Respiratory System
Anatomy

Overview

- Of all the substances that cells and the whole body must have to survive, O₂ 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 O₂
- Constant removal of carbon dioxide from the body is just as important for survival as a constant supply of O₂

Functions

- The organs of the respiratory system perform several functions:
  - Gas exchange via diffusion
  - Delivery of O₂ to body cells
  - Elimination of CO₂ 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
Respiration

- Ensures $O_2$ is supplied to body cells
- $CO_2$ is removed from the body cells
- Respiration = **homeostatic mechanism**
  - Helps maintain a constant environment
  - → body cells to function effectively

Respiratory Organs

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

- 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
Respiratory Tract Divisions

- Assist in the description of symptoms associated with common respiratory problems such as a cold
  - Upper respiratory tract
    - Nose
    - Pharynx
    - Larynx

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

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
Anatomy of the Respiratory System

Upper Respiratory Tract

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

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

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 & microorganisms.
Ciliated cells of the mucosa move contaminated mucus into the throat where it is swallowed.

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.
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

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)

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
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

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

Pharynx

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

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
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

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

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
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

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

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
Note the branching structure of the bronchi as the tubes become smaller & smaller.

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

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
Lungs

- Paired organs occupying most of the space of the thoracic cavity
- Consist of millions of small, cup-shaped out pockets (sacs) called \textit{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

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
Microscopic Anatomy of the Lungs
- The walls of the alveoli are one cell thick.
- The surface area of the alveoli is huge ~70m².
- As the capillary network is so closely associated with the cell wall, respiratory gases are easily diffused across the surface.

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

Histology of Alveoli
- http://webanatomy.net/histology/respiratory/alveoli.jpg
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

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.

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
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

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 paralyses 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

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/session2/Respiratory03_files/image002.jpg