THIEME
Atlas of Anatomy

Head, Neck, and Neuroanatomy

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Foreword by
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Second Edition

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Volume 3

Head, Neck, and Neuroanatomy

THIEME Atlas of Anatomy

2nd Edition

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Foreword

Each of the authors of the single volume Thieme Atlas of Anatomy was impressed with the extraordinary detail, accuracy, and beauty of the illustrations that were created for the Thieme three volume series of anatomy atlases. We felt these images were one of the most significant additions to anatomic education in the past 50 years. The effective pedagogical approach of this series, with two-page learning units that combined the outstanding illustrations and captions that emphasized the functional and clinical significance of structures, coupled with the numerous tables summarizing key information, was unique. We also felt that the overall organization of each region, with structures presented first systemically–musculoskeletal, vascular, and nervous–and then topographically, supported classroom learning and active dissection in the laboratory.

This series combines the best of a clinically oriented text and an atlas. Its detail and pedagogical presentation make it a complete support for classroom and laboratory instruction and a reference for life in all the medical, dental, and allied health fields. Each of the volumes–General Anatomy and Musculoskeletal System, Neck and Internal Organs, and Head, Neck, and Neuroanatomy–can also be used as a stand-alone text/atlas for an in-depth study of systems often involved in the allied health/medical specialty fields.

We were delighted when Thieme asked us to work with them to create a single-volume atlas from this groundbreaking series, and we owe a great debt to the authors and illustrators of this series in as much as their materials and vision formed the general framework for the single volume Thieme Atlas of Anatomy.

We thank the authors and illustrators for this very special contribution to the teaching of anatomy and recommend it for thorough mastery of anatomy and its clinically functional importance in all fields of health care-related specialties.

Lawrence M. Ross, Brian R. MacPherson, and Anne M. Gilroy

Preface to the Second Edition

Six years have passed since the first edition of the Thieme Atlas of Anatomy: General Anatomy and Musculoskeletal System was published. It has passed its first test and met the needs of students and practitioners everywhere, as evidenced by the many letters and e-mails we have received. We thank you for your praise and constructive criticism, which helps us keep improving this atlas.

Clinical knowledge presented in conjunction with anatomy is increasingly important earlier and earlier in the study of medicine. This has been further strengthened in this edition with the inclusion of about 30 new two-page spreads across the book devoted to

- osteoarthritis of the hip joint,
- compression syndromes of peripheral nerves,
- conduction anesthesia of peripheral nerves,
- shoulder arthroscopy and degenerative changes of the shoul der joint,
- functions of individual muscles and the symptoms associated with shortening or weakening of these muscles, and
- diagnostic imaging of the large joints, such as the shoulder, elbow, and wrist, and the hip, knee, and ankle.

In addition, we have added spreads on important foundational information on the common imaging planes for plain film, MRI, and CT scans, the structure of skeletal muscle fibers, the structure and chemical composition of hyaline cartilage, and the regeneration of peripheral nerves.

We have also checked, corrected, and updated all the information in this atlas.

With these improvements, this atlas is even better suited to students of medicine in what the World Health Organization (WHO) is again calling the “Decade of Bones and Joints” (first 2000 to 2010 and now 2010 to 2020) to draw attention to the continuing prominence and dramatic rise of diseases of the musculoskeletal system with the rise in average life expectancy worldwide. Today more than half the chronic diseases of those over 60 involve the bones (e.g., osteoporosis) and joints (e.g., osteoarthritis), with tremendous economic consequences. One of the main reasons WHO is publicizing this is so that the world’s universities appropriately prepare physicians, physical therapists, and other health care workers to address the growing global burden of these diseases due to the aging population.

This atlas emphasizes the correlations between physiologic changes in the course of life, the frequency of certain pathologic phenomena, and effective diagnostics while teaching the anatomy, better preparing students to treat patients with musculoskeletal diseases when they meet them in the clinic or in practice. When an elderly person suffers a fracture, it is not sufficient to just address the fracture. The doctor must learn why the fracture happened and address the underlying cause. Does, for example, the patient have osteoporosis, or is he or she so inflexible that any unexpected need to move leads to a fall? Interdisciplinary cooperation is needed to address these causes and provide appropriate preventive and rehabilitative care. The older we get, the more important it is for us to keep the musculoskeletal system in motion to curb degenerative disease and prevent injury.

We hope that this atlas, continues to meet your needs in the classroom and clinic, helps you attain a more nuanced understanding of the anatomy of the musculoskeletal system, and brings the fascination of anatomy in motion home to you.

Our special thanks to Prof. Dr. Cristoph Viebahn, Georg-August University, Göttingen, and Prof. Dr. Thilo Wedel, Christian-Albrechts University, Kiel, for their commitment to and constructive help on the new edition.

Michael Schuenke, Erik Schulte, Udo Schumacher,
Markus Voll, and Karl Wesker
Kiel, Mainz, Hamburg, Munich, and Berlin

Preface to the First Edition

When Thieme started planning this atlas, they sought the opinions of students and instructors in both the United States and Europe on what constituted an "ideal" atlas of anatomy—ideal to learn from, to master extensive amounts of information while on a busy class schedule, and, in the process, to acquire sound, up-to-date knowledge. The result of our work in response to what Thieme learned is this atlas. The Thieme Atlas of Anatomy, unlike most other atlases, is a comprehensive educational tool that combines illustrations with explanatory text and summary tables, introducing clinical applications throughout, and presenting anatomic concepts in a step-by-step sequence that includes system-by-system and topographical views.

Since the Thieme Atlas of Anatomy is based on a fresh approach to the underlying subject matter, it was necessary to create an entirely new set of illustrations for it—a task that took eight years. Our goal was to provide illustrations that would compellingly demonstrate anatomic relations and concepts, revealing the underlying simplicity of human anatomy without sacrificing detail or aesthetics.

With the Thieme Atlas of Anatomy, it was our intention to create an atlas that would guide students in their initial study of anatomy, stimulate their enthusiasm for this intriguing and vitally important subject, and provide a reliable reference for experienced students and professionals alike.

"If you want to attain the possible, you must attempt the impossible" (Rabindranath Tagore).

Michael Schuenke, Erik Schulte, Udo Schumacher,
Markus Voll, and Karl Wesker

Acknowledgments

First, we wish to thank our families. This atlas is dedicated to them.

We also thank Prof. Reinhard Gossrau, M.D., for his critical comments and suggestions. We are grateful to several colleagues who rendered valuable help in proofreading: Mrs. Gabriele Schünke, Jakob Fay, M.D., Ms. Claudia Dücker, Ms. Simin Rassouli, Ms. Heinke Teichmann, and Ms. Sylvia Zilles. We are also grateful to Dr. Julia Jürns-Kuhnke for helping with the figure labels.

We extend special thanks to Stephanie Gay and Bert Sender, who prepared the layouts. Their ability to arrange the text and illustrations on facing pages for maximum clarity has contributed greatly to the quality of the atlas.

We particularly acknowledge the efforts of those who handled this project on the publishing side: Jürgen Lüthje, M.D., Ph.D., executive editor at Thieme Medical Publishers, has "made the impossible possible." He not only reconciled the wishes of the authors and artists with the demands of reality but also managed to keep a team of five people working together for years on a project whose goal was known to us from the beginning but whose full dimensions we only came to appreciate over time. He is deserving of our most sincere and heartfelt thanks.

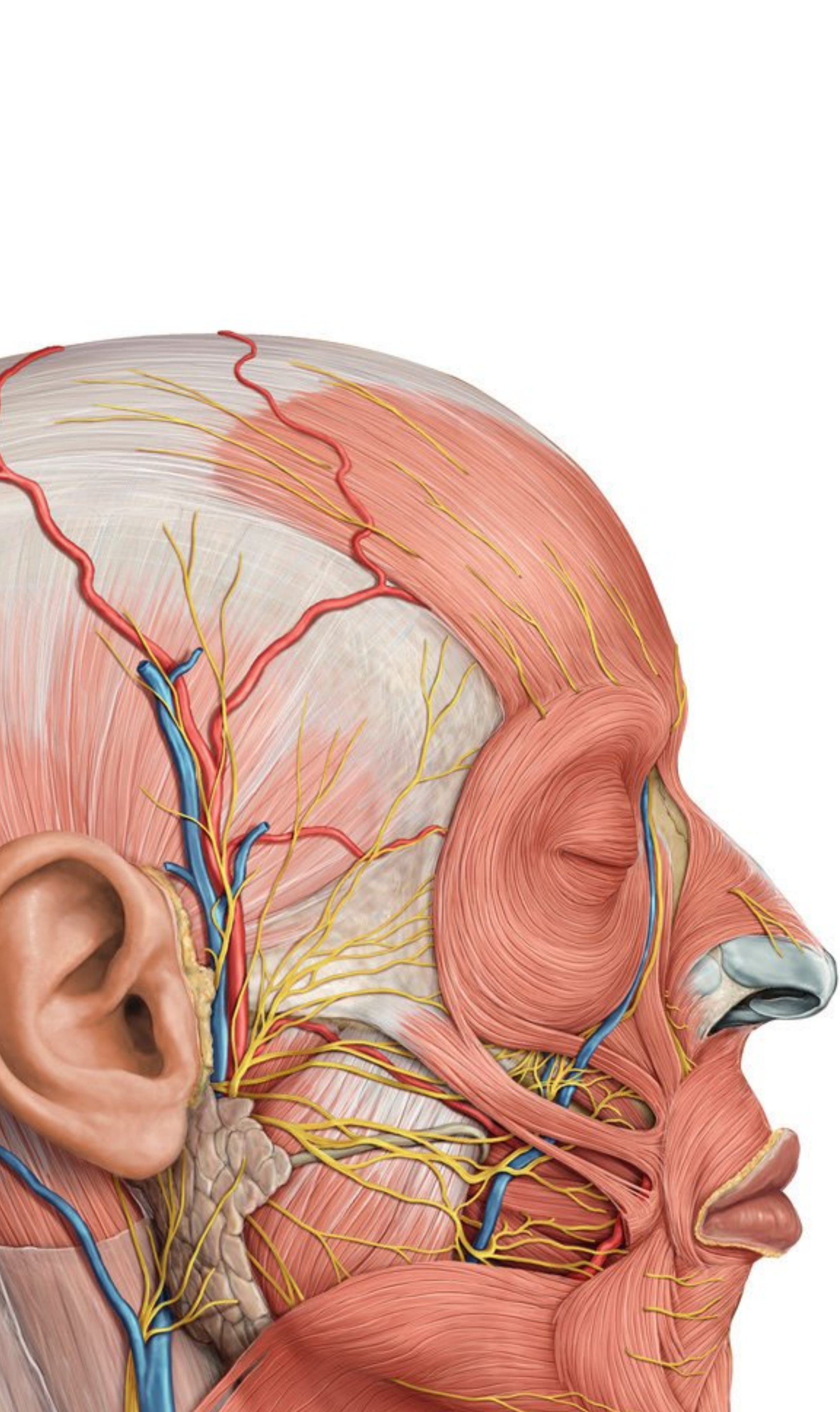
Sabine Bartl, developmental editor, became a touchstone for the authors in the best sense of the word. She was able to determine whether a beginning student, and thus one who is not (yet) a professional, could clearly appreciate the logic of the presentation. The authors are indebted to her.

