BIOZONE

AP® BIOLOGY

REVISED EDITION

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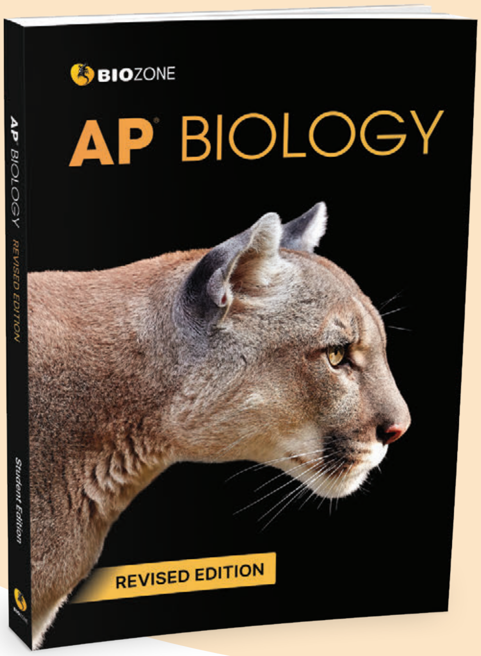


AP® BIOLOGY

Available in **PRINT** + **DIGITAL** formats.

This edition of **AP® Biology** has been written to meet the requirements of the 2025 AP® Biology CED, while retaining the familiar unit-based structure teachers love. This edition contains new and updated activities to address content changes in the 2025 CED, revised chapter introductions to reflect the new learning objectives, and refreshed Science Practices and Big Idea coding.

BIOZONE's commitment to deliver clear, student-centric instruction, purposeful practice, and exam ready skill development is evident throughout. Clear presentation, a highly visual approach, and integration of relevant and engaging illustrative examples readies students for college level courses, developing the essential inquiry and reasoning skills they will need as 21st century scientists.

ISBN: 978-1-99-101471-9
Edition: 4th
No. Pages: 484

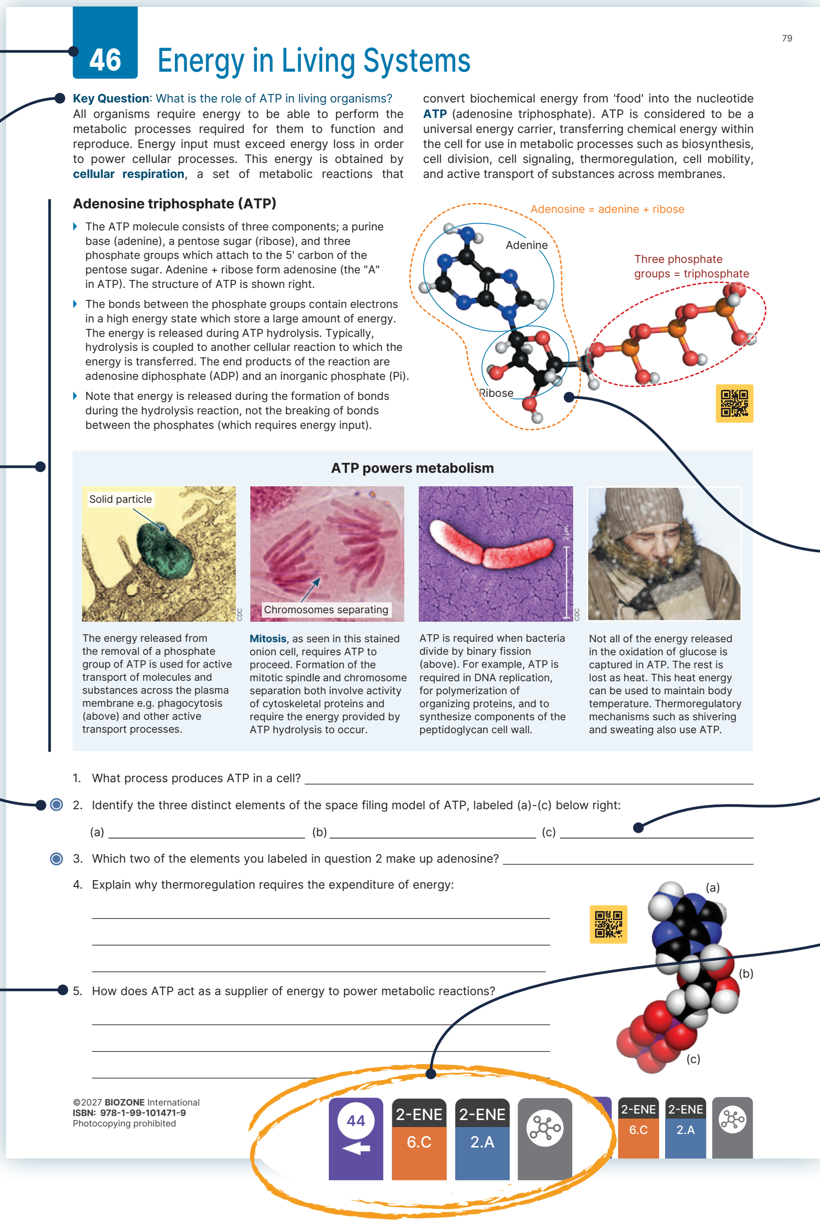
Activity number
Activities are numbered to make navigation through the book easier.

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

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

Color coded bullets
Science Practice bullets identify where a skill is covered within the questions. The bullets are color coded to match the CED skills.

Critical thinking questions
A direct questioning style helps students easily interpret the question. A wide range of tasks, including free response, data analysis and presentation, and the interpretation and evaluation of evidence, scaffold student learning to build confidence and competence.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46 Energy in Living Systems

Key Question: What is the role of ATP in living organisms?
All organisms require energy to be able to perform the metabolic processes required for them to function and reproduce. Energy input must exceed energy loss in order to power cellular processes. This energy is obtained by **cellular respiration**, a set of metabolic reactions that convert biochemical energy from 'food' into the nucleotide **ATP** (adenosine triphosphate). ATP is considered to be a universal energy carrier, transferring chemical energy within the cell for use in metabolic processes such as biosynthesis, cell division, cell signaling, thermoregulation, cell mobility, and active transport of substances across membranes.

Adenosine triphosphate (ATP)

- The ATP molecule consists of three components; a purine base (adenine), a pentose sugar (ribose), and three phosphate groups which attach to the 5' carbon of the pentose sugar. Adenine + ribose form adenosine (the "A" in ATP). The structure of ATP is shown right.
- The bonds between the phosphate groups contain electrons in a high energy state which store a large amount of energy. The energy is released during ATP hydrolysis. Typically, hydrolysis is coupled to another cellular reaction to which the energy is transferred. The end products of the reaction are adenosine diphosphate (ADP) and an inorganic phosphate (Pi).
- Note that energy is released during the formation of bonds during the hydrolysis reaction, not the breaking of bonds between the phosphates (which requires energy input).

Adenosine = adenine + ribose
Adenine
Three phosphate groups = triphosphate
Ribose

ATP powers metabolism

Solid particle
Chromosomes separating

The energy released from the removal of a phosphate group of ATP is used for active transport of molecules and substances across the plasma membrane e.g. phagocytosis (above) and other active transport processes.

Mitosis, as seen in this stained onion cell, requires ATP to proceed. Formation of the mitotic spindle and chromosome separation both involve activity of cytoskeletal proteins and require the energy provided by ATP hydrolysis to occur.

ATP is required when bacteria divide by binary fission (above). For example, ATP is required in DNA replication, for polymerization of organizing proteins, and to synthesize components of the peptidoglycan cell wall.

Not all of the energy released in the oxidation of glucose is captured in ATP. The rest is lost as heat. This heat energy can be used to maintain body temperature. Thermoregulatory mechanisms such as shivering and sweating also use ATP.

1. What process produces ATP in a cell? ______
2. Identify the three distinct elements of the space filing model of ATP, labeled (a)-(c) below right:
(a) ______ (b) ______ (c) ______
3. Which two of the elements you labeled in question 2 make up adenosine? ______
4. Explain why thermoregulation requires the expenditure of energy:
5. How does ATP act as a supplier of energy to power metabolic reactions?

(a) (b) (c)

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44 | 2-ENE 6.C | 2-ENE 2.A | 2-ENE 6.C | 2-ENE 2.A

QR Codes
Scan the QR code to directly interact with 3D models.

Comprehensive diagrams
Provide an engaging, highly visual delivery of the important information.

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

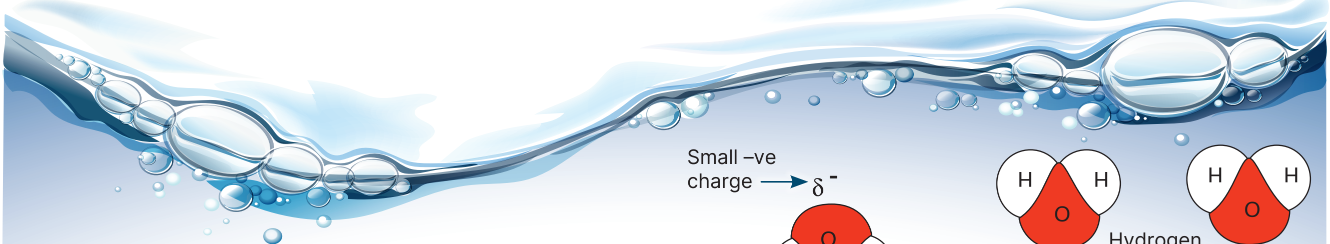
Activity coding system
Tab codes indicate online support via BIOZONE's Resource Hub and identify the key Science Practices/ Skills and Big Ideas that spiral across topics and units. Purple connect tabs point forward or back to related content in the book.

