Definitions- Impulse, stimulation, conduction, response, EEG and epilepsy.

Impulse: A wave of physical and chemical excitation along a nerve fiber in response to a stimulus, accompanied by a transient change in electric potential in the membrane of the fiber.
Stimulation: **Stimulation** is the action of various agents (stimuli) on muscles, nerves, or a sensory end organ, by which activity is evoked.

Conduction: The transmission of a nerve impulse in the form of a wave of excitation within a single neuron or from one cell to another.

Response: Response is the reaction of the nerve fibre towards a particular stimulus

EEG Electroencephalograph: **Electroencephalography** (**EEG**) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp.

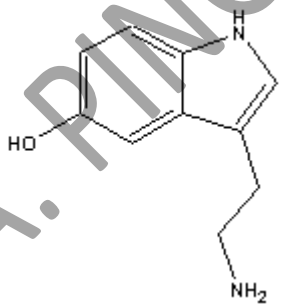
Epilepsy: Epilepsy is a brain disorder involving repeated, spontaneous seizures of any type. Seizures ("fits," convulsions) are episodes of disturbed brain function that cause changes in attention or behavior. They are caused by abnormally excited electrical signals in the brain.

Neurotransmitter:

Neurotransmitters are endogenous chemicals which transmit signals from a neuron to a target cell across a synapse. Neurotransmitters are packaged into synaptic vesicles clustered beneath the membrane on the presynaptic side of a synapse, and are released into the synaptic cleft, where they bind to receptors in the membrane on the postsynaptic side of the synapse.

Serotonin

Serotonin was first recognised as a powerful vasoconstrictor in blood serum. It was isolated in 1948 by Page and was later found to be associated with the central nervous system.



The chemical name for serotonin is 5-hydoxytryptamine which is often abbreviated to 5-HT.

Serotonin is naturally produced in the Pineal gland which lies deep at the centre of the human brain. The average adult human possesses only 5 to 10 mg of serotonin, 90 % of which is in the intestine and the rest in blood platelets and the brain.

One role of this 'wonder drug' is as a neurotransmitter, allowing numerous functions in the human body including the control of

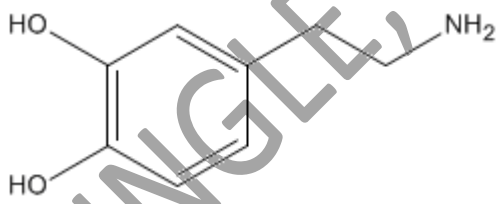
- appetite,
- sleep,
- memory and learning,
- temperature regulation,
- mood,
- behaviour,
- cardiovascular function,
- muscle contraction,
- endocrine regulation and
- depression.

Low serotonin levels are believed to be the cause of many cases of mild to severe depression which can lead to symptoms such as

- anxiety,
- apathy,
- fear,
- feelings of worthlessness,
- insomnia and
- fatigue

Dopamine:

Dopamine is found in the brains of most animals, both vertebrates and invertebrates. It belongs to a family of molecules called catecholamines. This is because it possesses both an amine group and the 1,2-dihydroxy substituted benzene, or catechol, ring. The IUPAC name for dopamine is 4-(2-aminoethyl)benzene-1,2-diol.



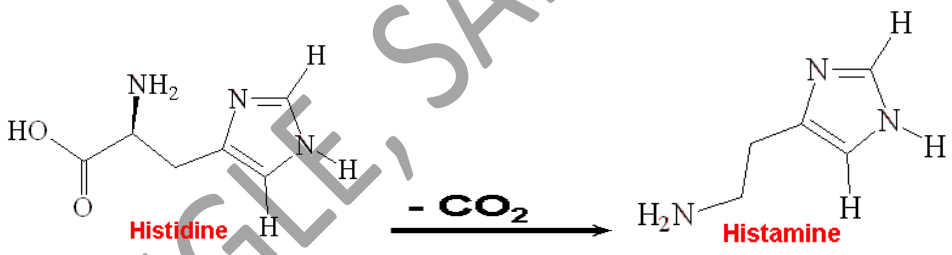
Dopamine has many biological functions.

- It is a precursor to norepinephrine which in turn is used to synthesise epinephrine in the body. Both of these molecules are hormones.
- Dopamine also acts as a neurohormone.
- It reduces the production of prolactin.
- Most well know function of dopamine is as a neurotransmitter. Neurotransmitters are chemicals that can cross a gap between neurons referred to as a synapse. A nerve impulse travels along the neuron and when it reaches the end a neurotransmitter is released. The neurotransmitter crosses the synapse, bridging the gap between the two neurons. This allows the impulse to continue.

