Chapter 2: The Invisible Living World: Beyond Our Naked Eye

Exercises — Keep the Curiosity Alive

Q1 Various parts of a cell are given below. Write them in the appropriate places in the following diagram (a Venn diagram with three overlapping circles for Animal Cell, Plant Cell, and Bacterial Cell).
Nucleus Cytoplasm Cell wall Chloroplast Cell membrane Nucleoid

SOLUTION

We compare which of the six structures are present in each of the three cell types:

Animal cell: cell membrane ✓, cytoplasm ✓, nucleus ✓	No cell wall, no chloroplast, no nucleoid
Plant cell: cell membrane ✓, cytoplasm ✓, nucleus ✓, cell wall ✓, chloroplast ✓	No nucleoid
Bacterial cell: cell membrane ✓, cytoplasm ✓, cell wall ✓, nucleoid ✓	No true nucleus, no chloroplast

Common to all three cells (centre overlap): Cell membrane, Cytoplasm
— All living cells — animal, plant, and bacterial — are bounded by a cell membrane and filled with cytoplasm.

Only in Animal Cell (exclusive to animal): (none of the listed parts)
— Nucleus is shared between animal and plant cells, so it goes in the Animal–Plant overlap.

Animal + Plant overlap (not in bacteria): Nucleus
— Both animal and plant cells have a well-defined nucleus enclosed by a nuclear membrane. Bacteria lack a true nucleus; they have a nucleoid instead.

Plant + Bacterial overlap (not in animal): Cell wall
— Both plant cells and bacterial cells have a cell wall outside the cell membrane. Animal cells do not.

Only in Plant Cell (exclusive to plant): Chloroplast
— Chloroplasts are found only in plant (and algal) cells. They contain chlorophyll and carry out photosynthesis. Animal and bacterial cells lack chloroplasts.

Only in Bacterial Cell (exclusive to bacteria): Nucleoid

— Bacteria do not have a membrane-bound nucleus. Instead, their genetic material is concentrated in a region called the nucleoid. This is the key feature that distinguishes bacteria from plant, animal, and fungal cells.

Answer: Common to all three: Cell membrane, Cytoplasm. Animal + Plant overlap: Nucleus. Plant + Bacterial overlap: Cell wall. Only in Plant Cell: Chloroplast. Only in Bacterial Cell: Nucleoid. (No listed part is exclusive to animal cells only.)

Q2 Aanandi took two test tubes and marked them A and B. She put two spoonfuls of sugar solution in each of the test tubes. In test tube B, she added a spoonful of yeast. Then she attached two incompletely inflated balloons to the mouth of each test tube. She kept the set-up in a warm place, away from sunlight.
(i) What do you predict will happen after 3–4 hours? She observed that the balloon attached to test tube B was inflated. What can be a possible explanation for this?
(a) Water evaporated in test tube B and filled the balloon with the water vapour.
(b) The warm atmosphere expanded the air inside the test tube B, which inflated the balloon.
(c) Yeast produced a gas inside the test tube B which inflated the balloon.
(d) Sugar reacted with warm air, which produced gas, eventually inflating the balloon.
(ii) She took another test tube, 1/4 filled with lime water. She removed the balloon from test tube B in such a manner that the gas inside the balloon did not escape. She attached the balloon to the test tube with lime water and shook it well. What do you think she wants to find out?

SOLUTION

(i) Prediction and explanation:

Test tube A (no yeast): No fermentation occurs. The sugar solution remains unchanged, and no gas is produced. The balloon on test tube A stays deflated or nearly so.

Test tube B (with yeast): Yeast is a microorganism (a fungus) that ferments sugar in warm conditions. It breaks down glucose into ethanol and carbon dioxide gas:

Glucose → Ethanol + Carbon dioxide

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

The CO_2 gas produced by yeast fills the balloon on test tube B, causing it to inflate.

Evaluating the options:
(a) Incorrect — Water evaporation would occur in both test tubes equally (both contain sugar solution). It cannot explain why only test tube B's balloon inflated.
(b) Incorrect — A warm atmosphere would expand the air equally in both test tubes. Both balloons would inflate by the same amount, but only B inflated more.
(c) Correct — Yeast ferments sugar and produces CO_2 gas. This gas accumulates inside test tube B and inflates the balloon attached to it.
(d) Incorrect — Sugar does not react with warm air to produce gas. This is not a known chemical reaction.

