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- Pre-natal growth proper.
- Development of the skull.
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## **Post-natal Growth and Development :**

- The cranial vault.
  - The cranial base.
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# Introduction:

- Growth and development of an individual can be divided into –
  - 1) pre-natal period (dynamic phase)
  - 2) post-natal period

## **Pre-natal period:**

Arbitrarily divided into three periods-

- Period of the ovum.
  - Period of the embryo
  - Period of the fetus.
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## ■ **Period of ovum:**

1. Extends for a period of approximately 2 weeks from the time of fertilization.
  2. During this period the cleavage of the ovum and the attachment of the ovum to the intra-uterine wall occurs.
  3. At the end of this period the ovum is only 1.5 mm in length, and cephalad differentiation has not yet begun.
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## ■ **Period of embryo:**

1. Extends from 14<sup>th</sup> day to 56<sup>th</sup> day of intra-uterine life.
  2. During this period the major part of the development of the facial and the cranial region occurs.
  3. At the end of this period, embryo is 18 mm long and the head starts to assume human proportions.
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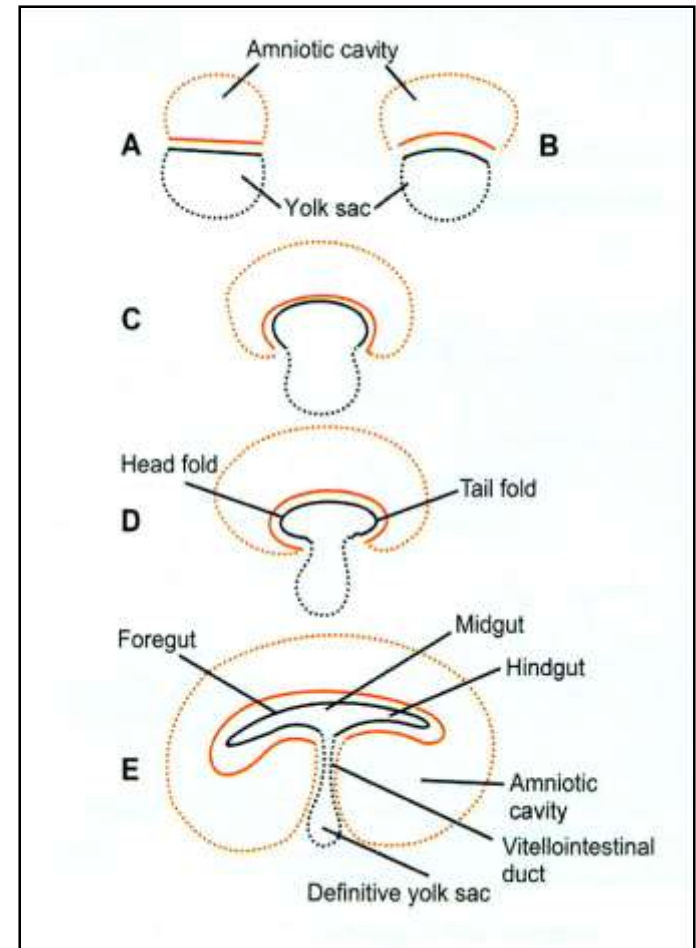
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## ■ **Period of Fetus:**

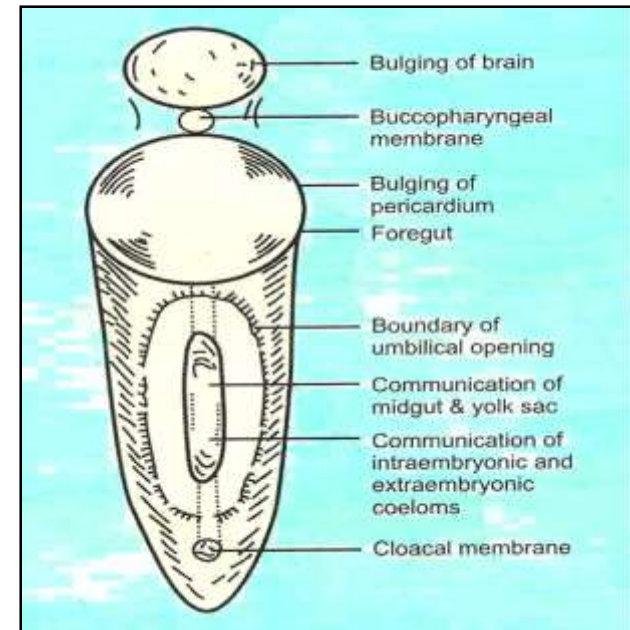
- This phase Extends from 56<sup>th</sup> day of intra-uterine life till birth.
  - In this period, accelerated growth of the craniofacial structures occurs resulting in an increase in their size.
  - During this period the fetus triples in length from 20 mm to 60 mm. tremendous acceleration of growth is the theme.
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# Pre-natal growth proper

