

MODULE 3

HUMAN ORGAN SYSTEM AND BIODESIGN

Contents:

- Brain as a CPU system (architecture, CNS and Peripheral nerve system, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease)
- Eye as a camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye)
- Heart as a pump system (architecture, electrical signaling- ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators)
- Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine)
- Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems)

INTRODUCTION

The human body is like a machine made up of different systems that work together to keep us alive and healthy. These systems include our bones (skeletal system), muscles (muscular system), heart and blood vessels (cardiovascular system), lungs (respiratory system), brain and nerves (nervous system), stomach and intestines (digestive system), kidneys and bladder (urinary system), glands that produce hormones (endocrine system), a network of vessels that help fight off infections (lymphatic system), organs for having babies (reproductive system), and our skin, hair, and nails (integumentary system). Each system has its own job, but they all work together to keep us going.

Bio design is a design approach that utilizes living organisms or living materials in various fields such as fashion, textiles, furniture, and architecture. It involves using processes inspired by nature to create innovative and sustainable products.

For example, in fashion, designers may use living organisms like bacteria to create dyes or fabrics that change color in response to environmental conditions. In architecture, bio design can involve using living materials such as algae or fungi to create self-healing concrete or bio-facades that improve air quality.

This approach is increasingly being adopted by non-profits, design companies, and universities worldwide, including UC Davis, to develop products that are more sustainable and environmentally friendly.

BRAIN AS A CPU SYSTEM

Comparison Between Brain and CPU

- Both the brain and CPU transmit information using electrical signals.
- The brain uses chemicals (neurotransmitters) along with electrical signals, while a computer uses electricity alone.
- Electrical signals travel faster in a computer than in the nervous system.
- Both process information and generate outputs, but the brain is more adaptive and capable of learning.

What is a Brain-Computer Interface (BCI)?

A **BCI system** is a **computer-based system** that:

- Takes brain signals, analyses them, and translates them into commands.
- Controls external devices using brain activity, bypassing muscles and the peripheral nervous system.

Key Characteristics of BCI:

- Does not involve voice commands or muscle movements.
- EEG (Electroencephalography) alone is not BCI – it only records brain signals but does not generate an output.
- Not a mind-reading tool – BCI does not extract thoughts unwillingly.
- Requires user intent to function and act on their environment.

Applications of BCI:

- **Medicine & Neurotechnology** – Assisting individuals with disabilities (e.g., controlling prosthetic limbs).
- **Smart Environments** – Controlling home automation through brain signals.
- **Neuro-marketing & Advertising** – Understanding consumer responses using brain activity.
- **Education & Self-Regulation** – Enhancing learning and cognitive training.
- **Security & Identification** – Using brainwave patterns for authentication.

While the brain and CPU share similarities in processing and transmitting information, the brain is far more advanced, capable of learning, adapting, and managing complex tasks like emotions and perception. BCI technology bridges the gap between the brain and computers, enabling new possibilities in various fields.

Comparison between brain and computer:

Basis for Comparison	Brain	Computer
Construction	Neurons and synapses	ICs, transistors, diodes, capacitors, transistors, etc.
Memory growth	Increases each time by connecting synaptic links	Increases by adding more memory chips
Backup systems	Built-in backup system	Backup system is constructed manually
Memory power	100 teraflops (100 trillion calculations/seconds)	100 million megabytes
Memory density	10^7 circuits/cm ³	10^{14} bits/cm ³
Energy consumption	12 watts of power	Gigawatts of power
Information storage	Stored in electrochemical and electric impulses	Stored in numeric and symbolic form (i.e. in binary bits).
Size and weigh	The brain's volume is 1500 cm ³ and weight is around 3.3pounds.	Variable weight and size from few grams to tons.
Transmission of information	Uses chemicals to fire the action potential in the neurons.	Communication is achieved through electrical coded signals.
Information processing power	Low	High
Input/output equipment	Sensory organs	Keyboards, web cameras, mouse etc.

Structural organization	Self-organized	Pre-programmed structure
Parallelism	Massive	Limited
Reliability and damageability properties	Brain is self-organizing, self-maintaining and reliable.	Computers perform a monotonous job and can't correct itself.

Central nervous system (CNS):

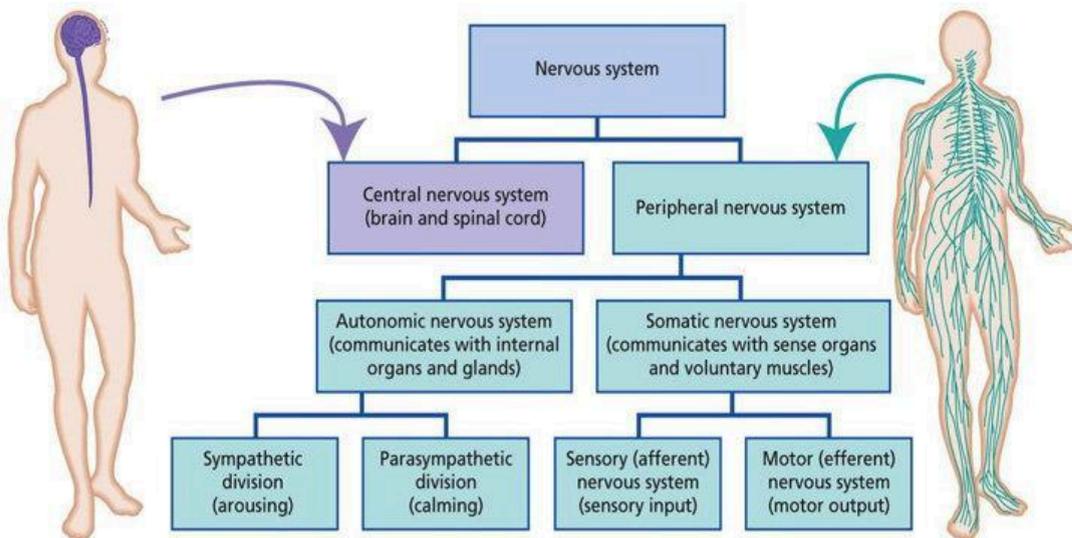
The Central Nervous System (CNS) includes the brain and spinal cord. The brain acts as the body's "control center," managing various functions. Within the CNS, there are centers responsible for sensory processing, motor control, and integrating information. These centers can be further categorized into Lower Centers, which include the spinal cord and brain stem, and higher centers that communicate with the brain through effectors.

Peripheral Nervous System (PNS):

The Peripheral Nervous System (PNS) is a network of nerves that connect the brain and spinal cord to the rest of the body. It includes sensory receptors that detect changes in the internal and external environment. Information from these receptors is sent to the Central Nervous System (CNS) through afferent sensory nerves.

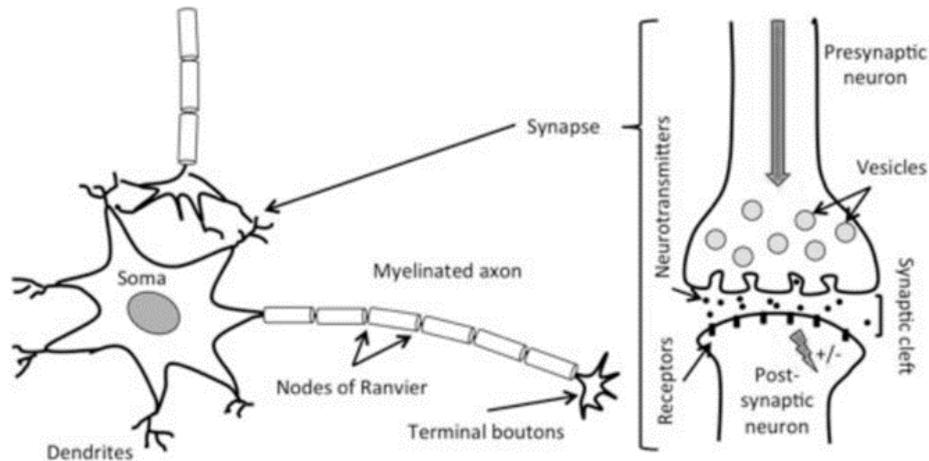
The PNS is further divided into the Autonomic Nervous System (ANS) and the Somatic Nervous System (SNS). The ANS controls involuntary functions of internal organs, blood vessels, and smooth and cardiac muscles. The SNS controls voluntary movements of the skin, bones, joints, and skeletal muscles.

These two systems work together, with nerves from the PNS entering and becoming part of the CNS, and vice versa. This allows for



coordinated responses to stimuli and helps maintain homeostasis in the body.

SIGNAL TRANSMISSION:



- Neurons communicate using chemicals called neurotransmitters.
- Communication occurs at specialized points called synapses.

Neurotransmitter Release:

- Presynaptic neuron releases neurotransmitters from axon terminals.
- Axon terminals are located at the end of the neuron's axon.

Signal Transmission:

- Electrical impulse travels from dendrites (signal reception) to cell body.
- Then down the axon (signal conduction) to axon terminals for signal transmission.

Synaptic Transmission:

- Neurotransmitters travel across synapse to bind to receptors on postsynaptic neuron.
- This transmission allows for communication between neurons.

ELECTRO ENCEPHALO GRAM [EEG]:

An **Electroencephalogram (EEG)** is a test that measures the brain's electrical activity using small metal discs (**electrodes**) attached to the scalp. Brain cells communicate through electrical impulses, which remain active even during sleep. These impulses appear as wavy lines in an EEG recording.

