HUMAN ORGAN SYSTEMS AND BIO DESIGNS - 2

Lungs as purification systems (architecture, gas exchange mechanisms)

Lung Architecture

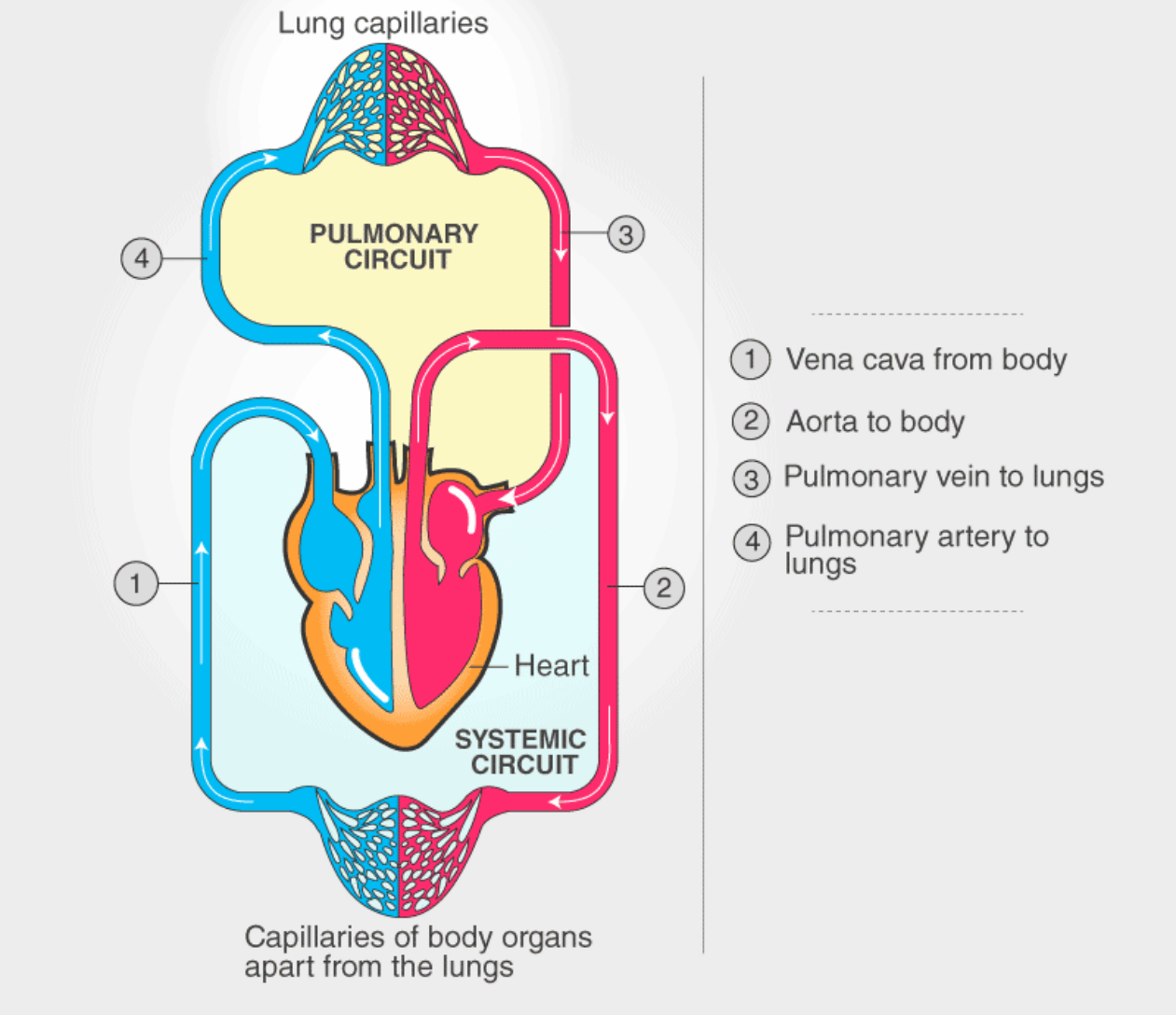
The lungs are the **major organs of the respiratory system**, which helps provide the body with a continuous supply of oxygen.

The main role of lungs' is to bring in air from the atmosphere and pass oxygen into the bloodstream. From there, it circulates to the rest of the body.

The organs require help from surrounding structures in the body in order to breathe properly.

Respiration – Also known as cellular respiration, is the energy releasing reaction that takes place inside of cells. Oxygen combines with sugar to release energy.

Whole Circulation



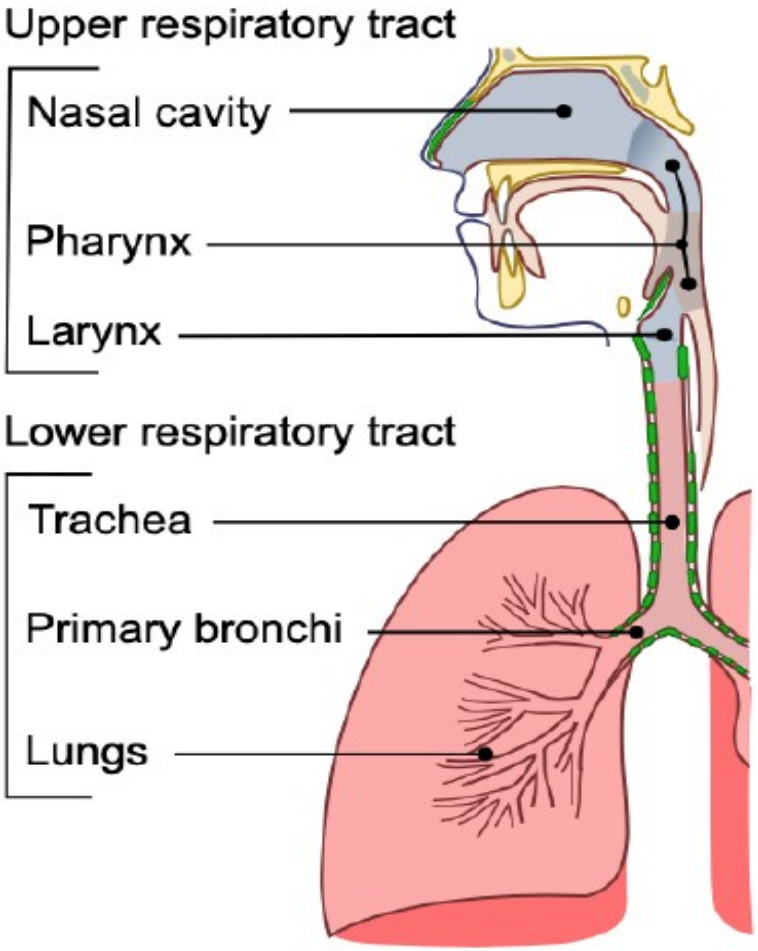
The organs of the respiratory system form a continuous system of passages called the **respiratory tract ,** through which air flows into and out of the body.

The respiratory tract has two major divisions: the upper respiratory tract and the lower respiratory tract.

In addition to these organs, certain muscles of the thorax (the body cavity that fills the chest) are also involved in respiration by enabling breathing.

Most important is a large muscle called the diaphragm, which lies below the lungs and separates the thorax from the abdomen.

Smaller muscles between the ribs also play a role in breathing.



The Path of Air in the Body

Air inside the body after inhalation moves across
Upper respiratory tract and lower respiratory tract

Upper Respiratory Tract

1. Nose or Mouth – moistens and heats the air before going into the trachea.
 Cilia and mucus trap dirt in the air.

2. Larynx – part of the trachea where our vocal cords are located.

Lower Respiratory Tract

1. Trachea – the tube that leads from the nose and mouth to the lungs.

The walls have rings of cartilage to protect the trachea and prevent it from collapsing.

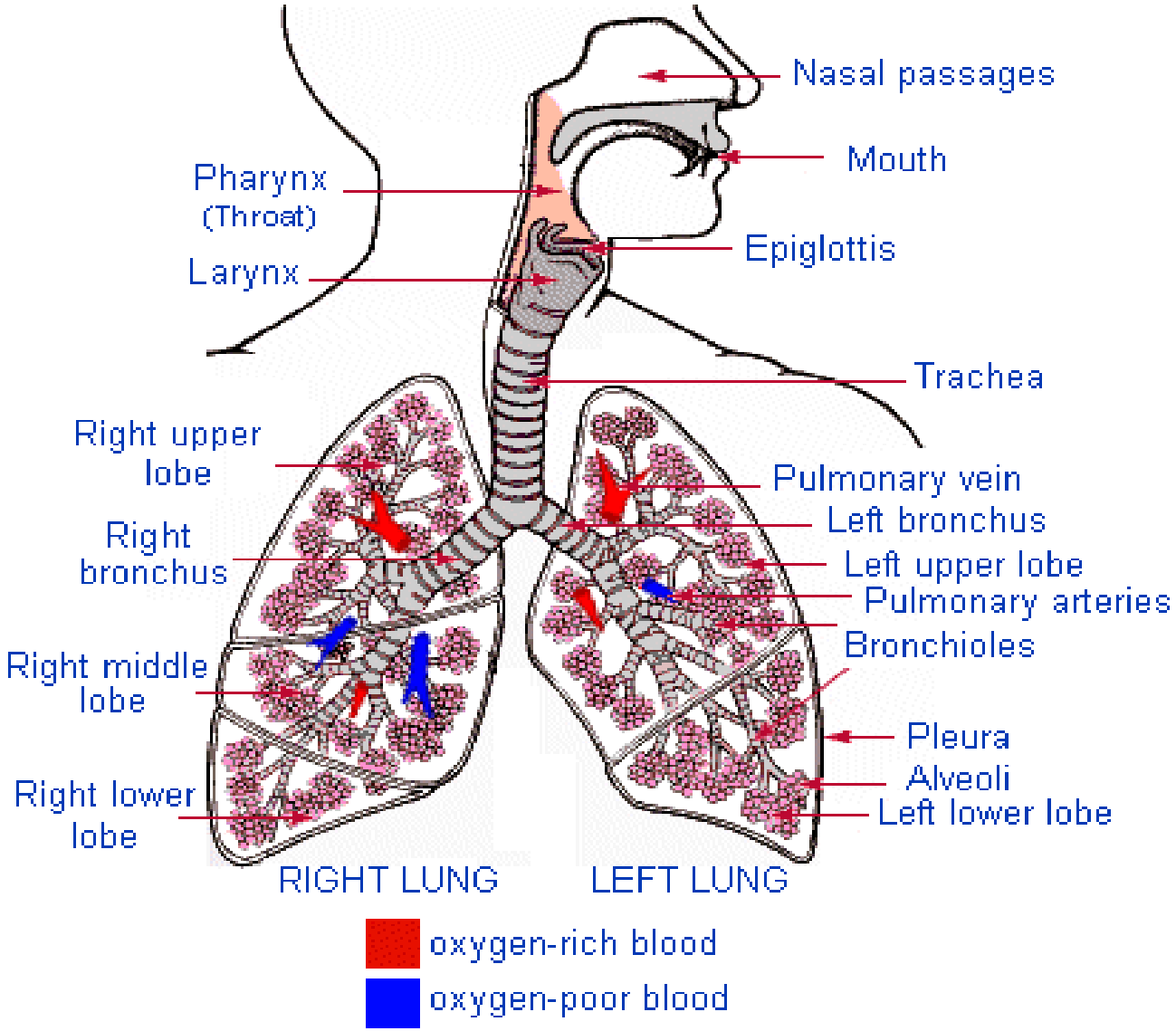
2. Bronchi – the trachea splits into right and left bronchi, each one leading into your right and left lung.

Each bronchus (singular) leads air into the lungs and divides into smaller and smaller tubes, like a tree trunk divides into smaller and smaller branches.

3. Alveoli – grape-like structures at the end of the bronchi. This is where our blood picks up the oxygen we need.

4. Diaphragm – a large dome-shaped muscle, just under the lungs, that moves to inflate the lungs with air.

The Path Air Takes In The Body

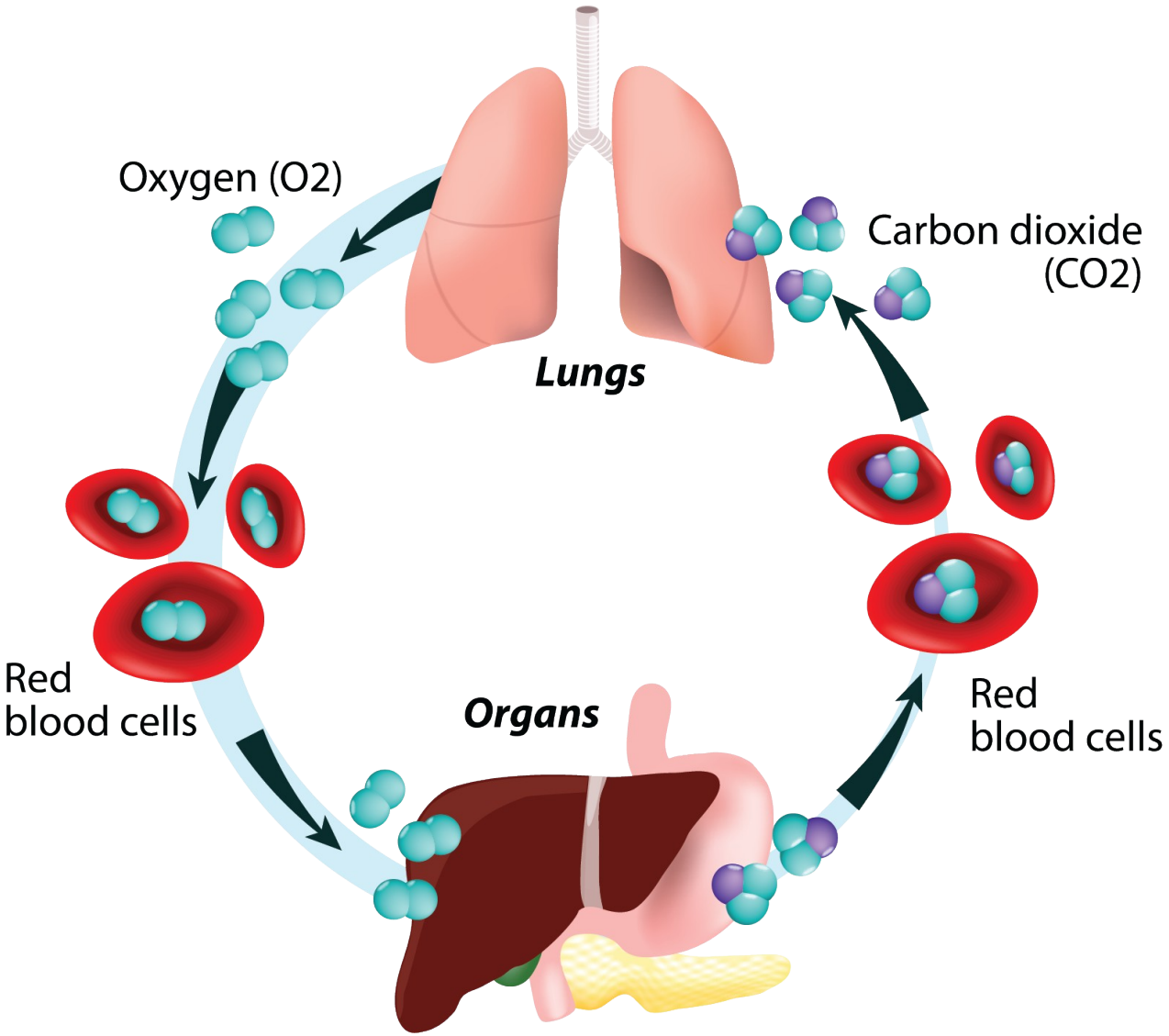


Large Surface Area

The alveoli greatly increase the surface area of our lungs. If they were cut open and spread out evenly, the alveoli would cover an area the size of a tennis court!

Capillaries, very tiny blood vessels, surround each alveoli cluster so the blood can pick up large amounts of oxygen.

