

Peter Arnold, Inc.

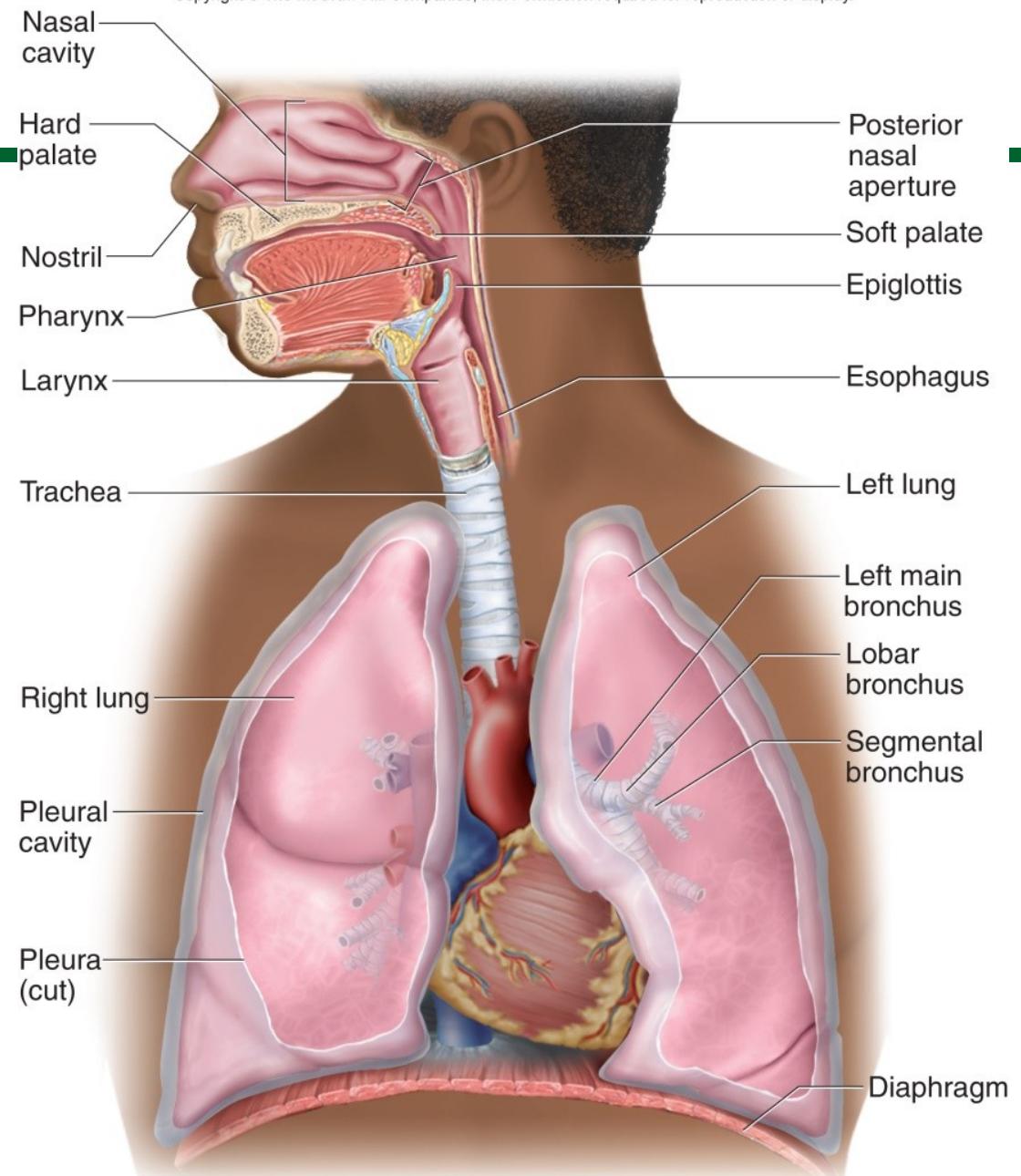
Respiratory

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# BI 455 CHAPTER 17

# What is respiration?

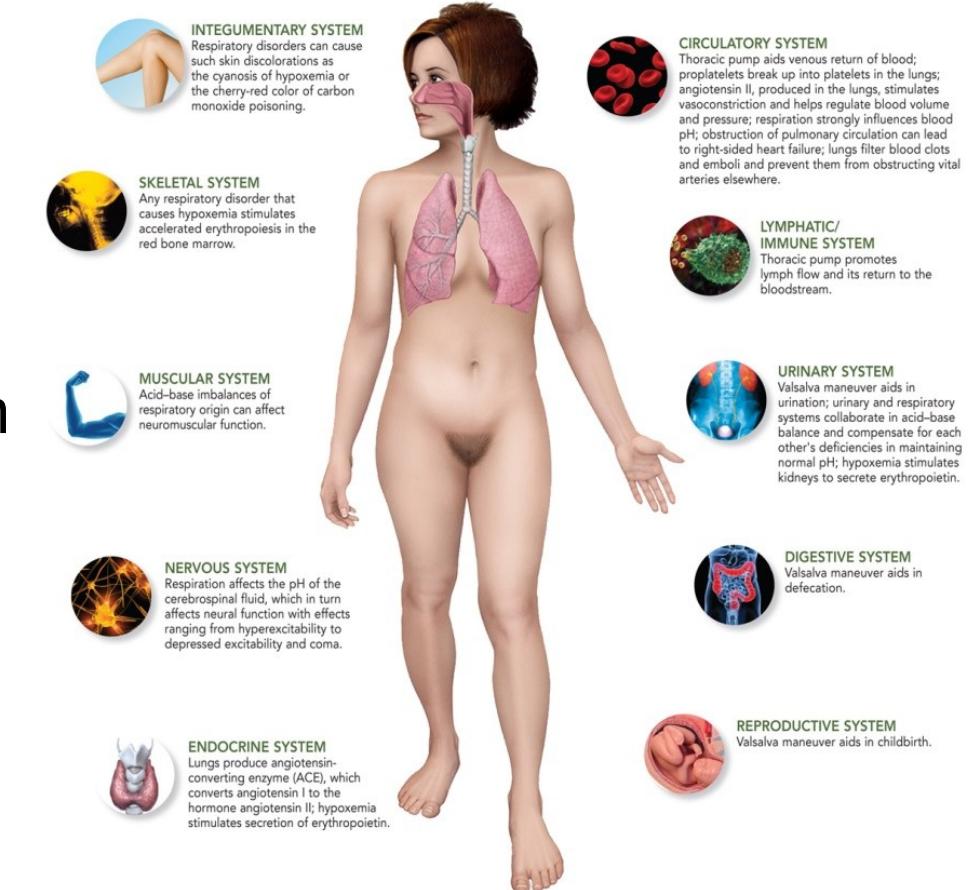
1. Ventilation of the lungs (breathing)
2. The exchange of gases between the air and blood, and between blood and the tissue fluid
3. The use of oxygen in cellular metabolism (ATP production)



# Functions of the Respiratory System

1. O<sub>2</sub> and CO<sub>2</sub> exchange between blood and air
2. Speech
3. Provides the sense of smell
4. Affects pH of body fluids by eliminating CO<sub>2</sub>
5. Affects blood pressure by synthesis of vasoconstrictor, angiotensin II
6. Breathing creates pressure gradients between thorax and abdomen that promote the flow of lymph and venous blood
7. Breath-holding helps expel abdominal contents during urination, defecation, and childbirth (Valsalva maneuver)

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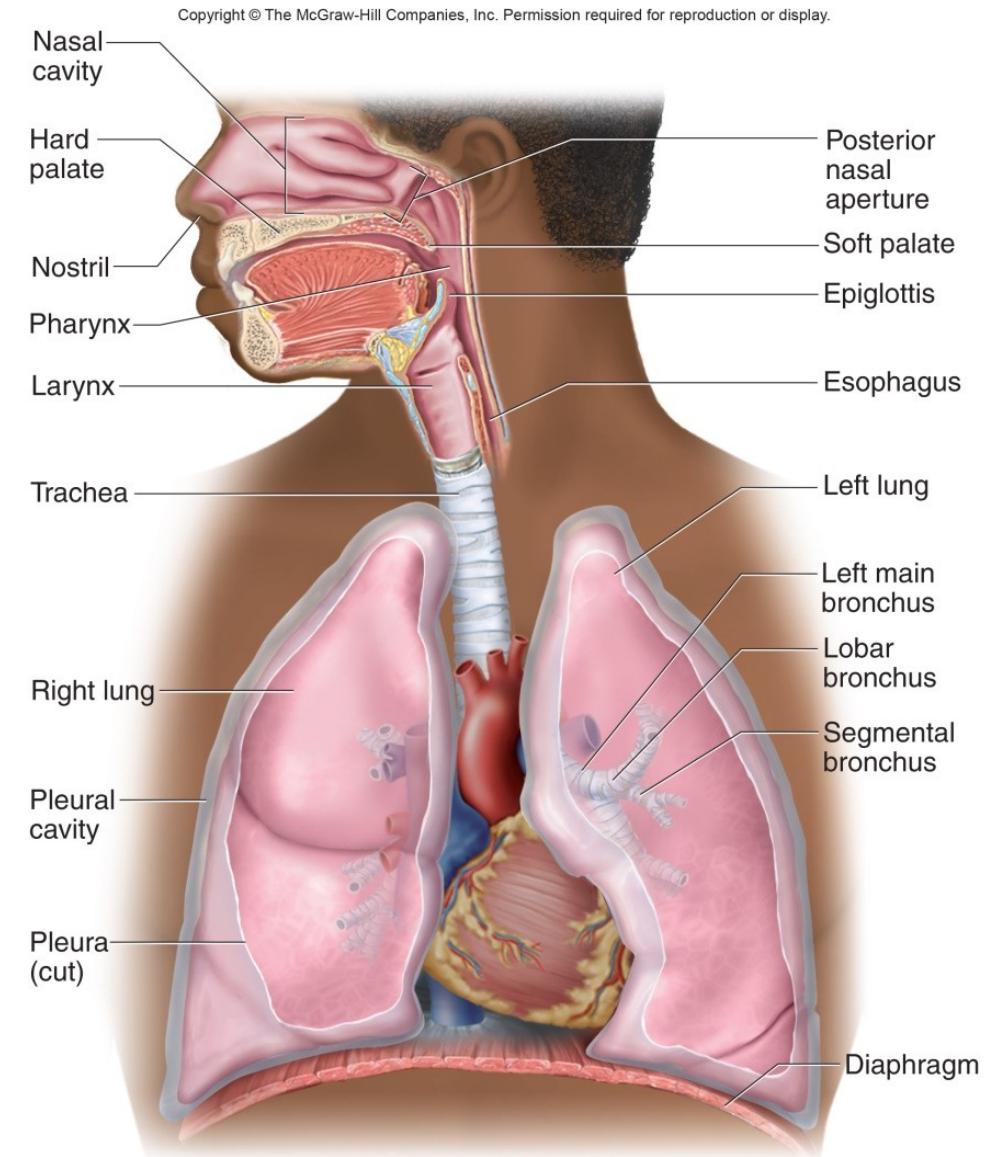