Uses of EEG

EEG is primarily used to diagnose **epilepsy** and other brain disorders by detecting abnormal brain activity. It is also helpful in diagnosing and monitoring:

- Epilepsy & Seizure Disorders
- Brain Tumors
- Brain Damage (from head injuries)
- Encephalopathy (brain dysfunction due to various causes)
- Sleep Disorders
- Stroke
- Brain Death Confirmation (for patients in a persistent coma)
- Anesthesia Monitoring (during medically induced comas)

How EEG Works

- EEG measures voltage fluctuations in brain activity using electrodes and a bio-amplifier.
- It records the posterior dominant rhythm (PDR), first described by Hans Berger.
- It detects abnormal electrical discharges (sharp waves, spikes, and wave complexes) in epilepsy patients.
- It helps analyze seizure onset, spread, and evolution, and can detect status epilepticus (continuous seizures).

Comparison with Other Imaging Techniques

Feature	EEG	MRI/CT/PET
Purpose	Measures electrical activity	High-resolution brain imaging
Spatial Resolution	Limited	High
Temporal Resolution	Millisecond-range (fast)	Slower
Mobility	Portable	Not portable

EEG was previously a first-line method for diagnosing tumours and strokes, but its use has decreased with the advancement of MRI and CT scans. However, EEG remains a valuable tool for real-time brain activity analysis, making it useful in clinical and research settings.

Advanced EEG Techniques

- **Evoked Potentials (EP):** Measures EEG responses to specific stimuli (visual, auditory, somatosensory).
- **Event-Related Potentials (ERP):** Analyses brain responses linked to cognitive processing, widely used in cognitive science, psychology, and psychophysiological research.

ROBOTIC ARMS FOR PROSTHETICS:

Robotic prosthetic limbs are advanced artificial limbs that integrate mechatronics, intelligent sensing, and control systems to restore lost sensorimotor functions while maintaining the physical appearance of a natural limb.

Purpose and Benefits

Robotic prosthetics aim to:

- Restore lost limb functions (movement, grasping, walking)
- Improve aesthetics for a natural appearance
- Enhance social interaction for amputees
- Improve quality of life by increasing comfort and usability
- Enable productivity for amputees in society

Advancements in Technology

- **Sensor Technology:** Significant improvements in intelligent sensors allow more precise control of artificial limbs.
- **Muscle Signal Detection:** Most robotic prostheses work by detecting electrical signals from muscles in the residual limb.
- **User Control:** Some amputees can move their artificial hand by contracting remaining forearm muscles that originally controlled fingers.

Uses of Robotic Prosthetic Limbs

- **Daily Activities:** Walking, eating, dressing, and other essential tasks.
- **Industrial Applications:** Robotic arms can automate palletizing (stacking goods), reducing labour costs and injury risks.

Conclusion

Robotic prosthetic limbs represent a major advancement in assistive technology, significantly improving the lives of amputees by restoring functionality, mobility, and independence. With ongoing innovations in sensor technology and intelligent control systems, the field continues to evolve, offering better solutions for amputees worldwide.

ENGINEERING SOLUTIONS FOR PARKINSON'S DISEASE:

Parkinson's disease is a progressive disorder that affects the nervous system and parts of the body controlled by nerves. Symptoms start slowly and may include tremors, stiffness, or slowing of movement. These symptoms are caused by a loss of neurons in the brain that produce dopamine, a chemical messenger that helps control movement.

While Parkinson's disease cannot be cured, medications can help control symptoms. In more advanced cases, surgery may be an option. Lifestyle changes, such as regular aerobic exercise, can also help manage the disease.

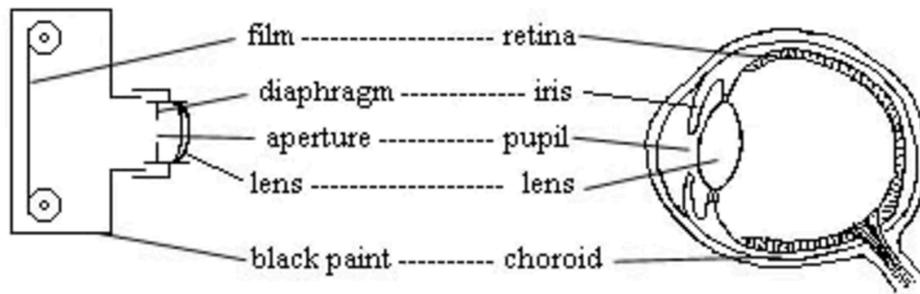
ENGINEERING SOLUTIONS ARE AS FOLLOWS:

Deep Brain Stimulation (DBS):

- Surgical procedure involving implantation of a device (neurotransmitter) in specific brain areas.
- Device sends electrical impulses to reduce Parkinson's symptoms like tremors, rigidity, and slowness of movement.

Medications for Parkinson's:

- Levodopa, dopamine agonists, enzyme inhibitors, anticholinergic drugs, and amantadine.



- Each medication works differently to manage symptoms.

Engineering

Neurons for Parkinson's:

- Transplanting embryonic neurons into the brain to replace damaged ones.
- Promising but limited by the availability of human embryonic tissue.

Creating Neurons from Mouse Cells:

- Mouse cells transformed into neurons using a transcription factor.
- Co-culturing with astrocytes to develop dopaminergic neurons.
- Engineered neurons can release dopamine and maintain characteristics after transplantation.

EYE AS A CAMERA SYSTEM:

The human eye is a wonderful instrument, relying on refraction and lenses to form images. There are many similarities between the human eye and a camera. A diaphragm to control the amount of light that gets through to the lens. This is the shutter in a camera, and the pupil at the center of the iris, in the human eye. A lens to focus the light and create an image. The image is real and inverted. In camera, film is used to record the image; in the eye, the image is focused on the retina, and a system of rods and cones is the end of an image-processing system that converts the image to electrical impulses and sends the information along the optic nerve to the brain. The human eye can be analogized to a camera system, as both the eye and a camera capture light and convert it into an image.

The main components of the eye that correspond to a camera system include:

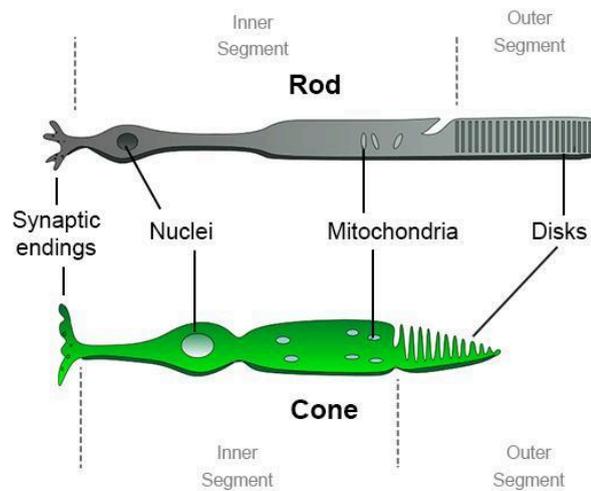
- **The Cornea:** This transparent outer layer of the eye functions like a camera lens, bending light to focus it onto the retina.
- **The Iris:** The iris functions like the diaphragm in a camera, controlling the amount of light that enters the eye.
- **The Pupil:** The pupil functions like the aperture in a camera, adjusting the size to control the amount of light entering the eye.
- **The Retina:** The retina functions like the camera film or sensor, capturing the light and converting it into electrical signals that are sent to the brain.

- **The Optic Nerve:** The optic nerve functions like the cable connecting the camera to a computer, transmitting the electrical signals from the retina to the brain.
- In both the eye and a camera, the captured light is transformed into an image by the lens and the light-sensitive component.
- The eye processes the image further, allowing for visual perception, while a camera stores the image for later use.

ROD AND

Imagine the back of your eye. The most important part of colorful vision lies in an even tinier area called the macula. Both the macula and fovea are light-sensitive.

These cells are the key players in converting light into electrical signals that your brain interprets as vision.



ARCHITECTURE OF CONE CELLS:

The retina is like a projector screen at the back of your eye. The most important part of that screen, responsible for sharp, colorful vision, is the macula. Right in the center of the macula is a tiny spot called the fovea. This is the area where you see fine details and colors. The macula and fovea are packed with special cells called photoreceptors. These are the key players in converting light into electrical signals that your brain interprets as vision.

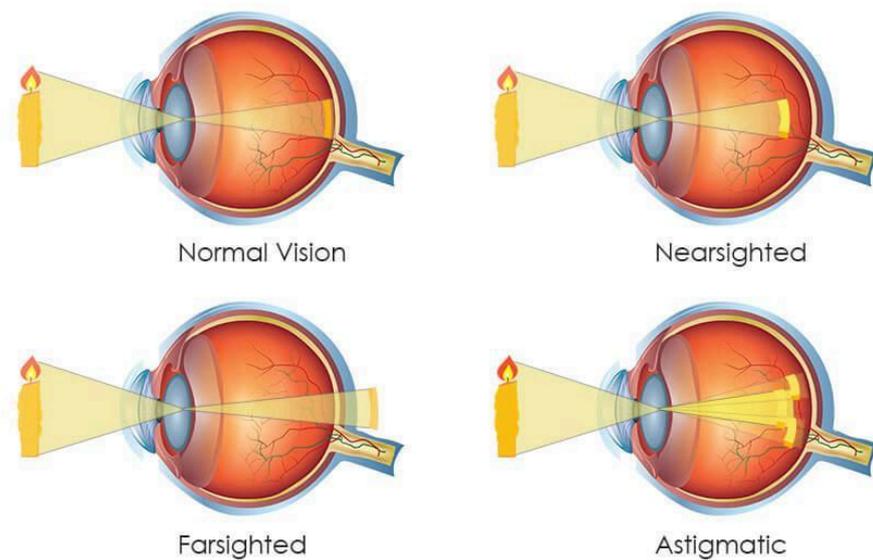
Photoreceptors in the retina are classified into two groups, named after their physical morphologies.

