ANTOMY LAB 5

Cerebrospinal Fluid

This sheet is a pure-lab-handout-sheet.

❖ the choroid plexus

- Synthesis of CSF occurs there.
- It's the **barrier** between the cerebral capillary blood and the CSF, HOW?

> Remember that the skull bone is lined by dura matter → then subarachnoid → then Pia mater → then the brain tissue.
> Between the subarachnoid and the Pia matter there's CSF in the subarachnoid space.

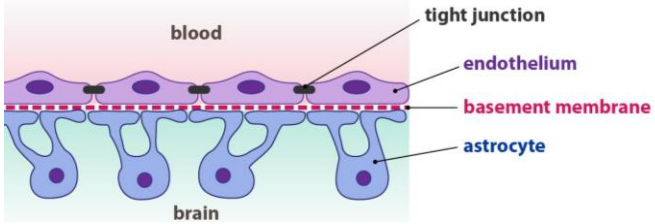
- The choroid plexus is simply a **modified capillary**, composed of 3 layers:
  1. capillary endothelial cells and basement membrane (like any capillary)
  2. neuroglial membrane
  3. epithelial cells of choroid plexus ;
     (these epithelial cells resample epithelial cells of renal distal tubules and contain transport mechanisms that move solutes and fluid from capillary blood into CSF)

❖ the Blood Brain Barrier (BBB)

The barrier between **cerebral capillary blood** and **interstitial fluid** of the brain.
The BBB is also a **modified capillary**, composed of:

1. capillary endothelial cells (with **tight junction**) and basement membrane
2. neuroglial membrane
3. Glial end feet **(projections of astrocytes from the brain side of the barrier)**
   **notice how both bloody and brainy components contribute in the barrier formation. العزل من الطرفين

No epithelial cells in BBB



> The BBB is a very special barrier that FUNCTIONALLLY differs in two ways from the analogous barrier in other tissues:
>
> 1. The junctions between endothelial cells in the brain are so "**tight**" that few substances can cross between the cells.
> 2. Only a few substances can pass through the endothelial cells:
>   - Lipid-soluble substances (e.g., oxygen and carbon dioxide) can cross the blood-brain barrier, but water-soluble substances are excluded.

Formation of the CSF

- **CSF** is formed by the **epithelial cells** of the choroid plexus.
- Transport mechanisms in these cells **secrete some substances** from blood into CSF and **absorb** other substances from CSF into blood. (this is mediated by epithelial cells of the choroid plexus) تبادل المواد المختلفة بالاتجاهين
- Molecules such as **protein and cholesterol** are **excluded** from CSF because of their **large molecular size**. " cannot pass through the choroid plexus"
- **Lipid-soluble** substances such as oxygen and carbon dioxide **move freely** and equilibrate between the two compartments (both the CSF and the blood have equal amount of O2 , CO2 .. lipid soluble substances).

  (remember the BBB has the same selectivity toward these substances)

  **BUT are all substances (molecules, Ions, etc.) present at same concentration At both the CSF and the cerebral blood?

  It depends:

  Depending on the **transport mechanisms** and the **characteristics of the barrier**, some substances are present in higher concentration in CSF than in blood; some are present at approximately the same. Concentration and some are present in lower concentration in CSF than in blood.

  look at this table which compares the composition of CSF and blood

[CSF] ≈ [Blood]	[CSF] < [Blood]	[CSF] > [Blood]
Na^+	K^+	Mg^{2+}
Cl^-	Ca^{2+}	Creatinine
HCO_3^-	Glucose	
Osmolarity	Cholesterol*	
	Protein*	