Gas exchange



Gas Exchange mechanism in lungs

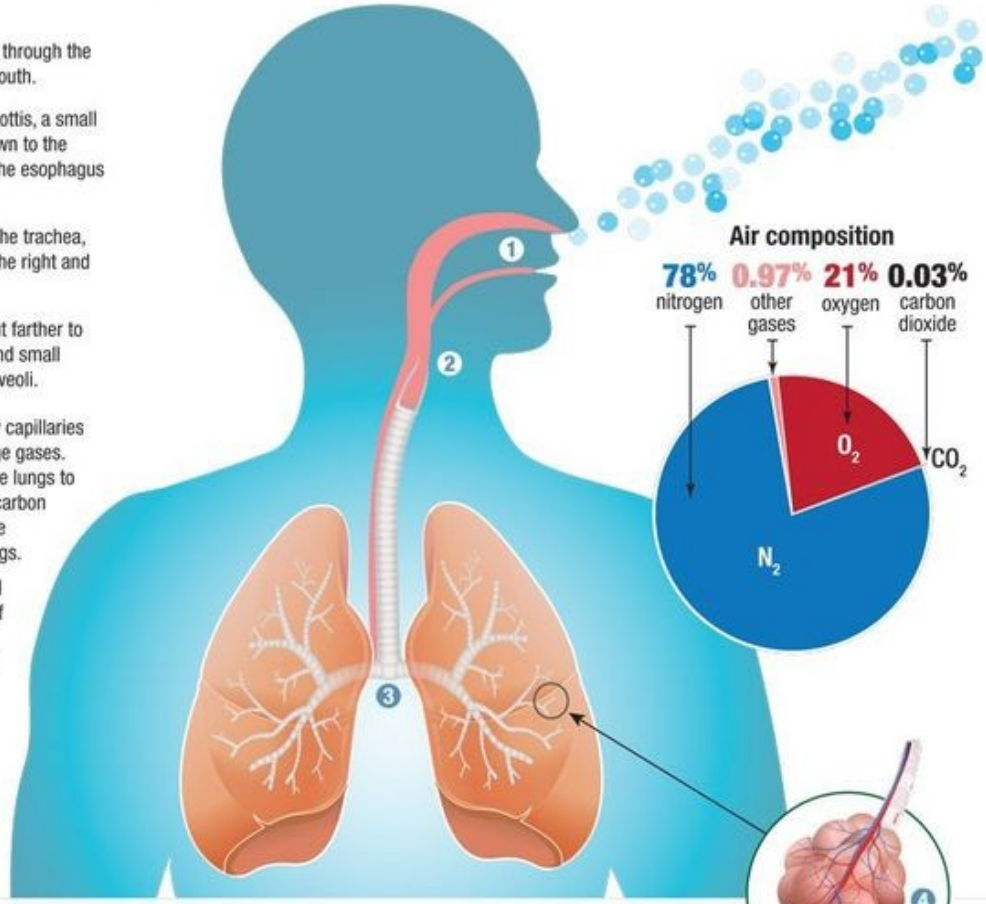
- **In gas exchange process, oxygen is in and carbon dioxide is out.**
- **The gas exchange occurs in the lungs between alveolar air and blood of the pulmonary capillaries.**
- **Lungs contains millions of alveoli shows maximum surface area. For efficient gas exchange to occur alveoli must be ventilated and highly perfused (Permeable) .**
- **Ventilation (V) applied to flow of air into and out of the alveoli, while perfusion (Q) refers to flow of blood to alveolar capillaries.**

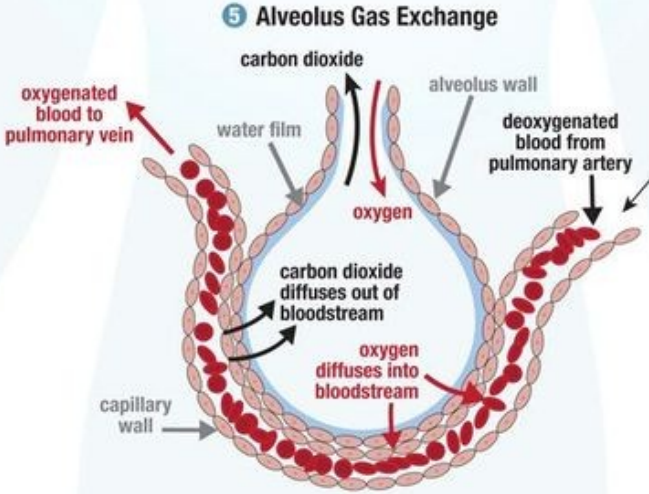
Gas exchange : Cont…

- **Individual alveoli have variable degree of ventilation and perfusion in the different regions of the lungs.**
- **Overall changes in ventilation and perfusion in the lungs are measured by the ration of ventilation to perfusion (V/Q) .**
- **Changes in V/Q ratio can affect gas exchange may result in low oxygen .**
- **Gas exchange in the alveoli occurs primarily by diffusion. Passing of gas from the alveoli to capillary blood, it must must pass through alveolar surfactant, other structure**

1. Air flows into the body through the nasal passages and mouth.
2. Air passes by the epiglottis, a small flap that directs air down to the lungs and food down the esophagus to the stomach.
3. Air then travels down the trachea, or windpipe, and into the right and left bronchi.
4. These tubes branch out farther to become bronchioles and small air-filled sacs called alveoli.
5. Around the alveoli, tiny capillaries bring blood to exchange gases. Oxygen moves from the lungs to the bloodstream, and carbon dioxide moves from the bloodstream to the lungs.

   The exchange is based on the concentration of gases in the blood compared to gases in the alveolus.





Did you know?

Algae produce approximately **75%** of the oxygen we breathe.

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Disease Related to Lungs

Asthma is a long-term inflammatory disease of the airways of the lungs. It is characterized by variable and recurring symptoms, reversible airflow obstruction, and easily triggered bronchospasms.

Symptoms include episodes of wheezing, coughing, chest tightness, and shortness of breath.

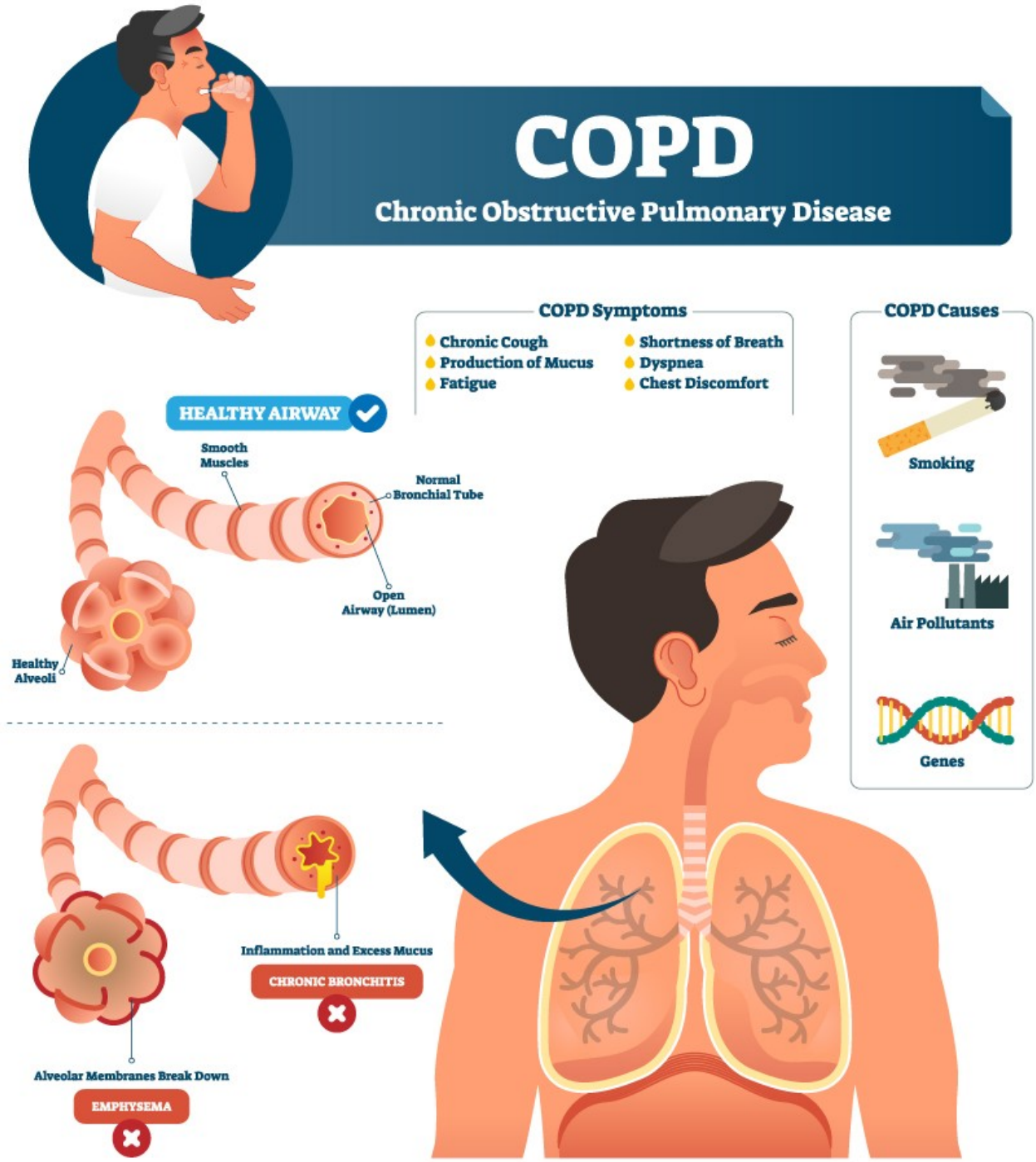
Bronchitis is inflammation of the bronchi (large and medium-sized airways) in the lungs that causes coughing.

Bronchitis usually begins as an infection in the nose, ears, throat, or sinuses. The infection then makes its way down to the bronchi.

Emphysema is a lung condition that causes shortness of breath. In people with emphysema, the air sacs in the lungs (alveoli) are damaged.

COPD

- **It** is a chronic inflammatory lung disease that causes obstructed airflow from the lungs.
- Symptoms include breathing difficulty, cough, mucus (sputum) production and wheezing.
- It's typically caused by long-term exposure to irritating gases. People with COPD are at increased risk of developing heart disease, lung cancer



Chronic inflammatory lung disease that causes obstructed airflow from the lungs.

Symptoms include breathing difficulty, cough, mucus (sputum) production and wheezing.

It's typically caused by long-term exposure to irritating gases or particulate matter, most often from cigarette smoke.

COPD requirement: Oxygen at 24% (via a Venturi mask) at 2-3 L/minute or at 28% (via Venturi mask, 4 L/minute) or nasal cannula at 1-2 L/minute. = **oxygen**

Lung Function Tests

Lung function tests, also known as pulmonary function tests, check how well the lungs work and can help investigate breathing problems and diagnose lung conditions.

Examples of lung function tests

- **Spirometry:** This test measures how much and how quickly people can move air in and out of their lungs.
- **Plethysmography:** Also known as a lung volume test, this measures the amount of air individuals can hold in the lungs and how much air remains after breathing out.
- **Gas diffusion test:** This test can measure gases, such as oxygen, moving from the lungs to the bloodstream.
- **Exercise stress test:** This test typically involves a bike or treadmill to investigate how exercise affects lung function.

Respiratory volume

- There are many factors that influence lung capcity.
  - Size, age, sex, physical condition, ect.
- Tidal Volume (TV) is the amount of quiet breathing into and out of the lungs with each breath (500mL normally)
- Inspiratory Reserve Volume (IRV): The amount of air that can be taken in forcibly over the tidal volume. (2100-3200mL normally)
- Expiratory Reserve Volume (ERV): The amount of air that can be forcibly exhaled after a tidal expiration. (1200mL normally)
- Residual Volume: The amount of air still remaining in the lungs that cannot be voluntarily expelled (1200mL normally) It is important because it permits gas exchange to continue between breaths and keeps alveoli open.

Lung Capacities

Tidal Volume **It is the volume of air inhaled or exhaled from the lungs in normal breathing and symbolically represented as TV**

Inspiratory capacity(IC)

It is the maximum volume of air (By force) that can be inhaled following a resting state. Hence it can be measured by the sum of inspiratory reserve volume and tidal volume

Vital Capacity(VC)

It is the total amount of air exhaled after maximal inhalation. It is the value corresponding to 4800 or 4.8 Lt .

it can be calculated by the sum of tidal volume, inspiratory reserve volume, and expiratory reserve volume. VC = TV+IRV+ERV.

Total Lung Capacity(TLC)

It is the maximum volume of air the lungs can accommodate or sum of all volume compartments or volume of air in lungs after maximum inspiration.

The normal value is about 6,000mL (4-6 L). TLC is calculated by summation of the four primary lung volumes (TV, IRV, ERV, RV).

Lungs as purification systems (spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine)

Spirometry

Spirometry (meaning the measuring of breath) is the most common of the pulmonary function tests (PFTs).
It measures lung function, specifically the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled.

Spirometry is helpful in assessing breathing patterns that identify conditions such as asthma, pulmonary fibrosis, cystic fibrosis, and COPD.

- Spirometer is a mechanical hand-held breathing device in which the patient is instructed to take slow deep breaths through the device's mouthpiece

- The device gives the patient visual feedback on the volume of the inhalation.
- Incentive spirometers are available either by measuring the volume of inspiration (volume-oriented devices) or measuring the flow rate (flow-oriented devices).

- A standard flow-oriented incentive spirometer consists of three chambers in a row.
- The patient inhales through a mouthpiece connected to the unit with the three chambers.
- Each chamber contains a ball that has printed on the outside of the chamber the least amount of flow needed to raise the ball.

- With an airflow rate of 600 to 1200 milliliters (mL) per second, the deep breath lifts the balls.

- When all three balls reach the top of the unit, the patient has reached a flow speed of 1200 mL/second.
- The colored balls indirectly give the patient a visual indication of the inhaled volume.
- The visual feedback works to improve compliance in performing the slow, sustained deep inspiration.

Procedure in Spirometry

Generally, patients are required to take deepest breathe and then exhaled into the sensors as long as possible for 6 seconds and some times followed by rapid inspiration.

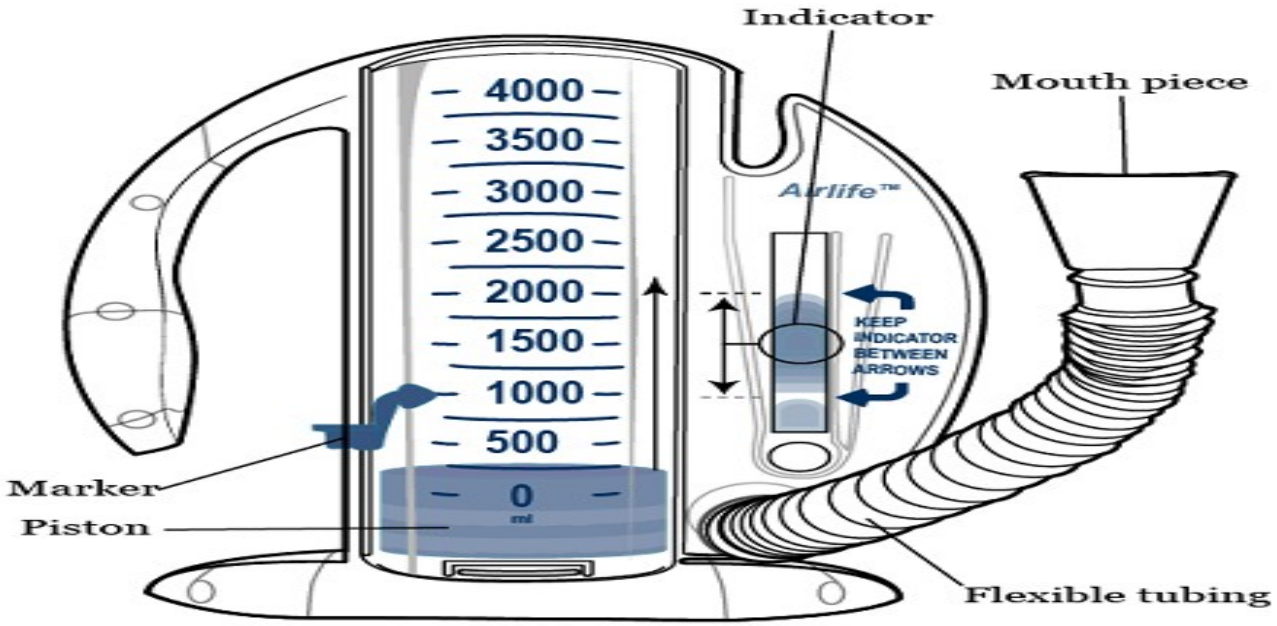
- **The tests are also carried out by a span of breathing in and out from the sensor (tidal volume), or the rapid breath in (forced inspiratory part) will come before the forced expiration.**
- **One of the preliminary spirometer measurement is forced vital capacity (FVC)**

- **FCV is the total amount of air forcefully breathe out after breathing deeply.**
- **Normal or abnormal values are evaluated**
- **The procedure of spirometry has 3 phases: 1) maximal inspiration; 2) a “blast” of exhalation; 3) continued complete exhalation to the end of the test**

Volume oriented Spirometer

Volume measurement spirometer: Wet spirometer measure volume directly and are accurate for measuring forced expiratory volume (FEV) and vital capacity (VC).

They are simple without any electronic accessory and values are measured directly but have limited range of parameters

