

Respiration

Energy is needed for cell activities:
growth, reproduction, repair, movement,
etc...

Metabolism refers to all of the chemical reactions in the body, where molecules are synthesized (anabolism) and decomposed (catabolism). Metabolism is a balancing act between using energy for anabolic reactions and releasing energy for catabolic reactions.

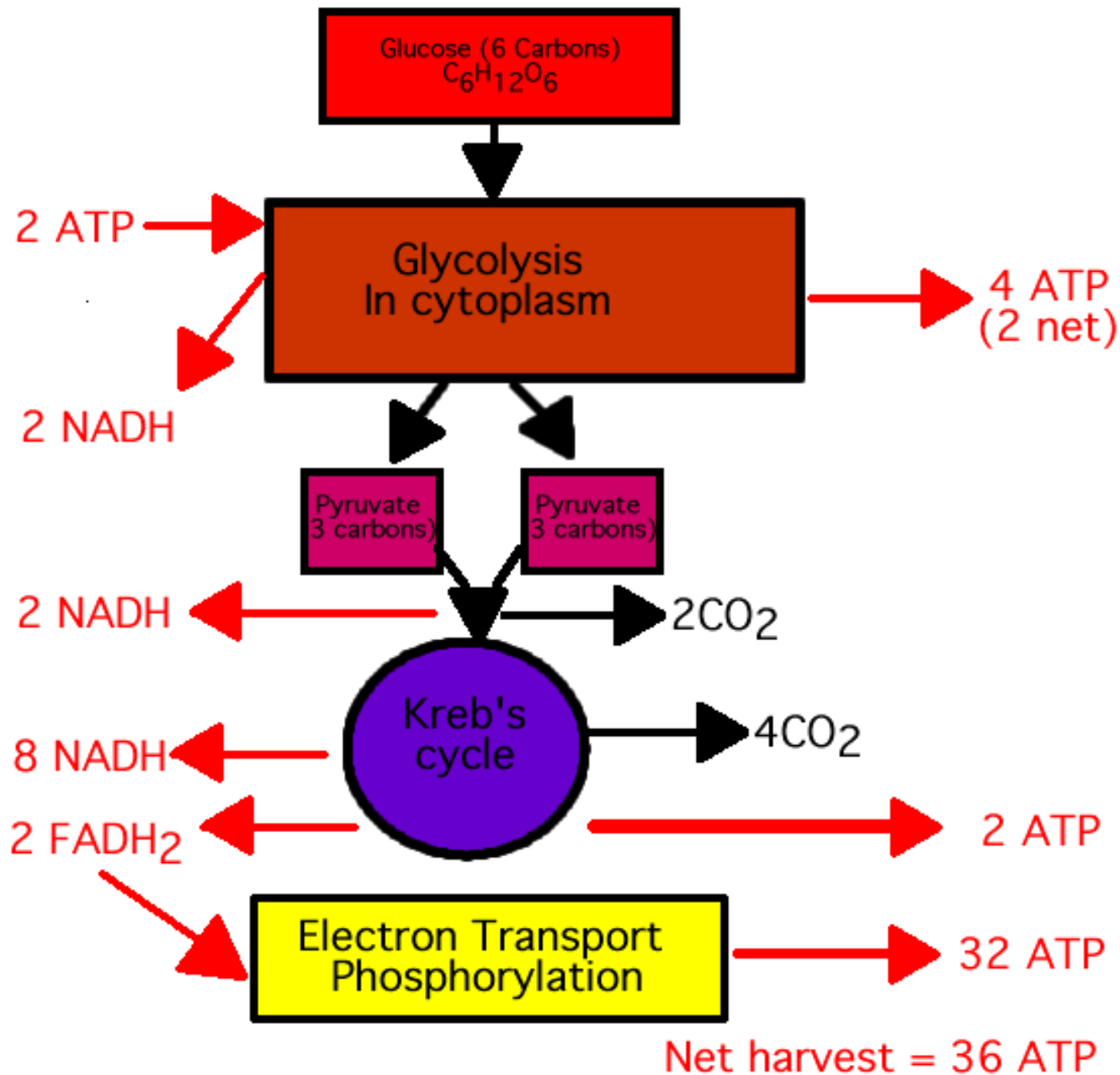
Aerobic Cellular Respiration

Summary: Some of this process occurs in the mitochondria of cells.

glucose + oxygen-----> carbon
dioxide + ENERGY (**36 net** or 38 total
ATP) + H₂O

This reaction consists of three stages:

- 1) Glycolysis
- 2) Kreb's Cycle
- 3) Electron Transport Chain



Glycolysis

Glucose is the primary source of energy for cellular activities.

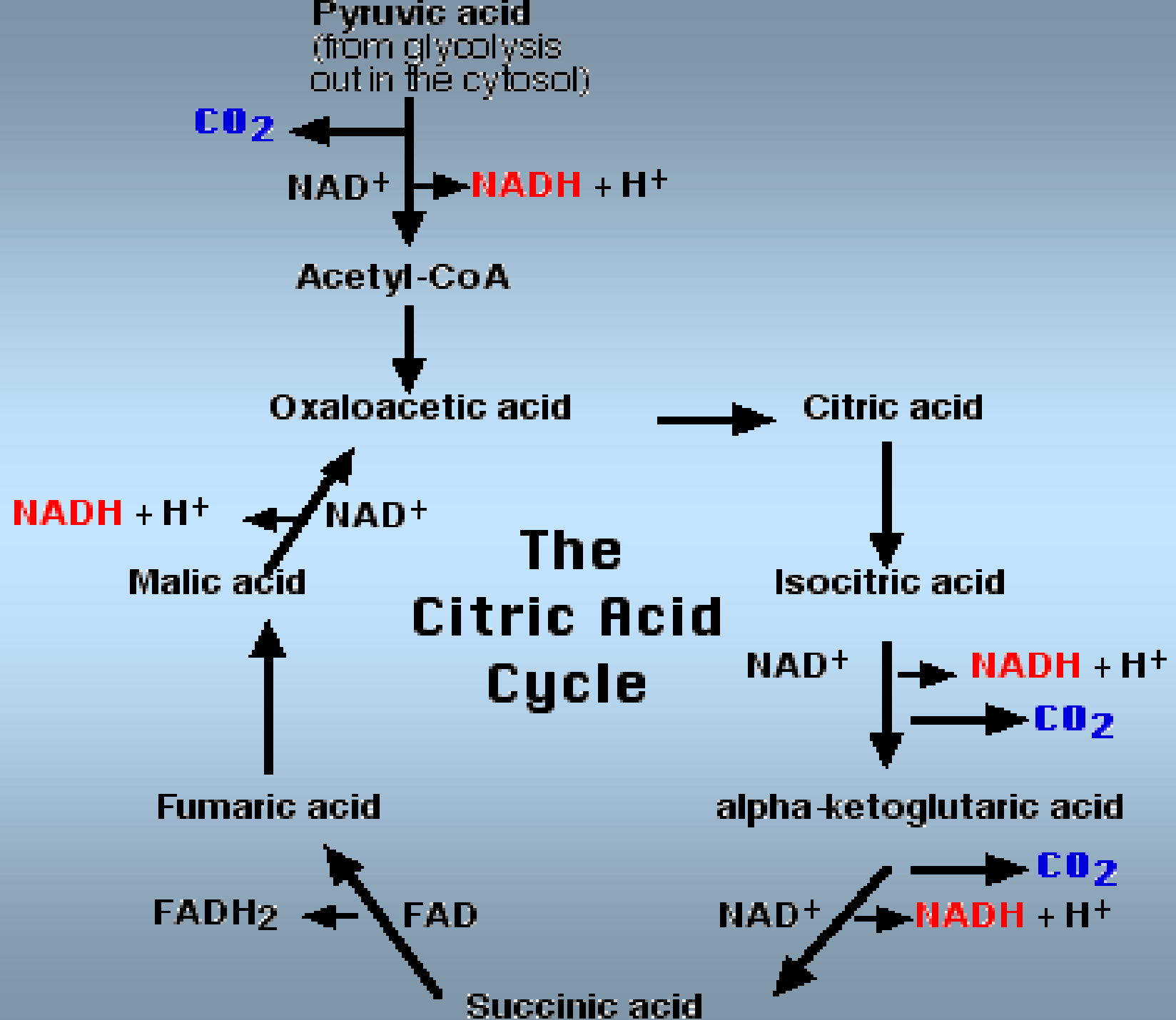
Glucose is broken down to produce 2 pyruvic acid molecules and 2ATP are produced.

