



# Atlas of HUMAN ANATOMY

MARK NIELSEN  
SHAWN MILLER

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# **ATLAS OF HUMAN ANATOMY**

**Mark Nielsen**  
University of Utah

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University of Utah



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ISBN-13: 978-0470-50145-0

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

# Preface

Anatomy is a visual science, and in no other subject does the age-old saying ring so true — “a picture is worth a thousand words.” With this in mind we created this book to teach anatomy with the real thing — photographs of cadaver dissections and the bones of the skeleton, and micrographs of the body’s tissues. We believe that every word that has ever been written about anatomy is the result of someone describing what they observed in a dissection (or as is the case of many authors today, the words are paraphrased from somebody else’s knowledge and writings about dissection). In this book we provide you with the *images* of *real* anatomy, with the hope that this will help you better visualize the *words* of anatomy.

We often hear that photographs can never clarify and teach anatomy as well as art. While it is true that the artist has much more creative license than the dissector, it is also true that a lot of anatomical art does not always accurately depict what is actually observed by a dissector; or for that matter, a surgeon in a clinical setting. We believe that *good* dissection and photography can be instructive, especially when creatively coupled with teaching concepts. With this in mind, another objective of this book is to present images that teach, and not just showcase a plethora of anatomy. Each dissection was made with an instructive purpose and reference images are used to highlight and focus on the patterns or concepts depicted by the dissections. There are many simple patterns of design that organize and clarify the structure of the vertebrate body. We attempt to show these patterns in our presentation of anatomical structure throughout the chapters of this book. The few words that accompany the images in the book draw attention to the patterns and the basic structure-function relationships of the dissections and micrographs.

It has also been our goal to create a book that will benefit students at all levels of anatomy education. The chapters are constructed with a systematic approach to anatomy to meet the needs of the typical undergraduate anatomy course. Each chapter illustrates the concepts and features of a body system and depicts those features with clear dissections and reference images of the dissections. On the other hand, because it is dissection based the book is also an excellent reference for the medical student, physical therapy student, or other graduate student who is studying cadaver anatomy from a regional approach. Even the layperson who wants to learn more about their amazing body can benefit from the beautiful anatomy images throughout the book. Students can continue their exploration of anatomy using Real Anatomy, 3-D imaging software that enables students to dissect through layers of the real human body.

To learn more about Real Anatomy, visit <http://www.wiley.com/college/sc/realanatomy>

In conclusion we would like to thank a few individuals for their help with the dissections that were photographed for this book. Good dissection is a time consuming task that requires a strong knowledge of anatomy, skill and dexterity, and above all a lot of patience. Nathan Mortensen played a major role in helping with the dissections throughout the pages of this book. Also, the following individuals each contributed one or two dissections, and we want to thank them for their contribution: Richard Homer, Torrence Meyer, Jordan Barker, Jon Groot, and John Dimitropoulos. We also want to thank Alexa Doig who took a few of the cadaver photographs.

We hope this book expands your vista of the amazing machine we call the human body. We would love to have any feedback you have on how we might improve the book for future editions.

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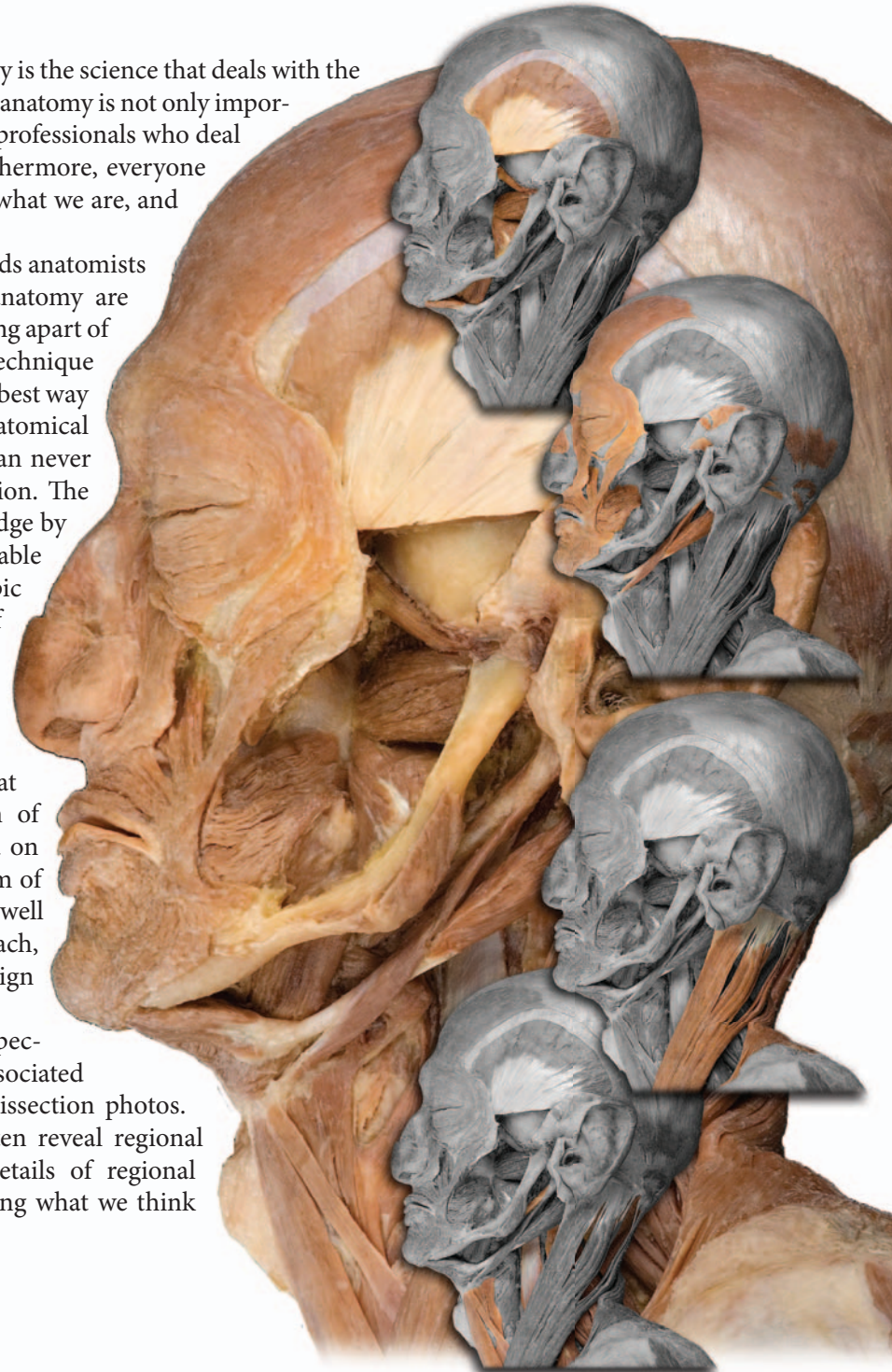
# 1 Introduction

Human anatomy is the science that deals with the structure and design of the human body. A knowledge of anatomy is not only important for the anatomist, but is an essential tool for all the professionals who deal with the human body in any of a variety of ways. Furthermore, everyone can benefit from a knowledge of anatomy because it is what we are, and understanding our bodies can be invaluable.

Anatomy is an ancient science. The principal methods anatomists used, and still use, to reveal what is known about anatomy are dissection and microscopy. Dissection involves the cutting apart of a body to reveal its gross structure. This was the first technique used to discover the structure of the body and is still the best way to truly understand the design and relationship of anatomical detail. The best drawings, photos, and virtual images can never reveal what the dissector experiences during a dissection. The advent of the microscope expanded anatomical knowledge by revealing microscopic perspectives that were not available to the unaided eye. This understanding of microscopic structure opened the door to an increased knowledge of the functional aspects of anatomy.

In this atlas we attempt to teach the elegant structure and design of the human body using the tools and methods of the anatomist — dissection and microscopy. While there are numerous excellent visual resources that depict anatomy, we believe that, with the exception of personal dissection study, excellent photographs based on excellent dissections and microscopy are the truest form of anatomical imagery. Nothing depicts the actual thing as well as the actual thing. Our goal is to create images that teach, and to use that imagery to highlight the patterns and design features of anatomy.

This atlas approaches the body from a systemic perspective; that is, it covers each body system and the organs associated with that system. Each system is highlighted in the dissection photos. However, the dissections of the systemic anatomy often reveal regional perspectives and relationships, and the structural details of regional anatomy are labeled on every image. Have fun exploring what we think might be the next best thing to dissection.



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anatomy in

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# Design of the Book

The design features of the *Atlas of Human Anatomy* are illustrated on this page using a sample page from the book. Each page will begin with a short introduction to the featured anatomy of the page.

This brief narrative will occupy this text space. Below this narrative, the majority of the page will focus on the images of anatomy and the appropriate labels for the images. The design elements used to teach and illustrate the anatomy are highlighted in the boxes below.

## Featured Structure

The page heading will list the anatomical structure or feature that is the focal point of the page

## Stomach

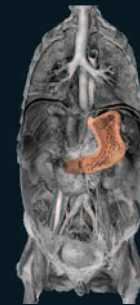
The stomach is a J-shaped organ of variable size and shape and has the greatest diameter of any part of the gut tube. It occupies the upper left quadrant of the abdominal cavity, where it is anchored to the posterior abdominal wall by a mesentery. The stomach performs several functions, the most important of which is to store ingested food until it can be emptied into the small intestine at a rate that allows for optimal digestion and absorption.

## Descriptive Narrative

A brief description of the structure and function of the anatomical structures on the page

## Reference Image

The reference image helps to quickly identify the featured anatomy and see its relationships



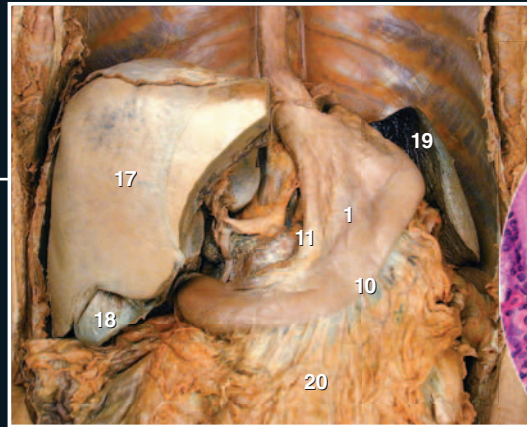
## Structure List

Numbered list of all the structures visible on the anatomical images

- |                     |                      |                        |
|---------------------|----------------------|------------------------|
| 1 Stomach           | 7 Pylorus            | 13 Surface mucous cell |
| 2 Cardia of stomach | 8 Pyloric sphincter  | 14 Lamina propria      |
| 3 Fundus of stomach | 9 Gastric rugae      | 15 Mucous neck cell    |
| 4 Body of stomach   | 10 Greater curvature | 16 Gastric glands      |
| 5 Pyloric antrum    | 11 Lesser curvature  | 17 Liver               |
| 6 Pyloric canal     | 12 Gastric pit       | 18 Gallbladder         |
|                     |                      | 19 Spleen              |
|                     |                      | 20 Greater omentum     |

## Dissection Images

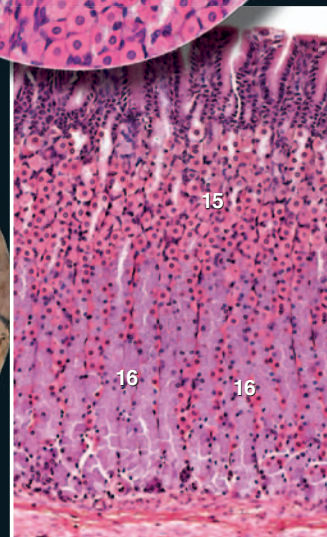
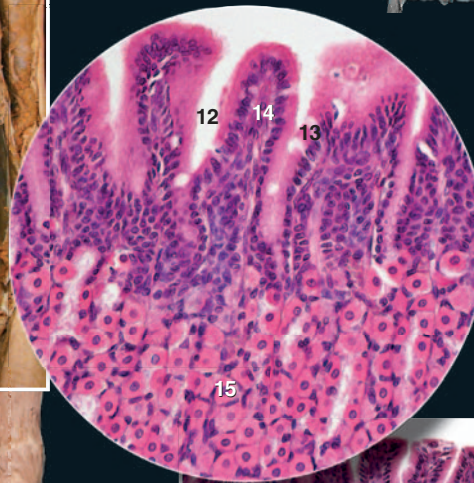
Beautiful dissections illustrate the anatomy of the body system



Abdominal dissection revealing stomach  
Anterior view

## Microscope Images

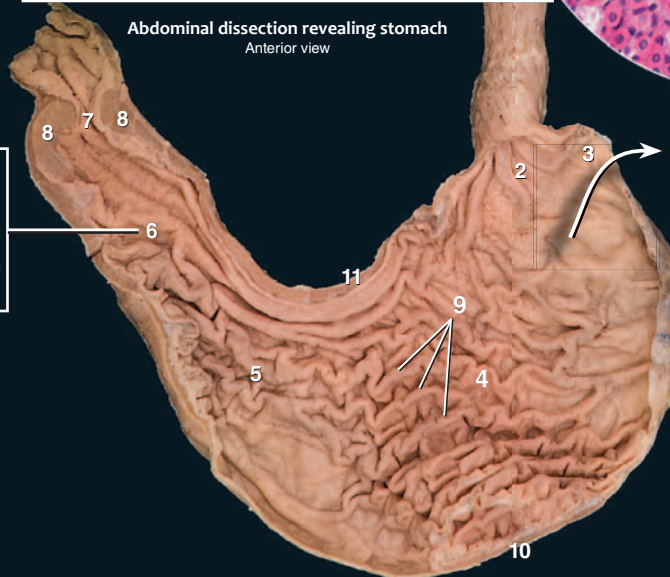
Crisp histology photomicrographs illustrate the contextual microscopic structure of the anatomy



Photomicrograph of stomach mucosa  
with callout above  
40x and 100x

## Numbered Structures

Unobtrusive numbered structures without the clutter and distraction of leader lines



Frontal section of stomach  
Anterior view

## Captions

Captions describe the image and the view or magnification of the anatomy or histology



# 2 Histology

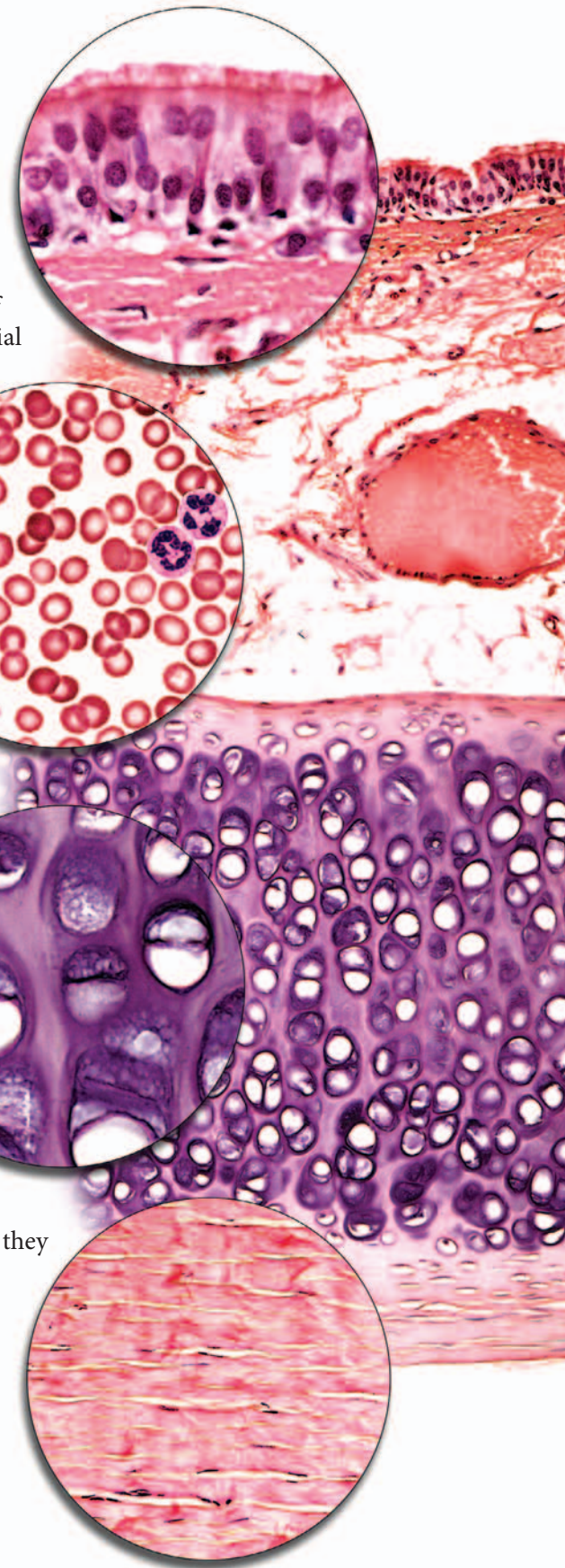
Histology is the study of tissues, and tissues are the building materials of the body. Like the materials we use to make the clothing we wear, tissues are the materials that form the various layers and structures of all the body's organs. For example, you might wear a light undershirt of cotton beneath a silk long-sleeved shirt and wear a wool sweater over the top of the two shirts. Each layer of clothing is made of a different material, and the material is organized into a unique structure that has its own functional qualities. The same is true of the organs of the body. Each organ consists of distinct structural layers, and each layer is a specific type of tissue. For example, the stomach has an inner lining of simple columnar epithelium that is in contact with the food we eat and secretes enzymes to help digest the food. This epithelial layer is surrounded by a vascular layer of loose connective tissue that contains the blood vessels that transport the absorbed molecules from the stomach. Smooth muscle tissue surrounds the two inner layers and helps toss and turn the food within the stomach and move it toward the small intestine. The smooth muscle tissue is covered by a slippery, thin layer of simple squamous epithelium that forms the outer surface of the stomach and allows it to move against neighboring organs while reducing the damaging friction. And just as the layers of clothing have names — undershirt, long-sleeved shirt, sweater — so also do the structural layers of an organ such as the stomach — mucosa, submucosa, muscularis, and serosa.

All the tissues of the body can be organized into four basic tissue categories — epithelial tissue, connective and supporting tissue, muscle tissue, and nervous tissue. Each tissue category has unique structural features that are shared by the tissues of that category. Epithelial tissues are surface tissues that consist of numerous cells tightly packed together. Connective and supporting tissues share the common feature of having relatively few cells that are scattered within a surrounding fibrous extracellular matrix. Muscle tissue consists of elongated cells with specialized protein arrangements that are designed to shorten. Nervous tissue cells are branching, wire-like cells with a great variety of shapes and lengths. In this chapter you will explore these four tissue categories and the specific tissue types that comprise each category. In the chapters that follow, the different tissues will be observed in the context of the organs and organ systems they form.



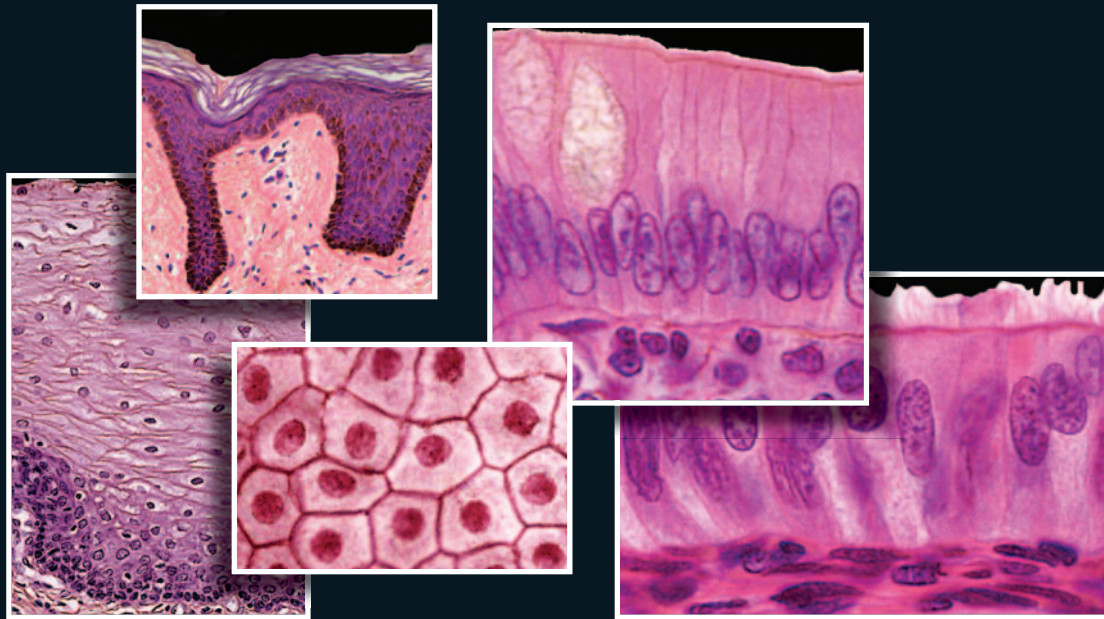
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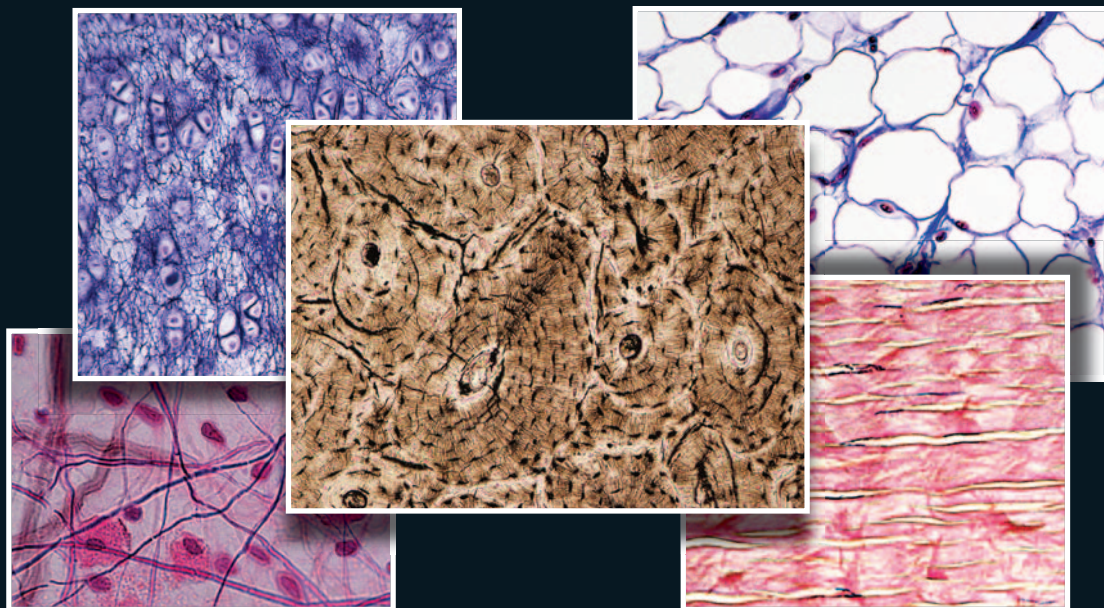


# Tissues

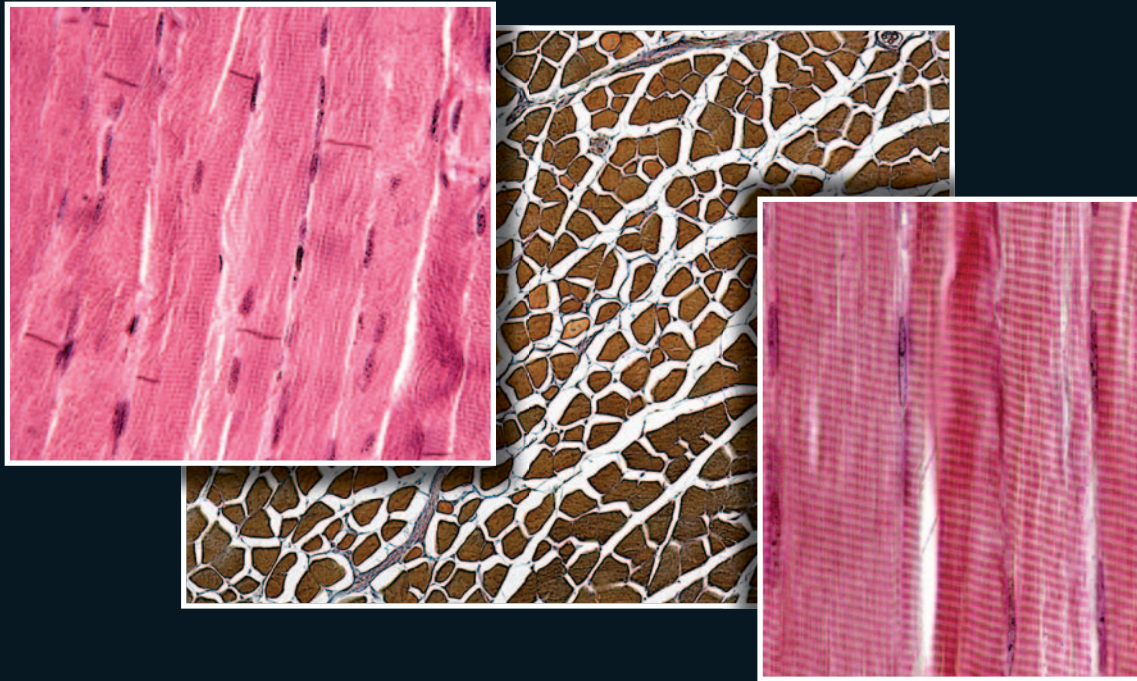
The facing pages show photomicrograph collages of the four principal tissue categories—epithelial tissue, connective and supporting tissue, muscle tissue, and nervous tissue. The photomicrographs illustrate the key structural features shared by the tissues in each category. Note the numerous closely packed cells of the epithelial tissues and contrast them with the scattered cells and the fibrous surrounding matrix of the connective and supporting tissues. In the muscle tissue observe the long, slender specialized cells that are designed to shorten, and in the nerve tissue the branched, wire-like cells.



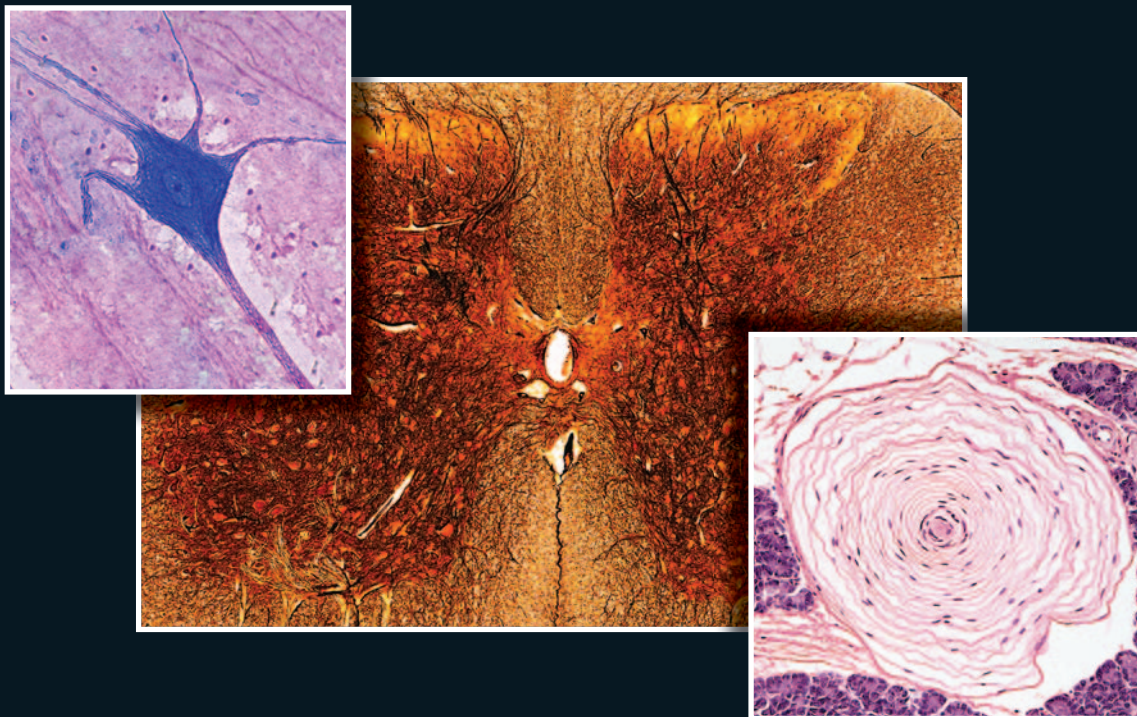
Epithelial Tissues



Connective and Supporting Tissues



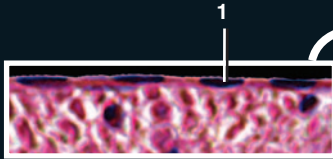
Muscle Tissues



Nerve Tissues

# Epithelial Tissue

Epithelial tissues are surface tissues that consist of numerous cells, with each cell forming membrane to membrane contact with its neighbors. As a general rule, descriptions of epithelial tissues are based on the shape of their cells and on the number of cell layers present. By combining the shape names — squamous (flat cells), cuboidal, and columnar — with the term simple if there is a single layer of cells or the term stratified if there is more than one layer of cells, almost all of the epithelial tissues can be described and named. The photomicrographs on this page and the facing page represent the simple (single cell layer) epithelial tissues.

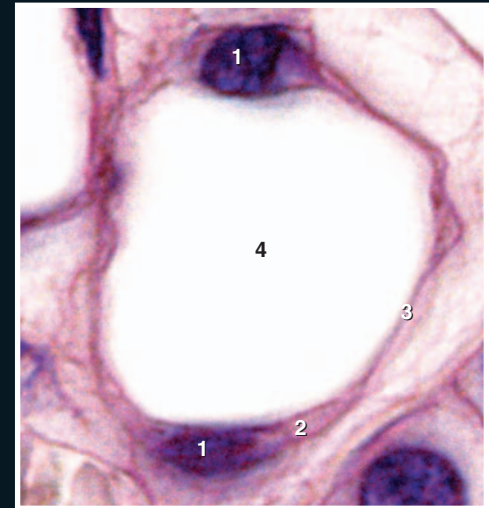


**Simple squamous epithelium, mesothelium**  
Section of mesentery, 400x

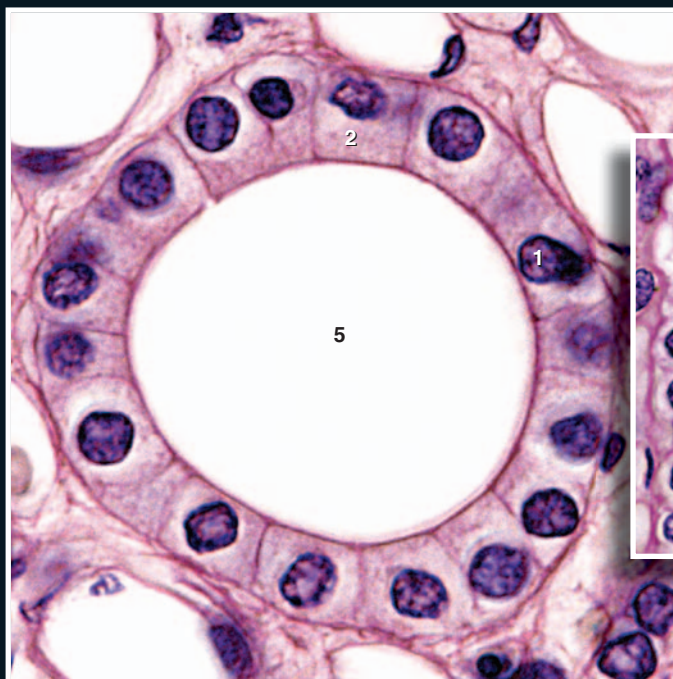
- |                     |                                      |
|---------------------|--------------------------------------|
| 1 Nucleus           | 7 Mucous in goblet cell              |
| 2 Cytoplasm         | 8 Microvilli                         |
| 3 Cell membrane     | 9 Basement membrane                  |
| 4 Capillary lumen   | 10 Blood vessel with red blood cells |
| 5 Glandular lumen   | 11 Cilia                             |
| 6 Connective tissue | 12 Basal cell                        |



**Simple squamous epithelium, mesothelium**  
Surface view of mesentery, 400x



**Simple squamous epithelium, endothelium**  
Section of capillary, 630x



**Simple cuboidal epithelium**  
Urinary tubes in kidney - transverse section, 630x (left); longitudinal section, 400x (right)



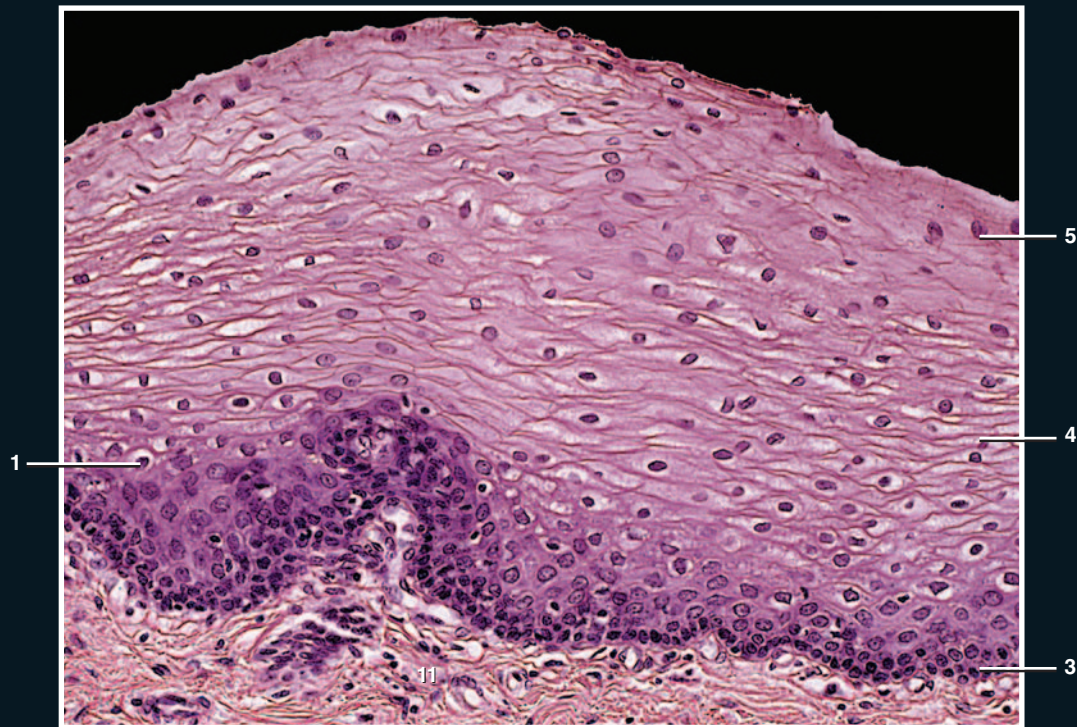
**Simple columnar epithelium**  
 Section of mucosa of small intestine, 630x



**Pseudostratified columnar epithelium**  
 Section of mucosa of larynx, 400x

# Epithelial Tissue

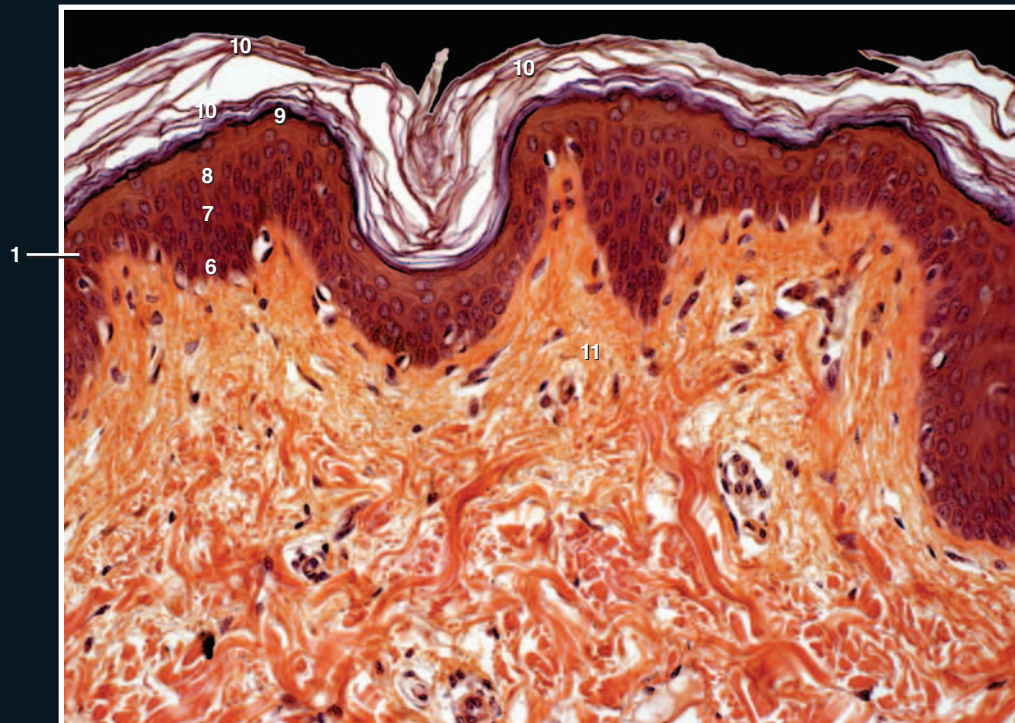
The photomicrographs on this and the facing page illustrate the stratified (more than one layer of cells) epithelial tissues. Note that the tissues range from two layers to numerous layers and the cell shape used for the tissue name is the shape of the cells found in the surface layer.



- 1 Nucleus
- 2 Cytoplasm
- 3 Basal cell layer
- 4 Intermediate cell layer
- 5 Superficial cell layer
- 6 Stratum basale
- 7 Stratum spinosum
- 8 Stratum granulosum
- 9 Stratum lucidum
- 10 Stratum corneum
- 11 Connective tissue
- 12 Basement membrane
- 13 Glandular lumen

**Nonkeratinized stratified squamous epithelium**

Section of esophageal mucosa, 200x

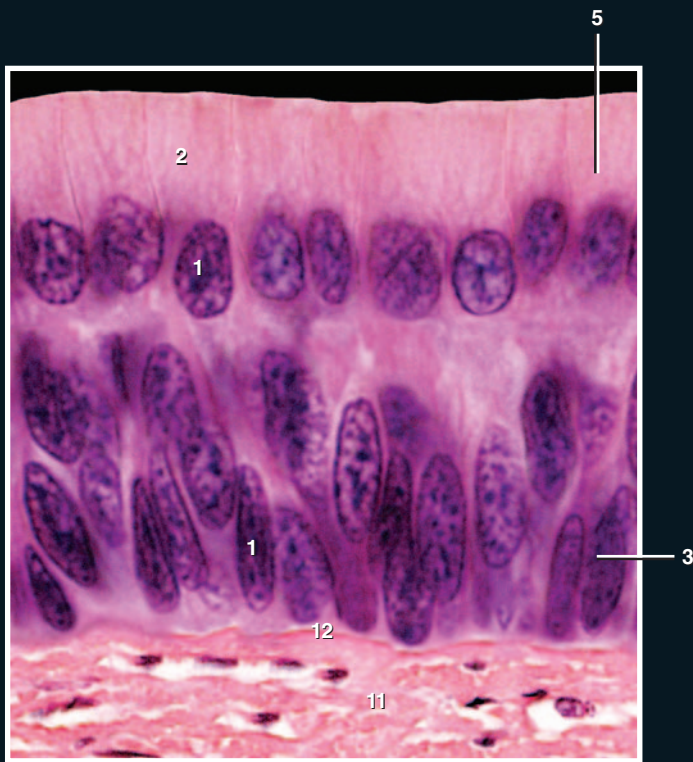


**Keratinized stratified squamous epithelium**

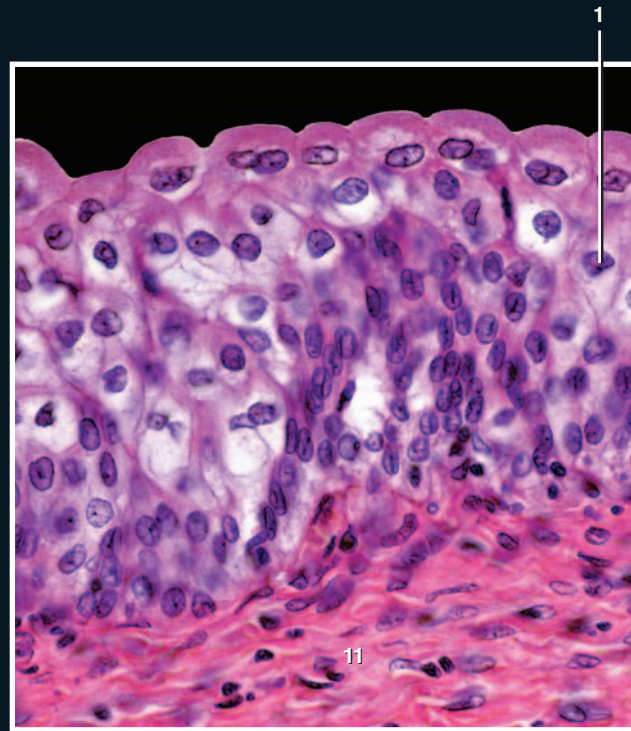
Section of skin, 200x



**Stratified cuboidal epithelium**  
Section of duct of esophageal gland, 400x



**Stratified columnar epithelium**  
Section of pharyngeal mucosa, 400x



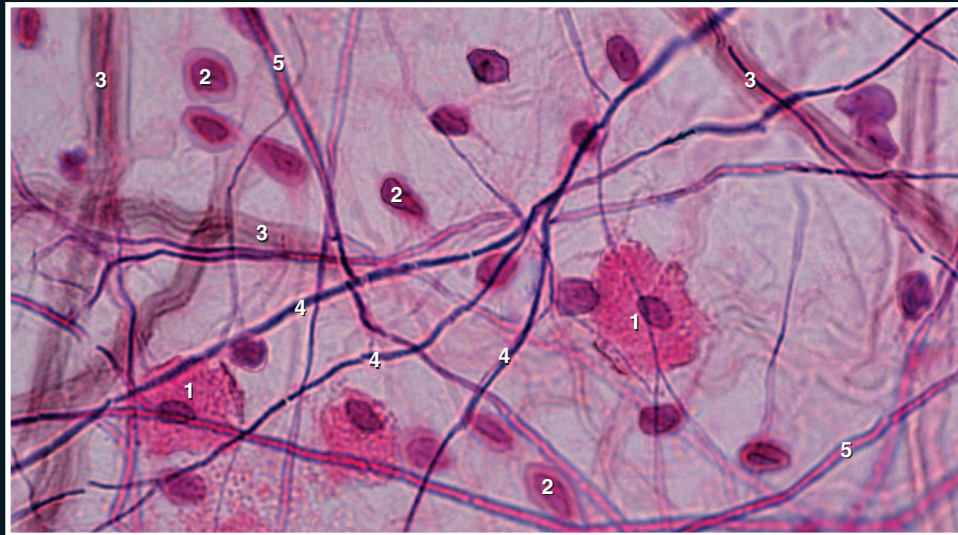
**Transitional epithelium**  
Section of urinary bladder mucosa, 400x

# Connective Tissue

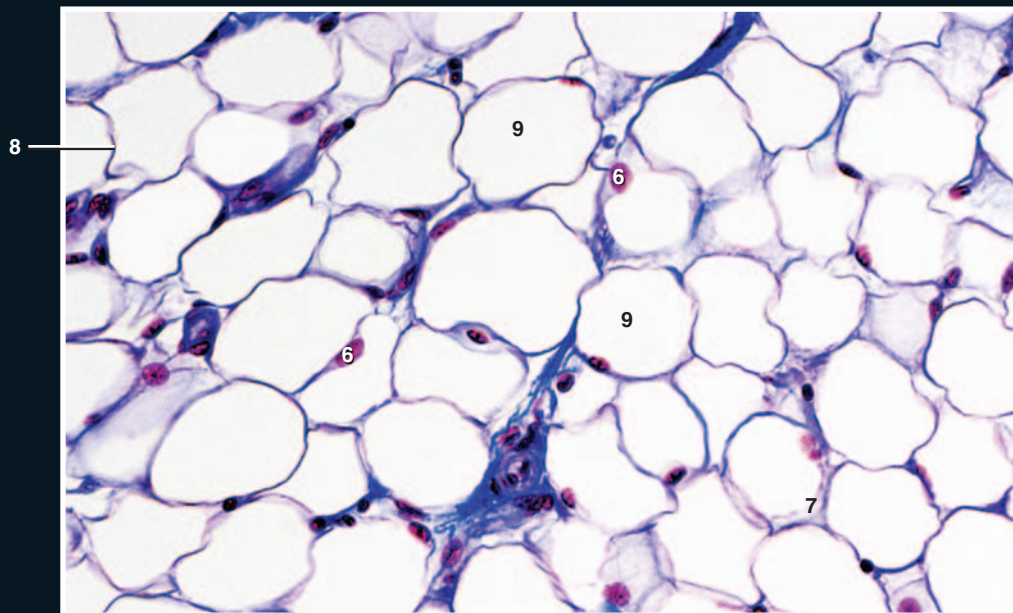
Connective tissues have relatively few cells and the cells are surrounded by an extracellular matrix of fibers, which the cells secrete.

The classification and names of connective tissues arise from the type and arrangement of the fibers produced by the cells and secreted into the surrounding matrix. There are three named fibers in the matrix — collagen fibers, reticular fibers (actually a thin form of collagen), and elastic fibers. The fibers are deposited in varying degrees of density and are arranged in different patterns. The tissue names are based on the different fiber types and patterns in the matrix.

- |                           |                              |
|---------------------------|------------------------------|
| 1 Mast cell               | 7 Cytoplasm                  |
| 2 Fibroblast              | 8 Plasma membrane            |
| 3 Collagen fiber          | 9 Lipid storage area         |
| 4 Elastic fiber           | 10 Nucleus of reticular cell |
| 5 Reticular fiber         | 11 Nucleus of fibroblast     |
| 6 Nucleus of adipose cell | 12 Elastic lamella           |

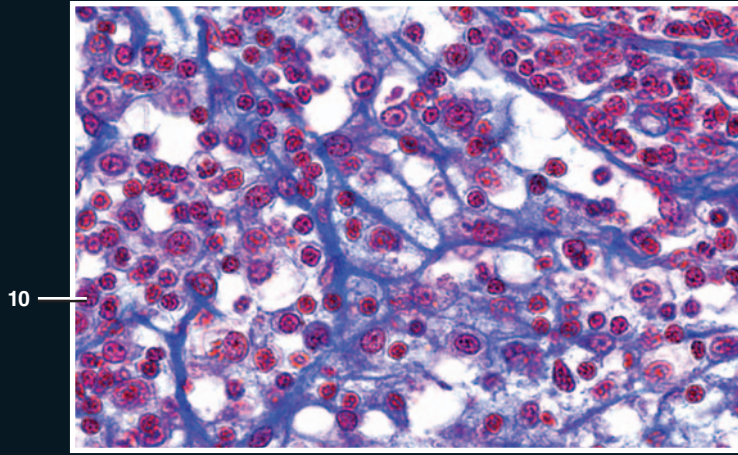


**Loose (areolar) connective tissue**  
Section of subcutaneous layer of integument, 400x

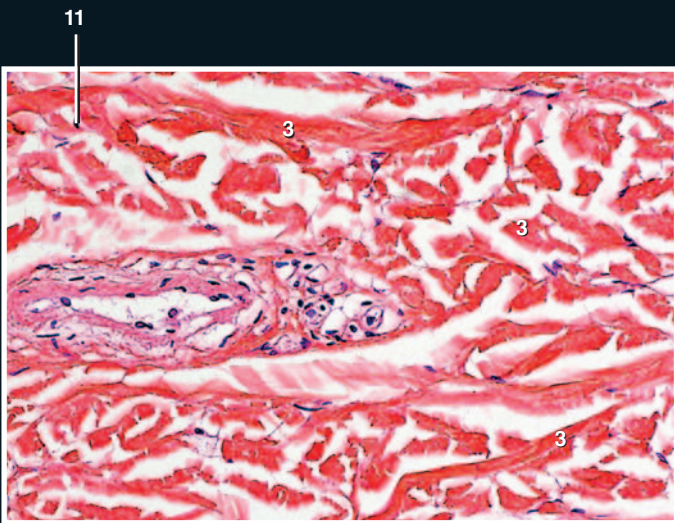


**Adipose tissue**  
Section of epicardial fat, 200x

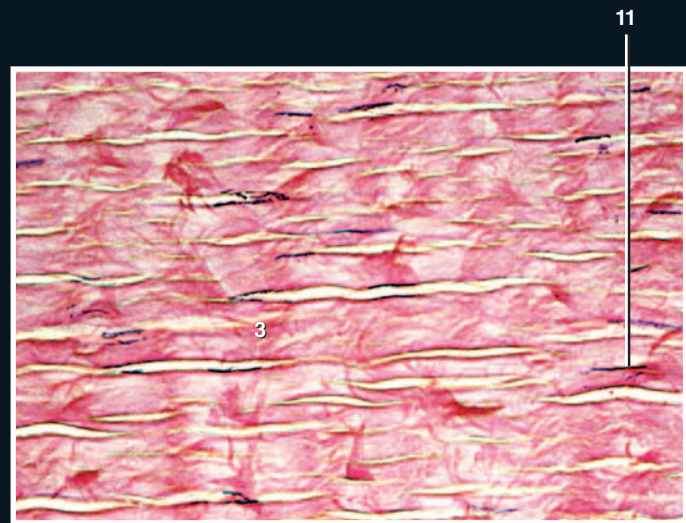




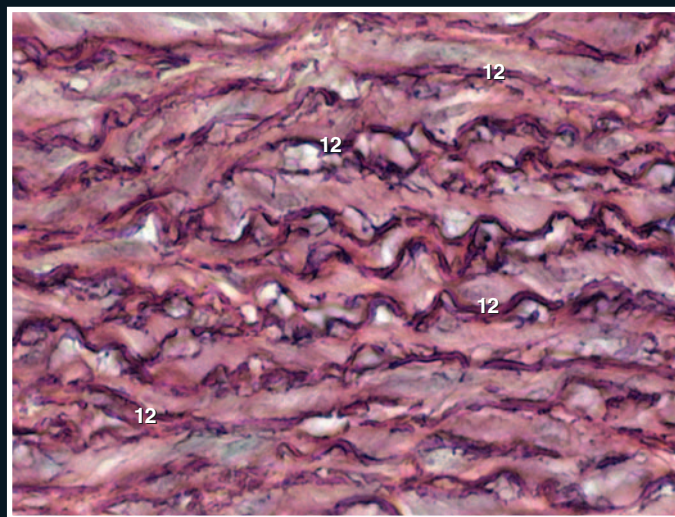
**Reticular tissue**  
Section of lymph node, 400x



**Dense irregular connective tissue**  
Section of dermis, 200x



**Dense regular (collagenous) connective tissue**  
Section of tendon, 200x

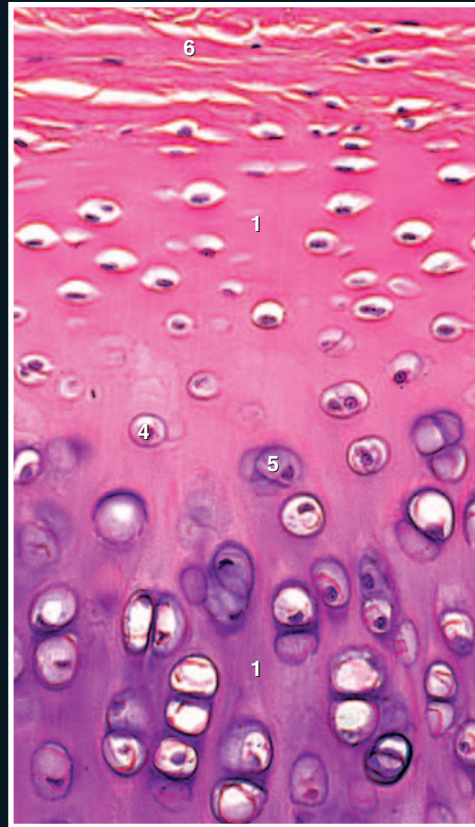


**Dense regular (elastic) connective tissue**  
Section of tunica media of aorta, 400x

# Supporting Tissue

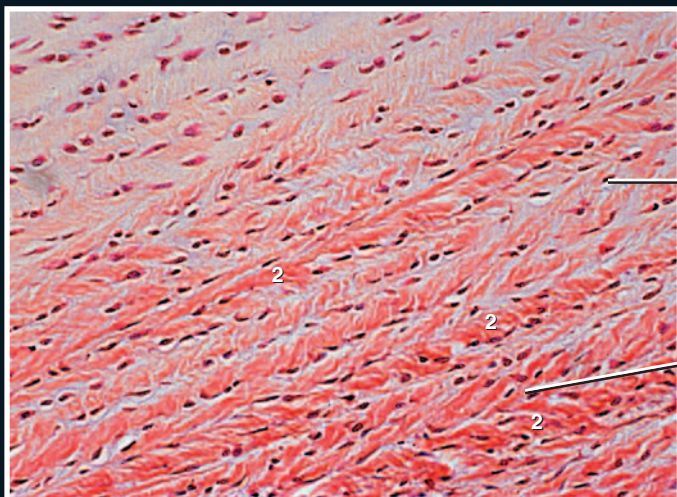
The supporting tissue category consists of the skeletal tissues—cartilage and bone. Like the connective tissues, the supporting tissues have relatively few cells surrounded by a significant amount of extracellular matrix, which for the most part the cells produce. However, unlike the soft matrix of the connective tissues, the extracellular matrix of the supporting tissues is firm and rubber-like in cartilage and hard in bone tissue.

- 1 Hyaline ground substance
- 2 Collagen fibers in ground substance
- 3 Elastic fibers in ground substance
- 4 Chondrocyte nucleus
- 5 Chondrocyte in lacuna
- 6 Perichondrium
- 7 Bone trabecula
- 8 Osteocyte
- 9 Red bone marrow
- 10 Canaliculi
- 11 Lacuna
- 12 Lamella
- 13 Central canal



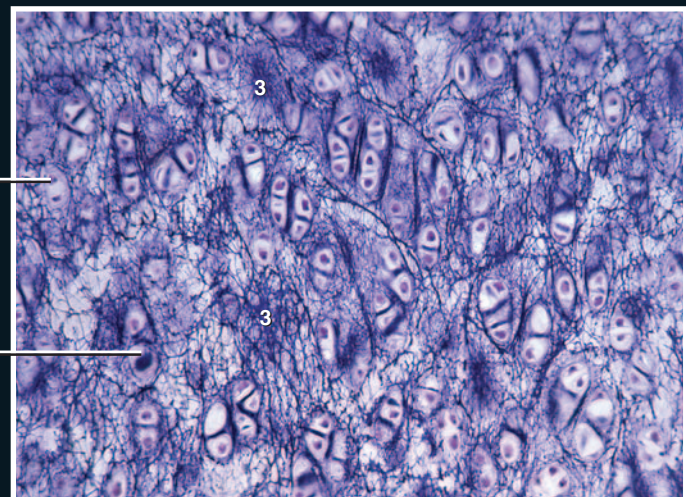
**Hyaline cartilage**

Section of cartilage in developing fetal bone, 200x



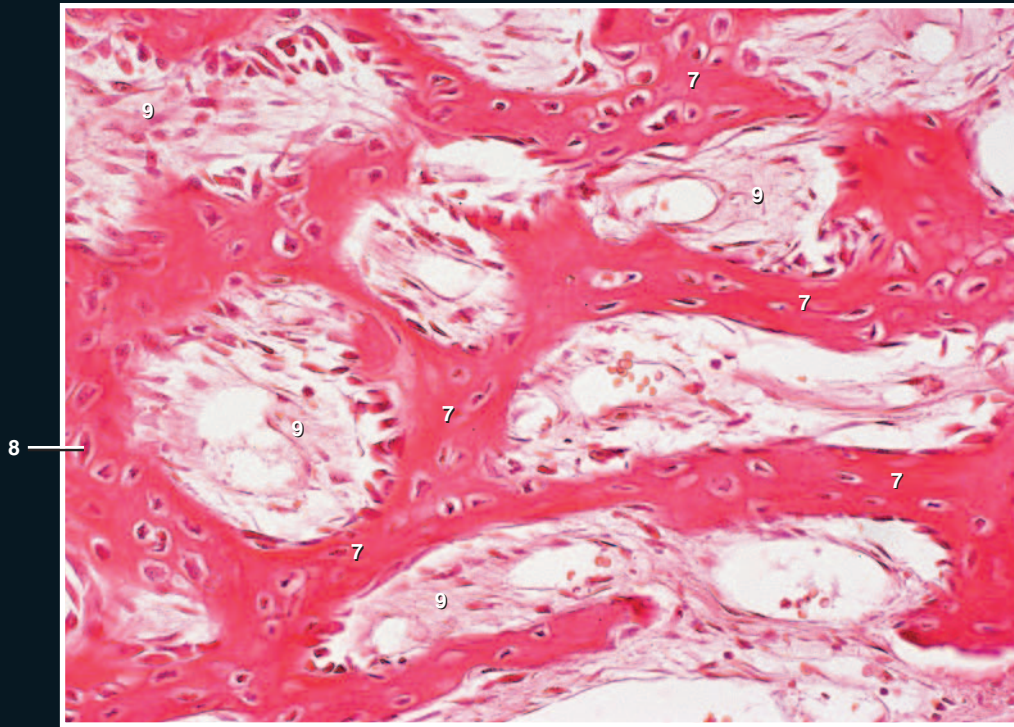
**Fibrocartilage**

Section of intervertebral disc, 200x

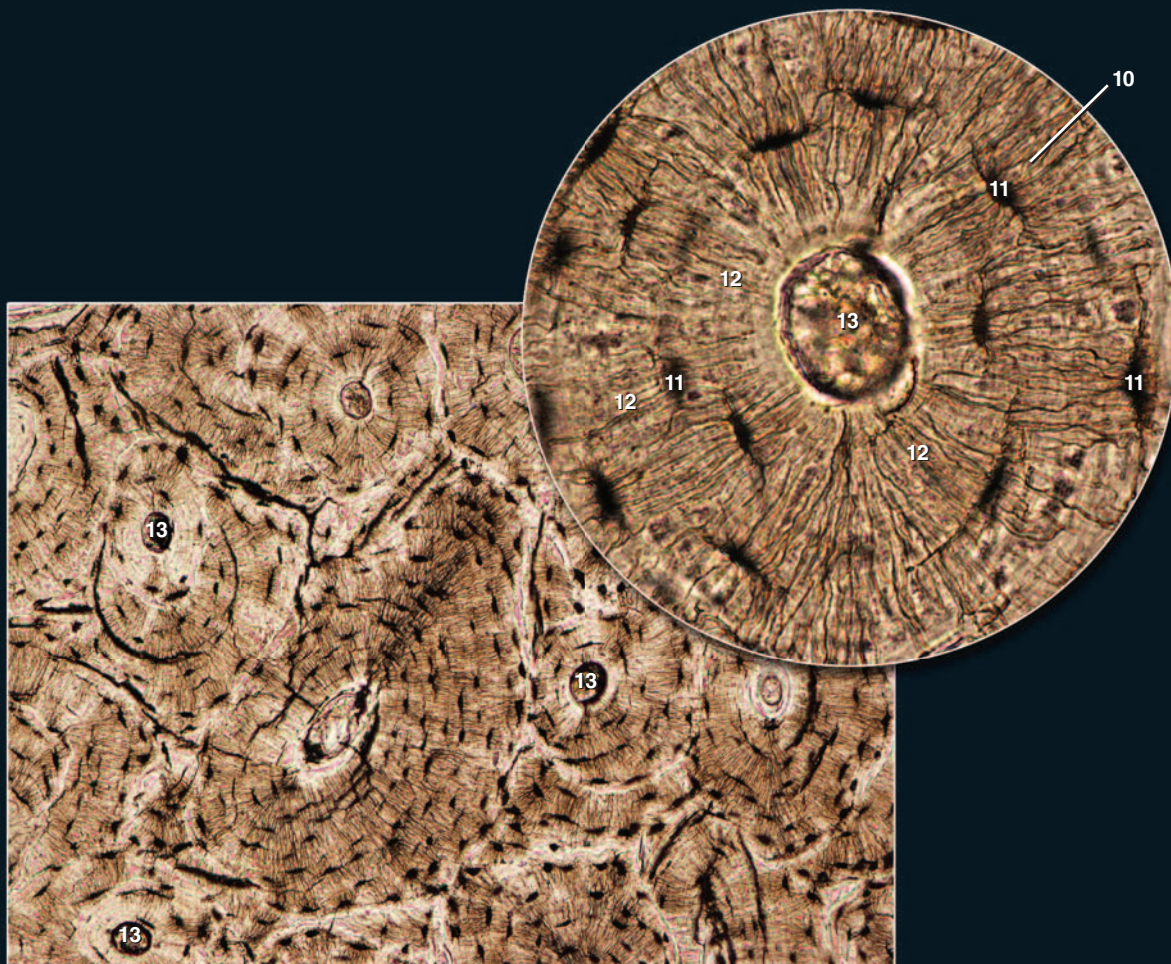


**Elastic cartilage**

Section of cartilage from auricle of ear, 400x



**Spongy bone**  
 Section of epiphysis of metacarpal bone, 200x



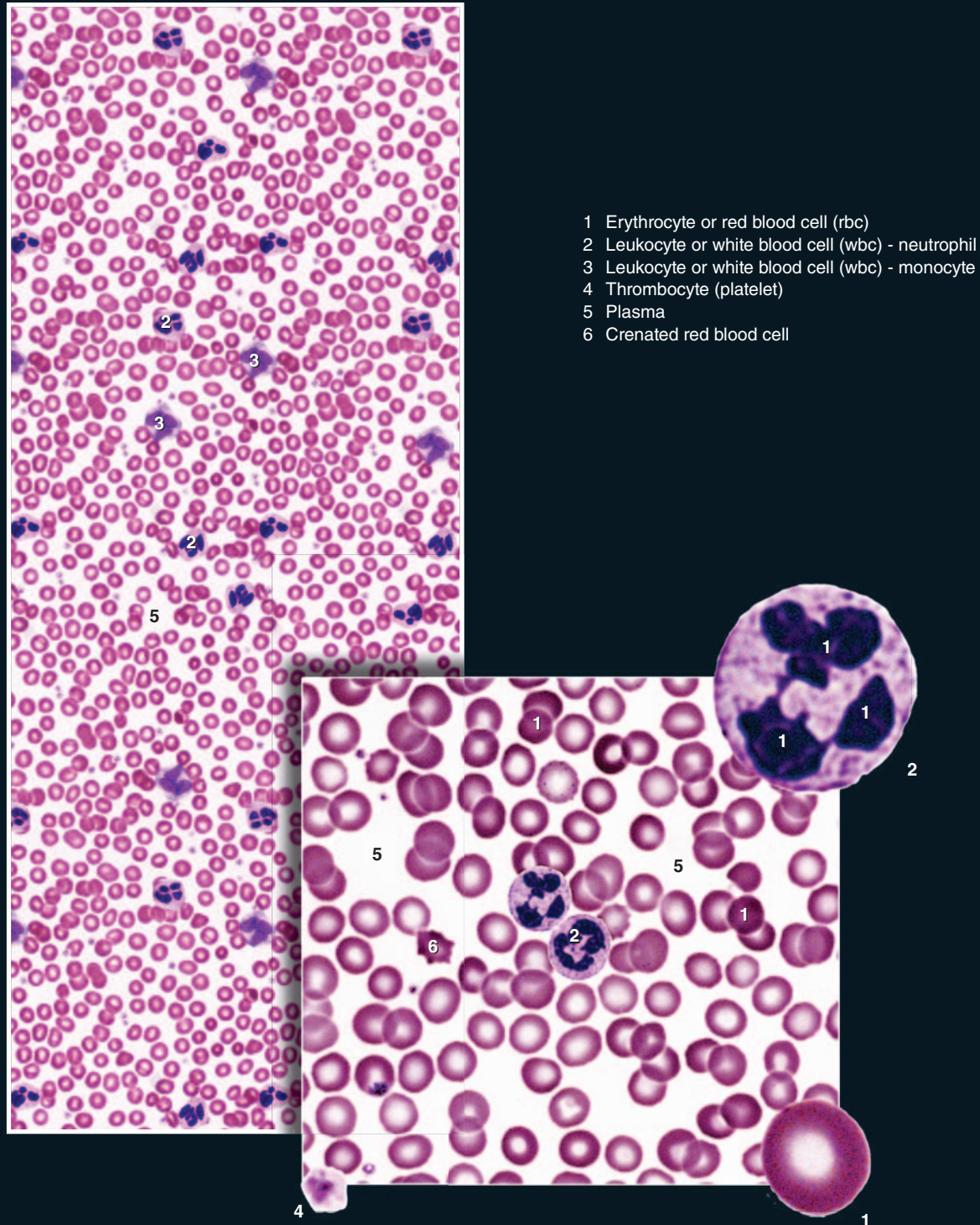
**Compact bone**  
 Section of diaphysis of fibula, 100x; callout of osteon, 400x

# Hematolymphoid Complex

is a greater percentage of the tissue than are the cells. However, the extracellular matrix of blood and lymph is a liquid matrix called plasma, rather than the soft, firm matrix of connective tissues. The most recent *Terminologia Histologica* places blood and lymph in their own subcategory called the hematolymphoid complex.

The tissues blood and lymph traditionally were classified as connective tissues because, like all connective tissues, the extracellular matrix

of blood and lymph is a liquid matrix called plasma, rather than the soft, firm matrix of connective tissues. The most recent *Terminologia Histologica* places blood and lymph in their own subcategory called the hematolymphoid complex.



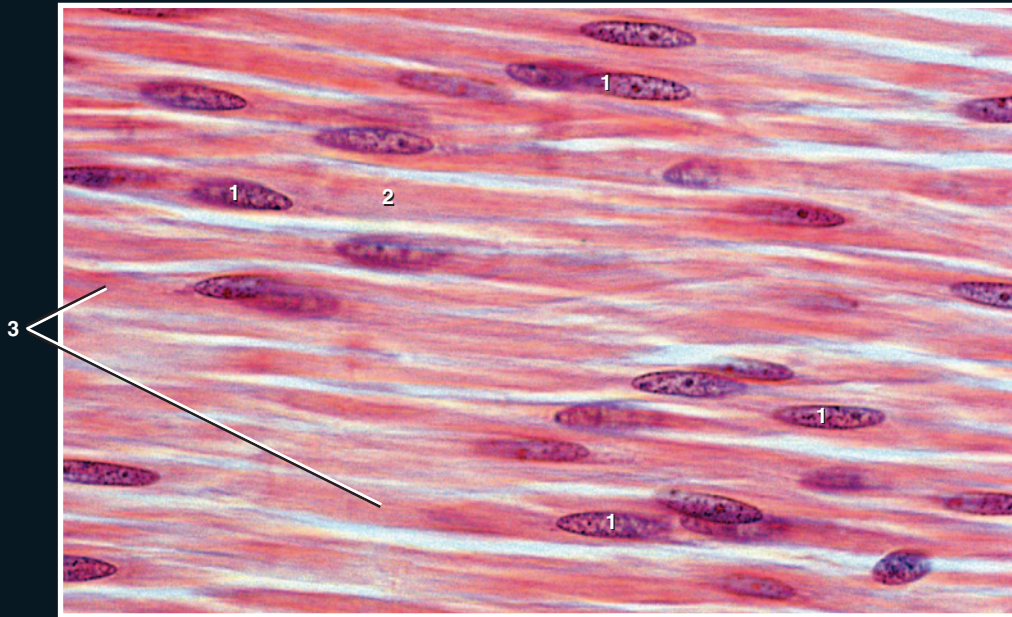
**Blood smear**

Wright's stain, 200x; enlargement, 630x; individual cells, 1500x

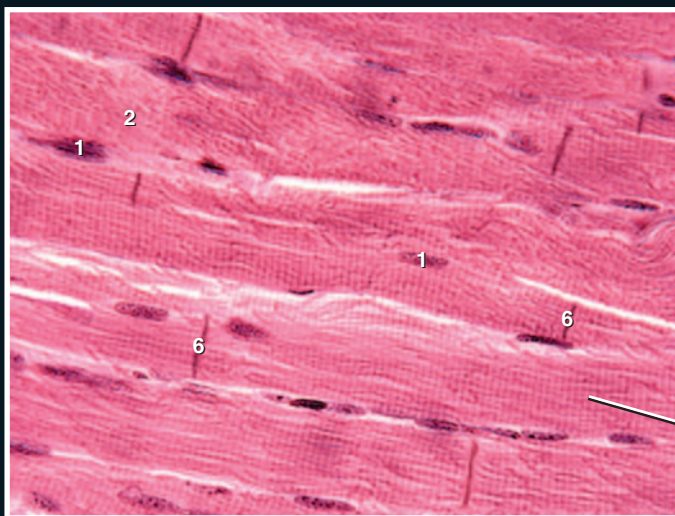
# Muscle Tissue

Muscle cells are long, slender cells that have special arrangements of the proteins actin and myosin within the cytoplasm. The architectural design of these proteins forms the muscle cell "machinery" that allows the cell to specialize at contracting (shortening). The names of the different types of muscle tissues arise from the arrangement of the contractile proteins within their cells. In some tissues the protein arrangement gives the cell a striated, or striped, appearance (striated muscle), while in other tissues the striped appearance is not evident (non-striated or smooth muscle).

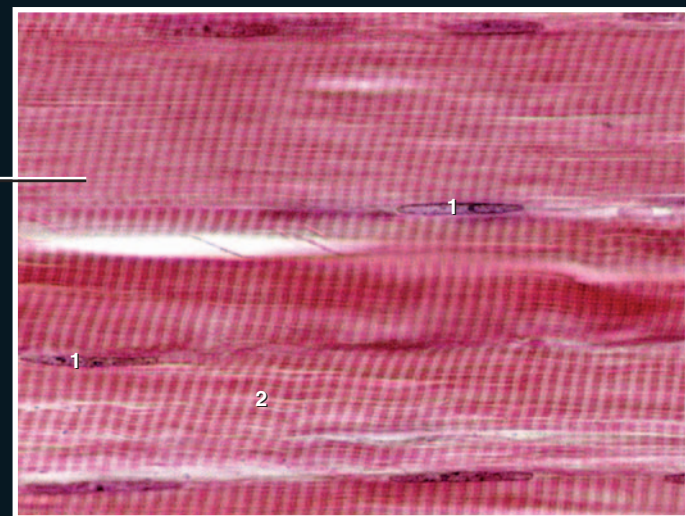
- 1 Nucleus
- 2 Sarcoplasm
- 3 Smooth muscle cell
- 4 Cardiac muscle cell
- 5 Skeletal muscle cell
- 6 Intercalated disc



**Smooth (nonstriated) muscle tissue**  
Longitudinal section of muscular wall of intestine, 500x



**Cardiac striated muscle tissue**  
Section of ventricle of heart, 500x

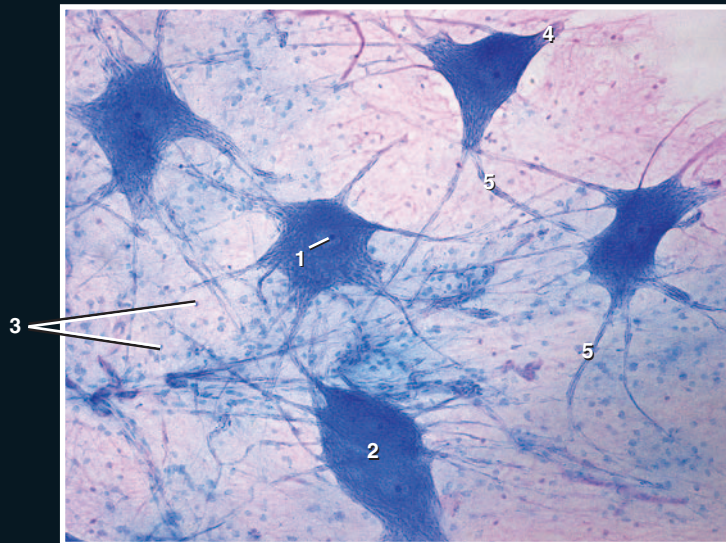


**Skeletal striated muscle tissue**  
Section of vastus lateralis muscle, 400x

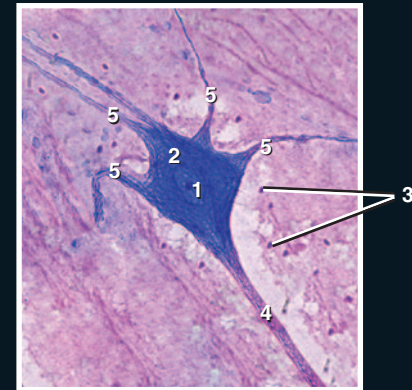
# Nerve Tissue

Nervous tissue forms the complex electrical computing system of the body. The cells that characterize nervous tissue are the branched, wire-like cells called neurons. Surrounding the neurons of the nervous tissue are the smaller, more numerous glial cells that are involved in protecting, insulating, and nourishing the neurons. The neurons can be grouped together in long slender structures called nerves, or they can form the complex circuit boards we call the spinal cord and brain.

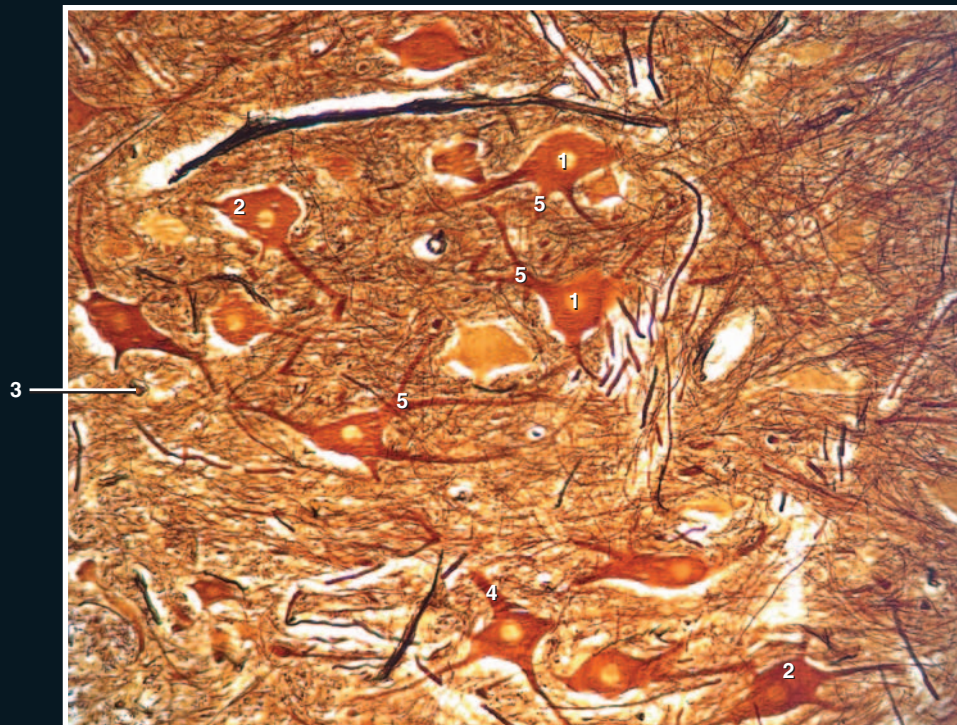
- 1 Nucleus of multipolar neuron
- 2 Cell body of multipolar neuron
- 3 Nucleus of glial cell
- 4 Axon
- 5 Dendrite



**Nerve tissue**  
Multipolar neuron smear, 400x



**Neuron**  
400x

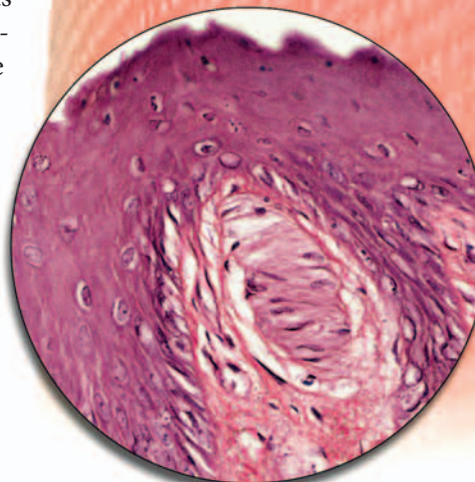
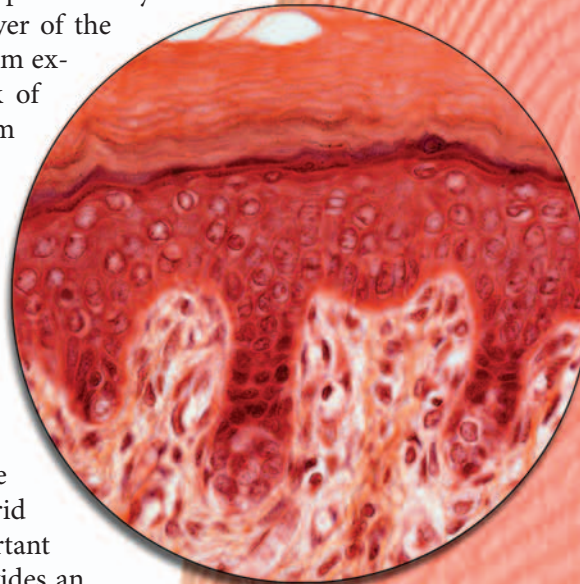
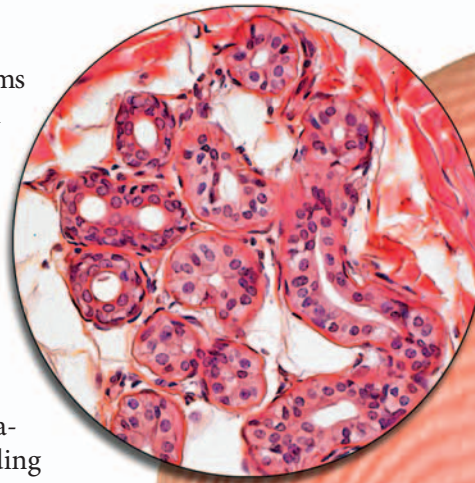


**Nerve tissue**  
Section of ventral horn of spinal cord, 200x

# 3 Integument

The integument forms the organ system that covers the body. From the Latin meaning to cover inward, the integument is an important system that performs a variety of functions that are essential to life. The outer layers of the integument called the epidermis and dermis form the skin, which is an important protective layer. The skin protects the body in a number of ways. Its tough, outer-covering of dead cells protects the more delicate deeper layers from friction and abrasion. The pigment cells in the epidermis produce melanin, a protective pigment that absorbs damaging ultraviolet radiation from the sun, to protect the rapidly dividing keratinocytes that make up the majority of the epidermal layer of the skin. The structure of the epidermal layer of the skin and its secretions also protect the body from excessive water loss or gain. The large network of blood vessels and numerous sweat glands form an evaporative cooling system that help to protect the body from overheating in warm conditions or during exercise. Additionally, the impenetrable skin and some of its special cells form a first line of defense against bacterial invasion.

These are just some of the functions of the integument. Other important functions are the following: it is a major surface for sensory perception to receive input or stimuli from the environment, it is an excretory surface to help rid the body of metabolic wastes, it plays an important role in energy storage and metabolism, it provides an important site for the production of vitamin D and various growth factors, and it plays a major role in sociosexual communication and identification. This chapter will depict the structural features of the integument that account for this wide variety of important functions.



Find more information  
about the integument in

REALANATOMY

# Subdivisions of the Integument

The integument consists of two major parts or layers of anatomy, the skin and the subcutaneous layer, or hypodermis.

The cadaver and histology images on this and the facing page illustrate these two layers of anatomy. The skin, consisting of the superficial epidermis and the deeper dermis, structurally combines an epithelial tissue and connective tissue to form the body's covering organ. The skin is an organ that produces hairs, various glands, finger and toe nails, and accounts for the majority of the functions of the integument. The subcutaneous layer is a variable layer that can consist of fat, fibrous connective tissue, loose connective tissue, and smooth muscle.



**Epidermal layer of the skin**  
Anterior view



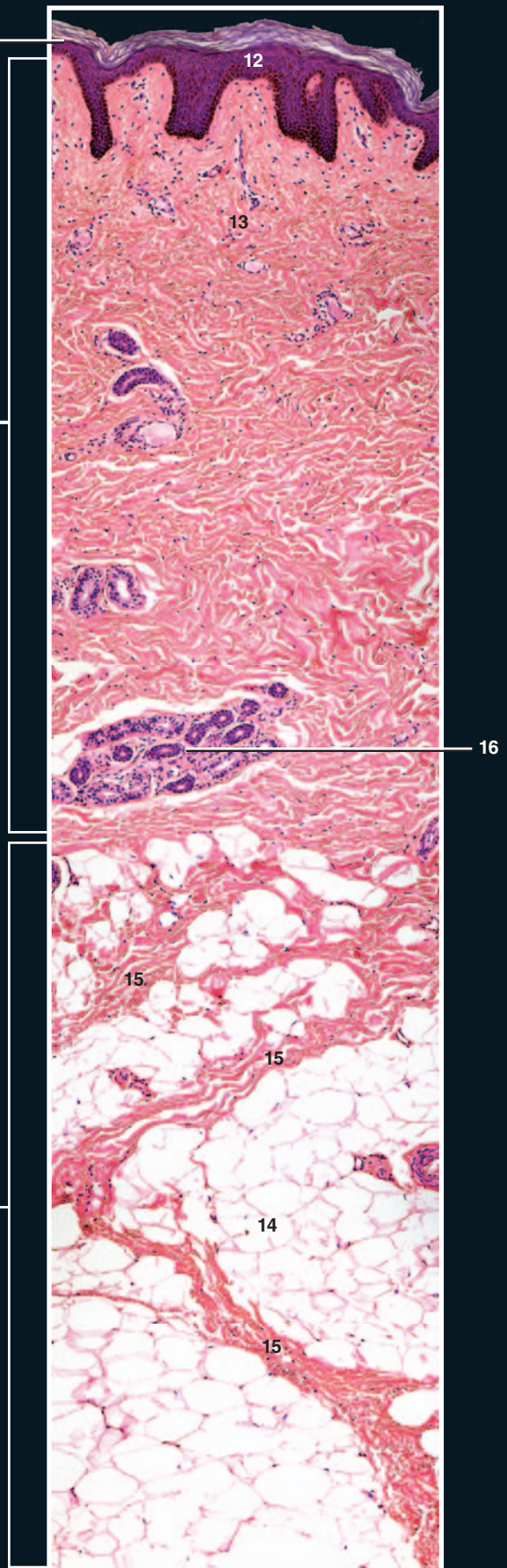
**Subcutaneous layer of the integument**  
Anterior view



- 1 Epidermis
- 2 Dermis
- 3 Subcutaneous layer
- 4 Fascia
- 5 Periosteum
- 6 Compact bone of tibia
- 7 Fibula
- 8 Medullary cavity
- 9 Interosseous membrane
- 10 Tendon
- 11 Muscle
- 12 Stratified squamous epithelium
- 13 Dense irregular connective tissue
- 14 Adipose tissue
- 15 Retinaculum cutis
- 16 Secretory coils of sweat gland



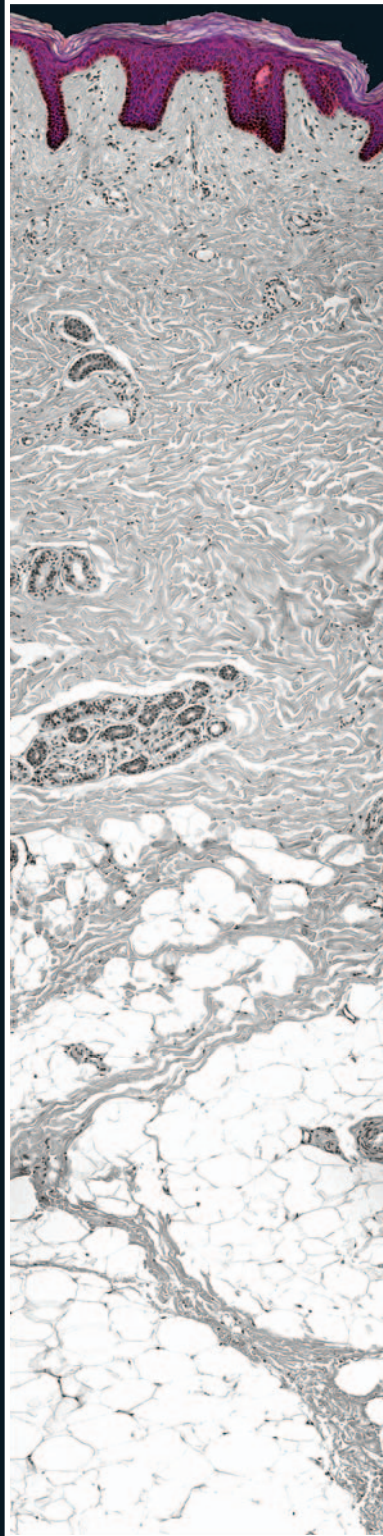
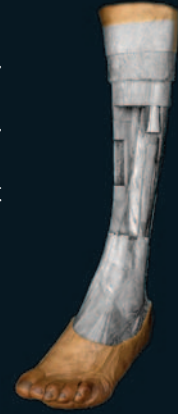
**Step dissection of leg showing layers of the integument**  
Anterolateral view



**Integument**  
Section of integument, 100x

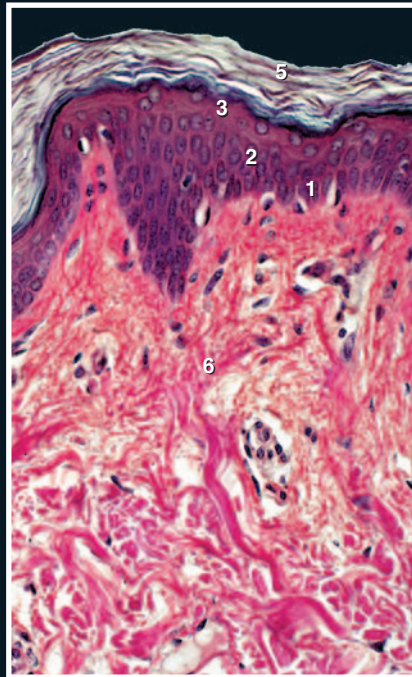
# Skin - Epidermis

The stratified squamous epithelial epidermis is the superficial layer of the skin. This cellular layer and its derivatives — hairs, nails, and glands — is the most recognizable part of our anatomy. It can range in thickness from a .10 mm (0.0039 in) on the eyelids to 1.5 mm (0.059 in) on the palms and soles. Keratinocytes are the primary cells of the epidermis. They proliferate from the stratum basale and differentiate as they push toward the surface, where they eventually form dead cells filled with the protein keratin. Also present in the basal layer are melanocytes that produce the brown pigment melanin to protect the skin from the ultraviolet radiation from the sun.

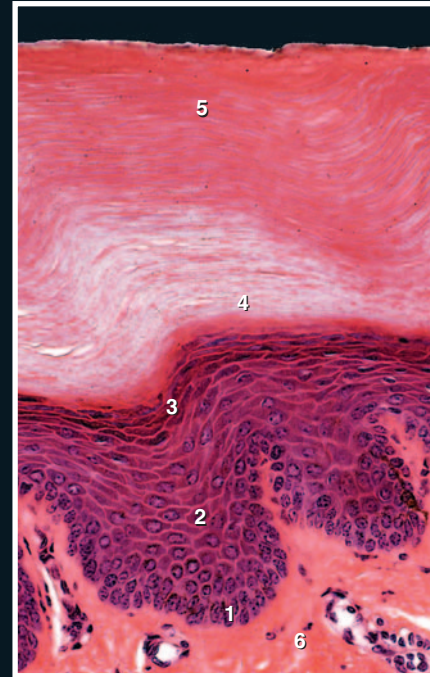


Epidermis of integument  
100x

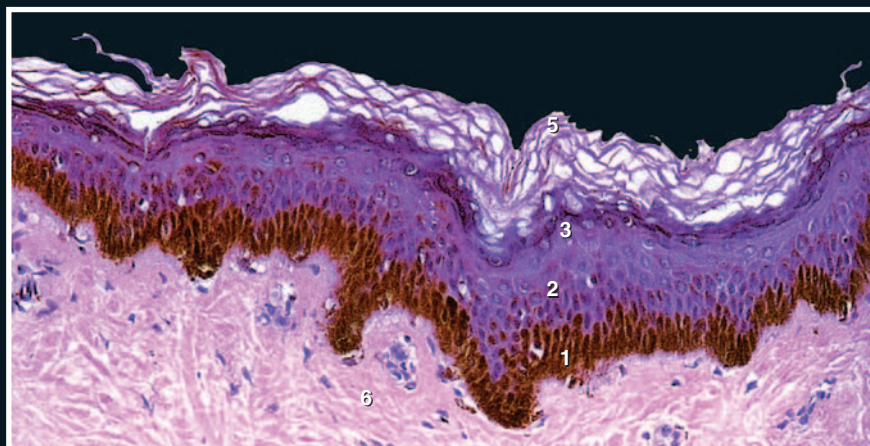
- |                      |                               |
|----------------------|-------------------------------|
| 1 Stratum basale     | 4 Stratum lucidum             |
| 2 Stratum spinosum   | 5 Stratum corneum             |
| 3 Stratum granulosum | 6 Connective tissue of dermis |



Epidermis of skin of a Caucasian  
Section of thin skin, 200x



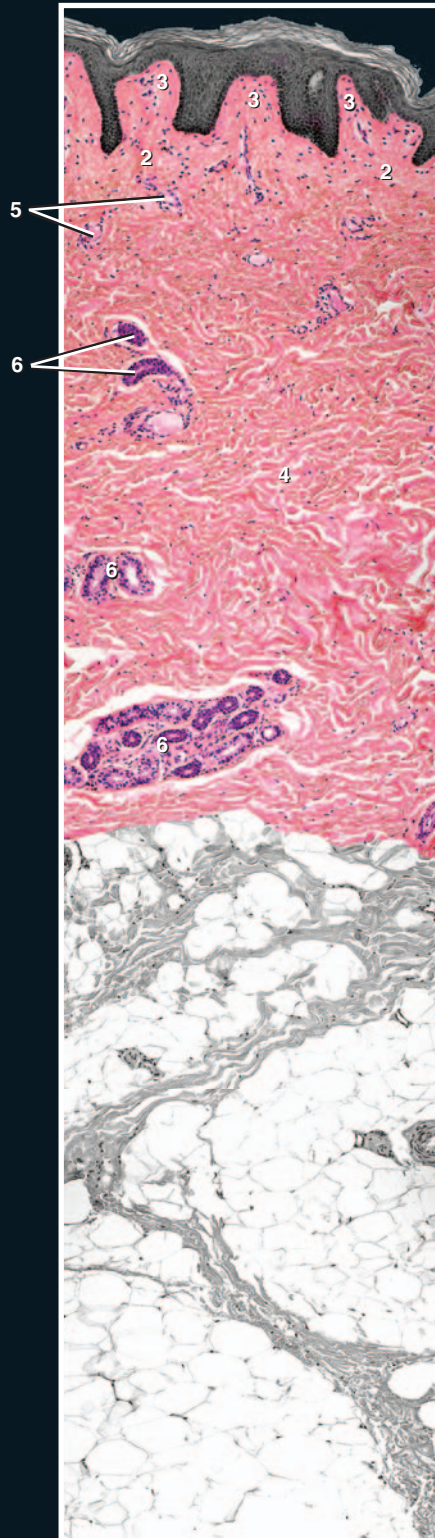
Epidermis of skin of a Caucasian  
Section of thick palmar skin, 200x



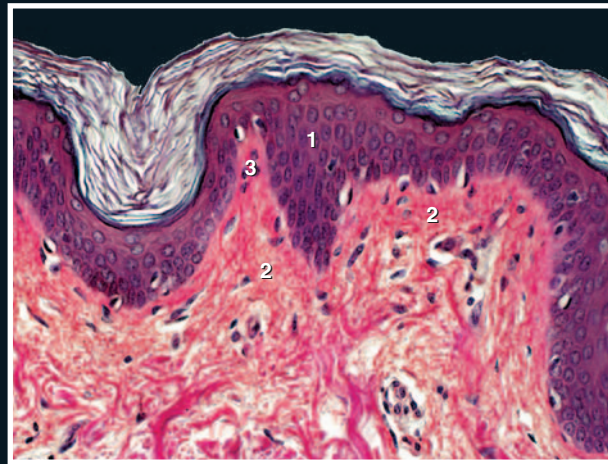
Epidermis of skin of a black  
Section of thin skin, 200x

# Skin - Dermis

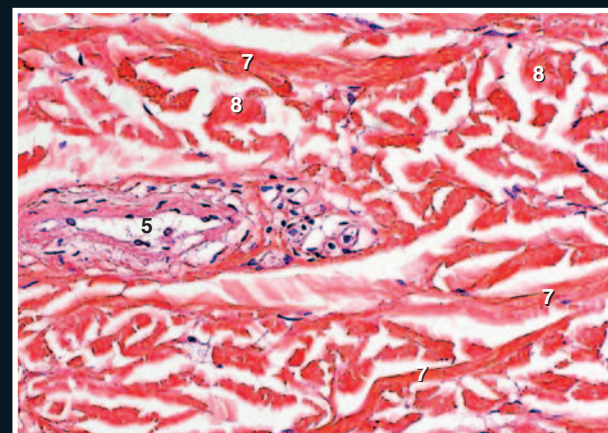
The connective tissue dermis sits deep to the epidermis where it forms the strong binding layer of the skin. The zone of interface between the dermis and epidermis is an intricate peg and socket-like arrangement between the two layers. The dermal pegs are called dermal papillae. This arrangement has multiple functions. It assures that the two layers are strongly united, it increases the surface area to improve the blood supply to the avascular epidermis, and it increases the contact surface for sensory receptors. On the palms and soles the arrangement of the dermal papillae creates the friction ridges we call fingerprints.



**Dermis of integument**  
100x

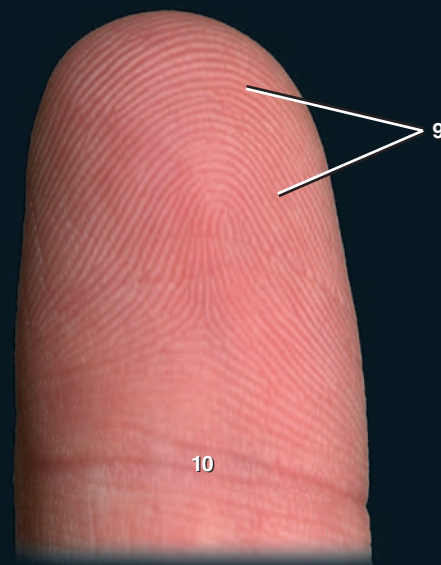


**Loose connective tissue of stratum papillare**  
Section of dermis, 200x



**Dense irregular connective tissue of stratum reticulare**  
Section of dermis, 200x

- 1 Epidermis
- 2 Loose connective tissue of stratum papillare
- 3 Dermal papilla of the stratum papillare
- 4 Dense connective tissue of stratum reticulare
- 5 Blood vessel in dermis
- 6 Sweat glands in dermis
- 7 Longitudinal collagen fibers
- 8 Transverse collagen fibers
- 9 Friction ridges formed by dermal papillae
- 10 Flexion crease line

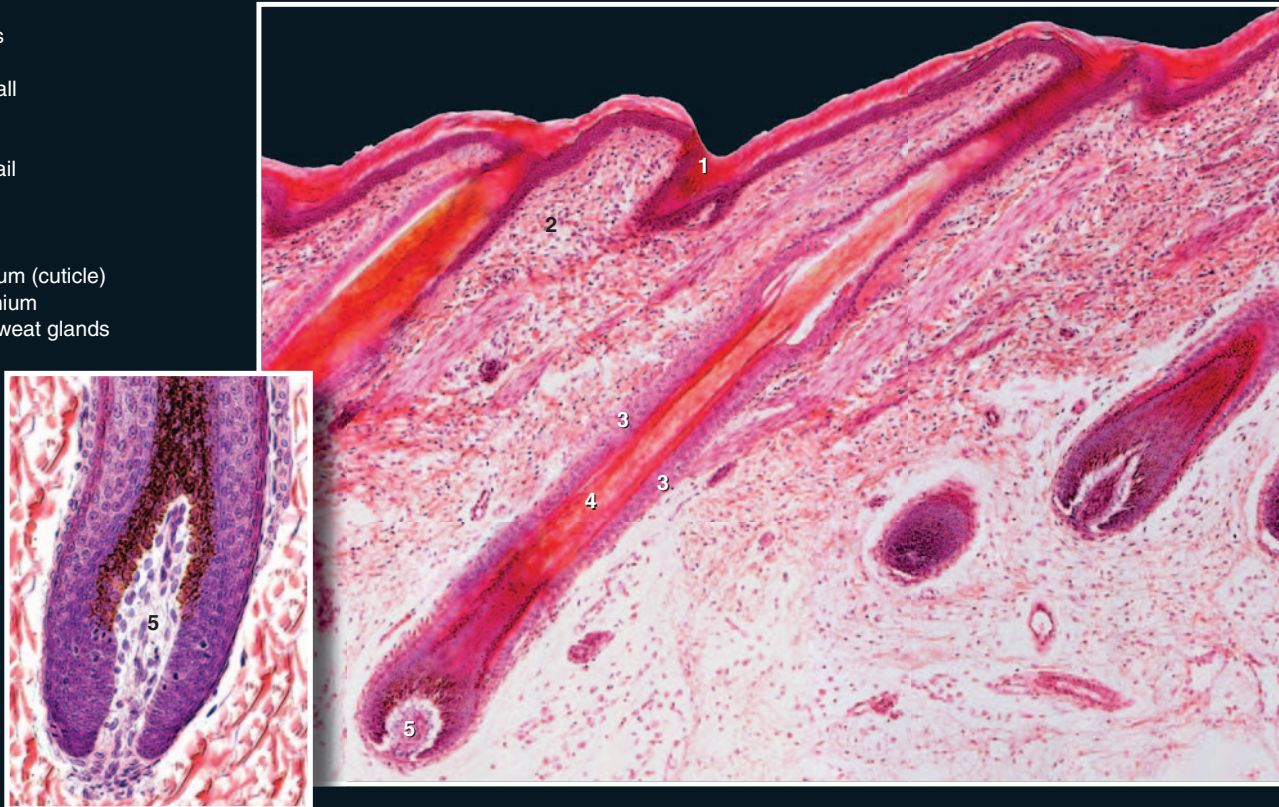


**Friction ridges (fingerprints) of right index finger**  
Anterior view

# Skin - Hairs and Nails

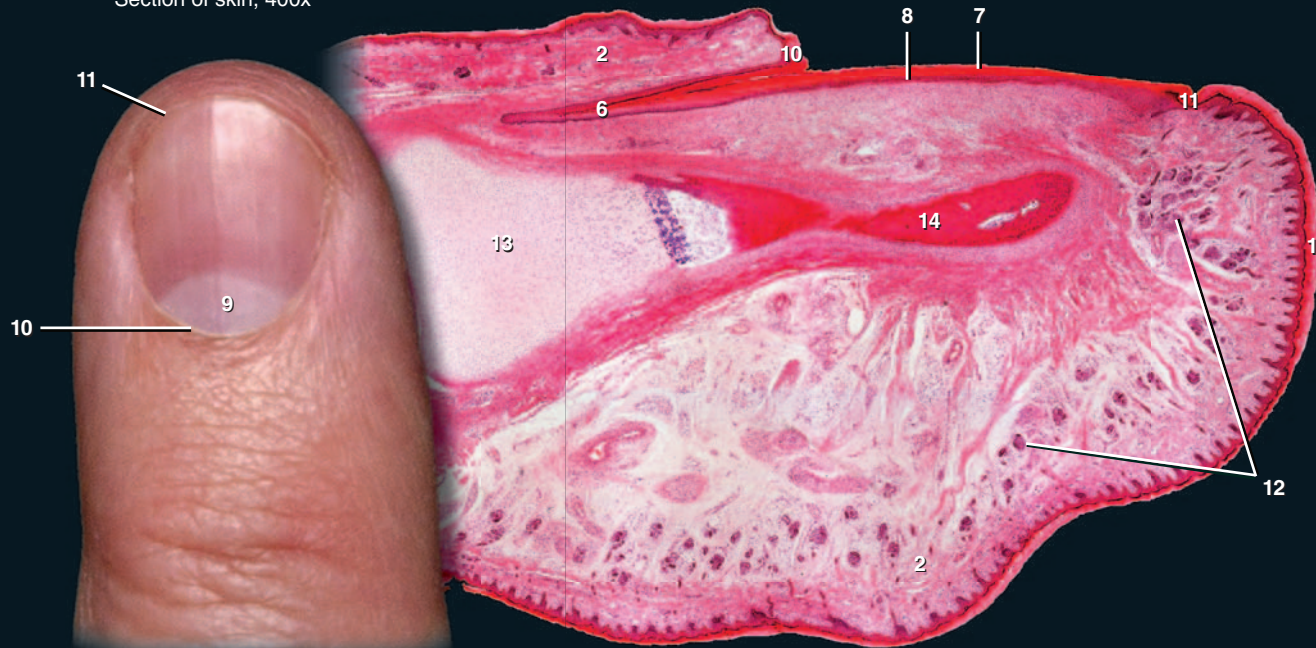
During embryonic and fetal development, the epithelial cells of the epidermis push down (invaginate) into the connective tissue dermis. This developmental process creates a hair follicle, a baglike extension of the epidermis that projects into the dermis and is responsible for producing the hair. The hair is a column of dead keratinocytes that arise from the basal keratinocytes at the bottom of the hair follicle. A sebaceous gland, also derived from the epidermal epithelium, empties into the hair follicle, and a small band of dermal smooth muscle, the arrector pili muscle, attaches to the base of the follicle. When the muscle shortens it produces "goose bumps" on the surface of the skin and causes the hair to "stand up." Nails also arise from invaginations that produce the shallow nail fold and root. A plate of strongly keratinized tissue emerges from the nail root to cover the dorsal ends of the fingers and toes.

- 1 Epidermis
- 2 Dermis
- 3 Follicle wall
- 4 Hair
- 5 Papilla
- 6 Root of nail
- 7 Nail
- 8 Nail bed
- 9 Lunula
- 10 Eponychium (cuticle)
- 11 Hyponychium
- 12 Eccrine sweat glands
- 13 Cartilage
- 14 Bone



**Hair bulb**  
Section of skin, 400x

**Hair follicle**  
Section of skin, 100x



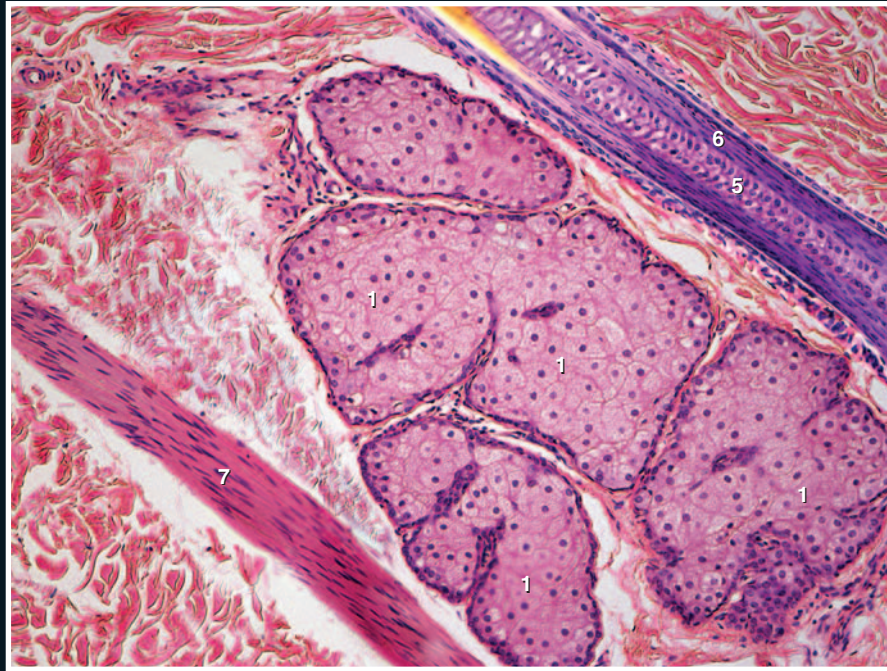
**Fingernail of an adult**  
Dorsal view

**Finger of a child**  
Longitudinal section, 50x

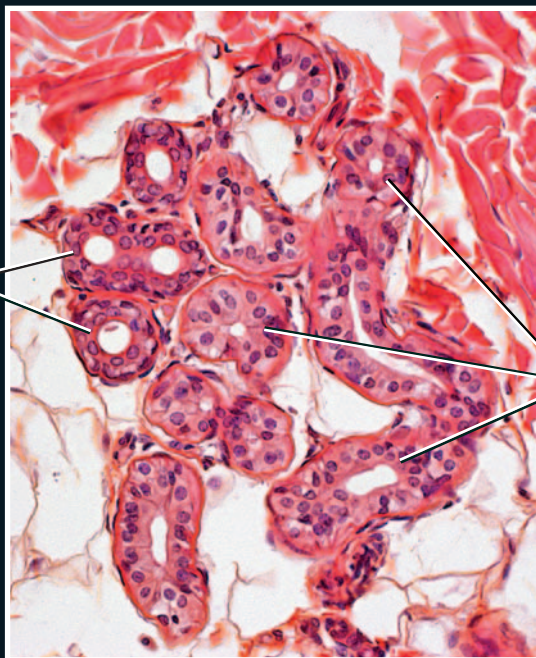
# Skin - Glands

Like hairs, glands arise as invaginations of the epidermis into the dermis during embryonic and fetal life. The three prominent glands of the skin are the sebaceous gland, the eccrine sweat gland, and the apocrine sweat gland. The sebaceous and apocrine sweat glands typically empty into a hair follicle, whereas the eccrine sweat gland empties onto the surface of the epidermis.

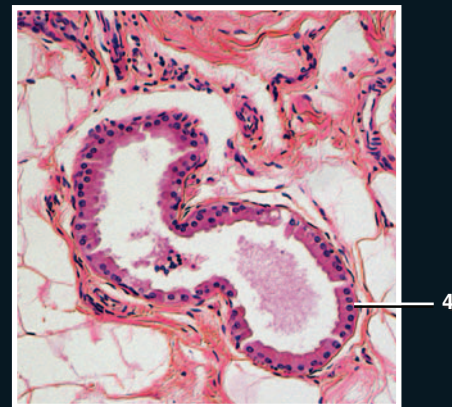
- |                             |                        |
|-----------------------------|------------------------|
| 1 Sebaceous secretory cells | 5 Hair                 |
| 2 Eccrine secretory cell    | 6 Hair follicle        |
| 3 Eccrine duct cell         | 7 Arrector pili muscle |
| 4 Apocrine secretory cell   |                        |



**Sebaceous gland**  
Section of dermis, 200x



**Eccrine sweat gland**  
Section of dermis, 200x



**Apocrine sweat gland**  
Section of thin skin, 200x

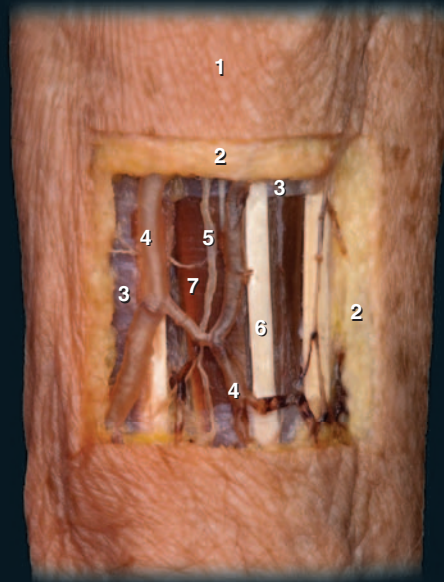
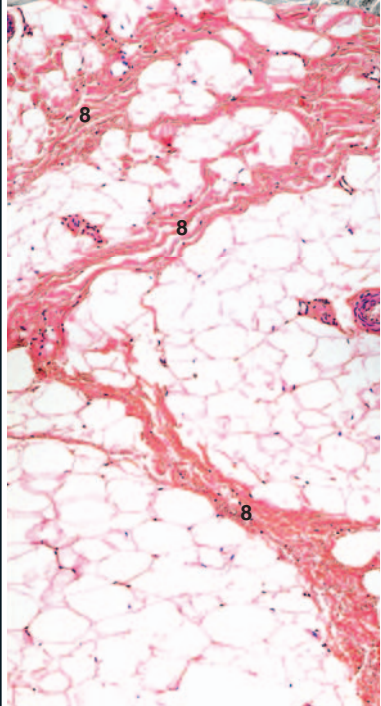
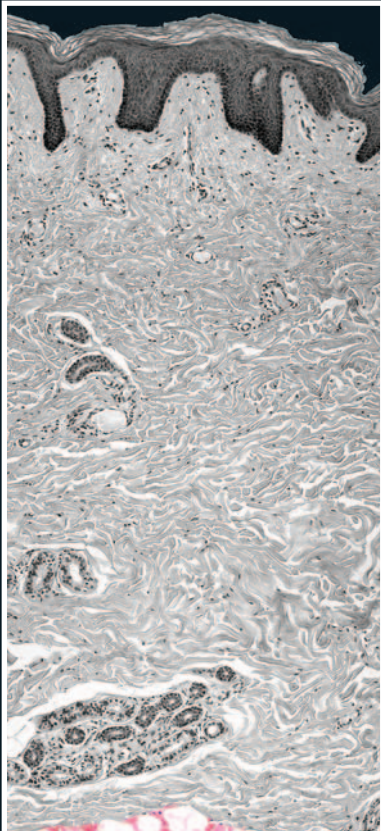
# Subcutaneous Layer

The subcutaneous layer, also called the hypodermis, is a layer of variable thickness that ranges from a thin layer of loose connective tissue to a

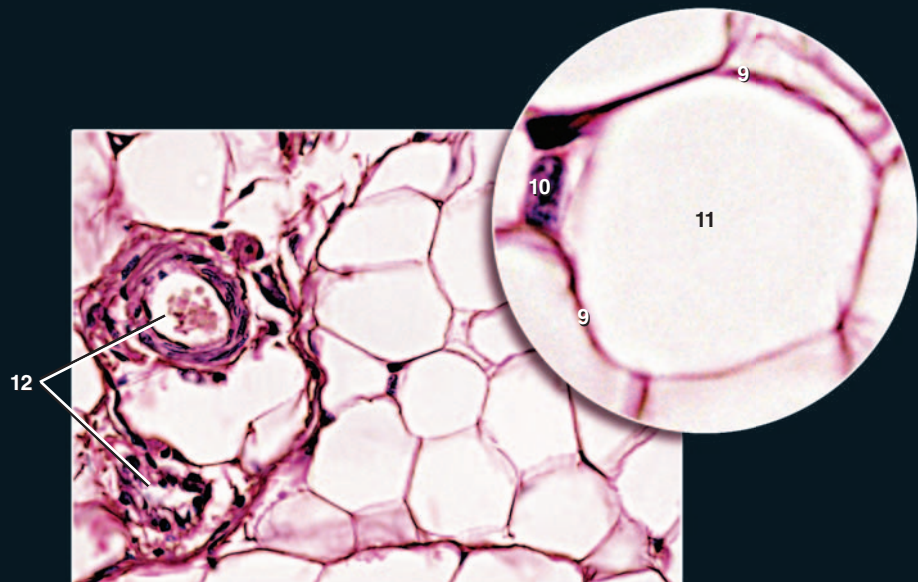
thick fibroadipose layer. This layer is a prominent location of fat storage in the body. In addition, it functions as an insulative layer and is the site of distribution of the main venous drainage channels of the integument and the cutaneous nerves that supply the skin.



- |                      |  |
|----------------------|--|
| 1 Epidermis of skin  | 7 Muscle                               |
| 2 Subcutaneous layer | 8 Retinaculum cutis                    |
| 3 Fascia             | 9 Adipose cell membrane                |
| 4 Superficial veins  | 10 Nucleus of adipose cell             |
| 5 Cutaneous nerve    | 11 Fat storage vacuole of adipose cell |
| 6 Tendon             | 12 Blood vessel                        |



**Superficial veins and cutaneous nerves in the subcutaneous layer**  
Step dissection of antebrachial integument, anterior view



**Subcutaneous layer of integument**  
100x

**Subcutaneous adipose tissue (left), adipose cell (callout)**  
Section of subcutaneous layer, 200x and 640x

# 4

# Skeletal System

The skeletal system forms the internal framework for the soft tissues of the body. This is not a static framework, but a highly dynamic internal scaffolding. It is dynamic in many ways. On one hand, because of its jointed design, it shows extreme flexibility of movement when acted upon by muscles. At another extreme, the cells of skeletal tissue are constantly monitoring and changing the micro-structure of this amazing tissue called bone, providing it with maximal strength, toughness, and resilience. In addition to its dynamic role of support, it also serves a protective role for many organs of the body. This dynamic framework also exhibits a tremendous capacity for growth and repair. It is a storehouse of calcium ions, ions that play a significant role in many of the body's functions.

The skeleton consists of 206 separate bones, ignoring various sesamoid bones and the fact that some bones represent the fusion of multiple bones. These bones range in size from the small ear ossicles measuring a few millimeters in length to the large femur measuring up to fifty centimeters. The skeleton is divisible into two portions, the axial skeleton and the appendicular skeleton. The axial skeleton includes the cranium, vertebral column, ribs, and sternum. The appendicular skeleton consists of the bones of the limbs and their girdles. The individual bones of the skeleton come in a variety of shapes. Some are long and tubular, while others have the spread-winged appearance of a butterfly. Bones can be grouped into four shape categories. Although not that meaningful, the four categories descriptively group the bones. The four shape categories are: long bones, short bones, flat bones, and irregular bones. Long bones are unique in having a diaphysis or shaft with a medullary cavity. The other bone types lack this hollow tubular region. The short, flat, and irregular bones are similar in having outer plates of compact bone surrounding internal centers of spongy bone. In general, long bones and short bones are found in the appendicular skeleton, while flat bones and irregular bones occur in the axial skeleton. In the right hands, the skeleton can be a library of information. Its markings, foramina, landmarks, and canals each tell a story about the soft tissues of the body. A strong foundation of skeletal anatomy is an important starting point in understanding anatomy.

This chapter covers bone tissue and the general structure of bones and the skeleton. In the two chapters that follow you will explore the two subdivisions of the skeleton — the axial skeleton and the appendicular skeleton.

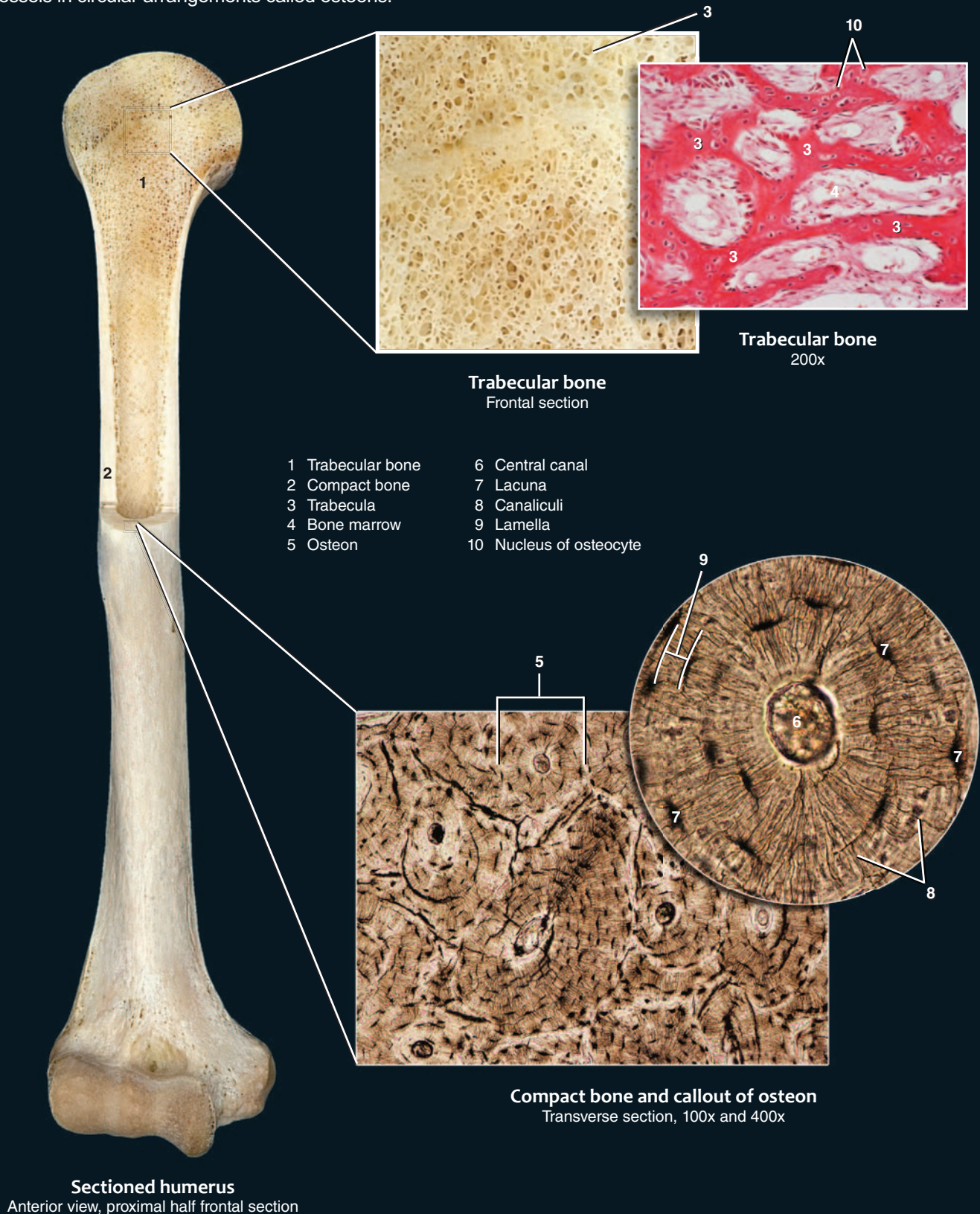


Find more information  
about the skeletal system in

**REALANATOMY**

# Bone Tissue

The tissue bone has two general forms — trabecular or spongy bone and compact bone. Trabecular bone is an internal bone that always resides deep to the more dense compact bone. Like its name implies, trabecular bone has many small beams of bone tissue connected together in complex array around obvious spaces in the tissue. To the unaided eye this gives the bone a spongy appearance. Bone marrow fills the spaces in the trabecular bone. The second type of bone tissue, compact bone, is very dense and solid looking to the unaided eye. Compact bone forms the outer surface of all bones and can range in thickness from paper thin to many centimeters thick. Microscopic analysis of this dense bone reveals that it has many microscopic spaces containing cells and blood vessels in circular arrangements called osteons.



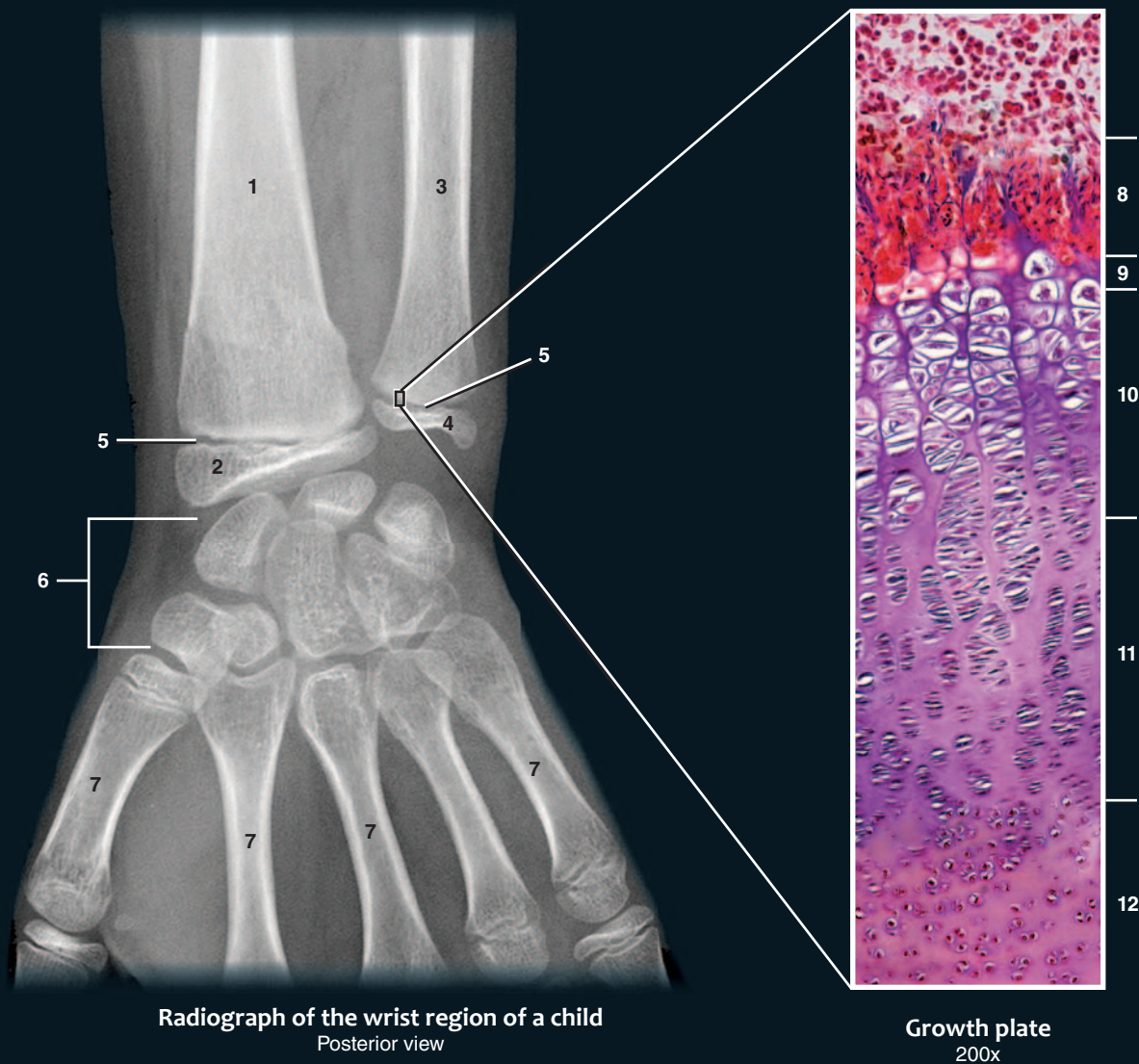
- 1 Trabecular bone
- 2 Compact bone
- 3 Trabecula
- 4 Bone marrow
- 5 Osteon
- 6 Central canal
- 7 Lacuna
- 8 Canaliculi
- 9 Lamella
- 10 Nucleus of osteocyte



# Cartilage Growth Plate

Bone tissue forms during development by either replacing cartilage tissue precursors (endochondral ossification) or by developing within mesenchymal connective tissue (intramembranous ossification). In endochondral ossification cartilaginous growth plates remain between developing bone centers to allow a bone to increase in length and size. During an individual's young life, the growth plates are evident on a radiograph and are a clear indication that the individual is still growing.

- |                    |                                    |
|--------------------|------------------------------------|
| 1 Radial diaphysis | 7 Metacarpal bones                 |
| 2 Radial epiphysis | 8 Developing diaphysial bone       |
| 3 Ulnar diaphysis  | 9 Zone of calcified cartilage      |
| 4 Ulnar epiphysis  | 10 Zone of hypertrophied cartilage |
| 5 Growth plate     | 11 Zone of proliferating cartilage |
| 6 Carpal bones     | 12 Zone of resting cartilage       |



Radiograph of the wrist region of a child  
Posterior view

Growth plate  
200x

# Bone Types

The bones of the skeleton come in a variety of sizes and shapes. The form of each bone emerges from its position and functional role in the skeletal system. In an effort to classify the different bones of the body anatomists define four general categories of bones based on their size and shape. Long bones, as their name suggests, are longer in one dimension than any other dimension. The long bones range in size from the short phalanges of the digits to the long proximal humerus and femur of the limb skeletons. Conversely, short bones are small, block-like bones. Like the long bones, short bones occur in the limb skeletons where they form the bones of the wrist and ankle. Flat bones are plate-like bones and are common in the cranium. The final category, irregular bones, is a mixed group of bones that have a variety of shapes and locations within the skeleton.



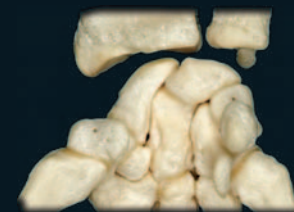
Flat bones



Long bones



Irregular bones



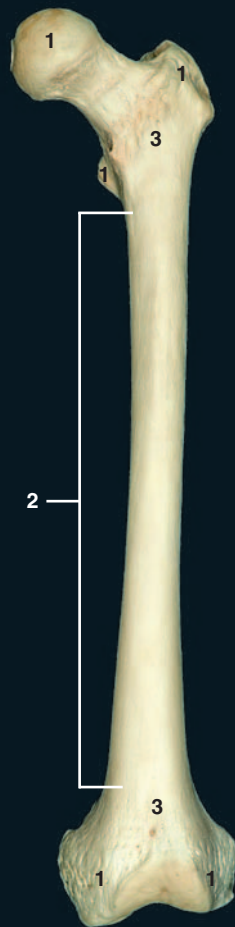
Short bones

# Anatomy of a Bone

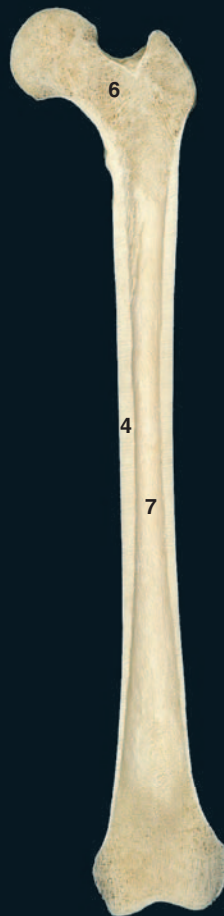
occupies the core of the bone beneath the compact bone. Areas of compact bone covered by articular cartilage form smooth subchondral compact bone surfaces. These subchondral bone surfaces mark the joint surfaces of bones. The photos below illustrate the basic parts and features of a long bone.

All bones share basic features in common. Compact bone tissue forms all the visible outer surface of the bone and can vary from a paper-thin covering to a thick wall of bone. Trabecular bone tissue

- 1 Epiphyses
- 2 Diaphysis
- 3 Metaphysis
- 4 Compact bone
- 5 Subchondral bone
- 6 Trabecular bone
- 7 Medullary cavity
- 8 Epiphysial line



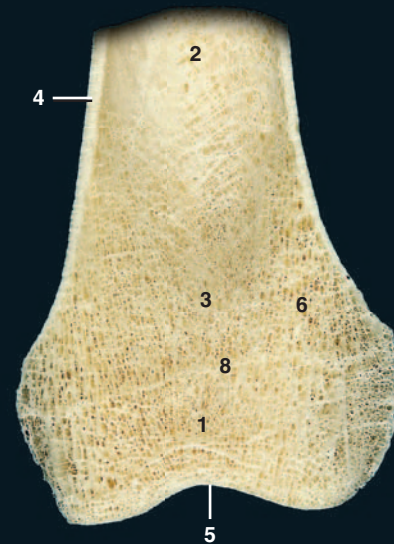
**Femur**  
Anterior view



**Femur**  
Frontal section



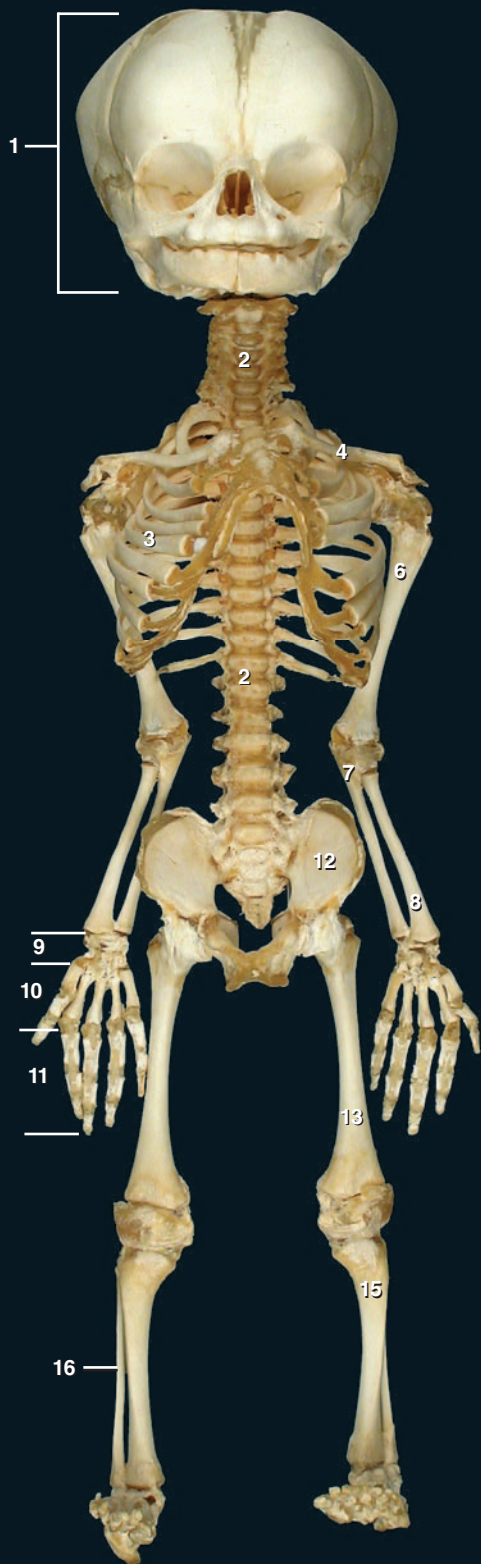
**Proximal end of femur**  
Frontal section



**Distal end of femur**  
Frontal section

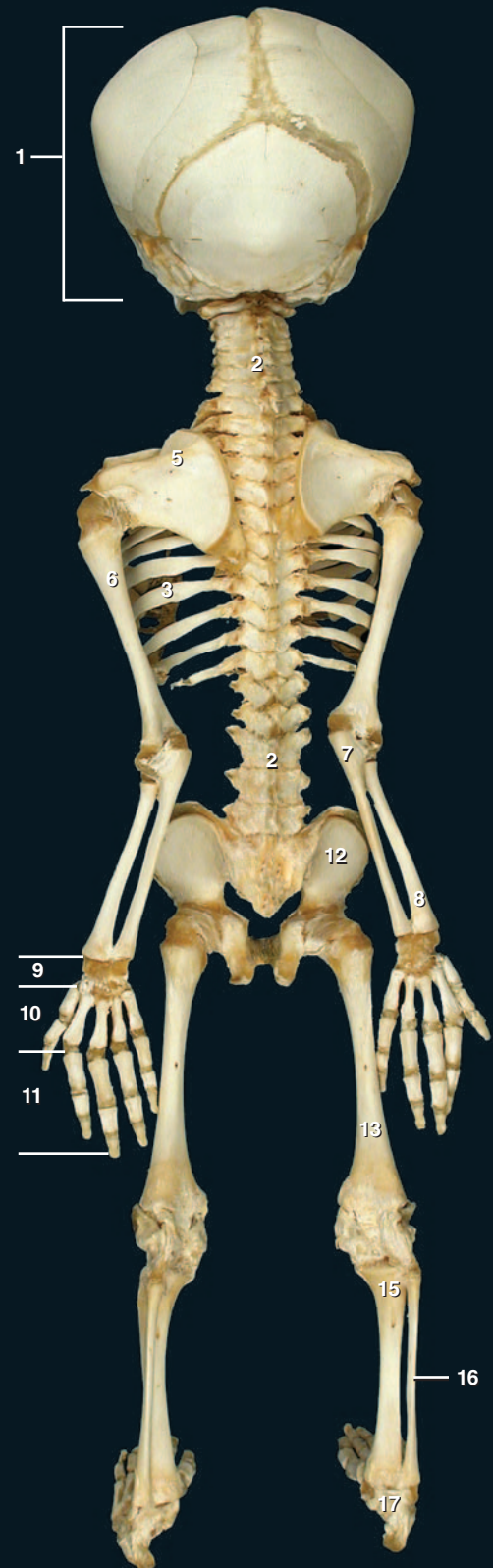
# Skeleton

The first appearance of the skeletal elements arises during the second month of embryonic life when connective tissue and cartilage precursors to the bones arise. Slowly through fetal life, childhood, puberty, and the teenage years the bones mature into their adult forms. This developmental process combines more than 500 bone-forming centers into the final 206 bones of the skeleton. This page, the facing page, and the page that follows depict changes in the skeleton from a newborn to an adult.

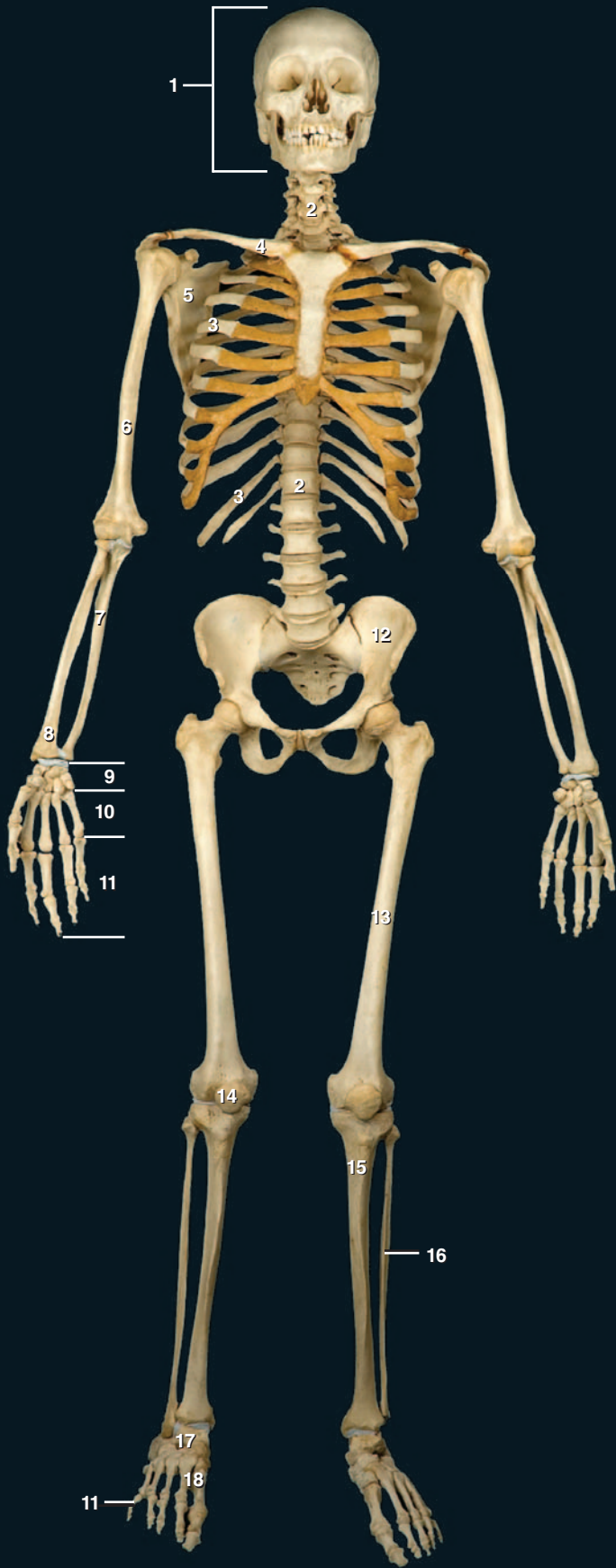


Newborn skeleton  
Anterior view

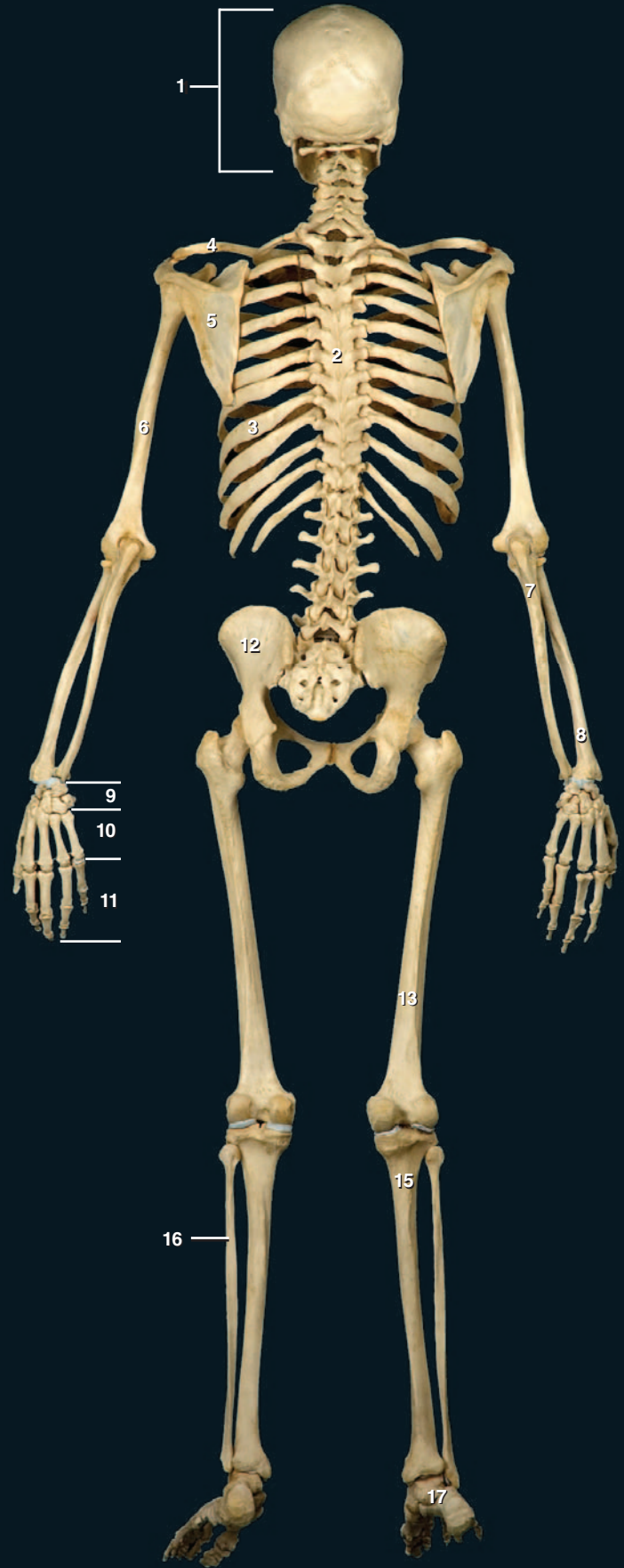
- 1 Cranial bones
- 2 Vertebral column
- 3 Ribs
- 4 Clavicle
- 5 Scapula
- 6 Humerus
- 7 Ulna
- 8 Radius
- 9 Carpals
- 10 Metacarpals
- 11 Phalanges
- 12 Os coxae
- 13 Femur
- 14 Patella
- 15 Tibia
- 16 Fibula
- 17 Tarsals
- 18 Metatarsals



Newborn skeleton  
Posterior view

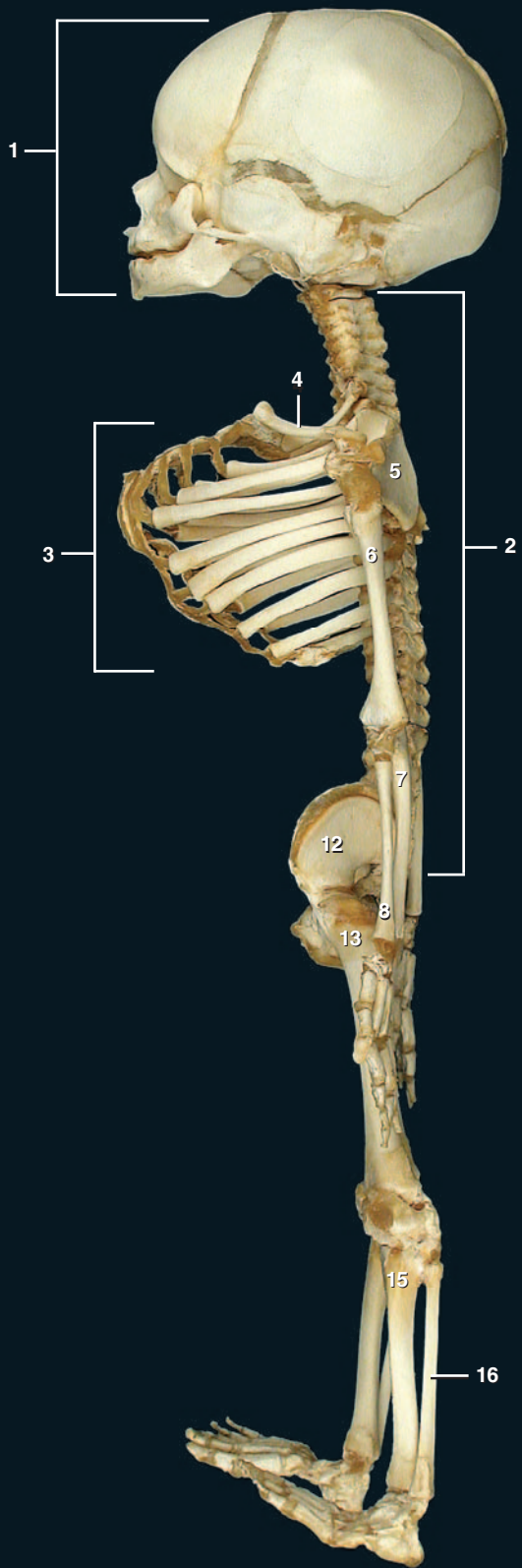


**Adult skeleton**  
Anterior view

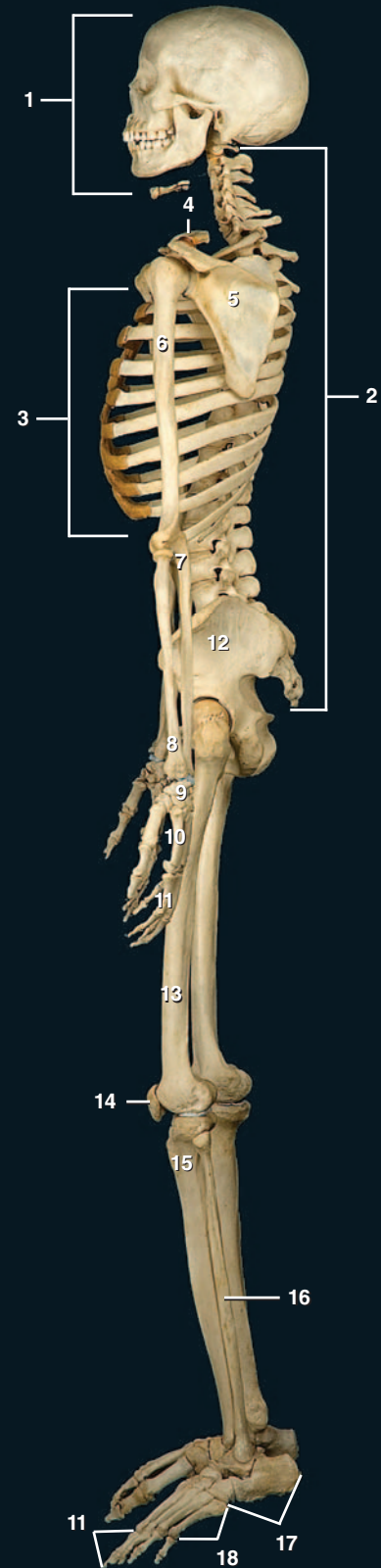


**Adult skeleton**  
Posterior view

- |                    |                |                |
|--------------------|----------------|----------------|
| 1 Cranial bones    | 7 Ulna         | 13 Femur       |
| 2 Vertebral column | 8 Radius       | 14 Patella     |
| 3 Ribs             | 9 Carpals      | 15 Tibia       |
| 4 Clavicle         | 10 Metacarpals | 16 Fibula      |
| 5 Scapula          | 11 Phalanges   | 17 Tarsals     |
| 6 Humerus          | 12 Os coxae    | 18 Metatarsals |



**Newborn skeleton**  
Lateral view



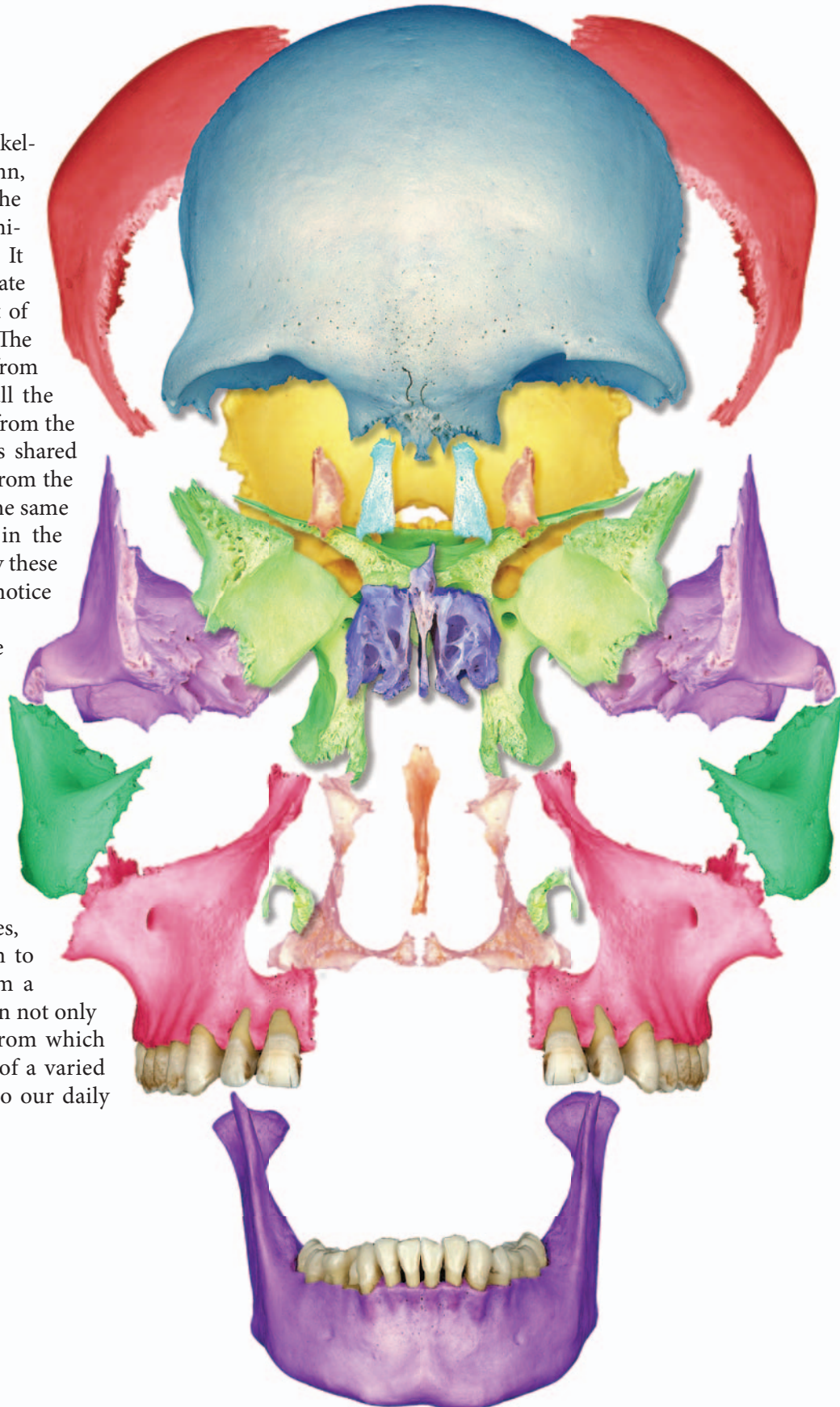
**Adult skeleton**  
Lateral view

# 5

# Axial Skeleton

The axial skeleton, comprised of the skull, vertebral column, ribs, and sternum, forms the central axis of the body. This sturdy central core is the most primitive portion of the vertebrate skeletal system. It evolved as the initial skeleton of the first vertebrate animals, to which the limb bones (the subject of the next chapter) were much later additions. The majority of the axial skeleton's bony elements, from the bones at the base of the skull through all the vertebrae and ribs, form as serial homologues from the segmental embryonic somites. Because of this shared developmental similarity each body segment, from the base of the skull to the end of the coccyx, has the same basic skeletal design. This is clearly evident in the structure of the vertebrae and ribs. As you study these skeletal elements in the photos of this chapter, notice their similarities.

The elements of the axial skeleton have many functional roles in the body. Both the cranial skeleton and the vertebral column form a strong protective case around the delicate tissues of the central nervous system. Additionally, the cranium fixes in space important nervous structures, such as the internal ear and eye, both of which would not function properly in an unstable environment. The cranium also plays an important role in the acquisition and processing of food, respiratory gases, and sensory input such as sound. In addition to protecting the spinal cord, the vertebrae form a strong, flexible rod. This strong, flexible column not only forms the central support axis of the body from which the limbs are suspended, but is also capable of a varied range of joint movements that are essential to our daily functions.



Find more information  
about the axial skeleton in

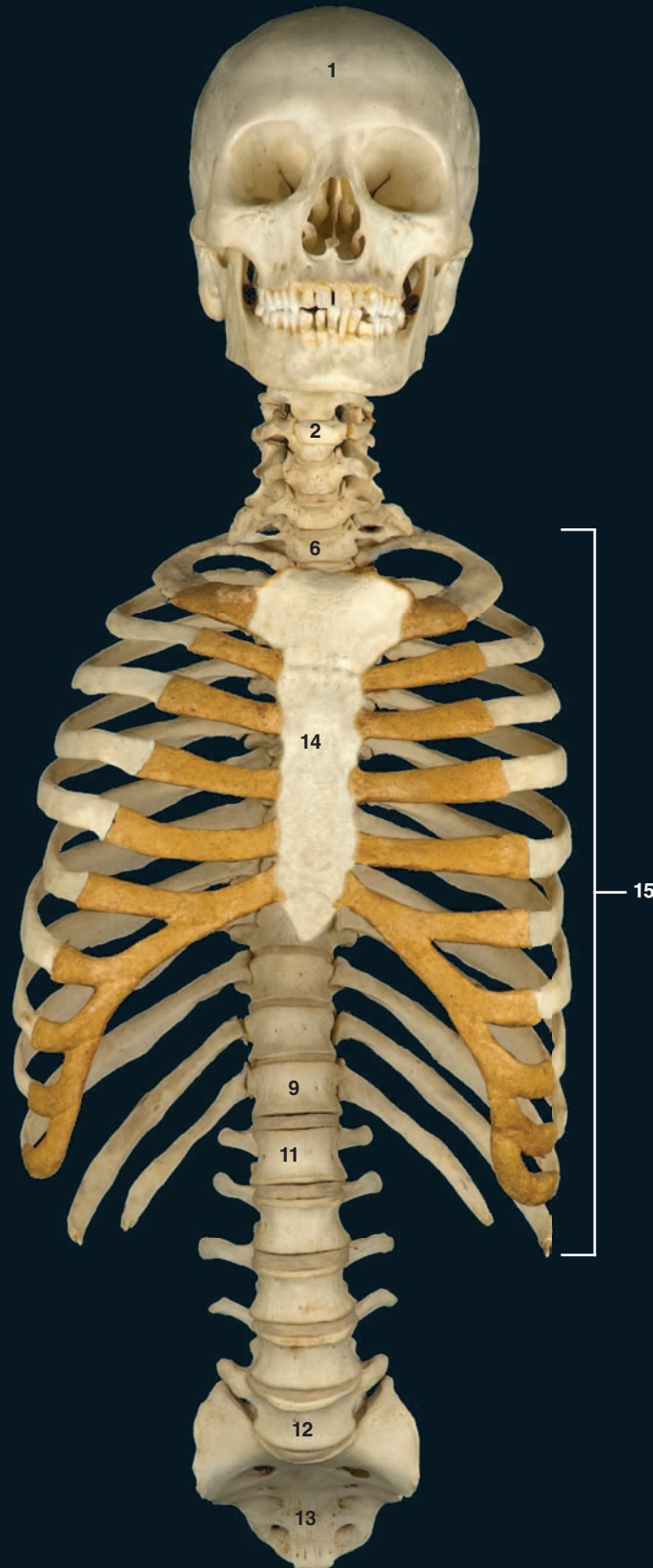
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# Axial Skeleton

The axial skeleton is clearly depicted in the photos below. Note that this portion of the skeleton consists of three principal skeletal regions — the cranium, the vertebral column, and the rib cage. There are 29 cranial bones, 26 vertebral bones, and 25 bones in the rib cage. On the pages that follow, each of the axial skeletal regions and the respective bones will be explored in greater detail.

