Growth & development

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The study of head form in man has always been of considerable interest to anthropologists, anatomists and other students of human growth

As orthodontists we are interested in understanding how the face changes from its embryologic form through childhood, adolescence and adulthood. Of particular interests is an understanding of how and where the growth occurs, how much growth is remaining and in which direction and when the growth will express itself, what role the genetic and environmental factors play in influencing facial growth and in turn how we can influence these factors with our treatment to achieve the optimum results in each individual.

DEFINITIONS RELATED TO GROWTH

- The self multiplication of living substance (JX Huxley)
- Increase in size, change in proportion and progressive complexity (Krogman)
- Entire series of sequential anatomic and physiological changes taking place from the beginning of prenatal life to senility (Meredith)
- Quantitative aspect of biologic development per unit of time (Moyers)
- Change in any morphological parameter which is measurable (Moss)

- Development means progress towards maturity (Todd)

- All the naturally occurring unidirectional changes in the life of an individual from its existence as a single cell to its elaboration as a multifunctional unit terminating in death**(Moyers)**

METHODS OF STUDYING PHYSICAL GROWTH

The data collection for the evaluation of physical growth is done in two way:

1. Measurement approach
2. Experimental approach

Measurement approach

It is based on the techniques for measuring living animals (including humans), with the implication that measurement itself will do no harm and that the animal will be available for additional measurements at another time

Experimental approach

This approach uses experiments in which growth is manipulated in some way. This implies that the subject will be available for some detailed study that may be destructive. For this reason, such experimental studies are restricted to non-human species.

METHODS OF COLLECTING GROWTH DATA

The data gathered as by previously mentions means is then subjected to statistical analysis to arrive at a conclusion. The studies conducted thereof are of two types:

1. Longitudinal studies

2. Cross-sectional studies

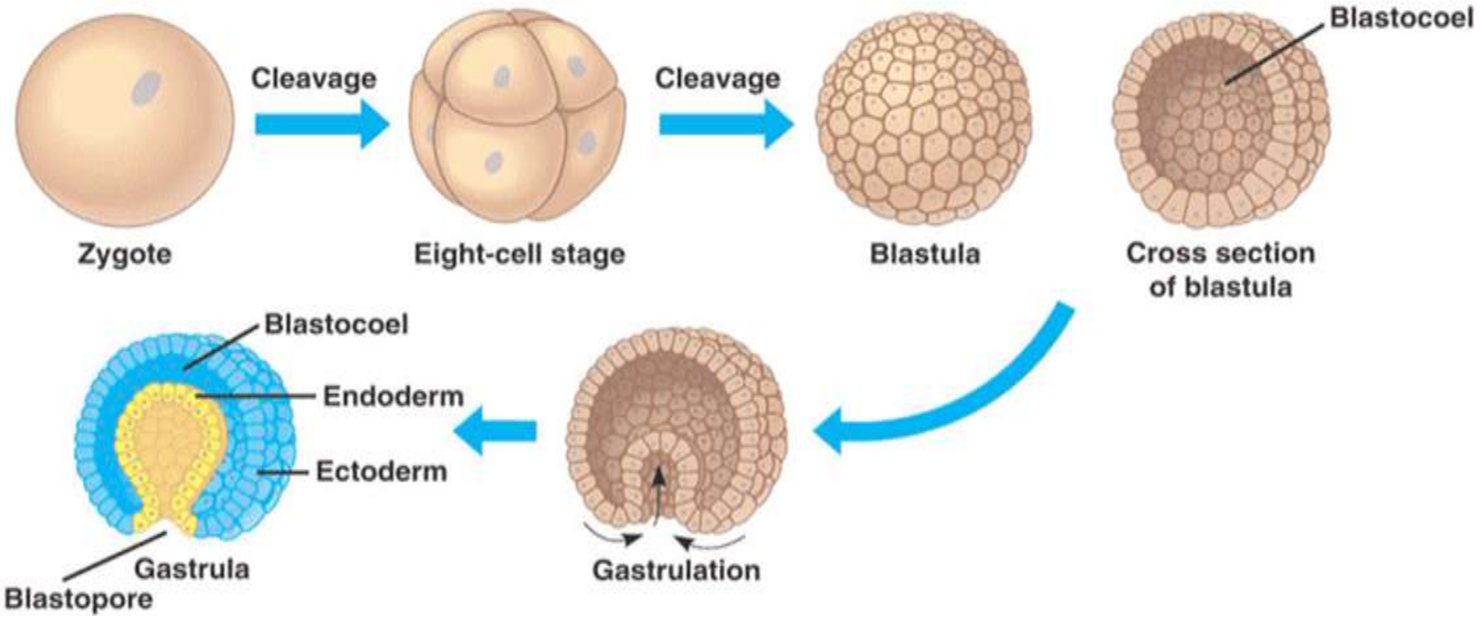
Longitudinal studies involve gathering data of a given individual or subject over varying periods of time at regular intervals. This represents an example of a study on long-term basis. Although it has an advantage of studying the developmental pattern of the subject over a period of time giving a good insight into the variations involved, yet the major draw back is that it is very time consuming and runs the risk of loss of subject(s) due to that. Furthermore, it requires elaborate maintenance of records over time, making it an expensive proposition

