BIOZONE

IB BIOLOGY

DIPLOMA PROGRAMME

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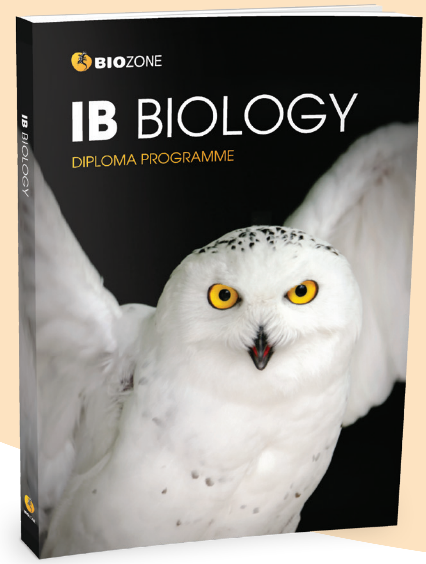
IB BIOLOGY



BIOZONE's **IB Biology** has been specifically written for the latest IB Biology Diploma programme (first assessed in 2025). This comprehensive title integrates BOTH **standard level** (SL) and **higher level** (HL) material, ensuring seamless delivery of the IB programme with no content gaps.

The structure of IB Biology has a thematic approach. It follows the **four themes** presented in the syllabus roadmap: **Unity and Diversity**, **Form and Function**, **Interaction and Interdependence**, and **Continuity and Change**. The delivery spirals, allowing exploration of the **four levels of organization** (molecules, cells, organisms, and ecosystems) within the context of each theme. A **Science Practices** chapter has been added at the end of the book that contains material to support students with the scientific investigation component of the program.

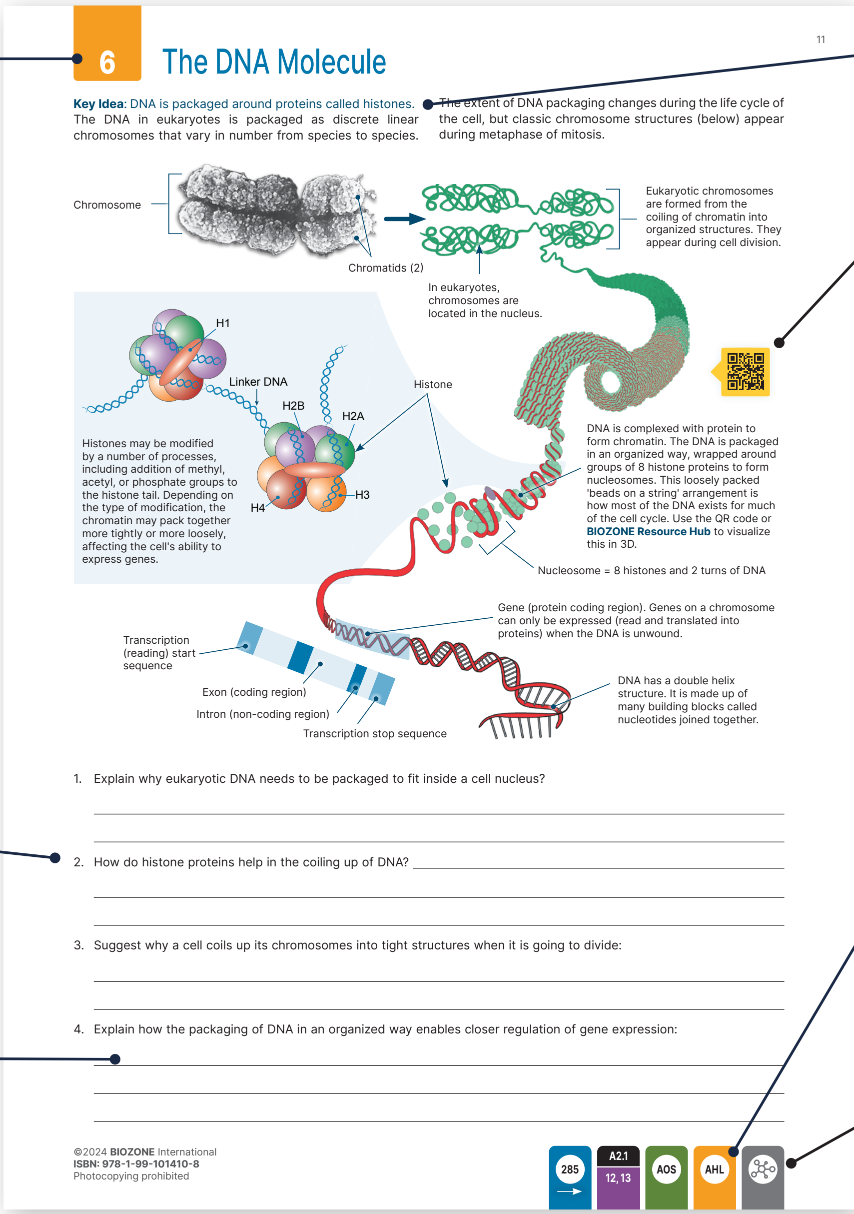
Activity number
Activities are numbered to make navigation through the book easier. SL activities are in blue, with AHL activities in orange.

Comprehensive, engaging diagrams
Engaging, high quality diagrams provide a visual focus whilst delivering important information in an accessible format.

Content organization
Logically organized content makes it easier for students to access and engage with the information.

Direct questioning
A direct questioning style helps students easily identify what is being asked.

Write-on answers
Students input their answers directly onto the page. This becomes their **record of work** and helps them revise for tests and exams.



6 The DNA Molecule

11

Key Idea: DNA is packaged around proteins called histones.

The DNA in eukaryotes is packaged as discrete linear chromosomes that vary in number from species to species. The extent of DNA packaging changes during the life cycle of the cell, but classic chromosome structures (below) appear during metaphase of mitosis.

1. Explain why eukaryotic DNA needs to be packaged to fit inside a cell nucleus?

2. How do histone proteins help in the coiling up of DNA?

3. Suggest why a cell coils up its chromosomes into tight structures when it is going to divide:

4. Explain how the packaging of DNA in an organized way enables closer regulation of gene expression:

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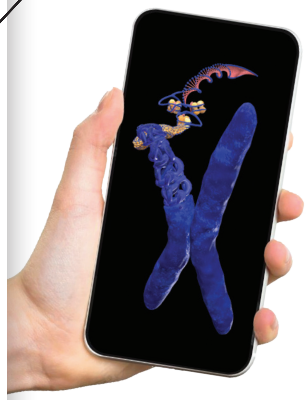
285 | A2.1 12, 13 | AOS | AHL

Key Idea
A key idea provides a primary focus for the activity. It helps students to understand where the activity's emphasis lies.

QR Codes
Scan QR codes to directly interact with 3D models (below).



Activity coding system
Tabs indicate if the Activity contains material covering Additional Higher Level, Nature of Science, and/or Application of Skills, and also the theme and content statements covered. Blue tabs indicated interconnectedness of content in other Activities.

Resource Hub
Grey tabs indicate that the Activity has relevant Open Educational Resources available in the Resource Hub (e.g. videos, interactives, 3D models).

www.**BIOZONE**.com/us/IB3

Chapter 1: Unity and Diversity

Molecules

A1.1 Water

Guiding Questions:
- What physical and chemical properties of water make it essential for life?
- What are the challenges and opportunities of water as a habitat?

