
Netter's Head and Neck Anatomy for Dentistry

2nd Edition

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I dedicate this book to the following influential people in my life,

To my mother Chari, who worked tirelessly and sacrificed everything throughout her life so that her children would not be without.

To Elizabeth, who made me a better man. I owe you everything for all that you have done for me.

To my brother John, who helped raise me.

To the late Father John G. Holbrook, S.J., who helped me appreciate the importance of service to others. He taught me the dedicated ways of *cura personalis*, or care for the individual. I have tried to live by those words every day of my life.

About the Author

Neil S. Norton, PhD, joined Creighton University in 1996 and is currently the Director of Admissions, Assistant Dean for Student Affairs, and Professor of Oral Biology in the School of Dentistry. After graduating Phi Beta Kappa from Randolph-Macon College with a BA in Biology he went on to receive his PhD training in Anatomy from the University of Nebraska Medical Center. Dr. Norton has been the recipient of numerous teaching awards including ten Outstanding Instructor of the Year Awards from the Freshman classes and eight Dr. Theodore J. Urban Pre-Clinical Awards, presented by graduating Senior classes for dedication and outstanding Basic Science instruction. Dr. Norton is the third professor in the history of the School of Dentistry to receive the prestigious Robert F. Kennedy Memorial Award for Teaching Achievement, the highest teaching recognition offered by the University. In 2007 Dr. Norton received the GlaxoSmithKline Sensodyne Teaching Award, the highest national teaching award given by the American Dental Education Association (ADEA). An active member of the School of Dentistry faculty, he was elected by colleagues to honorary membership in Omicron Kappa Upsilon, the Honor Dental Society whose regular membership is reserved for dentists. His teaching responsibilities include Head and Neck Anatomy, General Anatomy, Neuroscience, and Pain Control. Dr. Norton served four years as President of the University Faculty and chaired many committees, including the University Committee on Rank and Tenure and the University Committee on Academic Freedom and Responsibility. Currently he serves as the Faculty Athletic Representative for Creighton. He continues to actively publish on a variety of anatomical topics in addition to his administrative duties. He is an active member of the American Association of Clinical Anatomists (AACA) and has served as the Treasurer since 2006.

Frank H. Netter, MD

Frank H. Netter was born in 1906, in New York City. He studied art at the Art Student's League and the National Academy of Design before entering medical school at New York University, where he received his MD degree in 1931. During his student years, Dr. Netter's notebook sketches attracted the attention of the medical faculty and other physicians, allowing him to augment his income by illustrating articles and textbooks. He continued illustrating as a sideline after establishing a surgical practice in 1933, but he ultimately opted to give up his practice in favor of a full-time commitment to art. After service in the United States Army during World War II, Dr. Netter began his long collaboration with the CIBA Pharmaceutical Company (now Novartis Pharmaceuticals). This 45-year partnership resulted in the production of the extraordinary collection of medical art so familiar to physicians and other medical professionals worldwide.

In 2005, Elsevier, Inc., purchased the Netter Collection and all publications from Icon Learning Systems. There are now over 50 publications featuring the art of Dr. Netter available through Elsevier, Inc. (in the United States: www.us.elsevierhealth.com/Netter and outside the United States: www.elsevierhealth.com).

Dr. Netter's works are among the finest examples of the use of illustration in the teaching of medical concepts. The 13-book *Netter Collection of Medical Illustrations*, which includes the greater part of the more than 20,000 paintings created by Dr. Netter, became and remains one of the most famous medical works ever published. *The Netter Atlas of Human Anatomy*, first published in 1989, presents the anatomical paintings from the Netter Collection. Now translated into 16 languages, it is the anatomy atlas of choice among medical and health professions students the world over.

The Netter illustrations are appreciated not only for their aesthetic qualities, but, more important, for their intellectual content. As Dr. Netter wrote in 1949, ". . . clarification of a subject is the aim and goal of illustration. No matter how beautifully painted, how delicately and subtly rendered a subject may be, it is of little value as a *medical illustration* if it does not serve to make clear some medical point." Dr. Netter's planning, conception, point of view, and approach are what inform his paintings and what makes them so intellectually valuable.

Frank H. Netter, MD, physician and artist, died in 1991.

Learn more about the physician-artist whose work has inspired the Netter Reference collection at www.netterimages.com/artist/netter.htm.

Carlos Machado, MD

Carlos Machado was chosen by Novartis to be Dr. Netter's successor. He continues to be the main artist who contributes to the Netter collection of medical illustrations.

Self-taught in medical illustration, cardiologist Carlos Machado has contributed meticulous updates to some of Dr. Netter's original plates and has created many paintings of his own in the style of Netter as an extension of the Netter collection. Dr. Machado's photorealistic expertise and his keen insight into the physician/patient relationship inform his vivid and unforgettable visual style. His dedication to researching each topic and subject he paints places him among the premier medical illustrators at work today.

Learn more about his background and see more of his art at www.netterimages.com/artist/machado.htm.

Acknowledgments

The second edition of *Netter's Head & Neck Anatomy for Dentistry* book has been a labor of love. Like the 1st edition, it is the culmination of many hours of hard, but very satisfying, work. I am truly indebted to the help of many talented and dedicated individuals.

I started at the Creighton University School of Dentistry in 1996 and was overwhelmed by the comradery that existed at both the School and University level. I am grateful every day to be part of such a fine institution that is committed to the education of students. The support and assistance my fellow colleagues provided has been immeasurable. I would especially like to thank for their review of chapters, suggestions, and willingness to provide materials: Drs. W. Thomas Cavel, Paul Edwards, Terry Lanphier, Takanari Miyamoto, Cyndi Russell, Tarjit Saini, and Timothy McVaney. I owe a very special thanks to my Dean, Dr. Wayne W. Barkmeier. He was the person willing to give a young anatomist an opportunity at Creighton, and I owe my career to Dr. Barkmeier. It was he and Dr. Frank J. Ayers who pushed me and provided me the opportunity in Admissions and Student Affairs. For that, I'll always be grateful.

Additionally, I am grateful to Dr. Laura C. Barritt who was instrumental in the creation of the Development section of the book, as well as providing various suggestions in many other chapters. Another special thanks goes to my chair, Dr. Margaret A. Jergenson. Since 1996, Dr. Jergenson and I have taught general anatomy and head and neck anatomy to freshman dental students. As a dentist, her clinical background has been invaluable in helping me appreciate head and neck anatomy from a dental perspective. Together, we have enjoyed a great time working together as the anatomical team in the School of Dentistry. I could not ask for a better colleague with whom to teach anatomy.