Glucose-----> 2 pyruvic acid + 2
ATP

Kreb's Cycle

Pyruvic acid is converted into Acetyl coenzyme A, then in a complex series of reactions it is broken down and CO₂ is released. Hydrogen ions and electrons are transferred to carrier molecules (NADH and FADH₂).

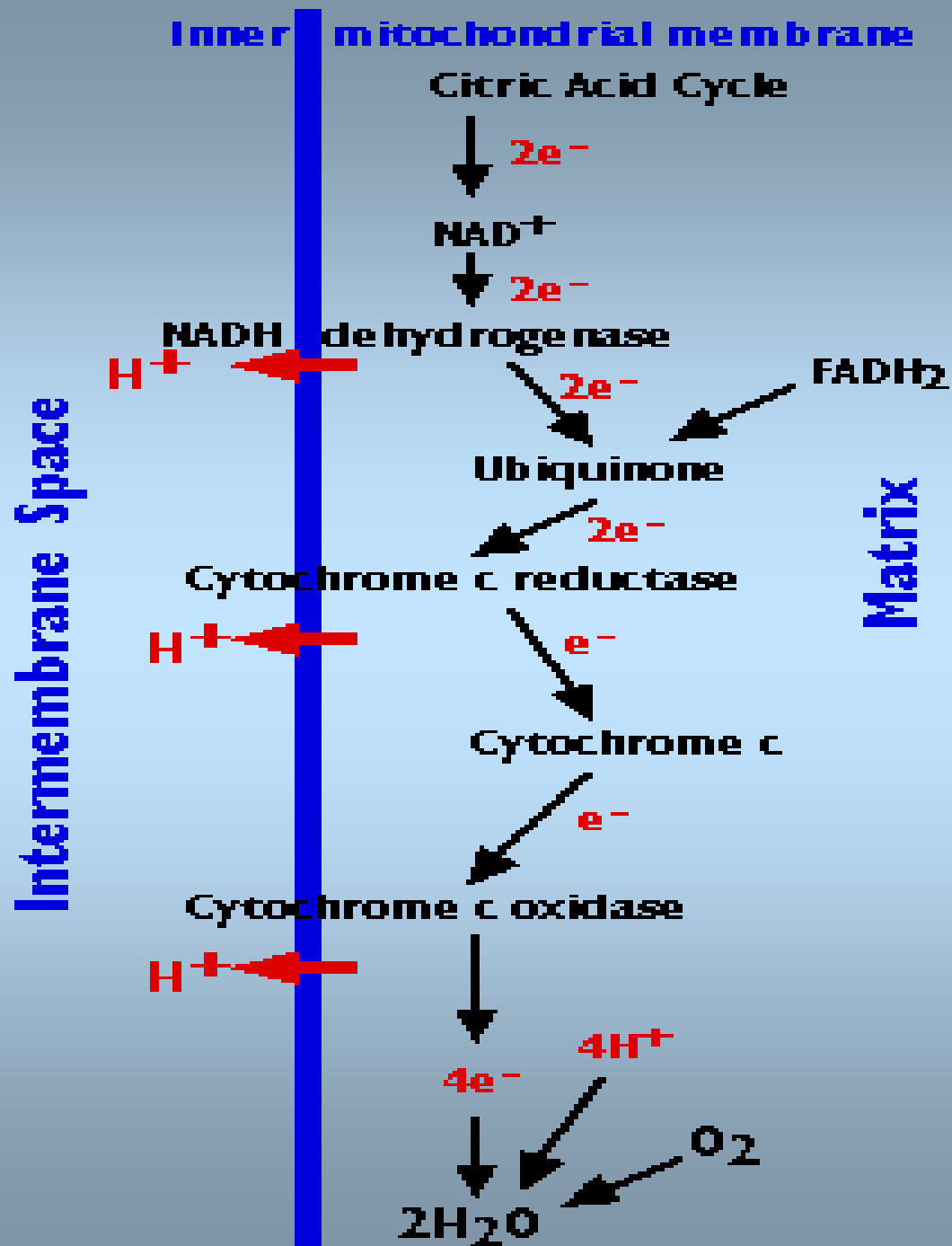
Pyruvic acid----->
CO₂ + e⁻ and H⁺ (electron carrier molecules)

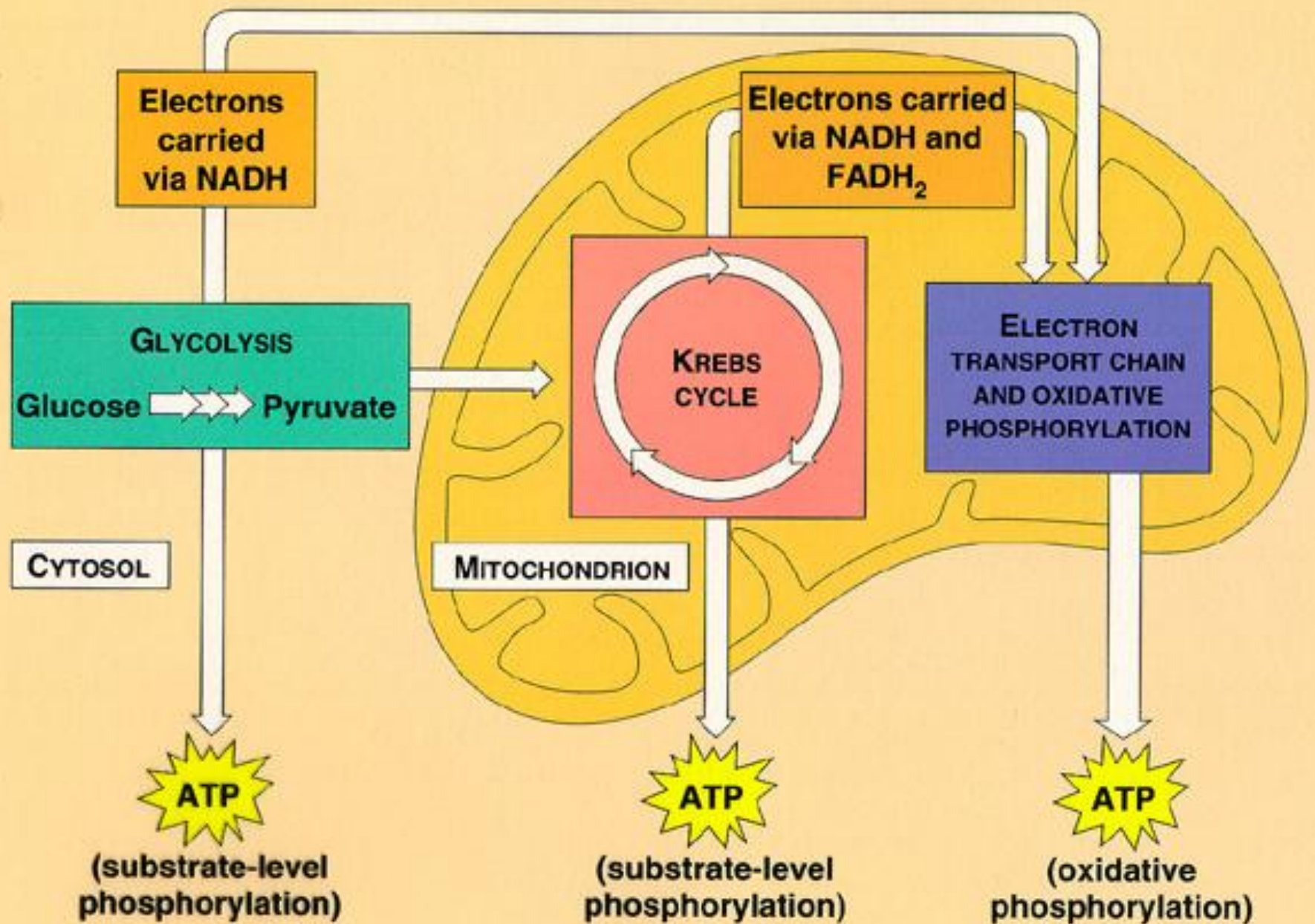


Electron Transport Chain

Consists of a series of reactions where e^- and H^+ are transferred from molecule to molecule with ATP being released at each step. Oxygen acts as the final hydrogen acceptor and water is produced.