- There are many dopamine receptors in the brain and it is thought that dopamine is responsible for a general feeling of well-being. For example, dopamine has been linked with feelings of happiness, excitement and positivity as well as the eagerness to go after goals or rewards. Nicotine present in cigarette smoke increases the secretion of dopamine in the brain and hence relieves feelings of anxiety. Other drugs also increase dopamine levels in the brain.

Histamine

It is an amine produced by your body that is used to maintain homeostasis (the body's natural balance of chemicals, temperature, metabolic rates, etc). It is also a neurotransmitter and plays a role in your immune system. In the body, histamine is synthesised by the enzyme catalysed decarboxylation of the amino acid histidine. Histamine is stored in several places around the body, mainly in special cells called *mast cells*(photo, right). These are found in abundance around areas particularly prone to injury, such as blood vessels and extremities. Histamine is also stored in a special type of white blood cell found in the blood stream called *basophils*. Histamine from these sources is used mainly as part of your body's immune system, where the histamine release is stimulated by Immunoglobulin E, a type of mammalian antibody. The antibody is triggered by a number of causes, usually an invading bacterium or virus, but it could also be a pollen cell or an allergic reaction to something the body has come into contact with. It results in the stored histamine being released into the body. This has a different effect depending upon which of the four known receptors it comes into contact with.

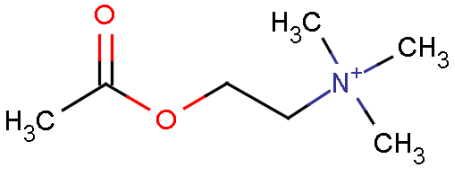


Acetyl Choline

Acetylcholine is the neurotransmitter produced by neurons referred to as cholinergic neurons. In the peripheral nervous system acetylcholine plays a role in skeletal muscle movement, as well as in the regulation of smooth muscle and cardiac muscle. In the central nervous system acetylcholine is believed to be involved in learning, memory, and mood.

Acetylcholine is synthesized from choline and acetyl coenzyme A through the action of the enzyme choline acetyltransferase and becomes packaged into membrane-

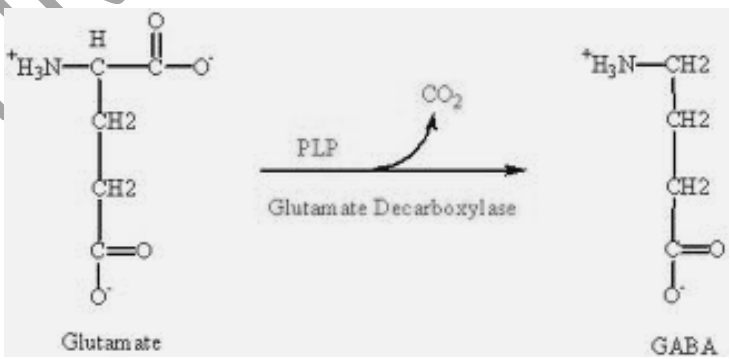
bound **vesicles** . After the arrival of a nerve signal at the termination of an axon, the vesicles fuse with the cell membrane, causing the release of acetylcholine into the **synaptic cleft** . For the nerve signal to continue, acetylcholine must diffuse to another nearby neuron or muscle cell, where it will bind and activate a **receptor** protein. The action of acetylcholine is terminated rapidly, in around 10 milliseconds; an enzyme (*cholinesterase*) breaks the transmitter down into choline and an acetate ion. The choline is then available for re-uptake into the nerve terminal.



GABA:

γ-Aminobutyric acid (**GABA**) is the chief inhibitory neurotransmitter in the mammalian central nervous system. It plays a role in regulating neuronal excitability throughout the nervous system. it is synthesized in the brain. It is synthesized from glutamate using the enzyme L-glutamic acid decarboxylase and pyridoxal phosphate (which is the active form of vitamin B6) as a cofactor via a metabolic pathway called the GABA shunt. This process converts glutamate, the principal excitatory neurotransmitter, into the principal inhibitory neurotransmitter (GABA).

In vertebrates, GABA acts at inhibitory synapses in the brain by binding to specific transmembrane receptors in the plasma membrane of both pre- and postsynaptic neuronal processes. This binding causes the opening of ion channels to allow the flow of either negatively charged chloride ions into the cell or positively charged potassium ions out of the cell. Depending on which ion channels open, the membrane potential is either hyperpolarized or repolarized. This action results in a negative change in the transmembrane potential, usually causing hyperpolarization.