My sincere appreciation to my Creighton colleagues. Creighton is a family, and I have been fortunate to spend my career at such a fine university. Over the years there are a few individuals who have helped me immensely. In particular, I owe a special acknowledgment of gratitude to Frs. Richard Hauser, S.J., and Thomas Shanahan, S.J. Last, a special thanks goes to Fr. John P. Schlegel, S.J. For eleven of my fifteen years at Creighton, Fr. Schlegel served as the President of Creighton University. In my previous role as President of the University Faculty, I worked with Fr. Schlegel on many issues and was always grateful to be working for a President committed to his students, staff, and faculty.

Thank you to the reviewers who examined the chapters in the first edition and provided excellent feedback: Drs. Robert Spears, Kathleen M. Klueber, and Brian R. MacPherson, and Professor Cindy Evans. My sincere appreciation goes to friend and colleague Dr. Thomas Quinn, who offered helpful comments and words of encouragement throughout the textual writing and development of the art.

I enlisted the help of my dental students to make *Netter's Head and Neck Anatomy for Dentistry* more student-friendly. Special thanks go to Dr. Joseph Opack for providing excellent critiques on chapters and Dr. Ryan Dobbs for his assistance in keeping many of my chapters well organized and developed. Additional thanks go to Drs. Steve Midstokke and Paul Mendes for helping in the creation of some of the new pieces of art. A special thanks to Dr. Kyle D. Smith for helping select many of the new cone beam images that have been incorporated into the second edition.

This book would not be possible if not for the beautiful new artwork created by the incredible medical illustrators at Elsevier. Their hard work not only supplemented the illustrations of Dr. Frank Netter, Carlos Machado, MD, and John Craig, MD, seamlessly,

but also added to the vast Netter collection of anatomical pieces. Tiffany DaVanzo was instrumental in the creation of the new pieces in the second edition. I am very grateful to the work of Kip Carter, William Winn, and Andrew Swift. All of these illustrators helped put my vision into art. Their artistic interpretations are simply magnificent.

The Elsevier team deserves a special thanks for making this project happen, including Elyse O'Grady, Marybeth Thiel, Anne Lenehan, and Carol O'Connell. Additionally, I would like to acknowledge the work of those who helped me complete the first edition of the book: Jennifer Surich, Carolyn Kruse, and Jonathan Dimes.

A very special thanks goes to Paul Kelly. I have had the great honor and privilege of knowing Paul for the past 10 years. I remember many conversations with Paul over the years in which he encouraged me to put together an anatomical project for dentistry. I presented him with the rough outline and prospectus for a text/atlas that evolved into the first edition of this book.

Lastly, I thank all of the students whom I have instructed over my career. You have always served as a great inspiration to me. It has been an honor and privilege to be a part of your education. *Netter's Head and Neck Anatomy for Dentistry* is for you.

Preface

Netter's Head and Neck Anatomy for Dentistry is a text/atlas written to help dental students and professionals learn and review head and neck anatomy. Designed for first-year dental students, it also serves to teach anatomy to students of dental hygiene as well as a review for the practicing clinician. The head and neck comprise the foundation for dental anatomical study. The many small, inter-related structures are not easily observable, which makes head and neck anatomy one of the most difficult disciplines for students to master.

This second edition has three major additions from the first edition. First is the inclusion of an introductory chapter on upper limb, thorax, and abdomen. These sections are included in dental school courses of gross anatomy, and it was a goal to create one book that would fully cover head and neck anatomy but also provide the basic anatomy needed to successfully complete the upper limb, thorax, and abdomen portions of an anatomy course. The second addition is the inclusion of over 20 radiographic images to complement the anatomy illustrations throughout the text. Radiology is an important part of the education of dental students and it is a natural addition to any anatomy text. The third addition is the inclusion of review questions that cover all of the chapters in the text. The multiple-choice questions are designed to serve as a review for the reader.

To understand the clinical significance of an anatomical concept is to understand the anatomy. It is with that in mind that a series of clinical correlates that relate to dentistry are provided at the end every chapter. Many anatomical topics covered in head and neck courses have been expanded especially for this text. A chapter has been dedicated to the temporomandibular joint. In the chapter on the oral cavity, more information has been provided for the reader on such topics as dentition. Chapters on the development of the head and neck and basic neuroscience are included to help connect with other related anatomical areas. A chapter on intraoral injections is included to help teach and reinforce an area often overlooked. The intent of these chapters is to provide the reader with a brief overview of important concepts related to head and neck anatomy.

A superb team of medical illustrators created new art to complement the anatomical illustrations of Dr. Frank H. Netter, which resulted in a more complete learning tool. Essential information is presented in tables and brief text that are integrated with the Netter art to help bridge gaps and augment the readers' knowledge of head and neck anatomy.

Netter's Head and Neck Anatomy for Dentistry is for those in all stages of the dental profession. My hope is that this book will provide an essential resource to readers in helping them to learn and appreciate the complex anatomy of the head and neck.

CHAPTER 1

DEVELOPMENT OF THE HEAD AND NECK

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1 Overview

GENERAL INFORMATION

3 major germ layers form the initial developing embryo:

- Ectoderm
- Mesoderm
- Endoderm

Mesoderm differentiates into:

- Paraxial mesoderm
- Intermediate mesoderm
- Lateral plate mesoderm

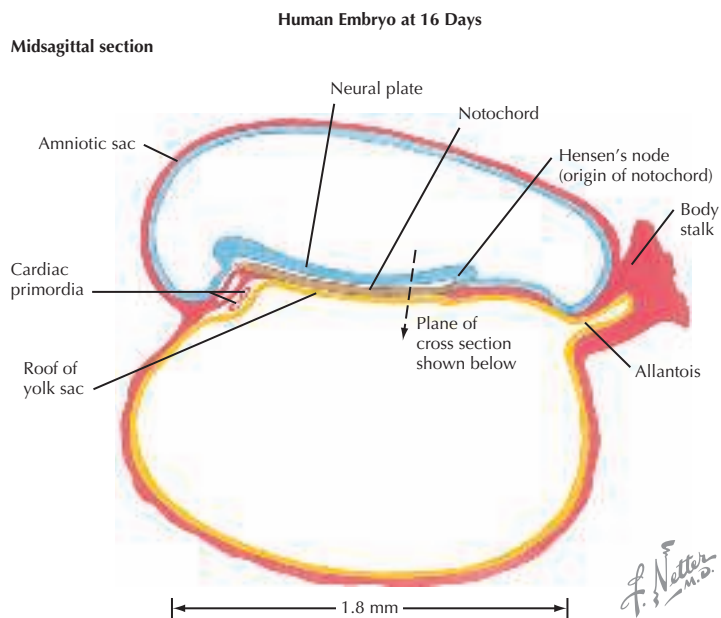
Ectoderm gives rise to 2 layers:

- Neuroectoderm
- Neural crest

The head and neck are formed by:

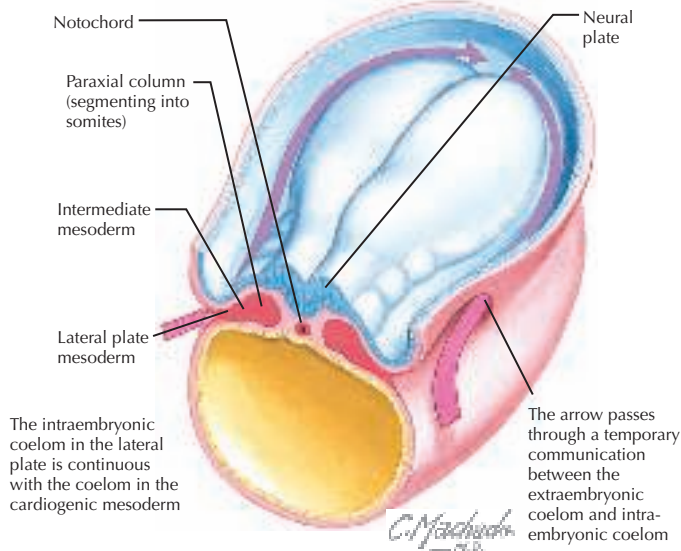
- Paraxial mesoderm
- Lateral plate mesoderm
- Neural crest
- Ectodermal placodes

Most of the head and neck is formed from the pharyngeal arches

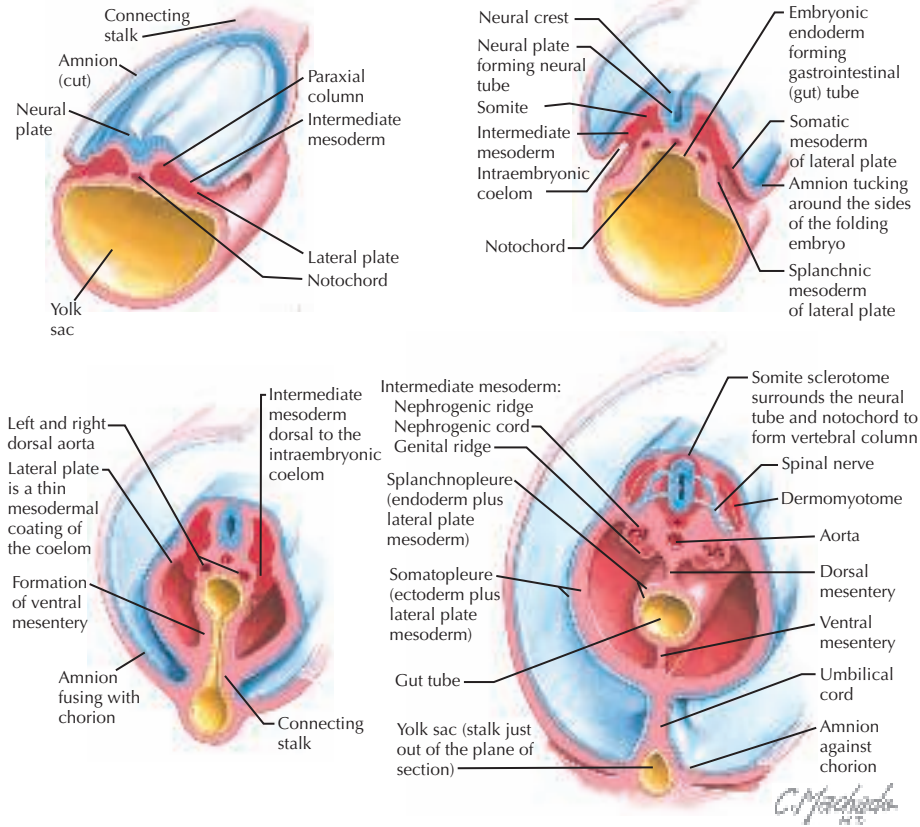


GENERAL INFORMATION CONTINUED

Cross section of embryo



Vertebrate Body Plan after 4 Weeks



1 Pharyngeal Arches

GENERAL INFORMATION

Start forming in the 4th week of development

Develop as blocks separated by pharyngeal clefts

Initially, 6 arches develop, but the 5th regresses

Arising from the endoderm are compartments called pharyngeal pouches that extend toward the pharyngeal clefts

Help form 4 of the 5 swellings of the face:

- 2 mandibular processes (pharyngeal arch)
- 2 maxillary processes (pharyngeal arch)
- 1 frontonasal prominence

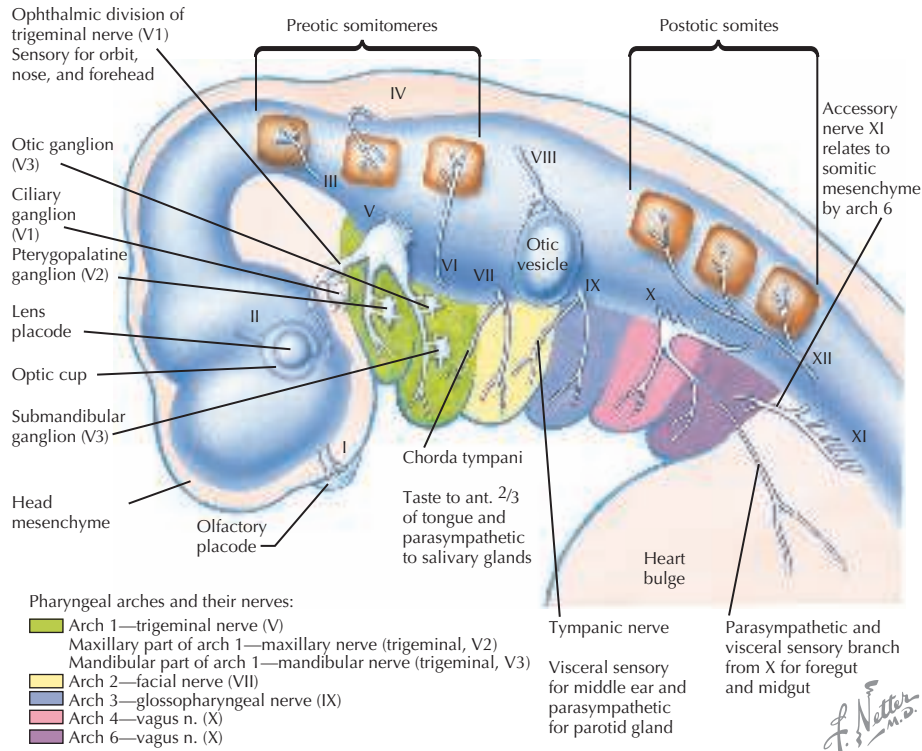
Composed of:

- External surface—ectoderm
- Internal surface—endoderm
- Central part—lateral plate mesoderm, paraxial mesoderm, neural crest

