THEORIES OF GROWTH

Department of Orthodontics

LEARNING OBJECTIVES

- To understand the different mechanisms of bone growth
- To understand the concept of different theories of bone growth
- To understand the contributions of different theories in the growth of craniofacial region.

CONTENTS

- The Genetic "Theory”
- Sicher's Hypothesis (Sutural Dominance)
- Cartilaginous theory/Scott's Hypothesis (Nasal Septum)
- Moss' Hypothesis (Functional Matrix)
- Von Limborgh’s epigenetic Theory

The Genetic "Theory"

The genetic theory simply said that genes determine all.

Mendel (1822-1884)- specific traits were passed between generations in a particulate, discrete manner from both parents according to a set of mathematical principals.

Carlson, David S. "Theories of craniofacial growth in the postgenomic era." *Seminars in Orthodontics*. Vol. 11. No. 4. WB Saunders, 2005.

Handbook of Orthodontics by Robert E Moyers , 4th edition,1988

The field of genetics was characterized by two principal foci.

- Transmission genetics was based in the Mendelian Laws of Inheritance and was characterized by a statistical approach that required no understanding of the nature of genes or their expression. As a result, transmission genetics was of little help or consequence for the study of development and growth.

- The second focus concerned the nature of the gene itself and the mechanisms of gene action during development.

Carlson, David S. "Theories of craniofacial growth in the postgenomic era." *Seminars in Orthodontics*. Vol. 11. No. 4. WB Saunders, 2005.

- Although called a theory it was more assumed than proven.

- The general assumptions were found to be flawed and hence there was uneasiness with the all embracing aspects of the ‘theory.’

Sicher's Hypothesis (Sutural Dominance Theory)

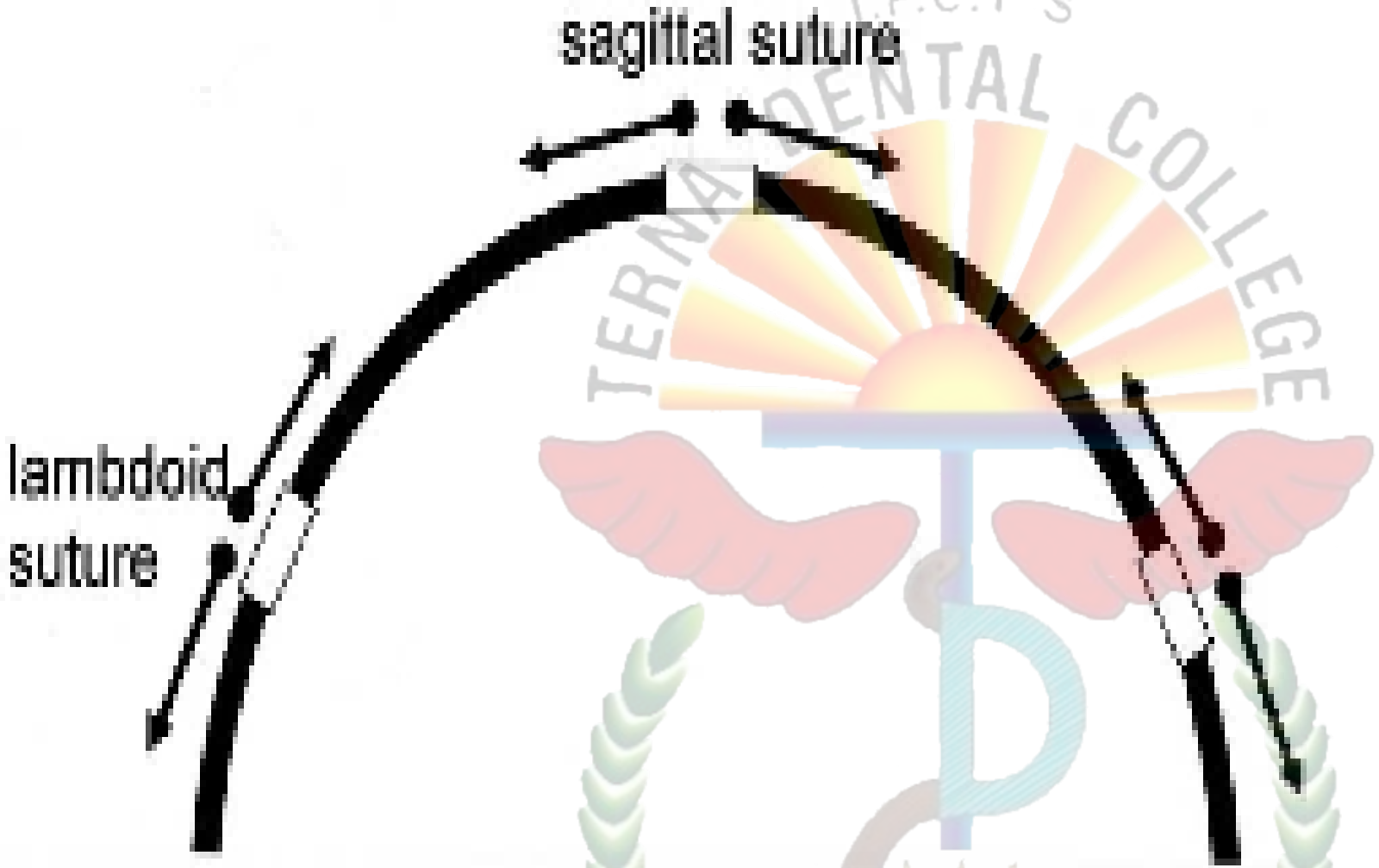
- The sutural theory was largely the work of two anatomists, Joseph Weinmann and Harry Sicher

- Primary event in sutural growth is the proliferation of the connective tissue between the two bones.