Cross-sectional studies on the other hand involve gathering data from different samples and are therefore faster. Also, it is less expensive with a possibility of studying larger samples, and can be repeated if required. However, it may not provide conclusive evidence because not all individuals grow in same way . Also such a study would obscure individual variation

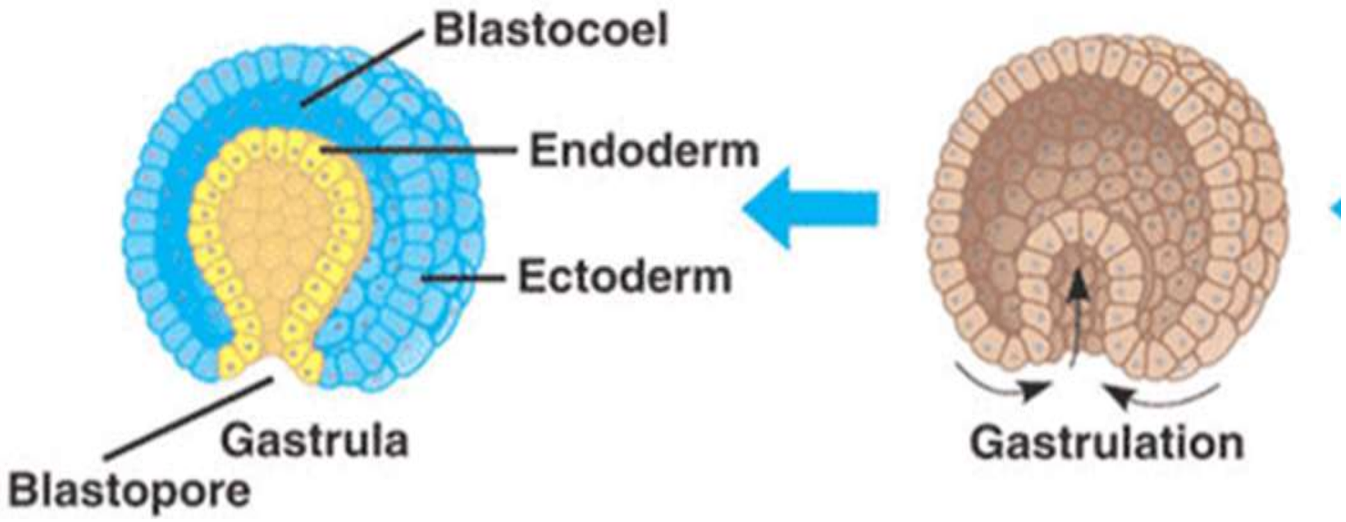
An understanding of craniofacial development and growth is essential for the accurate diagnosis and treatment planning of even the most straightforward malocclusion as the majority of orthodontic treatment is still performed on growing individuals – children

The early embryo is derived from three primary germ layers of tissue :

- Ectoderm (first germ layer);
- Endoderm (second germ layer).
- Mesoderm (third germ layer).



1. Neural crest

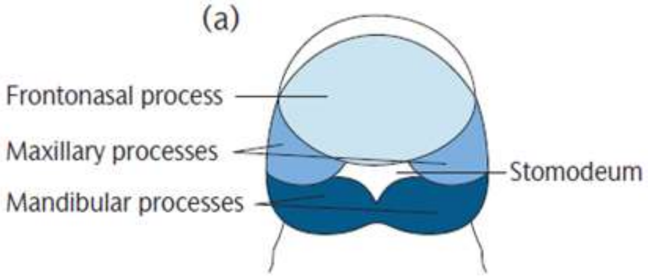


Derivatives of cranial neural crest cells

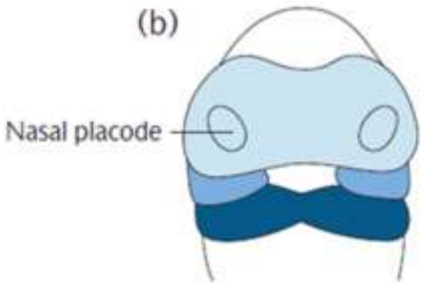
1. Cartilage and bone of the prechordal skull
2. Meckel's (1st), Reichart's (2nd) and other pharyngeal arch cartilages
3. Intramembranous bones of the craniofacial skeleton
4. Odontoblasts
5. Connective tissue
6. Dermis of the face and neck
7. Tendons and fascia of craniofacial voluntary muscles
8. Meninges of the brain
9. Neurones of most cranial nerve ganglia
10. Parafollicular (calcitonin) cells of thyroid gland
11. Melanocytes

