

Pressure

By the end of this section, you will be able to:

- 1- Explain the concept of pressure the in human body.**
- 2- Explain systolic and diastolic blood pressures.**
- 3- Describe pressures in the eye, skull, Digestive System , bladder, and skeletal system.**
- 4-What Is the principle of Hyperbaric Oxygen Therapy? How Is the Treatment Performed?**

Pressure is defined as the force per unit area. The pressure P under a column of liquid can be calculated from the following law:

$$P = \rho g h$$

Where the: ρ is the density of the liquid

g is the acceleration due to the gravity h is height of the column

Ex:- what height of water will be produced the same pressure as 120 mmHg.

► Solution: $P = \rho g h = 13.6 \times 980 \times 12$

► $= 1.6 \times 10^5 \text{ dy/cm}^2$

► For water $P = \rho g h$

► $1.6 \times 10^5 = 1 \times 980 \times h$

► So $h = 163 \text{ cm H}_2\text{O}$

Or $(\rho g h)_{\text{Hg}} = (\rho g h)_{\text{H}_2\text{O}}$ •

$$\rho_{\text{Hg}} h_{\text{Hg}} = \rho_{\text{H}_2\text{O}} h_{\text{H}_2\text{O}}$$
 •

$$h_{\text{H}_2\text{O}} = (13.6 \times 12) / 1 = 163 \text{ cmH}_2\text{O}$$
 •

Ex:- Calculate the atmospheric pressure in N/m^2

➔ Solution:- 1 atm = 760 mmHg = 76 cmHg

➔ The atmospheric pressure in N/m^2 is equal

➔
$$P = \rho g h =$$
$$13600 \text{kg/m}^3 \times 9.8 \text{m/s}^2 \times 0.76 \text{m}$$
$$= 1.01 \times 10^5 \text{ N/m}^2$$

Gauge Pressure

- ➔ **The excess pressure over atmospheric pressure.**

Negative Pressure

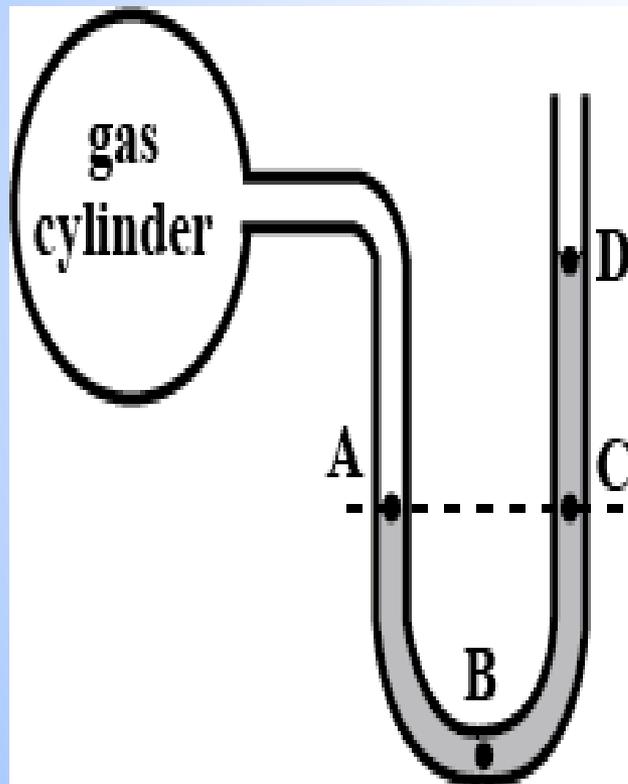
- ▶ Any pressure lower than atmospheric pressure. For example: The lung pressure during inspiration is a few centimeter of water negative
- ▶ There are numbers of places in the body where the pressure is lower than atmospheric pressure or negative .For example when we breath inspire the pressure in the lungs must be lower than the atmospheric pressure .

The most common clinical instrument used in the measuring pressure is the sphygmomanometer, which measure s blood pressure.

Typical pressure in the normal body

<u>Different parts of the body</u>	<u>Typical pressure(mmHg)</u>
<u>Arterial blood pressure</u>	
Max.(systole)	100 - 140
<u>Min.(diastole)</u>	<u>60 - 90</u>
<u>Venous blood pressure</u>	<u>3 - 7</u>
<u>Middle ear pressure</u>	<u>less than 1</u>
<u>Eye pressure</u>	<u>20</u>
<u>CSF inside the brain</u>	<u>5 - 12</u>

Measurement of pressure in the body
An instrument that measures pressure is called a manometer.

