

# Respiratory System

## Anatomy

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## Overview

- ◆ Of all the substances that cells and the whole body must have to survive,  $O_2$  is by far the most crucial
- ◆ A person can live a few weeks without food, a few days without water, but only a few minutes without  $O_2$
- ◆ Constant removal of carbon dioxide from the body is just as important for survival as a constant supply of  $O_2$

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## Functions

- ◆ The organs of the respiratory system perform several functions:
  - Gas exchange via diffusion
    - ◆ Delivery of  $O_2$  to body cells
    - ◆ Elimination of  $CO_2$  produced by body cells
  - Regulation of blood pH
  - Filter, warm & humidify the air we breathe
  - Contain receptors for the sense of smell
  - Production of vocal sounds
  - Excretion of heat & water

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## Respiration

- ◆ Ensures O<sub>2</sub> is supplied to body cells
- ◆ CO<sub>2</sub> is removed from the body cells
- ◆ Respiration
  - = **homeostatic mechanism**
  - Helps maintain a constant environment
  - body cells to function effectively

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## Respiratory Organs

- ◆ Organs of the respiratory system
  - Nose & nasal cavities
  - Pharynx
  - Larynx
  - Trachea
  - Bronchi
  - Lungs
  - Alveoli

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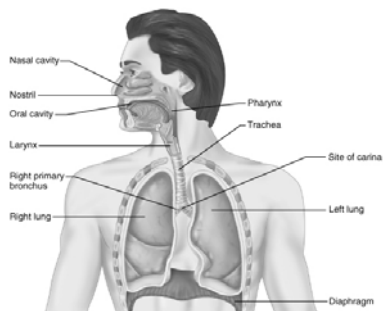
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- ◆ Basic structure is that of a tube with many branches ending in millions of extremely tiny, very thin-walled sacs called **alveoli**
- ◆ Consists of passageways that filter incoming air & carry it into the lungs



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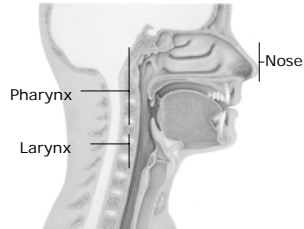
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## Respiratory Tract Divisions

- ◆ Assist in the description of symptoms associated with common respiratory problems such as a cold

- Upper respiratory tract
  - Nose
  - Pharynx
  - Larynx



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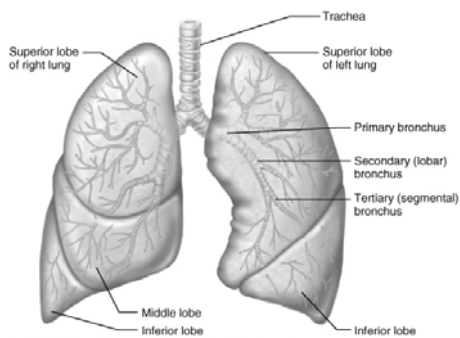
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- ◆ Lower respiratory tract in the thorax
  - trachea, bronchial tree & lungs



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## Respiratory Tract

- ◆ Nose, pharynx, larynx, trachea, bronchi & bronchioles are hollow tubes
  - Form air passageways
  - Constitute conducting portion of respiratory system
- ◆ Air sacs & alveoli
  - Respiratory portion of the respiratory system
  - Gas exchange occurs in the alveoli (large surface area)
  - Alveoli sacs are delicate elastic membranes with extensive capillary network of the pulmonary circulation

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# Anatomy of the Respiratory System

## Upper Respiratory Tract

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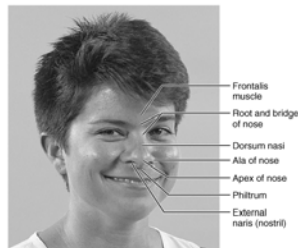
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### Nose

- ◆ Air enters the respiratory tract through the external nares or nostrils
- ◆ Flows into the right & left nasal cavities, (lined by respiratory mucosa)
- ◆ A partition called the nasal septum separates these two cavities
- ◆ Air may also enter via the mouth - the nasal cavities & mouth meet at the region at the back of the mouth = pharynx



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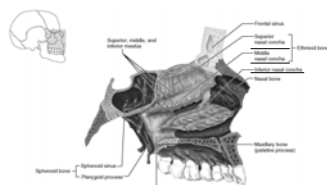
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- ◆ Surface is moist from mucus & warm from blood flow
- ◆ Nerve endings responsible for the sense of smell (olfactory receptors) are located in the nasal mucosa
- ◆ Three conchae protrude into the nasal cavity
- ◆ These increase surface area over which air must flow as it passes through the nasal cavity