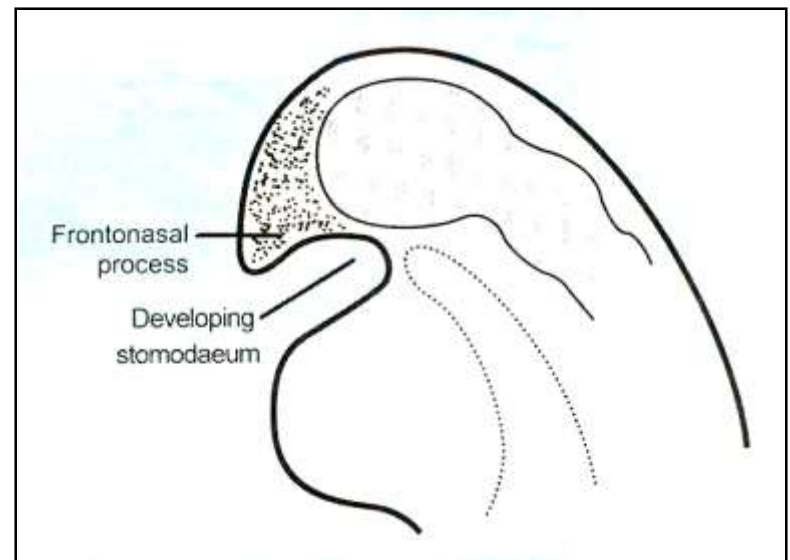
- The growth of the cranial, facial and oral structures begins around the 21<sup>st</sup> day.(period of embryo) after conception. At this stage the head begins to take shape.
- The embryonic disc bulge upwards into the amniotic cavity. As this continues the embryonic disc becomes folded on itself at the head and tail ends. These are called **head and tail folds**.



- After the formation of head fold, the developing brain and pericardium form two prominent bulgings in the ventral aspect of embryo.
- In between them there is a depression called **stomodaeum**, the floor of which is formed by the **buccopharyngeal membrane**. This membrane separates the stomodaeum from the **foregut**.

