Most Commonly Asked Questions and Answers

SER vs RER:

- RER has ribosomes, while SER doesn't.
- RER has flattened sac within the cytoplasm known as cisternae , while SER has a tubular structure.
- RER is usually continuous with the nuclear membrane, while SER is not continuous with the nuclear membrane.
- RER has a regular layered arrangement, while SER is irregular.
- RER is responsible for modifying & processing of proteins that the ribosomes create, while SER is responsible for the lipid synthesis of steroid hormones such as estrogen & testosterone. It also synthesizes, stored and transports carbohydrates.

Golgi Body:

- They have flattened sacs with layered appearance. The cisternae are not continuous with the outer membrane of the nuclear envelope.
- They have swellings are the ends of the sacs for vesicle formation.
- They do not have ribosomes.
- Golgi work with the ER to refine, store & distribute its products. Golgi modify proteins & lipids, package them into vesicles for storage or transport. They also forms primary lysosomes.

Lysosomes:

- Lysosomes are specialized vesicles (membrane-bound sacs) which contain hydrolytic enzymes. Hydrolytic enzymes break down biological molecules;
- Waste materials, such as worn-out organelles.
- Engulfed pathogens during phagocytosis.
- Cell debris during apoptosis (programmed cell death): If the cell is damaged beyond repair, lysosomes can help it to self-destruct.
- Release enzymes to the outside of the cell to remove harmful materials around the cell boundary. The released enzymes can destroy the cell itself, a process called Autolysis or Autophagy (Cell Suicide). Many Diseases such as Tay Sachs are caused by lysosomes.

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Virus:

- Protein Coat/Capsid & Nucleic acid.
- Their size is form 15nm – 1000nm (170 nm). Some are enveloped.
- For a virus to work, first the virus needs to attach to the inside of a host's body.
- Viruses will then attach themselves to the receptors on host's cell surface membrane. This can trigger a conformational changes in the viral protein.
- After a virus binds to the surface of the host cell, it can start to move across the outer covering or membrane of the host cell.
- Once inside, viruses released their genomes and also disrupt or hijack various parts of the cellular machinery. Viral genomes direct host cells to ultimately produce viral protein.

Protein Structures:

- Primary Structure is the sequence of amino acids joined by peptide bonds.
- Secondary Structure has many α-helix or β-pleated sheets. Hydrogen bonds form causing the molecule chain to either fold or coil itself.
- Tertiary Structure has many interactions b/w side chains. The R groups interactions include Hydrogen bonds, hydrophobic & hydrophilic interactions, disulfide bridges b/w 2 cysteine amino acids. Helical form bends itself to form a more compact molecule; coils & folds.
- Quaternary Structures include having 2 or more polypeptide chains.

Collagen:

- 3 polypeptide chains lie together to form a triple helix. Hydrogen bonds hold the 3 polypeptide chains together in a tight coil. Almost every third amino acid in each polypeptide is glycine, the smallest amino acid. Glycine is found on the insides of the strands and its small size allows the three strands to lie close together and so form a tight coil. Any other amino acid would be too large.
- Each complete, three-stranded tropocollagen interacts with other collagen molecules running parallel to it. Covalent bonds form between R groups of amino acids lying next to each other. These cross-links hold many collagen molecules side by side, forming fibrils.

- Many collagen molecules lie parallel. The ends of the parallel molecules are staggered; if they were not, there would be a weak spot running right across the collagen fibril. Finally, many fibrils lie alongside each other, forming strong bundles called fibers.
- Polypeptide (mostly repeat of amino acid sequence proline-alanine-glycine) → Triple-helical collagen molecule (tropocollagen) → fibrils → fibers

Cellulose:

- Cellulose is made by many condensation reactions joining long chains of beta-glucose molecules joined by β-1,4-glycosidic linkages.
- Long, straight/linear, unbranched chains lie parallel & held together by many hydrogen bonds forming rope-like microfibrils, which are layered to form a mesh network called fibrils.
- Hydrogen bonds are weak, however collectively they provide strength & maintain shape.
- The fibrils are arranged in angles with many gaps providing passage of water.
- Cellulose is very strong & prevents cells from bursting when they take in excess water.

