stenosis of the cerebral aqueduct or the interventricular foramen leading to hydrocephalus.
- Could damage nerves that are responsible for vision or hearing.
- May induce inflammation in region of the cortex which will become fibrotic (irritant focus leading to epilepsy).
- Neck stiffness.

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