We are grateful to Antje Bühl, who was there from the beginning as project assistant, working "behind the scenes" on numerous tasks such as repeated proofreading and helping to arrange the figure labels.

We owe a great debt of thanks to Martin Spencker, managing director of Educational Publications at Thieme, especially to his ability to make quick and unconventional decisions when dealing with problems and uncertainties. His openness to all the concerns of the authors and artists established conditions for a cooperative partnership.

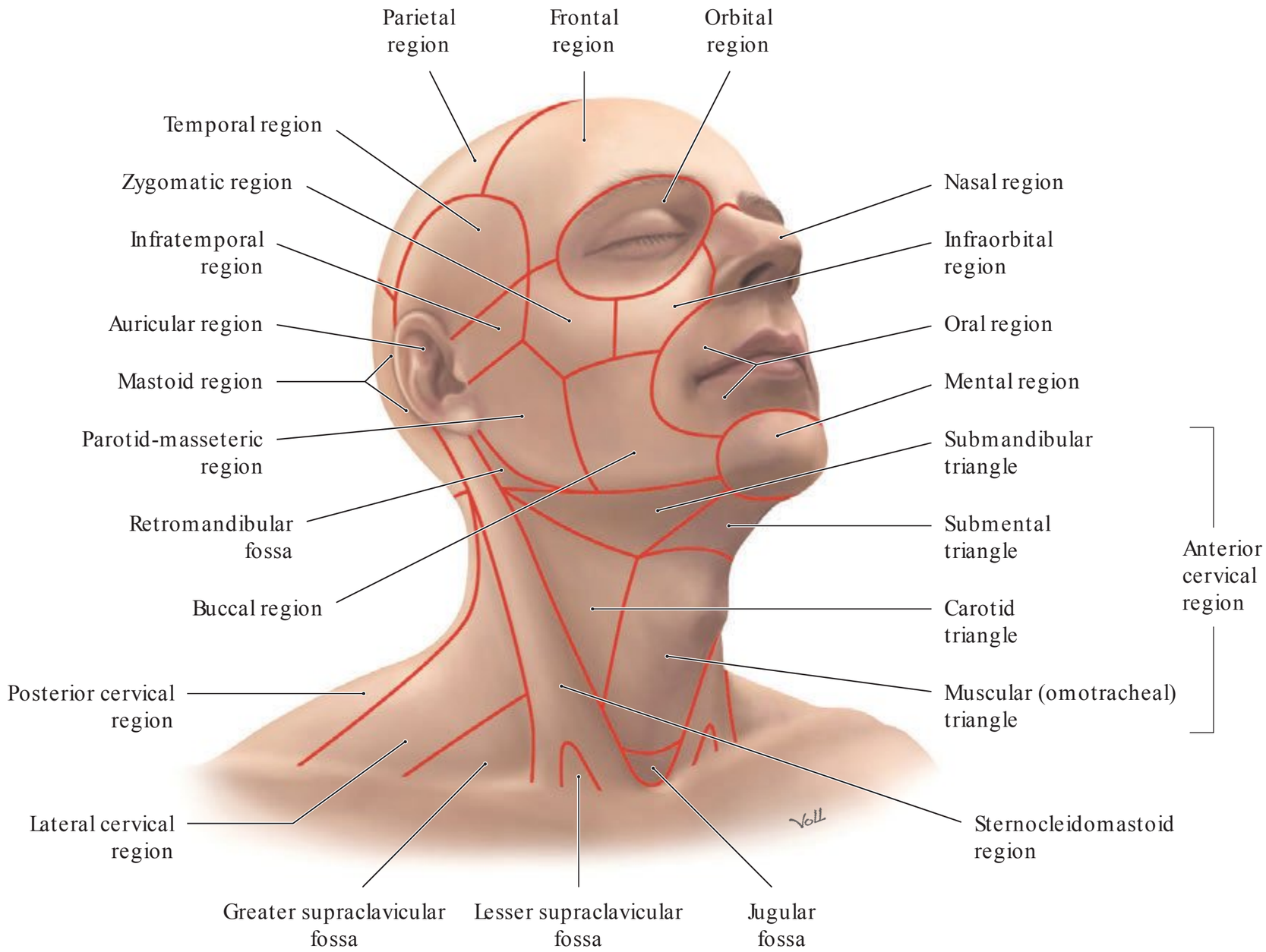
Without exception, our collaboration with the entire staff at Thieme Medical Publishers was consistently pleasant and cordial. Unfortunately, we do not have room to list everyone who helped in the publication of the Atlas, and we must limit our acknowledgments to a few colleagues who made a particularly notable contribution: Rainer Zepf and Martin Waletzko for support in all technical matters; Susanne Tochtermann-Wenzel and Manfred Lehnert, representing all those who were involved in the production of the book; Almut Leopold for the index; Marie-Luise Kürschner and her team for creating the cover design; to Liesa Arendt, Birgit Carlsen, and Anne Döbler, representing all those who handled marketing, sales, and promotion.

The Authors

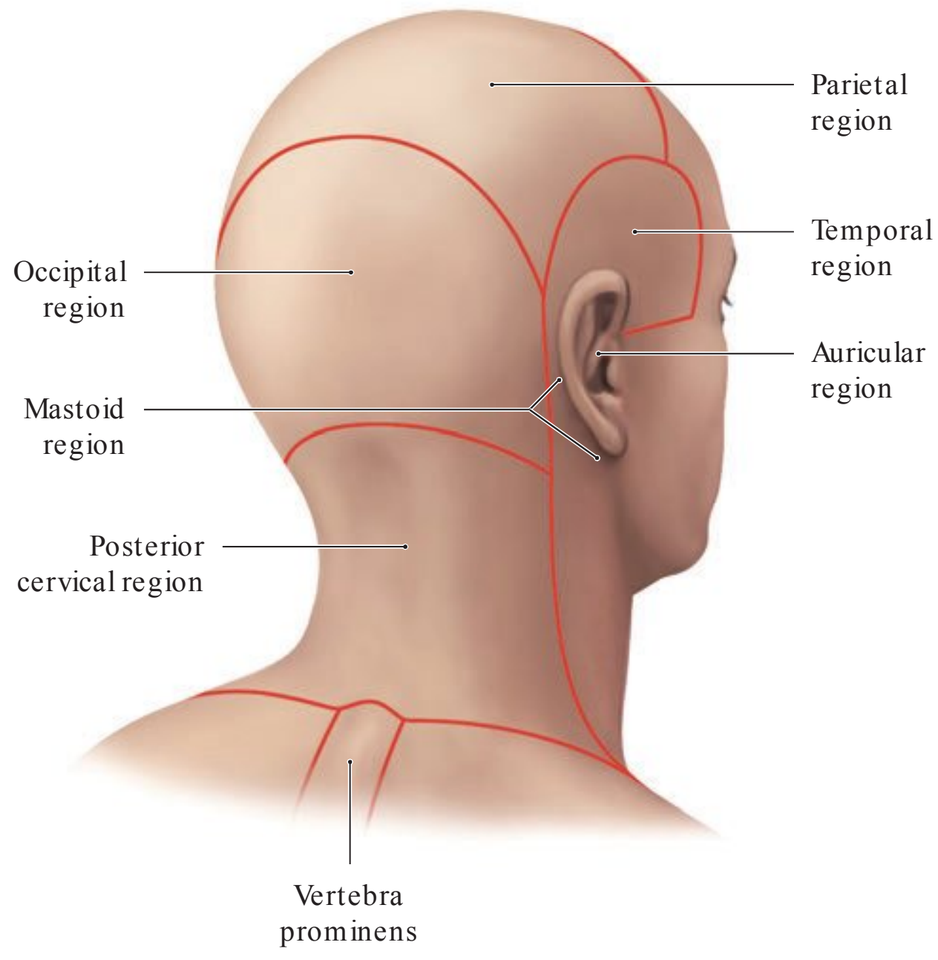


Head and Neck

1.1 Regions and Palpable Bony Landmarks



A Head and neck regions
Right anterior view.