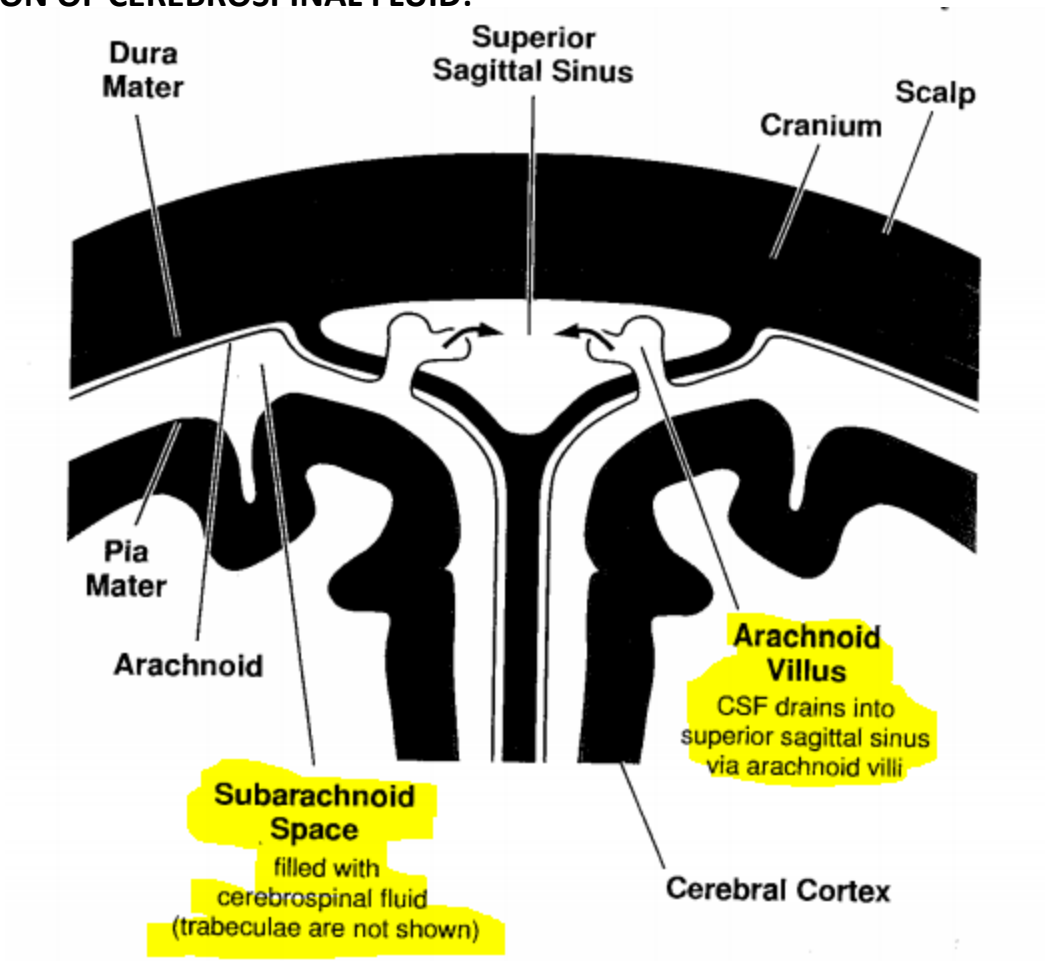
* Negligible in CSF.

The first column list the ions that are equally distributed at both compartment, the second column list the ions that are present less at the CSF (notice how large substances like cholesterol & proteins are negligible),the 3rd column for substances present more at the CSF.

What about the CSF and the interstitial fluid?

- Many substances readily exchange between brain interstitial fluid and CSF, thus the compositions of interstitial fluid and CSF are similar to each other but different from blood (as the above mentioned table).

❖ **ABSORPTION OF CEREBROSPINAL FLUID:**



- The cerebrospinal fluid is absorbed into the **arachnoid villi** which are a projection into the dural venous sinuses, especially the superior sagittal sinus, look at the figure.
  ****Notice how the villi are nothing but a projection of the subarachnoid space which contains CSF, so when there's too many CSF it simply drained into the venous blood via this projection (or connection).**

  But things couldn't be that simple at the CNS system , continue reading:
- The arachnoid villi are grouped together to form **arachnoid granulations**.
  (بكونوا كل واحد لحال بس يتجمعوا مع بعض بعمله هذا الكائن)

