GROWTH AND DEVELOPMENT

Introduction

Growth is defined as an increase in size, change in proportion, and progressive complexity, while **Development** means progress toward maturity.

Knowledge about growth and development is very important for orthodontists since the face changes from its embryologic form through childhood, adolescence, and adulthood. Understanding how and where growth occurs, how much growth is remaining, in which direction, and what role the genetic and environmental factors play in influencing facial growth can, in turn, influence these factors with treatment to achieve the optimum results in each individual.

Growth can be divided into two periods: <u>prenatal</u> and <u>postnatal</u>.

The prenatal (neonatal) period: It could be divided into three periods:

1. Period of ovum (from fertilization to the 14th day)

During this period, human development begins when a sperm fertilizes the oocyte, forming a zygote. Fertilization occurs in the uterine tube (oviduct). The zygote undergoes a series of mitotic divisions as it moves along the uterine tube toward the uterus. The cells resulting from this division are called blastomers. They adhere to one another and form a ball of cells called a morula (16- 32-celled stage), which enters the uterus about three days after fertilization. Fluid from the uterine cavity enters the intercellular spaces between the inner and outer cell mass. Later, the intercellular spaces fuse to form a single cavity called blastocele, and this stage of the embryo is called blast

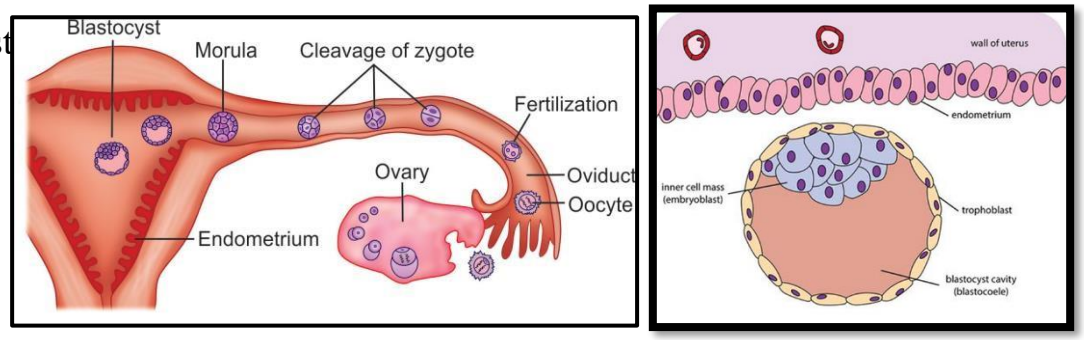

Figure 1

Six days after fertilization, two distinct cell types comprise the blastocyst:

- The **trophoblast** forms a single layer of cells covering the outside of the blastocyst. The inner cell mass which is a cluster of cells located inside the trophoblast.
- The inner cell mass develops into embryo whereas the trophoblast forms the embryonic part of the placenta and other peripheral structures associated with the embryo.

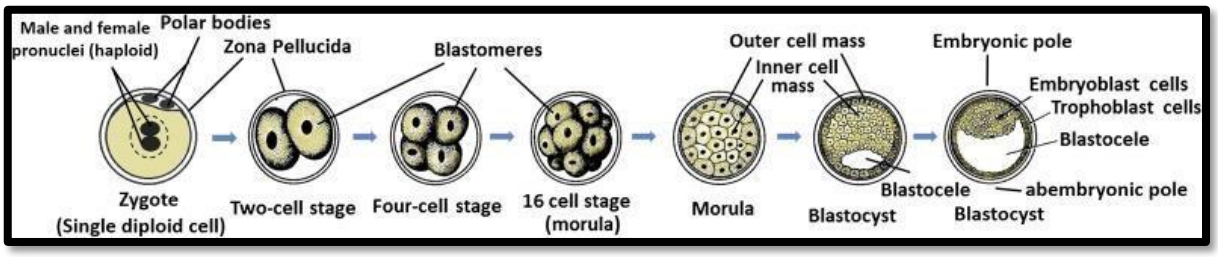

Figure 2

2. Period of embryo (from 14th to 56th day)

During this period, most organs and organ systems are formed. It is also the period of differentiation, and most congenital malformations develop during this period. At the end of this period, the developing individual has a recognizable human appearance.