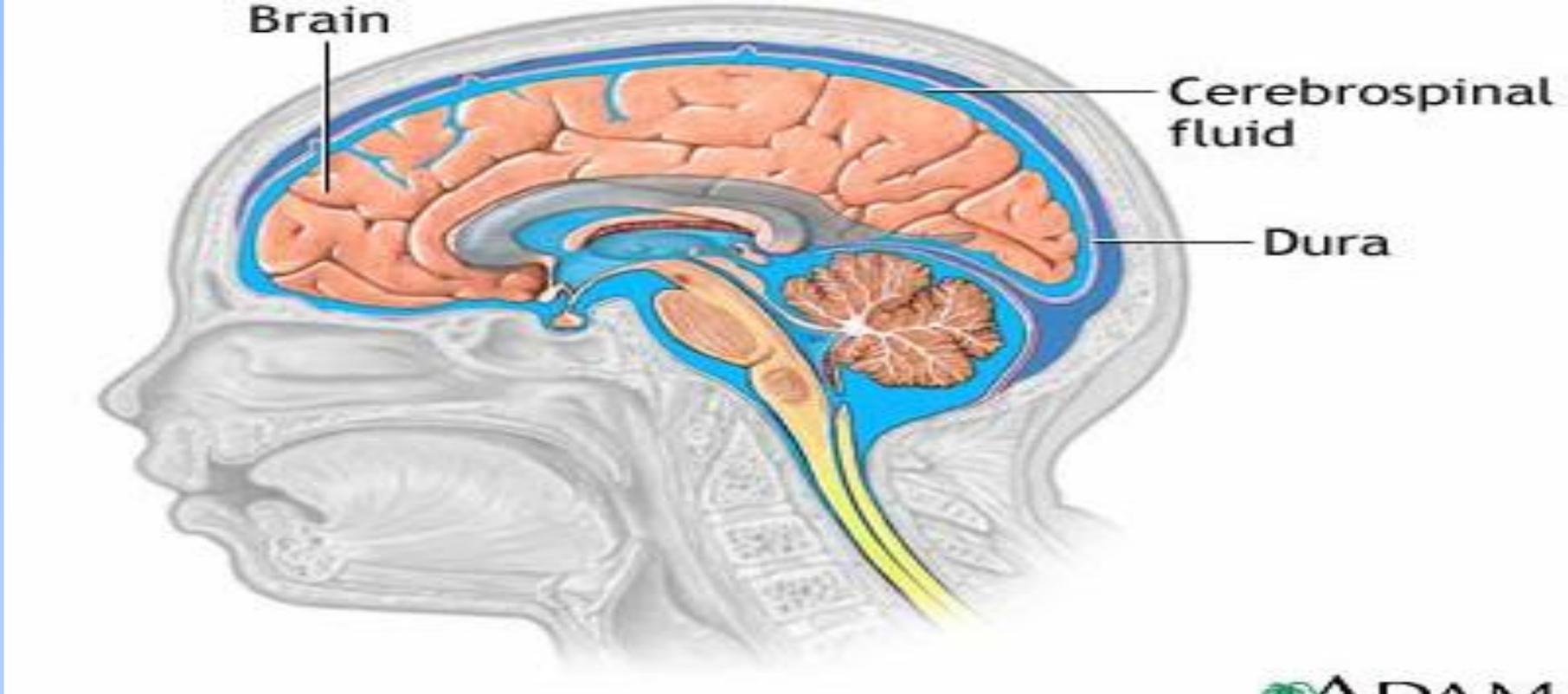


- ▶ A common type of manometer is a U-shaped tube containing a fluid that is connected to the pressure to be measured.

The common clinical instrument used in measuring pressure is the sphygmomanometer

Pressure inside the skull

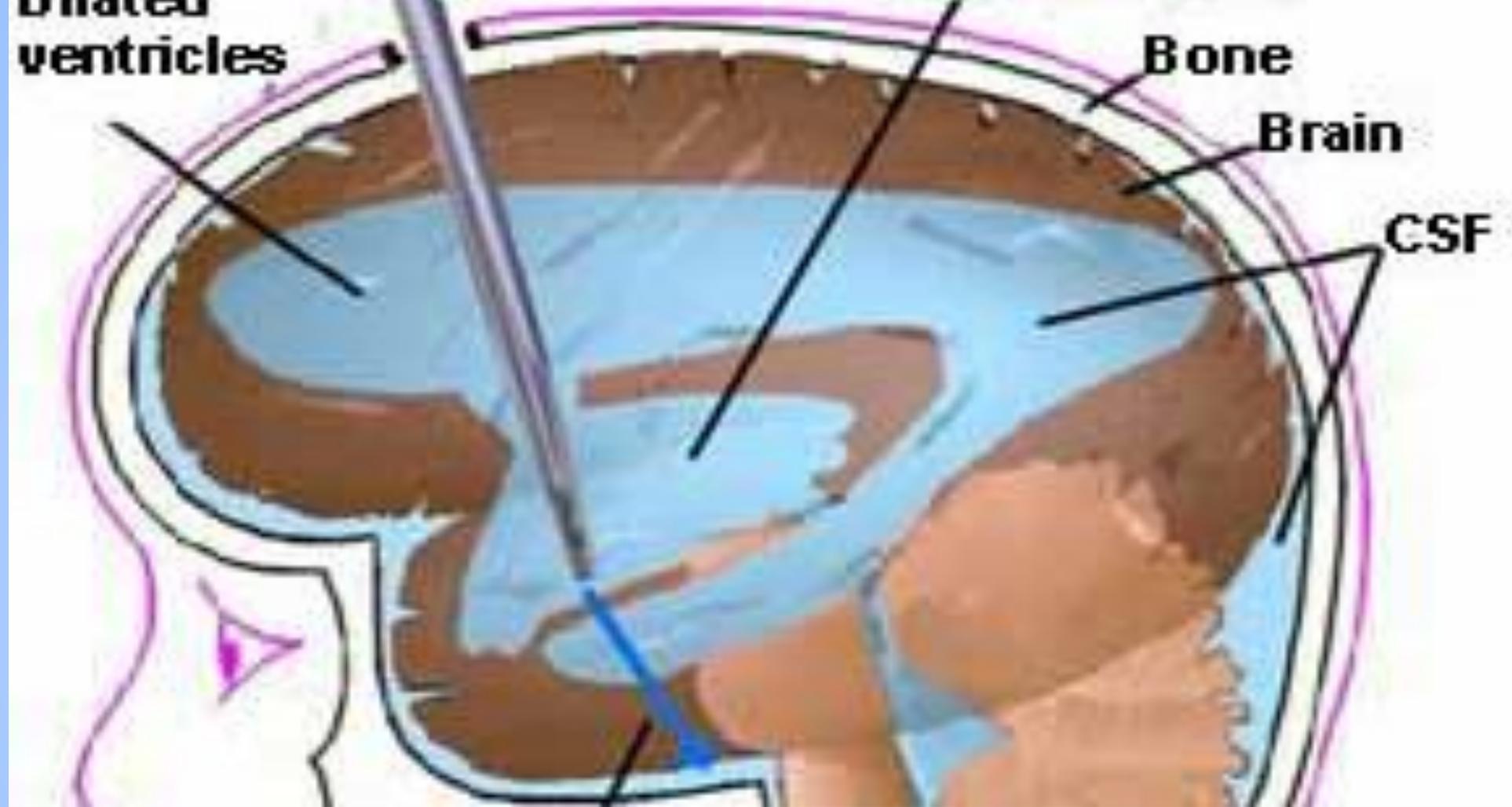
- ➔ The brain contains approximately 150cm³ of cerebral spinal fluid (CSF) in a series of inter connected openings called ventricles