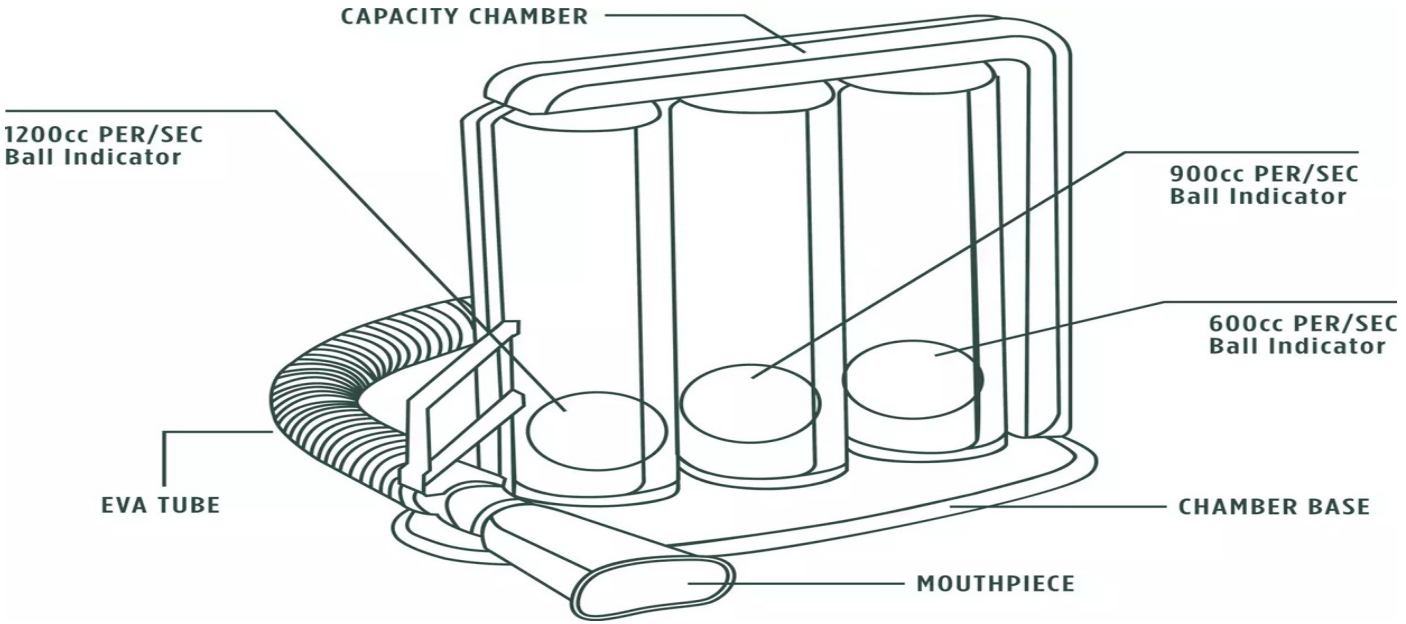


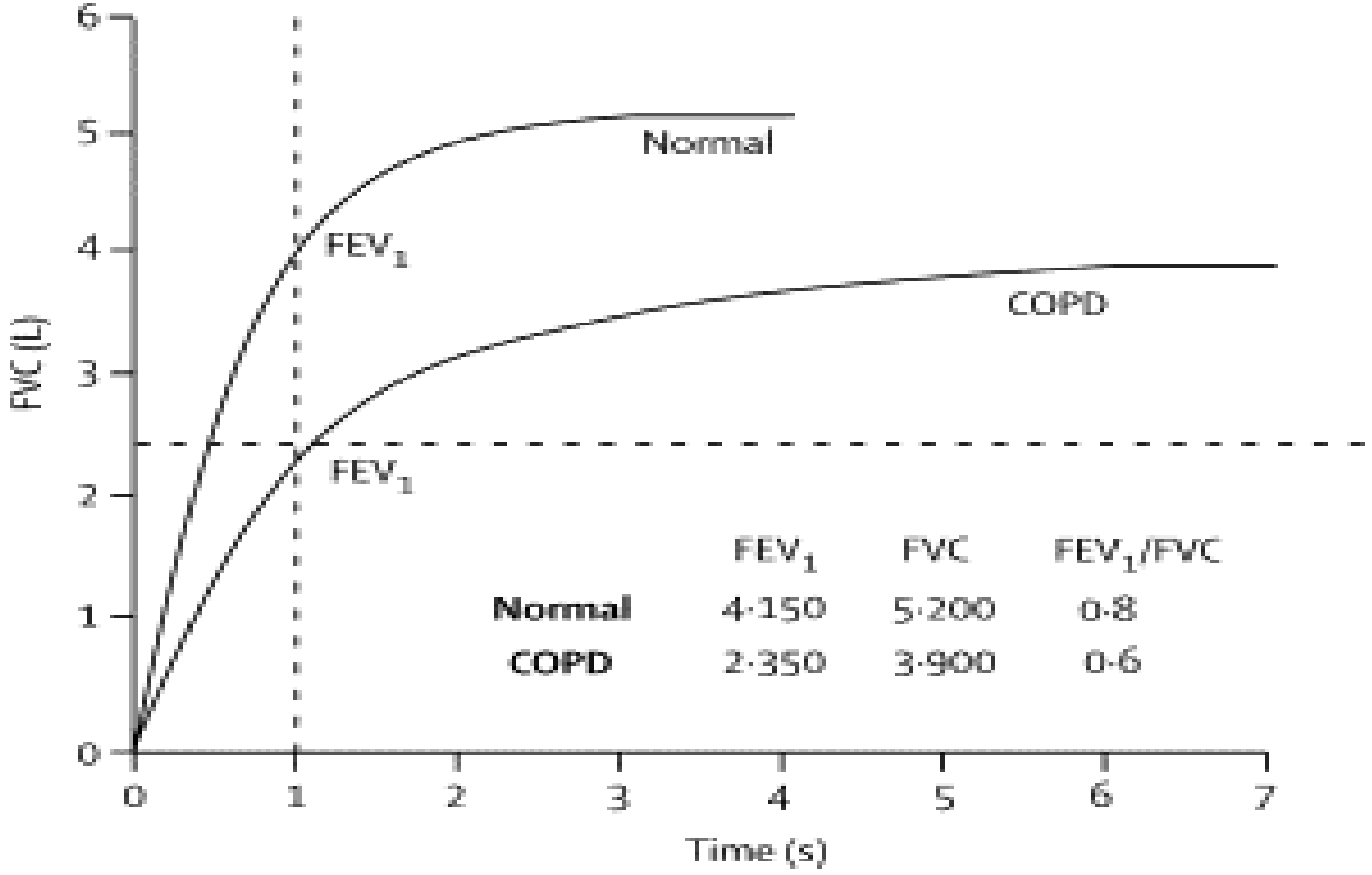
Flow oriented spirometer

Flow measurement spirometer: The most widely used in pulmonary function testing lab is the pneumatograph spirometer.

In this pressure drop over resistance is measured.

The pressure drop divided by the resistance of the pneumotachograph yields the flow, which can be transformed into a volume by time integration

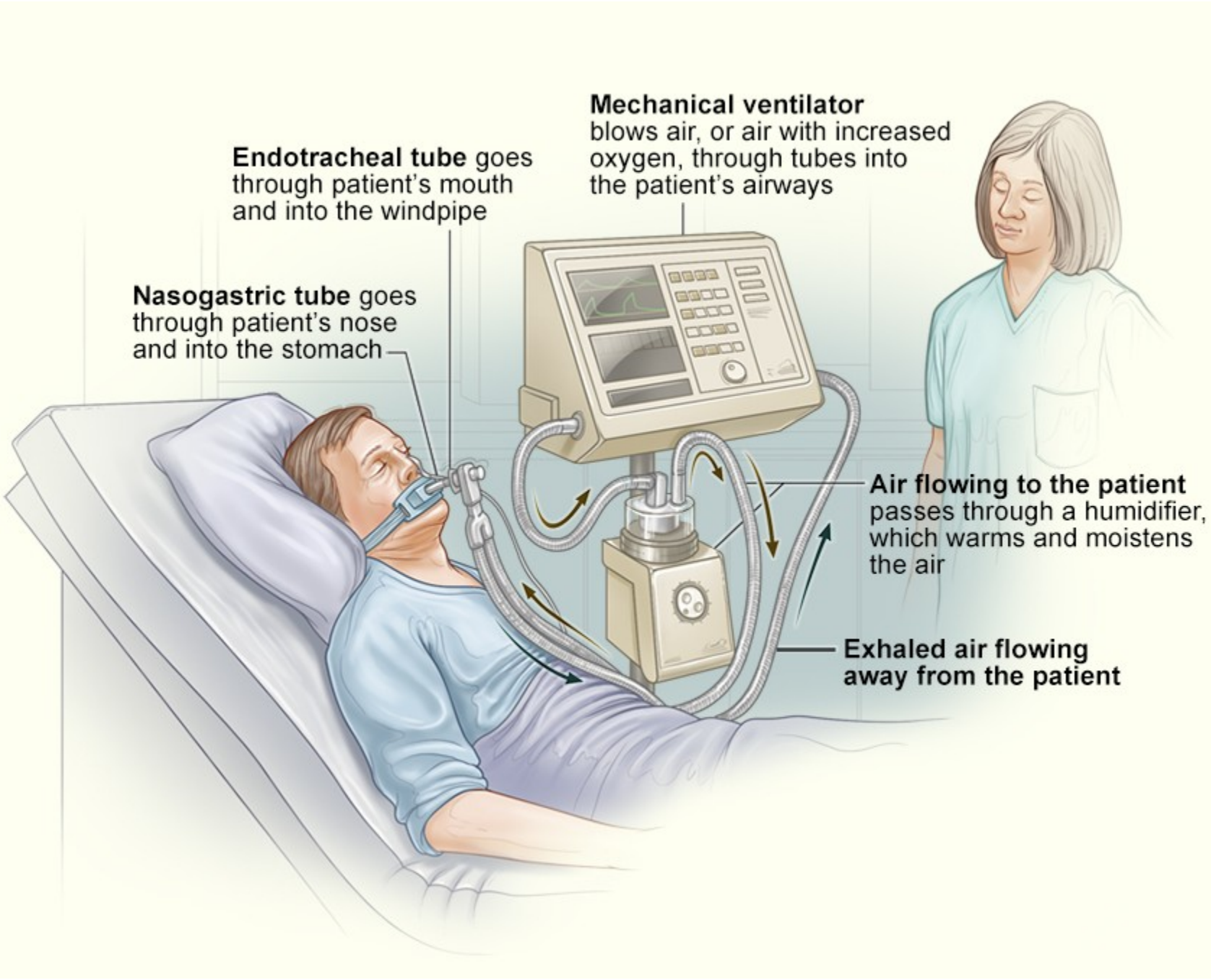



FVC (L)
Time (s)
Normal
COPD
FEV1
FEV1
FEV1 FVC FEV1/FVC
Normal 4·150 5·200 0·8
COPD 2·350 3·900 0·6

Ventilators

A ventilator is a machine that provides mechanical ventilation by moving breathable air into and out of the lungs, to deliver breaths to a patient who is physically unable to breathe, or breathing insufficiently.

Ventilators are computerized microprocessor-controlled machines, but patients can also be ventilated with a simple, hand-operated bag valve mask.


Mechanical ventilator blows air, or air with increased oxygen, through tubes into the patient's airways
Endotracheal tube goes through patient's mouth and into the windpipe
Nasogastric tube goes through patient's nose and into the stomach
Air flowing to the patient passes through a humidifier, which warms and moistens the air
Exhaled air flowing away from the patient

Working mechanism of Ventilator

During ventilation process, insertion of endotracheal tube (ET tube) through the patient's nose or mouth and into their windpipe (trachea).

The ET tube is then connected to the ventilator.

Both ET and ventilators prform various functions.

The ventilator pushes a mixture of air and oxygen into the patient's lungs to get oxygen into the body.

The ventilator can also hold a constant amount of low pressure, called positive end-expiratory pressure (PEEP), in order to keep the air sacs in the lung from collapsing.

Oxygen saturates are constantly monitored.

Respiratory tract infections

Infections can occur at any point in the respiratory tract. Some examples include:

- **Upper respiratory tract infection (URTI):** The most frequent URTI is the common cold. Others include laryngitis, pharyngitis, and tonsillitis.

- **Lower respiratory tract infection (LRTI):** The most common type is bacterial infection, especially bacterial pneumonia. Other causes of LRTI include viruses and fungi.

Lung cancer

Pleural cavity diseases

The pleural cavity is the gap between the inner and outer pleural membranes that encase the outside of the lungs. Pleural effusion describes a build-up of fluid in the pleural cavity.

Pulmonary vascular disease

Pulmonary vascular diseases affect the vessels that carry blood through the lungs.

Heart-lung machine

In 1931, American surgeon **John H. Gibbon, Jr.** (1903–1974) decided to build a heart-lung machine after a young female patient died of blocked lung circulation.

The heart-lung machine (HLM) is a device used to provide blood circulation and oxygenation while the heart is stopped.

It is a means of keeping a patient alive while his/her heart is stopped or even removed from the body.

Usually called the heart-lung machine, the device also is referred to as cardiopulmonary bypass, indicating its function as a means to substitute for the normal functions of the heart (cardio) and lungs (pulmonary).

It is the function of the heart to provide circulation of blood at all times.

It pushes blood out into the body and through the lungs. It must function every minute of every day of life to maintain the health of the tissues throughout the body.

Heart-lung machine

A heart-lung machine is a equipment that temporarily takes over the work of the heart and/or lungs, providing blood and oxygen to the body.

Also called a cardiopulmonary bypass machine (CBM) or a heart-lung bypass machine, it is most often used during serious procedures that require the heart to be stopped.

Patients are kept on a heart-lung machine for only as long as it takes to stop the heart from beating, complete open-heart surgery or a procedure on the lungs, and restart the heart

Heart Lung Machine

Heart lung machine (HLM) is instrument that temporarily perform the functions of heart and lungs by pumping blood and oxygen to the body during bypass surgery.

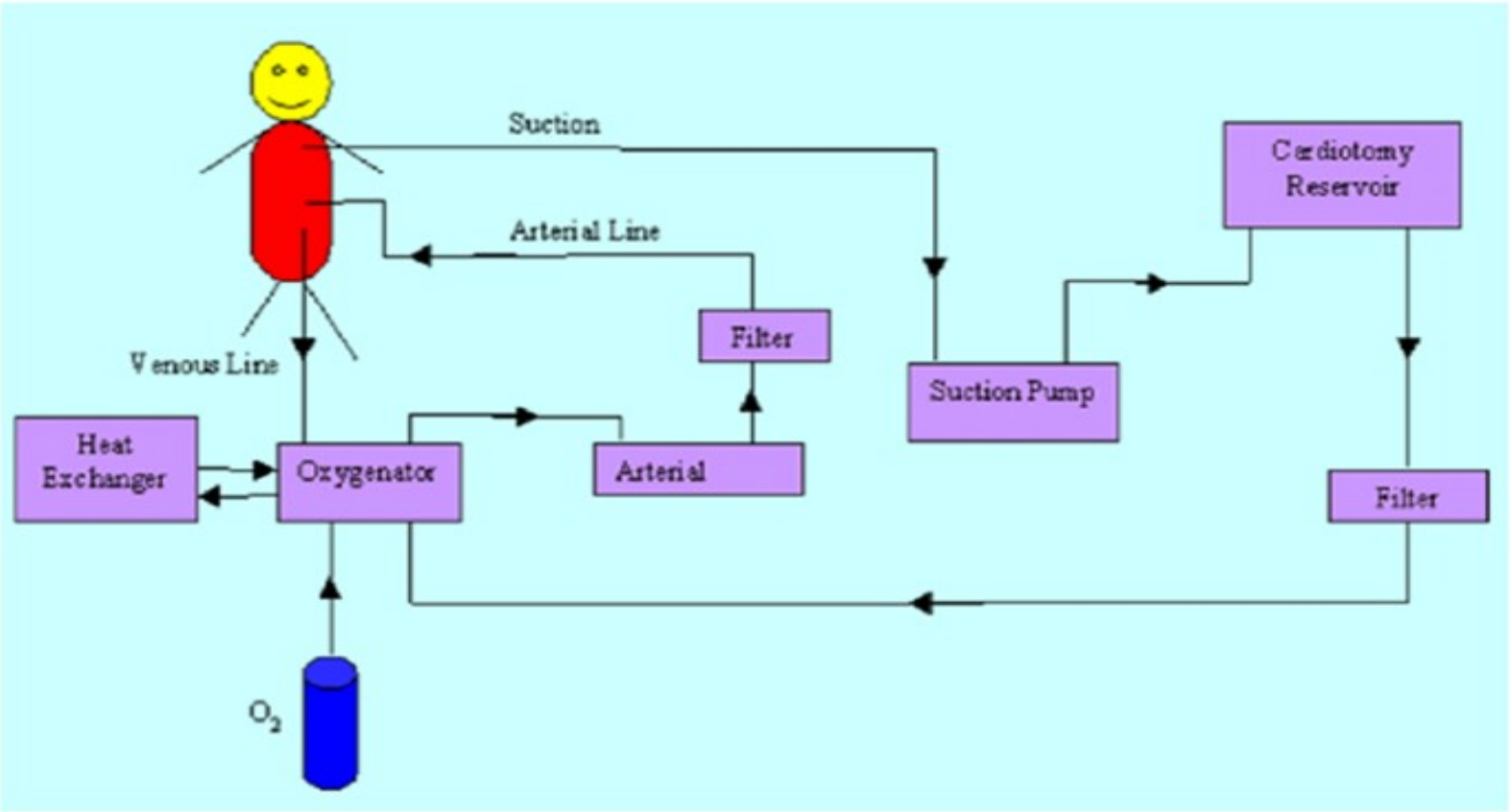
Some times called (CBM) cardiopulmonary bypass machine or heart lung bypass machine.

During by pass or open heart surgery the heart lung machine (HLM) diverts the blood away from the heart and lungs into a machine that takes over the heart's pumping and lung's ventilatory functions of these organs.

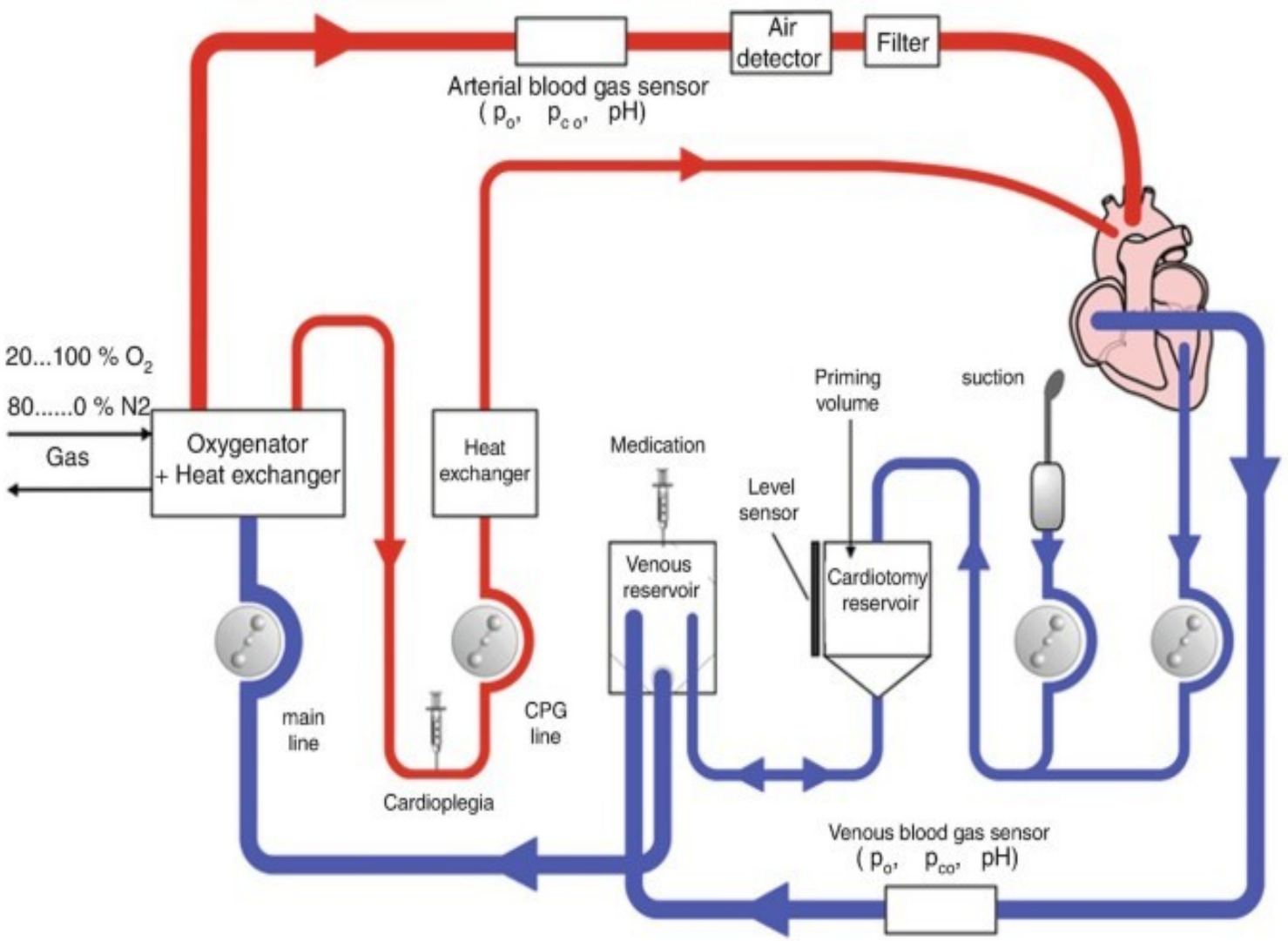
By employing HLM , a cardio surgeon can operate on a heart that has been arrested and is not full of blood.

