

<b>SB1c Specialised cells</b>	
How Egg Cells Are Adapted to Their Function (Short Answer):	<p><b>Large cytoplasm</b> to provide nutrients for the developing embryo.  <b>Haploid nucleus</b> with half the genetic information (23 chromosomes).  <b>Membrane changes after fertilisation</b> to stop other sperm entering.  <b>Large size</b> helps it be easily targeted by sperm.</p>
How Ciliated Epithelial Cells Are Adapted to Their Function:	<p><b>Tiny hair-like structures (cilia)</b> on their surface <b>beat in rhythm</b> to move mucus, dust, and pathogens away from the lungs.  <b>Found in airways</b> like the trachea and bronchi to help keep them clear.  <b>Work alongside goblet cells</b>, which produce the mucus they move.</p>
Draw conclusions about a cell's function from its adaptations.	<p><b><u>Egg Cell</u></b>  <b>Adaptations:</b>          Large cytoplasm          Haploid nucleus (23 chromosomes)          Membrane that changes after fertilisation  <b>Conclusion:</b>          These features show the cell is specialised for <b>reproduction</b> — it can support a developing embryo and only allows one sperm to fertilise it.</p> <p><b><u>Sperm Cell</u></b>  <b>Adaptations:</b>          Long tail for swimming          Many mitochondria for energy          Haploid nucleus          Acrosome with enzymes to penetrate the egg  <b>Conclusion:</b>          The sperm cell is adapted to <b>travel to and fertilise an egg</b>, which is its function in reproduction.</p> <p><b><u>Ciliated Epithelial Cell</u></b>  <b>Adaptations:</b>          Cilia (tiny hair-like structures) that move rhythmically          Found in airways or oviducts  <b>Conclusion:</b>          This cell is adapted to <b>move substances</b>, like <b>mucus in the lungs</b> or <b>egg cells in the oviduct</b>.</p> <p><b><u>Palisade Cell (plant)</u></b>  <b>Adaptations:</b>          Packed with chloroplasts          Tall and tightly packed          Found near the leaf surface  <b>Conclusion:</b>          These adaptations make it specialised for <b>photosynthesis</b>.</p> <p><b><u>Tips for Students:</u></b>  <b>Look at the structure:</b> Shape, organelles, features.  <b>Think about what that structure helps the cell do.</b>  <b>Match the function:</b> Movement? Energy? Transport? Reproduction?</p>
SB1d Inside bacteria	

<p>Identify the common parts of bacteria</p>	<p><u>Common Parts of a Bacterial Cell</u>  <b>Cell Wall</b> – provides shape and support (not made of cellulose like in plants).  <b>Cell Membrane</b> – controls what enters and leaves the cell.  <b>Cytoplasm</b> – where most of the cell’s chemical reactions happen.  <b>Chromosomal DNA</b> – one long circular chromosome that floats in the cytoplasm (no nucleus).  <b>Plasmids</b> – small rings of extra DNA that can be passed between bacteria.  <b>Flagella</b> (sometimes present) – tail-like structures that help bacteria move.  <b>Slime Capsule</b> (in some bacteria) – protects the cell and helps it stick to surfaces.</p> <p><b>Key point for exams:</b>          Bacteria are <b>prokaryotic cells</b>, which means <b>they don’t have a nucleus or membrane-bound organelles</b>.</p>														
<p>Describe the functions of common parts of bacteria</p>	<table border="1" data-bbox="528 618 1469 1055"> <tr> <td><b>Cell wall</b></td> <td>Provides structure and protection. Maintains the shape of the cell.</td> </tr> <tr> <td><b>Cell membrane</b></td> <td>Controls the movement of substances in and out of the cell.</td> </tr> <tr> <td><b>Cytoplasm</b></td> <td>Where chemical reactions occur (like respiration).</td> </tr> <tr> <td><b>Chromosomal DNA</b></td> <td>Carries the main genetic information. Not enclosed in a nucleus.</td> </tr> <tr> <td><b>Plasmids</b></td> <td>Small loops of extra DNA; often carry genes for antibiotic resistance.</td> </tr> <tr> <td><b>Flagella (if present)</b></td> <td>Helps the bacterium move through liquids.</td> </tr> <tr> <td><b>Slime capsule (in some)</b></td> <td>Protects the cell and helps it stick to surfaces or evade the immune system.</td> </tr> </table> <p><b>Key Exam Reminder:</b>          Bacteria are prokaryotic cells, so they don’t have a nucleus or membrane-bound organelles.</p>	<b>Cell wall</b>	Provides structure and protection. Maintains the shape of the cell.	<b>Cell membrane</b>	Controls the movement of substances in and out of the cell.	<b>Cytoplasm</b>	Where chemical reactions occur (like respiration).	<b>Chromosomal DNA</b>	Carries the main genetic information. Not enclosed in a nucleus.	<b>Plasmids</b>	Small loops of extra DNA; often carry genes for antibiotic resistance.	<b>Flagella (if present)</b>	Helps the bacterium move through liquids.	<b>Slime capsule (in some)</b>	Protects the cell and helps it stick to surfaces or evade the immune system.
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<p>Why Bacteria Are Classified as Prokaryotic ?</p>	<p>Bacteria are classified as <b>prokaryotic</b> because:          They <b>do not have a nucleus</b> – their genetic material (DNA) is <b>free in the cytoplasm</b>.          They <b>lack membrane-bound organelles</b> (like mitochondria or chloroplasts).          They are <b>usually smaller and simpler</b> than eukaryotic cells (like animal or plant cells).</p>														
<p>Changing Numbers to and From Standard Form</p>	<p>What is Standard Form?  <b>Standard form</b> is a way of writing <b>very large or very small numbers</b> using powers of 10. The format is: <math>A \times 10^n</math> where <math>1 \leq A &lt; 10</math></p> <hr/> <p><b>Converting to Standard Form</b>          For large numbers: Move the decimal point <b>left</b> until 1 digit is in front of it.  <b>Example:</b> <math>4500000 = 4.5 \times 10^6</math>          ☞ The decimal moved 6 places left.</p> <hr/> <p><b>For small numbers:</b>          Move the decimal point <b>right</b> until 1 digit is in front.  <b>Example:</b> <math>0.00032 = 3.2 \times 10^{-4}</math>          ☞ The decimal moved 4 places right (so power is negative).</p> <hr/> <p><b>Converting from Standard Form</b>          Just do the multiplication:          Positive power → Move decimal right <math>2.3 \times 10^4 = 23000</math>          Negative power → Move decimal left <math>7.1 \times 10^{-3} = 0.0071</math></p>														

	<p>🔪 Practice Questions</p> <p>Convert <b>to standard form</b>:</p> <p>76000 0.005 891000000 0.000087</p> <p>Convert <b>from standard form</b>:</p> <p><math>6.5 \times 10^3</math> <math>2.4 \times 10^{-2}</math> <math>9.9 \times 10^5</math> <math>3.1 \times 10^{-4}</math></p> <hr/> <p>✓ Answers:</p> <p><math>7.6 \times 10^4</math> <math>5 \times 10^{-3}</math> <math>8.91 \times 10^8</math> <math>8.7 \times 10^{-5}</math> 6500 0.024 990000 0.00031</p>																														
<p>Compare eukaryotic and prokaryotic cells</p>	<p><b>Comparison of Eukaryotic and Prokaryotic Cells</b></p> <table border="1"> <thead> <tr> <th>Feature</th> <th>Eukaryotic Cells</th> <th>Prokaryotic Cells</th> </tr> </thead> <tbody> <tr> <td><b>Examples</b></td> <td>Animal cells, plant cells, fungi, protists</td> <td>Bacteria</td> </tr> <tr> <td><b>Nucleus</b></td> <td>Present (DNA is inside a nucleus)</td> <td>Absent (DNA floats freely in cytoplasm)</td> </tr> <tr> <td><b>DNA form</b></td> <td>Linear DNA (in chromosomes)</td> <td>Circular DNA (single loop)</td> </tr> <tr> <td><b>Membrane-bound organelles</b></td> <td>Present (e.g. mitochondria, chloroplasts)</td> <td>Absent</td> </tr> <tr> <td><b>Size</b></td> <td>Larger (10–100 <math>\mu\text{m}</math>)</td> <td>Smaller (1–10 <math>\mu\text{m}</math>)</td> </tr> <tr> <td><b>Cell wall</b></td> <td>Present in plants/fungi (made of cellulose or chitin)</td> <td>Present in all bacteria (made of peptidoglycan)</td> </tr> <tr> <td><b>Ribosomes</b></td> <td>Larger (80S)</td> <td>Smaller (70S)</td> </tr> <tr> <td><b>Plasmids</b></td> <td>Rare</td> <td>Often present</td> </tr> <tr> <td><b>Reproduction</b></td> <td>Mitosis/meiosis (sexual/asexual)</td> <td>Binary fission (asexual only)</td> </tr> </tbody> </table>	Feature	Eukaryotic Cells	Prokaryotic Cells	<b>Examples</b>	Animal cells, plant cells, fungi, protists	Bacteria	<b>Nucleus</b>	Present (DNA is inside a nucleus)	Absent (DNA floats freely in cytoplasm)	<b>DNA form</b>	Linear DNA (in chromosomes)	Circular DNA (single loop)	<b>Membrane-bound organelles</b>	Present (e.g. mitochondria, chloroplasts)	Absent	<b>Size</b>	Larger (10–100 $\mu\text{m}$ )	Smaller (1–10 $\mu\text{m}$ )	<b>Cell wall</b>	Present in plants/fungi (made of cellulose or chitin)	Present in all bacteria (made of peptidoglycan)	<b>Ribosomes</b>	Larger (80S)	Smaller (70S)	<b>Plasmids</b>	Rare	Often present	<b>Reproduction</b>	Mitosis/meiosis (sexual/asexual)	Binary fission (asexual only)
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<p>SB1e Enzymes and nutrition</p>	<p>🔪 <b>Enzymes</b> are <b>biological catalysts</b> – they <b>speed up chemical reactions</b> in living organisms.</p> <p>🔪 Made of <b>proteins</b>.</p> <p>🔪 They are <b>specific</b> – each enzyme works with <b>one particular substrate</b>.</p>																														
	<p>Enzymes are proteins.</p>																														
<p>Give examples of enzymes and where they are found in the human body and in other species</p>	<p>Enzymes in the Human Body:</p> <p><b>Amylase</b> <b>Function:</b> Breaks down starch into sugars. <b>Location:</b> Saliva (mouth) and pancreas.</p> <p><b>Pepsin</b> <b>Function:</b> Breaks down proteins into smaller peptides. <b>Location:</b> Stomach.</p>																														

	<p><b>Lipase</b>  <b>Function:</b> Breaks down fats into fatty acids and glycerol.  <b>Location:</b> Pancreas and small intestine.</p> <p><b>DNA Polymerase</b>  <b>Function:</b> Helps in DNA replication.  <b>Location:</b> Inside cells, in the nucleus.</p> <hr/> <p>Enzymes in Other Species:</p> <p><b>Cellulase</b>  <b>Function:</b> Breaks down cellulose (plant fiber).  <b>Location:</b> Found in some bacteria, fungi, and herbivorous animals like termites and cows (through their gut microbes).</p> <p><b>Catalase</b>  <b>Function:</b> Breaks down hydrogen peroxide into water and oxygen.  <b>Location:</b> Found in many living organisms, including humans, plants, and bacteria.</p> <p><b>Trypsin</b> (also found in humans)  <b>Function:</b> Breaks down proteins in the small intestine.  <b>Location:</b> Pancreas of mammals and some other animals.</p>
Recall the subunits from which carbohydrates, proteins and lipids are formed (sugars, amino acids, fatty acids and glycerol).	<p>☑ <b>Carbohydrates</b> are made up of <b>sugars</b> (simple sugars called monosaccharides, like glucose).</p> <p>☑ <b>Proteins</b> are made up of <b>amino acids</b>.</p> <p>☑ <b>Lipids</b> are made up of <b>fatty acids</b> and <b>glycerol</b>.</p>
Describe what enzymes do (catalyse the synthesis and breakdown of substances, such as carbohydrates, proteins and lipids, by speeding up the rate of reaction)	Enzymes are biological catalysts that speed up chemical reactions in the body. They catalyse both the <b>breakdown</b> (digestion) and <b>synthesis</b> (building) of substances like carbohydrates, proteins, and lipids by lowering the activation energy needed, which increases the rate of these reactions. This allows important processes, such as digestion and metabolism, to happen quickly and efficiently.
Define an enzyme as a biological catalyst.	An enzyme is a <b>biological catalyst</b> , which means it is a protein that speeds up chemical reactions in living organisms without being used up or changed in the process.
Explain why catalysis by enzymes is important for life processes	Catalysis by enzymes is important for life processes because enzymes speed up the chemical reactions that are essential for cells to function properly. Without enzymes, these reactions would happen too slowly to sustain life. Enzymes allow processes like digestion, energy production, and DNA replication to occur quickly and efficiently at the temperatures and conditions inside living organisms, making life possible.
SB1f Testing foods	
Describe how to test for starch in food	<p>To test for starch in food, follow these steps:</p> <ul style="list-style-type: none"> <li>• Take a small sample of the food you want to test.</li> <li>• Add a few drops of <b>iodine solution</b> (usually yellow-brown).</li> <li>• Observe any colour change.</li> </ul> <p><b>Result:</b></p> <ul style="list-style-type: none"> <li>• If starch is present, the iodine solution will turn <b>blue-black</b>.</li> <li>• If no starch is present, the iodine will remain yellow-brown.</li> </ul> <p>This colour change indicates the presence of starch in the food.</p>
Describe how to test for reducing sugars in food	<p>To test for reducing sugars in food, use <b>Benedict's test</b> by following these steps:</p> <ol style="list-style-type: none"> <li>1. Take a small amount of the food sample (if solid, first dissolve it in water).</li> </ol>

	<ol style="list-style-type: none"> <li>2. Add an equal volume of <b>Benedict’s solution</b> to the sample in a test tube.</li> <li>3. Heat the test tube gently in a boiling water bath for about 2–5 minutes.</li> <li>4. Observe any color change.</li> </ol> <p><b>Result:</b></p> <ol style="list-style-type: none"> <li>1. If reducing sugars are present, the solution will change from blue to <b>green, yellow, orange, or brick-red</b> depending on the amount of sugar.</li> <li>2. If no reducing sugars are present, the solution remains blue.</li> </ol> <p>This test detects sugars like glucose and fructose.</p>
<p>Describe how to test for proteins in food</p>	<p>To test for proteins in food, use the <b>biuret test</b> by following these steps:</p> <ol style="list-style-type: none"> <li>1. Take a small sample of the food (if solid, dissolve it in water).</li> <li>2. Add a few drops of <b>biuret solution</b> (or dilute sodium hydroxide followed by copper sulphate solution) to the sample.</li> <li>3. Gently mix the solution.</li> </ol> <p><b>Result:</b></p> <ol style="list-style-type: none"> <li>1. If protein is present, the solution will turn <b>purple or violet</b>.</li> <li>2. If no protein is present, the solution remains <b>blue</b>.</li> </ol> <p>This colour change indicates the presence of proteins in the food.</p>
<p>Describe how to test for lipids in food</p>	<p>To test for lipids in food, you can use the <b>emulsion test</b> by following these steps:</p> <ol style="list-style-type: none"> <li>1. Take a small sample of the food (if solid, crush or blend it).</li> <li>2. Add the food sample to a test tube with some <b>ethanol</b> (or alcohol) and shake well to dissolve any lipids.</li> <li>3. Pour the ethanol solution into a test tube containing <b>water</b>.</li> <li>4. Observe the mixture.</li> </ol> <p><b>Result:</b></p> <ol style="list-style-type: none"> <li>1. If lipids are present, a <b>milky white (cloudy) emulsion</b> will form.</li> <li>2. If no lipids are present, the solution will remain clear.</li> </ol> <p>This indicates the presence of fats or oils in the food.</p>
<p>Explain how calorimetry can be used to measure the energy in food</p>	<p>Calorimetry measures the energy in food by burning a known amount of the food to release heat and using that heat to warm a known volume of water. Here’s how it works:</p> <ol style="list-style-type: none"> <li>1. A small, weighed sample of food is burned in a sealed container called a <b>calorimeter</b>.</li> <li>2. The heat released from burning the food transfers to a known volume of water surrounding the container.</li> <li>3. The temperature increase of the water is measured.</li> <li>4. Using the temperature change, volume of water, and its specific heat capacity, you calculate the amount of energy released by the food as it burns.</li> </ol> <p>This energy is usually expressed in <b>kilojoules (kJ)</b> or <b>calories</b> and represents the energy available from the food when consumed.</p>
<p>Evaluate calorimetry tests for accuracy</p>	<p>Calorimetry tests are useful for estimating the energy content of food, but their accuracy can be affected by several factors:</p> <p><b>Strengths:</b></p> <p><b>Simple and quick</b> method to get an estimate of energy content. Measures actual heat released from burning the food, which relates directly to energy content.</p> <p><b>Limitations / Sources of Inaccuracy:</b></p> <ol style="list-style-type: none"> <li>1. <b>Incomplete combustion:</b> If the food doesn’t burn completely, not all energy is released and measured, leading to underestimation.</li> <li>2. <b>Heat loss:</b> Some heat escapes into the surroundings instead of heating the water, causing lower temperature changes and underestimations.</li> </ol>

	<p>3. <b>Energy used to evaporate water:</b> Water content in the food can absorb energy for evaporation, which isn't measured as heat transferred to the water.</p> <p>4. <b>Measurement errors:</b> Inaccurate weighing of food, volume of water, or temperature readings can affect results.</p> <p>5. <b>Not accounting for energy lost in digestion:</b> The energy measured is total combustion energy, but the body may not absorb all this energy during digestion.</p> <p><b>Summary:</b> Calorimetry provides a reasonable estimate of food energy but is not perfectly accurate due to heat loss, incomplete burning, and practical measurement issues. More precise methods, like bomb calorimetry in controlled lab settings, reduce some of these errors.</p>
SB1g Enzyme action	
State what enzyme specificity means.	Enzyme specificity means that each enzyme only works on a particular substrate or type of substrate, fitting together like a "lock and key." This means an enzyme can only catalyse a specific reaction or set of reactions with certain molecules.
State that an enzyme's action is due to its active site	An enzyme's action is due to its <b>active site</b> , which is the specific region where the substrate binds and the chemical reaction takes place.
Describe the role of the active site in enzyme function (including specificity).	The active site of an enzyme is a specially shaped area that fits only specific substrate molecules, like a key fitting into a lock. This shape gives the enzyme <b>specificity</b> , meaning it can only bind to and act on particular substrates. When the substrate binds to the active site, the enzyme helps to speed up the chemical reaction by lowering the activation energy, allowing the reaction to happen faster.
Use the lock-and-key model to develop explanations for enzyme activity	<p>The <b>lock-and-key model</b> explains enzyme activity by comparing the enzyme to a lock and the substrate to a key:</p> <ol style="list-style-type: none"> <li>1. The enzyme has a specific <b>active site</b> (the "lock") with a unique shape.</li> <li>2. Only a substrate molecule with the matching shape (the "key") can fit exactly into this active site.</li> <li>3. When the substrate binds to the active site, the enzyme forms an enzyme-substrate complex.</li> <li>4. This precise fit allows the enzyme to catalyse the reaction efficiently by lowering the activation energy needed.</li> <li>5. After the reaction, the products are released, and the enzyme remains unchanged, ready to bind with another substrate.</li> </ol> <p>This model explains why enzymes are <b>specific</b> and only work with certain substrates.</p>
Explain why enzymes have a particular shape, as a result of the sequence of amino acids in the chain	Enzymes have a particular shape because of the specific <b>sequence of amino acids</b> in their protein chain. This sequence determines how the chain folds into a unique three-dimensional structure through chemical bonds and interactions like hydrogen bonds, ionic bonds, and disulfide bridges. The folding creates the enzyme's active site with a precise shape that fits its substrate. If the amino acid sequence changes, the enzyme's shape can change too, which may affect its ability to function properly.
Explain how enzymes become denatured.	<p>Enzymes become <b>denatured</b> when their three-dimensional structure is altered, causing the active site to change shape. This can happen due to factors like:</p> <p><b>High temperatures</b> (heat can break the bonds holding the enzyme's shape)</p> <p><b>Extreme pH levels</b> (too acidic or too alkaline conditions can disrupt bonds)</p>

	When denatured, the enzyme can no longer bind to its substrate properly, so its activity is lost or greatly reduced. Denaturation is usually irreversible.												
SB1h Enzyme activity													
Describe the effect of temperature on enzyme activity.	<p>The effect of temperature on enzyme activity is as follows:</p> <ol style="list-style-type: none"> <li>1. As temperature increases, enzyme activity <b>increases</b> because molecules move faster, leading to more frequent collisions between enzyme and substrate.</li> <li>2. The enzyme has an <b>optimum temperature</b> at which its activity is highest.</li> <li>3. If the temperature rises above the optimum, the enzyme begins to <b>denature</b>, losing its shape and active site, so activity <b>decreases sharply</b>.</li> <li>4. At low temperatures, enzyme activity is <b>slow</b> because molecules move less and collisions happen less often.</li> </ol> <p>So, enzyme activity increases with temperature up to a point, then drops rapidly after denaturation.</p>												
Describe the effect of substrate concentration on enzyme activity	<p>The effect of substrate concentration on enzyme activity is:</p> <ol style="list-style-type: none"> <li>1. As substrate concentration <b>increases</b>, enzyme activity <b>increases</b> because more substrate molecules are available to bind to the enzyme's active sites.</li> <li>2. However, this increase only continues up to a point called the <b>saturation point</b>, where all the active sites of the enzymes are occupied.</li> <li>3. Beyond this point, increasing substrate concentration <b>does not increase</b> enzyme activity because the enzymes are working at their maximum rate.</li> <li>4. At low substrate concentrations, enzyme activity is limited by the amount of substrate available.</li> </ol>												
Describe the effect of pH on enzyme activity	<p>The effect of pH on enzyme activity is:</p> <ol style="list-style-type: none"> <li>1. Each enzyme has an <b>optimum pH</b> at which it works best.</li> <li>2. If the pH moves away from this optimum (either too acidic or too alkaline), enzyme activity <b>decreases</b>.</li> <li>3. Extreme pH levels can cause the enzyme to <b>denature</b>, changing the shape of its active site and stopping it from working properly.</li> <li>4. Small changes in pH can affect the bonds that maintain the enzyme's shape, reducing its ability to bind to the substrate.</li> </ol>												
Explain what is meant by the optimum pH/temperature of an enzyme	The <b>optimum pH</b> or <b>optimum temperature</b> of an enzyme is the specific pH level or temperature at which the enzyme works <b>best</b> and its activity is at its <b>highest</b> . At this point, the enzyme's shape and active site are perfect for binding the substrate and catalysing the reaction efficiently. If the pH or temperature moves away from this optimum, the enzyme's activity decreases.												
Calculate the rate of enzyme activity from experimental data	<p>Example:</p> <p>You measure how long it takes for an enzyme to break down a substrate, producing oxygen bubbles. You record the volume of oxygen produced every 30 seconds.</p> <table> <thead> <tr> <th>Time (seconds)</th> <th>Volume of Oxygen (cm<sup>3</sup>)</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>30</td> <td>15</td> </tr> <tr> <td>60</td> <td>30</td> </tr> <tr> <td>90</td> <td>45</td> </tr> <tr> <td>120</td> <td>60</td> </tr> </tbody> </table>	Time (seconds)	Volume of Oxygen (cm <sup>3</sup> )	0	0	30	15	60	30	90	45	120	60
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	<p>Calculate the rate of enzyme activity:  The <b>rate</b> is usually expressed as the amount of product formed (oxygen) per unit time.  Between 0 and 120 seconds:  Volume of oxygen produced = 60 cm<sup>3</sup>  Time = 120 seconds  Rate = Volume of oxygen produced / Time  Rate = 60 cm<sup>3</sup> ÷ 120 s = <b>0.5 cm<sup>3</sup> per second</b></p> <hr/> <p>Summary:  The enzyme produces oxygen at a rate of <b>0.5 cm<sup>3</sup>/s</b> during the experiment.</p>
<p>Explain why temperature, substrate concentration and PH affect enzyme activity</p>	<p>Here's why <b>temperature</b>, <b>substrate concentration</b>, and <b>pH</b> affect enzyme activity:</p> <p><b>1. Temperature:</b>  Increasing temperature makes molecules move faster, so enzymes and substrates collide more often, <b>increasing enzyme activity</b>.  But if the temperature gets too high, the enzyme's shape changes (it <b>denatures</b>), especially the active site, so it can no longer bind to the substrate, causing activity to <b>drop sharply</b>.  At low temperatures, enzyme activity is slow because molecules move less and collide less frequently.</p> <p><b>2. Substrate Concentration:</b>  When substrate concentration is low, increasing it means more substrate molecules are available, so enzyme activity <b>increases</b>.  However, once all enzyme active sites are occupied (saturation), increasing substrate concentration further <b>does not increase</b> activity because the enzymes are working at their maximum rate.</p> <p><b>3. pH:</b>  Each enzyme works best at an <b>optimum pH</b> where its shape and charge allow the substrate to bind effectively.  If pH moves away from this optimum (too acidic or too alkaline), it can change the enzyme's shape and charge, especially in the active site, causing enzyme activity to <b>decrease</b>.  Extreme pH levels can cause the enzyme to <b>denature</b>, permanently stopping its function.</p>
<p>SB1i Transporting substances</p>	
<p>State that substances are transported by diffusion, osmosis and active transport</p>	<p>Substances are transported in cells by <b>diffusion</b>, <b>osmosis</b>, and <b>active transport</b>.</p>
<p>Describe how substances are transported by active transport (including the need for energy)</p>	<p><b>Active transport</b> is the movement of substances <b>from a lower concentration to a higher concentration</b> — <b>against the concentration gradient</b>. This process <b>requires energy</b>, which is provided by <b>ATP</b> (from respiration) in the cell.  Active transport uses <b>special carrier proteins</b> in the cell membrane that <b>pump</b> substances into or out of the cell. This allows cells to absorb important substances (like minerals or glucose) even when they are in lower concentration outside the cell.</p> <p><b>Example:</b>  Root hair cells in plants use active transport to absorb <b>minerals</b> from the soil, even when the concentration of minerals is lower in the soil than in the root cells.</p>

<p>Explain how substances are transported by diffusion</p>	<p><b>Diffusion</b> is the movement of particles from an area of <b>higher concentration to an area of lower concentration</b>, down a <b>concentration gradient</b>, until they are evenly spread out.</p> <p>In biology, diffusion is how substances like <b>oxygen, carbon dioxide</b>, and <b>glucose</b> move into and out of cells. It does <b>not require energy</b> and happens naturally.</p> <p><b>Example:</b>  <b>Oxygen</b> diffuses from the air in the lungs into the blood because there is a higher concentration of oxygen in the lungs than in the blood.  <b>Carbon dioxide</b> diffuses from the blood into the lungs to be exhaled.</p>
<p>Explain how substances are transported by osmosis.</p>	<p><b>Osmosis</b> is the movement of <b>water molecules</b> from a region of <b>higher water concentration</b> to a region of <b>lower water concentration</b> through a <b>partially permeable membrane</b>.</p> <p>It is a special type of diffusion that only involves <b>water</b>, and it does <b>not require energy</b>.</p> <p><b>Key Points:</b>  Water moves <b>down its concentration gradient</b>.  The <b>partially permeable membrane</b> allows water to pass through, but not larger solute molecules.</p> <p><b>Example:</b>  In plant roots, water moves by osmosis from the soil (where there is a higher water concentration) into the root hair cells (where there is a lower water concentration).  In animal cells, water can move in or out depending on the concentration of solutes inside and outside the cell, affecting cell size and shape.</p>
<p>Explain the effects of osmosis on cells and tissues</p>	<p><b>Osmosis</b> can have different effects on <b>cells and tissues</b> depending on the concentration of water inside the cell compared to the outside environment. Here's how:</p> <hr/> <p>1. In Animal Cells (e.g., red blood cells):  <b>In a dilute solution (more water outside):</b>  Water enters the cell by osmosis → the cell <b>swells</b> and may <b>burst</b> (lysis) because animal cells have no cell wall to stop the expansion.  <b>In a concentrated solution (less water outside):</b>  Water leaves the cell by osmosis → the cell <b>shrinks</b> and becomes <b>crenated</b> (shriveled).</p> <hr/> <p>2. In Plant Cells:  <b>In a dilute solution:</b>  Water enters the cell by osmosis → the <b>vacuole swells</b>, and the cell becomes <b>turgid</b> (firm). This is a healthy state for plant cells.  <b>In a concentrated solution:</b>  Water leaves the cell by osmosis → the <b>cytoplasm shrinks away</b> from the cell wall, and the cell becomes <b>plasmolysed</b>. This can cause the plant to wilt.</p>
<p>Investigate osmosis in potatoes</p>	<p><b>Investigating Osmosis in Potatoes – Practical Summary</b></p> <p>This classic experiment demonstrates osmosis using <b>potato cylinders</b> placed in different concentrations of <b>sugar or salt solution</b>.</p> <hr/> <p><b>Aim:</b>  To investigate how different concentrations of a solution affect osmosis in potato tissue.</p> <hr/> <p><b>Method:</b></p>

	<p>Cut <b>equal-sized potato cylinders</b> using a cork borer and ruler (e.g. 5 cm long). Measure and record their <b>initial mass</b> using a balance.</p> <p>Prepare <b>solutions</b> of varying concentrations (e.g. pure water, 0.2 M, 0.4 M, 0.6 M, 0.8 M, 1.0 M sugar solution).</p> <p>Place a potato cylinder in each solution and leave for at least <b>30 minutes to 1 hour</b>.</p> <p>Remove the potato cylinders, blot them gently to remove excess solution, and <b>re-measure the mass</b>.</p> <p>Calculate the <b>change in mass</b> and the <b>percentage change</b>:</p> $\text{Percentage change} = \frac{\text{Final mass} - \text{Initial mass}}{\text{Initial Mass}} \times 100$ <p><b>Expected Results:</b></p> <p>In <b>pure water</b> (high water concentration), potato cylinders <b>gain mass</b> (water moves into cells by osmosis).</p> <p>In <b>high sugar concentrations</b> (low water concentration), potato cylinders <b>lose mass</b> (water moves out of cells).</p> <p>There is usually a point where there is <b>no change in mass</b> — this is where the solution concentration equals the concentration inside the potato cells (no net osmosis).</p> <p><b>Conclusion:</b></p> <p>This experiment shows that water moves in or out of cells by <b>osmosis</b>, depending on the concentration of the surrounding solution. The results help to demonstrate the effect of osmosis on plant tissue.</p>
Calculate percentage gain and loss of mass in osmosis	<p>o calculate the <b>percentage gain or loss of mass</b> in an osmosis experiment (like with potato cylinders), use this formula:</p> <hr/> <p><b>Percentage Change in Mass Formula:</b></p> $\text{Percentage change} = \frac{\text{Final mass} - \text{Initial mass}}{\text{Initial Mass}} \times 100$ <p>Example 1 – Gain in Mass (Osmosis into the potato):</p> <p><b>Initial mass</b> = 2.0 g</p> <p><b>Final mass</b> = 2.4 g</p> $\frac{2.4 - 2.0}{2.0} \times 100 = \frac{0.4}{2.0} \times 100 = 20\%$ <p>The potato <b>gained</b> 20% in mass.</p> <p>Example 2 – Loss in Mass (Osmosis out of the potato):</p> <p><b>Initial mass</b> = 2.0 g</p> <p><b>Final mass</b> = 1.6 g</p> $\frac{1.6 - 2.0}{2.0} \times 100 = \frac{-0.4}{2.0} \times 100 = -20\%$ <p>The potato <b>lost</b> 20% in mass (the minus sign shows it was a decrease).</p>
SB2 Cells and control	
SB2a Mitosis	
List the names and order of the stages of the cell cycle, including mitosis	<p>The <b>cell cycle</b> is the series of stages a cell goes through to grow and divide. It includes <b>interphase</b> and <b>mitosis</b>, followed by <b>cytokinesis</b>.</p> <p>Here is the correct <b>order</b> of the stages:</p> <p><b>Interphase</b> – The cell grows, carries out normal functions, and copies its DNA.</p> <p><b>Mitosis</b> – The nucleus divides in four stages:</p> <p><b>Prophase</b></p> <p><b>Metaphase</b></p>

