ANSWER KEY & MARKING SCHEME

CLASS- XI

BIOTECHNOLOGY (2025-2026)

Q.no	Questions	Marks
1.	b. To cut DNA at specific recognition sites	1
2.	a) Energy storage	1
3.	c) Elaioplasts	1
4.	b) To amplify DNA sequences	1
5.	b) Robert Holley	1
6.	a) Cell-mediated	1
7.	A and R both are true and R explains A	1

8.	A is true, R is also true but R does not explain A	1

9.	A is true, R is false	1
10.	Variable Number Tandem Repeats	1
11.	Bioreactors	1
12.	Ribosome	1
13.	Taq polymerase	1
14.	Golgi apparatus	1
15.	DNA and proteins	1

16.	Bioreactors are specially designed vessels or containers that provide a controlled environment for the growth of microorganisms, cells, or tissues to produce biological products like enzymes, vaccines, or recombinant proteins. They maintain **optimal conditions** such as temperature, pH, oxygen supply, and nutrients to support biological processes efficiently Example: A **Stirred Tank Bioreactor** is a common example. It is used for **large-scale production** of insulin, antibiotics, or bioenzymes.	2

17.	The **structural unit of DNA** is called a **nucleotide**. 1. A **nitrogenous base** (Adenine, Thymine, Cytosine, or Guanine) 2. A **deoxyribose sugar** 3. A **phosphate group** **Or** Applications of Biotechnology in Medicine: 1. Production of Insulin – Recombinant DNA technology is used to produce human insulin for diabetic patients. 2. Gene Therapy – Used to correct genetic disorders by inserting healthy genes. 3. Production of Vaccines – Biotechnology helps in developing modern vaccines, like Hepatitis B and COVID-19. 4. Monoclonal Antibodies – Used in diagnosis and treatment of cancers and autoimmune diseases. 5. Personalized Medicine – Tailored treatments based on individual genetic makeup.	2

18.	The Law of Segregation states that: “Every individual possesses two alleles for each trait, and these alleles separate (segregate) during the formation of gametes, so that each gamete carries only one allele for each trait.” Relation to Mendelian Inheritance: • This law is the first law of Mendel. • It explains how traits are inherited from one generation to the next. • During meiosis, the two alleles of a gene present in a parent segregate into different gametes, ensuring equal chances of passing either allele to offspring.	**2**
	• Example: In a cross between Tt × Tt, the tall (T) and short (t) alleles segregate, leading to a 3:1 ratio in F2 generation (Tall : Short)	

19.	Plasmids are small, circular, double-stranded DNA molecules found in bacteria that can replicate independently of the bacterial chromosome. When used as vectors in genetic engineering, plasmids act as carriers to transfer foreign genes into a host cell (usually bacteria) for cloning or expression of those genes. Why Plasmids are Good Vectors: • They have a replication origin (ori) – so they can copy themselves. • Can be easily modified in labs. • Often contain selectable markers like antibiotic resistance genes.	**2**

20.		etween RER (Rough E		
	Feature	nooth Endoplasmic Ret	SER (Smooth Endoplasmic Reticulum)	
	Ribosomes	RER (Rough Endoplasmic Reticulum) Present on the surface, giving it a rough appearance	Absent on surface, hence smooth appearance	
	Main Function	Synthesis of proteins	Synthesis of lipids and steroids, detoxification of drugs	

		2

	Appearance	Rough and grainy under microscope	Smooth and tubular		
	Associated With	Golgi apparatus and protein transport	Lipid metabolism and detoxification processes		
	Location	Common near the nucleus	Spread throughout the cytoplasm		
	Examples of Products	Enzymes, hormones, membrane proteins	Cholesterol, hormones, membrane lipids		

