DOT POINT

VCE BIOLOGY UNITS 1 AND 2

• Kerri Humphreys •

Science Press

Unit 1 How Do Organisms Regulate Their Functions?

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Unit 1

How Do Organisms Regulate Their Functions?

In this unit you will:

- Examine the structure and functioning of prokaryotic and eukaryotic cells.
- Investigate how the plasma membrane controls movement of substances into and out of the cell.
- Explore cellular growth, replacement and death.
- Focus on the role of stem cells in differentiation, specialisation and renewal of cells.
- Relate cell specialisation in vascular plants and animals to the functioning of systems.
- Focus on the regulation of water balance in plants and temperature, blood glucose and water balance in animals.
- Consider the role of homeostatic mechanisms in maintaining an animal's internal environment within a narrow range of tolerance levels.
- Study malfunctions in homeostatic mechanisms.

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Area Of Study 1

How Do Cells Function?

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1.1 Cell structure and function.

1.1.1 Cells as the basic structural feature of life on Earth including the distinction between prokaryotic and eukaryotic cells.

1.1.1.1 List the characteristics that are used to define living things.

1.1.1.2 State the cell theory.

1.1.1.3 Explain how two areas of evidence support the cell theory.

1.1.1.4 Distinguish between a prokaryote and a eukaryote.

1.1.1.5 Which groups of organisms are eukaryotes and give an example of each.

1.1.1.6 The prokaryotes make up two of the three domains of living things. What are these domains and name some examples that are in each domain.

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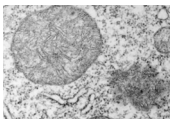
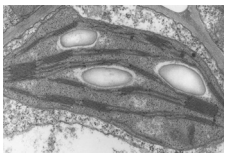
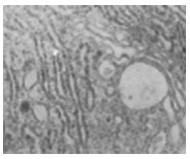
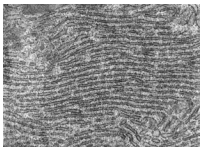
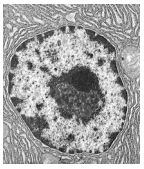
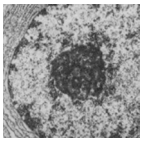
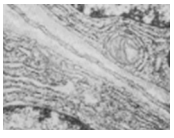
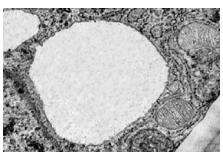
1.1.3.7 Complete the following table to summarise the organelle, its structure and its function.

Organelle	Its structure	Description and function
Mitochondria		
Chloroplast		
Golgi body		
Lysosome		
Endoplasmic reticulum		
Ribosome	 Ribosome Black dot on ER	
Nucleus		
Nucleolus		
Cell membrane		
Vacuole		

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2.1.2.12 How does an endocrine gland differ from an exocrine gland?