3. Period of fetus (56th day to birth)

Continued development is predominantly growth without significant further differentiation. Overall increase in the size of the fetus also occurs due to an accelerated growth. In addition to the increase in size, the proportion of the structures also changes. Most of the craniofacial structures are formed in the first trimester of pregnancy.

The growth of the cranial, facial, and oral structures begins around the 21st day (period of the embryo) after conception. At this stage, the embryo is about 3 mm in size, and the head begins to take shape. After the formation of the head fold, the developing brain and the pericardium form two prominent bulgings in the ventral aspect of the embryo. In between them, there is a depression called the stomodeum, the floor of which is formed by the buccopharyngeal membrane. This membrane separates the stomodaeum from the foregut (Fig 3).

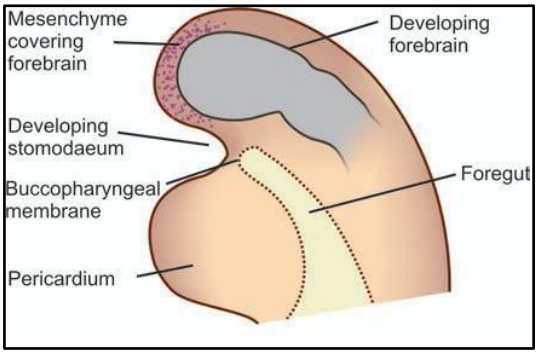

Figure 3

Soon the mesoderm covering the developing brain proliferates and forms a downward projection that overlaps the upper part of the stomodaeum. This downward projection is called the frontonasal process (Fig. 4). As is evident till now, the neck is not yet present. The neck is formed by the elongation of the region between the stomodeum and the pericardium. This is achieved partly by a descent of the developing heart and mainly due to the appearance of a series of mesodermal thickenings in the wall of the foregut. These are called the pharyngeal or the branchial arch (Fig. 5).