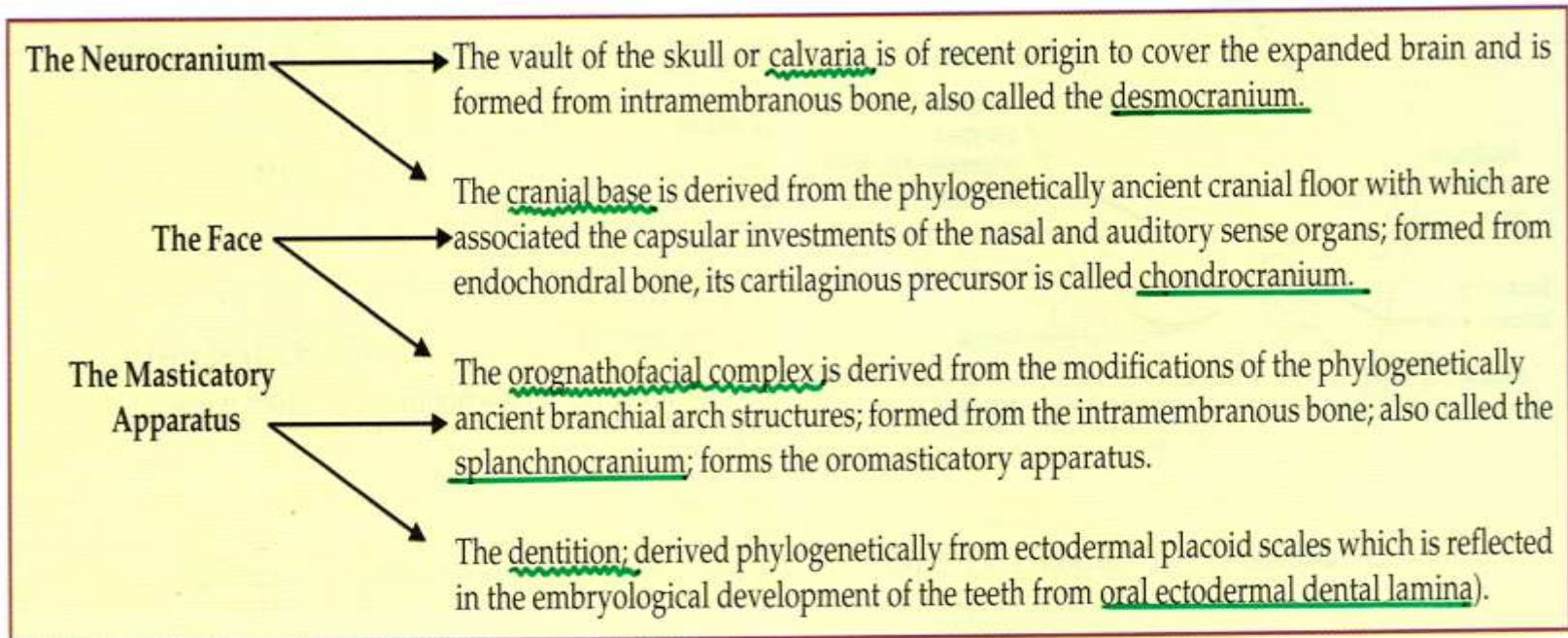


- Soon the mesoderm covering the developing brain proliferates and forms a downward projection that overlaps the upper part of the stomodaeum called as **frontonasal process**.



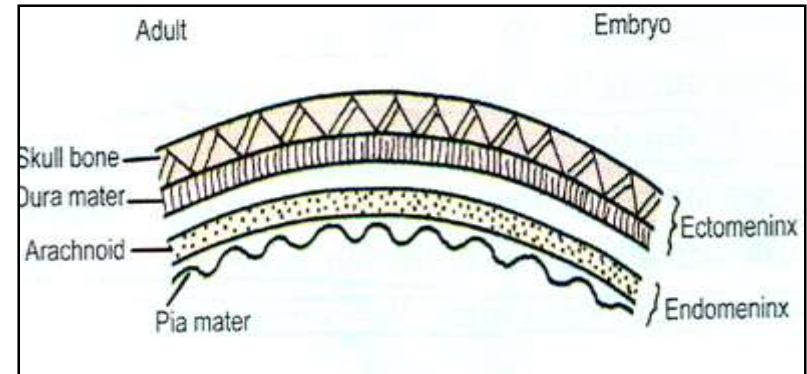
# Development of the skull

- The development of the skull is a blend of the morphogenesis and growth of three main skull entities.



# The calvaria

- The **mesenchyme** that give rise to vault of the neurocranium is first arranged as a capsular membrane around the developing brain.



- The membrane is composed of two layers, an inner **endomeninx**, of neural crest origin and an outer **ectomeninx**, of mesodermal origin.
- The **endomeninx** forms the two leptomeningeal coverings of the brain- **pia mater** and the **arachnoid**.

