BIOZONE

NCEA **LEVEL 2**

BIOLOGY

EXTERNALS

Achievement Standard **2.4**

Life processes at the cellular level

Key terms

Cell structure
eukaryotic
organelle

Movement of materials
active transport
diffusion
endocytosis
exocytosis
ion pump
osmosis
partially permeable
passive transport
plasma membrane
surface area: volume ratio

Enzymes and energy
active site
aerobic
anaerobic
ATP
Calvin cycle
catalyst
cellular respiration
chloroplast
denaturation
electron transport chain
enzyme
fermentation
glycolysis
Krebs cycle
light dependent phase
light independent phase
metabolic pathway
metabolism
mitochondrion
photosynthesis

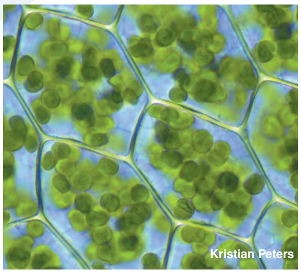
Cell division
cell cycle
chromosome
cytokinesis
DNA replication
mitosis
semi-conservative

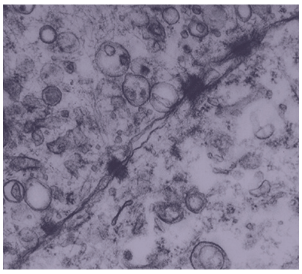
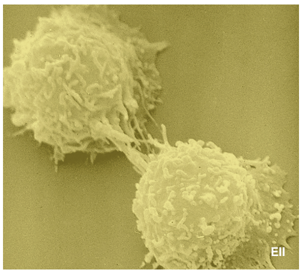
Plant and animal cells are eukaryotic cells. They have a number of features in common but also several distinguishing features. Cells exchange substances with their environment to maintain the reactions of life (metabolism). These reactions are catalysed by enzymes.

Achievement criteria and explanatory notes

Achievement criteria for achieved, merit, and excellence

- ☐ A Demonstrate understanding of life processes at the cellular level: Define and use annotated diagrams or models to describe life processes at the cellular level. Describe characteristics of, or provide an account of, life processes at the cellular level.
- ☐ M Demonstrate in-depth understanding of life processes at the cellular level: Use biological ideas to give reasons how or why life processes occur at the cellular level.
- ☐ E Demonstrate comprehensive understanding of life processes at the cellular level: Link biological ideas about life processes at the cellular level. The discussion may involve justifying, relating, evaluating, comparing and contrasting, or analysing.



Explanatory notes: Life processes at the cellular level

Life processes for plant and animal cells to include the following...

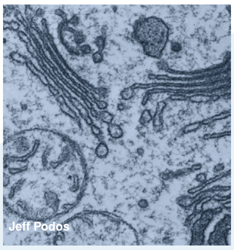
		Activity number
☐	1 Photosynthesis: The process that converts light energy into chemical energy.	36-42
☐	2 Cellular respiration: The oxidation of complex organic substances to produce usable energy as ATP.	29-35
☐	3 Cell division: DNA replication and mitosis as part of the cell cycle.	47-55

Biological ideas relating to life processes

Select biological ideas relating to each of life process from...

		Activity number
☐	i Reasons for similarities and differences between plant and animal cells such as size and shape, and type and number of organelles present.	1-9
☐	ii Movement of materials, including diffusion, osmosis, and active transport.	9-18
☐	iii Enzyme activity (although specific names of enzymes is not required).	22-28
☐	iv Factors affecting the process (e.g. photosynthesis, cellular respiration, cell transport processes, enzyme activity, cell division).	14 26-28 33 40 41 50
☐	v Details of the processes as they relate to the overall functioning of the cell (although the names of specific stages are not required).	30-32 38-39 47 48 52 53

What you need to know for this Achievement Standard

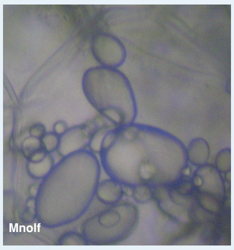


Structure of plant and animal cells

Activities 1-9, 19-21

By the end of this section you should be able to:

- ☐ Describe the structure of a plant cell and an animal cell.
- ☐ Identify, describe, and give reasons for similarities and differences between plant and animal cells. Include reference to cell size and shape and number and type of organelles present.
- ☐ Recognise different types of specialised plant and animal cells and explain how the cell's features relate to its functional role.

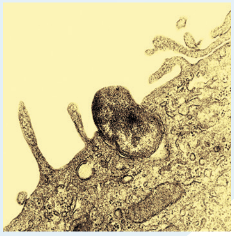


Movement of materials

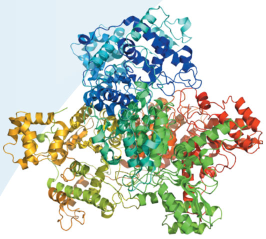
Activities 10-21

By the end of this section you should be able to:

- ☐ Define the term concentration gradient and explain its significance to the movement of materials within and between cells.
- ☐ Describe the structure of cellular membranes in relation to the movement of substances within and between cells. Define selectively permeable.



- ☐ Define the term passive transport. Explain the movement of materials by diffusion, including facilitated diffusion and the role of membrane proteins in moving material across membranes.
- ☐ Explain the movement of water by osmosis and explain its significance in terms of the tonicity of the cell.
- ☐ Define active transport and explain why energy is needed to move molecules and ions against their concentration gradient.
- ☐ Explain the movement of materials by active transport mechanisms including ion pumps, endocytosis, and exocytosis.

