# Chapter 2: Cell: The Building Block of Life

## Exercises — Revise, Reflect, Refine

Q1 Differentiate between the following pairs of terms based on the clues given in parentheses:
(i) Cell membrane and cell wall (permeability)
(ii) RER and SER (structure)
(iii) Chloroplasts and chromoplasts (pigments)

### SOLUTION

(i) Cell membrane vs Cell wall — Permeability:
Cell membrane (plasma membrane) is selectively permeable — it allows only certain substances (water, small molecules, specific ions) to pass through while restricting others. This selectivity is essential for controlling what enters and exits the cell.
Cell wall is fully permeable — it has large pores and allows water, minerals, gases, and most small molecules to pass freely. It does not act as a barrier; its function is structural support, not selective transport.

(ii) RER vs SER — Structure:
Rough Endoplasmic Reticulum (RER) has ribosomes attached on its outer surface, giving it a rough, granular appearance under the electron microscope. These ribosomes synthesise proteins that are transported through the ER.
Smooth Endoplasmic Reticulum (SER) lacks ribosomes on its surface and therefore appears smooth. It is involved in the synthesis of lipids, steroids, and detoxification of drugs and poisons.

(iii) Chloroplasts vs Chromoplasts — Pigments:
Chloroplasts contain the green pigment chlorophyll (and accessory pigments such as carotenoids). Chlorophyll captures light energy and drives photosynthesis.
Chromoplasts contain coloured (non-green) pigments such as carotenoids (yellow, orange, red). They are responsible for the characteristic colours of flowers and ripe fruits, which attract pollinators and seed-dispersing animals.

Answer: (i) Cell membrane is selectively permeable (controls passage of specific substances); cell wall is fully permeable (large pores, allows free passage — functions for structural support, not selective transport). (ii) RER has ribosomes on its surface (rough appearance); SER lacks ribosomes (smooth appearance). (iii) Chloroplasts contain the green pigment chlorophyll; chromoplasts contain non-green coloured pigments such as carotenoids (yellow/orange/red).

Q2 Two similar animal cells are placed in two different solutions:
- Cell X is placed in pure water.
- Cell Y is placed in a concentrated salt solution.
Cells are observed after some time. Cell X swells, and Cell Y shrinks. Which statement provides the correct explanation for the above observations?
(i) Salt molecules moved into Cell Y, causing it to shrink.
(ii) Water moved into Cell X and more water moved out of Cell Y than the salt solution entered in it.
(iii) Water moved into Cell X and moved out of Cell Y through the cell membrane.
(iv) Solute movement caused osmosis in both cells.

SOLUTION

Cell X is placed in pure water — the solution outside is hypotonic (lower solute concentration) relative to the cell's cytoplasm. Water moves into Cell X by osmosis through the semipermeable cell membrane, causing it to swell.
Cell Y is placed in a concentrated salt solution — the solution outside is hypertonic (higher solute concentration) relative to the cell's cytoplasm. Water moves out of Cell Y by osmosis through the cell membrane, causing it to shrink.

Evaluating each option:
(i) Incorrect — Salt (solute) molecules do not move through the semipermeable cell membrane in significant amounts; it is water that moves.
(ii) Incorrect — This partially describes the outcome but incorrectly implies solute entered Cell Y; the cell membrane prevents free passage of the salt.
(iii) Correct — Water entered Cell X (hypotonic surroundings) and exited Cell Y (hypertonic surroundings) through the semipermeable cell membrane. This is osmosis.
(iv) Incorrect — Osmosis is the movement of WATER (solvent), not solute; solute movement is not osmosis.

Answer: Option (iii): Water moved into Cell X and moved out of Cell Y through the cell membrane (osmosis through the semipermeable cell membrane).

Q3 Look at the diagram of a cell in Fig. 2.20. Identify the parts labelled from (a) to (g) and correctly match them with their functions given below:
(i) Controlling all the activities of a cell.
(ii) Site of cellular respiration.
(iii) Storage organelle that also provides rigidity to the cell.
(iv) Separates the cell contents from surroundings.
(v) Provides structural rigidity to the cell.
(vi) Packs and stores materials received from ER.
(vii) Helps in manufacturing food.

SOLUTION

Fig. 2.20 shows a plant cell. Reading the labels from the diagram:

(a) — Nucleus: the large, membrane-bound structure controlling all cell activities.

