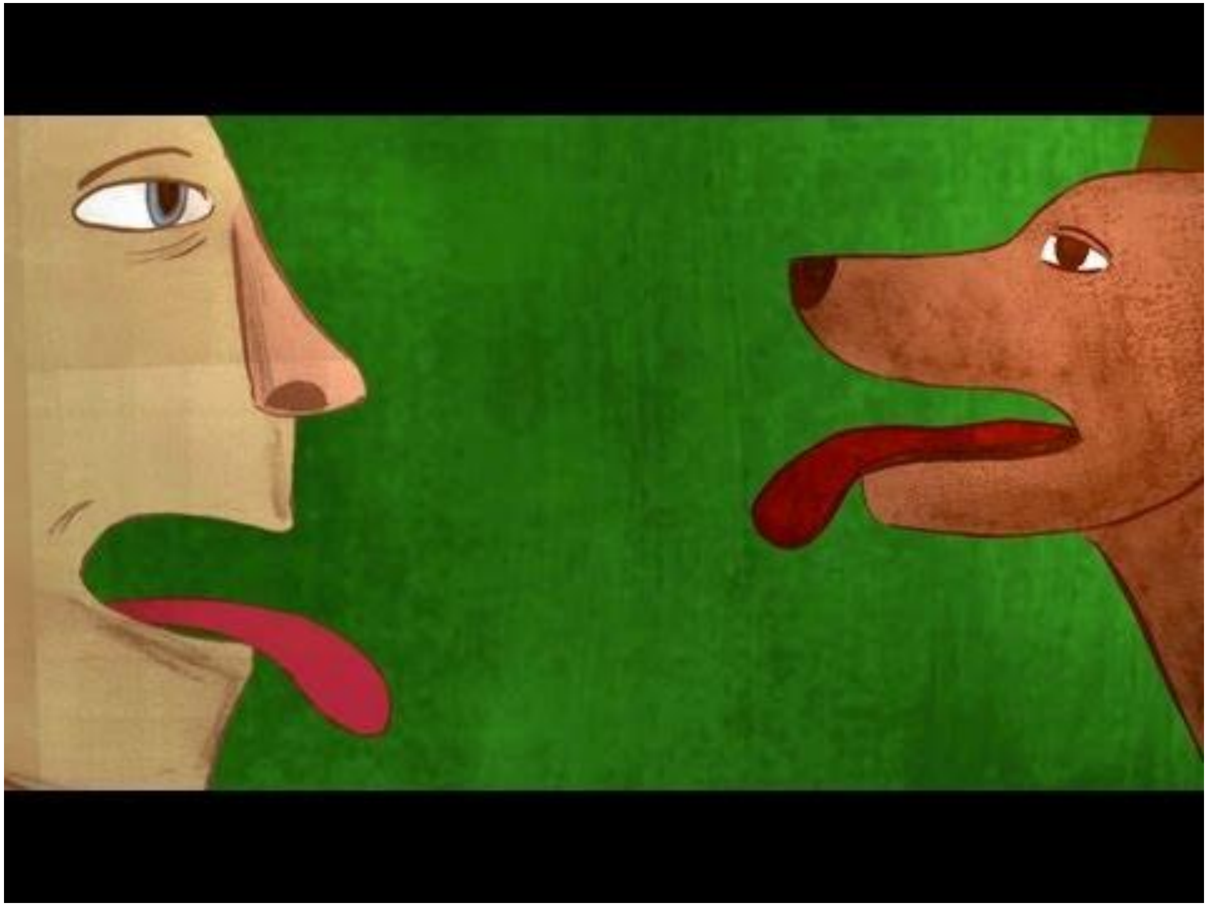
Unit 4: Exercise Physiology

Topic 2.1. Structure and Function of the Respiratory System

TedED: How Breathing Works



Question 1: What are some physiological responses to immediate exercise and exercise prolonged exercise? List as many as possible. (physiological response - a response that triggers a bodily or physical response to a stimulus)

Question 2: Why does your blood flow increase in response to prolonged exercise? Answer for two other responses on your list.

Question 3: Is your maximum heart rate linked to your relative level of fitness? Why or why not?

Question 4: Your resting heart rate lowers when your fitness level increases. Why? Does your breathing rate lower too?

Question 5: What rises first, heart rate or breathing rate, in response to exercise?

Question 6: What are some physiological responses to holding your breath? List as many as possible. (physiological response - a response that triggers a bodily or physical response to a stimulus)

Question 7: Why do we breath? (“to get oxygen” or “to not die” are not sufficient answers)

Question 8: What happens to our bodies when we breath?

Question 9: How does breathing rate change with exercise?

2.1.1 List the principal structures of the ventilatory system

- The principle structures of the respiratory system are:
  - Nose/Mouth – used for inhalation of oxygen-rich air and expelling carbon dioxide rich air
  - Pharynx - passageway leading from the oral and nasal cavities in the head to the larynx
  - Larynx (voice box) - tubular structure connected to the top of the trachea
  - Trachea (windpipe) - conveys air from the larynx to the two main bronchi, with the lungs and their air sacs as the ultimate destination

2.1.1 List the principal structures of the ventilatory system

- The principle structures of the respiratory system are:
  - Bronchi (bronchus singular) - airway in the respiratory tract that conducts air into the lungs. Bronchi will branch into smaller tubes that become bronchioles.
  - Bronchioles - any of the minute branches into which a bronchus divides.
  - Lungs - each of the pair of organs situated within the rib cage, consisting of elastic sacs with branching passages into which air is drawn, so that oxygen can pass into the blood and carbon dioxide be removed.
  - Alveoli - any of the many tiny air sacs in the lungs where the exchange of oxygen and carbon dioxide takes place.

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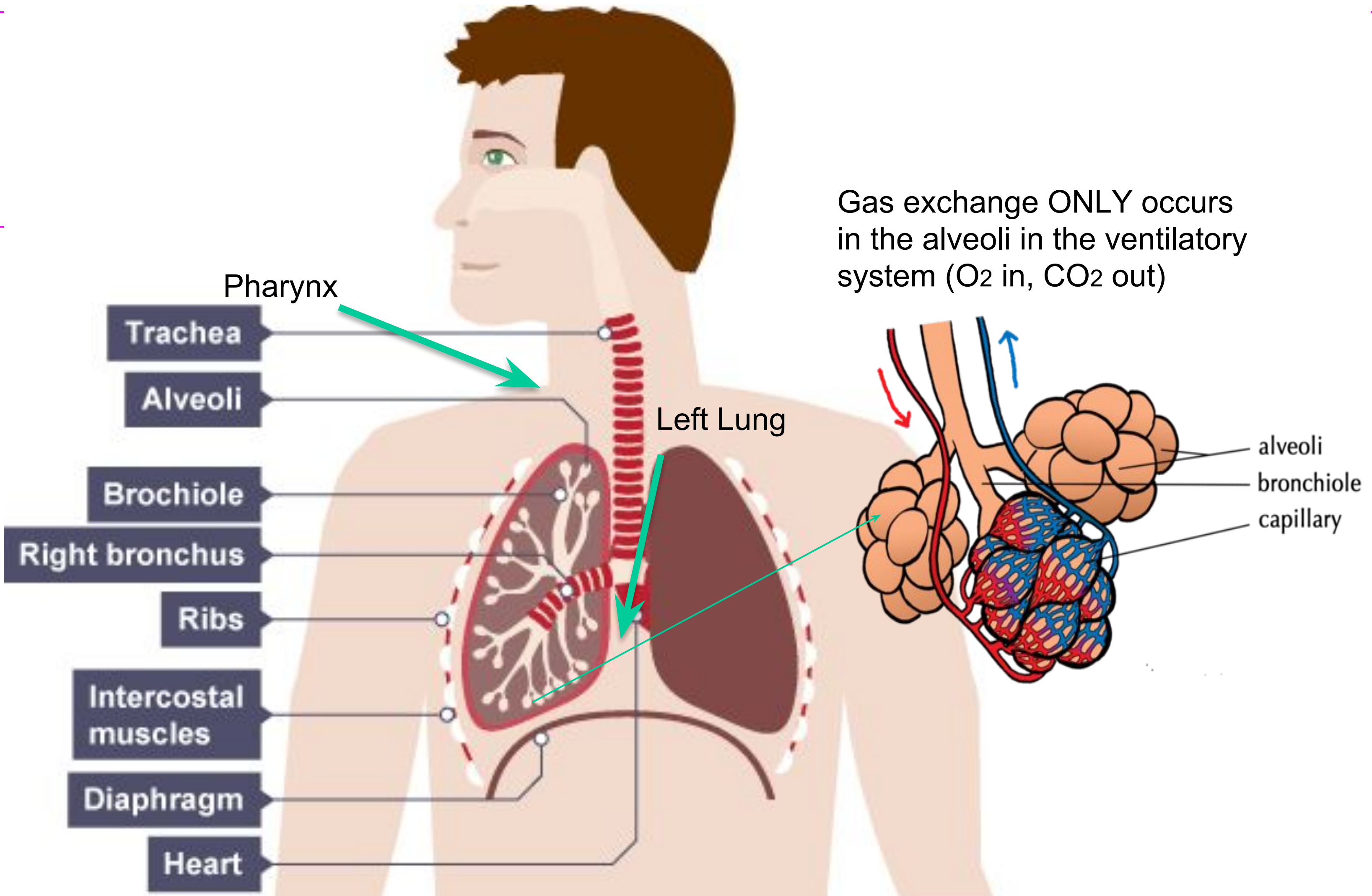
Topic 2
Exercise Physiology

Sub-topics

1. Structure & function of the ventilatory system

2. Structure & function of the cardiovascular system

2.1.1 List the principal structures of the ventilatory system

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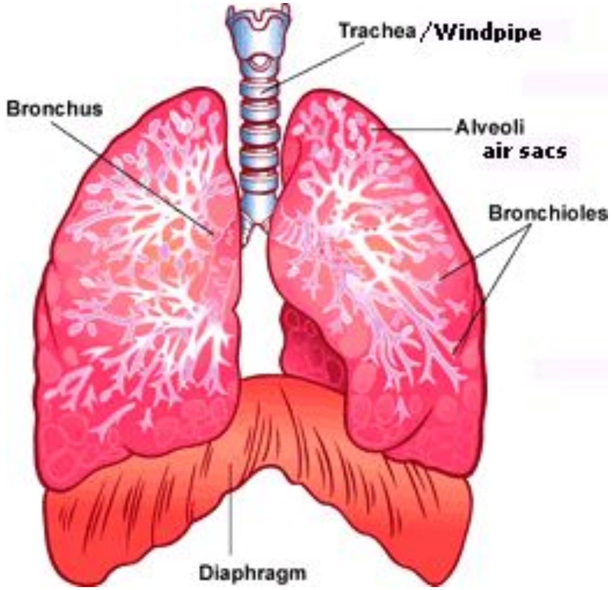
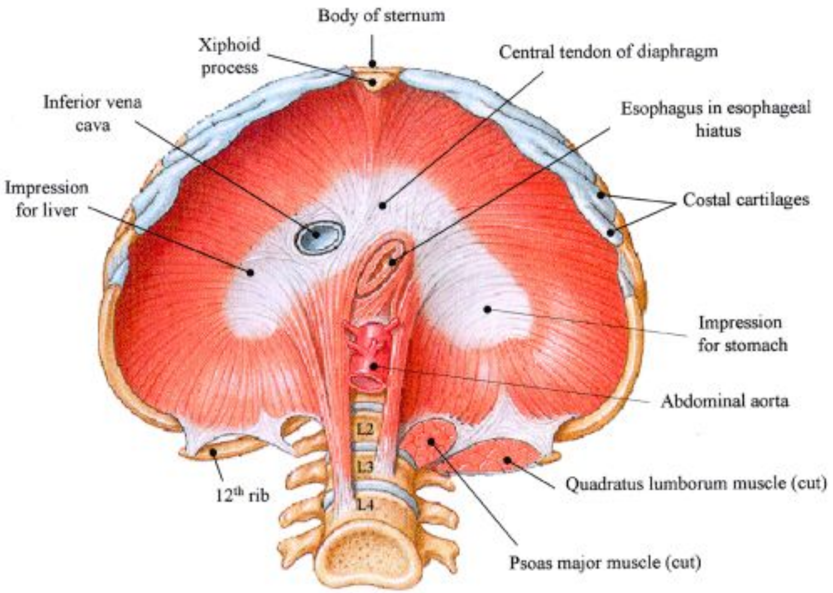
Exercise physiology

2.1.2 Outline the functions of the conducting airways

Diaphragm - a dome-shaped, muscular partition separating the thorax from the abdomen in mammals. It plays a major role in breathing, as its contraction increases the volume of the thorax and so inflates the lungs.





Exercise physiology

Tricks to preventing or getting rid of a side cramp (of the diaphragm)

- **Eat mindfully pre-run.** Foods that are higher in fat and fiber take longer to digest. That doesn't mean they are bad foods, but if you eat them within one to two hours before a run, they can cause havoc—creating stomach upset, stitches, and other problems.
- **Invest in a solid warmup.** Going from sitting to running speed can create irregular, rapid-fire breathing patterns, which can translate to you bending over in pain on the side of the road
- **Regulate your breathing.** Match your breathing to your strides—inhaling for two to four strides and exhaling for the same. The faster the pace, the shorter the sequence (fast pace = one or two strides per breath, slower = three or four strides per breath). This can not only prevent stitches, but also improve the efficiency of your oxygen transport.
- **Slow down and exhale to release the stitch.** If you still get another side cramp, implement this strategy and it will go away in seconds (I promise). Slow your pace and exhale as the foot on the opposite side of the cramp strikes the ground. When you exhale, you relax the muscles of your diaphragm. When this happens in unison with your foot striking the ground, the impact forces travel up the body and through your core (your side too) and exacerbate (piss off) the muscles in spasm creating that stitch. When you change the side of the landing forces to the opposite side, the tension causing the stitch releases.

Exercise physiology

2.1.2 Outline the functions of the conducting airways

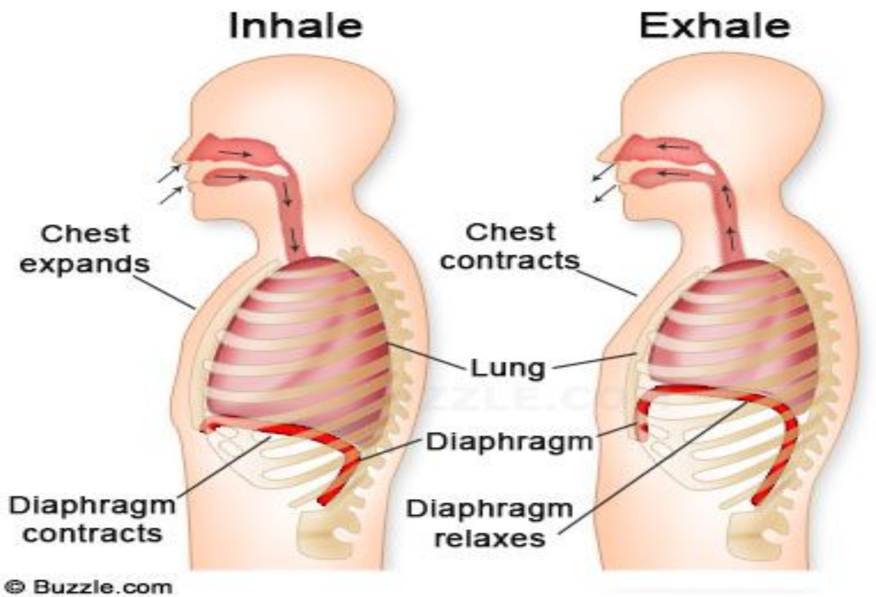
- Breathing based on physics
- Air flows from areas of high pressure to low pressure
- Inhalation occurs when the air pressure in the lungs is lower than in the atmosphere

- At rest, inhalation caused by diaphragm contraction
- Diaphragm pulls downward (contracts) and creates a vacuum in the chest cavity by increasing lung volume.
- Draws air in due to pressure imbalance

Exercise physiology

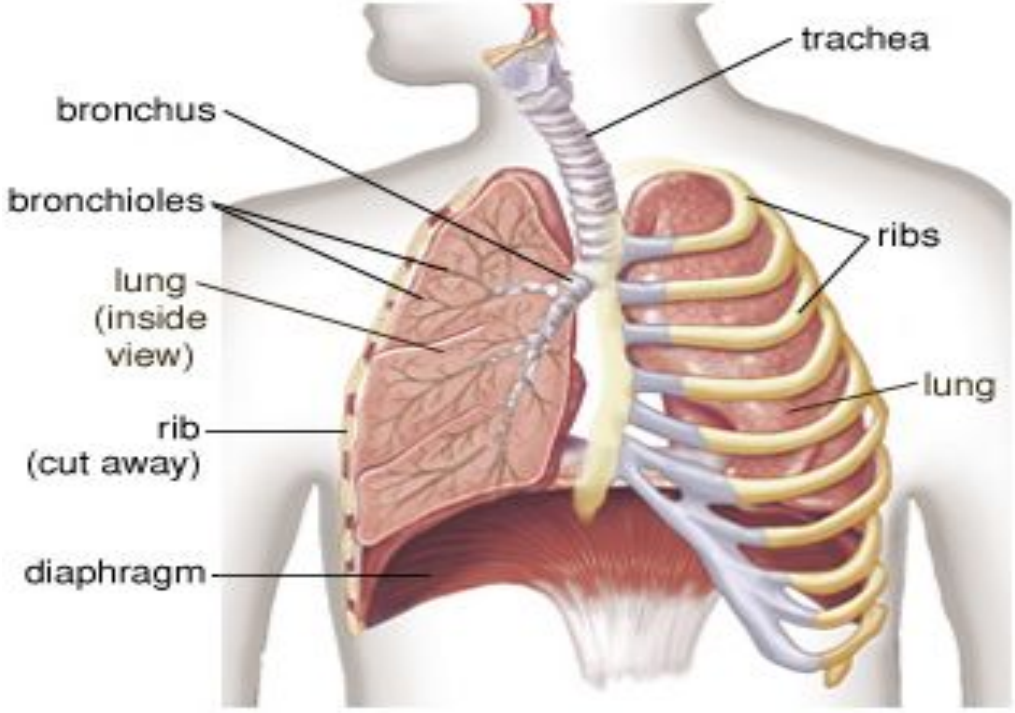
2.1.2 Outline the functions of the conducting airways

- The exhalation process is passive (no energy required) because as the diaphragm relaxes it returns to original position, shrinking lung volume and creating greater pressure in the lungs compared to atmosphere.