CSF (brain)----to ventricles-----to spinal column-----to circulatory system.

One of the ventricles, the aqueduct is especially narrow.

-If at birth this opening is blocked for any reason, the CSF is trapped inside the skull and increases the internal pressure. The increased pressure causes the skull to enlarge. This serious condition is called hydrocephalous.



It can often be corrected by surgically installing a by _ pass drainage system for CSF.

Measuring the CSF pressure

- It is not convenient to measure the SCF pressure directly. There are two methods:
- 1-Crude method: This method can measure the pressure inside the skull by measuring the circumference of the skull just above the ears. Normal values for newborn infants are from (32-37) cm, and a larger value may indicate hydrocephalus.



2-Transillumination: is a qualitative method of detection. Make use of the light –scattering properties of the rather clear CSF inside the skull.

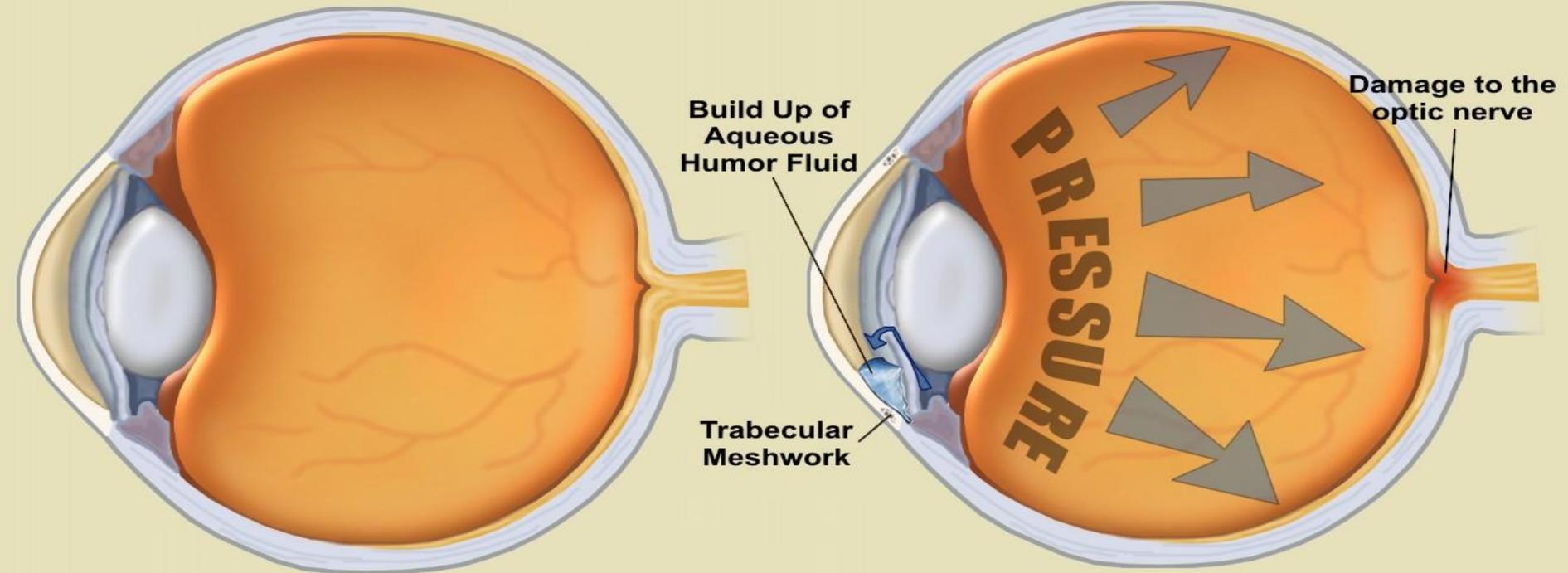
A bright light is shined through a body cavity or organ such as the brain



Eye pressure

Normal Eye

Eye with Glaucoma



The clear fluids in the eye ball (aqueous and vitreous humors) that transmit the light to the retina (the light sensitive part of the eye), are under pressure and maintain the eye ball in a fixed size and shape

-If a partial blockage of the drain system occurs, the pressure increase of restrict the blood supply to the retina then affect the vision. This condition, called glaucoma.