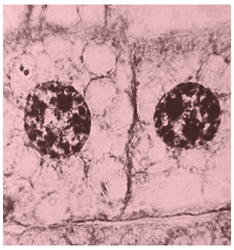


Enzymes and energy transformations

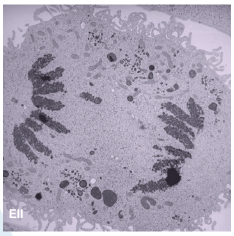
Activities 22-46

By the end of this section you should be able to:

- ☐ Describe how enzymes work, including reference to the active site and activation energy.
- ☐ Use examples to explain how enzymes regulate sequential steps in metabolic pathways.
- ☐ Describe factors affecting the activity of enzymes (and therefore reactions they catalyse). Include reference to substrate concentration, enzyme concentration, pH, and temperature.
- ☐ Describe and explain enzyme denaturation.



- ☐ Compare and contrast cellular respiration and photosynthesis as energy transformation processes. Explain the universal role of ATP in cells.
- ☐ Describe and explain the breakdown of glucose by cellular respiration including glycolysis, the Krebs cycle, and the electron transport chain.
- ☐ Describe ATP production by fermentation when oxygen is absent.
- ☐ Describe and explain the fixation of carbon in green plants by photosynthesis, including the inputs and outputs of the light dependent and light independent phases.
- ☐ Describe factors that affect the rate of photosynthesis.



Cell division

Activities 47-58

By the end of this section you should be able to:

- ☐ Describe DNA replication and explain its role in preparing the cell for division.
- ☐ Explain the role of enzymes in DNA replication and the significance of DNA's anti-parallel nature.
- ☐ Identify phases in the cell cycle and explain the importance of each stage.
- ☐ Describe the role of mitosis in organisms.
- ☐ Describe mitosis and cytokinesis, including the cellular outcome and the behaviour of the chromosomes. What factors determine whether or not a cell enters mitosis?

1 The Structure of Plant Cells

Key Idea: Plant cells are eukaryotic cells. They share many features in common with animal cells, but they also have several unique features.

Amyloplast
Specialised plastids which synthesise and store starch.

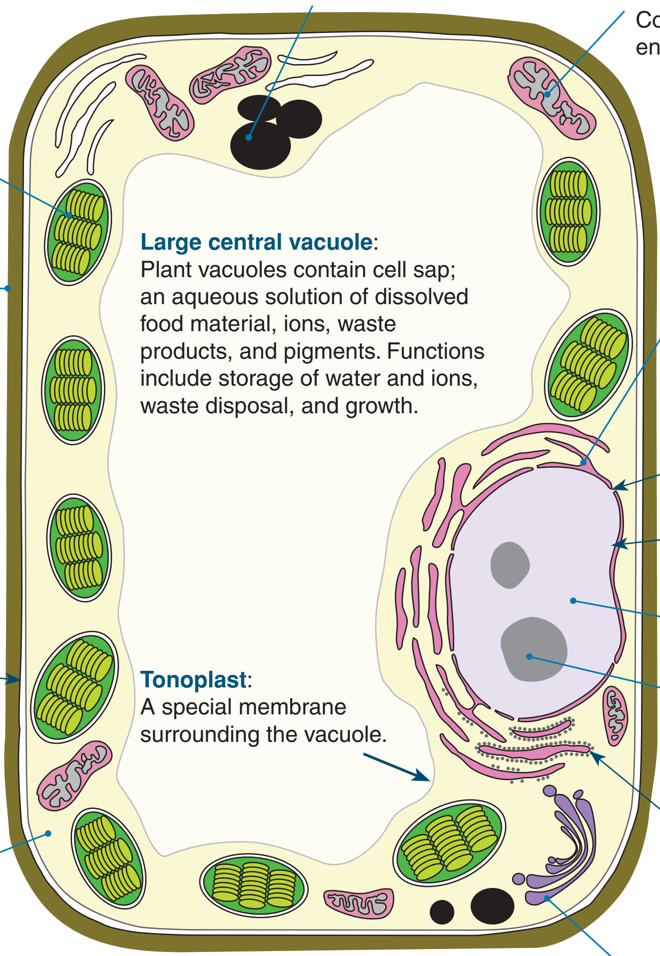
Mitochondrion
Convert chemical energy into ATP.

Chloroplast
Specialised plastids containing the green pigment chlorophyll. They are the sites for photosynthesis.

Endoplasmic reticulum (ER)
A network of tubes and flattened sacs. ER is continuous with the nuclear membrane. ER may be smooth (smooth ER) or have ribosomes attached (rough ER).

Large central vacuole: Plant vacuoles contain cell sap; an aqueous solution of dissolved food material, ions, waste products, and pigments. Functions include storage of water and ions, waste disposal, and growth.

Cellulose cell wall
A semi-rigid structure outside the plasma membrane, made mainly from cellulose. It protects the cell, maintains its shape, and prevents excessive water uptake. It provides rigidity to plant structures but still allows materials to pass into and out of the cell.



Nuclear pore

Nuclear membrane

Nucleus contains most of a cell's DNA.

Nucleolus

Plasma membrane
Located inside the cell wall in plants. Controls the movement of substances in and out of the cell.

Tonoplast: A special membrane surrounding the vacuole.

Ribosomes
Manufacture proteins.

Cytoplasm
A watery solution containing dissolved substances, enzymes, and the cell organelles and structures.

Cell cytoskeleton
(located within cytoplasm) provides structure and shape to a cell, is responsible for cell movement and provides intracellular transport of organelles and other structures.