(b) — Mitochondria: double-membrane organelles that are the site of cellular respiration.

(c) — Vacuole: the large central vacuole in plant cells; stores water, sap, and waste materials, and by maintaining turgor pressure provides rigidity.

(d) — Cell membrane (plasma membrane): the selectively permeable membrane that separates the cell contents from the surroundings.

(e) — Cell wall: the rigid, non-living layer outside the cell membrane that provides structural rigidity to plant cells.

(f) — Golgi apparatus (Golgi body): the stack of flattened membrane sacs that packs and stores materials (proteins and lipids) received from the ER and dispatches them to their destinations.

(g) — Chloroplast: the plastid containing chlorophyll; it traps light energy and manufactures food (glucose) by photosynthesis.

Matching summary:
(i) Controlling all activities → (a) Nucleus
(ii) Site of cellular respiration → (b) Mitochondria
(iii) Storage organelle + rigidity → (c) Vacuole
(iv) Separates cell from surroundings → (d) Cell membrane
(v) Provides structural rigidity → (e) Cell wall
(vi) Packs and stores materials from ER → (f) Golgi apparatus

(vii) Helps in manufacturing food → (g) Chloroplast

Answer: (a) Nucleus — (i); (b) Mitochondria — (ii); (c) Vacuole — (iii); (d) Cell membrane — (iv); (e) Cell wall — (v); (f) Golgi apparatus — (vi); (g) Chloroplast — (vii).

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Q4 Which of the following option(s) of the pairs of cell organelles are correctly placed under the given categories?

| Option | Present in the plant cells | Absent in the animal cells |
|---|---|---|
| (i) | Leucoplast | Cell wall |
| (ii) | Mitochondria | Ribosome |
| (iii) | Cell wall | Golgi apparatus |
| (iv) | Lysosome | Endoplasmic reticulum |

SOLUTION

We check each option against what is present in plant cells and absent in animal cells:

(i) Leucoplast — Present in plant cells: YES (leucoplasts are colourless plastids found in plant cells storing starch, oils, or proteins). Cell wall — Absent in animal cells: YES (animal cells lack a cell wall). Both sub-entries are correct. => Option (i) is CORRECT.

(ii) Mitochondria — Present in plant cells: YES. Ribosome — Absent in animal cells: NO (ribosomes are present in ALL living cells, both plant and animal). => Option (ii) is INCORRECT.

(iii) Cell wall — Present in plant cells: YES. Golgi apparatus — Absent in animal cells: NO (Golgi apparatus is present in animal cells too). => Option (iii) is INCORRECT.

(iv) Lysosome — Present in plant cells: Lysosomes are primarily associated with animal cells; in plant cells, the vacuole often performs digestive functions. Endoplasmic reticulum — Absent in animal cells: NO (ER is present in all eukaryotic cells, including animal cells). => Option (iv) is INCORRECT.

Answer: Option (i) only — Leucoplast is present in plant cells, and cell wall is absent in animal cells. Both placements are correct.

Q5 Two students, Renu and Rohit, were having a discussion on the plastids. Renu emphasised that all parts of the plants, even roots, contain plastids. However, Rohit did not agree with the statement and told her that plastids are absent in plant roots since the roots are underground and do not need to perform photosynthesis. Who is correct? Justify your answer.

SOLUTION

Rohit is partially correct in noting that photosynthesis does not occur in roots, but his conclusion — that plastids are absent in roots — is incorrect.

Plastids are of three main types: chloroplasts (green, for photosynthesis), chromoplasts (coloured, for pigmentation), and leucoplasts (colourless, for storage of starch, fats, and proteins).

Root cells contain leucoplasts. Leucoplasts store starch and other reserve materials. They do not need light or chlorophyll for their function.

Therefore, Renu is correct: all plant cells — including root cells — contain plastids (specifically leucoplasts in non-photosynthetic, underground parts). Rohit is wrong because he incorrectly equates all plastids with chloroplasts/photosynthesis.

Answer: Renu is correct. All plant cells contain plastids, but not all plastids are chloroplasts. Root cells contain leucoplasts (colourless storage plastids), which do not perform photosynthesis. Rohit incorrectly assumed all plastids must carry out photosynthesis.

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Q6 Mitochondria and chloroplasts are two important organelles in a plant cell. Discuss how these two organelles are structurally and functionally similar to each other, and different from each other.

