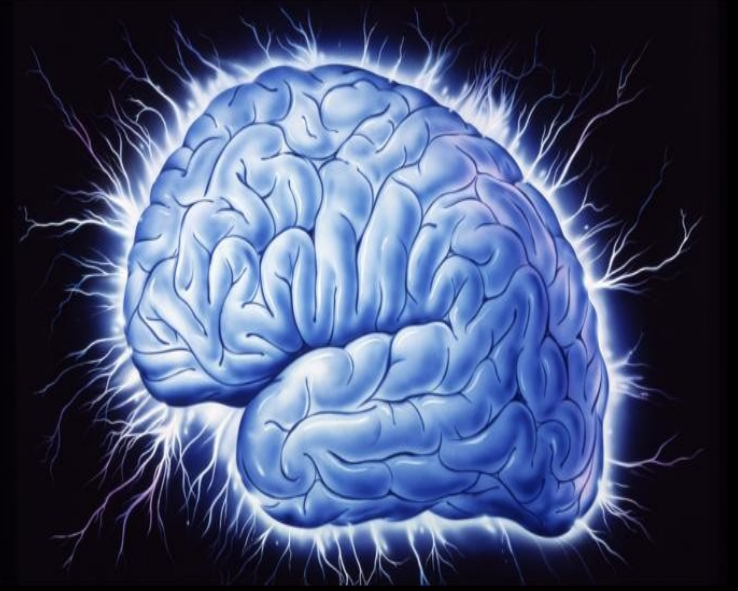


CEREBRAL CIRCULATION



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Objectives

- At the end of the lecture you should know:
 - Functional anatomy and peculiarities of cerebral circulation.
 - Measurement of CC
 - Kety's method
 - RA method
 - Factors regulating CBF
 - perfusion pressure
 - Cerebrovascular resistance
 - Blood Brain Barrier
 - Applied aspects



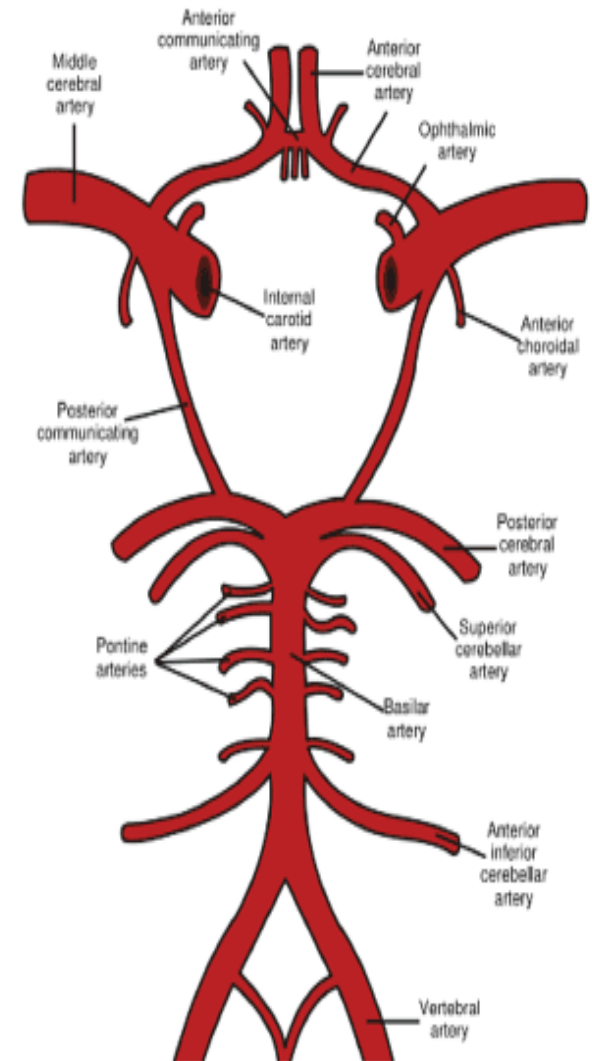
Introduction

- It is the blood flow to the brain.
 - Supplies oxygen, glucose and nutrients.
 - Removes CO₂, lactic acid & metabolites.
- Cerebral vasculature has unique physiology & anatomy.
- Brain is highly vulnerable to disruption in blood flow.



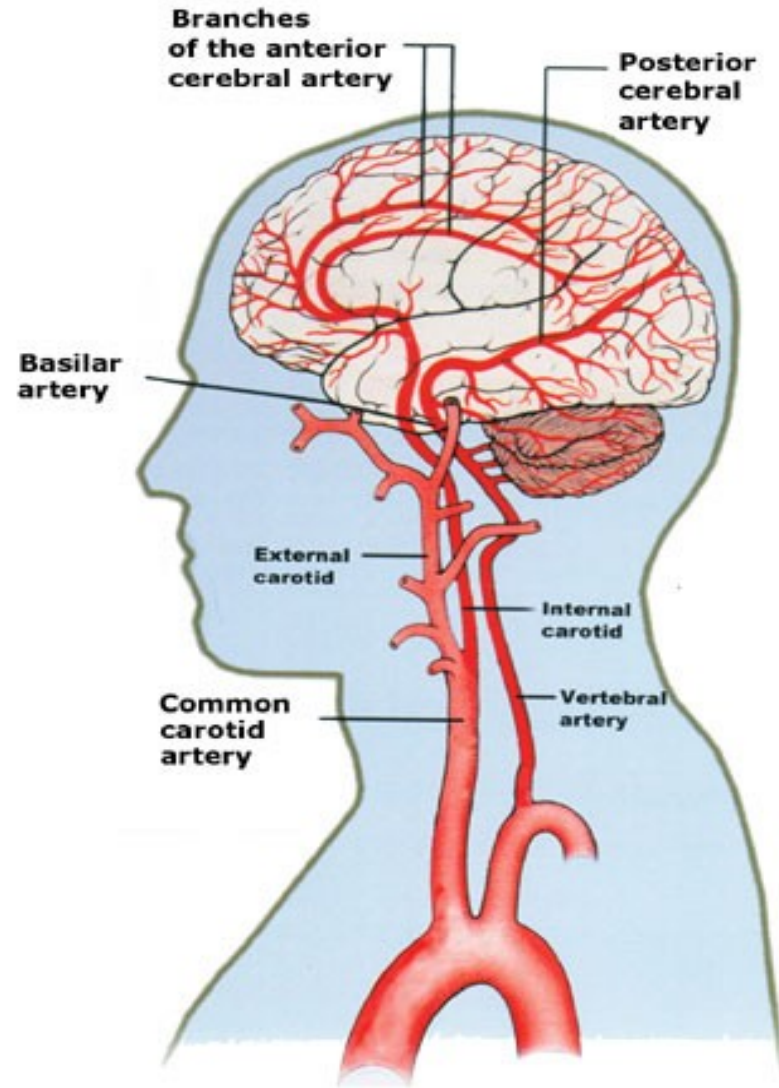
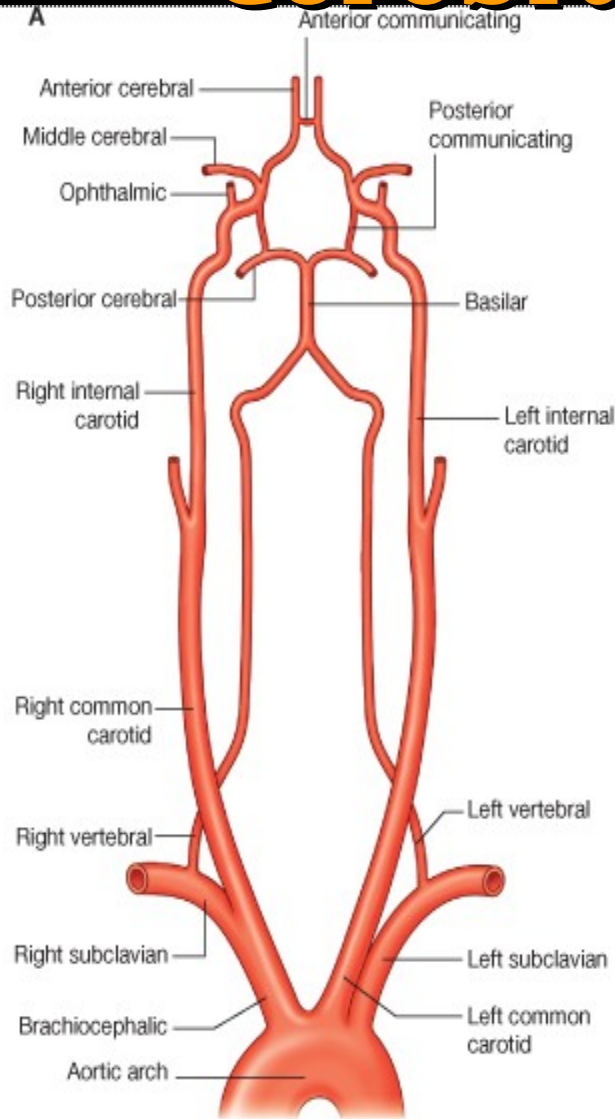
Functional Anatomy