# Conducting Division of the Respiratory System

Nose, pharynx, larynx, trachea, bronchi, lungs

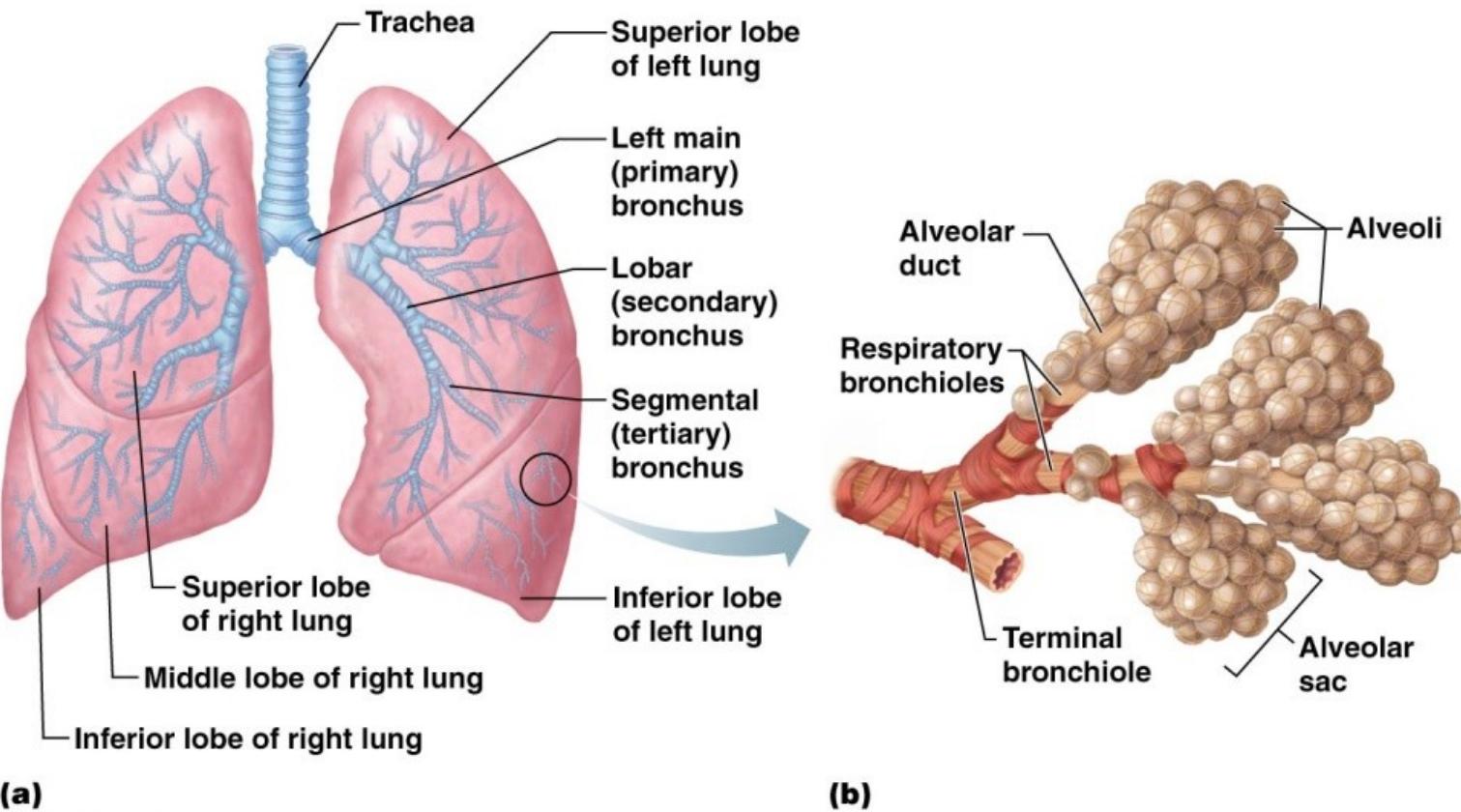
- Those passages that serve only for airflow
- No gas exchange
- Nostrils through major bronchioles
- **Upper respiratory tract:** Nose through larynx
- **Lower respiratory tract:** Trachea through lungs

Conducting division “conditions” air by warming, moistening, and removing particulate materials

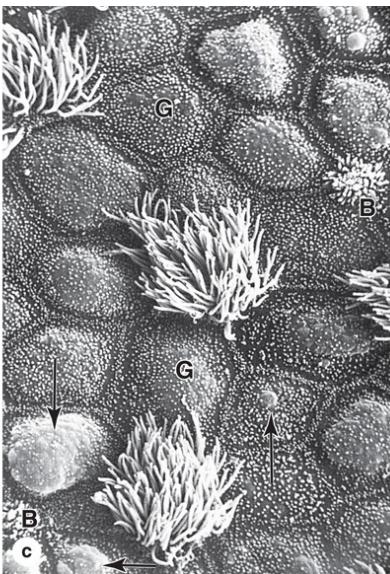
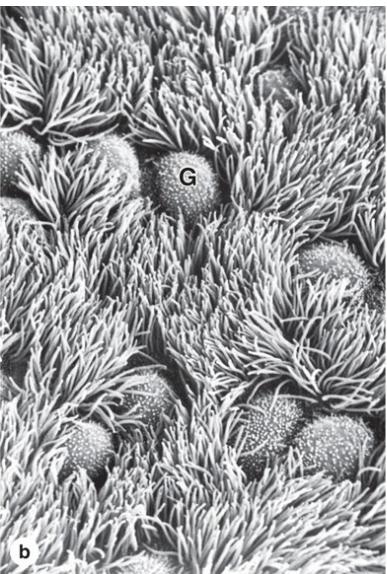
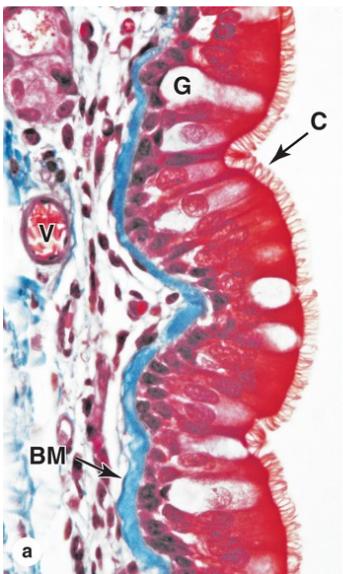


# Respiratory Division of the Respiratory System: respiratory bronchioles, alveolar ducts, alveolar sacs, alveoli

- Incoming air stops in the alveoli
- Millions of thin-walled, microscopic air sacs exchange gases with the bloodstream through the alveolar wall, and then flows back out



# Respiratory epithelium is the classic example of pseudostratified ciliated columnar epithelium.



## Respiratory mucosa cell types

**Ciliated cells (C):** tall columnar cells with cilia that project into the mucus covering the surface of the epithelium

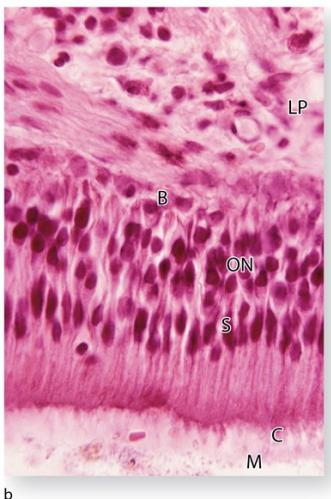
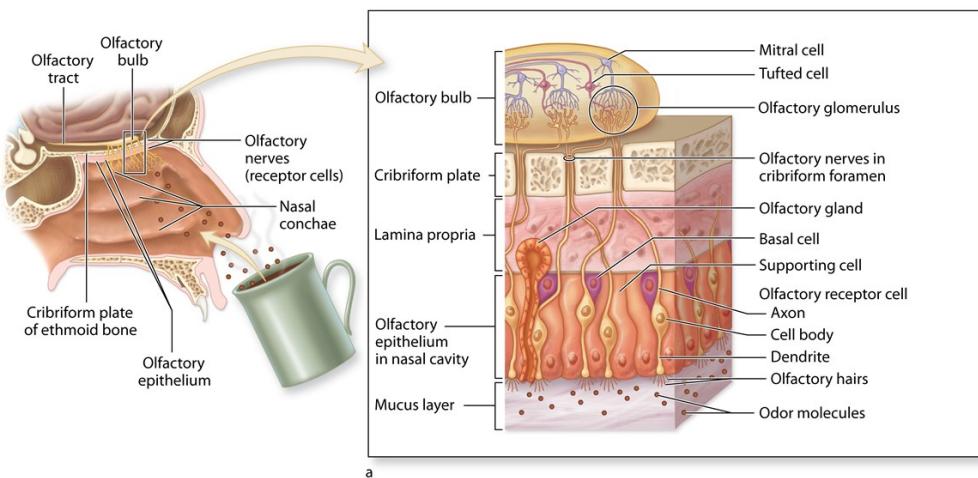
**Goblet cells (G):** synthesize and secrete mucus

**Brush cells (B):** a general name for those cells in the respiratory tract that bear short, blunt microvilli

**Small granule cells (Kulchitsky cells):** endocrine cells of the diffuse neuroendocrine system (DNES)

**Basal cells:** stem cells from which the other cell types arise (at base of columnar cells)

# Olfactory Region Sends Axons to the Brain



**MEDICAL APPLICATION:** The loss or reduction of the ability to smell, anosmia or hyposmia, respectively, can be caused by damage to the olfactory epithelium or nerve. Can be caused by intranasal drug use. The olfactory neurons are the best-known neurons to be replaced regularly because of regenerative activity of the epithelial stem cells from which they arise. For this reason, loss of the sense of smell due to toxic fumes or physical injury to the olfactory mucosa itself is usually temporary.

Aging and the loss of smell, taste:  
[https://www.youtube.com/watch?v=A\\_aevsFwlJA](https://www.youtube.com/watch?v=A_aevsFwlJA)

## Pseudostratified epithelium

(Only a thin basement membrane separates the olfactory basal cells (**B**) from the underlying lamina propria (**LP**). Nuclei of the bipolar olfactory neurons (**ON**) lie in the middle of the pseudostratified olfactory epithelium, with a zone of supporting cell (**S**) nuclei above it. At the apical end of the cells are the nonmotile cilia (**C**), or olfactory hairs, and a layer of mucus (**M**).

# The Larynx (voice box): cartilaginous chamber which keeps food and drink out of the airway

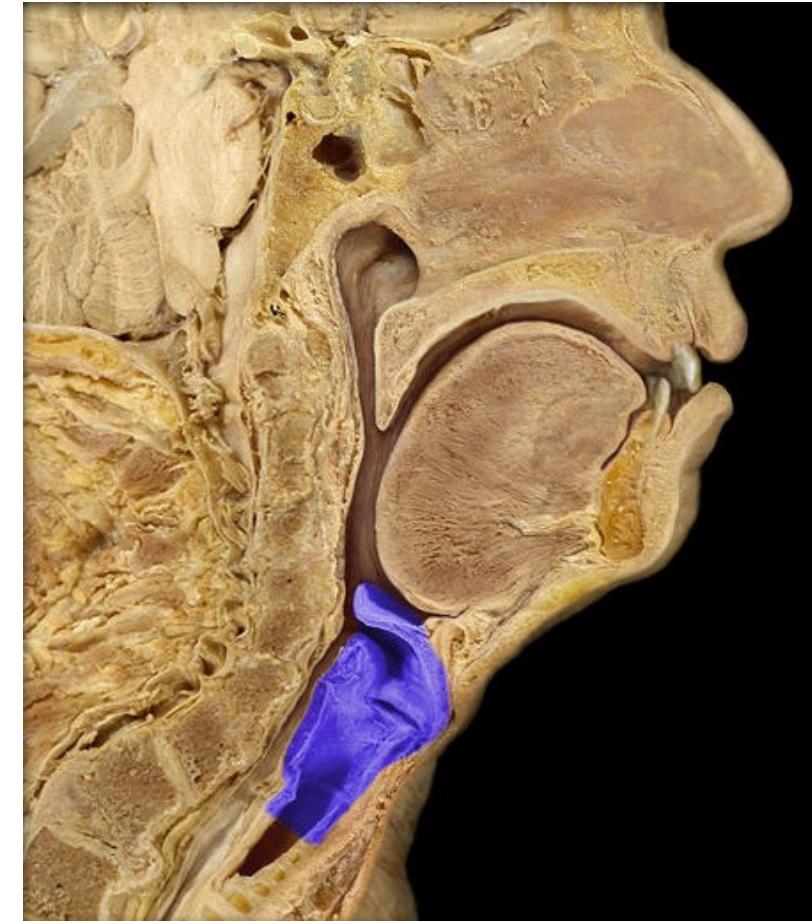
Has evolved role in production of sound

**Epiglottis:** flap of tissue that guards the superior opening of the larynx

- At rest, stands almost vertically
- Swallowing closes airway and directs food to esophagus behind it