Golgi apparatus
Stores, modifies, and packages proteins.

Features of a plant cell

Plant cells are eukaryotic cells. Features which identify plant cells as eukaryotic cells include:

- Presence of a membrane-bound nucleus.
- Presence of membrane-bound organelles (e.g. mitochondrion, Golgi apparatus, endoplasmic reticulum).

Plant cells share many structures and organelles in common with animal cells, but they also have several features not seen in animal cells. Features which can be used to identify a plant cell include the presence of:

- **Cellulose cell wall**
- **Chloroplast**
- **Amyloplast**
- **Large vacuole** (often centrally located)

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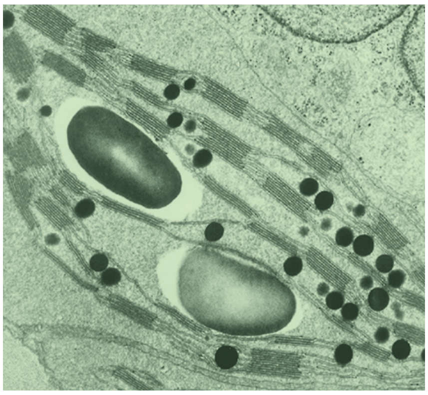

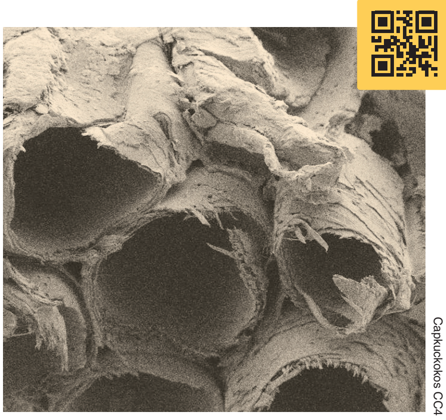

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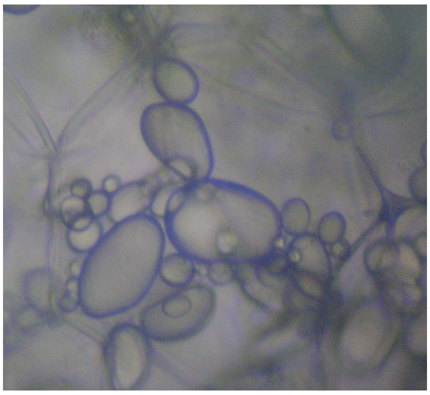

Mnolf

Chloroplasts are found in cells in the green parts of the plant, such as the leaves and sometimes the stem. These parts are exposed to light and are photosynthetic. In leaves, they are found in palisade and spongy mesophyll cells.

Plant cells are surrounded by **cellulose cell walls**. The cellulose supports the cell (and the plant). Cellulose is a polysaccharide, made up of repeating glucose units. The cell wall also contains the polymer lignin, especially in woody parts of the plant.

Amyloplasts (above) and chloroplasts are types of organelles called **plastids**. Plants have different types of plastids. They have roles in storing fats, protein, starch (amyloplasts), pigments, and tannins, as well as carrying out photosynthesis (chloroplasts).

1. What are the functions of the cell wall in plants? ______________________

2. (a) What structure takes up the majority of space in the plant cell? ______________________

   (b) What are its roles? ______________________

3. Identify two structures in the diagram that are not found in animal cells: ______________________

4. (a) In which parts of the plant are chloroplasts found? ______________________

   (b) Why are they found there? ______________________

5. What is the function of cellulose and lignin? ______________________

6. Briefly describe the functions of the following:

   (a) Chloroplasts: ______________________

   (b) Plasma membrane: ______________________

   (c) Nucleus: ______________________

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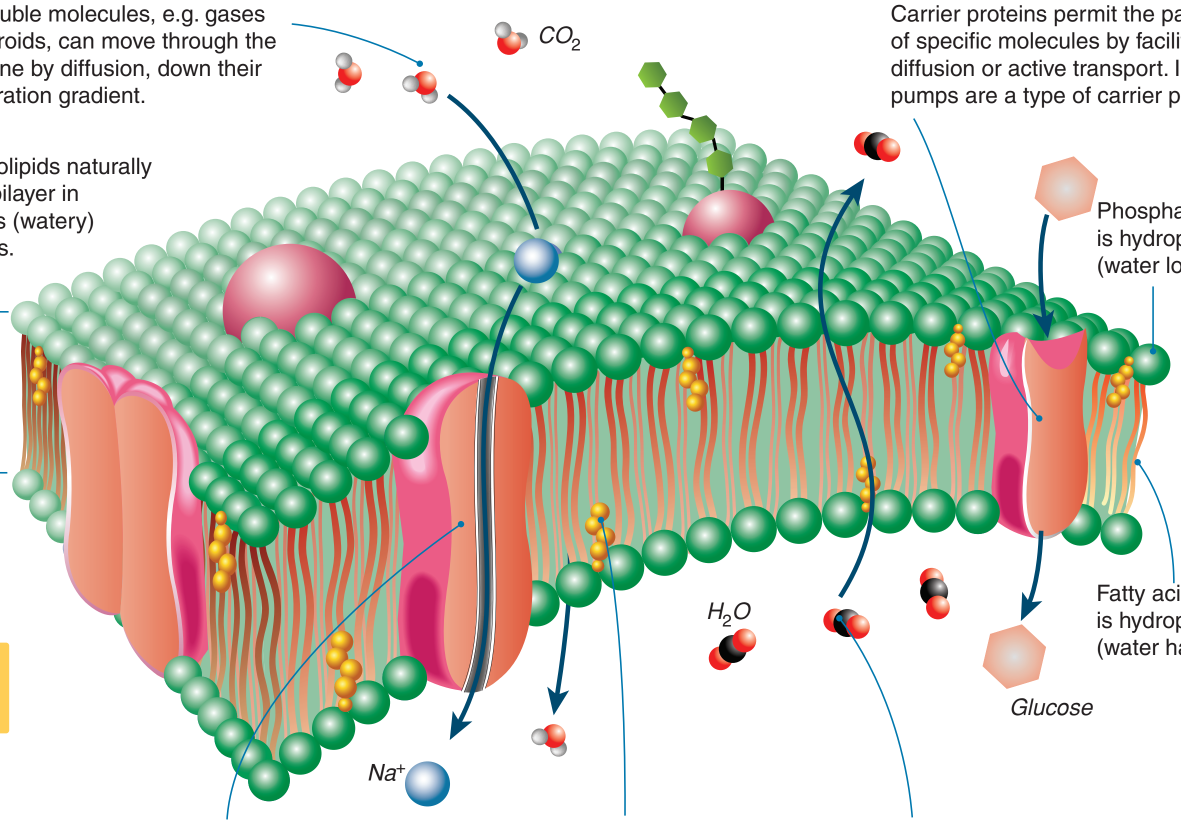
9 The Structure of Membranes