- Brain is supplied by 4 arteries
 - 2 Internal carotid arteries
 - 2 vertebral arteries
- The vessels are interconnected in brain to form an arterial circle (**Circle of Willis**) below the hypothalamus.
- 6 large vessels originate from COW which supply the cerebral cortex.



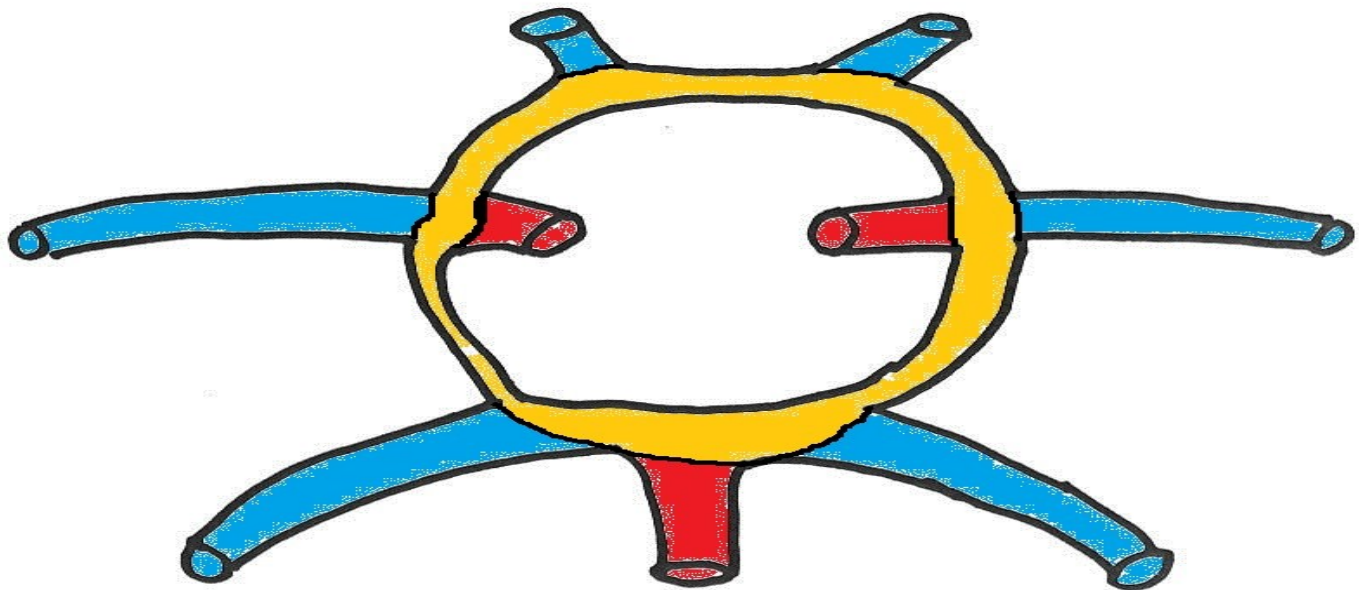
1. The Circle of Willis, as illustrated here, connects the anterior and posterior circulatory systems.

Cerebral Circulation



Easy way to remember COW

The Circle of Willis



Functional Anatomy

- Normally no crossing over of blood from one side to the other.
 - Equal pressure on both sides
 - Limited flow through anastomotic channels
 - Caution in older subjects



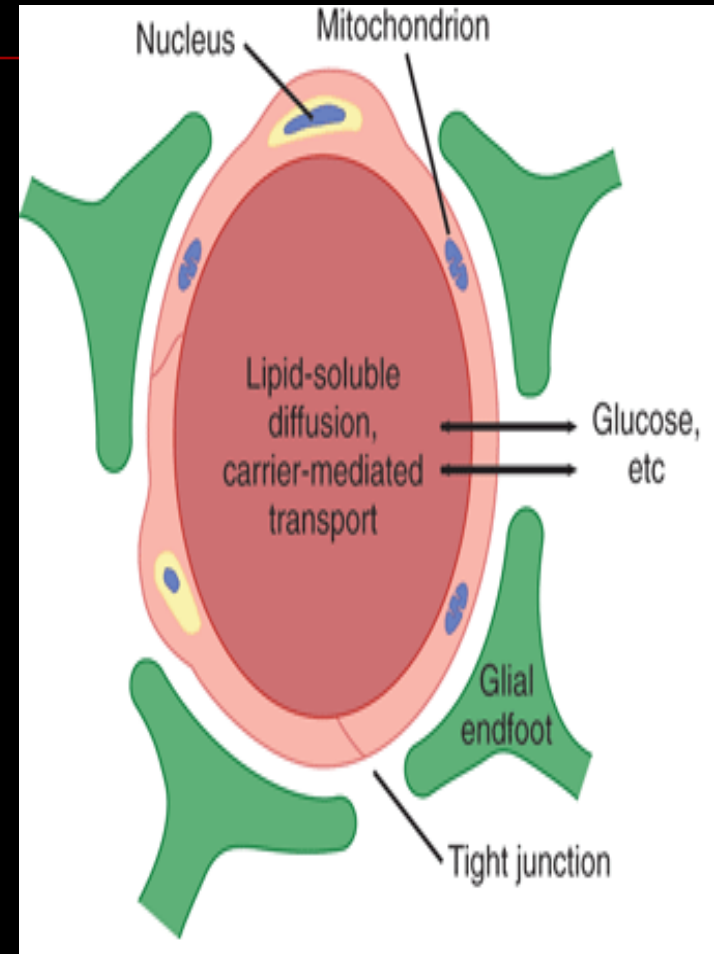
Functional Anatomy

Cerebral capillaries:

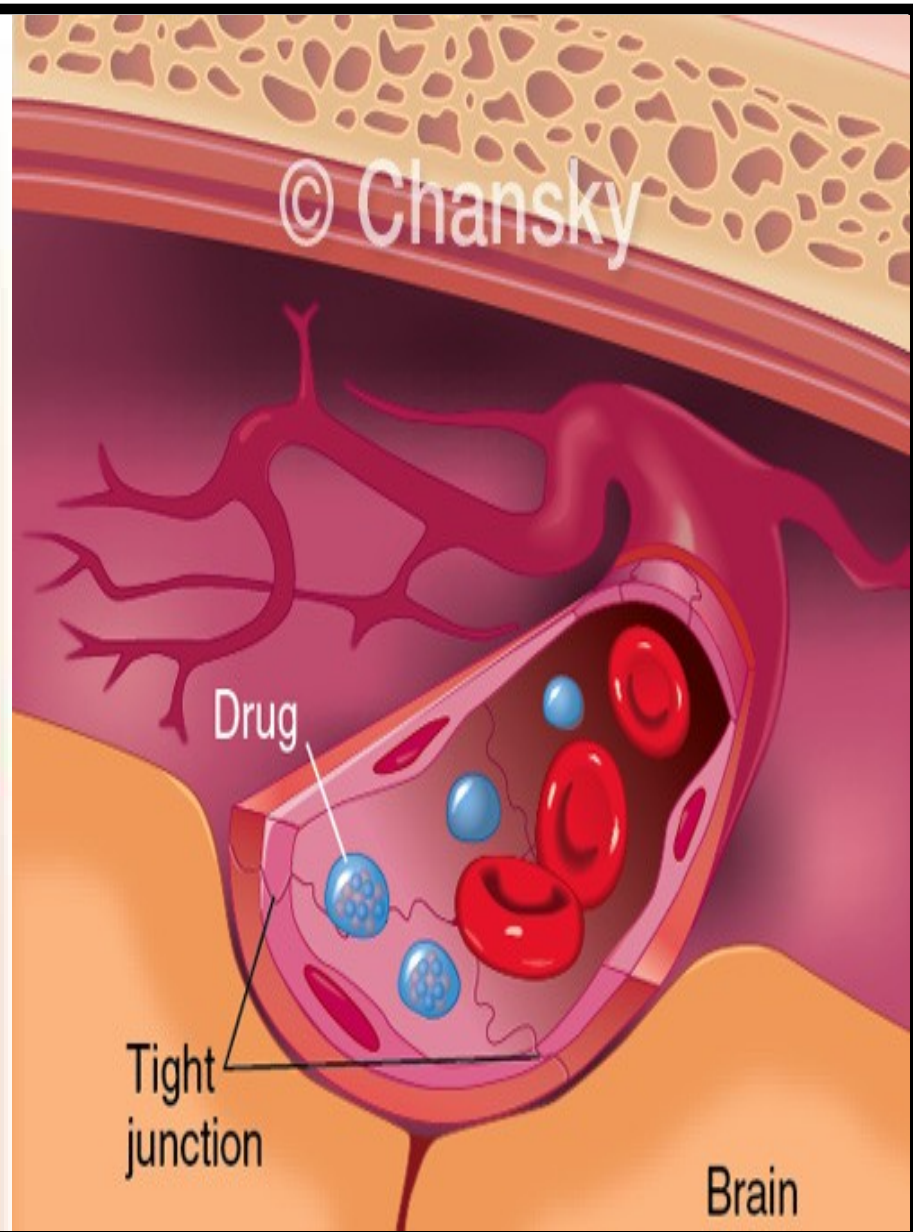
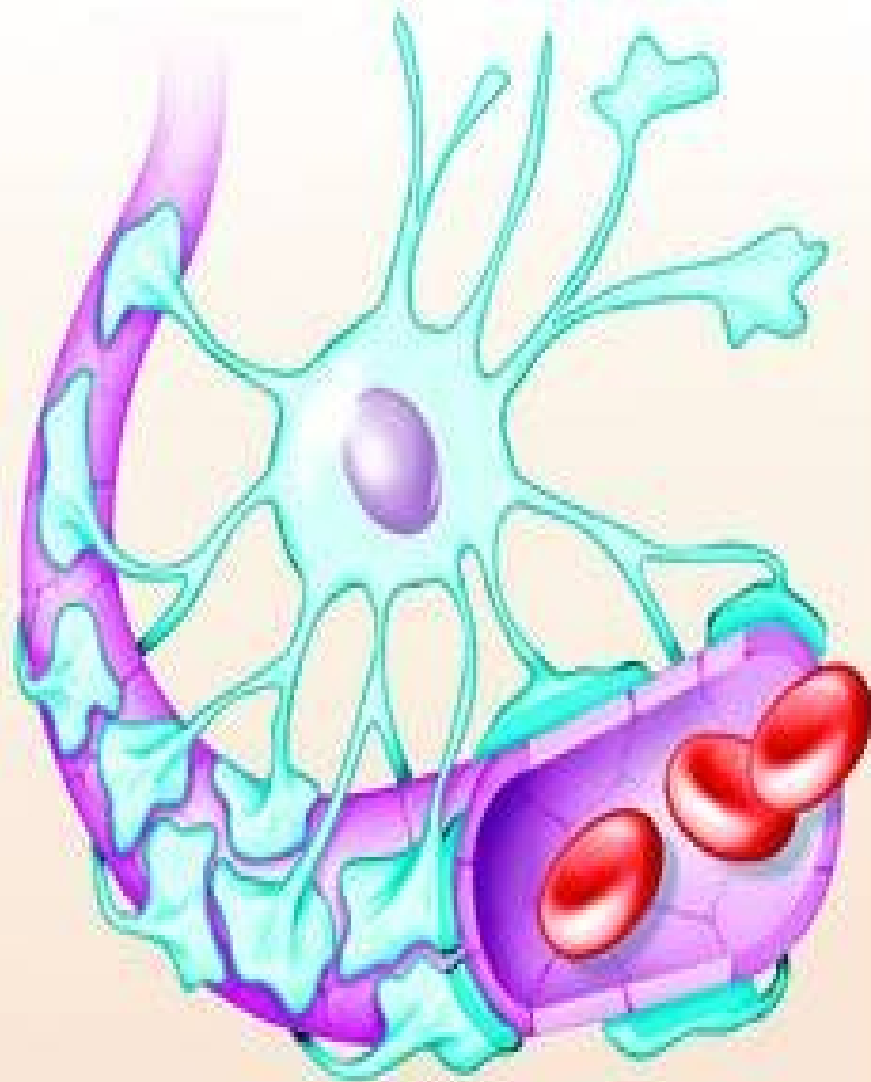
- Non-fenestrated capillaries with tight junctions b/w endothelial cells.

(Capillaries in choroid plexus are fenestrated)

- Few vesicles in endothelial cells
- Limited diffusion & vesicular transport
- Surrounded by end feet of astrocytes; induce tight junctions in endo. cells



- Anatomic basis for BBB



Functional Anatomy

■ Venous drainage:

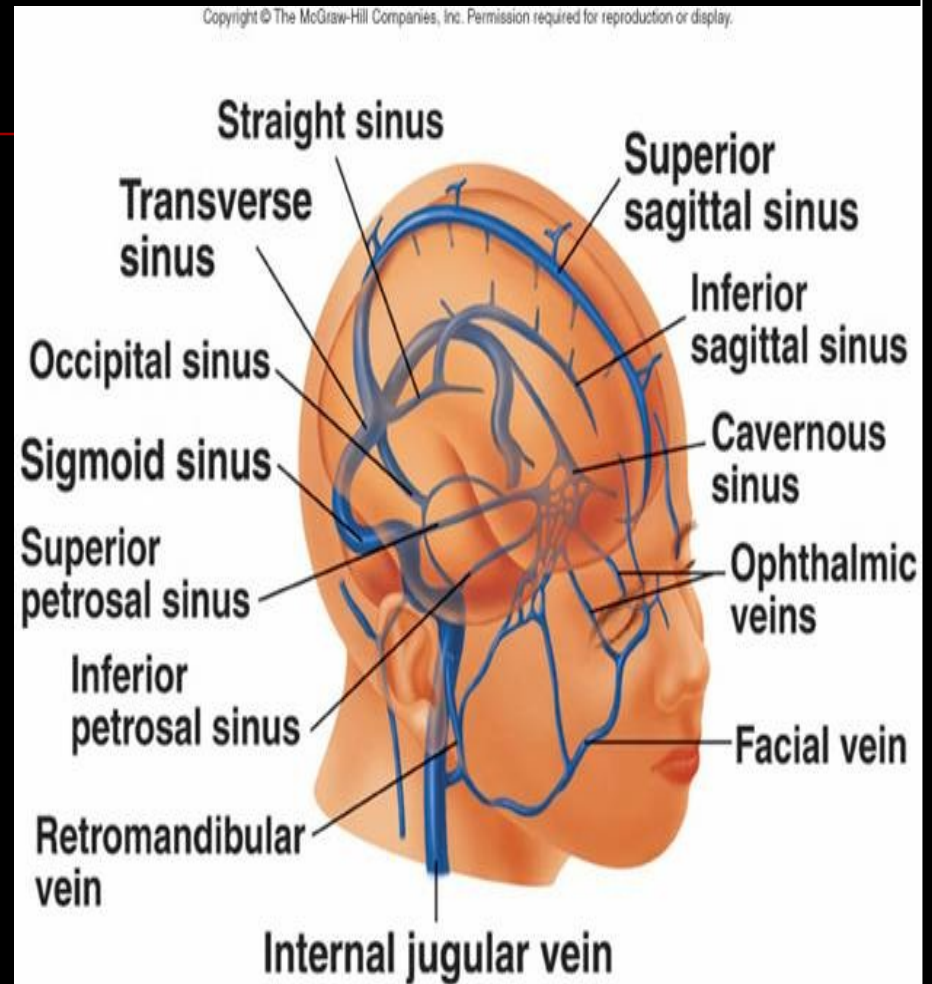
Cerebral veins



Cerebral venous sinuses



Internal jugular veins



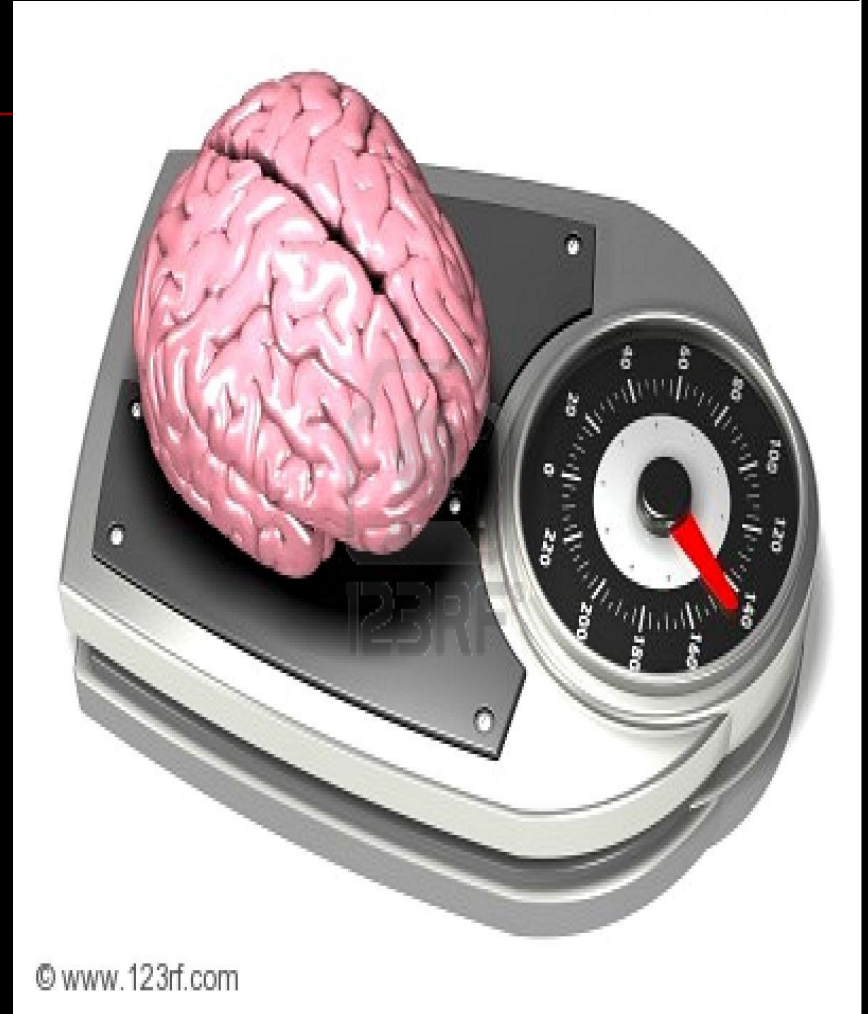
Facts

- Total brain weight in a 63 kg man
1400 gm (2.5% of TBW)
- **Blood supply**
 - 750 ml/min
 - 54 ml/100 gm/min
 - 13.9% of total cardiac output
- **Oxygen supply**
 - 46 ml/min
 - 3.3 ml/100gm/min
 - 18.4% of total O₂ consumption



Measurement of cerebral blood flow

- Kety's method
- Radio-active method
- Others
 - CT-scan
 - MRI
 - PET



Kety's Method

- Based on Fick's principle

Amount of substance taken up by
an organ in per unit time

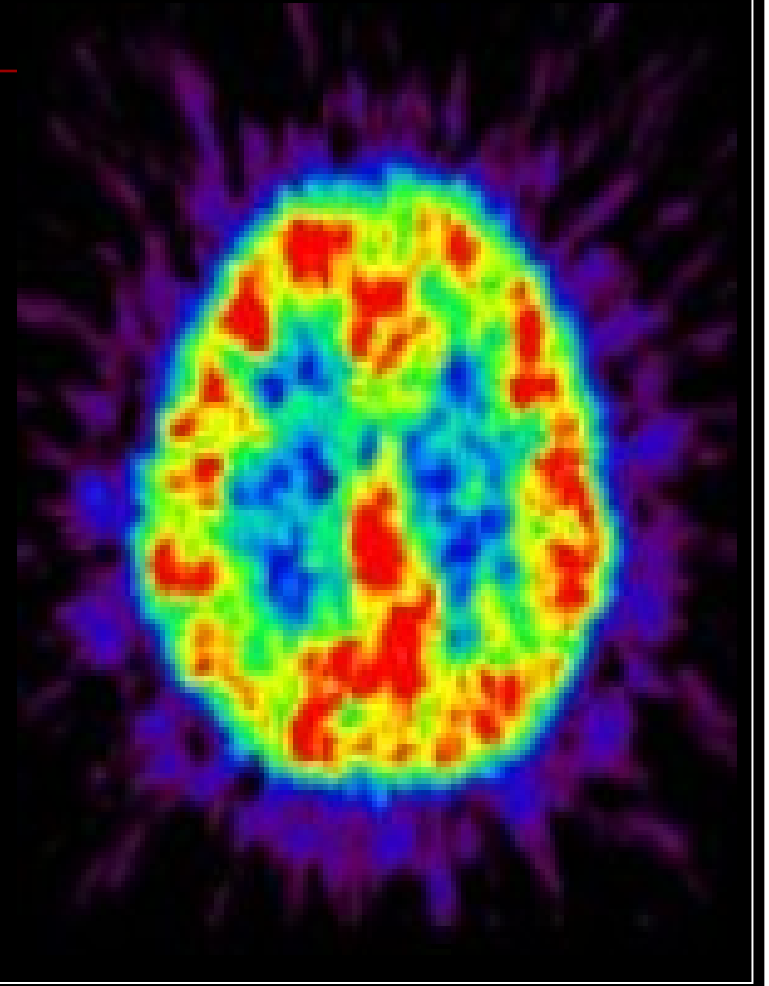
Blood flow = Arterio-venous difference of the
substance across the organ

Kety's Method

- ~~Breathe 15% Nitrous oxide for 10 min.~~
- Serial samples are taken for every minute from IJV and some peripheral artery.
- **Disadvantage:**
 - Provides an average value for perfused areas of brain; gives no information about regional differences in blood flow.
 - Not used for the rapidly changing blood flow.