Exercise physiology

2.1.2 Outline the functions of the conducting airways



BREATHING MOVEMENTS VIDEO

Exercise physiology

2.1.2 Outline the functions of the conducting airways

During exercise, more oxygen is needed in the active muscles and more carbon dioxide is being produced.

- More air needs to be inhaled and exhaled at a faster rate
- Additional muscles must be recruited to make this happen - external intercostal muscles (chest muscles), abdominals and even shoulders can assist in increasing lung volume
- Compression also can use the contractions of these muscles to expel air faster thus increasing respiration rate.

- Uses/needs an incredible amount of energy

Exercise physiology

2.1.3 Define respiratory terms

- Atmospheric pressure – pressure exerted by the weight of the atmosphere
- Intra alveolar (intrapulmonary) pressure – pressure of the lungs relative to the atmosphere
- Pulmonary ventilation - is commonly referred to as breathing. It is the process of air flowing into the lungs during inspiration (inhalation) and out of the lungs during expiration (exhalation).
- Total Lung Capacity (TLC) – the amount of gas contained in the lung at the end of a maximal inhalation
- Tidal volume (V_T)– the amount of air moving into and out of the lungs while at rest.

Stop and draw Lung Volume Diagram

2.1.3 Define respiratory terms

- Vital Capacity (VC) – the greatest volume of gas that, following maximum inhalation, can be expelled during a complete, slow, forced exhalation
- Expiratory reserve volume (ERV) – the additional maximal volume of air that can be **expelled from the lungs** by forced exhalation after normal exhalation (after lowest tidal volume)
- Inspiratory reserve volume (IRV) - the additional maximal volume of air that can be **drawn into the lungs** by forced inhalation after normal inhalation (after highest tidal volume)
- Residual Volume (RV) - **volume** representing the amount of air left in the lungs after a forced exhalation; this **volume** cannot be measured, only calculated. (about 20% of TLC)
  - RV+VC= TLC

2.1.3 Define respiratory terms

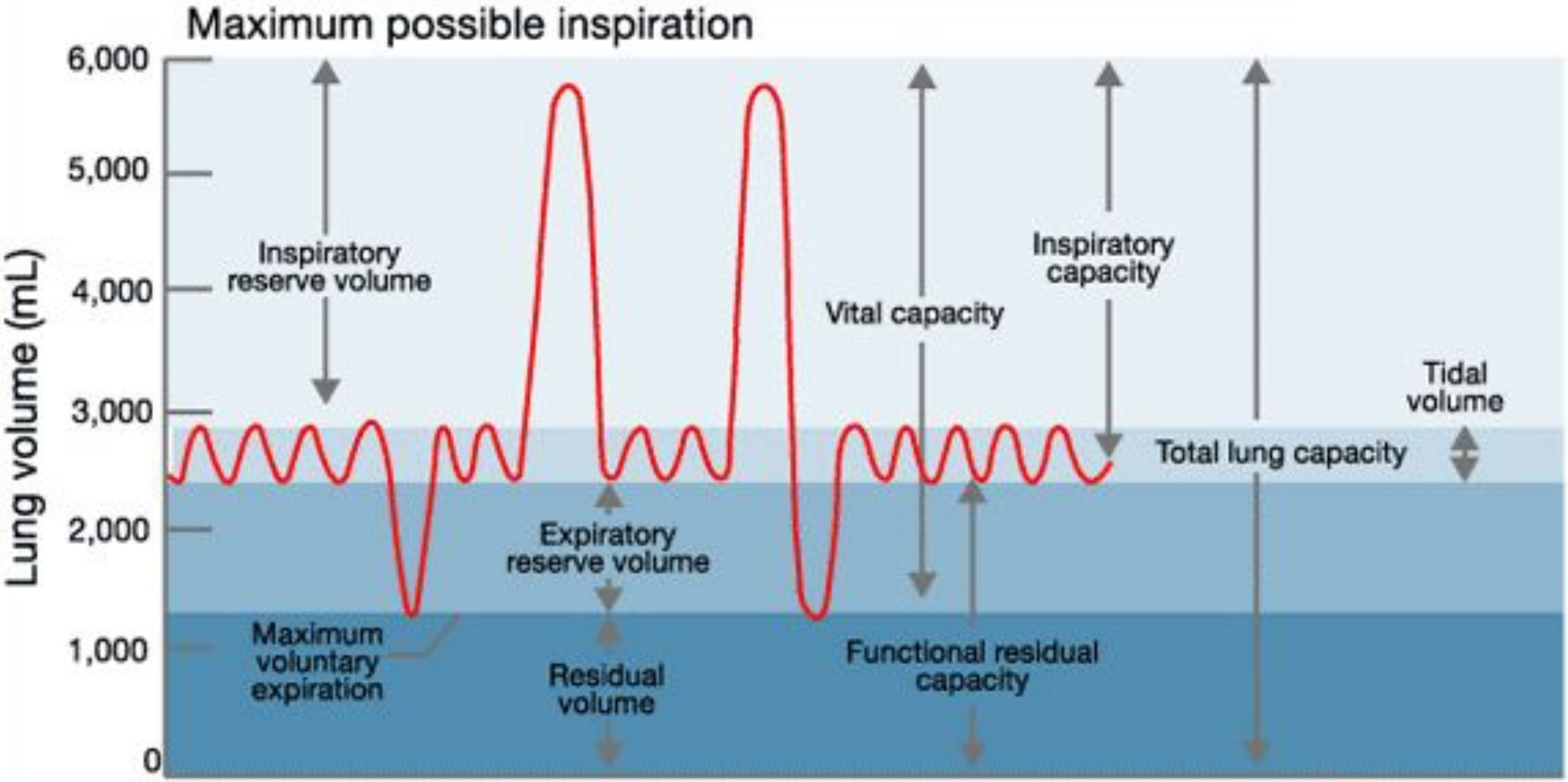
- **Total lung capacity** can be calculated by adding **vital capacity** to **residual volume** of the lungs.
- During normal, quiet respiration, about 500mL of air is inspired. The same amount of air moves out with expiration. This volume of air is called the **tidal volume.**
- When we forcibly take a deep breath, we can take in up to 3100mL above the tidal volume. This additional air is the **inspiratory reserve volume.**

  - Browne et. al 2001

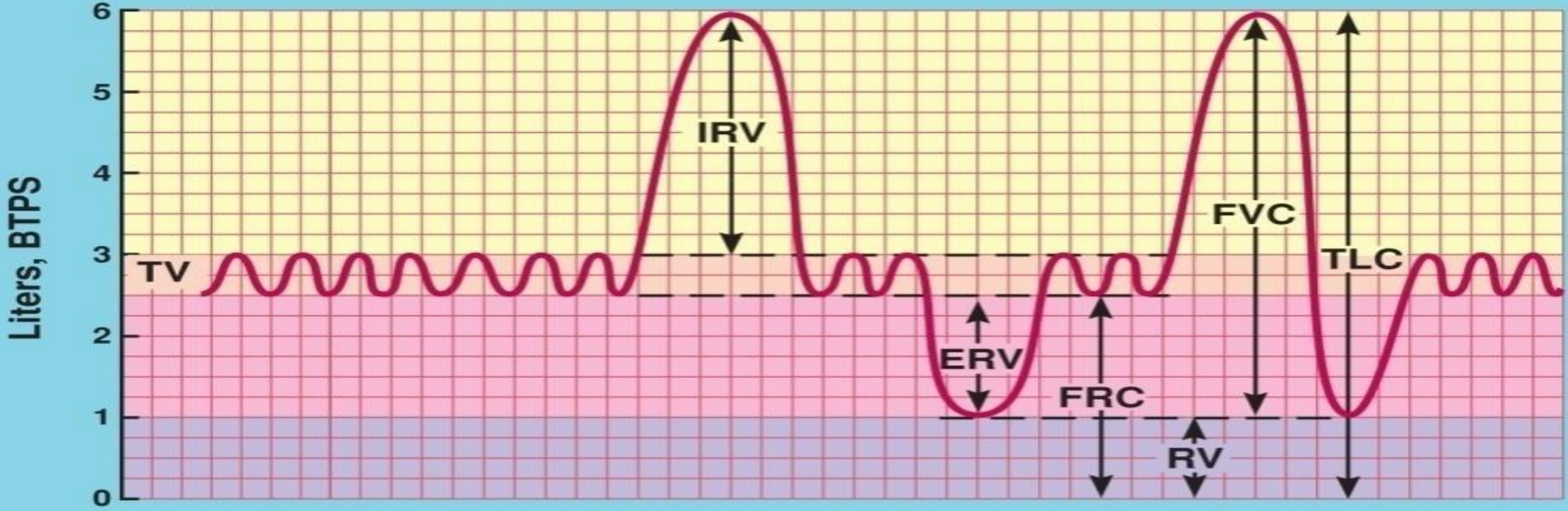
2.1.3 Define respiratory terms

- We can also forcibly exhale. This is termed the **expiratory reserve volume.**
- Forced Expiratory Volume (FEV) – Test of dynamic lung function
- Even after the expiratory reserve volume is expelled, some air is still trapped in the lungs because of pressure. This is called the **residual volume.**
- This also allows for uninterrupted gaseous exchange during the breathing cycle.

Lung Volumes and Capacities



AnaesthesiaUK



Lung Volume/Capacity	Definition	Average Values (mL) Males	Average Values (mL) Females
Tidal Volume (**TV**)	Volume inspired or expired per breath	600	500
Inspiratory Reserve Volume (**IRV**)	Maximum inspiration at end of tidal inspiration	3000	1900
Expiratory Reserve Volume (**ERV**)	Maximum expiration at end of tidal expiration	1200	800
Total Lung Capacity (**TLC**)	Volume in lungs after maximum inspiration	6000	4200
Residual Lung Volume (**RLV**)	Volume in lungs after maximum expiration	1200	1000
Forced Vital Capacity (**FVC**)	Maximum volume expired after maximum inspiration	4800	3200
Inspiratory Capacity (**IC**)	Maximum volume inspired following tidal expiration	3600	2400
Functional Residual Capacity (**FRC**)	Volume in lungs after tidal expiration	2400	1800

Exercise physiology

2.1.4 Explain the mechanics of ventilation in the human lungs

Composition of Inhaled & Exhaled Air

Components of air	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.03%	4%
Nitrogen	78%	78%
Water vapour	Varies (depends on the humidity of air)	More (usually saturated)
Dust particles	Varies	Usually none
Temperature (heat)	Varies (follows atmospheric temp.)	Body temperature