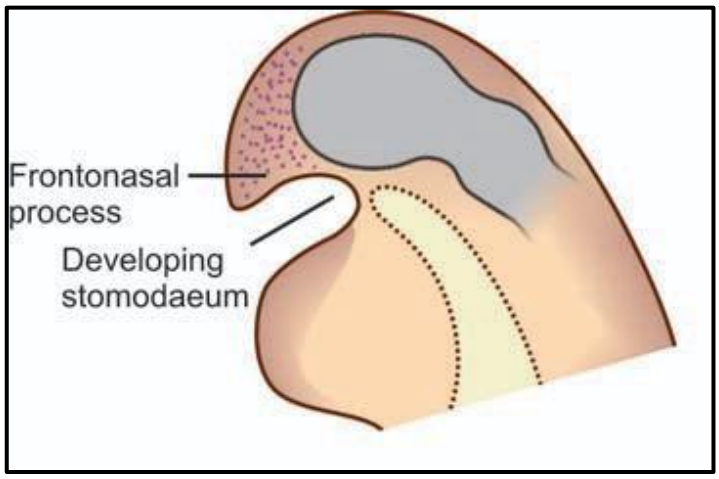

Figure 4

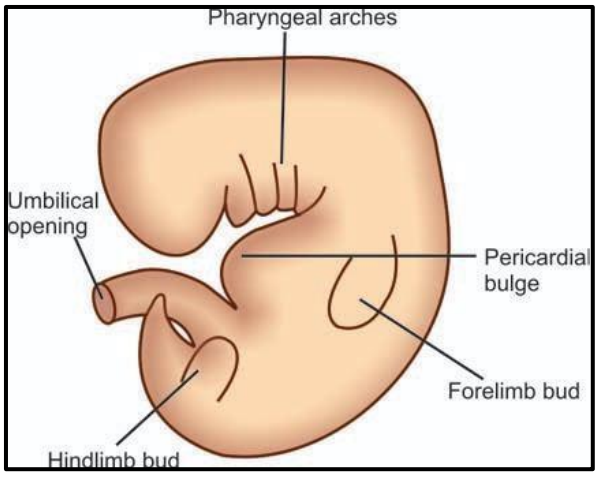

Figure 5

In the third week, the head is composed mainly of the pros-encephalon, with frontal prominence representing the most caudal portion of the pros-encephalon and overhanging the developing oral groove. This oral groove is bounded on its lateral sides by the rudimentary maxillary processes. The mandibular arch is below the groove, while the frontal process is above (Figure 6).

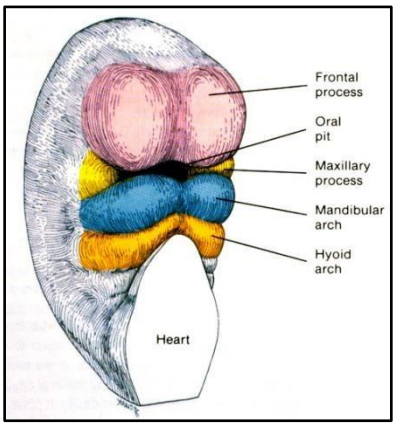

Figure 6

The frontal prominence, mandibular arch, and maxillary processes are called together the stomodeum. During the following few weeks, the oral groove deepens, and the oral plate (buccopharyngeal membrane), which consists of an ectodermal floor of the stomodeum and endodermal lining of the foregut ruptures to establish the oral opening.

During the fourth week, two ectodermal proliferations can be noticed on either side of the frontal process. These will later give rise to the nasal placodes, which develop into nasal pits and the olfactory epithelium, Figure 7.

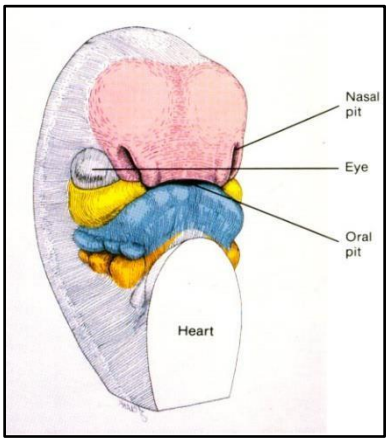

Figure 7

At this time, the branchial arches could also be seen, distinguished as four arches with a fifth transitory branchial arch. The first arch is called the mandibular arch, while the second is called the hyoid arch, Figure 8.

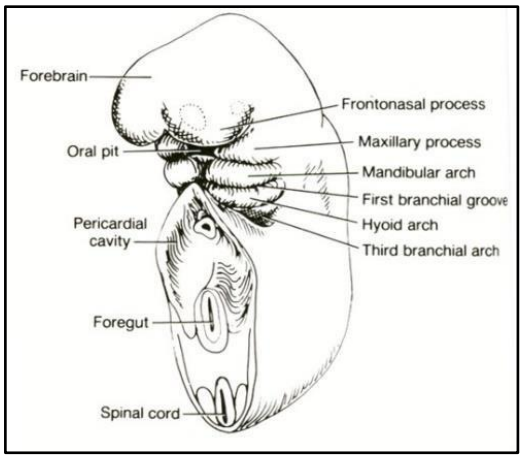

Figure 8

In the 5th week, the nasal pits widen, and the medial and lateral walls of the nasal pits start to proliferate and grow downward, giving rise to the medial nasal and lateral nasal processes, Figure 9.

