VTU Question paper with Answers June/July 2023

Biology for Engineers (21BE45)

CBCS SCHEME

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21BE45

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2023

Biology for Engineers

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

			M	L	C
		Module – 1			
Q.1	a.	What is a biomolecule? Explain the classification of biomolecule.	07	L2	CO1
	b.	Explain the role of DNA vaccine for rabies and RNA vaccine for COVID-19.	07	L2	CO1
	c.	Write a short note on cellulose based bio-filters.	06	L2	CO1
		OR			
Q.2	a.	Explain the DNA finger printing in forensic applications.	07	L2	CO1
	b.	Explain the role of lipids and its application in cleaning agents.	07	L2	CO1
	c.	Write a short note on biosensors and bioplastics.	06	L2	CO1
		Module – 2			
Q.3	a.	Explain brain as a CPU system.	07	L3	CO1
	b.	Explain eye as a camera system.	07	L3	CO1
	c.	Write a short note on cardiac pacemaker.	06	L2	CO1
		OR			
Q.4	a.	Explain the robotic arms for prosthetics.	07	L3	CO1
	b.	Explain heart as a pump system.	07	L3	CO1
	c.	Write a short note on engineering solutions for Parkinson's disease.	06	L2	CO1
		Module – 3			
Q.5	a.	Explain the lungs as a purification system.	07	L3	CO2
	b.	Explain the kidney as filtration system.	07	L3	CO2
	c.	Write a short note on spirometry and ventilator.	06	L2	CO2
		OR			
Q.6	a.	Explain muscular and skeletal system as scaffolds.	07	L3	CO2
	b.	Explain bio-engineering solutions for muscular dystrophy and osteoporosis.	07	L3	CO2
	c.	Write a short note on Chronic Obstructive Pulmonary Disease (COPD).	06	L2	CO2
		Module – 4			
Q.7	a.	Explain the terms Echolocation Ultrasonography and Sonars.	07	L3	CO3
	b.	Explain the process of Photosynthesis and Photovoltaic cells.	07	L3	CO3
	c.	Write a short note on Bionic leaf, GPS, Bird flight and aircraft.	06	L2	CO3
		OR			
Q.8	a.	Explain the terms Lotus leaf effect, Plant Burrs and Super hydrophobic and self-cleaning surfaces.	07	L3	CO3
	b.	Explain the terms Spark skin and Swimsuits, Bullet train using biological concepts.	07	L3	CO3
	c.	Write a short note on Hemoglobin – Based Oxygen Carriers (HBOC's) and Perfluorocarbons (PFC).	06	L2	CO3
		Module – 5			
Q.9	a.	Explain the DNA Organic and Biocomputing.	07	L3	CO4
	b.	Explain the Bioimaging and Artificial intelligence for Disease Diagnosis.	07	L3	CO4
	c.	Write a short note on Self healing Bioconcrete.	06	L2	CO4
		OR			
Q.10	a.	Explain the importance of Bioimaging.	07	L3	CO4
	b.	Explain Bioremediation and Bio-Mining via microbial surface adsorption.	07	L3	CO4
	c.	Write s short note on Nanomedicines and Bioleaching.	06	L2	CO4

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1. a) What is a biomolecule? Explain the classification of biomolecules.

Ans: Biomolecule, also called biological molecule, any of numerous substances that are produced by cells and living organisms.

Biomolecules have a wide range of sizes and structures and perform a vast array of functions. The four major types of biomolecules are carbohydrates, lipids, nucleic acids, and proteins. . Among biomolecules, nucleic acids, namely DNA and RNA, have the unique function of storing an organism's genetic code—the sequence of nucleotides that determines the amino acid sequence of proteins, which are of critical importance to life on Earth.

Carbohydrates, which are made up primarily of molecules containing atoms of carbon, hydrogen, and oxygen, are essential energy sources and structural components of all life, and they are among the most abundant biomolecules on Earth.

Lipids, another key biomolecule of living organisms, fulfill a variety of roles, including serving as a source ofstored energy and acting as chemical messengers. They also form membranes, which separate cells from theirenvironments and compartmentalize the cell interior, giving rise to organelles, such as the nucleus and the
mitochondrion, in higher (more complex) organisms. Examples include cytidine, uridine, adenosine, guanosine, and thymidine. Nucleosides that are phosphorylated become nucleotides. Apart from serving as a structural unit of nucleic acids, nucleotides may also serve as sources of chemical energy (e.g. adenosine triphosphate or ATP).

Nucleic acids are biopolymers, macromolecules, essential to all known forms of life. They are composed of nucleotides, which are the monomers made of three components: a 5-carbon sugar, a phosphate group and a nitrogenous base. The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). If the sugar is ribose, the polymer is RNA; if the sugar is the ribose derivative deoxyribose, the polymer is DNA.

Protein is found throughout the body—in muscle, bone, skin, hair, and virtually every other body part or tissue. It makes up the enzymes that power many chemical reactions and the haemoglobin that carries oxygen in your blood.

1. b) Explain the role of DNA vaccine for rabies and RNA vaccine for COVID-19?

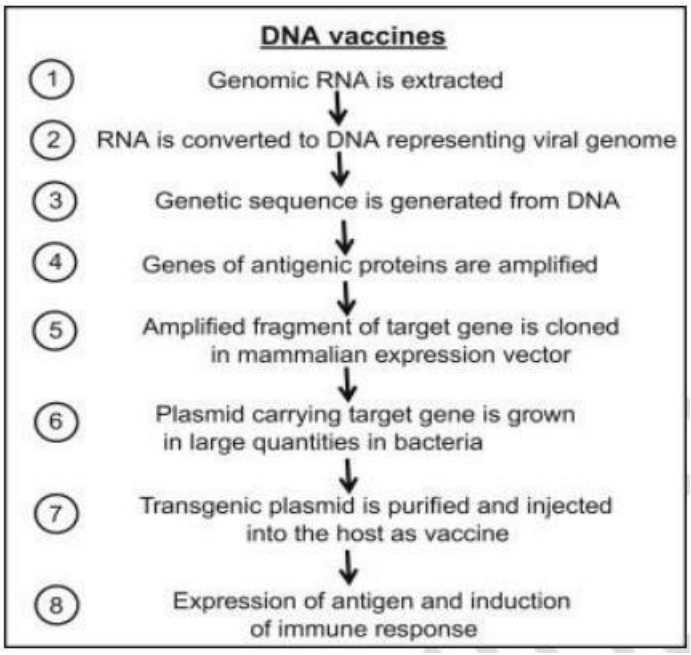
Ans: Nucleic acids are biopolymers, macromolecules, essential to all known forms of life. They are composed of nucleotides, which are the monomer components:

• A 5-carbon sugar, a phosphate group and a nitrogenous base. The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). If the sugar is ribose, the polymer is RNA; if the sugar is the ribose derivative deoxyribose, the polymer is DNA.

• Rabies is a preventable viral disease most often transmitted through the bite of a rabid animal. The rabies virus infects the central nervous system of mammals, ultimately causing disease in the brain and death. Most rabies

cases reported to the Centers for Disease Control and Prevention (CDC) each year occur in wild animals like bats, raccoons, skunks, and foxes, although any mammal can get rabies.

• A DNA vaccine, using a pCl-neo plasmid encoding the glycoprotein gene of a Mexican isolate of rabies virus, was developed to induce long-lasting protective immunity against rabies virus in dogs



Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Messenger RNA, or mRNA technology, instructs cells to make a protein that generates an immune response in the body, thus producing the antibodies that provide protection against a disease.

It is the basis for the Pfizer/BioNTech and Moderna COVID-19 vaccines being used by governments worldwide, and in the UN-supported COVAX global vaccine solidarity initiative. Messenger ribonucleic acid (mRNA) is a molecule that provides cells with instructions for making proteins.

mRNA vaccines contain the instructions for making the SARS-CoV-2 spike protein. This protein is found on the surface of the virus that causes COVID-19. The mRNA molecule is essentially a recipe, telling the cells of the body how to make the spike protein.

COVID-19 mRNA vaccines are given by injection, usually into the muscle of the upper arm. After the protein piece is made, the cell breaks down the instructions and gets rid of them. The mRNA never enters the central part (nucleus) of the cell, which is where our DNA (genetic material) is found. Your DNA can't be altered by mRNA vaccines. The cell then displays the protein piece on its surface.

Our immune system recognizes that the protein doesn't belong there and begins building an immune response and making antibodies.

1. c) Write a short note on cellulose-based bio filters?

Ans: It is extremely abundant, easily renewable, and biodegradable. Due to inter- and intra-molecular hydrogen bonding between the hydroxyl groups of the neighboring cellulose chains, cellulose is insoluble in water, despite being hydrophilic, and is difficult to dissolve with common organic solvents.

The interest in the use of bio-based filters for water purification has increased in recent years; as such filters have the potential to be affordable, lightweight and biodegradable. Research has been focused on creating bio-based membranes for micro- and ultrafiltration from cellulose nano-fibrils (CNFs).

Filters based on cellulose pulp fibers do usually have large pores that facilitate water percolation but they do not sufficiently remove bacteria through size exclusion; other techniques are therefore needed to achieve bacteria-reducing effect. Several groups have addressed this issue by incorporating antibacterial metal nanoparticles into cellulose-based water filters; both silver nanoparticles (AgNPs) and copper nanoparticles (CuNPs) are known to have good antibacterial effects.