EXCRETION

Physiology of Urine Formation:

The function of nephron is to **produce urine.** The urine formation takes place in three steps namely,

- glomerular filtration,
- tubular reabsorption and
- tubular secretion.

I- The Glomerular Filteration (Ultra filtration)

It is the process of filtration of substances from glomerular blood into the lumen of the Bowman's capsule in the form of nephric filtrate'.

The filtration is facilitated by two factors namely, nature of the capillaries and the pressures operating.

> Nature of the glomerular capillaries

• The glomerular capillaries are highly coiled and are characterized by having very thin walls with many tiny slit pores. The coiled nature offers greater surface area for filtration while the pores permit the passage of molecules less than 80A°.

• This prevents the blood cells and protein molecules larger than 80A° to get filtered. Hence, glomerular filtrate resembles the blood plasma in composition. The glomerulus, thus functions as a mechanical filter.

> The blood pressures

The blood pressure in the capillaries drives the plasma from the glomerulus into the Bowman's capsule. There are three pressures that are concerned with filtration. They are glomerular hydrostatic pressure, glomerular osmotic pressure and capsular hydrostatic pressure.

i. Glomerular hydrostatic pressure (GHP) : It is the 'pressure developed in the glomerulus due to the flow of blood from wide afferent renal arteriole to narrow efferent renal arteriole'.

• This pressure is about 75mm of Hg. This is a positive pressure and it favours the filtration of blood.

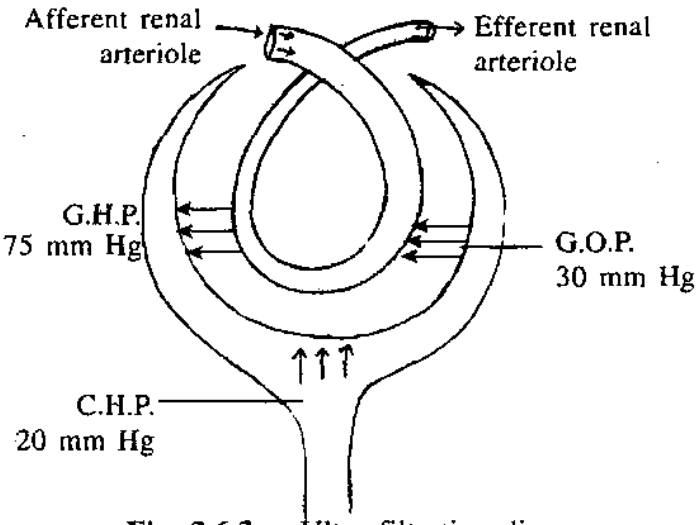


Fig. 3.6.3 : Ultra filtration diagram

ii. Glomerular osmotic pressure (GOP) or Blood colloidal osmotic pressure (BCOP) : It is the high osmotic pressure exerted by proteins found in glomerular blood. This tries to draw water from the glomerular filtrate.

• This is about 30 mm Hg. This is a negative pressure which resists filtration of plasma.

iii. The Capsular hydrostatic pressure (CHP) : It is 'the pressure exerted by the preexisting nephric filtrate in Bowman's capsule. This prevents the entry of fresh filtrate.

• This is about 20 mm of Hg. This is a negative pressure and it resists the filtration of plasma.

GHP	(GOP + CHP)	= net filtration pressure
75 mm Hg -	(30+20) mm Hg	= 25mm Hg.

Therefore, the net filtration pressure is 25 mm Hg.

• Both kidneys produce 180 litres of nephric filtrate at rest. Nephric filtrate contains useful materials like water, glucose, amino acids, fatty acids, vitamins, ions of K^+, Na^+, $HCO3^-$ and waste materials like urea, uric acidand ammonia.

• Since the filtrate contains both useful as well as waste materials, glomerular filtration is called non-selective filtration or primary urine

II. Selective reabsorption :

It is 'the process of absorption of substances from nephric filtrate into the peritubular capillaries'. It is a selective process. Here, the nephric filtrate contains materials useful for the body. They are reabsorbed into the blood in different regions of the nephron by passive and active transport. The substances reabsorbed are water, glucose, amino acids, fatty acids, vitamins, ions of K^+, Na^+ and $HCO3^-$.

Tubular reabsorption takes place at different regions of the nephron.

> Reabsorption at the proximal convoluted tubule (PCT)

• Most of the tubular reabsorption takes place in the proximal convoluted tubule. The type of reabsorption in proximal convoluted tubule is by osmosis and active transport.