- Replacement of the proliferating connective tissue was necessary for functional maintenance of the bones.

- Sicher held sutures, cartilage, and periosteum all responsible for facial growth and assumed all were under tight intrinsic genetic control.

Handbook of Orthodontics by Robert E Moyers , 4th edition,1988



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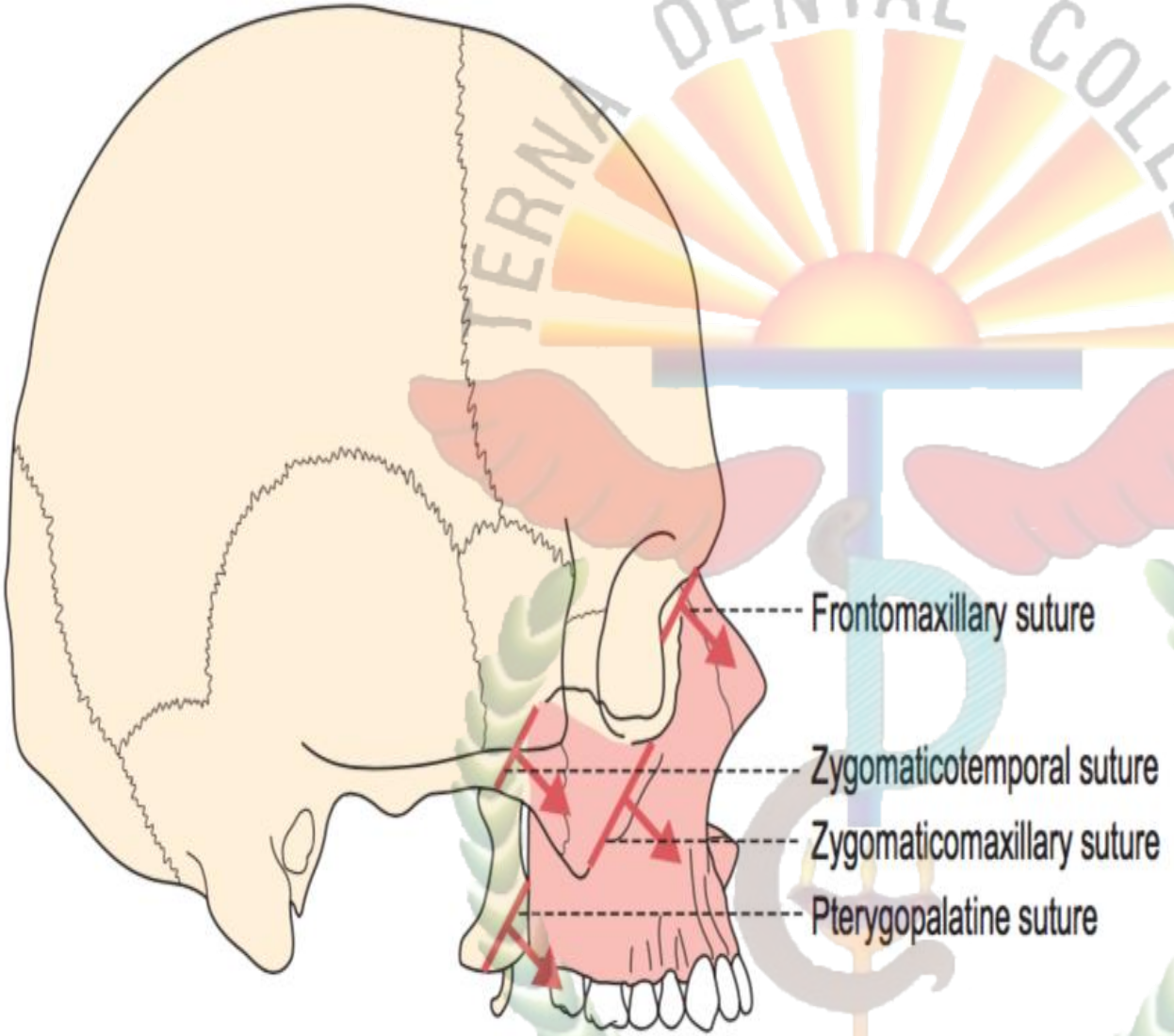

A Textbook of Orthodontics ,T. D. FOSTER 3rd edition

- The sutural theory accounted for two major factors that were difficult to resolve within the remodeling theory.

1.It was consistent with the established fact that periosteal remodeling of bone is under strong local influences by the functional environment, and thus is unlikely to be under strong intrinsic, hereditary control.

2.The sutural theory was consistent with the contemporary understanding of the importance of cartilaginous structures and skeletal joints in the development and postnatal growth of bones.

Handbook of Orthodontics by Robert E Moyers , 4th edition,1988

- The sutural theory also reinforced the concept that growth of the face and jaws was essentially immutable.

- Sutures as well as the cartilages of the craniofacial skeleton were the locations of centers of bone growth at which the inherited, immutable pattern of craniofacial form and facial type, however determined, was expressed.