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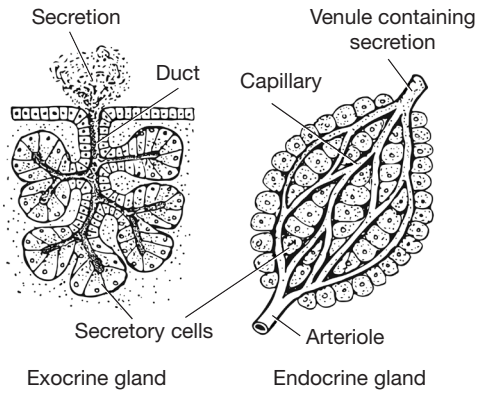
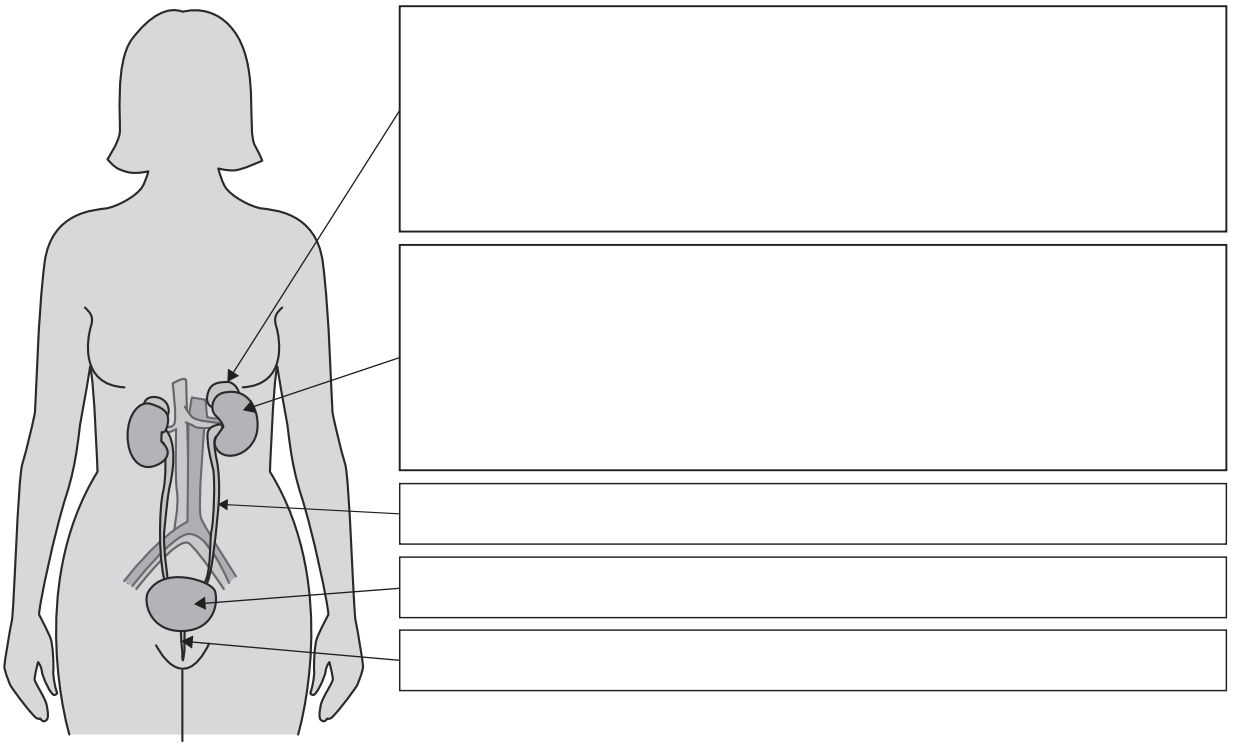


2.1.2.13 Label and annotate the diagram of the mammalian urinary system to identify parts and outline the function of each part.



2.1.2.14 Complete the table to identify the metabolic waste excreted by the following parts of the human body.

Body part	How it is involved in excretion
Lungs	
Sweat glands	
Liver and intestines	
Kidneys	

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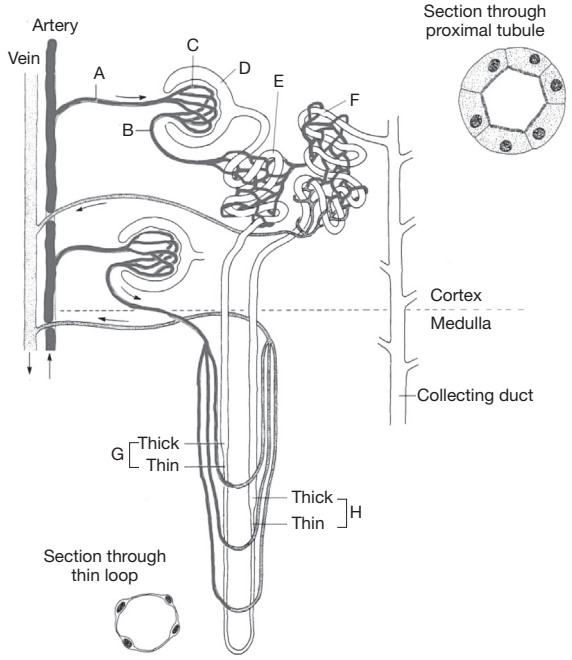
2.2.2.13

(a) Label the parts of the nephron.



(b) Each nephron has two arterioles and two sets of capillaries. Outline these two systems.

.....

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(c) The diagram shows the difference in cross-section between the cells in the proximal tubule and the cells in the loop of Henle. Outline why the differences are needed.

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2.2.2.14 The diagram shows a feedback mechanism for osmoregulation controlled by ADH (antidiuretic hormone).