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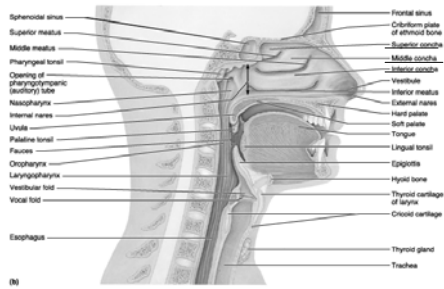
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## Nose



The structure of the conchae increases the surface area over which inhaled air travels ensuring that it is thoroughly warmed & filtered

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## Nose

- ◆ Blood vessels in the nasal mucosa cool hot air & warm cold air
- ◆ Air entering the nose is generally contaminated with one or more common irritants such as insects, dust, pollen & bacteria
- ◆ Air is purified removing almost all contaminants before inspired air reaches the lungs
- ◆ Mucus secreted by mucosa adds moisture to dry air while trapping fine dust particles & micro-organisms
- ◆ Ciliated cells of the mucosa move contaminated mucus into the throat where it is swallowed

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### ◆ Clinical Example:

- Because the mucosa lines the nose, sinus infections often develop from colds in which the nasal mucosa is inflamed
- When the nasal cavity is blocked, the air in the sinuses is absorbed
- Sometimes a sinus headache is incurred & localised over the inflamed area

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## Paranasal Sinuses

- ◆ Four paranasal sinuses- the frontal, maxillary, sphenoidal & ethmoidal – drain into the nasal cavities
- ◆ Paranasal sinuses are lined with mucous membrane that assists in the production of mucus for the respiratory tract
- ◆ Hollow spaces help to lighten the skull & serve as resonant chambers for the production of sound

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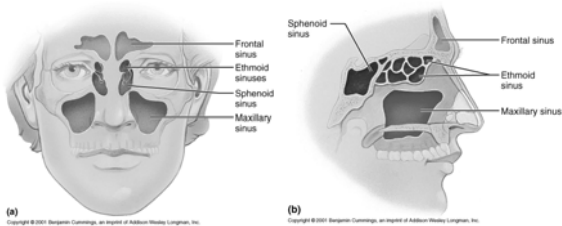
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## Paranasal Sinuses



You can see how a sinus headache would be quite uncomfortable as the pressure within the cavity would build up & be unable to escape (see slide 15)

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## Pharynx

- ◆ Extends from the nasal cavities to the larynx
- ◆ Behind the nasal cavities & above the soft palate is the nasopharynx
- ◆ Dorsally is the oropharynx = digestive & respiratory passageways meet
- ◆ Inferior to oropharynx lies the laryngopharynx immediately before the larynx

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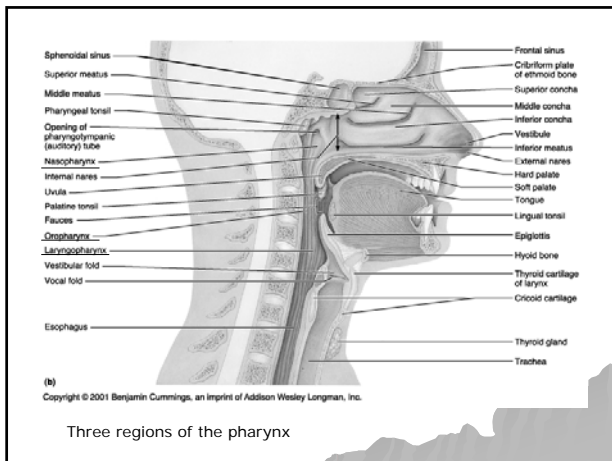
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## Pharynx

- ◆ Two auditory tubes, the Eustachian tubes open from the middle ear into the lateral walls of the nasopharynx
  - Equalise air pressure between the nasopharynx & the middle ear

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## Pharynx

- ◆ Pharyngeal tonsils lie on posterior wall of nasopharynx
  - Traps airborne infectious agents
  - Swollen tonsils are referred to as adenoids which may obstruct the passage of air
- ◆ Palatine tonsils lie on the lateral aspects of the pharynx behind the mouth
  - Function same as pharyngeal tonsil
  - Tonsillitis = inflammation of the palatine tonsils - obstructs nasopharynx, forcing mouth breathing
    - air is not properly moistened, warmed or filtered before reaching the lungs