	<p><b>Anaphase</b>  <b>Telophase</b>  <b>Cytokinesis</b> – The cytoplasm and cell membrane divide, forming two identical daughter cells.                  Summary of Order:  <b>Interphase → Prophase → Metaphase → Anaphase → Telophase → Cytokinesis</b></p>
<p>Describe what happens in each stage of the cell cycle, including mitosis</p>	<p><b>1. Interphase</b>                  The cell grows larger and carries out normal functions.                  DNA is <b>replicated</b> (copied) so there are two identical sets of chromosomes.                  The cell prepares for division by producing extra organelles and molecules.</p> <hr/> <p><b>2. Prophase</b>                  Chromosomes <b>condense</b> and become visible under a microscope.                  Each chromosome consists of two sister chromatids joined at the centromere.                  The nuclear membrane begins to break down.                  Spindle fibers start to form from the centrioles.</p> <hr/> <p><b>3. Metaphase</b>                  Chromosomes line up along the <b>middle (equator)</b> of the cell.                  Spindle fibers attach to the centromeres of each chromosome.</p> <hr/> <p><b>4. Anaphase</b>                  The spindle fibers pull the sister chromatids <b>apart</b> toward opposite poles of the cell.                  Each chromatid is now considered an individual chromosome.</p> <hr/> <p><b>5. Telophase</b>                  Chromosomes arrive at the poles and begin to <b>uncoil</b>.                  Nuclear membranes <b>re-form</b> around each set of chromosomes.                  The spindle fibers break down.</p> <hr/> <p><b>6. Cytokinesis</b>                  The <b>cytoplasm divides</b>, splitting the cell into two genetically identical daughter cells.                  Each new cell has a complete set of chromosomes and its own cell membrane.</p>
<p>Describe why mitosis is important for an organism. (growth, repair, asexual reproduction)</p>	<p>Mitosis is important for an organism because it allows:  <b>Growth:</b> It produces new cells so the organism can grow larger.  <b>Repair:</b> It replaces damaged or dead cells to heal wounds and maintain healthy tissues.  <b>Asexual reproduction:</b> In some organisms, mitosis creates genetically identical offspring without the need for a mate.                  Overall, mitosis ensures that cells divide accurately to produce identical cells, maintaining the organism’s structure and function.</p>
<p>Explain why organisms may rely on asexual reproduction.</p>	<p>Organisms may rely on <b>asexual reproduction</b> because:                  It allows them to reproduce <b>quickly</b> and <b>efficiently</b>, producing many offspring in a short time.                  It does <b>not require a mate</b>, which is helpful when mates are scarce or conditions are stable.                  Offspring are <b>genetically identical</b> to the parent, which is advantageous in a stable environment where the parent’s traits are well-suited to survival.                  It requires <b>less energy and resources</b> compared to sexual reproduction.</p>

	However, because offspring are genetically identical, asexual reproduction results in less genetic variation, which can be a disadvantage if the environment changes.
Describe how mitosis produces genetically identical, diploid cells.	<p>Mitosis produces genetically identical, <b>diploid</b> cells through the following process:</p> <p>Before mitosis begins, during <b>interphase</b>, the cell's DNA is <b>replicated</b>, so each chromosome consists of two identical sister chromatids.</p> <p>During mitosis, the sister chromatids are separated and evenly divided between two new nuclei.</p> <p>Each new nucleus receives the <b>full set of chromosomes</b>, maintaining the <b>diploid</b> number (two sets of chromosomes — one from each parent).</p> <p>As a result, the two daughter cells formed at the end of mitosis have <b>exactly the same genetic information</b> as the original parent cell.</p> <p>This ensures that the new cells are genetically identical and have the correct number of chromosomes.</p>
Describe how cancers grow	<p>Cancers grow because of <b>uncontrolled cell division</b>. Normally, the cell cycle is tightly regulated to ensure cells only divide when needed. However, in cancer: <b>Mutations</b> occur in genes that control the cell cycle, causing the regulation to fail.</p> <p>Cells start to divide <b>rapidly and uncontrollably</b>, without the usual checks and balances.</p> <p>This leads to the formation of a <b>mass of abnormal cells</b> called a <b>tumor</b>.</p> <p>Some cancer cells can <b>invade nearby tissues</b> and spread to other parts of the body (metastasis), making the disease more serious.</p> <p>In summary, cancer growth results from cells dividing too quickly and not dying when they should.</p>
SB2b Growth in animals	
Define growth in animals as an increase in cell number and size.	<b>Growth in animals</b> is defined as an increase in the <b>number</b> of cells (cell division) and the <b>size</b> of those cells.
Give examples of specialised animal cells	<p>Here are some examples of specialised animal cells:</p> <p><b>Red blood cells</b> – carry oxygen around the body.</p> <p><b>Nerve cells (neurons)</b> – transmit electrical signals.</p> <p><b>Muscle cells</b> – contract to produce movement.</p> <p><b>Sperm cells</b> – carry genetic material for reproduction.</p> <p><b>White blood cells</b> – help fight infection.</p> <p><b>Fat cells (adipose cells)</b> – store energy as fat.</p>
Describe how structure of specialised animal cells is related to their function.	<p>Here's how the structure of specialised animal cells relates to their function:</p> <p><b>Red blood cells:</b> They are <b>biconcave</b> and have <b>no nucleus</b>, which increases surface area and allows more space to carry oxygen using hemoglobin. Their shape helps them flow easily through blood vessels.</p> <p><b>Nerve cells (neurons):</b> They have <b>long extensions (axons and dendrites)</b> that allow them to transmit electrical signals quickly over long distances. The branching dendrites receive signals from other neurons.</p> <p><b>Muscle cells:</b> They contain many <b>contractile proteins</b> (actin and myosin) and are <b>elongated</b>, which helps them contract and generate movement.</p> <p><b>Sperm cells:</b> They have a <b>tail (flagellum)</b> for swimming, a <b>head</b> containing genetic material, and enzymes in the head to help penetrate the egg.</p> <p><b>White blood cells:</b> They have a flexible shape to move through blood vessel walls and engulf pathogens by <b>phagocytosis</b>.</p>

	<p><b>Fat cells:</b> They have a large <b>fat storage droplet</b> to store energy and a thin layer of cytoplasm around it.</p> <hr/> <p>The specialised structures enable each cell type to perform its specific role efficiently.</p>
<p>Explain why cell differentiation is important in the development of specialised cells.</p>	<p><b>Cell differentiation</b> is important because it allows unspecialised cells (like stem cells) to develop into <b>specialised cells</b> with unique structures and functions. This process is essential for:</p> <ol style="list-style-type: none"> <li>1. Creating different types of cells needed for the various tissues and organs in the body.</li> <li>2. Ensuring cells can perform specific tasks effectively, such as carrying oxygen, transmitting signals, or contracting muscles.</li> <li>3. Supporting the growth, development, and repair of multicellular organisms by producing cells suited for particular roles.</li> </ol> <p>Without differentiation, all cells would be the same and unable to carry out the diverse functions necessary for life.</p>
<p>Use percentile growth curves to interpret growth in children.</p>	<p><b>Using percentile growth curves to interpret growth in children:</b> Percentile growth curves are charts that show the distribution of measurements (like height, weight, or head circumference) for children of the same age and sex. They help compare an individual child's growth to a reference population.</p> <ol style="list-style-type: none"> <li>1. Each <b>percentile</b> represents the position of a child relative to others. For example, the <b>50th percentile</b> means the child is exactly average — half of children are taller or heavier, and half are shorter or lighter.</li> <li>2. If a child's measurements consistently follow a certain percentile line over time, it indicates <b>steady growth</b>.</li> <li>3. Moving <b>up</b> or <b>down</b> percentiles may suggest a change in the child's growth rate, which could be normal or might indicate a health or nutritional concern.</li> <li>4. Doctors use these curves to identify children who are growing <b>too slowly</b> (below lower percentiles) or <b>too quickly</b> (above higher percentiles) and may need further assessment.</li> </ol> <p>In summary, percentile growth curves are valuable tools to monitor and interpret a child's growth pattern compared to peers.</p>
<p>SB2c Growth in plants</p>	
<p>Describe the stages of growth in plants (cell division/mitosis, elongation, differentiation).</p>	<p>The stages of growth in plants include:</p> <ol style="list-style-type: none"> <li>1. <b>Cell Division (Mitosis):</b> New plant cells are produced by mitosis, mainly in regions called <b>meristems</b> (e.g., root tips and shoot tips).</li> <li>2. <b>Cell Elongation:</b> After division, the new cells <b>elongate</b> (grow longer), increasing the length of roots and shoots.</li> <li>3. <b>Cell Differentiation:</b> The elongated cells <b>differentiate</b> into specialised cells with specific structures and functions, forming tissues like xylem, phloem, and epidermis.</li> </ol> <p>These stages work together to allow plants to grow in size and develop specialized tissues.</p>
<p>Give examples of specialised plant cells</p>	<p>Here are some examples of specialised plant cells:</p> <ul style="list-style-type: none"> <li>• <b>Root hair cells</b> — increase the surface area of roots for water and mineral absorption.</li> </ul>

	<ul style="list-style-type: none"> <li>• <b>Xylem vessels</b> — transport water and minerals from roots to leaves; have thick, lignified walls.</li> <li>• <b>Phloem cells</b> — transport sugars and nutrients around the plant; include sieve tube elements and companion cells.</li> <li>• <b>Guard cells</b> — control the opening and closing of stomata to regulate gas exchange and water loss.</li> <li>• <b>Palisade mesophyll cells</b> — contain many chloroplasts for photosynthesis.</li> <li>• <b>Collenchyma cells</b> — provide flexible support to growing parts of the plant.</li> </ul>
<p>Describe how the structures of specialised plant cells are related to their functions.</p>	<p>1. Root Hair Cells  <b>Function:</b> Absorb water and minerals from the soil.  <b>Structure and Adaptations:</b>            Long, thin <b>extension</b> increases surface area for absorption.  <b>Thin cell wall</b> makes it easier for water to enter.  <b>No chloroplasts</b>, as they are underground and don't photosynthesise.</p> <hr/> <p>2. Xylem Vessels  <b>Function:</b> Transport water and minerals from roots to the rest of the plant.  <b>Structure and Adaptations:</b>            Made of <b>dead, hollow cells</b> joined end to end to form continuous tubes.  <b>Thick walls</b> strengthened with <b>lignin</b> to prevent collapse.  <b>No end walls or cytoplasm</b>, allowing water to flow freely.</p> <hr/> <p>3. Phloem Cells  <b>Function:</b> Transport sugars (mainly sucrose) and other nutrients.  <b>Structure and Adaptations:</b>  <b>Sieve tube elements</b> have holes in end walls (sieve plates) for sap to move through.  <b>Companion cells</b> provide energy and support for sieve tubes, as sieve tubes have little cytoplasm and no nucleus.</p> <hr/> <p>4. Guard Cells  <b>Function:</b> Control the opening and closing of stomata for gas exchange and water regulation.  <b>Structure and Adaptations:</b>            Have <b>thick inner walls and thin outer walls</b> to control stomatal opening.  <b>Can change shape</b> by taking in or releasing water, allowing the stomata to open or close.            Contain <b>chloroplasts</b> to respond to light levels.</p> <hr/> <p>5. Palisade Mesophyll Cells  <b>Function:</b> Carry out photosynthesis.  <b>Structure and Adaptations:</b>            Packed with <b>chloroplasts</b> to capture light energy.            Located near the <b>upper surface of the leaf</b> to absorb maximum sunlight.            Regular, box-like shape to pack tightly together.</p> <hr/> <p>Each plant cell is adapted structurally to carry out its specific role efficiently, supporting the plant's survival and growth.</p>
<p>Explain why cell differentiation is important in the development of specialised cells in plants.</p>	<p><b>Cell differentiation</b> is important in the development of specialised cells in plants because it allows unspecialised cells (like those in the meristems) to become cells with specific structures and functions. This is essential for:</p>

	<ol style="list-style-type: none"> <li><b>Forming different tissues</b> such as xylem, phloem, and epidermis, each with a unique role in the plant.</li> <li><b>Supporting growth</b> by producing the right types of cells in the right places, such as root hair cells for absorption and palisade cells for photosynthesis.</li> <li><b>Allowing efficient transport</b> of water, minerals, and sugars through specialised conducting cells like xylem and phloem.</li> <li><b>Improving survival</b>, as specialised cells help the plant adapt to its environment (e.g. guard cells regulating water loss).</li> </ol> <p>Without differentiation, the plant wouldn't be able to develop complex structures or carry out essential functions.</p>									
SB2d Stem cells										
Describe where stem cells are found	<p><b>Stem cells</b> are found in the following places:</p> <p>In animals:  <b>Embryos</b> – embryonic stem cells can become <b>any type of cell</b> in the body (they are <b>pluripotent</b>).  <b>Adult tissues</b> – adult stem cells are found in places like <b>bone marrow</b>, skin, and the gut. They can become a <b>limited range of specialised cells</b> (they are <b>multipotent</b>).</p> <p>In plants:  <b>Meristems</b> – found in <b>growing regions</b> such as root tips and shoot tips. These stem cells can divide throughout the plant's life and form <b>any type of plant cell</b>.</p> <p>Stem cells are important because they can divide and develop into the specialised cells needed for growth, repair, and development.</p>									
Describe the function of stem cells in plants and animals	<p>Function of Stem Cells in Plants and Animals:</p> <hr/> <p>In Animals:  <b>Growth</b> – Stem cells produce new cells during early development and childhood growth.  <b>Repair and Replacement</b> – Adult stem cells replace damaged or old cells (e.g. skin, blood, or gut lining).  <b>Development</b> – Embryonic stem cells can become any type of specialised cell needed to form all the body's tissues and organs.</p> <hr/> <p>In Plants:  <b>Continuous Growth</b> – Stem cells in meristems allow plants to grow throughout their life, especially at root and shoot tips.  <b>Formation of New Organs</b> – They can develop into different types of cells needed for new leaves, flowers, or roots.  <b>Regeneration</b> – Plants can regrow damaged parts thanks to stem cell activity in the meristems.</p> <hr/> <p>In both plants and animals, stem cells are vital for <b>development, repair, and maintaining healthy tissues</b>.</p>									
Compare embryonic and adult stem cells in animals	<p><b>Comparison of Embryonic and Adult Stem Cells in Animals:</b></p> <table border="1" data-bbox="528 1868 1469 2085"> <thead> <tr> <th>Feature</th> <th>Embryonic Stem Cells</th> <th>Adult Stem Cells</th> </tr> </thead> <tbody> <tr> <td>Location</td> <td>Found in early-stage embryos</td> <td>Found in specific tissues (e.g. bone marrow, skin)</td> </tr> <tr> <td>Potency</td> <td><b>Pluripotent</b> – can become <b>any type of cell</b></td> <td><b>Multipotent</b> – can become <b>some cell types</b>, usually related to their tissue of origin</td> </tr> </tbody> </table>	Feature	Embryonic Stem Cells	Adult Stem Cells	Location	Found in early-stage embryos	Found in specific tissues (e.g. bone marrow, skin)	Potency	<b>Pluripotent</b> – can become <b>any type of cell</b>	<b>Multipotent</b> – can become <b>some cell types</b> , usually related to their tissue of origin
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	<table border="1"> <tr> <td data-bbox="523 114 715 226"><b>Role</b></td> <td data-bbox="715 114 1059 226">Important for <b>early development</b> and forming all body tissues</td> <td data-bbox="1059 114 1476 226">Involved in <b>repair and maintenance</b> of tissues</td> </tr> <tr> <td data-bbox="523 226 715 293"><b>Availability</b></td> <td data-bbox="715 226 1059 293">Available in large numbers during early development</td> <td data-bbox="1059 226 1476 293">Fewer in number and harder to extract</td> </tr> <tr> <td data-bbox="523 293 715 405"><b>Ethical concerns</b></td> <td data-bbox="715 293 1059 405">Use raises <b>ethical issues</b> as it involves destroying embryos</td> <td data-bbox="1059 293 1476 405">Fewer ethical concerns</td> </tr> </table> <p data-bbox="523 405 1476 584"><b>Summary:</b> Embryonic stem cells have more potential because they can become any cell type, but they are ethically controversial. Adult stem cells are more limited but useful for specific tissue repair and have fewer ethical concerns.</p>	<b>Role</b>	Important for <b>early development</b> and forming all body tissues	Involved in <b>repair and maintenance</b> of tissues	<b>Availability</b>	Available in large numbers during early development	Fewer in number and harder to extract	<b>Ethical concerns</b>	Use raises <b>ethical issues</b> as it involves destroying embryos	Fewer ethical concerns
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<b>Ethical concerns</b>	Use raises <b>ethical issues</b> as it involves destroying embryos	Fewer ethical concerns								
Give examples of where stem cells may be used in medicine	<p data-bbox="523 584 1476 645">Here are some examples of where <b>stem cells may be used in medicine:</b></p> <hr/> <p data-bbox="523 656 1476 824"><b>1. Bone Marrow Transplants</b> Used to treat <b>leukaemia</b> and other blood disorders. Healthy <b>adult stem cells</b> from a donor's bone marrow are transplanted to replace damaged blood-forming cells.</p> <hr/> <p data-bbox="523 835 1476 958"><b>2. Treating Type 1 Diabetes</b> Stem cells could be used to grow new <b>insulin-producing cells</b> in the pancreas to replace those destroyed by the immune system.</p> <hr/> <p data-bbox="523 969 1476 1137"><b>3. Repairing Damaged Tissues or Organs</b> Stem cells may help <b>regenerate heart muscle</b> after a heart attack. Potential to repair <b>spinal cord injuries</b> and treat conditions like <b>Parkinson's disease</b> or <b>multiple sclerosis</b>.</p> <hr/> <p data-bbox="523 1149 1476 1272"><b>4. Drug Testing and Development</b> Lab-grown stem cells can be used to create models of <b>human tissues</b> for testing new medicines safely and effectively.</p> <hr/> <p data-bbox="523 1283 1476 1429"><b>5. Growing Organs for Transplant (<i>in the future</i>)</b> Research is exploring how stem cells could be used to <b>grow organs</b> in the lab for transplantation, reducing the need for donors.</p> <hr/> <p data-bbox="523 1440 1476 1547">Stem cell therapies offer great promise for treating a wide range of diseases and injuries by replacing or repairing damaged cells.</p>									
Identify benefits and risks of using stem cells in medicine	<p data-bbox="523 1547 1476 1585"><b>Benefits of Using Stem Cells in Medicine:</b></p> <ul style="list-style-type: none"> <li data-bbox="523 1585 1476 1664">✓ <b>Treating diseases:</b> Stem cells can help treat conditions like leukaemia, diabetes, Parkinson's disease, and spinal cord injuries.</li> <li data-bbox="523 1664 1476 1742">✓ <b>Tissue and organ repair:</b> They can regenerate damaged tissues, such as heart muscle after a heart attack.</li> <li data-bbox="523 1742 1476 1821">✓ <b>No need for donors:</b> In the future, stem cells might be used to grow organs, reducing organ transplant waiting lists.</li> <li data-bbox="523 1821 1476 1899">✓ <b>Personalised medicine:</b> Stem cells from a patient's own body reduce the risk of rejection and improve compatibility.</li> <li data-bbox="523 1899 1476 1977">✓ <b>Drug testing:</b> Stem cells can be used to test new drugs on human cells in the lab, reducing the need for animal testing.</li> </ul> <hr/> <p data-bbox="523 2000 1476 2038"><b>Risks of Using Stem Cells in Medicine:</b></p> <ul style="list-style-type: none"> <li data-bbox="523 2038 1476 2101">⚠ <b>Ethical concerns:</b> Using embryonic stem cells involves destroying embryos, which raises moral and ethical issues for some people.</li> </ul>									

	<p>⚠ <b>Risk of rejection:</b> Transplanted stem cells from donors might be rejected by the patient’s immune system.</p> <p>⚠ <b>Uncontrolled growth:</b> Stem cells may divide uncontrollably, possibly forming <b>tumours</b> or leading to <b>cancer</b>.</p> <p>⚠ <b>Infection or complications:</b> Like any medical treatment, stem cell therapy can involve surgical risks, infections, or other side effects.</p> <p>⚠ <b>High cost and accessibility:</b> Stem cell treatments can be expensive and are not yet widely available.</p> <hr/> <p><b>Summary:</b> Stem cells have the potential to revolutionise medicine but must be used carefully, considering both their powerful benefits and possible risks.</p>
<p>Evaluate the use of stem cells in medicine (by comparing their benefits and risks)</p>	<p>Evaluation of the Use of Stem Cells in Medicine The use of stem cells in medicine offers exciting possibilities but also presents challenges that must be carefully considered.</p> <hr/> <p>✓ Benefits:</p> <p><b>Treatment of serious diseases:</b> Stem cells can help treat conditions like leukaemia, Parkinson’s disease, spinal cord injuries, and type 1 diabetes by replacing damaged cells with healthy ones.</p> <p><b>Regeneration of tissues:</b> Stem cells have the unique ability to regenerate damaged tissues, such as heart muscle after a heart attack, improving recovery and quality of life.</p> <p><b>Personalised therapy:</b> Using a patient’s own stem cells can reduce the risk of rejection and improve treatment success.</p> <p><b>Scientific advancement:</b> Stem cells help scientists better understand human development and disease, and can be used to test drugs more safely and efficiently.</p> <hr/> <p>⚠ Risks and Concerns:</p> <p><b>Ethical issues:</b> The use of embryonic stem cells involves destroying human embryos, which many people believe is morally wrong.</p> <p><b>Risk of uncontrolled cell growth:</b> Stem cells may divide uncontrollably and lead to <b>tumour formation</b> or <b>cancer</b>.</p> <p><b>Immune rejection:</b> If stem cells are from a donor, the body may see them as foreign and reject them.</p> <p><b>Cost and accessibility:</b> Treatments are still expensive and experimental, making them unavailable to many people.</p> <p><b>Limited understanding:</b> Some treatments are still in early stages, and long-term effects are not fully known.</p> <hr/> <p>Conclusion: Stem cell therapies have <b>great medical potential</b> and could revolutionise treatment for many currently untreatable conditions. However, their use must be <b>balanced with ethical responsibility</b>, careful monitoring of <b>side effects</b>, and more <b>research</b> to ensure safety and effectiveness. As technology improves, stem cell therapy is likely to become more widely accepted and accessible.</p>
<p>SB2e The brain</p>	
<p>Describe what the brain is made up of</p>	<p>The <b>brain</b> is made up of billions of <b>neurons</b> (nerve cells) and is supported by <b>glial cells</b> that provide nutrients and protection. It is divided into different <b>regions</b>, each with specialised functions. The brain is also surrounded by <b>protective membranes</b> called the <b>meninges</b> and is cushioned by <b>cerebrospinal fluid</b>.</p>

	<p>The brain is part of the <b>central nervous system (CNS)</b> and is mainly made up of:</p> <p><b>Grey matter</b> – contains neuron cell bodies and is involved in processing information.</p> <p><b>White matter</b> – made of nerve fibres (axons) that carry messages between brain areas and the spinal cord.</p> <p><b>Blood vessels</b> – supply oxygen and nutrients to keep brain cells alive. Together, these structures allow the brain to control everything from movement and senses to emotions and memory.</p>
<p>Identify different parts of the brain (cerebellum, cerebral hemispheres, medulla oblongata).</p>	<p>Here are the main parts of the brain and their functions:</p> <hr/> <p>1. Cerebral Hemispheres (Cerebrum): The largest part of the brain, divided into <b>left and right hemispheres</b>. Responsible for <b>thinking, memory, personality, language, and voluntary movements</b>. Controls the <b>opposite side</b> of the body (e.g., the left hemisphere controls the right side).</p> <hr/> <p>2. Cerebellum: Located at the <b>back of the brain</b>, underneath the cerebrum. Controls <b>balance, posture, and coordination of movement</b>. Helps make movements <b>smooth and precise</b>.</p> <hr/> <p>3. Medulla Oblongata: Found at the <b>base of the brain</b>, where it connects to the spinal cord. Controls <b>automatic (involuntary) functions</b> like <b>heartbeat, breathing, and digestion</b>. Vital for keeping you alive without conscious effort.</p> <hr/> <p>Each part of the brain plays a critical role in the way your body functions and responds to the environment.</p>
<p>Describe the functions of different parts of the brain (cerebellum, cerebral hemispheres, medulla oblongata).</p>	<p>Here are the functions of different parts of the brain:</p> <hr/> <p>1. Cerebral Hemispheres (Cerebrum): Control <b>voluntary movements</b> (e.g., walking, writing). Responsible for <b>intelligence, memory, reasoning, and problem-solving</b>. Manage <b>sensory processing</b> like vision, hearing, touch, and taste. Control <b>language and speech</b>. Involved in <b>emotion and personality</b>.</p> <hr/> <p>2. Cerebellum: Coordinates <b>balance and posture</b>. Controls <b>fine motor skills</b> and <b>muscle coordination</b> to produce smooth, precise movements. Helps with <b>learning motor skills</b> such as riding a bike or playing an instrument.</p> <hr/> <p>3. Medulla Oblongata: Regulates <b>involuntary functions</b> vital for survival, such as: <b>Heartbeat</b> <b>Breathing rate</b> <b>Swallowing and digestion</b> Acts as a communication pathway between the brain and spinal cord.</p> <hr/>

	Each part works together to control body functions and respond to the environment effectively.
SB2g The nervous system	
List the parts of the nervous system.	<p>The <b>parts of the nervous system</b> are:</p> <ol style="list-style-type: none"> <li>1. <b>Central Nervous System (CNS):</b> <ol style="list-style-type: none"> <li>a. <b>Brain</b></li> <li>b. <b>Spinal cord</b></li> </ol> </li> <li>2. <b>Peripheral Nervous System (PNS):</b> <ol style="list-style-type: none"> <li>a. <b>Sensory (afferent) neurons</b> – carry signals from sensory organs to the CNS</li> <li>b. <b>Motor (efferent) neurons</b> – carry signals from the CNS to muscles and glands</li> </ol> </li> <li>3. <b>Autonomic Nervous System (ANS):</b> <ol style="list-style-type: none"> <li>a. Controls involuntary actions (e.g., heart rate, digestion)</li> <li>b. Divided into <b>sympathetic</b> and <b>parasympathetic</b> systems</li> </ol> </li> <li>4. _____</li> </ol> <p>Together, these parts coordinate the body's response to internal and external stimuli.</p>
Describe how the nervous system detects stimuli	<p>The nervous system detects stimuli through <b>sensory receptors</b> located in sense organs (like the skin, eyes, ears, nose, and tongue). These receptors respond to different types of stimuli such as:</p> <ol style="list-style-type: none"> <li>1. <b>Light</b> (detected by photoreceptors in the eyes)</li> <li>2. <b>Sound</b> (detected by mechanoreceptors in the ears)</li> <li>3. <b>Touch, pressure, temperature, and pain</b> (detected by receptors in the skin)</li> <li>4. <b>Chemicals</b> (detected by chemoreceptors in the nose and tongue)</li> </ol> <p>When a stimulus is detected, the sensory receptors <b>convert it into electrical impulses</b> (nerve signals). These impulses are then transmitted by <b>sensory neurons</b> to the <b>central nervous system (brain and spinal cord)</b>, where they are processed and a response is coordinated.</p>
Describe the structure of sensory neurones	<p>Structure of Sensory Neurones:</p> <p>Sensory neurones are specialised nerve cells that carry electrical impulses <b>from sensory receptors</b> to the <b>central nervous system (CNS)</b>. Their key structural features include:</p> <ol style="list-style-type: none"> <li>1. <b>Dendrites:</b> Branched endings that receive signals from sensory receptors.</li> <li>2. <b>Cell body:</b> Contains the nucleus and is usually located <b>off to one side</b> of the axon (in a structure called the <b>dorsal root ganglion</b>).</li> <li>3. <b>Axon:</b> A long, thin fiber that carries impulses <b>towards the CNS</b>.</li> <li>4. <b>Myelin sheath:</b> A fatty layer that covers the axon, speeding up impulse transmission.</li> <li>5. <b>Axon terminals:</b> Endings that pass the signal to other neurons in the spinal cord or brain.</li> </ol> <hr/> <p>This structure enables sensory neurones to efficiently detect stimuli and transmit signals quickly to the CNS for processing.</p>

<p>Describe the routes that impulses take to and from the brain</p>	<p>Routes That Impulses Take To and From the Brain:</p> <hr/> <ol style="list-style-type: none"> <li>1. <b>Sensory Input (To the Brain):</b> <ol style="list-style-type: none"> <li>a. <b>Stimulus detected</b> by sensory receptors (e.g., in skin, eyes).</li> <li>b. <b>Sensory neurons</b> carry electrical impulses from the receptors.</li> <li>c. The impulses travel along the <b>peripheral nerves</b> to the <b>spinal cord</b>.</li> <li>d. From the spinal cord, impulses are transmitted up to the <b>brain</b> (central nervous system) via nerve pathways.</li> <li>e. The brain processes the information and interprets the stimulus.</li> </ol> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>2. <b>Motor Output (From the Brain):</b> <ol style="list-style-type: none"> <li>a. After processing, the brain sends <b>response signals</b> through <b>motor neurons</b>.</li> <li>b. The impulses travel down from the brain through the <b>spinal cord</b>.</li> <li>c. From the spinal cord, the impulses travel via peripheral nerves to the <b>effectors</b> (muscles or glands).</li> <li>d. The effectors carry out the response (e.g., muscle contraction or secretion).</li> </ol> </li> </ol> <hr/> <p>This two-way communication enables the body to <b>detect stimuli, process information, and respond appropriately</b>.</p>
<p>Explain how sensory neurones are adapted to their functions (including the myelin sheath).</p>	<p>Sensory neurones are specially adapted to effectively detect stimuli and transmit electrical impulses quickly to the central nervous system. Here's how their structure supports their function:</p> <ol style="list-style-type: none"> <li>1. <b>Long dendrites:</b> Sensory neurones have long dendrites that allow them to receive signals from sensory receptors located far from the cell body, helping them collect information efficiently.</li> <li>2. <b>Cell body positioned off to the side:</b> The cell body is located in a ganglion off the main pathway, which allows the impulse to travel quickly along the axon without interruption.</li> <li>3. <b>Long axon:</b> Their long axon enables impulses to travel over long distances from the sensory receptors to the spinal cord or brain.</li> <li>4. <b>Myelin sheath:</b> This fatty insulating layer surrounds the axon and speeds up impulse transmission by allowing the electrical signal to jump between gaps called <b>nodes of Ranvier</b> (a process called saltatory conduction).</li> <li>5. <b>Axon terminals:</b> These endings connect to neurons in the CNS, allowing effective transmission of impulses.</li> </ol> <p>Together, these adaptations allow sensory neurones to rapidly and efficiently carry information from the body's sensors to the brain for processing.</p>
<p>SB2h The eye</p>	
<ol style="list-style-type: none"> <li>1. Identify the main parts of the eye</li> </ol>	<ol style="list-style-type: none"> <li>1. <b>Cornea</b> – the transparent outer layer that helps focus light into the eye.</li> <li>2. <b>Iris</b> – the colored part of the eye that controls the size of the pupil.</li> <li>3. <b>Pupil</b> – the opening in the iris that lets light enter the eye.</li> <li>4. <b>Lens</b> – focuses light rays onto the retina.</li> <li>5. <b>Retina</b> – contains light-sensitive cells (photoreceptors) that detect light and send signals to the brain.</li> <li>6. <b>Optic nerve</b> – carries visual information from the retina to the brain.</li> <li>7. <b>Sclera</b> – the white, protective outer layer of the eye.</li> <li>8. <b>Ciliary muscles</b> – adjust the shape of the lens for focusing on objects at different distances.</li> <li>9. <b>Vitreous humour</b> – the clear gel that fills the eye and helps maintain its shape.</li> </ol>