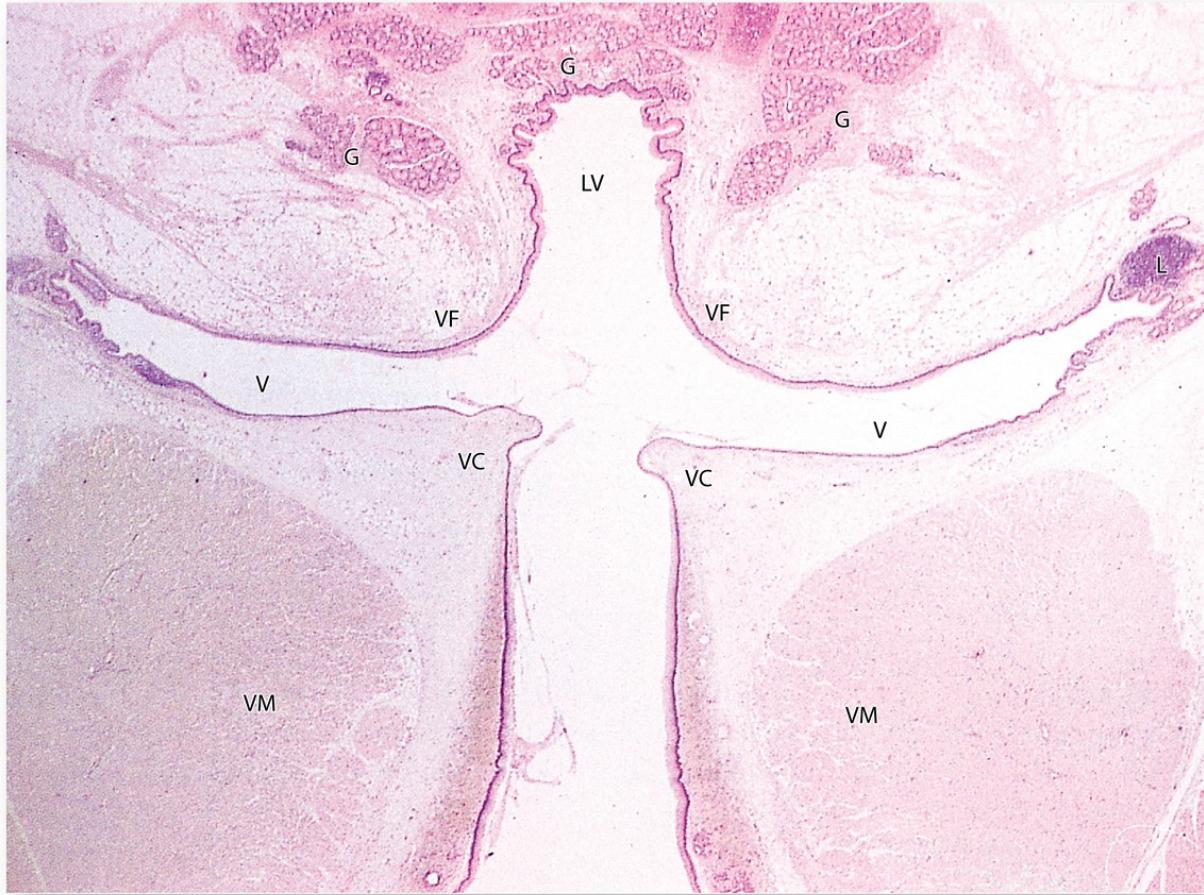
» » **MEDICAL APPLICATION:** Inflammation of the larynx, or laryngitis, changes the shape of the vocal folds or other parts of the larynx, producing loss of voice.

Benign reactive polyps, called singer's nodules, are frequent in the stratified squamous epithelium of the true vocal cords, affecting the voice



Laryngitis [https://www.youtube.com/watch?v=puqe3\\_HkDZA](https://www.youtube.com/watch?v=puqe3_HkDZA)

# Larynx: short air passage between the pharynx and trachea



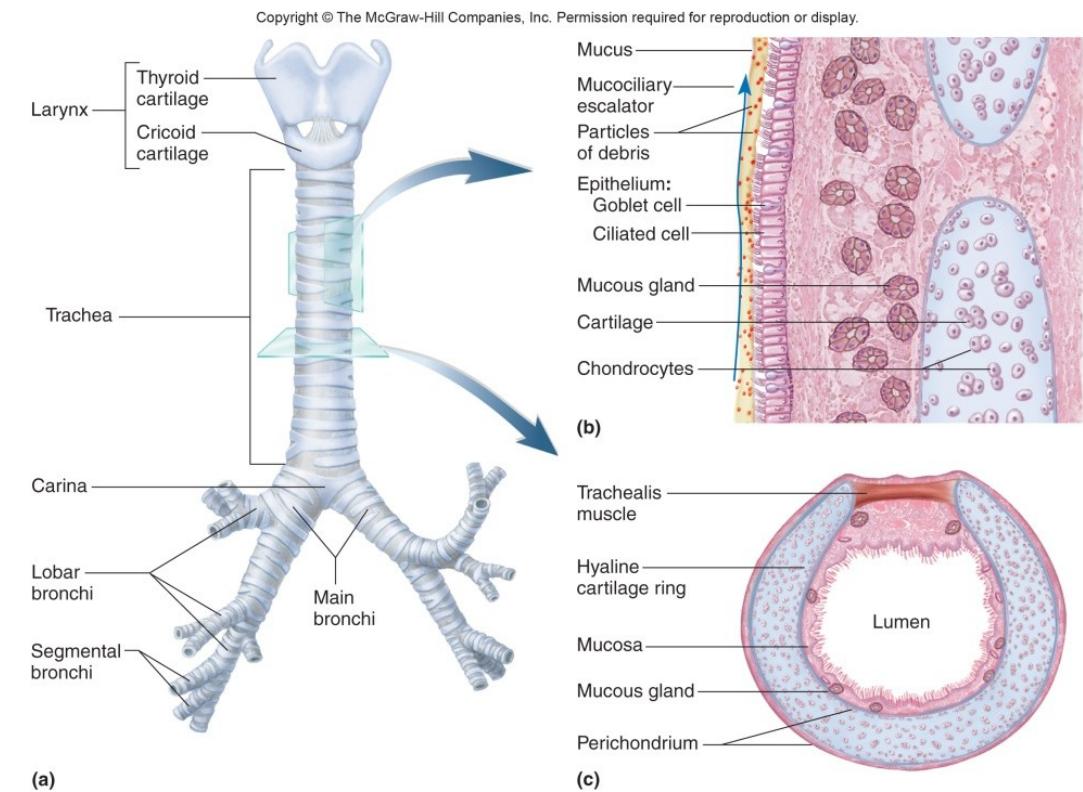
- laryngeal vestibule (**LV**)
- seromucous glands (**G**).
- vestibular folds (**VF**): Bulge of lateral walls, contain seromucous glands and areolar tissue with MALT, often with lymphoid nodules (**L**) and are largely covered by respiratory epithelium, with regions near the epiglottis having stratified squamous epithelium.
- ventricle (**V**)
- vocal folds or cords (**VC**): Lateral folds, covered by stratified squamous epithelium and contain a large striated vocalis muscle (**VM**). Variable tension of VM ligaments caused by the muscles produces different sounds as air is expelled across the vocal cords.

# The Trachea: 16 to 20 C-shaped rings of hyaline cartilage prevent collapse during inhalation

**Inner lining** : mucous secreting pseudostratified columnar epithelium

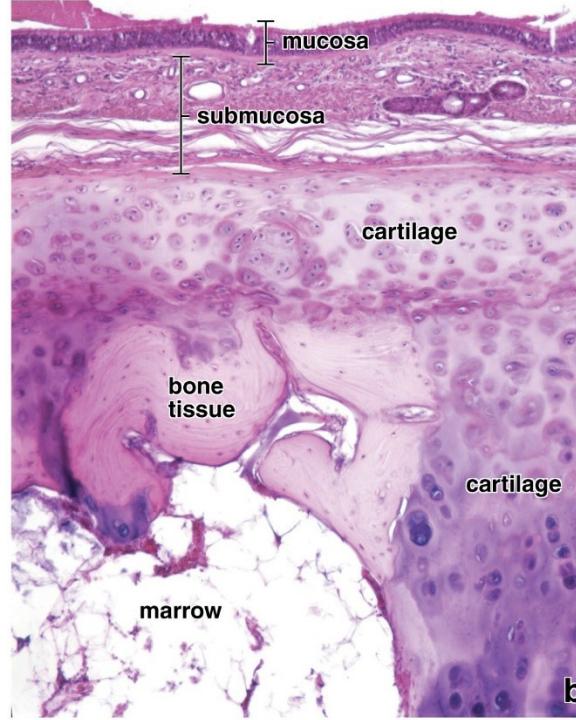
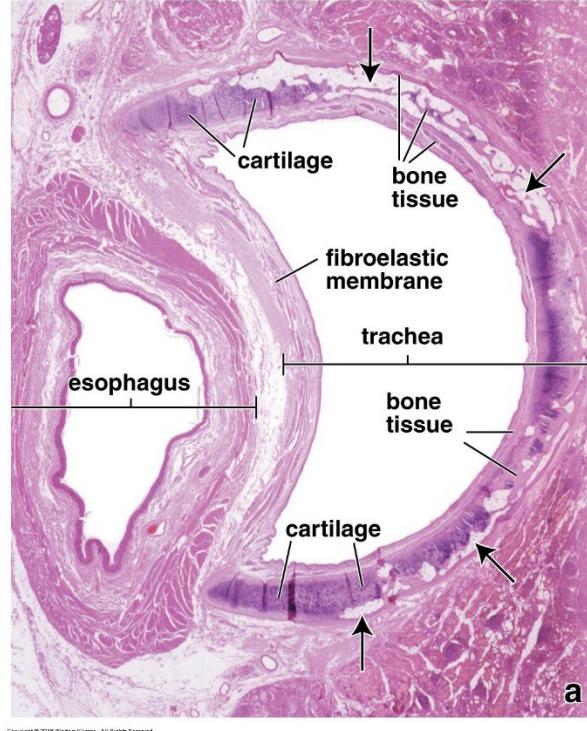
**Mucociliary escalator**: Mucus traps inhaled particles, upward beating cilia drives mucus toward pharynx where it is swallowed

**Middle tracheal layer**: connective tissue; contains lymphatic nodules, mucous and serous glands, and the tracheal cartilage.



**MEDICAL APPLICATION:** Coughing is a reflex action produced most often by viral infection or other irritation of the trachea or other region of the respiratory tract. A persistent dry cough, in which no mucus (phlegm) is produced, can be treated by cough suppressants that act on the brainstem and vagus nerve, while productive coughs are often treated with expectorants that help loosen mucus covering the re [Coughing: https://www.youtube.com/watch?v=usAqJoVYVSc](https://www.youtube.com/watch?v=usAqJoVYVSc)

# Relationship between the trachea and the esophagus at the base of the neck



Cartilaginous tracheal rings: keep the trachea patent, have a C-shaped appearance.

Cartilage gap: fibroelastic membrane that contains the trachealis muscle and numerous seromucous glands.

In this specimen, the tracheal ring has been transformed, in part, to bone, a process that occurs in aging.

TABLE 17-1

## Histologic features of the upper respiratory tract, larynx, and trachea.

Region	Epithelium	Glands	Musculoskeletal Support	Other Features and Major Functions
Vestibules of nasal cavities	Stratified squamous, keratinized to nonkeratinized	Sebaceous and sweat glands	Hyaline cartilage	Vibrissae (stiff hairs) and moisture both filter and humidify air
Most areas of nasal cavities	Respiratory	Seromucous glands	Bone and hyaline cartilage	Rich vasculature and glands warm, humidify, and clean air
Superior areas of nasal cavities	Olfactory, with bipolar neurons	Serous (Bowman) glands	Bone (ethmoid)	Solubilize and detect odorant molecules in air
Nasopharynx and posterior oropharynx	Respiratory and stratified squamous	Seromucous glands	Bone and skeletal muscle	Conduct air to larynx; pharyngeal and palatine tonsils
Larynx	Respiratory and stratified squamous	Mucous glands, smaller seromucous glands	Elastic and hyaline cartilage, ligaments, skeletal muscle	Site for phonation; epiglottis closes while swallowing
Trachea	Respiratory	Mainly mucous glands, some serous or mixed glands	C-shaped rings of hyaline cartilage, with smooth (trachealis) muscle in posterior opening of each	Conduct air to primary bronchi entering lungs; some MALT