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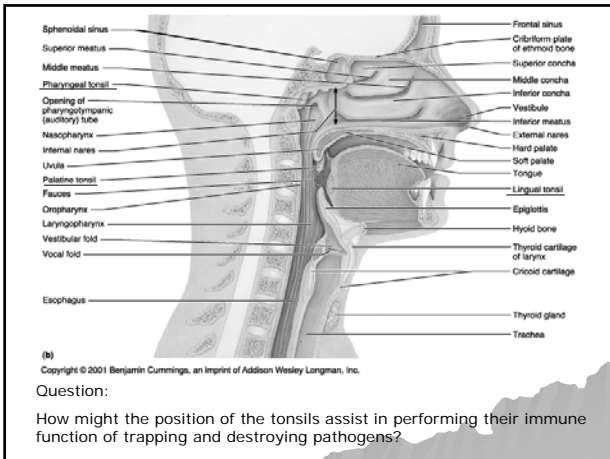
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Question:

How might the position of the tonsils assist in performing their immune function of trapping and destroying pathogens?

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## Pharynx

- ◆ The pharynx is a passageway for both the digestive & respiratory systems
- ◆ Distally, the pharynx branches into two tubes
  - Oesophagus → stomach
  - Larynx → lungs

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## Larynx

- ◆ Cartilaginous structure connecting the pharynx & trachea at the level of the cervical vertebrae
- ◆ Connective tissue containing nine pieces of cartilage arranged in box-like formation
- ◆ Largest cartilage is the thyroid cartilage, AKA "Adam's apple"
  - Thyroid cartilage is visible in the ventral aspect of the throat and is more pronounced in adult males than adult females

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- ◆ The cricoid cartilage resembles a signet ring
  - Connects larynx & trachea
- ◆ The epiglottis, a leaf-shaped "lid" at the entry to the larynx
  - Seals off the respiratory tract when food passes into the oesophagus
- ◆ Opening to the larynx is called the glottis
  - During swallowing the larynx is pulled upward, the epiglottis closes to route food/fluid to the stomach
  - If anything other than air enters the larynx, a cough reflex is triggered to expel the substance & prevent it going to the lungs

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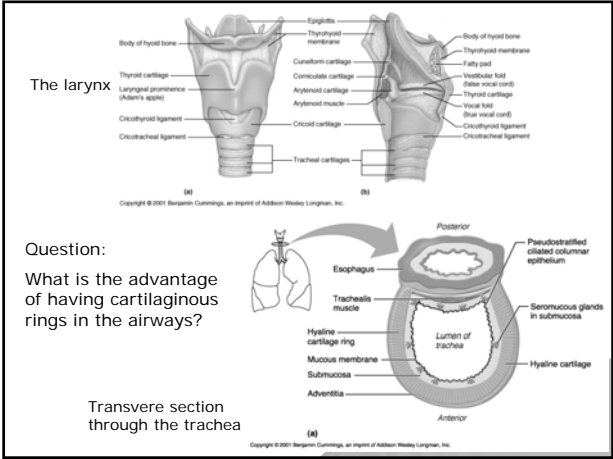
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Question:  
What is the advantage of having cartilaginous rings in the airways?

Transverse section through the trachea

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## Larynx

- ◆ Larynx is a passageway for air & produces sound
- ◆ Two folds of tissue project from the lateral walls of the larynx = vocal cords
- ◆ Exhalation → vocal cords vibrate
  - produce sounds that can be modified into words by muscles of the neck, lips, tongue, & cheeks
- ◆ Length of vocal cords determines pitch → females & children have shorter vocal cords = voices of a higher pitch
  - Read page 842 Jenkins, Kemnitz & Tortora Structures of voice production

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## Trachea

- ◆ Larynx opens into a rigid tube = trachea
- ◆ Trachea is ~12 to 15cms long in the midline of the neck
- ◆ Supported & held open by a stack of C-shaped rings of cartilage open at the dorsal aspect
- ◆ The area between adjacent cartilages & the tips of cartilage contains connective tissue & smooth muscle
- ◆ The trachea is an open passageway for incoming & outgoing air
- ◆ Ciliated cells filter air before it enters the bronchi