Key Idea: The plasma membrane encloses the cell and regulates the entry and exit of substances into the cell. It is a phospholipid bilayer with embedded proteins moving freely within it.

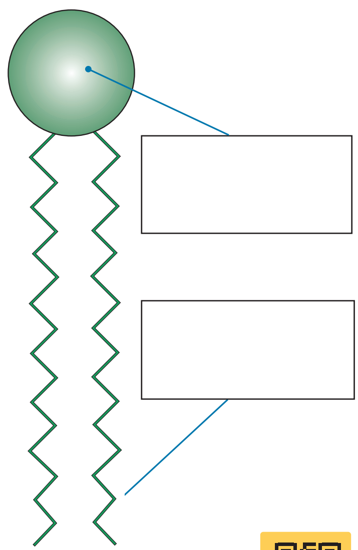
- The cell surface (or plasma) membrane encloses the cell's contents. The fluid-mosaic model of membrane structure describes a phospholipid bilayer within which various proteins can move about freely.
- The plasma membrane is a dynamic structure and is actively involved in cellular activities. It is selectively permeable, allowing some molecules, but not others, to pass. Proteins in the membrane enable the cell to regulate the movement of materials into and out of the cell. This enables the cell to obtain what it needs for its metabolism.



1. Describe the fluid mosaic model of membrane structure: ______

2. (a) What are the two main roles of the plasma membrane? ______

(b) How is its structure related to these roles? ______



3. On the diagram (right) label the hydrophobic and hydrophilic ends of the phospholipid and indicate which end is attracted to water:

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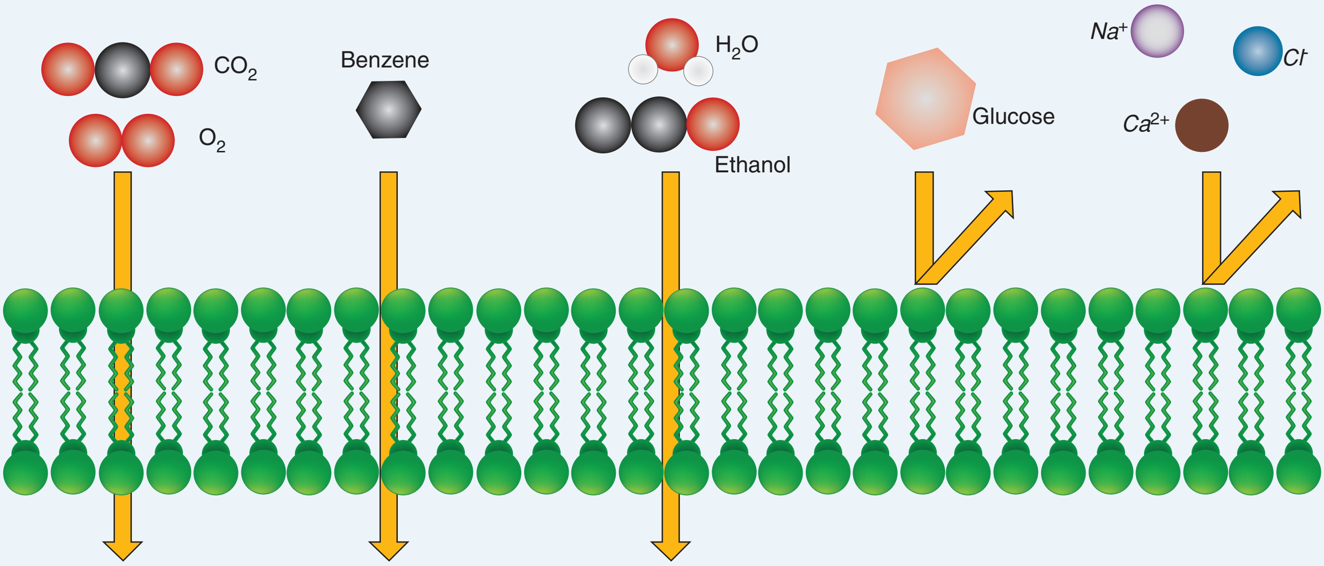
What can cross a lipid bilayer?