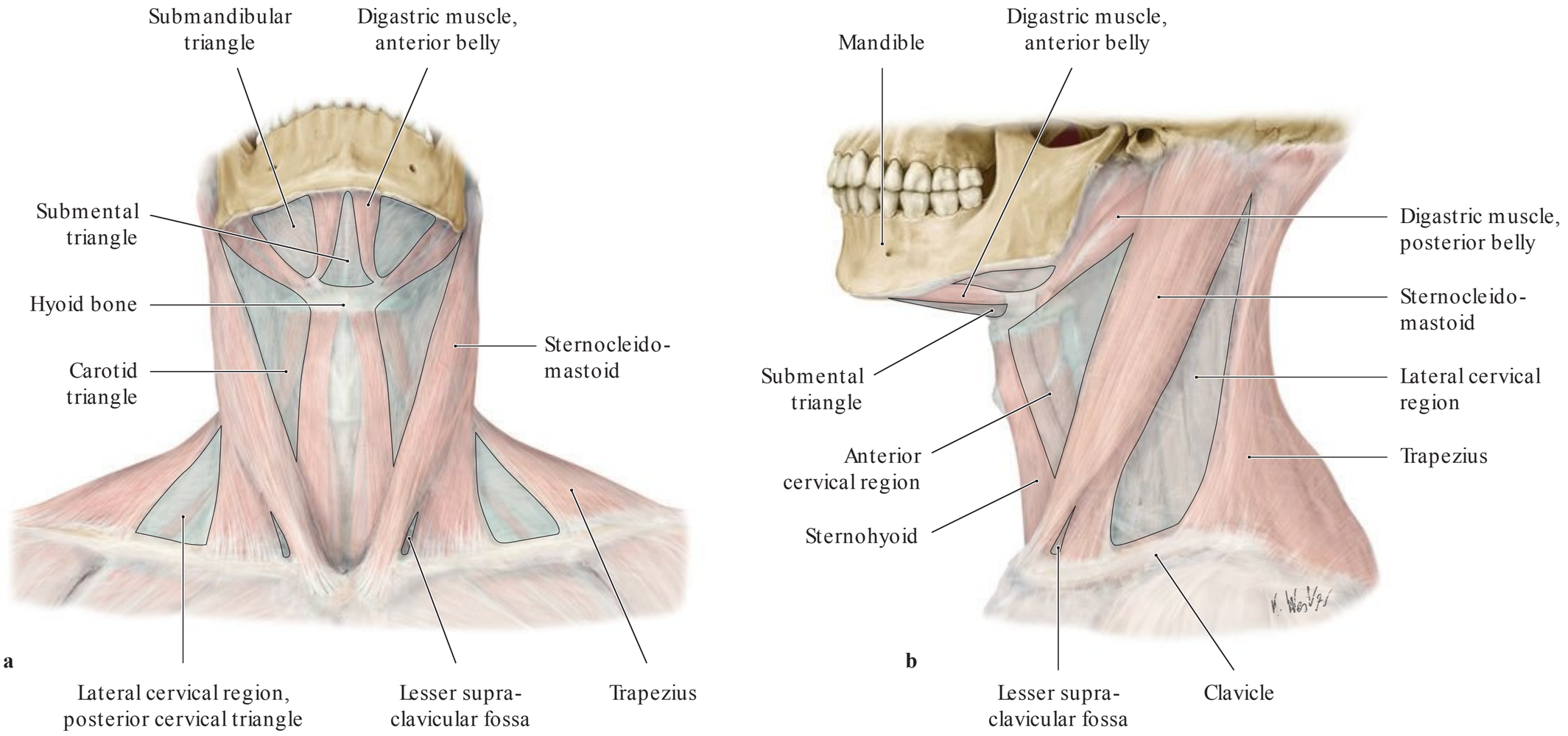


B Head and neck regions
Right posterior view.

C Head and neck regions

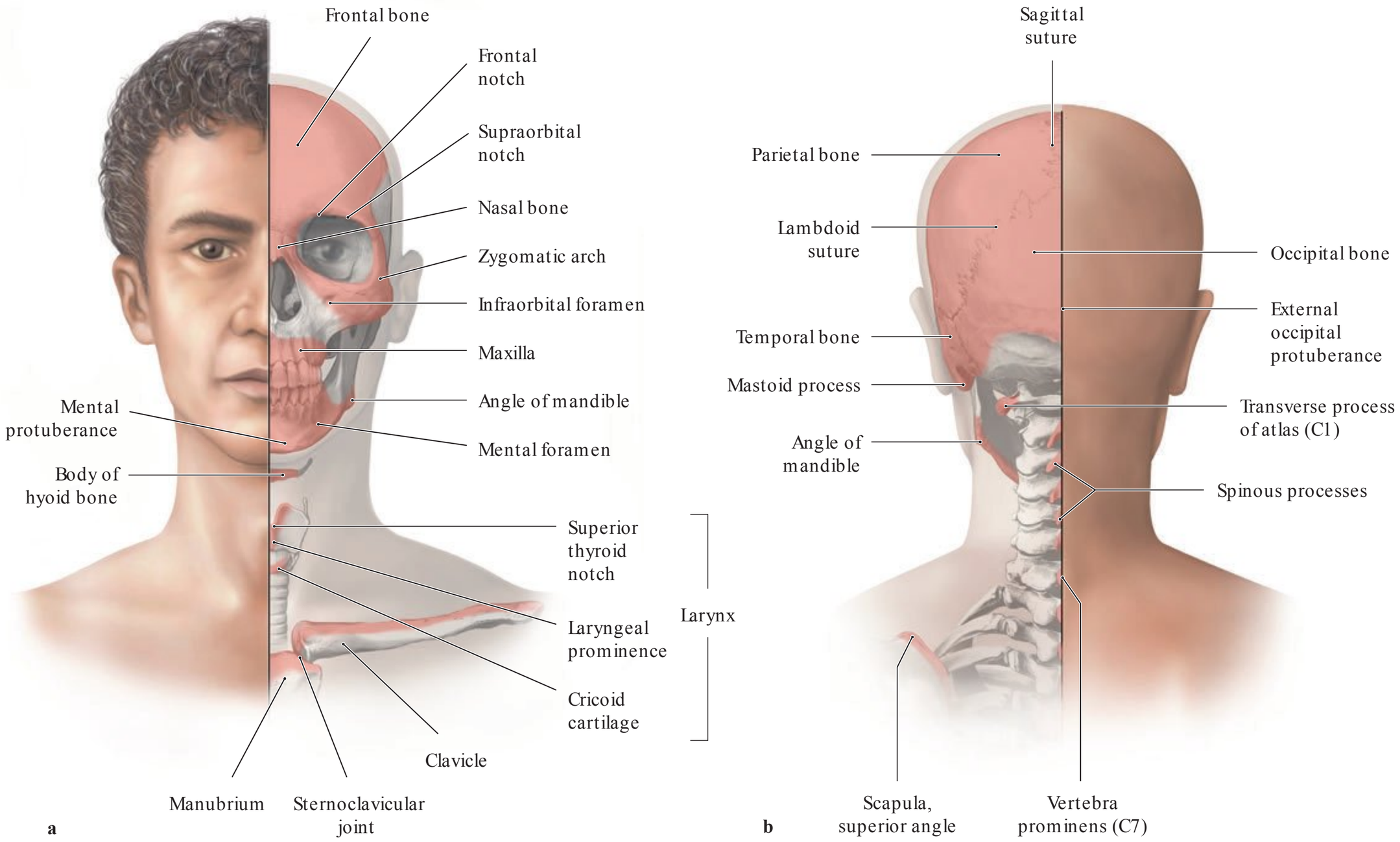
Head regions	Neck regions
• Frontal region • Parietal region • Occipital region • Temporal region • Auricular region • Mastoid region • Facial region – Orbital region – Infraorbital region – Buccal region – Parotid-masseteric region – Zygomatic region – Nasal region – Oral region – Mental region	• Anterior cervical regions – Submandibular triangle – Carotid triangle – Muscular (omotracheal) triangle – Submental triangle • Sternocleidomastoid region – Lesser supraclavicular fossa • Lateral cervical region – Omoclavicular triangle (major supraclavicular fossa) • Posterior cervical region

The regions of the head and neck are clinically important since they can exhibit many skin lesions, the location of which must be precisely described. This is particularly important for skin cancer given that the tissue fluid, through which the tumor cells spread, drains into different groups of lymph nodes named for their location.



D Regions of the neck (cervical regions)
a Right lateral view, **b** left posterior oblique view.

These neck muscles are easily visible and palpable making them suitable as landmarks for a topographical classification of the neck.



E Palpable bony landmarks at the head and neck
a Frontal view; **b** Dorsal view.

1.2 Head and Neck and Cervical Fasciae

The head and neck form an anatomical and functional unit with the neck connecting the head and the trunk. The neck contains many pathways to which the cervical viscera are indirectly attached. In the head however, there is only visceral fascia around the parotid gland but no general fasciae. Multiple fascial layers subdivide the neck into compartments which will be referred to when describing the location of structures within the neck.

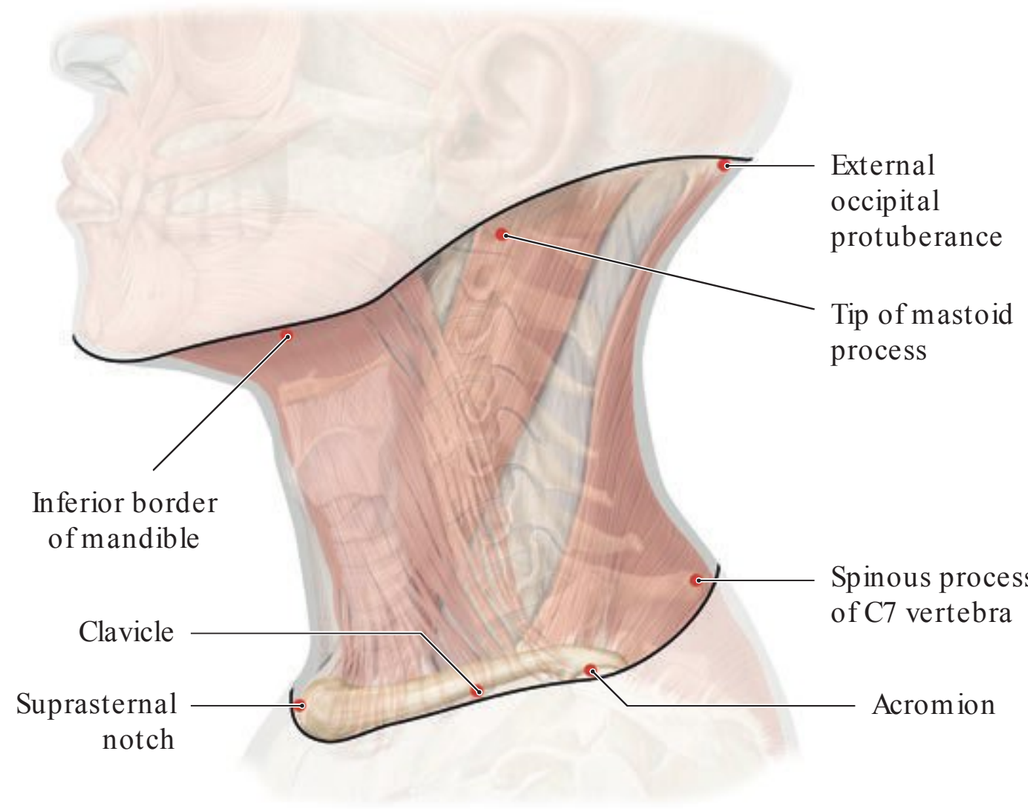
A Sequence of topics in this chaper about the head and neck