- Each arachnoid villus is a diverticulum of the subarachnoid space that pierces the dura

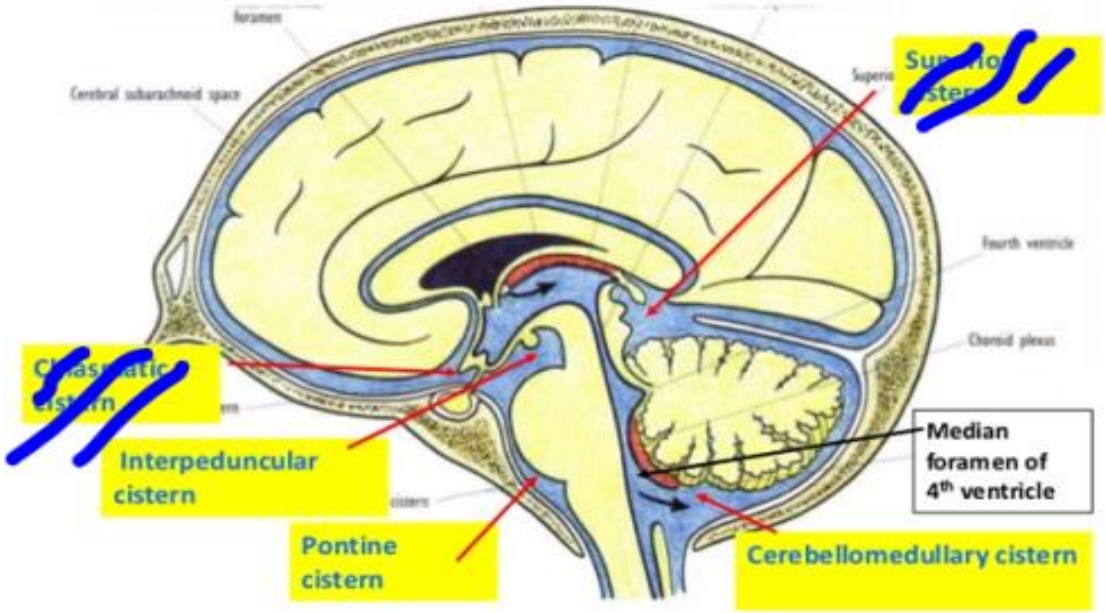
- Absorption of cerebrospinal fluid into the venous sinuses occurs when the cerebrospinal fluid pressure exceeds that in the sinus.
  it's the overproduction of the CSF that drive the CSF increment of pressure → then drive its movement into the blood which has lower pressure (remember things move from high to low pressure PASSIVELY)

Why is it the CSF that moves via the villi? , why don't the blood use the villi to get access to the CSF ? , if it's about the pressure gradient → could a hypertensive patient have a leakage of blood via the villi??

- Studies of the arachnoid villi indicate that **fine tubules** lined with endothelium→ permit a direct flow of fluid from the subarachnoid space into the lumen of the venous sinuses.

> ❀ the venous Pressure rise and exceed the cerebrospinal fluid pressure → **compression of the villi closes the tubules and prevents the reflux of blood** into the subarachnoid space.
> **(One direction flow)**
> **Note: Some of the cerebrospinal fluid is absorbed directly into the veins in the subarachnoid space and escapes through the perineural lymph vessels of the cranial and spinal nerves.

Circulation of CSF in subarachnoid space :



