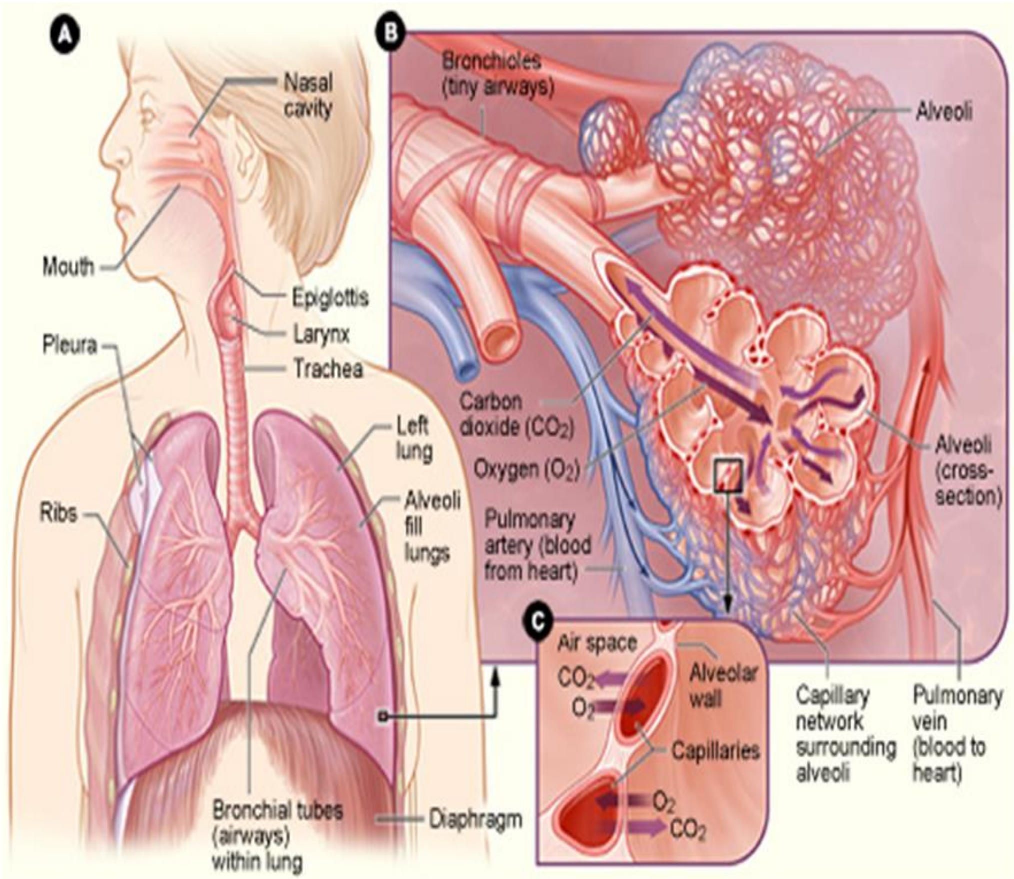
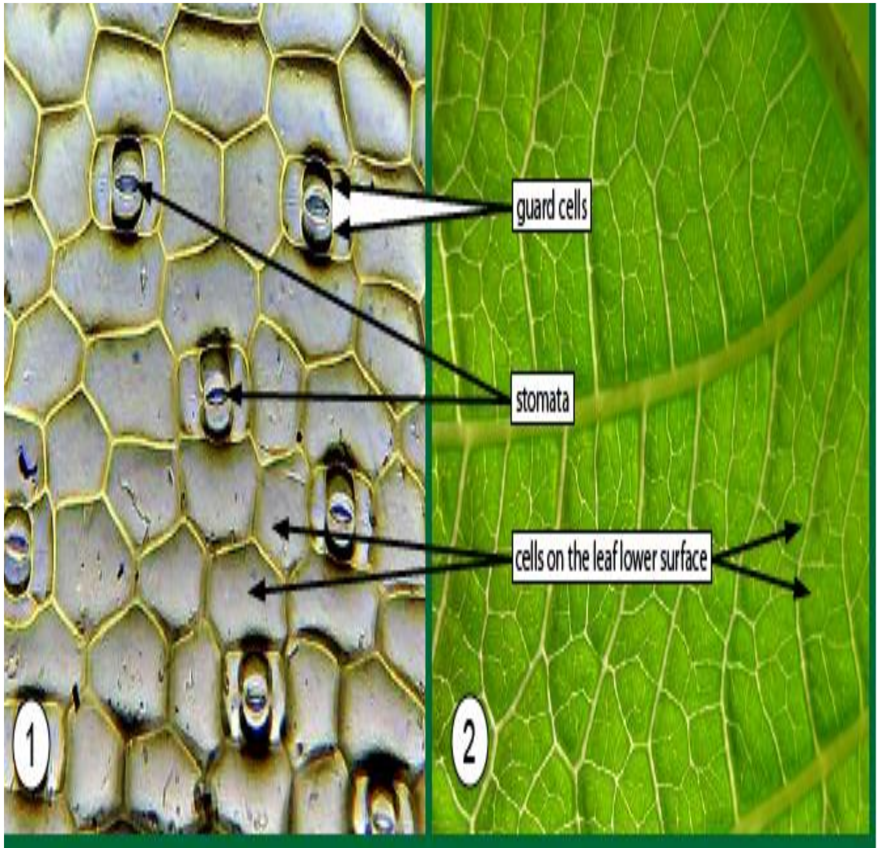
CHAPTER 7:
GASEOUS EXCHANGE & ITS CONTROL



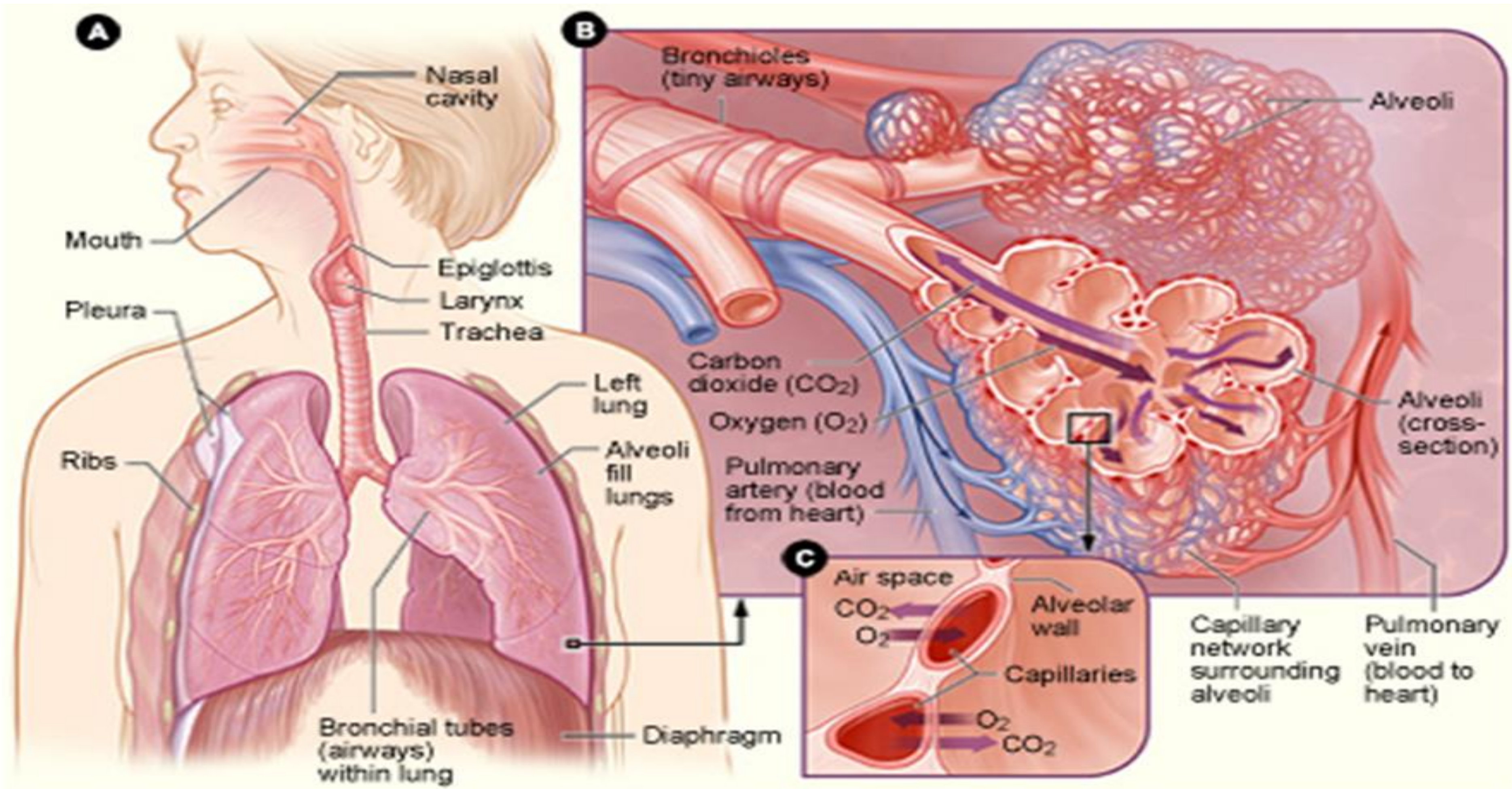


CHAPTER 7.0:

GASEOUS EXCHANGE & ITS CONTROL

- 7.1 Gaseous exchange and control in mammals
- 7.2 Role of chemoreceptors in controlling breathing
- 7.3 Gaseous exchange and control in plants

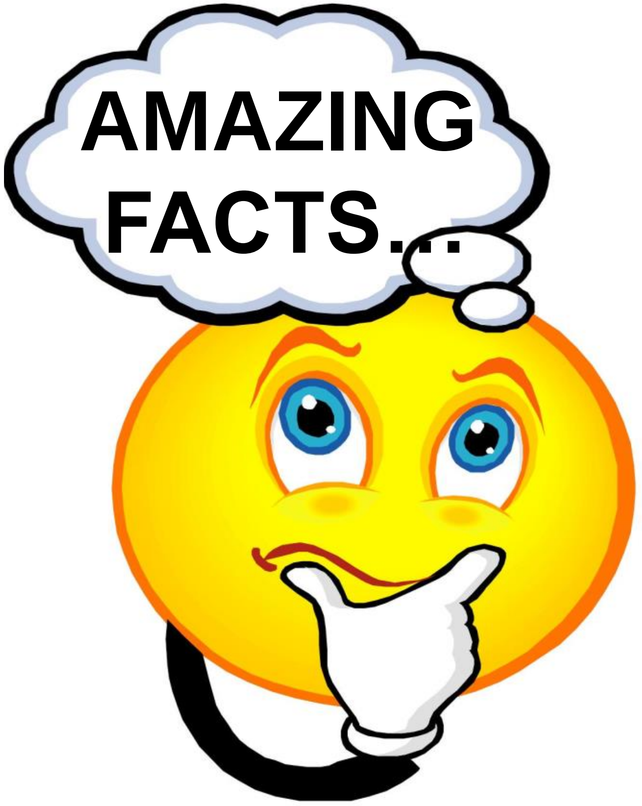
7.1
GASEOUS EXCHANGE AND CONTROL IN MAMMALS



A red blood cell contains about 250 million hemoglobin molecules, which carry oxygen through the blood.

Each hemoglobin molecule can carry four oxygen molecules.

There are 4 million to 6 million red blood cells in each microliter (cubic millimeter) of blood.



