UNIT – 3

RESPIRATORY SYSTEM

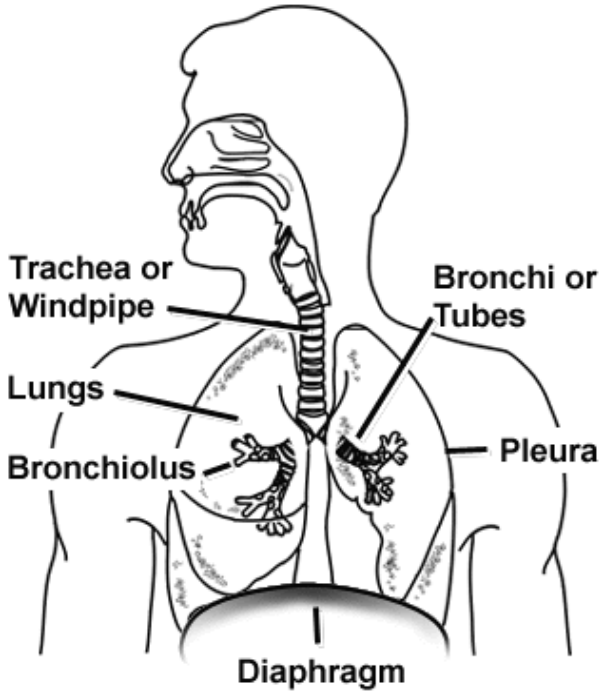
The exchange of gases in any biological process is termed respiration. To sustain life, the human body must take in oxygen, which combines with carbon, hydrogen, and various nutrients to produce heat and energy for the performance of work.

As a result of this process of metabolism, which takes place in the cells, a certain amount of water is produced along with the principal waste product, carbon dioxide (CO_2).

The entire process of taking in oxygen from the environment, transporting the oxygen to the cells, removing the carbon dioxide from the cells, and exhausting this waste product into the atmosphere must be considered within the definition of respiration.

Physiology of Respiratory System

- Air enters the lungs through the air passages, which include the nasal cavities, pharynx, larynx, trachea, bronchi, and bronchioles, as shown in Figure.

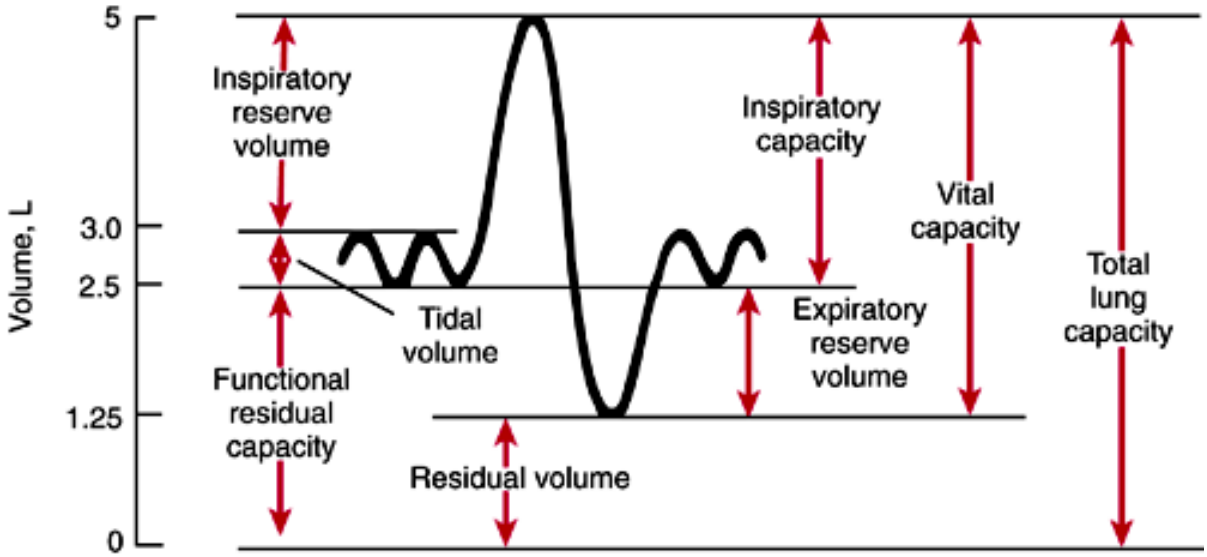


- The lungs are elastic bags located in a closed cavity, called the thorax or thoracic cavity. The right lung consists of three lobes (upper, middle, and lower), and the left lung has two lobes (upper and lower).
- The larynx, sometimes called the "voice box" (because it contains the vocal cords), is connected to the bronchi through the trachea, sometimes called the "windpipe."
- Above the larynx is the epiglottis, a valve that closes whenever a person swallows, so that food and liquids are directed to the esophagus (tube leading to the stomach) and into the stomach rather than into the larynx and trachea.