• About 65% of water is reabsorbed by osmosis (because the peritubular blood has higher osmotic pressure than the nephric filtrate)

• Major part of the useful solutes like glucose, amino acids, fatty acids, salts and vitamins are reabsorbed either by passive diffusion or by active transport.

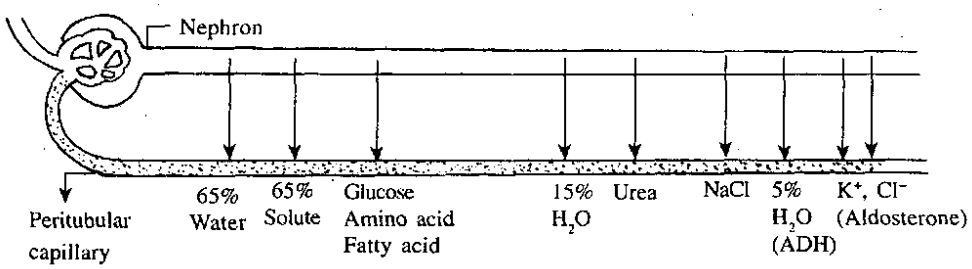


Fig. 3.6.3 a : Diagrammatic representation of tubular reabsorption

> Reabsorption in Henle's loop

• From the descending limb of Henle's loop about 15% of water is reabsorbed by osmosis.

• From the lower thin segment of the ascending limb, urea is reabsorbed by diffusion and active transport.

• Whereas from the thick segment of the ascending limb Na^+ and Cl^- are reabsorbed by active transport.

> Reabsorption in distal convoluted tubule (DCT)

• From DCT 5% of water is reabsorbed under the influence of anti -diuretic hormone (ADH)

• From the DCT sodium ions, potassium, chloride and bicarbonate are reabsorbed in variable amounts under the influence of hormone aldosterone

> Reabsorption in the collecting duct

• From the collecting duct, about 14.5% of water is reabsorbed into the interstitium under the influence of anti-diuretic hormone (ADH)

• Sodium ions are reabsorbed in variable amounts under the influence of hormone aldosterone.

• Certain amount of urea is also reabsorbed.

III. Tubular secretion : It is 'the process of secretion of substances from the peritubular capillaries into the nephric filtrate. It is the reversal of tubular secretion. It takes place mostly in the distal convoluted tubule by active and passive transport.

• Substances actively secreted into the tubule are hydrogen ion, potassium ion, minor nitrogenous wastes like ammonia, creatinine, hippuric acid, toxic substances, drugs etc.

• Thus, at the end of tubular secretion 180L of nephric filtrate is converted into 2 litre of urine.

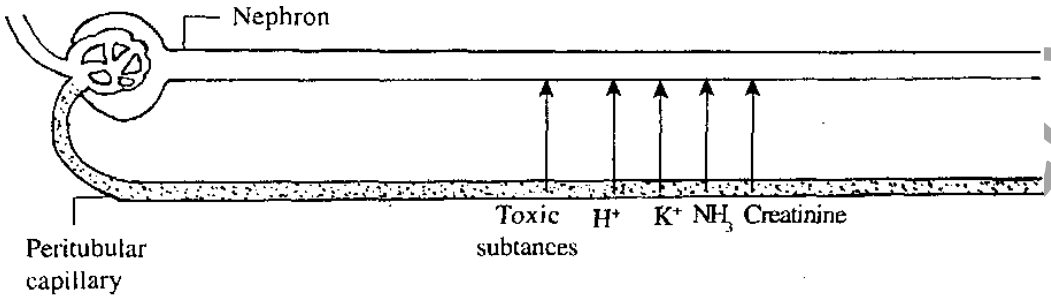


Fig. 3.6.3 b : Diagrammatic representation of tubular secretion

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Counter Current Mechanism of Urine concentration:

Counter current mechanism is that process which changes isotonic filtrate to hypertonic urine.

The urine is about 4 times as concentrated as blood plasma in humans.

There are 2 counter current mechanisms operating inside the kidneys.