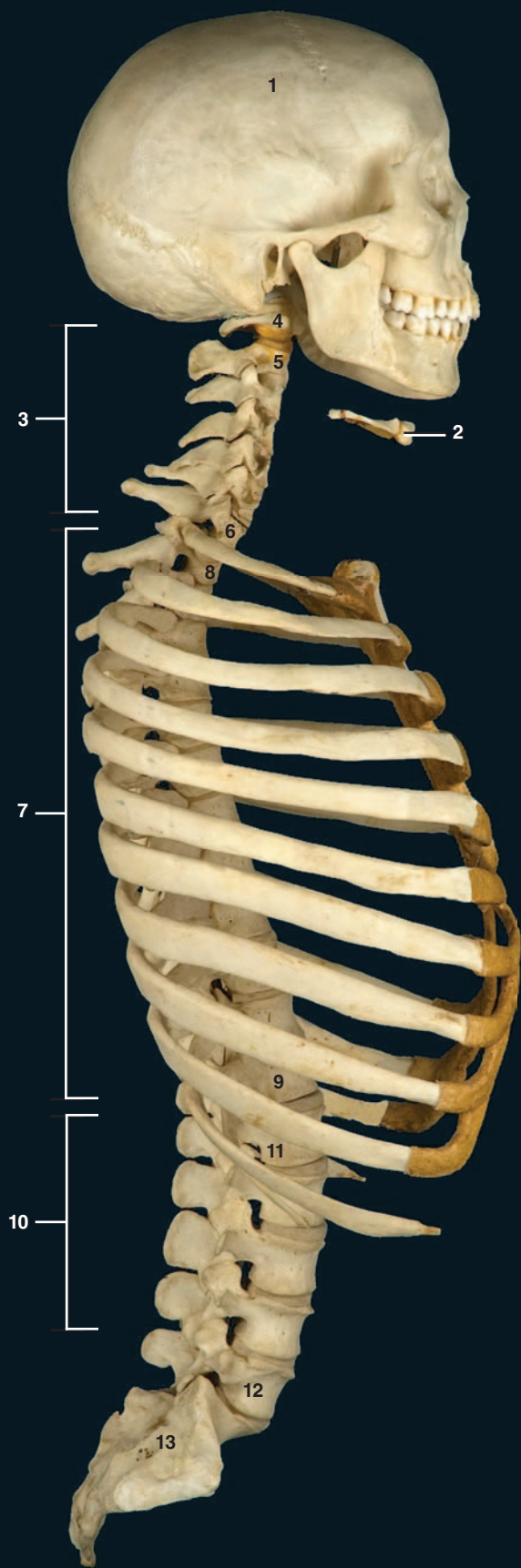


- 1 Cranium
- 2 Hyoid bone
- 3 Cervical vertebral column
- 4 Cervical vertebra 1 - Atlas
- 5 Cervical vertebra 2 - Axis
- 6 Cervical vertebra 7
- 7 Thoracic vertebral column
- 8 Thoracic vertebra 1
- 9 Thoracic vertebra 12
- 10 Lumbar vertebral column
- 11 Lumbar vertebra 1
- 12 Lumbar vertebra 5
- 13 Sacrum
- 14 Sternum
- 15 Ribs

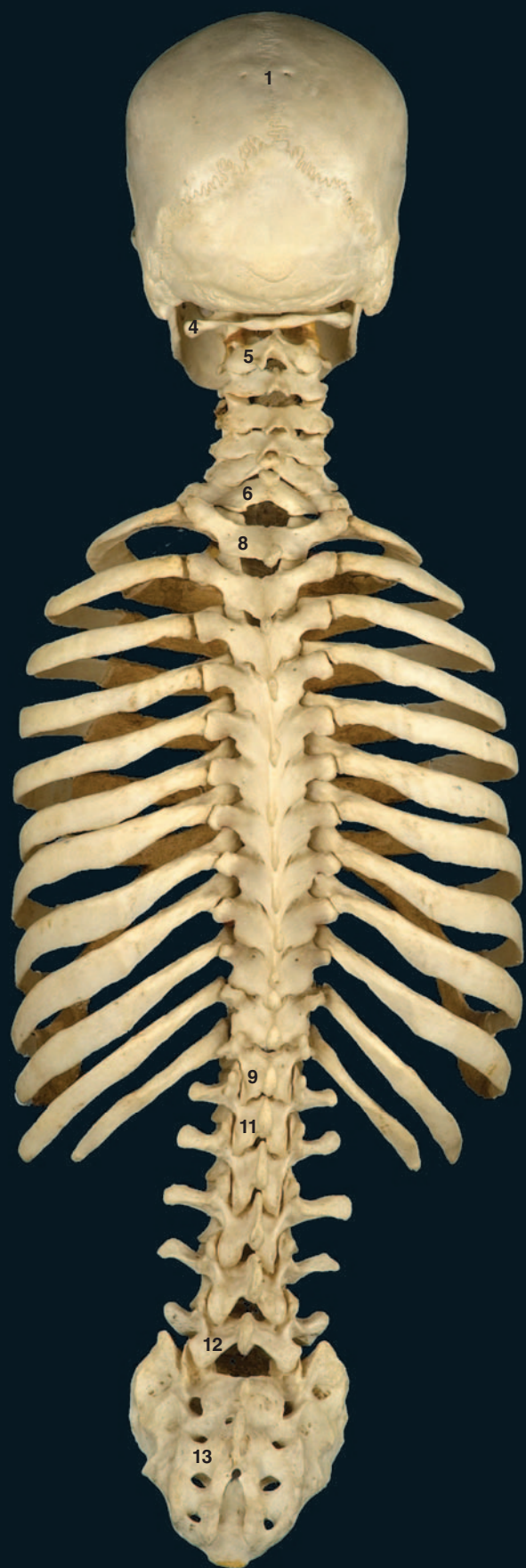


**Axial skeleton**  
Anterior view





**Axial skeleton**  
Lateral view



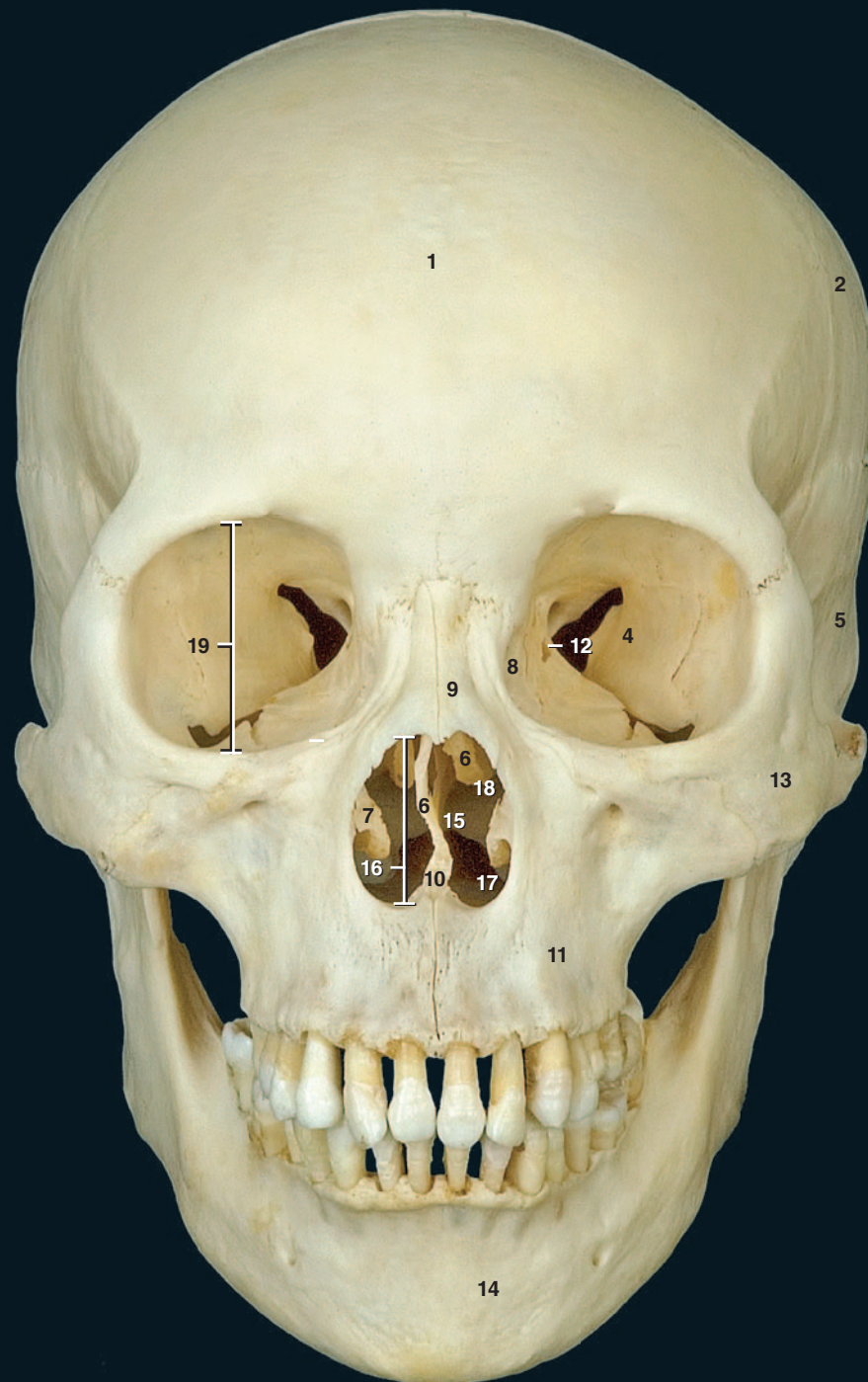
**Axial skeleton**  
Posterior view

# Cranium

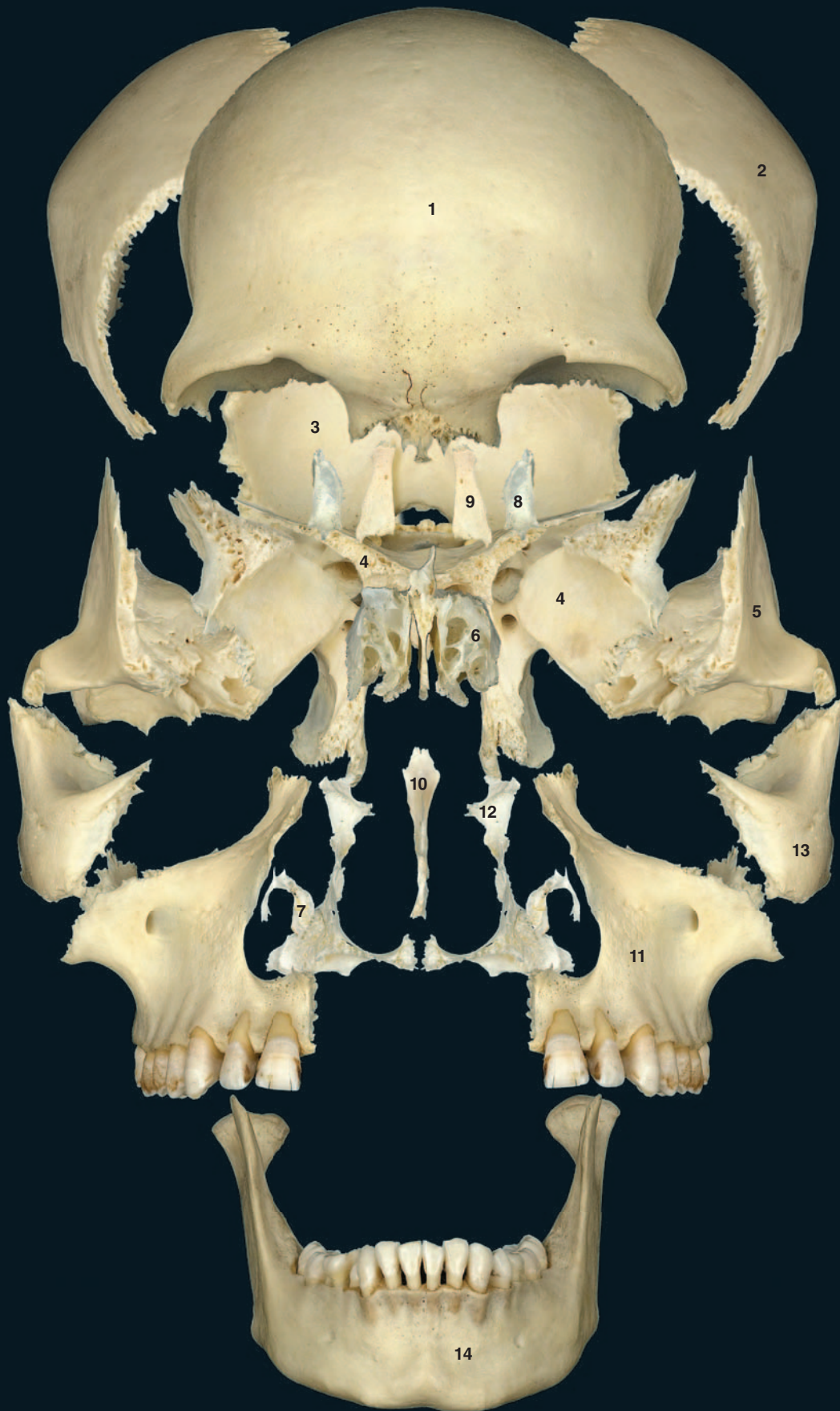
The cranium is the composite skeleton of the head and is composed of 29 bones. The bones of the cranium range from simple, non-descript plates of bone to the most intricate bones of the skeleton. The cranial bones have a range of important functions, that include protecting the delicate brain tissue, fixing the vestibular apparatus of the inner ear in three-dimensional space, maintaining open air passageways for respiration, and acquiring and processing food, to name a few. There are two main subdivisions of the cranium — the neurocranium or brain box is the region that surrounds and encases the brain, and the viscerocranium or facial skeleton is the area contributing to the orbits, nasal cavity, and oral cavity. This page and the facing page, and the four page spreads that follow, depict the five normas, or views, of the cranium in both articulated and disarticulated cranial images. The bones of the skull are labeled on these views, along with key landmarks that can only be labeled on the articulated cranium. Individual landmarks of the bones are labeled on the individual pictures of the cranial bones on the pages that follow. This spread is of the norma facialis or facial aspect of the cranium.



- 1 Frontal bone
- 2 Parietal bone
- 3 Occipital bone
- 4 Sphenoid bone
- 5 Temporal bone
- 6 Ethmoid bone
- 7 Inferior nasal concha
- 8 Lacrimal bone
- 9 Nasal bone
- 10 Vomer
- 11 Maxilla
- 12 Palatine bone
- 13 Zygomatic bone
- 14 Mandible
- 15 Bony nasal cavity
- 16 Piriform aperture
- 17 Inferior nasal meatus
- 18 Middle nasal meatus
- 19 Orbit



**Cranium**  
Anterior view

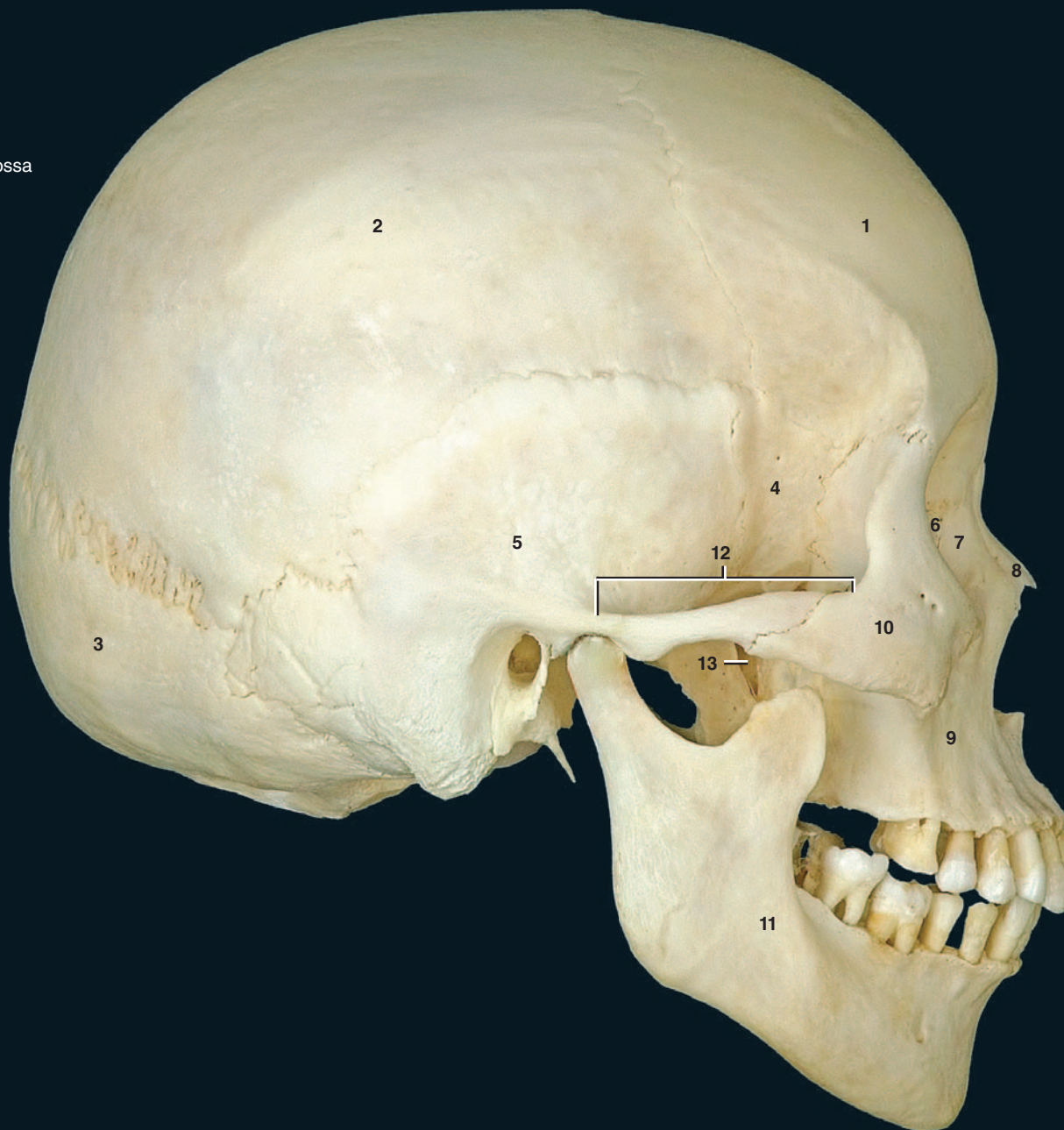


Bones of the cranium disarticulated  
Anterior view

# Cranium

This page spread depicts the norma lateralis, or lateral aspect of the cranium. In this view both the brain box and facial skeleton are clearly visible and the relative proportions of the two cranial regions are evident. In the disarticulated view, only those bones that are visible in the lateral aspect are shown.

- 1 Frontal bone
- 2 Parietal bone
- 3 Occipital bone
- 4 Sphenoid bone
- 5 Temporal bone
- 6 Ethmoid bone
- 7 Lacrimal bone
- 8 Nasal bone
- 9 Maxilla
- 10 Zygomatic bone
- 11 Mandible
- 12 Zygomatic arch
- 13 Pterygopalatine fossa



**Cranium**  
Lateral view

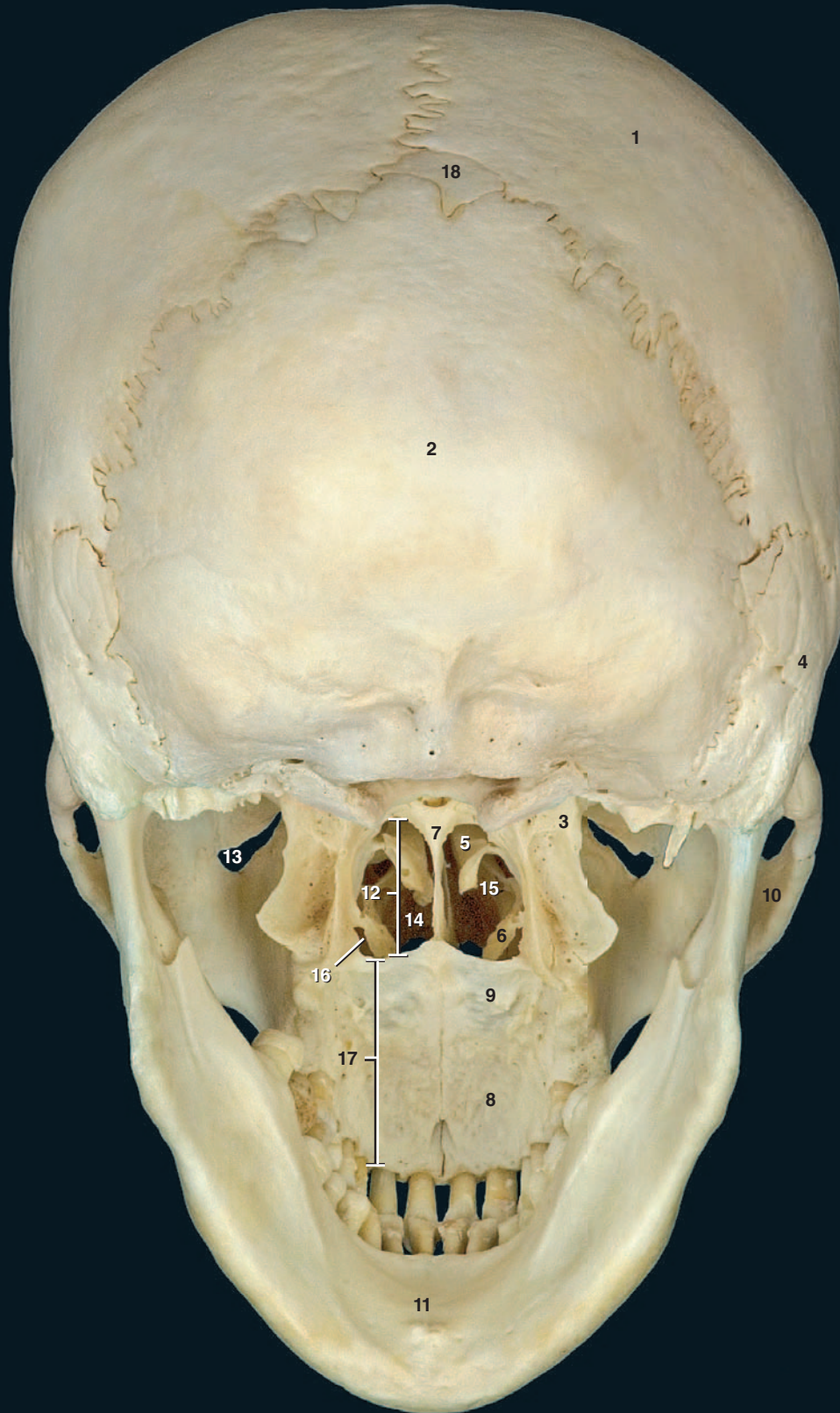


Bones of the cranium disarticulated  
Lateral view

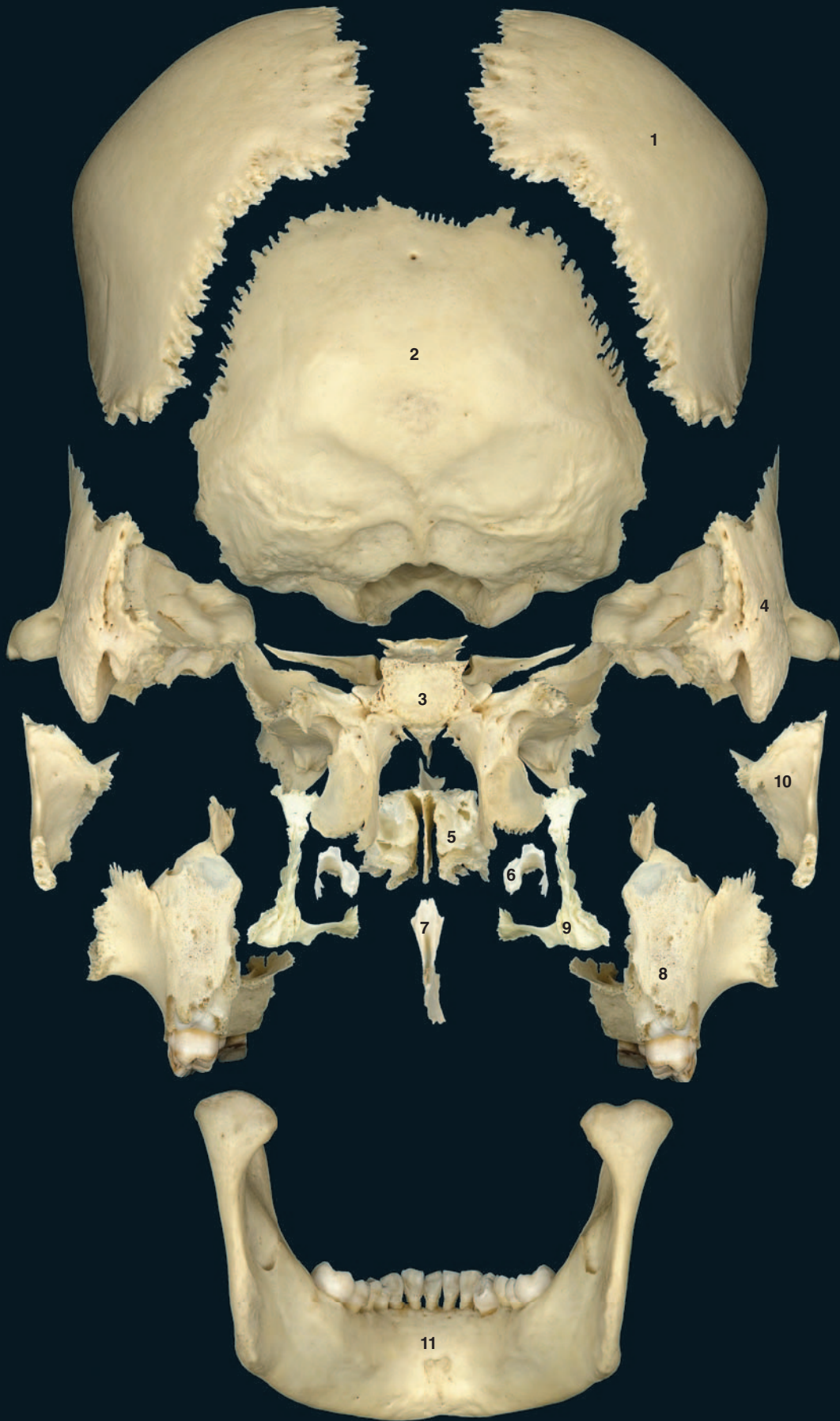
# Cranium

This page spread depicts the norma occipitalis, or occipital aspect of the cranium. From this posterior view the internal aspects of the bones of the oral and nasal cavities are clearly visible. In the disarticulated view only those bones that are visible in the occipital aspect of the cranium are depicted.

- 1 Parietal bone
- 2 Occipital bone
- 3 Sphenoid bone
- 4 Temporal bone
- 5 Ethmoid bone
- 6 Inferior nasal concha
- 7 Vomer
- 8 Maxilla
- 9 Palatine bone
- 10 Zygomatic bone
- 11 Mandible
- 12 Choana or posterior nasal aperture
- 13 Inferior orbital fissure
- 14 Bony nasal cavity
- 15 Middle nasal meatus
- 16 Inferior nasal meatus
- 17 Bony palate
- 18 Sutural bone



**Cranium**  
Posterior view



Bones of the cranium disarticulated  
Posterior view

# Cranium

This page spread depicts the norma superior, or superior aspect of the cranium. This view clearly depicts the neurocranium or brain box, while the facial skeleton is almost completely hidden from view. In the disarticulated view only those bones that are visible in the superior aspect of the cranium are depicted.

- 1 Frontal bone
- 2 Parietal bone
- 3 Occipital bone
- 4 Temporal bone
- 5 Nasal bone
- 6 Maxilla
- 7 Zygomatic bone



**Cranium**  
Superior view





Bones of the cranium disarticulated  
Superior view

# Cranium

This page spread depicts the norma inferior (basalis), or inferior aspect of the cranium. The mandible has been removed to more clearly reveal the basicranium. This view clearly depicts the floor of the brain box, the bony palate forming the roof of the oral cavity, and mandibular tooth row. In the disarticulated view only those bones that are visible in the inferior aspect of the cranium are depicted.

- 1 Occipital bone
- 2 Sphenoid bone
- 3 Temporal bone
- 4 Vomer
- 5 Maxilla
- 6 Palatine bone
- 7 Zygomatic bone
- 8 Bony palate
- 9 Choana or posterior nasal aperture
- 10 Zygomatic arch
- 11 Jugular foramen
- 12 Foramen lacerum
- 13 Greater palatine foramen
- 14 Incisive fossa



**Cranium**  
Inferior view



Bones of the cranium disarticulated  
Inferior view

# Cranium

This page spread depicts the cranium sectioned in a parasagittal plane through the right side of the nasal cavity just lateral to the bony nasal septum. The section below depicts the lateral wall of the right nasal cavity, and the section on the opposite page depicts the medial (septal) wall of the right nasal cavity. The osseous sinuses that communicate with the nasal cavity are all visible in these sections.



**Parasagittal section of the cranium**  
Medial view of the right side

- |                  |                         |                               |                                  |
|------------------|-------------------------|-------------------------------|----------------------------------|
| 1 Frontal bone   | 7 Inferior nasal concha | 13 External table of calvaria | 19 Ethmoidal air cells (sinuses) |
| 2 Parietal bone  | 8 Nasal bone            | 14 Diploë                     | 20 Maxillary sinus               |
| 3 Occipital bone | 9 Vomer                 | 15 Internal table of calvaria | 21 Incisive canal                |
| 4 Sphenoid bone  | 10 Maxilla              | 16 Groove for sigmoid sinus   | 22 Bony nasal septum             |
| 5 Temporal bone  | 11 Palatine bone        | 17 Sphenoidal sinus           | 23 Sphenopalatine foramen        |
| 6 Ethmoid bone   | 12 Mandible             | 18 Frontal sinus              | 24 Inferior nasal meatus         |



**Parasagittal section of the cranium**  
Medial view of the left side



- |                  |                  |                            |                            |
|------------------|------------------|----------------------------|----------------------------|
| 1 Frontal bone   | 5 Temporal bone  | 9 Foramen lacerum          | 13 Anterior cranial fossa  |
| 2 Parietal bone  | 6 Ethmoid bone   | 10 Jugular foramen         | 14 Middle cranial fossa    |
| 3 Occipital bone | 7 Clivus         | 11 Petrosphenoidal fissure | 15 Posterior cranial fossa |
| 4 Sphenoid bone  | 8 Foramen caecum | 12 Petro-occipital fissure | 16 Granular foveolae       |



**Removed calvaria**  
Inferior or internal view

# Cranial Bones – Frontal

The unpaired frontal bone has a bowl-like shape that consists of two parts, an internally concave

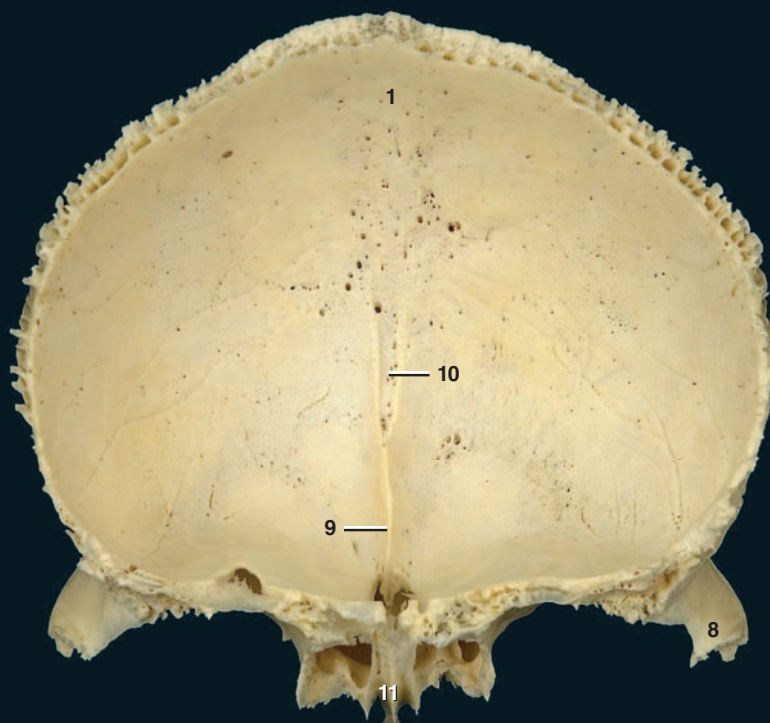
vertical portion termed the squama and a horizontal plate that forms the superior walls of the orbits. The bone has a smooth external surface, while its internal surface consists of impressions made by the meningeal vessels and scattered foramina that transmit diploic vessels. The squamous portion of the bone is thick. It consists of internal and external laminae of compact bone sandwiching a layer of trabecular bone called diploë. Near the anterior, inferior midline the spongy bone is absent between the external and internal laminae and in its place are variably sized spaces — the frontal sinuses. The orbital plate consists of a thin plate of compact bone, which is often so thin that it is translucent. The frontal bone articulates with twelve bones.



- 1 Squamous part
- 2 Frontal tuber
- 3 Glabella
- 4 Superciliary arch
- 5 Supra-orbital notch or foramen
- 6 Frontal notch or foramen
- 7 Temporal surface
- 8 Zygomatic process
- 9 Frontal crest
- 10 Groove for superior sagittal sinus
- 11 Nasal spine
- 12 Orbital surface
- 13 Trochlear spine
- 14 Lacrimal fossa
- 15 Ethmoidal notch
- 16 Frontal sinus



**Frontal bone**  
Anterior view

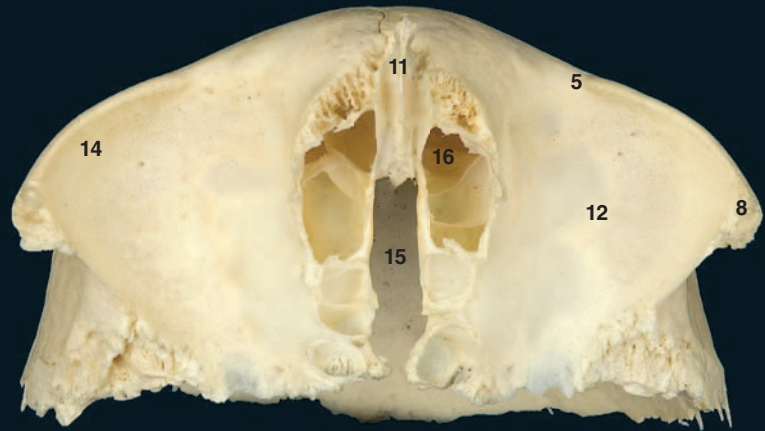


**Frontal bone**  
Posterior view

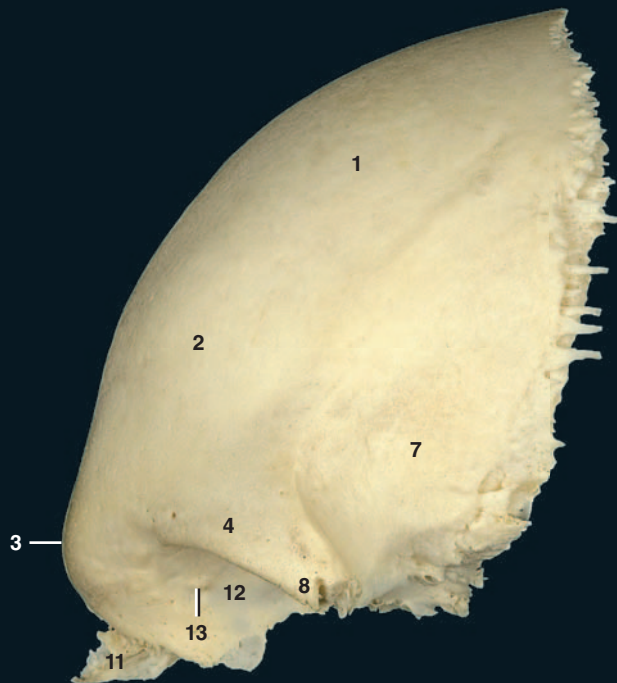




**Frontal bone**  
Superior view, anterior to bottom



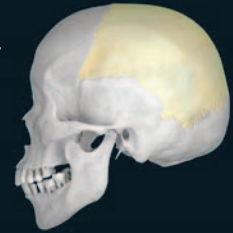
**Frontal bone**  
Inferior view, anterior to top



**Frontal bone**  
Lateral view, anterior to left

# Cranial Bones – Parietal

The parietal bones are large quadrilateral bones forming the greater part of the roof and sides of the cranium.



The external surface of each parietal bone is slightly convex while the internal surface is concave and marked with impressions from meningeal vessels. The inferior border forms a beveled articular surface, while the superior, anterior, and posterior borders form deeply denticulate articular surfaces. The bone consists of inner and outer laminae of compact bone sandwiching a layer of trabecular bone, the diploë. Each parietal bone articulates with five bones.

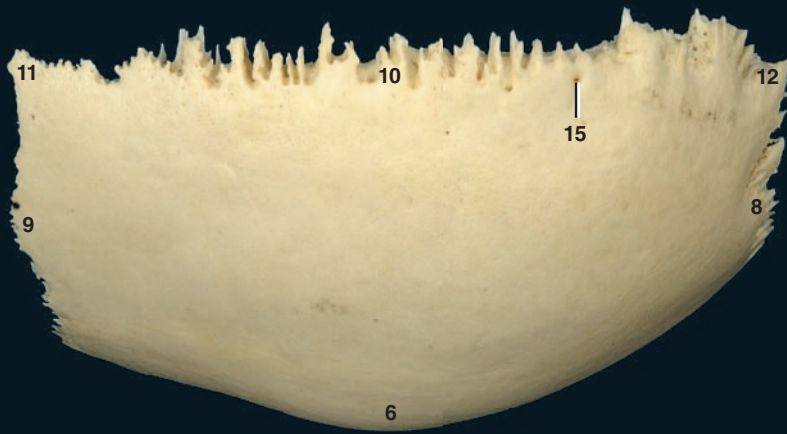
- 1 Groove for sigmoid sinus
- 2 Groove for superior sagittal sinus
- 3 Grooves for middle meningeal artery
- 4 Superior temporal line
- 5 Inferior temporal line
- 6 Parietal tuber
- 7 Squamosal border
- 8 Occipital border
- 9 Frontal border
- 10 Sagittal border
- 11 Frontal angle
- 12 Occipital angle
- 13 Sphenoid angle
- 14 Mastoid angle
- 15 Parietal foramen



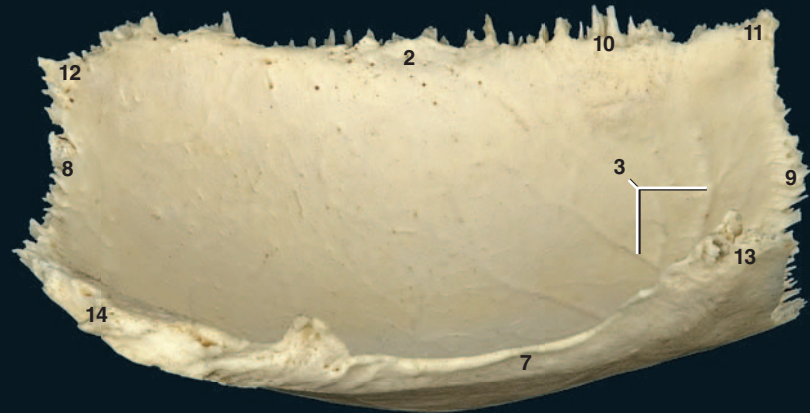
**Left parietal bone**  
Lateral view, anterior to right



**Left parietal bone**  
Medial view, anterior to right



**Left parietal bone**  
Superior view, anterior to left



**Left parietal bone**  
Inferior view, anterior to right



**Left parietal bone**  
Anterior view



**Left parietal bone**  
Posterior view

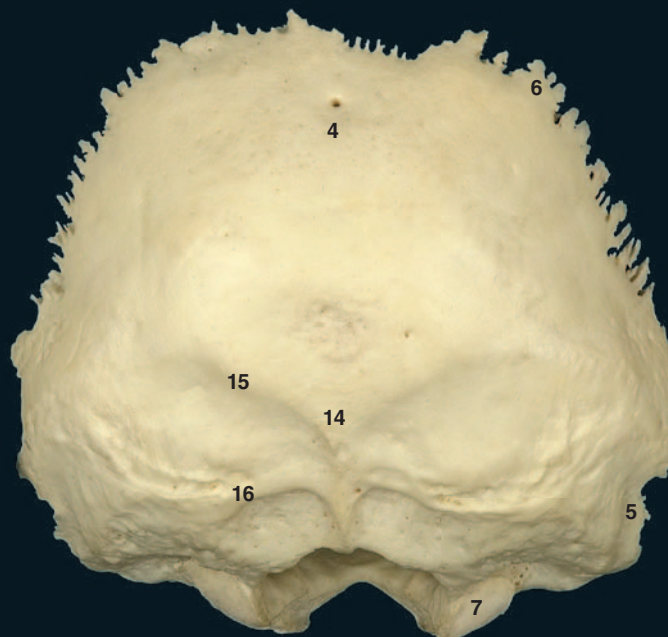
# Cranial Bones – Occipital

The occipital bone forms the greater part of the posterior and inferior cranium. Viewed from

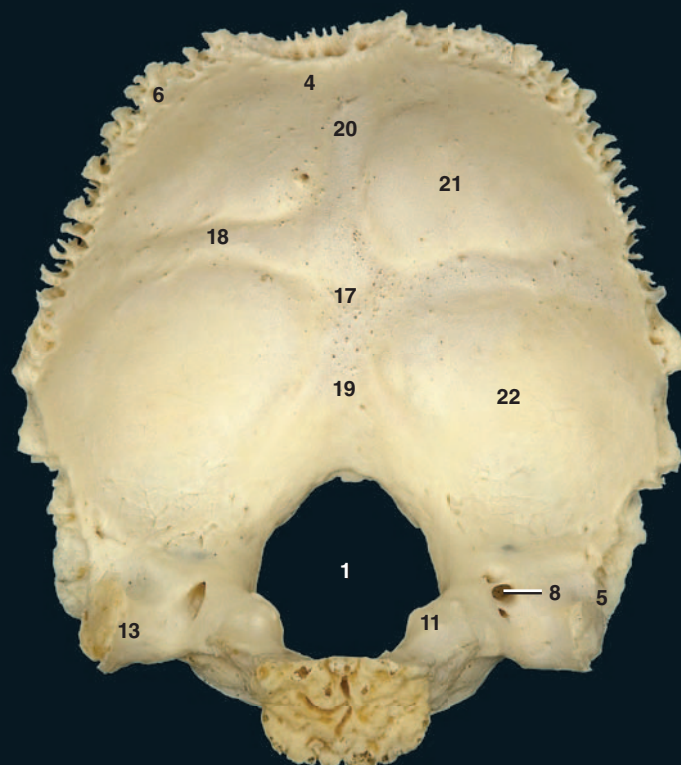


behind it has an oval to round shape. The bone has four distinct regions. The squamous portion is the internally concave posterosuperior plate and forms the greater part of the bone. The thick quadrilateral basioccipital, or basilar part, contributes to the base of the cranium anterior to the foramen magnum. Lateral to this and converging with the squama are the two condylar parts or exoccipitals. Together the four regions of the bone form the borders to the large circular opening, the foramen magnum, which provides passage for the spinal cord between the cranial vault and the spinal canal. The occipital bone articulates with six bones.

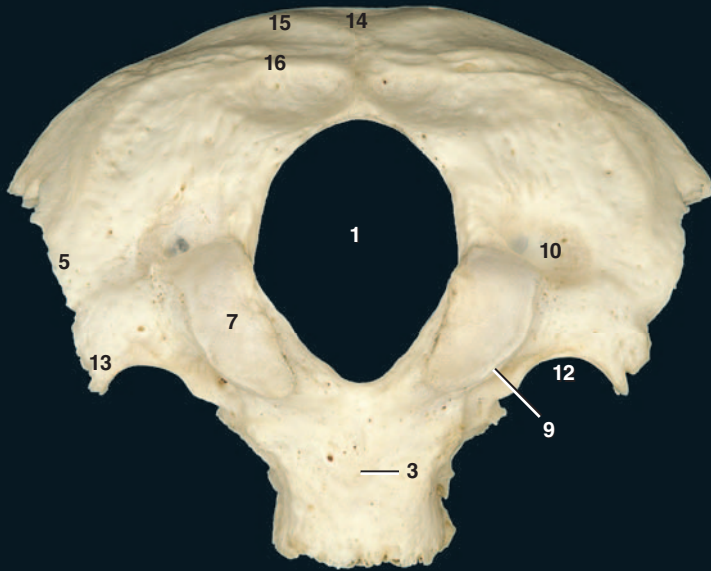
- 1 Foramen magnum
- 2 Clivus
- 3 Pharyngeal tubercle
- 4 Squamous part
- 5 Mastoid border
- 6 Lambdoid border
- 7 Occipital condyle
- 8 Condylar canal
- 9 Hypoglossal canal
- 10 Condylar fossa
- 11 Jugular tubercle
- 12 Jugular notch
- 13 Jugular process
- 14 External occipital protuberance
- 15 Superior nuchal line
- 16 Inferior nuchal line
- 17 Internal occipital protuberance
- 18 Groove for transverse sinus
- 19 Groove for occipital sinus
- 20 Groove for superior sagittal sinus
- 21 Cerebral fossa
- 22 Cerebellar fossa



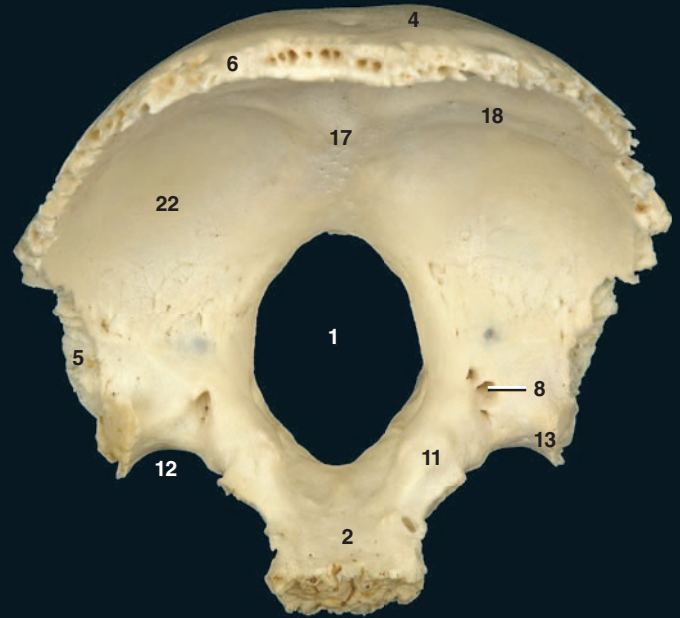
**Occipital bone**  
Posterior view



**Occipital bone**  
Anterior view



**Occipital bone**  
Inferior view, anterior to bottom



**Occipital bone**  
Superior view, anterior to bottom



**Occipital bone**  
Lateral view, anterior to right

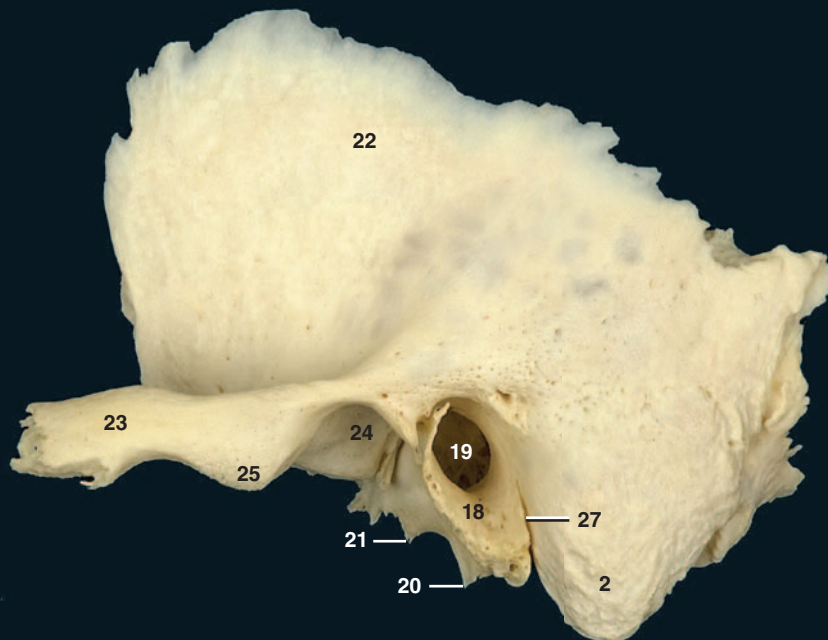
# Cranial Bones – Temporal

The temporal bone is a complex bone with five distinct parts. The squamous part of

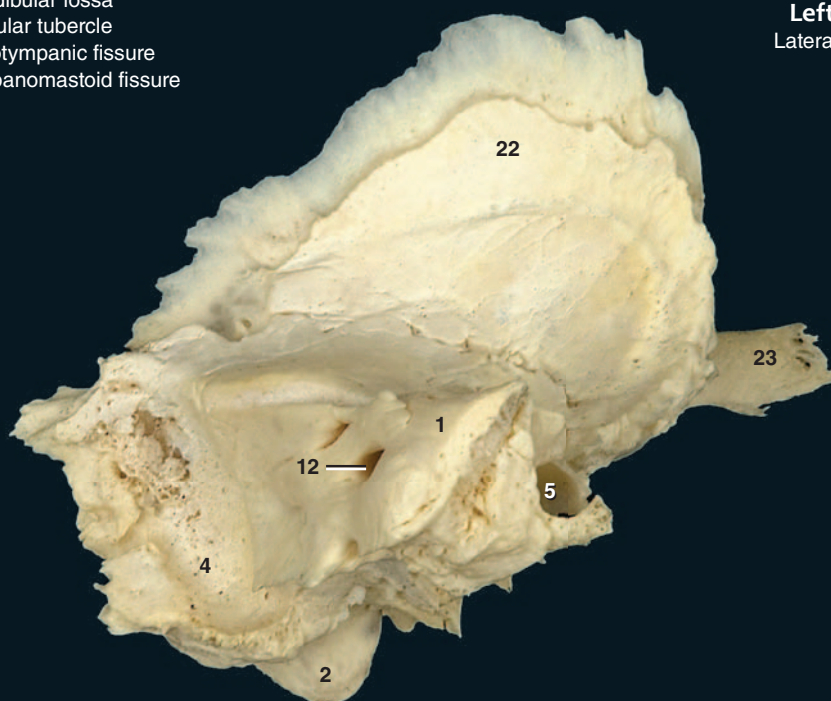


the bone is the thin lateral plate that contributes to the lateral wall of the cranium. It projects anteriorly as the zygomatic process and forms the mandibular fossa for the temporomandibular joint. The styloid part is represented by the styloid process. This projection of bone arises from the upper elements of the second pharyngeal arch. The petrous part forms the thick pyramidal base of the bone. It begins posterior to the external acoustic meatus as the mastoid process and ends where it forms a junction with the basi-occipital and greater wing of the sphenoid. The name petrous describes its rock-like appearance. This is the thickest part of the temporal bone. It arises from the otic capsules that stabilize the delicate internal ear structures. The mastoid is the posterolateral protuberance of the petrous portion that is easily palpable just posterior to the ear. The tympanic part of the temporal bone is the ring-like plate that forms the walls of the external acoustic meatus. Each temporal bone articulates with five bones.

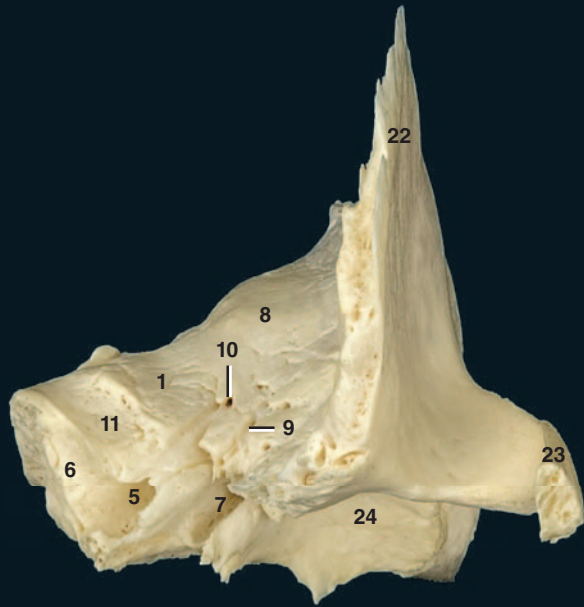
- 1 Petrous part
- 2 Mastoid process
- 3 Mastoid notch
- 4 Groove for sigmoid sinus
- 5 Carotid canal
- 6 Apex of petrous part
- 7 Muscotubal canal
- 8 Tegmen tympani
- 9 Hiatus for greater petrosal nerve
- 10 Hiatus for lesser petrosal nerve
- 11 Trigeminal impression
- 12 Internal acoustic meatus
- 13 Mastoid canaliculus
- 14 Tympanic canaliculus
- 15 Styloid process (broken)
- 16 Stylomastoid foramen
- 17 Jugular notch
- 18 Tympanic ring
- 19 External acoustic meatus
- 20 Greater tympanic spine
- 21 Lesser tympanic spine
- 22 Squamous part
- 23 Zygomatic process
- 24 Mandibular fossa
- 25 Articular tubercle
- 26 Petrotympanic fissure
- 27 Tympanomastoid fissure



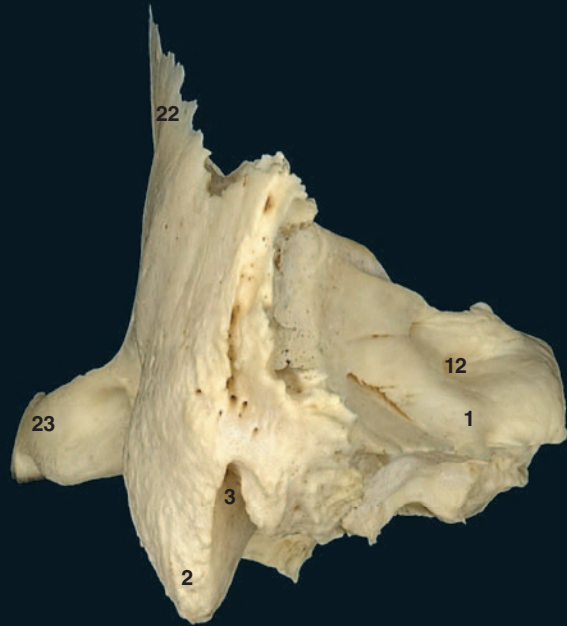
**Left temporal bone**  
Lateral view, anterior to left



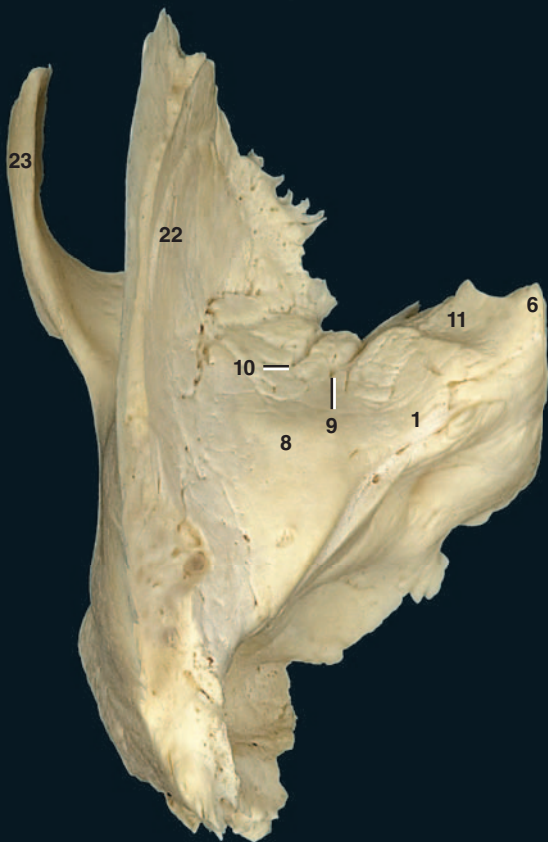
**Left temporal bone**  
Medial view, anterior to right



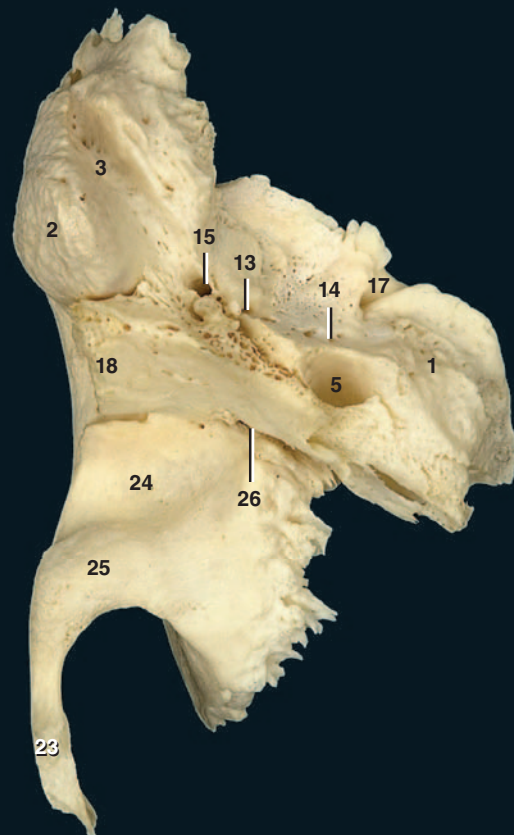
**Left temporal bone**  
Anterior view



**Left temporal bone**  
Posterior view



**Left temporal bone**  
Superior view, anterior at top



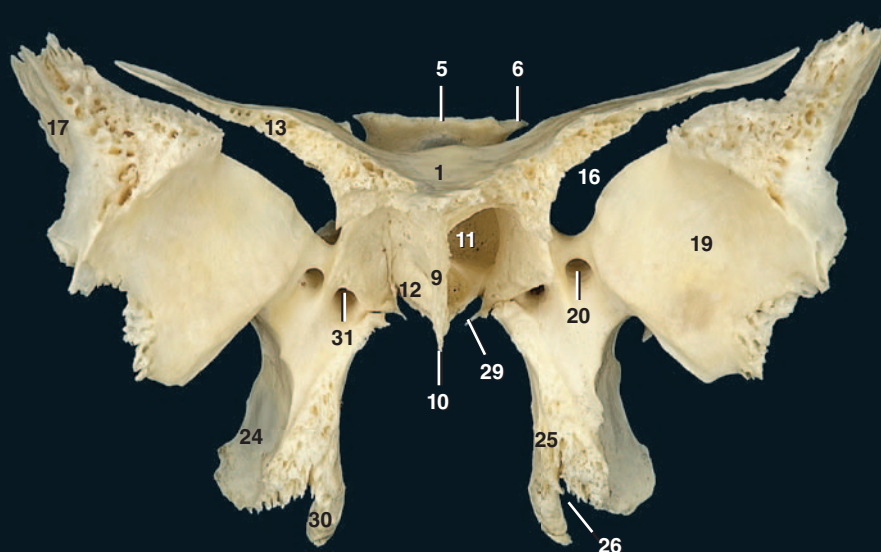
**Left temporal bone**  
Inferior view, anterior at bottom

# Cranial Bones – Sphenoid

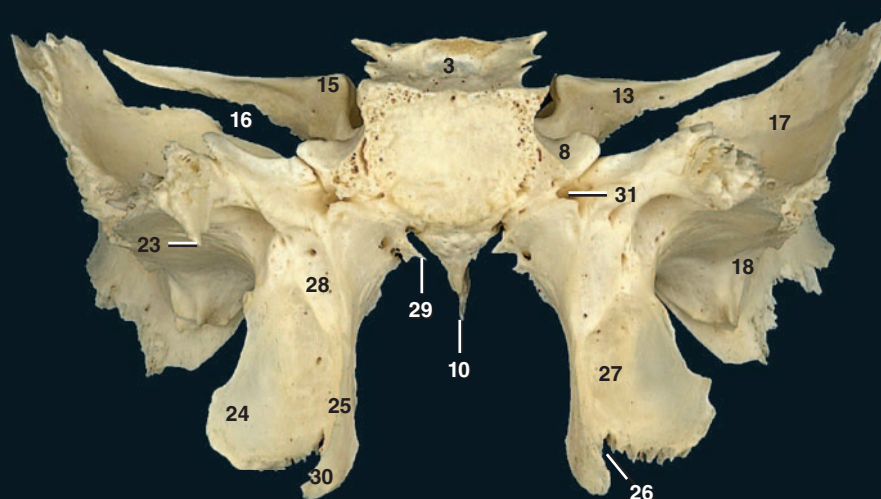
The sphenoid bone is a complex bone that has the spread-winged appearance of a butterfly. Like its name suggests, it is wedged into the center of the cranium where it articulates with twelve neighboring bones and contributes to much of the cranial base. It is divisible into four principal components — the body, greater wings, lesser wings, and pterygoid processes. With the calvaria removed the bone is visible from any view. This bone plays a prominent role at the base of the skull. It supports the brain, serves to protect the optic stalks and capsules, provides passage for many vessels and nerves entering and leaving the skull, and forms a sinus cavity that communicates with the nasal cavity.



- 1 Jugum
- 2 Sella turcica
- 3 Tuberculum sellae
- 4 Hypophysial fossa
- 5 Dorsum sellae
- 6 Posterior clinoid process
- 7 Middle clinoid process
- 8 Carotid sulcus
- 9 Sphenoidal crest
- 10 Sphenoidal rostrum
- 11 Sphenoidal sinus
- 12 Sphenoidal concha
- 13 Lesser wing
- 14 Optic canal
- 15 Anterior clinoid process
- 16 Superior orbital fissure
- 17 Greater wing
- 18 Infratemporal crest
- 19 Orbital surface
- 20 Foramen rotundum
- 21 Foramen ovale
- 22 Foramen spinosum
- 23 Spine of sphenoid bone
- 24 Lateral plate of pterygoid process
- 25 Medial plate of pterygoid process
- 26 Pterygoid notch
- 27 Pterygoid fossa
- 28 Scaphoid fossa
- 29 Vaginal process
- 30 Pterygoid hamulus
- 31 Pterygoid canal

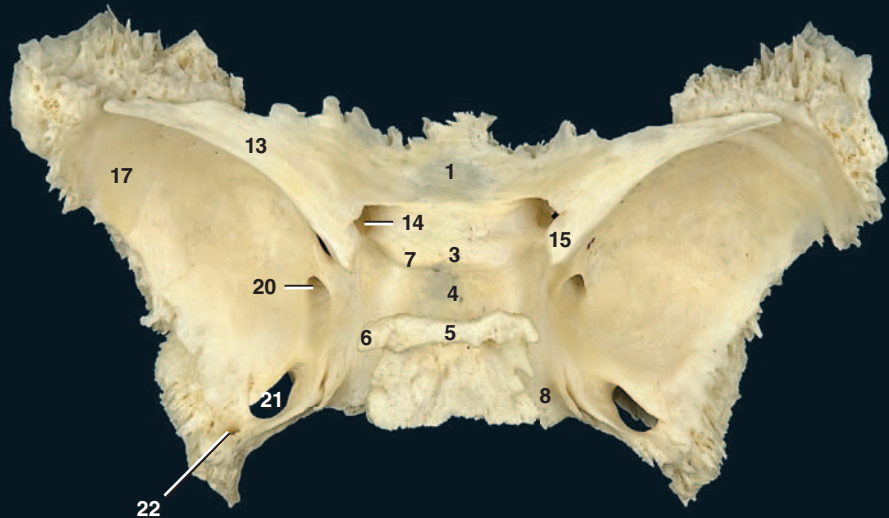


**Sphenoid bone**  
Anterior view

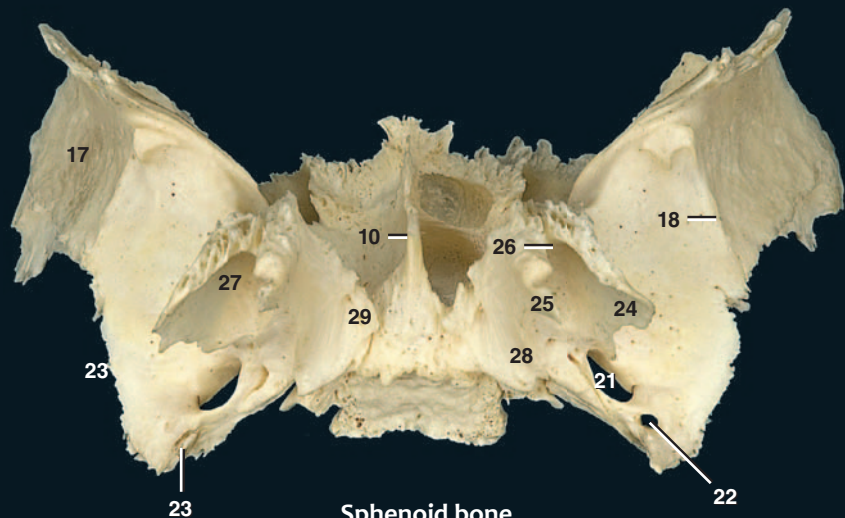


**Sphenoid bone**  
Posterior view





**Sphenoid bone**  
Superior view, anterior at top



**Sphenoid bone**  
Inferior view, anterior at top



**Sphenoid bone**  
Lateral view, anterior to left

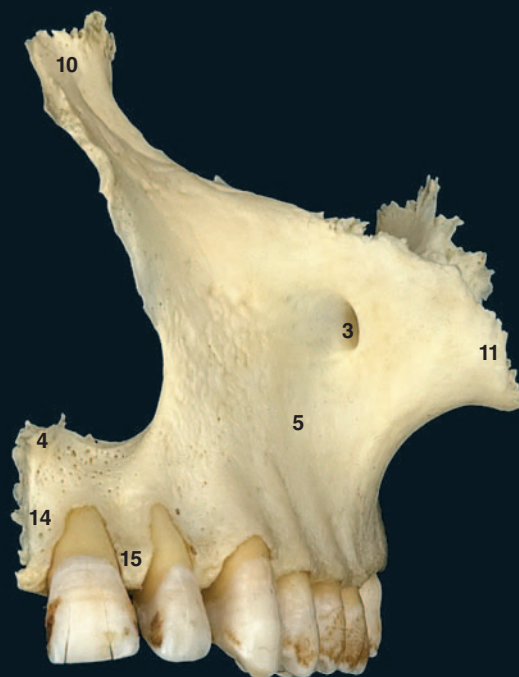
# Cranial Bones – Maxilla

The maxillae are large, paired bones that unite to form the upper jaw. They also contribute to the

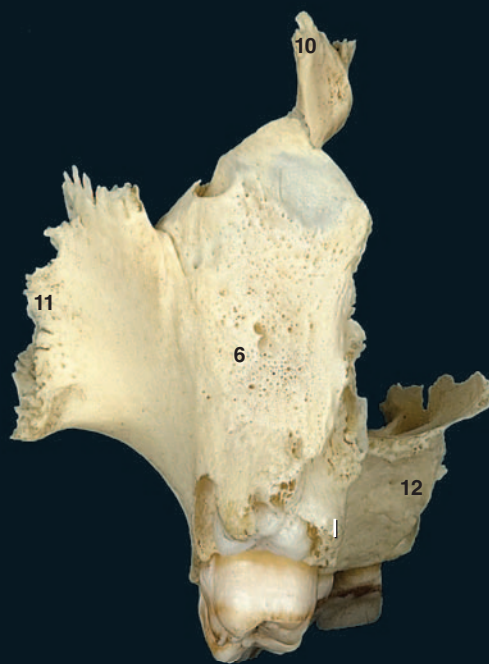
walls of the nasal cavity, orbit, oral cavity, and maxillary sinus. The maxillary sinus is the hollow central cavity within the large body of the maxilla. Four variable-shaped processes project from the maxillary body. The processes are the posterolateral zygomatic process, the medial projecting palatine process, the arched inferior process called the alveolar, and the superiorly projecting frontal process. Each maxilla articulates with nine bones.



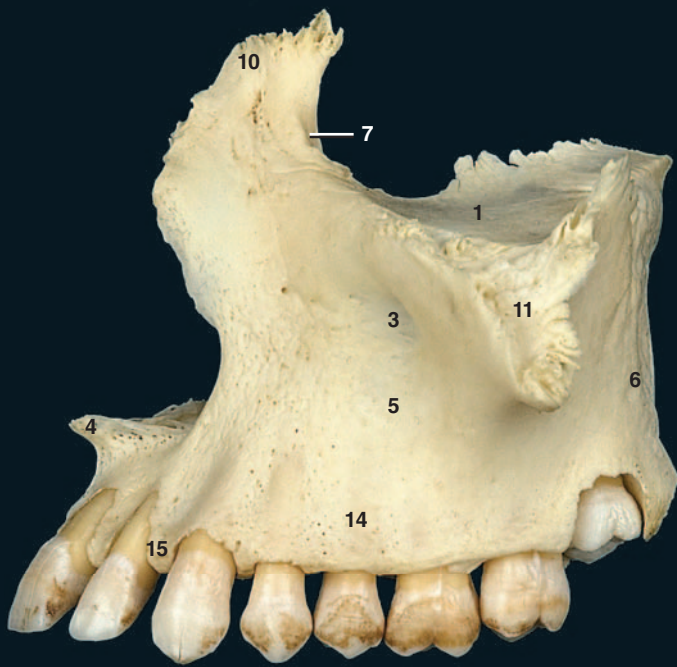
- 1 Orbital surface
- 2 Infra-orbital groove
- 3 Infra-orbital foramen
- 4 Anterior nasal spine
- 5 Canine fossa
- 6 Maxillary tuberosity
- 7 Lacrimal groove
- 8 Maxillary sinus
- 9 Greater palatine groove
- 10 Frontal process
- 11 Zygomatic process
- 12 Palatine process
- 13 Incisive canal
- 14 Alveolar process
- 15 Inter-alveolar septum



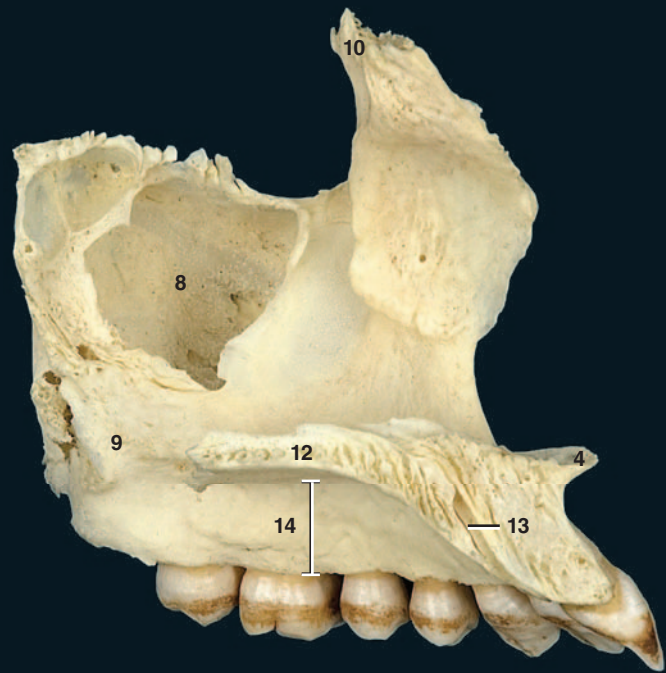
**Left maxilla**  
Anterior view



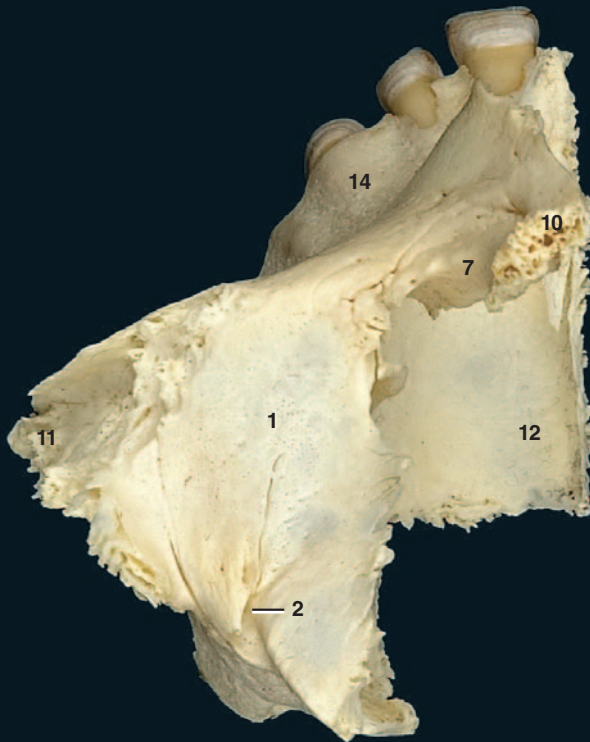
**Left maxilla**  
Posterior view



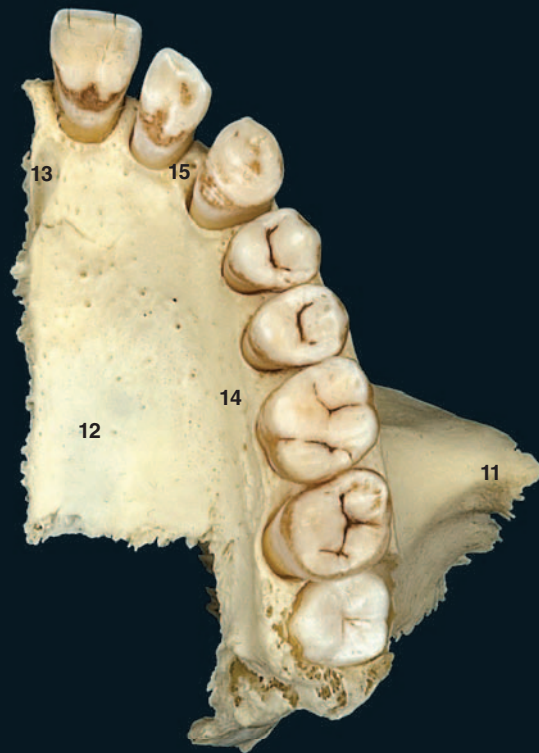
**Left maxilla**  
Lateral view, anterior to left



**Left maxilla**  
Medial view, anterior to right



**Left maxilla**  
Superior view, anterior at top



**Left maxilla**  
Inferior view, anterior at top

# Cranial Bones – Mandible

The mandible, the largest of the facial bones, forms the lower jaw. The bone has an

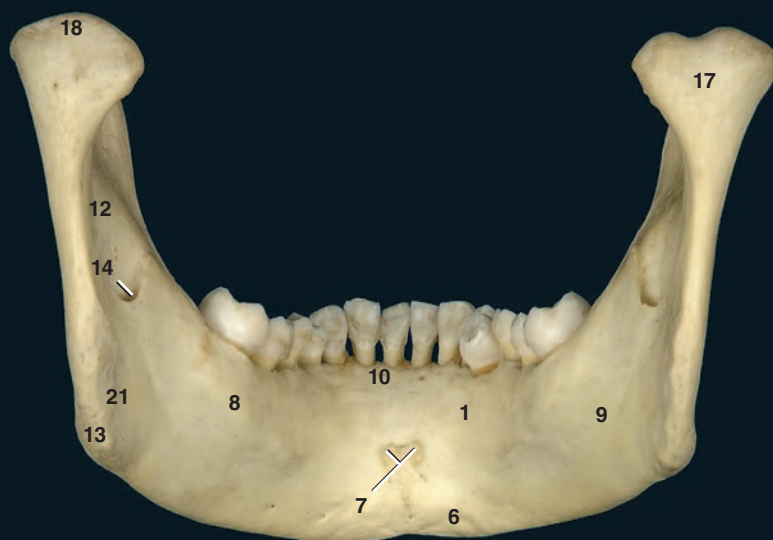


arched body with a tooth-bearing alveolar process. Posteriorly each side of the arched body joins the vertically directed rami at the mandibular angle. The superior aspects of the two rami articulate with the temporal bones at the base of the cranium. The mandible is a strong bone composed predominantly of compact bone. It houses the lower tooth row in its alveolar arch. The strong masticatory muscles act on this bone to move it in the temporomandibular joint. Its shape can vary exceedingly with age. If the teeth are lost, bone gets resorbed on the alveolar surface leading to the thinning of the dental arch. The mandible articulates with two bones.

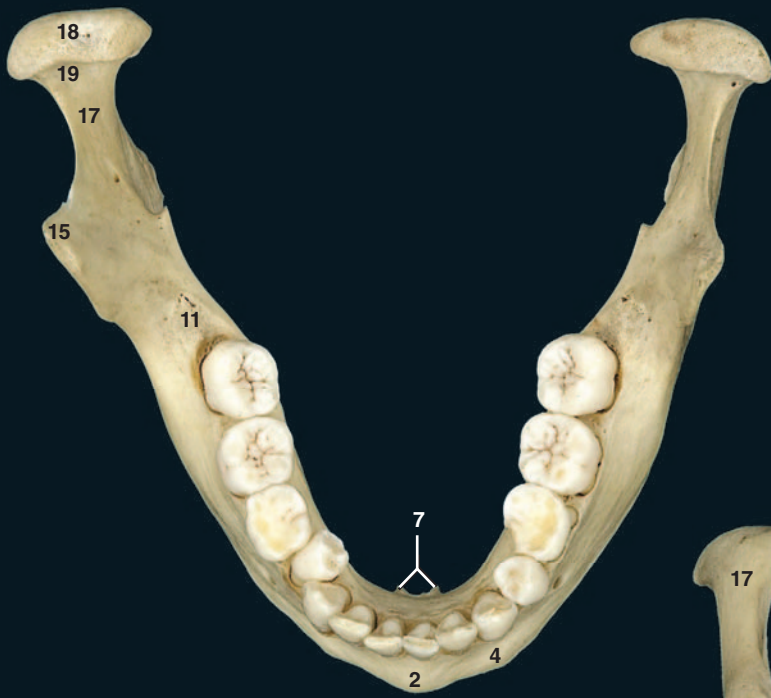
- 1 Body of mandible
- 2 Mental protuberance
- 3 Mental foramen
- 4 Mental tubercle
- 5 Oblique line
- 6 Digastric fossa
- 7 Mental spines
- 8 Mylohyoid line
- 9 Submandibular fossa
- 10 Alveolar part
- 11 Retromolar triangle
- 12 Ramus of mandible
- 13 Angle of mandible
- 14 Mandibular foramen
- 15 Coronoid process
- 16 Mandibular notch
- 17 Condylar process
- 18 Head of mandible
- 19 Pterygoid fovea
- 20 Masseteric tuberosity
- 21 Pterygoid tuberosity



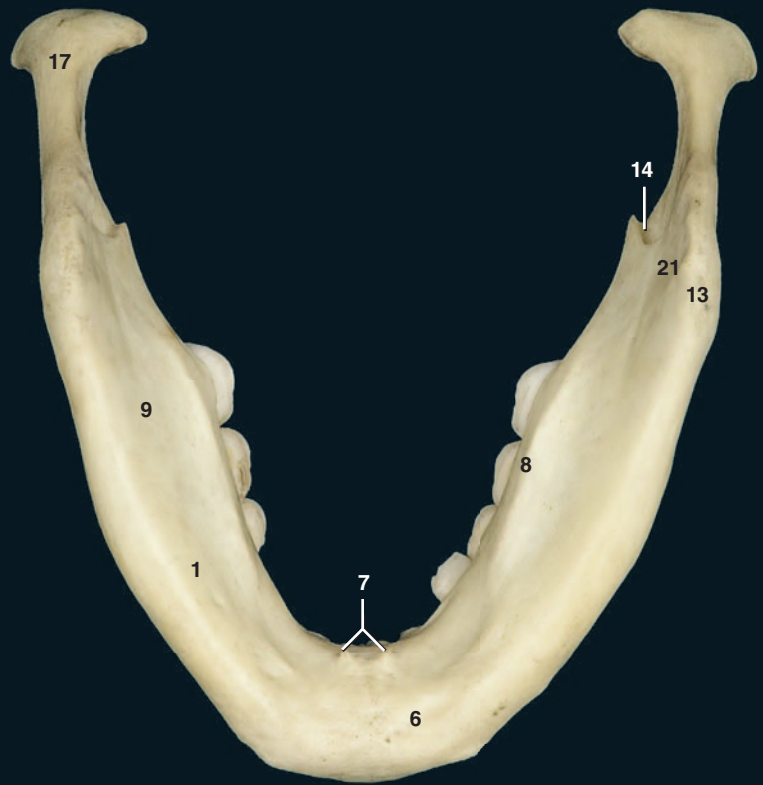
**Mandible**  
Anterior view



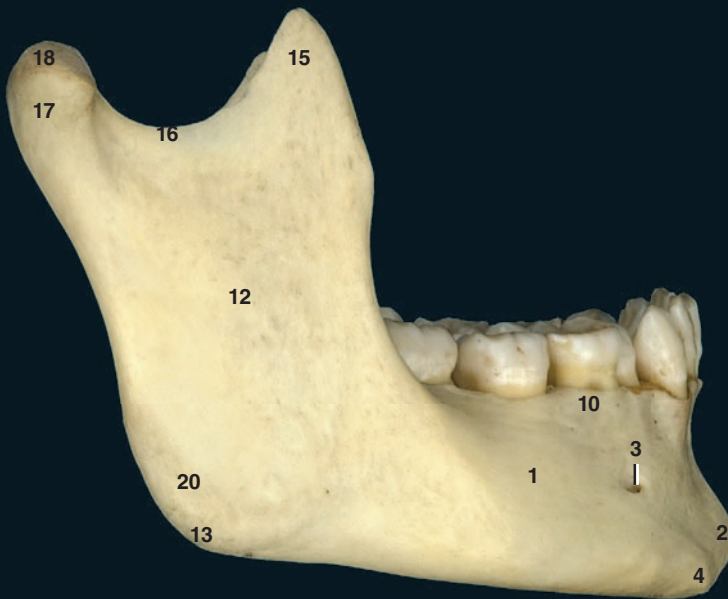
**Mandible**  
Posterior view



**Mandible**  
Superior view, anterior at bottom



**Mandible**  
Inferior view, anterior at bottom



**Mandible**  
Lateral view, anterior to right

# Cranial Bones – Ethmoid

The term ethmoid comes from the Greek term *ethmos* meaning sieve. Galen called the bone the



sieve-like bone because of the many small foramina that transmit the olfactory nerves to the nasal cavity. This unpaired bone is both complex and delicate and is the central bone of the nasal cavity. Wedged between the two orbits, the bone consists of a median vertical plate, a horizontal plate perforated by many small foramina, and bilateral pneumatic, labyrinthine regions. The labyrinthine regions form most of the medial walls of the orbit and the superior and middle nasal conchae. This bone consists of thin laminae of compact bone surrounding many small air sinuses, which communicate with the nasal cavity. The ethmoid bone articulates with thirteen bones, more articulations than any other cranial bone.

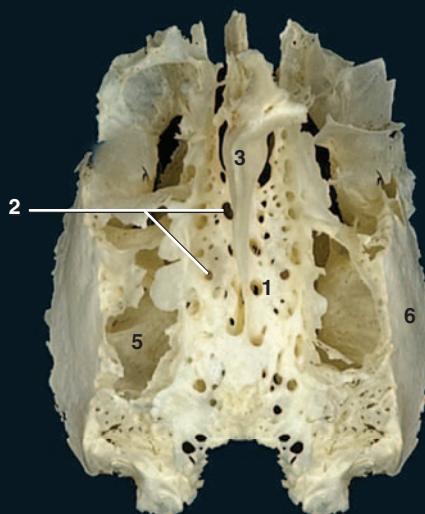
- 1 Cribriform plate
- 2 Cribriform foramina
- 3 Crista galli
- 4 Perpendicular plate
- 5 Ethmoidal air cells
- 6 Orbital plate
- 7 Superior nasal concha
- 8 Middle nasal concha
- 9 Ethmoidal bulla
- 10 Uncinate process
- 11 Ethmoidal infundibulum



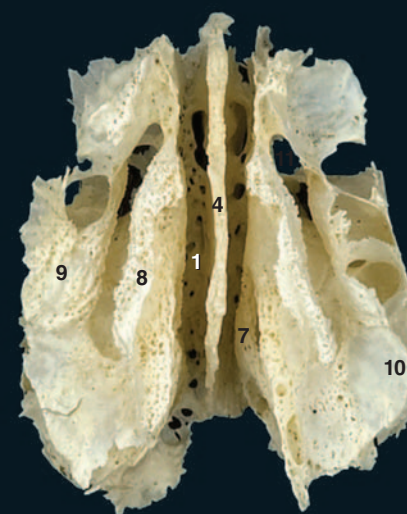
**Ethmoid bone**  
Anterior view



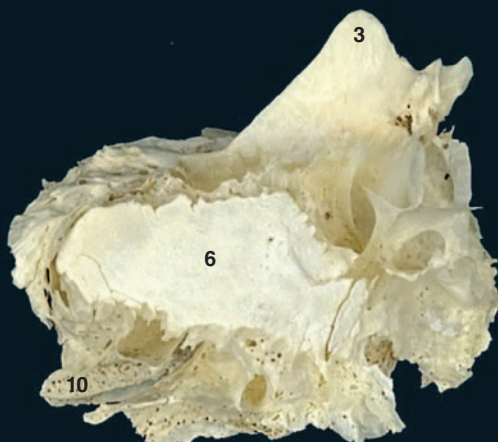
**Ethmoid bone**  
Posterior view



**Ethmoid bone**  
Superior view, anterior at top



**Ethmoid bone**  
Inferior view, anterior at top



**Ethmoid bone**  
Lateral view, anterior at right

# Cranial Bones – Zygomatic

the Greek word zygón meaning yoke, after its resemblance to a yoke placed on oxen. This yoke-shaped bone has three distinct surfaces, five borders, and two processes. It is situated anterolateral on the face as the “cheekbone”, and contributes to the lateral and inferior walls of the orbit. It consists of external and internal laminae of compact bone with an inner core of spongy bone. The zygomatic bone articulates with four bones.

The zygomatic bone, originally named by Galen the os zygoma, comes from



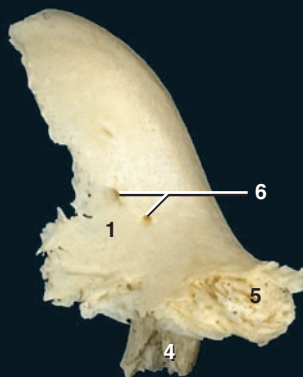
- 1 Orbital surface
- 2 Temporal surface
- 3 Lateral surface
- 4 Temporal process
- 5 Frontal process
- 6 Zygomatico-orbital foramen
- 7 Zygomaticofacial foramen
- 8 Zygomaticotemporal foramen



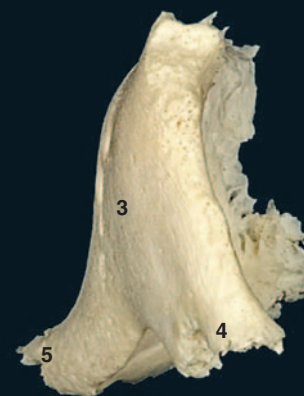
**Right zygomatic bone**  
Anterior view



**Right zygomatic bone**  
Posterior view



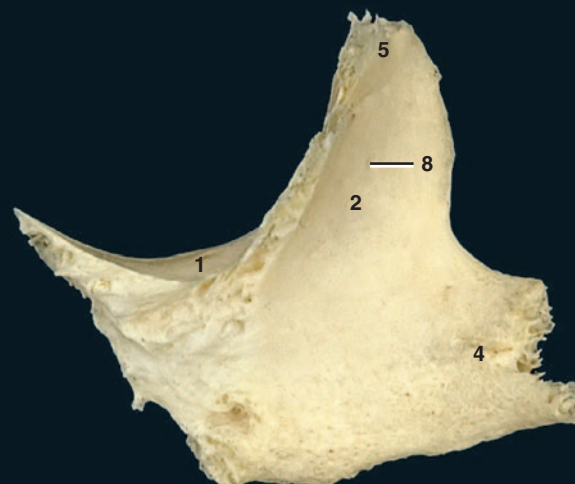
**Right zygomatic bone**  
Superior view, anterior to top



**Right zygomatic bone**  
Inferior view, anterior to top



**Right zygomatic bone**  
Lateral view, anterior to right



**Right zygomatic bone**  
Medial view, anterior to left

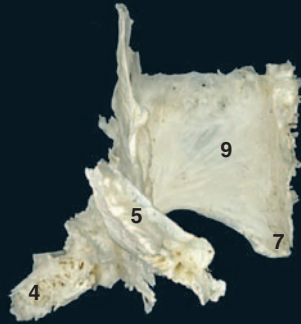
# Cranial Bones – Palatine

The palatine bone is a delicate and intricate bone that forms the shape of the letter L. It sits deep

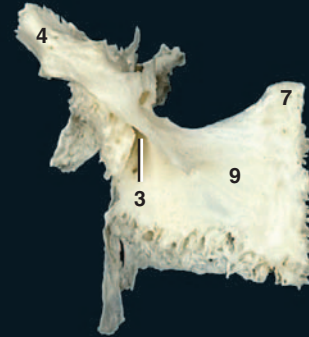
in the posterior facial region where it contributes to the roof of the mouth, floor of the orbit, floor and lateral walls of the nasal cavity, and to the pterygopalatine fossa. It has a strong horizontal plate with a delicate vertical lamina that projects superiorly. The palatine bone articulates with six bones.



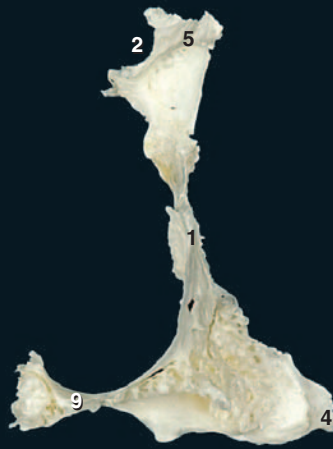
- 1 Perpendicular plate
- 2 Sphenopalatine notch
- 3 Greater palatine groove
- 4 Pyramidal process
- 5 Orbital process
- 6 Lesser palatine foramina
- 7 Posterior nasal spine
- 8 Conchal crest
- 9 Horizontal plate



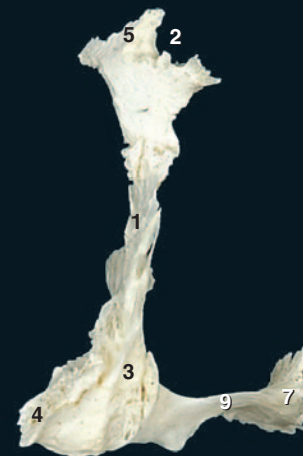
**Left palatine bone**  
Superior view, anterior at top



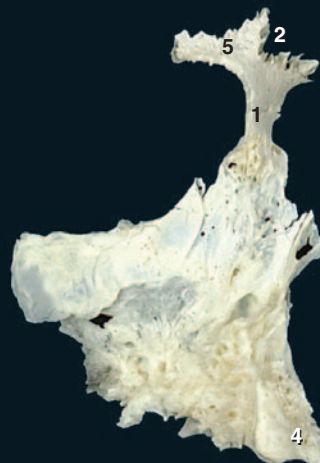
**Left palatine bone**  
Inferior view, anterior at bottom



**Left palatine bone**  
Anterior view, lateral at right



**Left palatine bone**  
Posterior view, lateral at left



**Left palatine bone**  
Lateral view, anterior at left



**Left palatine bone**  
Medial view, anterior at right



# Cranial Bones – Vomer

The vomer is a flat, triangular bone that resembles a plow. It has a flat, median, vertical blade-like process

with transverse posterosuperior projections resembling the handles of the plow. This is a small, thin, unpaired bone that sits in the median plane. It is wider at its superoposterior base and it tapers toward its antero-inferior apex. It forms the inferior portion of the bony nasal septum. Its surfaces face laterally and form the lower, medial wall of the nasal cavities. The vomer articulates with six bones and one cartilage.



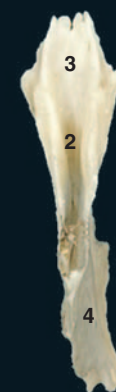
- 1 Ala of vomer
- 2 Vomerine groove
- 3 Vomerine crest of choana
- 4 Cuneiform part



**Vomer**  
Lateral view, anterior at left



**Vomer**  
Anterior view



**Vomer**  
Posterior view



**Vomer**  
Superior view, anterior at bottom



**Vomer**  
Inferior view, anterior at bottom

# Cranial Bones – Nasal

The paired nasal bones are small, rectangular bones with a subtle bow-like shape. They form the bridge of the nose



upon which a pair of eye glasses rest. The external surface of the bones provides attachment for the procerus and nasalis muscles, two thin muscles of facial expression. Each nasal bone articulates with four bones.

- 1 Ethmoidal groove
- 2 Nasal foramina
- 3 Superior border
- 4 Inferior border
- 5 Lateral border
- 6 Medial border



**Left nasal bone**  
Anterior view, lateral at left



**Left nasal bone**  
Posterior view, lateral at right



**Left nasal bone**  
Lateral view, anterior at right



**Left nasal bone**  
Medial view, anterior at left



**Left nasal bone**  
Superior view, anterior at bottom



**Left nasal bone**  
Inferior view, anterior at bottom

# Cranial Bones – Inferior Nasal Concha

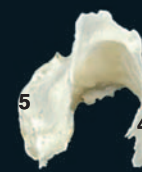
This is a small, delicate bone that projects from the lateral wall of the nasal cavity. It is scroll-like in appearance as it arches inferiorly and laterally from the nasal cavity's lateral wall. The medial surface of the bone is convex and furrowed by many longitudinal grooves that transport blood vessels beneath the thick nasal mucosa that covers this surface. The lateral surface of the bone is concave and forms most of the superior and medial boundary of the inferior nasal meatus. The inferior border of the bone has a rough, spongy appearance. Superiorly the bone forms an articular border with four bones.



- 1 Lacrimal process
- 2 Maxillary process
- 3 Ethmoidal process
- 4 Lateral surface
- 5 Medial surface



**Left inferior nasal concha**  
Anterior view, lateral at left



**Left inferior nasal concha**  
Posterior view, lateral at right



**Left inferior nasal concha**  
Lateral view, anterior at right



**Left inferior nasal concha**  
Medial view, anterior at left



**Left inferior nasal concha**  
Superior view, anterior at right



**Left inferior nasal concha**  
Inferior view, anterior at right

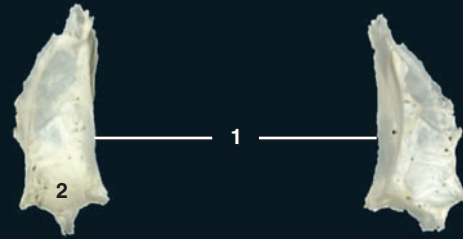
# Cranial Bones – Lacrimal

The lacrimal bone derives its name from the Latin word meaning tear because the bone houses

the “tear duct.” This small, delicate, quadrate-shaped bone has a vertical axis that is slightly longer than its horizontal axis. It is extremely thin. When it is held up to a light source, the light easily penetrates the bone. The bone sits in the anterior part of the medial wall of the orbit. The orbital surface is smooth and flat in its posterior half where it contributes to the medial wall of the orbit. Anteriorly this surface has a longitudinal groove that ends posteriorly in a longitudinal crest that is hook-shaped inferiorly. This groove supports the nasolacrimal duct. Covered with mucous membrane, the slightly rough, medial surface of the bone contributes to the nasal cavity. The lacrimal bone articulates with four bones.



- 1 Posterior lacrimal crest
- 2 Lacrimal groove
- 3 Lacrimal hamulus



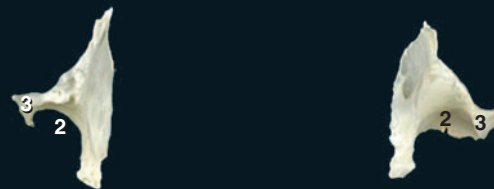
**Left lacrimal bone**  
Anterior view, lateral at right

**Left lacrimal bone**  
Posterior view, lateral at left



**Left lacrimal bone**  
Lateral view, anterior at left

**Left lacrimal bone**  
Medial view, anterior at right



**Left lacrimal bone**  
Superior view, lateral at right

**Left lacrimal bone**  
Inferior view, lateral at left

# Cranial Bones – Auditory Ossicles

The auditory ossicles are the smallest bones of the human skeleton. These

three small bones occupy the middle ear cavity, where they transmit and amplify the sound waves from the tympanic membrane to the inner ear. From lateral to medial the bones are the malleus, the incus, and the stapes, or in layman's terms the hammer, the anvil, and the stirrup, because of their striking resemblance to these structures.

- 1 Malleus
- 2 Incus
- 3 Stapes
- 4 Handle of malleus
- 5 Head of malleus
- 6 Neck of malleus
- 7 Lateral process
- 8 Anterior process
- 9 Body of incus
- 10 Long limb
- 11 Lenticular process
- 12 Short limb
- 13 Head of stapes
- 14 Anterior limb
- 15 Posterior limb
- 16 Footplate



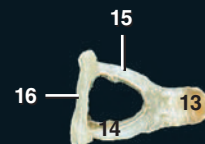
**Left auditory ossicles**  
Anterior view, lateral at left



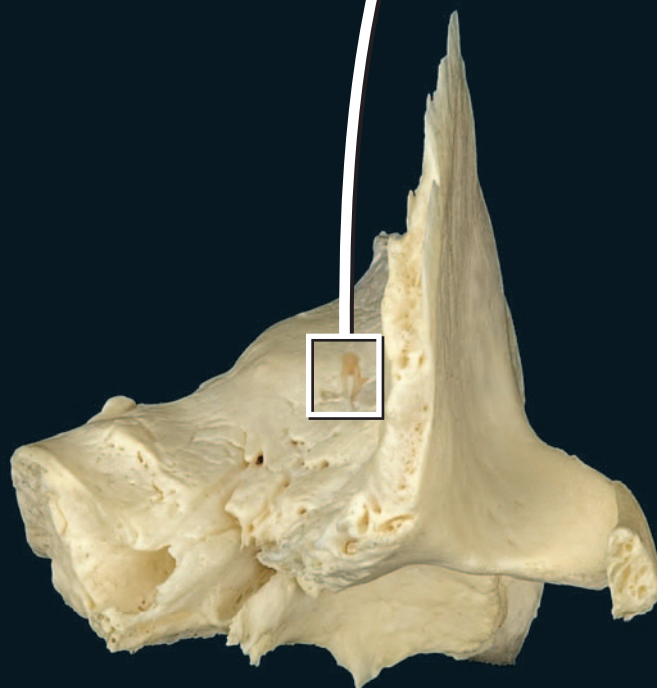
**Left malleus**  
Anterior view, lateral at left



**Left incus**  
Lateral view, anterior at left



**Left stapes**  
Superior view, lateral at left



**Auditory ossicles in situ within temporal bone**  
Anterior view, left temporal bone

# Cranial Bones – Hyoid

Suspended from the styloid processes of the temporal bones by the stylohyoid ligaments, the U-shaped hyoid bone

occupies the ventrosuperior neck just inferior to the mandible. It serves as a skeletal attachment site for muscles associated with the tongue, larynx, and pharynx. It consists of five elements — a body and bilateral lesser and greater cornua. The body is the rectangular ventral element that sits in the transverse plane. Projecting posterolaterally from the body are the paired, long, slender greater cornua. At the junction of the greater cornua and the body are smaller superior projections, the lesser cornua.



- 1 Body
- 2 Lesser horn
- 3 Greater horn



**Hyoid bone**  
Anterior view



**Hyoid bone**  
Lateral view, anterior at right



**Hyoid bone**  
Superior view, anterior at bottom

# Vertebral Column

The vertebral column consists of 26 bones that develop from a series of 33 identical embryonic body segments. Because they develop from similar repeating segments, each of the vertebrae has a similar structure. The bones of the vertebral column are grouped into seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, the sacrum consisting of five fused segments, and the coccyx comprised of three to five fused segments, most typically four. The column is the central axis of the body that supports the limbs and the cranium, protects the spinal cord, and provides attachment for muscles that move this flexible column of bones.



- 1 Cervical vertebrae
- 2 Thoracic vertebrae
- 3 Lumbar vertebrae
- 4 Sacrum
- 5 Coccyx
- 6 Thoracic kyphosis
- 7 Sacral kyphosis
- 8 Cervical lordosis
- 9 Lumbar lordosis
- 10 Intervertebral foramen

**Vertebral column**  
Anterior view

**Vertebral column**  
Lateral view, anterior at right

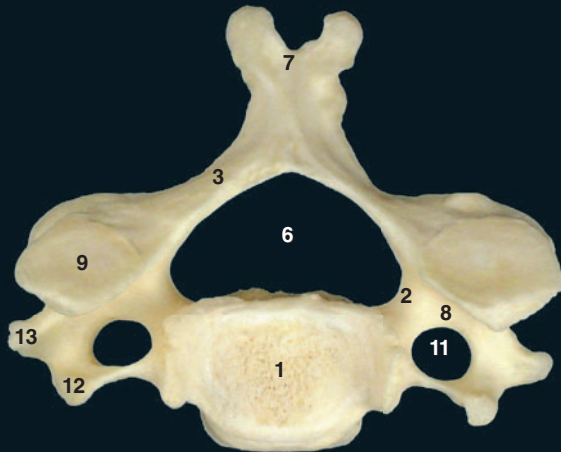
**Vertebral column**  
Posterior view

# Cervical Vertebrae

There are seven cervical vertebrae, which are the vertebrae with the greatest variation in shape. They form a delicate column of bones having a wide range of mobility at their joint surfaces. This is due to the fact that the first two cervical vertebrae, the atlas and axis, have forms that differ significantly from the remaining five vertebrae in the series. These differences arise as they become modified to provide the support and movement of the skull. The remaining cervical vertebrae show a lesser degree of mobility and have more uniform shapes. With few exceptions, the cervical vertebrae can be readily distinguished by the presence of a foramen in their transverse processes.



- |                                     |   |
|-------------------------------------|---|
| 1 Vertebral body                    | 12 Anterior tubercle of costal process  |
| 2 Pedicle                           | 13 Posterior tubercle of costal process |
| 3 Lamina                            | 14 Lateral mass                         |
| 4 Superior vertebral notch          | 15 Anterior arch                        |
| 5 Inferior vertebral notch          | 16 Anterior tubercle of anterior arch   |
| 6 Vertebral foramen                 | 17 Facet for dens                       |
| 7 Spinous process                   | 18 Posterior arch                       |
| 8 Transverse process                | 19 Posterior tubercle of posterior arch |
| 9 Superior articular process/facet  | 20 Groove for vertebral artery          |
| 10 Inferior articular process/facet | 21 Dens                                 |
| 11 Transverse foramen               | 22 Anterior articular facet of dens     |



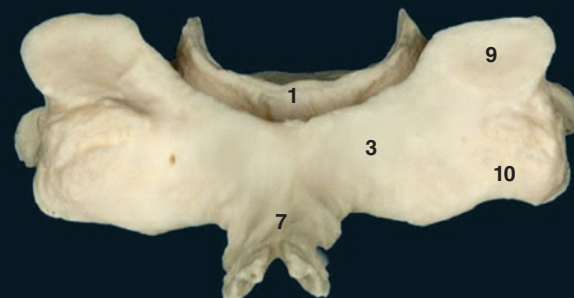
**Typical cervical vertebra**  
Superior view, anterior at bottom



**Typical cervical vertebra**  
Lateral view, anterior at right

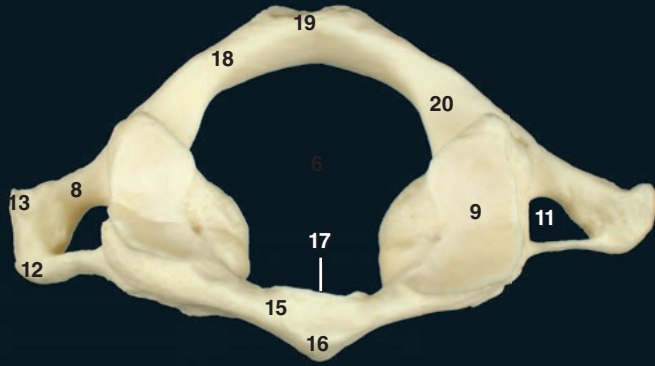


**Typical cervical vertebra**  
Anterior view, superior at top

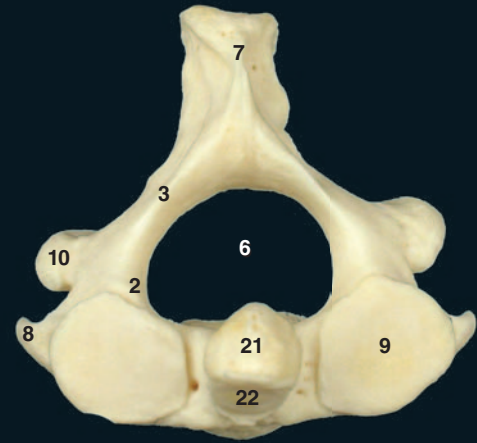


**Typical cervical vertebra**  
Posterior view, superior at top





**Atlas, 1st cervical vertebra**  
Superior view, anterior at bottom



**Axis, 2nd cervical vertebra**  
Superior view, anterior at bottom



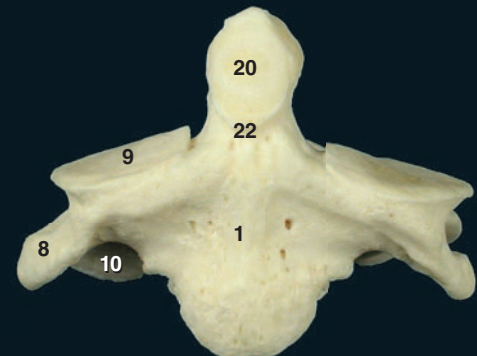
**Atlas, 1st cervical vertebra**  
Lateral view, anterior at right



**Axis, 2nd cervical vertebra**  
Lateral view, anterior at right



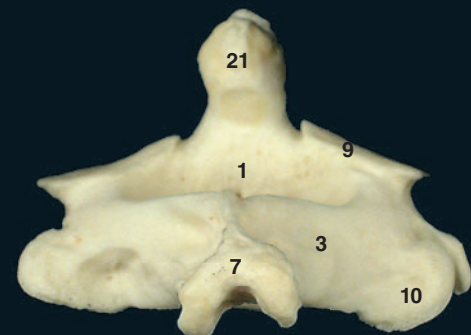
**Atlas, 1st cervical vertebra**  
Anterior view, superior at top



**Axis, 2nd cervical vertebra**  
Anterior view, superior at top



**Atlas, 1st cervical vertebra**  
Posterior view, superior at top



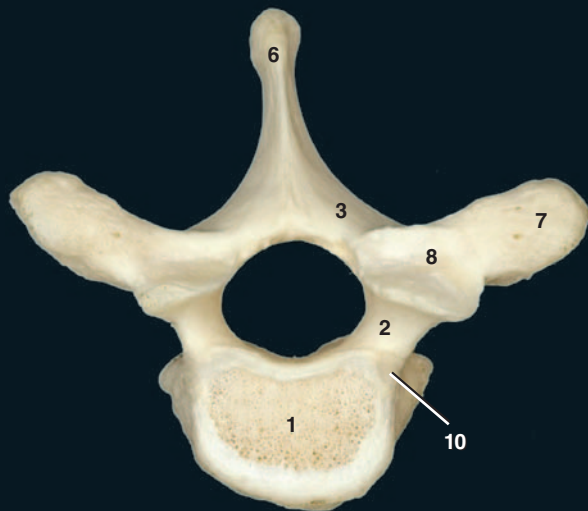
**Axis, 2nd cervical vertebra**  
Posterior view, superior at top

# Thoracic Vertebrae

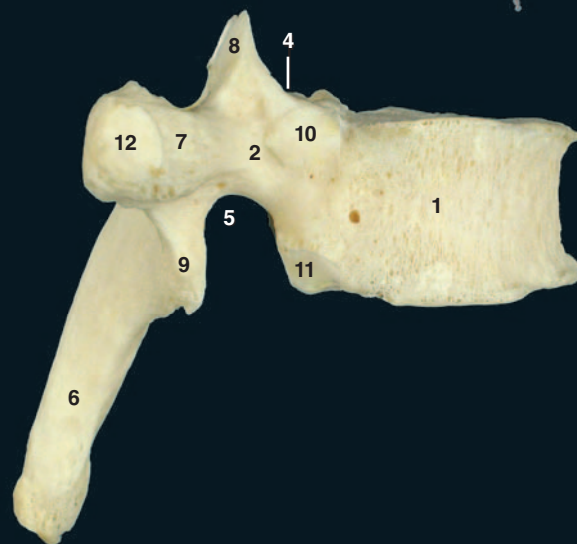
The thoracic portion of the vertebral column, consisting of the twelve thoracic vertebrae, get progressively larger from the cranial end to the caudal end of the series. Except at its junction with the lumbar vertebrae, the thoracic region is the least mobile region of vertebral column. In addition to articulating with each other, the thoracic vertebrae also articulate with the ribs. Additionally, the laminae and spines of these vertebrae project inferiorly to overlap the next vertebra below. This suite of characters produces a strong imbricated column of bone that forms the impressive thoracic rib cage. Because of their association with the ribs, the thoracic vertebrae are readily identified by the costal articular facets, which are present on the bodies and transverse processes.



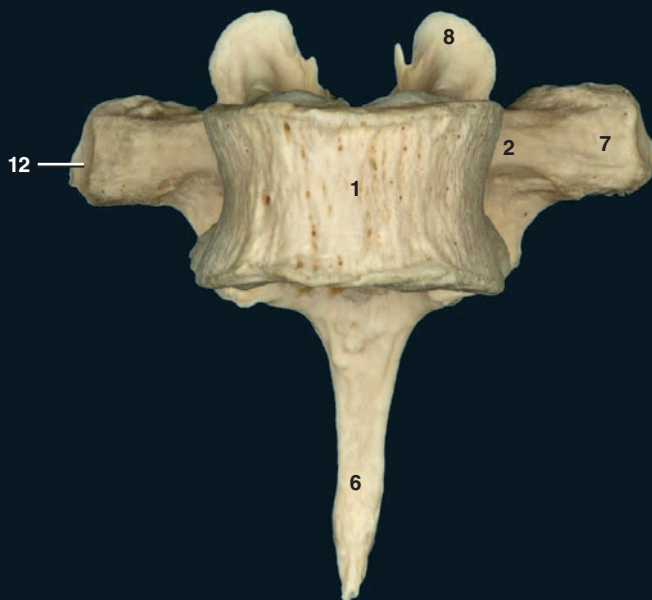
- |                            |                                    |
|----------------------------|------------------------------------|
| 1 Vertebral body           | 7 Transverse process               |
| 2 Pedicle                  | 8 Superior articular process/facet |
| 3 Lamina                   | 9 Inferior articular process/facet |
| 4 Superior vertebral notch | 10 Superior costal facet           |
| 5 Inferior vertebral notch | 11 Inferior costal facet           |
| 6 Spinous process          | 12 Transverse costal facet         |



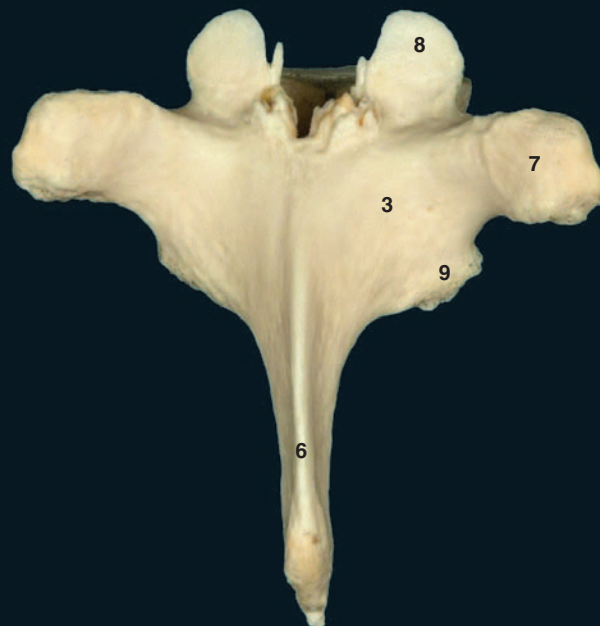
**Thoracic vertebra**  
Superior view, anterior at bottom



**Thoracic vertebra**  
Lateral view, anterior at right



**Thoracic vertebra**  
Anterior view, superior at top



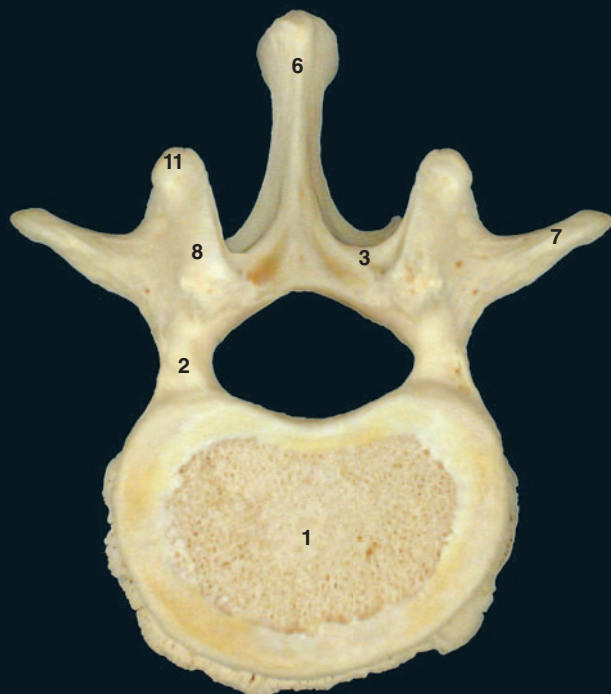
**Thoracic vertebra**  
Posterior view, superior at top

# Lumbar Vertebrae

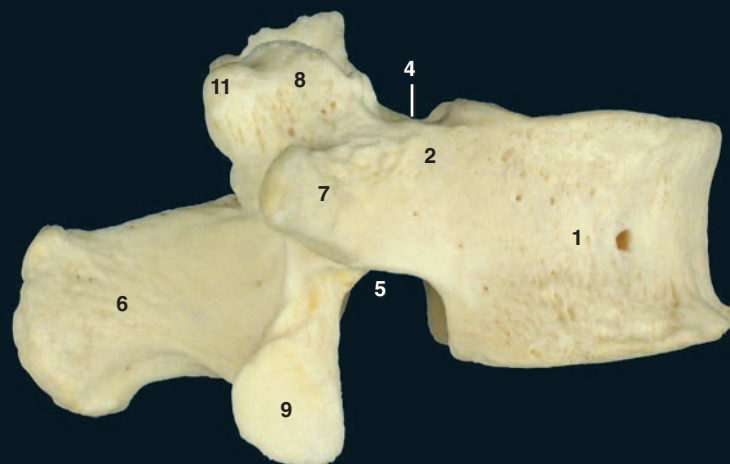
There are five lumbar vertebrae that form the lumbar portion of the vertebral column. The mobile vertebrae of this region are the largest of the true or mobile vertebrae. Their large size and lack of transverse foramina and costal facets are their diagnostic features. They form a strong column of support at the base of the vertebral column. The articular processes of the lumbar vertebrae are robust and have their facets oriented in the sagittal plane to provide for the flexion and extension movements characteristic of the lumbar vertebral column. They have thick pedicles arising from the superior aspect of the vertebral body. The laminae are thick and short and project posteriorly to unite as thick, quadrilateral spinous processes. The vertebral bodies have a large elliptical shape when viewed from above.



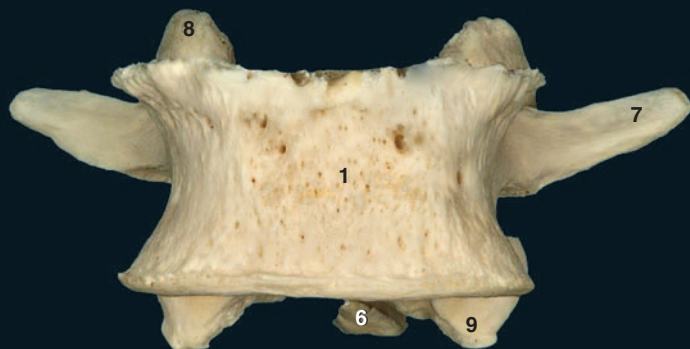
- |                            |   |
|----------------------------|---|
| 1 Vertebral body           | 7 Transverse process (costal process)                   |
| 2 Pedicle                  | 8 Superior articular process/facet                      |
| 3 Lamina                   | 9 Inferior articular process/facet                      |
| 4 Superior vertebral notch | 10 Accessory process (morphological transverse process) |
| 5 Inferior vertebral notch | 11 Mammillary process                                   |
| 6 Spinous process          |   |



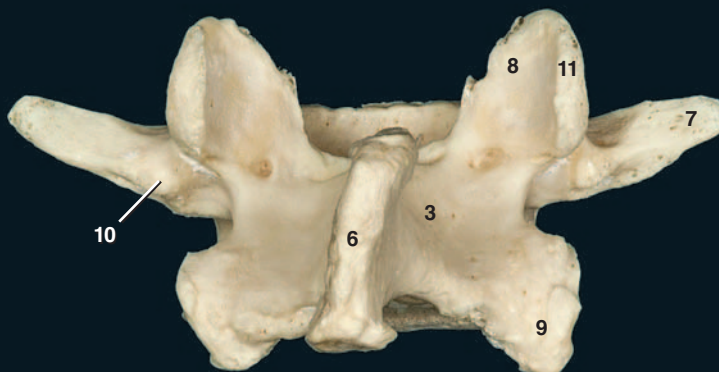
**Lumbar vertebra**  
Superior view, anterior at bottom



**Lumbar vertebra**  
Lateral view, anterior at right



**Lumbar vertebra**  
Anterior view, superior at top



**Lumbar vertebra**  
Posterior view, superior at top

# Sacrum and Coccyx

The sacrum is a large triangular-shaped mass that forms from the fusion of five vertebrocostal segments.

The base of the triangle is superior and tapers to a flat-

tened apex inferiorly. It is concave anteriorly and convex posteriorly. The lateral margins of the triangle are widest superiorly where the bone articulates with the two ilia. Forming the large basal portion of the vertebral column, the bone wedges between the two os coxae to form the posterior element of the pelvic skeleton. Its ventral surface, smoother than the rough dorsal surface, forms the posterior wall of the pelvis. Within this triangular mass of bone is a hollow sacral canal. This canal opens through foramina onto the ventral and dorsal surfaces of the bone. It forms a large oval surface superiorly that articulates with the fifth lumbar vertebra and a smaller oval facet at its apex for articulation with the coccyx.

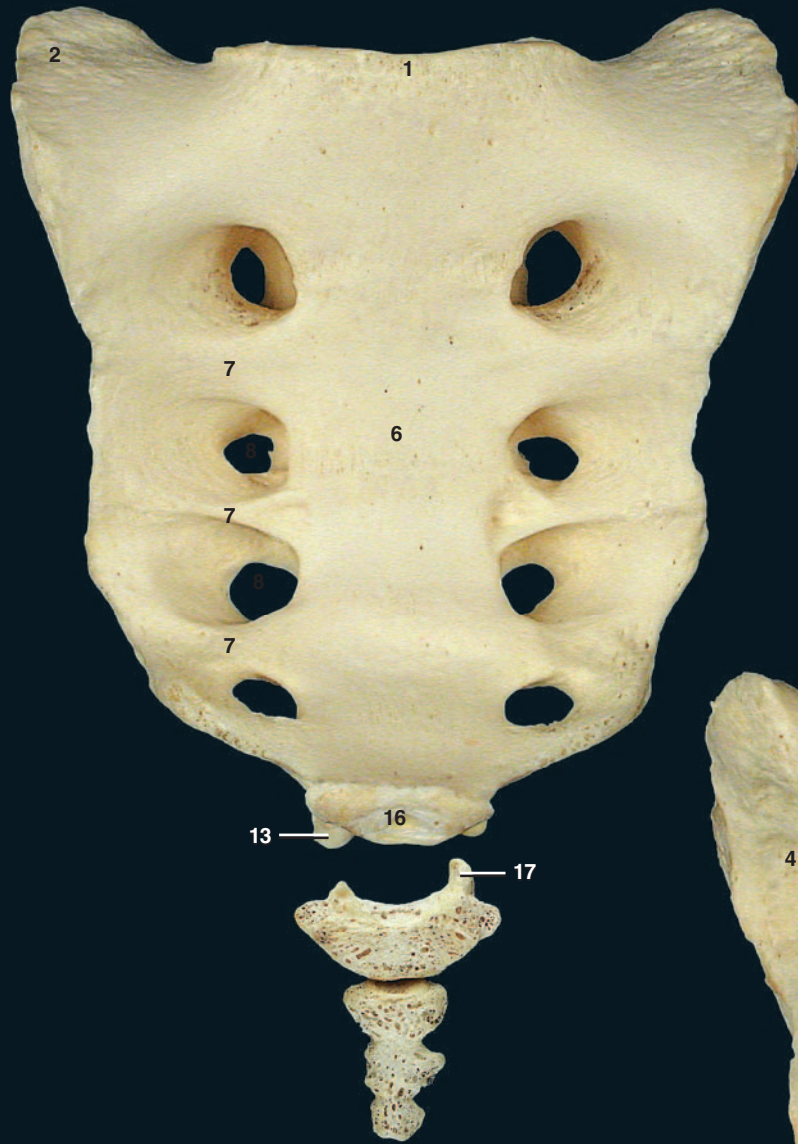
The coccyx is the terminal end of the vertebral column. It is a triangular bone that forms from the fusion of three to five vertebral segments, most commonly from four fused vertebrae. The superior surface of the first segment's body forms an oval articular surface with the inferior surface of the fifth sacral segment.



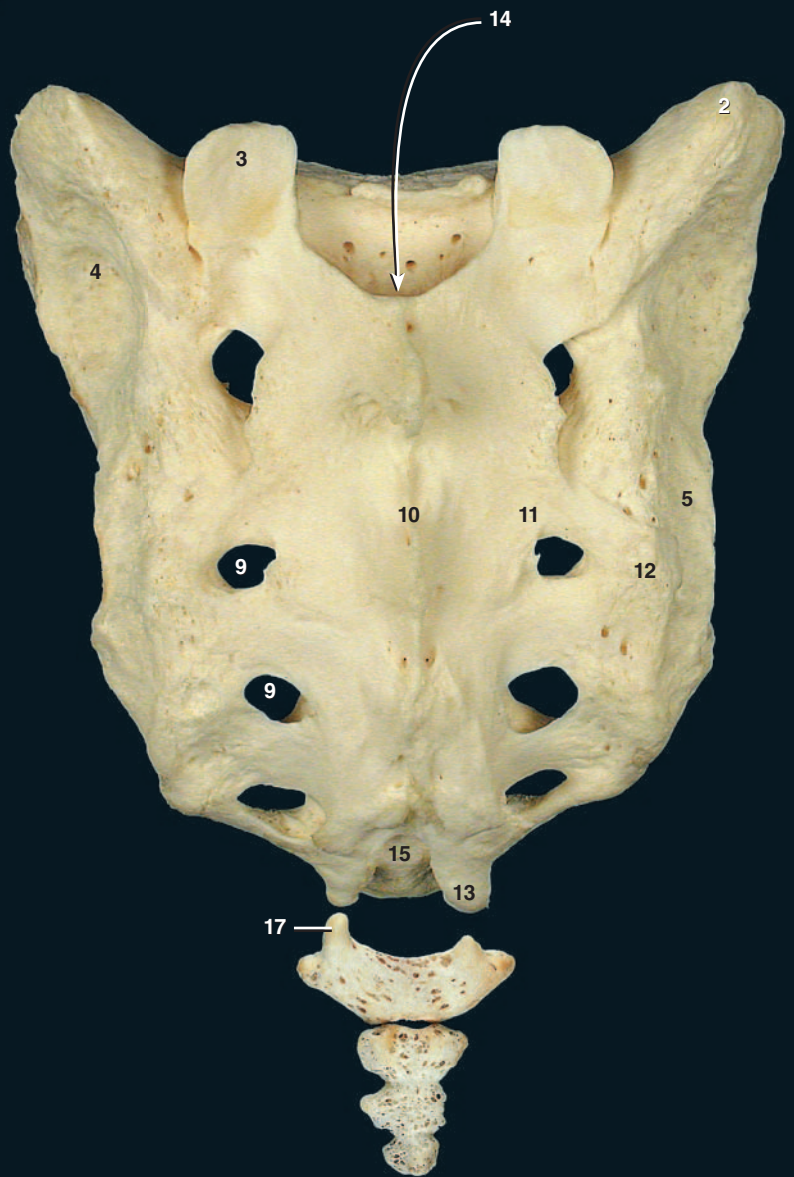
- 1 Promontory
- 2 Ala or wing
- 3 Superior articular process
- 4 Auricular surface
- 5 Sacral tuberosity
- 6 Pelvic surface
- 7 Transverse ridges
- 8 Anterior sacral foramina
- 9 Posterior sacral foramina
- 10 Median sacral crest
- 11 Intermediate sacral crest
- 12 Lateral sacral crest
- 13 Sacral cornu
- 14 Sacral canal
- 15 Sacral hiatus
- 16 Apex
- 17 Coccygeal cornu



**Sacrum and coccyx**  
Lateral view, anterior at right



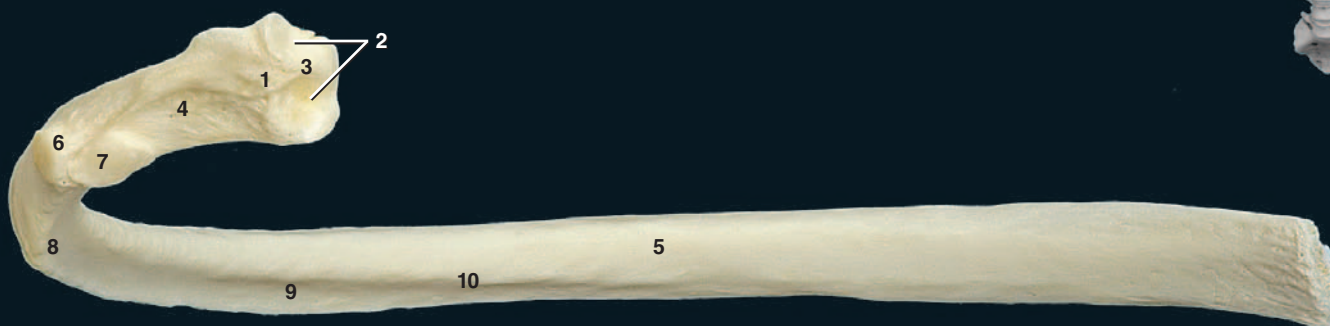
**Sacrum and coccyx**  
Anterior view, superior at top



**Sacrum and coccyx**  
Posterior view, superior at top

# Ribs

There are twelve paired ribs, a pair for each of the twelve thoracic vertebrae. The ribs unite the thoracic vertebrae to the sternum via costal cartilages to form the thoracic skeleton, a flexible, bony wall that protects thoracic viscera and facilitates respiratory function. Although only the twelve thoracic ribs are named ribs, there are in reality ribs at every vertebral level. The cervical, lumbar, sacral, and coccygeal ribs fuse to their corresponding vertebrae to contribute to the formation of the transverse process. The ribs can be divided into two groups — true ribs and false ribs. The last two false ribs are called floating ribs. True ribs, ribs one through seven, are those that have their costal cartilages attached directly to the sternum. False ribs, ribs eight through twelve, have costal cartilages that do not attach directly to the sternum. The costal cartilage of each of the first three false ribs attaches to the cartilage of the rib superior to it. The last two false ribs do not attach to other ribs and are therefore called floating ribs.

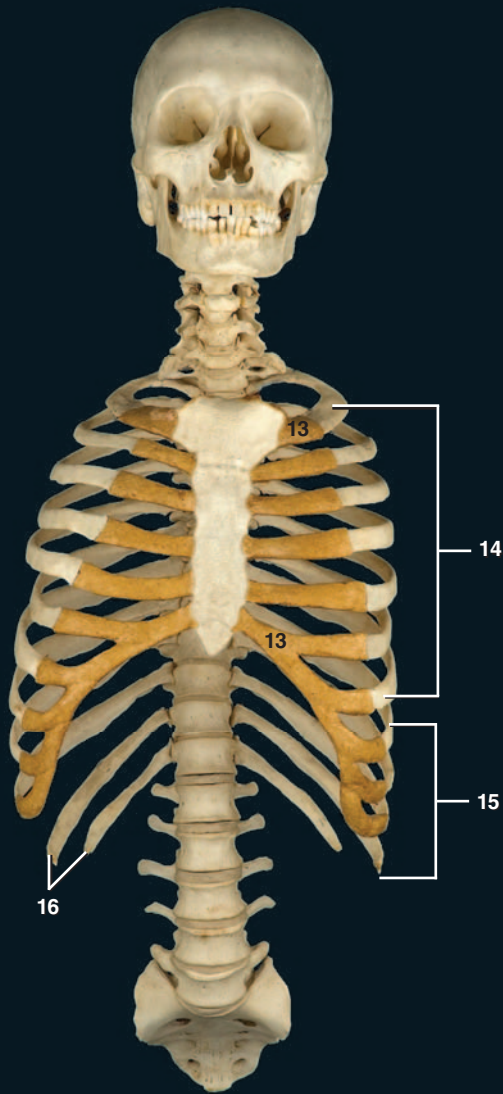


**Left sixth rib**  
Posterior view, superior at top

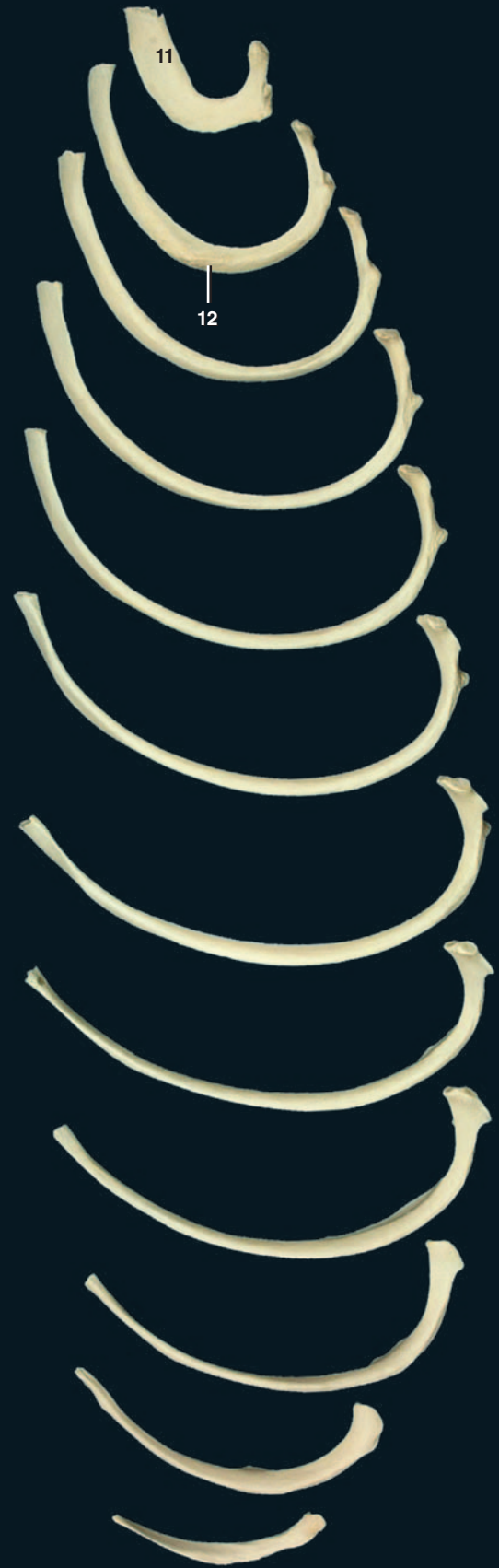


**Ribs and thoracic vertebra**  
Superior view, posterior at top

- 1 Head
- 2 Articular facets of head
- 3 Crest of head
- 4 Neck
- 5 Body or shaft
- 6 Tubercle
- 7 Articular facet of tubercle
- 8 Angle
- 9 Costal groove
- 10 Crest of body
- 11 Scalene tubercle (first rib)
- 12 Tuberosity of serratus anterior (second rib)
- 13 Costal cartilage
- 14 True ribs [I-VII]
- 15 False ribs [VII-XII]
- 16 Floating ribs [XI-XII]



**Rib cage**  
Anterior view



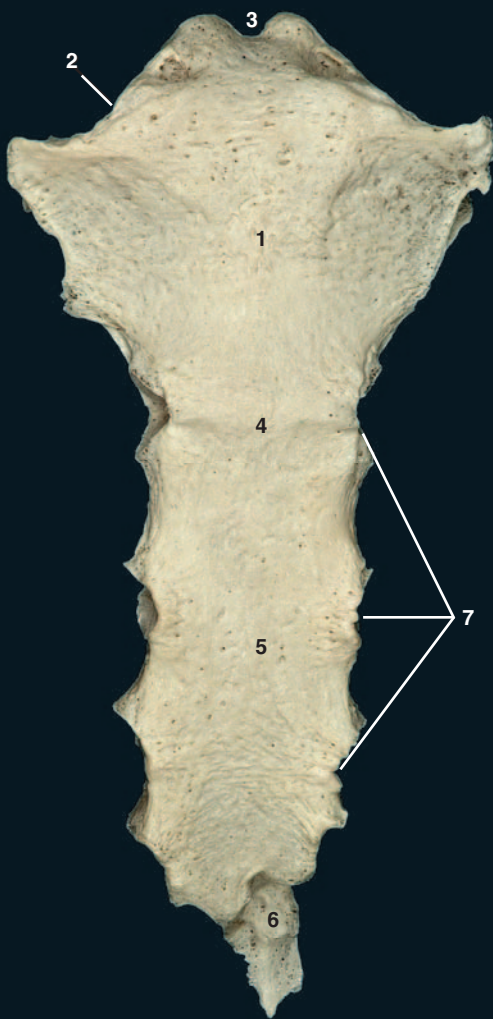
**Left ribs 1 through 12**  
Superior view, first rib at top, posterior to right

# Sternum

The sternum is the anterior bone of the thoracic wall. It forms from six segmental elements, or sternebrae, that fuse during development. The bone has the appearance of a sword with a wide handle called the manubrium, a tapering blade or body, and a sharp point-like apex named the xiphoid process. A distinct angle forms at the junction of the manubrium and the body. This angle is called the sternal angle. A horizontal plane extended posteriorly intersects the disc between the fourth and fifth thoracic vertebrae and marks the top of the heart in the thoracic cavity. The lateral margins of the bone are notched for reception of the costal cartilages and clavicles. Its anterior surface is slightly convex, while the posterior surface is weakly concave. The sternum articulates with sixteen bones, more articulations than any other bone in the body.



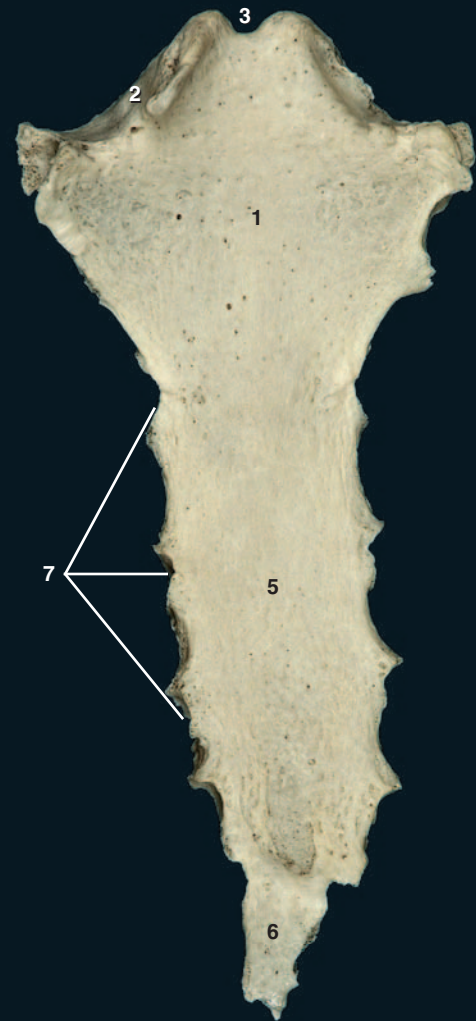
- |                                 |                   |
|---------------------------------|-------------------|
| 1 Manubrium                     | 5 Body            |
| 2 Clavicular notch              | 6 Xiphoid process |
| 3 Jugular or suprasternal notch | 7 Costal notches  |
| 4 Sternal angle                 |                   |



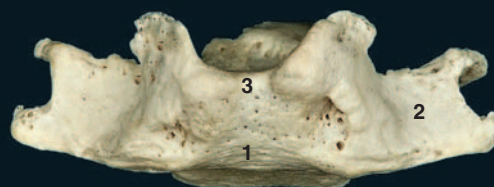
**Sternum**  
Anterior view, superior at top



**Sternum**  
Lateral view, anterior at left



**Sternum**  
Posterior view, superior at top



**Sternum**  
Superior view, posterior at top



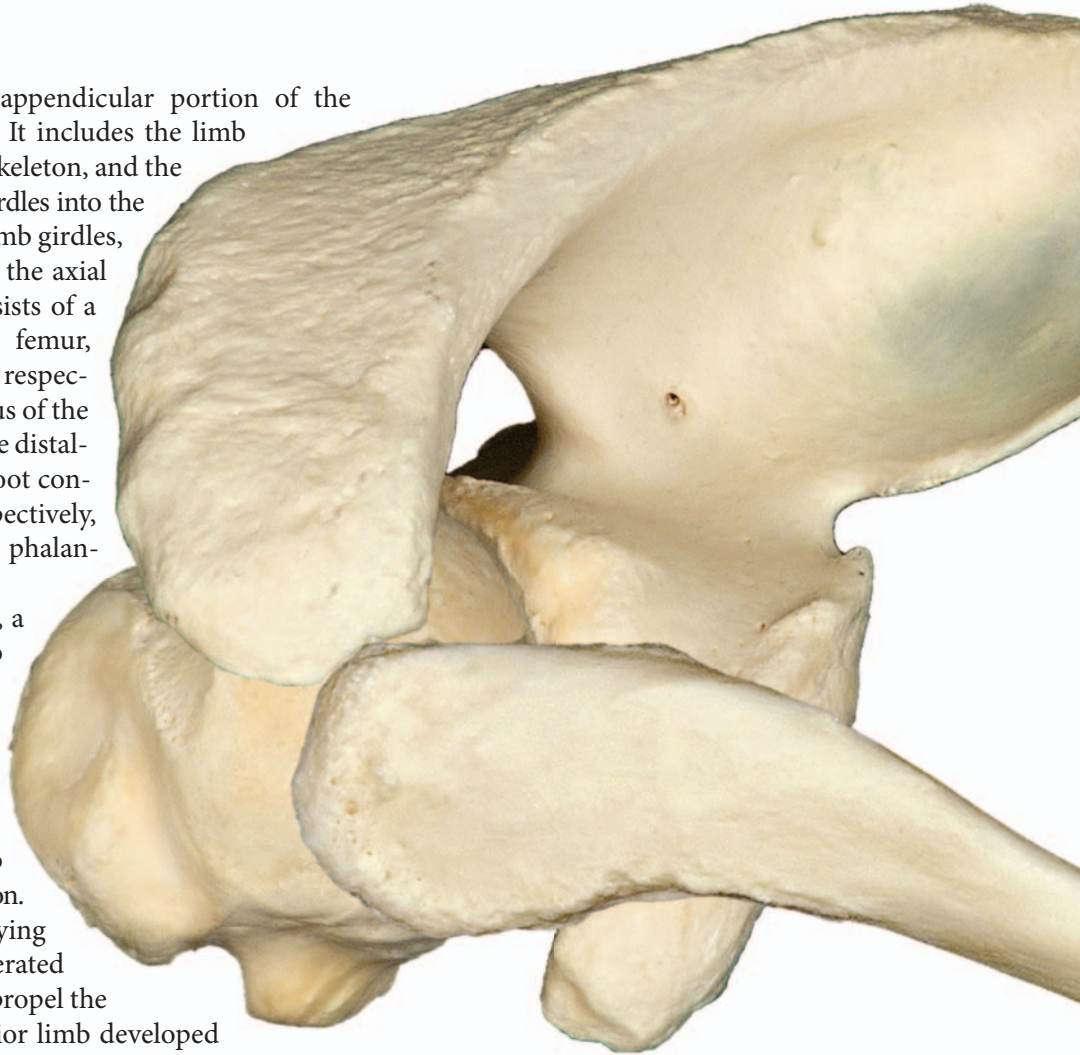
# 6

# Appendicular Skeleton

The appendicular portion of the skeleton forms the framework of the limbs. It includes the limb girdles, or fixed portion of the appendicular skeleton, and the series of bones that extend distally from the girdles into the limb proper, or free portion of the limb. The limb girdles, pectoral and pelvic, help anchor the limb to the axial skeleton. The free portion of each limb consists of a large proximal element, the humerus and femur, forming the skeleton of the arm and thigh, respectively. Next in sequence are the ulna and radius of the forearm, and the fibula and tibia of the leg. The distal-most regions of the limbs are the hand and foot consisting of the short carpal and tarsal bones, respectively, along with the metacarpals, metatarsals, and phalanges of the digits.

As the tetrapod (land) vertebrates evolved, a major difference emerged between the two limbs. The anterior, or upper limb, evolved as a steering device, while the posterior, or lower limb, became the locomotor limb. Accompanying these evolutionary modifications in limb function were important morphological differences. The powerful locomotor hind limb developed strong attachments to the axial skeleton. The strong iliosacral joint, with its accompanying ligaments, transfers the powerful forces generated by the posterior limb to the axial skeleton to propel the body forward. On the other hand, the anterior limb developed minimal, weak skeletal attachments between the girdle and axial skeleton while becoming a more mobile limb.

As you study the skeleton of the limbs in the photos that follow, note the similarities and differences that exist between the bones of the superior and inferior limb skeletons and think about the functional differences mentioned above.

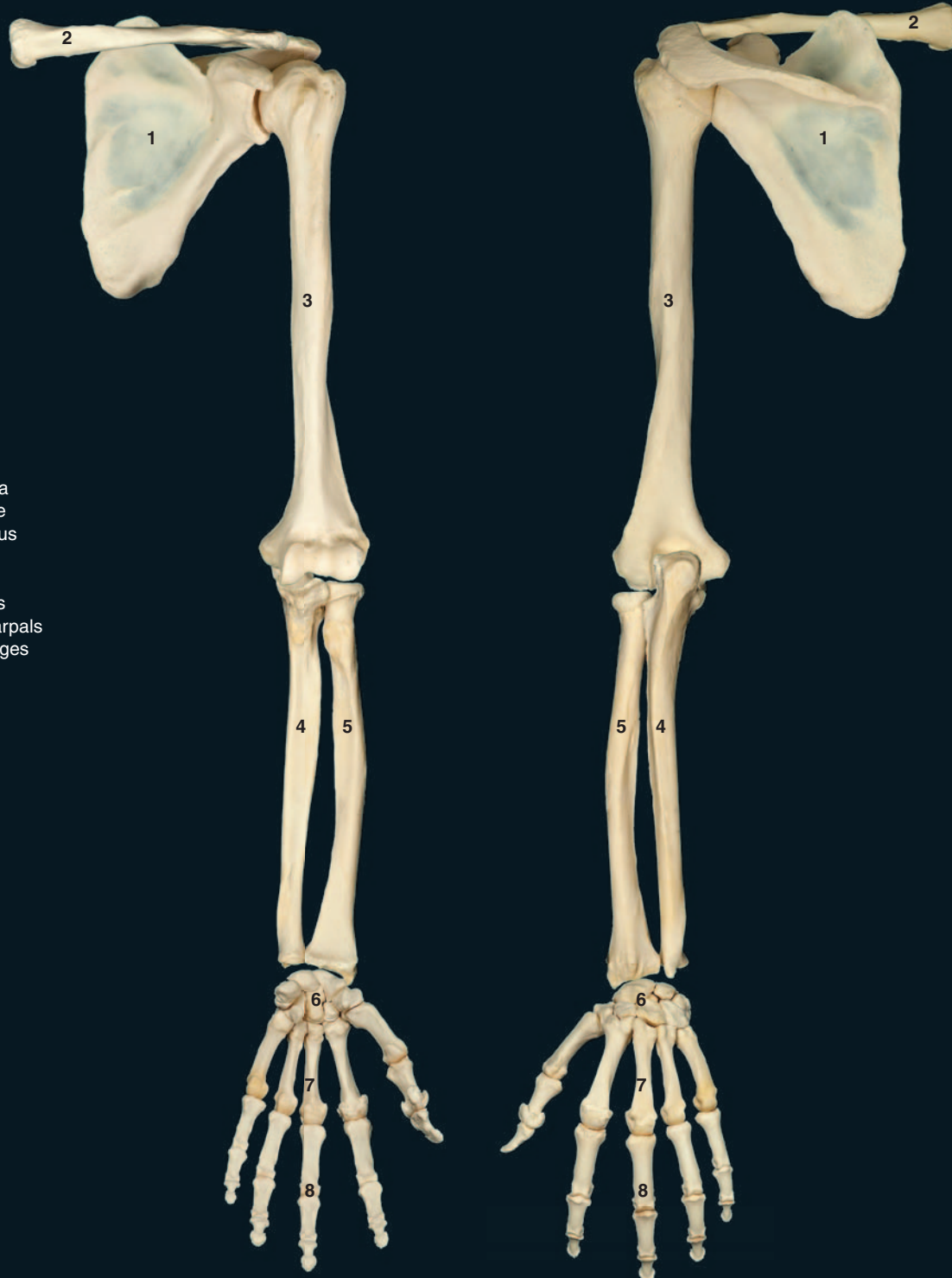


Find more information  
about the appendicular  
skeleton in

REALANATOMY

# Upper Limb

Each superior limb consists of 32 bones. The proximal end of the superior limb, the clavicle and scapula, form the pectoral or shoulder girdle. This girdle of bones provides a broad base of support that is primarily anchored to the axial skeleton by muscles rather than ligaments. The free part of the upper limb consists of the humerus, radius, ulna, and hand. The humerus forms the skeletal framework for the brachium. Distal to the brachium is the antebrachium containing the radius and ulna. The distal-most region of the superior limb is the hand consisting of a wrist region of eight carpal bones, the palm region consisting of five metacarpal bones, and the fourteen phalanges of the fingers and thumb.



- 1 Scapula
- 2 Clavicle
- 3 Humerus
- 4 Ulna
- 5 Radius
- 6 Carpals
- 7 Metacarpals
- 8 Phalanges

Left upper limb  
Anterior view

Left upper limb  
Posterior view

# Pectoral Girdle

The pectoral, or shoulder, girdle consisting of the scapula and the clavicle forms the base of the upper limb skeleton. The rod-like clavicle forms a horizontal strut that links the scapula to the sternum of the axial skeleton. The large triangular scapula presents an extensive surface area for muscle attachment and a large lateral fossa that articulates with the humerus of the free part of the upper limb. Except for the weak joint formed between the clavicle and the sternum, the pectoral girdle is essentially unattached by ligaments or joints to the axial skeleton. This was paramount in the evolutionary role of this limb as a steering device and shock absorber during locomotion.



Left pectoral girdle  
Lateral view

- 1 Scapula
- 2 Clavicle



Left pectoral girdle  
Superior view

# Clavicle

The clavicle has an S-shaped appearance that can range from an almost straight, shallow S-curve shape to a deeper, more prominent S-curve shape. The curve at the medial or sternal end of the bone is concave posteriorly, while the curve at the lateral or acromial end is concave anteriorly. This is one of the more variable bones of the skeleton. It is typically smooth and straight in females and rougher and more curved in males. The bone forms the ventral strut of the pectoral girdle that props the shoulder joint away from the rib cage. It is subcutaneous and easily palpable throughout its length. This combination of features makes it susceptible to fracture from falls onto the limb. The clavicle articulates with the three bones — the scapula, sternum, and first rib.



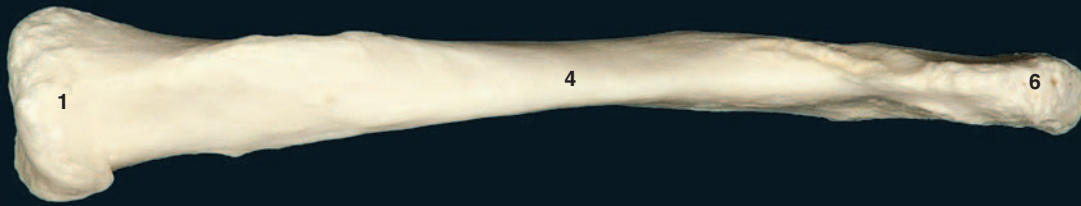
- 1 Sternal end
- 2 Sternal facet
- 3 Impression for costoclavicular ligament
- 4 Shaft or body
- 5 Subclavian groove
- 6 Acromial end
- 7 Acromial facet
- 8 Tuberosity for coracoclavicular ligament
- 9 Conoid tubercle
- 10 Trapezoid line



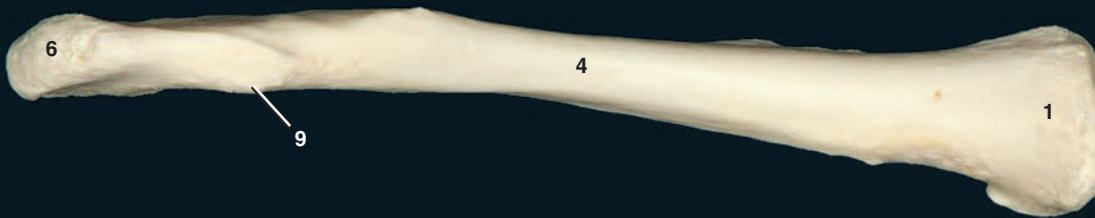
**Left clavicle**  
Superior view, lateral to right



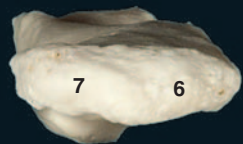
**Left clavicle**  
Inferior view, lateral to right



**Left clavicle**  
Anterior view, lateral to right



**Left clavicle**  
Posterior view, lateral to left



**Left clavicle**  
Lateral view, anterior to left



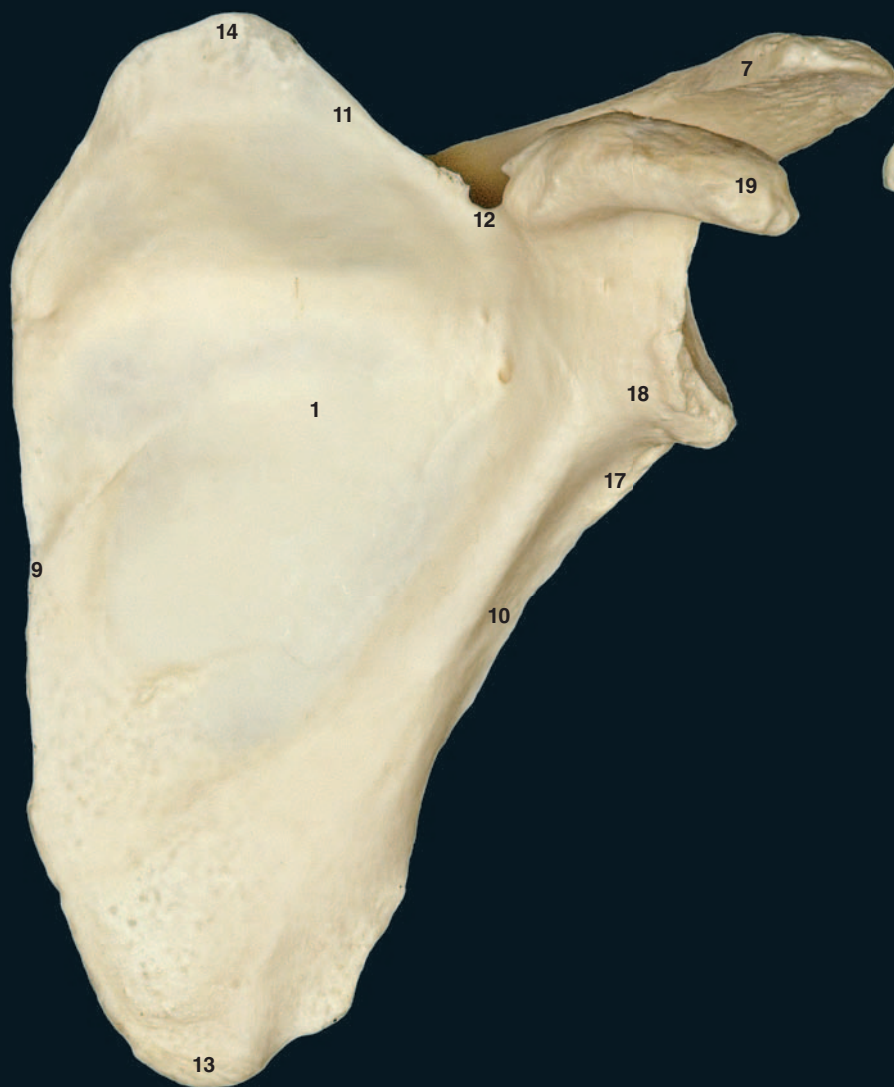
**Left clavicle**  
Medial view, anterior to right

# Scapula

The scapula is a flat, triangular bone with three prominent projections. The flattened triangular portion of the bone, the body, spans from the second to the seventh rib and consists of three borders (superior, lateral, and medial) and three angles (superior, inferior, and lateral) and is typically a very thin plate of bone. Its lateral angle is conspicuous as it forms the glenoid fossa, or shoulder socket that articulates with the head of the humerus. Its three prominent projections are the anterior projecting coracoid process, the posterior projecting ridge called the spine, and the flat laterally projecting acromion, which forms the lateral expansion of the spine. The scapula articulates with two bones — the clavicle and the humerus.



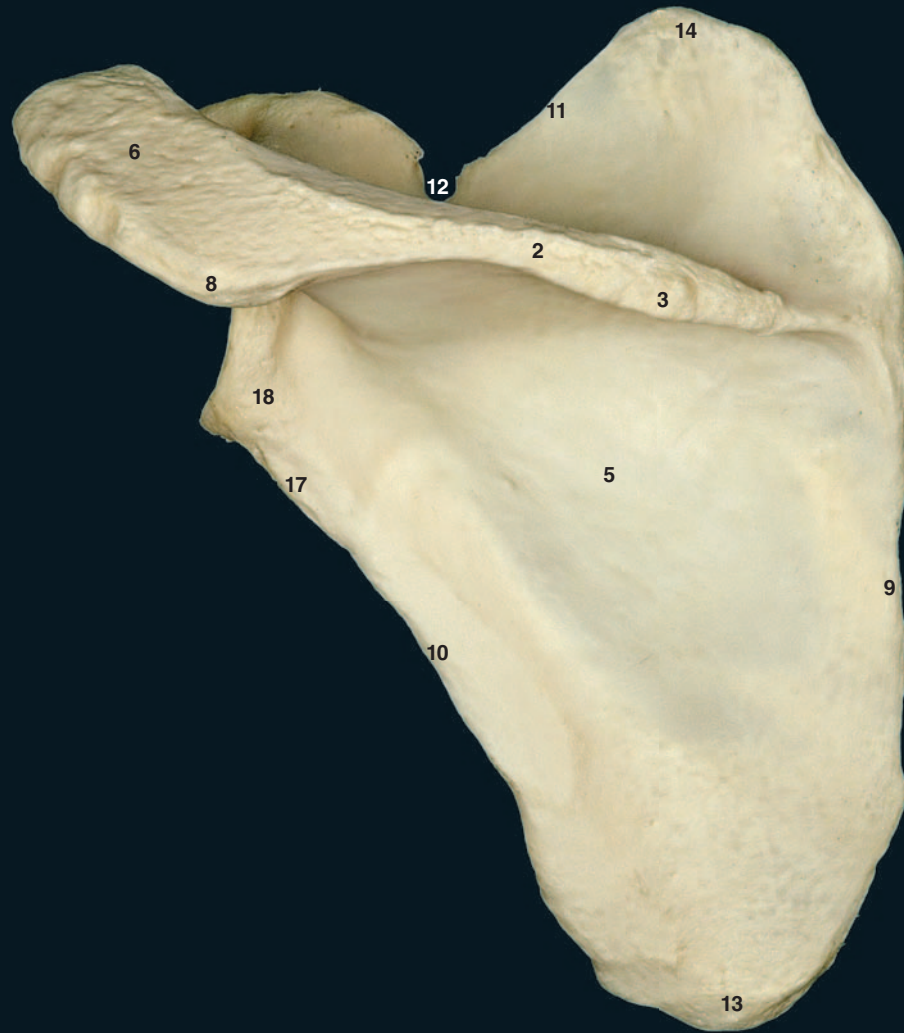
- |                      |                          |
|----------------------|--------------------------|
| 1 Subscapular fossa  | 11 Superior border       |
| 2 Spine              | 12 Suprascapular notch   |
| 3 Deltoid tubercle   | 13 Inferior angle        |
| 4 Supraspinous fossa | 14 Superior angle        |
| 5 Infraspinous fossa | 15 Glenoid cavity        |
| 6 Acromion           | 16 Supraglenoid tubercle |
| 7 Clavicular facet   | 17 Infraglenoid tubercle |
| 8 Acromial angle     | 18 Neck                  |
| 9 Medial border      | 19 Coracoid process      |
| 10 Lateral border    |                          |



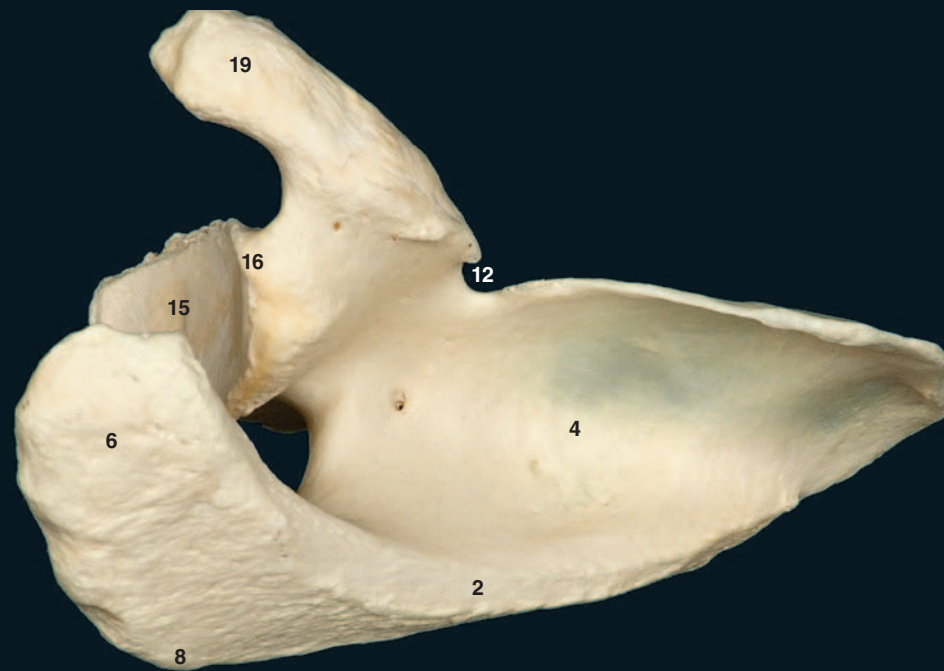
**Left scapula**  
Anterior view, lateral to right



**Left scapula**  
Lateral view, anterior to right



**Left scapula**  
Posterior view, Lateral to left



**Left scapula**  
Superior view, lateral to left

# Humerus

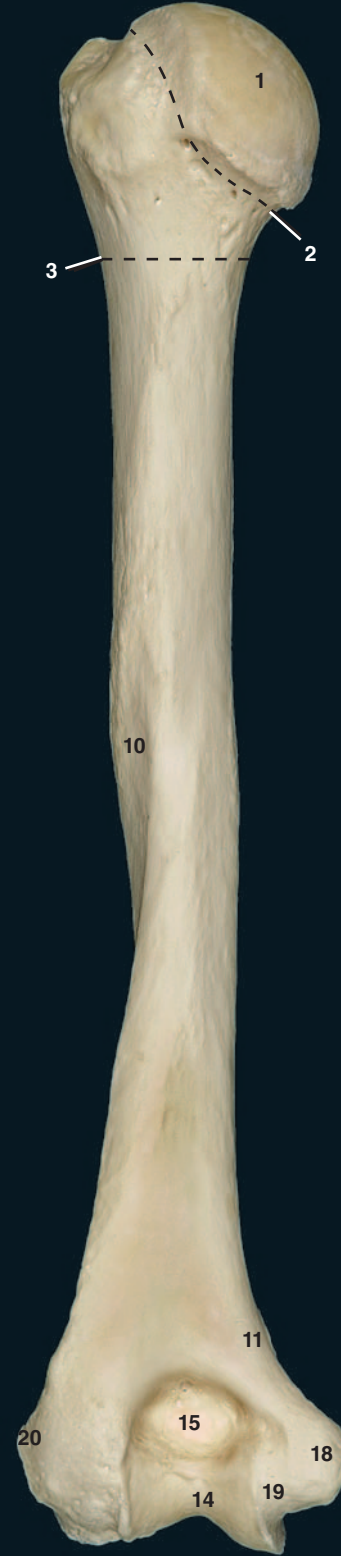
The humerus is the skeletal element of the brachium and it is the largest bone of the upper limb. It has a long cylindrical shaft that expands at the proximal and distal ends. The proximal end is rounded, while the distal end is flattened from anterior to posterior. The ends consist of a spongy core of bone covered with a thin lamina of compact bone. The shaft is a cylinder of thick compact bone surrounding a large medullary cavity. The humerus articulates with three bones — the scapula, ulna, and radius.