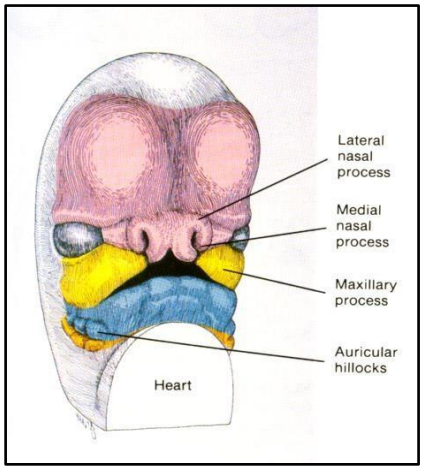

Figure 9

The maxillary processes on either side start to proliferate toward the medial nasal processes, and the union between the medial nasal and the maxillary processes gives rise to the maxilla, palate, upper lip, and the lower central part of the nose. The line of fusion of the two medial nasal processes is represented by a depression on the upper lip called the philtrum, the fusion of the medial nasal processes and the maxillary processes completes during the 7th week. Cleft lip develops if failure of fusion of these two processes takes place. This cleft may be unilateral or bilateral, but it is also can be complete or incomplete, Figure 10.

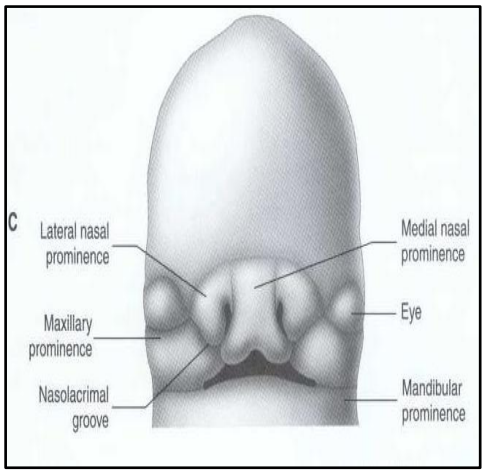

Figure 10

By the 8th week, the facial structures are apparent. The nose is more prominent, and the nasal septum elongates and narrows. The eyes migrate toward the midline, and the ears begin to develop. The nostrils are formed by an opening in the nasal pit area, which communicates with the upper part of the oral cavity, Figure 11. By the 12th week, the eyelids and nostrils have formed, and subsequent intrauterine changes lead to little further differentiation. These intrauterine changes involve increasing in size and changing in proportions.

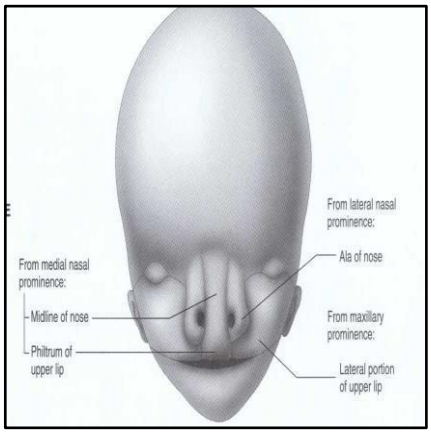

Figure 11

Development of Palate

The palate develops between 6th and 9th week of gestation. The entire palate develops from the following two structures:1. Primary palate. 2. Secondary palate.

Primary Palate

The primary palate is the triangular-shaped part of the palate anterior to the incisive foramen. It is developed from frontonasal process. The primary palate forms the premaxilla, which carries the incisor teeth **(Fig. 12)**.

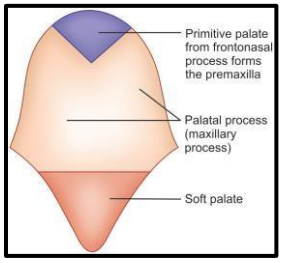

Figure 12

Secondary Palate

The secondary palate gives rise to the hard and soft palate posterior to the incisive foramen. It develops from the fusion of three parts as follows:

- Two "palatine shelves" which extend from left and right maxillary process towards the midline.
- Nasal septum, which grows downwards from the frontonasal process along the midline.
- The developing palatine shelves are first directed vertically downward with the tongue interposed between them **(Fig. 12A)**. After withdrawal of the tongue, the elongated shelves get oriented horizontally **(Fig. 12B)**.
- Horizontally oriented palatine shelves grow towards each other in the midline and are in close proximity with each other by 8 weeks of gestation
- The left and right palatine shelves fuse with the posterior margins of the primary palate, as well as with each other in midline.
- Fusion does not occur simultaneously in all fronts. Initial contact occurs in the center posterior to incisive foramen between the palatine shelves. From this point, fusion progresses in anterior and posterior directions as indicated by arrows in **Figure 12C**.
- The nasal septum grows downward and gets fused with the medial edges of palatine shelves in the midline thus, separating the stomatodeum into nasal and oral cavities.

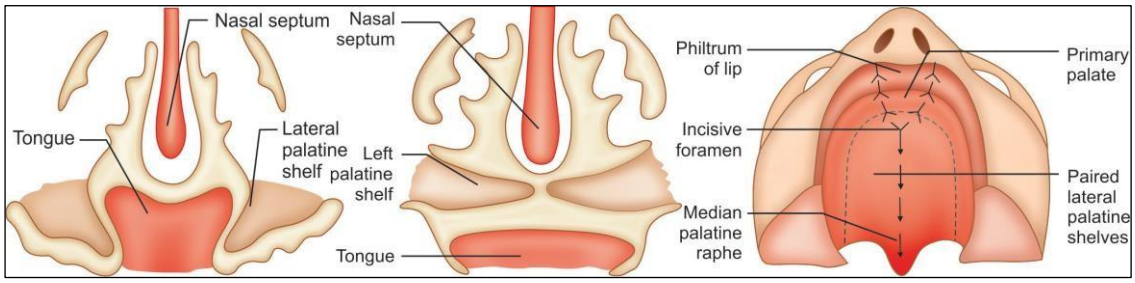

Figure 12

Development of Tongue

- The tongue begins to develop at about 4th week of gestation. The development of tongue begins as a midline enlargement in the floor of primitive pharynx called the "tuberculum impar." Two other bulges arise adjacent to the tuberculum impar called "lingual swellings". All these structures from the Ist arch mesenchyme.
- The lateral lingual swellings quickly enlarge and merge with each other and the tuberculum impar to form a large mass from which the two-thirds of the anterior tongue is formed. At this stage, a large swelling develops in the midline from mesenchyme of the II, III and IV arches. This swelling consists of a small part "copula" (associated with 2nd arch) and a large part "hypobranchial eminence" (primarily composed of 3rd arch mesenchyme).
- As the tongue develops, the hypobranchial eminence overgrows the copula and fuses with the tuberculum impar and lateral lingual swellings. The copula disappears without contributing to the formation of tongue. Thus, the posterior one-third or base of the tongue is derived from the third branchial arch. The body and base of the tongue are separated by a line of demarcation called "sulcus terminals." "Foramen caecum" is found in the midline of this structure (Fig. 13).