Rods:

- Highly sensitive to light, functioning in night vision.
- Responsible for scotopic vision, allowing vision in low-light conditions.
- Do not mediate color vision and have low spatial acuity.
- Structurally compartmentalized into five regions: outer segment, connecting cilium, inner segment, nuclear region, and synaptic region.

Cones:

- Active in higher light levels, responsible for photopic vision.
- Enable color vision and have high spatial acuity.
- Populate the central fovea exclusively.
- Three types of cones: short-wavelength sensitive cones (S-cones), middle-wavelength sensitive cones (M-cones), and long-wavelength sensitive cones (L-cones).
- Sensitive to different wavelengths of light, allowing perception of a wide spectrum of colors and detailed images in bright light.



OPTICAL

CORRECTIONS:

Optical corrections refer to devices or techniques used to improve or correct vision problems caused by a refractive error in the eye.

Vision Process Overview:

- Light enters the eye and hits the retina.
- Retina sends nerve signals to the optic nerve.
- Optic nerve transmits signals to the brain for processing into images.

Refractive Errors and Vision Problems:

- Refractive errors occur when light bends incorrectly, leading to blurry vision.
- Correcting refractive errors is a form of vision correction.

There are several types of refractive errors, including:

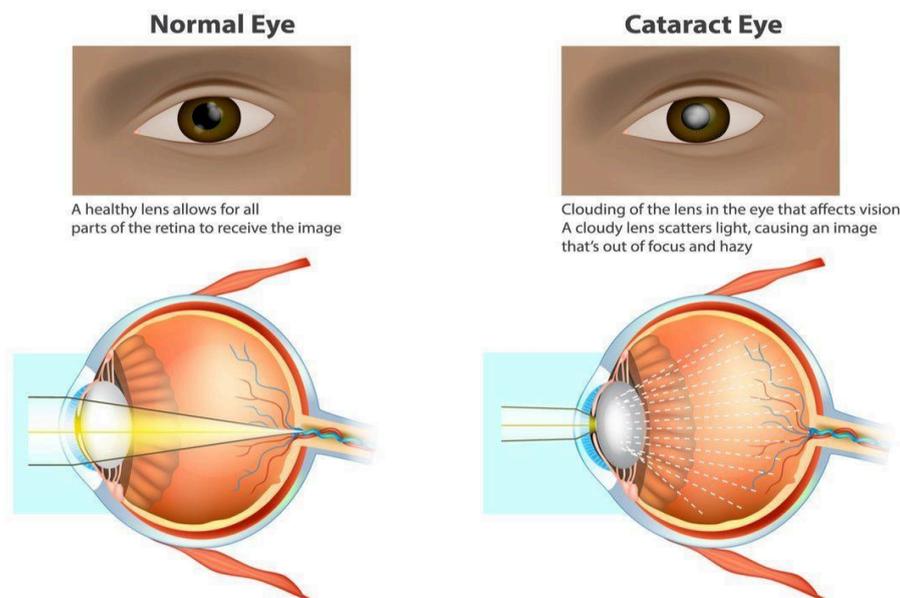
- Myopia (nearsightedness): Light is focused in front of the retina, making distant objects appear blurry.
- Hyperopia (farsightedness): Light is focused behind the retina, making near objects appear blurry.
- Astigmatism: Light is not focused evenly on the retina, leading to blurred or distorted vision.

Types of Vision Correction:

- Eyeglasses and optical lenses are common corrective measures.
- They provide basic vision correction but do not control the progression of refractive errors.

Long-Term Solutions:

- Patients with worsening vision may need new glasses or contacts.
- Longer-term solutions are needed for progressive refractive errors.



CATARACT: A cataract is a clouding of the normally clear lens of the eye.

Function of the Lens:

- The lens is located behind the iris (colored part of the eye) and focuses light that enters the eye.
- It helps produce clear, sharp images on the retina, which is the light-sensitive membrane in the eye.

Progression of Cataracts:

- Initially, cataracts may only affect a small part of the lens, causing minimal vision loss.
- As cataracts grow larger, they cloud more of the lens and distort light passing through, leading to more noticeable symptoms.

Impact on Vision:

- Clouding of the lens by a cataract can cause vision to become blurry or cloudy.
- This cloudiness interferes with the focusing of light onto the retina, affecting vision clarity.

Progression of Cataracts:

- As cataracts develop, the clouding becomes denser, scattering and blocking light passing through the lens.
- This prevents a sharply defined image from reaching the retina, resulting in blurred vision.
- Cataracts typically develop in both eyes, but one eye may be more affected than the other, leading to differences in vision between eyes.

Types of Cataracts:

- Cataracts can be partial or complete, stationary or progressive, hard or soft.
- The main types of age-related cataracts are nuclear sclerosis, cortical, and posterior subcapsular.

Nuclear Sclerosis:

- Nuclear sclerosis is the most common type of cataract, affecting the central or nuclear part of the lens.
- It causes the lens nucleus to become hard or sclerotic, with the deposition of brown pigment.
- In advanced stages, it is known as brunescant cataract.
- Early stages of nuclear sclerosis may cause a myopic shift, temporarily improving near vision in presbyopic patients (second sight).

LENS MATERIALS:

- Corrective spherocylindrical lenses treat refractive errors like myopia, hyperopia, presbyopia, and astigmatism.
- Lenses and prisms can improve eye alignment and treat double vision (diplopia) in strabismus.
- Eyeglasses protect the eyes from physical trauma and harmful radiation.
- Lenses can be made from optical glass, crystals, or plastics and designed for specific applications.
- Key properties include refractive index, Abbe number (chromatic dispersion), specific gravity, and ultraviolet absorption.
- Lens materials help correct refractive errors such as nearsightedness, farsightedness, astigmatism, or presbyopia.

Types of lens materials:

1. **CR-39:** Developed as a replacement for glass lenses during World War II, CR-39 is a plastic lens material that remains popular due to its light weight, good optical properties, and ability to tint well. However, it is thicker than other materials and prone to scratching.
2. **Crown Glass:** This is the most commonly used clear glass for ophthalmic lenses, known for its durability. It is mainly used for single vision lenses and the distance carrier for glass bifocals and trifocals. It has a refraction index of 1.523, an abbe value of 59, and blocks about 10% of UV light.
3. **Flint Glass:** Utilizing lead oxides to increase its refraction index, flint glass has an index of refraction ranging from 1.58 to 1.69. It is relatively soft, has a brilliant luster, and exhibits chromatic aberration. Its use today is limited to segments for some fused bifocals due to its weight and susceptibility to impact.
4. **Polycarbonate Lenses:** Originally developed for safety devices, polycarbonate lenses are highly impact-resistant and moldable under heat. They offer excellent durability and are lighter than

BIONIC

Bionic known as

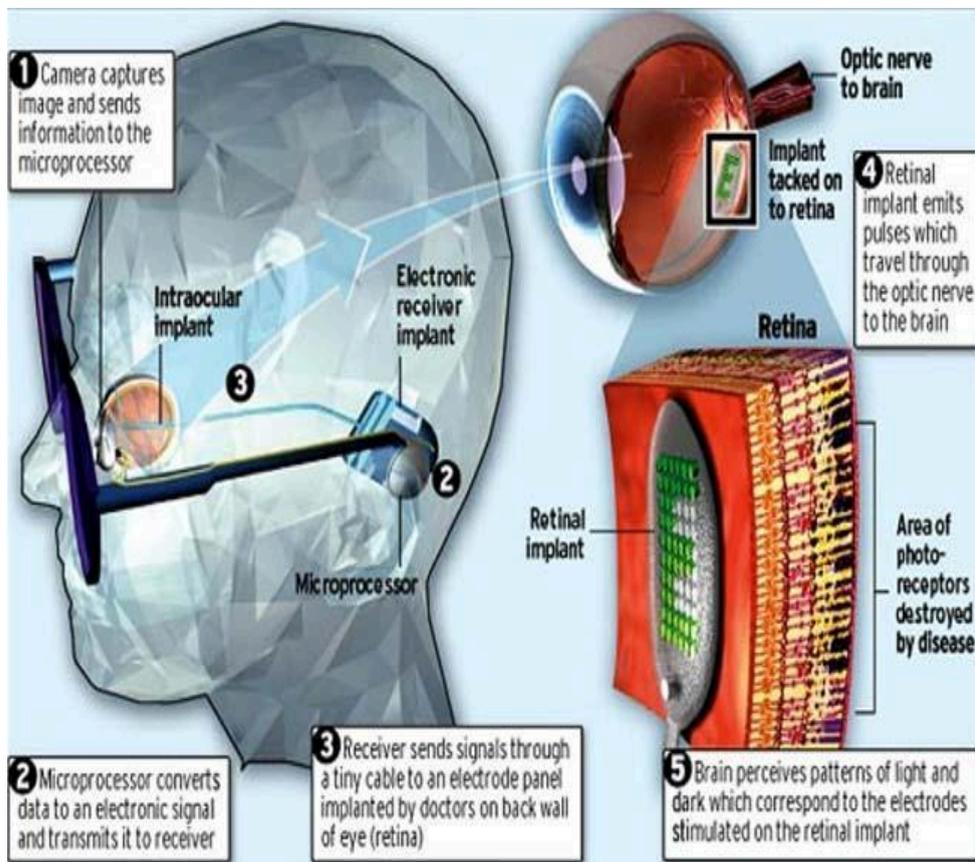
are a

offering

with

These to restore visual bypassing

retinal cells and directly stimulating the remaining healthy cells.



but crown glass heavier than CR-39.