Handbook of Orthodontics by Robert E Moyers , 4th edition,1988

- According to this theory , growth at the sutures should occur largely independent of the environment , and it would not be possible to change the expression of growth at the sutures very much.

- However , it is clear that sutures are not primary determinants of craniofacial growth

- Two lines of evidence lead to this conclusion are

1. When an area of the suture between two facial bones is transplanted to another location the tissue does not continue to grow. This indicates a lack of innate growth potential in the sutures.

2. it can be seen that growth at sutures will respond to outside influences under a number of circumstances

Cartilaginous theory/Scott's Hypothesis (Nasal Septum)

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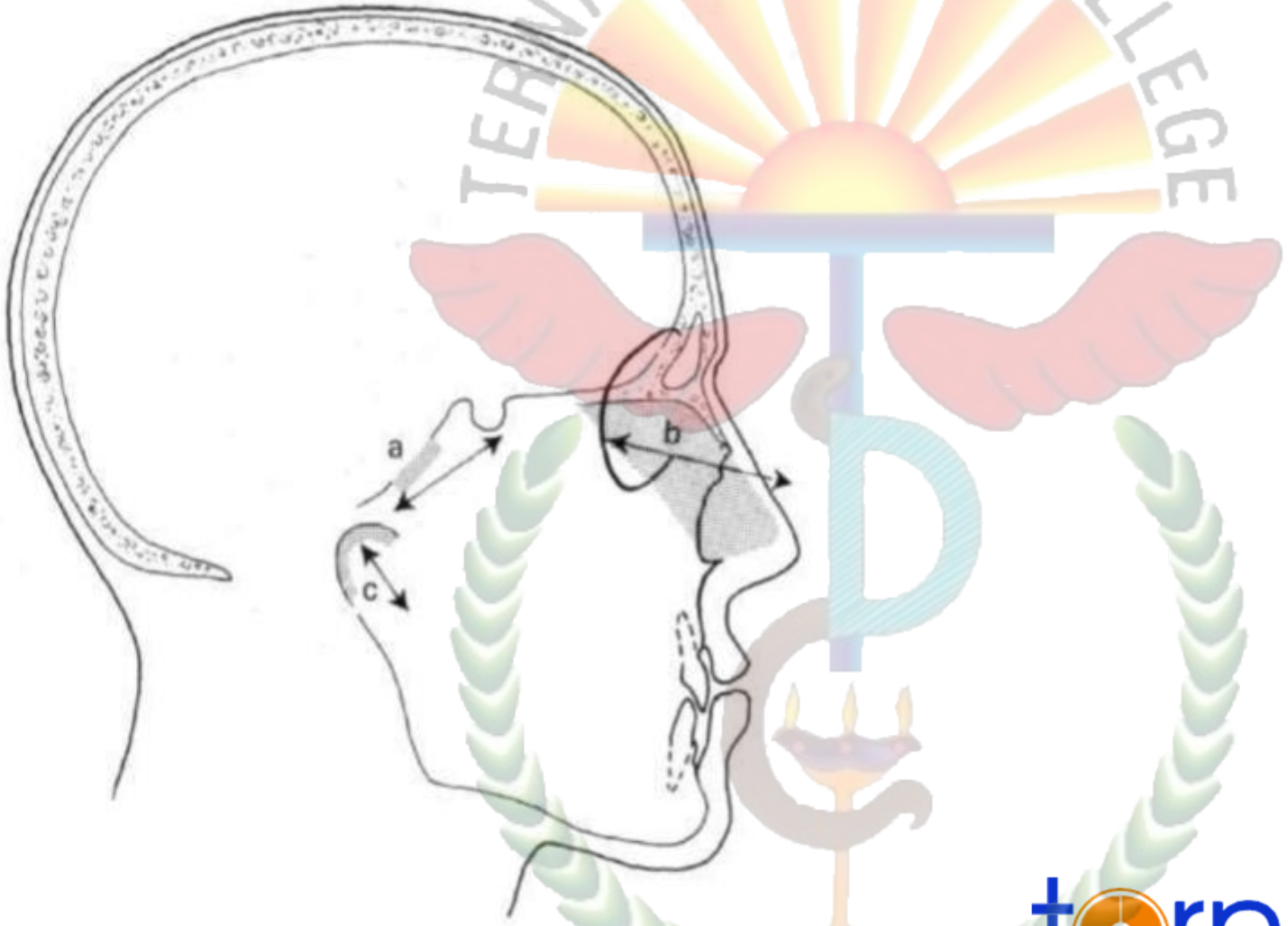