Overview	• Regions and palpable bony landmarks • Head and neck with cervical fasciae • Clinical anatomy of the head and neck • Embryology of the face • Embryology of the neck
Bones	• Cranial bones • Teeth • Cervical spine • Ligaments • Joints
Muscles	• Muscles of facial expression • Masticatory muscles • Neck muscles
Classification of pathways	• Arteries • Veins • Lymphatics • Nerves
Organs and their pathways	• Ear • Eye • Nose • Oral cavity • Pharynx • Parotid gland • Larynx • Thyroid and parathyroid glands
Topographical anatomy	• Anterior facial region • Neck, anterior view, superficial layers • Neck, anterior view, deep layers • Lateral head: superficial layer • Lateral head: middle and deeper layer • Infratemporal fossa • Pterygopalatine fossa • Posterior cervical triangle • Superior thoracic aperture, carotid triangle and deep lateral cervical region • Posterior neck and occiput regions • Cross section of the head and neck

B Cervical fascia

Deep to the skin is the superficial cervical fascia (subcutaneous tissue) which contains the platysma muscle anterolaterally. Deep to the superficial are the following layers of deep cervical fascia:

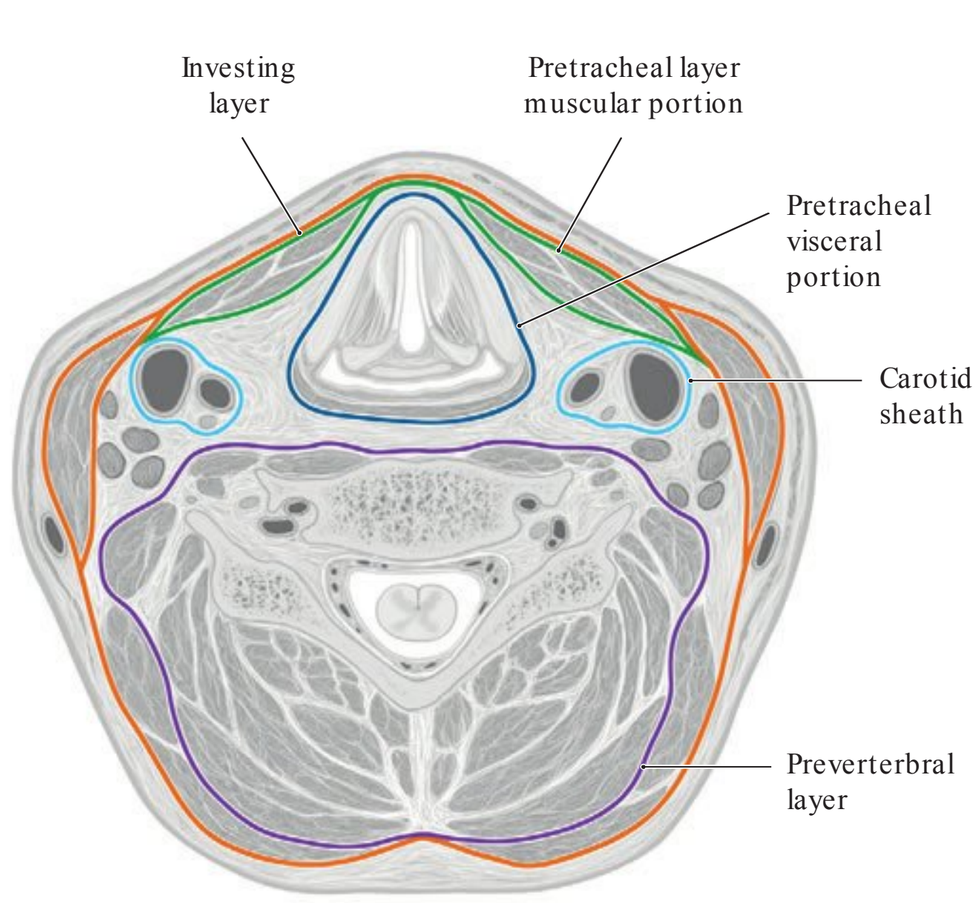
1. Investing layer: envelops the entire neck, and splits to enclose the sternocleidomastoid and trapezius muscles.
2. Pretracheal layer: the muscular portion encloses the infrahyoid muscles, while the visceral portion surrounds the thyroid gland, larynx, trachea, pharynx, and esophagus.
3. Prevertebral layer: surrounds the cervical vertebral column, and the muscles associated with it.
4. Carotid sheath: encloses the common carotid artery, internal jugular vein, and vagus nerve.
5. Visceral fascia: encloses the larynx, trachea, pharynx, esophagus and thyroid.



C Superficial and inferior boundaries of the neck

Left lateral view. The following palpable structures define the superior and inferior boundaries of the neck:

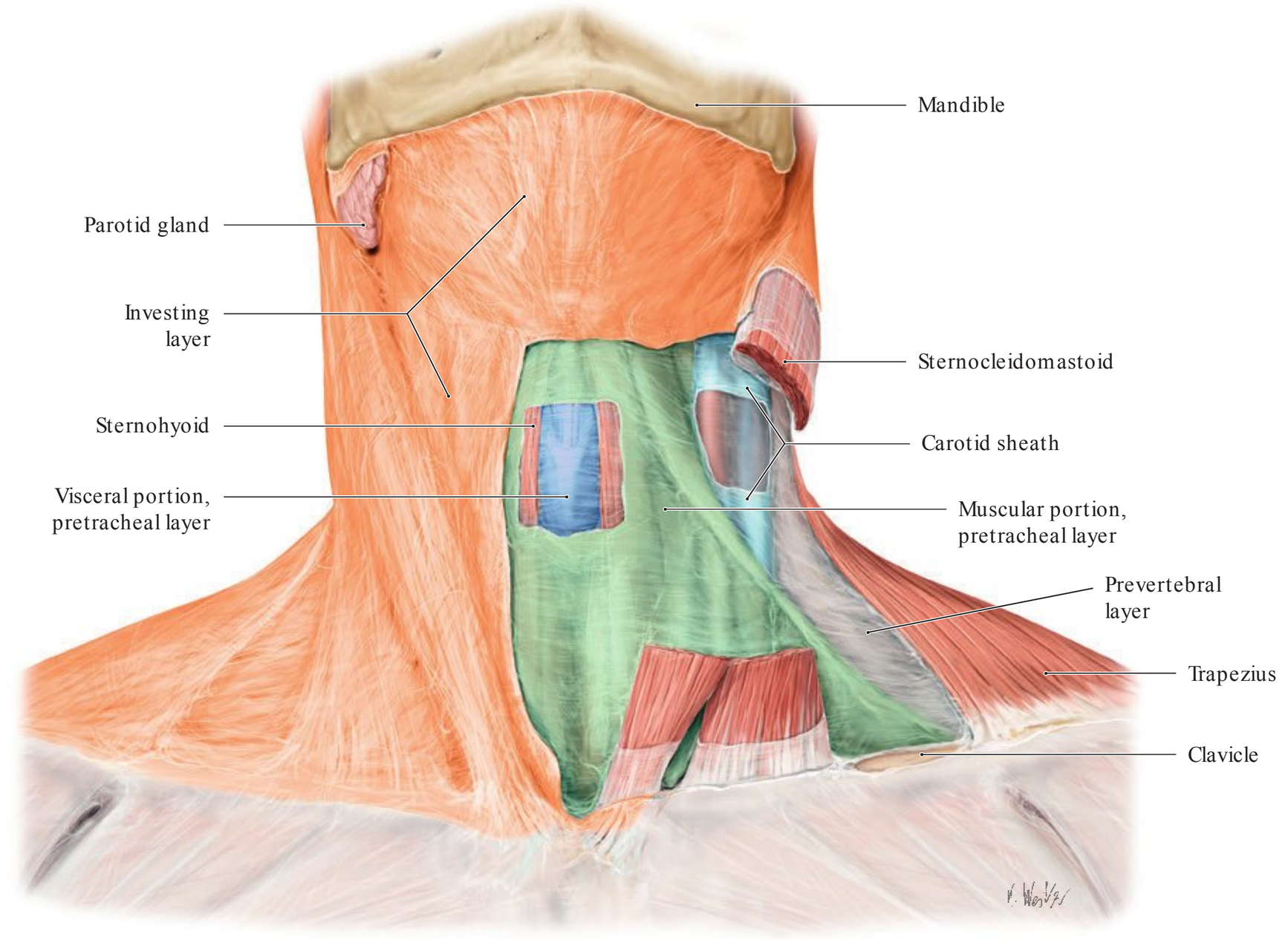
- Superior boundaries: inferior border of the mandible, tip of the mastoid process, and external occipital protuberance
- Inferior boundaries: suprasternal notch, clavicle, acromion, and spinous process of the C7 vertebra.