LEARNING OUTCOME (7.1)

At the end of this topic, student should be able to:

(a) Describe the structure of haemoglobin and its characteristics as respiratory pigments

(b) Describe three ways of carbon dioxide transport from respiring tissues to lungs

LEARNING OUTCOME (7.1)

At the end of this topic, student should be able to:

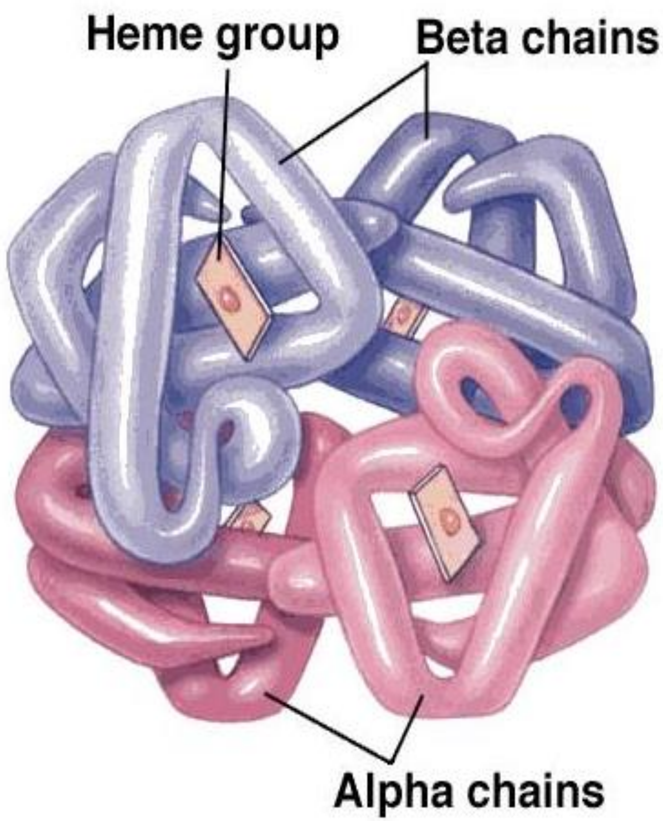
- (c) Analyse the oxygen dissociation curve of haemoglobin
- (d) Compare oxygen dissociation curve of haemoglobin and myoglobin

LEARNING OUTCOME (7.1)

At the end of this topic, student should be able to:

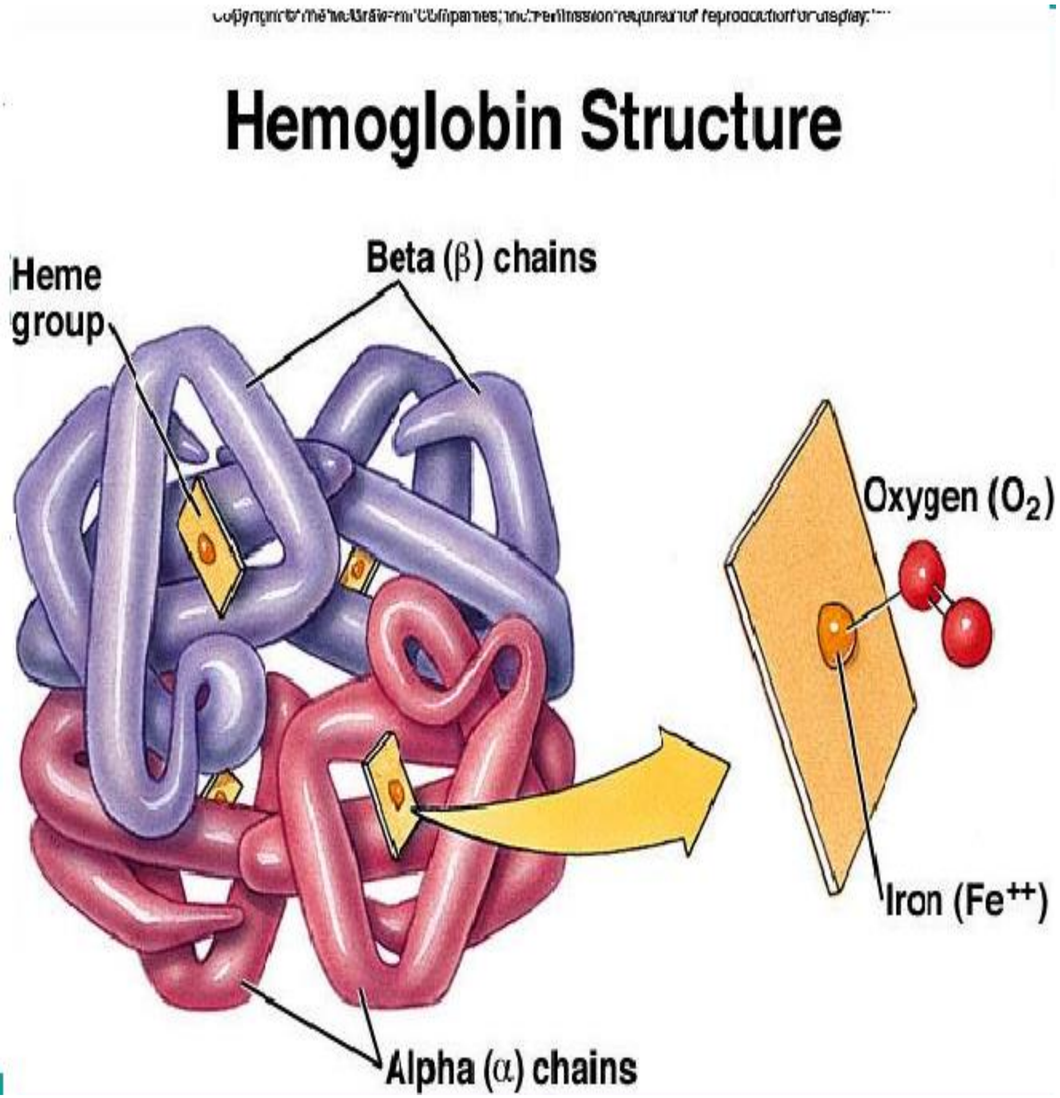
(e) Analyse the effect of the changes in partial pressure of carbon dioxide towards oxygen dissociation curve (Bohr effect)

STRUCTURE OF HAEMOGLOBIN



- A respiratory pigment
- Quaternary protein (globular)
  - Consist of four polypeptide subunits;
  - two α chain
  - two β chain
  - held together by hydrogen bond

STRUCTURE OF HAEMOGLOBIN



- Each polypeptide contains a haem group (prosthetic group), bind with an oxygen
- Therefore, one hemoglobin (Hb) molecule binds up to four oxygen molecules

CHARACTERISTICS OF HAEMOGLOBIN AS RESPIRATORY PIGMENT

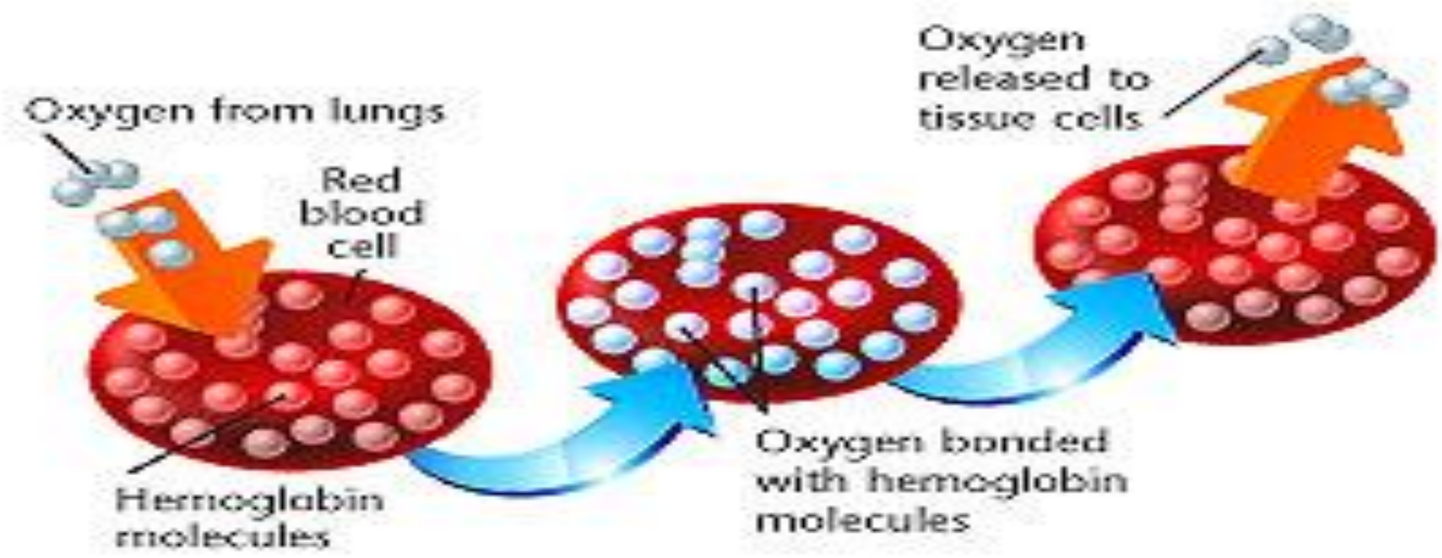
- Haemoglobin combines with O_2 to form oxyhaemoglobin and reversely

$$4\,Hb + 4O_2 \underset{\text{dissociate}}{\overset{\text{form}}{\rightleftharpoons}} Hb(O_2)_4$$

- At high concentration of O_2 (high partial pressure), haemoglobin combines with O_2 to form oxyhaemoglobin.
- At low concentration of O_2 , oxyhaemoglobin easily dissociates to form haemoglobin and O_2 (O_2 then liberated for cell used)

TRANSPORT OF O_2 IN BLOOD

Transportation of O_2(in blood) from the lungs to respiring tissues in the form of OXYHAEMOGLOBIN