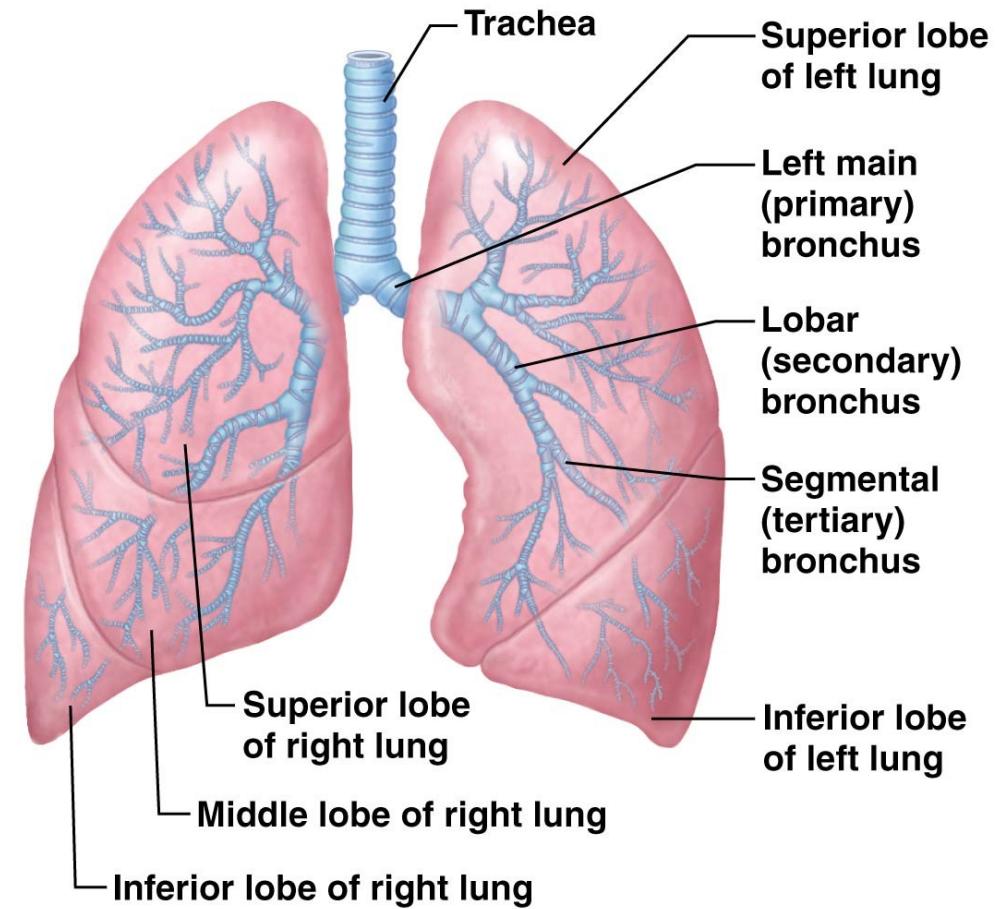
# Lungs are crowded by adjacent organs and are asymmetrical

**Right lung:** Shorter than left because the liver rises higher on the right

- three lobes: superior, middle, and inferior which are separated by **horizontal and oblique fissure**

**Left lung:** Taller and narrower because the heart tilts toward the left and occupies more space on this side of mediastinum

Cardiac impression: Indentation  
Two lobes: superior and inferior separated by a single oblique fissure



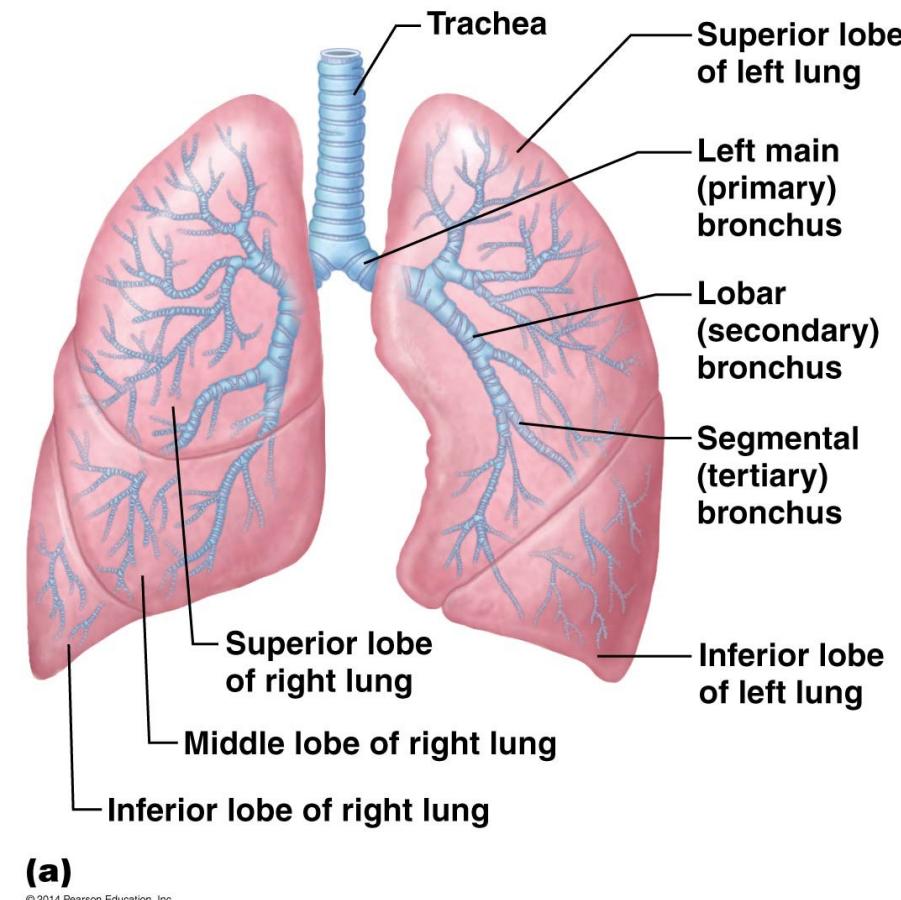
(a)

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# The Bronchial Tree: branching system of air tubes in each lung from main bronchus to 65,000 terminal bronchioles

Main (primary) bronchi: supported by C-shaped hyaline cartilage rings

- **Right main bronchus:** 2 to 3 cm long, arising from fork of trachea
  - slightly wider and more vertical than left
  - Aspirated (inhaled) foreign objects lodge right bronchus more often than the left
- **Left main bronchus:** about 5 cm long
  - Slightly narrower and more horizontal than the right



# The Bronchial Tree

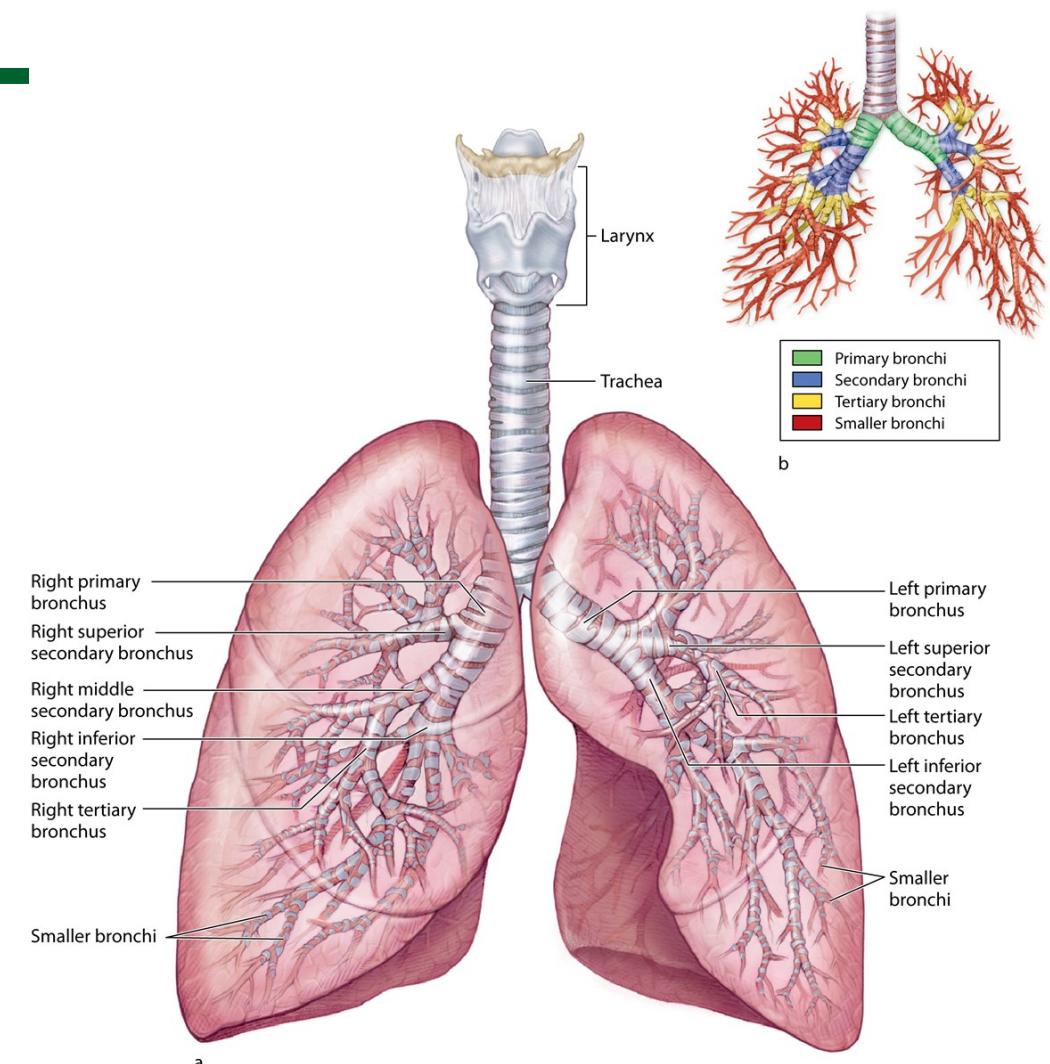
**Lobar (secondary) bronchi:** supported by crescent-shaped cartilage plates

- Three rt. lobar (secondary) bronchi
- Two lt. lobar bronchi

**Segmental (tertiary) bronchi:** supported by crescent-shaped cartilage plates

- 10 on right, 8 on left

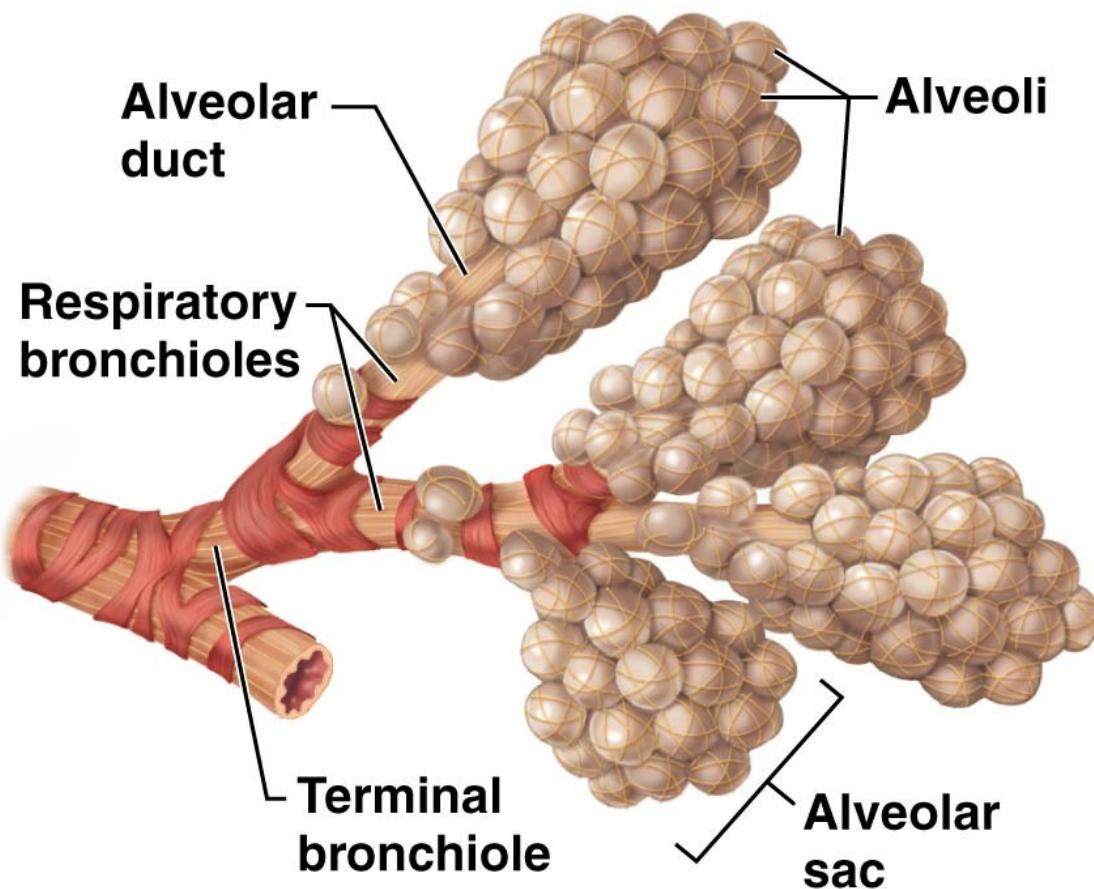
Primary → secondary → tertiary → bronchiole  
→ terminal bronchiole → respiratory  
bronchiole → alveolar duct → alveolar sac →  
alveoli