Facial development

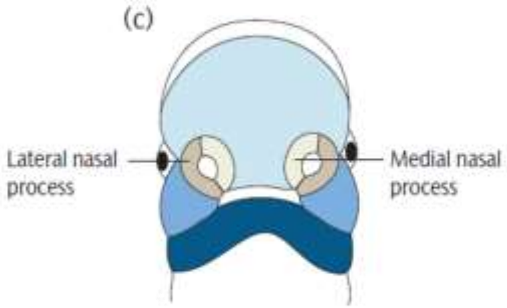
The development of the face begins at the end of the 4th week in utero(i.u.) with the appearance of five prominences around the stomodeum which is the primitive mouth and forms the topographical centre of the developing face. The maxillary swellings can be distinguished lateral , and the mandibular swellings caudal, to the stomodeum. The midline frontonasal process lies rostral to the stomodeum. Between 24 and 28days i.u. the paired maxillary swellings enlarge and grow ventrally and medially. A pair of ectodermal thickenings called the nasal placodes appear on the frontonasal process and begin to enlarge. From 28–32days the ectoderm at the centre of each nasal placode invaginates to form a nasal pit, dividing the raised rim of the placode into a lateral nasal process and a medial nasal process. Between 32 and 35 days each medial nasal process begins to migrate towards the other and they merge. The mandibular swellings have now merged to create the primordial lower lip. The nasal pits deepen and fuse to form a single, enlarged, ectodermalnasal sac. From 40–48 days there is lateral and inferior expansionof the now fused medial nasal processes to form the intermaxillary process. The tips of the maxillary swellings grow to meet this process.The intermaxillary process gives rise to the bridge and septum of thenose. From 7–10 weeks the ectoderm and mesoderm of the frontonasal process and the intermaxillary process proliferate, forming a midlinenasal septum. This divides the nasal cavity into two nasal passages which open into the pharynx, behind the secondary palate, through the definitive choana. The philtrum is now formed by merging of the paired maxillary processes in front of the intermaxillary process, and the lateral portions of the maxillary and mandibular swellings merge to create the cheeks and reduce the mouth to its final width



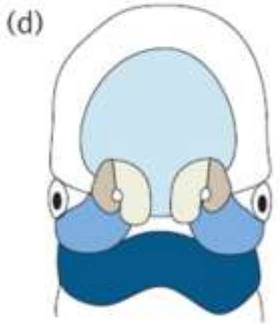
4th week i.u.



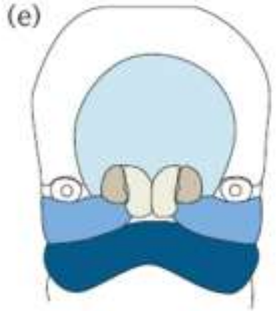
after day 28 i.u



32 days i.u



35 days i.u.



48 days i.u

The somite period

In the fourth week IU, there are ***six pharyngeal*** arches, which appear progressively during the fourth week of embryonic development. Each arch is covered externally by ectoderm and internally by endoderm, whilst a core of mesodermal tissue exists within. As development proceeds, this central core becomes **infiltrated** by cranial neural crest cells that migrate into the arches from their site of origin adjacent to the roof of the neural tube