- 1 Head
- 2 Anatomical neck
- 3 Surgical neck
- 4 Greater tubercle
- 5 Lesser tubercle
- 6 Intertubercular sulcus or groove
- 7 Crest of greater tubercle
- 8 Crest of lesser tubercle
- 9 Shaft or body
- 10 Groove for radial nerve
- 11 Medial supracondylar ridge
- 12 Deltoid tuberosity
- 13 Capitulum
- 14 Trochlea
- 15 Olecranon fossa
- 16 Coronoid fossa
- 17 Radial fossa
- 18 Medial epicondyle
- 19 Groove for ulnar nerve
- 20 Lateral epicondyle



**Left humerus**  
Anterior view, lateral to right



**Left humerus**  
Posterior view, lateral to left

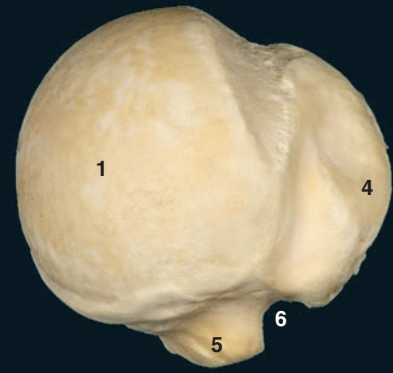




**Left humerus**  
Lateral view, anterior to left



**Left humerus**  
Medial view, anterior to right



**Left humerus**  
Superior view, lateral to left



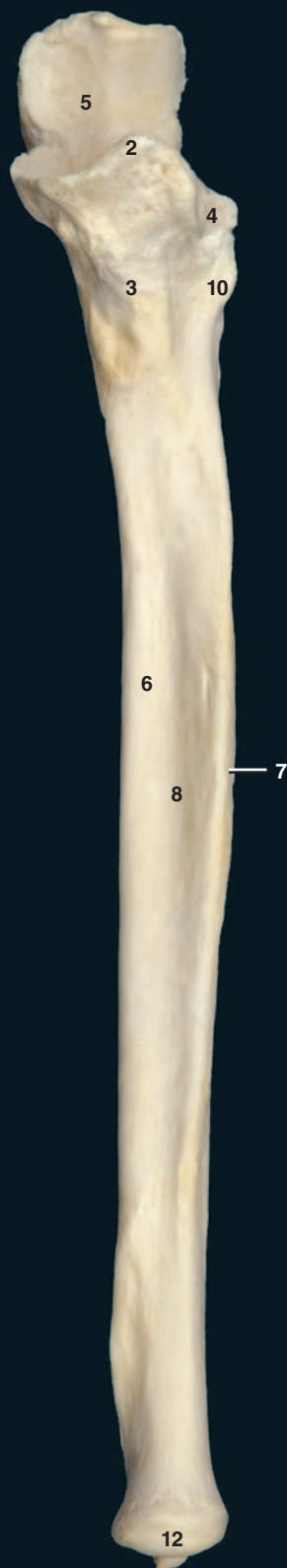
**Left humerus**  
Inferior view, lateral to right

# Ulna

The ulna is the medial and longer bone of the antebrachium. It is thick and notched at its proximal end where it is a major contributor to the elbow joint. From the notched proximal end it tapers to a thin shaft that ends distally as a small rounded head. The ulna articulates with two bones—the humerus and the radius.



- 1 Olecranon
- 2 Coronoid process
- 3 Ulnar tuberosity
- 4 Radial notch
- 5 Trochlear notch
- 6 Shaft or body
- 7 Interosseous border
- 8 Anterior border
- 9 Posterior border
- 10 Supinator crest
- 11 Head
- 12 Articular circumference
- 13 Ulnar styloid process



**Left ulna**  
Anterior view, lateral to right



**Left ulna**  
Posterior view, lateral to left



**Left ulna**  
Lateral view, anterior to left



**Left ulna**  
Medial view, anterior to right



**Left ulna**  
Superior view, lateral to left



**Left ulna**  
Inferior view, lateral to right

# Radius

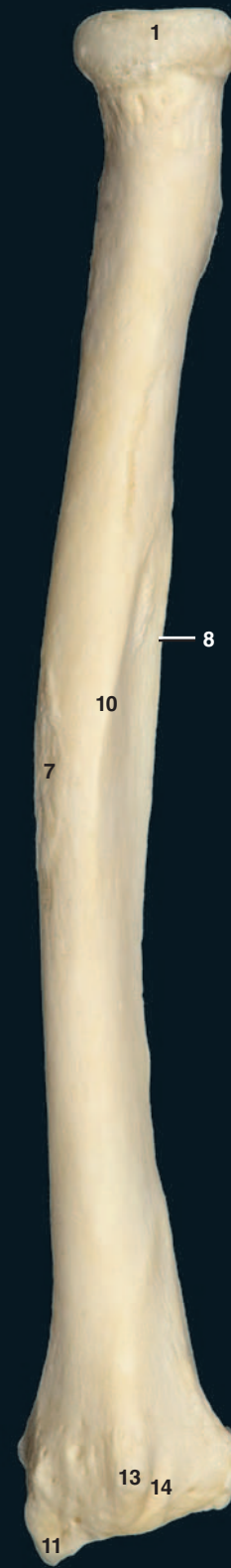
The radius is the lateral, slender, rod-like bone of the antebrachium. The rod-like shaft expands at both ends. The proximal end forms a wheel-like head with a proximal concavity, while the distal end expands from medial to lateral to form the widest part of the bone. The distal end is concave anteriorly and convex and grooved posteriorly. The ridge-like borders of the shaft give it a triangular shape in cross section. The radius articulates with four bones — the humerus, ulna, scaphoid, and lunate.



- 1 Head
- 2 Articular facet
- 3 Articular circumference
- 4 Neck
- 5 Shaft or body
- 6 Radial tuberosity
- 7 Pronator tuberosity
- 8 Interosseous border
- 9 Anterior border
- 10 Posterior border
- 11 Radial styloid process
- 12 Suprastyloid crest
- 13 Dorsal tubercle
- 14 Groove for extensor muscle tendons
- 15 Ulnar notch
- 16 Carpal articular surface



**Left radius**  
Anterior view, lateral to right



**Left radius**  
Posterior view, lateral to left



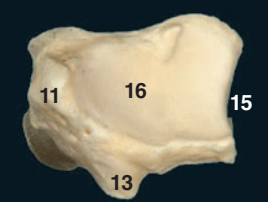
**Left radius**  
Lateral view, anterior to left



**Left radius**  
Medial view, anterior to right



**Left radius**  
Superior view, lateral to left



**Left radius**  
Inferior view, lateral to right

# Hand Skeleton

The hand is a composite structure consisting of 27 bones. The proximal end of the hand is the carpus or wrist. The carpal bones are eight in number and are arranged in two rows of four, a distal row and a proximal row. Distal to the carpus are the five digital rays. Each digit, called a finger of which there are four, consists of a metatarsal bone and three phalanges. The remaining digit, the thumb or pollex, has a metatarsal bone and only two phalanges. The photos of the hands below and on the opposing page are positioned as if you were looking at your own hand.



**Left hand**  
Anterior view, lateral to left

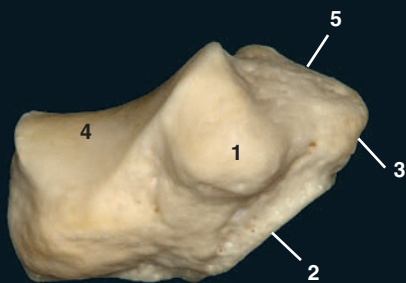
- |              |                     |
|--------------|---------------------|
| 1 Scaphoid   | 9 Metacarpal I      |
| 2 Lunate     | 10 Metacarpal II    |
| 3 Triquetrum | 11 Metacarpal III   |
| 4 Pisiform   | 12 Metacarpal IV    |
| 5 Trapezium  | 13 Metacarpal V     |
| 6 Trapezoid  | 14 Proximal phalanx |
| 7 Capitate   | 15 Middle phalanx   |
| 8 Hamate     | 16 Distal phalanx   |



**Left hand**  
Posterior view, lateral to right

# Carpal Bones

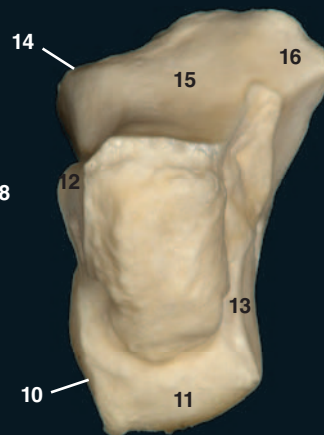
The eight carpal bones form the proximal end of the hand skeleton. The main features of this complex little series of bones are the numerous articular surfaces they form with one another and with the metacarpal and antebrachial bones. The carpal bones form two rows of four bones each. The two largest bones of the proximal row, the scaphoid and the lunate, articulate with the distal end of the radius. The row of distal bones form the skeletal foundation for the fingers and articulate with the metacarpal bones of the fingers and thumb. The anterior surface of the carpal bones forms the floor of the carpal tunnel that supports the major digital flexor tendons that enter the hand.



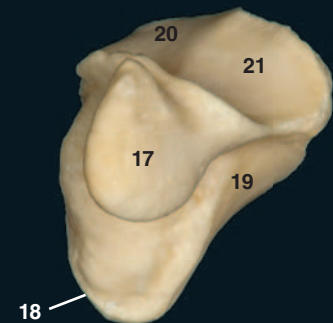
**Left trapezium**  
Anterior view, lateral to left



**Left trapezoid**  
Anterior view, lateral to left



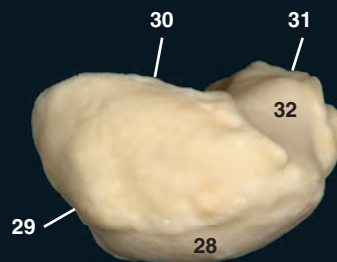
**Left capitate**  
Anterior view, lateral to left



**Left hamate**  
Anterior view, lateral to left



**Left scaphoid**  
Anterior view, lateral to left



**Left lunate**  
Anterior view, lateral to left



**Left triquetrum**  
Anterior view, lateral to left



**Left pisiform**  
Anterior view, lateral to left



**Trapezium**

- 1 Tubercle of trapezium
- 2 Articular surface with scaphoid
- 3 Articular surface with trapezoid
- 4 Articular surface with first metacarpal
- 5 Articular surface with second metacarpal

**Trapezoid**

- 6 Articular surface with scaphoid
- 7 Articular surface with trapezium
- 8 Articular surface with capitate
- 9 Articular surface with first metacarpal

**Capitate**

- 10 Articular surface with scaphoid
- 11 Articular surface with lunate
- 12 Articular surface with trapezoid
- 13 Articular surface with hamate
- 14 Articular surface with second metacarpal
- 15 Articular surface with third metacarpal
- 16 Articular surface with fourth metacarpal

**Hamate**

- 17 Hook of hamate or hamulus
- 18 Articular surface with lunate
- 19 Articular surface with triquetrum
- 20 Articular surface with fourth metacarpal
- 21 Articular surface with fifth metacarpal

**Scaphoid**

- 22 Scaphoid tubercle
- 23 Articular surface with radius
- 24 Articular surface with trapezium
- 25 Articular surface with trapezoid
- 26 Articular surface with capitate
- 27 Articular surface with lunate

**Lunate**

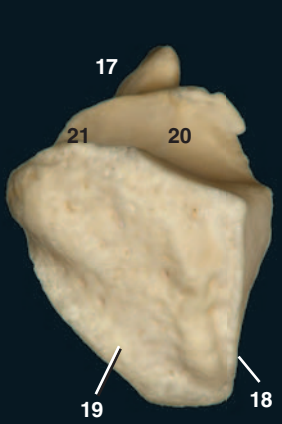
- 28 Articular surface with radius
- 29 Articular surface with scaphoid
- 30 Articular surface with capitate
- 31 Articular surface with hamate
- 32 Articular surface with triquetrum

**Triquetrum**

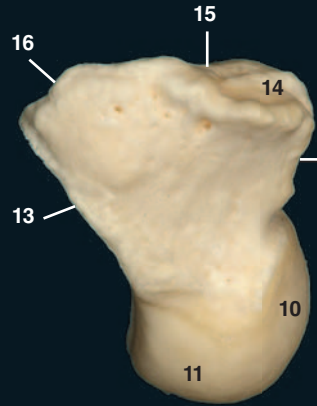
- 33 Articular surface with lunate
- 34 Articular surface with pisiform
- 35 Articular surface with hamate

**Pisiform**

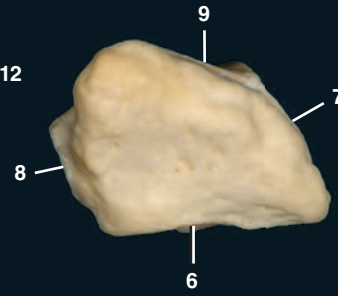
- 36 Articular surface with triquetrum



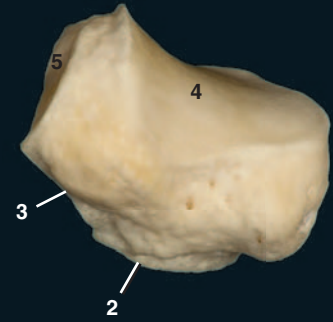
**Left hamate**  
Posterior view, lateral to right



**Left capitate**  
Posterior view, lateral to right



**Left trapezoid**  
Posterior view, lateral to right



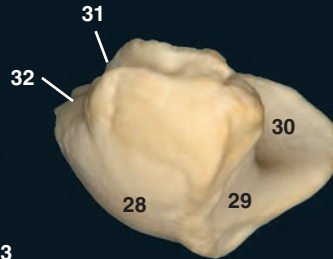
**Left trapezium**  
Posterior view, lateral to right



**Left pisiform**  
Posterior view, lateral to right



**Left triquetrum**  
Posterior view, lateral to right



**Left lunate**  
Posterior view, lateral to right



**Left scaphoid**  
Posterior view, lateral to right

# Metacarpals and Phalanges

The five digital rays of the hand consist of a series of four bones, except in the thumb where there are only three bones, that decrease in length from proximal to distal. Forming the skeleton of the palmar region of the hand are the stout metacarpal bones. Note their saddle-like bases and rounded heads. The anterior-posterior flattened phalanges project into the proper portion of the fingers and thumb from the metacarpal bones.



**Left phalanges**  
Anterior view, thumb to left



**Left metacarpal bones, numbered I to V from lateral to medial**  
Anterior view, thumb to left

- 1 Base of metacarpal
- 2 Shaft or body of metacarpal
- 3 Head of metacarpal
- 4 Styloid process of third metacarpal

- 5 Base of phalanx
- 6 Shaft or body of phalanx
- 7 Head of phalanx
- 8 Trochlea of phalanx
- 9 Tuberosity of distal phalanx



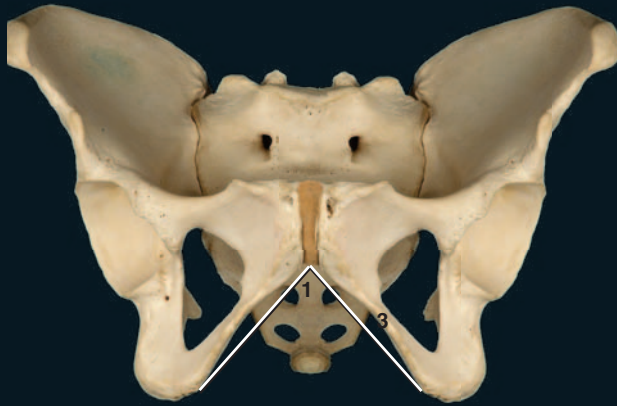
**Left phalanges**  
Posterior view, thumb to right



**Left metacarpal bones, numbered I to V from lateral to medial**  
Posterior view, thumb to right

# Pelvis - Female

The characteristic features of the female pelvis are related to the role of the female pelvis in childbirth. While there are numerous diagnostic features that help distinguish a female pelvis, some of the most obvious are those that increase the diameter of the pelvic outlet. For example, note the wider pubic angle (1) and greater sciatic notch (2) of the female pelvis.



**Female pelvis**  
Anterior view, superior to top



**Female pelvis**  
Posterior view, superior to top



**Female pelvis**  
Superior view, anterior to bottom



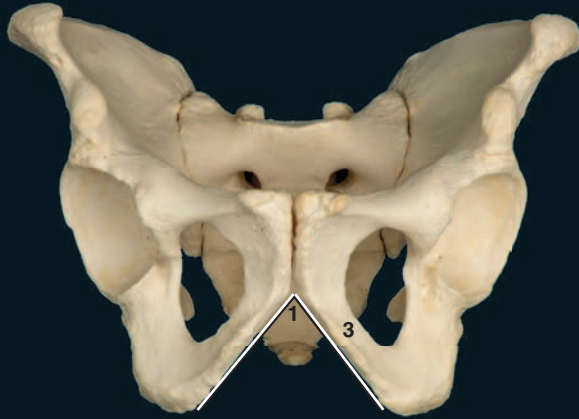
**Female pelvis**  
Inferior view, anterior to bottom



**Female pelvis**  
Lateral view, anterior to left

# Pelvis - Male

The male pelvis tends to have a more narrow profile than the pelvis of the female. Compare the diameter of the outlet, the angle of the pubic arch, and the width of the greater sciatic notch with those of the female pelvis. Also, note the stout, thick ischio-pubic ramus (3) of the male compared to the slender ischiopubic ramus of the female pelvis.



**Male pelvis**  
Anterior view, superior to top



**Male pelvis**  
Posterior view, superior to top



**Male pelvis**  
Superior view, anterior to bottom



**Male pelvis**  
Inferior view, anterior to bottom



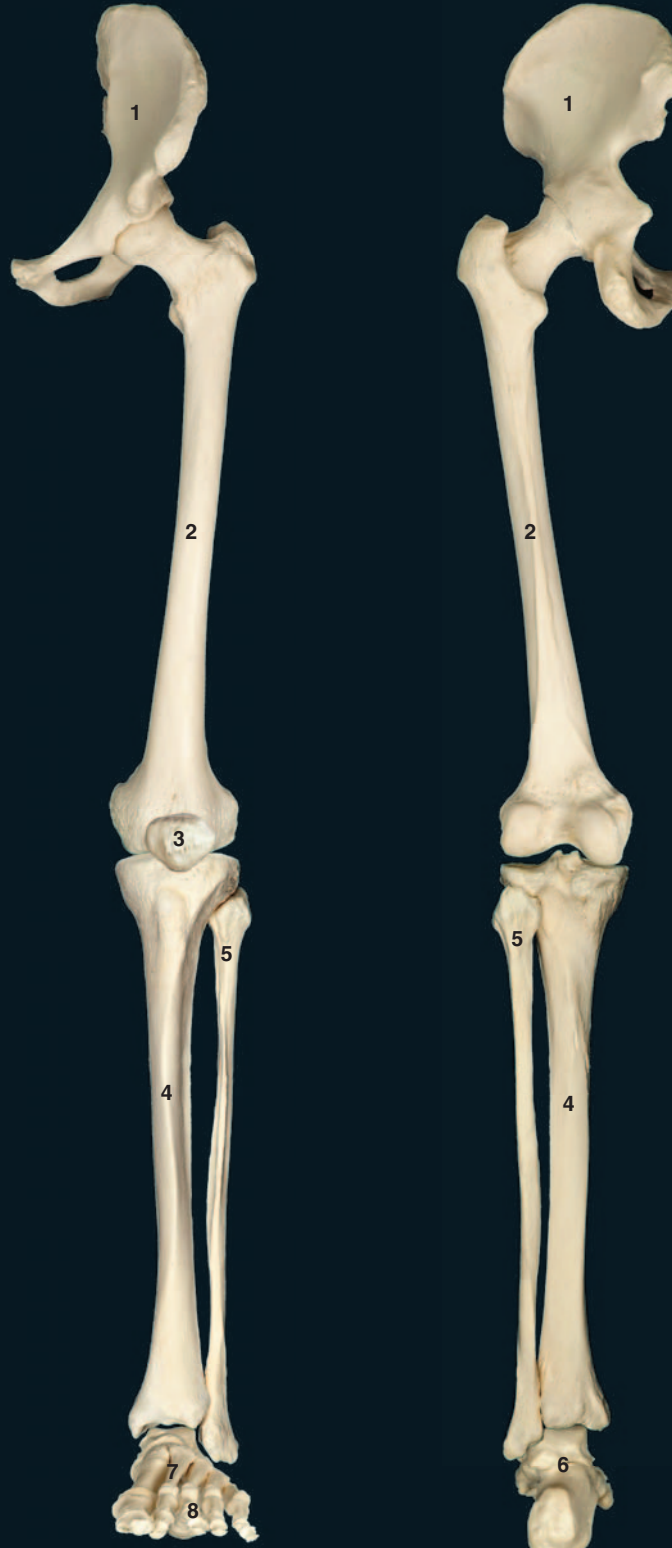
**Male pelvis**  
Lateral view, anterior to left

# Inferior Limb

Each inferior appendage consists of 31 bones. The broad base of the inferior limb is the pelvic girdle. This girdle is the strong fusion of three bones, the ilium, ischium, and pubis, to form the os coxae or hip bone. The os coxae is firmly anchored to the sacrum via strong ligaments and a synovial joint. Distal to the girdle is the free part of the lower limb. The bony framework of the thigh is the femur with the sesamoid patella at its distal end. Distal to the femur, the tibia and fibula form the skeleton of the crus or leg. The distal-most region of the inferior limb is the foot consisting of seven tarsal bones, five metatarsal bones, and fourteen phalanges.



- 1 Os coxae or hip bone
- 2 Femur
- 3 Patella
- 4 Tibia
- 5 Fibula
- 6 Tarsal bones
- 7 Metatarsal bones
- 8 Phalanges



**Left lower limb**  
Anterior view, lateral to right

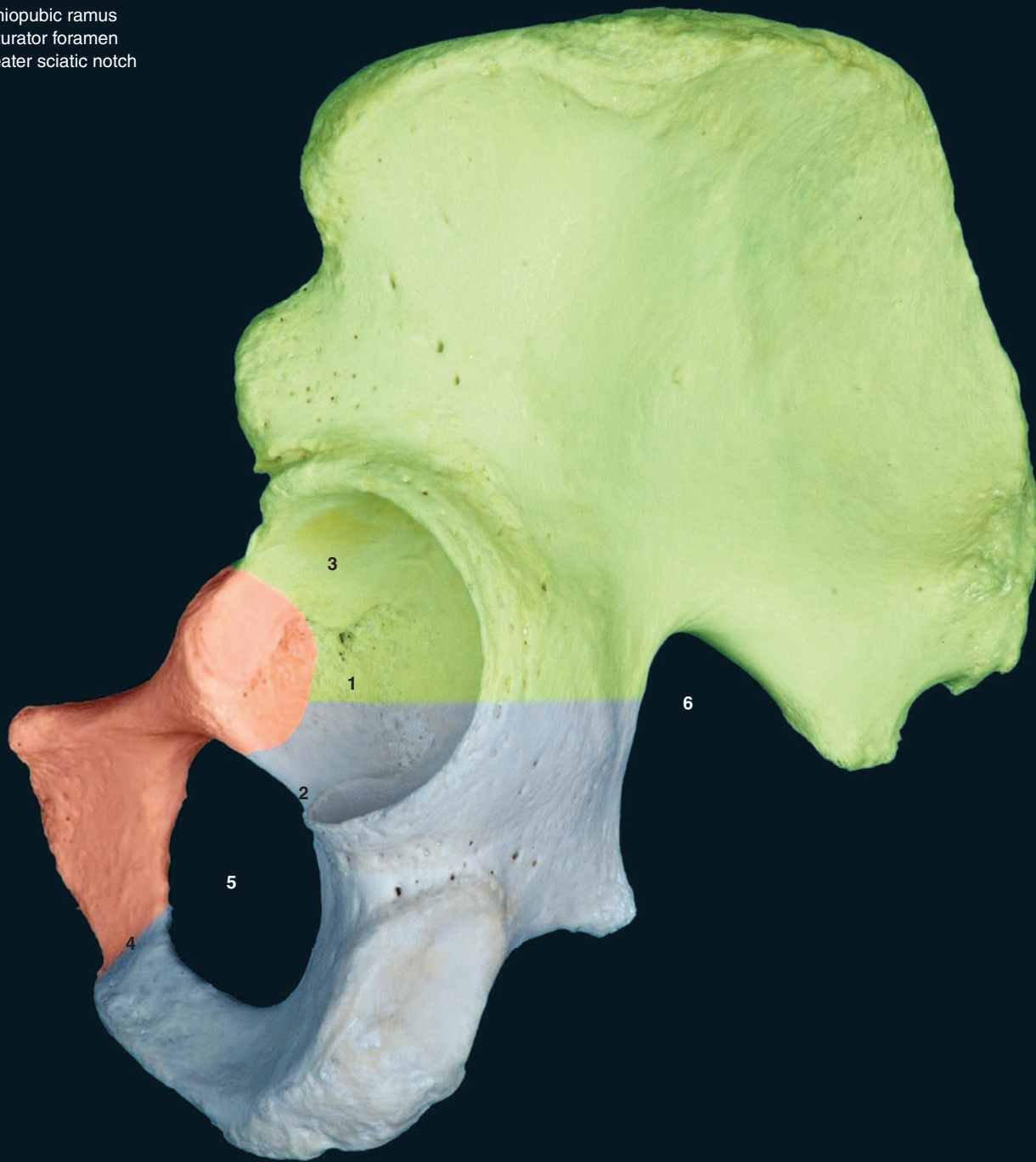
**Left lower limb**  
Posterior view, lateral to left

# Os Coxae

Each os coxae forms from three separate bony elements that fuse during development at their site of union within the acetabulum. The three bony elements are the ilium, ischium, and pubis. This strong girdle of bone unites the inferior limb to the axial skeleton and transfers the forces of locomotion from the inferior limb to the vertebral column. Each os coxae articulates with three bones — the femur, sacrum, and opposite os coxae. The photo on this page depicts the three bones of the os coxae — the ilium (green), the ischium (blue), and the pubis (red). Landmarks that are shared by the bones are depicted on this image. The following two pages show all the landmarks of the individual bones of the os coxae.



- 1 Acetabulum
- 2 Acetabular notch
- 3 Lunate surface
- 4 Ischiopubic ramus
- 5 Obturator foramen
- 6 Greater sciatic notch



**Left os coxae showing individual bones**  
Lateral view, anterior to left

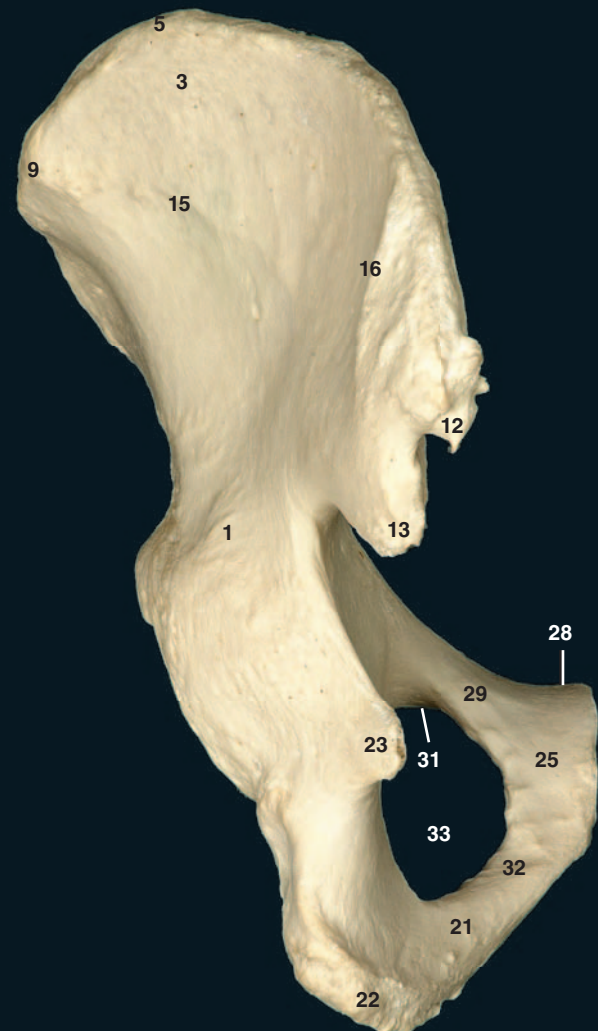
# Os Coxae

## Ilium

- |                           |                                   |                           |
|---------------------------|-----------------------------------|---------------------------|
| 1 Body of ilium           | 7 Intermediate zone of crest      | 14 Iliac fossa            |
| 2 Supra-acetabular groove | 8 Inner lip of crest              | 15 Anterior gluteal line  |
| 3 Ala or wing             | 9 Tuberculum of crest             | 16 Posterior gluteal line |
| 4 Arcuate line            | 10 Anterior superior iliac spine  | 17 Inferior gluteal line  |
| 5 Iliac crest             | 11 Anterior inferior iliac spine  | 18 Auricular surface      |
| 6 Outer lip of crest      | 12 Posterior superior iliac spine | 19 Iliac tuberosity       |
|                           | 13 Posterior inferior iliac spine |                           |



**Left os coxae**  
Anterior view, lateral to right



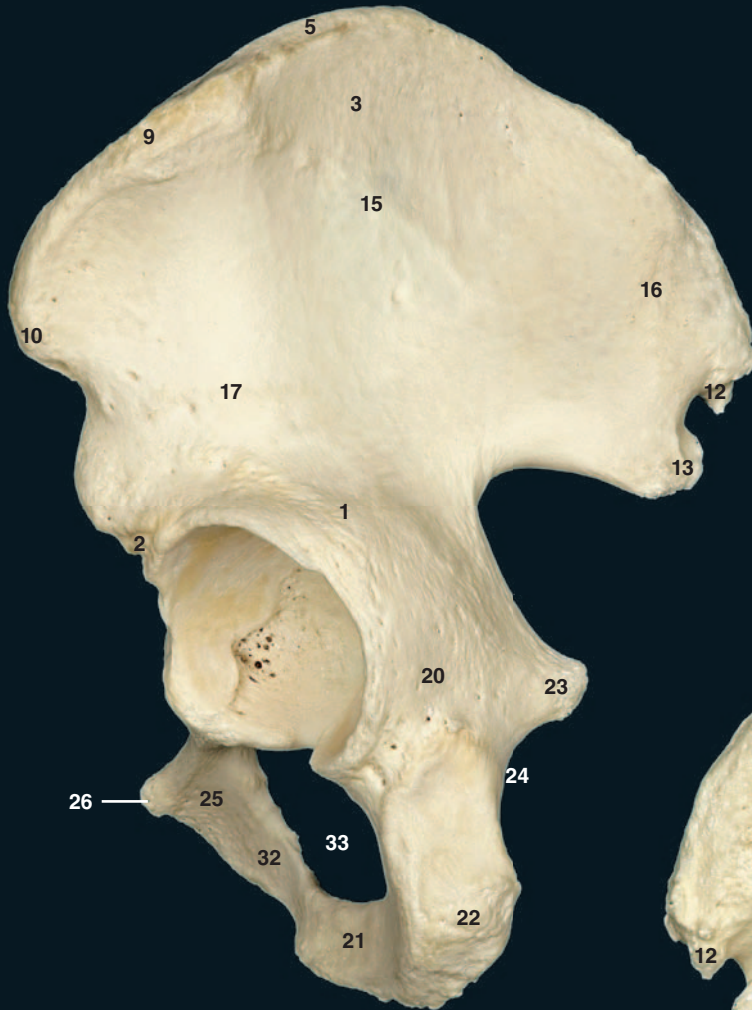
**Left os coxae**  
Posterior view, lateral to right



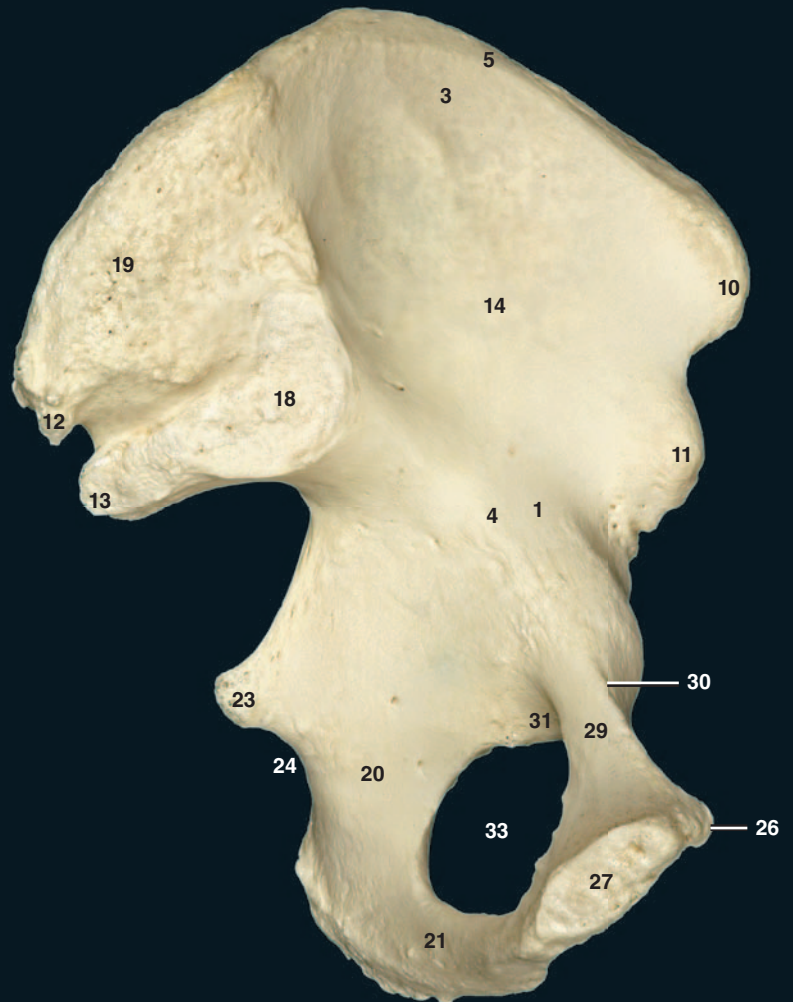
- Ischium
- 20 Body of ischium
- 21 Ischial ramus
- 22 Ischial tuberosity
- 23 Ischial spine
- 24 Lesser sciatic notch

- Pubis
- 25 Body of pubis
- 26 Pubic tubercle
- 27 Symphyseal surface
- 28 Pubic crest
- 29 Superior pubic ramus

- 30 Pecten pubis or pectineal line
- 31 Obturator groove
- 32 Inferior pubic ramus
- 33 Obturator foramen



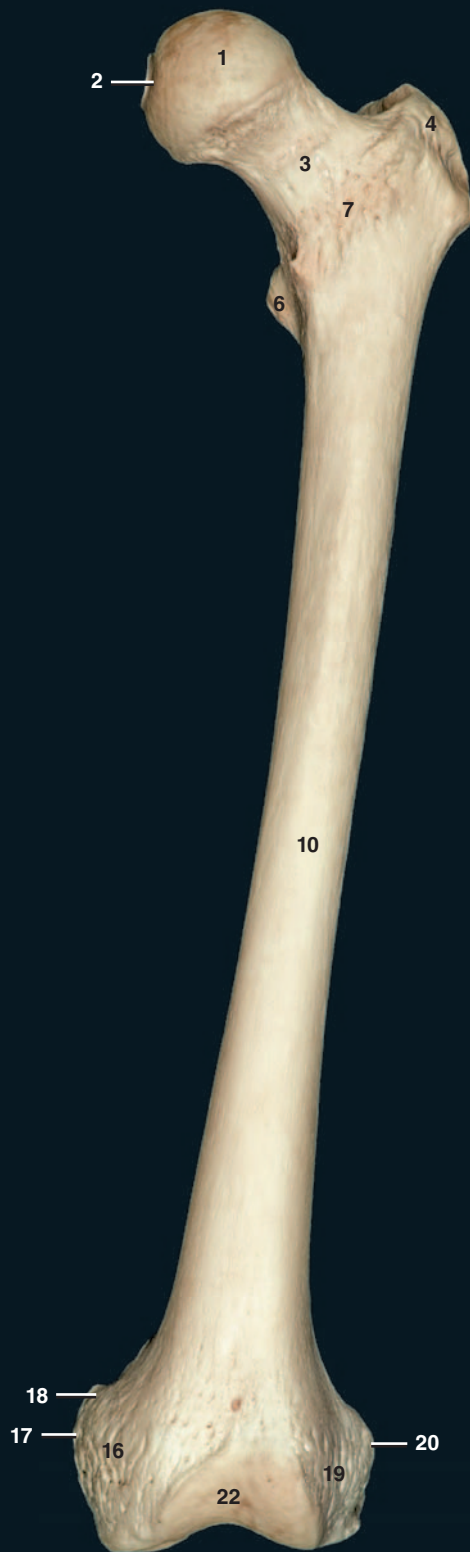
**Left os coxae**  
Lateral view, anterior to left



**Left os coxae**  
Medial view, anterior to right

# Femur

The femur is the longest bone of the body. The strong shaft forms a long cylindrical tube with a slight forward bow. The strong wall of the shaft is thickest near the narrow center of the bone where the medullary cavity is also the most spacious. As the shaft becomes progressively wider toward each end, the compact wall of bone becomes thinner and the medullary cavity accumulates spongy bone. The proximal end consists of a short cantilevered neck capped by a smooth, round articular head. Projections of bone, the trochanters, form at the base of the cantilevered neck. The distal end consists of two large, knuckle-like processes separated by an intermediate groove. The femur articulates with three bones: the os coxae, patella, and tibia.



**Left femur**  
Anterior view, lateral to right

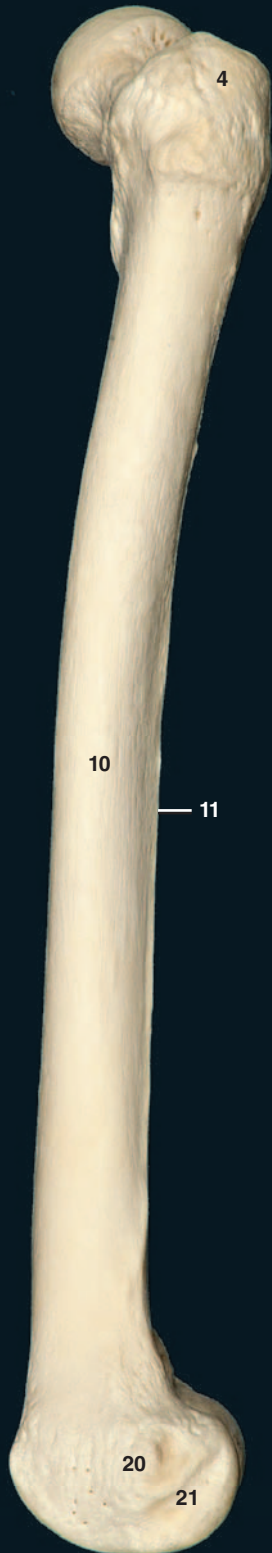


**Left femur**  
Posterior view, lateral to left

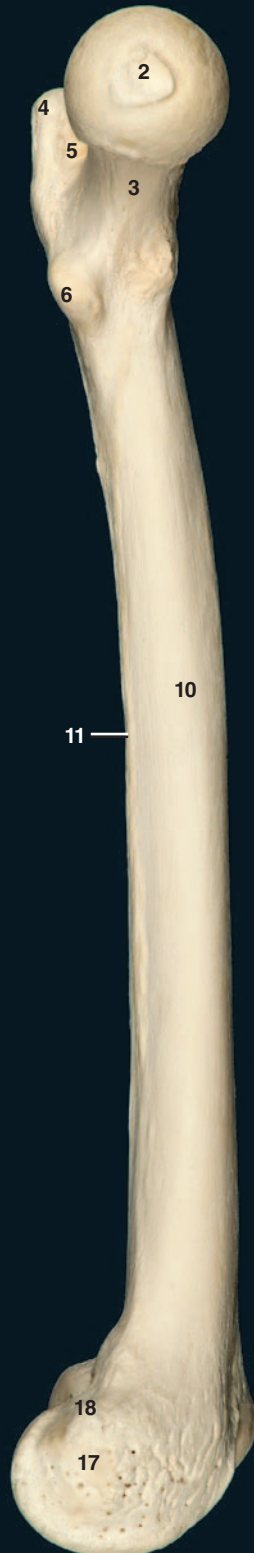
- 1 Head
- 2 Fovea for ligament of head
- 3 Neck
- 4 Greater trochanter
- 5 Trochanteric fossa
- 6 Lesser trochanter
- 7 Intertrochanteric line
- 8 Intertrochanteric crest

- 9 Quadrate tubercle
- 10 Shaft or body
- 11 Linea aspera
- 12 Pectineal or spiral line
- 13 Gluteal tuberosity
- 14 Medial supracondylar line
- 15 Lateral supracondylar line
- 16 Medial condyle

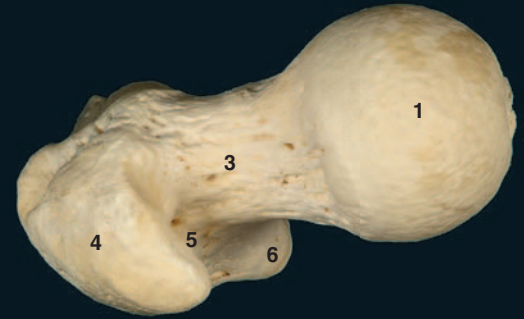
- 17 Medial epicondyle
- 18 Adductor tubercle
- 19 Lateral condyle
- 20 Lateral epicondyle
- 21 Groove for popliteus
- 22 Patellar surface
- 23 Intercondylar fossa



**Left femur**  
Lateral view, anterior to left



**Left femur**  
Medial view, anterior to right



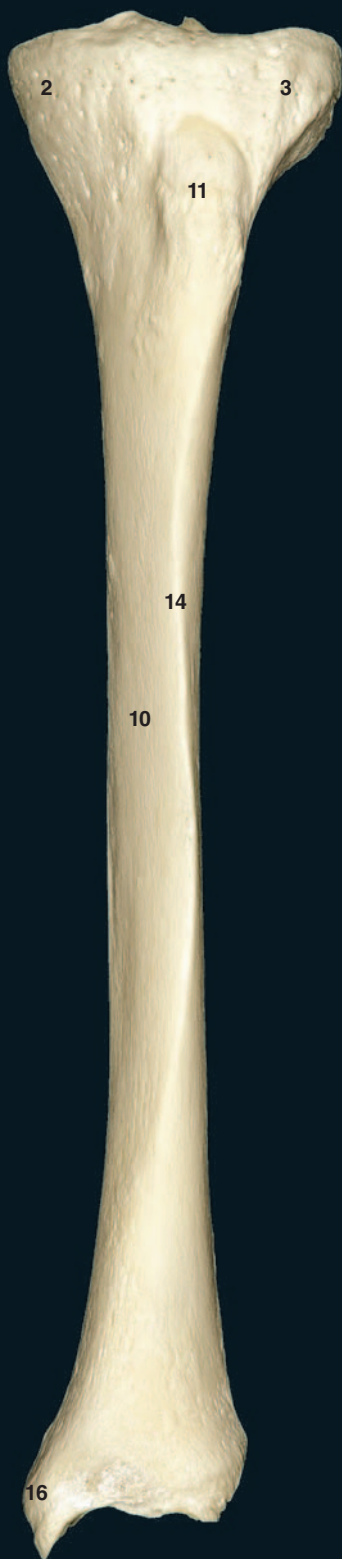
**Left femur**  
Superior view, lateral to left



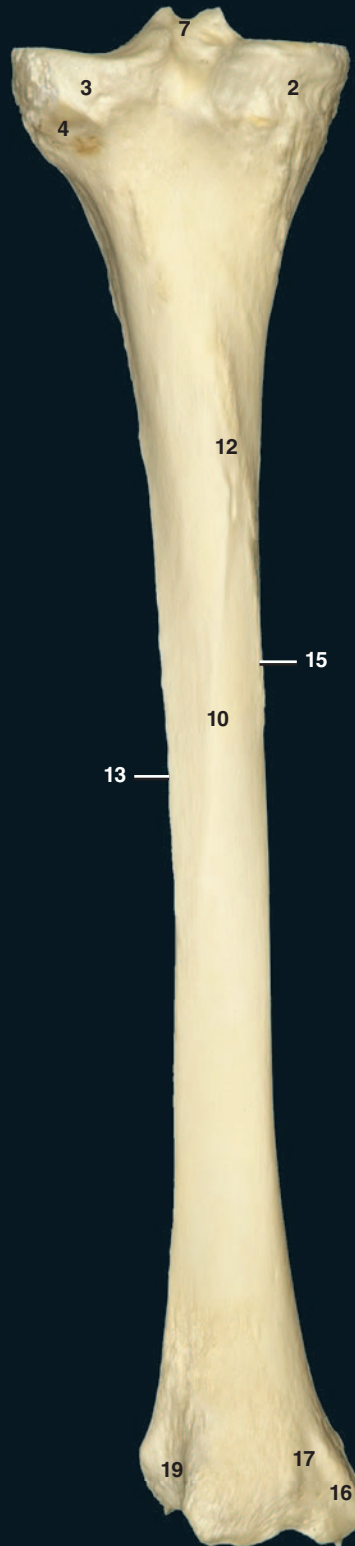
**Left femur**  
Inferior view, lateral to right

# Tibia

The tibia is the large, medial bone of the leg skeleton. It is the second longest bone of the body, only exceeded in length by the femur. Its strong shaft, consisting of thick walls of compact bone, is triangular in cross-section. The shaft expands proximally into a fluted extremity of spongy bone with a flat plateau-like superior surface largely covered with articular cartilage. The smaller distal end is more knob-like with a pronounced medial projection, the malleolus. The shaft has a strong anterior crest with sloping surfaces to either side. The bone is easily palpable throughout its length. The tibia articulates with three bones — the femur, fibula, and talus.



**Left tibia**  
Anterior view, lateral to right

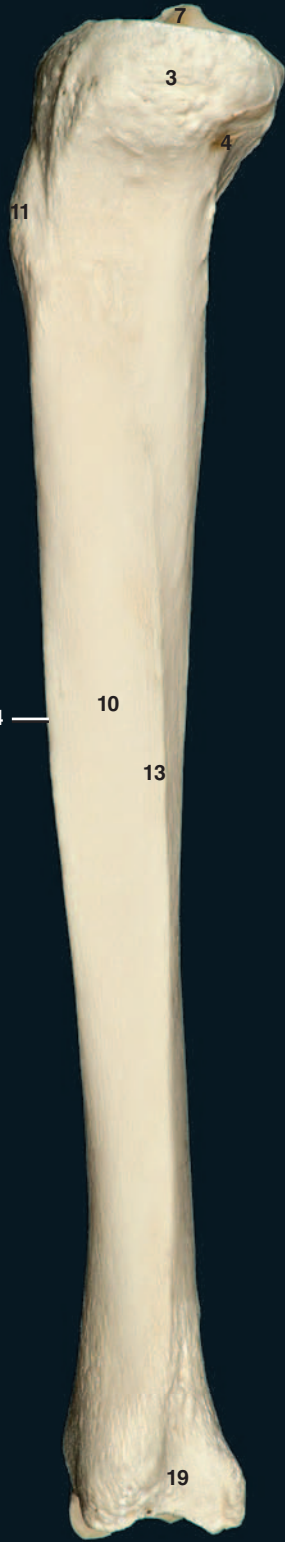


**Left tibia**  
Posterior view, lateral to left

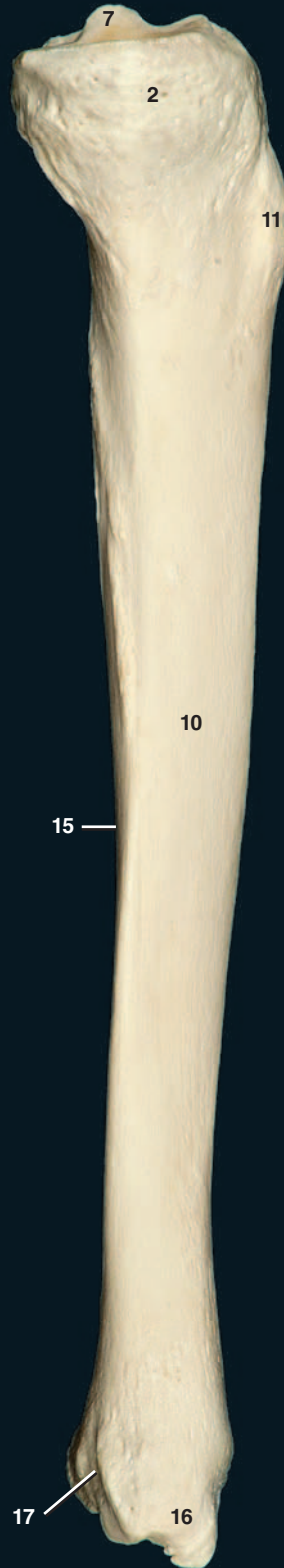
- 1 Superior articular surface
- 2 Medial condyle
- 3 Lateral condyle
- 4 Fibular articular facet
- 5 Anterior intercondylar area
- 6 Posterior intercondylar area
- 7 Intercondylar eminence

- 8 Medial intercondylar tubercle
- 9 Lateral intercondylar tubercle
- 10 Shaft or body
- 11 Tibial tuberosity
- 12 Soleal line
- 13 Interosseous border
- 14 Anterior border

- 15 Posterior border
- 16 Medial malleolus
- 17 Malleolar groove
- 18 Malleolar articular facet
- 19 Fibular notch
- 20 Inferior articular surface



**Left tibia**  
Lateral view, anterior to left



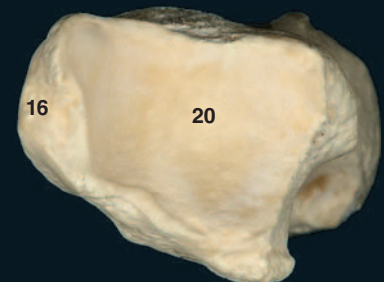
**Left tibia**  
Medial view, anterior to right



**Left tibia**  
Superior view, lateral to left



**Left tibia**  
Close-up of lateral view



**Left tibia**  
Inferior view, lateral to right

# Fibula

The fibula is the lateral bone of the leg skeleton. It is a slender, splint-like bone that is slightly expanded at both ends. It plays no role in the weight-bearing function of the lower limb, but serves as a significant site of muscle attachment. It is not easily palpable except at its proximal and distal ends, the shaft being totally surrounded with muscle. The fibula articulates with two bones — the tibia and talus.



- 1 Head
- 2 Articular facet for tibia
- 3 Apex of head
- 4 Neck
- 5 Shaft or body
- 6 Interosseous border
- 7 Anterior border
- 8 Posterior border
- 9 Lateral malleolus
- 10 Articular facet for talus
- 11 Malleolar fossa
- 12 Malleolar groove



**Left fibula**  
Anterior view, lateral to right



**Left fibula**  
Posterior view, lateral to left



**Left fibula**  
Lateral view, anterior to left



**Left fibula**  
Medial view, anterior to right



**Left fibula**  
Superior view, lateral to left



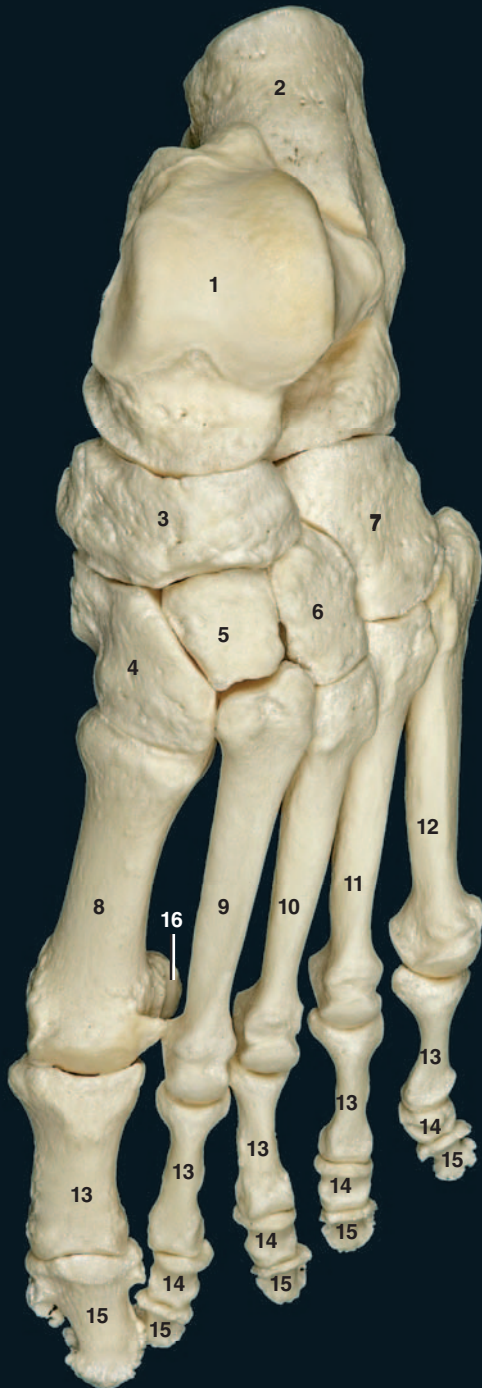
**Left fibula**  
Inferior view, lateral to right

# Foot Skeleton

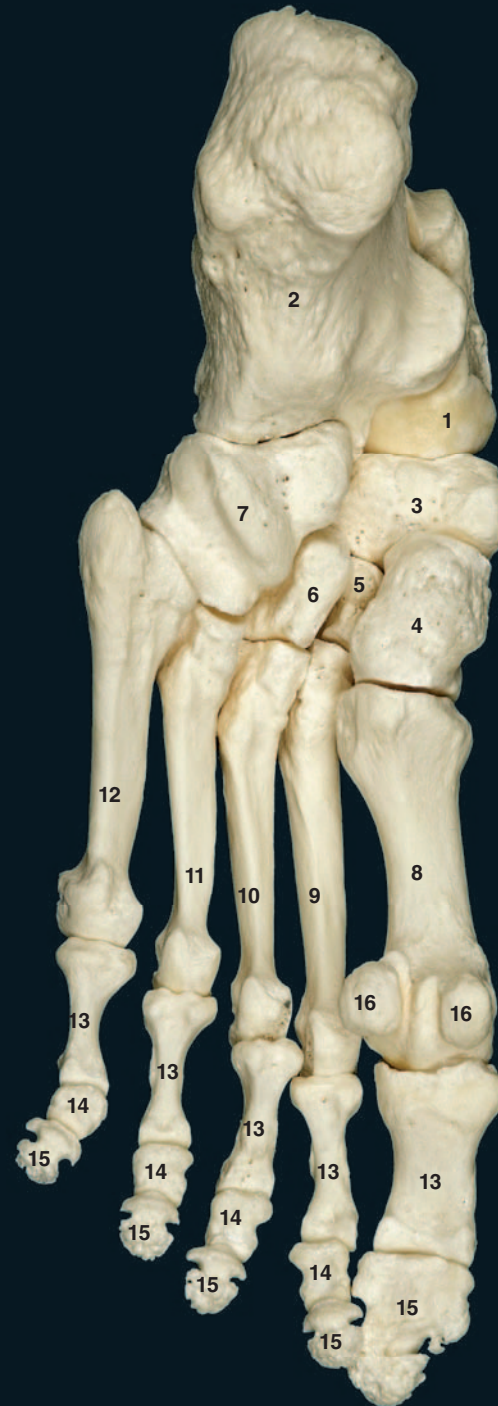
Like the hand, the foot is a composite structure comprised of 26 bones, not counting the small sesamoid bones that are found in certain tendons. The proximal end of the foot is the tarsus or ankle. There are seven tarsal bones that show a greater range in size and shape than their carpal counterparts in the hand. Distal to the tarsals are the five digital rays. The four lateral digits consist of a metatarsal bone and three phalanges. The large medial digit, the hallux or great toe, has a metatarsal bone and only two phalanges. Two prominent sesamoid bones (bones that form in tendons) are present on the plantar surface at the head end of the first metatarsal.



- |                          |                   |                     |
|--------------------------|-------------------|---------------------|
| 1 Talus                  | 7 Cuboid          | 12 Metatarsal V     |
| 2 Calcaneus              | 8 Metatarsal I    | 13 Proximal phalanx |
| 3 Navicular              | 9 Metatarsal II   | 14 Middle phalanx   |
| 4 Medial cuneiform       | 10 Metatarsal III | 15 Distal phalanx   |
| 5 Intermediate cuneiform | 11 Metatarsal IV  | 16 Sesamoid bones   |
| 6 Lateral cuneiform      |                   |                     |



**Left foot**  
Dorsal view, lateral to right

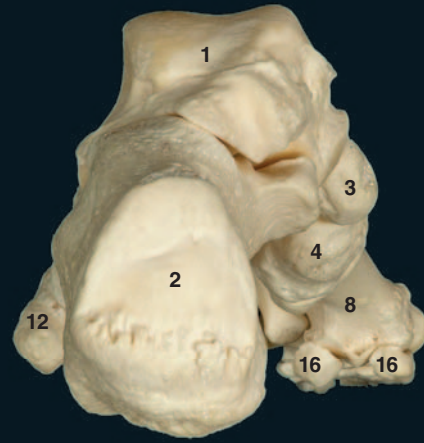


**Left foot**  
Plantar view, lateral to left

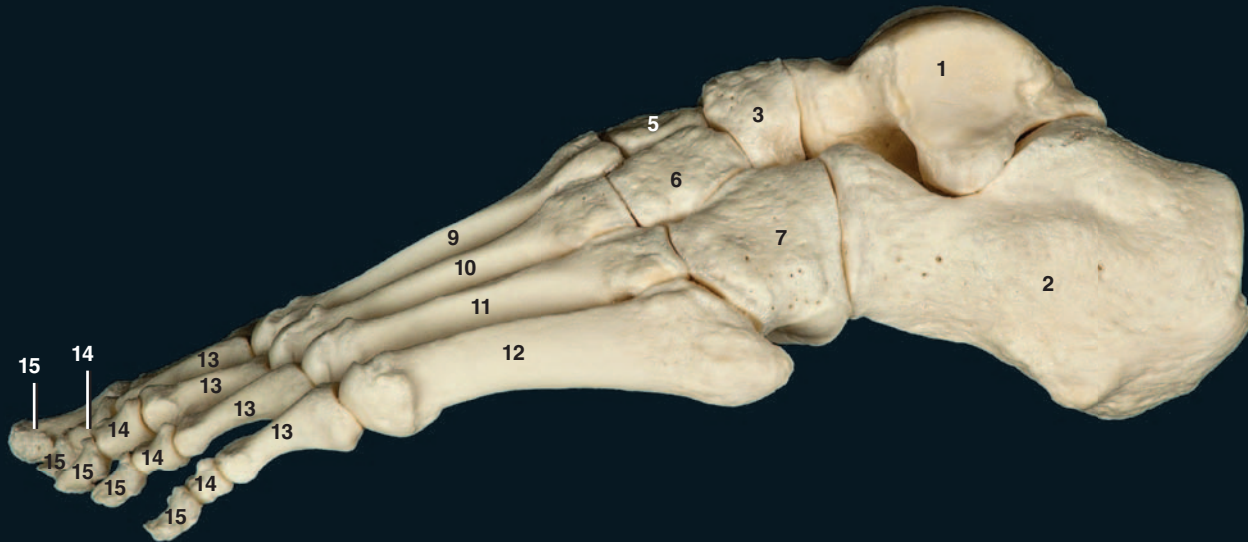




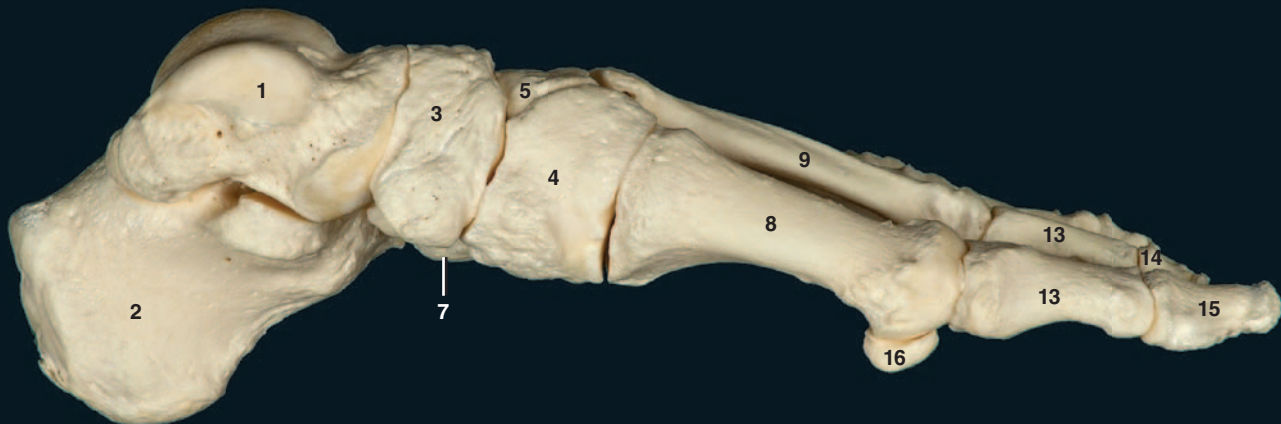
**Left foot**  
Anterior view, lateral to right



**Left foot**  
Posterior view, lateral to left



**Left foot**  
Lateral view, anterior to left



**Left foot**  
Medial view, anterior to right

# Tarsal Bones - Talus

The next four pages depict the tarsal bones. Like the carpals, this is a complex series of bones that form numerous articulations with

one another. All the tarsal bones were photographed at the same scale so you can see their relative sizes. The talus is the second largest and most proximal of the tarsal bones. It forms the ankle joint with the distal end of the leg skeleton. It consists of a cuboid body, a distally directed neck capped by a convex, oval head, a proximolateral facet for the fibular malleolus, and a proximal trochlea for the tibia. It articulates with four bones — the tibia, fibula, calcaneus, and navicular.



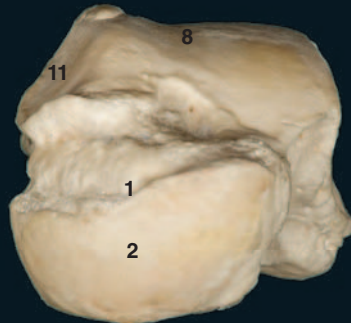
- 1 Head
- 2 Navicular articular surface
- 3 Anterior facet for calcaneus
- 4 Neck
- 5 Middle facet for calcaneus
- 6 Sulcus tali
- 7 Body
- 8 Trochlea of talus
- 9 Lateral malleolar facet
- 10 Lateral process
- 11 Medial malleolar facet
- 12 Posterior process
- 13 Groove for flexor hallucis longus
- 14 Lateral tubercle
- 15 Medial tubercle
- 16 Posterior calcaneal articular facet



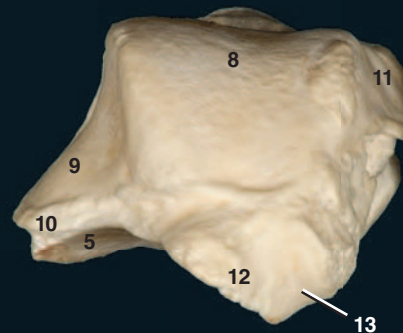
**Left talus**  
Superior view, lateral to left



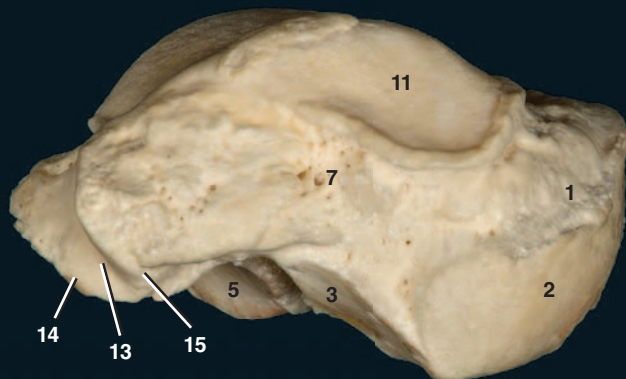
**Left talus**  
Inferior view, lateral to right



**Left talus**  
Anterior view, lateral to left



**Left talus**  
Posterior view, lateral to right



**Left talus**  
Medial view, anterior to right



**Left talus**  
Lateral view, anterior to left

# Tarsal Bones - Calcaneus

The calcaneus is the largest bone of the foot and its long axis parallels the long axis of the foot.

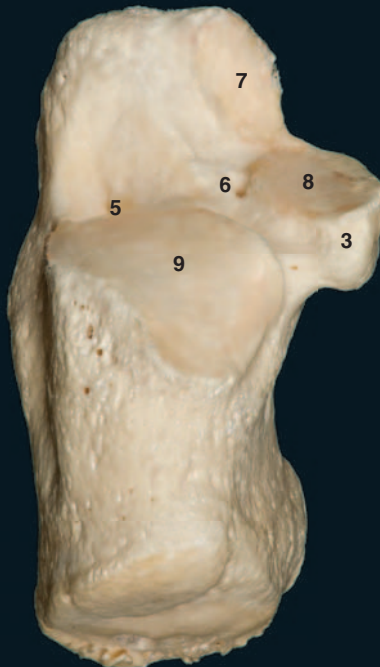


Its distal end forms a series of articular surfaces with neighboring bones. Its posterior or proximal end is box-like and forms a roughened calcaneal tubercle at the posterior surface. The calcaneus articulates with two bones — the talus and the cuboid.

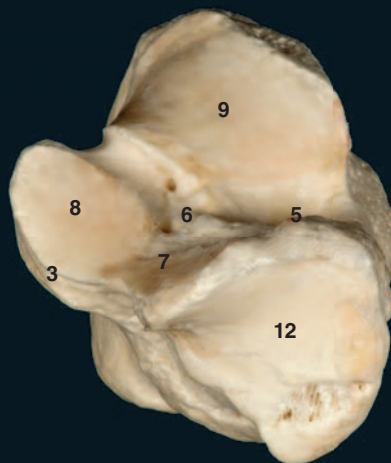
- 1 Calcaneal tuberosity
- 2 Calcaneal tubercle
- 3 Sustentaculum tali
- 4 Groove for flexor hallucis longus
- 5 Calcaneal sulcus
- 6 Tarsal sinus
- 7 Anterior talar articular surface
- 8 Middle talar articular surface
- 9 Posterior talar articular surface
- 10 Groove for fibularis longus
- 11 Fibular trochlea
- 12 Articular surface for cuboid



**Left calcaneus**  
Posterior view, lateral to left



**Left calcaneus**  
Superior view, lateral to left



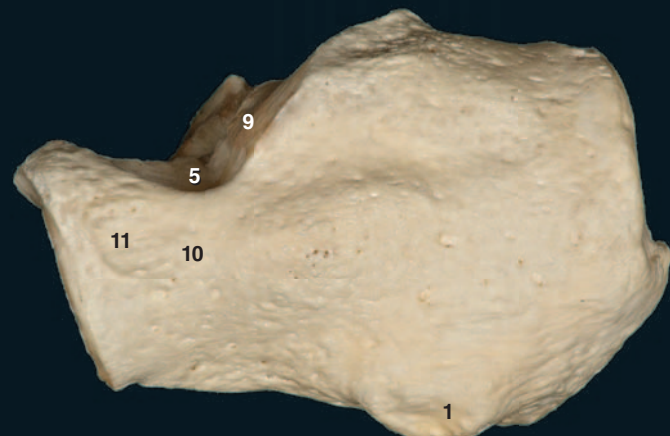
**Left calcaneus**  
Anterior view, lateral to right



**Left calcaneus**  
Inferior view, lateral to right



**Left calcaneus**  
Medial view, anterior to right



**Left calcaneus**  
Lateral view, anterior to left

# Tarsal Bones - Cuboid and Navicular

The cuboid bone, like its name suggests, has a cube shape when viewed from above, but has ridges and grooves on its plantar surface. It is the lateral bone in the distal series of tarsal bones and articulates with the fourth and fifth metatarsals. With a good imagination one can visualize the hull of a ship when observing the navicular bone. This ship-shaped bone is an intermediate bone between the talus and the three cuneiforms on the medial aspect of the foot.



## Cuboid

- 1 Groove for fibularis longus
- 2 Cuboid tuberosity
- 3 Calcaneal process
- 4 Articular surface for calcaneus
- 5 Articular surface for navicular
- 6 Articular surface for lateral cuneiform
- 7 Articular surface for fourth metatarsal
- 8 Articular surface for fifth metatarsal

## Navicular

- 9 Tuberosity
- 10 Articular surface for talus
- 11 Articular surface for cuboid
- 12 Articular surface for medial cuneiform
- 13 Articular surface for intermediate cuneiform
- 14 Articular surface for lateral cuneiform



**Left cuboid**  
Superior view, lateral to left



**Left cuboid**  
Inferior view, lateral to right



**Left navicular**  
Superior view, lateral to left



**Left navicular**  
Inferior view, lateral to right



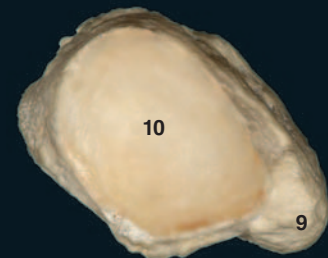
**Left cuboid**  
Anterior view, lateral to right



**Left cuboid**  
Posterior view, lateral to left



**Left navicular**  
Anterior view, lateral to right



**Left navicular**  
Posterior view, lateral to left



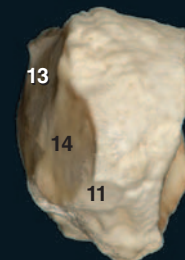
**Left cuboid**  
Medial view, anterior to right



**Left cuboid**  
Lateral view, anterior to left



**Left navicular**  
Medial view, anterior to right

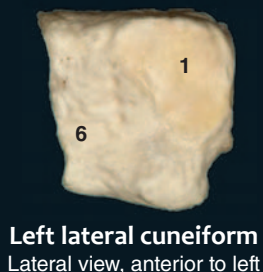
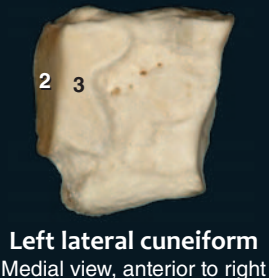
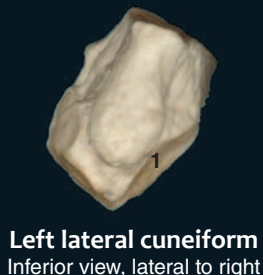


**Left navicular**  
Lateral view, anterior to left

# Tarsal Bones - Cuneiforms

The wedge-shaped cuneiforms are the distal tarsal bones on the medial aspect

of the ankle. They articulate with the three medial metatarsal bones. Their wedge shapes contribute to the formation of the transverse arch of the foot.



## Lateral cuneiform

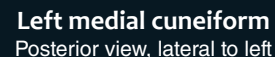
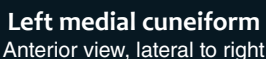
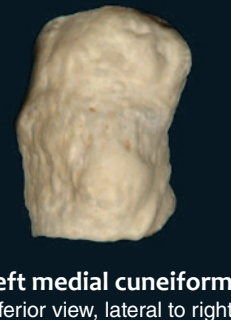
- 1 Articular surface for cuboid
- 2 Articular surface for navicular
- 3 Articular surface for middle cuneiform
- 4 Articular surface for second metatarsal
- 5 Articular surface for third metatarsal
- 6 Articular surface for fourth metatarsal

## Middle cuneiform

- 7 Articular surface for navicular
- 8 Articular surface for medial cuneiform
- 9 Articular surface for lateral cuneiform
- 10 Articular surface for second metatarsal

## Medial cuneiform

- 11 Articular surface for navicular
- 12 Articular surface for middle cuneiform
- 13 Articular surface for second metatarsal
- 14 Articular surface for first metatarsal



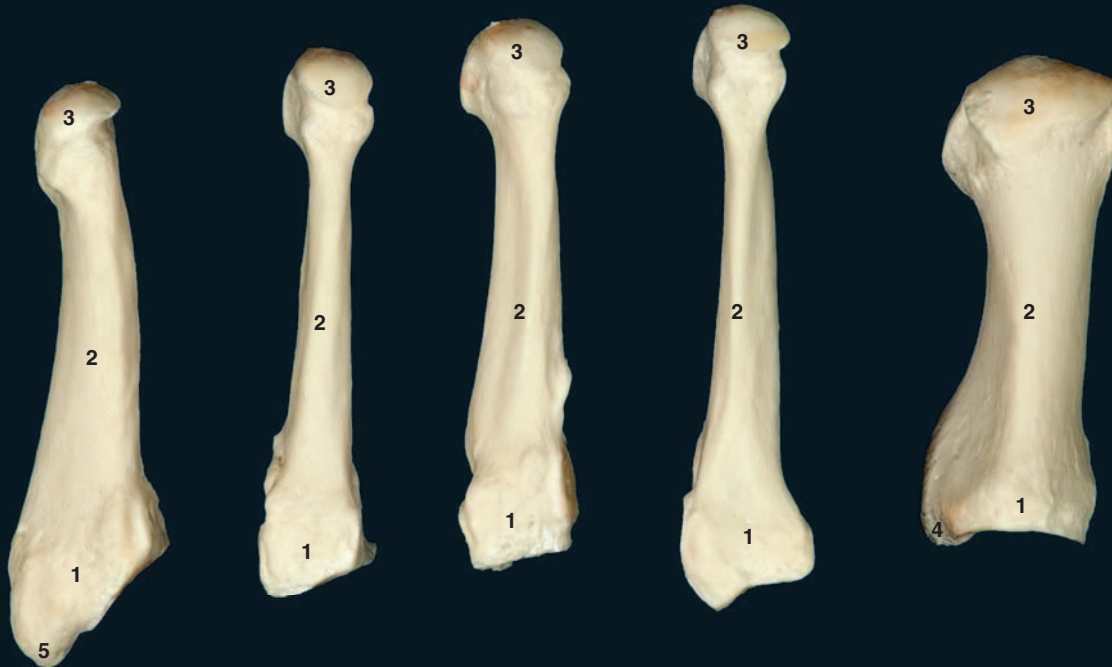
# Metatarsal Bones

The five metatarsal bones form the central portion of the foot skeleton. The three central metatarsals most closely resemble one another, while the first and fifth metatarsals are the most distinct.

The first metatarsal is short and thick compared to its counterparts, while the distinguishing feature of the fifth metatarsal bone is the projecting tuberosity at its proximal end.



- 1 Base
- 2 Shaft or body
- 3 Head
- 4 Tuberosity of first metatarsal
- 5 Tuberosity of fifth metatarsal



Left metatarsal bones, numbered I to V from medial to lateral  
Dorsal view, lateral to left



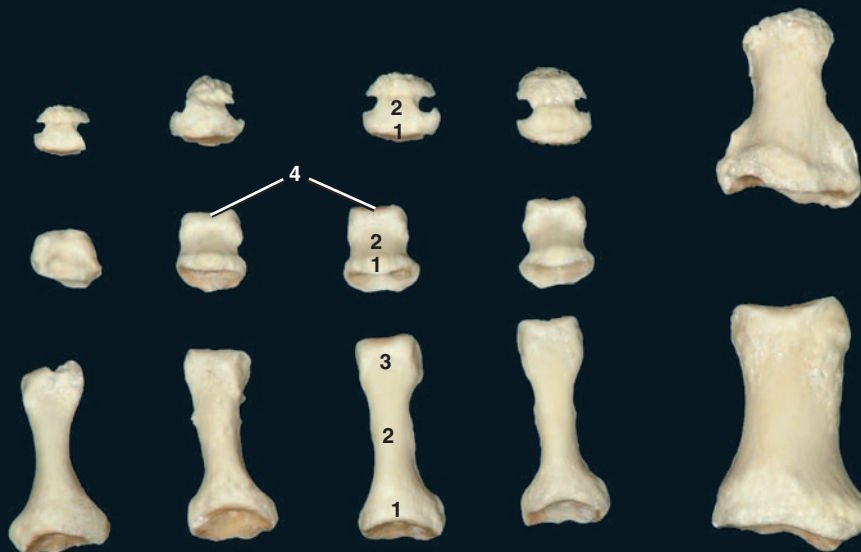
Left metatarsal bones, numbered I to V from medial to lateral  
Plantar view, lateral to right

# Phalanges

Similar in number to the phalanges of the hand, the phalanges of the foot are much smaller than those of the hand, with the exception of the large first toe. The proximal phalanges have broad bases that form the widest part of the bone. From the base a narrow shaft projects to a rounded head with a trochlear articular surface. The middle and distal phalanges are short bones that can be easily distinguished by their distal ends. The middle phalanges have a trochlear articular surface on their distal head, while the distal phalanges have a broad tuberosity at their distal ends.



- 1 Base
- 2 Shaft or body
- 3 Head
- 4 Trochlea
- 5 Tuberosity of distal phalanx



**Left phalanges**  
Dorsal view, lateral to left



**Left phalanges**  
Plantar view, lateral to right

# Patella

The patella is the largest sesamoid bone of the body. A sesamoid bone is a bone that forms within a tendon. The patella occupies the posterior half of the quadriceps tendon just anterior to the knee joint. It is a disc-like bone with a curved superior margin and a triangular inferior border. The posterior surface of the bone is smooth and articulates with the femur, while the anterior surface of the bone is rough by its attachment to the quadriceps tendon.



- 1 Base
- 2 Apex
- 3 Articular surface
- 4 Anterior surface





# 7

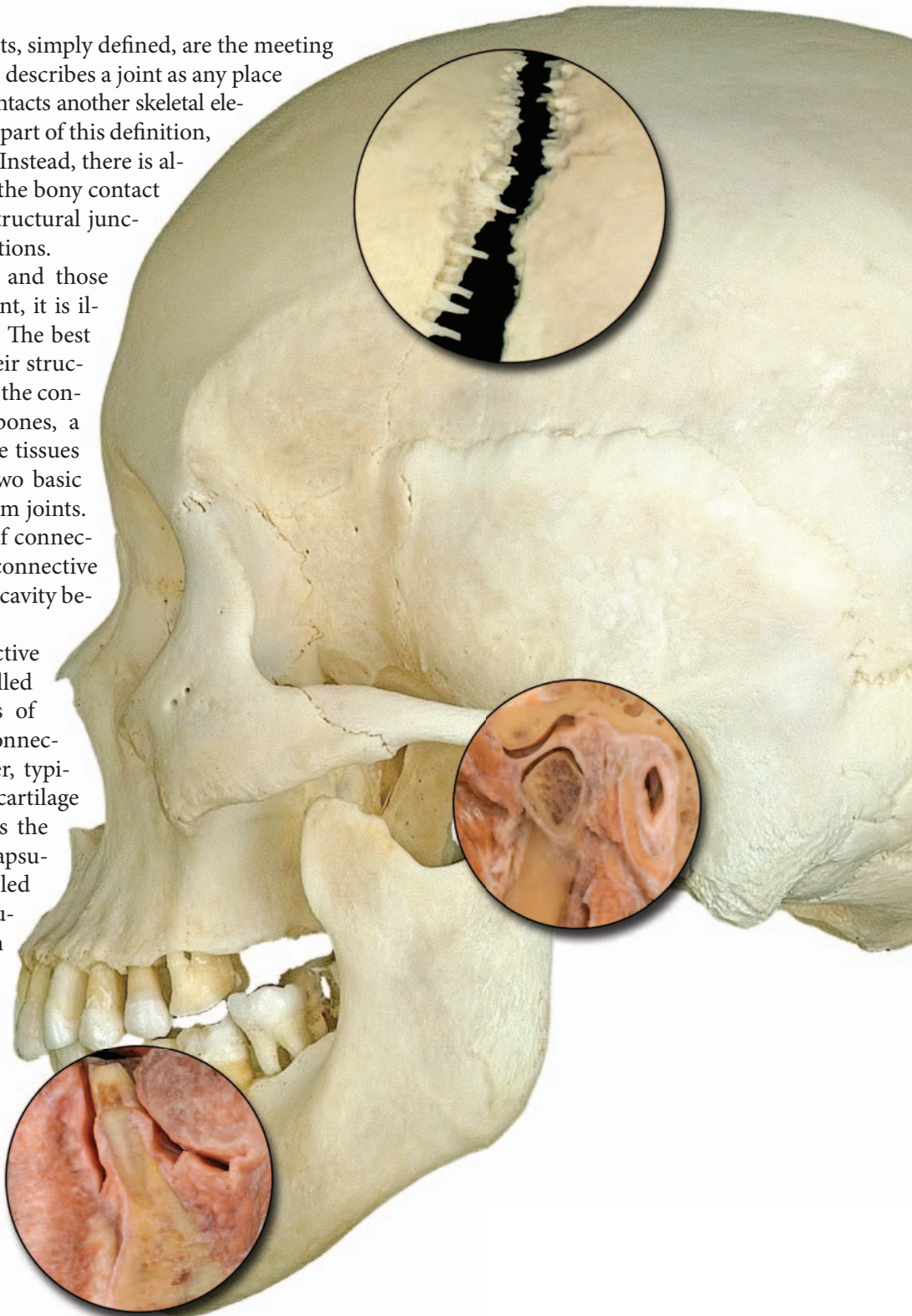
# Articular System

Joints, simply defined, are the meeting places between bones. This simple definition describes a joint as any place in the skeleton where one skeletal element contacts another skeletal element. It is important to understand that, as a part of this definition, the bones never contact each other directly. Instead, there is always some other connective tissue between the bony contact surfaces. Joints come in a wide variety of structural junctions, with an accompanying variety of functions.

Because joints have various functions and those functions do not always deal with movement, it is illogical to define joints by their movements. The best method for classifying joints is based on their structure. Because the structure of joints includes the connective tissues between the neighboring bones, a classification based on the structure of those tissues is logical. At the simplest level, there are two basic ways bones connect with one another to form joints. Either they are connected by solid masses of connective tissue, or they are bound together by a connective tissue capsule, which surrounds a lubricated cavity between the adjoining bones.

Joints formed by a solid core of connective tissue between the neighboring bones are called synarthroses. There are two subcategories of synarthroses — fibrous joints, which have connective tissue cores of connective tissue proper, typically dense irregular connective tissue, and cartilage joints, which use some form of cartilage as the connecting tissue between the bones. The capsular joints, with their lubricated cavity, are called diarthroses or synovial joints. There are numerous subcategories of diarthroses, each based on the structure and function of their articular surfaces.

In addition to joints, this chapter will also illustrate other closely related synovial structures — bursae and synovial (tendon) sheaths.



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about arthrology in

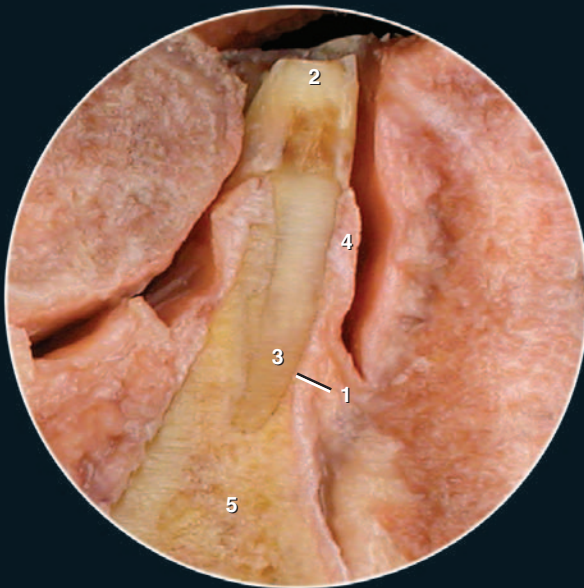
**REALANATOMY**

# Synarthrosis - Fibrous Joints

Fibrous joints are synarthrotic joints that bind bone to bone with collagenous connective tissue. The amount of connective

tissue binding the neighboring bones can vary considerably. Examples of fibrous joints are depicted on this and the facing page. Gomphoses and sutures (the four different suture types are shown on the opposite page) have a very thin membrane of collagenous connective tissue anchoring neighboring bony structures to one another. On the other hand, the syndesmoses between the tibia and fibula — both the interosseous membrane and the tibiofibular ligaments at the distal end — have considerably more binding connective tissue. There is also an example of another syndesmosis, the interspinous ligament, in the next section.

- 1 Periodontal membrane
- 2 Crown of tooth
- 3 Root of tooth
- 4 Gingiva
- 5 Mandible
- 6 Tibia
- 7 Fibula
- 8 Interosseous membrane
- 9 Anterior tibiofibular ligament of tibiofibular syndesmosis
- 10 Patellar ligament (cut)

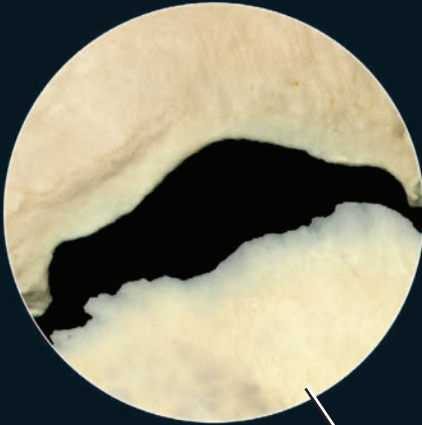


**Dento-alveolar syndesmosis or gomphosis**  
Sagittal section of tooth in mandible

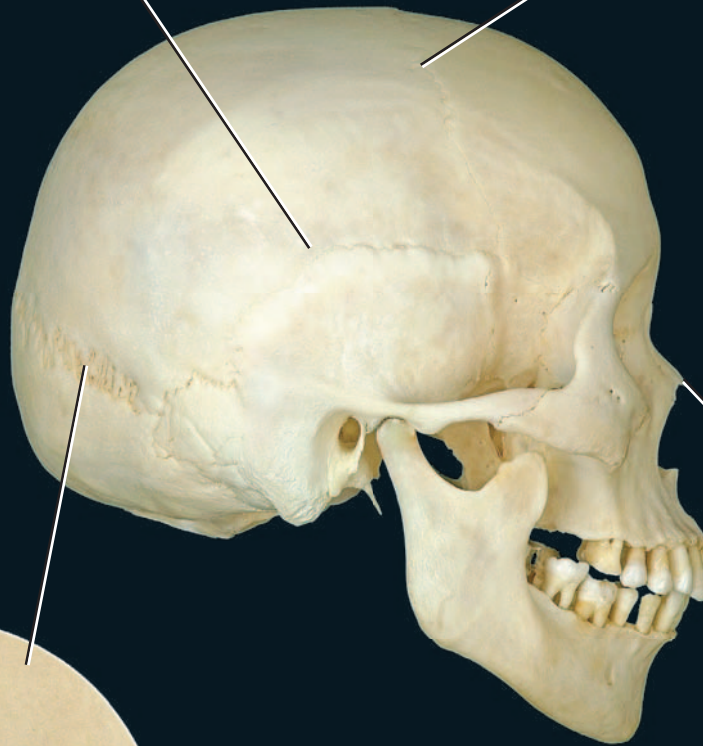
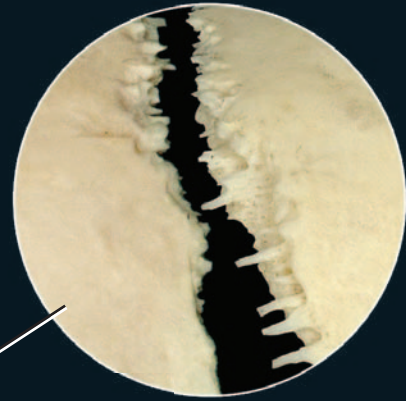


**Crural skeleton – tibia and fibula**  
Anterior view

**Squamous-type suture**  
Squamous or temporoparietal suture



**Serrate-type suture**  
Coronal or frontoparietal suture



**Denticulate-type suture**  
Lamboidal or parieto-occipital suture



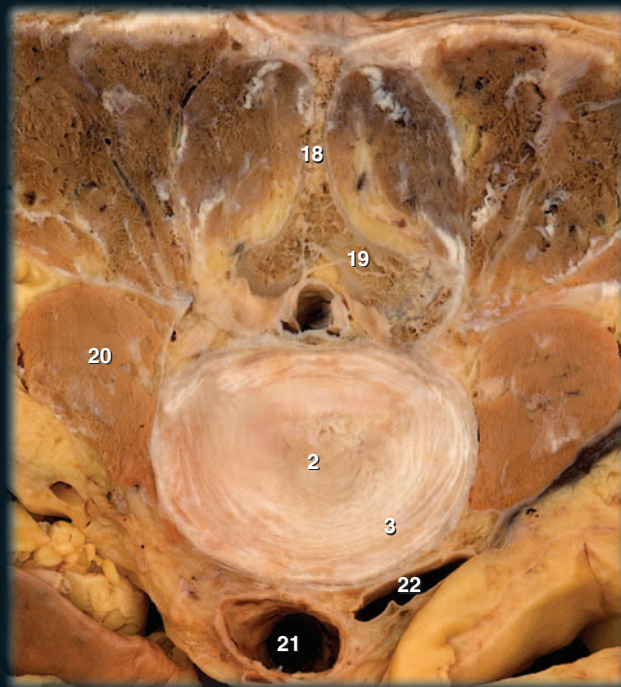
**Plane-type suture**  
Internasal suture

# Synarthrosis - Cartilaginous Joints

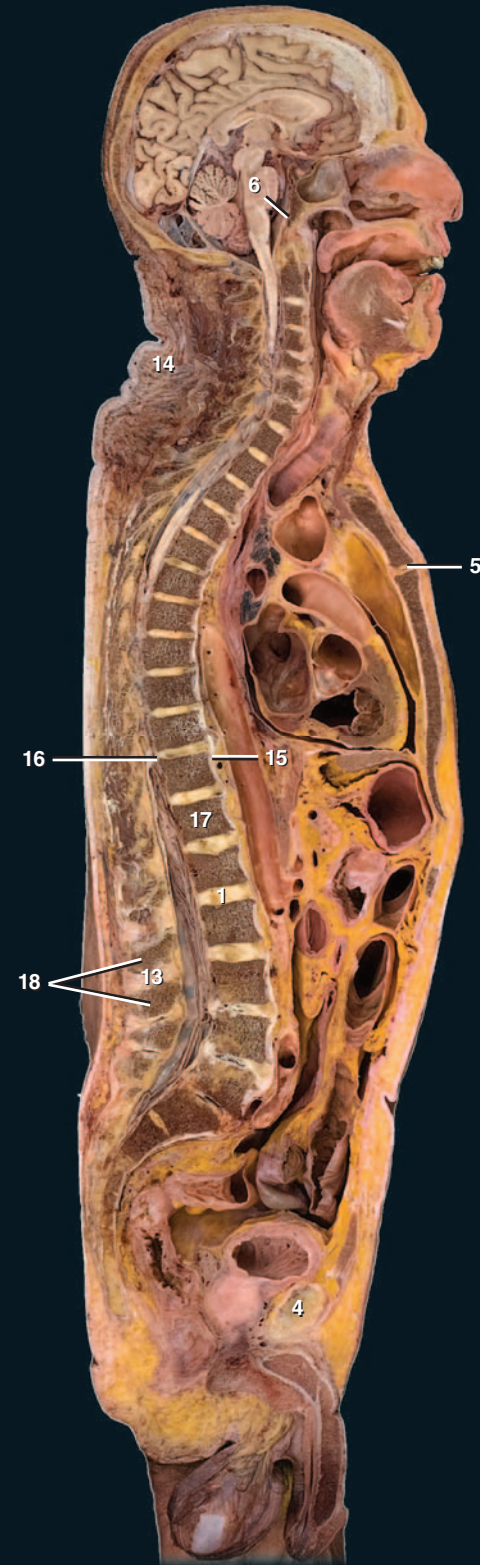
Like the fibrous joints, the cartilaginous joints join neighboring skeletal elements

with a solid mass of connective tissue, but the uniting tissue is some type of cartilage instead of collagenous connective tissue proper. The three types of cartilaginous joints are: 1) synchondroses, 2) symphyses, and 3) epiphysial cartilages or primary cartilaginous joints. The photos on these facing pages depict the different categories of cartilaginous joints. A few syndesmoses from the fibrous joint category are also evident.

- 1 Intervertebral disc (symphysis)
- 2 Nucleus pulposus of intervertebral disc
- 3 Anulus fibrosus of intervertebral disc
- 4 Pubic symphysis
- 5 Manubriosternal synchondrosis
- 6 Spheno-occipital synchondrosis
- 7 Epiphysial cartilage or primary cartilaginous joint
- 8 Sternocostal (synchondrosis)
- 9 Sternocostal (typically synovial but can be symphyseal)
- 10 Interchondral (synovial)
- 11 Interchondral (synchondrosis)
- 12 Costochondral (synchondrosis)
- 13 Interspinous ligament (vertebral syndesmosis)
- 14 Nuchal ligament (vertebral syndesmosis)
- 15 Anterior longitudinal ligament (vertebral syndesmosis)
- 16 Posterior longitudinal ligament (vertebral syndesmosis)
- 17 Body of vertebra
- 18 Spinous process of vertebra
- 19 Lamina of vertebra
- 20 Psoas major muscle
- 21 Aorta
- 22 Inferior vena cava



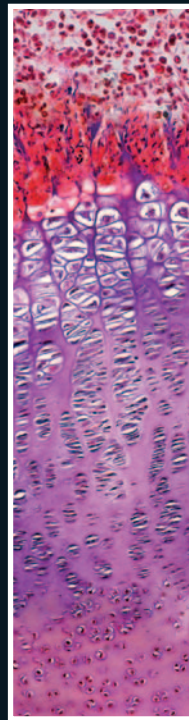
Transverse section of lumbar intervertebral disc  
Inferior view



Sagittal section of head and trunk  
Medial view



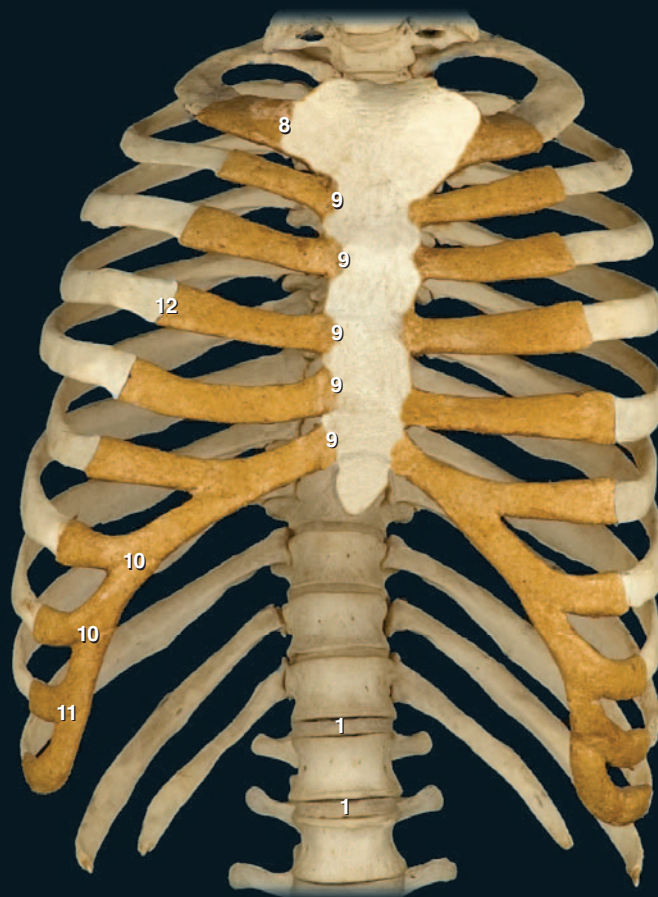
**Fetal skeleton**  
Posterior view



**Epiphysal cartilage**  
200x



**Radiograph of juvenile wrist region**  
Anterior view



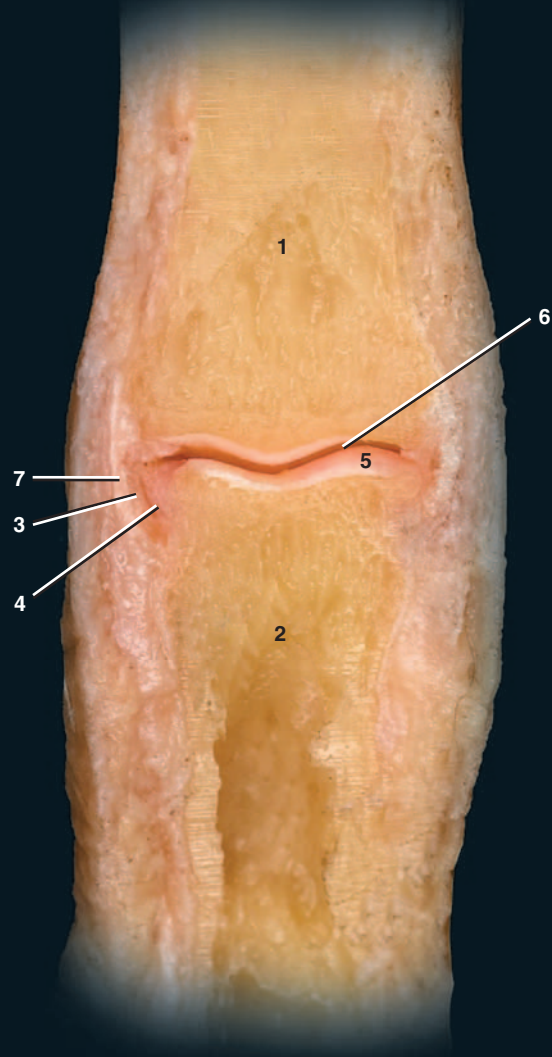
**Joints of the thoracic cage**  
Anterior view

# Diarthroses or Synovial Joints

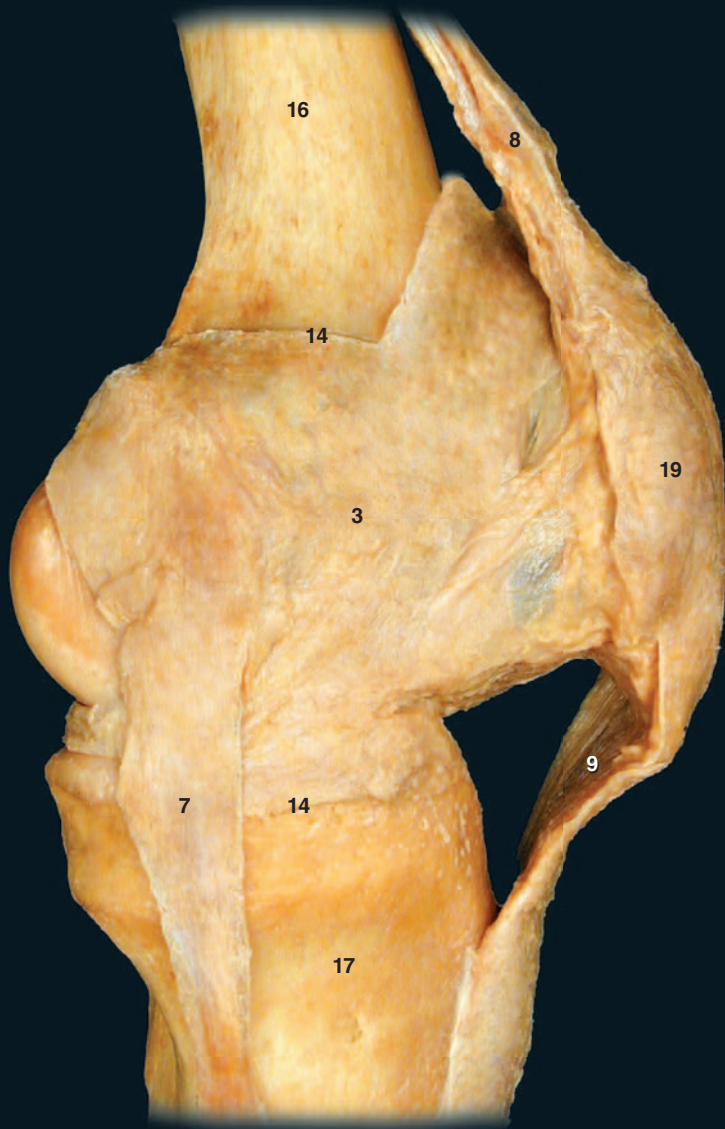
Diarthroses differ from synarthroses in one major way: instead of connecting neighboring bones by a solid mass

of connective tissue, the bony connection consists of a double-layered connective tissue capsule that surrounds a lubricated cavity between the bones. Within the capsule the ends of neighboring bony surfaces are covered by a smooth layer of hyaline cartilage. As a result of this design there is typically a much greater range of motion present in synovial joints, and they form the joints of the skeleton that are responsible for the major movements of the body. The outer layer of the capsule, the fibrous membrane, is continuous with the periosteum on the adjoining bones, while the inner layer of the capsule, the synovial membrane, attaches from the border of the articular cartilage on one bone to the border of the articular cartilage on the other bone. Additionally, the synovial membrane secretes synovial fluid, a lubricant that reduces friction between the mobile cartilage-covered articular surfaces of the bones. The section through a finger joint below and the dissections of the knee joint on the opposite page illustrate the basic features of a synovial joint. The pages that follow depict the major synovial joints of the skeleton. One other key feature among synovial joints that is responsible for their varied range of motion is the shape of the adjoining bone surfaces. It is this feature that anatomists use to describe the different types of synovial joints.

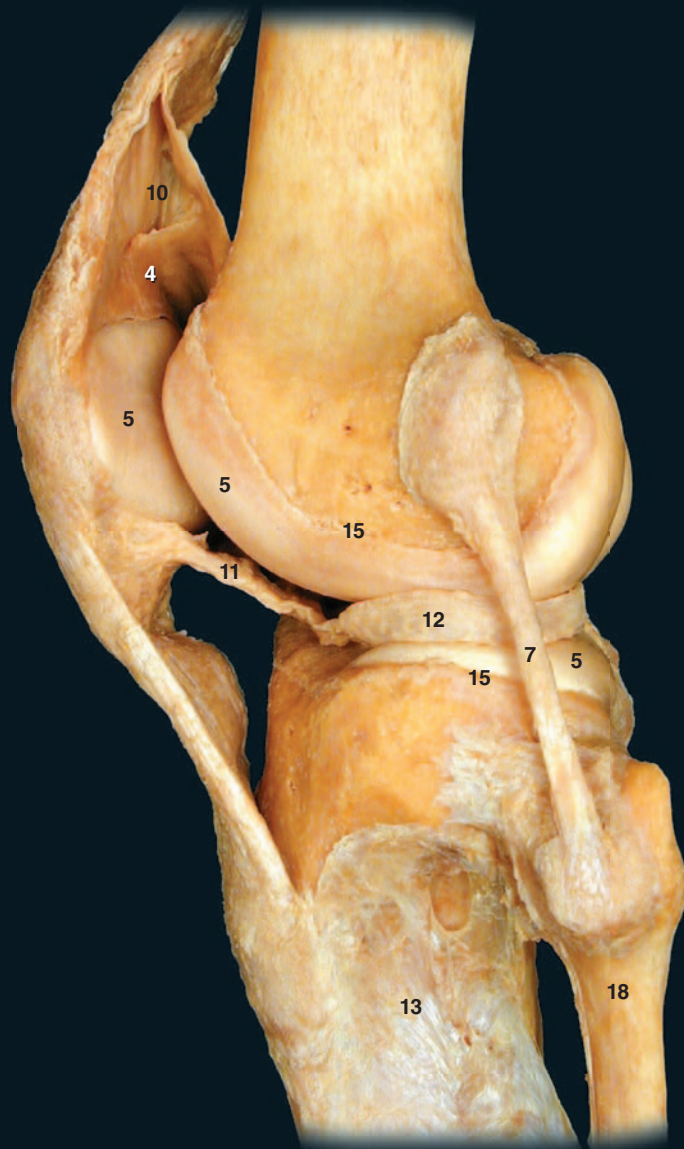
- 1 Middle phalanx of index finger
- 2 Proximal phalanx of index finger
- 3 Fibrous membrane of joint capsule
- 4 Synovial membrane of joint capsule
- 5 Articular cartilage
- 6 Joint cavity
- 7 Collateral ligament
- 8 Quadriceps tendon
- 9 Patellar ligament
- 10 Suprapatellar bursa
- 11 Synovial fold
- 12 Meniscus
- 13 Periosteum
- 14 Junction of periosteum (removed) with fibrous membrane
- 15 Junction of synovial membrane (removed) with articular cartilage
- 16 Femur with periosteum removed
- 17 Tibia with periosteum removed
- 18 Fibula with periosteum removed
- 19 Patella within quadriceps tendon



Proximal interphalangeal joint showing design of synovial joint  
Frontal section, anterior view



Dissection of knee showing design of synovial joint  
Medial view

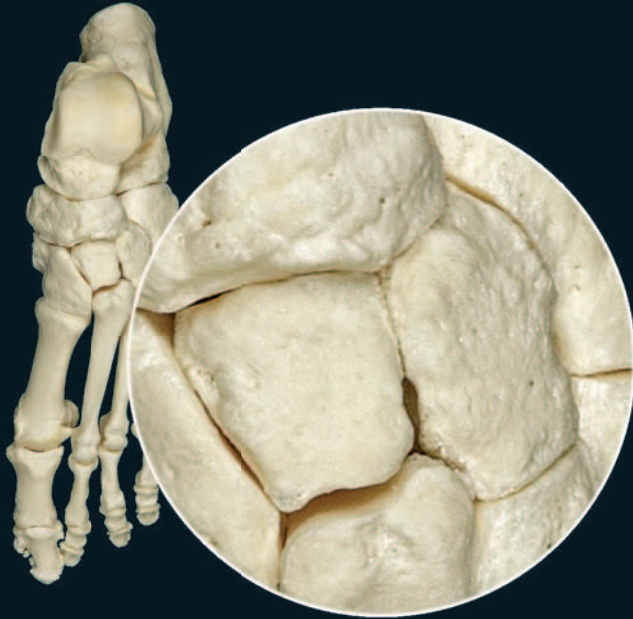


Dissection of knee showing design of synovial joint  
Lateral view

# Types of Synovial Joints

There are seven types of synovial joints in the body. Each of the different synovial joints has the basic structural features common to all synovial joints but is

further classified based on the shape of and motion that occurs at the articular surfaces of the joint. The different types of synovial joint are depicted below and on the opposite page. Note the shapes of the reciprocal surfaces as you study these photos.



**Plane joint examples**  
Intertarsal joints



**Pivot joint examples**  
Proximal radio-ulnar joint of elbow



**Hinge joint example**  
Humero-ulnar joint of elbow

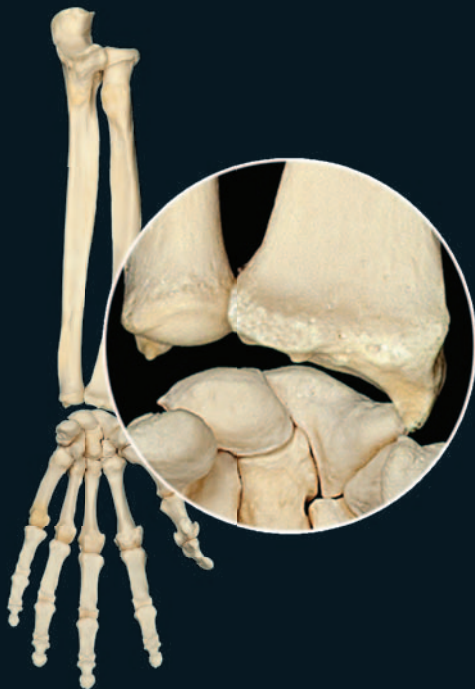




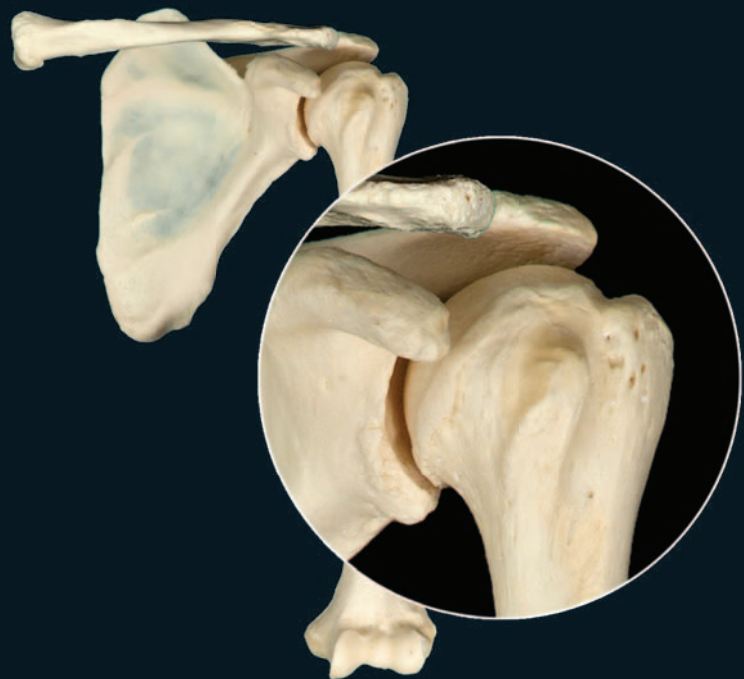
**Bicondylar joint example**  
Knee joint



**Saddle joint example**  
Metacarpal-carpal joint of thumb



**Condylar joint example**  
Wrist joint



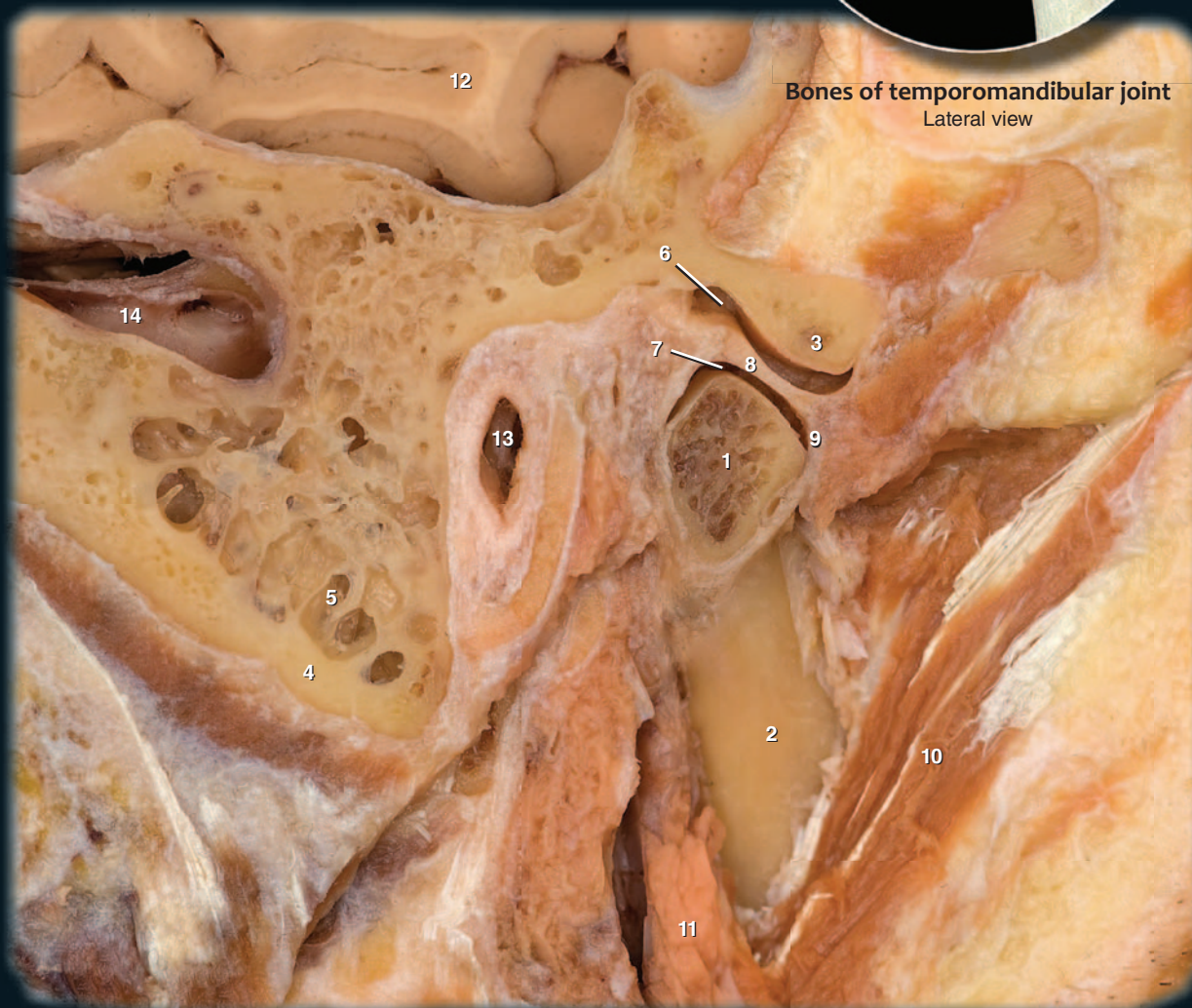
**Ball and socket joint example**  
Shoulder joint

# Temporomandibular Joint

The complex temporomandibular joint differs from other synovial joints by having an articular disc that usually separates the joint into two separate

synovial capsules, one above and one below the disc. The articular surfaces have a covering of dense fibrocartilage rather than the typical hyaline cartilage of most synovial joints. With its associated ligaments this joint structure accounts for the complex series of movements that are essential during the activities of eating and speech. Each temporomandibular joint is a condylar joint and both joints together form a bicondylar joint. The fibrous membrane of the articular capsule spans from temporal bone to mandible only on the lateral side. Anteriorly, medially, and posteriorly the fibers attach from mandible and temporal bone to the articular disc. Extrinsic ligaments that help stabilize the joint are the lateral temporomandibular ligament, sphenomandibular ligament, and stylomandibular ligament.

- |  |                             |
|--|-----------------------------|
| 1 Mandibular condyle                       | 8 Articular disc            |
| 2 Mandibular ramus                         | 9 Joint (articular) capsule |
| 3 Articular tubercle of temporal bone      | 10 Masseter muscle          |
| 4 Mastoid process of temporal bone         | 11 Parotid gland            |
| 5 Mastoid air cells                        | 12 Brain                    |
| 6 Superior compartment of articular cavity | 13 External acoustic meatus |
| 7 Inferior compartment of articular cavity | 14 Sigmoid venous sinus     |



**Bones of temporomandibular joint**  
Lateral view

**Section of right temporomandibular joint**  
Lateral view of sagittal section

# Glenohumeral Joint

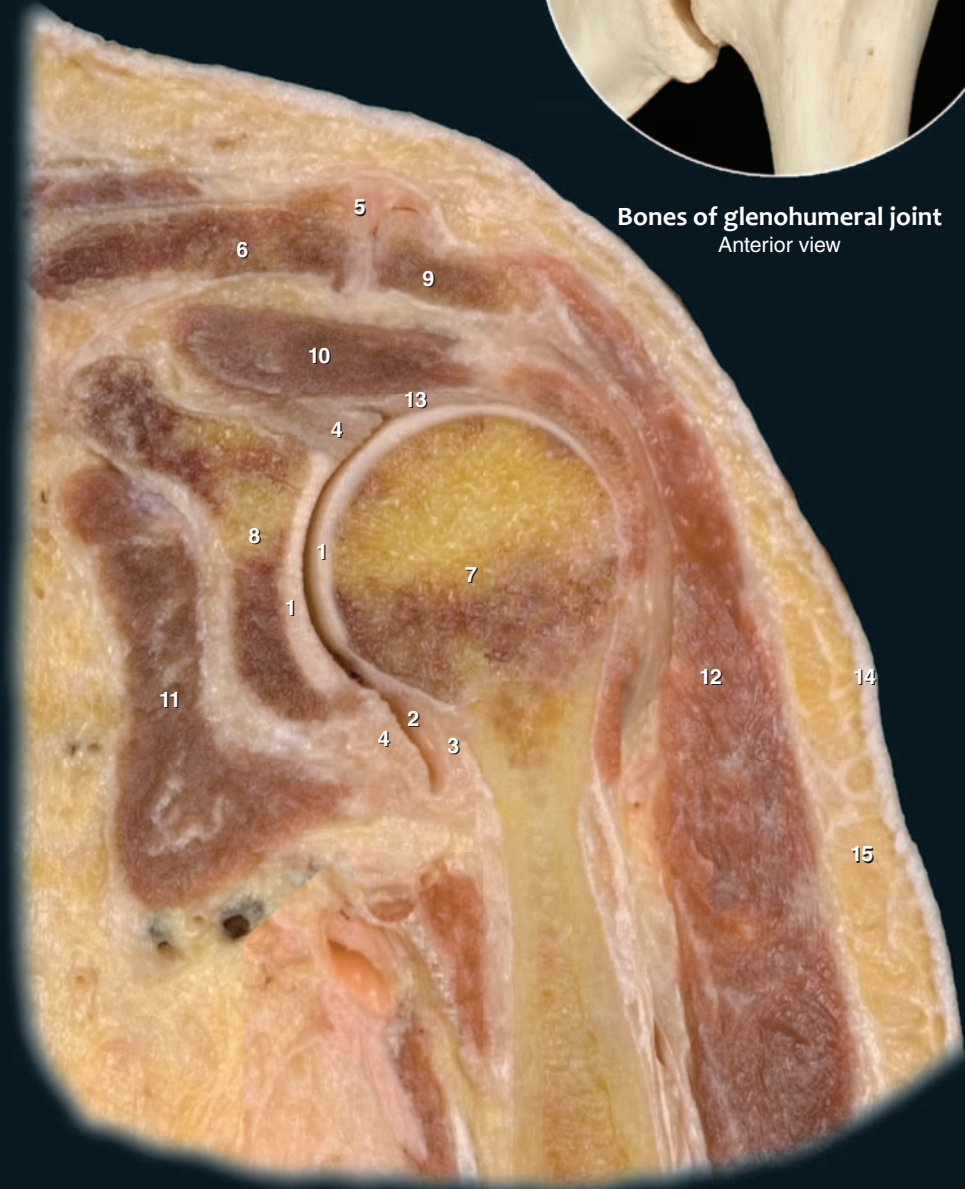
The glenohumeral or shoulder joint is a ball and socket joint and is the most mobile joint in the body. The tremendous range of motion at this joint is the result of few external ligaments that present little

limitation to movement, and shallow, ovoid articular surfaces that make movements in all planes of space possible. In fact, surrounding muscles and tendons play a more significant role in joint support than do the joint structures. The capsular ligament is extremely lax, providing limited support to the joint. Blending with the capsule are the tendons of four muscles. Together the capsule and tendons form the rotator cuff, which is the major support structure of the joint.

- 1 Articular cartilage
- 2 Synovial membrane
- 3 Fibrous membrane
- 4 Glenoid labrum
- 5 Acromioclavicular ligament
- 6 Clavicle
- 7 Humerus
- 8 Glenoid of scapula
- 9 Acromion of scapula
- 10 Supraspinatus muscle
- 11 Subscapularis muscle
- 12 Deltoid muscle
- 13 Tendon of long head of biceps brachii
- 14 Skin
- 15 Subcutaneous layer



**Bones of glenohumeral joint**  
Anterior view



**Section of left glenohumeral joint**  
Anterior view of frontal section

# Elbow Joint

The elbow joint is a complex joint comprised of multiple articular surfaces within one articular capsule. The elbow joint can be subdivided into three distinct articular interfaces — the humero-ulnar joint (hinge), the humeroradial joint (combined hinge and pivot), and the proximal radioulnar joint (pivot). Two distinct pairs of movements occur as a result of the articulations within the elbow joint — the hinged movements of flexion and extension, and the rotational movements of pronation and supination. Unlike the shoulder joint, the joints of the elbow have strong extrinsic ligaments that limit movements and stabilize the articulating bones. The fibrous capsule is thin anteriorly and posteriorly, allowing for free range of motion during flexion and extension. On either side the capsule is reinforced by strong extrinsic ligaments, the ulnar collateral and radial collateral ligaments. Wrapping from the back of the ulna at the base of the olecranon to the front of the ulna at the lateral surface of the coronoid process is the semicircular anular ligament. With the radial notch of the ulna this ligament forms a fibro-osseous ring for the pivoting action of the radial head.

- 1 Articular cartilage
- 2 Joint (articular) capsule
- 3 Articular (synovial) cavity
- 4 Capitulum of humerus
- 5 Olecranon of ulna
- 6 Head of radius
- 7 Anular ligament
- 8 Biceps brachii muscle
- 9 Brachialis muscle
- 10 Triceps brachii muscle
- 11 Brachioradialis muscle



**Bones of elbow joint**  
Anterior view



**Section of pronated left elbow joint**  
Medial view of sagittal section

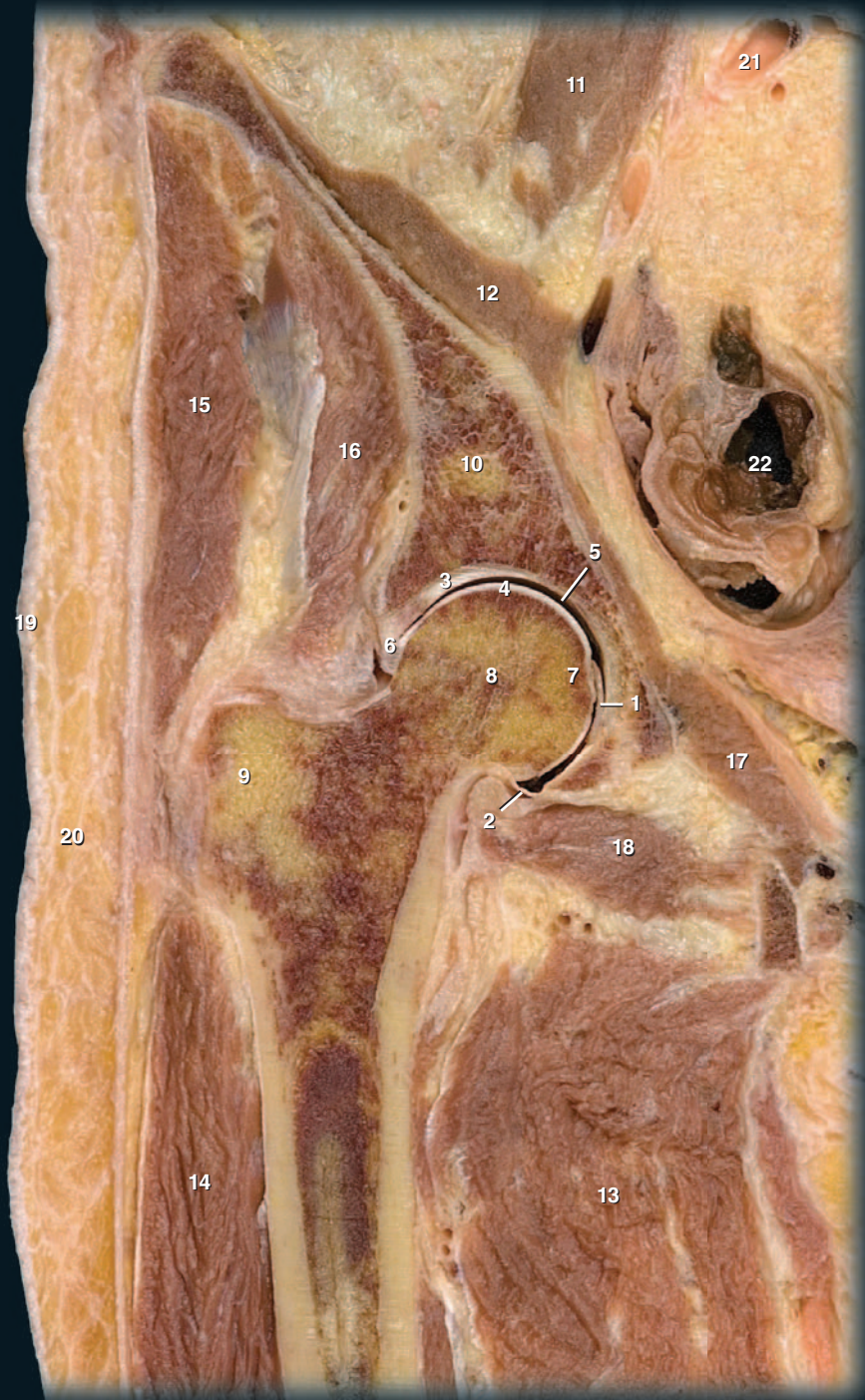
# Hip Joint

Like the shoulder joint the hip joint, also a ball and socket joint, allows for great freedom of motion, although the range of motion is not quite as great as that of the shoulder. This comparative decrease in mobility results from the deep hip socket with its extended labrum, which almost completely engulfs the head of the femur. In addition, thick extrinsic ligaments tightly surround the joint to form a strong, reinforced capsule. The three major ligaments of the hip joint, the iliofemoral, pubofemoral, and ischiofemoral, form a sheath around the fibrous capsule. The iliofemoral ligament is argued to be the strongest ligament in the human body. Often called the Y-shaped ligament it passes superior and anterior to the joint, running from the anterior inferior iliac spine to the intertrochanteric line. With the thinner pubofemoral and ischiofemoral ligaments it spirals around the joint to stabilize this powerful joint. In addition to these large ligaments, a triangular flat band, the ligament of the head of the femur, extends from the fovea of the femoral head to the margins of the acetabular fossa. This ligament is also important because it functions as a pathway for blood vessels that supply the bone tissue in the head of the femur.

- 1 Ligament of head of femur
- 2 Joint (articular) capsule
- 3 Articular cartilage of acetabulum
- 4 Articular cartilage of femur
- 5 Articular (synovial) cavity
- 6 Acetabular labrum
- 7 Fovea capitis of femur
- 8 Head of femur
- 9 Greater trochanter of femur
- 10 Os coxae
- 11 Psoas major muscle
- 12 Iliacus muscle
- 13 Adductor muscles
- 14 Vastus lateralis muscle
- 15 Gluteus medius muscle
- 16 Gluteus minimis muscle
- 17 Obturator internus muscle
- 18 Obturator externus muscle
- 19 Skin
- 20 Subcutaneous layer
- 21 External iliac artery
- 22 Intestine



**Bones of hip joint**  
Anterior view



**Section of right hip joint**  
Anterior view of frontal section

# Knee Joint

The knee joint is a combined bicondylar and saddle joint. The relationships between the femur and the tibia provide no interlocking joint mechanisms or stability between the neighboring bones, and from this perspective the knee joint is completely unstable. The strength of the knee joint is dependent on strong ligaments and surrounding muscles. Although its primary motions are of a hinge nature, it is a complex joint with subtle rotational and sliding movements also. The major stabilizers of the joint are four strong ligaments. Two collateral ligaments support the joint on either side, while two cruciate ligaments criss-cross through the middle of the joint. The tibial or medial collateral ligament is a strong, flat band that stretches from the femoral epicondyle to the tibial condyle. Posteriorly it firmly attaches to the joint capsule and the medial meniscus, while anteriorly bursae separate it from these structures. The fibular or lateral collateral ligament is a strong cord that runs from the lateral femoral

of the knee joint is dependent on strong ligaments and surrounding muscles. Although its primary motions are of a hinge nature, it is a complex joint with subtle rotational and sliding movements also. The major stabilizers of the joint are four strong ligaments. Two collateral ligaments support the joint on either side, while two cruciate ligaments criss-cross through the middle of the joint. The tibial or medial collateral ligament is a strong, flat band that stretches from the femoral epicondyle to the tibial condyle. Posteriorly it firmly attaches to the joint capsule and the medial meniscus, while anteriorly bursae separate it from these structures. The fibular or lateral collateral ligament is a strong cord that runs from the lateral femoral

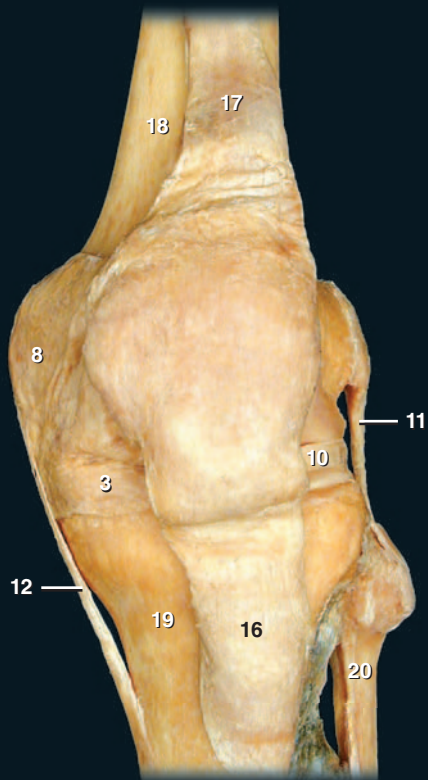
- 1 Articular (synovial) cavity
- 2 Articular cartilage
- 3 Medial meniscus
- 4 Suprapatellar bursa
- 5 Prepatellar bursa
- 6 Infrapatellar bursa
- 7 Infrapatellar fat pad
- 8 Fibrous membrane of joint capsule
- 9 Synovial membrane of joint capsule
- 10 Lateral meniscus
- 11 Fibular collateral ligament
- 12 Tibial collateral ligament
- 13 Anterior cruciate ligament
- 14 Posterior cruciate ligament
- 15 Oblique popliteal ligament
- 16 Patellar ligament
- 17 Quadriceps tendon
- 18 Femur
- 19 Tibia
- 20 Fibula
- 21 Patella
- 22 Periosteum
- 23 Semimembranosus muscle
- 24 Gastrocnemius muscle
- 25 Soleus muscle
- 26 Popliteal fat



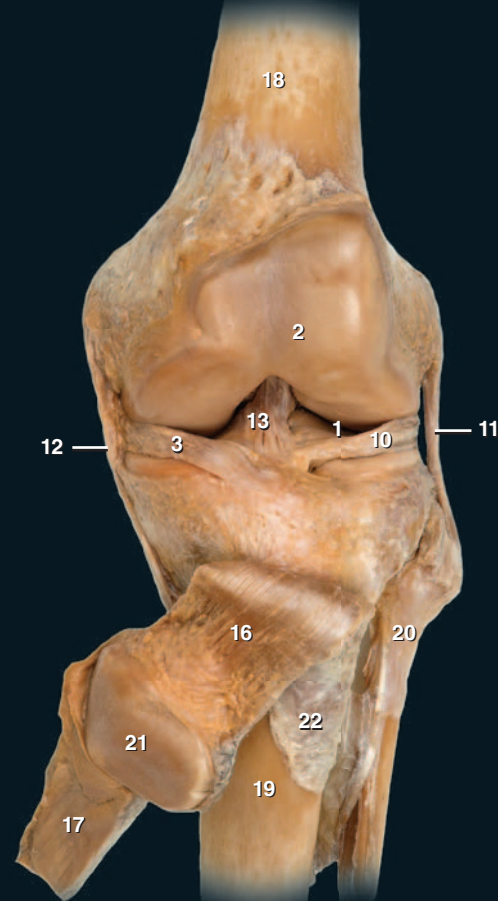
**Bones of knee joint**  
Anterior view

**Section of right knee joint**  
Lateral view of sagittal section

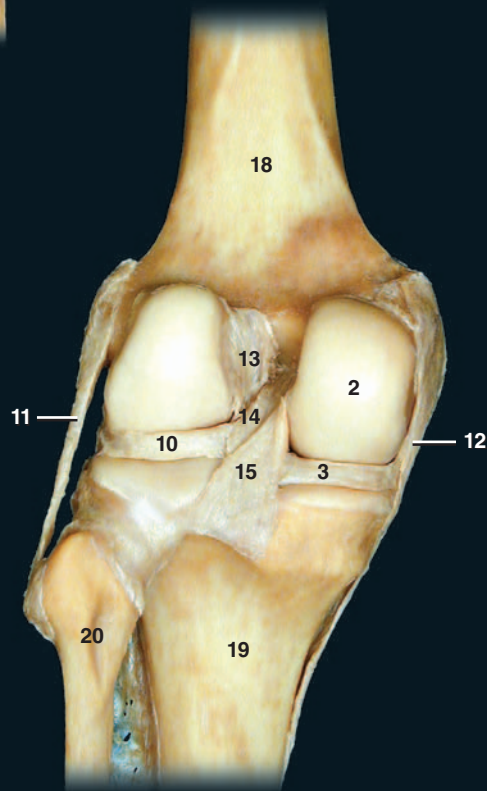
epicondyle to the head of the fibula. Unlike the tibial collateral ligament it does not attach to the lateral meniscus or joint capsule. The cruciate ligaments stabilize the knee from excessive anterior-posterior and rotational movements. The anterior cruciate ligament ascends posterolaterally from the medial aspect of the intercondylar area to the medial aspect of the lateral condyle of the femur. The shorter posterior cruciate ligament ascends from the posterior intercondylar area to the medial femoral condyle. Both cruciates have fibers that blend with the lateral meniscus. In addition to these ligamentous structures, two semilunar menisci project into the capsule between the femoral condyles and the articular plateaus of the tibia. The large, extensive articular capsule connects the femur, patella, and tibia.



**Dissection of left knee joint**  
Anterior view



**Dissection of left knee joint**  
Anterior view



**Dissection of left knee joint**  
Posterior view

# Synovial Bursae and Sheaths

A synovial bursa is a small sac-like structure interposed between structures that generate significant amounts of friction.

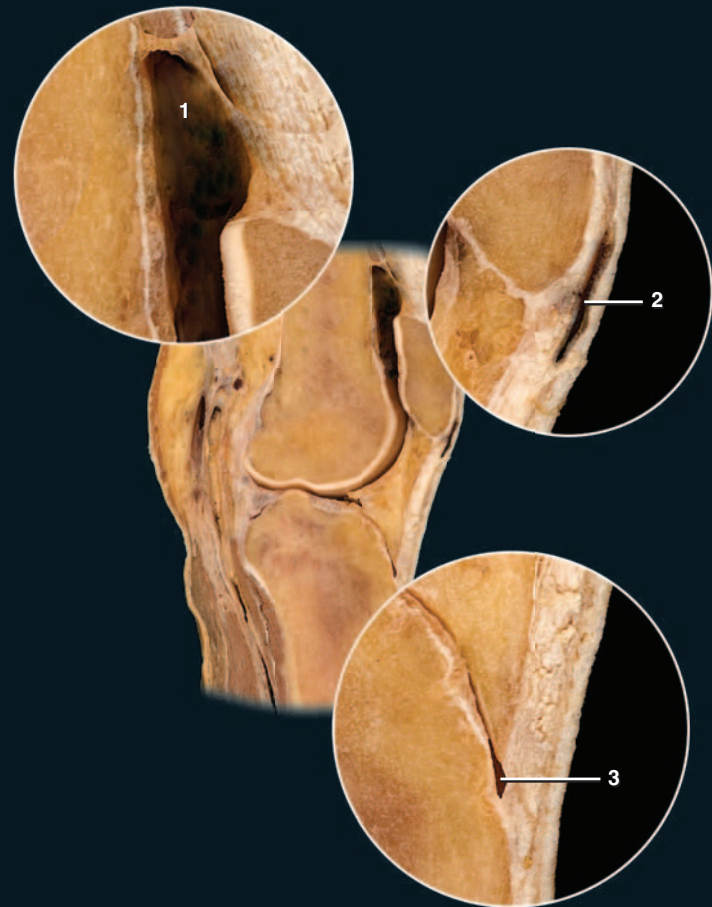
Bursae have a similar design to the articular capsule of a synovial joint. These small bags have an outer fibrous membrane of dense irregular collagenous connective tissue and an inner lining of synovial membrane. The synovial membrane produces a small amount of synovia as a lubricant inside the sac. The fibrous membrane binds to surrounding tissues, allowing the juxtaposed walls of synovial membrane to rub together in a frictionless manner. Many bursae arise as outgrowths of synovial joint cavities. In some cases these pinch off from the joint forming sacs that are independent from the joint, while other bursal sacs retain their connections with the joint cavity. A synovial sheath is a modified bursa that wraps around a tendon to protect it from friction on all sides. In the tight confines of the wrist, ankle, and digits, tendons often pass beneath fibrous bands called retinacula. The retinaculum is a connective tissue band that crosses over the tendons and keeps them from being displaced upward when the muscle shortens and bends the joints. Because the retinaculum and bone create a fibro-osseous tunnel around the tendon, considerable friction can occur on all surfaces of the tendon at these locations. As the tendon moves through the tunnel, the juxtaposed synovial membranes smoothly glide over each other with minimal friction.

- 1 Suprapatellar bursa
- 2 Prepatellar bursa
- 3 Infrapatellar bursa
- 4 Synovial (tendon) sheath
- 5 Retinaculum
- 6 Flexor digitorum superficialis tendon
- 7 Flexor digitorum profundus tendon
- 8 Lumbrical muscles
- 9 Flexor digiti minimi brevis muscle
- 10 Abductor digiti minimi muscle



**Tendon sheath of fingers**

Anterior view, pin inserted into tendon sheath



**Synovial bursae around the knee joint**

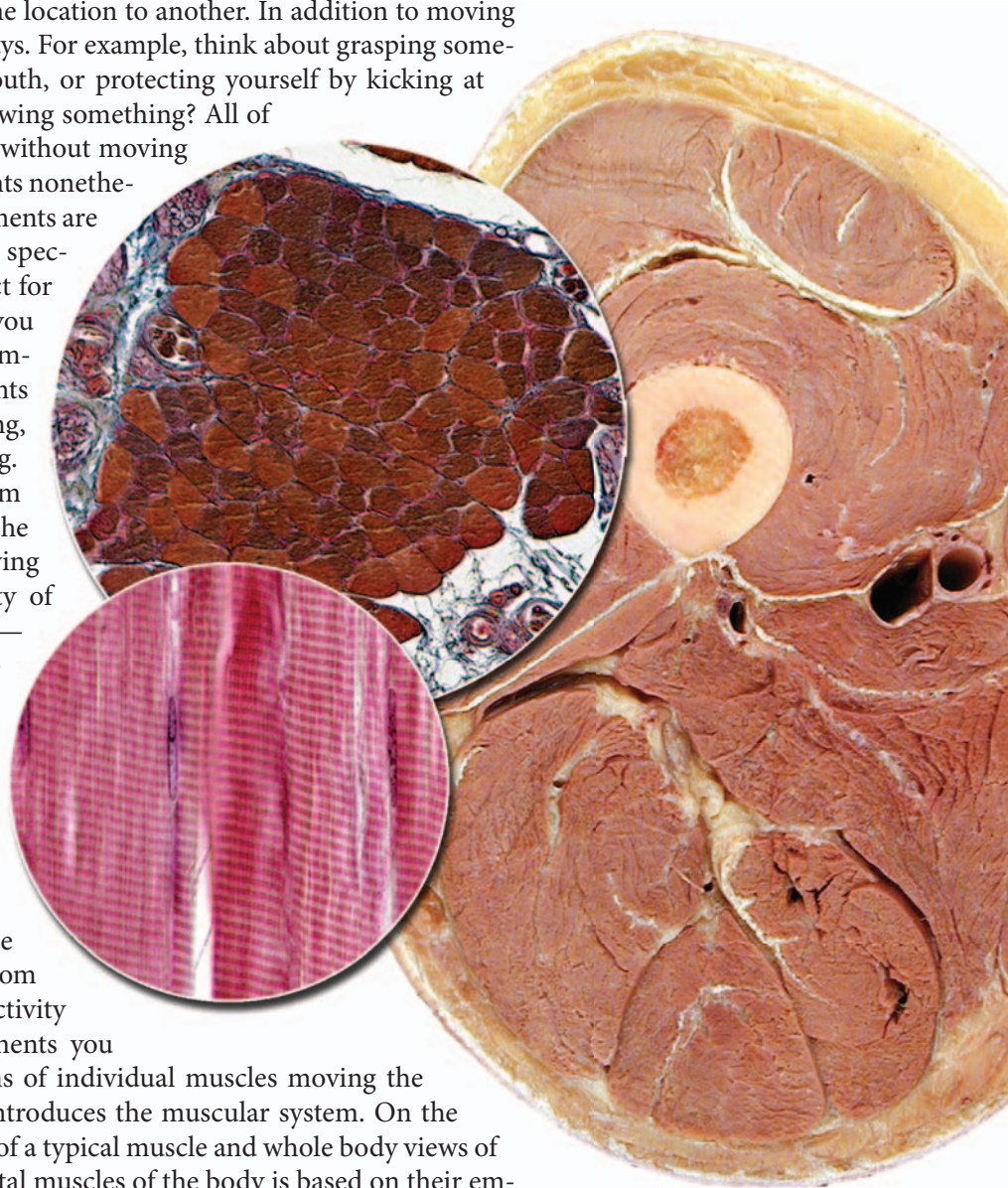
Medial view of sagittal section



# 8 Muscular System

Bodies are designed to move! We move when we walk, jog, or run, activities that transport our bodies from one location to another. In addition to moving from location to location we also move in other ways. For example, think about grasping something with your hands and placing it in your mouth, or protecting yourself by kicking at something with your lower limb. How about throwing something? All of these activities are forms of movement that occur without moving from one location to another, yet they are movements nonetheless. Like moving about, these other types of movements are not only essential for survival, but define the broad spectrum for the majority of human movement. Reflect for a moment on the wide variety of movements that you make without moving from place to place. For example, think about the variety of intricate movements required to eat a meal, movements such as grasping, manipulating, cutting, chewing, and swallowing. Another example is getting dressed for the day. From the simple movements of pulling on clothing to the intricate movements of buttoning shirts and tying shoelaces, getting dressed involves a wide variety of movements. And here is something else to ponder — how about all the movements involved in communication? Think of the wide array of movements that you produce as you communicate with others — whether the communication involves writing a note on a piece of paper, typing a letter on the keyboard of a computer, signaling pleasure and happiness with a smile, or using your voice to talk to a friend on the telephone.

We could go on and on discussing the wide variety of movement and its importance, but the bottom line is all movement results from the combined activity of individual muscles. The most detailed movements you make can be broken down into the simple actions of individual muscles moving the bones of the skeleton at the joints. This chapter introduces the muscular system. On the pages that follow you will see the structural design of a typical muscle and whole body views of the muscles of the body. Our approach to the skeletal muscles of the body is based on their embryonic origins. The four chapters that follow this chapter cover each of the developmental groups of muscles — muscles of the head, muscles of the trunk, muscles of the upper limb, and muscles of the lower limb. The logic of this approach will be further discussed as we introduce each chapter.



Find more information  
about the muscular system in

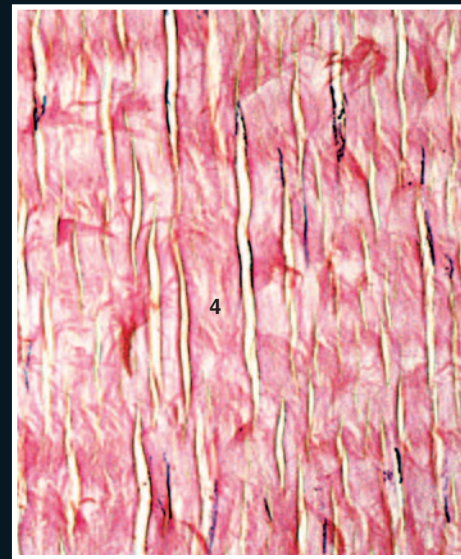
REALANATOMY

# Anatomy of a Muscle

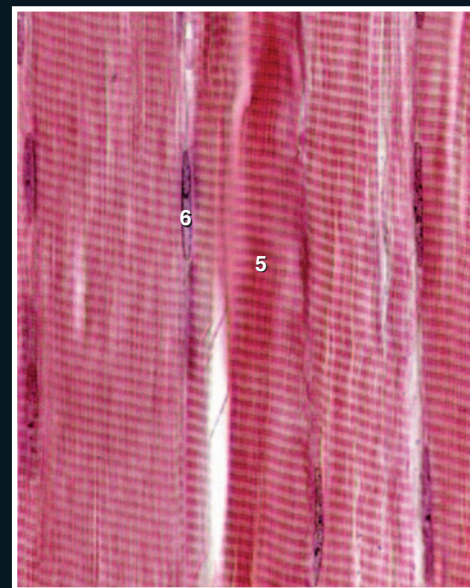
While there is a wide variety to the shape, size, and architecture of the skeletal muscles of the body, most muscles share a common basic design — a tendon of origin, a muscle body

or belly, and a tendon of insertion. The tendons, projecting from the muscle belly, are a continuation of the connective tissue surrounding the muscle cells within the belly of the muscle. As the connective tissue projects beyond the muscle cells, it condenses to become the tendons, which merge and blend with the periosteum to attach the muscle to bone.

- |                        |                          |                                |
|------------------------|--------------------------|--------------------------------|
| 1 Muscle belly or body | 7 Biceps brachii muscle  | 13 Blood vessels in perimysium |
| 2 Tendon of origin     | 8 Brachialis muscle      | 14 Nerve in perimysium         |
| 3 Tendon of insertion  | 9 Triceps brachii muscle | 15 Fascia                      |
| 4 Collagen fiber       | 10 Epimysium             | 16 Subcutaneous layer          |
| 5 Muscle cell or fiber | 11 Perimysium            | 17 Skin                        |
| 6 Nucleus              | 12 Endomysium            | 18 Periosteum                  |

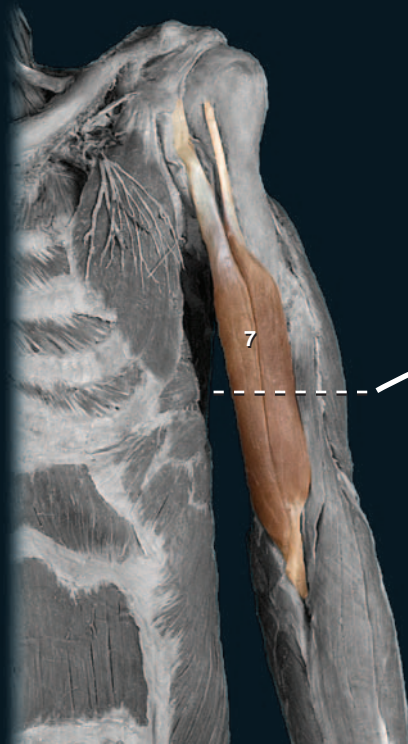


Dense regular connective tissue of tendon  
200x

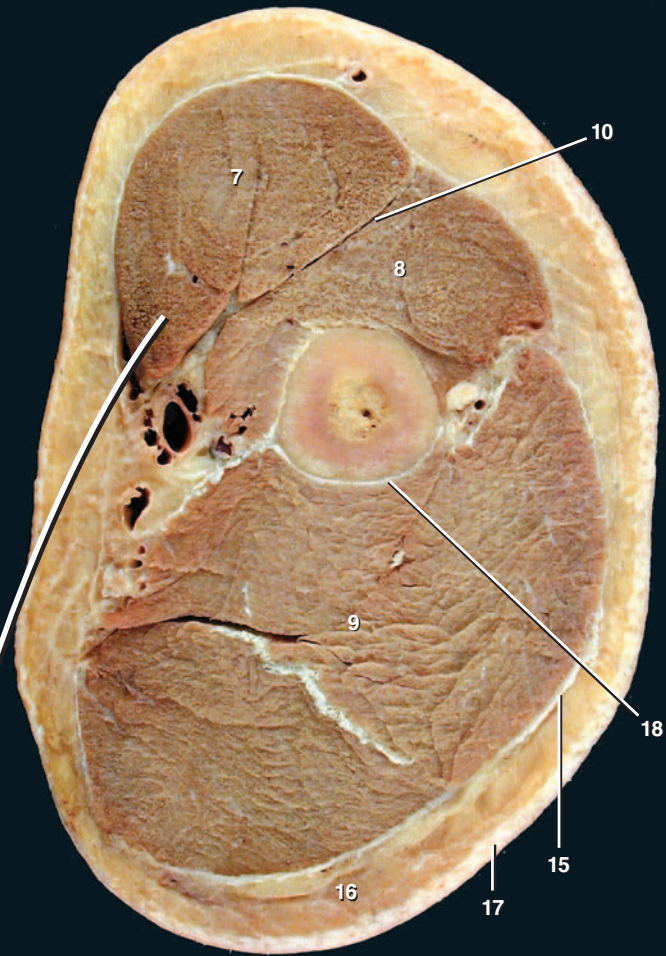


Skeletal muscle tissue of muscle belly  
400x

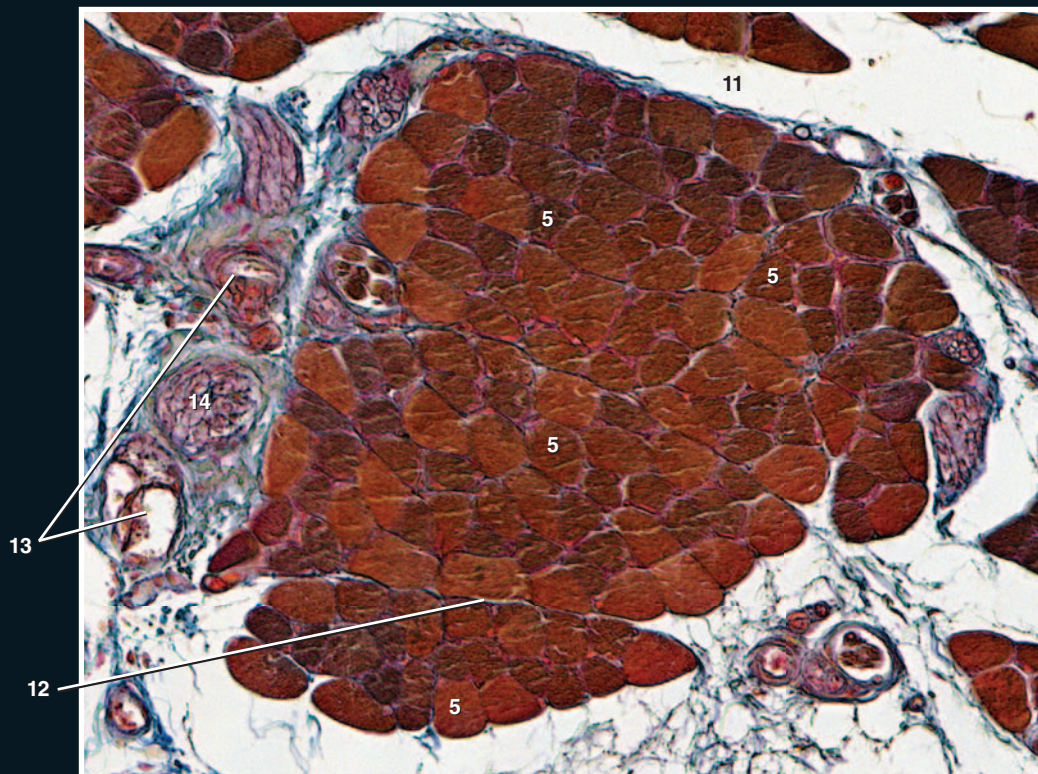
Dissection of brachium highlighting biceps brachii  
as example of muscle anatomy  
Anterior view



Dashed line shows level of transverse section  
Anterior view



Transverse section of left brachium at level of dashed line  
Inferior (distal) view, anterior at top



Photomicrograph of muscle fasciculus  
Transverse section, 100x

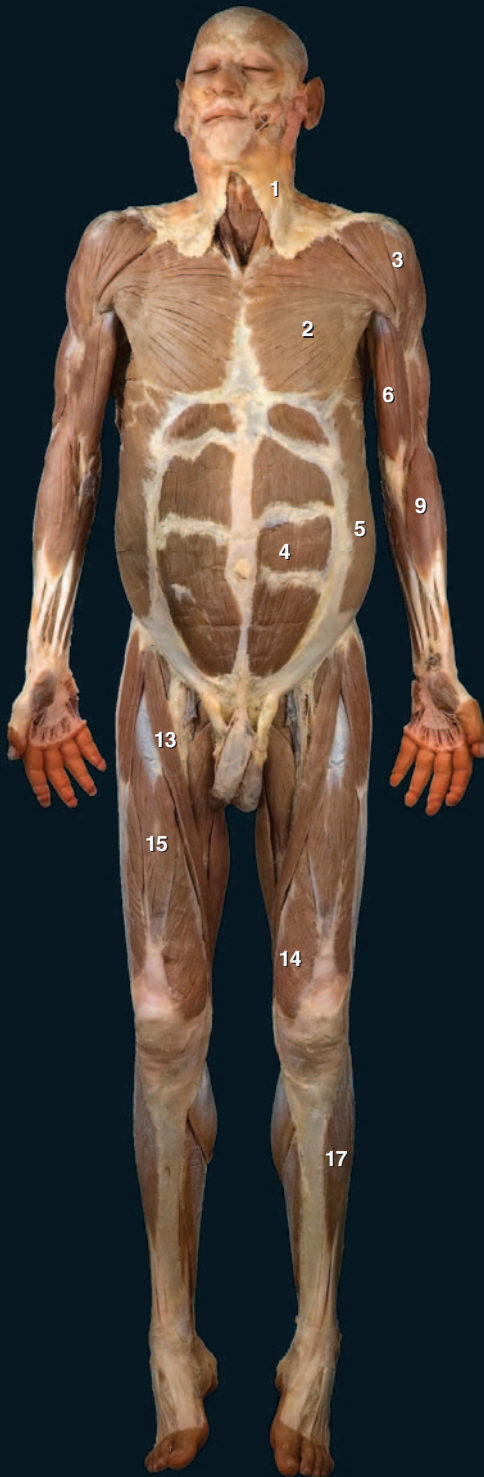
# Skeletal Muscles

In the dissections below, the integument and fascia were removed to reveal the superficial skeletal muscles. Some of the larger muscles are identified here. More detailed muscle labeling will occur in the next four chapters.

- 1 Platysma
- 2 Pectoralis major
- 3 Deltoid
- 4 Rectus abdominis
- 5 External oblique
- 6 Biceps brachii

- 7 Triceps brachii
- 8 Trapezius
- 9 Brachioradialis
- 10 Latissimus dorsi
- 11 Gluteus maximus
- 12 Biceps femoris

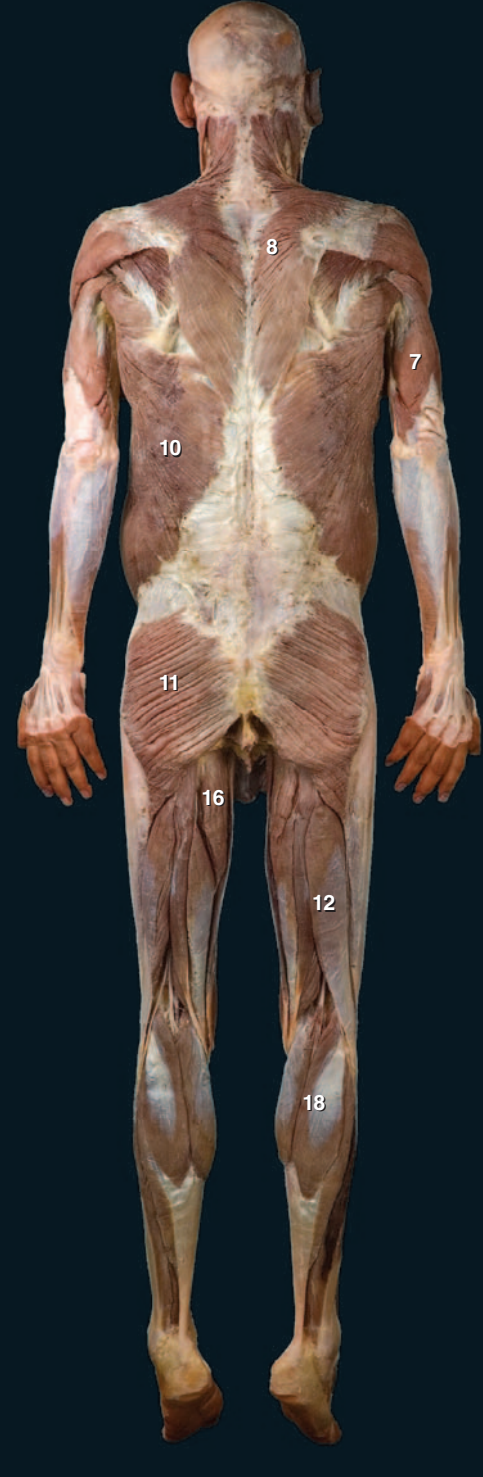
- 13 Sartorius
- 14 Vastus medialis
- 15 Rectus femoris
- 16 Adductor magnus
- 17 Tibialis anterior
- 18 Gastrocnemius



Skeletal muscles of the body  
Anterior view



Skeletal muscles of the body  
Lateral view



Skeletal muscles of the body  
Posterior view

# 9

# Head Muscles

Head muscles, like the platysma and risorius seen in the photo on this page, arise from two sources during embryonic development. One source is the pharyngeal arches, which give rise to the majority of the head muscles. Muscles of the pharyngeal arches include the muscles of mastication, muscles of the middle ear, muscles of facial expression, muscles of the palate, muscles of the pharynx, muscles of the larynx, and the sternocleidomastoid and trapezius. The second category of head muscles includes those muscles that arise from the pre-otic and occipital somites. The pre-otic somites give rise to the extraocular muscles, and the occipital somites give rise to the tongue muscles. Grouping muscles by their developmental origin is an effective way to understand the muscles because muscles that share a developmental origin share a common nerve supply. For example, during development all the muscles of the first pharyngeal arch are innervated by the mandibular branch of the trigeminal nerve; therefore the mandibular nerve and its branches innervate all eight muscles that arise from the first pharyngeal arch. The same is true for each of the other arches, as well as the head somites. This chapter will showcase the muscles of the head and emphasize their developmental origin and neuromuscular pairing. With a few exceptions, all of the head muscles are depicted in the photos throughout this chapter. The following page outlines the developmental groups of head musculature and their nerve associations.



Find more information  
about the muscles of the  
head in

**REALANATOMY**

# Head Muscles

This chapter presents numerous dissections of the head and neck that depict the muscles of the head. We define the head muscles as all muscles that arise from the pharyngeal (branchial) arches or the head somites (pre-otic and occipital). All of these muscles arise from the paraxial mesoderm of the embryonic head. Unlike many anatomy sources that mix these muscles into multiple groups, with no logic to their innervation, we choose to present them based on their embryonic origins. Taking this approach makes it very easy to learn the innervation patterns of the head muscles because each developmental group is associated with a distinct cranial nerve or set of cranial nerves (see groups below). Accompanying each labeled dissection photograph on the pages that follow are small reference photos that clearly depict each of the developmental muscle groups of the head. Since some of the head muscles migrate into the neck, we also depict the somitic muscles of the neck in the reference photos, to help distinguish them from the true head muscles. The somitic muscles of the neck will be the subject of the next chapter. For example, the first photo (see opposite page) labels numerous head muscles. The reference photos clearly reveal that the labeled muscles are primarily from two sources — the first pharyngeal arch and the second pharyngeal arch (accounting for the majority of the muscles). The third reference photo shows that some muscles are from neck somites.