Radio-Active Method

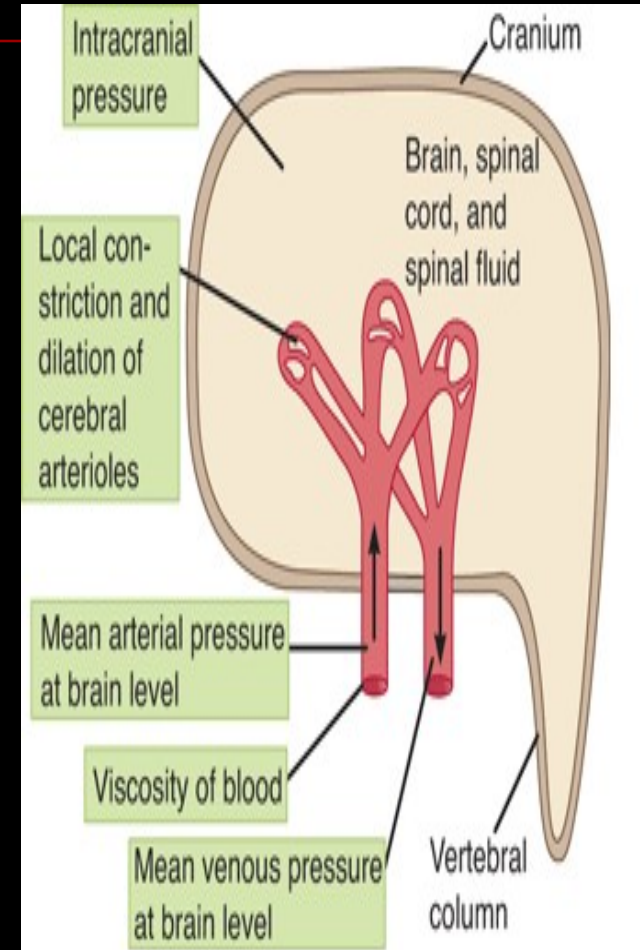
- A RA substance is injected into carotid artery.
- then the radioactivity of each segment of the cortex is recorded with a scintillator.
- Radio active Xe^{133} , Xe^{123} , 2-deoxy-glucose is used
- **Advantage** – Blood flow to different regions of cerebral cortex can be measured in conscious person.



Factors Regulating CBF

- ~~Marked local fluctuations in CBF with local activity, but total CBF relatively constant.~~
- CBF is regulated by:
 - Cerebral perfusion pressure
 - Cerebral vascular resistance

- **Cerebral Blood Flow =**
$$\Delta P \pi R^4 / 8 \eta L$$



Cerebral Perfusion Pressure (CPP)

- It is the net pressure gradient causing blood flow to the brain.

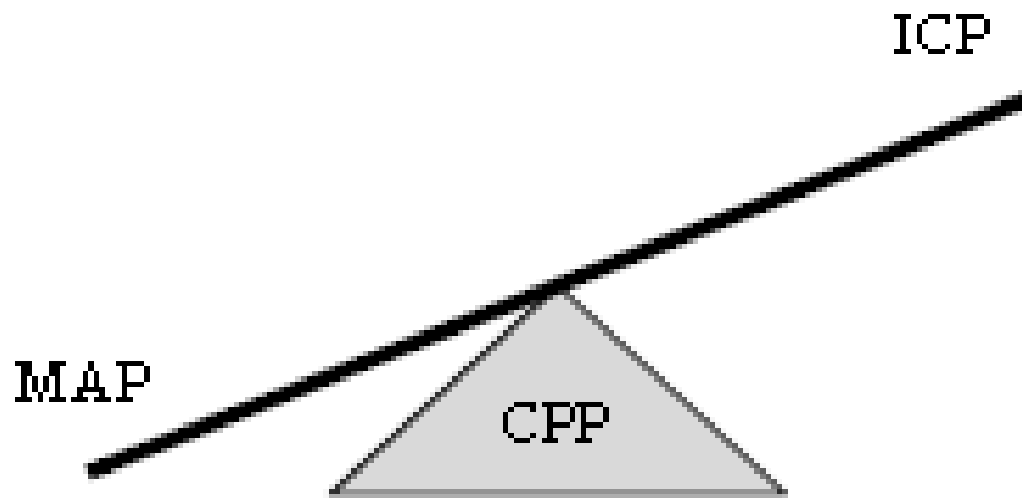
$$\text{CPP} = \text{MAP} - \text{MCVP}$$

$$(\text{MCVP} = \text{ICP})$$

$$\text{CPP} = \text{MAP} - \text{ICP}$$

- Inc. CPP causes inc. CBF
- Any factor affecting MAP (e.g. hemorrhage) or ICP will affect the CBF.
- CBF is maintained normal over a wide range of MAP by 'autoregulation'

Cerebral Perfusion Balance



Role of ICP in maintaining CBF

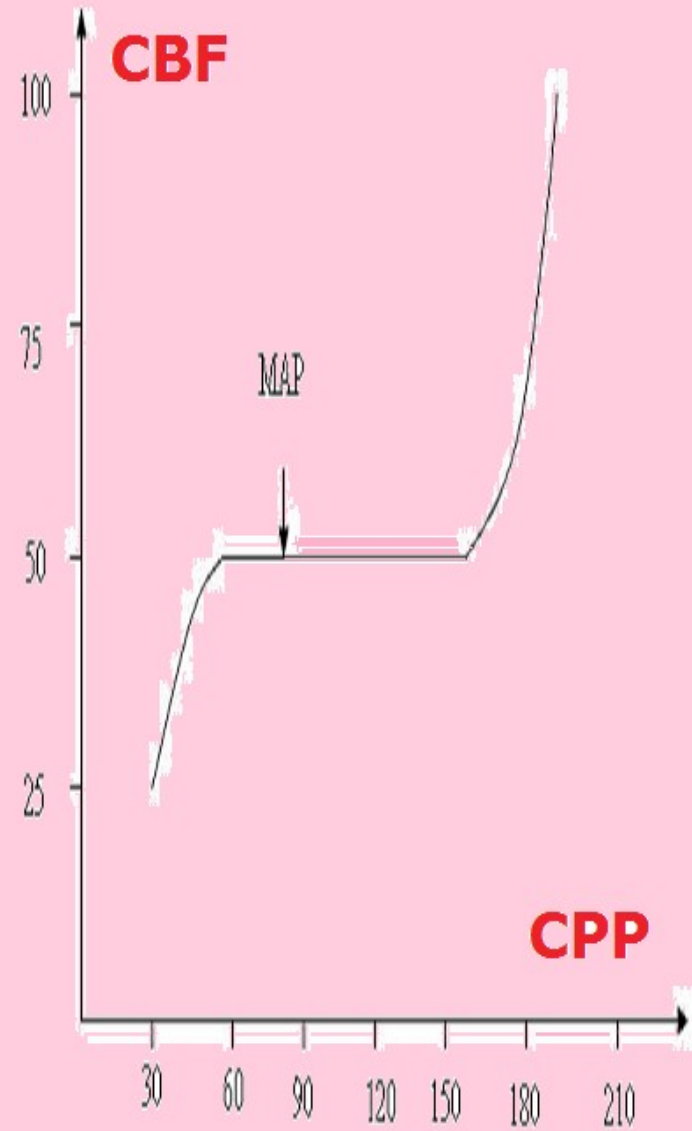
- The volume of blood, spinal fluid, and brain in the cranium at any time must be relatively constant (**Monro-Kellie doctrine**).
 - Inc. ICP → dec. CBF
 - Dec. ICP → inc. CBF
- **Cushing's reflex**
 - Inc. intracranial pr. → Dec. CBF → VMC ischemia
→ inc symp. discharge → inc BP → inc. CBF

