Answers

Unit 2 :

1. ECG : Electrocardiograph
   EMG : Electromyography
   EEG : Electroencephalogram
   MRI : Magnetic Resource Imaging
   X-RAY : X- Radiation

2. Instrument which records the electrical activity of the heart is electrocardiograph.

3. A normal ECG makes a specific pattern of three recognizable waves in a cardiac cycle. These wave are- P wave, QRS wave and T-wave, P-R interval, S-T segment.

   P-wave:

   It is a small upward wave that appears first

   It indicates atrial depolarization (systole), during which excitation spreads from SA node to all over atrium

   About 0.1 second after P-wave begins, atria contracts. Hence P-wave represents atrial systole

   QRS wave:

   It is the second wave that begins as a little downward wave but continues as a large upright triangular wave and ends as downward wave

   It represents the ventricular depolarization (systole)

Just after QRS wave begins, ventricles starts to contracts. Hence QRS wave represents ventricular systole

T- wave:

It is third small wave in the form of a dome-shaped upward deflection.

It indicates ventricular repolarization (diastole)

It also represents the beginning of ventricular diastole

** ATRIAL DIASTOLE MERGES WITH QRS-WAVE

P-R interval:

It represents the time required for an impulse to travel through the atria, AV node and bundle of his to reach ventricles.

S-T segment:

It is measured from the end of S to the beginning of T-wave

It represents the time when ventricular fibres are fully depolarized.

Application of ECG:

it indicates the rate and rhythm or pattern of contraction of heart

it gives a clue about the condition of heart muscle and is used to diagnose heart disorders it helps the doctors to determine whether the heart is normal, enlarged or if its certain regions are damaged

it can also reveal irregularities in heart's rhythm known as 'arrhythmia'

it is used by doctors to diagnose heart damage in conditions like high blood pressure, rheumatic fever and birth defects

an ECG also helps to determine the location and amount of injury caused by heart attack and later helps to assess the extent of recovery

Electromyography (EMG) signals can be used for clinical/biomedical applications, Evolvable Hardware Chip (EHW) development, and modern
human **computer** interaction. EMG signals acquired from muscles require advanced methods for detection, decomposition, processing, and classification.

MRI can be **used to detect** brain tumors, traumatic brain injury, developmental anomalies, multiple sclerosis, stroke, dementia, infection, **and** the causes **of** headache.

x-rays are an integral part of contemporary hospitals and medical centres.
Radiation therapy. X-rays play an important role in the fight against cancer, with high energy radiation used to kill cancer cells and shrink tumours.
Airport security.
Revealing counterfeit art.
X ray is more dangerous than MRI for human body.

4. Types of Biomedical Instrumentation Systems
   Direct/Indirect

Invasive/Noninvasive

Contact/Remote

Sense/Actuate

Dynamic/Static

Direct/Indirect: The sensing system measure a physiologic parameter directly, such as the average volume blood flow in an artery, or measures a parameter **related to** the physiologic parameter of interest (e.g., ECG recording at the body surface is related to propagation of the action potential in the heart but is **not a** measurement of the propagation waveform).
Invasive/Noninvasive: Direct electrical recording of the action potential in nerve fibers using animplantable electrode system is an example of an invasive sensor. An imaging system measuring blood flow dynamics in an artery (e.g., ultrasound color flow imaging of the carotid artery) is an example of a non-invasive sensor.
Contact/Remote: A strain gauge sensor attached to a muscle fiber can record deformations and forces in the muscle. An MRI or ultrasound imaging system can measure internal deformations and forces without contacting the tissue.
Sense/Actuate: A sensor detects biochemical, bioelectrical, or biophysical parameters. An actuator delivers external agents via direct or indirect contact and/or controls

biochemical, bioelectrical, or biophysical parameters. An automated insulin delivery pump is an example of a direct, contact actuator. Noninvasive surgery with high intensity, focused ultrasound (HIFU) is an example of a remote, noninvasive actuator.