# Respiratory bronchioles

- Have **alveoli** budding from their walls
- Considered the beginning of the **respiratory division** since alveoli participate in gas exchange
- Divide into 2 to 10 **alveolar ducts**
- End in **alveolar sacs**: grapelike clusters of alveoli arrayed around a central space called the **atrium**

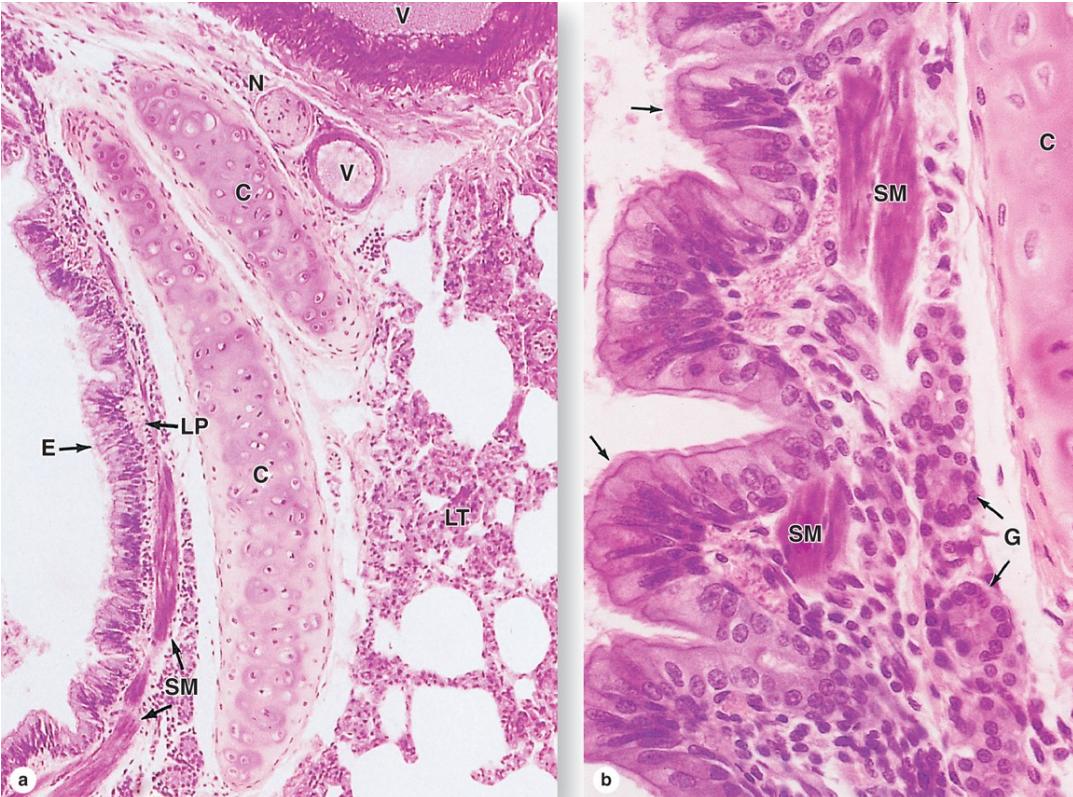
Primary → secondary → tertiary →  
bronchiole → terminal bronchiole →  
respiratory bronchiole → alveolar duct  
→ alveolar sac → alveoli



(b)

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# Bronchial tree is lined with ciliated pseudostratified columnar epithelium (E) to intercept inhaled pathogens



**Elastic connective tissue:** Contributes to the recoil that expels air from lungs

The lamina propria (**LP**) contains well-developed layer of smooth muscle (**SM**) which **contracts or relaxes to constrict or dilate the airway**, regulating airflow

The submucosa is the site of the supporting cartilage (**C**) and the adventitia includes blood vessels (**V**) and nerves (**N**). Lung tissue (**LT**) directly surrounds the adventitia of bronchi.

The lamina propria has both smooth muscle (**SM**) and small serous glands (**G**) near cartilage (**C**).

**MEDICAL APPLICATION:** Asthma is produced by chronic inflammation within the bronchial tree of the lungs. Sudden constrictions of the smooth muscle is caused by mast cells, resulting in difficulty in breathing.

Epinephrine and other sympathomimetic drugs relax the muscle and increase the bronchiole diameter by stimulating the sympathetic nervous system.

<https://ed.ted.com/lessons/how-does-asthma-work-christopher-e-gaw>

**MEDICAL APPLICATION:** **Squamous cell carcinoma**, which is closely correlated with a history of smoking, arises most often from epithelial cells of segmental bronchi.

**Adenocarcinoma**, the most common lung cancer in nonsmokers, usually arises from epithelial cells more peripherally, in bronchioles and alveoli. **Small cell carcinoma**, a less common but highly malignant form of lung cancer, develops after neoplastic transformation of small granule Kulchitsky cells in bronchial respiratory epithelium.

Clinical Features	Pathologic Changes	M
	 Normal Epithelium/Hyperplasia	
	 Squamous Dysplasia	
	 Angiogenic Squamous Dysplasia	
Smoking (with or without COPD)		
	 Inflammatory Changes	
	 Normal Epithelium	
	 Adenomatous Alveolar Hyperplasia	
Non-Smoking	 Normal Epithelium	

Dysplasia: The Progression of Cancer:

[https://www.youtube.com/watch?v=Gh\\_1PfLKqg4](https://www.youtube.com/watch?v=Gh_1PfLKqg4)

## Terminal bronchiole tissue lacks cartilage, has ciliated cuboidal epithelium and well developed layer of smooth muscle

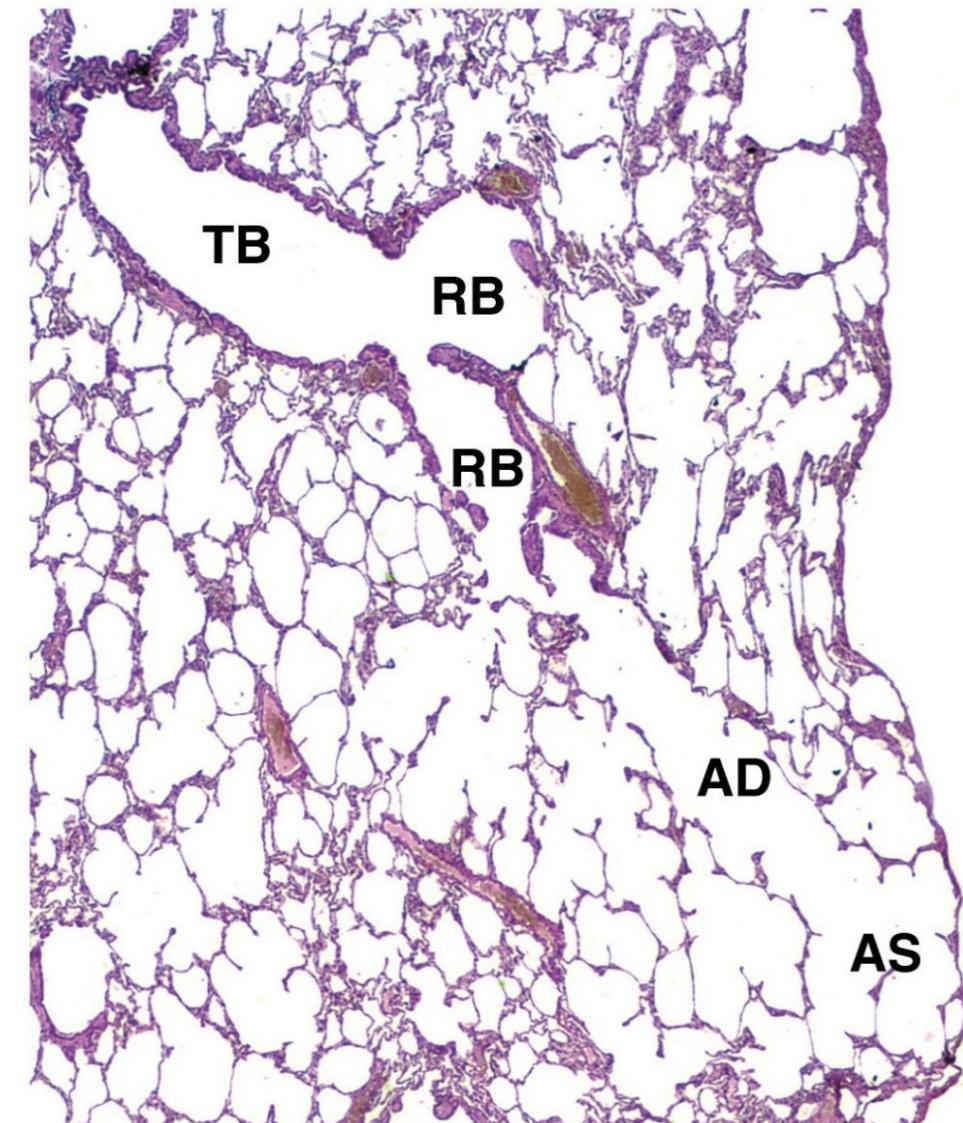
Each bronchiole divides into 50 to 80 **terminal bronchioles (TB)**, Final branches of conducting division

**Terminal bronchiole tissue:** no mucous glands or goblet cells, but have cilia that move mucus draining into them back by **mucociliary escalator**

Each terminal bronchiole gives off two or more smaller **respiratory bronchioles (RB)**

### Alveolar Ducts (AV) & Alveolar Sacs (AS)

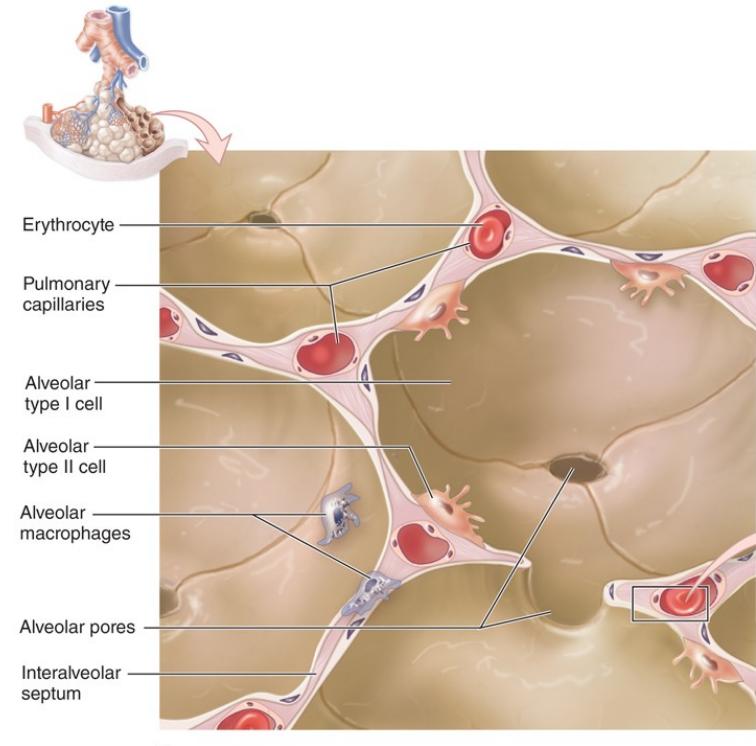
**MEDICAL APPLICATION** Bronchioles are affected by measles virus or adenovirus, both of which can cause bronchiolitis.



- **Squamous (type I) alveolar cells:** Thin, broad cells allowing **rapid gas exchange**, 95% of alveolus surface area
- **Great (type II) alveolar cells:** Round to cuboidal cells that repair the alveolar epithelium when the squamous (type I) cells are damaged
  - Secrete **pulmonary surfactant:** phospholipids and proteins that coat alveoli and prevents collapse during exhalation
- **Alveolar macrophages (dust cells):** keep alveoli free from debris by phagocytizing dust particles

**MEDICAL APPLICATION:** Infant respiratory distress syndrome, the leading cause of death in premature babies, is due to incomplete differentiation of type II alveolar cells and a resulting deficit of surfactant and difficulty in expanding the alveoli in breathing.