<p>Explain how the cornea, lens, iris and retina are adapted to their functions</p>	<p>Here's how each part of the eye is adapted to its function:</p> <hr/> <p>Cornea:</p> <ul style="list-style-type: none"> <li>• <b>Transparent</b> to allow light to enter the eye.</li> <li>• <b>Curved shape</b> helps to bend (refract) light rays to start focusing them onto the retina.</li> </ul> <hr/> <p>Lens:</p> <ul style="list-style-type: none"> <li>• <b>Flexible and transparent</b> to let light pass through and focus it precisely on the retina.</li> <li>• Can <b>change shape</b> (with help from ciliary muscles) to focus on objects at different distances — a process called <b>accommodation</b>.</li> </ul> <hr/> <p>Iris:</p> <ul style="list-style-type: none"> <li>• Contains <b>muscle fibres</b> that can <b>contract or relax</b> to adjust the size of the pupil.</li> <li>• Controls the amount of light entering the eye to protect the retina from too much light and improve vision in different lighting conditions.</li> </ul> <hr/> <p>Retina:</p> <ul style="list-style-type: none"> <li>• Contains millions of <b>photoreceptor cells</b> (rods and cones) that detect light intensity and color.</li> <li>• Converts light into <b>electrical impulses</b> which are sent to the brain via the optic nerve.</li> <li>• Its <b>layered structure</b> allows efficient capture and processing of light signals.</li> </ul> <hr/> <p>Each part's special structure ensures the eye can capture, focus, and interpret light effectively for clear vision.</p>
<p>Explain how receptor cells allow full colour vision in bright light.</p>	<p>Receptor cells in the retina called <b>cones</b> enable full colour vision in bright light. Here's how they work:</p> <ol style="list-style-type: none"> <li>1. There are <b>three types of cone cells</b>, each sensitive to a different range of wavelengths (colours):             <ol style="list-style-type: none"> <li>a. <b>Red cones</b> respond mostly to long wavelengths (red light).</li> <li>b. <b>Green cones</b> respond mostly to medium wavelengths (green light).</li> <li>c. <b>Blue cones</b> respond mostly to short wavelengths (blue light).</li> </ol> </li> <li>2. When bright light enters the eye, these cones are <b>activated</b> and send electrical signals to the brain.</li> <li>3. The brain <b>combines the input</b> from the three types of cones to interpret and perceive a wide range of colours.</li> <li>4. Because cones require bright light to function well, full colour vision is best in <b>bright lighting conditions</b>.</li> </ol> <hr/> <p>This system of different cones working together allows humans to see millions of colours and distinguish subtle differences.</p>
<p>Describe common eye defects (cataracts, long-sightedness, short-sightedness, colour blindness)</p>	<p>Here are common eye defects and their descriptions:</p> <hr/> <ol style="list-style-type: none"> <li>1. Cataracts:             <ul style="list-style-type: none"> <li>• The <b>lens becomes cloudy</b>, causing blurred or dim vision.</li> <li>• Usually develops with age or due to injury or illness.</li> <li>• Light cannot pass clearly through the lens, reducing vision quality.</li> </ul> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>2. Long-sightedness (Hyperopia):</li> </ol>

	<ul style="list-style-type: none"> <li>• Difficulty focusing on <b>near objects</b>; distant objects are seen more clearly.</li> <li>• Caused when the eyeball is <b>too short</b> or the lens is not curved enough, so light focuses <b>behind the retina</b>.</li> <li>• Corrected with <b>convex (converging) lenses</b> that help focus light on the retina.</li> </ul> <hr/> <p>3. Short-sightedness (Myopia):</p> <ul style="list-style-type: none"> <li>• Difficulty seeing <b>distant objects</b> clearly; near objects are clear.</li> <li>• Caused when the eyeball is <b>too long</b> or the lens is too curved, so light focuses <b>in front of the retina</b>.</li> <li>• Corrected with <b>concave (diverging) lenses</b> that spread light rays out before they enter the eye.</li> </ul> <hr/> <p>4. Colour Blindness:</p> <ul style="list-style-type: none"> <li>• Difficulty distinguishing certain colours, usually red and green.</li> <li>• Caused by defects or absence of certain types of <b>cone cells</b> in the retina.</li> <li>• It is usually inherited and more common in males.</li> <li>• There is no cure, but special lenses can help improve colour perception.</li> </ul> <hr/> <p>Each defect affects vision differently and may require specific treatments or corrective lenses.</p>
<p>Describe how cataracts are treated</p>	<p><b>Treatment of Cataracts:</b></p> <ol style="list-style-type: none"> <li>1. Cataracts are commonly treated through <b>surgery</b>.</li> <li>2. During the surgery, the <b>cloudy lens</b> is removed from the eye.</li> <li>3. The natural lens is usually replaced with a <b>clear artificial lens implant</b> (called an intraocular lens).</li> <li>4. This restores clear vision by allowing light to properly focus on the retina.</li> <li>5. Cataract surgery is generally safe and effective, with most patients experiencing significant improvement in vision.</li> </ol>
<p>Explain how long- and short-sightedness can be corrected</p>	<p>Here's how long-sightedness and short-sightedness are corrected using lenses:</p> <hr/> <p><b>Long-sightedness (Hyperopia):</b></p> <ul style="list-style-type: none"> <li>• The eye focuses light <b>behind the retina</b> because the eyeball is too short or the lens is not curved enough.</li> <li>• Corrected by wearing <b>convex lenses</b> (also called converging lenses).</li> <li>• Convex lenses <b>bend light rays inward</b> before they enter the eye, helping to focus the image directly on the retina, improving near vision.</li> </ul> <hr/> <p>Short-sightedness (Myopia):</p> <ul style="list-style-type: none"> <li>• The eye focuses light <b>in front of the retina</b> because the eyeball is too long or the lens is too curved.</li> <li>• Corrected by wearing <b>concave lenses</b> (also called diverging lenses).</li> <li>• Concave lenses <b>spread light rays out</b> before they enter the eye, moving the focus back onto the retina, improving distance vision.</li> </ul> <hr/> <p>Both types of lenses help the eye form a clear image on the retina, correcting the blurry vision caused by these defects.</p>
<p>SB2i Neurotransmission speeds</p>	

<p>Describe how the nervous system responds to stimuli.</p>	<p>The nervous system responds to stimuli through a rapid, coordinated process:</p> <ol style="list-style-type: none"> <li><b>Detection:</b> Sensory receptors detect a stimulus (e.g., heat, light, pressure).</li> <li><b>Transmission:</b> Sensory neurones carry electrical impulses from the receptors to the central nervous system (brain and spinal cord).</li> <li><b>Processing:</b> The brain or spinal cord processes the information and decides on a response.</li> <li><b>Response:</b> Motor neurones carry impulses from the CNS to effectors (muscles or glands).</li> <li><b>Action:</b> Effectors carry out the response, such as muscle contraction or gland secretion.</li> </ol> <p>This process allows the body to quickly detect changes in the environment and respond appropriately to maintain safety and homeostasis.</p>
<p>Describe the structures of motor neurones and relay neurones.</p>	<p>Here's a description of the structures of <b>motor neurones</b> and <b>relay neurones</b>:</p> <hr/> <p>Motor Neurones:</p> <ul style="list-style-type: none"> <li>• <b>Dendrites:</b> Receive signals from other neurones.</li> <li>• <b>Cell body:</b> Contains the nucleus and cellular organelles, usually located at one end.</li> <li>• <b>Long axon:</b> Carries electrical impulses <b>away from the CNS</b> to effectors (muscles or glands).</li> <li>• <b>Myelin sheath:</b> Fatty layer insulating the axon to speed up impulse transmission.</li> <li>• <b>Axon terminals:</b> Endings that connect to muscles or glands to trigger a response.</li> </ul> <hr/> <p>Relay Neurones (Interneurones):</p> <ul style="list-style-type: none"> <li>• <b>Short dendrites:</b> Receive impulses from sensory neurones.</li> <li>• <b>Cell body:</b> Located centrally in the neurone.</li> <li>• <b>Short or no axon:</b> Relay neurones usually have short axons that connect sensory neurones to motor neurones within the CNS.</li> <li>• They act as <b>connectors</b> or processors between sensory input and motor output.</li> </ul> <hr/> <p><b>Summary:</b> Motor neurones have long axons to reach muscles/glands, while relay neurones have shorter structures specialized for connecting sensory and motor neurones inside the CNS.</p>
<p>Explain how motor neurones are adapted to their functions.</p>	<p>Motor neurones are specially adapted to efficiently carry signals from the central nervous system to muscles or glands, enabling a quick response. Their adaptations include:</p> <ol style="list-style-type: none"> <li><b>Long axon:</b> Allows impulses to travel a long distance from the spinal cord or brain directly to the effector (muscle or gland).</li> <li><b>Myelin sheath:</b> This insulating layer speeds up the transmission of electrical impulses along the axon by allowing impulses to jump between nodes of Ranvier (saltatory conduction).</li> <li><b>Many dendrites:</b> They receive signals from relay neurones, ensuring effective communication within the nervous system.</li> <li><b>Axon terminals:</b> These endings form connections with muscles or glands to transmit the nerve impulse, triggering contraction or secretion.</li> </ol> <p>These features allow motor neurones to rapidly and precisely control muscle movement or gland activity in response to stimuli.</p>
<p>Explain the action and function of synapses.</p>	<p><b>Synapses</b> are the tiny gaps between two neurones (nerve cells) or between a neurone and an effector (muscle or gland). They play a crucial role in transmitting nerve impulses.</p>

	<hr/> <p>Function of Synapses:</p> <ol style="list-style-type: none"> <li>1. To <b>transmit electrical signals</b> from one neurone to the next neurone or effector.</li> <li>2. To <b>ensure one-way transmission</b> of impulses, preventing signals from traveling backward.</li> <li>3. To <b>allow integration and processing</b> of signals by enabling neurones to connect with many others.</li> </ol> <hr/> <p>Action of Synapses:</p> <ol style="list-style-type: none"> <li>1. When an electrical impulse (action potential) reaches the end of a neurone (the presynaptic terminal), it triggers the release of <b>chemical messengers called neurotransmitters</b>.</li> <li>2. Neurotransmitters are released into the <b>synaptic cleft</b> (the small gap between neurones).</li> <li>3. They <b>diffuse across the synaptic cleft</b> and bind to specific receptors on the membrane of the next neurone (postsynaptic membrane).</li> <li>4. This binding causes ion channels to open in the postsynaptic neurone, generating a new electrical impulse.</li> <li>5. The neurotransmitters are then <b>broken down or reabsorbed</b> to stop the signal and prepare the synapse for the next impulse.</li> </ol>
<p>Explain how the structure of the reflex arc allows a faster response.</p>	<p>The structure of the reflex arc allows a faster response because it <b>bypasses the brain</b> and involves only a few neurones, making the reaction quicker and automatic. Here's how:</p> <ol style="list-style-type: none"> <li>1. <b>Sensory neurone</b> detects the stimulus and sends an impulse directly to the <b>spinal cord</b>.</li> <li>2. In the spinal cord, the impulse passes to a <b>relay neurone</b> (interneuron) which quickly connects to a <b>motor neurone</b>.</li> <li>3. The <b>motor neurone</b> immediately sends the impulse to the <b>effector</b> (muscle or gland), causing a rapid response.</li> </ol> <p>Because the impulse does <b>not need to travel all the way to the brain first</b>, the reflex arc provides a much faster reaction to protect the body from harm. This quick pathway is vital for reflex actions like pulling your hand away from a hot object.</p>
<p>Describe the structure and function of the reflex arc?</p>	<p><b>Structure of the Reflex Arc:</b></p> <ol style="list-style-type: none"> <li>1. <b>Receptor:</b> Detects the stimulus (e.g., heat, pain).</li> <li>2. <b>Sensory neurone:</b> Carries the electrical impulse from the receptor to the spinal cord.</li> <li>3. <b>Relay neurone (interneuron):</b> Located in the spinal cord; connects the sensory neurone to the motor neurone.</li> <li>4. <b>Motor neurone:</b> Carries the impulse from the spinal cord to the effector.</li> <li>5. <b>Effector:</b> Usually a muscle or gland that carries out the response (e.g., muscle contraction or secretion).</li> </ol> <hr/> <p><b>Function of the Reflex Arc:</b></p> <ol style="list-style-type: none"> <li>1. Provides a <b>rapid, automatic response</b> to harmful stimuli to protect the body.</li> <li>2. The impulse travels through the <b>sensory neurone to the spinal cord</b>, bypassing the brain for speed.</li> <li>3. The <b>relay neurone quickly passes the impulse</b> to the motor neurone.</li> <li>4. The <b>motor neurone activates the effector</b>, producing an immediate reaction (like pulling away from a hot object).</li> </ol> <hr/>

	This quick, automatic pathway helps protect the body from injury by enabling fast reflex actions.
SB3 Genetics	
SB3a Sexual and asexual reproduction	
Describe features of asexual reproduction (rapid reproductive cycle, no need for mate, no variation of offspring)	<p><b>Asexual reproduction</b> has the following key features:</p> <ul style="list-style-type: none"> <li>• <b>No need for a mate</b> – only one parent is needed, so organisms can reproduce alone.</li> <li>• <b>Rapid reproductive cycle</b> – it is usually faster than sexual reproduction, allowing for quick population growth.</li> <li>• <b>No genetic variation</b> – offspring are genetically identical to the parent (clones), unless a mutation occurs.</li> </ul> <p>This method is common in bacteria, some plants, and simple animals.</p>
Explain how some features of asexual reproduction can be advantageous or disadvantageous	<p><b>Advantages of asexual reproduction:</b></p> <ul style="list-style-type: none"> <li>• ✓ <b>Rapid population growth</b> – because it's fast, organisms can quickly colonise an area (e.g. bacteria doubling every few hours).</li> <li>• ✓ <b>No mate needed</b> – useful when individuals are isolated or in stable environments.</li> <li>• ✓ <b>Clones well-suited to environment</b> – if the parent thrives, so will the offspring in the same conditions.</li> </ul> <p><b>Disadvantages of asexual reproduction:</b></p> <ul style="list-style-type: none"> <li>• ✗ <b>No genetic variation</b> – all offspring are identical, so if the environment changes (e.g. disease, temperature), they may all be affected.</li> <li>• ✗ <b>Less ability to adapt</b> – without variation, evolution is slower and the species may struggle to survive long-term changes.</li> </ul> <p>So, asexual reproduction is great in stable conditions, but risky when the environment becomes challenging.</p>
Describe features of sexual reproduction (slower reproductive cycle, requires mate, variation in offspring).	<p><b>Sexual reproduction</b> has the following key features:</p> <ul style="list-style-type: none"> <li>• <b>Requires a mate</b> – two parents are needed to combine genetic material.</li> <li>• <b>Slower reproductive cycle</b> – finding a mate and producing offspring takes more time than asexual reproduction.</li> <li>• <b>Genetic variation in offspring</b> – each offspring is genetically different from both parents due to the mixing of genes.</li> </ul> <p>This variation increases the chances of survival in changing environments, as some individuals may have traits that help them adapt.</p>
Explain how some features of sexual reproduction can be advantageous or disadvantageous	<p><b>Advantages of sexual reproduction:</b></p> <ul style="list-style-type: none"> <li>• ✓ <b>Genetic variation</b> – offspring are all different, increasing the chance that some will survive diseases or environmental changes.</li> <li>• ✓ <b>Adaptation and evolution</b> – variation allows natural selection to act, helping species adapt over time.</li> <li>• ✓ <b>Survival in changing environments</b> – diverse traits mean some individuals may cope better with new conditions.</li> </ul> <p><b>Disadvantages of sexual reproduction:</b></p> <ul style="list-style-type: none"> <li>• ✗ <b>Requires a mate</b> – finding a partner takes time and energy, which can delay reproduction or reduce survival chances.</li> <li>• ✗ <b>Slower reproductive cycle</b> – fewer offspring may be produced over a given time compared to asexual reproduction.</li> <li>• ✗ <b>Not always guaranteed</b> – reproduction depends on mating success, which can be affected by population size or health.</li> </ul> <p>In summary, sexual reproduction is more beneficial in changing environments, while it can be less efficient when rapid reproduction is needed.</p>

<p>Compare the advantages and disadvantages of asexual and sexual reproduction in evaluating the life cycle of an organism</p>	<p>When comparing <b>asexual</b> and <b>sexual reproduction</b> in the context of an organism's life cycle, we look at how each method supports survival, adaptation, and reproduction over time.</p> <hr/> <p> Asexual Reproduction</p> <p><b>Advantages:</b></p> <ol style="list-style-type: none"> <li>✓ <b>Fast and efficient</b> – organisms can reproduce rapidly without a mate (e.g. bacteria, some plants).</li> <li>✓ <b>Energy-saving</b> – no need to find a partner or engage in mating behaviour.</li> <li>✓ <b>Useful in stable environments</b> – offspring are well-suited if conditions don't change.</li> </ol> <p><b>Disadvantages:</b></p> <ol style="list-style-type: none"> <li>✗ <b>No genetic variation</b> – all offspring are clones; a single disease or environmental change can wipe them all out.</li> <li>✗ <b>Limited adaptability</b> – less potential for evolution or survival in new conditions.</li> </ol> <hr/> <p> Sexual Reproduction</p> <p><b>Advantages:</b></p> <ol style="list-style-type: none"> <li>✓ <b>Genetic variation</b> – increases survival chances when environments change.</li> <li>✓ <b>Supports evolution</b> – natural selection can act on a wide range of traits.</li> <li>✓ <b>Disease resistance</b> – diversity can help a population avoid being wiped out by one illness.</li> </ol> <p><b>Disadvantages:</b></p> <ol style="list-style-type: none"> <li>✗ <b>Slower and more complex</b> – finding a mate takes time and energy.</li> <li>✗ <b>Fewer offspring in same time frame</b> – compared to rapid asexual methods.</li> <li>✗ <b>Not ideal in isolated or low-population areas</b> – if mates are hard to find, reproduction may not happen.</li> </ol> <hr/> <p> Evaluation in Life Cycles</p> <ul style="list-style-type: none"> <li>• <b>Organisms with short life cycles</b> (e.g. bacteria) often benefit from asexual reproduction to reproduce quickly and exploit resources.</li> <li>• <b>Organisms in changing environments</b> (e.g. mammals, insects) often rely on sexual reproduction to introduce variation and improve long-term survival.</li> <li>• Some species (like certain fungi or plants) use <b>both</b> methods depending on conditions — asexual when stable, sexual when stressed or changing.</li> </ul> <hr/> <p><b>Conclusion:</b>  The choice between asexual and sexual reproduction in an organism's life cycle depends on <b>speed vs. adaptability</b>. Asexual reproduction supports rapid growth, while sexual reproduction provides resilience and evolution over time.  Top of Form  Bottom of Form</p>
SB3b Meiosis	
Recall that gametes are produced by meiosis.	<p><b>Gametes are produced by meiosis.</b>  Meiosis is a type of cell division that creates <b>sex cells (gametes)</b> such as sperm</p>

	and egg cells in animals, or pollen and ovules in plants. These cells have <b>half the number of chromosomes</b> (haploid) compared to normal body cells.
Describe what happens in meiosis. [without details of the stages]	In <b>meiosis</b> , a cell divides <b>twice</b> to produce <b>four gametes</b> , each with <b>half the number of chromosomes</b> (haploid) compared to the original cell. This process introduces <b>genetic variation</b> because the gametes are <b>all different</b> from each other and from the parent cell. Meiosis is essential for <b>sexual reproduction</b> , ensuring offspring have the correct number of chromosomes.
Explain why haploid gametes are needed for sexual reproduction	<b>Haploid gametes</b> are needed for sexual reproduction because they contain <b>half the number of chromosomes</b> of a normal body cell. When two gametes (e.g. sperm and egg) fuse during fertilisation, their chromosomes combine to form a <b>diploid zygote</b> with the full number of chromosomes. This ensures that the offspring has the correct number of chromosomes and maintains the species' chromosome number across generations.
Recall what an organism's genome is.	An organism's <b>genome</b> is the <b>entire set of genetic material</b> in its cells. It includes <b>all the DNA</b> , including <b>all the genes</b> and the non-coding sequences that control how genes are used. The genome determines an organism's inherited characteristics.
Describe where genes are found	<b>Genes</b> are found on <b>chromosomes</b> , which are located inside the <b>nucleus</b> of a cell. Each gene is a short section of <b>DNA</b> that carries instructions for making a specific protein. Chromosomes come in pairs, and humans have <b>23 pairs</b> of chromosomes in each body cell.
Recall the function of genes	Genes function as the basic units of heredity in living organisms. They carry the instructions (encoded in DNA) that determine the characteristics and traits an organism inherits from its parents. Specifically, genes: <ol style="list-style-type: none"> <li><b>Contain genetic information</b> that codes for proteins, which perform most life functions and make up the structure of cells.</li> <li><b>Guide the development, growth, and functioning</b> of an organism by directing protein synthesis.</li> <li><b>Transmit hereditary traits</b> from one generation to the next.</li> <li>Influence physical traits (like eye color, height) and biological processes (like metabolism).</li> </ol> In short, genes act like biological blueprints that control how organisms develop and operate.
SB3c DNA	
Recall where DNA is found in a eukaryotic cell.	In a eukaryotic cell, DNA is found mainly in the <b>nucleus</b> , where it is organized into chromosomes. Additionally, small amounts of DNA are also found in <b>mitochondria</b> (and in plant cells, also in <b>chloroplasts</b> ). So, to summarize for SB3c: <ul style="list-style-type: none"> <li><b>Nucleus</b> — the primary location of DNA.</li> <li><b>Mitochondria</b> — contain their own small circular DNA.</li> <li>(In plant cells) <b>Chloroplasts</b> — also contain their own DNA.</li> </ul>
Name the bases in DNA	The bases in DNA are: <ul style="list-style-type: none"> <li><b>Adenine (A)</b></li> <li><b>Thymine (T)</b></li> <li><b>Cytosine (C)</b></li> <li><b>Guanine (G)</b></li> </ul> These bases pair up specifically: Adenine pairs with Thymine, and Cytosine pairs with Guanine.

<p>Recall the pairing of bases in DNA</p>	<p>In DNA, the base pairing is very specific:</p> <ul style="list-style-type: none"> <li>• <b>Adenine (A)</b> pairs with <b>Thymine (T)</b></li> <li>• <b>Cytosine (C)</b> pairs with <b>Guanine (G)</b></li> </ul> <p>These pairs are held together by hydrogen bonds, forming the rungs of the DNA double helix.</p>
<p>Describe how DNA strands are held together.</p>	<p>DNA strands are held together by <b>hydrogen bonds</b> between the complementary bases on each strand. Specifically:</p> <ul style="list-style-type: none"> <li>• Adenine (A) forms <b>two hydrogen bonds</b> with Thymine (T).</li> <li>• Cytosine (C) forms <b>three hydrogen bonds</b> with Guanine (G).</li> </ul> <p>These hydrogen bonds create a stable but flexible connection between the two strands, forming the famous <b>double helix</b> structure of DNA. Additionally, the <b>sugar-phosphate backbone</b> of each strand is held together by strong <b>covalent bonds</b>, but the two strands themselves are linked by these hydrogen bonds between bases.</p>
<p>Describe the overall structure of DNA</p>	<p>The overall structure of DNA is a <b>double helix</b>, which looks like a twisted ladder or spiral staircase. Key features include:</p> <ol style="list-style-type: none"> <li>1. <b>Two strands</b> of nucleotides running in opposite directions (antiparallel).</li> <li>2. Each strand has a <b>sugar-phosphate backbone</b> forming the sides of the ladder.</li> <li>3. <b>Nitrogenous bases</b> (adenine, thymine, cytosine, guanine) form the “rungs” of the ladder.</li> <li>4. Bases pair specifically: adenine with thymine, cytosine with guanine, held together by hydrogen bonds.</li> <li>5. The double helix twists around an axis, giving DNA its characteristic spiral shape.</li> </ol> <p>This structure allows DNA to store genetic information compactly and be copied accurately during cell division.</p>
<p>Describe how DNA can be extracted from fruit</p>	<p>Here’s a simple way to extract DNA from fruit (like strawberries or bananas) using household materials:</p> <p><b>Materials:</b></p> <ul style="list-style-type: none"> <li>• Fruit (e.g., strawberries or banana)</li> <li>• Dish soap (liquid detergent)</li> <li>• Salt</li> <li>• Water</li> <li>• Coffee filter or cheesecloth</li> <li>• Resealable plastic bag</li> <li>• Test tube or clear glass container</li> <li>• Isopropyl alcohol (chilled, 70% or higher)</li> </ul> <p><b>Steps:</b></p> <ol style="list-style-type: none"> <li>1. <b>Prepare the extraction solution:</b> Mix about 100 ml of water with a teaspoon of salt and 1-2 teaspoons of dish soap. Stir gently to combine.</li> <li>2. <b>Mash the fruit:</b> Place some fruit (about 1/2 cup) into the plastic bag and mash it thoroughly until it becomes a pulpy mixture.</li> <li>3. <b>Add the extraction solution:</b> Pour the soap and salt solution into the bag with the mashed fruit. Seal the bag and gently mix for 5-10 minutes. The soap breaks down cell membranes, and salt helps the DNA stick together.</li> <li>4. <b>Filter the mixture:</b> Pour the liquid through a coffee filter or cheesecloth into a test tube or</li> </ol>

	<p>clear container. This removes solid bits and leaves a clear liquid containing DNA.</p> <ol style="list-style-type: none"> <li>5. <b>Add cold alcohol:</b> Carefully pour chilled isopropyl alcohol down the side of the container so it forms a layer on top of the fruit liquid. Do not mix.</li> <li>6. <b>Observe the DNA:</b> After a few minutes, white, stringy, cloudy strands will appear between the alcohol and fruit liquid layers. This is the DNA, which precipitates out because it is not soluble in alcohol.</li> </ol> <hr/> <p>This simple method shows how DNA can be extracted and seen without complex lab equipment. Want me to help with a step-by-step guide for a particular fruit?</p>
SB3f Mendel	
Recall who discovered the basis of genetics.	In SB3f Mendel, the basis of genetics was discovered by <b>Gregor Mendel</b> . He is known as the "father of genetics" for his work on how traits are inherited through pea plant experiments.
Describe how breeding pea plants was used to work out the basis of genetics.	<p>Gregor Mendel used breeding of pea plants to work out the basis of genetics through careful experiments involving the inheritance of specific traits. Here's how he did it:</p> <ol style="list-style-type: none"> <li>1. <b>Selected pea plants with contrasting traits:</b> For example, he studied traits like flower color (purple or white), seed shape (round or wrinkled), and plant height (tall or short).</li> <li>2. <b>Cross-bred plants with different traits:</b> Mendel cross-pollinated plants with contrasting traits (e.g., a tall plant with a short plant) to observe how traits were passed to the next generation.</li> <li>3. <b>Observed the offspring (F1 generation):</b> He noticed that when he crossed two pure-bred plants with contrasting traits, all the first generation (F1) offspring showed only one of the traits (dominant trait).</li> <li>4. <b>Allowed F1 plants to self-pollinate to produce F2 generation:</b> In the second generation (F2), the hidden (recessive) trait reappeared in a predictable ratio — about 3 dominant : 1 recessive.</li> <li>5. <b>Formulated principles of inheritance:</b> From his observations, Mendel deduced that traits are controlled by "factors" (now called genes) that come in pairs. One factor can mask the other (dominant vs. recessive), and these factors segregate independently during reproduction.</li> </ol> <p>Mendel's pea plant breeding experiments established the fundamental laws of inheritance that form the basis of genetics today.</p>
Describe why it was difficult to understand inheritance before the idea of genes.	<p>Before the idea of genes was discovered, understanding inheritance was difficult because:</p> <ol style="list-style-type: none"> <li>1. People <b>didn't know what controlled traits</b> or how characteristics were passed from parents to offspring.</li> <li>2. The process seemed <b>random and confusing</b>, especially when offspring showed traits that didn't always look like either parent.</li> <li>3. There was <b>no clear explanation for dominant and recessive traits</b> or why some traits skipped generations.</li> <li>4. Scientists lacked a <b>mechanism</b> to explain how inherited information was stored, copied, and passed on.</li> </ol>

	<p>5. Without the concept of genes, inheritance appeared as a <b>mixing of traits</b>, which didn't accurately describe how traits are actually inherited.</p> <p>The discovery of genes provided a clear framework—discrete units of inheritance that explain patterns of traits—making it much easier to understand how inheritance works.</p>
SB3g Alleles	
Describe the difference between a gene and an allele	<p>In SB3g Alleles:</p> <ul style="list-style-type: none"> <li>• A <b>gene</b> is a section of DNA that codes for a specific characteristic or trait (e.g., eye color).</li> <li>• An <b>allele</b> is a different version or form of the same gene (e.g., the gene for eye color may have an allele for blue eyes and an allele for brown eyes).</li> </ul> <p>So, <b>genes</b> are the instructions for traits, and <b>alleles</b> are the variations of those instructions.</p>
Explain the effects of alleles on inherited characteristics.	<p>Alleles affect inherited characteristics by determining which version of a trait an organism shows. Here's how:</p> <ol style="list-style-type: none"> <li>1. Each individual inherits <b>two alleles</b> for each gene (one from each parent).</li> <li>2. <b>Dominant alleles</b> will <b>mask</b> the effect of recessive alleles if both are present, so the dominant trait is shown.</li> <li>3. <b>Recessive alleles</b> only show their effect if the individual has <b>two copies</b> of the recessive allele (no dominant allele present).</li> <li>4. The combination of alleles an organism has is called its <b>genotype</b>, and the physical appearance or characteristic it shows is called its <b>phenotype</b>.</li> <li>5. Different combinations of alleles result in variation in inherited traits between individuals.</li> </ol> <p>In summary, alleles control the variation seen in inherited characteristics by influencing which traits are expressed.</p>
Describe the relationship between a genotype and a phenotype	<p>The relationship between <b>genotype</b> and <b>phenotype</b> is:</p> <ul style="list-style-type: none"> <li>• The <b>genotype</b> is the genetic makeup of an organism — the specific alleles it has for a particular gene (e.g., AA, Aa, or aa).</li> <li>• The <b>phenotype</b> is the observable physical or biochemical characteristics or traits that result from the genotype (e.g., having blue or brown eyes).</li> </ul> <p>In other words, the <b>genotype determines the phenotype</b>, but the phenotype can also be influenced by environmental factors.</p>
Identify homozygous and heterozygous genotypes.	<p>Here's how to identify homozygous and heterozygous genotypes:</p> <ul style="list-style-type: none"> <li>• <b>Homozygous genotype:</b> Both alleles for a gene are the <b>same</b> (e.g., <b>AA</b> or <b>aa</b>).</li> <li>• <b>Heterozygous genotype:</b> The two alleles for a gene are <b>different</b> (e.g., <b>Aa</b>).</li> </ul> <p>So, homozygous means identical alleles, and heterozygous means different alleles.</p>
Use genetic diagrams to work out possible combinations of alleles in the offspring of parents	<p>Here's a step-by-step guide on how to use a genetic diagram (a Punnett square) to work out possible allele combinations in offspring:</p> <hr/> <p><b>Example:</b> Suppose we have two parents with genotypes for a gene: Parent 1: <b>Aa</b> (heterozygous) Parent 2: <b>Aa</b> (heterozygous)</p>

	<hr/> <p><b>Step 1:</b> Write down the alleles each parent can pass on  Parent 1 alleles: <b>A</b> and <b>a</b>  Parent 2 alleles: <b>A</b> and <b>a</b></p> <hr/> <p><b>Step 2:</b> Draw a 2x2 grid</p> <table border="1" data-bbox="528 327 1050 443"> <tr> <td></td> <td><b>A (Parent 2)</b></td> <td><b>a (Parent 2)</b></td> </tr> <tr> <td><b>A (Parent 1)</b></td> <td></td> <td></td> </tr> <tr> <td><b>a (Parent 1)</b></td> <td></td> <td></td> </tr> </table> <hr/> <p><b>Step 3:</b> Fill in the grid by combining alleles</p> <table border="1" data-bbox="528 510 1050 627"> <tr> <td></td> <td><b>A (Parent 2)</b></td> <td><b>a (Parent 2)</b></td> </tr> <tr> <td><b>A (Parent 1)</b></td> <td><b>AA</b></td> <td><b>Aa</b></td> </tr> <tr> <td><b>a (Parent 1)</b></td> <td><b>Aa</b></td> <td><b>aa</b></td> </tr> </table> <hr/> <p><b>Step 4:</b> Interpret the results  <b>AA:</b> Homozygous dominant  <b>Aa:</b> Heterozygous (dominant trait shows)  <b>aa:</b> Homozygous recessive</p> <hr/> <p><b>Step 5:</b> Calculate probabilities  1 out of 4 = <b>AA</b> (25%)  2 out of 4 = <b>Aa</b> (50%)  1 out of 4 = <b>aa</b> (25%)</p> <hr/> <p><b>Summary:</b>  There's a 75% chance the offspring will show the dominant trait (AA or Aa).  There's a 25% chance the offspring will show the recessive trait (aa).</p>		<b>A (Parent 2)</b>	<b>a (Parent 2)</b>	<b>A (Parent 1)</b>			<b>a (Parent 1)</b>				<b>A (Parent 2)</b>	<b>a (Parent 2)</b>	<b>A (Parent 1)</b>	<b>AA</b>	<b>Aa</b>	<b>a (Parent 1)</b>	<b>Aa</b>	<b>aa</b>
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<b>A (Parent 1)</b>	<b>AA</b>	<b>Aa</b>																	
<b>a (Parent 1)</b>	<b>Aa</b>	<b>aa</b>																	
<p>Explain why the effects of some alleles in an organism's genotype are not seen in its phenotype.</p>	<p>Some alleles in an organism's genotype don't show up in its phenotype because they are <b>recessive alleles</b>. Here's why:</p> <ol style="list-style-type: none"> <li>1. When an organism has <b>one dominant and one recessive allele</b> (heterozygous), the <b>dominant allele masks the effect of the recessive allele</b>.</li> <li>2. As a result, the trait controlled by the recessive allele <b>is not visible</b> in the phenotype.</li> <li>3. The recessive trait only appears in the phenotype if the organism has <b>two recessive alleles</b> (homozygous recessive).</li> </ol> <p>So, some alleles are hidden or "carried" without affecting the organism's appearance because dominant alleles overpower recessive ones.</p>																		
<p>SB3h Inheritance</p>																			
<p>Use Punnett squares to work out possible combinations of alleles in the offspring of parents.</p>	<p>Here's a clear guide to using Punnett squares for SB3h Inheritance to work out possible allele combinations in offspring:</p> <hr/> <p>Step-by-step: Using a Punnett Square</p> <hr/> <p>Example problem:  <b>Parents' genotypes:</b>  Parent 1: <b>Bb</b> (heterozygous)  Parent 2: <b>bb</b> (homozygous recessive)</p> <hr/> <p><b>Step 1:</b> Write the alleles each parent can pass on  Parent 1 alleles: <b>B</b> and <b>b</b>  Parent 2 alleles: <b>b</b> and <b>b</b></p>																		

**Step 2:** Draw a 2x2 Punnett square grid

	<b>b (Parent 2)</b>	<b>b (Parent 2)</b>
<b>B (Parent 1)</b>		
<b>b (Parent 1)</b>		

**Step 3:** Fill in the grid by combining alleles

	<b>b (Parent 2)</b>	<b>b (Parent 2)</b>
<b>B (Parent 1)</b>	<b>Bb</b>	<b>Bb</b>
<b>b (Parent 1)</b>	<b>bb</b>	<b>bb</b>

**Step 4:** Interpret the results

**Bb:** Heterozygous (shows dominant trait)

**bb:** Homozygous recessive (shows recessive trait)

**Step 5:** Calculate probabilities

2 out of 4 = **Bb** (50%) — dominant trait

2 out of 4 = **bb** (50%) — recessive trait

Summary:

There's a **50% chance** the offspring will have the dominant trait.

