

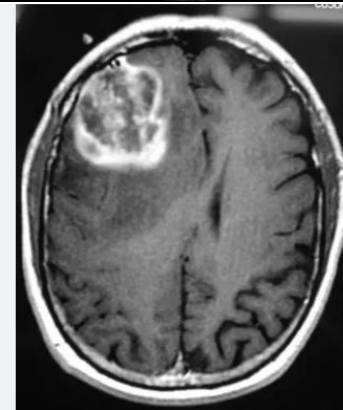
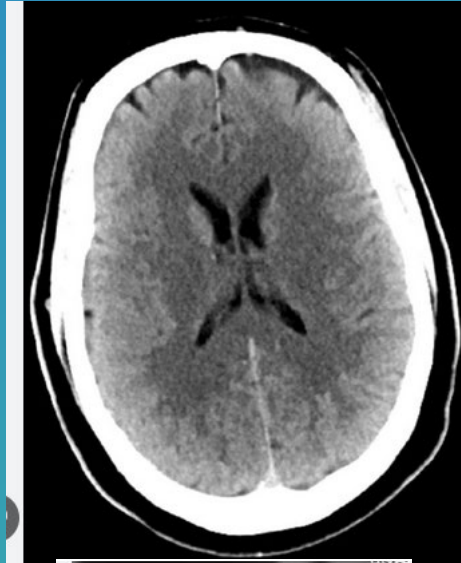
# BETTY MALANOWSKI, BS, IMG, CTR, FCDS FIELD COORDINATOR



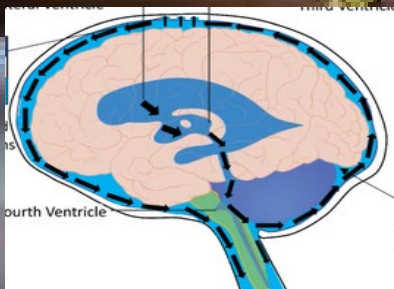
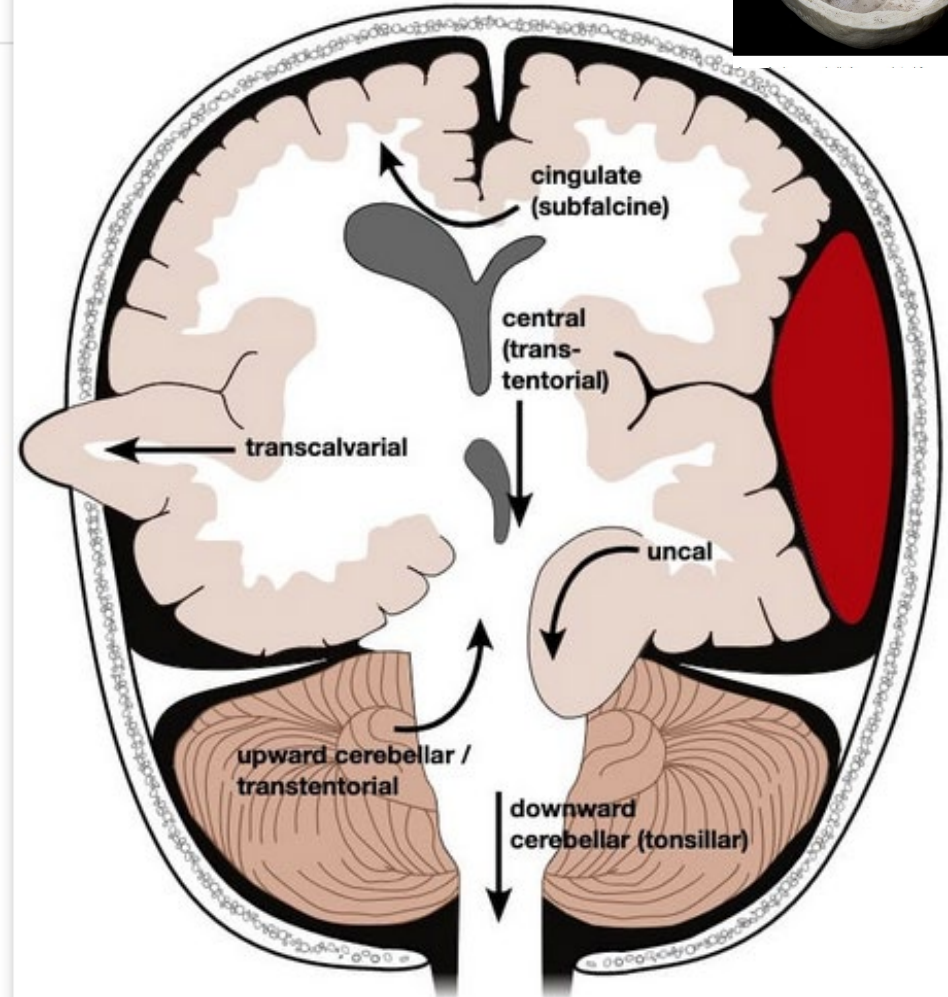
**Skull, Brain/CNS pathologies and some basics.**

# SKULL: HEAD for can EXPAND in BABIES but NOT in Adults.

Foramen Magnum

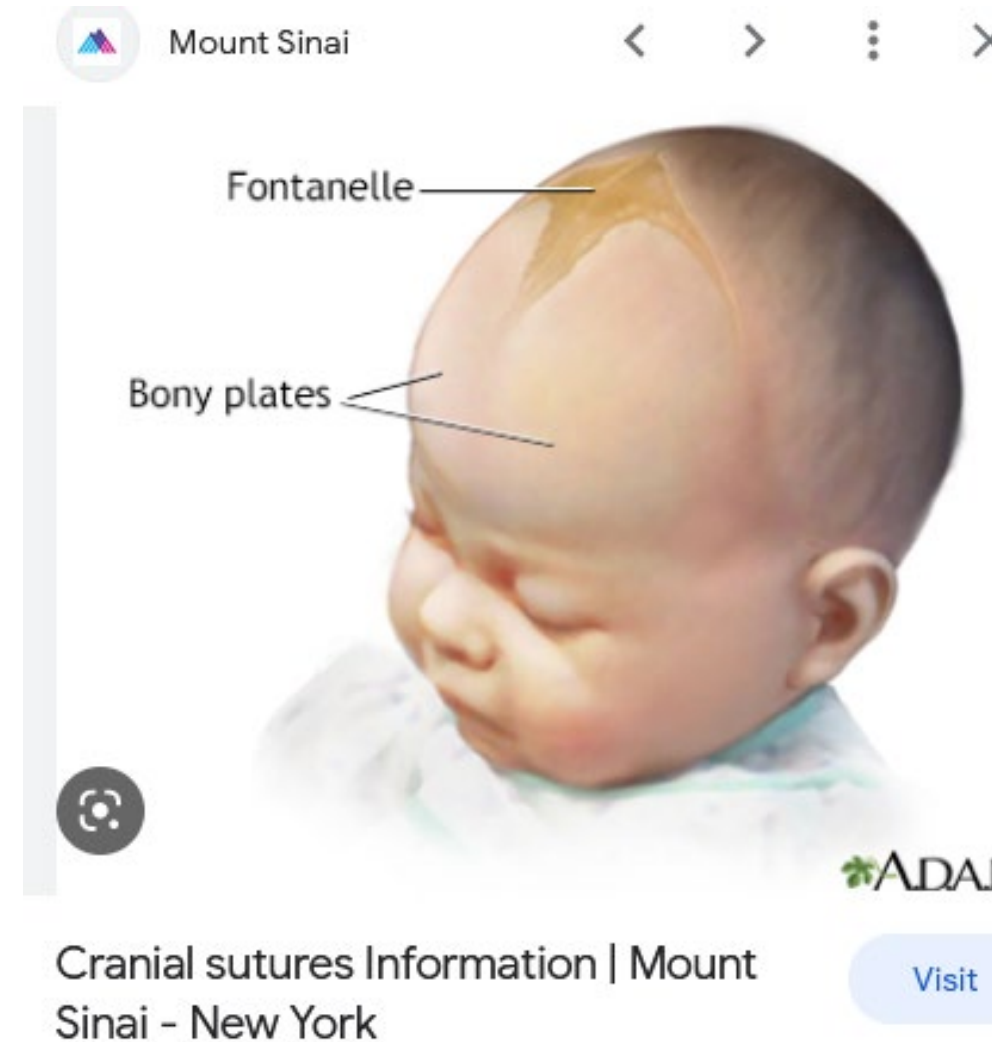
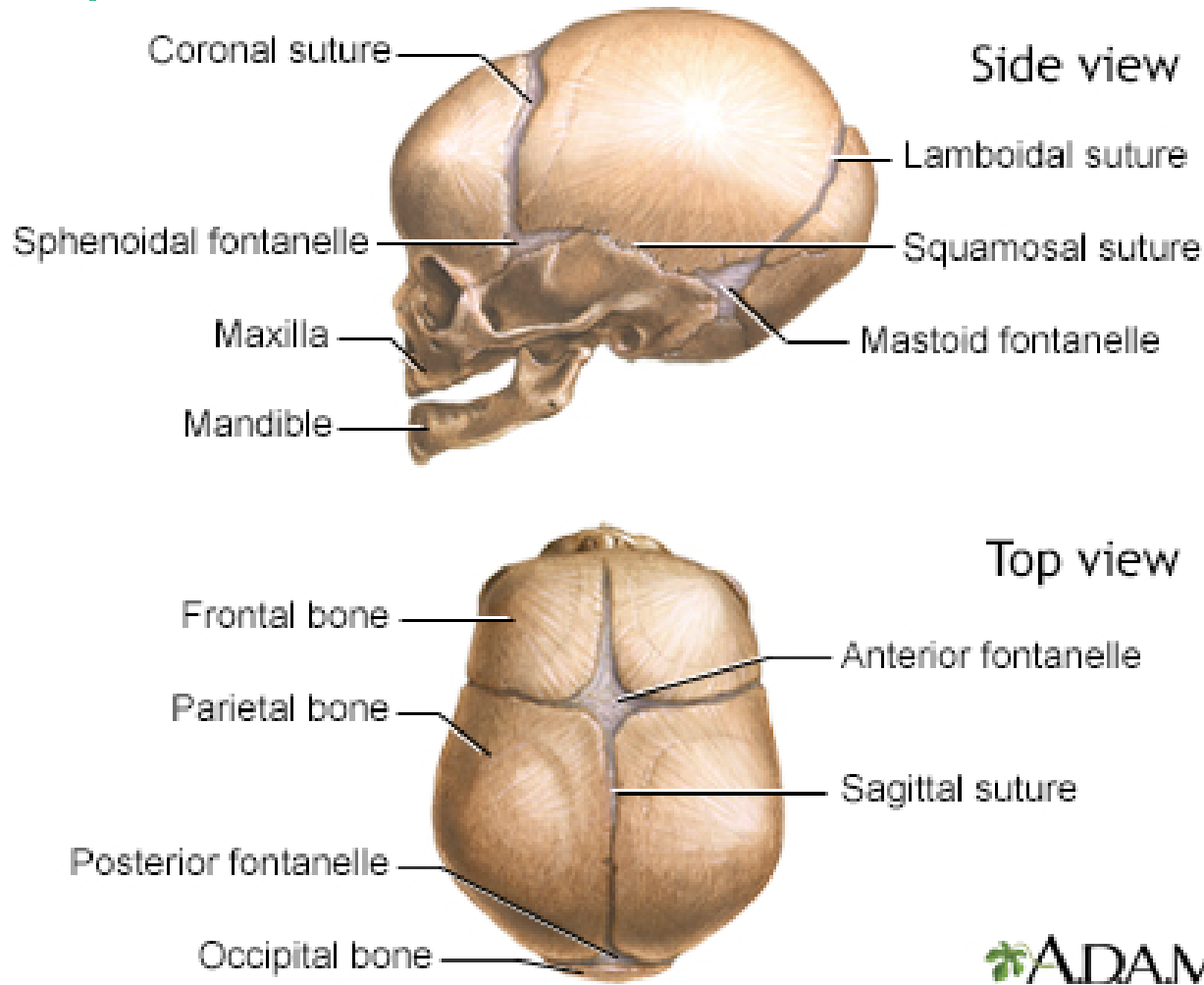


Glioblastoma



## WHY?

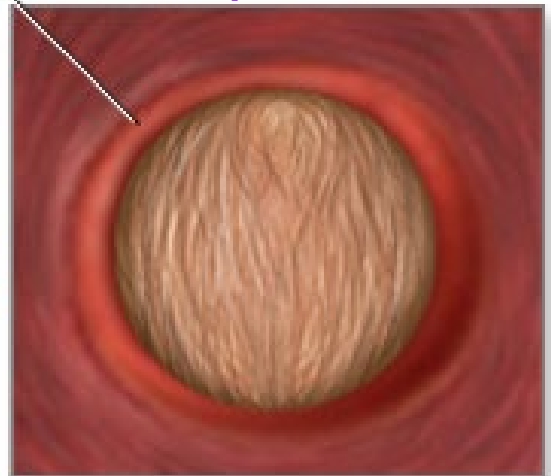
## SKULL/CRANIUM



- These gaps are composed of **membranous connective tissue** and are known as fontanelles. Fontanelles, often referred to as "soft spots," are one of the most prominent anatomical features of the newborn's skull. Six fontanelles are present during infancy, with the most notable being the anterior and posterior fontanelles.

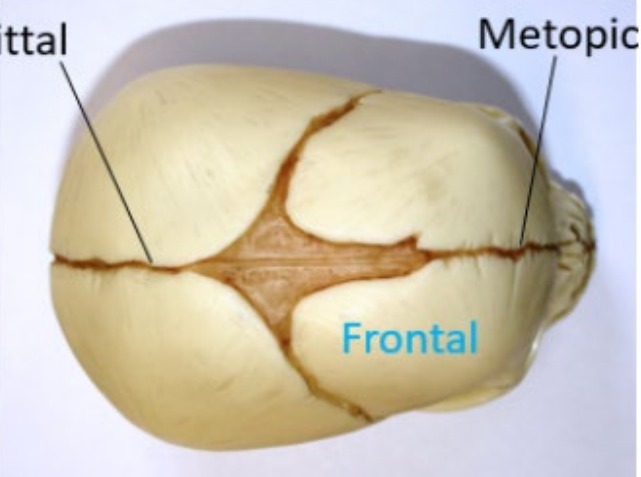
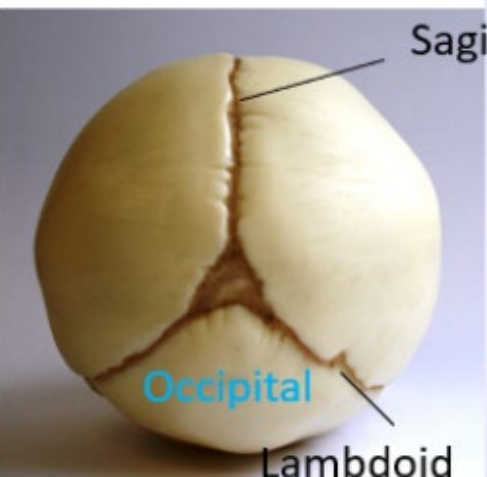
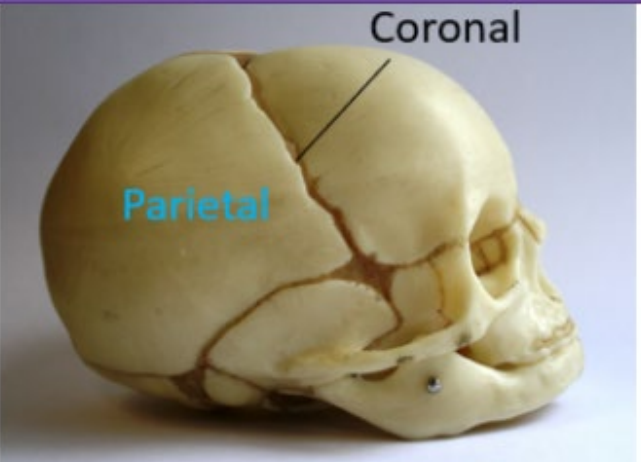
Babies are born with five major bones of the skull: two frontal bones, two parietal bones, and one occipital bone. Where these bones meet are called sutures. Cranial sutures are special joints of the skull bones that play several important roles in the growing child. First, sutures allow the skull bones to move during birth to allow the head to fit through the birth canal. Second, sutures allow the skull to grow quickly during the first few years of life in response to the rapidly growing brain.

Cervix  
Cervix fully dilated 10 cms.



Infant Skull

Bones / Sutures

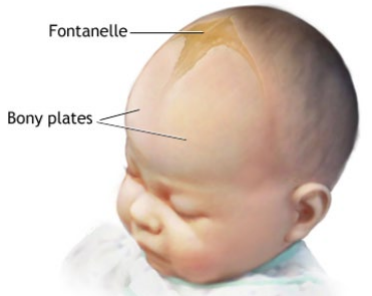


Baby Ruby's beautiful cone head is the result of her skull bones overlapping and narrowing her head to exit the womb. The #newborn head will return back to shape in one day. #humanbirth #midwifery #birth #day1 @anakedmidwife



ADAM.

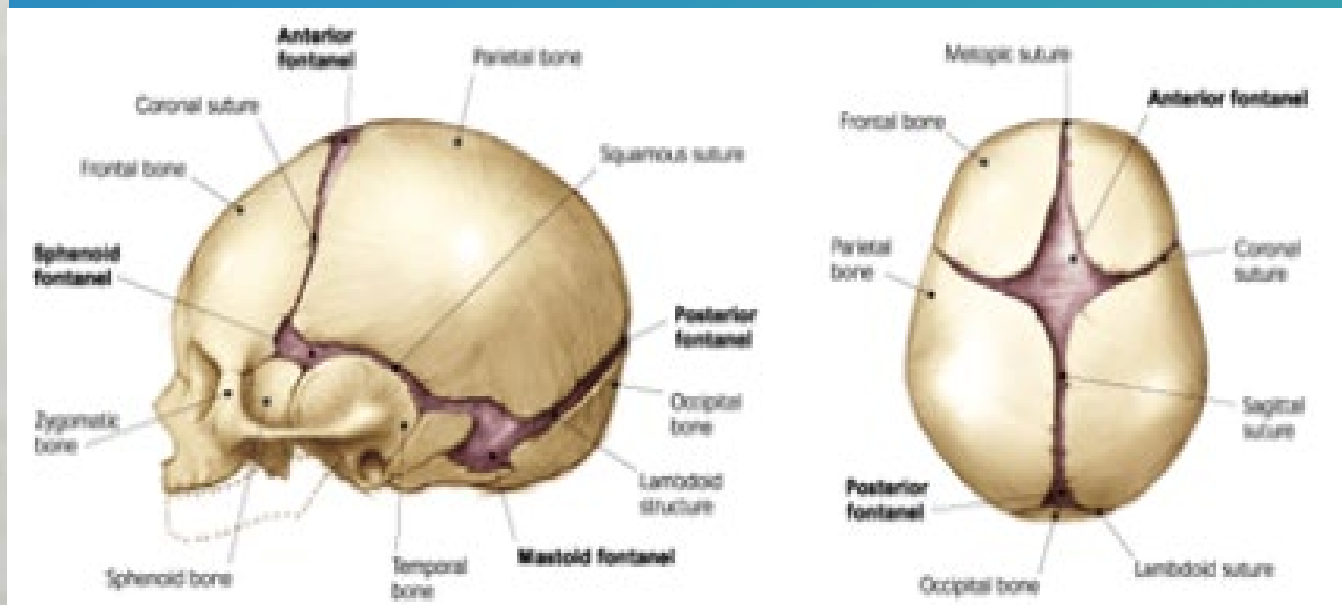
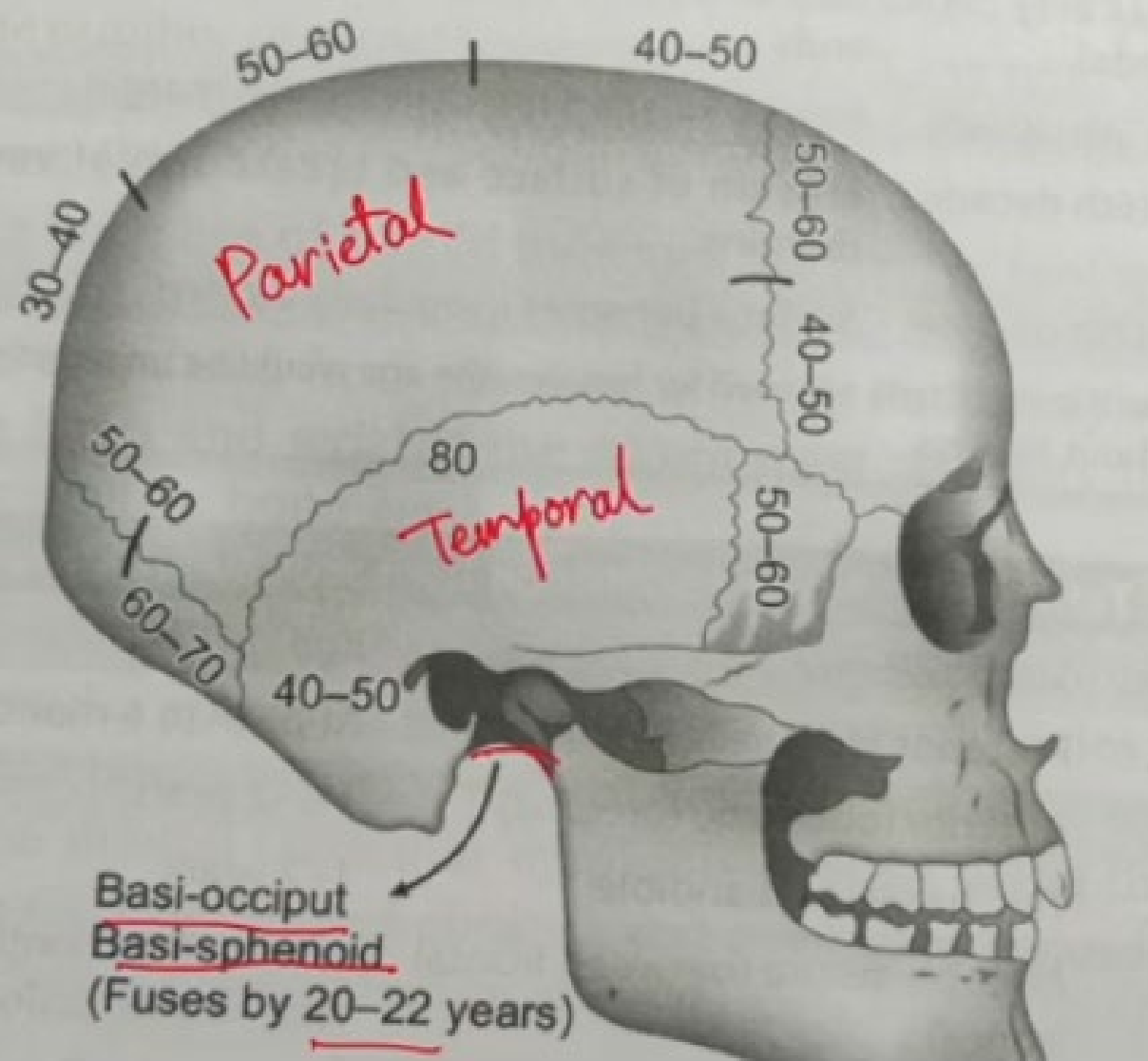
Fontanelles



FONTANELLES, often referred to as "soft spots". Cranial SUTURES are fibrous bands of tissue that connect bones of the skull.

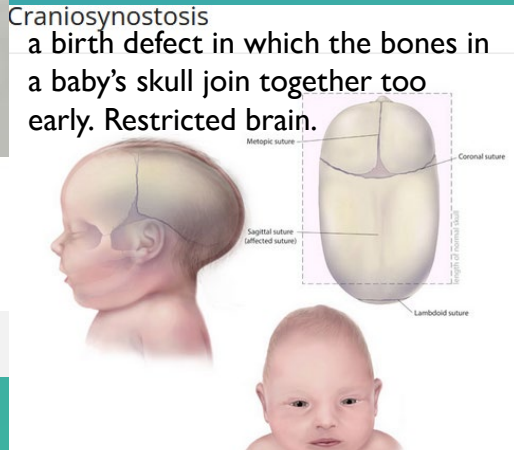
SKULL/CRANIUM

ADAM.



Typically, fontanelles close by the time your baby is 18 months old. The posterior fontanelle usually closes first — within 2 months of birth. The anterior fontanelle closes between 7 and 18 months.

Craniosynostosis  
a birth defect in which the bones in a baby's skull join together too early. Restricted brain.



Cranial suture	Closure begins (years)	Facial suture	Closure begins (years)
Metopic*	2	Palatal	30-35
Sagittal	22	Frontomaxillary	68-71
Coronal	24	Frontozygomatic	72
Lambdoid	26	Zygomaticotemporal	70-71
Squamosal	35-39	Zygomaxillary	70-72
Sphenofrontal	22	Frontonasal	68
Sphenoparietal	29	Nasomaxillary	68
Sphenotemporal	28-32		
Masto-occipital	26-30		

From Cohen,<sup>(11)</sup> Based on data from Miroué and Rosenberg,<sup>(16)</sup> Kokich,<sup>(17)</sup> Todd and Lyon,<sup>(18,19)</sup> and Caffey.<sup>(20)</sup>

\*Usually obliterated by the third year; persists throughout life in 10%.

# n | Age determination | Skull suture closure

FORENSICS 116

# SKULL/CRANIUM

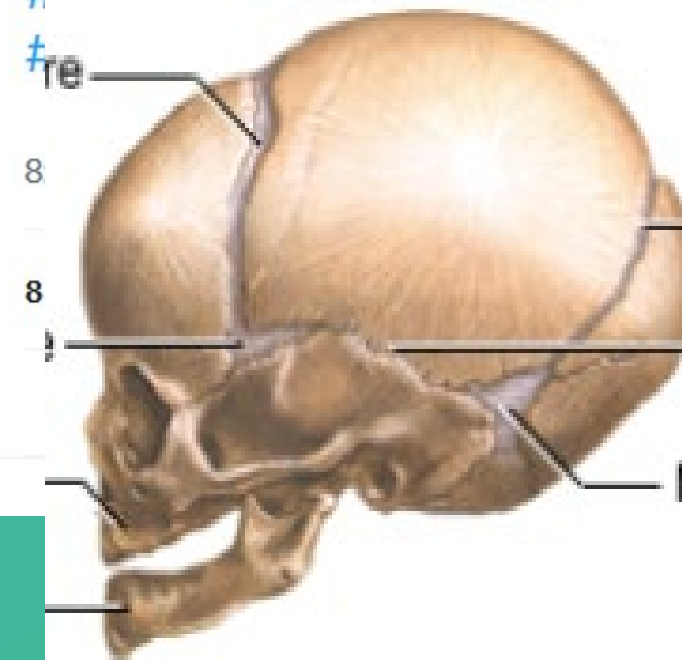
developmental delays or intellectual disabilities...

# SKULL/CRANIUM

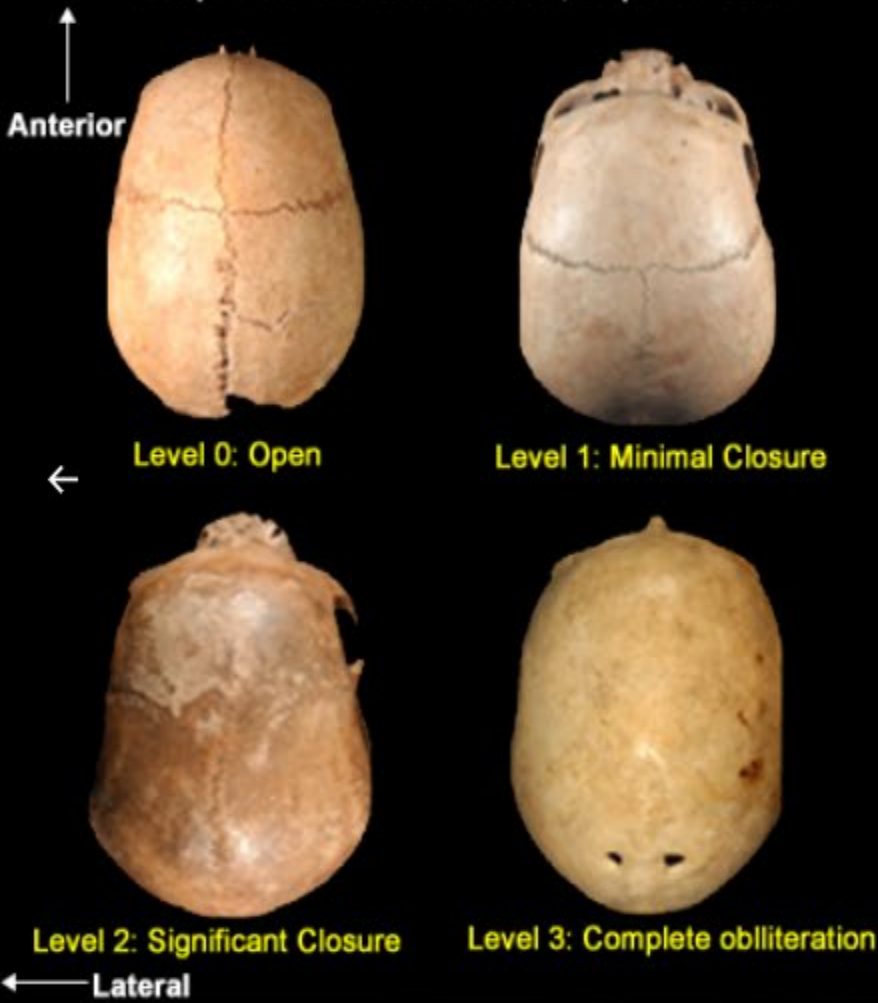
The skull can be used to [#estimate #age](#). 🧠

[#Cranial #sutures](#), the lines where the different sections of your skull join, are scored from a scale of 0 (open) to 3 (completely obliterated). The ratings are combined and provide an age range.

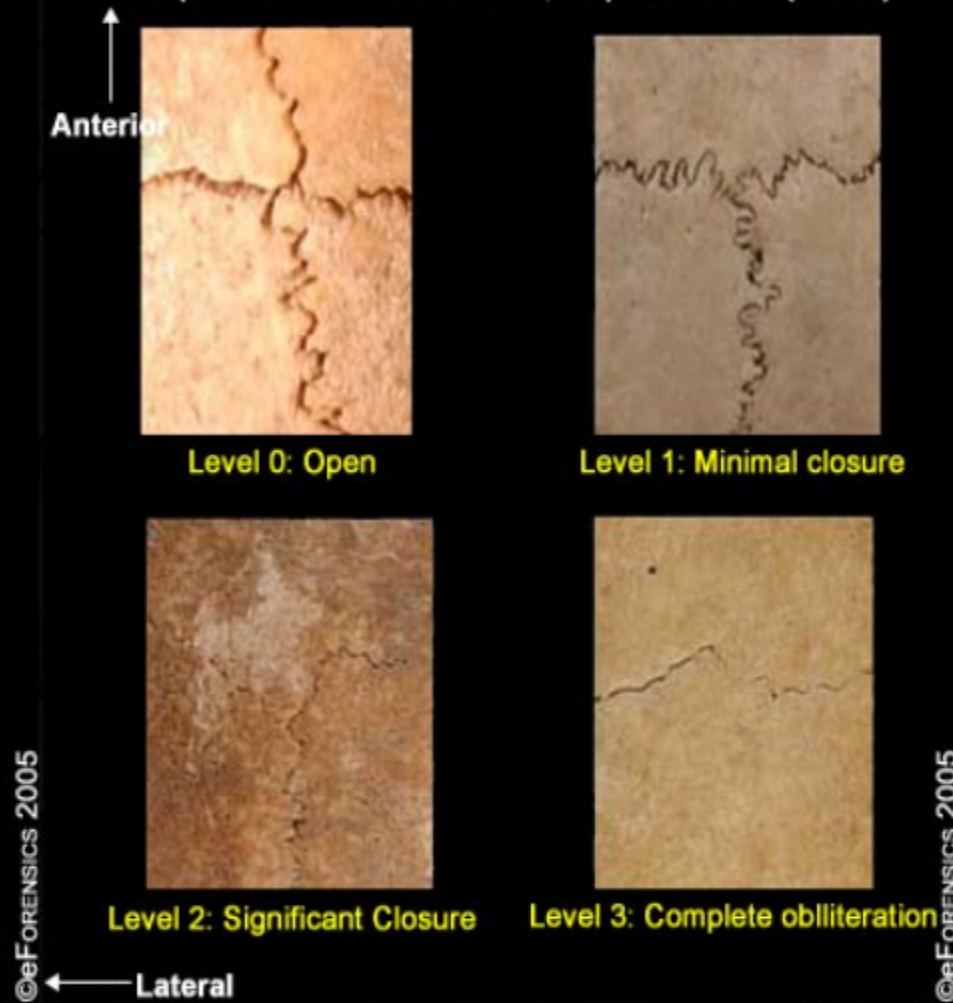
[#STEM #ForensicScience](#)



Comparative Cranial Sutures, Superior View



Comparative Cranial Sutures, Superior View (Detail)



Contrast ADULT skull vs baby skull

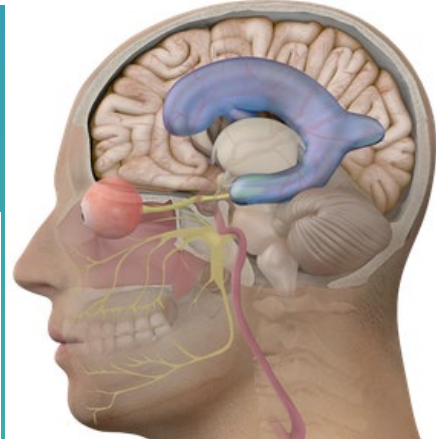
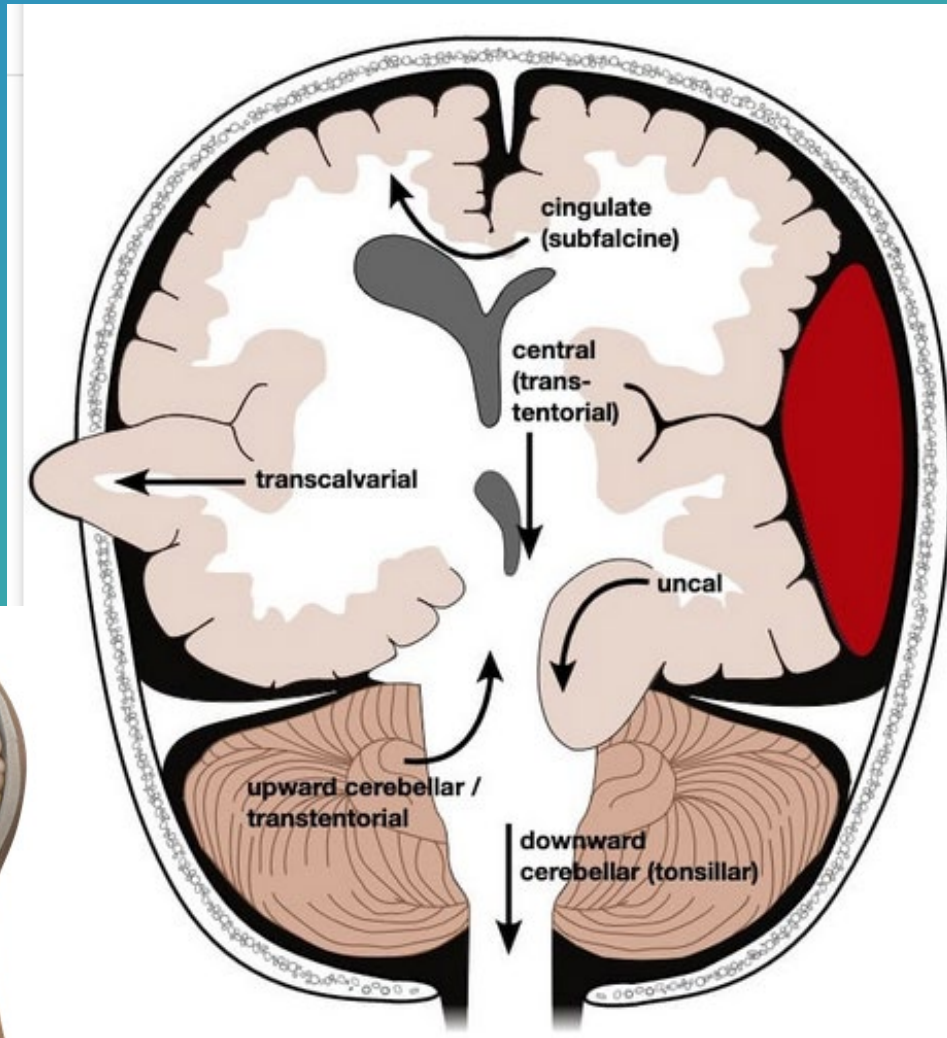
# SKULL/CRANIUM



Excess **CSF, blood** from trauma, infections or **tumors** inside the skull of an adult may herniate the brain because of lack of space.