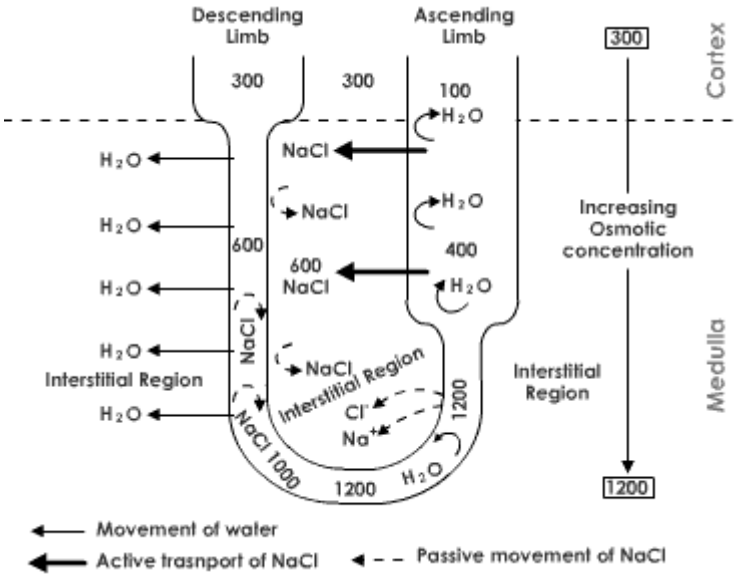
a) Vasa rectae

Inside the renal medulla, the efferent arteriole forms a capillary network around the tubules. Some of these blood capillaries are parallel, wide, thin walled, straight and loop like and are called vasa rectae. The blood flows in opposite directions in the 2 limbs of the vasa rectae. Blood entering the renal medulla in the descending limb comes very close to the outgoing blood in the ascending limb.

When the blood flows towards the renal medulla, Na^+ and Cl^- diffuse in the blood from interstitial fluid, but as the blood flows towards the renal cortex Na^+ and Cl^- diffuse into the interstitial fluid. This checks the loss of Na^+ and Cl^- from the renal medulla and maintains a high concentration of these in the interstitial fluid.

Henle's loop

The glomerular filtrate flows in opposite directions in the two limbs of Henle's loop.



As the filtrate passes through the ascending limb of the loop of Henle, NaCl is lost to the interstitial fluid in the renal medulla by diffusion.

The increased concentration of the solutes in the interstitial fluid draws out water by osmosis from the narrow region of the descending limb and also from the collecting duct, both being permeable to water.

The water so drawn quickly enters the vasa recta and is being carried away. This maintains a high concentration of solutes in the interstitial fluid and helps turn the isotonic glomerular filtrate into a hypertonic urine.

There is no water reabsorption from the ascending limb because its walls are impermeable to water. As large amounts of Na^+ is lost due to active transport, the filtrate again becomes isotonic.

The water reabsorption mainly occurs through the wall of the collecting tubules, the permeability of which is controlled by vasopressin or antidiuretic hormone (ADH) of the posterior lobe of pituitary gland. The secretion of ADH is controlled by the osmotic pressure of the blood.

Renal Failure:

Renal failure is a serious medical condition affecting the kidneys. When a person suffers from renal failure, their kidneys are not functioning properly or no longer work at all.

The kidneys are glands that are located in the abdominal region just above the pelvis on either side of the body. When functioning normally, the kidneys separate and filter excess water and waste from the blood stream. The kidneys are responsible for producing urine, which is used

to flush away the toxins. The kidneys also maintain a healthy balance of fluids and electrolytes, or salt compounds, in the body.

In renal failure the kidneys undergo cellular death and are unable to filter wastes, produce urine and maintain fluid balances. This dysfunction causes a build up of toxins in the body which can affect the blood, brain and heart, as well as other complications. Renal failure is very serious and even deadly if left untreated.

There are two types of renal failure: acute and chronic.

Acute renal failure:

Acute renal failure occurs suddenly and is usually initiated by underlying causes, for example dehydration, infection, serious injury to the kidney or the chronic use of over the counter pain medications like Tylenol (acetaminophen) or Advil (ibuprofen). Acute renal failure is often reversible with no lasting damage.

Chronic renal failure

It is more serious than acute renal failure because symptoms may not appear until the kidneys are extremely damaged. Chronic renal failure can be caused by other long term diseases, such as diabetes and high blood pressure. Chronic renal failure can worsen over time, especially when the problem has gone undiagnosed and treatment is delayed.

The symptoms of renal failure include edema, which is an accumulation of fluid characterized by swelling, and a decrease in urination. Other symptoms may include a general ill feeling, exhaustion and headaches.

Renal Calculi

Renal calculi are small chunks of crystallized material which become trapped in the kidneys, bladder, or urinary tract. A renal calculus can be extremely painful, and the patient may not be able to pass it without assistance.

Kidney stones may not produce symptoms until they begin to move down the tubes (ureters) through which urine empties into the bladder. When this happens, the stones can block the flow of urine out of the kidneys. This causes swelling of the kidney or kidneys, causing pain. The pain is usually severe.