(a) Identify the receptors, control centre and effector which controls the release of ADH.

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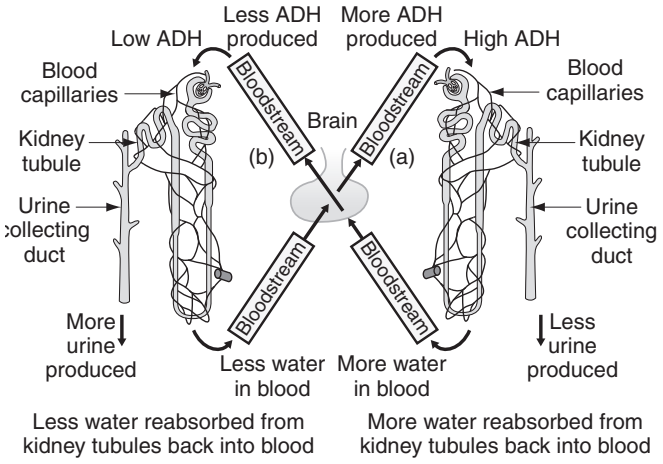
(b) Outline the conditions which would cause very little ADH to be released.



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(c) Explain the need for osmoregulation.

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1.3.3.8 Explain how crossbreeding experiments can identify the relative positions of linked genes.

1.3.3.9 Explain how chromosome mapping is useful in identifying relationships between species.

1.3.3.10

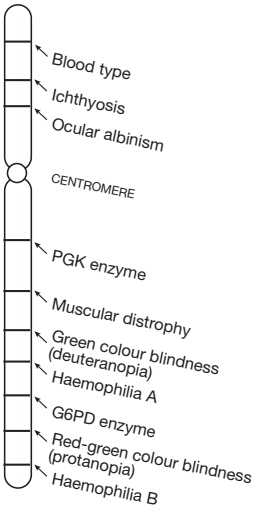
(a) In guinea pigs coat colour and coat length sort independently during meiosis.

(i) What does this mean about the location of the genes?

(ii) If black hair is dominant over white hair and short hair is dominant over long hair, what are the genotypes and phenotypes of the F_1 and F_2 generations of a homozygous black, short hair guinea pig crossed with a white, long hair guinea pig? Show all your working.

(b) The diagram shows linkage on the X chromosome (the location of the genes is not drawn to scale).

Explain how linkage would have been used to assist in the construction of this map using examples from this chromosome.



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Area Of Study 2

How Do Inherited Adaptations Impact On Diversity?

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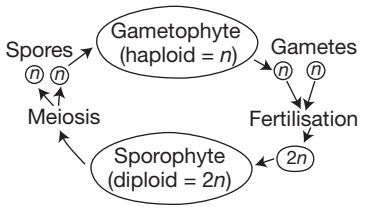
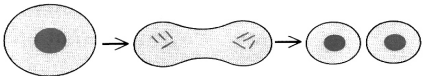
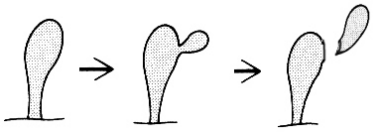
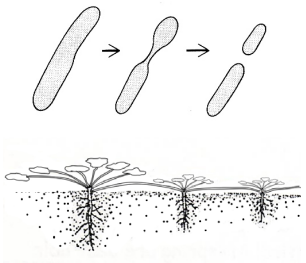
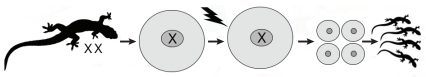
2.1 Reproductive strategies.

2.1.1 Biological advantages and disadvantages of asexual reproduction.

2.1.1.1 Complete the table to give the basic features of different types of asexual reproduction.

Type of asexual reproduction	Example	
	Diagram	Description
Spores		
Binary fission		
Budding		
Fragmentation and vegetative propagation		
Parthenogenesis		

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2.1.3 The process and application of reproductive cloning techniques.