Cerebral Vascular Resistance

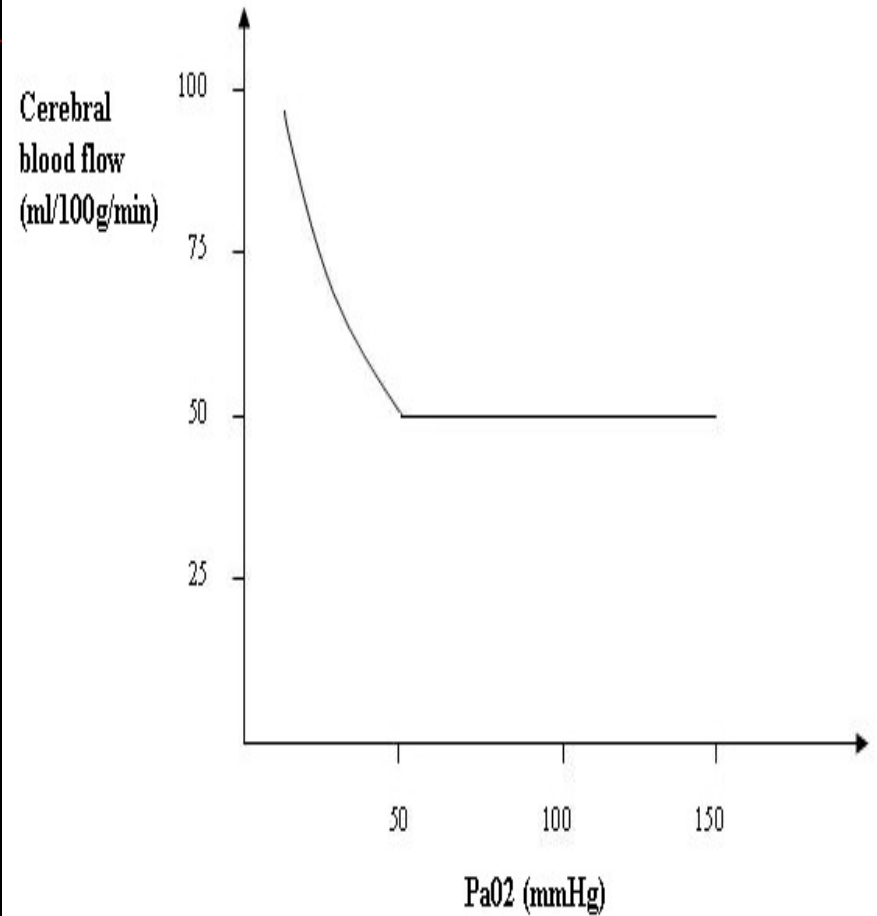
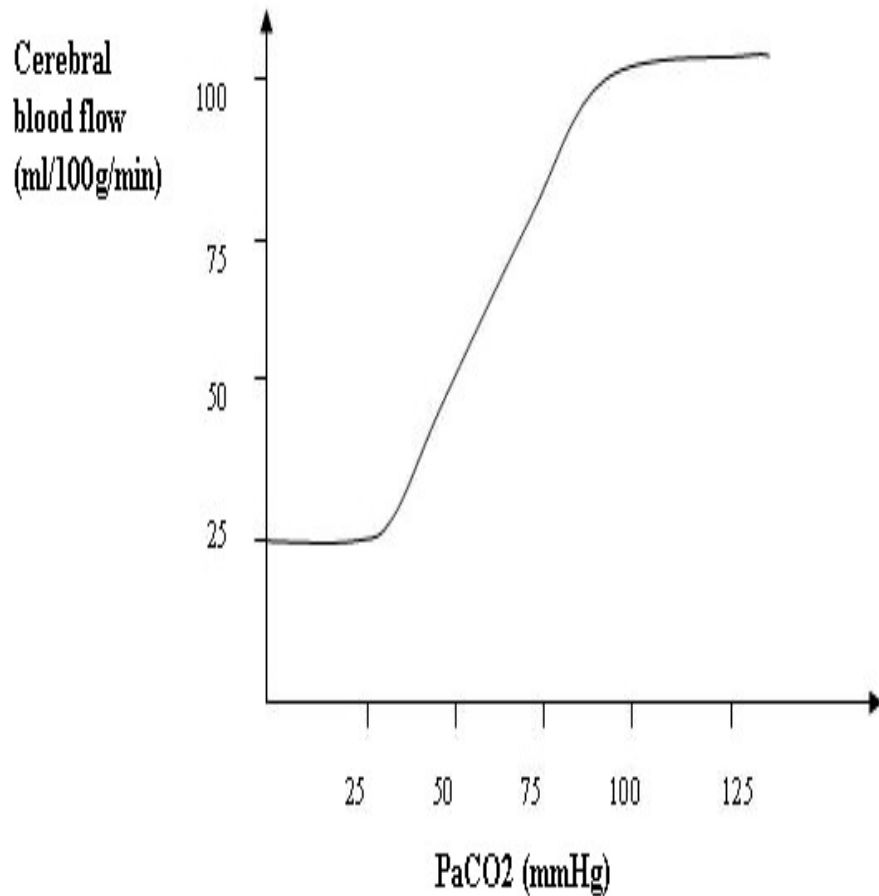
- CBF is inversely related to CVR.
- Factors regulating CVR are:
 - Autoregulation
 - Metabolic regulation
 - pCO₂
 - pO₂
 - H⁺ concentration
 - Neuronal regulation
 - Sympathetic discharge

Autoregulation

- Maintains constant blood flow to the brain despite wide fluctuations in CPP.
- It is the inherent property of resistance vessels
 - inc. BP → vasoconstriction
 - dec. BP → vasodilation
- Maintains blood flow in the range of 60 – 150 mm Hg CPP.



Metabolic regulation



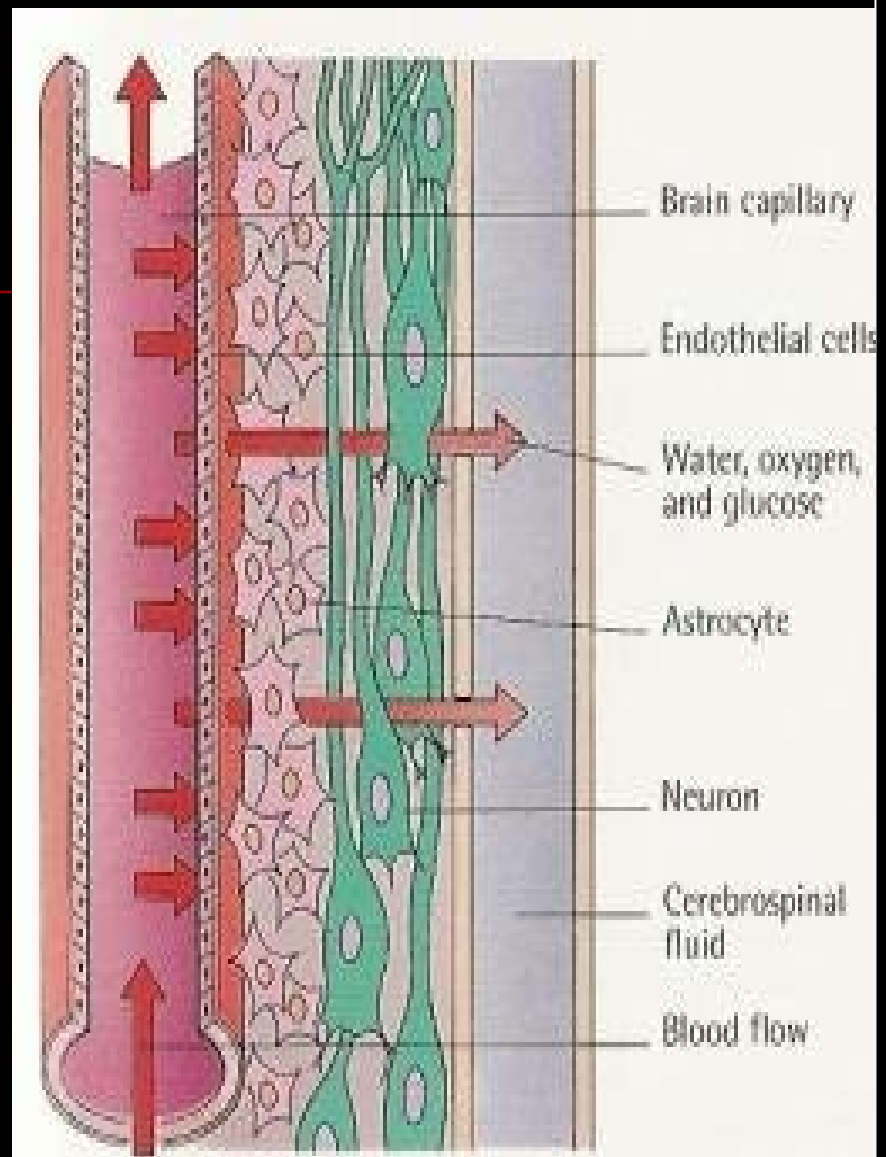
Blood Brain Barrier

Separates the brain and cerebrospinal fluid (CSF) from the blood

Regulates the exchange of substances between the blood and the brain.