Skeletal components develop from the neural crest tissue

Muscular structures develop collectively from the mesoderm

Each arch is innervated by a cranial nerve that migrates with the muscles

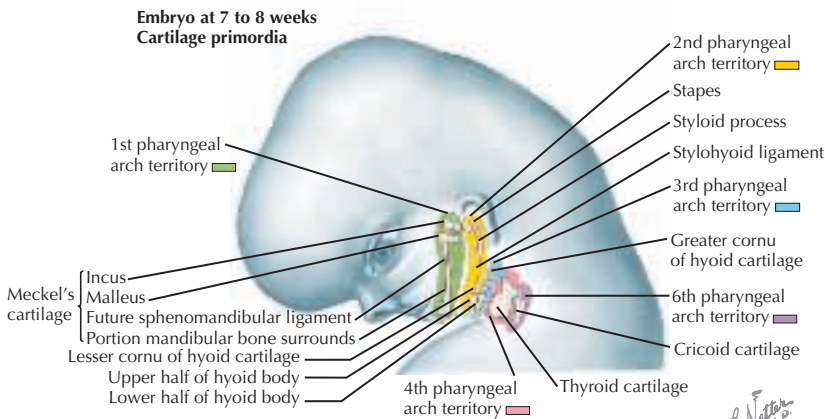
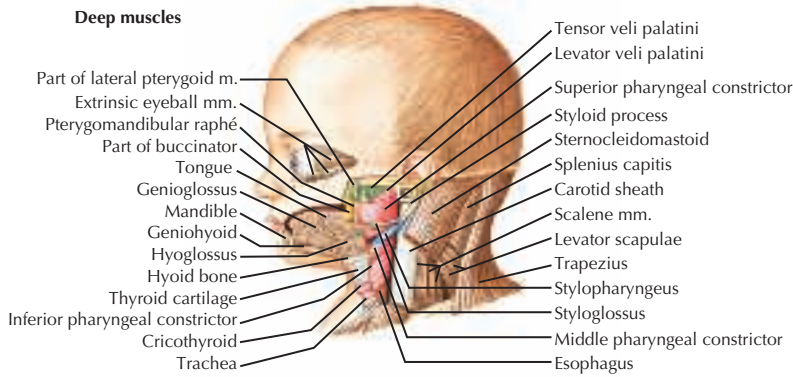
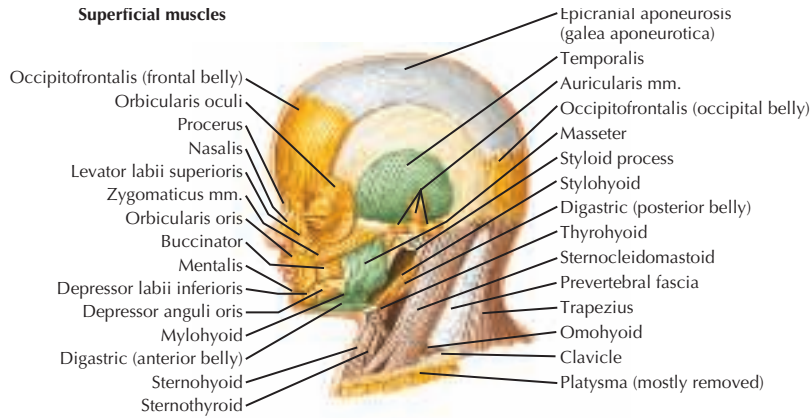


DERIVATIVES OF THE PHARYNGEAL ARCHES

Arch	Muscles from Mesoderm	Skeletal Structures from Neural Crest	Cartilage Structures	Connective Tissue Structures	Nerve
1 Develops into: • Maxillary process • Mandibular process	Masseter Temporalis Lateral pterygoid Medial pterygoid Mylohyoid Anterior digastric Tensor tympani Tensor veli palatini	Maxilla Temporal (squamous portion) Zygoma Mandible Malleus Incus	Meckel's cartilage (degenerates in adulthood)	Sphenomandibular ligament Anterior ligament of the malleus	Trigeminal
2	Muscles of facial expression Posterior digastric Stylohyoid Stapedius	Lesser cornu of the hyoid Superior part of the hyoid body Styloid process Stapes	Reichert's cartilage	Stylohyoid ligament Connective tissue of the tonsil	Facial
3	Stylopharyngeus	Greater cornu of the hyoid Inferior part of the hyoid body		Connective tissue of the thymus and inferior parathyroid	Glossopharyngeal
4	Musculus uvulae Levator veli palatini Palatopharyngeus Palatoglossus Superior constrictor Middle constrictor Inferior constrictor Salpingopharyngeus Cricothyroid		Thyroid (from lateral plate mesoderm) Epiglottis	Connective tissue of the superior parathyroid and the thyroid	Vagus
6	Thyroarytenoid Vocalis Lateral cricoarytenoid Oblique arytenoids Transverse arytenoids Posterior cricoarytenoid Aryepiglottis Thyroepiglottis		Arytenoid Cricoid Cuneiform Corniculate (from lateral plate mesoderm)		Vagus

1 Pharyngeal Arches

DERIVATIVES OF THE PHARYNGEAL ARCHES *CONTINUED*



PHARYNGEAL ARCH BONES AND CARTILAGE

Arch #	Derivatives of Arch Cartilages
1	Malleus, incus, sphenomandibular ligament
2	Stapes, styloid process, stylohyoid ligament, upper half of hyoid
3	Lower half and greater horns of hyoid
4	Thyroid and epiglottic cartilages of larynx
6	Cricoid, arytenoid, and corniculate cartilages of larynx

Pharyngeal Pouches, Membranes, and Clefts

GENERAL INFORMATION

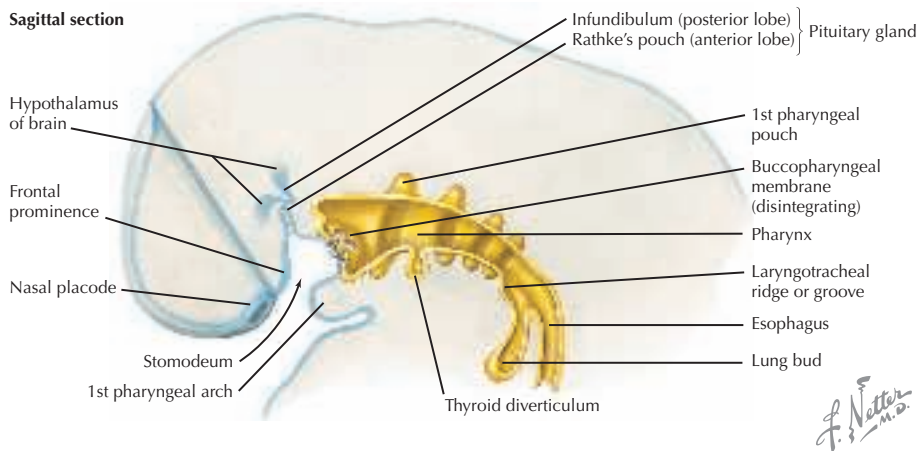
Pharyngeal pouches—4 develop from endoderm