2.1.3.1 What is a clone?

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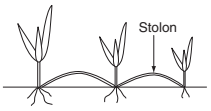
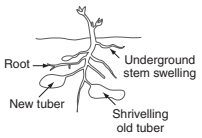
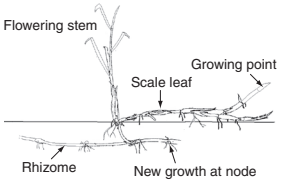
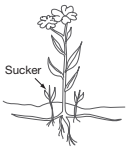
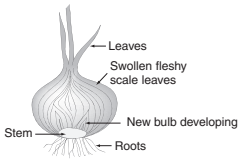
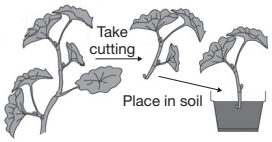
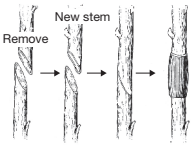
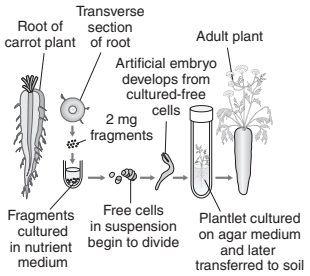
2.1.3.2 Complete the table to summarise ways agriculture and horticulture use different cloning methods.

Cloning method	Diagram	Features and uses
Stolon		
Tubers		
Rhizome		
Suckers		
Bulbs		
Cuttings		
Grafting		
Tissue culture		

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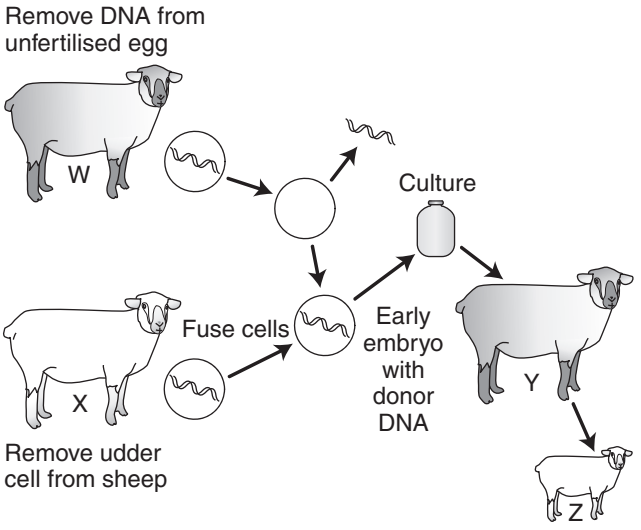
2.1.3.3 Discuss why plant hormones are used in agriculture when using 'cuttings' to clone a plant.

2.1.3.4 Discuss why plant cloning techniques have been used for thousands of years.

2.1.3.5 The diagram shows one method used in the cloning of animals. Refer to the diagram to explain this process.



2.1.3.6 Describe how cloning can alter the genetic composition of a population.

2.1.3.7 How could you verify the animal produced was a clone?

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2.2 Adaptations and diversity.

2.2.1 The biological importance of genetic diversity within a species or population.

2.2.1.1 Define genetic diversity.

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2.2.1.2 Outline the biological importance of genetic diversity.

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2.2.1.3 How can you measure genetic diversity?

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2.2.1.4 What conditions favour genetic diversity remaining constant in a population?

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2.2.2 Structural, physiological and behavioural adaptations that enhance an organism's survival and enable life to exist in a wide range of environments.

2.2.2.1 Define adaptation.

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2.2.2.2 Complete the table by defining structural, physiological and behavioural adaptations.

Structural adaptation	Physiological adaptation	Behavioural adaptation

2.2.2.3 The platypus is an Australian monotreme with specific adaptations to survive in its environment. Identify structural, a behavioural and a physiological adaptation of the platypus.

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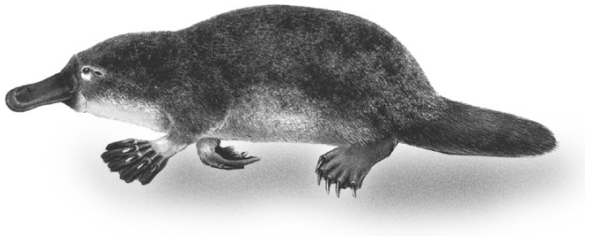

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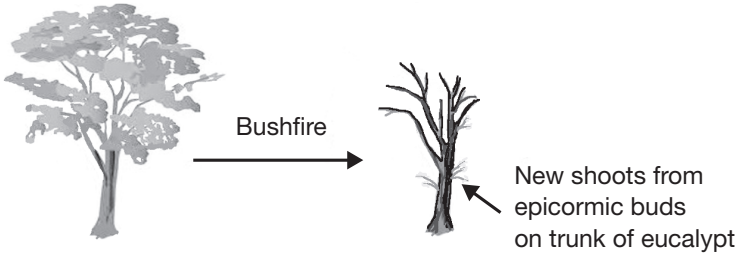
2.2.4.5 Explain why it is highly important to record and preserve Aboriginal rock paintings and also respect the culture of the traditional owners of these sites.

