# The Respiratory System

AusDBF - eLearning Modules

**Please scroll through each of the pages in this presentation**

Our Mission: To connect people with dragon boating across Australia

# The Respiratory System

## Welcome to AusDBF eLearning module – The Respiratory System

**This presentation contains texts, graphics, videos and an online survey questionnaire.**

**It is important that you read all the text and instructions before you proceed to the next page or option.**

**Any queries please contact development@ausdbf.com.au**

Our Mission: To connect people with dragon boating across Australia

# Control of Ventilation

- the breathing rate increases when the partial pressure of carbon dioxide in the blood increases.
- this is detected by central blood gas chemoreceptors on the anterior surface of the medulla oblongata
- exercise increases the breathing rate due to the extra carbon dioxide produced by the enhanced metabolism of the exercising muscles
- in addition passive movements of the limbs also reflexively produce an increase in the breathing rate

# The Respiratory System

## Introduction

**The respiratory system (also known as the ventilatory system) consists of specific organs and structures enabling gaseous exchange, oxygen ($O_2$) and carbon dioxide ($CO_2$) to occur in the lungs.**

**With the help of the cardiovascular system, both $O_2$ and $CO_2$ can then be transported around the body, via the blood, to the muscle sites to assist with energy production and hence movement.**

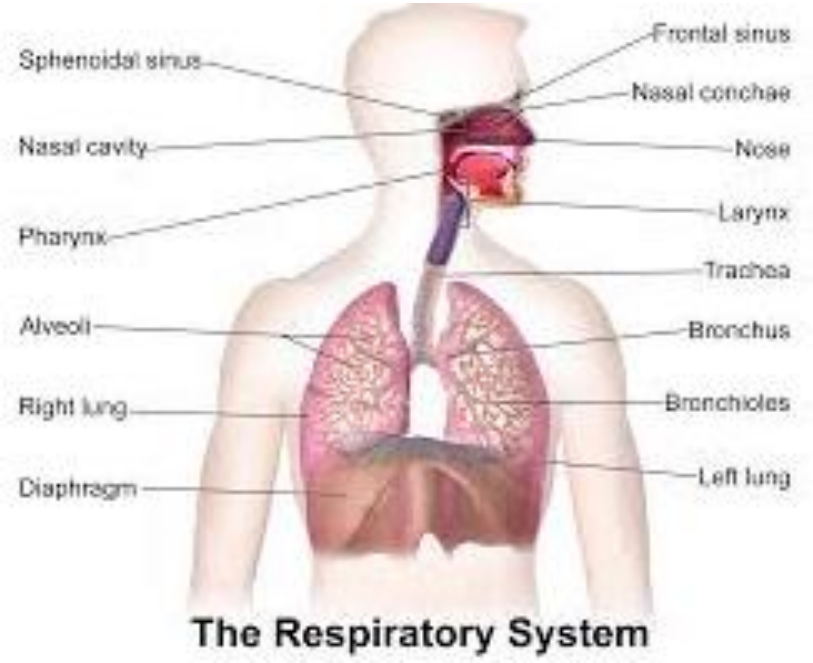
**Gas exchange in the lungs occurs in millions of small air sacs called alveoli. These microscopic air sacs have a very rich blood supply, thus bringing the air into close contact with the blood.**

# Functions of the Respiratory System

## The main functions of the Respiratory System

- enables air, from the atmosphere, to be brought INTO & OUT of the lungs
- transfers oxygen into the blood
- removes carbon dioxide from the blood
- expels HEAT and WATER VAPOUR through the air being breathed out
- enables speech, via the vocal chords, as air is breathed out

# The structure of the  Respiratory System




Lungs are the major organs of the Respiratory System, and are located within the chest cavity, behind the ribs.

The lungs are supported by the “conducting system”, the pleura and diaphragm.