Structural arrangement of capillaries and astrocytes

selectively determine which substances can move from the circulating blood to the CSF of the brain.

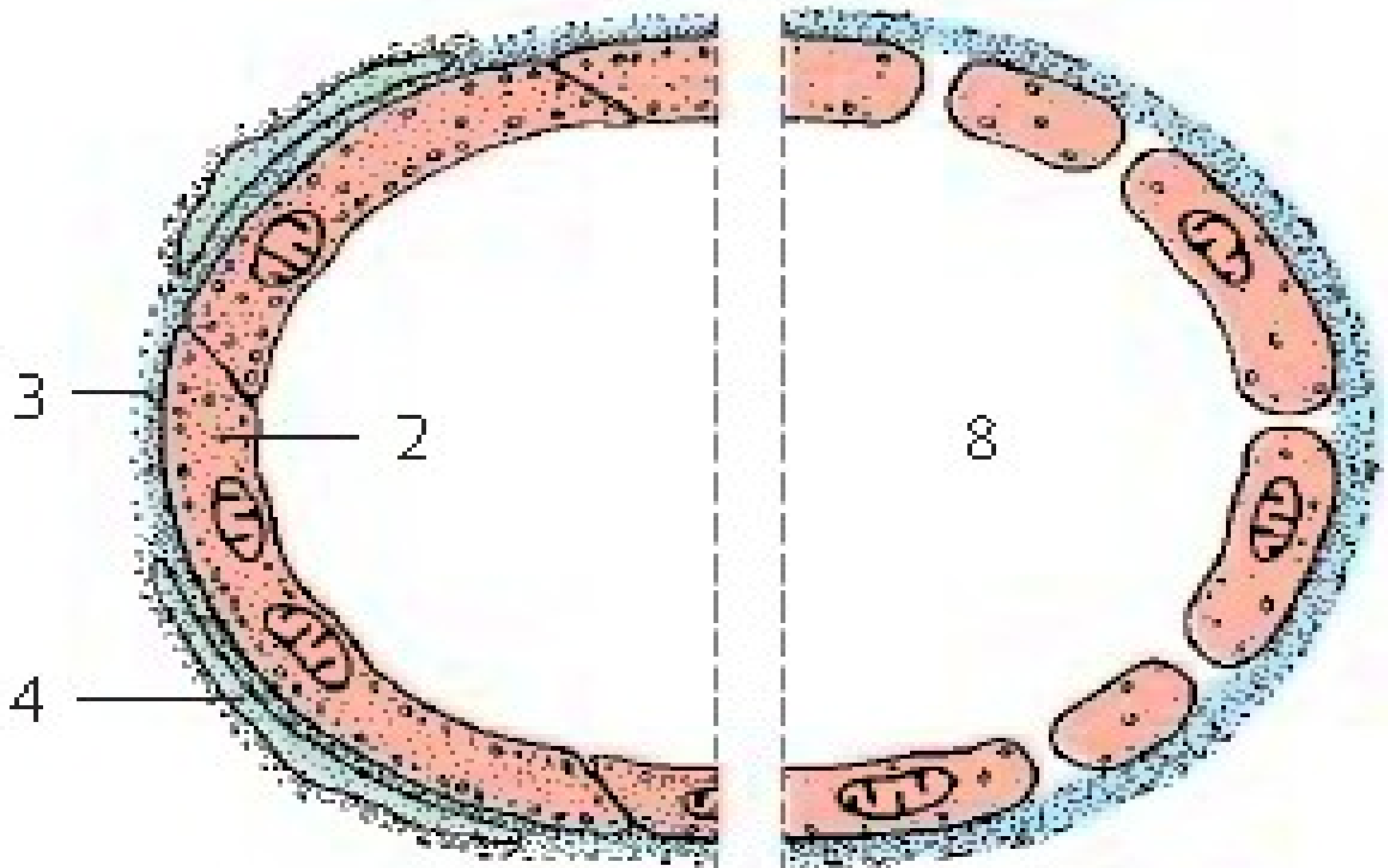


THE ANATOMICAL AND PHYSIOLOGICAL BASIS FOR THE PRESENCE OF BLOOD BRAIN BARRIER

- Non-fenestrated capillaries.
- Tight junctions between capillary endothelial cells.
- Paucity of the vesicles in the endothelial cytoplasm.
- Presence of numerous carrier-mediated & active transport mechanisms in cerebral capillaries.

- **The blood-CSF barrier is due to tight junctions in choroid plexus endothelial cells. The capillaries in choroid plexus are fenestrated with no tight junctions.**

BRAIN CAPILLARY Vs RENAL CAPILLARY



PROPERTIES OF BBB

- Only few substances can freely diffuse through BBB.
 - CO₂, O₂, water & free forms of steroid hormones.
- H⁺ & HCO⁻ only slowly penetrate the BBB.
- Proteins, polypeptides & protein bound forms of hormones do not cross BBB.
- Glucose is transported by GLUT1 transporter.
- Active transporters are also present.
 - for various ions (Na⁺- K⁺-2Cl⁻ co transporter)
 - thyroid hormones, organic acids, choline, nucleic acid precursors, amino acids etc.

SIGNIFICANCE OF BBB

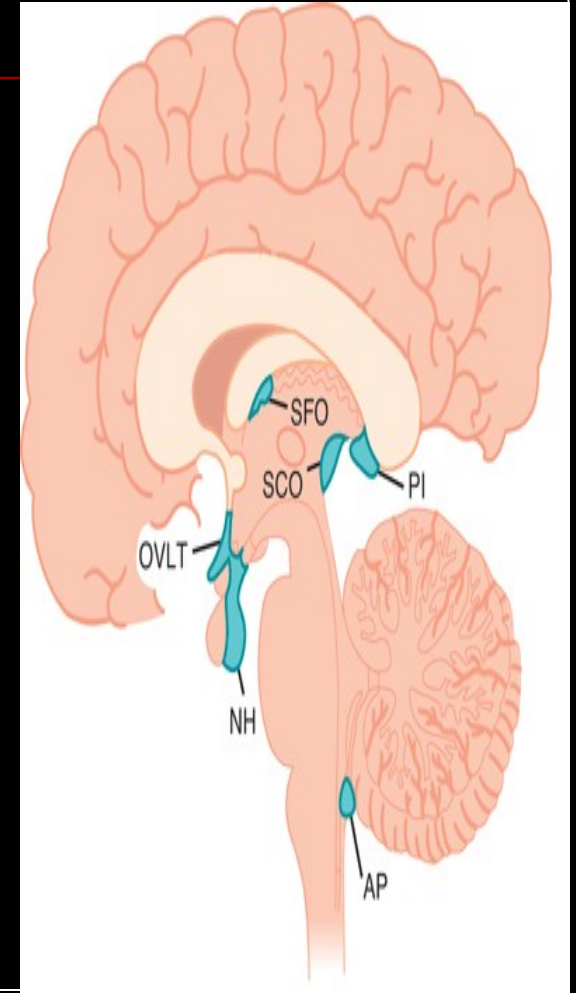
- It maintains the homeostasis in CNS.
- Protects the brain from endogenous & exogenous toxins.
- Prevents the escape of neurotransmitters into general circulation.

CIRCUMVENTRICULAR ORGANS

The parts of the brain which have fenestrated capillaries and thus no BBB.

- Posterior pituitary (Neurohypophysis) with Median Eminence
- Area Postrema
- Organum Vasculosum of Lamina Terminalis (OVLT)
- Subfornical Organ (SFO)

Anterior pituitary & Pineal Gland are also outside BBB, but they are not part of the brain.