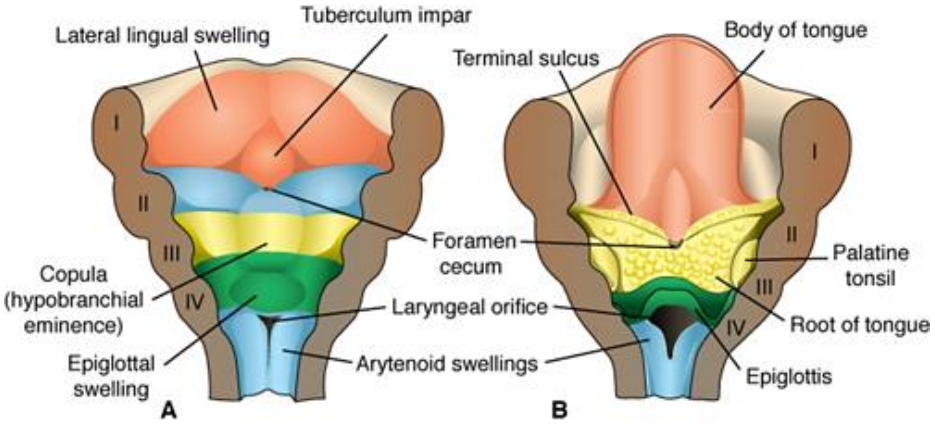

Figure 13

Development of Skull

The skull can be divided into the following components

I. Neurocranium: Cranial vault and Cranial base

II. Viscerocranium: The facial skeleton including Maxilla and Mandible.

The cranial vault and face develop from intramembranous ossification where bones are formed directly in mesenchyme with no cartilaginous precursors. The cranial base undergoes endochondral ossification. Some of the membranous bones may develop secondary cartilages subsequently that provide further growth.

I. ***Neurocranium*** **(calvaria and base of the skull)**

*The cartilaginous neurocranium (chondrocranium) consists of several cartilages that fuse and undergo endochondral ossification to give rise to the base of the skull. The cartilage junctions between two bones are called synchondroses. The occipital bone, the body of the sphenoid bone, the ethmoid bone, the vomer bone of the nasal septum, and the petrous and mastoid parts of the temporal bone are formed by the cartilaginous neurocranium.

*The membranous neurocranium gives rise to the flat bones of the calvaria, including the superior portion of the frontal, parietal, and occipital bones.

II. Viscerocranium which arises from the pharyngeal arches.

The cartilaginous viscercranium includes the middle ear ossicles, the styloid process of the temporal bone, the and hyoid bone.

*The membranous viscerocranium includes the maxilla, zygomatic bones, the squamous temporal bones, and the mandible. These bones form by intramembranous ossification except for the mandibular condyle and the midline of the chin.

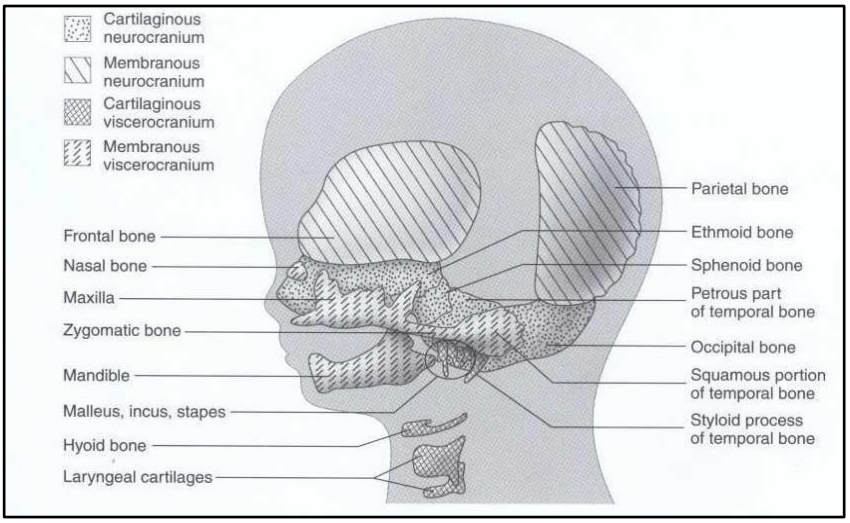

Figure 14

The development of Maxilla and Maxillary Sinus

The maxilla develops from a center of ossification in the mesenchyme of the maxillary process of the first pharyngeal arch. No primary cartilage exists in the maxillary process but the center of ossification is closely associated with the cartilage of the "nasal capsule."

„ Similar to the mandibular development, the center of ossification appears in the angle between divisions of a nerve that is between "anterosuperior alveolar" and "inferior orbital nerve." From this center, ossification spreads posteriorly towards the developing zygoma, anteriorly towards the premaxillary region and superiorly to form the frontal process of maxilla.