- The trachea is about 1.5 to 2.5 cm in diameter and approximately 11 cm long, extending from the larynx to the upper boundary of the chest.
- Here it bifurcates (forks) into the right and left main stem bronchi. Each bronchus enters into the corresponding lung and divides like the limbs of a tree into smaller branches.
- The branches are of unequal length and at different angles, normally present in the human body. Farther along these branching, the air-conducting tubes are called bronchioles.
- As they continue to decrease, they form the terminal bronchioles, which branch again into the respiratory bronchioles, where some alveoli are attached as small air sacs in the walls of the lung.
- After some additional branching, these air sacs increase in number, becoming the pulmonary alveoli. The alveoli are estimated that, some 300 million alveoli are found in the lungs.
- The lungs are covered by a thin membrane called the pleura. The part of the pleural membrane lining the thoracic wall is called the parietal pleura, whereas that portion covering and firmly adherent to the surface of the lungs themselves is called the pulmonary pleura or visceral pleura.
- Breathing is accomplished by musculature that changes the volume of the thoracic cavity and, in so doing, creates negative and positive pressures that move air into and out of the lungs.
- Two sets of muscles are involved: those in and near the diaphragm that cause the diaphragm to move up and down, changing the size of the thoracic cavity

Lung Volumes and Capacities

The basic pulmonary tests designed for determination of lung volumes and capacities which are a function of an individual's physical characteristics and the condition of his breathing mechanism, are given in Figure



The tidal volume (TV), or normal depth of breathing, is the volume of gas inspired or expired during each normal, quiet, respiration cycle.

Inspiratory reserve volume (IRV) is the extra volume of gas that a person can inspire with maximal effort after reaching the normal end inspiratory level. The end inspiratory level is the level reached at the end of a normal, quiet inspiration.

The expiratory reserve volume (ERV) is that extra volume of gas that can be expired with maximum effort beyond the end expiratory level. The end expiratory level is the level reached at the end of a normal, quiet expiration.

The residual volume (RV) is the volume of gas remaining in the lungs at the end of a maximal expiration.

The vital capacity (VC) is the maximum volume of gas that can be expelled from the lungs by forceful effort after a maximal inspiration. The vital capacity is also the sum of the tidal volume, inspiratory reserve volume, and expiratory reserve volume.

The total lung capacity (TLC) is the amount of gas contained in the lungs at the end of a maximal inspiration. It is the sum of the vital capacity and residual volume. Total lung capacity

is also the sum of the tidal volume, inspiratory reserve volume, expiratory reserve volume, and residual volume.

The inspiratory capacity (IC) is the maximum amount of gas that can be inspired after reaching the end expiratory level. It is the sum of the tidal volume and the inspiratory reserve volume.

The functional residual capacity, often referred to by its abbreviation, FRC, is the volume of gas remaining in the lungs at the end expiratory level. It is the sum of the residual volume and the expiratory reserve volume.

In addition to the static volumes and capacities given above, several dynamic measures are used to assess the breathing mechanism. They are Forced Expiratory volume and Maximum voluntary ventilation.