# ADULT BRAIN HERNIATION



Hydrocephalus in adult

Enlarged brain ventricles | Copyright PNI

Brain Herniation • LITFL • CCC Neurology

Visit

**MEDULLA OBLONGATA:** Respiratory center, cardiovascular functions, swallowing.  
**CEREBELLAR TONSILS:** Coordinating movement in distal extremities.

Medullary Herniation due to Meningoencephalitis (inflammation produces edema).

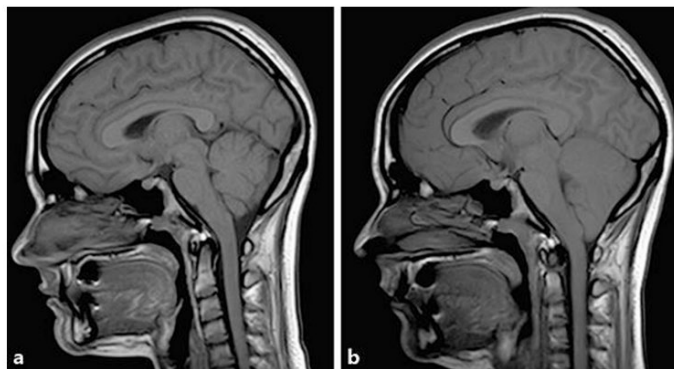
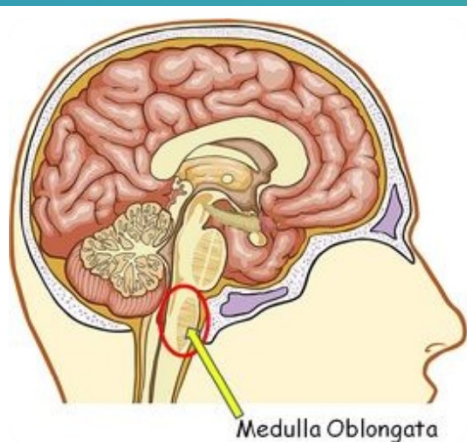
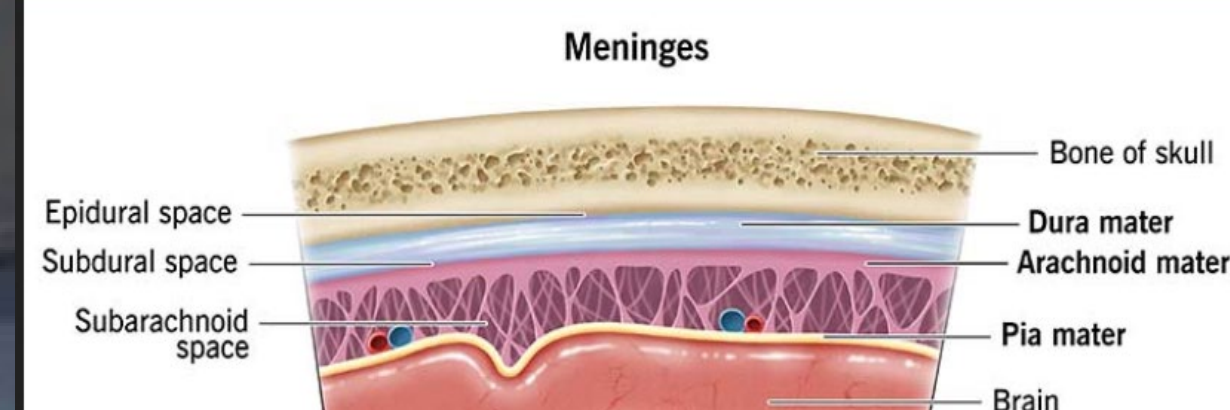
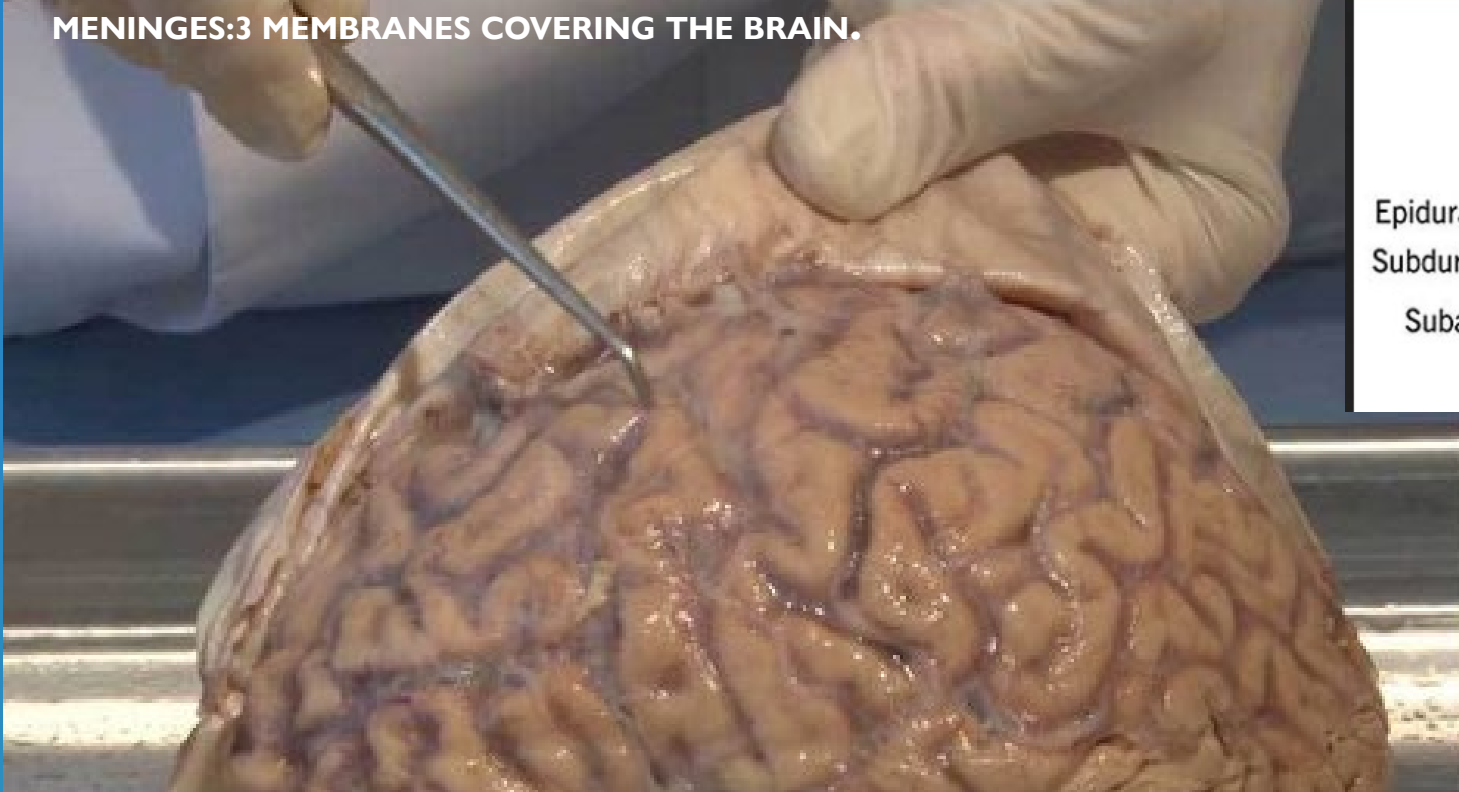


Fig. 1. a Sagittal T1 MRI brain prior to neurological deterioration. b Repeat MRI brain following neurological deterioration demonstrating new tonsillar herniation.

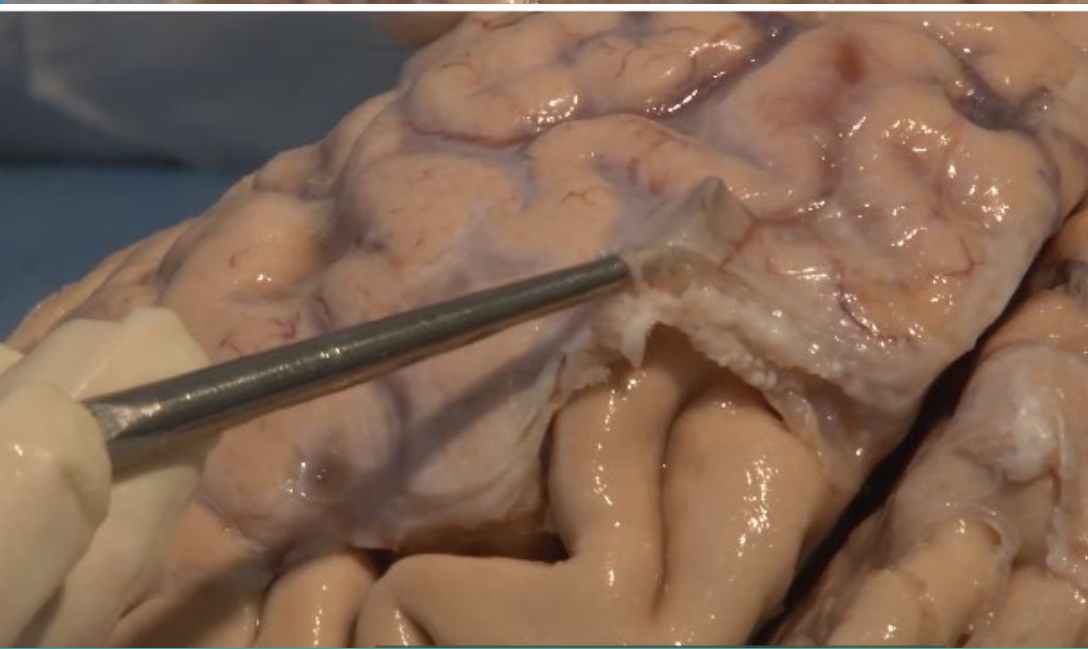


Medulla Oblongata

# MENINGES: 3 MEMBRANES COVERING THE BRAIN.



**DURA MATER**  
OUTER LAYER

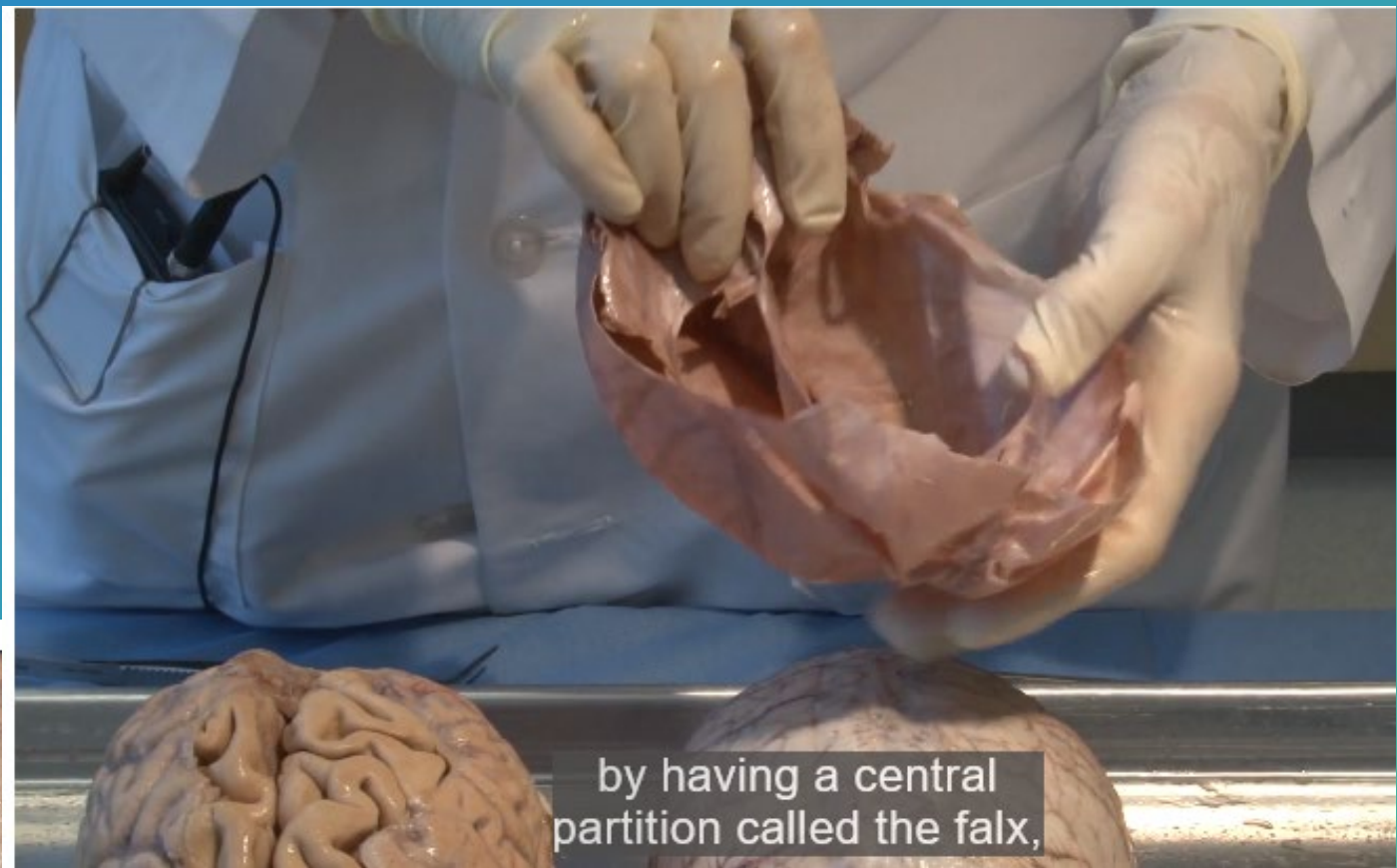
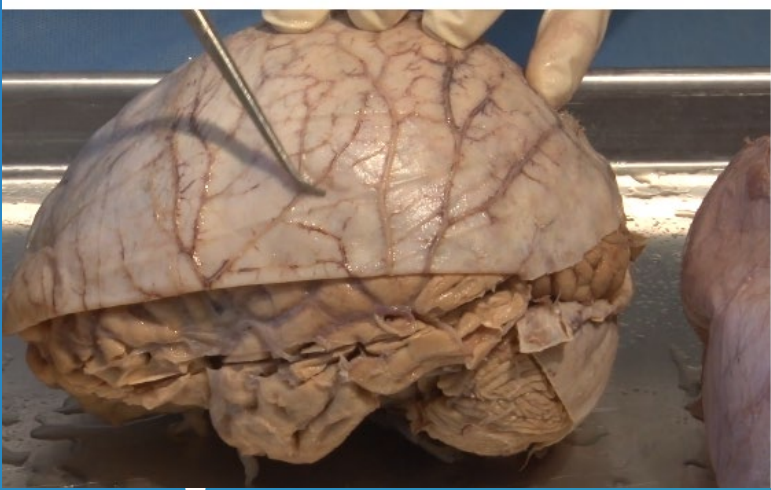


**ARACHNOIDS**  
  
(SUBARACHNOID SPACE WITH CSF)

**PIA MATER**  
INNER LAYER



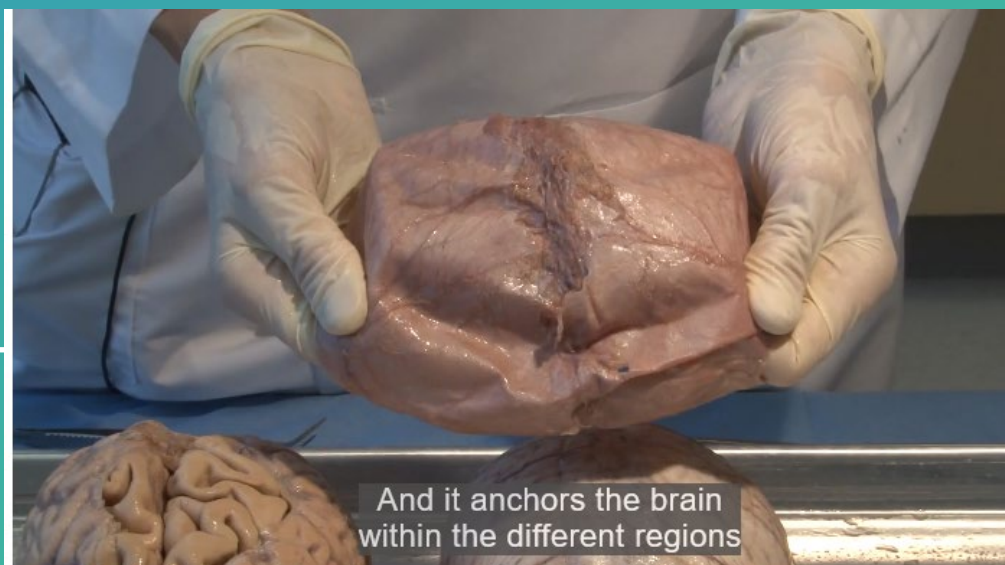
# MENINGES



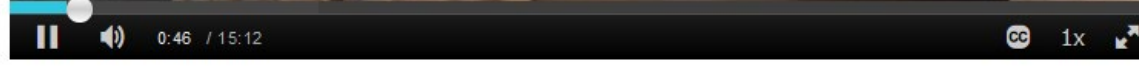
by having a central partition called the falx,

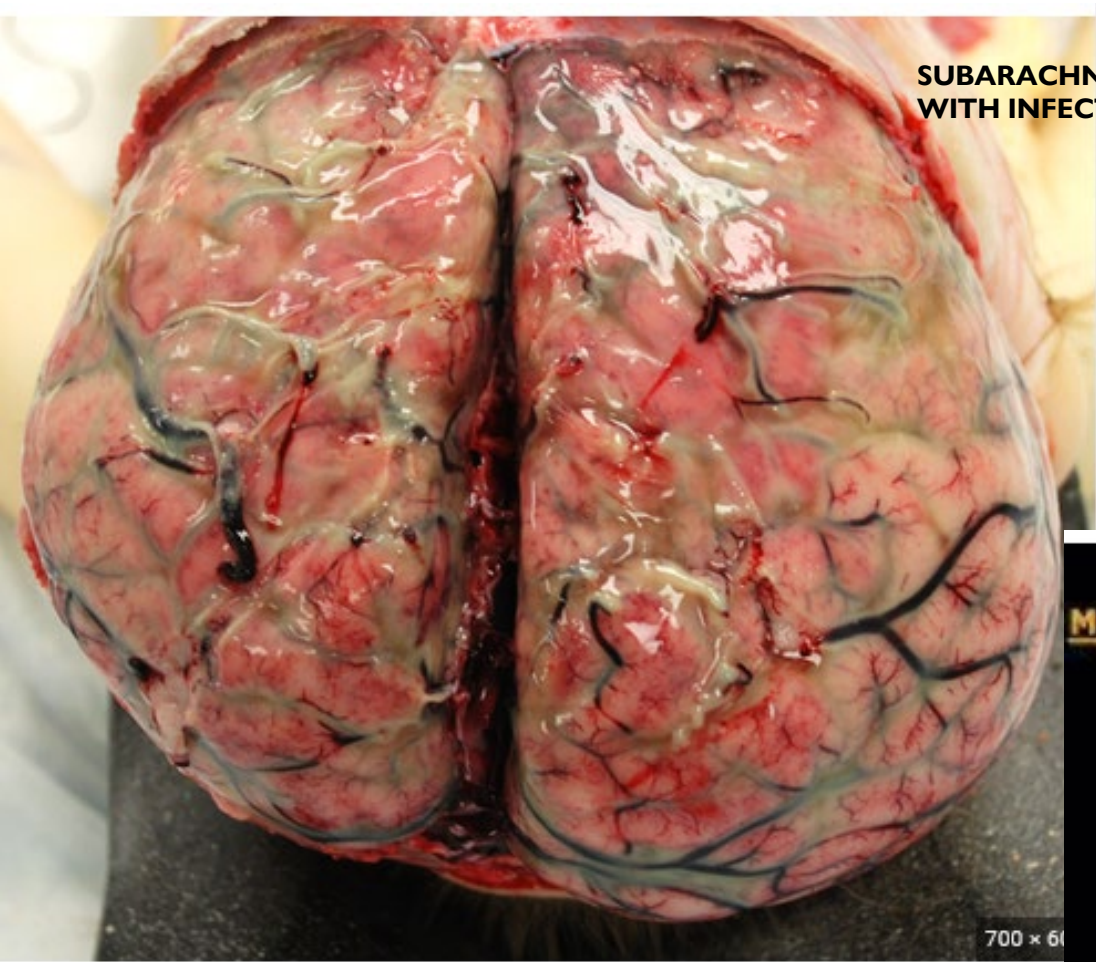


of the pia and the arachnoid that cover this bare gyrus

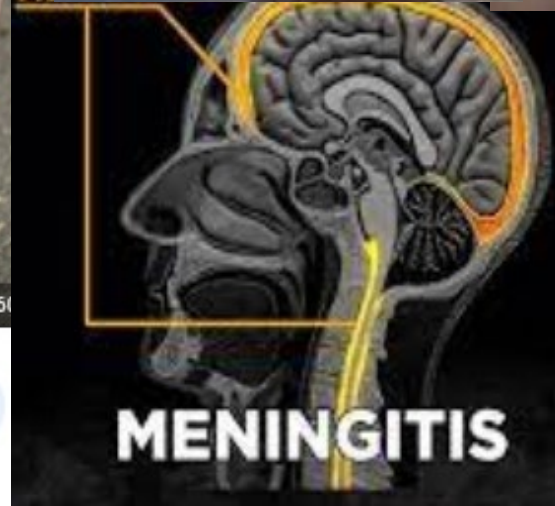
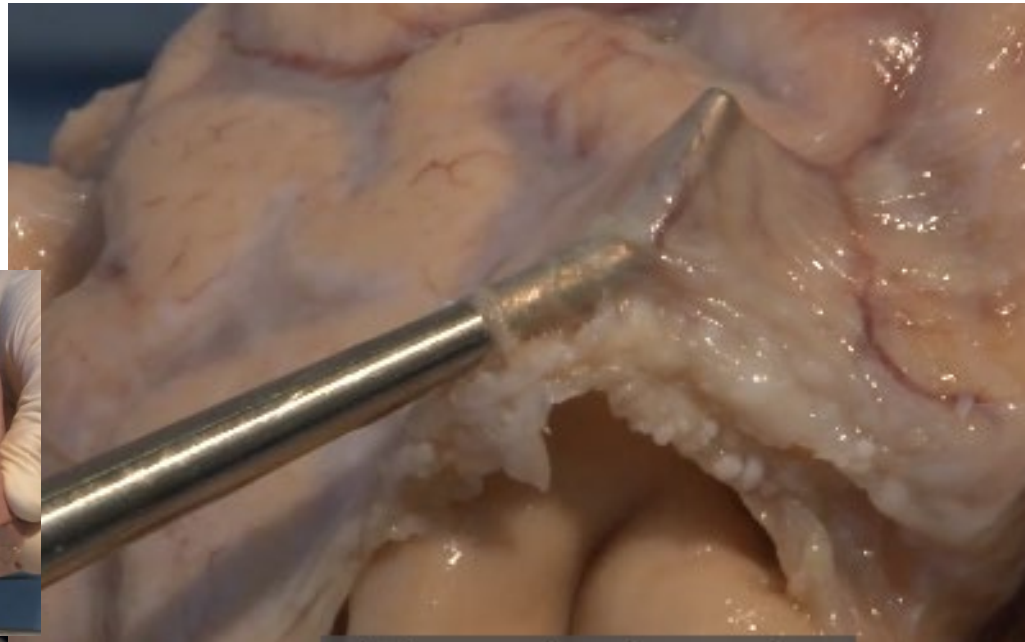


And it anchors the brain within the different regions



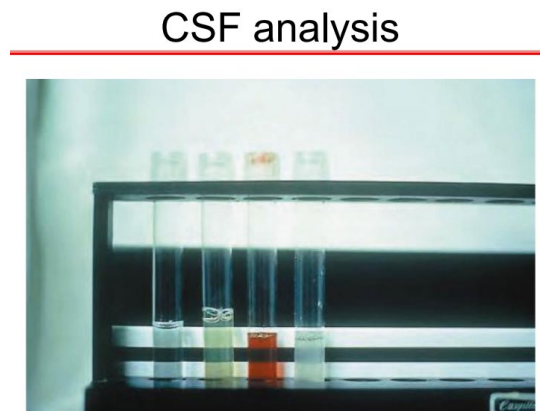


**SUBARACHNOID SPACE WITH INFECTED CSF.**



**MENINGIOMAS:**  
Tumors that arise from **MENINGES**.

**MENINGIOMAS NEVER** arise from the Brain.



**Figure 9-4** Tubes of CSF. Appearance left to right is normal, xanthochromic, hemolyzed and cloudy.

CSF analysis

Visit

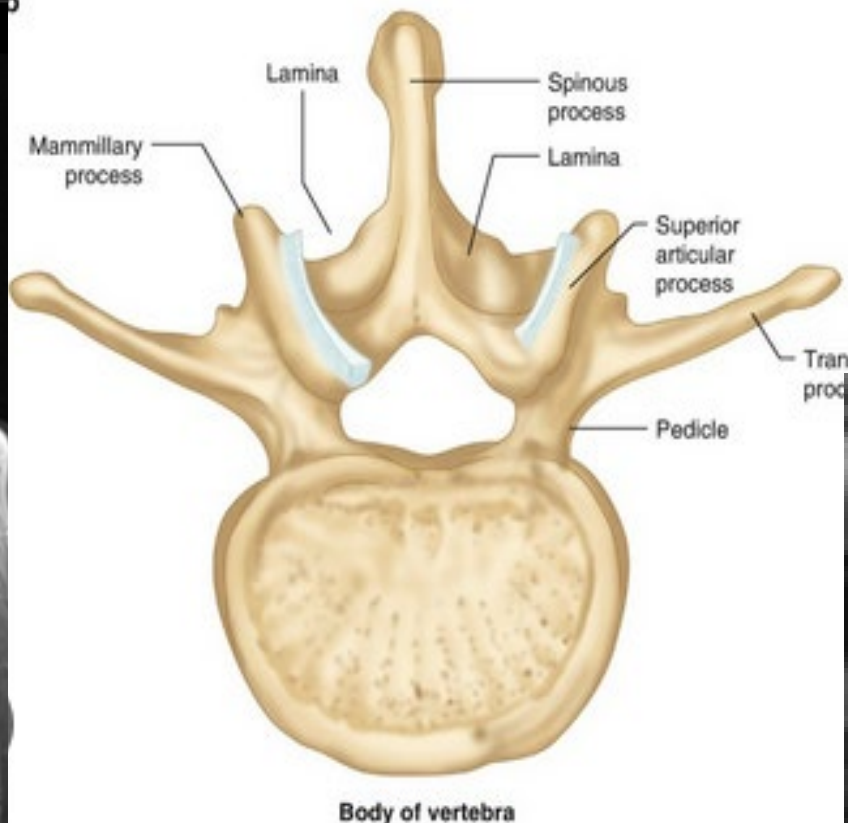
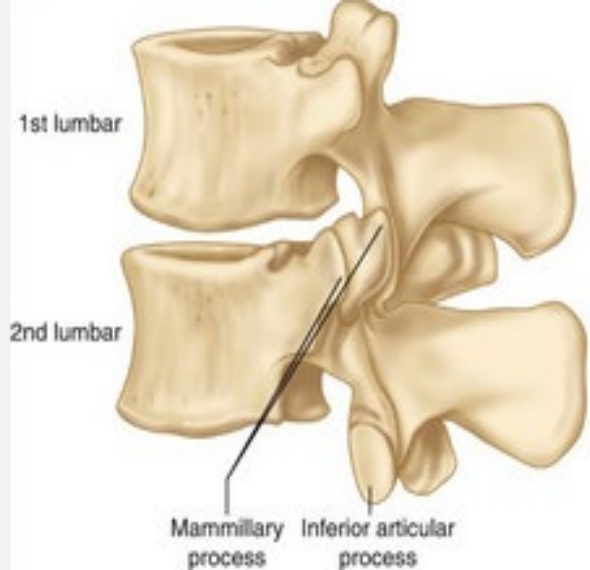
**MENINGES:** Protective membranes covering the brain.

**Dura mater** Under normal conditions, there's trauma to your brain (such as a brain bleed) or other medical condition.

The **subdural space** is a space between your dura mater and your arachnoid mater. Under normal conditions, this space isn't a space, but can be opened if there's trauma to your brain (such as a brain bleed) or other medical condition.

**Arachnoid mater** The **subarachnoid space** is a space between your arachnoid mater and pia mater. It's filled with cerebrospinal fluid. Cerebrospinal fluid cushions and protects your brain and spinal cord.

**Pia mater**

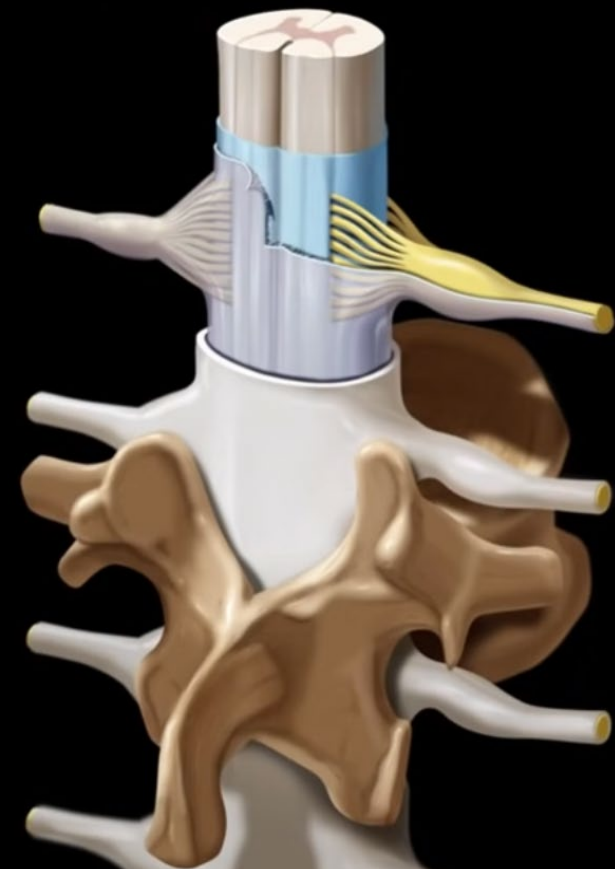


# SPINAL CORD

## • Meninges

- Dura mater
- Arachnoid mater
- Sub-arachnoid space
- Pia mater
- Dentate ligaments

STABILITY to the spinal cord.



## • SPINAL MENINGIOMA

All medical terms have a root word. -oma means tumor. Meningioma-meaning: tumor of the meninges.

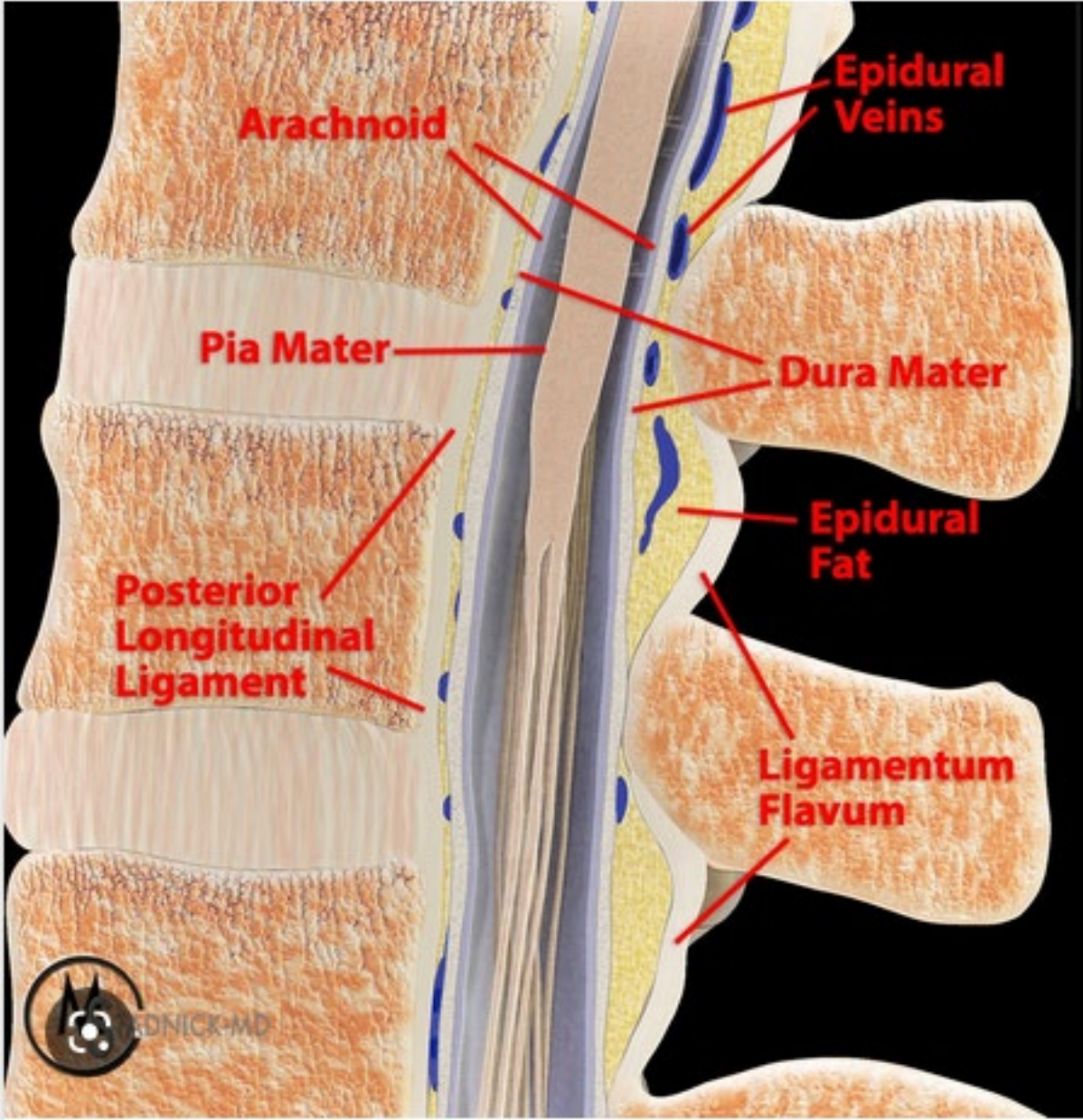
Difficulty walking or maintaining balance.