SOLUTION

SIMILARITIES (structural and functional):

1. Both are double-membrane bound organelles — they have an outer membrane and an inner membrane, creating two distinct compartments.
2. Both contain their own DNA and ribosomes (70S type), which allows them to synthesise some of their own proteins. This is evidence for the endosymbiotic theory.
3. Both are semi-autonomous — they divide by binary fission and have some control over their own reproduction.
4. Both are involved in energy transformation: mitochondria convert chemical

energy (from food) into ATP; chloroplasts convert light energy into chemical energy (glucose).
5. Both are found in plant cells.

DIFFERENCES:

Structure:
Mitochondria — The inner membrane is folded into structures called cristae, which increase the surface area for ATP synthesis. The interior space is the matrix.
Chloroplasts — The inner membrane encloses a fluid-filled stroma. Within the stroma are stacks of disc-like thylakoids (grana) containing chlorophyll. Chloroplasts are typically larger than mitochondria.

Function:
Mitochondria — Perform cellular respiration; break down glucose and other organic molecules in the presence of oxygen to release energy stored as ATP. Present in nearly all eukaryotic cells (both plant and animal).
Chloroplasts — Perform photosynthesis; use sunlight, $CO_2$, and water to synthesise glucose and release $O_2$. Found only in plant cells and certain algae (not in animal cells).

Pigments:
Mitochondria — No photosynthetic pigments.
Chloroplasts — Contain chlorophyll and carotenoid pigments.

Answer: Both are double-membrane organelles with own DNA and ribosomes (semi-autonomous), and both carry out energy transformations. Differences: mitochondria (cristae, matrix) perform cellular respiration to produce ATP and are present in both plant and animal cells; chloroplasts (thylakoids, stroma, chlorophyll) perform photosynthesis and occur only in plant/algal cells.

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Q7 Which of the following pairs of cell organelles contains DNA?
(i) Chloroplasts, Ribosomes
(ii) Mitochondria, Nucleus
(iii) Golgi bodies, Ribosomes
(iv) Nucleus, Lysosomes

SOLUTION

Checking each organelle for presence of its own DNA:

Nucleus — YES: contains chromosomal DNA (the main genetic material of the cell).
Mitochondria — YES: contain their own circular DNA (mitochondrial DNA, mtDNA) — evidence of endosymbiotic origin.
Chloroplasts — YES: contain their own circular DNA (cpDNA) — also evidence of endosymbiotic origin.
Ribosomes — NO: ribosomes are made of rRNA and protein but do not contain their own DNA.
Golgi bodies — NO: no DNA.
Lysosomes — NO: no DNA.

Evaluating options:
(i) Chloroplasts (YES) + Ribosomes (NO) — Not both have DNA.
(ii) Mitochondria (YES) + Nucleus (YES) — BOTH contain DNA. Correct.
(iii) Golgi bodies (NO) + Ribosomes (NO) — Neither has DNA.
(iv) Nucleus (YES) + Lysosomes (NO) — Not both have DNA.

Answer: Option (ii): Mitochondria and Nucleus. Both contain DNA — the nucleus holds chromosomal DNA, and mitochondria have their own circular DNA (mtDNA).

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Q8 A researcher carried out an experiment in which she took two carrots of similar size. She placed one carrot in plain water (A) and the other carrot in concentrated salt solution (B) (Fig. 2.21). After 24 hours she recorded her observations.
(i) What hypothesis does she want to test through this experiment?
(ii) What would you suggest for the improvement of this experiment?
(iii) Why does the carrot in plain water stay stiff and crunchy, but the carrot in concentrated salt solution become rubbery and limp?

SOLUTION

(i) Hypothesis:
The researcher wants to test the hypothesis that the movement of water through the cell membrane by osmosis depends on the relative concentration of the solution surrounding the cells. Specifically: cells placed in a hypotonic solution (plain water) will gain water and become turgid, while cells placed in a hypertonic solution (concentrated salt) will lose water and become flaccid.

(ii) Improvements to the experiment:
1. Use a control variable: measure and record the initial mass (weight) and length of both carrots before placing them in the solutions, then measure again after 24

hours. This gives quantitative data rather than just qualitative observations.
2. Use multiple carrots in each solution to get reproducible results and reduce experimental error.
3. Specify the exact concentration of the salt solution so the experiment can be replicated.
4. Keep the temperature constant throughout the experiment, as temperature affects osmosis rates.