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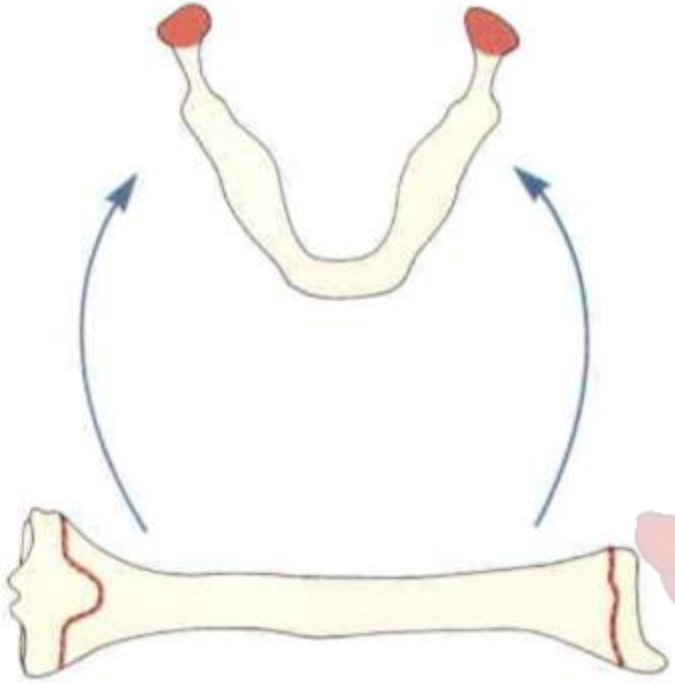
- 
- of a long bone , bent into a horseshoe
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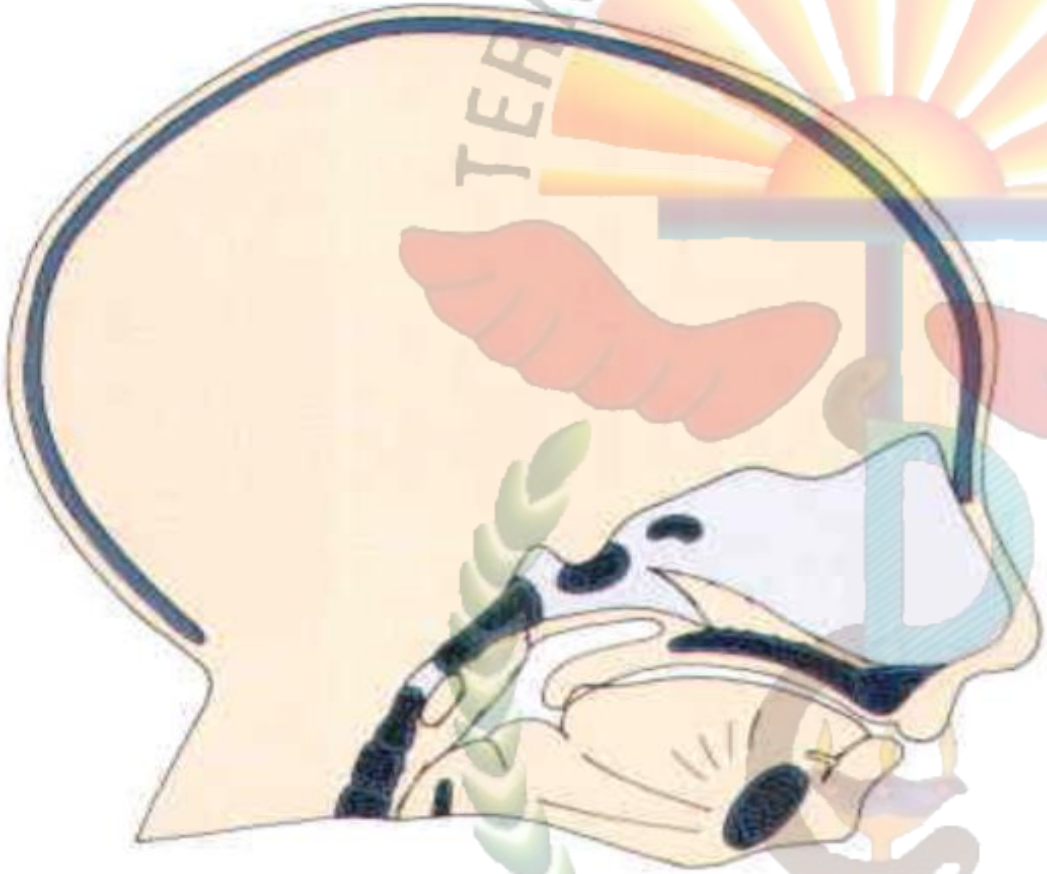

