

Biochemistry of respiration

The goals of respiration are to provide oxygen to the tissues and to remove carbon dioxide. To achieve these goals, respiration can be divided into four major functions: (1) pulmonary ventilation, which means the inflow and outflow of air between the atmosphere and the lung alveoli; (2) diffusion of oxygen and carbon dioxide between the alveoli and the blood; (3) transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells; and (4) regulation of ventilation and other facets of respiration.

Air pressures in lungs

The air pressure in lungs is denoted as centimetres of water. 1 cm of water pressure indicates the amount of pressure exerted by column of water of 1 cm height at 4°C at the standard acceleration due to gravity. The air pressure in lungs is contributed by

1. **Pleural pressure.**
2. **Alveolar pressure.**

Pleural pressure indicates the pressure of the fluid in the thin space between lung pleura and the chest wall pleura. The normal pleural pressure in the beginning of inspiration is –5 cms of water. The suction of pleural fluid into the lymphatic channels leads to causation of suction pressure in lungs.

Alveolar pressure: it is the pressure of the air inside the lung alveoli. –1 cm water pressure needed to suck 0.5 liters of air.

Surfactant, Surface Tension, and Collapse of the Alveoli

Principle of Surface Tension:

When water forms a surface with air, the water molecules on the surface of the water have an especially strong attraction for one another. As a result, the water surface is always attempting to contract. This is what holds raindrops together: that is, there is a tight contractile membrane of water molecules around the entire surface of the raindrop. Now let us reverse these principles and see what happens on the inner surfaces of the alveoli. Here, the water surface is also attempting to contract. This results in an attempt to force the air out of the alveoli through the bronchi and, in doing so, causes the alveoli to try to collapse. The net effect is to cause an elastic contractile force of the entire lungs, which is called the surface tension elastic force.

Surfactant and Its Effect on Surface Tension:

Surfactant is a surface active agent in water, which means that it greatly reduces the surface tension of water. It is secreted by special surfactant-secreting epithelial cells called type II alveolar epithelial cells, which constitute about 10 per cent of the surface area of the alveoli. These cells are granular, containing lipid inclusions that are secreted in the surfactant into the alveoli. Surfactant is a complex mixture of several phospholipids, proteins, and ions. The most important components are the phospholipid dipalmitoylphosphatidylcholine, surfactant apoproteins, and calcium ions. The dipalmitoylphosphatidylcholine, along with several less important phospholipids, is responsible for reducing the surface tension. It does this by not dissolving uniformly in the fluid lining the alveolar surface. Instead, part of the molecule dissolves, while the remainder spreads over the surface of the water in the alveoli.

This surface has from one twelfth to one half the surface tension of a pure water surface. In quantitative terms, the surface tension of different water fluids is approximately the following: pure water, 72 dynes/cm; normal fluids lining the alveoli but without surfactant, 50 dynes/cm; normal fluids lining the alveoli and with normal amounts of surfactant included, between 5 and 30 dynes/cm.

Pulmonary Volumes

1. The tidal volume is the volume of air inspired or expired with each normal breath; it amounts to about 500 milliliters in the adult male.
2. The inspiratory reserve volume is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force; it is usually equal to about 3000 milliliters.
3. The expiratory reserve volume is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration; this normally amounts to about 1100 milliliters.
4. The residual volume is the volume of air remaining in the lungs after the most forceful expiration; this volume averages about 1200 milliliters.