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Exercise physiology

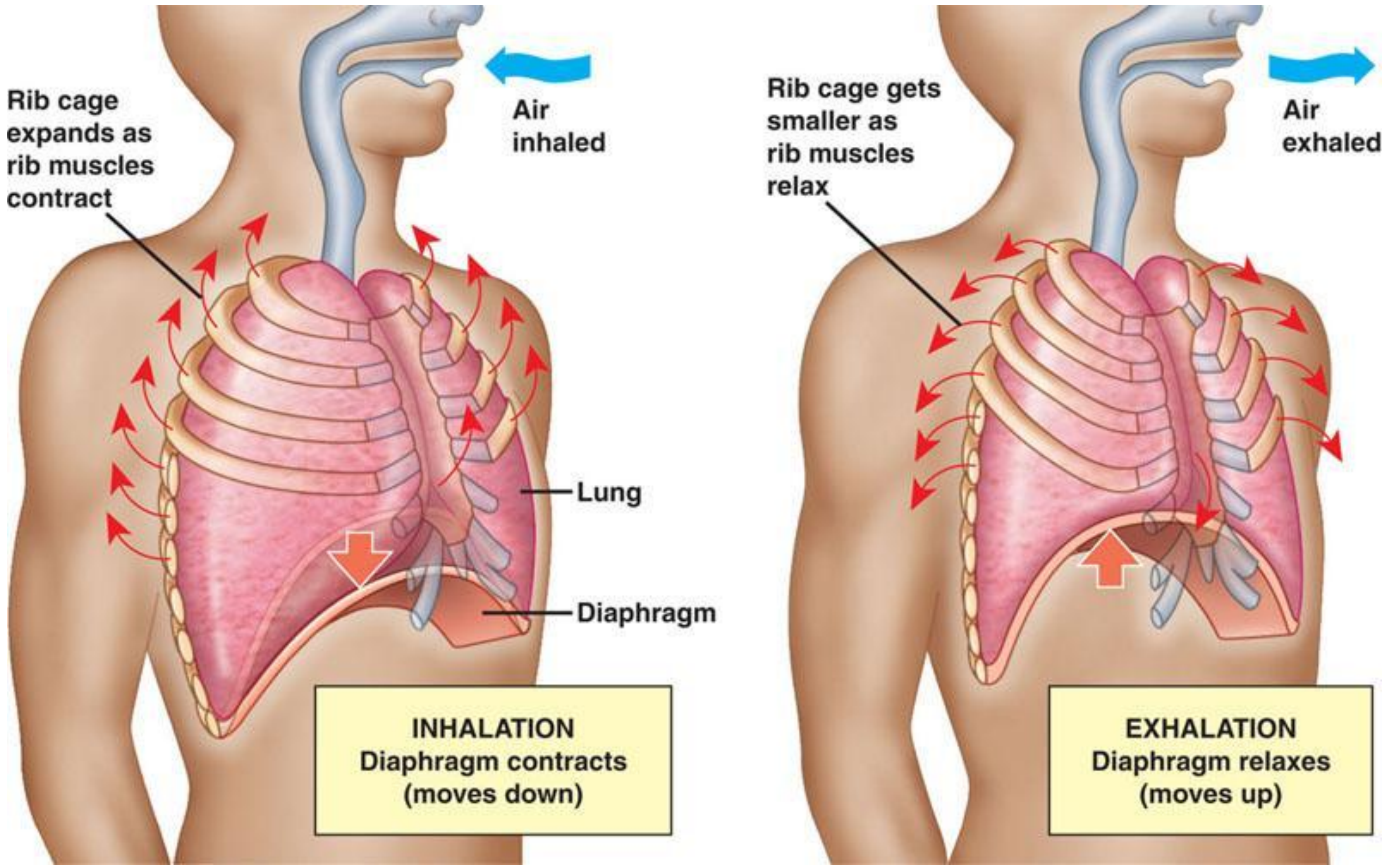
Topic 2
Exercise Physiology

2.1.4 Explain the mechanics of ventilation in the human lungs

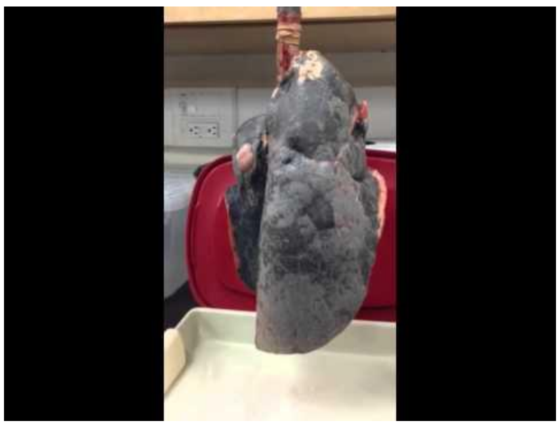
Sub-topics

1. Structure & function of the ventilatory system

2. Structure & function of the cardiovascular system



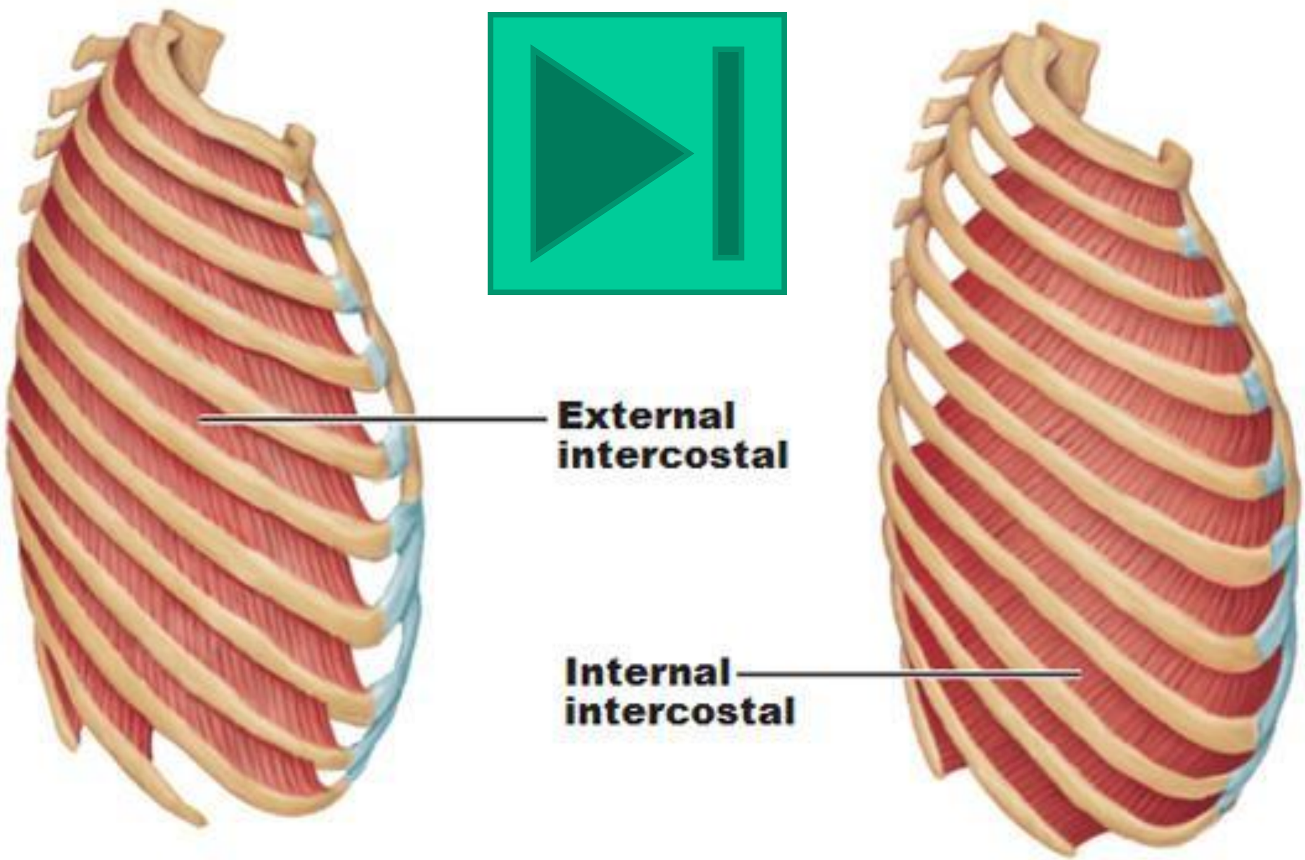
Punctured Lung



Pig Lungs

A little gruesome
You can close your eyes if it makes you uncomfortable.

2.1.4 Explain the mechanics of ventilation in the human lungs



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Exercise physiology

Topic 2
Exercise Physiology

2.1.4 Explain the mechanics of ventilation in the human lungs

Sub-topics

1. Structure & function of the ventilatory system
2. Structure & function of the cardiovascular system

Explain how the role between volume and pressure regulates breathing.

Discuss the role of the intercostal muscles.

2.1.4 Explain the mechanics of ventilation in the human lungs

- V_E = volume of air being exhaled per minute
- V_T = tidal volume
- B_f = breathing frequency (breaths per minute)

- V_E ($L.min^{-1}$) = V_T ($L.Breath^{-1}$) x B_f ($breaths.min^{-1}$)

Page 35

TO DO

Complete the table below that presents some data collected during an exercise test.

	EXERCISE INTENSITY DURING RUNNING AT PROGRESSIVELY FASTER SPEEDS						
	Rest	8 $km.h^{-1}$	10 $km.h^{-1}$	12 $km.h^{-1}$	14 $km.h^{-1}$	16 $km.h^{-1}$	18 $km.h^{-1}$
V_T ($L.br^{-1}$)	0.67	2		3.3	3.6		4
B_f ($br.min^{-1}$)	12		22.3	24.2		30	38
$\dot{V}_E$ ($L.min^{-1}$)	8	40	58		98	115	

↑ Table 2.1: Comparison of $\dot{V}_E$, V_T and B_f values at rest and during incremental exercise

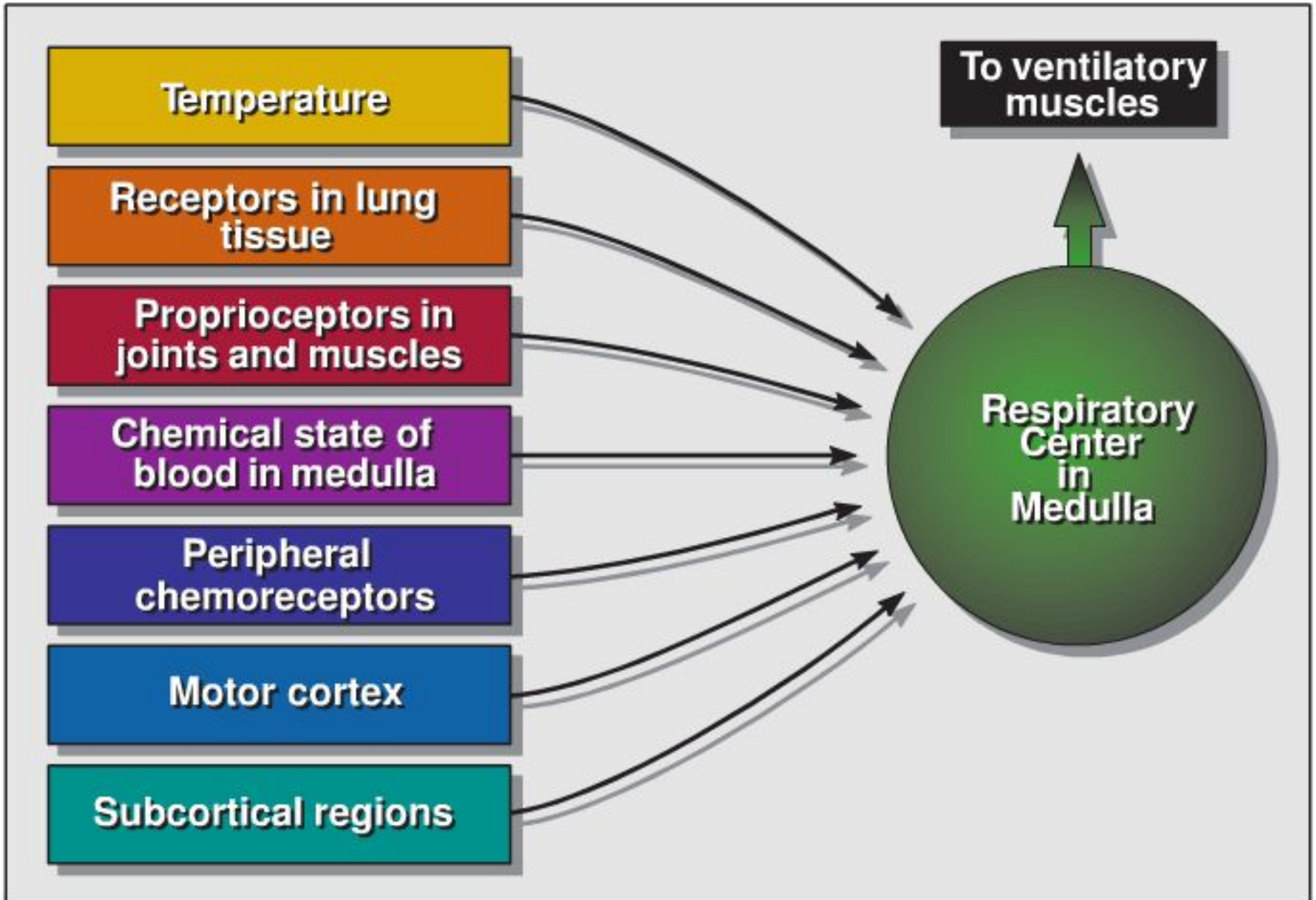
As exercise intensity increases, how is the increased ventilation achieved?

Exercise physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

- Ventilation increases in response to increasing intensity of exercise
- The main objective is to maintain resting oxygen and carbon dioxide levels in blood
- This is achieved by increasing breathing rate and depth of breathing
- **Regulation of breathing is quite complex and no single factor is responsible.** Carbon dioxide levels in the blood is commonly thought to be the main driving factor.

2.1.5 Describe the nervous and chemical control of ventilation during exercise



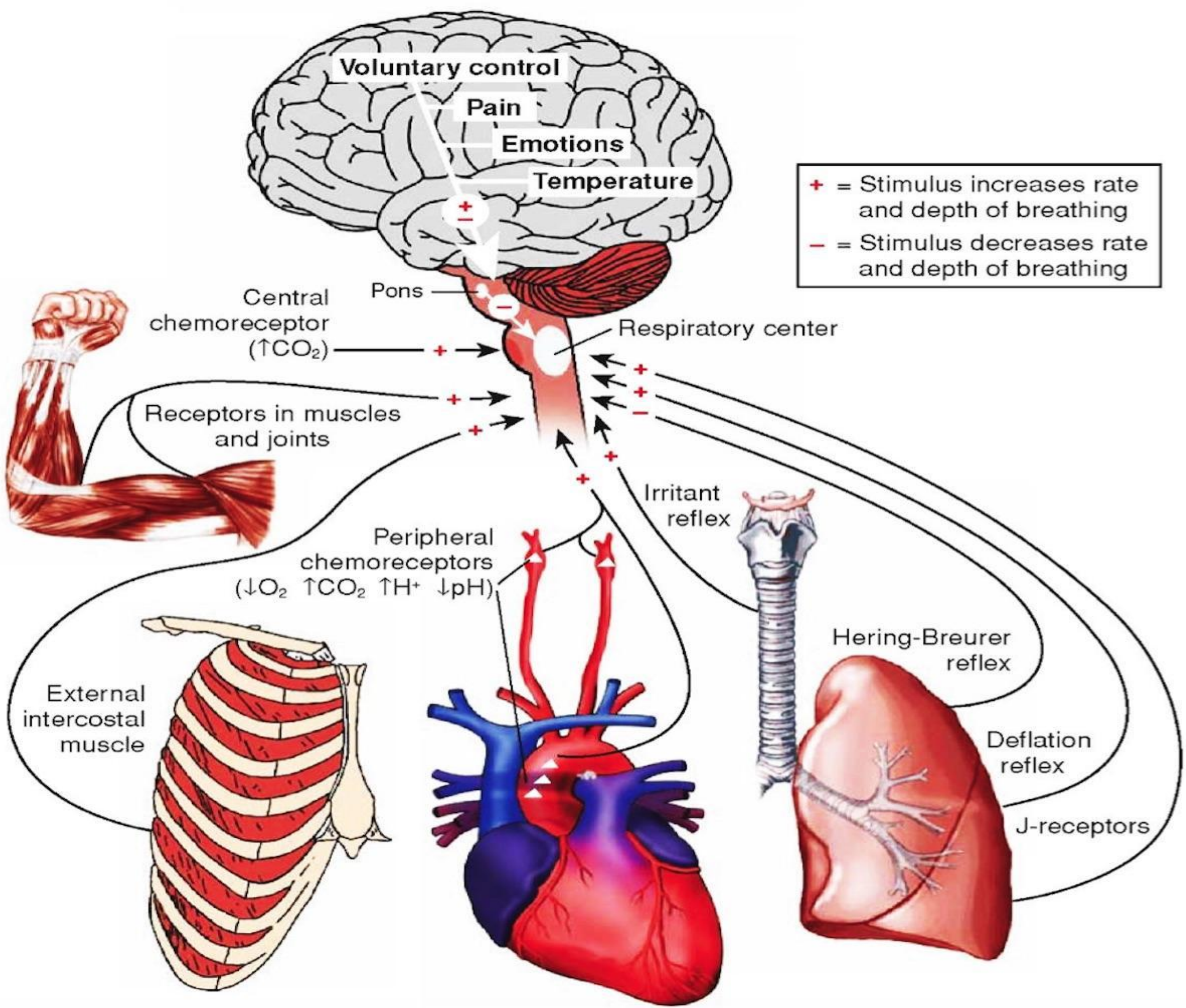
2.1.5 Describe the nervous and chemical control of ventilation during exercise

Inspiration is activated via the respiratory center in the medulla of the brain

The lungs inflate because motor neurons activate the diaphragm and the external intercostal muscles.

Inflation of the lung tissue stimulates **stretch receptors** in the bronchioles that inhibit inspiration and stimulate expiration. (don’t want to stretch too much)

Expiration begins with a recoil of the stretched lung tissue and the inspiratory muscles are stimulated to relax. The internal intercostals muscles will be stimulated while inspiratory muscle activation is inhibited.



Voluntary control
Pain
Emotions
Temperature
+ = Stimulus increases rate and depth of breathing
– = Stimulus decreases rate and depth of breathing
Pons
Central chemoreceptor (↑CO_2)
Respiratory center
Receptors in muscles and joints
Irritant reflex
Peripheral chemoreceptors (↓O_2 ↑CO_2 ↑H^+ ↓pH)
Hering-Breurer reflex
External intercostal muscle
Deflation reflex
J-receptors

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Exercise physiology

Topic 2
Exercise Physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

Sub-topics

1. Structure & function of the ventilatory system

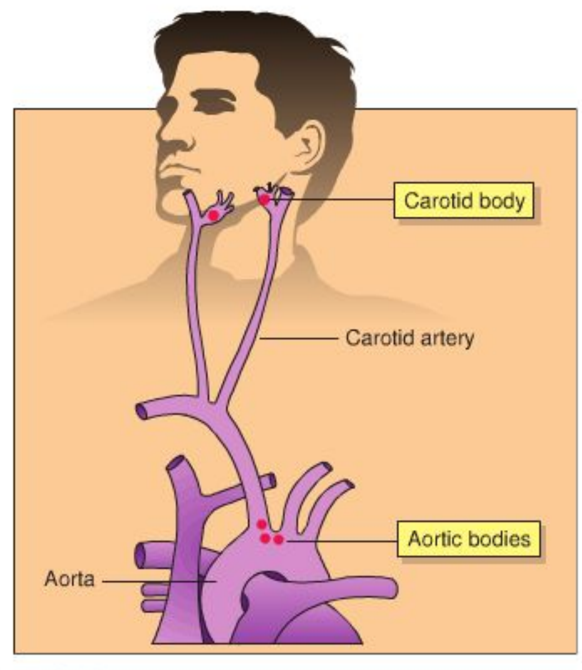
2. Structure & function of the cardiovascular system

Chemical state of blood in medulla

Peripheral chemoreceptors

- The chemical state of blood regulates pulmonary ventilation at rest and exercise.
- Variations in PO_2, O_2, CO_2 acidity and temperature activate sensors in the brain (medulla) and arterial system to adjust ventilation and maintain blood chemistry within narrow limits.