Glaucoma: 1- moderate-----tunnel vision

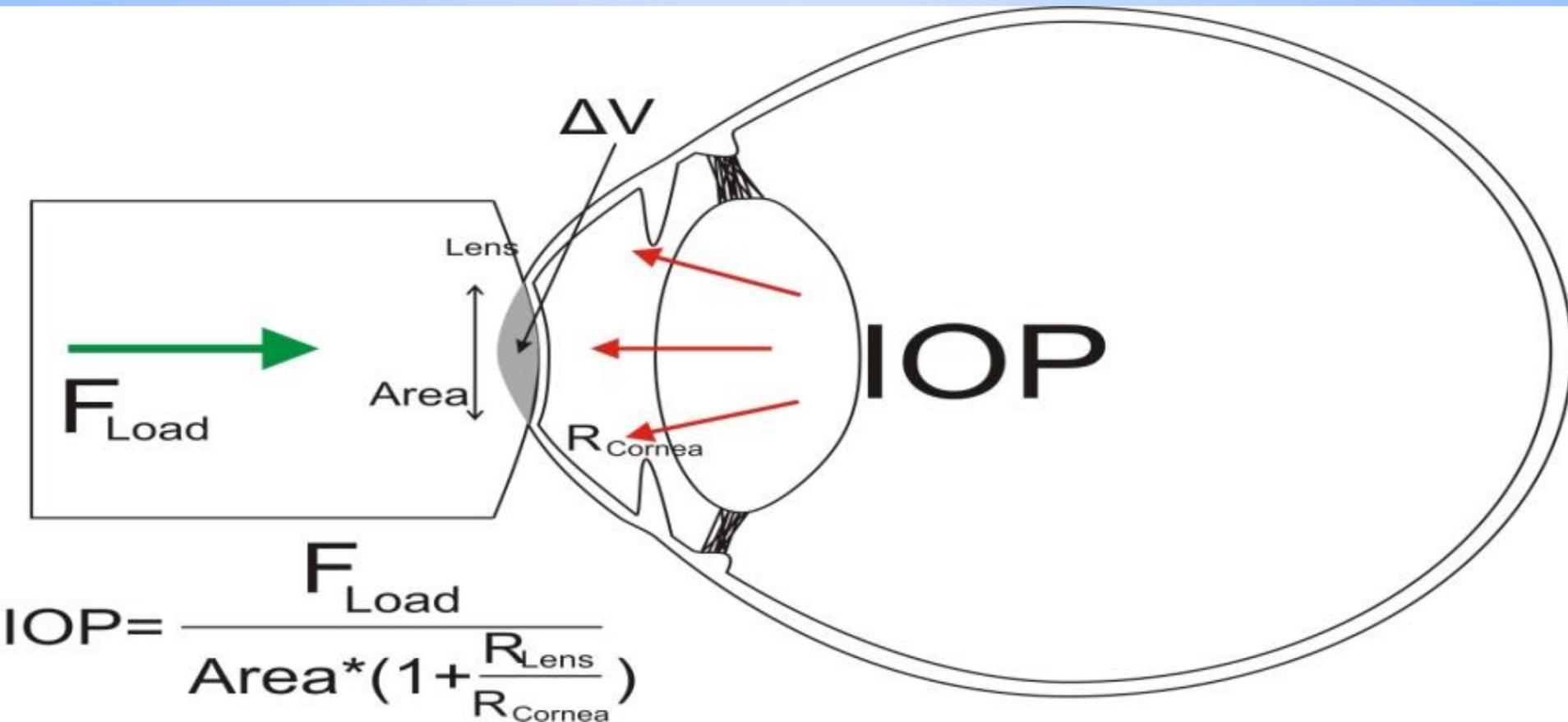
2- severe-----

blindness

-The pressure in normal eyes ranges from (12 – 23) mmHg.