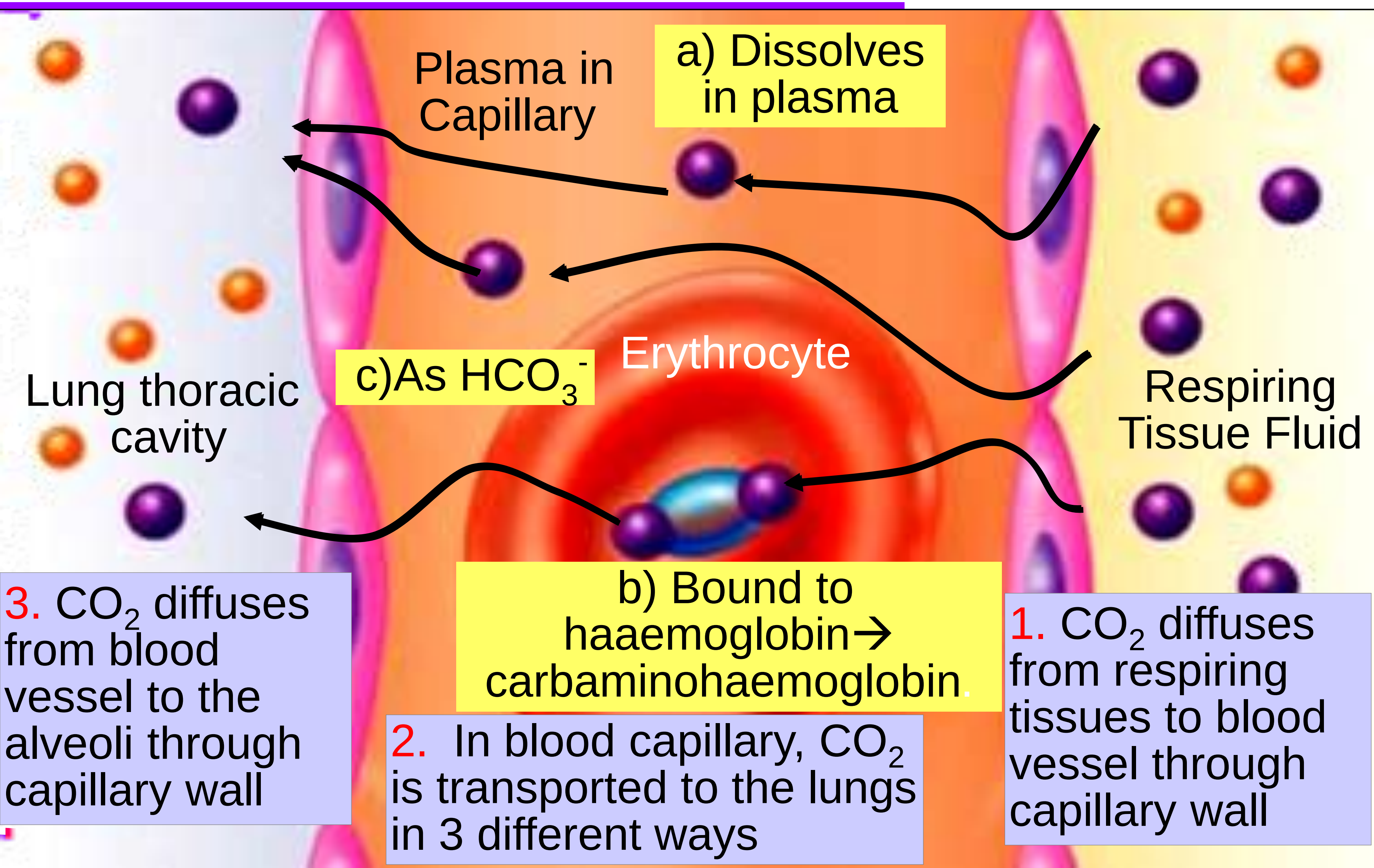


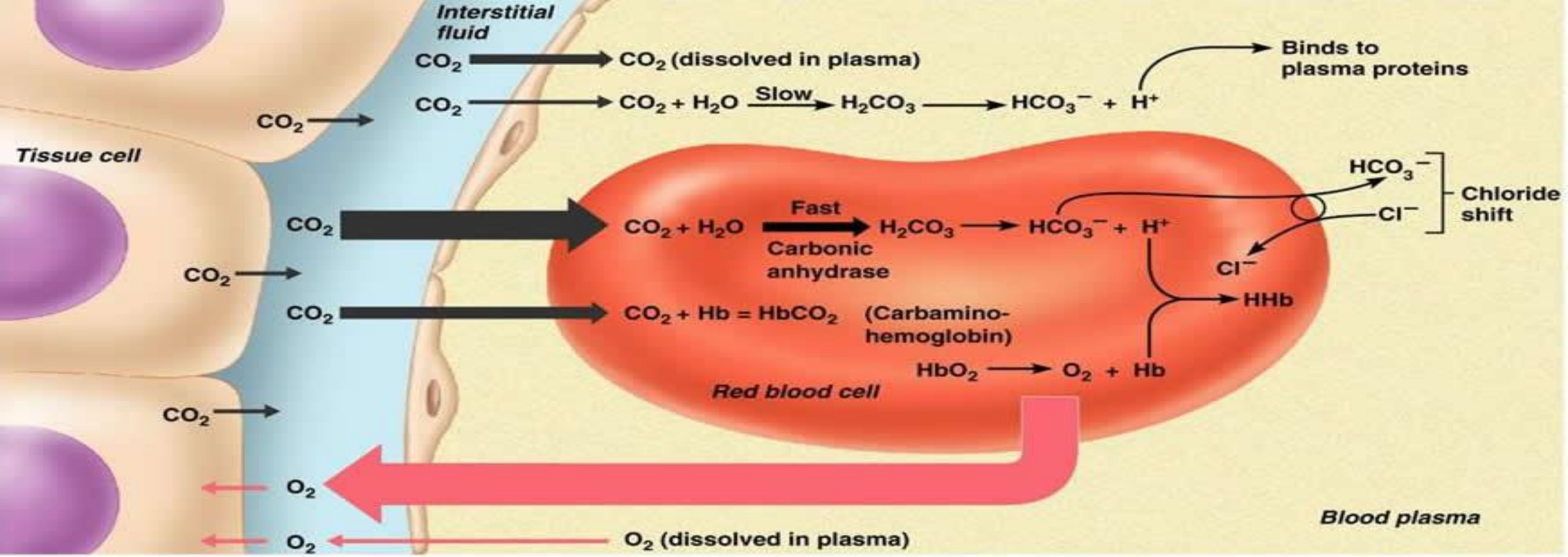
CO_2 TRANSPORTATION IN BLOOD

CO_2 is transported from respiring tissues to the lungs in 3 different ways:

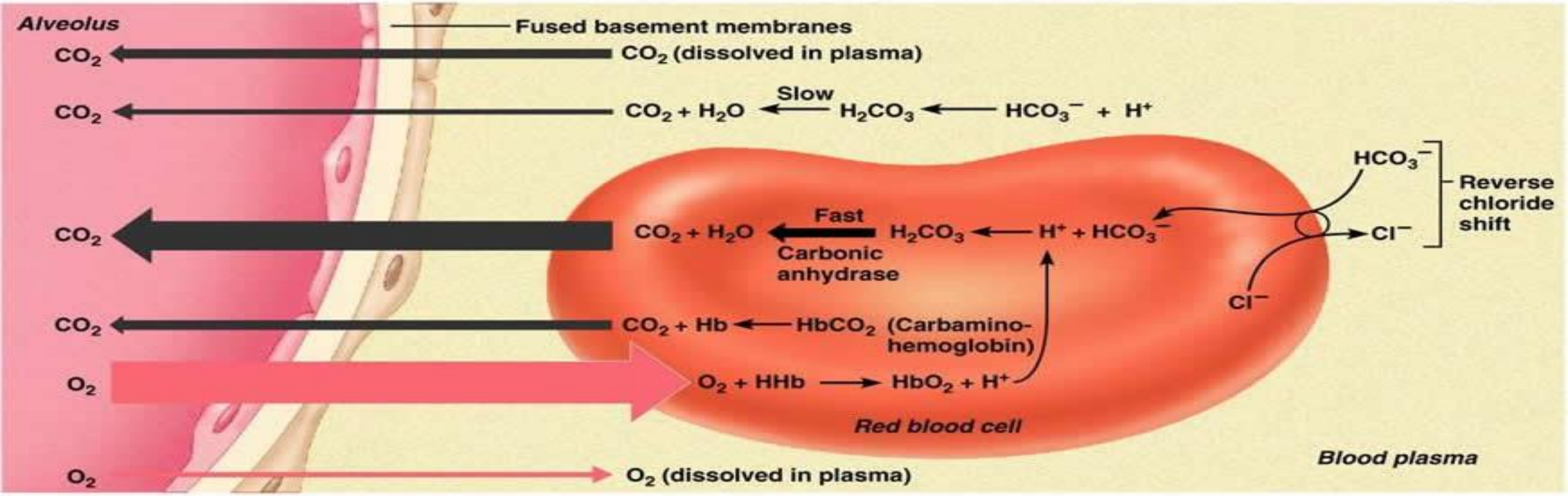
- Dissolved in blood plasma (about 7%)
- As bicarbonate ions (HCO_3^-) (about 70%)
- As carbaminohaemoglobin (about 23%)

TRANSPORT OF CO_2



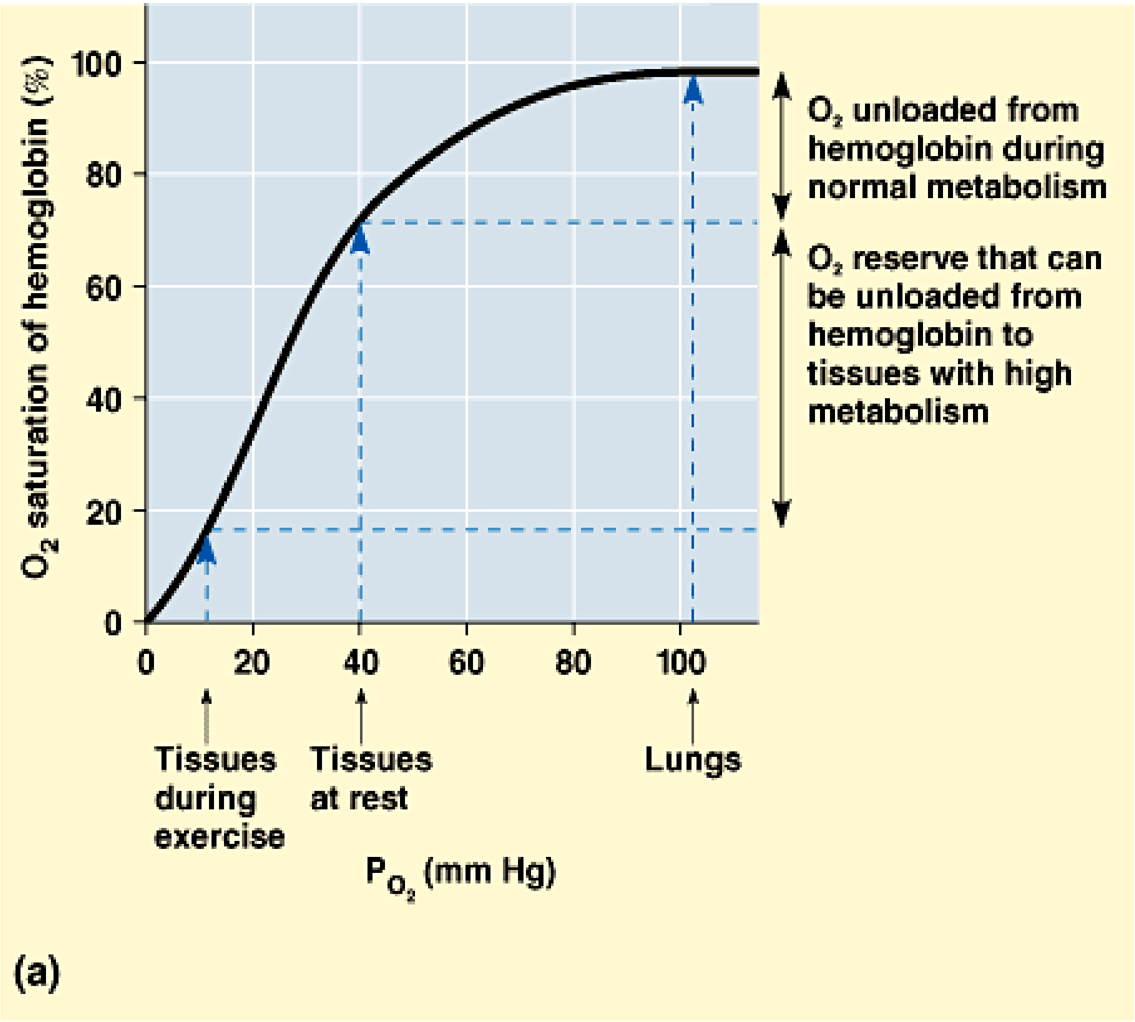


(a) **Oxygen release and carbon dioxide pickup at the tissues**



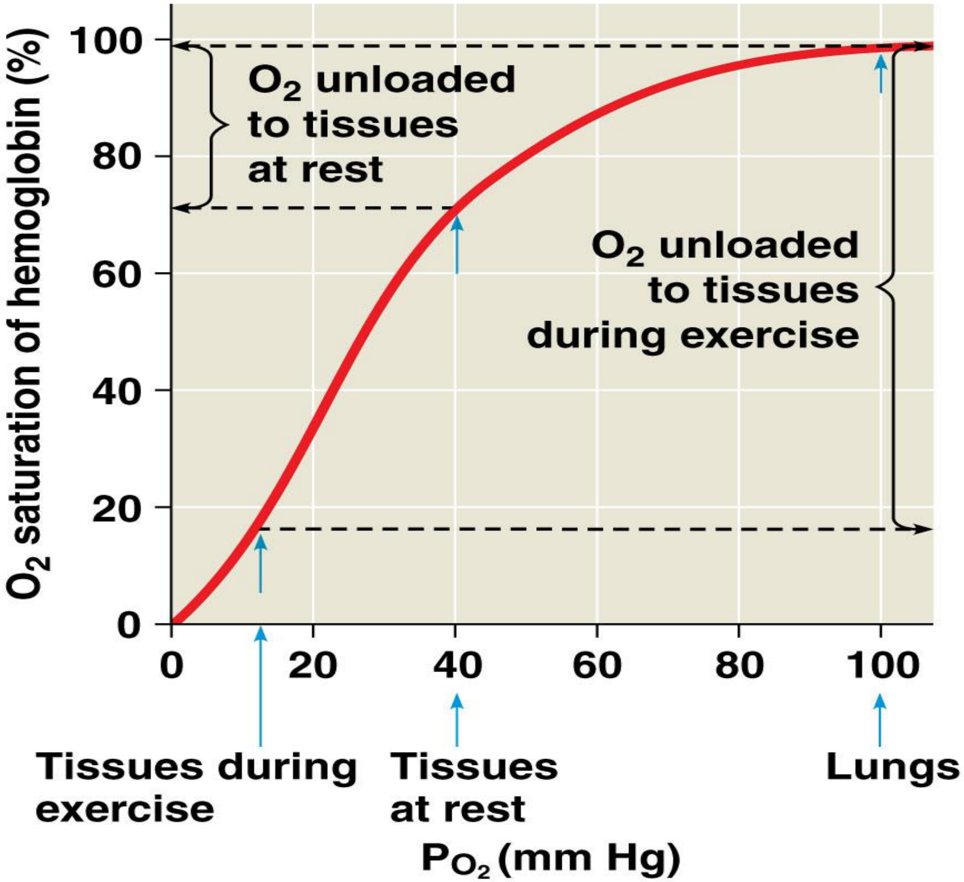
(b) **Oxygen pickup and carbon dioxide release in the lungs**

OXYGEN DISSOCIATION CURVES OF HAEMOGLOBIN



The curve shows the relative amounts of oxygen bound to haemoglobin that exposed to solutions (medium) with different partial pressure of oxygen (P_{O_2})