PO_2 = partial pressure of oxygen.
- It is the individual **pressure** exerted independently by a particular gas within a mixture of gasses.



Proprioceptors in joints and muscles

Exercise physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

- When we exercise, we experience an increase in depth and rate of respiration to meet the increased oxygen requirement.

- The increase in respiration often precedes the actual increased oxygen requirement!!! What?!?!

- There are at least 2 components to this increase in respiration that precedes the increased oxygen requirement.

1) The first component is "anticipation of exercise" and may involve activation of the sympathetic nervous system in order to prepare the body for activity

Proprioceptors in joints and muscles

Exercise physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

2) The second component involves activation of stretch receptors (proprioceptors) in **skeletal muscle and joints**.

- Increased activity of stretch receptors is detected by the medulla and results in increased rate and depth of respiration.
- The effect is very rapid and shows the value of stretching/warming up before exercise (ie. in addition to heating up muscles and connective tissues and reducing stretch-related injuries).
- This allows the body to properly prepare for exercise and helps control breathing, heart rate, temperature, etc.

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Proprioceptors in joints and muscles

Exercise physiology

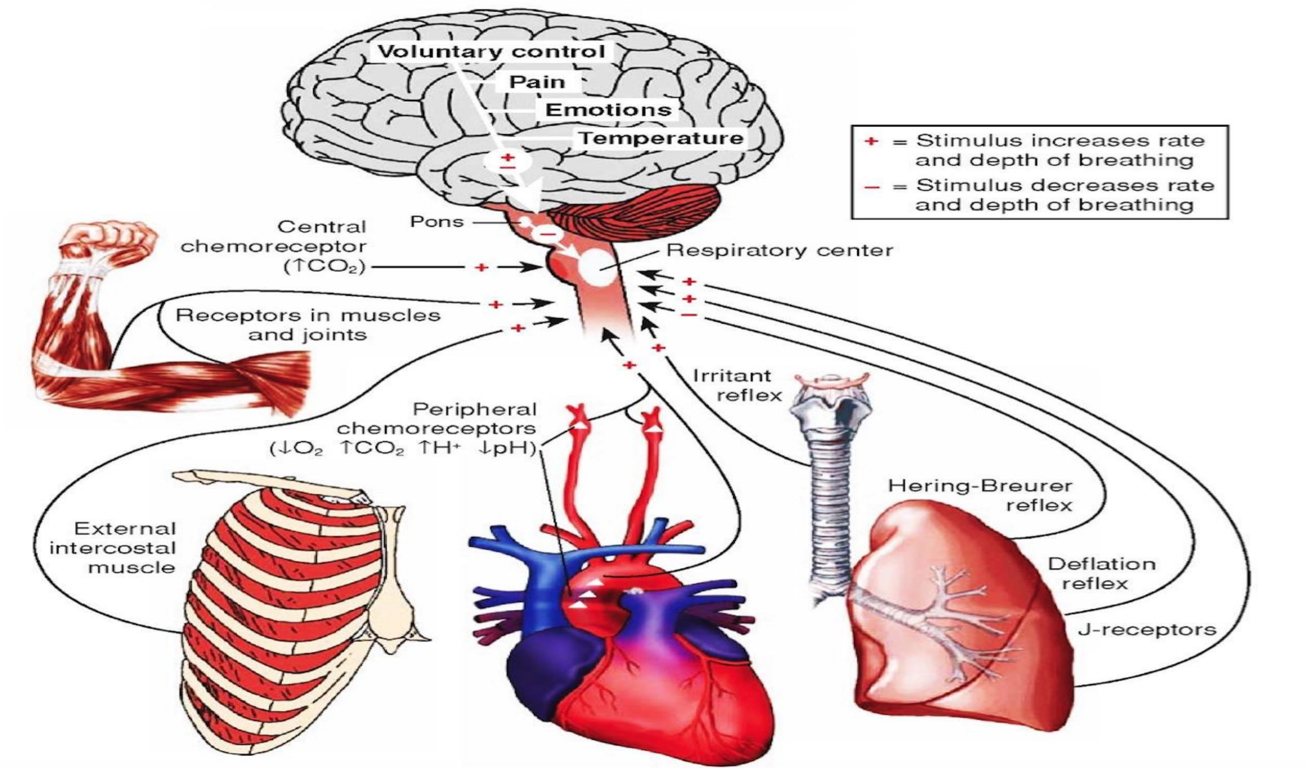
Topic 2
Exercise Physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

Sub-topics

1. Structure & function of the ventilatory system

2. Structure & function of the cardiovascular system

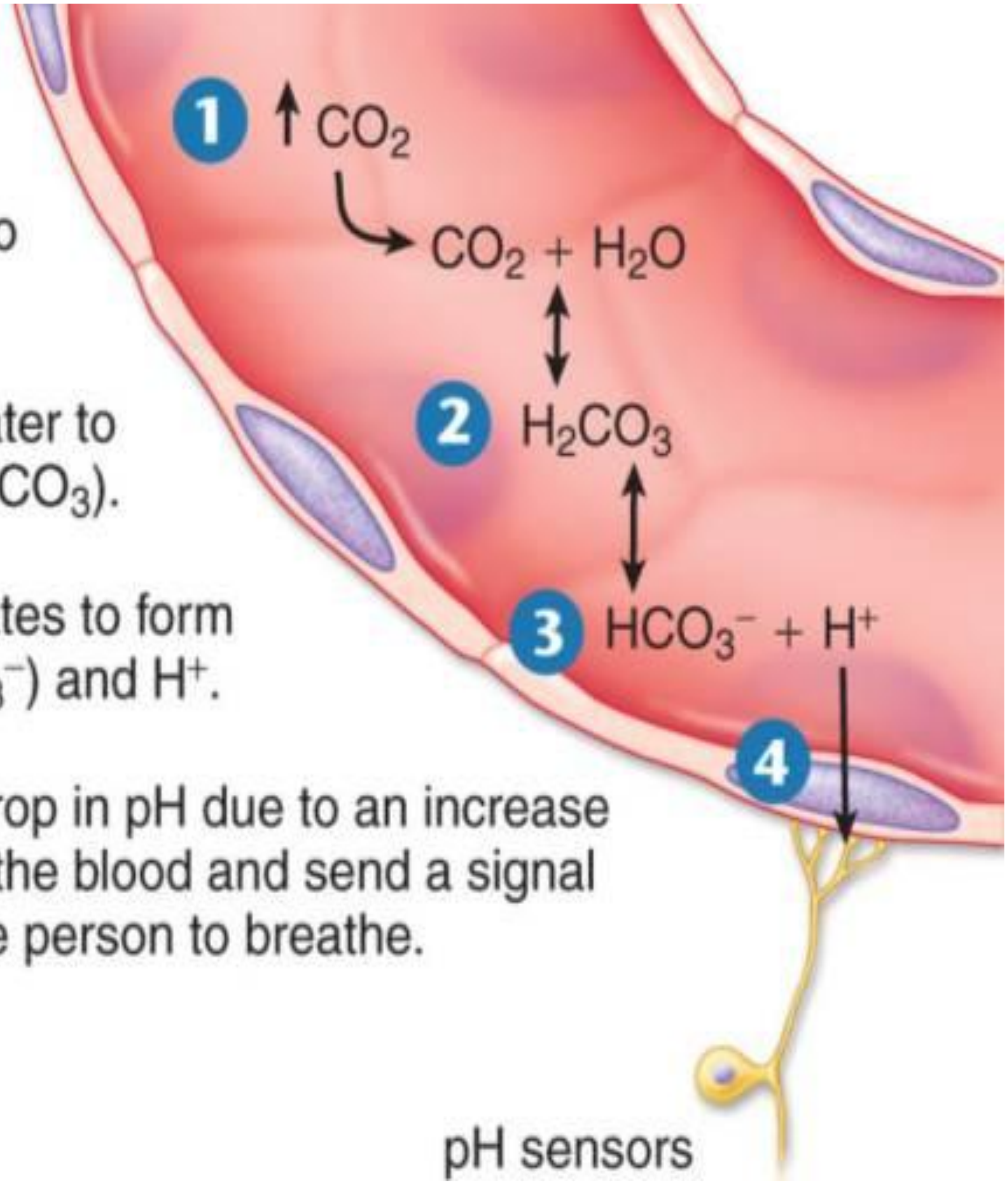


- Carbon dioxide (CO_2) diffuses through the alveolar walls much more easily than oxygen
- CO_2 is produced by muscles then sent into bloodstream. CO_2 reacts with **carbonic anhydrase & H_2O** (enzyme to speed up reactions) in red blood cells (RBC's) and forms **carbonic acid**
- After being further reduced, it is now **bicarbonate** (HCO_3^-) which dissolves in **blood plasma** (discussed in a few slides). Blood pH drops and sensors force us to breathe.

- This is necessary to transport CO_2 out of the body because we don't want gases in the bloodstream

- All of these reactions are reversed in the lungs so we can transfer and exhale CO_2 from our bodies

1. Holding one's breath causes levels of CO_2 to rise in the blood.
2. CO_2 combines with water to form carbonic acid (H_2CO_3).
3. Carbonic acid dissociates to form bicarbonate ion (HCO_3^-) and H^+.
4. pH sensors detect a drop in pH due to an increase in H^+ concentration in the blood and send a signal to the brain, forcing the person to breathe.



Exercise physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

- As it is, carbon dioxide excretion is far more easily hindered than is oxygen absorption.
- **Thus breathing is governed not by oxygen, but the carbon dioxide content of the blood.**

Exercise physiology

2.1.5 Describe the nervous and chemical control of ventilation during exercise

- HYPERVENTIALTION
- An increase in ventilation above what is required
- Exhale too much CO2 and inhale too much O2
- Leads to an increased blood pH
- Typically caused by a state of panic, dizziness, tingling in the lips, hands or feet, headache, weakness, fainting and seizures are common

Hyperventilation video

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Exercise physiology

Topic 2

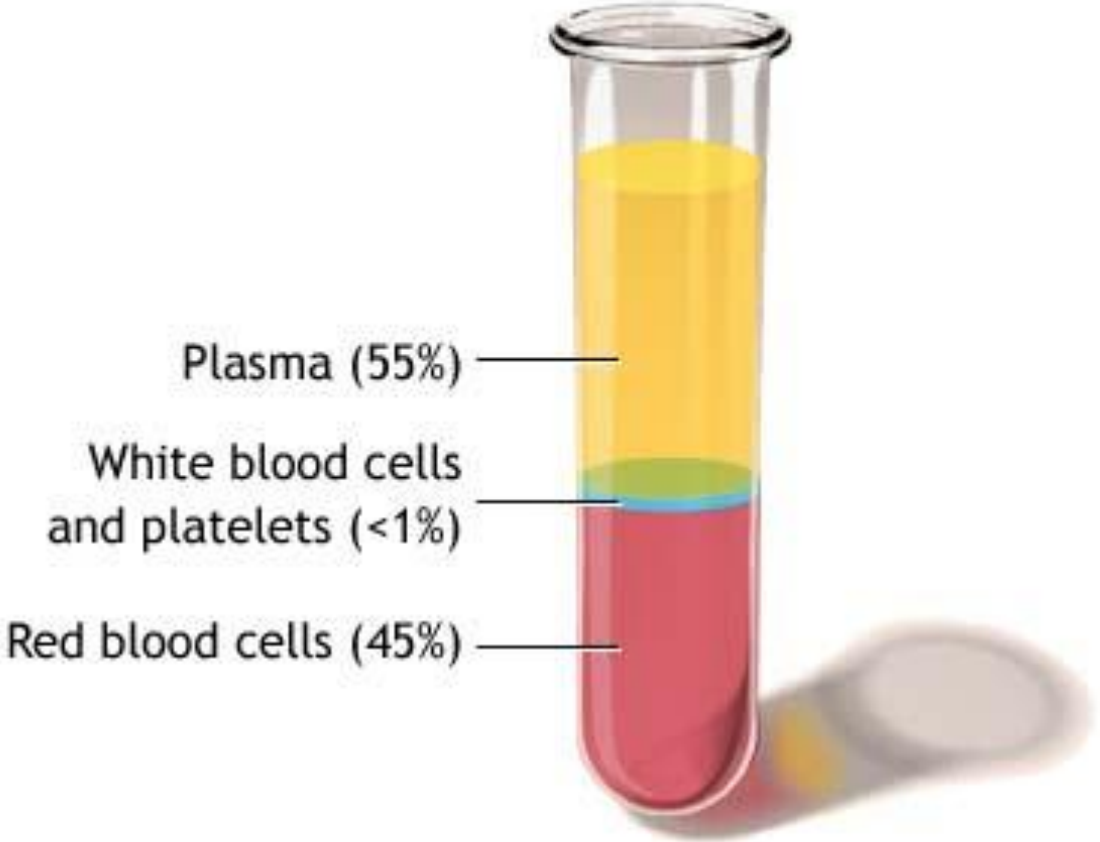
Exercise Physiology

2.1.6 Outline the role of hemoglobin in oxygen transportation

Sub-topics

1. Structure & function of the ventilatory system

2. Structure & function of the cardiovascular system



Summary

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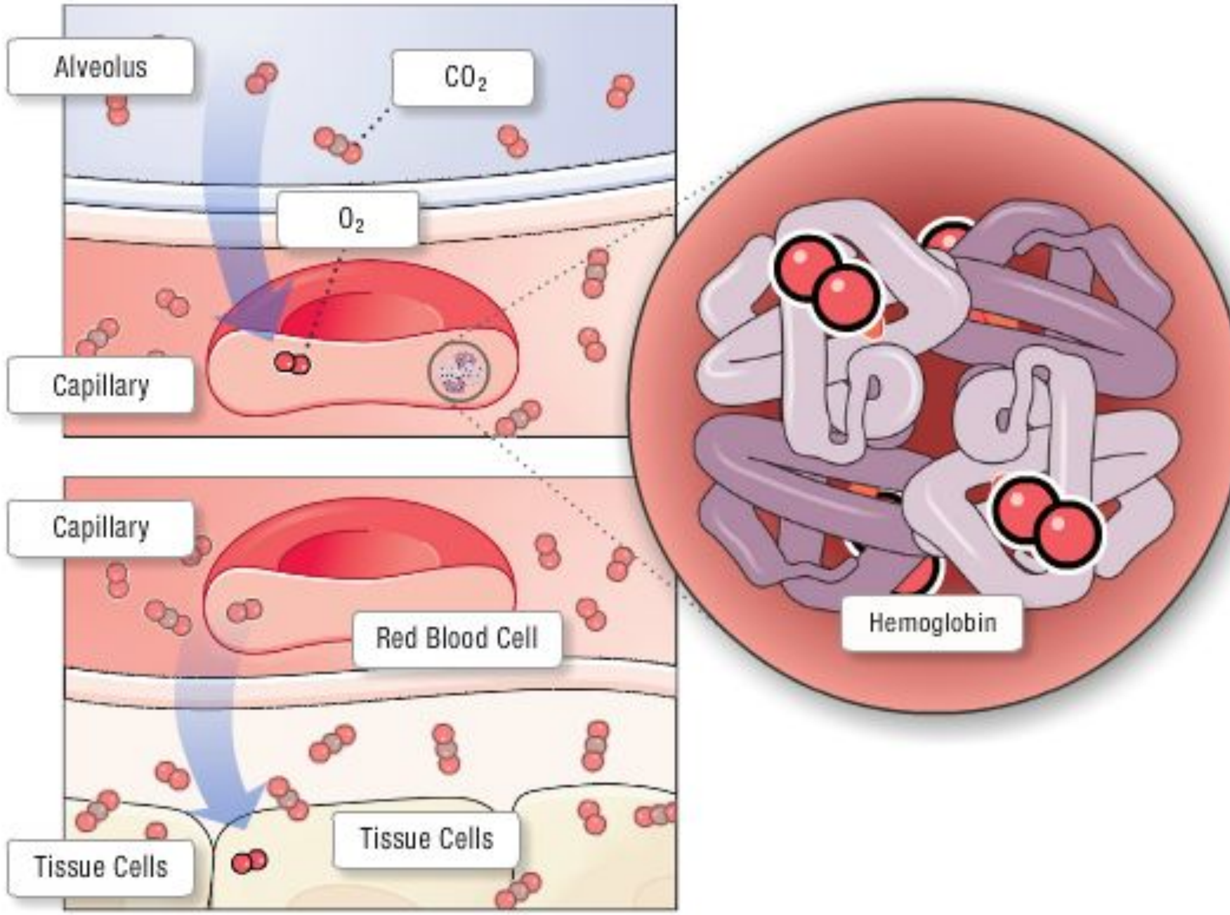
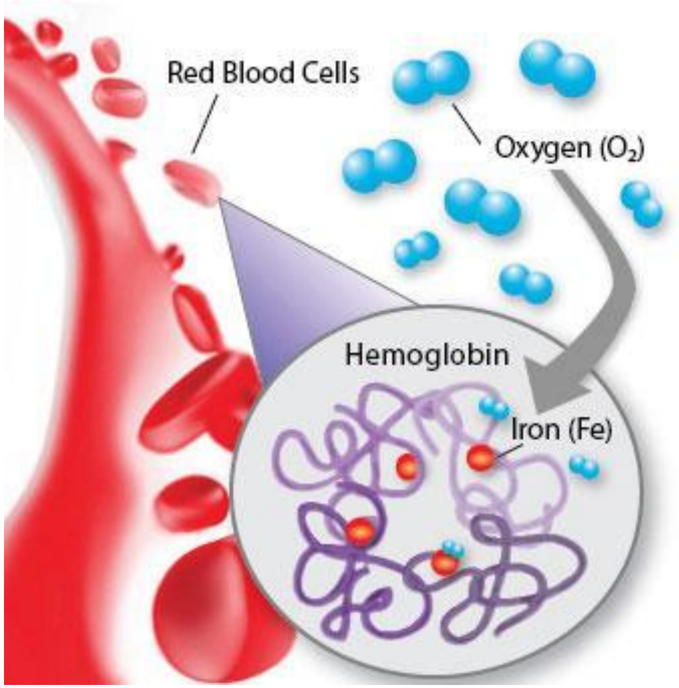