Weakness.

Pain at the tumor site.

Loss of bowel or bladder control.

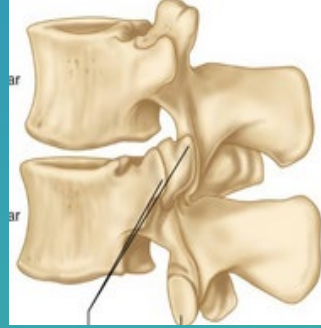




# SPINAL CORD MENINGES:

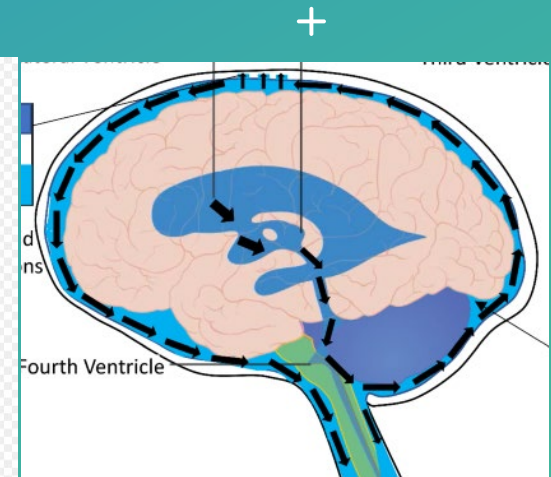
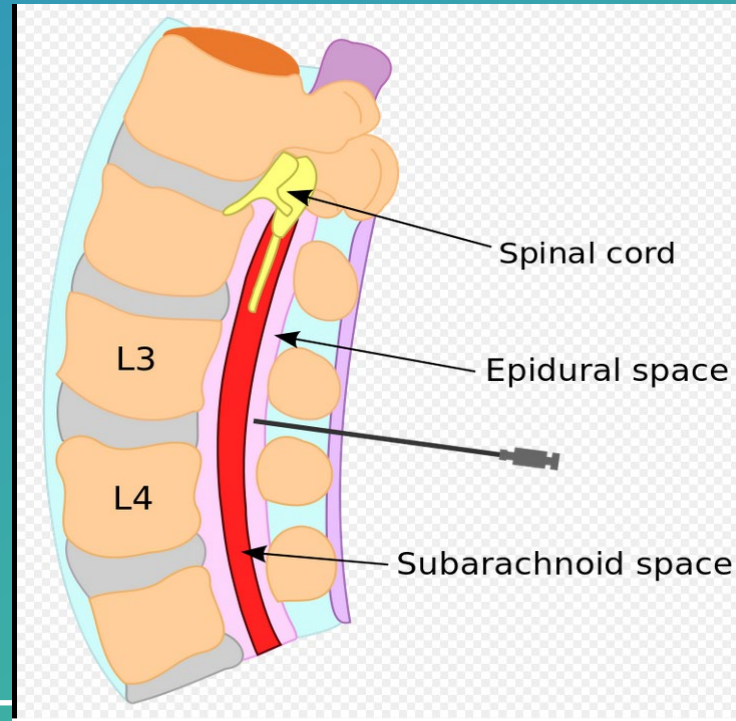
## Dura mater

## Arachnoid mater

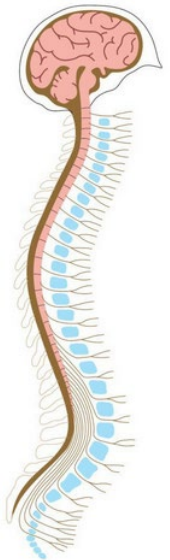


The **subarachnoid space** is a space between your arachnoid mater and pia mater. It's filled with cerebrospinal fluid. Cerebrospinal fluid cushions and protects your brain and spinal cord.

## Pia mater



The spinal cord ends between the first and second lumbar vertebra in the middle of your back, at which point, only cerebrospinal fluid is present. This is the site where a lumbar puncture (“spinal tap”) is performed. (Cleveland Clinic). Also in L4-L5.



CNS :

- Brain
- Spinal Cord

MENINGES :

Membranes that cover the CNS.

# MENINGIOMAS ARISE FROM MENINGES (CEREBRAL MENINGES/ SPINAL MENINGES)

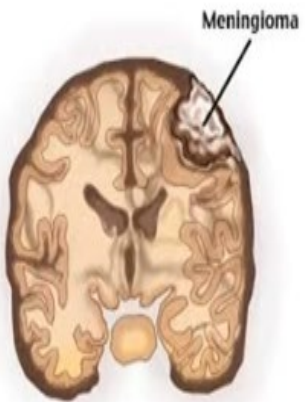


The brain shrinks with increasing age. Cerebral ATROPHY occurs naturally in all humans. But cell loss can be accelerated by: **injury, infection, dementia, stroke, and**

**Huntington's disease...**

...leads to cerebral atrophy

## MENINGIOMAS ARE DISTINCT FROM THE BRAIN



C70 MENINGES	
C70.0	<b>Cerebral meninges</b> Cranial dura mater Cranial meninges Cranial pia mater Falx cerebelli Falx cerebri Falx, NOS Intracranial meninges Intracranial arachnoid Tentorium cerebelli Tentorium, NOS
C70.1	<b>Spinal meninges</b> Spinal arachnoid Spinal dura mater Spinal pia mater
C70.9	<b>Meninges, NOS</b> Arachnoid, NOS Dura, NOS Dura mater, NOS Pia mater, NOS

C71 BRAIN

### INTRACRANIAL

Meningioma in PARIETAL LOBE: code to cerebral meninges. Do NOT code to Brain.

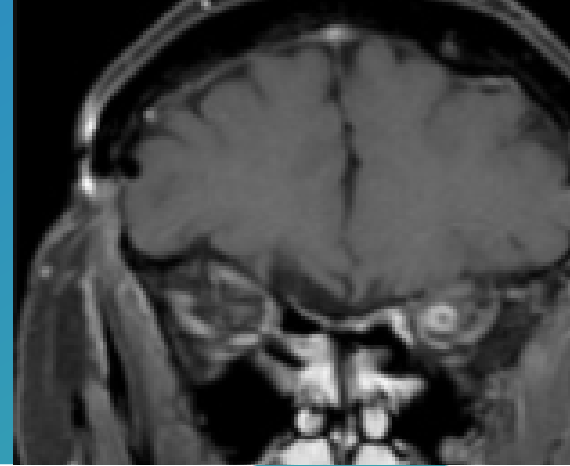
### Spinal Cord

ICD-0  
THIRD  
EDITION





Optic Nerve Sheath  
**Meningiomas** (ONSM) are  
**uncommon, benign**  
**neoplasms originating**  
**from the**  
**meningothelial cells of**  
**the meninges**  
**surrounding the optic**  
**nerve.**

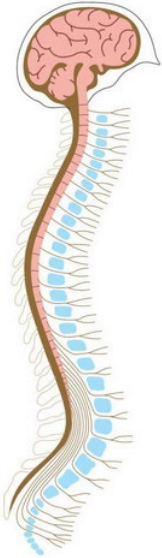


OBITS: TINY 4-5 MM FOCUS  
LT OPTIC CANAL  
INSEPARABLE FROM LT  
OPTIC NERVE SHEATH  
RAISING STRONG  
SUSPICION FOR TINY OPTIC  
NERVE SHEATH  
MENINGIOMA. ASSOCIATED  
MASS EFFECT ON LT OPTIC  
NERVE & LT OPTIC NERVE  
ATROPHY.

MRI OBITS:  
SUBTLE  
MENINGIOMA  
OF LT OPTIC  
NERVE/ORBITAL  
APEX 4MM.



# Benign Brain Tumor Cancer Registries Amendment Act



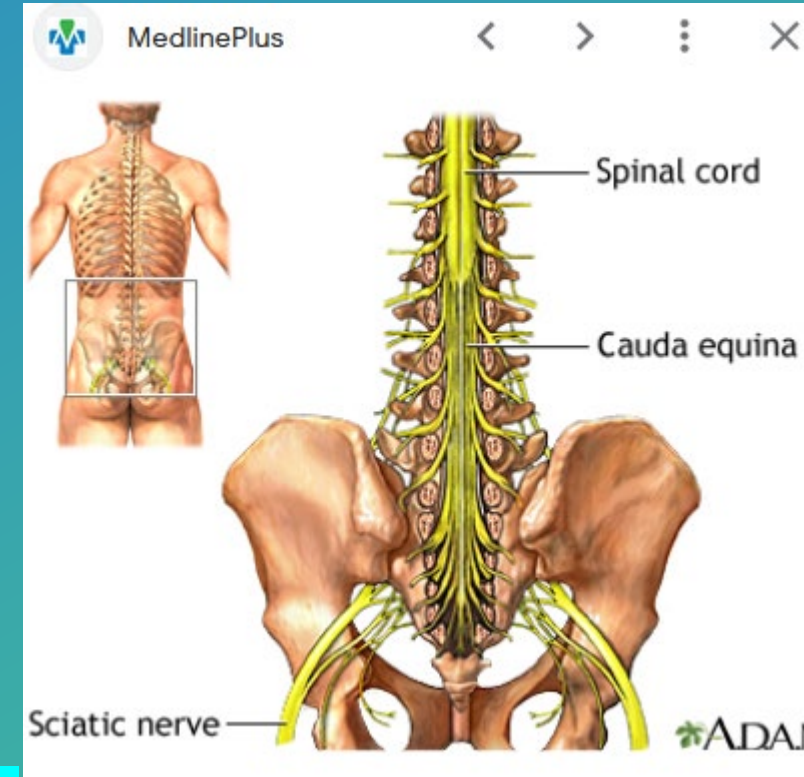
## Definitions of Reportable Cases

The Benign Brain Tumor Cancer Registries Amendment Act refers to CNS tumors as “brain-related tumors.” The law defines these tumors as follows:

The term ‘brain-related tumor’ means a listed primary tumor (whether malignant or benign) occurring in any of the following sites:

- (I) the brain, meninges, spinal cord, cauda equina, a cranial nerve(s), or any other part of the central nervous system,
- (II) the pituitary gland, pineal gland, or craniopharyngeal duct.

Spinal cord ends between L1-L2

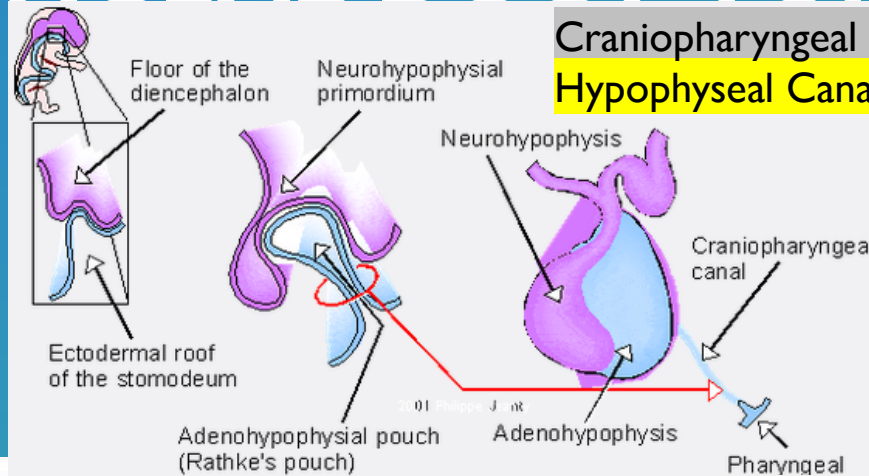


The collection of nerves at the end of the spinal cord is known as the cauda equina, due to its resemblance to a horse's tail.

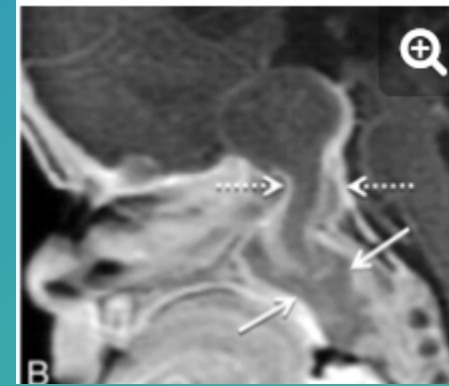
Craniopharyngiomas are different than Craniopharyngeal duct/channel defect tumors but they both share embryology defects from Pituitary development/Rathke's pouch

# CRANIOPHARYNGEAL DUCT TUMORS

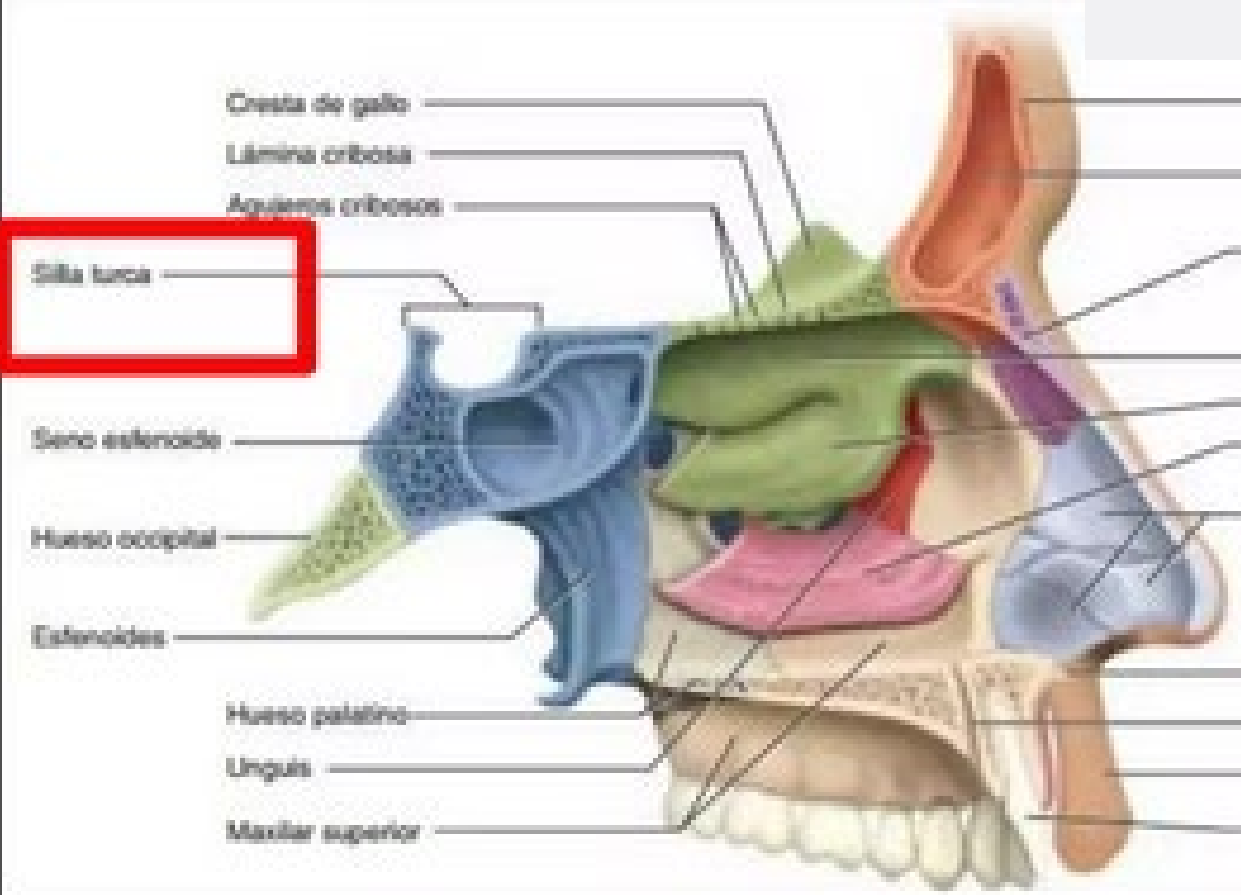
Craniopharyngeal duct is a **bony channel embryological defect** that connects the floor of the Sella turcica, along the midline, to the nasopharynx. AKA **persistent craniopharyngeal canal (CPC)** It is thought that the structure either results from incomplete closure of Rathke's pouch or is a former vascular channel remaining from ossification of the sphenoid during development.



Craniopharyngeal duct aka as **Persistent Hypophyseal Canal or CPC**

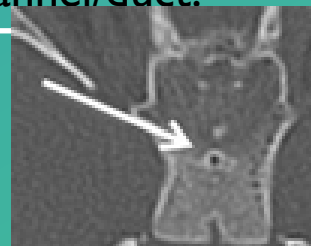


herniated CSF and the adenohypophysis (dashed arrow). This is a type 3B CPC. B, Sagittal T1 postcontrast MR image in an 8-week-old girl who underwent imaging for a nasopharyngeal mass demonstrates a nasopharyngeal glioma (arrows), with mild enhancement extending into the suprasellar space through a large CPC (dashed arrows). This is a type 3C CPC.



**Persistent Craniopharyngeal duct with ectopic pituitary teratoma**

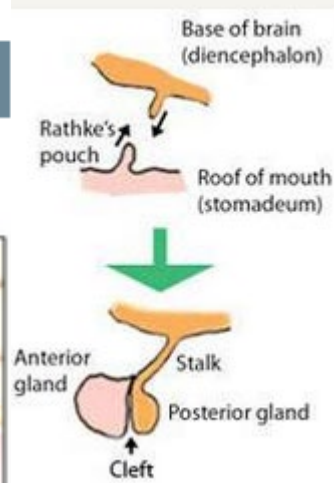
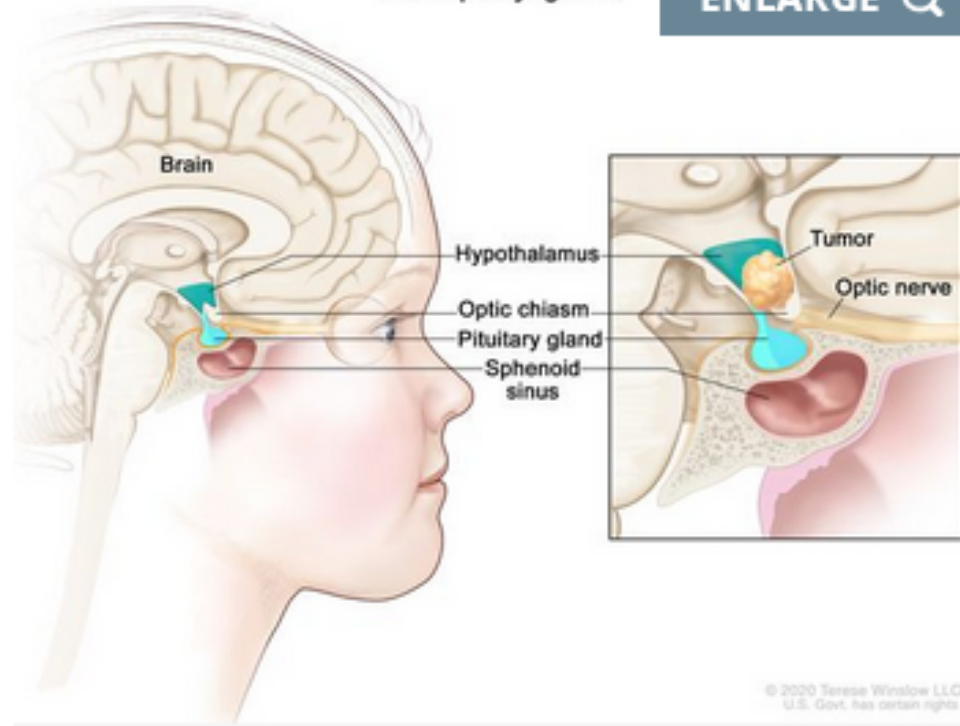
Normally should be **NO communication channel/duct.**





Craniopharyngioma

ENLARGE 🔍

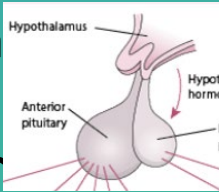


# Craniopharyngioma (Rathke's pouch tumor)

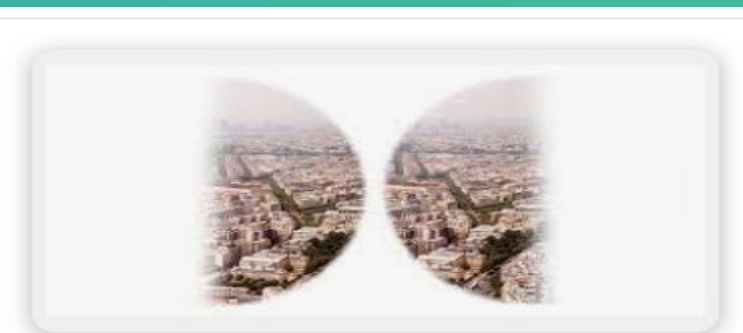
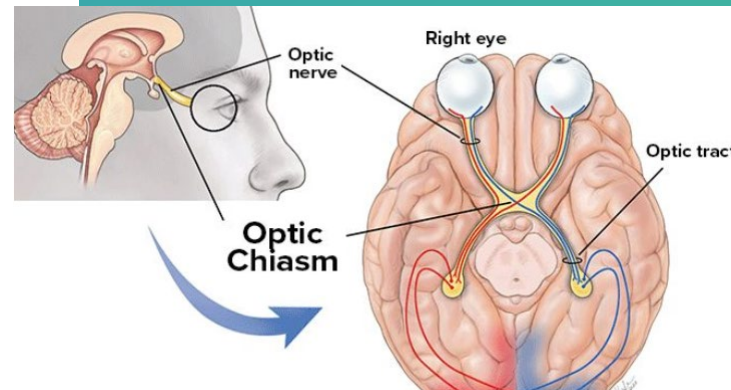
The place where the anterior and posterior glands meet is called Rathke's pouch. Rathke's pouch will develop into the anterior pituitary or adenohypophysis. Craniopharyngiomas develop from embryonic remnants of the Rathke's pouch epithelium.

Visual impairment (blurred, temporal hemianopia), headache, endocrine deficiency. Bimodal presentation: 5-15 and 45-60 y/o.

**Bitemporal hemianopsia** (or bitemporal hemianopia) describes the ocular defect that leads to impaired peripheral vision in the outer temporal halves of the visual field of each eye.



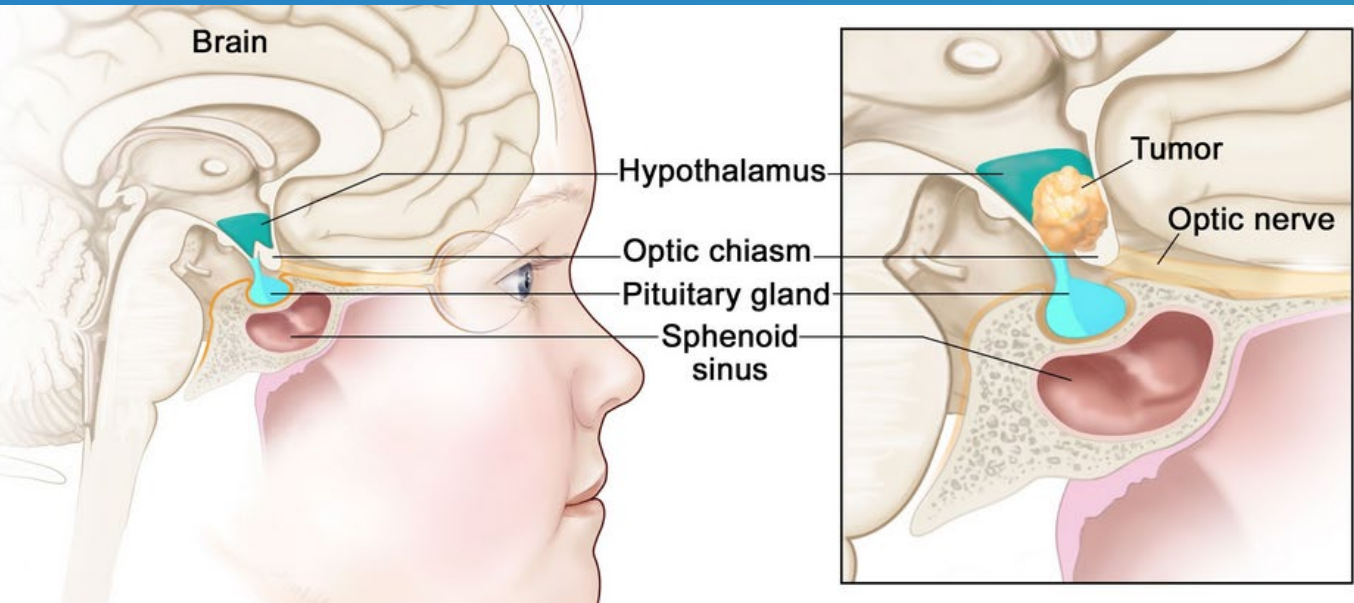
Craniopharyngiomas are rare brain tumors that usually form near the pituitary gland and the hypothalamus. They are benign (not cancer) and do not spread to other parts of the brain or to other parts of the body. However, they may grow and press on nearby parts of the brain, including the pituitary gland, optic chiasm, and optic nerve. Craniopharyngiomas usually occur in children and young adults.



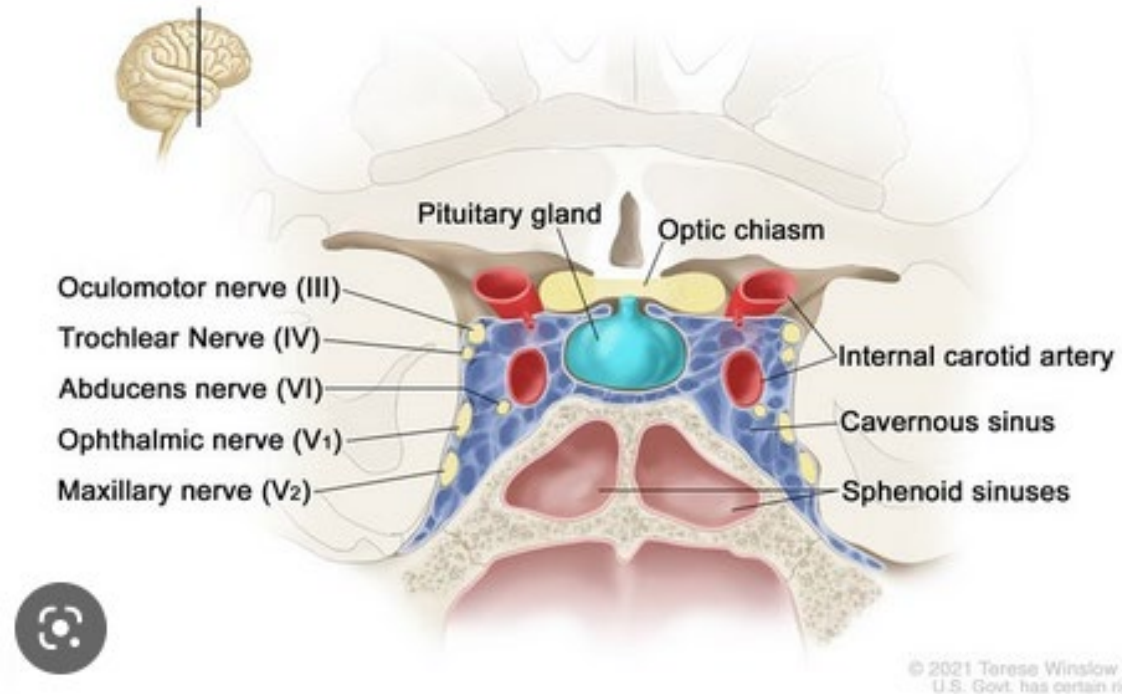
Wikipedia

Bitemporal hemianopsia - Wikipedia

# CRANIOPHARYNGIOMA



## Areas of the Brain That May Be Affected by Craniopharyngioma



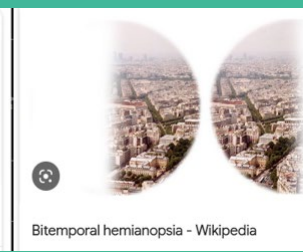
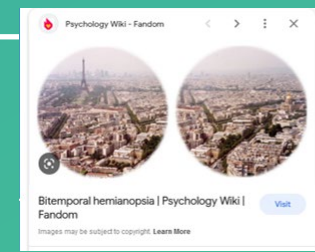
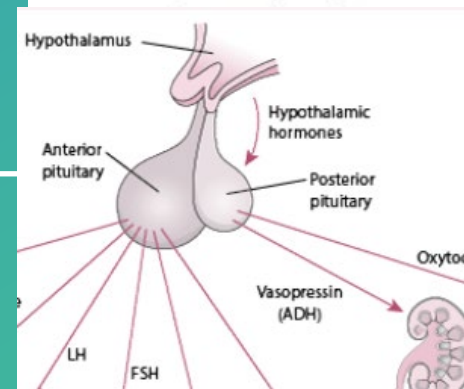
Craniopharyngioma, Child, HP: Image

Visit

Craniopharyngioma can produce panhypopituitarism and diabetes insipidus. What is panhypopituitarism? Panhypopituitarism is **a condition in which the production and secretion of all hormones by the pituitary gland is reduced.**

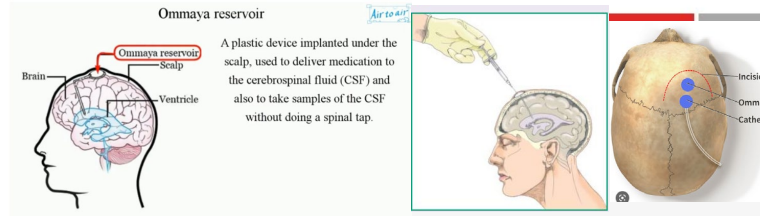
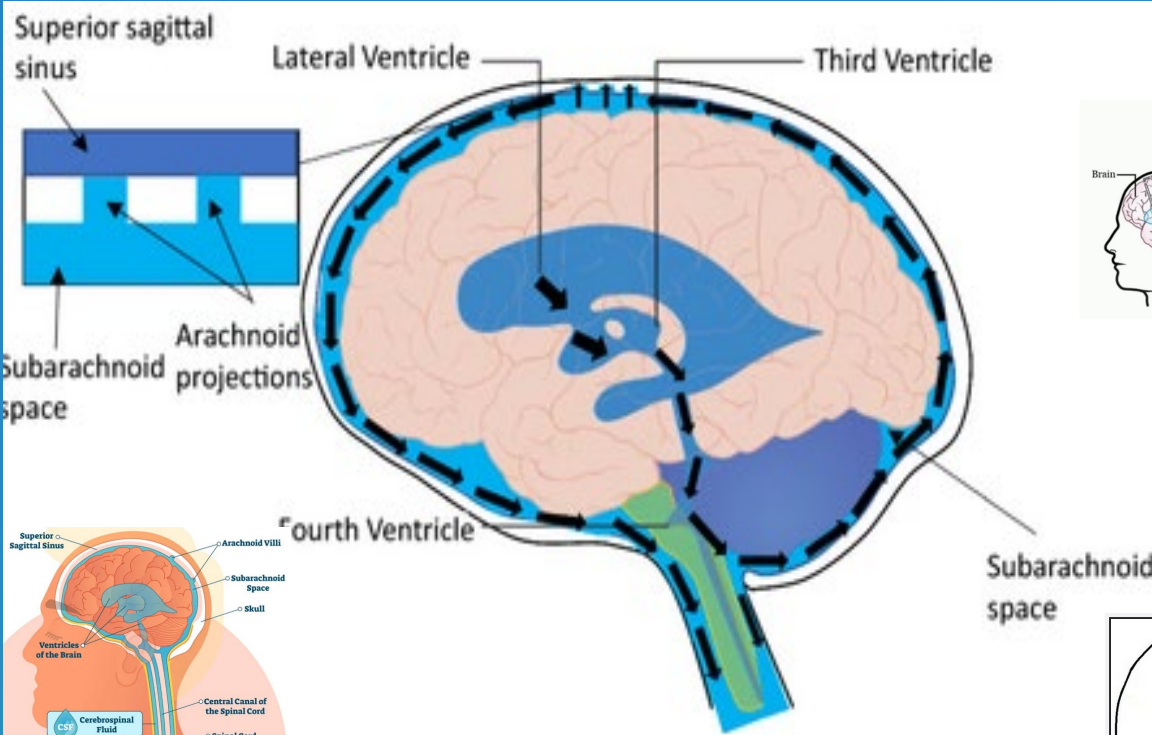
Diabetes INSIPIDUS is a rare and treatable condition in which your body produces too much urine (polyuria, polydipsia). Diabetes insipidus is mostly caused by an issue with how your body makes and uses antidiuretic hormone (ADH, or vasopressin).

DIABETES MELLITUS IS DIFFERENT THAN DIABETES INSIPIDUS. Both may make you drink liters of water (polydipsia), polyuria.