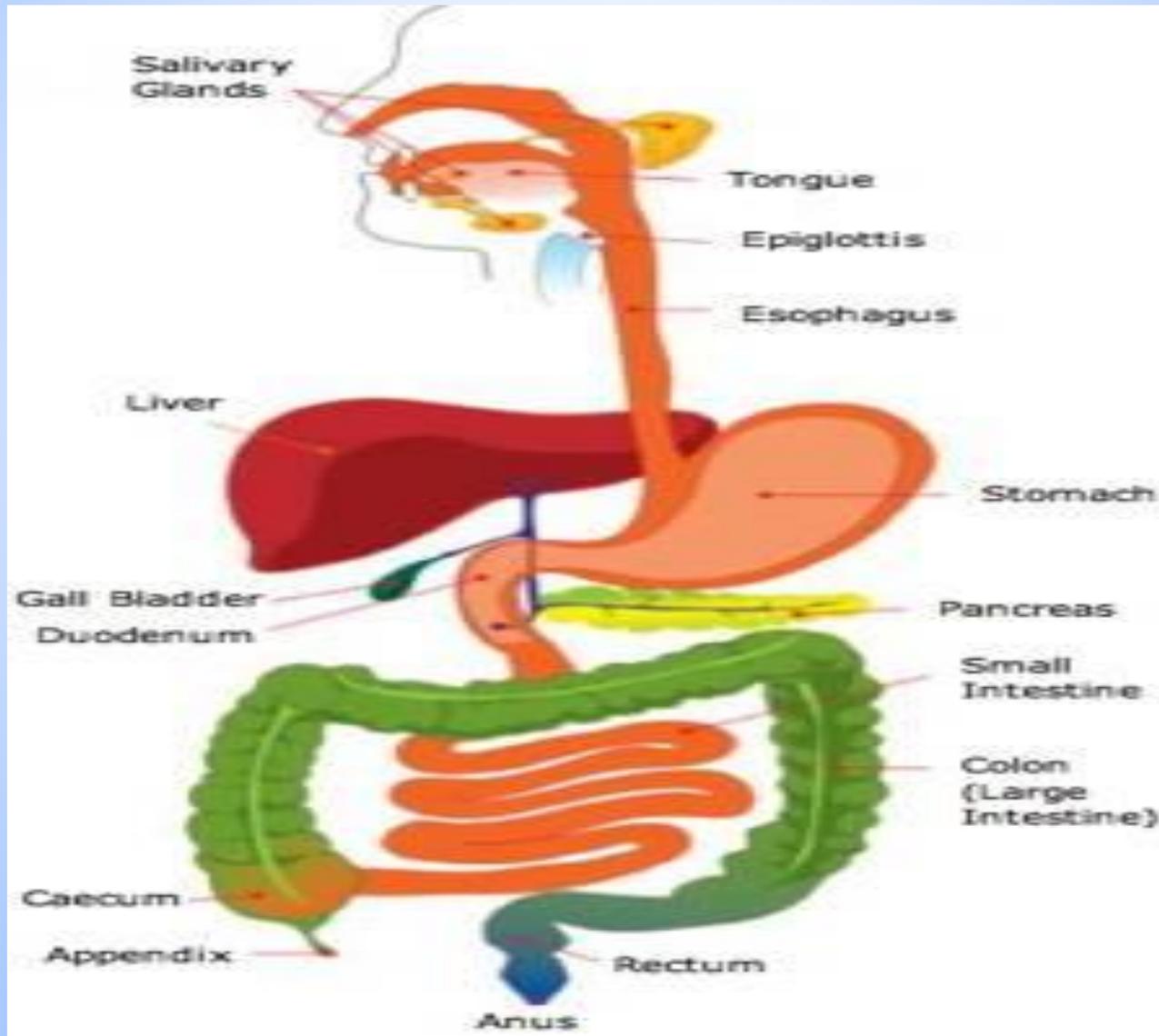
Measuring the eye pressure

- 1-By feel the physicians estimate the pressure inside the eye by feel as they pressed on the eye with their fingertips.
- 2-By the tonometer



An instrument is used to measure intraocular pressure(IOP).

Pressure in the Digestive System



- Opening through the body**
- Over 6 m**
- Closed in the lower end and has several restrictions**
- Valves and sphincters permit unidirectional flow of food.**

Pressure in the gastrointestinal (GI) system

- Greater than atmospheric pressure in most parts**

-Esophagus pressure is usually less than atmospheric pressure

-Pressure in the stomach

A-Eating increases the pressure in the stomach slowly due to increased volume

B-Air swallowed during eating increases the pressure in the stomach → burping or belching

-Pressure in the gut

A-Bacteria action generates gas (flatus) →increase gut pressure

B- Belts, girdles, or swimming → affect gut pressure

Pylorus : valve

-Prevents the flow of food back into the stomach from the small intestine

-blockage in the small or large intestine → high pressure between the blockage and the pylorus → blockage of blood flow to critical organs → death

-Treatment

A-Intubation: a hollow tube through the nose, stomach, and pylorus

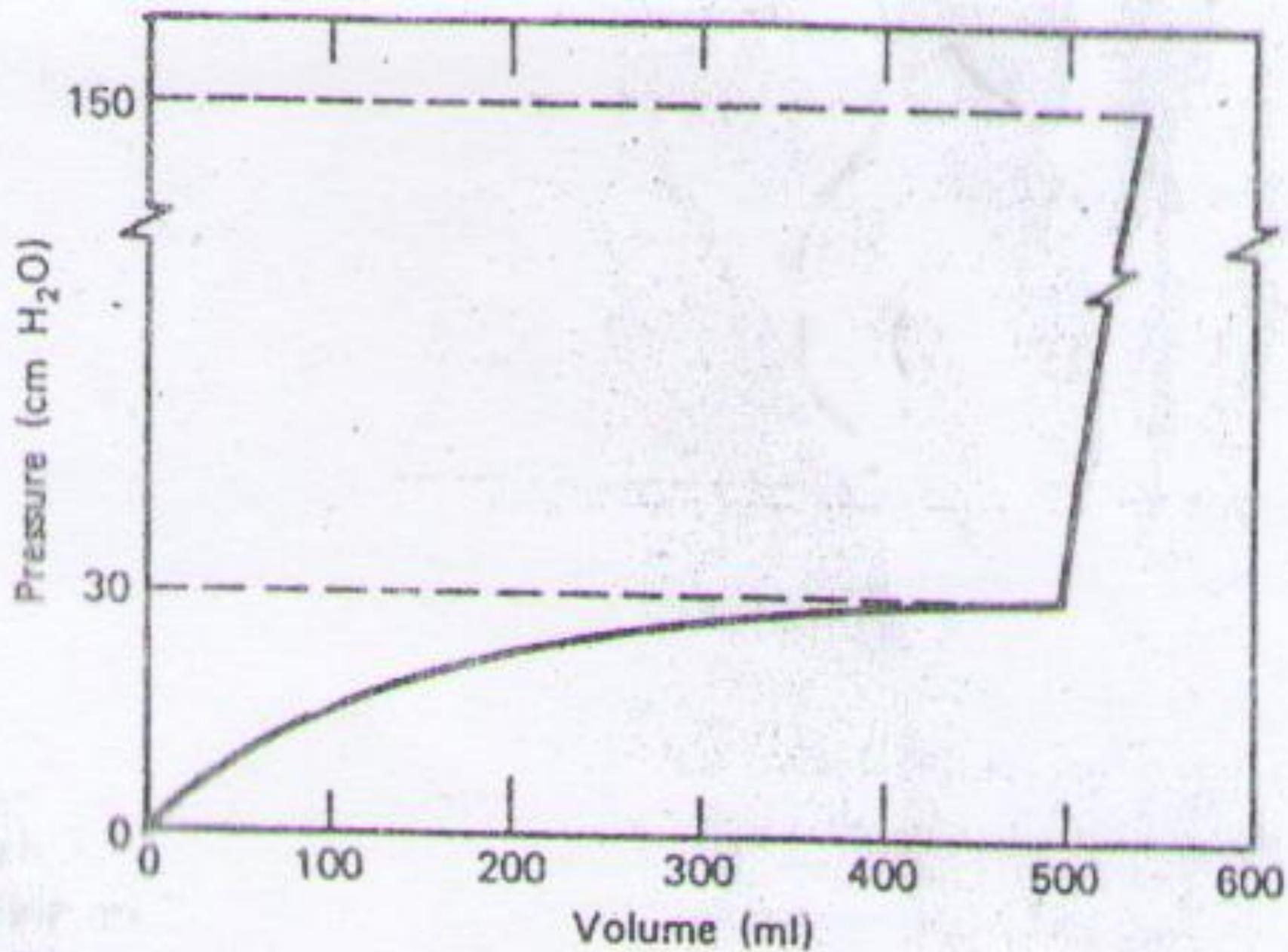
B-Surgery in a pressure-controlled operating room