OXYGEN DISSOCIATION CURVES OF HAEMOGLOBIN

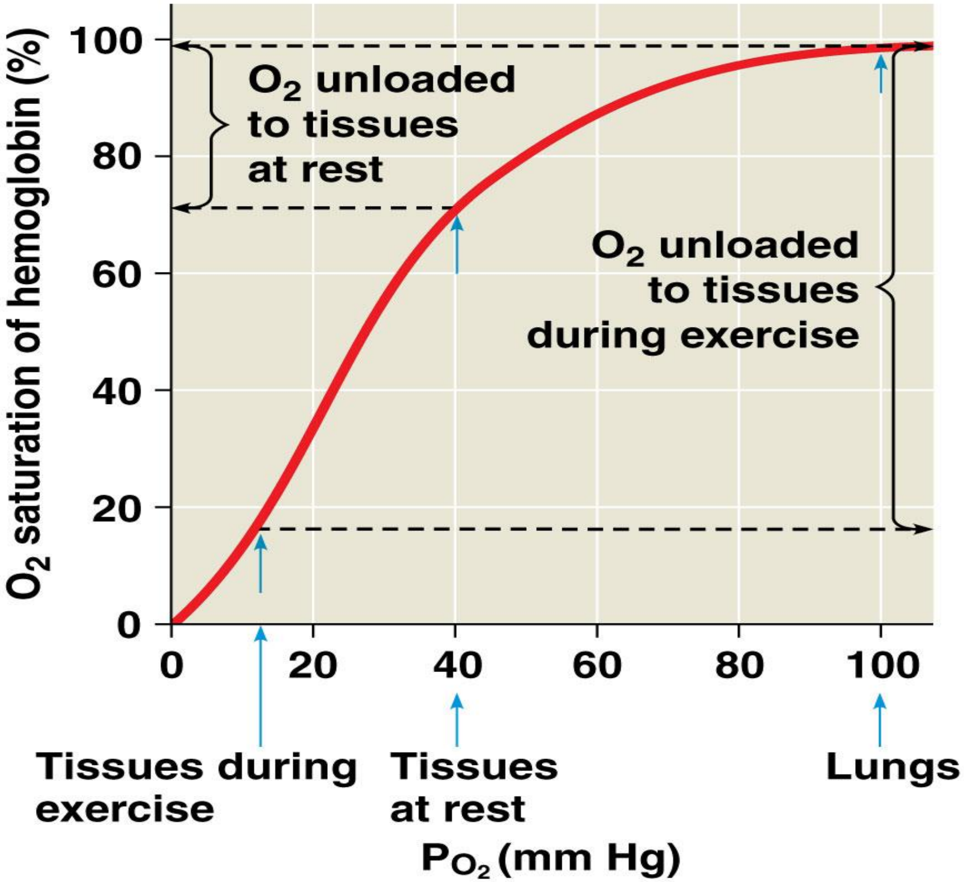


(a) P_{O_2} and hemoglobin dissociation at pH 7.4

When the partial pressure of oxygen is high as in lung's capillaries

Haemoglobin has a higher affinity for oxygen to form oxyhaemoglobin (HbO_2)

OXYGEN DISSOCIATION CURVES OF HAEMOGLOBIN



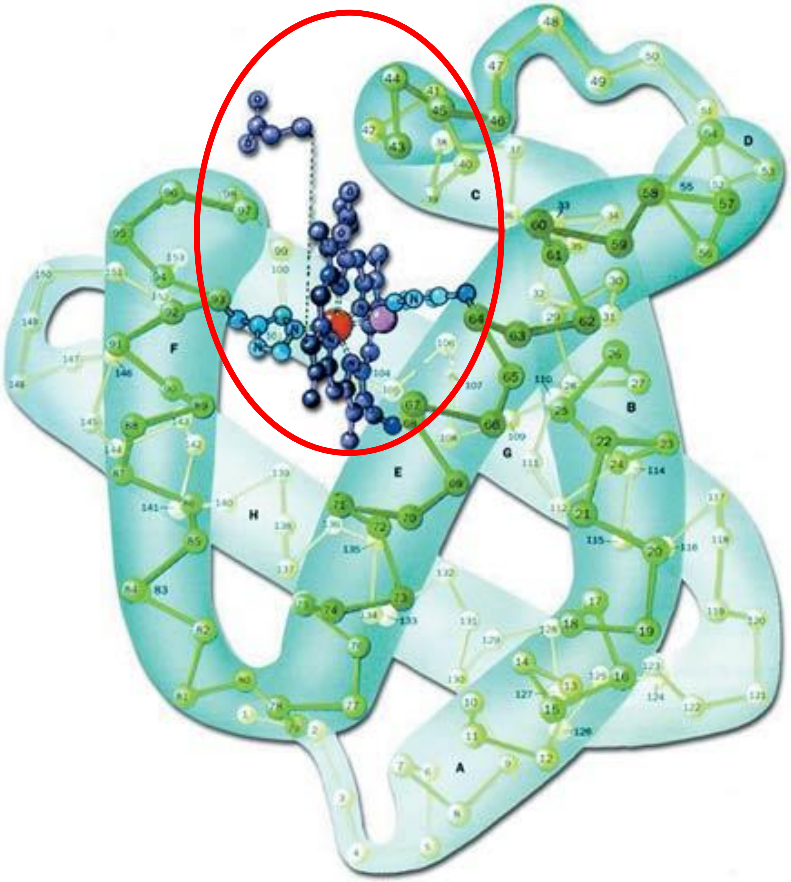
(a) P_{O_2} and hemoglobin dissociation at pH 7.4

When the partial pressure of oxygen is low as in respiring tissues

The oxyhaemoglobin easily dissociates; and oxygen is liberated to the respiring tissues

MYOGLOBIN

Haem group

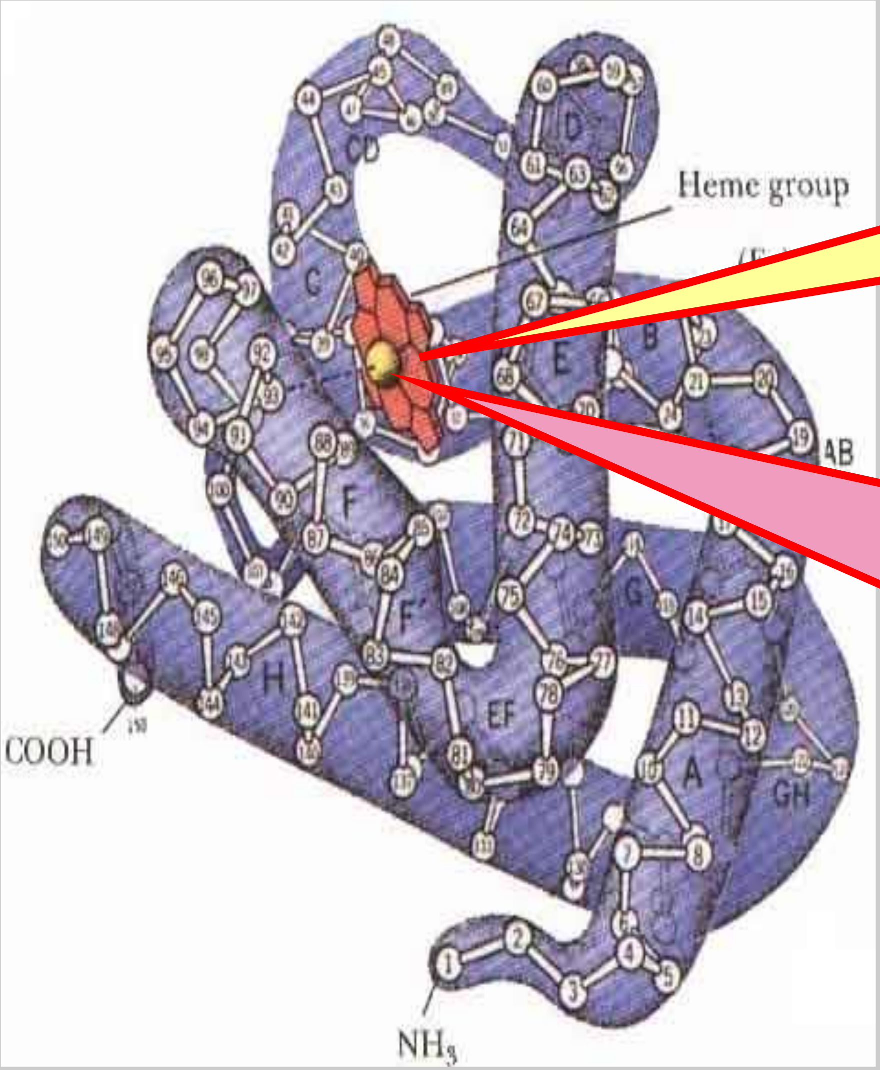


One of the respiratory pigment

Compose of a single polypeptide chain with an iron atom (haem group) that bind to one O_2 molecule

Have a higher affinity for oxygen than haemoglobin (in muscle tissue)

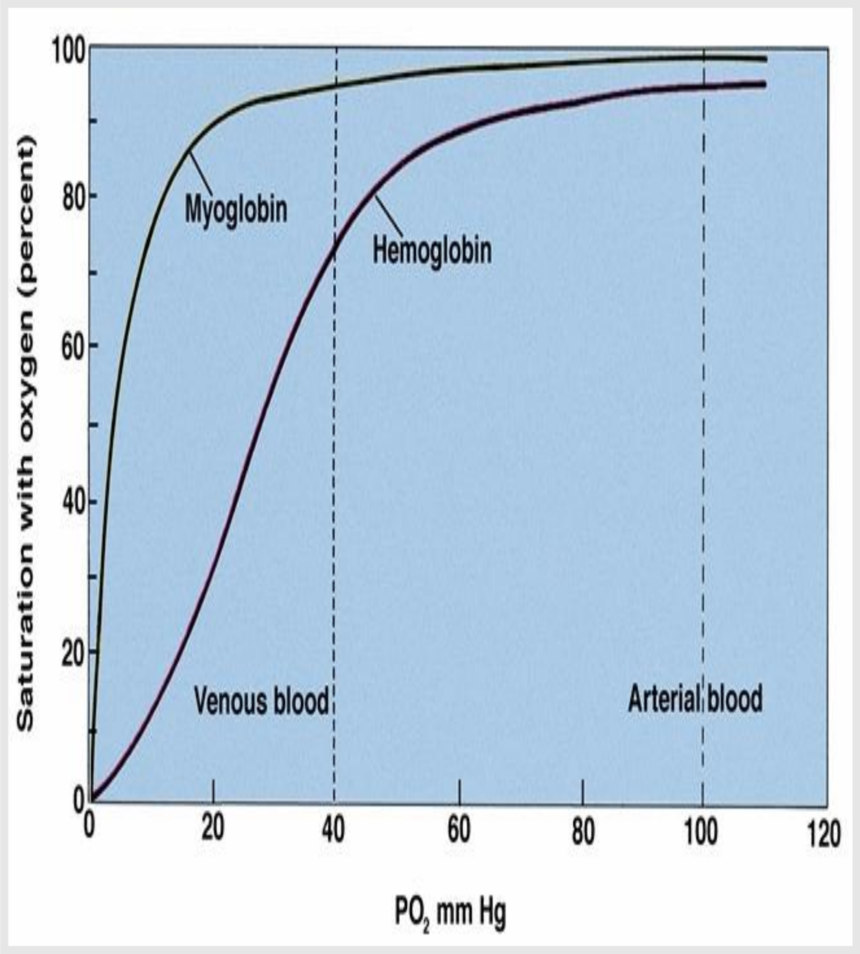
MYOGLOBIN



Function :
To store O_2 in the muscle

Myoglobin only will release O_2 (that bind to it) if the O_2 supply of haemoglobin in muscle cells has been exhausted

COMPARISON BETWEEN OXYGEN DISSOCIATION CURVES OF HAEMOGLOBIN & MYOGLOBIN

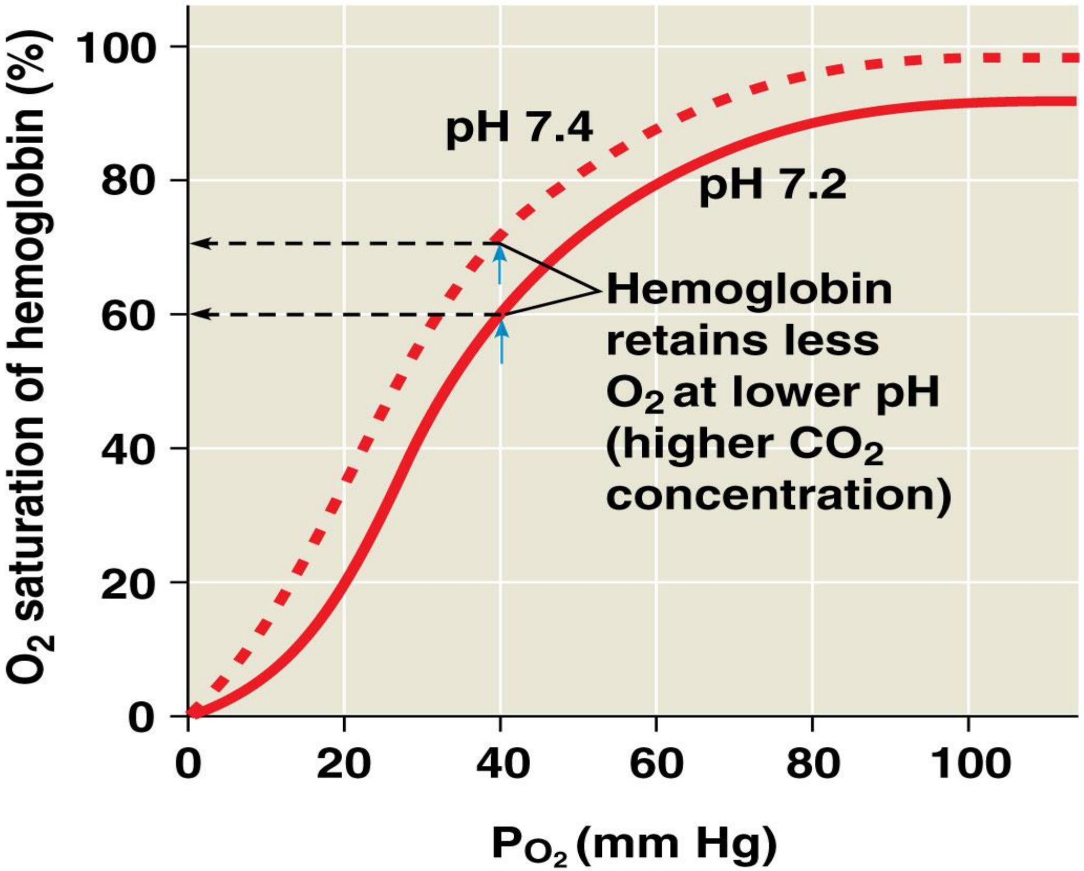


The O_2 dissociation curve of myoglobin is displaced to the left of the oxygen dissociation curve of haemoglobin.