(iii) Explanation using osmosis:
Carrot cells contain cell sap (a solution of salts and sugars) inside their vacuoles.
Carrot in plain water (A): The water outside is hypotonic compared to the cell sap. Water moves into the carrot cells by osmosis through the semipermeable cell membrane. The vacuoles fill with water, creating turgor pressure against the cell wall. This makes the carrot firm, stiff, and crunchy.
Carrot in concentrated salt solution (B): The salt solution outside is hypertonic compared to the cell sap. Water moves out of the carrot cells by osmosis. The vacuoles shrink (plasmolysis in plant cells) and the cells lose turgor pressure. Without internal water pressure, the carrot becomes soft, rubbery, and limp.

Answer: (i) Hypothesis: the direction of osmosis depends on relative solute concentrations — cells in hypotonic solution gain water (swell/stiffen); cells in hypertonic solution lose water (shrink/become limp). (ii) Improvements: measure initial and final mass/length of carrots for quantitative data; use replicates; control temperature; specify salt concentration exactly. (iii) In plain water (hypotonic), water enters cells by osmosis → turgor pressure → stiff and crunchy. In salt solution (hypertonic), water exits cells by osmosis → loss of turgor → rubbery and limp.

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Q9 Indicate the presence or absence of following structures in bacterial and animal cells:

| Structures in a cell | Bacterial cell | Animal cell |
|---|---|---|
| Chromosome | | |
| Nucleus | | |
| Mitochondria | | |
| Golgi complex | | |
| Chromoplasts | | |

SOLUTION

Bacteria are prokaryotes; animal cells are eukaryotes. Key differences:

Chromosome:
Bacterial cell — Present (a single circular chromosome made of naked DNA, located in the nucleoid region, not enclosed in a membrane).
Animal cell — Present (multiple linear chromosomes enclosed within the nucleus).

Nucleus:
Bacterial cell — Absent (prokaryotes have no membrane-bound nucleus; their DNA is in the nucleoid region).
Animal cell — Present (membrane-bound true nucleus).

Mitochondria:
Bacterial cell — Absent (bacteria lack membrane-bound organelles; energy is produced at the plasma membrane and mesosome).
Animal cell — Present (the powerhouse of the cell; site of aerobic respiration).

Golgi complex:
Bacterial cell — Absent (no membrane-bound organelles).
Animal cell — Present (involved in packaging and dispatching proteins and lipids).

Chromoplasts:
Bacterial cell — Absent (plastids are found only in plant cells and algae, not in bacteria).
Animal cell — Absent (plastids are exclusive to plant cells and certain algae; animal cells have no plastids).

Answer: Chromosome: Bacterial cell — Present (single circular, no membrane); Animal cell — Present (multiple linear, in nucleus). Nucleus: Bacterial — Absent; Animal — Present. Mitochondria: Bacterial — Absent; Animal — Present. Golgi complex: Bacterial — Absent; Animal — Present. Chromoplasts: Bacterial — Absent; Animal — Absent.

Q10 Carry out the following experiment:
Take four peeled potato halves and scoop each one out to make potato cups. One of these potato cups should be made from a boiled potato. Place each of the potato cups in a beaker containing water (Fig. 2.22). Set up as follows:
(a) Keep Cup A empty.
(b) Add one teaspoon sugar in Cup B.
(c) Add one teaspoon salt in Cup C.
(d) Add one teaspoon sugar in the boiled potato in Cup D.
Observe the four potato cups at least two hours and answer the following questions:
(i) Explain why water gathers in the hollowed portion of Cup B and Cup C.
(ii) Why is Cup A necessary for this experiment?
(iii) Explain why water does not gather in the hollowed portions of Cups A and D.

SOLUTION

(i) Water in Cup B and Cup C:
In Cup B, sugar is dissolved inside the hollow. In Cup C, salt is dissolved inside the hollow. Both sugar and salt create a concentrated (hypertonic) solution inside the potato cup compared to the plain water in the beaker outside.
Water moves from the region of higher water concentration (outside the potato — the beaker water) to the region of lower water concentration (inside the potato cup — the sugar/salt solution) by osmosis through the semipermeable cell membranes of the potato cells.
As a result, water is drawn through the potato cells into the hollowed portion, making water appear to 'gather' there.