2.1.6 Outline the role of Hemoglobin oxygen transportation

- Hemoglobin is the iron containing oxygen transport protein in the red blood cells.
- It transports oxygen from the lungs to the rest of the body, such as the muscles, where it releases its oxygen.
- Each molecule of hemoglobin can carry 4 oxygen molecules
- It can also carry CO2 as carbaminohemoglobin back to the lungs for diffusion and expiration.



2.1.6 Outline the role of hemoglobin in oxygen transportation

- Oxygen at the lungs is collected mostly by red blood cells (~95%) where they combine with hemoglobin to form oxy-hemoglobin (O_2 saturated hemoglobin) and the rest (~5%) diffuses into blood plasma (O_2 has low solubility)

- This oxygen dissolved in the plasma determines the movement of oxygen from cells into the blood (pressure gradient)

- Plasma PO_2 determines the loading of hemoglobin at the lungs and the unloading of oxygen at the cells

- When there is low PO_2, hemoglobin gives up its oxygen to the plasma (it now becomes part of the blood) which increases the PO_2 of the blood in relation to surrounding cells. Oxygen moves from the blood to the cells.

- At rest only 25% of the oxygen content of blood is used with rest remaining in circulation.

Exercise physiology

2.1.6 Outline the role of hemoglobin in oxygen transportation

Diffusion - The passive movement of molecules or particles along a concentration gradient, or from regions of higher to regions of lower concentration in relation to surface area – Ficks Law

Gas concentration reflects the amount of gas in a given volume, (determined by the gas' partial pressure and solubility)
Partial pressure = percentage concentration x total pressure of gas mixture i.e. $PC0_2$ and PO_2

Gas pressure represents the force exerted by the gas molecules against the surfaces they encounter i.e. breathing

Fick's Law

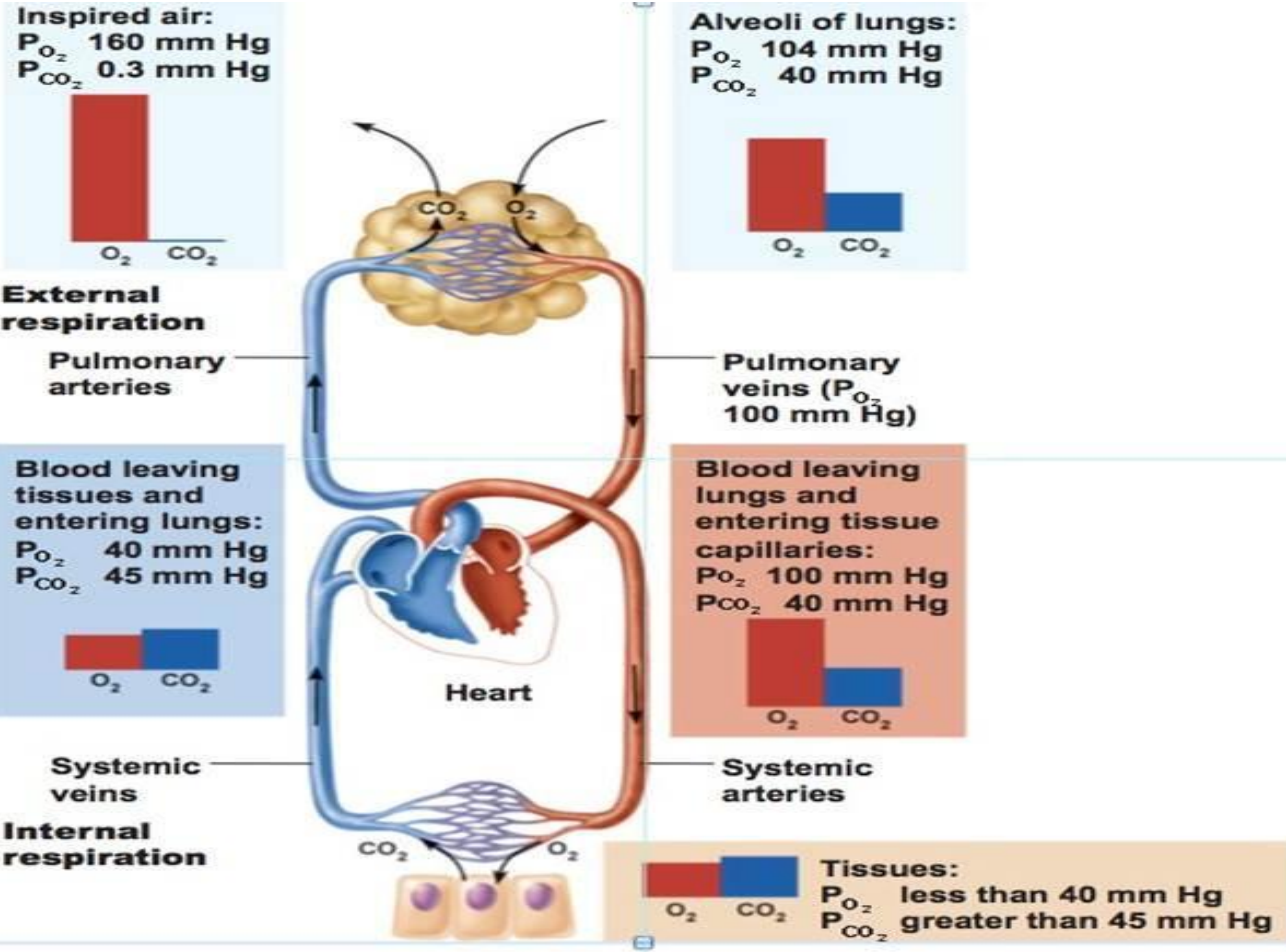
Fick's law is used to measure the rate of diffusion.

It states that:

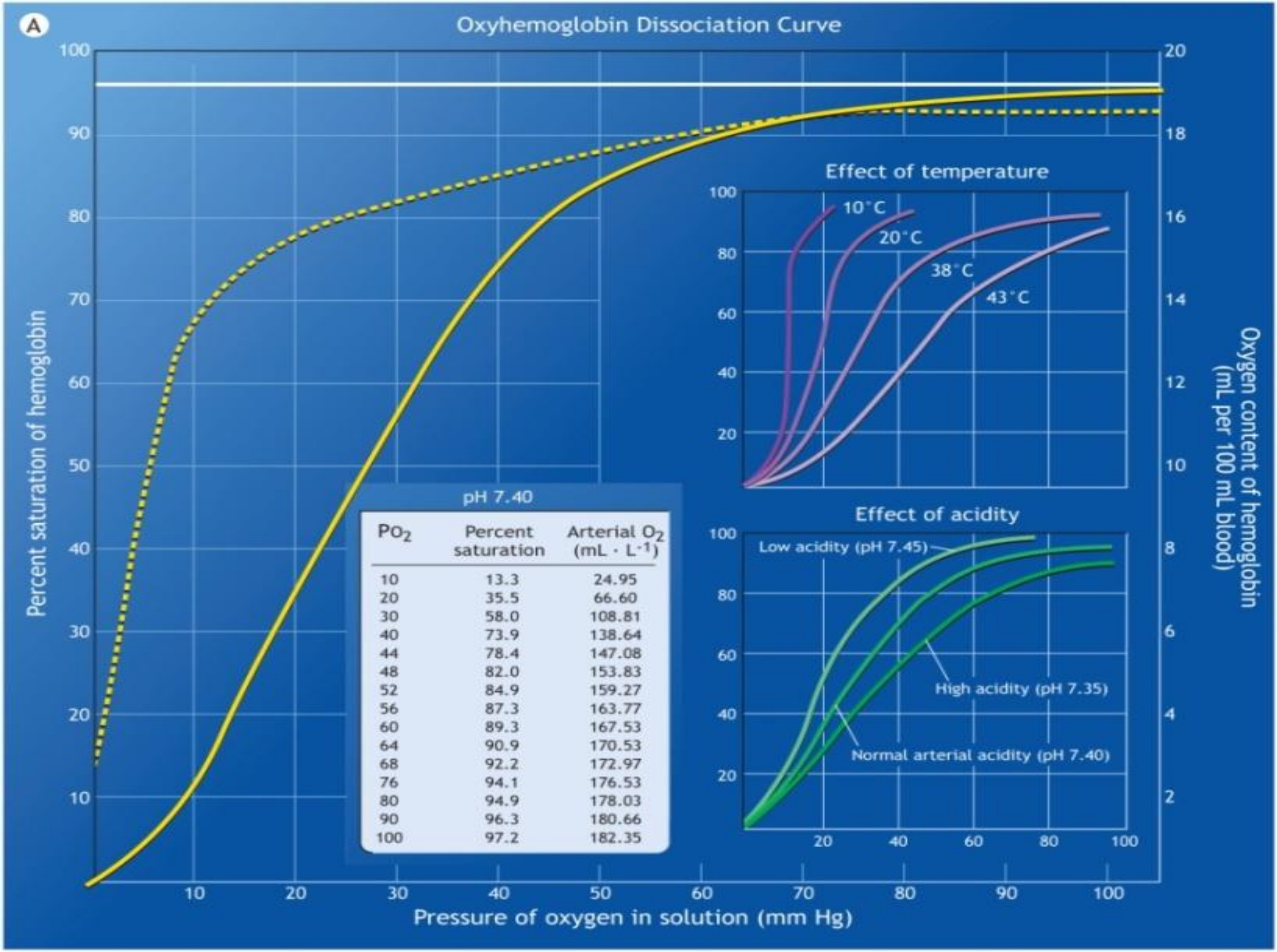
$$\text{Rate of diffusion} \propto \frac{\text{Area of diffusion surface} \times \text{Difference in concentration}}{\text{Thickness of surface over which diffusion takes place}}$$

The larger the area and difference in concentration and the thinner the surface, the quicker the rate.

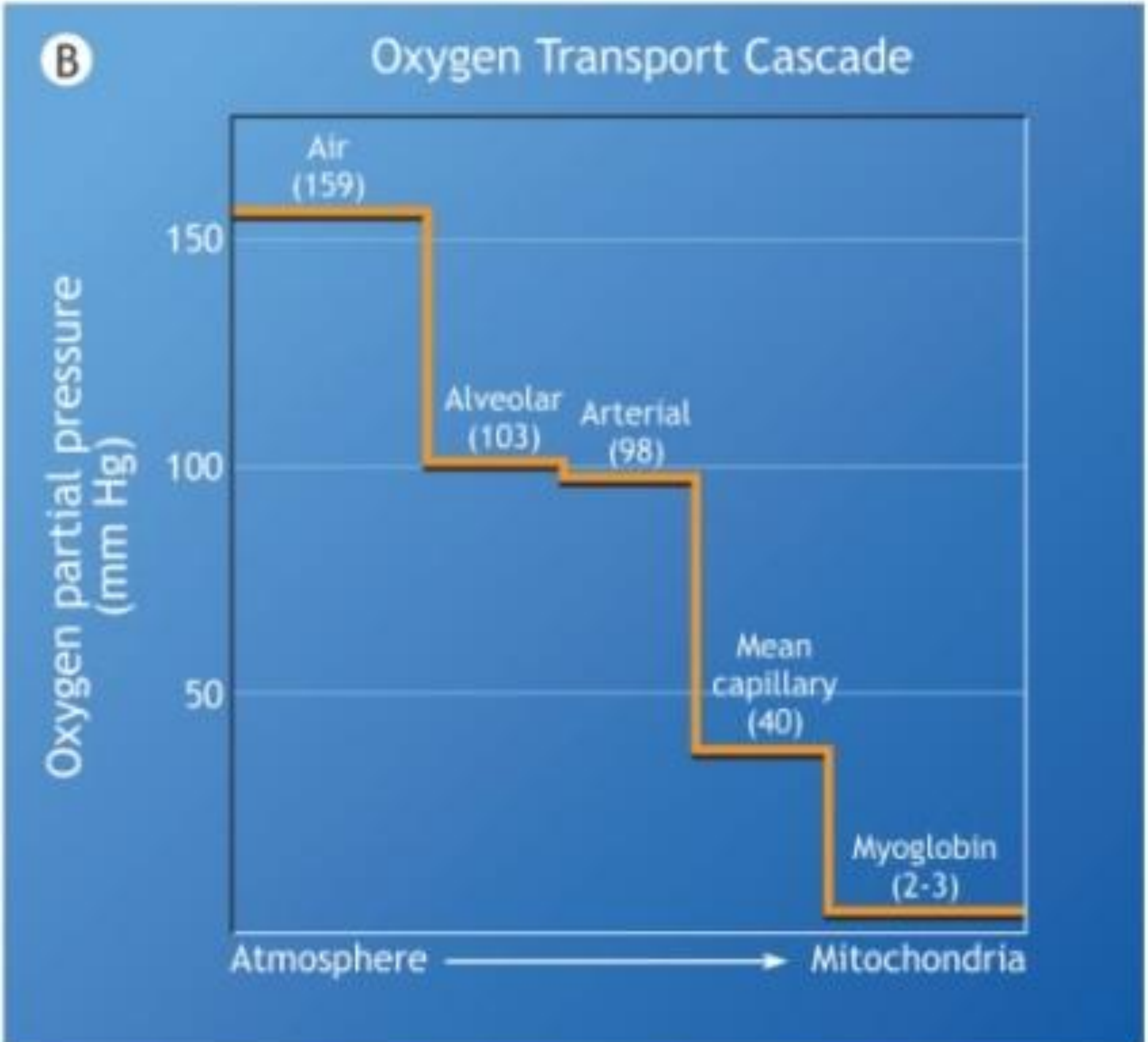
So, for example, in the lung the surface area is made very large by the presence of many alveoli. The difference in concentration is maintained by breathing, which brings in air with a high oxygen concentration and removes the air with a high carbon dioxide concentration and by a good blood supply. The capillaries surrounding the alveoli take away the oxygenated blood and replace it with blood with a high carbon dioxide concentration. The walls of the alveoli are only one cell thick, so the surface across which diffusion occurs is thin and the rate is high