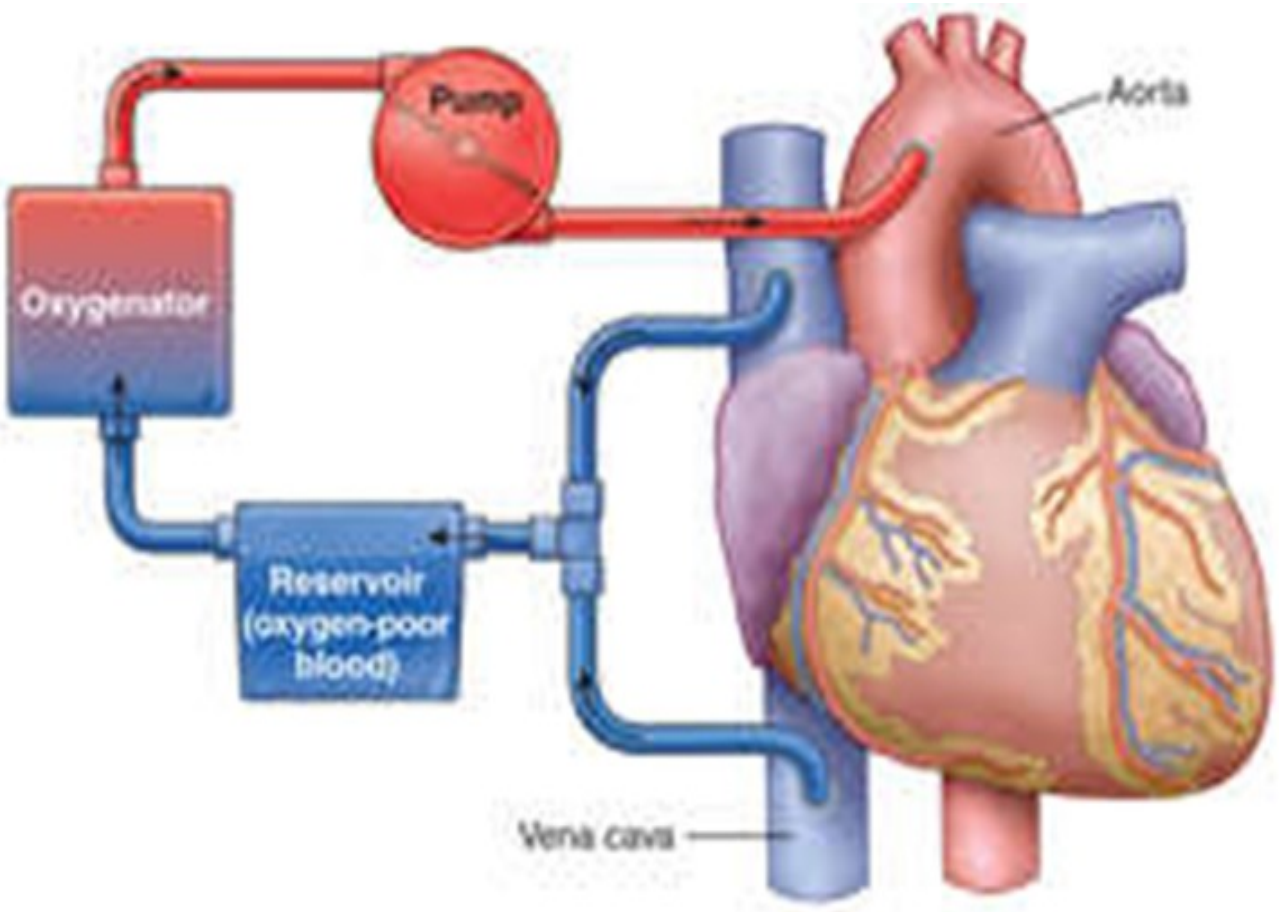
- The Heart Lung Machine employs gravity to divert oxygen-poor blood from the right atrium (upper chamber of heart) into a reservoir also Known as cardiaotomy reservoir. Blood is filtered for any clots.
- The blood is then pumped through an oxygenator which is normally performs function of the right ventricle (lower chamber of heart) , which removes carbon dioxide and pump oxygen (normally the function of the lungs).
- In addition, one more pump of HLM pump oxygenated blood back into the body. Which are the normal functions of the left side of the heart.
- Hence totally bypassing heart and lungs hence it is known as bypass surgery

Flow Diagram of HLM

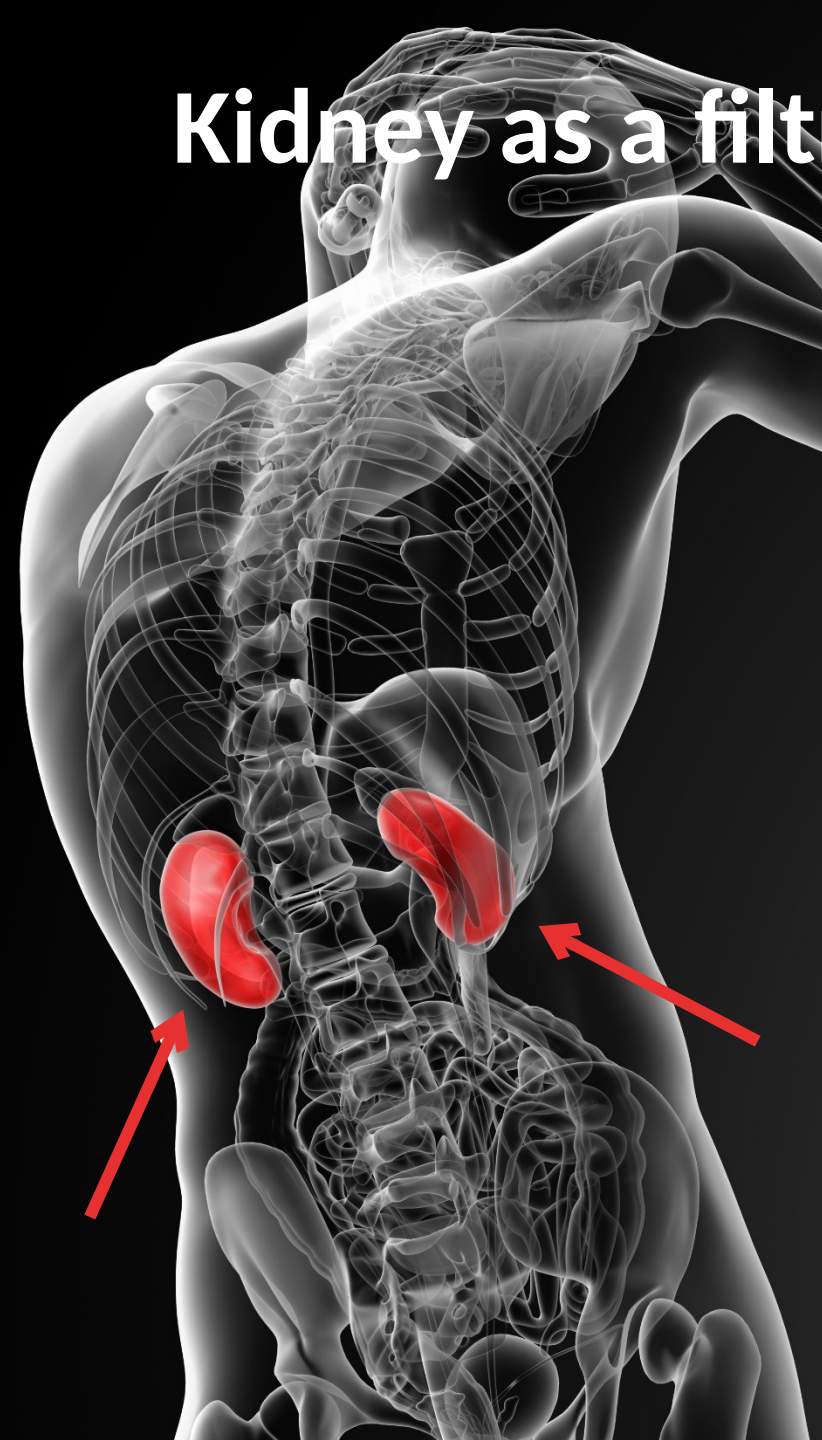


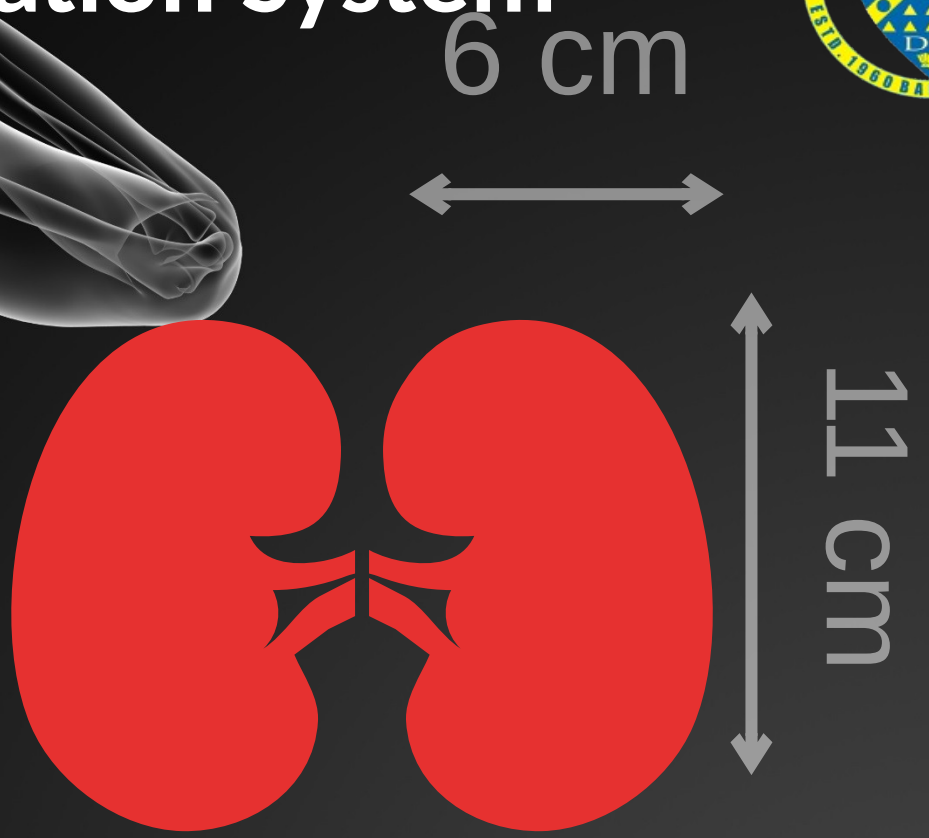
Heart Machine Lung




Pump
Aorta
Oxygenator
Reservoir
(oxygen-poor
blood)
Vena cava

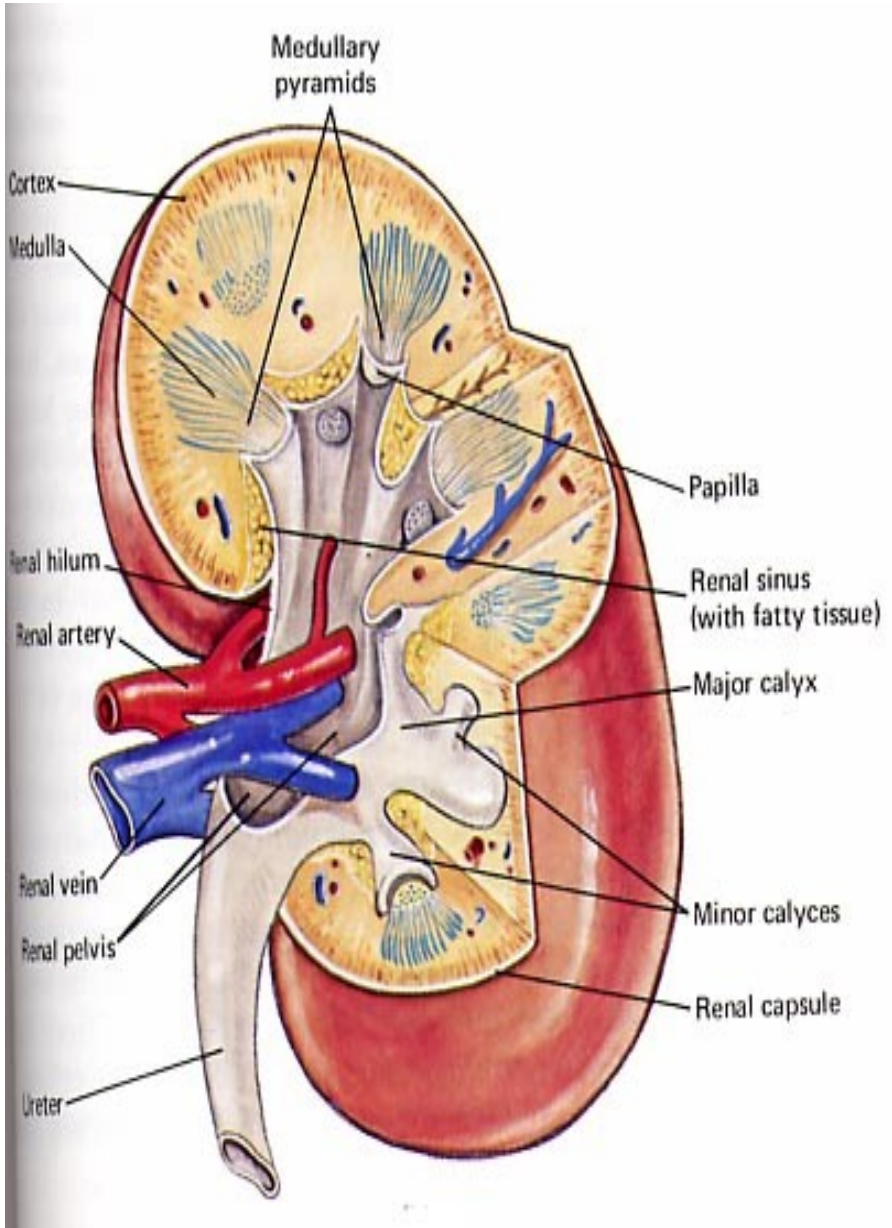
Kidney as a filtration System





In adults a kidney is about 10 cm long, 6 cm broad and 4 cm thick—about the size of your fist. It weighs approximately 150-170 grams (5.2 – 5.9 Oz).

Structure of kidney



Cortex
Glomeruli

Medulla
Renal tubules
(with calyces forming the medulary pyramids)

Ureter
Takes urine to bladder

Blood carried to the kidney by the renal artery and taken away by the renal vein.

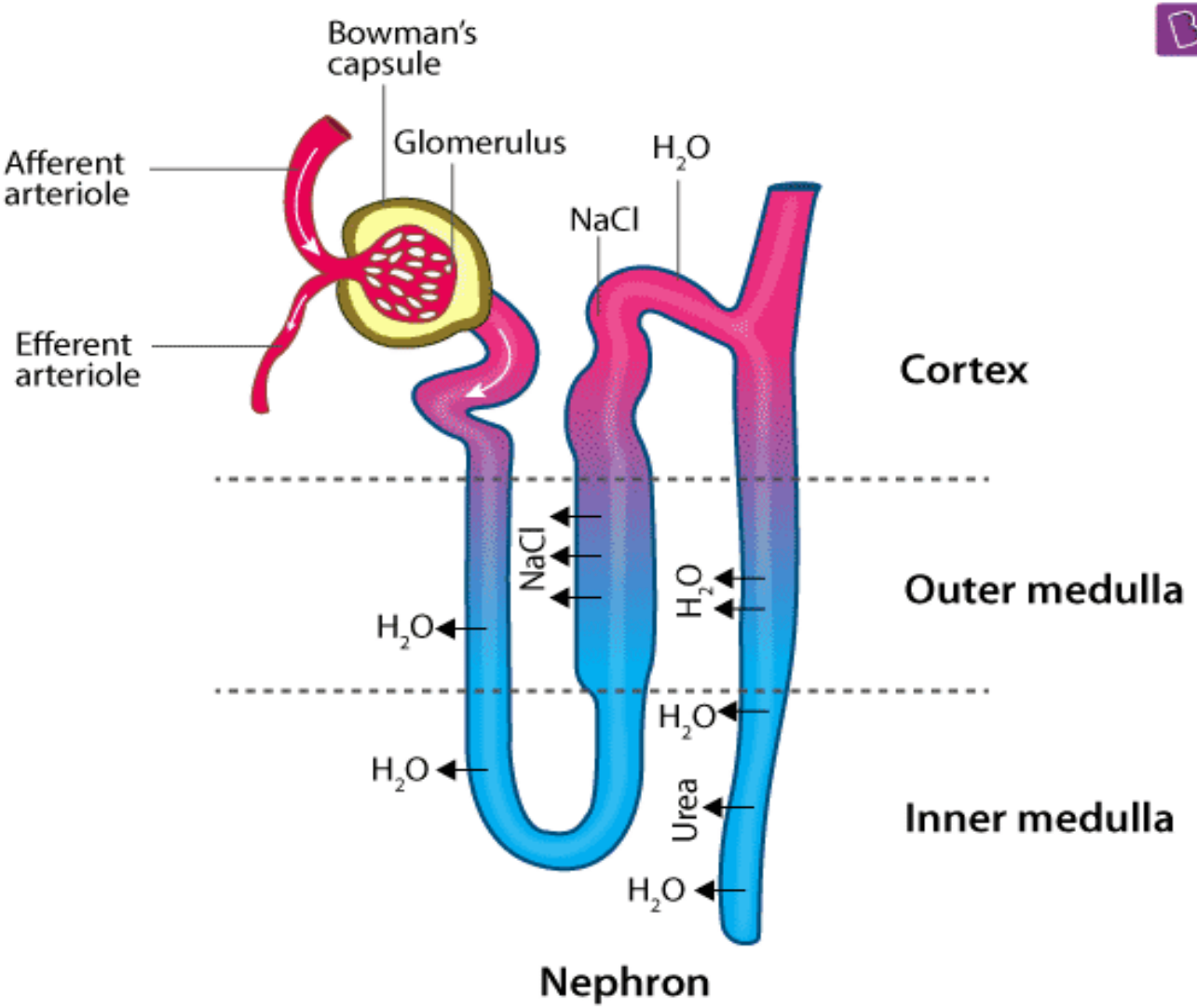
Structure of nephron : (Filtration Unit)

Nephron is the functional unit of the kidney, the structure that actually produces urine in the process of removing waste and excess substances from the blood

1 millions nephrons in each human kidney. Each nephron is a long tubule, about 30–55 mm (1.2–2.2 inches) long.