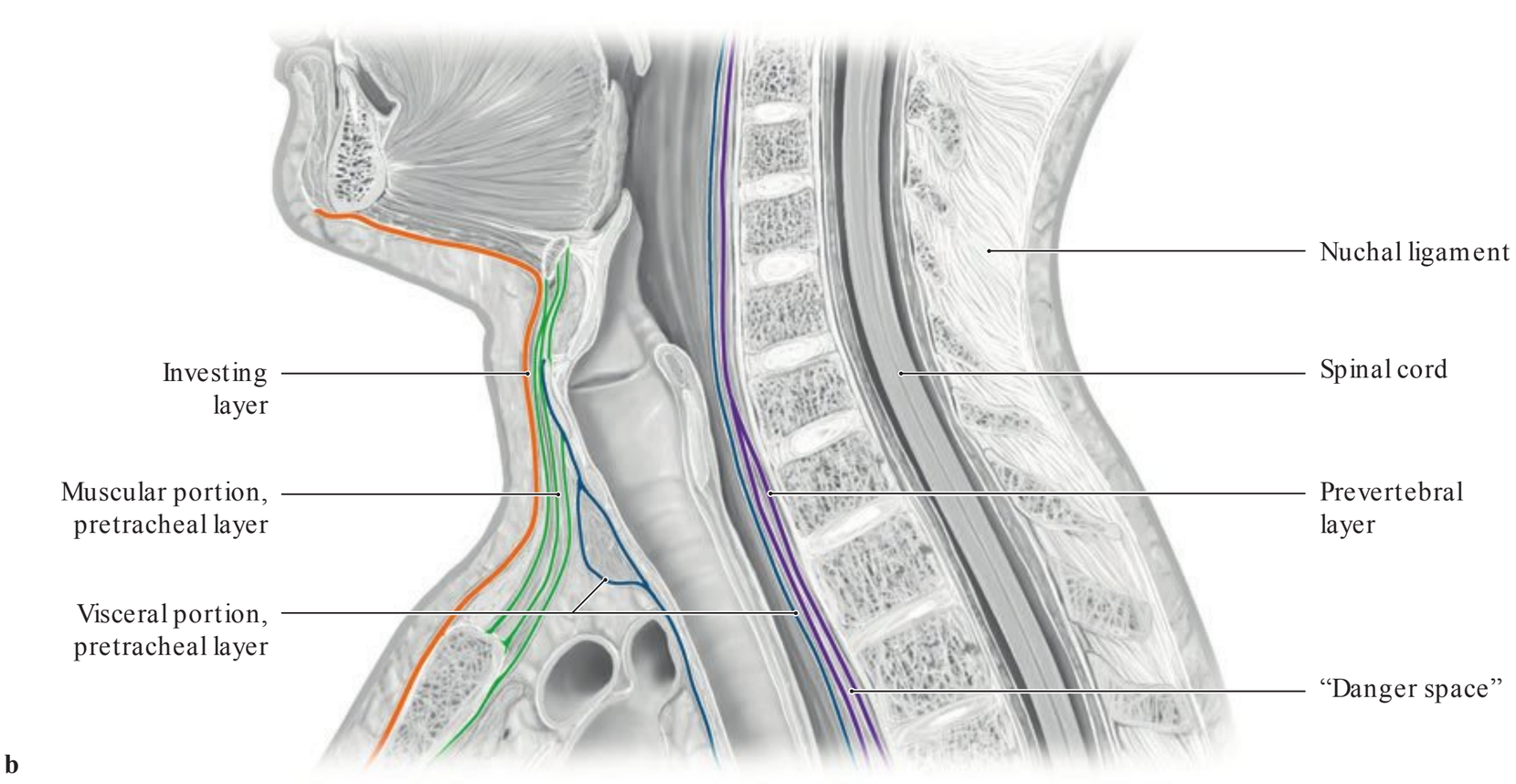
D Relationships of the deep fascia in the neck. Transverse section at the level of the C5 vertebra

The full extent of the cervical fascia is best appreciated in a transverse section of the neck:

- The muscle fascia splits into three layers:
  – Superficial lamina (orange),
  – Pretracheal lamina (green), and
  – Prevertebral lamina (violet).
- There is also a neurovascular fascia, called the carotid sheath (light blue), and
- a visceral fascia (dark blue).



a



b

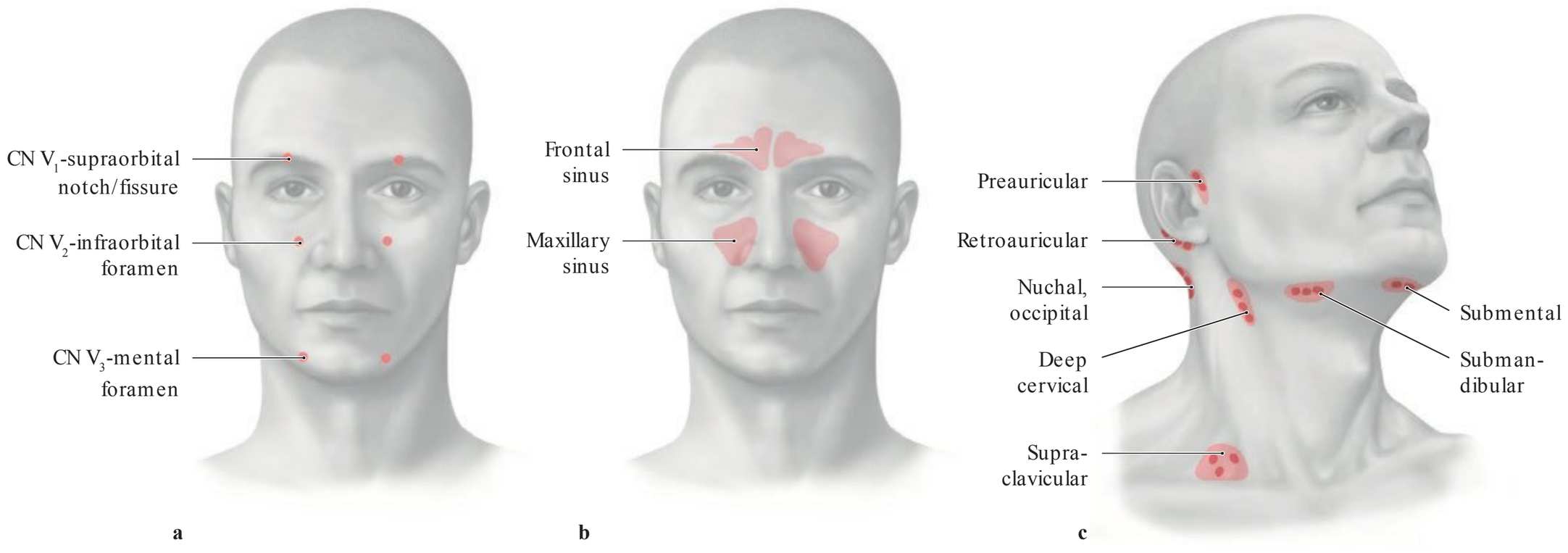
E Fascial relationships in the neck

a Anterior view. The cutaneous muscle of the neck, the platysma, is highly variable in its development and is subcutaneous in location, overlying the superficial cervical fascia. In the dissection shown, the platysma has been removed at the level of the inferior mandibular border on each side. The cervical fasciae form a fibrous sheet that encloses the muscles, neurovascular structures, and cervical viscera (see **B** for further details). These fasciae subdivide the neck into spaces, some of which are open superiorly and inferiorly for the passage of neurovascular structures. The investing layer of the deep cervical fascia has been removed at left center in this dissection. Just deep to the investing layer is the muscular portion of the pretreacheal layer, part of which has been removed to display the visceral portion of the pretracheal layer. The neurovascular structures are surrounded by a condensation of the cervical fascia called the carotid sheath. The deepest layer of the deep cervical fascia, called the prevertebral layer, is visible posteriorly on the left side. These fascia-bounded connective-tissue spaces in the neck are important clinically because they provide routes for the spread of inflammatory processes, although the inflammation may (at least initially) remain confined to the affected compartment

b Left lateral view. This midsagittal section shows that the deepest layer of the deep cervical fascia, the prevertebral layer, directly overlies the vertebral column in the median plane and is split into two parts. With tuberculous osteomyelitis of the cervical spine, for example, a gravitation abscess may develop in the "danger space" along the prevertebral fascia (retropharyngeal abscess). This fascia encloses muscles laterally and posteriorly (see **D**). The carotid sheath is located farther laterally and does not appear in the midsagittal section.

1.3 Clinical Anatomy

A Cleavage or tension lines
Anterior oblique view.
Skin and its subcutaneous tissue are under tension explaining why a small, round needle hole can result in a small longish slit in the skin aligned along the tension lines in the area around the incision. To promote swift healing and reduce visible scarring, incisions in the head region are aligned along these tension lines. Knowledge of the tension line patterns in the face and neck are critically important in plastic surgery to minimalize scarring in these highly visible areas.