EYES:

eyes, also visual prostheses, remarkable technological advancement hope to individuals severe retinal degeneration. devices aim some level of perception by damaged

How it Works:

The bionic eye system has two main components:

- **External System:** A miniature camera mounted on eyeglasses captures visual information from the environment. This information is then processed and converted into electrical signals. (Current models typically don't use high-frequency radio waves for data transmission.)
- **Internal Implant:** A microchip containing an electrode array, often made up of around 3,500 **micro photodiodes**, is surgically implanted onto the retina. These miniature solar cells act as artificial photoreceptors, converting light directly into electrical signals. The implant receives additional electrical signals from the external system for further processing.

Stimulating Vision:

The electrical stimulation from the implant triggers the healthy retinal cells, mimicking the natural process of light transduction (converting light into electrical signals). These signals are then relayed through the optic nerve to the brain, creating a rudimentary sense of vision.

Limitations and Future Prospects:

Bionic eye technology is still under development. While it doesn't restore perfect vision, it can provide some level of light perception and even allow users to distinguish shapes and objects. The technology is expensive and requires further research to improve its effectiveness and affordability.

HEART AS A PUMP SYSTEM:

The heart functions as a double pump, circulating blood throughout the body. The right-side pumps deoxygenated blood to the lungs, while the left side pumps oxygenated blood to the body.

Structure and Function

Heart Section	Heart Section
Right Atrium	Receives deoxygenated blood from the body through the superior and inferior vena cava.
Right Ventricle	Pumps blood to the lungs through the pulmonary artery for oxygenation.
Left Atrium	Receives oxygenated blood from the lungs through the pulmonary veins.
Left Ventricle	Pumps oxygen-rich blood to the body through the aorta.

Blood Flow Through the Heart

1. Deoxygenated blood from the body enters the right atrium via the vena cava.
2. It flows through the tricuspid valve into the right ventricle.
3. The right ventricle pumps blood through the pulmonic valve into the pulmonary artery, which carries blood to the lungs.
4. In the lungs, blood picks up oxygen and releases carbon dioxide.
5. Oxygenated blood returns to the left atrium via the pulmonary veins.
6. It passes through the mitral valve into the left ventricle.

7. The left ventricle pumps blood through the aortic valve into the aorta, which distributes it throughout the body.
8. Blood returns to the right atrium via the vena cava, and the cycle repeats.

Key Facts About the Heart

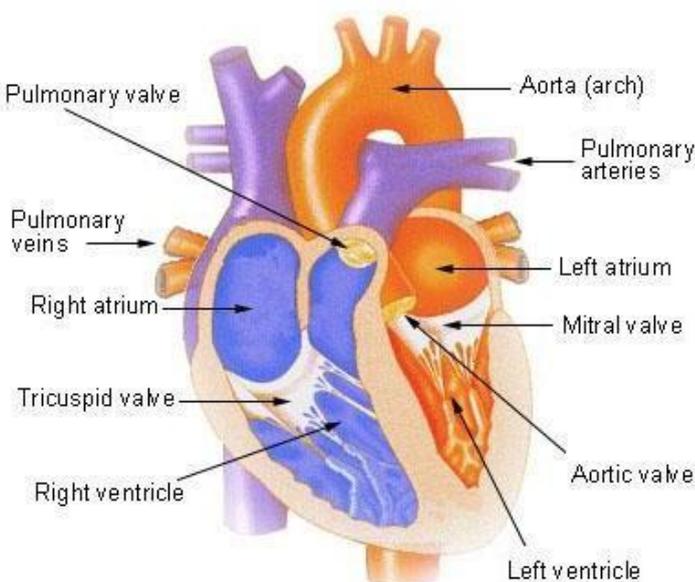
- The heart beats 70-80 times per minute in a healthy individual.
- It is strong enough to pump blood up to 30 feet in distance.
- The pulmonary circulation involves pumping blood to the lungs for oxygenation.
- The systemic circulation delivers oxygenated blood to the body.
- Regular physical activity improves heart efficiency.

Heart Assist Devices

- **Left Ventricular Assist Device (LVAD):** Uses thick tubes and an external pump to assist the heart.

- **Percutaneous**
smaller tube
directly into

Internal View of the Heart



Heart Pumps: Uses a smaller tube inserted via a catheter directly into the heart chambers.

ELECTRICAL SIGNALING:

Pacemaker: The sinus node, located in the right atrium, is the heart's natural pacemaker.

Impulse Generation: It generates electrical impulses regularly, 60-100 times per minute under normal conditions.

Atrial Activation: This electrical signal spreads through the heart, causing the atria to contract first.

Ventricular Contraction: The signal travels down specialized pathways, triggering the ventricles to contract.

Blood Pumping: Ventricular contraction pumps blood out of the heart.

ECG MONITORING:

Electrocardiography (ECG) is a quick and widely accessible method for diagnosing cardiovascular diseases. Over the years, ECG monitoring systems have evolved due to advancements in smart

technologies, including IoT, edge computing, and mobile computing.

These systems are now used in hospitals, homes, outpatient clinics, and remote healthcare settings. The availability of portable ECG devices has significantly improved heart health monitoring and early detection of abnormalities.

Applications of ECG Monitoring

ECG monitoring serves multiple purposes:

1. **Disease Diagnosis & Control** – Detects irregular heart rhythms and other cardiac conditions.
2. **Daily Activity & Sports Monitoring** – Used by athletes and fitness enthusiasts to track heart performance.
3. **Wearable & Smart Devices** – Smartwatches and mobile health applications enable continuous ECG tracking.

Challenges in ECG Monitoring

One of the biggest challenges in ECG monitoring is the diversity of technologies and data processing methods. This makes it difficult to develop a unified ECG classification system.

Existing studies often focus on specific areas, such as wearable sensors, disease diagnosis, or heartbeat detection. However, a comprehensive, expert-verified system is needed to improve ECG analysis, classification, and interpretation.

ECG Classification & AI Integration

Traditional ECG Classification

In traditional ECG analysis, signal preprocessing techniques such as wavelet transform and manual feature extraction are used. However, these methods increase computational load and delay real-time classification, making them less efficient for immediate medical use.

Deep Learning in ECG Analysis

Recently, Deep Neural Networks (DNNs) have been introduced for automatic feature learning from ECG data. Unlike traditional methods, DNN-based models can analyze ECG signals without extensive preprocessing.

Advantages of DNN-based ECG analysis:

- Eliminates complex signal preprocessing steps.
- Improves accuracy as training data increases.
- Supports real-time monitoring & early detection of heart conditions.

AI in Heart Failure (HF) Detection

Artificial Intelligence (AI) has also been applied in detecting heart failure (HF) and other cardiac disorders. AI-based ECG analysis can assist in early identification, reducing the likelihood of misdiagnosis.

Some benefits of AI-powered ECG analysis include:

- Automated ECG interpretation, minimizing human error.
- Faster and more accurate diagnosis of heart conditions.
- Integration with wearable devices for continuous heart health monitoring.

ECG in Healthcare & Future Trends

According to the World Health Organization (WHO), 18 million people die annually due to heart disease worldwide. As heart disease becomes more prevalent, ECG monitoring is becoming a vital tool for preventing cardiac emergencies.

The rise of wearable ECG devices allows individuals to monitor their heart health from home. However, managing large amounts of ECG data remains a challenge for both healthcare professionals and medical systems.

By integrating ECG monitoring with AI, healthcare providers can enhance early detection, diagnosis, and treatment of heart diseases, ultimately saving more lives.

REASONS FOR BLOCKAGES OF BLOOD VESSELS:

What is CAD?

- A common heart condition where the coronary arteries struggle to supply enough blood, oxygen, and nutrients to the heart muscle.

Causes of CAD:

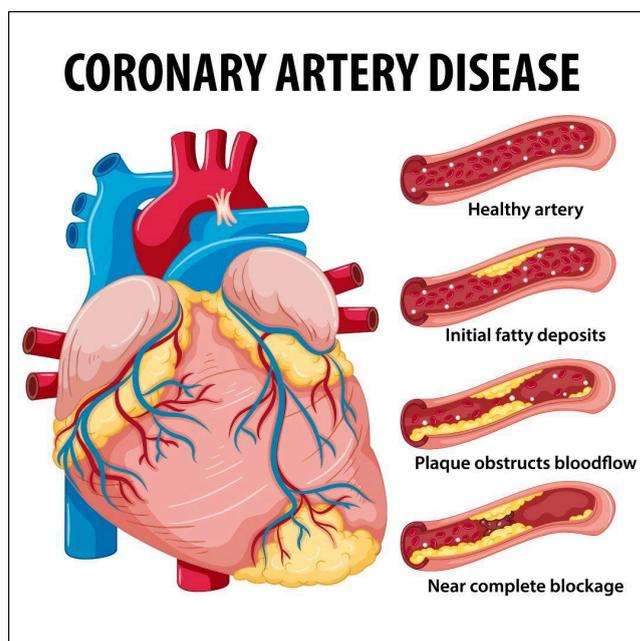
- **Atherosclerosis:** Build-up of plaque (fats, cholesterol, other substances) on the inner walls of coronary arteries.
- **Plaque Buildup:** Narrowing of arteries, restricting blood flow.
- **Plaque Rupture:** Can lead to blood clot formation, further blocking blood flow.

Risk Factors for CAD (besides high cholesterol):

- Diabetes or insulin resistance
- High blood pressure
- Sedentary lifestyle (lack of exercise)
- Smoking or tobacco use

Symptoms of CAD (occur when heart doesn't get enough oxygen-rich blood):

- Chest pain (angina)
- Shortness of breath
- **Complete blockage:** Can cause a heart attack



DESIGN OF STENTS:

A stent is a small, expandable tube inserted into a narrowed artery to keep it open. Imagine it like a tiny scaffold that holds the artery open from the inside, ensuring a clear passage for blood flow. Most stents are made of wire mesh, but some variations exist:

- **Wire Mesh Stents:** These are the most common type, typically permanent.
- **Stent Grafts:** These larger fabric tubes are used for wider arteries.
- **Dissolving Stents:** These are coated with medication and slowly dissolve over time, leaving the artery unobstructed. The medication helps prevent future blockages.