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- The **ectomeninx** differentiates into the inner duramater covering the brain. Which remains unossified, and an outer superficial membrane with chondrogenic and osteogenic properties.
  - Osteogenesis of the ectomeninx occurs as **intramembraneous** bone formation over the dome of the brain, forming the skull vault or **calvaria**, while the ectomeninx forming the floor of the brain chondrifies as the **chondrocranium** that later ossifies **endochondrally**.
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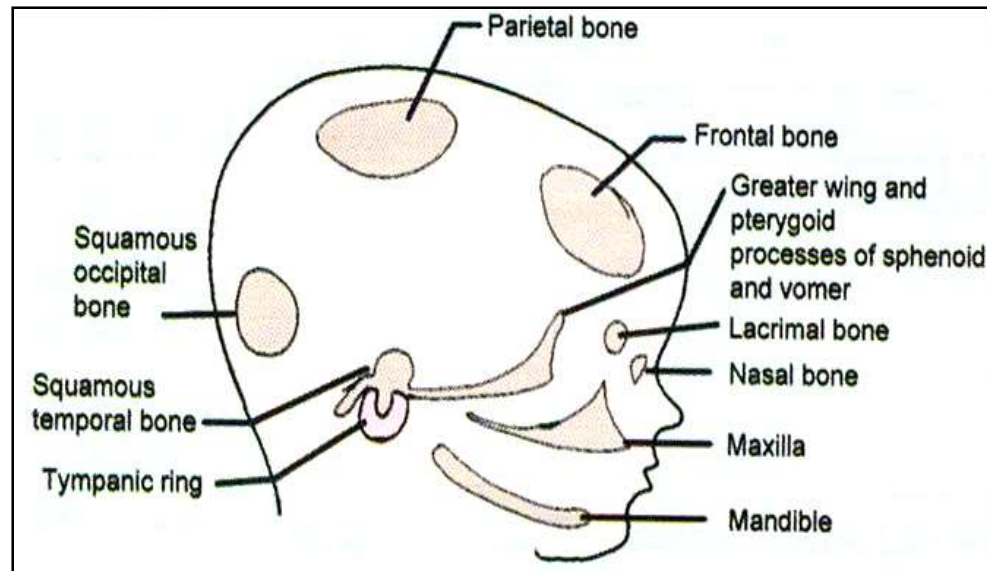
- 
- Ossification of the intramembranous calvarial bones depends upon the presence of the brain, for in its absence(ancephaly) no bony calvaria develops.
  - Several primary and secondary ossification centers develop in the outer layer of the ectomeninx to form individual bones.
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<u>Part of bone</u>	<u>Timing</u> <i>(IU)</i>	<u>no. of ossification</u> <u>centers</u>
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Frontal bones(pair)	8 <sup>th</sup> week	1 (pri)
Parietal bones(two)	8 <sup>th</sup> week	2(pri)
Occipital bone (sup. squamous part)	8 <sup>th</sup> week	1 (pri)

- Some unusual ossification centers develop between individual calvarial bones, their independent existance is recognised by small sutural bones called **wormian bones.**

- The earliest centers of ossification appear during the 7<sup>th</sup> to 8<sup>th</sup> weeks IU, but ossification is not completed well after birth. The mesenchyme between the bones develops fibres to form articulations. The membranous mesenchyme covering the bones forms the periosteum.



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# The cranial Base

- Conversion of the ectomeninx mesenchyme into cartilage constitutes the beginning of the ***chondrocranium*** that commences from the 40<sup>th</sup> day IU onwards.
  - Approximately 110 ossification centers appear in the embryonic human skull. Many of these centers fuse to produce 45 separate bones in the neonatal skull. In young adult, 32 separate skull bones are recognised.
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- Centers of ossification within the basal plate, commencing with the basioccipital in the 10<sup>th</sup> week of IU lay the basis for the endochondral bone portions of the **occipital, sphenoid and temporal bones** (all of which also have intramembraneous bone components i.e **mixed**) and for the ***wholly endochondral ethmoid and inferior nasal concha bones.***
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### The Occipital Bone (7 Ossification Centers)

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Supranuchal squamous part	Intramembranous	8th week	02
Below superior nuchal line	Endochondral	10th week	02
Basilar part	Endochondral	11th week	01
Condylar part	Endochondral	12th week	02

### The Temporal Bone (11 Centers of Ossification)

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Squamous	Intramembranous	8th week	01
Tympanic ring	Intramembranous	12th week	04
Premastoid	Endochondral	20th week	04
Styloid	Endochondral	36- 38th week	02

## The Sphenoid Bone (up to 15 Centers of Ossification)

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Greater wing of sphenoid and lateral pterygoid plate	Intramembranous	8th week	02
Medial pterygoid plate*	Endochondral		01
Presphenoid	Endochondral	20th week	05
Postsphenoid	Endochondral	16th week	04

The ossification center for the medial pterygoid plate first appears in a nodule of secondary cartilage that forms the pterygoid hamulus, but subsequent ossification of the pterygoid plate is intramembranous.