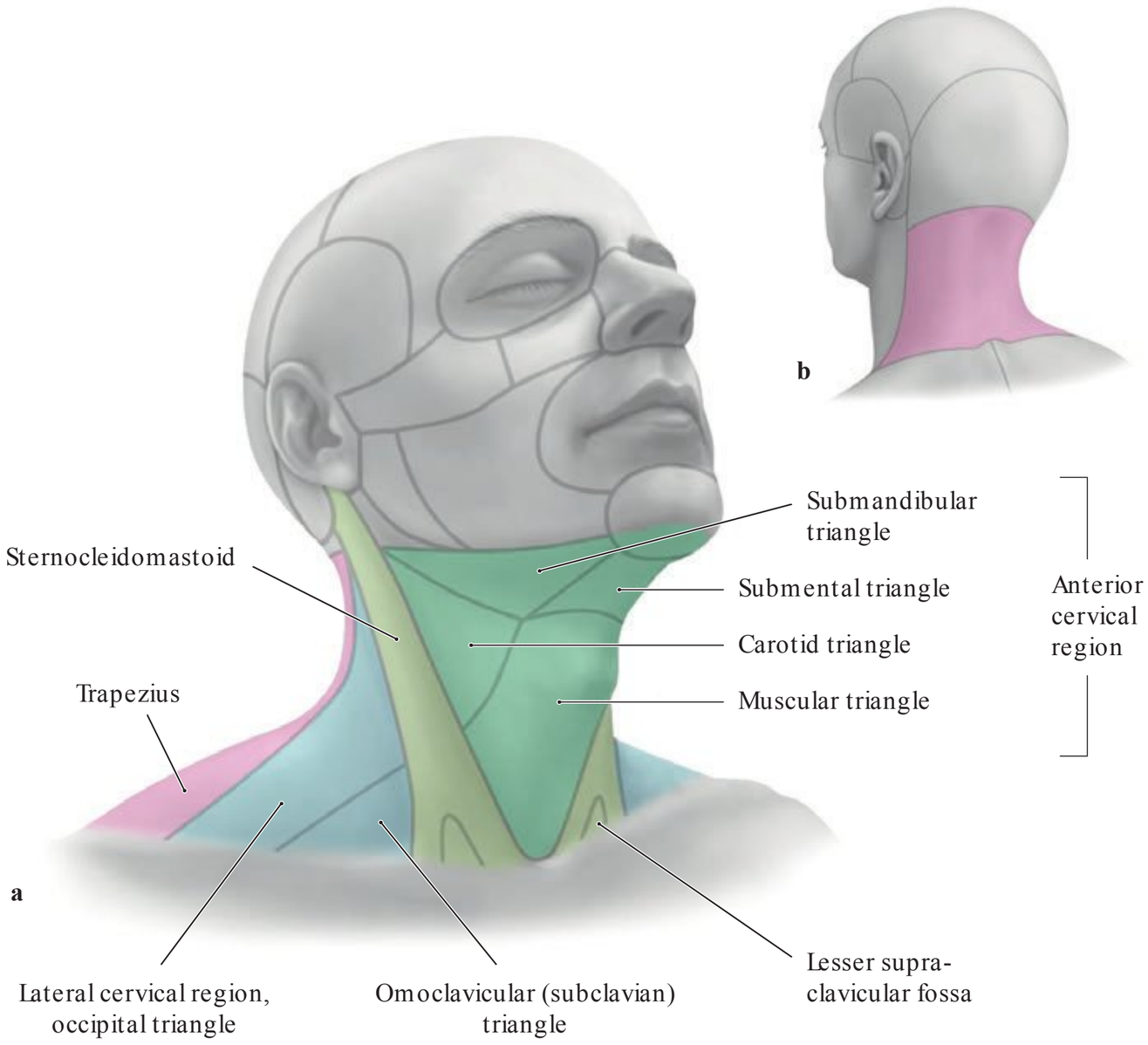
a **b** **c**

B Projection of clinically important structures onto the head and neck
Frontal view (**a** and **b**) and right lateral view (**c**).

a Exit points of the trigeminal nerve (CN V - sensory): These points are important for sensory testing of the head. If the pressure of a fingertip placed at these exit points causes pain, the respective branch of the trigeminal nerve is stimulated.

b Skin areas above the paranasal sinuses: When paranasal sinuses are inflamed, the skin areas above them are sensitive to pressure causing pain.

c Superficial lymph nodes at the junction between head and neck: The most important of lymph node groups are shown here. If the lymph nodes are enlarged, the cause can be related to inflammation or a tumor in the tributary area of the nodes. During a clinical examination of the head, these lymph node groups are always palpated.



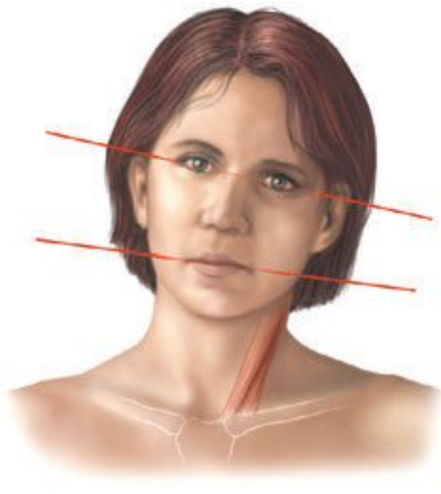
C Regions of the neck (cervical regions)
a Right lateral view; **b** Left posterior view.
Certain deeper structures of the neck project onto other regions. Conversely, pathological changes in one region can be referred to the underlying anatomical structure.

Anterior cervical region
- Submandibular triangle
  - Submandibular lymph nodes
  - Submandibular gland
  - Hypoglossal nerve
  - Parotid gland (posterior)
- Carotid triangle
  - Carotid bifurcation
  - Carotid body
  - Hypoglossal nerve
- Muscular triangle
  - Thyroid gland
  - Larynx
  - Trachea
  - Esophagus
- Submental triangle
  - Submental lymph nodes

Sternocleidomastoid region
- Sternocleidomastoid muscle
- Carotid artery
- Internal jugular vein
- Vagus nerve
- Jugular lymph nodes

Lateral cervical region
- Lateral lymph nodes
- Accessory nerve
- Cervical plexus
- Brachial plexus

Regio cervicalis posterior
- Neck muscles
- Trigonum arteriae vertebralis

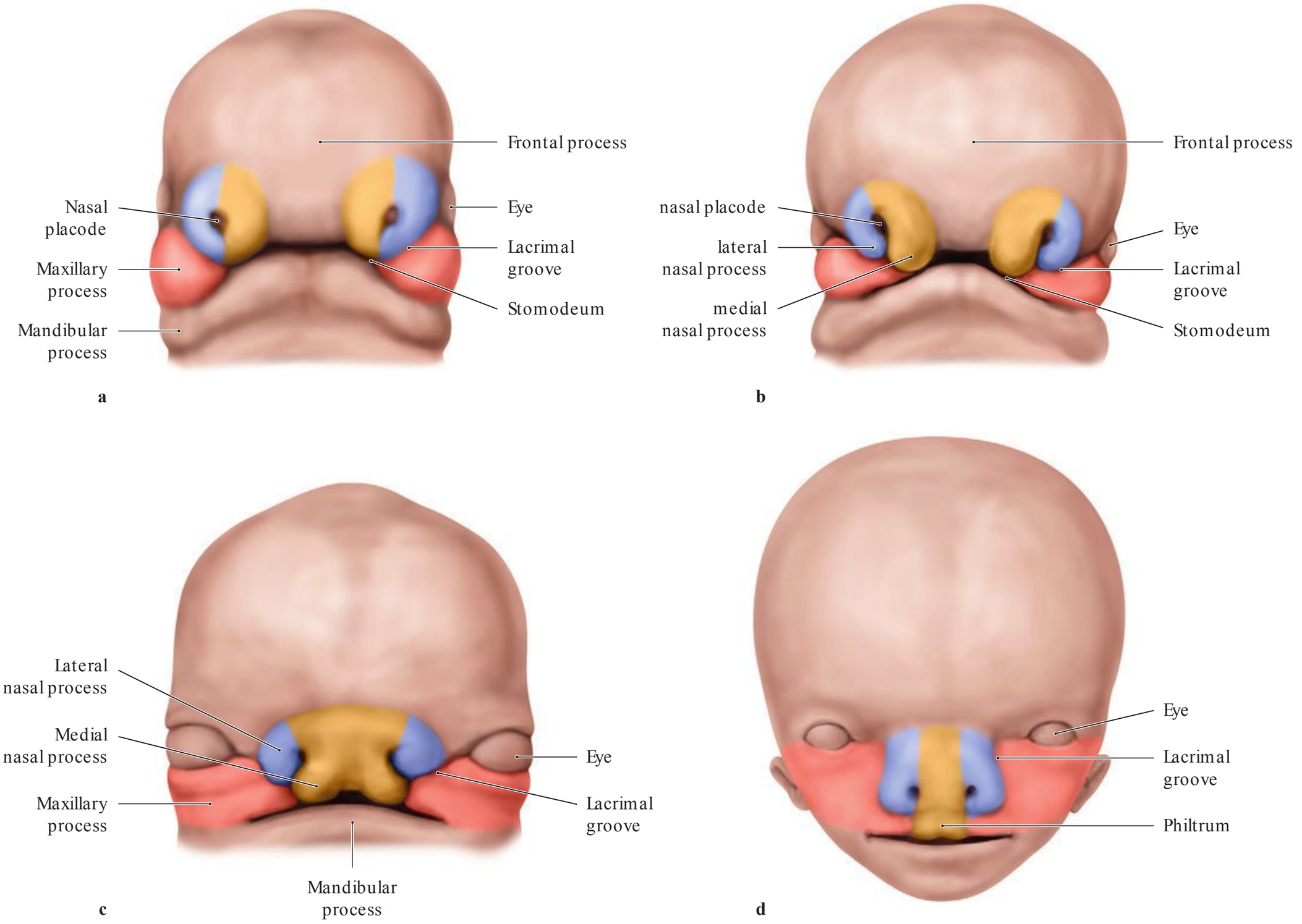


D Left-sided muscular torticollis (after Anschütz)
Torticollis and struma (swellings of the neck - see **E**) can be readily diagnosed by visual examination. In the case of torticollis, the sternocleidomastoid muscle is shortened—most commonly as a result of intrauterine malposition in infants. The head is tilted toward the affected side and is slightly rotated toward the opposite side. Without therapy (physical therapy/surgery) torticollis secondarily leads to asymmetrical growth of spinal column and facial skeleton. The effects of the cranial asymmetry may include a convergence of the facial planes toward the affected side (see lines).

E Retrosternal goiter (after Hegglin)
A goiter that arises from the inferior poles (see p. 214) of the thyroid gland may extend to the thoracic inlet and compress the cervical veins at that level. The result of this is venous congestion and dilation in the head and neck region.