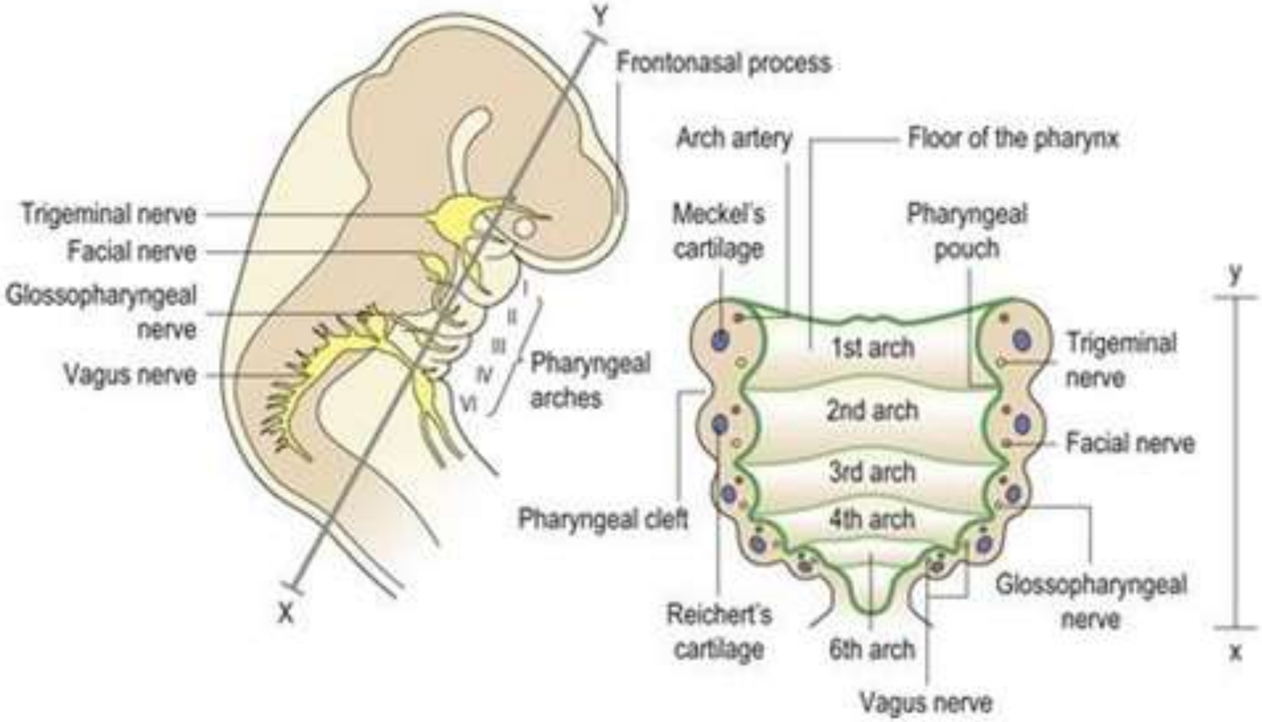


Figure 2.7 The pharyngeal arches.

The pharyngeal arches give rise to a number of skeletal structures within the head and neck:

- **The first arch** gives rise to the upper and lower jaws, the dentition, the malleus and incus (middle ear ossicles) and sphenomandibular ligament. Its nerve is the trigeminal.

- **The second arch** gives rise to the styloid process, stylohyoid ligament, stapes (middle ear ossicle) and the **lesser horn** and upper part of the body of the hyoid bone. Its nerve is the facial.
- **The third arch** gives rise to the **greater horn** and lower part of the body of the hyoid bone. Its nerve is the glossopharyngeal.

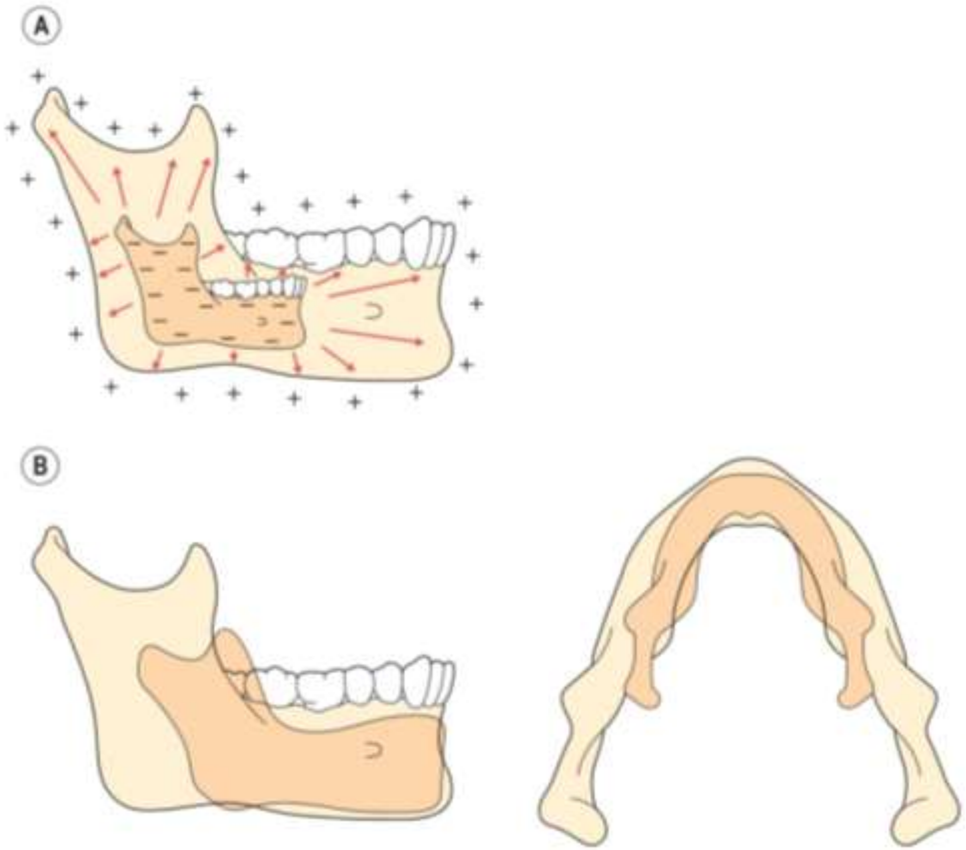
- **The fourth arch** gives rise to the laryngeal cartilages (Thyroid and cricoid). Its nerve is the vagus.
- **The fifth pharyngeal arch** is the exception, rapidly degenerating after formation and making no contribution towards any permanent structures in the human.