An alternative method to physically remove bacteria from water, while keeping the filter pore size larger than bacteria, is to use positively charged filters that adsorb negatively charged bacteria onto the surfaces of the filters. This allows negatively charged particles much smaller than the filter pore size to be efficiently removed from water and this is an interesting approach for removing bacteria from water without adding any toxic chemicals or reducing the flow by reducing the pore size.

Both Gram-positive and Gram-negative bacteria have a negative net surface charge on the cell envelope, due to peptidoglycans, lipo-saccharides and proteins in the cell wall, and this makes their removal nonselective and efficient for most types of bacteria.

2. a) Explain the DNA finger printing in forensic applications?

Ans: DNA fingerprinting, also called DNA typing, DNA profiling, genetic fingerprinting, genotyping, or identity testing, in genetics, method of isolating and identifying variable elements within the base-pair sequence of DNA (deoxyribonucleic acid). The procedure for creating a DNA fingerprint consists of first obtaining a sample of cells, such as skin, hair, or blood cells, which contain DNA. The DNA is extracted from the cells and purified, the DNA was then cut at specific points along the strand with proteins known as restriction enzymes. The enzymes produced fragments of varying lengths that were sorted by placing them on a gel and then subjecting the gel to an electric current (electrophoresis): the shorter the fragment, the more quickly it moved toward the positive pole (anode). The sorted double-stranded DNA fragments were then subjected to a blotting technique in which they were split into single strands and transferred to a nylon sheet. The fragments underwent autoradiography in which they were exposed to DNA probes—pieces of synthetic DNA that were made radioactive and that bound to the mini satellites. A piece of X-ray film was then exposed to the fragments, and a dark mark was produced at any point where a radioactive probe had become attached. The resultant pattern of marks could then be analyzed.

The DNA testing process is comprised of four main steps, including extraction, quantitation, amplification, and capillary electrophoresis. DNA fingerprinting is a laboratory technique used to determine the probable identity of a person based on the nucleotide sequences of certain regions of human DNA that are unique to individuals. Forensic genetic fingerprinting can be defined as the comparison of the DNA in a person's nucleated cells with that identified in biological matter found at the scene of a crime or with the DNA of another person for the purpose of identification or exclusion.

2. b) Explain the role of lipids and its application in cleaning agents?

Ans: SUPERHYDROPHOBIC AND SELF-CLEANING SURFACES: The self-cleaning function of superhydrophobic surfaces is conventionally attributed to the removal of contaminating particles by impacting or rolling water droplets, which implies the action of external forces such as gravity. Here, we demonstrate a unique self-cleaning mechanism whereby the contaminated superhydrophobic surface is exposed to condensing

water vapor, and the contaminants are autonomously removed by the self-propelled jumping motion of the resulting liquid condensate, which partially covers or fully encloses the contaminating particles. The jumping motion of the superhydrophobic surface is powered by the surface energy released upon the coalescence of the condensed water phase around the contaminants. The jumping-condensate mechanism is shown to spontaneously clean superhydrophobic cicada wings, where the contaminating particles cannot be removed by gravity, wing vibration, or wind flow. Our findings offer insights into the development of self-cleaning materials.

Mechanism: An autonomous mechanism to achieve self-cleaning on superhydrophobic surfaces, where the contaminants are removed by self-propelled jumping condensate powered by surface energy. When exposed to condensing water vapor, the contaminating particles are either fully enclosed or partially covered with the resulting liquid condensate. Building upon our previous publications showing self-propelled jumping upon drop coalescence (5, 6), we show particle removal by the merged condensate drop with a size comparable to or larger than that of the contaminating particle(s). Further, we report a distinct jumping mechanism upon particle aggregation, without a condensate drop of comparable size to that of the particles, where a group of particles exposed to water condensate clusters together by capillarity and self-propels away from the superhydrophobic surface.

2. c) Write a short note on biosensor and bioplastics.

Ans: Biosensors can be defined as analytical devices which include a combination of biological detecting elements like a sensor system and a transducer. When we compare with any other presently existing diagnostic device, these sensors are advanced in the conditions of selectivity as well as sensitivity. The applications of these Biosensors mainly include checking ecological pollution control, in the agriculture field as well as food industries. The main features of biosensors are stability, cost, sensitivity, and reproducibility.

Bioplastics are one type of plastic which can be generated from natural resources such as starches and vegetable oils. Bioplastics are basically classified as bio based and/or biodegradable. Not all bio-based plastics are biodegradable and similarly not all biodegradable plastics are bio based. Bioplastics are referred to as bio based when the focus of the material is on the origin of the carbon building block and not by where it ends up at the end of its cycle life. Bio plastics are said to be biodegradable if they are broken down with the effect of the right environmental conditions and microbes which in turn use them as a food source. The bioplastics are considered compostable if within 180 days, a complete microbial assimilation of the fragmented food source takes place in a compost environment.

3. a) Explain brain as a CPU system?

Ans: Both CPU and brain use electrical signals to send messages. The brain uses chemicals to transmit information; the computer uses electricity. Even though electrical signals travel at high speeds in the nervous system, they travel even faster through the wires in a computer. Both transmit information.

A BCI system is a computer-based system that takes brain signals, analyses them and translates them into commands that are relayed to a device to trigger a desired action. A BCI system does not use peripheral nerves and head muscles. The CNS (Central Nervous System), for example, is used to measure signals produced by the central nervous system. Thus, for example, a sensor that is activated by the voice or the movement of a muscle is not a BCI system. Also, an EEG is not BCI itself, because it only records brain signals but it does not produce an output that acts on the user's environment. It is also wrong to think that BCI is a mind-reader. They do not export information from unsuspecting users or users unwillingly using the system. They allow users to act in

their environment when they want it by reading their brain signals rather than muscles. The user and the BCI work together. The user, after a training session, produces brain signals encoded by the BCI system. The BCI then translates these commands and transmits them into an output device. Brain computer interfaces have contributed to various areas of research. Applications that are about medicine, neuro-technology and smart environment, neuro-marketing and advertising, education and self-regulation, games and entertainment, as well as security and identification.

3. b) Explain eye as a camera system?

Ans: 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, including: 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. A method of sensing the image. In a 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 front end of an image-processing system that converts the image to electrical impulses and sends the information along the optic nerve to the brain. There are two photoreceptors: RODS AND CONES.

These photoreceptors are localized around an area near the centre of the retina called the macula, which is the functional center of the retina. The fovea is located in the centre of the macula. The macula is responsible for high-resolution, color vision, provided by different types of photoreceptors.

Photoreceptors in the retina are classified into two groups, named after their physical morphologies. Rod cells are highly sensitive to light and function in night vision, whereas cone cells are capable of detecting a wide spectrum of light photons and are responsible for colour vision. Rods and cones are structurally compartmentalized. They consist of five principal regions: Outer segment, connecting cilium, Inner segment, nuclear region, Synaptic region, Rods are responsible for vision at low light levels (scotopic vision). They do not mediate color vision and have a low spatial acuity. Cones are active at higher light levels (photopic vision), are capable of color vision and are responsible for high spatial acuity. The central fovea is populated exclusively by cones. There are 3 types of cones which we will refer to as the short-wavelength sensitive cones, the middle-wavelength sensitive cones and the long-wavelength sensitive cones or S-cone, M-cones, and Lcones for short.

3. c) Write a short note on Cardiac pacemaker?

Ans: A pacemaker is a small device that's placed (implanted) in the chest to help control the heartbeat. It's used to prevent the heart from beating too slowly. Implanting a pacemaker in the chest requires a surgical procedure. A pacemaker is also called a cardiac pacing device.

Types: Single chamber pacemaker. This type usually carries electrical impulses to the right ventricle of your heart. Dual chamber pacemaker. This type carries electrical impulses to the right ventricle and the right atrium of your heart to help control the timing of contractions between the two chambers. Biventricular pacemaker. Biventricular pacing, also called cardiac resynchronization therapy, is for people who have heart failure and heartbeat problems. This type of pacemaker stimulates both of the lower heart chambers (the right and left ventricles) to make the heartbeat more efficiently. A pacemaker is implanted to help control your heartbeat. Your doctor may recommend a temporary pacemaker when you have a slow heartbeat (bradycardia) after a heart attack, surgery or medication overdose but your heartbeat is otherwise expected to recover. A pacemaker may be implanted permanently to correct a chronic slow or irregular heartbeat or to help treat heart failure. Pacemakers

work only when needed. If your heartbeat is too slow (bradycardia), the pacemaker sends electrical signals to your heart to correct the beat.

Some newer pacemakers also have sensors that detect body motion or breathing rate and signal the devices to increase heart rate during exercise, as needed.