Dynamic/Static: Static instruments measure temporal averages of physiologic parameters. Real-time instruments have a time response faster than or equal to the physiologic time constants of the sensed parameter. For example a real-time, ultrasound Doppler system can measure changes in arterial blood velocity over a cardiac cycle.

5. Test used to evaluate the electrical activity in the brain is EEG.
6. True.

EEG measures the electrical impulses in your brain by using several electrodes that are attached to your scalp.

7. A biosensor is an analytical device for the detection of an analyte that combines a biological component with a physicochemical detector component. It consists of 2 parts:

- the sensitive biological element (biological material) (e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids etc.). The sensitive elements can be created by biological engineering.
- the transducer or the detector element that transforms the signal resulting from the interaction of the analyte with the biological element into another signal (i.e., transducers) that can be more easily measured and quantified.

It detects, records and transmits information regarding a physiological change or the presence of various chemical or biological materials in the environment. An analyte can be a protein, toxin, sugar, antibiotic or vitamin present in the body fluid.

Biosensor is a combination of two parts:

1. bio-element- This part is also known as bioreceptor, biocatalyst or biological active material. It can be an enzyme, antibody, organelle, hormones, nucleic acids or whole cells.
2. sensor-element- This part is also known as transducer. It can be carbon electrode, oxygen electrode, an ion-sensitive electrode, a photocell or a thermistor.

Biosensors were first developed by **Clark (Father of Biosensors)** in 1962.

Characteristics of Biosensor

1. Selectivity is probably the most important feature of a biosensor. Selectivity means that sensor detects a certain analyte and doesn’t react to admixtures and contaminants. Antigen-antibody interaction has the highest selectivity, it is analyte-specific.
2. Precision is usually characterised in terms of the standard deviation of measurements. Precision is a characteristic of

any scientific device that makes quantitative measurements. If biosensor is not accurate, then there will be fluctuations in the measurements.

3. Signal stability shows the signal drift under constant conditions which causes an error in measured concentration. Signal stability influences the precision of sensor. It is an important characteristic of a sensor that performs continuous monitoring. Signal drift is usually measured in percent per hour.
4. Sensitivity (detection limit) shows the minimal amount (or concentration) of analyte that can be detected.
5. Working range is the range of analyte concentrations in which the sensor can operate. Working range of sensor should correlate with the range of possible concentrations analyte in the assay. For example, glucose concentration in blood typically varies from 0.2mM to 20 mM. Working range of glucose sensors shouldn't be less.
6. Linear range is the range of analyte concentrations in which the sensor response changes linearly with the concentration.
7. Response time is time required to analyze the assay.

Principle of Biosensors

The biological material (enzymes) is firstly immobilized on the immobilization support. Then the sample is passed through the membrane so that analyte present in the sample can react with the immobilized material. After interaction, a biological signal will be produced. This biological signal is then converted by sensor element into electrical signal.

1. Bioreceptor: An analyte present in the sample would bind to this component only. But it should be highly specific.

e.g., glucose oxidase acts only on glucose to produce gluconic acid and hydrogen peroxide. Bioreceptor should be stable under storage conditions and it should be immobilized.

2. Transducer: acts as an interface since it is present between first and third component.Itmeasures the physical change that occurs with the reaction at the bioreceptor then transforming that energy into measurable electrical output.
3. Detector:Signals from the transducer are passed to a microprocessor where they are amplified and analyzed.The data is then converted to concentration units and transferred to a display or/and data storage device.

8. Father of bio sensor is Leland Clark.

9. False. Analyte is not also known as bio receptor.

10. **Receptors**
Chemoreceptors

A sensory cell or organ which is responsive to chemical stimuli.

Sensory Receptor (Taste bud receptor)

Internal peripheral chemoreceptor

Hot and Cold Receptors

Non specialized sense receptor that codes absolute and relative changes in temperature.