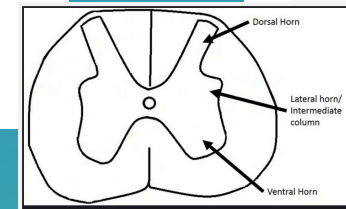
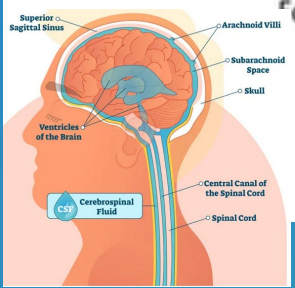
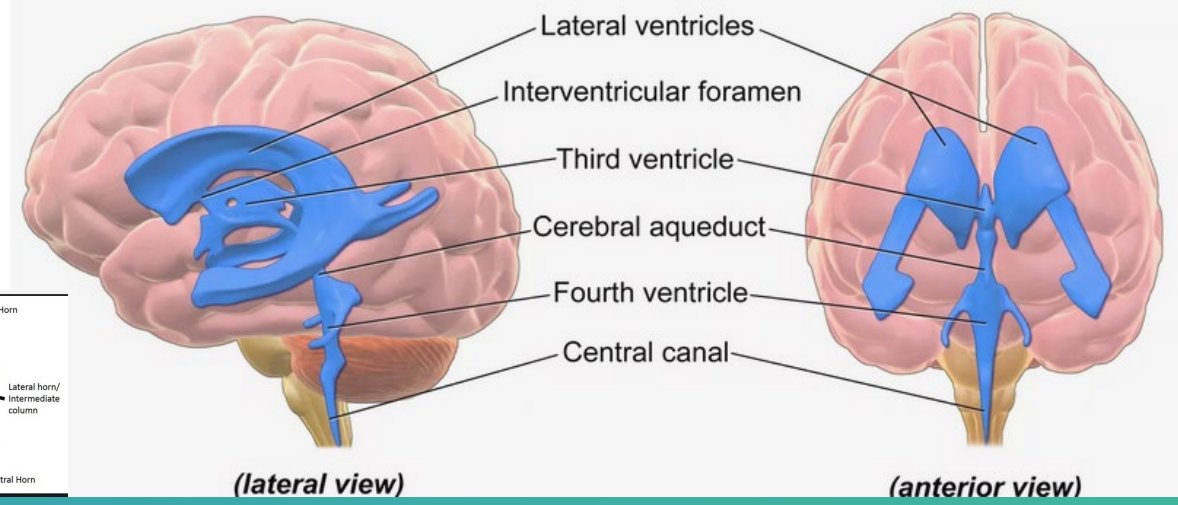


# Ventricular System of the Brain

PRINT

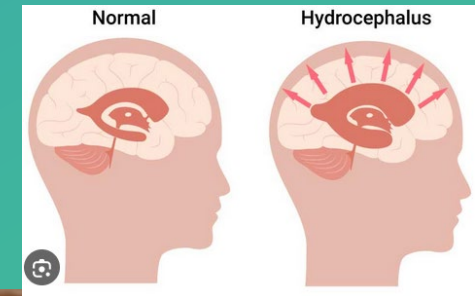
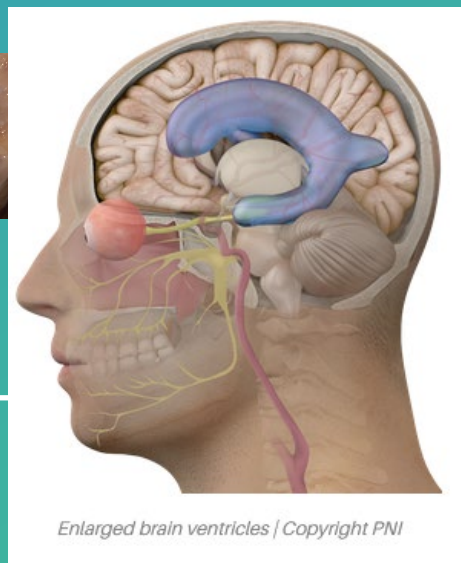
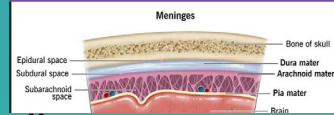
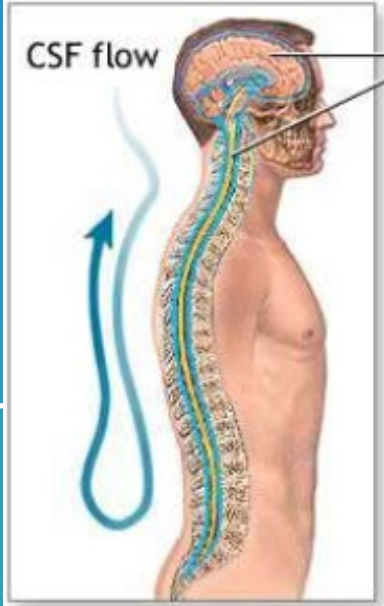


EMAIL



**The CNS (Central Nervous System)** is composed of the brain and the spinal cord

**The CSF (Cerebro Spinal Fluid)** assists the brain by providing protection, nourishment, and waste removal.  
 --CSF acts as a shock absorber, cushioning the brain against the skull.  
 ---CSF allows the brain and spinal cord to become buoyant, reducing the effective weight of the brain from its normal 1,500 grams to a much lesser 50 grams.



# BRAIN PATHOGEN BARRIERS

## -Blood-brain barrier

was discovered in the late 19th century, when the German physician Paul Ehrlich injected a dye into the bloodstream of a mouse. To his surprise, the dye infiltrated all tissues except the brain and spinal cord.

## -Blood-CSF barrier

The purpose is to protect against circulating toxins or pathogens that could cause brain infections, while at the same time allowing vital nutrients to reach the brain.

## Blood-Brain Barrier in diseases

The blood-brain barrier may become leaky in many neurological diseases, such as amyotrophic lateral sclerosis, epilepsy, brain trauma .



amyotrophic lateral sclerosis



epilepsy



brain trauma

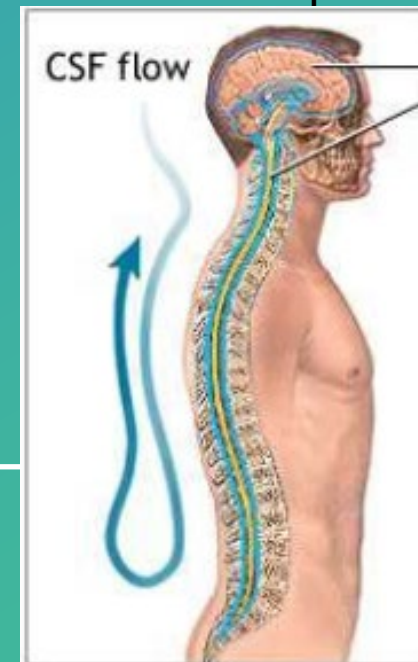
Animapix  
Bio  
and  
Art

**Leptomeningeal disease** occurs when cancer cells migrate from your breast, lung, or some other part of your body to your cerebrospinal fluid (CSF). Leptomeninges: Arachnoid and Pia mater.



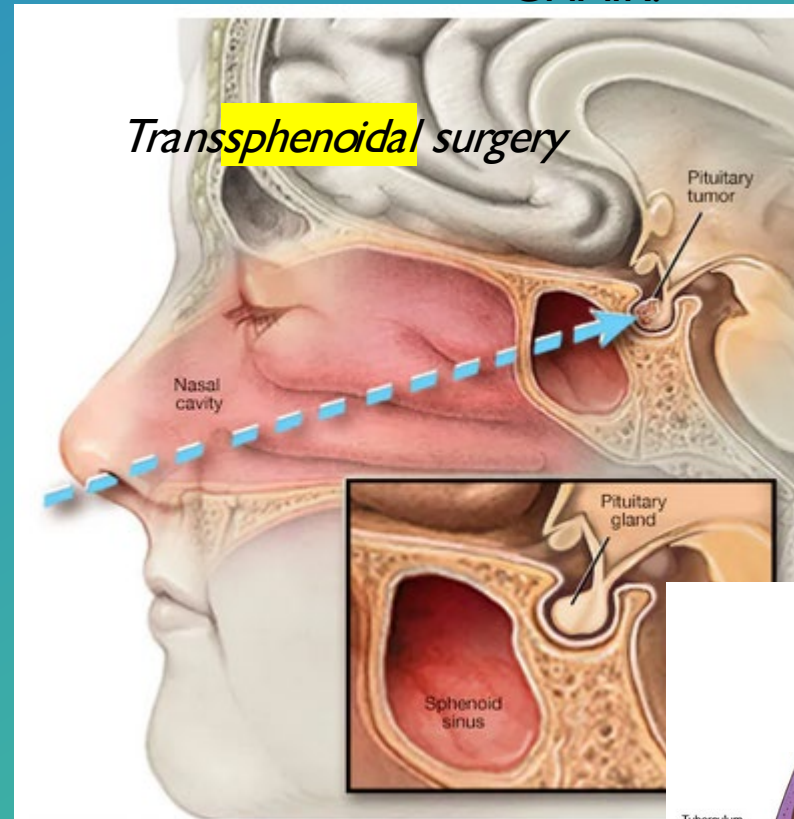
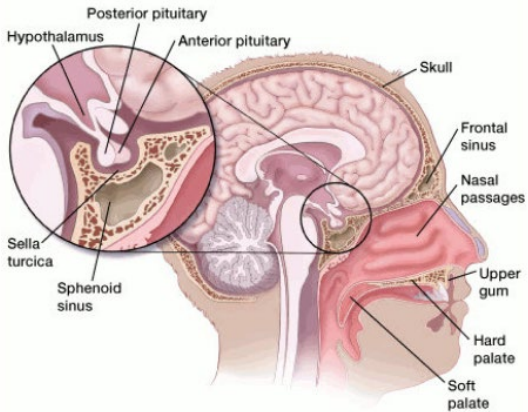
**Leptomeningeal disease** occurs here in the **Subarachnoid space!** Where the **CSF** circulates.

Leptomeninges: **the two innermost layers of the meninges**; cerebrospinal fluid circulates between these innermost layers (**Arachnoid** mater (web-like), and **Pia** mater).

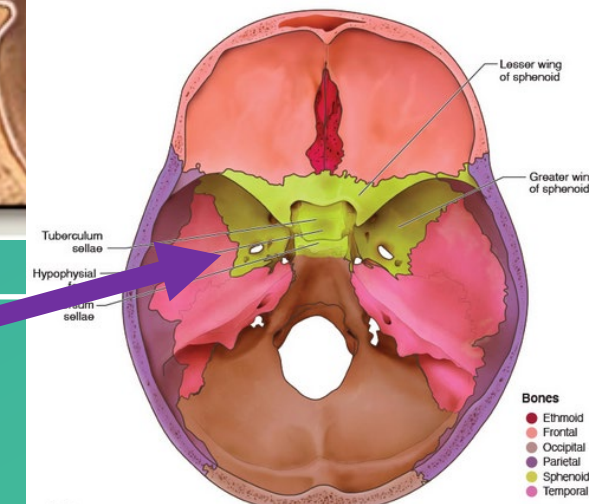
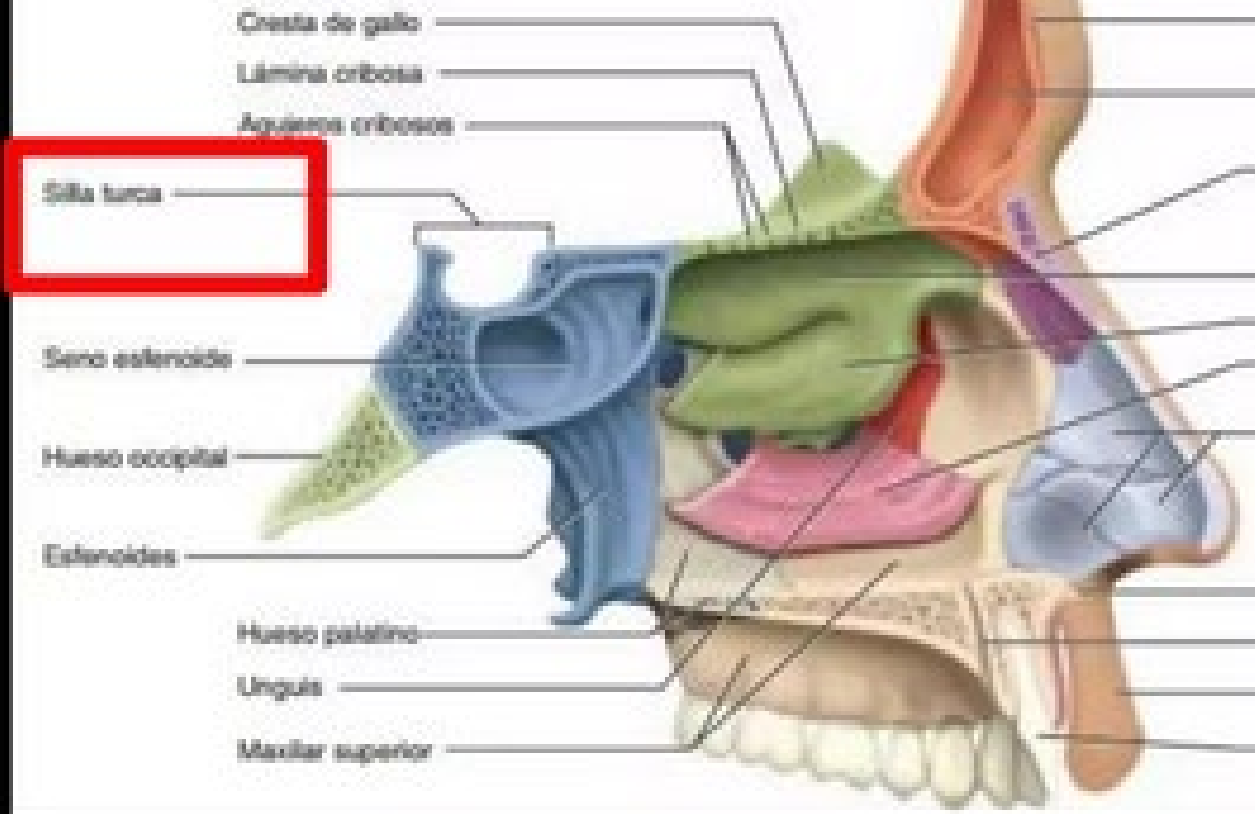


# MASTER GLAND PITUITARY GLAND SITS ON A CHAIR

“Sella Turcica” translated to Spanish is Turk CHAIR.

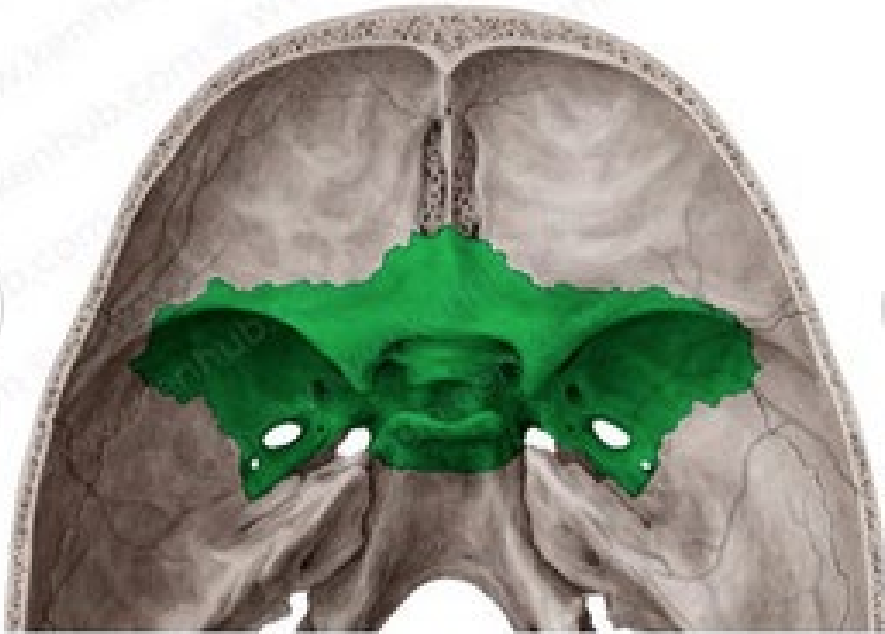


+  
○  
●

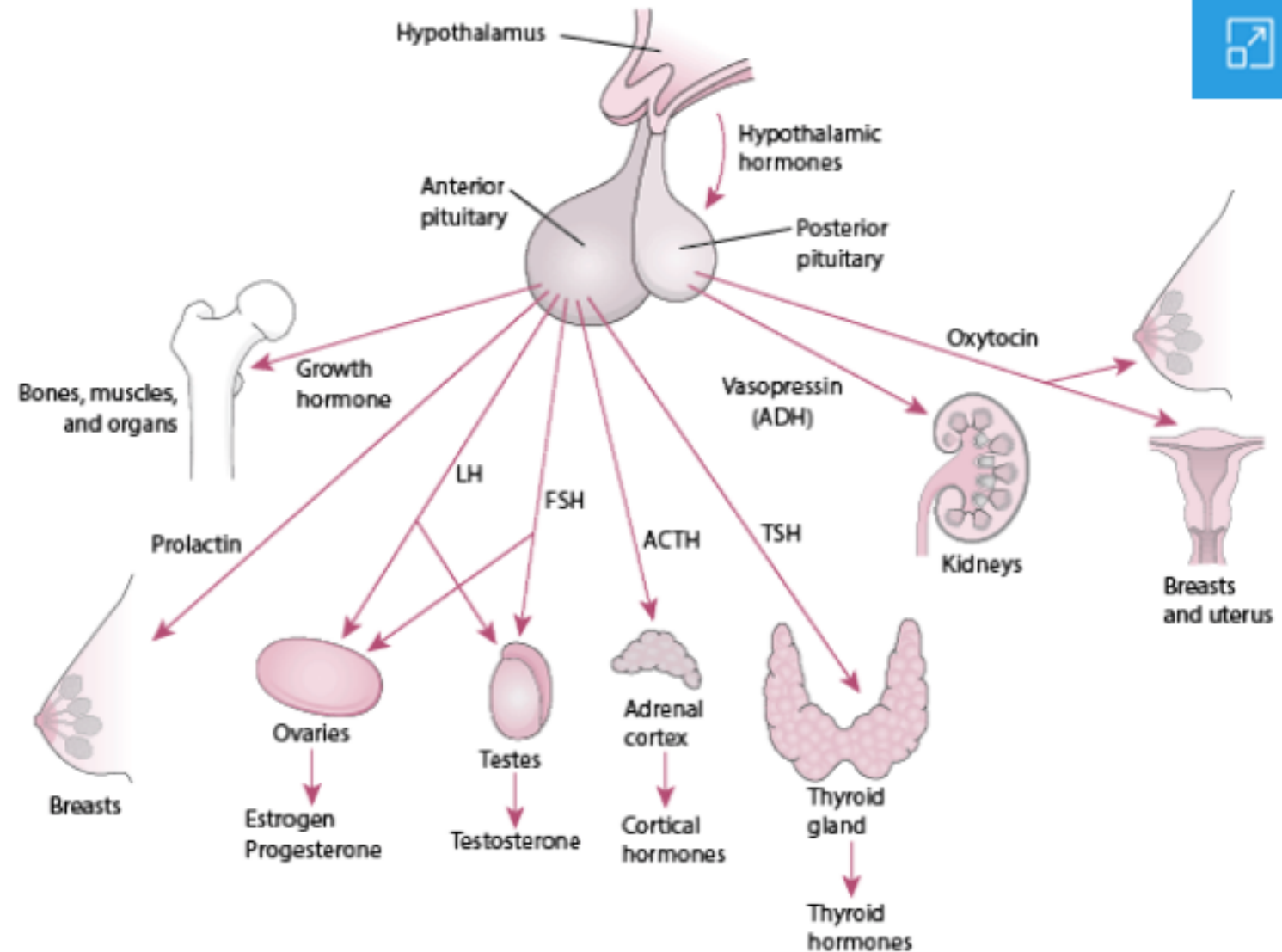


sphenoid bone in green.

# SPHENOID BONE



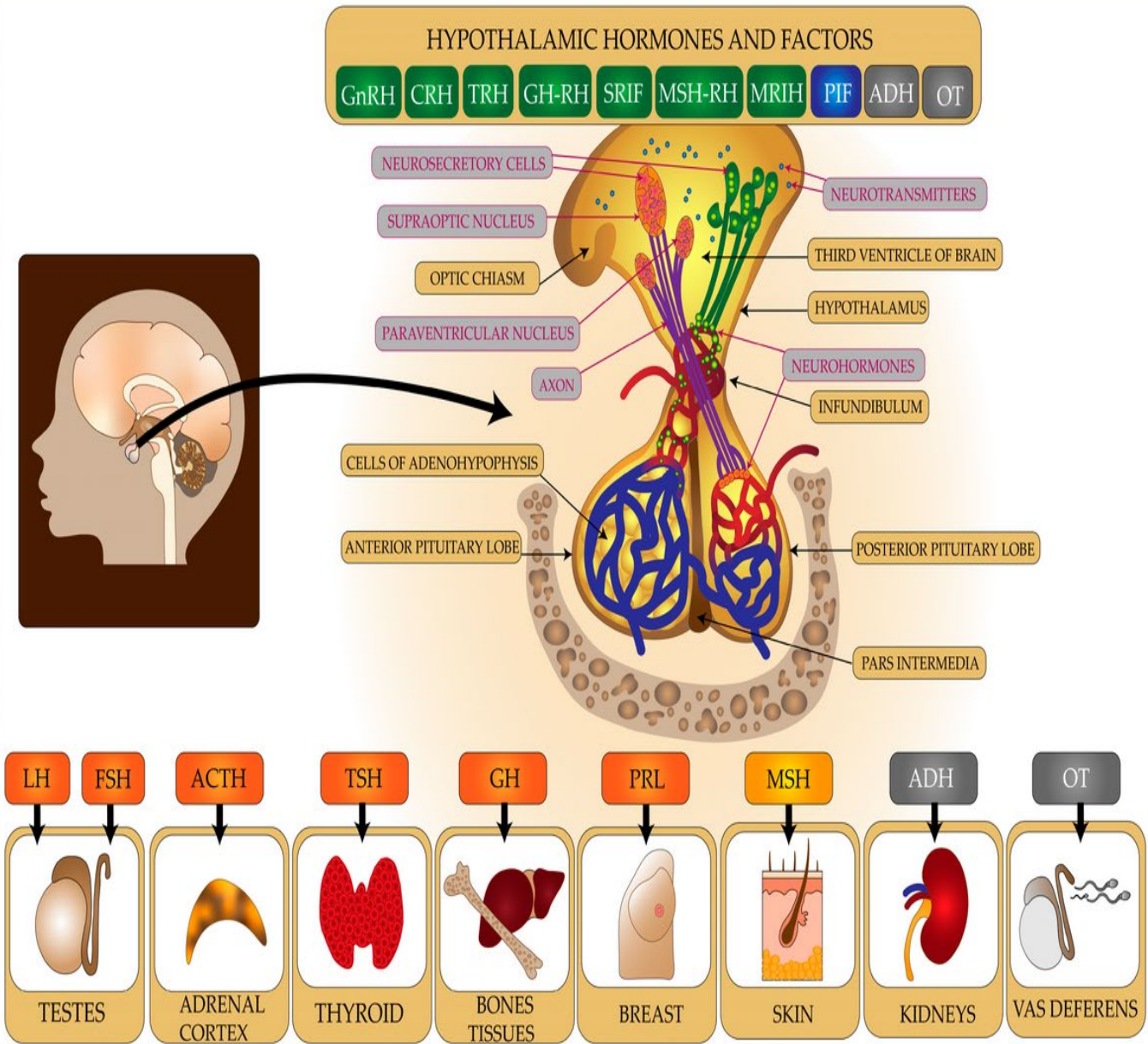
## The Pituitary and Its Target Organs



## Pituitary Adenomas

Pituitary adenomas are the fourth most common intracranial tumor after gliomas, meningiomas and schwannomas. A large majority of pituitary adenomas are benign and are relatively slow growing. Adenomas are by far the most common disease affecting the pituitary gland. These tumors most commonly affect people in their 30s or 40s, although they can be diagnosed in children as well.

# HYPOTHALAMIC-HYPOPHYSIS AXIS



- **PITUITARY MICROADENOMAS:** tumors smaller than 10 millimeters are called often secrete anterior pituitary hormones. These smaller, functional adenomas are usually detected earlier because the increased levels of hormones cause abnormal changes in the body: Endocrine Dysfunction. Approximately 50 percent of pituitary adenomas are diagnosed when they are smaller than 5 millimeters in size.

- **PITUITARY MACROADENOMAS**

Adenomas larger than a dime coin size (10 millimeters) are usually do not secrete hormones. These tumors often produce symptoms by “mass effect,” compressing nearby brain or cranial nerve structures.

**The functioning** (endocrine-active) tumors include almost 70% of pituitary tumors which produce 1 or 2 hormones that are measurable in the serum and cause definite clinical syndromes, that are classified based on their secretory product(s).

**Non-functioning adenomas** are endocrine-inactive tumors.

## PITUITARY MICROADENOMAS:

### Endocrine dysfunction.

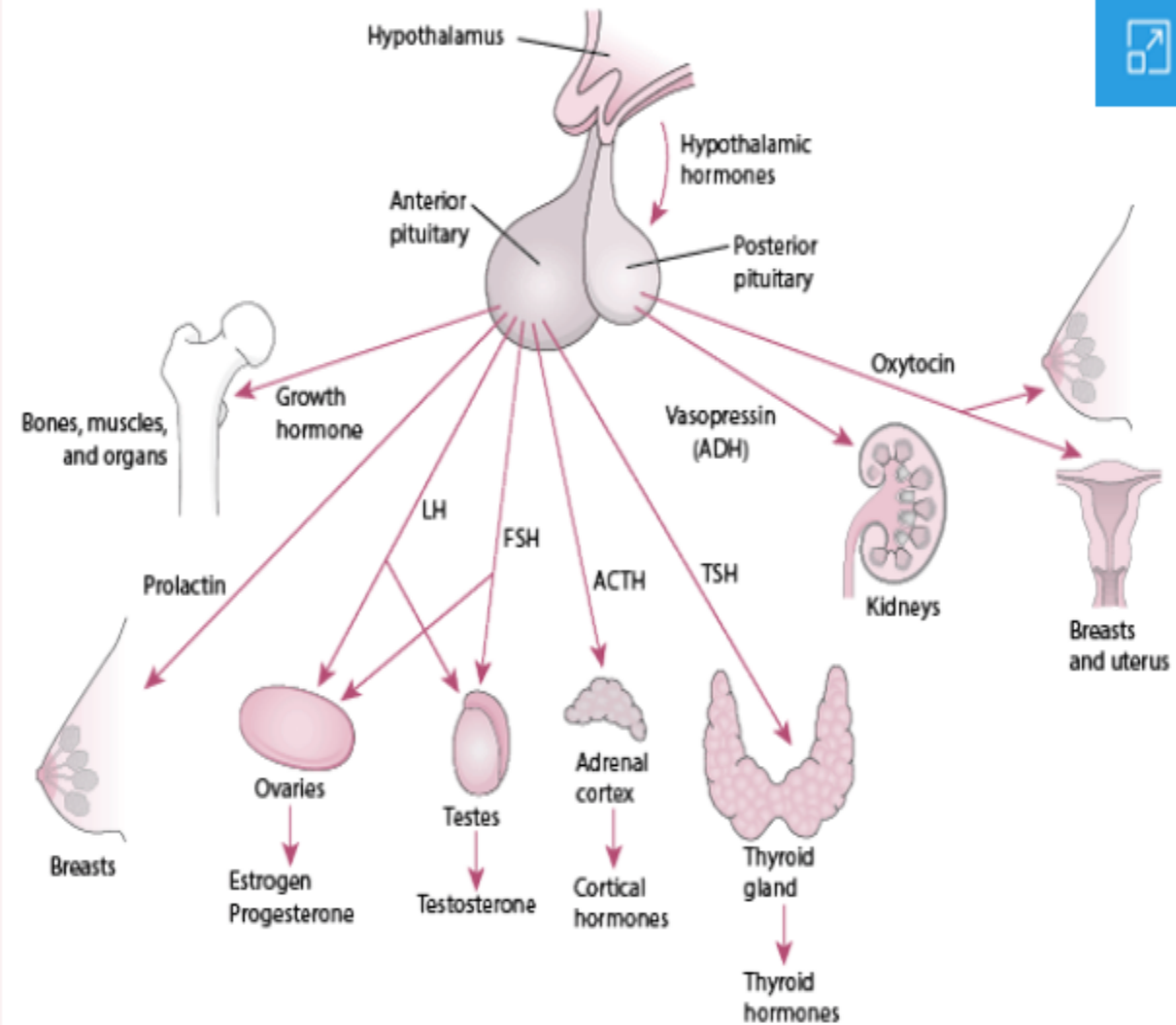
- Growth hormone: Gigantism, acromegaly.
- Prolactin excess: Galactorrhea.
- LH, FSH : fertility, menstrual periods.
- ACTH (Adrenocorticotropic hormone) hormone EXCESS: Secondary hypercortisolism.
- TSH: underproduction of thyroid hormone, as in Hypothyroidism (cold intolerance, weight gain, constipation) or excess as in Hyperthyroidism (heat intolerance, weight loss, diarrhea, fast heart beat).
- Oxytocin (oxytocin hormone initiates labor, uterine contractions, and milk ejection in mothers.)
- Vasopressin (ADH): may produce DIABETES INSIPIDUS (Is different than Diabetes Mellitus)

## PITUITARY MACROADENOMAS:

### Mass effect.

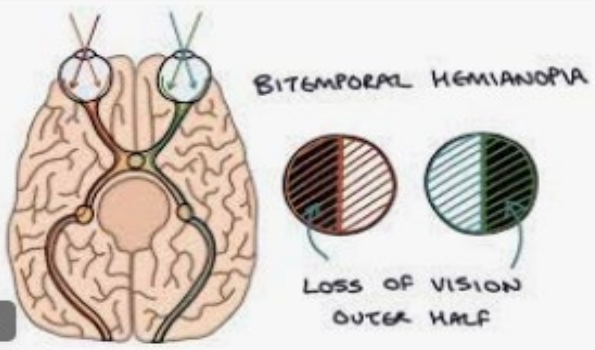
- Visual problems (double vision, bitemporal hemianopsia)

## The Pituitary and Its Target Organs

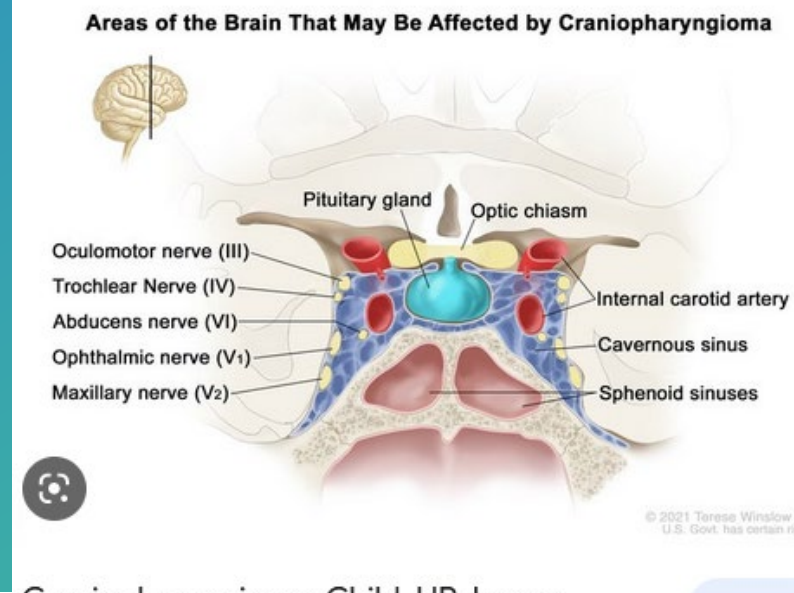
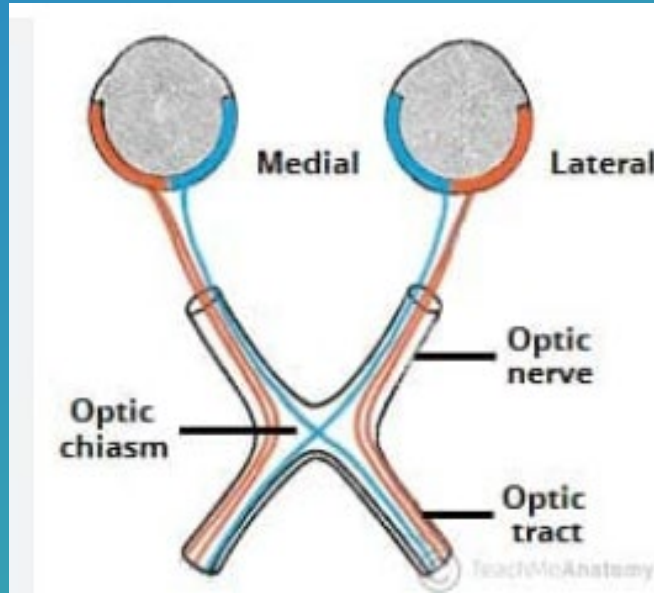
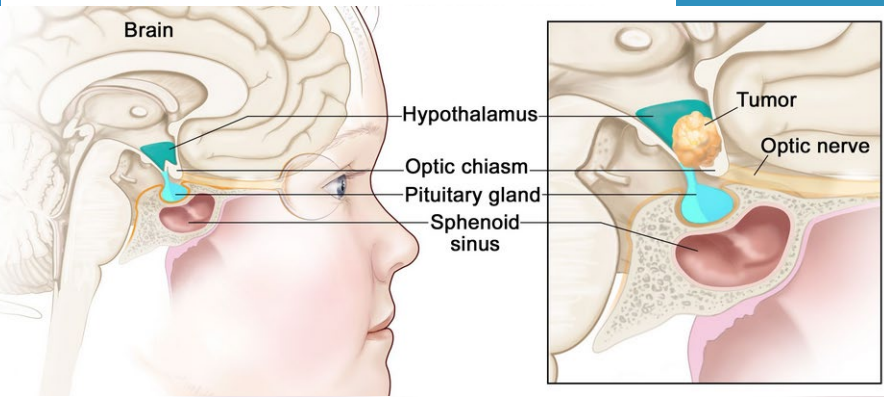




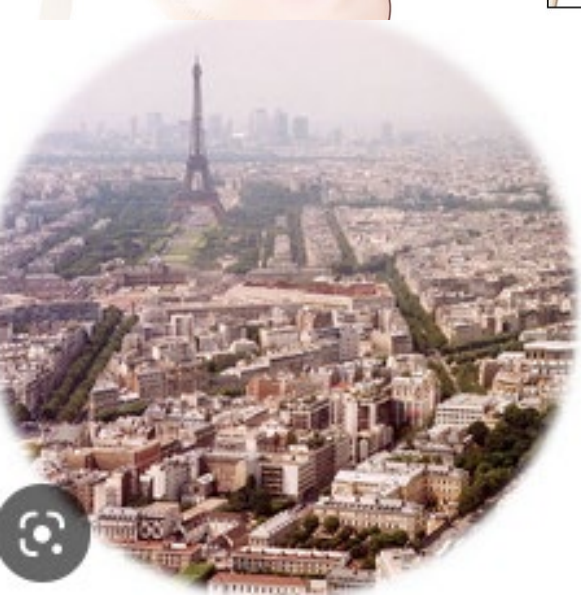
**CHILDREN CAN HAVE ACCIDENTS AT CROSSING THE STREET OR WHEN RIDING A BICYCLE FOR EXAMPLE. ADULTS CAN HAVE CAR ACCIDENTS BECAUSE OF LOSS OF PERIPHERAL VISION DUE TO COMPRESSION OF THE OPTIC CHIASM.**



YouTube  
Understanding Bitemporal Hemianopia ...