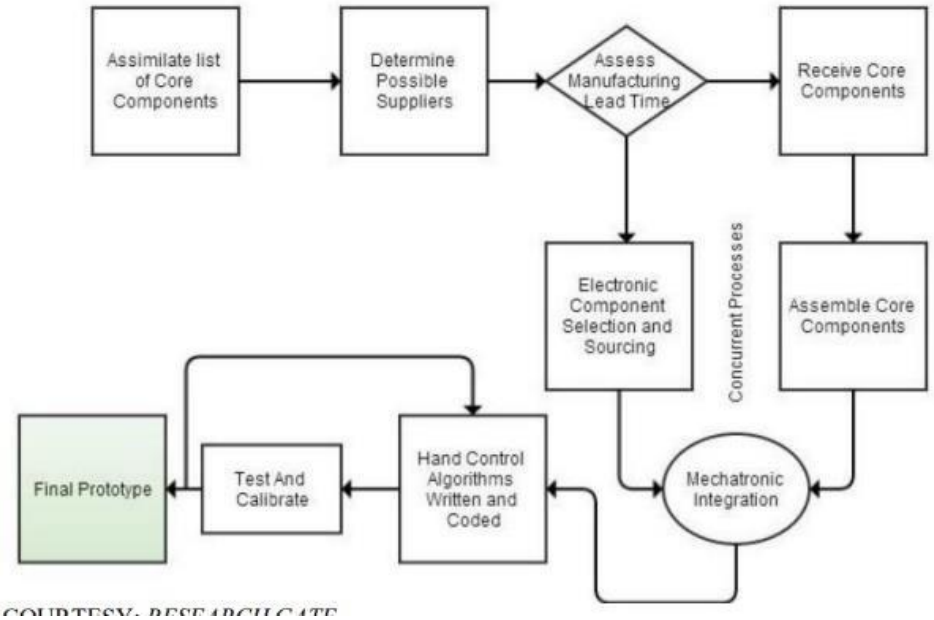
A pacemaker has two parts:

1) Pulse generator. This small metal container houses a battery and the electrical circuitry that controls the rate of electrical pulses sent to the heart.

2) Leads (electrodes). One to three flexible, insulated wires are each placed in one or more chambers of the heart and deliver the electrical pulses to adjust the heart rate. However, some newer pacemakers don't require leads. These devices, called leadless pacemakers, are implanted directly into the heart muscle.

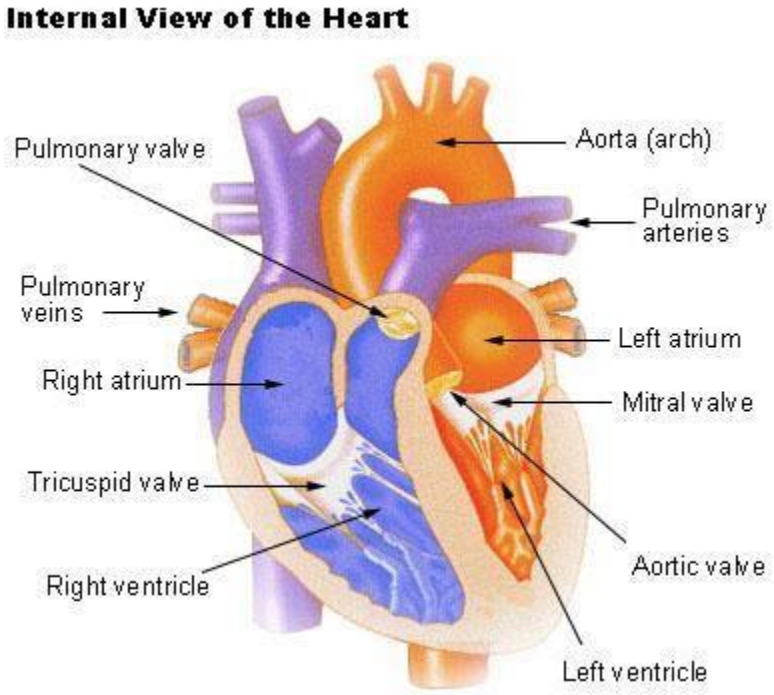
4. a) Explain the robotic arms for prosthetics?

Ans: Robotic prosthetic limb is a well-established research area that integrates advanced mechatronics, intelligent sensing, and control for achieving higher order lost sensorimotor functions while maintaining the physical appearance of amputated limb. Robotic prosthetic limbs are expected to replace the missing limbs of an amputee restoring the lost functions and providing aesthetic appearance. The main aspects are enhanced social interaction, comfortable amputee's life, and productive amputee to the society. With the advancement of sensor technology, in the last few decades significant contributions have been made in this area. Most current robotic prostheses work by recording—from the surface of the skin—electrical signals from muscles left intact after an amputation. Some amputees can guide their artificial hand by contracting muscles remaining in the forearm that would have controlled their fingers. If you are missing an arm or leg, an artificial limb can sometimes replace it. The device, which is called a prosthesis, can help you to perform daily activities such as walking, eating, or dressing. Robotic arms can be used to automate the process of placing goods or products onto pallets. By automating the process, palletizing becomes more accurate, cost-effective, and predictable. The use of robotic arms also frees human workers from performing tasks that present a risk of bodily injury.



4. b) Explain Heart as a pumping system?

Ans: Heart is sort of like a pump, or two pumps in one. The right side of your heart receives blood from the body and pumps it to the lungs. The left side of the heart does the exact opposite: It receives blood from the lungs and pumps it out to the body. While an LVAD consists of thick tubes and a pump connected externally to the heart muscle and aorta, percutaneous heart pumps place a much smaller tube inside the heart's chambers. These tiny heart pumps are placed in the heart via a thin tube called a catheter that is threaded through a puncture site in the skin. The human heart is very strong and is capable of pumping blood up to 30 feet distance. An average heart beats maximum of 70-80 beats per minute and is considered healthy. The efficiency of the heart can be maintained and improved by performing physical activity. The heart is called a double pump because each side pumps blood to a different circulation. Deoxygenated blood from the body drains to the right side of the heart. This is the first pump that sends blood to the lungs, called the pulmonary circulation, where it becomes oxygenated and releases carbon dioxide.



The human heart is a four-chambered muscular organ, shaped and sized roughly like a man's closed fist with two-thirds of the mass to the left of midline. The heart is enclosed in a pericardial sac that is lined with the parietal layers of a serous membrane. The visceral layer of the serous membrane forms the epicardium.

The myocardium of the heart wall is a working muscle that needs a continuous supply of oxygen and nutrients to function efficiently. For this reason, cardiac muscle has an extensive network of blood vessels to bring oxygen to the contracting cells and to remove waste products.

4. c) Write a short note on engineering solution for Parkinson's disease.

Ans: Parkinson's disease is a progressive disorder that affects the nervous system and the parts of the body controlled by the nerves. Symptoms start slowly. The first symptom may be a barely noticeable tremor in just one hand. Tremors are common, but the disorder may also cause stiffness or slowing of movement. In Parkinson's disease, certain nerve cells (neurons) in the brain gradually break down or die. Many of the symptoms are due to a loss of neurons that produce a chemical messenger in your brain called dopamine. When dopamine levels decrease, it causes atypical brain activity, leading to impaired movement and other symptoms of Parkinson's disease. Parkinson's disease can't be cured, but medications can help control the symptoms, often dramatically. In some more advanced cases, surgery may be advised. Your health care provider may also recommend lifestyle changes, especially ongoing aerobic exercise.

ENGINEERING SOLUTIONS TO THIS DISEASE ARE:

Deep Brain Stimulation – Deep Brain Stimulation (DBS) involves surgically implanting a neurotransmitter that

sends electrical impulses to specific areas of your brain. This procedure has helped many people with Parkinson's reduce symptoms such as tremor, rigidity, and bradykinesia. There are six main types of medications available to treat symptoms of Parkinson disease: levodopa, dopamine agonists, and inhibitors of enzymes that inactivate dopamine (monoamine oxidase type B [MAO B] inhibitors and catechol-O-methyl transferase [COMT] inhibitors, anticholinergic drugs, and amantadine.

ENGINEERING NEURONS are another treatment method for this. Transplantation of embryonic neurons can restore functional dopaminergic neurons in the brains of patients with Parkinson's disease. But while promising, cell transplantation therapy is still out of reach to most patients, in part because of the inaccessibility of human embryonic tissue.

First obtained neuronal stem cells from mouse cells transfected with a transcription factor that encourages cells to adopt a neuronal fate. They then co-cultured the cells with astrocytes, which release a factor that induces development into dopaminergic neurons. The engineered cells released dopamine, and some maintained the characteristics of dopaminergic neurons for up to two weeks after implantation into mouse brains.

5. a) Explain lungs as a purification system?

Ans: The lung parenchyma is mainly comprised of numerous air-containing passages and intervening fine structures, corresponding to alveolar ductal lumens and alveoli, as well as alveolar septa and small pulmonary vessels occupying 10% of total parenchymal volume. The primary function of the lungs is gas exchange. However, the lungs perform several important non-respiratory functions that are vital for normal physiology. The lung, with its unique ability to distend and recruit pulmonary vasculature, acts as a reservoir of blood, fine-tuning preload to the left heart to optimize cardiac output.

The lung acts as a filter against endogenous and exogenous emboli, preventing them from accessing systemic circulation. • Pulmonary epithelium forms the first line of defense against inhaled particles.

• Pulmonary endothelial cells are responsible for the uptake, metabolism, and biotransformation of several exogenous and endogenous substances.

• Pulmonary metabolic capacity is easily saturated, but pulmonary endothelial binding of some drugs alters their pharmacokinetics.

