# Respiratory System

## Human respiration

**Works together with the circulatory system**

**Exchange of gases between atmosphere, blood, and cells**

**If respiratory system and/or circulatory system fails, death will occur**

**Cells need O2 for work; release CO2 as a waste product**

**Accumulation of excess CO2 is toxic to cells and MUST be removed.**

**Types of respiration**

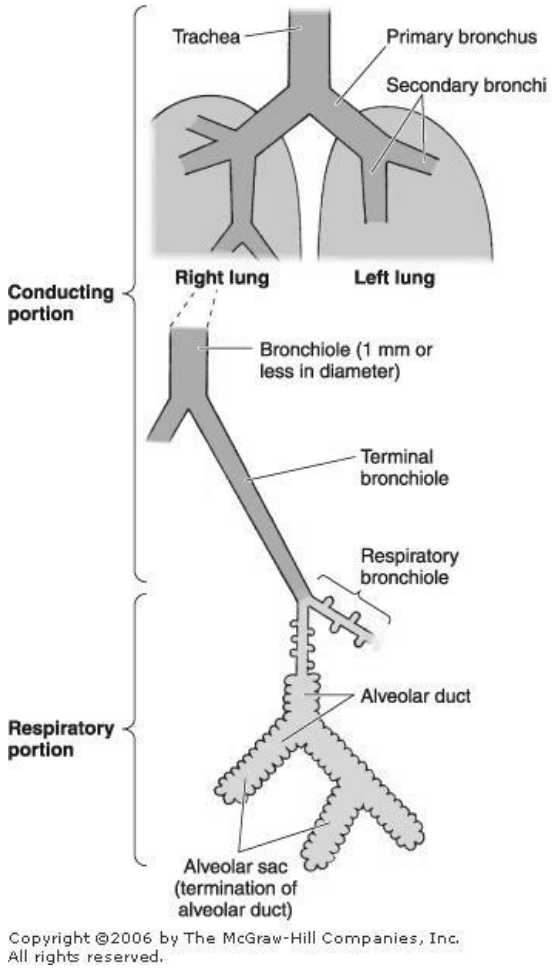
**a. Mechanical: Through the respiratory system. It helps move air into and out of the lungs.**

**b. Cellular : a series of metabolic processes that take place within a cell. Cellular respiration produces energy, which is vital because the energy is used to maintain life.**

The respiratory system includes the **lungs** and a system of tubes that links the sites of gas exchange with the external environment.

The respiratory system is customarily divided into two principal regions :

i. a **conducting portion,** consisting of the nasal cavity, nasopharynx, larynx, trachea, bronchi (Gr. *bronchos,* windpipe), bronchioles, and terminal bronchioles;
ii. and a **respiratory portion** (where gas exchange takes place), consisting of respiratory bronchioles, alveolar ducts, and alveoli. **Alveoli** are specialized saclike structures that make up the greater part of the lungs. They are the main sites for the principal function of the lungs the exchange of $O_2$ and $CO_2$ between inspired air and blood.



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The conducting portion serves two main functions:

i. To provide a conduit through which air can travel to and from the lungs.
ii. And to condition the inspired air , by cleaning and warming the inhaled air,

## Nasal Cavity: Are paired chambers separated by a cartilaginous and bony septum

Respiratory Epithelium

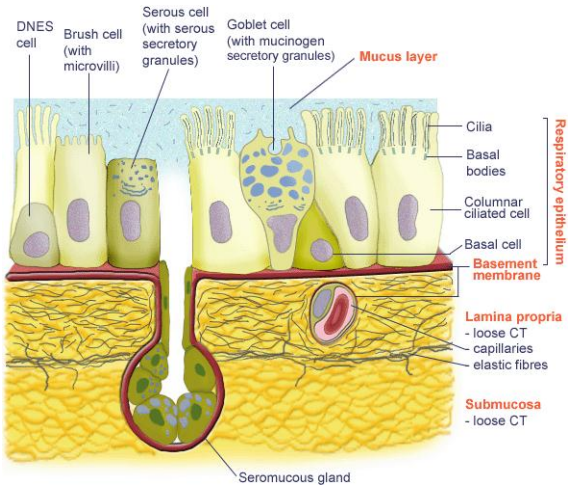
Most of the conducting portion is lined with ciliated pseudostratified columnar epithelium that contains a rich population of goblet cells and is known as **respiratory epithelium** .