There's a **50% chance** the offspring will have the recessive trait.

Interpret family pedigree charts to work out possible inherited genotypes and phenotypes.

Here's how to interpret **family pedigree charts** to work out possible inherited genotypes and phenotypes:

**What is a pedigree chart?**

- A **pedigree chart** is a diagram that shows how a trait is inherited through several generations of a family.
- It uses symbols:
  - **Squares** represent males
  - **Circles** represent females
  - Shaded shapes indicate individuals **with the trait**
  - Unshaded shapes indicate individuals **without the trait**

**How to interpret a pedigree chart:**

1. **Identify whether the trait is dominant or recessive:**

- a. If the trait **appears in every generation**, it is likely **dominant**.
- b. If the trait **skips generations** (parents don't show it but children do), it's likely **recessive**.

2. **Determine the genotype of individuals:**

- a. Individuals **with the dominant trait** could be either **homozygous dominant (AA)** or **heterozygous (Aa)**.
- b. Individuals **with the recessive trait** must be **homozygous recessive (aa)**.
- c. Individuals **without the trait** but have affected children must be **carriers** (heterozygous, Aa) if the trait is recessive.

3. **Use the chart to predict genotypes of offspring:**

- a. Based on parents' genotypes, you can use **Punnett squares** to predict the chance of children inheriting certain genotypes and phenotypes.

**Example:**

If two parents without the trait (unshaded) have a child **with** the recessive trait (shaded), both parents must be **carriers (Aa)**.

	<p>If a parent has the dominant trait and the other does not, the child's chances depend on whether the parent is homozygous dominant (AA) or heterozygous (Aa).</p> <hr/> <p><b>Summary:</b>          Use the pattern of affected and unaffected individuals to guess if the trait is dominant or recessive.          Assign possible genotypes based on this and known family members.          Use Punnett squares if needed to predict offspring genotypes and phenotypes.</p>									
<p>Describe how sex is determined in humans</p>	<p>In humans, sex is determined by the <b>sex chromosomes</b> inherited from the parents:</p> <ol style="list-style-type: none"> <li>1. Humans have <b>23 pairs of chromosomes</b>, including <b>1 pair of sex chromosomes</b>.</li> <li>2. Females have <b>two X chromosomes (XX)</b>.</li> <li>3. Males have <b>one X and one Y chromosome (XY)</b>.</li> </ol> <hr/> <p>How it works:</p> <ol style="list-style-type: none"> <li>1. The <b>mother always contributes an X chromosome</b> (because she has XX).</li> <li>2. The <b>father can contribute either an X or a Y chromosome</b> (because he has XY).</li> <li>3. If the sperm carrying an <b>X chromosome</b> fertilizes the egg, the offspring will be <b>female (XX)</b>.</li> <li>4. If the sperm carrying a <b>Y chromosome</b> fertilizes the egg, the offspring will be <b>male (XY)</b>.</li> </ol> <hr/> <p>So, <b>the sex of a baby depends on which sperm fertilizes the egg</b>, making males the sex-determining parent.</p>									
<p>Calculate ratios of phenotypes (controlled by alleles of a single gene) when organisms are crossed.</p>	<p>Here's how to calculate the ratios of phenotypes controlled by alleles of a single gene when organisms are crossed:</p> <hr/> <p><b>Step 1:</b> Identify the parents' genotypes          For example, consider a gene with:  <b>Dominant allele:</b> A (shows dominant trait)  <b>Recessive allele:</b> a (shows recessive trait)</p> <hr/> <p><b>Step 2:</b> Set up a Punnett square          Example cross: <b>Aa</b> (heterozygous) × <b>Aa</b> (heterozygous)</p> <table border="1" data-bbox="528 1543 1046 1659"> <tr> <td></td> <td><b>A (Parent 2)</b></td> <td><b>a (Parent 2)</b></td> </tr> <tr> <td><b>A (Parent 1)</b></td> <td>AA</td> <td>Aa</td> </tr> <tr> <td><b>a (Parent 1)</b></td> <td>Aa</td> <td>aa</td> </tr> </table> <hr/> <p><b>Step 3:</b> List genotypes and count  <b>AA:</b> 1  <b>Aa:</b> 2  <b>aa:</b> 1</p> <hr/> <p><b>Step 4:</b> Determine phenotypes and ratio  <b>AA and Aa</b> show the dominant trait  <b>aa</b> shows the recessive trait  <b>Phenotype ratio:</b>          Dominant trait = 3          Recessive trait = 1</p>		<b>A (Parent 2)</b>	<b>a (Parent 2)</b>	<b>A (Parent 1)</b>	AA	Aa	<b>a (Parent 1)</b>	Aa	aa
	<b>A (Parent 2)</b>	<b>a (Parent 2)</b>								
<b>A (Parent 1)</b>	AA	Aa								
<b>a (Parent 1)</b>	Aa	aa								

	<p><b>Example 2:</b> Cross AA × aa</p> <table border="1" data-bbox="528 152 1043 264"> <thead> <tr> <th></th> <th>a (Parent 2)</th> <th>a (Parent 2)</th> </tr> </thead> <tbody> <tr> <td>A (Parent 1)</td> <td>Aa</td> <td>Aa</td> </tr> <tr> <td>A (Parent 1)</td> <td>Aa</td> <td>Aa</td> </tr> </tbody> </table> <p>All offspring are <b>Aa</b> (heterozygous, dominant phenotype).  <b>Phenotype ratio:</b> 100% dominant trait.</p> <hr/> <p><b>Summary:</b>  Use Punnett squares to find all possible genotypes.  Group genotypes by phenotype (dominant or recessive).  Calculate the ratio by counting how many show each phenotype.  If you want, I can help with a specific cross or more examples!</p>		a (Parent 2)	a (Parent 2)	A (Parent 1)	Aa	Aa	A (Parent 1)	Aa	Aa
	a (Parent 2)	a (Parent 2)								
A (Parent 1)	Aa	Aa								
A (Parent 1)	Aa	Aa								
<p>Calculate probabilities of certain phenotypes occurring when organisms are crossed</p>	<p>To calculate the <b>probability</b> of certain phenotypes when organisms are crossed, follow these steps:</p> <hr/> <p><b>Step 1:</b> Identify the parents' genotypes  Example:  Parent 1: <b>Aa</b> (heterozygous)  Parent 2: <b>aa</b> (homozygous recessive)</p> <hr/> <p><b>Step 2:</b> Set up the Punnett square</p> <table border="1" data-bbox="528 907 1043 1019"> <thead> <tr> <th></th> <th>a (Parent 2)</th> <th>a (Parent 2)</th> </tr> </thead> <tbody> <tr> <td>A (Parent 1)</td> <td>Aa</td> <td>Aa</td> </tr> <tr> <td>a (Parent 1)</td> <td>aa</td> <td>aa</td> </tr> </tbody> </table> <hr/> <p><b>Step 3:</b> List all offspring genotypes  <b>Aa:</b> 2 out of 4  <b>aa:</b> 2 out of 4</p> <hr/> <p><b>Step 4:</b> Identify phenotypes for each genotype  <b>Aa:</b> dominant phenotype  <b>aa:</b> recessive phenotype</p> <hr/> <p><b>Step 5:</b> Calculate probability of each phenotype  Probability of <b>dominant phenotype</b> = 2/4 = <b>50%</b>  Probability of <b>recessive phenotype</b> = 2/4 = <b>50%</b></p> <hr/> <p><b>General tip:</b>  Probability = (Number of offspring with phenotype) ÷ (Total number of offspring possible)</p>		a (Parent 2)	a (Parent 2)	A (Parent 1)	Aa	Aa	a (Parent 1)	aa	aa
	a (Parent 2)	a (Parent 2)								
A (Parent 1)	Aa	Aa								
a (Parent 1)	aa	aa								
<p>SB3i Multiple and missing alleles</p>										
<p>Describe ABO blood groups as an example of multiple alleles for one gene.</p>	<p>In the <b>ABO blood group system</b>, the gene that determines blood type has <b>multiple alleles: A, B, and O</b>. This means that instead of just having two possible forms (alleles) of a gene, there are three. Each person inherits <b>two alleles</b>, one from each parent.</p> <ul style="list-style-type: none"> <li>• The <b>A allele</b> and the <b>B allele</b> are <b>codominant</b>, meaning both can be expressed if inherited together (resulting in <b>blood group AB</b>).</li> <li>• The <b>O allele</b> is <b>recessive</b>, so it is only expressed if the person inherits two O alleles (resulting in <b>blood group O</b>).</li> </ul> <p>Possible combinations and resulting blood types:</p> <ul style="list-style-type: none"> <li>• <b>AA or AO</b> → Blood group <b>A</b></li> <li>• <b>BB or BO</b> → Blood group <b>B</b></li> <li>• <b>AB</b> → Blood group <b>AB</b></li> </ul>									

	<ul style="list-style-type: none"> <li>• <b>OO</b> → Blood group <b>O</b></li> </ul> <p>This is an example of <b>multiple alleles</b> affecting a single characteristic — in this case, a person's blood type.</p>																				
<p>Describe how ABO blood groups are inherited</p>	<p><b>ABO blood groups</b> are inherited through the combination of <b>two alleles</b>, one from each parent, for a single gene that has <b>three possible alleles: A, B, and O</b>.</p> <ul style="list-style-type: none"> <li>• The <b>A</b> and <b>B</b> alleles are <b>codominant</b>, meaning if both are inherited, <b>both are expressed</b> (resulting in <b>blood group AB</b>).</li> <li>• The <b>O</b> allele is <b>recessive</b>, so it is only expressed when <b>two O alleles</b> are inherited (resulting in <b>blood group O</b>).</li> </ul> <p>Here's how the inheritance works:</p> <table border="1" data-bbox="528 548 1433 734"> <thead> <tr> <th>Parent 1</th> <th>Parent 2</th> <th>Possible Child Genotypes</th> <th>Possible Blood Groups</th> </tr> </thead> <tbody> <tr> <td>AO</td> <td>BO</td> <td>AB, AO, BO, OO</td> <td>A, B, AB, O</td> </tr> <tr> <td>AA</td> <td>BO</td> <td>AB, AO</td> <td>A, AB</td> </tr> <tr> <td>AB</td> <td>OO</td> <td>AO, BO</td> <td>A, B</td> </tr> <tr> <td>AO</td> <td>AO</td> <td>AA, AO, OO</td> <td>A, O</td> </tr> </tbody> </table> <p>So, the <b>child's blood group depends on the combination of alleles inherited</b> from each parent. This follows <b>Mendelian inheritance patterns</b>, with added complexity due to <b>codominance</b> and <b>multiple alleles</b>.</p>	Parent 1	Parent 2	Possible Child Genotypes	Possible Blood Groups	AO	BO	AB, AO, BO, OO	A, B, AB, O	AA	BO	AB, AO	A, AB	AB	OO	AO, BO	A, B	AO	AO	AA, AO, OO	A, O
Parent 1	Parent 2	Possible Child Genotypes	Possible Blood Groups																		
AO	BO	AB, AO, BO, OO	A, B, AB, O																		
AA	BO	AB, AO	A, AB																		
AB	OO	AO, BO	A, B																		
AO	AO	AA, AO, OO	A, O																		
<p>Explain the inheritance of codominance</p>	<p><b>Codominance</b> is a type of inheritance where <b>both alleles in a gene pair are fully expressed</b> in the phenotype of a heterozygous individual. This means that <b>neither allele is dominant or recessive</b> over the other — <b>both traits appear together</b>.</p> <p><b>Example: ABO Blood Group System</b></p> <p>In the <b>ABO blood group</b>, the <b>A</b> and <b>B</b> alleles are <b>codominant</b>:</p> <ul style="list-style-type: none"> <li>• If a person inherits an <b>A allele</b> from one parent and a <b>B allele</b> from the other, their blood type is <b>AB</b>.</li> <li>• In this case, <b>both the A and B proteins (antigens)</b> are expressed on the surface of the red blood cells — <b>neither is hidden or blended</b>.</li> </ul> <p>Key Features of Codominance:</p> <ul style="list-style-type: none"> <li>• Both alleles contribute equally and visibly to the phenotype.</li> <li>• The heterozygous phenotype shows <b>both traits side by side</b>, not mixed.</li> </ul> <p><b>Other Examples:</b></p> <ul style="list-style-type: none"> <li>• In some cattle, a red-haired cow and a white-haired bull may produce offspring with <b>both red and white hairs</b> (called <b>roan coat</b>) — another example of codominance.</li> </ul> <p>So, <b>codominance inheritance</b> allows for a <b>clear expression of both alleles</b> in the heterozygous organism.</p>																				
<p>SB3j Gene mutation</p>																					
<p>Give examples of characteristics controlled by multiple genes</p>	<p>Examples of characteristics controlled by <b>multiple genes</b> (also known as <b>polygenic inheritance</b>) include:</p> <ul style="list-style-type: none"> <li>• <b>Height</b> – influenced by the interaction of many different genes, along with environmental factors like nutrition.</li> <li>• <b>Skin colour</b> – determined by several genes that affect the amount and type of melanin produced.</li> <li>• <b>Eye colour</b> – involves multiple genes, not just the commonly known brown or blue alleles.</li> <li>• <b>Body weight</b> – affected by many genes that influence metabolism, appetite, and fat storage.</li> </ul>																				

	<ul style="list-style-type: none"> <li>• <b>Intelligence</b> – believed to be influenced by a large number of genes, as well as environment and education.</li> </ul> <p>These traits show a <b>range of variation</b>, rather than clear-cut categories, because they are controlled by the <b>combined effect of many genes</b>.</p>
<p>Define the term mutation</p>	<p>A <b>mutation</b> is a <b>change in the DNA sequence</b> of a gene.</p> <p>Mutations can happen <b>spontaneously</b> during DNA replication or be caused by factors such as <b>radiation, chemicals, or viruses</b>. They may:</p> <ul style="list-style-type: none"> <li>• Have <b>no effect</b>,</li> <li>• Lead to a <b>beneficial change</b>, or</li> <li>• Cause a <b>harmful effect</b>, such as a genetic disorder.</li> </ul> <p>Mutations are a <b>source of genetic variation</b> and can be inherited if they occur in reproductive cells.</p>
<p>Describe some potential applications of mapping human genomes.</p>	<p>Mapping the human genome has several important applications, including:</p> <ol style="list-style-type: none"> <li>1. <b>Identifying genetic disorders:</b> Helps detect genes linked to inherited diseases like cystic fibrosis or sickle cell anaemia, allowing early diagnosis and treatment.</li> <li>2. <b>Personalised medicine:</b> Enables doctors to tailor treatments based on an individual’s genetic makeup, improving effectiveness and reducing side effects.</li> <li>3. <b>Predicting disease risk:</b> Allows people to understand their likelihood of developing conditions such as cancer, diabetes, or heart disease.</li> <li>4. <b>Gene therapy:</b> Provides the foundation for developing treatments that correct faulty genes.</li> <li>5. <b>Tracing ancestry and evolution:</b> Helps scientists understand human origins, migrations, and how populations are related.</li> <li>6. <b>Drug development:</b> Assists pharmaceutical companies in designing more targeted and effective medications.</li> </ol> <p>Overall, genome mapping is transforming both healthcare and biological research.</p>
<p>Explain how a mutation can cause variation (limited to changes in the protein formed, which can affect processes in which that protein is needed)</p>	<p>A <b>mutation</b> is a change in the <b>DNA sequence</b> of a gene. Since genes code for <b>proteins</b>, a mutation can change the <b>sequence of amino acids</b> in the protein that is made.</p> <p>This can lead to:</p> <ol style="list-style-type: none"> <li>1. A <b>different protein shape</b>, which may affect how the protein works.</li> <li>2. The protein becoming <b>non-functional</b> or <b>less effective</b>, which can disrupt the <b>biological processes</b> it is involved in.</li> <li>3. In some cases, the protein might gain a <b>new or enhanced function</b>.</li> </ol> <p>Because proteins control traits and bodily processes, these changes can lead to <b>variation</b> in characteristics between individuals. For example, a mutation in a gene involved in melanin production could lead to differences in <b>skin, hair, or eye colour</b>.</p>
<p>Give examples of mutations in human genes that affect the phenotype, and examples of those that have little or no obvious effect</p>	<p>Here are examples of mutations in human genes and their effects on the <b>phenotype</b>:</p> <p><b>Mutations that affect the phenotype:</b></p> <ol style="list-style-type: none"> <li>1. <b>Cystic Fibrosis</b> – caused by a mutation in the <b>CFTR gene</b>, leading to thick, sticky mucus in the lungs and digestive system.</li> <li>2. <b>Sickle Cell Anaemia</b> – caused by a mutation in the <b>HBB gene</b>, changing the shape of red blood cells and leading to pain and fatigue.</li> <li>3. <b>Albinism</b> – caused by mutations in genes involved in <b>melanin production</b>, leading to very light skin, hair, and eyes.</li> </ol>

	<p>4. <b>Huntington’s Disease</b> – a mutation in the <b>HTT gene</b> causes progressive brain disorder symptoms like memory loss and movement problems.</p> <p><b>Mutations with little or no obvious effect:</b></p> <ol style="list-style-type: none"> <li>1. <b>Silent mutations</b> – these change the DNA sequence but not the amino acid in the protein, so the function stays the same.</li> <li>2. <b>Mutations in non-coding regions</b> – changes in parts of DNA that don't code for proteins often have no effect.</li> <li>3. <b>Redundancy in the genetic code</b> – sometimes different codons code for the same amino acid, so a mutation may not change the protein at all.</li> </ol> <p>These examples show that while some mutations can cause serious conditions, others may go completely unnoticed.</p>
<p>Explain why many mutations have no effect on the phenotype.</p>	<p>Many mutations have <b>no effect on the phenotype</b> for several reasons:</p> <ol style="list-style-type: none"> <li>1. <b>Silent mutations:</b> These are changes in the DNA that <b>do not change the amino acid</b> sequence of the protein. This happens because the genetic code is <b>redundant</b> (multiple codons can code for the same amino acid).</li> <li>2. <b>Non-coding regions:</b> Some mutations occur in parts of the DNA that <b>do not code for proteins</b> (e.g. introns or regulatory regions), so they may not affect how a protein is made.</li> <li>3. <b>No effect on protein function:</b> Even if the amino acid changes, it might not change the <b>shape or function</b> of the protein, so the phenotype stays the same.</li> <li>4. <b>Recessive mutations:</b> If a harmful mutation is <b>recessive</b>, it may be masked by a <b>normal dominant allele</b>, so the person still shows the typical phenotype.</li> </ol> <p>In summary, not all mutations change how the body works — many are <b>harmless or neutral</b> in their effect.</p>
<p>SB3k Variation</p>	
<p>Distinguish between genetic variation and environmental variation.</p>	<p><b>Variation</b>, the distinction between <b>genetic variation</b> and <b>environmental variation</b> is key to understanding how individuals within a species can differ.</p> <p><b>Genetic Variation</b></p> <ol style="list-style-type: none"> <li>1. <b>Definition:</b> Differences between individuals that are inherited from their parents through genes.</li> <li>2. <b>Cause:</b> Caused by differences in the <b>DNA</b> (genetic material) passed down during reproduction.</li> <li>3. <b>Examples:</b> <ol style="list-style-type: none"> <li>a. Eye colour</li> <li>b. Blood group</li> <li>c. Natural hair colour</li> <li>d. Ability to roll the tongue</li> </ol> </li> </ol> <p>These traits are controlled by <b>alleles</b> (different versions of genes) and are largely unaffected by the environment.</p> <hr/> <p><b>Environmental Variation</b></p> <ol style="list-style-type: none"> <li>1. <b>Definition:</b> Differences between individuals caused by the <b>environment</b> they live in, not their genes.</li> <li>2. <b>Cause:</b> Influenced by <b>lifestyle, experiences, and surroundings</b>.</li> <li>3. <b>Examples:</b> <ol style="list-style-type: none"> <li>a. Scars or injuries</li> <li>b. Piercings or tattoos</li> <li>c. Accents or language spoken</li> <li>d. Muscle size due to exercise</li> </ol> </li> </ol> <p>These variations are not inherited and cannot be passed on genetically.</p>

	<p><b>Combined Variation</b> Some characteristics are influenced by <b>both</b> genetic and environmental factors: <b>Examples:</b></p> <ol style="list-style-type: none"> <li>1. Height (genetics + diet)</li> <li>2. Weight (genetics + exercise and diet)</li> <li>3. Intelligence (genes + education and environment)</li> </ol>															
<p>Distinguish between continuous and discontinuous variation</p>	<p><b>Continuous Variation</b></p> <ol style="list-style-type: none"> <li>1. <b>Definition:</b> Variation that shows a <b>range</b> of values with no distinct categories.</li> <li>2. <b>Changes gradually</b> between individuals.</li> <li>3. Usually influenced by <b>multiple genes (polygenic inheritance)</b> and the <b>environment</b>.</li> <li>4. <b>Examples:</b> <ol style="list-style-type: none"> <li>a. Height</li> <li>b. Weight</li> <li>c. Skin colour</li> <li>d. Foot length</li> </ol> </li> </ol> <p>◆ <b>Data Type:</b> Measured in <b>quantities</b> (e.g., cm, kg)</p> <p>◆ <b>Graph Shape:</b> Forms a <b>bell-shaped curve</b> or <b>normal distribution</b></p> <hr/> <p>☒ <b>Discontinuous Variation</b></p> <p><b>Definition:</b> Variation with <b>distinct categories</b> and no values in between.</p> <ol style="list-style-type: none"> <li>1. Controlled mostly by a <b>single gene</b> (monogenic), and <b>not affected</b> by the environment.</li> <li>2. <b>Examples:</b> <ol style="list-style-type: none"> <li>a. Blood group (A, B, AB, O)</li> <li>b. Ability to roll tongue (can or can't)</li> <li>c. Eye colour</li> <li>d. Attached or free earlobes</li> </ol> </li> </ol> <p>◆ <b>Data Type:</b> <b>Categorical</b></p> <p>◆ <b>Graph Shape:</b> Shown using a <b>bar chart</b> with separate columns</p> <hr/> <p><b>Quick Summary Table:</b></p> <table border="1" data-bbox="528 1379 1406 1563"> <thead> <tr> <th>Feature</th> <th>Continuous Variation</th> <th>Discontinuous Variation</th> </tr> </thead> <tbody> <tr> <td>Type of data</td> <td>Quantitative (measured)</td> <td>Categorical (grouped)</td> </tr> <tr> <td>Graph used</td> <td>Line/Histogram (curve)</td> <td>Bar chart (separate bars)</td> </tr> <tr> <td>Influenced by</td> <td>Many genes + environment</td> <td>One/few genes</td> </tr> <tr> <td>Examples</td> <td>Height, weight</td> <td>Blood group, eye colour</td> </tr> </tbody> </table>	Feature	Continuous Variation	Discontinuous Variation	Type of data	Quantitative (measured)	Categorical (grouped)	Graph used	Line/Histogram (curve)	Bar chart (separate bars)	Influenced by	Many genes + environment	One/few genes	Examples	Height, weight	Blood group, eye colour
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Examples	Height, weight	Blood group, eye colour														
<p>Describe the causes of genetic variation (mutation and sexual reproduction).</p>	<p><b>Causes of Genetic Variation</b> Genetic variation refers to the <b>differences in DNA</b> between individuals of the same species. It is essential for evolution and the survival of populations. The <b>two main causes</b> of genetic variation are:</p> <hr/> <p><b>1. Mutation</b></p> <ol style="list-style-type: none"> <li>A. A <b>mutation</b> is a <b>permanent change</b> in the DNA sequence of a gene.</li> <li>B. Mutations can occur <b>spontaneously</b> or be caused by environmental factors (e.g., radiation, chemicals).</li> <li>C. <b>Types of mutations:</b> <ol style="list-style-type: none"> <li>a. <b>Gene mutation</b> – changes in the DNA within a gene (e.g., sickle cell anaemia).</li> <li>b. <b>Chromosome mutation</b> – changes in the structure or number of chromosomes.</li> </ol> </li> <li>D. Most mutations have <b>no effect</b>, but some may be <b>harmful</b> or <b>beneficial</b>, contributing to variation.</li> </ol>															

◆ **Example:** A mutation might change a person's eye colour or cause a genetic disorder.

**2. Sexual Reproduction**

- A. Sexual reproduction mixes genetic material from **two parents**, creating **unique offspring**.
- B. Causes variation through:
- a. **Meiosis** – a special type of cell division that:
    - Produces gametes (sperm and egg cells).
    - Involves **crossing over** and **independent assortment** of chromosomes.
    - This leads to **different combinations of alleles**.
  - b. **Fertilisation** – the random joining of two gametes:
    - Each offspring gets a unique mix of alleles from their parents.
    - This results in **genetically different individuals**, even among siblings.

◆ **Example:** Siblings have the same parents but look different due to the mixing of genes.

**Summary Table:**

Cause	Description	Result
<b>Mutation</b>	Changes in DNA sequence	New alleles
<b>Sexual reproduction</b>	Mixing of genes during meiosis and fertilisation	Unique offspring with varied traits

Describe the causes of environmental variation (differences in the environment, acquired characteristics)

**Causes of Environmental Variation**

Environmental variation refers to the **differences between individuals caused by the environment** they live in, not by their genes. These variations are **acquired during life** and **not inherited**.

◆ **1. Differences in the Environment**

Environmental factors can affect the way an organism grows or behaves. These include:

- A. **Diet** – affects height, weight, and health  
☞ Example: A child may be genetically tall, but poor nutrition can prevent them from reaching full height.
- B. **Climate** – affects skin tone or fur thickness  
☞ Example: People living in sunny climates often have darker skin due to more melanin production.
- C. **Exercise** – affects muscle growth and body shape  
☞ Example: A person who trains regularly may become more muscular, regardless of their genes.
- D. **Education and lifestyle** – can influence skills or habits  
☞ Example: Language skills or musical ability often improve with practice and exposure.

◆ **2. Acquired Characteristics**

These are traits an organism **develops during its lifetime** due to environmental influences. They are **not passed on genetically** to the next generation.