GAS EXCHANGE MECHANISMS:

Air enters the body through the mouth or nose and quickly moves to the pharynx or throat. From there, it passes through the larynx, or voice box, and enters the trachea. The trachea is a strong tube that contains rings of cartilage that prevent it from collapsing. Within the lungs, the trachea branches into a left and right bronchus. These further divide into smaller and smaller branches called bronchioles. The smallest bronchioles end in tiny air sacs. These are called alveoli. They inflate when a person inhales and deflate when a person exhales. During gas exchange oxygen moves from the lungs to the bloodstream. At the same time, carbon dioxide passes from the blood to the lungs. This happens in the lungs between the alveoli and a network of tiny blood vessels called capillaries, which are located in the walls of the alveoli.

5. b) Explain Kidney as filtration system?

Ans. The kidneys are two bean-shaped organs, each about the size of a fist. They are located just below the rib cage, one on each side of the spine. Healthy kidneys filter about a half cup of blood every minute, removing wastes and extra water to make urine. The urine flows from the kidneys to the bladder through two thin tubes of muscle called ureters, one on each side of the bladder. Your bladder stores urine. Kidneys, ureters, and bladder are part of your urinary tract.

Each kidney is made up of about a million filtering units called nephrons. Each nephron includes a filter, called the glomerulus, and a tubule. The nephrons work through a two-step process: the glomerulus filters blood, and the tubule returns needed substances to your blood and removes wastes.

Each nephron has a glomerulus to filter your blood and a tubule that returns needed substances to your blood and pulls out additional wastes. Wastes and extra water become urine. The glomerulus filters your blood. As blood flows into each nephron, it enters a cluster of tiny blood vessels—the glomerulus. The thin walls of the glomerulus allow smaller molecules, wastes, and fluid—mostly water—to pass into the tubule. Larger molecules, such as proteins and blood cells, stay in the blood vessel. The tubule returns needed substances to your blood and removes wastes.

A blood vessel runs alongside the tubule. As the filtered fluid moves along the tubule, the blood vessel reabsorbs almost all of the water, along with minerals and nutrients your body needs. The tubule helps remove excess acid from the blood. The remaining fluid and wastes in the tubule become urine.

Flow of blood through kidneys:

Blood flows into the kidney through the renal artery. This large blood vessel branches into smaller and smaller blood vessels until the blood reaches the nephrons. In the nephron, blood is filtered by the tiny blood vessels of the glomeruli and then flows out of the kidney through the renal vein. Blood circulates through your kidneys many times a day. In a single day, kidneys filter about 150 quarts of blood. Most of the water and other substances that filter through your glomeruli are returned to the blood by the tubules. Only 1 to 2 quarts become urine. When the kidney doesn't function properly, chronic kidney disease occurs when a disease or condition impairs kidney function, causing kidney damage to worsen over several months or years.

5. c) Write a short note on spirometry and ventilator?

Ans: Spirometry (spy-ROM-uh-tree) is a common office test used to assess how well your lungs work by measuring how much air you inhale, how much you exhale, and how quickly you exhale. Spirometry is used to diagnose asthma, chronic obstructive pulmonary disease (COPD), and other conditions that affect breathing.

175 years have elapsed since John Hutchinson introduced the world to his version of an apparatus that had been in development for nearly two centuries, the spirometer.

Spirometers can be divided into two basic groups:

• Volume-measurement devices (e.g. wet and dry spirometers).

• Flow-measurement devices (e.g. pneumotachograph systems, mass flow meters).

Requirements of an acceptable spirometer are:

• Spirometers must be able to accumulate volume for ≥15 s.

• The measuring volume should be ≥8 L (body temperature and pressure, saturated).

• The accuracy of reading should be at least ±3% (or ±0.05 L) with flows from 0–14 L per s.

• The total resistance to airflow at 14 L per s should be <1.5 cmH2O per L per s (<0.15 kPa per L per s).

VENTILATOR:

Mechanical ventilators are machines that act as bellows to move air in and out of your lungs. Your respiratory therapist and doctor set the ventilator to control how often it pushes air into your lungs and how much air you get. You may be fitted with a mask to get air from the ventilator into your lungs or you may need a breathing tube if your breathing problem is more serious. When you're ready to be taken off the ventilator, your healthcare team will

“wean” you or decrease the ventilator support until you can start breathing on your own.

6. a) Explain muscular and skeletal system as scaffolds?

Ans: Skeletal muscle architecture is one of the most important properties that determine a muscle’s force and excursion capability. In the current review, basic architectural terms first are reviewed, and then specific examples relevant to upper extremity anatomy are presented. Specific examples of anatomic considerations required for surgical reconstruction after radial nerve palsy also are detailed. Together, these data show not only the wide variety of architectural designs in human muscles but the importance of considering architectural design when making surgical decisions. The relationship between structure and function in skeletal muscle has been described and probed for more than a century. A classic study has elucidated the microscopic and ultrastructural properties of skeletal muscle fibers, yielding great insights into their function. However, less attention has been given to excellent and insightful studies of the macroscopic properties of skeletal muscle tissues dating back to the 1600s. This macroscopic arrangement of muscle fibers is known as a muscle’s architecture.

Mechanism

The nervous system (your body’s command center) controls your voluntary muscle movements. Voluntary muscles are ones you control intentionally. Some involve large muscle groups to do activities like jumping. Others use smaller movements, like pushing a button. Movements happen when:

Our nervous system (brain and nerves) sends a message to activate your skeletal (voluntary) muscles. Our muscle fibers contract (tense up) in response to the message. When the muscle activates or bunches up, it pulls on the tendon. Tendons attach muscles to bones. The tendon pulls the bone, making it move. To relax the muscle, your nervous system sends another message. It triggers the muscles to relax or deactivate. The relaxed muscle releases tension, moving the bone to a resting position.

Hundreds of conditions can cause problems with the musculoskeletal system. They can affect the way you move, speak and interact with the world. Some of the most common causes of musculoskeletal pain and movement problems are:

- Aging
- Arthritis
- Back problems

- Cancer
- Congenital abnormalities
- Injuries
- Osteoporosis
- Muscular dystrophy

Everyone has pain in their muscles and joints from time to time. One of the most common musculoskeletal conditions is Osteoporosis. More than 60% of people in the United States have Osteoporosis at some point in their lives. Arthritis is also very common. More than 54 million adults in the U.S. have Muscular dystrophy. Most people recover from these disorders without long-term health problems.

6. b) Explain bio engineering solution for muscular dystrophy and osteoporosis?

Ans: Awareness is increasing that bone morbidity due to osteoporosis is a major complication of Duchenne muscular dystrophy (DMD) and its treatment and that it requires monitoring for early diagnosis and intervention to prevent clinically important sequelae. The traditional method of fabricating 3D muscle constructs first developed more than 25 years ago involves casting myogenic cells within a cylindrically shaped collagen-I gel that is anchored at the ends to porous felts. In this system, cell-mediated gel compaction and remodeling result in the generation of uniaxial passive stress within the gel, which, in turn, promotes the fusion of myoblasts into myotubes and also myotube alignment. Alternatively, myoblasts, or mixtures of myogenic precursors and fibroblasts, can be cultured on laminin- or hydrogel-coated dishes until spontaneous contractions of formed myotubes detach the entire cell layer, allowing it to self-assembly into a cylindrical tissue construct attached at the ends to premade suture anchors.

Although cell alignment within 3D constructs is not required for the formation of contractile myotubes, it increases fusion efficiency while passive stress promotes both cell survival and myogenesis. In addition to collagen I, different natural hydrogels and their chemically modified derivatives can support the 3D growth and fusion of myogenic cells; the most functional results have been achieved using fibrin-based gels. Carefully optimizing the composition of the fibrin gel to enhance cell-matrix interactions as well as optimizing the starting cell population to improve myogenic fusion and SC maintenance and providing dynamic culture conditions to improve cell survival and maturation have enabled rodent skeletal muscle tissues to be engineered with contractile properties comparable to those of native muscle (e.g., twitch and tetanus-force amplitudes).

Rapid-prototyping techniques for hydrogel molding can be further used to vary local myofiber alignment and to design complex muscle structures, and advanced biomaterials can deliver angiogenic, myogenic, and pro-survival factors to cells in a spatiotemporally controlled fashion. In addition to using biomaterial scaffolds, scaffold-free muscle tissue constructs have been generated using magnetic fields that allow the controlled assembly of magnetically labeled cells, as well as thermo-responsive polymers that allow controlled cell detachment from culture surfaces.

Although hydrogels have been the dominant muscle-engineering scaffold in vitro, in vivo studiesof muscle repair have mainly utilized acellular natural scaffolds, porous matrices made ofdegradable polymeric materials, or scaffold-free myoblast sheets.

6. c) Write a short note on chronic obstructive pulmonary disease?

Ans: Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory lung disease that causes obstructed airflow from the lungs. Symptoms include breathing difficulty, cough, mucus (sputum) production, and wheezing. It's typically caused by long-term exposure to irritating gases or particulate matter, most often from cigarette smoke. People with COPD are at increased risk of developing heart disease, lung cancer, and a variety of other conditions. Emphysema and chronic bronchitis are the two most common conditions that contribute to COPD. These two conditions usually occur together and can vary in severity among individuals with COPD.

Symptoms:

COPD symptoms often don't appear until significant lung damage has occurred, and they usually worsen over time, particularly if smoking exposure continues.