F Assessing the central venous pressure in the neck in a semi-upright position
Normally the cervical veins are collapsed in the sitting position. But in a patient with right-sided heart failure, there is diminished venous return to the right heart, causing distention of the jugular veins. The extent of the venous congestion is indicated by the level of pulsations in the external jugular vein (the "venous pulse," upper end of the blue line). The higher the level of jugular pulsation, the greater the backup of blood into the vein. This provides a means of assessing the severity of right-sided heart failure.

1.4 Embryology of the Face



A Fusion of facial prominences (after Sadler)
Frontal view. Understanding the clinically important development of the cleft lip, jaw, and palate (**c**) requires knowledge of facial development.

a Embryo at five weeks. The surface ectoderm of the 1st branchial arch invaginates to form the stomodeum which later connects to the endodermal epithelium of the oral cavity. The facial outline develops from facial prominences, the tissue of which arises from the 1st branchial arch or neural crest mesenchyme. The mandibular processes are located caudal to the stomodeum with the maxillary processes located lateral to it. Superomedial to the maxillary processes are the medial and lateral nasal process. Both medial nasal processes border the frontal process.

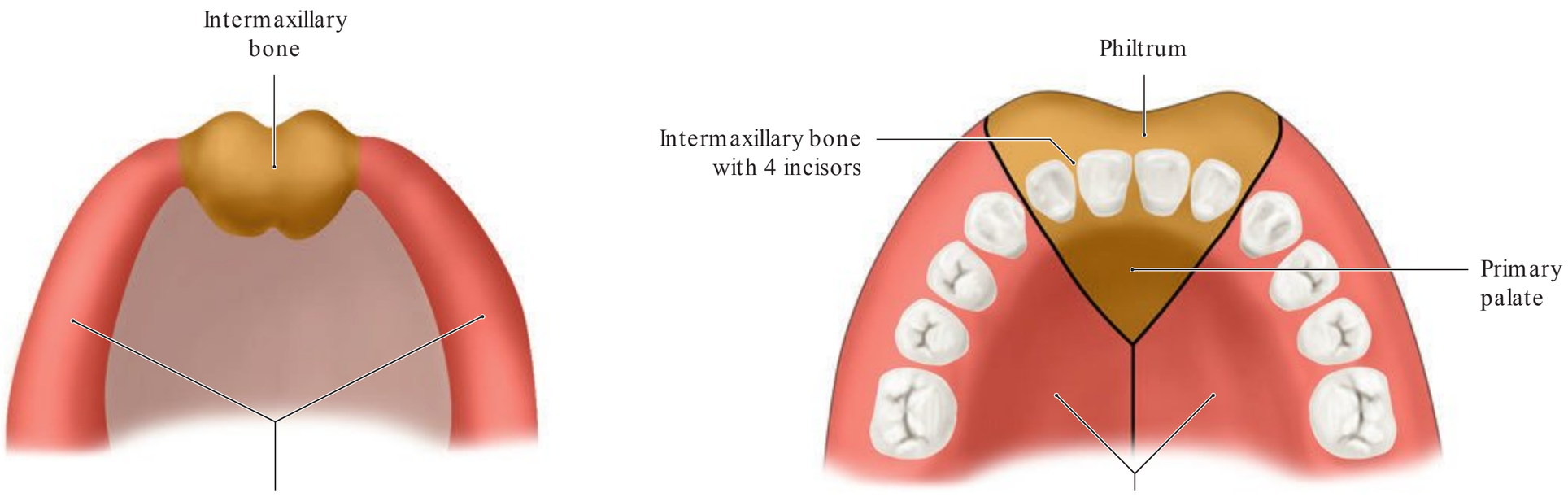
b Embryo at six weeks. A furrow separates the nasal processes from the maxillary process.

c Embryo at seven weeks. The medial nasal processes have fused along the midline and their inferolateral margins contact the maxillary processes on either side.

d Embryo at ten weeks. Cell migration is completed.

B Facial prominences and their derivatives (after Sadler)

Facial prominence	Derivative
Frontal process	Forehead, bridge of nose, medial and lateral nasal process
Maxillary process	Cheeks, lateral parts of upper lip
Medial nasal process	Philtrum, tip of the nose and ridge of the nose
Lateral nasal process	Nasal wing
Mandibular process	Lower lip

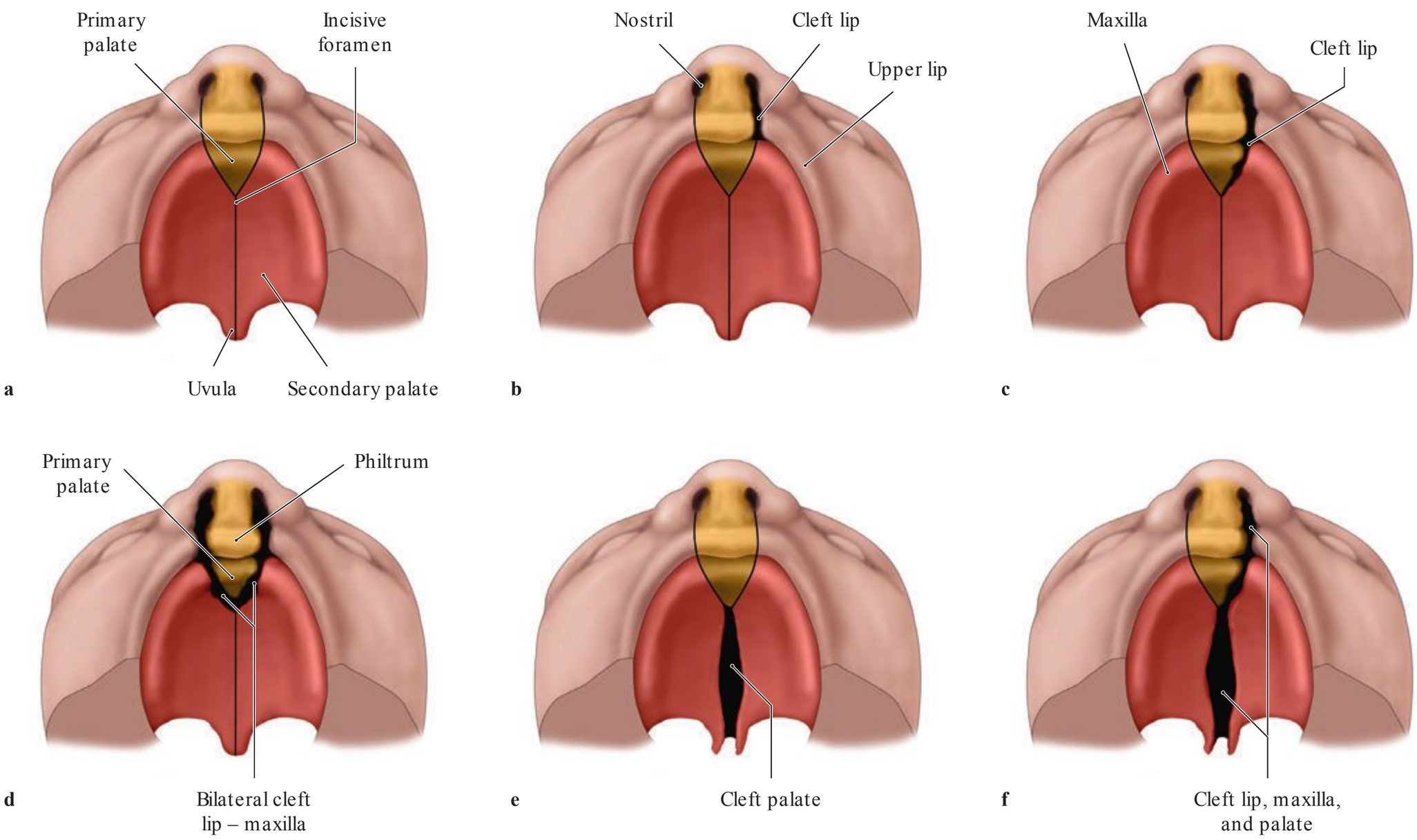


a **b**

C Intermaxillary segment (after Sadler)
Caudal view of palate.

a The medial nasal processes develop bone tissue that fuses along the midline and gives rise to a separate bone, the intermaxillary bone.

b The philtrum also arises from tissue of the medial nasal process along with intermaxillary bone and its four incisors. The bone of the primary palate fuses with the maxillary processes (secondary palate) and is no longer a separate bone in adults.



a **b** **c**

d Bilateral cleft lip – maxilla **e** Cleft palate **f** Cleft lip, maxilla, and palate

D Formation of facial clefts (after Sadler)
Caudal and ventral view.

a **Normal condition.** The palatine bones and the maxillary processes have fused with the primary palate. The surface epithelium forms oral mucosa that lines the roof of the oral cavity. The bony palate beneath the oral mucosa separates the oral and nasal cavities.

b **Cheiloschisis.** A cleft lip that extends up to the nose (harelip) occurs on the left side if the tissue of the upper lip does not fuse on the left side.

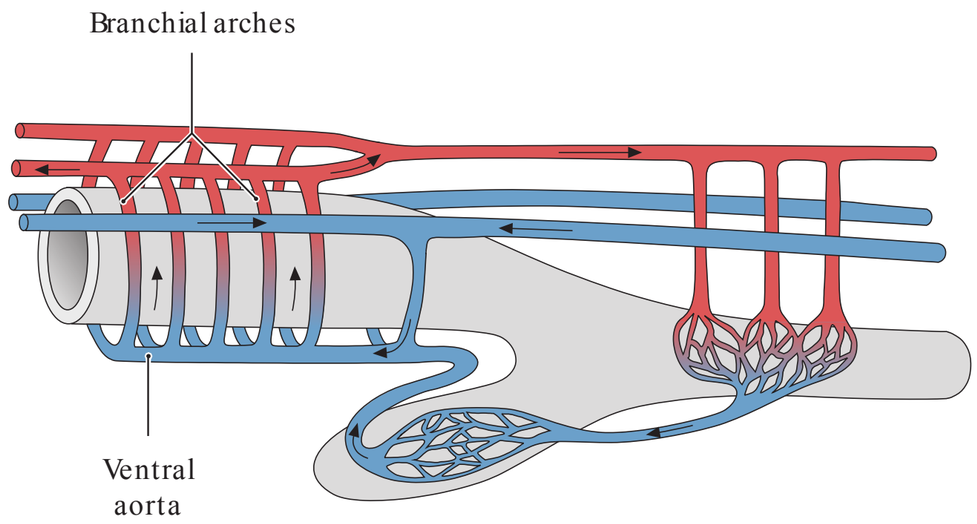
c **Cheilognathoschisis.** A cleft lip and maxilla occurs if the fusion of primary and secondary palates on the left side does not occur.

d Cleft formation can also occur bilaterally: bilateral cleft lip and maxilla.

e **Palatoschisis.** Incomplete fusion of the primary and secondary palates on both sides results in an isolated cleft palate.