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## Trachea

- ◆ By pushing against your throat about an inch above the sternum, you can feel the shape of the trachea
- ◆ Only if you use considerable force can you squeeze it closed
- ◆ Air has no other way to get to the lungs, & complete tracheal obstruction can squeeze the trachea shut & cause death in a matter of minutes
  - Eg. choking on food, tumour or infection causing inflammation of the lymph nodes of the neck

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## Bronchi

- ◆ The trachea branches into two primary bronchi
  - Same structure as the trachea
  - Right bronchus is slightly larger & more vertical than the left
- ◆ Bronchi become smaller & smaller → secondary bronchi then tertiary bronchi
- ◆ As they extend further into the lungs diameter is reduced to about one millimetre
- ◆ Bronchi are now called bronchioles
- ◆ The amount of cartilage reduces as the tubes become smaller & smaller disappearing in the distal bronchioles

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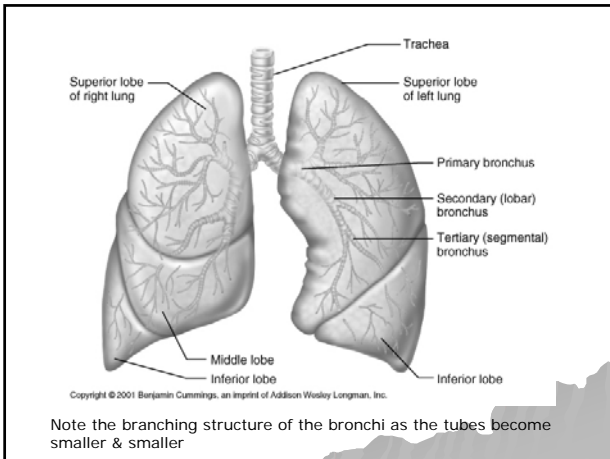
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## Bronchioles

- ◆ Bronchioles are composed of smooth muscle supported by connective tissue
- ◆ Subdivide until they form the smallest air passageways = terminal bronchioles
- ◆ Terminal bronchioles extend into the alveoli
- ◆ Alveoli resemble a single grape & are effective in gas exchange as they are thin-walled & in contact with a blood capillary
- ◆ Membrane inside each alveoli is covered in surfactant which reduces surface tension, keeping them from collapsing as air moves in & out during respiration
- ◆ Branching & rebranching of the bronchi & bronchioles within the lungs is called the bronchial tree

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## Bronchi

Clinical Examples:

- ◆ Inflammation of the bronchial tree is commonly known as bronchitis
- ◆ Asthma also affects the bronchial tree
  - Asthma is accompanied by periodic attacks of wheezing & difficult breathing
  - Caused by spasms of the smooth muscles (as there is no cartilage to hold them open)
  - Often triggered by allergens in the environment
- Read page 844-845 Jenkins, Kemnitz & Tortora Bronchi

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## Lungs

- ◆ Paired organs occupying most of the space of the thoracic cavity
- ◆ Consist of millions of small, cup-shaped out pockets (sacs) called **alveoli**
- ◆ Respiratory membranes of alveoli are a thin barrier in which gases can pass by diffusion
- ◆ ~ 300 million alveoli in an average adult
- ◆ Lungs are separated from one another by a median dividing wall
- ◆ Called the mediastinum
  - contains the heart, thymus, oesophagus, large blood vessels embedded in connective tissue

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## Lungs

- ◆ Lungs are conical shaped with elastic, spongy texture due to the nature of the alveoli
- ◆ Right lung is subdivided into three lobes
- ◆ Left lung is subdivided into two lobes
- ◆ Each lobe is divided into smaller lobules, each lobule is serviced by a large bronchiole

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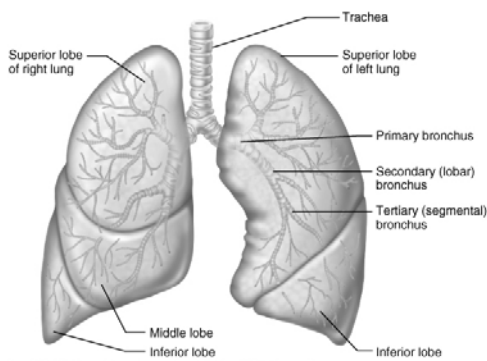
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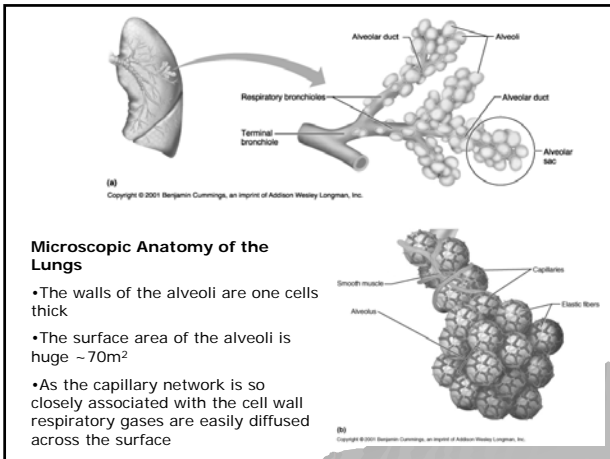
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## Respiratory Membrane