Signs and symptoms of COPD may include:

- Shortness of breath, especially during physical activities
- Wheezing • Chest tightness
- A chronic cough that may produce mucus (sputum) that may be clear, white, yellow, or greenish
- Frequent respiratory infections
- Lack of energy
- Unintended weight loss (in later stages)
- Swelling in ankles, feet, or legs

Several kinds of medications are used to treat the symptoms and complications of COPD.

You may take some medications regularly and others as needed.

- Bronchodilators
- Inhaled steroids
- Combination inhalers
- Oral steroids
- Phosphodiesterase-4 inhibitors
- Theophylline
- Antibiotics

Mechanical ventilation is a lifesaving therapy in patients who have acute respiratory failure due to chronic obstructive pulmonary disease (COPD). Mechanical ventilation either invasive or noninvasive has an important role in the management of acute exacerbation of COPD (AECOPD).

7. a) Explain the terms Echolocation ultrasonography and sonars?

Ans: Vision and hearing are akin in that each interprets detections of reflected waves of energy. Vision processes light waves that travel from their source, bounce off surfaces throughout the environment and enter the eyes. Similarly, the auditory system processes sound waves as they travel from their source, bounce off surfaces, and enter the ears. Both neural systems can extract a great deal of information about the environment by interpreting the complex patterns of reflected energy that their sense organs receive. In the case of sound, these waves of reflected energy are referred to as echoes.

ULTRASONOGRAPHY:

Ultrasound: Ultrasound refers to sound above the human audible limit of 20 kHz. Ultrasound of frequencies up to 10 MHz and beyond is used in medical diagnosis, therapy, and surgery. In investigative applications, an ultrasound source (transmitter) directs pulses into the body. When the pulse encounters a boundary between organs or between two tissue regions of different densities, reflections of sound occur. By scanning the body with Ultrasound and detecting echoes generated by various organs, a sonogram of the internal structure(s) can be generated. The method is called diagnostic imaging by echolocation.

Diagnostic ultrasound, also called sonography or diagnostic medical sonography, is an imaging method that uses sound waves to produce images of structures within your body. The images can provide valuable information for diagnosing and directing treatment for a variety of diseases and conditions.

SONARS:

Sonar (sound navigation and ranging or sonic navigation and ranging) is a technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, measure distances (ranging), communicate with or detect objects on or under the surface of the water, such as other vessels.

"Sonar" can refer to one of two types of technology:

- passive sonar means listening for the sound made by vessels.
- active sonar means emitting pulses of sounds and listening for echoes.

Sonar may be used as a means of acoustic location and of measurement of the echo characteristics of "targets" in the water. Acoustic location in the air was used before the introduction of radar. Sonar may also be used for robot navigation, and SODAR (an upward-looking in-air sonar) is used for atmospheric investigations. The term sonar is also used for the equipment used to generate and receive the sound. The acoustic frequencies used in sonar systems vary from very low (infrasonic) to extremely high (ultrasonic). The study of underwater sound is known as underwater acoustics or hydroacoustic.

7. b) Explain the process of photosynthesis and photovoltaic cells?

Ans: PHOTOSYNTHESIS

Most life on Earth depends on photosynthesis. The process is carried out by plants, algae, and some types of bacteria, which capture energy from sunlight to produce oxygen (O_2) and chemical energy stored in glucose (a sugar). Herbivores then obtain this energy by eating plants, and carnivores obtain it by eating herbivores.

The Process:

During photosynthesis, plants take in carbon dioxide (CO_2) and water (H_2O) from the air and soil. Within the plant cell, the water is oxidized, meaning it loses electrons, while the carbon dioxide is reduced, meaning it gains electrons. This transforms the water into oxygen and the carbon dioxide into glucose. The plant then releases the oxygen back into the air, and stores energy within the glucose molecules.

Chlorophyll:

Inside the plant cell are small organelles called chloroplasts, which store the energy of sunlight. Within the thylakoid membranes of the chloroplast is a light-absorbing pigment called chlorophyll, which is responsible for giving the plant its green color. During photosynthesis, chlorophyll absorbs energy from blue- and red-light waves and reflects green-light waves, making the plant appear green.

PHOTOVOLTAIC CELLS:

The sun's copious energy is captured by two engineering systems: photosynthetic plant cells and photovoltaic cells (PV). Photosynthesis converts solar energy into chemical energy, delivering different types of products such as building blocks, biofuels, and biomass; photovoltaics turn it into electricity which can be stored and used to perform work.

Understanding better the way by which natural photosynthetic complexes perform these processes may lead to insight into the design of artificial photosynthetic systems and the development of new technologies forsolar energy conversion. A broad variety of bio-inspired concepts and applications are emerging, ranging from light-induced water splitting, Plant Microbial Fuel Cells to hybrid systems. These latter combine photosynthesis and photovoltaics and have great potential in Agri photovoltaic concepts such as the side-by-side arrangement of solar cells and plants, and systems consisting of transparent solar cells which are placed in front or above the plant. One of the applications that can contribute to bringing together the worlds of photosynthesis and photovoltaics is the photovoltaic cell.

A solar cell, or photovoltaic cell, is an electronic device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Individual solar cell devices are often the electrical building blocks of photovoltaic modules, known colloquially as solar panels. The common single-junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 volts to 0.6 volts.

Application:

- Remote Locations
- Stand-Alone Power.
- Power in Space.
- Building-Related Needs.
- Military Uses.
- Transportation.

7. c) Write a short note on Bionic leaf, GPS, Bird flight and aircraft?

Ans: BIONIC LEAF:

The Bionic Leaf is a biomimetic system that gathers solar energy via photovoltaic cells that can be stored or used in several different functions. Bionic leaves can be composed of both synthetic (metals, ceramics, polymers, etc.) and organic materials (bacteria), or solely made of synthetic materials. The Bionic Leaf has the potential to be implemented in communities, such as urbanized areas to provide clean air as well as providing needed clean energy.

Natural Photosynthesis vs. The Bionic Leaf at its simplest form. In natural photosynthesis, photosynthetic organisms produce energy-rich organic molecules from water and carbon dioxide by using solar radiation. Therefore, the process of photosynthesis removes carbon dioxide, a greenhouse gas, from the air. Artificial photosynthesis, as performed by the Bionic Leaf, is approximately 10 times more efficient than natural photosynthesis. Using a catalyst, the Bionic Leaf can remove excess carbon dioxide in the air and convert that to use alcohol fuels, like isopropanol and isobutanol. The efficiency of the Bionic Leaf's artificial photosynthesis is the result of bypassing obstacles in natural photosynthesis through its artificiality. In natural systems, numerous energy conversion bottlenecks limit the overall efficiency of photosynthesis. As a result, most plants do not exceed 1% efficiency and even microalgae grown in bioreactors do not exceed 3%. Existing artificial photosynthetic solar-to-fuels cycles may exceed natural efficiencies but cannot complete the cycle via carbon fixation. When the catalysts of the Bionic Leaf are coupled with the bacterium Ralstonia eutropha, this results in a hybrid system capable of carbon dioxide fixation. This system can store more than half of its input energy as products of carbon dioxide fixation. Overall, the hybrid design allows for artificial photosynthesis with efficiencies rivaling that of natural photosynthesis.

BIRD FLYING:

Bird flight is the primary mode of locomotion used by most bird species in which birds take off and fly. Flight assists birds with feeding, breeding, avoiding predators, and migrating. Bird flight is one of the most complex forms of locomotion in the animal kingdom. Each facet of this type of motion, including hovering, taking off, and landing, involves many complex movements. As different bird species adapted over millions of years through evolution for specific environments, prey, predators, and other needs, they developed specializations in their wings and acquired different forms of flight.

GPS is a system. It’s made up of three parts: satellites, ground stations, and receivers. Satellites act like stars in constellations—we know where they are supposed to be at any given time. The ground stations use radar to make sure they are actually where we think they are. A receiver, as you might find in your phone or your car, is constantly listening for a signal from these satellites. The receiver figures out how far away they are from some of them. Once the receiver calculates its distance from four or more satellites, it knows exactly where you are. Presto! From miles up in space your location on the ground can be determined with incredible precision! They can usually determine where you are within a few yards of your actual location. More high-tech receivers, though, can figure out where you are within a few inches!

AIRCRAFT:

MECHANISM:

Lift, Drag, and Thrust: The fundamentals of bird flight are similar to those of aircraft, in which the aerodynamic forces sustain flight lift, drag, and thrust. Lift force is produced by the action of airflow on the wing, which is an air foil. The air foil is shaped such that the air provides a net upward force on the wing, while the movement of air is directed downward. The additional net lift may come from airflow around the bird's body in some species, especially during intermittent flight while the wings are folded or semi-folded (cf. lifting body).

Aerodynamic drag is the force opposite to the direction of motion, and hence the source of energy loss in flight. The drag force can be separated into two portions, lift-induced drag, which is the inherent cost of the wing producing lift (this energy ends up primarily in the wingtip vortices), and parasitic drag, including skin friction drag from the friction of air and body surfaces and form drag from the bird's frontal area. The streamlining of the bird's body and wings reduces these forces. Unlike aircraft, which have engines to produce thrust, birds flap their wings with a given flapping amplitude and frequency to generate thrust.

8. a) Explain the terms Lotus leaf effect, plant burrs and super hydrophobic and self-cleaning surfaces?