Growth and Development 2
(Post natal)

The adult skull is composed of **28 individual bones** and represents one of the most complex regions of the body. The skull bones either develop from a cartilaginous template, ossify directly from membrane, or are composite, being formed following contributions from both mechanisms . Growth of this region therefore represents a combination of endochondral and periosteal modes of osteogenesis (intramembranous)

Mechanisms of craniofacial bone growth

It is clear from the direct comparison of different skull bones that postnatal growth of the craniofacial region **does not result from a simple** proportional enlargement of each individual bony element



The mandible does not grow by a simple symmetrical enlargement (A); rather the condyle and ramus elongate in a posterior and superior direction, whilst the body of the mandible lengthens (B).

Endochondral bone growth occurs through cartilaginous replacement, whilst **intramembranous** bones grow as a result of periosteal remodelling. The complexity and diversity of the skull arises because the constituent bones enlarge differentially, in both a temporal and spatial manner

A. Endochondral bone formation : formed first in cartilage, then transformed into bone. Bones formed in this way are probably **less susceptible to environmental** influences during growth and are under more direct genetic control. The bones of the cranial base are endochondral.

B. Intramembranous bone formation: formed by secretion of bone matrix directly within connective tissues, without intermediate formation of cartilage. Growth of intramembranous bones is **more influenced** by the environmental forces around them. The cranial vault, maxilla, and mandible are all examples of intramembranous bones.

Theories of Growth Control

Direct genetic control.

Epigenetic growth control

Environmental growth control

Direct genetic control: Bone, like other tissues, is directly under the control of genetics.

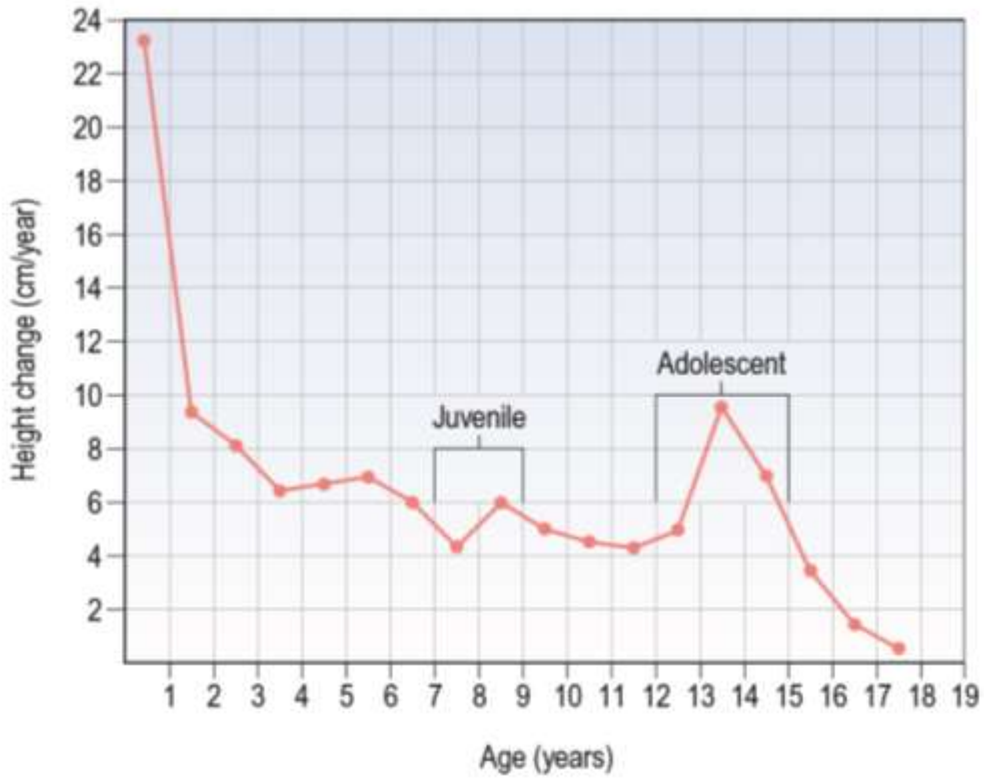
Epigenetic growth control: Cartilage is the primary determinant of skeletal growth and then indirectly controls the growth of bone. Cartilage grows and is then replaced by bone.

Environmental growth control: the functional matrix theory. Growth of bone is influenced by adjacent soft tissues through environmental changes in forces exerted on the bones that stimulate their growth