Median sagittal section to show the subarachnoid cisterns & circulation of CSF

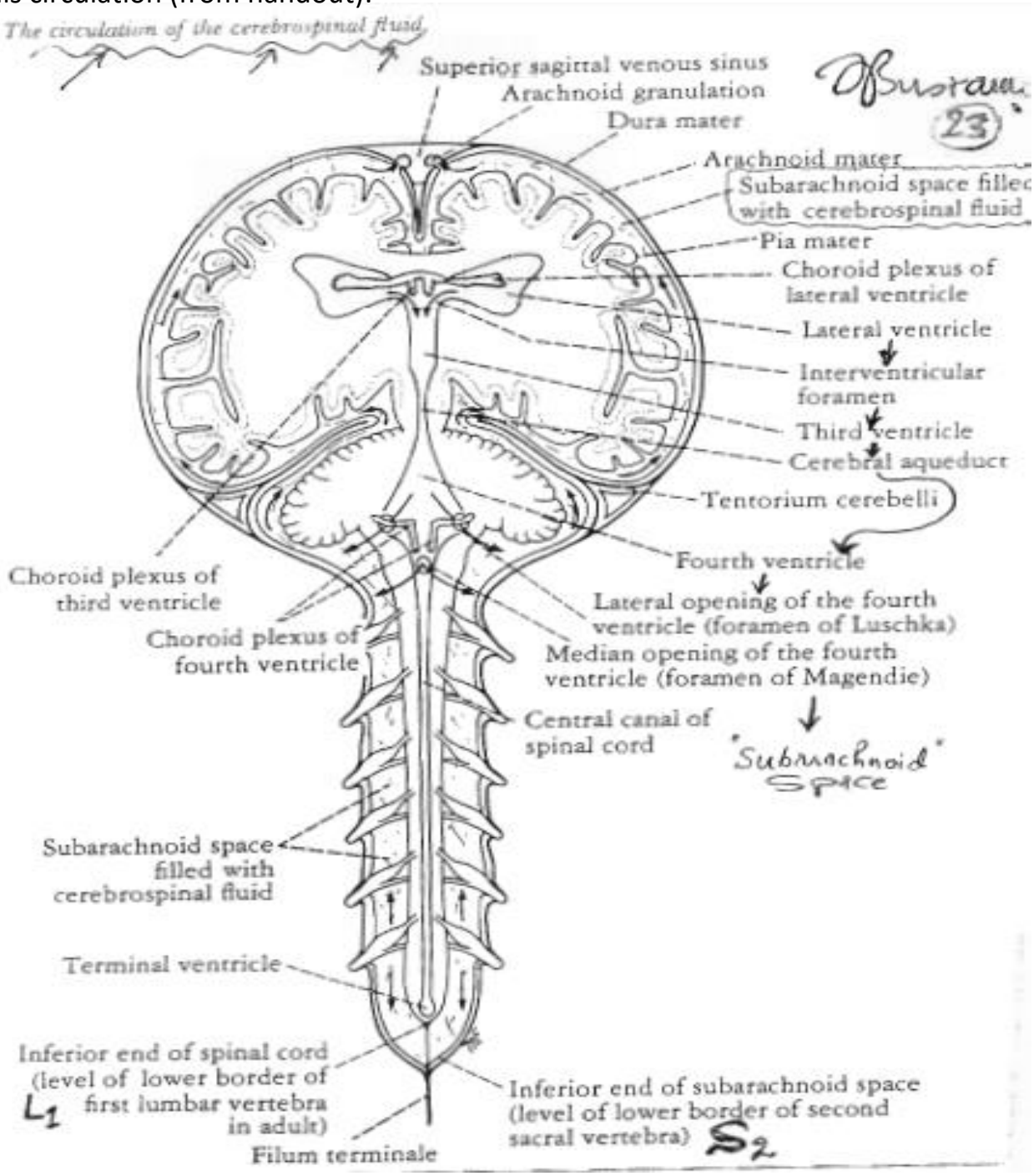
❖ **Subarachnoid Cisterns**.

- In certain locations around the base of the brain the arachnoid does not closely follow the surface of the brain they form the same curvature (as usual) so that the subarachnoid space expands to form cisterns. (like gaps or subarachnoid space expansions)
  Most important cisterns:- you can see them at the figure below

1. The **cerebellomedullary cistern**→ lies between the cerebellum and the medulla oblongata
2. The **pontine cistern** →lies on the anterior surface of the pons
3. The **interpeduncular cistern**→ lies on the anterior surface of the midbrain between the crus cerebri.