Why are stents used?

Stents are particularly useful for treating coronary artery disease (CAD), where plaque buildup narrows arteries supplying blood to the heart. This restricted blood flow can lead to:

- **Chest pain (angina):** Occurs when the heart muscle doesn't receive enough oxygen-rich blood.
- **Heart attack:** A complete blockage of blood flow to a part of the heart muscle.

How do stents help?

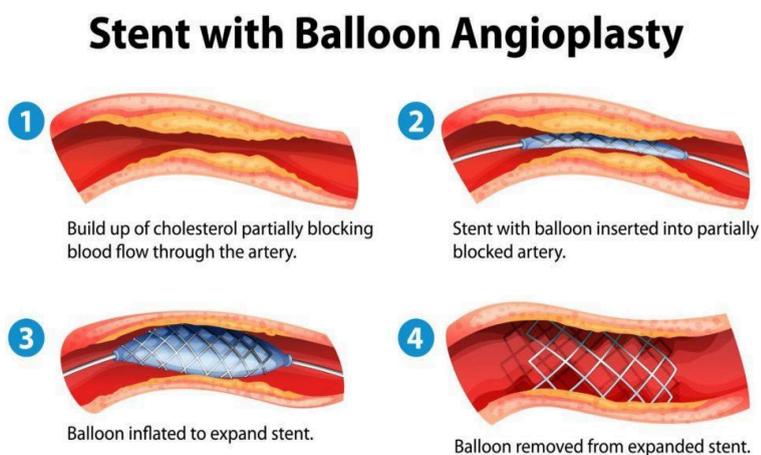
By keeping the artery open, stents can:

- Reduce chest pain (angina)
- Improve blood flow to the heart
- Reduce the risk of heart attack

Stent Insertion Procedure:

Stent insertion is usually a minimally invasive procedure:

1. **Small Incision:** The doctor makes a small cut in your body.
2. **Catheter Insertion:** A thin, flexible tube (catheter) is inserted into the artery and guided to the blockage using specialized tools and imaging techniques (angiogram).
3. **Stent Placement:** The stent is compressed onto a balloon at the tip of the catheter. Once positioned, the balloon inflates, expanding the stent and pushing against the artery wall to hold it open.
4. **Stent Release and Closure:** The balloon is deflated, leaving the stent in place. The catheter and other tools are removed, and the incision is closed.



PACE MAKERS:

A pacemaker is a small medical device implanted in the chest to regulate your heartbeat. It acts like a tiny conductor, ensuring your heart beats at a proper, stable rhythm, especially when it's beating too slowly.

Types of Pacemakers:

Pacemakers come in different configurations depending on the specific heart rhythm problem:

- **Single-chamber pacemaker:** Most common type, sends electrical impulses to the right ventricle (lower heart chamber) to stimulate contractions.
- **Dual-chamber pacemaker:** Sends impulses to both the right ventricle and atrium (upper heart chamber) to improve coordination between chamber contractions.
- **Biventricular pacemaker:** Used for heart failure patients with irregular heartbeats. Stimulates both lower chambers (right and left ventricles) for more efficient heart function.

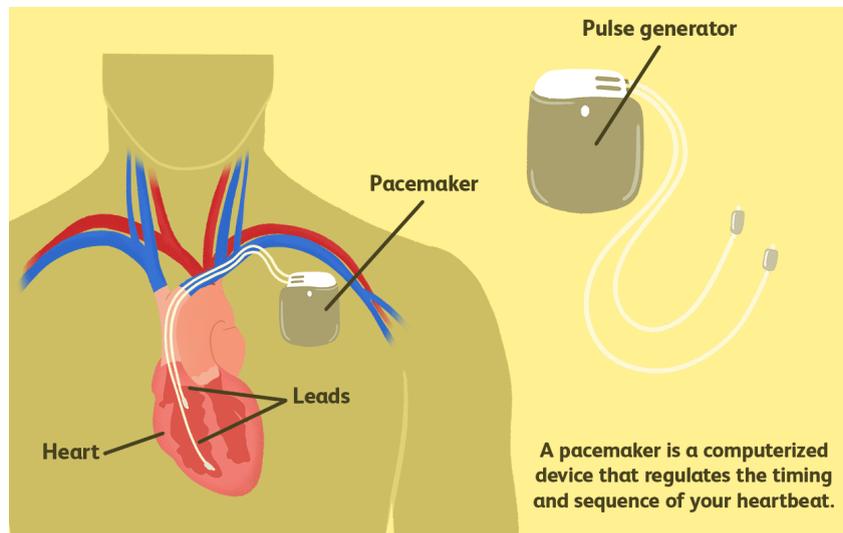
Temporary vs. Permanent Pacemakers:

- **Temporary pacemakers:** Used for short-term situations where the heart is expected to recover, such as after a heart attack, surgery, or medication overdose.
- **Permanent pacemakers:** Implanted for chronic slow or irregular heartbeats, or to manage heart failure.

How Pacemakers Work:

Pacemakers are smart devices that only intervene when needed. Here's the process:

1. **Monitoring Heartbeat:** The pacemaker constantly monitors your heart rate.
2. **Stimulating the Heart:** If the heartbeat falls below a certain rate, the pacemaker sends electrical signals to the heart muscle through electrodes to correct the rhythm.



3. **Activity-Responsive Pacemakers:** Some newer models have sensors that detect activity levels or breathing rate. These pacemakers can adjust the heart rate to meet the increased demands of exercise.

Pacemaker Components:

A pacemaker typically consists of two main parts:

- **Pulse Generator:** A small metal container housing the battery and circuitry that controls the electrical pulses sent to the heart.
- **Leads (electrodes):** Flexible insulated wires placed in the heart chambers to deliver the electrical signals and adjust the heart rate. However, some newer pacemakers, called leadless pacemakers, are implanted directly into the heart muscle, eliminating the need for leads.

DEFIBRILLATORS:

A defibrillator is a life-saving device that delivers an electric shock to the heart to restore a normal heartbeat. It's used to treat arrhythmias, irregular heart rhythms that are either too slow or too fast. In severe cases, defibrillators can also restart a heart that has completely stopped (cardiac arrest).

Types of Defibrillators:

Defibrillators come in different forms, each suited for specific situations:

- **Automated External Defibrillators (AEDs):** Portable, user-friendly devices found in public places. Even bystanders with no medical training can use them during cardiac emergencies. AEDs analyze the heart rhythm and deliver a shock if needed.

Public Access



AED

- automatic
- external
- portable
- battery-operated

Personal Devices



ICD

- implant
- Rx



WCD

- external
- wearable
- Rx

Professional Devices



ALS

- professional
- Rx

- **Implantable Cardioverter Defibrillators (ICDs):** These are surgically implanted devices placed inside the chest or abdomen. They continuously monitor heart rhythm and deliver shocks to correct arrhythmias.
- **Wearable Cardioverter Defibrillators (WCDs):** These vest-like devices are worn under clothing. They have sensors on the skin that monitor heart rhythm and deliver shocks if necessary. Similar to ICDs, WCDs can deliver low-energy shocks to regulate heart rate or high-energy shocks for defibrillation.

How Defibrillators Work:

The core function of all defibrillators is the same:

1. **Heart Rhythm Monitoring:** The device continuously monitors the heart's electrical activity.
2. **Shock Delivery (if needed):** If an abnormal rhythm is detected (arrhythmia or cardiac arrest), the defibrillator delivers an electrical shock to disrupt the irregular rhythm and allow the heart to re-establish a normal heartbeat.

LUNGS AS A PURIFICATION SYSTEM:

Every cell in our body needs oxygen to survive. The air we breathe contains oxygen and other gases, and the respiratory system plays a vital role in moving fresh air into our body while removing waste gases.

Once oxygen enters the lungs, it is transferred into the bloodstream and carried throughout the body. At the cellular level, oxygen is exchanged for a waste gas called carbon dioxide. The bloodstream then carries carbon dioxide back to the lungs, where it is removed from the body through exhalation. This automatic process is known as gas exchange.

Functions of the Respiratory System

In addition to gas exchange, the respiratory system performs several other important functions, including:

1. **Regulating Air Temperature & Humidity** – Ensuring that the air we breathe is at the right temperature and moisture level.
2. **Protecting the Body from Harmful Substances** – This is achieved through coughing, sneezing, filtering, or swallowing unwanted particles.
3. **Supporting the Sense of Smell** – The respiratory system helps in detecting and identifying different scents.

Lungs and Blood Purification

The lungs help purify the blood by exchanging gases. Arteries carry oxygen-rich blood from the heart to different parts of the body, while veins return oxygen-depleted blood back to the heart.

When we inhale, oxygen from the air comes in contact with impure blood in the lungs. The blood absorbs oxygen and releases waste gases, such as carbon dioxide in the form of carbonic acid. This purified blood is then carried back to the heart by the veins, ensuring that the body receives the oxygen it needs to function properly.

The Lung as an Air Purification System

The lungs not only purify blood but also clean the air we breathe by removing harmful substances and adding oxygen to the bloodstream. This process involves three main steps:

1. **Filtration:** The nose and mouth act as the first line of defence against harmful particles such as dust, dirt, and bacteria. Tiny hairs in the nose, called cilia, along with mucus produced by the respiratory system, trap these particles and prevent them from entering the lungs.
2. **Moisturization:** As air travels through the respiratory tract, it is humidified by the moist lining of the airways. This helps prevent the airways from drying out and ensures smooth airflow.
3. **Gas Exchange:** When the air reaches the alveoli (tiny air sacs in the lungs), oxygen diffuses into the bloodstream through the alveolar and capillary walls, while carbon dioxide moves in the opposite direction to be exhaled. This exchange ensures that fresh oxygen enters the bloodstream while waste carbon dioxide is removed from the body.