Its affinity towards oxygen is higher.

Its ODC is hyperbolic.

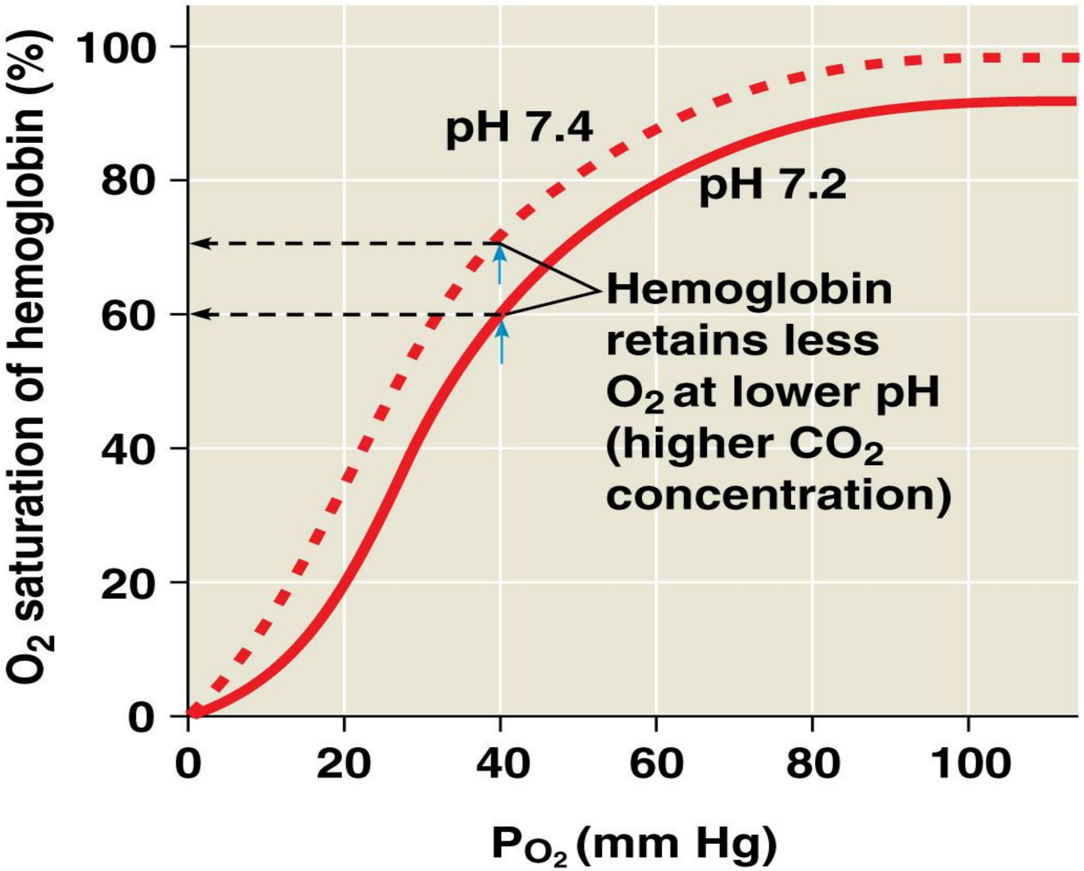
BOHR EFFECT



(b) pH and hemoglobin dissociation

The effect of pH / concentration of CO_2 on the affinity of haemoglobin towards oxygen

BOHR EFFECT

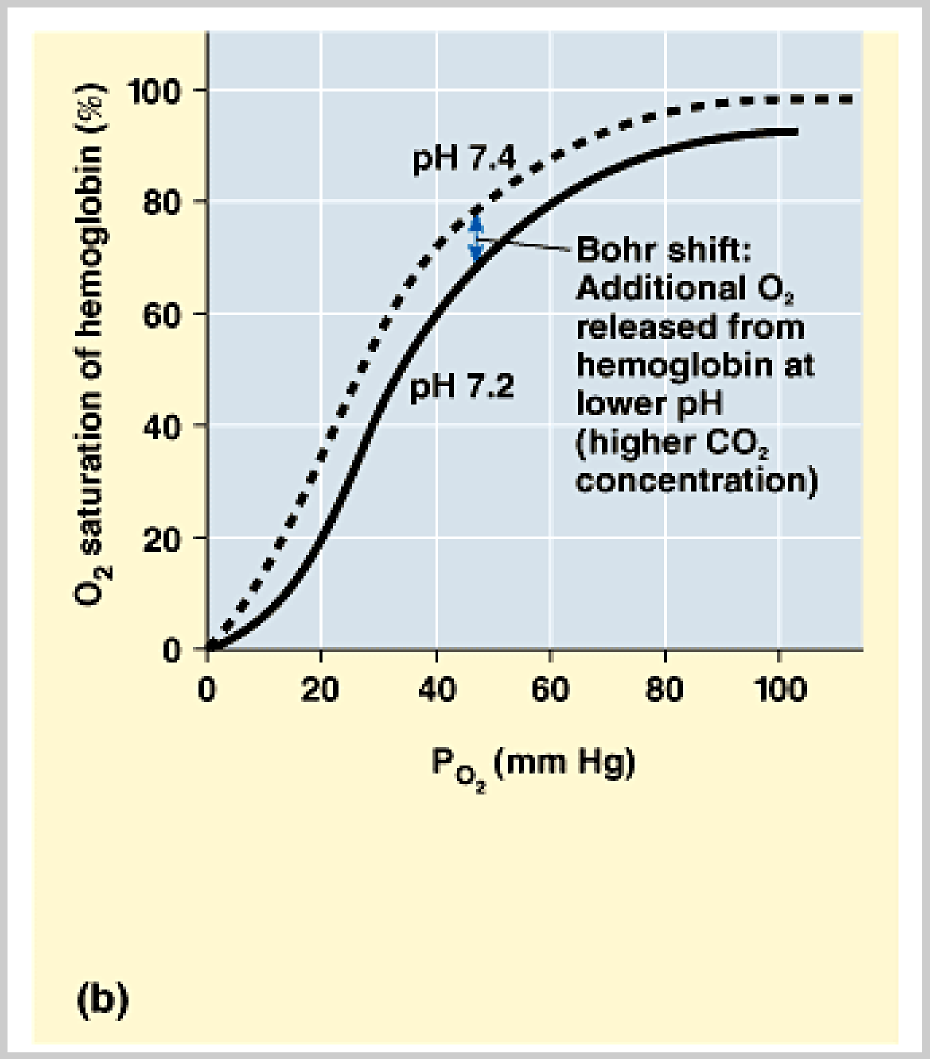


(b) pH and hemoglobin dissociation

A decrease in pH shifts the curve to the right

(refers: Bohr effect)

BOHR SHIFT DUE TO PARTIAL PRESSURE OF CARBON DIOXIDE

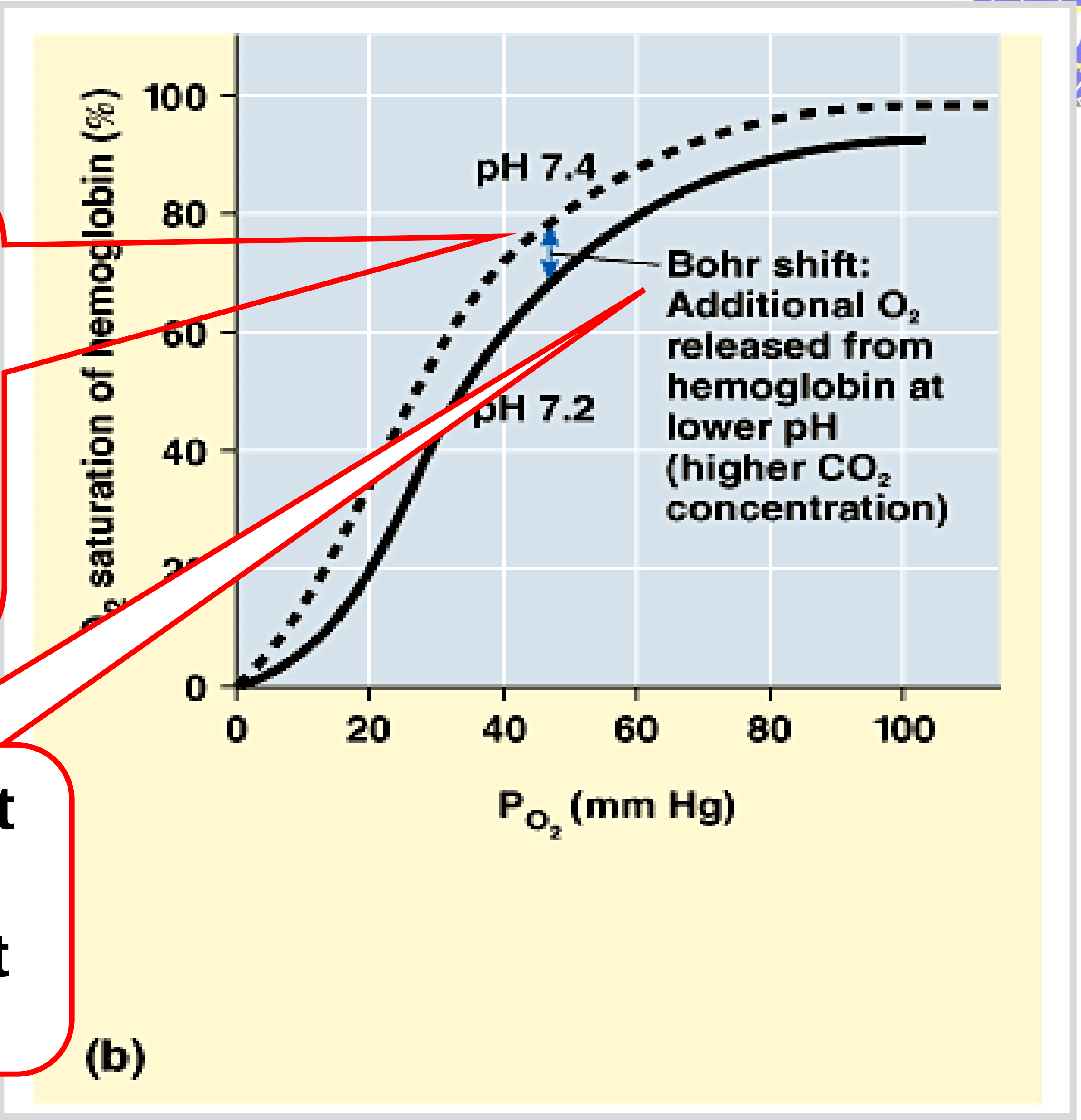


Partial pressure of CO_2 increases

pH also decreases (increase of H^+)