Learning Outcomes:

		Learning Outcome	Activity Number
☐	1	Explain the significance of water as a medium for cellular processes, and a requirement for the origin of cells.	1
☐	2	Model a water molecule, showing the hydrogen bonding with correct notation.	1
☐	3	Link the property of water cohesion to its importance to biological processes, including transport in the xylem and movement of organisms on water due to surface tension.	1
☐	4	Link the property of water adhesion to materials, due to polarity, to its significance for organisms, including soil and plant cell wall capillary action.	1
☐	5	Explain how solvent properties of water allow it to function as a medium for plant and animal metabolism and transport in plants and animals, for both hydrophilic and hydrophobic molecules.	1
☐	6	Compare and contrast the physical properties of water and air, and how they impact the animals in aquatic habitats.	1
☐	7	**AHL:** Evaluate the extraplanetary asteroid hypothesis for the origin and retention of water on Earth.	2
☐	8	**AHL:** Explain the relationship between water on 'Goldilocks zone' planets and the possibility of finding extraterrestrial life.	2

A1.2 Nucleic acids

Guiding Questions:
- How does the structure of nucleic acids allow hereditary information to be stored?
- How does the structure of DNA facilitate accurate replication?

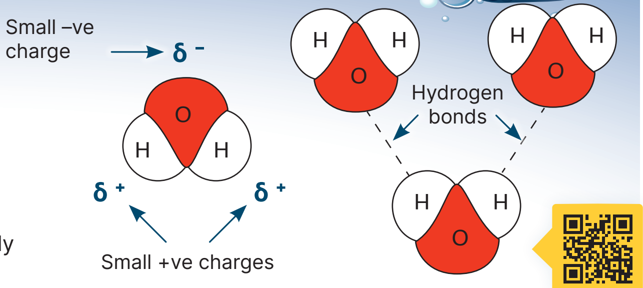
Learning Outcomes:

		Learning Outcome	Activity Number
☐	1	Identify DNA as the genetic material found in all living organisms.	3
☐	2	Use and draw models of a nucleotide, identifying the components.	3, 8
☐	3	Link the properties of the sugar–phosphate bonding to its role as the 'backbone' of DNA and RNA.	3, 5
☐	4	Recall nitrogenous base names in DNA and RNA.	3
☐	5	Understand that RNA polymers are formed by condensation of nucleotide monomers. Draw and recognise nucleotides and RNA polymers.	3
☐	6	Recognise DNA as a double helix. Use diagrams to show the two DNA strands as anti-parallel.	3, 8
☐	7	Draw diagrams to compare and contrast the components of DNA and RNA.	3, 5
☐	8	Explain how complementary base pairing enables DNA to function as genetic material. Base pairs are held together by hydrogen bonds.	3
☐	9	Link the structure of DNA to its ability to economically store huge quantities of information using almost limitless different sequence combinations.	3
☐	10	Explain that all living organisms using the same genetic code in DNA is evidence of common ancestry.	3
☐	11	**AHL:** Relate the DNA and RNA 5' to 3' linkage directionality to the processes of replication, transcription and translation.	4
☐	12	**AHL:** Explain the purpose of purine-to-pyrimidine bonding in enabling DNA helix stability.	4
☐	13	**AHL:** Understand that histone proteins make up the core of a nucleosome. **AOS:** Use digital molecular visualization to investigate the structure of a nucleosome.	6
☐	14	**AHL:** Understand how the Hershey Chase experiment supported the conclusion that DNA was the genetic material. **NOS:** Appreciate how technological developments provided tools for Hershey and Chase to carry out their investigation into DNA.	7
☐	15	**AHL: NOS:** Investigate Chargaff's pyrimidine and purine data, and how their ratios addressed the 'problem of induction' and falsified the tetranucleotide hypothesis.	7

1 Water in Living Systems

Key Idea: Water's molecular structure accounts for its properties and for its central role in life's processes.

Water (H_2O) is the main component of living things, and typically makes up about 70% of any organism. Water is important in cell chemistry as it takes part in, and is a common product of, many reactions. Its cohesive, adhesive, thermal, and solvent properties come about because of its polarity and its ability to form hydrogen bonds with other polar molecules. Water's physical and chemical properties are essential for sustaining life.

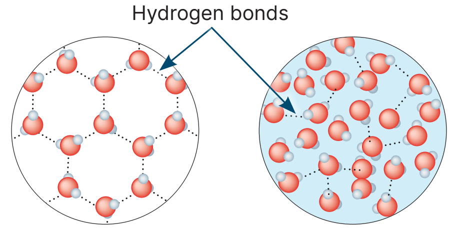


Water forms hydrogen bonds

A water molecule is polar, meaning it has a positively and a negatively charged region. In water, each oxygen has a slight negative charge (δ⁻) and each hydrogen has a slight positive charge (δ⁺). Water molecules form large numbers of weak hydrogen bonds with other water molecules (top right). Individually, hydrogen bonds are weak, but collectively, they are strong enough to account for the unique properties of water including its cohesion, high boiling point, high heat of fusion (energy required to cause a change of state from solid to liquid), and high latent heat of vaporization (below, right).

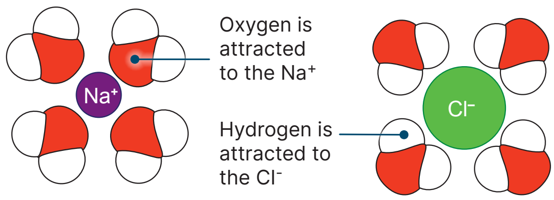
When water is in a liquid state, it has enough energy that hydrogen bonds are continually breaking and reforming. When water loses energy (e.g. cooled), the hydrogen bonds are strong enough to hold water molecules in place, forming a lattice which causes ice to expand. The expansion causes ice to be less dense than liquid water.

Intermolecular bonds between water and other polar molecules or ions are important for biological systems. Inorganic ions may have a positive or negative charge, e.g. positive sodium ion (Na^+) and negative chloride ion (Cl^-). The charged water molecules are attracted to charged ions and surround them. This formation of intermolecular bonds between water and the ions keeps ions dissolved in water. Polar molecules such as amino acids and carbohydrates also dissolve readily in water.



Ice: H-bonds are fixed in an interconnected framework.

Liquid water: H-bonds constantly break and reform.



Water surrounding a positive ion (Na^+)

Water surrounding a negative ion (Cl^-)

Cohesive properties

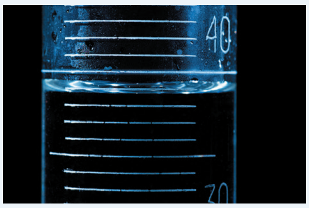
Water molecules are cohesive: they stick together because hydrogen bonds form between individual molecules. Cohesion allows water to form droplets and is responsible for the surface tension that many small organisms rely on.

Example: The cohesive and adhesive properties of water allow it to move as an unbroken column through the xylem of plants. This process is essential for water uptake from the soil.

Adhesive properties

Water is attracted to other molecules because of its polar nature. Water will form thin films and 'climb' up surfaces when the molecular forces between them (adhesive forces) are greater than the cohesive forces.

Example: Adhesion enables capillary action, i.e. the ability of a liquid to flow against gravity in a narrow space. This property is also shown by the meniscus of a liquid in a tube.



Solvent properties

Water's polarity allows it to dissociate ions in salts and bond to other polar substances, e.g. alcohols and acids, dissolving them. In contrast, non-polar substances such as fats and oils are not water soluble.