2.2.4.6 When did Aboriginals arrive in Australia?

2.2.4.7 When did the dingo arrive in Australia?

2.2.4.8 Outline some of the geological events that resulted in changes to ecosystems that have been witnessed by Aborigines since their arrival in Australia.

2.2.4.9 The diagram shows a eucalypt before and after a bushfire.



Use the diagram to explain how Aboriginal land management practices influence the evolution of Australian plants such as the Eucalypts.

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Answers

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Unit 1 How Do Organisms Regulate Their Functions?

1.1.1.1 Living organisms can – 1. Respire. 2. Assimilate food for growth and energy. 3. Grow. 4. Reproduce. 5. Respond to stimuli from their environment. 6. Excrete. 7. Move around. 8. Metabolise. 9. Excrete unwanted waste products of metabolic reactions.

1.1.1.2 The cell theory states that – 1. All living things are made of cells and of substances produced by cells. 2. All cells come from pre-existing cells. 3. The cell is the basic unit in which the processes of living take place.

1.1.1.3 Areas of evidence – 1. The work by Schleiden and Schwann who first proposed the cell theory involved the investigation of plant and animal tissues under a light microscope. They found that the cell is the basic unit of structure, physiology and organisation in living things. 2. The experiments where the nucleus is removed from cells show that after a certain time the cell will die. This evidence shows that the biochemical reactions for life occur in a cell and the nucleus controls these reactions in these cells.

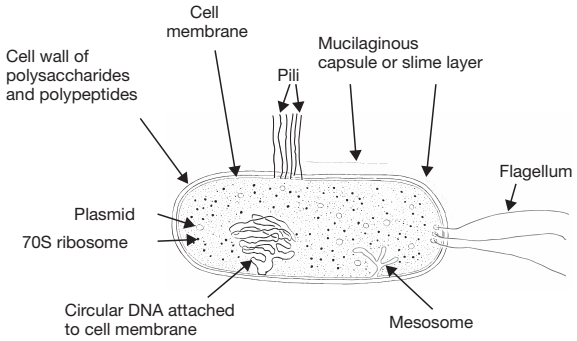
1.1.1.4 A prokaryote does not have membrane bound organelles, e.g. nucleus, mitochondria or chloroplasts whereas a eukaryote has membrane bound organelles, e.g. nucleus and mitochondria.

1.1.1.5 Eukaryotes include plants, e.g. couch grass, eucalypts; animals, e.g. kangaroos, sharks; fungi, e.g. yeast, mushrooms; protists, e.g. euglena.

1.1.1.6 The prokaryotes are in the Archaea domain, e.g. extremophiles such as methanogens *Methanosarcina*, halophiles *Halobacterium* and thermophiles *Thermococcus* and in the bacteria domain, e.g. cyanobacteria *Nostoc* and nitrogen fixing bacteria *Rhizobia*.

1.1.1.7 The Gram stain was instigated by Christian Gram in 1884 and shows two different kinds of bacterial cell walls – gram negative stain red, gram positive stain purple. Gram positive bacteria have a thick layer of peptidoglycan (50% to 90%) in their cell wall while gram negative bacteria have a thinner layer of peptidoglycan (10% envelope).