General growth of the body

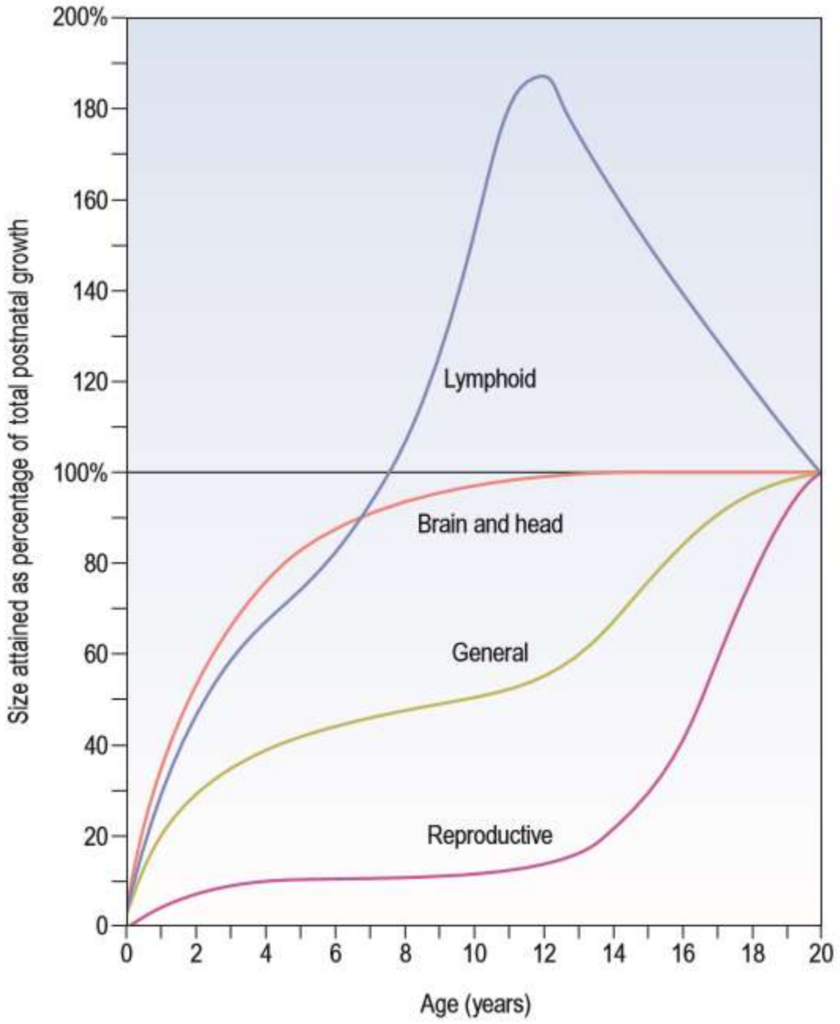
general phases in the growth curve

- A rapid rate of growth at birth, which progressively decelerates until around 3 years of age;
- A slowly decelerating phase, which persists until the adolescent growth spurt in the early teenage years and is interrupted by a brief juvenile growth spurt at around 6 to 8 years; and
- An adolescent growth spurt, which is followed by a progressive deceleration in growth velocity until adulthood.