Ans: The lotus leaf is well-known for having a highly water-repellent, or superhydrophobic, surface, thus giving the name to the lotus effect. Water repellency has received much attention in the development of self-cleaning materials, and it has been studied in both natural and artificial systems.

SUPERHYDROPHOBIC AND SELF-CLEANING SURFACES:

The self-cleaning function of superhydrophobic surfaces is conventionally attributed to the removal of contaminating particles by impacting or rolling water droplets, which implies the action of external forces such as gravity. Here, we demonstrate a unique self-cleaning mechanism whereby the contaminated superhydrophobic surface is exposed to condensing water vapor, and the contaminants are autonomously removed by the self-propelled jumping motion of the resulting liquid condensate, which partially covers or fully encloses the contaminating particles. The jumping motion of the superhydrophobic surface is powered by the surface energy released upon the coalescence of the condensed water phase around the contaminants. The jumping-condensate mechanism is shown to spontaneously clean superhydrophobic cicada wings, where the contaminating particles cannot be removed by gravity, wing vibration, or wind flow. Our findings offer insights into the development of self-cleaning materials.

Mechanism:

An autonomous mechanism to achieve self-cleaning on superhydrophobic surfaces, where the contaminants are removed by self-propelled jumping condensate powered by surface energy. When exposed to condensing water vapor, the contaminating particles are either fully enclosed or partially covered with the resulting liquid condensate. Building upon our previous publications showing self-propelled jumping upon drop coalescence (5, 6), we show particle removal by the merged condensate drop with a size comparable to or larger than that of the contaminating particle(s). Further, we report a distinct jumping mechanism upon particle aggregation, without a condensate drop of comparable size to that of the particles, where a group of particles exposed to water condensate clusters together by capillarity and self-propels away from the superhydrophobic surface.

PLANT BURRS:

A bur (also spelled burr) is a seed or dry fruit or infructescence that has hooks or teeth. The main function of the bur is to spread the seeds of the bur plant, often through epizoochory. The hooks of the bur are used to catch on to for example fur or fabric, so that the bur, which contains seeds, then can be transported along with the thing it attached itself to. Another use for the spines and hooks is physical protection against herbivores. Their ability to stick to animals and fabrics has shaped their reputation as bothersome.

Some other forms of diaspores, such as the stems of certain species of cactus also are covered with thorns and may function as burs. Bur-bearing plants such as Xanthium species are often single□stemmed when growing in dense groups, but branch and spread when growing singly. The number of burs per fruit along with the size and shape can vary largely between different bur plants.

8. b) Explain the terms shark skin and swimsuits, bullet train using biological concepts?

Ans: SHARK SKIN:

The texture is rough since it has small scales similar to teeth, called Dermal Denticles. Each species has uniquely shaped Denticles. They have a covering of dentine, a central pulp canal containing blood vessels, and asingle nerve.

The Denticles play an important part in swimming efficiency. The water is channeled by the ‘skin teeth' and flows across the fins and around the body. The teeth also break up the interface between skin and water, reducing the friction between the two entities. The teeth and skin also help protect the shark from injuries and several elements in the water. It's like a suit of armor for sharks.

SHARK SKIN AND SWIMSUITS:

Scientists have been able to replicate the dermal Denticles in swimsuits and also the bottom of ships or boats. When cargo ships can squeeze out even a single percent in efficiency, they burn less bunker oil and don’t require cleaning chemicals for their hulls. Besides that, this sharkskin mechanism is also applied to create surfaces in hospitals that resist bacteria growth since the bacteria can’t catch hold of the rough surface. Sharkskin-inspired swimsuits received a lot of media attention during the 2008 Summer Olympics when the spotlight was shining on Michael Phelps. However, they are now banned in most of the major competitions.

THE BEAK THAT INSPIRED A BULLET TRAIN:

The secret is in the shape of the kingfisher’s beak. A long and narrow cone, the kingfisher’s beak parts and enters the water without creating a compression wave below the surface or a noisy splash above. The fine point of the conical beak presents little surface area or resistance to the water upon entry, and the evenly and gradually enlarging cross-section of the beak keeps fluid flowing smoothly around it as it penetrates further into the water column. This buys the bird crucial milliseconds to reach the fish before the fish knows to flee. The length of the beak is critical here: the longer it is, the more gradually the angle of the wedge expands. A shorter, fatter, or rounder beak would increase the wedge angle, resulting in a splash, a compression wave, and a fleeing fish.

The Potential:

Eiji Nakatsu, the chief engineer of the company operating Japan’s fastest trains, wondered if the kingfisher’s beak might serve as a model for how to redesign trains not to create such a thunderous noise when leaving tunnels and breaking through the barrier of tunnel air and outside-air. Sure enough, as his team tested different shapes for the front of the new train, the train became quieter and more efficient as the geometry of its nose became more like the shape of a kingfisher’s beak, requiring 15% less energy while traveling even faster than before.

8. c) Write a short note on Haemoglobin- based oxygen carries (HBOC’S) and perfluorocarbons(PFC)?

Ans: HUMAN BLOOD SUBSTITUTES:

Shortages in blood supplies and concerns about the safety of donated blood have fueled the development of so-called blood substitutes. The two major types of blood substitutes are volume expanders, which include solutions such as saline that are used to replace lost plasma volume, and oxygen therapeutics, which are agents designed to replace oxygen normally carried by the hemoglobin in red blood cells. Of these two types of blood substitutes, the development of oxygen therapeutics has been the most challenging. One of the first groups of agents developed and tested were perfluorocarbons, which effectively transport and deliver oxygen to tissues but causecomplex side effects, including flulike reactions, and are not metabolized by the body. Other oxygen therapeutics include agents called hemoglobin-based oxygen carriers (HBOCs), which are made by genetically or chemically engineering hemoglobin isolated from the red blood cells of humans or bovines. HBOCs do not require refrigeration, are compatible with all blood types, and efficiently distribute oxygen to tissues. A primary concern associated with these agents is their potential to cause severe immune reactions. Blood from the human umbilical cord has been studied for its potential as a substitute source of red blood cells for transfusion. Red blood cells can be extracted from cord blood via sedimentation as the blood is cooled. Donated cord blood can

be screened for infectious organisms and other contaminants. Research concerning its potential use for transfusion is ongoing. Of particular concern for implementation are the establishment of safe, effective, and ethical procedures for cord blood collection as well as the development of criteria that help to ensure safe transfusion and the preservation of cord blood quality.

Hemoglobin-based oxygen carriers (HBOCs) AND Perfluorocarbons (PFC):

Pharmaceutical companies attempted to develop HBOCs (also called oxygen therapeutics) and PFCs starting in the 1980s and at first, seemed to have some success. However, the results of most human clinical trials have been disappointing. A study published in 2008 in the Journal of the American Medical Association summarized the results of 16 clinical trials on five different blood substitutes administered to 3,500 patients. Those receiving blood substitutes had a threefold increase in the risk of heart attacks compared with the control group given human donor blood. However, a closer analysis of the results showed that some of the negative statistics were misleading. The artificial blood products reviewed in this study varied in their benefits and risks, and some blood substitutes had very few serious side effects. The findings suggest that some blood substitutes may be safer and more beneficial than scientists originally thought.

1) HBOCs:

Hemoglobin-based oxygen carriers (HBOCs) are "made of" natural hemoglobins that were originally developed as blood substitutes but have been extended to a variety of hypoxic clinical situations due to their ability to release oxygen. Compared with traditional preservation protocols, the addition of HBOCs to traditional preservation protocols provides more oxygen to organs to meet their energy metabolic needs, prolongs preservation time, reduces ischemia-reperfusion injury to grafts, improves graft quality, and even increases the number of transplantable donors. The focus of the present study was to review the potential applications of HBOCs in solid organ preservation and provide new approaches to understanding the mechanism of promising strategies for organ preservation.

2) PFCs:

PFCs remain in the bloodstream for about 48 hours. Because of their oxygen-dissolving ability, PFCs were the first group of artificial blood products studied by scientists. They are first□generation blood substitutes. Unlike the red-coloured HBOCs, PFCs are usually white. However, since they do not mix with blood they must be emulsified before they can be given to patients. PFCs are such good oxygen carriers that researchers are now trying to find out if they can reduce swollen brain tissue in traumatic brain injury. PFC particles may cause flu-like symptoms in some patients when they exhale these compounds.

9.a) Explain the DNA organic and Biocomputing?

Ans: DNA ORIGAMI AND BIOCOMPUTING:

Biological materials are self-assembled with near-atomic precision in living cells, whereas synthetic 3D structures generally lack such precision and controllability. Recently, DNA nanotechnology, especially DNA origami technology, has been useful in the bottom-up fabrication of well-defined nanostructures ranging from tens of nanometers to sub-micrometers. In this Primer, we summarize the methodologies of DNA origami technology, including origami design, synthesis, functionalization and characterization. We highlight applications of origami structures in nanofabrication, nano photonics and nanoelectronics, catalysis, computation, molecular machines, bioimaging, drug delivery and biophysics. We identify challenges for the field, including size limits, stability issues and the scale of production, and discuss their possible solutions. We

further provide an outlook on next-generation DNA origami techniques that will allow in vivo synthesis and multiscale manufacturing.