Peripheral Nervous System have warmth receptors.

Warmth receptors are unmylinated C- fibre receptors that respond to cold have mylinated C-fibres

Baroreceptors

These are pressure receptors are sensors located in the blood vessels that sense pressure of blood in blood vessels.

They sense the blood pressure and relay the information to the brain, so that a proper blood pressure can be maintained.

Two types:
Arterial baroreceptors
Low pressure baroreceptors

Sensors for smell and vision

Sensors for Smell are also called olfactory receptors which are located in nasal cavity.

Olfactory receptor sense smell and give signal to brain and then it is possible to detect smell.

Optical receptors are present in eyes

Taste receptors are for taste

Osmolarity receptors detect the osmolarity of blood and are found in hypothalamus

11. A **transducer** plays a very important role in any instrumentation system. An electrical **transducer** is a device which is capable of converting the physical quantity into a proportional electrical quantity such as voltage or electric current. Hence it converts any quantity to be measured into usable electrical signal. This physical quantity which is to be measured can be pressure, level, temperature, displacement etc. The output which is obtained from the transducer is in the electrical form and is equivalent to the measured quantity. For example, a temperature transducer will convert temperature to an equivalent electrical potential. This output signal can be used to control the physical quantity or display it.

Active Transducer

Active transducers are those which do not require any power source for their operation. They work on the energy conversion principle. They produce an electrical signal proportional to the input (physical quantity). For example, a thermocouple is an active transducer.

Passive Transducers

Transducers which require an external power source for their operation is called as a passive transducer. They produce an output signal in the form of some variation in resistance, capacitance or any other electrical parameter, which then has to be converted to an equivalent current or voltage signal. For example, a photocell (LDR) is a passive transducer which will vary the resistance of the cell when light falls on it. This change in resistance is converted to proportional signal with the help of a bridge circuit. Hence a photocell can be used to measure the intensity of light.

12. LVDT stands for linear variable differential transformer.

13. True. Active transducers includes photovoltaic cells

14. Chromatography is the process for identification, purification and separation of components of a mixture on the basis of difference in their affinity for mobile and stationary phase.

15. BAC stands for bacterial artificial chromosomes.
    YAC stands for yeast artificial chromosomes.

16. Plasmids are double-stranded, closed circular DNA molecules, which exist in the cell as extrachromosomal

17. Biosensors was first developed by Clark in 1962.

18. Electroencephalograph is an instrument for recording the electrical activity of brain by suitably placing surface electrodes on scalp.

19. ECG records electrical activity of the heart.

20. Full form of RDT is recombinant dna technology.

Steps of RDT :

(i) Isolation of Genetic Material.
(ii) Restriction Enzyme Digestion.
(iii) Amplification using PCR.
(iv) Ligation of DNA molecules.
(v) Insertion of Recombinant DNA into Host.
(vi) Isolation of Recombinant Cells.

Application of Recombinant DNA technology

Recombinant DNA is widely used in biotechnology, medicine and research.

The most common application of recombinant DNA is in basic research, in which the technology is important to most current work in the biological and biomedical sciences.

Recombinant DNA is used to identify, map and sequence genes, and to determine their function.

Recombinant proteins are widely used as reagents in laboratory experiments and to generate antibody probes for examining protein synthesis within cells and organisms.

Many additional practical applications of recombinant DNA are found in industry, food production, human and veterinary medicine, agriculture, and bioengineering.

DNA technology is also used to detect the presence of HIV in a person.

Application of recombinant DNA technology in Agriculture – For example, manufacture of Bt-Cotton to protect the plant against ball worms.

Application of medicines – Insulin production by DNA recombinant technology is a classic example.

Gene Therapy – It is used as an attempt to correct the gene defects which give rise to heredity diseases.

Clinical diagnosis – ELISA is an example where the application of recombinant DNA is possible.