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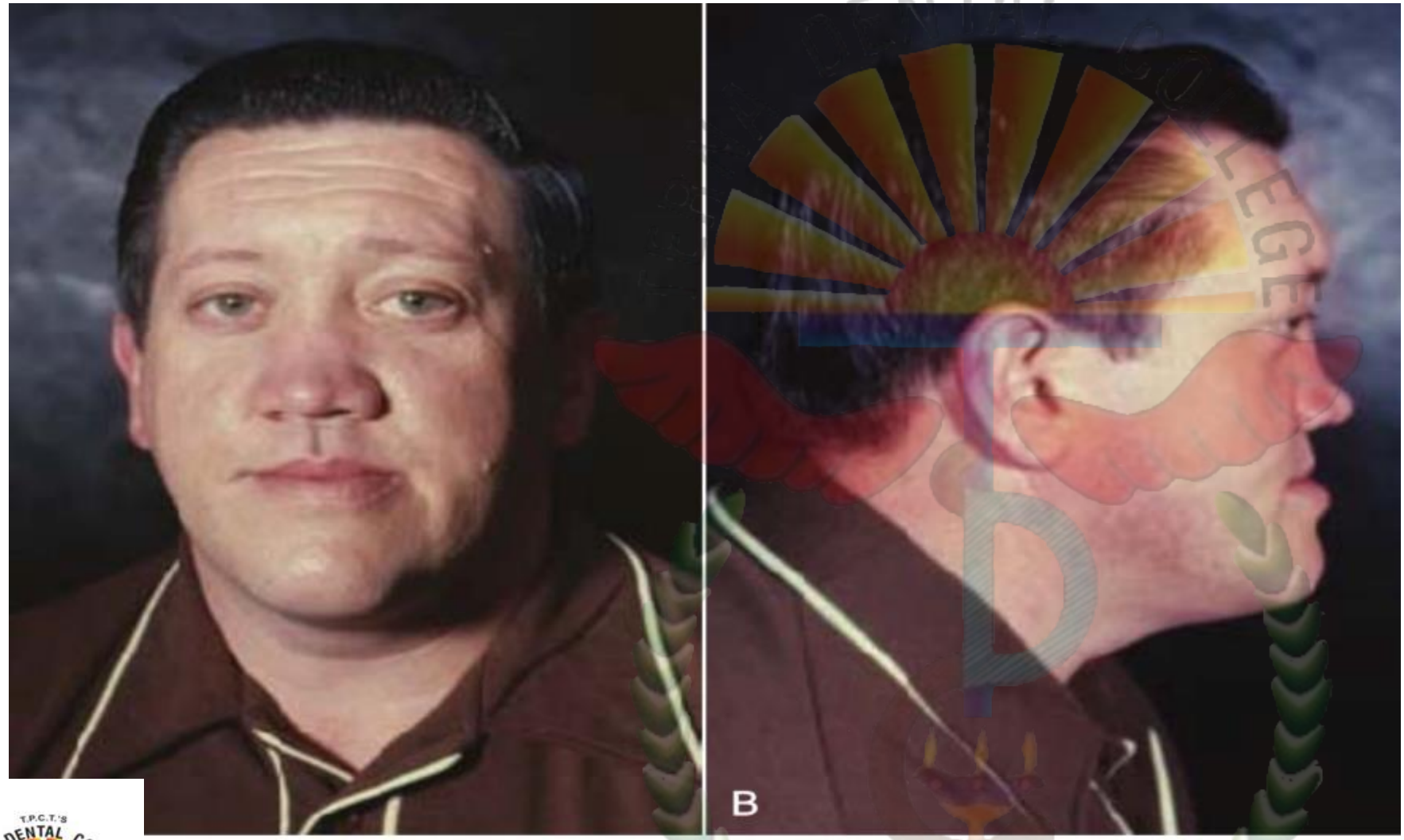

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Transplantation	Result
Epiphyseal plate	It will continue to grow in a new location or in culture , indicating that these cartilages do have innate growth potential
Spheno-occipital synchondrosis	Also grows when transplanted but not as well
Nasal septum	Gave equivocal results : sometimes it grew, sometimes it did not
Mandibular condyle	Little or no growth was observe

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Conclusion

Nasal septum may be important for the anteroposterior growth of the face

But it is not considered as an active contributor for vertical development of the face

Moss' Hypothesis (Functional Matrix)

- According to Moss, bone and cartilage lack growth determination and grow in response to intrinsic growth of associated tissues termed as "functional matrices."

- Moss argues, the skeletal tissues grow only in response to soft-tissue growth and the effect is a passive translation of skeletal components in space.

Carlson, David S. "Theories of craniofacial growth in the postgenomic era." *Seminars in Orthodontics*. Vol. 11. No. 4. WB Saunders,

- The functional matrix hypothesis explicitly claims that the origin, growth, and maintenance of all skeletal tissue and organs are always secondary, compensatory, and obligatory responses to temporally and operationally prior events or processes that occur in specifically related nonskeletal tissues, organs, or functioning spaces (functional ma- trices).

Moss, Melvin L. "Genetics, epigenetics, and causation." *American journal of orthodontics* 80.4 (1981): 366-375.

The functional cranial component is composed of two parts:

functional matrix

- which actually carries out the function

skeletal unit

- whose biomechanical role it is to protect, and/or support its specific functional matrix.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-

Skeletal units

- May be composed of bone, cartilage, or tendinous tissues.
- The skeletal units can be

Micro skeletal units

Macro skeletal units

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

- Microskeletal untis

When a bone consists of a number of skeletal units, we call them micro skeletal units.

- Macroskeletal units

When adjoining portions of a number of neighboring bones are united to function as a single cranial component, we term this as a macro-skeletal unit.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal o orthodontics* 55.6 (1969): 566-577.

Functional matrix

- The functional matrix includes muscles, glands, nerves, vessels, fat, teeth , etc.
- When this functional matrix grows or is moved, the related skeletal unit (the alveolar bone) responds appropriately to this morphogenetically primary demand.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

Types of Functional matrices

- Periosteal matrix
- Capsular matrix

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

Periosteal matrices

- The best example of periosteal matrix is the effect of the temporalis muscle on the coronoid process

- The coronoid process does not grow first to provide a “platform” upon which the temporalis muscle can then alter its functions.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

- Experimental removal of the mammalian temporalis muscle, or its denervation, experimentally, postinfectively, or posttraumatically, invariably results in an actual diminution of coronoid process size and shape or, indeed, in its total disappearance

- Similarly, it is well established that functional hypertrophy or hyperactivity of the temporalis muscle is productive of increased coronoid process size and also alteration of its shape.