> ❀ Significance of these cisterns : In the past they used to **drain CSF** from them (if the lumbar puncture is difficult to preform , for any reason), they used to use the **cerebellomedullary cistern** as it's wide and can be easily approached , but it is a dangerous procedure as the medulla is its ant wall and it contain vital centers.

We have explained **the CSF circulation in previous labs, read the following to remind yourself with this circulation (from handout):



➔ The fluid passes from the **lateral ventricles** into the **third ventricle** through the **interventricular foramina** .It then passes into the **fourth ventricle** through the **cerebral aqueduct.** **The circulation is aided by the arterial pulsations of the choroid plexuses.** From the fourth ventricle, the fluid passes through the median aperture and the lateral foramina of the lateral recesses of the fourth ventricle and enters the subarachnoid space. The fluid then flows superiorly through the interval in the tentorium cerebelli to reach the inferior surface of the cerebrum it now moves superiorly over the lateral aspect of each cerebral hemisphere. Some of the cerebrospinal fluid moves inferiorly in the subarachnoid space around the spinal cord and cauda equina. **The pulsations of the cerebral and spinal arteries and the movements of the vertebral column facilitate this flow of fluid.**

❖ **Papilledema:** "was discussed briefly in lab 2"

- **Increased intracranial pressure** is reflected at the <u>optic nerve</u> as it's <u>surrounded by meninges</u> (dura, subarachnoid, pia) so it's like a continuation of the ventricles and spaces of the brain which contain CSF.
- the optic nerve reach the sclera and enter via the optic disc.
- The artery and veins of retina <u>cross through the meninges</u> of the optic nerve.
- In case of Increased intracranial pressure >> the **disc bulges** as the <u>retinal artery</u> and <u>vein</u> (which are passing through the meninges) **get congested**
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- This process take time (from few days – one week)
- Most commonly the increased intracranial pressure is caused by **tumors**,
  and most commonly **cerebellum tumor**, as it's infratentorial (the tentorium is semi-rigid so it cannot freely moved) and it forms the posterior surface of the 4th ventricle→ so when a cerebellar tumor arise → 4th ventricle is compressed → the CSF cannot be drained to subarachnoid space→ increase intracranial pressure→ papilledema.

- Also if a tumor arises at the <u>orbital surface</u> of the <u>frontal lobe</u> (part of frontal association area) the **ipsilateral optic nerve is compressed → atrophies** (<u>LMN lesion</u>).
  <u>But the contralateral eye will suffer from papilledema</u> → because by default the tumor increased the intracranial pressure.
  This is called **<u>foster Kennedy syndrome</u>.**
  Note : other signs of brain tumor are headache + vomiting
  - **Headache**: increased intracranial pressure will stretch the dura >> stretch the nerve endings → pain.
  - **Vomiting**: stimulation of vomiting centers at the brain stem, the Vagus nuclei...