Pharyngeal clefts—each is a groove formed from ectoderm

Pharyngeal membranes—each is composed of tissue located between a pharyngeal pouch and a pharyngeal cleft; composed of external ectoderm, mesoderm and neural crest in the core, and an internal endoderm lining

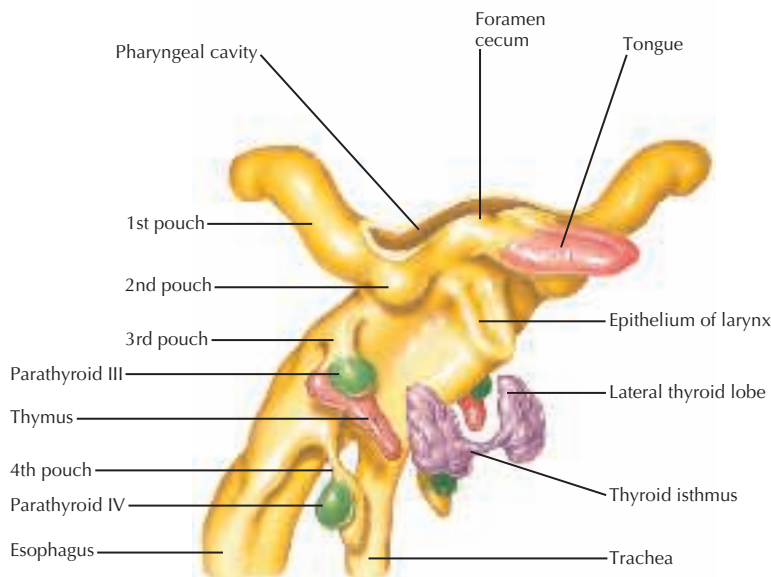
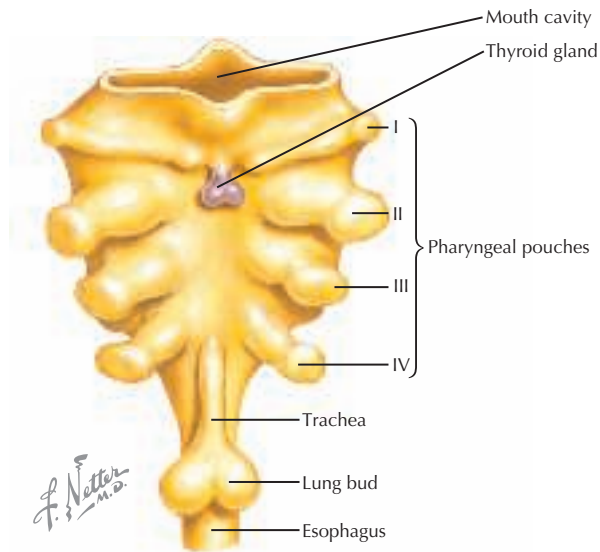
PHARYNGEAL POUCHES

Pouch	Location	Embryonic Structure	Adult Structure
1	Opposite the 1st pharyngeal cleft, separated by the 1st pharyngeal membrane	Tubotympanic recess	Epithelium of the auditory tube and tympanic cavity
2	Opposite the 2nd pharyngeal cleft, separated by the 2nd pharyngeal membrane	Primitive palatine tonsils	Tonsillar fossa Epithelium of the palatine tonsil
3	Opposite the 3rd pharyngeal cleft, separated by the 3rd pharyngeal membrane	Divides into a dorsal and a ventral part Dorsal part migrates inferiorly toward the thorax	Inferior parathyroid gland (from the dorsal part) Thymus (from the ventral part)
4	Opposite the 4th pharyngeal cleft, separated by the 4th pharyngeal membrane	Divides into a dorsal and a ventral part Ventral part is invaded by neural crest to form the parafollicular cells	Superior parathyroid gland (from the dorsal part) Ultimobranchial body (from the ventral part)



1 Pharyngeal Pouches, Membranes, and Clefts

PHARYNGEAL POUCHES *CONTINUED*



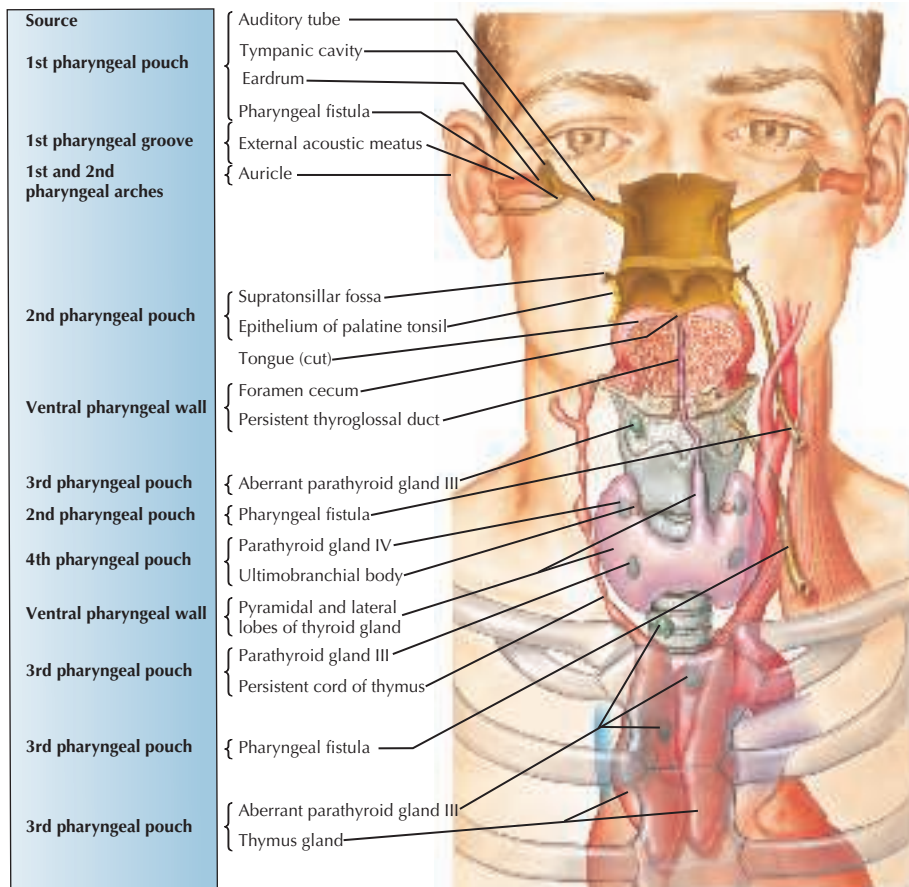
Pharyngeal Pouches, Membranes, and Clefts

PHARYNGEAL MEMBRANES

Membrane	Location	Adult Structure
1	Between the 1st pharyngeal cleft and the 1st pharyngeal pouch	Tympanic membrane
2	Between the 2nd pharyngeal cleft and the 2nd pharyngeal pouch	
3	Between the 3rd pharyngeal cleft and the 3rd pharyngeal pouch	
4	Between the 4th pharyngeal cleft and the 4th pharyngeal pouch	