Pressure in the skeleton

- ▶ -the highest pressures in the body are found in the weight bearing bone (joints).
- ▶ -The pressure in the knee joint may be more than 10 atm
 $P = F/A$ ------(1)
- ▶ -The surface area of a bone at the joint is greater than its area either above or below the joint. The larger area at the joint distributes the force, thus reducing the pressure, according to equation (1).
- ▶ -Bone has adapted in another way to reduce pressure, the finger bones are flat rather force is spread over a larger surface, this reducing the tissues over the bones according to $P = F/A$.

Pressure in the urinary bladder

- ➡ -The interval pressure in the bladder is due to the accumulation of urine. The figure below shows the typical pressure-volume curves for the bladder, which stretches as the volume increase.



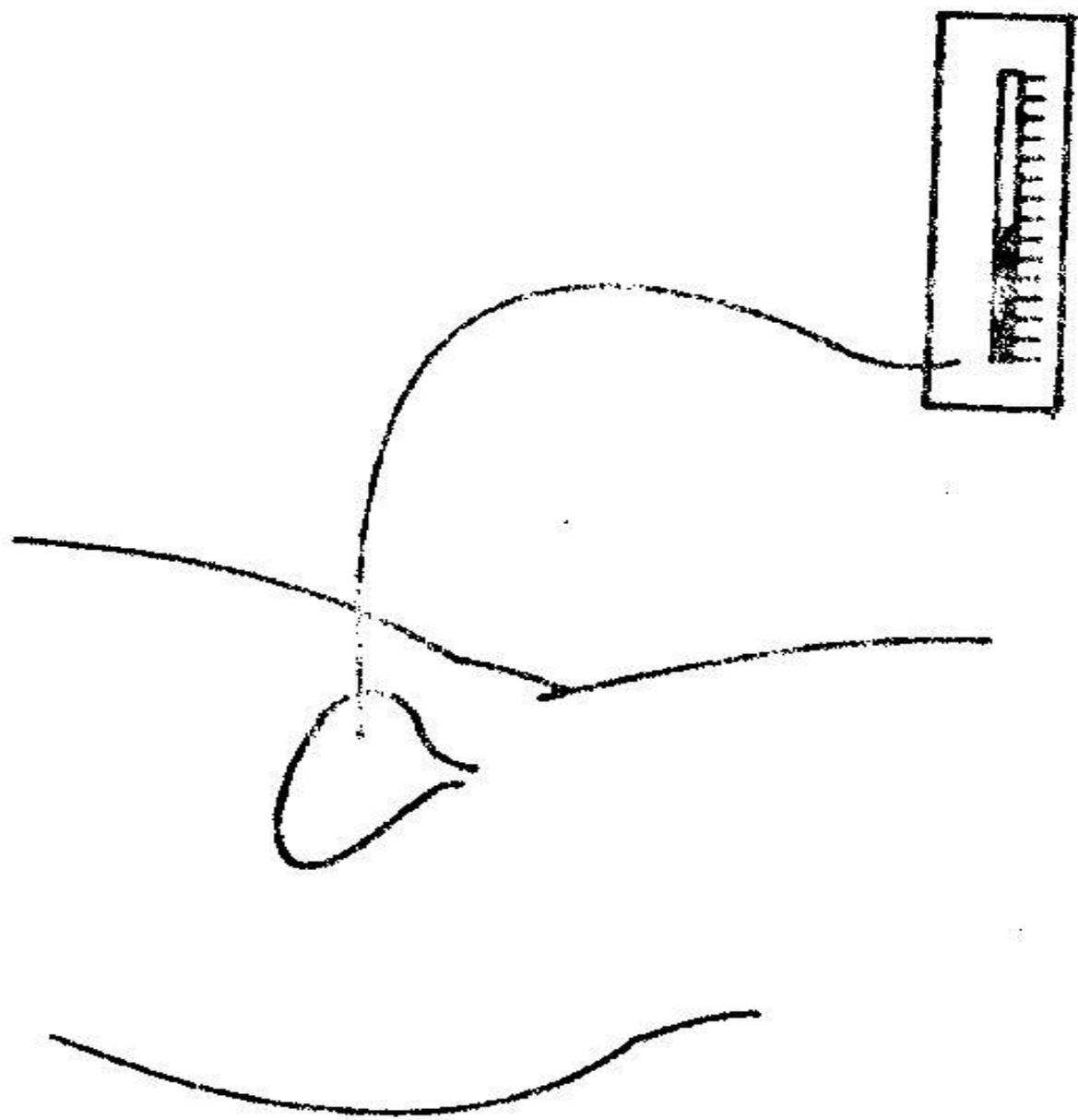
-For adult, the typical max. Volume in the bladder before voiding is 500ml. At some pressure nearly 30cmH₂O the micturition reflex occurs.