Hydrogen Bonding b/w water molecules:

- Water molecules are polar. Hydrogen is partial positive, while Oxygen is partial negative. The partial negative oxygen of 1 water molecule is attracted towards the partial positive hydrogen of the neighboring water molecule.

Lock & Key Hypothesis:

- Active site has a complementary shape to a substrate for it to fit.
- The substrate collides with the active side of an enzyme and gets attached to it like a key, fits into a lock. (Perfect fit.)
- Substrate binds with the active site.
- A catalyzed reaction takes place with the enzyme: & the substrate breaks down. Product is formed and the unchanged enzyme is free to be reused.
- The product leaves the active site like a key leaves a lock.

Induced fit:

- When the substrate attaches to the Enzyme, temporary hydrogen bonds form b/w the enzyme & substrate & structural changes occur so that the active site fits precisely around the substrate (the substrate induces the active site to change shape).
- The shape of the active site changes and moves the substrate closer to the enzyme. Amino acids are moulded into a precise form.
- Enzyme wraps around substrate to distort its bonds. This lowers the activation energy.
- An enzyme-substrate complex forms.
- A reaction will take place and the product, being a different shape to the substrate, moves away from the active site. The active site then returns to its original shape.

Enzyme Immobilization:

- Protection from degradation and deactivation.
- Reuse of enzymes from many reaction cycles, lowering the total production cost of enzyme mediated reactions.
- Ability to stop the reaction rapidly by removing the enzyme from the reaction solution.
- Enhanced stability.
- Product is not contaminated with the enzyme.
- Inert.
- Physically strong and stable.
- Cost effective.
- Longer shelf life
- Reduction in production inhibition

Stages of Cell Signaling:

- Secretion of specific chemicals (ligands) from cells into the bloodstream.
- Transport of ligands to target cells through the extracellular space.
- Binding of ligands to cell surface membrane receptors on target cells.
- Shape of the ligand is complementary to the shape of the receptors.
- Ligand binding triggers reactions within a cell.
- This thus, produces a response within the cells via second messenger.

Na-K Pump:

- Particles enter the pump on the side with a lower conc. & initially bind to a specific site to that type of particle.
- Energy from ATP is required, & a phosphate group is transferred for the conformational change in shape of the pump.
- The pump's shape change opens a channel to the outside of the cell, and the three sodium ions are released. A particle is released on the side of higher conc.
- (3 Na^+ out and 2 K^+ in)
- Pump returns to its original shape.
- The slight electrical imbalance allows a potential difference.

Na Glucose Co-Transport:

- This process is facilitated by symporters which could transfer 2 substances in the same direction. E.g. sodium-glucose symporter. This symporter uses the sodium ions to move glucose into the cell. The movement of sodium ions through the symporter provides the required energy for the glucose to move through the symporter as well.
- Absorption of sodium ions and glucose by cells lining the mammalian ileum takes place by co-transport.
- An electrochemical gradient, created by primary active transport, can move other substances against their concentration gradients, a process called co-transport or secondary active transport.

Sucrose H+ symport:

- A sucrose H^+ symporter in the companion cell membrane then cotransports sucrose & H^+ back into the cell, using stored energy from the proton gradient. This allows sucrose to move into the companion against the concentration gradient without the direct use of ATP.

Endocytosis:

- In endocytosis, an outside molecule is engulfed by the cell membrane and brought inside the cell.

- The cellular uptake of macromolecules and particulate substances by localized regions of the plasma membrane that surround the substance and pinch off to form an intracellular vesicle.

Mitotic Cell Cycle:

- Prophase: chromosomes condense, shorten & thicken forming heterochromatin. Nucleolus disintegrates, nuclear envelope disintegrates. Spindle formation occurs.
- Metaphase: chromosomes line up along the equator. Each sister chromatid is attached at the centromere to a spindle fibre originating from opposite poles.
- Anaphase: Centromere divides. Spindle fibers contract & pull individual chromatids apart at the centromere. Chromatids now called daughter chromosomes move to opposite poles of the cell with centromere leading towards the poles. The energy required is provided by aerobic respiration in mitochondria, which gather around spindle fibers.
- Telophase: Chromosomes uncoil & become indistinct (becomes chromatin). Nucleolus reintegrates, nuclear envelope reintegrates. Spindle disintegrates.