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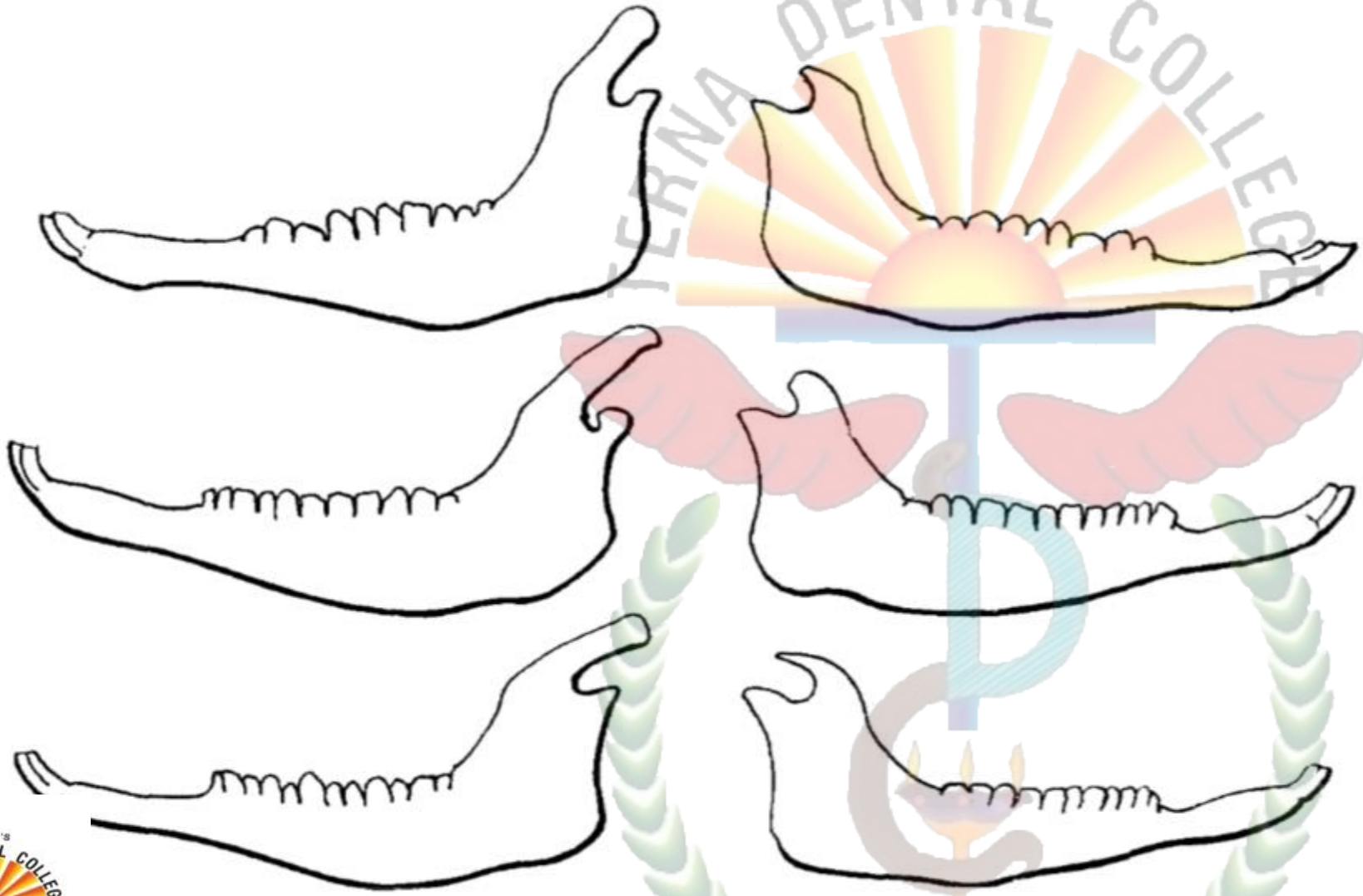


Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-

- The total growth changes in all aspects of coronoid process form (size and shape) are at all times a direct and compensatory response to the morphogenetically and temporally prior demands of the temporalis muscle function.

- Muscles are excellent examples of periosteal functional matrices, they do not comprise this entire category. Blood vessels, nerves, and glands produce morphologic changes in their related skeletal units in a completely homologous manner