-The resulting sizable muscular contraction in the bladder wall produces a momentary pressure of up to 150cmH₂O.

The pressure in the bladder can be measured:

1-By passing a catheter with a pressure sensor into the bladder through the urinary passage (urethra).

2-By a needle inserted through the wall of the abdomen directly into the bladder. This technique gives information about the function of the exit valves that cannot be obtained with the catheter technique.



-The bladder pressure increases during coughing , straining , sitting up , also during pregnancy the weight of fetus over the bladder increase the bladder pressure and causes frequent urination.

Normal voiding pressure is fairly low (20 – 40) cmH₂O but for men who suffer from prostate obstruction of the urinary passage it may be over 100 cmH₂O

Pressure effects while diving

- ▶ **The body is composed primarily of solids and liquids, which are nearly incompressible. Pressure changes; do not greatly affect most of it . However, there are gas cavities in the body where sudden pressure changes can produce profound effects.**

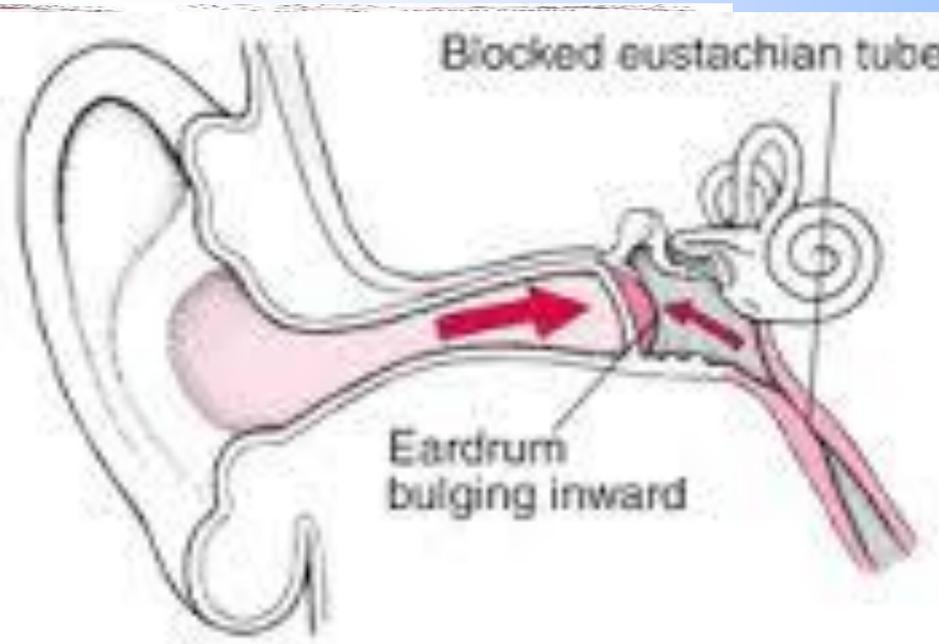
Boyles law

- ▶ For a fixed quantity of gas a fixed temperature the product of the absolute and volume is constant.
- ▶ $PV = \text{constant}$
- ▶ $P_1V_1 = P_2V_2$
- ▶ That is, if the absolute pressure is doubled, the volume is halved.

-The middle ear is one of the air cavities that exist within the body. For comfort the pressure in the middle ear should be equal to the pressure to the pressure on the outside of the eardrum.



Equal Air Pressure



Unequal Air Pressure

This equalized is produced by air flowing through the Eustachian tube, which is usually closed except during swallowing, chewing, and yawning

- When diving many people has difficulty obtaining pressure equalization and feels pressure on their ears.**

**-(120mmHg) across the eardrum
, which can occur in about 1.7 m
of water ,can cause damage
(rupture) to the eardrum . One
method of equalization used by
diver is to raise the pressure in
the mouth by holding the nose
and trying to blow**

The pressure in the lung

Pressure in the lung at any depth greater than the pressure in the lung at sea level. This means that the air in the lung is denser under water and that the partial pressure of all the air components are proportionately higher.

1-The higher partial pressure of O_2 causes more O_2 molecules to be transformed into the blood, and oxygen poisoning results if the partial pressure of the O_2 gets high. Partial pressure of O_2 is 0.8 atm and absolute air pressure is 4 atm at depth of 30m.