Answer to (i): Option (c) — Yeast produced a gas (CO_2) inside test tube B which inflated the balloon.

(ii) Purpose of the lime water test:
Aanandi wants to identify the gas produced by yeast in test tube B.
She is testing whether the gas is carbon dioxide (CO_2).
CO_2 reacts with lime water [calcium hydroxide, $Ca(OH)_2$]: $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
Calcium carbonate ($CaCO_3$) is a white, insoluble solid — its formation makes the lime water turn milky or cloudy.
If the lime water turns milky after shaking with the gas from the balloon, it confirms the gas produced by yeast during fermentation is CO_2.

Answer: (i) Option (c): Yeast produces CO_2 gas by fermenting sugar (fermentation: glucose → ethanol + CO_2), which inflates the balloon on test tube B. (ii) She wants to identify the gas as CO_2 — CO_2 turns lime water milky by forming white $CaCO_3$ precipitate.

Q3 A farmer was planting wheat crops in his field. He added nitrogen-rich fertiliser to the soil to get a good yield of crops. In the neighbouring field, another farmer was growing bean crops, but she preferred not to add nitrogen fertiliser to get healthy crops. Can you think of the reasons?

SOLUTION

Wheat is NOT a legume. Its roots do not contain nitrogen-fixing bacteria. Therefore, wheat plants cannot obtain nitrogen from the atmosphere on their own. The soil's natural nitrogen may get depleted over time, so the wheat farmer must add nitrogen-rich fertiliser to supply the nitrogen needed for healthy crop growth.

Beans are legumes (belonging to the family Fabaceae/Leguminosae). The roots of legume plants contain special swollen structures called root nodules.
These nodules harbour nitrogen-fixing bacteria called Rhizobium.
Rhizobium bacteria form a symbiotic (mutually beneficial) relationship with the bean plant:
— The bacteria receive shelter and nutrients (sugars) from the plant.
— In return, the bacteria trap (fix) atmospheric nitrogen (N_2) from the air and convert it into ammonia (NH_3) and nitrates — forms that the plant can absorb and use.

Because of this biological nitrogen fixation by Rhizobium, the bean crop gets its nitrogen naturally from the air through its root nodules. The farmer does not need to add nitrogen fertiliser — the plant's own bacterial partners supply it.

This is also why farmers practise crop rotation — growing legumes in a field before planting other crops naturally restores the soil's nitrogen content and keeps it fertile for the next crop.

Answer: Beans are legumes whose root nodules contain Rhizobium bacteria. These bacteria fix atmospheric nitrogen and supply it to the plant naturally, so no external nitrogen fertiliser is needed. Wheat has no such bacteria, so its farmer must add nitrogen fertiliser.

Q4 Snehal dug two pits, A and B, in her garden. In pit A, she put fruit and vegetable peels and mixed it with dried leaves. In pit B, she dumped the same kind of waste without mixing it with dried leaves. She covered both the pits with soil and observed after 3 weeks. What is she trying to test?

SOLUTION

Snehal has set up a controlled experiment with one variable:
— Pit A: fruit/vegetable peels + dried leaves (mixed together, then covered with soil)
— Pit B: fruit/vegetable peels only, NO dried leaves (covered with soil)
All other conditions are the same — same type of organic waste, same soil cover, same location, same duration (3 weeks).

She is testing: whether mixing fruit and vegetable peels with dried leaves affects the rate or quality of decomposition (composting).

The scientific reasoning behind the experiment:

Fruit and vegetable peels are nitrogen-rich (green/wet material). Dried leaves are carbon-rich (brown/dry material).
Good compost requires a balanced carbon-to-nitrogen (C:N) ratio. Mixing dried leaves with vegetable peels provides this balance.
Dried leaves also create air pockets in the compost heap, improving aeration — which helps aerobic decomposing microorganisms (bacteria and fungi) break down the waste faster.

After 3 weeks, she will compare how well the organic matter in each pit has decomposed. She expects pit A to show better or faster decomposition into dark, nutrient-rich manure compared to pit B.

Answer: She is testing whether mixing fruit/vegetable peels with dried leaves speeds up or improves decomposition (composting) compared to peels alone. Dried leaves provide carbon-rich material and aeration, creating better conditions for decomposing microorganisms.