# Structure of the Respiratory System

**The major elements of the "conducting system" provides the pathway for air to move into the lungs, where gaseous exchange occurs.**

**Nasal Cavity**

- air enters here from outside the body
- the interior of the nose lined with cilia, fine hair-like fibres which filter foreign particles from the air as it enters the respiratory tract.
- the air is warmed and moistened ready to be used here

**Pharynx**

- also known as the throat, this is where the mouth and nasal cavities combine.
- here food enters the oesophagus (the digestive system) and air continues into the larynx and is further warmed.

**Larynx**

- contains the vocal chords - the voice box
- is more prominent in males and known as the "Adam's Apple"

# Structure of the Respiratory System

**Trachea**

- also known as the windpipe
- it enables the passage of air into the lungs
- is made up of rings of hyaline cartilage, enclosed by other cartilage and tissue
- is well protected as it sits behind the sternum
- divides into two bronchi *(sing. bronchus)*

**Bronchi**

- there are two bronchi
- the main branches of the trachea, structurally are the same as for the trachea
- each bronchus leads into one of the lungs
- each bronchus subdivides into a series of smaller air passages, the bronchioles

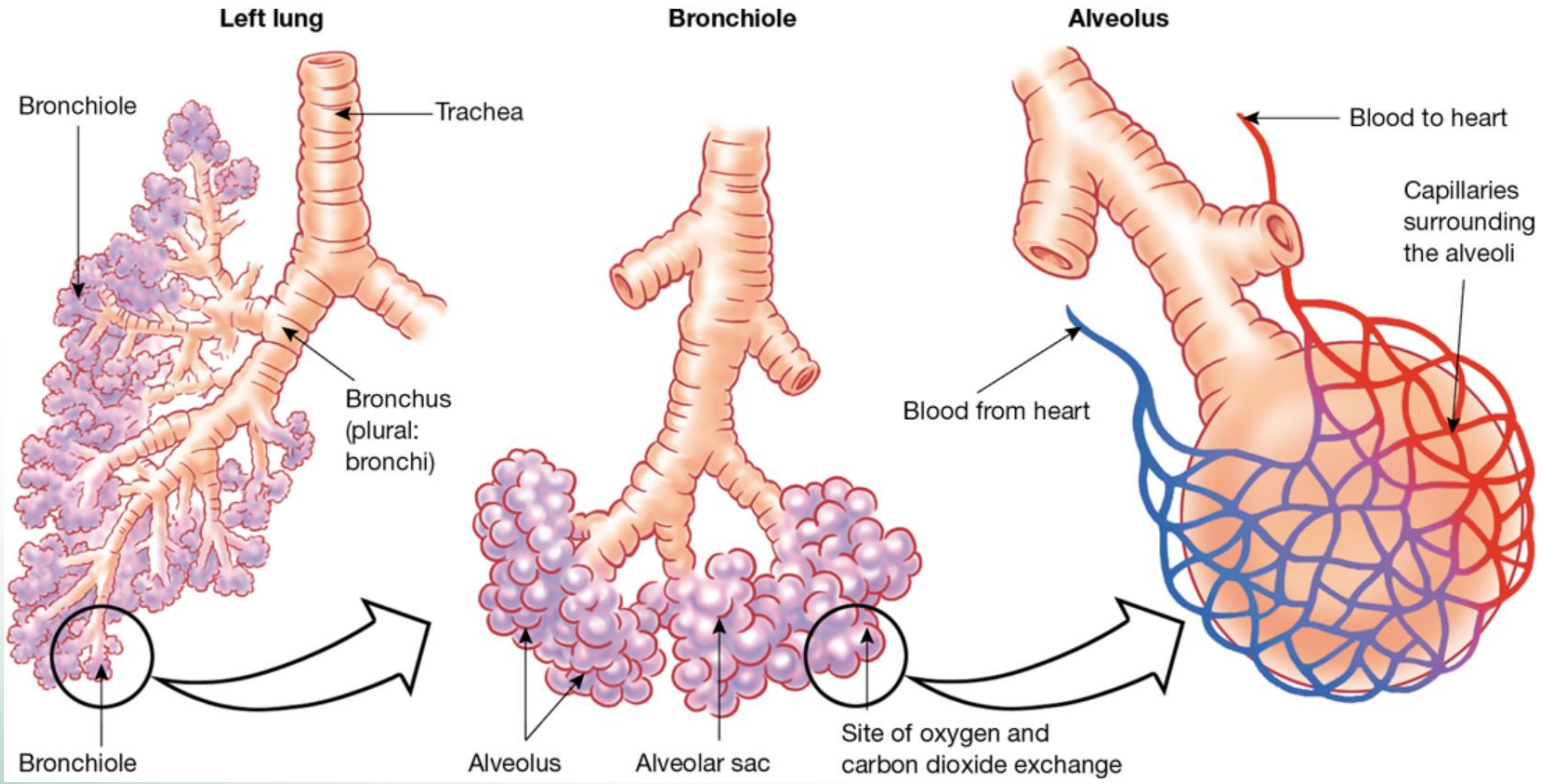
**Bronchioles**

- the bronchioles subdivide into a series of further subdividing air passages

**Terminal bronchioles**

- smaller bronchioles that terminate to form the alveoli (air sacs)

# A close up look inside the lungs




Our Mission: To connect people with dragon boating across Australia