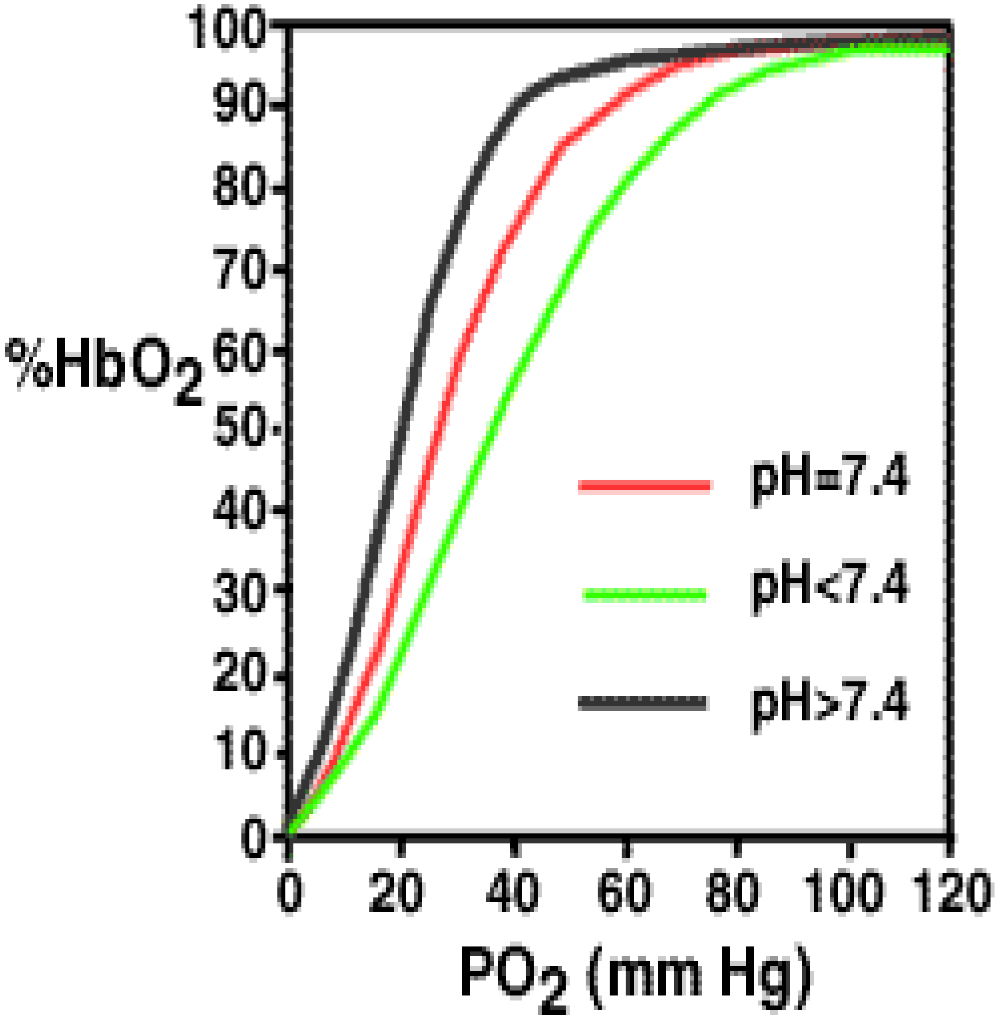
Haemoglobin has a low affinity for O_2

Increase in CO_2 pressure will shift the O_2 dissociation curve to the right



This effect known as Bohr Shift

BOHR EFFECT

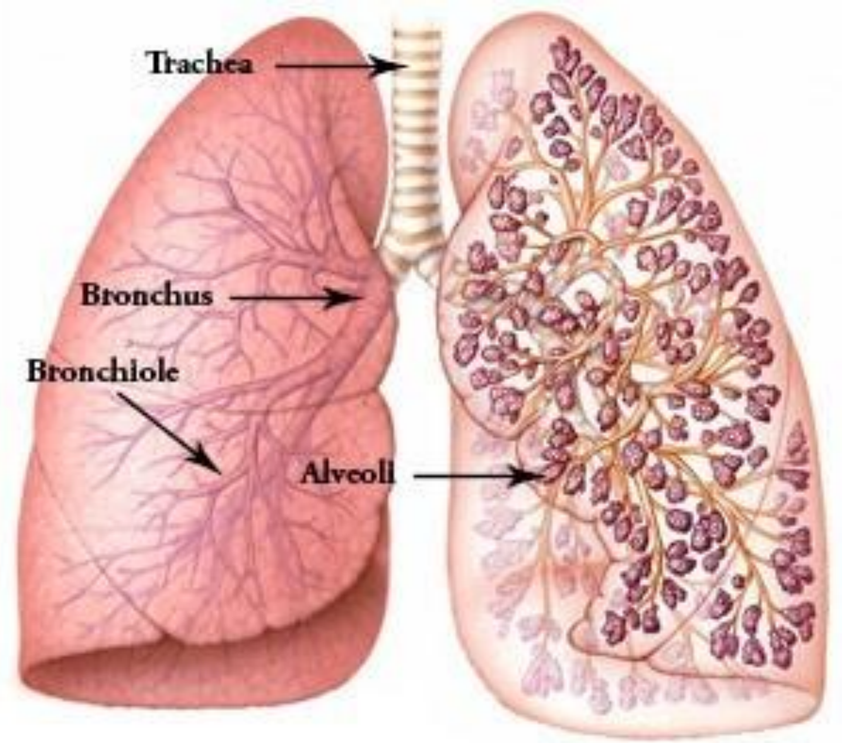


Red line represents ODC at a normal pH.

Green line represents ODC during exercises.

Black line represents ODC at lungs.

7.2
ROLES OF CHEMORECEPTORS IN CONTROLLING BREATHING



LEARNING OUTCOME (7.2)

At the end of this topic, student should be able to:

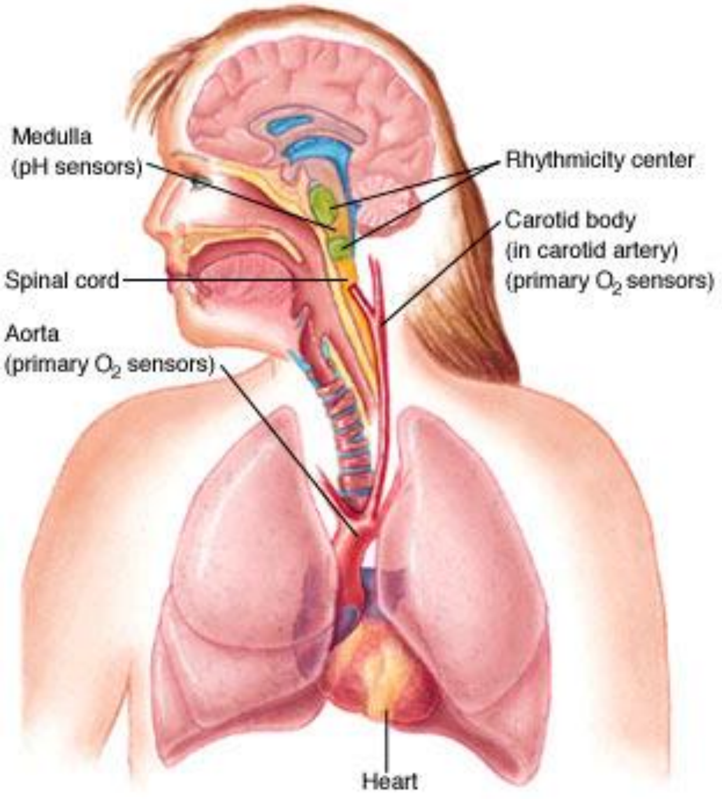
1.
- State the types of chemoreceptors

2.
- Explain the role of chemoreceptors in controlling the rate of breathing

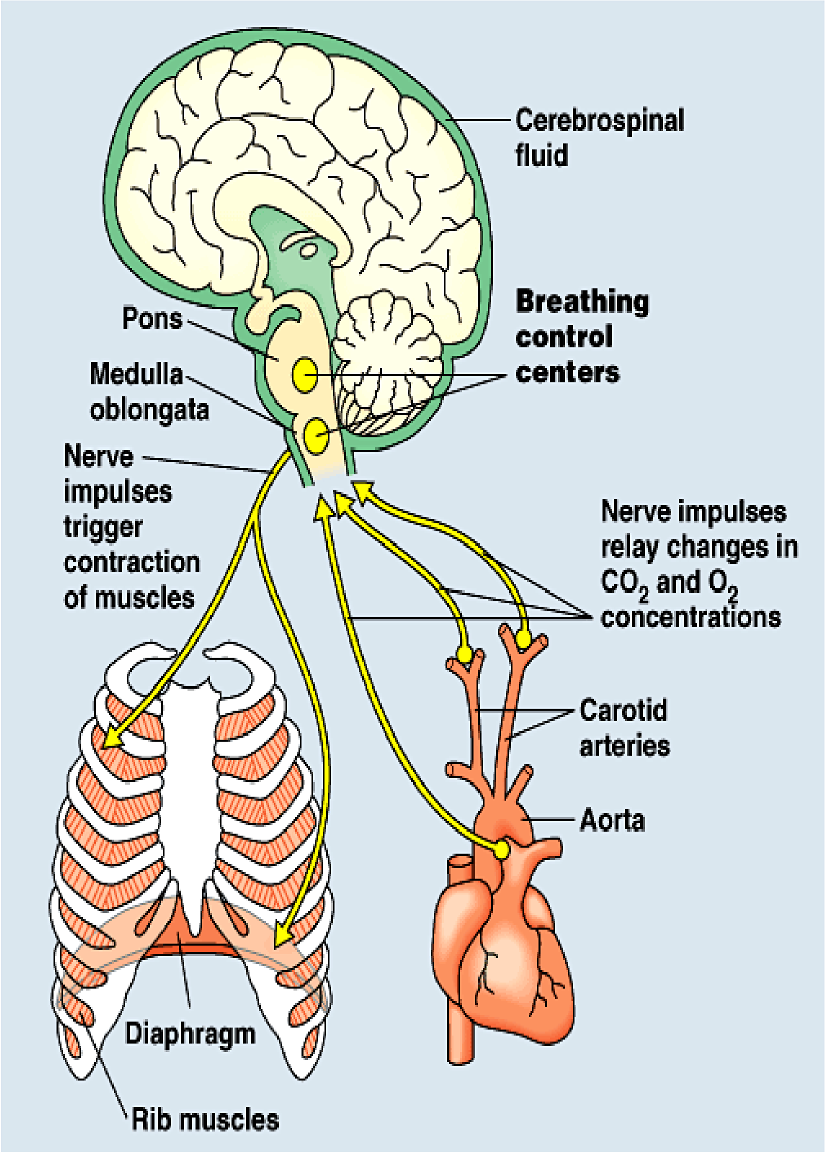
TYPES OF CHEMORECEPTORS

Chemoreceptor

- Central chemoreceptor: located in medulla oblongata
- Peripheral chemoreceptor : located in aortic bodies (aorta) and carotid bodies (carotid artery at neck)



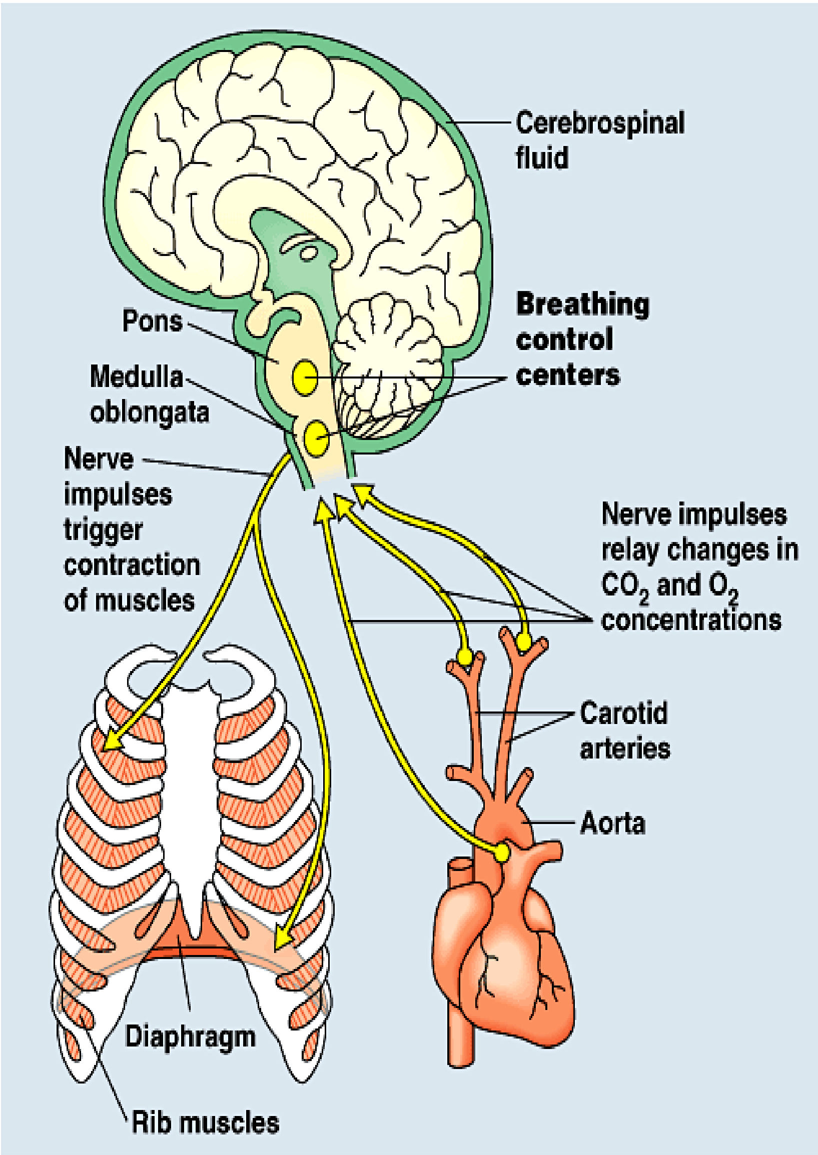
PROPERTIES OF CHEMORECEPTORS



Chemoreceptors

- sensory receptor neurons that responsive to chemicals change
- sensitive to
  - ✓ decrease in pH
  - ✓ increase in $[H^+]$
  - ✓ increase of CO_2 partial pressure (low partial pressure of O_2)

ROLE OF CHEMORECEPTORS IN CONTROLLING THE RATE OF BREATHING



Chemoreceptors

- Send nerve impulses to respiratory centre to increase alveolar ventilation

BREATHING CONTROLLING MECHANISM BY RESPIRATORY CENTER

CO_2 levels in tissue increase, lowers blood pH → chemoreceptors in carotid artery and aorta detect decrease in blood pH