Gases

Small uncharged molecules can diffuse easily through the membrane.

Hydrophobic molecules

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

Small polar molecules

Small polar molecules are small enough to diffuse through. Aquaporins (water channels) increase rate of water movement.

Large polar molecules

Large polar molecules cannot directly cross the membrane. Transport (by facilitated diffusion or active transport) involves carrier proteins.

Charged molecules

Ions can be transported across the membrane via channel proteins, e.g. ion channels (passive) or ion pumps (active).

4. What is the purpose of carrier proteins in the membrane? ____________________

____

____

____

5. What is the purpose of channel proteins in the membrane? ____________________

____

____

____

6. In the diagram above, identify the molecule(s) that:

(a) Can diffuse through the plasma membrane on their own: ____________________

____

(b) Can diffuse through the membrane via channel proteins: ____________________

____

(c) Must be transported across the membrane by carrier proteins: ____________________

____

7. Explain why ions have to pass through a protein channel in the lipid bilayer: ____________________

____

____

____

____

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69 Dominant and Recessive Traits

Key Idea: Traits are controlled by genes, and can be inherited and passed from one generation to the next. A trait may be caused by a dominant or recessive allele.

Traits are inherited

- **Traits** are particular variants of a phenotypic (observed physical) character. For example, a phenotype is eye colour, a trait is blue eye colour.
- Traits are controlled by alleles (variations of a gene).Traits are inherited and the alleles controlling a trait may be dominant or recessive (although degrees of dominance are also possible).
- Dominant alleles produce a dominant trait. A dominant trait overrides a recessive trait. Only one copy of the dominant allele needs to be present for the dominant trait to be expressed.
- In contrast, a recessive trait will only be expressed when an individual has two copies of the recessive allele.

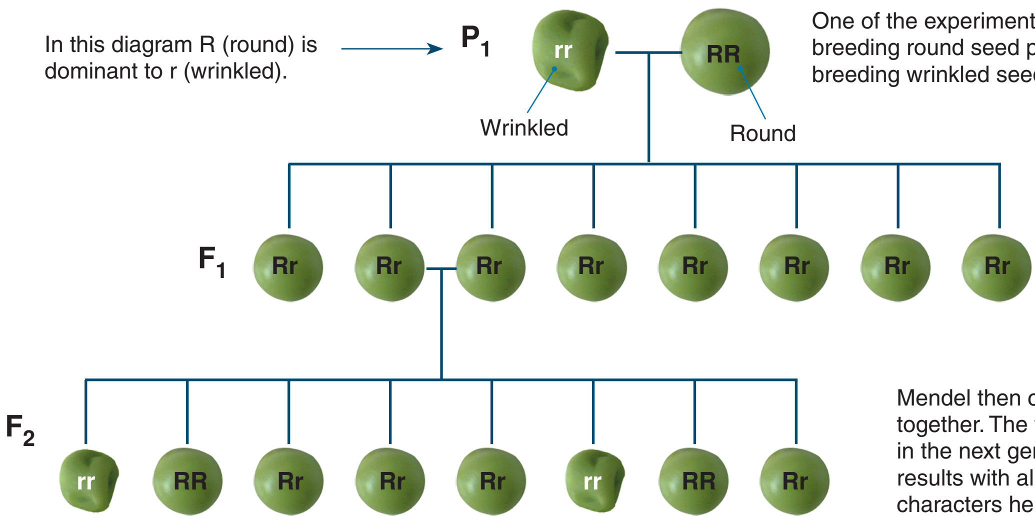
Mendel's experiments

Some of the best known experiments in phenotypes are the experiments carried out by Gregor Mendel (right) on pea plants. During one of the experiments (shown below) he noticed how traits expressed in one generation disappeared in the second generation, but reappeared in the third generation. In his experiments Mendel used true breeding plants. When self-crossed, true breeding organisms produce offspring with the same phenotypes as the parents.

Mendel studied seven phenotypic characters of the pea plant:

- Flower colour (violet or white)
- Pod colour (green or yellow)
- Height (tall or short)
- Position of the flowers on the stem (axial or terminal)
- Pod shape (inflated or constricted)
- Seed shape (round of wrinkled)
- Seed colour (yellow or green)

In this diagram R (round) is dominant to r (wrinkled).



One of the experiments crossed true breeding round seed plants with true breeding wrinkled seed plants.

Out of the thousands of seeds produced, all were round, none were wrinkled.

Mendel then crossed the F_1 offspring together. The wrinkled seed reappeared in the next generation. He saw similar results with all the other phenotypic characters he studied.

How can this be explained?

Mendel was able to explain his observations in the following way:

- Traits are determined by a unit, which passes unchanged from parent to offspring (we now know that these units are genes).
- Each individual inherits one unit (gene) for each trait from each parent (each individual has two units).
- Traits may not physically appear in an individual, but the units (genes) for them can still be passed to its offspring.

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1. Define a trait: ____

____

2. Describe the difference between the expression of dominant and recessive traits: ____

____

____

____

3. In Mendel's pea experiments on the previous page:

(a) What was the ratio of smooth seeds to wrinkled seeds in the F_2 generation? ____

____

(b) Why did the wrinkled seed trait not appear in the F_1 generation? ____

____

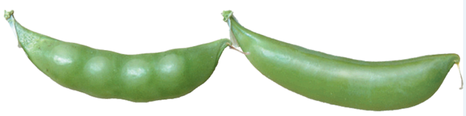
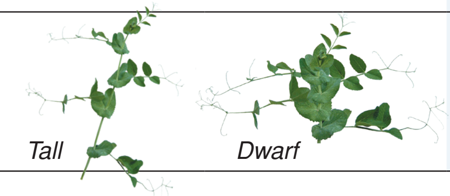
____

____

4. Mendel examined seven phenotypic traits. Some of his results from crossing heterozygous plants are tabulated below. The numbers in the results column represent how many offspring had those phenotypic features.