# Structure of the Respiratory System

**Alveoli** *(sing. alveolus)*

- are found at the end of the bronchioles
- are microscopic and only one cell thick
- are shaped like “cup shaped” sacs
- are surrounded by a very rich network of capillaries
- this where the exchange of $O_2$ for $CO_2$ and water occurs

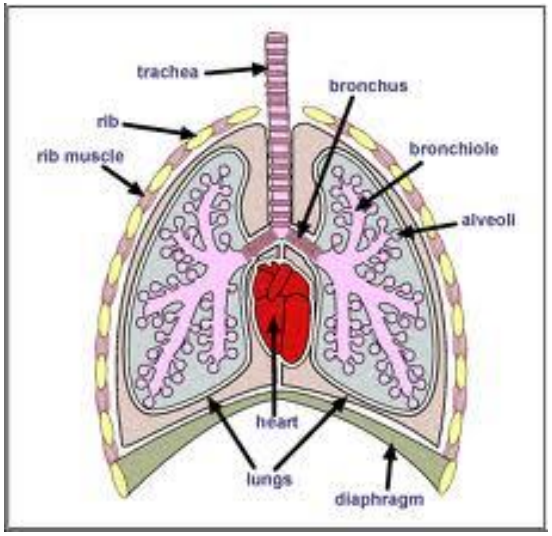
**The Pleura**

- is a thin membrane that surrounds each lung, one that folds back on itself to form the pleural sac
- the pleural sac contains a small amount of fluid used to assist with lubrication as the lungs expand and contract during respiration
- the pleura is attached to the inside of the chest cavity and to the top of the diaphragm.

# Structure of the Respiratory System

## The Diaphragm

- is an **involuntary** smooth muscle
- an involuntary muscle contracts and relaxes to aid breathing, whether during sleep or consciousness.
- with contraction and relaxation, it moves up and down
- this causes the chest cavity to decreases and increases in size, causing breathing (inspiration and expiration)
- Is shaped like a parachute




# Other interesting Facts

## Vocalization

- the movement of air through the larynx, pharynx and mouth allows us to communicate, speak, articulate and sing.
- the vibration of air flowing across the larynx (vocal cords) results in sound.

## Being “winded”

- a blow to the midriff, during sport, may hit the diaphragm, causing it to spasm.
- the athlete in this case is ‘winded’ and may have difficulty breathing.
- encouraged the athlete to relax and wait for the muscle spasm to subside, and allow normal breathing.