PHARYNGEAL CLEFTS

Cleft	Location	Adult Structure
1	A groove between the 1st and 2nd pharyngeal arches	External acoustic meatus
2	A groove between the 2nd and 3rd pharyngeal arches	Obliterated cervical sinus by the 2nd pharyngeal arch, which grows over the cleft
3	A groove between the 3rd and 4th pharyngeal arches	
4	A groove between the 4th and 6th pharyngeal arches	



F. Netter M.D.

1 Skull

GENERAL INFORMATION

Skull is formed from:

- Lateral plate mesoderm (neck region)
- Paraxial mesoderm
- Neural crest

Bony skull is formed by either of 2 mechanisms:

- Intramembranous ossification
- Endochondral ossification

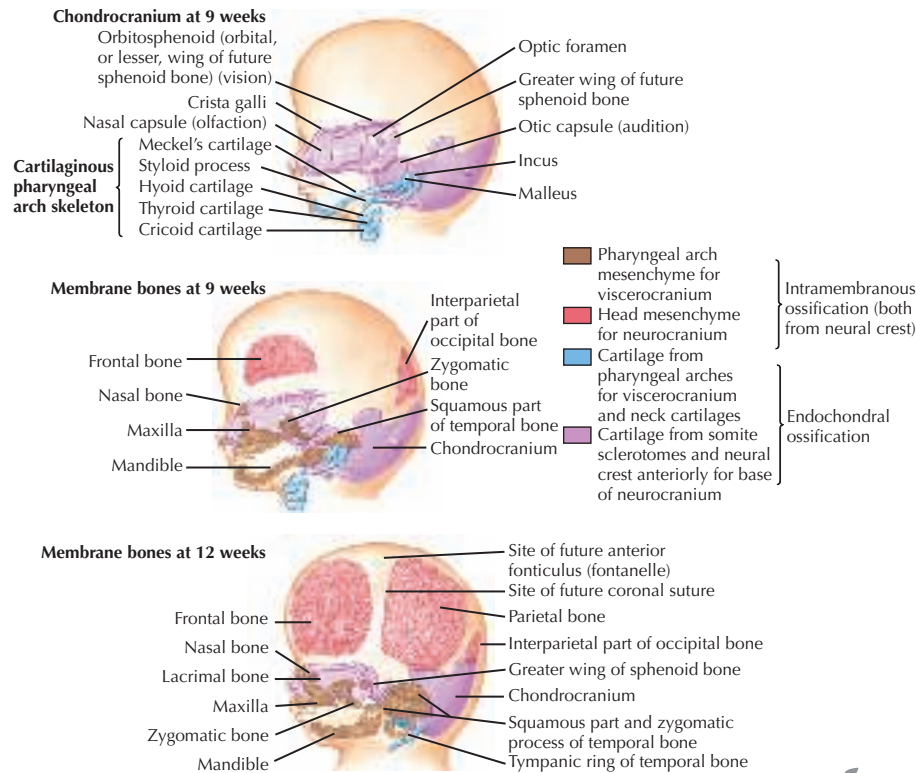
Skull development is divided into 2 parts:

- Viscerocranium—forms the bones of the face
- Neurocranium—forms the bones of the cranial base and cranial vault and can be divided into membranous neurocranium and cartilaginous neurocranium

VISCEROCRANIUM

Germ Layers	Origins	Adult Structure	Ossification	
Neural crest	1st pharyngeal arch	<i>Maxillary process</i>	Maxilla	Intramembranous
			Temporal bone	
			Zygoma	
			Palatine	
			Lacrima	
			Vomer	
			Nasal	
		Inferior nasal concha	Endochondral	
		<i>Mandibular process</i>	Mandible	Intramembranous and endochondral
	Sphenomandibular ligament		Not ossified	
	Malleus		Endochondral	
	Incus			
	2nd pharyngeal arch	Styloid process	Endochondral	
		Stapes		
		Hyoid		
Stylohyoid ligament		Not ossified		

VISCEROCRANIUM CONTINUED



SKULL FONTANELLES

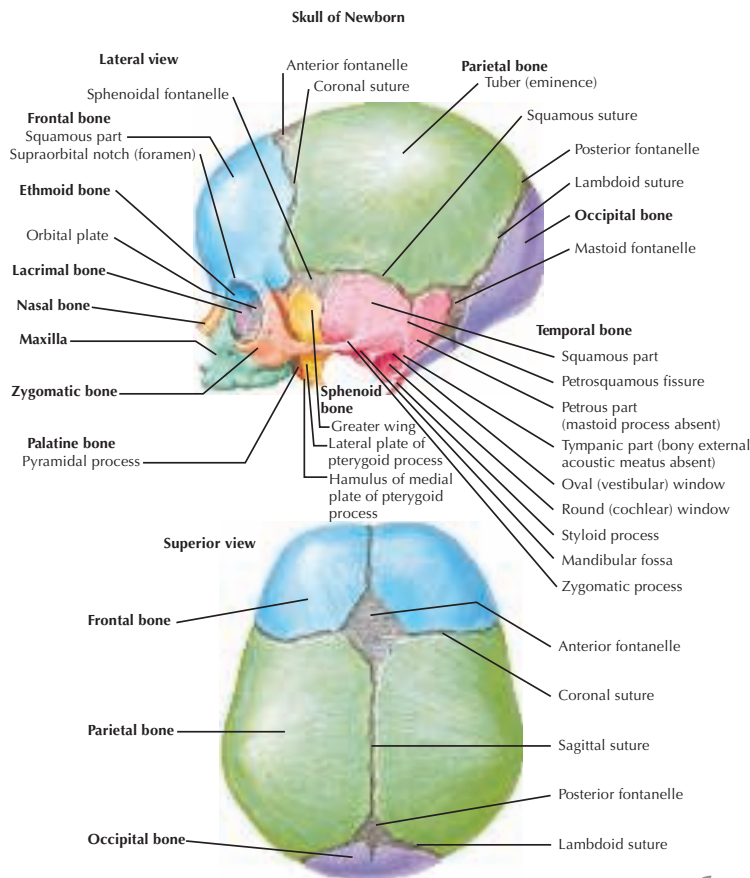
Fontanelle	Time of Closure
Anterior fontanelle (bregma)	4–26 months
Posterior fontanelle (lambda)	1–2 months
Sphenoidal fontanelle (pterion)	2–3 months
Mastoid fontanelle (asterion)	12–18 months

MEMBRANOUS NEUROCRANIUM

Germ Layer	Portions of Neurocranium	Adult Structure	Ossification
Neural crest	Main portion of the roof and lateral sides of the cranial vault	Frontal bone Squamous portion of the temporal bone	Intramembranous
Paraxial mesoderm		Parietal bone Occipital bone (intraparietal portion)	