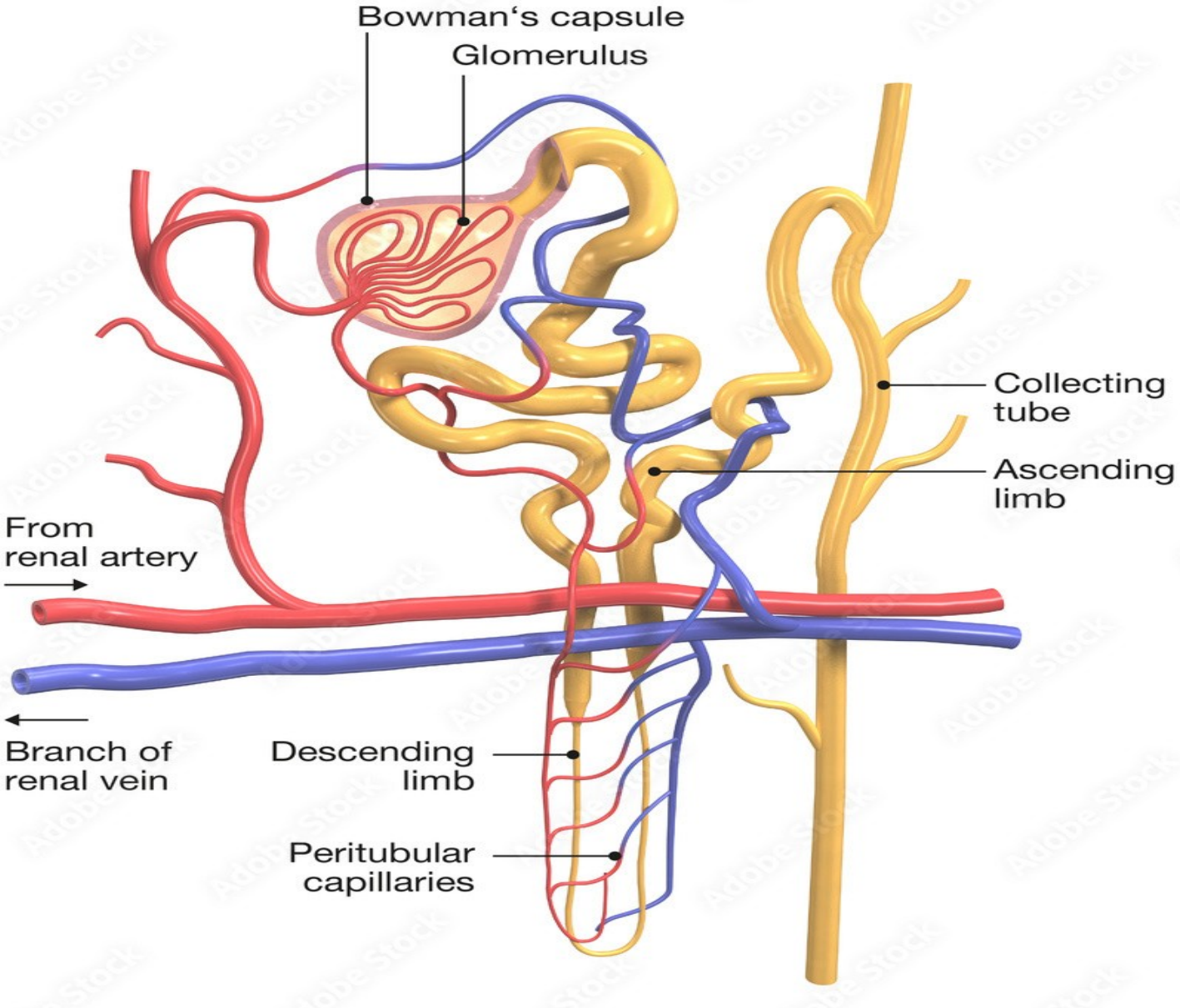
At one end this tube is closed, expanded, and folded into a double-walled cuplike structure. This structure, called the bowman capsule . It encloses a cluster of microscopic blood vessels known as capillaries—called the **glomerulus**.

Nephron structure : Key filtration Unit



Mechanism of Ultra-filtration

Nephron contains glome rules and long renal tubules
Glomerulus filtered excess of water , remove toxic waste from the blood through semipermeable membrane.
Filtrate then enters long renal tubule , upper portion of tubule is known as proximal convolutional tubule (PCT), it involves in reabsorption of electrolytes amino acids etc back in to the blood.
Finally the blood emerges from the kidney is free from toxic and balanced volume of the water.



Functions of Kidney

- **R**emove waste products from the body.
- **R**emove drugs from the body.
- **B**alance the body's fluids.
- **R**elease hormones that regulate blood pressure.
- **P**roduce an active form of vitamin D that promotes strong, healthy bones.
- **C**ontrol the production of red blood cells. (RBC)

Every minute

1200

ml of blood enters both kidneys

20%

of the total blood pumped by the heart

In one day

1700

liters of blood is purified

3592.7

pints

Early kidney disease

has no signs or symptoms

Chronic Kidney Disease : CKD

Kidney disease is one of the leading cause of death in many developed countries.

Kidney complication may worsen blood pressure, anaemia, and even nerve damage, electrolytes imbalance.

The key reason for CKD are diabetic and high blood pressure, high blood sugar can damage renal blood vessels . nerves.

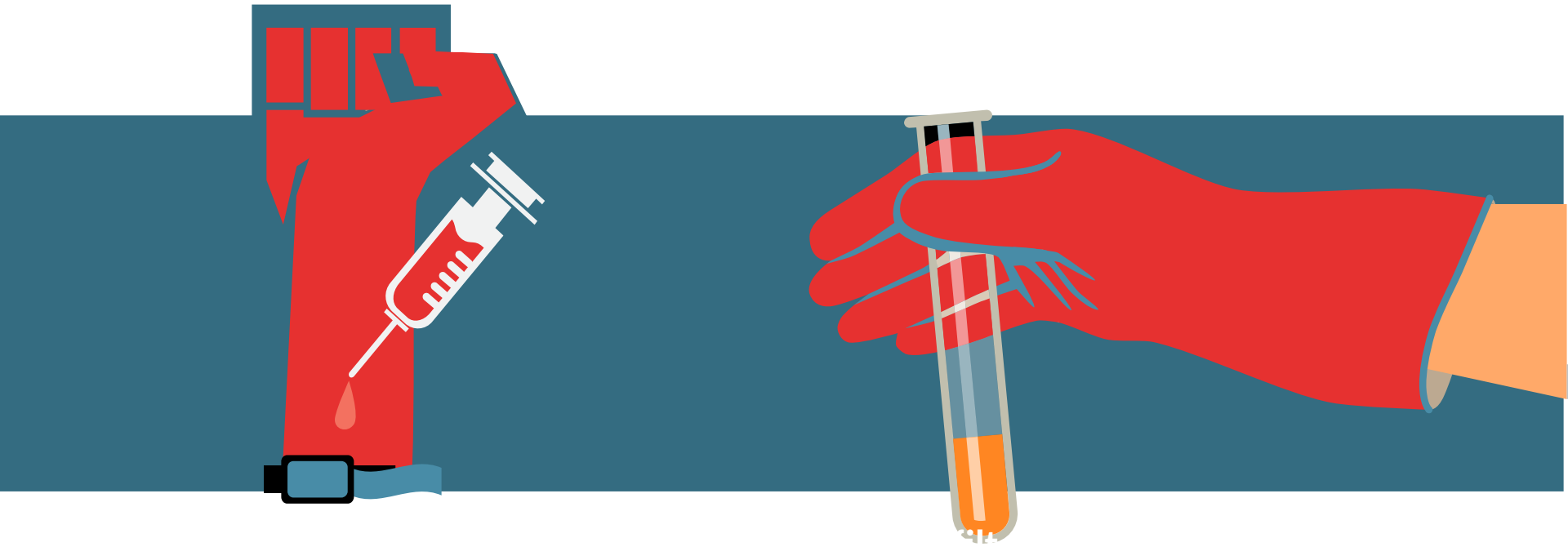
In addition, glomerulonephritis can cause kidney inflammation and results in damaging of kidney filtration units

The blood and urine test are generally done to find out kidney disease such as creatine level in blood and protein in urine.

Diabetes or high blood sugar can cause damage to nephrons (filtration unit).
High blood sugar can increase osmotic pressure in the glomerulus and enhances rate of filtration in turn kidney excrete high amount of sugar in the urine
Similarly, blood pressure can narrow and harden blood vessels in kidney and also increase pressure in the glomerulus of nephron.
High blood pressure can damage nephrons and in turn leads to CKD gradually.

Blood and urine tests

are the only way to know



Kidneys function
less than 10%
of normal

End stage kidney disease

Kidneys
no longer
function
at all

Dialysis

Trans-plantation

PRINCIPLE OFDIALYSIS

Dialysis works on the principles of the diffusion of solutes and ultrafiltration of fluid across a semi-permeable membrane.
Diffusion describes a property of substances in water.

. Substances in water tend to move
. From an area of high concentration
. To an area of low concentration.

. Blood flows by one side of a semipermeable membrane
. A dialysate (or special dialysis fluid) flows by the opposite side.

Diffusion
Osmosis
Ultra filtration & solvent drag

Methods or Types of Dialysis

METHODS OF DIALYSIS INCLUDE

- Hemodialysis
- Peritoneal dialysis

HEMODIALYSIS

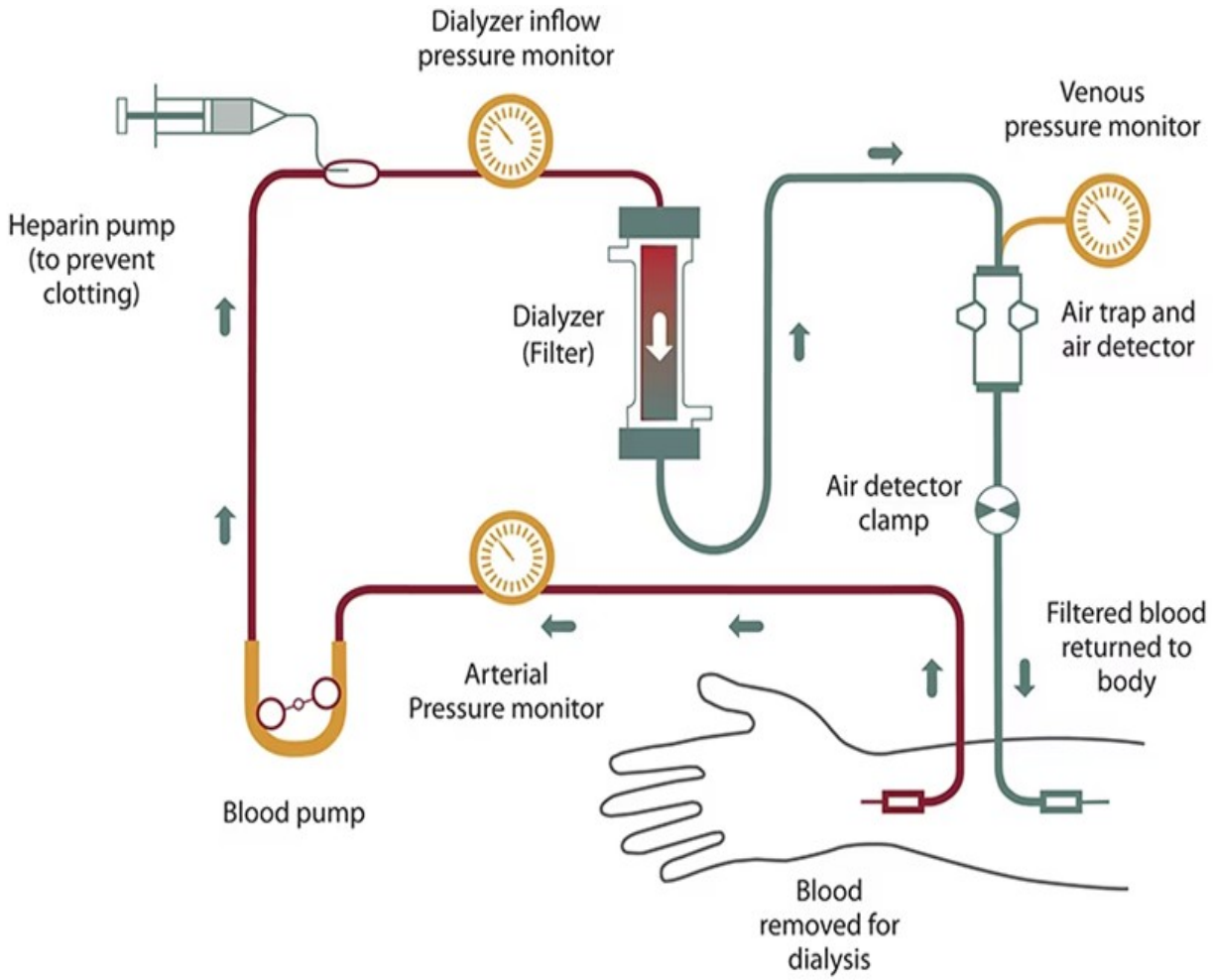
- It is the procedure of cleansing the blood of accumulated waste products. It is used for patient with end stage renal failure or for acutely ill patient who require short term.

FUNCTIONS OF HEMODIALYSIS:

Cleanses the blood of accumulated waste products
Removes the by-products of protein metabolism such as urea, creatinine, and uric acid.

Removes excessive fluids
Maintains or restores the buffer system of the body
Maintains or restores electrolyte levels

Overview : Haemo-Dialysis Process



Dialyzer(Artificial Kidney)

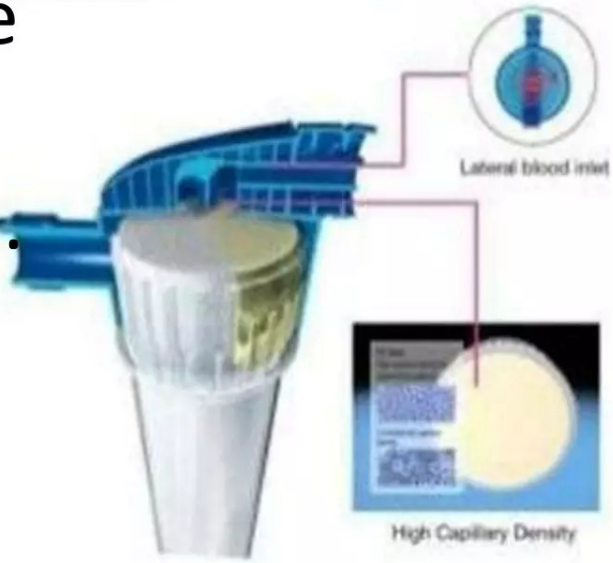
" Plastic chamber - contains bundles of capillary

tube through which blood circulates while

dialysis solution travels outside the bundle in

opposite counter current direction.

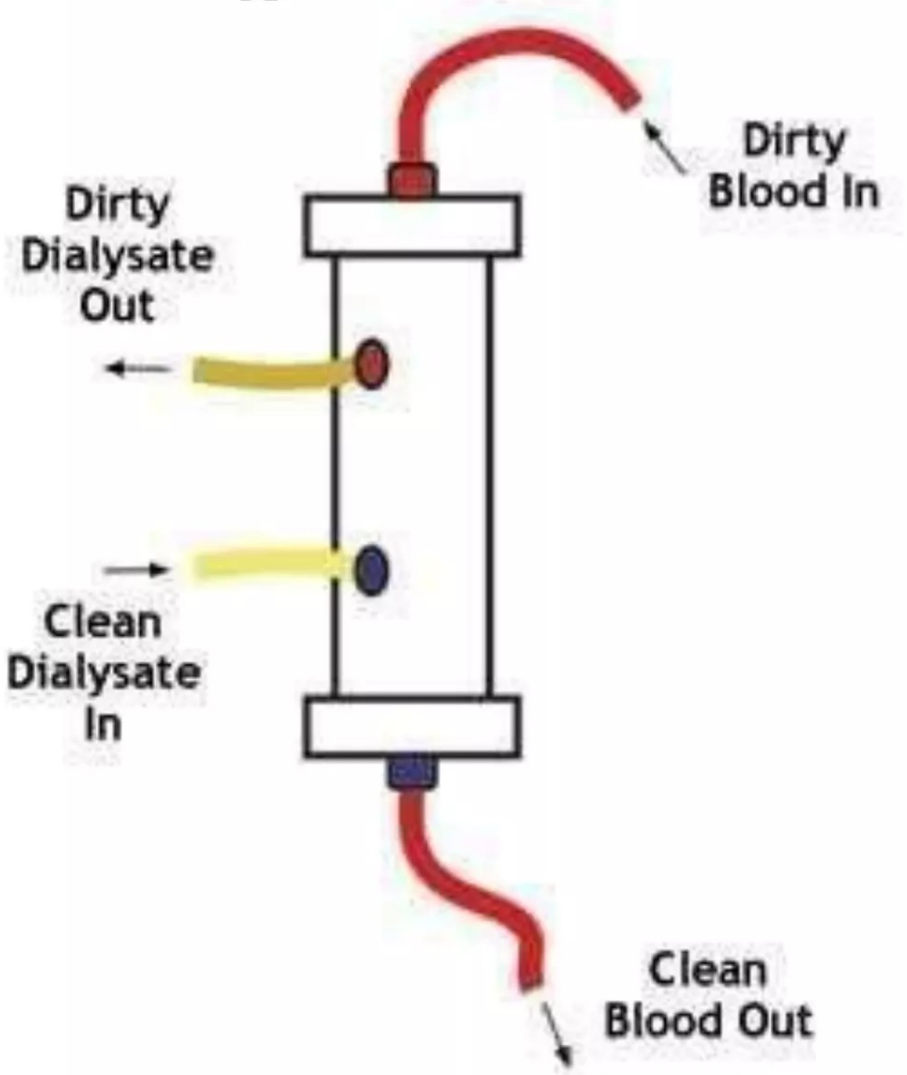
Diffusion & ultrafiltration happens here.