## Cells of the alveolus

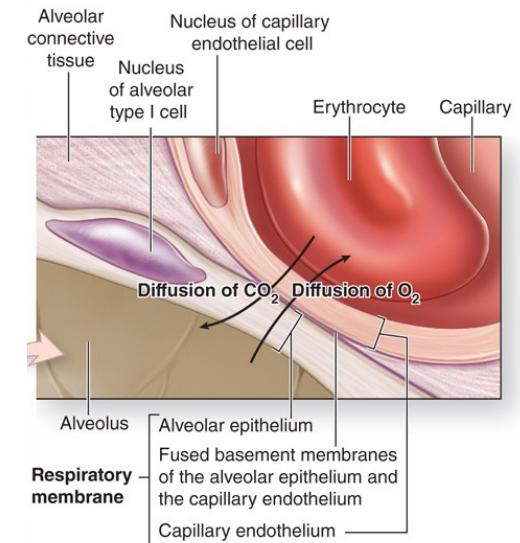
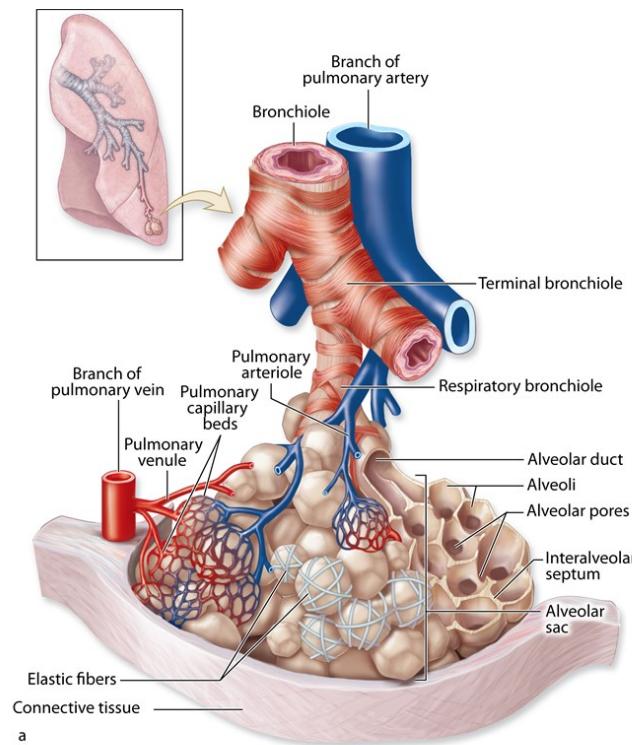


# Respiratory membrane: the barrier between the alveolar air and blood, prevents fluid from accumulating in alveoli

Each alveolus is surrounded by a basket of blood capillaries supplied by the pulmonary artery

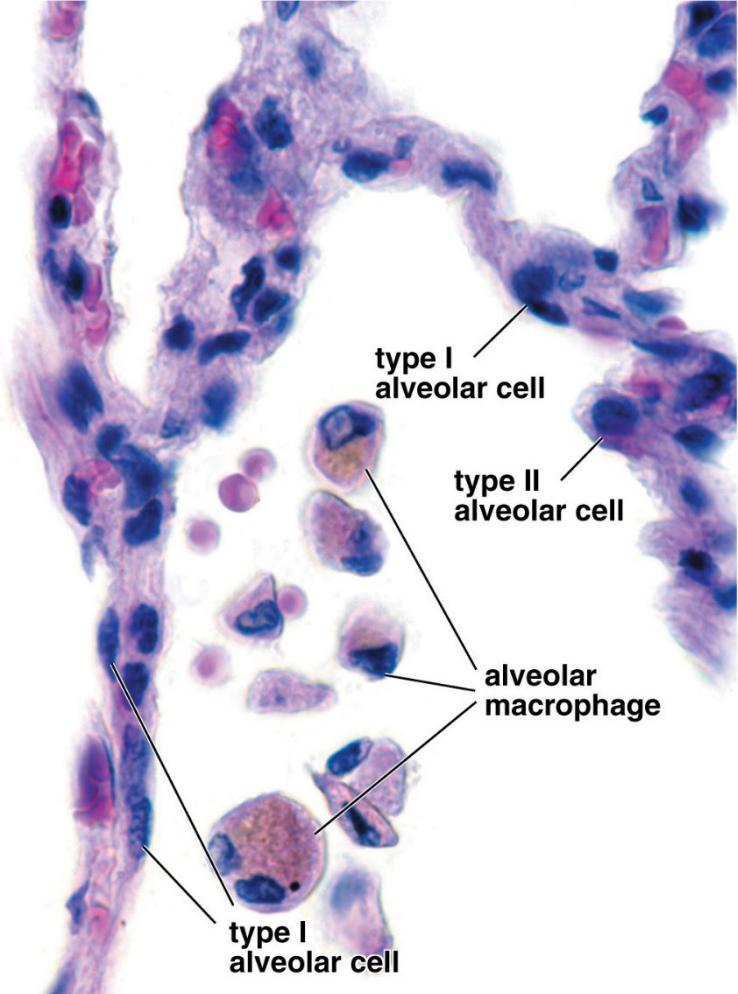
**MEDICAL APPLICATION:** Diffuse alveolar damage or adult respiratory distress syndrome can be produced by various types of injuries to the alveolar epithelial and the capillary endothelial cells. Common causes of such injuries include viral and bacterial respiratory tract infections or inhalation of toxic gases.

**MEDICAL APPLICATION** In congestive heart failure, the lungs become congested with blood, and erythrocytes pass into the alveoli, where they are phagocytized by alveolar macrophages.



# Alveoli and Alveolar Macrophages

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**MEDICAL APPLICATION:** Emphysema, a chronic lung disease most commonly caused by cigarette smoking, involves dilation and permanent enlargement of the bronchioles leading to pulmonary acini and accompanying loss of cells in the alveoli and other parts of the airway walls, leading to an irreversible loss of respiratory function.

**TABLE 17-2****Features of airways within the lungs.**

Region of Airway	Epithelium	Muscle and Skeletal Support	Other Features and Major Functions
Bronchi	Respiratory	Prominent spiral bands of smooth muscle; irregular hyaline cartilage plates	Repeated branching; conduct air deeper into lungs
Bronchioles	Simple ciliated cuboidal to columnar, with Clara cells	Prominent circular layer of smooth muscle; no cartilage	Conduct air; important in bronchoconstriction and bronchodilation
Terminal bronchioles	Simple cuboidal, ciliated and Clara cells	Thin, incomplete circular layer of smooth muscle; no cartilage	Conduct air to respiratory portions of lungs; Clara cells with several protective functions
Respiratory bronchioles	Simple cuboidal, ciliated and Clara cells, with scattered alveoli	Fewer smooth muscle fibers, mostly around alveolar openings	Conduct air deeper, with some gas exchange and protective Clara cells
Alveolar ducts and sacs	Simple cuboidal between many alveoli	Bands of smooth muscle around alveolar openings	Conduct air, with much gas exchange
Alveoli	Types I and II alveolar cells (pneumocytes)	None (but with network of elastic and reticular fibers)	Sites of all gas exchange; surfactant from type II pneumocytes; dust cells



Skin

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## BI 455 CHAPTER 18

# The Integumentary System: skin, hair, nails, and cutaneous glands

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## Functions

**Resistance to trauma and infection:** few organisms able to penetrate if intact

cells packed with tough **keratin** and linked by strong desmosomes

dryness of skin and protective acid layer helps keep organisms on skin in check

## **Water retention**

**Vitamin D synthesis:** important for  $\text{Ca}^{2+}$  absorption

**Sensation:** temperature, touch, and texture, pressure, vibration, and injury

## **Thermoregulation**

## **Nonverbal communication**



Intro to the integument:

<http://www.youtube.com/watch?v=BVIIgHyNRdl&feature=related>

(watch till 5:20)

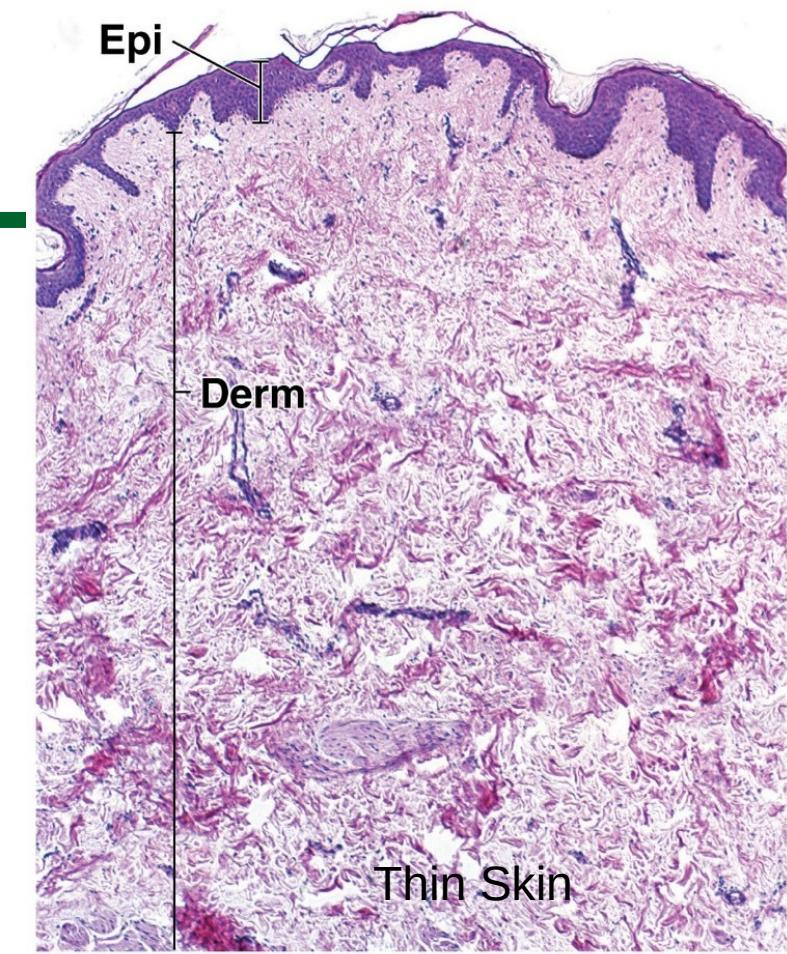
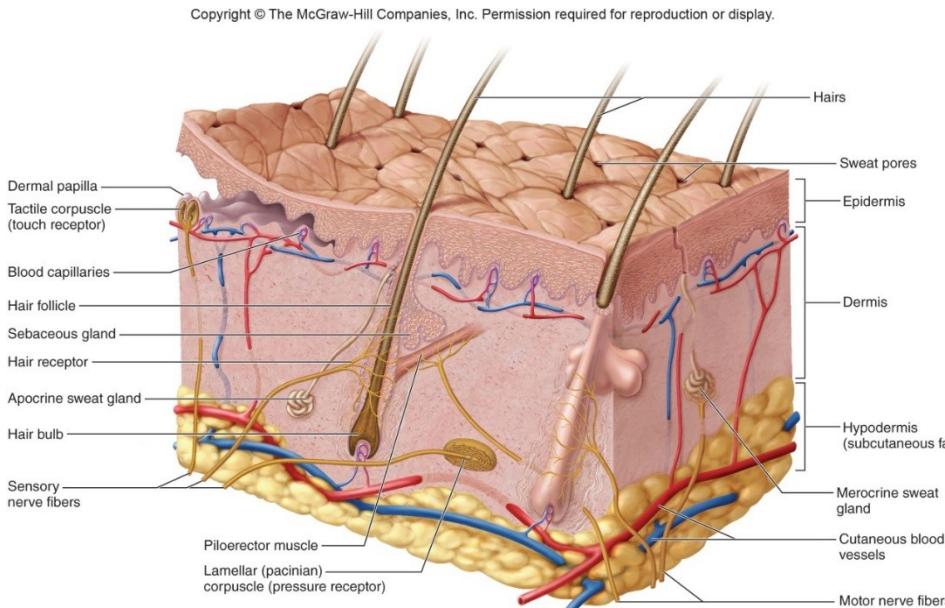
# The Skin and Subcutaneous Tissue

**Skin:** 2 layered membrane covering external surface of body

**Epidermis:** superficial epithelium

**Dermis:** deeper connective tissue

**Hypodermis:** loose connective tissue between skin and muscles



**>> MEDICAL APPLICATION:** Friction blisters are lymph-filled spaces created between the epidermis and dermis of thick skin by excessive rubbing, producing a protective thickening and hardening of the outer cornified epidermal layers, seen as corns and calluses.