Architecture of the Lungs

Lung Parenchyma and Structure

The lung parenchyma is primarily composed of numerous air-containing passages and fine structures such as alveolar ducts, alveoli, alveolar septa, and small pulmonary vessels. These structures together make up 10% of the total parenchymal volume.

While the primary function of the lungs is gas exchange, they also perform several important non-respiratory functions that contribute to overall physiological balance.

Non-Respiratory Functions of the Lungs

Apart from breathing, the lungs play a crucial role in:

1. **Acting as a Blood Reservoir** – The lung's ability to expand and regulate pulmonary vasculature helps fine-tune the preload to the left heart, optimizing cardiac output.
2. **Filtering Emboli** – The lungs act as a filter against both endogenous (from within the body) and exogenous (from external sources) emboli, preventing them from entering the systemic circulation.
3. **Defensive Barrier** – The pulmonary epithelium forms the first line of defence against inhaled particles, preventing harmful substances from reaching deeper lung structures.
4. **Metabolic Functions** – Pulmonary endothelial cells are responsible for uptake, metabolism, and biotransformation of various exogenous and endogenous substances.
5. **Influencing Drug Absorption** – While the lung's metabolic capacity can become easily saturated, the binding of certain drugs by pulmonary endothelial cells affects their pharmacokinetics, influencing how they are processed in the body.

Lung Architecture and Airway Divisions

The lungs are designed to maximize surface area for efficient gas exchange. The main components of the lung structure include:

1. Trachea

The trachea (windpipe) serves as the main airway, connecting the larynx (voice box) to the lungs. It is lined with cilia and mucus-secreting glands, which help trap harmful substances and prevent them from reaching the lungs.

2. Bronchi

The trachea divides into two main bronchi, with each bronchus leading to one lung. These larger airways then continue branching into smaller airways called bronchioles.

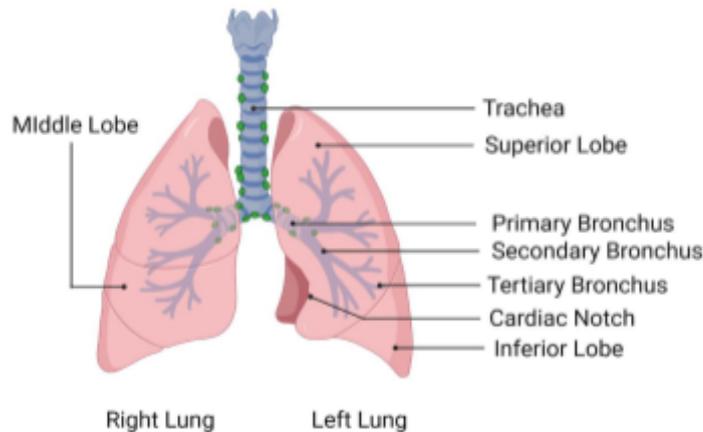
3. Bronchioles

The bronchioles are the smaller branches of the bronchi that direct air towards the alveoli. They are surrounded by tiny air sacs known as alveoli, which serve as the primary sites for gas exchange.

4. Alveoli

The alveoli are tiny, thin-walled air sacs, densely surrounded by capillaries. Their close proximity to capillaries allows for the rapid diffusion of oxygen into the blood and the removal of carbon dioxide from the bloodstream into the alveoli, where it is exhaled.

Structure of Lungs



GAS EXCHANGE MECHANISMS:

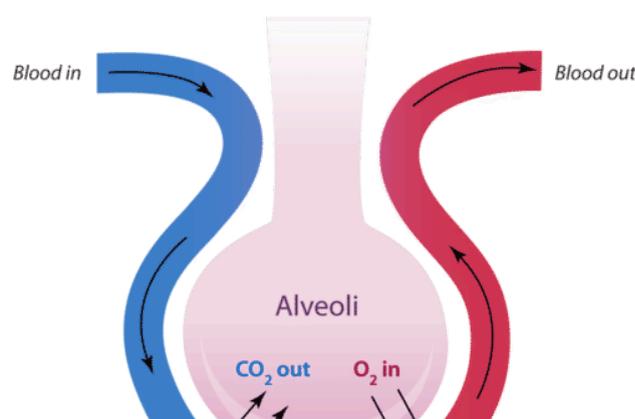
The Journey of Air:

1. **Entry Point:** Air enters through the mouth or nose.
2. **Throat:** It travels down the pharynx (throat).
3. **Voice Box:** It passes through the larynx (voice box).
4. **Windpipe:** It enters the trachea, a sturdy tube with cartilage rings to prevent collapsing.
5. **Branching Out:** Inside the lungs, the trachea splits into left and right bronchi.
6. **Getting Smaller:** These bronchi further divide into even smaller tubes called bronchioles.
7. **Air Sacs:** The tiniest bronchioles end in clusters of microscopic air sacs known as alveoli.

The Gas Exchange Mechanism:

- **Diffusion:** In the alveoli, a vital process called diffusion takes place.
- **Oxygen In, Carbon Dioxide Out:** Due to differences in pressure, oxygen from the air in the alveoli moves (diffuses) into the bloodstream. Meanwhile, carbon dioxide from the blood travels in the opposite direction, diffusing into the air sacs to be exhaled.
- **Pressure Gradients:** This movement happens because of partial pressure differences.
 1. **Oxygen:** The air in the alveoli has higher oxygen pressure than the blood, causing oxygen to move into the bloodstream.
 2. **Carbon Dioxide:** The blood has higher carbon dioxide pressure than the air in the alveoli, causing it to move out.
- **Haemoglobin's Role:** Oxygen in the bloodstream binds to haemoglobin in red blood cells, forming oxyhaemoglobin for transport throughout the body. This entire process ensures our bodies receive the life-sustaining oxygen they need while eliminating waste carbon dioxide.

Pulmonary Gas Exchange



SPIROMETRY:

Introduction

Spirometry (spy-ROM-uh-tree) is a common diagnostic test used to assess lung function by measuring:

- The amount of air inhaled.
- The amount of air exhaled.
- The speed of exhalation.

It is widely used to diagnose asthma, chronic obstructive pulmonary disease (COPD), and other respiratory conditions that affect breathing.

History:

Spirometry was introduced 175 years ago by John Hutchinson, building on nearly two centuries of development of lung function measurement devices.

Types of Spirometers

Spirometers are classified into two main categories:

1. **Volume-Measurement Devices**
 - Example: Wet and dry spirometers.
2. **Flow-Measurement Devices**
 - Example: Pneumotachograph systems, mass flow meters.

Principle of Spirometry

Spirometry measures the volume of air exhaled from the lungs within a specific time period.

This helps assess how efficiently the lungs can move air in and out, aiding in diagnosing lung function abnormalities.

How Spirometry Works

- Spirometry is performed using a spirometer, a device consisting of:
 - A mouthpiece
 - A flow sensor
 - A volume sensor
- The patient is instructed to exhale as forcefully as possible into the spirometer.
- The device records the volume and flow rate of the exhaled air.
- The data is displayed on a flow-volume loop graph, which provides key insights into lung function.

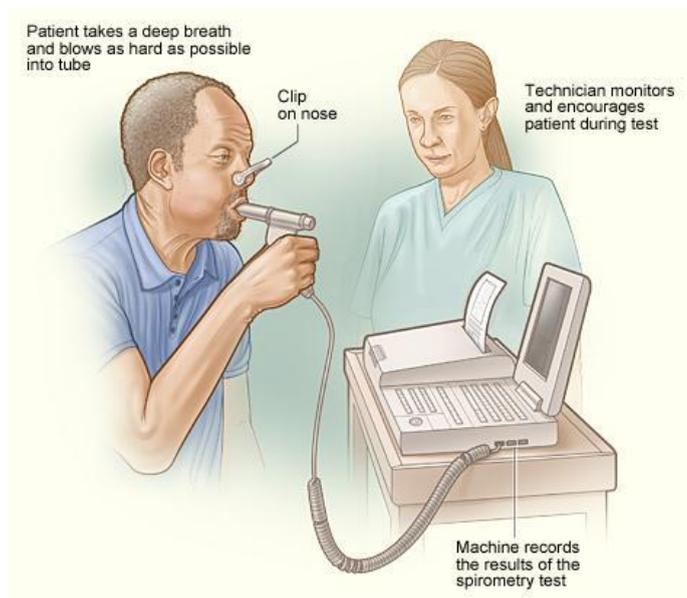
Interpreting

The results help function or conditions.

- A decrease flow rate restriction asthma or

Requirements of
For accuracy and must:

1. Measure for at least (adjusted to body temperature and pressure).
2. Measure (adjusted to body temperature and pressure).
3. Have an accuracy of at least $\pm 3\%$ (or ± 0.05 L) for flow rates between 0-14 L/s.
4. Maintain airflow resistance ≤ 1.5 cm H₂O per L/s (or 0.15 kPa per L/s) at 14 L/s flow rate.