## Surface area of the all the alveoli in the human lung…

- if flattened out would cover a tennis court

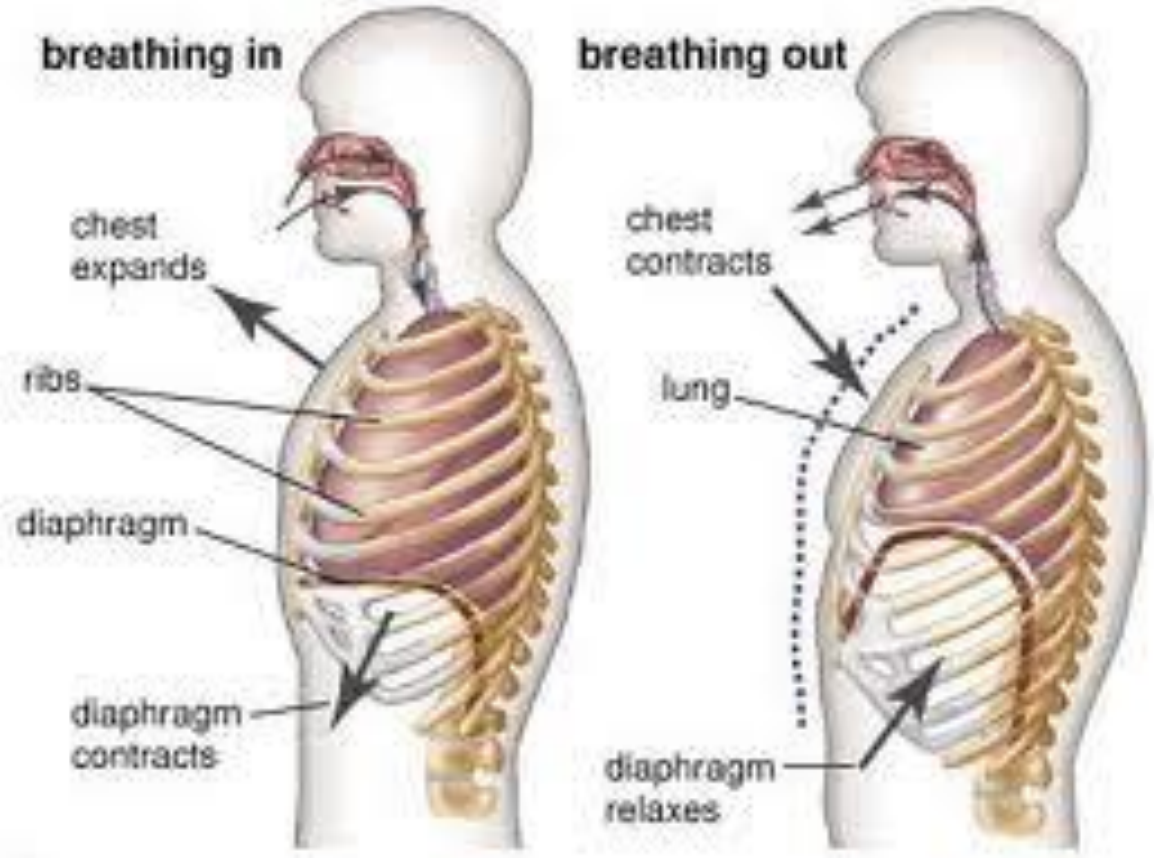
## The human lungs contain……

- Approximately 3 litres of alveolar air.