„ Ossification also spreads into the palatine processes to form the hard palate. The medial alveolar plate develops from the junction of the palatal process and the main body of the developing maxilla.

„ The medial alveolar plate, together with the lateral alveolar plate, forms a trough of bone around the maxillary tooth germs. The alveolar process contains the tooth germs in their bony crypts.

„ A secondary cartilage called "zygomatic/malar cartilage" also contributes to the development of maxilla. It appears in the developing zygomatic process and adds considerably to the development of the maxilla.

„ The maxillary sinus forms around 3rd month. The body of the maxilla remains relatively small at birth as the maxillary sinus is still small at birth about the size of a small pea.

The development of the mandible

The mandible initially develops intramembranously but its subsequent growth is related to the appearance of secondary cartilages. The "condylar cartilage" is the most important. During the 2nd month of intra-uterine, the primary cartilage of the 1st arch, Meckel's cartilage, serves as a precursor of the mandibular mesenchyme, which forms around it and is responsible for mandibular growth activity. A condensation of mesenchyme occurs on the lateral aspect of Meckel's cartilage in relation to the inferior alveolar nerve. At 7th week, intramembranous ossification begins in this mesenchymal condensation. Further spread of the developing bone in anterior and posterior directions produces a plate of bone on the lateral aspect of Meckel's cartilage, which extends toward the midline, where it

comes into approximation with a similar bone forming on the opposite side. However, the two plates of bone remain separated by fibrous tissue mandibular symphysis until shortly after birth. By the 10th week, the rudimentary mandible is formed almost entirely by membranous ossification with little or no direct involvement of Meckel's cartilage.

Further growth of the mandible until birth is influenced greatly by the appearance of secondary cartilages and the development of the muscular attachments. The mandible develops largely from intramembranous ossification, except in the following three areas where endochondrial ossification occurs aided by their respective secondary cartilages:

I. Condylar process—condylar cartilage

II. Coronoid process—coronoid cartilage

III. Mental region—symphyseal cartilage.

The activity of the condylar cartilage does not appear until the 4th or 5th month of postnatal life and continues until the age of 20 years so it has no role in the prenatal life.

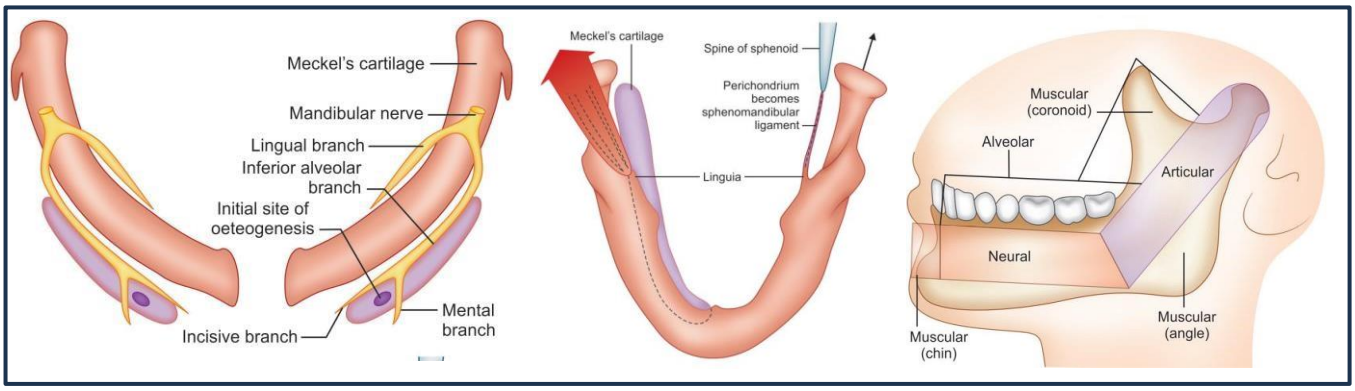

Figure 15

Good luck