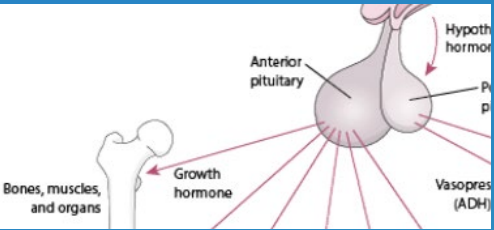


Craniopharyngioma, Child, HP: Image



Visit

# GROWTH HORMONE EXCESS



## GIGANTISM



File:Acromegaly classic woman.gif

[File](#)

[File history](#)

[File usage](#)



# Gigantism



- Growth plates usually close near the end of puberty (13-15 years for girls and 15-17 years for boys).

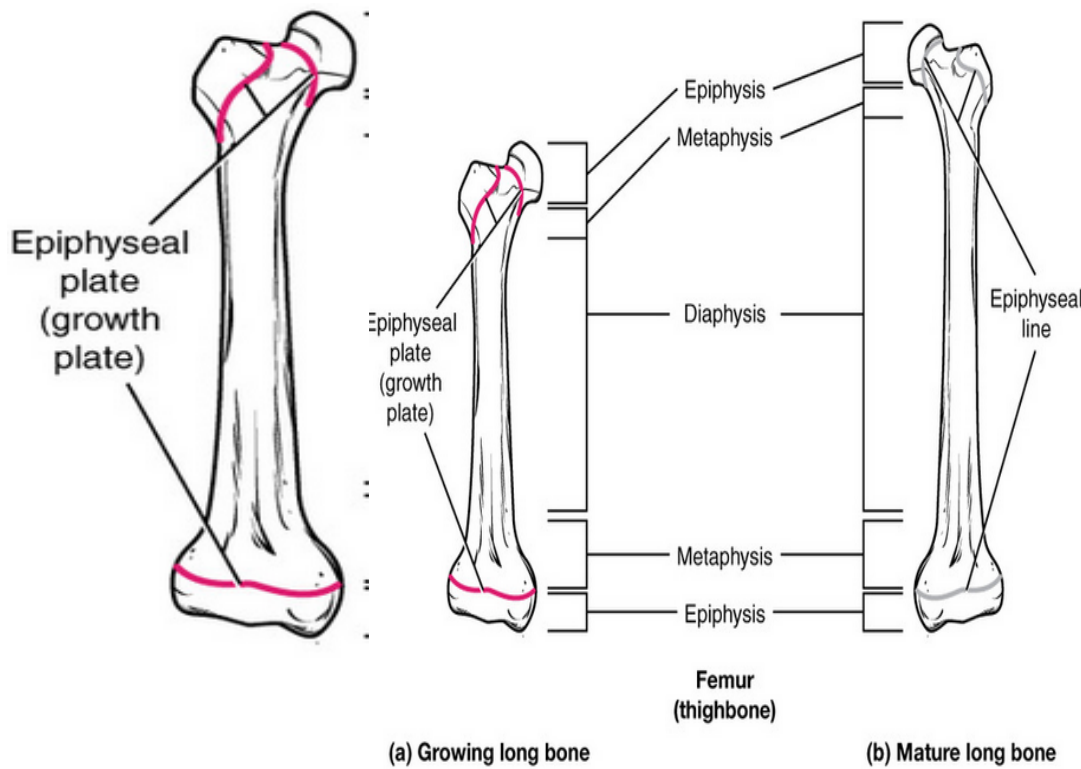
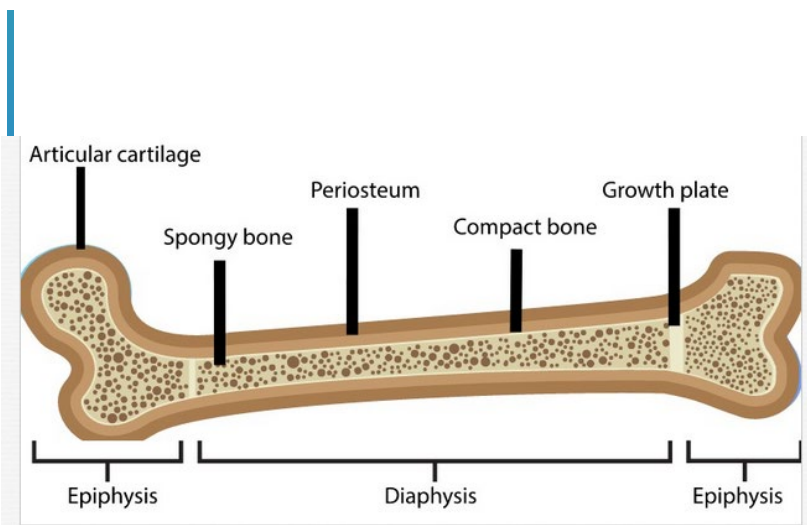
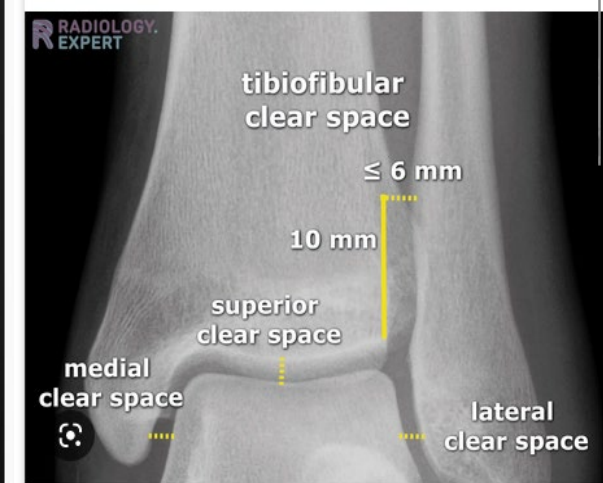


Figure 38.8.1: From epiphyseal plate to epiphyseal line: As a bone matures, the epiphyseal plate progresses to an epiphyseal line. (a) Epiphyseal plates are visible in a growing bone. (b) Epiphyseal lines are the remnants of epiphyseal plates in a mature bone.



Radiogram of distal tibia (left) and fibula (right) showing two epiphyseal plates

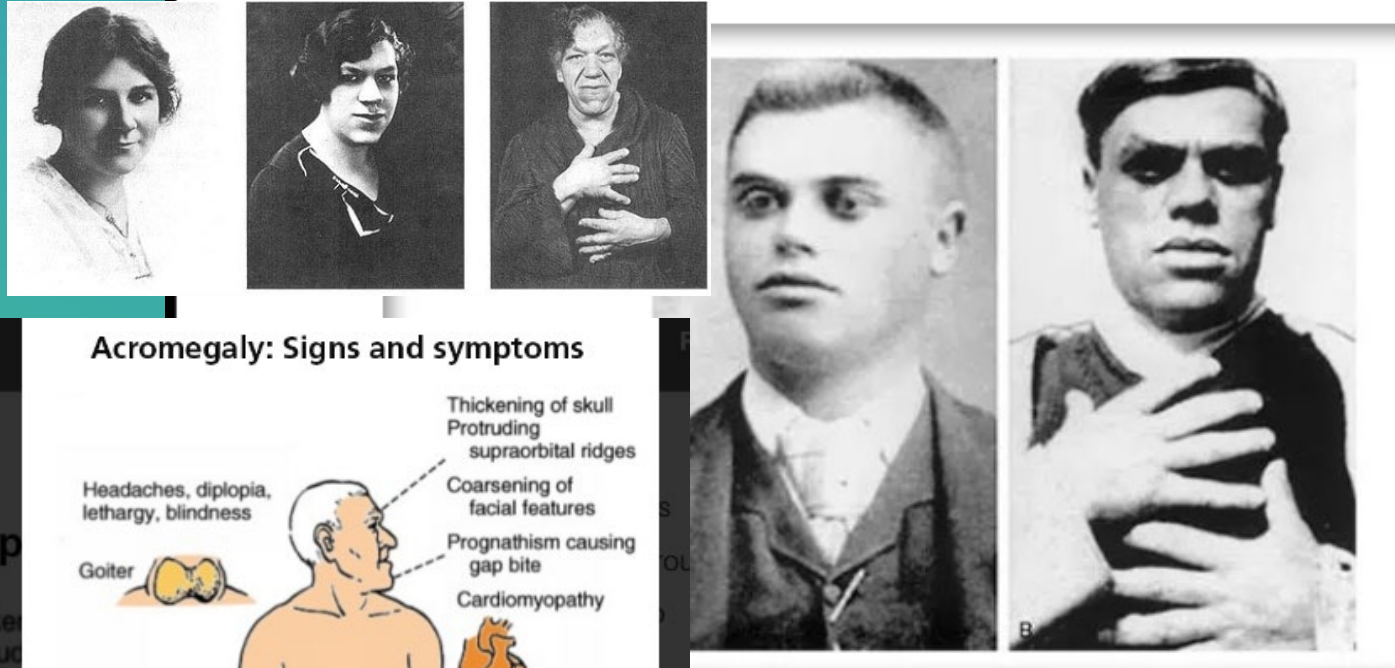
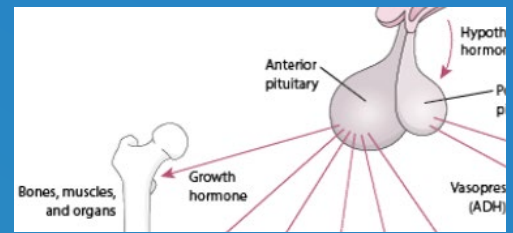


Normal anatomy - Radiology.expert

[Visit](#)

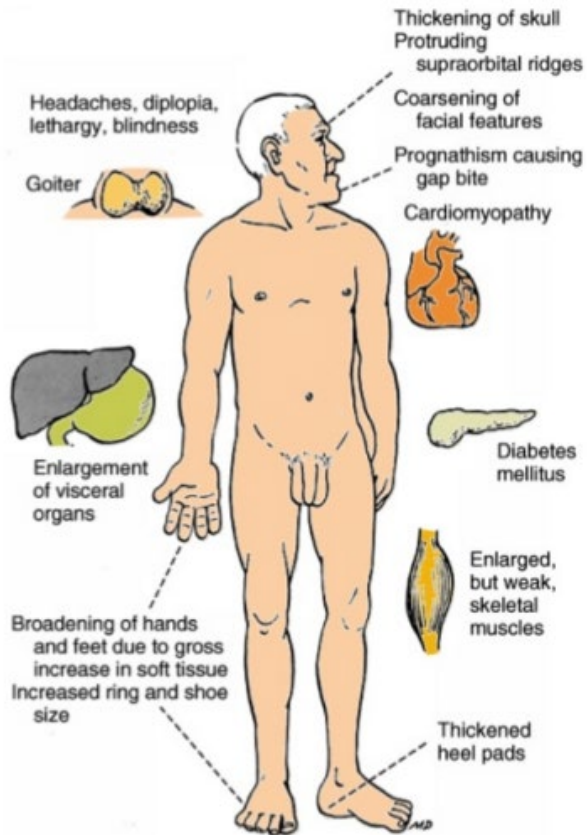
# Acromegaly

UPDATED ON JANUARY 25, 2014 BY MATT VERA BSN, R.N.



**Acromegaly** is what the condition is called when **excessive GH production** develops in an adult after he or she has reached their final height. It comes from the Greek words **akron (extremity)** and **megas (big)**. Continued stimulation of tissue growth **causes large hands and feet, nose, jaw and forehead**, which are the most noticeable features.

## Acromegaly: Signs and symptoms



**Rings** do not fit anymore, **Hats** are too small and need bigger **shoes**.

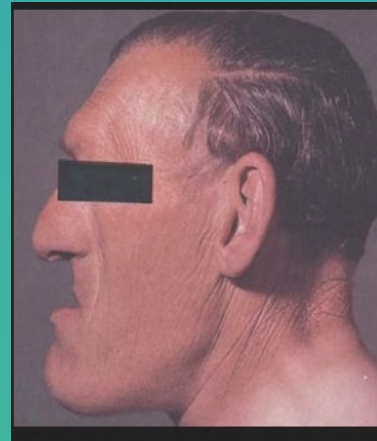
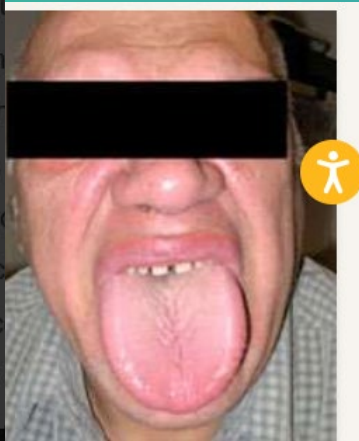


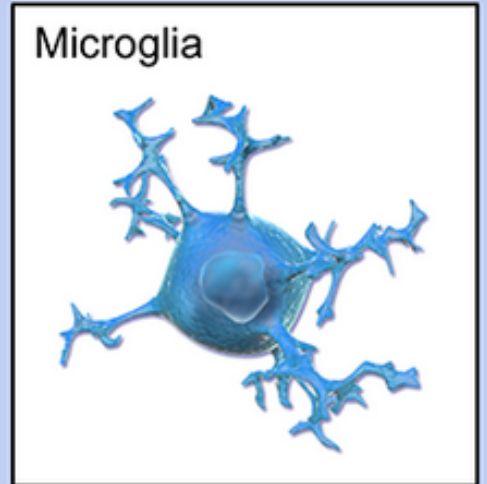
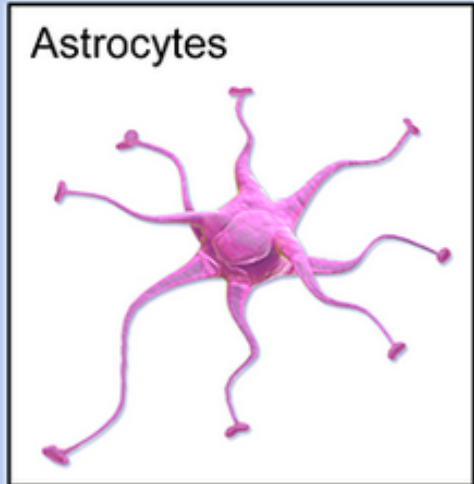
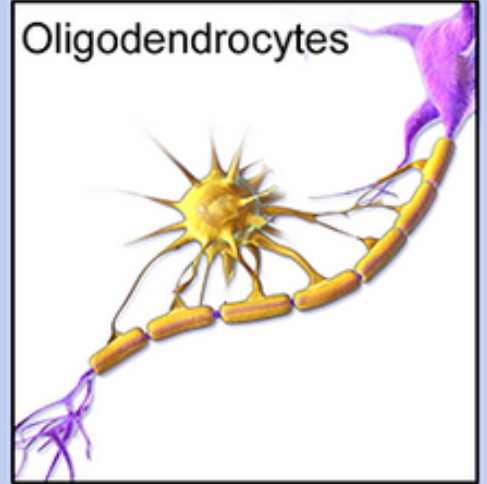
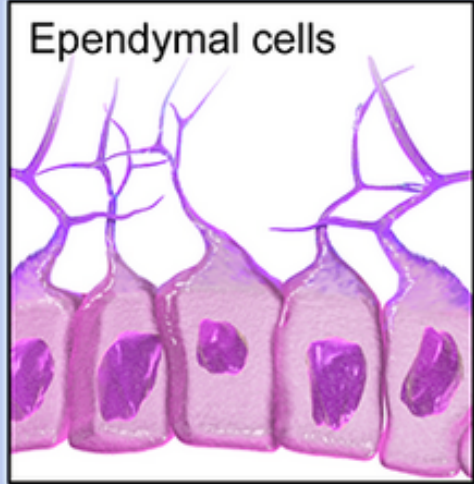
Photo of person's mouth with acromegaly. According to Shlomo Melamed, MD (world's leading authority on acromegaly) mouth exhibits classic teeth gapping symptoms on lower jaw. Photo taken November 2004 at the offices of Kenneth Yamanka, DDS, P.C. ... [More details](#)  
Offices of Kenneth Yamanka, DDS - my dentist's office © Public Domain view terms

**GLIOMAS** originates from **GLIAL** cells. **Glial** (Neuroglial) cells support, nourish, and protect the neurons.

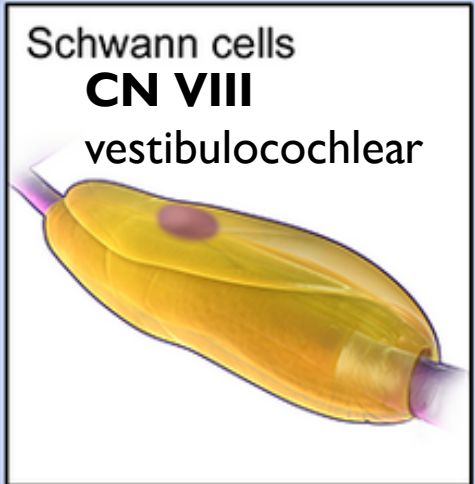
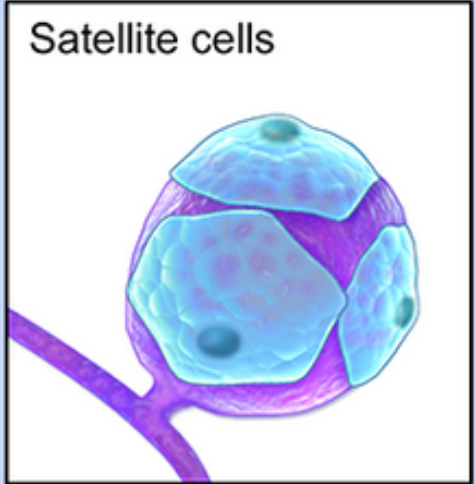
## Types of Neuroglia (Glial Cells)

cranial nerves (olfactory I and optic nerves ii, are considered to be extensions of the CNS

### Central Nervous System (Brain and Spinal cord)



### Peripheral Nervous System Cranial Nerves




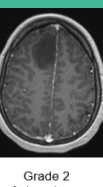
-**Microglia** are the brain's **immune** cells. Microglia cells removes the toxic agent and/or clears away the dead cells.

-**Astrocyte** supports the nervous system by providing nutrients to neurons, maintaining the integrity of the blood-brain barrier, regulating blood flow in the brain, and maintaining synapses.

-**Ependymal cells** produce cerebrospinal fluid CSF that cushions the neurons.

-**Oligodendrocytes and Schwann cells** have the same function: Myelination to **SPEED THE NERVE ELECTRICAL IMPULSE.**

-OMA suffix means: TUMOUR, TUMOR  
ASTROCYTOMAS  
EPENDYMOMAS  
SCHWANNOMA... 



## Non-neuronal Cells of the Central Nervous System

**Astrocytes:** structural support of blood-brain-barrier and synapses



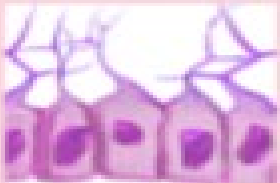
**Oligodendrocytes:** production of myelin sheaths, insulating coating for axons



**Microglia:** innate immune system of the brain



**Ependymal:** maintains extracellular environment



### Astrocytoma:

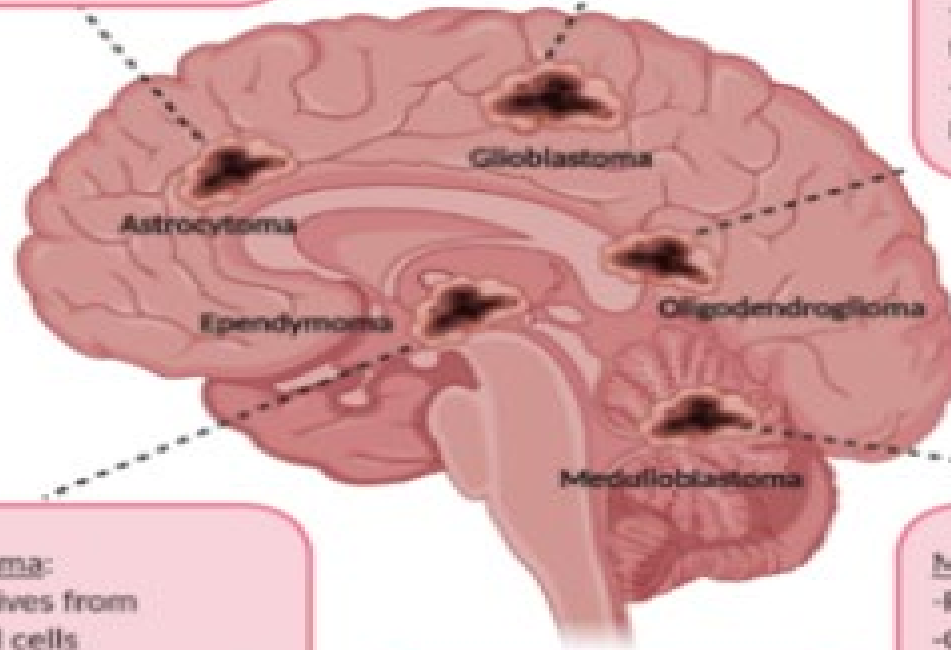
- Cell of origin: neural stem cells, astrocytes
- Pilocytic astrocytoma (grade I)
- Diffuse astrocytoma with IDH mutations (grade II)
- Anaplastic astrocytoma with IDH mutations (grade III)

### Glioblastoma:

- Cell of origin: neural stem cells, microglia
- Classified as a grade IV astrocytoma
- Most common brain tumor in adults
- Constitutes up to 54% of all gliomas

### Oligodendroglioma:

- Cell of origin: neural stem cells, oligodendrocytes
- Oligodendroglioma with IDH mutations, 1p/19q co-deletion (grade II)
- Anaplastic oligodendroglioma with IDH mutations, 1p/19q co-deletion (grade III)
- Second most common brain tumor in adults
- Constitutes 5-20% of all gliomas



### Ependymoma:

- Name derives from ependymal cells
- Sub-ependymomas (Grade I)
- Ependymoma (Grade II)
- Anaplastic ependymomas (Grade III)

### Brain metastases:

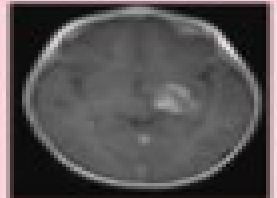
- Estimated to be caused by 30% of all systemic malignancies in adults
- Most common primary are lung, breast, and melanomas.

### Medulloblastoma:

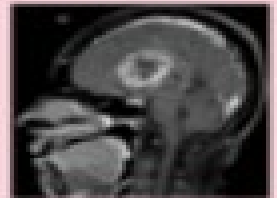
- Primary embryonal tumors
- Originates from the cerebellum
- Grade IV classification
- Second to leukemia as the most common type of childhood tumor

## Magnetic Resonance Imaging of Brain Tumors

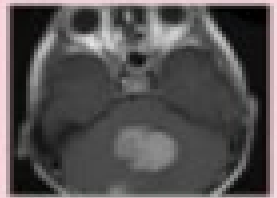
### Astrocytoma:



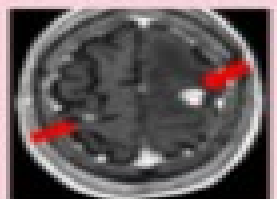
### Glioblastoma:

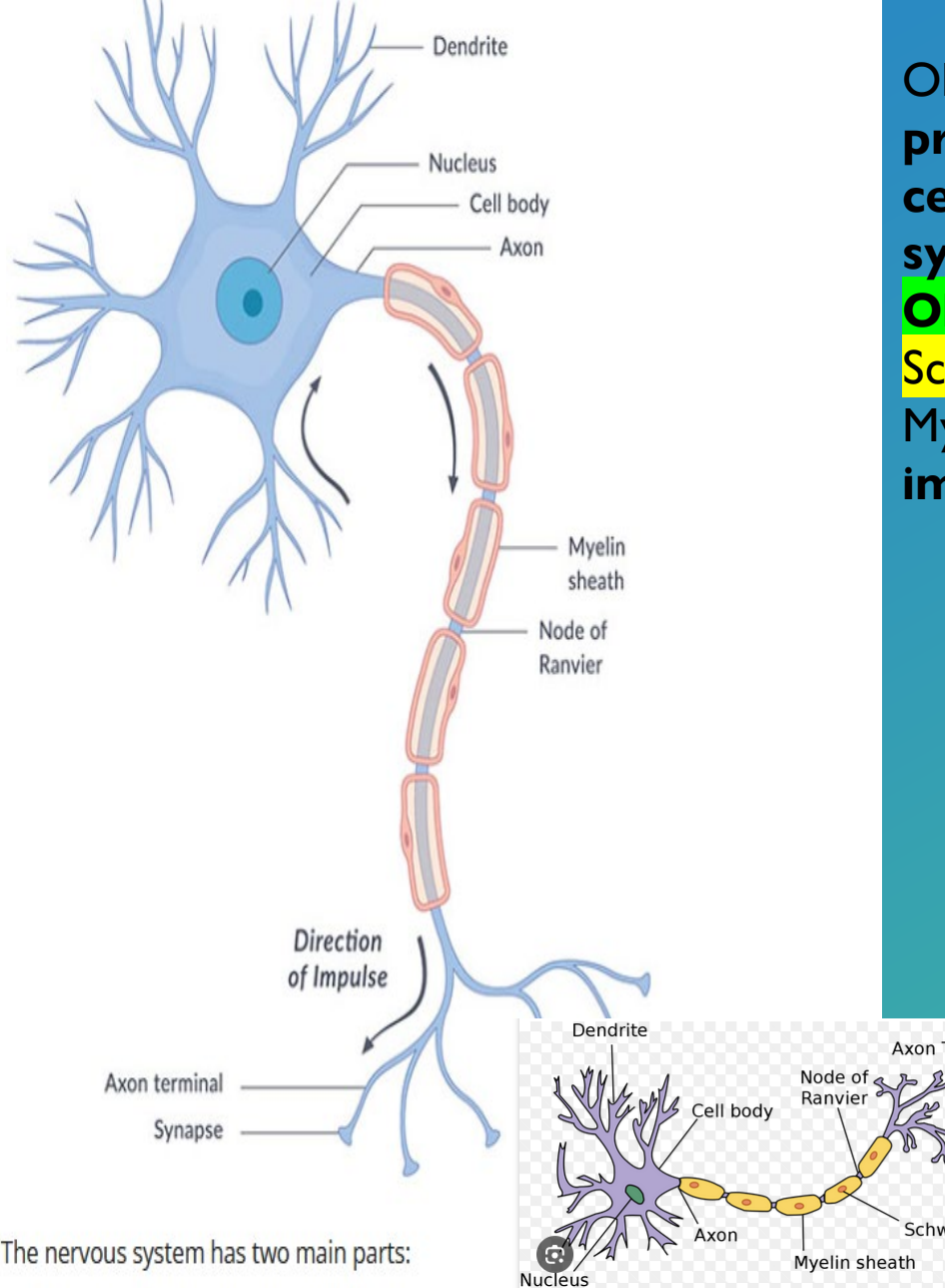


### Medulloblastoma:



### Brain metastasis:





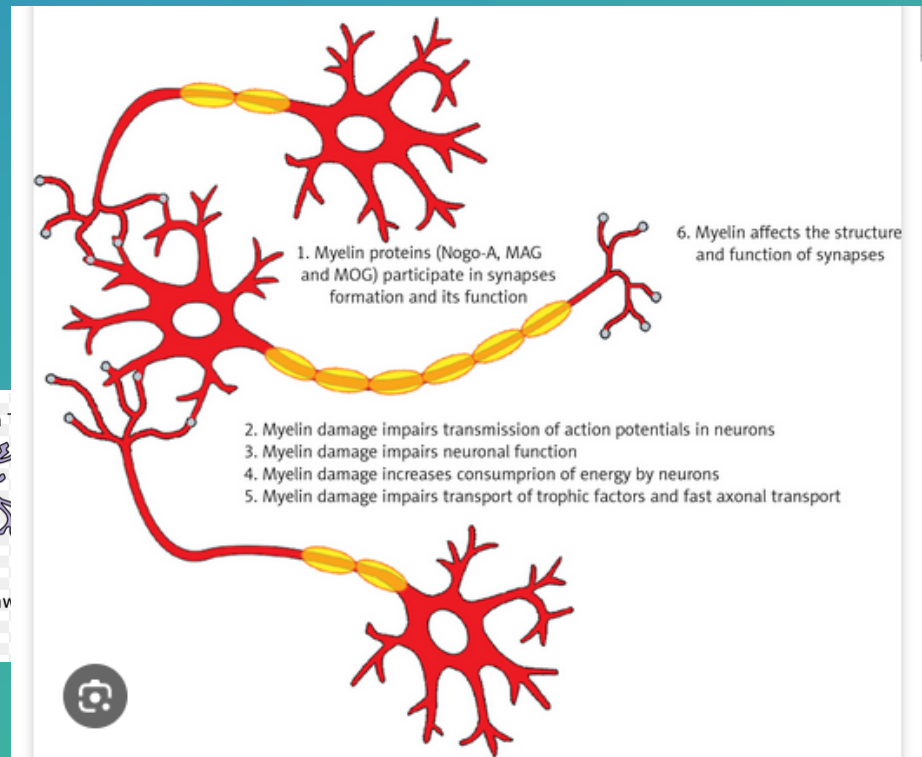
The nervous system has two main parts:

- The **central nervous system** is made up of the brain and spinal cord.
- The **peripheral nervous system** is made up of nerves that branch off from the spinal cord and extend to all parts of the body

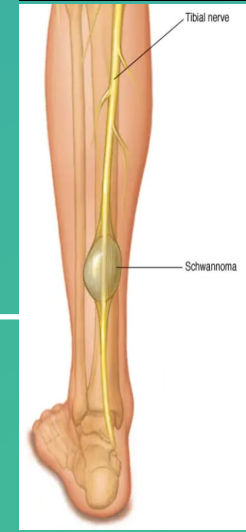
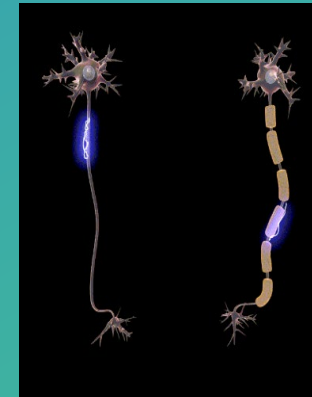
Oligodendrocytes and Schwann cells are **engaged in myelin production, maintenance and repairing** respectively in the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**.

**Oligodendrocytes** myelinate the **central nervous system**, while **Schwann cells** myelinate the **peripheral nervous system**.

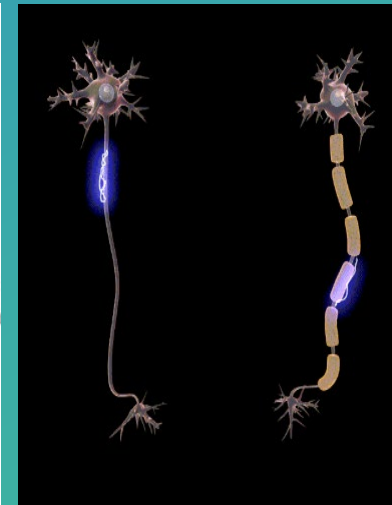
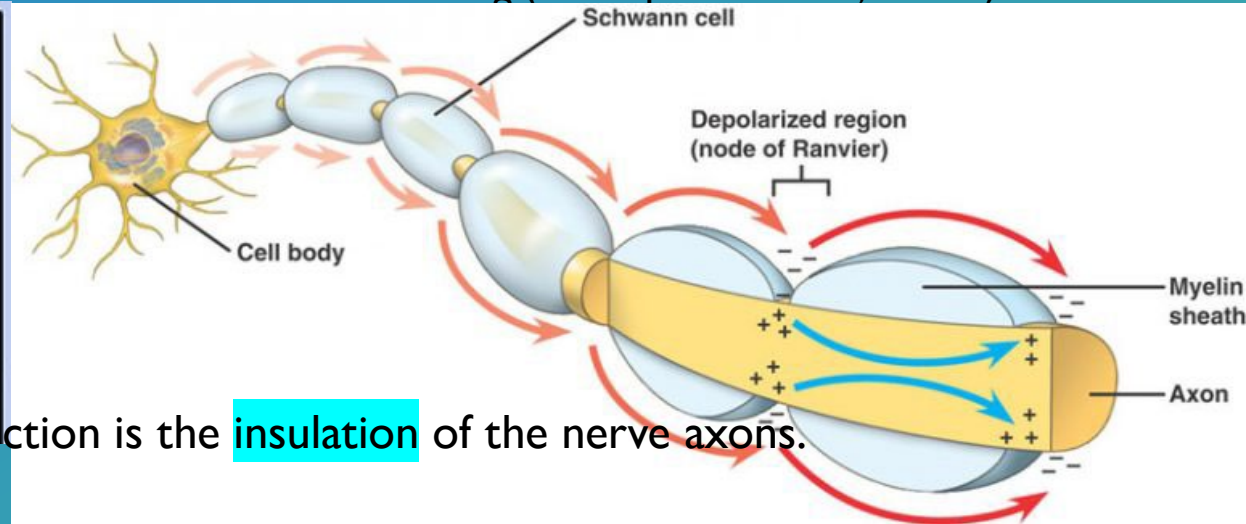
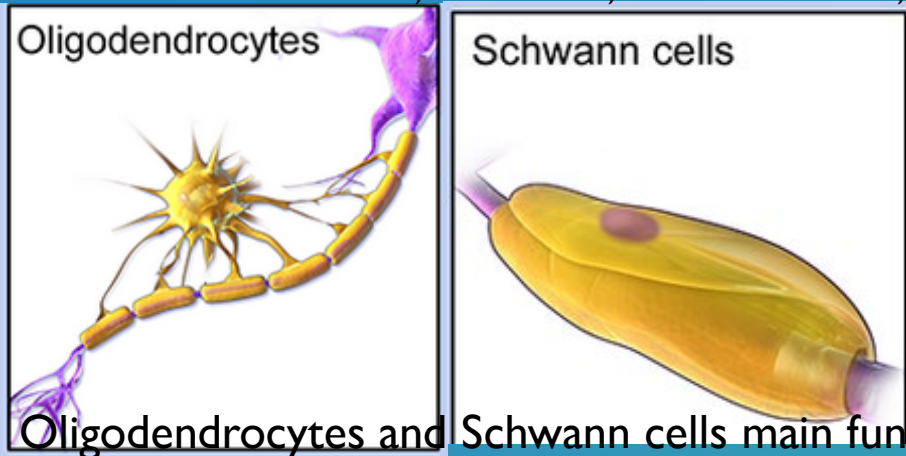
Myelin is an insulating layer. This myelin sheath **allows electrical impulses to transmit quickly and efficiently along the nerve cells**.



The role of myelin damage in Alzheimer's



**Myelin sheaths** are multilayered membrane extensions off of the axon. Neurons with myelin on their axons are referred to as myelinated and the process of developing a myelin sheath is myelination. Myelin is formed by Schwann cells or Oligodendrocytes attaching to the axon. Myelin helps to speed up the propagation of an action potential along the axon by the process of saltatory conduction ("Myelin: an Overview," 2015). **Multiple sclerosis** is a disease in which myelin degrades in the patient (**Demyelination**). This leads to weakness, numbness, muscle stiffness, and even issues with thinking ("Multiple Sclerosis," 2016).