See our website for more details and local pricing
www.BIOZONE.com/us

1 Water in Living Systems

Key Question: How does water's molecular structure account 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. It is the universal solvent.

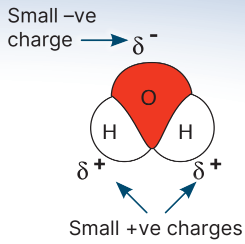


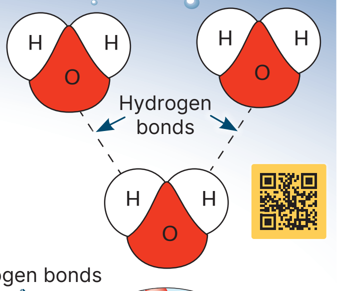
Water forms hydrogen bonds

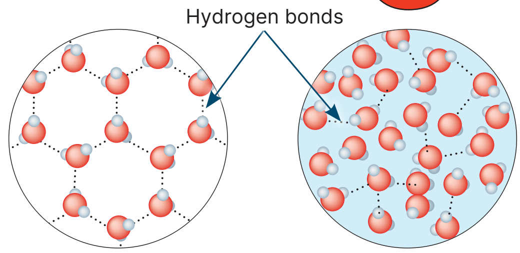
A water molecule is polar, meaning it has a positively and a negatively charged region. In water, oxygen has a slight negative charge (δ^-) and each hydrogen has a slight positive charge (δ^+). Water molecules form large numbers of weak hydrogen bonds with other water molecules (far right). Individually, 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 latent 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, hydrogen bonds are breaking, reforming, and moving around. When water becomes a solid, the bonds become less flexible, causing the water to expand. The expansion causes ice's density to decrease.

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.

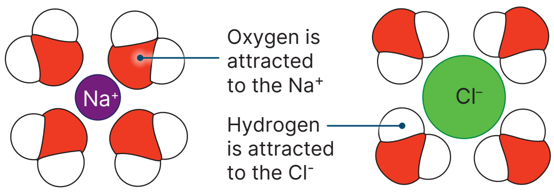






Ice: H-bonds are fixed in an interconnected framework

Liquid water: H-bonds constantly break and reform



Water surrounding a positive ion (Na^+)

Water surrounding a negative ion (Cl^-)

Cohesive properties

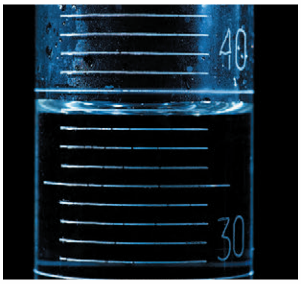
Water molecules are cohesive: they stick together because hydrogen bonds form between water molecules. Cohesion allows water to form droplets and is responsible for the **surface tension** that many small organisms rely on.

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 to 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 (below).



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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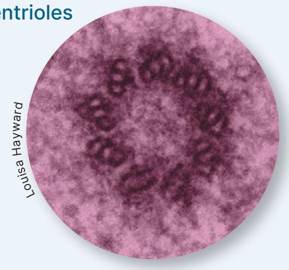
2 The Biochemical Nature of the Cell

Key Question: What atoms and molecules do organisms obtain from their environment and what do they do with them?

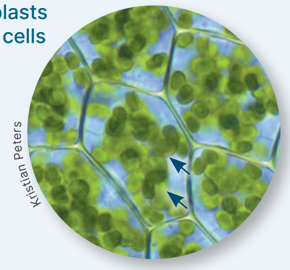
Water is the main component of cells and organisms, providing an aqueous environment in which metabolic reactions can occur. Apart from water, most other substances in cells are compounds of carbon, hydrogen, oxygen, and nitrogen. Life on Earth is carbon based. Carbon is able to form up to four valence bonds with other atoms simultaneously so it can combine with many other elements to form a large number of carbon-based (or organic) molecules. The organic molecules that make up living things can be grouped into four broad classes: **carbohydrates**, **lipids**, **proteins**, and **nucleic acids**. In addition, a small number of inorganic ions are also components of larger molecules.

The components of cells

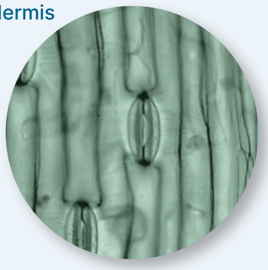
Centrioles



Chloroplasts in plant cells



Plant epidermis

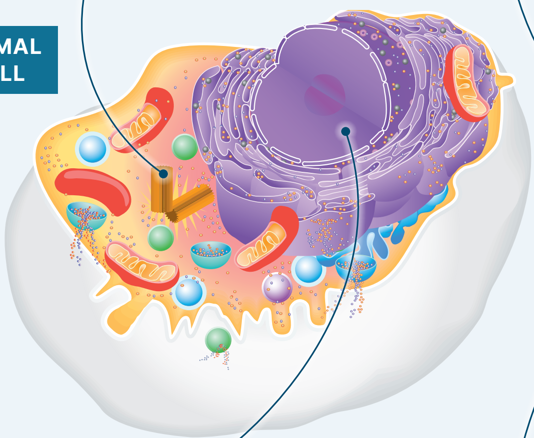


Proteins have an enormous number of structural and functional roles in plants and animals, e.g. as enzymes, structural materials (such as collagen), in transport, and movement (e.g. cytoskeleton and centrioles).
Components: C, H, O, N, S, P

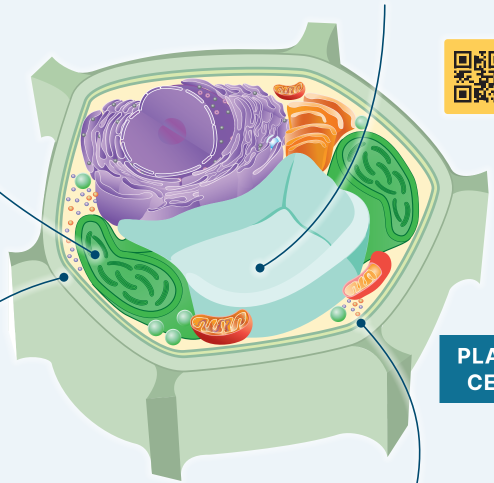
Inorganic ions: Dissolved ions participate in metabolic reactions and are components of larger organic molecules, e.g. Mg2+ is a component of the green chlorophyll pigment in the chloroplasts of green plants.

Water is a major component of cells: many substances dissolve in it and metabolic reactions occur in it. In plant cells, fluid pressure against the cell wall provides turgor, which supports the cell.
Components: H, O

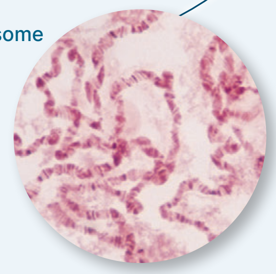
ANIMAL CELL



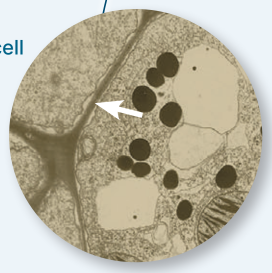
PLANT CELL



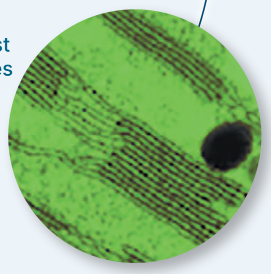
Chromosome



Plant cell wall



Chloroplast membranes



Nucleotides and nucleic acids
Nucleic acids encode information for the construction and functioning of an organism (DNA and RNA). **ATP**, a **nucleotide** derivative, is the energy carrier of the cell.
Components: C, H, O, N, P

Carbohydrates form the structural components of cells, e.g. cellulose cell walls (arrowed). They are important in providing usable energy as glucose, in energy storage, and they are involved in cellular recognition.
Components: C, H, O

Simple lipids provide a concentrated source of energy. **Phospholipids** (a complex lipid) are a major component of cellular membranes, including the membranes of organelles such as **chloroplasts** and **mitochondria**.
Components: C, H, O (lipids)
C, H, O, P, N (phospholipids)

1. (a) List the four main macromolecule components of living organisms: ____________________

____

(b) List the elements that all these macromolecules share: ____________________

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21 A Closer look at Chloroplasts and Mitochondria

Key Question: What are the important structural features of mitochondria and chloroplasts?

Chloroplasts and **mitochondria** are **organelles** involved in the production of energy storage molecules in cells. Both are membranous organelles in which specialized biochemical reactions occur. Chloroplasts are found only in plant cells and some protists, whereas mitochondria are found in all eukaryotic cells. Mitochondria contain proteins (including ATP synthase) involved in the production of ATP, the energy storage molecule of cells. The number of mitochondria in each cell is variable. Red blood cells have no mitochondria, whereas a heart cell can have up to 5000. Chloroplasts are the organelles responsible for **photosynthesis**. A mesophyll leaf cell contains between 50-100 chloroplasts. Chloroplasts have an internal structure characterized by a system of membranous structures with bound light-capturing pigments. These absorb light of specific wavelengths, capturing light energy, which is then used to fix carbon into carbohydrates.