Electron carrier molecules
(e^- and H^+) + oxygen \longrightarrow H_2O .





Anaerobic Respiration

Is a process that does not involve the use of oxygen. The ATP production can take place but the net energy yield is much lower. This process begins with glycolysis:

Glycolysis

Glucose is the primary source of energy for cellular activities.

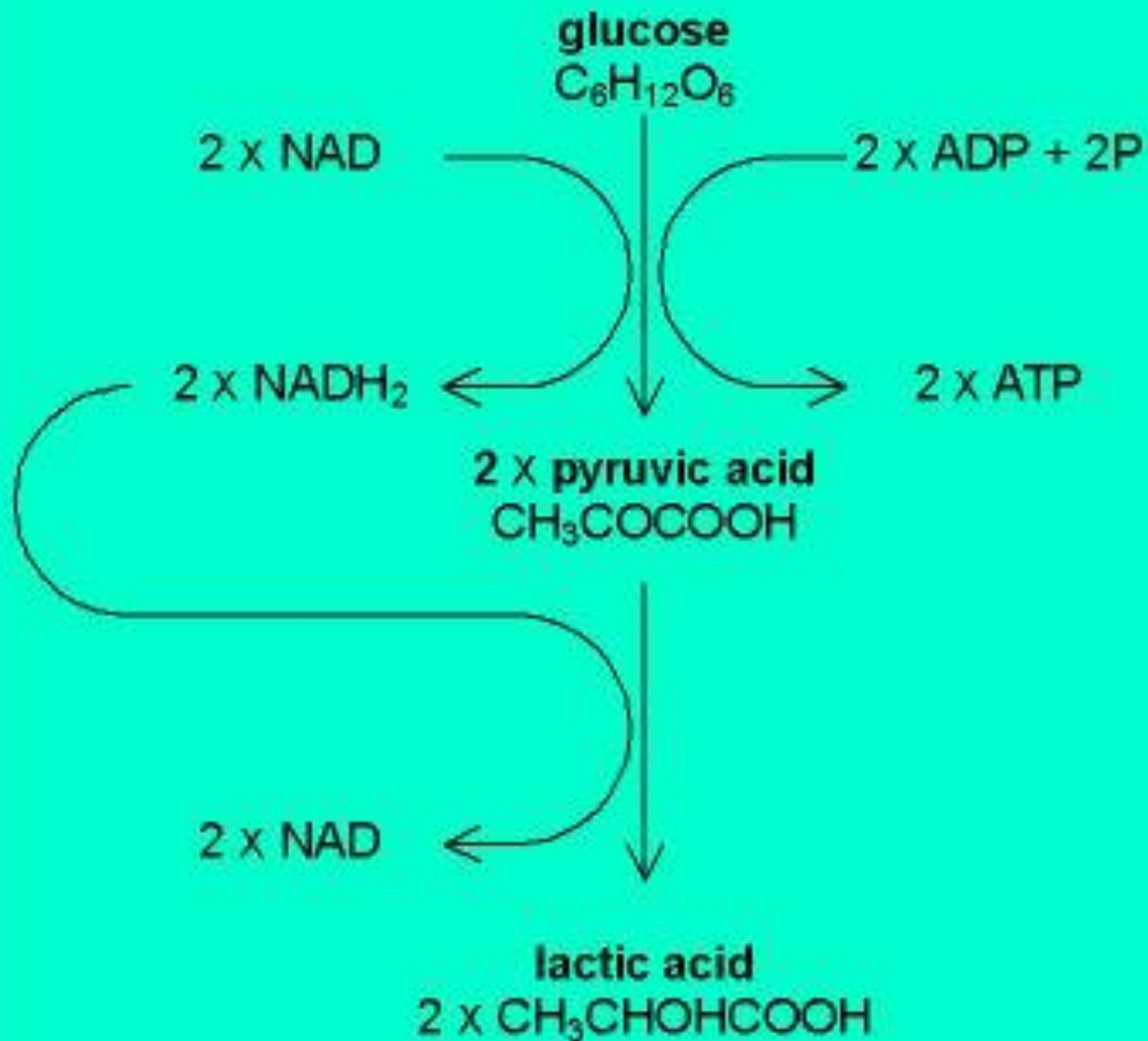
Glucose is broken down to produce 2 pyruvic acid molecules and 2ATP are produced.

Glucose-----> 2 pyruvic acid + 2
ATP

Pyruvic acid -----> Lactic acid + 2
ATP

When oxygen is not available the pyruvic acid produced during glycolysis can be converted into **lactic acid** with a net energy gain of 2 additional ATP.

ANAEROBIC RESPIRATION



Since a relatively small amount of energy is released from the glucose molecule in the absence of oxygen , intense cellular activity like muscle fiber contraction during heavy exercise can continue for only a short period of time.

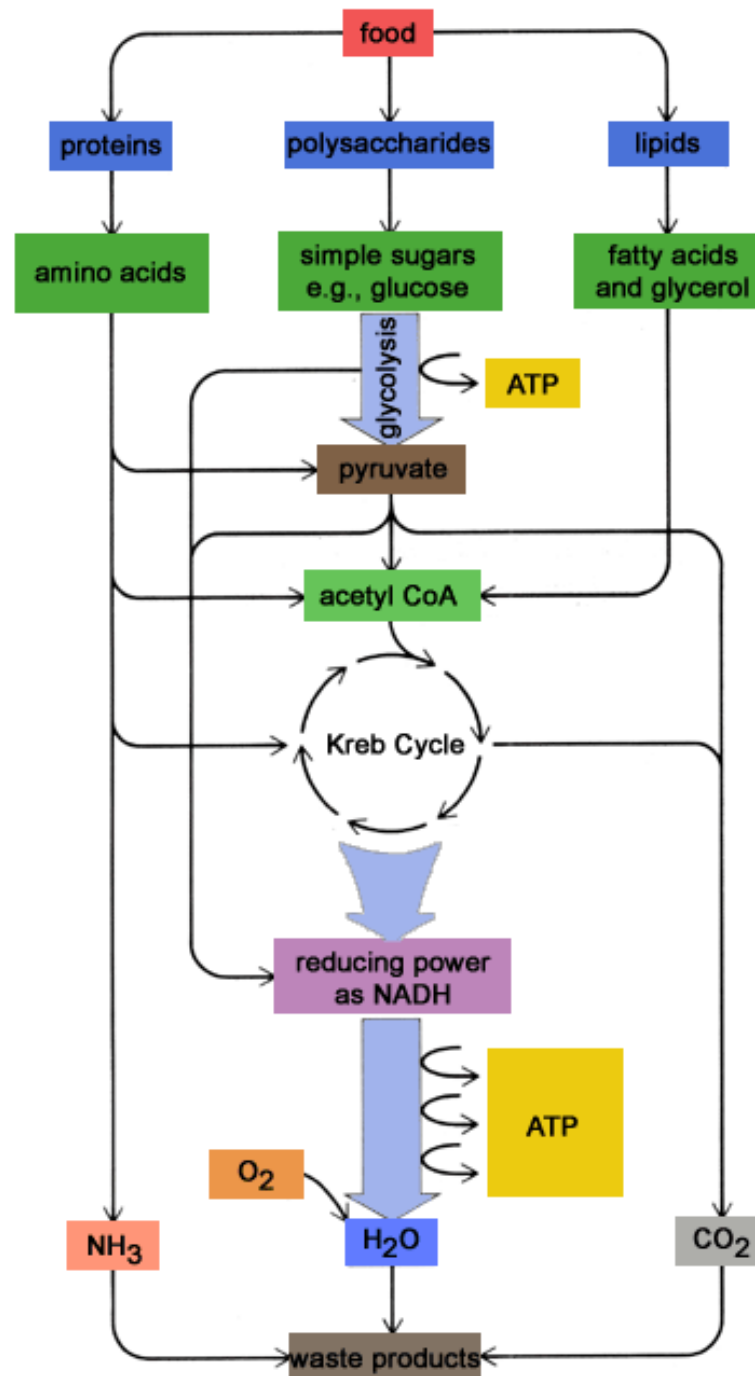
The lactic acid can then be transported to the liver where it is converted back into pyruvic acid, or it stays in the cell until oxygen is present and then it is converted back into pyruvic acid where it will enter Krebs's cycle.