Example: Blood plasma in humans and other animals is largely water and transports many water-soluble substances, including ions, glucose, and amino acids, around the body.

Thermal properties

Water has the highest specific heat capacity of all liquids, so it takes a lot of energy before it will change temperature. It also has high latent heat of vaporization, so it takes a lot of energy to transform it from the liquid to the gas phase.

Examples: High specific heat capacity means that large water bodies will maintain a relatively stable temperature. High heat of vaporization makes sweating a very effective cooling mechanism.

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The importance of water in biological systems

micro_photo - Fotolia

Life originated in water and it still plays a major role in most of life's activities, such as metabolic processes, which depend on dissolved reactants (solutes) coming into contact. Water can also act as an acid (donating H^+) or a base (receiving H^+) in chemical reactions.

Water's cohesion is responsible for its high specific heat capacity (a function of its many hydrogen bonds). This means water bodies heat up and cool down only slowly, providing a relatively stable thermal environment. The greater the body of water, the more thermally stable it is.

Rido - stock.adobe.com

Water's high latent heat of vaporization means that a change of state from liquid to gas absorbs a lot of energy. When water in sweat evaporates from the skin's surface, it transfers heat from the body to the air, producing cooling. Panting, in animals that do not sweat, operates the same way.

NOAA

Aquatic animals need to regulate their buoyancy to maintain their position in the water column. Bony fish do this with a swim bladder. Some aquatic birds, such as the black throated loon, are able to compress the air in their lungs to reduce buoyancy and help diving.

yang yu - stock.adobe.com

Water is known as the universal solvent because many substances will dissolve in it. In natural waters, dissolved minerals, such as calcium, are available to aquatic organisms, e.g. shell building organisms such as the hard corals above.

Water's high thermal conductivity means it can quickly remove body heat from animals that are not insulated. Seals, e.g. ringed seal above, and other marine mammals have insulating layers of blubber to help retain their body heat. Out of water, these animals can run the risk of overheating.

1. Explain how water's molecular structure accounts for each of the following:

   a) Water's cohesion and high heat capacity: ______________________

   b) Water's solvent properties: ______________________

   c) Water's high latent heat of vaporization: ______________________

2. Use the diagrams opposite to explain why water is less dense in its solid form (as ice) than in its liquid form:

   ____

3. Summarize the ways in which living systems depend on the properties of water arising from its molecular structure:

   ____

4. Why do marine mammals risk overheating when out of water? ______________________

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2 The Origin of Earth's Water

Key Idea: As far as we know, Earth is the only place in the Universe where life exists. The presence of liquid water on the surface is an important factor for the presence of life.

There is one thing that life absolutely must have to survive: liquid water. Water is important as a medium for dissolved molecules and ions to carry out the reactions of life. Earth's water is thought to have been acquired through collisions with icy bodies and accretion of minerals and molecules from the original gas cloud from which the solar system formed. Water is also present on many moons in the solar system.

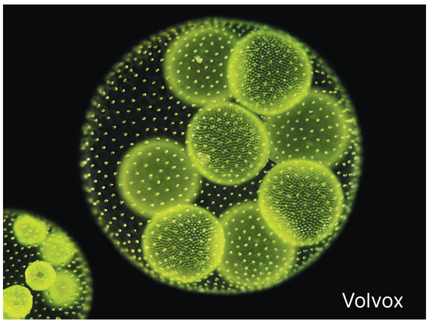
- It is thought that much of Earth's water arrived via collisions with icy bodies. Because of the distance from the Sun that Earth formed, liquid water is unlikely to have condensed during or soon after formation, although hydrated minerals may have been present.
- Evidence from the study of meteorites and comets shows that Earth's water is likely to have come from the impact of icy asteroids and planetesimals. The deuterium/hydrogen ratios of water in carbonaceous chondrite asteroids are similar to the ratios found on Earth. Comets, however, have a much higher deuterium/hydrogen ratio and so are unlikely to have delivered much water. It is thought that comets may have contributed only around 10% of Earth's water.

All three phases of water exist on Earth's surface.

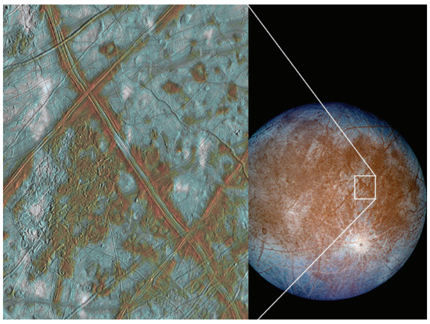
Earth's is positioned in the 'Goldilocks zone', not so far from the Sun that water on the surface freezes but not so close that it vaporizes.

Water and extraterrestrial life

Water is essential for life as we know it. Earth's position in the habitable zone of the solar system means it has a surface temperature where water can exist in all three phases. Earth's gravity is important in being able to hold on to its water, stopping it from evaporating into space (unlike Mars for example).

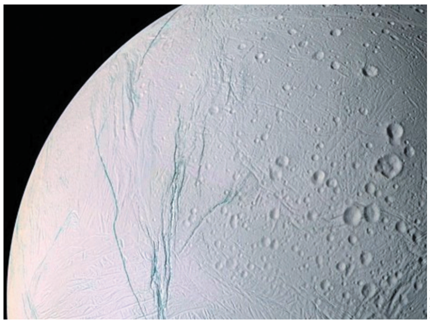


Water plays a role in many of the metabolic processes of life Earth. Because of this, it is essential for life as we know it. Earth is not the only place in the solar system with liquid water on its surface. There are 23 moons that are known or suspected to have large bodies of liquid water on them.



NASA

Jupiter's moons Ganymede and Europa (above) both have oceans containing far more liquid water than all of Earth's oceans combined. These are covered by ice sheets many kilometres thick. Evidence shows that they may be heated by hydrothermal vents and tidal stretching from Jupiter's gravity.



NASA

Saturn's moon Enceladus (above) also has a vast ocean beneath its icy surface. The presence of hydrothermal vents and mineral rich water lends weight to the idea life could evolve there, as it is thought life could have evolved on Earth near hydrothermal vents.