Q5 Identify the following microorganisms:
(i) I live in every kind of environment, and inside your gut.
(ii) I make bread and cakes soft and fluffy.
(iii) I live in the roots of pulse crops and provide nutrients for their growth.

SOLUTION

(i) I live in every kind of environment, and inside your gut.
This describes Bacteria.
Bacteria are found in virtually every environment on Earth — in soil, water, air, hot springs, polar ice, and inside the bodies of living organisms. Our intestines (gut) contain trillions of bacteria that aid in digestion.

(ii) I make bread and cakes soft and fluffy.
This describes Yeast (specifically Saccharomyces cerevisiae).
Yeast is a unicellular fungus. When added to dough with sugar in warm conditions, yeast ferments the sugar and releases carbon dioxide (CO_2) gas. The CO_2 bubbles are trapped in the dough, causing it to rise and become soft and fluffy. This process is used in making bread, cakes, and pastries.

(iii) I live in the roots of pulse crops and provide nutrients for their growth.
This describes Rhizobium bacteria.
Rhizobium lives in the root nodules of legumes (pulse crops) such as peas,

beans, and lentils. These bacteria fix atmospheric nitrogen and convert it into a form (ammonia/nitrates) that the plant can use as a nutrient. This increases soil fertility and promotes healthy plant growth.

Answer: (i) Bacteria — found in all environments including the human gut. (ii) Yeast — a fungus that produces CO_2 by fermenting sugar, making dough rise. (iii) Rhizobium bacteria — live in root nodules of legumes and fix atmospheric nitrogen.

Q6 Design an experiment to test that microorganisms need optimal temperature, air, and moisture for their growth.

SOLUTION

Aim: To test that microorganisms need optimal temperature, air, and moisture for their growth.

Materials required: 9 slices of bread, water, sealed plastic bags/airtight containers, refrigerator, labels.

Experimental design — three separate sub-experiments (one variable at a time):

Sub-experiment 1 — Effect of Temperature:
Take 3 bread slices. Sprinkle a few drops of water on each to keep moisture equal.
— Slice T1: Keep in a warm place (25–35°C, room temperature / near a warm window).
— Slice T2: Keep in a cool place (refrigerator, ~4°C).
— Slice T3: Keep at a very hot/dry place (near a heat source, >60°C).
All slices are open to air. Observe after 3–5 days.
Expected result: Mould grows best on Slice T1 (warm), poorly or not at all on T2 (cold) and T3 (too hot).

Sub-experiment 2 — Effect of Moisture:
Take 2 bread slices at room temperature, both open to air.
— Slice M1: Sprinkle water on the surface (moist).
— Slice M2: Leave it as it is and dry it slightly (dry).
Observe after 3–5 days.
Expected result: Mould grows on Slice M1 (moist); Slice M2 (dry) shows little or no mould.

Sub-experiment 3 — Effect of Air:
Take 2 bread slices at room temperature. Sprinkle equal water on each.

— Slice A1: Place in an open container (access to air).
— Slice A2: Place in a sealed airtight plastic bag (restricted air/oxygen).
Observe after 3–5 days.
Expected result: Mould grows more readily on Slice A1 (with air); growth is slower or absent on Slice A2 (no air) for aerobic microorganisms.

Observation and conclusion: Mould grows best under warm temperature, moist conditions, and with adequate air. This demonstrates that microorganisms need optimal temperature, moisture, and air for their growth.

Answer: Use bread slices as the growth medium. Test one variable at a time: (1) Temperature — warm vs cold vs very hot; (2) Moisture — wet bread vs dry bread; (3) Air — open container vs sealed bag. Observe mould growth after 3–5 days. Mould grows best in warm, moist, airy conditions — confirming that microorganisms need optimal temperature, moisture, and air.

Q7 Take 2 slices of bread. Place one slice in a plate near the sink. Place the other slice in the refrigerator. Compare after three days. Note your observations. Give reasons for your observations.

SOLUTION

Predicted observations after three days:

Slice near the sink:
— The area near a sink is typically warm, humid, and exposed to air.
— You will likely observe patches of mould (white, grey, green, or black fuzzy growth) on this bread slice.
— The bread may smell musty or sour and its texture may have changed (become soft or discoloured).

Slice in the refrigerator:
— The refrigerator maintains a cold temperature (~4°C).
— This bread slice will remain relatively fresh — little or no mould growth is observed.
— The bread may dry out slightly but will show no or very little microbial growth.