## Muscles of the First Pharyngeal Arch

(Nerve supply - mandibular branch of the trigeminal nerve CN V)

- Temporalis
- Masseter
- Medial pterygoid
- Lateral pterygoid
- Anterior digastric
- Mylohyoid
- \*Tensor tympani
- Tensor veli palatini

## Muscles of the Second Pharyngeal Arch

(Nerve supply - facial nerve CN VII)

- Occipitofrontalis
- Temporoparietalis
- Transversus nuchae
- Procerus
- Nasalis
- \*Depressor septi nasi
- Orbicularis oculi
- Corrugator supercilii
- Depressor supercilii
- Auricularis anterior
- Auricularis superior
- Auricularis posterior
- Intrinsic auricular muscles
  - Helicis major muscle
  - Helicis minor muscle
  - Tragicus muscle
  - \*Pyramidal muscle of auricle
  - Antitragicus muscle
  - \*Transverse muscle of auricle
  - \*Oblique muscle of auricle
- Orbicularis oris
- Depressor anguli oris
- Transversus menti
- Risorius
- Zygomaticus major
- Zygomaticus minor
- Levator labii superioris
- Levator labii superioris alaeque nasi
- Depressor labii inferioris
- Levator anguli oris
- Buccinator
- Mentalis
- \*Stapedius
- Stylohyoid
- Posterior digastric
- Platysma

## Muscle of the Third Pharyngeal Arch

(Nerve supply - glossopharyngeal nerve CN IX)

- Stylopharyngeus

## Muscles of the Fourth Pharyngeal Arch

(Nerve supply - vagus nerve CN X)

- Levator veli palatini
- Palatoglossus
- Palatopharyngeus
- Musculus uvulae
- Superior pharyngeal constrictor
- Middle pharyngeal constrictor
- Inferior pharyngeal constrictor
- Cricothyroid
- Salpingopharyngeus

## Muscles of the Sixth Pharyngeal Arch

(Nerve supply - vagus nerve CN X)

- Posterior crico-arytenoid
- Lateral crico-arytenoid
- Vocalis
- Thyro-arytenoid
- Oblique arytenoid
- Transverse arytenoid

## Muscles of the Posterior Pharyngeal Arch

(Nerve supply - accessory nerve CN XI)

- Sternocleidomastoid
- Trapezius

## Muscles of the Pre-otic Somites

(Nerve supply - oculomotor CN III, trochlear CN IV, and abducens CN VI)

- Superior rectus
- Inferior rectus
- \*Medial rectus
- Lateral rectus
- Superior oblique
- Inferior oblique
- Levator palpebrae superioris

## Muscles of the Occipital Somites

(Nerve supply - hypoglossal nerve CN XII)

- Genioglossus
- Hyoglossus
- Styloglossus
- Superior longitudinal muscle
- Inferior longitudinal muscle
- Transverse muscle
- Vertical muscle

All the muscles listed above are depicted in photos in this chapter except those marked with an asterisk.

- |                                       |                             |  |
|---------------------------------------|-----------------------------|--|
| 1 Masseter                            | 10 Depressor supercilii     | 19 Levator labii superioris alaeque nasi |
| 2 Anterior belly of digastricus (cut) | 11 Auricularis anterior     | 20 Depressor labii inferioris            |
| 3 Mylohyoid                           | 12 Auricularis superior     | 21 Levator anguli oris                   |
| 4 Frontal belly of occipitofrontalis  | 13 Orbicularis oris         | 22 Buccinator                            |
| 5 Temporoparietalis                   | 14 Depressor anguli oris    | 23 Mentalis                              |
| 6 Procerus                            | 15 Transversus menti        | 24 Posterior digastricus                 |
| 7 Nasalis                             | 16 Zygomaticus major        | 25 Epicranial aponeurosis                |
| 8 Orbicularis oculi                   | 17 Zygomaticus minor        | 26 Temporal fascia                       |
| 9 Corrugator supercilii               | 18 Levator labii superioris | 27 Parotid gland (cut)                   |



**Superficial head muscles**  
Anterolateral view



**First arch muscles**



**Second arch muscles**

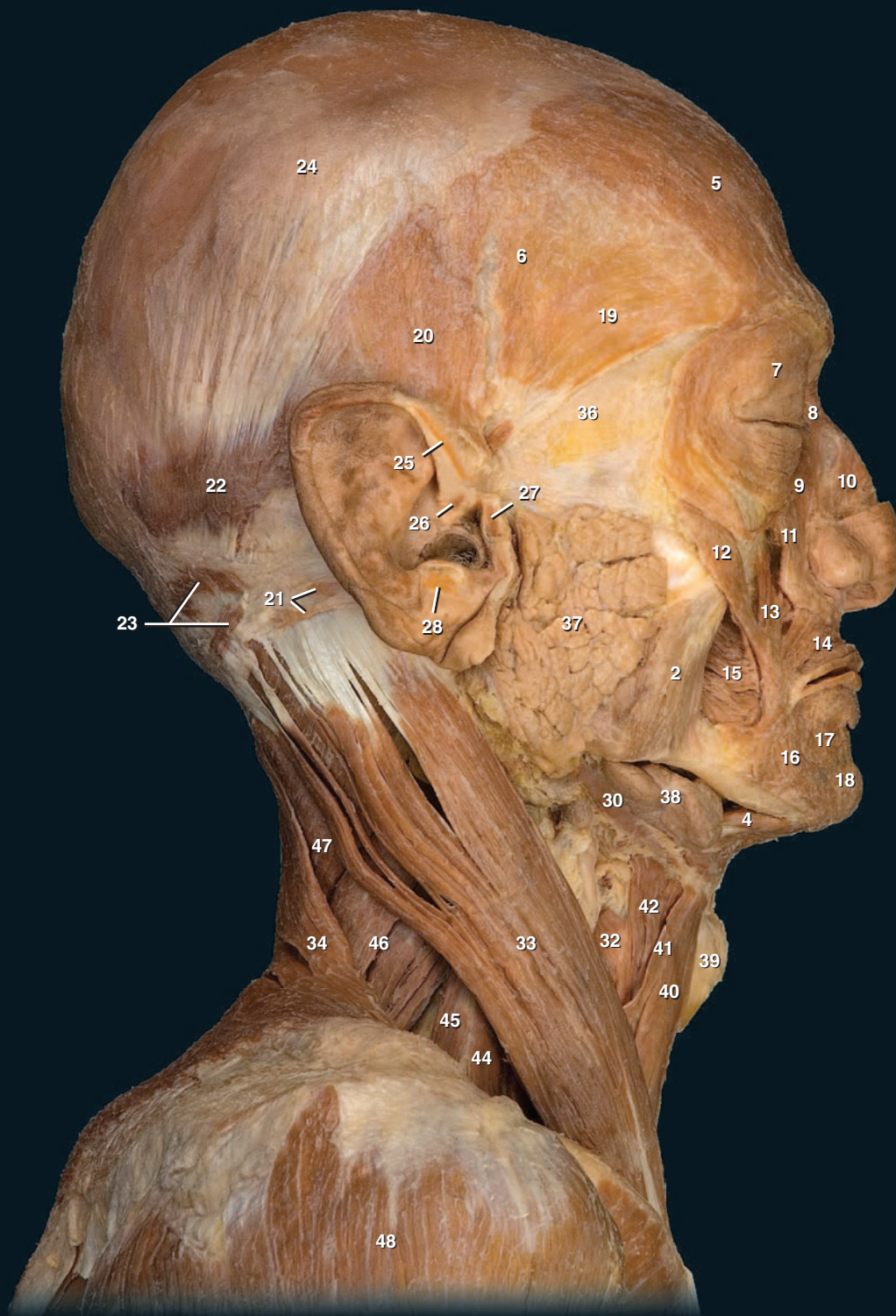


**Somitic muscles**  
of neck

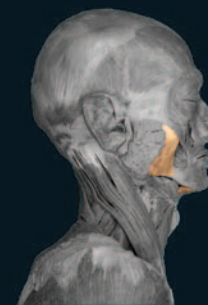
# Head Muscles

The dissections depicted on this page and the facing page represent two stages in a dissection of the head. Below is a superficial dissection with the integument and some fascia removed. On the opposing page some superficial muscles were removed. Most of the head muscle groups are represented. Note also the somitic muscles of the neck that are visible.

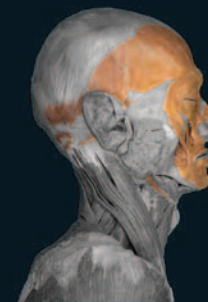
- |                                      |   |                               |
|--------------------------------------|---|-------------------------------|
| 1 Temporalis                         | 7 Orbicularis oculi                     | 13 Levator anguli oris        |
| 2 Masseter                           | 8 Procerus                              | 14 Orbicularis oris           |
| 3 Mylohyoid                          | 9 Levator labii superioris alaeque nasi | 15 Buccinator                 |
| 4 Anterior belly of digastricus      | 10 Nasalis                              | 16 Depressor anguli oris      |
| 5 Frontal belly of occipitofrontalis | 11 Levator labii superioris             | 17 Depressor labii inferioris |
| 6 Temporoparietalis                  | 12 Zygomaticus major                    | 18 Mentalis                   |



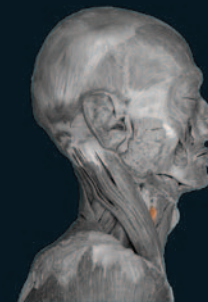
Head muscles, superficial dissection  
Lateral view



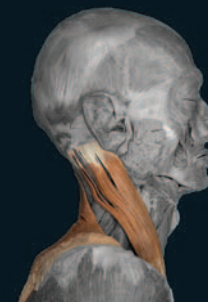
First arch muscles



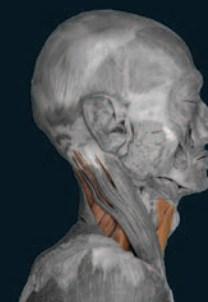
Second arch muscles



Fourth arch muscles



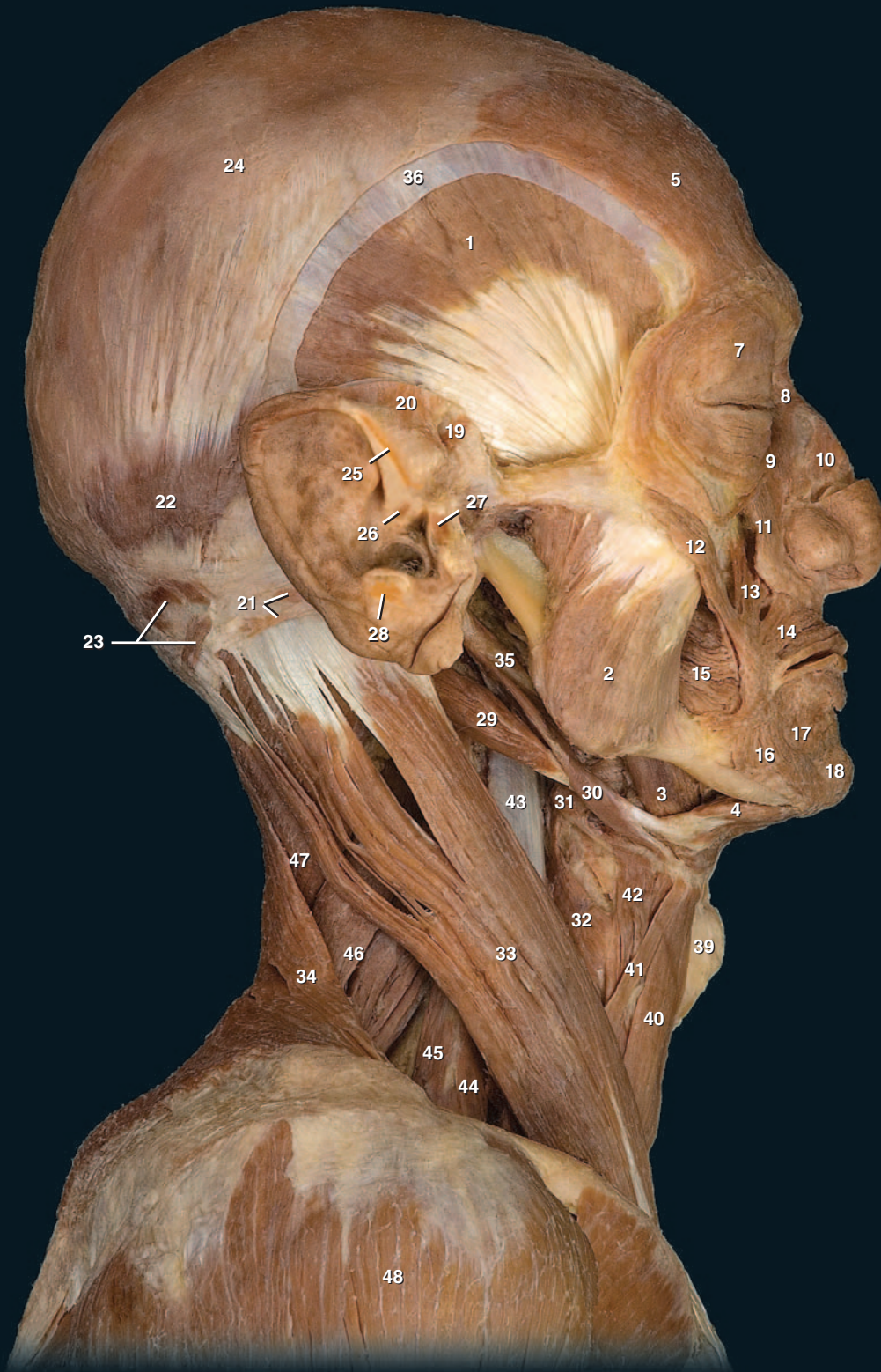
Posterior arch muscles



Somitic muscles  
of neck



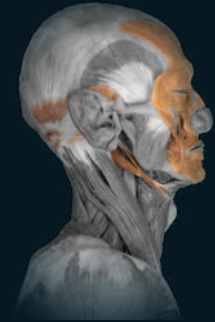
- |   |                                    |                      |
|---|------------------------------------|----------------------|
| 19 Auricularis anterior                 | 29 Posterior belly of digastricus  | 39 Thyroid cartilage |
| 20 Auricularis superior                 | 30 Stylohyoid                      | 40 Sternohyoid       |
| 21 Auricularis posterior                | 31 Middle pharyngeal constrictor   | 41 Omohyoid          |
| 22 Occipital belly of occipitofrontalis | 32 Inferior pharyngeal constrictor | 42 Thyrohyoid        |
| 23 Transversus nuchae                   | 33 Sternocleidomastoid             | 43 Longus colli      |
| 24 Epicranial aponeurosis               | 34 Trapezius                       | 44 Middle scalene    |
| 25 Helicis major                        | 35 Styloglossus                    | 45 Posterior scalene |
| 26 Helicis minor                        | 36 Temporal fascia                 | 46 Levator scapulae  |
| 27 Tragicus                             | 37 Parotid gland                   | 47 Splenius capitis  |
| 28 Antitragicus                         | 38 Submandibular gland             | 48 Deltoid           |



Head muscles, masticatory muscles exposed  
Lateral view



First arch muscles



Second arch muscles



Fourth arch muscles



Posterior arch muscles



Somitic muscles  
of head and neck

# Head Muscles

The lateral head dissections below and opposite are deeper dissections that expose the deep masticatory muscles (below) and the extraocular muscles (opposite).

- 1 Temporalis
- 2 Masseter
- 3 Medial pterygoid
- 4 Lateral pterygoid
- 5 Anterior belly of digastric

- 6 Mylohyoid
- 7 Frontal belly of occipitofrontalis
- 8 Occipital belly of occipitofrontalis
- 9 Transversus nuchae
- 10 Procerus

- 11 Nasalis
- 12 Orbicularis oculi
- 13 Auricularis anterior (cut)
- 14 Auricularis superior (cut)
- 15 Auricularis posterior



Head muscles, deep masticatory muscles exposed  
Lateral view, portion of mandible removed



First arch muscles



Second arch muscles



Fourth arch muscles

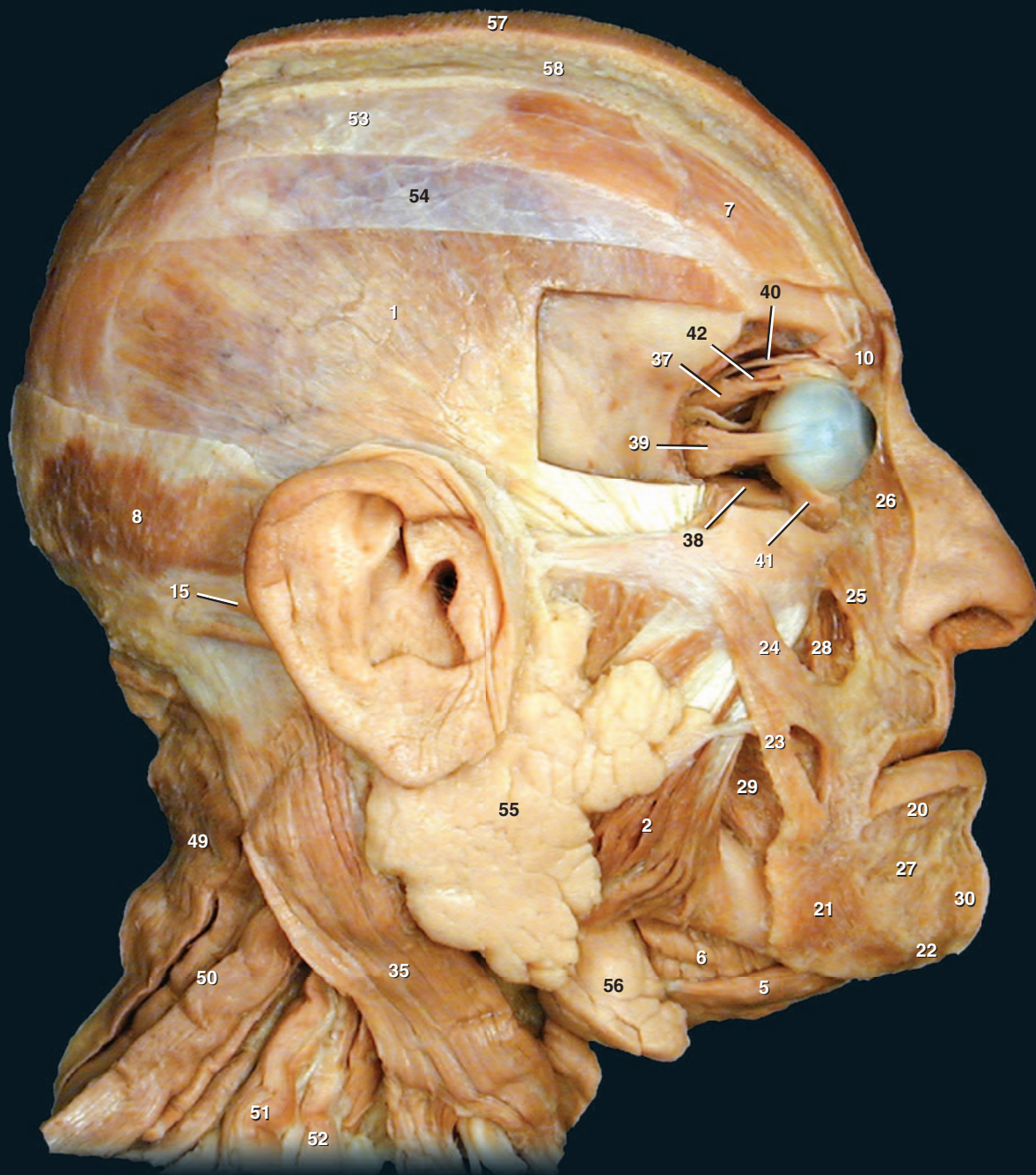


Posterior arch muscles

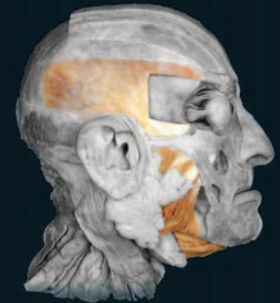


Somitic muscles  
of head and neck

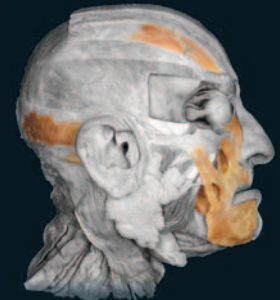
- |  |                                    |                                 |                           |
|--|------------------------------------|---------------------------------|---------------------------|
| 16 Helicis major                         | 27 Depressor labii inferioris      | 38 Inferior rectus              | 49 Splenius capitis       |
| 17 Helicis minor                         | 28 Levator anguli oris             | 39 Lateral rectus               | 50 Levator scapulae       |
| 18 Tragicus                              | 29 Buccinator                      | 40 Supra-orbital nerve          | 51 Posterior scalene      |
| 19 Antitragicus                          | 30 Mentalis                        | 41 Inferior oblique             | 52 Middle scalene         |
| 20 Orbicularis oris                      | 31 Stylohyoid                      | 42 Levator palpebrae superioris | 53 Epicranial aponeurosis |
| 21 Depressor anguli oris                 | 32 Posterior belly of digastricus  | 43 Styloglossus                 | 54 Temporal fascia (cut)  |
| 22 Transversus menti                     | 33 Middle pharyngeal constrictor   | 44 Hyoglossus                   | 55 Parotid gland          |
| 23 Zygomaticus major                     | 34 Inferior pharyngeal constrictor | 45 Sternohyoid                  | 56 Submandibular gland    |
| 24 Zygomaticus minor                     | 35 Sternocleidomastoid             | 46 Omohyoid                     | 57 Skin                   |
| 25 Levator labii superioris              | 36 Trapezius                       | 47 Thyrohyoid                   | 58 Subcutaneous layer     |
| 26 Levator labii superioris alaeque nasi | 37 Superior rectus                 | 48 Longus colli                 | 59 Thyroid cartilage      |



**Head muscles, extraocular muscles exposed**  
Lateral view, lateral wall of orbit removed



**First arch muscles**



**Second arch muscles**



**Posterior arch muscles**



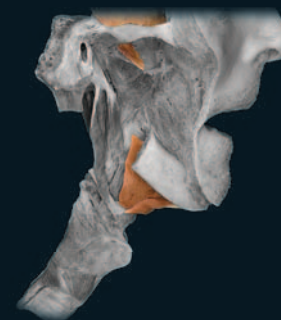
**Somitic muscles**  
of head and neck

# Head Muscles

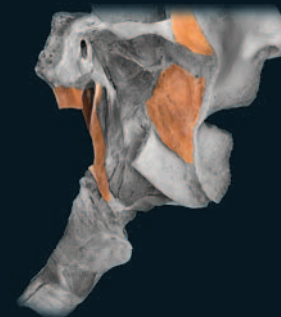
The dissections on this and the opposing page are deep dissections of the head and neck that expose many of the muscles of the palate, pharynx, and tongue. The palatal and pharyngeal muscles, along with the muscles of the larynx, are the deepest of the head muscles. These groups arise from the third, fourth, and sixth arches and form the muscular walls to the upper regions of the embryonic gut tube. All of the "true" tongue muscles (the palatoglossus is included by many with the tongue muscles, but it is a muscle of the palate from fourth arch origin) arise from the occipital somites and are innervated by the cranial nerve XII, the hypoglossal nerve. The hypoglossal nerve is the lowest of the ventral motor nerves arising from the brainstem and is developmentally paired with the occipital somites.



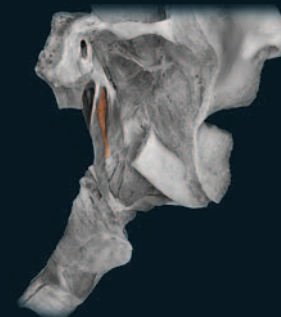
Head muscles, palatal and pharyngeal muscles exposed  
Lateral view, mandibular ramus removed



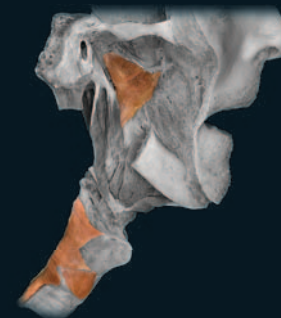
First arch muscles



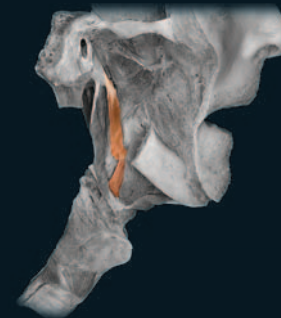
Second arch muscles



Third arch muscles

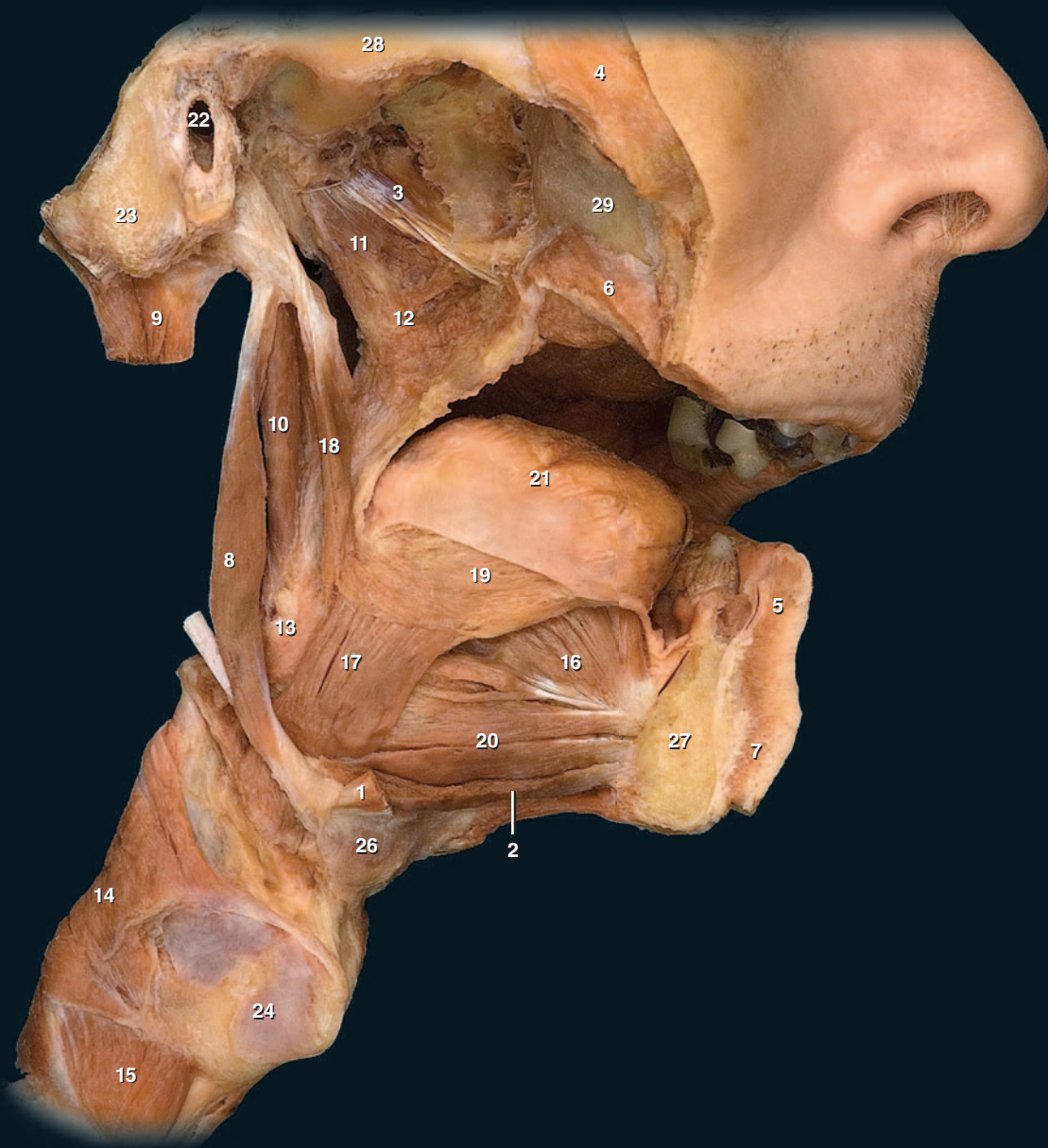


Fourth arch muscles



Somitic muscles  
of head

- |  |                                    |                             |
|--|------------------------------------|-----------------------------|
| 1 Anterior belly of digastricus        | 11 Levator veli palatini           | 21 Mucosa of tongue         |
| 2 Mylohyoid                            | 12 Superior pharyngeal constrictor | 22 External acoustic meatus |
| 3 Tensor veli palatini                 | 13 Middle pharyngeal constrictor   | 23 Mastoid process          |
| 4 Orbicularis oculi                    | 14 Inferior pharyngeal constrictor | 24 Thyroid cartilage        |
| 5 Orbicularis oris                     | 15 Cricothyroid                    | 25 Trachea                  |
| 6 Buccinator                           | 16 Genioglossus                    | 26 Hyoid bone               |
| 7 Mentalis                             | 17 Hyoglossus                      | 27 Mandible (cut)           |
| 8 Stylohyoid                           | 18 Styloglossus                    | 28 Zygomatic arch           |
| 9 Posterior belly of digastricus (cut) | 19 Inferior longitudinal muscle    | 29 Maxilla                  |
| 10 Stylopharyngeus                     | 20 Geniohyoid                      |                             |



**Head muscles, tongue muscles exposed**  
Lateral view, right half of mandible removed



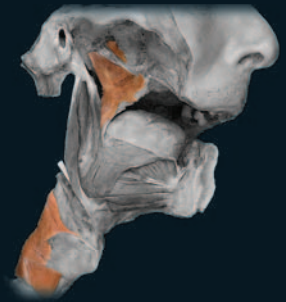
**First arch muscles**



**Second arch muscles**



**Third arch muscles**



**Fourth arch muscles**



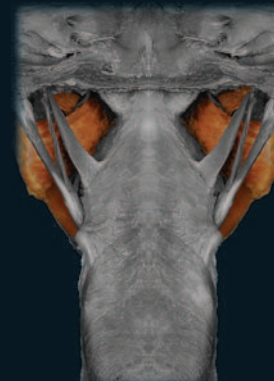
**Somitic muscles  
of head**

# Head Muscles

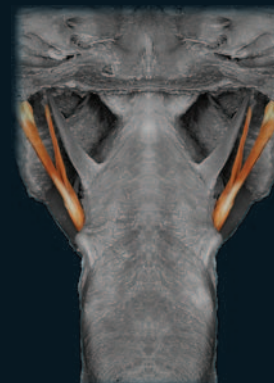
The dissections on this and the opposing page are deep dissections of the head and neck that expose the palate and muscular wall of the pharynx and larynx (muscles that arise from the third, fourth, and sixth pharyngeal arches). These are the deepest muscles of the head and neck, and they form the muscular walls of the upper end of the embryonic gut tube. The dissection below depicts the posterior wall of the pharynx. On the opposing page the pharyngeal wall has been sectioned to reveal the inside of the palate and larynx from behind.



**Head muscles, posterior wall of pharynx exposed**  
Posterior view, cervical vertebrae and occipital bone removed



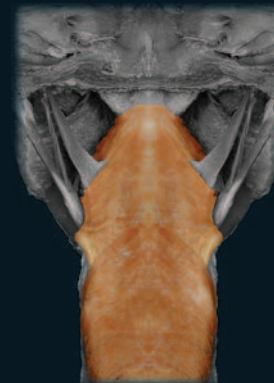
**First arch muscles**



**Second arch muscles**



**Third arch muscles**



**Fourth arch muscles**

- |                                    |                                    |                                |
|------------------------------------|------------------------------------|--------------------------------|
| 1 Masseter                         | 11 Middle pharyngeal constrictor   | 20 Palatine tonsil             |
| 2 Medial pterygoid                 | 12 Inferior pharyngeal constrictor | 21 Tongue                      |
| 3 Lateral pterygoid                | 13 Salpingopharyngeus              | 22 Epiglottis                  |
| 4 Stylohyoid                       | 14 Posterior crico-arytenoid       | 23 Cricoid cartilage           |
| 5 Posterior belly of digastricus   | 15 Oblique arytenoid               | 24 Esophagus                   |
| 6 Stylopharyngeus                  | 16 Transverse arytenoid            | 25 Trachea                     |
| 7 Levator veli palatini            | 17 Styloglossus                    | 26 Greater cornu of hyoid bone |
| 8 Palatopharyngeus                 | 18 Pharyngotympanic tube           | 27 Aryepiglottic fold          |
| 9 Musculus uvulae                  | 19 Bony nasal septum               | 28 Pharyngobasilar fascia      |
| 10 Superior pharyngeal constrictor |                                    |                                |



**Head muscles, posterior wall of pharynx cut and reflected**  
Posterior view, cervical vertebrae and occipital bone removed



**First arch muscles**



**Second arch muscles**



**Third arch muscles**



**Fourth arch muscles**



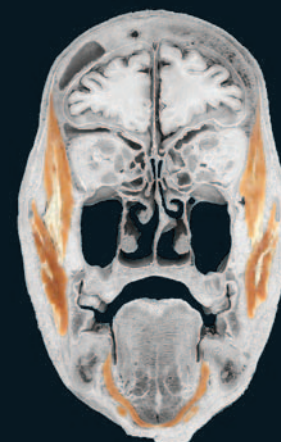
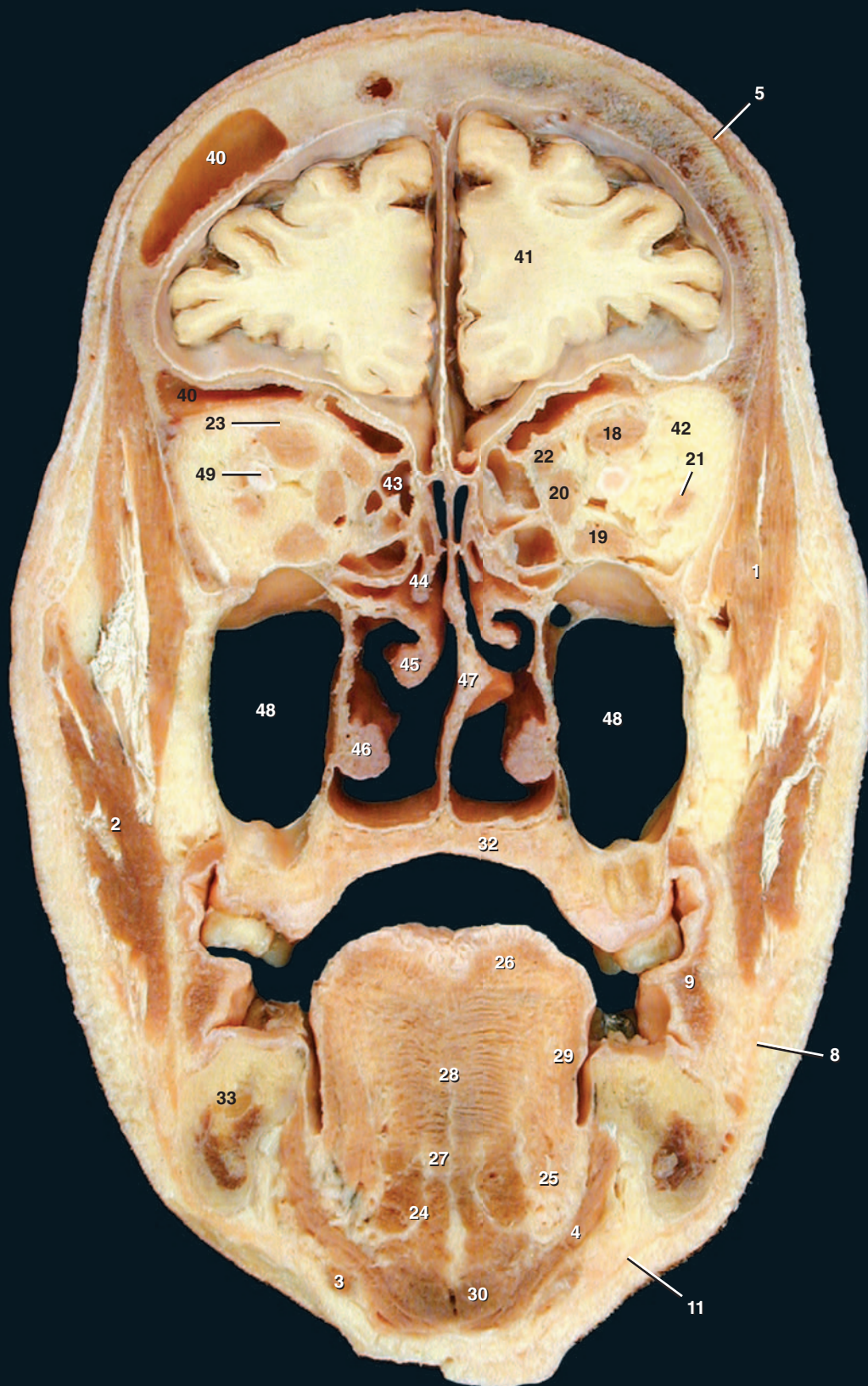
**Sixth arch muscles**



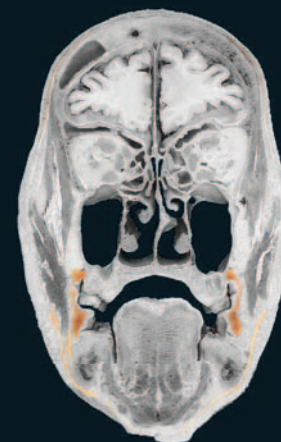
**Somitic muscles  
of head**

# Head Muscles

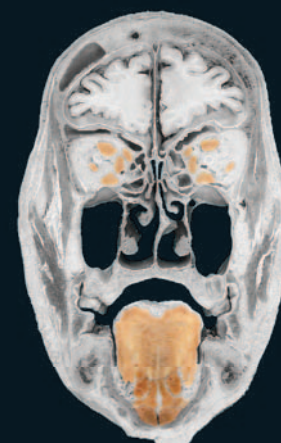
Sectional anatomy broadens perspective and showcases anatomical relationships in ways that are not possible to achieve by dissection alone. The frontal and parasagittal sections on these pages depict and clarify the relationships of many of the head muscles and show the relationships these muscles have with other structures of the head.



First arch muscles



Second arch muscles

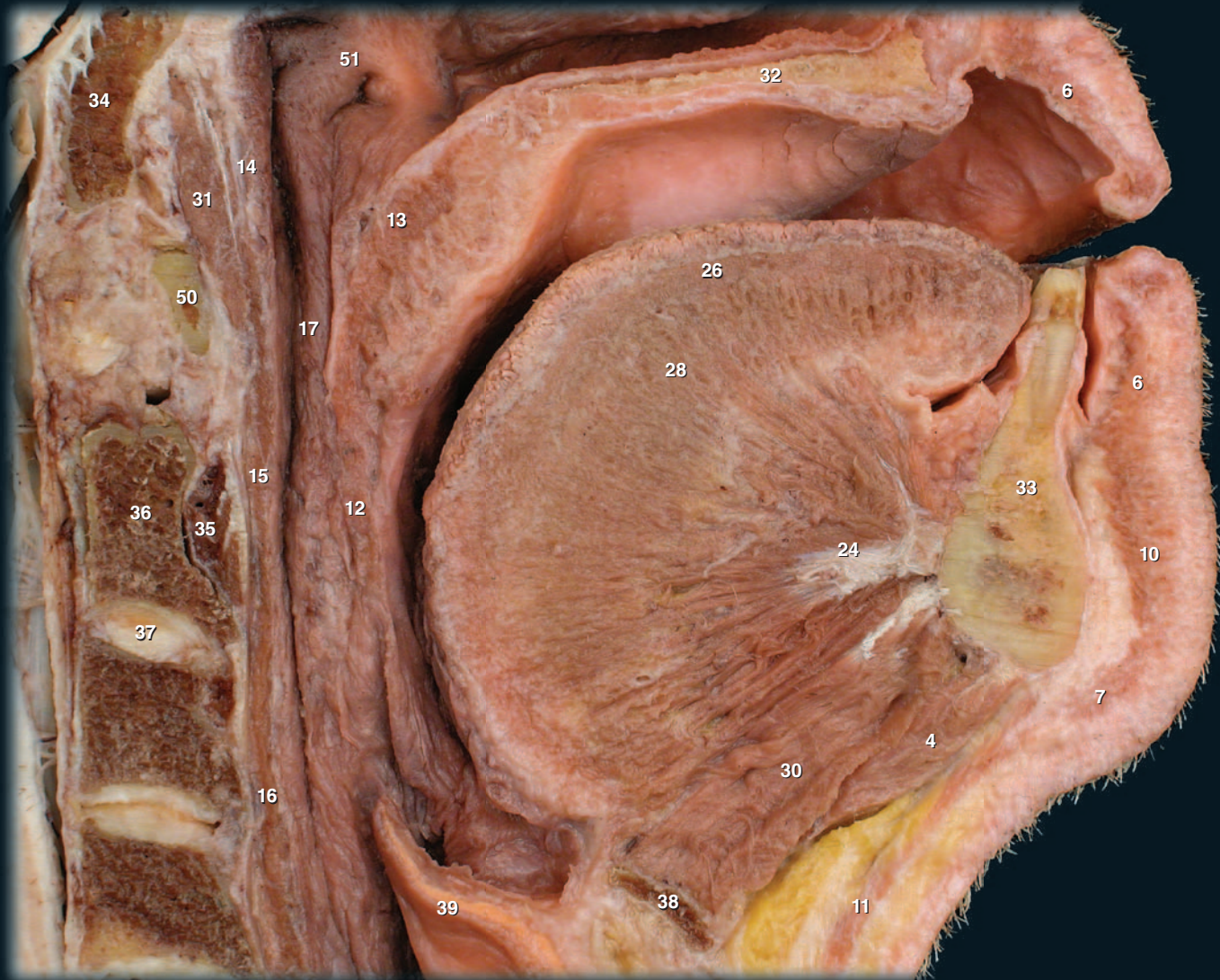


Somatic muscles of head

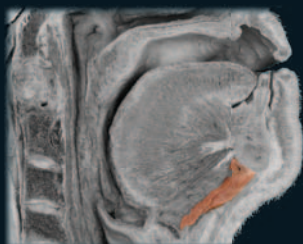
Head muscles, frontal section through orbits, nasal cavity, and oral cavity  
Posterior view



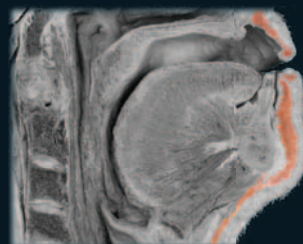
- |                                      |                                    |                                 |  |
|--------------------------------------|------------------------------------|---------------------------------|--|
| 1 Temporalis                         | 14 Superior pharyngeal constrictor | 27 Inferior longitudinal muscle | 40 Frontal sinus                           |
| 2 Masseter                           | 15 Middle pharyngeal constrictor   | 28 Transversus muscle           | 41 Frontal lobe of cerebrum                |
| 3 Anterior digastric                 | 16 Inferior pharyngeal constrictor | 29 Vertical muscle              | 42 Periorbital fat                         |
| 4 Mylohyoid                          | 17 Salpingopharyngeus              | 30 Geniohyoid                   | 43 Ethmoidal air cells                     |
| 5 Frontal belly of occipitofrontalis | 18 Superior rectus                 | 31 Longus capitis               | 44 Superior nasal conchae                  |
| 6 Orbicularis oris                   | 19 Inferior rectus                 | 32 Hard palate                  | 45 Middle nasal conchae                    |
| 7 Transversus menti                  | 20 Medial rectus                   | 33 Mandible                     | 46 Inferior nasal conchae                  |
| 8 Risorius                           | 21 Lateral rectus                  | 34 Occipital bone               | 47 Bony nasal septum                       |
| 9 Buccinator                         | 22 Superior oblique                | 35 Atlas                        | 48 Maxillary sinus                         |
| 10 Mentalis                          | 23 Levator palpebrae superioris    | 36 Axis                         | 49 Optic nerve                             |
| 11 Platysma                          | 24 Genioglossus                    | 37 Intervertebral disc          | 50 Occipital condyle                       |
| 12 Palatopharyngeus                  | 25 Hyoglossus                      | 38 Hyoid bone                   | 51 Torus tubarius of pharyngotympanic tube |
| 13 Musculus uvulae                   | 26 Superior longitudinal muscle    | 39 Epiglottis                   |  |



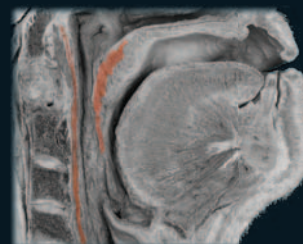
**Head muscles, parasagittal section through oral cavity and pharynx**  
Posterior view, section is 1.2 cm lateral to the midline



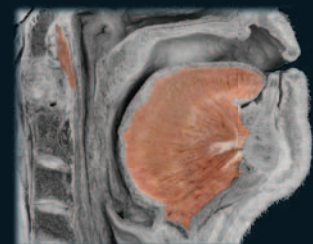
**First arch muscles**



**Second arch muscles**



**Fourth arch muscles**

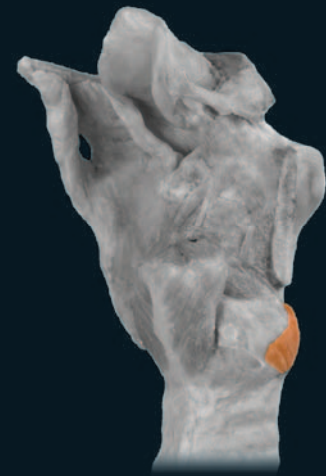


**Somitic muscles  
of head and neck**

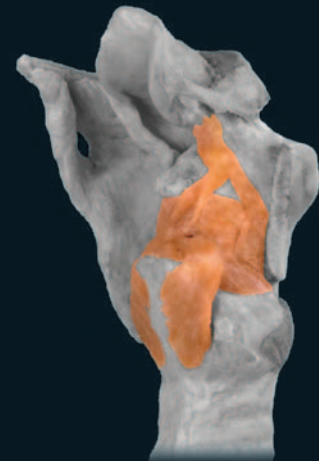
# Head Muscles

The dissection on this page exposes the deepest of the head muscles, those of the sixth pharyngeal arch. This group, found within the wall of the larynx, is the small series of muscles that are responsible for sound production. Contractions of these muscles vary the tension on the vocal folds and adjust the size of the rima glottidis. A cut anterior portion of the cricothyroid is also visible; however this muscle is actually the anterior continuation of the inferior pharyngeal constrictor and develops from the fourth pharyngeal arch.

- |  |                            |
|--|----------------------------|
| 1 Posterior crico-arytenoid                | 8 Cricothyroid (cut)       |
| 2 Lateral crico-arytenoid                  | 9 Hyoid bone               |
| 3 Thyro-arytenoid                          | 10 Epiglottis              |
| 4 Thyro-epiglottic part of thyro-arytenoid | 11 Thyroid cartilage (cut) |
| 5 Oblique arytenoid                        | 12 Cricoid cartilage       |
| 6 Ary-epiglottic part of oblique arytenoid | 13 Trachea                 |
| 7 Transverse arytenoid                     | 14 Thyrohyoid membrane     |



Fourth arch muscle



Sixth arch muscles

Dissection of the larynx, right lamina and horns removed  
Posterolateral view

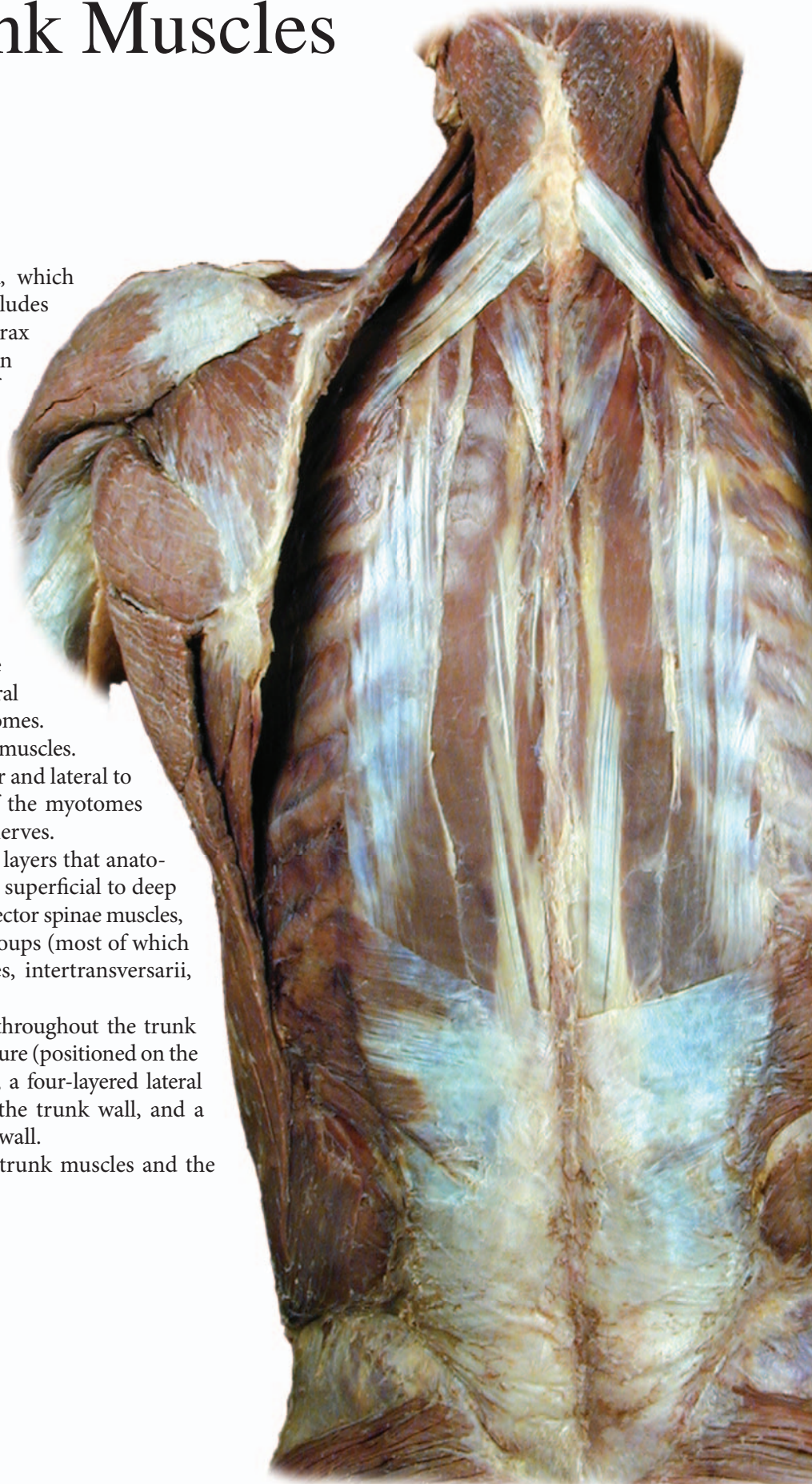
# 10 Trunk Muscles

The trunk, which is defined by the span of the vertebral column, includes the neck (span of the cervical vertebrae), the thorax (span of the thoracic vertebrae), the abdomen (span of the lumbar vertebrae), and the pelvis (span of the sacral vertebrae). The muscles of the trunk are the most primitive muscles in the vertebrate body. This series of muscles arises as epithelial migrations from the myotomes of the embryonic somites and forms a distinct muscle pattern throughout the length of the trunk. The trunk muscle pattern has two distinct subdivisions, the epaxial muscles and the hypaxial muscles, which are separated by a transverse intermuscular septum. The epaxial muscles, situated posterior to the vertebral axis, are the extensor muscles of the vertebral column that develop from the epimere of the myotomes. The dorsal rami of the spinal nerves innervate these muscles. The hypaxial muscles, positioned primarily anterior and lateral to the vertebral axis, develop from the hypomere of the myotomes and are supplied by the ventral rami of the spinal nerves.

The epaxial muscles form a number of muscle layers that anatomists typically describe as a series of groups. From superficial to deep the groups are the spinotransversales muscles, the erector spinae muscles, the transversospinales muscles, and the deepest groups (most of which are intersegmental) consisting of the interspinales, intertransversarii, and suboccipital muscles.

The hypaxial muscles form a distinct pattern throughout the trunk wall. This pattern consists of a subvertebral musculature (positioned on the anterior and lateral aspect of the vertebral bodies), a four-layered lateral wall of muscles situated on the lateral aspect of the trunk wall, and a ventral strap of musculature on the anterior trunk wall.

The photos in this chapter clearly depict the trunk muscles and the patterns outlined above.



Find more information  
about the muscles of the  
trunk in

REALANATOMY

# Epaxial Muscles

The epaxial muscles, or vertebral extensors, develop on the dorsal side of the vertebral column and skull. These muscles arise from the myotomal epimere of all the trunk somites and span the entire length of the vertebral column to the posterior aspect of the occipital bone. They comprise the intrinsic muscles of the vertebral column, which are often referred to as the “true back muscles.” The vertebral extensors form four distinct muscle groups. These groups are, from superficial to deep, the spinotransversales (splenius muscles), the erector spinae, the transversospinales (three layers — the semispinalis, multifidus, and rotatores layers), and the intersegmental muscles. However, each of the four groups does not extend the entire length of the vertebral column, and in some regions not all four layers are represented. All epaxial muscles receive a nerve supply from the dorsal (posterior) rami of the spinal nerves.



## Epaxial Muscle Layers

- Spinotransversales — Splenius layer
- Erector spinae layer
- Transversospinalis — Semispinalis layer
- Transversospinalis — Multifidus layer
- Transversospinalis — Rotatores layer
- Deep intersegmental layer

## Vertical muscle subdivisions within muscle layers

### Capitis Muscles

- Splenius capitis
- Erector spinae capitis
  - Longissimus capitis
  - Spinalis capitis
- Transversospinales capitis
  - Semispinalis capitis
- Suboccipitales
  - Rectus capitis posterior major
  - Rectus capitis posterior minor
  - Obliquus capitis superior
  - Obliquus capitis inferior

### Cervical Muscles

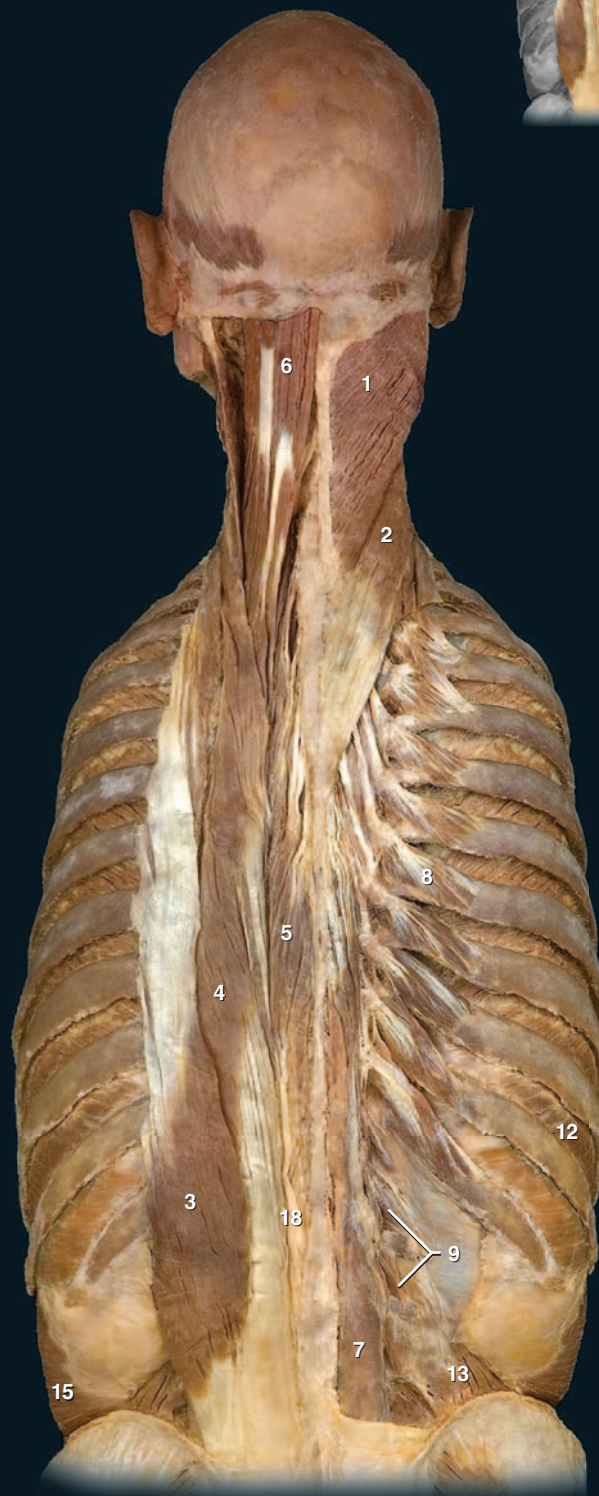
- Splenius cervicis
- Erector spinae cervicis
  - Iliocostalis cervicis
  - Longissimus cervicis
  - Spinalis cervicis
- Transversospinales cervicis
  - Semispinalis cervicis
  - Multifidus cervicis
  - Rotatores cervicis
- Interspinales cervicis
- Intertransversarii posteriores cervicis medialis

### Thoracic Muscles

- Erector spinae thoracis
  - Iliocostalis thoracis
  - Longissimus thoracis
  - Spinalis thoracis
- Transversospinales thoracis
  - Semispinalis thoracis
  - Multifidus thoracis
  - Rotatores thoracis
- Interspinales thoracis
- Intertransversarii thoracis
- Levatores costarum

### Lumbar Muscles

- Erector spinae lumborum
  - Iliocostalis lumborum
- Transversospinales lumborum
  - Multifidus lumborum
  - Rotatores lumborum
- Interspinales lumborum
- Intertransversarii lumborum medialis



Dissection of epaxial musculature  
Posterior view

# Spinotransversales Muscles

The spinotransversales muscles are the superficial-most epaxial muscles and are only present in the superior half of the vertebral column. This group is comprised of two named muscles — the splenius capitis and splenius cervicis. They span from the midthoracic region to the base of the occipital bone. As their name suggests, the fibers attach to the spinous processes of the vertebrae and course laterally to attach to the vertebral transverse processes. These flat bands of muscle are primary extensors of the upper vertebral column and head.



## Splenius Musculature

- 1 Splenius capitis muscle
- 2 Splenius cervicis muscle

## Other Muscles and Structures

- 3 Iliocostalis muscle
- 4 Longissimus muscle
- 5 Spinalis muscle
- 6 Semispinalis muscle
- 7 Multifidus muscle
- 8 Levatores costarum muscle
- 9 Intertransversarii muscle
- 10 Posterior scalene muscle
- 11 External intercostal muscle
- 12 Internal intercostal muscle
- 13 Quadratus lumborum muscle
- 14 External oblique muscle
- 15 Transversus abdominis muscle
- 16 Gluteus maximus muscle
- 17 Fascia of gluteus medius muscle
- 18 Supraspinous ligament
- 19 Nuchal ligament



Dissection of splenius and erector spinae muscles  
Posterior view

# Erector Spinae Muscles

The erector spinae muscles comprise the second layer of epaxial muscles.

Unlike the splenius muscles, the erector spinae muscle group spans the entire length of the vertebral column. The erector spinae is divided into three parts, which from medial to lateral are the spinalis muscle, the longissimus muscle, and the iliocostalis muscle. This strong group of epaxial muscles consists of muscle fibers that course vertically and somewhat laterally as they span multiple vertebral levels. They function as primary extensors of the vertebral column.

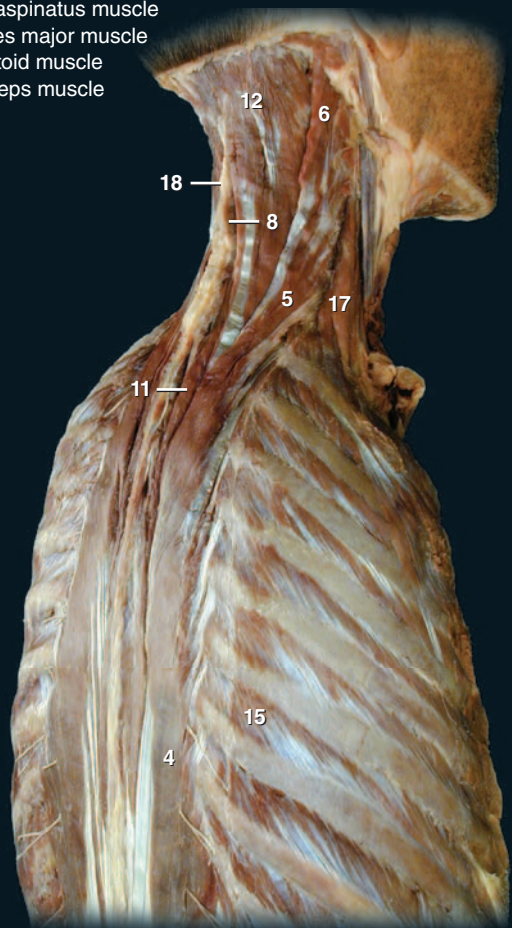


## Erector Spinae and Semispinalis Musculature

- 1 Iliocostalis lumborum muscle - lumbar part
- 2 Iliocostalis lumborum muscle - thoracic part
- 3 Iliocostalis cervicis muscle
- 4 Longissimus thoracis muscle
- 5 Longissimus cervicis muscle
- 6 Longissimus capitis muscle
- 7 Spinalis thoracis muscle
- 8 Spinalis cervicis muscle
- 9 Spinalis capitis muscle
- 10 Semispinalis thoracis muscle
- 11 Semispinalis cervicis muscle
- 12 Semispinalis capitis muscle

## Other Muscles and Structures

- 13 Multifidus muscle
- 14 Levatores costarum muscle
- 15 External intercostal muscle
- 16 Internal intercostal muscle
- 17 Middle scalene muscle
- 18 Nuchal ligament
- 19 Trapezius muscle
- 20 Rhomboideus major muscle
- 21 Latissimus dorsi muscle
- 22 Infraspinatus muscle
- 23 Teres major muscle
- 24 Deltoid muscle
- 25 Triceps muscle



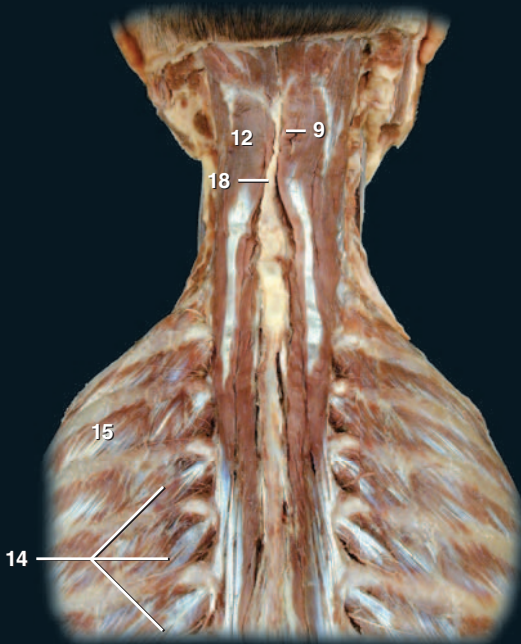
Dissection of erector spinae muscles  
Posterolateral view



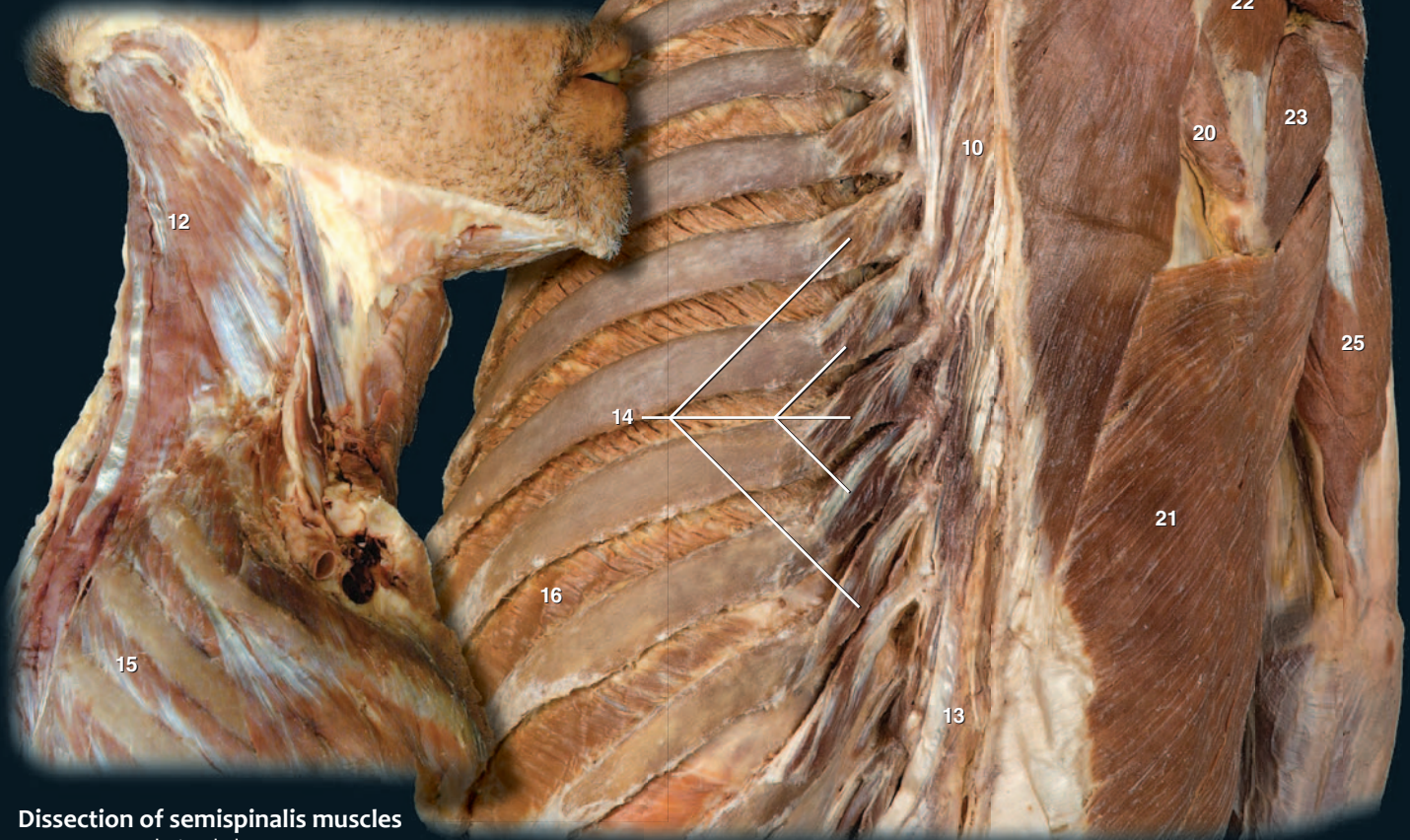
Dissection of erector spinae muscles  
Posterior view

# Transversospinales Muscles

The transversospinales muscles form the third layer of epaxial muscles. This deeper layer of muscles has shorter muscle fibers, on average, than its two superficial counterparts, and the fibers angle from lateral (transverse processes) to medial (spinous processes) as they course from sacrum to cranium. Within this group there are three muscles — the semispinalis, multifidus, and the rotatores muscles. The more superficial semispinalis muscle is depicted on this page.



Dissection of semispinalis muscles  
Posterior view



Dissection of semispinalis muscles  
Lateral view

Dissection of semispinalis layer on left and limb muscles on right  
Posterolateral view

# Transversospinales Muscles

The multifidus layer of the transversospinales musculature is highlighted on

this page, and the deeper rotatores are evident on the opposite page along with the deeper intersegmental muscles. The multifidus muscles span three to five vertebral levels in their span from the sacrum to the second cervical vertebra, while the deepest member, the rotatores, typically span only one to two vertebrae. The transversospinales muscles assist their more superficial counterparts with extension of the vertebral column and play important roles in the maintenance of posture.



Dissection of multifidus muscles  
Posterior view



Dissection of multifidus and intersegmental muscles  
Posterolateral view



# Intersegmental Muscles

The small intersegmental muscles — the interspinales muscles, intertransversarii muscles, levatores costarum, and suboccipital muscles — in general span a single intervertebral joint. The interspinales and intertransversarii muscles contribute little to any significant vertebral movements. They contain large numbers of sensory neurons within their musculotendinous fasciculi. These spindle-like sensory receptors in the muscles monitor muscle tension. These small muscles, with their poor mechanical advantage, probably function as receptors that monitor the regional movements of the vertebral column and supply feedback that influences the action of the larger surrounding muscles. Associated deep in the junction of the cranium and vertebral column are the four suboccipital muscles. The suboccipital muscles are homologous to the other deep muscles at more inferior vertebral levels, but are developmentally modified and enlarged to function with their specialized vertebral counterparts — the axis, atlas, and occipital bone.

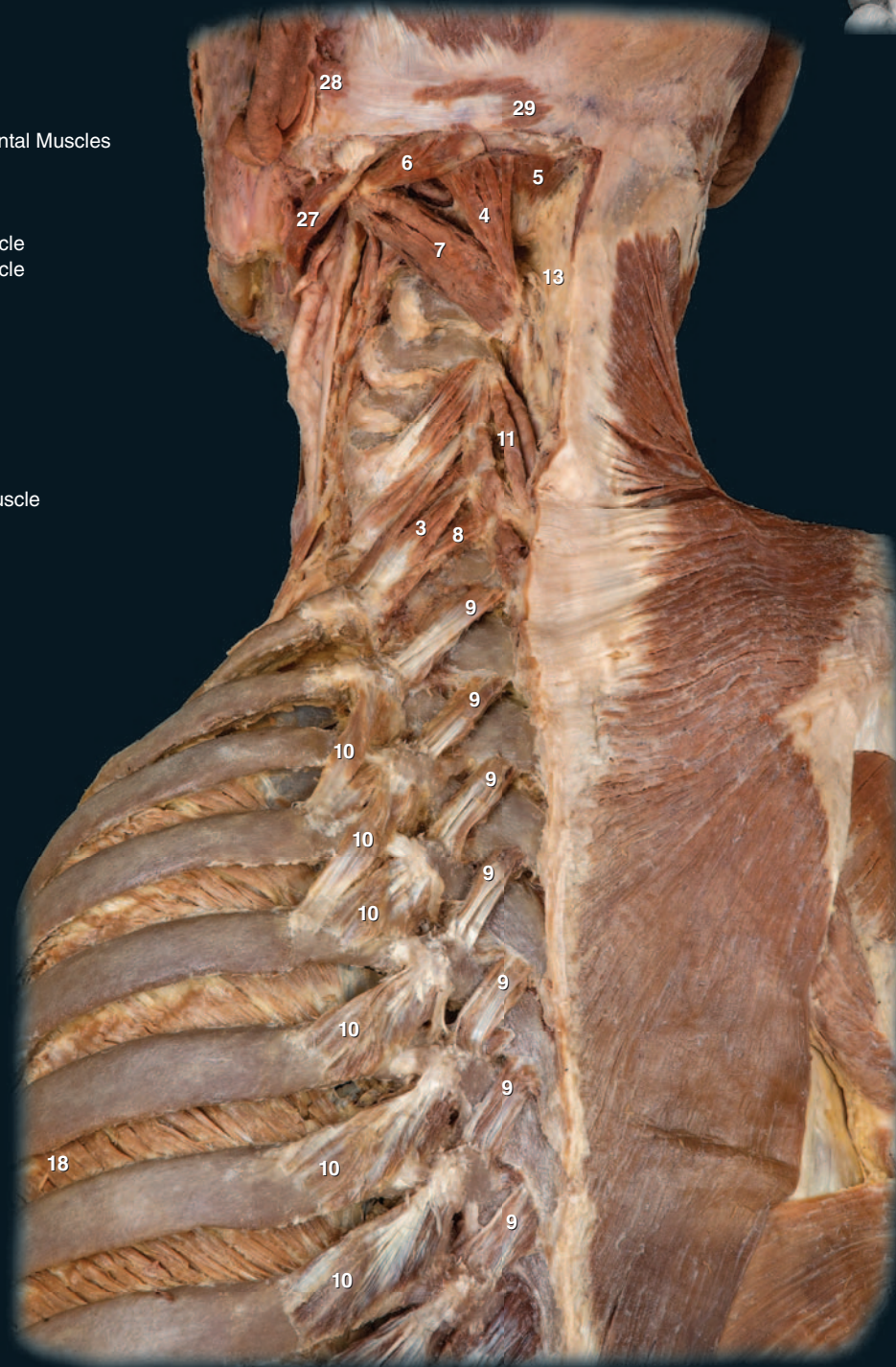


## Multifidus, Rotatores, and Intersegmental Muscles

- 1 Multifidus lumborum muscle
- 2 Multifidus thoracis muscle
- 3 Multifidus cervicis muscle
- 4 Rectus capitis posterior major muscle
- 5 Rectus capitis posterior minor muscle
- 6 Obliquus capitis superior muscle
- 7 Obliquus capitis inferior muscle
- 8 Rotatores cervicis muscle
- 9 Rotatores thoracis muscle
- 10 Levatores costarum muscle

## Other Muscles and Structures

- 11 Semispinalis cervicis muscle
- 12 Medial lumbar intertransversarii muscle
- 13 Nuchal ligament
- 14 External oblique muscle
- 15 Transversus abdominis muscle
- 16 Quadratus lumborum muscle
- 17 External intercostal muscle
- 18 Internal intercostal muscle
- 19 Middle scalene muscle
- 20 Trapezius muscle
- 21 Deltoid muscle
- 22 Latissimus dorsi muscle
- 23 Infraspinatus muscle
- 24 Teres major muscle
- 25 Rhomboideus major muscle
- 26 Triceps muscle
- 27 Posterior digastric muscle
- 28 Auricularis posterior muscle
- 29 Transversus nuchae muscle



Dissection of upper deep intersegmental muscles on left  
Posterior view

# Intersegmental Muscles

The intertransversarii muscles are a mixed group that are technically misnamed. The epaxial intertransverse muscles (present at cervical, thoracic, and lumbar

levels) are the “true intertransverse” muscles. They attach to the transverse elements of the vertebral arch. The hypaxial intertransverse muscles should be named intercostal muscles. They are only present in the cervical and lumbar regions and attach to the costal processes (ribs) of the cervical and lumbar vertebrae, which are unfortunately named transverse processes even though they are not homologous with the thoracic transverse processes. These cervical and lumbar transverse processes are homologous with the thoracic ribs. There are no thoracic hypaxial intertransverse muscles because they are already present as the intercostal muscles and in this region they are properly named.

## Rotatores and Intersegmental Muscles

- 1 Rotatores thoracis muscle
- 2 Rotatores lumborum muscle
- 3 Levatores costarum muscle
- 4 Interspinales thoracis muscle
- 5 Interspinales lumborum muscle
- 6 Thoracic intertransversarii muscle
- 7 Medial lumbar intertransversarii muscle

## Other Muscles and Structures

- 8 Intertransversarii laterales lumborum muscle - dorsal part
- 9 Intertransversarii laterales lumborum muscle - ventral part
- 10 Internal intercostal muscle
- 11 Quadratus lumborum muscle
- 12 Iliocostalis muscle (cut)
- 13 Multifidus muscle (cut)
- 14 Trapezius muscle
- 15 Latissimus dorsi muscle
- 16 Rib 12
- 17 Iliac crest
- 18 Thoracolumbar fascia
- 19 Supraspinous ligament



Dissection of lower deep intersegmental muscles on left  
Posterolateral view

# Hypaxial Muscles

The hypaxial muscles develop from the hypomere of each somite's myotome and form the lateral and ventral muscle wall of the trunk. As the hypomeres migrate to form the ventrolateral muscle wall of the trunk, a repeating segmental pattern emerges. This common muscle pattern is present in the anterior and lateral muscles of the neck, the thorax, the abdomen, and in a modified form in the wall and floor of the pelvis. Each hypomere contributes six basic muscles, per side, to the trunk wall. The six muscles are a ventral muscle, a series of four superficial to deep lateral muscles, and a subvertebral muscle. This simple, eloquent design runs the entire length of the trunk. Understanding and recognizing this pattern of design not only clarifies trunk wall anatomy, but also helps simplify the task of learning the myriad of hypaxial trunk muscles. These hypaxial trunk muscles are the flexors and rotators of the vertebral column. They also support the internal viscera of the abdomen and thorax and play important roles in respiration, vocalization, urination, and defecation. The ventral (anterior) ramus of each spinal nerve supplies all of the hypaxial muscles. The hypaxial muscle pattern and the muscles that form the pattern are summarized below. On the next two pages the pattern is clearly demonstrated.

## Hypaxial Muscle Pattern

- Ventral musculature
- Four-layered lateral musculature
  - Supracostal or outermost muscle layer
  - External muscle layer
  - Middle muscle layer
  - Internal muscle layer
- Subvertebral musculature

### Cervical Hypaxial Muscles

- Ventral musculature
  - Geniohyoid muscle
  - Thyrohyoid muscle
  - Superior omohyoid muscle
  - Inferior omohyoid muscle
  - Sternohyoid muscle
  - Sternohyoid muscle
- Four-layered lateral musculature
  - Supracostal layer
    - Levator scapulae muscle
  - External layer
    - Posterior scalene muscle
  - Middle layer
    - Middle scalene muscle
    - Lateral posterior cervical intertransversarii muscle
  - Internal layer
    - Anterior scalene muscle
    - Anterior cervical intertransversarii muscle
- Subvertebral musculature
  - Longus capitis muscle
  - Longus colli muscle

### Thoracic Hypaxial Muscles

- Ventral musculature
  - Sternalis muscle (present in about 10% of people)
- Four-layered lateral musculature
  - Supracostal layer
    - Serratus posterior superior muscle
    - Serratus posterior inferior muscle
    - Rhomboideus major muscle (annexed by the limb)
    - Rhomboideus minor muscle (annexed by the limb)
    - Serratus anterior muscle (annexed by the limb)
  - External layer
    - External intercostal muscle
  - Middle layer
    - Internal intercostal muscle
  - Internal layer
    - Innermost intercostal muscle
    - Subcostal muscle
    - Transversus thoracis muscle
    - Diaphragm
- Subvertebral musculature
  - Longus capitis muscle

### Lumbar Hypaxial Muscles

- Ventral musculature
  - Rectus abdominis muscle
  - Pyramidalis muscle
- Four-layered lateral musculature
  - Supracostal layer
    - External oblique muscle - superficial lamina
  - External layer
    - External oblique muscle - deep lamina
  - Middle layer
    - Internal oblique muscle
    - Cremaster muscle
    - Intertransversarii laterales lumborum muscle - dorsal part
  - Internal layer
    - Transversus abdominis muscle
    - Quadratus lumborum muscle
    - Intertransversarii laterales lumborum muscle - ventral part
- Subvertebral musculature
  - Psoas major muscle (annexed by the limb)
  - Psoas minor muscle

### Pelvis/Perineal Hypaxial Muscles

- Ventral musculature
  - Not present as it terminates on the pubic crest
- Four-layered lateral musculature
  - Supracostal layer
    - Not present
  - External layer
    - Obturator externus muscle (annexed by the limb)
    - Bulbospongiosus muscle
    - Ischiocavernosus muscle
    - Superficial transverse perinei muscle
    - Superficial external anal sphincter
  - Middle layer
    - Obturator internus muscle (annexed by the limb)
    - Deep transverse perinei - male
    - Compressor urethrae - female
    - Sphincter urethrovaginalis -female
    - External urethral sphincter
    - Deep external anal sphincter
  - Internal layer
    - Levator ani muscle
    - Ischiococcygeus muscle
- Subvertebral musculature
  - Not present as psoas is annexed by the limb

# Hypaxial Muscle Pattern

The dissection photos on this and the facing page clearly depict the pattern of design that arises from the hypomere migration in the trunk wall. Note that

both the ventral and subvertebral muscles are reduced in the thorax because the sturdy thoracic cage leads to a lack of mobility in the thoracic vertebral column. Also, note that the lateral supracostal muscles of the neck and thorax are annexed by the pectoral girdle to support the unattached upper limb. The clear relationship of the serratus anterior and its abdominal homologue – the superficial lamina of the external oblique muscle – is also evident, as well as the continuity of the deep lamina of the external oblique and its homologue, the external intercostal muscle. Finally, note how the subvertebral psoas major is annexed away from the sacrum and onto the lower limb.



Ventral hypaxial muscles  
Anterior view



Lateral supracostal hypaxial muscles  
Lateral view



Lateral external hypaxial muscles  
Lateral view

Ventral Musculature

- 1 Sternohyoid muscle
- 2 Sternothyroid muscle
- 3 Thyrohyoid muscle
- 4 Omohyoid muscle
- 5 Rectus abdominis muscle

Lateral Supracostal Musculature

- 6 Levator scapulae muscle
- 7 Serratus anterior muscle
- 8 Serratus posterior inferior muscle
- 9 External oblique muscle (superficial lamina)

Lateral External Musculature

- 10 Posterior scalene muscle
- 11 External intercostal muscle
- 12 External oblique muscle (deep lamina)

Lateral Middle Musculature

- 13 Middle scalene muscle
- 14 Internal intercostal muscle
- 15 Internal oblique muscle

Lateral Internal Musculature

- 16 Anterior scalene muscle

17 Innermost intercostal muscle

- 18 Transversus abdominis muscle

Subvertebral Musculature

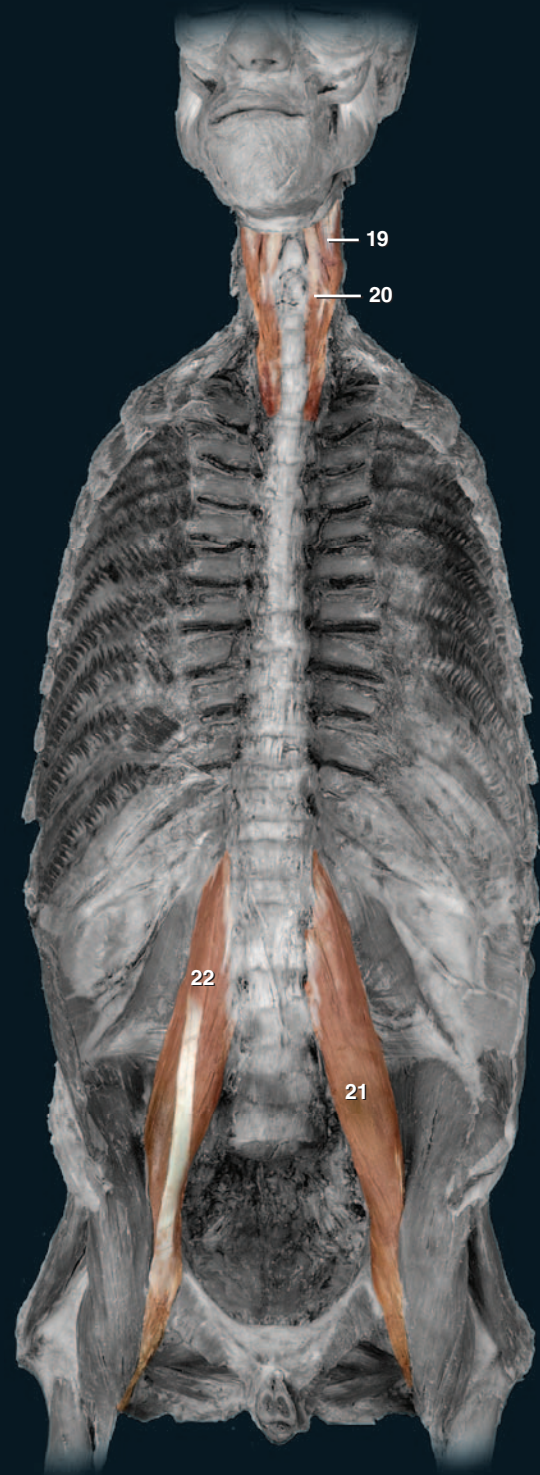
- 19 Longus capitis muscle
- 20 Longus colli muscle
- 21 Psoas major muscle
- 22 Psoas minor muscle



Lateral middle hypaxial muscles  
Lateral view



Lateral internal hypaxial muscles  
Lateral view



Subvertebral hypaxial muscles  
Lateral view

# Cervical Hypaxial Muscles

The muscular wall of the neck arises from the hypomeres of the cervical somites and develops in accordance with the anterior and lateral

body wall muscle pattern. A close scrutiny of the cervical hypaxial muscles reveals a ventral muscle, which has split into numerous subdivisions, a four-layered lateral muscle wall where the muscles have lost their sheet-like structure, and a subvertebral muscle on the anterior surface of the neck vertebrae. The cervical trunk muscles have a variety of functions. Some of the muscles function to stabilize and move the cervical vertebral column. Some of the muscles assist in raising the upper ribs. Some are annexed by the upper limb to support the pectoral girdle. The strap-like ventral muscles, which run from sternum to larynx to hyoid bone to mandible, are active during mastication, swallowing, respiration, and sound production. These seemingly varied muscles are all innervated by the anterior rami of the cervical spinal nerves.

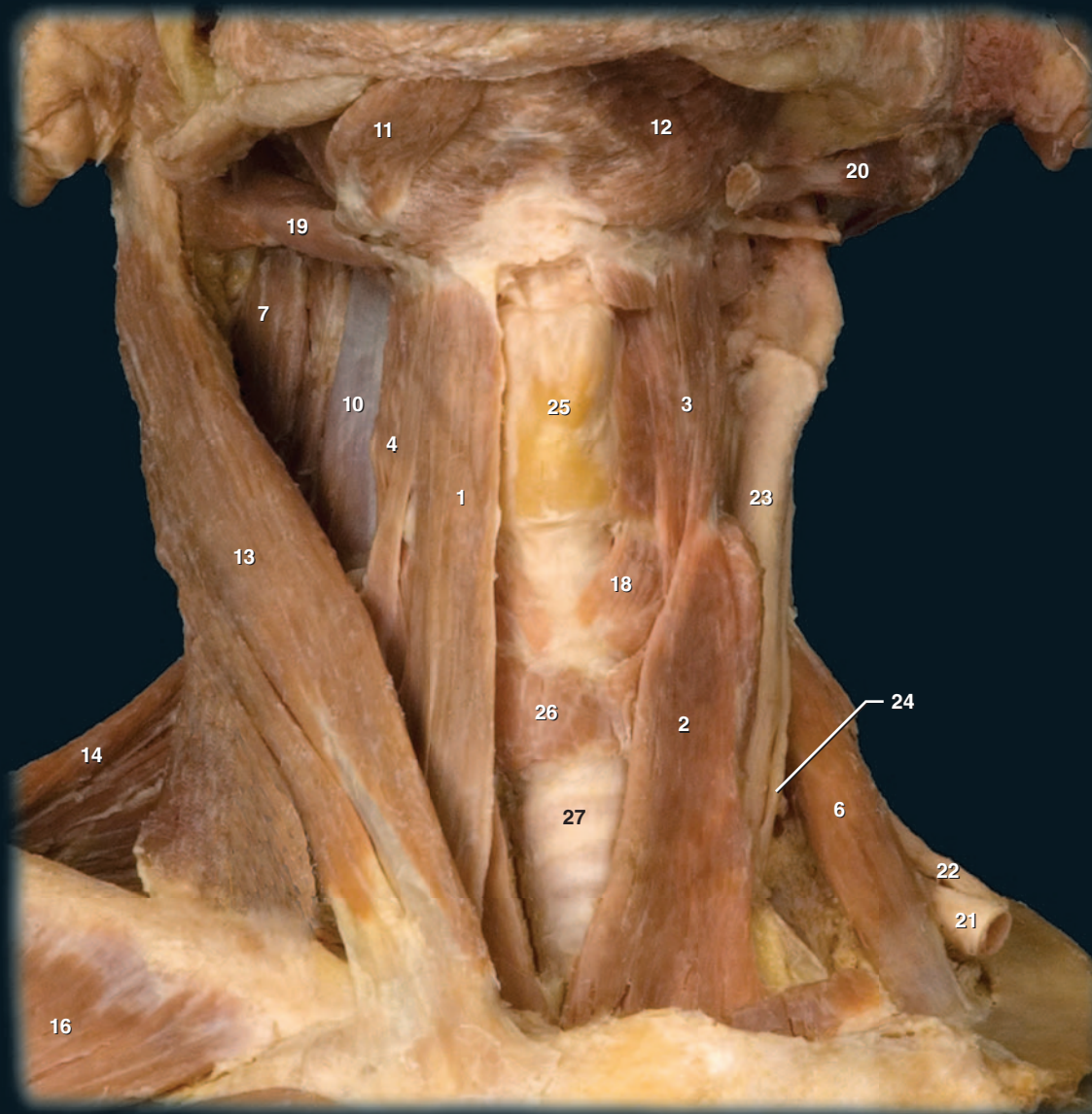
## Cervical Hypaxial Muscles

- 1 Sternohyoid muscle
- 2 Sternothyroid muscle
- 3 Thyrohyoid muscle
- 4 Omohyoid muscle
- 5 Geniohyoid muscle
- 6 Anterior scalene muscle
- 7 Middle scalene muscle
- 8 Posterior scalene muscle
- 9 Levator scapulae muscle
- 10 Longus colli muscle

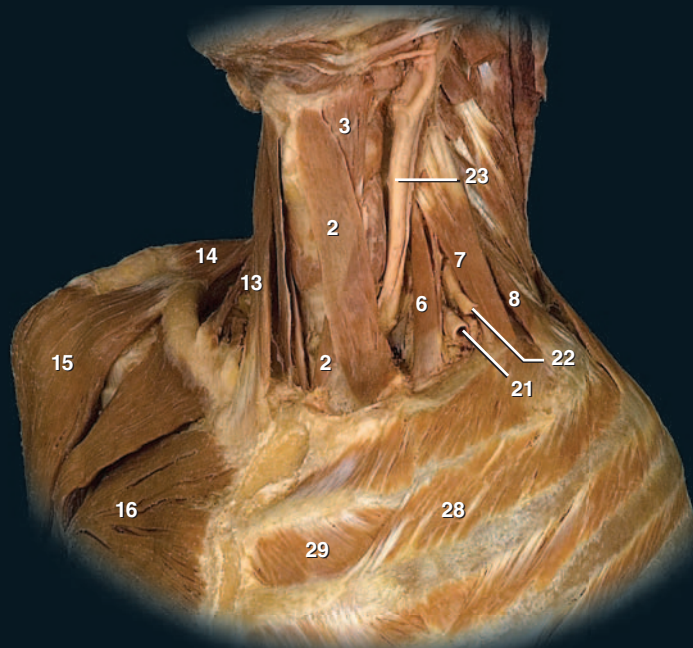
## Other Muscles and Structures

- 11 Anterior digastric muscle
- 12 Mylohyoid muscle
- 13 Sternocleidomastoid muscle
- 14 Trapezius muscle
- 15 Deltoid muscle
- 16 Pectoralis major muscle
- 17 Serratus anterior muscle
- 18 Cricothyroid muscle
- 19 Stylohyoid muscle
- 20 Posterior digastric muscle

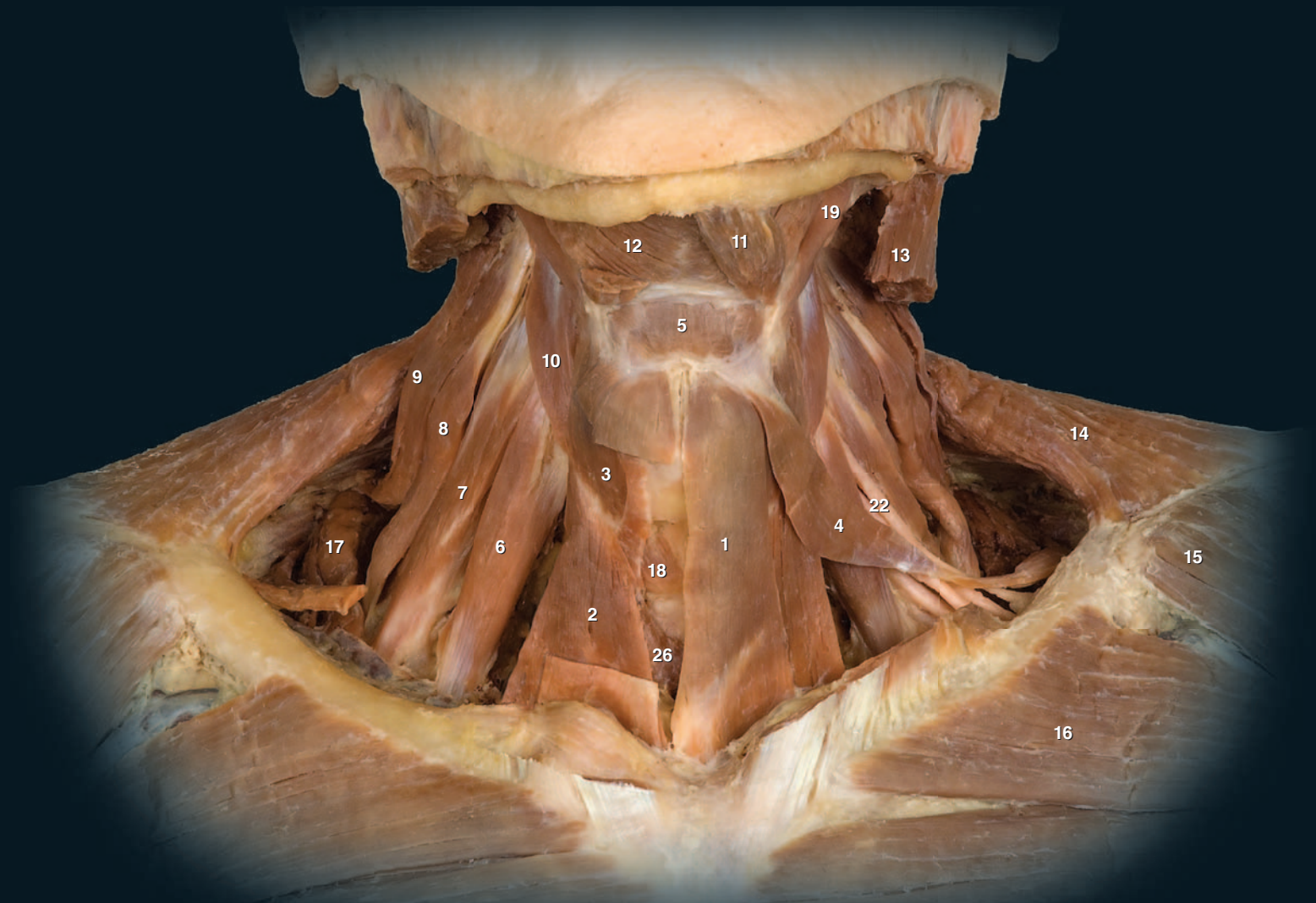
- 21 Subclavian artery
- 22 Root of brachial plexus
- 23 Common carotid artery
- 24 Vagus nerve
- 25 Thyroid cartilage
- 26 Thyroid gland
- 27 Trachea
- 28 External intercostal muscle
- 29 Internal intercostal muscle



Dissection of neck muscles  
Anterior view



Dissection of cervical hypaxial muscles  
Anterolateral view



Dissection of cervical hypaxial muscles  
Anterior view

# Thoracic and Abdominal Hypaxial Muscles

The muscles of the thorax and abdomen develop from the hypomere of the thoracic and abdominal somites of the embryo. Like the neck they clearly demonstrate the muscle pattern of the vertebrate body wall. The thoracic body wall differs from the abdomen in having well-developed ribs that dominate the wall and limit the movements of the vertebral column. Because of the well-developed segmental ribs, the muscles of the thoracic wall retain their segmental origins. The uniquely mammalian diaphragm muscle is a member of this group that plays an important role in respiration. The outermost layer of the lateral muscle wall is well developed in the thorax. Some portions of this muscle layer remain associated with the ribs, while the rhomboid muscles (depicted in the upper limb chapter that follows) and large serratus anterior muscle migrate onto the scapula to become principal stabilizers of the upper limb. The ventral ramus of each of the thoracic and upper lumbar spinal nerves innervates these muscles.

## Thoracic and Abdominal Musculature

- 1 Rectus abdominis muscle
- 2 Serratus anterior muscle
- 3 External intercostal muscle
- 4 External oblique muscle (superficial lamina)
- 5 External oblique muscle (deep lamina)
- 6 Internal intercostal muscle
- 7 Internal oblique muscle
- 8 Innermost intercostal muscle
- 9 Transversus abdominis muscle

## Other Muscles and Structures

- 10 Platysma muscle
- 11 Sternohyoid muscle

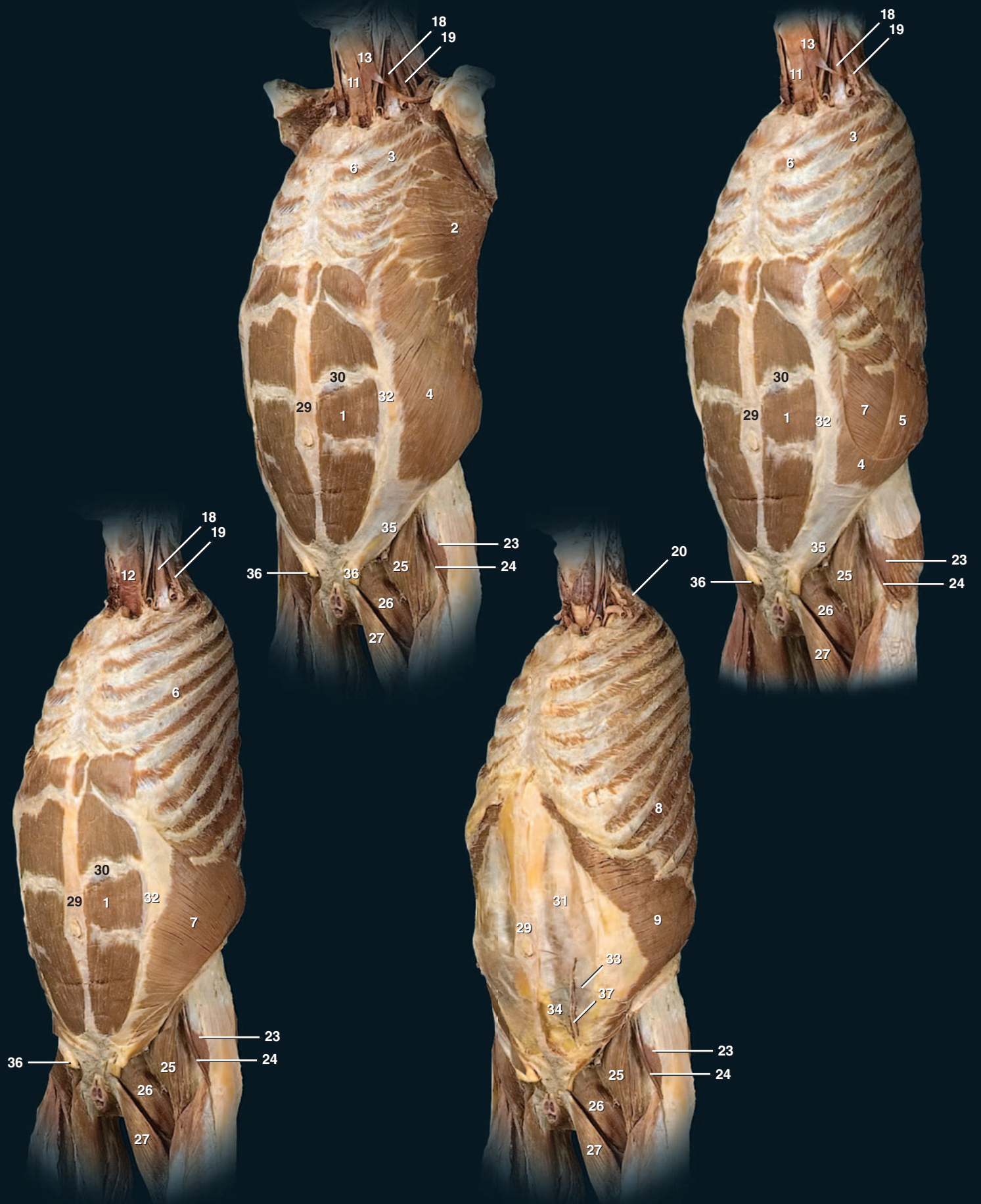
- 12 Sternothyroid muscle
- 13 Omohyoid muscle
- 14 Sternocleidomastoid muscle
- 15 Trapezius muscle
- 16 Deltoid muscle
- 17 Pectoralis major muscle
- 18 Anterior scalene muscle
- 19 Middle scalene muscle
- 20 Posterior scalene muscle
- 21 Biceps brachii muscle
- 22 Tensor fasciae latae muscle
- 23 Gluteus medius muscle
- 24 Gluteus minimis muscle
- 25 Iliopsoas muscle

- 26 Pectineus muscle
- 27 Adductor longus muscle
- 28 External lamina of rectus sheath
- 29 Linea alba
- 30 Tendinous intersections
- 31 Internal lamina of rectus sheath
- 32 Semilunar line
- 33 Arcuate line
- 34 Transversalis fascia
- 35 Inguinal ligament
- 36 Spermatic cord
- 37 Inferior epigastric vessels
- 38 Cutaneous nerves



Dissections of thoracic and abdominal hypaxial muscles  
Anterior view

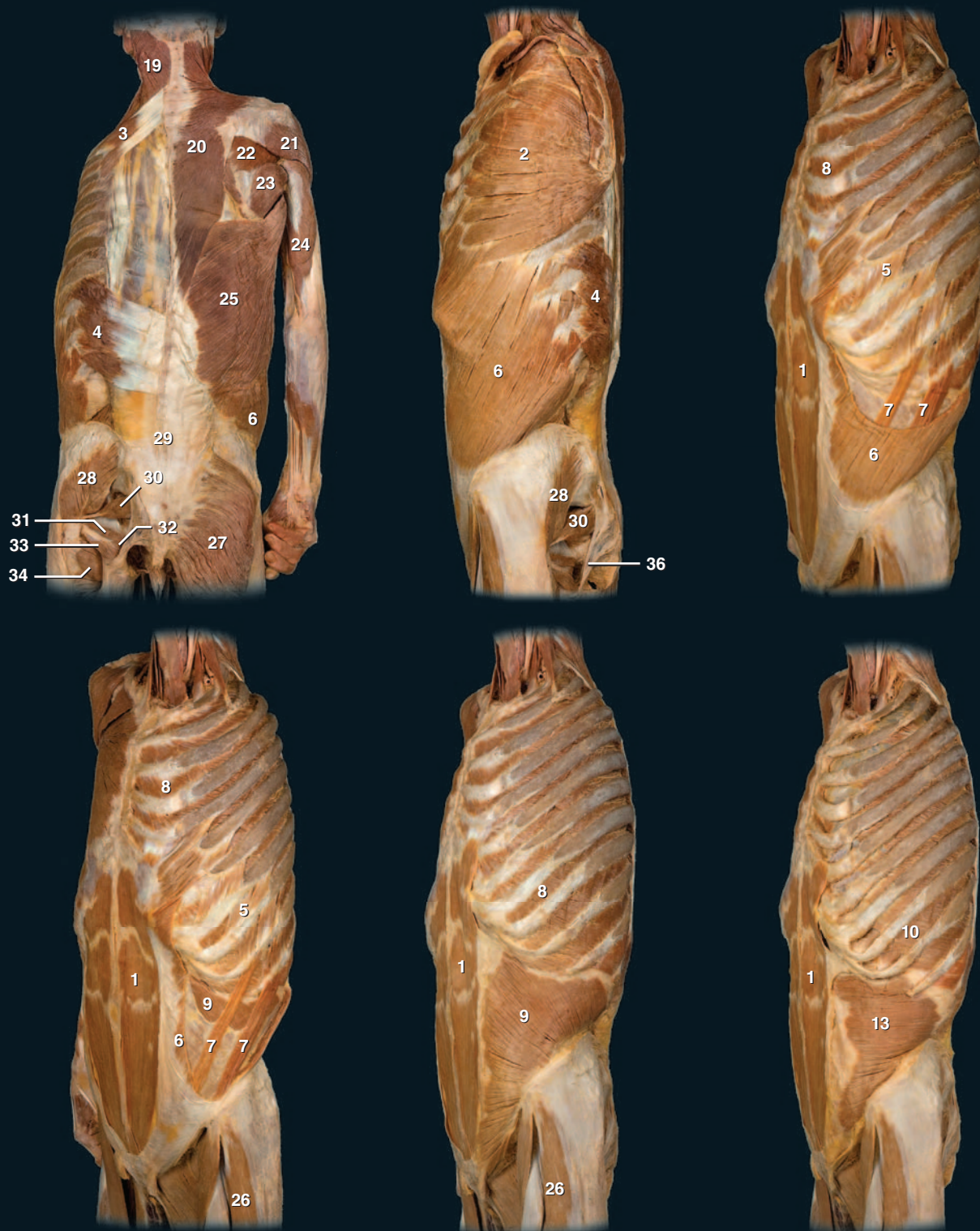




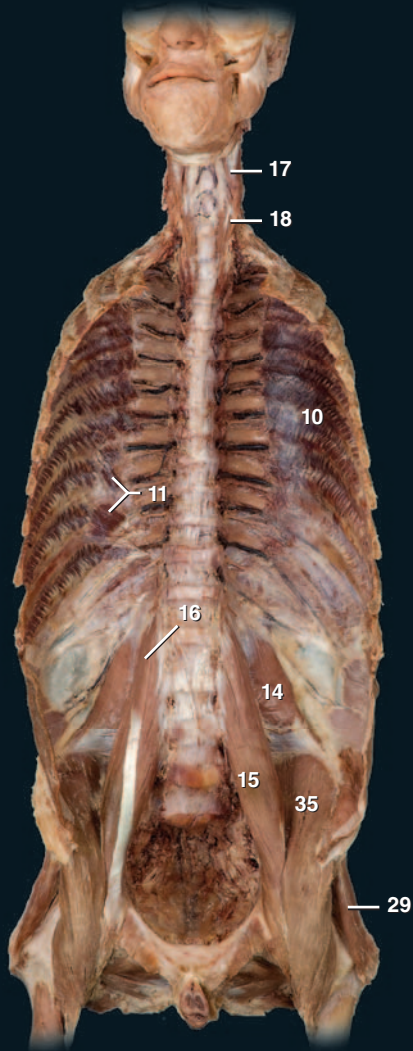
Dissections of thoracic and abdominal hypaxial muscles  
Anteriolateral view

# Thoracic and Abdominal Hypaxial Muscles

Again we would have you notice the rarely described deep lamina of the external oblique muscle. Notice its continuity with the external intercostal muscles, while the superficial lamina of the external oblique interdigitates with the serratus anterior muscle. Also note the similar fiber orientations of the intercostal muscles and their homologues in the abdominal wall. The photos of the diaphragm on the opposite page clearly reveal the continuity of this internal layer muscle with its internal homologue in the abdomen – the transversus abdominis muscle.



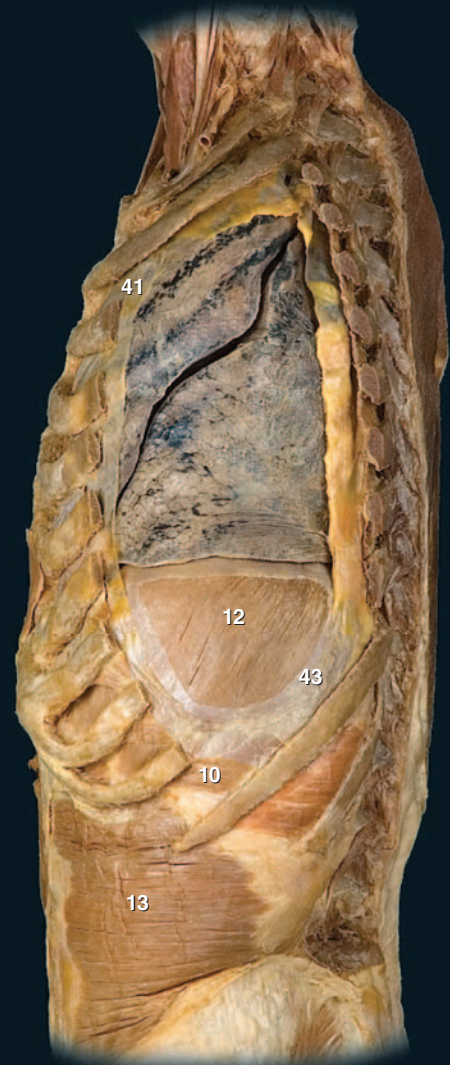
Dissections of lateral muscle layers of thoracic and abdominal wall  
 Posterior view upper left, Lateral view upper center, Posterolateral view all others



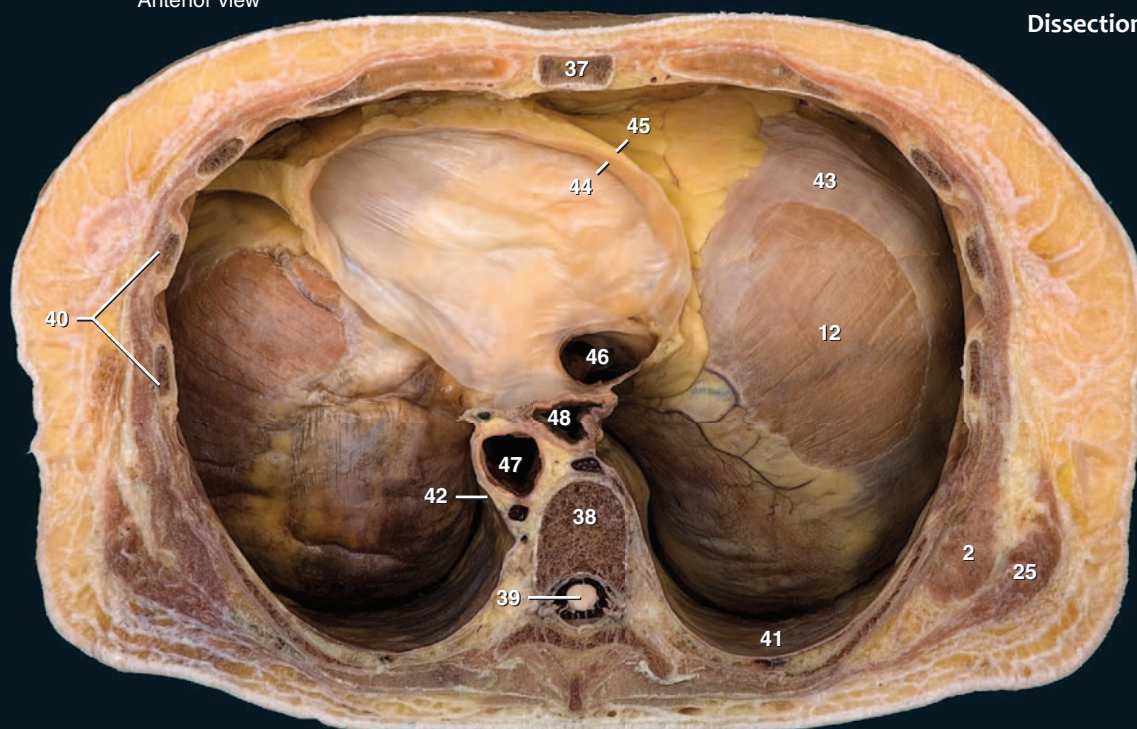
Dissection of hypaxial subvertebral muscles  
Anterior view

- Thoracic and Abdominal Musculature
- 1 Rectus abdominis muscle
  - 2 Serratus anterior muscle
  - 3 Serratus posterior superior muscle
  - 4 Serratus posterior inferior muscle
  - 5 External intercostal muscle
  - 6 External oblique muscle (superficial lamina)
  - 7 External oblique muscle (deep lamina)
  - 8 Internal intercostal muscle
  - 9 Internal oblique muscle
  - 10 Innermost intercostal muscle
  - 11 Subcostal muscle
  - 12 Diaphragm
  - 13 Transversus abdominis muscle
  - 14 Quadratus lumborum muscle
  - 15 Psoas major muscle
  - 16 Psoas minor muscle

- Other Muscles and Structures
- 17 Longus capitis muscle
  - 18 Longus colli muscle
  - 19 Splenius capitis muscle
  - 20 Trapezius muscle
  - 21 Deltoid muscle
  - 22 Infraspinatus muscle
  - 23 Teres major muscle
  - 24 Triceps brachii muscle
  - 25 Latissimus dorsi muscle
  - 26 Tensor fasciae latae muscle
  - 27 Gluteus maximus muscle
  - 28 Gluteus medius muscle
  - 29 Gluteus minimus muscle
  - 30 Piriformis muscle
  - 31 Superior gemellus muscle
  - 32 Obturator internus muscle
  - 33 Inferior gemellus muscle
  - 34 Quadratus femoris muscle
  - 35 Iliacus muscle
  - 36 Sacrotuberous ligament



Dissection revealing diaphragm  
Lateral view



Dissection revealing diaphragm  
Superior view

- 37 Sternum
- 38 Thoracic vertebra
- 39 Spinal cord
- 40 Ribs
- 41 Costal pleura
- 42 Mediastinal pleura
- 43 Diaphragmatic pleura
- 44 Parietal pericardium
- 45 Fibrous pericardium
- 46 Inferior vena cava
- 47 Thoracic aorta
- 48 Esophagus

# Perineal Hypaxial Muscles

The ventral, subvertebral, and lateral supracostal muscles are either annexed by the lower limb or terminate above the pelvic region of the trunk.

Therefore, the three inner layers of the lateral wall become the major contributors to the pelvic hypaxial wall. The three muscle layers from each side pass into the bottom of the pelvis where they meet in the midline to surround the urethra, vagina, and anus. This three-layered muscle floor at the bottom of the pelvis is called the pelvic diaphragm (internal layer) and the perineum (middle and external layers.) The pelvic diaphragm forms a basin-shaped floor that supports the pelvic viscera. The perineal muscles span the diamond-shaped pelvic outlet, and are divided into an anterior urogenital triangle and a posterior anal triangle. The perineal muscles support the pelvic viscera, form important sphincter muscles that surround the urethral and anal orifices, assist in erectile function, and propel the sperm from the male penis during ejaculation. Additional views of these muscles in both the male and female are depicted in the reproductive system chapter.

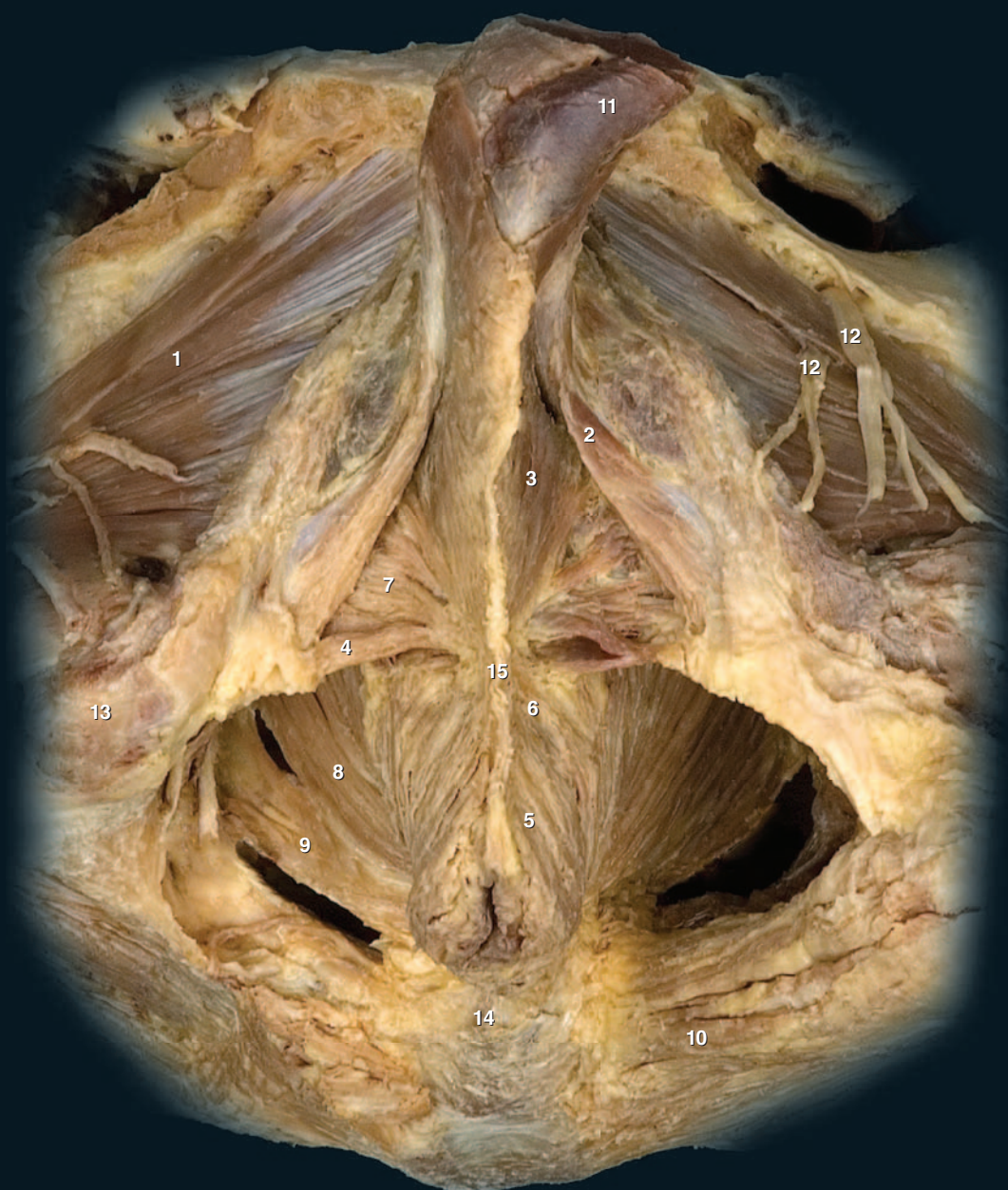
## Perineal Musculature

- 1 Obturator externus muscle
- 2 Ischiocavernosus muscle
- 3 Bulbospongiosus muscle
- 4 Superficial transverse perinei muscle
- 5 Superficial external anal sphincter muscle

- 6 Deep external anal sphincter muscle
- 7 Deep transverse perinei muscle
- 8 Levator ani muscle
- 9 Ischiooccygeus muscle

## Other Muscles and Structures

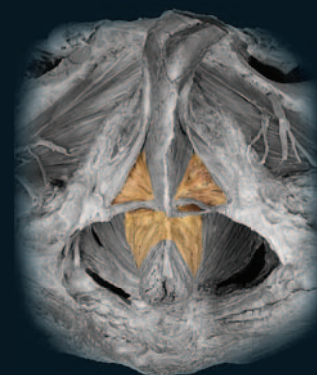
- 10 Gluteus maximus muscle
- 11 Penis (cut)
- 12 Obturator nerve
- 13 Ischial tuberosity
- 14 Coccyx
- 15 Perineal body



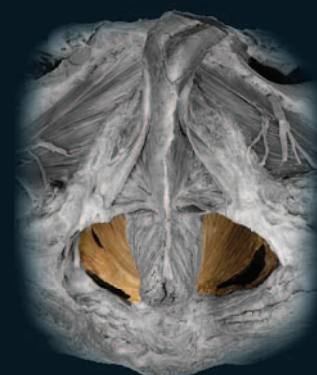
Dissection of male perineal muscles  
Inferior view



External perineal muscles



Middle perineal muscles



Internal perineal muscles

# 11 Upper Limb Muscles

While the majority of the muscles of the upper limb arise as true limb muscles from the embryonic somites, some of the upper limb muscles are annexed from the body wall and head musculature to support and stabilize the scapula and suspend it from the trunk skeleton. The levator scapulae, rhomboideus major and minor, serratus anterior, pectoralis minor, and subclavius muscles are annexed lateral body wall muscles that help suspend the scapula, while the trapezius is an annexed branchial arch muscle that is also a part of the scapular group. Unlike these annexed body wall and head muscles, the true muscles of the limb arise from mesenchymal migrations of the somites into the developing limb bud. These migrations form two distinct muscle masses in the limb, an anterior muscle group and a posterior muscle group. As the limb develops, the two distinct muscle groups become separated by connective tissue septa and bones into anterior and posterior muscle compartments within the different sections of the limb. As the ventral rami of the associated spinal nerves grow into the developing upper limb bud, a nerve network, or plexus, develops. From this plexus posterior divisions of the network send branches into the posterior muscle compartments and anterior divisions of the network send branches into the anterior muscle compartments. At the proximal end of the limb, some of the true limb muscles from the anterior and posterior compartments increase in size and migrate back onto the trunk. As they spread onto the trunk, they cover the body wall muscles and attach to the axial skeleton. This muscular expansion of the proximal limb muscles increases their mechanical advantage at the shoulder joint. Because of this interesting arrangement of body wall muscles and true limb muscles at the shoulder end of the superior limb, a clear compartment organization is not evident. For this reason, we will group these muscles into groups that share some common feature, such as a common attachment or function. In the limb proper we group the muscles into their developmental anterior and posterior muscle compartments. This greatly simplifies the learning process because most of the muscles in a compartment share common attachments, actions, and nerves. Grouping things in this way can help to simplify the learning process.



Find more information  
about the muscles of the  
upper limb in

REALANATOMY

# Upper Limb Muscles

This chapter depicts the interesting array of muscles of the upper limb. Because of its weak ligamentous association with the axial skeleton, the upper limb annexed muscles from the

outer layer of the trunk wall and head to help suspend it from the axial skeleton. This scapular muscle sling, which has no homologous counterpart in the lower limb, is the major difference between the muscles of the upper and lower limbs. On the pages that follow we present the muscles of the upper limb and organize them primarily by developmental groups, with the exception of the muscles of the shoulder joint (see the outline below). The opposite page and the two pages that follow show anterior and posterior views of the upper limb muscles and their relationships to the trunk musculature.

## Pectoral Girdle Muscles

(Annexed from head muscles (trapezius) and outermost layer of lateral trunk muscles to support and stabilize scapula)

- Trapezius
- Levator scapulae
- Rhomboideus major
- Rhomboideus minor
- Serratus anterior
- Pectoralis minor
- Subclavius

## Shoulder Joint Muscles

### Rotator cuff muscles

(Muscles with a ligamentous role that function as stabilizers of the weakly ligamentous shoulder joint)

- Supraspinatus
- Infraspinatus
- Teres minor
- Subscapularis

### Intertubercular groove muscles

(Muscles that share an insertion on the intertubercular groove and are prime movers of the shoulder joint)

- Pectoralis major
- Latissimus dorsi
- Teres major
- Deltoid

## Anterior Brachial Muscles

(Nerve supply - musculocutaneous nerve; function as flexors of the shoulder and elbow)

- Coracobrachialis
- Brachialis
- Biceps brachii

## Posterior Brachial Muscles

(Nerve supply - radial nerve, like all posterior compartment muscles; functions as extensor of shoulder and elbow)

- Triceps brachii

## Anterior Antebrachial Muscles

(Nerve supply - median and ulnar nerves; function as flexors of wrist and digits)

### Superficial muscles

- Pronator teres
- Flexor carpi radialis
- Palmaris longus
- Flexor carpi ulnaris
- Flexor digitorum superficialis

### Deep muscles

- Flexor digitorum profundus
- Flexor pollicis longus
- Pronator quadratus

## Posterior Antebrachial Muscles

(Nerve supply - radial nerve; function as extensors of the wrist and digits)

### Lateral muscles

- Brachioradialis
- Extensor carpi radialis longus
- Extensor carpi radialis brevis
- Extensor digitorum
- Extensor digiti minimi
- Extensor carpi ulnaris
- Anconeus
- Supinator

### Radial muscles

- Abductor pollicis longus
- Extensor pollicis longus
- Extensor pollicis brevis
- Extensor indicis

## Hand Muscles

(All intrinsic hand muscles arise from anterior muscles of embryonic limb and are innervated by the median and ulnar nerve from the anterior divisions of the plexus)

### Thenar Muscles

(All supplied by the median nerve except adductor pollicis)

- Abductor pollicis brevis
- Flexor pollicis brevis
- Opponens pollicis
- Adductor pollicis

### Hypothenar Muscles

(All supplied by the ulnar nerve)

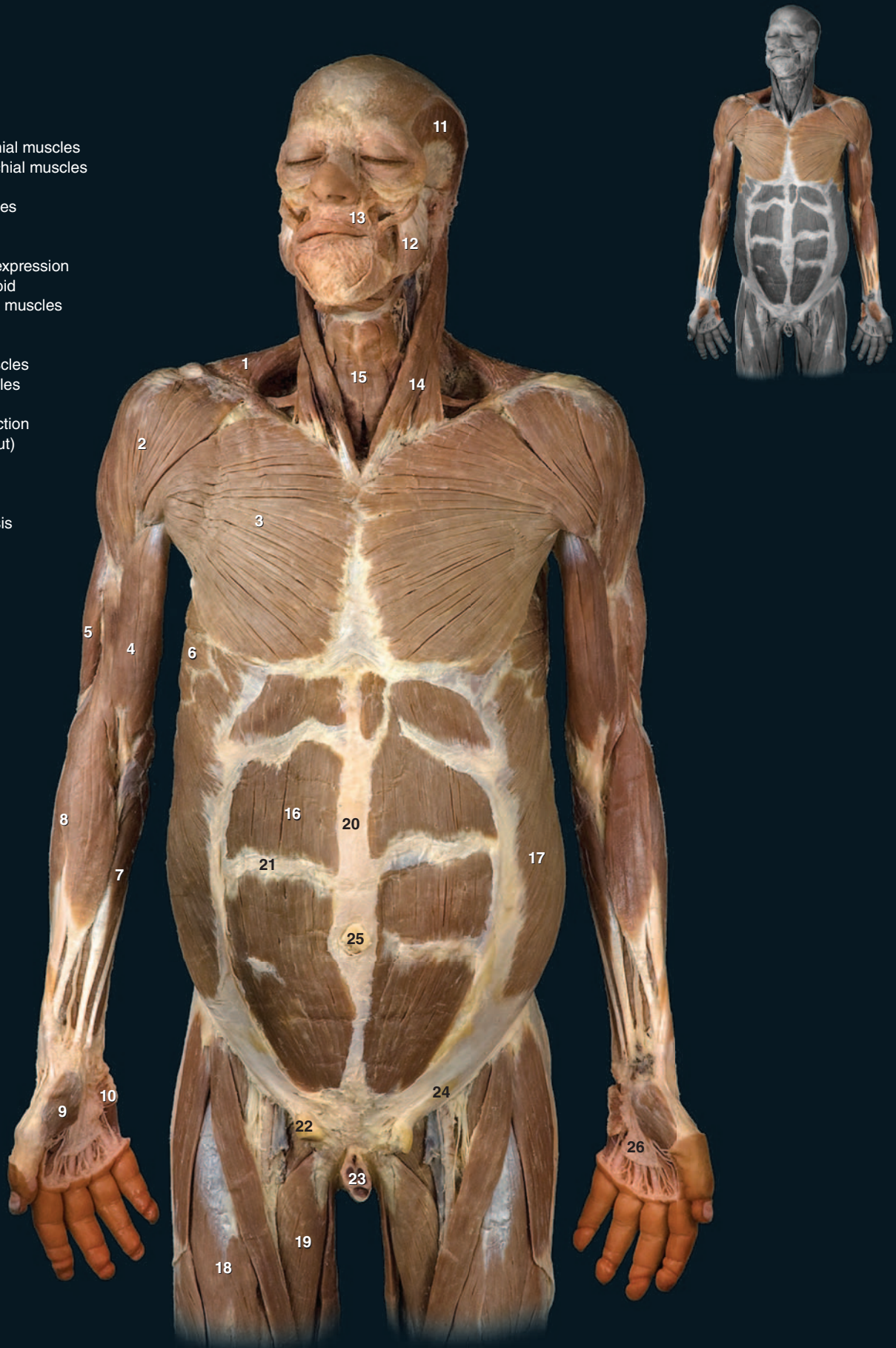
- Palmaris brevis
- Abductor digiti minimi
- Flexor digiti minimi
- Opponens digiti minimi

### Intermetacarpal Muscles

(All supplied by the ulnar nerve except first two lumbricals)

- Lumbricales
- Palmar interossei
- Dorsal interossei

- 1 Trapezius
- 2 Deltoid
- 3 Pectoralis major
- 4 Biceps brachii
- 5 Triceps brachii
- 6 Serratus anterior
- 7 Anterior antebrachial muscles
- 8 Posterior antebrachial muscles
- 9 Thenar muscles
- 10 Hypothenar muscles
- 11 Temporalis
- 12 Masseter
- 13 Muscles of facial expression
- 14 Sternocleidomastoid
- 15 Cervical body wall muscles
- 16 Rectus abdominis
- 17 External oblique
- 18 Anterior thigh muscles
- 19 Medial thigh muscles
- 20 Linea alba
- 21 Tendinous intersection
- 22 Spermatic cord (cut)
- 23 Penis (cut)
- 24 Inguinal ligament
- 25 Umbilicus
- 26 Palmar aponeurosis



**Muscles of the upper limb**  
Anterior view

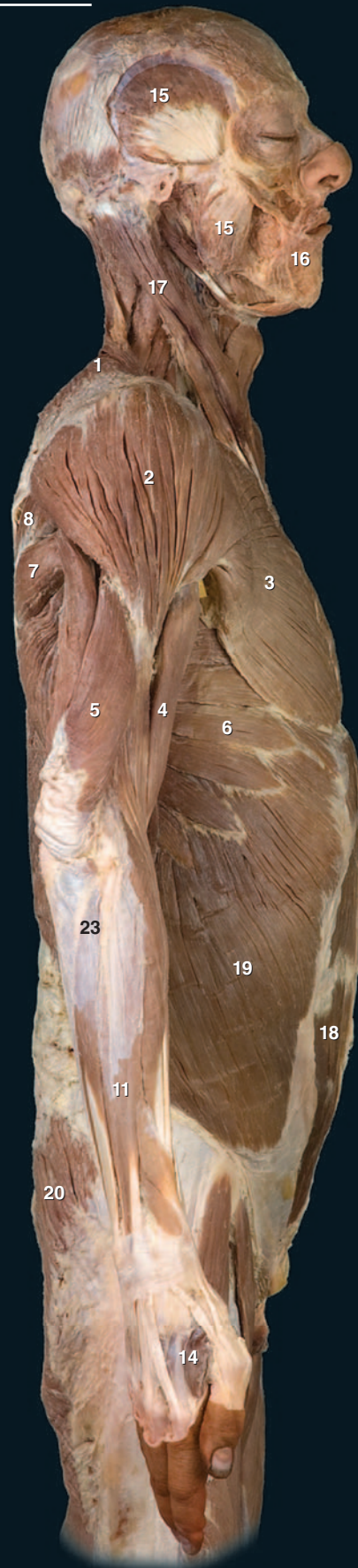
# Upper Limb Muscles

## Upper Limb Muscles

- 1 Trapezius
- 2 Deltoid
- 3 Pectoralis major
- 4 Biceps brachii
- 5 Triceps brachii
- 6 Serratus anterior
- 7 Teres major
- 8 Infraspinatus
- 9 Teres minor
- 10 Latissimus dorsi
- 11 Posterior antebrachial muscles
- 12 Anterior antebrachial muscles
- 13 Hypothenar muscles
- 14 Intermetacarpal muscle

## Other Muscles and Structures

- 15 Muscles of mastication
- 16 Muscles of facial expression
- 17 Sternocleidomastoid
- 18 Rectus abdominis
- 19 External oblique
- 20 Gluteal muscles
- 21 Posterior thigh muscles
- 22 Thoracolumbar fascia
- 23 Antebrachial fascia
- 24 Iliotibial tract



Muscles of the upper limb  
Right lateral view





**Muscles of the upper limb**  
Posterior view

# Scapular Muscles

The muscles that insert on the scapula and anchor it to the trunk form an extensive muscular sling. During development the upper limb annexes these

muscles from the head and trunk wall. They share the common functional goal of moving the scapula, stabilizing it, and anchoring it to the axial skeleton. These muscles are some of the larger muscles of the upper limb, yet produce visibly minor movements of the skeleton. Realize, however, that their major role is to stabilize and anchor the scapula to the axial skeleton. With the exception of the pectoralis minor, the nerves that supply these muscles arise from the roots of the brachial plexus.



## Scapular Muscles

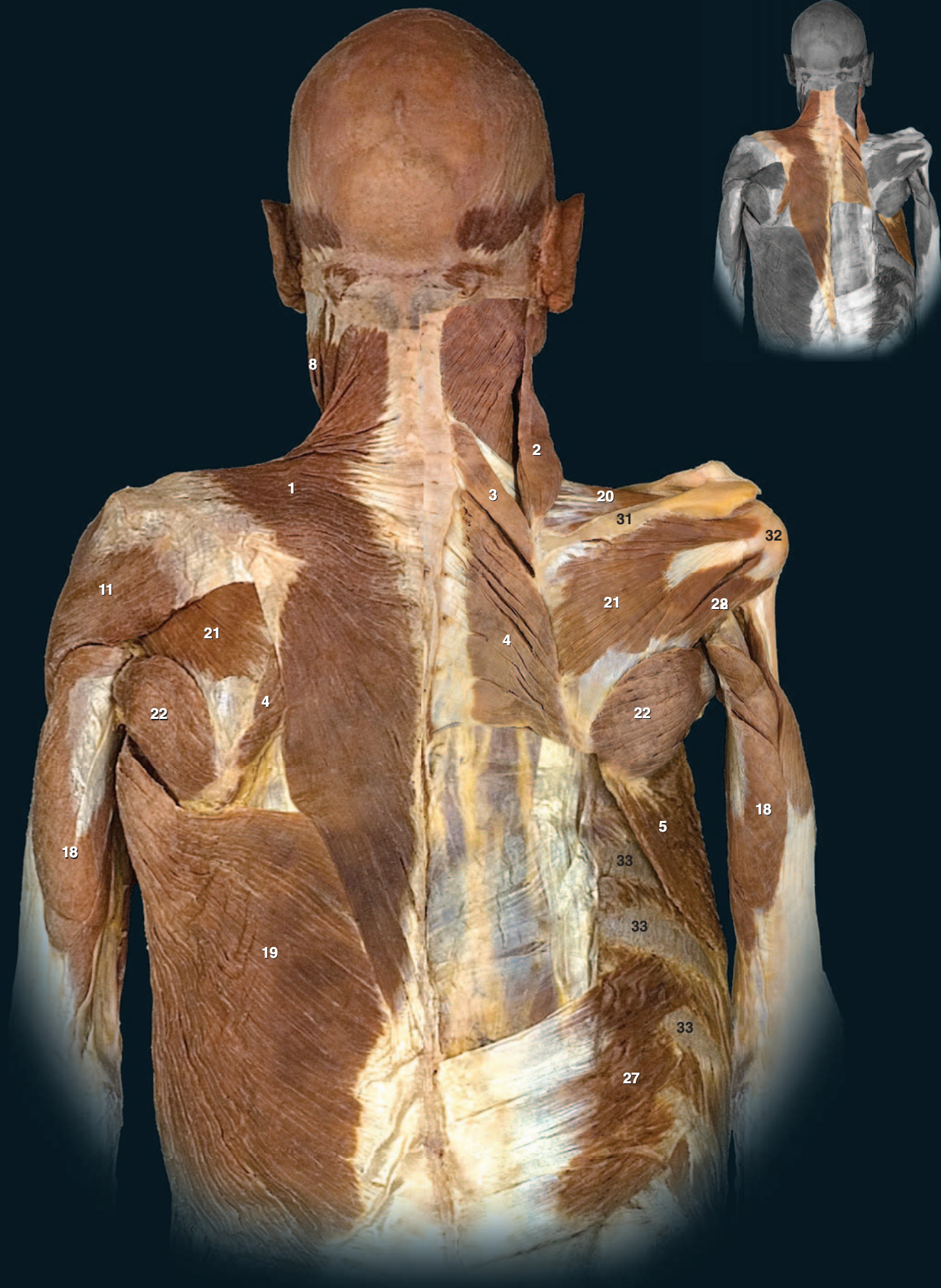
- 1 Trapezius
- 2 Levator scapulae
- 3 Rhomboideus minor
- 4 Rhomboideus major
- 5 Serratus anterior
- 6 Pectoralis minor
- 7 Subclavius

## Other Muscles and Structures

- 8 Sternocleidomastoid
- 9 Omohyoid
- 10 Clavicle
- 11 Deltoid
- 12 Coracobrachialis
- 13 Pectoralis major (cut)
- 14 External intercostal
- 15 Internal intercostal
- 16 Biceps brachii
- 17 Brachialis
- 18 Triceps brachii
- 19 Latissimus dorsi
- 20 Supraspinatus
- 21 Infraspinatus
- 22 Teres major
- 23 External oblique
- 24 Rectus abdominis
- 25 Brachioradialis
- 26 Extensor carpi radialis longus
- 27 Serratus posterior inferior
- 28 Teres minor
- 29 External oblique aponeurosis
- 30 Trachea
- 31 Spine of scapula
- 32 Greater tubercle of humerus
- 33 Rib



Muscles of right brachium, shoulder, and chest  
Anterior view



**Muscles of neck, shoulder, and back**  
Posterior view

# Shoulder Muscles - Rotator Cuff

The rotator cuff muscles are an important muscle group that play a critical role in stabilizing the shoulder joint. The four muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) have thick, flat tendons of insertion that form a strong musculotendinous cuff around all but the inferior aspect of the glenohumeral joint. These tendons are intimately applied to the fibrous membrane of the joint capsule. Individually each muscle contributes little to the total range of motion of the humerus at the glenohumeral joint. However, they play a prominent role in stabilizing the joint and positioning and stabilizing the head of the humerus in the glenoid cavity. When the rotator cuff muscles are compromised by injury, the shoulder joint loses stability and becomes highly susceptible to dislocation.

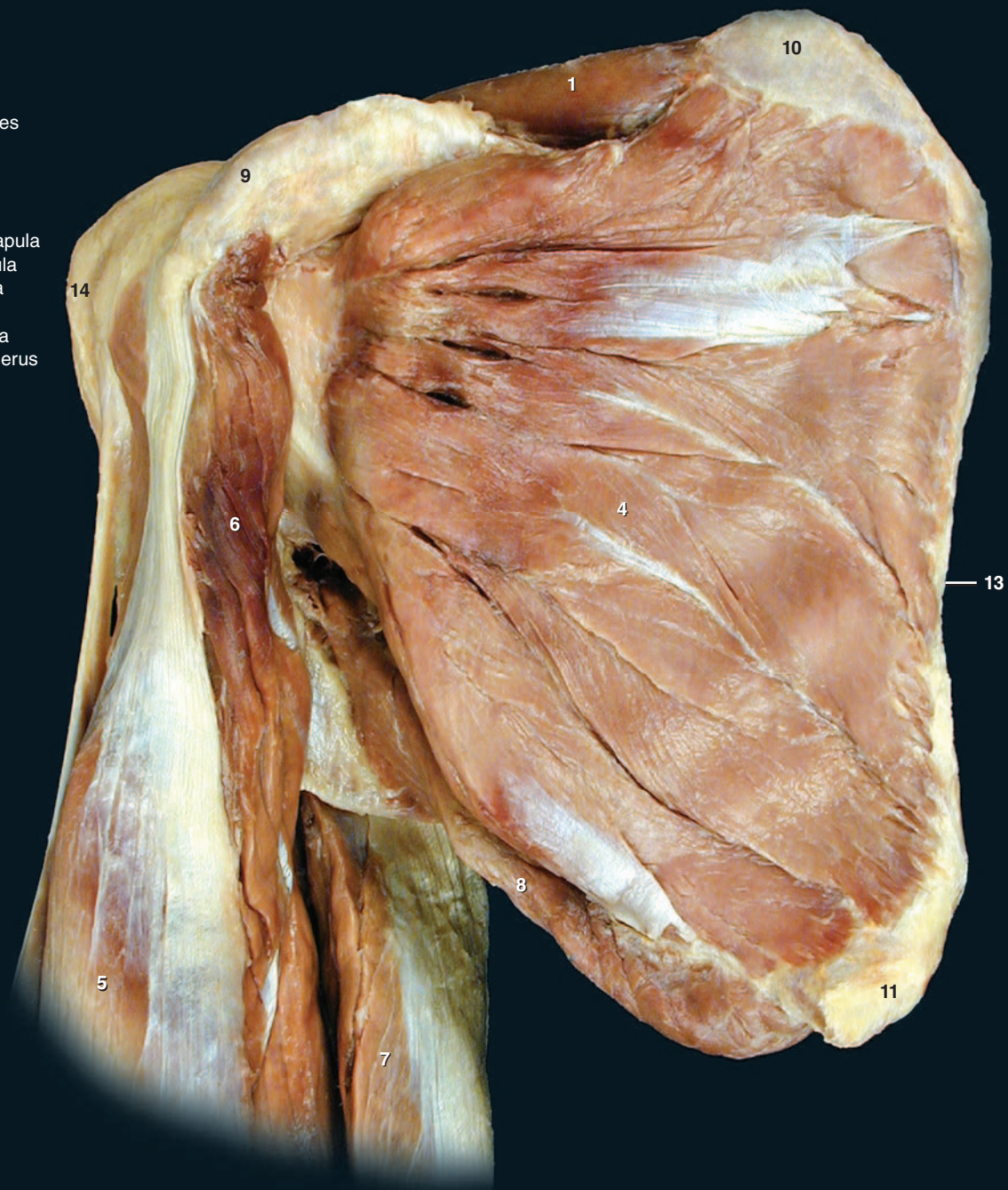


## Rotator Cuff Muscles

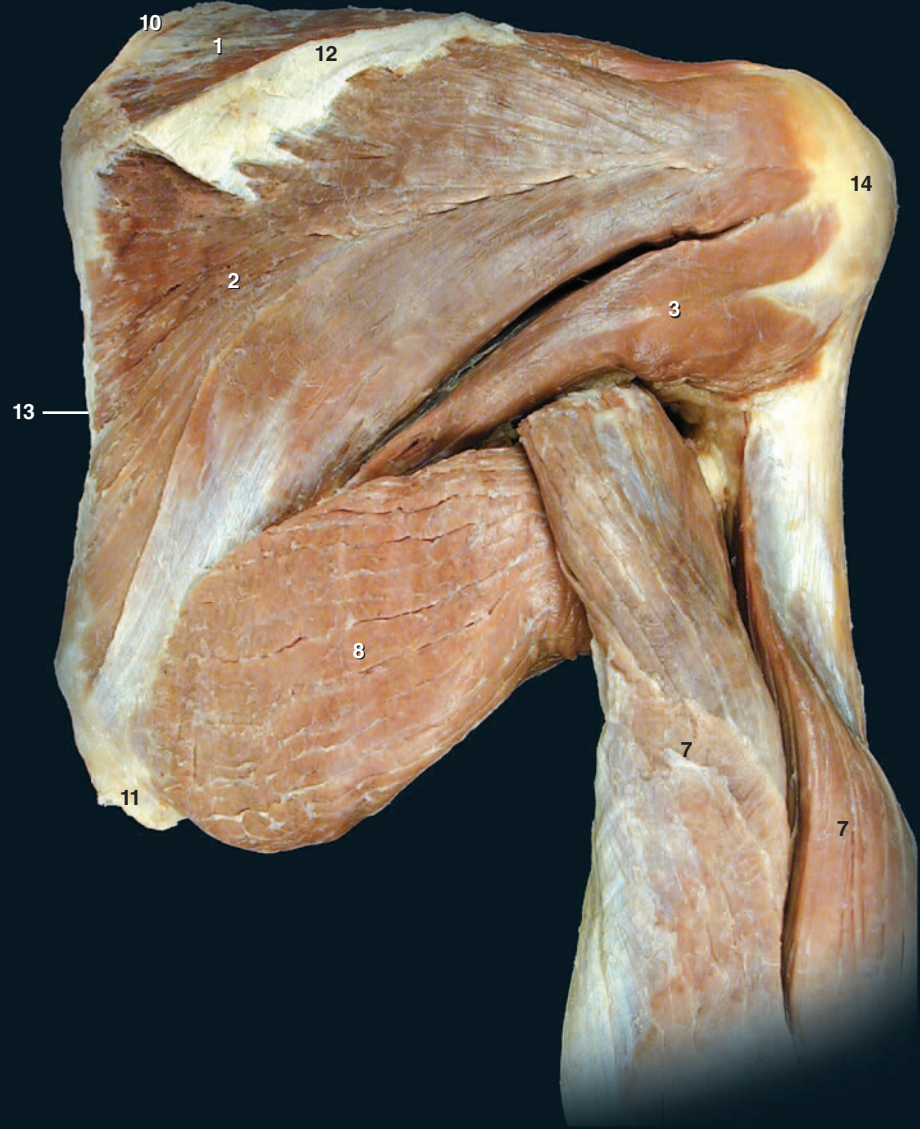
- 1 Supraspinatus
- 2 Infraspinatus
- 3 Teres minor
- 4 Subscapularis

## Other Muscles and Structures

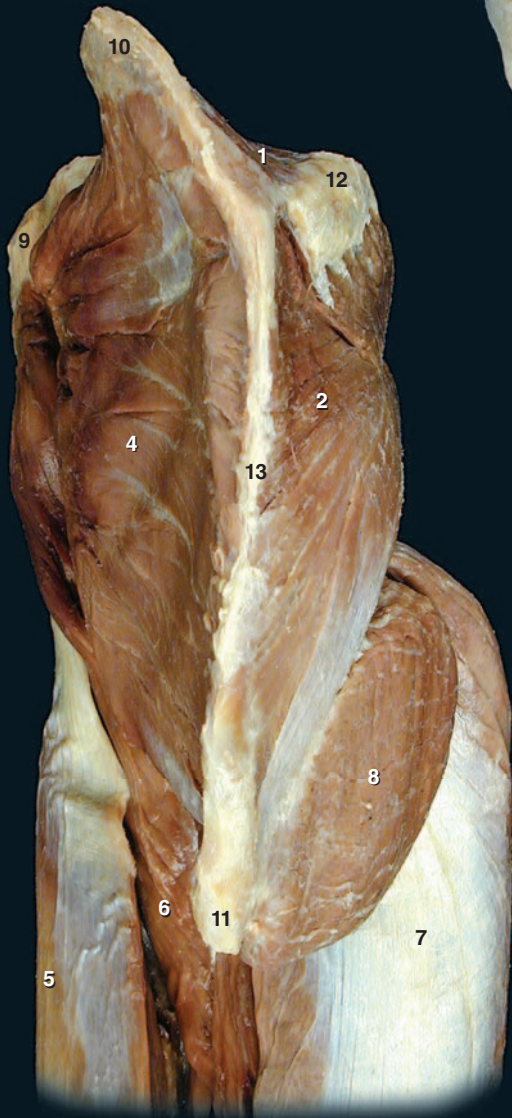
- 5 Biceps brachii
- 6 Coracobrachialis
- 7 Triceps brachii
- 8 Teres major
- 9 Coracoid process of scapula
- 10 Superior angle of scapula
- 11 Inferior angle of scapula
- 12 Spine of scapula
- 13 Medial border of scapula
- 14 Greater tubercle of humerus



Deep dissection of the right shoulder muscles  
Anterior view



Deep dissection of the right shoulder muscles  
Posterior view



Deep dissection of the right shoulder muscles  
Medial view



# Shoulder Muscles - Prime Movers

The prime movers of the shoulder joint are the muscles that share a common attachment on the intertubercular groove (pectoralis major, teres major, and latissimus dorsi) and the deltoid muscle. These large muscles are superficial to the muscles of the rotator cuff and form extensive attachments on the pectoral girdle and axial skeleton. Inserting more distally on the humerus than the muscles of the rotator cuff, they have a better mechanical advantage and produce the major movements of the shoulder joint. The intertubercular groove muscles also form the anterior and posterior walls of the axilla. The large pectoralis major forms the anterior wall of the axilla, while the sheet-like latissimus dorsi and thick, round teres major form the posterior axillary wall.

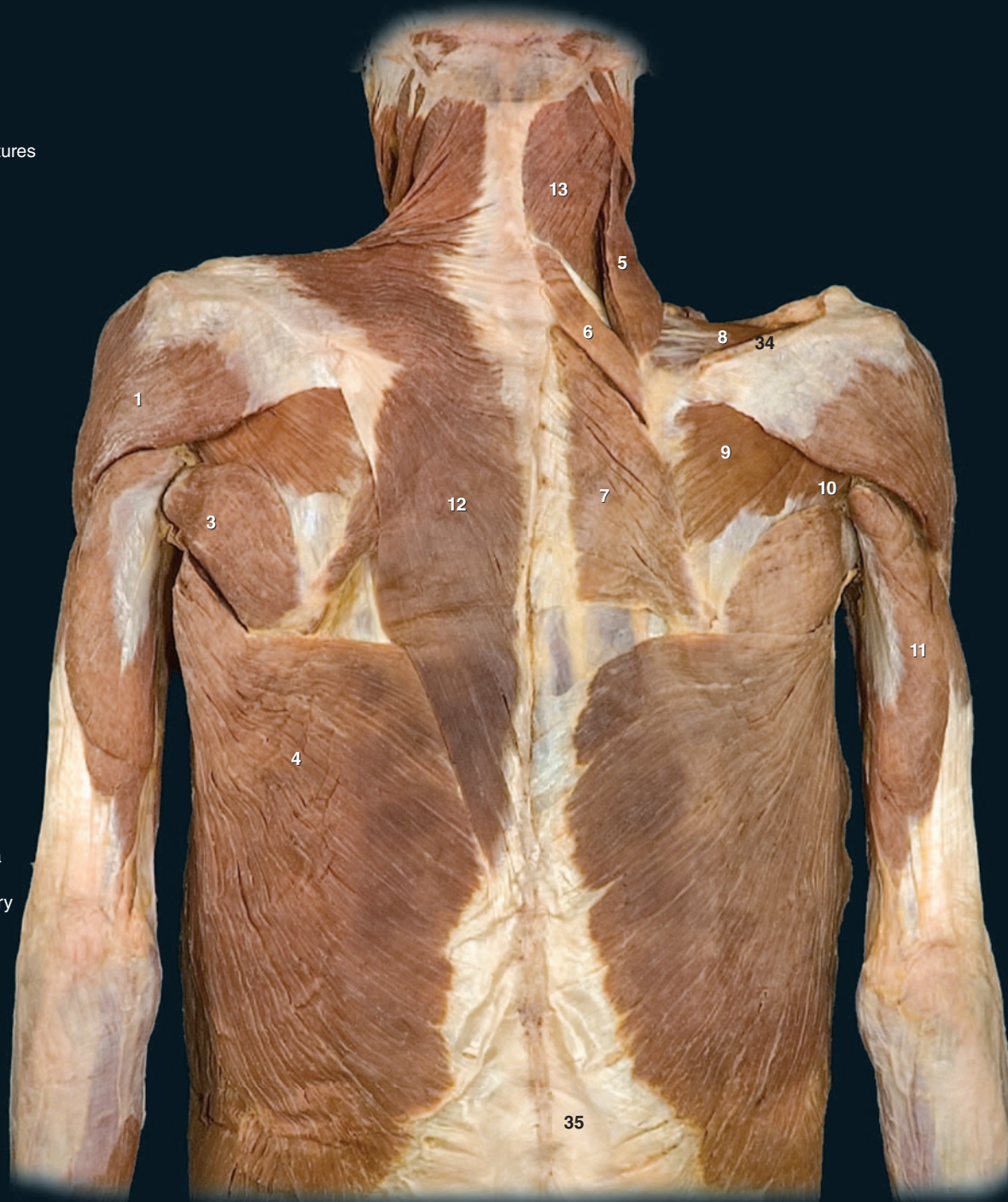


## Shoulder Prime Movers

- 1 Deltoid
- 2 Pectoralis major
- 3 Teres major
- 4 Latissimus dorsi

## Other Muscles and Structures

- 5 Levator scapulae
- 6 Rhomboideus minor
- 7 Rhomboideus major
- 8 Supraspinatus
- 9 Infraspinatus
- 10 Teres minor
- 11 Triceps brachii
- 12 Trapezius
- 13 Spleneus capitis
- 14 Serratus anterior
- 15 Pectoralis minor
- 16 External intercostal
- 17 Internal intercostal
- 18 Rectus abdominis
- 19 Coracobrachialis
- 20 Biceps brachii
- 21 Brachialis
- 22 Posterior scalene
- 23 Middle scalene
- 24 Anterior scalene
- 25 Omohyoid
- 26 Sternohyoid
- 27 Sternothyroid
- 28 Thyrohyoid
- 29 Sternocleidomastoid
- 30 External oblique
- 31 Brachioradialis
- 32 Clavicle
- 33 Humerus
- 34 Spine of scapula
- 35 Thoracolumbar fascia
- 36 Linea alba
- 37 Common carotid artery



Muscles of neck, shoulder, brachium, and back  
Posterior view



Muscles of neck, shoulder, brachium, and chest  
Anterior view

# Anterior Brachial Muscles

The anterior muscle compartment of the brachium consists of

three muscles — the coracobrachialis, brachialis, and biceps brachii. The coracobrachialis and brachialis each cross a single joint, the shoulder joint and elbow joint respectively. The biceps brachii crosses three joints, the shoulder, and the humero-ulnar and radio-ulnar joints of the elbow. The muscles share in common the actions of flexion of the shoulder and elbow. All three muscles are innervated by the musculocutaneous nerve.

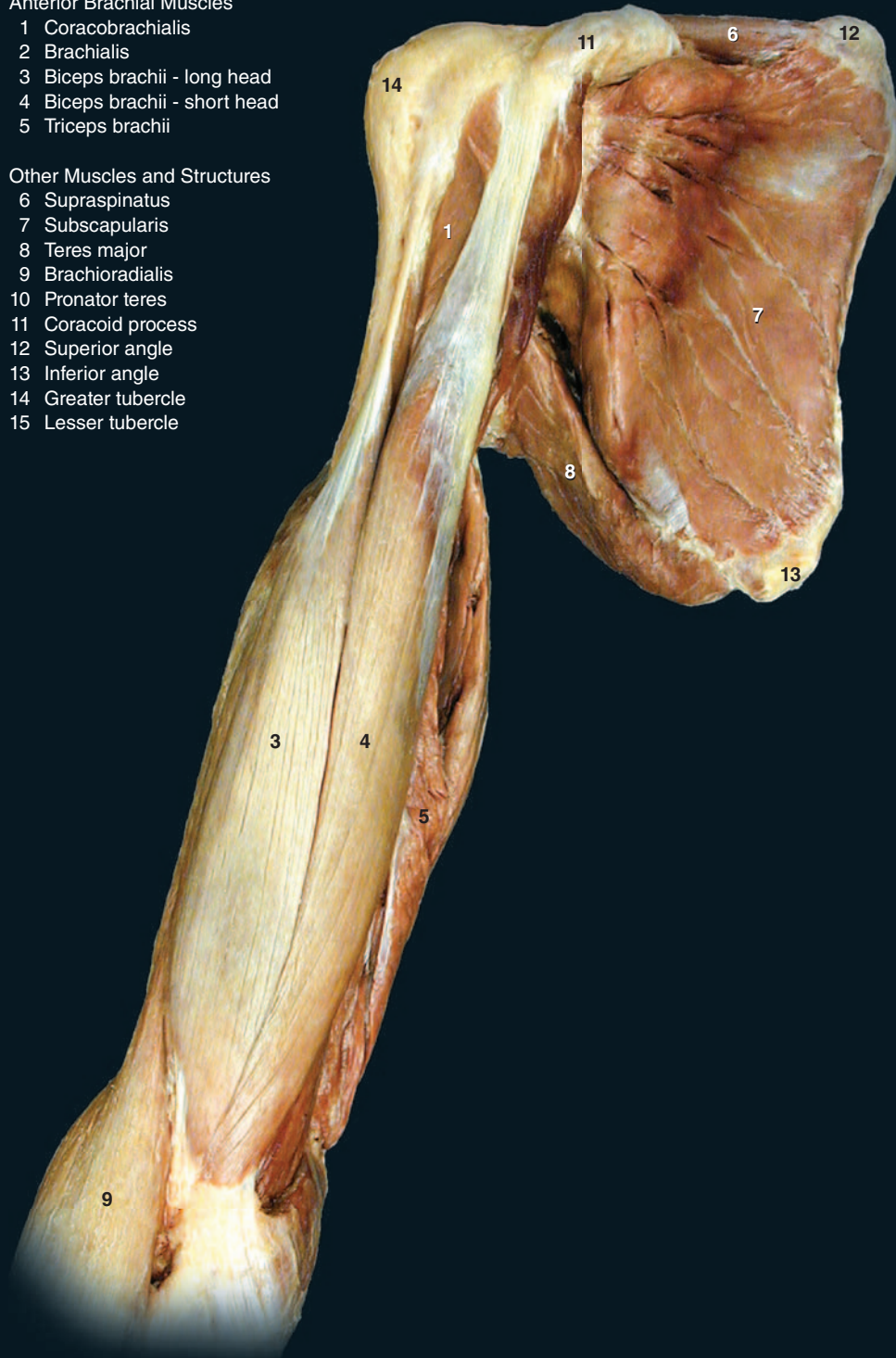


## Anterior Brachial Muscles

- 1 Coracobrachialis
- 2 Brachialis
- 3 Biceps brachii - long head
- 4 Biceps brachii - short head
- 5 Triceps brachii

## Other Muscles and Structures

- 6 Supraspinatus
- 7 Subscapularis
- 8 Teres major
- 9 Brachioradialis
- 10 Pronator teres
- 11 Coracoid process
- 12 Superior angle
- 13 Inferior angle
- 14 Greater tubercle
- 15 Lesser tubercle



Muscles of the right brachium and scapula  
Anterior view



Deep muscles of the right brachium  
Anterior view



# Posterior Brachial Muscles

The three headed triceps brachii muscle is the sole muscle of the posterior compartment of the brachium. This large muscle extends the shoulder and elbow joints and is innervated by the radial nerve.

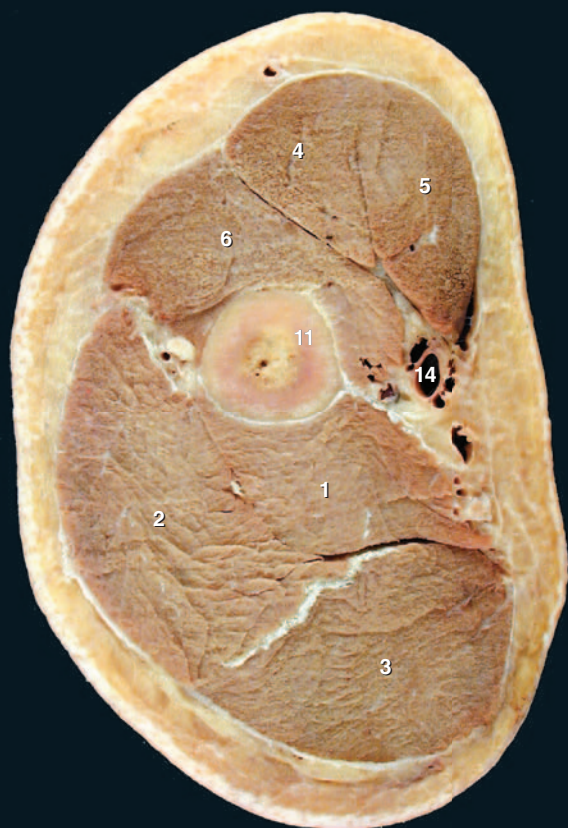


## Posterior Brachial Muscles

- 1 Triceps brachii - medial head
- 2 Triceps brachii - lateral head
- 3 Triceps brachii - long head
- 4 Biceps brachii - long head
- 5 Beceps brachii - short head
- 6 Brachialis

## Other Muscles and Structures

- 7 Supraspinatus
- 8 Infraspinatus
- 9 Teres minor
- 10 Teres major
- 11 Humerus
- 12 Greater tubercle
- 13 Spine of scapula
- 14 Brachial artery



Transverse section of right midbrachim  
Inferior view

Muscles of the right brachium and scapula  
Posterior view

# Anterior Antebrachial Muscles

The muscles of the anterior antebrachium form three

distinct muscle layers. The superficial group has four superficial muscles (pronator teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris) covering the intermediate flexor digitorum superficialis. All five of these muscles share a common attachment on the medial epicondyle of the humerus. The three deep muscles (flexor digitorum profundus, flexor pollicis longus, and pronator quadratus) do not cross the elbow joint. Other than the two pronators, all the muscles are flexors of either the wrist or digits. The median nerve innervates all but the flexor carpi ulnaris and the ulnar half of the flexor digitorum profundus, both of which are supplied by the ulnar nerve.