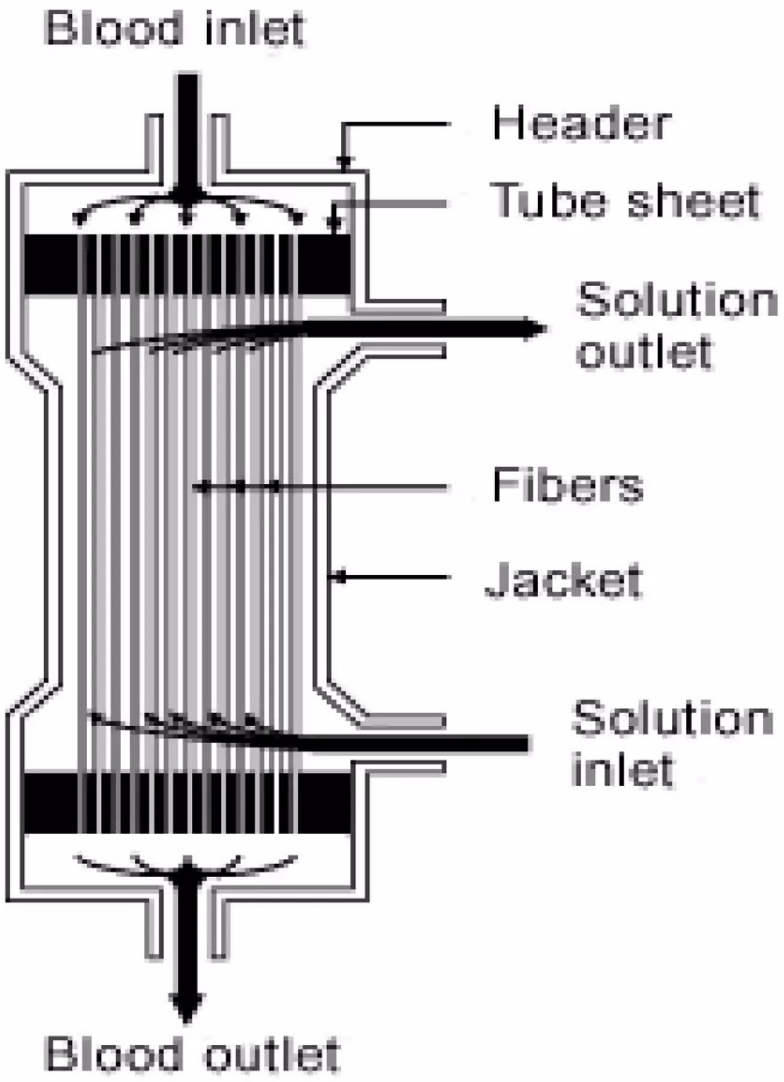


Blood Delivery system

Blood Pump - moves blood from access site through the dialyzer &
back to the patient
Blood flow Rate - 250-500 ml/min

DIALYZE
R


Dirty Blood In
Dirty Dialysate Out
Clean Dialysate In
Clean Blood Out


Blood inlet
Header
Tube sheet
Solution outlet
Fibers
Jacket
Solution inlet
Blood outlet

How dialysis machine works?

The basic principle of dialysis machine or artificial kidney is to pass blood through minute blood channels (instead of blood vessels in machine) bounded by thin membrane.

On the other side of the membrane is a dialysis fluid into which unwanted substances in the blood pass by diffusion.

The dialysis machine pumps blood through the filter and returns the blood to the body.

Dialysis filter works like natural nephron in order to remove waste and excess of water from the blood.

During the process, the dialysis machine checks the blood pressure and controls rapid flow of blood flows through the filter and fluid is removed from the body

Blood enters at one end of the filter and is forced into many, very thin, hollow fibres.

As blood moves swiftly through the hollow fibre, dialysis solution passes in the opposite direction on the outside of the fibres.

Waste products from the blood move into the dialysis solution.

PROCEDURE

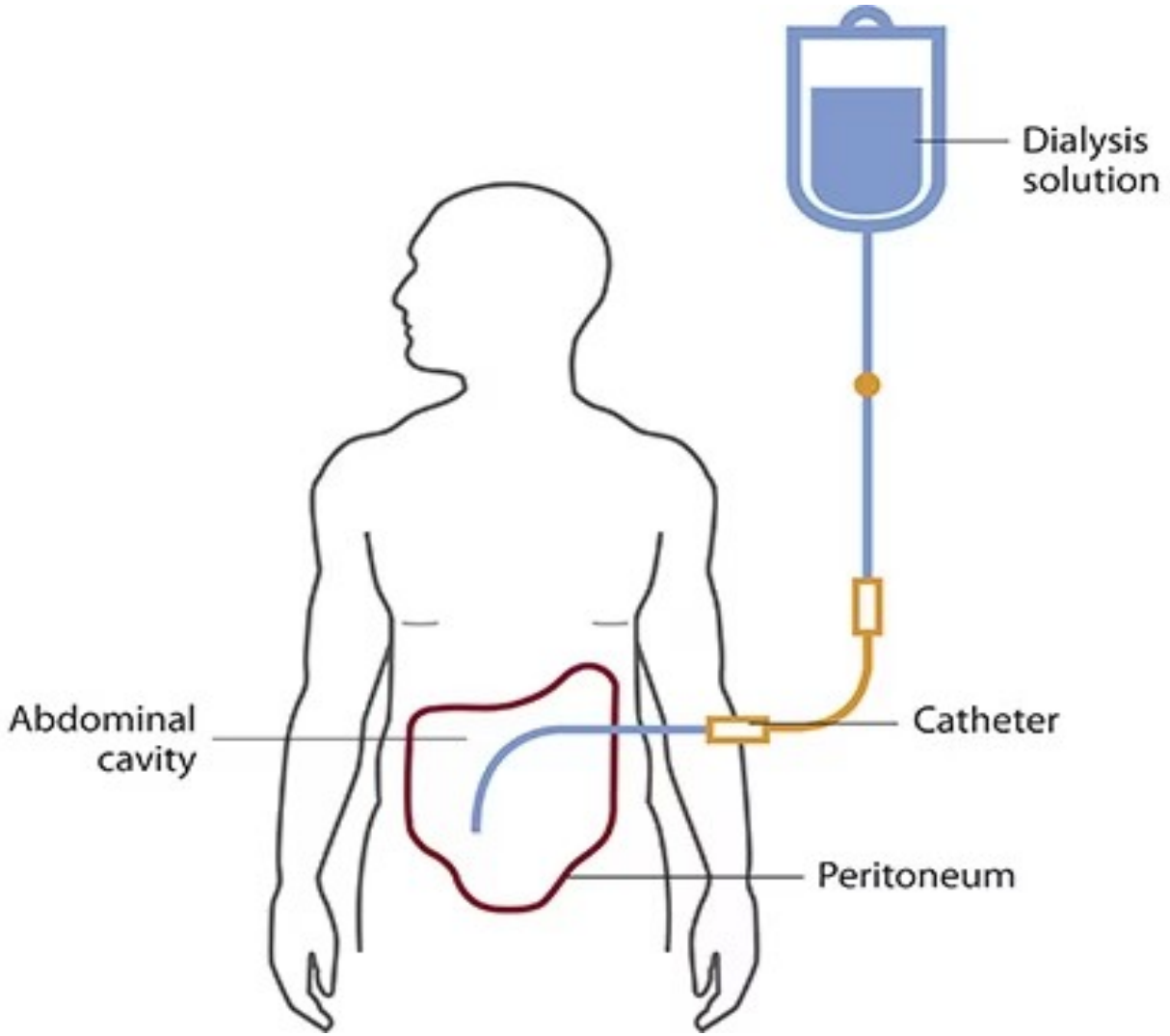
- Patient access is prepared and cannulated (Thin tube in to veins)
- Heparin is administered
- Heparin and red blood flows through semipermeable dialysis in one direction and dialysis solution surrounds the membrane and flows in the opposite direction.
- Dialysis solution consist of highly purified water to which sodium, potassium , calcium, magnesium chloride, and dextrose have been added, bicarbonate is added to achieve the the proper pH balance.

- Through the process of diffusion solute in the form of electrolytes, metabolic waste products acid base balance components can be removed or added to the blood.
- Excess water is removed from the blood (ultrafiltration).
- The blood is then returned to the body through patient access.

Peritoneal dialysis: Introduction

- **Peritoneal dialysis**(PD) is a treatment for patients with severe chronic kidney disease.
- A dialysis technique that uses the patient's own body tissue-**peritoneal membrane** inside the abdominal cavity as a filter.

Peritoneal Dialysis



A few weeks before you start peritoneal dialysis , a surgeon places a soft tube, called a catheter, in your belly.

When start the treatment, dialysis solution—water with salt and other additives—flows from a bag through the catheter into your belly.

When the bag is empty, you disconnect it and place a cap on your catheter so you can move around and do your normal activities.

While the dialysis solution is inside your belly, it absorbs wastes and extra fluid from your body.

Muscular and Skeletal System

The muscular and skeletal system or musculoskeletal system includes bones, muscles, tendons, ligaments and soft tissues

Benefits

Support your body's weight,
Maintain your posture
Help in the movement

1. ***Bones***:. The inner part of bones are softer and less dense than the hard outer part

Protects internal organs, tissues, store calcium and fats. in addition it also produce blood cells.

More than 200 bones in the body work with muscles, tendon and ligament for movements

2. ***Cartilage***: Acts as cushions for bones inside the joints along with spine and ribcage. It also protects bones from rubbing each other. Cartilages are present mainly in our nose, ears, and lungs

Skeletal muscles

Three types of muscles in the body : 1. Skeletal muscles, Cardiac muscles and smooth muscles (in the blood vessels ,organs, digestive tract and skin)

What is skeletal muscle?

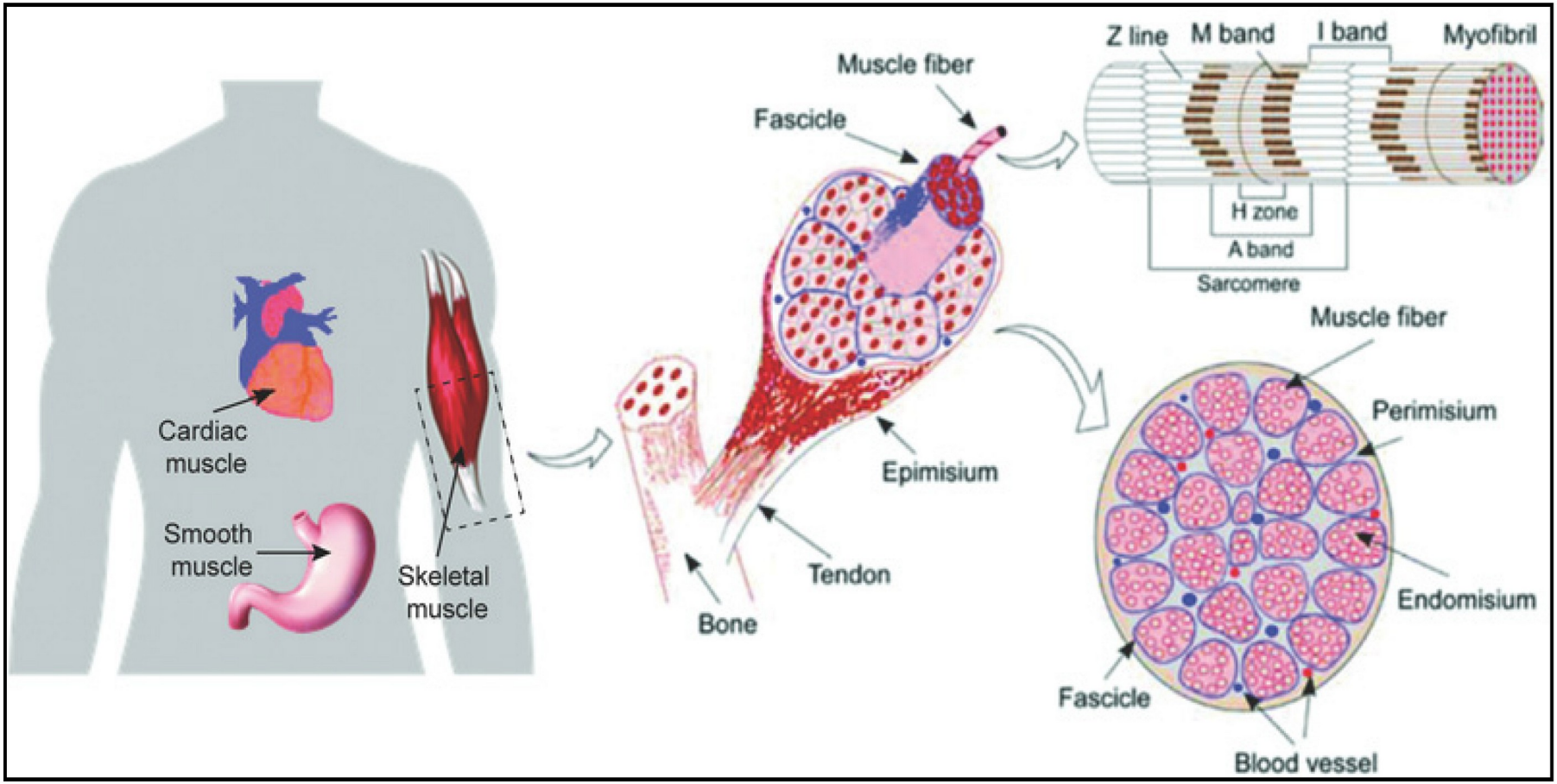
The majority of the muscles in the body are skeletal muscles. They make up between 30 to 40% of your total body mass.

Tendons (tough bands of connective tissue) attach skeletal muscle tissue to bones throughout your body.

Your shoulder muscles, hamstring muscles and abdominal muscles are all examples of skeletal muscles.

Muscles:

Skeletal muscle is the largest tissue in the body, accounting for almost 40% of body mass.
Skeletal muscle architecture is characterized by unique arrangement of muscle fibers, also called myofibers.
Groups of myofibers form the fascicles, and bundles of fascicles make up the whole muscle tissue .
Myofibers are formed by the fusion of myoblasts to produce myotubes


Cardiac muscle
Smooth muscle
Skeletal muscle
Muscle fiber
Fascicle
Epimisium
Tendon
Bone
Z line
M band
I band
Myofibril
H zone
A band
Sarcomere
Muscle fiber
Perimisium
Endomisium
Fascicle
Blood vessel

What is the purpose of the skeletal muscles?

The skeletal muscles are a vital part of your musculoskeletal system. They serve a variety of functions, including:

- **Chewing and swallowing, which are the first parts of digestion.**
- **Expanding and contracting your chest cavity so you can inhale and exhale at will.**
- **Maintaining body posture.**
- **Moving the bones in different parts of your body.**
- **Protecting joints and holding them in place.**

Musculoskeletal System

Provides structure and movement for the body
Consists of bones, skeletal muscles, and joints
Allows the body to stand erect and move
Supports and protects organs
Produces red blood cells

Skeletal muscles consist of flexible muscle fibers that range from less than half an inch to just over three inches in diameter.