Inspired air:
P_{O_2} 160 mm Hg
P_{CO_2} 0.3 mm Hg
O_2 CO_2
Alveoli of lungs:
P_{O_2} 104 mm Hg
P_{CO_2} 40 mm Hg
O_2 CO_2
CO_2 O_2
External respiration
Pulmonary arteries
Pulmonary veins (P_{O_2} 100 mm Hg)
Blood leaving tissues and entering lungs:
P_{O_2} 40 mm Hg
P_{CO_2} 45 mm Hg
O_2 CO_2
Blood leaving lungs and entering tissue capillaries:
P_{O_2} 100 mm Hg
P_{CO_2} 40 mm Hg
O_2 CO_2
Heart
Systemic veins
Systemic arteries
Internal respiration
CO_2 O_2
Tissues:
P_{O_2} less than 40 mm Hg
P_{CO_2} greater than 45 mm Hg
O_2 CO_2



Po_2	Percent saturation	Arterial O_2 ($mL \cdot L^{-1}$)
10	13.3	24.95
20	35.5	66.60
30	58.0	108.81
40	73.9	138.64
44	78.4	147.08
48	82.0	153.83
52	84.9	159.27
56	87.3	163.77
60	89.3	167.53
64	90.9	170.53
68	92.2	172.97
76	94.1	176.53
80	94.9	178.03
90	96.3	180.66
100	97.2	182.35


B
Oxygen Transport Cascade
Air
(159)
Alveolar
(103)
Arterial
(98)
Mean
capillary
(40)
Myoglobin
(2-3)
150
100
50
Oxygen partial pressure
(mm Hg)
Atmosphere
Mitochondria

Carbon Dioxide Transport

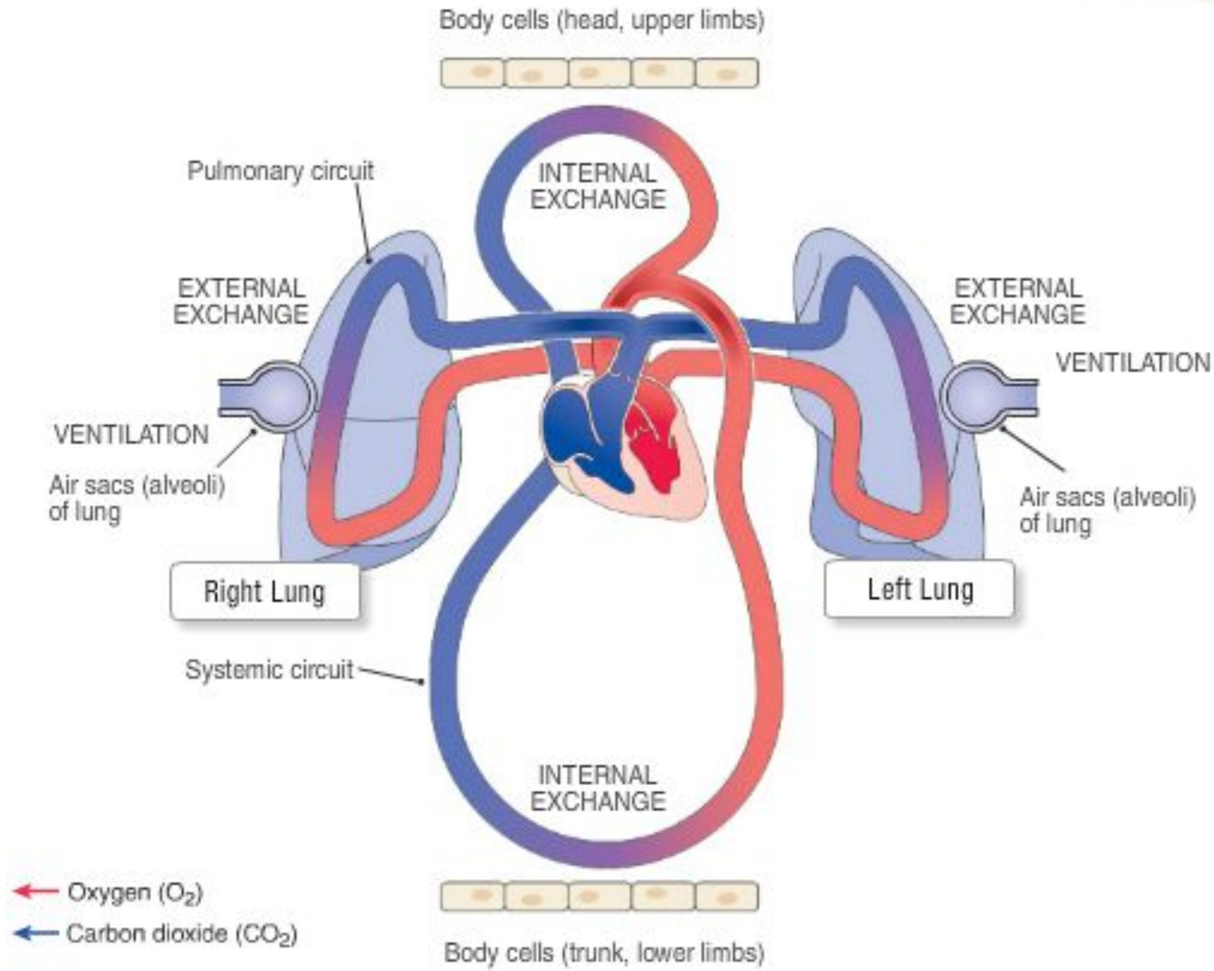
The transport of carbon dioxide occurs in three ways:

1. In physical solution in plasma. This accounts for only a small amount of the total carbon dioxide transported.

2. Combined with hemoglobin within the red blood cell.

And

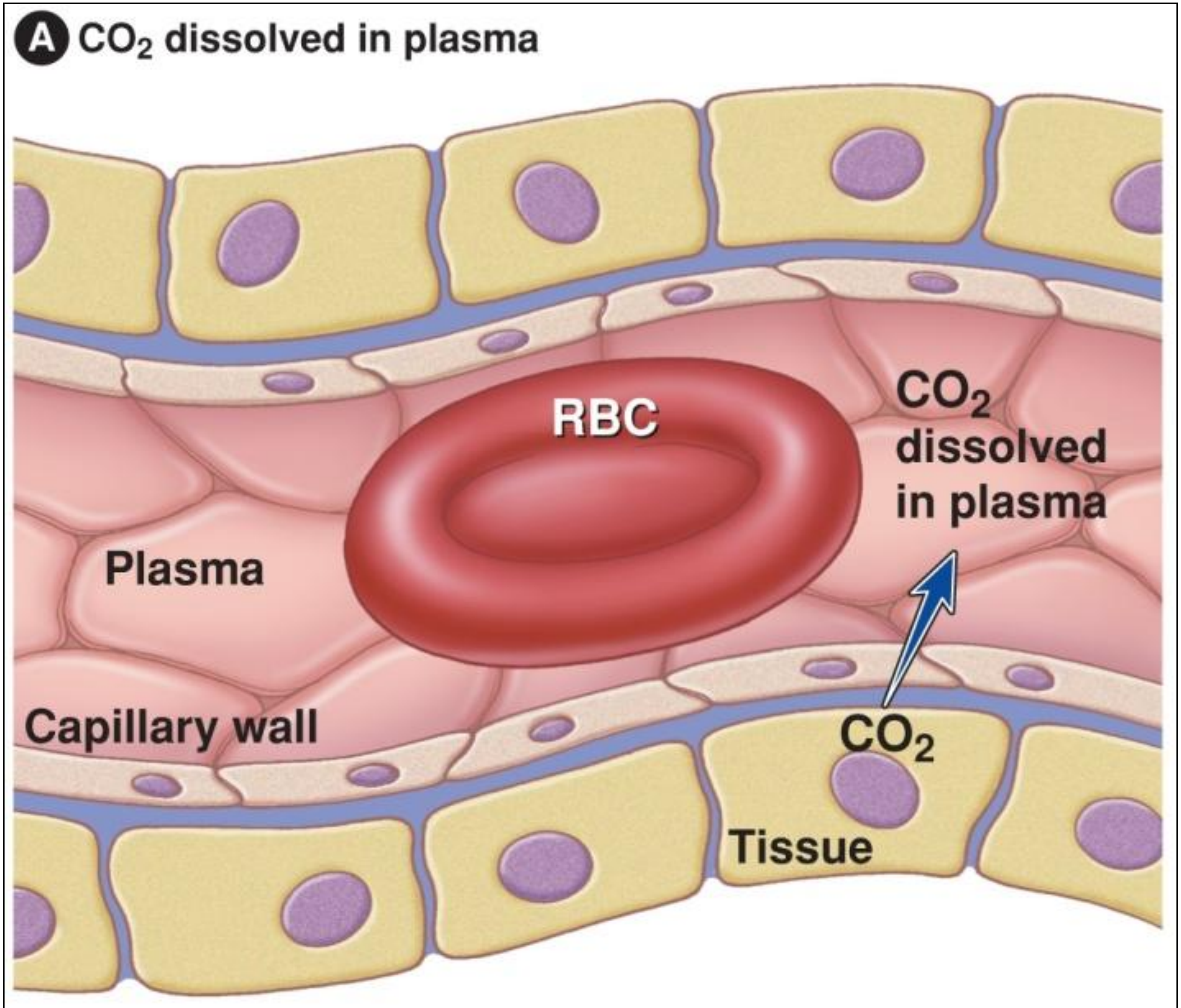
3. As plasma bicarbonate.

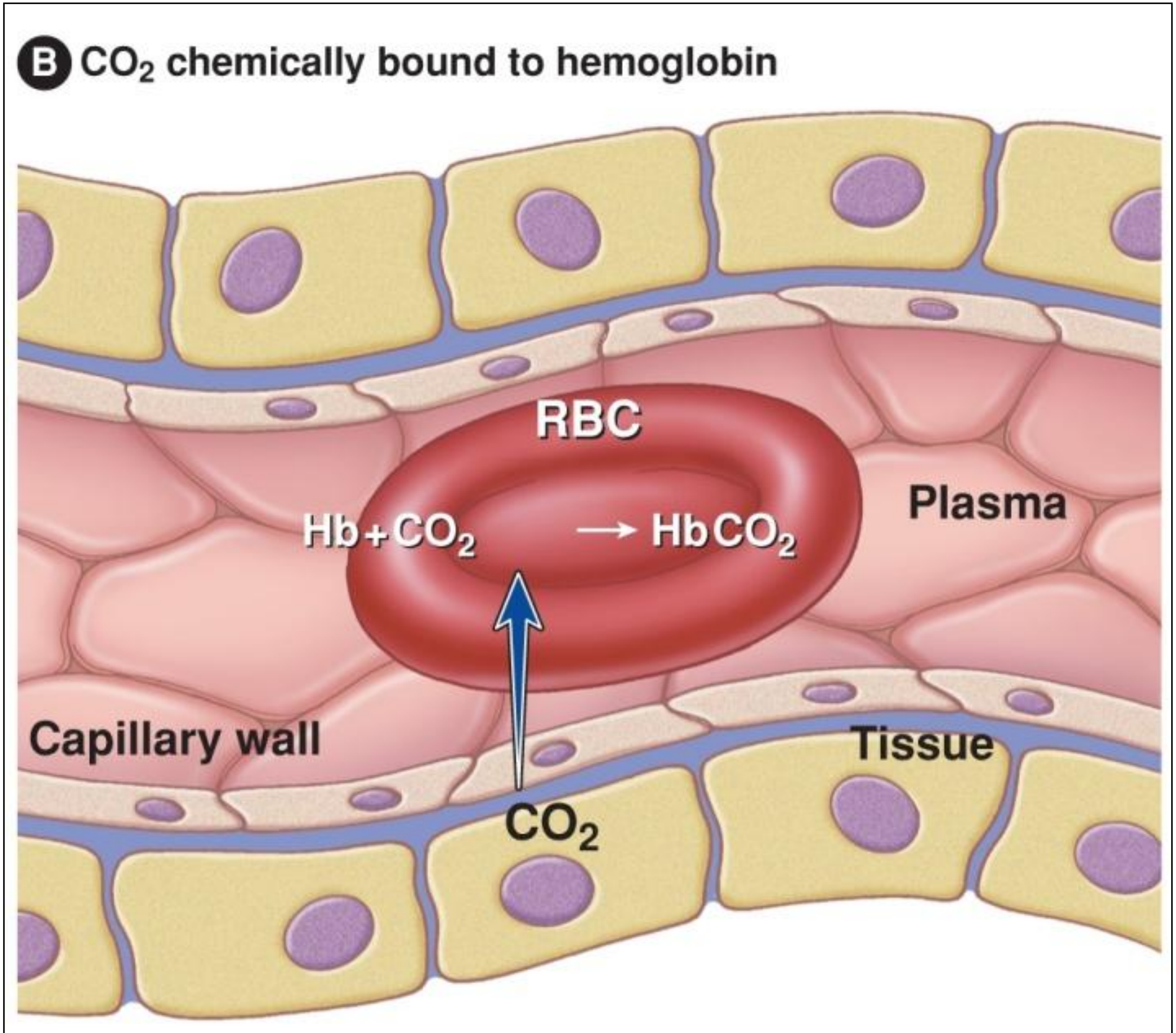


Exercise physiology

2.1.5 Describe the significance of carbon dioxide in the control of pulmonary ventilation

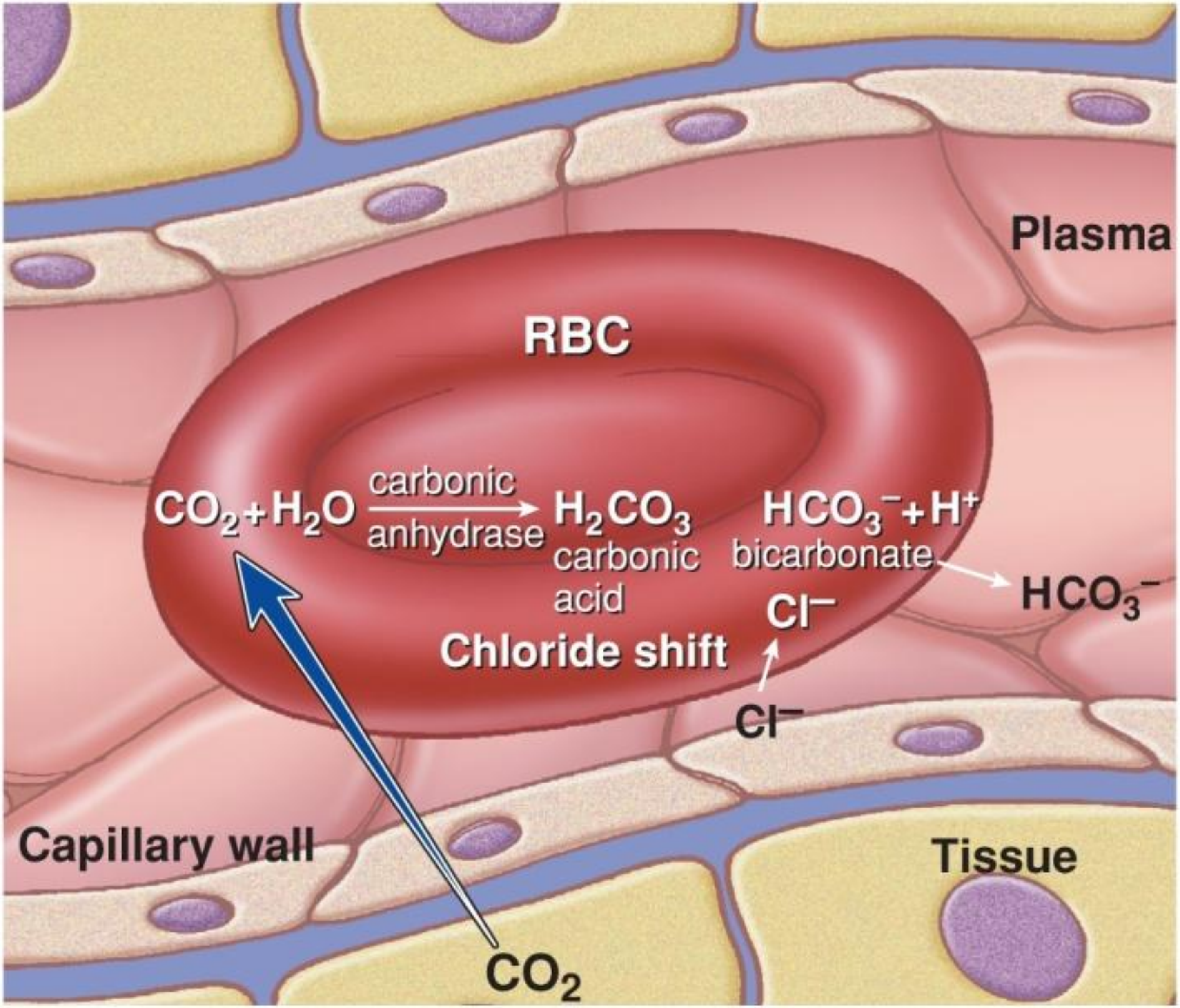
- Physical solution in plasma (7%–10%); establishes the PCO_2 of the blood
- Loose combination with Hb (20%)
- Combined with water as bicarbonate (70%)