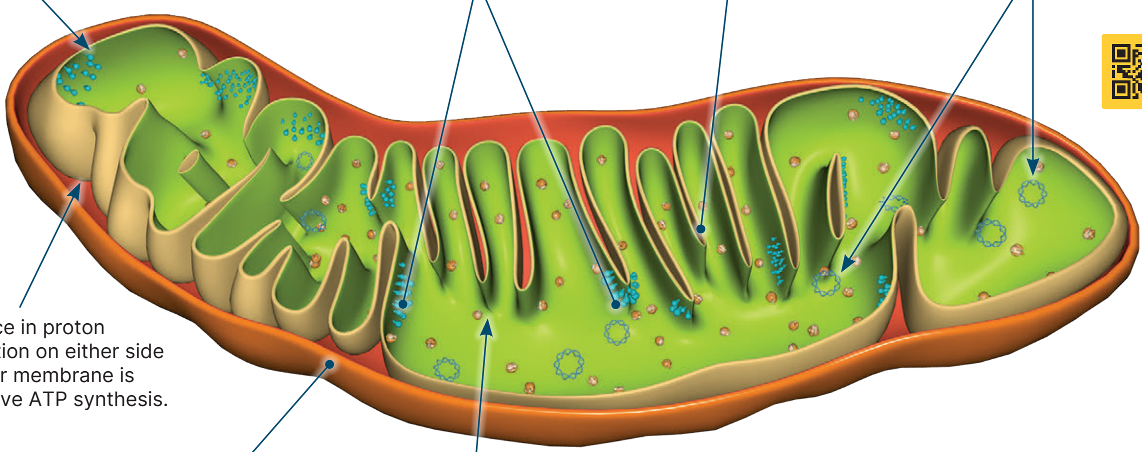
The structure of a mitochondrion

Mitochondria are enclosed by a double membrane envelope (inner and outer membrane). The inner membrane is highly folded.

The electron transport chain and ATP synthesis occur on the inner membrane catalyzed by the enzyme ATP synthase.

The inward foldings are called cristae.

Like chloroplasts, mitochondria have their own circular DNA (plasmids).

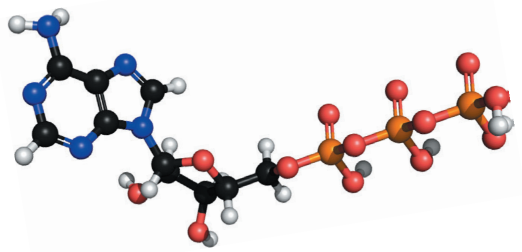


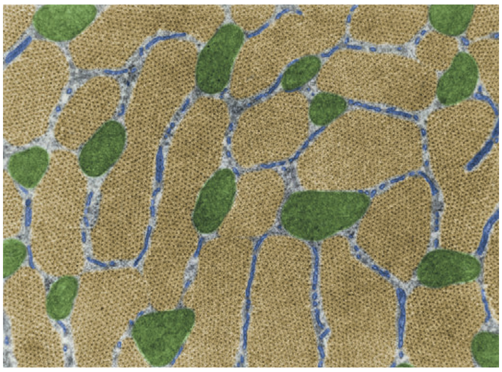
A difference in proton concentration on either side of the inner membrane is used to drive ATP synthesis.

Mitochondria are much smaller than chloroplasts, ranging from about 0.75 to 3 μm.

The space enclosed by the inner membrane is called the matrix. It is where the Krebs cycle (part of cellular respiration) occurs.

ATP is produced in the mitochondria. It is an energy carrying molecule used to drive chemical reactions in the body.





False color TEM showing cross-sectioned muscle myofibrils (yellow) and many mitochondria (green).

1. What is the function of mitochondria? ______________________________

2. What is the function of the cristae? ______________________________

____

____

3. What is the purpose of the inner membrane? ______________________________

____

____

4. Why would very active cells, such as heart cells, need a large number of mitochondria? ______________________________

____

____

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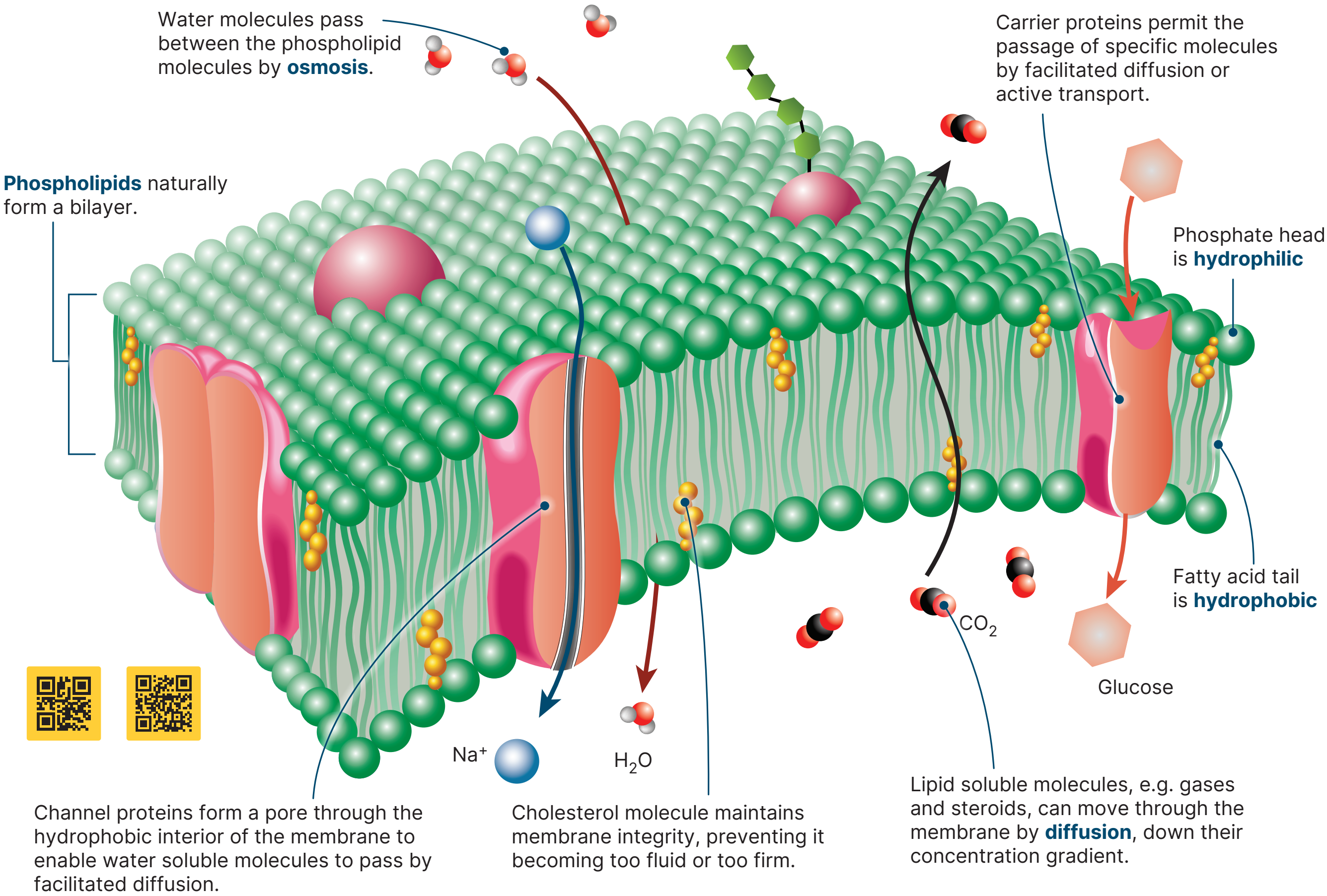
26 The Structure of Membranes

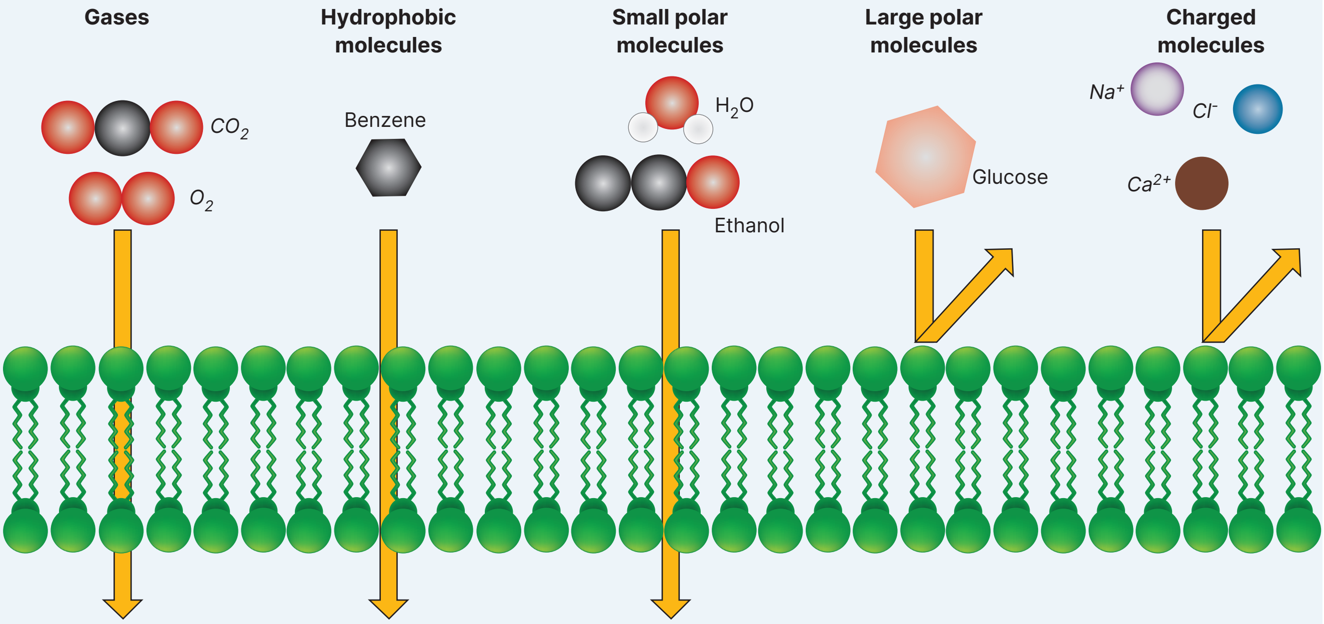
Key Question: What are cellular membranes made of and how do they regulate entry into and exit from the cell?