(ii) Why Cup A (empty cup) is necessary:
Cup A is the control for this experiment. It contains no sugar or salt, so there is no concentration difference between the inside of the hollow and the water in the beaker. Any water that enters Cup A would be due to factors other than osmosis (e.g., absorption by capillary action or gravity). Comparing Cup A with Cups B and C confirms that water gathering in B and C is specifically due to the presence of the solute (sugar/salt) and the resulting osmosis — not some other cause.

(iii) Why water does not gather in Cup A and Cup D:
Cup A (empty raw potato): There is no solute inside the hollow, so there is no concentration gradient across the potato cells. No osmosis occurs and no water gathers.
Cup D (boiled potato + sugar): Boiling kills the potato cells and denatures the

membrane proteins, destroying the selective permeability of the cell membranes. Even though sugar is present inside (creating a concentration gradient), the dead cells can no longer act as a semipermeable membrane. Osmosis cannot take place through dead, non-functional membranes. Therefore, water does not accumulate in Cup D.

Answer: (i) Sugar/salt inside Cups B/C creates a hypertonic solution; water moves in from the beaker by osmosis through the potato's semipermeable cell membranes. (ii) Cup A is the control — it shows no solute = no osmosis, confirming the solute is responsible for water gathering in B and C. (iii) Cup A: no concentration gradient, no osmosis. Cup D: boiling kills cells and destroys membrane permeability, so osmosis cannot occur despite the sugar being present.

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Q11 Identify the pair that incorrectly matches the cell organelle with its function.
(i) Ribosome — Protein synthesis
(ii) SER — Lipid and cellulose synthesis
(iii) Lysosome — Digestion of foreign agents

SOLUTION

Checking each pair:

(i) Ribosome — Protein synthesis: CORRECT. Ribosomes are the sites of protein synthesis (translation of mRNA). This is their primary and well-established function.

(ii) SER — Lipid and cellulose synthesis: INCORRECT. Smooth Endoplasmic Reticulum (SER) synthesises lipids and steroids, and is involved in detoxification. It does NOT synthesise cellulose. Cellulose is a structural carbohydrate synthesised by enzymes called cellulose synthases at the plasma membrane, with the Golgi apparatus involved in delivering the necessary precursors. SER has no role in cellulose synthesis.

(iii) Lysosome — Digestion of foreign agents: CORRECT. Lysosomes contain hydrolytic (digestive) enzymes that break down foreign materials (pathogens, worn-out cell parts, food particles engulfed by phagocytosis). This is their correct function.

Answer: Option (ii) SER — Lipid and cellulose synthesis is the incorrect match. SER synthesises lipids and steroids, not cellulose. Cellulose synthesis is carried out by cellulose synthase enzymes at the plasma membrane (not by SER).

Q12 What outcome do you expect, if all the mitochondria are removed from a eukaryotic cell?

SOLUTION

Mitochondria are the sites of aerobic cellular respiration — the process by which glucose and oxygen are used to produce ATP (adenosine triphosphate), the cell's primary energy currency. Most of the cell's usable energy (~36–38 ATP per glucose molecule) is produced in the mitochondria.

If all mitochondria are removed from a eukaryotic cell:

1. ATP production will drop drastically: Only anaerobic glycolysis (in the cytoplasm) will remain, producing just 2 ATP per glucose molecule — a very small fraction of the cell's normal energy supply.
2. All energy-demanding cellular processes will fail or severely slow down: active transport across membranes, muscle contraction, protein synthesis, cell division, nerve impulse transmission, etc.
3. The cell will be unable to carry out the Krebs (citric acid) cycle and oxidative phosphorylation (electron transport chain), cutting off the majority of ATP production.
4. The cell will eventually die, as it cannot sustain its energy needs on glycolysis alone (and the lactic acid or ethanol produced in anaerobic respiration is toxic at high concentrations).

Additionally, mitochondria play roles beyond energy production: they regulate calcium ion levels, participate in apoptosis (programmed cell death), and in animal cells produce heat. Losing mitochondria would disrupt all these functions as well.

Answer: Without mitochondria, the cell loses its primary source of ATP (aerobic respiration stops). Only anaerobic glycolysis remains, producing just 2 ATP per glucose instead of ~36–38. The cell cannot sustain energy-demanding processes — active transport, cell division, protein synthesis, etc. — and will eventually die.