Advantages of Mitosis:

- Asexual Reproduction.
- Replacement of damaged or dead cells: This is possible using mitosis followed by cell division.
- Repair of tissues by cell replacement.
- Growth by increasing the number of cells.

Telomeres:

- Non-coding DNA (DNA that does not contain genes) that is made up of short base sequences that are repeated many times.
- In telomeres, one strand is rich in the base guanine (G) and the other strand is rich in the complementary base cytosine (C).
- The main function of telomeres is to ensure that the very ends of the DNA molecules are included in DNA replication during mitosis.
- This is because the copying enzyme responsible for DNA replication is unable to run right to the very end of the DNA molecule and stops a little short of

the end. If this end part of the DNA molecule contained an important gene, that piece of genetic information would be lost during DNA replication.

- In each subsequent cell division, a little more genetic information would be lost.
- Telomeres therefore act as a 'buffer' region of non-essential DNA and ensure that no important coding sections near the ends of the DNA molecules are left out of the replication process.
- Telomerase enzyme adds additional bases at each end of the chromatids.

Advantages of Stem Cells:

- Tissue repair.
- Replacement of dead or worn out cells.

DNA:

- 2 strands of DNA joined together to form a double helix. Strands are held together by hydrogen bonds.
- Complementary base pairing occurred b/w antiparallel strands in a 3' to 5' direction.
- Each strand has a deoxyribose sugar phosphate backbone with phosphodiester bonds.

mRNA:

- Single Stranded, without hydrogen bonding as no base pairing occurs.
- Uracil is present instead of thymine with a ribose sugar.
- It is linear, non-helical single stranded molecule.

Semi-Conservative Replication:

- Semi-Conservative Replication of DNA occurs during the S Phase of the cell cycle. 2 sister chromatids are formed.
- Each chromosome has 1 old and 1 new sister chromatid.

Transcription and replication:

- DNA replication is semi-conservative with each newly formed molecule contains one original and one newly synthesized strand.

- DNA (double helix / molecule) unwinds, hydrogen bonds break between, base pairs & the 2 strands are separated
- Both strands used as templates;
- DNA polymerase,
  e.g. involved in polynucleotide formation / phosphodiester bond formation / catalyses synthesis
- DNA polymerase attaches free activated (DNA) nucleotides to each other forming 1 continuous strand , with the removal of 2 phosphate.
- Complementary (DNA) nucleotides added, A pairs with T and C pairs with G. The energy released from the removal of phosphates is used to make hydrogen bonds b/w complementary base pairs.
- Process, occurs / continues, along whole DNA molecule.
- Polymerase running continuously in the strand in a 5' to 3' direction is the leading strand.
- Polymerase running sporadically in the strand in a 3' to 5' direction forms DNA in Okazaki fragments is the lagging strand.
- Okazaki fragments /movement of polymerase in one direction /nucleotides added in one direction.
- The lagging strand is joined together using ligase.
- AVP;
  e.g. ref. to repair/proofreading
  ref. to helicase (unwinding) / ligase (joining Okazaki fragments)