CARTILAGINOUS NEUROCRANIUM

Germ Layer	Portions of Neurocranium	Adult Structure	Ossification
Neural crest	Prechordal Anterior to the sella turcica	Ethmoid Sphenoid	Endochondral
Paraxial mesoderm	Chordal Posterior to the sella turcica	Petrous portion of the temporal bone Mastoid process of the temporal bone Occipital bone	



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GENERAL INFORMATION

The face is formed mainly from neural crest, which makes 3 swellings that surround the stomodeum:

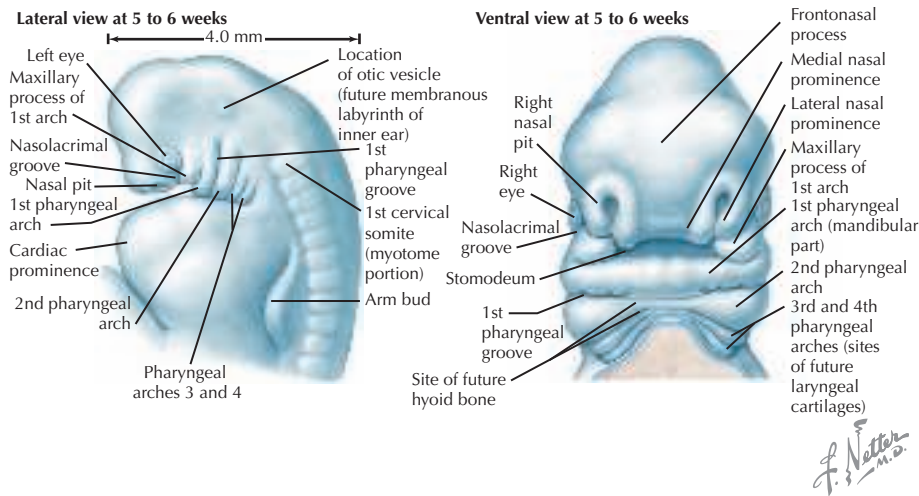
- Frontonasal prominence
- Maxillary prominence (from the 1st pharyngeal arch)
- Mandibular prominence (from the 1st pharyngeal arch)

Lateral to the frontonasal prominence, 2 additional areas of ectoderm form the 2 nasal placodes that invaginate in the center to form nasal pits, creating ridges of tissue on either side of the pits:

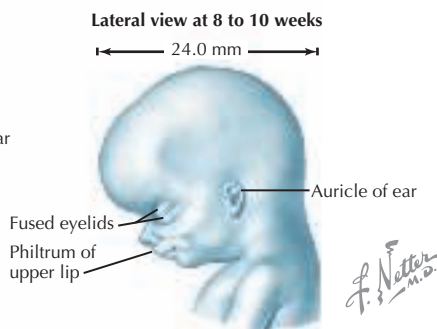
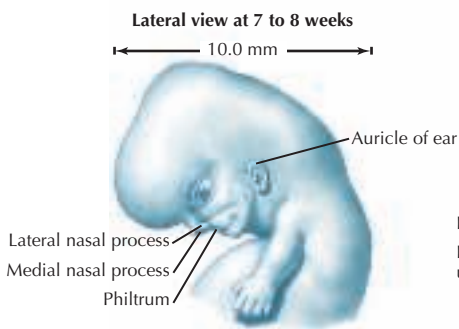
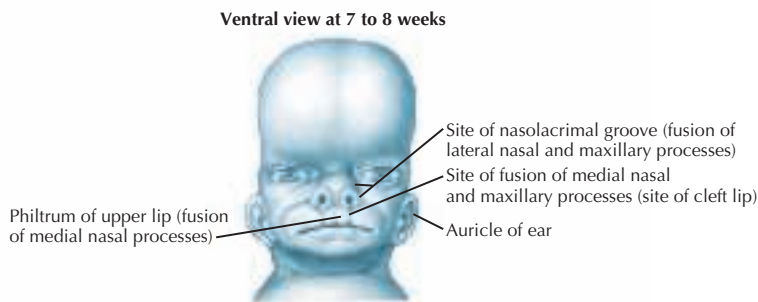
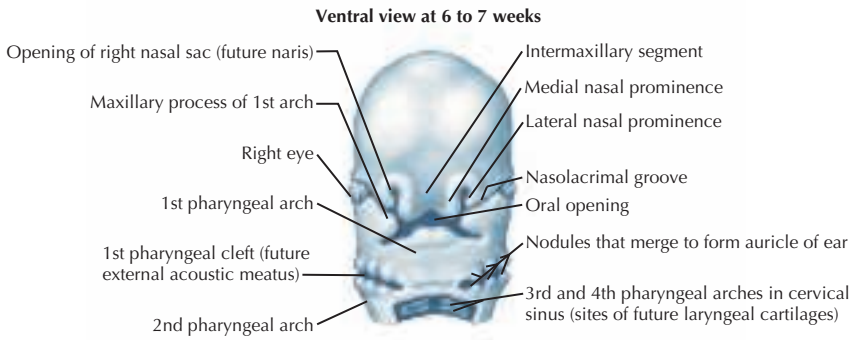
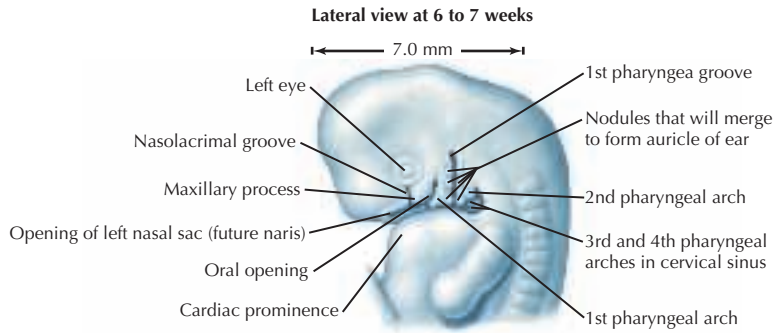
- Lateral nasal prominence
- Medial nasal prominence

Fusion of the medial nasal prominences at the midline results in formation of the intermaxillary segment

ADULT STRUCTURES OF THE FACE	
Structure(s)	Develop(s) from
Upper lip	Maxillary prominence Medial nasal prominence
Lower lip	Mandibular prominence
Lacrimal sac Nasolacrimal duct	A nasolacrimal groove that separates the lateral nasal prominence and the maxillary prominence
Nose	Frontonasal prominence Medial nasal prominence Lateral nasal prominence
Cheeks	Maxillary prominence
Philtrum Primary palate Upper jaw containing the central and lateral incisors	Intermaxillary segment



GENERAL INFORMATION CONTINUED



GENERAL INFORMATION

Formed by the:

- Primary palate (intermaxillary segment)
- Secondary palate (protrusions from the maxillary prominences)