1. Why is water needed for life? ______________________________

2. What are some factors that help maintain liquid water on Earth's surface? Explain: ______________________________

3. Explain why Earth's water is likely to have come from asteroids rather than comets: ______________________________

4. What is the Goldilocks zone? ______________________________

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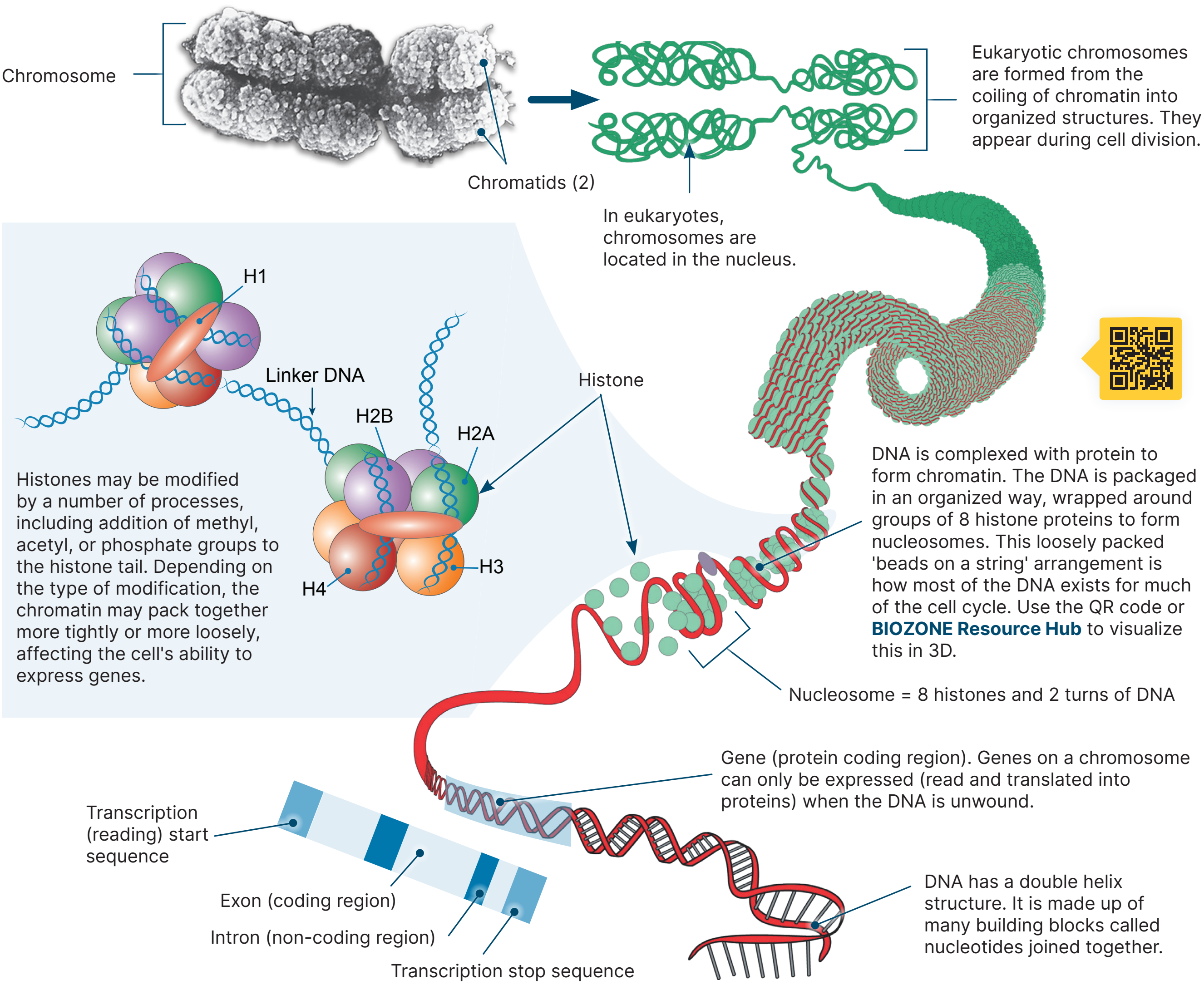
6 The DNA Molecule

Key Idea: DNA is packaged around proteins called histones. The DNA in eukaryotes is packaged as discrete linear chromosomes that vary in number from species to species.

The extent of DNA packaging changes during the life cycle of the cell, but classic chromosome structures (below) appear during metaphase of mitosis.



1. Explain why eukaryotic DNA needs to be packaged to fit inside a cell nucleus?

2. How do histone proteins help in the coiling up of DNA?

3. Suggest why a cell coils up its chromosomes into tight structures when it is going to divide:

4. Explain how the packaging of DNA in an organized way enables closer regulation of gene expression:

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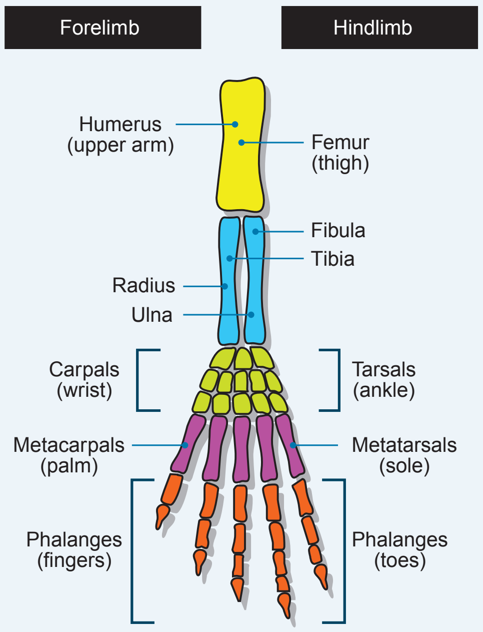
50 Homologous Structures

Key Idea: Homologous structures (homologies) are structural similarities present as a result of common ancestry. The common structural components have been adapted for different purposes in different taxa.

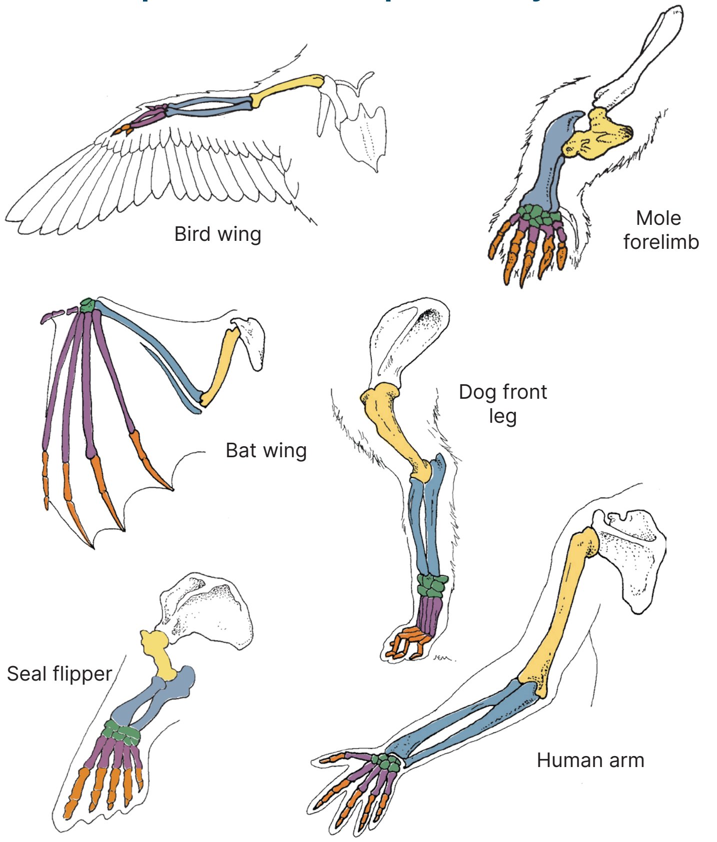
The bones of the forelimb of air-breathing vertebrates are composed of similar bones arranged in a comparable pattern. This is indicative of common ancestry. The early land vertebrates were amphibians with a pentadactyl limb structure (a limb with five fingers or toes). All vertebrates that descended from these early amphibians have limbs with this same basic pentadactyl pattern. They also illustrate the phenomenon known as adaptive radiation, since the basic limb plan has been adapted to meet the requirements of different niches.

Generalized pentadactyl limb

The forelimbs and hind limbs have the same arrangement of bones but different names. In many cases, the basic limb plan has been adapted, e.g. by loss or fusion of bones, to meet the requirements of different niches, e.g. during adaptive radiation of the mammals.