✓ **Examples of acquired characteristics:**

- Scars
- Accents
- Tattoos
- Piercings
- Muscle development due to gym training

**Summary Table:**

Environmental Factor	Effect/Variation Caused
Diet	Changes in height, weight, health

	<table border="1" data-bbox="528 114 1249 219"> <tr> <td>Climate</td> <td>Skin colour, hair type, body adaptation</td> </tr> <tr> <td>Exercise</td> <td>Muscle size, fitness level</td> </tr> <tr> <td>Education/Lifestyle</td> <td>Skills, knowledge, personality traits</td> </tr> </table> <p>★ <b>Key point:</b> Environmental variation is <b>not controlled by genes</b> and <b>cannot be inherited</b>, but it can have a big impact on an individual's appearance, behaviour, and development.</p>	Climate	Skin colour, hair type, body adaptation	Exercise	Muscle size, fitness level	Education/Lifestyle	Skills, knowledge, personality traits									
Climate	Skin colour, hair type, body adaptation															
Exercise	Muscle size, fitness level															
Education/Lifestyle	Skills, knowledge, personality traits															
<p>Analyse the contribution of genes and environment to the variation in a characteristic</p>	<p><b>Analysing the Contribution of Genes and Environment to Variation in a Characteristic</b></p> <p>Most characteristics in living organisms are influenced by <b>both genetic factors</b> (what you inherit) and <b>environmental factors</b> (what happens to you). These two sources of variation often work <b>together</b>, making it important to understand <b>how much each contributes</b> to the final outcome.</p> <hr/> <p>📌 <b>1. Genetic Contribution</b></p> <p>Genes are passed from parents to offspring and determine many <b>inherited characteristics</b>, such as:</p> <ul style="list-style-type: none"> <li>A. <b>Natural eye colour</b></li> <li>B. <b>Blood group</b></li> <li>C. <b>Natural hair colour</b></li> <li>D. <b>Genetic disorders</b></li> </ul> <p>These characteristics are usually <b>fixed</b> by DNA and not affected by the environment. For example:</p> <ul style="list-style-type: none"> <li>✓ A person's <b>blood group</b> is purely determined by their genes – no environmental factor can change it.</li> </ul> <p>However, for <b>some traits</b>, genes set a potential range. For instance:</p> <ul style="list-style-type: none"> <li>→ A person may be genetically programmed to be <b>tall</b>, but this won't happen without proper nutrition.</li> </ul> <hr/> <p>🔧 <b>2. Environmental Contribution</b></p> <p>The <b>environment</b> can influence how genetic potential is <b>expressed</b>, or it can introduce completely <b>acquired traits</b>. Environmental influences include:</p> <ul style="list-style-type: none"> <li>A. <b>Diet</b></li> <li>B. <b>Exercise</b></li> <li>C. <b>Climate</b></li> <li>D. <b>Access to healthcare</b></li> <li>E. <b>Education and upbringing</b></li> </ul> <p>For example:</p> <ul style="list-style-type: none"> <li>✓ A person may <b>gain weight</b> due to overeating, even if they are genetically slim.</li> <li>✓ An athlete's performance may improve due to training, not just genetics.</li> </ul> <hr/> <p>🔄 <b>3. Combined Effect (Genes + Environment)</b></p> <p>Some characteristics are the <b>result of both genetic and environmental influences</b>, such as:</p> <table border="1" data-bbox="528 1765 1469 2092"> <thead> <tr> <th>Characteristic</th> <th>Genetic Influence</th> <th>Environmental Influence</th> </tr> </thead> <tbody> <tr> <td>Height</td> <td>Genes set potential height range</td> <td>Diet and nutrition affect actual height</td> </tr> <tr> <td>Intelligence</td> <td>Some ability is inherited</td> <td>Education and life experiences impact it</td> </tr> <tr> <td>Skin colour</td> <td>Inherited melanin level</td> <td>Sun exposure can darken the skin</td> </tr> <tr> <td>Athletic ability</td> <td>Muscle type and reaction speed inherited</td> <td>Training and coaching improve performance</td> </tr> </tbody> </table>	Characteristic	Genetic Influence	Environmental Influence	Height	Genes set potential height range	Diet and nutrition affect actual height	Intelligence	Some ability is inherited	Education and life experiences impact it	Skin colour	Inherited melanin level	Sun exposure can darken the skin	Athletic ability	Muscle type and reaction speed inherited	Training and coaching improve performance
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	<p>📌 <b>Conclusion:</b> Most characteristics are <b>multifactorial</b> – meaning they result from a <b>combination of genes and environment</b>. It's not always easy to separate their effects, but scientific studies (like on identical twins) help to understand the balance.</p> <p>✓ <b>Summary Point:</b> Genes provide the blueprint, but the environment shapes how that blueprint is built in real life.</p>
SB4 Natural Selection and Genetic Modification	
SB4a Evidence for human evolution	
Define 'evolution'.	<p><b>Evolution</b> is the <b>gradual change in the inherited characteristics</b> of a species <b>over time</b>. This process leads to the development of <b>new species</b> from earlier forms through mechanisms like <b>natural selection</b> and <b>genetic variation</b>.</p> <hr/> <p><b>Key points to remember:</b></p> <ul style="list-style-type: none"> <li>• Happens <b>over many generations</b>.</li> <li>• Driven by <b>mutations, variation, and selection pressures</b>.</li> <li>• Supported by fossil evidence and DNA analysis.</li> </ul>
Recognise binomial species names	<p><b>Recognising Binomial Species Names (SB4a – Evidence for Human Evolution)</b></p> <ol style="list-style-type: none"> <li>1. <b>Binomial species names</b> are the scientific names given to organisms using <b>two Latin (or Latinised) words</b>:</li> <li>2. <b>Genus name</b> – Always <b>capitalised</b></li> </ol> <p><b>Species name</b> – Always <b>lowercase</b></p> <p>📌 <b>Example:</b> <b>Homo sapiens</b> – modern humans <i>Homo</i> = Genus <i>sapiens</i> = Species</p> <hr/> <p>✓ <b>Key Features to Recognise:</b></p> <ul style="list-style-type: none"> <li>• Two-part name</li> <li>• Written in italics (or underlined when handwritten)</li> <li>• First word capitalised, second lowercase</li> </ul> <p>📌 <b>Other examples:</b></p> <ul style="list-style-type: none"> <li>• <b>Canis lupus</b> (grey wolf)</li> <li>• <b>Pan troglodytes</b> (chimpanzee)</li> <li>• <b>Felis catus</b> (domestic cat)</li> </ul>
Explain how evidence from fossils and stone tools supports current ideas about human evolution	<p><b>Fossil Evidence</b> Fossils provide physical remains of early human ancestors and show <b>how humans have changed over time</b>:</p> <ol style="list-style-type: none"> <li>1. <b>Older fossils</b> (e.g., <i>Australopithecus afarensis</i>, like "Lucy") have:       <ol style="list-style-type: none"> <li>a. Smaller brains</li> <li>b. More ape-like features</li> <li>c. Evidence of bipedalism (walking on two legs)</li> </ol> </li> <li>2. <b>More recent fossils</b> (e.g., <i>Homo habilis</i>, <i>Homo erectus</i>, <i>Homo sapiens</i>):       <ol style="list-style-type: none"> <li>a. Larger brains</li> <li>b. Flatter faces, smaller jaws</li> <li>c. More advanced tool use</li> <li>d. Signs of culture and communication</li> </ol> </li> </ol>

	<p>This fossil progression shows a <b>gradual change</b> in human features and abilities over <b>millions of years</b>, supporting the theory of evolution.</p> <hr/> <p><b>📦 Stone Tool Evidence</b> Stone tools show how <b>technology and intelligence improved</b> over time:</p> <table border="1" data-bbox="528 293 1469 551"> <thead> <tr> <th>Species</th> <th>Tools Used</th> <th>Significance</th> </tr> </thead> <tbody> <tr> <td><i>Homo habilis</i></td> <td>Simple tools (sharp flakes)</td> <td>First evidence of tool use (2.5 million years ago)</td> </tr> <tr> <td><i>Homo erectus</i></td> <td>Hand axes and scrapers</td> <td>More advanced, used for hunting and skinning</td> </tr> <tr> <td><i>Homo sapiens</i></td> <td>Arrowheads, needles, fish hooks</td> <td>Very complex tools; suggest planning, communication</td> </tr> </tbody> </table> <p>Scientists date these tools and match them with fossil finds. The <b>increasing complexity</b> of tools links to <b>increasing brain size</b> and <b>cognitive ability</b>, supporting the idea that humans evolved over time.</p> <hr/> <p><b>🔍 Summary</b> Fossils show <b>physical changes</b> in humans over millions of years. Tools show <b>intellectual and cultural development</b>. Together, they provide strong evidence for <b>human evolution</b>.</p>	Species	Tools Used	Significance	<i>Homo habilis</i>	Simple tools (sharp flakes)	First evidence of tool use (2.5 million years ago)	<i>Homo erectus</i>	Hand axes and scrapers	More advanced, used for hunting and skinning	<i>Homo sapiens</i>	Arrowheads, needles, fish hooks	Very complex tools; suggest planning, communication
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<p>Recall how stone tools are dated from their environment.</p>	<p>Stone tools are dated by examining <b>the age of the rocks or material found around them</b>. Two main methods are used:</p> <hr/> <p><b>1. Relative Dating</b></p> <p>A. Looks at <b>which rock layer</b> the tool is found in. B. Tools found <b>deeper</b> in the ground are usually <b>older</b> than those found in upper layers. C. This is based on the principle of <b>stratigraphy</b> (older layers are beneath newer ones). ✓ Example: If a stone tool is found below a layer with a fossil known to be 1.5 million years old, the tool is likely <b>older</b> than that.</p> <hr/> <p><b>2. Absolute Dating (Radiometric Dating)</b></p> <p>A. Measures the <b>actual age</b> of the surrounding material using the decay of radioactive elements. B. One common method is <b>carbon dating</b> (for organic material up to ~50,000 years old). C. For much older tools, scientists use <b>potassium-argon dating</b> on volcanic rock near the tool. ✓ Example: If volcanic ash above the tool is dated to 2 million years ago, the tool must be <b>older</b> than that ash layer.</p> <hr/> <p><b>📦 Summary:</b> <b>Relative dating</b> uses rock layers to compare ages. <b>Absolute dating</b> gives a more precise age using radioactive decay. These methods help scientists <b>accurately date tools</b> and match them to human ancestors.</p>												
<p>Describe how stone tools created by humanlike species have developed over time.</p>	<p>Stone tools made by early human ancestors have changed <b>significantly</b> over millions of years, showing <b>increasing skill, intelligence, and precision</b>.</p> <hr/> <p><b>◆ 1. Early Tools (~3.3 to 2.5 million years ago)</b></p> <p>A. <b>Species:</b> <i>Australopithecus</i> or early <i>Homo habilis</i></p>												

	<p>B. <b>Type:</b> Simple stone flakes and cores  C. <b>Use:</b> Cutting meat or plants  D. <b>Features:</b></p> <ul style="list-style-type: none"> <li>• Very basic shape</li> <li>• Made by striking one stone against another</li> </ul> <p>☒ <b>Low skill level, basic understanding of tool use</b></p> <hr/> <p>◆ <b>2. Oldowan Tools (~2.5 to 1.5 million years ago)</b></p> <p>A. <b>Species:</b> <i>Homo habilis</i>  B. <b>Type:</b> Choppers and scrapers  C. <b>Use:</b> Cutting meat, cracking bones, scraping hides  D. <b>Features:</b></p> <ul style="list-style-type: none"> <li>• One sharp edge</li> <li>• Rough shape, but clearly used for specific tasks</li> </ul> <p>☒ <b>Shows increasing planning and purpose</b></p> <hr/> <p>◆ <b>3. Acheulean Tools (~1.6 million to 200,000 years ago)</b></p> <p>A. <b>Species:</b> <i>Homo erectus</i>  B. <b>Type:</b> Hand axes and cleavers  C. <b>Use:</b> Butchering animals, digging, chopping wood  D. <b>Features:</b></p> <ul style="list-style-type: none"> <li>• Symmetrical, tear-drop shaped</li> <li>• Sharper and more refined</li> <li>• Made with more strikes and skill</li> </ul> <p>☒ <b>Greater understanding of design and material</b></p> <hr/> <p>◆ <b>4. Mousterian Tools (~300,000 to 40,000 years ago)</b></p> <p>A. <b>Species:</b> <i>Homo neanderthalensis</i>  B. <b>Type:</b> Flint tools, spears, points  C. <b>Use:</b> Hunting, cutting, shaping wood  D. <b>Features:</b></p> <ul style="list-style-type: none"> <li>• Multiple parts and tool types</li> <li>• Carefully shaped, smaller flakes</li> </ul> <p>☒ <b>Toolkits for different jobs, better planning</b></p> <hr/> <p>◆ <b>5. Upper Paleolithic Tools (~40,000 to 10,000 years ago)</b></p> <p>A. <b>Species:</b> <i>Homo sapiens</i>  B. <b>Type:</b> Needles, fish hooks, blades, arrows  C. <b>Use:</b> Hunting, sewing, fishing  D. <b>Features:</b></p> <ul style="list-style-type: none"> <li>• Very refined and specialised</li> <li>• Made from stone, bone, and antler</li> </ul> <p>☒ <b>Highly advanced thinking and creativity</b></p> <hr/> <p>★ <b>Summary:</b>  As human-like species evolved, their tools became:</p> <ul style="list-style-type: none"> <li>• More <b>complex</b> and <b>precise</b></li> <li>• Made from a <b>wider range of materials</b></li> <li>• Designed for <b>specific tasks</b></li> </ul> <p>This shows increasing <b>brain development, problem-solving, and culture.</b></p>
<p>Describe the fossil evidence for human-like species that lived 4.4, 3.2 and 1.6 million years ago</p>	<p>Here's a clear description of the <b>fossil evidence for human-like species</b> that lived <b>4.4, 3.2, and 1.6 million years ago</b>, which supports the <b>evolution of humans</b>:</p>

◆ **4.4 Million Years Ago – *Ardipithecus ramidus* ("Ardi")**

- A. **Discovered in:** Ethiopia
- B. **Height:** About 1.2 metres
- C. **Brain size:** Similar to a chimpanzee (300–350 cm<sup>3</sup>)
- D. **Features:**
  - Long arms and toes for climbing trees
  - But also a structure that suggests it could walk upright (bipedal)
  - Small canine teeth compared to apes

☑ **Ardi shows a mix of tree-dwelling and upright-walking features — evidence of transition from ape-like ancestors.**

◆ **3.2 Million Years Ago – *Australopithecus afarensis* ("Lucy")**

- A. **Discovered in:** Ethiopia
- B. **Height:** About 1.1 metres
- C. **Brain size:** About 400 cm<sup>3</sup>
- D. **Features:**
  - More curved spine — evidence of upright walking
  - Legs were longer than Ardi's, better for walking
  - Still had long arms and curved fingers for climbing

☑ **Lucy shows clearer adaptation to bipedalism, but still with climbing features — a more advanced stage than Ardi.**

◆ **1.6 Million Years Ago – *Homo erectus***

- A. **Discovered in:** Africa and later Asia
- B. **Height:** About 1.8 metres
- C. **Brain size:** About 850 cm<sup>3</sup>
- D. **Features:**
  - Fully adapted for upright walking
  - Used more advanced stone tools (e.g., hand axes)
  - Evidence of living in groups and possibly using fire

☑ ***Homo erectus* was much more like modern humans — upright, intelligent, and skilled in tool use.**

★ **Summary Table:**

Species	Lived (mya)	Key Features	Brain Size
<i>Ardipithecus ramidus</i>	4.4	Climbing & some walking; small canines	~300–350 cm <sup>3</sup>
<i>Australopithecus afarensis</i>	3.2	Upright walking; still some climbing traits	~400 cm <sup>3</sup>
<i>Homo erectus</i>	1.6	Fully upright; tool use; larger brain	~850 cm <sup>3</sup>

SB4b Darwin's theory

Recall the cause of genetic variation

Cause of Genetic Variation – SB4b Darwin's Theory

**Genetic variation** is caused by:

1. **Mutations** –
  - a. Random changes in the **DNA sequence** of a gene.
  - b. These can lead to new alleles (versions of a gene).
  - c. Mutations can be inherited if they occur in sex cells (gametes).
2. **Sexual reproduction** –
  - a. During reproduction, offspring receive a mix of genes from **both parents**.
  - b. This results in unique combinations of alleles in each individual.

	<p>c. <b>Meiosis</b> (cell division for making gametes) introduces further variation through <b>independent assortment</b> and <b>crossing over</b>.</p> <p>✓ <b>So, the two main causes of genetic variation are:</b></p> <ul style="list-style-type: none"> <li>◆ <b>Mutations</b></li> <li>◆ <b>Sexual reproduction</b></li> </ul>
<p>Describe how adaptations allow organisms to survive.</p>	<p>How Adaptations Allow Organisms to Survive</p> <p><b>Adaptations</b> are characteristics that help an organism <b>survive</b> and <b>reproduce</b> in its environment. These traits develop over time through the process of <b>natural selection</b>.</p> <p>There are <b>three main types of adaptations</b>:</p> <hr/> <p>1. Structural adaptations          These are <b>physical features</b> of an organism.          Example:          A <b>polar bear</b> has thick fur and a layer of fat to keep warm in freezing climates.  <b>Cacti</b> have thick stems to store water and spines to reduce water loss and protect from animals.</p> <hr/> <p>2. Behavioural adaptations          These are <b>actions or patterns of activity</b> that help the organism survive.          Example:  <b>Birds migrating</b> to warmer places in winter.  <b>Nocturnal animals</b> being active at night to avoid predators or heat.</p> <hr/> <p>3. Physiological adaptations          These involve the way the <b>body functions internally</b>.          Example:  <b>Snakes</b> producing venom to catch prey or defend themselves.  <b>Camels</b> producing dry faeces and concentrated urine to conserve water.</p> <hr/> <p>✓ Summary:          Adaptations improve an organism's <b>chances of survival</b> in a particular environment. Organisms with the best adaptations are more likely to survive, reproduce, and pass on their genes — this is how evolution works over time.</p>
<p>Explain how natural selection allows some members of a species to survive better than others when conditions change</p>	<p><b>How Natural Selection Allows Some Members of a Species to Survive Better Than Others</b></p> <p><b>Natural selection</b> is the process where individuals with <b>advantageous traits</b> are more likely to <b>survive, reproduce</b>, and pass those traits on to their offspring. When <b>conditions change</b>, natural selection helps some members of a species survive better than others.</p> <hr/> <p>✓ <b>Step-by-step Explanation:</b></p> <ol style="list-style-type: none"> <li>1. <b>Genetic Variation Exists</b> <ul style="list-style-type: none"> <li>• Within a species, individuals have <b>genetic differences</b> due to <b>mutations</b> and <b>sexual reproduction</b>.</li> <li>• This means not all members are exactly the same.</li> </ul> </li> <li>2. <b>Change in Environment or Conditions</b> <ul style="list-style-type: none"> <li>• Something changes — e.g. <b>climate, food availability, or new predators/diseases</b>.</li> </ul> </li> <li>3. <b>Some Traits Become More Useful</b> <ul style="list-style-type: none"> <li>• Certain individuals have <b>traits</b> (adaptations) that <b>help them survive</b> better in the new conditions.</li> <li>• Example: In colder weather, animals with <b>thicker fur</b> may survive better.</li> </ul> </li> </ol>

	<p>4. <b>Survival and Reproduction</b></p> <ul style="list-style-type: none"> <li>• The individuals with these useful traits are <b>more likely to survive</b>, find food, avoid predators, and <b>reproduce</b>.</li> </ul> <p>5. <b>Passing on Genes</b></p> <p>6. These individuals pass their <b>beneficial genes</b> to the next generation.</p> <p>7. <b>Over Time, the Population Changes</b></p> <p>8. More and more individuals in future generations <b>inherit the advantageous traits</b>.</p> <p>The species becomes <b>better suited</b> (adapted) to the new environment.</p> <hr/> <p><b>🔑 Example:</b></p> <p>In a population of rabbits, some have <b>brown fur</b> and some have <b>white fur</b>. If the environment becomes snowy, white rabbits are <b>less visible</b> to predators.</p> <p>More <b>white rabbits survive and reproduce</b>.</p> <p>Over time, more of the population will be <b>white</b> — this is <b>natural selection</b> in action.</p>
<p>Explain how natural selection can lead to the evolution of a new species.</p>	<p><b>Natural selection</b> can cause changes in a population over a long time. If those changes become great enough, a <b>new species</b> can form — this process is called <b>speciation</b>.</p> <hr/> <p>✓ Step-by-Step Explanation:</p> <ol style="list-style-type: none"> <li>1. <b>Variation Exists Within a Species</b> <ul style="list-style-type: none"> <li>• Individuals in a species have <b>genetic differences</b> due to <b>mutations</b> and <b>sexual reproduction</b>.</li> </ul> </li> <li>2. <b>Isolation</b> <ul style="list-style-type: none"> <li>• A population may become <b>isolated</b> — for example, by a <b>physical barrier</b> (like a river or mountain), or by <b>behavioural changes</b>.</li> <li>• This stops individuals from <b>breeding</b> with each other.</li> </ul> </li> <li>3. <b>Different Conditions</b> <ul style="list-style-type: none"> <li>• The two (or more) groups now live in <b>different environments</b>.</li> <li>• They face <b>different selection pressures</b> — e.g. different predators, climates, or food sources.</li> </ul> </li> <li>4. <b>Natural Selection in Each Group</b> <ul style="list-style-type: none"> <li>• In each group, individuals with traits that suit their new environment <b>survive and reproduce</b>.</li> <li>• Over generations, <b>advantageous traits</b> become more common in each group.</li> </ul> </li> <li>5. <b>Genetic Differences Build Up</b> <ul style="list-style-type: none"> <li>• Over many generations, the gene pools of the two groups become more and more <b>different</b>.</li> </ul> </li> <li>6. <b>New Species Formed</b> <ul style="list-style-type: none"> <li>• Eventually, individuals from the two groups can <b>no longer breed</b> with each other to produce <b>fertile offspring</b>.</li> <li>• At this point, they are considered <b>two different species</b> — <b>speciation has occurred</b>.</li> </ul> </li> </ol> <hr/> <p><b>🔑 Example:</b></p> <ul style="list-style-type: none"> <li>• A group of birds gets separated by a storm onto two different islands.</li> <li>• On one island, birds with strong beaks survive better (cracking nuts).</li> <li>• On the other, birds with long beaks survive better (getting insects).</li> <li>• Over thousands of years, the two bird populations evolve into <b>two different species</b> that can't interbreed.</li> </ul>

<p>Explain how the development of resistance in organisms supports Darwin's theory.</p>	<p>The development of <b>resistance</b> in organisms — such as <b>antibiotic resistance in bacteria</b> or <b>pesticide resistance in insects</b> — provides strong <b>real-world evidence</b> for <b>Darwin's theory of evolution by natural selection</b>.</p> <hr/> <p>✓ Step-by-Step Explanation:</p> <p>7. <b>Variation Exists</b></p> <ul style="list-style-type: none"> <li>• In any population of bacteria (or insects), there is <b>natural variation</b> caused by <b>random mutations</b> in their DNA.</li> <li>• Some individuals may have a <b>mutation</b> that makes them <b>resistant</b> to an antibiotic or pesticide.</li> </ul> <p>8. <b>Selection Pressure</b></p> <ul style="list-style-type: none"> <li>• When antibiotics (or pesticides) are used, they create a <b>selection pressure</b>:             <ul style="list-style-type: none"> <li>→ Most of the non-resistant organisms are <b>killed</b>.</li> <li>→ The resistant ones <b>survive</b>.</li> </ul> </li> </ul> <p>9. <b>Survival and Reproduction</b></p> <p>10. The resistant individuals <b>survive, reproduce</b>, and pass on the <b>resistant genes</b> to their offspring.</p> <p>11. <b>Population Changes Over Time</b></p> <p>12. Over many generations, the <b>resistant form becomes more common</b> in the population.</p> <p>13. Eventually, most (or all) of the population may become <b>resistant</b>.</p> <hr/> <p>🔍 Why This Supports Darwin's Theory:</p> <p>It shows that:          There is <b>variation</b> in a population.          Individuals with <b>advantageous traits</b> survive and reproduce.          These traits are <b>inherited</b>.          Over time, the <b>population evolves</b>.          This exactly matches Darwin's ideas of <b>natural selection</b> and <b>descent with modification</b> — providing <b>observable evidence</b> for <b>evolution in action</b>.</p> <hr/> <p>📌 Example:</p> <p>MRSA (a type of bacteria) developed resistance to antibiotics like methicillin. Overusing antibiotics increased the selection pressure. Resistant strains survived and spread — just as Darwin's theory would predict.</p>
<p>SB4c Development of evolution theory</p>	<p>SB4c – Development of Evolution Theory</p>
<p>Recall the names of the scientists who first developed the idea of evolution by natural selection.</p>	<p><b>Recall the names of the scientists who first developed the idea of evolution by natural selection:</b></p> <p>The two main scientists who first developed the idea of evolution by natural selection are:</p> <ul style="list-style-type: none"> <li>• <b>Charles Darwin</b></li> <li>• <b>Alfred Russel Wallace</b></li> </ul> <hr/> <p>📌 Key Points:</p> <ul style="list-style-type: none"> <li>• <b>Charles Darwin</b> is most well known for his book "<i>On the Origin of Species</i>" (published in 1859), where he explained the theory of evolution by natural selection.</li> <li>• <b>Alfred Russel Wallace</b> independently came up with a similar theory around the same time. He sent his ideas to Darwin, which encouraged Darwin to publish his work.</li> </ul>

	Together, they helped shape the modern understanding of <b>evolution</b> through <b>natural selection</b> .
Describe some of the evidence that Darwin and Wallace used to support their idea	<p><b>SB4c – Development of Evolution Theory</b>  <b>Describe some of the evidence that Darwin and Wallace used to support their idea of evolution by natural selection:</b>  Both <b>Darwin</b> and <b>Wallace</b> used observations from nature to support their theory. Here's a summary of the key evidence they gathered:</p> <hr/> <p><b>Q Darwin's Evidence:</b></p> <ol style="list-style-type: none"> <li><b>Fossil Record</b> <ul style="list-style-type: none"> <li>He studied fossils and noticed how organisms changed over time.</li> <li>Older fossils showed simpler organisms, while newer fossils were more complex and similar to modern species.</li> </ul> </li> <li><b>Galápagos Finches</b> <ul style="list-style-type: none"> <li>During his voyage on the HMS <i>Beagle</i>, Darwin observed finches on different Galápagos Islands.</li> <li>He noticed they had different beak shapes adapted to different food sources (e.g., seeds, insects, fruit).</li> <li>This showed how species could change to suit their environment.</li> </ul> </li> <li><b>Artificial Selection (Selective Breeding)</b> <ul style="list-style-type: none"> <li>Darwin saw how humans could breed animals and plants for desired traits (e.g., dogs, pigeons, crops).</li> </ul> </li> </ol> <p>This suggested nature could also “select” traits over time—natural selection.</p> <hr/> <p><b>Q Wallace's Evidence:</b></p> <ol style="list-style-type: none"> <li><b>Observations from the Malay Archipelago</b> <ul style="list-style-type: none"> <li>Wallace studied animals and plants in Southeast Asia.</li> <li>He noticed species on nearby islands were similar but showed slight differences, suggesting common ancestry with variation due to environment.</li> </ul> </li> <li><b>Warning Colouration in Animals</b> <ul style="list-style-type: none"> <li>Wallace noted that bright colours in animals (e.g. butterflies, frogs) often signalled they were poisonous.</li> </ul> </li> </ol> <p>This trait helped them survive by warning predators—a clear example of natural selection in action.</p> <hr/> <p><b>☑ Summary:</b>  Both scientists used <b>geographical distribution, comparative anatomy, fossils, and observed traits in animals</b> to support their theory. They showed that:</p> <ul style="list-style-type: none"> <li>Species change over time.</li> <li>Those with the best adaptations are more likely to survive and reproduce.</li> <li>Over many generations, this leads to evolution.</li> </ul>
Explain the impact of the idea of evolution by natural selection on modern biology	<p>The Impact of the Idea of Evolution by Natural Selection on Modern Biology  The theory of <b>evolution by natural selection</b>, first proposed by <b>Charles Darwin</b> and <b>Alfred Russel Wallace</b>, has had a huge impact on modern biology. Here's how:</p> <hr/> <ol style="list-style-type: none"> <li>Understanding the Unity and Diversity of Life <ul style="list-style-type: none"> <li>Evolution explains how all living organisms are related through <b>common ancestry</b>.</li> <li>It also explains the <b>diversity</b> of life — different species have adapted to different environments over time.</li> </ul> </li> </ol>

	<hr/> <p>2. Advances in Genetics</p> <ul style="list-style-type: none"> <li>• Darwin didn't know about <b>genes</b>, but modern science has shown that <b>genetic variation</b> is the basis of natural selection.</li> <li>• Evolutionary theory now works hand-in-hand with <b>DNA analysis</b>, helping scientists understand how traits are inherited and how species evolve.</li> </ul> <hr/> <p>3. Medicine and Antibiotic Resistance</p> <ul style="list-style-type: none"> <li>• The theory helps explain how <b>bacteria evolve resistance</b> to antibiotics.</li> <li>• This understanding is vital for developing <b>new drugs</b> and managing <b>disease outbreaks</b>.</li> </ul> <hr/> <p>4. Agriculture and Selective Breeding</p> <ul style="list-style-type: none"> <li>• Natural selection principles are used in <b>artificial selection</b> to breed plants and animals with desired traits (e.g. drought-resistant crops, higher-yield animals).</li> </ul> <hr/> <p>5. Conservation Biology</p> <ul style="list-style-type: none"> <li>• Evolutionary theory helps identify <b>important species</b> and populations to protect.</li> <li>• Conservation efforts now focus on <b>genetic diversity</b>, which is essential for the survival of species in changing environments.</li> </ul> <hr/> <p>6. Classification and Taxonomy</p> <ul style="list-style-type: none"> <li>• Modern classification systems are based on <b>evolutionary relationships</b> (phylogenetics), often using <b>DNA comparisons</b> to group organisms by common ancestors.</li> </ul> <hr/> <p>📄 Summary:</p> <p>Evolution by natural selection is the <b>foundation of modern biology</b>. It explains how life changes, adapts, and survives — guiding research in <b>genetics, medicine, ecology, and conservation</b>.</p>
<p>Recall what is meant by the pentadactyl limb, and where it is found?</p>	<p>What is the Pentadactyl Limb?</p> <p>The <b>pentadactyl limb</b> is a type of limb that has <b>five digits</b> (fingers or toes). The word comes from:</p> <p><b>"Penta"</b> = five</p> <p><b>"Dactyl"</b> = fingers/toes</p> <hr/> <p>✓ Where is it Found?</p> <p>The pentadactyl limb is found in <b>many vertebrate animals</b>, including:</p> <ul style="list-style-type: none"> <li>• <b>Humans</b> 🧑</li> <li>• <b>Cats</b> 🐱</li> <li>• <b>Bats</b> 🦇</li> <li>• <b>Whales</b> 🐳</li> <li>• <b>Birds</b> 🐦</li> </ul> <p>Even though the limbs look different and are used in different ways (e.g. walking, flying, swimming), they <b>share the same basic structure</b>:</p> <ul style="list-style-type: none"> <li>• One upper bone (humerus)</li> <li>• Two lower bones (radius and ulna)</li> <li>• A group of wrist bones</li> <li>• Five digits</li> </ul> <hr/> <p>📖 Why is it Important in Evolution?</p>

	<p>The pentadactyl limb is <b>evidence for evolution</b>. It suggests that all these animals evolved from a <b>common ancestor</b> with this basic limb structure, and then the limbs adapted over time for different functions.</p>															
<p>Explain how changes in the pentadactyl limb provide evidence for evolution by natural selection.</p>	<p>How Changes in the Pentadactyl Limb Provide Evidence for Evolution by Natural Selection</p> <p>The <b>pentadactyl limb</b> is a common limb structure found in many vertebrates (e.g. humans, bats, whales, cats). It consists of:</p> <ol style="list-style-type: none"> <li>1. One upper bone (humerus)</li> <li>2. Two lower bones (radius and ulna)</li> <li>3. Wrist bones (carpals)</li> <li>4. Five digits (fingers or toes)</li> </ol> <hr/> <p>🔄 Variation in Function, Same Structure</p> <p>Although the structure is the same, the <b>form and function of the limb have changed</b> in different animals:</p> <table border="1" data-bbox="528 689 1469 983"> <thead> <tr> <th>Animal</th> <th>Use of Limb</th> <th>Adaptation Example</th> </tr> </thead> <tbody> <tr> <td>Human</td> <td>Grasping &amp; tools</td> <td>Short fingers and opposable thumbs</td> </tr> <tr> <td>Bat</td> <td>Flying</td> <td>Long finger bones supporting wing membranes</td> </tr> <tr> <td>Whale</td> <td>Swimming</td> <td>Flattened limbs with short, wide bones (flippers)</td> </tr> <tr> <td>Cat</td> <td>Walking &amp; hunting</td> <td>Sharp claws and strong, flexible digits</td> </tr> </tbody> </table> <hr/> <p><input type="checkbox"/> Natural Selection in Action</p> <p>These differences arose due to <b>natural selection</b>:</p> <ol style="list-style-type: none"> <li>1. <b>Genetic variation</b> existed in early ancestors with pentadactyl limbs.</li> <li>2. <b>Mutations</b> caused small changes in limb size, shape, or function.</li> <li>3. In different environments, certain limb shapes were <b>more useful</b> (e.g. long fingers for flying in bats).</li> <li>4. Animals with helpful limb adaptations were <b>more likely to survive and reproduce</b>.</li> <li>5. Over many generations, those adaptations became more common in the population.</li> </ol> <hr/> <p>✓ Evidence for Evolution</p> <ul style="list-style-type: none"> <li>• The <b>shared pentadactyl structure</b> shows that these animals <b>evolved from a common ancestor</b>.</li> <li>• The <b>differences in limb function</b> show how <b>natural selection shaped</b> those limbs for survival in different environments.</li> </ul> <p>So, the pentadactyl limb supports the idea that <b>species change over time</b> through <b>evolution by natural selection</b>.</p>	Animal	Use of Limb	Adaptation Example	Human	Grasping & tools	Short fingers and opposable thumbs	Bat	Flying	Long finger bones supporting wing membranes	Whale	Swimming	Flattened limbs with short, wide bones (flippers)	Cat	Walking & hunting	Sharp claws and strong, flexible digits
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<p>SB4d Classification</p>																
<p>Describe how organisms are classified into smaller and smaller groups (based on their characteristics)</p>	<p>Organisms are classified into smaller and smaller groups based on their <b>shared characteristics</b>, using a system called <b>biological classification</b> or <b>taxonomy</b>. This system helps scientists organise living things and understand how different organisms are related to each other.</p> <hr/> <p>📊 Levels of Classification (from largest to smallest):</p> <ol style="list-style-type: none"> <li>1. <b>Kingdom</b> – the broadest group (e.g. Animalia, Plantae)</li> <li>2. <b>Phylum</b> – based on major body plans (e.g. vertebrates vs invertebrates)</li> <li>3. <b>Class</b> – more specific traits (e.g. mammals, birds, reptiles)</li> <li>4. <b>Order</b> – groups within a class (e.g. primates, carnivores)</li> </ol>															