**MEDICAL APPLICATION**

**Immotile cilia syndrome,** a disorder that causes infertility in men and chronic respiratory tract infections in both sexes, is caused by immobility of cilia and flagella induced, in some cases, by deficiency of **dynein,** a protein normally present in the cilia. Dynein participates in the ciliary movement

# Mucociliary Escalator

The cilia of the respiratory epithelium beat in concert cranially, effectively moving secreted mucus containing trapped foreign particles toward the oropharynx, for either expectoration or swallowing to the stomach where the acidic pH helps to neutralize foreign material and micro-organisms. This system is collectively known as the *mucociliary escalator* and serves two functions: to keep the lower respiratory tract sterile, and to prevent mucus accumulation in the lungs.
The *mucocilliary escalator* is vital for the movement of mucus up the respiratory tract to the pharynx. The mucus layer is biphasic with a serous, sol layer in which the cilia beat and, above this, a viscoelastic or gel layer. Due to the viscous properties of this upper mucous layer, the tips of the cilia catch in the layer, which may contain particulate matter, and drag it cranially toward the oropharynx.



## Paranasal Sinuses

The paranasal sinuses are closed cavities in the frontal, maxillary, ethmoid, and sphenoid bones.

They are lined with a thinner respiratory epithelium that contains few goblet cells.
***MEDICAL APPLICATION***

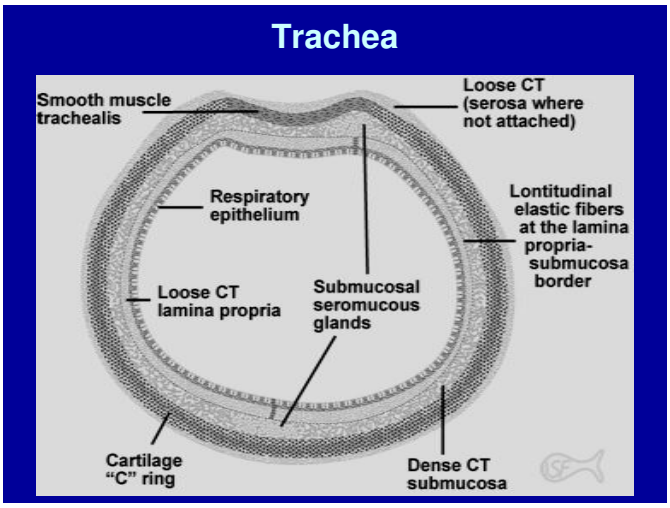
**Sinusitis** is an inflammatory process of the sinuses that may persist for long periods of time, mainly because of obstruction of drainage orifices.

### Larynx

The larynx is an irregular tube that connects the pharynx to the trachea. Within the lamina propria lie a number of laryngeal cartilages. The larger cartilages (thyroid, cricoid, and most of the arytenoids) are hyaline. The smaller cartilages (epiglottis, cuneiform, corniculate, and the tips of the arytenoids) are elastic cartilages. In addition to their supporting role (maintenance of an open airway), these cartilages serve as a valve to prevent swallowed food or fluid from entering the trachea. They also participate in producing sounds for phonation.

## Trachea

The trachea is lined with a typical respiratory mucosa . In the lamina propria are 20 **C**-shaped rings of hyaline cartilage that keep the tracheal lumen open and numerous seromucous glands that produce a more fluid mucus. The open ends of these cartilage rings are located on the posterior surface of the trachea. A fibroelastic ligament and bundle of smooth muscle bind to the perichondrium and bridge the open ends of these **C**-shaped cartilages.




## Bronchial Tree

The trachea divides into two **primary bronchi** that enter the lungs at the hilum.