Specializations of pentadactyl limbs



1. Briefly describe the purpose of the major anatomical change that has taken place in each of the limb examples above:

(a) Bird wing: *Highly modified for flight. Forelimb is shaped for aerodynamic lift and feather attachment.*

(b) Human arm: ______

(c) Seal flipper: ______

(d) Dog front leg: ______

(e) Mole forelimb: ______

(f) Bat wing: ______

2. Explain how homology in the pentadactyl limb is evidence for evolution: ______

3. Homology is due to divergent evolution. Define this term and explain how discovery of a new species of whale fossil, complete with limb bones, could be classified using evidence from anatomical homology:

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64 Carbohydrate Chemistry

Key Idea: Monosaccharides are the building blocks for larger carbohydrates. They can exist as isomers.

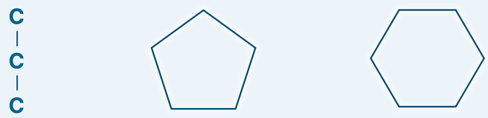
Sugars (monosaccharides and disaccharides) play a central role in cells, providing energy and joining together to form carbohydrate macromolecules, such as starch and glycogen. Monosaccharide polymers form the major component of most plants (as cellulose). Monosaccharides are important as a primary energy source for cellular metabolism. Carbohydrates have the general formula $C_x(H_2O)_y$, where x and y are variable numbers (often but not always the same).

Monosaccharides

- Monosaccharides are single-sugar molecules and include glucose (grape sugar and blood sugar) and fructose (honey and fruit juices). They are used as a primary energy source for fuelling cell metabolism.
- They can be joined together to form disaccharides (two monomers) and polysaccharides (many monomers).
- Monosaccharides can be classified by the number of carbon atoms they contain. Some important monosaccharides are the hexoses (6 carbons) and the pentoses (5 carbons). The most common arrangements found in sugars are hexose (6 sided) or pentose (5 sided) rings (below).
- The commonly occurring monosaccharides contain between three and seven carbon atoms in their carbon chains and, of these, the 6C hexose sugars occur most frequently. All monosaccharides are reducing sugars (they can participate in reduction reactions).

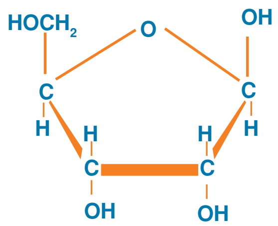
Examples of monosaccharide structures

Triose | Pentose | Hexose



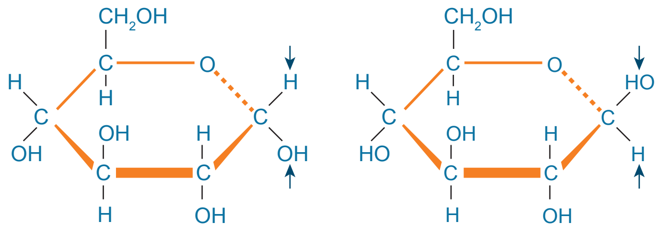
e.g. glyceraldehyde | e.g. ribose deoxyribose | e.g. glucose, fructose, galactose

Ribose: a pentose monosaccharide



Ribose is a pentose (5 carbon) monosaccharide which can form a ring structure (left). Ribose is a component of the nucleic acid, ribonucleic acid (RNA).

Glucose isomers

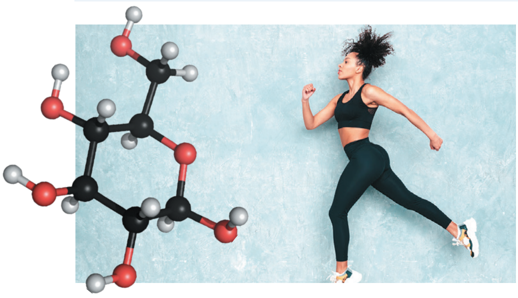


α-glucose

β-glucose

Isomers are compounds with the same chemical formula (same types and numbers of atoms) but different arrangements of atoms. The different arrangement of the atoms means that each isomer has different properties.

Molecules such as glucose can have many different isomers, e.g. α and β glucose, above, including straight and ring forms.



Glucose is a versatile molecule. It provides energy to power cellular reactions, can form energy storage molecules such as glycogen, or it can be used to build structural molecules.

Plants make their glucose via the process of photosynthesis. Animals and other heterotrophic organisms obtain their glucose by consuming plants or other organisms.

Rufino Uribe

Fructose, often called fruit sugar, is a simple monosaccharide. It is often derived from sugar cane (above). Both fructose and glucose can be directly absorbed into the bloodstream.

1. Describe the two major functions of monosaccharides:

   a) ____________________

   b) ____________________

2. Describe the structural differences between the ring forms of glucose and ribose: ____________________

____

3. Using glucose as an example, define the term isomer and state its importance: ____________________

____

____

____

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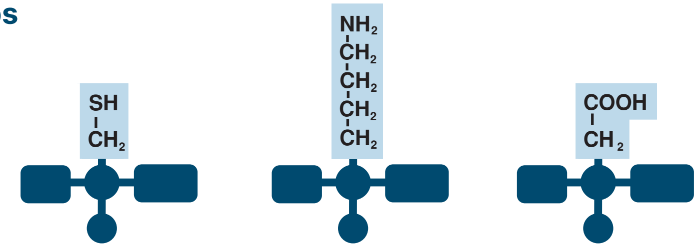
73 R-Groups

Key Idea: The variable R group gives amino acids their properties and ultimately determines the final protein shape.

All amino acids have a common structure, but the R group is different in each type of amino acid. The property of the R group determines how it will interact with other amino acids and ultimately determines how the amino acid chain folds up into a functional protein. For example, the hydrophobic R groups of soluble proteins are folded into the protein's interior, while hydrophilic groups are arranged on the outside.

Different amino acids have different R groups

- The R group in the amino acid determines the chemical properties of the amino acid. Different amino acids have different R groups and therefore different chemical properties. Amino acids can be grouped according to these properties. Common groupings are nonpolar (hydrophobic), polar (hydrophilic), positively charged (basic), or negatively charged (acidic).
- The property of the R group determines how the amino acid will interact with others and how the amino acid chain will fold up into a functional protein. For example, the hydrophobic R groups of soluble proteins will be folded into the protein's interior.