	<p>5. <b>Family</b> – more closely related organisms (e.g. humans and great apes)          6. <b>Genus</b> – very closely related species (e.g. <i>Homo</i>)          7. <b>Species</b> – the most specific group; organisms that can breed and produce fertile offspring (e.g. <i>Homo sapiens</i>)</p> <hr/> <p>☒ Classification is Based On:</p> <ol style="list-style-type: none"> <li>1. <b>Physical characteristics</b> (e.g. body structure, number of legs, type of skeleton)</li> <li>2. <b>Genetic similarities</b> (DNA comparisons)</li> <li>3. <b>Biochemical features</b> (e.g. types of proteins)</li> <li>4. <b>Reproductive methods</b></li> <li>5. <b>Development patterns</b></li> </ol> <hr/> <p>☞ Example:          For humans:</p> <ol style="list-style-type: none"> <li>1. <b>Kingdom:</b> Animalia</li> <li>2. <b>Phylum:</b> Chordata</li> <li>3. <b>Class:</b> Mammalia</li> <li>4. <b>Order:</b> Primates</li> <li>5. <b>Family:</b> Hominidae</li> <li>6. <b>Genus:</b> <i>Homo</i></li> <li>7. <b>Species:</b> <i>Homo sapiens</i></li> </ol> <hr/> <p>This system helps scientists communicate clearly, avoid confusion, and study evolutionary relationships.</p>
<p>Identify genus and species from a binomial name</p>	<p>A <b>binomial name</b> (or scientific name) is made up of <b>two parts</b>:</p> <ol style="list-style-type: none"> <li>1. <b>Genus</b> – written <b>first</b> and <b>capitalised</b></li> <li>2. <b>Species</b> – written <b>second</b> and in <b>lowercase</b></li> </ol> <p>☒ Example:  <b>Homo sapiens</b></p> <ul style="list-style-type: none"> <li>• <b>Genus:</b> <i>Homo</i></li> <li>• <b>Species:</b> <i>sapiens</i></li> </ul> <p>✓ Always written in italics (or underlined when handwritten).</p> <hr/> <p>🔍 Another example:  <b>Canis lupus</b></p> <ul style="list-style-type: none"> <li>• <b>Genus:</b> <i>Canis</i></li> <li>• <b>Species:</b> <i>lupus</i> (the grey wolf)</li> </ul> <p>This naming system is part of <b>binomial classification</b>, developed by <b>Carl Linnaeus</b>.</p>
<p>Identify an organism as a member of one of the five kingdoms.</p>	<p>To <b>classify an organism</b> into one of the <b>five kingdoms</b>, scientists examine key features such as cell structure, method of nutrition, and reproduction. The five kingdoms are:</p> <hr/> <p>☒ 1. Monera (Prokaryotes – Bacteria &amp; Archaea)</p> <ul style="list-style-type: none"> <li>• <b>Cell type:</b> Prokaryotic (no nucleus)</li> <li>• <b>Unicellular</b></li> <li>• <b>Example:</b> <i>Escherichia coli</i> (E. coli)</li> </ul> <hr/> <p>♣ 2. Fungi</p> <p><b>Cell type:</b> Eukaryotic (has a nucleus)  <b>Mostly multicellular</b> (yeast is unicellular)  <b>Nutrition:</b> Absorbs nutrients (saprotrophic)  <b>Cell walls made of chitin</b>  <b>Example:</b> <i>Mushrooms, yeast</i></p>


	<hr/> <p>🌿 3. Plantae  <b>Cell type:</b> Eukaryotic  <b>Multicellular</b>  <b>Nutrition:</b> Photosynthetic (autotrophic)  <b>Cell walls made of cellulose</b>  <b>Example:</b> <i>Oak tree, algae</i></p> <hr/> <p>🐾 4. Animalia  <b>Cell type:</b> Eukaryotic  <b>Multicellular</b>  <b>Nutrition:</b> Ingests food (heterotrophic)  <b>No cell walls</b>  <b>Example:</b> <i>Humans, dogs, insects</i></p> <hr/> <p>🔍 5. Protista  <b>Cell type:</b> Eukaryotic  <b>Mostly unicellular</b>  <b>Mixed characteristics (can be plant-like, animal-like, or fungal-like)</b>  <b>Example:</b> <i>Amoeba, Euglena, Paramecium</i></p> <hr/> <p>To <b>identify</b> the kingdom, ask:  Does it have a nucleus?  Is it unicellular or multicellular?  How does it obtain energy?  Does it have a cell wall (and what's it made of)?</p>
<p>Describe what genetic analysis is</p>	<p><b>Genetic analysis</b> is the process of studying an organism's DNA (genetic material) to understand its genes, genetic structure, and heredity.  It can involve:  <b>Identifying specific genes</b> responsible for traits or diseases  <b>Comparing DNA sequences</b> between individuals or species  <b>Tracing inheritance</b> of traits from parents to offspring  <b>Studying mutations</b> and their effects on organisms  Genetic analysis is widely used in medicine, forensics, agriculture, and evolutionary biology to understand how traits are passed on, how species are related, and how genetic conditions arise.</p>
<p>why biologists often now classify organisms into three domains.</p>	<p>Biologists now often classify organisms into <b>three domains—Bacteria, Archaea, and Eukarya</b>—because this system better reflects the <b>evolutionary relationships</b> between organisms based on their <b>genetic and molecular differences</b>.  Reasons for using three domains:</p> <ol style="list-style-type: none"> <li>1. <b>Genetic evidence:</b> DNA and RNA analysis has shown that Archaea are <b>genetically very different</b> from Bacteria, even though both are single-celled and lack a nucleus.</li> <li>2. <b>Cell structure differences:</b> <ul style="list-style-type: none"> <li>• <b>Bacteria:</b> Have cell walls with peptidoglycan and simple cell structures.</li> <li>• <b>Archaea:</b> Have unique cell membranes and no peptidoglycan; often live in extreme environments.</li> <li>• <b>Eukarya:</b> Have complex cells with nuclei and organelles (e.g. plants, animals, fungi, and protists).</li> </ul> </li> <li>3. <b>More accurate evolutionary tree:</b> The three-domain system, introduced by <b>Carl Woese</b>, reflects the major divisions in the <b>tree of life</b> and shows how all life evolved from a common ancestor.</li> </ol>

	This system provides a clearer understanding of how different groups of organisms are related and how life has evolved over billions of years.
SB4e Breeds and varieties	
Describe why new breeds and varieties are created.	<p>In <b>SB4e Breeds and Varieties</b>, new <b>breeds and varieties</b> are created through <b>selective breeding</b> to achieve specific <b>desirable characteristics</b> in plants or animals.</p> <p>Reasons why new breeds and varieties are created:</p> <ol style="list-style-type: none"> <li><b>Improved yield</b> – e.g. crops that produce more fruit or grain.</li> <li><b>Better quality</b> – e.g. tastier fruit, longer-lasting vegetables, or higher-quality meat.</li> <li><b>Disease resistance</b> – plants or animals that are less likely to be affected by certain diseases.</li> <li><b>Adaptation to environment</b> – e.g. crops that grow better in drought or colder climates.</li> <li><b>Appearance</b> – e.g. animals bred for certain colours, shapes, or sizes for farming or pets.</li> <li><b>Behavioral traits</b> – e.g. dogs bred for friendliness, intelligence, or herding ability.</li> </ol> <p>How it works:</p> <ol style="list-style-type: none"> <li>Individuals with desired traits are <b>selected</b> and <b>bred together</b>.</li> <li>The <b>offspring</b> that inherit those traits are then <b>selected and bred</b> again.</li> <li>Over several generations, the traits become <b>more common</b>, creating a new <b>breed (animals)</b> or <b>variety (plants)</b>.</li> </ol> <p>This method allows humans to influence the <b>genetic makeup</b> of organisms for <b>agricultural, commercial, or personal purposes</b>.</p>
Describe what is meant by a 'genetically modified organism'	<p>A <b>genetically modified organism (GMO)</b> is an organism whose <b>DNA has been changed using genetic engineering techniques</b>.</p> <p>In more detail:</p> <ol style="list-style-type: none"> <li>Scientists <b>add, remove, or alter genes</b> in the organism's DNA.</li> <li>These genes often come from a <b>different species</b> to give the organism <b>new traits</b> that it wouldn't naturally have.</li> </ol> <p>Examples of GMOs:</p> <ul style="list-style-type: none"> <li><b>GM crops</b> like corn or soybeans that are resistant to pests or herbicides.</li> <li><b>GM bacteria</b> used to produce insulin for people with diabetes.</li> <li><b>GM animals</b>, such as mice modified for medical research.</li> </ul> <p>Purpose:</p> <ul style="list-style-type: none"> <li>Genetically modifying organisms can improve <b>agricultural yield, nutritional value, disease resistance</b>, or create organisms that can <b>produce medicines or other useful substances</b>.</li> </ul>
Describe how selective breeding is carried out	<p><b>Selective breeding</b>, also known as <b>artificial selection</b>, is the process by which humans breed plants or animals for specific desirable traits.</p> <p>Steps in Selective Breeding:</p> <ol style="list-style-type: none"> <li><b>Choose parents with desired characteristics</b> <ul style="list-style-type: none"> <li>For example, cows that produce more milk or plants with larger fruit.</li> </ul> </li> <li><b>Breed the selected parents together</b> <ul style="list-style-type: none"> <li>This produces offspring that are more likely to inherit the desired traits.</li> </ul> </li> <li><b>Select the best offspring</b></li> </ol>

	<ul style="list-style-type: none"> <li>• From the next generation, individuals showing the desired traits most strongly are chosen.</li> </ul> <p>4. <b>Repeat over many generations</b></p> <ul style="list-style-type: none"> <li>• The process is repeated over several generations so that the trait becomes more common and consistent in the population.</li> </ul> <p>Example:</p> <ul style="list-style-type: none"> <li>• <b>Dogs</b> bred for specific behaviors (e.g. herding, guarding).</li> <li>• <b>Wheat plants</b> bred for disease resistance and high yield.</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Can reduce genetic variation.</li> <li>• May increase the risk of inherited diseases due to inbreeding.</li> </ul>
<p>Explain the impact of selective breeding on domesticated plants and animals</p>	<p><b>The impact of selective breeding on domesticated plants and animals</b> has been significant, both positively and negatively.</p> <hr/> <p>✓ Positive Impacts:</p> <ol style="list-style-type: none"> <li>1. <b>Increased Yield and Productivity</b> <ul style="list-style-type: none"> <li>• Plants produce more fruit, grains, or vegetables.</li> <li>• Animals (e.g. cows, chickens) produce more milk, eggs, or meat.</li> </ul> </li> <li>2. <b>Desirable Traits Enhanced</b> <ul style="list-style-type: none"> <li>• Disease resistance in plants.</li> <li>• Docility, size, or coat type in animals.</li> </ul> </li> <li>3. <b>Better Suitability for Human Use</b> <ul style="list-style-type: none"> <li>• Crops tailored for taste, size, or shelf life.</li> <li>• Animals suited for specific tasks (e.g. herding, companionship, transport).</li> </ul> </li> </ol> <hr/> <p>⚠ Negative Impacts:</p> <ol style="list-style-type: none"> <li>1. <b>Reduced Genetic Diversity</b> <ul style="list-style-type: none"> <li>• Makes populations more vulnerable to disease and environmental change.</li> </ul> </li> <li>2. <b>Increased Risk of Inherited Disorders</b> <ul style="list-style-type: none"> <li>• Especially in animals, due to inbreeding (e.g. hip problems in pedigree dogs).</li> </ul> </li> <li>3. <b>Loss of Natural Behaviors or Traits</b> <ul style="list-style-type: none"> <li>• Some traits selected for human convenience may reduce the animal's natural survival abilities.</li> </ul> </li> </ol> <hr/> <p>In Summary:          Selective breeding has made plants and animals more useful to humans, but it must be managed carefully to avoid long-term health and genetic problems in populations.</p>
<p>SB4f Tissue culture</p>	
<p>Describe how tissue culture is carried out</p>	<p><b>Tissue culture</b> is a method used to grow new plants from a small piece of plant tissue in a sterile environment.</p> <hr/> <p>🔧 How Tissue Culture Is Carried Out:</p> <ol style="list-style-type: none"> <li>1. <b>Selection of Plant Material (Explant):</b> <ul style="list-style-type: none"> <li>• A small piece of plant tissue (often from the shoot or root tip) is taken. This part contains <b>undifferentiated cells</b> (meristem cells) that can develop into a whole plant.</li> </ul> </li> <li>2. <b>Sterilisation:</b></li> </ol>

	<ul style="list-style-type: none"> <li>• The explant is sterilised using a <b>bleach or alcohol solution</b> to kill any microbes.</li> </ul> <p>3. <b>Placement on Growth Medium:</b></p> <ul style="list-style-type: none"> <li>• The explant is placed in a <b>sterile petri dish or container</b> containing a <b>nutrient-rich agar jelly</b>.</li> <li>• The medium contains <b>glucose, minerals, and plant hormones</b> (like auxins and cytokinins) to stimulate cell division and growth.</li> </ul> <p>4. <b>Callus Formation:</b></p> <ul style="list-style-type: none"> <li>• The cells divide to form a <b>mass of undifferentiated cells</b> called a <b>callus</b>.</li> </ul> <p>5. <b>Development into Plantlets:</b></p> <ul style="list-style-type: none"> <li>• Hormone levels are adjusted to encourage the callus to form <b>roots, stems, and leaves</b>.</li> <li>• These small plants are called <b>plantlets</b>.</li> </ul> <p>6. <b>Transfer to Soil:</b></p> <ul style="list-style-type: none"> <li>• Once the plantlets are large and strong enough, they are <b>transferred to compost or soil</b> to continue growing normally.</li> </ul> <hr/> <p>✓ Uses of Tissue Culture:</p> <ul style="list-style-type: none"> <li>• Producing <b>large numbers of genetically identical plants</b> (clones).</li> <li>• Saving <b>rare or endangered plant species</b>.</li> <li>• Producing <b>disease-free plants</b> in agriculture.</li> </ul> <hr/> <p>Tissue culture is a key biotechnology tool in modern farming and research.</p>
<p>Explain why tissue culture produces many identical cells.</p>	<p><b>Tissue culture produces many identical cells because it involves cloning.</b> Here's why:</p> <hr/> <p>✓ Key Reasons:</p> <ol style="list-style-type: none"> <li>1. <b>Starts from a single parent cell or tissue (explant):</b> <ul style="list-style-type: none"> <li>• The tissue used comes from <i>one plant</i>, so all cells carry the <b>same genetic material</b> (DNA).</li> </ul> </li> <li>2. <b>Mitosis is the process of cell division used:</b> <ul style="list-style-type: none"> <li>• In tissue culture, cells divide by <b>mitosis</b>, which produces <b>genetically identical daughter cells</b>.</li> </ul> </li> <li>3. <b>Controlled environment prevents variation:</b> <ul style="list-style-type: none"> <li>• The process takes place in a <b>sterile lab</b> using controlled nutrients and hormones, reducing the chance of mutation or change.</li> </ul> </li> </ol> <hr/> <p>🔄 Result:</p> <p>All the new plants or cells produced are <b>clones</b>—they have <b>identical DNA</b> and will show <b>the same characteristics</b> as the parent plant. This makes tissue culture useful for producing large numbers of <b>uniform, high-quality plants</b>.</p>
<p>Describe advantages of using tissue culture in medical research.</p>	<p><b>Advantages of Using Tissue Culture in Medical Research:</b></p> <ol style="list-style-type: none"> <li>1. ✓ <b>Controlled Study of Cells:</b> <ul style="list-style-type: none"> <li>• Scientists can observe how human or animal cells grow, divide, and respond to treatments in a controlled environment.</li> </ul> </li> <li>2. ✓ <b>Testing New Drugs and Treatments:</b> <ul style="list-style-type: none"> <li>• Tissue culture allows researchers to test the effects of new medicines or chemicals on cells before using them in live animals or humans.</li> </ul> </li> <li>3. ✓ <b>Study of Disease Mechanisms:</b> <ul style="list-style-type: none"> <li>• Researchers can use tissue culture to understand how diseases like cancer or infections affect cells.</li> </ul> </li> </ol>

	<p>4. ✓ <b>Reduces the Need for Animal Testing:</b></p> <ul style="list-style-type: none"> <li>• Since experiments can be done directly on cultured cells, fewer animals are needed for research.</li> </ul> <p>5. ✓ <b>Fast and Reproducible Results:</b></p> <ul style="list-style-type: none"> <li>• Cells grow quickly and uniformly, allowing experiments to be repeated easily for reliable results.</li> </ul> <p>6. ✓ <b>Cloning and Genetic Studies:</b></p> <ul style="list-style-type: none"> <li>• Tissue culture is used to clone specific cells or study genetic conditions under controlled conditions.</li> </ul> <p>7. ✓ <b>Production of Vaccines:</b></p> <ul style="list-style-type: none"> <li>• Tissue culture is used to grow viruses for vaccines, like polio or flu vaccines.</li> </ul> <hr/> <p>In summary, tissue culture provides a <b>safe, ethical, and efficient</b> way to study cells and develop new medical treatments.</p>
<p>Describe advantages of using tissue culture in plant breeding programmes.</p>	<p><b>Advantages of Using Tissue Culture in Plant Breeding Programmes:</b></p> <ol style="list-style-type: none"> <li>✓ <b>Produces Large Numbers of Plants Quickly:</b> <ul style="list-style-type: none"> <li>• From just a few parent cells, thousands of identical plants can be produced in a short time.</li> </ul> </li> <li>✓ <b>Genetically Identical Plants (Clones):</b> <ul style="list-style-type: none"> <li>• All plants have the same desirable characteristics, such as disease resistance, high yield, or good taste.</li> </ul> </li> <li>✓ <b>Grow Plants All Year Round:</b> <ul style="list-style-type: none"> <li>• Tissue culture is done in controlled lab conditions, so it is not affected by seasons or weather.</li> </ul> </li> <li>✓ <b>Preserves Rare or Endangered Plants:</b> <ul style="list-style-type: none"> <li>• Rare species can be cloned and saved from extinction.</li> </ul> </li> <li>✓ <b>Disease-Free Plants:</b> <ul style="list-style-type: none"> <li>• Plants can be grown from clean, healthy tissue to ensure they are free from viruses or other infections.</li> </ul> </li> <li>✓ <b>Faster Breeding Cycles:</b> <ul style="list-style-type: none"> <li>• Tissue culture speeds up the process of developing and testing new varieties.</li> </ul> </li> <li>✓ <b>Space Efficient:</b> <ul style="list-style-type: none"> <li>• Thousands of tiny plantlets can be grown in a small laboratory space before being transferred to soil.</li> </ul> </li> </ol> <hr/> <p>In summary, tissue culture allows <b>fast, reliable, and large-scale production</b> of high-quality plants, making it a powerful tool in modern plant breeding programmes.</p>
<p>SB4g Genes in agriculture and medicine</p>	
<p>recall some uses of selectively bred organisms (in agriculture).</p>	<p>Selective breeding in agriculture is used to produce plants and animals with desirable traits. Examples include:</p> <hr/> <p>🐘 In Animals:</p> <ol style="list-style-type: none"> <li><b>Higher milk yield in cows</b> → Cows are bred to produce more milk or better quality milk.</li> <li><b>Faster growth in chickens</b> → Chickens are selected for rapid growth and increased meat production.</li> </ol>

	<p>3. <b>Disease resistance in livestock</b> → Animals are bred to be more resistant to certain infections or conditions.</p> <p>4. <b>Better egg-laying in hens</b> → Hens are chosen for higher egg production and consistency.</p> <hr/> <p> In Plants:</p> <p>1. <b>Higher crop yield</b> → Wheat, rice, and maize varieties are bred to produce more grain per plant.</p> <p>2. <b>Drought resistance</b> → Crops like maize are bred to grow in areas with less water.</p> <p>3. <b>Pest and disease resistance</b> → Plants are selected to naturally resist insects or diseases, reducing the need for chemicals.</p> <p>4. <b>Improved taste or shelf life</b> → Fruits and vegetables like tomatoes or apples are bred to taste better or last longer after harvest.</p>
<p>Recall some uses of genetically engineered organisms (in agriculture, in medicine)</p>	<p><b>Uses of Genetically Engineered Organisms (GEOs):</b></p> <hr/> <p>In Agriculture:</p> <p>1. <b>Pest-resistant crops</b> (e.g., Bt corn): Engineered to produce proteins that kill specific insect pests, reducing the need for chemical pesticides.</p> <p>2. <b>Herbicide-resistant crops</b> (e.g., Roundup Ready soybeans): Can survive specific herbicides, allowing farmers to control weeds without harming the crop.</p> <p>3. <b>Improved nutritional content</b> (e.g., Golden Rice): Modified to contain extra vitamins or nutrients to address dietary deficiencies.</p> <p>4. <b>Drought-resistant crops:</b> Engineered to tolerate low water conditions, improving crop survival in dry areas.</p> <hr/> <p>In Medicine:</p> <p>1. <b>Production of insulin:</b> Genetically engineered bacteria produce human insulin for diabetes treatment.</p> <p>2. <b>Gene therapy:</b> Using genetically modified viruses to deliver healthy genes to patients with genetic disorders.</p> <p>3. <b>Vaccines:</b> Some vaccines are produced using genetically engineered organisms to improve safety and effectiveness.</p> <p>4. <b>Production of human growth hormone and clotting factors:</b> Manufactured through genetically engineered microbes for treating deficiencies and diseases.</p> <hr/> <p><b>Summary:</b> Genetically engineered organisms are used to <b>enhance crop resilience and nutrition</b> in agriculture and to <b>produce vital medicines and therapies</b> in healthcare.</p>
<p>Evaluate the benefits and risks of using selective breeding and genetic engineering to produce new varieties and breeds</p>	<p>the benefits and risks of <b>selective breeding</b> and <b>genetic engineering</b> for producing new varieties and breeds:</p> <hr/> <p>Selective Breeding</p> <p><b>Benefits:</b></p> <p>1. <b>Improves desirable traits:</b> Farmers can enhance qualities such as yield, disease resistance, growth rate, or flavor.</p> <p>2. <b>Relatively natural process:</b> Uses traditional breeding methods, often accepted socially and ethically.</p>

3. **Cost-effective:** Requires less advanced technology compared to genetic engineering.
4. **Established practice:** Has been used for thousands of years with many successes.

**Risks:**

1. **Reduced genetic diversity:** Repeated breeding of similar individuals can lead to inbreeding, making populations more vulnerable to diseases or environmental changes.
2. **Unintended traits:** Sometimes, alongside desired traits, unwanted characteristics can also be inherited.
3. **Slower process:** Takes multiple generations to achieve significant changes.
4. **Ethical concerns:** Overemphasis on certain traits can compromise animal welfare (e.g., breeding for rapid growth causing health issues).

Genetic Engineering

**Benefits:**

1. **Precision:** Specific genes can be inserted, removed, or altered, allowing targeted improvements.
2. **Faster results:** Desired traits can be introduced in a single generation.
3. **Introduction of novel traits:** Traits from unrelated species can be transferred, such as pest resistance or vitamin enrichment.
4. **Potential for medical advancements:** Producing medicines, vaccines, and gene therapies.

**Risks:**

1. **Ethical and social concerns:** Public apprehension about 'GMOs' regarding safety, naturalness, and corporate control.
2. **Potential environmental impact:** Gene flow to wild relatives or unintended effects on non-target organisms.
3. **Unknown long-term effects:** Possible unforeseen consequences on ecosystems and human health.
4. **Cost and accessibility:** High development costs and technology may be inaccessible to small-scale farmers.

Summary

Aspect	Selective Breeding	Genetic Engineering
Speed	Slow, multiple generations	Fast, single generation
Precision	Less precise, traits inherited broadly	Highly precise gene targeting
Genetic Diversity	Reduced due to inbreeding risks	Potential risk if genes spread unintentionally
Ethical Issues	Welfare concerns, natural process	Public concern over GMOs and ethics
Environmental Impact	Generally lower risk	Potential ecological risks
Cost and Technology	Low-tech, cost-effective	High-tech, expensive

Both methods have important roles in improving agriculture and medicine, but careful management and regulation are essential to minimize risks and maximize benefits.

<p>Give examples of useful GM organisms.</p>	<p>Here are some examples of useful genetically modified (GM) organisms in agriculture:</p> <ol style="list-style-type: none"> <li>1. <b>GM Crops with Pest Resistance</b> <ol style="list-style-type: none"> <li>a. <i>Bt Corn</i> and <i>Bt Cotton</i>: Engineered to produce a toxin from the bacterium <i>Bacillus thuringiensis</i> that kills certain insect pests, reducing the need for chemical pesticides.</li> </ol> </li> <li>2. <b>GM Crops with Herbicide Tolerance</b> <ol style="list-style-type: none"> <li>b. <i>Roundup Ready Soybeans</i>: Modified to tolerate the herbicide glyphosate, allowing farmers to control weeds without harming the crop.</li> </ol> </li> <li>3. <b>GM Crops with Improved Nutritional Content</b> <ol style="list-style-type: none"> <li>c. <i>Golden Rice</i>: Engineered to produce beta-carotene, a precursor of vitamin A, to help combat vitamin A deficiency in some populations.</li> </ol> </li> <li>4. <b>GM Crops with Enhanced Stress Tolerance</b> <ol style="list-style-type: none"> <li>d. Drought-tolerant maize varieties designed to grow better in dry conditions.</li> </ol> </li> <li>5. <b>GM Animals</b> <ol style="list-style-type: none"> <li>e. <i>GM Salmon</i>: Modified to grow faster than wild-type salmon, reaching market size more quickly.</li> </ol> </li> </ol> <p>These GM organisms help increase crop yields, reduce pesticide use, improve nutrition, and enhance food security.</p>
<p>Describe how crop plants can be modified to make them resistant to insect pests.</p>	<p>Crop plants can be modified to resist insect pests through <b>genetic engineering</b> by introducing specific genes that produce natural insecticides. A common method is to insert a gene from the bacterium <i>Bacillus thuringiensis</i> (Bt) into the crop's DNA. This gene enables the plant to produce Bt toxin, a protein that is toxic to certain insect pests but safe for humans and other animals.</p> <p>When insects feed on the modified plant, the Bt toxin disrupts their digestive system, killing or deterring them from causing damage. This reduces the need for chemical pesticides, making crop production more environmentally friendly and efficient. Examples of such crops include Bt corn and Bt cotton.</p>
<p>Explain how using GM organisms can increase the amount of food we produce</p>	<p>Using genetically modified (GM) organisms can increase food production in several ways:</p> <ol style="list-style-type: none"> <li>1. <b>Pest Resistance:</b> GM crops can be engineered to resist insect pests (e.g., Bt crops), reducing crop losses and minimizing the need for chemical pesticides. This leads to higher yields.</li> <li>2. <b>Disease Resistance:</b> Some GM plants are modified to resist diseases caused by viruses, bacteria, or fungi, helping crops survive and produce more food.</li> <li>3. <b>Herbicide Tolerance:</b> GM crops can tolerate specific herbicides, allowing farmers to control weeds more effectively without harming the crop, which improves growth and yield.</li> <li>4. <b>Improved Stress Tolerance:</b> GM organisms can be designed to withstand environmental stresses such as drought, salinity, or extreme temperatures, enabling crops to grow in less ideal conditions and increasing overall food production.</li> <li>5. <b>Enhanced Nutritional Content:</b> Some GM crops are modified to have higher nutrient levels, improving the quality and value of food.</li> <li>6. By reducing losses and improving crop performance, GM organisms contribute to producing more food on the same amount of land, helping to meet the demands of a growing global population.</li> </ol>

<p>Explain how using GM organisms can cause problems in the environment.</p>	<p>Using genetically modified (GM) organisms can cause environmental problems in several ways:</p> <ol style="list-style-type: none"> <li>1. <b>Loss of Biodiversity:</b> GM crops that dominate farming could reduce the variety of plants and animals in an ecosystem, leading to decreased biodiversity.</li> <li>2. <b>Gene Transfer to Wild Species:</b> Genes from GM crops might spread to wild relatives through cross-pollination, potentially creating “superweeds” that are resistant to herbicides and harder to control.</li> <li>3. <b>Impact on Non-target Organisms:</b> GM crops designed to kill pests may also harm beneficial insects or other wildlife that are not the intended targets, disrupting ecosystems.</li> <li>4. <b>Development of Resistance:</b> Pests and weeds may evolve resistance to the traits engineered into GM crops (like pest resistance), making these crops less effective and possibly leading to increased use of chemical controls.</li> <li>5. <b>Soil and Water Effects:</b> Changes in plant chemistry or agricultural practices linked to GM crops can affect soil health or water quality through runoff or altered nutrient cycles.</li> </ol> <p>These potential environmental risks highlight the need for careful regulation and monitoring of GM organism use.</p>
<p>Evaluate the advantages and disadvantages of using GM organisms.</p>	<p>Here’s an evaluation of the advantages and disadvantages of using genetically modified (GM) organisms:</p> <hr/> <p>Advantages of GM Organisms</p> <ol style="list-style-type: none"> <li>1. <b>Increased Crop Yield:</b> GM crops can be engineered to resist pests, diseases, and harsh environmental conditions, leading to higher and more reliable yields.</li> <li>2. <b>Reduced Use of Chemicals:</b> Pest-resistant GM plants can reduce the need for chemical pesticides, which benefits the environment and lowers farmers’ costs.</li> <li>3. <b>Improved Nutritional Content:</b> Some GM crops are modified to have enhanced vitamins or minerals, helping to address nutritional deficiencies in populations (e.g., Golden Rice with Vitamin A).</li> <li>4. <b>Resistance to Herbicides:</b> GM crops can tolerate specific herbicides, making weed control easier and more efficient for farmers.</li> <li>5. <b>Medical Advances:</b> GM organisms are used to produce medicines, vaccines, and hormones (like insulin), improving healthcare outcomes.</li> <li>6. <b>Economic Benefits:</b> Increased productivity and lower input costs can boost farmers’ incomes and contribute to food security.</li> </ol> <hr/> <p>Disadvantages of GM Organisms</p> <ol style="list-style-type: none"> <li>1. <b>Environmental Risks:</b> GM crops may cause loss of biodiversity, gene flow to wild relatives (creating superweeds), and harm to non-target species.</li> <li>2. <b>Resistance Development:</b> Pests and weeds can evolve resistance to GM traits, potentially leading to more aggressive problems over time.</li> <li>3. <b>Ethical and Social Concerns:</b> Some people have ethical objections to modifying organisms, and there are concerns about corporate control over seeds and food supply.</li> </ol>

	<p><b>4. Health Concerns:</b> Although no conclusive evidence shows GM foods are harmful, some worry about potential allergenicity or long-term health effects.</p> <p><b>5. Cost and Accessibility:</b> Developing GM crops can be expensive, and patented seeds may be costly or unavailable to small-scale farmers, especially in developing countries.</p> <p><b>6. Regulatory and Market Barriers:</b> GM crops face strict regulations and consumer resistance in many countries, which can limit their adoption.</p> <hr/> <p><b>Conclusion</b> GM organisms offer significant benefits in agriculture and medicine, particularly for improving yields, reducing chemical use, and enhancing nutrition. However, they also pose environmental, ethical, and socioeconomic challenges that require careful management, regulation, and ongoing research to ensure sustainable and equitable use.</p>
SB4i Fertilisers and biological control	
Describe the principle of biological control.	The principle of biological control involves using living organisms to reduce the population of pests and harmful species in a natural and environmentally friendly way. Instead of using chemical pesticides, biological control introduces natural predators, parasites, or pathogens to target and manage pest populations, helping to protect crops and maintain ecological balance.
Explain why we need to produce more food.	We need to produce more food because the global population is increasing rapidly, which leads to higher demand for food. Additionally, factors such as changing diets, food waste, limited agricultural land, and the impacts of climate change on crop yields all contribute to the need for increased food production to ensure food security and meet the nutritional needs of everyone.
Explain how biological control can help to increase crop yield	Biological control helps increase crop yield by using natural predators, parasites, or pathogens to reduce the population of crop pests. This reduces the damage pests cause to plants, allowing crops to grow healthier and produce more. Unlike chemical pesticides, biological control is often more sustainable and environmentally friendly, helping maintain a balanced ecosystem while protecting the crops.
Explain how biological control can cause problems (in decreasing biodiversity)	Biological control can cause problems by sometimes reducing biodiversity. When a natural predator or parasite is introduced to control a pest, it may also affect non-target species, including beneficial insects or other wildlife. This can disrupt the local ecosystem balance and lead to a decline in the variety of species (biodiversity) in the area. Additionally, if the introduced control organism becomes invasive, it may outcompete native species, further reducing biodiversity.
Explain how fertilisers can increase crop yield.	Fertilisers increase crop yield by providing essential nutrients that plants need to grow, such as nitrogen, phosphorus, and potassium. These nutrients help plants develop strong roots, healthy leaves, and produce more flowers and fruits. By replenishing nutrients in the soil that have been used up by previous crops, fertilisers improve soil fertility and promote faster, healthier plant growth, leading to higher crop yields.
Explain how fertilisers can damage the environment ( by causing pollution)	Fertilisers can damage the environment by causing pollution in several ways: 1. <b>Water Pollution (Eutrophication):</b> When excess fertiliser is washed off fields by rain, nutrients like nitrogen and phosphorus enter rivers, lakes, and oceans. This causes rapid growth of algae (algal blooms), which depletes oxygen in the water and harms aquatic life.