Spirometry Results

determine normal lung identify respiratory

in exhaled air volume or may indicate airway due to conditions such as COPD.

an Acceptable Spirometer
reliability, a spirometer

1. Accumulate volume ≥ 15 seconds.
volume of at least ≥ 8 L

Calculating Normal Respiration Rate Using a Spirometer

The **FEV₁/FVC Ratio (FEV₁%)** is calculated as:

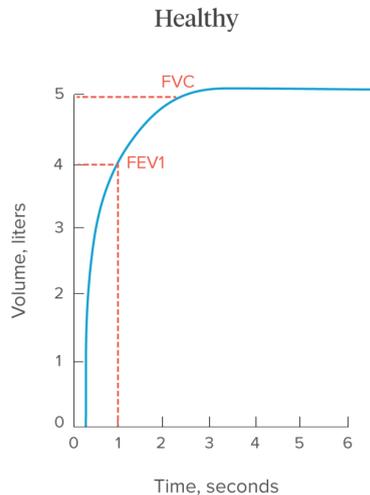
$$FEV_1\% = (FEV_1/FVC) \times 100$$

Where:

- **FEV₁ (Forced Expiratory Volume in 1 second)** → The volume of air exhaled in the first second.
- **FVC (Forced Vital Capacity)** → The total volume of air exhaled forcefully after a deep breath.
- **Measured Column** → Displays the absolute (numerical) ratio.
- **Predicted Column** → Displays the ratio as a percentage of the expected value for a person of the same age, gender, and height.

Normal Range

In healthy adults (same gender, height, and age), the normal predicted FEV₁% should be between 70% and 85%.



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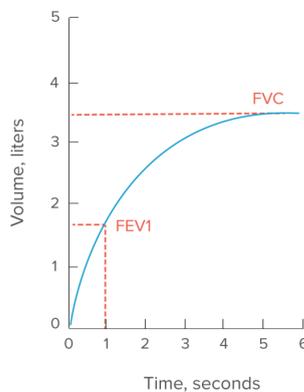
ABNORMAL LUNG PHYSIOLOGY:

Percentages lower than 70% are considered abnormal. This is a crucial measurement because obstructive diseases such as COPD, chronic bronchitis, and emphysema increase airway resistance, leading to FEV₁% values between 45% and 60%. In contrast, restrictive diseases like pulmonary fibrosis reduce both FEV₁ and FVC values, but the FEV₁% may remain within the normal range or even increase.

Chronic Pulmonary

- COPD is a disease that

Abnormal



Obstructive Disease (COPD):

chronic inflammatory lung makes breathing difficult.

- It's often caused by long-term exposure to irritants like cigarette smoke.

Emphysema and Chronic Bronchitis

- These two conditions, often occurring together, contribute to COPD.
- **Emphysema:** Damages air sacs (alveoli) in the lungs, reducing their elasticity and hindering airflow.
- **Chronic Bronchitis:** Inflames the airways, leading to excessive mucus production and airway narrowing.

Symptoms Often Appear Late

- Early COPD symptoms may be difficult to notice, worsening over time, especially with continued smoking.

Beware These Warning Signs:

- Shortness of breath, especially during activities
- Wheezing
- Chest tightness
- Chronic cough with mucus (sputum)
- Frequent respiratory infections
- Fatigue
- Unintended weight loss (later stages)
- Swollen ankles, feet, or legs

Diagnosis: Uncovering the Problem

- Doctors may use various tests to diagnose COPD, including:
 - Lung function tests (spirometry)
 - Chest X-ray
 - CT scan
 - Blood tests

Treatment Strategies: Managing Symptoms

- While there's no cure for COPD, medications can help manage symptoms and improve quality of life:
 - Bronchodilators: Relax muscles in airways to ease breathing.
 - Inhaled steroids: Reduce inflammation in the airways.
 - Antibiotics: Fight respiratory infections.

VENTILATOR:

Ventilators are machines that assist breathing by forcing air into and out of the lungs. They are used for patients with severe respiratory failure who are unable to breathe adequately on their own.

Settings and Modes:

Doctors and respiratory therapists adjust ventilator settings to control factors like:

- How often air is pushed into the lungs (frequency)

- Amount of air delivered (volume)
- Oxygen concentration in the air

Delivery Methods:

Air or oxygenated air is delivered through:

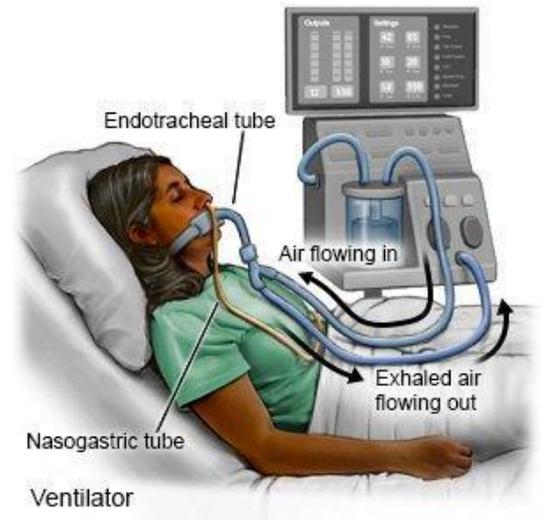
- **Face mask:** Non-invasive option for less severe cases.
- **Breathing tube:** Inserted through the mouth or nose for more serious situations.

Weaning from the Ventilator:

As the patient's condition improves, ventilator support is gradually reduced (weaning) until they can breathe independently.

Benefits and Risks:

- **Benefits:** Lifesaving for patients with respiratory failure.
- **Risks:**
 - Increased risk of pneumonia with prolonged use.
 - Discomfort or pain from the breathing tube.



Close Monitoring:

- Healthcare professionals meticulously monitor and manage ventilator use to:
 - Ensure adequate breathing support.
 - Minimize potential complications.

HEART LUNG MACHINE:

In open-heart surgery, a heart-lung machine (also called cardiopulmonary bypass machine) acts as a temporary substitute for the heart and lungs.

How it Works:

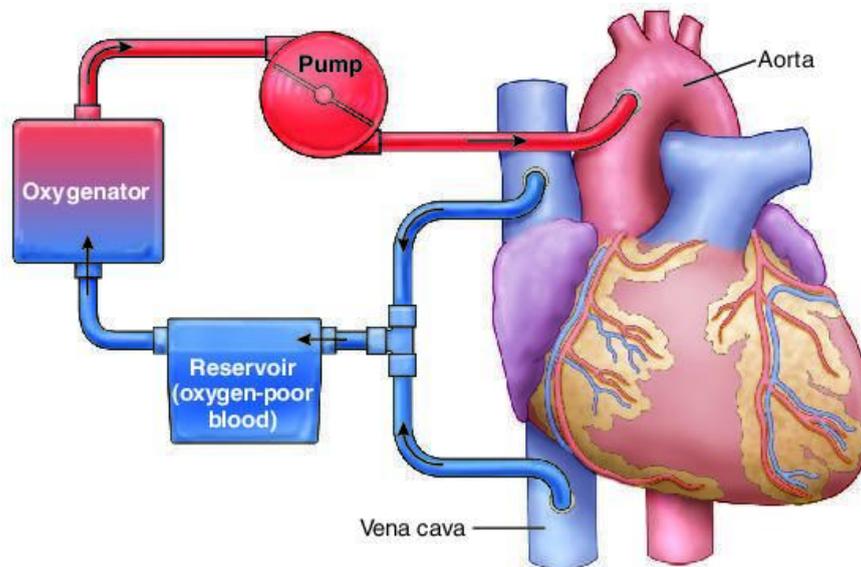
1. **Blood Removal:** Blood is drawn from the body through a tube.
2. **Oxygenation:** The machine removes carbon dioxide and adds oxygen to the blood, mimicking the function of the lungs.
3. **Circulation:** A pump, acting like the heart, keeps the blood circulating throughout the body.
4. **Blood Return:** The oxygenated blood is then pumped back into the body.

Benefits of a Heart-Lung Machine:

- **Surgical Freedom:** By taking over the functions of the heart and lungs, the machine allows surgeons to operate on a still heart, providing a clear and stable surgical field.
- **Complex Procedures Made Possible:** This technology has revolutionized heart surgery, enabling more intricate procedures with improved patient outcomes.

Potential Risks and Considerations:

- **Blood Clots:** The process of circulating blood outside the body can increase the risk of blood clot formation.
- **Bleeding:** There's a possibility of increased bleeding during or after surgery.
- **Infection:** As with any medical procedure, there's a risk of infection.
- **Long-Term Effects:** Some studies suggest potential long-term cognitive effects, although more research is needed to fully understand this.



KIDNEY AS FILTRATION SYSTEM:

Kidney Function:

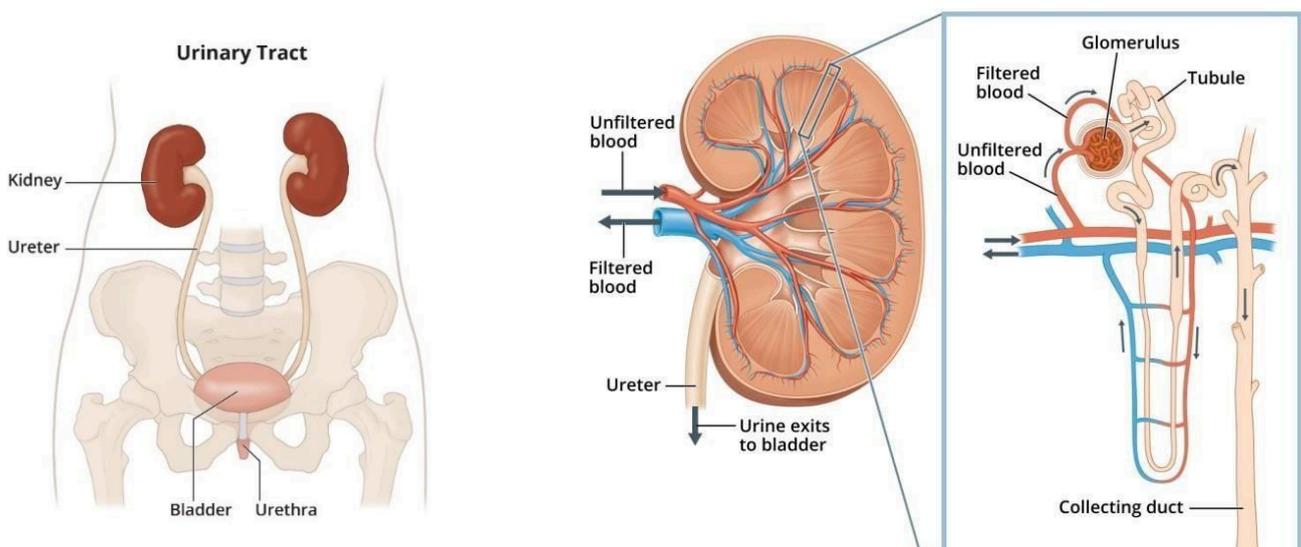
- **Waste Removal:** Eliminates waste and excess fluid from the body.
- **Acid Removal:** Removes acid produced by body cells.
- **Fluid and Mineral Balance:** Maintains a balance of water, salts, and minerals (sodium, calcium, phosphorus, potassium) in the blood, crucial for normal nerve, muscle, and tissue function.