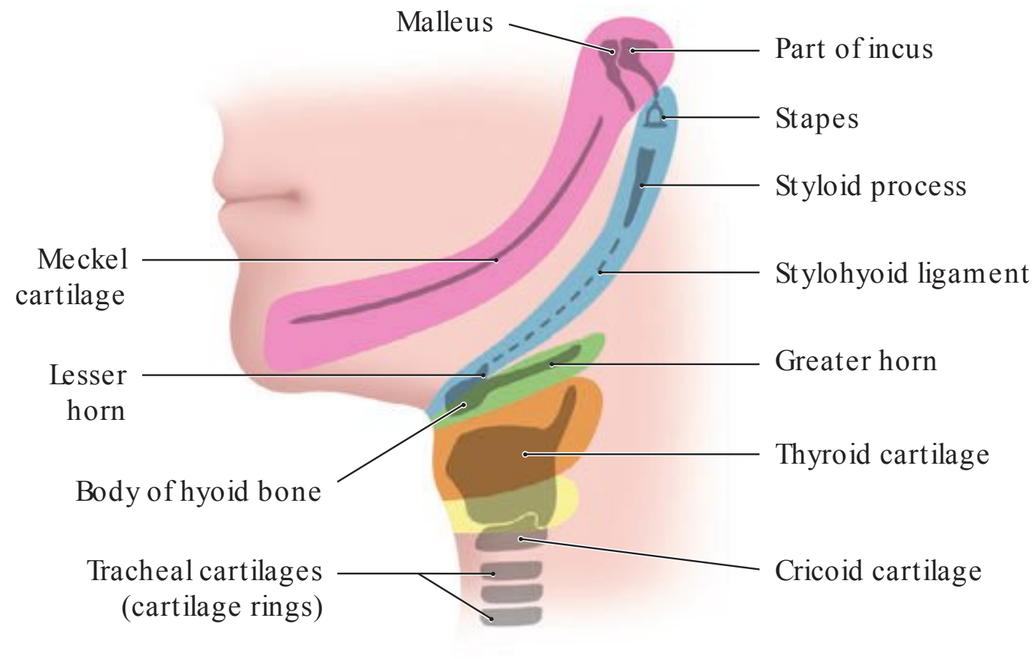
f **Cheilognathopalatoschisis.** Combination of all three: unilateral cleft lip, maxilla, and palate. If it occurs bilaterally it is known as cleft palate.

1.5 Embryology of the Neck



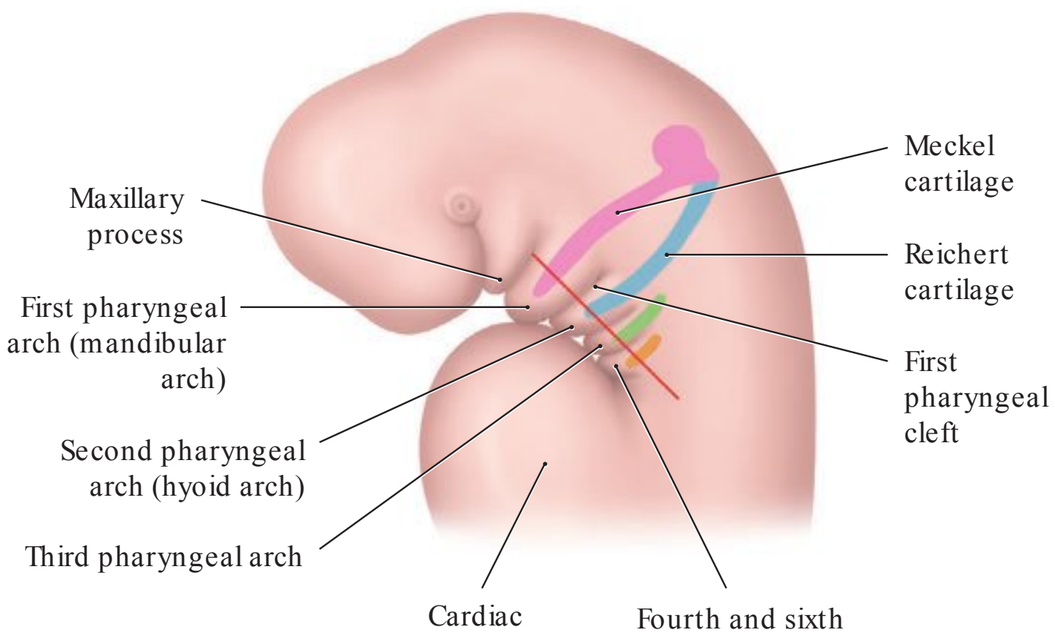
A The branchial arches of the lancelet (after Romer, Parsons, and Frick)

Left lateral view. This simplified schematic of the circulatory system of a lancelet fish illustrates the basic relation between the vascular tree and the branchial arches in chordates, including the vertebrates. Oxygen-depleted blood (in blue) is pumped rostrally (toward the head) through a ventral aorta to a series of branchial arches, where it passes through gills, picks up oxygen (red), and then is distributed to the body (compare this paired, segmental arterial arch with the thoracic segment in humans). A similar anatomical organization and circulatory pattern is seen in the human embryo, where the gills and branchial arches are transformed into pharyngeal arches which develop into various structures in the head and neck. Errors during this developmental process give rise to a series of relatively common anatomical anomalies in the neck (see **G**).



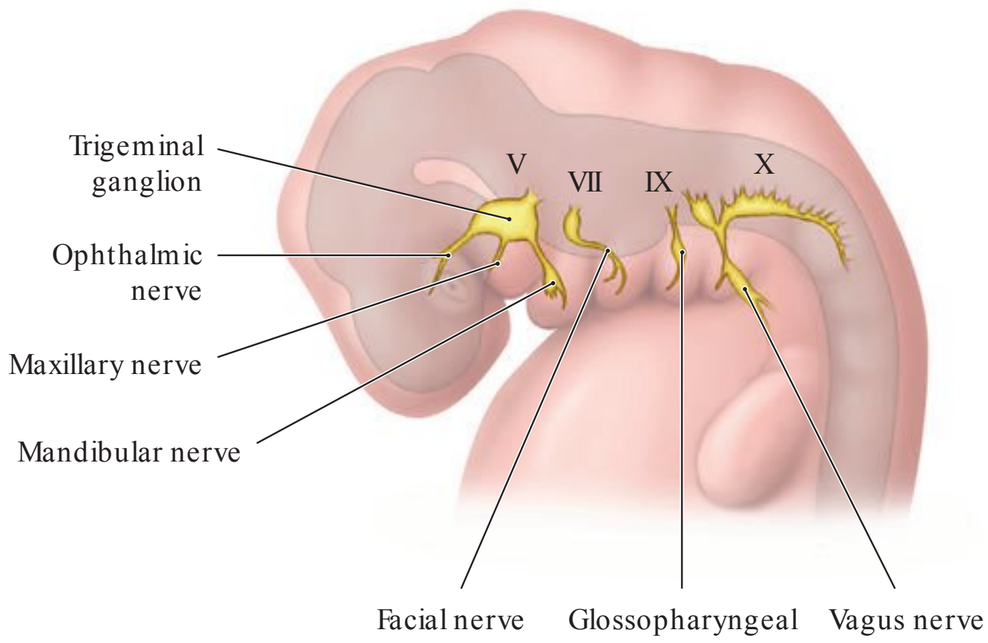
C Derivation of musculoskeletal structures from the pharyngeal arches in the adult (after Sadler)

Left lateral view. Besides the cartilaginous rudiments of the skeleton (see labels), the muscles and their associated nerves can be traced embryologically to specific pharyngeal arches. The first pharyngeal arch gives rise to the masticatory muscles, the mylohyoid muscle, the anterior belly of the digastric muscle, the tensor veli palatini, and the tensor tympani. The second pharyngeal arch gives origin to the muscles of facial expression, the posterior belly of the digastric, the stylohyoid muscle, and the stapedius. The stylopharyngeus muscle is derived from the third pharyngeal arch. The fourth and sixth pharyngeal arches give rise to the cricothyroid muscle, levator levi palatini, constrictor pharyngis, and the intrinsic muscles of the larynx. The nerve supply to the muscles can also be explained in terms of their embryologic origins (see **D**).



B Pharyngeal arches and pharyngeal clefts of a 4-week-old embryo (after Sadler)

Left lateral view. The human embryo has four pharyngeal arches separated by intervening pharyngeal clefts. The cartilages of the four pharyngeal arches are shown in different colors. Like other tissues of the pharyngeal arches, they migrate with further development to form various skeletal and ligamentous elements in the adult (see **C**).



D Innervation of the pharyngeal arches

Left lateral view. Each of the pharyngeal arches is associated with a cranial nerve:

First pharyngeal arch	Trigeminal nerve (CN V) (mandibular nerve)
Second pharyngeal arch	Facial nerve (CN VII)
Third pharyngeal arch	Glossopharyngeal nerve (CN IX)
Fourth and sixth pharyngeal arches	Vagus nerve (CN X) (superior and recurrent laryngeal nerves)