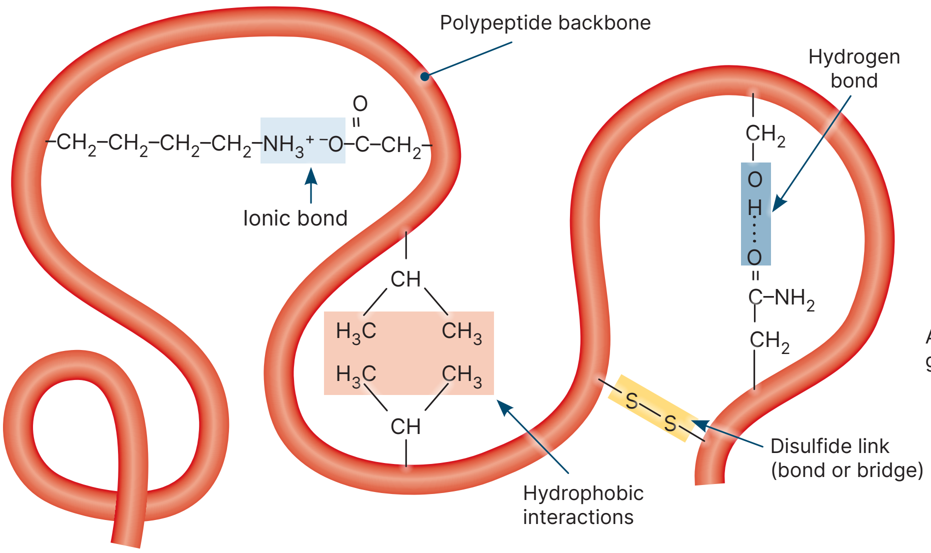


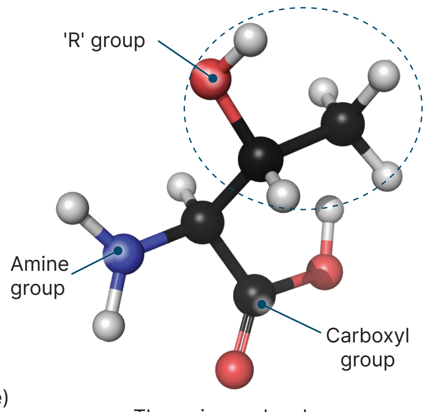
Cysteine
The 'R' group of cysteine forms disulfide bridges with other cysteines to create cross linkages in a polypeptide chain.

Lysine
The 'R' group of lysine gives the amino acid an alkaline property.

Aspartic acid
The 'R' group of aspartic acid gives the amino acid an acidic property.

Links between amino acids





Threonine molecular structure

1. (a) Name the different interactions that can shape the polypeptide: ______

   (b) Which of the interactions would be the strongest: ______

2. Do some research to assign each of the 20 amino acids found in proteins to one of the four groups below. Use a standard 3-letter code to identify each amino acid:

   (a) Nonpolar (hydrophobic): ______

   (b) Polar (hydrophilic): ______

   (c) Positively charged (basic): ______

   (d) Negatively charged (acidic): ______

3. Which type(s) of amino acids would you find on the surface of a soluble protein? Which type(s) would you find in the interior? Explain:

______

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93 Constraints to Cell Size

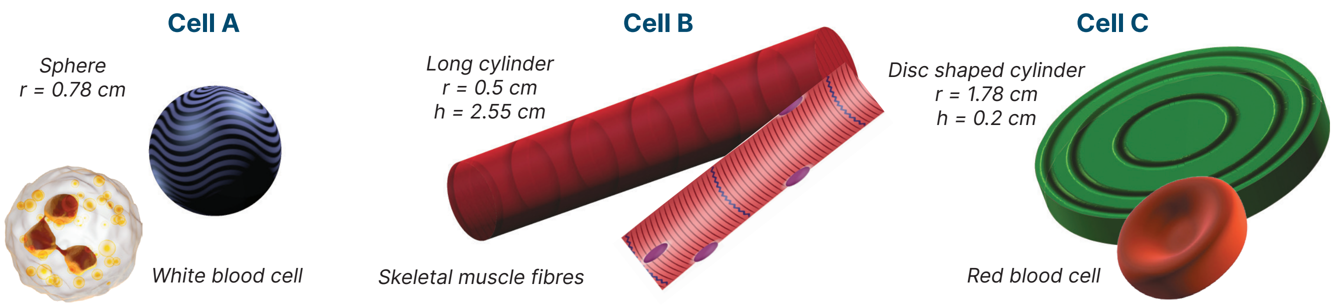
Key Idea: Demand for exchanged materials sets the limits to a cell's size due to the surface area to volume ratio.

In order to function, a cell must obtain the raw materials it needs and dispose of the waste products of metabolism. These exchanges must occur across the plasma membrane. In a spherical cell, the cell volume increases faster than the corresponding surface area. Although cells with larger surface areas facilitate the exchange of materials across the membranes, larger volume cells have a greater demand for materials to be transported across at a faster rate. As the cell becomes larger, it becomes more and more difficult for it to obtain all the materials it needs to sustain its metabolism. The size of cells can be constrained when material requirements exceed the exchange rate. The surface-area-to-volume relationship of the cells can be estimated using the appropriate formula for their shape.

Calculating surface area to volume ratios

- Mathematical formulae can be used to calculate the surface area and volume, and consequently the ratio between them.
- Models of spheres and cylinders can be used to approximate different types of cells.

	Sphere	Cube	Cylinder
Biological example	**Staphylococcus bacterial cell**	**Kidney tubule cell**	**Axon of neuron**
Surface area: The sum of all areas of all shapes covering an object's surface.	$4\pi r^2$	$6w^2$	$(2\pi r^2) + (2\pi rh)$
Volume: The amount that a 3-dimensional shape can hold.	$\frac{4}{3}\pi r^3$	w^3	$\pi r^2 h$



r = radius l = length w = width h = height π = 3.14

1. Use the formulae for a sphere and a cylinder above to calculate the **surface area** of cells A, B, and C.

   (a) SA cell A: ______________________ (c) SA cell C: ______________________

   (b) SA cell B: ______________________

2. Use the formulae for a sphere and a cylinder above to calculate the **volume** of cells A, B, and C.

   (a) Volume cell A: ______________________ (c) Volume cell C: ______________________

   (b) Volume cell B: ______________________

3. Which of the cells above (A, B, C) has the greater surface area to volume ratio? Describe how changing the shape of a cell affects its surface area and its ability to obtain nutrients and dispose of wastes:

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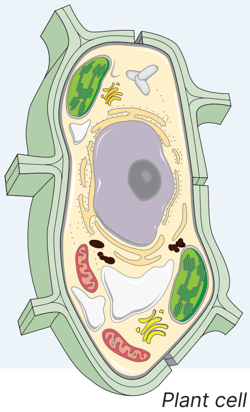
Using models in science

Models are important ways of representing scientific concepts and ideas visually using a simplistic version. They help to visualize trends and patterns in data and can be used to show the complexity of relationships within a system.

Models can describe the relationship between variables, such as the surface area to volume of a cell, or comparing cell sizes to each other.

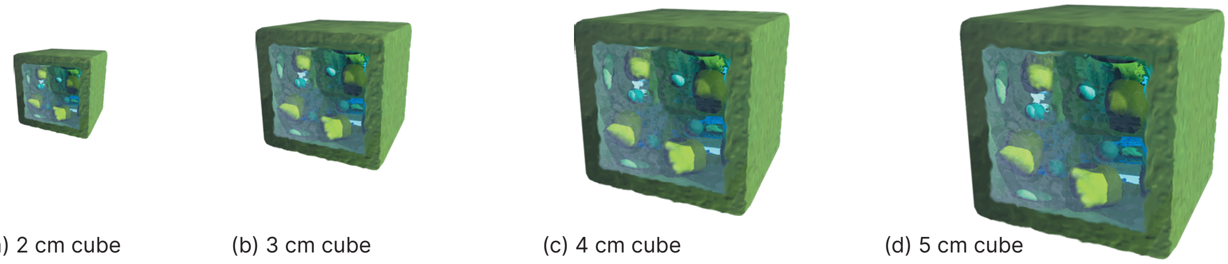
Scientific information can be represented visually or modelled in many different ways. Representations vary widely, depending on what type of information is being conveyed. The ability to describe and explain visual representations helps you to communicate information about the biological principles, concepts, and processes they involve.