- ◆ Respiratory membrane separates the air in the alveoli from the blood in surrounding capillaries
- ◆ Consists of four cell layers
  - Alveolar wall of Type I & Type II alveolar cells
  - Epithelial basement membrane
  - Capillary basement membrane
  - Capillary endothelium
- Read page 849-850 Jenkins, Kemnitz & Tortora Alveoli

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## Histology of Alveoli

The micrograph shows a cross-section of alveoli. Labels include: Alveoli, capillary, Type I cell, Type II cell, and Epithelial basement membrane.

<http://webanatomy.net/histology/respiratory/alveoli.jpg>

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## Pleura

- ◆ Two-layered membrane surrounding each lung
- ◆ Inner layer = visceral pleura
  - covers the surface of each lung
  - reaches into the fissures between the lobes of the lung
  - encloses the mediastinum
- ◆ Outer layer = parietal pleura
  - lines the inner surface of the thoracic cavity

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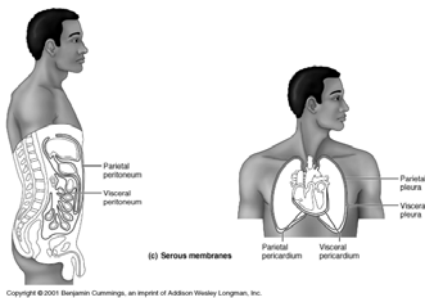
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Who remembers Fred Dagg & his song 'If it weren't for your gumboots'? The pleurisy mentioned in the song is an inflammation of the pleurae. It is a very painful condition as it reduces the ability of the pleural surfaces to move over each other causing rubbing/friction with each breath.

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## Pleura

- ◆ Visceral & parietal pleura are continuous with one another where the primary bronchus, blood vessels & nerves enter each lung
- ◆ Two layers of the pleura form a collapsed sac
- ◆ Area within the sac = pleural cavity
  - Fluid in the cavity keeps the two-pleural membranes in close contact with each other & allows them to glide smoothly over each other
  - Fluid adheres the two layers of the pleura to one another

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## Respiratory Mucosa

- ◆ Membrane lining most of the air distribution tubes in the respiratory system = **respiratory mucosa**
- ◆ Respiratory mucosa is covered with mucus & lines the tubes of the respiratory tree
- ◆ Protective mucus is an important air purification mechanism

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## Respiratory Mucosa

- ◆ ~125ml of respiratory mucus is produced daily
- ◆ Forms a continuous blanket that covers the lining of the air distribution tubes in the respiratory tree
- ◆ Mucus moves upward to the pharynx on millions of hairlike cilia that cover the epithelial cells in the respiratory mucosa
- ◆ Cigarette smoke paralyzes cilia → accumulations of mucus & the typical smoker's cough, which is an effort to clear the secretions

– Read Cari's story in chapter 22 of Jenkins, Kemnitz & Tortora for more on the effects of smoking on the respiratory tract

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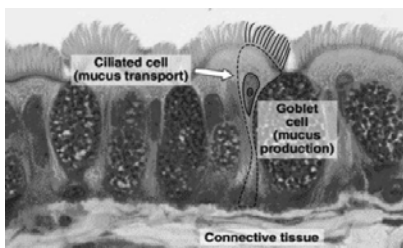
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## Respiratory Mucosa

- This image shows the respiratory mucosa
- The cilia lining the epithelium are clearly seen
- Mucus producing goblet cells are also visible



[http://www.mc.vanderbilt.edu/histology/labmanual2002/labsection2/Respiratory03\\_files/image002.jpg](http://www.mc.vanderbilt.edu/histology/labmanual2002/labsection2/Respiratory03_files/image002.jpg)

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