Hormone Production:

- **Blood Pressure Control:** Produces hormones that help regulate blood pressure.
- **Red Blood Cell Production:** Produces hormones involved in the production of red blood cells.
- **Bone Health:** Helps keep bones strong and healthy.

Architecture:

- **Location:** Two bean-shaped organs below the rib cage, one on either side of the spine.
- **Filtration Champions:** They filter about half a cup of blood per minute, removing waste and excess water to create urine.



The Urinary Tract: Working Together

- **Kidneys:** Filter blood and produce urine.
- **Ureters:** Thin tubes carrying urine from the kidneys to the bladder.
- **Bladder:** Stores urine until it's released from the body.

The Microscopic Marvel: The Nephron

- The nephron is the functional unit of the kidney, responsible for filtration and reabsorption.
- Key components of the nephron:
 - **Bowman's Capsule:** Cup-shaped structure that collects filtrate from the blood.
 - **Glomerulus:** Network of tiny blood vessels within Bowman's capsule that performs initial filtration.
 - **Proximal Convoluted Tubule:** Reabsorbs essential substances like water, glucose, and electrolytes back into the bloodstream.
 - **Loop of Henle:** U-shaped structure crucial for water and ion reabsorption.
 - **Distal Convoluted Tubule:** Fine-tunes the balance of electrolytes and other substances in the bloodstream.
 - **Collecting Duct:** Collects the filtrate and directs it to the ureter for excretion as urine.

Blood Supply and Filtrate Flow

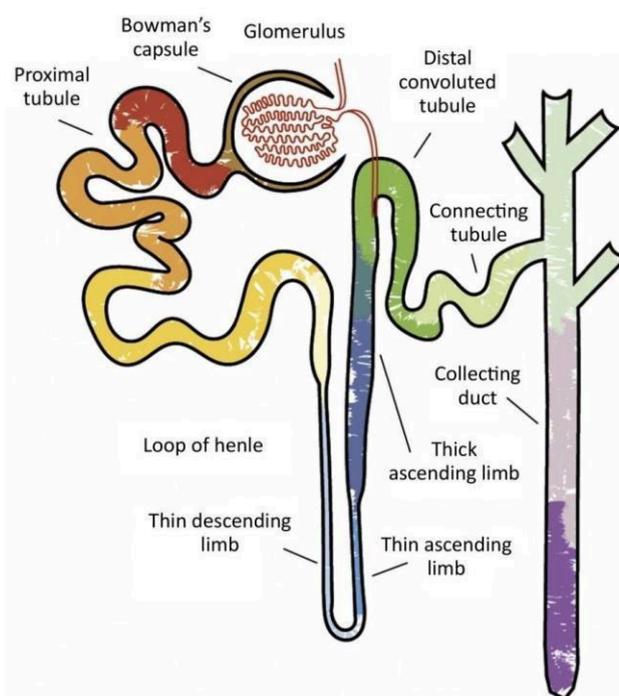
- A network of blood vessels surrounds the nephron, supplying blood for filtration and carrying away reabsorbed substances.
- The filtrate produced in the nephron travels through the renal tubules, where essential components are reabsorbed, and waste products are eliminated as urine.

MECHANISM OF FILTRATION:

Our kidneys are remarkable organs that act as a sophisticated filtration system. Here's a step-by-step look at how they work:

1. **Blood Arrival:** Blood arrives at the kidneys via the renal arteries and enters tiny filtering units called glomeruli.
2. **Initial Filtration:** Due to high blood pressure within the glomeruli, a portion of the blood plasma (fluid containing dissolved substances) filters out and enters Bowman's capsule, located around the glomerulus.
3. **The Tubular Highway:** The filtrate then travels to the renal tubules, the kidney's workhorses of filtration.
4. **Selective Reabsorption:** As the filtrate travels through the tubules lined with specialized cells, essential components like water, glucose, amino acids, and electrolytes are selectively reabsorbed back into the bloodstream.
5. **Waste Disposal:** At the same time, the tubules aren't shy about getting rid of unwanted guests. Waste products like urea and creatinine are actively secreted from the bloodstream into the filtrate.

6. **The Final Product:** The remaining filtrate, now transformed into urine, continues its journey to the renal pelvis, ureters, and finally reaches the bladder for storage and eventual elimination from the body.



The Importance of process of filtration, vital for maintaining a electrolytes in the components are effectively internal environment

Balance: This intricate reabsorption, and secretion is healthy balance of fluids and body. It ensures that essential retained while waste products removed, keeping our functioning optimally.

Chronic Kidney

CKD refers to a gradual decline in kidney function, where the kidneys lose their ability to effectively filter waste products from the blood. This build-up of waste can lead to various health problems if left unchecked.

Disease (CKD):

Potential Complications of CKD:

- **High Blood Pressure:** CKD can contribute to or worsen high blood pressure.
- **Anaemia:** Reduced red blood cell production due to decreased hormone production by the kidneys.
- **Weak Bones:** CKD can affect calcium and vitamin D metabolism, leading to weak bones.
- **Poor Nutritional Health:** Difficulty maintaining proper nutrition due to dietary restrictions and decreased absorption.
- **Nerve Damage:** Waste product build-up can damage nerves, causing pain, numbness, or tingling.

Symptoms of CKD:

Early stages of CKD often present no noticeable symptoms. Regular blood and urine tests are crucial for early detection. These tests typically measure:

- **Creatinine Level in Blood:** Indicates how well the kidneys are filtering waste.
- **Protein in Urine:** The presence of protein in the urine can be a sign of kidney damage.

Treatment Strategies for CKD:

- **Management of Underlying Cause:** If possible, addressing the underlying cause of CKD (e.g., diabetes, high blood pressure) can slow its progression.
- **Symptom Control:** Medications and lifestyle modifications may help manage symptoms like high blood pressure and anaemia.
- **Slowing Progression:** Certain medications and dietary changes may help slow the decline of kidney function.
- **Dialysis or Transplant:** In severe CKD stages, dialysis (artificial blood filtration) or a kidney transplant might be necessary.

DIALYSIS:

Dialysis is a lifesaving medical treatment that acts as a substitute for failing kidneys. When kidneys can't filter waste products and excess fluids from the blood, dialysis steps in to perform this vital function.

Two Main Dialysis Methods:

1. **Haemodialysis (HD):** This type of dialysis diverts blood to an external machine that acts as an artificial kidney. Here's the process:
 - Blood is removed from the body through an access point (usually in the arm).
 - The machine filters out waste and excess fluids.
 - The cleaned blood is then returned to the body.
2. **Peritoneal Dialysis (PD):** This method uses the patient's own abdomen (belly) as a natural filter. Here's how it works:
 - Dialysis fluid is sterile and specially formulated to draw out waste products.
 - The fluid is cycled into the peritoneal cavity (the space within the abdomen) through a catheter.
 - Waste products from the blood vessels lining the abdomen are removed by the dialysis fluid.
 - The used dialysis fluid is then drained out and replaced with fresh fluid.

Choosing the Right Dialysis Option:

The type of dialysis chosen depends on various factors, including a patient's medical condition, lifestyle preferences, and overall health. Doctors work with patients to determine the most suitable option.

Question bank:

- 1) Describe the human organ system and bio design.
- 2) Explain Brain-Computer Interface (BCI).
- 3) Differentiate between the brain and a computer.
- 4) Describe the two nervous systems in the human body.
- 5) Illustrate how signal transmission takes place in the nervous system.
- 6) Summarize the EEG process and its applications.

- 7) Describe the importance of robotic arms in prosthetics.
- 8) Explain how engineering solutions help in managing Parkinson's disease.
- 9) Relate the structure and function of the eye to a camera system.
- 10) Explain the architecture of rod and cone cells.
- 11) Discuss types of refractive errors and optical corrections used for vision problems.
- 12) Define and explain cataract.
- 13) Identify the lens materials used for correcting refractive errors in the eye.
- 14) Summarize the concept of bionic eyes.
- 15) Explain how the heart functions as a pump system.
- 16) Describe the ECG monitoring system and its purpose.
- 17) Identify the reasons for blockages in blood vessels.
- 18) Explain what stents are and how they help in treating heart diseases.
- 19) Describe pacemakers, their types, and how they work.
- 20) Explain what defibrillators are and describe their types.
- 21) Describe how the lungs function as a purification system.
- 22) Explain the architecture of the lungs.
- 23) Explain the mechanism of gas exchange in the lungs.
- 24) Define spirometry and differentiate between normal and abnormal lung physiology.
- 25) Explain COPD, its symptoms, diagnostic tests, and medications.
- 26) Summarize the function and use of a ventilator.
- 27) Describe the working of a heart-lung machine.
- 28) Explain how the kidney functions as a filtration system and describe its mechanism.
- 29) Define CKD and explain its symptoms along with the dialysis process.
- 30) Explain dialysis and its types.