	<p>2. <b>Soil Degradation:</b> Overuse of fertilisers can alter soil chemistry, reduce soil fertility over time, and harm beneficial soil organisms.</p> <p>3. <b>Air Pollution:</b> Some fertilisers release nitrous oxide, a greenhouse gas, into the atmosphere, contributing to climate change.</p> <p>4. <b>Groundwater Contamination:</b> Nitrates from fertilisers can seep into groundwater, making it unsafe to drink and causing health problems.</p> <p>Overall, improper fertiliser use leads to pollution that harms ecosystems, wildlife, and human health.</p>
<b>SB5 Health, Disease and the Development of Medicines</b>	
<b>SB5a Health and disease</b>	
Define the term health	<b>Health</b> is defined as a state of complete physical, mental, and social well-being, and not merely the absence of disease or illness.
Define the term disease	<b>Disease</b> is a condition that causes the body or mind to function abnormally, resulting in symptoms or harm to health. It can be caused by infections, genetic factors, environmental influences, or lifestyle choices.
Describe how communicable and noncommunicable diseases differ	<p><b>Communicable diseases</b> are illnesses caused by pathogens (such as bacteria, viruses, fungi, or parasites) and can be <b>spread from person to person</b>, or through animals, air, water, or surfaces. Examples: Influenza, tuberculosis, COVID-19.</p> <p><b>Non-communicable diseases</b> are <b>not infectious</b> and <b>cannot be passed</b> from person to person. They are often caused by genetics, lifestyle choices, or environmental factors. Examples: Diabetes, heart disease, cancer.</p> <p><b>Key differences:</b></p> <ol style="list-style-type: none"> <li><b>Cause:</b> Communicable (pathogens); Non-communicable (lifestyle/genetic/environmental).</li> <li><b>Spread:</b> Communicable can spread between organisms; non-communicable cannot.</li> <li><b>Prevention:</b> Communicable diseases may be prevented by hygiene and vaccines; non-communicable diseases may be prevented by healthy lifestyle choices.</li> </ol>
Outline the role of the immune system in protecting against disease.	<p>The <b>immune system</b> protects the body from <b>disease-causing microorganisms</b> (pathogens) through a series of <b>defence mechanisms</b>:</p> <ol style="list-style-type: none"> <li>Physical and Chemical Barriers (First Line of Defence): <ul style="list-style-type: none"> <li><b>Skin</b> acts as a physical barrier.</li> <li><b>Mucus, tears, and stomach acid</b> trap and kill pathogens.</li> </ul> </li> <li>White Blood Cells (Second Line of Defence): There are several types of white blood cells with different roles: <ol style="list-style-type: none"> <li><b>Phagocytes:</b> Engulf and digest pathogens in a process called <b>phagocytosis</b>.</li> <li><b>Lymphocytes:</b> Produce <b>antibodies</b> that target specific antigens on pathogens. <ul style="list-style-type: none"> <li>These antibodies bind to pathogens and help destroy them.</li> <li>They also produce <b>antitoxins</b> to neutralise toxins released by bacteria.</li> <li>Some become <b>memory cells</b> that "remember" the pathogen and allow a faster response if the body is infected again.</li> </ul> </li> </ol> </li> <li>Immunity: <ol style="list-style-type: none"> <li>After exposure to a pathogen, the immune system <b>remembers it</b>.</li> </ol> </li> </ol>

	<p>B. If the pathogen enters again, the body produces a <b>faster and stronger immune response</b>, preventing illness. This is called <b>immunity</b>.</p> <p>In summary, the immune system <b>detects, attacks, and remembers</b> pathogens to <b>protect the body from future infections</b>.</p>
<p>Explain how disease can affect the immune system</p>	<p>Disease can affect the immune system in several ways, depending on the type and severity of the disease:</p> <hr/> <p>1. Some diseases weaken the immune system          Certain diseases directly <b>attack and damage immune cells</b>, making it harder for the body to defend itself against other infections.  <b>Example:</b>          A. <b>HIV (Human Immunodeficiency Virus)</b> infects and destroys <b>white blood cells</b> (especially helper T-cells).          B. Over time, this severely weakens the immune system, leading to <b>AIDS</b>, where the body becomes vulnerable to many other infections and cancers.</p> <hr/> <p>2. Chronic diseases can lower immune function          Conditions like <b>diabetes, cancer, or autoimmune diseases</b> can reduce the immune system's effectiveness:          A. The body becomes less efficient at detecting or fighting off pathogens.          B. Treatments for these diseases (e.g. chemotherapy or immunosuppressants) can also <b>suppress the immune response</b>.</p> <hr/> <p>3. One disease can make you more likely to get another          If your immune system is busy fighting one illness or weakened by it, you're more <b>susceptible to secondary infections</b>.  <b>Example:</b></p> <ul style="list-style-type: none"> <li>After having the <b>flu</b>, some people develop <b>pneumonia</b> due to a weakened immune system.</li> </ul> <hr/> <p><b>Summary:</b>          Disease can affect the immune system by:          A. <b>Directly attacking immune cells</b> (e.g., HIV),          B. <b>Reducing immune function</b> through chronic illness or medication,          C. <b>Increasing vulnerability</b> to other infections.</p>
<p><b>SB5b Non-communicable disease</b></p>	
<p>Give examples of non-communicable diseases.</p>	<p>Examples of Non-Communicable Diseases (NCDs):          Non-communicable diseases are <b>not caused by infectious agents</b> and <b>cannot be passed from person to person</b>. They usually develop due to genetic, lifestyle, or environmental factors.</p> <hr/> <p>1. Cardiovascular diseases  <b>Examples:</b> Heart attack, stroke, high blood pressure  <b>Cause:</b> Often linked to poor diet, smoking, lack of exercise</p> <hr/> <p>2. Cancers  <b>Examples:</b> Lung cancer, breast cancer, skin cancer  <b>Cause:</b> Uncontrolled growth of cells; can be triggered by genetics, smoking, UV exposure, or other carcinogens</p> <hr/> <p>3. Diabetes (Type 1 and Type 2)</p>

	<p><b>Type 1:</b> Usually genetic, the immune system destroys insulin-producing cells  <b>Type 2:</b> Linked to lifestyle (e.g. poor diet, lack of exercise)</p> <hr/> <p>4. Chronic respiratory diseases  <b>Examples:</b> Asthma, chronic obstructive pulmonary disease (COPD)  <b>Cause:</b> Allergens, smoking, air pollution</p> <hr/> <p>5. Neurological diseases  <b>Examples:</b> Alzheimer’s disease, Parkinson’s disease  <b>Cause:</b> Degeneration of nerve cells, often age-related or genetic</p> <hr/> <p>These conditions usually develop <b>over time</b> and can be <b>managed but not cured</b> in most cases.</p>
<p>Define the term malnutrition</p>	<p><b>Malnutrition</b> is a condition that occurs when a person’s diet does <b>not provide the right amount of nutrients</b> for proper growth, development, and health.</p> <hr/> <p>🔍 Key Points:</p> <p>A. It includes <b>undernutrition</b> (not enough food or nutrients) and <b>overnutrition</b> (too many nutrients or too much food).  B. Can lead to <b>health problems</b> such as stunted growth, weakened immunity, fatigue, obesity, or deficiency diseases (like rickets or scurvy).</p> <hr/> <p><b>Definition:</b>  <b>Malnutrition</b> is a condition caused by an <b>imbalance in a person’s diet</b>, where they may receive <b>too little or too much of essential nutrients</b>.</p>
<p>Explain how diet can lead to malnutrition.</p>	<p>Diet can lead to <b>malnutrition</b> when it lacks the <b>right balance of nutrients</b>, or when a person <b>eats too much or too little</b> of certain foods over time.</p> <hr/> <p>🔍 How diet causes malnutrition:</p> <p>1. <b>Undernutrition (Not enough nutrients):</b></p> <ol style="list-style-type: none"> <li><b>Too little food overall</b> → Not enough energy (calories), leading to weight loss and fatigue.</li> <li><b>Lack of protein</b> → Muscle wasting, poor growth (e.g. kwashiorkor).</li> <li><b>Lack of vitamins/minerals</b> → Deficiency diseases like: <ul style="list-style-type: none"> <li><b>Vitamin D deficiency</b> → Rickets (soft bones).</li> <li><b>Iron deficiency</b> → Anaemia (tiredness, weakness).</li> </ul> </li> </ol> <p>2. <b>Overnutrition (Too many nutrients):</b></p> <ol style="list-style-type: none"> <li><b>Too much fat/sugar</b> → Obesity, type 2 diabetes, heart disease.</li> <li><b>Excess salt</b> → High blood pressure, increased risk of stroke.</li> </ol> <hr/> <p>✓ Summary:  A poor diet—whether from eating <b>too little, too much, or the wrong balance</b> of nutrients—can cause <b>malnutrition</b>, leading to <b>serious health problems</b>.</p>
<p>Describe the link between alcohol and liver disease</p>	<p>The Link Between Alcohol and Liver Disease:  Alcohol is <b>processed by the liver</b>, but <b>drinking too much over time</b> can <b>damage liver cells</b>, leading to <b>liver disease</b>. Here’s how:</p> <hr/> <p>🔍 How Alcohol Affects the Liver:</p> <p>1. <b>Fatty Liver (Steatosis):</b></p> <ol style="list-style-type: none"> <li>The <b>first stage</b> of liver damage.</li> <li>Alcohol causes <b>fat to build up</b> in liver cells.</li> <li>Usually has no symptoms but is a <b>warning sign</b>.</li> </ol> <p>2. <b>Alcoholic Hepatitis:</b></p>

	<p>a. Continued drinking leads to <b>inflammation of the liver</b>.</p> <p>b. Can cause <b>pain, fever, nausea</b>, and even <b>liver failure</b> in severe cases.</p> <p>3. <b>Cirrhosis:</b></p> <p>a. <b>Long-term damage</b> causes <b>scar tissue</b> to replace healthy liver tissue.</p> <p>b. Scar tissue blocks blood flow and reduces liver function.</p> <p>c. Can lead to <b>permanent liver failure</b>, internal bleeding, and death.</p> <hr/> <p>⚠ Why It's Dangerous:</p> <ul style="list-style-type: none"> <li>• The liver is vital for <b>removing toxins</b>, producing enzymes, and storing nutrients.</li> <li>• Once it's <b>badly scarred</b>, the damage is <b>usually permanent</b>.</li> <li>• <b>Heavy, long-term alcohol use</b> greatly increases the risk of liver disease.</li> </ul> <hr/> <p>✓ Summary:</p> <p><b>Excessive alcohol consumption</b> over time <b>damages liver cells</b>, leading to <b>fatty liver, hepatitis</b>, and eventually <b>cirrhosis</b>—a serious, often life-threatening condition.</p>
<p>Explain the effect of alcohol consumption on liver disease at local, national and global levels.</p>	<p>The Effect of Alcohol Consumption on Liver Disease at Local, National, and Global Levels</p> <hr/> <p>Local Level (e.g. community or city):</p> <ol style="list-style-type: none"> <li>1. <b>Increased hospital admissions:</b> Local hospitals may see more patients with alcohol-related liver problems, putting pressure on healthcare services.</li> <li>2. <b>Lost productivity:</b> People with liver disease may be too ill to work, impacting local businesses and economies.</li> <li>3. <b>Social impacts:</b> Families may face stress, financial difficulties, and emotional trauma due to illness or loss of loved ones.</li> <li>4. <b>Health education demands:</b> Local public health teams may need to run more awareness campaigns to reduce drinking.</li> </ol> <hr/> <p>GB National Level (e.g. UK):</p> <ol style="list-style-type: none"> <li>1. <b>NHS burden:</b> Liver disease, largely due to alcohol, costs the NHS billions of pounds each year in treatment and care.</li> <li>2. <b>Rising death rates:</b> In the UK, alcohol-related liver disease is a leading cause of preventable deaths.</li> <li>3. <b>Government policy:</b> The government may introduce measures like minimum pricing, restricted advertising, or health warnings on alcohol.</li> <li>4. <b>Inequality impact:</b> Liver disease is more common in deprived areas where alcohol abuse may be higher due to social stress.</li> </ol> <hr/> <p>🌐 Global Level:</p> <ol style="list-style-type: none"> <li>1. <b>Major health issue:</b> According to the WHO, alcohol causes around 3 million deaths globally every year, many from liver disease.</li> <li>2. <b>Developing countries:</b> In many low- and middle-income nations, health systems struggle to treat chronic liver conditions.</li> <li>3. <b>Cultural variation:</b> Drinking habits vary, but many countries face increasing rates of alcohol abuse and liver disease.</li> <li>4. <b>Global initiatives:</b> International health bodies promote awareness, responsible drinking, and support for alcohol dependency.</li> </ol> <hr/> <p>✓ Summary:</p>

	Alcohol consumption contributes significantly to liver disease, with serious consequences at every level—from individual communities to worldwide health systems. Tackling the issue requires education, healthcare resources, and policies to reduce harmful drinking.
<b>SB5c Cardiovascular disease</b>	
Describe how obesity is measured (BMI and waist : hip calculations)	<p>How Obesity is Measured</p> <p><b>1. Body Mass Index (BMI):</b> BMI is calculated using the formula:</p> $\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$ <p>It provides a simple numerical measure to classify individuals as underweight, normal weight, overweight, or obese based on standard ranges.</p> <p><b>BMI categories:</b></p> <ul style="list-style-type: none"> <li>• Underweight: BMI less than 18.5</li> <li>• Normal weight: BMI 18.5 – 24.9</li> <li>• Overweight: BMI 25 – 29.9</li> <li>• Obese: BMI 30 or above</li> </ul> <p><b>2. Waist-to-Hip Ratio (WHR):</b> WHR is calculated by dividing the waist circumference by the hip circumference:</p> $\text{WHR} = \frac{\text{Waist Circumference}}{\text{Hip Circumference}}$ <ol style="list-style-type: none"> <li>1. It helps assess fat distribution and risk of cardiovascular disease.</li> <li>2. Higher WHR indicates more abdominal fat, which is linked to greater health risks.</li> <li>3. Typical risk thresholds: <ul style="list-style-type: none"> <li>• For men: WHR above 0.90 indicates higher risk</li> <li>• For women: WHR above 0.85 indicates higher risk</li> </ul> </li> </ol> <hr/> <p>Both measurements are commonly used to evaluate obesity and related health risks such as cardiovascular disease.</p>
Describe how obesity correlates with cardiovascular disease.	<p>Obesity is strongly linked to cardiovascular disease (CVD) through several mechanisms:</p> <ol style="list-style-type: none"> <li>1. <b>Increased Blood Pressure:</b> Excess body fat increases the workload on the heart, often leading to high blood pressure (hypertension), which damages arteries and raises the risk of heart attacks and strokes.</li> <li>2. <b>High Cholesterol Levels:</b> Obesity is associated with higher levels of LDL (“bad” cholesterol) and lower levels of HDL (“good” cholesterol), promoting the buildup of fatty plaques in arteries (atherosclerosis) that restrict blood flow.</li> <li>3. <b>Inflammation:</b> Fat tissue, especially around the abdomen, produces inflammatory substances that can damage blood vessels and contribute to the development of CVD.</li> <li>4. <b>Insulin Resistance and Diabetes:</b> Obesity often leads to insulin resistance, increasing the risk of type 2 diabetes, which further raises the likelihood of cardiovascular complications.</li> <li>5. <b>Increased Risk of Blood Clots:</b> Obese individuals have a higher tendency for blood clot formation, which can block arteries and cause heart attacks or strokes.</li> </ol>

	<p>Overall, obesity significantly raises the risk of developing cardiovascular disease by affecting blood pressure, cholesterol levels, blood sugar control, and vascular health.</p>																
<p>Describe how smoking correlates with cardiovascular disease.</p>	<p>Smoking is strongly linked to cardiovascular disease (CVD) through several harmful effects on the heart and blood vessels:</p> <ol style="list-style-type: none"> <li><b>1. Damage to Blood Vessels:</b> Chemicals in cigarette smoke damage the lining of blood vessels (endothelium), making them more prone to atherosclerosis (the buildup of fatty plaques).</li> <li><b>2. Increased Blood Pressure and Heart Rate:</b> Nicotine raises blood pressure and heart rate, putting extra strain on the heart.</li> <li><b>3. Reduced Oxygen Supply:</b> Carbon monoxide in smoke binds to red blood cells, reducing oxygen delivery to the heart and other organs.</li> <li><b>4. Increased Blood Clotting:</b> Smoking increases the tendency of blood to clot, which can block arteries and cause heart attacks or strokes.</li> <li><b>5. Lowered Good Cholesterol (HDL):</b> Smoking reduces levels of HDL cholesterol, which normally helps protect arteries.</li> </ol> <p>These effects collectively increase the risk of heart attacks, strokes, and other cardiovascular problems in smokers compared to non-smokers.</p>																
<p>Explain why exercise and diet affect obesity</p>	<p>Exercise and diet affect obesity because they influence the balance between calories consumed and calories burned:</p> <ol style="list-style-type: none"> <li><b>1. Diet:</b> Eating more calories than the body needs leads to excess energy being stored as fat, causing weight gain and obesity. Unhealthy diets high in fats and sugars increase this risk.</li> <li><b>2. Exercise:</b> Physical activity burns calories, helping to reduce stored fat and maintain a healthy weight. Lack of exercise means fewer calories are used, making weight gain more likely if calorie intake is high.</li> </ol> <p>Together, a balanced diet and regular exercise help maintain energy balance and prevent obesity.</p>																
<p>Compare how cardiovascular diseases are treated</p>	<p>Here's a comparison of common treatments for cardiovascular diseases (CVD):</p> <table border="1" data-bbox="528 1402 1469 2083"> <thead> <tr> <th>Treatment Type</th> <th>Description</th> <th>Purpose</th> <th>Examples</th> </tr> </thead> <tbody> <tr> <td><b>Lifestyle changes</b></td> <td>Modifying diet, increasing exercise, quitting smoking, reducing alcohol</td> <td>To reduce risk factors and improve heart health naturally</td> <td>Healthy eating, regular physical activity, smoking cessation</td> </tr> <tr> <td><b>Medications</b></td> <td>Drugs prescribed to manage symptoms or risk factors</td> <td>To control blood pressure, cholesterol, or prevent blood clots</td> <td>Statins, beta-blockers, ACE inhibitors, anticoagulants</td> </tr> <tr> <td><b>Surgical procedures</b></td> <td>Invasive interventions to repair or improve heart function</td> <td>To treat blockages, restore blood flow, or repair heart damage</td> <td>Angioplasty, stent placement, bypass surgery, valve repair/replacement</td> </tr> </tbody> </table>	Treatment Type	Description	Purpose	Examples	<b>Lifestyle changes</b>	Modifying diet, increasing exercise, quitting smoking, reducing alcohol	To reduce risk factors and improve heart health naturally	Healthy eating, regular physical activity, smoking cessation	<b>Medications</b>	Drugs prescribed to manage symptoms or risk factors	To control blood pressure, cholesterol, or prevent blood clots	Statins, beta-blockers, ACE inhibitors, anticoagulants	<b>Surgical procedures</b>	Invasive interventions to repair or improve heart function	To treat blockages, restore blood flow, or repair heart damage	Angioplasty, stent placement, bypass surgery, valve repair/replacement
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	<p><b>Device implantation</b></p>	<p>Use of medical devices to support heart function</p>	<p>To regulate heartbeat or assist pumping</p>	<p>Pacemakers, defibrillators, ventricular assist devices</p>
	<p><b>Rehabilitation</b></p>	<p>Structured programs post-treatment to improve recovery</p>	<p>To support lifestyle changes and monitor health</p>	<p>Cardiac rehab programs including exercise, education, and counseling</p>
<p><b>Summary:</b>                      Lifestyle changes are foundational and used for prevention and alongside other treatments.                      Medications help manage symptoms and reduce risks.                      Surgery and devices are for more severe cases needing physical intervention.                      Rehabilitation supports long-term recovery and prevention.                      Each treatment plan is tailored to the individual’s condition and severity of disease.</p>				
<p><b>SB5d Pathogens</b></p>				
<p>Describe some problems and diseases caused by bacteria</p>	<p>Here’s a description for <b>problems and diseases caused by bacteria:</b>                      Bacteria are microscopic single-celled organisms that can cause a range of diseases and health problems in humans. Some bacteria are beneficial, but pathogenic bacteria can invade the body, multiply, and release toxins that damage tissues and cause illness.</p> <p><b>Examples of diseases caused by bacteria:</b></p> <ol style="list-style-type: none"> <li>1. <b>Tuberculosis (TB):</b> Caused by <i>Mycobacterium tuberculosis</i>, affects the lungs and can cause coughing, weight loss, and fatigue.</li> <li>2. <b>Cholera:</b> Caused by <i>Vibrio cholerae</i>, leads to severe diarrhea and dehydration.</li> <li>3. <b>Strep throat:</b> Caused by <i>Streptococcus pyogenes</i>, results in sore throat, fever, and swollen lymph nodes.</li> <li>4. <b>Salmonellosis:</b> Caused by <i>Salmonella</i> bacteria, leads to food poisoning with symptoms like diarrhea, vomiting, and abdominal cramps.</li> <li>5. <b>Typhoid fever:</b> Caused by <i>Salmonella typhi</i>, characterized by high fever, weakness, and abdominal pain.</li> <li>6. <b>Bacterial meningitis:</b> Infection of the membranes around the brain and spinal cord, caused by several types of bacteria such as <i>Neisseria meningitidis</i>.</li> </ol> <p><b>Problems caused by bacteria include:</b></p> <ul style="list-style-type: none"> <li>• Tissue damage and inflammation due to bacterial toxins.</li> <li>• Spread of infection within the body leading to severe illness.</li> <li>• Antibiotic resistance making some bacterial infections difficult to treat.</li> <li>• Contamination of food and water supplies causing outbreaks.</li> </ul> <p>Effective hygiene, vaccination, and antibiotics are crucial in preventing and treating bacterial diseases.</p>			
<p>Describe a disease caused by a virus.</p>	<p>Here’s a description of a disease caused by a virus:  <b>Influenza (Flu):</b>                      Influenza is a contagious respiratory illness caused by influenza viruses. It affects the nose, throat, and sometimes the lungs. Common symptoms include fever, cough, sore throat, runny or stuffy nose, body aches, fatigue, and headaches. The flu spreads easily from person to person through droplets when an infected person coughs or sneezes.</p>			

	<p>Viruses like the influenza virus invade healthy cells and use them to reproduce, damaging or destroying the cells in the process. This leads to the symptoms experienced during infection.</p> <p>Influenza can range from mild to severe, and in some cases, especially in young children, elderly people, or those with weakened immune systems, it can lead to serious complications such as pneumonia.</p> <p>Prevention includes annual flu vaccinations, good hygiene practices like regular handwashing, and avoiding close contact with infected individuals.</p>
<p>Describe a disease caused by a protist</p>	<p>Here's a description of a disease caused by a protist:</p> <p><b>Malaria:</b> Malaria is a serious infectious disease caused by protist parasites of the genus <i>Plasmodium</i>. It is transmitted to humans through the bite of infected female <i>Anopheles</i> mosquitoes.</p> <p>Once inside the human body, the <i>Plasmodium</i> parasites multiply in the liver and then infect red blood cells. This leads to symptoms such as high fever, chills, sweating, headache, fatigue, and muscle aches. If untreated, malaria can cause severe complications and can be fatal.</p> <p>Prevention methods include using insecticide-treated mosquito nets, insect repellents, eliminating mosquito breeding sites, and taking antimalarial medications in high-risk areas.</p>
<p>Describe a disease caused by a fungus</p>	<p>Here's a description of a disease caused by a fungus:</p> <p><b>Athlete's Foot:</b> Athlete's foot is a common fungal infection caused by fungi called <i>dermatophytes</i>. It typically affects the skin on the feet, especially between the toes.</p> <p>The infection causes itching, redness, cracking, and peeling of the skin. It can also lead to blisters and discomfort. Athlete's foot is contagious and can spread through direct contact or by sharing contaminated surfaces like towels or floors.</p> <p>Treatment usually involves antifungal creams, powders, or sprays, and keeping the feet clean and dry helps prevent the infection from worsening or recurring.</p>
<p>Explain how signs of a disease can be used to identify the pathogen</p>	<p>Signs of a disease can help identify the pathogen because different pathogens often cause characteristic symptoms or physical changes in the infected organism. For example:</p> <p><b>Specific symptoms:</b> Some pathogens cause unique signs (like the rash from chickenpox caused by a virus or the swollen lymph nodes from bacterial infections).</p> <p><b>Pattern of symptoms:</b> The combination and progression of symptoms can suggest a particular type of pathogen (virus, bacteria, fungus, or protist).</p> <p><b>Visible signs:</b> Some diseases produce distinctive visible signs, such as lesions, ulcers, or discolored tissue, which help narrow down the cause.</p> <p><b>Diagnostic tests guided by signs:</b> Based on signs, doctors can perform targeted laboratory tests (cultures, microscopy, or molecular tests) to detect the exact pathogen.</p> <p>Thus, observing disease signs provides crucial clues for identifying the pathogen responsible for the illness.</p>

SB5e Spreading pathogens	
<p>State the ways in which pathogens can be spread.</p>	<p>Pathogens can be spread in several ways, including:</p> <ol style="list-style-type: none"> <li><b>Airborne transmission</b> – Through droplets in the air from coughing, sneezing, or talking (e.g. flu, tuberculosis).</li> <li><b>Direct contact</b> – Through physical contact with an infected person or contaminated surfaces (e.g. athlete’s foot, impetigo).</li> <li><b>Contaminated food and water</b> – Ingesting food or water carrying pathogens (e.g. salmonella, cholera).</li> <li><b>Vector transmission</b> – Spread by animals that carry pathogens (e.g. malaria via mosquitoes).</li> <li><b>Body fluids</b> – Through blood, saliva, semen, or other fluids (e.g. HIV, hepatitis B).</li> <li><b>Mother to child</b> – During pregnancy, childbirth, or breastfeeding (e.g. HIV, rubella).</li> </ol> <p>Understanding these pathways is essential for preventing the spread of infectious diseases.</p>
<p>Give examples of pathogens that are spread in different ways (e.g. cholera bacteria by water, tuberculosis bacteria and chalara dieback fungi by air, malaria protist by vector, Helicobacter by mouth, Ebola by body fluids).</p>	<p>Here are examples of pathogens and how they are spread:</p> <ol style="list-style-type: none"> <li><b>Cholera (bacteria)</b> – Spread through <b>contaminated water</b>. <i>Pathogen: Vibrio cholerae</i></li> <li><b>Tuberculosis (bacteria)</b> – Spread through the <b>air</b> by coughing or sneezing. <i>Pathogen: Mycobacterium tuberculosis</i></li> <li><b>Chalara dieback (fungus)</b> – Spread through the <b>air</b> via spores that infect ash trees. <i>Pathogen: Hymenoscyphus fraxineus</i></li> <li><b>Malaria (protist)</b> – Spread by a <b>vector</b>, specifically female <i>Anopheles</i> mosquitoes. <i>Pathogen: Plasmodium species</i></li> <li><b>Helicobacter pylori (bacteria)</b> – Spread through the <b>mouth</b>, often via contaminated food, water, or saliva. <i>Pathogen: Helicobacter pylori</i></li> <li><b>Ebola (virus)</b> – Spread through <b>body fluids</b> such as blood, vomit, or saliva. <i>Pathogen: Ebola virus</i></li> </ol> <p>Each example shows a different transmission route, highlighting how diverse and adaptable pathogens can be.</p>
<p>Explain how the spread of different pathogens can be reduced or prevented</p>	<p>The spread of different pathogens can be reduced or prevented using a variety of methods tailored to how each pathogen is transmitted:</p> <hr/> <p><b>1. Waterborne pathogens (e.g., Cholera):</b> <b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li>Ensure access to <b>clean drinking water</b>.</li> <li>Use <b>water purification tablets</b> or boil water before drinking.</li> <li>Promote <b>good sanitation and hygiene</b>, such as proper sewage disposal and handwashing.</li> </ol> <hr/> <p><b>2. Airborne pathogens (e.g., Tuberculosis, Chalara dieback):</b> <b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li><b>Ventilate indoor spaces</b> to reduce airborne transmission.</li> <li>Encourage the use of <b>face masks</b> in crowded or enclosed areas.</li> <li><b>Isolate infected individuals</b> when necessary.</li> <li>In the case of plants (e.g., Chalara dieback), <b>burn infected trees</b> and restrict movement of infected wood.</li> </ol> <hr/> <p><b>3. Vector-borne pathogens (e.g., Malaria):</b> <b>Prevention methods:</b></p>

	<ol style="list-style-type: none"> <li>1. Use <b>insect repellents</b> and <b>insecticide-treated bed nets</b>.</li> <li>2. Eliminate <b>standing water</b> where mosquitoes breed.</li> <li>3. Introduce <b>biological control</b>, such as fish that eat mosquito larvae.</li> <li>4. Use <b>antimalarial medications</b> as prevention in high-risk areas.</li> </ol> <hr/> <p><b>4. Pathogens spread through the mouth (e.g., Helicobacter pylori):</b>  <b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li>1. Practice <b>good hand hygiene</b>.</li> <li>2. Ensure <b>food safety</b> by cooking and storing food properly.</li> <li>3. Drink <b>clean, treated water</b>.</li> <li>4. Avoid <b>sharing utensils</b> or food in unhygienic conditions.</li> </ol> <hr/> <p><b>5. Pathogens spread through body fluids (e.g., Ebola):</b>  <b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li>1. Wear <b>protective clothing (PPE)</b> when caring for infected individuals.</li> <li>2. Avoid direct contact with <b>blood or bodily fluids</b> of infected persons.</li> <li>3. Properly <b>disinfect contaminated surfaces and instruments</b>.</li> <li>4. Implement <b>quarantine and screening</b> procedures during outbreaks.</li> </ol> <hr/> <p>By applying the appropriate prevention methods for each mode of transmission, the spread of communicable diseases can be significantly controlled.</p>
<p><b>SB5f Virus life cycles</b></p>	
<p>Describe the structure of a virus.</p>	<p>Structure of a Virus (SB5f – Virus Life Cycles)</p> <p>A virus is a <b>non-cellular</b> infectious agent with a simple structure. It is much smaller than bacteria and consists of the following basic components:</p> <hr/> <ol style="list-style-type: none"> <li>1. Genetic Material:             <ol style="list-style-type: none"> <li>1. <b>Either DNA or RNA</b>, never both.</li> <li>2. Contains the instructions to make new virus particles.</li> <li>3. This genetic material takes over the host cell's machinery.</li> </ol> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>2. Protein Coat (Capsid):             <ol style="list-style-type: none"> <li>1. A <b>protective outer shell</b> made of protein.</li> <li>2. Surrounds and protects the viral genetic material.</li> <li>3. Helps the virus attach to and enter host cells.</li> </ol> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>3. Attachment Proteins (Spikes):             <ol style="list-style-type: none"> <li>1. Found on the surface of the capsid or viral envelope.</li> <li>2. <b>Allow the virus to bind</b> to specific receptor sites on host cells.</li> <li>3. These proteins determine which organisms or cell types the virus can infect.</li> </ol> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>4. (Optional) Lipid Envelope:             <ol style="list-style-type: none"> <li>1. Some viruses (e.g., influenza, HIV) have an <b>outer lipid envelope</b> derived from the host cell membrane.</li> <li>2. Contains <b>embedded proteins</b> that help in infection.</li> <li>3. Makes them more susceptible to disinfectants.</li> </ol> </li> </ol> <hr/> <p><b>Summary:</b> A virus is made up of genetic material (DNA or RNA), a protein coat called a capsid, and sometimes an outer lipid envelope. Attachment proteins on its surface allow it to infect specific host cells.</p>
<p>Explain how viruses differ from cells.</p>	<p>How Viruses Differ from Cells</p>

Viruses are **very different from cells** in both structure and function. Here's a clear comparison:

### 1. Structure

Feature	Viruses	Cells (e.g., human or bacterial)
<b>Cell structure</b>	Not made of cells	Made of one or more cells
<b>Organelles</b>	No organelles (no nucleus, mitochondria, etc.)	Have organelles to carry out life processes
<b>Membrane</b>	May or may not have a lipid envelope	Always have a cell membrane (and often a cell wall)
<b>Size</b>	Much smaller (typically 20–400 nanometres)	Larger (typically 1–100 micrometres)

### 2. Genetic Material

- **Viruses:** Have either DNA or RNA (never both).
- **Cells:** Contain **both DNA and RNA** for normal cellular processes.

### 3. Life Processes

Process	Viruses	Cells
<b>Reproduction</b>	Can only reproduce inside host cells	Reproduce independently (mitosis/meiosis)
<b>Metabolism</b>	No metabolism	Carry out metabolic reactions
<b>Growth</b>	Do not grow	Grow and divide
<b>Response to stimuli</b>	No response	Can respond to the environment

### 4. Living or Non-living?

- **Viruses** are considered **non-living** because they:
  - Cannot reproduce on their own
  - Do not carry out metabolism
- **Cells** are **living units** of organisms.

### ✓ Summary

Viruses are **non-living particles** that lack cell structures and can only reproduce by infecting living cells. Cells are **living units** that can grow, reproduce, and perform all life processes independently.

Describe the lytic pathway of a virus life cycle.

The Lytic Pathway of a Virus Life Cycle

The **lytic pathway** is one of the two main ways viruses reproduce. In this process, the virus **hijacks a host cell** to make copies of itself, eventually destroying the host cell.