Plant cell model

The effect of increasing size

- The size and shape of a cell reflects its function and the need for essential molecules to move in and out. The greater the spherical diameter of a cell, the more material it contains and the further molecules have to move in order to reach the centre. At the same time, its metabolic requirements for raw materials increase. Molecules diffusing into the cell are used up faster than they can be supplied and may not reach the cell's centre, leaving it starved of essential molecules, e.g. oxygen.
- The transport of substances across membranes allows cells to exchange matter with their environment. Simple diffusion and transport involving membrane proteins are both affected by cell size and shape because these things affect the amount of surface area available relative to the cell's volume. The larger a cell, the more materials, e.g. oxygen, it needs, and the further molecules need to move to reach their destination within the cell.
- A cell's surface area is important in determining how many molecules it can obtain. Its volume is important in determining how quickly molecules can reach certain parts of the cell. Surface area to volume ratio is therefore crucial to cell function.



(a) 2 cm cube (b) 3 cm cube (c) 4 cm cube (d) 5 cm cube

4. The diagram above shows four hypothetical cells of different sizes. They range from a small 2 cm cube to a 5 cm cube (not to scale). Explain in general terms how a change in size effects the surface area and the volume of the cell:

____

____

____

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5. Use the formulae provided on the previous page to calculate the surface area (SA), volume (V), and the ratio of surface area to volume (SA:V) for each of the four cuboidal cells **(a)-(d)** above. Show your calculations.

(a) SA: ____________ V: ____________ SA:V ____________

(b) SA: ____________ V: ____________ SA:V ____________

(c) SA: ____________ V: ____________ SA:V ____________

(d) SA: ____________ V: ____________ SA:V ____________

6. What are the advantages of using a model to demonstrate the surface-area-to-volume relationship of cells:

____

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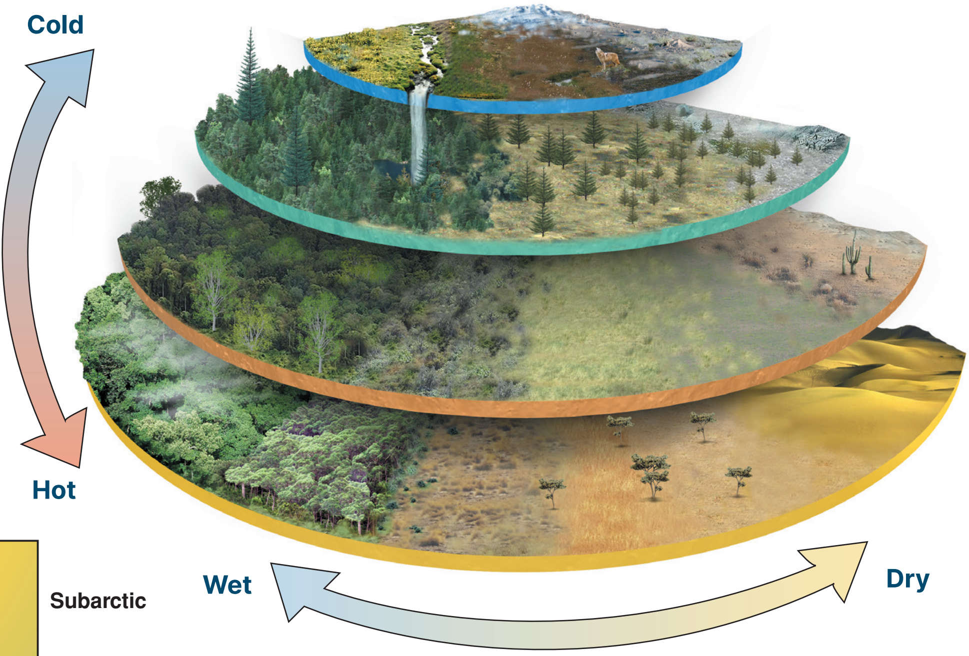
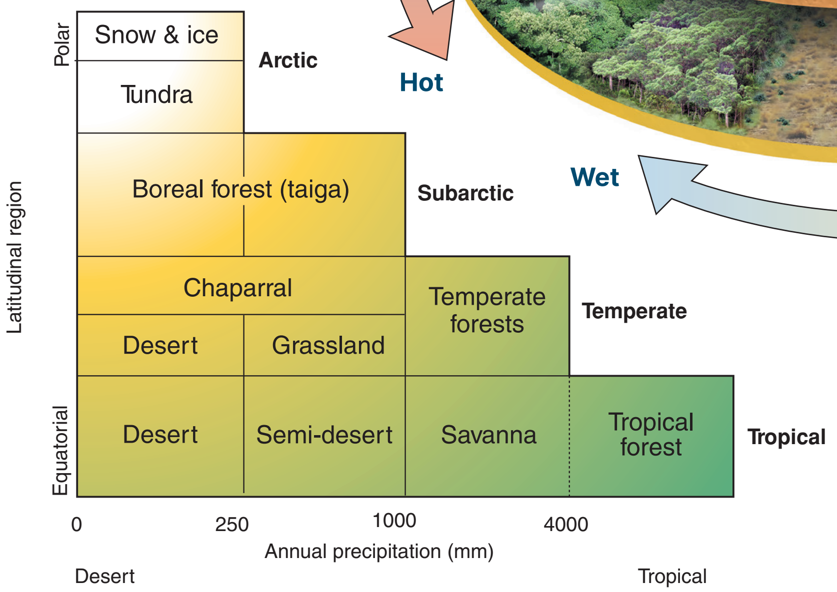
135 Abiotic Factors Affect Biome Distribution

Key Idea: Temperature and rainfall play an important role in determining the geographical location of terrestrial biomes.

Temperature and precipitation are excellent predictors of biome distribution. Temperature decreases from the equator to the poles. Temperature and precipitation act together as limiting factors to determine the type of desert, grassland, or forest biome in a region. Latitude directly affects solar input and temperature.

Within a single latitudinal region, the level of precipitation (rainfall) governs the type of plant community found. Note that the effect of altitude is similar to that of latitude: ice will occur at high altitudes even at low-latitudes.





As the Earth curves towards the poles, solar energy is spread out over an ever increasing area. This energy must also travel through a greater amount of the atmosphere, expending more energy than at low latitudes.

1. Explain how temperature and rainfall affect the distribution of biomes: ______________________________

2. Explain why biomes are not evenly distributed about the globe: ______________________________

3. Explain how the landscape can modify climate: ______________________________

4. Explain why higher latitudes receive less solar energy than lower latitudes: ______________________________

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138 Adaptations to Tropical Environments