↓

discharged nerve impulses

← Through afferent neuron

to inspiratory centre

Sent nerve impulse

Efferent neuron (phrenic nerve)

↓

diaphragm

Efferent neuron (intercostal nerve)

↓

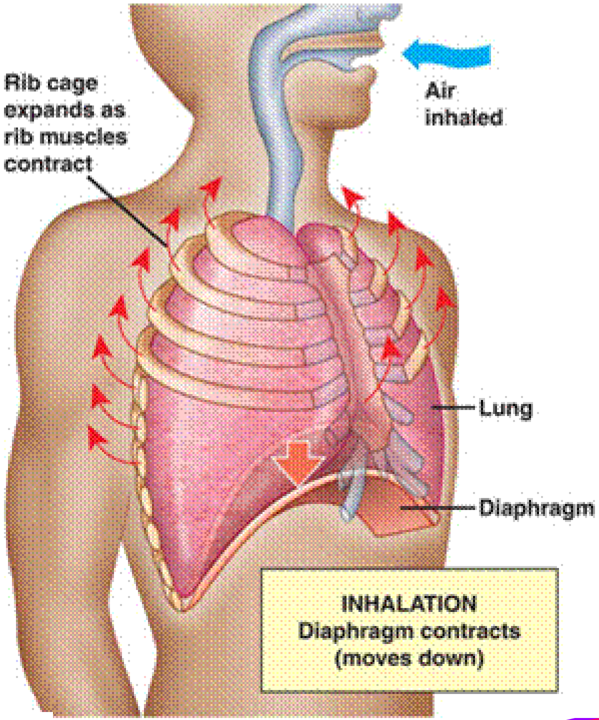
outer intercostal muscles

contract

In lung: volume increase, pressure decrease

→ inspiration

Air rush into lung



BREATHING CONTROLLING MECHANISM BY RESPIRATORY CENTER

When air enter the bronchus→ bronchus expand

Pulmonary stretch receptor in wall (smooth receptor)bronchus & bronchioles detect the stretching of the lung tissue

Impulses sent through vagus nerves to expiratory centre

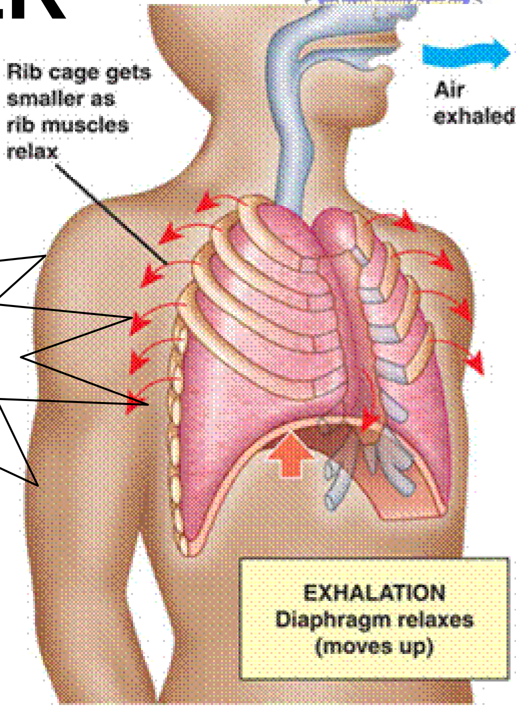
inspiratory centre inhibited

diaphragm & outer intercostal muscles relax

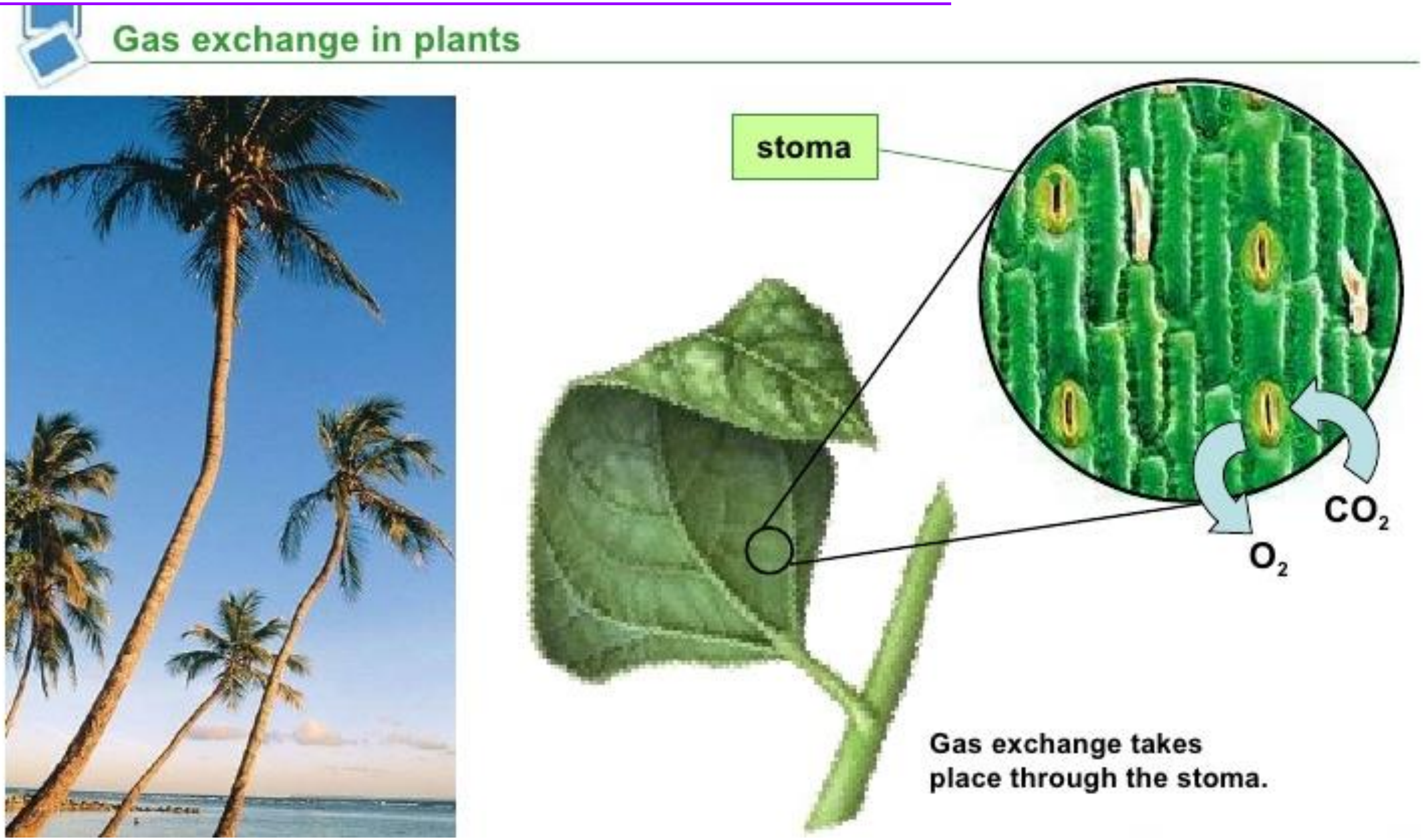
In lung: volume decrease, pressure increase

Expiration occur

Air exits the lung



7.3 GASEOUS EXCHANGE AND CONTROL IN PLANTS



LEARNING OUTCOME (7.3)

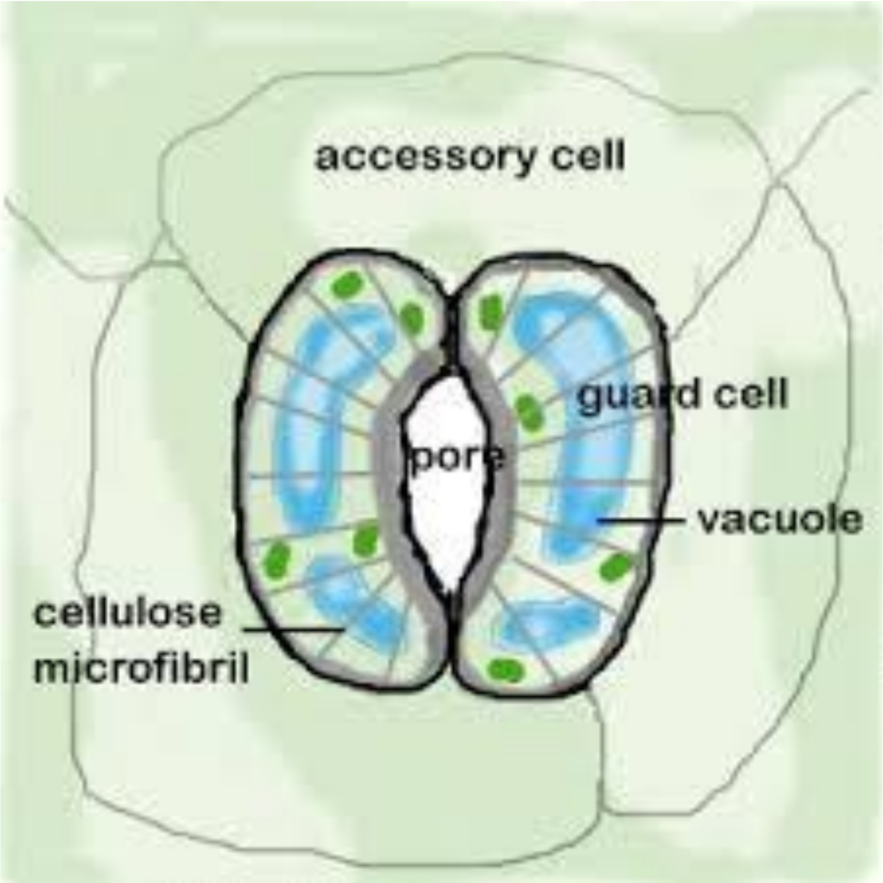
At the end of this topic, student should be able to:

1.

- Explain the regulation of the stomatal opening and closing based on starch-sugar hypothesis

GUARD CELL

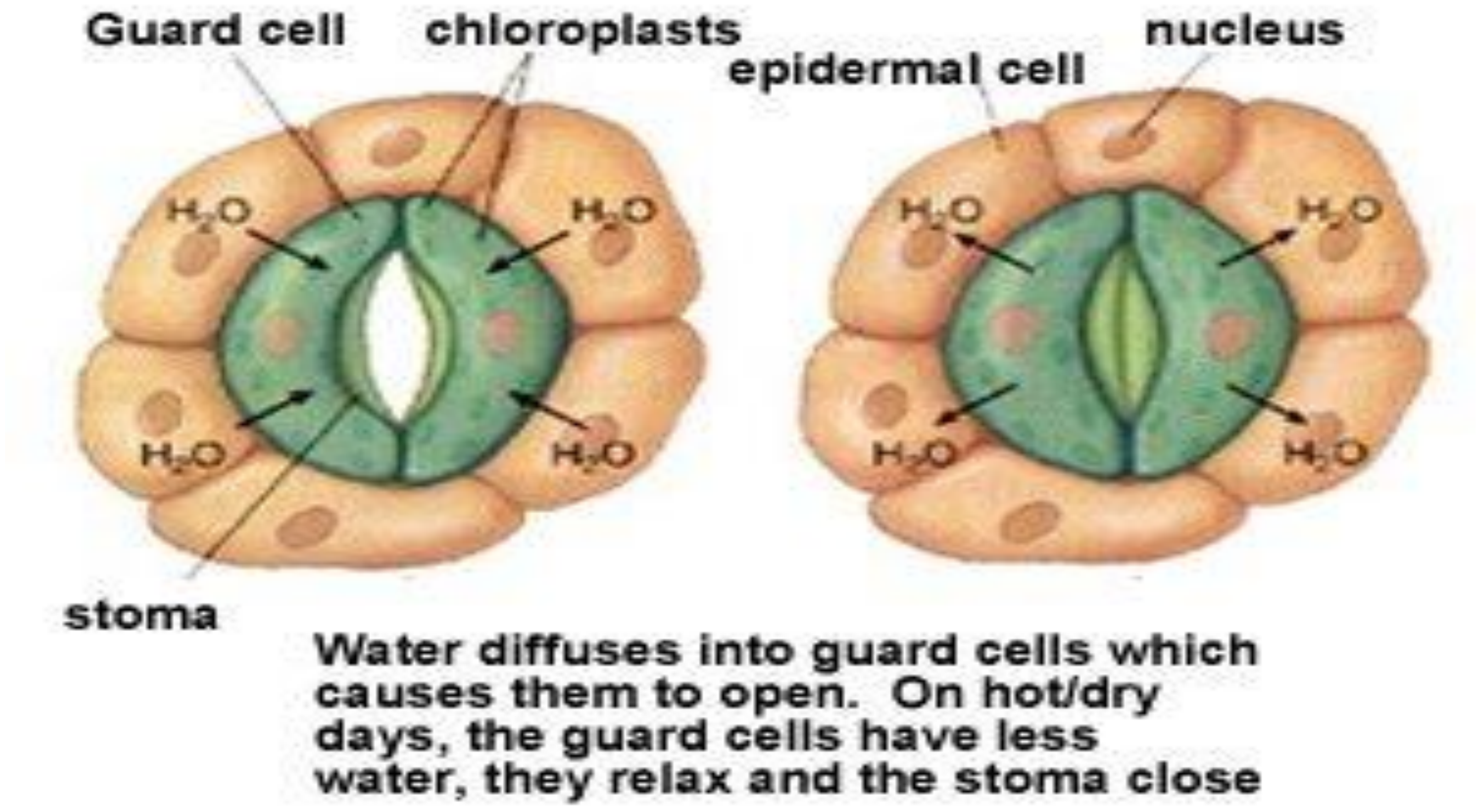
The guard cells are living cells with protoplast, nucleus, chloroplasts and sap vacuole