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

CAPSULAR MATRIX

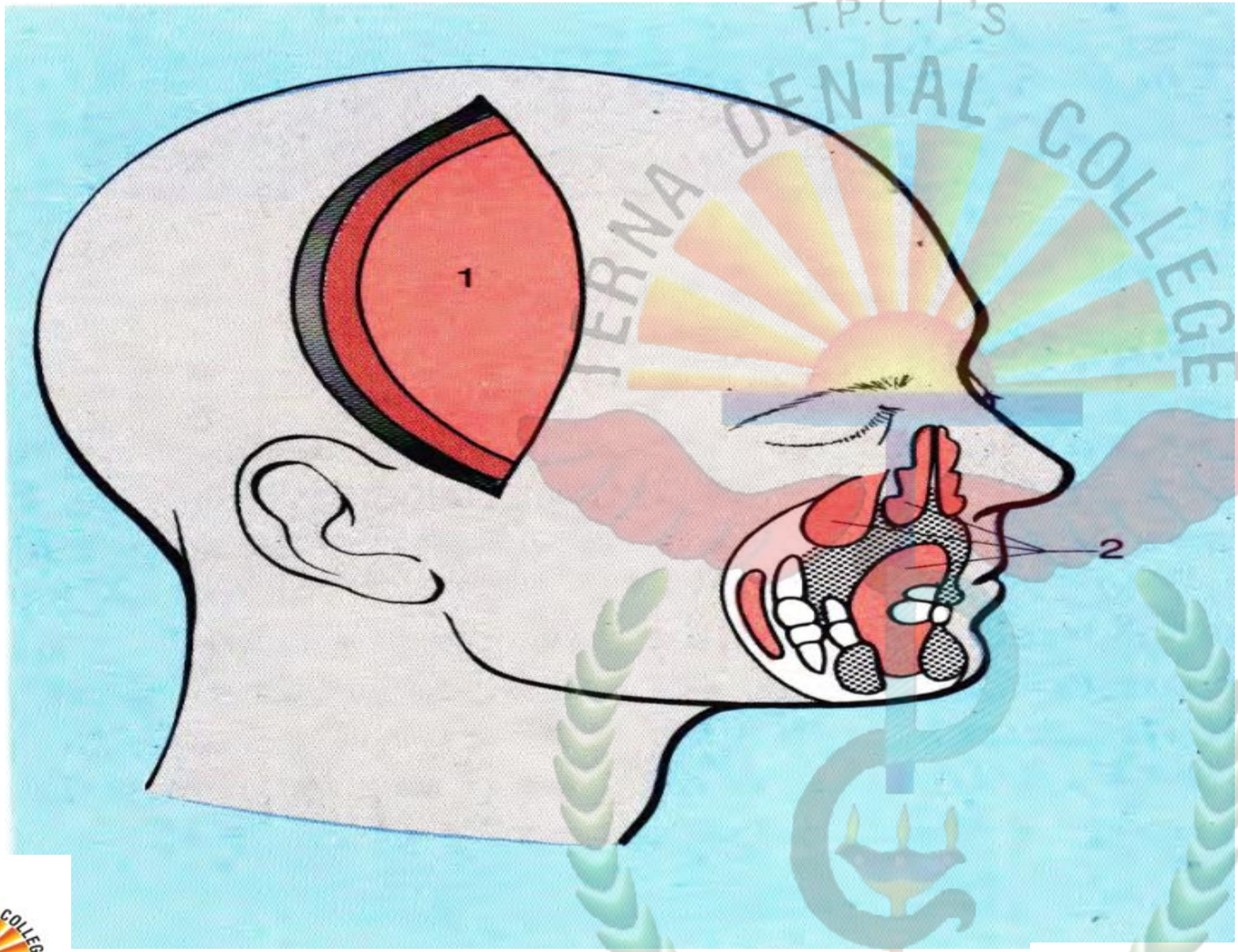
- All the periosteal matrices and their skeletal units are organized in the form of cranial capsules.

Neurocranial

- the neural mass which consists of the brain , leptomeninges and cerebrospinal fluid

Orofacial

- the oronasopharyngeal functioning spaces



Color Atlas of Dental Medicine ,
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Neurocranial capsule

- The composition of this capsule are the five layers of the scalp, the bone itself, and the two-layer dura mater.
- The total neural mass volume which is morphogenetically significant,.
- The expansion of this capsular matrix volume is the primary event in the expansion of the neurocranial capsule.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

- All of the included and enclosed functional cranial components(the periosteal matrices and their microskeletal units) are passively and secondarily translated in space.

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Orofacial matrices

- All functional cranial components of the facial skull arise, grow, and are maintained within an orofacial (splanchnocranial) capsule
- This capsule surrounds and protects the oronasopharyngeal functioning spaces.
- It is the volumetric growth of these spaces which is the primary morphogenetic event in facial skull growth.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

- The oral and pharyngeal regions have a primary function in maintaining a patent airway.
- This is accomplished by a dynamic musculoskeletal postural balance
- which is termed the “airway-maintenance mechanism. ”

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969):

- Post- natal development of the tongue is also integrally related to the acquisition of an open masticatory cavity

- It is this expansion of available performance area which makes the anteriorward elongation and greater motility of the tongue feasible and possible.

Moss, Melvin L., and Letty Salentijn. "The primary role of functional matrices in facial growth." *American journal of orthodontics* 55.6 (1969): 566-577.

Mandibular growth

- Mandibular is a combination of the morphologic effects of both capsular and periosteal matrices

- The enclosed and embedded macroskeletal unit (“mandible”) is passively and secondarily translated in space.

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- The periosteal matrices related to the constituent mandibular microskeletal units respond to this volumetric expansion.

- Such an alteration in their spatial position inevitably causes them to grow; that is, causes changes in their functional demands.

- The sum of translation plus changes in form comprises the totality of mandibular growth.