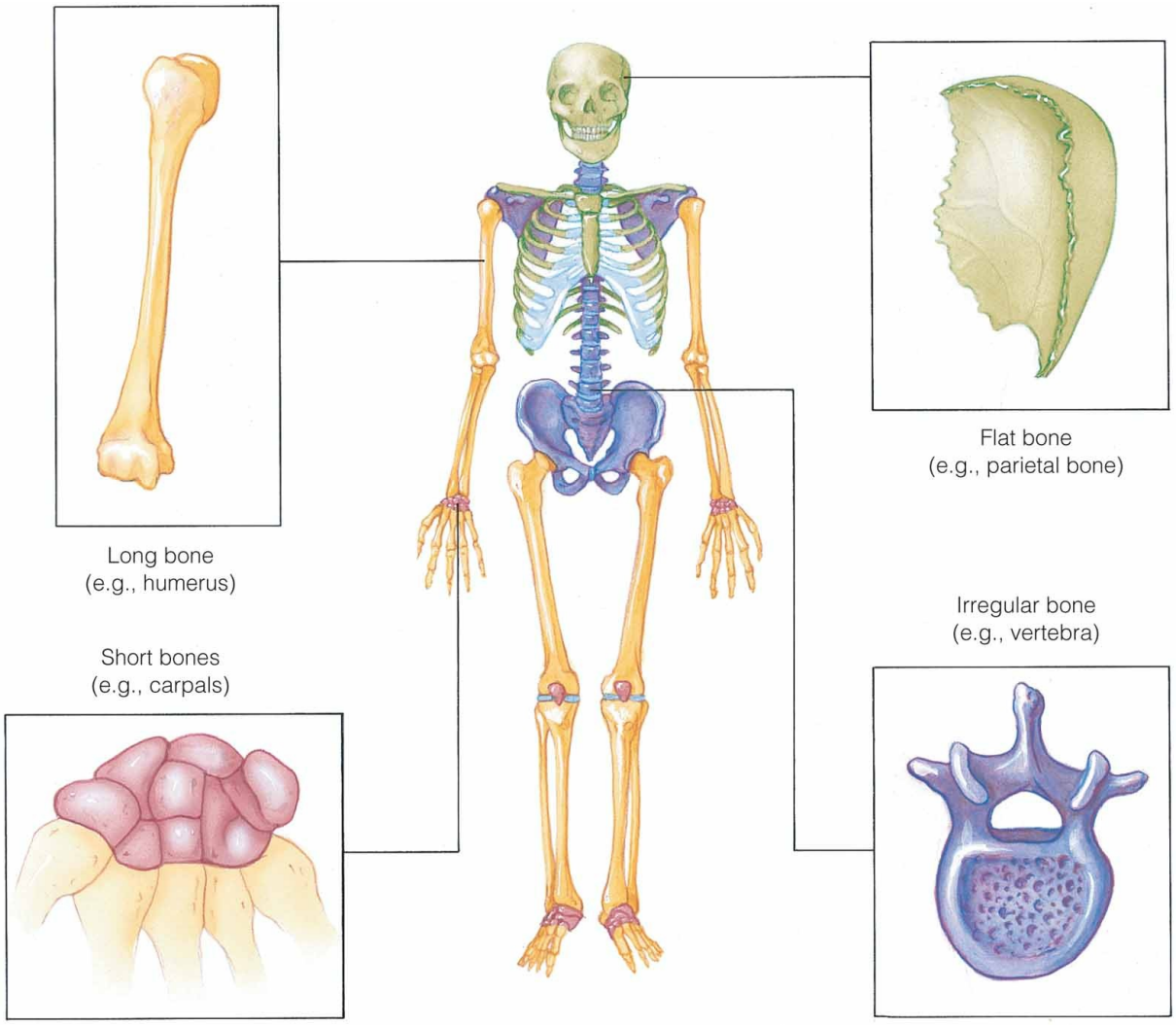
These fibers usually span the length of the muscle.

The fibers contract (tighten), which allows the muscles to move bones so you can perform lots of different movements.

Musculoskeletal System

Stores fat and minerals
Generates heat
Skeleton
Consists of 206 bones
Provides support for the soft tissue and organs of the body

Classification of bones according to shape.



Skeleton

Major functions

- Framework for the body
- Protect structures
- Act as levers for movement
- Store fat and minerals
- Produce blood cells

Skeletal Muscles

Major functions

- Movement
- Posture
- Body heat
- Joints

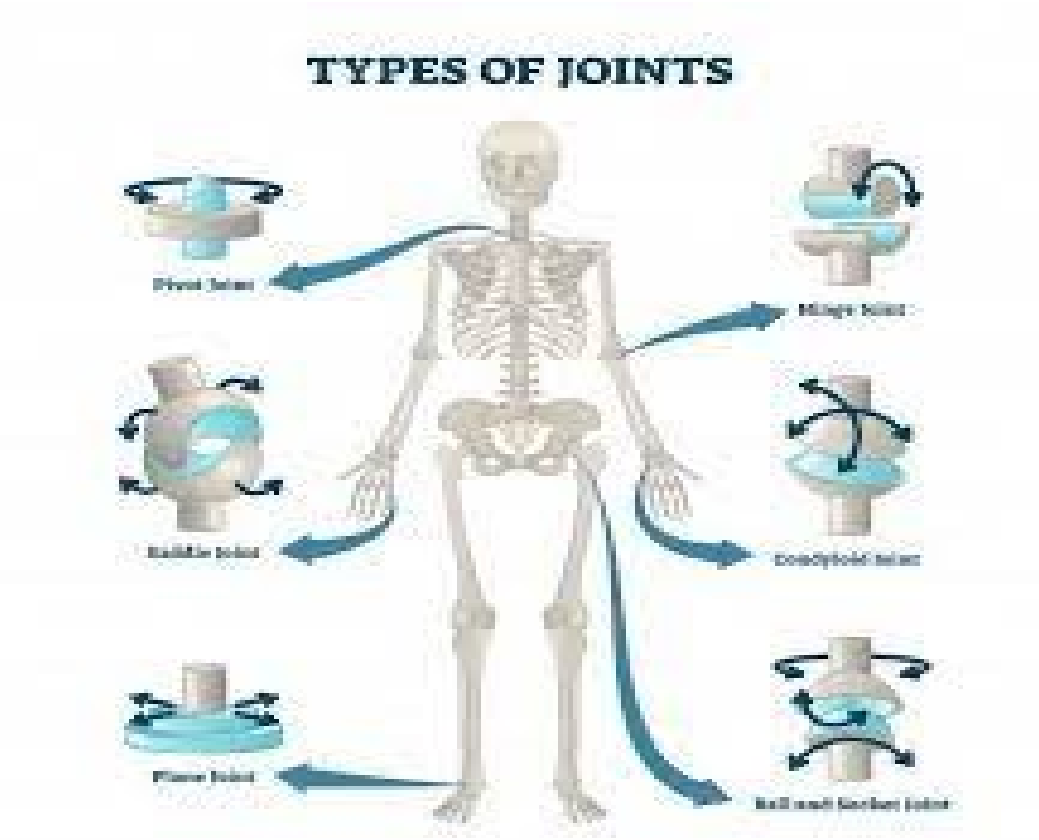
Fibrous

Cartilaginous

Synovial

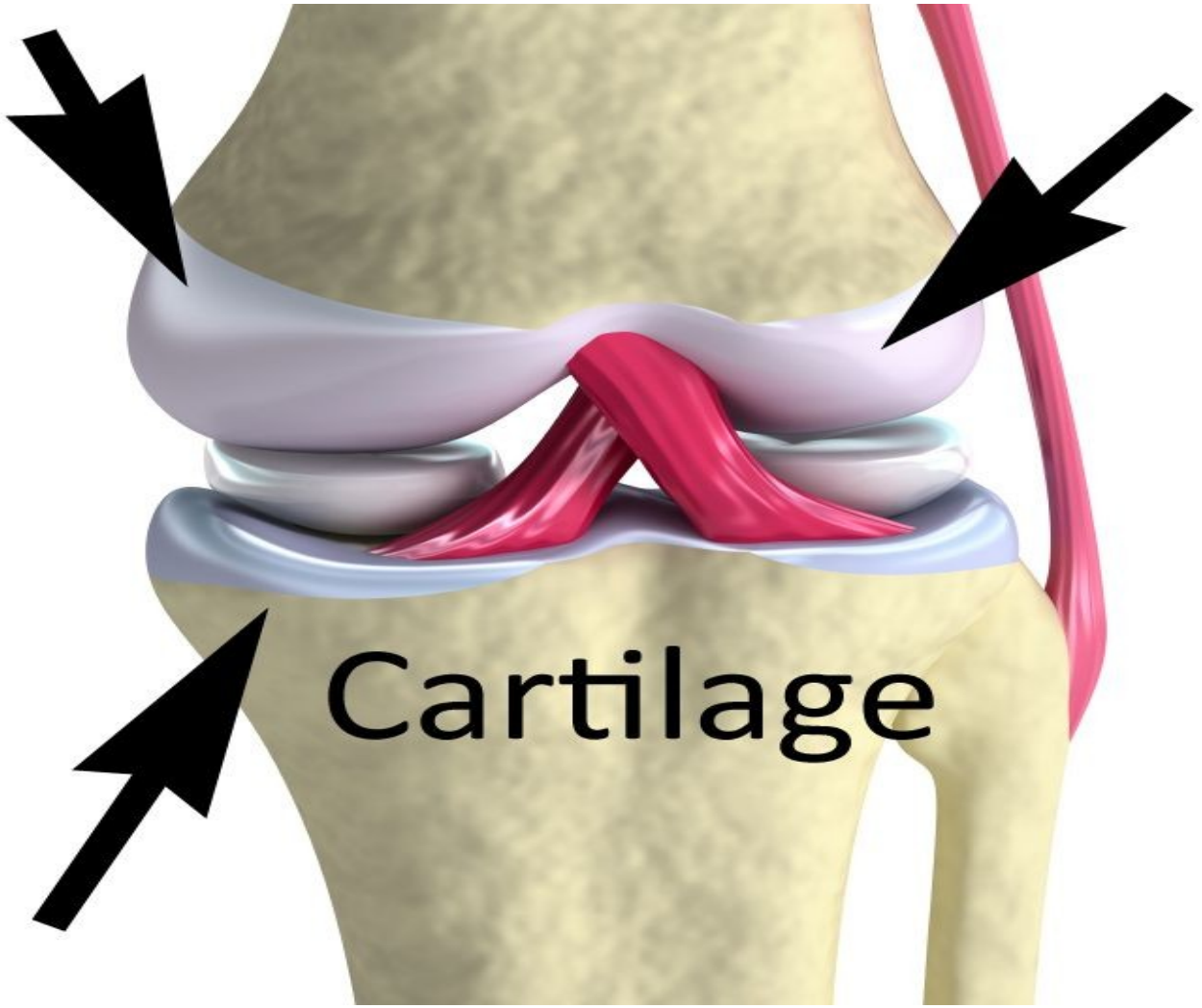
Major Joints

Ankle
Spine
shoulder joints



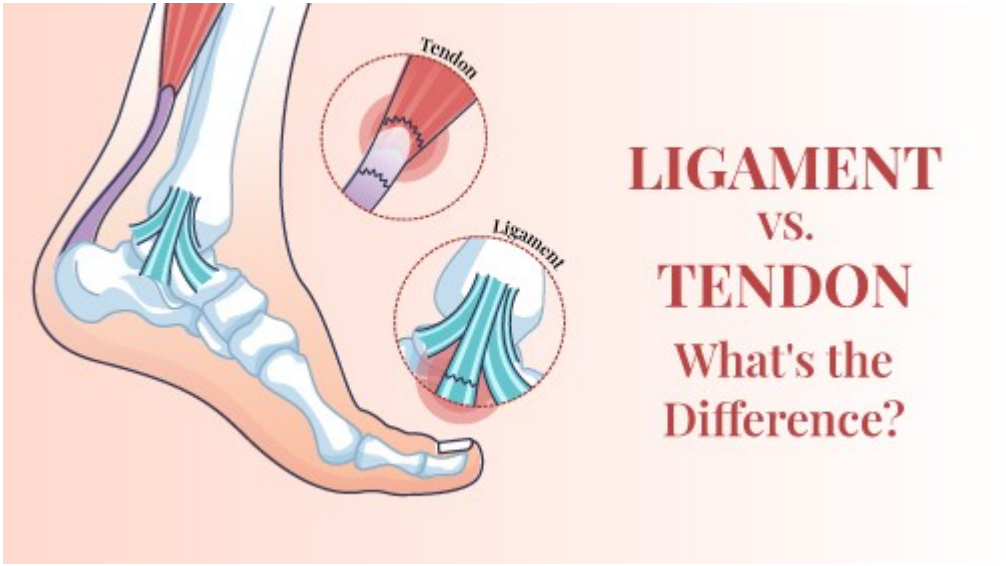
Joint Movements

Flexion
Extension
Rotation
Circumduction
Elevation
Protrusion
Retraction
Abduction


Cartilage

1. **Ligaments: Made of tough fibers, ligaments connect bones and help stabilize joints.**

Tendons: Tendons connect muscles to bones., tendons are tough but not very stretchy.



How musculoskeletal works

It works by controlling of our voluntary muscle movement by nervous system. voluntary muscles are the ones control intestinally.

Mechanism of musculoskeletal movements takes place when our nervous brain sends signal to sensitize the skeletal muscles.

Muscle fibres contract begins in response

The activated or sensitized muscle pulls on the tendon.

The tendon in turn attaches muscles to the bone.

Tendon pulls the bone and facilitates its movement

The brain sends another signal to relax the muscle and deactivate it.

Finally, the relaxed muscle releases tension, moving the bone to a resting position

1. Muscular dystrophy (MD)

What is muscular dystrophy?

MD is a group of muscle diseases caused by mutations (changes in protein coding sequence of DNA) in a person DNA

Certain muscle protein is responsible for giving strength to muscle fibre.

When wrong protein is produced by the body due to mutation lead to muscle weakness.

Over the period of time, muscle weakness due to break down of skeletal muscle leading to increasing level of disability.

Lab grown cells for MD

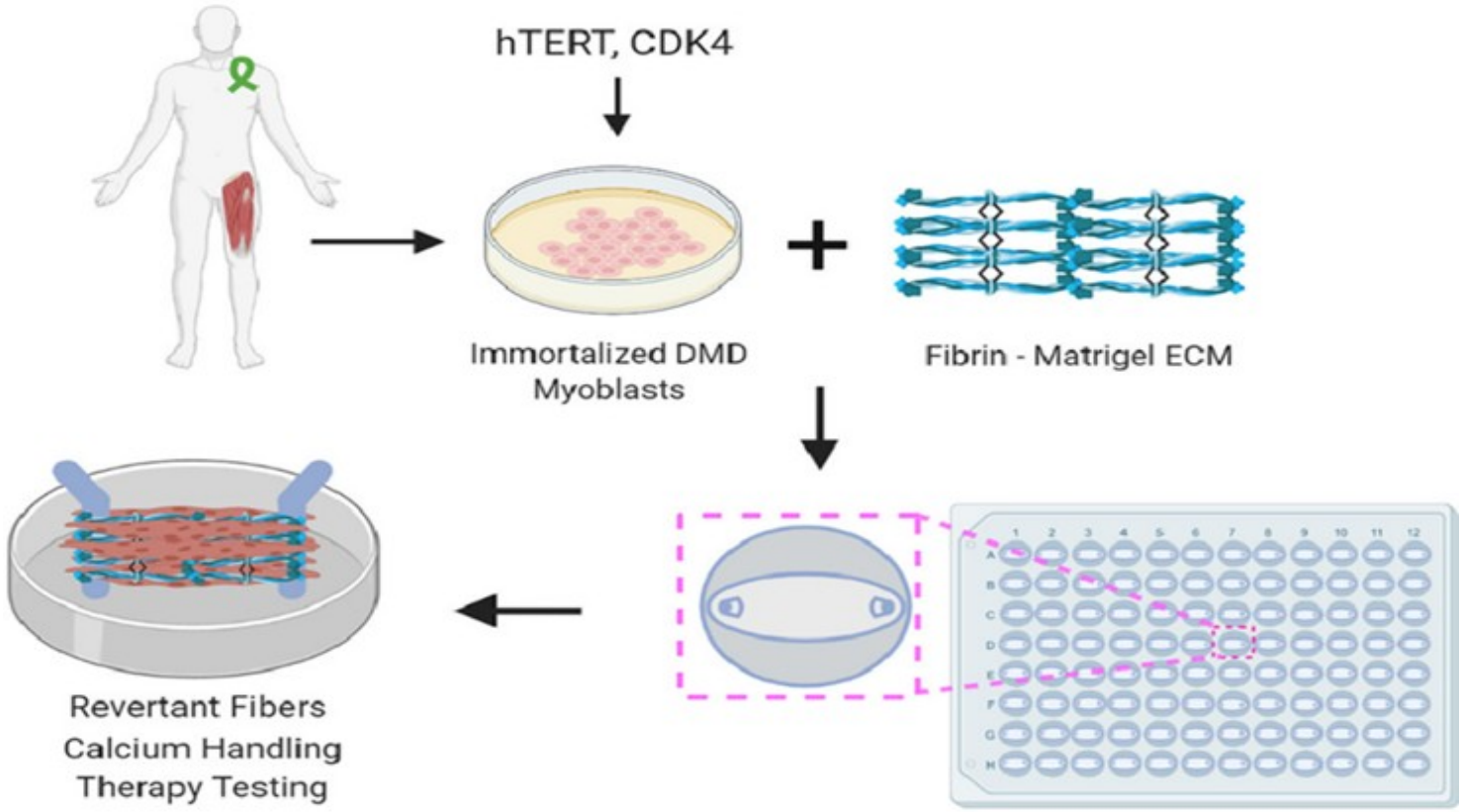
Cell therapy technique can be used as engineering solution for DMD.

Some of the skeletal muscle cells can be grown in the laboratory and lab grown cells are delivered to the body through repeated injection at many point.

Hydrogels are convenient biomaterial for transfer of cells in to the body Hydrogels acts as scaffolds that mimic or resemble the properties of the native muscle , play a crucial role in building skeletal muscle tissue constructs *in lab*.

Lab grown artificial skeletal muscle tissue is beneficial to replace dysfunctional skeletal muscle,

A 3D Culture Method to Model DMD



3D printing culture for Muscular Dystrophy problem

The most recent published approaches to culture myofibers on aligned structures can be classified into three main types: micropatterning, electrospinning, and bioprinting.

The simplest models for generating skeletal muscle *in vitro* are based on the 2D and 3D culture of myoblasts seeded on micromolded substrates.
Electrospinning technique has been successfully used to generate mature myotubes over microfibres fibrin bundles

Wearable robotic exoskeletons (WREs) can serve as means to accomplish the goal.