There are several types of kidney stones based on the type of crystals of which they consist. The majority are calcium oxalate stones, followed by calcium phosphate stones.

Dialysis

The technique for removing waste products from the blood is called dialysis. In dialysis, blood from an artery in the arm (or leg) is drawn into a dialysis machine and the purified blood is fed into a vein.

The kidneys filter and purify the blood, throwing out the impurities through the urine.

If the kidneys become diseased and cease functioning, the blood gets poisoned and the patient dies.

The only way to deal with kidney failure is to transplant a healthy kidney obtained from a living or just dead person — or to remove the impurities from the blood artificially. Dialysis is the technique which is generally adopted to treat renal failure.

The person requiring dialysis has to undergo an 8–hour session connected to the dialysis machine every two or three days.It is an exhausting and costly process.

Dialysis works on the principles of the diffusion of solutes and ultrafiltration of fluid across a semi-permeable membrane. 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 semi-permeable membrane, and a dialysate, or special dialysis fluid, flows by the opposite side. Smaller solutes and fluid pass through the membrane, but the membrane blocks the passage of larger substances (for example, red blood cells, large proteins).

Definition and Significance

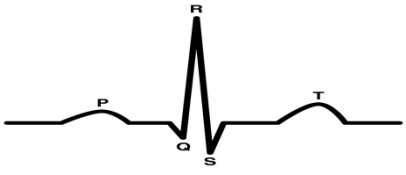
ECG: Electrocardiograph:

Electrocardiograph is a trans-thoracic interpretation of the electrical activity of theheart over time captured and externally recorded by skin electrodes

Significance of ECG:

The ECG records the electrical activity that results when the heart muscle cells in the atria and ventricles contract.

- Atrial contractions (both right and left) show up as the P wave.
- Ventricular contractions (both right and left) show as a series of 3 waves, Q-R-S, known as the QRS complex.
- The third and last common wave in an ECG is the T wave. This reflects the electrical activity produced when the ventricles are recharging for the next contraction (repolarizing).
- The electrical activity results in P, QRS, and T waves that have a myriad of sizes and shapes. When viewed from multiple anatomic-electric perspectives (that is, leads), these waves can show a wide range of abnormalities of both the electrical conduction system and the muscle tissue of the heart's 4 pumping chambers.



Eco Cardiograph:

An echocardiogram is a test in which ultrasound is used to examine the heart. An Echocardiograph can be of two types:

M- Type: It provides single-dimension images and allows accurate measurement of the heart chambers.

2-D Echo: This echocardiogram offers far more sophisticated and advanced imaging and is capable of displaying a cross-sectional "slice" of the beating heart, including the chambers, valves and the major blood vessels that exit from the left and right ventricle.

A colorless gel is then applied to the chest and the echo transducer is placed on top of it. The echo technologist then makes recordings from different parts of the chest to obtain several views of the heart.

Color Doppler

Color Doppler uses standard ultrasound methods to produce a picture of a blood vessel. A computer converts the Doppler sounds into colors that are overlaid on the image of the blood vessel and that represent the speed and direction of blood flow through the vessel.

A Doppler ultrasound test uses reflected sound waves to evaluate blood as it flows through a blood vessel. It helps doctors evaluate blood flow through the major arteries and veins of the arms, legs, and neck. It can show blocked or reduced blood flow through narrowing in the major arteries of the neck that could cause a stroke. It also can reveal blood clots in leg veins that could break loose and block blood flow to the lungs. During pregnancy, Doppler ultrasound may be used to look at blood flow in an unborn baby (fetus) to check the health of the fetus.

During Doppler ultrasound, a handheld instrument (transducer) is passed lightly over the skin above a blood vessel. The transducer sends and receives sound waves that are amplified through a microphone. The sound waves bounce off solid objects, including blood cells. The movement of blood cells causes a change in pitch of the reflected sound waves (called the Doppler effect). If there is no blood flow, the pitch does not change. Information from the reflected sound waves can be processed by a computer to provide graphs or pictures that represent the flow of blood through the blood vessels.

Angiography

Angiography or **arteriography** is a medical imaging technique used to visualize the inside, or lumen, of blood vessels and organs of the body, with particular interest in the arteries, veins and the heart chambers. This is traditionally done by injecting a radio-opaque contrast agent into the blood vessel and imaging using X-ray based techniques such as fluoroscopy.

One of most common angiograms performed is to visualize the blood in the coronary arteries. A long, thin, flexible tube called a catheter is used to administer the x-ray contrast agent at

the desired area to be visualized. The catheter is threaded into an artery in the forearm, and the tip is advanced through the arterial system into the major coronary artery.