# Characteristics of skin

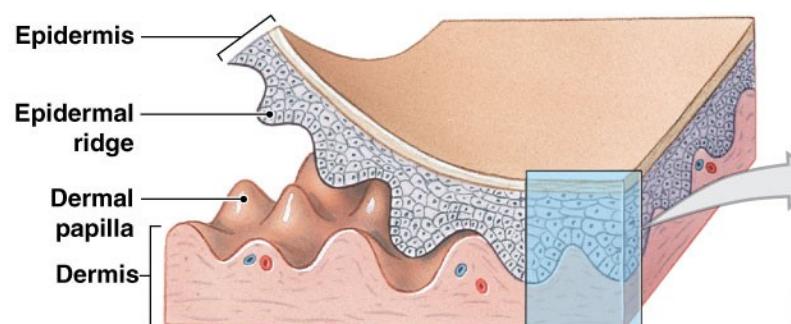
15% of body weight, ranges from 0.5mm to 6 mm, due mostly to variations in dermis

**Thick skin:** Epidermis about 0.5 mm thick, thick layer of dead cells, *stratum corneum*

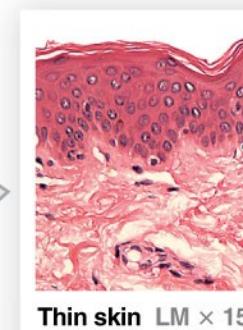
- Covers palms, soles, surfaces of fingers and toes, subject to greatest mechanical stress
- Has sweat glands, but no hair follicles or sebaceous glands

**Thin skin:** epidermis  
about 0.1 mm thick

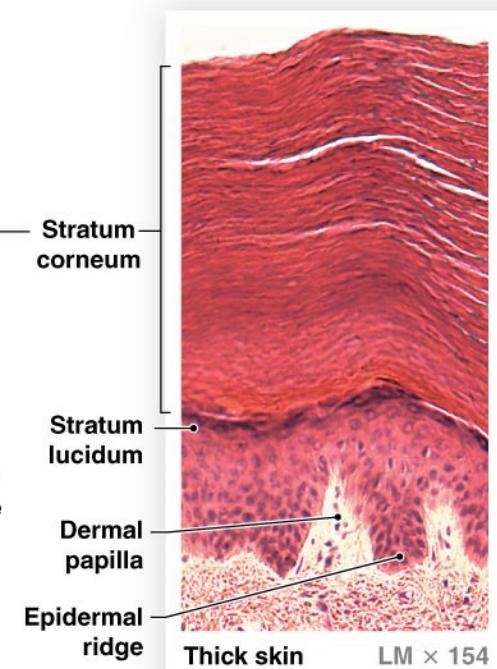
- Has hair follicles, sebaceous and sweat glands



**a** The structural relationship and interface between the epidermis and underlying dermis. The proportions of the various layers differ with the location sampled.



**b** A micrograph of thin skin, which covers most of the exposed body surface.



**c** A micrograph of thick skin, which covers the surface of the palms and the soles of the feet.

# Layers of skin

Layers of the skin:

<https://www.youtube.com/watch?v=oPzbwx8u7bU>

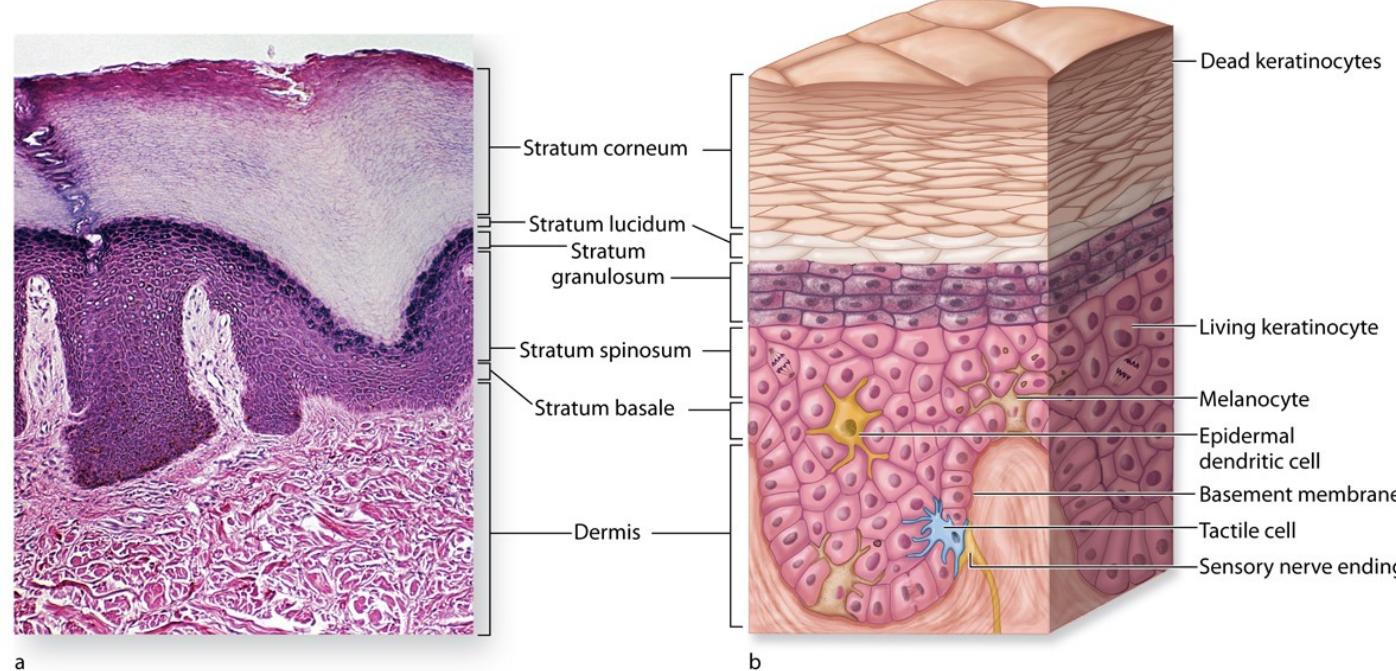
**Stratum basale:** single layer of stem cells, keratinocytes, melanocytes, and tactile cells

**Stratum spinosum:** keratinocytes that flatten as they produce keratin, and cease dividing as pushed upward). Also contain dendritic cells.

**Stratum granulosum:** three to five layers of flat dying keratinocytes. Keratin filaments in thick bundles produce water barrier

**Stratum lucidum** clear layer of dead cells present only in thick skin of palms and soles

**Stratum corneum:** up to 30 layers of dead anucleate squamous keratinocytes packed with keratin, gives skin toughness cells flaking off (exfoliate) are replaced by new cells 30 to 40 days from “birth” to exfoliation



# Cells of epidermis

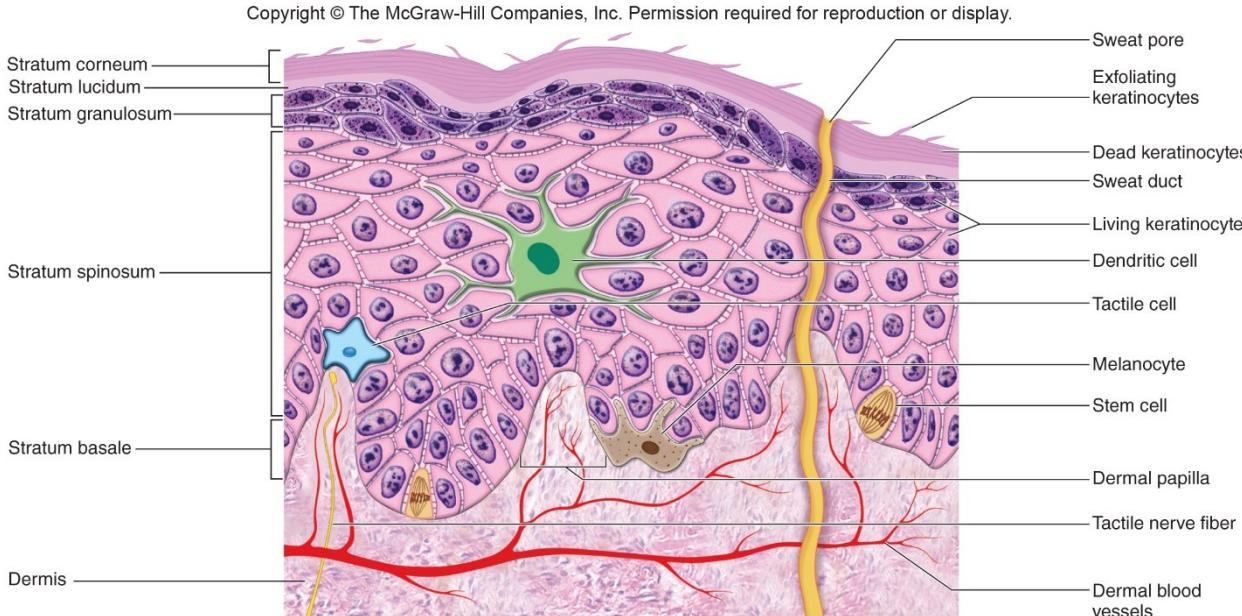
Keratinized stratified squamous epithelium is mostly **keratinocytes** packed with keratin

**Melanocytes:** pigment-producing cells

**Merkel's cells:** cells specialized for touch

**Stem cells:** divide and replace epidermal cells that die

**Dendritic Langerhans' cells:** Antigen Presenting Cells

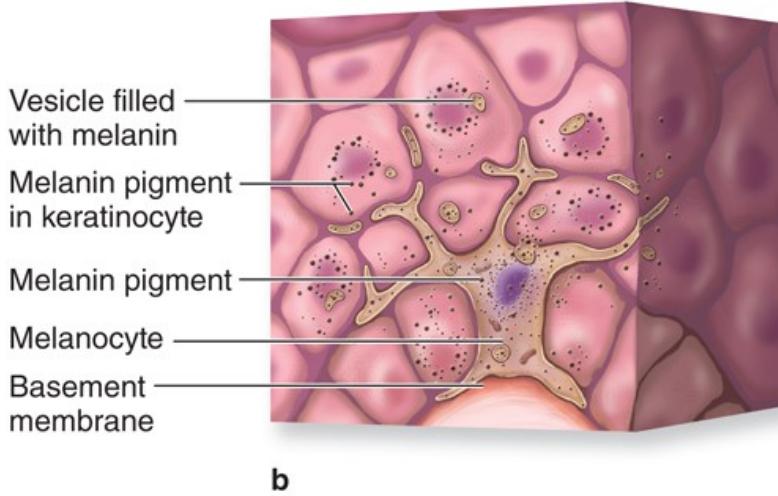
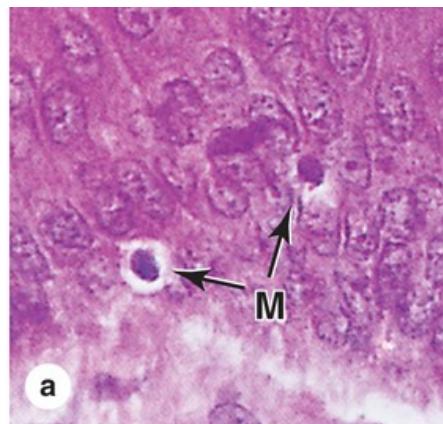
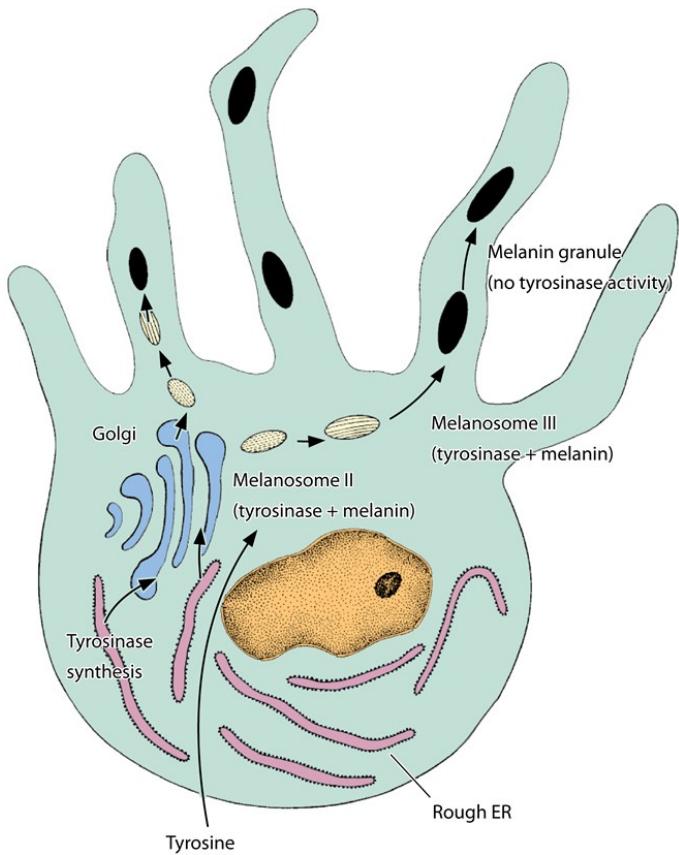


## »» MEDICAL APPLICATION

In psoriasis, keratinocytes are overproduced, causing at least slight thickening of the epidermal layers and increased keratinization and desquamation.