Q13 Which phenomenon inhibits the formation of tumors in the human body? Can plants also develop tumors? Explain.

SOLUTION

Phenomenon that inhibits tumour formation in humans:

Programmed Cell Death (PCD), also called apoptosis, is the genetically controlled and organised process of selective cell self-destruction. In normal cells, there are internal checkpoints that detect DNA damage, abnormal growth signals, or uncontrolled division. When such errors are detected, the cell is signalled to undergo apoptosis — it dismantles itself in a controlled way so that it does not divide uncontrollably.

Contact inhibition is another phenomenon: normal animal cells stop dividing when they come into contact with neighbouring cells (they 'sense' that the space is filled). Cancer cells lose this contact inhibition and keep dividing, forming tumours.

Together, PCD/apoptosis and contact inhibition act as safeguards against tumour formation. When these mechanisms fail (due to genetic mutations), cells divide uncontrollably, resulting in tumours.

Can plants develop tumours?

Yes, plants can also develop tumours. Unlike animals, plant cells do not show contact inhibition in the same way — they can continue dividing. Crown gall disease, caused by the bacterium Agrobacterium tumefaciens, is a well-known example of plant tumour formation. The bacterium inserts a piece of its DNA (T-DNA from the Ti plasmid) into the plant cell's genome, causing the cells to divide uncontrollably and form a gall (tumour).

However, plant tumours generally do not spread (metastasise) to other parts of the plant the way cancerous tumours can spread in animals, because plant cells are enclosed in rigid cell walls and are not as mobile.

Answer: Apoptosis (Programmed Cell Death) and contact inhibition prevent tumour formation in humans — when these fail, cells divide uncontrollably. Yes, plants can develop tumours; crown gall disease (caused by Agrobacterium tumefaciens) is a classic example. Plant tumours generally do not metastasise due to the rigid cell wall.

Q14 The cell membrane of a cell is made up of proteins and lipids. Which cell organelles help in the synthesis of cell membrane? Write the path of these compounds from their site of synthesis to the cell membrane and show this through a labelled diagram.

SOLUTION

Cell membrane components and their sites of synthesis:
Lipids (phospholipids) — synthesised on the Smooth Endoplasmic Reticulum (SER).
Proteins — synthesised on ribosomes attached to the Rough Endoplasmic Reticulum (RER).

Path of lipids:
SER (synthesis) => vesicles bud off from SER => Golgi apparatus (processing and packaging) => vesicles bud off from Golgi => fuse with the cell (plasma) membrane.

Path of proteins:
Ribosomes on RER (synthesis) => proteins enter RER lumen => vesicles bud off from RER => Golgi apparatus (modification, sorting, packaging) => vesicles bud off from Golgi => fuse with the cell (plasma) membrane.

Summary — Organelles involved:
1. Ribosomes (on RER) — protein synthesis.
2. Rough Endoplasmic Reticulum (RER) — initial processing and transport of membrane proteins.
3. Smooth Endoplasmic Reticulum (SER) — synthesis of phospholipids.
4. Golgi apparatus — final processing, sorting, and packaging of both proteins and lipids into vesicles for delivery to the cell membrane.

Labelled diagram description (for student to draw):
Draw: Nucleus (with DNA) -> RER (with ribosomes on surface, proteins being made) -> transport vesicle (arrow from RER) -> Golgi apparatus (stack of cisternae) -> secretory vesicle (arrow from Golgi) -> Cell membrane (plasma membrane). Alongside: SER (smooth membranes) -> transport vesicle -> Golgi -> vesicle -> Cell membrane. Label each organelle and each vesicle with arrows showing direction of transport.

Answer: Proteins are synthesised by ribosomes on the RER; lipids are synthesised in the SER. Both are packaged by the Golgi apparatus into vesicles that fuse with the cell membrane. Path: Ribosomes/RER (proteins) or SER (lipids) => Golgi apparatus (processing + packaging) => transport vesicles => cell membrane.

Q15 What would happen if gametes are formed by mitotic divisions?

SOLUTION

Normal situation: Gametes (sperm and egg) are formed by meiosis, which halves the chromosome number (from 2n to n — diploid to haploid).
When two gametes fuse at fertilisation, the resulting zygote has the full diploid number (2n) restored: n + n = 2n.