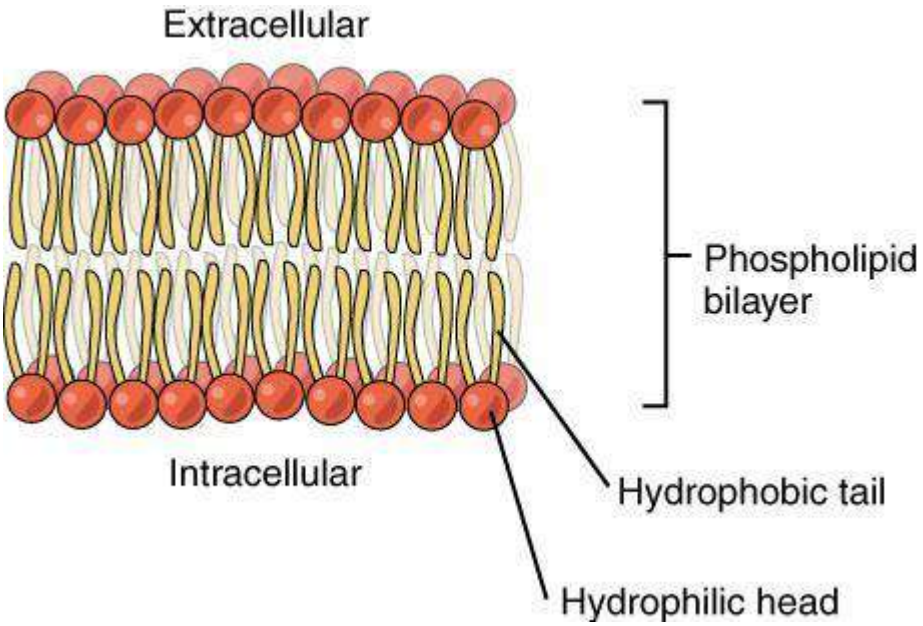
of

Or

Structure of Plasma Membrane – Singer & Nicolson Model (Fluid Mosaic Model)

The Fluid Mosaic Model was proposed by Singer and Nicolson in 1972. According to this model:

- The plasma membrane is a flexible (fluid) bilayer phospholipids.
- Proteins are embedded within this bilayer like a mosaic.
- The membrane is semipermeable, allowing selective movement of substances.



21.	Haemophilia Haemophilia is a genetic disorder in which the blood lacks certain clotting factors, resulting in delayed or prolonged bleeding. • It is a sex-linked recessive disorder, mostly affecting males. • Caused due to mutation in genes coding for Factor VIII or IX. • Even minor injuries can lead to severe internal bleeding. • Inheritance: Carried by females (carriers) and passed on to male children. Thalassemia Thalassemia is an inherited blood disorder in which the body makes an abnormal form or inadequate amount of haemoglobin. • This leads to destruction of red blood cells and causes anaemia. • Two main types: o Alpha-thalassemia o Beta-thalassemia (more common in India) • Symptoms: Weakness, pale skin, fatigue, delayed growth. • Treatment: Regular blood transfusions, iron chelation therapy, and in severe cases, bone marrow transplant. Or Gene Mapping – Explanation Gene Mapping is the process of determining the specific location (position) of genes on a chromosome. It helps in identifying the order and distance between genes based on how often they are inherited together. Key Points: • Shows the linear arrangement of genes. • Helps in locating disease-causing genes. • Measured in map units or centimorgans (cM).	2

	○ 1 centimorgan = 1% chance of recombination between two genes during meiosis. The concept of gene mapping was first given by Thomas Hunt Morgan and his student Alfred Sturtevant in the early 1900s while working on Drosophila (fruit fly). • Alfred Sturtevant is credited with creating the first genetic map in 1913.	
22.	The Central Dogma of Molecular Biology describes the flow of genetic information within a biological system. The Central Dogma states that: DNA → RNA → Protein This means genetic information flows from: 1. DNA (Deoxyribonucleic acid) → 2. RNA (Ribonucleic acid) → 3. Protein (functional molecules in the cell)	**3**
	Steps Involved: 1. Transcription ○ DNA is used to create a complementary mRNA strand. ○ Occurs in the nucleus. ○ Example: A → U, T → A, G → C, C → G 2. Translation ○ mRNA is read by ribosomes to assemble amino acids into a protein. ○ Occurs in the cytoplasm (at ribosomes). ○ Each codon (3 RNA bases) codes for one amino acid. Importance: • Explains how genes control cell function through the production of proteins. • Fundamental to understanding genetic expression and biotechnology.	
23.	**Feature** **Plant Cell** **Animal Cell** **Structure**	