DNA origami is the nanoscale folding of DNA to create arbitrary two- and three-dimensional shapes at the nanoscale. The specificity of the interactions between complementary base pairs makes DNA a useful construction material, through design of its base sequences. DNA is a well□understood material that is suitable for creating scaffolds that hold other molecules in place or to create structures all on its own.

The current method of DNA origami was developed by Paul Rothemund at the California Institute of Technology. The process involves the folding of a long single strand of viral DNA (typically the 7,249 bp genomic DNA of M13 bacteriophage) aided by multiple smaller "staple" strands. These shorter strands bind the longer in various places, resulting in the formation of a pre-defined two- or three-dimensional shape. Examples include a smiley face and a coarse map of China and the Americas, along with many three-dimensional structures such as cubes.

To produce a desired shape, images are drawn with a raster fill of a single long DNA molecule. This design is then fed into a computer program that calculates the placement of individual staple strands. Each staple binds to a specific region of the DNA template, and thus due to Watson-Crick base pairing, the necessary sequences of all staple strands are known and displayed. The DNA is mixed, then heated and cooled. As the DNA cools, the various staples pull the long strand into the desired shape. Designs are directly observable via several methods, including electron microscopy, atomic force microscopy, or fluorescence microscopy when DNA is coupled to fluorescent materials.

Bottom-up self-assembly methods are considered promising alternatives that offer cheap, parallel synthesis of nanostructures under relatively mild conditions. Since the creation of this method, software was developed to assist the process using CAD software. This allows researchers to use a computer to determine the way to create the correct staples needed to form a certain shape. One such software called caDNAno is an open source software for creating such structures from DNA. The use of software has not only increased the ease of the process but has also drastically reduced the errors made by manual calculations.

Applications:

Many potential applications have been suggested in literature, including enzyme immobilization, drug delivery systems, and nanotechnological self-assembly of materials. Though DNA is not the natural choice for building active structures for nanorobotic applications, due to its lack of structural and catalytic versatility, several papers have examined the possibility of molecular walkers on origami and switches for algorithmic computing. The following paragraphs list some of the reported applications conducted in the laboratories with clinical potential.

Long strands of DNA are folded into a complex scaffold of staple strands having 200–300 nucleotides. This leads to formation of a complex structure that has characteristic features because of their nanoscale dimensions. These DNA nanostrustures are known to still be in their preliminary developmental stages, since key domains, such as their biocompatibility and physiochemical characterizations are yet to be established. However, theoretically, DNA origami has the immense potential to contribute significantly in a wide range of fields, such as diagnosis and drug delivery. Cancer therapy and diagnosis is one such potential domain where DNA origami showed significant anticancer efficacy and may contribute immensely.

BIOCOMPUTING:

A computer that uses components of biological origin (such as molecules of DNA) instead of electrical components. The device is rudimentary—it can only perform basic high-school-level math problems. In the quest to understand and model the healthy or sick human body, re searchers and medical doctors are utilizing more and more quantitative tools and techniques. This trend is pushing the envelope of a new field we call

Biomedical Computing, as an exciting frontier among signal processing, pattern recognition, optimization, nonlinear dynamics, computer science and biology, chemistry and medicine.

Computing process which uses synthesized biological components to store and manipulate data analogous to processes in the human body. The result is small, faster computing processes that operates with great accuracy. Main component used is DNA. The main application is in disease prediction and disease diagnosis.

9. b) Explain the bioimaging and artificial intelligence for disease diagnosis?

Ans: 1) BIOIMAGING

Bioimaging is a noninvasive process of visualizing biological activity in a specific period. It does not inhibit the various life processes such as movement, respiration, etc., and it helps to report the 3D structure of specimens apart from inferencing physically. It is helpful in connecting the observation of subcellular structures and all the tissues in the multicellular organisms. The imaging of biological samples, or bioimaging, plays a key role in current life science research, enabling scientists to analyze molecules, cells and tissues from a range of living systems. Nanoparticle fluorescence imaging has been used in gene detection, protein analysis, enzyme activity evaluation, element tracing, cell tracking, early stage disease diagnosis, tumor related research, and monitoring real time therapeutic effects. Bioimaging spans the observation of subcellular structures and entire cells over tissues up to entire multicellular organisms. Among others, it uses light, fluorescence, electrons, ultrasound, X-ray, magnetic resonance and positrons as sources for imaging.

2) ARTIFICIAL INTELLIGENCE IN DISEASE DIAGNOSIS

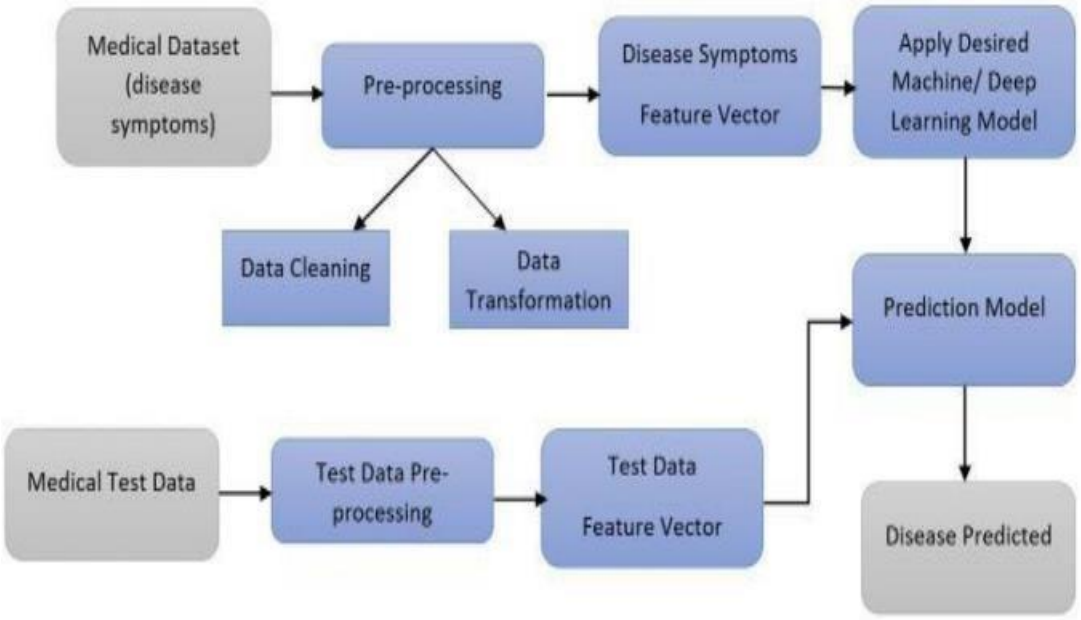
Artificial intelligence can assist providers in a variety of patient care and intelligent health systems. Artificial intelligence techniques ranging from machine learning to deep learning are prevalent in healthcare for disease diagnosis, drug discovery, and patient risk identification. Numerous medical data sources are required to perfectly diagnose diseases using artificial intelligence techniques, such as ultrasound, magnetic resonance imaging, mammography, genomics, computed tomography scan, etc. Furthermore, artificial intelligence primarily enhanced the infirmary experience and sped up preparing patients to continue their rehabilitation at home.

Detecting any irresistible ailment is nearly an afterward movement and forestalling its spread requires ongoing data and examination. Hence, acting rapidly with accurate data tosses a significant effect on the lives of individuals around the globe socially and financially (Minaee et al. 2020). The best thing about applying AI in health care is to improve from gathering and processing valuable data to programming surgeon robots. AI describes the capability of a machine to study the way a human learns, e.g., through image identification and detecting pattern in a problematic situation. AI in health care alters how information gets composed, analysed, and developed for patient care.

System planning is the fundamental abstract design of the system. It includes the framework's views, the course of action of the framework, and how the framework carries on underneath clear conditions. A solid grip of the framework design can help the client realize the limits and boundaries of the said framework. In pre-preparing, real-world information requires upkeep and pre-preparing before being taken care of by the calculation. Because of the justifiable explanation, real-world data regularly contains mistakes regarding the utilized measures yet cannot practice such blunders. Accordingly, information pre-preparing takes this crude information, cycles it, eliminates errors, and spares it an extra examination. Information experiences a progression of steps during pre-handling: Information is purged by various strategies in information cleaning. These strategies involve gathering information, such as filling the information spaces that are left clear or

decreasing information, such as the disposal of commas or other obscure characters. In information osmosis, the information is joined from a combination of sources.

The information is then amended for any blend of mistakes, and they are quickly taken care of. Information Alteration: Data in this progression is standardized, which depends upon the given calculation. Information standardization can be executed utilizing several ways. This progression is obligatory in most information mining calculations, as the information wants to be as perfect as possible. Information is then mutual and developed.



9.c) Write a short note on self-healing bio concrete?

Ans: Bio-concrete is a self-healing form of concrete designed to repair its own cracks. To heal cracks in the concrete, Jonkers chose bacteria (Bacillus pseudormus and B. cohnii), that are able to produce limestone on a biological basis. The positive side-effect of this property: the bacteria consume oxygen, which in turn prevents the internal corrosion of reinforced concrete. However, the bacteria do not pose a risk to human health, since they can only survive under the alkaline conditions inside the concrete. Based on these findings, Jonkers and his team of researchers developed three different bacterial concrete mixtures: self-healing concrete, repair mortar, and a liquid repair system.