A CO_2 dissolved in plasma
RBC
CO_2 dissolved in plasma
Plasma
Capillary wall
CO_2
Tissue



20% = Carboaminohaemoglobin

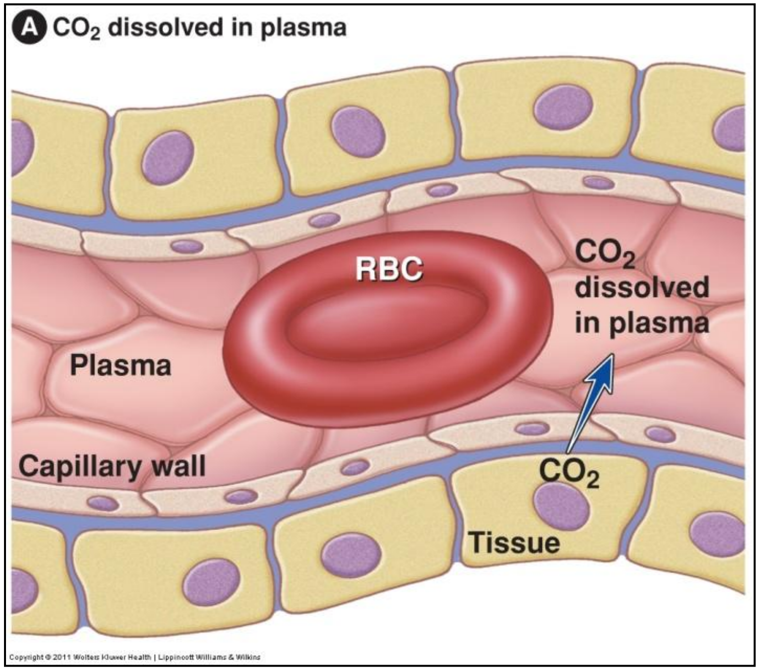
C CO_2 combined with water as bicarbonate



Exercise physiology

2.1.5 Describe the significance of carbon dioxide in the control of pulmonary ventilation

- CO2 combines with water in the red blood cell to form Carbonic acid (CO2+H2O=H2CO3)
- Carbonic acid ionises into Hydrogen ions (H+) and bicarbonate ions (HCO3)
- At the lungs, as blood PCO2 lowers Hydrogen ions and Bicarbonate ions recombine to form carbonic acid which in turn is broken down to CO2 and water



A CO2 dissolved in plasma
RBC
CO2
dissolved
in plasma
Plasma
Capillary wall
CO2
Tissue
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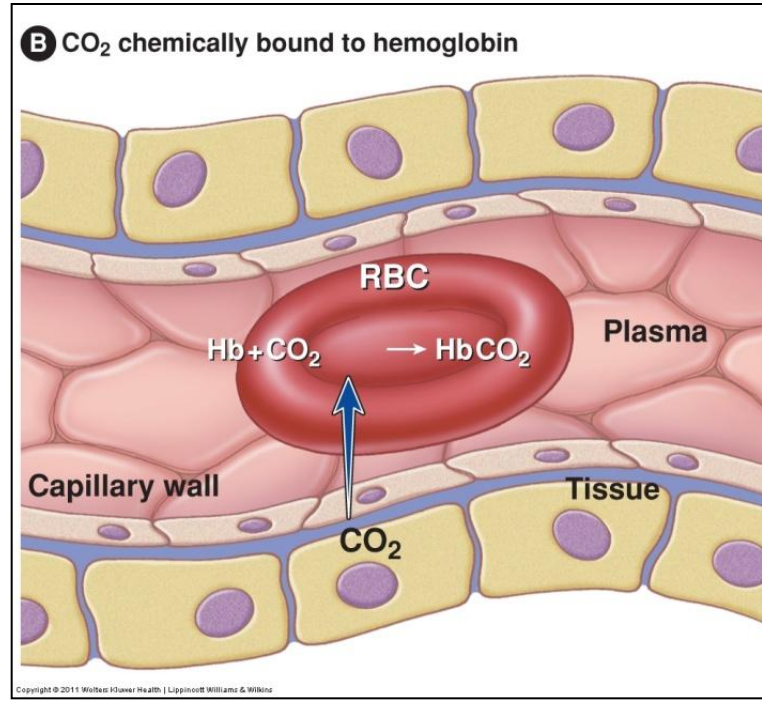

B CO2 chemically bound to hemoglobin
RBC
Hb+CO2 → HbCO2
Plasma
Capillary wall
Tissue
CO2
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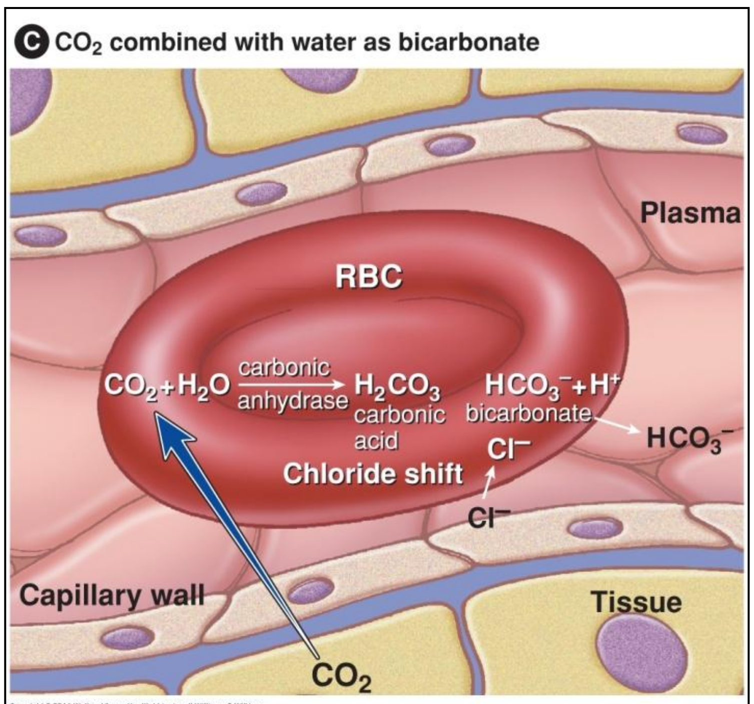

C CO2 combined with water as bicarbonate
Plasma
RBC
CO2+H2O
carbonic
anhydrase
H2CO3
carbonic
acid
HCO3−+H+
bicarbonate
HCO3−
Cl−
Chloride shift
Cl−
Capillary wall
Tissue
CO2
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Exercise physiology

2.1.5 Describe the significance of carbon dioxide in the control of pulmonary ventilation

1. List two functions of the ventilatroy system
2. List 2 factors that determine lung filling.
3. List an average tidal volume for men and women.
4. List the average vital capacity for men and women.
5. Compute V_E for an individual with a tidal volume of 0.6 L and a breathing rate of 15 breaths per minute.
6. List 2 ways oxygen transports in blood.
7. Name 3 factors that regulate pulmonary ventilation
8. Why do some swimmers hyperventilate on the starting blocks?
9. Use Ficks law to explain the efficiency of the alveoli
10. Explain how training improves the efficiency of the respiratory system

Exercise physiology

2.1.5 Describe the significance of carbon dioxide in the control of pulmonary ventilation

1. **List two functions of the ventilatroy system**
2. **List 2 factors that determine lung filling.**
   - Magnitude of inspiratory movements
   - Pressure gradient between air inside and air outside the lung
3. **List an average tidal volume for men and women.**
   - **0.4l – 1l**
4. **List the average vital capacity for men and women**
   - **Men 4-5litres women 3-4litres**
5. **Compute V_E for an individual with a tidal volume of 0.6 L and a breathing rate of 15 breaths per minute.**
   - $9.0\ L\cdot min^{-1} = 15\ ´\ 0.6\ L$

IB
Sports, exercise and health science

Topic 2
Exercise Physiology

Sub-topics

1. Structure & function of the ventilatory system

2. Structure & function of the cardiovascular system

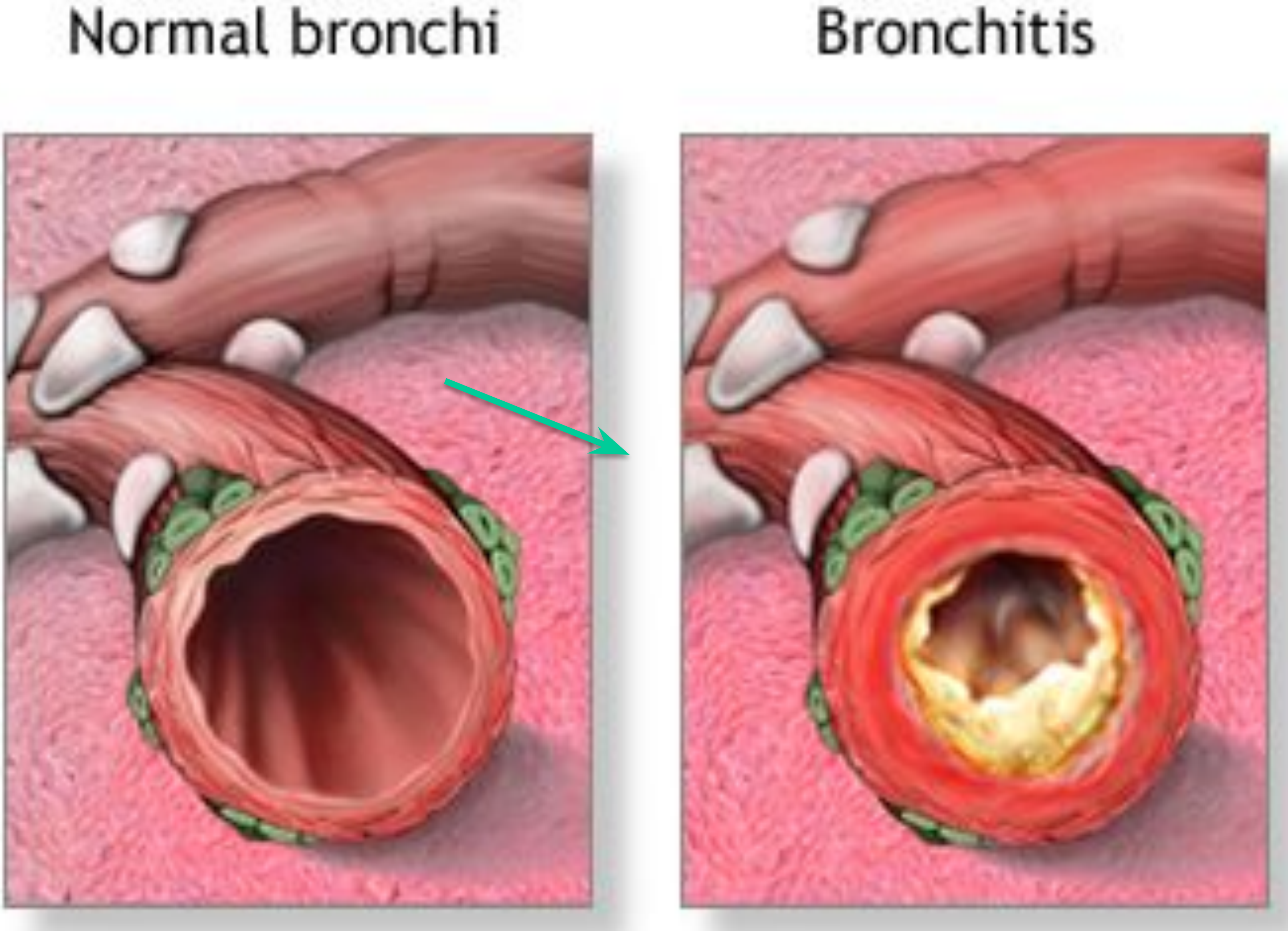
Exercise physiology

2.1.5 Describe the significance of carbon dioxide in the control of pulmonary ventilation

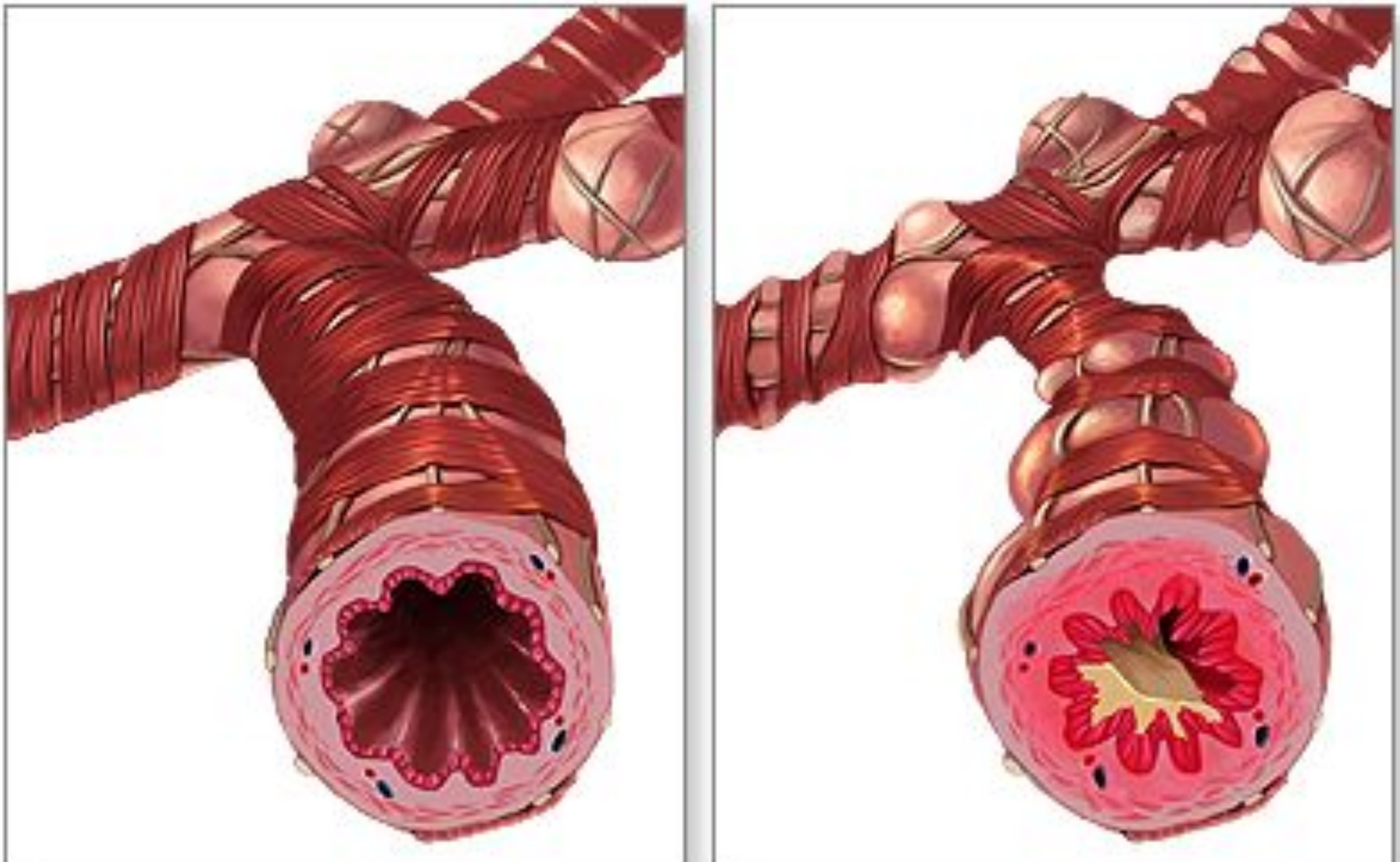
1. List 2 ways oxygen transports in blood.
2. Name 3 factors that regulate pulmonary ventilation
   - Lung and muscle stretch receptors
   - Chemoreceptors in the aorta, brain and neck
3. Why do some swimmers hyperventilate on the starting blocks?
4. Use Ficks law to explain the efficiency of the alveoli