The amount of oxygen needed to convert the lactic acid in a cell into pyruvic acid is called the **oxygen debt**. This is the reason you continue to breathe heavily for several minutes after strenuous exercise.

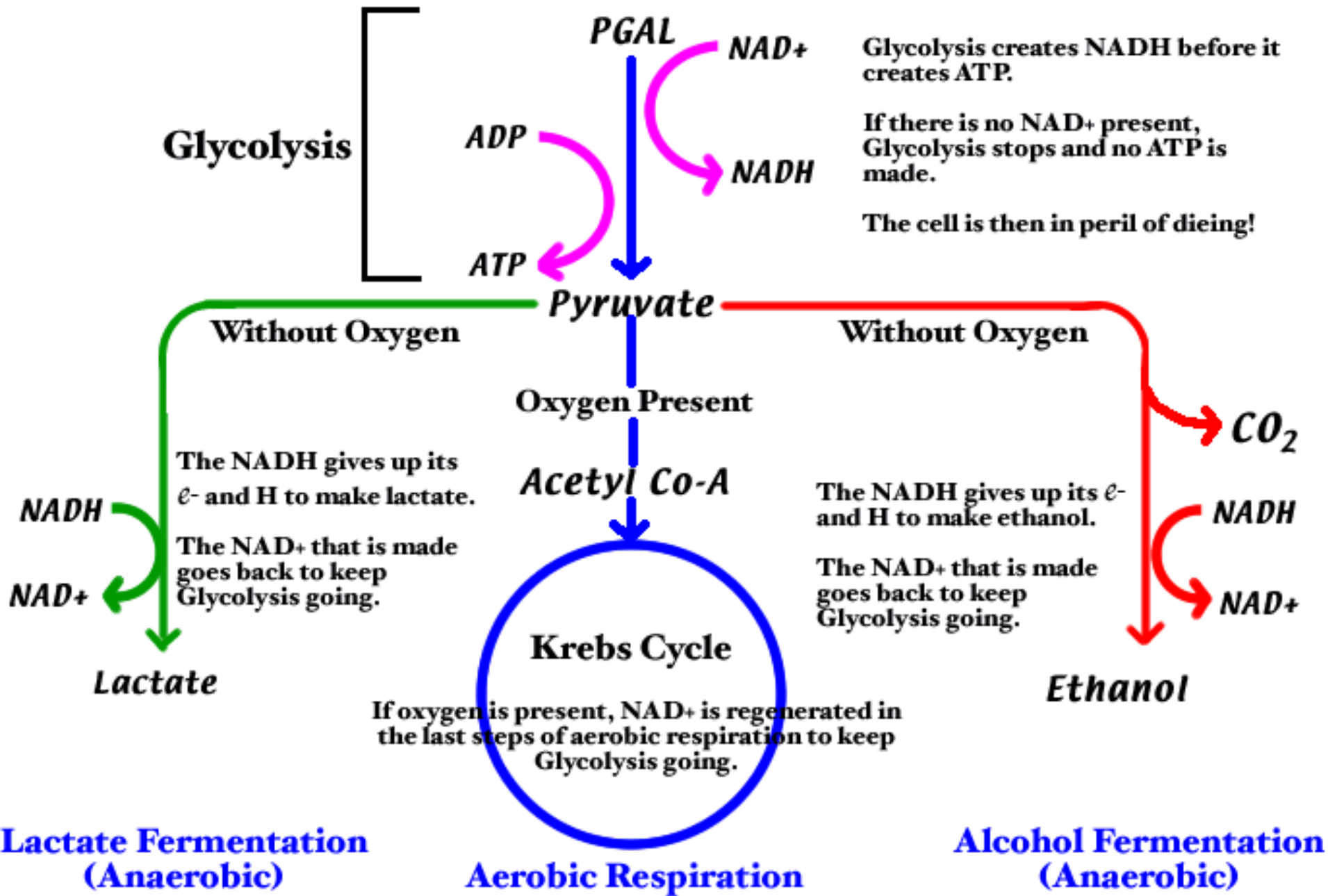
stage 1:
breakdown of
large macro-
molecules to
simple subunits

stage 2:
breakdown of
simple subunits
to acetyl CoA
accompanied by
production of
limited ATP
and NADH

stage 3:
complete oxida-
tion of acetyl
CoA to H_2O and
 CO_2 involves
production of
much NADH,
which yields
much ATP via
electron
transport



A Cell's Decision: When to do Aerobic or Anaerobic Respiration?



The Respiratory System

Human respiration can be classified into three **processes**:

1. Pulmonary ventilation - Breathing (movement of air into and out of lungs)
2. External Respiration - Exchange of gases between the lungs and blood
3. Internal Respiration - Exchange of gases between blood and cells

The upper respiratory system is composed of the nose and throat.

The lower respiratory system contains the larynx, trachea, bronchi, and lungs.

Organs

The nostrils or external nares are the openings to the nasal cavity. The nasal cavity is separated into right and left sides by the nasal septum.

The nasal cavity is involved in:

A. warming, moistening, and filtering incoming air.

B. detecting olfactory stimuli (sense of smell)

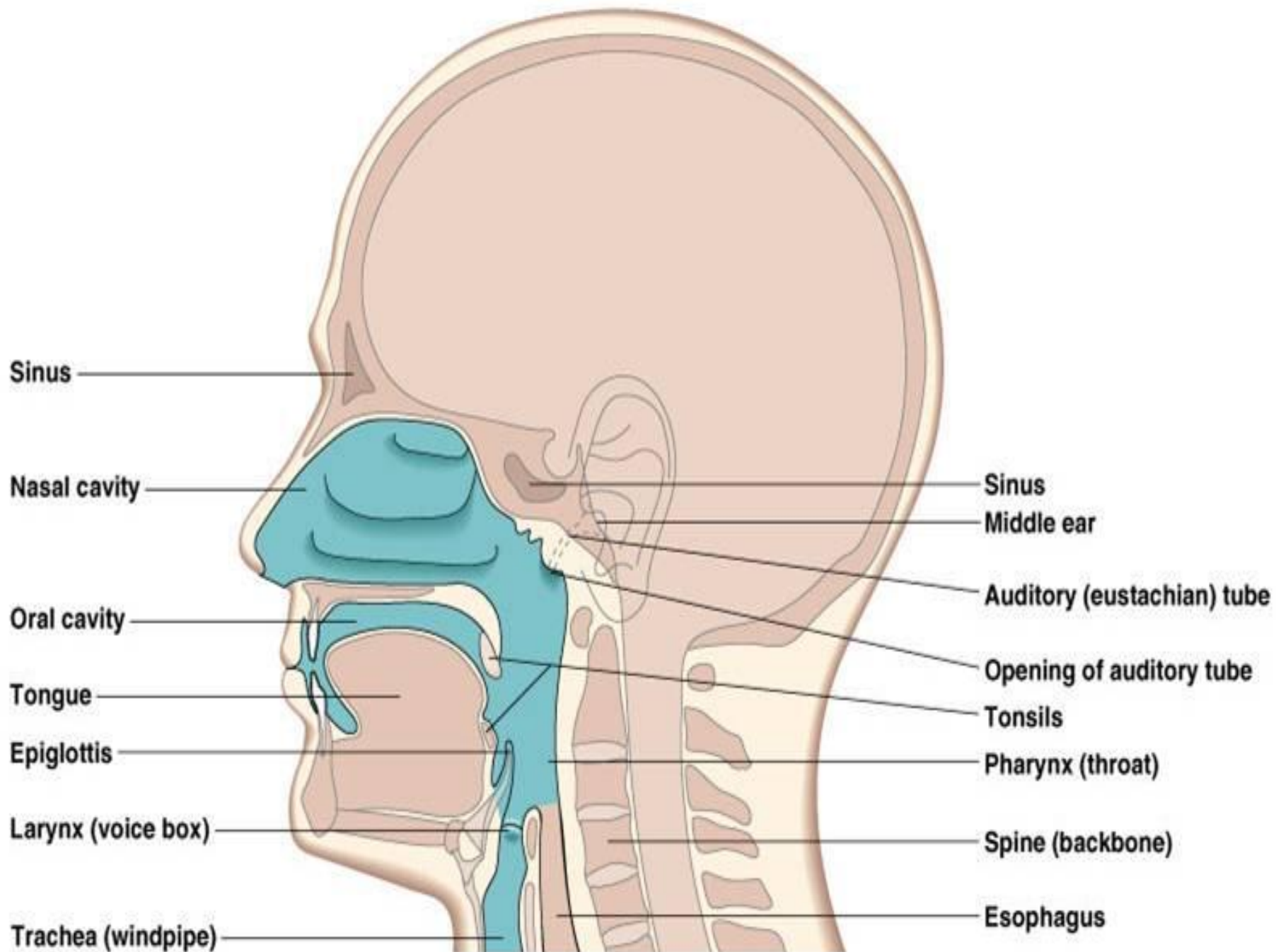
A mucous membrane lines the nasal cavity which has ridges or shelves called the nasal conchae or turbinates. Cilia epithelial cells along with nasal hairs serve to trap dust particles and move them to the pharynx.

The pharynx lies in the back of the throat and is a common passageway for air and food. The nasopharynx is the upper portion , the middle portion is called the oropharynx, and the lower portion is the laryngopharynx.

The larynx is the voice box, and contains a pair of true vocal cords called the glottis. The larynx is covered by a structure called the epiglottis which covers the larynx and prevents food from entering during swallowing.

As air passes over the true vocal cords
they vibrate to produce sound.

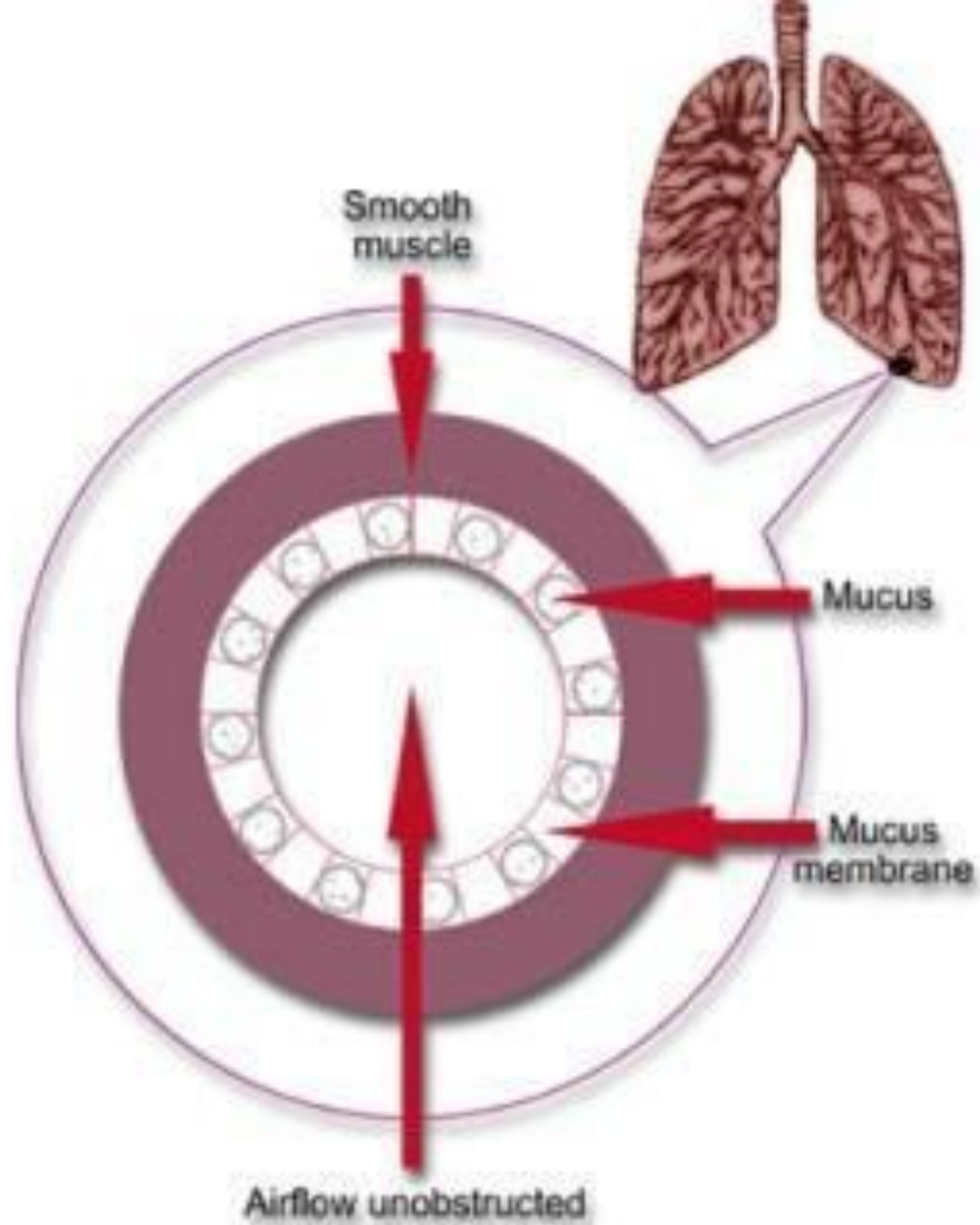
Muscles are attached to the vocal cords
can tighten them producing sounds with
a higher pitch by vibrating more rapidly.