## Anterior Antebrachial Muscles

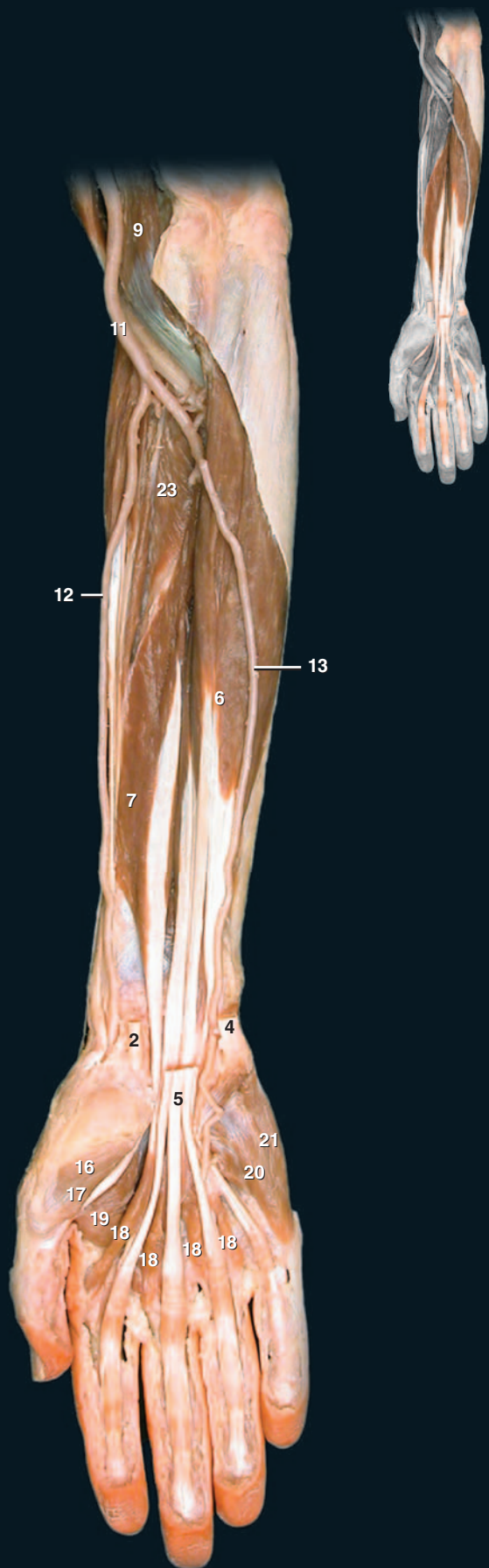
- 1 Pronator teres
- 2 Flexor carpi radialis
- 3 Palmaris longus
- 4 Flexor carpi ulnaris
- 5 Flexor digitorum superficialis
- 6 Flexor digitorum profundus
- 7 Flexor pollicis longus
- 8 Pronator quadratus

## Other Muscles and Structures

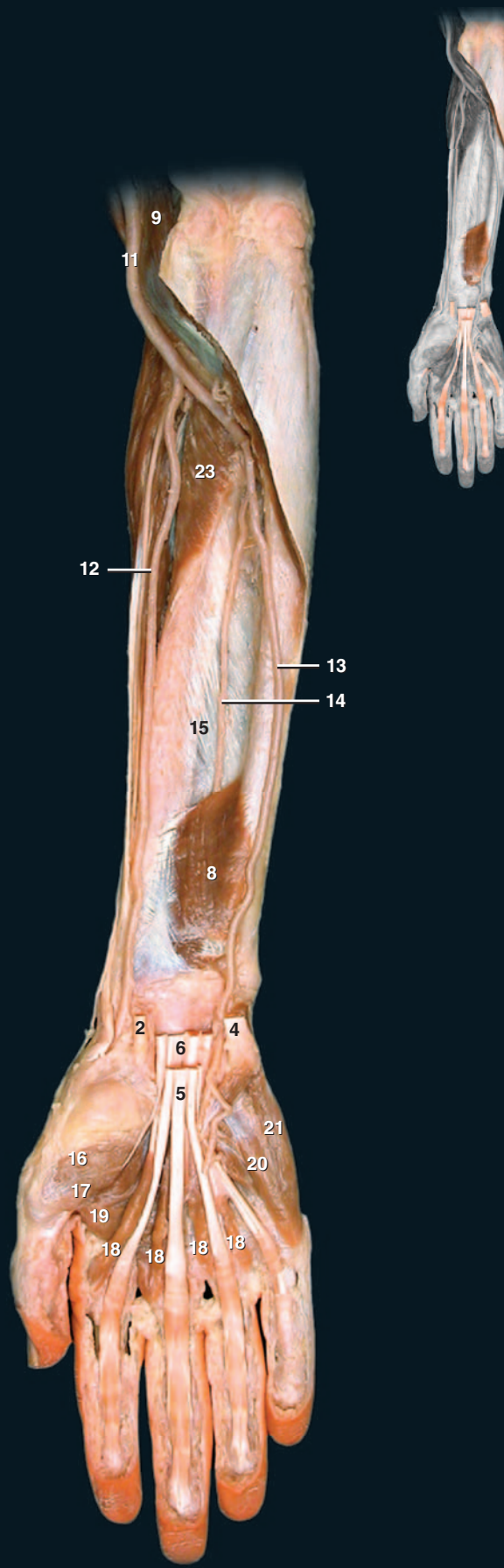
- 9 Brachialis
- 10 Palmar aponeurosis
- 11 Brachial artery
- 12 Radial artery
- 13 Ulnar artery
- 14 Anterior interosseous artery
- 15 Interosseous membrane
- 16 Abductor pollicis brevis
- 17 Flexor pollicis brevis
- 18 Lumbricals
- 19 Adductor pollicis
- 20 Flexor digiti minimi brevis
- 21 Abductor digiti minimi
- 22 Palmaris brevis
- 23 Supinator
- 24 Superficial transverse metacarpal ligament



Superficial muscles of the right antebrachium  
Anterior view, hand pronated



**Deep muscles of the right antebrachium**  
 Anterior view, superficial muscles removed and hand pronated



**Deep muscles of the right antebrachium**  
 Anterior view, muscles removed to expose pronator quadratus

# Posterior Antebrachial Muscles

There are two muscle groups in the posterior

antebrachium — the eight muscles of the lateral group that share a common attachment on or near the lateral epicondyle of the humerus and the four muscles of the radial group that course along the distal aspect of the radius to insert on the thumb and first finger. Like the triceps of the posterior brachial compartment, all the muscles of the posterior antebrachium receive innervation via the radial nerve. With a few exceptions, the muscles are extensors of either the elbow, wrist, or digits.



## Posterior Antebrachial Muscles

- 1 Brachioradialis
- 2 Anconeus
- 3 Supinator
- 4 Extensor carpi radialis longus
- 5 Extensor carpi radialis brevis
- 6 Extensor digitorum
- 7 Extensor digiti minimi
- 8 Extensor carpi ulnaris
- 9 Abductor pollicis longus
- 10 Extensor pollicis longus
- 11 Extensor pollicis brevis
- 12 Extensor indicis

## Other Muscles and Structures

- 13 Biceps brachii
- 14 Brachialis
- 15 Triceps brachii
- 16 Flexor carpi radialis
- 17 Pronator teres
- 18 Flexor pollicis longus
- 19 Abductor digiti minimi
- 20 Dorsal interossei



Superficial muscles of the right antebrachium

Posterior view, hand pronated



**Deep muscles of the right antebrachium**  
 Posterior view, lateral group muscles removed and hand pronated



**Deep muscles of the right antebrachium**  
 Anterolateral view, lateral group muscles removed and hand pronated

# Hand Muscles

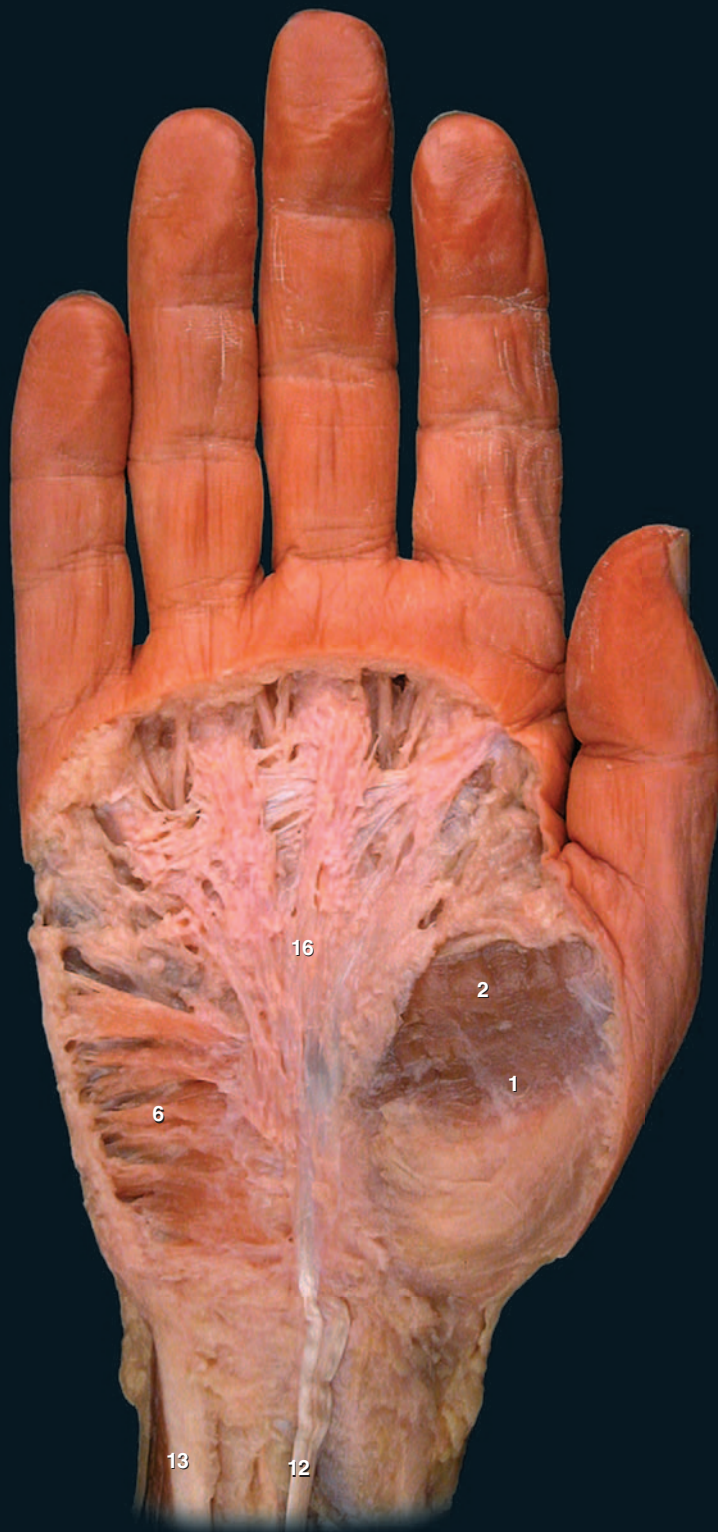
There are three muscle groups in the hand — the muscles of the thenar eminence at the base of the thumb, the muscles of the hypothenar eminence at the base of the little finger, and the three layers of intermetacarpal muscles that occupy the spaces between the metacarpal bones. All of these muscles arise from the anterior muscles of the embryonic limb bud and receive anterior division nerve supply from the median and ulnar nerves as they pass from the anterior antebrachium into the hand. While the median nerve supplies the majority of the muscles of the anterior antebrachium, the ulnar nerve supplies all but three of the muscles in the hand.



Muscles of the thenar eminence



Muscles of the hypothenar eminence



Superficial muscles of the right hand  
Anterior view

Hand Muscles

- 1 Abductor pollicis brevis
- 2 Flexor pollicis brevis
- 3 Adductor pollicis
- 4 Abductor digiti minimi
- 5 Flexor digiti minimi brevis
- 6 Palmaris brevis

Lumbricals

- 7 Lumbricals
- 8 Palmar interossei
- 9 Dorsal interossei

Other Muscles and Structures

- 10 Flexor digitorum superficialis
- 11 Flexor digitorum profundus

Palmaris longus

- 12 Palmaris longus
- 13 Flexor carpi ulnaris
- 14 Flexor pollicis longus
- 15 Flexor carpi radialis
- 16 Palmar aponeurosis
- 17 Flexor retinaculum
- 18 Ulna



Intermediate muscles of the right hand  
Anterior view



Muscles of the  
thenar eminence



Muscles of the  
hypothenar eminence



Intermetacarpal muscles

# Hand Muscles

## Hand Muscles

- 1 Abductor pollicis brevis (cut)
- 2 Flexor pollicis brevis (cut)
- 3 Opponens pollicis
- 4 Adductor pollicis
- 5 Abductor digiti minimi
- 6 Flexor digiti minimi brevis
- 7 Opponens digiti minimi
- 8 Palmaris brevis

- 9 Lumbricals (cut)
- 10 Palmar interossei
- 11 Dorsal interossei

- ## Other Muscles and Structures
- 12 Flexor digitorum superficialis
  - 13 Flexor digitorum profundus
  - 14 Carpal tunnel



Deep muscles of the right hand  
Anterior view



Muscles of the  
thenar eminence



Muscles of the  
hypothenar eminence

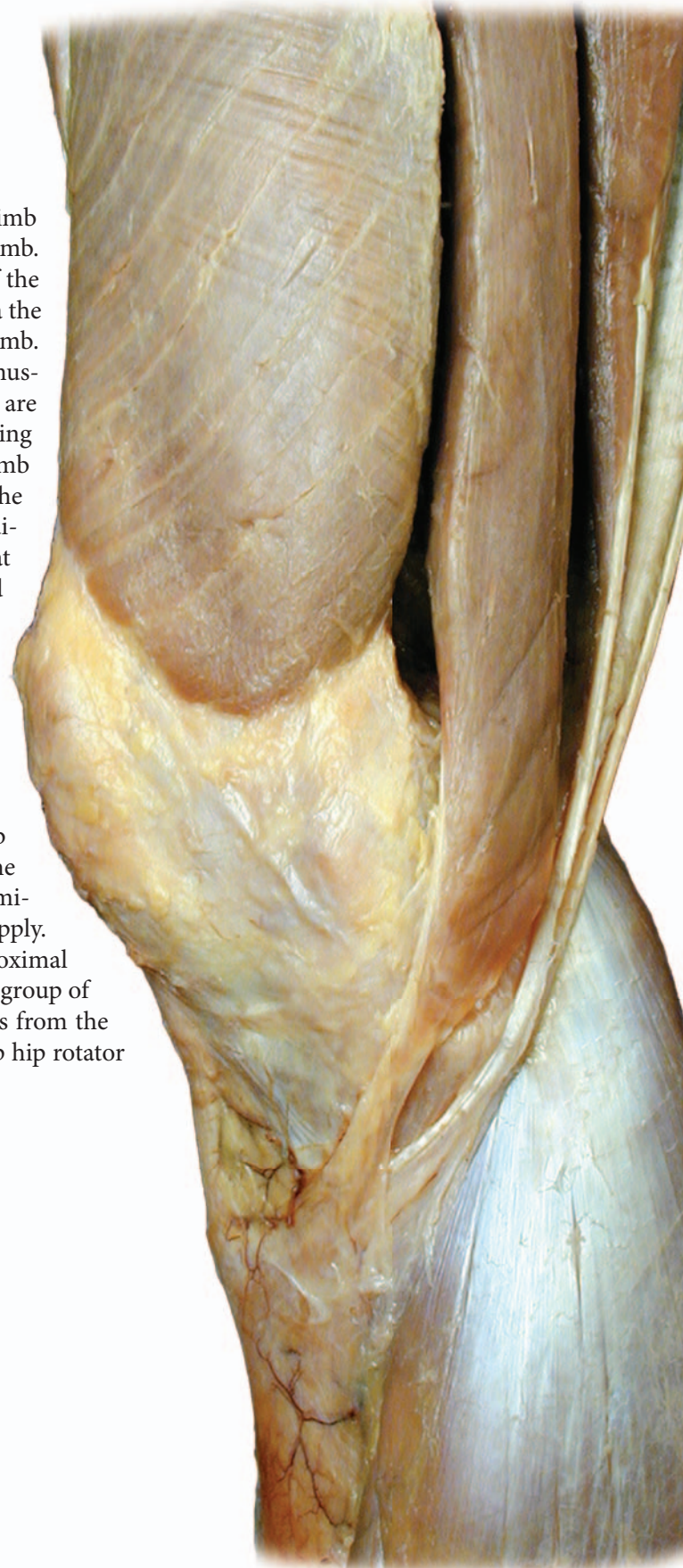


Intermetacarpal muscles



# 12 Lower Limb Muscles

The design of the inferior limb musculature is similar to that of the true limb muscles of the superior limb. The major difference between the two limbs is that the proximal end of the lower limb forms a direct skeletal attachment to the vertebral column via the strong sacro-iliac joint, unlike the unattached scapula of the superior limb. Because of this difference, the inferior limb does not require body wall muscles to support, stabilize, and suspend it from the axial skeleton. There are two additional features that are important to keep in mind when studying this powerful locomotor limb. First, during development of the lower limb the embryonic posterior muscles rotate and reposition themselves to the anterior aspect of the limb. For this reason the knee and ankle move directly opposite the elbow and wrist. The second notable feature is that there are three muscle compartments in the thigh and leg, as compared to just two in the brachium and antebrachium. One of the two original compartments in each lower limb segment (thigh and leg) splits to give rise to an additional compartment. The thigh has an anterior compartment and a posterior compartment, but the posterior compartment is subdivided into posterior and medial compartments. The leg has a large posterior compartment and a smaller anterior compartment and the anterior compartment is subdivided into anterior and lateral compartments. As with the upper limb, we present the muscles of the lower limb proper in their muscle compartments. Again, this greatly simplifies the learning process because most of the muscles in a compartment share similar attachments, perform common actions, and have a common nerve supply. Unlike the compartmental muscles of the lower limb proper, the proximal muscles of the lower limb that surround the hip joint are a more diverse group of muscles. Some are true limb muscles, while others are annexed muscles from the trunk wall. We organize these hip muscles into three groups — the deep hip rotator muscles, the gluteal muscles, and the hip flexors.



Find more information  
about the muscles of the  
lower limb in

**REALANATOMY**

# Lower Limb Muscles

The muscles of the lower limb share similarities with their upper limb counterparts, yet have important differences. As you will notice in the groups below there are no homologues in

the lower limb to the scapular muscles of the upper limb. Like the shoulder muscles, the muscles surrounding the hip joint are a varied group of muscles, with some annexed from the body wall of the abdominopelvic region. In the limb proper the muscles develop in muscular compartments as they do in the upper limb; however, the embryonic posterior aspect of the limb rotates to an anterior position. As a result, the nerves that arise from the posterior divisions of the lumbosacral plexus innervate the anterior muscle compartments, and the nerves from the anterior divisions of the plexus innervate the posterior muscle compartments. The developmental groups of muscles and their nerve supply are outlined below.

## Hip Muscles

Gluteal muscles  
(Nerve supply - gluteal nerves, superior to maximus and inferior to the other three; arise from lateral aspect of ilium and are prime movers and stabilizers of hip joint)

Gluteus maximus  
Gluteus medius  
Gluteus minimus  
Tensor fasciae latae

## Deep hip rotator muscles

(All are lateral rotators of the hip joint and insert on the medial aspect of greater trochanter)

Piriformis  
Obturator internus  
Obturator externus  
Superior gemellus  
Inferior gemellus  
Quadratus femoris

## Hip flexor muscles

Psoas major  
Iliacus

## Anterior Thigh Muscles

(Nerve supply - femoral nerve; major extensor group of the knee)

Sartorius  
Quadriceps femoris  
Rectus femoris  
Vastus lateralis  
Vastus intermedius  
Vastus medialis  
Articularis genu

## Medial Thigh Muscles

(Nerve supply - obturator nerve with exception of pectineus, which is supplied by femoral nerve and condylar head of adductor magnus, which is supplied by tibial nerve)

Pectineus  
Adductor brevis  
Adductor longus  
Adductor magnus  
Adductor minimus  
Gracilis

## Posterior Thigh Muscles

(Nerve supply - Tibial nerve with exception of short head of biceps femoris, which is supplied by common fibular nerve)

Biceps femoris  
Semitendinosus  
Semimembranosus

## Anterior Leg Muscles

(Nerve supply - deep fibular nerve)

Tibialis anterior  
Extensor digitorum longus  
Extensor hallucis longus  
Peroneus tertius

## Lateral Leg Muscles

(Nerve supply - superficial fibular nerve)

Peroneus longus  
Peroneus brevis

## Posterior Leg Muscles

(Nerve supply - tibial nerve)

Triceps surae  
Gastrocnemius  
Soleus  
Plantaris  
Popliteus  
Tibialis posterior  
Flexor digitorum longus  
Flexor hallucis longus

## Dorsal Foot Muscles

(Nerve supply - deep fibular nerve)

Extensor hallucis brevis  
Extensor digitorum brevis

## Plantar Foot Muscles

(Nerve supply - tibial nerve via its terminal branches, medial plantar nerve supplies first lumbrical, abductor hallucis, flexor hallucis brevis, and flexor digitorum brevis; lateral plantar nerve supplies all the others)

### First layer

Abductor hallucis  
Flexor digitorum brevis  
Abductor digiti minimi

### Second layer

Quadratus plantae  
Lumbricales

### Third layer

Flexor hallucis brevis  
Adductor hallucis  
Flexor digiti minimi brevis

### Fourth layer

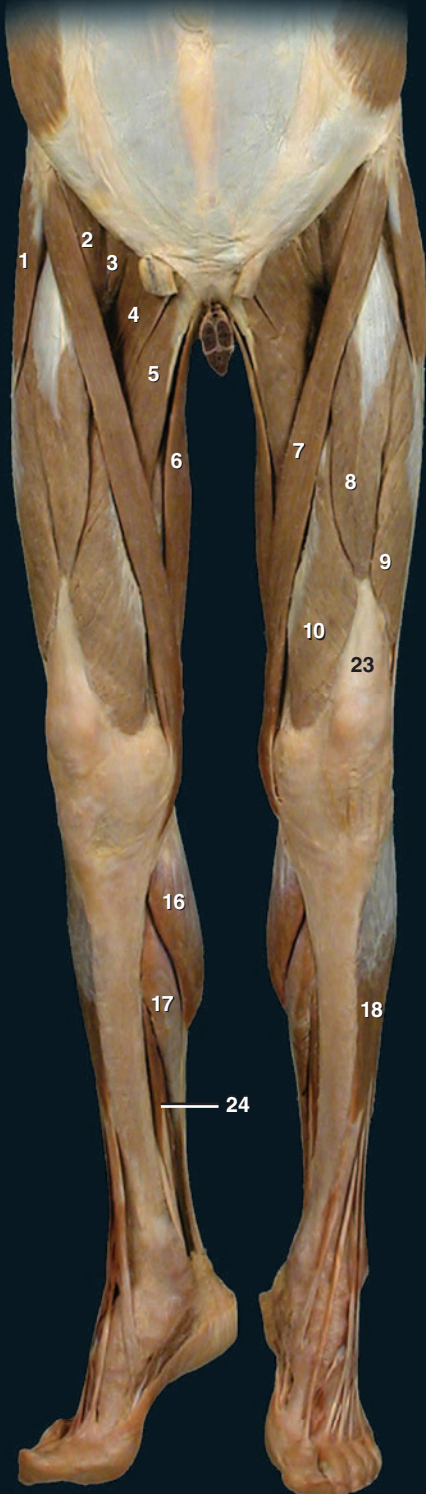
Plantar interossei  
Dorsal interossei



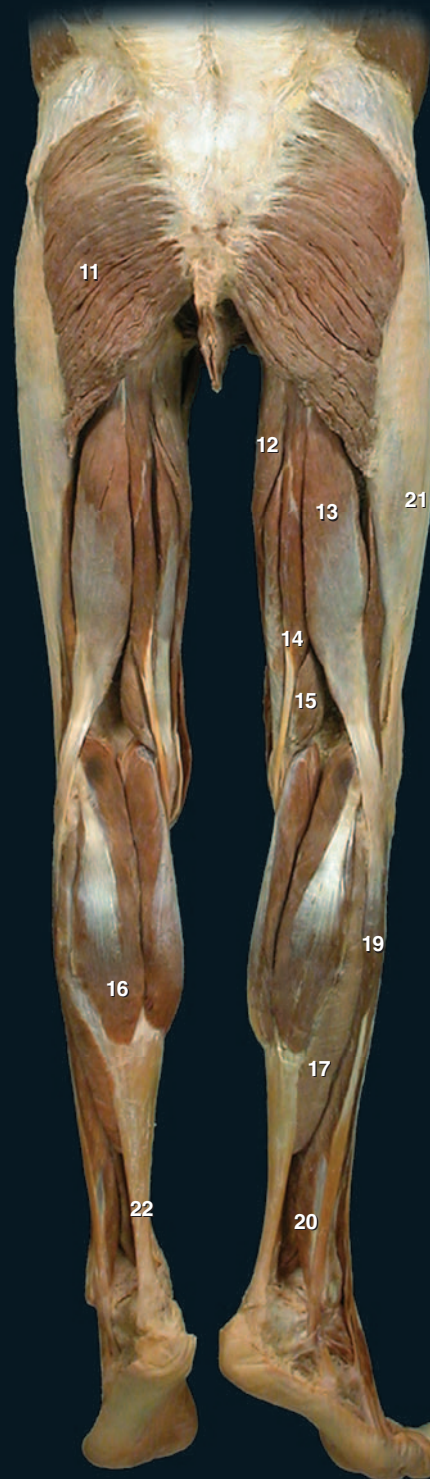
- 1 Tensor fasciae latae
- 2 Iliacus
- 3 Psoas major
- 4 Pectineus
- 5 Adductor longus
- 6 Gracilis
- 7 Sartorius
- 8 Rectus femoris

- 9 Vastus lateralis
- 10 Vastus medialis
- 11 Gluteus maximus
- 12 Adductor magnus
- 13 Biceps femoris
- 14 Semitendinosus
- 15 Semimembranosus
- 16 Gastrocnemius

- 17 Soleus
- 18 Tibialis anterior
- 19 Fibularis longus
- 20 Fibularis brevis
- 21 Iliotibial tract
- 22 Calcaneal tendon
- 23 Quadriceps tendon
- 24 Flexor digitorum longus



**Muscles of the lower limb**  
Anterior view



**Muscles of the lower limb**  
Posterior view

# Hip Muscles

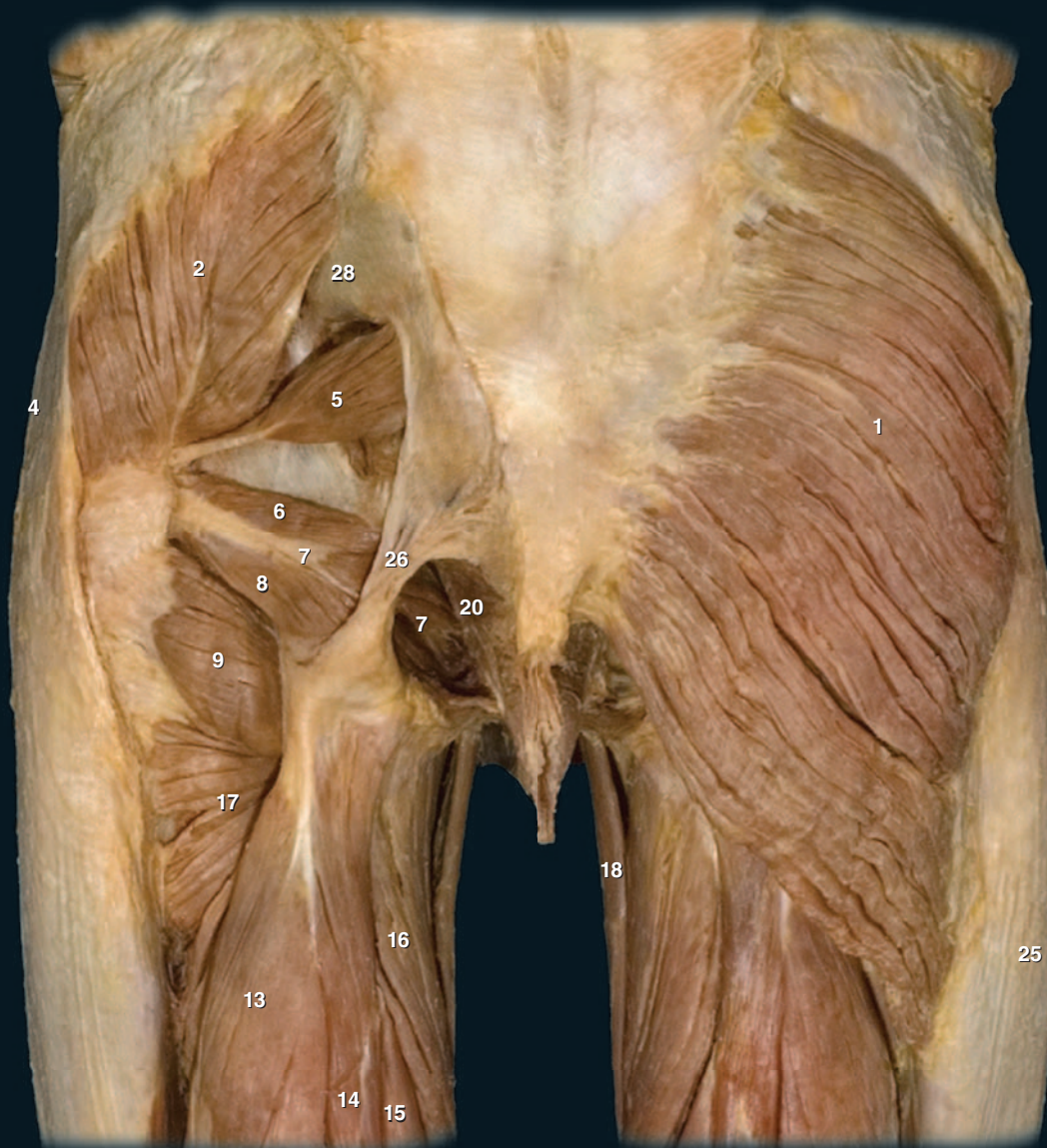
The muscles that surround the hip joint form three groups. The gluteal muscles arise from the posterior musculature of the embryonic limb bud and are prime movers of the hip joint. They create the characteristic profile of the human buttocks. The deep hip rotator muscles are closely associated with the body wall of the pelvic region. Five of the six muscles sit deep to the gluteal musculature on the posterior aspect of the hip joint. The hip flexors are deep body wall muscles of the abdominal wall that have been annexed by the lower limb during development. These muscles, the psoas major and iliacus, form a pulley over the superior ramus of the pubis on their descent onto the lesser trochanter of the femur.



Gluteal muscles



Deep hip rotator muscles



Muscles of the gluteal region, gluteus maximus removed on left  
Posterior view

- Gluteal Muscles**
- 1 Gluteus maximus
  - 2 Gluteus medius
  - 3 Gluteus minimus
  - 4 Tensor fasciae latae

- Deep Hip Rotator Muscles**
- 5 Piriformis
  - 6 Superior gemellus

- 7 Obturator internus
- 8 Inferior gemellus
- 9 Quadratus femoris
- 10 Obturator externus

- Hip Flexor Muscles**
- 11 Psoas major
  - 12 Iliacus

- Other Muscles and Structures**
- 13 Biceps femoris
  - 14 Semitendinosus
  - 15 Semimembranosus
  - 16 Adductor magnus
  - 17 Adductor minimus
  - 18 Gracilis
  - 19 Vastus intermedius
  - 20 Pelvic diaphragm

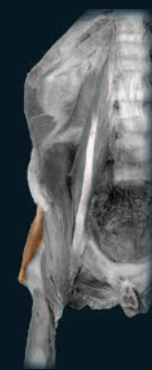
- 21 Transversus abdominis
- 22 Quadratus lumborum
- 23 Psoas minor
- 24 Pectineus (cut)
- 25 Iliotibial tract
- 26 Sacrotuberous ligament
- 27 Penis (cut)
- 28 Ilium
- 29 Femur



**Deep hip rotator muscles**



**Gluteal muscles**



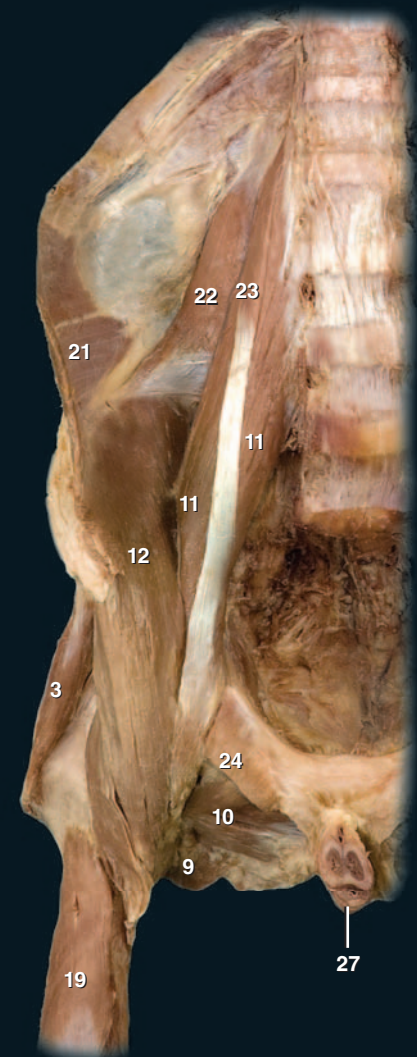
**Gluteal muscles**



**Hip flexor muscles**



**Muscles of gluteal region, gluteus maximus and medius removed**  
Posterolateral view



**Deep dissection of iliopsoas muscles**  
Anterior view

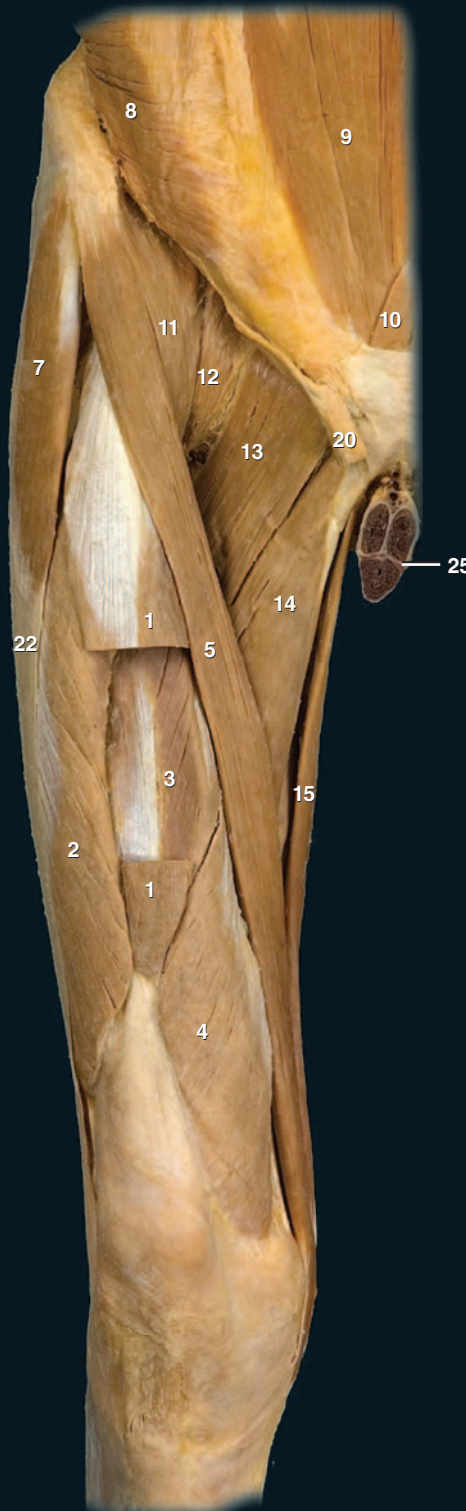
# Anterior Thigh Muscles

The four major muscles of the anterior compartment form the quadriceps femoris muscle group. The four muscles of this

group converge to form the strong quadriceps tendon that surrounds all but the posterior surface of the patella. As the sole extensors of the knee, the quadriceps are essential for running, jumping, and kicking. The sartorius, which is the longest muscle in the body, is a knee flexor. The small articularis genu raises the suprapatellar bursa during extension of the knee. All of the muscles in this compartment receive their innervation via the femoral nerve from the posterior divisions of the lumbar plexus.



**Muscles of the thigh**  
Anterior view, left thigh



**Muscles of the thigh, rectus femoris cut**  
Anterior view, left thigh



# Medial Thigh Muscles

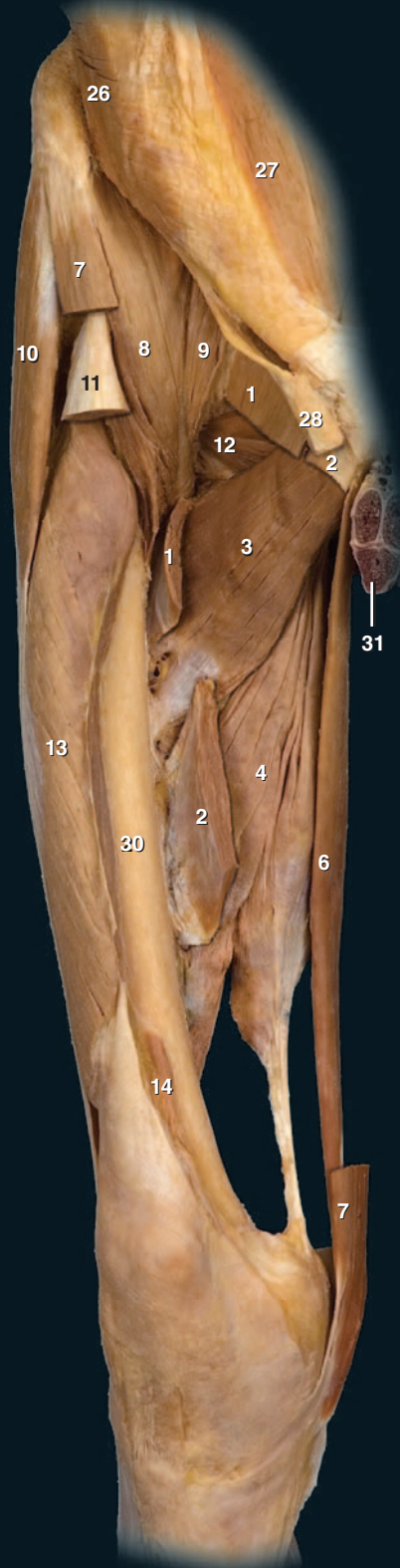
The six muscles of the medial compartment are all capable of adducting the hip joint. The pectineus and four adductor muscles all originate from a medial position on the pubis and ischium and project laterally to insert on the posterior surface of the femur. The gracilis muscle differs from the others in the group by crossing the knee joint in addition to the hip. It courses with the sartorius muscle as a flexor of the knee. With the exception of the pectineus and condylar part of the adductor magnus, all the muscles are innervated by the obturator nerve, which arises from the anterior divisions of the lumbar plexus.

## Medial Thigh Muscles

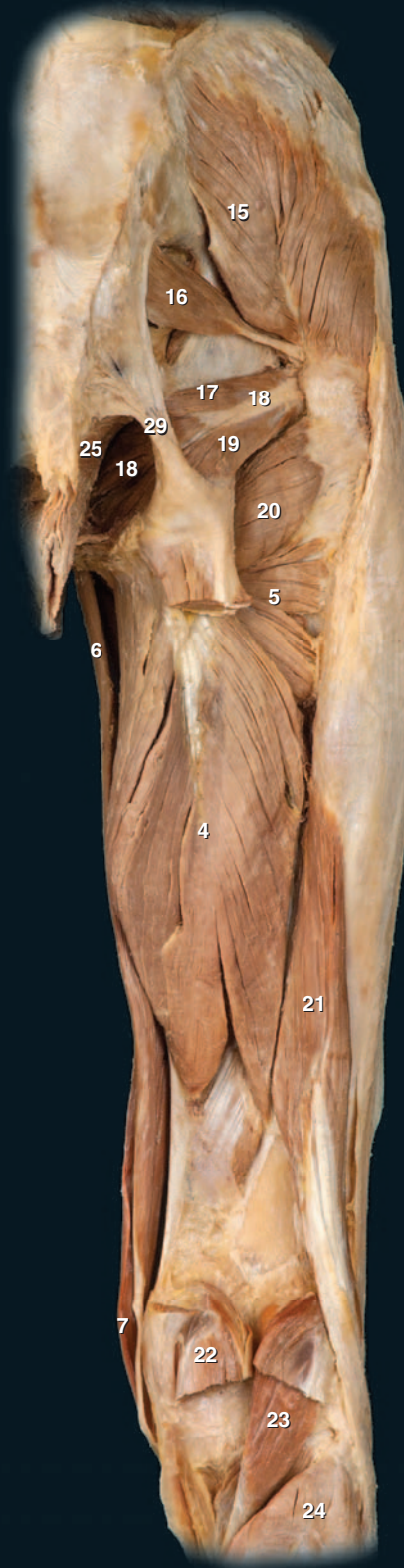
- 1 Pectineus
- 2 Adductor longus
- 3 Adductor brevis
- 4 Adductor magnus
- 5 Adductor minimus
- 6 Gracilis

## Other Muscles and Structures

- 7 Sartorius
- 8 Iliacus
- 9 Psoas major
- 10 Tensor fasciae latae
- 11 Rectus femoris
- 12 Obturator externus
- 13 Vastus lateralis
- 14 Articularis genus
- 15 Gluteus medius
- 16 Piriformis
- 17 Superior gemellus
- 18 Obturator internus
- 19 Inferior gemellus
- 20 Quadratus femoris
- 21 Biceps femoris (short head)
- 22 Gastrocnemius
- 23 Plantaris
- 24 Soleus
- 25 Pelvic diaphragm
- 26 Transversus abdominis
- 27 Rectus abdominis
- 28 Spermatic cord
- 29 Sacrotuberous ligament
- 30 Femur
- 31 Penis (cut)



Dissection of medial thigh muscles  
Anterior view, right thigh



Dissection of medial thigh muscles  
Posterior view, right thigh





# Posterior Thigh Muscles

Like the medial compartment of the thigh, the biceps femoris, semimembranosus, and semitendinosus

arise from the embryonic anterior, or flexor, musculature. The muscles of this compartment, the smallest of the three thigh compartments, are long, two-joint muscles that share much in common. All three muscles arise from the ischial tuberosity, extend the hip and flex the knee, and receive their nerve supply via the tibial branch of the sciatic nerve (with the exception of the short head of the biceps femoris, which is innervated by the common fibular branch of the sciatic nerve). Often referred to as the hamstring muscles, these muscles work with the sartorius and gracilis as the strong flexors of the knee joint.



## Posterior Thigh Muscles

- 1 Biceps femoris (long head)
- 2 Biceps femoris (short head)
- 3 Semitendinosus
- 4 Semimembranosus

## Other Muscles and Structures

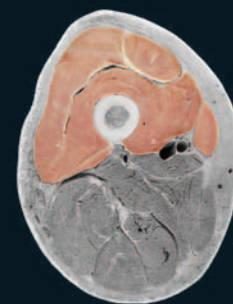
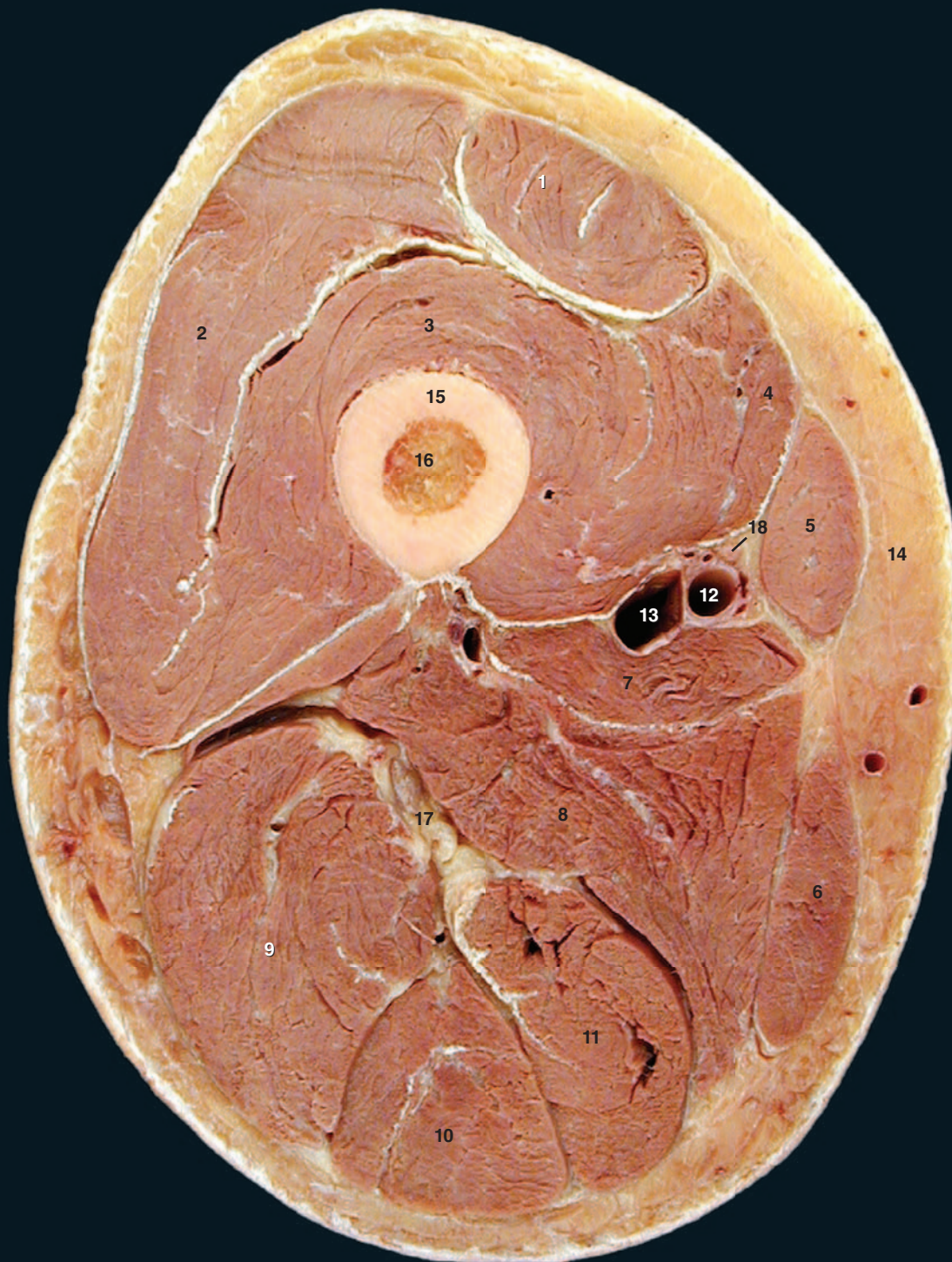
- 5 Gluteus maximus
- 6 Gluteus medius
- 7 Piriformis
- 8 Superior gemellus
- 9 Obturator internus
- 10 Inferior gemellus
- 11 Quadratus femoris
- 12 Adductor minimus
- 13 Adductor magnus
- 14 Pelvic diaphragm
- 15 Gracilis
- 16 Gastrocnemius
- 17 Sacrotuberous ligament
- 18 Iliotibial tract
- 19 Ilium



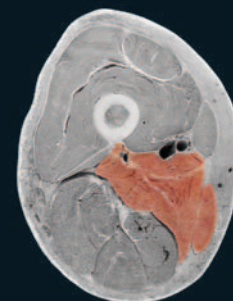
Muscles of the gluteal region and thigh  
Posterior view, gluteus maximus removed on left

# Thigh Muscles

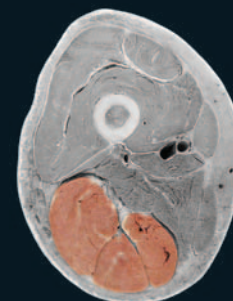
- |                      |                    |                       |
|----------------------|--------------------|-----------------------|
| 1 Rectus femoris     | 7 Adductor longus  | 13 Femoral vein       |
| 2 Vastus lateralis   | 8 Adductor magnus  | 14 Hypodermis         |
| 3 Vastus intermedius | 9 Biceps femoris   | 15 Femur              |
| 4 Vastus medialis    | 10 Semitendinosus  | 16 Yellow bone marrow |
| 5 Sartorius          | 11 Semimembranosus | 17 Sciatic nerve      |
| 6 Gracilis           | 12 Femoral artery  | 18 Saphenous nerve    |



Anterior compartment



Medial compartment



Posterior compartment

Transverse section of right thigh  
Inferior view, level at mid thigh

# Anterior Leg Muscles

The anterior compartment of the leg consists of four muscles, all of which dorsal flex the ankle joint and are innervated by the deep fibular nerve

from the posterior divisions of the sacral plexus. These muscles sit in a tight fascial compartment anterior to the interosseous membrane and between the tibia and fibula. As their tendons cross the ankle joint they are held firmly in place between the tibial and fibular malleoli by two strong retinacular bands. Two of the muscles, the tibialis anterior and fibularis tertius, insert on the ankle. The other two muscles, the extensor digitorum longus and extensor hallucis longus, reach the ends of the digits and also function as digital extensors.



## Anterior Leg Muscles

- 1 Tibialis anterior
- 2 Extensor digitorum longus
- 3 Extensor hallucis longus
- 4 Fibularis tertius

## Other Muscles and Structures

- 5 Vastus lateralis
- 6 Fibularis longus
- 7 Fibularis brevis
- 8 Gastrocnemius
- 9 Soleus
- 10 Extensor hallucis brevis
- 11 Extensor digitorum brevis
- 12 Interosseous membrane
- 13 Anterior tibial vessels
- 14 Extensor retinaculum
- 15 Tibia
- 16 Patellar ligament



Superficial muscles of the anterior crus  
Anterior view



Deep muscles of the anterior crus  
Anterolateral view

# Lateral Leg Muscles

The small lateral compartment, like the anterior compartment, arises from the embryonic dorsal limb muscles. The two muscles within this compartment, the fibularis longus and fibularis brevis, are similar. They both arise from the lateral aspect of the fibula. They both pursue a pulley-like course behind the lateral malleolus, under the cover of a retinaculum, in their passage to the bottom of the foot. They both plantar flex and evert the foot. The superficial fibular nerve, from the posterior divisions of the sacral plexus, supplies both muscles.

## Lateral Leg Muscles

- 1 Fibularis longus
- 2 Fibularis brevis

## Other Muscles and Structures

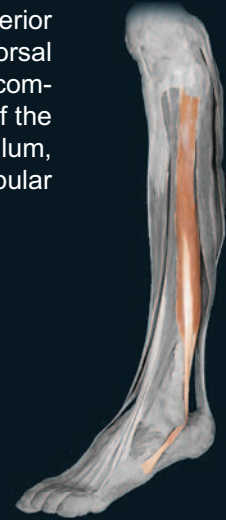
- 3 Gastrocnemius
- 4 Soleus
- 5 Fibularis tertius
- 6 Extensor digitorum longus
- 7 Tibialis anterior
- 8 Extensor hallucis longus
- 9 Extensor digitorum brevis
- 10 Interosseous membrane
- 11 Calcaneal tendon
- 12 Femur
- 13 Tibia
- 14 Fibula
- 15 Lateral malleolus
- 16 Patellar ligament



**Muscles of the crus**  
Lateral view



**Deep muscles of the crus**  
Lateral view



# Posterior Leg Muscles

The posterior compartment of the leg comprises the large muscle mass on the back of the leg that is often referred to as the calf. This compartment has two distinct muscle groups – a large superficial group and a smaller deep group. The superficial group, the gastrocnemius, the soleus, and the plantaris, each insert on the calcaneus. The gastrocnemius and soleus combine to form the large tendocalcaneus, or Achilles tendon. The smaller, deep group consists of four muscles, three of which form a pulley-like arrangement around the medial malleolus. These are the flexor hallucis longus, flexor digitorum longus, and tibialis anterior. The fourth muscle in the group is the deeply situated popliteus that occupies the floor of the popliteal fossa.

## Posterior Leg Muscles

- 1 Tibialis posterior
- 2 Flexor digitorum longus
- 3 Flexor hallucis longus
- 4 Popliteus
- 5 Plantaris
- 6 Soleus
- 7 Gastrocnemius

## Other Muscles and Structures

- 8 Fibularis brevis
- 9 Fibularis longus (tendon)
- 10 Flexor digitorum brevis
- 11 Abductor hallucis
- 12 Flexor hallucis brevis
- 13 Abductor digiti minimi
- 14 Calcaneal tendon
- 15 Fibula



Superficial muscles of the crus  
Posterior view

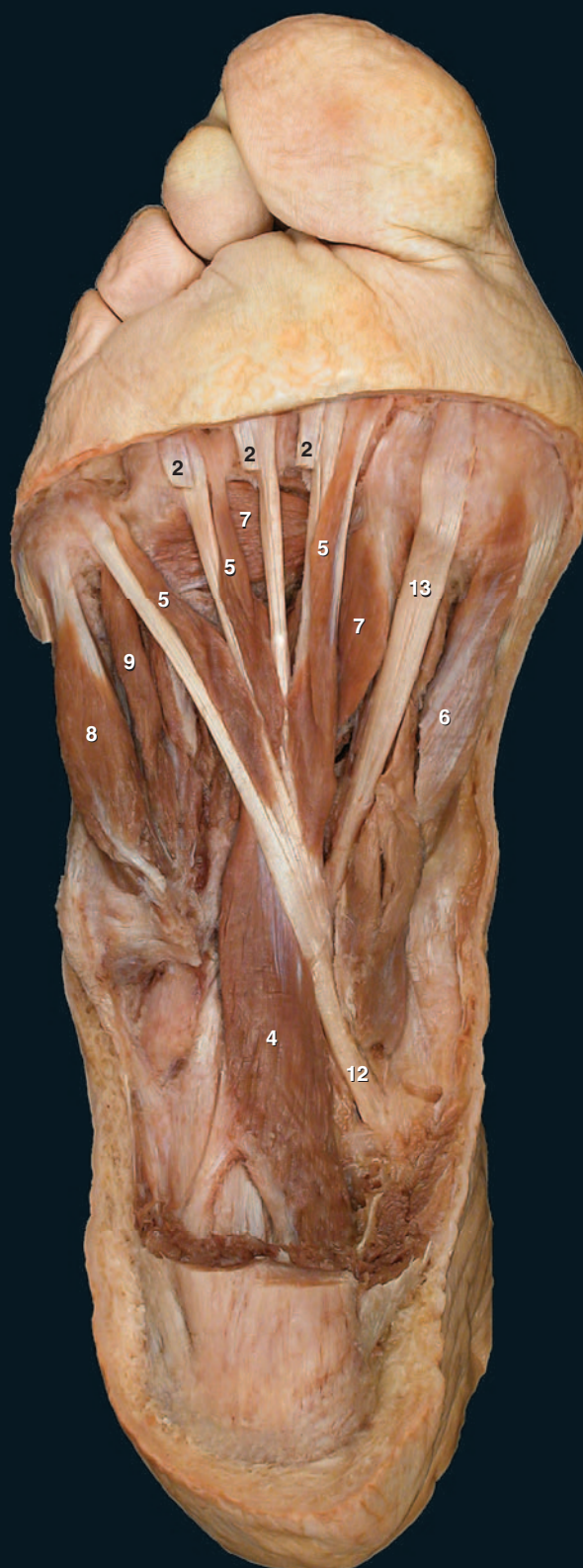
Deep muscles of the crus  
Posterior view

# Foot Muscles

Situated on the dorsal surface of the foot are two short digital extensor muscles, the extensor hallucis brevis and extensor digitorum brevis. These thin muscle sheets help the long digital extensors of the anterior compartment extend the digits. Like the anterior compartment muscles, they are innervated by the deep fibular nerve. The plantar muscles of the foot are much more substantial than the thin dorsal muscles of the foot. These muscles sit beneath the thick subcutaneous fat pad on the bottom of the foot. From superficial to deep, the plantar muscles form four layers.



Dissection of foot, plantar aponeurosis removed  
Plantar view



Dissection of foot, first muscle layer removed  
Plantar view



Layer one



Layer two

Foot Muscles

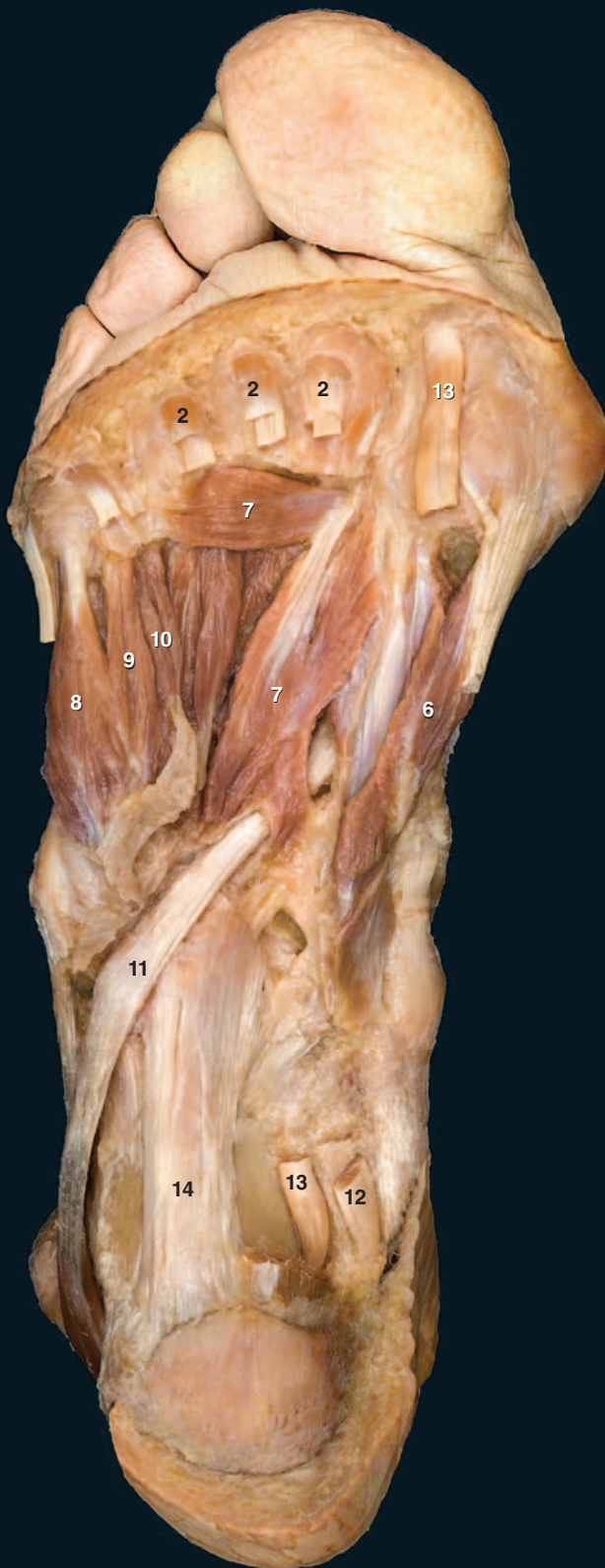
- 1 Abductor hallucis
- 2 Flexor digitorum brevis
- 3 Abductor digiti minimi
- 4 Quadratus plantae
- 5 Lumbricals

6 Flexor hallucis brevis

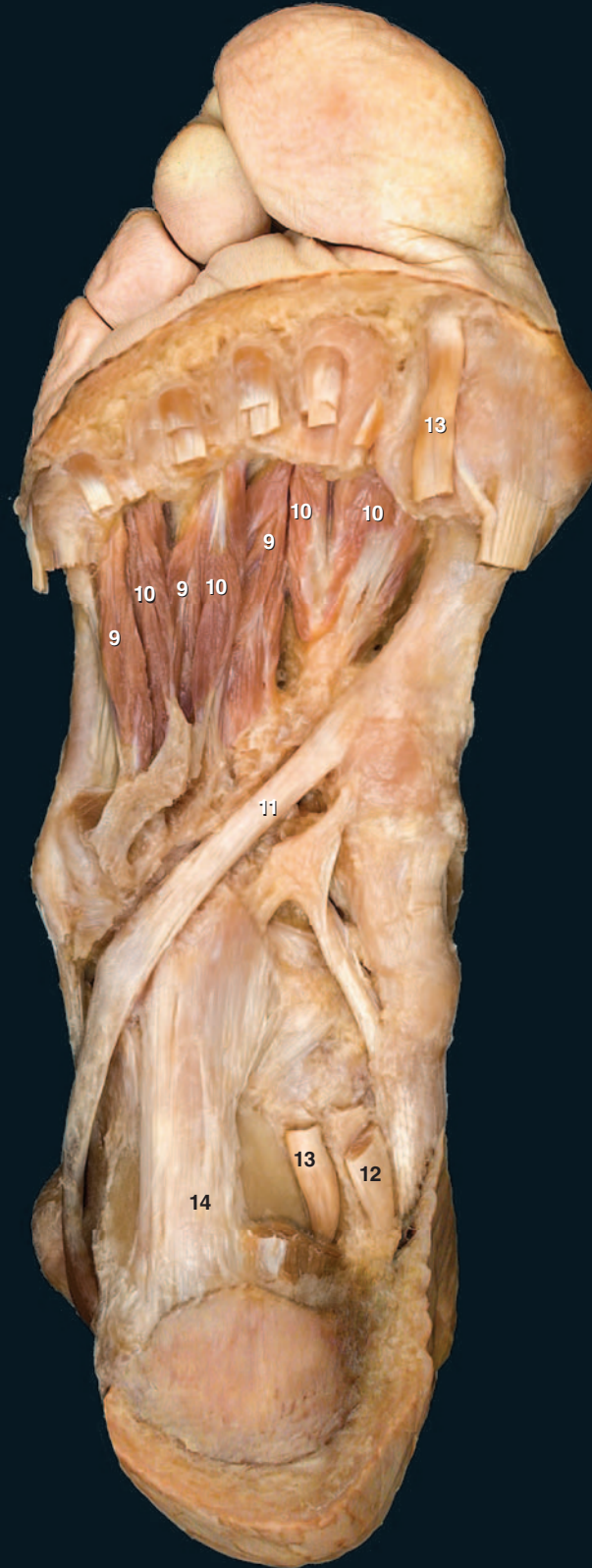
- 7 Adductor hallucis
- 8 Flexor digiti minimi brevis
- 9 Plantar interossei
- 10 Dorsal interossei

Other Muscles and Structures

- 11 Fibularis longus (tendon)
- 12 Flexor digitorum longus (tendon)
- 13 Flexor hallucis longus (tendon)
- 14 Long plantar ligament



Dissection of foot, second muscle layer removed  
Plantar view



Dissection of foot, third muscle layer removed  
Plantar view



Layer three



Layer four

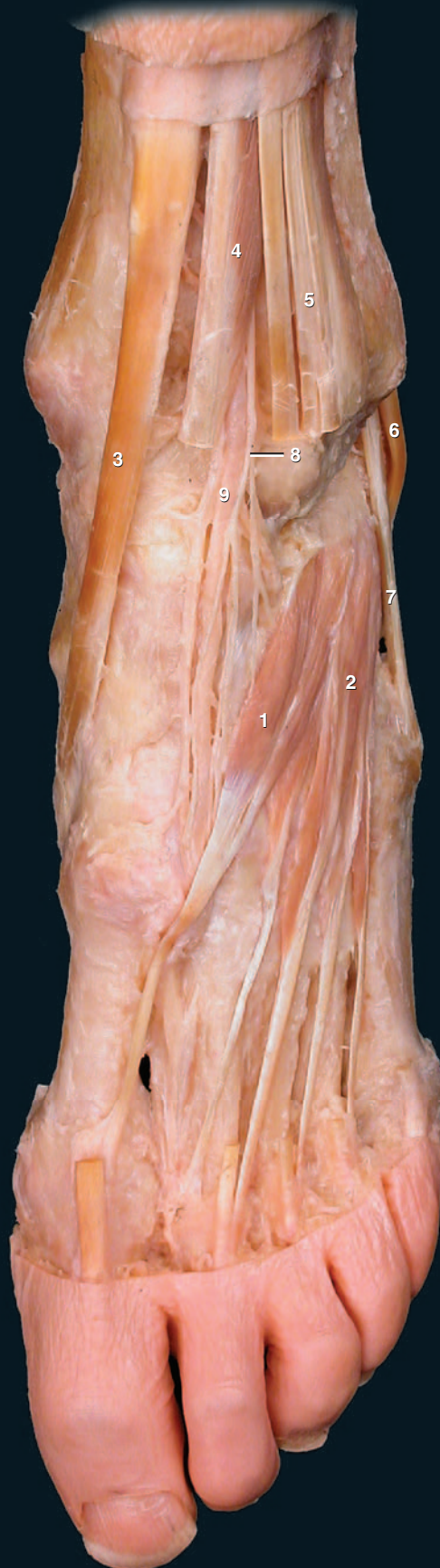
# Foot Muscles

## Foot Muscles

- 1 Extensor hallucis brevis
- 2 Extensor digitorum brevis

## Other Muscles and Structures

- 3 Tibialis anterior (tendon)
- 4 Extensor hallucis longus (cut)
- 5 Extensor digitorum longus (cut)
- 6 Fibularis longus (tendon)
- 7 Fibularis brevis (tendon)
- 8 Deep fibular nerve
- 9 Dorsalis pedis artery



Dorsal foot muscles

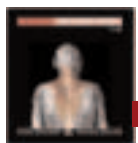
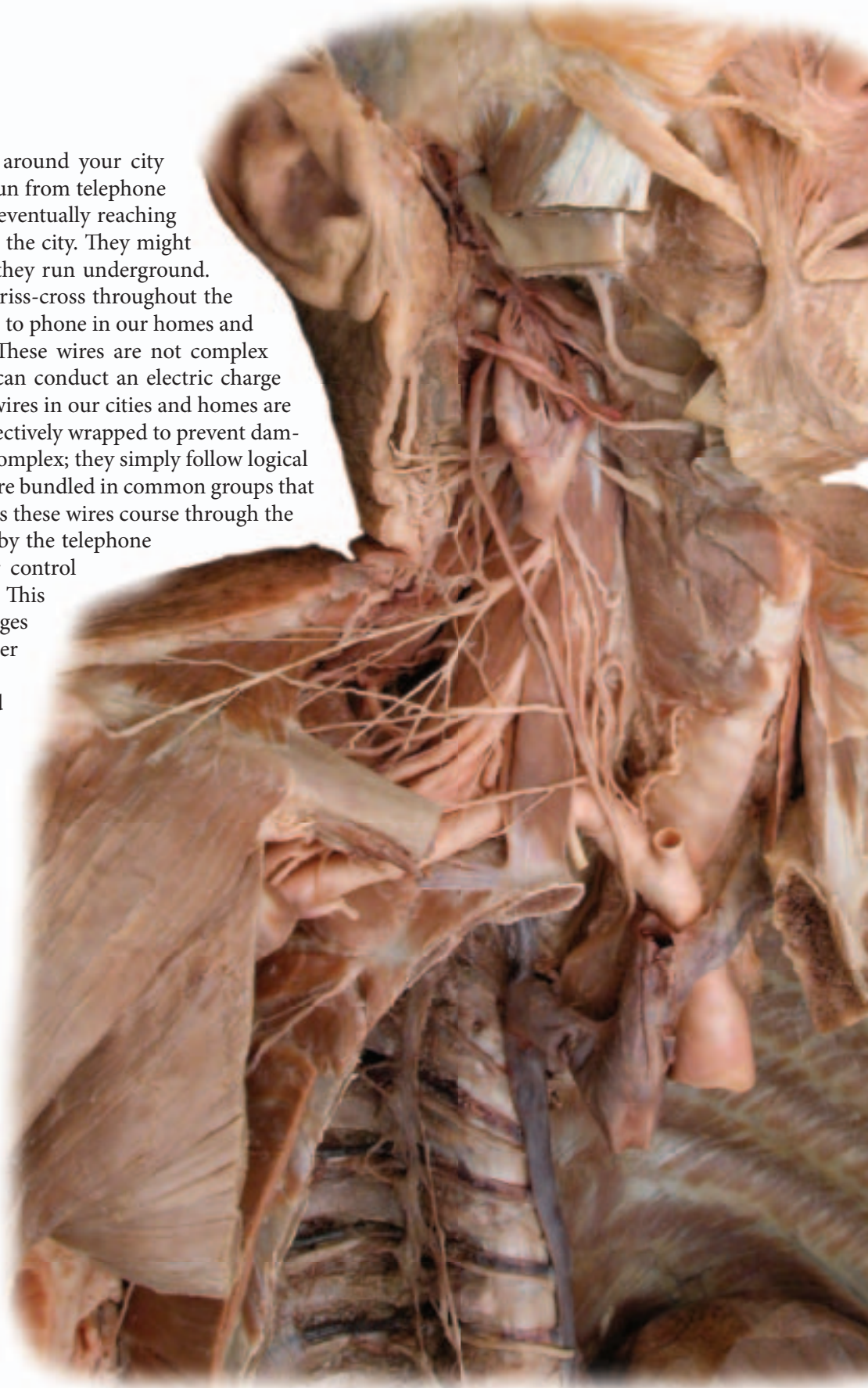
Dissection of left foot  
Dorsal view



# 13 Peripheral Nervous System

Look around your city or town and notice the telephone wires that run from telephone pole to telephone pole along the city streets, eventually reaching the homes and places of business throughout the city. They might not always be visible because in some cities they run underground. Regardless of where they occur, these wires criss-cross throughout the city distributing electrical current from phone to phone in our homes and places of school, work, and entertainment. These wires are not complex structures; they are simply metal wires that can conduct an electric charge from one phone to another. These telephone wires in our cities and homes are typically insulated from one another and protectively wrapped to prevent damage. Their pathways through the city are not complex; they simply follow logical routes to different parts of the city. The wires are bundled in common groups that follow shared pathways to similar locations. As these wires course through the city they relay to telephone centers operated by the telephone companies. At these centers the wires enter control rooms where they form complex circuits. This complex circuitry allows the electrical messages to be processed and directed to the proper phones.

Like the telephone wires of our cities and homes, the nerves of the peripheral nervous system are really rather simple structures. They consist of long, insulated axons bundled together in protective collagenous wrappings. These axons pass in bundled groups that follow logical routes to the different regions of the body where they communicate with receptor (sensory receptors) or effector structures (muscles or glands). Like telephone wires, these neuronal wires conduct electrical messages to and from the central processing center (brain and spinal cord). This chapter will depict the basic design of the structures called nerves and demonstrate the pathways of the nerves throughout the body.



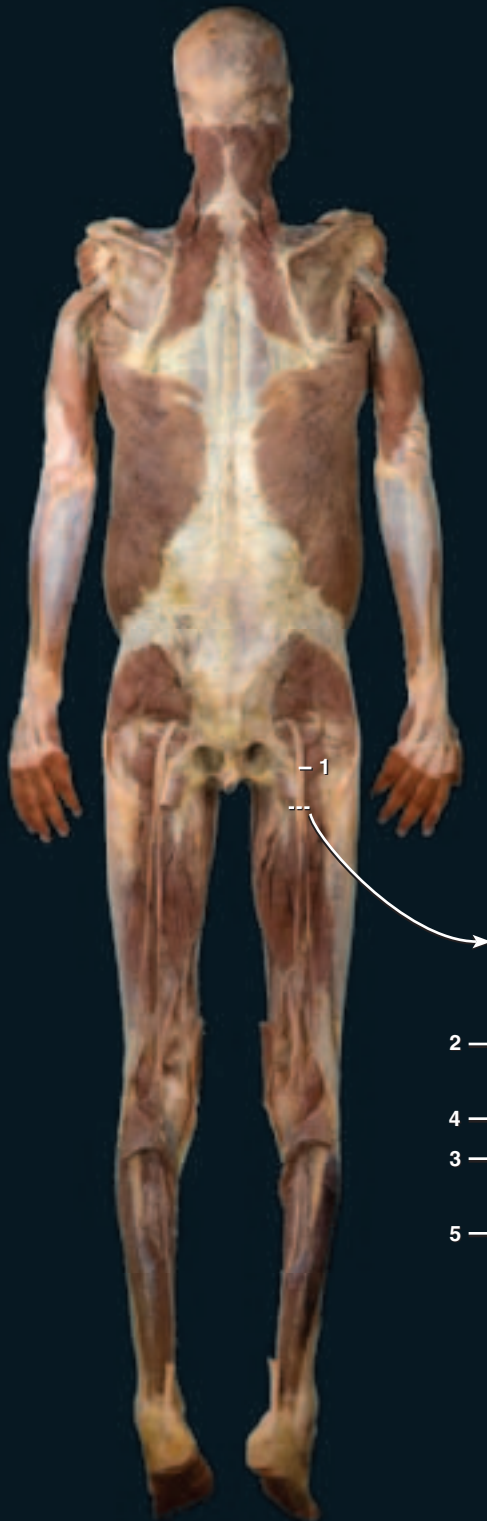
*Find more information  
about the peripheral  
nervous system in*

**REALANATOMY**

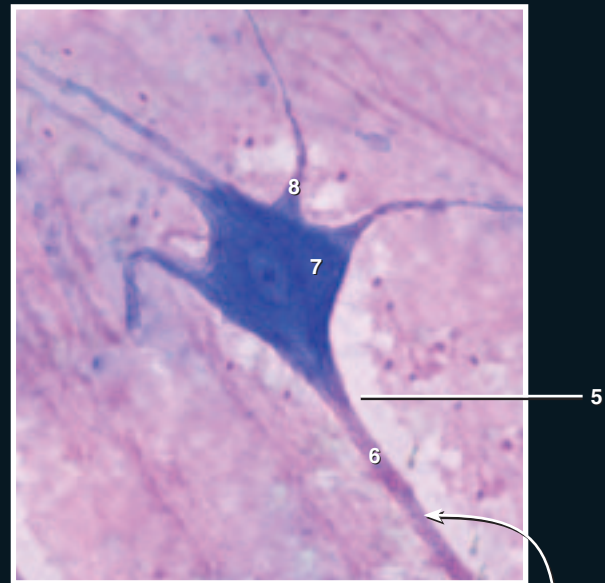
# Structure of a Nerve

Nerves are bundles of axons running between the central nervous system and the peripheral tissues of the body. While all nerves have a similar basic structure, they vary in the types and numbers of

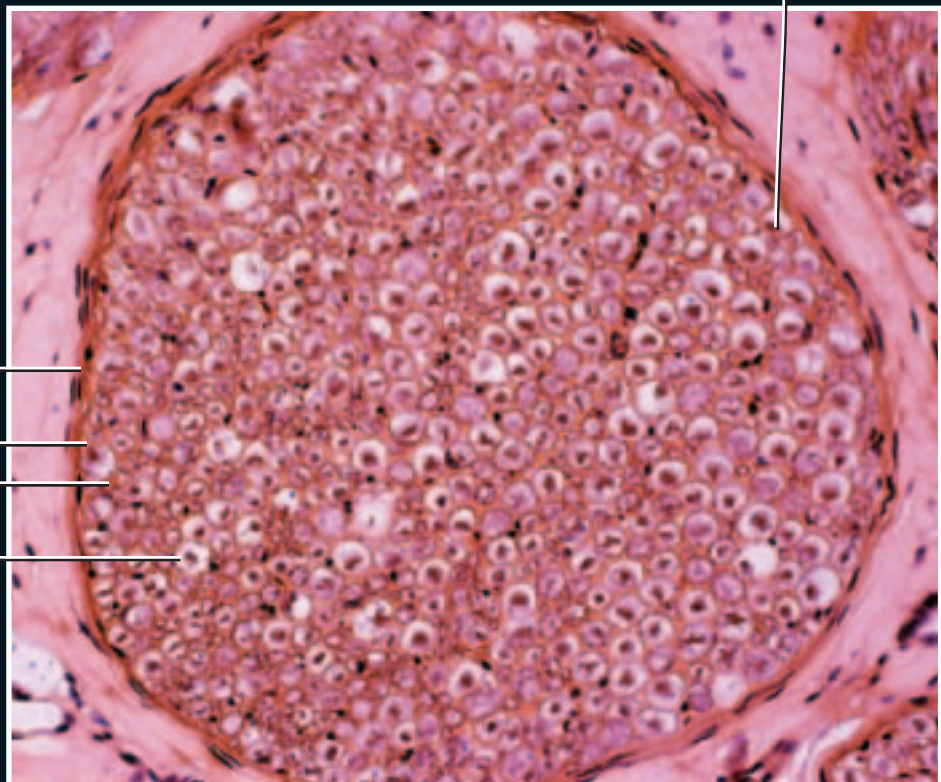
neurons bundled within. The basic design of a nerve consists of neurons wrapped by neurolemmocytes to form the nerve fiber. The fibers are protectively wrapped and nourished by a vascular loose connective tissue, the endoneurium. Many endoneurial wrapped fibers are surrounded by a collagenous perineurium to form the fasciculus of the nerve, and all the fasciculi are wrapped in a collagenous sheath, the epineurium, to form the nerve.



Dissection of sciatic nerve  
Posterior view



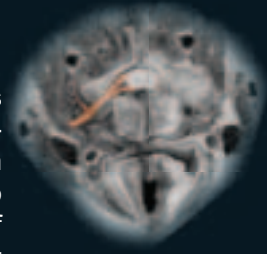
Photomicrograph of multipolar neuron  
400x



Photomicrograph of nerve cross-section  
200x

# Spinal Nerve Structure

The spinal nerves arise from the spinal cord as a series of small neuronal bundles called rootlets — ventral (motor) rootlets and dorsal (sensory) rootlets. Each series of ventral rootlets converges to form larger ventral roots. Likewise each series of dorsal rootlets converges to form larger dorsal roots. The dorsal and ventral roots project laterally and converge to form the spinal nerve trunk. A ganglion, the dorsal root ganglion, is present on the dorsal root just prior to the spinal nerve trunk. Branching from the trunk are two large branches and a variable series of smaller branches. Each branch follows a specific course to different peripheral regions. The two largest branches, the ventral ramus and dorsal ramus, are somatic branches that run in the musculoskeletal wall of the body. Smaller visceral branches, the meningeal nerve, the white and gray communicating rami, and the parasympathetic splanchnic nerves form the autonomic pathways to smooth muscle and glandular tissue.



## Structure of a Nerve

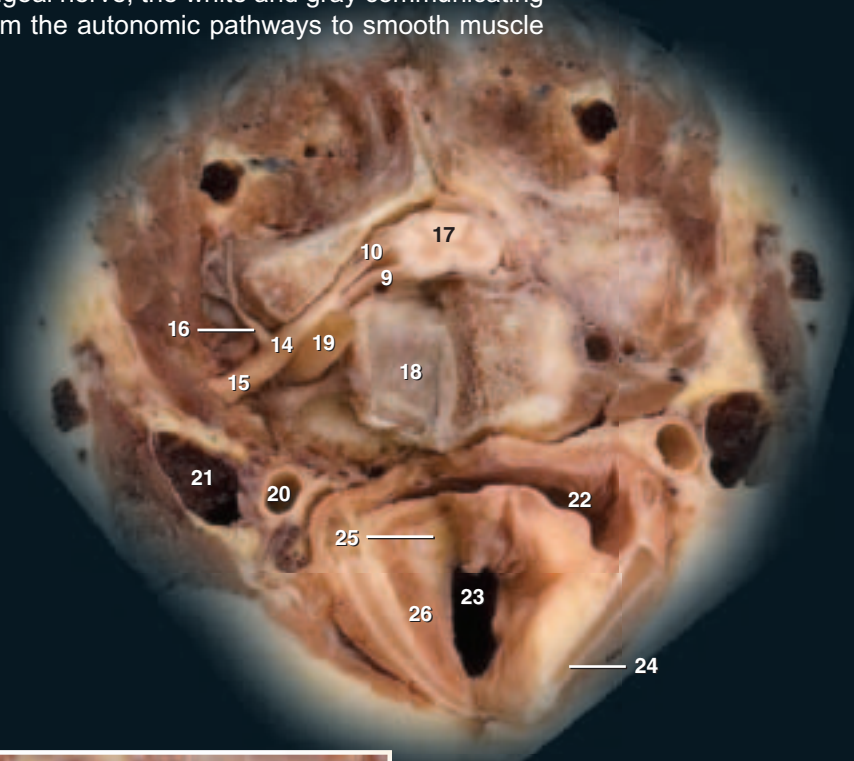
- 1 Sciatic nerve
- 2 Epineurium
- 3 Perineurium
- 4 Endoneurium
- 5 Myelin sheath
- 6 Axon
- 7 Cell body
- 8 Dendrite

## Spinal Nerve Structures

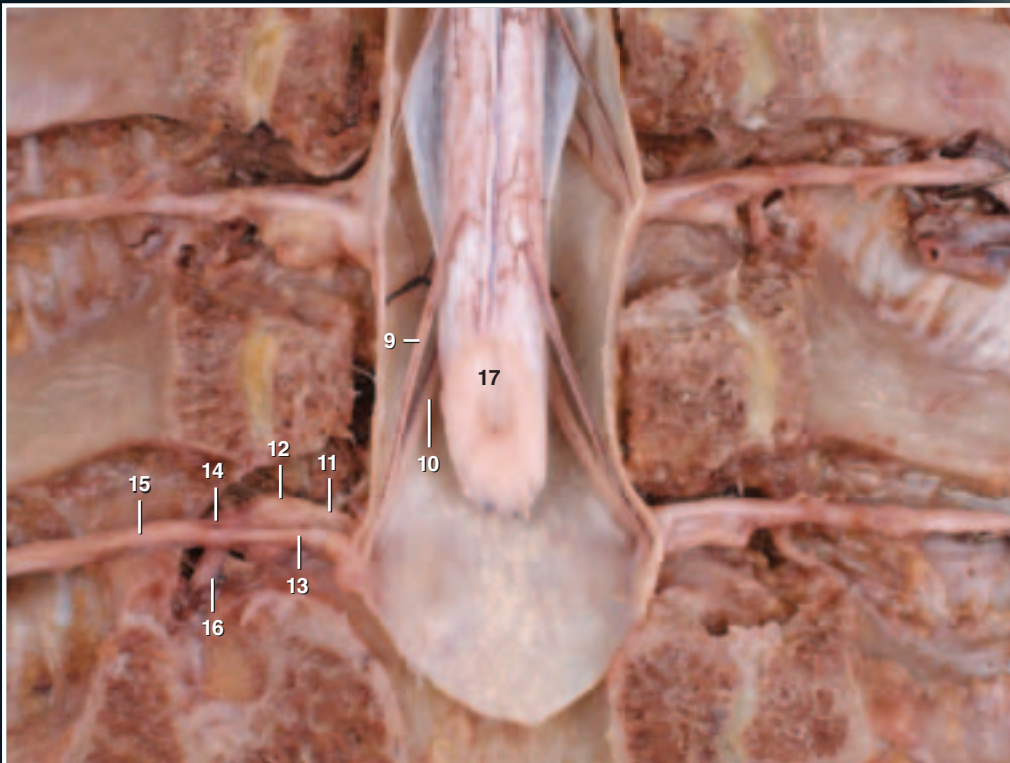
- 9 Ventral rootlets
- 10 Dorsal rootlets
- 11 Dorsal root
- 12 Dorsal root ganglion
- 13 Ventral root
- 14 Spinal nerve trunk
- 15 Ventral ramus
- 16 Dorsal ramus

## Other Structures

- 17 Spinal cord
- 18 Cervical vertebra
- 19 Vertebral artery
- 20 Common carotid artery
- 21 Internal jugular vein
- 22 Laryngopharynx
- 23 Larynx
- 24 Thyroid cartilage
- 25 Cricoid cartilage
- 26 Vocalis muscle



Dissection of cervical spinal cord  
Superior view



Dissection of spinal cord, thoracic vertebral bodies removed  
Anterior view

# Spinal Nerves

With slight variation, the basic pattern of the spinal nerve repeats itself thirty-one times along the entire length of the spinal cord. With the exception of the first spinal nerve, each spinal nerve level emerges from within the vertebral column to pass peripherally between successive vertebrae. Because of the developmental differences in the growth rate of the vertebral column and associated spinal cord, the lower roots of the spinal nerves are dragged downward by the lengthening vertebral column. With each succeeding spinal nerve level the roots become longer and more oblique in their course, eventually extending beyond the end of the spinal cord as the vertically oriented cauda equina.

## Spinal Nerves

- 1 Spinal nerve
- 2 Cervical dorsal rootlets
- 3 Thoracic dorsal rootlets
- 4 Lumbosacral dorsal rootlets
- 5 Dorsal rami
- 6 Cauda equina
- 7 Filum terminale

## Other Structures

- 8 Cerebrum
- 9 Cerebellum
- 10 Medulla oblongata
- 11 Spinal cord
- 12 Dura mater
- 13 Superior sagittal sinus
- 14 Transverse sinus
- 15 Opening of straight sinus
- 16 Confluence of sinuses

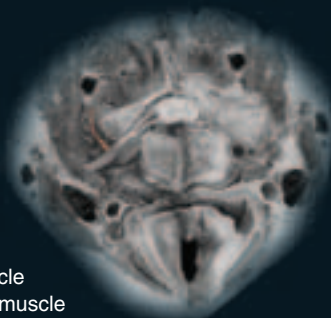


Dissection exposing cauda equina  
Posterior view

Dissection revealing spinal cord and brain  
Posterior view

# Dorsal Rami

The dorsal rami of the spinal nerves arise at all spinal levels and pursue a posterior course into the muscles, connective tissue, and skin of the back. They innervate all the epaxial muscles comprising the extensors of the vertebral column. The cutaneous distribution of the dorsal rami spans from the top of the head, down the posterior trunk, to the superior half of the gluteal region. With the exception of levels C1, S4, S5, and the coccygeal, the dorsal rami split into lateral and medial branches as they course posteriorly into the back.



## Dorsal Rami

- 1 Greater occipital nerve
- 2 Least occipital nerve
- 3 Dorsal ramus
- 4 Medial branch
- 5 Lateral branch

## Other Structures

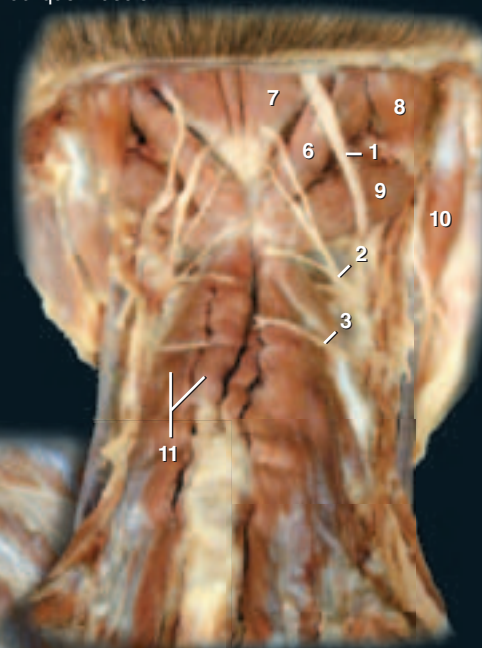
- 6 Rectus capitis posterior major muscle
- 7 Rectus capitis posterior minor muscle
- 8 Obliquus superioris muscle
- 9 Obliquus inferioris muscle
- 10 Posterior digastricus muscle

## Other Structures

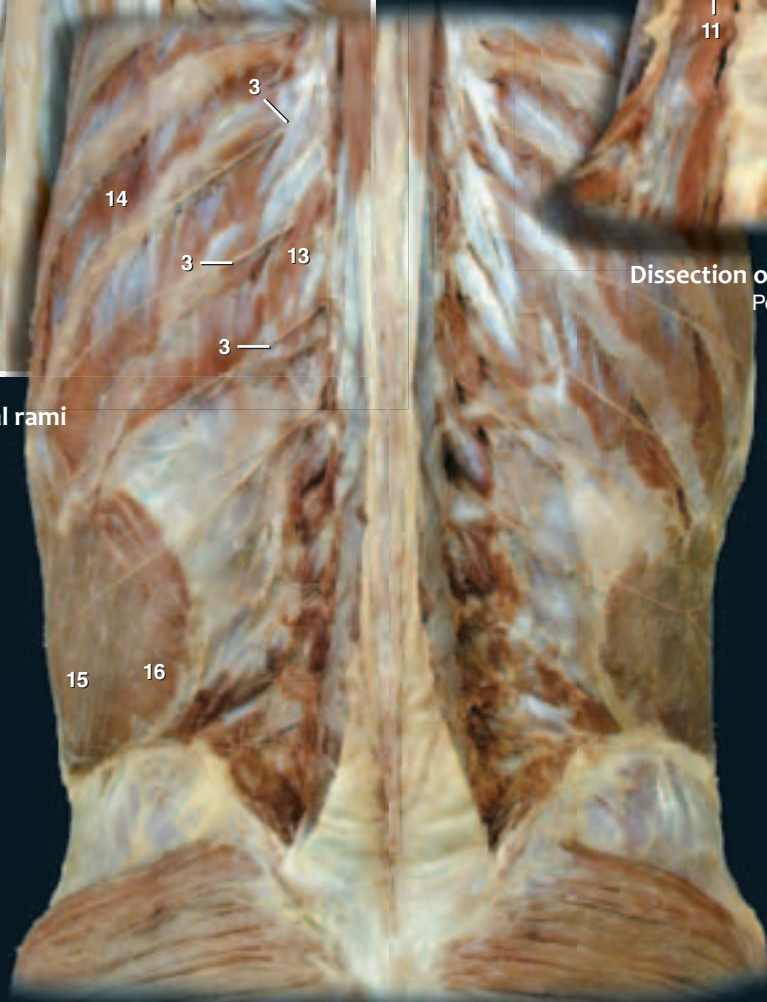
- 11 Semispinalis cervicis muscle
- 12 Intertransversarii thoracic muscle
- 13 Levatores costarum muscles
- 14 External intercostal muscle
- 15 External oblique muscle
- 16 Internal oblique muscle



Deep dissection exposing dorsal rami  
Posterior view



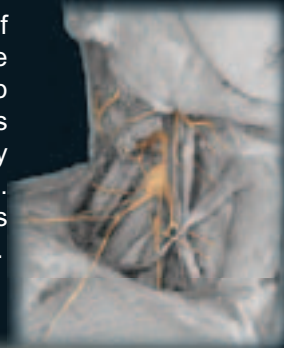
Dissection of cervical dorsal rami  
Posterior view



Erector spinae muscle removed to expose dorsal rami  
Posterior view

# Cervical Plexus

This next series of pages illustrates the ventral rami of the spinal nerves. The ventral rami innervate the majority of the skeletal muscles (all hypaxial and limb muscles). The cervical plexus forms from the ventral rami of the first four cervical spinal nerves. As these ventral rami pass laterally between the middle and internal layers of the lateral cervical body wall, they form ascending and descending branches that communicate to form the cervical plexus. Emerging from this plexus are the nerves that innervate the muscles of the hypaxial cervical wall, as well as cutaneous branches that serve the overlying skin of the lateral head, neck and upper thorax.

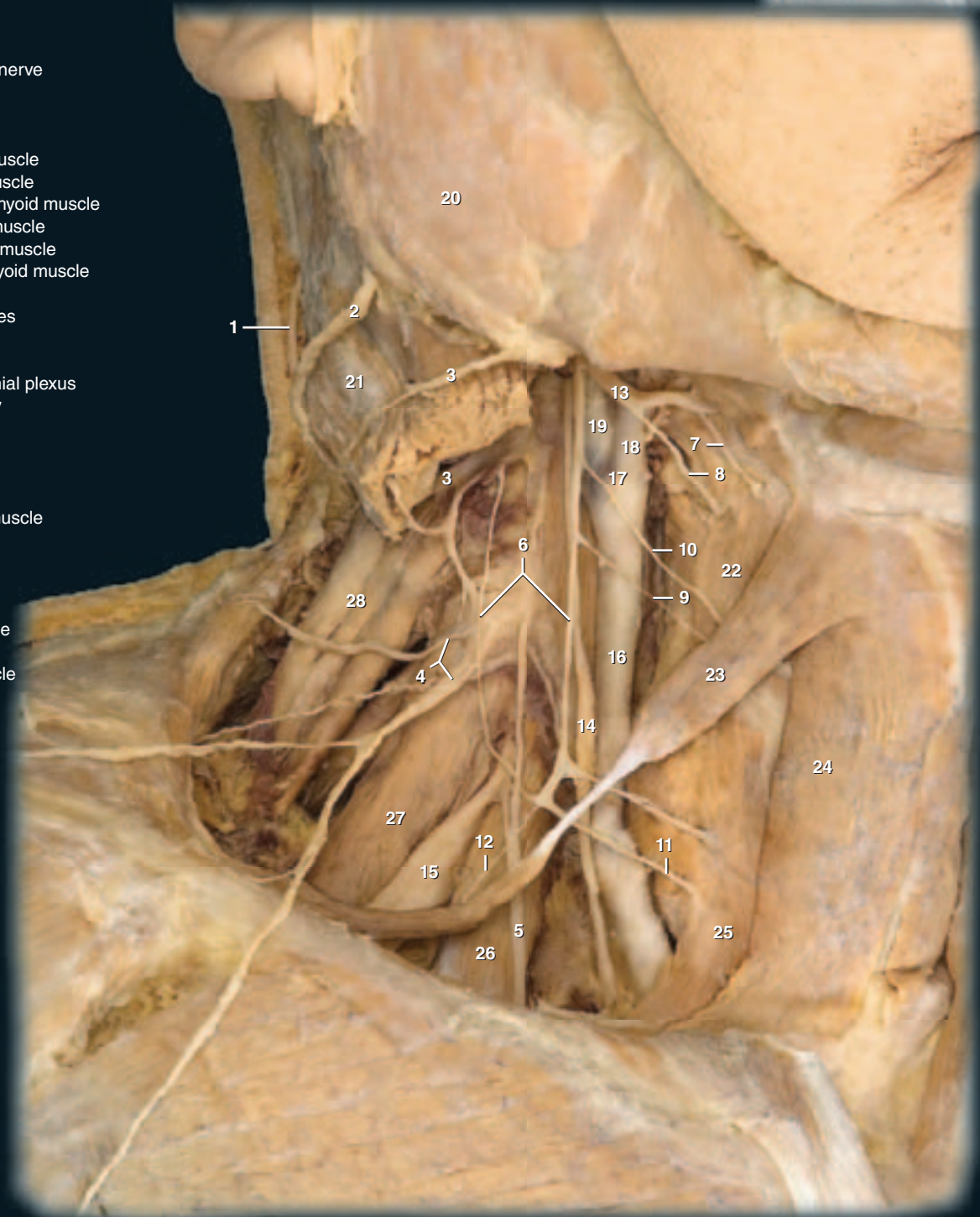


## Cervical Plexus Nerves

- 1 Lesser occipital nerve
- 2 Great auricular nerve
- 3 Transverse cutaneous nerve
- 4 Supraclavicular nerve
- 5 Phrenic nerve
- 6 Ansa cervicalis
- 7 Nerve to geniohyoid muscle
- 8 Nerve to thyrohyoid muscle
- 9 Nerve to superior omohyoid muscle
- 10 Nerve to sternohyoid muscle
- 11 Nerve to sternothyroid muscle
- 12 Nerve to inferior omohyoid muscle

## Other Nerves and Structures

- 13 Hypoglossal nerve
- 14 Vagus nerve
- 15 Superior trunk of brachial plexus
- 16 Common carotid artery
- 17 Carotid sinus
- 18 Internal carotid artery
- 19 External carotid artery
- 20 Parotid gland
- 21 Sternocleidomastoid muscle
- 22 Thyrohyoid muscle
- 23 Omohyoid muscle
- 24 Sternohyoid muscle
- 25 Sternothyroid muscle
- 26 Anterior scalene muscle
- 27 Middle scalene muscle
- 28 Levator scapulae muscle



Dissection of cervical plexus  
Anterior view

# Brachial Plexus

The brachial plexus arises from the last four cervical ventral rami and the first thoracic ventral ramus. The four cervical ventral rami pass laterally between the middle and internal layers of the lateral cervical body wall, the middle and anterior scalene muscles, respectively. As they emerge through the scalenes, they connect with one another as well as with the ascending branch of the first thoracic ventral ramus. This is the beginning of the nerve plexus that will innervate almost all the muscles and associated skin of the upper limb.



## Brachial Plexus Nerves

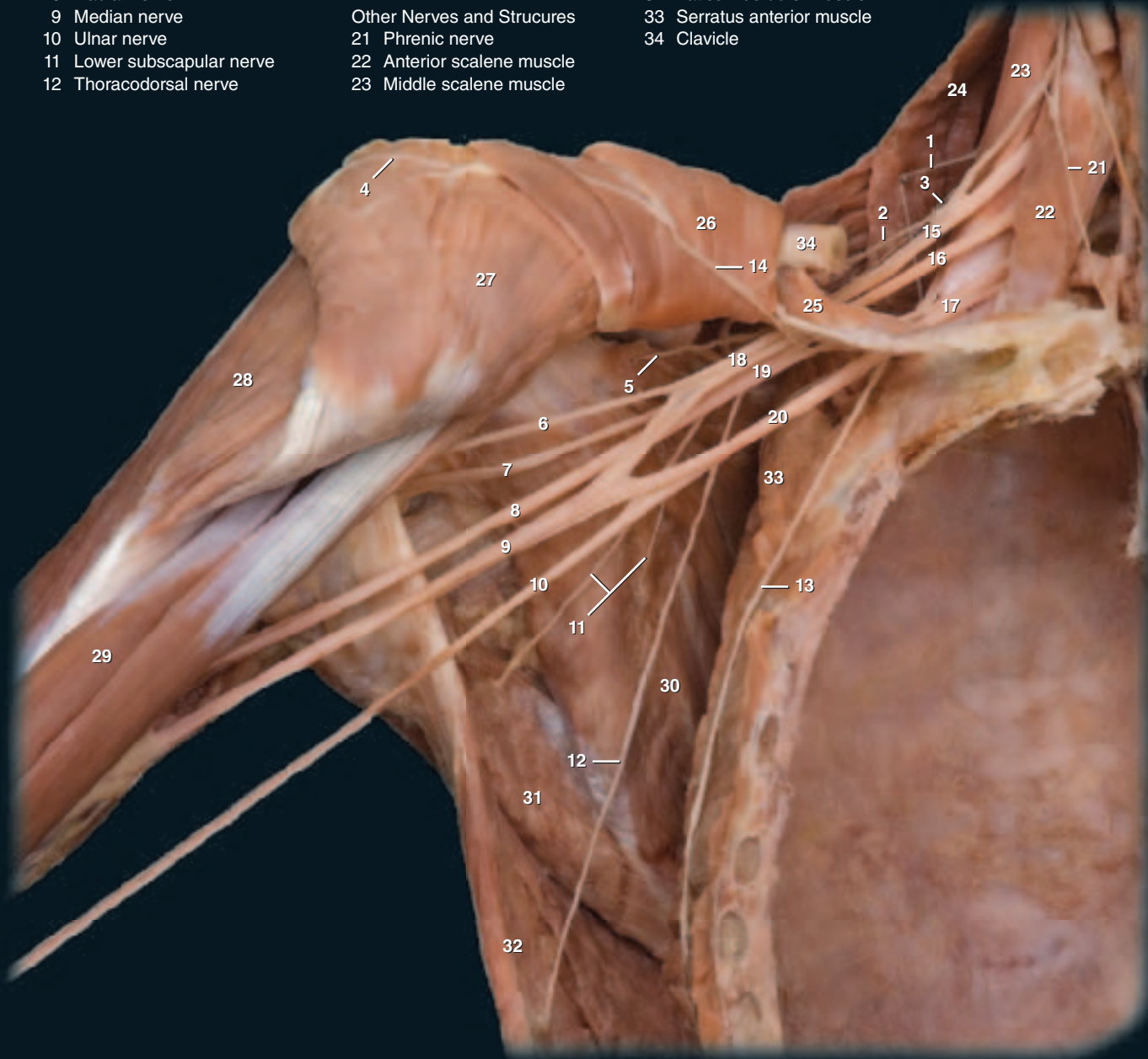
- 1 Dorsal scapular nerve
- 2 Suprascapular nerve
- 3 Nerve to the subclavius muscle
- 4 Lateral pectoral nerve
- 5 Upper subscapular nerve
- 6 Musculocutaneous nerve
- 7 Axillary nerve
- 8 Radial nerve
- 9 Median nerve
- 10 Ulnar nerve
- 11 Lower subscapular nerve
- 12 Thoracodorsal nerve

- 13 Long thoracic nerve
- 14 Medial pectoral nerve
- 15 Superior trunk
- 16 Middle trunk
- 17 Inferior trunk
- 18 Lateral cord
- 19 Posterior cord
- 20 Medial cord

## Other Nerves and Structures

- 21 Phrenic nerve
- 22 Anterior scalene muscle
- 23 Middle scalene muscle

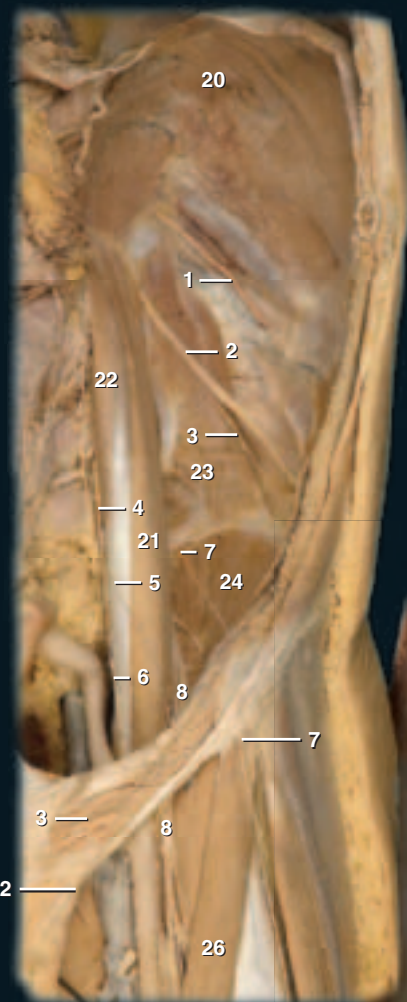
- 24 Levator scapulae muscle
- 25 Subclavius muscle
- 26 Pectoralis minor muscle
- 27 Pectoralis major muscle
- 28 Deltoid muscle
- 29 Biceps brachii muscle
- 30 Subscapularis muscle
- 31 Teres major muscle
- 32 Latissimus dorsi muscle
- 33 Serratus anterior muscle
- 34 Clavicle



Dissection of brachial plexus  
Anterior view

# Lumbar Plexus

The lumbar plexus arises from the ventral rami of the first four lumbar spinal nerves. The plexus emerges laterally through the intervertebral foramina to pass anterolateral between the two heads of the psoas major muscle. The more superior branches of the plexus enter the abdominal body wall to innervate the abdominal muscles. The lower nerves of the plexus course into the lower limb as the lateral femoral cutaneous, femoral, and obturator nerves. The lumbar plexus is a transitory plexus that begins as a series of body wall nerves and eventually transitions into limb innervation. The first ventral ramus of the plexus is basically a segmental nerve that follows the basic segmental nerve pattern in the ventral body wall. The second lumbar ventral ramus forms segmental branches in the body wall and other branches that contribute to limb innervation. The third and fourth ventral rami contribute solely to innervation of the lower limb anatomy.



Abdominal dissection of lumbar plexus  
Anterior view

## Lumbar Plexus Nerves

- 1 Subcostal nerve
- 2 Iliohypogastric nerve
- 3 Ilioinguinal nerve
- 4 Genitofemoral nerve
- 5 Genital branch of genitofemoral nerve
- 6 Femoral branch of genitofemoral nerve
- 7 Lateral femoral cutaneous nerve
- 8 Femoral nerve
- 9 Obturator nerve
- 10 Lumbosacral trunk

## Sacral Plexus Nerves

- 11 Superior gluteal nerve
- 12 Inferior gluteal nerve
- 13 Posterior femoral cutaneous nerve
- 14 Nerve to the obturator internus muscle
- 15 Pudendal nerve
- 16 Perforating cutaneous nerve
- 17 Inferior cluneal nerve
- 18 Sciatic nerve
- 19 Upper bands of sacral plexus

## Other Structures

- 20 Diaphragm
- 21 Psoas major muscle
- 22 Psoas minor muscle
- 23 Quadratus lumborum muscle
- 24 Iliacus muscle
- 25 Obturator externus muscle
- 26 Sartorius muscle
- 27 Tensor fasciae latae muscle
- 28 Gluteus maximus muscle
- 29 Gluteus medius muscle
- 30 Gluteus minimus muscle
- 31 Piriformis muscle
- 32 Superior gemellus muscle
- 33 Obturator internus muscle
- 34 Inferior gemellus muscle
- 35 Sacrotuberous ligament
- 36 Penis

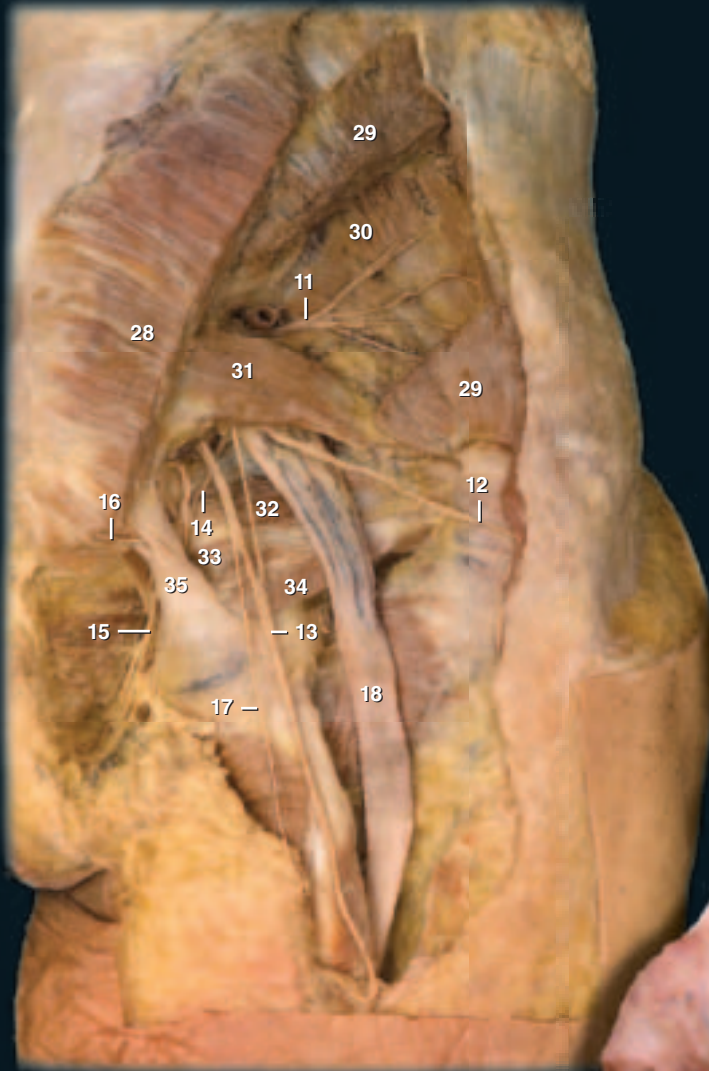


Pelvic dissection exposing lumbar and sacral plexus  
Anterior view



# Sacral Plexus

The sacral plexus forms from the ventral rami of the last two lumbar and the first four sacral spinal nerves. The fourth and fifth lumbar spinal nerves form a descending communication, the lumbosacral trunk, that joins with the upper sacral spinal nerves as they exit the anterior foramina of the sacrum. On the anterior surface of the sacrum the large roots of the plexus are noticeable before they exit through the greater sciatic notch on their course into the pelvic wall and lower limb. This plexus forms the total nerve supply to the pelvic body wall, and, along with the limb branches from the lumbar plexus, is the nerve supply for the lower limb.



**Dissection of sacral plexus nerves**  
Posterior view



**Dissection of pudendal nerves and vessels**  
Lateral view

# Intercostal Nerves

Unlike the ventral rami in the cervical, lumbar, and sacral regions, which form plexuses, most of the thoracic ventral rami remain segmental like their dorsal counterparts. These thoracic ventral rami, called the inter-

costal and subcostal nerves, emerge from the spinal nerve trunk and enter the intercostal space just inferior to each of the twelve ribs. Each of these segmental nerves has a similar structural design. The main trunk of the nerve runs through the intercostal space, with the segmental arteries and veins, between the middle and internal muscle layers of the body wall. Accompanying the main branch is a smaller collateral branch, which emerges from the main branch near the angle of the rib, and runs inferior to the main branch through the intercostal space. The main branch also gives rise to lateral and anterior cutaneous branches that supply the skin, or dermatome, of each segment.

## Intercostal Nerves

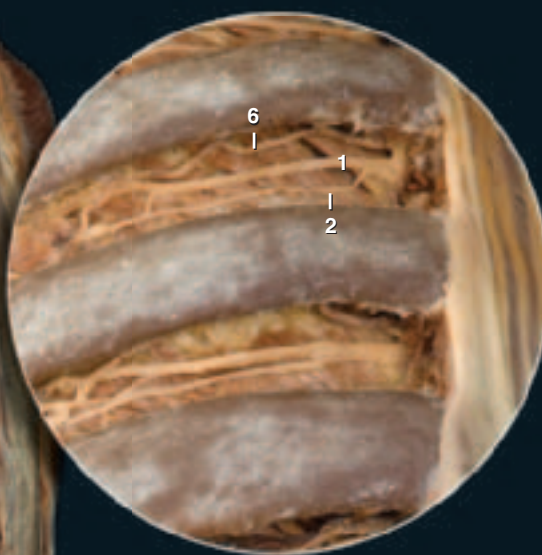
- 1 Main trunk
- 2 Collateral branch

## Other Nerves and Structures

- 3 Subcostal nerve
- 4 Iliohypogastric nerve
- 5 Posterior intercostal vein
- 6 Posterior intercostal artery
- 7 Innermost intercostal muscle
- 8 Transversus abdominis muscle
- 9 Gluteus medius muscle
- 10 Piriformis muscle
- 11 Iliocostalis muscles
- 12 Rib 12



**Dissection of intercostal nerves**  
Lateral view



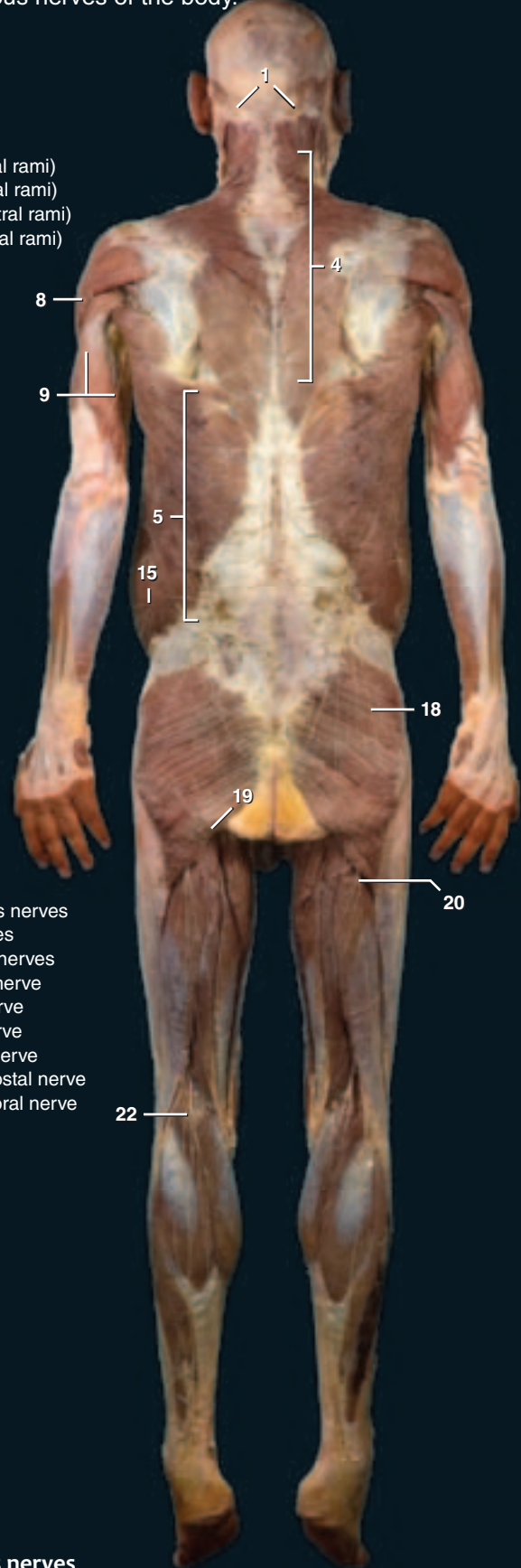
**Dissection of intercostal space**  
Lateral view

# Cutaneous Nerves

Many small nerves, named cutaneous nerves, branch from the spinal and cranial nerves and course through and between muscles to emerge into the integumentary covering of the body. These detailed dissections reveal all the cutaneous nerves of the body.



- 1 Greater occipital nerve
- 2 Transverse cervical nerves
- 3 Supraclavicular nerves
- 4 Medial cutaneous branches (dorsal rami)
- 5 Lateral cutaneous branches (dorsal rami)
- 6 Anterior cutaneous branches (ventral rami)
- 7 Lateral cutaneous branches (ventral rami)

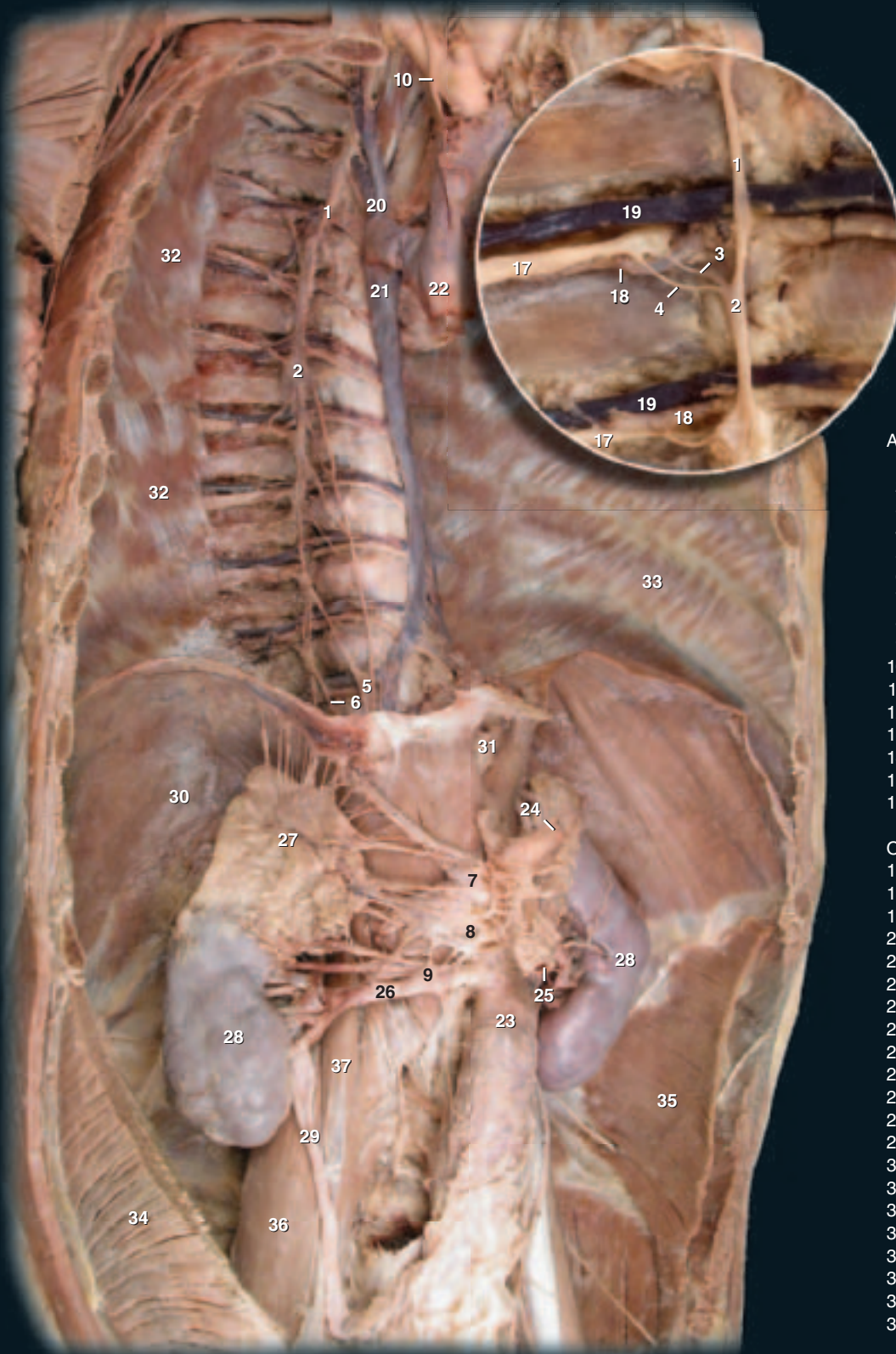


- 8 Superior lateral brachial cutaneous nerves
- 9 Posterior brachial cutaneous nerves
- 10 Inferior lateral brachial cutaneous nerves
- 11 Posterior antebrachial cutaneous nerve
- 12 Lateral antebrachial cutaneous nerve
- 13 Medial antebrachial cutaneous nerve
- 14 Femoral branch of genitofemoral nerve
- 15 Lateral cutaneous branch of subcostal nerve
- 16 Anterior cutaneous branch of femoral nerve
- 17 Lateral femoral cutaneous nerve
- 18 Superior cluneal nerves
- 19 Inferior cluneal nerve
- 20 Posterior femoral cutaneous nerve
- 21 Saphenous nerve
- 22 Lateral sural cutaneous nerve

**Dissections exposing cutaneous nerves**  
Anterior view to left, Posterior view to right

# Autonomic Nerves

In contrast to the somatic branches of the spinal nerve, the visceral branches leave the body wall to form nerve pathways that enter the body cavities. Within the cavities these nerves form the autonomic nerve pathways, sympathetic and parasympathetic, to the viscera. The autonomic nerves relay input signals from the wall of the tubular gut and other viscera, while carrying output signals to smooth muscle,



## Autonomic Nerves

- 1 Sympathetic trunk nerve
- 2 Sympathetic trunk ganglion
- 3 White communicating ramus
- 4 Gray communicating ramus
- 5 Greater splanchnic nerve
- 6 Lesser splanchnic nerve
- 7 Coeliac ganglion
- 8 Superior mesenteric ganglion
- 9 Aorticorenal ganglion
- 10 Vagus nerve
- 11 Recurrent laryngeal nerve
- 12 Anterior vagal trunk
- 13 Posterior vagal trunk
- 14 Inferior cardiac plexus
- 15 Pulmonary plexus
- 16 Esophageal plexus

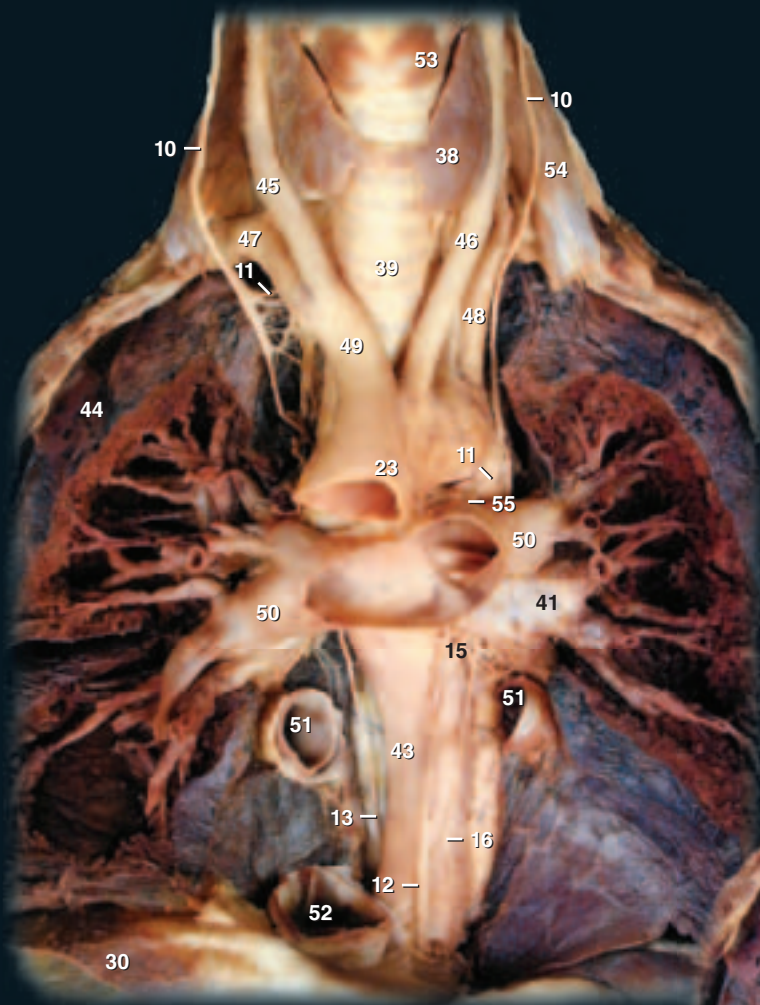
## Other Structures

- 17 Intercostal nerve
- 18 Posterior intercostal artery
- 19 Posterior intercostal vein
- 20 Right superior intercostal vein
- 21 Azygous vein
- 22 Superior vena cava
- 23 Aorta
- 24 Celiac trunk
- 25 Superior mesenteric artery
- 26 Renal artery
- 27 Suprarenal gland
- 28 Kidney
- 29 Ureter
- 30 Diaphragm
- 31 Esophageal hiatus
- 32 Subcostal muscle
- 33 Innermost intercostal muscle
- 34 Internal oblique muscle
- 35 Transversus abdominis muscle
- 36 Psoas major muscle
- 37 Psoas minor muscle

Deep dissection of sympathetic nerves, callout of communicating rami

Anterolateral view

cardiac muscle, and glands. Some of the autonomic nerves even rejoin the somatic pathways to supply the blood vessels and glands of the body wall. The sympathetic pathways are primarily associated with vascular smooth muscle control, and the parasympathetic pathways are principally responsible for the regulation and control of gut tube smooth muscle and glands. The sympathetic nerves are depicted on the opposite page, while the vagus nerve, which carries 75% of the parasympathetic output, is shown below as it follows the derivatives of the gut tube.



**Thoracic dissection revealing vagus nerve**  
Anterior view

- 38 Thyroid gland
- 39 Trachea
- 40 Principal bronchus
- 41 Lobar bronchus
- 42 Segmental bronchus
- 43 Esophagus
- 44 Lung
- 45 Right common carotid artery
- 46 Left common carotid artery
- 47 Right subclavian artery
- 48 Left subclavian artery
- 49 Brachiocephalic artery
- 50 Pulmonary arteries
- 51 Pulmonary veins
- 52 Inferior vena cava
- 53 Cricothyroid muscle
- 54 Anterior scalene muscle
- 55 Ligamentum arteriosum



**Deeper thoracic dissection revealing vagus nerve**  
Anterior view

# Cranial Nerves

Cranial nerves segregate into three distinct groups based on associations they form during development. In number there are twelve cranial nerves, which originate in pairs from a rostral to caudal sequence from the brain. The first category, the special sensory cranial nerves, are afferent pathways established between the the brain and the special sensory structures of the nose, eye, and ear. The second category, the ventral or somitic motor cranial nerves, are homologous with the ventral roots of the spinal nerves. They originate from the brainstem as efferent pathways to somitic skeletal muscles within the head. The final category, comprising the largest of the



## Special Sensory Nerves

- 1 Olfactory nerve
- 2 Optic nerve
- 3 Vestibulocochlear nerve

## Somitic Motor Nerves

- 4 Oculomotor nerve
- 5 Trochlear nerve
- 6 Abducens nerve
- 7 Hypoglossal nerve

## Pharyngeal Arch Nerves

- 8 Trigeminal nerve
- 9 Trigeminal ganglion
- 10 Ophthalmic branch
- 11 Maxillary branch
- 12 Mandibular branch
- 13 Facial nerve
- 14 Glossopharyngeal nerve
- 15 Vagus nerve
- 16 Accessory nerve

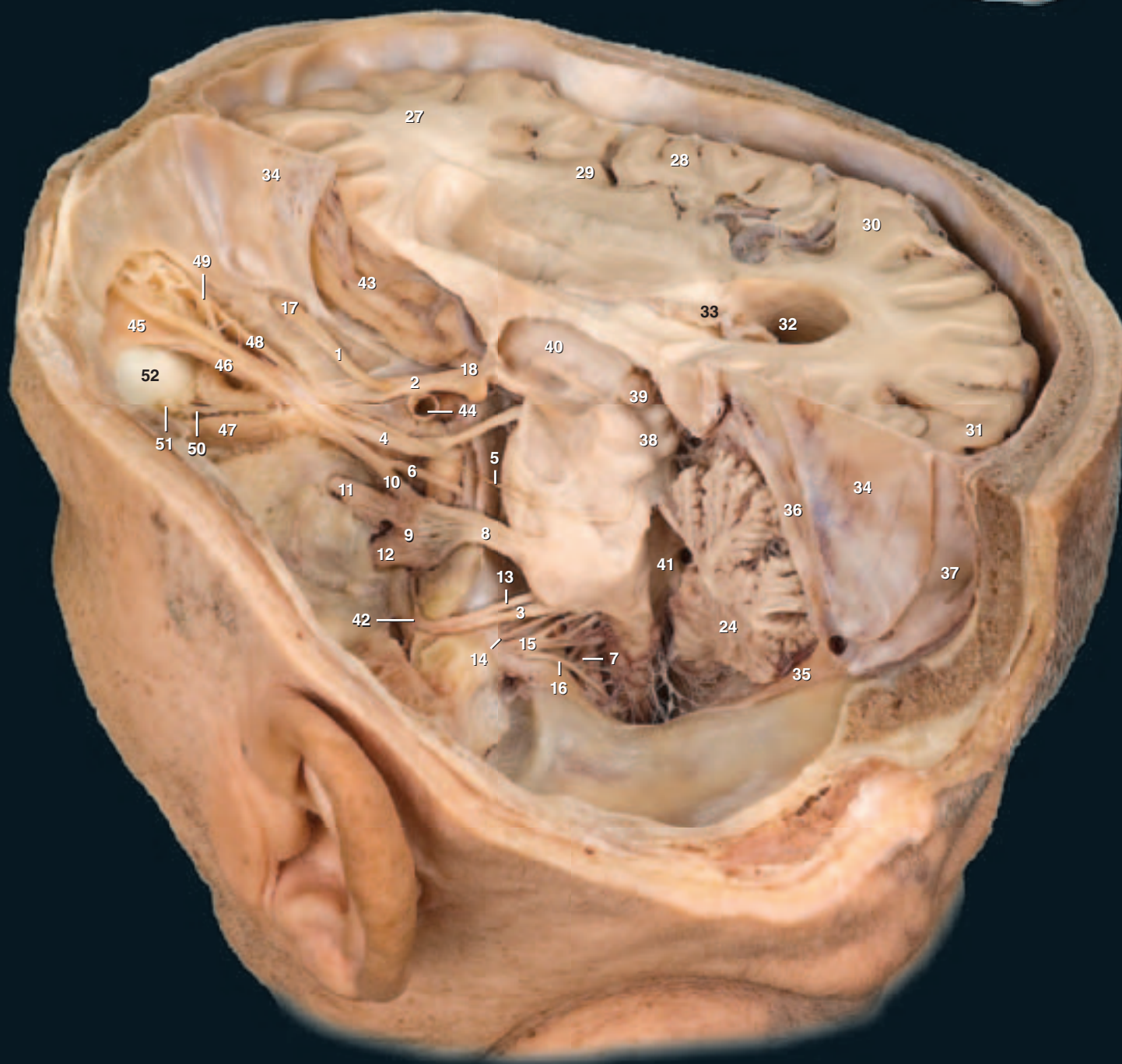
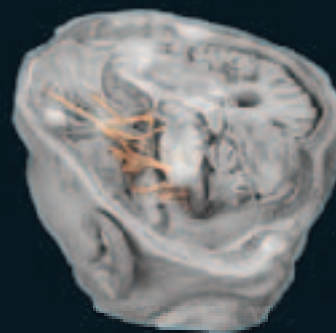
## Other Structures

- 17 Olfactory bulb
- 18 Optic chiasm
- 19 Optic tract
- 20 Infundibulum
- 21 Mammillary bodies
- 22 Cerebral peduncle
- 23 Pons
- 24 Cerebellum
- 25 Medulla oblongata
- 26 Spinal cord
- 27 Frontal lobe
- 28 Temporal lobe
- 29 Insular lobe
- 30 Parietal lobe
- 31 Occipital lobe
- 32 Right lateral ventricle
- 33 Choroid plexus
- 34 Falx cerebri
- 35 Falx cerebelli
- 36 Straight sinus
- 37 Superior sagittal sinus
- 38 Corpora quadrigemina
- 39 Pineal gland
- 40 Third ventricle
- 41 Fourth ventricle
- 42 Geniculate ganglion
- 43 Anterior cerebral artery
- 44 Internal carotid artery
- 45 Levator palpebrae superioris muscle
- 46 Superior rectus muscle
- 47 Lateral rectus muscle
- 48 Superior oblique muscle
- 49 Nasociliary nerve
- 50 Long ciliary nerve
- 51 Ciliary ganglion
- 52 Eye



Base of brain with cranial nerves  
Inferior view

cranial nerves, are those cranial nerves associated with the pharyngeal arches. The dorsal or pharyngeal arch cranial nerves are developmentally similar to the dorsal roots of the spinal nerves. These five dorsal cranial nerves form the general sensory afferent pathways from the peripheral tissues of the head. However, because these nerve pathways coursed through the specialized arches forming the pharyngeal wall of the foregut, they established parasympathetic efferent pathways to the glandular tissue of the gut wall, along with motor efferent pathways to the skeletal muscles derived from the pharyngeal arch tissues.

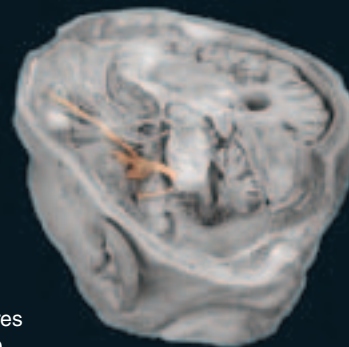


**Intracranial dissection of cranial nerves**  
Posterolateral view

# Cranial Nerves

Cranial nerves V and VII, the trigeminal and facial nerves respectively, have the most extensive distribution to the tissues of the head. This page

and the three pages that follow depict the peripheral distribution of many of the branches of the trigeminal and facial nerves.



## Trigeminal Nerve

- 1 Auriculotemporal nerve
- 2 Supraorbital nerve
- 3 Infraorbital nerve
- 4 Mental nerve
- 5 Maxillary branch
- 6 Nerve of the pterygoid canal
- 7 Pterygopalatine ganglion
- 8 Nasopalatine nerve (cut)

- 9 Superior posterior lateral nasal branch
- 10 Inferior posterior lateral nasal branch
- 11 Pharyngeal branch
- 12 Lesser palatine nerve
- 13 Greater palatine nerve

## Facial Nerve

- 14 Temporal branches
- 15 Zygomatic branches

- 16 Buccal branches
- 17 Mandibular branches
- 18 Cervical branch

## Other Nerves and Structures

- 19 Greater occipital nerve
- 20 Lesser occipital nerve
- 21 Great auricular nerve
- 22 Auricularis posterior muscle



Dissection of head exposing branches of the facial nerve  
Lateral view



23 Occipital belly of epicranii muscle  
 24 Galia aponeurotica  
 25 Frontal belly of epicranii muscle  
 26 Temporal fascia  
 27 Temporalis muscle  
 28 Orbicularis oculi muscle  
 29 Zygomaticus major muscle  
 30 Risorius muscle  
 31 Buccinator muscle

32 Masseter muscle  
 33 Posterior digastricus muscle  
 34 Parotid duct  
 35 External carotid artery  
 36 Submandibular gland  
 37 Frontal sinus  
 38 Cerebrum  
 39 Falx cerebri  
 40 Corpus callosum

41 Septum pellucidum  
 42 Thalamus  
 43 Midbrain  
 44 Pons  
 45 Cerebellum  
 46 Fourth ventricle  
 47 Choroid plexus  
 48 Medulla oblongata  
 49 Spinal cord

50 Pituitary gland  
 51 Torus tubarius  
 52 Maxillary sinus  
 53 Middle nasal concha  
 54 Inferior nasal concha  
 55 Hard palate  
 56 Soft palate  
 57 Uvula  
 58 Tongue



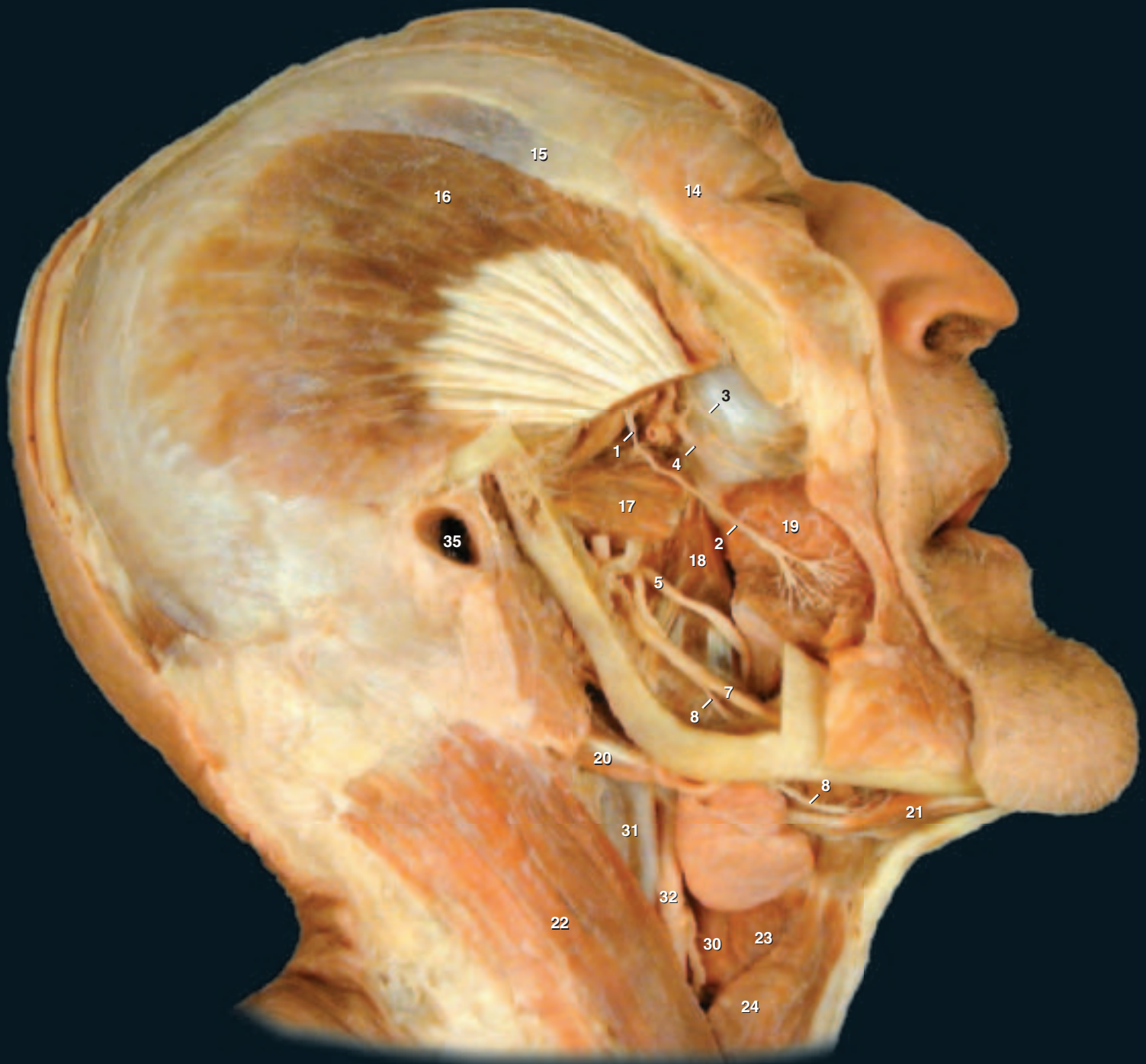
Parasagittal section and dissection of head exposing branches of the trigeminal and facial nerve  
 Medial view

# Cranial Nerves

- 1 Nerve to temporalis muscle
- 2 Buccal nerve
- 3 Middle superior alveolar nerve
- 4 Posterior superior alveolar nerve
- 5 Lingual nerve
- 6 Chorda tympani nerve

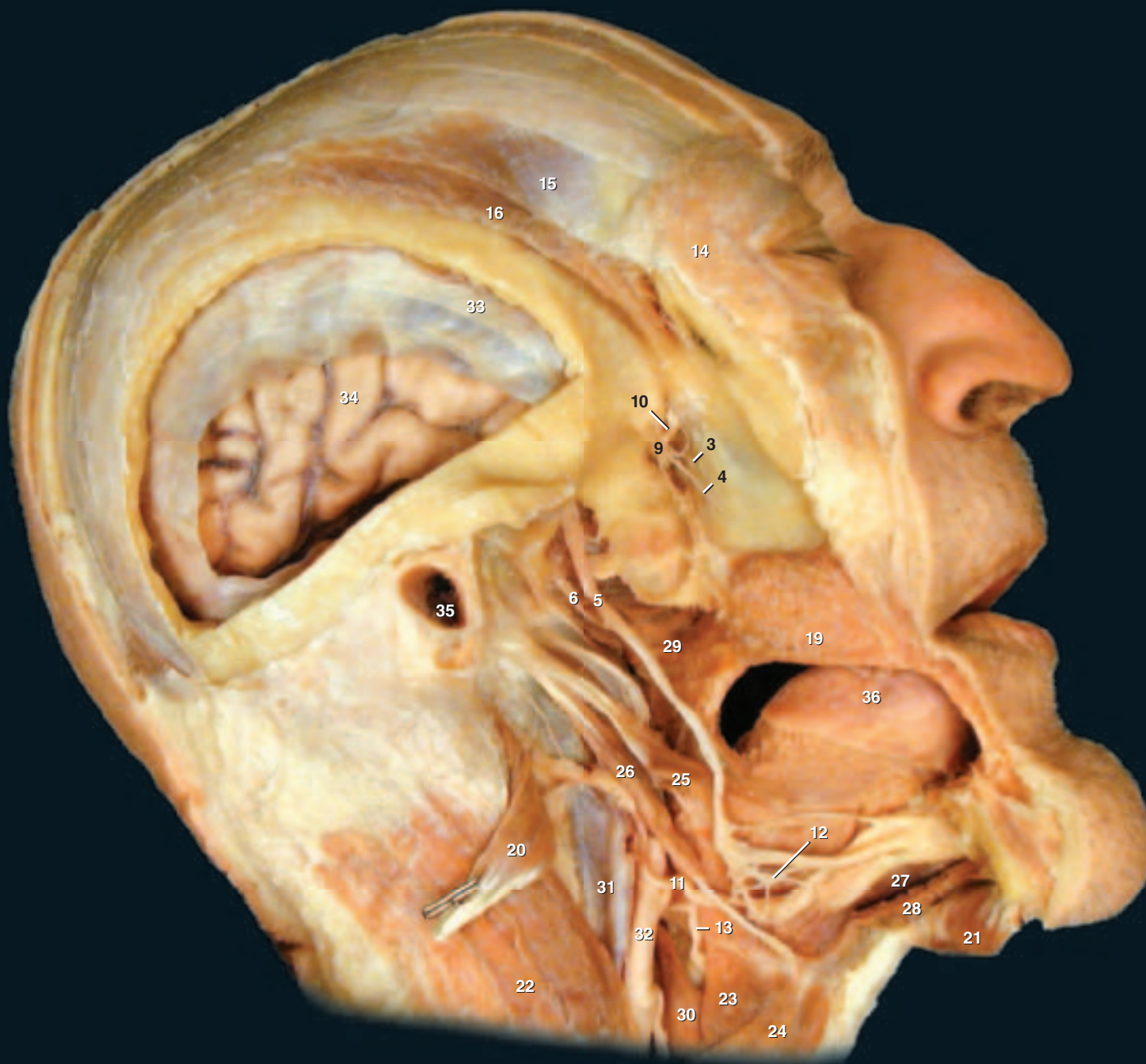
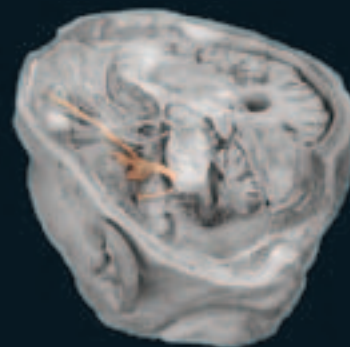
- 7 Inferior alveolar nerve
- 8 Nerve to mylohyoid muscle
- 9 Pterygopalatine ganglion
- 10 Infraorbital nerve
- 11 Hypoglossal nerve
- 12 Submandibular ganglion

- 13 Superior laryngeal nerve
- Other Structures
- 14 Orbicularis oculi muscle
  - 15 Temporal fascia
  - 16 Temporalis muscle



Dissection of head exposing branches of the trigeminal nerve  
Lateral view

- |                               |                                    |                             |
|-------------------------------|------------------------------------|-----------------------------|
| 17 Lateral pterygoid muscle   | 24 Omohyoid muscle                 | 31 Internal jugular vein    |
| 18 Medial pterygoid muscle    | 25 Styloglossus muscle             | 32 Common carotid artery    |
| 19 Buccinator muscle          | 26 Stylohyoid muscle               | 33 Dura mater               |
| 20 Posterior digastric muscle | 27 Geniohyoid muscle               | 34 Cerebrum                 |
| 21 Anterior digastric muscle  | 28 Mylohyoid muscle                | 35 External acoustic meatus |
| 22 Sternocleidomastoid muscle | 29 Superior pharyngeal constrictor | 36 Tongue                   |
| 23 Thyrohyoid muscle          | 30 Inferior pharyngeal constrictor |                             |

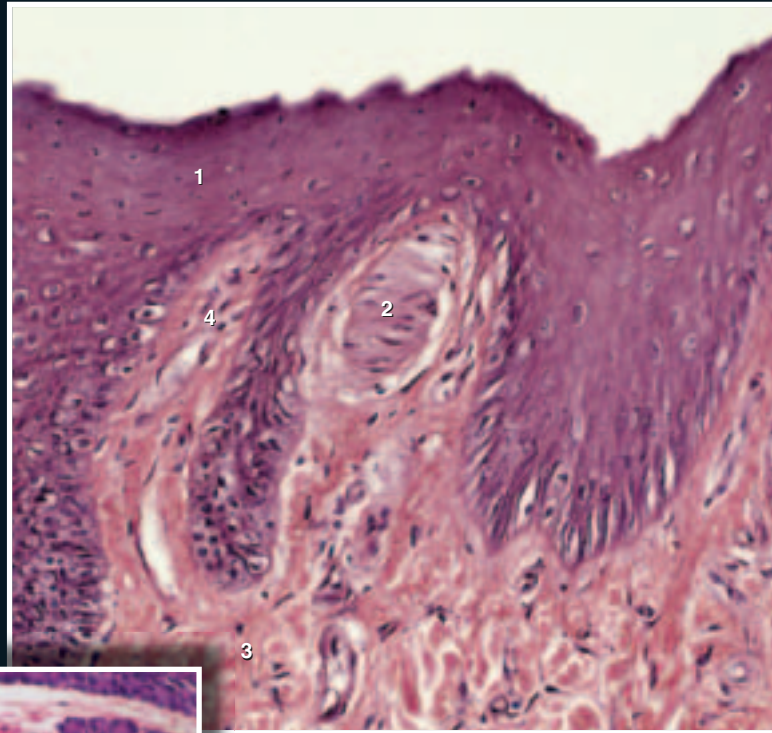


Dissection of head with mandible removed  
Lateral view

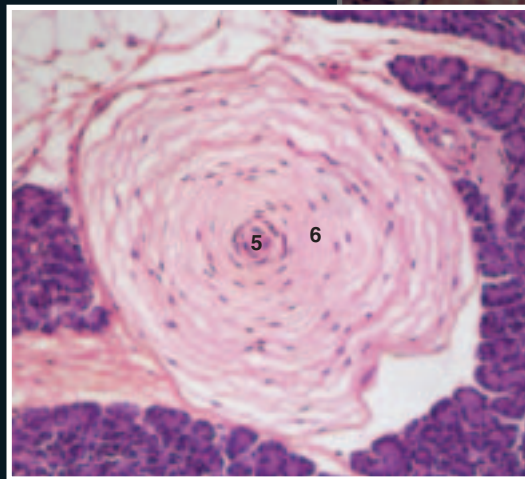
# Sensory Receptors

Sensory receptors are the transducers of the nervous system; that is, they convert the different types of energy we experience such as mechanical energy (touch, pressure, sound waves, etc.), thermal energy (heat), chemical energy (taste, smell), and electromagnetic energy (light) into the electrical energy of the nervous impulse. They do this by facilitating the depolarization of the peripheral terminals of the sensory neurons. This initiates the nervous impulse along the sensory neuron, and this input is carried by the sensory neuron to the processing centers of the brain and spinal cord, which will be the topic of the next chapter.

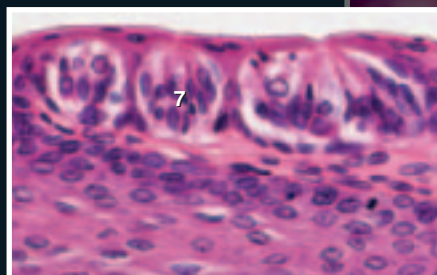
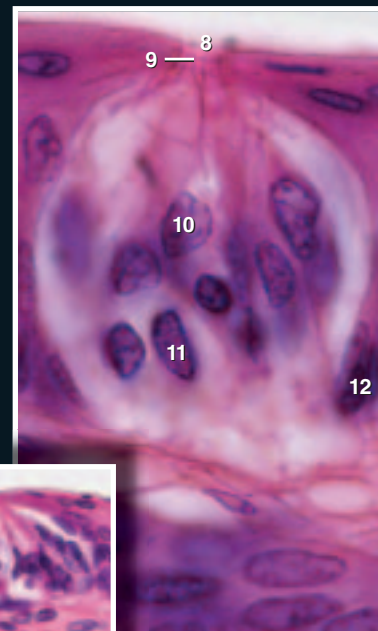
- 1 Epidermis
- 2 Corpuscle of touch (Meissner's)
- 3 Dermis
- 4 Dermal papilla
- 5 Neuron
- 6 Lamellated corpuscle
- 7 Taste bud
- 8 Taste pore
- 9 Gustatory hair
- 10 Gustatory receptor cell
- 11 Supporting cell
- 12 Basal cell



Photomicrograph of corpuscle of touch  
200x



Photomicrograph of lamellated corpuscle  
100x



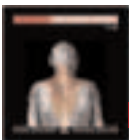
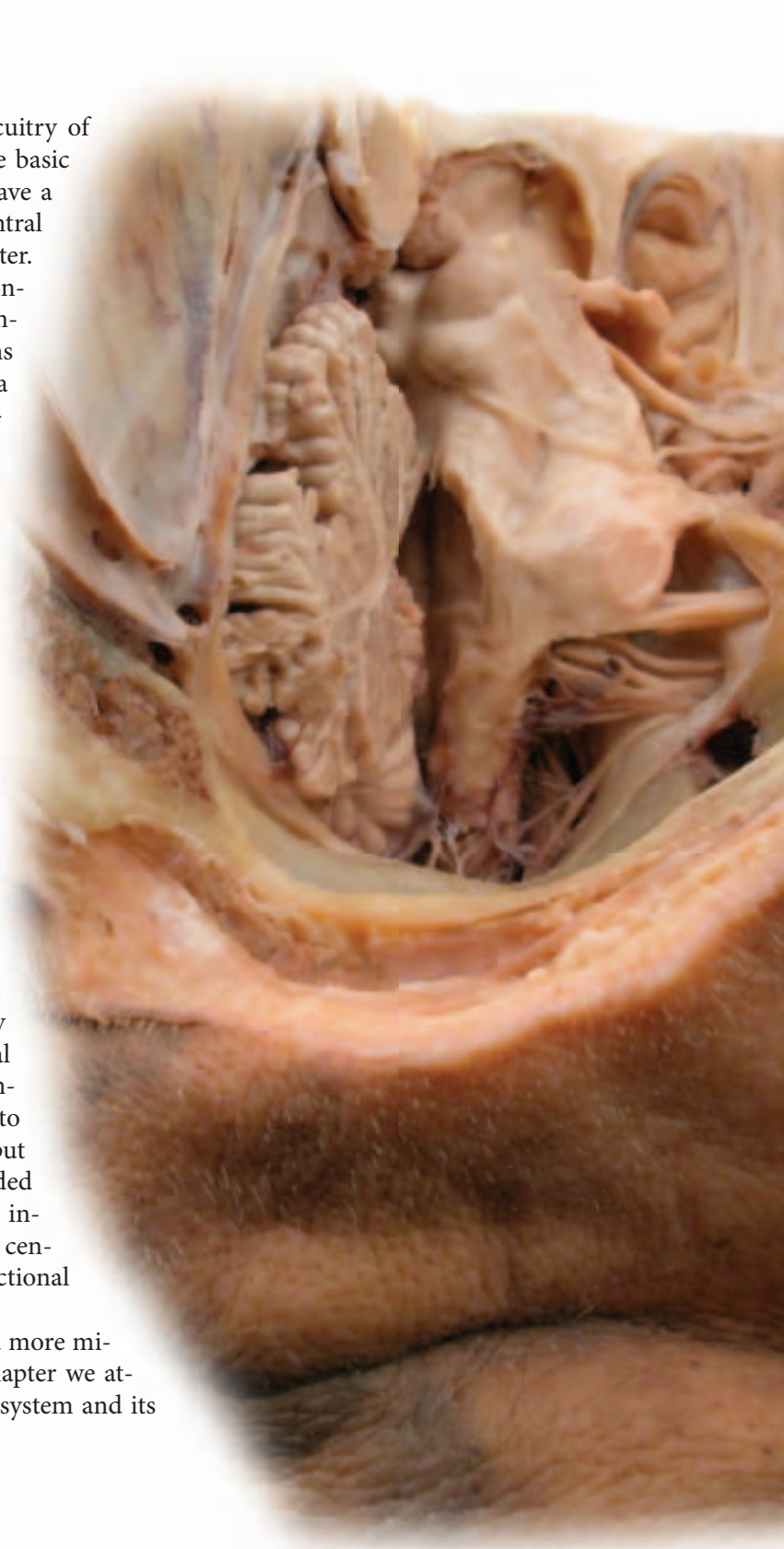
Photomicrographs of taste bud  
200x (left), 700x (right)

# 14 Central Nervous System

While the neuronal circuitry of the central nervous system is awe inspiring to say the least, the basic concepts behind this complex integration and control center have a simple design. At its simplest, the fundamental design of the central nervous system involves two features: gray matter and white matter. The gray matter centers represent the synaptic integration and control circuits; that is, these centers contain numerous highly dendritic interneurons along with the cell bodies of efferent neurons and axon terminals of incoming afferent neurons, all forming a myriad of synaptic circuits. In these gray centers input is integrated, compared, sensed, and stored to give rise to coordinated, controlled output. The white matter, on the other hand, represents conduction tracts between the synaptic gray centers. These white tracts consist mainly of the myelinated axons of interneurons relaying signals from one gray center to another.

A second simple concept to keep in mind is that the complexity of the central nervous system increases from a caudal to cranial direction. There is logic to this pattern because in the spinal cord the gray centers primarily function as integration networks that regulate input and output for their specific spinal nerve levels. In other words, they are segmental control centers. Input entering a spinal nerve level initiates reflexive output back to the peripheral tissues at that same spinal level. Connecting these segmental gray centers via interneuronal tracts leads to greater association between neighboring levels, therefore improving integration and control. If one segmental gray center can relay information received from its center to neighboring centers, then there can be a greater spread of control generated in response to local segmental input. Now take this a step further by relaying information via white tracts from each of the segmental control centers to higher centers. These higher centers receive input from all the lower segmental centers, integrating the input to gain a full body perspective, while generating the necessary output signals to exert coordinated full body control. Because of this added circuitry the cranial or brain end of the central nervous system increases in size. This additive accumulation of interconnected gray centers accounts for the structure of the brain and its amazing functional properties.

Because much of the central nervous system circuitry is of a more microscopic nature and beyond the scope of this book. In this chapter we attempt to depict the basic gross anatomy of the central nervous system and its protective coverings.



Find more information  
about the central nervous  
system in

REALANATOMY





Cervical spinal cord



Thoracic spinal cord



Lumbar spinal cord



Sacral spinal cord

Dissection of vertebral column and skull revealing brain and spinal cord  
 Posterior view, with call-out of terminal end of cord

# Brain

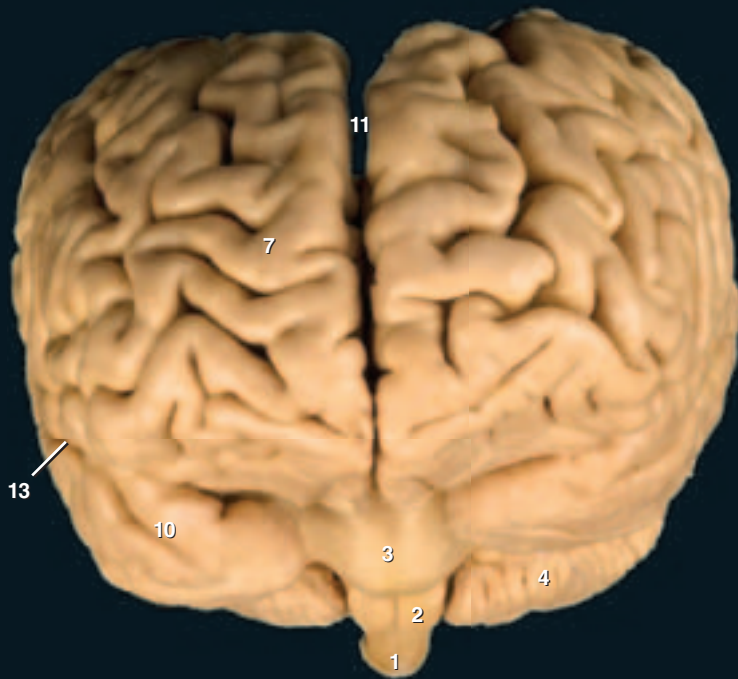
The brain is the large, anterior-expansion of the neural tube situated within the cranium. Rapid development of the rostral end of the neural tube forms three expanded regions — the prosencephalon, mesencephalon, and rhombencephalon. The prosencephalon undergoes further development to form the telencephalon and diencephalon, and the rhombencephalon continues to develop to form a metencephalon and myelencephalon. These five embryonic regions give rise to the brain. The telencephalon becomes the cerebrum, the diencephalon becomes the thalamic regions, the mesencephalon becomes the midbrain, the metencephalon becomes the cerebellum and pons, and the myelencephalon becomes the medulla oblongata. A variety of views of the full brain are depicted on this and the facing page.