### The Ethmoid Bone (03 Centers of Ossification)

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Entire bone	Endochondral	16th week and 36th week	01 +02

### The Inferior Nasal Concha

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Entire bone	Endochondral	20th week	01

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# The facial skeleton

For convenience, the face is divided into following thirds-

- The upper face (frontonasal process).
  - The middle face (maxillary process).
  - The lower face (mandibular process).
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- Their boundaries being approximately the horizontal planes passing through the pupils of the eyes and rima oris.
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- The **upper third** of face, which is primarily of neurocranial composition, initially **grows most rapidly** in keeping with its neurocranial association and the growth of the frontal lobes of the brain. Contrastingly the growth of ***middle and lower third is slow and fairly prolonged.***
  - The facial bones develop intramembraneously from ossification centers in the neural crest mesenchyme of the embryonic facial processes. The above can be shown as follows-
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## The Upper Face

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
The frontal bone	Intramembranous		01

## The Frontonasal Process

<i>Part of the bone</i>	<i>Ossification type</i>	<i>Timing (IU)</i>	<i>No. of ossification centers</i>
Nasal bone	Intramembranous	12th week	02 ( right and left)
Lacrimal bone	Intramembranous	12th week	02 ( right and left)

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# Post-natal Growth and Development

For simplicity, the growth of the craniofacial complex is divided into –

- The cranial vault
  - The cranial base
  - The nasomaxillary complex
  - The mandible
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# The cranial vault

- The growth of cranial base is because of enlarging brain.
- The rate of bone growth is more during infancy and by the fifth year of life more than 90% of the growth of cranial vault is achieved.

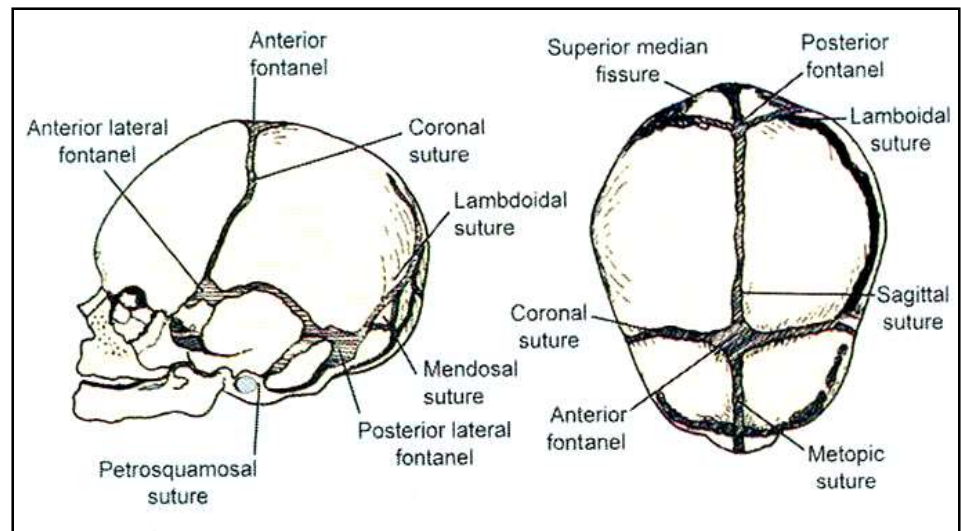
Birth	63 percent
06 months	76 percent
1 years	82 percent
2 years	87 percent
3 years	89 percent
5 years	91 percent
10 years	95 percent
15 years	98 percent

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- The cranial vault is made up of a no. of flat bones that are formed directly by intramembranous ossification, without cartilaginous precursors.
  - From the time that ossification begins at a number of centers that foreshadow the eventual anatomic bony units, the growth process is entirely the result of periosteal activity at the surfaces of the bones.
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- Some **selective resorption** occurs early in post-natal life on the inner surfaces of the cranial bones to help flatten them out as they expand.
  - **Apposition** can be seen on both the internal and external tables of the cranial bones as they become thicker.
  - This increase in thickness which permits the development of the **diploe** is not uniform.
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Remodelling and growth occur primarily at the periosteum lined contact areas between adjacent skull bone, called the **skeletal sutures**.

At birth, the flat bones of the skull are rather widely separated by relatively loose connective tissues. These open spaces, the **fontanelles**, allow a considerable amount of deformation of the skull at birth.