CIRCUMVENTRICULAR ORGANS

- The circumventricular organs provide a window for the interaction of brain with blood.
 - **Posterior pituitary:** secretes the oxytocin & vasopressin in general circulation.
 - **Median eminence:** site of entry of hypothalamic hypophysiotropic hormones into portal hypophysiotropic circulation.
 - **SFO/OVLT:** AT-II acts to increase water intake.
 - **Area postrema:** act as chemoreceptor trigger zone that initiates vomiting in response to chemical changes in plasma. AT-II acts on it to produce neurally mediated increase in BP.

Applied

- Cerebro-Vascular Accidents (CVA)/ Stroke
- Kernicterus
- Some drugs can not cross BBB
 - Penicillin – can't use for brain infections
 - Dopamine – given in precursor l-dopa form
- Injury, infection, tumors disrupt BBB
- Avoid hyperventilation & hypocapnea – dec. CBF.

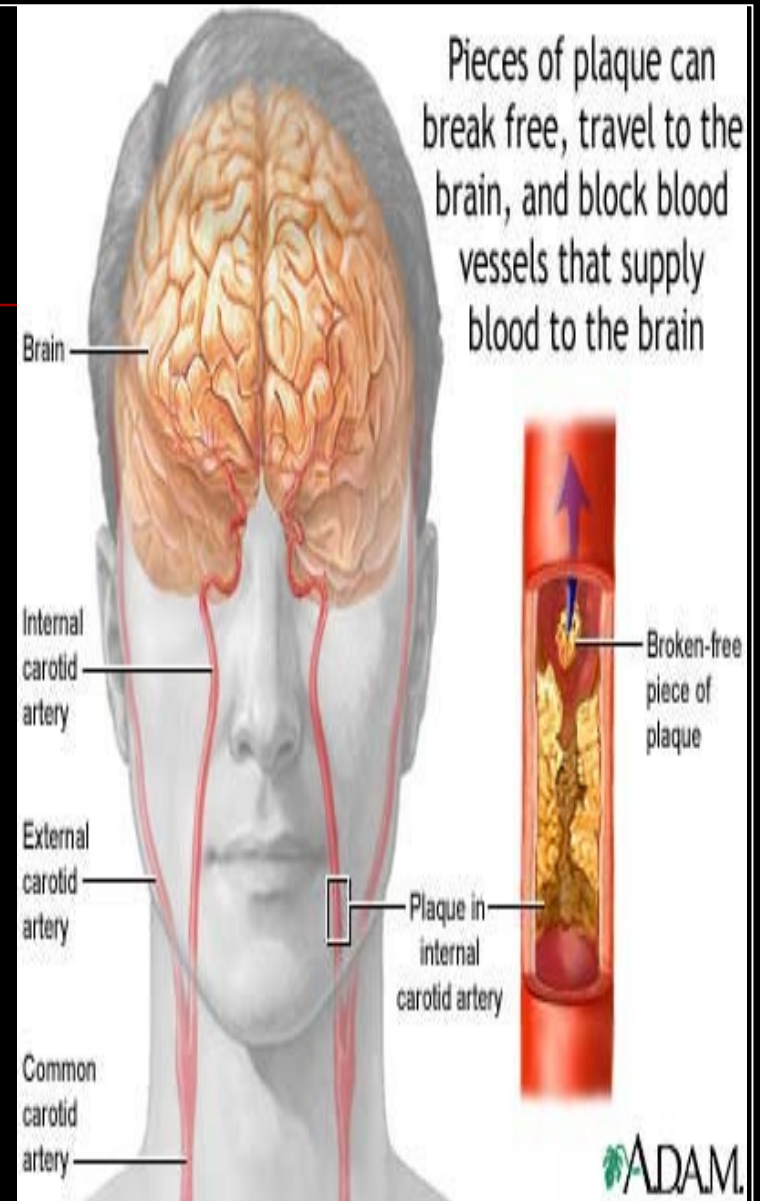
Stroke

Third most common cause of death after cancer & IHD.

Its an acute neurological syndrome produced d/t reduced O₂ supply to the brain.

Two types:

- Ischemic stroke
- Hemorrhagic stroke



Stroke

- Most commonly d/t thrombosis of MCA
- Sign & symptoms depend on the part of the brain affected.
- Hemiplegia, monoplegia, paraplegia.
- Sensory loss, CN, aphasia, memory loss etc.

STROKE RISK FACTORS

Irreversible

- Age
- Gender (M > F, except in the very young and very old)
- Race (Afro-Caribbean > Asian > European)
- Heredity

Modifiable

- Hypertension
- Heart disease (heart failure, atrial fibrillation)
- Diabetes
- Hyperlipidaemia
- Smoking
- Excess alcohol consumption
- Polycythaemia
- Oral contraceptives

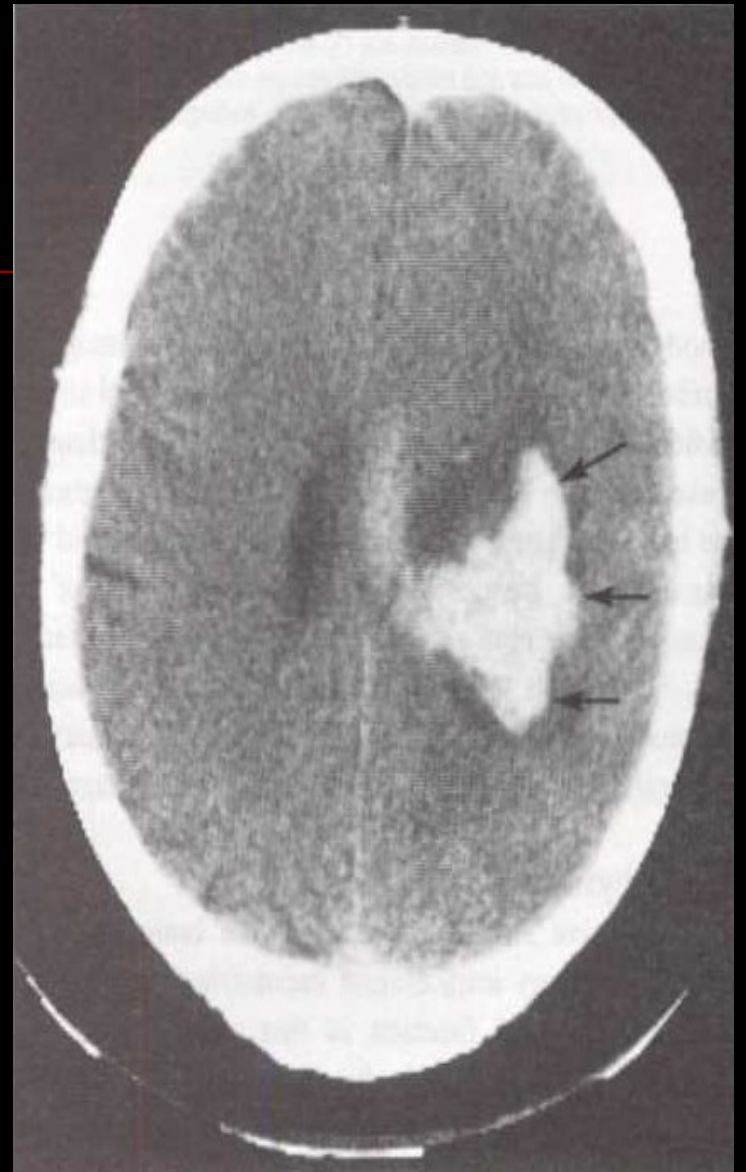
Stroke

■ Diagnosis:

- History
- Clinical Examination
- CT scan
- MRI
- Color doppler

■ Treatment:

- Thrombolysis (t-PA)
- Anticoagulants
- Antiplatelet agents
- Neuroprotection (hypothermia, drugs blocking excitatory AA pathways)



*Thank
You*