	Cell Wall	Present (made of cellulose)	Absent	**3**
	Shape	Usually rectangular or box-like	Usually round or irregular	
	Chloroplasts	Present (for photosynthesis)	Absent	

	Vacuole	One large central vacuole	Many small vacuoles (or sometimes none)	
	Centrioles	Absent (except in lower plants)	Present (important in cell division)	
	Lysosomes	Rare or absent	Common	
	Plastids	Present (chloroplast, chromoplast, etc.)	Not present	
	Energy Storage	Starch	Glycogen	
	Cilia and Flagella	Rare	Often present in some cells (e.g., sperm)	
	Function of Vacuole	Stores water, maintains turgor pressure	Helps in digestion and waste removal	

Or

What is Point Mutation?

A point mutation is a type of gene mutation where a single nucleotide base (A, T, C, or G) in the DNA sequence is changed, inserted, or deleted.

It affects only one point (base pair) in the DNA sequence — hence the name point mutation.

Types of Point Mutation:

1. Substitution – One base is replaced by another. Example:
   - Normal DNA: A A G (codes for Lysine)
   - Mutated DNA: A G G (codes for Arginine)
2. Insertion – An extra base is added.
   Example: A A G → A A **T** G (may shift the reading frame)
3. Deletion – A base is removed.
   Example: A A G → A _ G (frameshift mutation)

	Examples of Diseases Caused by Point Mutations: • Sickle Cell Anemia: A single base substitution (A → T) changes the codon from GAG (Glutamic acid) to GTG (Valine) in the hemoglobin gene. • Cystic Fibrosis: Caused by deletion of a single base leading to production of a non-functional protein.	
24.	Protein synthesis is the **biological process** by which **cells build proteins** using the instructions from DNA. It involves **two main stages: Transcription and Translation**.	
	Step 1: Transcription (DNA → mRNA) **Location**: Nucleus	**3**

	• DNA is used as a **template to create messenger RNA (mRNA)**. • The **enzyme RNA polymerase** reads the DNA strand and creates a complementary mRNA strand. • Example: DNA: TAC GGA → mRNA: AUG CCU This step copies the **gene's instructions** into a portable message (mRNA).	
	Step 2: mRNA Leaves Nucleus • The **mRNA exits the nucleus** and enters the **cytoplasm** to find a ribosome.	
	Step 3: Translation (mRNA → Protein) **Location**: Ribosome (in cytoplasm) • The ribosome reads the mRNA **3 bases at a time (codon)**. • Each codon codes for a specific **amino acid**. • **tRNA (transfer RNA)** brings the correct amino acid to the ribosome. • The amino acids are **linked together** to form a protein chain (polypeptide).	
	Step 4: Protein Formation • Once a stop codon is reached, the protein is **released and folded** into its functional shape.	

In Simple Terms:

1. **DNA** gives code.
2. **mRNA** carries the code.
3. **Ribosome** reads the code.
4. **tRNA** brings amino acids.
5. **Amino acids** form protein.

25.

Feature	RER (Rough ER)	SER (Smooth ER)
Ribosomes	Present on surface (gives rough appearance)	Absent on surface (smooth appearance)
Main Function	Protein synthesis and transport	Lipid synthesis, detoxification, and hormone production
Appearance	Flattened sacs	Tubular structure
Location	Near the nucleus	Throughout the cytoplasm
Associated Organelles	Works with Golgi body for protein modification	Works in metabolic processes like fat metabolism
Example of Products	Enzymes, membrane proteins	Steroids, lipids, detox enzymes