(a) Study the results for each of the six experiments below. Determine which of the two phenotypes is dominant, and which is the recessive. Place your answers in the spaces in the dominance column in the table below.

(b) Calculate the ratio of dominant phenotypes to recessive phenotypes (to two decimal places). The first one has been done for you (5474 ÷ 1850 = 2.96). Place your answers in the spaces provided in the table below:

Trait	Possible phenotypes	Results	Dominance	Ratio
Seed shape	 *Wrinkled* *Round*	Wrinkled 1850 Round 5474 **TOTAL 7324**	Dominant: Round Recessive: Wrinkled	2.96 : 1
Seed colour	 *Green* *Yellow*	Green 2001 Yellow 6022 **TOTAL 8023**	Dominant: Recessive	
Pod colour	 *Green* *Yellow*	Green 428 Yellow 152 **TOTAL 580**	Dominant: Recessive	
Flower position	 *Axial* *Terminal*	Axial 651 Terminal 207 **TOTAL 858**	Dominant: Recessive	
Pod shape	 *Constricted* *Inflated*	Constricted 299 Inflated 882 **TOTAL 1181**	Dominant: Recessive	
Stem length	 *Tall* *Dwarf*	Tall 787 Dwarf 277 **TOTAL 1064**	Dominant: Recessive	

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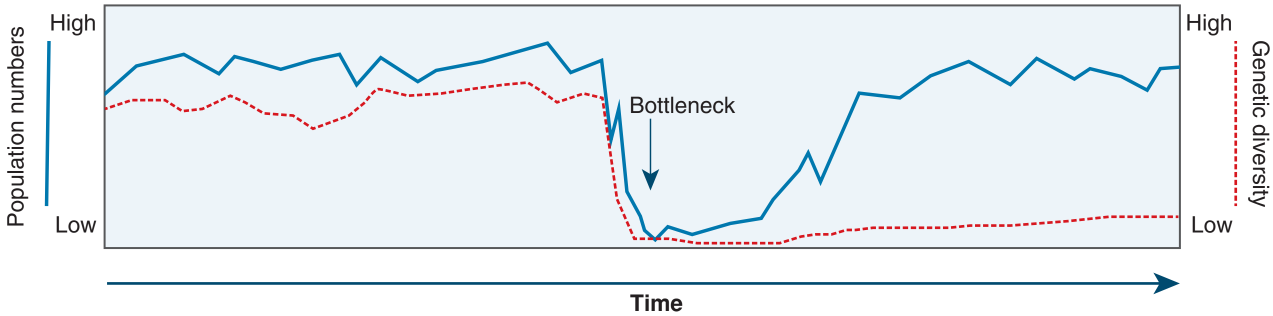
93 Population Bottlenecks

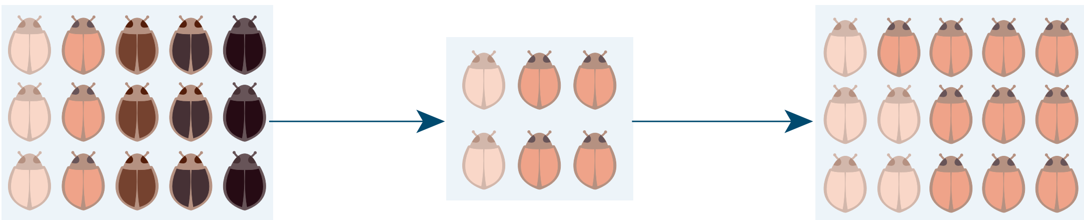
Key Idea: Population bottlenecks occur when population numbers and diversity fall dramatically. Although a population's numbers may recover, its genetic diversity may not.

- A **population** (or genetic) **bottleneck** is a sharp reduction in the size of a population (a population crash). Causes include natural disasters (earthquake, flood, fire, drought), disease, predation, climatic change, and human activity.
- A population crash may not select against one phenotype. It can affect all phenotypes equally although, for disease losses, it may be particular allele combinations that survive. Large scale catastrophes, such as fire or volcanic eruption, are examples of non-selective events.
- Following bottleneck events, the small number of individuals contributing to the gene pool may not have a representative sample of the alleles in the pre-catastrophe population. The population may recover, but genetic diversity is lost.
- Before increasing in size again, the population is also more susceptible to the effects of genetic drift and may be vulnerable to the detrimental effects of inbreeding.

Cheetahs are a species that has experienced a population bottleneck. Cheetahs nearly became extinct at the end of the last ice age. Today there are fewer than 8,000 surviving. The entire population exhibits very little genetic diversity and this lack of genetic diversity, threatens cheetah survival.

The effect of population bottlenecks on genetic diversity





Large, genetically diverse population.

Population numbers are drastically reduced. Much of the genetic diversity is lost.

Population numbers increase again, but the larger population has low genetic diversity.