The **plasma** (or cell surface) **membrane** encloses the cell's contents and regulates many of the cell's activities. Importantly, it controls what enters and leaves the cell by the use of carrier and channel proteins.

Fluid mosaic model of membrane structure



What can cross a lipid bilayer?



Small uncharged molecules can diffuse easily through the membrane.

Lipid soluble molecules diffuse into and out of the membrane unimpeded.

Polar molecules are small enough to diffuse through. Aquaporins increase the rate of water movement.

Cannot directly cross the membrane. Transport (by **facilitated diffusion** or active transport) involves membrane proteins.

Ions can be transported across the membrane by ion channels (passive) or **ion pumps** (active).

2-ENE 2.A
34
29

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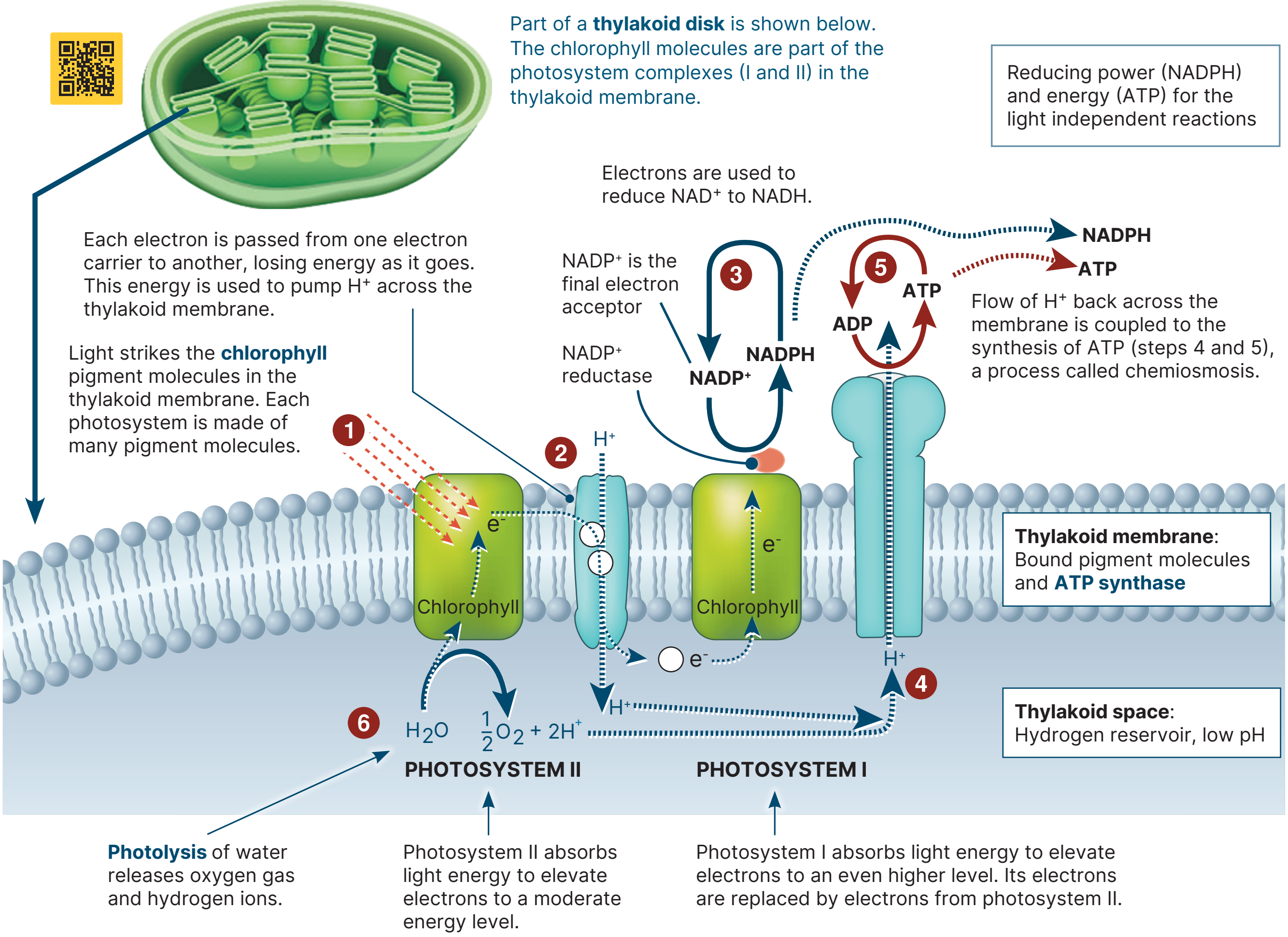
51 Light Dependent Reactions

Key Question: How is light energy used to drive the reduction of NADP⁺ and the production of ATP.

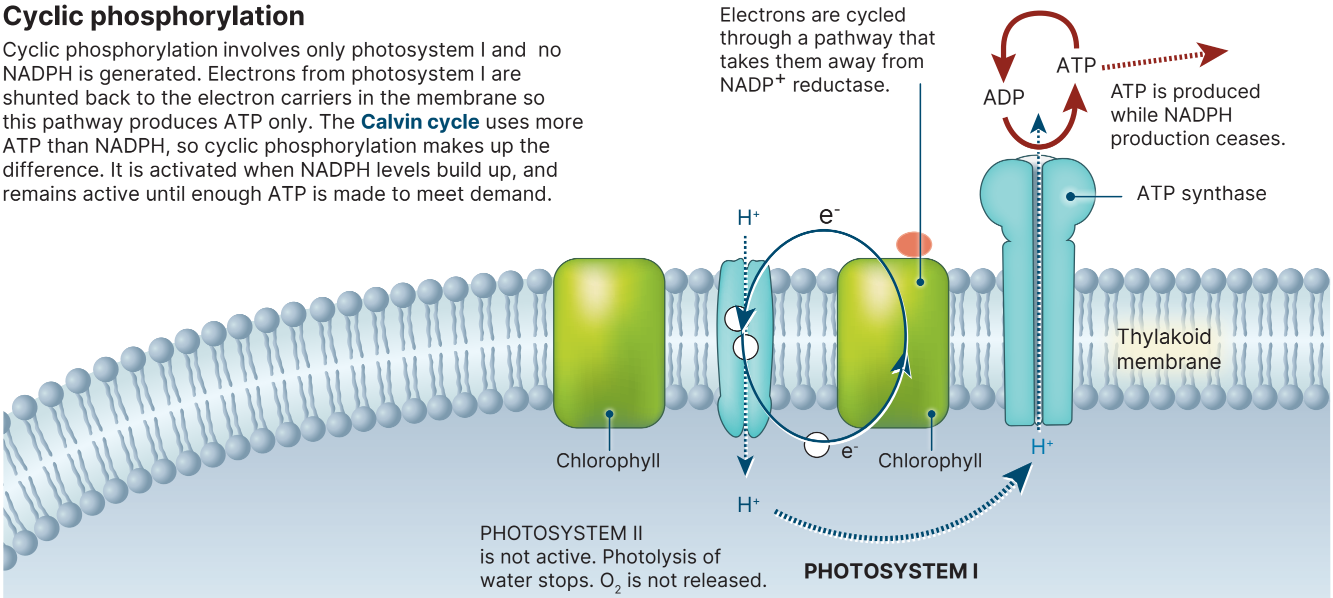
Photosynthesis is a redox process where water is split, and electrons and hydrogen ions are transferred from water to CO_2, reducing it to sugar. The electrons increase in potential energy as they move from water to sugar. The energy to do this is provided by light. Photosynthesis has two phases. In the **light dependent phase**, light energy is converted to chemical energy (**ATP** and NADPH). In the **light independent phase**, the chemical energy is used to synthesize carbohydrate. The light dependent reactions most commonly involve **non-cyclic photophosphorylation**, which produces ATP and NADPH in roughly equal quantities. The electrons lost are replaced from water. In **cyclic photophosphorylation**, the electrons lost from photosystem II are replaced by those from photosystem I. ATP is generated, but not NADPH.

Non-cyclic phosphorylation



Cyclic phosphorylation

Cyclic phosphorylation involves only photosystem I and no NADPH is generated. Electrons from photosystem I are shunted back to the electron carriers in the membrane so this pathway produces ATP only. The **Calvin cycle** uses more ATP than NADPH, so cyclic phosphorylation makes up the difference. It is activated when NADPH levels build up, and remains active until enough ATP is made to meet demand.