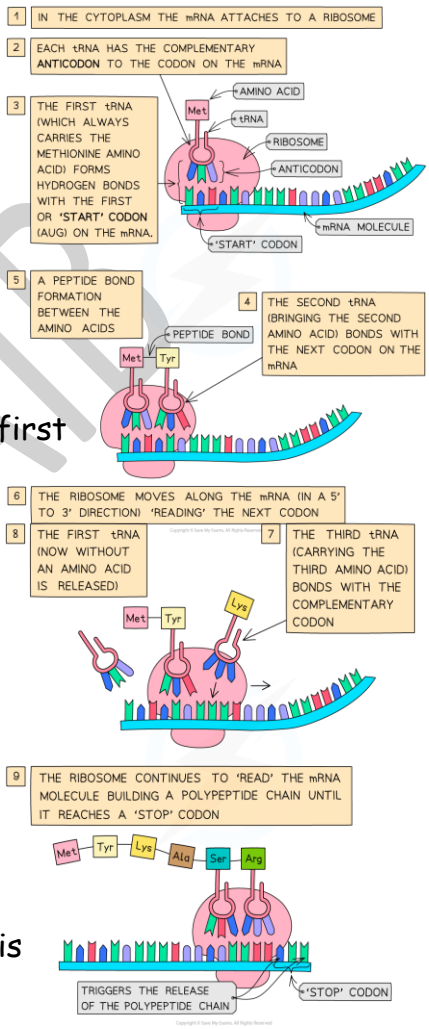
Polymerase & Ligase:

- Polymerase: Elongates the new strand in a 5' to 3' direction by adding activated nucleotides.
  The enzymes form phosphodiester bonds b/w neighboring nucleotides.
  The enzyme also proofreads to ensure complementary base pairing A=T, G≡C.
  It also repairs any mismatched base pairs
- Ligase: joins Okazaki fragments by forming phosphodiester bonds.
  Okazaki fragments are in the lagging strand & ligase helps join them to make them continuous.

Transcription:

- Hydrogen bonds in DNA are broken.
- One strand is the template strand or the transcribed strand.
- RNA polymerase will attach free RNA nucleotides together by the phosphodiester bonds.

Translation:



- two codons at a time are exposed (to the large subunit)
- a specific tRNA brings a specific amino acid
- a tRNA anticodon binds to the mRNA codon
- complementary base pairing occurs (by hydrogen bonding)
- a second tRNA brings another amino acid (next to the first amino acid)
- peptide bond formation between the two amino acids
- ribosome moves along the mRNA, one codon at a time / and next codon is 'read'
- the first tRNA leaves the ribosome

  AVP; e.g. first codon is always AUG

  first anticodon is always UAC

  first amino acid is always methionine ribosome moves along mRNA in a 5' to 3' direction

  role of peptidyl transferase eventually a stop codon is reached (and translation stops)

Splicing:

- When transcription of a gene occurs, both the exons and introns are transcribed.
- This means the RNA molecule formed (known as the primary transcript) also contains exons and introns.
- As the introns are not to be translated, they must be removed from the RNA molecule.
- The exons are then all fused together to form a continuous RNA molecule called mature mRNA that is ready to be translated.

- This process is sometimes called 'splicing' and is part of the process of post-transcriptional modification.

Xylem Structure:

- Thick cellulose walls that prevent collapse.
- Cell walls impregnated with lignin rings providing support under tension.
- No cytoplasm reducing resistance.
- Lack of end walls forming a long continuous tube of water & dissolved solutes.
- Pits in the Wall allowing lateral movement of water allowing continual flow, in case air bubbles are formed in the vessel.

Transpiration:

- Osmosis of soil water occurs from a region of higher w.p to a region of low w.p. (less -ve to more -ve) down a w.p gradient into the root hair cell.
- Water then moves from the root hair cells to the cortex cell's endodermis, via the apoplastic pathway. In the cell wall, water is stopped by a thick waxy strip made of suberin known as the Casparian strip.
- The water is then reverted to the symplastic pathway that uses cytoplasm & plasmodesmata to transport water from the endodermis to the pericycle & therefore the xylem.
- Water molecules stick with each other due to Hydrogen bonds called cohesion.
- Water molecules stick to the sides of the Xylem wall (cellulose) via adhesion.
- There is a low hydrostatic pressure in the xylem vessel. Cohesion & adhesion enable water to move up in a continuous column due to the transpiration pull.
- Water leaves the xylem vessel via pits. Water moves down the w.p gradient from one mesophyll cell to another via symplastic pathway. Symplastic pathway occurs through cell membrane/ plasmodesmata, & vacuolar pathway through the tonoplast.
- This will replenish the thin film of moisture lining the mesophyll cells.
- Evaporation of water from the from the cell wall of the spongy mesophyll cells.
- Water vapor enters substomatal air space & diffuses out through the stomata down the w.p gradient.