1. Define the term population bottleneck: ______________________________

____

2. Explain how a population bottleneck can decrease genetic diversity in a population: ______________________________

____

____

____

____

____

3. What events might cause a population bottleneck? ______________________________

____

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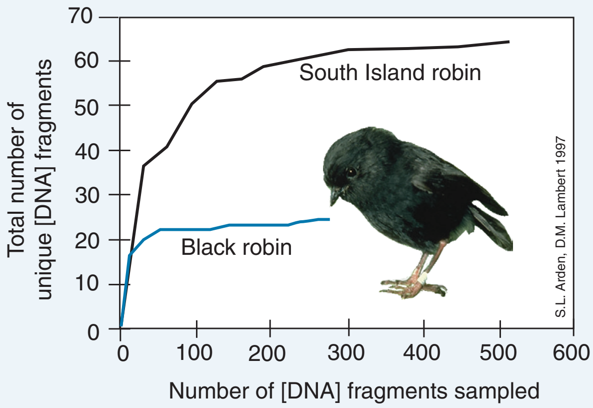
Case study: The Chatham Island black robin

Many native New Zealand birds have passed through bottleneck events, mostly due to the arrival of humans and loss of habitat. The Chatham Island (or black) robin (*Petroica traversi*) is an extreme example. When first described in 1872, it was common on the Chatham Islands. By 1938, it was extinct on all the islands except for one population of about 60 on Little Mangere Island. By the early 1970s, the black robin population had dropped to just 18. By 1980 it was five. Thanks to recovery efforts, the population is now close to 250. All of these are descended from one female, Old Blue. Analysis of the black robin's DNA shows it to have among the lowest genetic diversity of any reported bird species. The black robin is listed as critically endangered.



DNA profiling reveals that almost all the black robin's genetic variation is found after sampling just a few birds (unlike the related South Island robin).

Case study: Tasmanian devils

Tasmanian devils were once found throughout mainland Australia, but are now restricted to Tasmania. Genetic evidence suggests that the devils went through two population crashes, one 30,000 years ago and another 3000 years ago. Further modern declines (1850 to 1950) occurred as a result of trapping and disease. These historic population crashes are likely to be responsible for the very low diversity of MHC genes in devils. MHC genes are important in immunity and the body's self recognition system.

Low allelic diversity for MHC is implicated in the spread of devil facial tumour disease (DFTD). DFTD is a contagious cancer that appeared in Tasmanian devil populations in the mid 1990s and has resulted in the loss of 80% of the devil population. The cancerous cells are transmitted when the devils fight. Ordinarily this foreign material would be recognised and destroyed by the immune system. In Tasmanian devils, the immune diversity is so low that tumours can spread without invoking an immune response. However, recent evidence shows that some populations are developing immunity to DFTD. This may originate in individuals with MHC alleles distinctly different from the susceptible individuals.

4. Populations of endangered species have often experienced historic genetic bottlenecks. Explain how genetic bottlenecks might affect the ability of an endangered species to recover and maintain healthy populations:

5. Study the graph above and suggest why (based on unique DNA fragments) the South Island robin is less likely to be endangered than the Chatham Island black robin:

6. (a) What has been the genetic consequence of bottleneck events in the Tasmanian devil population?

(b) How has this led to increased susceptibility to disease, specifically infectious cancer?

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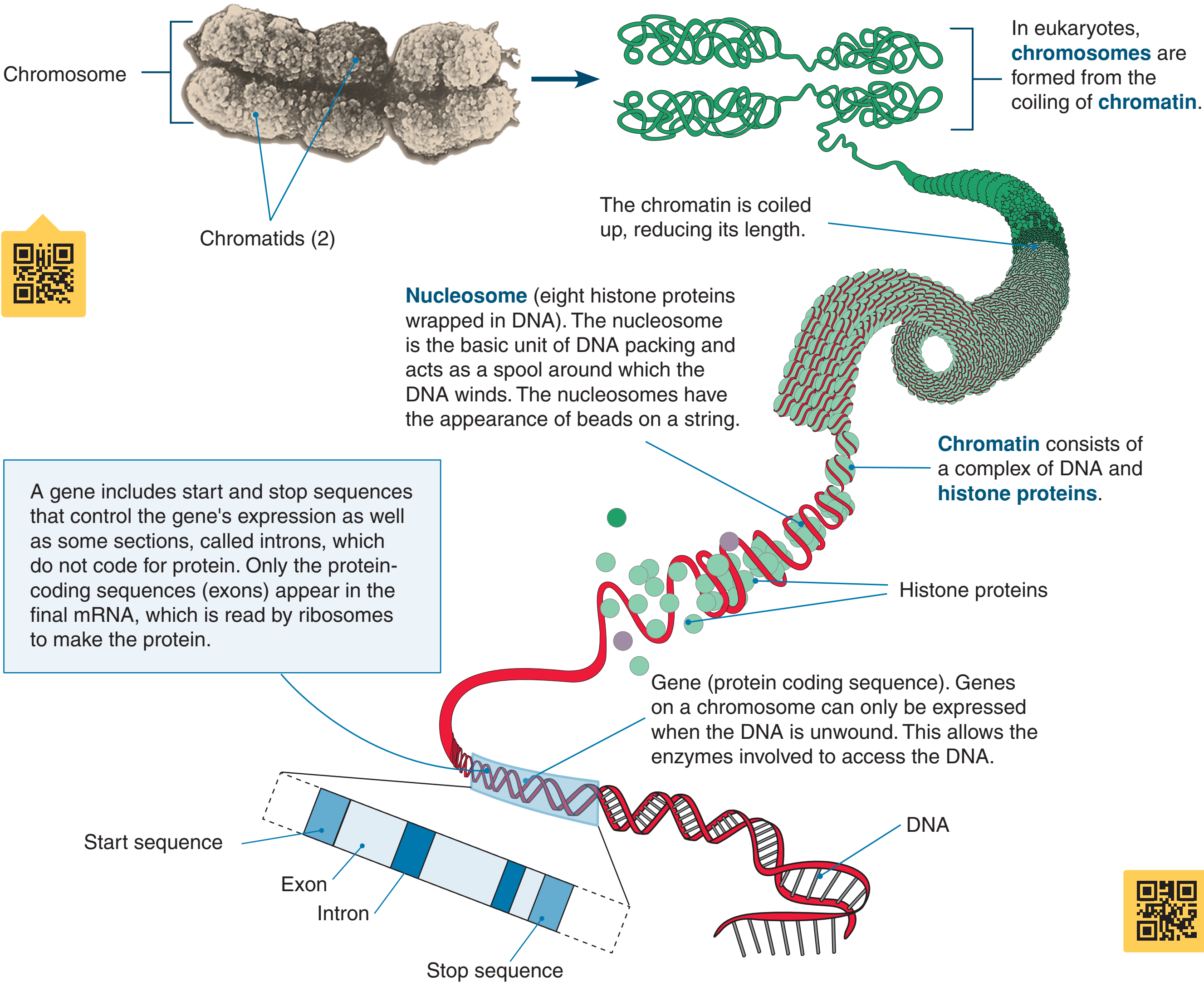
99 The Structure of Chromosomes