# Control of Ventilation

- ventilation of the lungs occurs via the respiratory centres in the medulla oblongata and the pons of the brainstem
- these areas form a series of neural pathways which receive information about the partial pressures of oxygen and carbon dioxide in the arterial blood
- this information determines the average rate of ventilation of the alveoli of the lungs, to keep these pressures constant.
- the respiratory centre does so via motor nerves which activate the diaphragm and other muscles of respiration

# The Mechanics of Breathing
## Inspiration and Expiration




Our Mission: To connect people with dragon boating across Australia

# Inspiration

- movement of the diaphragm initiates breathing
- when the diaphragm contracts it moves downwards and increases the size of chest cavity
- the intercostal muscles (found between each pair of ribs) also assists as pulls the ribcage outwards – other muscles in the neck and upper chest area also assist in the expansion of the chest cavity
- the increase in size of the chest cavity results in a **decrease in air pressure in the lungs**, lower than that of the atmosphere
- gases always travels from high pressure gradients to low pressure gradients
- **when the chest cavity INCREASES in size, air is drawn INTO the lungs**

# Expiration

- when the diaphragm relaxes it moves upwards, creating a dome like shape, and decreases the size of chest cavity
- the intercostal muscles (found between each pair of ribs) also assists as pulls the ribcage inwards
- the decrease in size of the chest cavity results in **an increase in air pressure in the lungs**, greater than that in the atmosphere
- gases always travels from high pressure gradients to low pressure gradients
- **when the chest cavity DECREASES in size, air is EXPELLED out of the lungs**

# Gaseous Exchange

**The respiratory and the cardiovascular system work together They transfer and transport gas molecules, in particular oxygen and carbon dioxide, around the body.**

- gases are exchanged through the process of diffusion.
- this involves the movement of molecules from a higher concentration to a lower concentration across a thin membrane.

**Pulmonary diffusion**

- is the process to describe the exchange of gases in the lungs.
- both capillaries and alveoli have very thin wall membranes, one cell thick
- these gases, $O_2$ and $CO_2$ move across these membranes, moving in the direction of from a high to a low concentration
- oxygen and $CO_2$ attaches to the haemoglobin in the red blood cells for transportation around the body

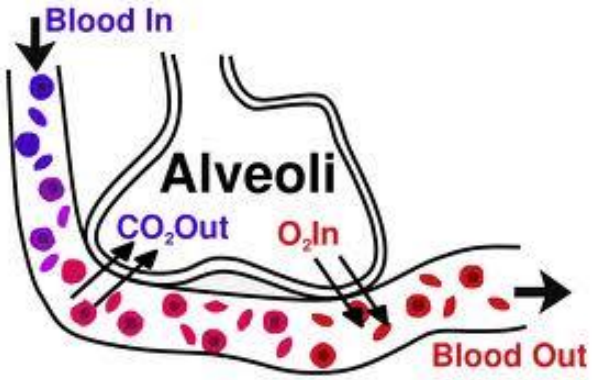
# Gaseous Exchange

**Gaseous exchanges occurs in the lungs at the alveoli/capillary**
(and also at the capillary/muscle interface)

**Pulmonary Diffusion**

**$O_2$ diffuses from**
- a high concentration in the alveoli
  **TO** a low concentration in the blood

**$CO_2$ diffuses from**
- a high concentration in the blood
  **TO** a low concentration in the alveoli



# Gaseous Exchange

**During inspiration**,

- $O_2$ enters the lungs via breathing
- the oxygen, $O_2$, in the alveoli is in a higher concentration than in the blood in the capillaries…so…..
- the $O_2$ diffuses, from the higher concentration in the alveoli, TO the lower concentrations in the blood in the capillaries

**During expiration**,

- the carbon dioxide, $CO_2$, in the capillaries is in a higher concentration than the air in the alveoli …so…..
- the $CO_2$ diffuses, from the higher concentration in the blood, TO the lower concentrations into the alveoli
- this $CO_2$ is expelled on outward breaths.

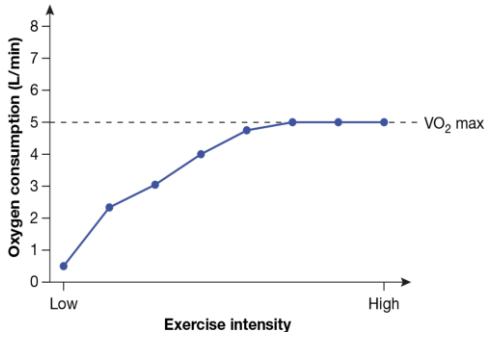
# Responses of the Respiratory System to Exercise

## Increased diffusion

- during exercise, the diffusion capacity at the alveoli/capillary and muscle/capillary interface is increased to allow greater amounts of oxygen and carbon dioxide to be exchanged at these sites.