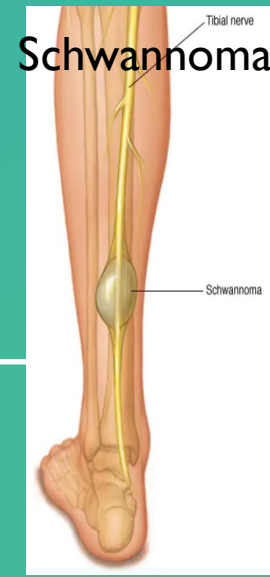
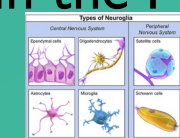


Oligodendrocytes and Schwann cells main function is the insulation of the nerve axons.

Oligodendrocytes are the cells which create myelin sheath around the axons of central nervous system. Schwann Cells are the cells which create myelin sheath around the axons of peripheral nervous system.

**OLIGODENDROGLIOMAS** are a type of glioma that are believed to originate from the oligodendrocytes of the brain or from a glial precursor cell. They occur primarily in adults (9.4% of all primary brain and central nervous system tumors) but are also found in children (4% of all primary brain tumors).

**SCHWANNOMAS** are GLIOMAS that arise from Schwann cells in the PNS. Schwannoma of the VIII cranial nerve are reportable.





**Oligodendrocytes** myelinate the **CNS**, while

**Schwann cells** myelinate the **PNS**.

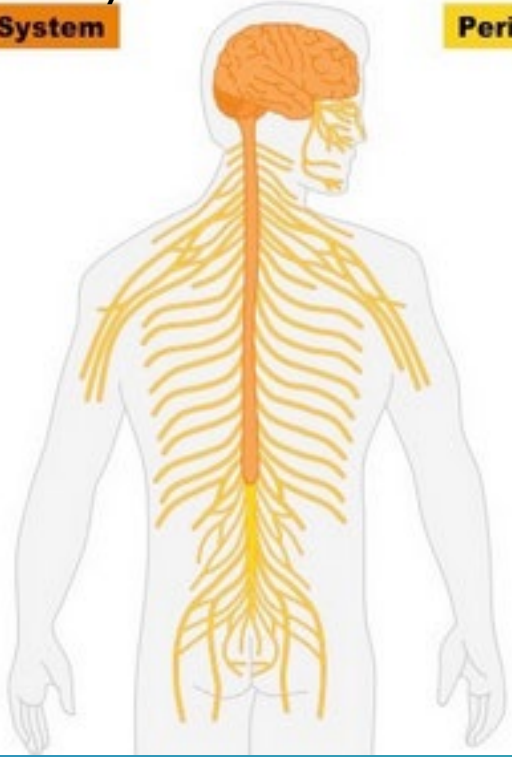
**Central Nervous System**

Composed of:

- Brain
- Spinal cord

Contains:

- Relay neurons (interneurons)



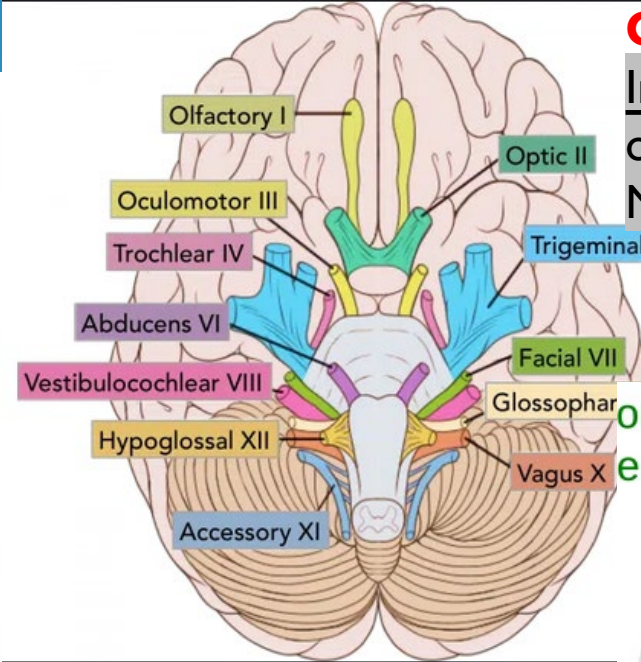
**Peripheral Nervous System**

Composed of:

- Cranial nerves
- Spinal nerves
- Peripheral nerves

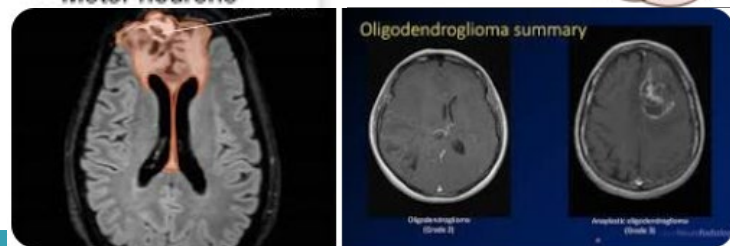
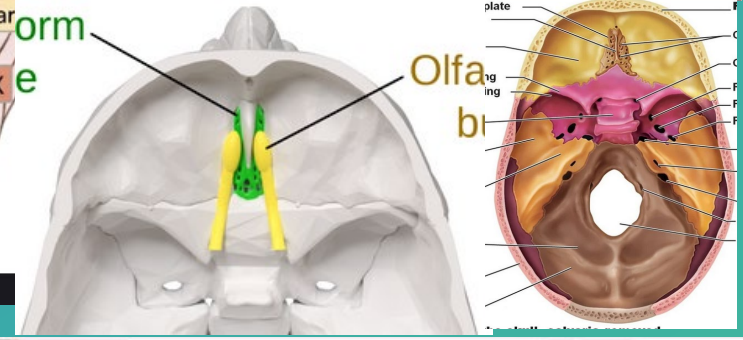
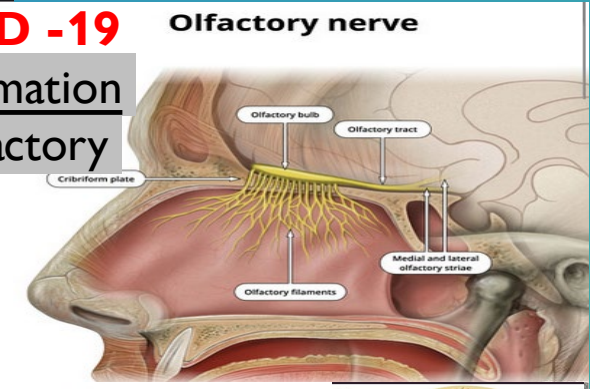
Contains:

- Sensory neurons
- Motor neurons



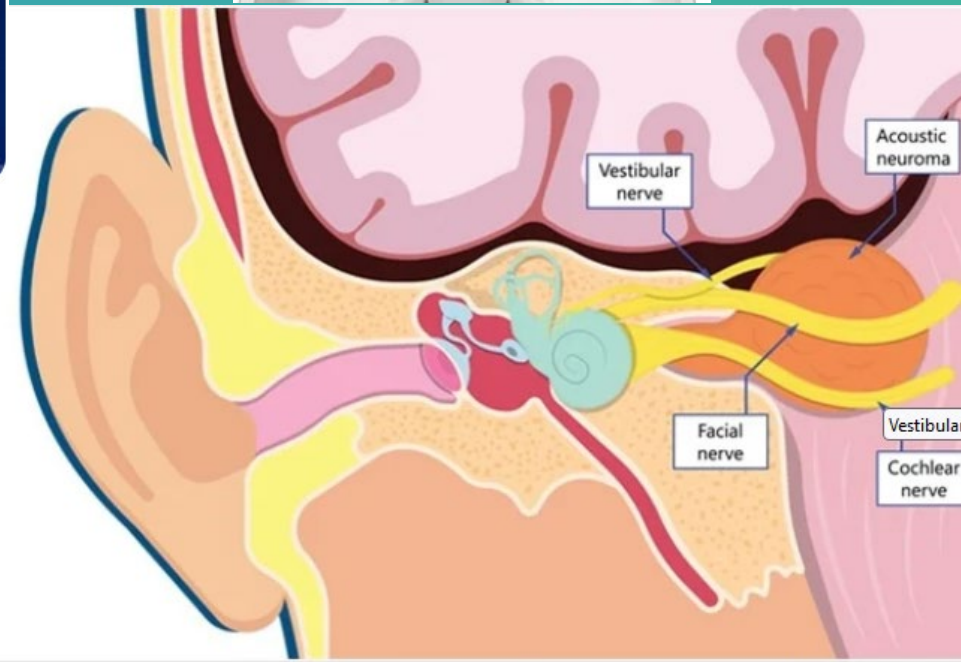
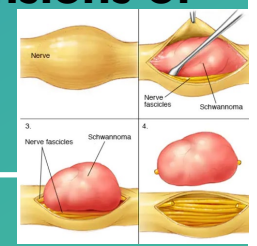
**COVID -19**

**Inflammation of Olfactory Nerve**



The 12 cranial nerves are generally considered to be components of the peripheral nervous system. However, the **first** and **second** cranial nerves (**olfactory** and **optic** nerves, respectively) are considered to be **extensions of the central nervous system**, because they are myelinated by oligodendrocytes, whereas the 10 other cranial nerves are myelinated by Schwann cells.

Cranial Nerve no. 8: Vestibulocochlear frequently gets **schwannomas** (PNS). Vestibular schwannoma also known as acoustic neuroma, acoustic neurinoma, or acoustic neurilemoma.



Vestibular Schwannoma (Acoustic Neuroma). Image Credit: Rumruay / Shutterstock

# GLIOBLASTOMA MULTIFORME (GBM) is the most common malignant type of astrocytic tumors.

**GLIOMAS: Grade 1:** There are many kinds of Grade 1 gliomas. Pilocytic astrocytoma are one example. These are more common in children.

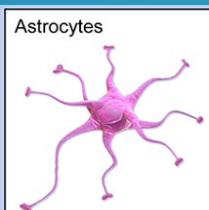
• **Grade 2:** Diffuse glioma, either astrocytoma or oligodendroglioma.

• **Grade 3:** Anaplastic glioma, either astrocytoma or oligodendroglioma.

• **Grade 4:** Either Glioblastoma Multiforme IDH wildtype or IDH-mutated astrocytoma. **Glioblastoma Multiforme IDH wildtype** is the most aggressive.

**-Blastomas** forms in precursor fetal cells that remain after birth.

Grade \ Type	WHO grade I	WHO grade II	WHO grade III	WHO grade IV
	↔ Circumscript		↔ Diffuse	
		↔ Low-grade		↔ High-grade
Astrocytoma	Pilocytic astrocytoma	Low-grade astrocytoma	Anaplastic astrocytoma	<b>Glioblastoma</b>
Oligodendroglioma		Low-grade oligodendroglioma	Anaplastic oligodendroglioma	
Oligo-astrocytoma		Low-grade oligo-astrocytoma	Anaplastic oligo-astrocytoma	



**Astrocyte** CNS GLIAL cell which supports the nervous system by providing nutrients to neurons, maintaining the integrity of the blood-brain barrier (their foot processes are an important component of the blood-brain barrier), regulating blood flow in the brain, and maintaining synapses.

**Microglia:** innate immune system of the brain



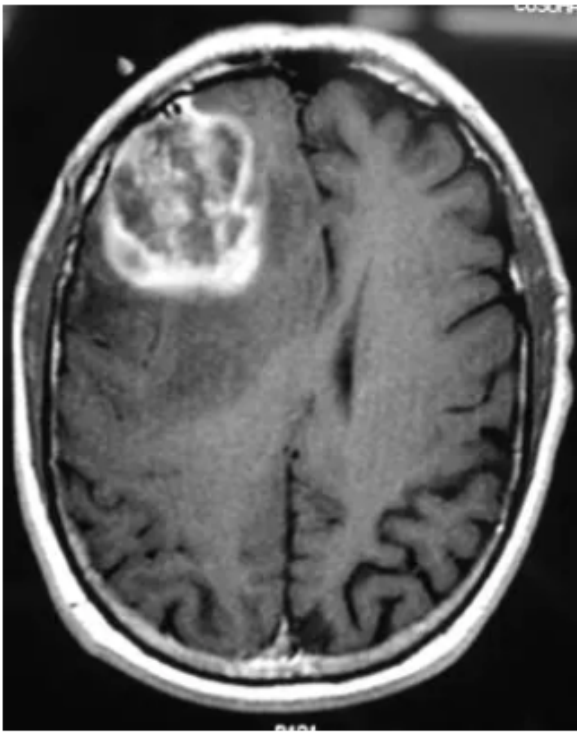
**Glioblastoma:**

- Cell of origin: neural stem cells, microglia
- Classified as a grade IV astrocytoma
- Most common brain tumor in adults
- Constitutes up to 54% of all gliomas

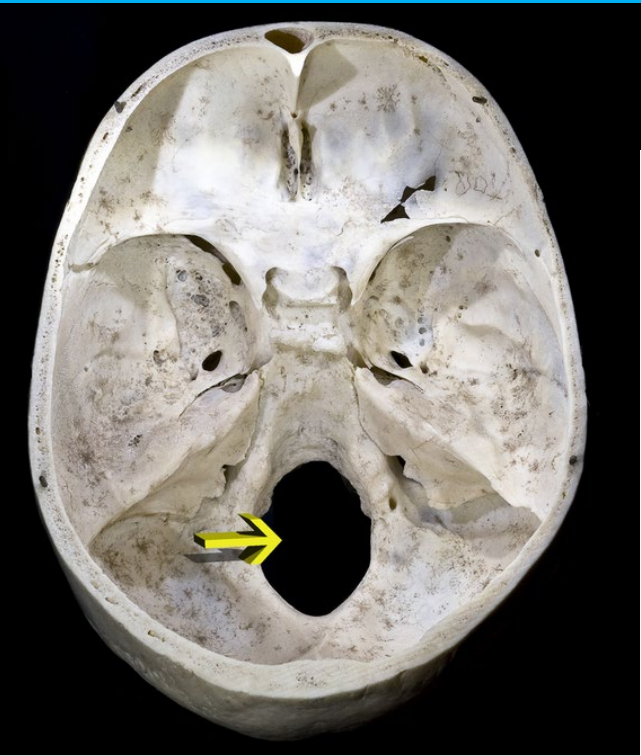
# Practice Essentials

Glioblastomas (malignant glioma) are the most common adult malignant brain tumors, and 20% of all primary brain neoplasms are glioblastoma tumors. Glioblastoma (GBM; malignant glioma) is the highest-grade form (grad IV) of astrocytoma and makes up about two thirds of all brain astrocytomas. [1, 2] Mortality associated with GBM is greater than 90% at 5 years, with a median survival of 12.6 months. [3] The prognosis for this tumor is at the extreme worst end because of its high-grade status. [3]

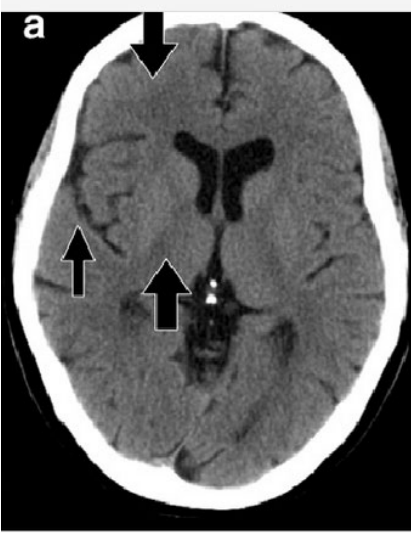
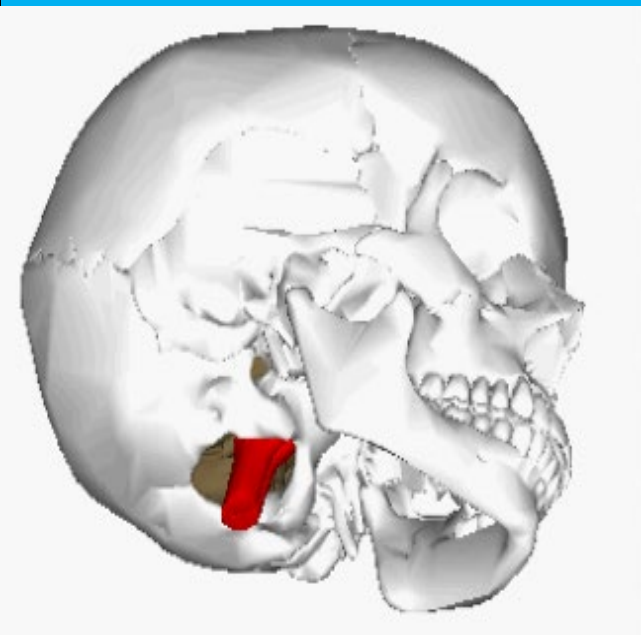
(See the images below.)



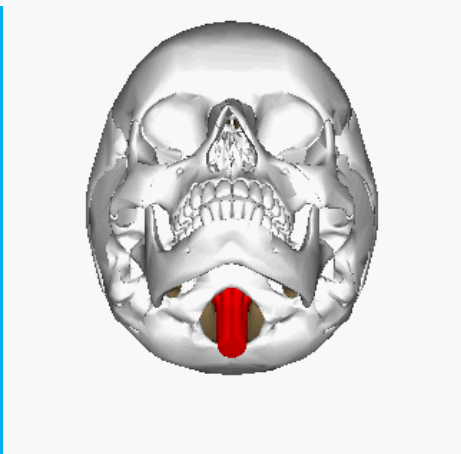
T1-weighted axial gadolinium-enhanced magnetic resonance image demonstrates an enhancing tumor of the right frontal lobe. Image courtesy of George Jallo, MD

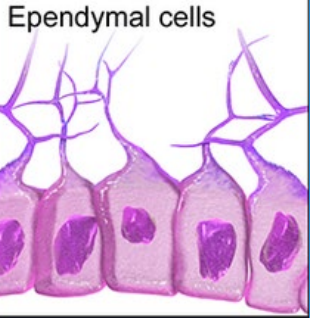


# Foramen magnum



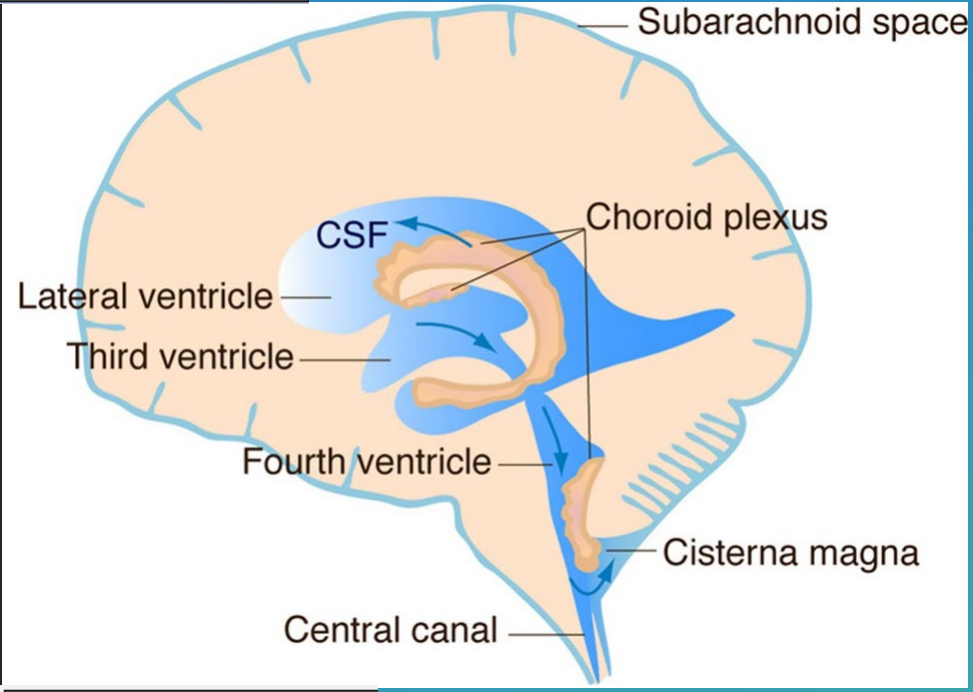
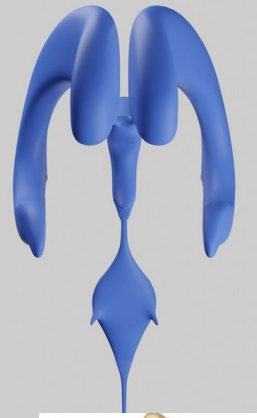
Normal CT of the brain of a 37-year-old living male pa



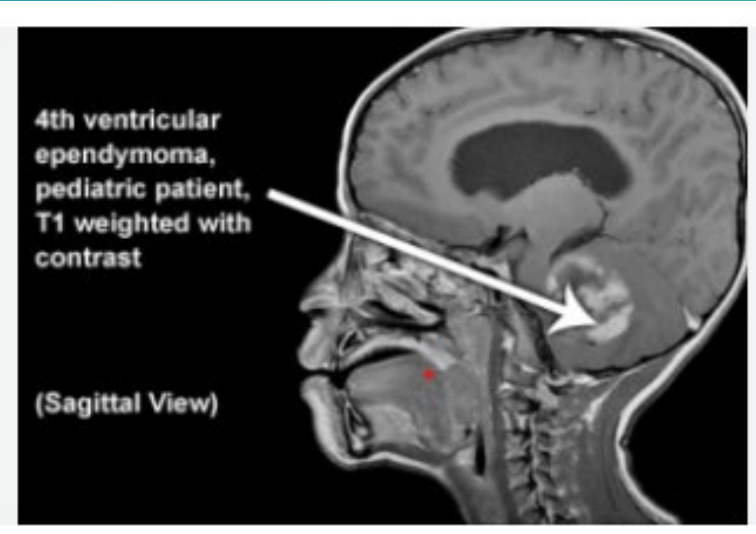
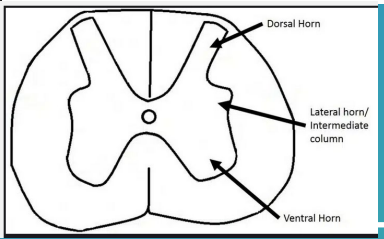
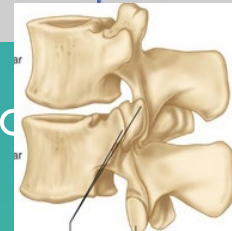


**Ependymal cells** are GLIAL cells which produce cerebrospinal fluid and support the CNS.

CSF is primarily produced by the **choroid plexus** of the ventricles ( $\leq 70\%$  of the volume); most of it is formed by the choroid plexus of the lateral ventricles. The rest of the CSF production is the result of trans**ependymal** flow from the brain to the ventricles.

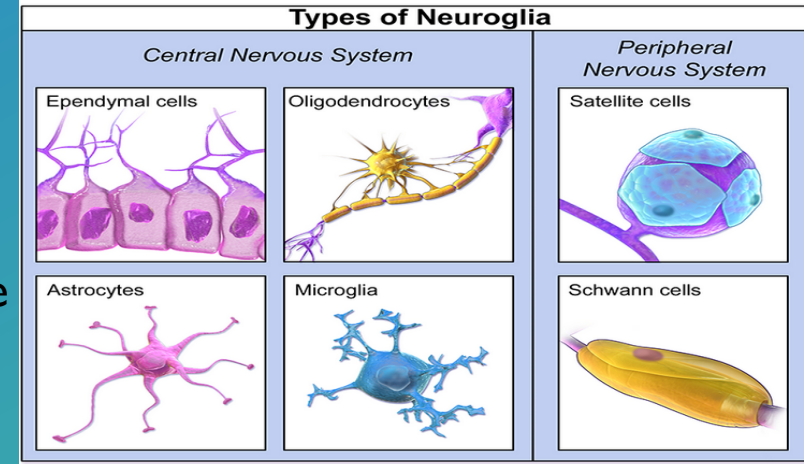


**Ependymomas are GLIOMAS.** It can form anywhere in the CNS (Brain/spinal cord). Ependymomas often occur mostly near the ventricles in the brain and the central canal of the spinal cord.



# EPENDYMOMA

# EPENDYMOMAS (**GLIOMAS**) CAUSE OBSTRUCTIVE HYDROCEPHALUS.



**Ependymal cells** produce cerebrospinal fluid CSF that cushions the neurons.

Ependymal cells



4th ventricular ependymoma, pediatric patient, T1 weighted with contrast

(Sagittal View)

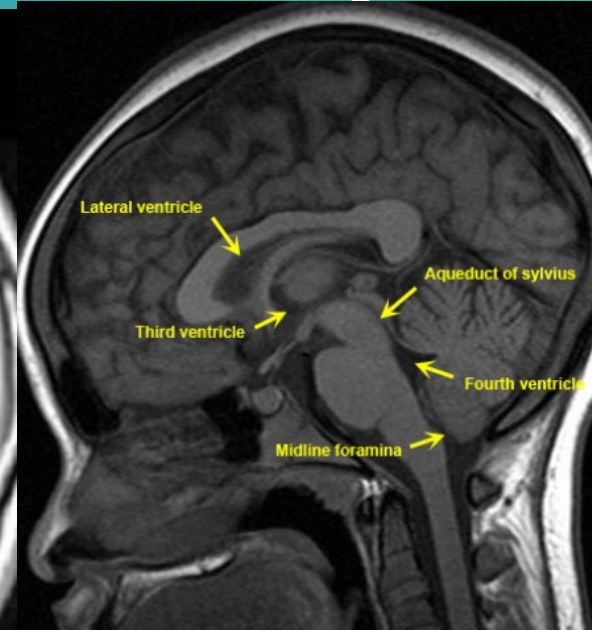
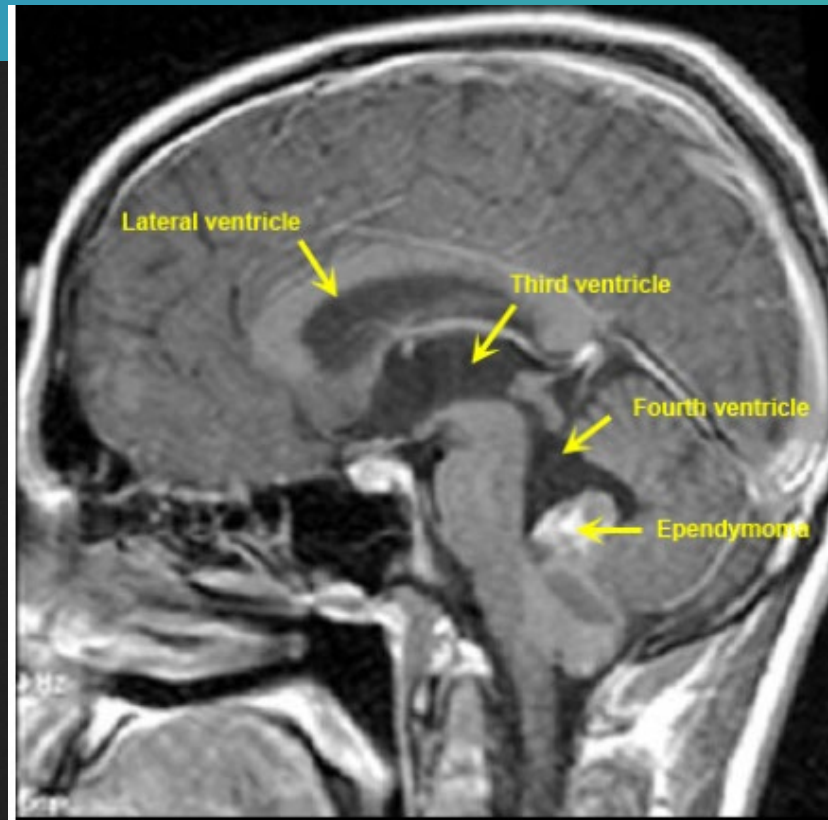
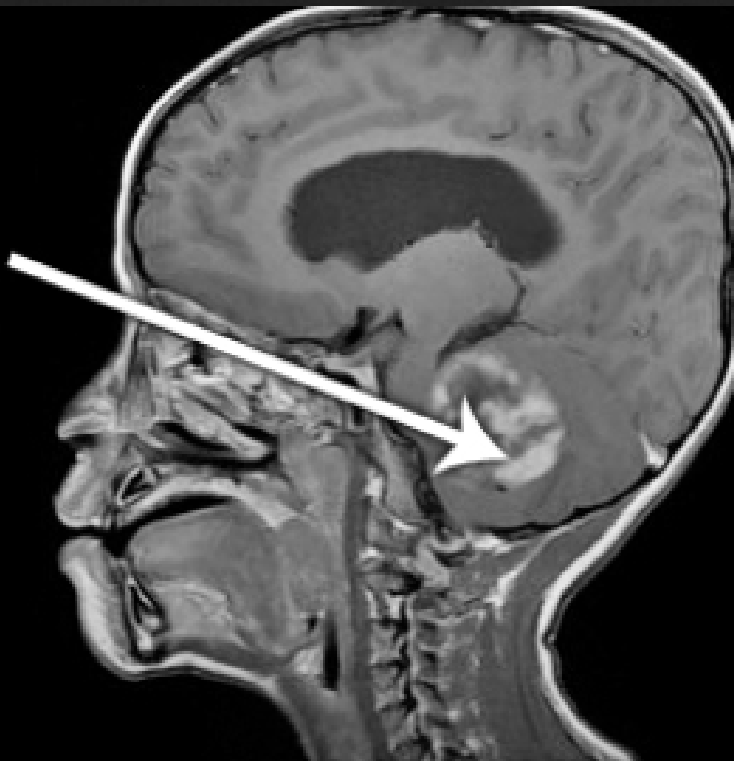
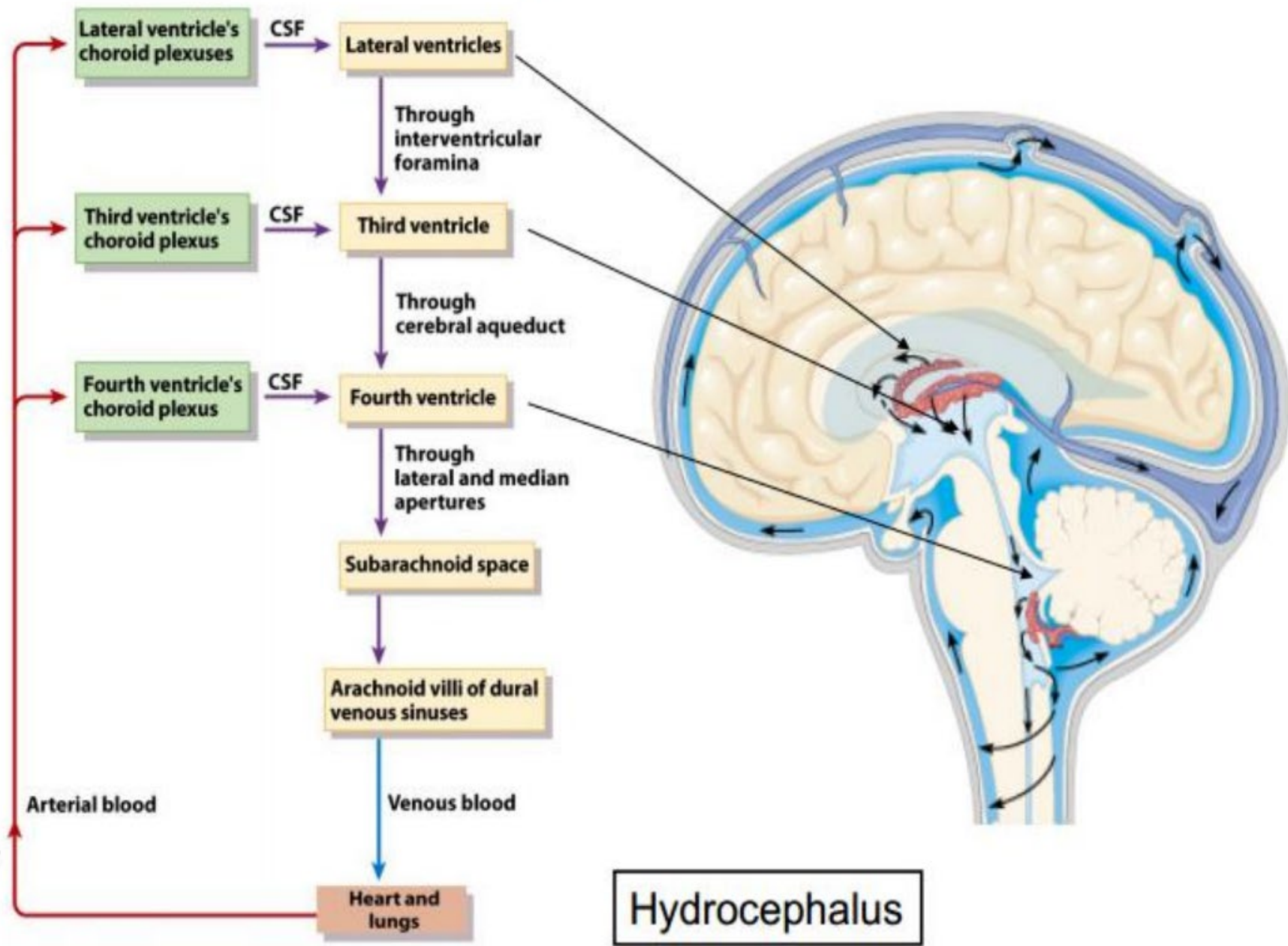
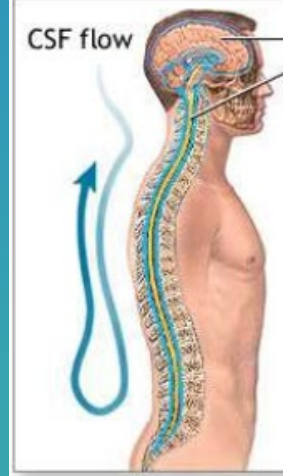
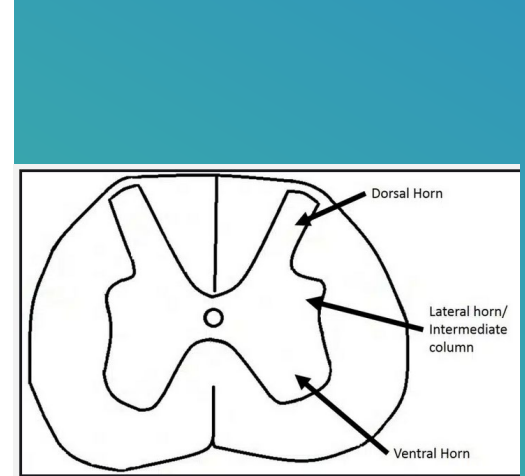
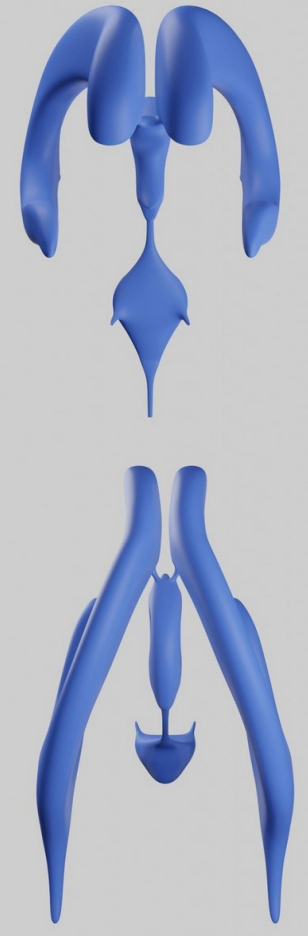


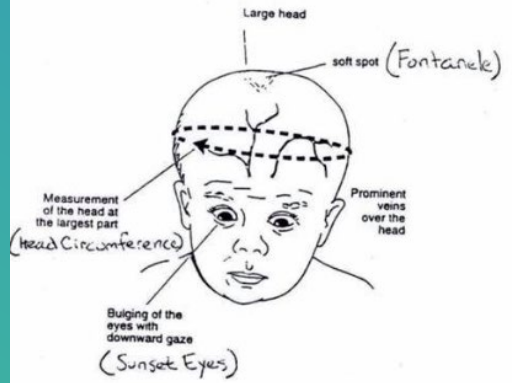
Figure 2. Post-contrast sagittal T1 wtd. MRI

# Pathway of CSF flow



The **ventricles** of the brain are a communicating network of cavities filled with cerebrospinal fluid (CSF). The **choroid plexuses** are located in the ventricles produce CSF, which fills the ventricles and subarachnoid space, following a cycle of constant production and reabsorption.