Key Idea: A chromosome is a single long molecule of DNA coiled around histone proteins. Chromosomes contain protein-coding regions called genes.

- In eukaryotes, DNA is complexed with proteins to form chromatin. The proteins in the chromatin are responsible for packaging the chromatin into discrete linear structures called chromosomes. The extent of packaging changes during the life cycle of the cell, with the chromosomes becoming visible during cell division.
- Each chromosome includes many DNA sequences called genes. A eukaryotic gene codes for protein but also includes regulatory regions which are involved in expression of the gene into the protein.



1. (a) Suggest a purpose for DNA coiling: ______________________________

   ____

   (b) What is the role of histones in this process? ______________________________

   ____

   ____

2. Identify three parts of the gene that do not appear in the final mRNA: ______________________________

   ____

3. What has to happen before a gene can be expressed (made into a protein)? ______________________________

   ____

   ____

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100 Nucleotides

Key Idea: Nucleotides are the building blocks of the nucleic acids, DNA and RNA. A nucleotide has three components; a base, a sugar, and a phosphate group.

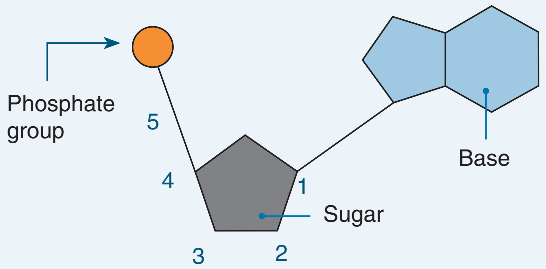
The structure of a nucleotide

Nucleotides are the building blocks of nucleic acids (DNA and RNA). Nucleotides have three parts to their structure (see diagrams below):

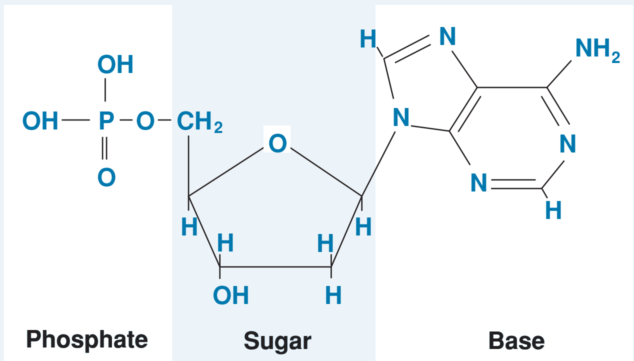
- A nitrogen containing base
- A five carbon sugar
- A phosphate group

Symbolic form of a nucleotide

(showing positions of the 5 C atoms on the sugar)



Chemical structure of a nucleotide



Nucleotide bases

Five different kinds of nitrogen bases are found in nucleotides. These are:

Adenine (A)

Guanine (G)

Cytosine (C)

Thymine (T)

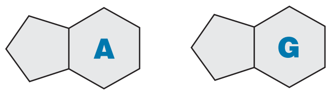
Uracil (U)

DNA contains adenine, guanine, cytosine, and thymine.

RNA also contains adenine, guanine, and cytosine, but uracil (U) is present instead of thymine.

Purines:

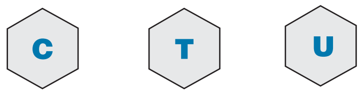
(two-ring bases)



Adenine Guanine

Pyrimidines:

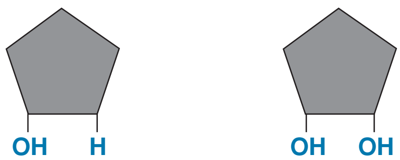
(single-ring bases)



Cytosine Thymine *(DNA only)* Uracil *(RNA only)*

Sugars

Nucleotides contain one of two different sorts of sugars. **Deoxyribose** sugar is only found in DNA. **Ribose** sugar is found in RNA.



Deoxyribose sugar (found in DNA) Ribose sugar (found in RNA)

1. What are the three components of a nucleotide? ______________________________

____

2. List the nucleotide bases present:

(a) In DNA: ______________________________

(b) In RNA: ______________________________

3. Name the sugar present: (a) In DNA: ______________ (b) In RNA: ______________

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