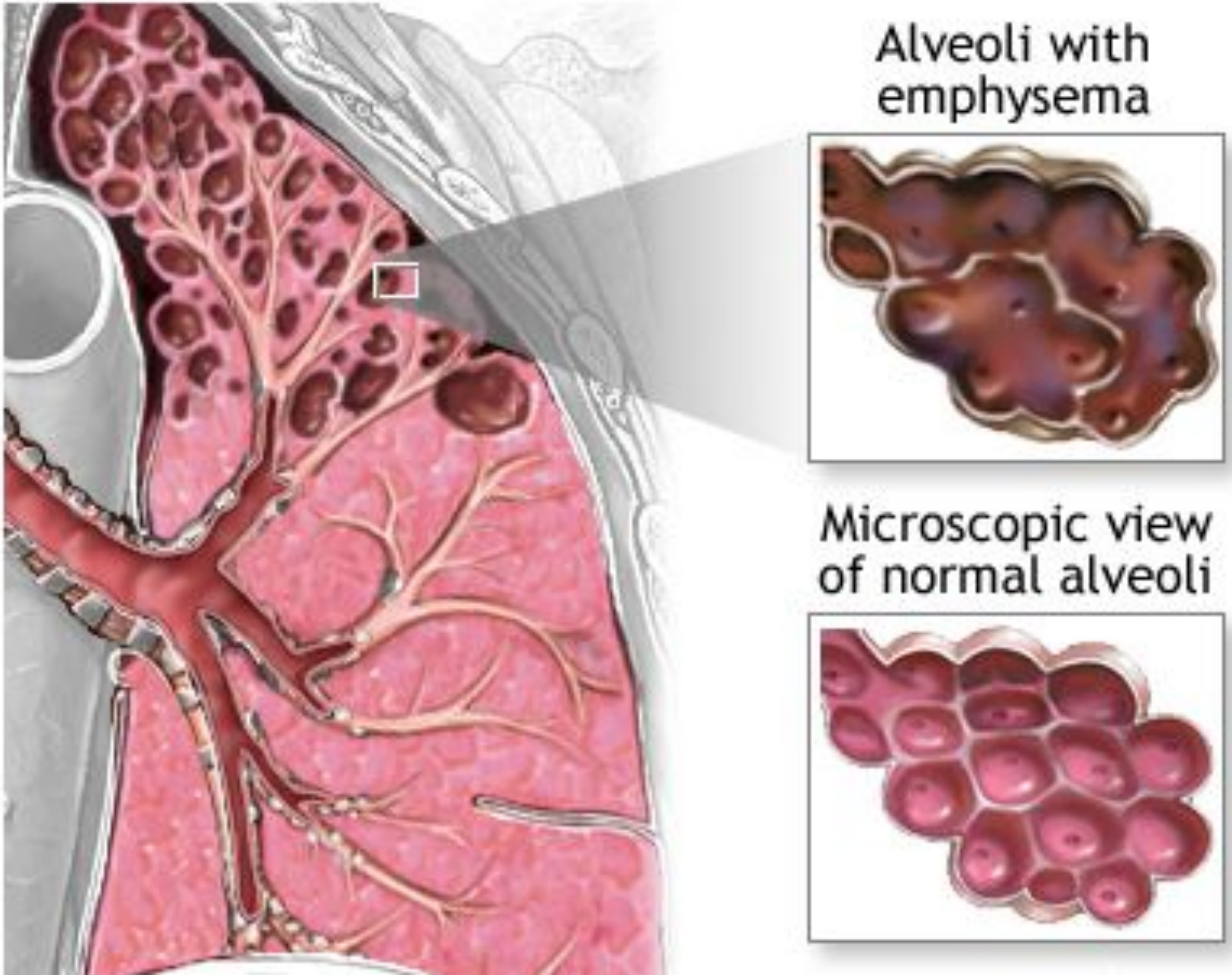
$$\text{Rate of diffusion} \propto \frac{\text{Area of diffusion surface x Difference in concentration}}{\text{Thickness of surface over which diffusion takes place}}$$

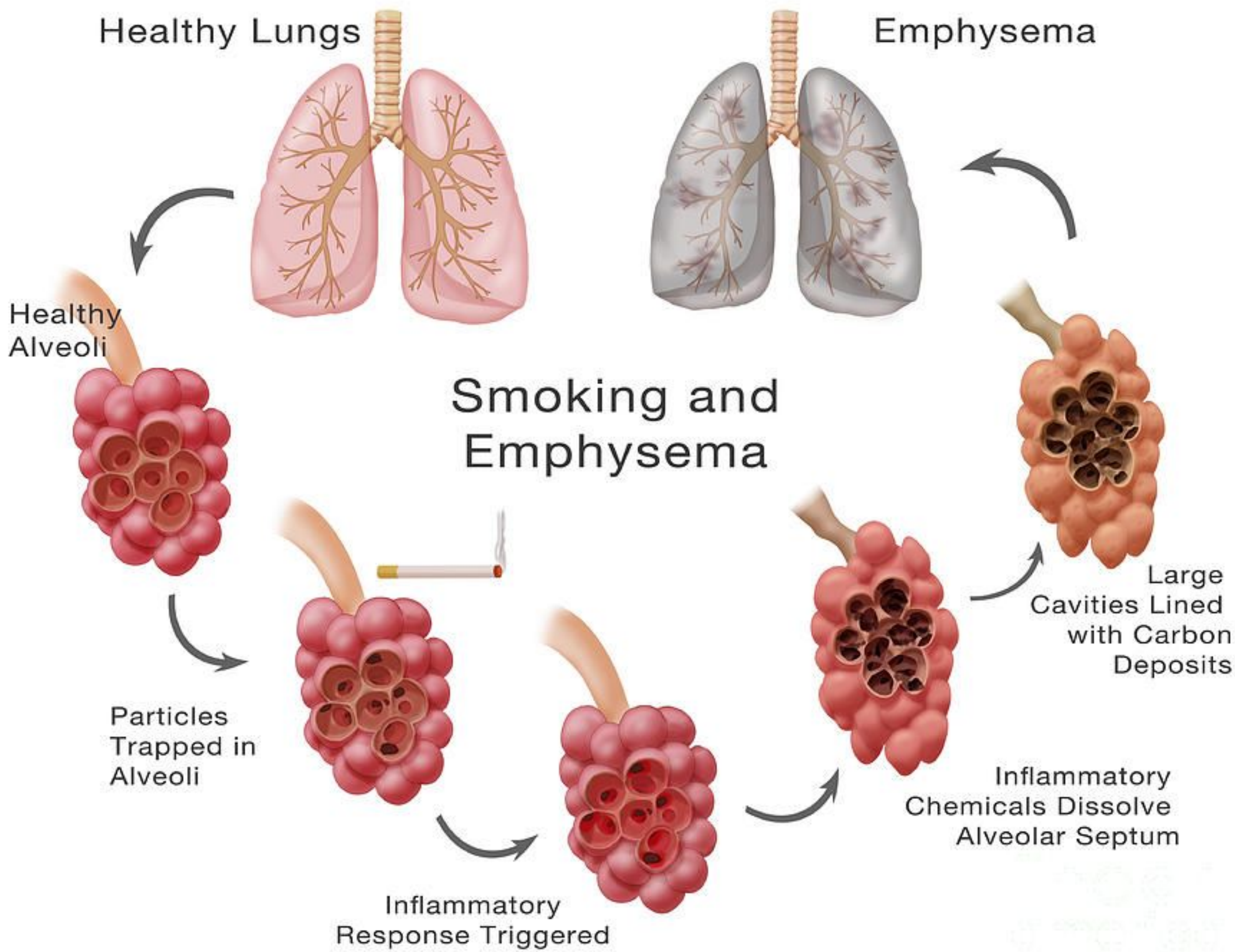
5. Explain how training improves the efficiency of the respiratory system


Normal bronchi
Bronchitis

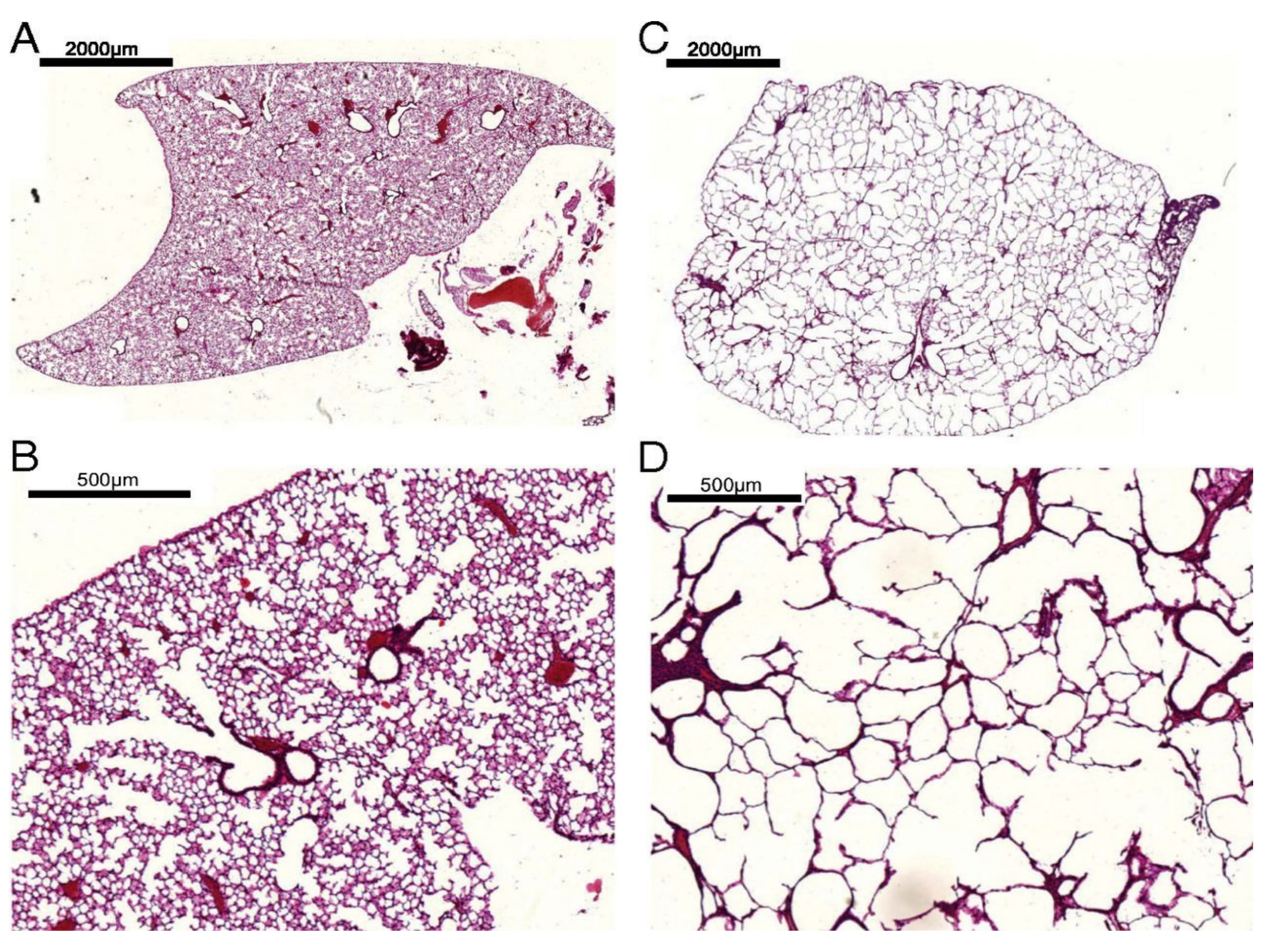
Normal bronchiole | Asthmatic bronchiole

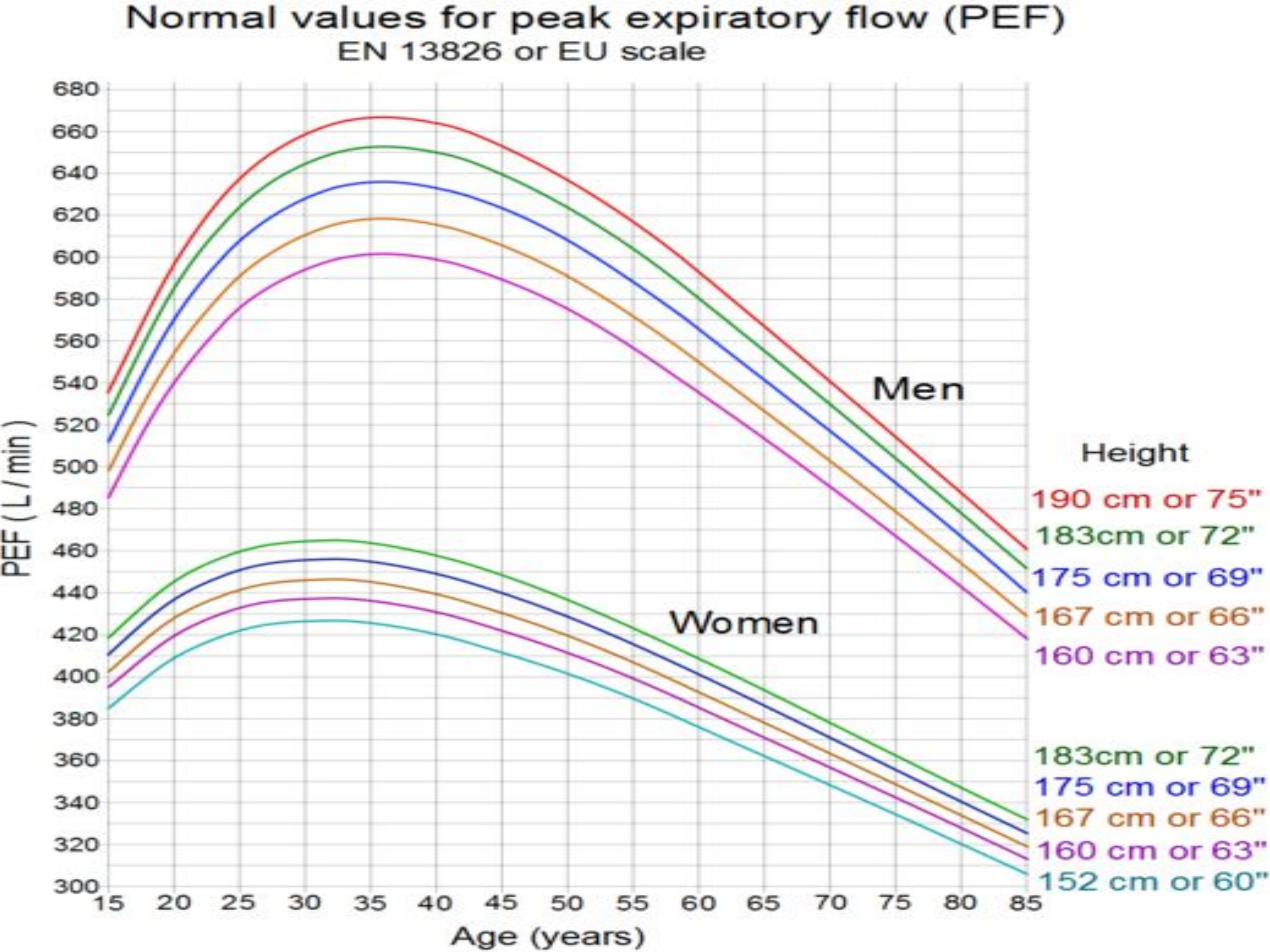



Alveoli with emphysema
Microscopic view of normal alveoli



Healthy Lungs
Emphysema
Smoking and Emphysema
Healthy Alveoli
Particles Trapped in Alveoli
Inflammatory Response Triggered
Inflammatory Chemicals Dissolve Alveolar Septum
Large Cavities Lined with Carbon Deposits


A
2000µm
B
500µm
C
2000µm
D
500µm


Normal values for peak expiratory flow (PEF)
EN 13826 or EU scale
PEF (L / min)
Age (years)
Men
Women
Height
190 cm or 75"
183cm or 72"
175 cm or 69"
167 cm or 66"
160 cm or 63"
183cm or 72"
175 cm or 69"
167 cm or 66"
160 cm or 63"
152 cm or 60"