Engineering solution for Osteoporosis

Osteoporosis is an age-related bone disease characterized by low bone mineral density and bone degradation, leading to an increased risk of fractures

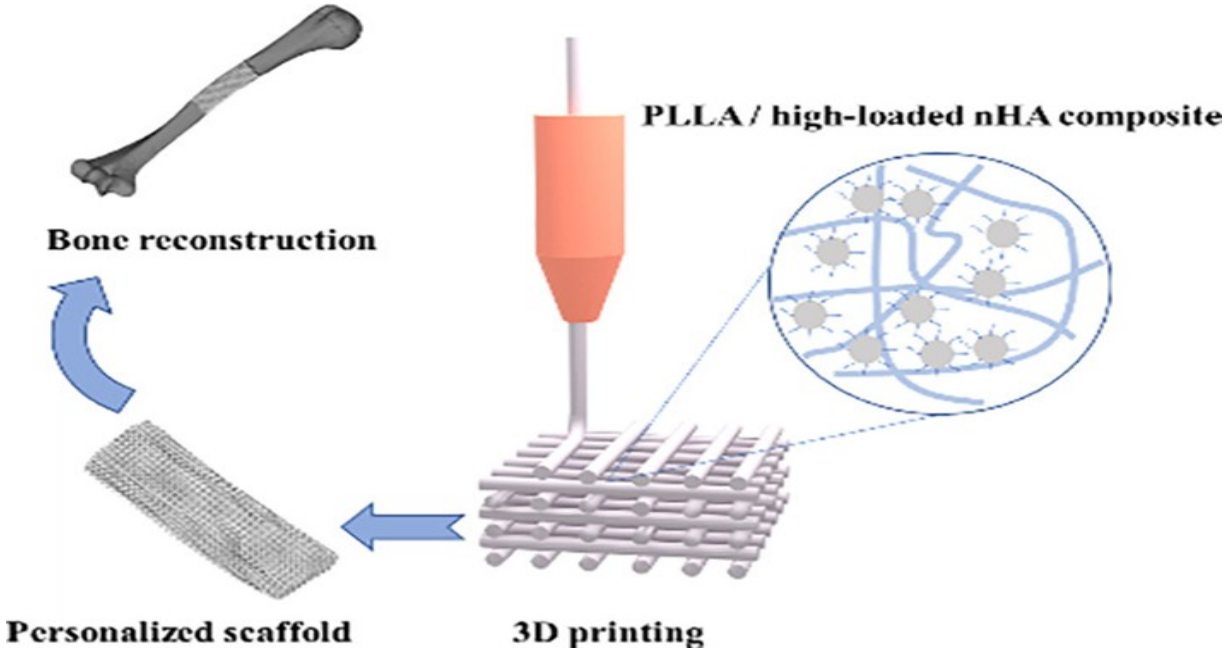
Biomimetic materials are designed and manufactured, and they create suitable conditions for restoration to promote tissue repair.

3D printing bone cell culture

3D printing is a manufacturing technology that deposits layers of medical biological materials and creates 3D objects based on a digital model of the patient's internal (anatomical) structure.

3D printing play a key role in orthopedic internal fixation surgery in the placement of pedicle screws during surgery

Scaffolds imitating 3D porous structures similar to native bone have been manufactured using 3D printing technology



Skeletal Muscular System

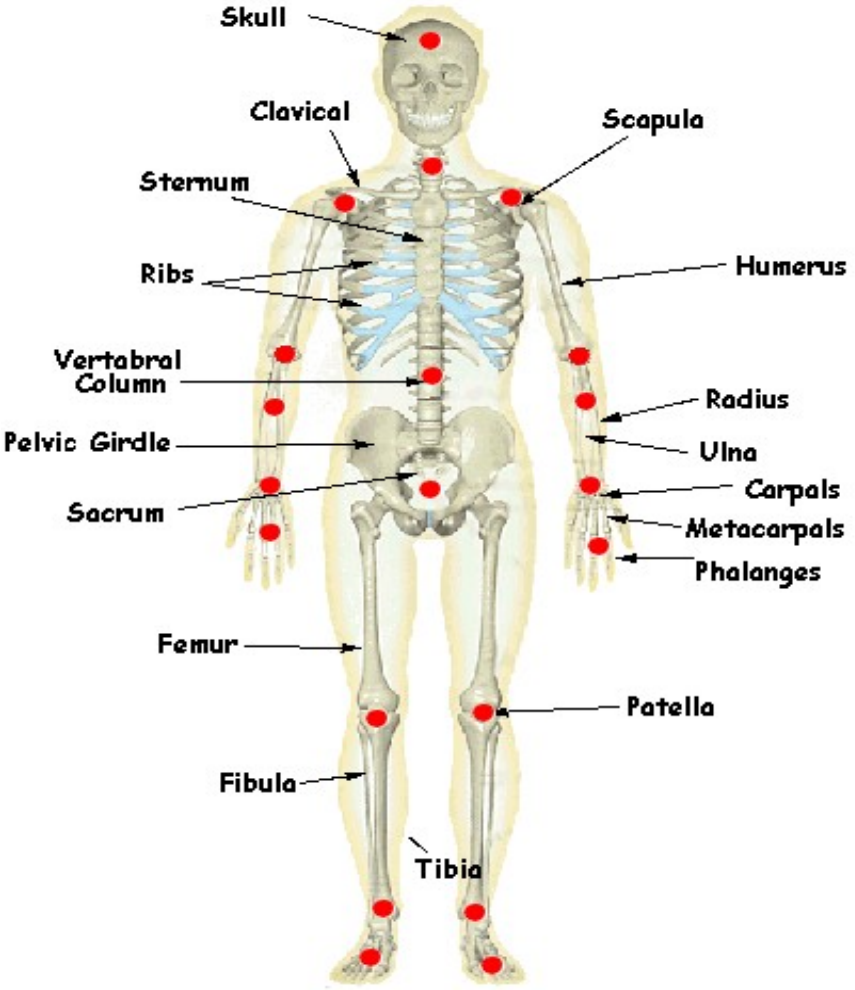
The Skeleton

Main functions of the skeleton are:

- Support- framework to maintain shape
- Protection- enclose vital organs and soft tissue.
- Movement- muscles attach to bone to form levers.
- Production of blood cells in marrow.
- Mineral storage- Calcium and Phosphorus

Human Skeleton

206 Bones



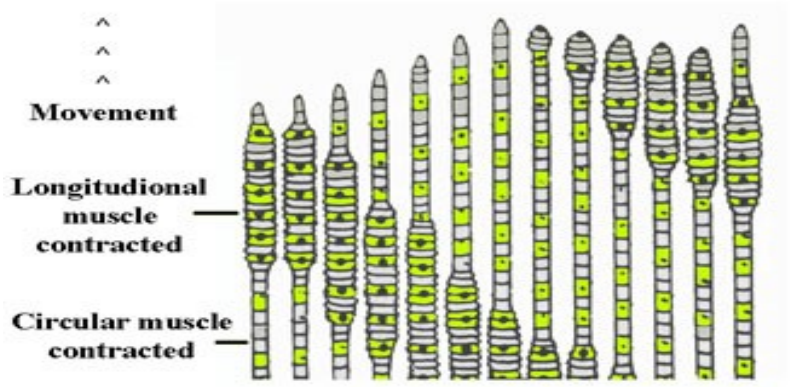
Types of Skeletons

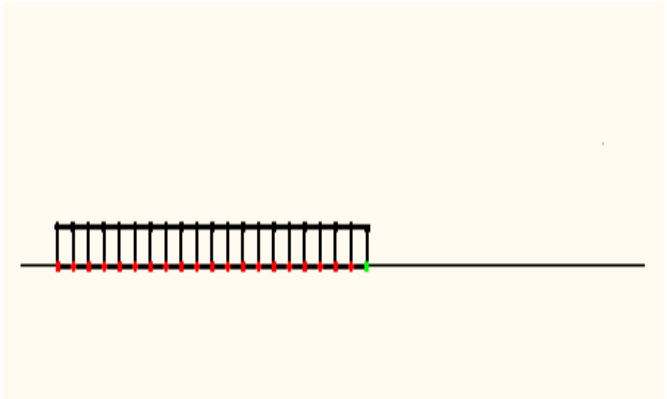
Hydrostatic Skeleton

Flexible cavities within an animals that provide structure through fluid pressure

It occurs in soft-bodies organism (jellyfish, earthworm's, annelids and other phylum of worms)

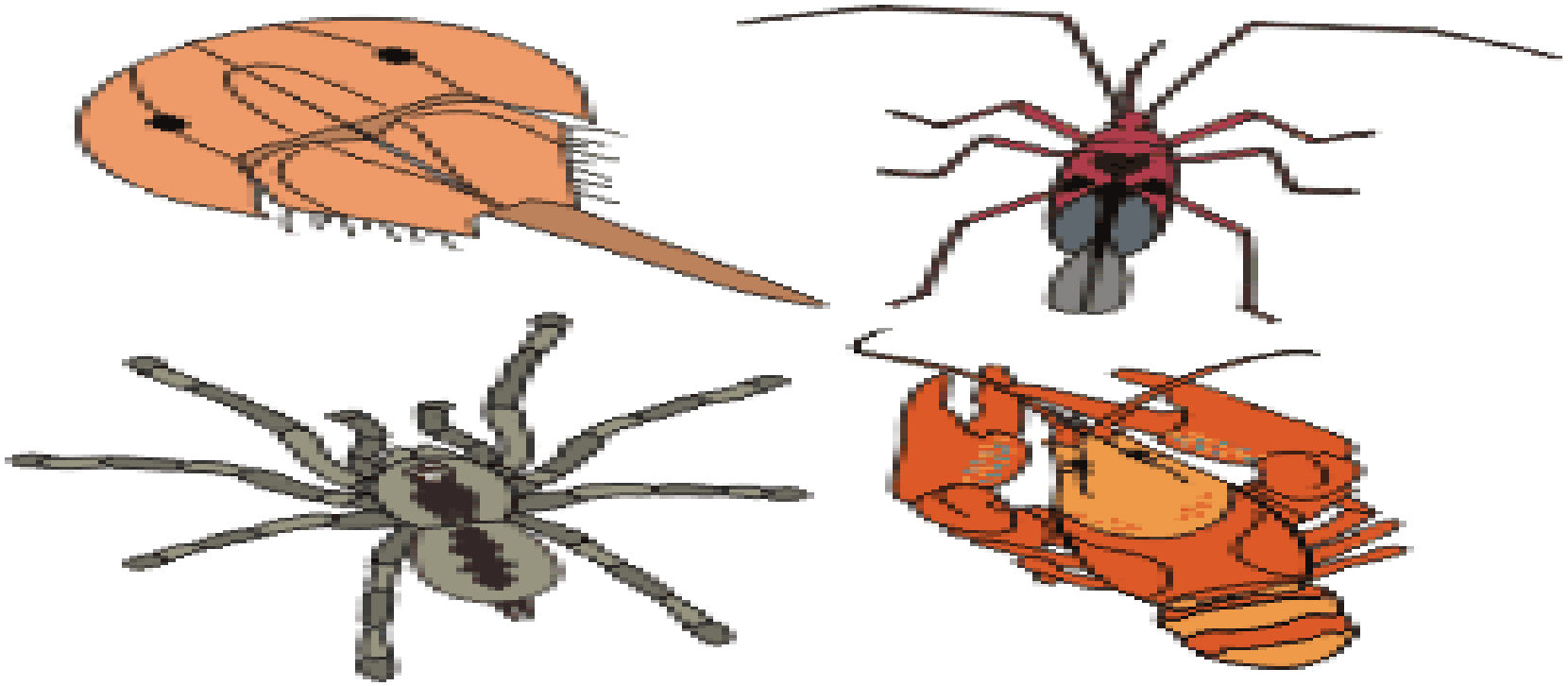
They use muscles surrounding these compartments to change shape and produce movement. (peristaltic movement)





Exoskeleton

A hard external skeleton that covers all of the muscles and organs of some invertebrates. (Insect, crustacean, and spiders (arthropods)
Composed of noncellular material (chitin, calcium salts) secreted by the epidermis. (light and strong)



Endoskeleton

Skeleton found within the body for structure and support.

Made up of hard supportive material buried within soft tissue.

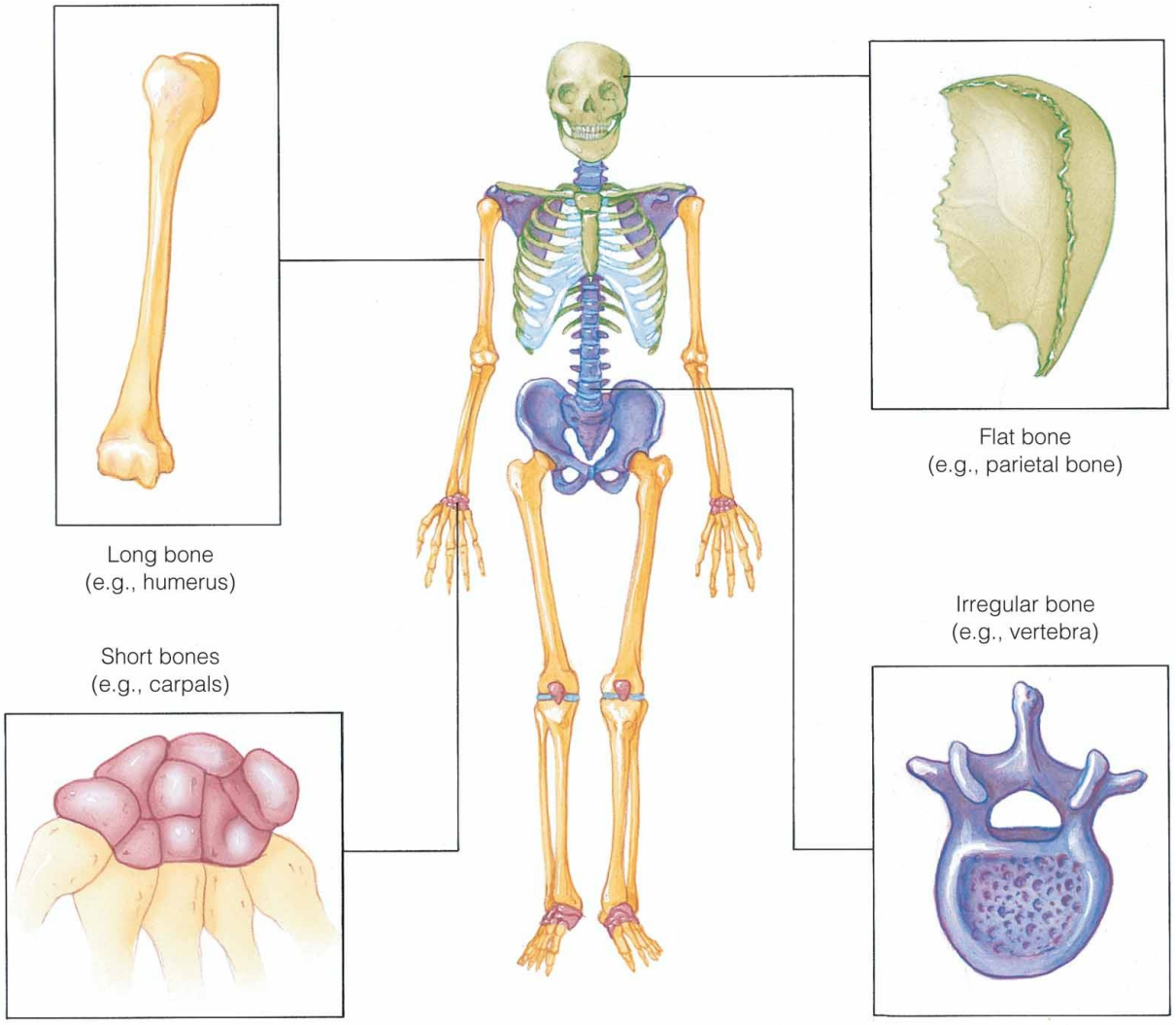
Found in chordates and echinoderms including cartilaginous fish

UNDERSTANDINGS

Bones and exoskeletons provide anchorage for muscles and act as levers.
Movement of the body requires muscles to work in antagonistic pairs.
Synovial joints allow certain movements but not others.
Skeletal muscle fibers are multinucleated and contain specialized endoplasmic reticulum.
Muscle fibers contain man myofibrils.

Each myofibril is made up of contractile sarcomeres.
The contraction of the skeletal muscle is achieved by the sliding of actin and myosin filaments.
Calcium ions and the proteins tropomyosin and troponin control muscle contractions.
ATP hydrolysis and cross bridge formation are necessary for the filaments to slide.

Classification of bones according to shape.



Joints

- Fibrous
- Cartilaginous
- Synovial

Major Joints

- Ankle

Tibia
Fibula
Talus

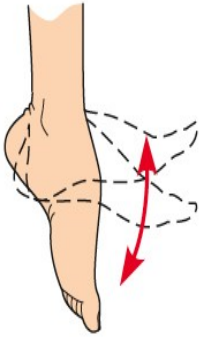
- Spine

7 cervical vertebrae
12 thoracic vertebrae
5 lumbar vertebrae
Sacrum

TYPE OF MOVEMENT

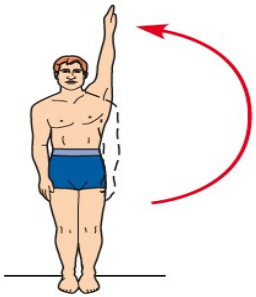
Gliding movements are the simplest type of joint movements. One flat bone surface glides or slips over another similar surface. The bones are merely displaced in relation to one another.

Flexion is a bending movement that decreases the angle of the joint and brings the articulating bones closer together. **Extension** increases the angle between the articulating bones. (**Hyperextension** is a bending of a joint beyond 180 degrees.)

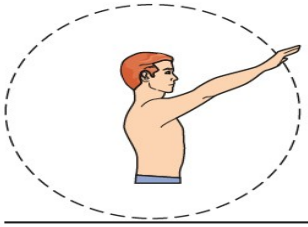


Flexion of the ankle so that the superior aspect of the foot approaches the shin is called **dorsiflexion.** Extension of the ankle (pointing the toes) is called **plantar flexion.**

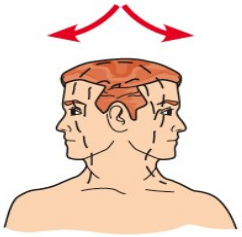
TYPE OF MOVEMENT



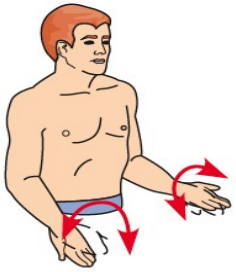
Abduction is movement of a limb away from the midline or median plane of the body, along the frontal plane. When the term is used to describe movement of the fingers or toes, it means spreading them apart. **Adduction** is the movement of a limb toward the body midline. Bringing the fingers close together is adduction.



Circumduction is the movement in which the limb describes a cone in space: While the distal end of the limb moves in a circle, the joint itself moves only slightly in the joint cavity.



Rotation is the turning movement of a bone around its own long axis. Rotation may occur toward the body midline or away from it.



The terms **supination** and **pronation** refer only to the movements of the radius around the ulna. Movement of the forearm so that the palm faces anteriorly or superiorly is called *supination*. In *pronation,* the palm moves to face posteriorly or inferiorly.