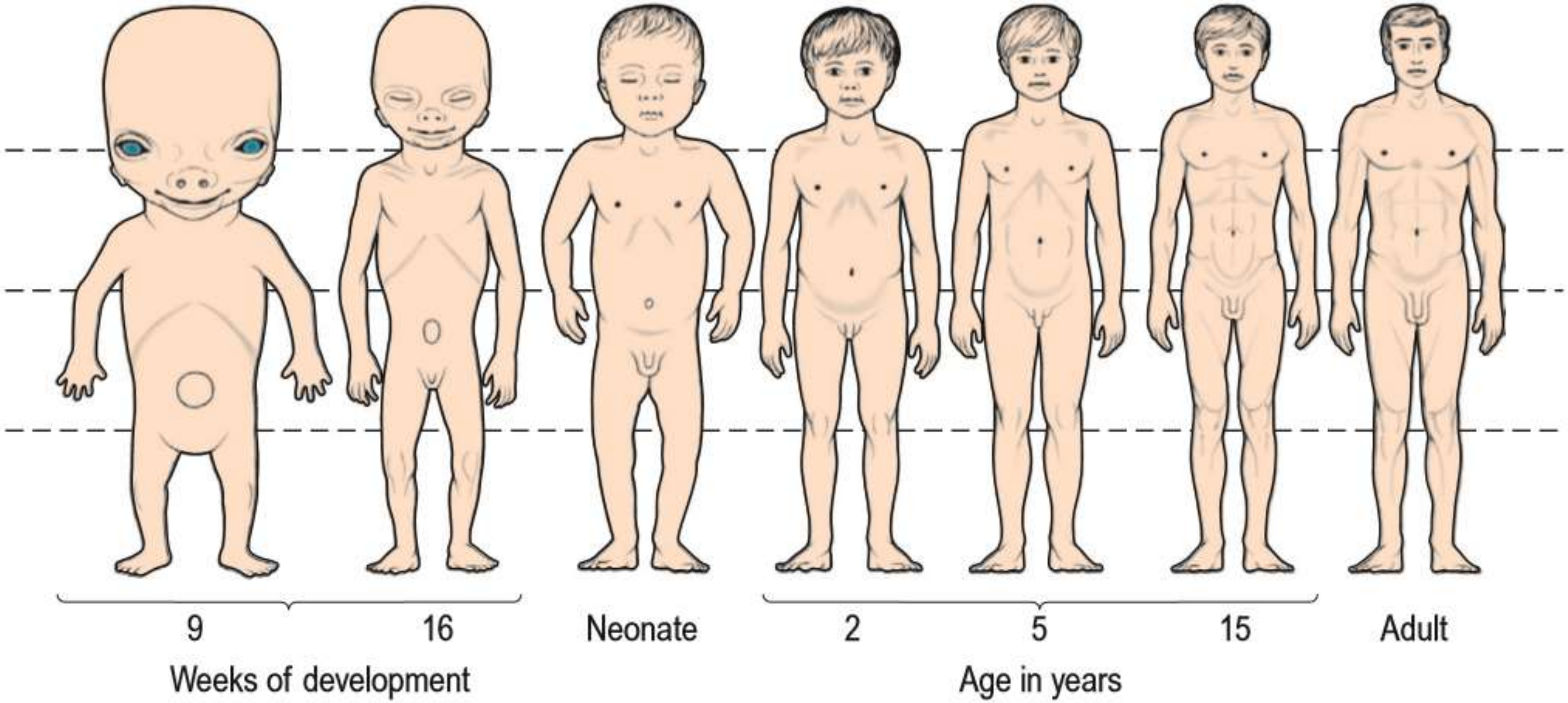


Height–velocity curve for a male from birth to 18 years of age. Note rapid deceleration of growth during the first 3 years and then a gradual deceleration, briefly interrupted by a juvenile growth spurt at 8 years and the more significant adolescent growth spurt at around 13 years of age

Whilst the **general trends** associated with height change are similar in males and females, some fundamental differences do occur between the sexes. In particular, the adolescent growth spurt is greater and occurs **later** in males, giving them a **longer** overall period of growth, greater acceleration during adolescence and generally an increased overall height. **In contrast**, other body tissues demonstrate quite different patterns of growth in comparison to height. For example, the central **nervous system** is well developed at birth and grows rapidly during the early years of life, being essentially complete by approximately 10 years of age, whereas the **reproductive organs** do not begin to increase in size until puberty



Growth curves of different tissue types, regions of the body and organ systems.



Changes in body proportions from the fifth month postconception to maturity. Note the large size of the head in relation to the rest of the body in the neonate.

Sites of Growth in the Craniofacial Complex

A. Cranial Vault

B. Cranial base

C. Maxilla

D. Mandible

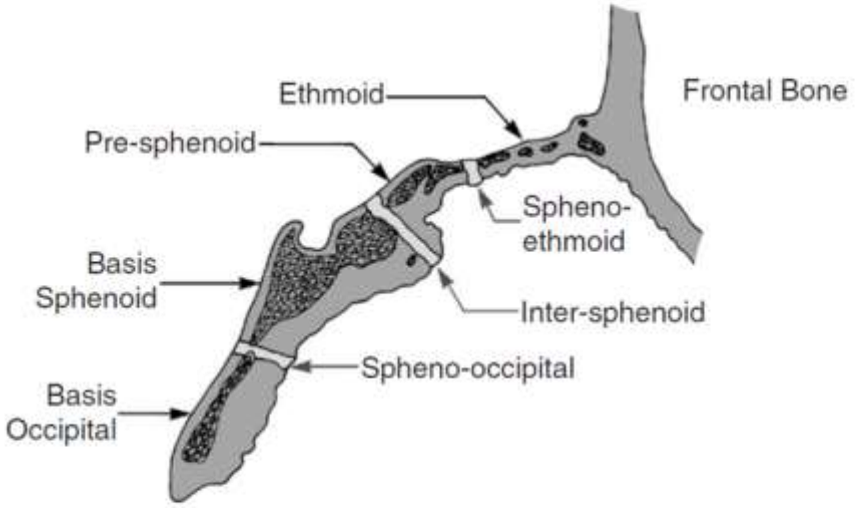
Cranial Vault

The space in the skull within the neurocranium, occupied by the brain

1. Intramembranous bones that form **without** cartilaginous precursors.
2. At birth, the bones are widely separated by **loose connective tissues** at the fontanelles. Apposition of bone along the edges of the fontanelles eliminates these open spaces but the bones remain separatedby the cranial sutures.
3. As brain growth occurs, the cranial bones are pushed apart and apposition of new bone occurs at the sutures.
4. Remodeling also occurs with new bone added on the external surfaces and removed on the internal surfaces.

Cranial base

1. Ethmoid, sphenoid, and occipital bones at the base of the skull are formed initially in cartilage and later transformed into bone by **endochondral** ossification.
2. As ossification occurs, three bands of cartilage remain, which are important growth centers called synchondroses: the sphenio-ethmoid synchondrosis , intersphenoid synchondrosis, and sphenooccipital synchondrosis.



3. Each synchondrosis acts like a two-sided epiphysealplate with growing cartilage in the middle and bands of maturing cartilage cells extending in both directions that will be replaced by bone.