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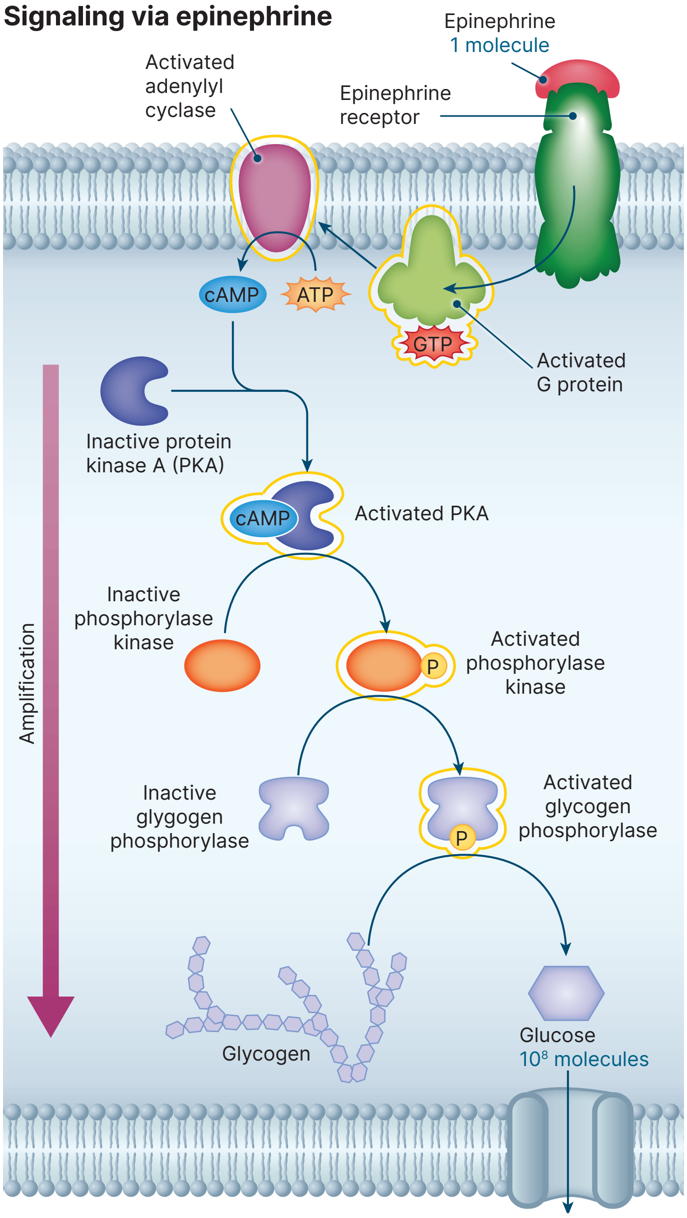
66 Signal Transduction and Environment

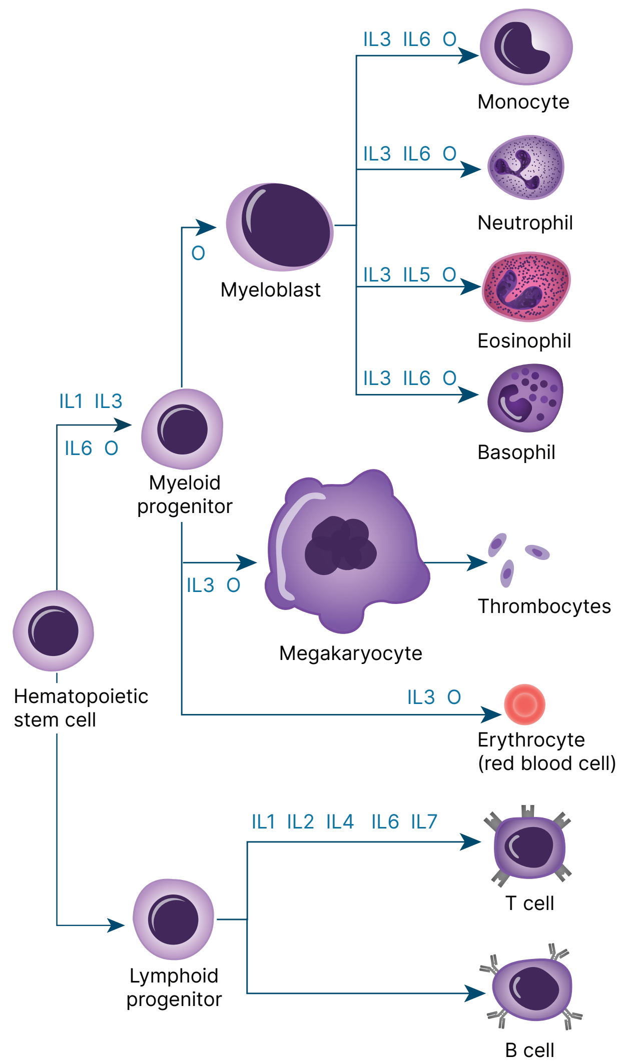
Key Question: What is the role of the cellular environment in eliciting a cellular response.

Cellular environments are dynamic. To survive and grow, cells must be able to respond appropriately to changes in the environment. As we have seen, this involves responding to signals that indicate environmental change. In multicellular organisms, this might mean responding to changes in the level of a circulating **hormone**. For unicellular organisms, it may involve making appropriate responses to changes in cell density or chemicals in the wider environment. These dynamic responses are mediated through **signal transduction** pathways and may include changes in the activity of preexisting **enzymes**, changes in the rates of synthesis of new enzymes, or changes in membrane-transport processes.

Signaling via epinephrine



Cytokines are non-hormone signaling molecules



Signal transduction involving epinephrine

As seen in the previous activity, second messengers relay a signal received by an extracellular **receptor** to a target within the cell to bring about a specific response such as enzyme activation. The process involves a signal cascade, which amplifies the original signal, so many molecules are activated. Common second messengers include cyclic AMP (cAMP) and Ca^{2+}.

Signal transduction pathways involving **phosphorylation cascades** work by activating a chain of protein kinases (enzymes that transfer phosphates). In the example shown above, epinephrine binds to receptors on a liver cell. The end result is the breakdown of stored glycogen into glucose monomers. Epinephrine is a hormone released as part of the fight-or-flight response. Rapid mobilization of glucose to provide energy is just one of its effects.

Signaling pathways control cell differentiation

Cytokines are a diverse group of small signaling proteins with roles in regulating immunity, inflammation, and the formation and differentiation of blood cells (hematopoiesis). They cannot cross the plasma membrane so also operate through extracellular (cell surface) receptors. Cytokines are involved in autocrine, paracrine and endocrine signaling.

Interleukins (IL) are common cytokines in hematopoiesis (above). The unique sequence in which different cytokines are expressed, along with other control processes such as DNA methylation, determine blood cell fate during differentiation. This diagram shows the involvement of multiple factors in cell differentiation. It is not intended that you memorize these.

3-IST 6.C
64 65 68 120

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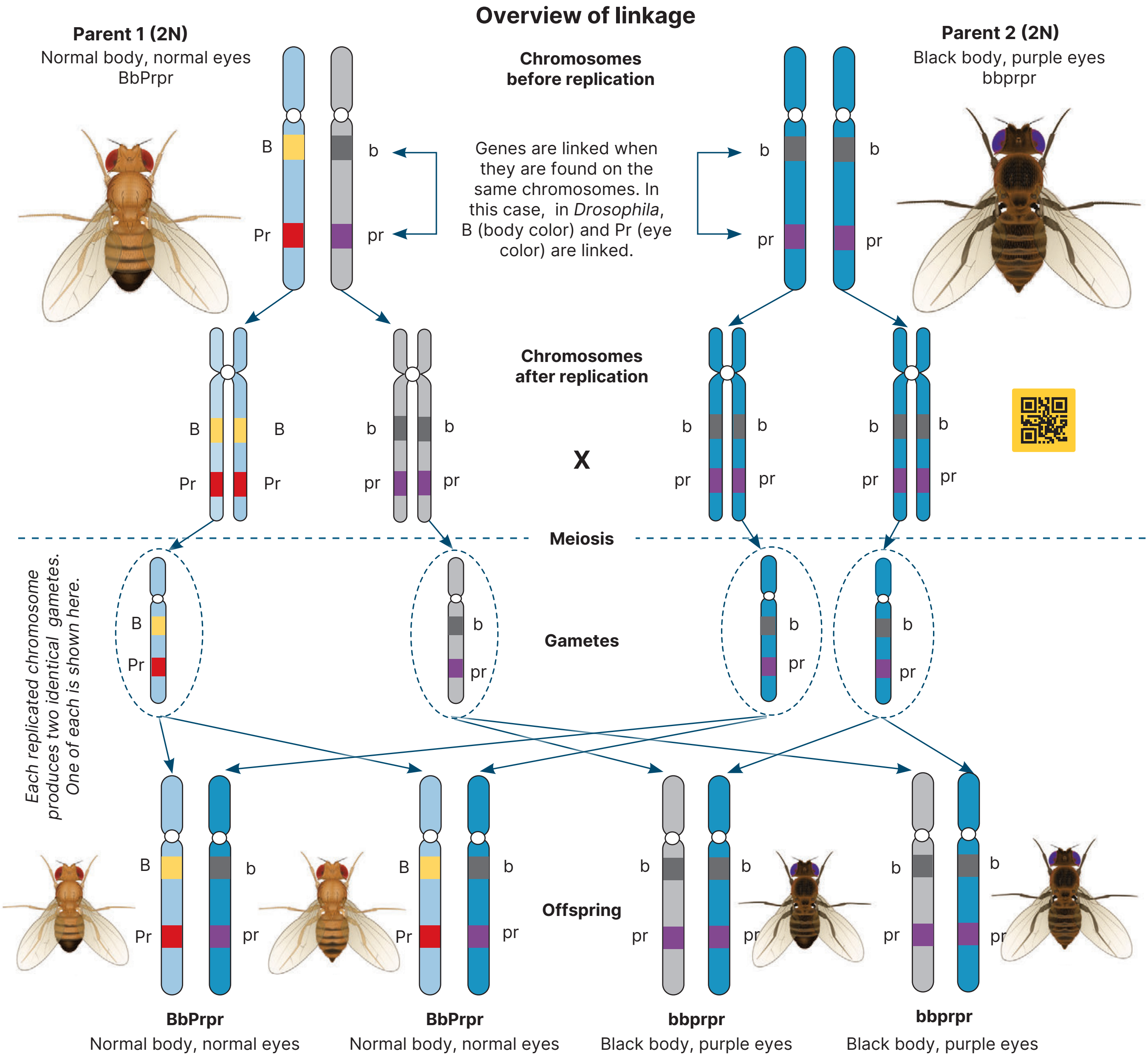
94 Inheritance of Linked Genes

Key Question: What is the effect of linkage on the amount of variation we see in the offspring of genetic crosses?