- |                             |                              |                            |
|-----------------------------|------------------------------|----------------------------|
| 1 Spinal cord               | 9 Occipital lobe of cerebrum | 17 Central sulcus          |
| 2 Medulla oblongata         | 10 Temporal lobe of cerebrum | 18 Precentral gyrus        |
| 3 Pons                      | 11 Longitudinal fissure      | 19 Postcentral gyrus       |
| 4 Cerebellum                | 12 Transverse fissure        | 20 Precentral sulcus       |
| 5 Midbrain                  | 13 Lateral cerebral sulcus   | 21 Postcentral sulcus      |
| 6 Diencephalon              | 14 Anterior median fissure   | 22 Inferior frontal gyrus  |
| 7 Frontal lobe of cerebrum  | 15 Gyrus                     | 23 Superior temporal gyrus |
| 8 Parietal lobe of cerebrum | 16 Sulcus                    |                            |



**Brain**  
Lateral view

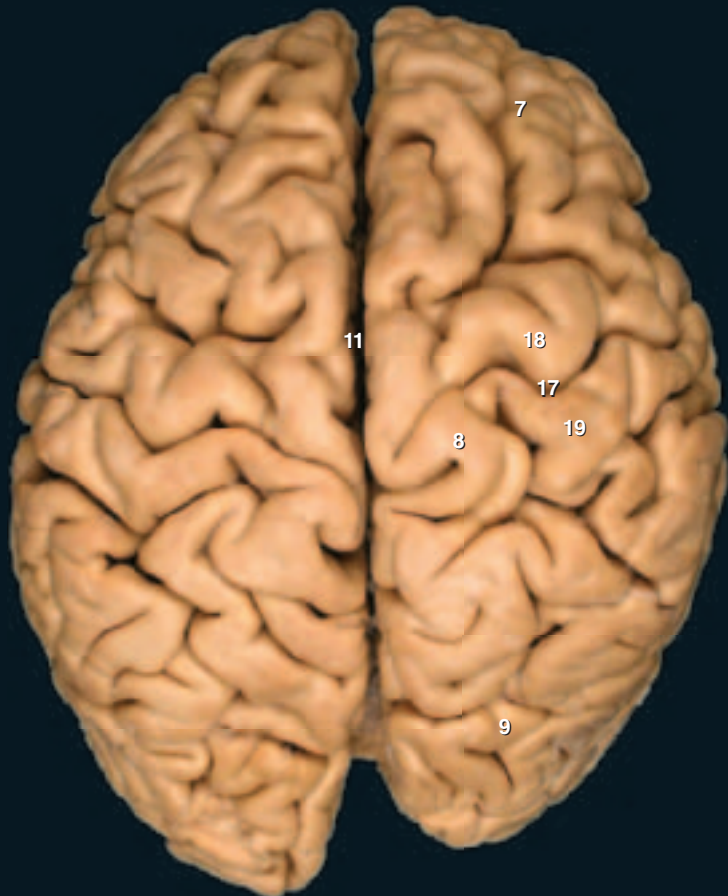




**Brain**  
Anterior view



**Brain**  
Posterior view



**Brain**  
Superior view

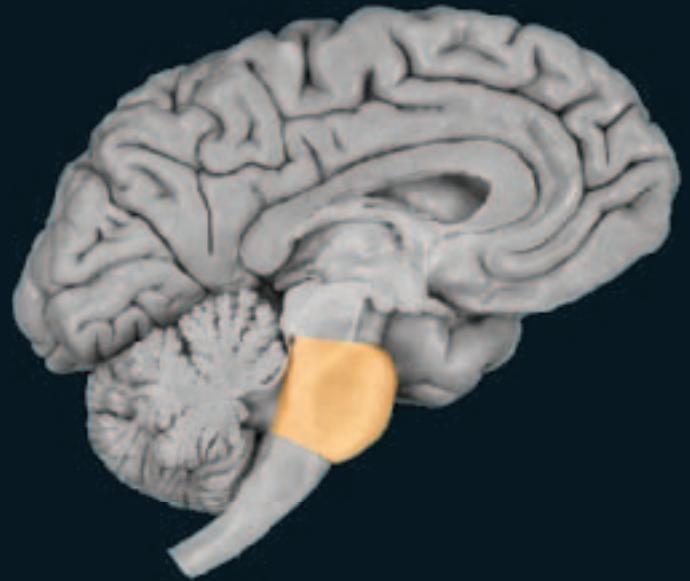


**Brain**  
Inferior view

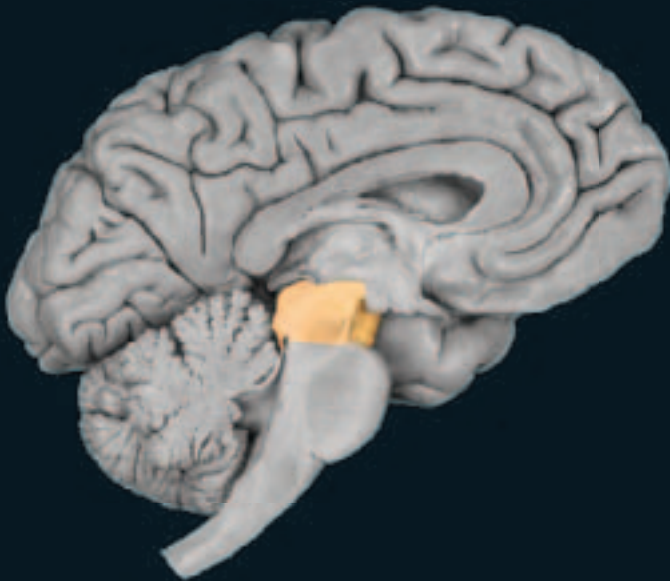




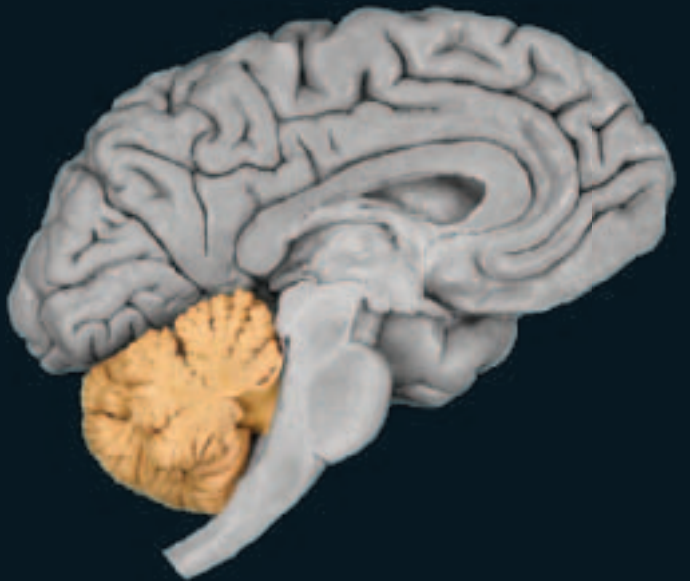
Medulla oblongata



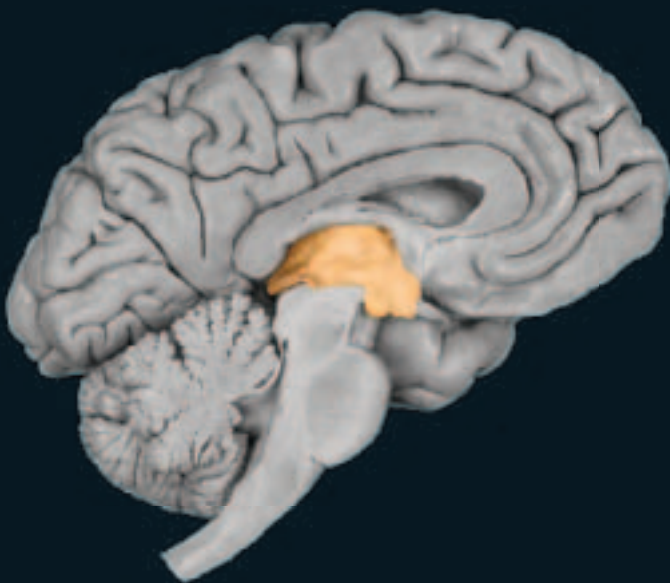
Pons



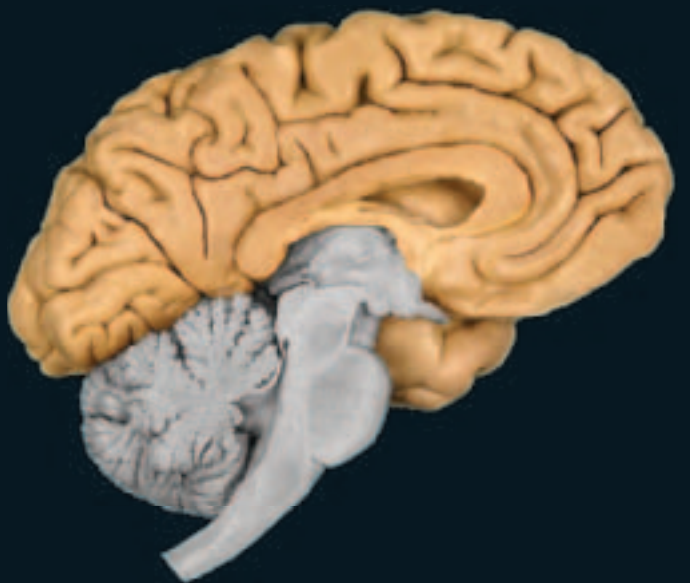
Midbrain



Cerebellum



Diencephalon – epithalamus, thalamus, hypothalamus



Cerebrum

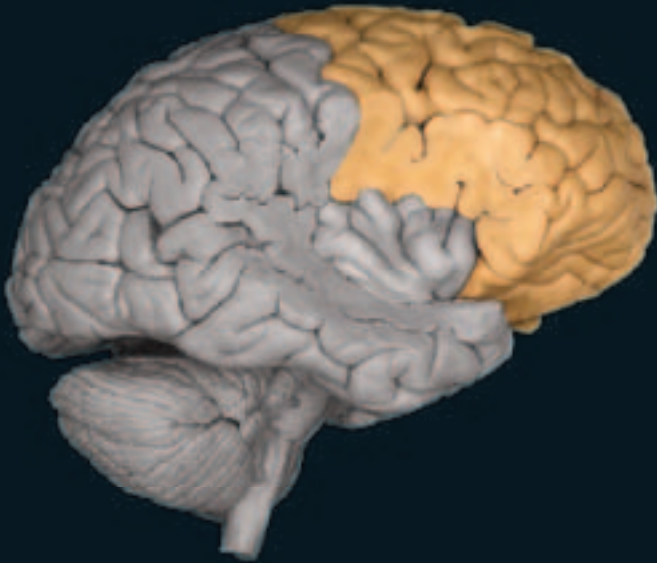
# Cerebrum

The cerebrum, by far the largest part of the human brain, consists of the cerebral hemispheres and the basal nuclei. The large, obvious cerebrum is divided into two halves, the right and left cerebral hemispheres. Each cerebral hemisphere has an outer layer of gray matter, the cerebral cortex, covering deeper networks of interconnecting white tracts that connect different areas of the cortex with one another and with lower brain centers. The amount of cortex is greatly increased by a complex folding of the cerebral surface. The folds produce hills, gyri (singular gyrus), and depressions, sulci (singular sulcus). This cortical surface forms the highest level of processing circuitry in the brain. The two hemispheres are connected to each other by the corpus callosum, a thick band consisting of an estimated 300 million neuronal axons traversing between the two hemispheres. Located deep within the cerebrum is another region of gray matter, the basal nuclei, which form key integration centers between the cortex and lower brain centers.

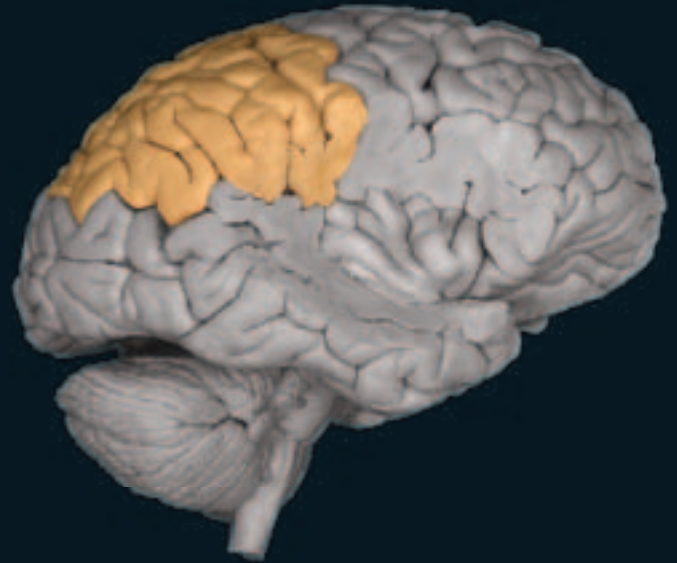
- |                               |                            |                      |
|-------------------------------|----------------------------|----------------------|
| 1 Central sulcus              | 8 Calcarine sulcus         | 15 Short gyri        |
| 2 Precentral gyrus            | 9 Superior temporal gyrus  | 16 Long gyrus        |
| 3 Postcentral gyrus           | 10 Middle temporal gyrus   | 17 Limen             |
| 4 Precentral sulcus           | 11 Inferior temporal gyrus | 18 Pons              |
| 5 Postcentral sulcus          | 12 Inferior frontal gyrus  | 19 Cerebellum        |
| 6 Parieto-occipital sulcus    | 13 Middle frontal gyrus    | 20 Medulla oblongata |
| 7 Transverse occipital sulcus | 14 Superior frontal gyrus  | 21 Spinal cord       |



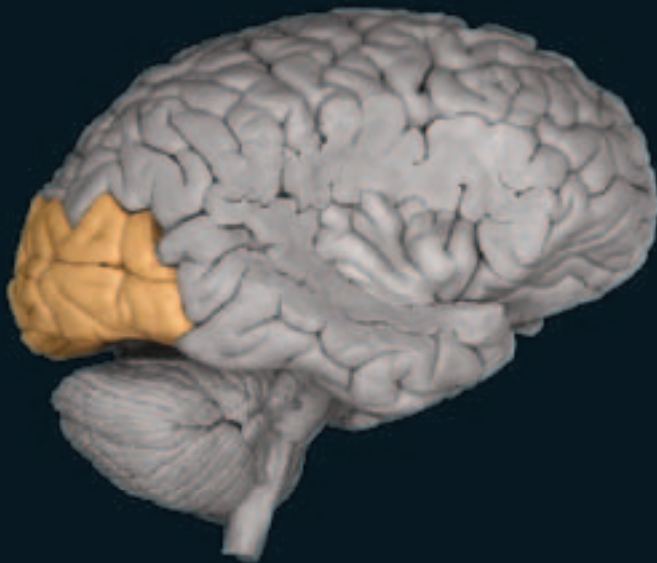
Brain dissection revealing insular lobe  
Lateral view



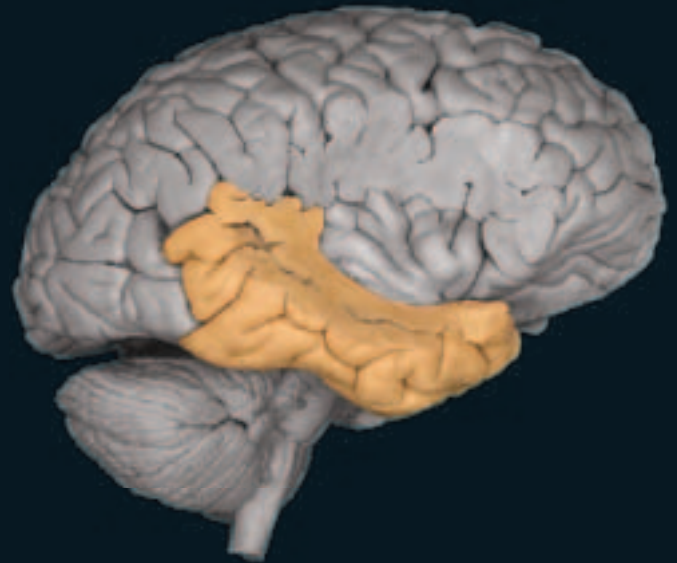
Frontal lobe



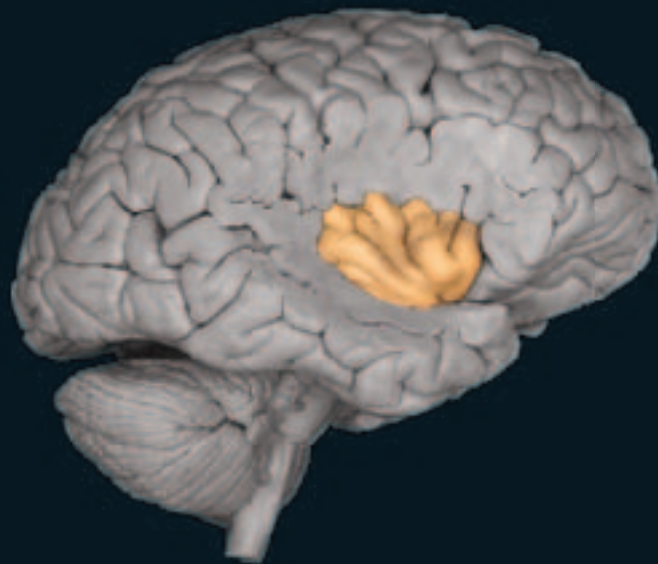
Parietal lobe



Occipital lobe



Temporal lobe



Insular lobe

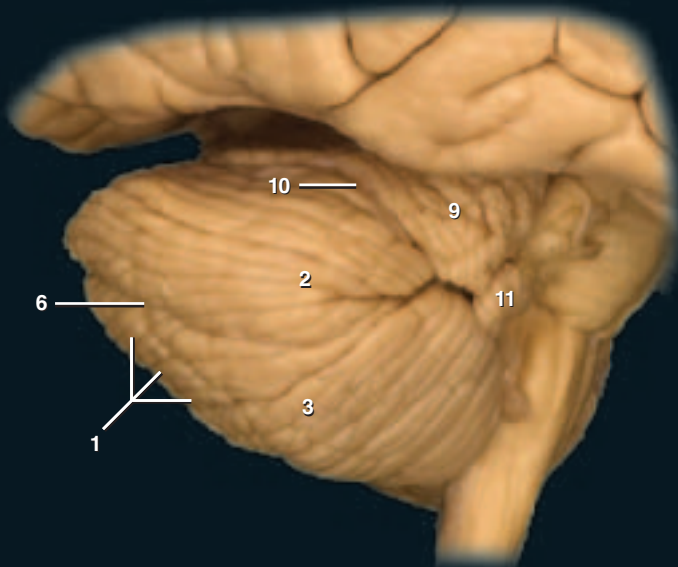
# Cerebellum

Immediately above the medulla oblongata the central nervous system expands dorsally to form the cerebellum, which means little brain. The cerebellum, like the cerebrum, has a highly folded surface that greatly increases the surface area of its outer gray matter cortex. It is estimated that the cerebellum has in the neighborhood of 10 billion neurons, which have a variety of functional roles. The cerebellum processes input received from the cerebral cortex, various brain stem nuclei, and peripheral sensory receptors to smooth and coordinate complex, skilled movements. It plays an important role in posture and balance and functions in cognition and language processing.

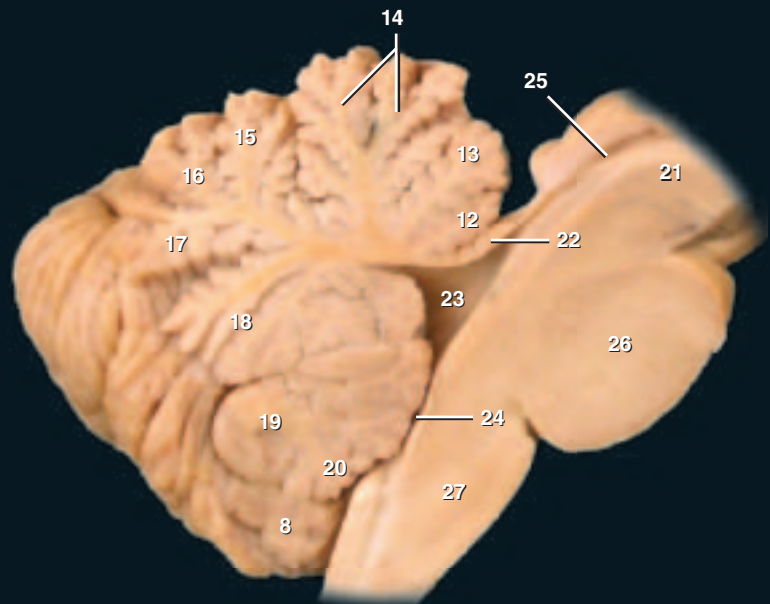
- |                                 |                    |                             |
|---------------------------------|--------------------|-----------------------------|
| 1 Folia of cerebellum           | 10 Primary fissure | 19 Uvula                    |
| 2 Anterior lobe of cerebellum   | 11 Flocculus       | 20 Nodulus                  |
| 3 Posterior lobe of cerebellum  | 12 Lingula         | 21 Midbrain                 |
| 4 Superior vermis               | 13 Central lobule  | 22 Superior medullary velum |
| 5 Inferior vermis               | 14 Culmen          | 23 Fourth ventricle         |
| 6 Postlunate fissure            | 15 Declive         | 24 Median aperture          |
| 7 Posterior cerebellar notch    | 16 Folium          | 25 Cerebral aqueduct        |
| 8 Tonsil                        | 17 Tuber           | 26 Pons                     |
| 9 Quadrangular lobe of anterior | 18 Pyramid         | 27 Medulla oblongata        |



**Cerebellum**  
Posterior view



**Cerebellum**  
Lateral view



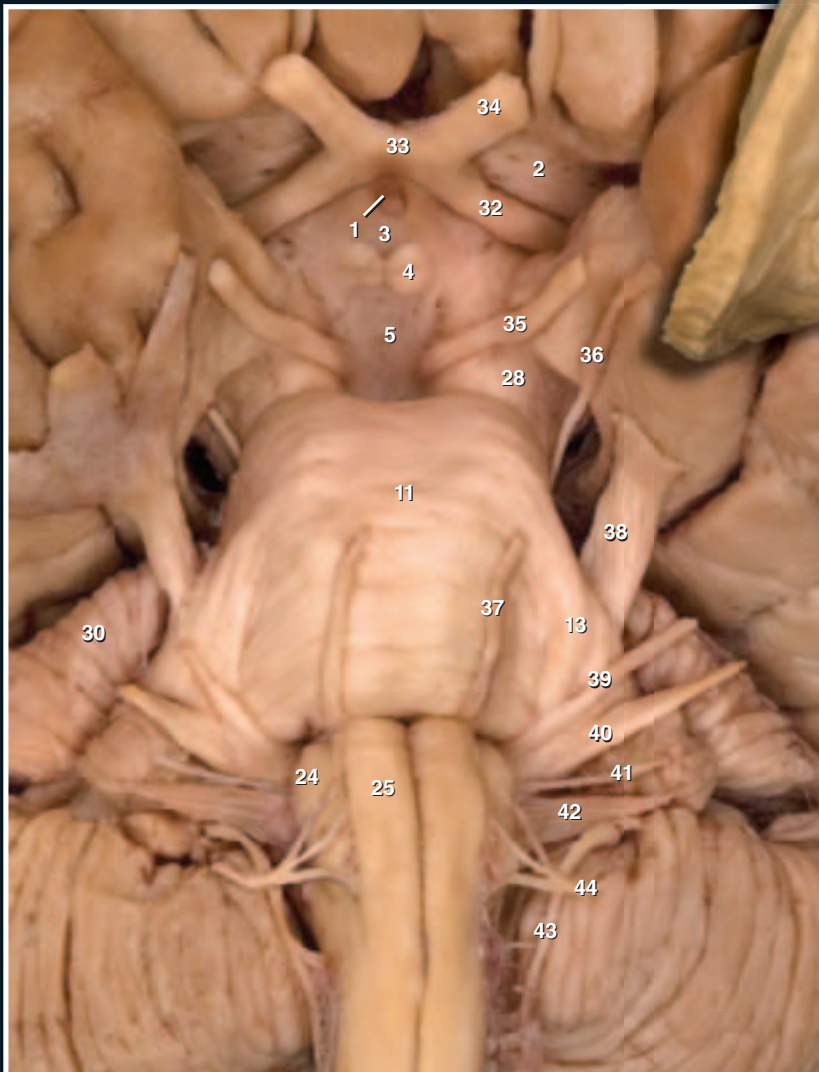
**Sagittal section of cerebellum**  
Medial view

# Diencephalon and Brainstem

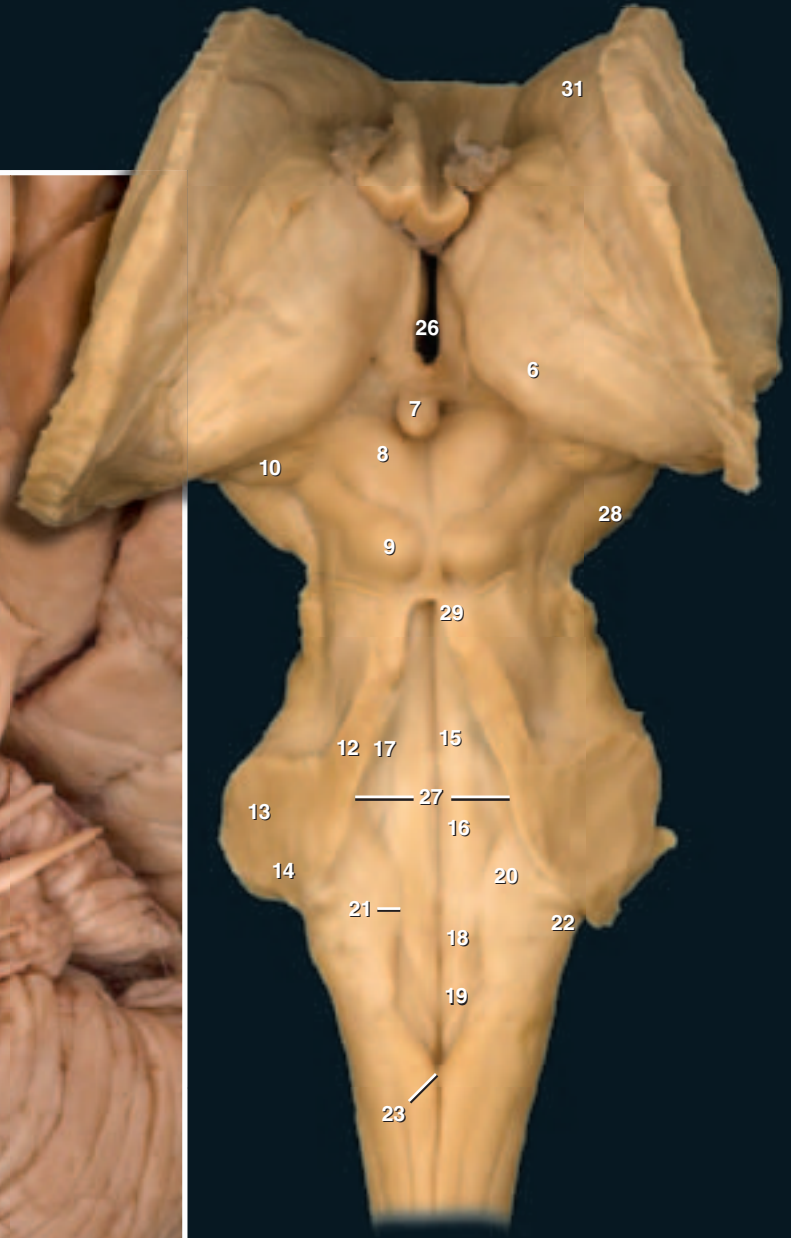
The diencephalon, rostral to the midbrain and almost completely surrounded by the cerebral hemispheres, consists of four

major parts — the thalamus, subthalamus, epithalamus, and hypothalamus. Projecting from the hypothalamus is the hypophysis, or pituitary gland. The brainstem consists of the medulla oblongata, pons, and midbrain. The medulla resembles the spinal cord in many ways. Like the cord it gives rise to many nerve roots; however, these are the roots of cranial nerves rather than spinal nerves. The pons is the bridge between the two cerebellar hemispheres. The ventral portion of the pons forms a large synaptic relay station consisting of scattered gray centers called the pontine nuclei. The dorsal portion of the pons is more like the other regions of the brainstem, the medulla and midbrain. The midbrain sits just above the pons and is obscured by the large, overlapping cerebral hemispheres. It contains nuclei for cranial nerves III and IV, as well as ascending and descending fiber tracts from the cerebrum.

- |                                  |                         |                              |                            |
|----------------------------------|-------------------------|------------------------------|----------------------------|
| 1 Infundibulum                   | 15 Medial eminence      | 29 Superior medullary vellum | 37 Abducens nerve          |
| 2 Anterior perforated substance  | 16 Facial colliculus    | 30 Flocculus of cerebellum   | 38 Trigeminal nerve        |
| 3 Tuber cinereum                 | 17 Locus ceruleus       | 31 Caudate nucleus           | 39 Facial nerve            |
| 4 Mammillary body                | 18 Trigeminal tubercle  | 32 Optic tract               | 40 Vestibulocochlear nerve |
| 5 Posterior perforated substance | 19 Hypoglossal tubercle | 33 Optic chiasm              | 41 Glossopharyngeal nerve  |
| 6 Pulvinar of thalamus           | 20 Vestibular area      | 34 Optic nerve               | 42 Vagus nerve             |
| 7 Pineal gland                   | 21 Sulcus limitans      | 35 Oculomotor nerve          | 43 Accessory nerve         |
| 8 Superior colliculus            | 22 Lateral recess       | 36 Trochlear nerve           | 44 Hypoglossal nerve       |
| 9 Inferior colliculus            | 23 Obex                 |                              |                            |
| 10 Medial geniculate ganglion    | 24 Olive                |                              |                            |
| 11 Pons                          | 25 Pyramid              |                              |                            |
| 12 Superior cerebellar peduncle  | 26 Third ventricle      |                              |                            |
| 13 Middle cerebellar peduncle    | 27 Fourth ventricle     |                              |                            |
| 14 Inferior cerebellar peduncle  | 28 Cerebral crus        |                              |                            |



**Brainstem**  
Ventral view

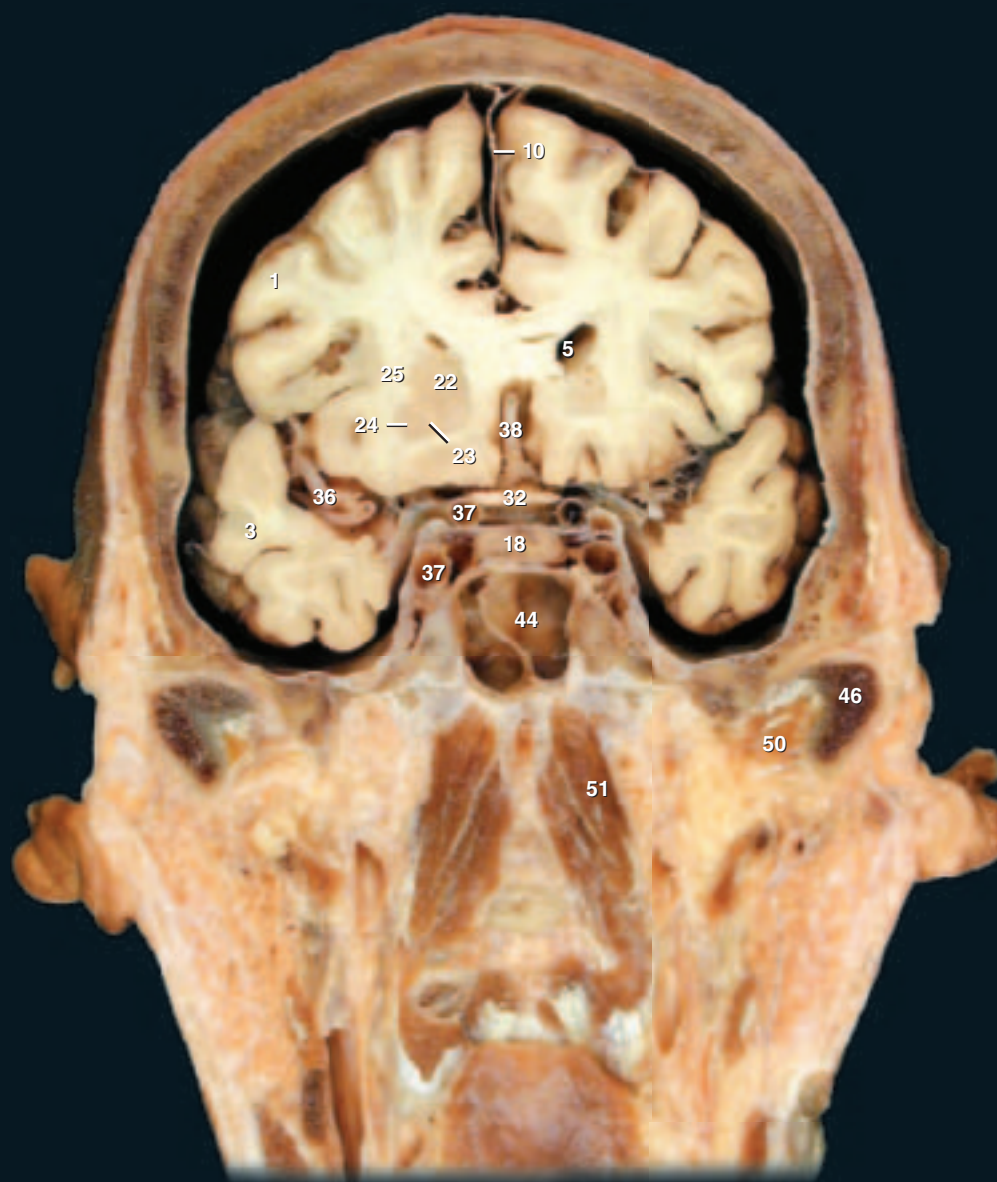


**Brainstem**  
Posterior view

# Brain Sections

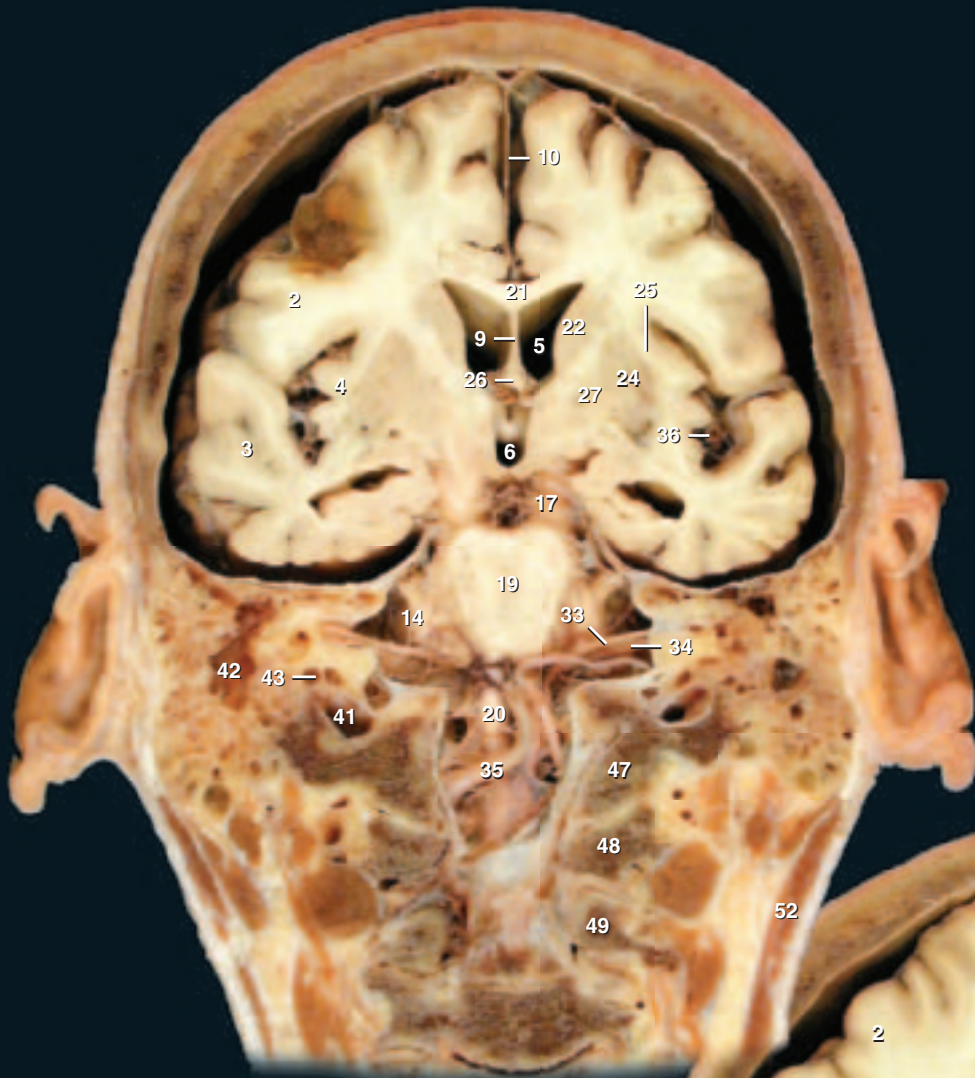
The brain sections on this and the following page depict aspects of brain anatomy that are not evident on the external views of the brain, and the association of the brain with surrounding structures of the head. Each section is approximately 2 centimeters thick and is an anterior view of three sections in succession. The first section begins at the anterior aspect of the ear and the last section is just posterior to the ear.

- |                                 |                                 |                             |                               |
|---------------------------------|---------------------------------|-----------------------------|-------------------------------|
| 1 Frontal lobe                  | 14 Flocculus                    | 27 Globus pallidus          | 40 Sigmoid sinus              |
| 2 Parietal lobe                 | 15 Superior vermis              | 28 Medial thalamic nucleus  | 41 Internal jugular vein      |
| 3 Temporal lobe                 | 16 Superior cerebellar peduncle | 29 Lateral thalamic nucleus | 42 Tympanic cavity            |
| 4 Insular lobe                  | 17 Cerebral peduncle            | 30 Dentate gyrus            | 43 Cochlea                    |
| 5 Lateral ventricle             | 18 Pituitary gland              | 31 Circular gyrus           | 44 Sphenoid sinus             |
| 6 Third ventricle               | 19 Pons                         | 32 Optic chiasm             | 45 Mastoid air cells          |
| 7 Cerebral aqueduct             | 20 Olive                        | 33 Facial nerve             | 46 Mandibular condyle         |
| 8 Fourth ventricle              | 21 Corpus callosum              | 34 Vestibulocochlear nerve  | 47 Occipital condyle          |
| 9 Septum pellucidum             | 22 Caudate nucleus              | 35 Vertebral artery         | 48 Atlas                      |
| 10 Falx cerebri                 | 23 Internal capsule             | 36 Middle cerebral artery   | 49 Axis                       |
| 11 Tentorium cerebelli          | 24 Putamen                      | 37 Internal carotid artery  | 50 Lateral pterygoid muscle   |
| 12 Anterior lobe of cerebellum  | 25 External capsule             | 38 Anterior cerebral artery | 51 Medial pterygoid muscle    |
| 13 Posterior lobe of cerebellum | 26 Body of fornix               | 39 Superior sagittal sinus  | 52 Sternocleidomastoid muscle |

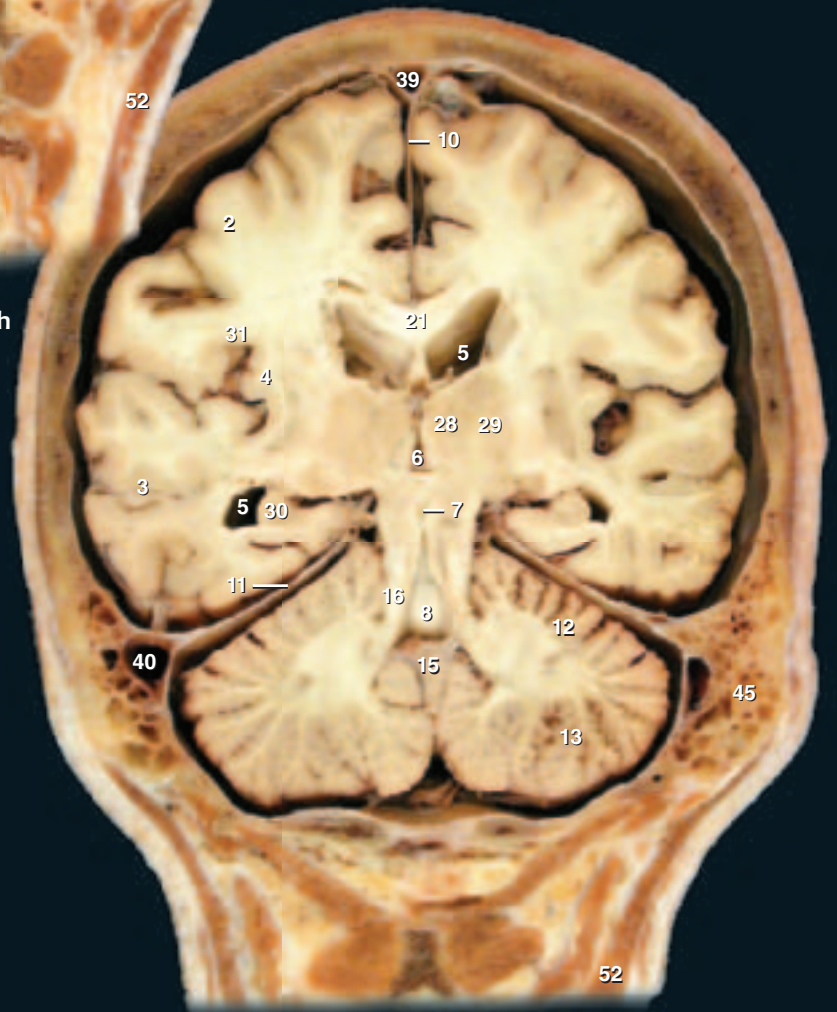


Frontal section of head at anterior aspect of auricle  
Anterior view





Frontal section of head through  
middle of auricle  
Anterior view

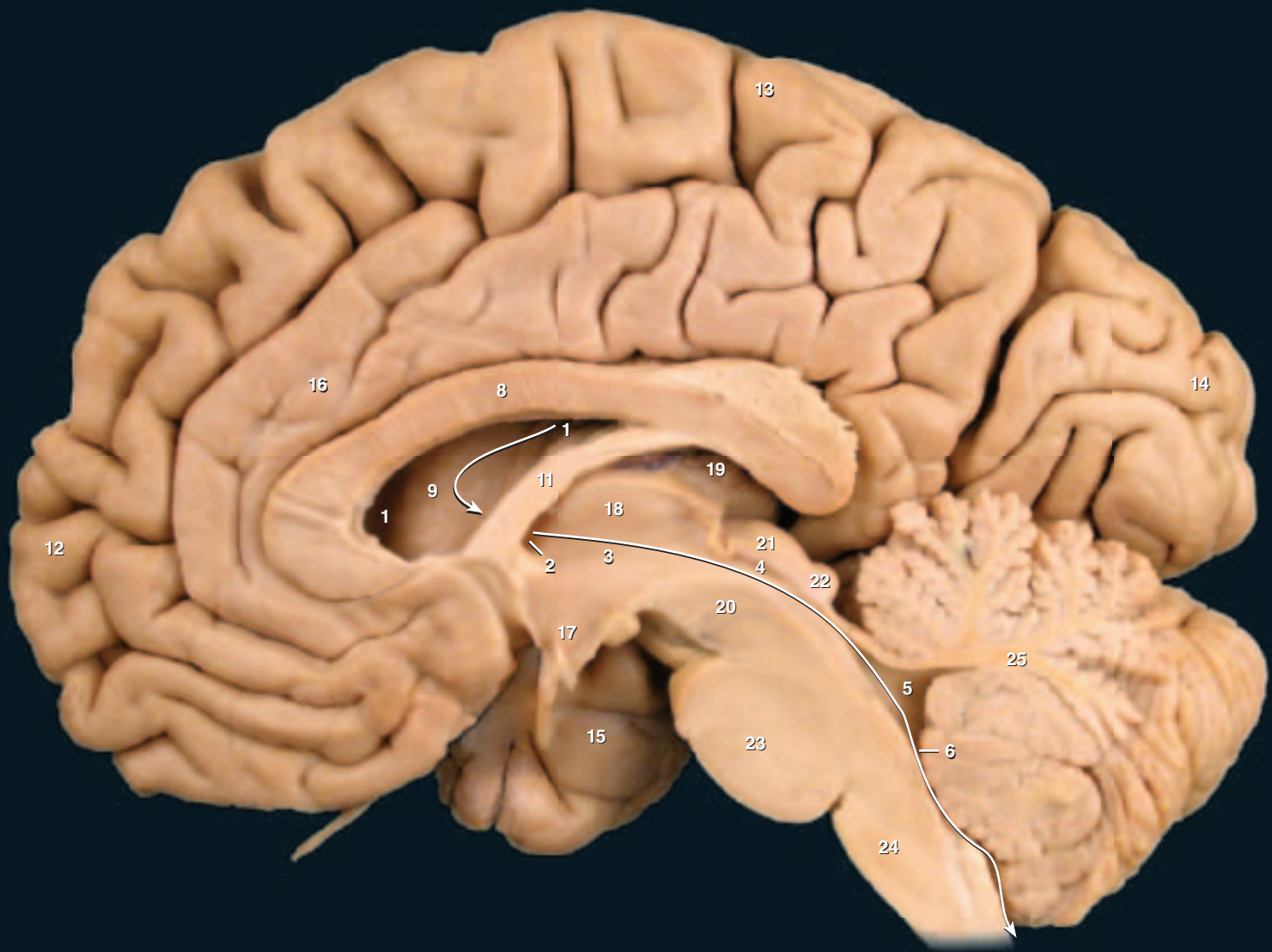


Frontal section of head just posterior to auricle  
Anterior view

# Ventricular System

Developmentally the entire central nervous system forms from the hollow neural tube. As development proceeds and the wall of the neural tube becomes increasingly thicker, the hollow lumen of the tube

undergoes changes in relative size and shape throughout different regions of the changing central nervous system. As a result of this developmental history, there remains a hollow interconnected center throughout the entire central nervous system. This hollow core forms the ventricular system. Beginning within the cerebral hemispheres are the large paired lateral ventricles. Each lateral ventricle has a C-shape like its corresponding hemisphere. The lateral ventricles communicate via the interventricular foramina with a midline cavity, the third ventricle. The third ventricle sits within the core of the diencephalon where the right and left thalamus form its lateral walls. From the third ventricle a narrow channel, the aqueduct of the midbrain or cerebral aqueduct, passes through the core of the midbrain. This narrow channel expands in the region of the pons and cerebellum to form the fourth ventricle. The fourth ventricle tapers through the medulla to enter the spinal cord as the central canal. Within the four ventricles of the brain convoluted aggregations of capillaries, called a choroid plexus, project into the cavity of the ventricle. These capillary projections are the principal site for the production of cerebrospinal fluid.



**Sagittal section of brain revealing the ventricular system**

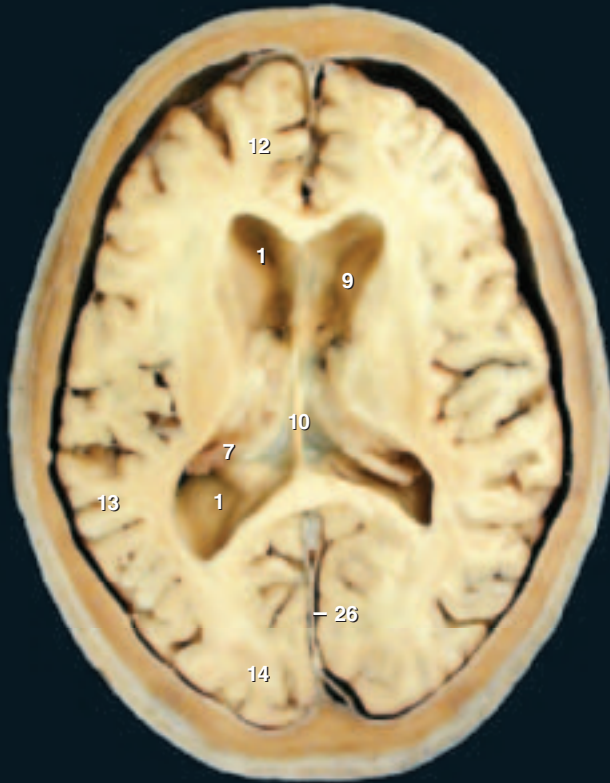
Medial view, arrows show path of cerebrospinal fluid

- 1 Lateral ventricle
- 2 Interventricular foramen
- 3 Third ventricle
- 4 Cerebral aqueduct
- 5 Fourth ventricle
- 6 Median aperture
- 7 Choroid plexus
- 8 Corpus callosum

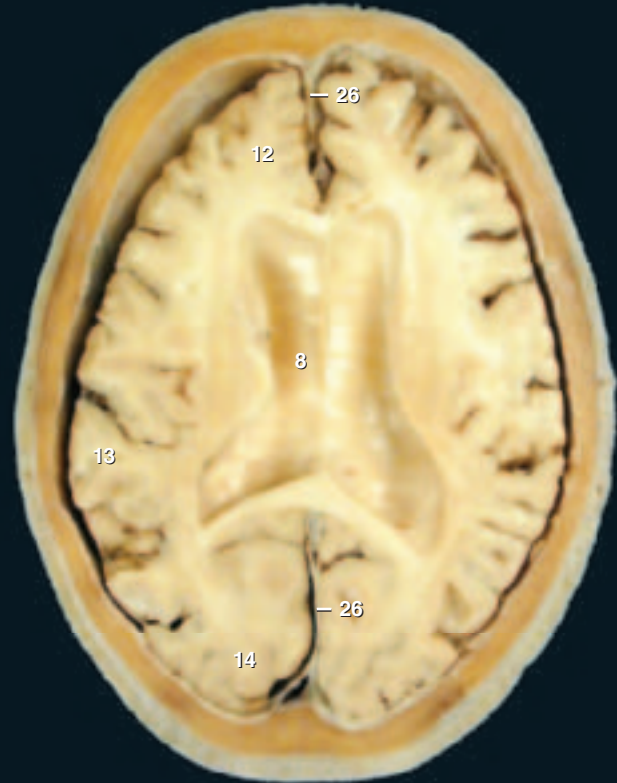
- 9 Caudate nucleus
- 10 Septum pellucidum
- 11 Fornix
- 12 Frontal lobe
- 13 Parietal lobe
- 14 Occipital lobe
- 15 Temporal lobe
- 16 Cingulate gyrus

- 17 Hypothalamus
- 18 Thalamus
- 19 Pineal gland
- 20 Midbrain
- 21 Superior colliculus
- 22 Inferior colliculus
- 23 Pons
- 24 Medulla oblongata

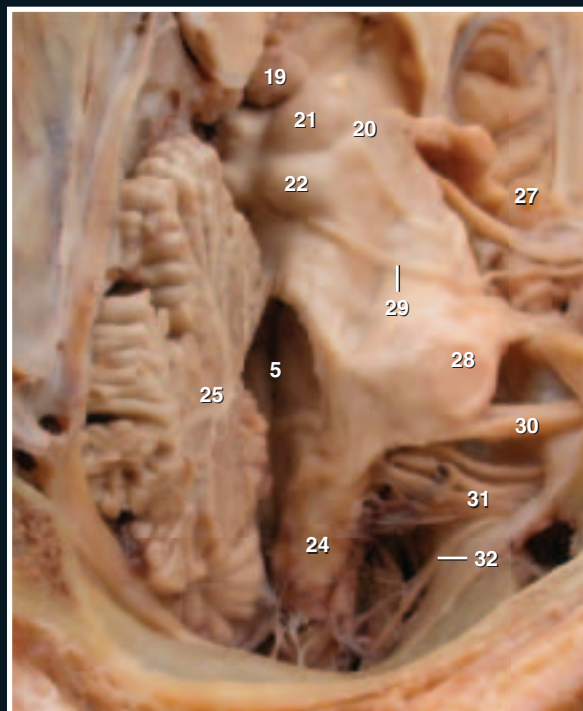
- 25 Cerebellum
- 26 Falx cerebri
- 27 Internal carotid artery
- 28 Middle cerebellar peduncle
- 29 Trochlear nerve
- 30 Vestibulocochlear nerve
- 31 Vagus nerve
- 32 Accessory nerve



**Floor of lateral ventricles**  
Superior view



**Roof of lateral ventricles**  
Inferior view



**Fourth ventricle**  
Posterolateral view

# Meninges

Within the cranium and vertebral column, the meninges form a protective encasement for the tissue of the brain and spinal cord. There are three meningeal membranes, the tough outer connective tissue pachymeninx, the dura mater, and the epithelial inner leptomeninges, the arachnoid mater and pia mater. Between the leptomeningeal layers there is a fluid compartment called the subarachnoid space. Cerebrospinal fluid, secreted from the choroid plexuses of the ventricles, exits the ventricles to fill this compartment. The cerebrospinal fluid forms a hydraulic shock absorber and suspension system for the brain and spinal cord. In addition to protecting the central nervous system, the meninges support many of the blood vessels that are associated with the brain. Within the cranium the subdivisions of the dura mater split to form large venous channels, the dural venous sinuses, which drain all the tissues of the cranial vault, and these splits also form strong, fibrous septa that separate different parts of the brain.

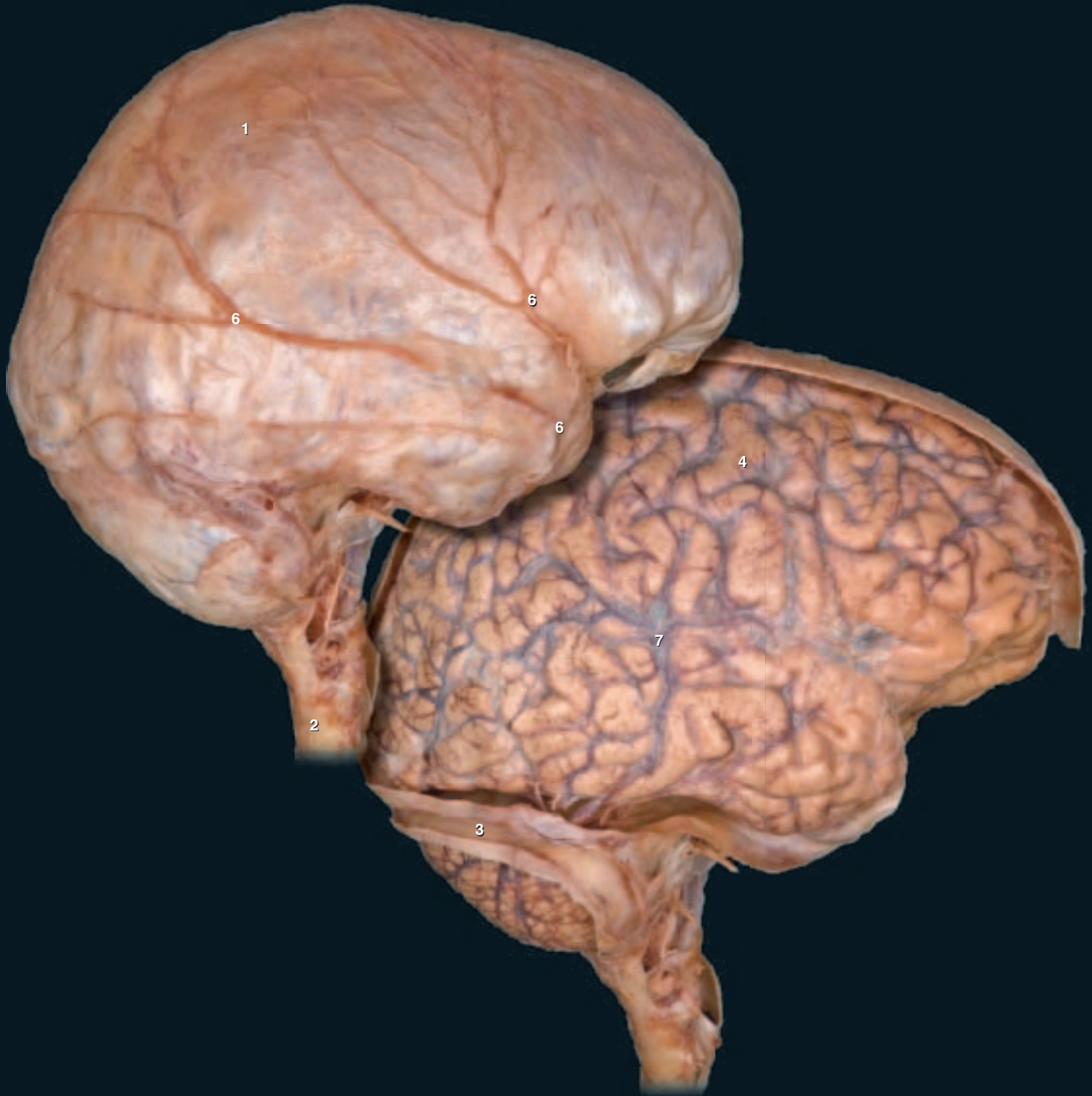


Dissection of cranial and spinal dura mater  
Posterior view



Dura removed to expose leptomeninges  
Posterior view

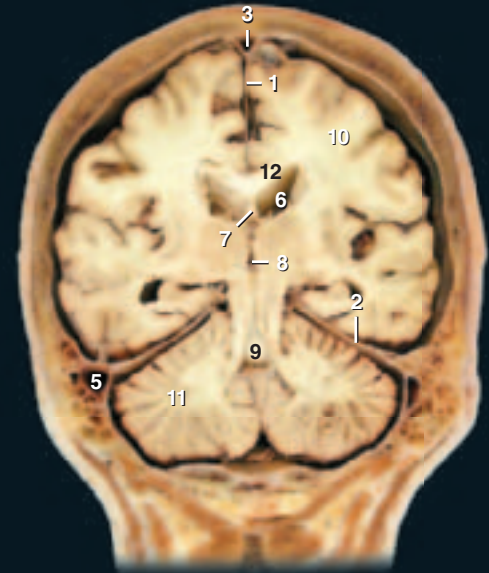
- 1 Cranial dura mater
- 2 Spinal dura mater
- 3 Dural venous sinus
- 4 Cranial leptomeninges - arachnoid is superficial to and covering pia mater
- 5 Spinal leptomeninges - arachnoid is superficial to and covering pia mater
- 6 Middle meningeal artery and branches in dura mater
- 7 Superficial middle cerebral vein and tributaries in subarachnoid space



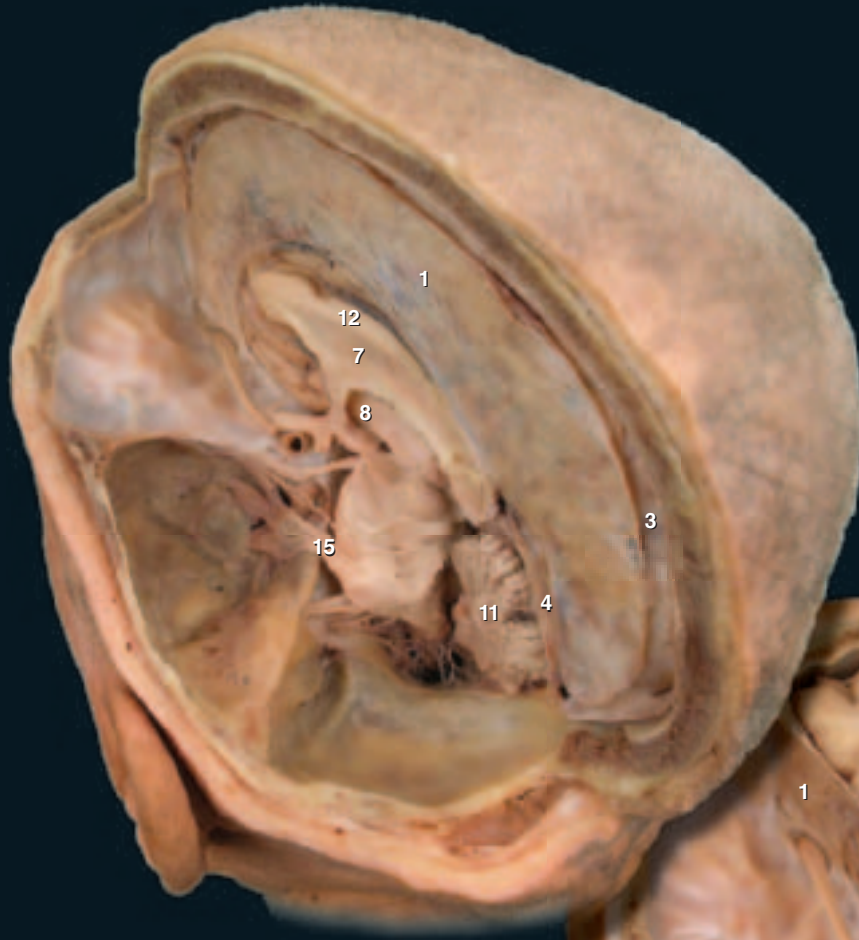
Dural sac (above), Leptomeninges (below)  
Lateral views

# Meninges

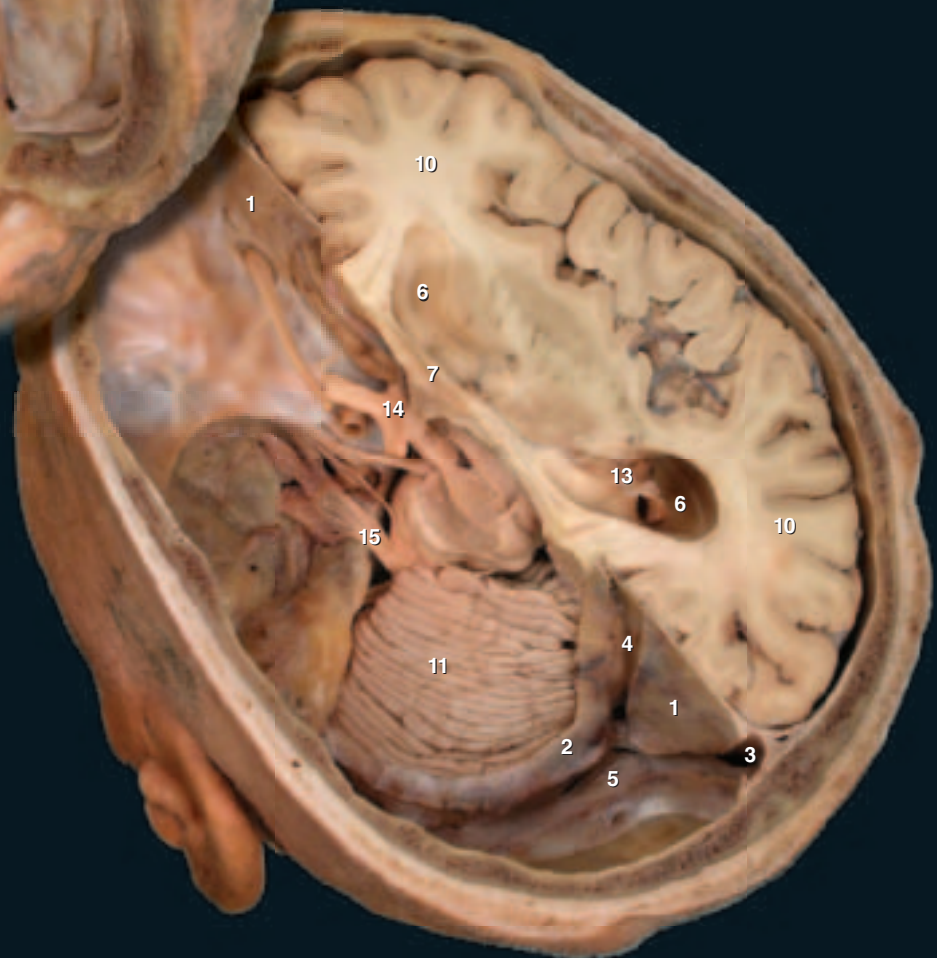
- |                             |                     |                     |
|-----------------------------|---------------------|---------------------|
| 1 Falx cerebri              | 6 Lateral ventricle | 11 Cerebellum       |
| 2 Tentorium cerebelli (cut) | 7 Septum pellucidum | 12 Corpus callosum  |
| 3 Superior sagittal sinus   | 8 Third ventricle   | 13 Choroid plexus   |
| 4 Straight sinus            | 9 Fourth ventricle  | 14 Optic chiasm     |
| 5 Transverse sinus          | 10 Cerebrum         | 15 Trigeminal nerve |



Head frontal section revealing dural septa  
Anterior view



Dissection of cranium  
Superoposterior view

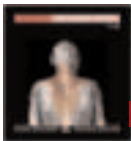
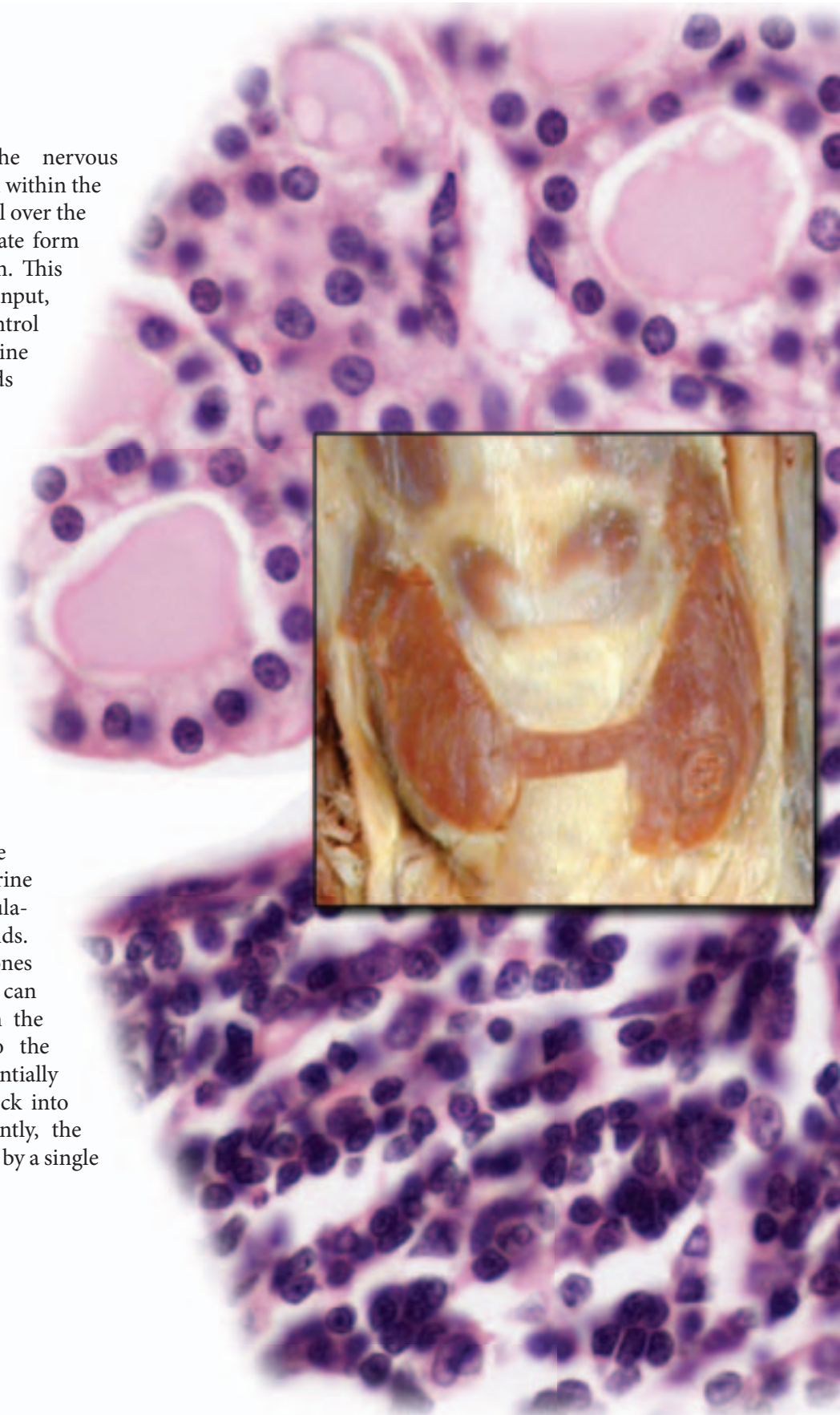


Dissection of cranium  
Superoposterior view

# 15 Endocrine System

Like the nervous system, the endocrine system is a control system within the body. The nervous system administers its control over the body tissues via long wirelike cells that originate from complex circuits in the central nervous system. This circuitry receives sensory input, processes this input, and generates regulatory output. Endocrine control works in a much different fashion. The endocrine system consists of a number of different glands that function like radio transmitting stations. Just as different radio stations send radio signals of different wavelengths into the air, endocrine glands distribute different types of small molecules called hormones throughout the body via the circulatory system. These small molecules travel through the blood stream and are detected by effector organs in different parts of the body, much like radio waves are detected by radios in different parts of a city. Effector organs have receptor sites that are specific to specific hormones. This results in a “lock and key” function at the effector cell. When the hormone binds to the receptor site, it initiates a regulatory effect on the cell.

Because the hormones are distributed by the circulatory system, the speed of endocrine regulation is slower than that of nervous regulation, many minutes compared to milliseconds. Also, because of the distribution of the hormones via the circulatory system, endocrine effects can be experienced anywhere there are cells with the appropriate receptor site. In comparison to the nervous system, endocrine distribution is potentially very widespread. Because the hormone can lock into the receptor site and not be degraded instantly, the duration can be longer lasting than that initiated by a single nervous impulse.



Find more information  
about the endocrine  
system in

REALANATOMY

# Hypothalamus

The hypothalamus occupies the area of the brain between the third ventricle and the subthalamus. It is a major intersection between the thalamus, cerebral cortex, and ascending fiber systems from the spinal cord and brainstem. It is the control center of the autonomic nervous system and regulates the function of numerous endocrine glands. The posterior pituitary gland, or neurohypophysis, is an outgrowth of the hypothalamus. Many factors influence the hypothalamus and dictate its controlling influence over tissues in the body. These factors include the nervous input that enters it, temperature, osmotic pressure, and levels of hormones in the circulating blood that pass through its capillaries.



- |                              |                      |
|------------------------------|----------------------|
| 1 Hypothalamus               | 9 Midbrain           |
| 2 Pineal gland               | 10 Pons              |
| 3 Frontal lobe of cerebrum   | 11 Cerebellum        |
| 4 Parietal lobe of cerebrum  | 12 Medulla oblongata |
| 5 Occipital lobe of cerebrum | 13 Lateral ventricle |
| 6 Temporal lobe of cerebrum  | 14 Fourth ventricle  |
| 7 Corpus callosum            | 15 Mammillary body   |
| 8 Thalamus                   | 16 Spinal cord       |

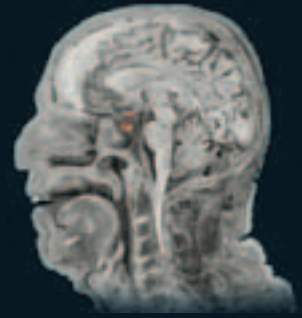


Sagittal section of brain  
Medial view



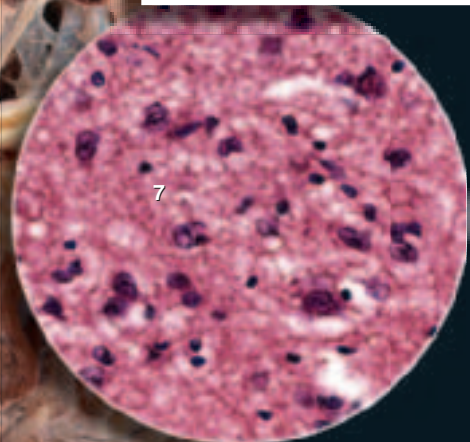
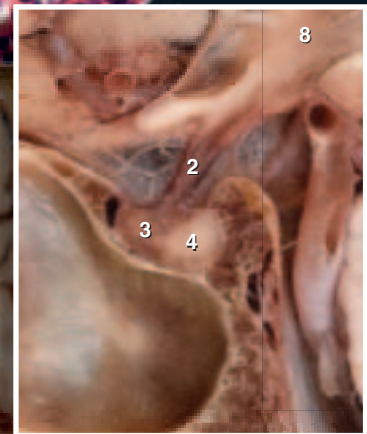
# Pituitary Gland

The pituitary gland, or hypophysis, “hangs” from the base of the brain via a connecting stalk, the infundibulum, which connects it to the hypothalamus. The infundibulum contains numerous nerve fibers that relay from the hypothalamus to the posterior portion of the pituitary gland. In addition to this nervous pathway between the hypothalamus and the pituitary, numerous small blood vessels pass between the two organs. The pituitary gland has two anatomically and functionally distinct lobes, the neurohypophysis (posterior lobe) and the adenohypophysis (anterior lobe). The posterior lobe arises as an outgrowth of the embryonic brain. It is composed of nervous tissue and forms a neural link with the hypothalamus through the infundibulum. The anterior lobe arises from the epithelial lining of the embryonic pharynx. It consists of glandular epithelial tissue and forms a vascular link with the hypothalamus via the small blood vessels that pass between the two regions.



- 1 Pituitary gland
- 2 Infundibulum
- 3 Adenohypophysis
- 4 Neurohypophysis
- 5 Parenchyma consisting of acidophils, basophils, and chromophobes
- 6 Capillary with red blood cells
- 7 Parenchyma consisting of axons and pituicytes
- 8 Hypothalamus
- 9 Cerebrum
- 10 Falx cerebri
- 11 Midbrain
- 12 Pons
- 13 Cerebellum
- 14 Medulla oblongata
- 15 Spinal cord
- 16 Nasal septum
- 17 Soft palate
- 18 Tongue
- 19 Epiglottis
- 20 Atlas
- 21 Axis
- 22 Intervertebral disc
- 23 Sphenoid sinus
- 24 Occipital bone

Photomicrograph of anterior pituitary  
200x

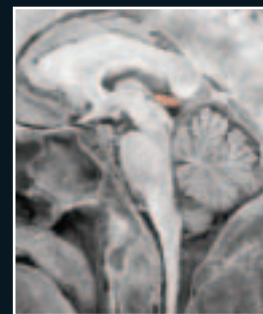


Photomicrograph of posterior pituitary  
200x

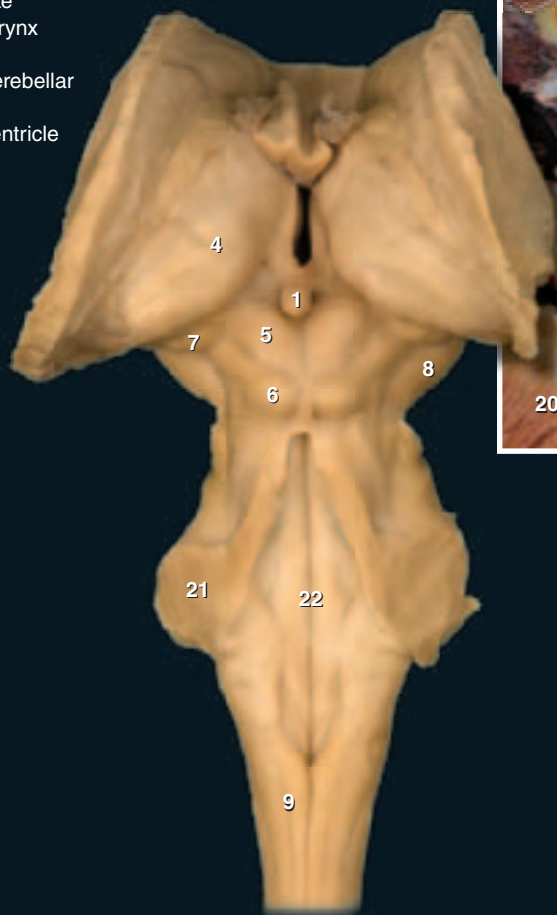
Sagittal section of head and neck with enlarged callout of pituitary gland  
Medial view

# Pineal Gland

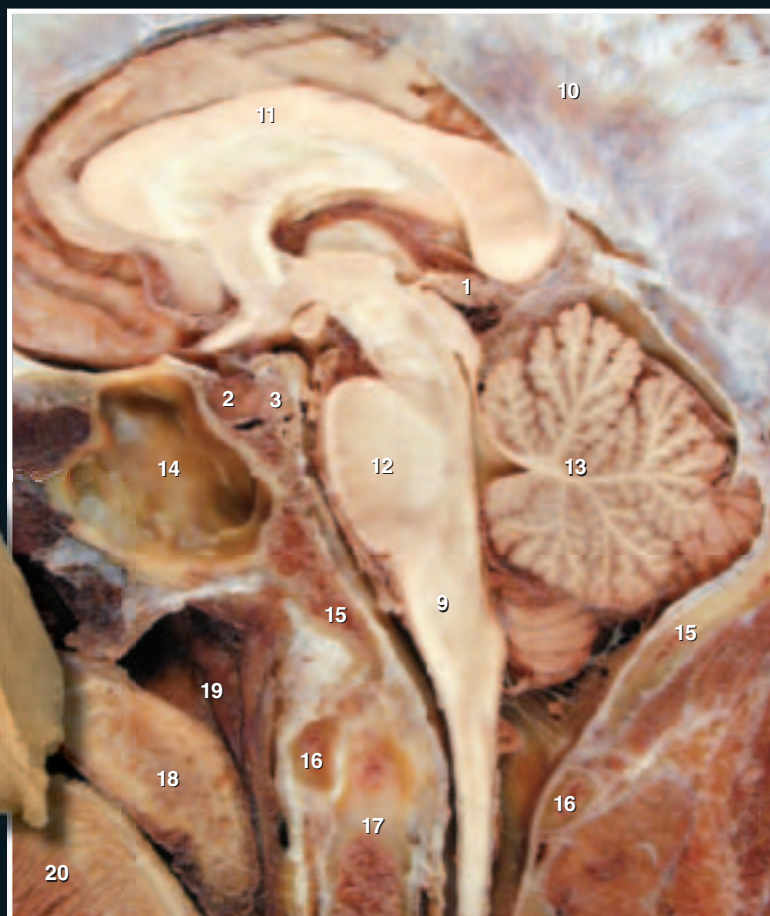
The pineal gland, a small reddish-gray body covered with pia mater, is a midline epithelial outgrowth of the embryonic mid-brain positioned in a depression between the two superior colliculi on the midbrain's dorsal surface. The distal end of this outgrowth becomes a small mass of secretory cells that resemble the shape of a pine cone. It is from this appearance that it derives its name. The pia mater sends septa into the pineal gland that divide it into cords of secretory cells that are intermingled with numerous blood capillaries. The secretory cells of the pineal gland, called pinealocytes, have arm-like processes that contact both neighboring capillaries and the ependymal cells that line the third ventricle. Hormonal secretions produced in the body of the cell are moved through the arm-like processes where they are released by exocytosis into the capillaries and cerebrospinal fluid. Projecting into these cords of tissue are sympathetic postganglionic neurons from the superior cervical sympathetic ganglion. The gland plays a role in integrating photoperiod and affecting circadian rhythms.



- 1 Pineal gland
- 2 Adenohypophysis
- 3 Neurohypophysis
- 4 Thalamus
- 5 Superior colliculi
- 6 Inferior colliculi
- 7 Medial geniculate nucleus
- 8 Cerebral peduncle
- 9 Medulla oblongata
- 10 Falx cerebri
- 11 Corpus callosum
- 12 Pons
- 13 Cerebellum
- 14 Sphenoid sinus
- 15 Occipital bone
- 16 Atlas
- 17 Axis
- 18 Soft palate
- 19 Nasopharynx
- 20 Tongue
- 21 Middle cerebellar peduncle
- 22 Fourth ventricle



Dissection of brainstem and diencephalon  
Posterior view



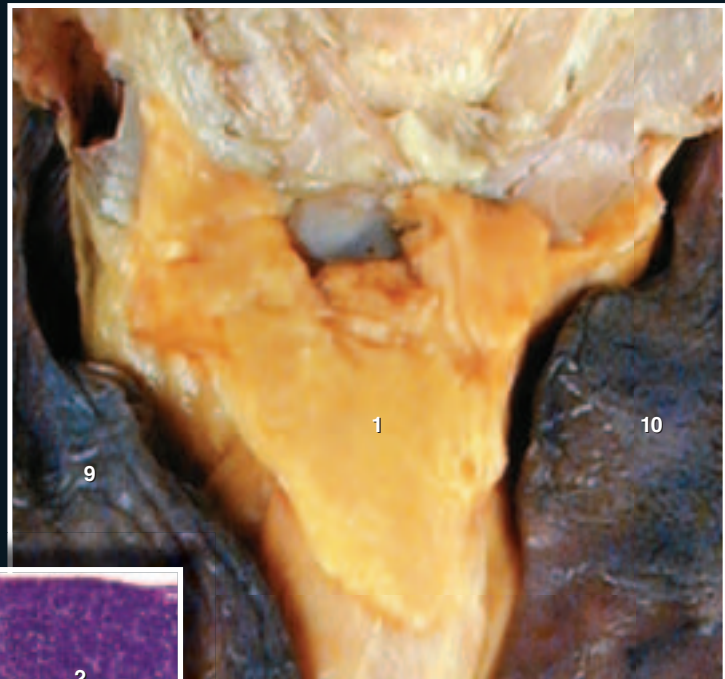
Sagittal section of brainstem and diencephalon in situ  
Medial view

# Thymus

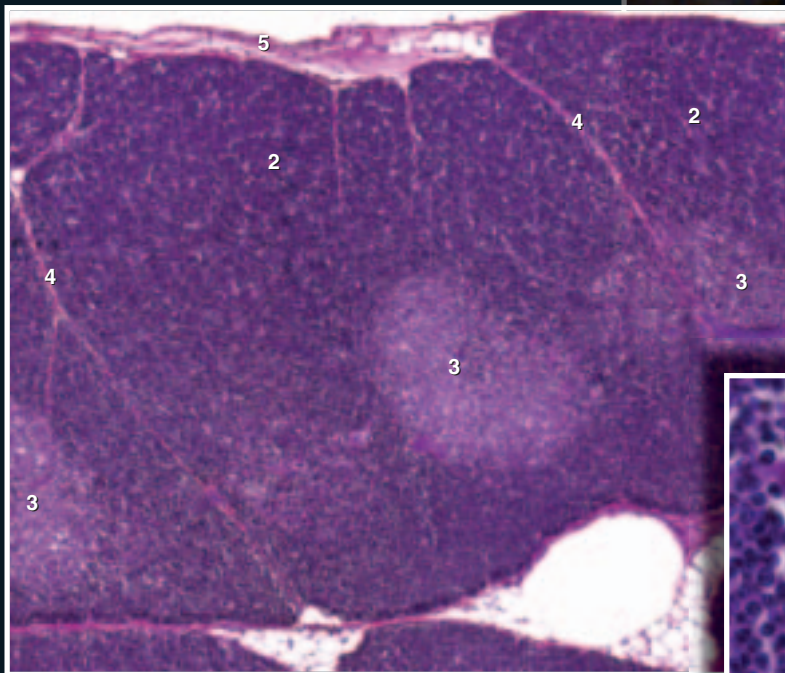
The thymus is one of the primary lymphoid organs, but it also has an endocrine component. The thymus provides the specialized environment for the precursor T cells to develop, differentiate, and undergo clonal expansion. This bilobed organ sits just posterior to the superior sternum along the midline. It spans from the top of the sternum, sometimes even projecting into the inferior cervical region, to the level of the fourth costal cartilages and sits anterior to the top of the heart and its great vessels. It has an outer fibrous capsule that sends fibrous septa, connective tissue walls, into the organ forming small lobular subregions. The thymus was once thought to diminish in size with age, but in actuality it does not. Because of its high content of lymphoid tissue and a rich blood supply, it has a reddish appearance in a living body. With age, however, fatty infiltrations replace the lymphoid tissue and it takes on more of the yellowish color of the invading fat. This gives it the false appearance of a reduction in size. The thymus produces hormones that promote the maturation of T cells and may help retard the aging process.



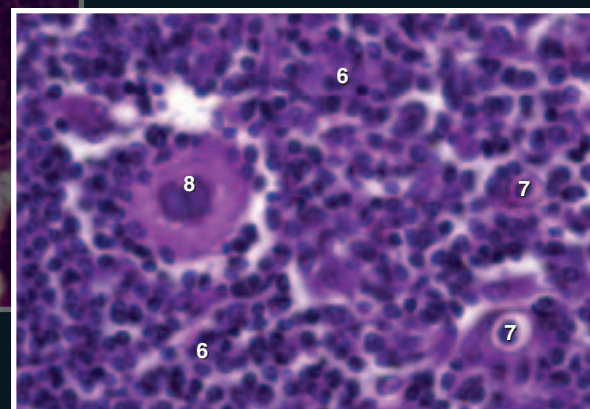
- 1 Thymus
- 2 Thymic cortex
- 3 Thymic medulla
- 4 Trabeculae
- 5 Capsule
- 6 Maturing T cells
- 7 Epithelioreticular cell
- 8 Thymic corpuscle
- 9 Right lung
- 10 Left lung



Thymus in situ  
Anterior view



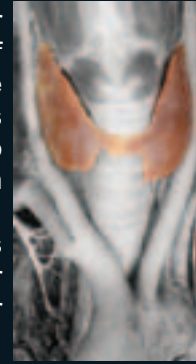
Photomicrograph of thymus  
50x



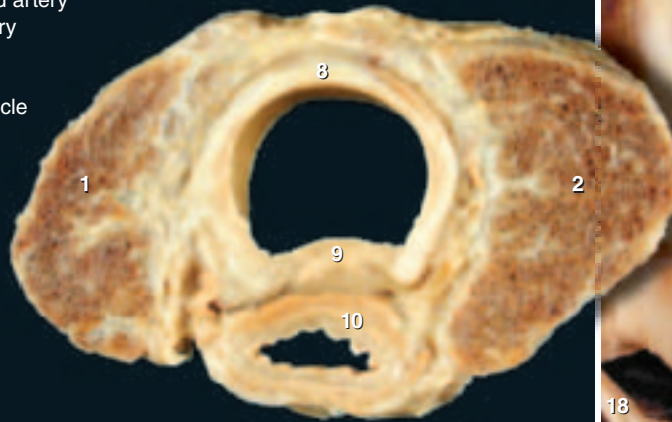
Photomicrograph of thymus  
400x

# Thyroid Gland

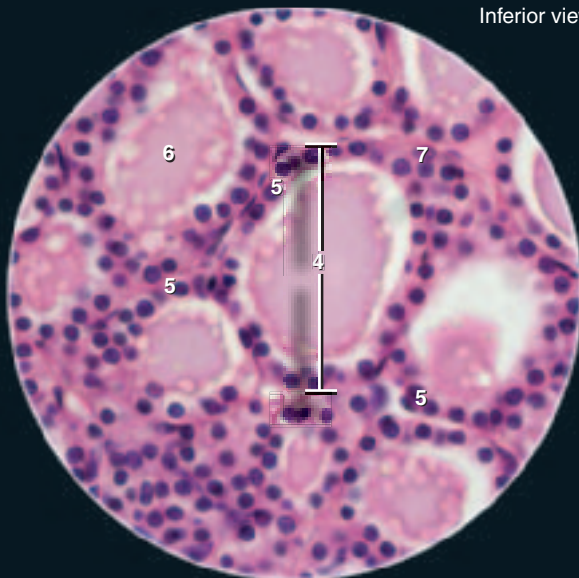
The thyroid gland is a bilobed organ positioned in the anterior neck. This highly vascular organ consists of two lateral lobes of gland called the isthmus. It is red-brown in color and is enveloped by a thin layer of connective tissue. This connective tissue capsule sends extensions into the gland that divide the vascular and epithelial core into masses of irregular shape and size. The epithelial cells within the compartments of the thyroid gland form the secretory tissues of the organ. The major thyroid secretory cells are arranged into hollow spheres, each of which forms a functional unit called a follicle. In a microscopic section the follicles appear as rings of follicular cells enclosing an inner lumen filled with colloid, a substance that serves as an extracellular storage site for thyroid hormones. Interspersed in the interstitial spaces between the follicles are other secretory cells, the C cells, so called because they secrete the peptide hormone calcitonin.



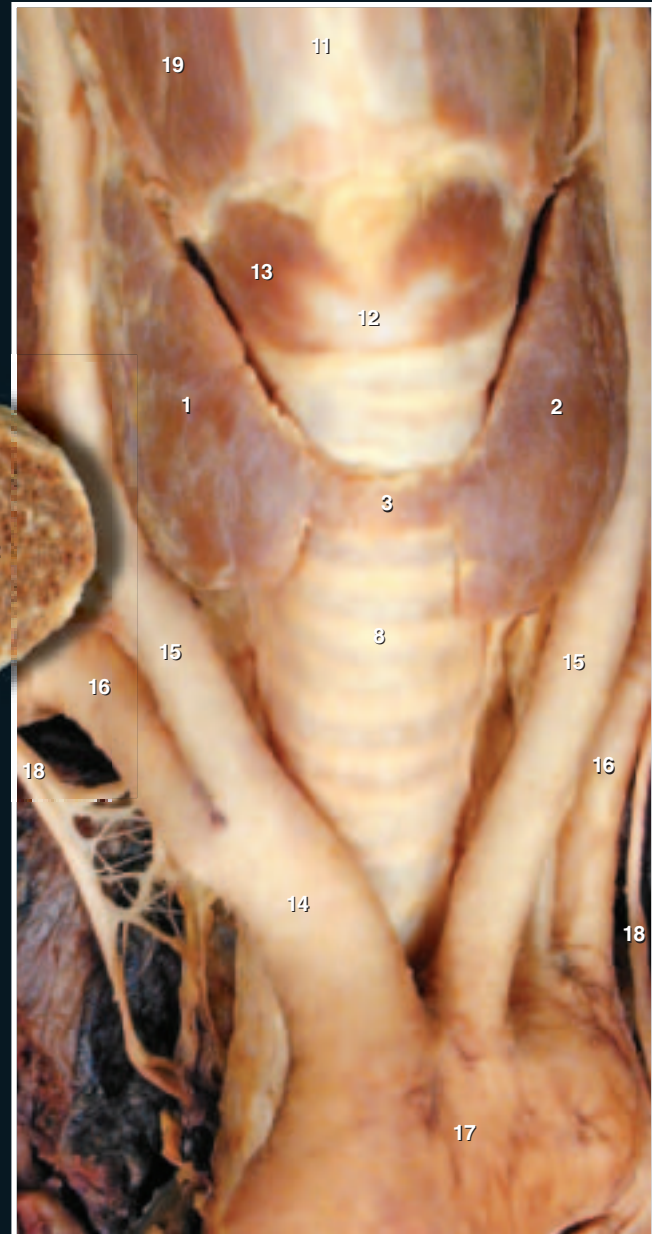
- 1 Right lobe of thyroid gland
- 2 Left lobe of thyroid gland
- 3 Isthmus of thyroid gland
- 4 Thyroid follicle
- 5 Follicular cell
- 6 Thyroglobulin (TGB)
- 7 Parafollicular (C) cell
- 8 Trachea
- 9 Fibromuscular membrane of trachea
- 10 Esophagus
- 11 Thyroid cartilage
- 12 Cricoid cartilage
- 13 Cricothyroid muscle
- 14 Brachiocephalic artery
- 15 Common carotid artery
- 16 Subclavian artery
- 17 Aortic arch
- 18 Vagus nerve
- 19 Thyrohyoid muscle



Transverse section of thyroid gland  
Inferior view



Photomicrograph of thyroid gland  
240x



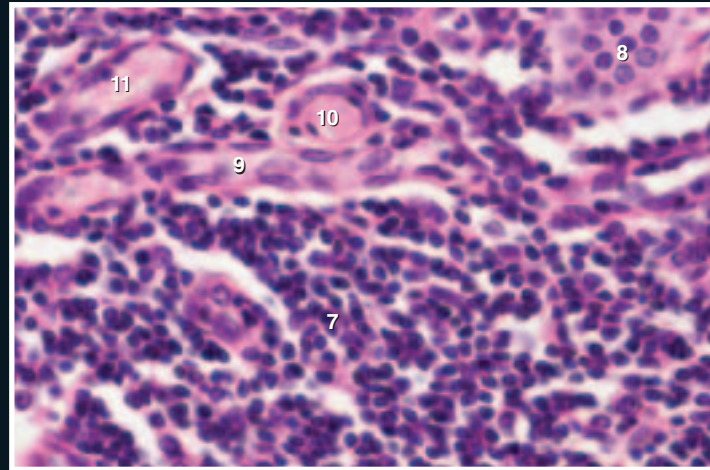
Thyroid gland in situ  
Anterior view

# Parathyroid Glands

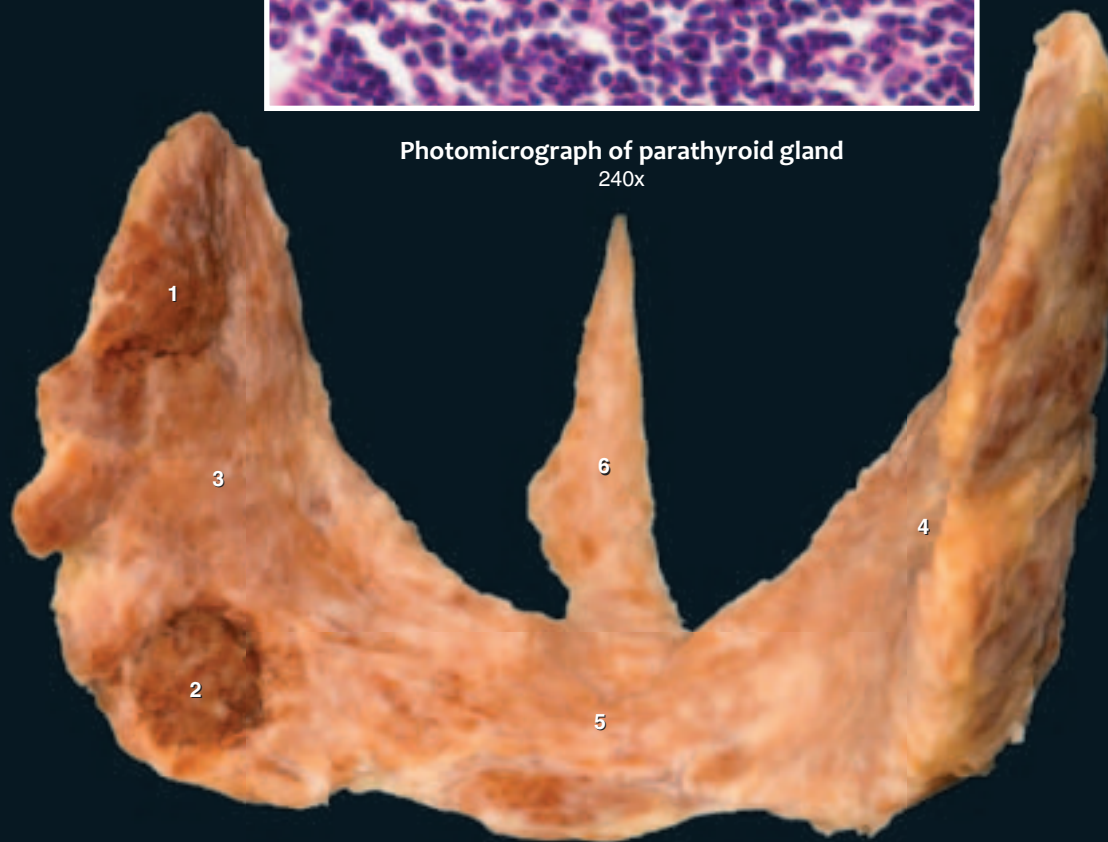
The parathyroid glands are small, oval, light brown glands situated on the posterior border of the two lateral lobes of the thyroid gland.

The parathyroid glands sit just beneath the connective tissue capsule of the thyroid gland. There are four parathyroid glands, two superior and two inferior. The endocrine cells of the parathyroid glands are called chief or principal cells. The chief cells form interconnecting columns of cells separated by fenestrated capillaries. The chief cells produce the parathyroid hormone.

- |                                   |                |
|-----------------------------------|----------------|
| 1 Superior parathyroid gland      | 7 Chief cell   |
| 2 Inferior parathyroid gland      | 8 Oxyphil cell |
| 3 Left lobe of thyroid gland      | 9 Capillary    |
| 4 Right lobe of thyroid gland     | 10 Arteriole   |
| 5 Isthmus of thyroid gland        | 11 Venule      |
| 6 Pyramidal lobe of thyroid gland |                |



Photomicrograph of parathyroid gland  
240x

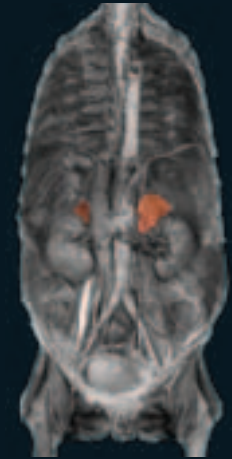


Thyroid and parathyroid glands (exposed on left)  
Posterior view

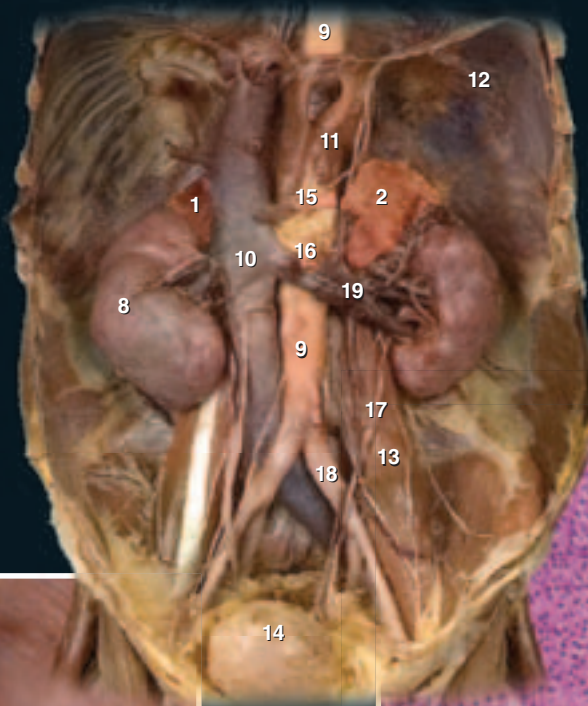
# Suprarenal Glands

There are two yellowish suprarenal or adrenal glands that sit on the superior end of the kidneys. Each gland is surrounded by a thin connective

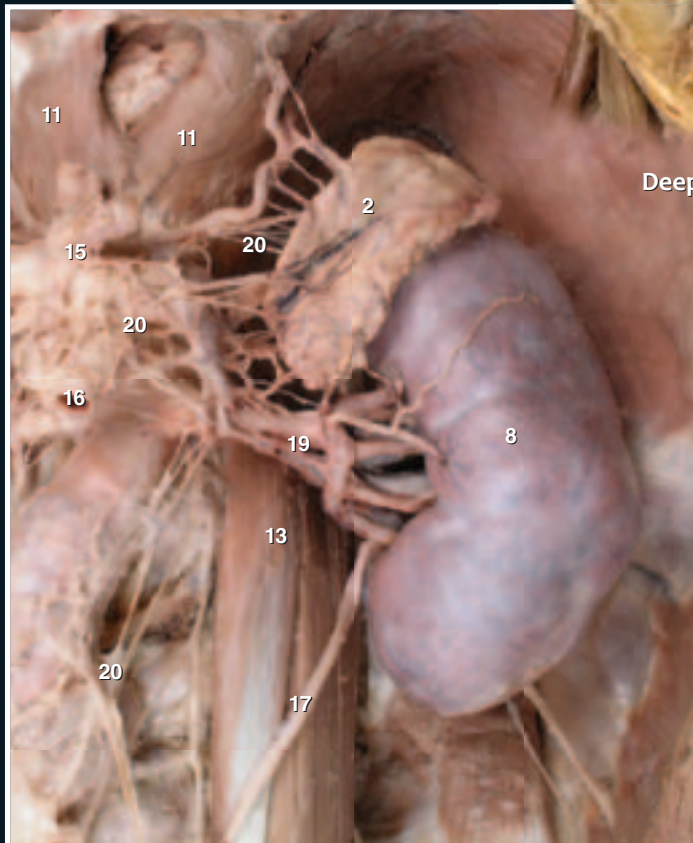
tissue envelope. These highly vascular organs are not symmetrical. The right suprarenal gland is slightly smaller and forms a flat tetrahedron or four-sided polygon. The left suprarenal gland, like the left kidney, is more superior than the right gland and has a semilunar shape that resembles a flattened stocking hat placed on the upper end of the kidney. Each suprarenal gland is actually composed of two endocrine organs, one surrounding the other. The inner portion of the gland, called the suprarenal medulla, forms approximately 20% of the organ. The medulla secretes catecholamines. The more massive outer part of the gland, called the suprarenal cortex, secretes a variety of steroid hormones. The two parts of the gland each have different embryonic origins. The suprarenal medulla forms from the embryonic mesoderm, and the suprarenal cortex forms from embryonic neural crest cells.



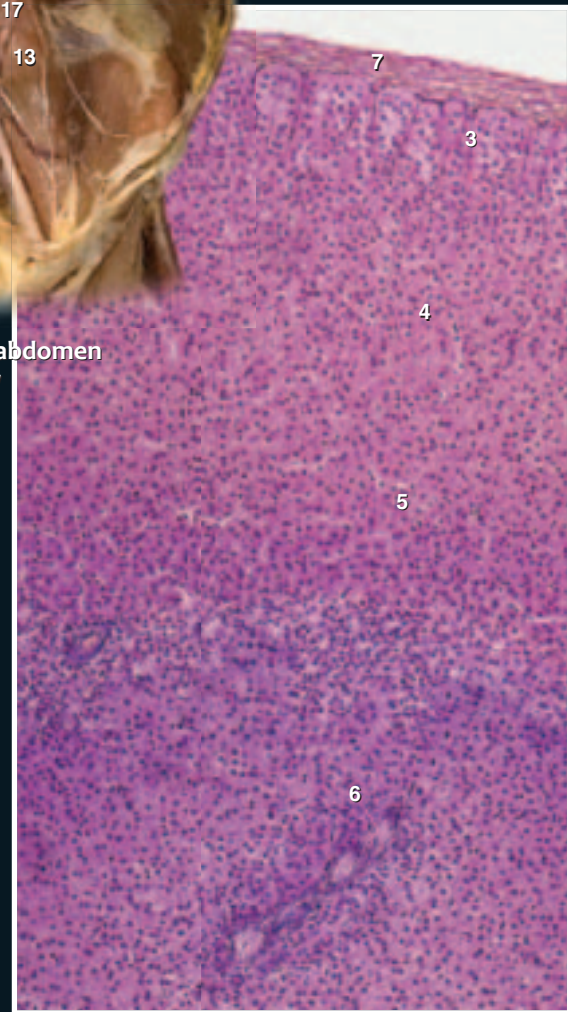
- 1 Right suprarenal gland
- 2 Left suprarenal gland
- 3 Zona glomerulosa of cortex
- 4 Zona fasciculata of cortex
- 5 Zona reticularis of cortex
- 6 Medulla
- 7 Capsule
- 8 Kidney
- 9 Aorta
- 10 Inferior vena cava
- 11 Crura of diaphragm
- 12 Diaphragm
- 13 Psoas major muscle
- 14 Bladder
- 15 Celiac artery
- 16 Superior mesenteric artery
- 17 Ureter
- 18 Common iliac artery
- 19 Renal vein and artery
- 20 Autonomic nerve plexus



Deep dissection of abdomen  
Anterior view



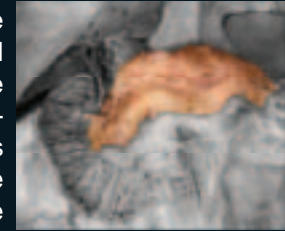
Left suprarenal gland  
Anterior view



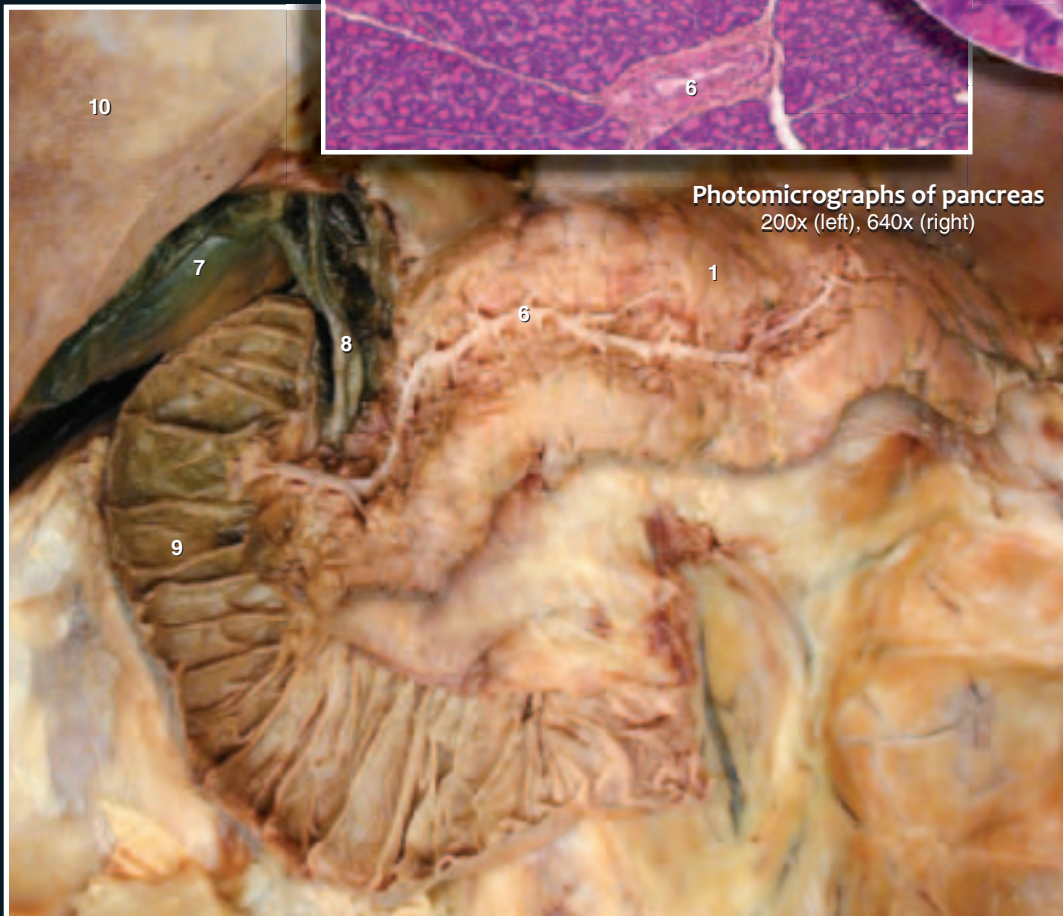
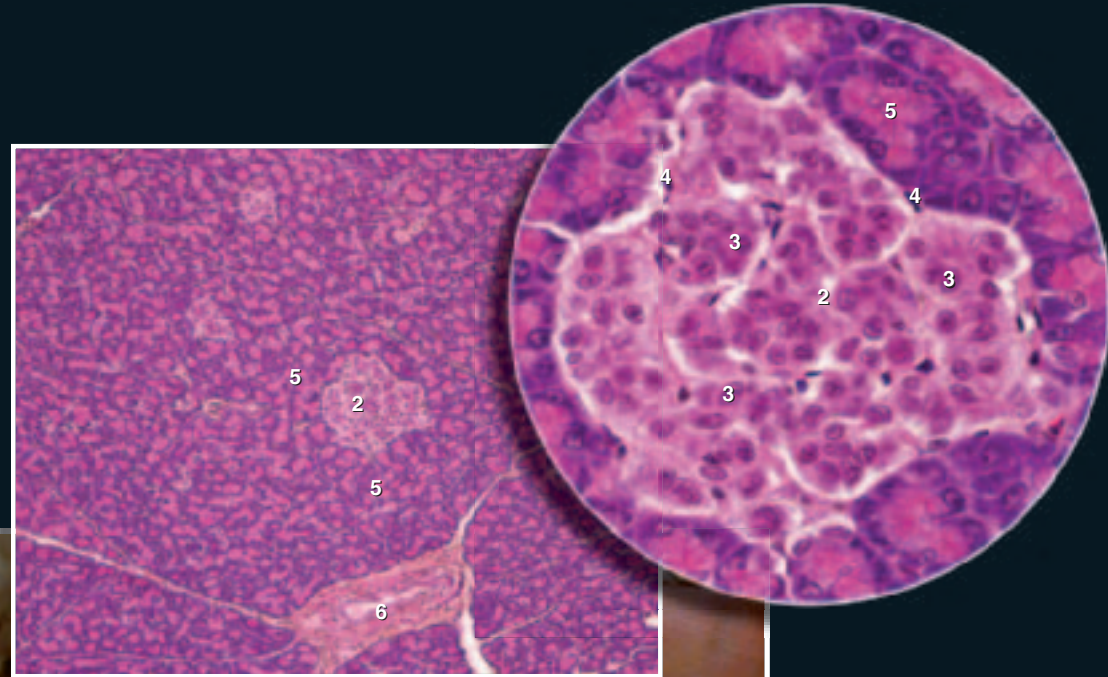
Photomicrograph of suprarenal gland  
100x

# Pancreas

The pancreas is a retroperitoneal organ that forms as an outgrowth of the duodenal lining. Situated posterior to the stomach it is pinkish in color and about 15 cm long, running from the loop of the duodenum on the right to the spleen on the left. It has four basic regions: a head, neck, body, and tail. The pancreas has two functional parts, the exocrine pancreas and the endocrine pancreas. The endocrine portion of the pancreas forms as small clusters of cells, the pancreatic islets, distributed among the exocrine acinar cells of the pancreas. They are far less numerous (approximately 5% of the pancreas) than the cells of the exocrine pancreas. There are four distinct cell types within the pancreatic islets: alpha or A cells, beta or B cells, delta or D cells, and F cells. The alpha (20%) and beta (70%) cells constitute the greater part of the pancreatic islets and produce the hormones glucagon and insulin, respectively. The other 10% of the islet cells are delta and F cells, which secrete somatostatin and pancreatic polypeptide, respectively.



- 1 Pancreas
- 2 Pancreatic islet
- 3 Beta cell
- 4 Alpha cell
- 5 Exocrine acinus
- 6 Pancreatic duct
- 7 Gallbladder
- 8 Common bile duct
- 9 Duodenum
- 10 Liver



Photomicrographs of pancreas  
200x (left), 640x (right)

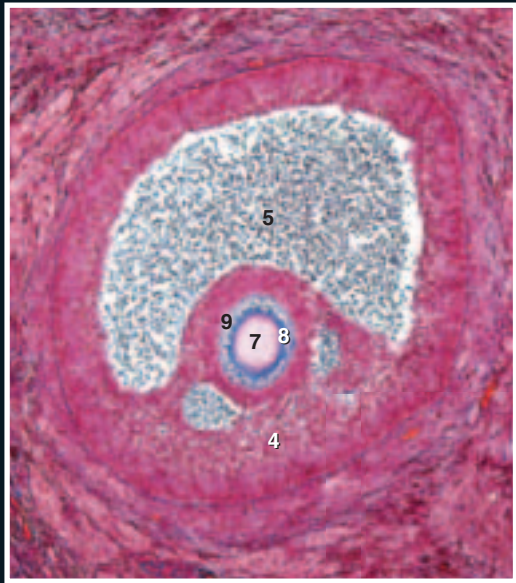
Pancreas in situ  
Anterior view

# Ovaries

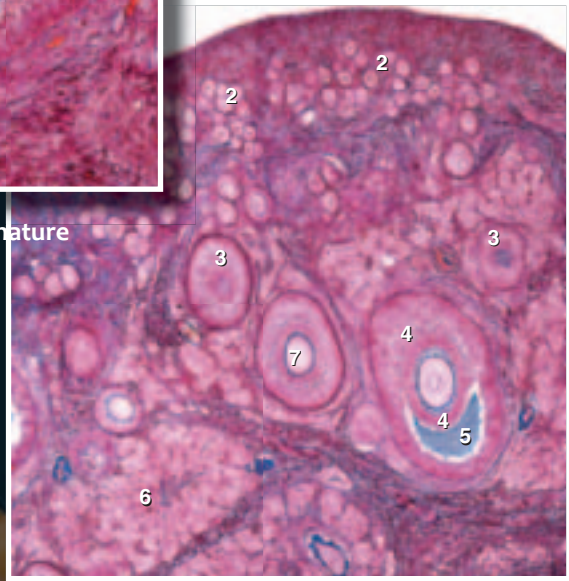
The ovaries are ovoid organs about the size of an unshelled almond and occupy the boundary zone between the abdominal and pelvic cavities. They consist of a dull white fibrous tissue embedded with oocytes, the "egg" cells of the female. Surrounding the oocytes are numerous follicular cells that undergo changes during the female menstrual cycle. The follicular cells are the endocrine cells of the ovary that produce the female steroidal hormones.



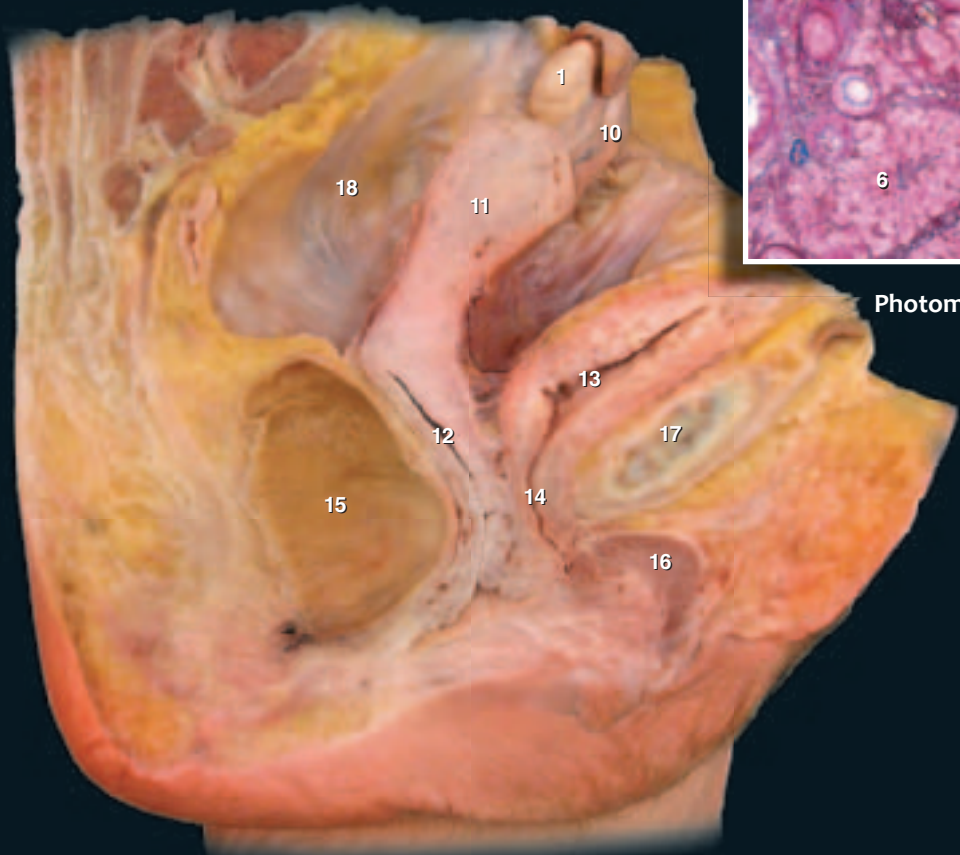
- 1 Ovary
- 2 Primordial follicle
- 3 Primary follicle granulosa cells
- 4 Secondary follicle granulosa cells
- 5 Follicular antrum
- 6 Corpus luteum
- 7 Primary oocyte
- 8 Zona pellucidum
- 9 Corona radiata
- 10 Uterine tube
- 11 Uterus
- 12 Vagina
- 13 Bladder
- 14 Urethra
- 15 Rectum
- 16 Clitoris
- 17 Pubic symphysis
- 18 Parietal peritoneum



Photomicrograph of mature ovarian follicle  
70x



Photomicrograph of ovary  
30x



Sagittal section of female pelvis  
Medial view



# Testes

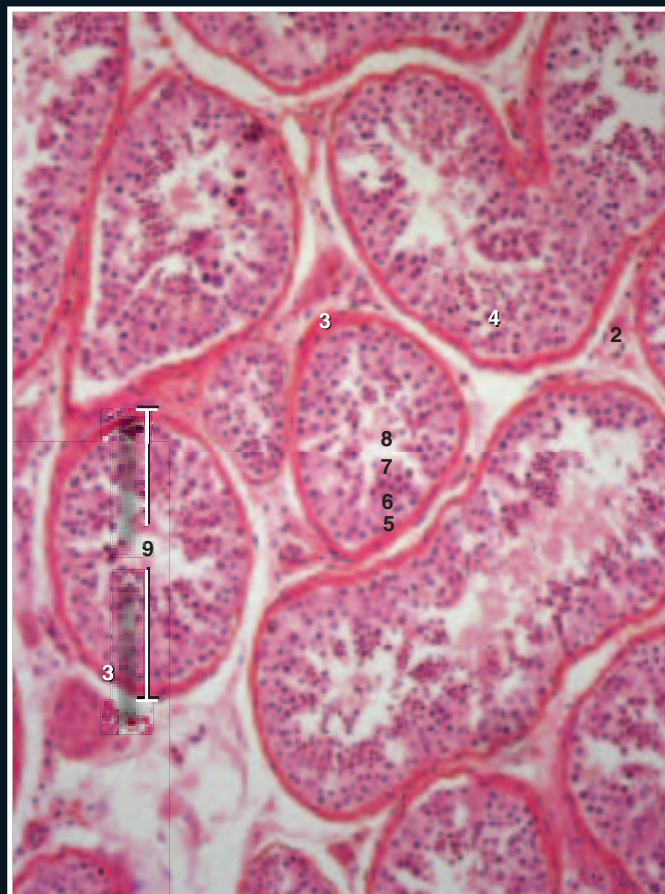
The testes are oval-shaped organs about 2 inches (5 cm) long and 1 inch (2.5 cm) wide that occupy the scrotal sac of a male. They are covered by a tough fibrous tunic and wrapped in a serous sac that separates them from the external tissues that surround them. Internally, the testes consist of numerous small compartments created by connective tissue bands that project inward from the outer fibrous tunic. Each testicular compartment is occupied by a thin, highly coiled seminiferous tubule. This thin tube is the site of sperm production. Situated between the tubules are the interstitial cells (of Leydig). It is these large interstitial cells that secrete the steroidal hormones in the testis.



- 1 Testis
- 2 Interstitial (Leydig) cell
- 3 Basement membrane
- 4 Sertoli cell
- 5 Spermatogonium
- 6 Primary spermatocyte
- 7 Secondary spermatocyte
- 8 Spermatid
- 9 Seminiferous tubule
- 10 Tunica albuginea
- 11 Epididymis
- 12 Spermatic cord



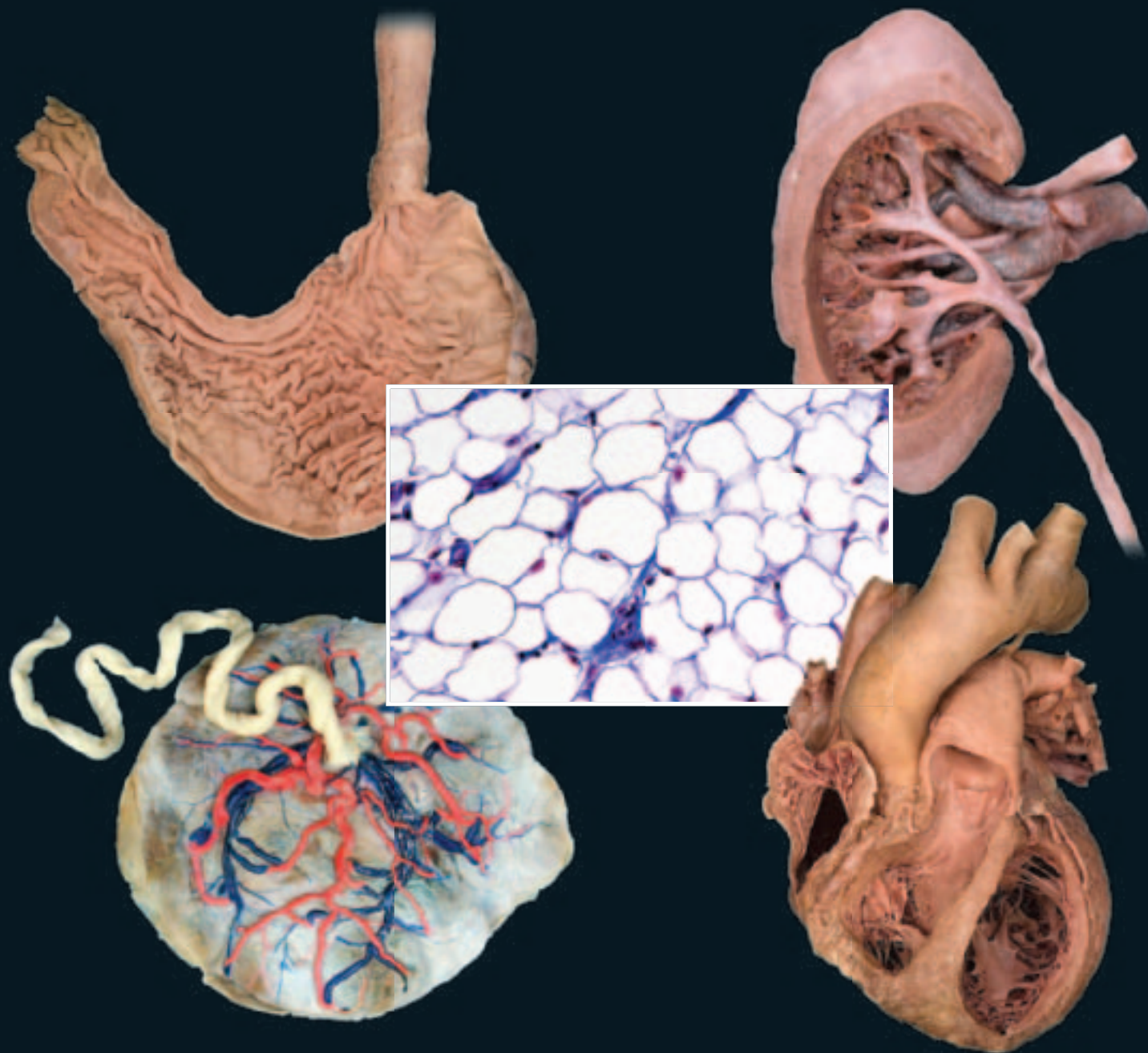
**Sagittal section of left testis**  
Medial view



**Photomicrograph of testis**  
40x

## Other Endocrine Structures

In addition to the endocrine organs discussed on the preceding pages, there are other endocrine tissues in the body. These include tissues in the wall of the gastrointestinal tract that produce hormones such as gastrin and secretin, tissues in the kidney that produce renin and erythropoietin, tissues in the atrium of the heart that produce atrial natriuretic peptide, tissues of the placenta that produce human chorionic gonadotropin, estrogens, and progesterone, and adipose tissue that produces leptin. These hormones have a variety of functions, from stimulating the release of digestive enzymes, to raising blood pressure, to decreasing blood pressure, to regulating reproductive cycles, and suppressing appetite.



### Other organs with endocrine tissues

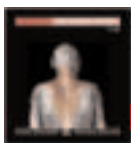
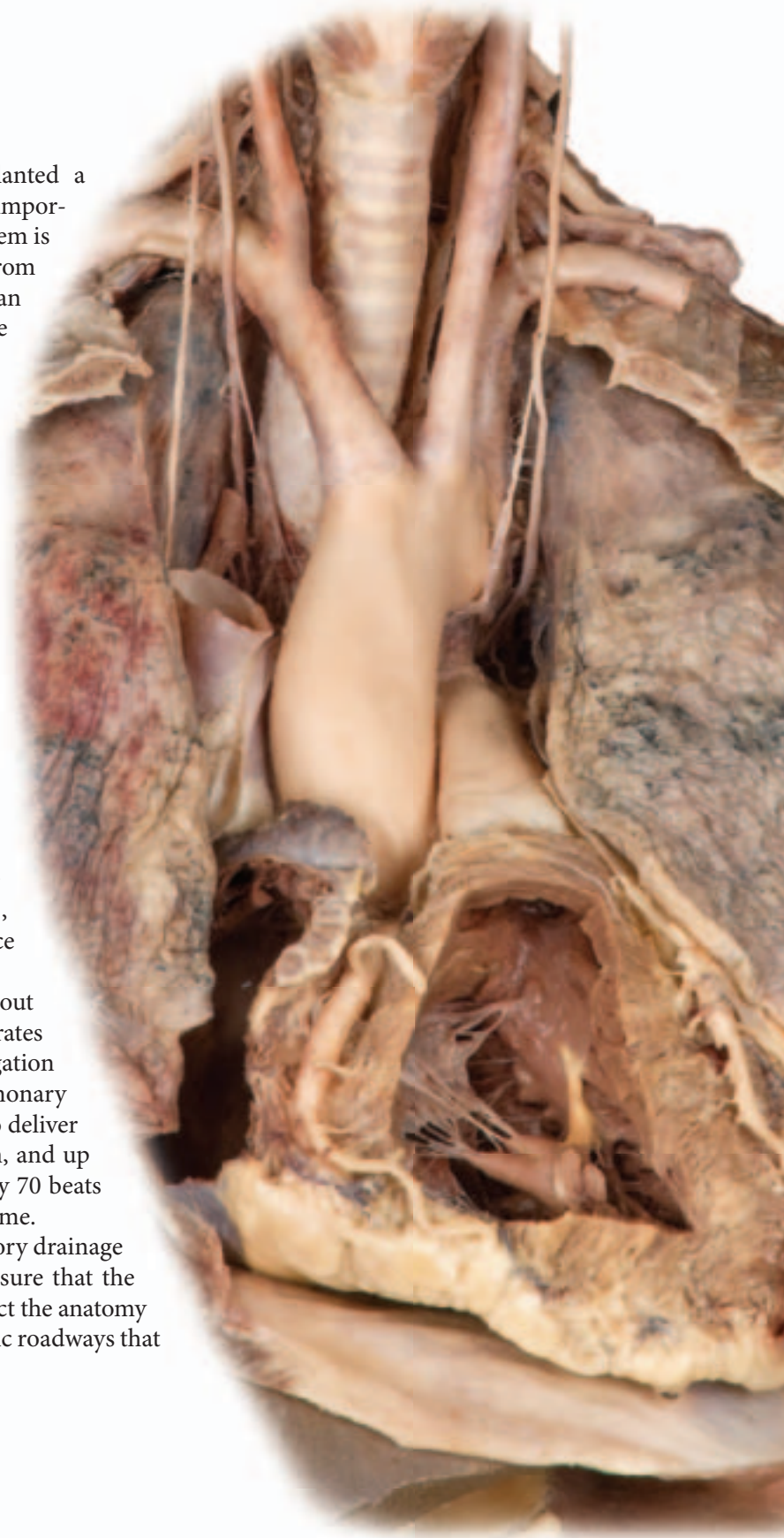
Stomach (upper left), kidney (upper right), heart (lower right), placenta (lower left), and adipose tissue (center)

# 16 Cardiovascular System

If you have ever planted a garden of significant size, you have probably experienced the importance of an irrigation system. At its simplest, an irrigation system is a network of channels or furrows that deliver needed water from one main source to the roots of all the garden's plants. Like an irrigation system, the body's blood vessels form an extensive network of "irrigation channels" to deliver needed fluid — in this case the homeostatically maintained blood — to all the body's cells. In fact, this delivery system is probably the most phenomenal irrigation network imaginable. Emanating from a muscular pump, the heart, these vessels form an extensive system of tubular roadways that carry nourishing blood away from the heart and toward the tissues. They then make a "U-turn" through small permeable, exchange vessels, the capillaries, which feed all the body's cells. Here, life-supporting molecules, such as water, oxygen, glucose, and amino acids are delivered to the cells, and the by-products of cellular metabolism are picked up from the surrounding tissue fluid. The blood then flows back to the heart through a series of return vessels, the veins, that parallel the delivery vessels. This circular pattern of flow to and from the heart constitutes the vascular (blood vessel) component of the cardiovascular (circulatory) system. This irrigation network is so impressive, that if all the blood vessels of the body were placed end-to-end they would extend 25,000 miles (96,500 km), which is approximately two times the equatorial circumference of the earth.

The irrigation network of blood vessels are of no value without a pump. The heart is the dual, self-regulating pump that generates the pressure to drive the blood through this impressive irrigation network. It pumps the blood through two cycles — a pulmonary cycle to pick up oxygen from the lungs and a systemic cycle to deliver the oxygen to all the cells of the body. Soon after conception, and up until death, the heart pumps blood. It averages approximately 70 beats per minute, or about 3 billion contractions in an average lifetime.

The final aspect of the cardiovascular system is the accessory drainage network — the lymphatics. These small vein-like vessels insure that the cardiac return equals the cardiac output. This chapter will depict the anatomy of this amazing muscular pump and the vascular and lymphatic roadways that distribute the blood throughout the body.



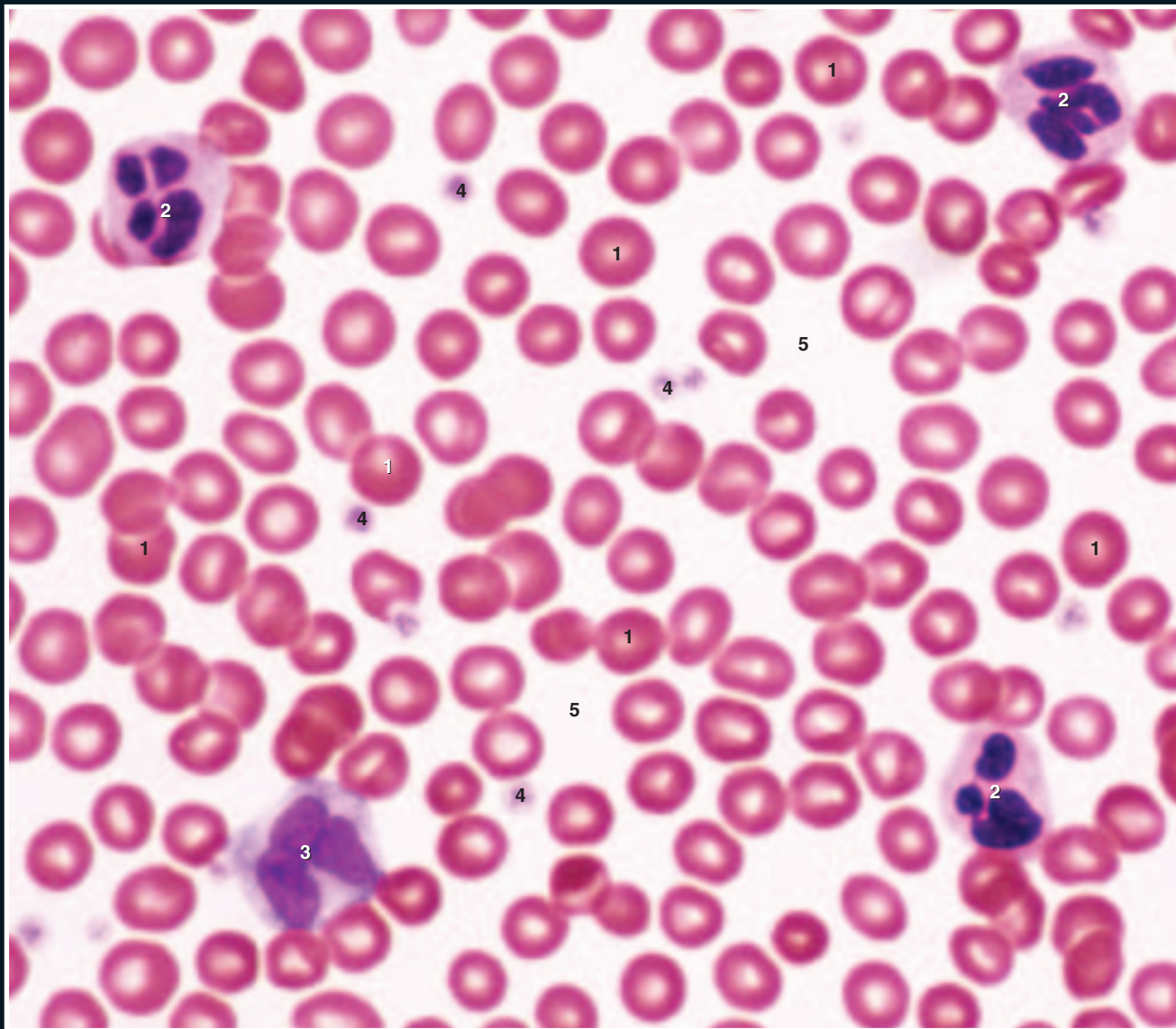
Find more information  
about the cardiovascular  
system in

REALANATOMY

# Blood

In the histology chapter we learned that the fluid material we call blood has been historically classified as a connective tissue. This classification was a result of the fact that, like other connective tissues, blood has more extracellular matrix than cells. More recently, however, blood has been placed in a tissue category of its own — the hematolymphoid complex. The extracellular portion of the blood is a water solution that gives rise to its liquid nature. Blood is closely related to other aqueous fluids within the body, in fact most of the other body fluids, such as interstitial fluid, lymph, cerebrospinal fluid, and aqueous humor, arise from the blood. These extracellular fluids are the water environment that nourish, protect, and exchange with every cell of the body. This water environment is derived from the blood, renewed by the blood, and returned to the blood. Dispersed in the blood plasma are the three groups of blood cells — erythrocytes (red blood cells), leukocytes (white blood cells), and thrombocytes (platelets). The blood smear below depicts the three cell categories.

- 1 Erythrocyte (red blood cell)
- 2 Leukocyte - neutrophil (white blood cell)
- 3 Leukocyte - monocyte (white blood cell)
- 4 Thrombocyte (platelet)
- 5 Blood plasma

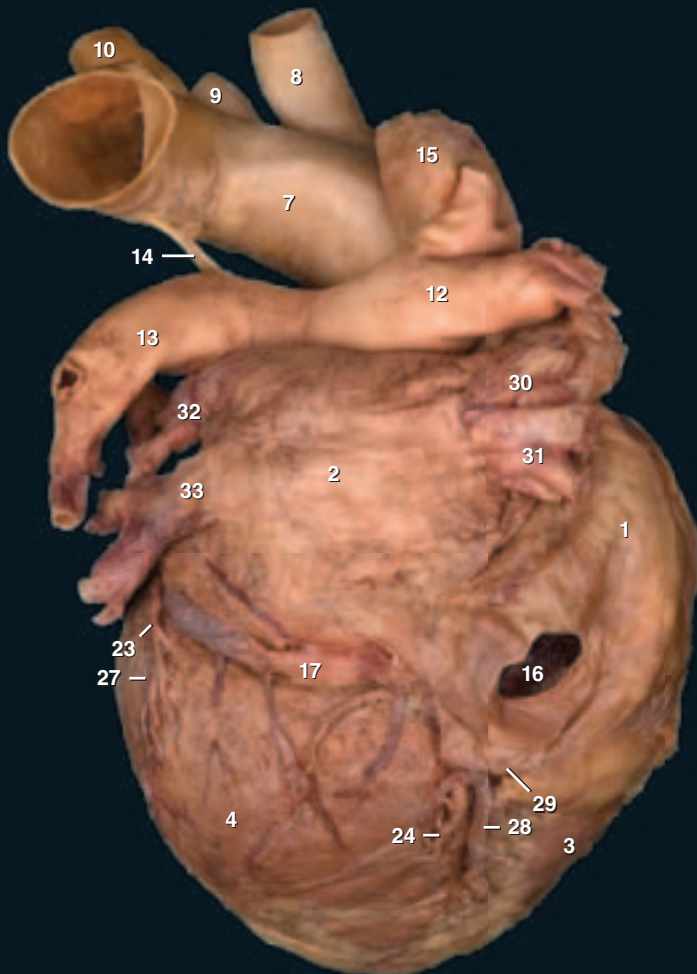


Blood smear  
700x

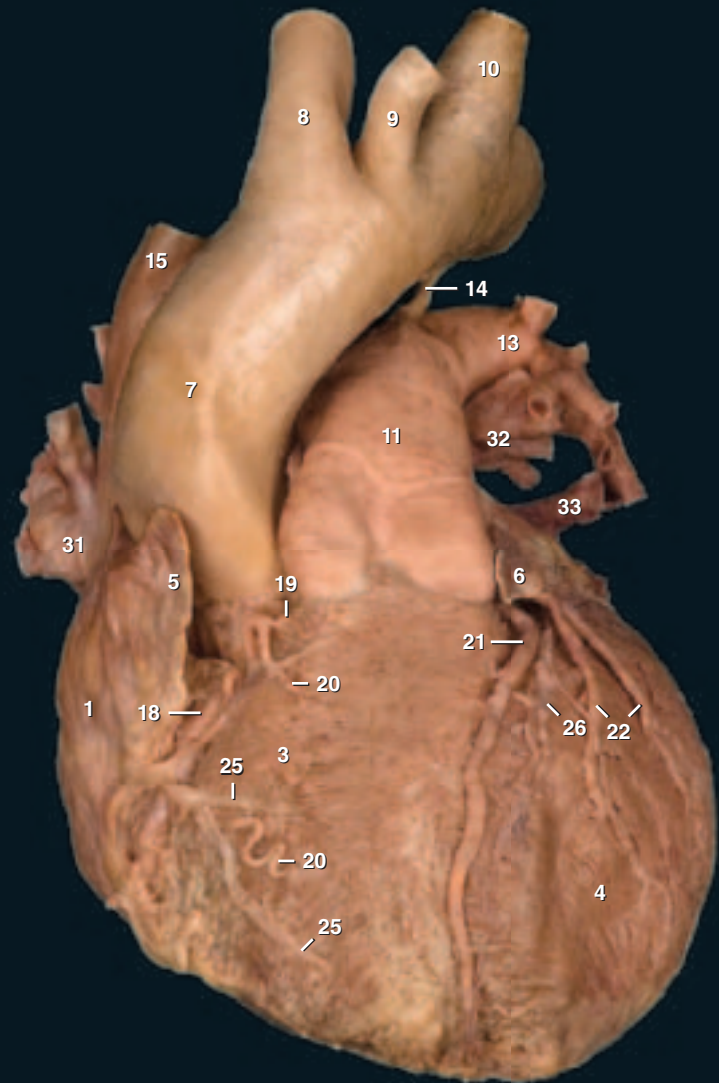
# Heart

From its origin in the embryo as a simple pumping tube, the heart develops into a strong fibromuscular organ. During its development the original tubular pump is folded and subdivided into a four chambered organ that has a pyramidal or conical form. It is approximately the size of a closed fist and weighs approximately 300 grams in males and a little less than this in females. For its small size, comprising only one half of one percent of the total body mass, it is an important and functionally amazing organ. The wall of the heart consists of three structural layers that each play significant roles in its function as an efficient pump. While the tissue makeup of this wall is similar at any location in the heart, the thickness can vary considerably. Internally a septum and series of valves divide the heart into four chambers through which the blood moves in a unidirectional flow. The chambers differ in structure and function, which is primarily reflected in the anatomy of their walls. Embedded within the walls of heart is a special electrical conduction system that helps regulate its coordinated pumping action.

- |                              |                                      |
|------------------------------|--------------------------------------|
| 1 Right atrium               | 18 Right coronary artery             |
| 2 Left atrium                | 19 Conus arteriosus branch           |
| 3 Right ventricle            | 20 Marginal branch                   |
| 4 Left ventricle             | 21 Anterior interventricular artery  |
| 5 Right auricle              | 22 Lateral branches                  |
| 6 Left auricle               | 23 Circumflex branch                 |
| 7 Aorta                      | 24 Posterior interventricular artery |
| 8 Brachiocephalic artery     | 25 Anterior cardiac vein             |
| 9 Left common carotid artery | 26 Great cardiac vein                |
| 10 Left subclavian artery    | 27 Posterior vein of left ventricle  |
| 11 Pulmonary trunk           | 28 Middle cardiac vein               |
| 12 Right pulmonary artery    | 29 Small cardiac vein                |
| 13 Left pulmonary artery     | 30 Right superior pulmonary vein     |
| 14 Ligamentum arteriosum     | 31 Right inferior pulmonary vein     |
| 15 Superior vena cava        | 32 Left superior pulmonary vein      |
| 16 Inferior vena cava        | 33 Left inferior pulmonary vein      |
| 17 Coronary sinus            |                                      |



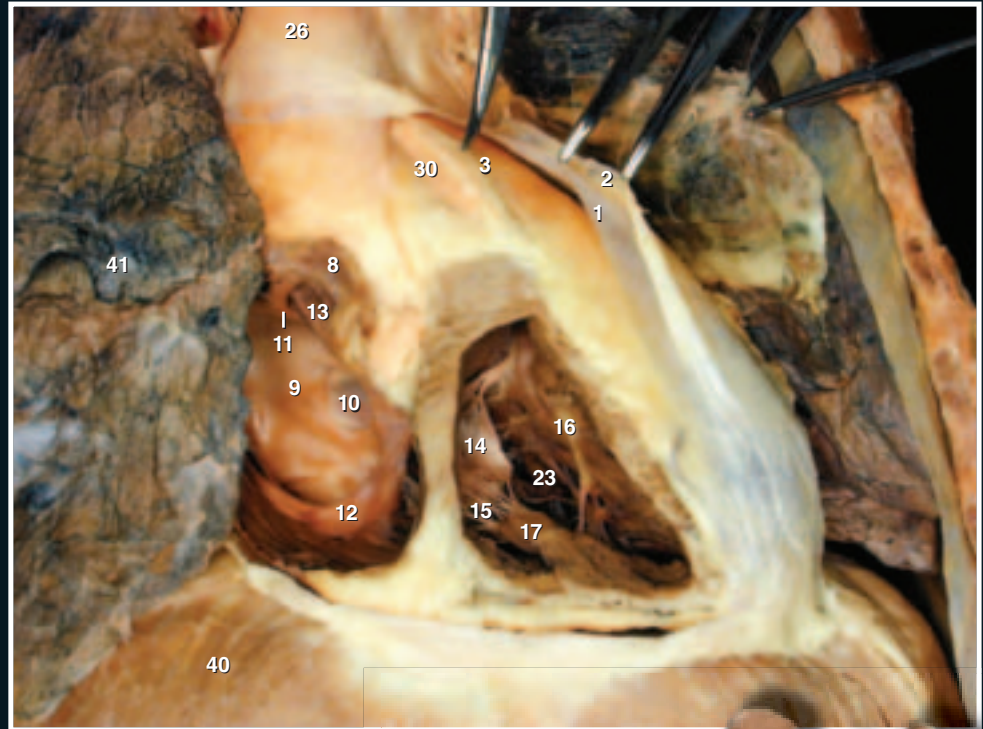
**Heart**  
Posterior view



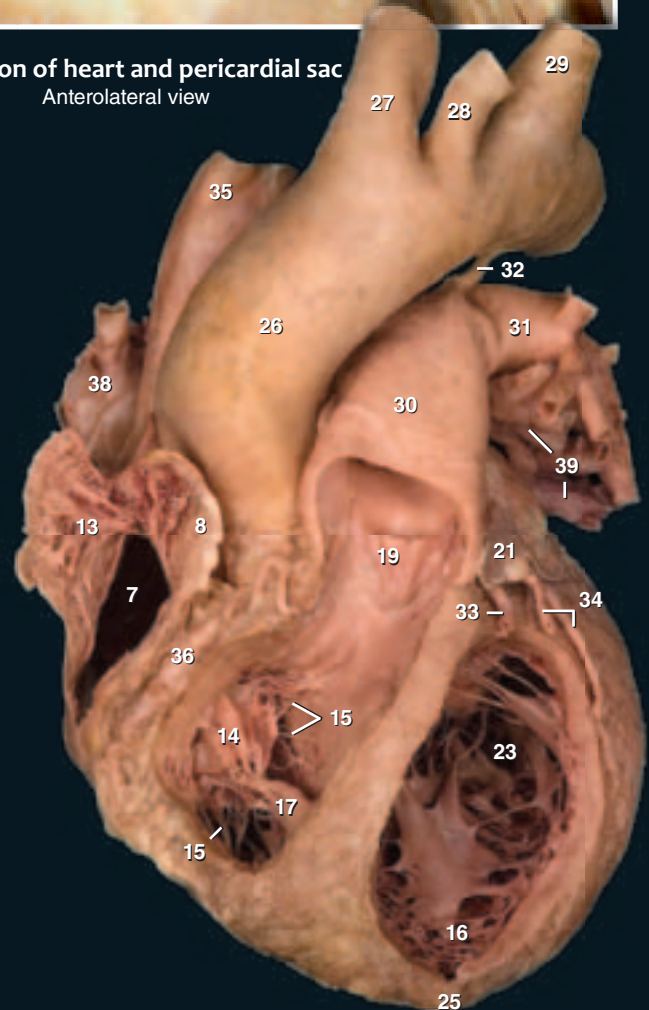
**Heart**  
Anterior view

# Heart

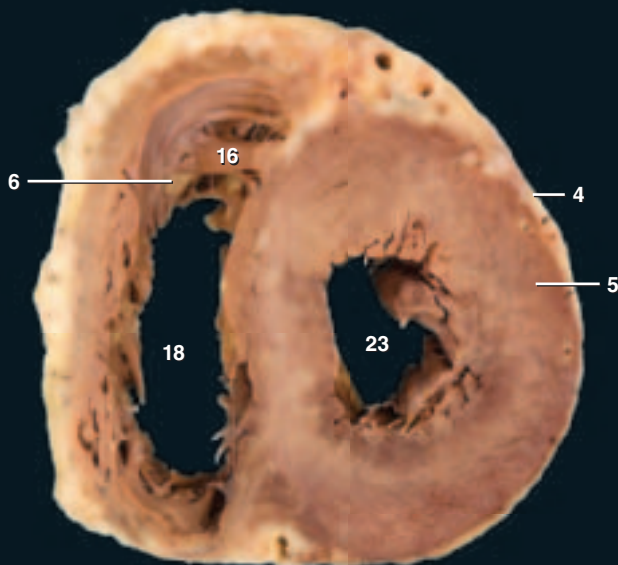
- 1 Parietal pericardium
- 2 Fibrous pericardium
- 3 Visceral pericardium
- 4 Epicardium
- 5 Myocardium
- 6 Endocardium
- 7 Right atrium
- 8 Right auricle
- 9 Interatrial septum
- 10 Fossa ovalis
- 11 Crista terminalis
- 12 Valve of inferior vena cava
- 13 Pectinate muscle
- 14 Tricuspid valve
- 15 Chordae tendineae
- 16 Trabeculae carnae
- 17 Papillary muscle
- 18 Right ventricle
- 19 Pulmonary valve
- 20 Left atrium
- 21 Left auricle
- 22 Bicuspid valve
- 23 Left ventricle
- 24 Aortic valve
- 25 Apex
- 26 Aorta
- 27 Brachiocephalic artery
- 28 Left common carotid artery
- 29 Left subclavian artery
- 30 Pulmonary trunk
- 31 Left pulmonary artery
- 32 Ligamentum arteriosum
- 33 Anterior interventricular artery
- 34 Lateral branches of interventricular artery
- 35 Superior vena cava
- 36 Right coronary artery
- 37 Left coronary artery
- 38 Right pulmonary veins
- 39 Left pulmonary veins
- 40 Diaphragm
- 41 Lung



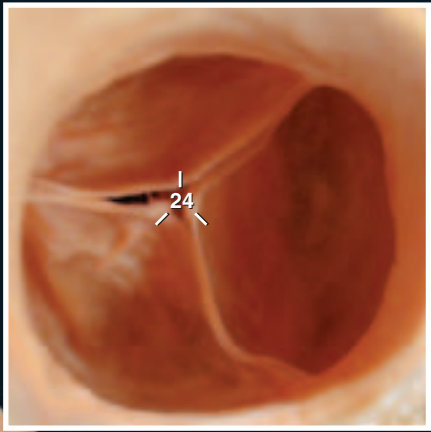
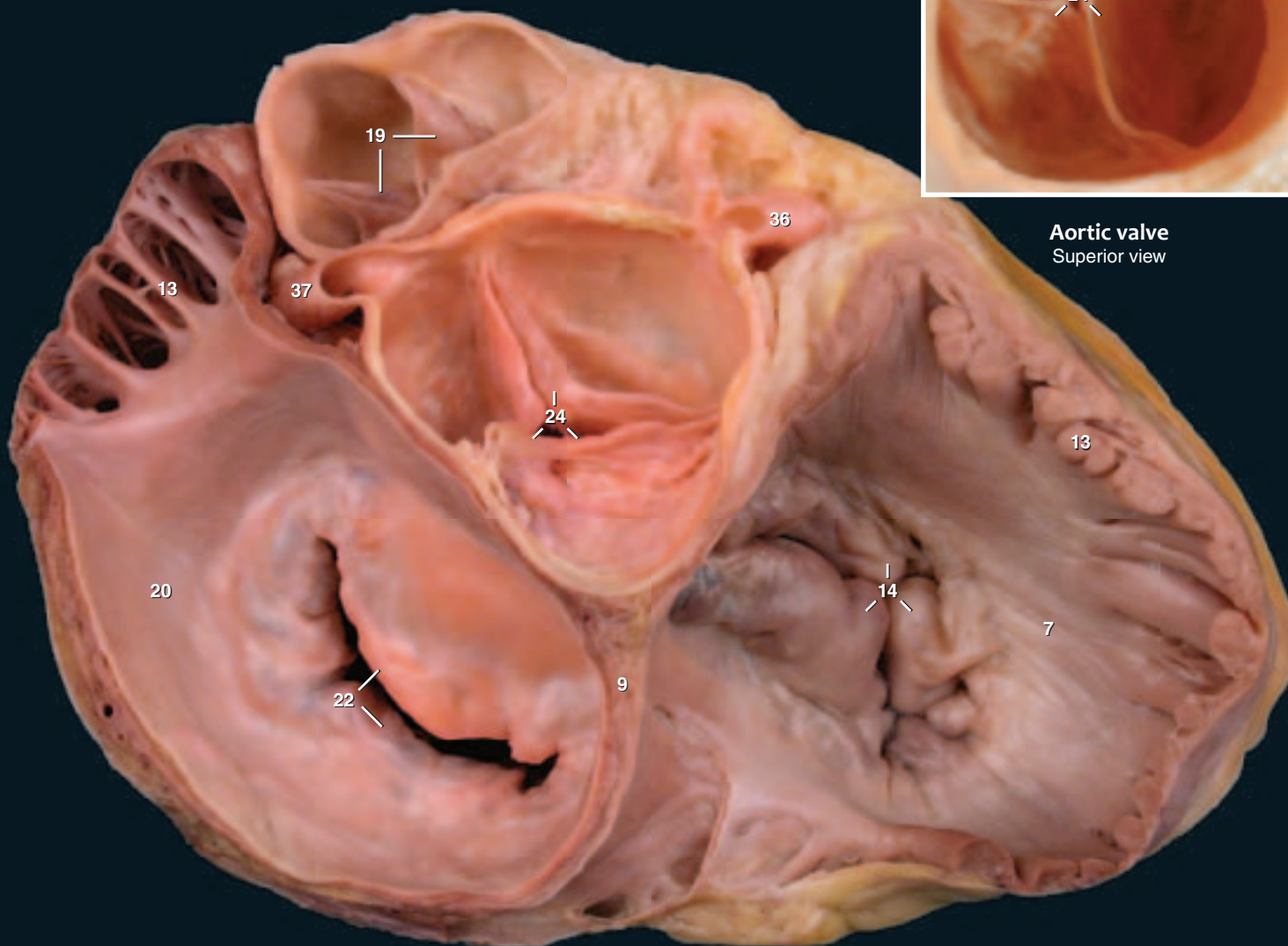
**Dissection of heart and pericardial sac**  
Anterolateral view



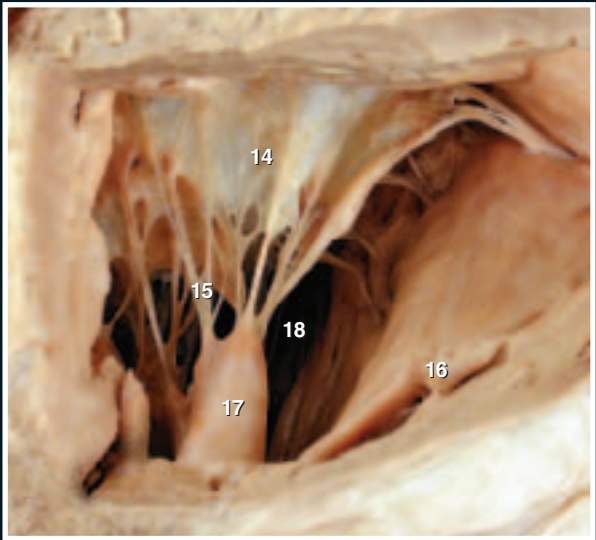
**Dissected heart showing interior of chambers**  
Anterior view



**Transverse section of heart comparing ventricle thickness**  
Inferior view, left ventricle at right



**Aortic valve**  
Superior view



**Dissection of heart revealing tricuspid valve**  
Anterior view

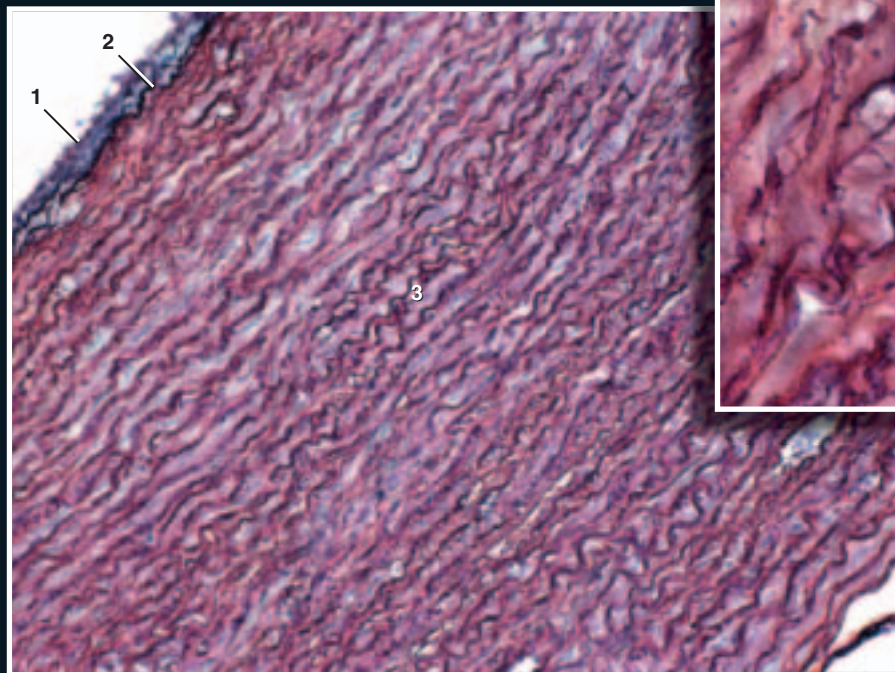
**Heart dissection with atria and arteries removed**  
Superior view, anterior at top

# Blood Vessels

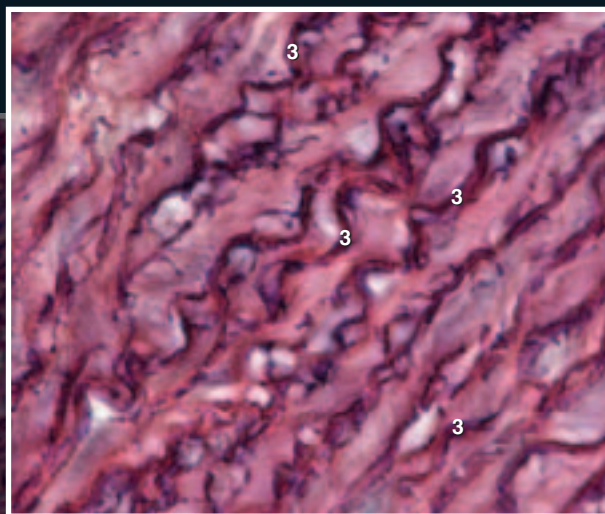
Like all tubes in the body, blood vessels have a basic pattern of design that involves three structural tunics, or layers. The inner layer of the vessel is the tunica intima.

This consists of the luminal endothelium and a thin network of underlying elastic connective tissue. The middle layer of the vessel is the tunica media, which consists of varying amounts of smooth muscle and elastic connective tissue. Variations in the tunica media define the different types of blood vessels. The outer layer, the tunica externa, is a dense connective tissue outer coat. The designations — elastic arteries, muscular arteries, arterioles, venules, and veins — are based on size differences and the differences in the vessels' tunica media. Elastic arteries have a thick elastic tunica media. Muscular arteries have a tunica media dominated by smooth muscle. Arterioles are tiny arteries with a muscular tunica media. All the venous vessels have a thin, almost non-existent tunica media. The smallest blood vessels, the capillaries, lose all the layers of their wall except the inner endothelium. These microscopic, thin walled tubes become the exchange vessels of the system.