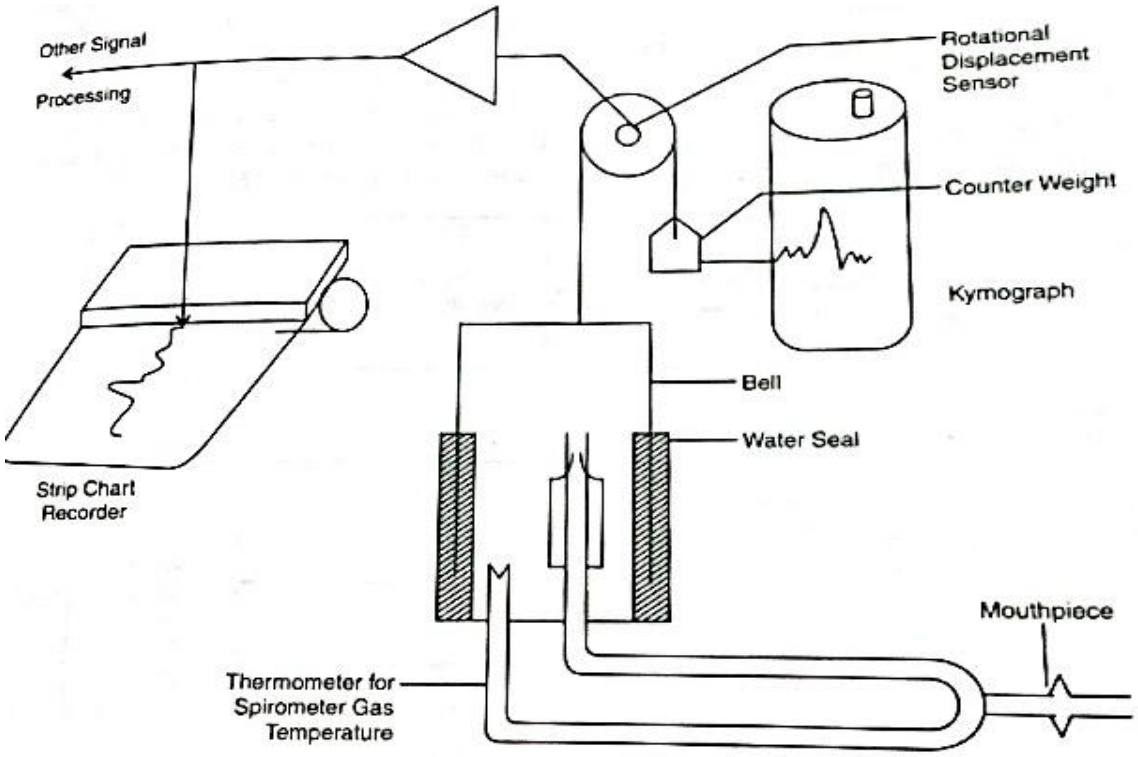
A measure of the maximum amount of gas that can be expelled in a given number of seconds is called **forced expiratory volume (FEV).** This is usually given with a subscript indicating the number of seconds over which the measurement is made. For example, FEV, indicates the amount of air that can be blown out in 1 second following a maximum inspiration, while FEV_3 is the maximum amount of air that can be expired in 3 seconds.

Maximal breathing capacity (MBC) or maximal voluntary ventilation (MVV) is a measure of the maximum amount of air that can be breathed in and blown out over a sustained interval, such as 15 or 20 seconds.

MECHANICS OF BREATHING

Water Sealed Spirometer

All the parameters dealing with the mechanics of breathing can be derived from measurement of lung volumes at various levels and conditions of breathing, pressures within the lungs and the thorax with respect to outside air pressure, and instantaneous airflow. The most widely used laboratory instrument for respiratory volume measurements is the recording spirometer, an example of which is shown in Figure.



All lung volumes and capacities that can be determined by measuring the amount of gas inspired or expired under a given set of conditions or during a specified time interval can be obtained by use of the spirometer. Included are the timed vital capacity and forced expiratory volume measurements.

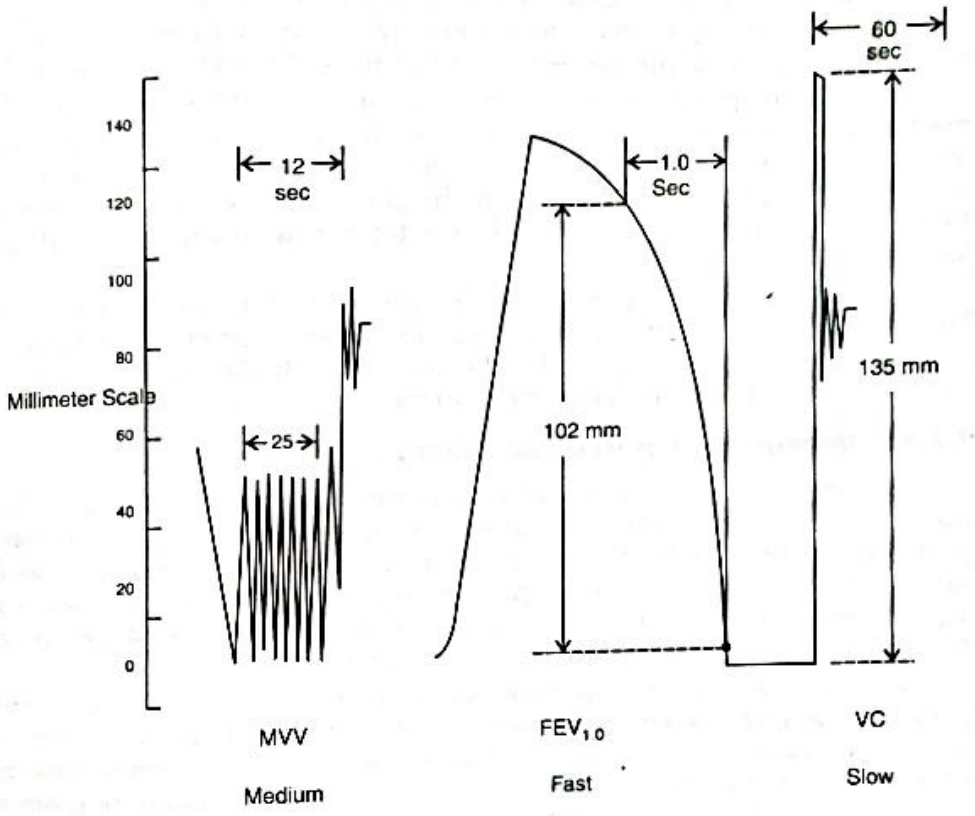
The only volume and capacity measurements that cannot be obtained with a spirometer are those requiring measurement of the gas that cannot be expelled from the lungs under any conditions. Such measurements include the residual volume, functional residual capacity, and total lung capacity.