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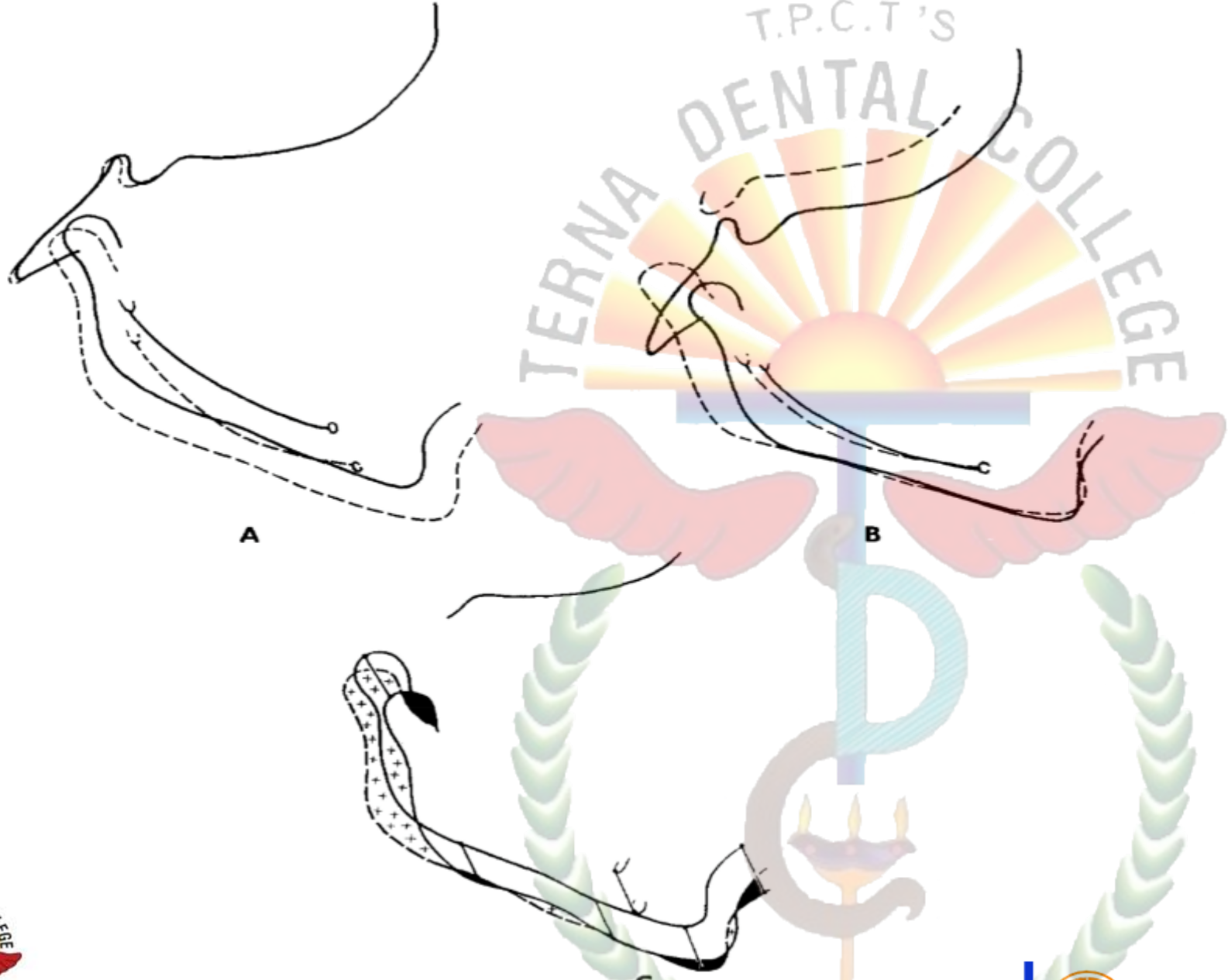

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Summary

Two basic types of matrices-periosteal and capsular.

Periosteal matrices act upon skeletal units by the process of osseous deposition and resorption to alter the size and shape of their respective skeletal units.

Capsular matrices act upon the functional cranial components by altering the volume of the capsules to bring about a passive translation of the cranial components in space

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Von Limborgh's Hypothesis

- Intrinsic Genetic factors –

  Genetic factors inherent to the skull tissues.

- Local Epigenetic factors –

  Genetically determined but manifest their influence in an indirect way on associated structures (brain, Eyes etc.).

Graber TM. Orthodontics Principles and practice ,*3rd Edition*

- General epigenetic Factors –

  Genetically determined influences originating from distant structures (sex hormones)

- Local Environmental Factors –

  Local non genetic influences originating from the external environment (local external pressure ,muscle forces)

- General Environment Factors -

  General non genetic influences originating from external environment (food, oxygen supply).

Evidences against the theory

- This synthesis of parts from the three basic theories of craniofacial growth, while representing a logical interpretation, does not answer all the questions

- The possible difference between control of appositional cartilaginous growth and interstitial cartilaginous growth can be raised

- Also, since neurocranium is completed quite early and thus provides a stable base for continued membranous growth in other areas , a question is asked concerning the influence of these membranous bones on the other membranous bones which are still growing

CONCLUSION

- UNDERSTANDING THE GROWTH PATTERN OF AN INDIVIDUAL HELPS IN TREATMENT PLANNING.

Take home message:

- Sutural and Cartilagenous theory of growth can act as an adjunct in the growth of the craniofacial region
- Functional matrix theory is the most widely accepted theory of growth

Expected questions:

SAQ

1. Sutural Theory

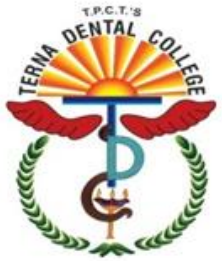
2. Functional matrix theory of growth

LAQ

1. Describe in detail the theories of

1

THANK YOU



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