Reasons:
Microorganisms such as bacteria and fungi (mould spores) are present everywhere in the air. They land on the bread and begin to grow when conditions are favourable.

Near the sink: The warm temperature (~25–30°C), high moisture (humidity near water), and exposure to air provide ideal conditions for microorganism growth. Mould spores germinate and grow rapidly, feeding on the starch and other nutrients in the bread.

In the refrigerator: The low temperature (~4°C) slows down or stops the metabolic processes of microorganisms. At such cold temperatures, bacteria and fungi cannot grow or reproduce effectively. Therefore, the bread stays fresh much longer.

This experiment shows that temperature and moisture are important factors controlling microbial growth.

Answer: Bread near the sink develops mould (warm, moist, airy conditions favour microbial growth). Bread in the refrigerator stays fresh (cold temperature slows or stops microbial growth). Microorganisms need warmth and moisture to grow — cold conditions inhibit them.

Q8 A student observes that when curd is left out for a day, it becomes more sour. What can be two possible explanations for this observation?

SOLUTION

Observation: Curd left out at room temperature for a day becomes more sour.

Possible Explanation 1 — Continued fermentation by Lactobacillus:
Curd already contains Lactobacillus bacteria. These bacteria are alive and active. When curd is left at room temperature (a warm environment), Lactobacillus continues to feed on lactose (the natural sugar in milk) and ferments it into lactic acid.
More time at room temperature → more fermentation → more lactic acid produced → curd becomes more sour.

Possible Explanation 2 — Contamination and growth of other acid-producing bacteria:
Curd left uncovered (or even covered) at room temperature can be contaminated by other bacteria from the surrounding air or environment.
Some of these bacteria also produce acids (such as acetic acid or lactic acid) as byproducts of their metabolism.
As these bacteria multiply over time, the concentration of acids in the curd increases, making it taste more sour.

Answer: 1. Lactobacillus bacteria already in the curd continue fermenting lactose into lactic acid at room temperature, increasing sourness over time. 2. Other acid-producing bacteria from the environment contaminate and multiply in the curd, adding more acid and making it sourer.

Q9 Observe the set-up given in Fig. 2.15 and answer the following questions.
The set-up shows: Flask A containing warm sugar solution + Yeast, connected by a delivery tube to Test tube B containing Lime water.
(i) What happens to the sugar solution in flask A?
(ii) What do you observe in test tube B after four hours? Why do you think this happened?
(iii) What would happen if yeast was not added in flask A?

SOLUTION

(i) What happens to the sugar solution in Flask A?
Yeast is a microorganism (a fungus) that ferments sugar in warm conditions.
In Flask A, yeast breaks down glucose in the warm sugar solution through fermentation:
Glucose → Ethanol + Carbon dioxide
$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$
The sugar is gradually consumed; ethanol (alcohol) is produced in the solution; and carbon dioxide (CO_2) gas is released as bubbles.
The solution may froth or foam as CO_2 bubbles escape. The liquid level may rise slightly and give off a faint alcoholic smell.

(ii) What do you observe in test tube B after four hours? Why?
Test tube B initially contains clear lime water [calcium hydroxide solution, $Ca(OH)_2$].
After four hours: the lime water turns milky (cloudy/white).

Why this happens:
The CO_2 gas produced by yeast fermentation in Flask A travels through the delivery tube and bubbles into the lime water in Test tube B.
CO_2 reacts with calcium hydroxide in a chemical reaction:
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
Calcium carbonate ($CaCO_3$) is a white, insoluble precipitate. Its formation makes the lime water turn milky or cloudy.
This milky appearance is the standard test for carbon dioxide.

(iii) What would happen if yeast was NOT added in Flask A?
Without yeast, no fermentation takes place.
No CO_2 gas is produced in Flask A.
No gas travels through the delivery tube to Test tube B.
Therefore, the lime water in Test tube B would remain clear and unchanged.
This control confirms that it is specifically the yeast (and its fermentation activity) that produces the CO_2 responsible for turning the lime water milky.

Answer: (i) Yeast ferments the sugar (glucose → ethanol + CO_2); sugar is consumed and CO_2 bubbles are released. (ii) Lime water turns milky — CO_2 from fermentation reacts with $Ca(OH)_2$ to form white $CaCO_3$ precipitate. (iii) Without yeast, no fermentation occurs, no CO_2 is produced, and lime water stays clear.