2-Breathing air at a depth of 30m is also dangerous because it may result in excess N_2 in the blood and tissues, there is a possibility of having:

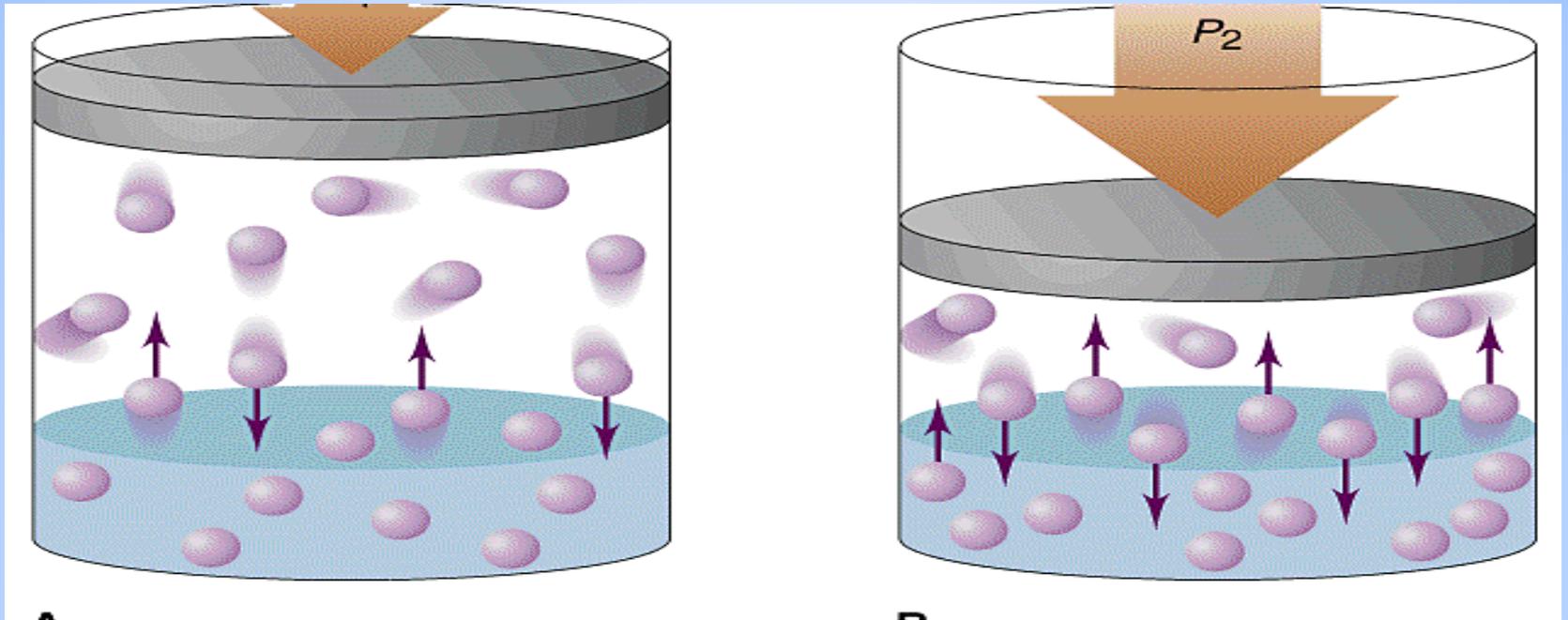
- Nitrogen narcosis (intoxication effect)**

- The bends or decompression sickness**

(a scant problem).

O_2 is attached to red blood cells, while N_2 is dissolved in the blood and tissues.

Henry's law



The amount of gas that will dissolve in a liquid is proportional to the partial pressure of the gas in contact with the liquid.

Hyperbaric oxygen therapy (HOT)

The body normally lives in an atmosphere that is about one fifth O_2 and four-fifth N_2 . In some medical situations it is beneficial to increase the proportion of O_2 in order to provide more O_2 to the tissue.

1-Gas gangrene:

The bacillus causes gas gangrene then it's treated with (H₂O₂). That is due to bacillus cannot survive in the presence of oxygen

2-Carbon monoxide poisoning:

-The red blood cells cannot carry O₂ to the tissues because the carbon monoxide fasters to the hemoglobin at the places normally used by O₂.

-Normally the amount of O₂ dissolved in the blood is about 2% of that carried on the red blood cells.

-By using the (HOT) technique, the partial pressure of O₂ can be increased by a factor of 15 , permitting enough O₂ to be dissolved to fill the body's needs

3-Treatment of cancer:

(HOT) with radiation is given to the patient in transparent plastic tank. The theory was that more oxygen would make the poorly oxygenated radiation –resistant cell in the center of the tumor more susceptible to radiation damage.



REVIEW QUESTIONS

1- Assume you are a shallow water diver preparing for a 10m dive into salt water.

a- what absolute pressure and gauge pressure will you experience?

b- Normally your lungs have an available volume of 6 liters. What will happen to that volume?

c- Suppose you cannot equalize in your middle ear. What will happen during the dive?

a-

$$\underline{\text{gauge pressure}} = \rho g h = 1000 \text{ Kg/m}^3 \times 10 \text{ m/s}^2 \times 10\text{m} = 10^5 \text{N/m}^2 = 1\text{Atm}$$

**Absolute pressure= Gauge pressure +
Atmospheric pressure**

$$= 1 \text{ atm} + 1 \text{ atm} = 2 \text{ atm}$$

b-

$$P_1 \times V_1 = P_2 \times V_2$$

$$1 \text{ atm} \times 6\text{L} = 2 \text{ atm} \times V_2$$

$$V_2 = 3 \text{ L}$$

C-

The eardrum will rupture.

H.W

Positive pressure is used in blood transfusions. Suppose a container is placed 1 m above a vein with a venous pressure of 2 mm Hg: if the density of blood is 1.04 g/cm^3 , what is the net pressure acting to transfer the blood into the vein?