Genes are linked when they are on the same chromosome. **Linked genes** tend to be inherited together but the further apart they are, the more likely it is that **crossing over** will occur between them in prophase I. This also means that the extent of crossing over (the frequency of **recombination**) can be used to work out how close together the genes are. In **genetic crosses**, linkage is indicated when a greater proportion of the offspring from a cross are of the parental type (than would be expected if the **alleles** were on separate chromosomes and assorting independently).



Possible offspring

Only two kinds of genotype combinations are possible. They are they same as the parent genotype.

1. What is the effect of linkage on the inheritance of genes? ______________________________

____

____

2. Explain how linkage decreases the amount of genetic variation in the offspring: ______________________________

____

____

____

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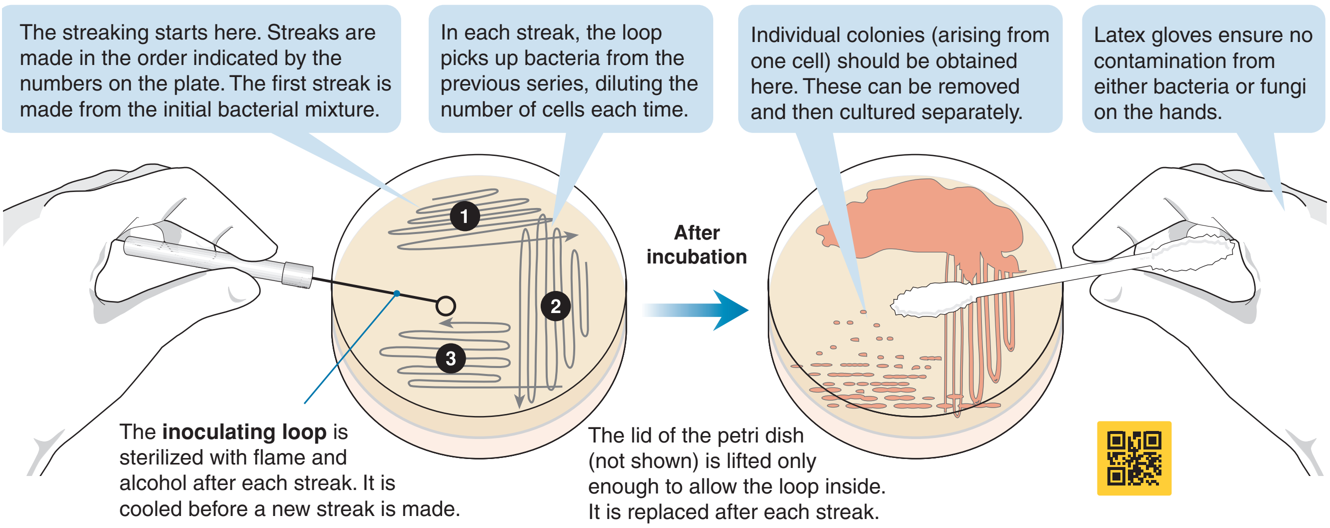
137 Aseptic Technique and Streak Plating

STUDENT SUPPORT FOR INVESTIGATION 8: *Bacterial transformation*

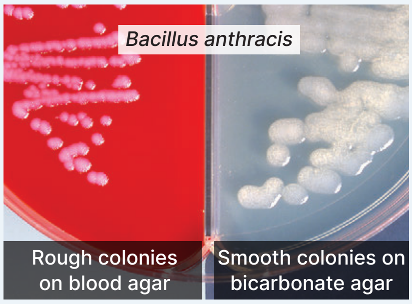
- The most common way of separating bacterial cells on an agar surface is the streak plate method. This method dilutes the sample by mechanical means. Contamination is minimized using a procedure called aseptic technique.
- After incubation, the area at the beginning of the streak pattern will show confluent growth (growth as a continuous sheet), while the area at the end of the streak will show individual colonies.
- Isolated colonies can be removed using aseptic techniques and transferred to a sterile medium. After incubation, assuming aseptic techniques have been used, all organisms in the new culture will be descendants of the same organism (i.e. a pure culture). The organism can then be identified and studied (e.g. for sensitivity to particular antibiotics).




GT

Colonies become visible when approximately 10 to 100 million bacterial cells are present. Note the well-isolated colonies in the photo above. A single colony may be removed for further investigation.

A swab containing a single strain of bacteria is used to inoculate additional nutrient plates to produce pure cultures of bacteria.



CDC

To test purity, a sample of a culture can be grown on a selective medium that promotes the growth of a single species. A selective medium may contain a nutrient specific to a particular species.

1. What is the purpose of streak plating? ____________________

2. Describe the process of streak plating: ____________________

____

____

3. Why is the lid only partially removed during streaking? ____________________

____

4. (a) How would you know if your streak plating had been effective? ____________________

____

(b) What could you do to test that all your colonies were the same species? ____________________

____

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156 Selection in Fast Plants

***STUDENT SUPPORT FOR INVESTIGATION 1:** Artificial selection*

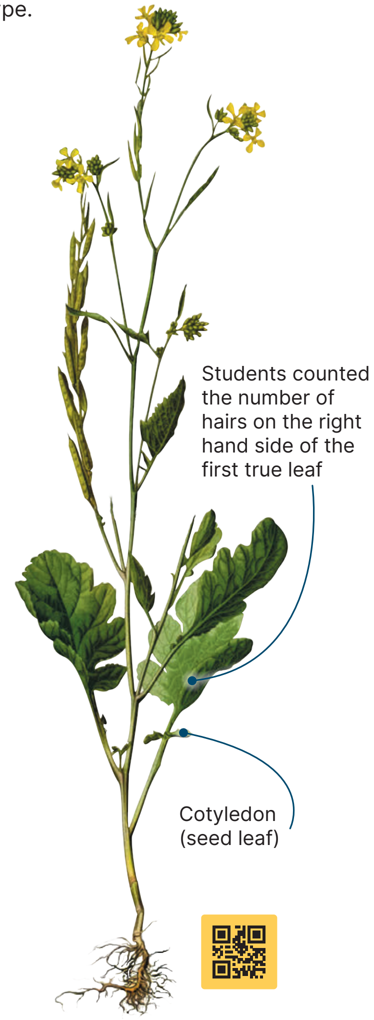
Artificial selection can be studied using Wisconsin Fast Plants®, plants bred to complete their life cycle in only five weeks. These plants show variation in quantifiable traits such hairiness (number of trichomes) and stem color. The students chose hairiness (number of trichomes) and selected plants by cross-pollinating the hairiest plants within a parental generation to produce a generation of offspring (F_1). The incidence of hairiness in the F_1 generation was studied to quantify the effect of artificial selection on phenotype.

Procedure

Students planted and grew Wisconsin Fast Plants® *Brassica rapa* seeds in the laboratory taking care to cultivate them in the soil, light, and moisture conditions required for optimal growth. At maturity (7-12 days) the students used a magnifier to count the number of trichomes (hairs) on the edge of the right hand side of the first true leaf of each plant. The class data for the parental generation are presented in Table 1. From the parental generation (F_0), students used small tags to identify and label the hairiest 10% of plants.

At day 14, when several flowers were present on each plant, the students cross pollinated the hairiest 10% of plants using pollination wands. This procedure was carried out for three consecutive days to ensure pollination was successful and fertilization had occurred.

Seeds were harvested from each plant between days 28-36, and placed in a paper bag for several days to dry. Once dry, the seeds were planted and grown under the same conditions as described above to produce the F_1 generation of plants. The number of hairs on each plant were counted at maturity using the same method described above. The results are presented in Table 1.



1. Record the frequency of trichomes for each of the categories listed below in table 2.

Table 2. Frequency of trichomes in parental and first generation plants

Number of trichomes	Parental generation		F_1 generation	
	Working	Frequency	Working	Frequency
0-4	*46x0 + 6x1 + 3x2 + 3x3 +2x4*			
5-9				
10-14				
15-19				
20-24				
25-29				
30-34				
35-39				
40-44				

Table 1. Trichomes counted for parental and F_1 generation fast plants (trichomes per plant).