Intermaxillary segment: the initial portion of the palate in development; contains the central and lateral incisors

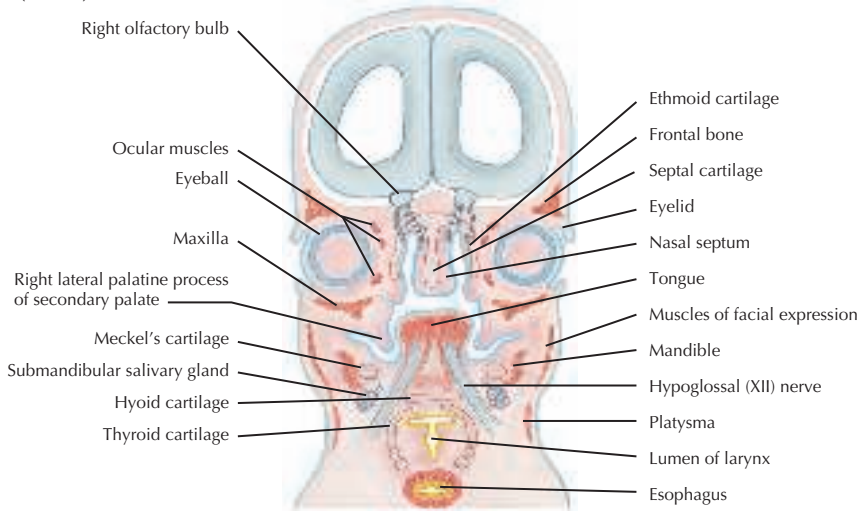
Swellings of the maxillary prominence form shelves that project medially and are separated by the tongue

When the tongue no longer occupies the space between the palatal shelves, these processes fuse together to form the secondary palate

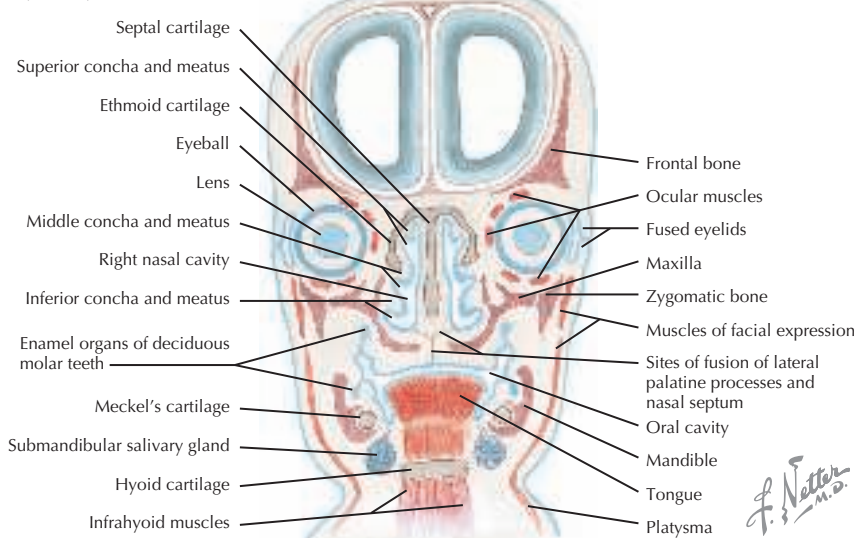
The primary and secondary palatal tissues all meet at the *incisive foramen*

Primary and secondary palates and the nasal septum fuse to form the definitive palate

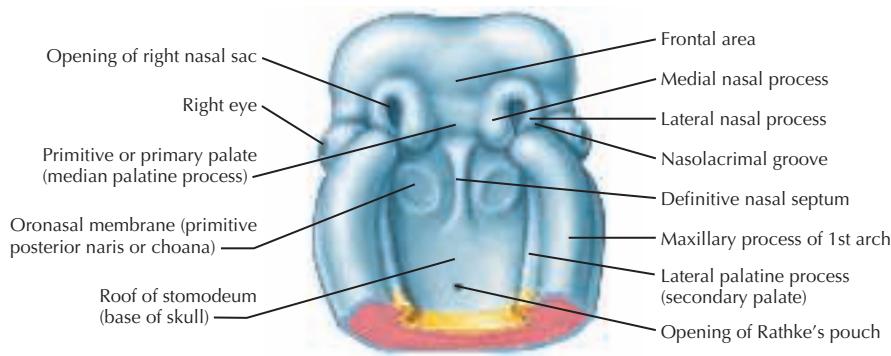
Frontal (coronal) section at 7 to 8 weeks



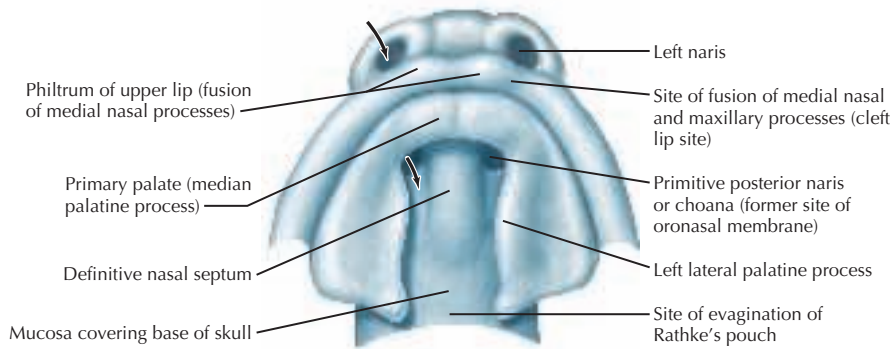
Frontal (coronal) section at 8 to 10 weeks



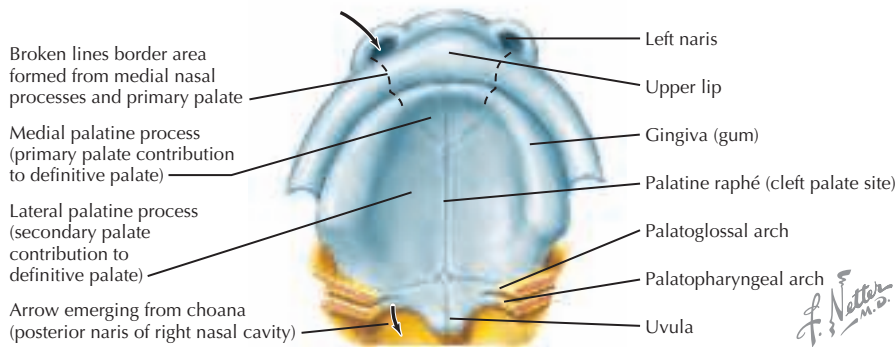
Roof of stomodeum (inferior view; 6 to 7 weeks)



Palate formation (inferior view; 7 to 8 weeks)



Roof of oral cavity (inferior view; 8 to 10 weeks)



F. Netter M.D.

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