Translocation:

- Proton pumping: companion cells use ATP to power a proton pump which actively transports H^+ ions out of the cell and into the apoplastic pathway. This creates a proton gradient. (Higher H^+ outside)
- Sucrose H^+ symporter in the companion cell membrane then cotransports sucrose & H^+ back into the cell, using stored energy from the proton gradient. This allows sucrose to move into the companion against the concentration gradient without the direct use of ATP.
- Sucrose transfer to sieve tube element: once inside the companion cells, sucrose moves into the sieve tube element through the plasmodesmata via passive diffusion.
- The high concentration of sucrose in the sieve tube element lowers the water potential there. The hydrostatic pressure at the source increases (sieve tube element). Sucrose moves out of these tubes from high hydrostatic pressure to low hydrostatic pressure & water moves in by osmosis.
- A pressure gradient by an increase in turgor pressure is created, & mass flows in the phloem from the source to the sink.

Hemoglobin Structure:

- Hemoglobin is the oxygen-carrying pigment found in red blood cells & is a globular protein. We have seen that it is made up of 4 polypeptide chains. Each chain is itself a protein known as globin.
- There are many types of globin; α-globin, & β-globin. 2 hemoglobin chains are made of α-globin, while 2 chains are made of β-globin.
- Each polypeptide chain contains the haem group. A group like this is a permanent part of a protein molecule but is not made of amino acids, is called a prosthetic group.

The importance of iron in hemoglobin:

- Each haem group contains an iron atom. One oxygen molecule, O, can bind with each iron atom. A complete hemoglobin molecule, with four haem groups, can carry four oxygen molecules (eight oxygen atoms) at a time.
- It is the haem group that is responsible for the color of hemoglobin. This color changes depending on whether or not the iron atoms are combined with oxygen.

- If they are, the molecule is known as oxyhemoglobin, & is bright red. If not, the color is purplish.

Cardiac Coordination:

- Sino-atrial node/SAN sends out, waves of excitation/waves of depolarisation/ (electrical) impulses/action potential(s);
- Wave of excitation/AW/SAN stimulates, (both) atria to contract/atrial systole.
- Fibrous ring/non-conducting tissue/insulating tissue (between atria and ventricles). Prevents impulse reaching the ventricles/prevents atria and ventricles contracting at the same time.
- Atrio-ventricular node/AVN delays impulse (by 0.1s) /prevents ventricles contracting at the same time as atria, allowing atria to empty/ventricles to fill completely.
- AVN sends out, waves of excitation/impulses to Purkyne tissue/Bundle of His (in septum) causing ventricles to contract together simultaneously.

Bohr's Shift:

- The Bohr shift describes the affect of high carbon dioxide concentration on hemoglobin's affinity for oxygen. When the partial pressure of carbon dioxide in the blood is high, hemoglobin's affinity for oxygen is reduced. This is the case in respiring tissues, where cells are producing carbon dioxide as a waste product of respiration.
- This occurs because CO_2 forms carbonic acid which lowers the pH of the blood. This is a helpful change because it means that hemoglobin gives up its oxygen more readily in the respiring tissues where it is needed.
- Hemoglobin's affinity for oxygen decreases & more oxygen is required to meet the demand for aerobic respiration.
- On a graph showing the dissociation curve, the curve shifts to the right when CO_2 levels increase. A second line is drawn to the right of and below the standard curve.
- Chloride Shift: The chloride shift is a process in red blood cells (RBCs) where chloride ions move into the cell in exchange for bicarbonate ions moving out.

