Mechanism of bone growth:
Bone does not grow interstitially (i.e. it does not expand by cell division within its mass) rather, it grows by activity at the margins of the bone tissue.
Bone is laid down in two ways:

1- Endochondral ossification: At cartilaginous growth center, chondroblasts lay down a matrix of cartilage within which ossification occurs. At primary growth centers there are zones of cell division, cell hypertrophy and calcification aligned in columns along the direction of the growth. This process is seen in both the epiphyseal plate of long bones and the synchondroses of the cranial bone. Near the outer end of each epiphyseal plate is a zone of actively dividing cartilage cells. Some of these, pushed toward the diaphysis by proliferative activity beneath, undergo hypertrophy, secrete an extracellular matrix, and eventually degenerate as the matrix begins to mineralize and then is rapidly replaced by bone (see Figure below). As long as the rate at which cartilage cells proliferate is equal to or greater than the rate at which they mature, growth will continue. Eventually, however, toward the end of the normal growth period, the rate of maturation exceeds the rate of proliferation, the last of the cartilage is replaced by bone, and the epiphyseal plate disappears. At that point, the growth of the bone is complete, except for surface changes in thickness, which can be produced by the periosteum.

Condylar cartilage also lays down bone but seems to be in different way, because the articular surface is covered by a dense connective tissue also the growth of the condylar seems to be a reactive process in response to the growth of other structure of the face.
2- **Intramembranous ossification**: Growth is gained by the process of remodeling (resorption and deposition), usually growth is occur by enlargement of bone by deposition on its periosteal (surface) and by resorption in some parts of its surface to maintain the overall shape of the bone in addition to that, the endosteal remodeling (deposition and resorption) maintains the internal architecture of cortical plate and trabeculae.

![Diagram](image)

**Sutural growth**: The bone of the face and skull articulate together mostly at sutures, and growth at sutures can be regarded as a special kind of periosteal remodeling—an infilling of bone in response to tensional growth forces separating the bones of either side of the suture.

Growth which causes the mass of the bone to be moved relative to its neighbors is known as **displacement** like the forward and downward of the maxillary complex (fig.1), while the change in the position of the bony structure owing to the remodeling of that structure is called **drift** as seen in (fig.2) in which the palate moves downward during growth.

![Figures](image)
Calvarium
The calvarium is the part of the skull which develops from the membranous bones surrounding the brain and therefore it follows the neural growth pattern. It comprises:
1- Parietal bones (2)
2- Fontal bone
3- Squamous part of temporal bones (2)
4- Occipital bone.
These bones articulate with each other at sutures that are not united at birth, usually there are six fontanelles (which facilitate birth of the newly born baby) are also present at birth which closes by 18 months.

Growth of calvarium consists of:
1- Drift: Internal cranial aspects of the bones are resorbed while bone is laid down on the external surface.
2- Displacement: The bones are separated by growing brain, with fill-in bone growth occurring at the sutures to maintain continuously of the cranial vault.

Cranial base: Growth occurs by:
1- Bone remodeling and sutural infilling usually occur as the brain enlarges.
2- The primary cartilaginous growth sites usually present in this region, one of the important sites of these is spheno-occipital synchondrosis which act from childhood till 15 years and fusing at approximately 20 years.
This synchondrosis (fig.3) is anterior to TMJ but posterior to the anterior cranial fossa, therefore its growth is clinically significant as it influences the overall facial skeletal pattern.
Naso-maxillary complex
Middle third of facial skeleton is a complex structure that composed of palatal, zygomatic, ethmoidal, vomer and nasal bones, these articulate with each other and with the anterior cranial base at sutures. Growth of maxillary complex occurs in part by displacement with fill-in growth at sutures and in part by periosteal drift and periosteal remodeling.

Anterio-posterior growth of the maxilla: usually occurs by deposition of bone posteriorly at the tuberosities, which of course lengthens the dental arch.

Downward growth of the maxilla: usually occurs by:
- Vertical development of the alveolar process
- Eruption of the teeth
- By inferior drift of the hard palate, i.e. the palate remodels downwards by deposition of bone on its inferior surface (the palatal vault) and resorption on its superior surface (the floor of the nose and maxillary sinuses).
Maxillary growth ceases on average at about 14 years in girls and rather later at about 16 years in boys

**Mandible**
The mandible is derived from the first pharyngeal arch and it is a membrane bone ossifying laterally to Meckles cartilage. **Most** of mandibular growth occurs as a result of *periosteal* activity (*intramembranous ossification*), muscular process develops at the angle of the mandible and the coronoids, and the alveolar processes develop vertically to keep pace with the eruption of the teeth. The anterior part of the mandible is displaced forward as the mandible is elongates by the growth at the condylar cartilage, while at the same time *periosteal remodeling* maintains its shape (bone is laid down in the posterior margin of the vertical ramus and resorbed on the anterior margin), this posterior drift of the ramus allows lengthening of the dental arch posteriorly to give enough space for the normal eruption of the posterior permanent molars, at the same time the vertical ramus becomes taller to accommodate the increase in the height of alveolar process.

Mandibular growth usually ceases rather later than maxillary growth, about 17 in girls and 19 in boys, although it may continue for longer period.

**Facial soft tissue growth**
An important concept is that the growth of the facial soft tissues does not perfectly parallel the growth of the underlying hard tissues.
Growth of the Lips

The lips trail behind the growth of the jaws prior to adolescence, then undergo a growth spurt to catch up. Because lip height is relatively short during the mixed dentition years, lip separation at rest (often termed lip incompetence) is maximal during childhood and decreases during adolescence (Figure 4). Because the lips move downward relative to the lips and teeth during adolescence (and continue to do so as the face ages), what looks like too much display of gingiva prior to and in adolescence can look perfectly normal in a young adult. Lip thickness reaches its maximum during adolescence, then decreases to the point that in their 20s and 30s, some women consider loss of lip thickness a problem and seek treatment to increase it.

Fig. 3: Lip thickness increases during the adolescent growth spurt, then decreases (and therefore is maximal at surprisingly early ages). For some girls, loss of lip thickness is perceived as a problem by their early 20s. A, Age 14-8, at the end of the adolescent growth spurt. B, Age 16-11. C, Age 18-6. D, Age 19-7