21. PCR (polymerase chain reaction) is a method to analyze a short sequence of DNA (or RNA) even in samples containing only minute quantities of DNA or RNA. PCR is used to reproduce (amplify) selected sections of DNA or RNA.

Each step -- denatauration (alteration of structure), annealing (joining), and extension -- takes place at a different temperature:

1. **Denaturation:** At 94 C (201.2 F), the double-stranded DNA melts and opens into two pieces of single-stranded DNA.
2. **Annealing:** At medium temperatures, around 54 C (129.2 F), the primers pair up (anneal) with the single-stranded "template" (The template is the sequence of DNA to be copied.) On the small length of double-stranded DNA (the joined primer and template), the polymerase attaches and starts copying the template.
3. **Extension:** At 72 C (161.6 F), the polymerase works best, and DNA building blocks complementary to the template are coupled to the primer, making a double stranded DNA molecule.

Applications of PCR

PCR is used in many research labs, and it also has practical **applications** in forensics, genetic testing, and diagnostics. For instance, **PCR** is used to amplify genes associated with genetic disorders from the DNA of patients (or from fetal DNA, in the case of prenatal testing).

22. Recombinant DNA in a living organism was first achieved in **1973** by **Herbert Boyer.**

23. A random DNA or cDNA segment or specific gene is linked into a vector to form rDNA molecule, which can be propagated in suitable host cells to a large number, is a cloning vector. There are different types of cloning vectors for use with different types of host cells. The largest number exists for E. coliand the best known of these is the plasmid vector. A vector should have the following features:

1. It must contain a replicon that enables it to replicate in host cells.

2. It should have several marker genes, which help to differentiate the transformed cells from the nontransformed cells and also from the transformed cells, which contain recombinant DNA molecules, e.g. genes for ampicillin and tetracycline resistance.

3. It should have a unique cleavage site within one of the marker genes so that insertion of foreign DNA into the marker gene leads to its inactivation and identification of recombinant DNA molecule.

4. For the expression of cloned DNA, the vector DNA should contain suitable control elements, such as promoters, terminators, and ribosome binding sites.

Plasmids are extrachromosomal DNA molecules. They are small, circular and have an ability to replicate autonomously. Replication of plasmid is not under the control of chromosomal

DNA. They are mostly found in bacteria. Some of the eukaryotes like yeast and plants also contain plasmids.

Their ability to replicate independently makes plasmid a cloning vector in the recombinant DNA technology for transferring and manipulating genes.

Many antibiotic-resistant genes in bacteria are present in plasmids.

The size of plasmid varies from a few base pairs to thousands of bp.

Plasmids also get transferred from one bacterial cell to another by the process of conjugation.

Plasmids carrying a specific gene are introduced into bacterial cells, which multiply rapidly and the required DNA fragment is produced in larger quantities.

Plasmids are used to prepare a recombinant DNA with the desired gene to transfer genes from one organism to another. This is known as genetic engineering.

Joshua Lederberg coined the term plasmid.

Types of vectors are :

(i) pBR322

(ii) pACYC184

(iii) pUC vectors

(iv) BACs (Bacterial Artificial Chromosomes)

(v) YACs (Yeast Artificial Chromosomes)

(vi) HACs (Human Artificial Chromosomes)

(vii) Expression vectors.

(viii) Transcription vectors.

24.Introns are capable of being transcribed but not translated.

25. True. Vectors designed specifically for the expression of the transgene in the target cell are called expression vectors.

26. Another name of DNA fingerprinting is DNA Profiling or DNA Typing.

27. The technique of fingerprinting is used for DNA analysis in forensic tests and paternity tests. Apart from these two fields, it is also used in determining the frequency of a particular gene in a population which gives rise to diversity. In case of the change in gene frequency or genetic drift, Fingerprinting can be used to trace the role of this change in evolution.

29. Applications of Chromatography

Pharmaceutical sector

- To identify and analyze samples for the presence of trace elements or chemicals.
- Separation of compounds based on their molecular weight and element composition.
- Detects the unknown compounds and purity of mixture.
- In drug development.