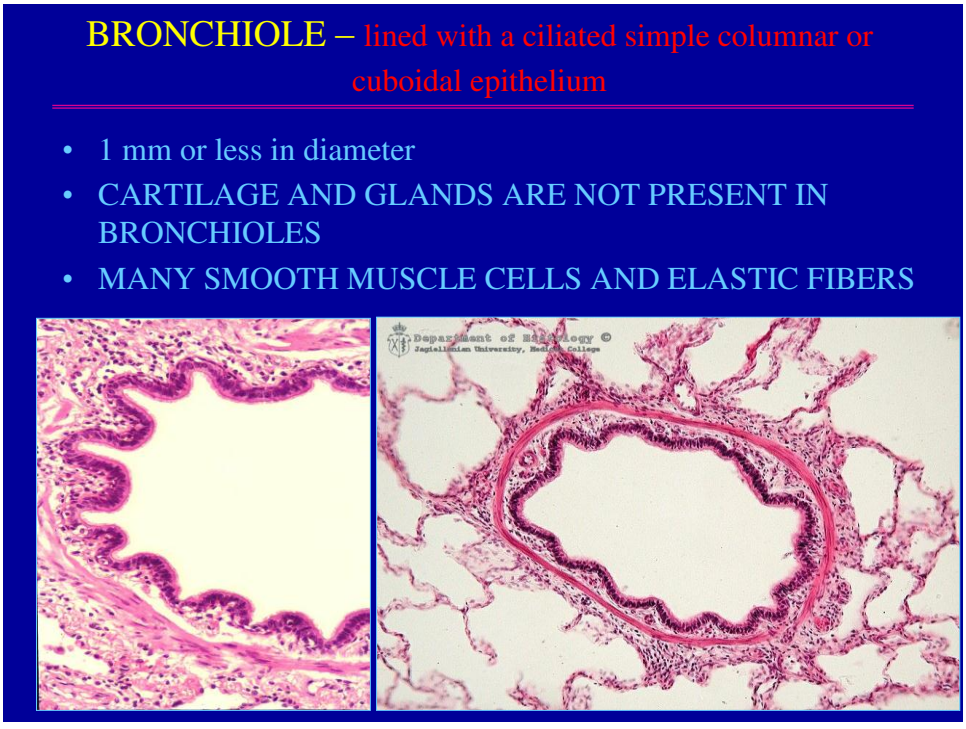
The **bronchi** divide repeatedly, giving rise to smaller bronchi, whose terminal branches are called **bronchioles.** Each bronchiole branches to form five to seven **terminal bronchioles.**

## Bronchi

The mucosa of the bronchi is structurally similar to the mucosa of the trachea . The bronchial cartilages are more irregular in shape than those found in the trachea; in the larger portions of the bronchi, the cartilage rings completely encircle the lumen. As bronchial diameter decreases, the cartilage rings are replaced with isolated plates of hyaline cartilage. The lamina propria is rich in elastic fibers and contains an abundance of mucous and serous glands whose ducts open into the bronchial lumen.

## Bronchioles

Bronchioles, intralobular airways with diameters of 5 mm or less, have **neither cartilage nor glands in their mucosa**; there are only scattered goblet cells within the epithelium of the initial segments. The epithelium of terminal bronchioles also contains **Clara cells**, which are devoid of cilia, have secretory granules in their apex, and are known to secrete proteins that protect the bronchiolar lining against oxidative pollutants and inflammation.




**Bronchiolar lamina** propria is composed largely of smooth muscle and elastic fibers. The musculature of both the bronchi and the bronchioles is under the control of the vagus

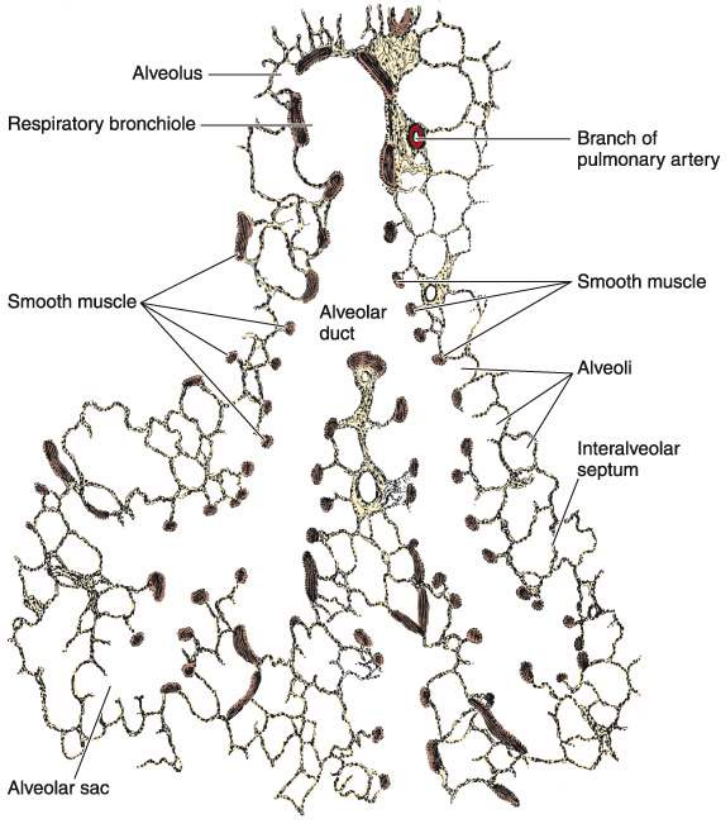
nerve and the sympathetic nervous system. Stimulation of the vagus nerve decreases the diameter of these structures; sympathetic stimulation produces the opposite effect.