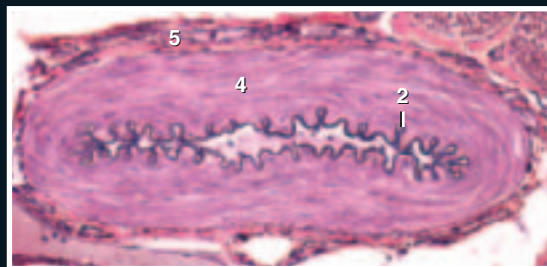
- |  |                             |
|--|-----------------------------|
| 1 Endothelium of tunica intima               | 6 Red blood cells           |
| 2 Internal elastic membrane of tunica intima | 7 White blood cells         |
| 3 Elastic lamellae of tunica media           | 8 Venous valves             |
| 4 Smooth muscle cells of tunica media        | 9 Nerve                     |
| 5 Connective tissue of tunica externa        | 10 Striated skeletal muscle |



Section of aorta — large elastic artery  
100x

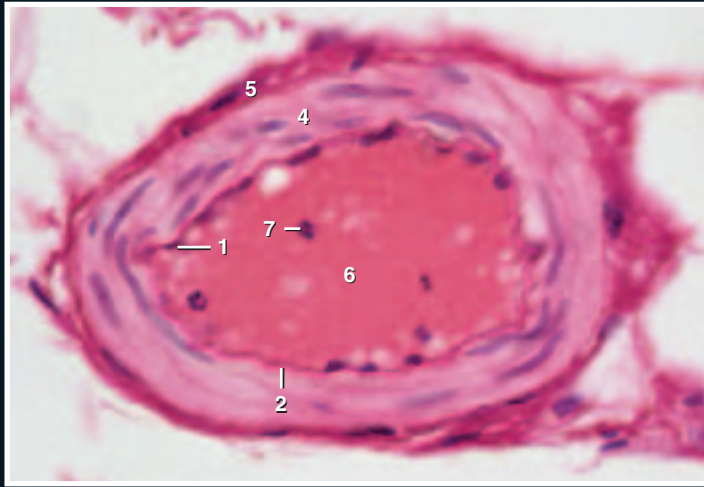


Elastic lamellae of aorta  
640x

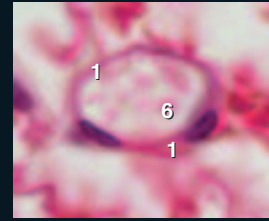


Muscular artery  
100x





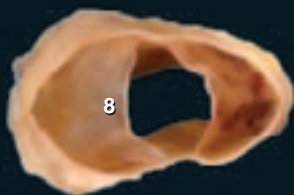
**Arteriole**  
500x



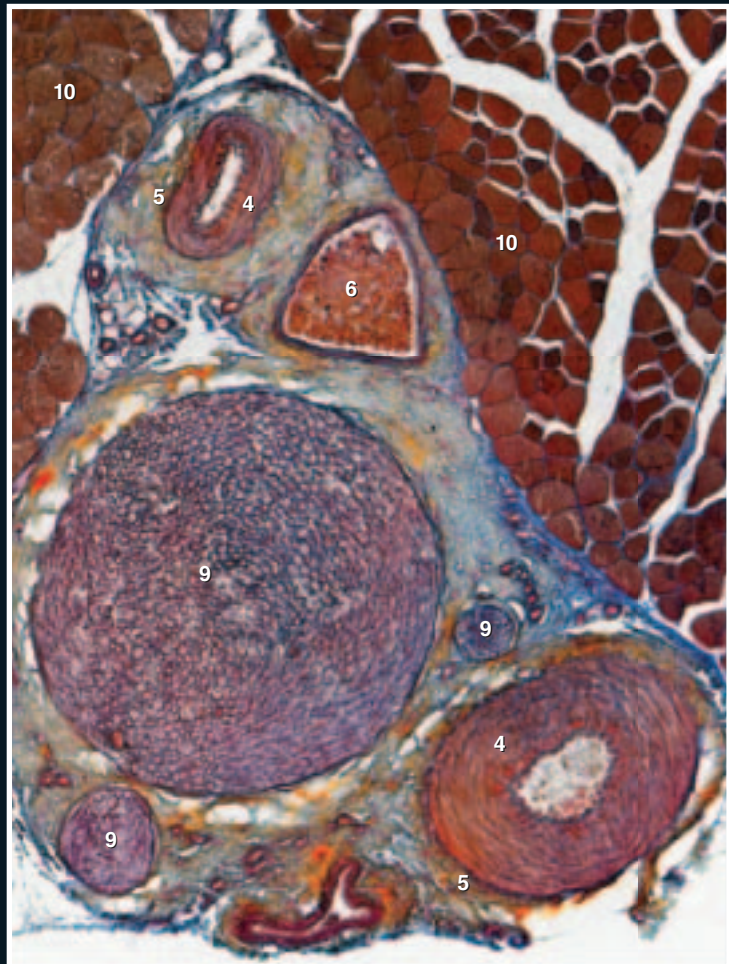
**Capillary**  
1000x



**Longitudinal section of vein showing valves**  
Anterior view



**Transverse section of vein showing valves**  
Superior view

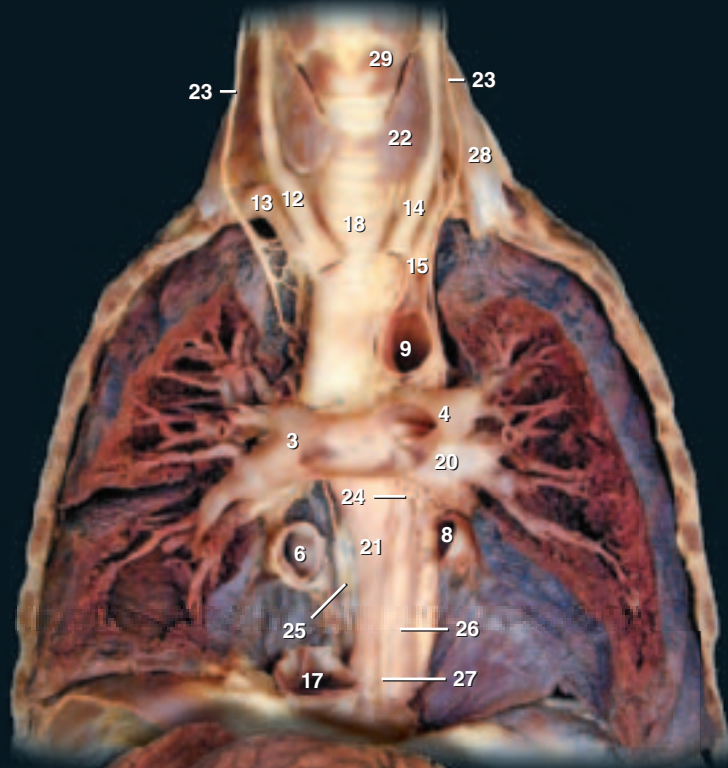


**Neurovascular bundle** — note thin-walled vein filled with red blood cells (6) compared to thick-walled muscular arteries (4)  
100x

# Pulmonary Circuit

The vascular system consists of two long circular loops of continuous branched tubing that each begin and end with the heart. Leaving the right ventricle and returning to the left atrium is the smaller pulmonary circulation. This circular loop courses through the lung tissues where its smallest vessels form an extensive interface with the small air sacs of the lungs. This important interface is the site of exchange of O<sub>2</sub> and CO<sub>2</sub> between the blood and air.

- |                                 |                             |
|---------------------------------|-----------------------------|
| 1 Heart                         | 16 Superior vena cava       |
| 2 Pulmonary trunk               | 17 Inferior vena cava       |
| 3 Right pulmonary artery        | 18 Trachea                  |
| 4 Left pulmonary artery         | 19 Right principal bronchus |
| 5 Right superior pulmonary vein | 20 Left principal bronchus  |
| 6 Right inferior pulmonary vein | 21 Esophagus                |
| 7 Left superior pulmonary vein  | 22 Thyroid gland            |
| 8 Left inferior pulmonary vein  | 23 Vagus nerve              |
| 9 Aorta                         | 24 Pulmonary plexus         |
| 10 Right coronary artery        | 25 Posterior vagal trunk    |
| 11 Left coronary artery         | 26 Esophageal plexus        |
| 12 Right common carotid artery  | 27 Anterior vagal trunk     |
| 13 Right subclavian artery      | 28 Anterior scalene muscle  |
| 14 Left common carotid artery   | 29 Cricothyroid muscle      |
| 15 Left subclavian artery       |                             |



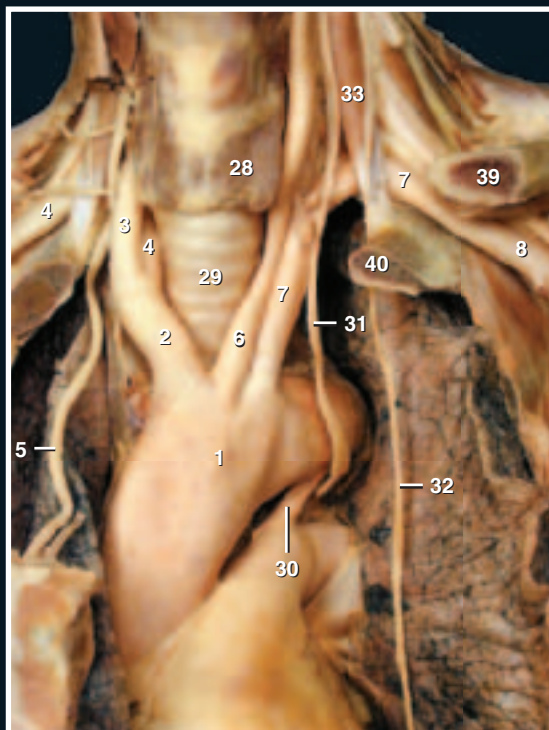
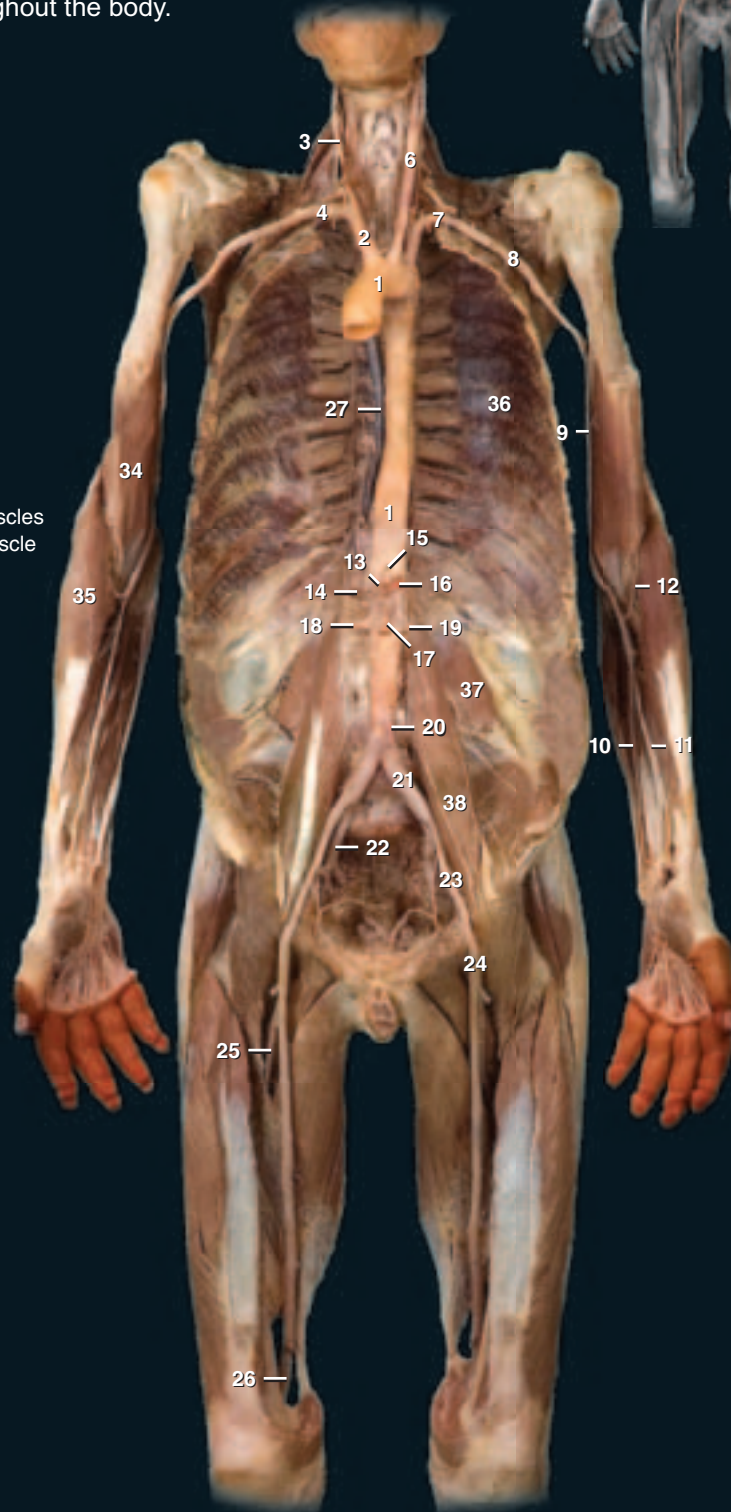
**Dissections of pulmonary trunk, arteries, and veins**  
Anterosuperior view below, anterior view above

# Systemic Circuit

The left ventricle pumps blood into the much larger systemic circulation, which is distributed throughout all the body's tissues. Unlike the smaller pulmonary circuit, the extensive systemic circuit serves a multitude of functions before returning to the right atrium: (1) it distributes the necessary nutrients and other supplies to all the body cells while removing their metabolic wastes; (2) it acquires metabolic fuel through the lining of the digestive system to distribute throughout the body; (3) it expels wastes and excess water and adjusts the body's electrolyte composition through its association with the tubes of the kidney; (4) it distributes generated heat throughout the body and plays an important role in adjusting heat loss to the external environment as it courses through the skin; and (5) it distributes hormones, regulatory chemical-messenger molecules secreted by endocrine glands, to various sites of action throughout the body.



- |                                  |                                  |
|----------------------------------|----------------------------------|
| 1 Aorta                          | 21 Common iliac arteries         |
| 2 Brachiocephalic artery         | 22 Internal iliac arteries       |
| 3 Right common carotid artery    | 23 External iliac artery         |
| 4 Right subclavian artery        | 24 Femoral artery                |
| 5 Right internal thoracic artery | 25 Deep femoral artery           |
| 6 Left common carotid artery     | 26 Popliteal artery              |
| 7 Left subclavian artery         | 27 Azygos vein                   |
| 8 Left axillary artery           | 28 Thyroid gland                 |
| 9 Left brachial artery           | 29 Trachea                       |
| 10 Left ulnar artery             | 30 Ligamentum arteriosum         |
| 11 Left radial artery            | 31 Vagus nerve                   |
| 12 Left radial recurrent artery  | 32 Phrenic nerve                 |
| 13 Coeliac trunk                 | 33 Anterior scalene muscle       |
| 14 Common hepatic artery         | 34 Brachialis muscle             |
| 15 Left gastric artery           | 35 Brachioradialis muscle        |
| 16 Splenic artery                | 36 Innermost intercostal muscles |
| 17 Superior mesenteric artery    | 37 Quadratus lumborum muscle     |
| 18 Right renal artery            | 38 Psoas major muscle            |
| 19 Left renal artery             | 39 Clavicle                      |
| 20 Inferior mesenteric artery    | 40 First rib                     |



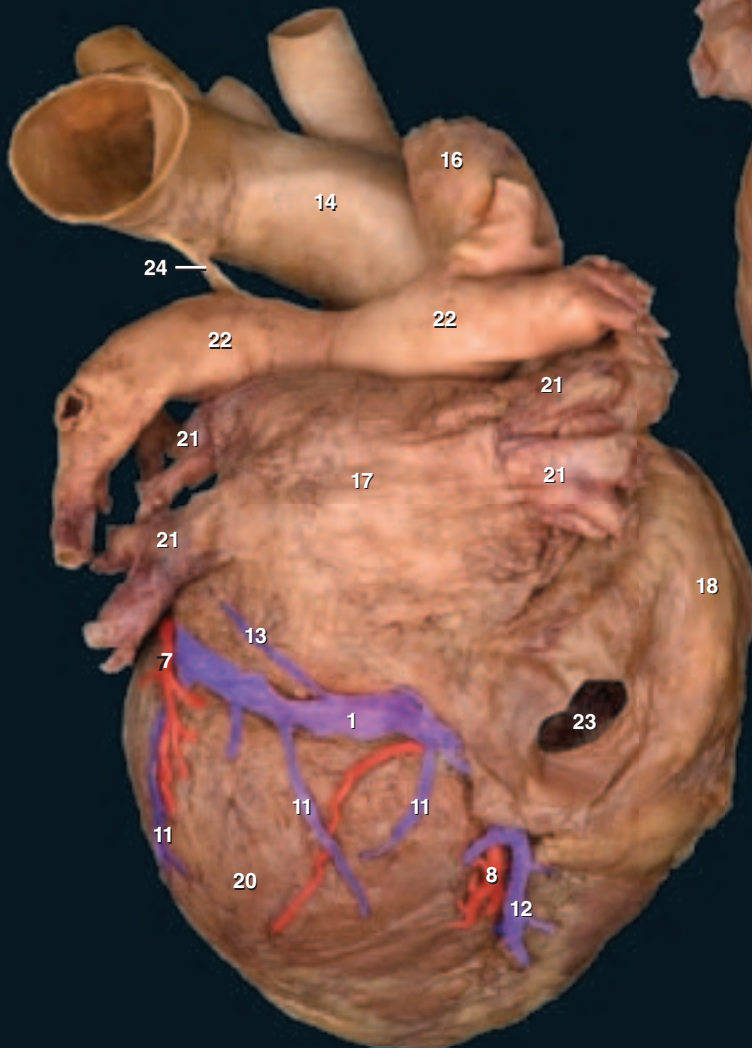
Dissection of aortic arch and its branches  
Anterior view

Dissection of major arterial pathways  
Anterior view

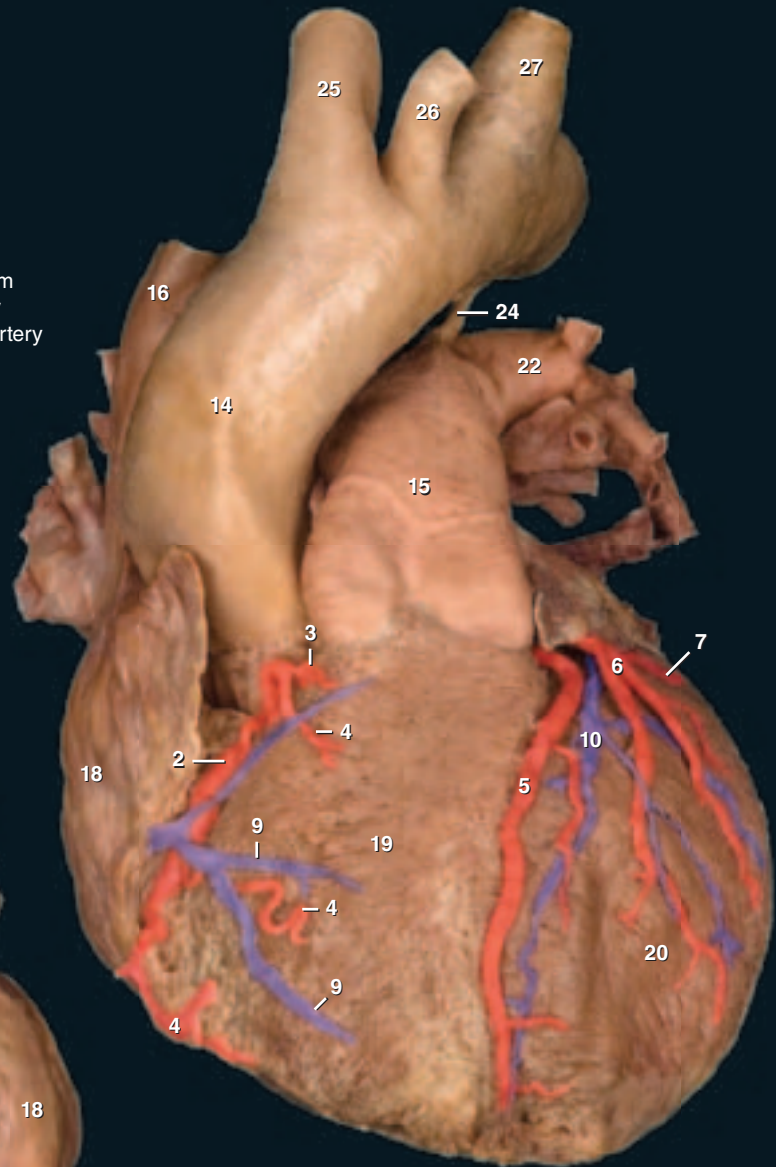
# Heart Vessels

The coronary arteries are the first branches of the aorta. These important vessels provide the constantly needed blood supply to the heart. The left coronary artery is, on average, larger than the right coronary artery and supplies a greater percentage of the heart tissue. Accompanying the branches of the coronary arteries, a series of cardiac veins emerge from the capillaries of the heart to return blood to the right atrial chamber, either by entering directly or by joining the large coronary sinus, which enters the right atrium from the posterior side.

- |                                      |                               |
|--------------------------------------|-------------------------------|
| 1 Coronary sinus                     | 15 Pulmonary trunk            |
| 2 Right coronary artery              | 16 Superior vena cava         |
| 3 Conus arteriosus branch            | 17 Left atrium                |
| 4 Marginal branch                    | 18 Right atrium               |
| 5 Anterior interventricular artery   | 19 Right ventricle            |
| 6 Lateral branches                   | 20 Left ventricle             |
| 7 Circumflex branch of left coronary | 21 Pulmonary veins            |
| 8 Posterior interventricular artery  | 22 Pulmonary artery           |
| 9 Anterior cardiac vein              | 23 Inferior vena cava         |
| 10 Great cardiac vein                | 24 Ligamentum arteriosum      |
| 11 Posterior vein of left ventricle  | 25 Brachiocephalic artery     |
| 12 Middle cardiac vein               | 26 Left common carotid artery |
| 13 Oblique vein                      | 27 Left subclavian artery     |
| 14 Aorta                             |                               |



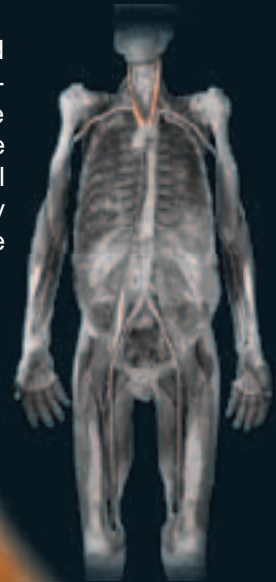
Dissection of coronary arteries, coronary sinus, and cardiac veins  
Posterior view



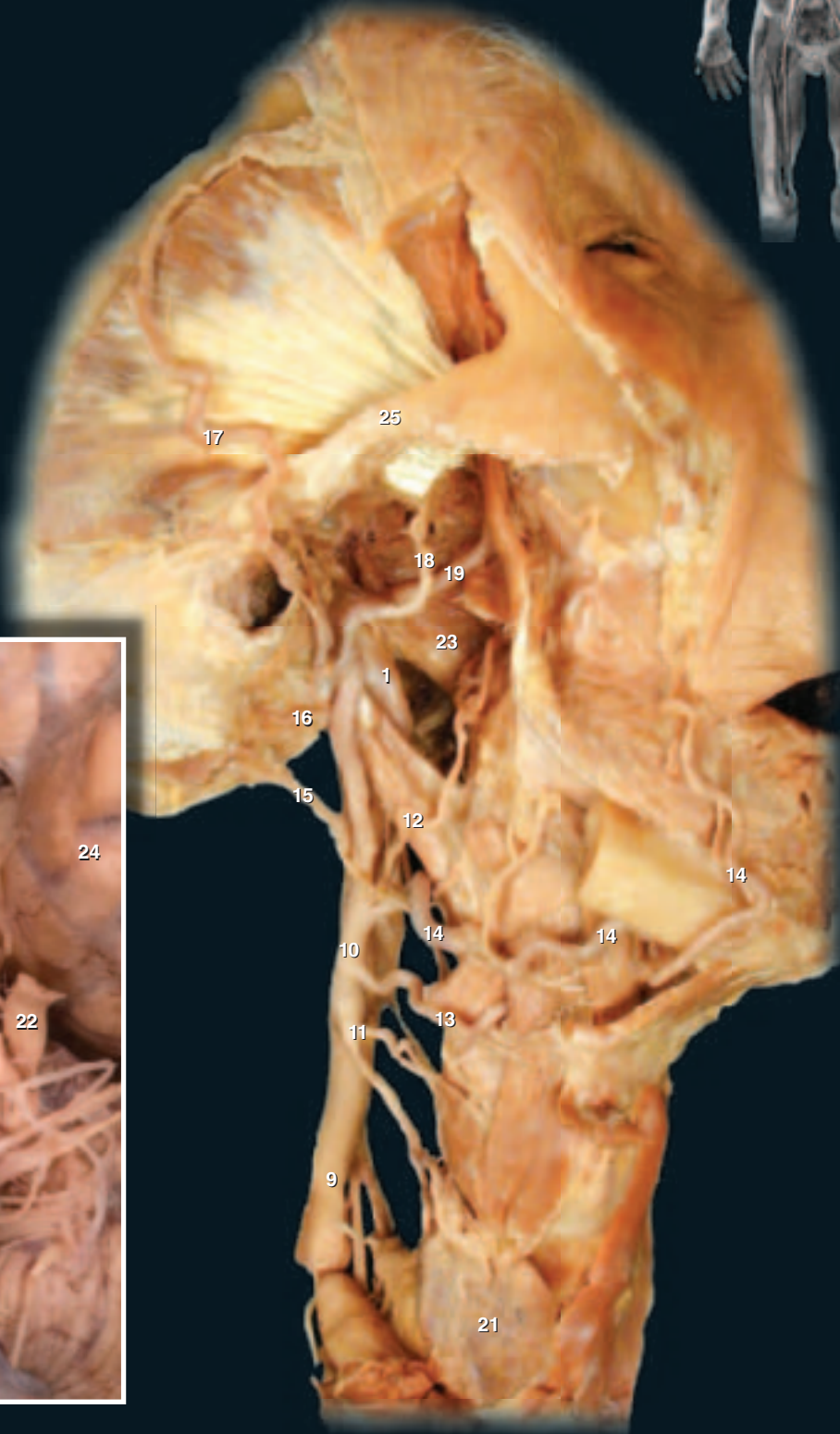
Dissection of coronary arteries and cardiac veins  
Anterior view

# Head Vessels

Like the heart, which needs a constant, uninterrupted blood supply, the brain tissue also must be guaranteed of a continuous perfusion in order to maintain its crucial functions. The common carotid arteries, arising from the aortic arch, bifurcate into external and internal carotids. The external carotid supplies all tissues of the head except the brain, while the function of the internal carotid is to supply the brain. Because of the brain's critical vascular needs the internal carotid artery has a partner, the vertebral artery, which courses cranially from the subclavian artery to assist with the essential blood supply to the brain.



- 1 Internal carotid artery
- 2 Basilar artery
- 3 Vertebral artery
- 4 Posterior cerebral artery
- 5 Posterior communicating artery
- 6 Middle cerebral artery
- 7 Posterior inferior cerebellar artery
- 8 Posterior superior cerebellar artery
- 9 Common carotid artery
- 10 External carotid artery
- 11 Superior thyroid artery
- 12 Ascending pharyngeal artery
- 13 Lingual artery
- 14 Facial artery
- 15 Occipital artery
- 16 Posterior auricular artery
- 17 Superficial temporal artery
- 18 Transverse facial artery
- 19 Maxillary artery
- 20 Optic chiasm
- 21 Thyroid gland
- 22 Trigeminal nerve
- 23 Lateral pterygoid muscle
- 24 Temporal lobe of cerebrum
- 25 Zygomatic arch

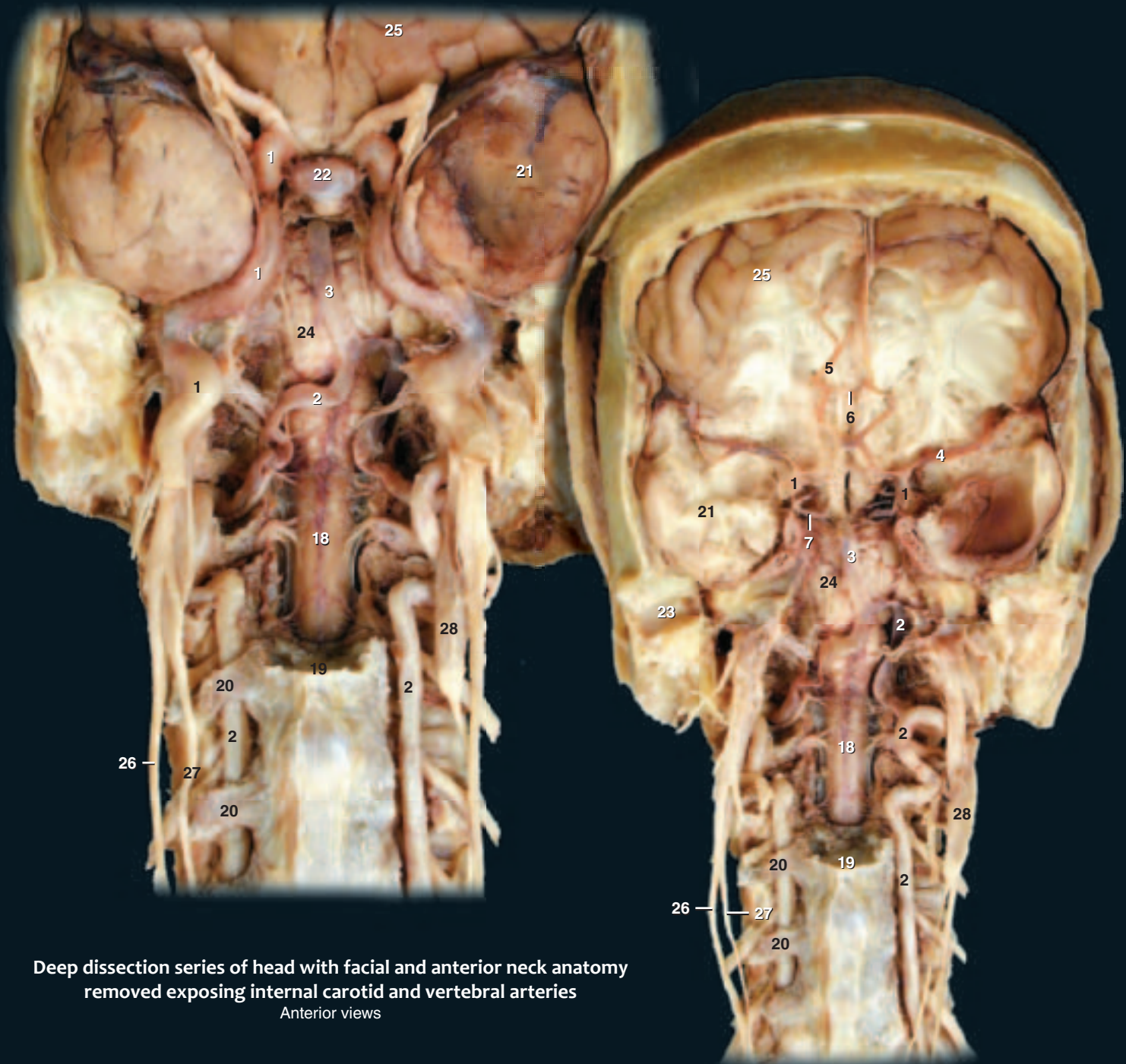


**Dissection of basilar artery**  
Inferior view

**Dissection of branches of external carotid artery**  
Lateral view

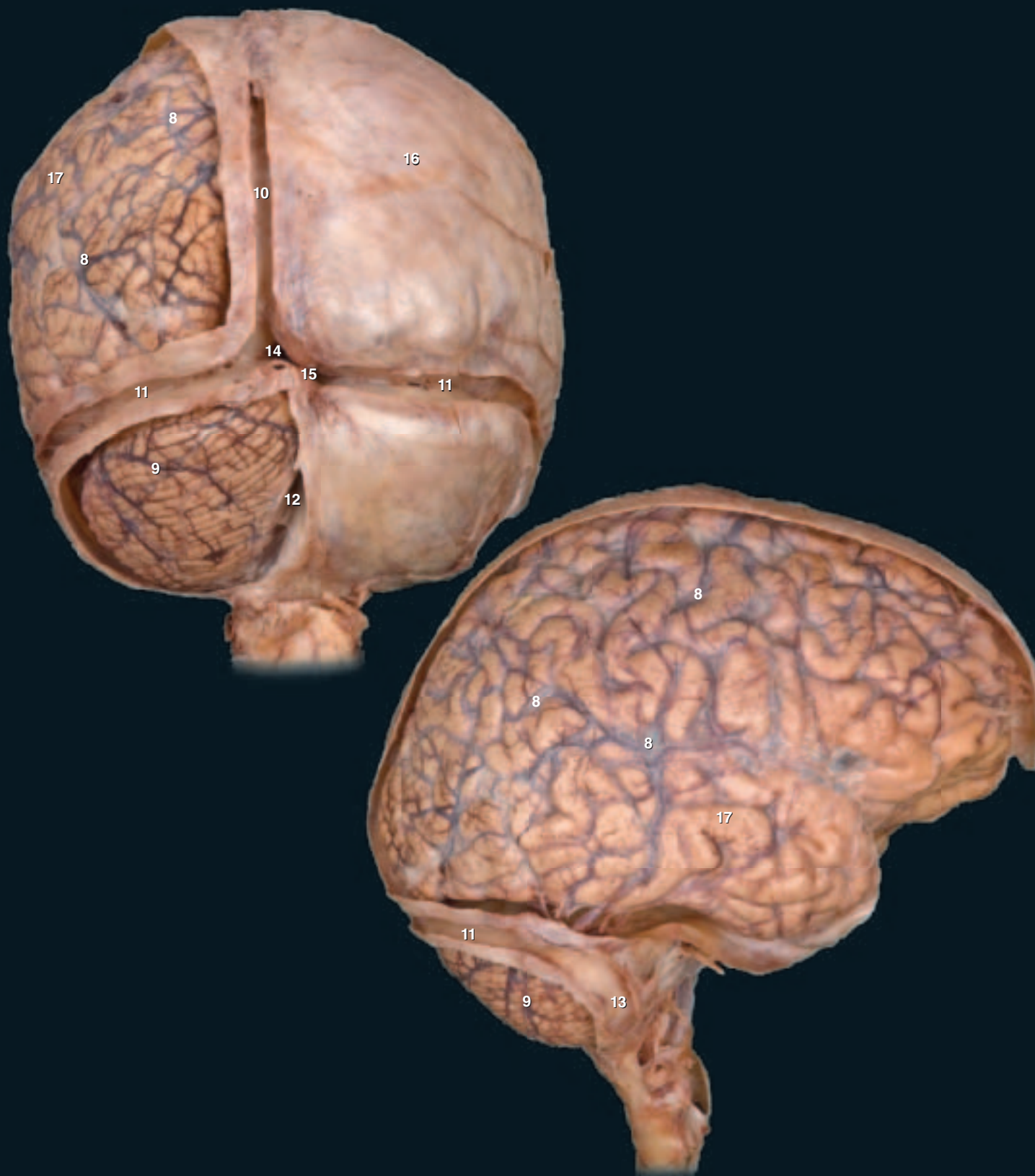
# Head Vessels

- |                                  |                              |                                |                               |
|----------------------------------|------------------------------|--------------------------------|-------------------------------|
| 1 Internal carotid artery        | 8 Cerebral veins             | 15 Confluence of the sinuses   | 22 Pituitary gland            |
| 2 Vertebral artery               | 9 Cerebellar veins           | 16 Dura mater                  | 23 External acoustic meatus   |
| 3 Basilar artery                 | 10 Superior sagittal sinus   | 17 Pia-arachnoid mater         | 24 Pons                       |
| 4 Middle cerebral artery         | 11 Transverse sinus          | 18 Spinal cord                 | 25 Frontal lobe of cerebrum   |
| 5 Anterior cerebral artery       | 12 Inferior sagittal sinus   | 19 Vertebral body              | 26 Vagus nerve                |
| 6 Anterior communicating artery  | 13 Sigmoid sinus             | 20 Cervical transverse process | 27 Cervical sympathetic trunk |
| 7 Posterior communicating artery | 14 Opening of straight sinus | 21 Temporal lobe of cerebrum   | 28 Superior cervical ganglion |



Deep dissection series of head with facial and anterior neck anatomy removed exposing internal carotid and vertebral arteries  
Anterior views

Unlike the internal and external carotid arteries, the internal and external jugular veins form a wide array of collateral circuitry. The major structural difference of the venous pathways in the head is the existence of dural venous sinuses within the skull. The dural venous sinuses are non-collapsible, endothelial lined spaces within the tough meningeal dura mater. All the smaller veins draining capillaries within the brain tissue enter into the dural venous sinuses. These dural sinuses converge with one another throughout the skull to exit the cranial vault via the internal jugular vein.

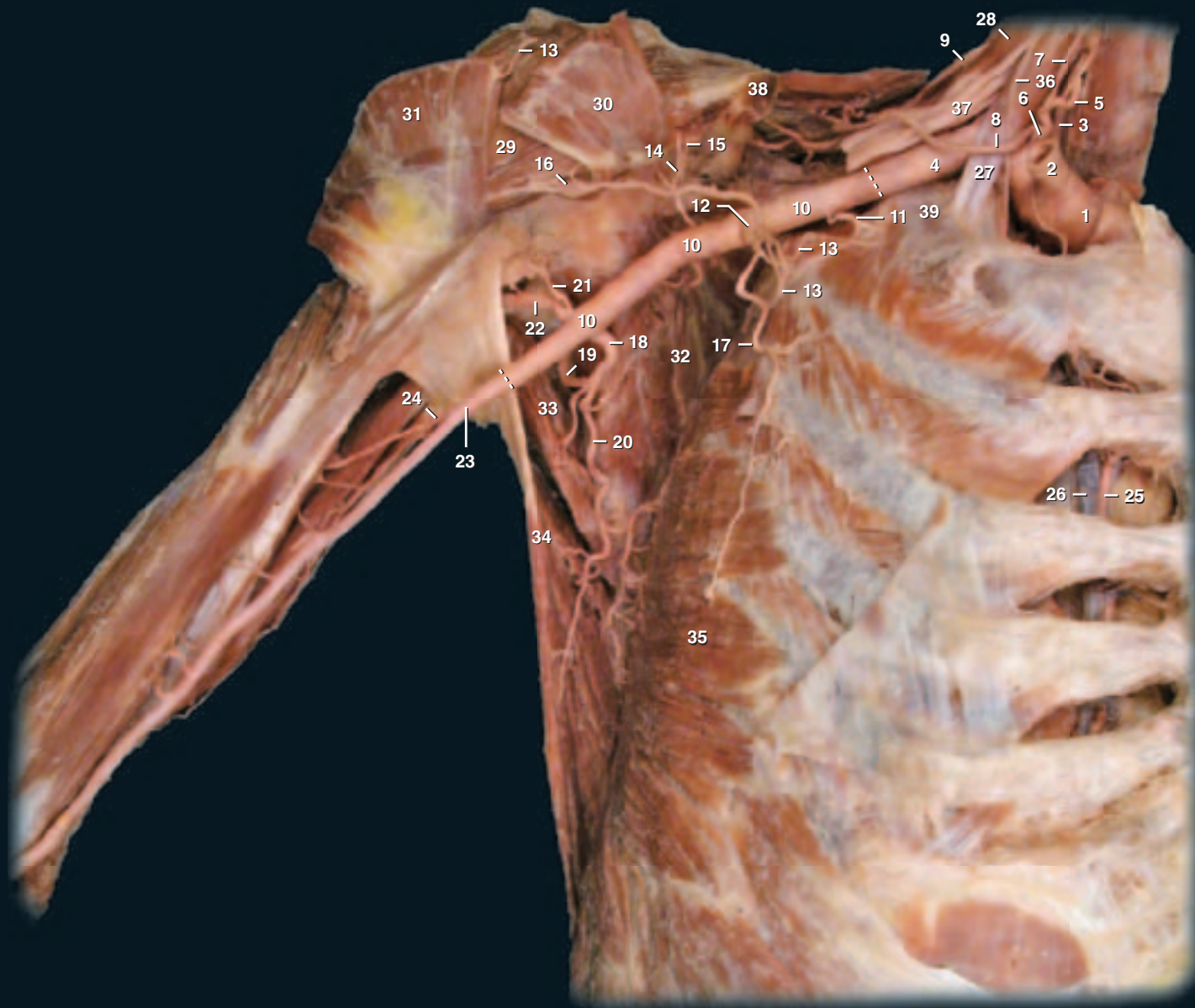
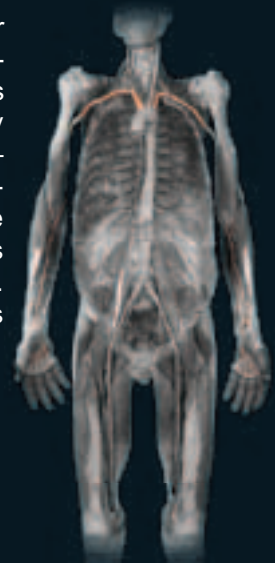


**Dissections of dural venous sinuses and cerebral veins**  
Posterior view (top), lateral view (bottom)

# Superior Limb Vessels

it gives rise to the various branches that supply the tissues of the limb. This large arterial roadway begins as the subclavian artery, takes on regional names — the axillary artery and brachial artery — as it tapers distally, then branches into the radial and ulnar arteries, which course through the antebrachium, paralleling the bones of the same names. The radial and ulnar arteries terminate as the collateral arches in the hand. This central pathway through the limb is the sole blood supply to this region, supplying the integument, muscles, bones, joints, and connective tissues of the upper limb. The deep venous pathways follow the arteries and have similar names. However, superficial veins that have no arterial counterparts aid the deep veins in returning blood to the heart.

The arterial pathway into the upper limb consists of a single, major arterial roadway that gradually tapers as



Dissection of subclavian and axillary arteries  
Anterior view



- |                             |                               |  |                             |
|-----------------------------|-------------------------------|--|-----------------------------|
| 1 Brachiocephalic artery    | 11 Superior thoracic artery   | 21 Posterior circumflex humeral artery | 31 Pectoralis major muscle  |
| 2 Common carotid artery     | 12 Thoracoacromial trunk      | 22 Anterior circumflex humeral artery  | 32 Subscapularis muscle     |
| 3 Vertebral artery          | 13 Pectoral artery            | 23 Brachial artery                     | 33 Teres major muscle       |
| 4 Subclavian artery         | 14 Acromial artery            | 24 Deep artery of arm                  | 34 Latissimus dorsi muscle  |
| 5 Thyrocervical trunk       | 15 Clavicular artery          | 25 Internal thoracic artery            | 35 Serratus anterior muscle |
| 6 Inferior thyroid artery   | 16 Deltoid artery             | 26 Internal thoracic vein              | 36 Phrenic nerve            |
| 7 Ascending cervical artery | 17 Lateral thoracic artery    | 27 Anterior scalene muscle             | 37 Brachial plexus          |
| 8 Suprascapular artery      | 18 Subscapular artery         | 28 Middle scalene muscle               | 38 Clavicle                 |
| 9 Dorsal scapular artery    | 19 Circumflex scapular artery | 29 Deltoid muscle                      | 39 First rib                |
| 10 Axillary artery          | 20 Thoracodorsal artery       | 30 Pectoralis minor muscle             | 40 Suprascapular nerve      |



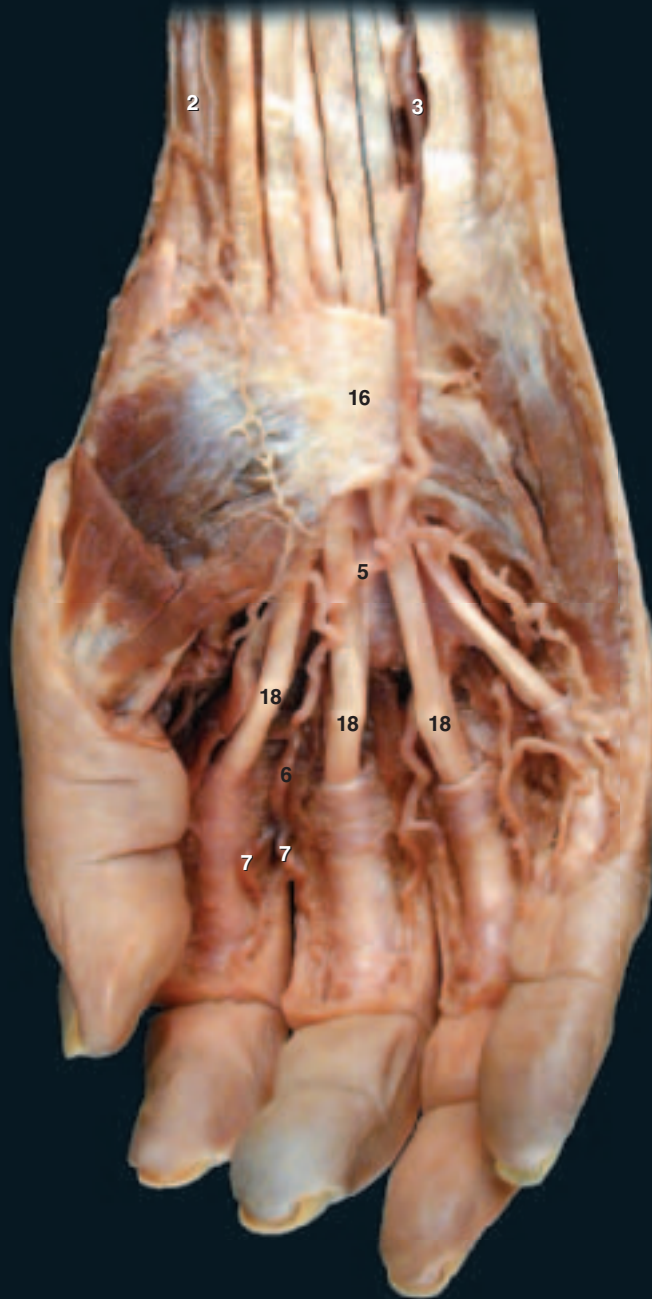
**Dissection of subclavian and axillary arteries**  
Anterosuperior view

# Superior Limb Vessels

- |                                |                             |   |                             |
|--------------------------------|-----------------------------|---|-----------------------------|
| 1 Brachial artery              | 8 Deep palmar arch          | 15 Interosseous membrane                  | 22 Triceps brachii muscle   |
| 2 Ulnar artery                 | 9 Cephalic vein             | 16 Transverse carpal ligament             | 23 Pectoralis major muscle  |
| 3 Radial artery                | 10 Median cubital vein      | 17 Supinator muscle                       | 24 Deltoid muscle           |
| 4 Anterior interosseous artery | 11 Basilic vein             | 18 Pronator quadratus muscle              | 25 Deltopectoral groove     |
| 5 Superficial palmar arch      | 12 Median antebrachial vein | 19 Flexor digitorum superficialis tendons | 26 Serratus anterior muscle |
| 6 Common digital artery        | 13 Accessory cephalic vein  | 20 Flexor digitorum profundus tendons     | 27 Brachioradialis muscle   |
| 7 Proper digital artery        | 14 Brachial vein            | 21 Biceps brachii muscle                  | 28 Coracobrachialis muscle  |

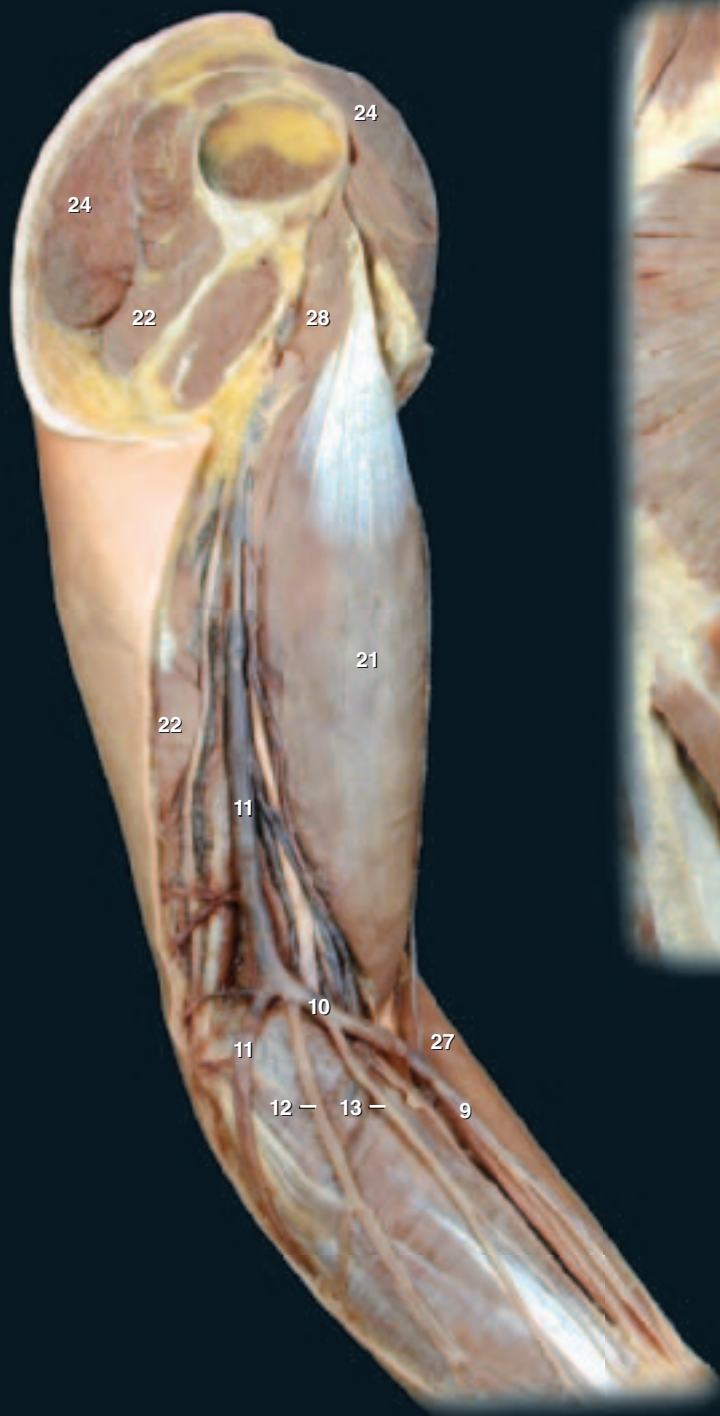


**Dissection of antebrachial arteries**  
Anterior view



**Dissection of palmar arterial arch and branches to digits**  
Anterior view

Within the upper limb there are two sets of veins: deep veins that accompany the arteries, and superficial veins that course through the hypodermis without arterial counterparts. The deep veins, running with the arteries of the upper limb, have the same names as their arterial counterparts. These veins are significantly smaller than the arteries they accompany and form vena comitans with anastomotic channels around the arteries. The superficial veins of the upper limb are large and numerous. There are three major superficial veins into which all the other superficial veins flow; they are the basilic vein, cephalic vein, and median cubital vein. The median cubital vein is a connecting vein between the cephalic vein and the basilic vein. The cephalic and basilic veins eventually pass deep to join the axillary vein at the proximal end of the limb. Most of the venous return from the upper limb passes through the superficial veins.



**Dissection of superficial vein of upper limb**  
Medial view of left upper limb



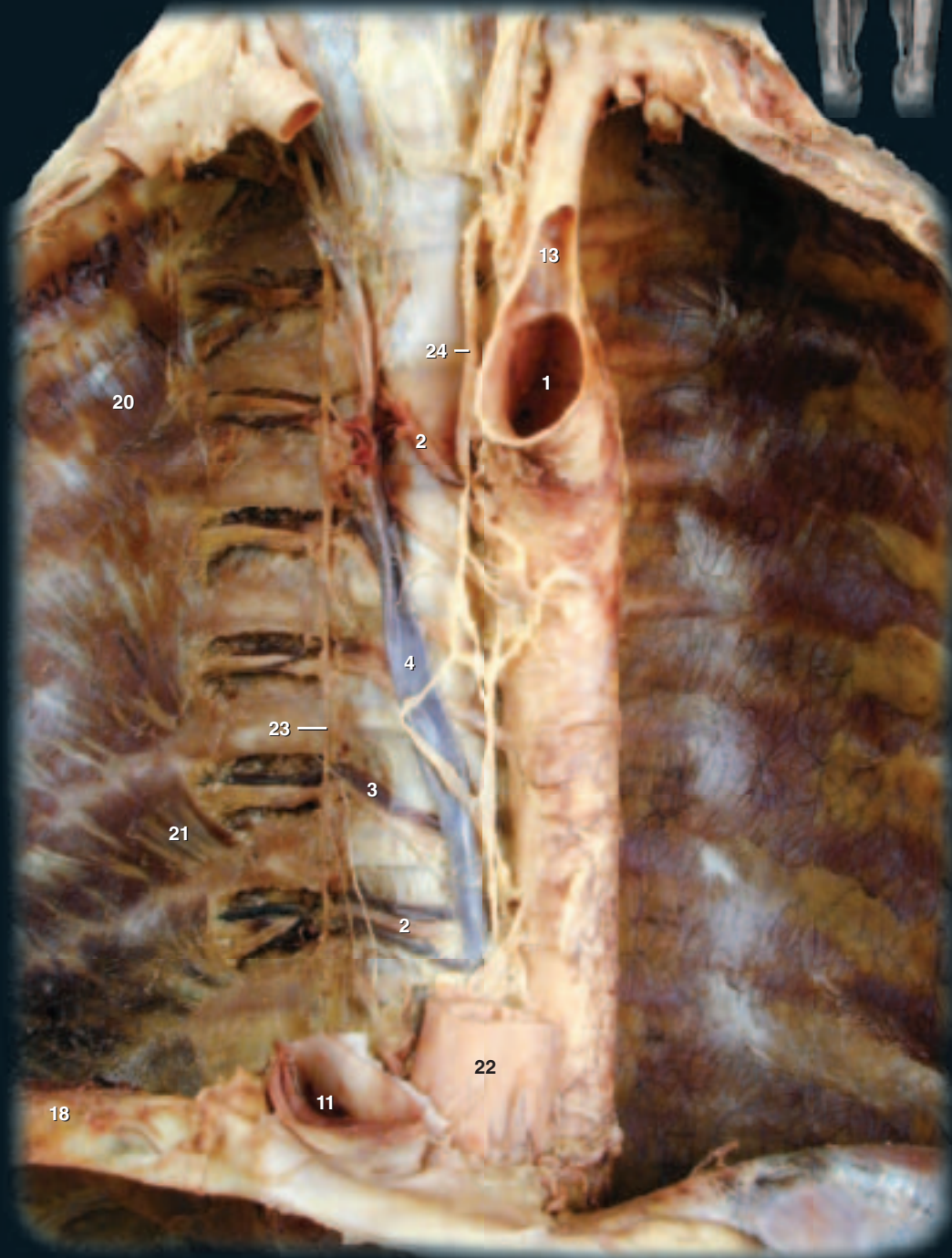
**Dissection of cephalic vein**  
Anterior view

# Thoracic Vessels

The branches of the aorta that supply the thoracic region can be divided into two principal groups — those that supply the thoracic body wall and those that supply thoracic viscera. Two arterial supply routes carry blood into the thoracic body wall. Posteriorly the aorta courses vertically down the vertebral column, while anteriorly the internal thoracic arteries arise from the subclavian arteries and course vertically down the inside of the sternum. Between these anterior and posterior supply arteries are interconnecting collateral arteries. These collateral vessels are the anterior intercostal arteries and the posterior intercostal arteries, which supply the tissues of the intercostal spaces and form collateral circuits between the anterior and posterior arterial pathways. All thoracic viscera receive their blood supply from branches of the aorta. The thoracic viscera include the heart, lungs with their associated bronchial tubes, and the esophagus.



- 1 Aorta
- 2 Posterior intercostal artery
- 3 Posterior intercostal vein
- 4 Azygos vein
- 5 Hemi-azygos vein
- 6 Accessory hemi-azygos vein
- 7 Superior vena cava
- 8 Brachiocephalic vein
- 9 Subclavian vein
- 10 Internal jugular vein
- 11 Inferior vena cava
- 12 Right atrium (cut)
- 13 Left subclavian artery
- 14 Left common carotid artery
- 15 Right common carotid artery
- 16 Hepatic vein
- 17 Trachea
- 18 Diaphragm
- 19 Esophageal hiatus
- 20 Subcostal muscle
- 21 Innermost intercostal muscle
- 22 Esophagus
- 23 Sympathetic trunk nerve
- 24 Thoracic lymphatic duct



Dissection of vessels of posterior thoracic wall  
Anterior view

Like the arterial supply to the thoracic wall, the venous drainage returns via both anterior-wall and posterior-wall drainage veins. The veins of the anterior wall have the same names as their arterial counterparts, while the veins of the posterior wall differ in name and structure. Unlike the aorta, which is the posterior-wall supply artery, the superior vena cava and inferior vena cava diverge from the posterior thoracic wall to enter the thoracic cavity and return their contents to the heart. In the absence of vena cavae in the posterior thoracic wall, an azygos system of veins is formed to drain the body wall and the thoracic viscera. These azygos veins communicate with the superior vena cava to return their contents to the heart. With the exception of the azygos veins, the veins are similar to the arteries in name and distribution.



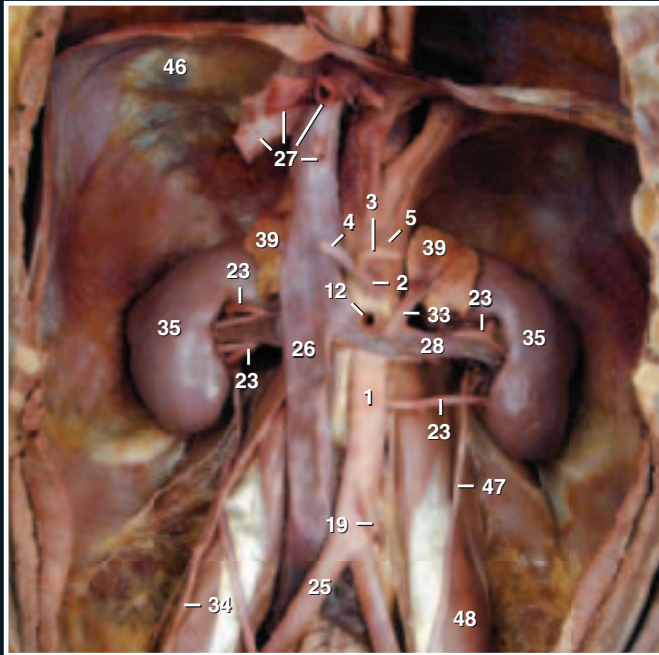
**Dissection of vena cavae and tributaries**  
Anterior view



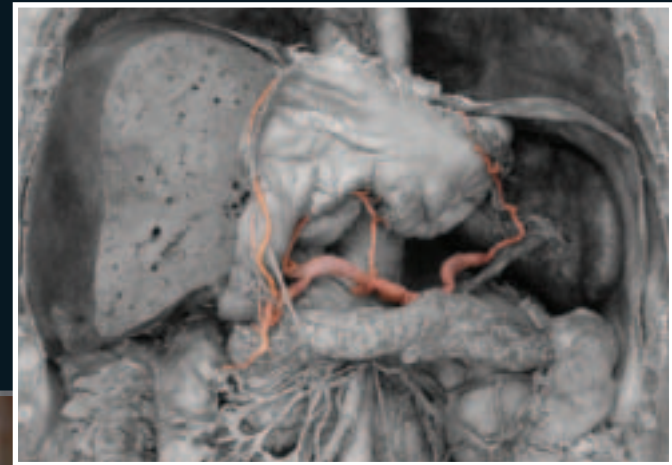
**Dissection of azygos veins**  
Anterior view

# Abdominal Vessels

Like the thorax, the abdomen has somatic arteries that supply the abdominal muscle wall and visceral arteries that supply the viscera of the abdominal cavity. These vessels follow the same pattern observed in the thoracic region; that is, the abdominal body wall has both anterior (epigastric arteries) and posterior (aorta) supply pathways that form interconnecting collateral arteries, while the viscera receive branches from the aorta — celiac artery to the foregut, superior mesenteric artery to the midgut, inferior mesenteric artery to the hindgut, and renal arteries to the kidneys.



Deep dissection of abdomen showing renal vessels  
Anterior view

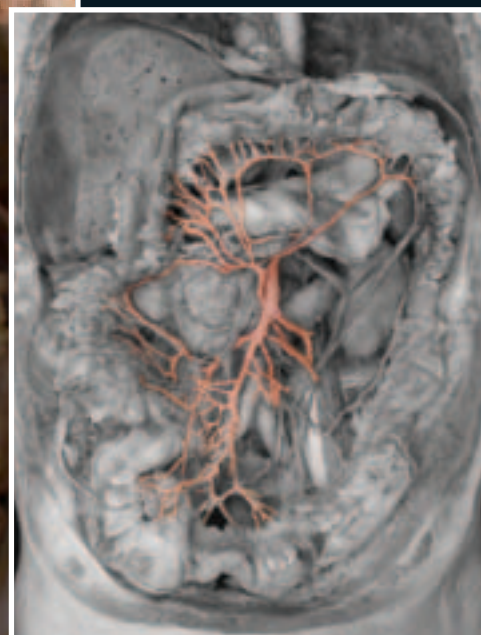
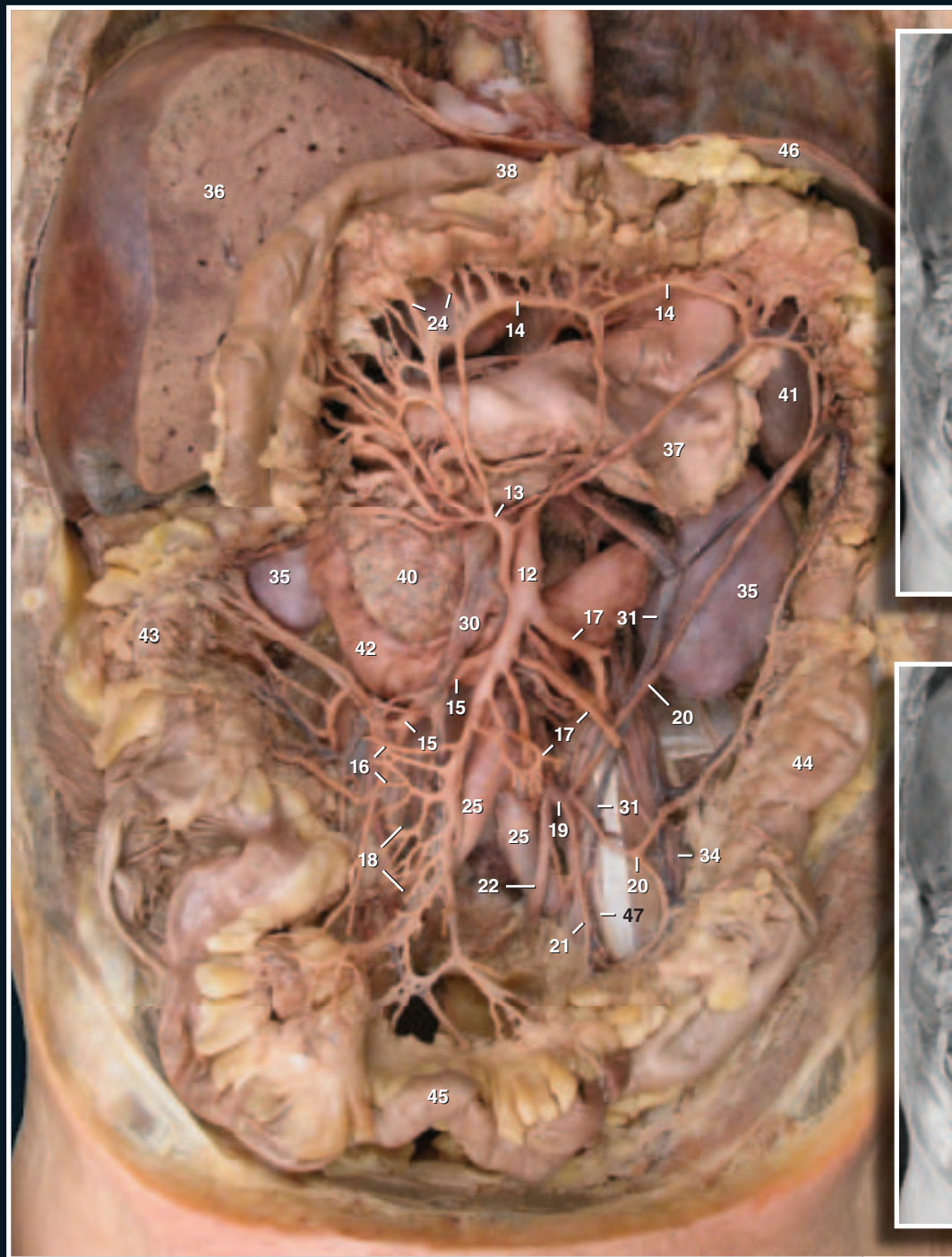


Branches of celiac artery

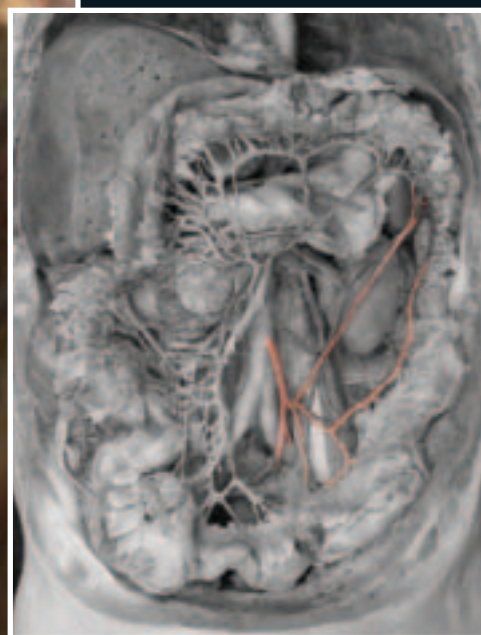


Dissection of abdomen showing celiac branches and supply of foregut viscera  
Anterior view, stomach reflected upward

- |  |                               |                             |                       |
|--|-------------------------------|-----------------------------|-----------------------|
| 1 Aorta                                | 13 Middle colic artery        | 25 Common iliac artery      | 37 Stomach            |
| 2 Celiac artery                        | 14 Marginal artery            | 26 Inferior vena cava       | 38 Transverse colon   |
| 3 Splenic artery                       | 15 Right colic artery         | 27 Hepatic vein             | 39 Suprarenal gland   |
| 4 Common hepatic artery                | 16 Ileocolic artery           | 28 Renal vein               | 40 Pancreas           |
| 5 Left gastric artery                  | 17 Jejunal arteries           | 29 Hepatic portal vein      | 41 Spleen             |
| 6 Right gastric artery                 | 18 Ileal arteries             | 30 Superior mesenteric vein | 42 Duodenum           |
| 7 Left gastro-omental artery           | 19 Inferior mesenteric artery | 31 Inferior mesenteric vein | 43 Ascending colon    |
| 8 Right gastro-omental artery          | 20 Left colic artery          | 32 Splenic vein             | 44 Descending colon   |
| 9 Proper hepatic artery                | 21 Sigmoid artery             | 33 Suprarenal vein          | 45 Ileum              |
| 10 Gastroduodenal artery               | 22 Superior rectal artery     | 34 Testicular vein          | 46 Diaphragm          |
| 11 Superior pancreaticoduodenal artery | 23 Renal artery               | 35 Kidney                   | 47 Ureter             |
| 12 Superior mesenteric artery          | 24 Segmental arteries         | 36 Liver                    | 48 Psoas major muscle |



Superior mesenteric artery



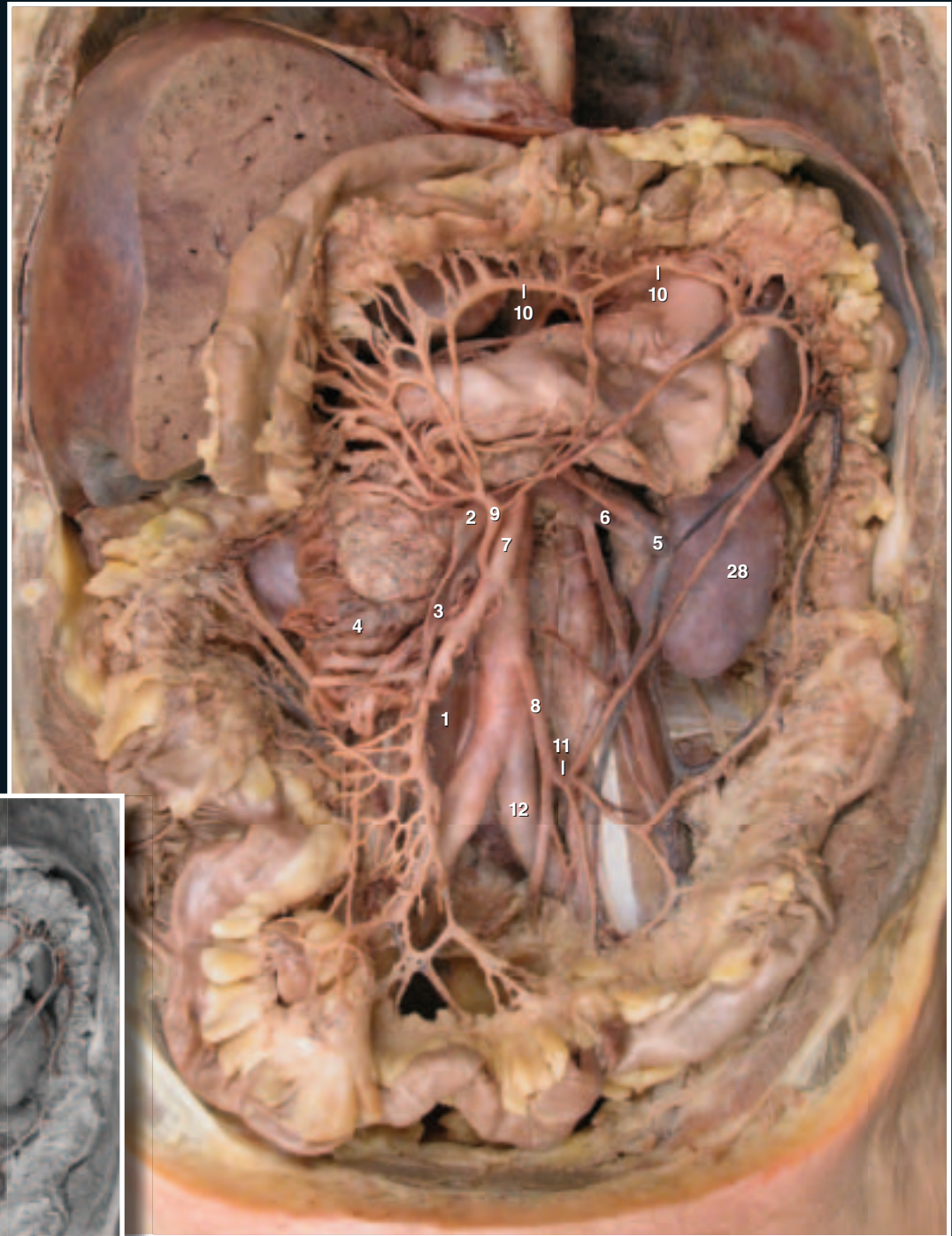
Inferior mesenteric artery

Dissection of abdomen showing arterial supply of midgut and hindgut viscera  
Anterior view

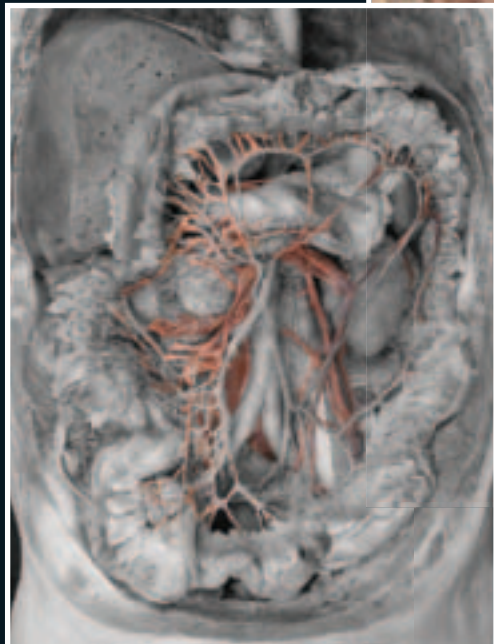
# Abdominal Vessels

The major difference between the arteries and veins of the abdomen is the fact that all the visceral venous return from the capillaries of the digestive system and spleen pass via the hepatic portal system to the capillaries of the liver before returning to the heart. Within the liver, both the hepatic artery and hepatic portal vein branch to form a complex network of specialized capillaries called the hepatic sinusoids. The hepatic sinusoids then drain into the hepatic veins to return the blood to the inferior vena cava.

- 1 Inferior vena cava
- 2 Hepatic portal vein
- 3 Superior mesenteric vein
- 4 Right colic vein
- 5 Inferior mesenteric vein
- 6 Renal vein
- 7 Superior mesenteric artery
- 8 Inferior mesenteric artery
- 9 Middle colic artery
- 10 Marginal artery
- 11 Left colic artery
- 12 Common iliac artery
- 13 External iliac artery
- 14 Internal iliac artery
- 15 Superior gluteal artery
- 16 Inferior gluteal artery
- 17 Obturator artery
- 18 Internal pudendal artery
- 19 Lateral sacral artery
- 20 Superior vesical artery
- 21 Vaginal artery
- 22 Obliterated umbilical artery
- 23 Uterus
- 24 Bladder
- 25 Prostate
- 26 Rectum
- 27 Stomach
- 28 Kidney
- 29 Upper bands of sacral plexus
- 30 Sympathetic trunk
- 31 Inferior vesical artery
- 32 Middle rectal artery
- 33 Obturator nerve
- 34 Uterine artery



Dissection of abdomen showing arteries and veins of the intestines  
Anterior view



Abdominal veins

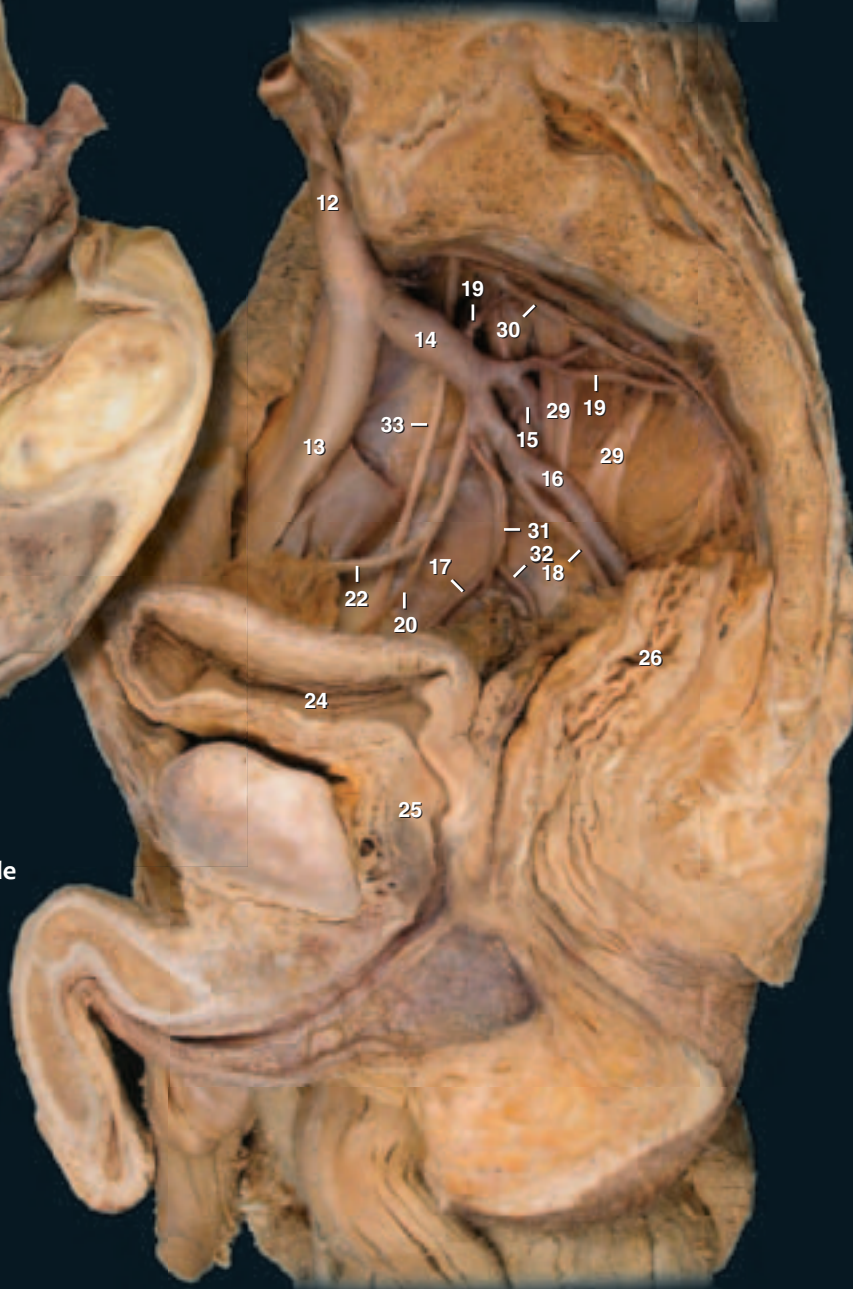


# Pelvic Vessels

The common iliac arteries, the terminal branches of the aorta, carry all of the blood supply to the lower limbs and pelvis. All pelvic viscera, along with the body wall anatomy of the pelvis and perineal regions, receive their blood supply from the internal iliac artery. Numerous branches arise from the internal iliac artery to supply the pelvic wall, the perineum, and the gluteal region. Other branches course into the pelvic cavity to supply the viscera. The veins are similar in name and course with the corresponding arteries.



**Dissection of pelvic arteries of female**  
Medial view, anterior at left



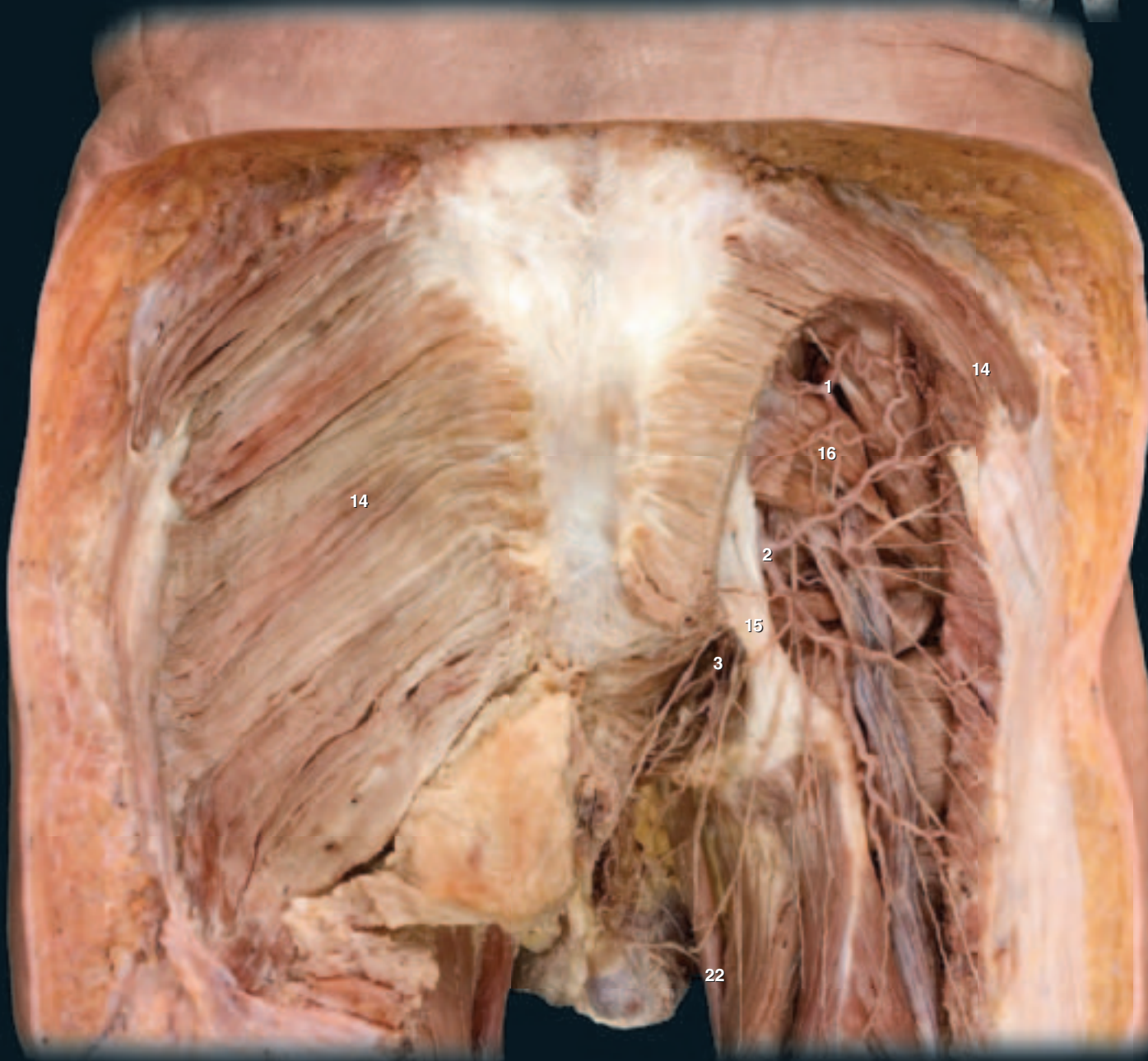
**Dissection of pelvic arteries of male**  
Medial view, anterior at right

# Inferior Limb Vessels

As in the upper limb, the main arterial pathway into the lower limb consists of a single, major arterial roadway that gradually tapers as it gives rise to numerous branches on its pathway through the limb. This large arterial roadway begins as the external iliac artery in the pelvis, passes beneath the inguinal ligament to enter the thigh as the femoral artery, passes to the back of the knee to become the popliteal artery, and in the proximal aspect of the leg bifurcates into the anterior tibial and posterior tibial arteries, which course through the leg and into the foot.



- |                                |                           |                              |
|--------------------------------|---------------------------|------------------------------|
| 1 Superior gluteal artery      | 10 Internal iliac artery  | 19 Adductor longus muscle    |
| 2 Inferior gluteal artery      | 11 External iliac vein    | 20 Rectus femoris muscle     |
| 3 Internal pudendal artery     | 12 Common iliac artery    | 21 Vastus intermedius muscle |
| 4 Femoral artery               | 13 Aorta                  | 22 Gracilis muscle           |
| 5 Deep artery of thigh         | 14 Gluteus maximus muscle | 23 Vastus lateralis muscle   |
| 6 Muscular branches of femoral | 15 Sacrotuberous ligament | 24 Vastus medialis muscle    |
| 7 Femoral vein                 | 16 Piriformis muscle      | 25 Fascia lata               |
| 8 Great saphenous vein         | 17 Spermatic cord (cut)   | 26 Sartorius muscle          |
| 9 External iliac artery        | 18 Penis (cut)            | 27 Iliacus muscle            |



Dissection of gluteal region showing gluteal arteries and nerves  
Posterior view



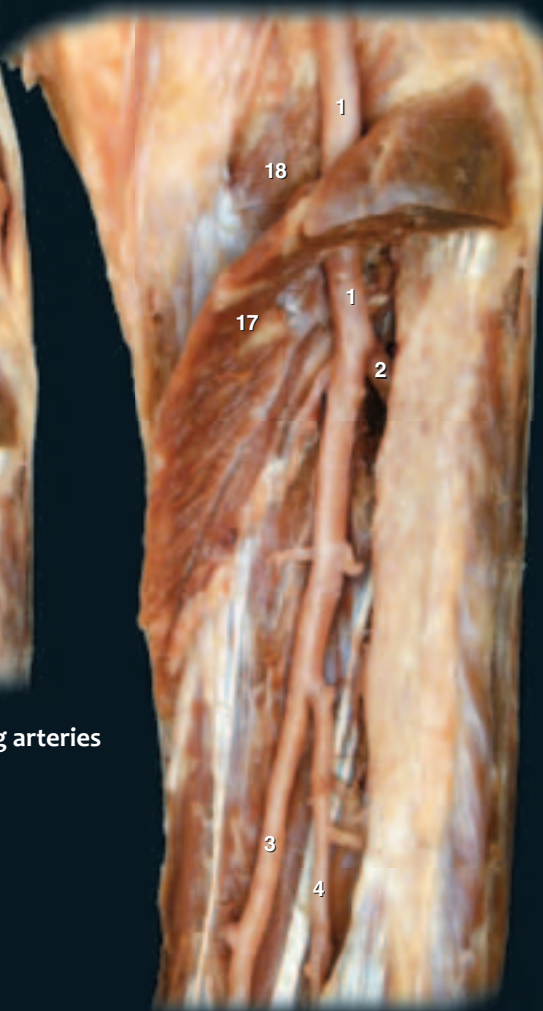
# Inferior Limb Vessels



**Dissection of popliteal and crural arteries**  
Posterior view



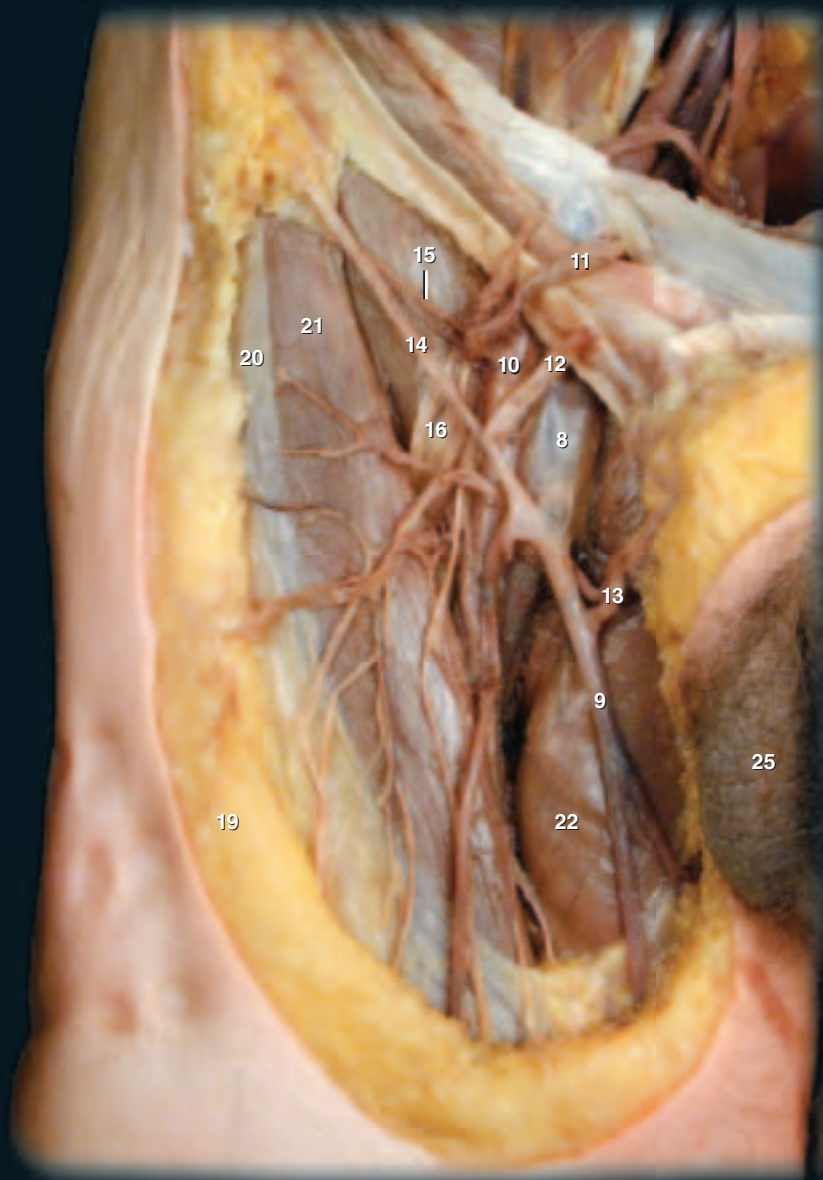
**Dissection of popliteal region revealing arteries**  
Posterior view



**Dissection of proximal crus revealing arteries**  
Posterior view

- 1 Popliteal artery
- 2 Anterior tibial artery
- 3 Posterior tibial artery
- 4 Fibular artery
- 5 Superior lateral genicular artery
- 6 Inferior lateral genicular artery
- 7 Inferior medial genicular artery
- 8 Femoral vein
- 9 Great saphenous vein
- 10 Femoral artery
- 11 Superficial epigastric artery
- 12 Superficial epigastric vein
- 13 External pudendal vein
- 14 Superficial circumflex iliac vein
- 15 Superficial circumflex iliac artery
- 16 Femoral nerve
- 17 Soleus muscle
- 18 Popliteus muscle
- 19 Subcutaneous layer
- 20 Fascia lata
- 21 Sartorius muscle
- 22 Adductor longus muscle
- 23 Biceps femoris muscle
- 24 Semitendinosus muscle
- 25 Scrotum

Similar to the veins of the upper limb, the venous pathways in the lower limb consist of both deep veins that accompany the arteries, and superficial veins that course through the hypodermis. In the foot and leg, the deep veins form vena comitans with their arterial counterparts; however, the more proximal popliteal and femoral veins are large single vessels accompanying their associated arteries. Two major superficial venous channels receive numerous tributaries from smaller superficial veins throughout the lower limb. These major superficial veins are the small saphenous vein and the great saphenous vein. Unlike the upper limb, the majority of venous blood flow through the lower limb passes via the deep veins. Anastomosing veins between the saphenous veins and the deep veins have one-way valves. The valves direct blood flow to the deep veins where contractions of surrounding skeletal muscles facilitate movement of the blood toward the heart.



**Dissection of femoral vein and tributaries in femoral triangle**  
Anterior view

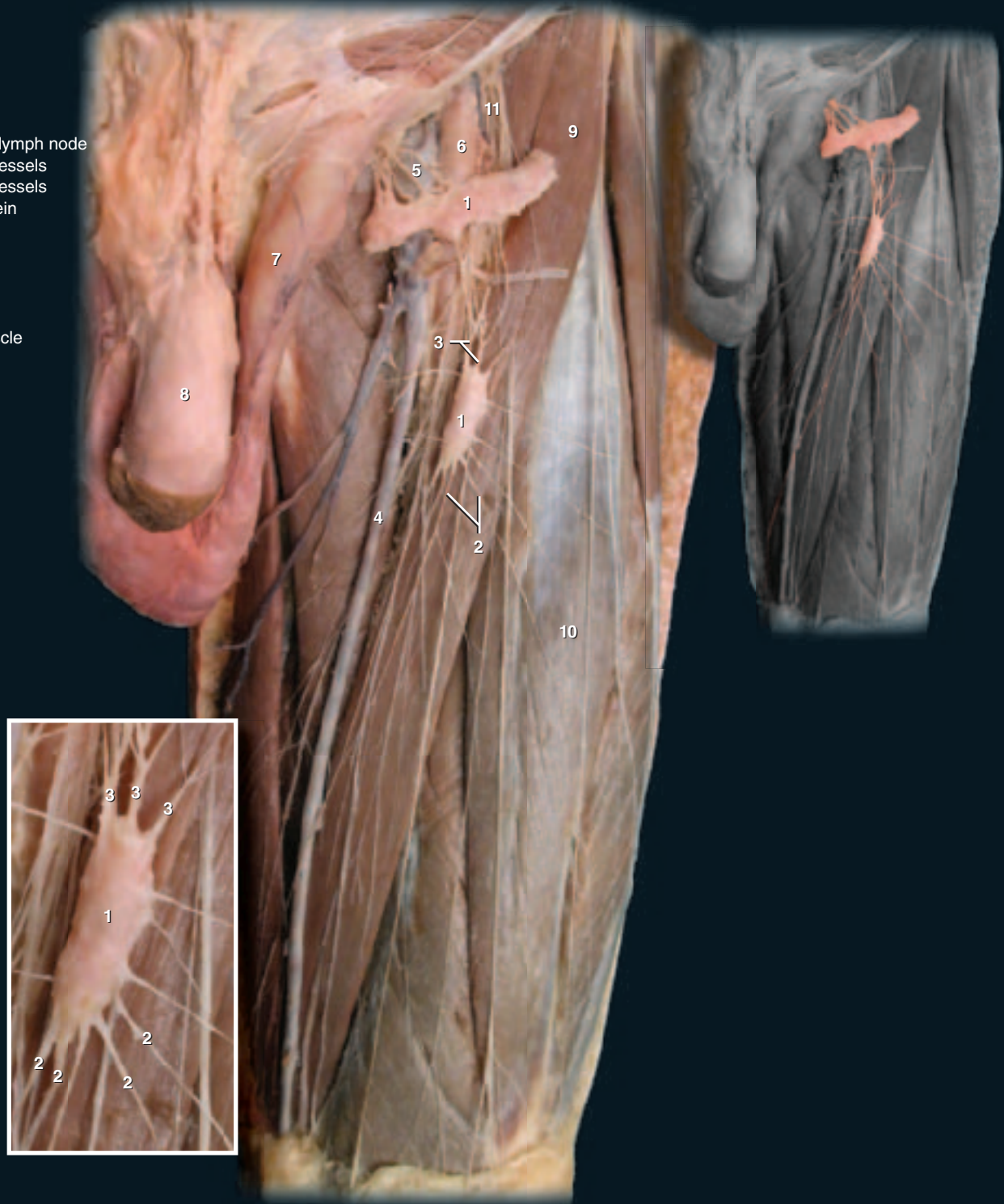


**Dissection of great saphenous vein**  
Anteromedial view

# Lymphatics

Even under normal circumstances, slightly more fluid is filtered out of the capillaries into the interstitial fluid than is reabsorbed from the interstitial fluid back into the plasma. On average, the net filtration pressure starts at 11 mm Hg at the beginning of the capillary, whereas the net reabsorption pressure only reaches 9 mm Hg by the vessel's end. Because of this pressure differential more fluid is filtered out of the first half of the capillary than is reabsorbed in its last half. If this extra filtered fluid were not drained away, the consequence of this unbalanced exchange would be accumulation of excess interstitial fluid, or edema. To circumvent this potentially disastrous problem, a system of accessory drainage vessels, the lymphatic vessels, evolved in vertebrate animals. This lymphatic system of vessels consists of an extensive network of one-way tubes that provide an accessory route through which fluid is returned from the interstitial fluid to the blood to keep the cardiac output and return equal.

- 1 Superficial inguinal lymph node
- 2 Afferent lymphatic vessels
- 3 Efferent lymphatic vessels
- 4 Great saphenous vein
- 5 Femoral vein
- 6 Femoral artery
- 7 Spermatic cord
- 8 Penis
- 9 Sartorius muscle
- 10 Rectus femoris muscle
- 11 Femoral nerve



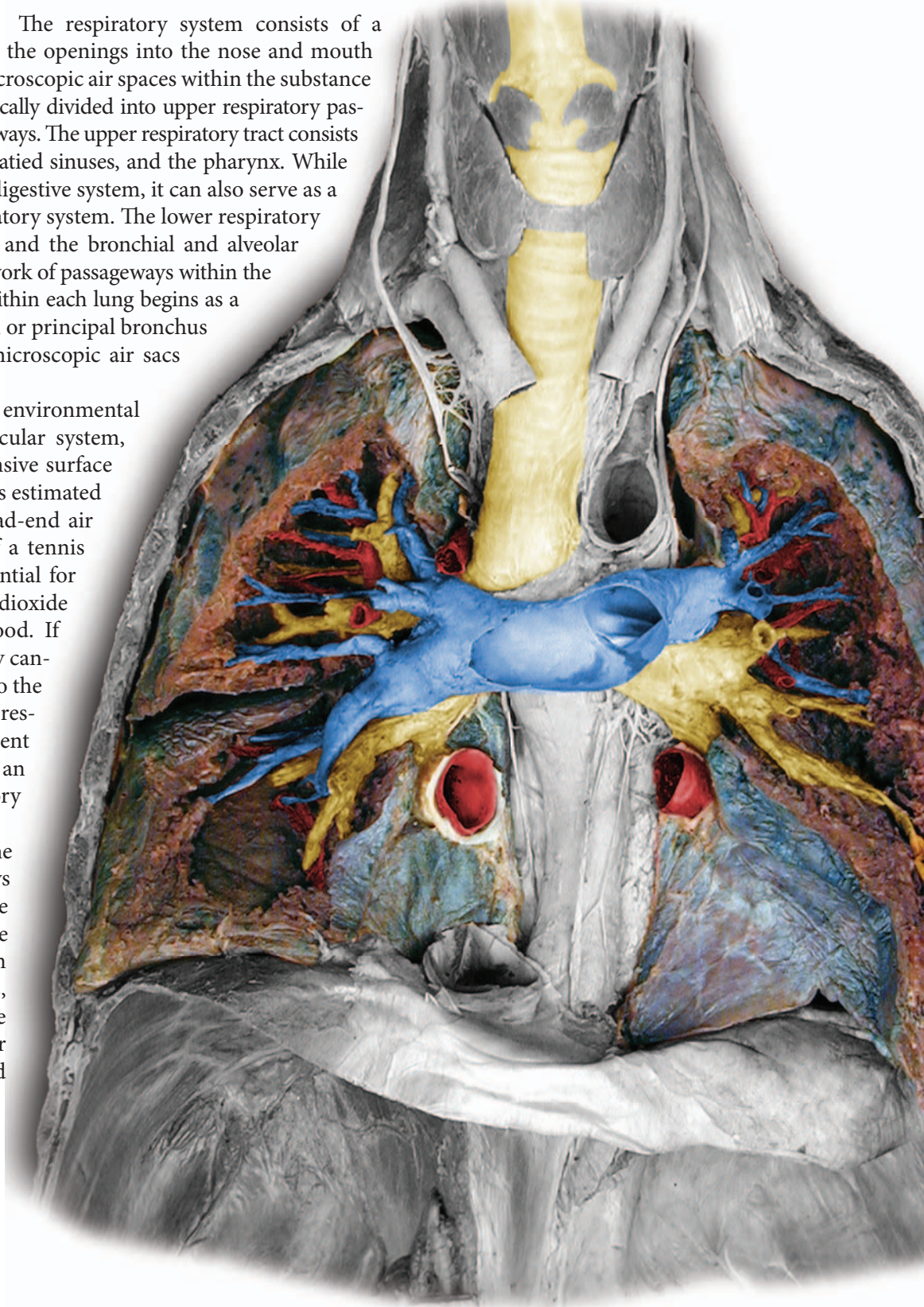
Dissection of lymphatic vessels and nodes in the thigh  
Anterior view

# 17 Respiratory System

The respiratory system consists of a network of passageways that begin at the openings into the nose and mouth and terminate in about 600 million microscopic air spaces within the substance of the lungs. The passageways are typically divided into upper respiratory passageways and lower respiratory passageways. The upper respiratory tract consists of the nose, the nasal cavity and associated sinuses, and the pharynx. While the mouth is typically included in the digestive system, it can also serve as a passageway for air entering the respiratory system. The lower respiratory tract consists of the larynx, trachea, and the bronchial and alveolar tubes that form a large, branching network of passageways within the lungs. This branching bronchial tree within each lung begins as a large, finger-sized tube called the main or principal bronchus and terminates in the lungs as the microscopic air sacs called alveoli.

Like other systems that form an environmental exchange surface with the cardiovascular system, the respiratory system forms an extensive surface area in contact with the capillaries. It is estimated that the surface area of the small dead-end air sacs in the lungs is about the size of a tennis court. This extensive interface is essential for the exchange of oxygen and carbon dioxide between the inhaled air and the blood. If body cells are deprived of oxygen, they cannot function and they die as a result. So the acquisition of oxygen through the respiratory passageways and its subsequent exchange with the capillary blood is an important function of the respiratory system.

In addition to gas exchange, the portion of the respiratory passageways referred to as the larynx is responsible for generating the sound waves that we manipulate into voice. Internal folds in the lining of the larynx, the vocal folds, vibrate as air passes upward from the lungs to produce the vibrations. For this reason the larynx is often referred to as the voice box.



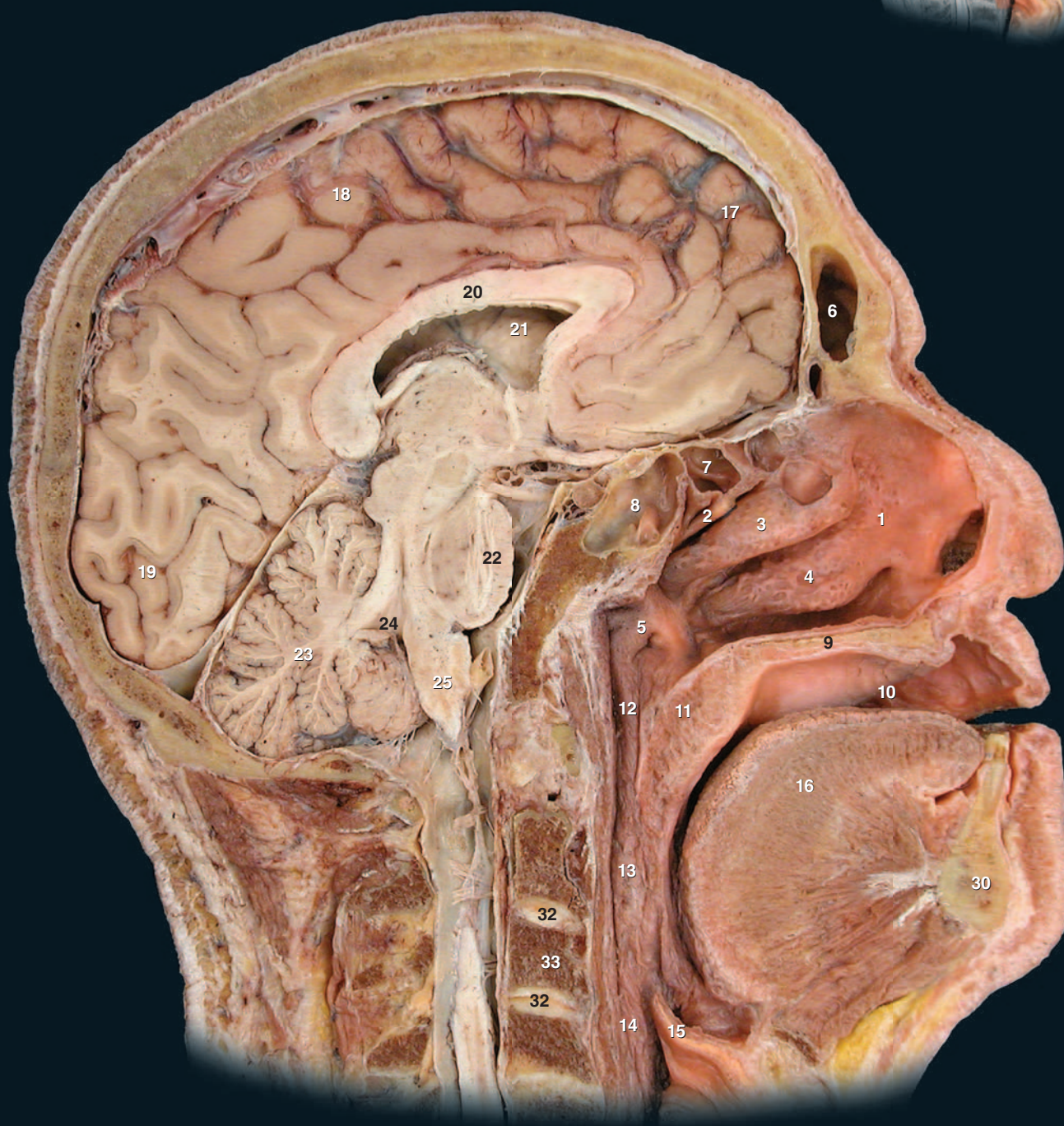
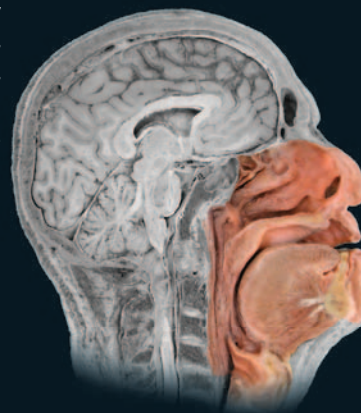
Find more information  
about the respiratory  
system in

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# Upper Respiratory Tract

The upper respiratory tract consists of the initial series of passageways that carry the inspired air through the head. The various sections of the head seen on this and the facing page show the passageways of the upper respiratory tract, which include the nose and nasal vestibule, the nasal cavity, the paranasal sinuses, nasopharynx, oropharynx, laryngopharynx, and even the oral cavity. The nasal cavity functions in filtering, warming, and humidifying the inspired air, while also detecting chemical odorants.

The upper respiratory tract consists of the initial series of passageways that carry the inspired air through the head.



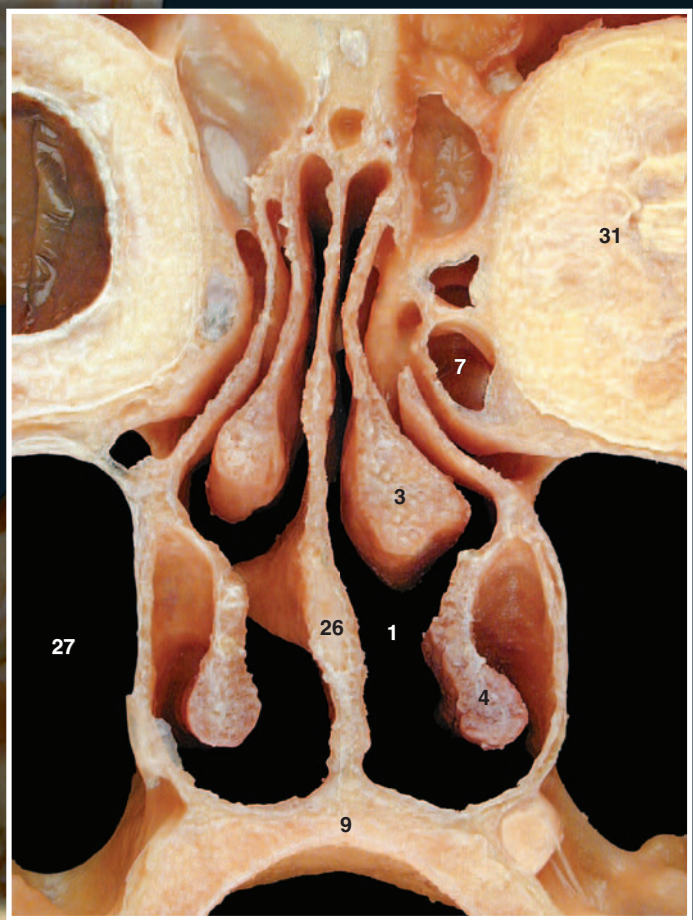
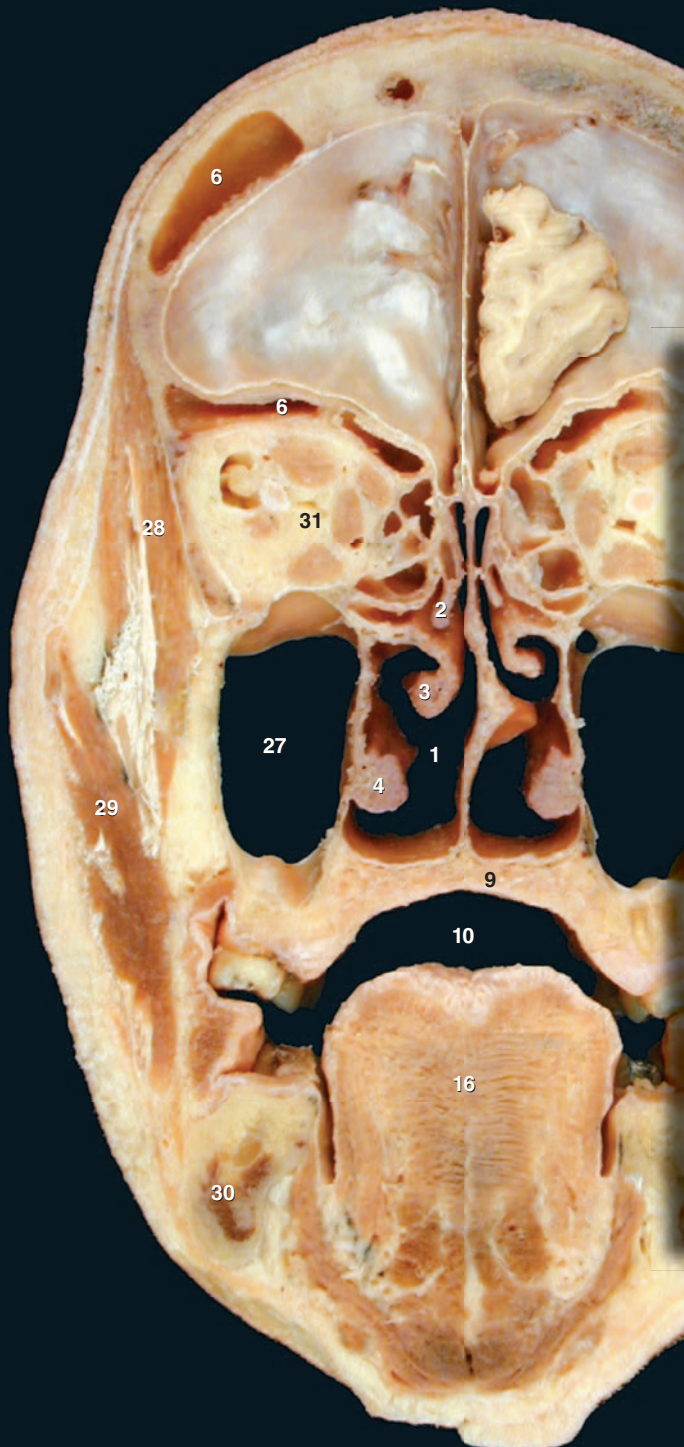
Sagittal section of head  
Medial view



- 1 Nasal cavity
- 2 Superior nasal concha
- 3 Middle nasal concha
- 4 Inferior nasal concha
- 5 Torus tuberosus
- 6 Frontal sinus
- 7 Ethmoid air cell
- 8 Sphenoidal sinus
- 9 Hard palate
- 10 Oral cavity
- 11 Soft palate

- 12 Nasopharynx
- 13 Oropharynx
- 14 Laryngopharynx
- 15 Epiglottis
- 16 Tongue
- 17 Frontal lobe
- 18 Parietal lobe
- 19 Occipital lobe
- 20 Corpus callosum
- 21 Lateral ventricle
- 22 Pons

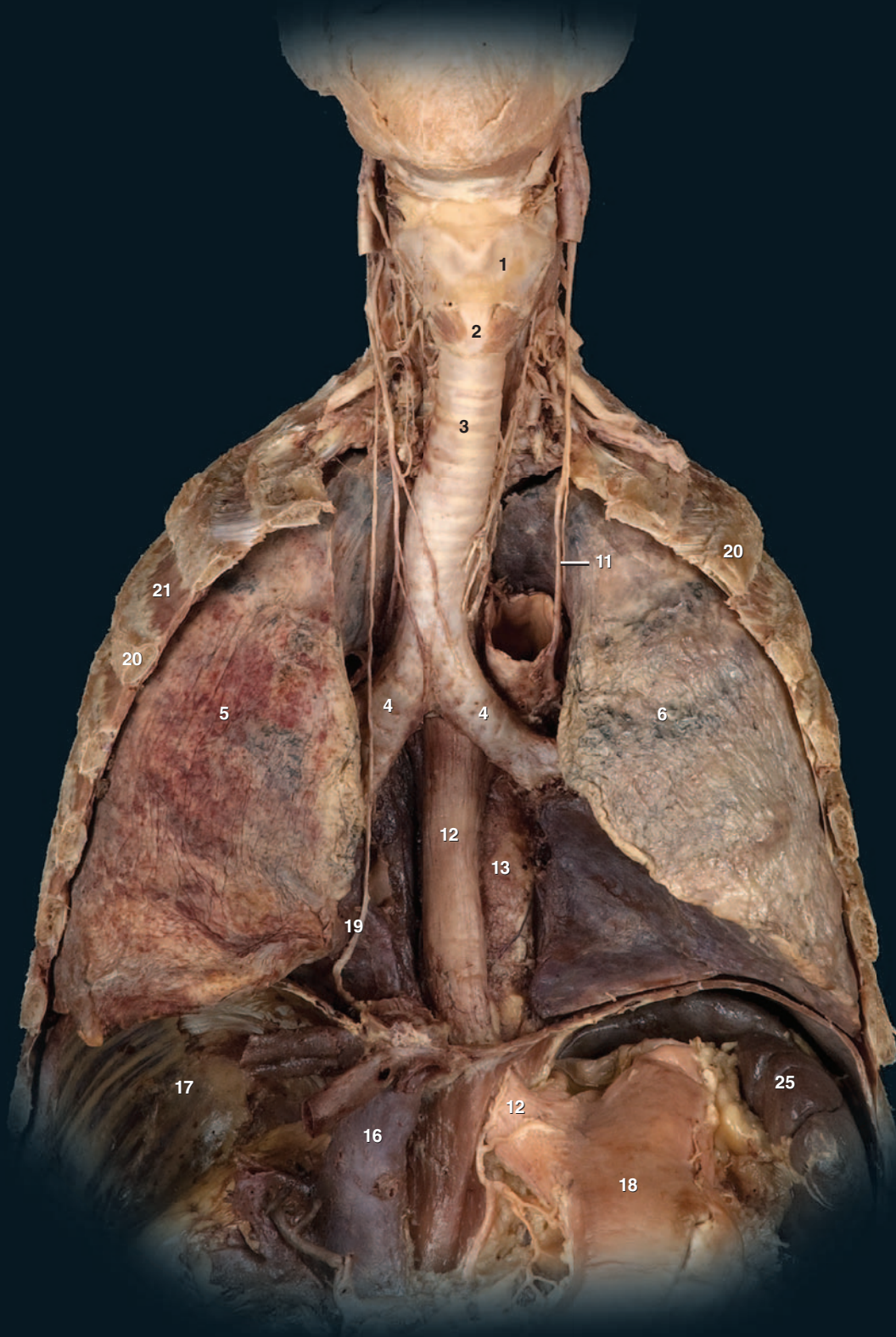
- 23 Cerebellum
- 24 Fourth ventricle
- 25 Medulla oblongata
- 26 Nasal septum
- 27 Maxillary sinus
- 28 Temporalis
- 29 Masseter
- 30 Mandible
- 31 Orbit
- 32 Intervertebral disc
- 33 Vertebral body



Frontal section of head  
Anterior view

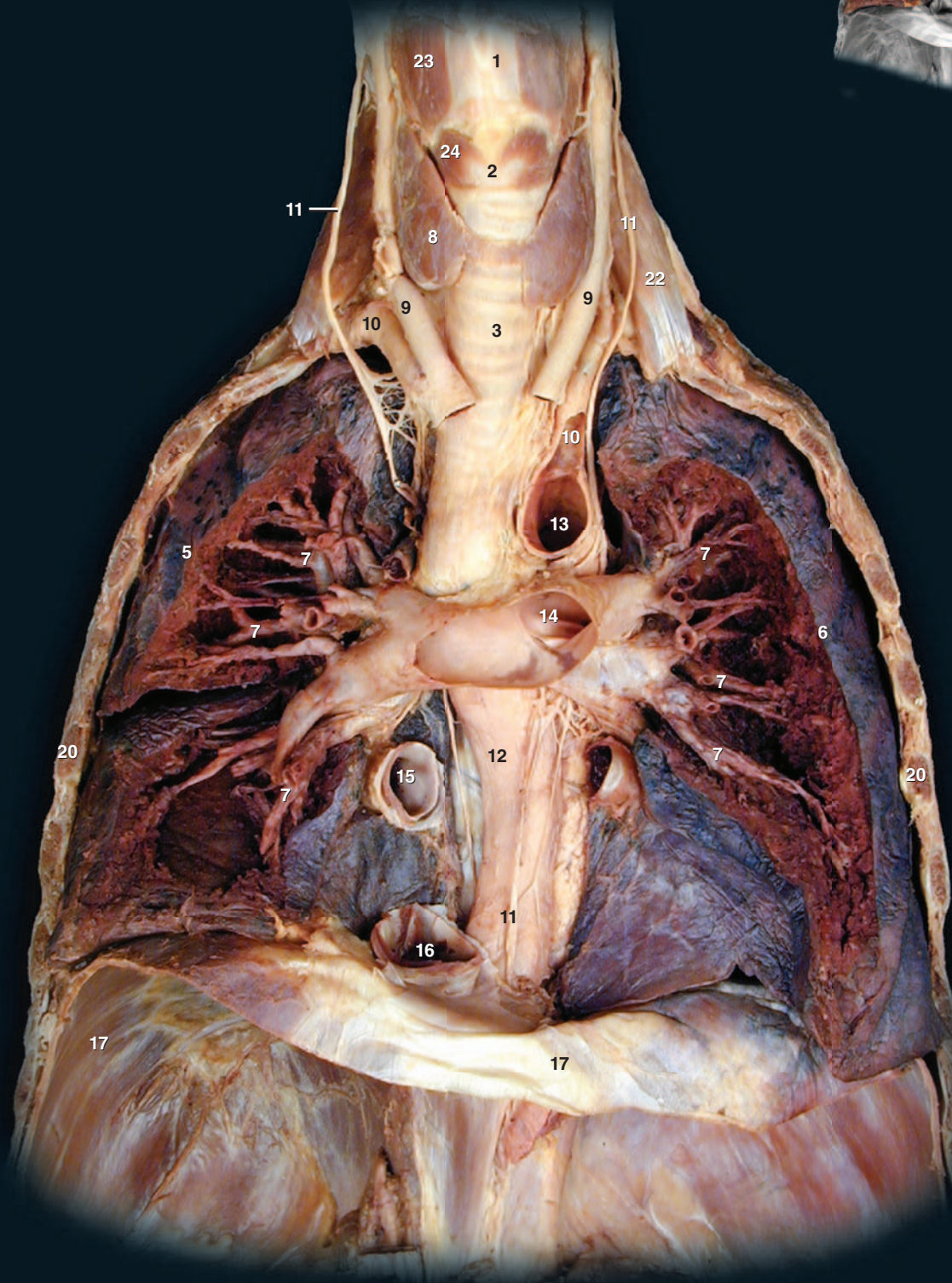
# Lower Respiratory Tract

The lower respiratory tract arises as an outgrowth of the tubular gut during embryonic development. This anterior outgrowth of the gut tube begins at the larynx (voice box), which is the upper expanded portion of the lower respiratory tract. It continues from the neck into the thorax as the trachea (windpipe), and forms a large branching network of tubes that enter the lungs, the bronchial tree. The pages that follow show the tubular organs and histology of the lower respiratory tract.



Lower respiratory tract and lungs in situ  
Anterior view

- |                               |                       |                            |
|-------------------------------|-----------------------|----------------------------|
| 1 Thyroid cartilage of larynx | 10 Subclavian artery  | 18 Stomach                 |
| 2 Cricoid cartilage of larynx | 11 Vagus nerve        | 19 Phrenic nerve           |
| 3 Trachea                     | 12 Esophagus          | 20 Rib                     |
| 4 Main (primary) bronchus     | 13 Aorta              | 21 Intercostal muscle      |
| 5 Right lung                  | 14 Pulmonary artery   | 22 Anterior scalene muscle |
| 6 Left lung                   | 15 Pulmonary vein     | 23 Thyrohyoid muscle       |
| 7 Bronchial tree              | 16 Inferior vena cava | 24 Cricothyroid muscle     |
| 8 Thyroid gland               | 17 Diaphragm          | 25 Spleen                  |
| 9 Common carotid artery       |                       |                            |



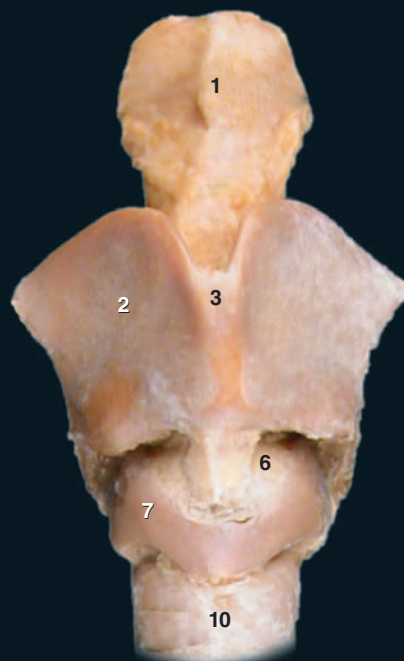
Dissection of lower respiratory tract and lungs in situ  
Anterior view

# Larynx

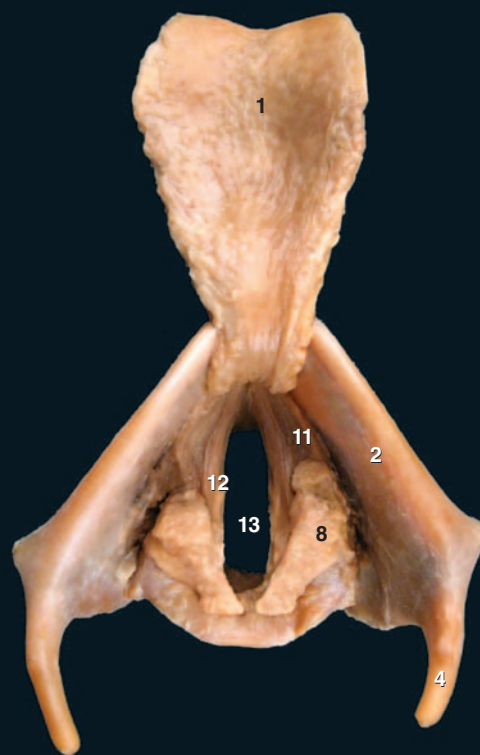
The entrance to the trachea is an expanded region called the larynx, or voice box. A series of large cartilages form the walls of this region. The soft tissue lining of the laryngeal cartilages folds into the larynx to form the vocal folds, flaps of tissue that lie across the opening of the larynx. Within the edges of the vocal folds are the vocal cords, two bands of elastic tissue that can be stretched and positioned in different shapes by laryngeal cartilages and muscles. As air is moved past the taut vocal cords, they vibrate to produce the many different sounds of speech. During swallowing, the vocal cords assume a function not related to speech; they are brought into tight apposition to each other to close off the rima glottidis, the entrance to the lower larynx and trachea.



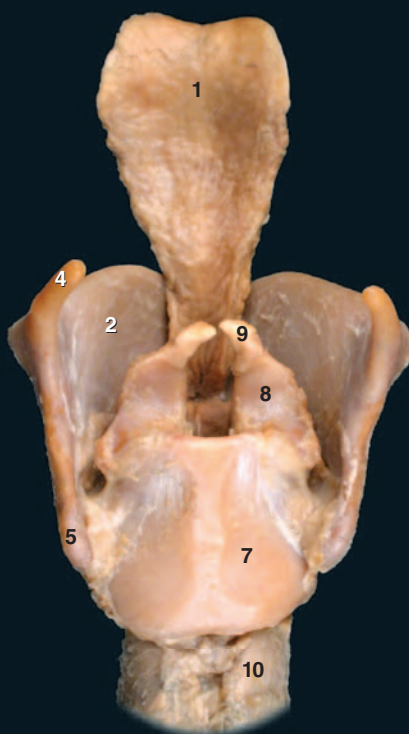
- 1 Epiglottis
- 2 Thyroid cartilage
- 3 Thyroid tubercle (Adam's apple)
- 4 Superior cornu
- 5 Inferior cornu
- 6 Cricothyroid membrane
- 7 Cricoid cartilage
- 8 Arytenoid cartilage
- 9 Corniculate cartilage
- 10 Trachea
- 11 Vocal fold
- 12 Vocal ligament
- 13 Rima glottidis



**Laryngeal cartilages**  
Anterior view



**Laryngeal cartilages**  
Superior view



**Laryngeal cartilages**  
Posterior view

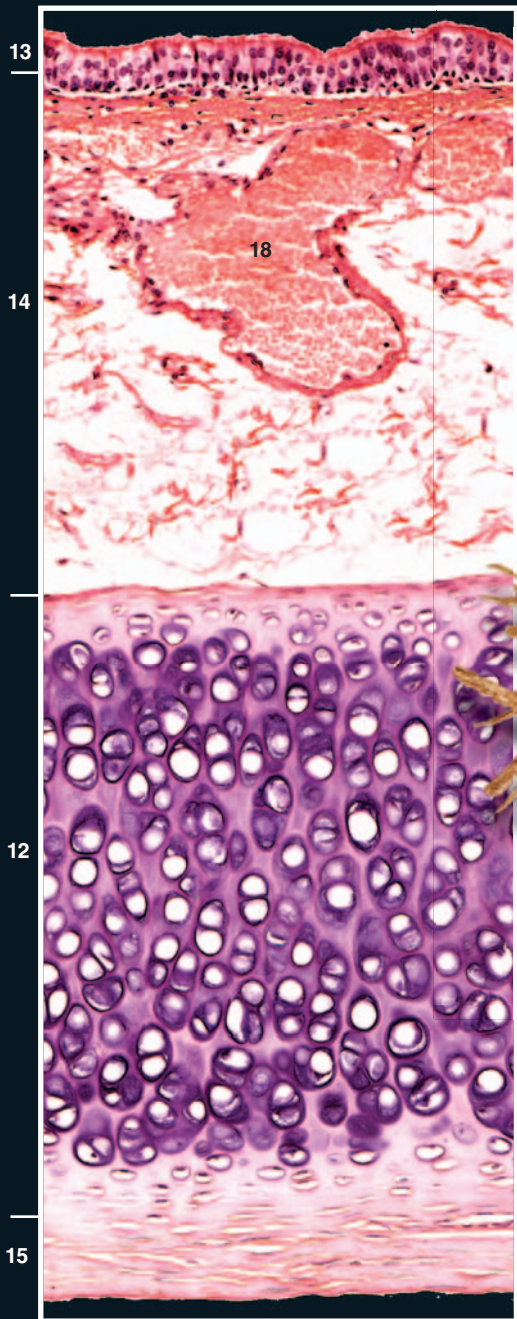
# Trachea and Bronchial Tree

The trachea, "wind-pipe," is the conduction tube that

transports the air to and from the lungs. It is reinforced by U-shaped cartilages. The trachea branches into two tubes called bronchi that enter the lungs. Each bronchus serves as the trunk of a highly branched, tree-like network of bronchial tubes that become progressively narrower, shorter, and more numerous as they spread throughout the tissues of the lung. These small tubes eventually terminate as the small, dead-end air sacs called alveoli, the principal site of gas exchange between air and blood.



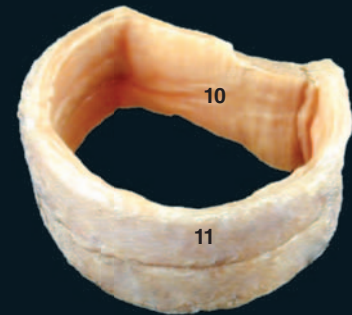
- |                                 |                                       |                                    |
|---------------------------------|---------------------------------------|------------------------------------|
| 1 Epiglottis                    | 8 Segmental (tertiary) bronchus       | 14 Tela submucosa (areolar ct)     |
| 2 Thyroid cartilage             | 9 Bronchiole                          | 15 Tunica adventitia (dense ct)    |
| 3 Cricoid cartilage             | 10 Fibromuscular membrane             | 16 Bronchiole cartilage (hyaline)  |
| 4 Trachea                       | 11 Tracheal ring                      | 17 Alveolar spaces                 |
| 5 Right main (primary) bronchus | 12 Hyaline cartilage of tracheal ring | 18 Vein with red blood cells (rbc) |
| 6 Left main (primary) bronchus  | 13 Tunica mucosa (pseudostratified)   | 19 Pulmonary vein with rbc's       |
| 7 Lobar (secondary) bronchus    |                                       |                                    |



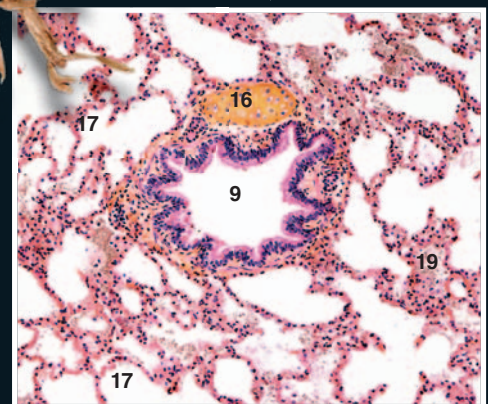
Photomicrograph of tracheal wall  
100x



Dissection of lower respiratory tract  
Anterior view



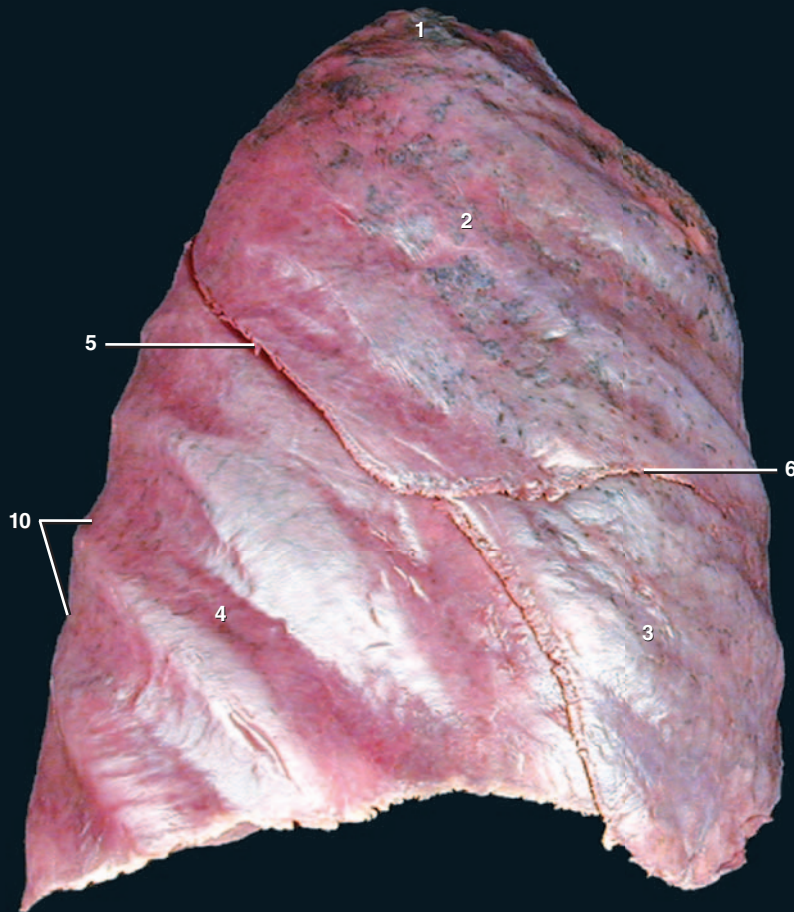
Section of trachea  
Anterolateral view



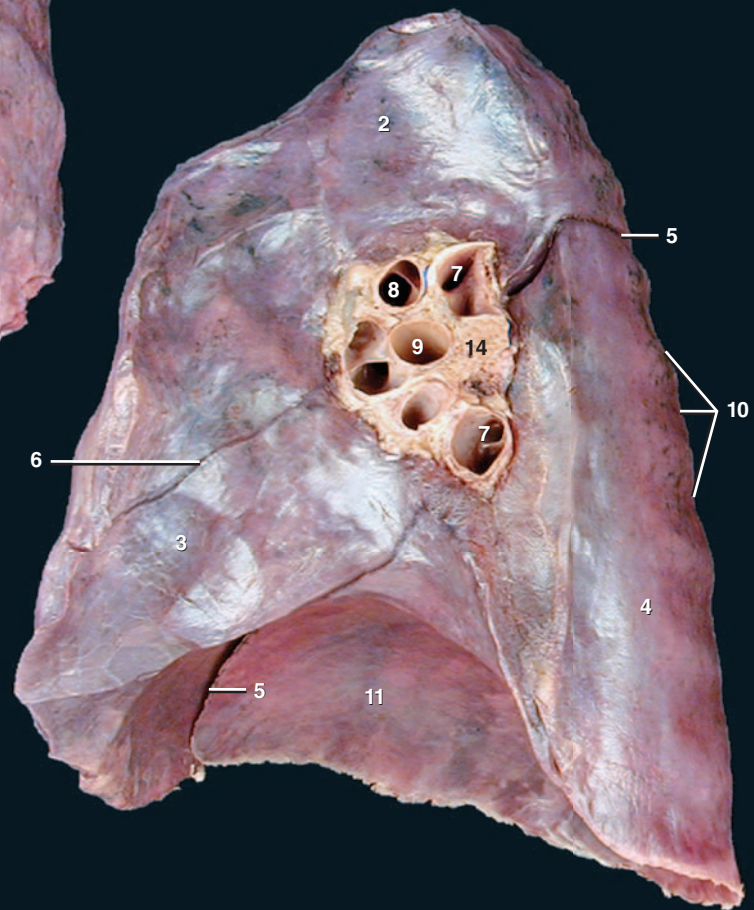
Photomicrograph of alveoli and small bronchial tube  
100x

# Lungs

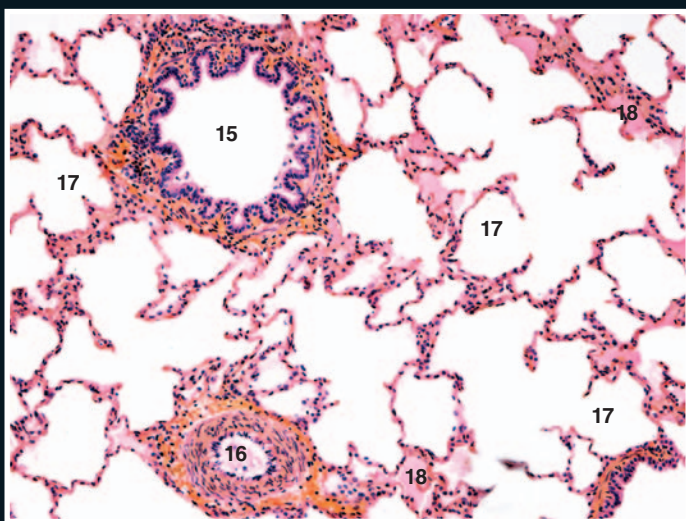
The lungs are the spongy, pyramidal-shaped organs that house the bronchial tree and the extensive pulmonary vascular network. Each lung is surrounded by a thin mesothelial covering, the visceral pleura, and sits on either side of the heart within the thoracic cavity. The vascular and respiratory passageways enter each lung on its medial aspect at the hilum. The wide base of the lung sits on the diaphragm inferiorly and tapers to a narrow apex superiorly. The right lung has three lobes and the left lung two lobes.



**Right lung**  
Lateral view, anterior to the right



**Right lung**  
Medial view, anterior to the left

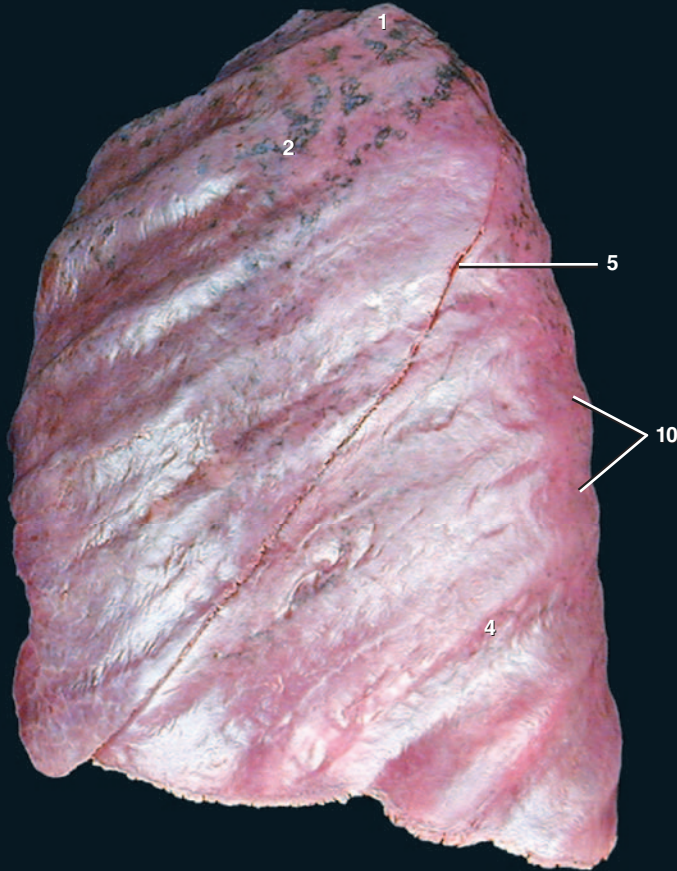


**Photomicrograph of lung tissue**  
100x

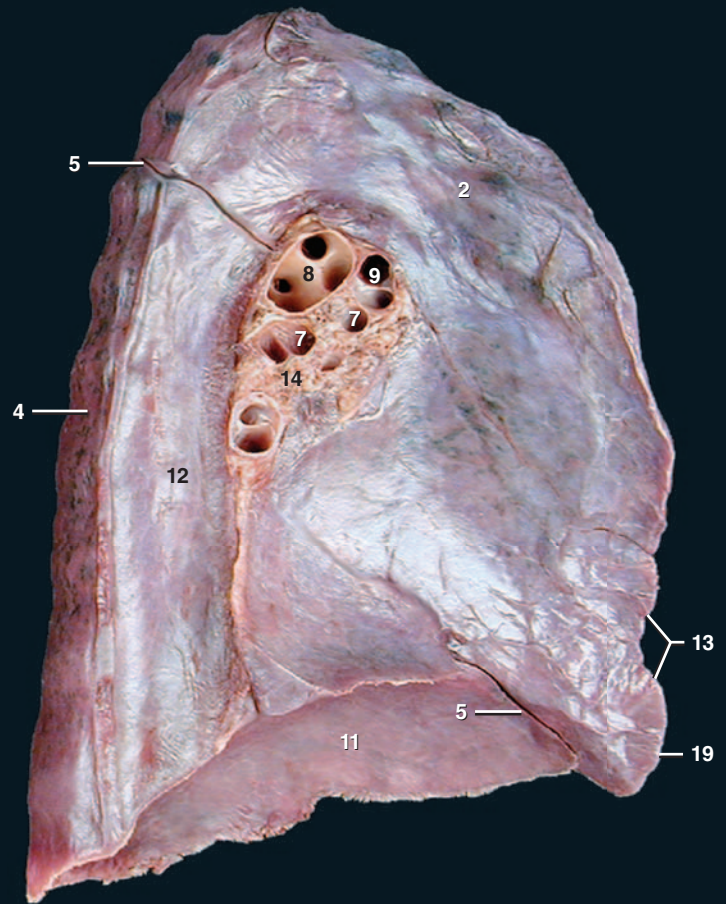
- 1 Apex
- 2 Superior lobe
- 3 Middle lobe
- 4 Inferior lobe
- 5 Oblique fissure
- 6 Transverse fissure
- 7 Segmental (tertiary) bronchus

- 8 Pulmonary artery
- 9 Pulmonary vein
- 10 Costal impression
- 11 Diaphragmatic surface
- 12 Aortic impression
- 13 Cardiac notch

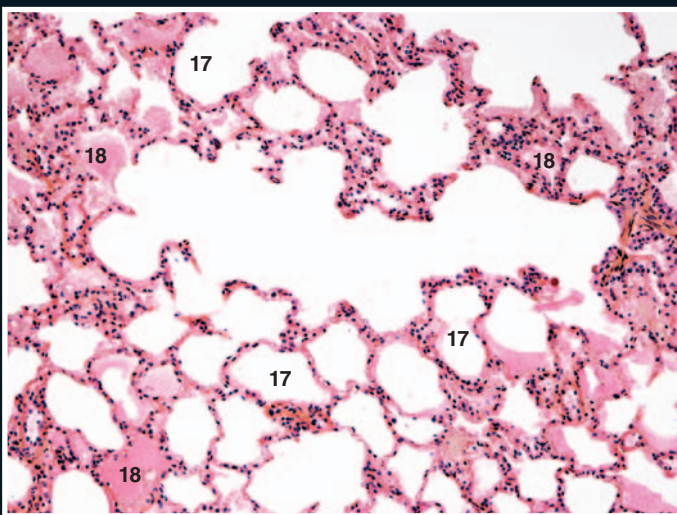
- 14 Hilum
- 15 Bronchiole
- 16 Small artery
- 17 Alveolar spaces
- 18 Blood vessels with rbc's
- 19 Lingula



**Left lung**  
Lateral view, anterior to the left



**Left lung**  
Medial view, anterior to the right

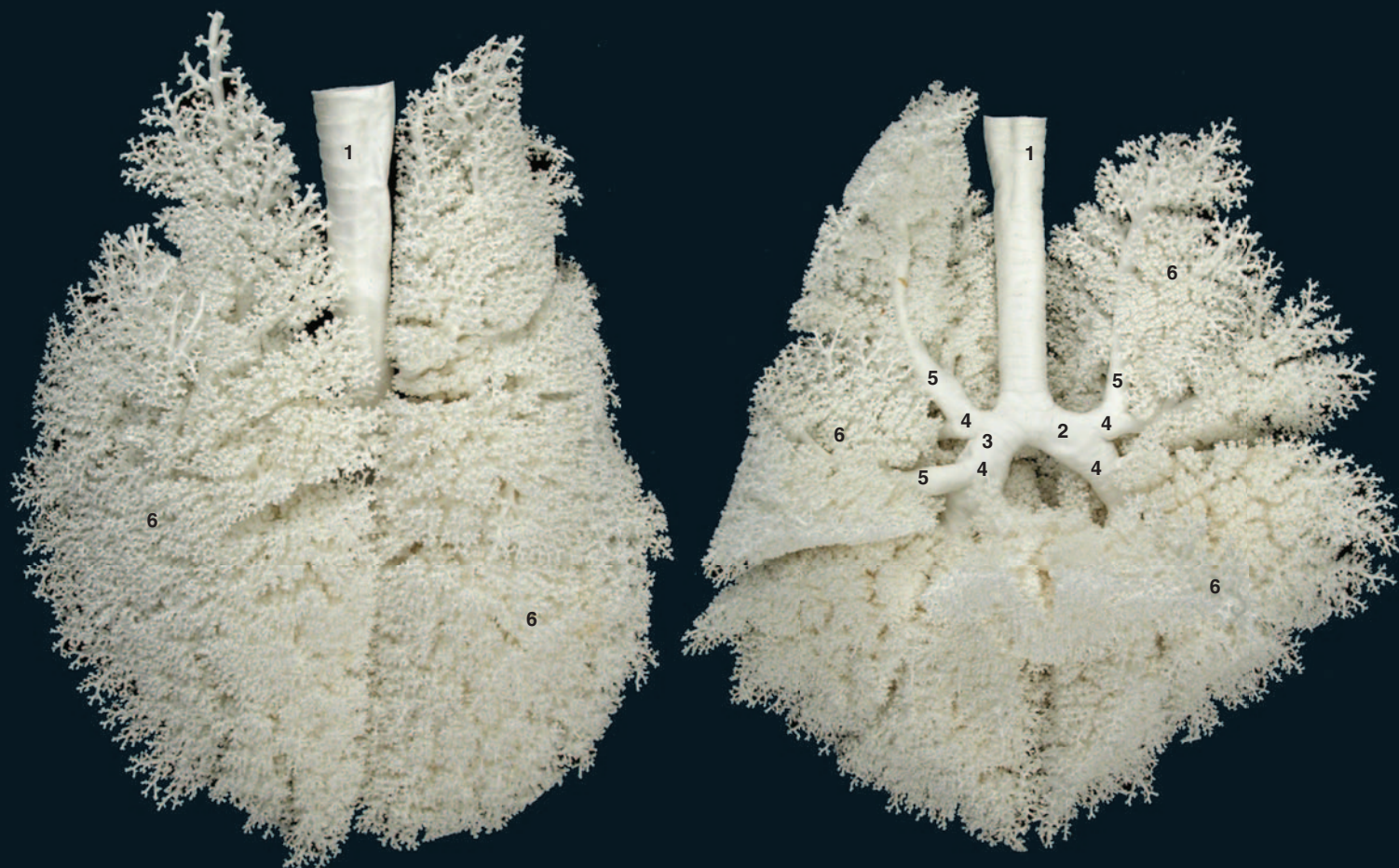


**Photomicrograph of lung tissue**  
100x

# Cast of Trachea and Bronchial Tree

The cast below is from a large dog's lungs and is approximately the same size as human lungs. The casts were created by forcing liquid latex into the respiratory passageways of the lungs and then letting the latex harden. The lungs were then placed in a weak acid until the organic tissue of the lungs was digested away. These views of the cast allow you to visualize the extensive nature of the bronchial tree as it branches out to the larger alveolar passageways within the lungs. The smaller alveolar spaces did not get incorporated into the casts.

- 1 Trachea
- 2 Right main (primary) bronchus
- 3 Left main (primary) bronchus
- 4 Lobar (secondary) bronchus
- 5 Segmental (tertiary) bronchus
- 6 Branching bronchiole network



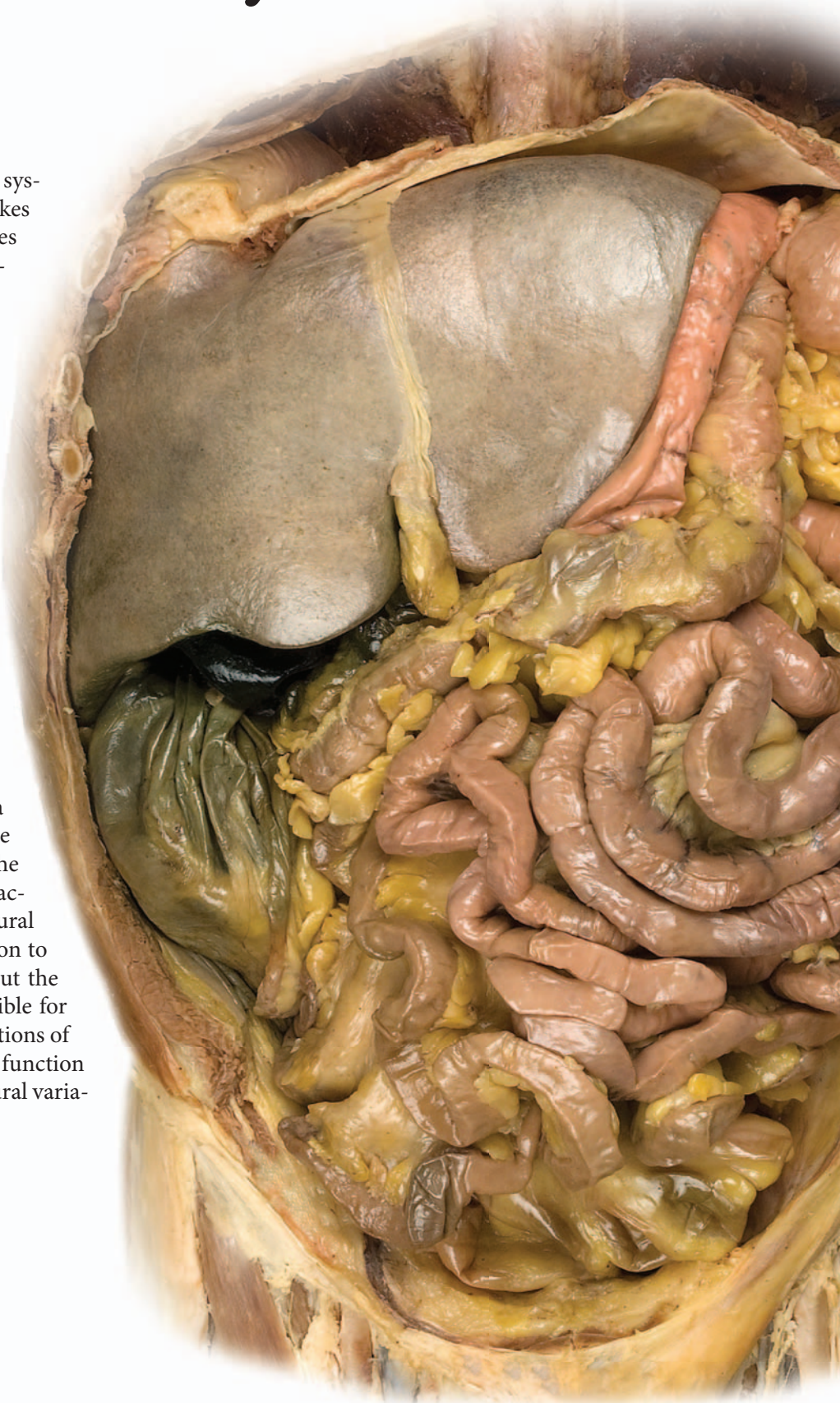
Latex cast of respiratory passageways of trachea and lungs of a dog  
Anterior view at left, posterior view at right



# 18 Digestive System

The digestive system is the extensive environmental interface that makes it possible to transfer nutrients, water, and electrolytes from the food we eat into the body's internal environment. This is made possible by a complex lining, which through a series of folds and a variety of small to microscopic projections greatly increases the surface interface between the digested contents within the gastrointestinal organs and the numerous small capillaries beneath this lining. To better appreciate the degree of this surface increase, realize that the average total surface area of the skin of an adult human is about 20 square feet, while the surface area of the digestive system is approximately 2,500 square feet, or about the size of a tennis court. To make the transfer across this extensive surface area possible, the food we eat must be broken down into small molecules that can be absorbed from the digestive tract into the circulatory system, which then distributes the molecular metabolites to the cells. Therefore, the digestive organs also function in the mechanical and chemical breakdown of the food.

Developmentally the digestive system begins as a simple tube called the gut tube or gut. As this simple tube develops into the highly convoluted organs of the adult anatomy, it undergoes structural changes that account for its various functions. Though these structural changes lead to differences in the tube from one region to the next, there is a basic pattern of design throughout the length of the tube. This structural pattern is responsible for the general function of the digestive system. Modifications of this pattern allow for the variation in structure and function along its length. This chapter will highlight the structural variation and underlying design of the digestive system.



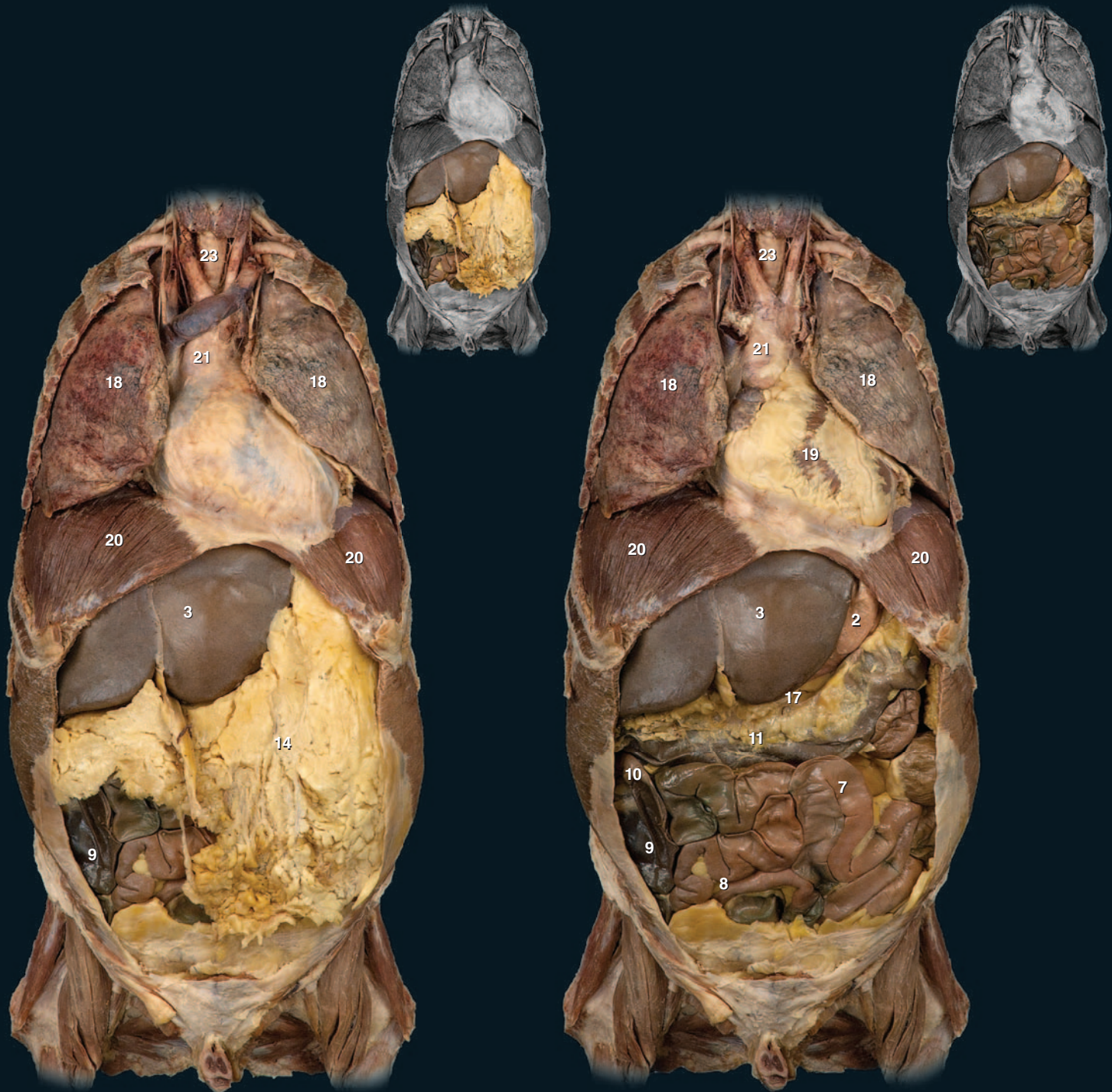
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about the digestive  
system in

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# Digestive System Organs

The digestive system begins at the mouth, where food and drink enter this tubular organ system to be processed by the teeth and tongue. From the mouth

the broken-down food moves through the transport tube called the esophagus to the storage and mixing organ called the stomach. The stomach thoroughly mixes digestive juices and mucous with the food as it tosses it around to produce a softened substance called chyme. The chyme is slowly moved into the small intestine where powerful digestive chemicals are added from the pancreas. As the chyme slowly moves through the long small intestine, the digestive enzymes break it into small metabolic fuel molecules that the intestine absorbs. The material that cannot be digested and absorbed is passed into the large intestine where the nondigested remains are held until they can be removed through the anus as feces. The photos on this and the facing page depict the digestive organs and their related mesenteries.



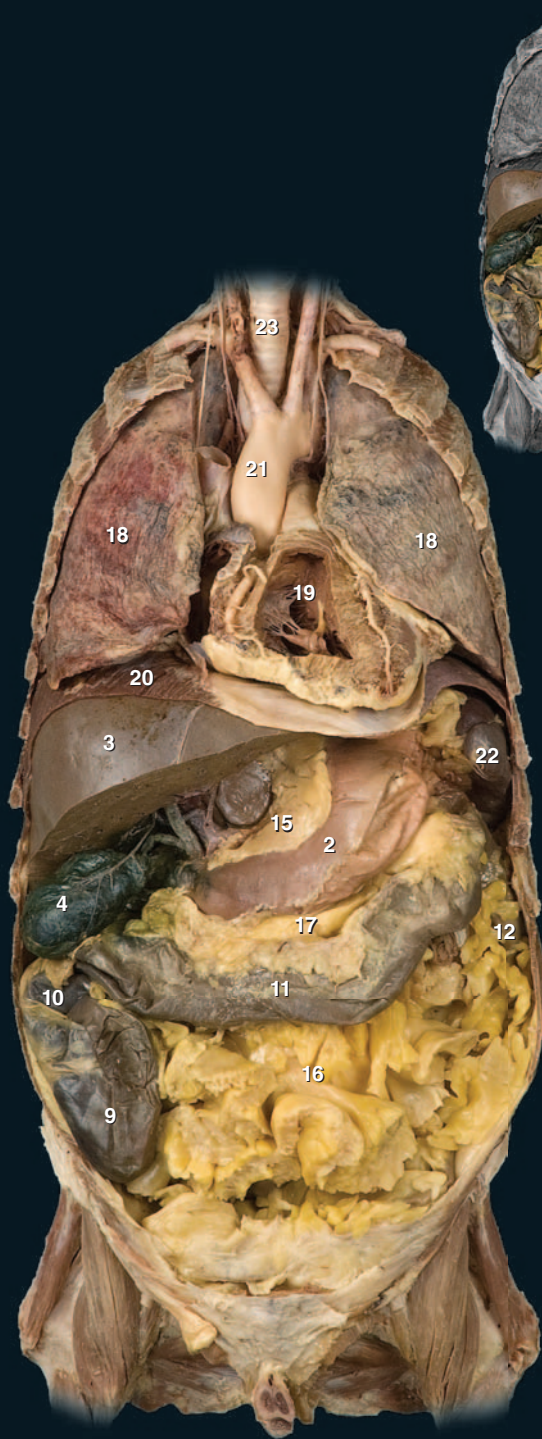
Superficial dissection of abdominal viscera  
Anterior view

Intermediate dissection of abdominal viscera  
Anterior view

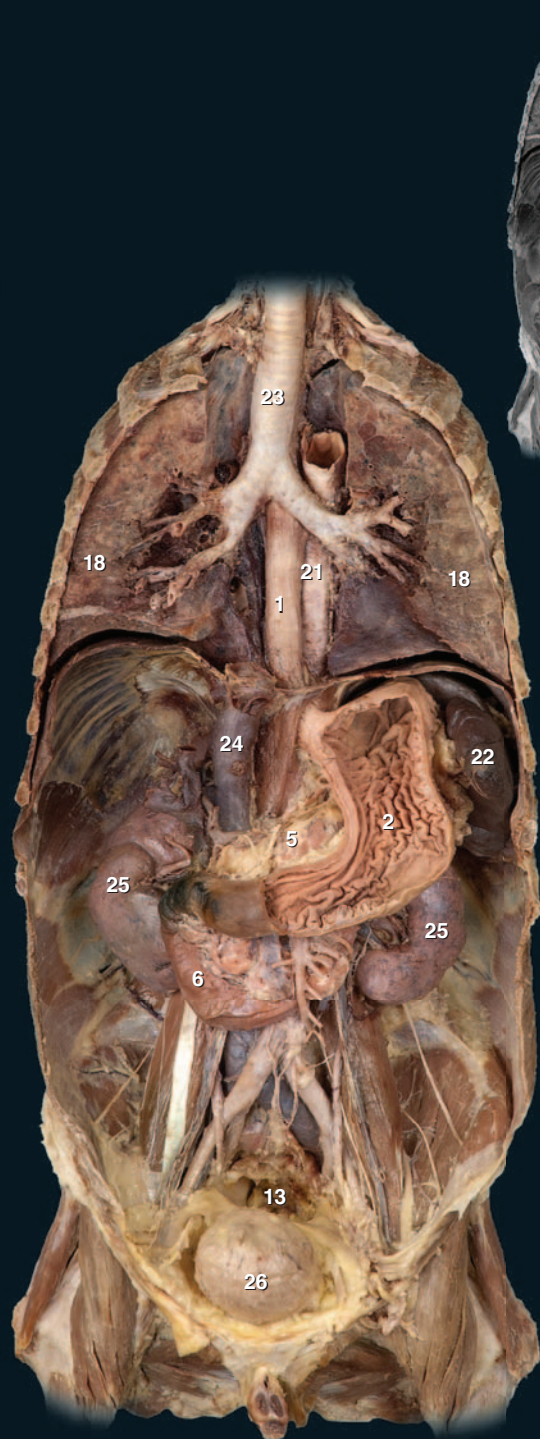
- 1 Esophagus
- 2 Stomach
- 3 Liver
- 4 Gallbladder
- 5 Pancreas
- 6 Duodenum
- 7 Jejunum
- 8 Ileum
- 9 Cecum

- 10 Ascending colon
- 11 Transverse colon
- 12 Descending colon
- 13 Rectum
- 14 Greater omentum
- 15 Lesser omentum
- 16 Mesentery
- 17 Transverse mesocolon
- 18 Lungs

- 19 Heart
- 20 Diaphragm
- 21 Aorta
- 22 Spleen
- 23 Trachea
- 24 Inferior vena cava
- 25 Kidney
- 26 Bladder



**Intermediate dissection of abdominal viscera**  
Anterior view



**Deep dissection of abdominal viscera**  
Anterior view

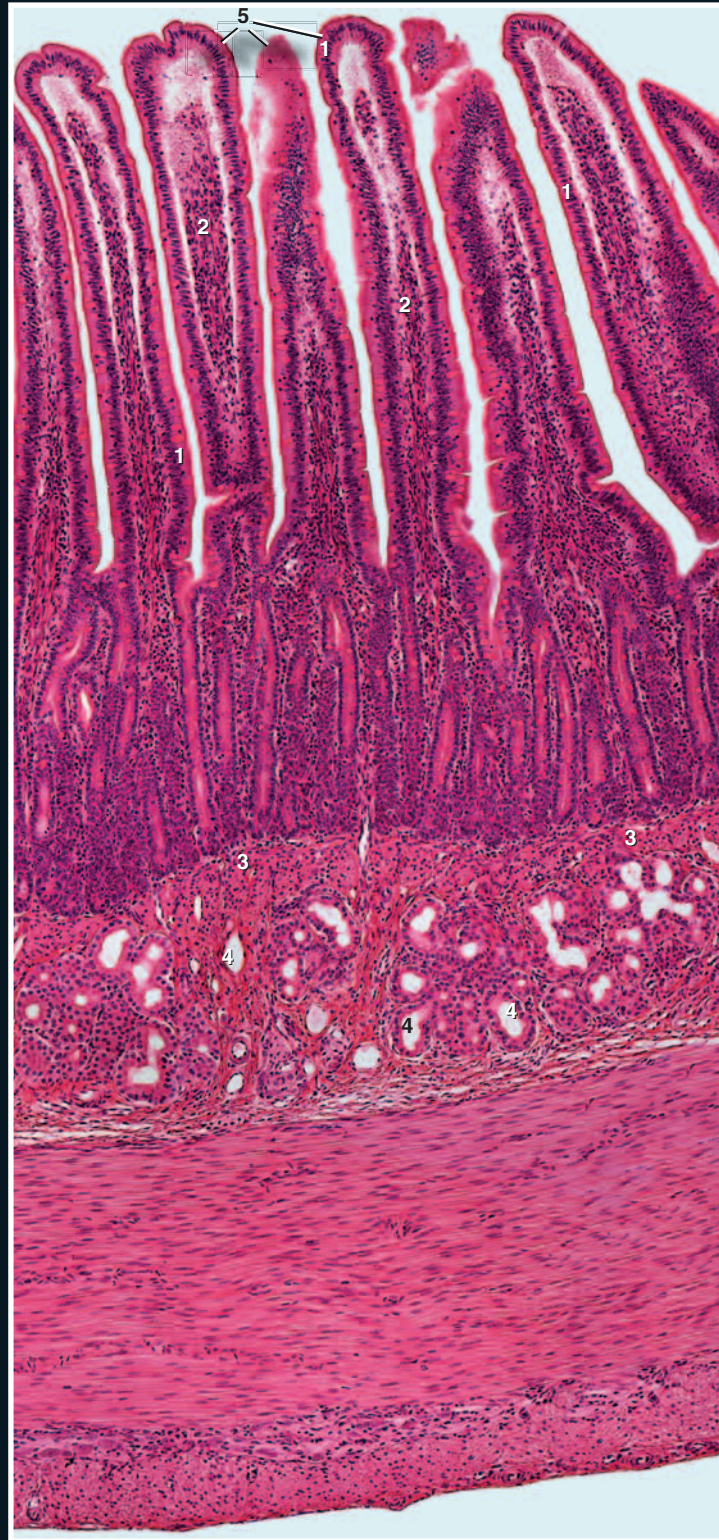


# Design of the Gut Wall

The wall of the digestive tract has a basic pattern of design that is found throughout its length. This pattern consists of three tunics or layers of anatomy. The tunica

mucosa and its subdivisions, including the tela submucosa, form the inner layer of the wall and consist of an extensive epithelial lining with an underlying vascular connective tissue. The middle layer, or tunica muscularis, consists of smooth muscle that provides for the varied types of movements that occur within the digestive organs. The majority of the organs have an outer layer, the tunica serosa, comprised of a lubricated mesothelial membrane that reduces friction as the organs move against one another. The image below, from the small intestine, illustrates the basic layers of the digestive tract wall.