In self-healing concrete, bacterial content is integrated during construction, while the repair mortar and liquid system only come into play when acute damage has occurred on concrete elements. Self-healing concrete is the most complex of the three variants. Bacterial spores are encapsulated within two-to four-millimeter wide clay pellets and added to the cement mix with separate nitrogen, phosphorous and a nutrient agent. This innovative approach ensures that bacteria can remain dormant in the concrete for up to 200 years. Contact with nutrients occurs only if water penetrates a crack – and not while mixing cement. This variant is well-suited for structures that are exposed to weathering, as well as points that are difficult to access for repair workers. Thus, the need for expensive and complex manual repairs is eliminated.

Self-healing concrete is nothing but concrete which can retain itself to the original state when it is subjected to cracks." Bio-concrete is a material that will biologically produce minerals like limestone with the help of bacteria present in it, which will heal cracks that appear on the concrete surfaces. Bacterial self-healing is an innovative technology allowing repairing open micro-cracks in concrete by $CaCO_3$ precipitation. This bio-

technology improves the durability of the structure. In this paper, peptone, yeast extract and Bacillus Subtilis were added as microbial adjuvant in concrete mix design.

Rahbar predicts self-healing concrete could extend the life of a structure from 20 years, for example, to 80 years. Other research into creating self-healing concrete has focused on adding microbes and Bacillus megaterium, a spore-forming bacteria that produces an enzyme that is expelled into the concrete mix.

The healing agent consisting of B. cohnii spores, calcium lactate and yeast extract immobilized in light-weight aggregates was also combined with cement, fly ash, limestone powder, VA Fibers, water in a repair mortar.

10. a) Explain the importance of bioimaging?

Ans:

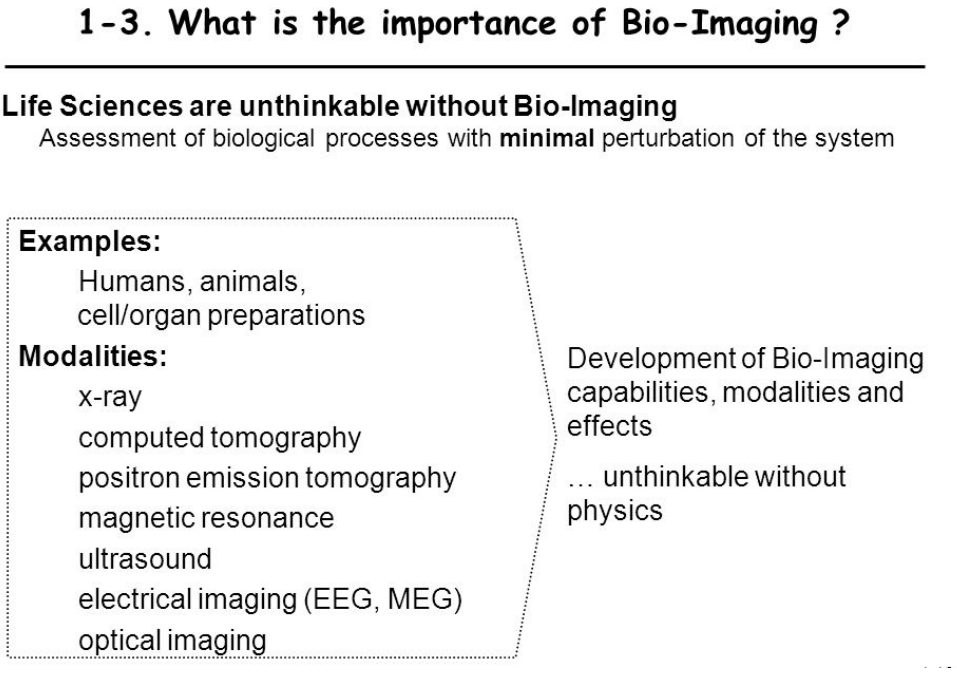
BIOIMAGING:

Bioimaging is a noninvasive process of visualizing biological activity in a specific period. It does not inhibit the various life processes such as movement, respiration, etc., and it helps to report the 3D structure of specimens apart from inferencing physically. It is helpful in connecting the observation of subcellular structures and all the tissues in the multicellular organisms.

The imaging of biological samples, or bioimaging, plays a key role in current life science research, enabling scientists to analyze molecules, cells and tissues from a range of living systems.

Nanoparticle fluorescence imaging has been used in gene detection, protein analysis, enzyme activity evaluation, element tracing, cell tracking, early stage disease diagnosis, tumor related research, and monitoring real time therapeutic effects.

Bioimaging spans the observation of subcellular structures and entire cells over tissues up to entire multicellular organisms. Among others, it uses light, fluorescence, electrons, ultrasound, X-ray, magnetic resonance and positrons as sources for imaging.



10. b) Explain bioremediation and bio mining via microbial surface adsorption?

Ans: 1) BIOREMEDIATION

Bioremediation is a biotechnical process, which abates or cleans up contamination. It is a type of waste management technique which involves the use of organisms to remove or utilize the pollutants from a polluted area. Types of Bioremediation.

Bioremediation is of three types –

1) Biostimulation: As the name suggests, the bacteria is stimulated to initiate the process. The contaminated soil is first mixed with special nutrients substances including other vital components either in the form of liquid or gas. It stimulates the growth of microbes thus resulting in efficient and quick removal of contaminants by microbes and other bacterias.
2) Bioaugmentation: At times, there are certain sites where microorganisms are required to extract the contaminants. For example – municipal wastewater. In these special cases, the process of

bioaugmentation is used. There's only one major drawback in this process. It almost becomes impossible to control the growth of microorganisms in the process of removing the contaminant.

3) Intrinsic Bioremediation: The process of intrinsic bioremediation is most effective in the soil and water because of these two biomes which always have a high probability of being full of contaminants and toxins. The process of intrinsic bioremediation is mostly used in underground places like underground petroleum tanks. In such place, it is difficult to detect a leakage and contaminants and toxins can find their way to enter through these leaks and contaminate the petrol. Thus, only microorganisms can remove the toxins and clean the tanks

Bioremediation helps clean up water sources, create healthier soil, and improve air quality around the globe. But unlike excavation-based remediation processes, which can be disruptive, bioremediation is less intrusive and can facilitate remediation of environmental impacts without damaging delicate ecosystems.

Immobilization of microbial cells and enzymes by adsorption takes place through their physical interaction with the surface of water-insoluble carriers. This method, commonly used in bioremediation processes, is quick, simple, eco-friendly and cost-effective. Microorganisms are utilized in bioremediation because of their ability to degrade environmental pollutants due to their metabolism via biochemical pathways related to the organism's activity and growth.

2) BIOMINING

Biomining is the process of using microorganisms (microbes) to extract metals of economic interest from rock ores or mine waste. Biomining techniques may also be used to clean up sites that have been polluted with metals.

Valuable metals are commonly bound up in solid minerals. Some microbes can oxidize those metals, allowing them to dissolve in water. This is the basic process behind most biomining, which is used for metals that can be more easily recovered when dissolved than from the solid rocks. A different biomining technique, for metals which are not dissolved by the microbes, uses microbes to break down the surrounding minerals, making it easier to recover the metal of interest directly from the remaining rock.

Most current biomining operations target valuable metals like copper, uranium, nickel, and gold that are commonly found in sulfidic (sulfur-bearing) minerals. Microbes are especially good at oxidizing sulfidic minerals, converting metals like iron and copper into forms that can dissolve more easily. Other metals, like gold, are not directly dissolved by this microbial process, but are made more accessible to traditional mining techniques because the minerals surrounding these metals are dissolved and removed by microbial processes. When the metal of interest is directly dissolved, the biomining process is called "bioleaching," and when the metal of interest is made more accessible or "enriched" in the material left behind, it is called "biooxidation." Both processes involve microbial reactions that can happen anywhere the microbes, rocks, and necessary nutrients, like oxygen, occur together.

10. c) Write a short note on Nano-medicines and bioleaching?

Ans: Bioleaching is a process in mining and biohydro metallurgy (natural processes of interactions between microbes and minerals) that extracts valuable metals from a low-grade ore with the help of microorganisms such as bacteria or archaea. Instead of separating the metal from the pyrite with high temperatures or pressures,bio-mining uses microbes from the Acidthiobacillus and Leptospirillum genera to do the job

A) Heavy metal ions adsorption process; the metal ions of wastewater adhere to the surface of nanoporous adsorbents, which has a high surface area due to its porosity. The adsorption process could be selective for one or more metals than others. The regeneration process could be achieved using a desorbing agent.

B) Various modification techniques (i.e., nitrogenation, oxidation, and sulfuration) are used to functionalize carbon with different functional groups. Functionalization enhances adsorption capacity and stability.

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials and biological devices to nano electronic biosensors, and even possible future applications of molecular nanotechnology such as biological machines.

Nanotechnology-on-a-chip is one more dimension of lab on a chip technology. Magnetic nanoparticles, bound to a suitable antibody, are used to label specific molecules, structures or microorganisms. In particular silica nanoparticles are inert from the photophysical point of view and might accumulate a large number of dye(s) within the nanoparticle shell. Gold nanoparticles tagged with short segments
Of DNA can be used for detection of genetic sequence in a sample. Multicolour optical coding for biologicalassays has been achieved by embedding different-sized quantum dots into polymeric microbeads. Nanopore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.