## Increased oxygen uptake ($VO_2$)

- oxygen uptake increases due to the greater demand for oxygen by the muscles
- increases linearly until maximum levels of oxygen uptake are achieved




## Increased efforts from ribcage muscles and diaphragm

- these muscles work harder to enable increased expansion and contraction of the chest cavity
- needed to accommodate the increased air volumes that are being demanded by the working muscles

# Responses of the Respiratory System to Exercise

- when you exercise your body, a greater availability of $O_2$ is required at the muscle sites, where greater energy production is required.

- we increase our breathing rate, and breath more deeply, to enable more $O_2$ to enter the lungs

- this enables greater amounts of $O_2$ to diffuse into the bloodstream, and be transported to the working muscles (and wastes and $CO_2$ to be breathed out)

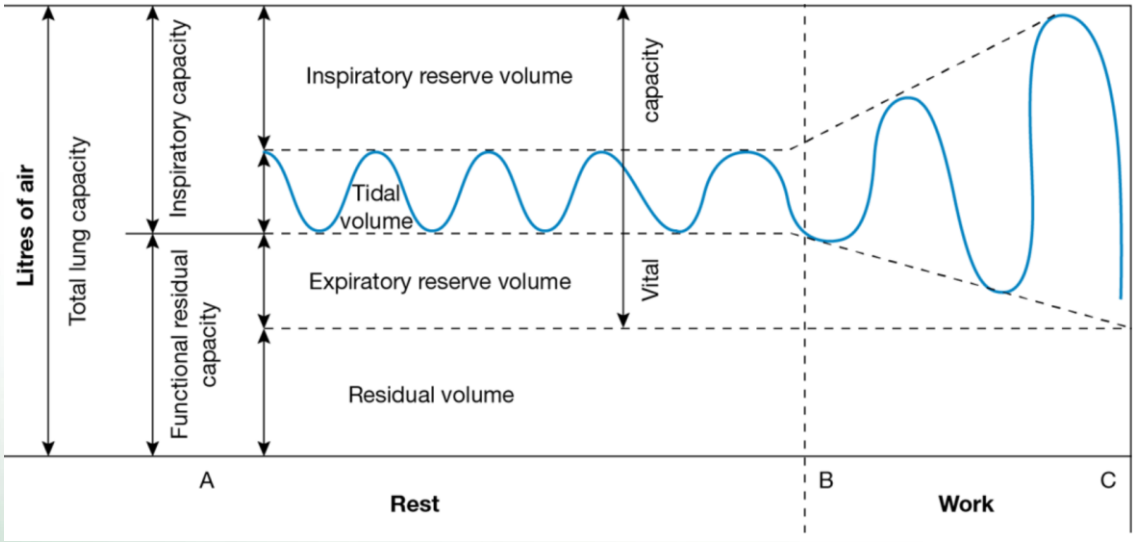
**Ventilation (V)** – amount of air breathed in & out in one minute
- at rest – approx. 6 Litres/min
- at exercise – can increase up to 120 Litres/min

**Respiratory Rate (RR)** – the amount of breathes in a minute
- resting breathing rate for an adult approximately 12 breaths /min
- during exercise this can increase to 30 breaths/min

**Tidal Volume** – the amount of air in one breath
- At rest – 0.5 Litres
- While exercising can increase to approx. 4 Litres

# Responses of the Respiratory System to Exercise

**This shows the relationship of the various lung capacities, at rest and during exercise**



# Lung Volumes and other related Definitions

VITAL CAPACITY (VC)