FUNCTIONS OF STOMATA

- Allow exchange of gases of the leaves
- Allow transpiration to occur
- Allowing water vapour to escape from stomata (leave cooling mechanism)
- Regulate water lost in leave

OPENING AND CLOSING OF STOMATA

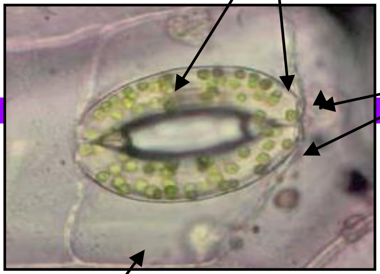


STARCH-SUGARS HYPOTHESIS

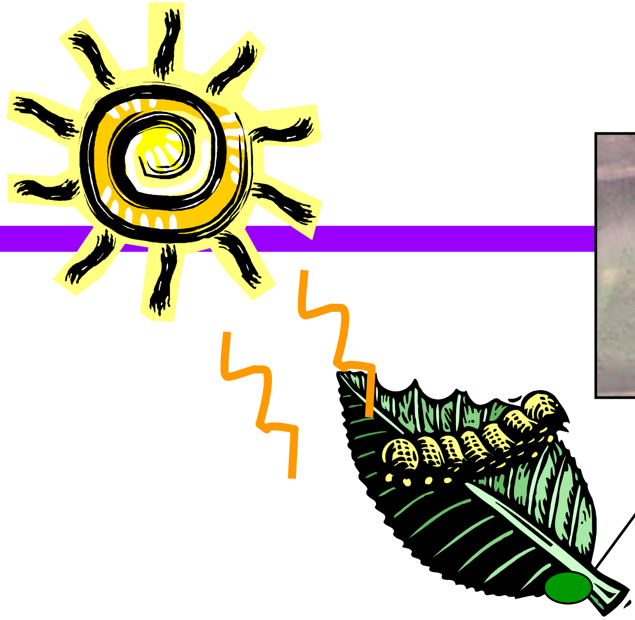
- Proposed by Llyod (1908)

- According to this hypothesis; the opening and closing of stomata is due to changes in turgidity of guard cells, which is associated with the conversion of starch to sugar (daytime when pH high) or conversion of sugar to starch in guard cells (when pH low).

chloroplasts



Guard cells



Photosynthesis in chloroplast of guard cells

Produced sugar (sucrose)

water potential of the guard cells ↓

Water diffuses from neighbouring cells

Guard cells turgid

Stomata open

Used CO_2

pH in guard cells ↑

Enzyme amylase

Starch → maltose

No photosynthesis during the night

respiration

release

CO_2 ↑ , pH ↓

⬇

Sugar → starch

⬇

Water potential of the guard cells ↑

⬇

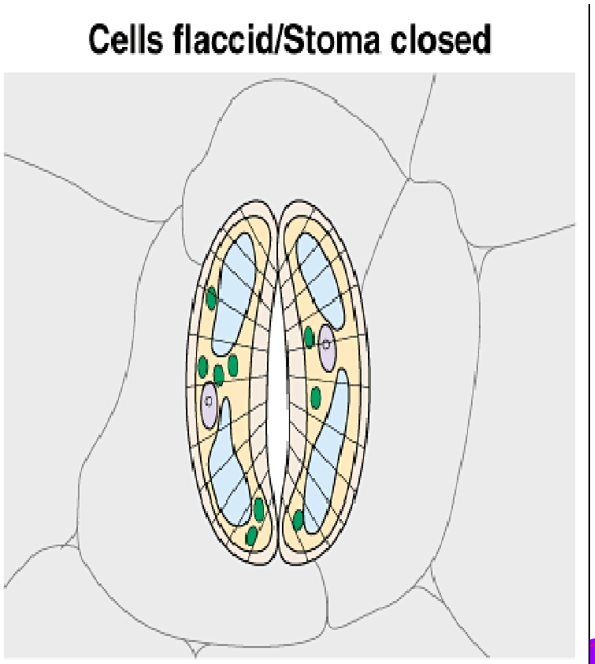
Water leaves the guard cells

⬇

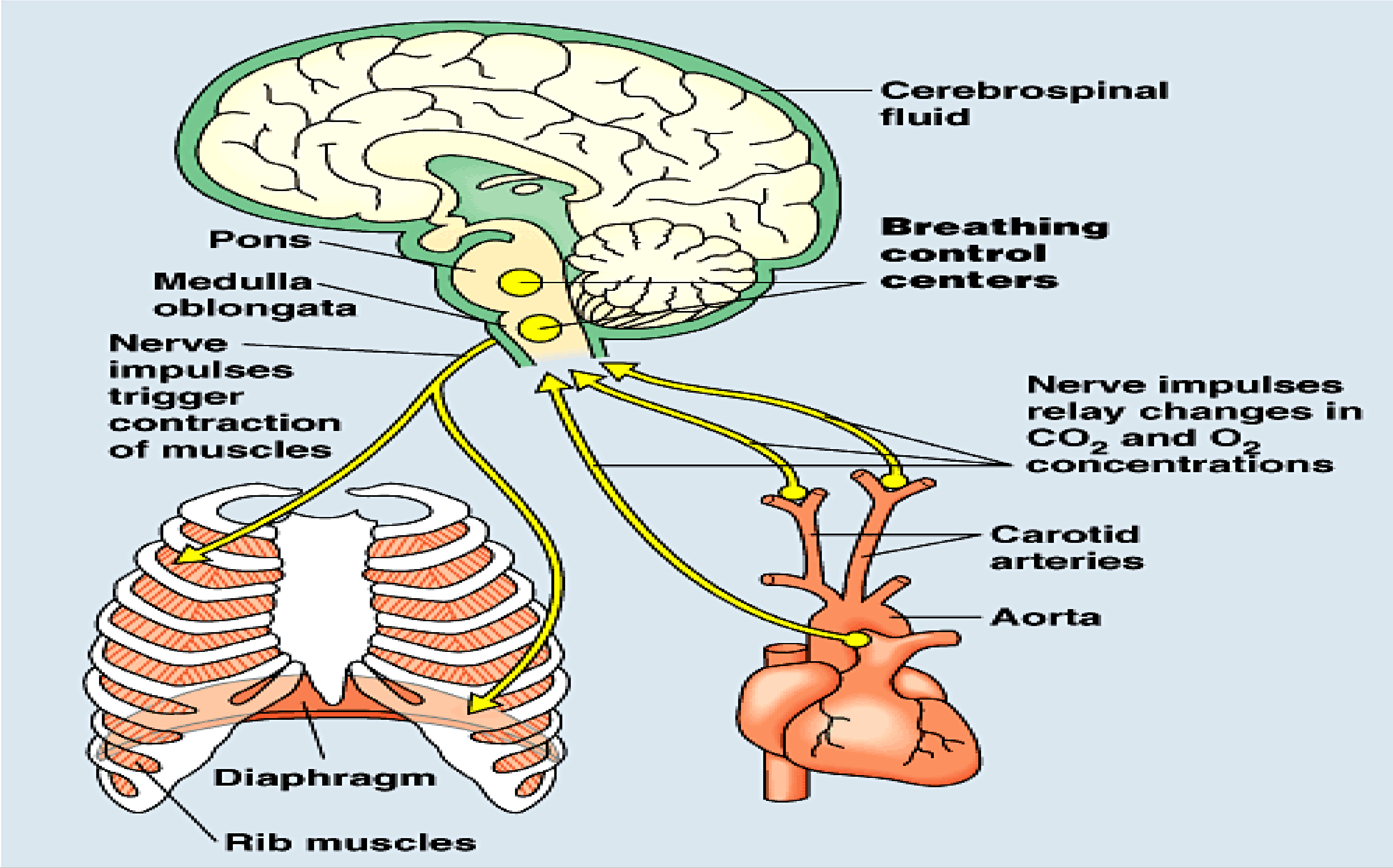
Guard cell become flaccid

⬇

Stomata close

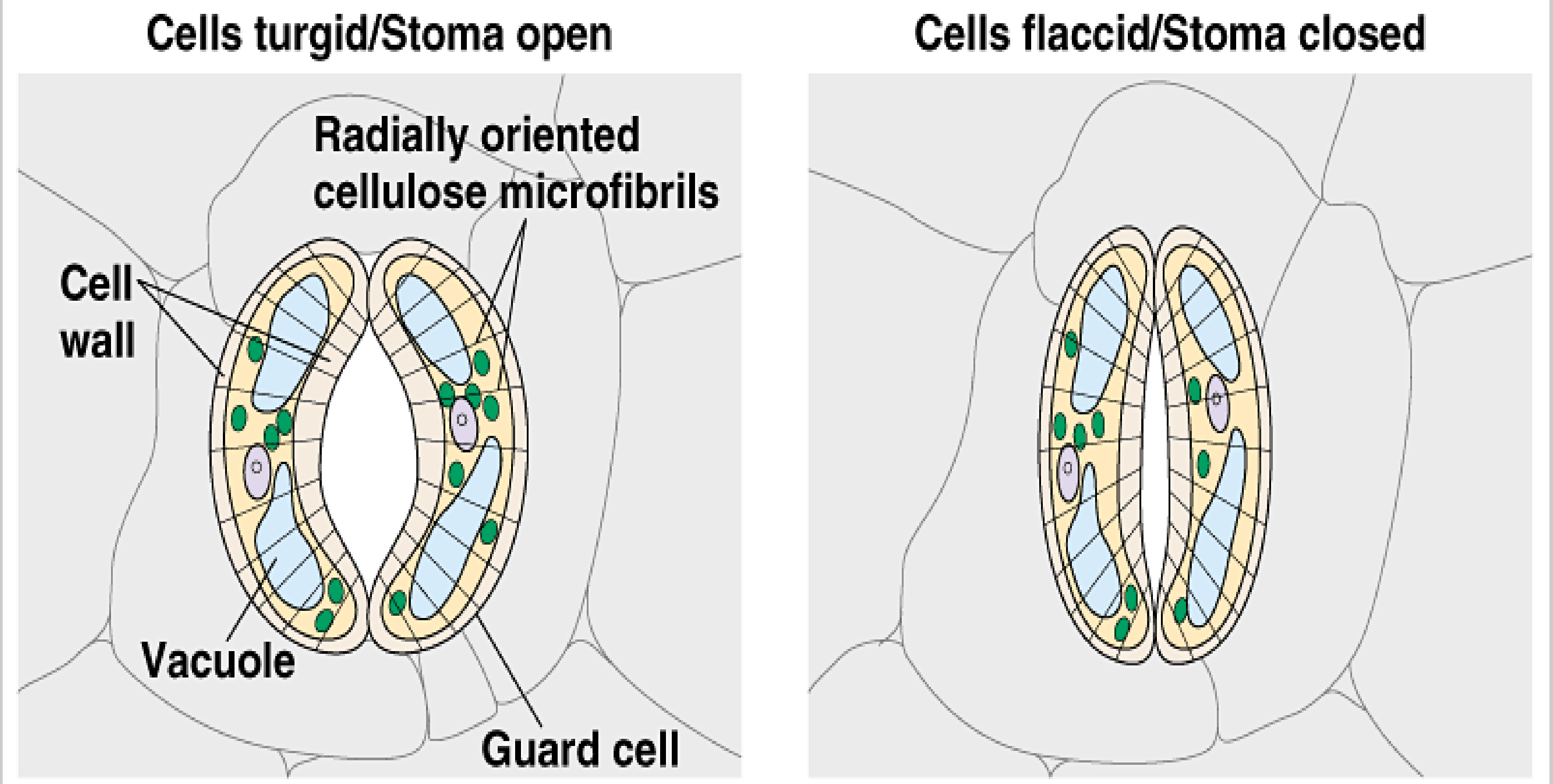


SUMMARY



Cerebrospinal fluid
Breathing control centers
Pons
Medulla oblongata
Nerve impulses trigger contraction of muscles
Nerve impulses relay changes in CO_2 and O_2 concentrations
Carotid arteries
Aorta
Diaphragm
Rib muscles

SUMMARY



(a) Changes in guard cell shape and stomatal opening and closing (surface view)

NEXT LECTURE

8.0 TRANSPORT SYSTEM