- Carbon Dioxide Transport: When carbon dioxide is produced in tissues, it diffuses into the blood and enters RBCs. Within the RBC, it's converted into bicarbonate ions (HCO3-) and hydrogen ions (H+) with the help of the enzyme carbonic anhydrase.
- Maintaining Electrical Neutrality: As bicarbonate ions move out of the RBC into the blood plasma, they leave behind a net positive charge inside the RBC. To maintain electrical balance, chloride ions (Cl^-) from the blood plasma move into the RBC, effectively replacing the lost bicarbonate ions.
- Role in Gas Exchange: This chloride shift, also known as the Hamburger phenomenon, is crucial for the efficient transport of carbon dioxide. By ensuring that bicarbonate ions are moved out of the RBC and replaced with chloride ions, the process allows the blood plasma to act as a storage site for bicarbonate and helps maintain the pH of the blood.
- Reverse Shift in the Lungs: In the lungs, the process is reversed. Bicarbonate ions move back into the RBC, chloride ions move out, and carbon dioxide is released from the RBC to be exhaled.

Tissue Fluid Formation:

- As blood flows through capillaries within tissues, hydrostatic pressure causes some of the plasma to leak out through the gaps between the cells in the walls of the capillary, and seeps into the spaces between the cells of the tissues.
- Tissue fluid allows the body to easily and quickly move dissolved molecules onto the body cells, and take away waste materials back into the blood.
- These spaces are filled with this leaked plasma, which is known as tissue fluid.
- In the formation of tissue fluid blood, plasma & the dissolved substances such as glucose, amino acids & salts moves out through fenestrations.

Phagocytosis:

- The foreign antigens on a pathogen are recognized by a phagocyte.
- The phagocyte's cytoplasm moves around the pathogen to engulf it.
- The pathogen is now trapped in a phagocytic vacuole (a bubble) in the phagocyte's cytoplasm.
- Fusion of lysosome occurs with the phagocytic vacuole. Pathogen is broken down by lysozymes, the enzymes found in lysosome.

- Then the phagocyte presents the pathogen's antigens. In order to activate other cells of the immune system, it sticks the antigens on its surface.

Primary & Secondary Immune Response:

- Primary Immune Response: antigen presentation
  Clonal Selection & clonal expansion by mitosis.
  B-Lymphocyte produces antibodies.
- Secondary Immune Response: memory B-Lymphocytes.
  Recognition of antigens.
  Clonal expansion.
  Plasma cells secrete antibodies.
  Faster & more antibodies are produces.

Vaccines with Attenuated Virus:

- Attenuated pathogen injected.
- Antigens trigger an immune response.
- Macrophages take up the virus by phagocytosis & present anitgens.
- Helper T-Lymphocytes activated.
- It can take days for a lymphocyte making complementary antibodies to be activated.
- Lymphocyte able to produce complementary antibodies multiplies by mitosis known as clonal expansion, antibodies are released.
- Memory cells lasting years are produced.
- Booster shots further stimulate memory cell formation.
- If antigen is encountered again, antibodies are produced much faster. This is long term immunity.

T lymphocytes:

- The antigen-presenting macrophage display the antigen on its cell surface membrane.
- As a result, T-cell is activated.
- These activated T-lymphocytes (those that have receptors specific to the antigen) divide by mitosis to increase in number (similar to the clonal selection and clonal expansion of B lymphocytes) and differentiate into two main types of T cell:
  - Helper T cells and Killer T cells

- Different kinds of T-cells respond in various ways. For e.g. Helper T-cells (T_H cells) aid in the release of chemical signals like cytokines and interleukins which stimulate and activate cytotoxic T-cells (T_C cells) and phagocytes that kill foreign and abnormal cells.
- Furthermore, Cytokines released T-Cytotoxic Cells & also facilitate in activating B-cells.
- Both T helper and Cytotoxic killer cells can divide to form memory cells to fight future infections.

Monoclonal Antibodies:

- They are produced by injecting mice with an antigen that stimulates the production of antibody-producing plasma cells.
- Isolated plasma cells from the mice are fused with immortal tumor cells, which result in hybridoma cells. The fusion of plasma and tumor cells can be assisted with the use of fusogens such as polyethylene glycol or an electric current.
- These hybrid cells are grown in a selective growth medium and screened for the production of the desired antibody.
- They are then cultured in a selective growth medium & screened to produce large numbers of monoclonal antibodies.