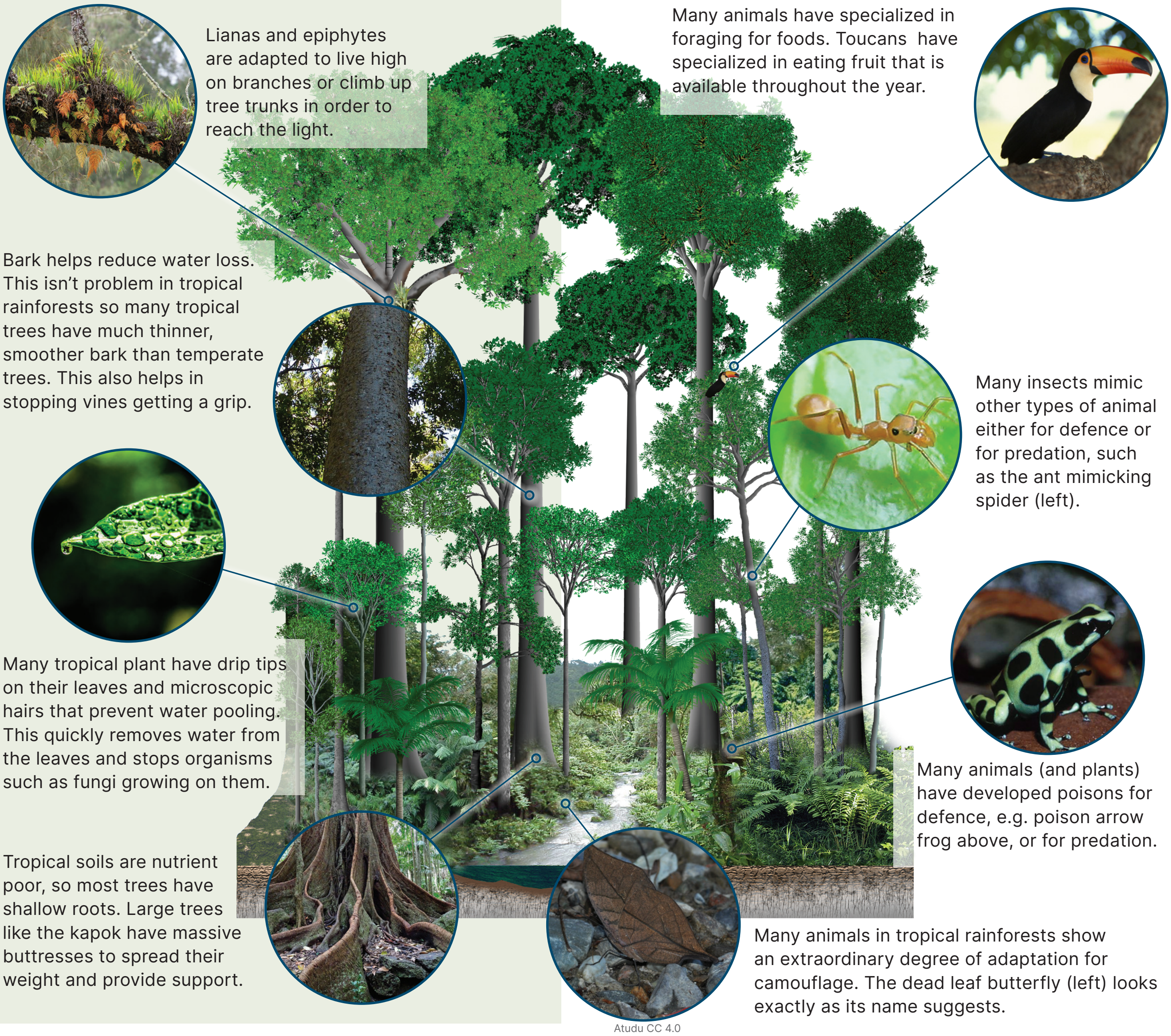
Key Idea: Tropical rainforests have the greatest biodiversity on Earth, with organisms showing a vast array of adaptations. Tropical environments have a large amount of light, warmth, and moisture: ideal for plant growth. This combination of factors has produced tropical rainforests with the highest biodiversity of any terrestrial environment. A single hectare may have over 42,000 different species of plants and animals. With such large numbers of organisms all competing for space and nutrients, it is unsurprising that the inhabitants of a tropical rainforest have evolved a vast array of adaptations, including camouflage, mimicry, and specialized diets.

Plant adaptations

Plants in tropical rainforest have adaptations to deal with excessive rain, low soil nutrients, low light levels, and other competing plants.

Animal adaptations

In tropical rainforests, animals have adaptations to take advantage of the variety of habitats. These include mimicry, camouflage and poisons.



Lianas and epiphytes are adapted to live high on branches or climb up tree trunks in order to reach the light.

Bark helps reduce water loss. This isn't problem in tropical rainforests so many tropical trees have much thinner, smoother bark than temperate trees. This also helps in stopping vines getting a grip.

Many tropical plant have drip tips on their leaves and microscopic hairs that prevent water pooling. This quickly removes water from the leaves and stops organisms such as fungi growing on them.

Tropical soils are nutrient poor, so most trees have shallow roots. Large trees like the kapok have massive buttresses to spread their weight and provide support.

Many animals have specialized in foraging for foods. Toucans have specialized in eating fruit that is available throughout the year.

Many insects mimic other types of animal either for defence or for predation, such as the ant mimicking spider (left).

Many animals (and plants) have developed poisons for defence, e.g. poison arrow frog above, or for predation.

Many animals in tropical rainforests show an extraordinary degree of adaptation for camouflage. The dead leaf butterfly (left) looks exactly as its name suggests.

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1. In a group of four, research plant and animal adaptations in tropical rainforests. Each person should identify one adaptation in a named plant and one in a named animal. Report back to your group with your findings and record all four plant and four animal adaptations below:

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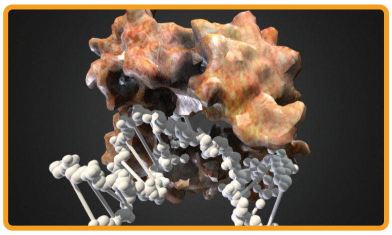

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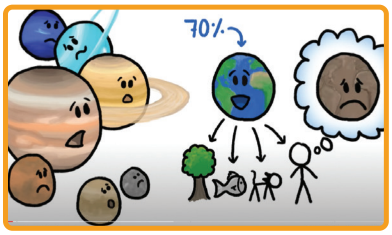

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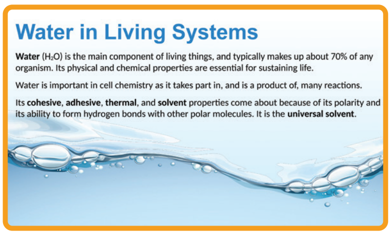

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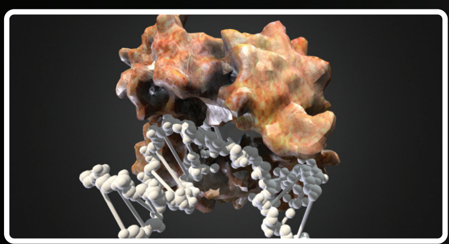

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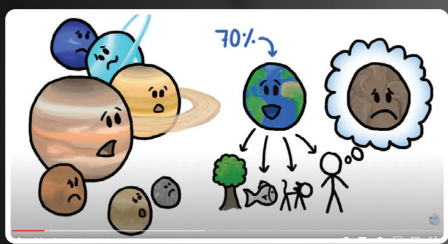

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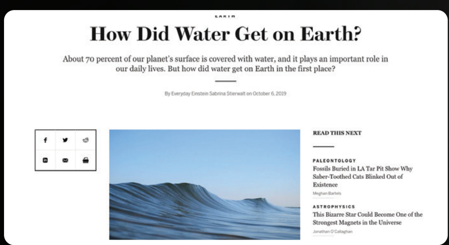

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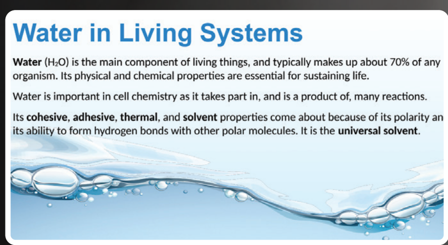

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