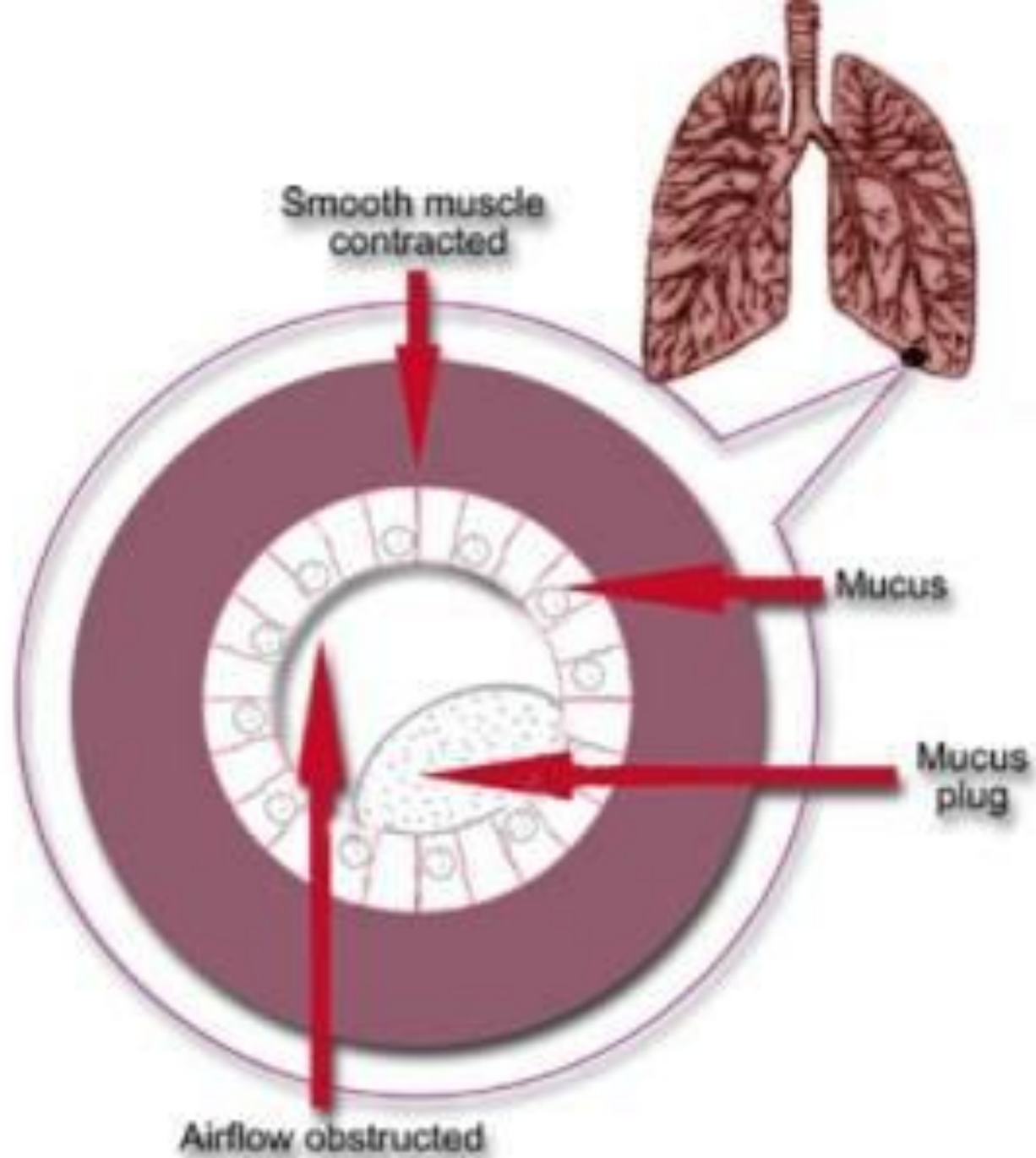


The trachea is the windpipe that leads to the lungs. It is supported by rings of cartilage which keep it from collapsing. The trachea is lined with epithelial cells with cilia. These cilia help to move dust particles upward toward the pharynx.

The trachea splits into the right and left primary bronchi that lead to each lung. These bronchi divide even further into the secondary bronchi and into even smaller tubes called the tertiary bronchi , and eventually into the bronchioles.

This system of branching tubes is called the bronchial tree. The bronchioles contain smooth muscle which in some people may go into spasms called an asthma attack that can constrict the tubes making it more difficult breathe.

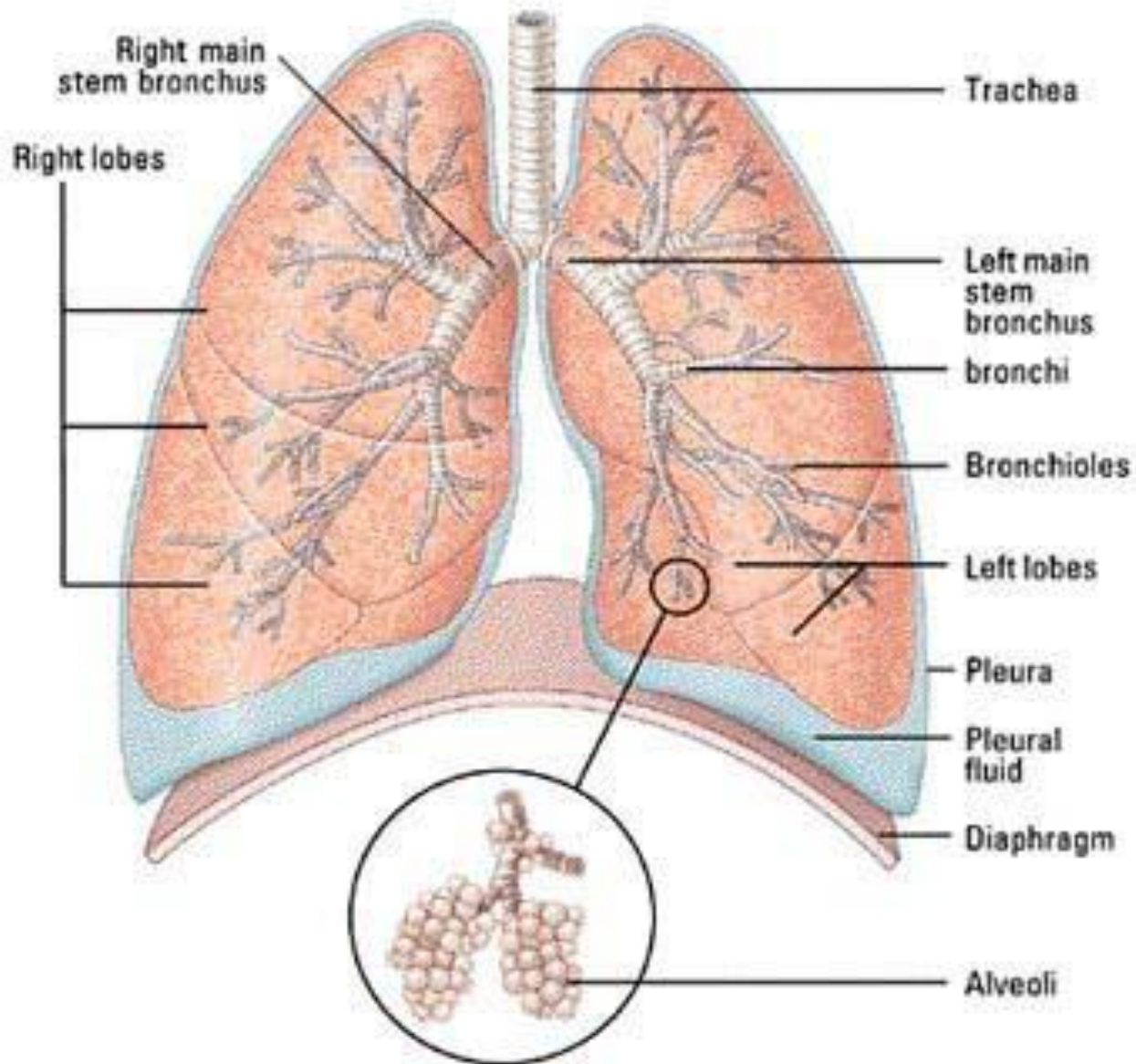




The right and left lungs are separated by the heart and other structures of the mediastinum. The outer layer of the pleural membrane is the parietal pleura which is attached to the wall of the thoracic cavity. The visceral pleura covers the lungs.