Parental generation			F_1 generation	
0	1	12	0	15
0	1	12	0	15
0	1	12	0	15
0	1	12	0	16
0	1	12	0	17
0	1	14	0	17
0	2	15	0	17
0	2	15	0	17
0	2	16	1	17
0	3	16	1	17
0	3	16	1	17
0	3	17	2	18
0	4	18	4	18
0	4	18	5	18
0	5	19	6	19
0	5	20	6	19
0	5	21	6	19
0	5	21	7	19
0	5	21	7	19
0	5	22	7	20
0	6	22	7	20
0	6	24	8	20
0	6	26	8	20
0	6	29	9	20
0	7	32	9	20
0	7	32	9	20
0	8	33	10	20
0	8	44	10	21
0	8		10	23
0	8		10	23
0	8		11	23
0	8		11	24
0	8		11	25
0	9		11	26
0	9		12	26
0	10		12	28
0	10		13	28
0	10		13	29
0	10		13	29
0	10		13	30
0	10		13	31
0	10		14	31
0	11		14	32
0	11		15	35
0	11		15	40
0	12		15	

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179 Master Genes and Evolutionary Change

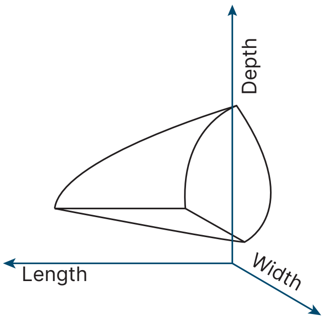
Key Question: What is the effect of changes in gene expression on the evolution of a species?

Bone morphogenetic proteins (BMPs) regulate bone and cartilage growth in embryos. BMP4 is a signaling molecule in a signal transduction pathway for the expression of genes controlling development of the skull, face, and jaws. The diverse shapes seen in the beaks of Darwin's finches and in the jaws of African cichlid fishes are the result of different levels of BMP4 expression. They show how different morphologies can arise by changing the expression of genes, and not necessarily the genes themselves. These processes are active in continuing the **evolution** of organisms today.

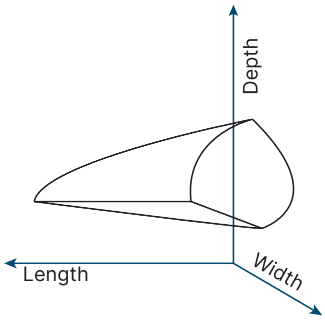
Beak shape is regulated by BMP4 and CaM1 expression

Two regulatory proteins, BMP4 and calmodulin (CaM1), are involved in controlling the shape of beaks in birds. Calmodulins are a group of calcium binding proteins. They have important roles in regulating a number of different protein targets, so are involved in regulating a variety of cell functions. In beak development, BMP4 controls width and CaM1 influences length.

The two extremes of beak shape in Darwin's finches are shown right. A wide range of beak shapes occur between these two extremes as a result of the different levels of expression of BMP4 and CaM1. The images below show some of the beak variation observed in Darwin's finches.



BMP4 (encoded by the BMP4 gene) controls beak width. Individuals expressing high levels of BMP4 early in development have deep, broad beaks, whereas individuals with low BMP4 expression developed narrower, shallower beaks.



CaM1 (encoded by the CaM1 gene)controls the length of the beak. When CaM1 is strongly expressed the beak tends to be more long and pointed than in individuals where CaM1 expression is lower.

The finches of the Galápagos Islands have adapted to occupy a wide range of different ecological niches, each specializing on different food sources. The shape of their beaks reflects this. Although several species of ground finch eat seeds, the size and hardness of the seeds they preferentially eat depends on their beak morphology. For example, the big, deep beak of the large ground finch allows it to break much harder, larger seeds than the smaller beaks of the two other ground finches.

The sharp-beaked finch (*G. difficilis*) feeds on a mixed diet of seeds and insects.

Low BMP4 Low beak depth/width
Low CaM Short beak

Compiled from various sources including:
LF DeLeon *et al*, J. Evol. Biol, 27 (2014) "*Darwin's finches and their diet niches: the sympatric coexistence of imperfect generalists.*" and A Abzhanov *et al.* Nature 442 (2006) " *The calmodulin pathway and evolution of elongated beak morphology in Darwin's finches.*"

Low BMP4 Low beak depth/width	Low/ moderate BMP4 Moderate beak depth/width	Moderate BMP4 Moderate beak depth/width	Early/high BMP4 High beak depth/width
High CaM Elongated beak	High CaM Elongated beak	Low CaM Short beak	Low CaM Short beak

Cactus finch (*G. scandens*)
Probes cactus flowers and fruit.

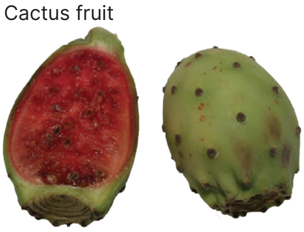
Large cactus finch (*G. conirostris*)
Feeds on seeds, insects, and cacti.

Medium ground finch (*G. fortis*)
Crushes seeds up to 1.5cm.

Large ground finch (*G.magnirostris*)
Crushes large, hard seeds up to 2 cm.

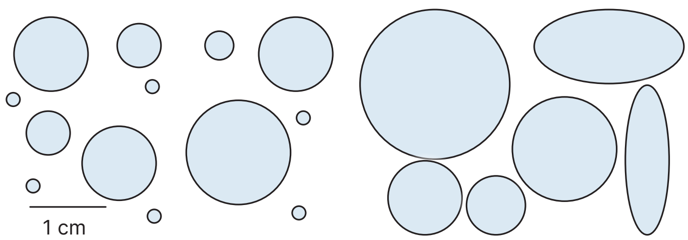
Finch photos all thanks to Prof. Jeff Podos unless otherwise stated

Cactus fruit



Cactus seeds

Roger Culos Muséum de Toulouse CC3.0



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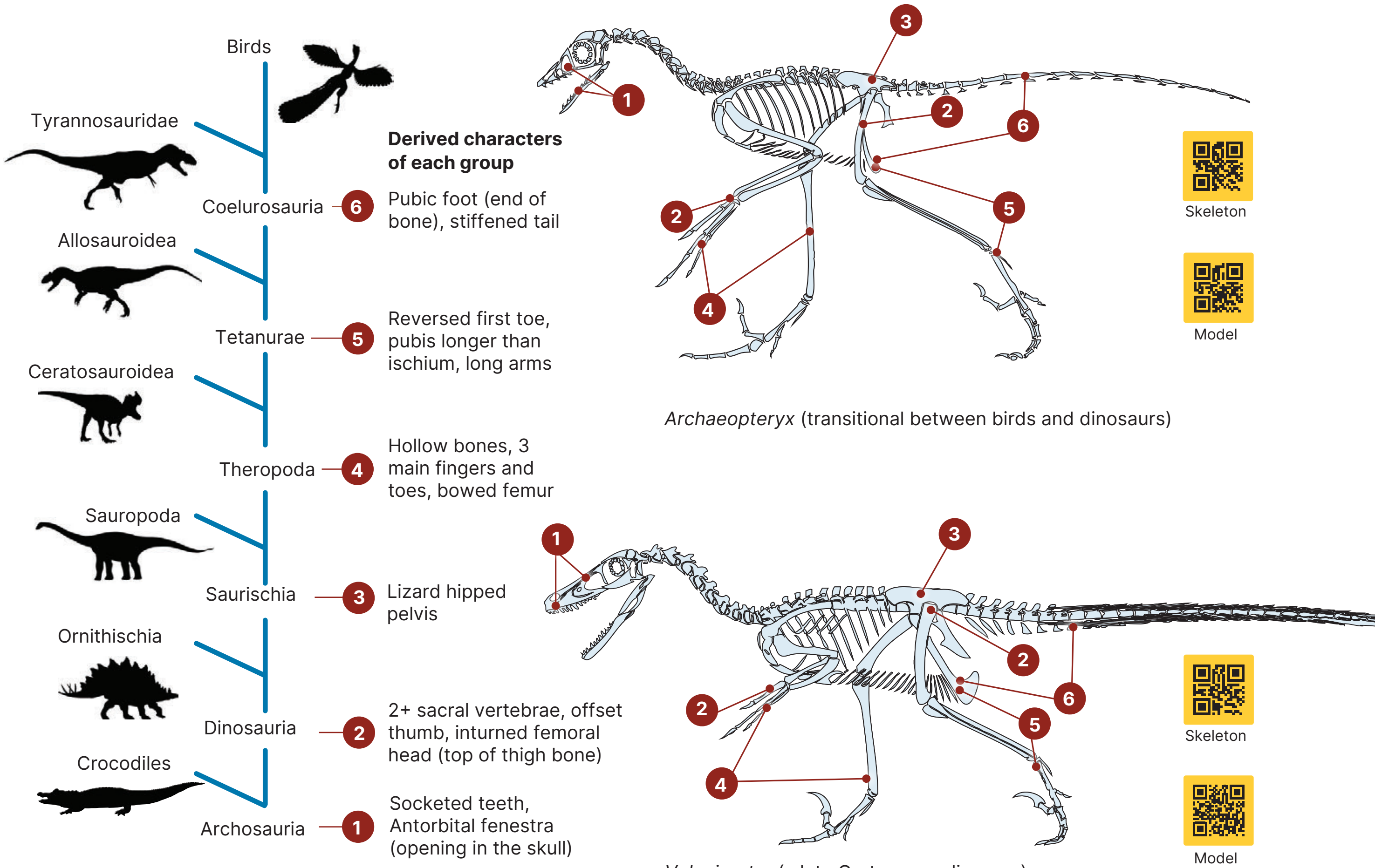
186 Why Are Birds Dinosaurs?

Key Question: What is the evidence from shared derived characters that puts birds and dinosaurs in the same taxon?

Defining groups of organisms and evaluating their ancestry using morphological features alone can be problematic because similarities in structure may not necessarily be the result of shared ancestry. This problem can be overcome by considering only **shared derived characters**, i.e. the characters of two of more taxa that are present in their most recent common ancestor but not in earlier ancestors. Tracing the **evolution** of derived character states can more accurately identify the evolutionary history of a taxon. The ancestry of birds illustrates this. Although birds are commonly regarded as a single taxon (and in modern terms they are) birds are simply the last in the lineage of the dinosaurs. Recent analysis of the protein structure of fossil collagen from *Tyrannosaur* fossils puts birds and dinosaurs in the same taxon.