If gametes were formed by mitosis instead:
Mitosis produces cells with the same chromosome number as the parent cell (2n → 2n). The gametes would be diploid (2n) instead of haploid (n).

Consequences:
1. At fertilisation, two diploid gametes would fuse: 2n + 2n = 4n (tetraploid zygote). The chromosome number would double with every generation.
2. Over successive generations, the chromosome number would keep increasing (4n, 8n, 16n...), which is unsustainable.
3. This would lead to genomic instability, developmental abnormalities, and ultimately the species would not survive in its current form.
4. There would be no genetic variation from independent assortment and crossing over (which occur during meiosis), reducing genetic diversity in the population.

Therefore, meiosis is essential to maintain the correct chromosome number across generations and to generate genetic diversity.

Answer: If gametes were formed by mitosis, they would be diploid (2n) instead of haploid (n). Fertilisation would produce tetraploid zygotes (4n), and the chromosome number would double each generation — eventually causing genomic instability and death of the species. Meiosis is therefore essential to maintain the species' chromosome number.

Q16 A farmer, Deepa, was very happy with the harvest of amla (Indian Gooseberry) and lemons on her farm. However, she could sell only one-fourth of the produce in the local market. She employed a traditional yet scientifically sound method to extend the shelf life of amla and lemons. She turned perishable produce into profitable products, such as pickles and sharbat, by adding appropriate amounts of salt, sugar, or jaggery to small pieces of fruit and their juices. These were then stored in small glass bottles for sale.
Based on the above passage answer the following questions:
(i) Which scientific concept has the farmer applied in the preservation of the farm produce?
(ii) How does the addition of high concentrations of salt and sugar create an environment that prevents the growth of spoilage-causing bacteria and fungi?
(iii) Suggest a healthy recipe of this kind for food preservation.
(iv) What are the scientific values addressed in this case?

SOLUTION

(i) Scientific concept applied:
The farmer has applied the principle of osmosis (specifically, the use of hypertonic solutions to preserve food). By adding high concentrations of salt, sugar, or jaggery, she creates a hypertonic environment around the food and any microorganisms present. This is the basis of traditional food preservation methods such as pickling and making sharbat/murabba.

(ii) How high concentrations of salt/sugar prevent microbial growth:
When salt or sugar is added in high concentrations, the surrounding medium becomes hypertonic relative to the cytoplasm of the bacterial or fungal cells.
By osmosis, water moves out of the microbial cells (from a region of higher water concentration inside the cell to lower water concentration in the salty/sugary medium).
This causes the microbial cells to undergo plasmolysis — the cytoplasm shrinks away from the cell wall as water exits.
The dehydrated microorganisms cannot carry out their metabolic activities, grow, or reproduce.
As a result, the bacteria and fungi that cause food spoilage are inhibited or killed, extending the shelf life of the food.

(iii) Suggested healthy recipe for food preservation:
Amla (Indian Gooseberry) Murabba:
- Wash and dry 500 g of fresh amla.

- Prick each amla with a fork so that the sugar syrup can penetrate.
- Prepare a sugar syrup by dissolving 500 g of jaggery or sugar in 200 mL of water and heating until the sugar dissolves.
- Add amla to the syrup along with a few cardamom pods and a pinch of saffron (optional).
- Simmer on low heat for 30–40 minutes until the amla is soft and well coated.
- Cool and store in sterilised glass jars. The high sugar concentration preserves the amla by osmosis.

This is a nutritious, vitamin C-rich preserve that lasts for months.

(iv) Scientific values addressed:

1. Application of scientific knowledge (osmosis) to solve a real-world problem (food wastage and post-harvest loss).
2. Sustainability and reduction of food waste — converting surplus produce into value-added products.
3. Food security — extending the availability of nutritious food beyond the harvest season.
4. Economic empowerment — creating additional income for the farmer through agro-processing.
5. Respect for traditional knowledge — using time-tested preservation methods that are scientifically validated.

Answer: (i) Osmosis — using hypertonic salt/sugar solutions to preserve food. (ii) High salt/sugar creates a hypertonic environment; water exits microbial cells by osmosis causing plasmolysis and death/inhibition of bacteria and fungi. (iii) Example: Amla murabba — cook amla in concentrated sugar/jaggery syrup and store in sealed glass jars. (iv) Scientific values: applying osmosis to prevent food waste, promoting sustainability, food security, economic empowerment, and validation of traditional preservation knowledge.