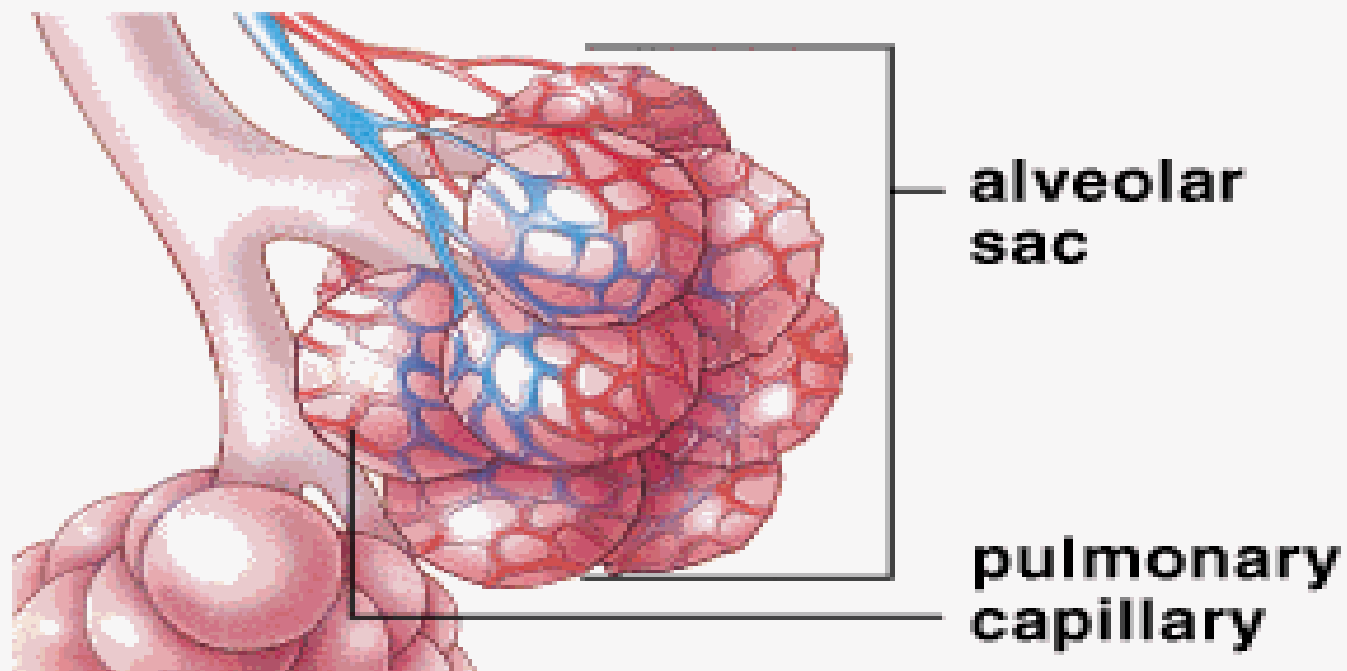
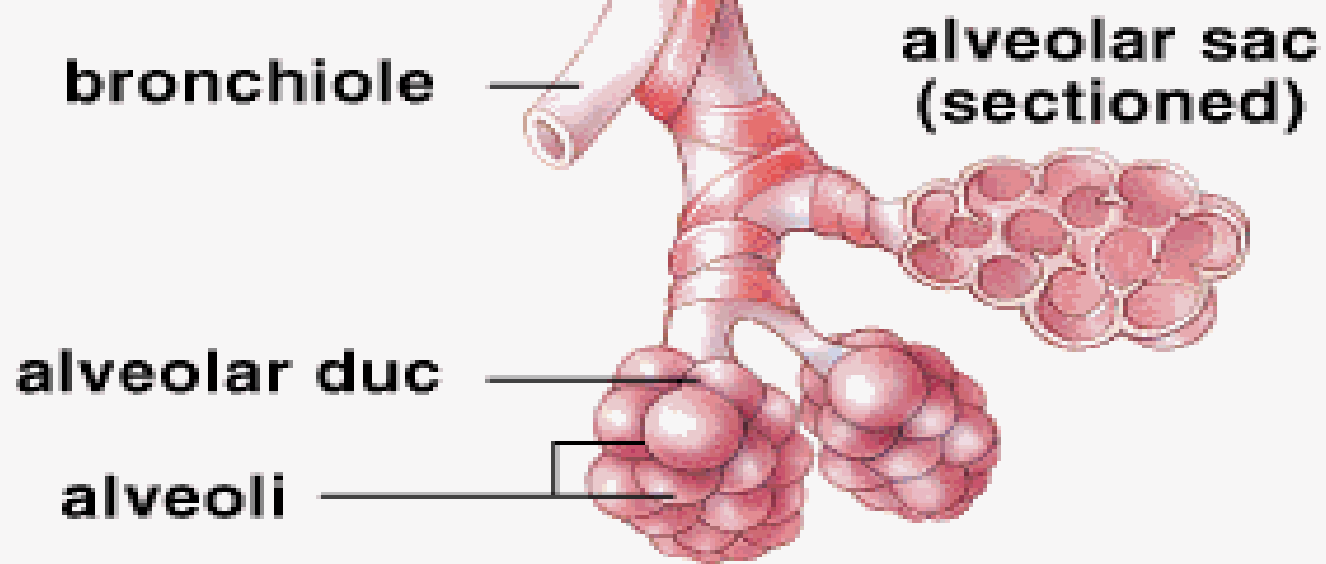
The right lung is divided by 2 fissures into three lobes. The left lung has 1 fissure and two lobes.

Lungs



Each microscopic bronchiole ends with tiny tubes called the alveolar ducts. These lead to tiny air sacs called the alveoli.

Each alveolus is surrounded by capillaries so respiratory gases move across what is called the alveolar-capillary membrane.



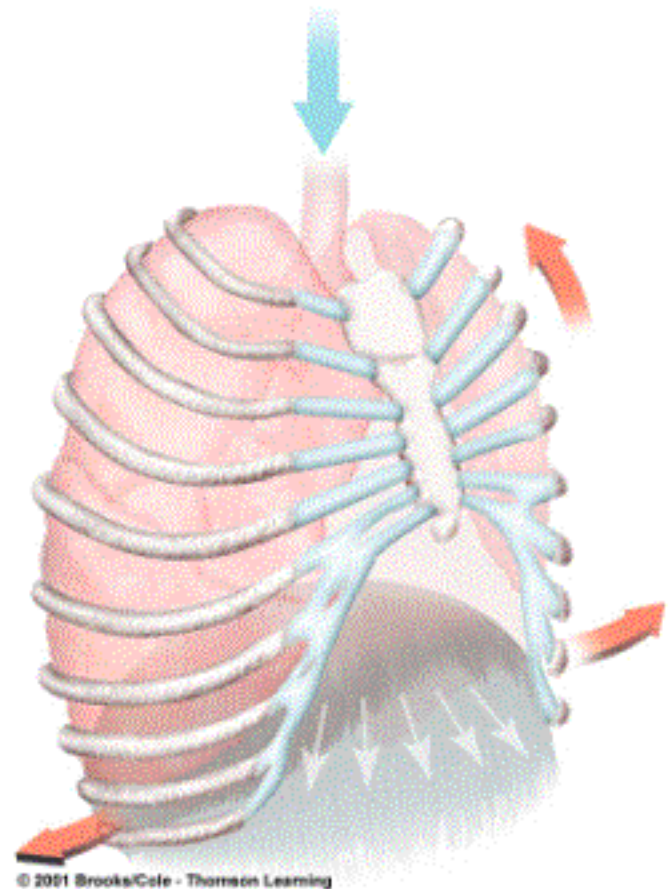
The primary purpose of respiration is to supply the bodies cells with oxygen for cellular respiration and to remove carbon dioxide released during cellular respiration.

The two phases of pulmonary ventilation or breathing are:

1. Inspiration-The volume of the thoracic cavity increases when the diaphragm pulls down and flattens as it contracts. The intercostal muscles pull the ribs up and out. As the chest cavity increases in size the pressure inside the cavity decreases below the atmospheric pressure outside the cavity, allowing air to rush in and fill the lungs.