### Steps of the Lytic Pathway:

#### 1. Attachment

The virus attaches to the surface of a **specific host cell**, matching with receptor proteins on the cell membrane.

#### 2. Injection / Entry

The virus **injects its genetic material** (DNA or RNA) into the host cell. In some cases, the entire virus enters the cell.

#### 3. Replication

The viral genetic material **takes control** of the host cell's machinery. It directs the cell to:

Copy the viral genetic material

Produce viral proteins (e.g. capsid proteins)

	<p>4. <b>Assembly</b> The newly made viral genetic material and proteins are <b>assembled into complete viruses</b> inside the host cell.</p> <p>5. <b>Lysis (Bursting)</b> The host cell <b>bursts (lyses)</b>, releasing <b>many new viruses</b> into the surroundings, ready to infect other cells.</p> <hr/> <p>Key Features of the Lytic Pathway:</p> <ul style="list-style-type: none"> <li>• <b>Fast process</b> (can take just hours)</li> <li>• <b>Destroys the host cell</b></li> <li>• Leads to <b>symptoms of infection quickly</b></li> <li>• Example viruses: <b>Influenza, T4 bacteriophage</b></li> </ul> <hr/> <p>Memory Tip: <b>“Lytic = Lyses (burst)”</b> — the cell is destroyed at the end of the cycle.</p>															
<p>Describe the lysogenic pathway of a virus life cycle</p>	<p>The Lysogenic Pathway of a Virus Life Cycle The <b>lysogenic pathway</b> is a viral reproduction method where the virus <b>does not destroy the host cell immediately</b>. Instead, the virus <b>inserts its genetic material into the host's DNA</b> and lies dormant for a time.</p> <hr/> <p>🔄 Steps of the Lysogenic Pathway:</p> <ol style="list-style-type: none"> <li>1. <b>Attachment</b> The virus <b>attaches</b> to the surface of a specific host cell.</li> <li>2. <b>Injection / Entry</b> The virus <b>injects its genetic material</b> (DNA or RNA) into the host cell.</li> <li>3. <b>Integration</b> The viral DNA becomes <b>incorporated into the host's DNA</b>. This viral DNA is now called a <b>provirus</b> (in animal cells) or <b>prophage</b> (in bacteria).</li> <li>4. <b>Dormancy (Latency)</b> The virus <b>remains inactive</b> inside the host cell. Each time the host cell divides, it <b>copies the viral DNA</b> along with its own. The virus is <b>invisible to the immune system</b> during this stage.</li> <li>5. <b>Trigger to Lytic Cycle</b> A change in conditions (e.g. stress, radiation, chemicals) can <b>activate the virus</b>, causing it to <b>enter the lytic pathway</b>: <ul style="list-style-type: none"> <li>• Viral DNA takes over the cell</li> <li>• The virus is copied and assembled</li> <li>• The cell eventually <b>bursts</b>, releasing new viruses</li> </ul> </li> </ol> <hr/> <p>Key Differences:</p> <table border="1" data-bbox="528 1559 1396 1742"> <thead> <tr> <th>Feature</th> <th>Lytic Pathway</th> <th>Lysogenic Pathway</th> </tr> </thead> <tbody> <tr> <td>Cell destruction</td> <td>Immediate</td> <td>Delayed</td> </tr> <tr> <td>Viral activity</td> <td>Active replication</td> <td>Dormant integration</td> </tr> <tr> <td>Symptoms</td> <td>Quick onset</td> <td>Delayed or hidden</td> </tr> <tr> <td>DNA status</td> <td>Separate from host DNA</td> <td>Integrated into host DNA</td> </tr> </tbody> </table> <hr/> <p>Memory Tip: <b>“Lysogenic = Latent”</b> — the virus stays hidden and quiet before attacking.</p>	Feature	Lytic Pathway	Lysogenic Pathway	Cell destruction	Immediate	Delayed	Viral activity	Active replication	Dormant integration	Symptoms	Quick onset	Delayed or hidden	DNA status	Separate from host DNA	Integrated into host DNA
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<p>Compare and contrast the lytic and lysogenic pathways.</p>	<p>Here's a clear <b>comparison and contrast</b> between the <b>lytic</b> and <b>lysogenic</b> pathways of viral replication:</p> <hr/> <p>Lytic vs. Lysogenic Pathways</p> <table border="1" data-bbox="528 1995 1469 2029"> <thead> <tr> <th>Feature</th> <th>Lytic Pathway</th> <th>Lysogenic Pathway</th> </tr> </thead> </table>	Feature	Lytic Pathway	Lysogenic Pathway												
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Calculate the cross-sectional area of viral cultures and clear agar jelly	<p>To <b>calculate the cross-sectional area of viral cultures or clear zones</b> (also called <i>plaques</i>) on agar jelly, we typically assume they are <b>circular</b>, and use the formula for the area of a circle:</p> <hr/> <p>Formula:  Area= <math>\pi r^2</math>  Where:  <math>\pi</math>= radius of the clear zone (in mm or cm)  <math>\pi \approx 3.14</math> (pi approx 3.14)</p> <hr/> <p>✓ Example:  If the clear zone (plaque) has a <b>diameter of 10 mm</b>, then the <b>radius</b> is:  <math>r = \frac{10}{2} = 5 \text{ mm}</math>  Area= <math>3.14 \times 5^2 = 3.14 \times 25 = 78.5 \text{ mm}^2</math></p> <hr/> <p>Application in Biology:</p> <ul style="list-style-type: none"> <li>• Larger <b>clear zones</b> mean <b>more effective viral killing</b> of bacteria or <b>greater virus replication</b>.</li> <li>• Comparing areas helps assess <b>virus strength</b> or the <b>effectiveness of disinfectants/antibiotics</b>.</li> </ul>																								
<b>SB5g Plant defences</b>																									
Describe some physical barriers of plants to pests and pathogens	<p>plants have several <b>physical barriers</b> that help protect them from pests and pathogens. These include:</p> <hr/> <p>🌿 Physical Barriers in Plants:</p> <p>6. <b>Waxy Cuticle:</b></p> <ol style="list-style-type: none"> <li>a. A waterproof layer on the surface of leaves and stems.</li> <li>b. Acts as a barrier to prevent water loss and stop pathogens from entering.</li> </ol>																								

	<p>7. <b>Cell Walls:</b></p> <ul style="list-style-type: none"> <li>a. Made of tough cellulose, providing structural support.</li> <li>b. Forms a barrier that is difficult for pathogens to penetrate.</li> </ul> <p>8. <b>Bark (in woody plants):</b></p> <ul style="list-style-type: none"> <li>a. Outer protective layer of tree trunks and branches.</li> <li>b. Acts like a tough shield against pests and pathogens.</li> </ul> <p>9. <b>Leaf Fall:</b></p> <ul style="list-style-type: none"> <li>a. Infected leaves may fall off to prevent the spread of disease to healthy parts of the plant.</li> </ul> <p>10. <b>Thorns and Hairs:</b></p> <ul style="list-style-type: none"> <li>a. Thorns deter animals from eating the plant.</li> <li>b. Hair-like structures can trap insects and limit access to the plant surface.</li> </ul> <hr/> <p>These physical defences work alongside chemical barriers (e.g. antibacterial chemicals, poisons) to help plants survive attacks.</p>
<p>Describe some chemical defence of plants to pests and pathogens</p>	<p>plants also have <b>chemical defences</b> to protect themselves against pests and pathogens.</p> <hr/> <p>🌿 Chemical Defences in Plants:</p> <ol style="list-style-type: none"> <li>1. <b>Antibacterial Chemicals:</b> <ul style="list-style-type: none"> <li>a. Kill bacteria or inhibit their growth.</li> <li>b. Example: <i>Mint</i> and <i>witch hazel</i> produce natural antibacterial substances.</li> </ul> </li> <li>2. <b>Antifungal Chemicals:</b> <ul style="list-style-type: none"> <li>a. Prevent the growth of fungi on leaves or stems.</li> <li>b. Example: Some types of pine trees produce resin that has antifungal properties.</li> </ul> </li> <li>3. <b>Poisons and Toxins:</b> <ul style="list-style-type: none"> <li>a. Deter herbivores from eating the plant by making it taste bad or causing harm.</li> <li>b. Example: <i>Deadly nightshade</i> and <i>foxglove</i> produce toxins that affect animal nervous systems.</li> </ul> </li> <li>4. <b>Insect-Repelling Chemicals:</b> <ul style="list-style-type: none"> <li>a. Some plants release substances that drive away insects.</li> <li>b. Example: <i>Lavender</i> and <i>citrus plants</i> produce natural insect repellents.</li> </ul> </li> </ol> <hr/> <p>These chemical defences often work together with <b>physical barriers</b> (like the waxy cuticle and thorns) to form a strong, two-layered protection system.</p>
<p>Describe how plant protective chemicals are used to treat human diseases or symptoms</p>	<p>Plants produce many <b>protective chemicals</b> that are not only useful for their own defence but have also been developed into <b>medicines</b> to treat human diseases and symptoms.</p> <hr/> <p>🌿 How Plant Protective Chemicals Are Used in Medicine:</p> <ol style="list-style-type: none"> <li>1. <b>Pain Relief:</b> <ul style="list-style-type: none"> <li>a. <b>Willow bark</b> contains a chemical called <b>salicin</b>, which has been developed into <b>aspirin</b>.</li> <li>b. Aspirin is widely used to reduce pain, inflammation, and fever.</li> </ul> </li> <li>2. <b>Heart Conditions:</b> <ul style="list-style-type: none"> <li>a. <b>Foxglove</b> (<i>Digitalis</i>) produces chemicals called <b>cardiac glycosides</b>.</li> <li>b. These are used to make the medicine <b>digitalin</b>, which helps regulate heartbeats in patients with heart problems.</li> </ul> </li> <li>3. <b>Cancer Treatment:</b></li> </ol>

	<p>a. The <b>periwinkle plant</b> produces compounds used in chemotherapy drugs like <b>vincristine</b> and <b>vinblastine</b>, which are effective in treating cancers such as leukaemia and lymphoma.</p> <p>4. <b>Anti-malarial:</b></p> <p>a. The <b>cinchona tree</b> bark contains <b>quinine</b>, a compound historically used to treat <b>malaria</b>.</p> <p>5. <b>Antibacterial and Antiviral Agents:</b></p> <p>a. Some plants (e.g., <b>tea tree, garlic</b>) produce <b>antimicrobial compounds</b> that can kill or stop the growth of bacteria and viruses. These are often used in natural remedies and being researched for medical applications.</p> <hr/> <p>✓ Summary: Plants create <b>natural defence chemicals</b> to protect themselves. Many of these have been adapted by scientists into <b>effective treatments for human illnesses</b>, demonstrating the close link between plant biology and modern medicine.</p>
<p>Describe examples of aseptic technique.</p>	<p><b>Aseptic techniques</b> are methods used to prevent contamination by unwanted microorganisms during experiments, especially when culturing bacteria or handling pathogens. These techniques help protect both the person doing the work and the integrity of the experiment.</p> <hr/> <p>☒ Examples of Aseptic Techniques:</p> <ol style="list-style-type: none"> <li><b>Washing hands and wearing gloves</b> <ul style="list-style-type: none"> <li>To reduce the number of microorganisms on the skin.</li> </ul> </li> <li><b>Disinfecting work surfaces</b> <ul style="list-style-type: none"> <li>Kills any microbes that could contaminate the experiment.</li> </ul> </li> <li><b>Sterilising equipment (e.g. with an autoclave or flame)</b> <ul style="list-style-type: none"> <li>Inoculating loops are passed through a flame until red hot.</li> <li>Petri dishes, pipettes, and other tools are sterilised before use.</li> </ul> </li> <li><b>Opening culture containers as briefly as possible</b> <ul style="list-style-type: none"> <li>Minimises exposure to airborne microbes.</li> </ul> </li> <li><b>Keeping Petri dish lids slightly open and at an angle when working</b> <ul style="list-style-type: none"> <li>Prevents microbes from falling in from the air.</li> </ul> </li> <li><b>Working near a Bunsen burner flame</b> <ul style="list-style-type: none"> <li>The rising hot air helps carry airborne contaminants away from the workspace.</li> </ul> </li> <li><b>Taping Petri dishes closed</b> <ul style="list-style-type: none"> <li>Prevents accidental opening and reduces the risk of contamination.</li> </ul> </li> <li><b>Incubating cultures at 25°C in schools (not body temperature)</b> <ul style="list-style-type: none"> <li>This avoids encouraging the growth of dangerous pathogens.</li> </ul> </li> </ol> <hr/> <p>✓ Summary: Aseptic techniques are essential for safe and reliable microbiology work. They help prevent contamination, protect the experimenter, and ensure valid results. Let me know if you'd like a diagram or quick quiz to go with this!</p>
<p>Explain why aseptic technique is used during the culture of microorganisms</p>	<p><b>Aseptic technique</b> is used during the culture of microorganisms to:</p> <hr/> <ol style="list-style-type: none"> <li>Prevent contamination of the culture <ul style="list-style-type: none"> <li>To ensure <b>only the desired microorganism</b> is grown.</li> <li>Avoids <b>unwanted microbes</b> (e.g. bacteria, fungi) entering the culture from the air, equipment, or hands.</li> </ul> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>Protect the person handling the culture</li> </ol>

	<ul style="list-style-type: none"> <li>• Stops <b>harmful microorganisms</b> from being accidentally inhaled, ingested, or spread to skin or surfaces.</li> <li>• Reduces the <b>risk of infection</b> or illness.</li> </ul> <hr/> <p>3. Ensure reliable and accurate results</p> <ul style="list-style-type: none"> <li>• Keeps the experiment <b>scientifically valid</b>, so conclusions are based on a <b>pure culture</b>.</li> <li>• Helps identify the effects of substances like antibiotics without interference from other organisms.</li> </ul> <hr/> <p>4. Prevent the spread of potentially harmful microbes</p> <ul style="list-style-type: none"> <li>• Stops microorganisms from escaping into the <b>school lab environment</b>, where they could cause harm.</li> </ul> <hr/> <p>Summary: Aseptic technique is essential to maintain safety, ensure valid scientific results, and protect both people and the environment from contamination.</p>
<p><b>SB5i Physical and chemical barriers</b></p>	
<p>Explain how the spread of the STIs Chlamydia and HIV can be reduced or prevented.</p>	<p>To reduce or prevent the spread of <b>STIs</b> like <b>Chlamydia</b> and <b>HIV</b>, both <b>physical</b> and <b>chemical barriers</b> can be used, along with behavioural strategies.</p> <hr/> <p><b>Chlamydia</b></p> <ol style="list-style-type: none"> <li>1. Caused by a <b>bacterium</b>.</li> <li>2. Spread through <b>unprotected sexual contact</b>.</li> </ol> <p><b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li>1. <b>Condoms</b> (Physical barrier) <ul style="list-style-type: none"> <li>– Using male or female condoms correctly during sex prevents the bacteria from passing between partners.</li> </ul> </li> <li>2. <b>Screening and treatment</b> <ul style="list-style-type: none"> <li>– Regular STI testing and <b>antibiotic treatment</b> help detect and cure infections early, reducing further spread.</li> </ul> </li> <li>3. <b>Abstinence or limiting sexual partners</b> <ul style="list-style-type: none"> <li>– Reduces the chance of exposure.</li> </ul> </li> </ol> <hr/> <p><b>HIV (Human Immunodeficiency Virus)</b></p> <ul style="list-style-type: none"> <li>• A <b>virus</b> that attacks the immune system.</li> <li>• Spread through <b>sexual contact</b>, <b>blood-to-blood contact</b>, and <b>mother-to-baby transmission</b>.</li> </ul> <p><b>Prevention methods:</b></p> <ol style="list-style-type: none"> <li>1. <b>Condoms</b> (Physical barrier) <ul style="list-style-type: none"> <li>– Prevents virus transmission during sex.</li> </ul> </li> <li>2. <b>Antiviral drugs (ARVs)</b> (Chemical barrier) <ul style="list-style-type: none"> <li>– People living with HIV take ARVs to reduce viral load and make transmission less likely.</li> <li>– Pregnant women with HIV take ARVs to prevent passing it to the baby.</li> </ul> </li> <li>3. <b>Avoid sharing needles</b> <ul style="list-style-type: none"> <li>– Important for drug users or in medical settings.</li> </ul> </li> <li>4. <b>Screening blood donations</b> <ul style="list-style-type: none"> <li>– Ensures HIV is not passed through blood transfusions.</li> </ul> </li> <li>5. <b>Education</b> <ul style="list-style-type: none"> <li>– Teaching safe sex and HIV awareness helps people make informed decisions.</li> </ul> </li> </ol> <hr/> <p>Summary:</p>

	<b>Disease</b>	<b>Type</b>	<b>Prevention</b>
	Chlamydia	Bacterial	Condoms, antibiotics, screening
	HIV	Viral	Condoms, antiviral drugs, safe needle use, screening blood
Give examples of physical barriers	<p>Physical Barriers in Humans:</p> <ol style="list-style-type: none"> <li>1. <b>Skin</b> – Acts as a tough, waterproof barrier preventing entry of pathogens.</li> <li>2. <b>Nasal hairs</b> – Trap dust, dirt, and microbes when breathing in through the nose.</li> <li>3. <b>Mucus in the respiratory tract</b> – Sticky fluid traps pathogens in the nose, trachea, and bronchi.</li> <li>4. <b>Cilia (in the airways)</b> – Tiny hair-like structures that move mucus (with trapped pathogens) out of the lungs toward the throat.</li> <li>5. <b>Stomach acid</b> – Although chemical, it's often included because it destroys swallowed microbes.</li> </ol> <hr/> <p>Physical Barriers in Plants:</p> <ol style="list-style-type: none"> <li>1. <b>Waxy cuticle on leaves</b> – Prevents pathogens from entering through the leaf surface.</li> <li>2. <b>Cell walls</b> – Made of cellulose, they provide a strong barrier to fungal and bacterial invasion.</li> <li>3. <b>Bark on trees</b> – Acts like skin for plants, shielding the inner tissues from attack.</li> </ol>		
Give examples of chemical barriers	<p>Here are <b>examples of chemical barriers</b> that help protect the body from infection:</p> <hr/> <p>☒ Chemical Barriers in Humans:</p> <ol style="list-style-type: none"> <li>1. <b>Stomach acid (hydrochloric acid)</b> – Kills most pathogens that enter the stomach with food or drink.</li> <li>2. <b>Lysozymes in tears and saliva</b> – Enzymes that break down bacterial cell walls, helping to kill microbes.</li> <li>3. <b>Mucus (with antimicrobial enzymes)</b> – In the respiratory tract, it traps and helps destroy pathogens.</li> <li>4. <b>Sebum (from skin glands)</b> – Has antimicrobial properties that can kill or slow the growth of certain microbes.</li> </ol> <hr/> <p>☞ Chemical Barriers in Plants:</p> <ol style="list-style-type: none"> <li>1. <b>Antibacterial chemicals</b> – Kill bacteria and are found in many plants (e.g., mint and garlic).</li> <li>2. <b>Antifungal chemicals</b> – Inhibit the growth of fungi and protect the plant's tissues.</li> <li>3. <b>Toxins</b> – Some plants produce toxins to deter pests and pathogens (e.g., nicotine in tobacco plants).</li> </ol>		
Describe how physical barriers protect the body (e.g. skin, mucus and cilia)	<p><b>Physical barriers</b> are the body's first line of defence against pathogens. They help to <b>block the entry</b> of harmful microorganisms like bacteria, viruses, and fungi. Here's how they work:</p> <hr/> <ol style="list-style-type: none"> <li>1. Skin <ul style="list-style-type: none"> <li>• <b>Acts as a tough outer layer</b> that covers the whole body.</li> <li>• Made of several layers of cells that are tightly packed, preventing microbes from entering.</li> <li>• <b>Produces natural oils (sebum)</b> that can kill bacteria.</li> <li>• If unbroken, it's a highly effective barrier to most pathogens.</li> </ul> </li> </ol> <hr/> <ol style="list-style-type: none"> <li>☞ 2. Mucus (in nose, throat, lungs, etc.)</li> </ol>		

	<ul style="list-style-type: none"> <li>• <b>Sticky substance</b> secreted by cells lining the respiratory and digestive tracts.</li> <li>• <b>Traps pathogens</b>, dust, and particles before they can enter deeper into the body.</li> <li>• Helps stop infections from reaching the lungs or stomach.</li> </ul> <hr/> <p> 3. Cilia (tiny hairs in the airways)</p> <ul style="list-style-type: none"> <li>• Found on the surface of cells lining the <b>nose, trachea, and bronchi</b>.</li> <li>• <b>Wave-like movements</b> push mucus (with trapped pathogens) up and out of the airways — either to be <b>coughed out or swallowed</b> into the stomach (where stomach acid kills microbes).</li> </ul> <hr/> <p>Summary: Physical barriers <b>form a shield</b> around the body to <b>prevent infection</b>. They work best alongside chemical barriers and the immune system.</p>
<p>Describe how chemical barriers protect the body (e.g. lysozymes, hydrochloric acid)</p>	<p><b>Chemical barriers</b> protect the body by <b>killing or weakening pathogens</b> before they can cause harm. These chemicals are naturally produced by the body and work alongside physical barriers to defend against infection.</p> <hr/> <p>1. Lysozymes (enzymes in tears, saliva, and mucus)</p> <ul style="list-style-type: none"> <li>• Found in <b>tears, saliva, nasal mucus, and other secretions</b>.</li> <li>• Lysozymes are <b>enzymes</b> that break down the <b>cell walls of bacteria</b>, causing them to burst and die.</li> <li>• Help protect areas like the <b>eyes, mouth, and nose</b> from infection.</li> </ul> <hr/> <p>2. Hydrochloric acid (in the stomach)</p> <ul style="list-style-type: none"> <li>• Found in <b>gastric juice</b> produced by the stomach lining.</li> <li>• <b>Very acidic (pH 1–2)</b> — strong enough to <b>kill most bacteria and viruses</b> swallowed in food or mucus.</li> <li>• Helps prevent infections from reaching the <b>intestines</b>.</li> </ul> <hr/> <p>3. Sebum (skin oil)</p> <ul style="list-style-type: none"> <li>• Produced by <b>sebaceous glands</b> in the skin.</li> <li>• Contains <b>fatty acids</b> and other chemicals that are <b>antibacterial and antifungal</b>.</li> <li>• Helps protect the <b>surface of the skin</b> from microbial growth.</li> </ul> <hr/> <p>Summary: Chemical barriers <b>actively destroy pathogens</b> or make the environment <b>unfavourable for them to survive</b>, helping to <b>prevent infection</b> before it starts.</p>
<p><b>SB5j The immune system</b></p>	
<p>State that the immune system protects the body by attacking pathogens</p>	<p>The immune system protects the body by identifying and attacking pathogens such as bacteria, viruses, and other harmful microorganisms to prevent infection and disease.</p>
<p>Describe how antigens trigger the release of antibodies and the production of memory lymphocytes</p>	<p>When a pathogen enters the body, its surface molecules called antigens are recognized as foreign by the immune system. This triggers specific white blood cells, called lymphocytes, to respond.</p> <p>First, B-lymphocytes produce antibodies that specifically bind to these antigens, marking the pathogens for destruction or neutralization. At the same time, some of these B-lymphocytes develop into memory lymphocytes. These memory cells remain in the body long-term, enabling a faster and</p>

	<p>stronger immune response if the same antigen is encountered again in the future.</p>
<p>Describe the role of antibodies in the immune response.</p>	<p>Antibodies are proteins produced by B-lymphocytes in response to the presence of antigens on pathogens. Their role in the immune response includes:</p> <ol style="list-style-type: none"> <li>1. <b>Binding specifically to antigens</b> on the surface of pathogens, which helps to neutralize or disable the harmful effects of the pathogen.</li> <li>2. <b>Marking pathogens for destruction</b> by other immune cells such as phagocytes, making it easier for the immune system to identify and eliminate the invaders.</li> <li>3. <b>Clumping pathogens together</b> (agglutination), which prevents them from spreading and makes them easier targets for immune cells.</li> </ol> <p>Overall, antibodies help the immune system to target and remove harmful pathogens effectively.</p>
<p>Describe the role of memory lymphocytes in triggering a secondary response</p>	<p>Memory lymphocytes play a crucial role in the immune system’s ability to respond faster and more effectively to a pathogen that the body has encountered before. Here’s how they work:</p> <ul style="list-style-type: none"> <li>• After the first infection, some B and T lymphocytes become memory cells.</li> <li>• These memory lymphocytes “remember” the specific antigens of the pathogen.</li> <li>• If the same pathogen enters the body again, memory lymphocytes quickly recognize it.</li> <li>• They trigger a faster and stronger immune response, known as the <b>secondary response</b>.</li> <li>• This rapid response often prevents the person from becoming ill or reduces the severity of the illness.</li> </ul> <p>In summary, memory lymphocytes enable long-term immunity by ensuring the body can respond swiftly and efficiently to repeat infections.</p>
<p>Explain how immunisation protects against infection by a pathogen</p>	<p>Immunisation protects against infection by introducing a safe form of a pathogen (such as a weakened, inactive, or part of the pathogen) into the body. This stimulates the immune system to respond without causing illness. Here’s how it works:</p> <ul style="list-style-type: none"> <li>• The immune system recognizes the introduced antigen and produces specific antibodies against it.</li> <li>• Memory lymphocytes are also produced, which “remember” the pathogen.</li> <li>• If the real pathogen later infects the body, the immune system can quickly recognize and attack it.</li> <li>• This fast response prevents the infection from developing or reduces its severity.</li> </ul> <p>Therefore, immunisation helps the body build immunity without experiencing the actual disease, protecting the person from future infections by that pathogen.</p>
<p>Discuss advantages and disadvantages of immunisation including herd immunity.</p>	<p>Here’s a discussion on the advantages and disadvantages of immunisation, including the concept of herd immunity:</p> <hr/> <p><b>Advantages of Immunisation</b></p> <ul style="list-style-type: none"> <li>• <b>Prevention of Infectious Diseases:</b> Immunisation protects individuals from serious and potentially life-threatening diseases by preparing the immune system to fight specific pathogens.</li> </ul>

	<ul style="list-style-type: none"> <li>● <b>Herd Immunity:</b> When a high percentage of a population is immunised, it reduces the overall spread of disease, protecting those who cannot be vaccinated (e.g., infants, elderly, or immunocompromised individuals).</li> <li>● <b>Reduction in Disease Outbreaks:</b> Vaccination programs have significantly decreased or even eradicated diseases such as smallpox and have reduced the incidence of polio, measles, and whooping cough.</li> <li>● <b>Cost-Effective Public Health Strategy:</b> Preventing disease through vaccines reduces the need for medical treatments and hospital stays, lowering healthcare costs and economic burden.</li> <li>● <b>Long-Term Protection:</b> Many vaccines provide long-lasting immunity, sometimes lifelong, reducing the need for repeated treatments.</li> </ul> <hr/> <p><b><u>Disadvantages of Immunisation</u></b></p> <ul style="list-style-type: none"> <li>● <b>Side Effects:</b> Some individuals may experience mild to moderate side effects like soreness, fever, or allergic reactions. Severe adverse reactions are very rare but possible.</li> <li>● <b>Incomplete Immunity:</b> No vaccine is 100% effective. Some vaccinated individuals might not develop full immunity, requiring booster shots.</li> <li>● <b>Access and Availability Issues:</b> In some regions, vaccines may not be easily accessible due to cost, supply chain problems, or lack of healthcare infrastructure.</li> <li>● <b>Vaccine Hesitancy and Misinformation:</b> Concerns about vaccine safety or misinformation can lead to lower vaccination rates, reducing herd immunity and increasing the risk of outbreaks.</li> <li>● <b>Pathogen Evolution:</b> In rare cases, pathogens can evolve and develop resistance to vaccines, requiring updates to vaccines (e.g., influenza vaccines).</li> </ul> <hr/> <p>Herd Immunity  <b>Definition:</b> Herd immunity occurs when a significant proportion of a population is immunised, making the spread of infectious disease unlikely and protecting those who are not immune.  <b>Importance:</b> It helps protect vulnerable groups who cannot be vaccinated due to medical reasons and reduces overall disease transmission.  <b>Challenges:</b> Achieving herd immunity requires a high vaccination coverage, which can be undermined by vaccine hesitancy or logistical barriers.</p>
<b>SB5k Antibiotics</b>	
Define the term antibiotic (as medicines that inhibit cell processes in bacteria)	An <b>antibiotic</b> is a medicine that inhibits the growth or kills bacteria by interfering with their essential cell processes, such as cell wall synthesis, protein production, or DNA replication.
Explain why antibiotics are useful for treating bacterial infections (because they do not damage human cell processes).	Antibiotics are useful for treating bacterial infections because they specifically target processes unique to bacterial cells, such as cell wall synthesis or bacterial protein production, which are not found in human cells. This means antibiotics can kill or inhibit bacteria without damaging human cell processes, making them effective and safe for treating bacterial infections.

<p>Explain why antibiotics cannot be used to treat infections by pathogens other than bacteria</p>	<p>Antibiotics cannot be used to treat infections caused by pathogens other than bacteria—such as viruses, fungi, or protists—because antibiotics specifically target bacterial cell processes. These processes, like cell wall synthesis or certain bacterial enzymes, are absent in viruses and other types of pathogens. Therefore, antibiotics have no effect on viruses or non-bacterial organisms and cannot cure infections caused by them.</p>
<p>Describe the stages of development of new medicines</p>	<p>The stages of development of new medicines typically include:</p> <ol style="list-style-type: none"> <li>1. <b>Discovery and Research:</b> Scientists identify potential compounds or substances that might have therapeutic effects, often through laboratory research and computer modeling.</li> <li>2. <b>Preclinical Testing:</b> The promising compounds are tested in the lab and on animals to evaluate safety, toxicity, dosage, and biological activity.</li> <li>3. <b>Clinical Trials (Human Testing):</b> This phase has three main stages: <ul style="list-style-type: none"> <li>• <b>Phase 1:</b> Small group of healthy volunteers to assess safety and dosage.</li> <li>• <b>Phase 2:</b> Larger group of patients to test effectiveness and side effects.</li> <li>• <b>Phase 3:</b> Large-scale testing on many patients to confirm effectiveness, monitor side effects, and compare with existing treatments.</li> </ul> </li> <li>4. <b>Regulatory Approval:</b> Data from trials is submitted to regulatory authorities (e.g., FDA, EMA) who review the evidence to approve or reject the medicine for public use.</li> <li>5. <b>Manufacturing and Marketing:</b> Once approved, the medicine is produced in large quantities and made available to patients.</li> <li>6. <b>Post-Market Surveillance:</b> Ongoing monitoring for long-term effects and rare side effects once the medicine is in general use.</li> </ol> <p>This entire process can take several years to ensure that new medicines are both safe and effective.</p>
<p>Explain why each stage of the development of a new medicine is needed.</p>	<p>Here's why each stage in the development of a new medicine is essential:</p> <ol style="list-style-type: none"> <li>1. <b>Discovery and Research:</b> <ul style="list-style-type: none"> <li>• To find potential compounds that could effectively treat a disease.</li> <li>• To understand how the compound might work and identify any initial risks or benefits.</li> </ul> </li> <li>2. <b>Preclinical Testing:</b> <ul style="list-style-type: none"> <li>• To check the safety and toxicity of the compound before giving it to humans.</li> <li>• To determine appropriate dosage and identify possible harmful effects.</li> </ul> </li> <li>3. <b>Clinical Trials:</b> <ul style="list-style-type: none"> <li>• <b>Phase 1:</b> Ensures the medicine is safe for humans and identifies safe dosage levels.</li> <li>• <b>Phase 2:</b> Tests if the medicine actually works in patients and monitors for side effects.</li> <li>• <b>Phase 3:</b> Confirms effectiveness on a larger scale, compares with existing treatments, and collects comprehensive safety data.</li> </ul> </li> <li>4. <b>Regulatory Approval:</b> <ul style="list-style-type: none"> <li>• To thoroughly review all evidence and ensure the medicine is safe and effective before it reaches the public.</li> <li>• To protect patients from unsafe or ineffective treatments.</li> </ul> </li> <li>5. <b>Manufacturing and Marketing:</b> <ul style="list-style-type: none"> <li>• To produce the medicine in consistent quality and quantity for widespread use.</li> <li>• To make the medicine available and accessible to those who need it.</li> </ul> </li> <li>6. <b>Post-Market Surveillance:</b></li> </ol>

	<ul style="list-style-type: none"><li>• To monitor long-term safety and effectiveness in the general population.</li><li>• To detect rare or delayed side effects that might not have appeared during trials.</li></ul> <p>Each stage is crucial to ensure that new medicines are both safe and beneficial before being widely used.</p>
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