(Figure 4: sunset appearance of the eyes with hydrocephalus )

ACCORDING TO THE COLLINS DICTIONARY: CHOROID PLEXUS IS A MULTILOBED VASCULAR MEMBRANE, PROJECTING INTO THE CEREBRAL VENTRICLES, THAT SECRETES CEREBROSPINAL FLUID CFS.

THEREFORE, THINK **CHOROID PLEXUS CARCINOMA** AS A POSSIBILITY IN HYDROCEPHALUS IN CHILDREN!

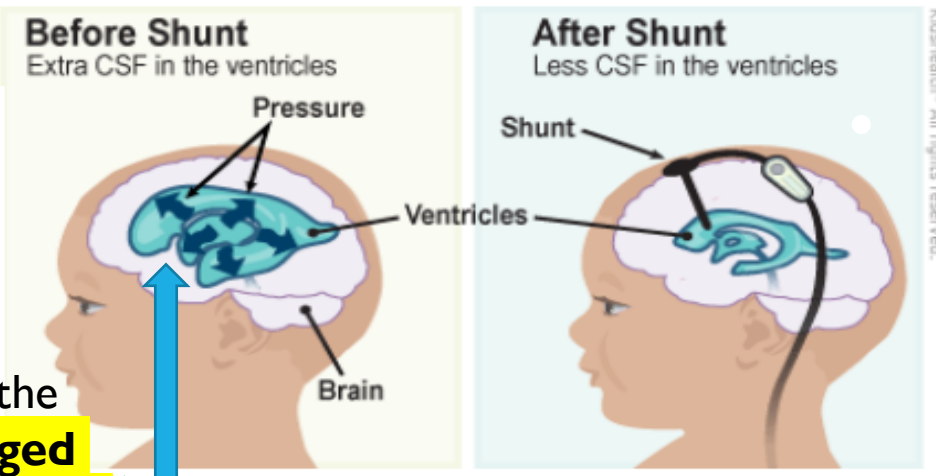
OTHER CAUSES OF HYDROCEPHALUS IS OBSTRUCTION OF NORMAL DRAINING, PRODUCING TOO MUCH OR OTHER CAUSES AS INFECTIONS, AQUEDUCT STENOSIS.

+

## Choroid plexus carcinoma

Choroid plexus carcinoma is a rare type of brain cancer that happens mainly in children.

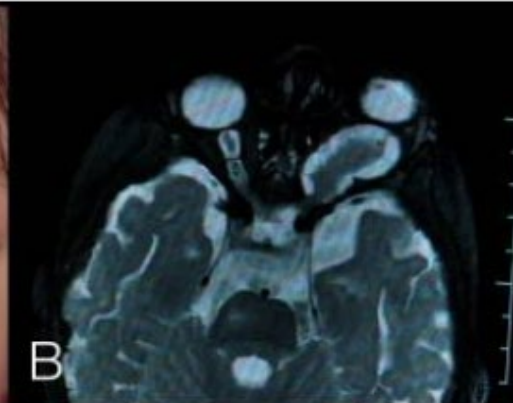
Choroid plexus carcinoma begins as a growth of cells in the part of the brain called the choroid plexus. Cells in the choroid plexus produce the fluid that surrounds and protects the brain and spinal cord. This fluid is called cerebrospinal fluid, also known as CSF. As the cancer grows, it can cause too much CSF in the brain. This can lead to symptoms such as irritability, nausea or vomiting, and headaches.



Note the **Enlarged ventricles!**

Treatments may include one of these surgeries:

- **Ventriculoperitoneal (VP) shunt surgery:** Doctors place a tube from the brain's ventricles to the peritoneal cavity, the space inside the belly where the stomach and the bowels sit. The tube is all inside the body under the skin. After it gets to the belly, the extra CSF is absorbed into the bloodstream. Shunts are replaced:
  - over time as a child grows and needs a bigger shunt



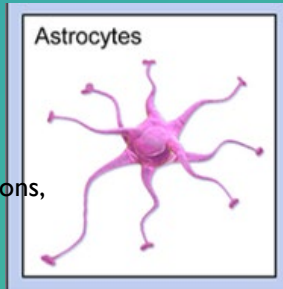
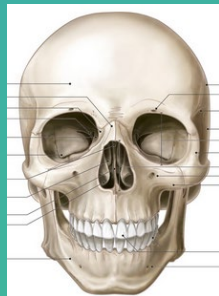
Left optic nerve **GLIOMA**. **A**: 12-month-old female presents with marked proptosis (eyeball protrusion, which occurs when the tumor is pushing the eye outward from the socket), esotropia ( a type of strabismus (eye misalignment) in which one or both eyes turn inward)) and lagophthalmos (incomplete or abnormal closure of the eyelids). There was total optic atrophy with a left afferent pupillary defect. **C**: The severity of proptosis is visible on the lateral view where most of the globe is prolapsed out of the orbit. **F**: Appearance one month after surgery. **A prosthetic eye is awaited**. Contributed by Prof. Bhupendra C K Patel MD, FRCS

### Primary tumors of the optic nerve

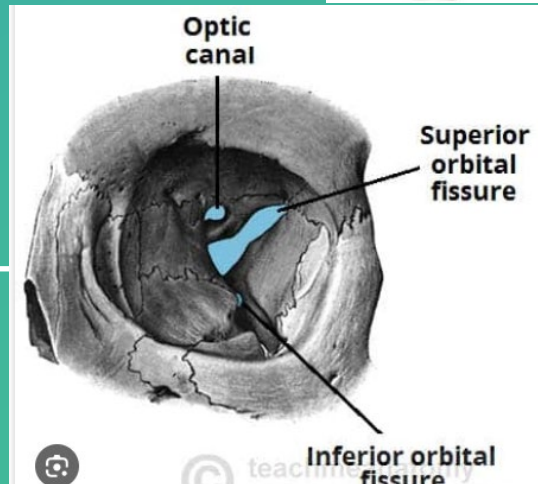
- **Optic nerve glioma**
- Malignant optic nerve glioma
- Optic nerve sheath **meningioma**
- **Ganglioglioma**
- Primary **lymphoma**

Optic nerve **GLIOMAS** primarily affect children. Although typically slow growing, the **location** of these tumors **makes resection impossible** without loss of vision in at least one eye.

Optic nerve gliomas and optic nerve sheath meningiomas make up just under 4% of orbital tumors. Optic nerve **GLIOMAS** are benign tumors classified as **pilocytic astrocytoma**. They make up half of all primary optic nerve tumors and between 1.5 and 4% of all orbital tumors.



**Astrocyte: GLIAL cell** which supports the nervous system by providing nutrients to neurons, maintaining the integrity of the blood-brain barrier, regulating blood flow in the brain, and maintaining synapses.  
-GLIOMAS originate from GLIAL cells-



Normal optic nerve

# NO SPACE



# RETINOBLASTOMA

**Retinoblastoma** is an eye cancer that begins in the **retina** — the sensitive lining on the inside of your eye. Retinoblastoma most commonly affects young children, but can rarely occur in adults. Retinoblastoma is a primitive **neuroectodermal** intraocular **malignancy**.

**Blastoma** is **cancer that affects a type of stem cell known as a precursor cell in a fetus**. A precursor cell is one that can become any type of body cell. **Blastomas forms in precursor fetal cells that remain after birth**. A developing baby that is not yet born has more precursor cells than an adult because the body is still forming. For this reason, blastomas are most common in children.

**-BLASTOMA** means a neoplasm consisting of immature undifferentiated cells called precursor cells. (Nephro**blastoma** (Wilms' tumor), Hepato**blastoma**, Medullo**blastoma**...)

**Leukocoria** :meaning “white pupil,” originates from the Greek words “leukos” (white) and “kore” (**pupil**). This is the most common early sign of retinoblastoma. But leukocoria can appear also in congenital cataracts, or other pathologies.

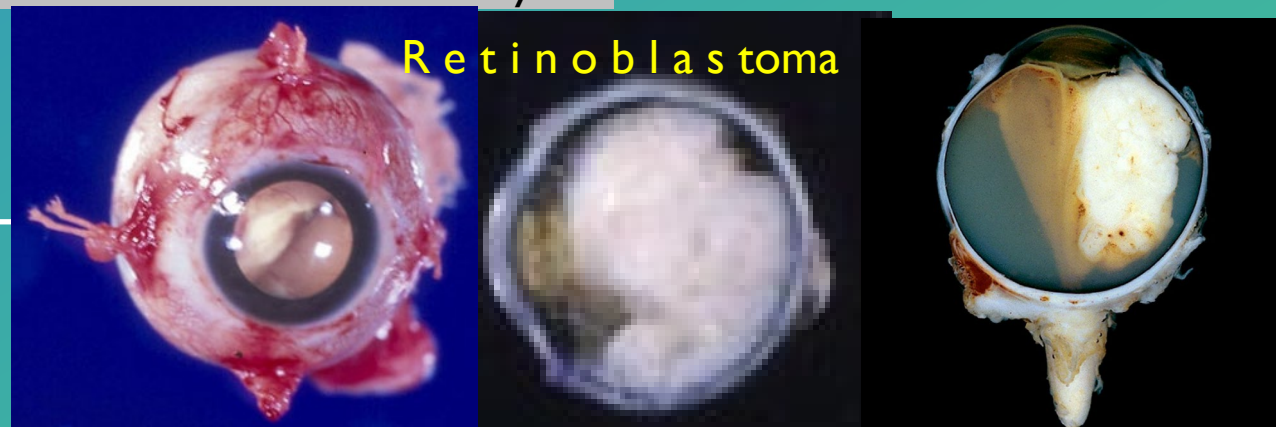


**eye cancer can kill**

A white glow in a child's eye could be a sign of cancer



**Metastases** generally occur within 12 months. Most commonly, metastases occur through direct invasion of the central nervous system **via the optic nerve**. The tumor also **may spread** through the subarachnoid space to the **contralateral optic nerve** or through the cerebrospinal fluid to the central nervous system, as well as hematogenous to **the lungs, bone, and brain**. Almost all untreated patients die of intracranial extension and disseminated disease within two years.



Retinoblastoma

Normal

In the developed world, Rb has one of the best cure rates of all childhood cancers (95%-98%), with more than nine out of every ten sufferers surviving into adulthood.

The main types of genes that play a role in cancer are:

•DNA repair genes

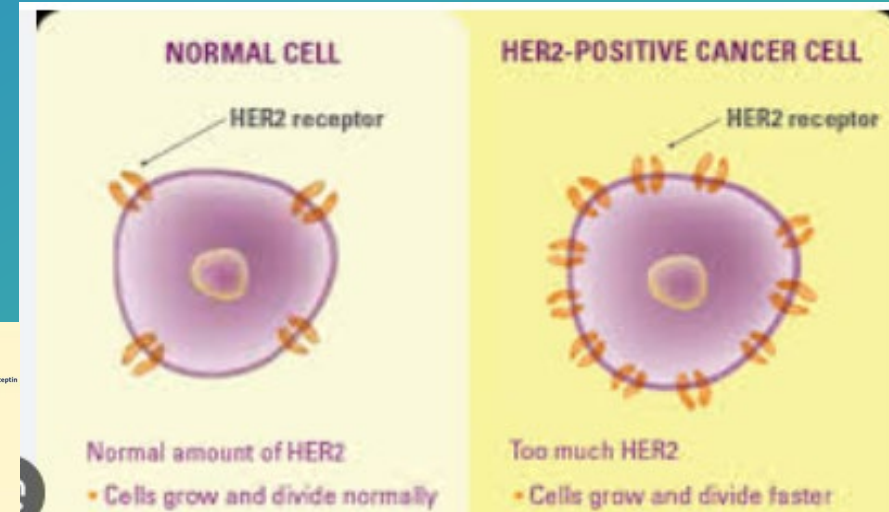
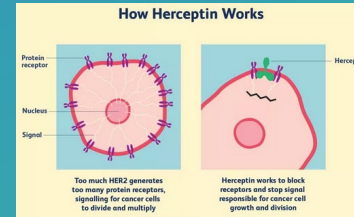
•Oncogenes (A PROTO-ONCOGENE (normal genes which regulate cell division of living cells) that **GAINED** function and became MUTATED and turned into an ONCOGENE) Examp. **HER2 ONCOGENE** in Breast Cancer.

•Tumor genes

(HER2: Human Epidermal **Growth** Factor Receptor 2)  
HER2 gene produces HER2 proteins which help cell grow and divide.

HER2 (+) Breast cancers means HER2 Gene is MUTATED with AMPLIFICATION and Overexpression of protein **HER2 receptors** which stimulate GROWTH.

TRASTUZUMAB (Herceptin) is antiHER2 and BLOCKS receptors.



Tumor suppressor genes (**LOSS** OF FUNCTION) Think: “CHECK POINT”

# RETINOBLASTOMA

Rb can occur in two forms: 1) A heritable form where there are often tumors in both eyes (bilateral) or sometimes only in one eye, and 2) A non-heritable form where there is a tumor in only one eye (unilateral). Approximately 55% of children with Rb have the non-genetic form.

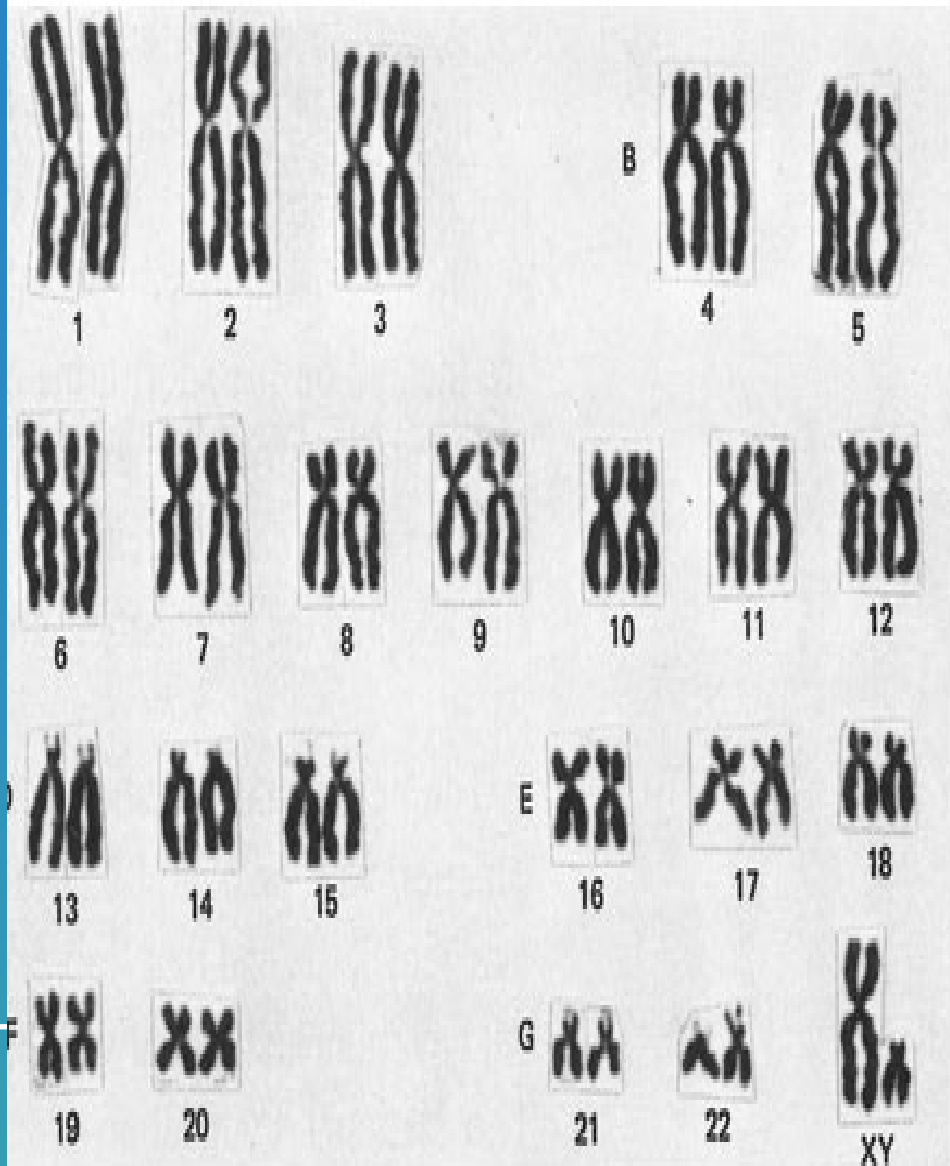
Retinoblastoma (Rb) can be inherited. Rb is quite rare and originates from the neural retina with a significant genetic component in etiology, which occurs in approximately 1 in every 20 000 births. In children with the heritable genetic form of Rb, there is a **mutation on chromosome 13**, called the **retinoblastoma 1 (Rb1) gene**.

The **Rb1** gene is the first cloned **tumor suppressor gene**. Keeps cells from dividing too rapidly in the cell cycle, **Rb1** gene.

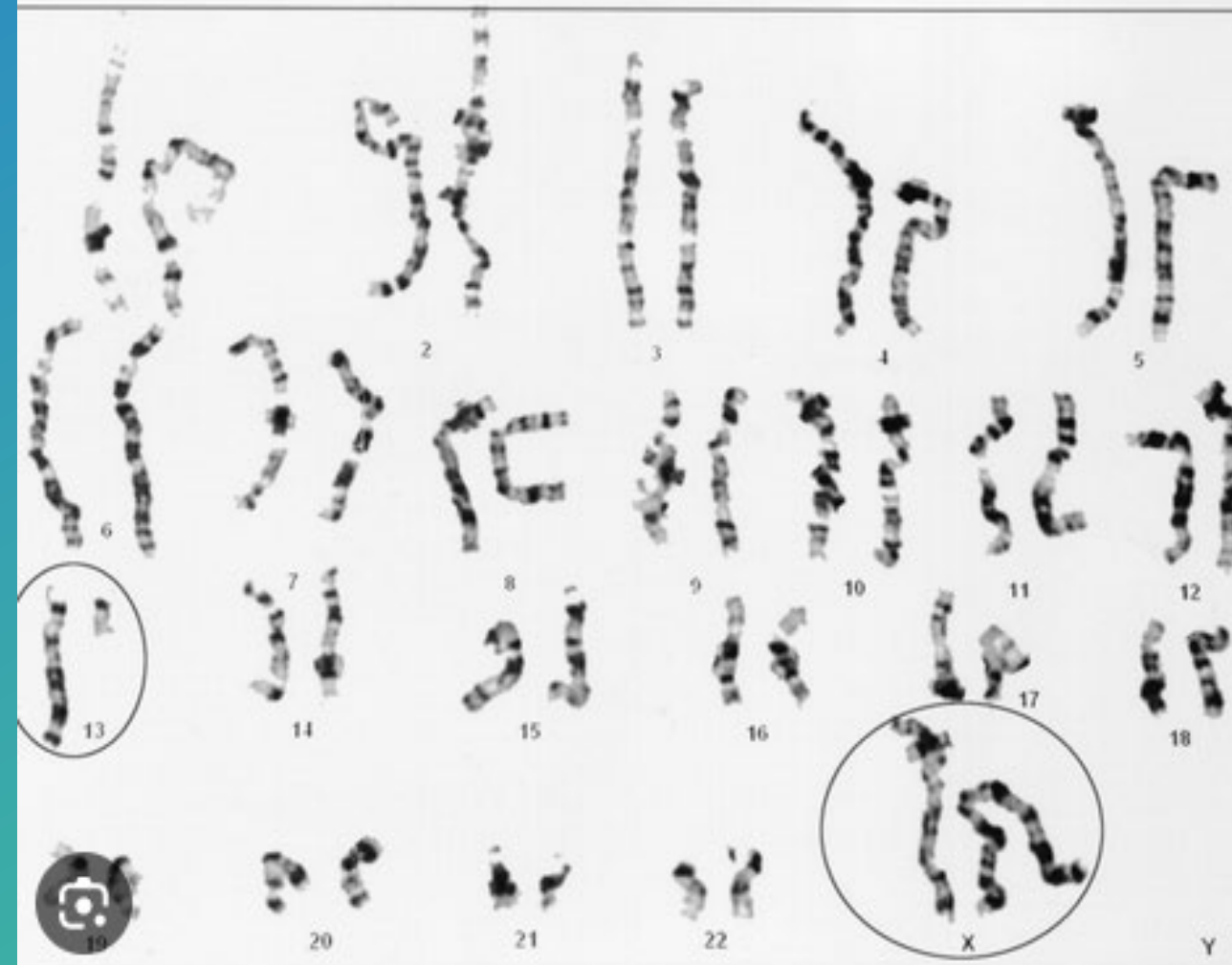
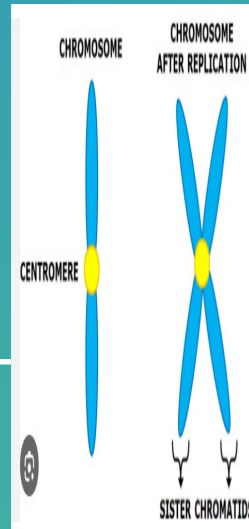
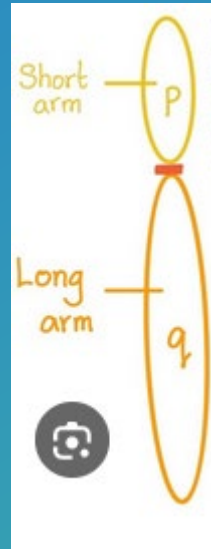
“Think check point” **LOSS** OF FUNCTION

**Chromosome 13q deletion syndrome** : partial deletions of one of the **long arms** of chromosome 13

**Retinoblastoma**: Mutation on **chromosome 13**, called the retinoblastoma 1 (Rb1) gene.



**Normal Karyotype 46, XY**



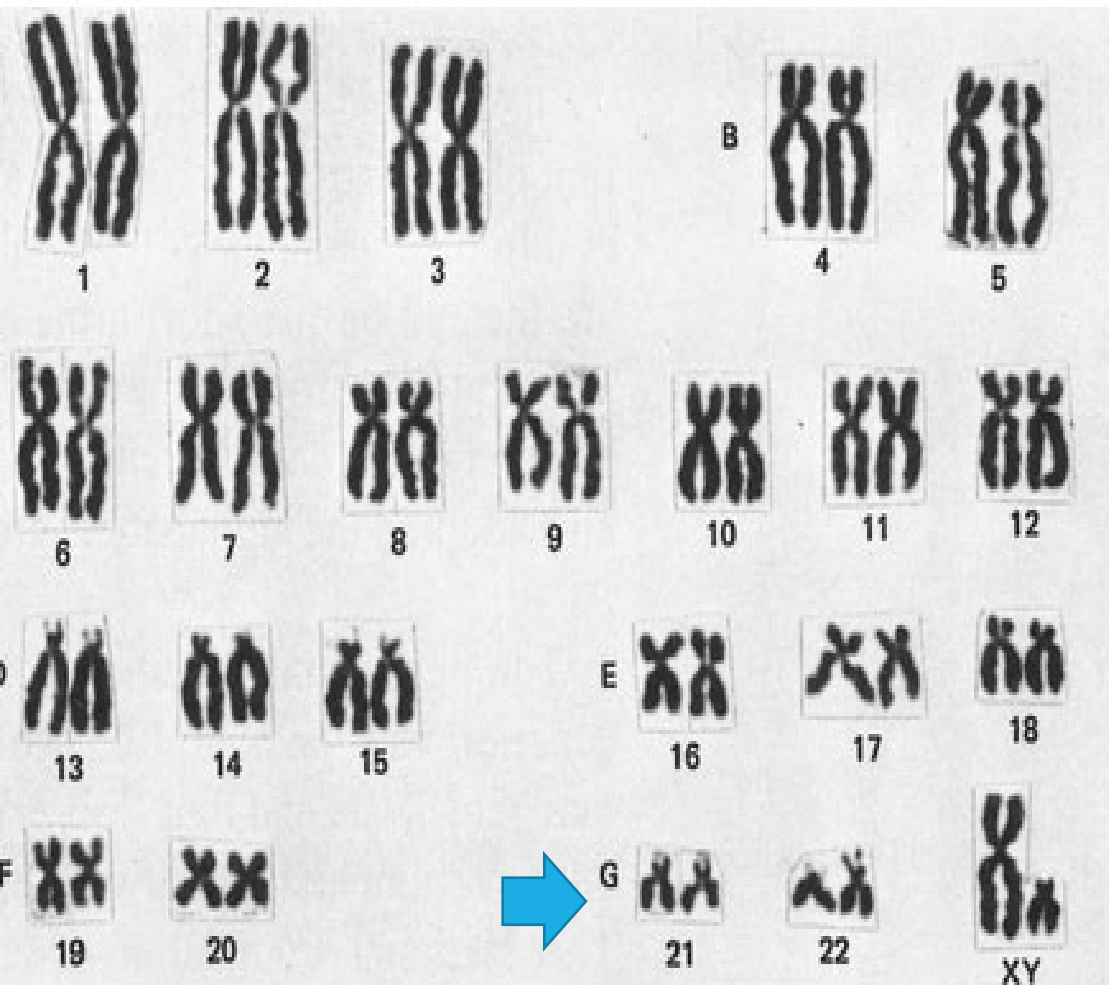
**Syndrome in girl give other birth defects**

Retinoblastoma in a patient with an X;13 translocation and facial abnormalities...

[Visit](#)

# Normal Karyotype

A karyotype is a picture of the 22 pairs of autosomes and the pair of sex chromosomes that have been isolated from a cell in metaphase. (23 mother + 23 father = 46XX, 46XY)



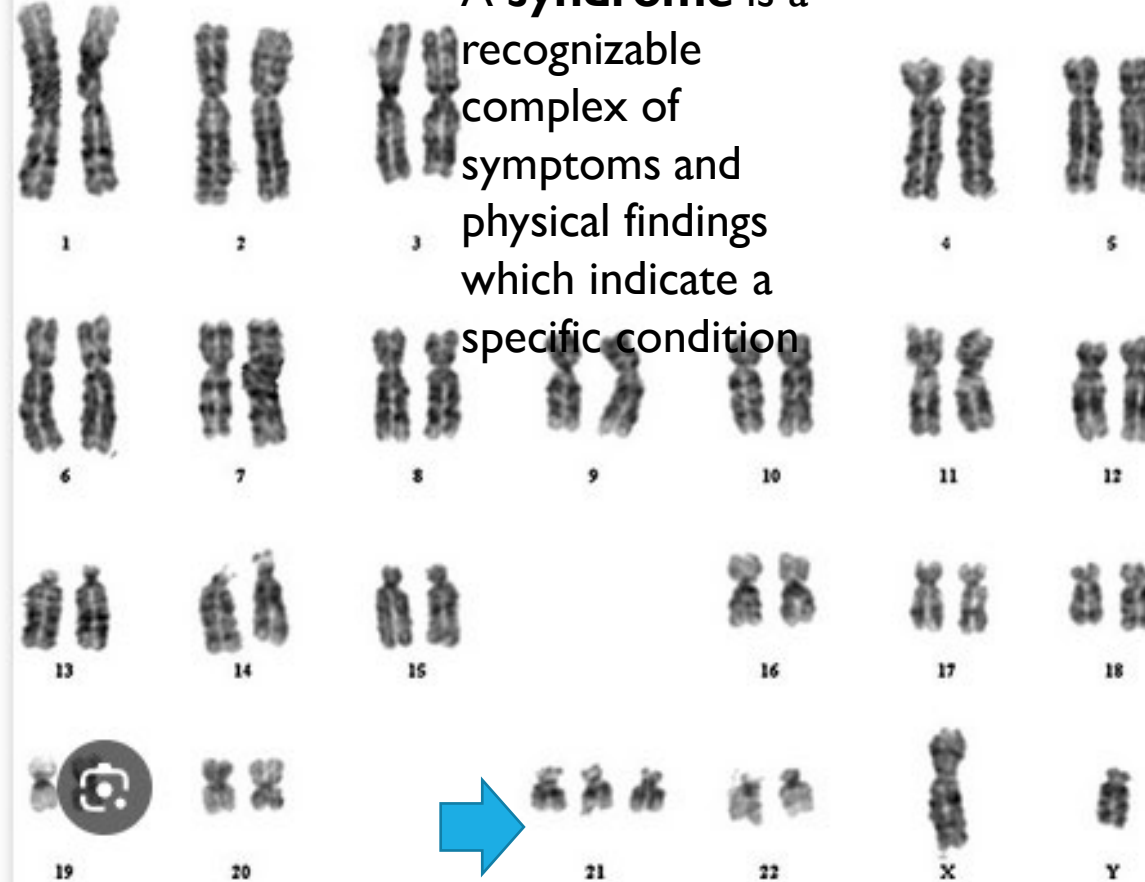
NORMAL 46, XY

# ABNORMAL KARYOTYPE

(47, XY,+21, Trisomy 21) **DOWN SYNDROME**. Increased risk **ALL** in children and Alzheimer's.



A **syndrome** is a recognizable complex of symptoms and physical findings which indicate a specific condition



Karyotype of a patient with trisomy 21

Visit

*RUNX1*  
gene/transcription factor  
in  
chromosome  
21 linked to  
Leukemias

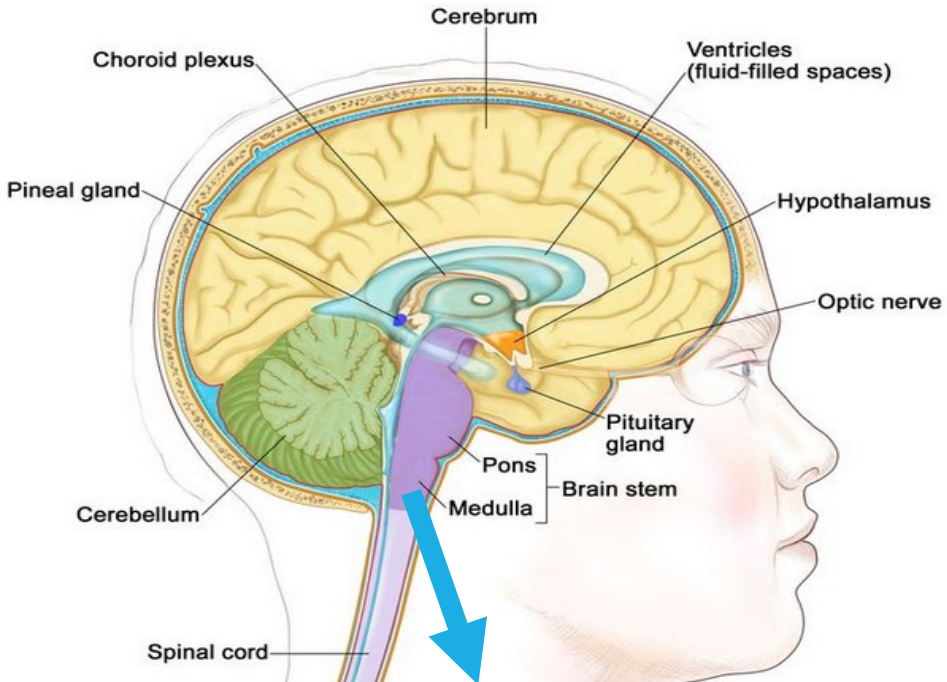
Children with Down's syndrome are at an increased risk of developing any type of acute leukemia. In particular, they are 150 times more likely to develop acute myeloid leukemia (**AML**) and are at a 33 times greater risk of developing acute lymphoblastic leukemia (**ALL**).