**MEDICAL APPLICATION**

The increase in bronchiole diameter in response to stimulation of the sympathetic nervous system explains why epinephrine and other sympathomimetic drugs are frequently used to relax smooth muscle during asthma attacks.

Respiratory Bronchioles

Each terminal bronchiole subdivides into two or more respiratory bronchioles that serve as regions of transition between the conducting and respiratory portions of the respiratory system. The respiratory bronchioles divided into alveoli which increase greatly in number. There are approximately 600 – 800 million alveoli in the two lungs of a human being.

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## Alveoli

The functional unit of the lung is the alveolus .Structurally, alveoli resemble small pockets that are open on one side, similar to the honeycombs of a beehive. Within these cuplike structures, $O_2$ and $CO_2$ are exchanged between the air and the blood. The structure of the alveolar walls is specialized for enhancing diffusion between the external and internal environments.

The epithelium of the alveoli is formed by two cell types:

1. Alveolar type I cells (small alveolar cells or **type I pneumocytes**) .They form the bulk (95%) of the surface of the alveolar walls. Through them the exchange of gases is occurring.
2. Alveolar type II cells (large alveolar cells or **type II pneumocytes**) Type II alveolar cells are precursors to pulmonary **surfactant** (the mixture of phospholipids which keep surface tension in the alveoli low and prevent collapse of the alveoli). They divide by mitosis to replace their own population and also the type I population.

**It has been estimated that approximately 87% of the total lung volume is alveolar, 6% of which is composed of tissue, and the remainder of which is ga**s.

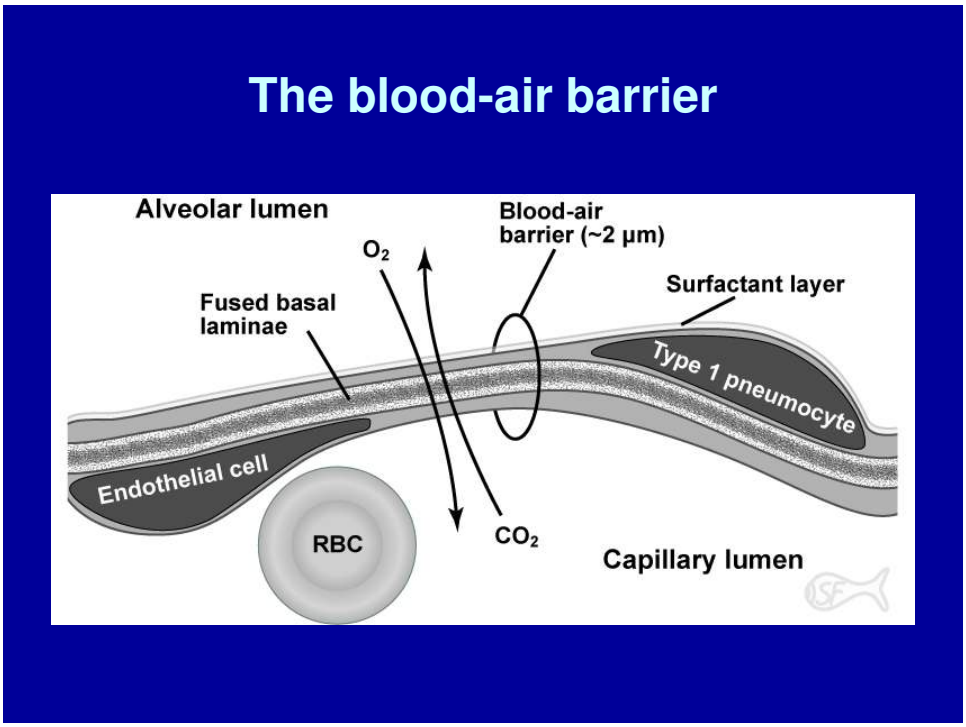
**MEDICAL APPLICATION**

The **respiratory distress syndrome** of the newborn is a life-threatening disorder of the lungs caused by a deficiency of surfactant. It is principally associated with prematurity and is the leading cause of mortality among premature infants.

## Blood air barrier

Air in the alveoli is separated from capillary blood by three components referred to collectively as the **blood air barrier.**The barrier is composed of:

i. The surface lining and cytoplasm of the alveolar cells,
ii. The fused basal laminae of the closely apposed alveolar and endothelial cells,
iii. The cytoplasm of the endothelial cells .




## Lung Macrophages

The alveolar macrophages that scavenge the outer surface of the epithelium within the surfactant layer are carried to the pharynx, where they are swallowed.