Once inside the coronary tube, after a lot of trial and error, a radioactive dye is injected through the hole in the catheter inside the coronary tubes and further fluoroscopy photographs are taken. f the dye seems to fill up the coronary tubes completely, the blockages are probably not there. It the dye can not fill the tubes (as roughly seen in the photos taken) inside, it is taken as filling defect and indirectly interpreted as blockages.

Angioplasty:

Angioplasty is the technique of mechanically widening a narrowed or obstructed blood vessel, typically as a result of atherosclerosis. An empty and collapsed balloon on a guide wire, known as a balloon catheter, is passed into the narrowed locations and then inflated to a fixed size using water pressures some 75 to 500 times normal blood pressure (6 to 20 atmospheres). The balloon crushes the fatty deposits, opening up the blood vessel for improved flow, and the balloon is then collapsed and withdrawn.

Angioplasty is a common medical procedure. It may be used to:

- Improve symptoms of Coronary Heart Disease (CHD), such as angina and shortness of breath. (Angina is chest pain or discomfort.)
- Reduce damage to the heart muscle caused by a heart attack. A heart attack occurs if blood flow through a coronary artery is completely blocked. The blockage usually is due to a blood clot that forms on the surface of plaque. During angioplasty, a small balloon is expanded inside the coronary artery to relieve the blockage.
- Reduce the risk of death in some patients.

Angina Pectoris

Angina is chest pain or discomfort that occurs when an area of your heart muscle doesn't get enough oxygen-rich blood. Angina may feel like pressure or squeezing in your chest. The pain also may occur in your shoulders, arms, neck, jaw, or back. Angina pain may even feel like indigestion.

Angina isn't a disease; it's a symptom of an underlying heart problem. Angina usually is a symptom of coronary heart disease (CHD), also called coronary artery disease.

Plaque narrows and stiffens the coronary arteries. This reduces the flow of oxygen-rich blood to the heart muscle, causing chest pain. Plaque buildup also can lead to a heart attack if the plaque ruptures (breaks open) and causes a blood clot to form that blocks the artery.

Heart Attack:

A heart attack occurs if the flow of oxygen-rich blood to a section of heart muscle suddenly becomes blocked. If blood flow isn't restored quickly, the section of heart muscle begins to die.

Heart attacks most often occur as a result of coronary heart disease (CHD), also called coronary artery disease. CHD is a condition in which a waxy substance called plaque (plak) builds up inside the coronary arteries. These arteries supply oxygen-rich blood to your heart.

When plaque builds up in the arteries, the condition is called atherosclerosis. The buildup of plaque occurs over many years.

Eventually, an area of plaque can rupture (break open) inside of an artery. This causes a blood clot to form on the plaque's surface. If the clot becomes large enough, it can mostly or completely block blood flow through a coronary artery.

If the blockage isn't treated quickly, the portion of heart muscle fed by the artery begins to die. Healthy heart tissue is replaced with scar tissue. This heart damage may not be obvious, or it may cause severe or long-lasting problems.

Heart attack symptoms include:

- Chest pain or discomfort. This involves uncomfortable pressure, squeezing, fullness, or pain in the center or left side of the chest that can be mild or strong. This discomfort or pain often lasts more than a few minutes or goes away and comes back.
- Upper body discomfort in one or both arms, the back, neck, jaw, or upper part of the stomach.
- Shortness of breath, which may occur with or before chest discomfort.
- Nausea (feeling sick to your stomach), vomiting, light-headedness or sudden dizziness, or breaking out in a cold sweat.

Coronary Bypass

Coronary Artery Bypass Surgery or CABG is a surgical procedure performed to restore the blood supply to sections of heart that have reduced or no blood supply.

The blockage or obstruction in the vessels is caused due to deposition of fat in the walls of the arteries and this gradual process is called atherosclerosis or arteriosclerosis. Obstruction leads to angina pain or death of heart muscles (also called myocardial infarction) and causes a 'heart attack'.

Arteries or veins from elsewhere in the patient's body are grafted to the coronary arteries to bypass atherosclerotic narrowing and improve the blood supply to the coronary circulation supplying the myocardium (heart muscle).

Cornary Bypass can be useful in :

- Improving your quality of life and decreasing angina and other CHD symptoms
- Allowing you to resume a more active lifestyle
- Improving the pumping action of your heart if it has been damaged by a heart attack
- Lowering the risk of a heart attack (in some patients, such as those who have diabetes)
- Improving the chance of survival

Glycogenesis:

Glycogenesis is the process of glycogen synthesis, in which glucose molecules are added to chains of glycogen for storage. This process is activated during rest periods following the Cori cycle, in the liver, and also activated by insulin in response to high glucose levels, for example after a carbohydrate-containing meal.