- 1 Simple columnar epithelium
- 2 Lamina propria
- 3 Muscularis mucosae
- 4 Submucosal (Brunner's) glands
- 5 Villi



Tunica mucosa  
consisting of:  
epithelium,  
lamina propria,  
and  
muscularis  
mucosae

Tela  
submucosa

Tunica muscularis  
circular layer

Tunica muscularis  
longitudinal layer  
Tunica serosa

Photomicrograph of small intestine wall

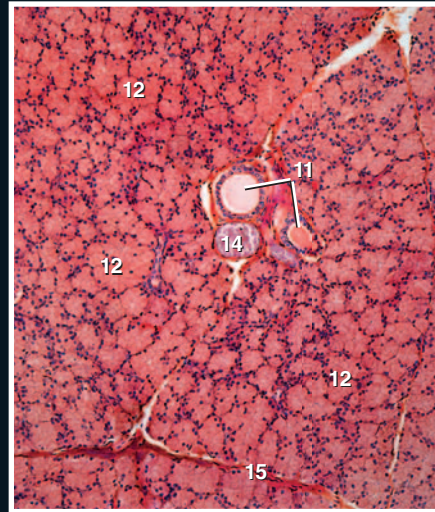
40x

# Mouth and Pharynx

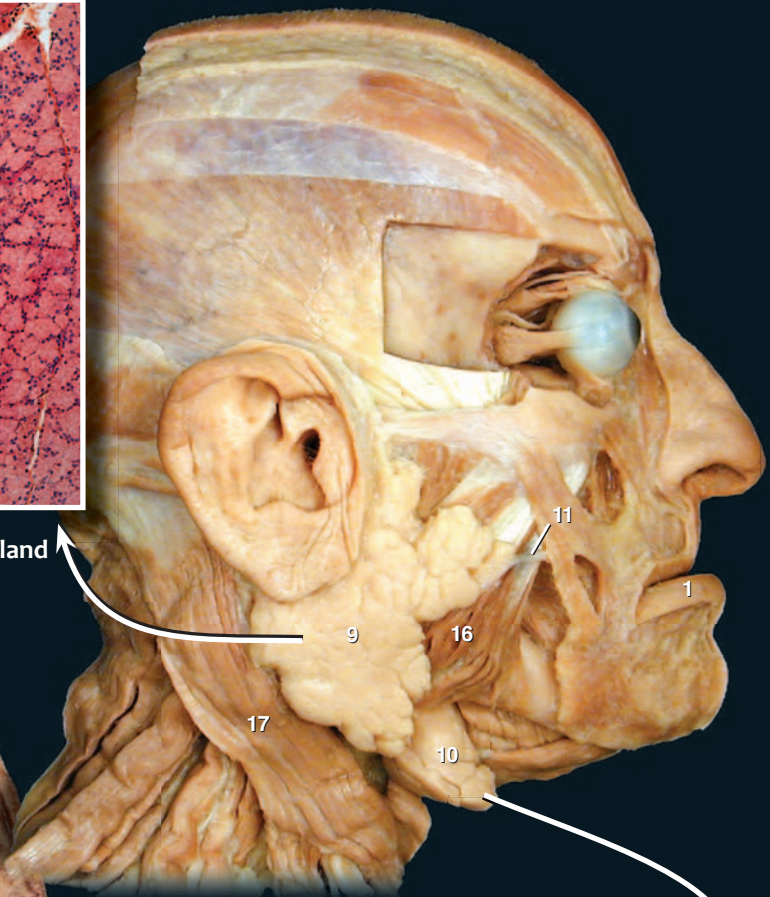
The mouth, or oral cavity, is the entryway into the digestive system. In addition to serving as the portal to the tubular gut, the mouth contains structures, such as the tongue, teeth, and salivary glands,

that help initiate the digestive process. The boundaries of this region are defined by the lips and cheeks, which form the anterior and lateral walls, the palate, which forms the roof, and numerous muscles, the most conspicuous being the muscles of the tongue, which form the floor of the mouth. The pharynx is the first portion of the gut tube and is divided into three regions. Each region communicates with a different cavity — the nasopharynx with the nasal cavity, the oropharynx with the oral cavity, and the laryngopharynx with the cavity of the larynx.

- 1 Lips
- 2 Teeth
- 3 Tongue
- 4 Hard palate
- 5 Soft palate
- 6 Nasopharynx
- 7 Oropharynx
- 8 Laryngopharynx
- 9 Parotid gland
- 10 Submandibular gland
- 11 Parotid duct
- 12 Serous acini
- 13 Mucous acini
- 14 Vein
- 15 Trabecula
- 16 Masseter
- 17 Sternocleidomastoid
- 18 Sphenoid sinus
- 19 Epiglottis
- 20 Vertebral column
- 21 Cerebrum
- 22 Spinal cord



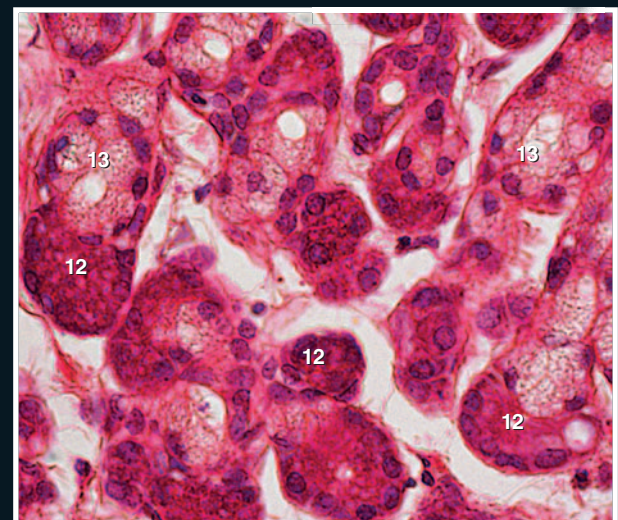
Photomicrograph of parotid gland  
100x



Dissection of head showing salivary glands  
Lateral view



Sagittal section of head and neck  
Medial view



Photomicrograph of submandibular gland  
240x

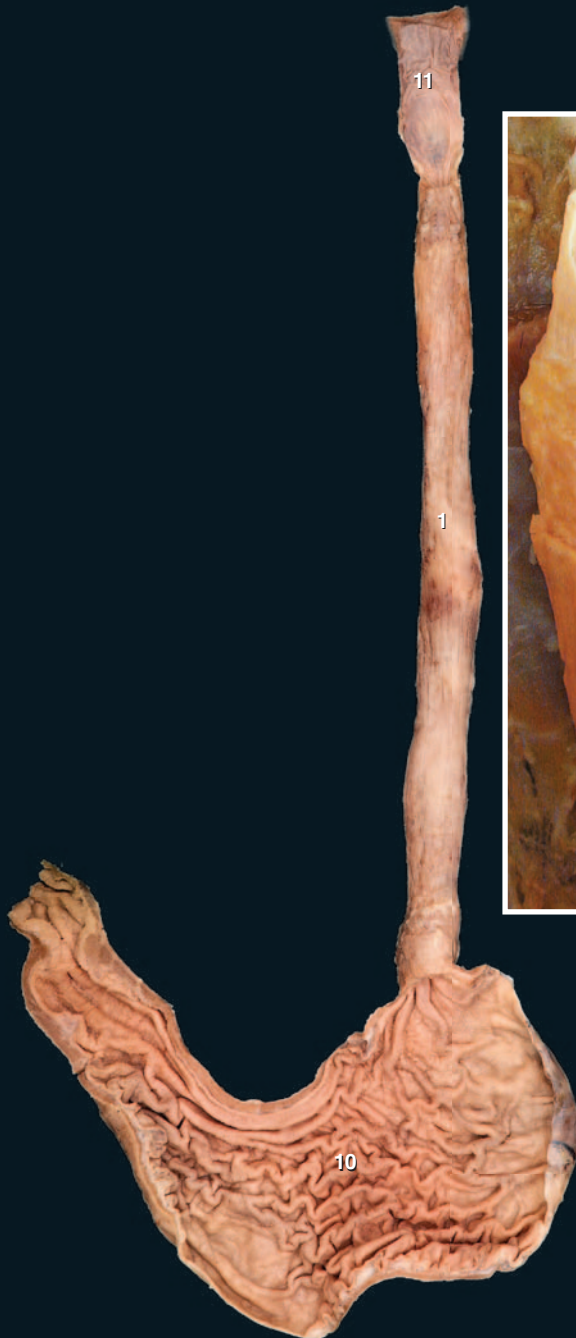
# Esophagus

Below the laryngopharynx the gut tube branches into an anterior respiratory tube, the larynx and a posterior digestive tube, the esophagus.

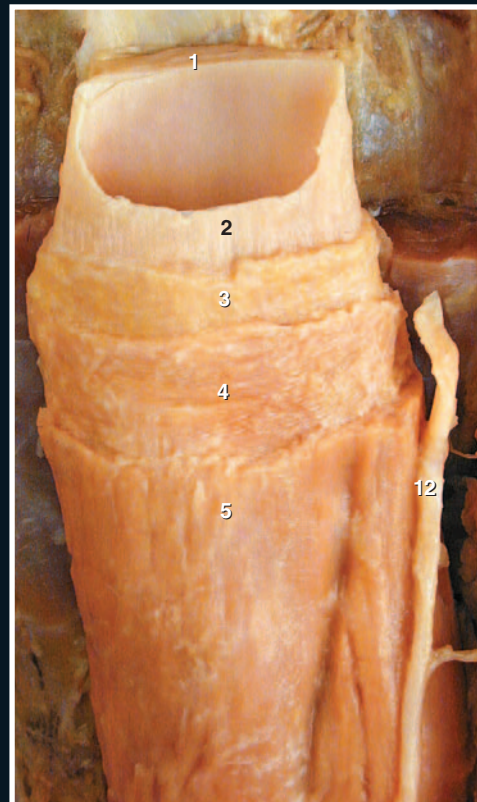
The esophagus is a narrow, collapsed muscular tube coursing from the laryngopharynx to the stomach. It is approximately 25 cm in length and begins near the level of the sixth cervical vertebra, where it runs inferiorly against the anterior surface of the thoracic vertebral column. At the level of the tenth thoracic vertebra it deviates slightly to the left passing through the esophageal hiatus of the diaphragm to enter the stomach. It functions as a muscular tube of transmission.



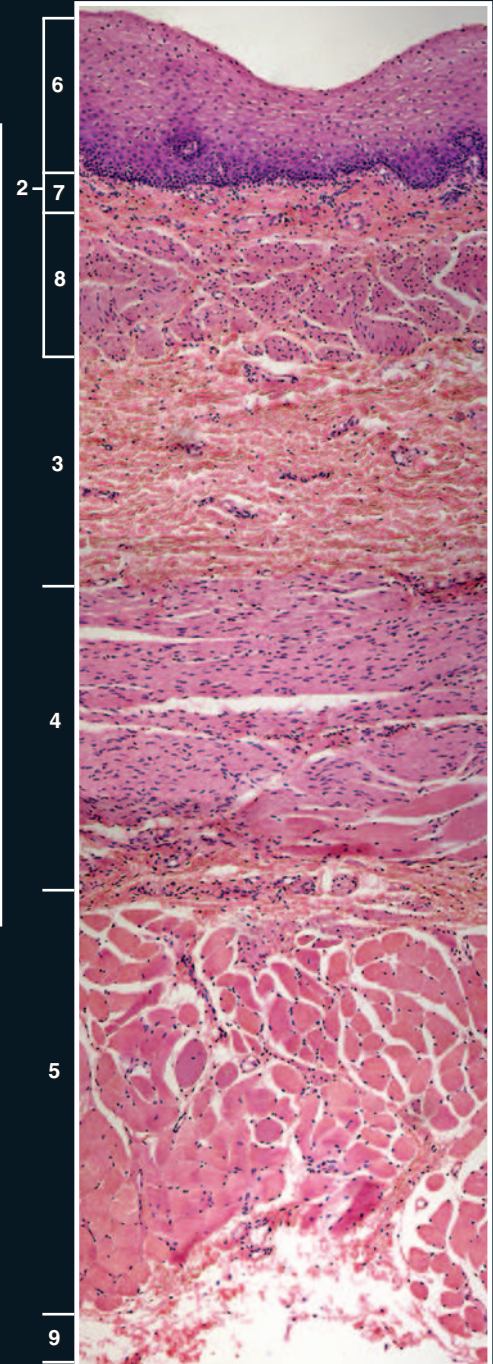
- |  |                          |
|--|--------------------------|
| 1 Esophagus                            | 7 Lamina propria         |
| 2 Tunica mucosa                        | 8 Muscularis mucosae     |
| 3 Tela submucosa                       | 9 Tunica adventitia      |
| 4 Tunica muscularis circular layer     | 10 Stomach               |
| 5 Tunica muscularis longitudinal layer | 11 Pharynx - dorsal wall |
| 6 Stratified squamous epithelium       | 12 Vagus nerve           |



Pharynx, esophagus, and stomach  
Anterior view



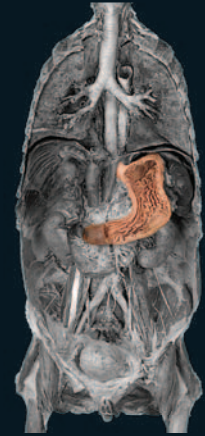
Step dissection of esophagus  
Anterior view



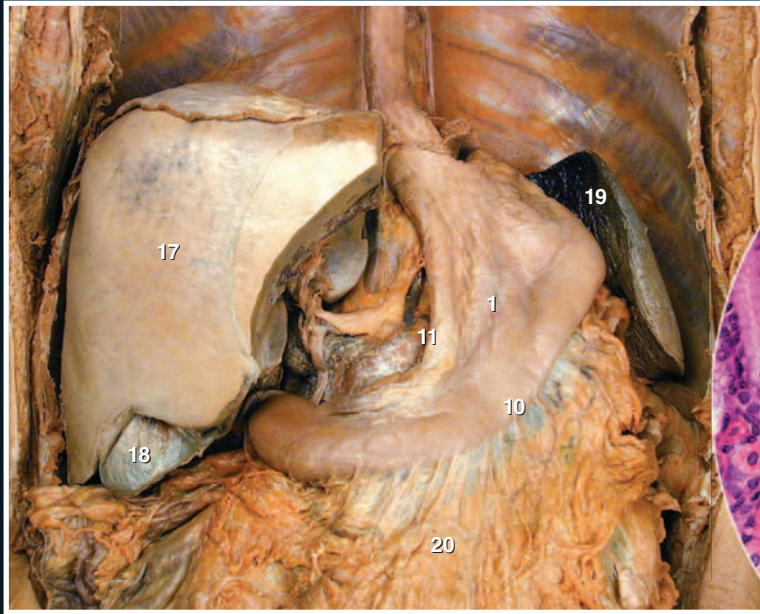
Photomicrograph of esophageal wall  
40x

# Stomach

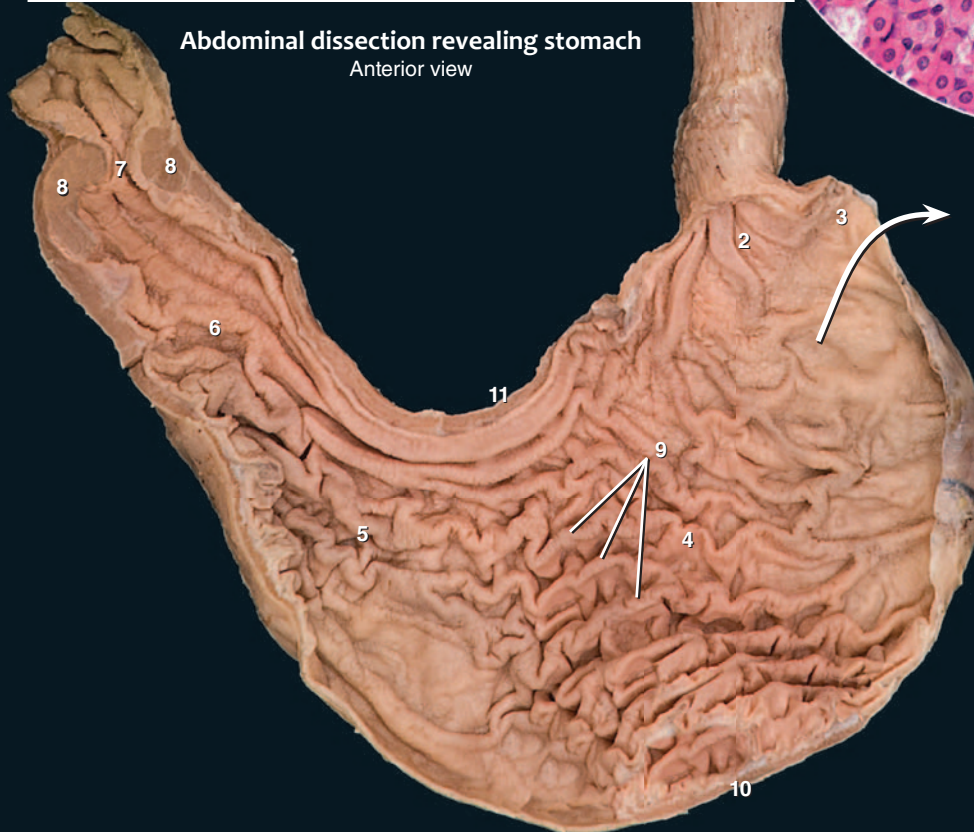
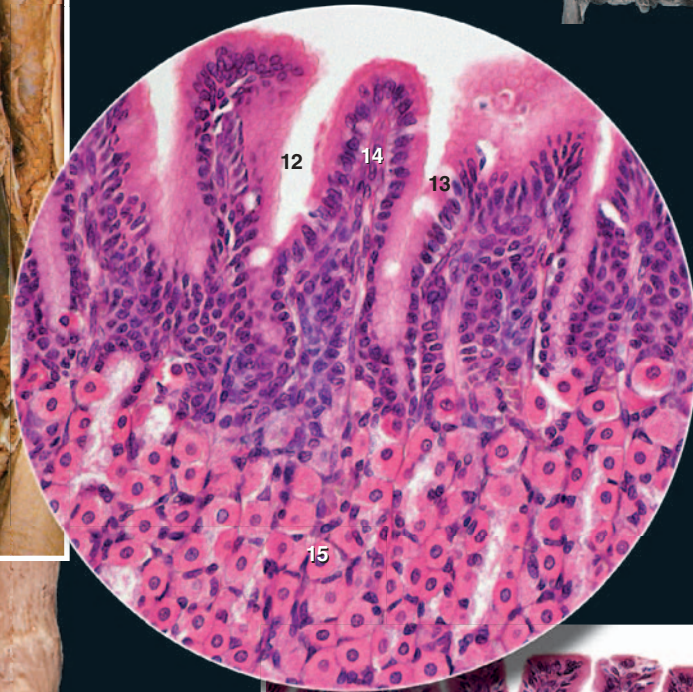
The stomach is a J-shaped organ of variable size and shape and has the greatest diameter of any part of the gut tube. It occupies the upper left quadrant of the abdominal cavity, where it is anchored to the posterior abdominal wall by a mesentery. The stomach performs several functions, the most important of which is to store ingested food until it can be emptied into the small intestine at a rate that allows for optimal digestion and absorption.



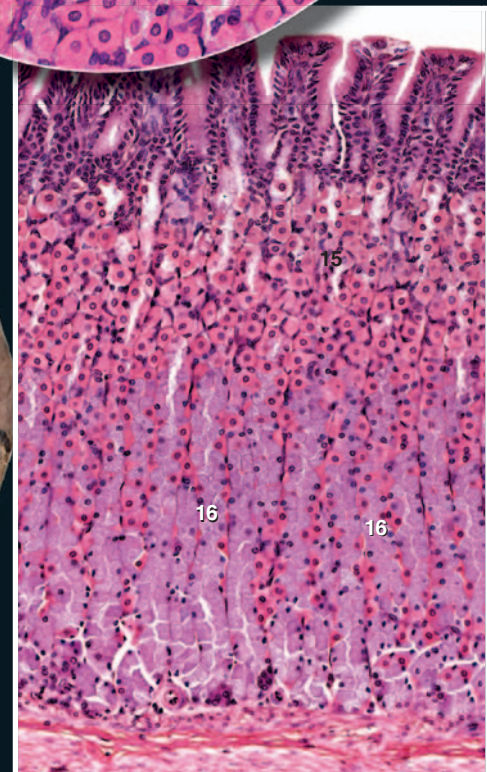
- |                     |                      |                        |
|---------------------|----------------------|------------------------|
| 1 Stomach           | 7 Pylorus            | 13 Surface mucous cell |
| 2 Cardia of stomach | 8 Pyloric sphincter  | 14 Lamina propria      |
| 3 Fundus of stomach | 9 Gastric rugae      | 15 Mucous neck cell    |
| 4 Body of stomach   | 10 Greater curvature | 16 Gastric glands      |
| 5 Pyloric antrum    | 11 Lesser curvature  | 17 Liver               |
| 6 Pyloric canal     | 12 Gastric pit       | 18 Gallbladder         |
|                     |                      | 19 Spleen              |
|                     |                      | 20 Greater omentum     |



Abdominal dissection revealing stomach  
Anterior view



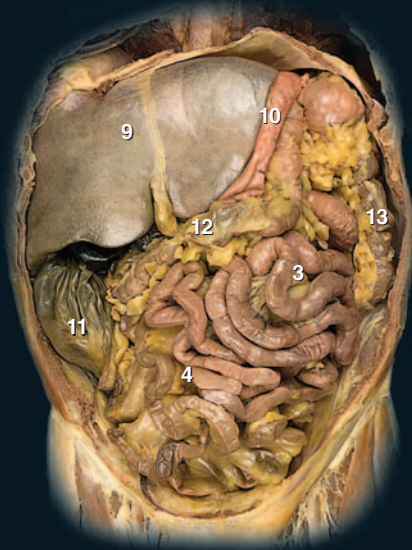
Frontal section of stomach  
Anterior view



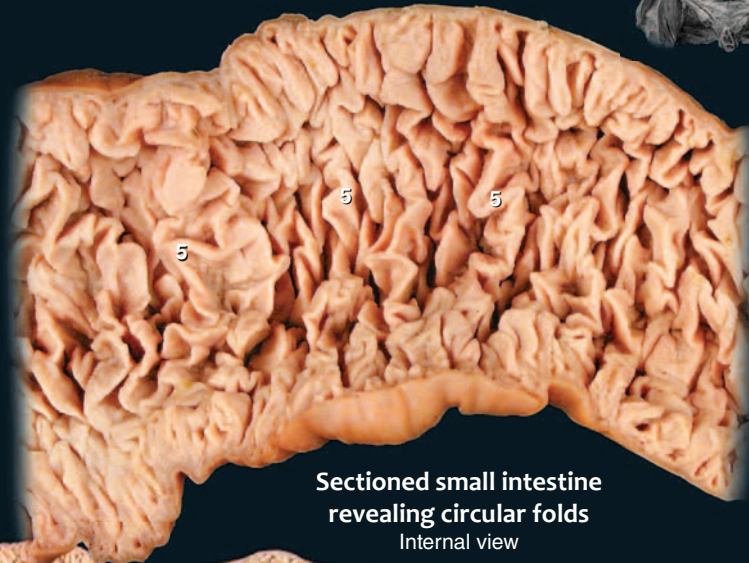
Photomicrograph of stomach mucosa  
with callout above  
40x and 100x

# Small Intestine

The small intestine is a highly coiled tube with a fairly consistent diameter from beginning to end. It is approximately 6 to 7 meters long in the cadaver but, because of its muscle tone only around 4 to 5 meters in the living. The small intestine occupies the greater part of the mid- to lower abdominal cavity and consists of three regions. The retroperitoneal first part is called the duodenum and is about 30 cm in length. This C-shaped region receives the secretions from the pancreas and liver. The remaining parts of the small intestine are the jejunum and ileum, which make up the bulk of the organ and are attached to the posterior wall of the abdomen by the mesentery. The small intestine is the principal site of digestion and absorption.



Small intestine in situ  
Anterior view



Sectioned small intestine  
revealing circular folds  
Internal view



Entire small intestine sectioned to show changes in  
internal surface from the duodenal end to the ileal end  
Internal view



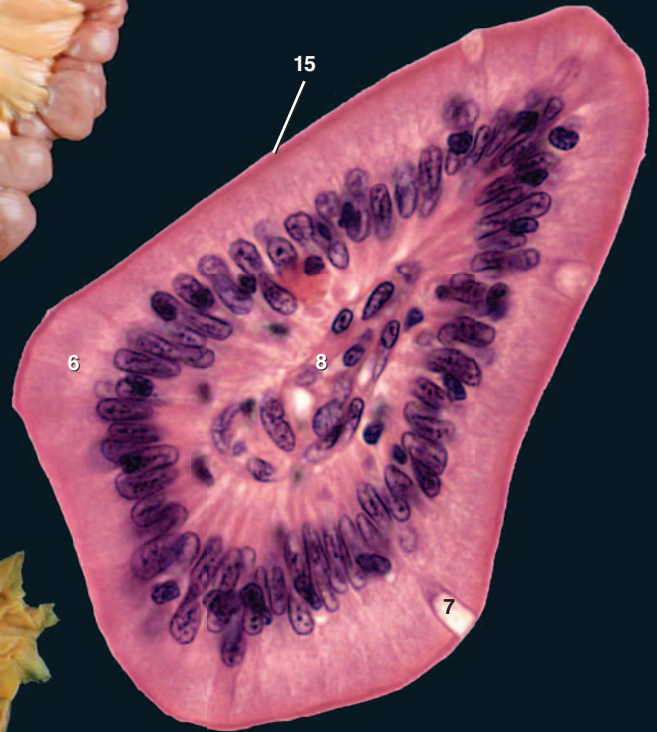
- 1 Duodenal end
- 2 Ileal end
- 3 Jejunum
- 4 Ileum
- 5 Circular folds

- 6 Simple columnar epithelium
- 7 Goblet cell
- 8 Lamina propria
- 9 Liver
- 10 Stomach

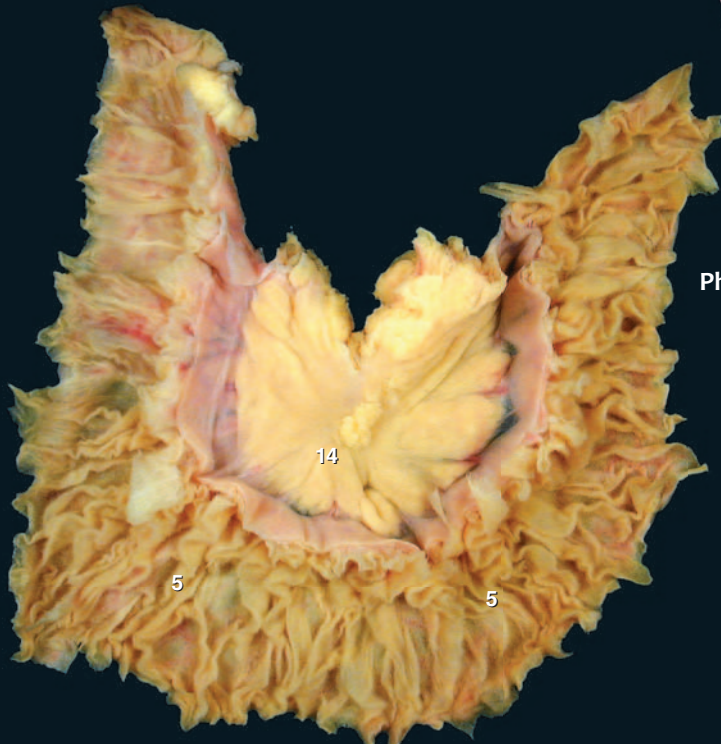
- 11 Cecum
- 12 Transverse colon
- 13 Descending colon
- 14 Mesentery
- 15 Microvillus brush border



**Loop of small intestine**  
Anterior view



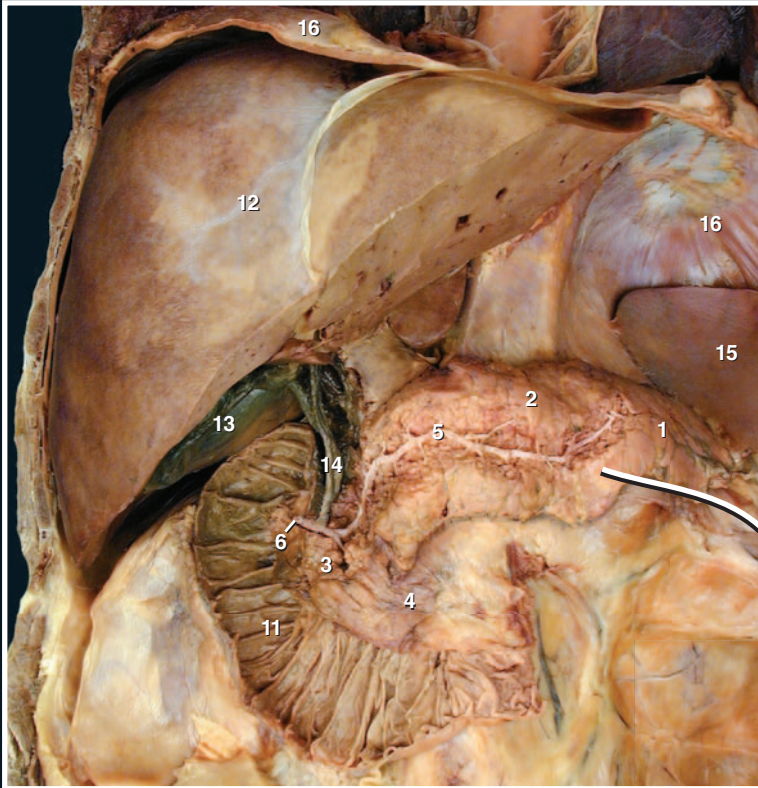
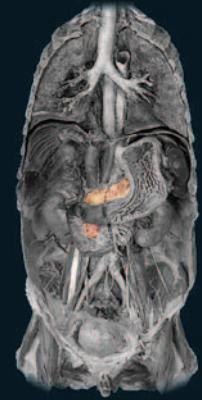
**Photomicrograph of cross-section of intestinal villus**  
400x



**Loop of small intestine from unembalmed cadaver, opened to show circular folds**  
Anterior view

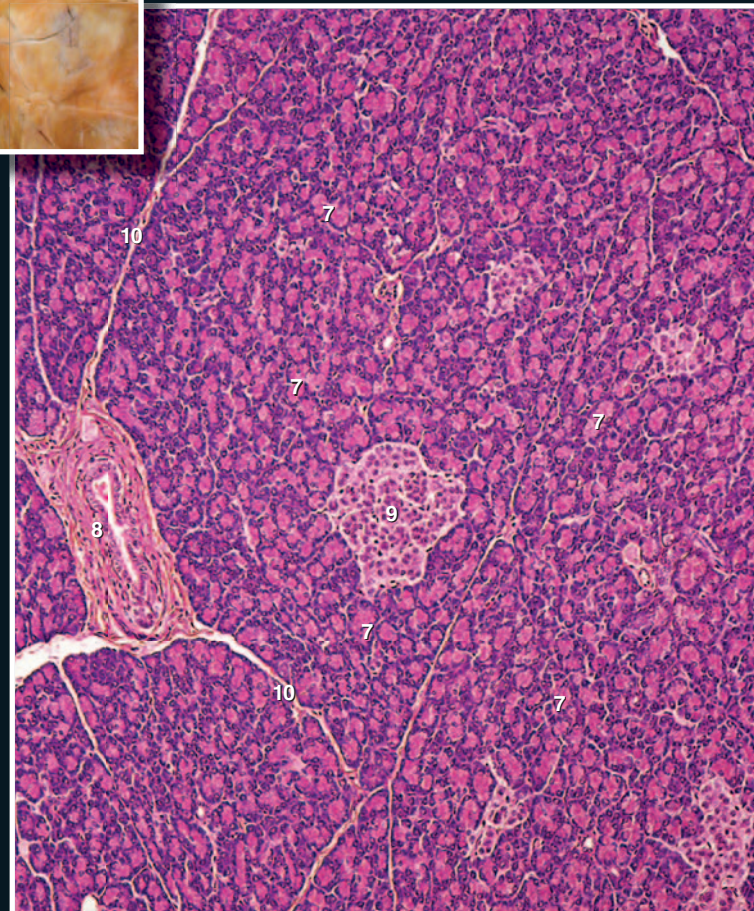
# Pancreas

The pancreas is a pinkish glandular structure situated posterior to the stomach in the retroperitoneal space of the abdominal cavity. It arises as an outgrowth of the duodenum during development and retains this connection via the pancreatic duct. It is a dual glandular organ consisting of both exocrine and endocrine glandular tissue. It has four basic regions: a head, neck, body, and tail. The exocrine glands and ducts produce and deliver the powerful digestive enzymes to the small intestine.



- 1 Tail of pancreas
- 2 Body of pancreas
- 3 Head of pancreas
- 4 Uncinate process of pancreas
- 5 Pancreatic duct (of Wirsung)
- 6 Major duodenal papilla
- 7 Exocrine acinus
- 8 Pancreatic ductule
- 9 Pancreatic islet (endocrine cells)
- 10 Trabecula
- 11 Duodenum
- 12 Liver
- 13 Gallbladder
- 14 Common bile duct
- 15 Spleen
- 16 Diaphragm

Abdominal dissection with part of liver  
and peritoneal organs removed  
Anterior view

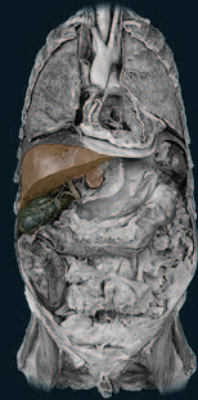


Photomicrograph of pancreas  
100x

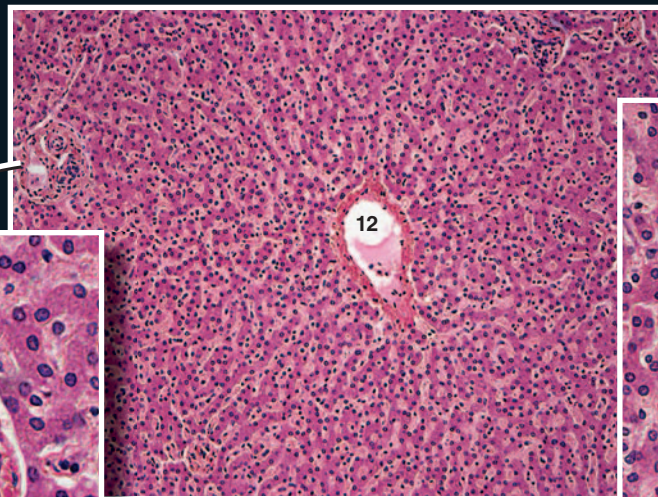
# Liver and Gallbladder

Besides pancreatic juice, the other secretory product emptied into the duodenum is bile. The biliary system, which

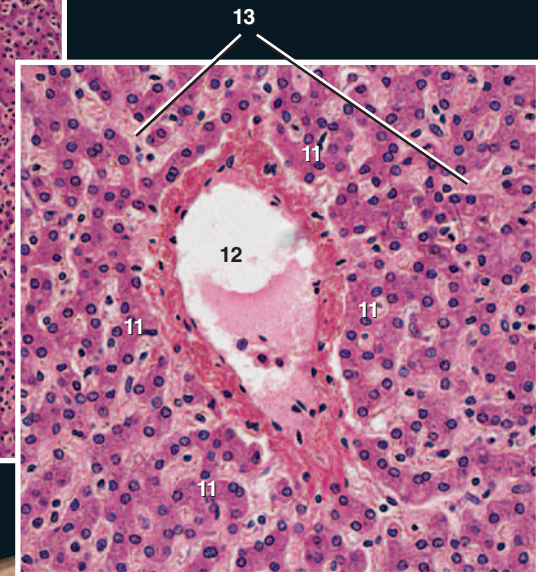
also develops as an embryonic outgrowth of the duodenum, includes the liver, the gallbladder, and associated ducts. The rounded, wedge-shaped liver, the largest organ of the abdomen, occupies a major portion of the upper right peritoneal cavity. The gallbladder is a pear-shaped, saccular organ situated in a depression on the inferior surface of the right lobe of the liver where it is a storage organ of the bile that is produced in the liver. Connecting the gallbladder to the common hepatic bile duct is the cystic bile duct. The junction of these ducts forms the main bile duct that drains into the duodenum. The liver is the largest and most important metabolic organ in the body, which in addition to producing the important bile salts associated with digestion, performs a myriad of metabolic functions.



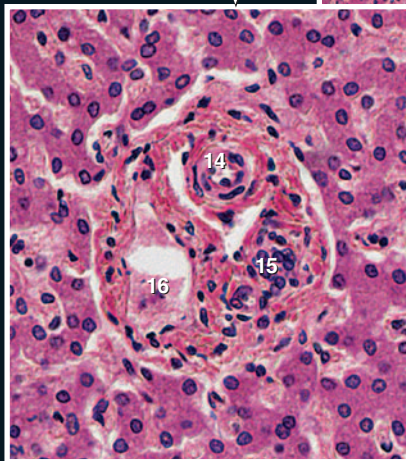
- |                          |                       |                                  |
|--------------------------|-----------------------|----------------------------------|
| 1 Right lobe of liver    | 7 Hepatic artery      | 12 Central vein                  |
| 2 Left lobe of liver     | 8 Hepatic portal vein | 13 Hepatic sinusoid              |
| 3 Caudate lobe of liver  | 9 Round ligament      | 14 Branch of hepatic artery      |
| 4 Quadrate lobe of liver | 10 Inferior vena cava | 15 Bile duct                     |
| 5 Gallbladder            | 11 Hepatocytes        | 16 Branch of hepatic portal vein |
| 6 Cystic bile duct       |                       |                                  |



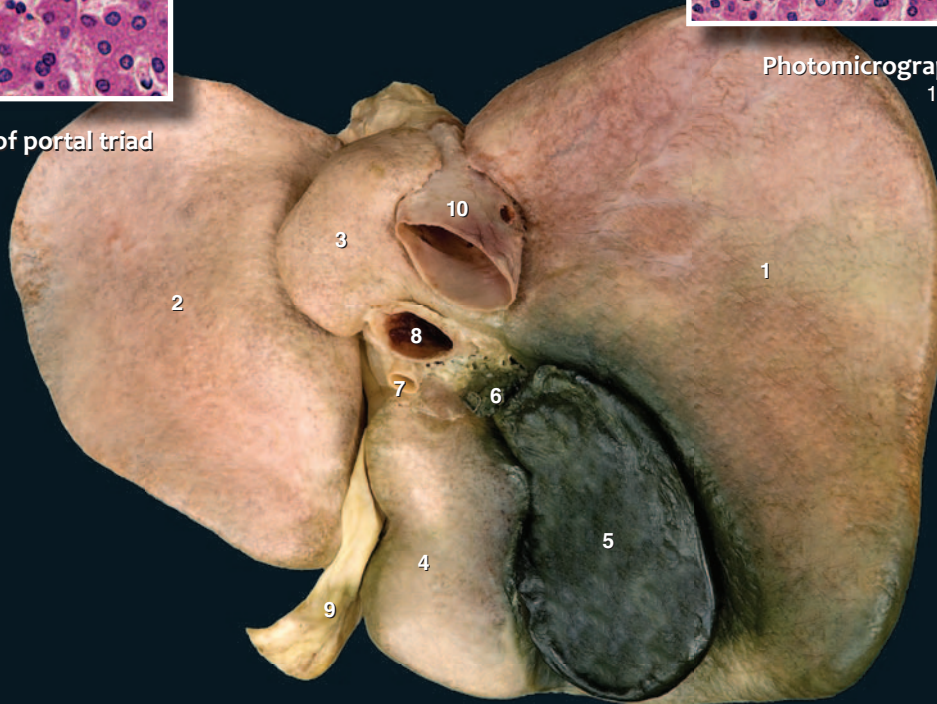
Photomicrograph of liver lobule  
50x



Photomicrograph of central vein  
100x



Photomicrograph of portal triad  
150x



Liver and gall bladder  
Inferior view, posterior at top

# Large Intestine

The large intestine is much shorter than the small intestine, averaging about 1.5 meters in length, but typically has a greater diameter, therefore the name. The large intestine consists of the cecum, appendix, colon, and rectum. The cecum receives indigestible material from the small intestine and then moves it through the subdivisions of the colon — the ascending colon, transverse colon, descending colon, and sigmoid colon — before it enters the terminal portion of the gut tube, the rectum. The **large intestine** is primarily a drying and storage organ of indigestible plant fibers. Minimal absorption of fluids occurs in the large intestine as the fecal contents are stored prior to evacuation.

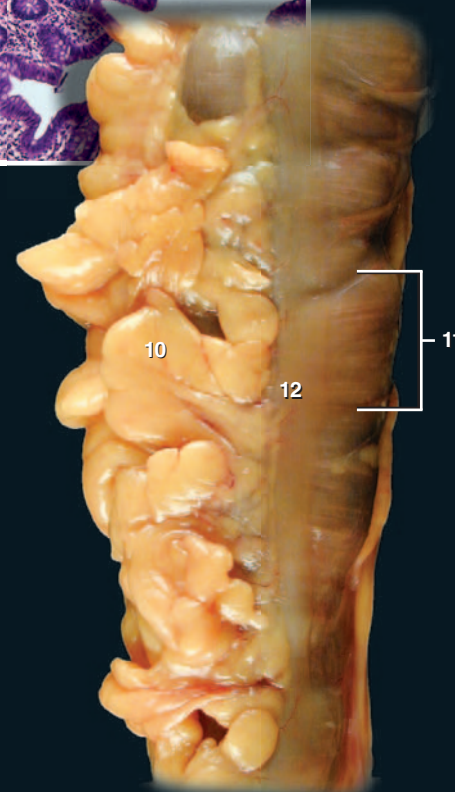


- |                                 |                                |                                    |
|---------------------------------|--------------------------------|------------------------------------|
| 1 Cecum                         | 9 Rectum                       | 17 Lamina propria                  |
| 2 Vermiform appendix            | 10 Omental or fatty appendices | 18 Tela submucosa                  |
| 3 Ascending colon               | 11 Haustra                     | 19 Ileum (cut)                     |
| 4 Right colic (hepatic) flexure | 12 Taeniae coli                | 20 Duodenal-jejunal junction (cut) |
| 5 Transverse colon              | 13 Absorptive cells            | 21 Stomach                         |
| 6 Left colic (splenic) flexure  | 14 Goblet cells                | 22 Root of the mesentery (cut)     |
| 7 Descending colon              | 15 Intestinal glands           |                                    |
| 8 Sigmoid colon                 | 16 Muscularis mucosae          |                                    |

Photomicrograph of of large intestine mucosa  
100x



Dissection of abdominal cavity with jejunum and ileum removed  
Anterior view

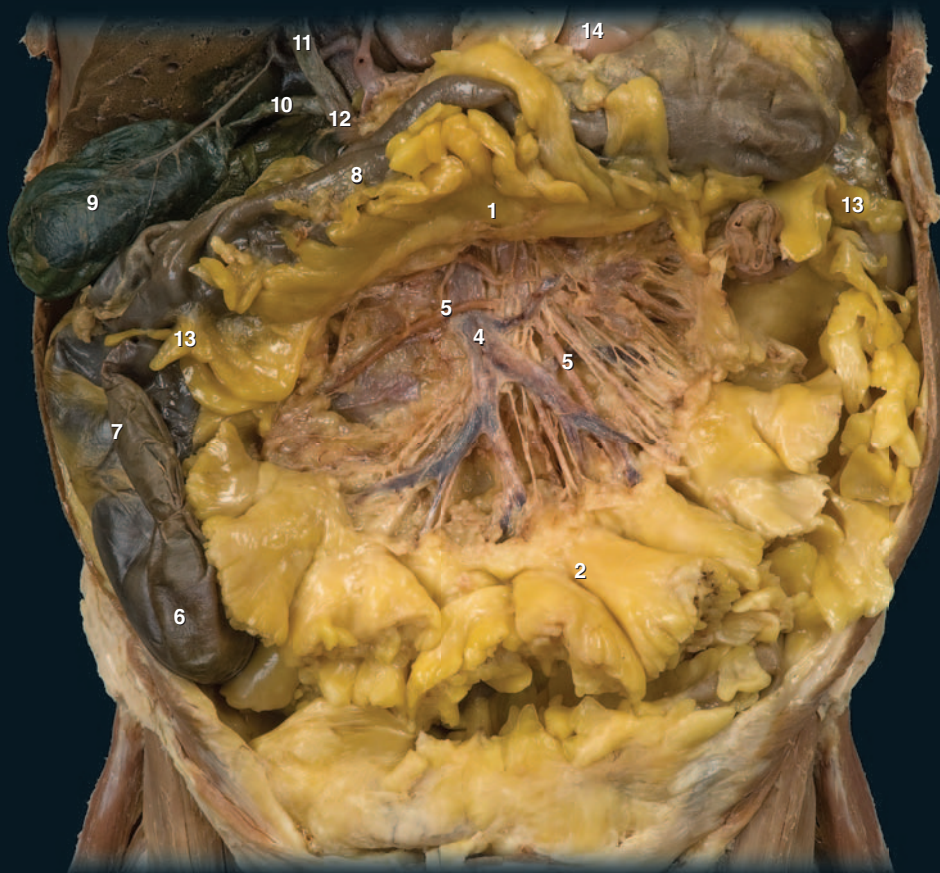


Portion of descending colon  
Anterior view

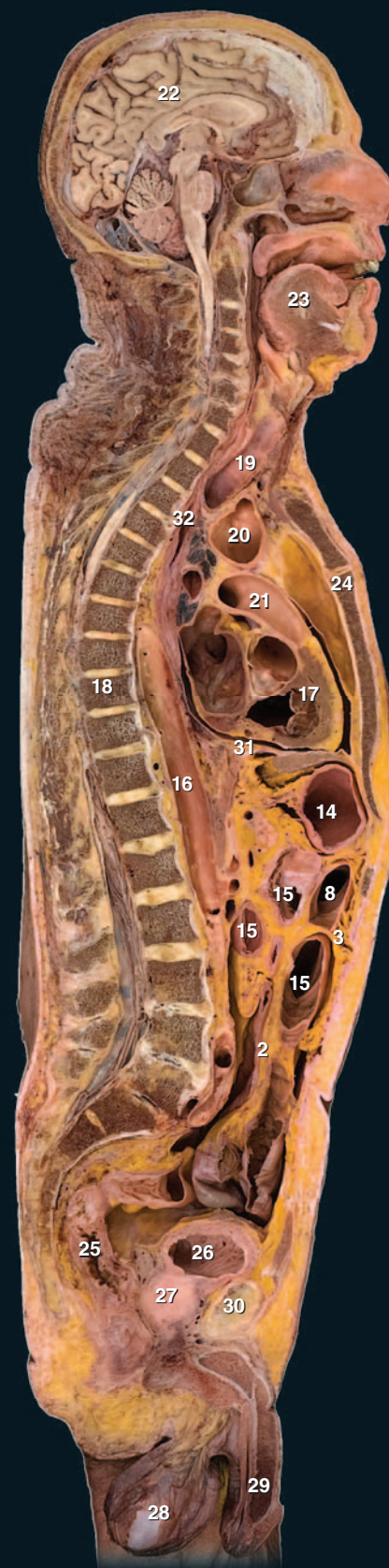
# Mesenteries

Mesenteries are reflections of the serous peritoneal membrane from the parietal layer lining the posterior abdominal wall to the visceral layer covering the peritoneal abdominal organs. The mesenteries not only support the digestive organs and help anchor them in the abdominal cavity, but also are the pathways for the vessels and nerves that supply the peritoneal organs.

- |   |                     |
|---|---------------------|
| 1 Transverse mesocolon                                | 17 Heart            |
| 2 The mesentery partially dissected to reveal vessels | 18 Vertebral column |
| 3 Greater omentum                                     | 19 Trachea          |
| 4 Superior mesenteric vein and tributaries            | 20 Aortic arch      |
| 5 Branches of superior mesenteric artery              | 21 Pulmonary trunk  |
| 6 Cecum   | 22 Brain            |
| 7 Ascending colon                                     | 23 Tongue           |
| 8 Transverse colon                                    | 24 Sternum          |
| 9 Gallbladder   | 25 Rectum           |
| 10 Cystic bile duct                                   | 26 Bladder          |
| 11 Common hepatic bile duct                           | 27 Prostate         |
| 12 Common bile duct                                   | 28 Testis           |
| 13 Omental or fatty appendices                        | 29 Penis            |
| 14 Stomach  | 30 Pubic symphysis  |
| 15 Small intestine                                    | 31 Diaphragm        |
| 16 Aorta  | 32 Esophagus        |



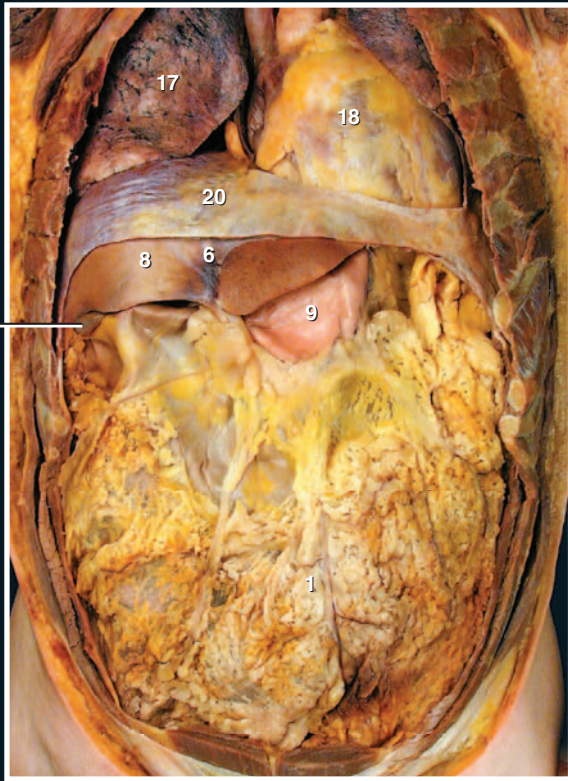
Dissection of the mesentery with jejunum and ileum removed  
Anterior view



Sagittal section of head and trunk  
Medial view

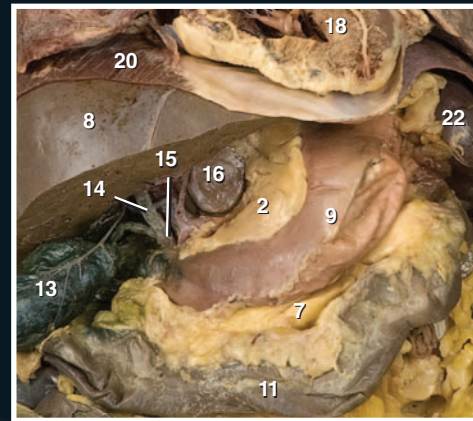
# Omenta

Omenta are mesenteric structures that unite two digestive organs. These reflections of the peritoneal membrane course from one abdominal digestive organ to another abdominal digestive organ, rather than from organ to body wall. There are two omenta in the abdominal cavity. The greater omentum is a peritoneal reflection between the greater curvature of the stomach and the transverse colon. The lesser omentum is a peritoneal reflection between the lesser curvature of the stomach and the liver.



Anterior body wall removed exposing body cavity  
Anterior view

- |   |                                  |
|---|----------------------------------|
| 1 Greater omentum                           | 12 Fossa for removed gallbladder |
| 2 Lesser omentum                            | 13 Gallbladder                   |
| 3 Hepatogastric ligament of lesser omentum  | 14 Common hepatic bile duct      |
| 4 Hepatoduodenal ligament of lesser omentum | 15 Common bile duct              |
| 5 Hepatorenal part of coronary ligament     | 16 Caudate lobe of liver         |
| 6 Falciform ligament                        | 17 Lung                          |
| 7 Transverse mesocolon                      | 18 Heart                         |
| 8 Liver                                     | 19 Breast                        |
| 9 Stomach                                   | 20 Diaphragm                     |
| 10 Duodenum                                 | 21 Epiploic foramen              |
| 11 Transverse colon                         | 22 Spleen                        |



Dissection of abdominal cavity with  
anterior aspect of liver removed  
Antero-inferior view



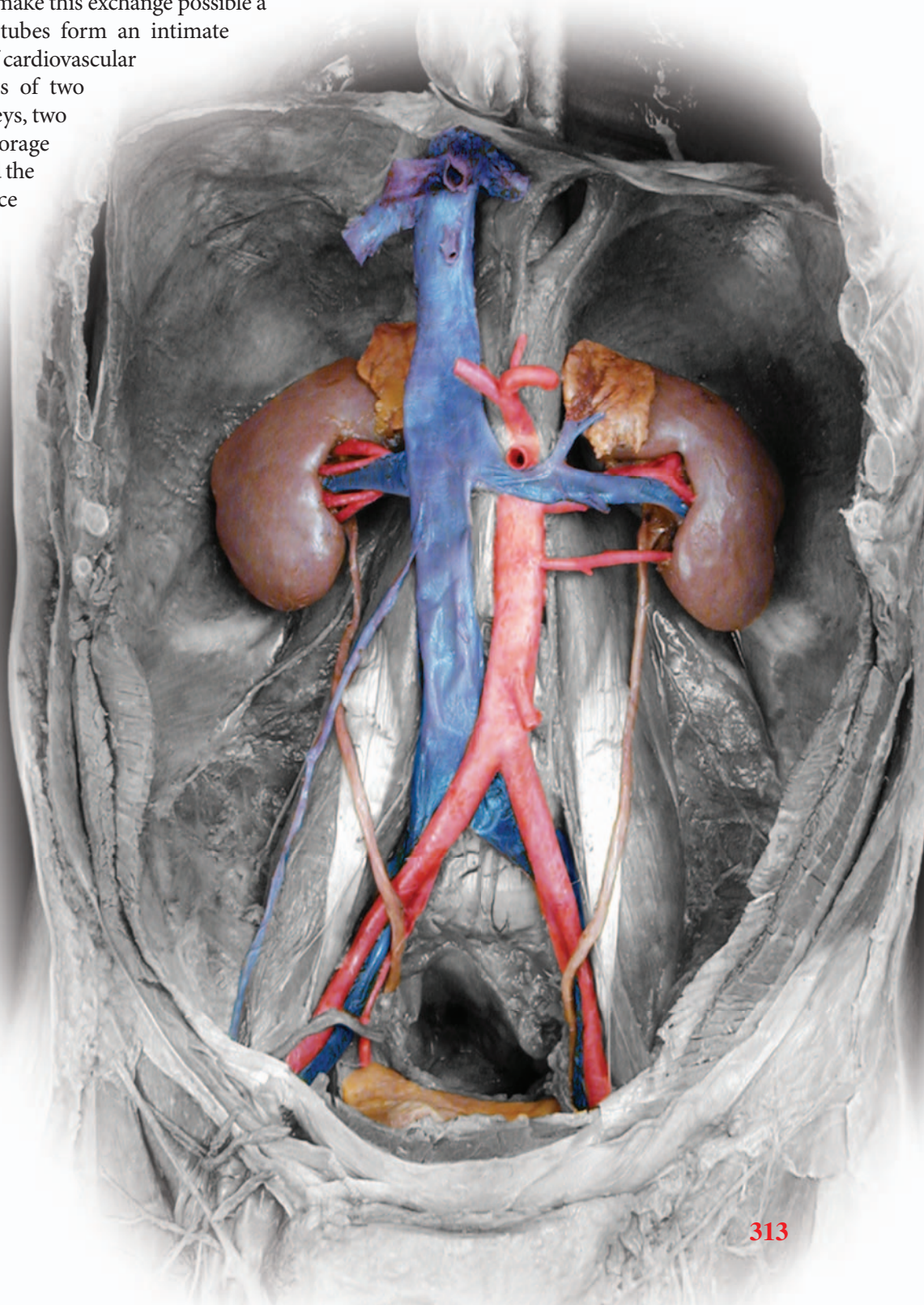
Superficial dissection of abdominal cavity with liver elevated  
Antero-inferior view

# 19

# Urinary System

Like the respiratory and digestive systems, the urinary system is an environmental exchange system. Like all the exchange systems of the body, the urinary system forms an immense interface with the cardiovascular system for the single purpose of regulating the homeostatic balance of the water environment (extracellular matrix) that surrounds every cell in the body. To make this exchange possible a large network of microscopic urinary tubes form an intimate interface with an equally large network of cardiovascular capillaries. The urinary system consists of two blood processing centers called the kidneys, two transport tubes called the ureters, a storage organ called the bladder, and a drain called the urethra. The kidneys continually produce urine, which is then moved via the ureters to the storage organ, the bladder. When it is convenient to remove the urine from the body, contractions in the wall of the bladder expell the urine through the urethra.

In order to survive, every body cell requires a water environment that is similar to the composition of the oceans in which cellular life first arose. The kidneys help maintain this intercellular water environment by filtering the blood and regulating its contents so the blood can help maintain the correct composition of the extracellular fluid that bathes every cell. By adjusting the amount of water in the plasma and the various plasma constituents, which are either conserved for the body or eliminated in the urine, the kidneys are able to maintain water and electrolyte balance within the very narrow range compatible with life, despite wide variations in intake and losses of these constituents through other avenues.



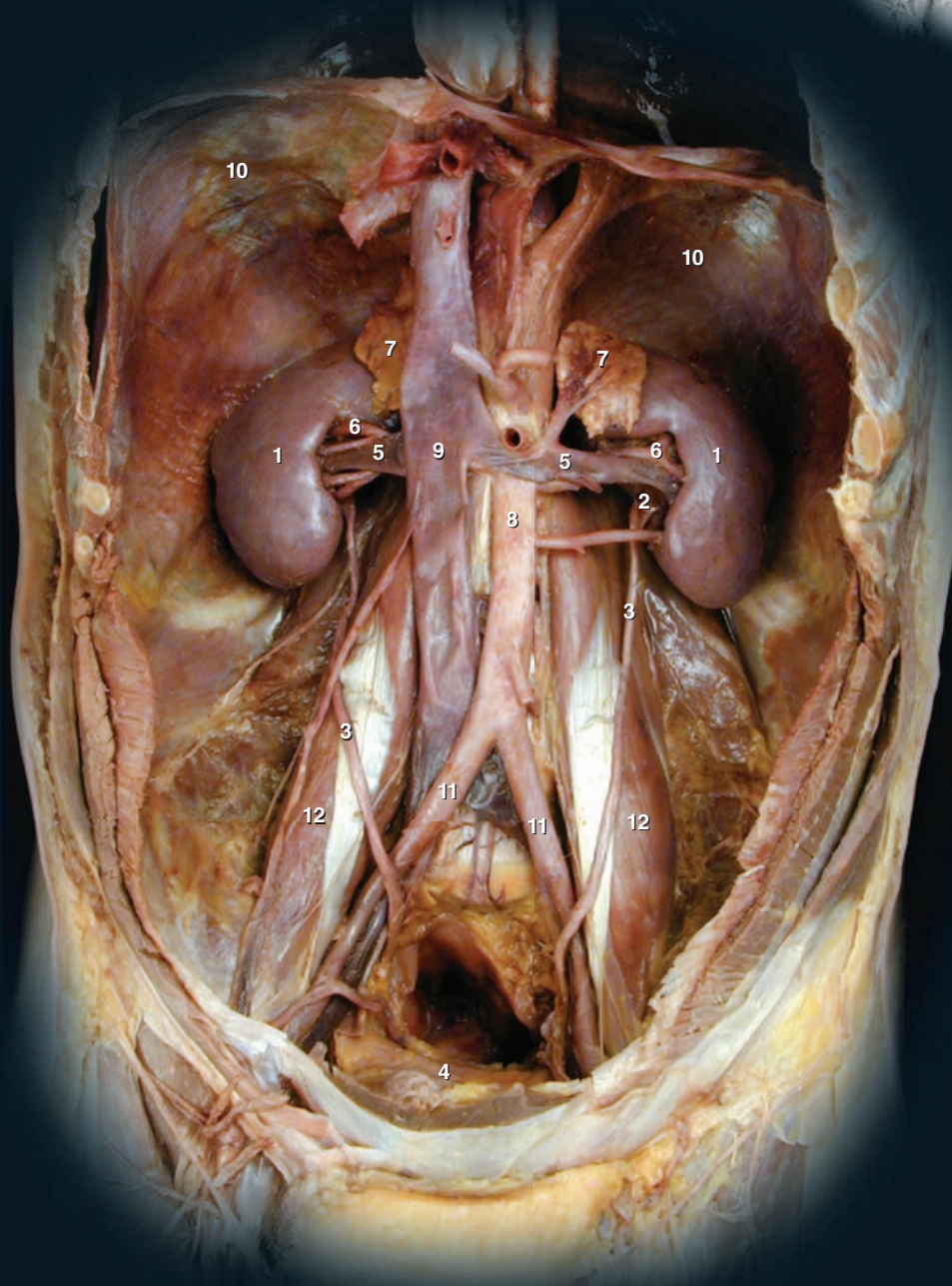
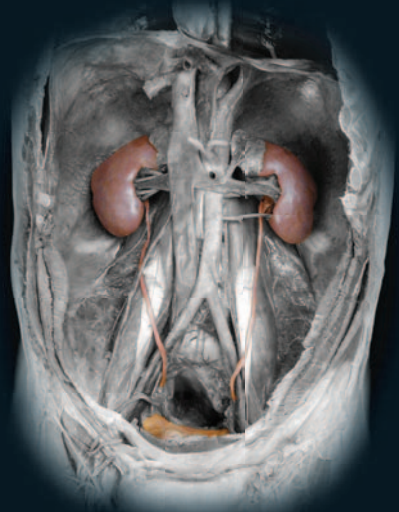
Find more information  
about the urinary  
system in

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# Urinary Organs

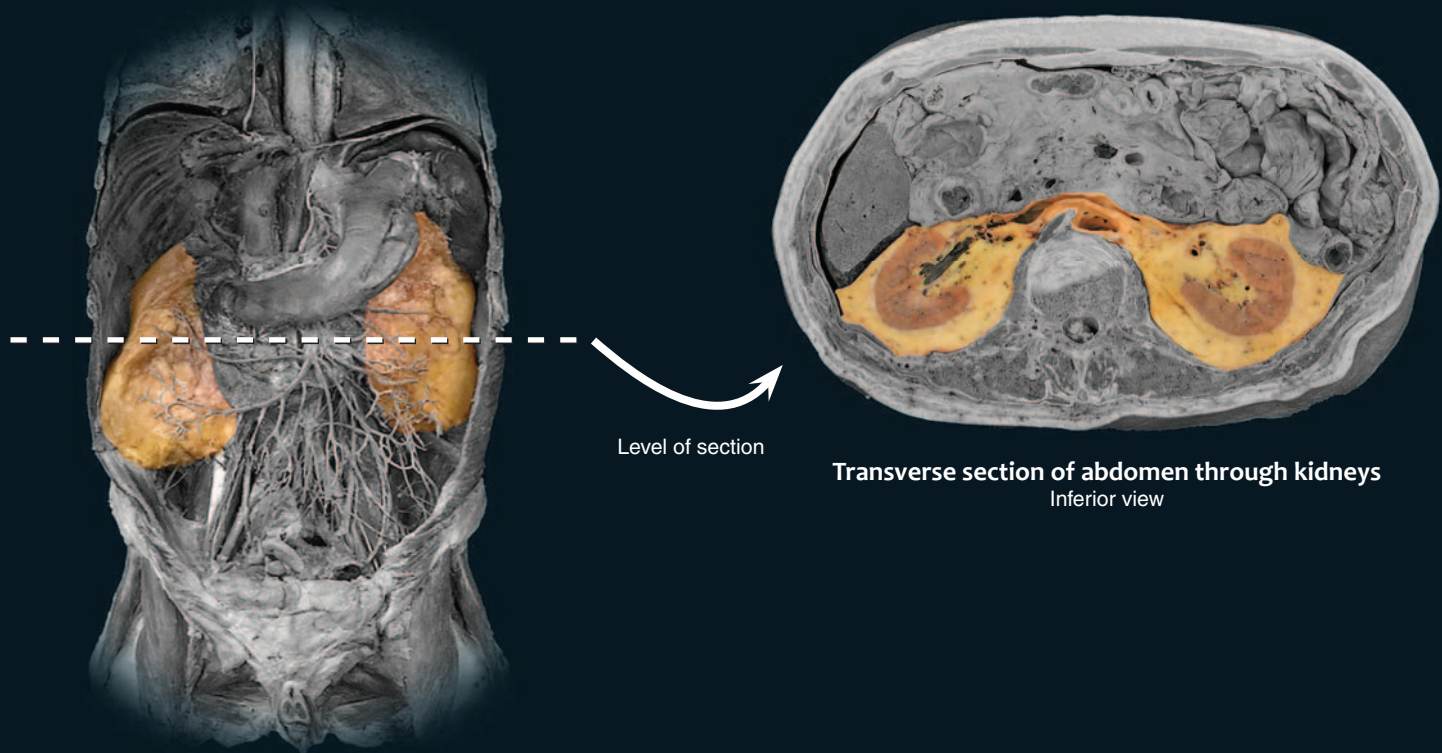
The organs of the urinary system include the paired kidneys, paired ureters, bladder, and urethra. The urinary organs occupy the retroperitoneal and subperitoneal spaces in the abdominopelvic cavity, where they are surrounded by a large amount of adipose tissue and some areolar connective tissue. The dissection images on this and the facing page depict the organs of the urinary system and their relations to other organs in the abdominopelvic cavity.

- |                |                        |                    |
|----------------|------------------------|--------------------|
| 1 Kidney       | 7 Adrenal gland        | 13 Liver           |
| 2 Renal pelvis | 8 Aorta                | 14 Lumbar vertebra |
| 3 Ureter       | 9 Inferior vena cava   | 15 Hilum           |
| 4 Bladder      | 10 Diaphragm           | 16 Perirenal fat   |
| 5 Renal vein   | 11 Common iliac artery | 17 Intestines      |
| 6 Renal artery | 12 Psoas major muscle  | 18 Mesenteric fat  |



Dissection of the retroperitoneal space of the abdominal cavity  
Anterior view





Level of section

Transverse section of abdomen through kidneys  
Inferior view

Dissection of abdomen showing perirenal fat  
Anterior view

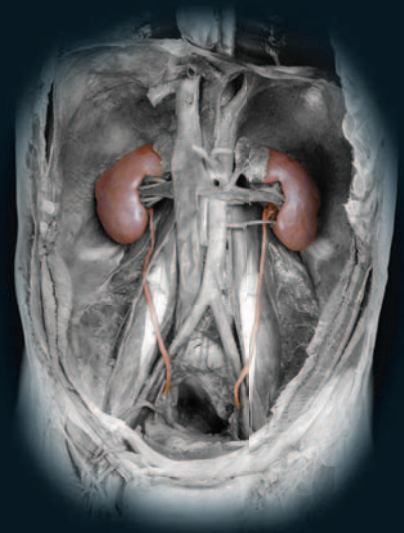


Transverse section of abdomen at level of first lumbar vertebra  
Inferior view

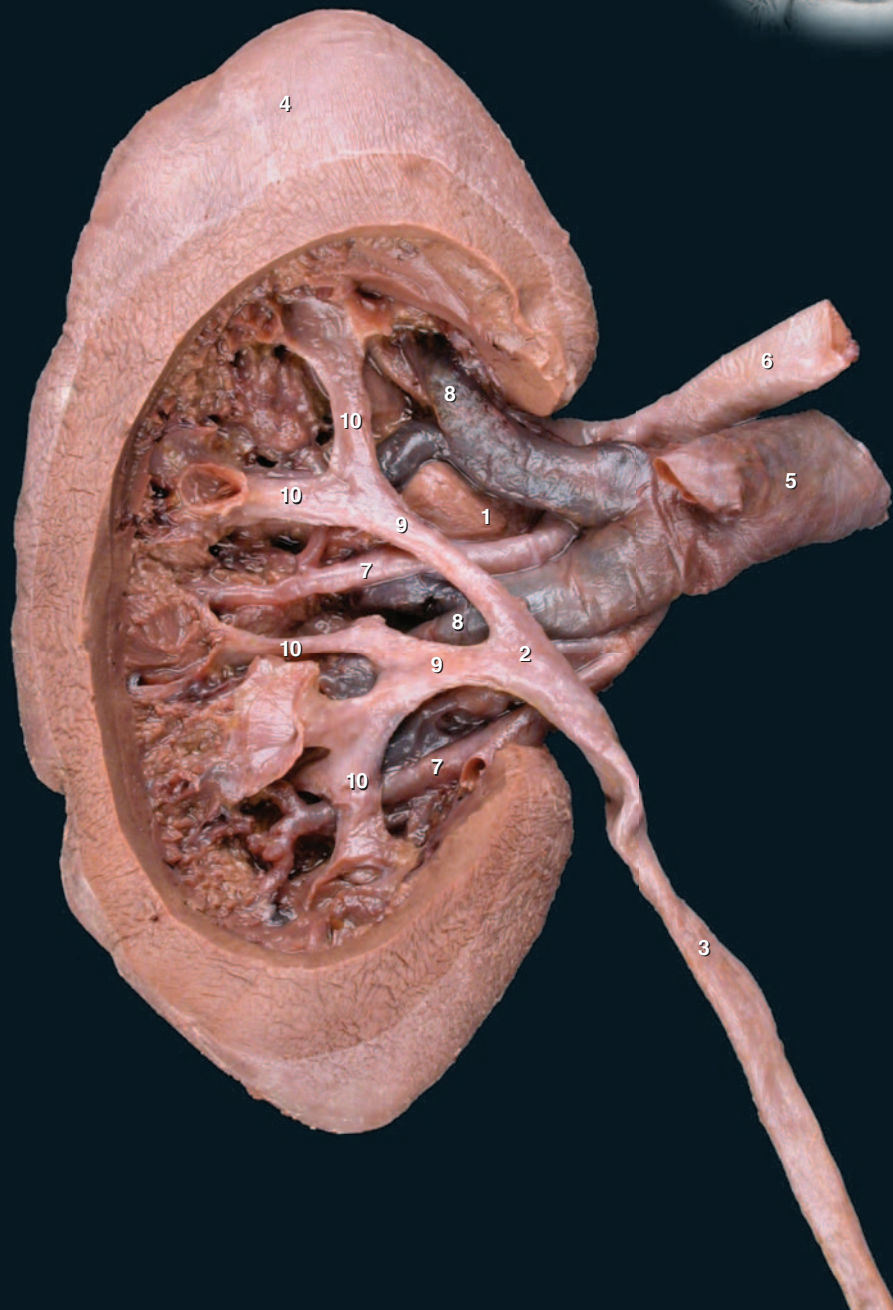
# Kidneys and Ureters

The paired kidneys are the processing organs of the urinary system that filter the blood

for the purpose of regulating the water and electrolyte balance of the tissue fluid, while removing unwanted waste products from the body. They occupy the retroperitoneal space of the abdominal cavity immediately anterior to the 12th ribs. The ureters descend from the kidneys lateral to the lumbar vertebrae, cross anterior to the psoas musculature and the common iliac vessels, and enter the pelvis to join the bladder.

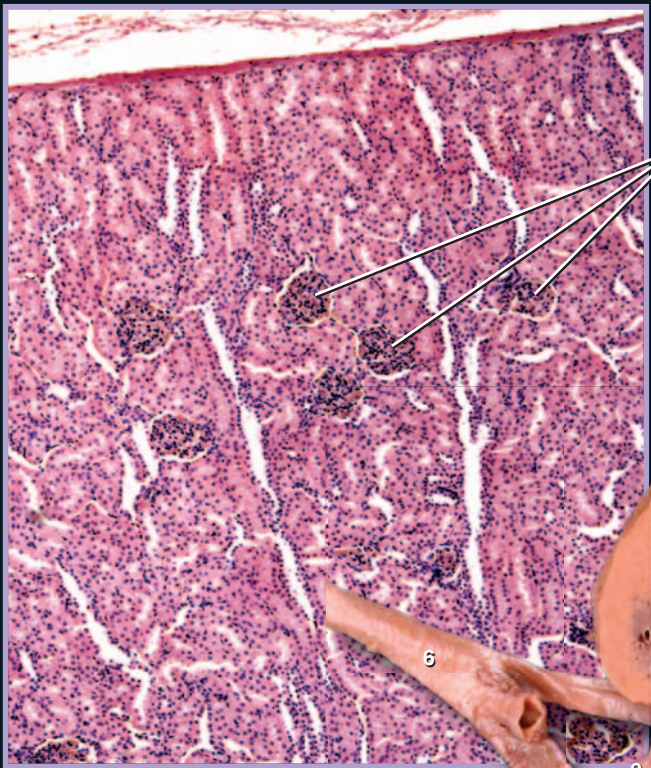


- |                 |                    |
|-----------------|--------------------|
| 1 Hilum         | 6 Renal artery     |
| 2 Renal pelvis  | 7 Segmental artery |
| 3 Ureter        | 8 Segmental vein   |
| 4 Renal capsule | 9 Major calyx      |
| 5 Renal vein    | 10 Minor calyx     |

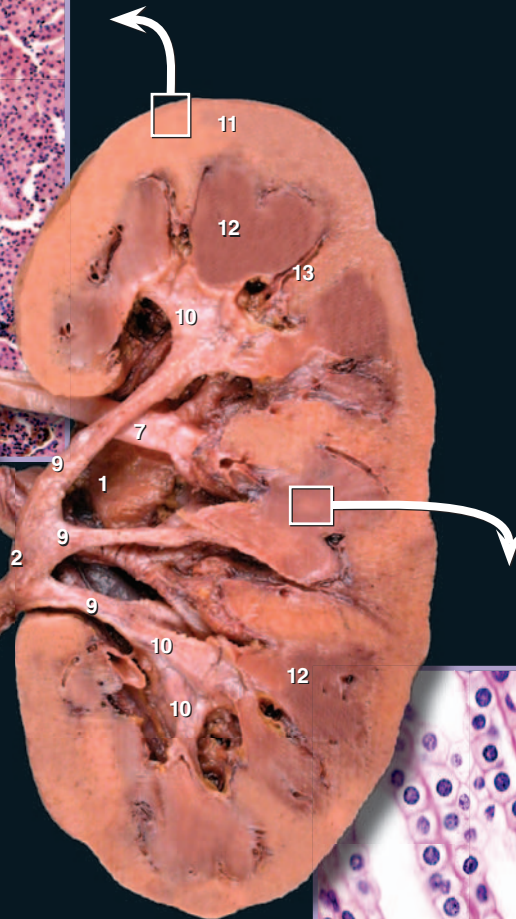


Dissection into medulla of left kidney  
Posterior view

- 11 Renal cortex
- 12 Renal pyramid
- 13 Renal column
- 14 Collecting tubule
- 15 Glomerulus surrounded by urinary tubules
- 16 Transitional epithelium of tunica mucosa
- 17 Smooth muscle of tunica muscularis
- 18 Connective tissue of tunica adventitia



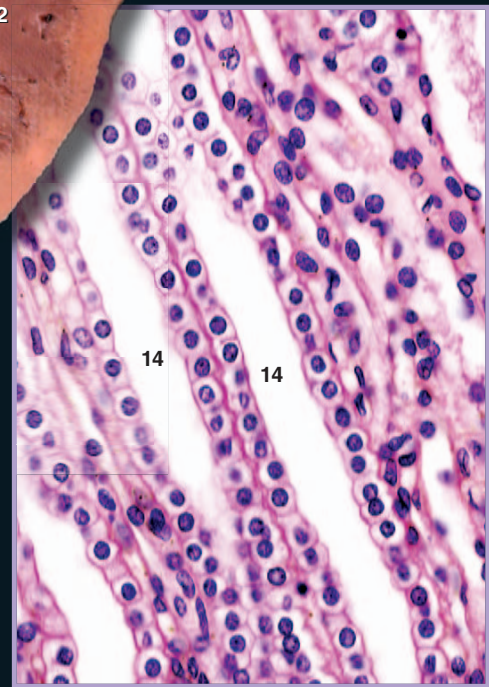
Longitudinal section of renal cortex  
50X



Frontal section of kidney  
Posterior view



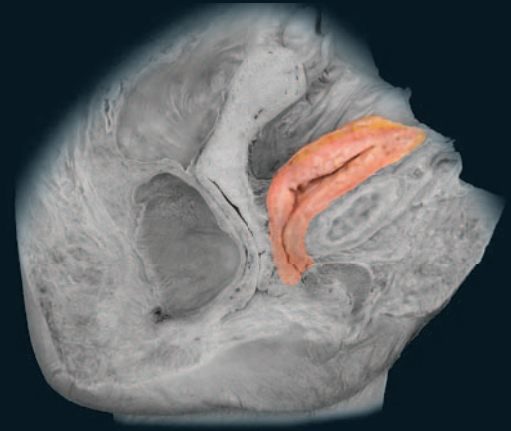
Transverse section of ureter  
200X



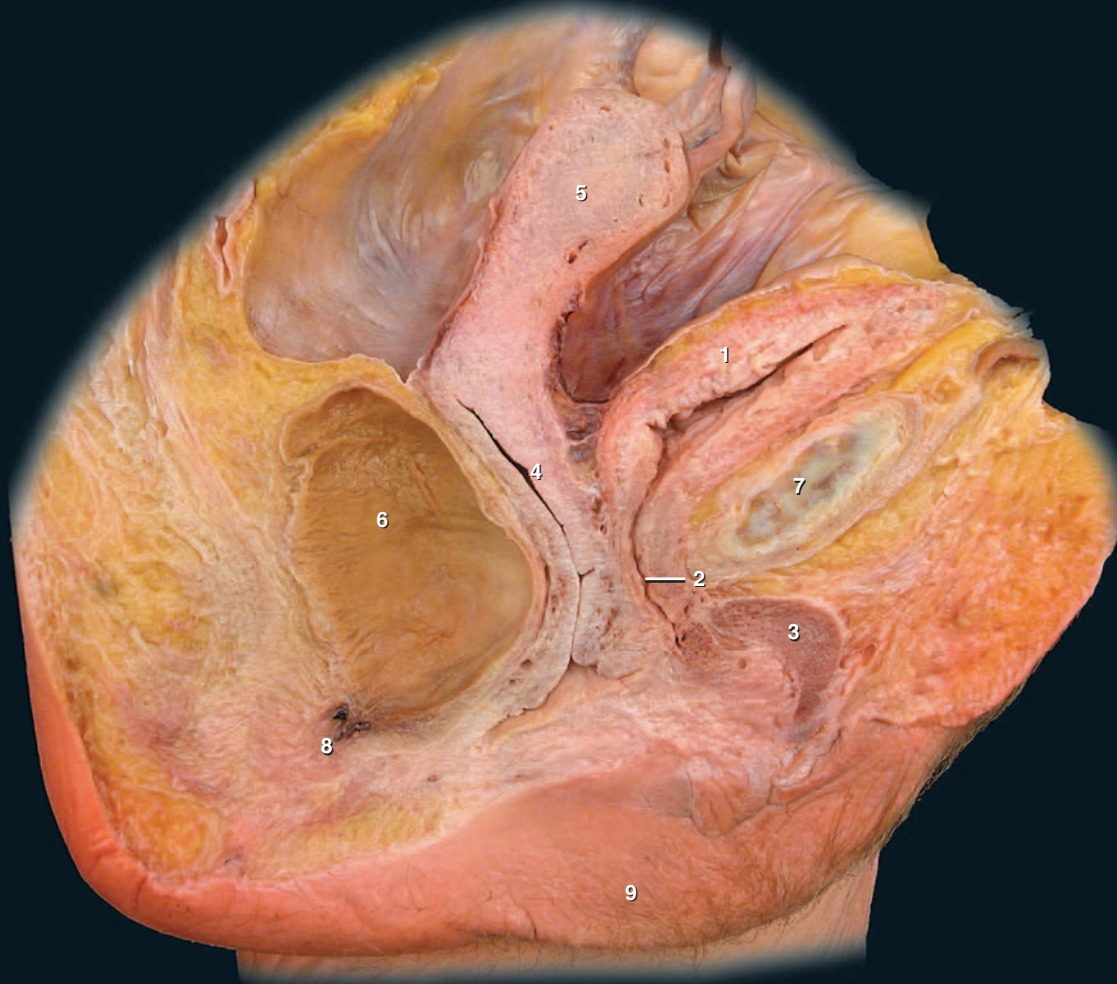
Longitudinal section of renal pyramid  
400X

# Bladder and Urethra

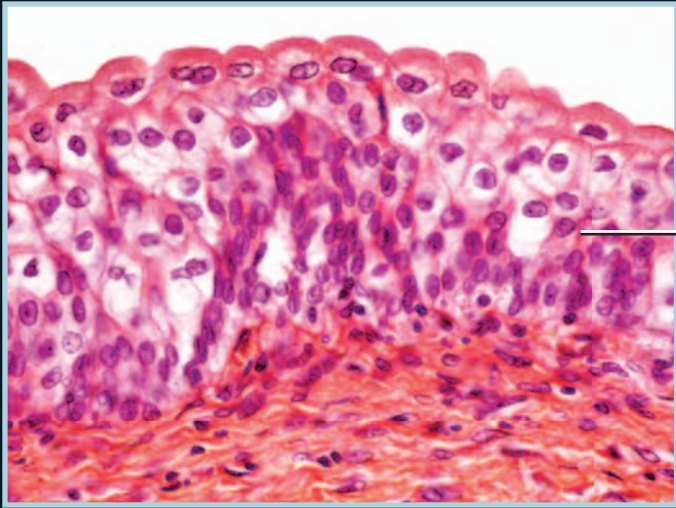
The bladder is the convenience organ of the urinary system that stores the urine, which is continually being produced by the kidneys, until it is convenient to remove it from the body. Arising from the inferior surface of the bladder is the drain for the bladder called the urethra. It is a short tube in females and a much longer tube in males. The male urethra not only transports urine, but also is the passageway for sperm as it exits during ejaculation.



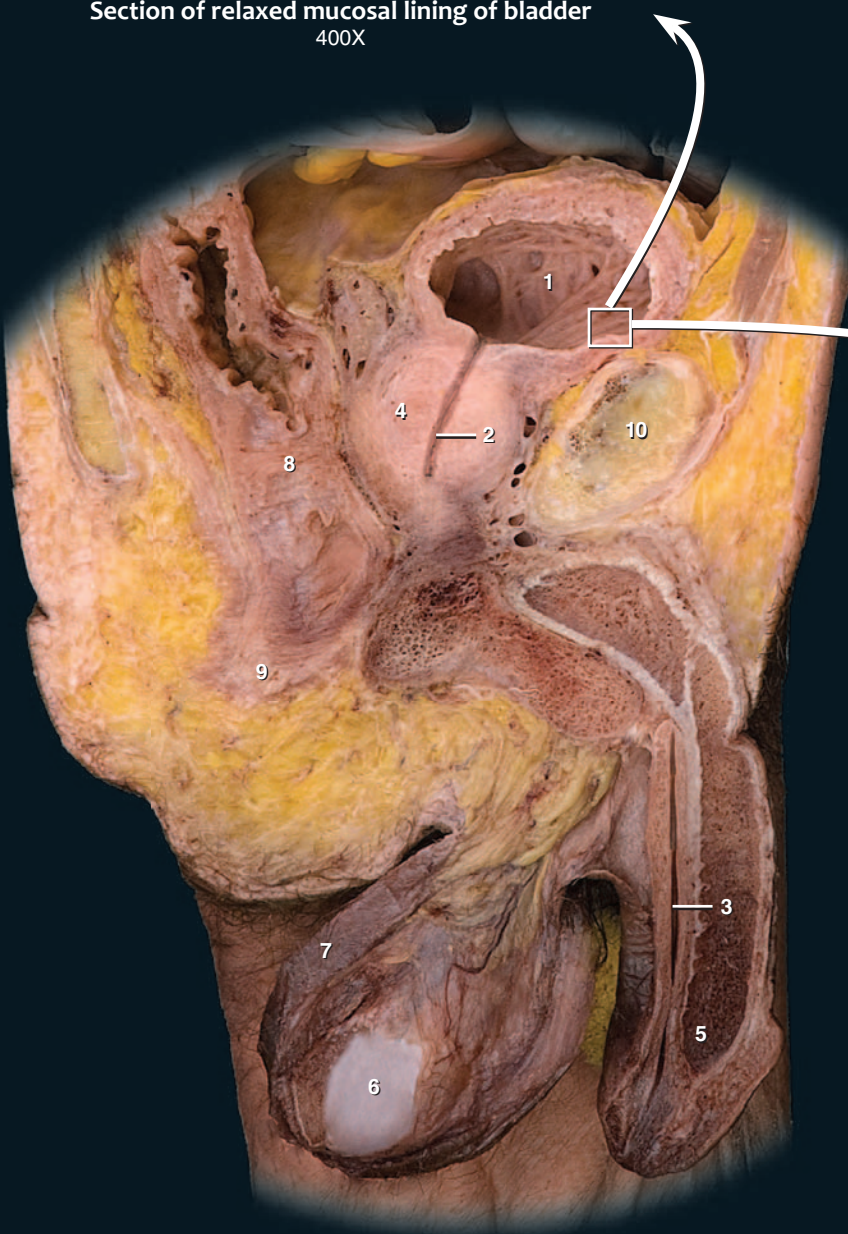
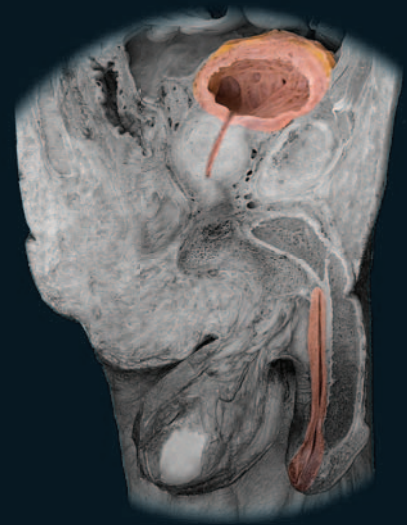
- | Female         | Male (opposite page)                        |
|----------------|---|
| 1 Bladder      | 1 Bladder                                   |
| 2 Urethra      | 2 Prostatic urethra                         |
| 3 Clitoris     | 3 Spongy urethra                            |
| 4 Vagina       | 4 Prostate                                  |
| 5 Uterus       | 5 Penis                                     |
| 6 Rectum       | 6 Testis                                    |
| 7 Pubis        | 7 Scrotum                                   |
| 8 Anus         | 8 Rectum                                    |
| 9 Labia majora | 9 Anus                                      |
|                | 10 Pubis                                    |
|                | 11 Transitional epithelium of tunica mucosa |



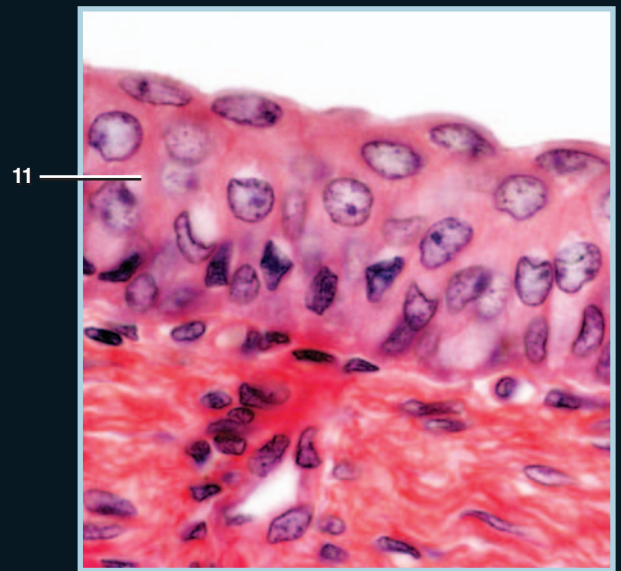
Sagittal section of female pelvis  
Medial view



Section of relaxed mucosal lining of bladder  
400X

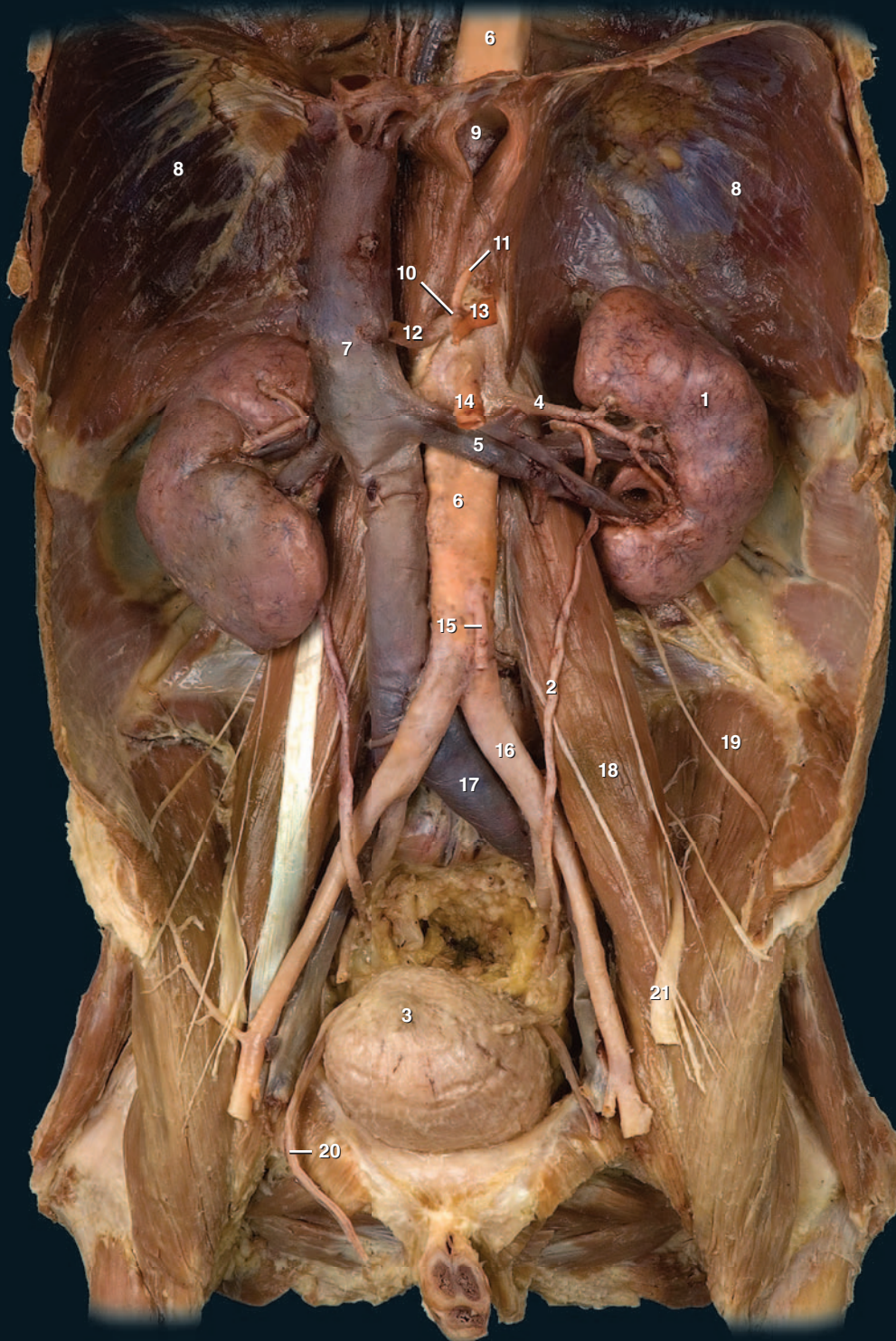


Sagittal section of male pelvis and penis  
Medial view



Section of distended mucosal lining of bladder  
640X

- |                      |                               |                               |
|----------------------|-------------------------------|-------------------------------|
| 1 Kidney             | 8 Diaphragm                   | 15 Inferior mesenteric artery |
| 2 Ureter             | 9 Esophageal hiatus           | 16 Common iliac artery        |
| 3 Bladder            | 10 Celiac artery              | 17 Common iliac vein          |
| 4 Renal artery       | 11 Left gastric artery        | 18 Psoas major muscle         |
| 5 Renal vein         | 12 Splenic artery             | 19 Iliacus muscle             |
| 6 Aorta              | 13 Common hepatic artery      | 20 Ductus deferens            |
| 7 Inferior vena cava | 14 Superior mesenteric artery | 21 Femoral nerve              |



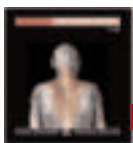
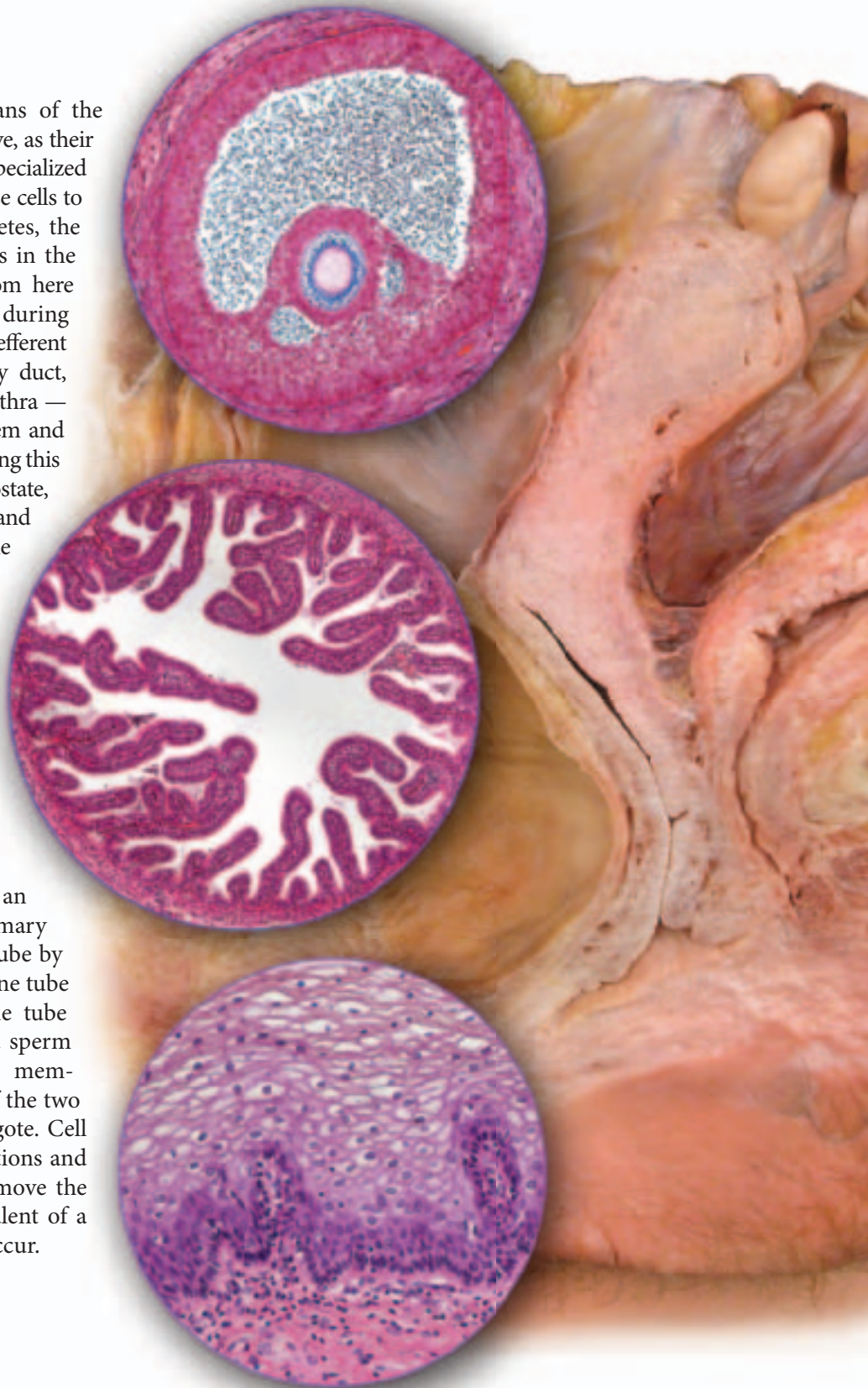
Dissection of urinary system  
Anterior view

# 20 Reproductive Systems

The organs of the male and female reproductive (genital) systems have, as their primary role, the responsibility of producing the specialized cells called gametes and making it possible for these cells to unite to form a new individual. The male gametes, the sperm, arise in the testes from meiotic divisions in the walls of the numerous seminiferous tubules. From here hundreds of millions of sperm make their way during ejaculation through a series of tubes — rete testis, efferent ductules, epididymis, ductus deferens, ejaculatory duct, prostatic urethra, intermediate urethra, spongy urethra — that move the sperm out of the male genital system and introduce them into the female genital system. During this passage secretions are added to the sperm by the prostate, seminal, and bulbourethral glands to help protect and nurture the sperm in their journey to unite with the female gamete.

The sperm are introduced by the male intermittent organ, the penis, into the female vagina, which serves the dual function of being a penile receptacle and the birth canal. Sperm deposited in the fornices of the vagina then enter the os of the uterine cervix and propel themselves to the top of the uterine cavity. Here the sperm enter the openings into the uterine tubes where they continue their journey toward the ovulated female gamete.

After rupturing the surface of the ovary in an event called ovulation, the female gamete, the primary oocyte, is swept into the ostium of the uterine tube by the fingerlike fimbriae. Ciliary action of the uterine tube mucosa carry the the oocyte down the uterine tube where the sperm and oocyte make contact. If a sperm penetrates the oocyte's surrounding cells and membranes, then fertilization occurs and the DNA of the two cells unite to form a new individual called a zygote. Cell divisions give rise to the embryo, and ciliary actions and muscular contractions in the wall of the tube move the embryo into the uterus, the mammalian equivalent of a nest, where the remainder of development will occur.

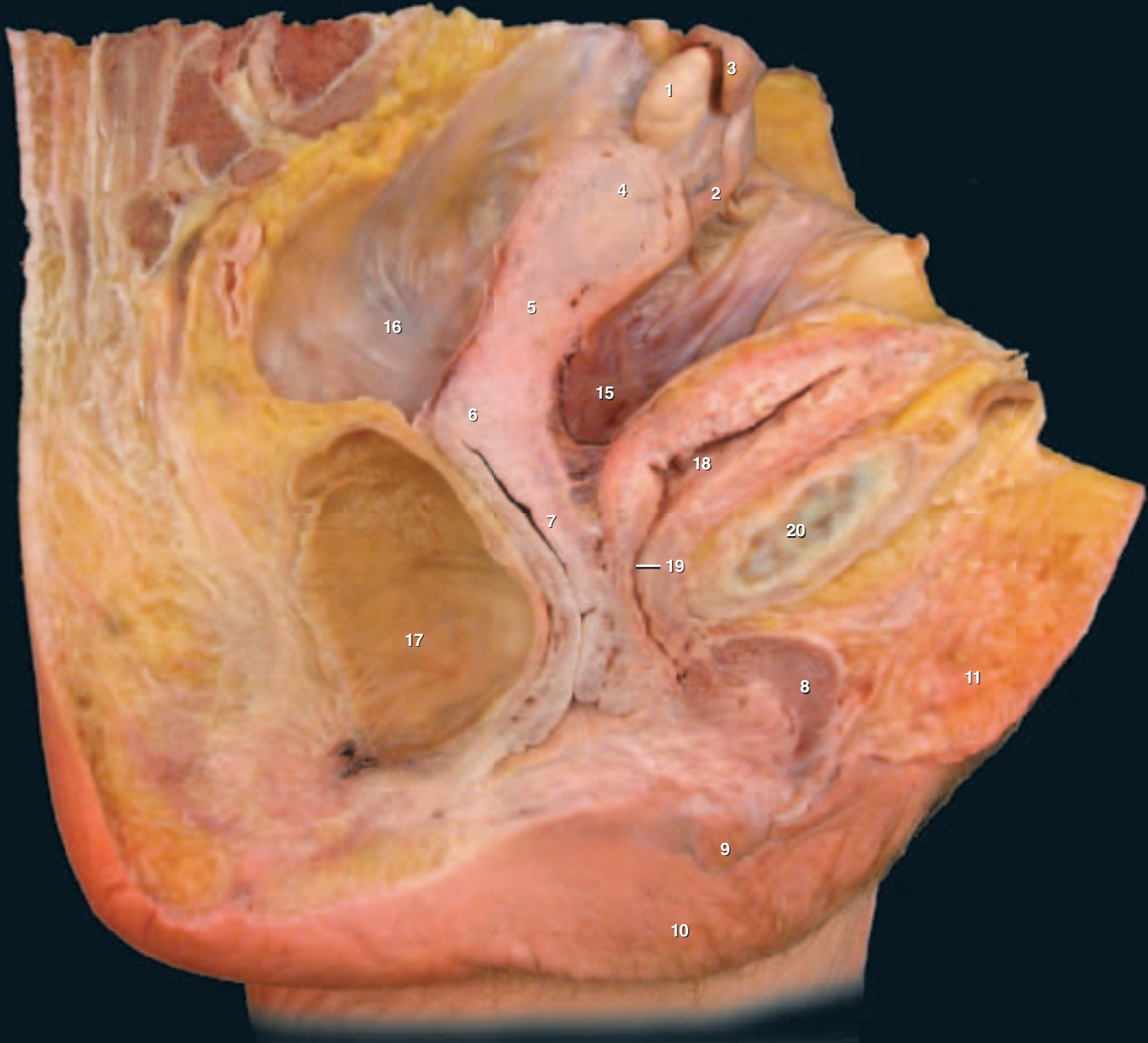
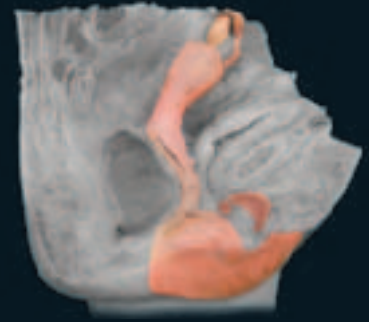


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# Female Reproductive Organs

The female genital organs consist of the internal genitalia and the external genitalia. The ovary, uterine tube, uterus, and vagina form the internal genitalia. These organs are responsible for production of the female gamete, the oocyte, and for nourishing, protecting, and delivering the new life that results from fertilization of the oocyte by the sperm. The external genitalia consist of the erectile tissues, glands, and folds of skin that protect the entry into the female internal genitalia. These organs are the clitoris, vestibular glands, and labia majora and minora.



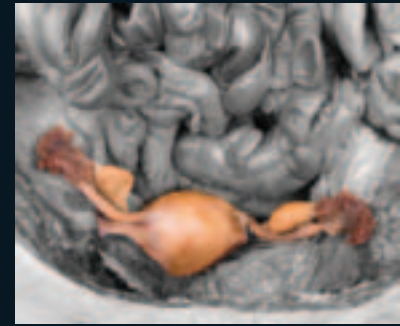
Sagittal section of female pelvis  
Medial view



- 1 Ovary
- 2 Uterine tube
- 3 Fimbriae
- 4 Fundus of uterus
- 5 Body of uterus
- 6 Cervix of uterus
- 7 Vagina
- 8 Clitoris

- 9 Labia minora
- 10 Labia majora
- 11 Mons pubis
- 12 Broad ligament
- 13 Round ligament of uterus
- 14 Ovarian ligament
- 15 Vesicouterine pouch
- 16 Rectouterine pouch

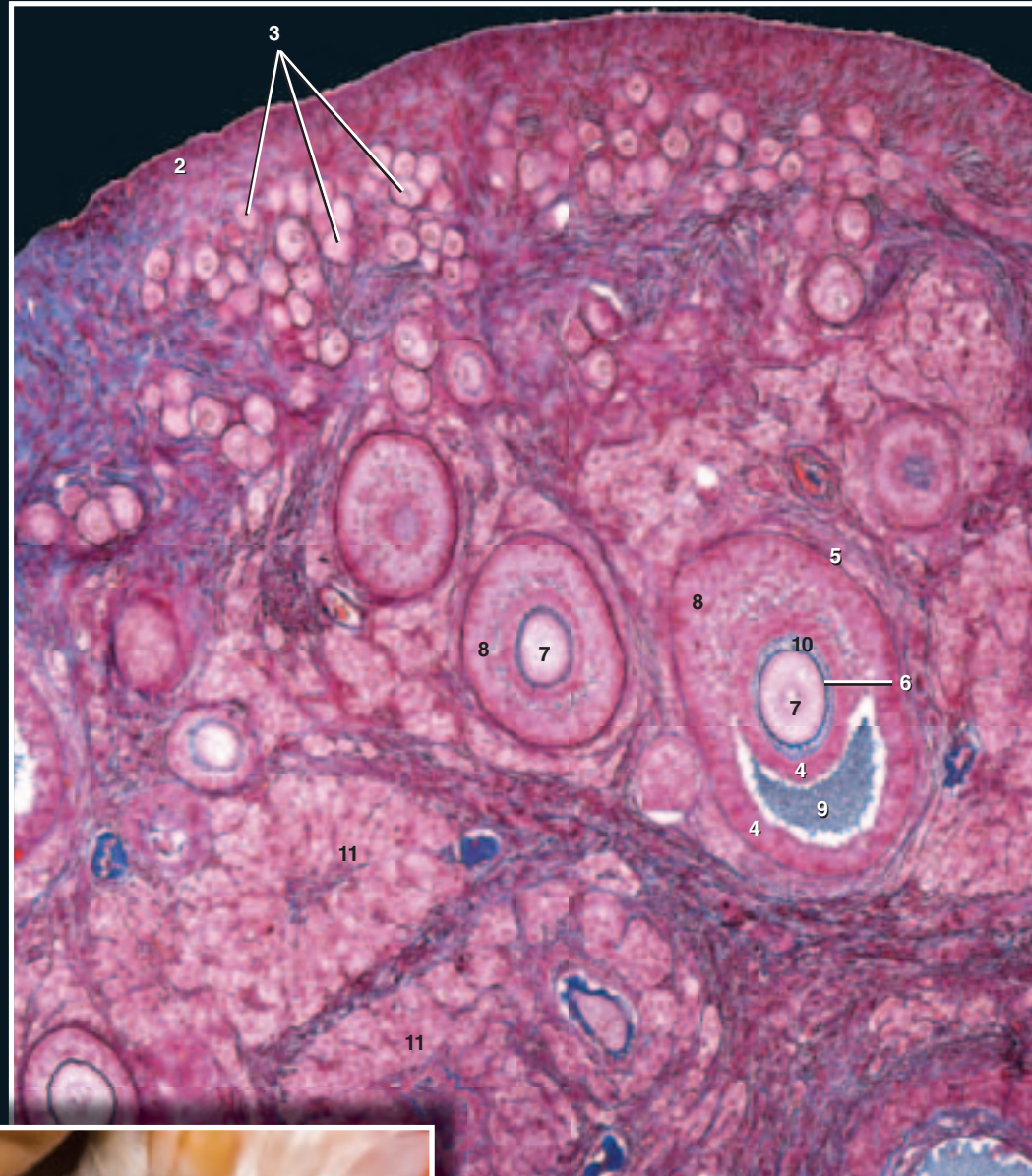
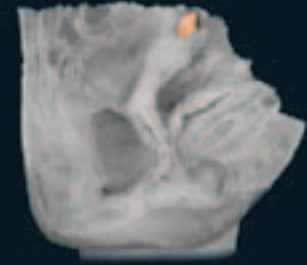
- 17 Rectum
- 18 Bladder
- 19 Urethra
- 20 Pubic symphysis
- 21 Cecum
- 22 Sigmoid colon
- 23 Ileum
- 24 Mesentery



**Dissection of female abdominopelvic cavity**  
Superoanterior view

# Ovary

The ovaries are the site of oocyte, "egg," production in the female. These solid organs are approximately the size of an unshelled almond and project into the lower abdominal cavity at the boundary of the pelvis where they are covered and supported by folds of the peritoneum. During embryonic life, millions of oogonia, potential oocytes, surrounded by nursing follicular cells begin their development. Of these millions of cells only about 500 are ever ovulated during the female's reproductive life. The follicular cells not only nurse the oocytes, but also are the endocrine cells of the ovary that produce the estrogens and progesterone.



- 1 Ovary
- 2 Tunica albuginea
- 3 Primordial follicle
- 4 Granulosa cells
- 5 Theca folliculi
- 6 Zona pellucida
- 7 Primary oocyte
- 8 Secondary follicle
- 9 Follicular antrum
- 10 Corona radiata
- 11 Corpus luteum
- 12 Infundibulum of uterine tube
- 13 Ampulla of uterine tube
- 14 Isthmus of uterine tube
- 15 Fimbriae of uterine tube
- 16 Round ligament of uterus
- 17 Ovarian ligament
- 18 Uterus

Photomicrograph of ovary  
50x



Ovary in situ  
Anterior view

# Uterus and Uterine Tubes

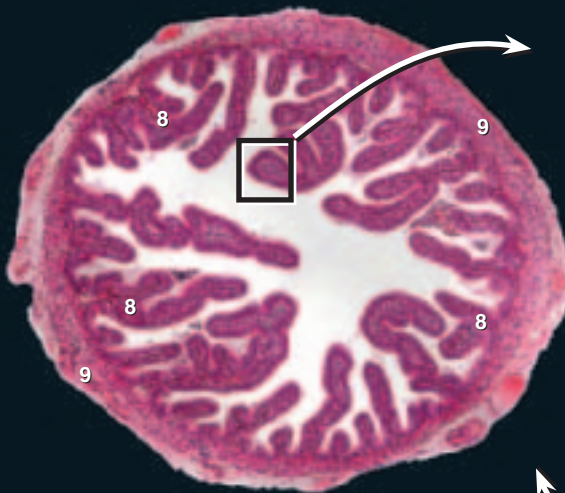
The uterine tubes, also called the oviducts or fallopian tubes, are suspended in the peritoneal fold, the broad ligament, along with the ovaries. In addition to transporting the oocyte toward the uterus, they are the site of fertilization of the oocyte by the sperm. The uterus is the thick smooth muscle organ that functions as the internal nest of mammalian animals. Note the vascular and glandular changes exhibited by the uterine endometrium as it progresses through the menstrual cycle.



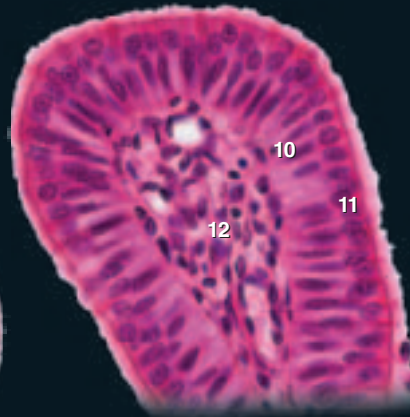
- 1 Uterine tube
- 2 Fimbriae
- 3 Mesosalpinx
- 4 Fundus of uterus
- 5 Body of uterus
- 6 Cervix of uterus
- 7 Vagina
- 8 Mucosa of uterine tube
- 9 Muscularis of uterine tube

- 10 Peg cells
  - 11 Ciliated columnar cells
  - 12 Lamina propria
  - 13 Perimetrium
- Endometrium:
- 14 Stratum functionalis
  - 15 Stratum basalis

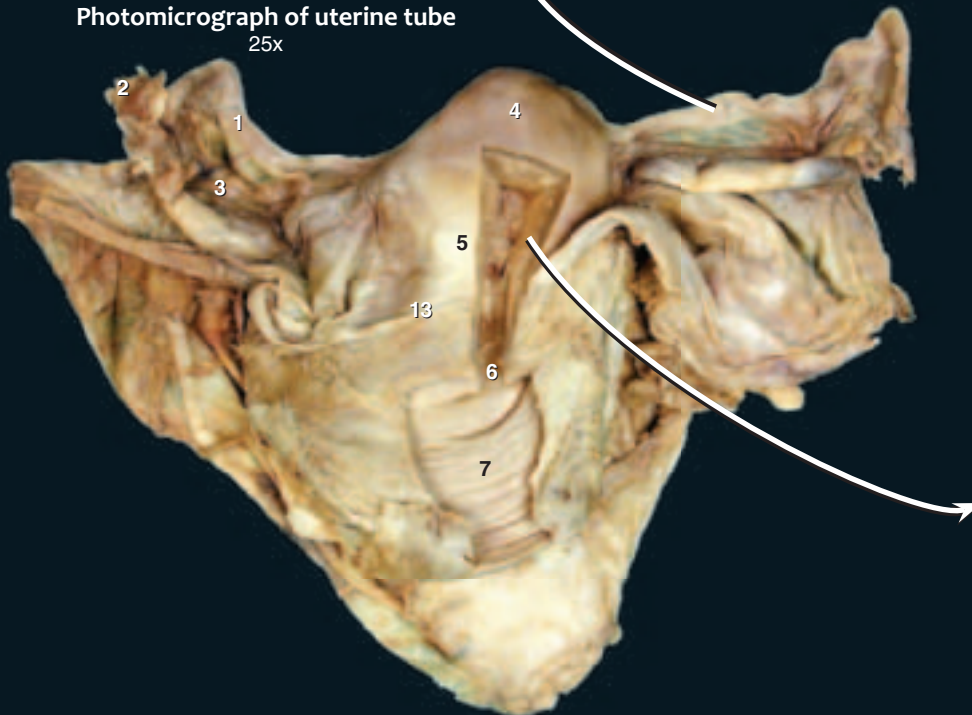
- Myometrium:
- 16 Inner longitudinal muscle
  - 17 Middle circular muscle
  - 18 Outer longitudinal muscle



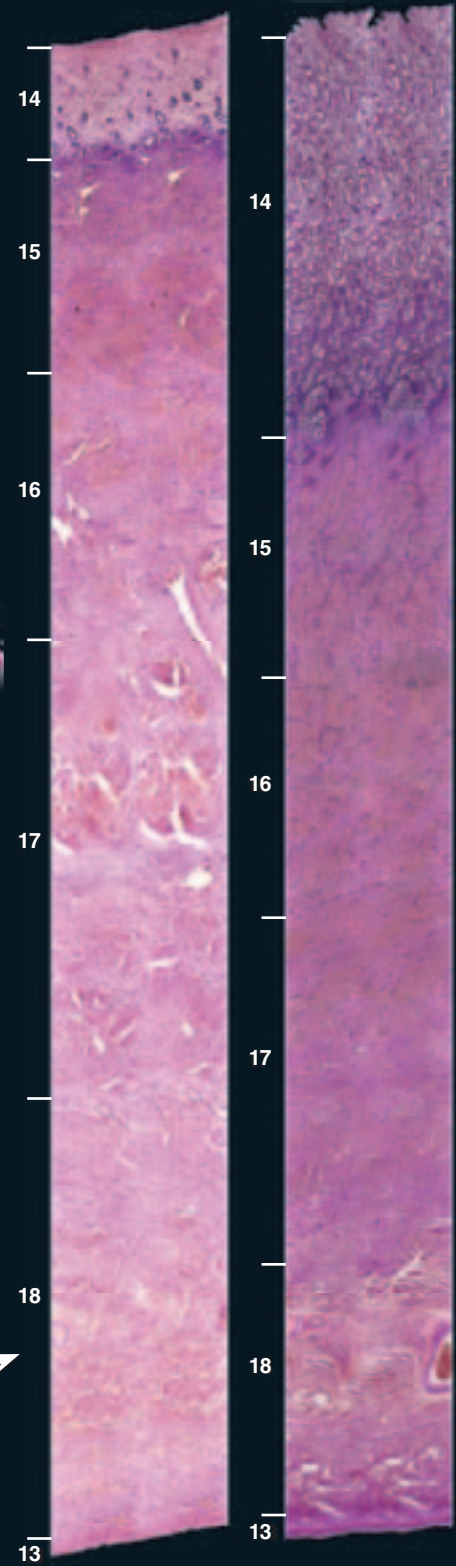
Photomicrograph of uterine tube  
25x



Photomicrograph of tunica mucosa  
of uterine tube  
400x



Female internal genitalia  
Anterior view



Photomicrograph of uterine wall,  
2nd week of menstrual cycle left,  
3rd week of menstrual cycle right  
16x (left), 20x (right)

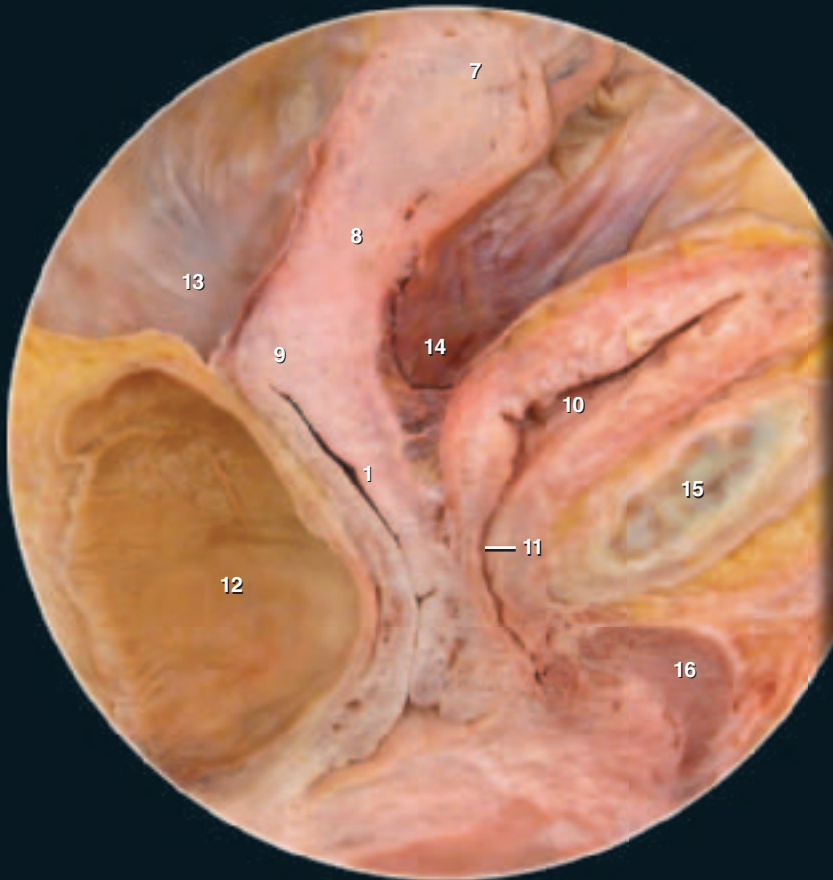
# Vagina

The vagina, from the Latin word meaning sheath, is the receptacle for the penis during sexual intercourse, the birth canal, and the outlet for the menstrual flow.

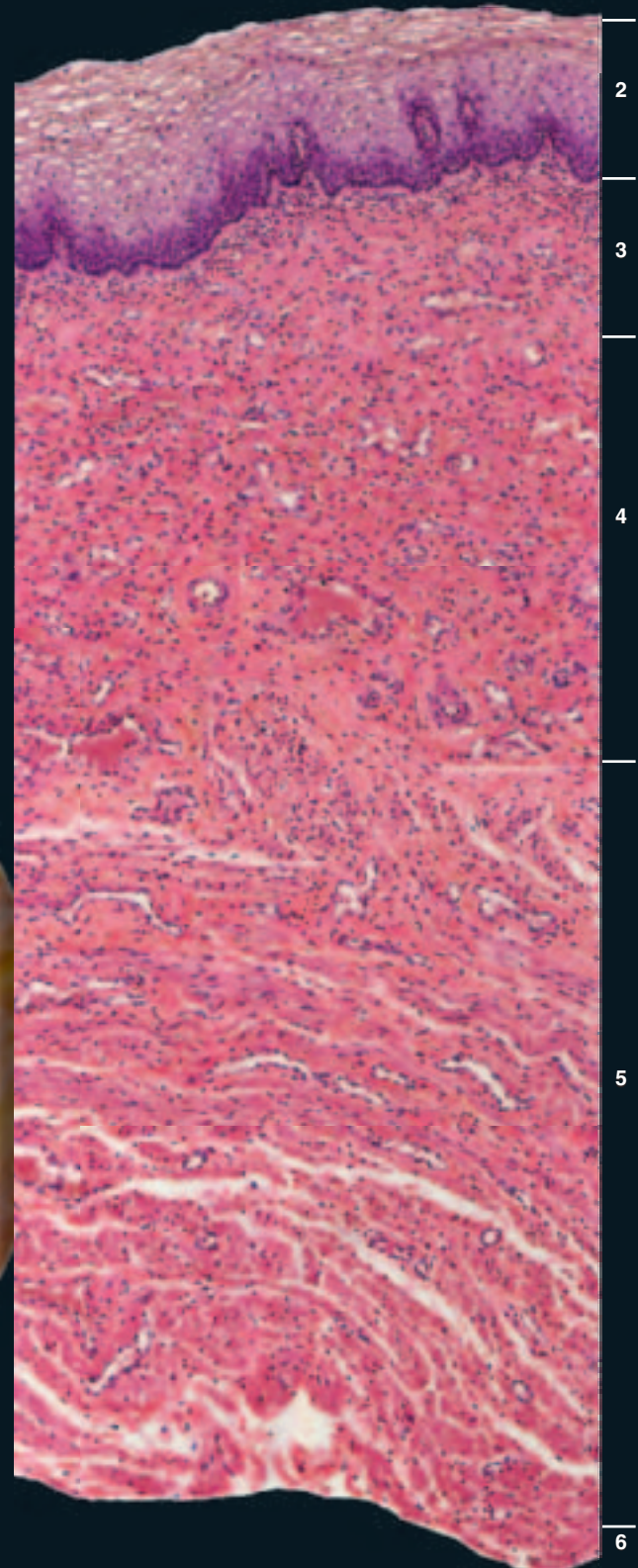
This muscular tube has a protective mucosal lining of stratified squamous epithelium. Approximately 10 cm (4 inches) in length, it expands at its superior end to form a cufflike wrapping around the cervix of the uterus. The caverns of the cufflike superior end are called the fornices, and it is in this region that the sperm are deposited during intercourse.



- 1 Vagina
- 2 Nonkeratinized stratified squamous epithelium of the mucosa
- 3 Lamina propria of the mucosa
- 4 Inner circular layer of tunica muscularis
- 5 Outer longitudinal layer of tunica muscularis
- 6 Adventitia
- 7 Fundus of uterus
- 8 Body of uterus
- 9 Cervix of uterus
- 10 Bladder
- 11 Urethra
- 12 Rectum
- 13 Rectouterine pouch
- 14 Vesicouterine pouch
- 15 Pubic symphysis
- 16 Clitoris



Sagittal section showing vagina in situ  
Medial view

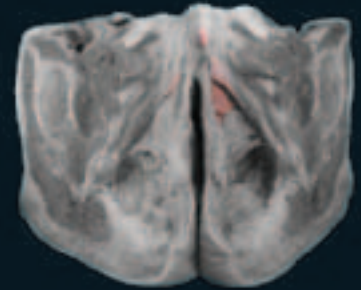


Photomicrograph of vaginal wall  
25x

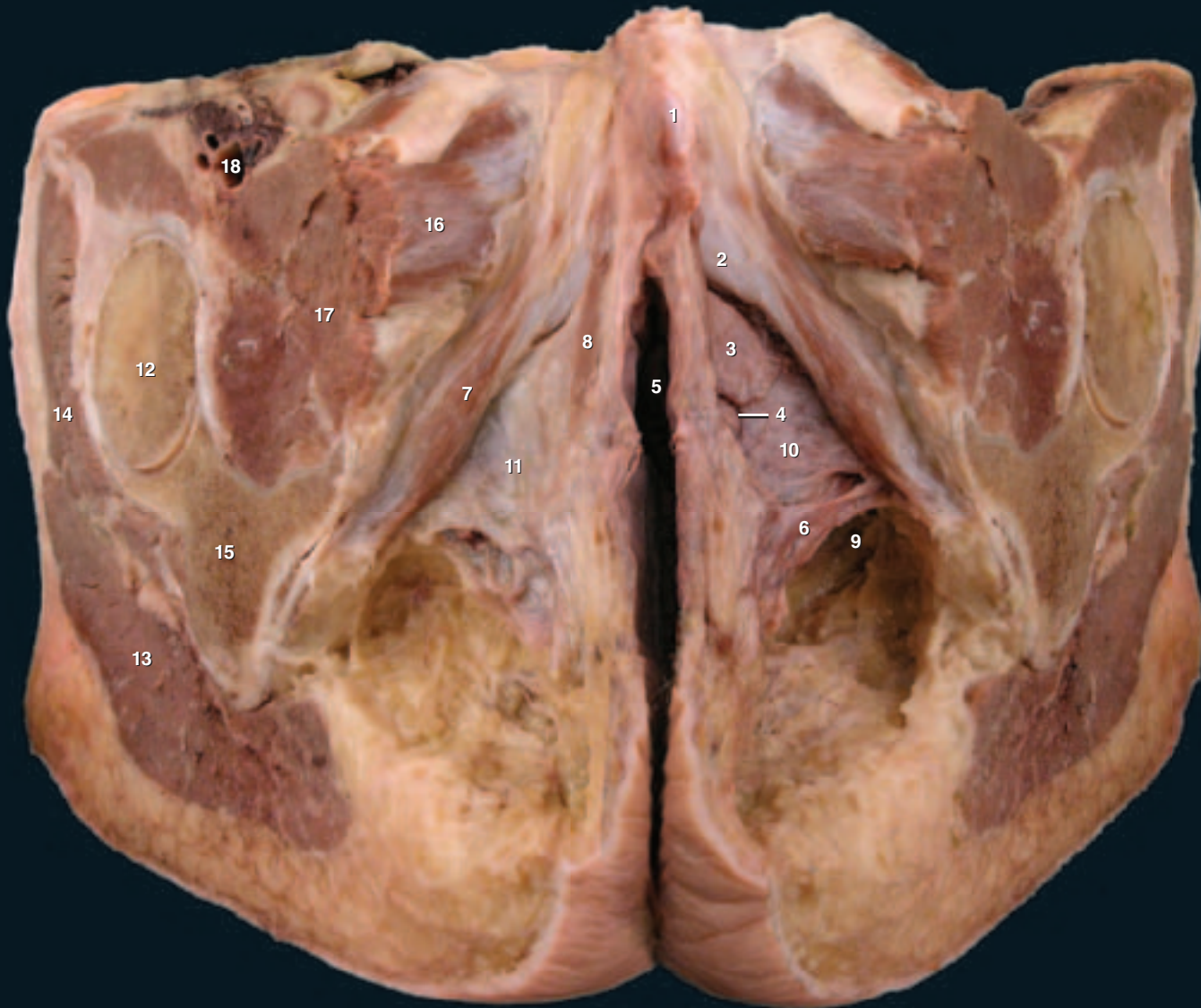
# Female External Genitalia

Surrounding the openings of the vagina and urethra in the perineum of the female are the external genital structures.

Bounding the openings on either side are the folds of skin called the labia majora and labia minora. Between these folds is the common entry way to both urethra and vagina, the vestibule. Deep to the labial skin are the erectile tissues of the female, the clitoris and bulb of the vestibule. The greater vestibular glands empty their lubricating secretions into the vestibule and opening of the vagina.



- |                                     |                           |                           |
|-------------------------------------|---------------------------|---------------------------|
| 1 Body of clitoris                  | 7 Ischiocavernosus muscle | 13 Gluteus maximus muscle |
| 2 Crura of clitoris                 | 8 Bulbospongiosus muscle  | 14 Gluteus medius muscle  |
| 3 Bulb of vestibule                 | 9 Ischioanal fossa        | 15 Ischium                |
| 4 Greater vestibular gland          | 10 Perineal membrane      | 16 Gracilis muscle        |
| 5 Vestibule                         | 11 Deep perineal fascia   | 17 Adductor muscles       |
| 6 Transverse perineal superficialis | 12 Head of femur          | 18 Femoral artery         |



Perineal dissection revealing details of external genitalia  
Inferior view

# Male Reproductive Organs

Like the female, there are both internal and external genital organs in the male.

The major difference between the sexes is the enlargement of the erectile tissue organs of the male and the descent of the gonads, the testes, from an internal position to a suspended position outside the body cavity. The male genital organs include the testes suspended in the scrotum. The testes consist of an extensive tubular system that gives rise to the sperm, which then pass through the tubular ducts of egress — the rete testis, epididymis, ductus deferens, ejaculatory duct, and urethra — to exit from the male body. Accessory glands of the male join the ducts of egress and add secretions to the sperm, and the erectile intromittant organ, the penis, introduces the sperm into the female system.



- 1 Scrotum
- 2 Testis
- 3 Glans penis
- 4 Corpus cavernosum penis
- 5 Corpus spongiosum penis
- 6 Bulb of penis
- 7 Spongy urethra
- 8 Crus of penis
- 9 Bulbourethral gland
- 10 Prostate gland
- 11 Seminal vesicle
- 12 Bladder
- 13 Pubic symphysis
- 14 Rectus abdominis
- 15 Rectum
- 16 Sigmoid colon
- 17 Small intestine
- 18 Sacrum



Parasagittal section of male pelvis  
Medial view

# Testis and Epididymis

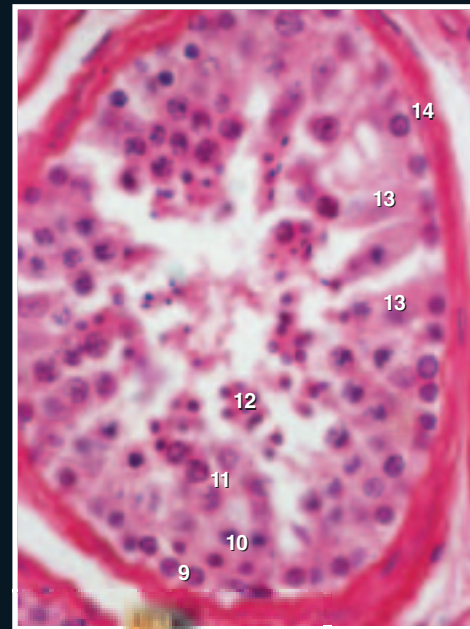
The testes are the site of sperm production in the male. Unlike the solid, cellular ovaries, the testes are collections of small, highly coiled tubes, the seminiferous tubules. Beginning at puberty the spermatogonia, sperm stem cells, in the walls of the seminiferous tubules begin meiosis and produce hundreds of millions of sperm cells daily. From the testis the sperm are moved into the epididymis where they are stored and reach maturity prior to passing into the ductus deferens.



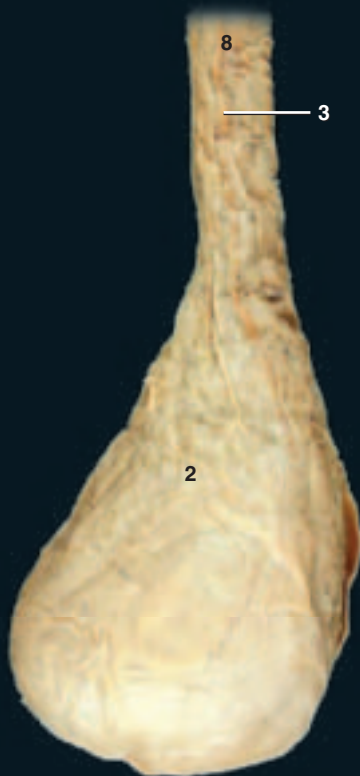
- |                              |                           |                                   |
|------------------------------|---------------------------|-----------------------------------|
| 1 Coelom of testis           | 7 Rete testis             | 13 Sertoli cell                   |
| 2 External spermatic fascia  | 8 Spermatic cord          | 14 Basement membrane              |
| 3 Cremaster muscle           | 9 Spermatogonium          | 15 Interstitial cells (of Leydig) |
| 4 Tunica albuginea of testis | 10 Primary spermatocyte   | 16 Sperm in lumen of epididymis   |
| 5 Epididymis                 | 11 Secondary spermatocyte | 17 Mucosa of epididymis           |
| 6 Seminiferous tubules       | 12 Spermatid              | 18 Stereocilia                    |



Photomicrograph of epididymis  
200x



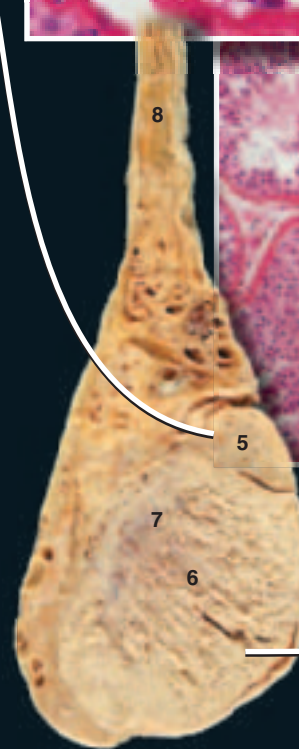
Photomicrograph of seminiferous tubules  
40x, callout 160x



Testis and spermatic cord with fascial coverings  
Medial view



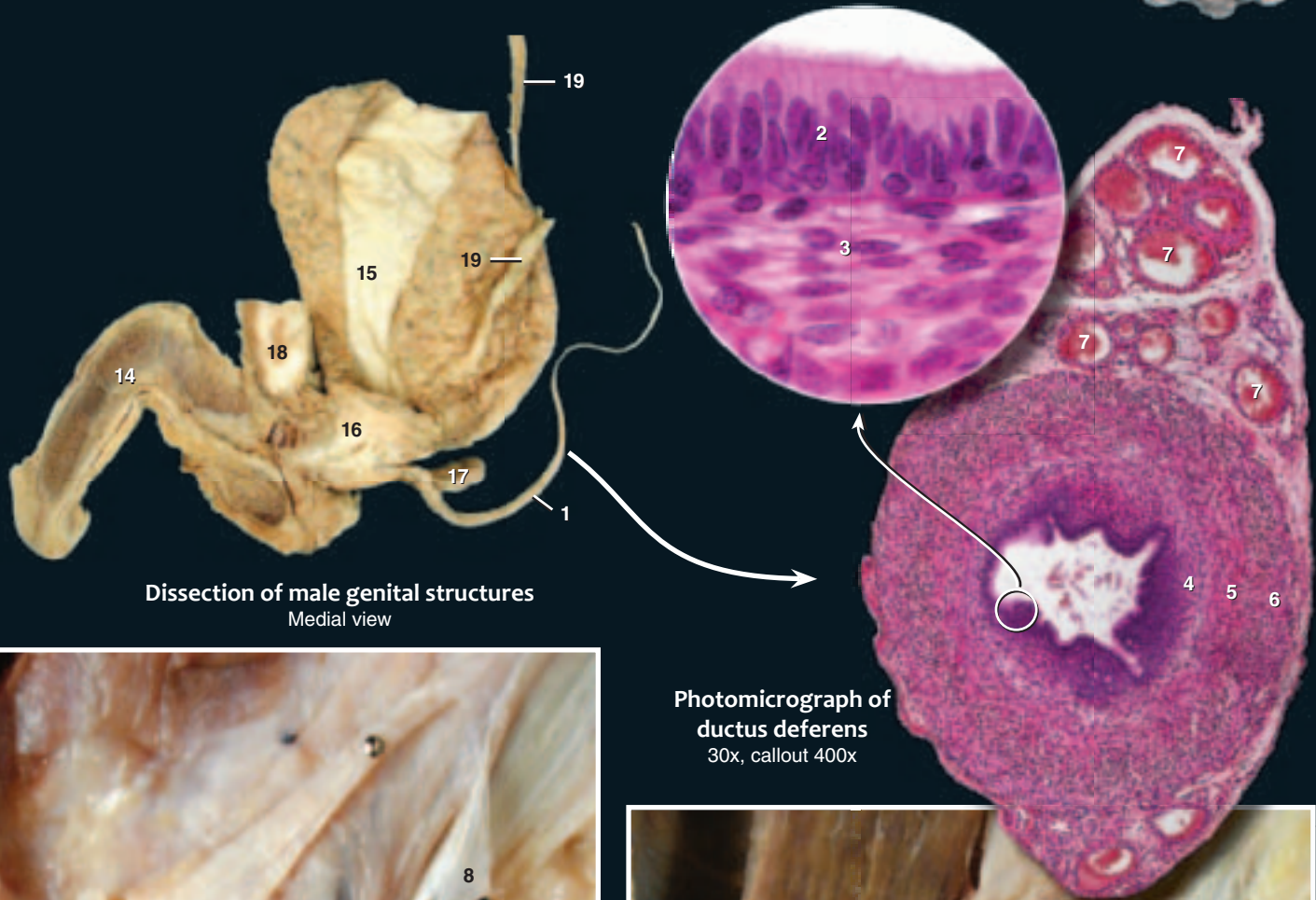
Testis and spermatic cord with fascia removed  
Medial view



Sagittal section of testis and spermatic cord  
Medial view

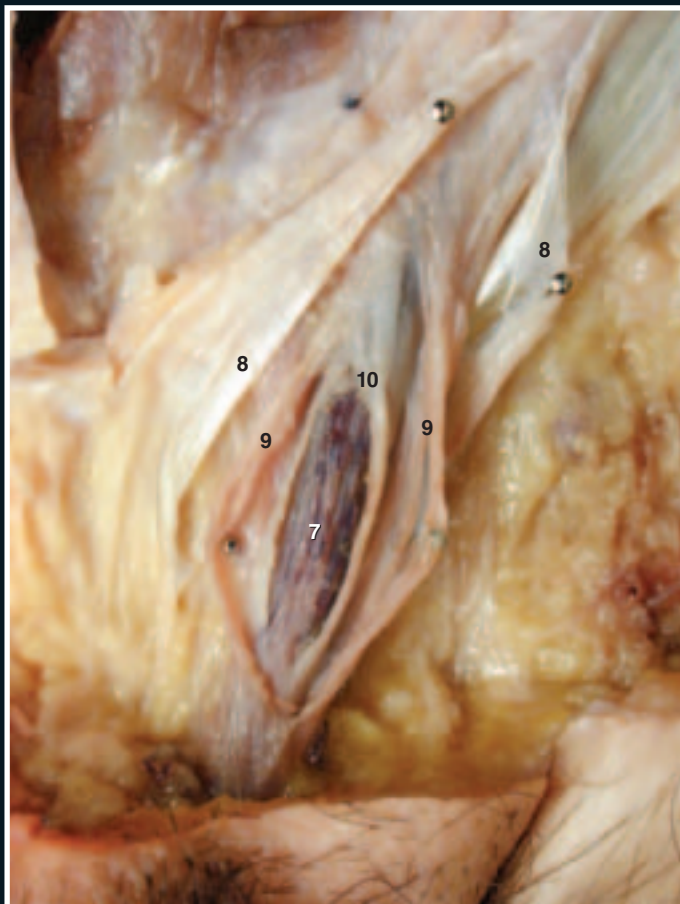
# Ductus Deferens and Spermatic Cord

The ductus (vas) deferens is the muscular tube that transports sperm from the epididymis to the ejaculatory duct within the prostate gland. Peristaltic muscle contractions in the tube move the sperm. The ductus deferens accompanies the testicular vessels and nerves within a wrapping of fascia and muscle, called the spermatic cord. The cord extends from the testis to the superficial inguinal ring in the abdominal wall.

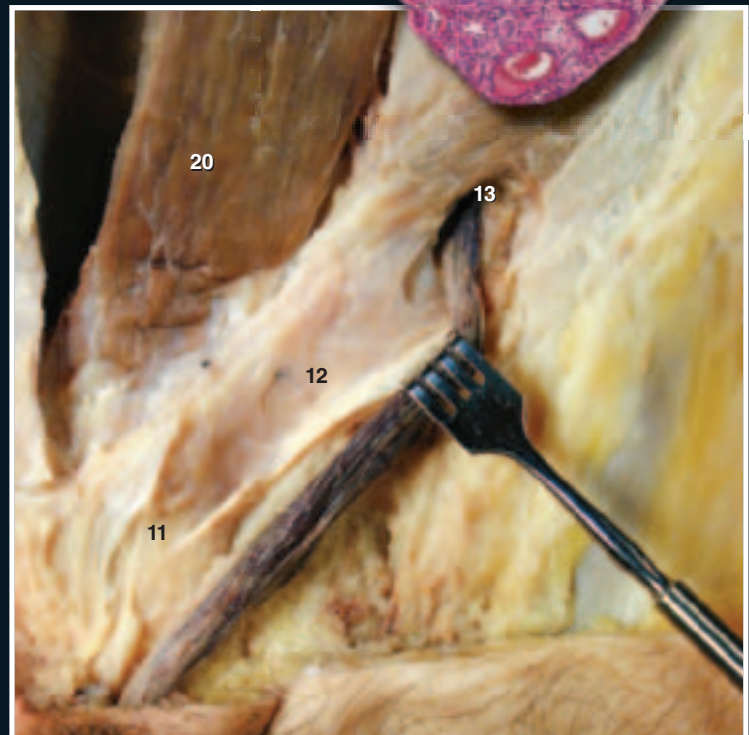


Dissection of male genital structures  
Medial view

Photomicrograph of  
ductus deferens  
30x, callout 400x



Dissection of spermatic cord exiting superficial inguinal ring  
Anterior view



Dissection of inguinal canal and spermatic cord  
Anterior view



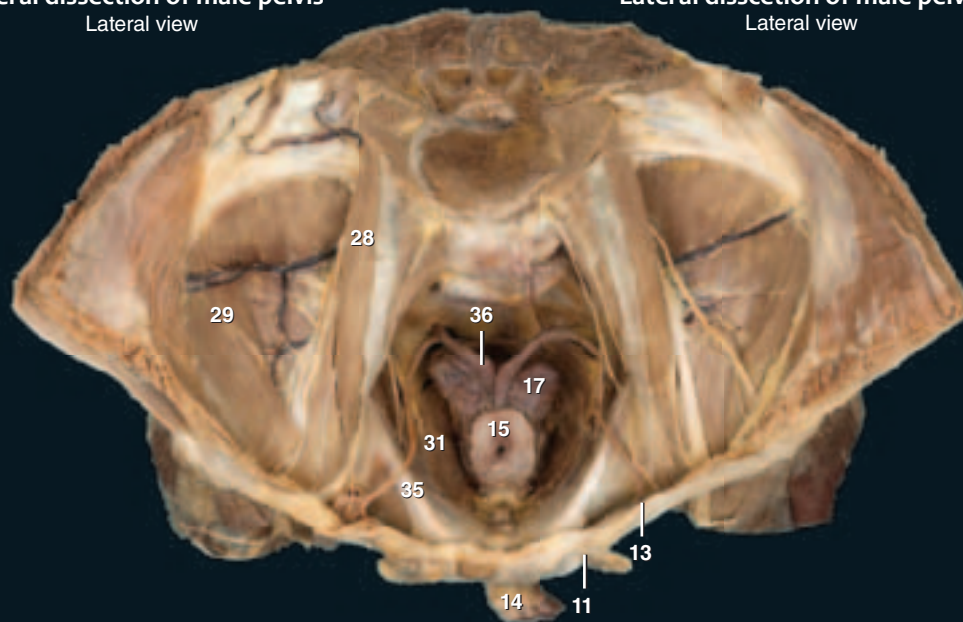
- |  |                              |                                  |                                  |
|--|------------------------------|----------------------------------|----------------------------------|
| 1 Ductus deferens                      | 10 Internal spermatic fascia | 19 Ureter                        | 28 Psoas major muscle            |
| 2 Pseudostratified columnar epithelium | 11 Superficial inguinal ring | 20 Rectus abdominis              | 29 Iliacus muscle                |
| 3 Lamina propria                       | 12 Inguinal canal            | 21 Superior ramus of pubis (cut) | 30 Sacrum                        |
| 4 Inner longitudinal muscle layer      | 13 Deep inguinal ring        | 22 Inferior ramus of pubis (cut) | 31 Levator ani muscle            |
| 5 Middle circular muscle layer         | 14 Penis                     | 23 Body of pubis (cut)           | 32 Sciatic nerve                 |
| 6 Outer longitudinal muscle layer      | 15 Bladder                   | 24 Pudendal nerve and vessels    | 33 Testis                        |
| 7 Testicular blood vessels             | 16 Prostate gland            | 25 Rectum (enlarged)             | 34 Obturator internus muscle     |
| 8 External spermatic fascia            | 17 Seminal vesicle           | 26 Internal iliac artery         | 35 Tendinous arch of levator ani |
| 9 Cremaster fascia                     | 18 Pubic symphysis           | 27 External iliac artery (cut)   | 36 Ampulla of ductus deferens    |



**Lateral dissection of male pelvis**  
Lateral view



**Lateral dissection of male pelvis**  
Lateral view



**Dissection of male pelvic cavity**  
Superior view, bladder removed

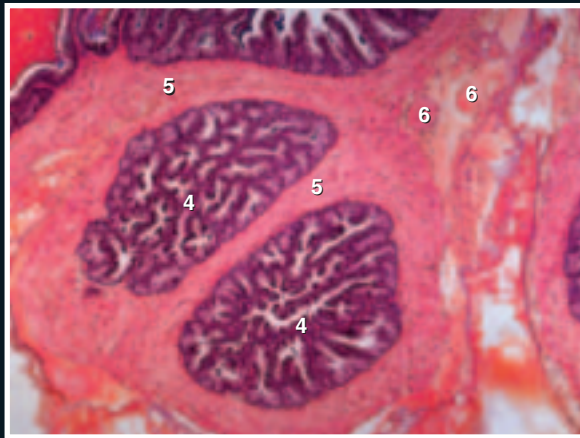
# Male Accessory Glands

Associated with the male ducts of egress are three glands, often referred to as the accessory sex glands



of the male. The three named glands are the paired seminal glands (vesicles), the unpaired prostate gland, and the paired bulbourethral glands. They arise as epithelial outgrowths of terminal end of the male ducts of egress at the base of the bladder. They produce secretions that protect and nourish the sperm.

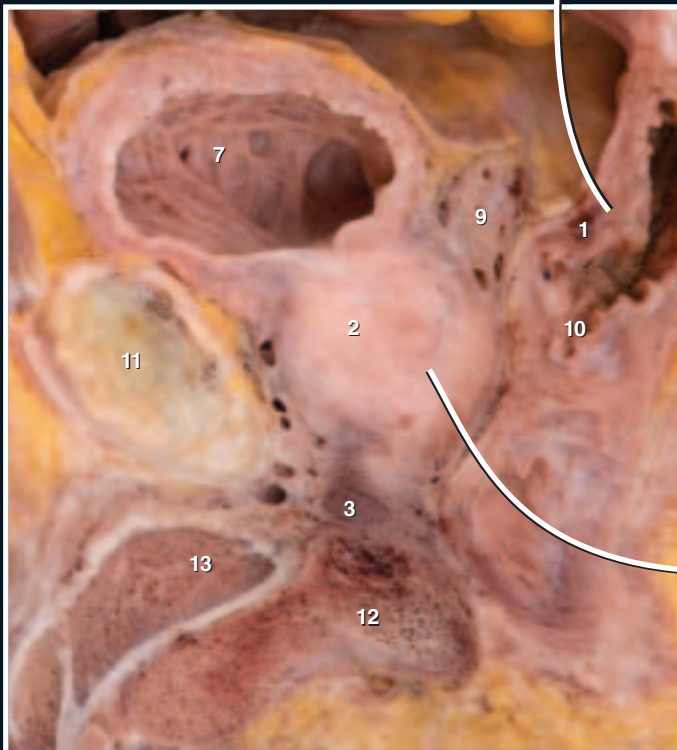
- |                        |                              |                                    |
|------------------------|------------------------------|------------------------------------|
| 1 Seminal vesicle      | 7 Bladder                    | 13 Crus of penis                   |
| 2 Prostate gland       | 8 Ductus deferens            | 14 Ilium                           |
| 3 Bulbourethral gland  | 9 Ampulla of ductus deferens | 15 Ischial tuberosity              |
| 4 Secretory epithelium | 10 Rectum                    | 16 Obturator internus muscle       |
| 5 Trabecula            | 11 Pubic symphysis           | 17 Levator ani muscle              |
| 6 Blood vessel         | 12 Bulb of penis             | 18 Deep transverse perineal muscle |



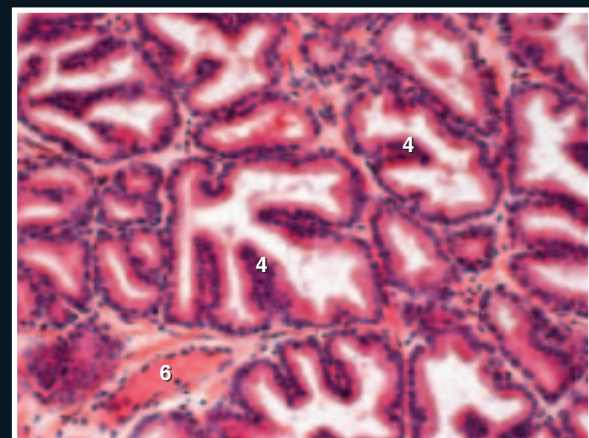
Photomicrograph of seminal vesicle  
50x



Dissection of pelvic region  
Posterior view



Parasagittal section revealing prostate  
and bulbourethral glands  
Medial view



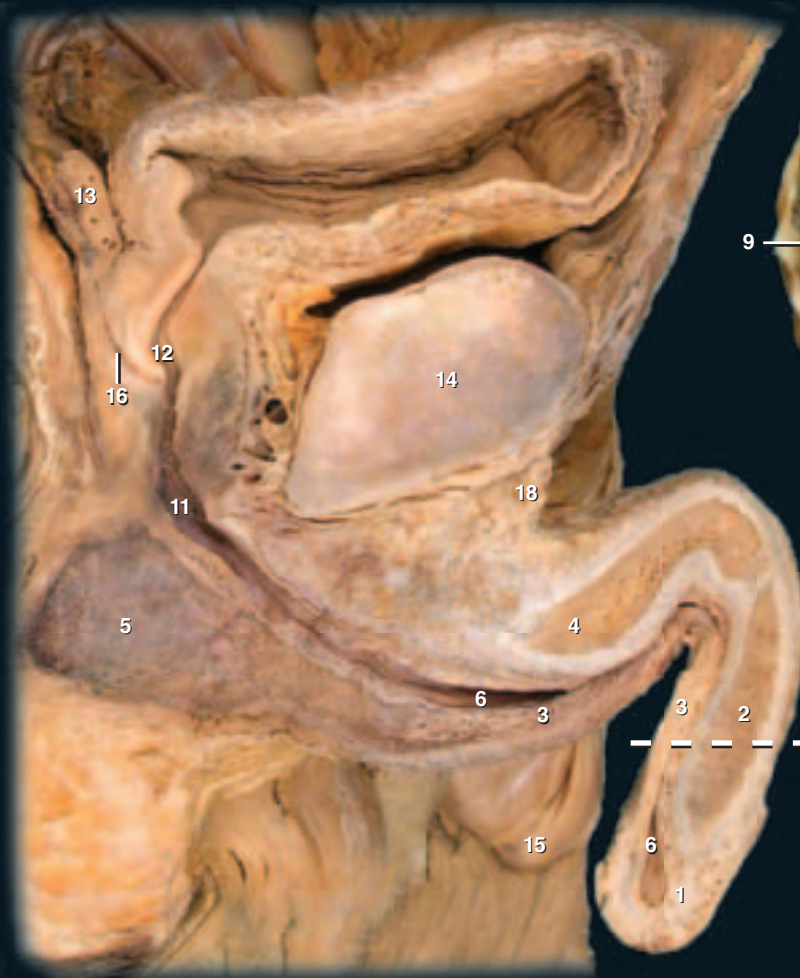
Photomicrograph of prostate gland  
200x

# Penis

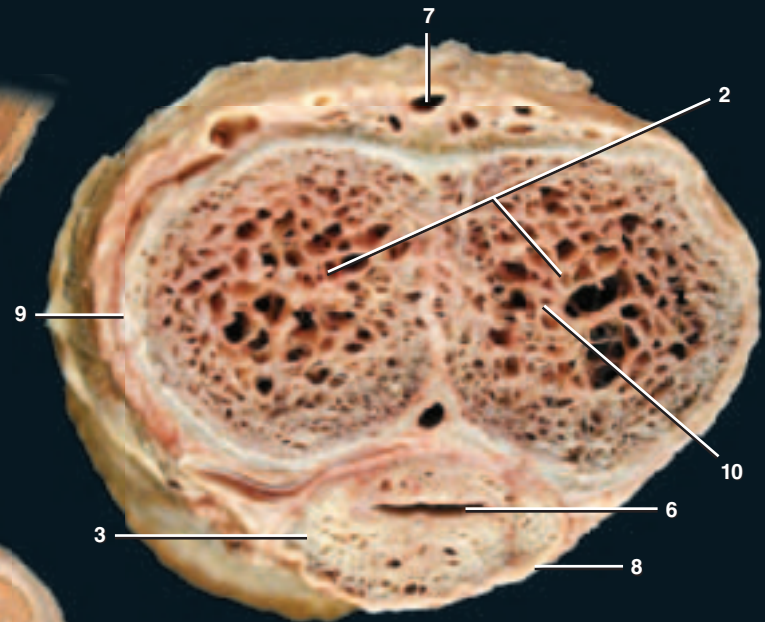
The penis is the intromittent organ of the male external genitalia through which the long urethra, in comparison to the female, courses as it transports both urine and semen from the male body. Along with the urethra, the penis consists of three masses of erectile tissue. On the dorsal aspect of the body of the penis are the paired corpora cavernosae. These erectile tissue bodies are the principal tissues of penile erection. At the base of the penis each corpus cavernosum extends laterally to form the crura of the penis. Each crus attaches to the inferior pubic ramus. On the ventral aspect of the penis is the slender unpaired corpus spongiosum, which surrounds the spongy urethra. The corpus spongiosum expands distally as the glans penis, which forms the expanded tip of the penis. It expands proximally to form the bulb of the penis in the perineum beneath the prostate gland. The glans is covered by a hood of skin, the prepuce, which can be removed via circumcision.



- |                           |   |                                 |
|---------------------------|---|---------------------------------|
| 1 Glans penis             | 7 Deep dorsal vein                      | 13 Ampulla of ductus deferens   |
| 2 Corpus cavernosum penis | 8 Tunica albuginea of corpus spongiosum | 14 Pubic symphysis              |
| 3 Corpus spongiosum penis | 9 Tunica albuginea of corpus cavernosum | 15 Testis                       |
| 4 Crus of penis           | 10 Deep (cavernous) artery of penis     | 16 Ejaculatory duct             |
| 5 Bulb of penis           | 11 Intermediate (membranous) urethra    | 17 Bladder                      |
| 6 Spongy urethra          | 12 Prostatic urethra                    | 18 Suspensory ligament of penis |



**Sagittal section of penis in situ**  
Medial view



**Transverse section of penis**  
Superior view

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