Chemical industry

- In testing water samples and also checks air quality.

- HPLC and GC are very much used for detecting various contaminants such as polychlorinated biphenyl (PCBs) in pesticides and oils.
- In various life sciences applications

Food Industry

- In food spoilage and additive detection
- Determining the nutritional quality of food

Forensic Science

- In forensic pathology and crime scene testing like analyzing blood and hair samples of crime place.

Molecular Biology Studies

- Various hyphenated techniques in chromatography such as EC-LC-MS are applied in the study of metabolomics and proteomics along with nucleic acid research.
- HPLC is used in Protein Separation like Insulin Purification, Plasma Fractionation, and Enzyme Purification and also in various departments like Fuel Industry, biotechnology, and biochemical processes.

30. Immunity is the ability of the body to defend itself against disease-causing organisms. Everyday our body comes in contact with several pathogens, but only a few results into diseases. The reason is, our body has the ability to release antibodies against these pathogens and protects the body against diseases. This defence mechanism is called immunity.

Types of Immunity

There are two major types of immunity:

1. Innate Immunity or Natural or Non-specific Immunity.
2. Acquired Immunity or Adaptive Immunity.

Innate Immunity

This type of immunity is present in an organism by birth.

This is activated immediately when the pathogen attacks. Innate immunity includes certain barriers and defence mechanisms that keep foreign particles out of the body.

Innate immunity refers to the body's defence system.

This immunity helps us by providing the natural resistance components including salivary enzymes, natural killer cells, intact skin and neutrophils, etc. which produce an initial response against the infections at birth prior to exposure to a pathogen or antigens.

It is a long-term immunity in which our body produces the antibodies on its own. Our body has few natural barriers to prevent the entry of pathogens.

Acquired Immunity

Acquired immunity or adaptive immunity is the immunity that our body acquires or gains over time. Unlike the innate immunity, this is not present by birth.

The ability of the immune system to adapt itself to disease and to generate pathogen-specific immunity is termed as acquired immunity. It is also known as adaptive immunity.

An individual acquires the immunity after the birth, hence is called as the acquired immunity.

It is specific and mediated by antibodies or lymphocytes which make the antigen harmless.

The main function of acquired immunity is to relieve the victim of the infectious disease and also prevent its attack in future.

It mainly consists of an advanced lymphatic defence system which functions by recognizing the own body cells and not reacting to them.

31. Acquired immunity acquires with the passage of life.

32. Innate immunity is present by birth.

33. The organs of the immune system which are involved in defending the body against invading pathogens causing infections or spread of tumours is termed as Lymphoid organs. It includes bone marrow, blood vessels, lymph nodes, lymphatic vessels, thymus, spleen, and various other clusters of lymphoid tissue.

Lymphoid organs are the site of origin, maturation, and proliferation of lymphocytes. They exist as primary, secondary or tertiary and these are based on their stage of development and maturation.

These organs consist of fluid connective tissues with different types of leukocytes or white blood cells. The highest percentage of Lymphocytes are present in the white blood cells or leukocytes.

Primary lymphoid organs

The primary lymphoid organs produce and allow the maturation of lymphocytes. It also serves by generating lymphocytes from immature progenitor cells. Therefore it is referred to as the central lymphoid organs. Examples of primary lymphoid organs include thymus and the bone marrow.3

Secondary lymphoid organs

The secondary lymphoid organs are referred to as the peripheral lymphoid organs as they are involved in promoting the sites for the interaction of lymphocytes with the antigen to become effector cells. They initiate an adaptive immune response. The secondary lymphoid organs Examples of secondary lymphoid organs spleen, tonsils, lymph nodes, appendix, etc. are secondary lymphoid organs.

Tertiary lymphoid organs

The tertiary lymphoid organs usually contain very less number of lymphocytes. It plays an important role during the inflammation process.