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- The cranial vault increases in **width** primarily through 'fill in' ossification of the proliferating connective tissue in the coronal, lambdoidal, interparietal, paritosphenoïdal and parietotemporal sutures.
  - It should be realized that there is actual translation as well as remodelling of the individual bones, with the structures being moved outward by the growing brain.
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- Increase in **length** on the brain case may be primarily due to the growth of the cranial base with active response at the coronal suture.
  - **Height** of the brain case is due to the activity of the parietal sutures along with occipital, temporal, and sphenoidal contiguous osseous structures.
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# The cranial base

- The cranial base, unlike cranial vault, is not completely dependent on brain growth and may have some intrinsic genetic guidance.
  - Centers of ossification appear in embryonic life in the chondrocranium, indicating the eventual location of the basiocciput, sphenoid and ethmoid bones that form the cranial base.
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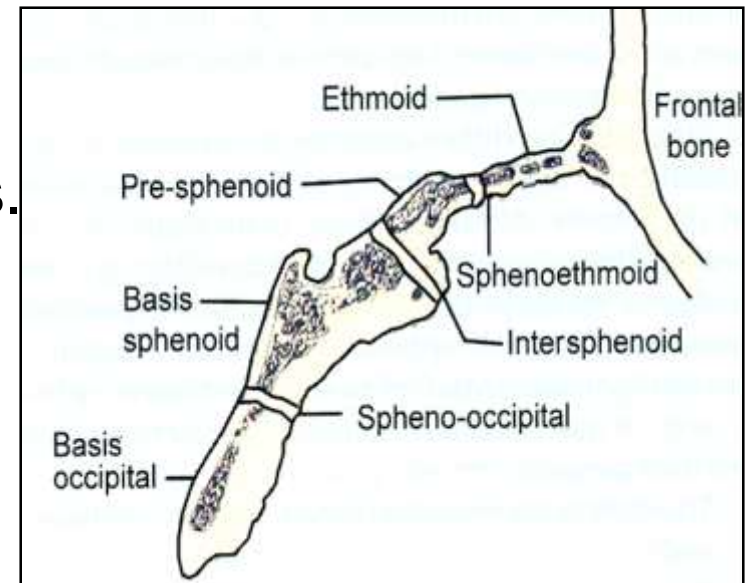
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# synchondroses

- Most of the bones of the cranial base are formed by a cartilaginous process. Later the cartilage is replaced by bone. However certain bands of cartilage remain at the junction of various bones. These areas are called ***Synchondroses***.
  - They are important growth sites of the cranial base. They are primary cartilages.
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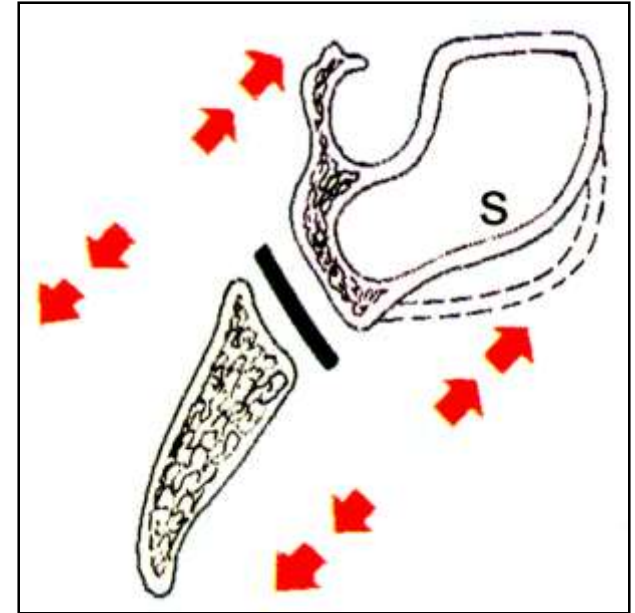
The important synchondroses found in the cranial base are –

- Spheno-occipital synchondrosis.
- Spheno-ethmoidal synchondrosis.
- Inter-sphenoidal synchondrosis.
- Intra-occipital synchondrosis.



## Spheno-occipital synchondrosis:

- It is the principal growth cartilage of the cranial base during childhood.
- Ossification here extends till the 20<sup>th</sup> year of life.
- The direction of growth here is upwards. It therefore carries the anterior part of the cranium bodily forwards.
- The growth at the synchondrosis continues till the obliteration of the same by formation of bone.



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- Activity at the **intersphenoidal synchondrosis** disappears at birth.
  - The **intraoccipital synchondrosis** closes in the 3<sup>rd</sup> to 5<sup>th</sup> year of life.
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**THANK YOU..**

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