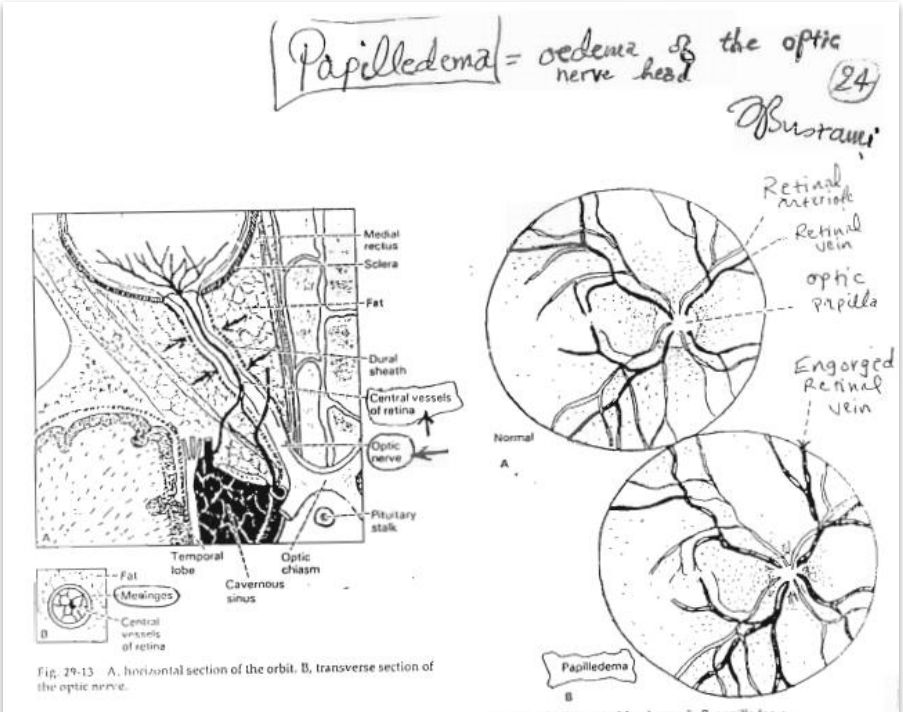

Fig. 29-13 A, horizontal section of the orbit. B, transverse section of the optic nerve.

FUNCTIONS OF THE CEREBROSPINAL FLUID

The cerebrospinal fluid serves as a protective cushion between the central nervous system and the surrounding bones. The close relationship of the fluid to the nervous tissue and the blood enables it to serve as a reservoir and assist in the regulation of the contents of the skull. The cerebrospinal fluid is an ideal physiological substrate and probably plays an active part in the nourishment of the nervous tissue; it almost certainly assists in the removal of products of neuronal metabolism. The secretions of the pineal gland possibly influence the activities of the pituitary gland by circulating through the cerebrospinal fluid in the third ventricle.

❖ **Hydrocephalus** (Important)

- ✓ It's an **abnormal increase in the volume of the cerebrospinal fluid** within the skull.
- ✓ If the hydrocephalus is accompanied by a raised cerebrospinal fluid pressure, then it is due to either :
    1. an abnormal increase in the formation of the fluid
    2. a blockage of the circulation of the fluid
    3. a diminished absorption of the fluid.

❁ Could the CSF volume increase with normal CSF pressure?
Yes rarely, hydrocephalus occurs with a normal cerebrospinal fluid pressure, HOW?

→ In these patients there is a compensatory **hypoplasia or atrophy of the brain substance.**
This could occur in children.

Final clinical correlation with regard to BBB and newborns:

- ✓ The blood-brain barrier protects the brain from toxic compounds.
- ✓ In the newborn child or premature infant these barriers are not fully developed → so toxic substances such as **bilirubin** can readily enter the central nervous system and produce **yellowing** of the **brain** and **kernicterus"اليرقان"**.

(لهيك بكونوا خايفين ع الولاد الصغار لما يصير عليهم صفار)

❖ **DO I ALWAYS NEED THE BBB at the brain?**

- ✓ In certain situations, however, it is important that the nerve cells be exposed without a barrier to the circulating blood. This enables neuronal receptors to → (sample the plasma directly and to respond and maintain the normal internal environment of the body within very fine limits).
- ✓ There is **no blood-brain barrier** in the "**pineal gland**", the **"hypothalamus",** the **"posterior lobe of the pituitary",** the **tuber cinereum**, the wall of the **optic recess**, and the area postrema at **the" lower end of the fourth ventricle"**. The blood-brain barrier is formed by the tight junctions between the endothelial cells of the blood capillaries. In these areas where the blood-brain barrier is absent, the capillary endothelium contains **(fenestrations)** across which proteins and small organic molecules may pass from the blood to the nervous tissue.

The rest of the lab is just a revision of previous labs and student' Qs.

**VERY important note regarding the coronal section in lab 3 :-
→ the grey mater superior to the corpus callosum is "**cingulate gyrus**"

REFERE To lab-handout pages
11 , 12 ,"the figure in 22",32, 33
And now you covered 100% of the lab material
and you're more than ready "inshallah"
& the vision is not included in the midterm

GOOD LUCK in the exam
و سامحونا على أي تقصير