- the maximum amount of air that can be expelled from the lungs after a maximal inspiration

TIDAL VOLUME

- the amount of air we inspire and expire in a normal breath

TOTAL LUNG CAPACITY (TLC)

- the volume of air that can be held in the lungs after maximum inspiration.
- TLC for males approximately 6 litres and females is approx. 4.2 litres
  Note the difference between genders

RESPIRATION RATE (RR)

- the number of times you breathe per minute
- the respiration rate of an average adult AT REST is 12-18 times per minute
- during EXERCISE the respiration rate of an average adult could increase up to 35 times per minute

# Ventilation, Tidal Volume and Respiratory Rate

## VENTILATION

- the amount of air inspired in one minute

**Ventilation = TV (tidal volume) x RR (respiratory rate)**

**AT REST**
Average adult ventilation = 0.5 x 12 = 6 litres per minute

- respiration rate (RR) of an average adult at rest is approx. 12 times/ minute
- tidal volume (TV) at rest is approx. 0.5 litres

**DURING EXERCISE**
Average adult ventilation = 4.0 x 30 = 120 litres per minute

- respiration rate of an average adult could increase up to 30 times/minute
- tidal volume can increase to approx. 4 llitres

# $VO_2$ Maximum. (Maximum Oxygen Uptake)

- is a measure of aerobic power (also known as aerobic capacity, cardiovascular endurance)
- is the maximum amount of oxygen that can be used by the muscles to produce work, measured in millilitres (mL) per kilogram of body weight per minute (ml/kg/min)
- is the best way of measuring efficiency of your circulatory, respiratory and muscular systems under exercise conditions

**Some tests commonly used to measure $V0_2$ max**

- ✓ Treadmill tests (direct measurement)
- ✓ 12 min walk/run (estimate)
- ✓ 20 metre multistage beep test (estimate)
- ✓ 2 km Rowing ergometer test (estimate)

# Oxygen Uptake

## Oxygen uptake increases with exercise


- At rest 3-4 mL/kg/min
- Exercise 30-50 mL/kg/min

## Average $VO_2$ max …..

- untrained males 42- 46 mL/kg/min
- untrained females 30 – 39 mL/kg/min

- Note the gender differences, due to heart, lung and body size for example

- Elite aerobic athletes, depending on their sport, can have $VO_2$ max readings of 50 – 85mL/kg/min

# Other function of the lungs

**Cough reflex and sneezing**

- often caused by the irritation of nerve endings within the nasal passages or airways

- these responses cause air to be expelled forcefully from the trachea or nose, respectively. In this manner, irritants caught in the mucus which lines the respiratory tract are expelled or moved to the mouth where they can be swallowed, or removed.

**During coughing**

- contraction of the smooth muscle in the airway walls narrows the trachea by pulling the ends of the cartilage plates together and by pushing soft tissue into the lumen.

- this increases the expired airflow rate to dislodge and remove any irritant particle or mucus.

# Respiratory System – possible medical issues

**Medical Issues are often classified into several general groups –**

- Airway obstructive conditions (eg. asthma, bronchitis, emphysema)
- Vascular diseases (eg. pulmonary oedema, pulmonary embolism, pulmonary hypertension)
- Infectious, environmental and other "diseases" (eg. pneumonia, tuberculosis, asbestosis, particulate pollutants)
- Pulmonary restrictive conditions (e.g., fibrosis, sarcoidosis, alveolar damage, pleural effusion)
- Primary cancers (eg. bronchial carcinoma, mesothelioma)
- Secondary cancers (eg. cancers that originated elsewhere in the body, but have seeded themselves in the lungs)
- Insufficient surfactant (eg. respiratory distress syndrome in pre-term babies) .

Please **turn up your volume** then

click on the URL link below to view a short video

of the Respiratory system.

When the video is completed

please return and go to the next slide in this presentation.

https://youtu.be/DZBQMnx3cv8