4. Eventually, these synchondroses become inactive:the intersphenoid probably around age 3, the spheno-ethmoid around age 7, and the sphenooccipitalconsiderably later.

5. Because they are endochondral bones, the bones making up the cranial base are minimally ***affected directly by growth of the brain***

Maxilla

1. Growth of the maxilla is **intramembranous**. Growth occurs at the sutures posterior and superior to the maxilla at its connections to the cranium and cranial base, and by surface remodeling.
2. The maxilla migrates downward and forward away from the cranial base , and undergoes significant surface remodeling.
3. Surface remodeling includes resorption of bone anteriorly and apposition of bone inferiorly.
4. Much of the anterior movement of the maxilla is negated by anterior resorption, and downward migration is augmented by inferior apposition of bone.
5. As with all bones, interstitial growth within the mineralized mass of the maxilla is not possible; addition of new bone can only occur at the surfaces. Thus, increased space for the eruption of posterior teeth occurs by addition of bone posteriorly at the tuberosity as the maxilla migrates downward and forward.

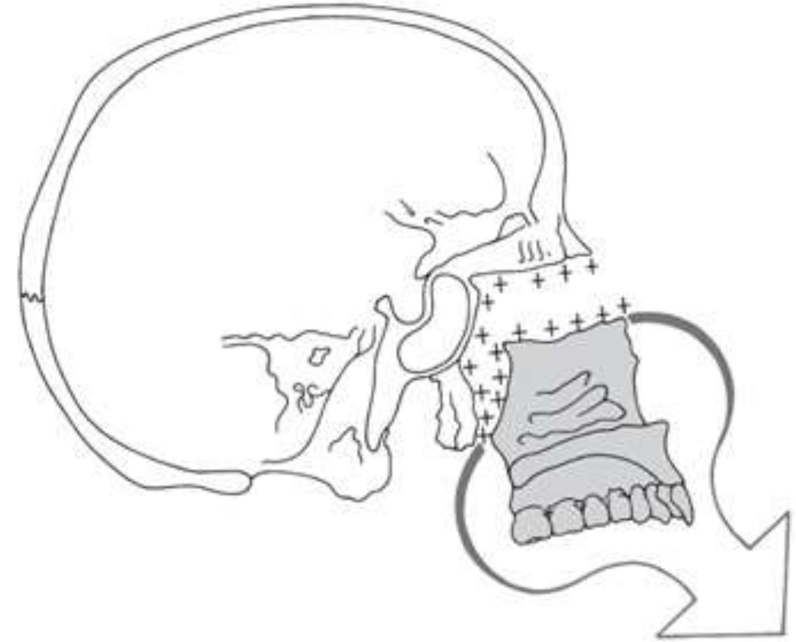


Figure 5–2. As growth of surrounding soft tissues translates the maxilla downward and forward, opening up space at its superior and posterior sutural attachments, new bone is added on both sides of the sutures. (From Proffit WR, Fields HW, Sarver DM: *Contemporary Orthodontics*, ed 4, St Louis, Mosby, 2007.)

Mandible

1. Growth of the mandible is both endochondral and intramembranous.

2. Cartilage covers the surface of the mandibular condyle at the TMJ. However**, <u>this cartilage does not grow independently like an epiphyseal plate or synchondrosis.</u>**

3. Cartilage is transformed into bone at the condyle as the mandible grows downward and forward, away from the cranial base. Surface apposition and resorption takes place in other areas of the mandible.

4. Most growth of the mandible occurs by new bone forming at the condyle and by resorption of the anterior part of the ramus with apposition posteriorly. Minor amounts of remodeling occur anteriorly and inferiorly.

5. As with the maxilla, interstitial growth within the mineralized mass of the mandible is not possible. Space for eruption of the posterior teeth occurs as the anterior portion of the ramus is resorbed extensively. Thus, in a child with crowded teeth it is not reasonable to expect that interstitial growth of the mandible will occur to create space within the body of the mandible to alleviate the crowding

6. Additional bone is formed by surface apposition on the posterior surface of the ramus

Mandibular growth rotation

As growth at the condyle facilitates movement of the mandible downward and forward, away from the cranial base, a gap is available between the maxilla and mandible in which the maxillary and mandibular teeth erupt.

a. Average closing rotation: in most children, condylar growth exceeds molar eruption and the mandible rotates slightly closed over time. This closing rotation, along with the downward and forward growth of the mandible itself, helps make the chin appear more prominent as children age. It also indicates that, in most cases, m posterior face height increases more than anterior face height.

b. Severe closing rotation: in some children, condylar growth greatly exceeds molar eruption and the mandible rotates more substantially closed, leading to development of a shorter face and a deeper anterior overbite tendency.

c. Opening rotation: rarely, condylar growth is less than molar eruption and the mandible rotatesopen during growth. In these children, a long lower face and tendency for an anterior open bite develops

Growth & Development

Growth

Increase in size or number

Anatomic

Development

Increase in complexity or specialization

Physiological or behavioral

Thank You