Inhalation

- Diaphragm flattens
- External intercostal muscles contract
- Volume of thoracic cavity increases
- Lungs expand
- Air flows down pressure gradient into lungs

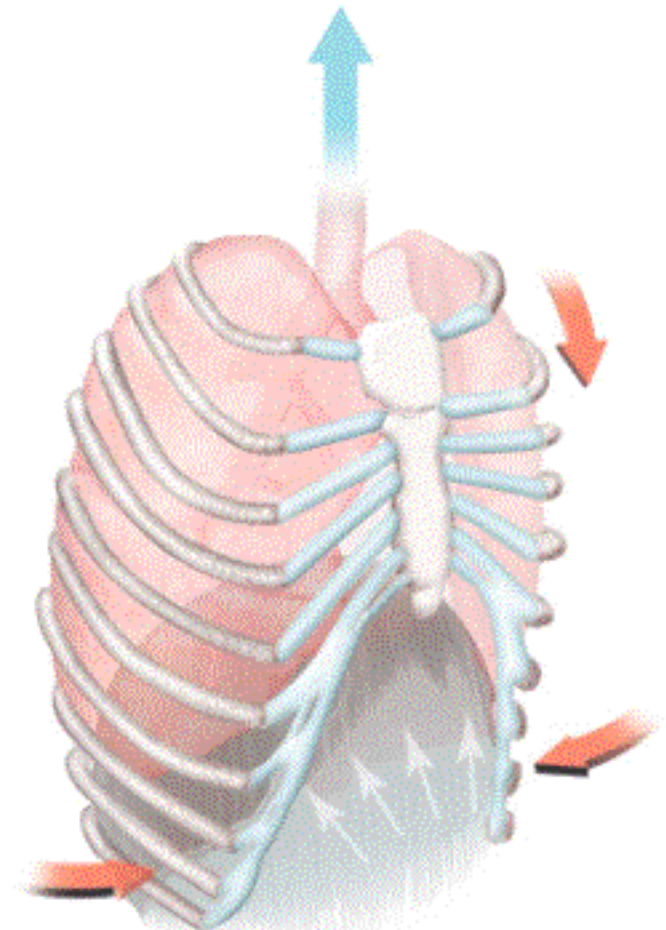


2. Expiration- The volume of the thoracic cavity decreases as the diaphragm relaxes and returns to its domed shape. The intercostal muscles relax and the ribs move down and in.

As the pressure inside the thoracic cavity increases above the atmospheric pressure outside the cavity, air is forced out of the lungs.

Normal (Passive) Exhalation

- Muscles of inhalation relax
- Thoracic cavity recoils
- Lung volume decreases
- Air flows down pressure gradient and out of lungs



Pulmonary Volumes

The amount of air moved in and out of the lungs is referred to as pulmonary volume.

Tidal Volume(TV)- the amount of air inspired and expired in normal quiet breathing.

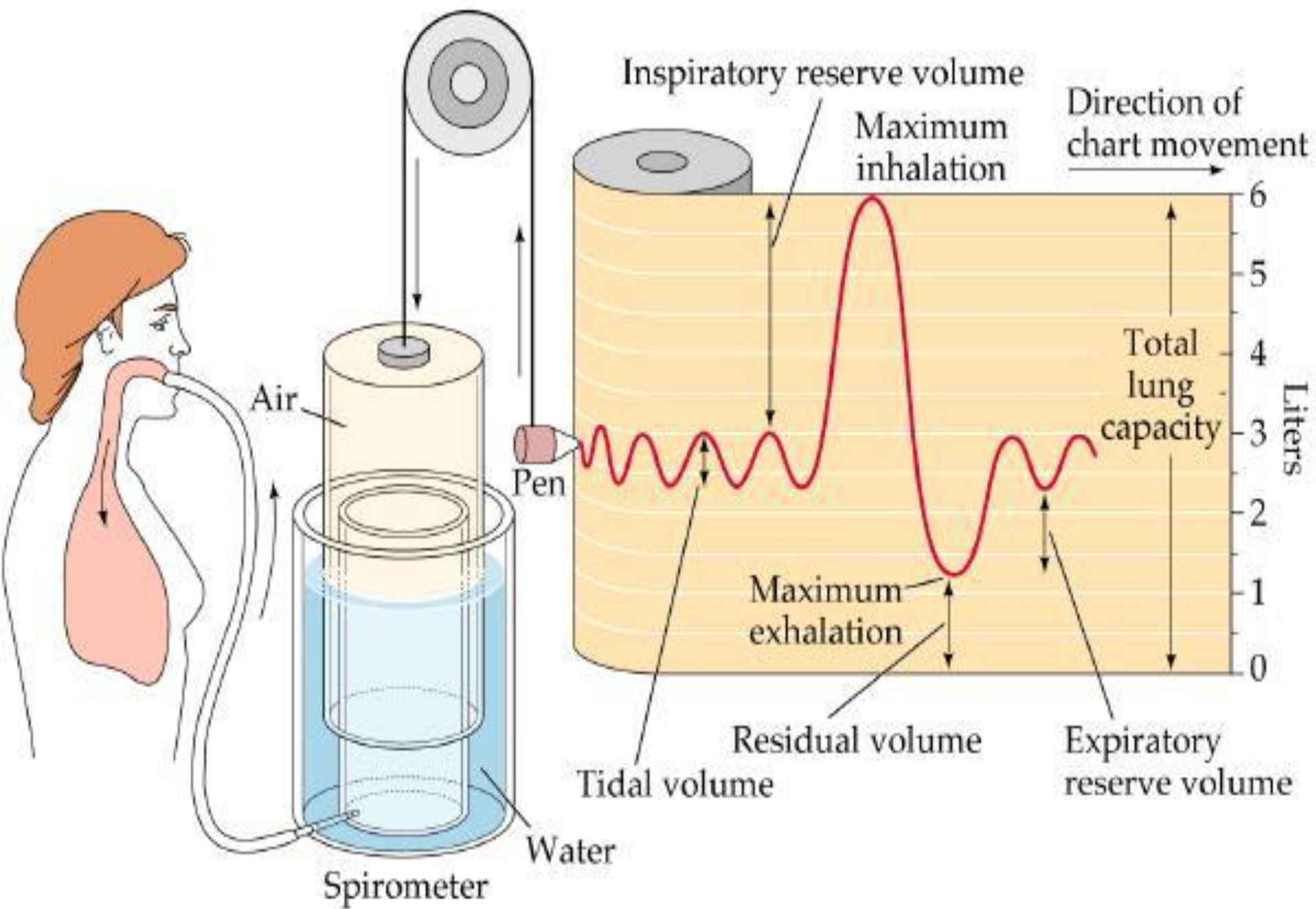
Inspiratory Reserve Volume(IRV)-The excess amount of air that can be inspired over a normal breath (tidal volume).

Expiratory Reserve Volume(ERV)-The amount of air that can be expired after a normal breath (tidal volume).

Residual Volume- The amount of air left in the lungs after expiratory reserve is expelled.

Vital capacity- The maximum amount of air that can be inspired and expired in a single breath.

$$\text{Vital Capacity} = \text{TV} + \text{IRV} + \text{ERV}$$



Control of Respiration

The respiratory center consists of groups of neurons located in the medulla oblongata and the pons.

The respiratory center has connections to the cerebral cortex which allows us to voluntarily control our breathing.

Breathing is also influenced by stretch receptors in the walls of the bronchi and bronchioles. During overinflation of the lungs these stretch receptors inhibit further inspiration and expiration begins.

The ultimate goal of the respiratory system is to maintain proper levels of carbon dioxide and oxygen in the body.

In the medulla oblongata there is a chemosensitive area that is sensitive to levels of carbon dioxide.

In addition there are chemoreceptors in other parts of the body that can detect changes in oxygen and carbon dioxide levels. When even slight increases in carbon dioxide levels are detected the respiratory center increases the rate of respiration.