Feature	Golgi Complex	Endoplasmic Reticulum (ER)
Structure	Stack of flattened, membrane-bound sacs (cisternae)	Network of tubules and sacs spread throughout cytoplasm
Types	No types	Two types: RER (with ribosomes) and SER (without ribosomes)
Function	Modifies, sorts, and packages proteins & lipids	Synthesizes proteins (RER) and lipids (SER)
Location	Near the nucleus and ER	Continuous with the nuclear envelope
Involvement in Transport	Involved in **shipping/packaging** of cellular products	Involved in **synthesis and initial transport**

	Associated Vesicles	Produces vesicles for secretion	Transports molecules to Golgi apparatus	
	Discovery	Discovered by **Camillo Golgi**	Discovered by **Keith Porter**	
26.	Complex Tissue in Plants and Their Functions			
	Name of Complex Tissues: 1. Xylem 2. Phloem These are called complex tissues because they are made up of more than one type of cell, working together to perform a specific function.			
	1. Xylem – *Water and Mineral Transport* Function: • Conducts water and dissolved minerals from roots to other parts of the plant. • Also provides mechanical support. Cell Types in Xylem: • Tracheids • Vessels • Xylem parenchyma • Xylem fibres			**3**
	2. Phloem – *Food Transport* Function: • Transports prepared food (mainly sucrose) from leaves to other parts of the plant (source to sink). • Supports growth and storage. Cell Types in Phloem: • Sieve tubes • Companion cells • Phloem parenchyma • Phloem fibres			

27.	**Who Gave the Concept of Gene Mapping?** The concept of **Gene Mapping** was first introduced by **Alfred Sturtevant** in **1913**, a student of **Thomas Hunt Morgan**. He worked on **fruit flies (Drosophila)** and constructed the first genetic linkage map.	

	What is Gene Mapping? **Gene mapping** is the process of determining the **location and order of genes** on a chromosome. It helps in identifying where a gene is located and how closely two genes are linked based on recombination frequency.	
	Unit of Gene Mapping: • The unit used is **centiMorgan (cM)**. • **1 centiMorgan = 1% recombination frequency** between two genes.	**3**
	Explanation (Simple Terms): • Genes that are **closer together** on a chromosome are **less likely to be separated** during recombination (crossing over). • The **further apart** the genes are, the **higher the chance of recombination**. • Gene maps help researchers in: ○ Identifying **disease-causing genes** ○ Studying **genetic inheritance** ○ Advancing biotechnology and genomics	
28.	What is Double Fertilization? Double fertilization is a unique process found only in flowering plants (angiosperms) where two male gametes fuse with two different cells in the embryo sac of the ovule. This process was discovered by Nawaschin in 1898.	
	Steps of Double Fertilization: 1. Pollination – Pollen lands on the stigma of a flower. 2. Pollen Tube Formation – Grows through the style and enters the ovule via the micropyle. 3. Two Male Gametes Released into the embryo sac. 4. First Fertilization (Syngamy): ○ One male gamete fuses with the egg cell.	**5**

	○ Forms a diploid zygote (2n) → develops into embryo. 5. Second Fertilization (Triple Fusion): ○ Other male gamete fuses with two polar nuclei. ○ Forms a triploid (3n) cell → develops into endosperm (nutritive tissue).	
	Result of Double Fertilization: • Zygote (2n) → forms the embryo • Endosperm (3n) → provides nutrition to the growing embryo	
	Why It Is Called "Double"? Because two fertilizations happen: 1. Egg + Sperm → Zygote 2. Polar nuclei + Sperm → Endosperm Or Different Phases of the Cell Cycle – Explained The cell cycle is the series of events that a cell goes through to grow and divide. It consists of two main stages: 1. Interphase – Cell prepares for division 2. M Phase (Mitotic phase) – Cell actually divides	
	1. Interphase (Preparation Phase) Interphase takes up about 90% of the cell cycle. It has three sub-phases: a) G_1 Phase (Gap 1) • The cell grows in size. • Proteins and organelles are synthesized. • The cell performs normal functions. b) S Phase (Synthesis Phase) • DNA replication occurs → chromosomes duplicate. • Each chromosome becomes two sister chromatids. c) G_2 Phase (Gap 2) • The cell prepares for mitosis. • Enzymes and other proteins required for cell division are produced.	