Derived characters shared by birds and dinosaurs



Archaeopteryx (transitional between birds and dinosaurs)

Velociraptor (a late Cretaceous dinosaur)

1. Explain how grouping organisms based on shared derived characters can help explain their evolutionary history:

2. Interpret the ladder of derived character states to explain why birds are considered to be the last organisms in the lineage of dinosaurs:

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Comparing diversity at two woodland sites

- Diversity indices are particularly useful when comparing the diversity of different areas or comparing the change in diversity over time. The investigation below gathered data using quadrats to survey of invertebrate diversity in two different types of forested land. The types and individuals of invertebrate species were recorded.

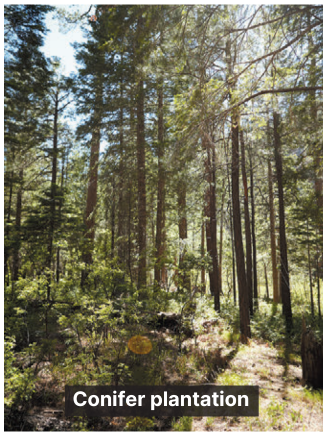
Observation

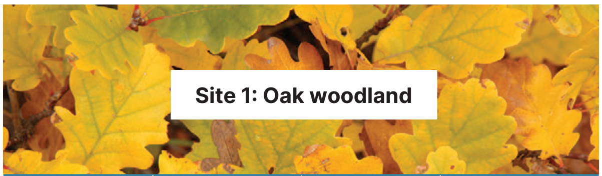
Walking through a conifer plantation, a student observed that there seemed to be only a few different invertebrate species in the forest leaf litter. They wondered if more invertebrate species would be found in a nearby oak woodland.

Hypothesis

The oak woodland has a more varied leaf litter composition than the conifer plantation, so will support a wider variety of invertebrate species.

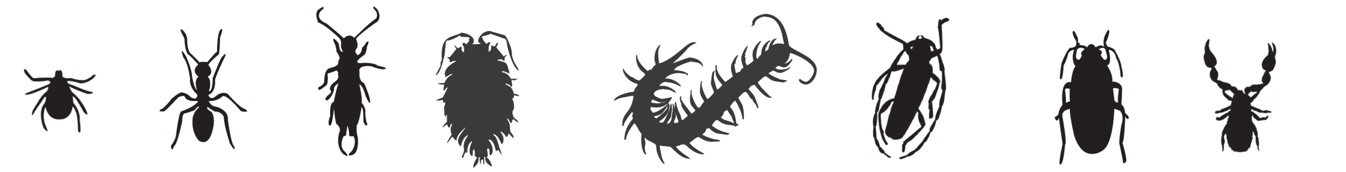
The null hypothesis is that there is no difference between the diversity of invertebrate species in oak woodland and coniferous plantation litter.





Species	Number of animals (n)	n/N	$(n/N)^2$
Species 1	35		
Species 2	14		
Species 3	13		
Species 4	12		
Species 5	8		
Species 6	6		
Species 7	6		
Species 8	4		
	$\sum n = 98$		$\sum(n/N)^2 =$

Species	Number of animals (n)	n/N	$(n/N)^2$
Species 1	74		
Species 2	20		
Species 3	3		
Species 4	3		
Species 5	1		
Species 6	0		
Species 7	0		
Species 8	0		
	$\sum n = 101$		$\sum(n/N)^2 =$



Species 1 Mite | Species 2 Ant | Species 3 Earwig | Species 4 Woodlice | Species 5 Centipede | Species 6 Longhorn beetle | Species 7 Small beetle | Species 8 Pseudoscorpion

3. (a) Complete the two tables above by calculating the values for n/N and $(n/N)^2$ for the student's two sampling sites:

   (b) Calculate the Simpson's Index of Diversity for site 1: ______

   (c) Calculate the Simpson's Index of Diversity for site 2: ______

   (d) Compare the diversity of the two sites and suggest any reasons for it: ______

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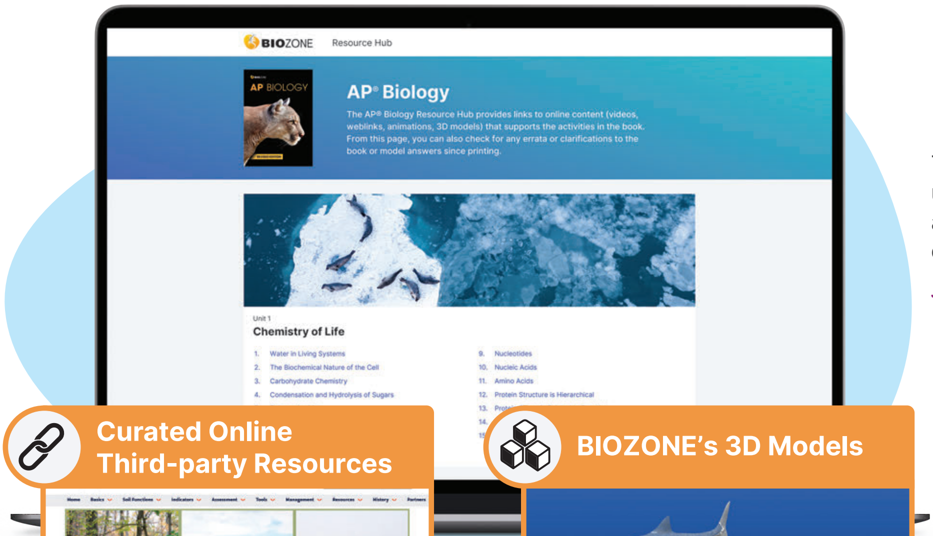

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The **Resource Hub** provides print book users with **FREE access** to curated material and resources which support the content of the worktext.

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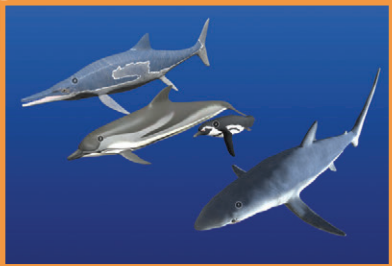

Interactive 3D models provide a fun way to engage students.

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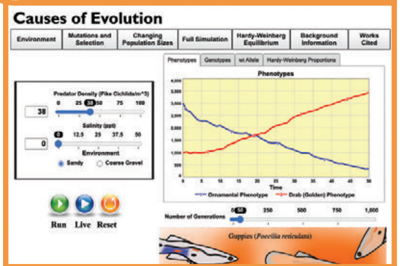

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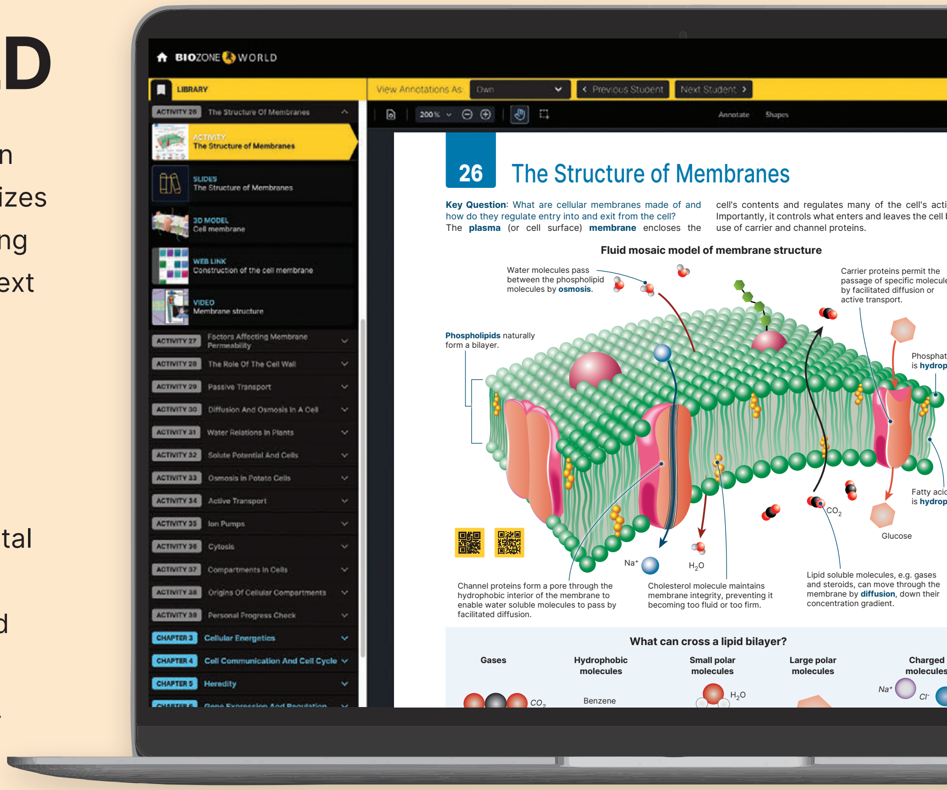

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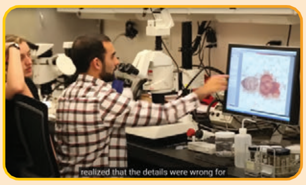

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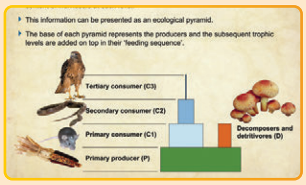

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