Steps:

- Glucose is converted into glucose-6-phosphate by the action of glucokinase or hexokinase.
- Glucose-6-phosphate is converted into glucose-1-phosphate by the action of Phosphoglucomutase, passing through an obligatory intermediate step of glucose-1,6-bisphosphate.
- Glucose-1-phosphate is converted into UDP-glucose by the action of Uridyl Transferase (also called UDP-glucose pyrophosphorylase) and pyrophosphate is formed, which is hydrolyzed by pyrophosphatase into 2 molecules of Pi.
- Glucose molecules are assembled in a chain by glycogen synthase, which must act on a pre-existing glycogen primer or glycogenin (small protein that forms the primer).

Glycogenolysis:

Glycogenolysis (also known as "Glycogenlysis") is the conversion of glycogen polymers to glucose monomers. Glycogen is catabolized by removal of a glucose monomer through cleavage with inorganic phosphate to produce glucose-1-phosphate. This derivative of glucose is then converted to glucose-6-phosphate, an intermediate in glycolysis.

The hormones glucagon and epinephrine stimulate glycogenolysis.

Glycogenolysis takes place in the muscle and liver tissues, where glycogen is stored, as a hormonal response to epinephrine (e.g., adrenergic stimulation) and/or glucagon.

Glycogen is a highly branched polymeric structure containing glucose as the basic monomer.

- First individual glucose molecules are hydrolyzed from the chain, followed by the addition of a phosphate group at C-1.This results in formation of Glucose 1-Phosphate.
- In the next step the phosphate is moved to the C-6 position to give glucose 6-phosphate, a cross road compound.
- Glucose-6-phosphate is the first step of the glycolysis pathway if glycogen is the carbohydrate source and further energy is needed. If energy is not immediately needed, the glucose-6-phosphate is converted to glucose for distribution in the blood to various cells such as brain cells.

Gluconeogenesis:

Gluconeogenesis (abbreviated **GNG**) is a metabolic pathway that results in the generation of glucose from non-carbohydrate carbon substrates such as lactate, glycerol, and glucogenic amino acids.

In animals, gluconeogenesis takes place mainly in the liver and, to a lesser extent, in the cortex of kidneys. This process occurs during periods of fasting, starvation, low-carbohydrate diets, or intense exercise.

The starting point of gluconeogenesis is pyruvic acid. Gluconeogenesis is a pathway consisting of eleven enzyme-catalyzed reactions. The pathway can begin in the mitochondria or cytoplasm, depending on the substrate being used. Many of the reactions are the reversible steps found in glycolysis.

- Gluconeogenesis begins in the mitochondria with the formation of oxaloacetate through carboxylation of pyruvate. This reaction also requires one molecule of ATP, and is catalyzed by pyruvate carboxylase. This enzyme is stimulated by high levels of acetyl-CoA (produced in β-oxidation in the liver) and inhibited by high levels of ADP.
- Oxaloacetate is reduced to malate using NADH, a step required for transport out of the mitochondria.
- Malate is oxidized to oxaloacetate using NAD^+ in the cytoplasm, where the remaining steps of gluconeogenesis occur.
- Oxaloacetate is decarboxylated and phosphorylated to produce phosphoenolpyruvate by phosphoenolpyruvate carboxykinase. One molecule of GTP is hydrolyzed to GDP during this reaction.
- The next steps in the reaction are the same as reversed glycolysis. However, fructose-1,6-bisphosphatase converts fructose-1,6-bisphosphate to fructose 6-phosphate, requiring one water molecule and releasing one phosphate. This is also the rate-limiting step of gluconeogenesis.
- Glucose-6-phosphate is formed from fructose 6-phosphate by phosphoglucoisomerase. Glucose-6-phosphate can be used in other metabolic pathways or dephosphorylated to free glucose. Whereas free glucose can easily diffuse in and out of the cell, the phosphorylated form (glucose-6-phosphate) is locked in the cell, a mechanism by which intracellular glucose levels are controlled by cells.
- The final reaction of gluconeogenesis, the formation of glucose, occurs in the lumen of the endoplasmic reticulum, where glucose-6-phosphate is hydrolyzed by glucose-6-phosphatase to produce glucose. Glucose is shuttled into the cytosol by glucose transporters located in the membrane of the endoplasmic reticulum.