	2. M Phase (Mitotic Phase) This phase includes the division of the nucleus and cytoplasm. It has two parts:	

	a) Mitosis (Karyokinesis) – Division of the nucleus Consists of 4 stages: 1. Prophase – Chromosomes condense, spindle forms. 2. Metaphase – Chromosomes align at the center (equator). 3. Anaphase – Sister chromatids separate and move to opposite poles. 4. Telophase – Nuclear membranes reappear, chromosomes decondense. b) Cytokinesis – Division of the cytoplasm • Two daughter cells are formed.	
29.	What is Pedigree Analysis? Pedigree analysis is a diagrammatic method used to study the inheritance of traits (especially genetic disorders) across multiple generations of a family. • It uses symbols to represent family members and shows how traits or disorders are passed on. • Commonly used in genetics, medicine, and counseling.	
	How It Helps in Identifying Genetic Disorders: 1. Tracks inheritance patterns of a disease (dominant, recessive, sex-linked). 2. Helps in identifying carriers of genetic disorders. 3. Predicts the probability of a disorder appearing in future generations. 4. Distinguishes between: ○ Mendelian disorders (like haemophilia, thalassemia) ○ Chromosomal disorders (like Down syndrome)	**5**
	Symbols Used in Pedigree Charts: Symbol Meaning ☐ Unaffected male ○ Unaffected female	

	■ Affected male ● Affected female ┬┴ Parents connected to children OR	

	Feature	Mendelian Disorders	Chromosomal Disorders	
	Cause	Caused by mutation in a single gene	Caused by change in number or structure of chromosomes	
	Inheritance Pattern	Follows Mendel's laws (dominant or recessive)	Does not follow Mendelian inheritance	
	Number of Genes Affected	Usually one gene	Multiple genes on the affected chromosome(s)	
	Diagnosis	Detected by pedigree analysis and molecular techniques	Detected by karyotyping (chromosome examination)	
	Examples	- Sickle Cell Anemia - Thalassemia - Hemophilia	- Down Syndrome - Turner Syndrome - Klinefelter Syndrome	

30.	Genotype: • Definition: The genetic makeup of an organism that determines a particular trait. • It refers to the combination of alleles inherited from the parents. • Example: ○ For tallness in pea plants: TT or Tt is the genotype. ○ For dwarf: tt Genotype is not always visible but controls what the organism can express.	
	Phenotype: • Definition: The observable physical traits or characteristics of an organism. • It is the expression of the genotype in interaction with the environment. • Example: ○ Tall or short pea plant. ○ Brown eyes, curly hair, etc. Phenotype is what you can see or measure.	**5**

	Or What is Haemophilia? Haemophilia is a genetic disorder in which a person's blood lacks clotting factors, making it difficult for blood to clot after an injury. • It leads to prolonged bleeding, even from small cuts or internal injuries. • People with haemophilia may suffer from spontaneous bleeding in joints, muscles, and internal organs.	
	Types of Haemophilia: 1. Haemophilia A – Deficiency of Clotting Factor VIII 2. Haemophilia B – Deficiency of Clotting Factor IX	

	Genetic Cause: • It is a sex-linked recessive disorder. • The gene responsible is present on the X chromosome. • Males (XY) are more commonly affected. • Females (XX) are usually carriers and rarely show symptoms.	
	Why is it Called “Royal Disease”? • Haemophilia was famously present in the royal families of Europe, especially in Queen Victoria’s descendants. • Queen Victoria was believed to be a carrier of the disease and passed it on to several royal families in Russia, Germany, and Spain. • Since it spread through royal bloodlines, it became known as the “Royal Disease.”	
	Symptoms of Haemophilia: • Easy bruising • Excessive bleeding after injuries or surgeries • Pain and swelling in joints due to internal bleeding	
	Treatment: • Replacement therapy: Injecting the missing clotting factor • Avoiding injury • Gene therapy (under research)	