The standard Spirometer consists of a movable bell inverted over a chamber of water. Inside the bell, above the water line, is the gas that is to be breathed.

The bell is counterbalanced by a weight to maintain the gas inside at atmospheric pressure so that its height above the water is proportional to the amount of gas in the bell.

A breathing tube connects the mouth of the patient with the gas under the bell. Thus, as the patient breathes into the tube, the bell moves up and down with each inspiration and expiration in proportion to the amount of air breathed in or out.

Attached to the bell or the counterbalancing mechanism is a pen that writes on an adjacent drum recorder, called a kymograph. As the kymograph rotates, the pen traces the breathing pattern of the patient. A typical spirogram can be seen from the following figure.



Respiratory Therapy Equipment

When a patient is incapable of adequate ventilation by natural processes, mechanical assistance must be provided so that sufficient oxygen is delivered to the organs and tissues of the body and excessive levels of carbon dioxide are not permitted to accumulate.

The procedures and instrumentation involved in providing mechanical assistance in respiration and in supplying hypoxic patients with higher-than-normal concentrations of oxygen or other therapeutic gases or medications constitute a field known as respiratory therapy.

Instruments for respiratory therapy include such devices as inhalators, ventilators, respirators, resuscitators, positive-pressure breathing apparatus, humidifiers, and nebulizers.

Inhalators:

- The term inhalator generally indicates a device used to supply oxygen or some other therapeutic gas to a patient who is able to breathe spontaneously without assistance.

- As a rule, inhalators are used when a concentration of oxygen higher than that of air is required. The inhalator consists of a source of the therapeutic gas, equipment for reducing the pressure and controlling the flow of the gas, and a device for administering the gas.

- The oxygen concentration presented to the patient is controlled by adjusting the flow of gas into the mask.

Ventilators and Respirators:

The terms ventilator and respirator are used interchangeably to describe equipment that may be employed continuously to improve ventilation of the lungs and to supply humidity or aerosol medications to the pulmonary tree.

Most respirators in common use are classified as assistor-controllers, and can be operated in any of three different modes. These modes differ in the method by which inspiration is initiated.

- **In the assist mode** inspiration is triggered by the patient. A pressure sensor responds to the slight negative pressure that occurs each time the patient attempts to inhale and triggers the apparatus to begin inflating the lungs. Thus, the respirator helps the patient inspire when he wants to breathe. The assist mode is used for patients who are able to control their breathing but are unable to inhale a sufficient amount of air without assistance or for whom breathing requires too much effort

- **In the control mode** breathing is controlled by a timer set to provide the desired respiration rate. Controlled ventilation is required for patients who are unable to breathe on their own. In this mode the respirator has complete control over the patient's respiration and does not respond to any respiratory effort on the part of the patient.

- **In the assist-control mode** the apparatus is normally triggered by the patient's attempts to breathe, as in the assist mode. However, if the patient fails to breathe within a predetermined time, a timer automatically triggers the device to inflate the lungs. Thus, the patient controls his own breathing as long as he can, but if he should fail to do so, the machine is able to take over for him. This mode is most frequently used in critical care settings.

Humidifiers, Nebulizers, and Aspirators:

In order to prevent damage to the patient's lungs, the air or oxygen applied during respiratory therapy must be humidified. Thus, virtually all inhalators, ventilators, and respirators include equipment to humidify the air, either by heat vaporization (steam) or by bubbling an air stream through a jar of water.

When therapy requires that water or some type of medication be suspended in the inspired air as an aerosol, a device called a **nebulizer** is used. In a nebulizer the water or medication is picked up by a high-velocity jet of oxygen (or some other gas) and break the substance into controllable-sized droplets or particles, which are then applied to the patient via a respirator.

Aspiration and other types of suction apparatus are often included as part of a ventilator or inhalator to remove mucus and other fluids from the airways. Where the aspirator is not provided as part of the respiratory therapy equipment, a separate suction device may be utilized.