Retinoblastoma	<p>RB1 mutation in Retinoblastoma <b>retinoblastoma 1 (Rb1) gene. Mutated Tumor suppressor gene.</b></p> <p>In an analysis of 192 patients with retinoblastoma with identifiable germline mutations in the RB gene (Harbour, 1998), the DNA alteration was a nonsense mutation in 83 (43%), frameshift in 67 (35%), intron mutation in 23 (12%), missense mutation in 11 (6%), in-frame deletion in 5 (3%), and promoter mutation in 3 (2%).</p>	<a href="#">Publications</a>
<a href="#">Acute Lymphocytic Leukaemia (ALL)</a>	<a href="#">RB1 and Acute Leukaemias</a>	<a href="#">► View Publications</a>
<a href="#">Lung Cancer</a>	<a href="#">RB1 and Lung Cancer</a>	<a href="#">► View Publications</a>
<a href="#">Breast Cancer</a>	<p><a href="#">RB1 mutations in Breast Cancer</a></p> <p>RB1 mutations are found in some breast cancers; there is a non-random relationship between p53 mutation and loss of material from the RB1 locus.</p>	<a href="#">► View Publications</a>
<a href="#">Bladder Cancer</a>	<a href="#">RB1 and Bladder Cancer</a>	<a href="#">► View Publications</a>
<a href="#">Osteosarcoma</a>	<a href="#">RB1 and Osteosarcoma</a>	<a href="#">► View Publications</a>
<a href="#">Esophageal Cancer</a>	<a href="#">RB1 and Esophageal Cancer</a>	<a href="#">► View Publications</a>
<a href="#">Adrenocortical Cancer</a>	<a href="#">RB1 and Adrenocortical Carcinoma</a>	<a href="#">► View Publications</a>

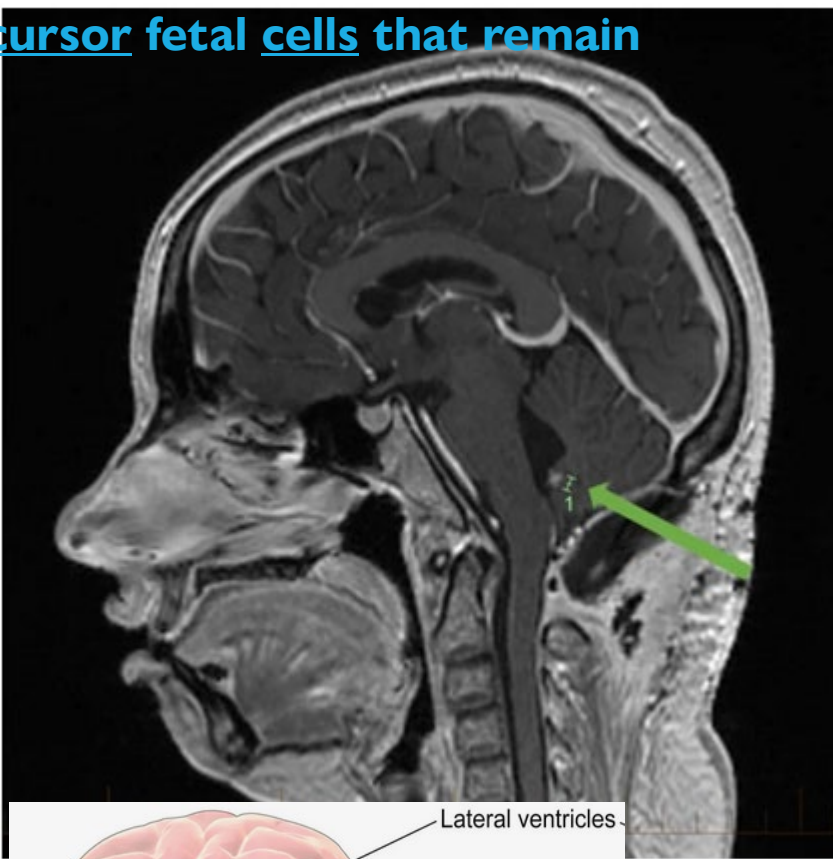
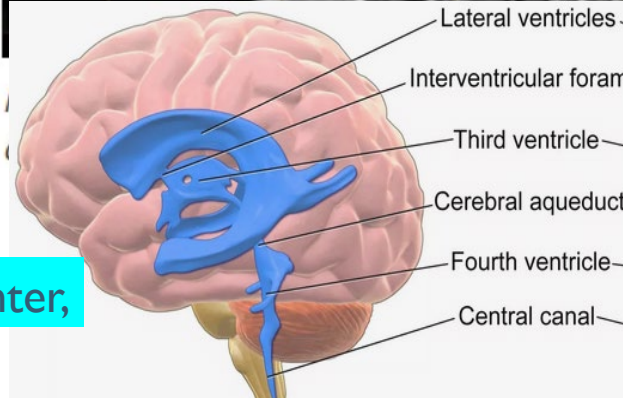
Blastomas forms in precursor fetal cells that remain after birth

# Medulloblastoma

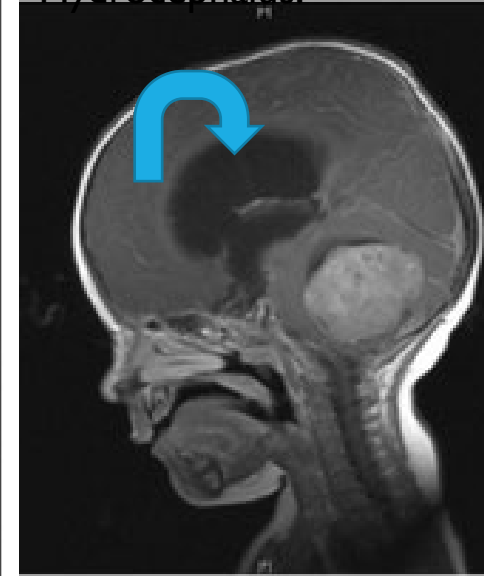
ENLARGE Q



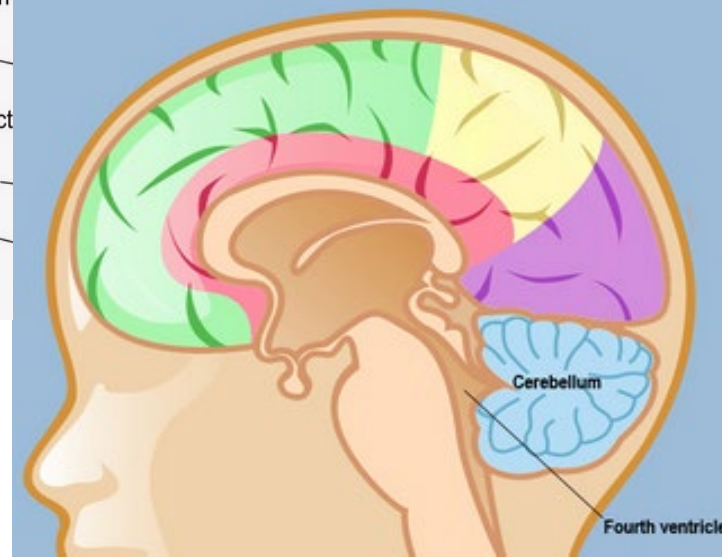
**MEDULLA OBLONGATA:** Respiratory center, cardiovascular functions, swallowing.



Note Enlarged VENTRICLES b/c obstruction of CSF: Hydrocephalus.



Medulloblastoma: C



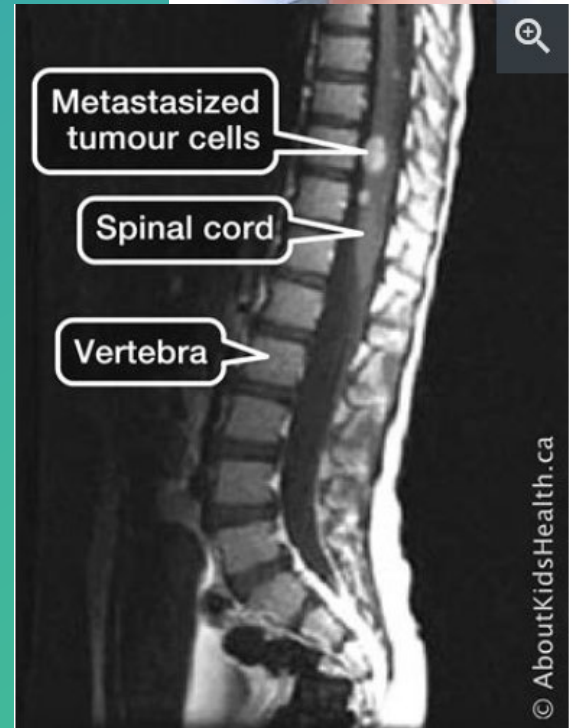
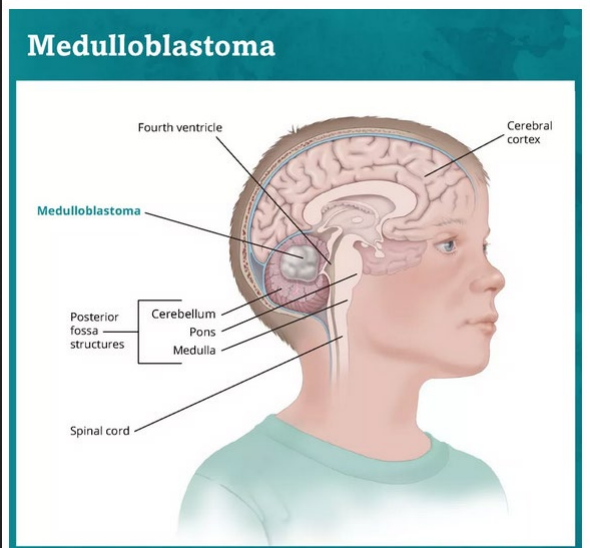
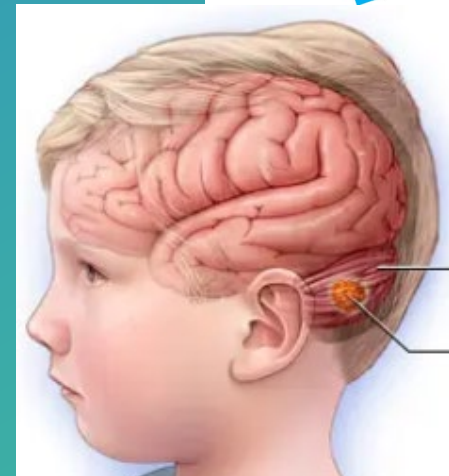
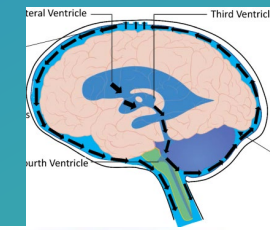
Medulloblastomas most commonly form in the cerebellum. Most occur in children between the ages of 1 and 9. It is less common in adults. The 5-year relative survival rate for medulloblastoma for children age 14 and younger is 72%. The 5-year relative survival rate for teens and young adults ages 15 to 39 is about 78%. The 5-year relative survival rate for people 40 or older is 66%.

Subgroup		WNT	SHH	Group 3	Group 4
Clinical Characteristics	% of Cases	10	30	25	35
	Age at Diagnosis				
	Gender Ratio (M:F)	1:1	1:1	2:1	3:1
	Anatomic Location				
	Histology	Classic, Rarely LCA	Desmoplastic, Classic, LCA	Classic, LCA	Classic, LCA
	Metastasis at Diagnosis (%)	5-10	15-20	40-45	35-40
	Recurrence Pattern	Rare; Local or metastatic	Local	Metastatic	Metastatic
	Prognosis	Very good	Infants good, others intermediate	Poor	Intermediate
Molecular Characteristics	Proposed Cell of Origin	Progenitor cells in the lower rhombic lip	Granule precursors of the external granule layer	Neural stem cells	Unipolar brush cells
	Recurrent Gene Amplifications	-	<i>MYCN</i> <i>GLI1</i> or <i>GLI2</i>	<i>MYC</i> <i>MYCN</i> <i>OTX2</i>	<i>SNCAIP</i> <i>MYCN</i> <i>OTX2</i> <i>CDK6</i>
	Recurrent SNVs	<i>CTNNB1</i> <i>DDX3X</i> <i>SMARCA4</i> <i>TP53</i>	<i>PTCH1</i> <i>TERT</i> <i>SUFU</i> <i>SMO</i> <i>TP53</i>	<i>SMARCA4</i> <i>KBTBD4</i> <i>CTDNEP1</i> <i>KMT2D</i>	<i>KDM6A</i> <i>ZMYM3</i> <i>KTM2C</i> <i>KBTBD4</i>
	Cytogenetic Events ■ Gain ■ Loss	6	3q, 9p 9q, 10q, 17p	1q, 7, 18 8, 10q, 11, 16q i17q	7, 18q 8, 11p, X i17q
	Other Recurrent Genetic Events	-	-	<i>GFI1</i> and <i>GFI1B</i> enhancer hijacking	<i>PRDM6</i> , <i>GFI1</i> , and <i>GFI1B</i> enhancer hijacking

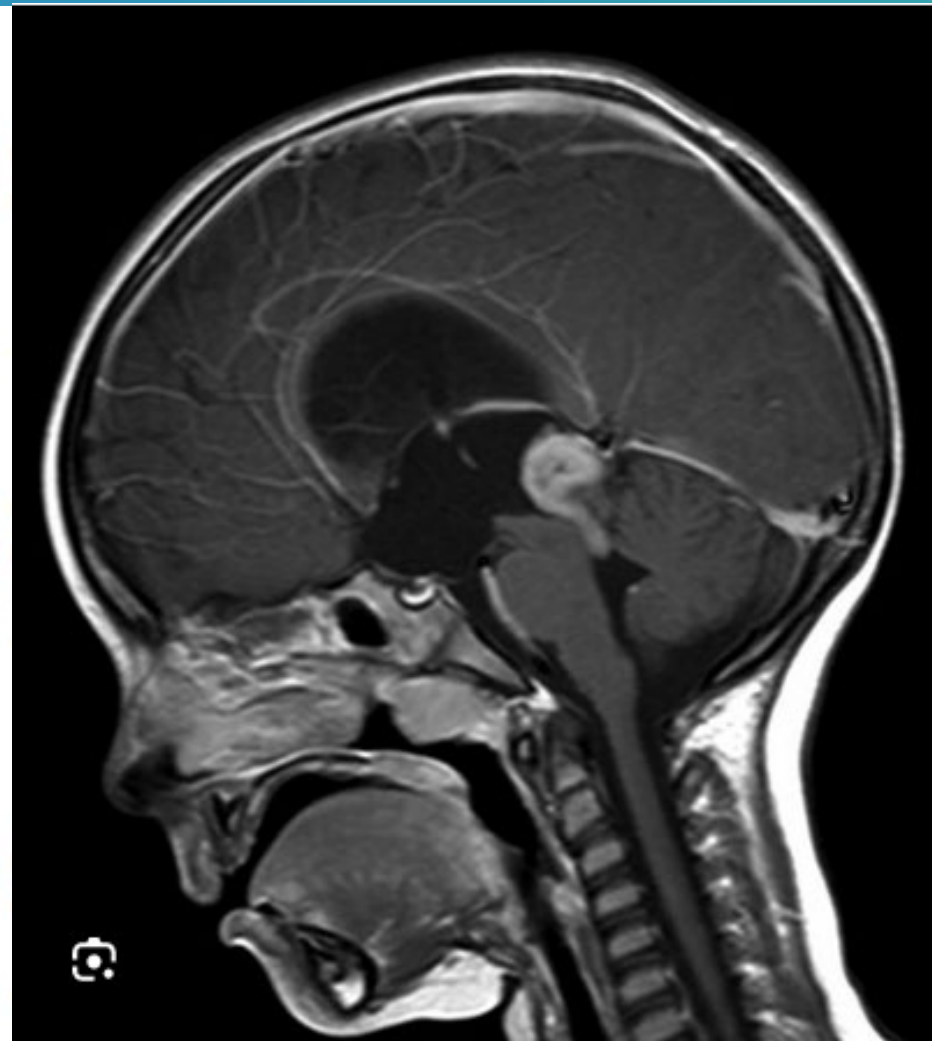
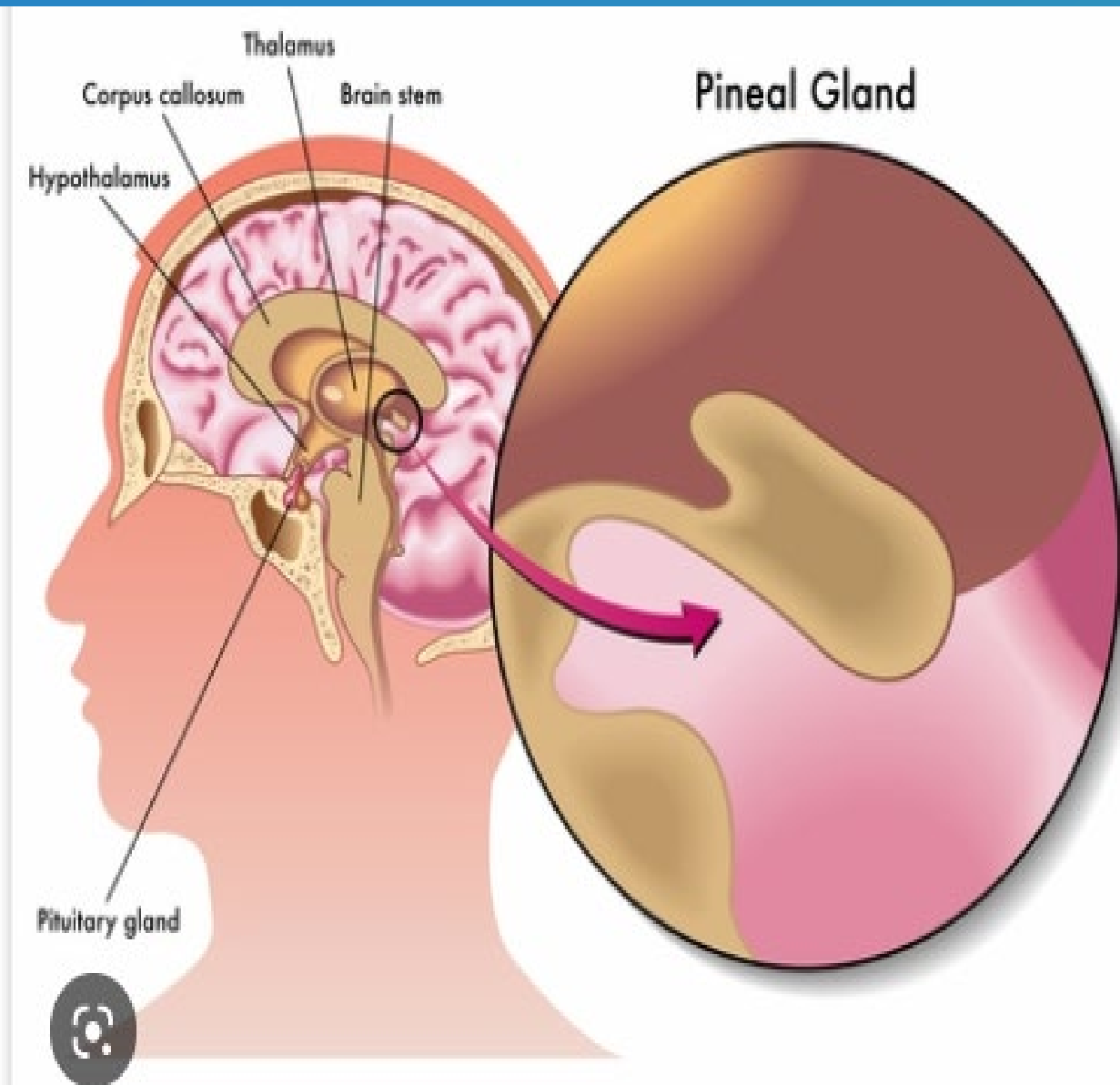
Age: Infant Child Adult

# 4 TYPES MEDULLOBLASTOMA

Medulloblastoma is defined by the World Health Organization (WHO) as "an embryonal neuroepithelial tumor arising in the cerebellum or dorsal brainstem, presenting mainly in childhood. The majority of medulloblastomas arise from the inferior cerebellar vermis, from which they extend into and typically fill the fourth ventricle. Obstruction of flow of cerebrospinal fluid (CSF) will produce hydrocephalus above this level. The neoplasm can also invade adjacent brainstem structures, including the cardiorespiratory centers of the fourth ventricular floor. The previously mentioned tendency of medulloblastoma to spread via CSF pathways can lead to diffuse "sugar coating" of the subarachnoid space and to nodular growths along the spinal cord or even ventricular surfaces. A smaller proportion of medulloblastomas occur in one of the cerebellar hemispheres of patients who are typically older (adolescents or young adults), a subset in which the desmoplastic/nodular variant predominates. [2] They can metastasize to other parts of the CNS through CSF.



# PINEALOMA

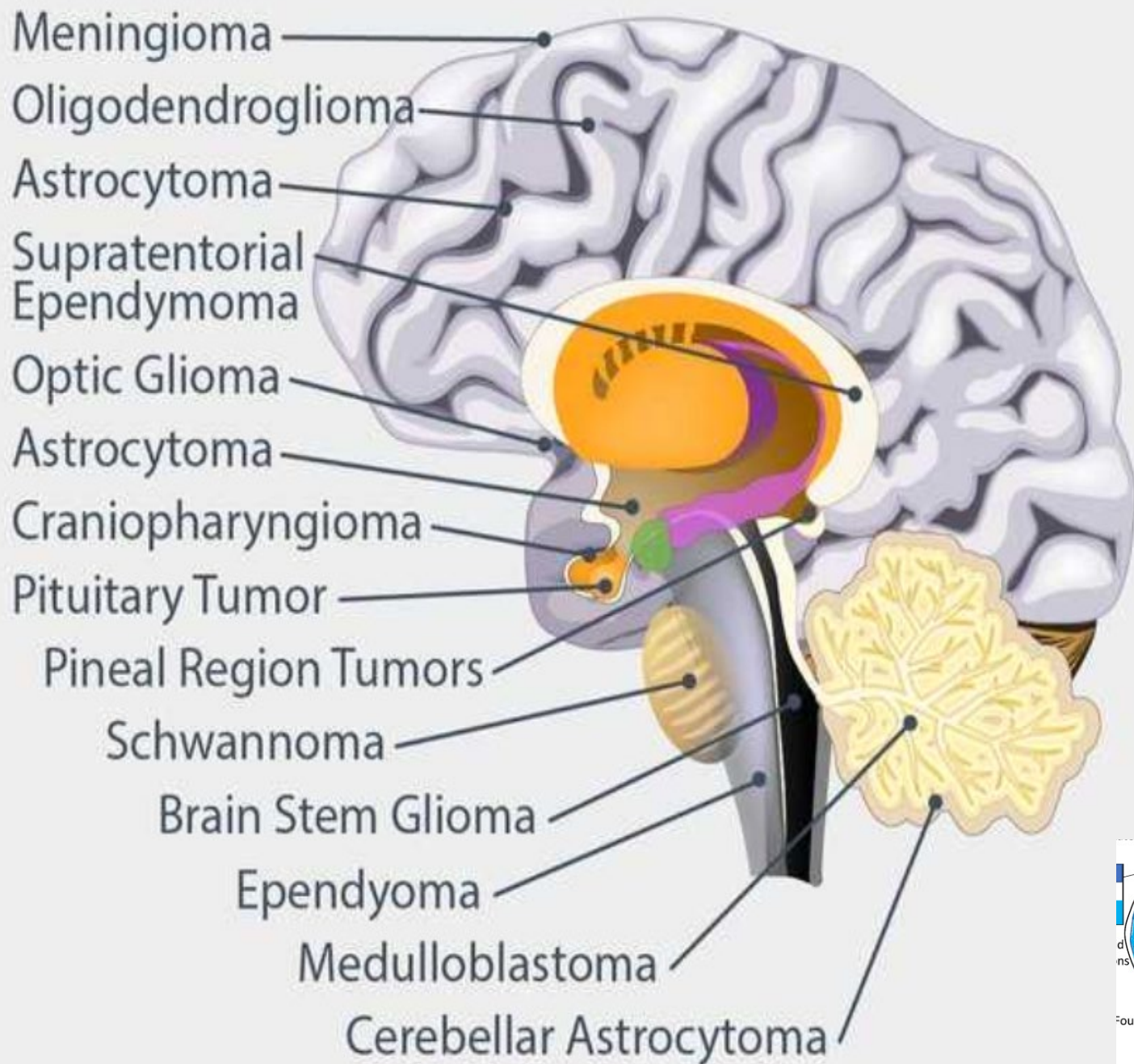


File: MRI image of pineoblastoma 2.jpg  
- wikidoc

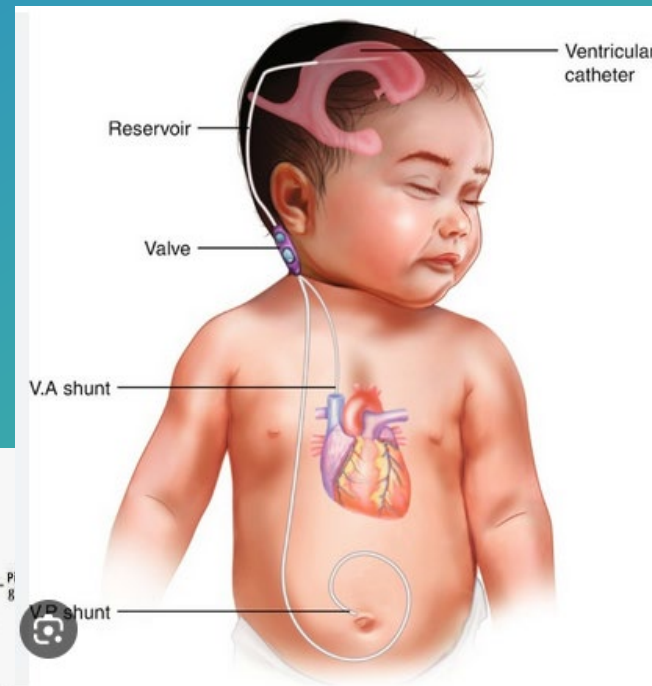
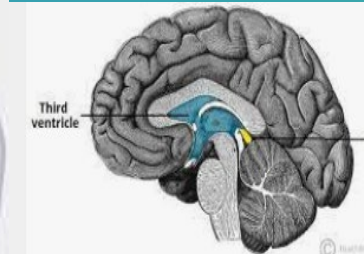
Visi



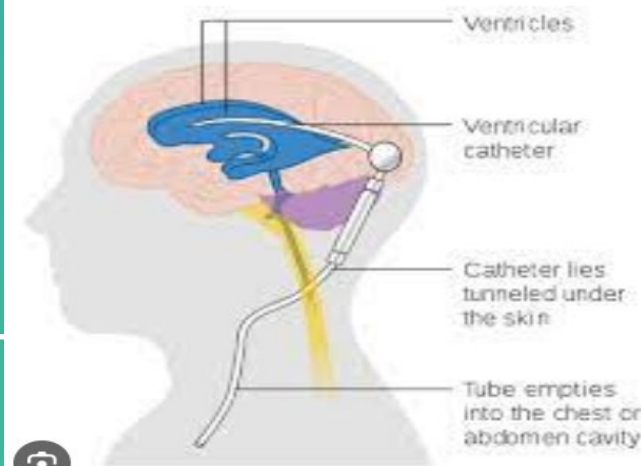
The location of common tumors within the brain.



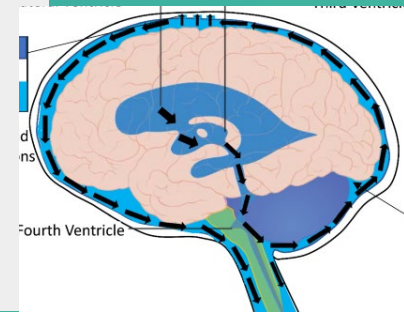
# TUMORS



Pediatrics Clerkship - T...



Ventriculoperitoneal Shunts |



**BETTY MALANOWSKI, BS, IMG, CTR,  
FCDS FIELD COORDINATOR**



- <https://teachmeanatomy.info/head/cranial-nerves/summary/>
- <https://www.mayoclinic.org/diseases-conditions/schwannoma/cdc-20352974>
- <https://study.com/learn/lesson/artrocytes-function-location-structure.html>
- <http://www.bechildcanceraware.org/wp-content/uploads/2010/02/Rbweek2012poster.jpg>
- <https://www.mdanderson.org/cancerwise/glioma-vs--glioblastoma--what-is-the-difference-in-these-brain-tumors-treatment-diagnosis.h00-159537378.html>
- [https://ranzcrpart1.fandom.com/wiki/Anterior\\_Cranial\\_Fossa](https://ranzcrpart1.fandom.com/wiki/Anterior_Cranial_Fossa)
- <https://www.childrenscolorado.org/conditions-and-advice/parenting/parenting-articles/fontanelles/>
- <https://brainstuff.org/blog/what-is-the-cribriform-plate>
- <https://www.cerebralpalsyguide.com/birth-injury/hydrocephalus/>
- <https://www.getbodysmart.com/spinal-cord/gray-matter-functions/>
- <https://www.pacificneuroscienceinstitute.org/blog/hydrocephalus/introducing-pacific-adult-hydrocephalus-center/>
- [https://emedicine.medscape.com/article/1923254-overview?icd=login\\_success\\_email\\_match\\_norm](https://emedicine.medscape.com/article/1923254-overview?icd=login_success_email_match_norm)
- [https://emedicine.medscape.com/article/1923254-overview?icd=login\\_success\\_email\\_match\\_norm#a2](https://emedicine.medscape.com/article/1923254-overview?icd=login_success_email_match_norm#a2)
- <https://www.scielo.org/article/spm/2020.v62n1/96-104/>
- <https://www.indiatvnews.com/news/world/nasa-looks-for-high-tech-airships-21992.html>
- <https://saludpublica.mx/index.php/spm/article/view/10501>
- <https://pubmed.ncbi.nlm.nih.gov/15520076/>
- <https://www.mayoclinic.org/diseases-conditions/retinoblastoma/symptoms-causes/syc-20351008>
- <https://www.slideteam.net/0314-thank-you-with-smiley.html>

- <https://www.mdpi.com/2075-4418/12/2/351> (Article Intracranial Meningioma in Elderly patients).
- [https://www.123rf.com/photo\\_165056273\\_brain-cancer-tumor-with-explanations-silhouette-of-kid-child-head-inner-view.html](https://www.123rf.com/photo_165056273_brain-cancer-tumor-with-explanations-silhouette-of-kid-child-head-inner-view.html)
- <https://encyclopedia.pub/entry/2756> Scholarly Community Encyclopedia
- <https://www.sciencedirect.com/science/article/pii/B9780128009451000057>
- <https://www.cancer.org/cancer/pituitary-tumors/about/what-is-pituitary-tumor.html>
- [https://www.physio-pedia.com/File:Acromegaly\\_classic\\_woman.gif](https://www.physio-pedia.com/File:Acromegaly_classic_woman.gif)
- <https://proactive4pt.com/growth-plate-injuries/> PROACTIVE Physical Therapy and Sports Medicine.
- <https://www.google.com/search?q=distal+tibia+anatomy+radiology&client=firefox-b-1-d&source=lnms&tbm=isch&sa=X&ved=2ahUKEwj6sVVs0IH-AhWpRTABHQ6NCFMQ0pQJegQIBxAC&biw=1192&bih=734&dpr=1.03#imgrc=uiXbW65s6SwnPM>
- <https://theconversation.com/unusual-conditions-what-are-gigantism-and-acromegaly-64000>
- <https://nurseslabs.com/acromegaly-nursing-management-2/> NurseLabs.
- <https://www.endocrinologyadvisor.com/home/topics/general-endocrinology/acromegaly-outlook-improves-with-better-diagnostics-and-treatment/>
- <https://axisimagingnews.com/market-trends/emerging-technology/13-48-million-awarded-develop-implantable-ultrasound-devices-spinal-cord-injury>
- <https://asbmr.onlinelibrary.wiley.com/doi/full/10.1359/jbmr.1997.12.3.322>
- <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/craniopharyngioma>
- <https://www.nichd.nih.gov/health/topics/neuro/conditioninfo/parts>
- [https://www.researchgate.net/figure/a-Normal-CT-of-the-brain-of-a-37-year-old-living-male-patient-Regular\\_fig1\\_278670308](https://www.researchgate.net/figure/a-Normal-CT-of-the-brain-of-a-37-year-old-living-male-patient-Regular_fig1_278670308)

- <https://www.cancer.gov/rare-brain-spine-tumor/tumors/medulloblastoma>
- <https://www.aao.org/education/disease-review/review-of-retinoblastoma>
- <https://pathology.or.jp/corepicturesEN/22/c10/01.html>
- [https://s3.amazonaws.com/static.wd7.us/e/e4/Retinoblastoma\\_gross\\_pathology.jpeg](https://s3.amazonaws.com/static.wd7.us/e/e4/Retinoblastoma_gross_pathology.jpeg)
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3340672/>
- <https://www.cancer.org/cancer/understanding-cancer/genes-and-cancer/oncogenes-tumor-suppressor-genes.html>
- <https://www.youtube.com/watch?v=dWixzl3wprc>
- <https://www.vecteezy.com/vector-art/8131474-trisomy-21-down-syndrome-karyotype>
- <https://study.com/learn/lesson/sister-chromatids-role-importance.html>
- <https://www.cancer.gov/rare-brain-spine-tumor/tumors/ependymoma>
- <https://www.physio-pedia.com/Ependymoma?veaction=edit>
- [https://images.ctfassets.net/pxkx5g3u6qc6/spu\\_wysiwyg\\_fid39329\\_asset/8f8f59f5289336eb977c108ac14da8ce/Khalil\\_TTumor\\_Fig1B.jpg?fm=webp&fit=thumb&q=65&w=1312&h=2170](https://images.ctfassets.net/pxkx5g3u6qc6/spu_wysiwyg_fid39329_asset/8f8f59f5289336eb977c108ac14da8ce/Khalil_TTumor_Fig1B.jpg?fm=webp&fit=thumb&q=65&w=1312&h=2170)
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3571582/>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2596698/>
- <https://www.aans.org/en/Patients/Neurosurgical-Conditions-and-Treatments/Cauda-Equina-Syndrome>
- <https://thefetus.net/content/persistent-craniopharyngeal-canal>
- [https://upload.wikimedia.org/wikipedia/commons/0/01/Medulla\\_oblongata\\_small.gif](https://upload.wikimedia.org/wikipedia/commons/0/01/Medulla_oblongata_small.gif)

- Neuropathology web
- <https://teachmeanatomy.info/head/cranial-nerves/optic-cnii/>
- American Brain Tumor Association.
- <https://www.news-medical.net/news/20230310/Scientists-identify-the-cause-of-leukemia-in-people-with-trisomy-21.aspx>
- National Ataxia Foundation
- <https://www.ataxia.org/scasourceposts/snapshot-what-is-cerebrospinal-fluid-csf/>
- <https://www.getbodysmart.com/motor-system/stretch-myotatic-reflex/>
- <https://www.getbodysmart.com/motor-system/stretch-myotatic-reflex/>
- <https://www.ncbi.nlm.nih.gov/books/NBK557878/>
- <https://www.verywellhealth.com/herceptin-biologic-therapy-for-breast-cancer-430573>
- <https://my.clevelandclinic.org/health/diseases/22954-gigantism>
- [https://bio.libretexts.org/Bookshelves/Introductory\\_and\\_General\\_Biology/Book%3A\\_General\\_Biology\\_%28Boundless%29%38%3A\\_The\\_Musculoskeletal\\_System/38.08%3A\\_Bone\\_-\\_Growth\\_of\\_Bone](https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_%28Boundless%29%38%3A_The_Musculoskeletal_System/38.08%3A_Bone_-_Growth_of_Bone)
- <https://forensicsdigest.com/estimation-age-skull/>
- <https://www.facebook.com/humnbirth/posts/baby-rubys-beautiful-cone-head-is-the-result-of-her-skull-bones-overlapping-and-/1756269561321515/>
- Human Birth project. @anakedmidwife
- <https://www.cancer.net/cancer-types/medulloblastoma-childhood/statistics>
- <https://miamineurosciencecenter.com/en/conditions/brain-tumors/types/>
- <https://www.uclahealth.org/medical-services/neurosurgery/pituitary-skull-base-tumor/conditions/rathkes-cleft-cyst>
- Mayo CLINIC
- <https://kidshealth.org/en/parents/hydrocephalus.html> Numerous
- <https://fluidsbarrierscns.biomedcentral.com/articles/10.1186/s12987-019-0129-6> bmc
- <https://www.pinterest.com/pin/herniated-disc--19773685851123289/>
- [https://link.springer.com/chapter/10.1007/978-3-030-84467-7\\_43](https://link.springer.com/chapter/10.1007/978-3-030-84467-7_43)[https://](https://www.kaltura.com/index.php/extwidget/preview/partner_id/816122/uiconf_id/44640271/entry_id/0_zmmtsryp/embed/dynamic)
- [www.kaltura.com/index.php/extwidget/preview/partner\\_id/816122/uiconf\\_id/44640271/entry\\_id/0\\_zmmtsryp/embed/dynamic](http://www.kaltura.com/index.php/extwidget/preview/partner_id/816122/uiconf_id/44640271/entry_id/0_zmmtsryp/embed/dynamic)
- [www.cancer.gov/types/pituitary/patient/pituitary-treatment-pdq](http://www.cancer.gov/types/pituitary/patient/pituitary-treatment-pdq)<https://www.eurorad.org/case/16584/>
- [https://www.stritch.luc.edu/lumen/meded/radio/curriculum/neurology/hydrocephalus\\_2013.htm](https://www.stritch.luc.edu/lumen/meded/radio/curriculum/neurology/hydrocephalus_2013.htm)