Psoriasis is caused by overactive T lymphocytes that trigger an autoimmune reaction in the skin, which can also lead to inflammation with redness, irritation, itching, and scaling, with a defective skin barrier.

# Melanocytes are scattered among the basal cells of the stratum basale



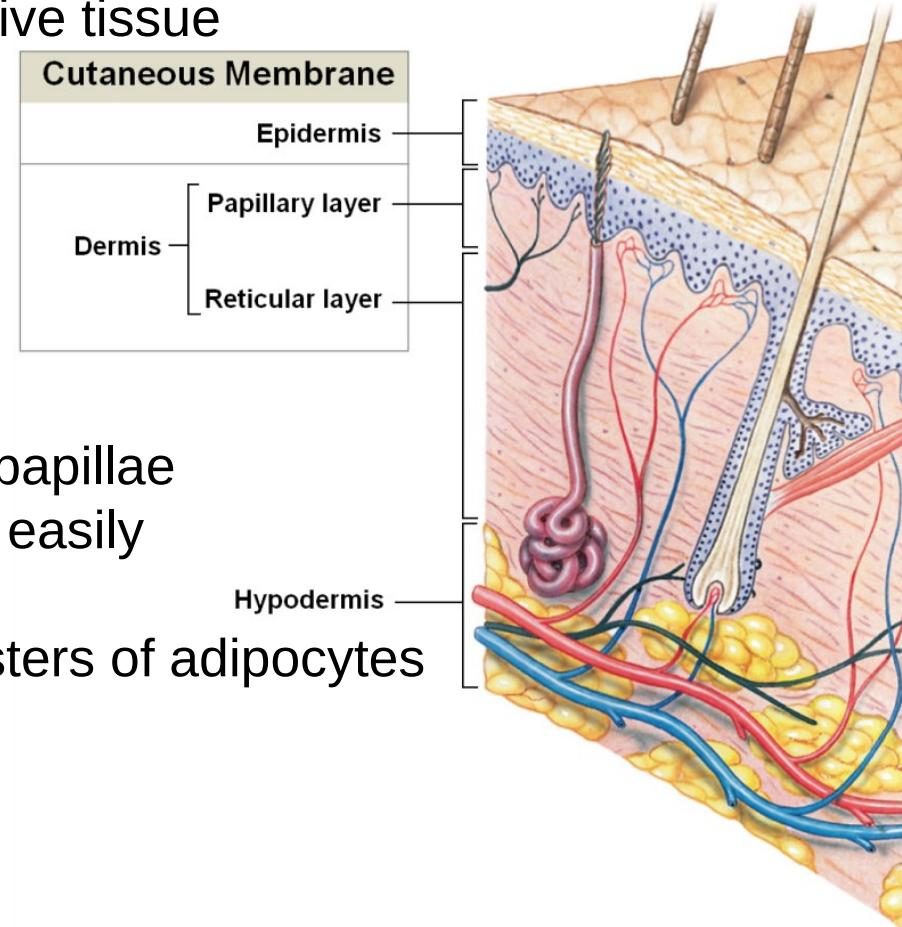
Melanocytes synthesize **melanin granules** and transfer them into neighboring **keratinocytes** of the basal and spinous layers. Typically melanocytes are pale-staining cells on the basement membrane, with lower total melanin content than the keratinocytes

A mature melanin granule is transported to the tips of the processes of melanocyte and transferred to the keratinocytes, where they accumulate as a supranuclear cap shading the DNA against the harmful effects of UV radiation.

**>> MEDICAL APPLICATION** In adults, one-third of all cancers originate in the skin. Most of these derive from cells of the basal or spinous layers, producing, respectively, basal cell carcinomas and squamous cell carcinomas.

## Dermis is mainly collagen

- From 0.2 mm to 6 mm
- Also has elastic and reticular fibers and cells of fibrous connective tissue
- Many blood vessels and nerve endings
- Sweat and sebaceous glands
- Hair or nails rooted here
- Where skeletal muscles attach on face



## Zones of Dermis

- **Papillary layer:** thin zone of areolar tissue in and near dermal papillae
  - loosely organized, which allows leukocytes to move around easily
- **Reticular layer:** four-fifths of dermis
  - thick bundles of collagen, elastic fibers, fibroblasts, and clusters of adipocytes
  - sweat glands, nail roots, and hair follicles

## Hypodermis (subcutaneous tissue) underlies dermis

- Looser connective tissue and more adipose tissue, Binds skin to muscles or other tissues
- Pads body
- Serves as an energy reservoir
- Provides thermal insulation
- Diffuses in thickness distribution heat

TABLE 18-1

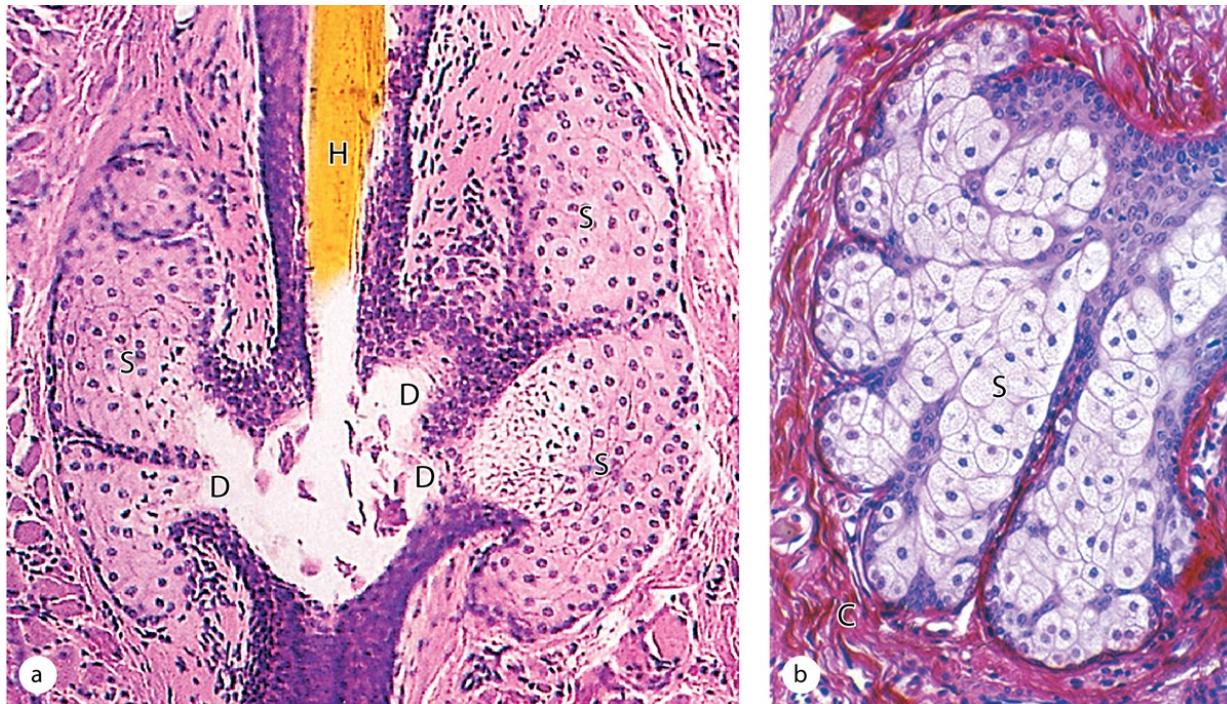
Skin layers and the subcutaneous layer.

Layer	Specific Layer	Description
Epidermis	Stratum corneum Stratum lucidum Stratum granulosum Stratum spinosum Stratum basale	Stratum corneum Most superficial layer; 20-30 layers of dead, flattened, anucleate, keratin-filled keratinocytes; protects against friction and water loss  Stratum lucidum 2-3 layers of anucleate, dead cells; seen only in thick skin  Stratum granulosum 3-5 layers of keratinocytes with distinct kerato-hyaline granules  Stratum spinosum Several layers of keratinocytes all joined by desmosomes; Langerhans cells present  Stratum basale Deepest, single layer of cuboidal to low columnar cells in contact with basement membrane; mitosis occurs here; melanocytes and Merkel cells also
Dermis	Papillary layer Reticular layer	Papillary layer More superficial layer of dermis; composed of areolar connective tissue; forms dermal papillae; contains subpapillary vascular plexus  Reticular layer Deeper layer of dermis; dense irregular connective tissue surrounding hair follicles, sebaceous glands and sweat glands, nerves, and deep plexus of blood vessels extending into subcutaneous layer
Subcutaneous layer	No specific layers	Not considered part of the integument; deep to dermis; composed of areolar and adipose connective tissue

## » MEDICAL APPLICATION

With age, collagen fibers thicken and collagen synthesis decreases. In old age, extensive cross-linking of collagen fibers and the loss of elastic fibers, especially after excessive exposure to the sun (solar elastosis), cause the skin to become more fragile, lose its suppleness, and develop wrinkles.

**Sebaceous glands secrete a complex, oily mixture of lipids called sebum into short ducts that in most areas open into hair follicles**



### Holocrine secretion

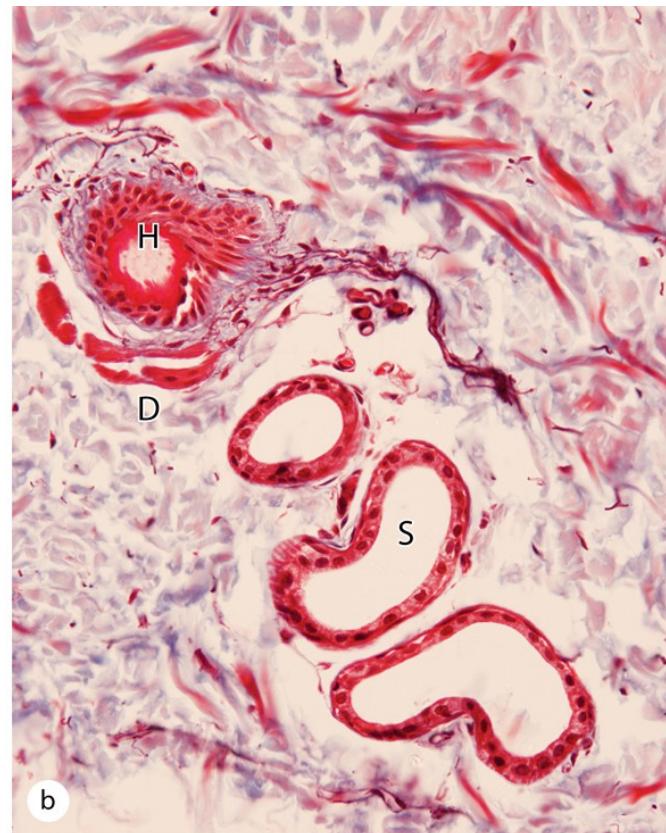
- (a) A section of a pilosebaceous unit shows acini composed of large sebocytes (**S**), which undergo terminal differentiation by filling with small lipid droplets and then disintegrating near the ducts (**D**) opening at the hair (**H**) shaft
- (b) The gland's capsule (**C**) and sebocytes (**S**) at higher magnification. Proliferation of the small progenitor cells just inside the capsule continuously forces sebum into the ducts

### »» MEDICAL APPLICATION

Acne vulgaris involves excessive keratinization within the pilosebaceous unit and excess sebum production. Blockage of ducts in the follicle allow anaerobic bacteria to grow in the accumulated sebum, leading to localized inflammation and neutrophil infiltration.



a



b

## Eccrine and apocrine sweat glands

(a) Eccrine glands have small lumens in the secretory components (**S**) and ducts (**D**), both of which have an irregular stratified cuboidal appearance. Both clear and acidophilic cells are seen in the stratified cuboidal epithelium of the secretory units.

(b) Apocrine sweat glands, which produce a more protein-rich secretion with pheromonal properties, are characterized by secretory portions (**S**) with lumens much larger than those of eccrine glands. Their ducts (**D**) open into hair follicles (**H**) rather than to the epidermal surface.

### » MEDICAL APPLICATION

The sweat of infants with cystic fibrosis (CF) is often salty and is commonly taken as indicative of this genetic disease. CF patients have defects in a transmembrane conductance regulator (CFTR) of epithelial cells that lead to disruptive accumulations of thick mucus in the respiratory and digestive tracts. Failure to remove salt from sweat is related to the same genetic defect.