1.1.1.8



1.1.1.9

System	Function	Components
Cell wall	Bacterial cell walls contain peptidoglycan (sugar polymers cross-linked by short polypeptides). Archaean cell walls contain polysaccharides and protein with no peptidoglycan.	Protect cell, gives cell shape.
Capsule	Cell wall can be covered by a capsule layer of polysaccharide or protein.	Capsule allows bacteria to attach to other cells, e.g. to form a colony or to adhere to a substrate or pathogens attach to host.
Plasma membrane	Phospholipid bilayer with wide variety of fatty acids present.	Controls substances in/out of cell.
Cytoplasm	Gel-like substance composed mainly of water with slats, enzymes, cell components and various organic molecules.	Most cellular activities occur in the cytoplasm.
Fimbriae	Protein tubes that extend from outer membrane. Usually short and present in large numbers.	Assist attaching to surfaces and other cells. Some used for motility.
Pili	Protein tubes that extend from outer membrane. Usually longer and fewer in number than fimbriae.	Sex pili used during conjugation and transfer of DNA.
Flagella	Protein structure with one end embedded in cell wall and plasma membrane. Can be concentrated at the end(s) or scattered over the surface.	Used for motility and cellular locomotion.
Ribosome	70S ribosome consisting of two units – a small unit (30S) and a large unit (50S). (The S stands for Svedberg unit which is a measure of time in sedimentation process during centrifuging.)	Responsible for protein synthesis as site of translation of mRNA code into a polypeptide.

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1.1.5.10

Feature	Meiosis	Mitosis
Purpose of process	Produce sex cells.	Growth, repair, maintenance.
Location in body	Body cells.	Reproductive organs.
Number of divisions in process	2	1
What happens to homologous chromosomes during process	Line up together at beginning forming tetrad.	Do not line up together.
Number of daughter cells produced	4	2
Chromosome number of daughter cell	Haploid.	Diploid.
Comparison of chromosomes to parent cell	Different.	Same.
Genetic variability produced	Daughter cells are different.	Daughter cells identical to each other and parent cell.

1.2.1.1 The genotype shows the genetic make-up or set of alleles of an organism that control a characteristic When writing the genotype for genotype it is customary to:

1. Represent the gene with a letter of the alphabet, e.g. for plant height the letter T can be chosen. It is a good idea to choose a letter of the alphabet that looks different in upper case and lower case.
2. The genotype will have two letters representing the two alleles – one from each parent.
3. The dominant allele is capitalised, e.g. T = tall pea plant height and the recessive allele is lower case, e.g. t = dwarf pea plant height.
4. The dominant allele is written first.

1.2.1.2 When both alleles are the same in the organism, e.g. TT or tt, the organism is homozygous for that trait. If the alleles are different, e.g. Tt, then the organism is heterozygous for that trait.

1.2.2.1 Phenotype is the observable physical and physiological traits of an organism and the outward appearance of an organism. A dominant phenotype can have two dominant alleles, e.g. TT or one dominant allele and one recessive allele, e.g. Tt. The recessive phenotype has two recessive alleles, e.g. tt.

1.2.2.2 Incomplete dominance occurs when the dominant allele does not completely mask the effects of the recessive allele and there is a third phenotype, e.g. red flower snapdragon (RR) crossed with a white flower snapdragon (WW) produces offspring that have pink flowers (RW). Codominance occurs when both alleles are expressed, e.g. in certain breeds of cattle a white form (WW) crossed with a red form (RR) produces roan offspring (RW) that has both red hair and white hair present.

1.2.2.3 The Mendelian ratio is 3 dominant : 1 recessive in a hybrid cross (F_2). In codominance the hybrid shows a different phenotype. Mendel's 3 : 1 does not account for a third phenotype.

1.2.2.4 If a man is blood group A, he could have the genotype either I^AI^A or I^Ai. A woman with blood group AB must have the genotype I^AI^B. Possible offspring can be predicted by the following two Punnett grids.

	I^A	I^A
I^A	I^AI^A	I^AI^A
I^B	I^AI^B	I^AI^B

	I^A	i
I^A	I^AI^A	I^Ai
I^B	I^AI^B	I^Bi

Offspring are phenotype 2 blood group A : 2 blood group B if father is homozygous.

Offspring are phenotype 2 blood group A : 1 blood group AB : 1 blood group B if father heterozygous.

1.2.3.1 Epigenetic inheritance is the inheritance of traits transmitted by mechanisms not directly involving the nucleotide sequence, e.g. epigenetic information is important in gene regulation.

1.2.3.2 Epigenetics studies the phenotypic expression of genes which depends on factors controlling transcription and translation during protein synthesis, the products of other genes and the environment.

1.2.3.3 An example to show how the phenotype of an individual does not always show the genotype is a plant with the genotype TT which should grow to a tall height but if it is grown in poor soil with a limited water supply then it may appear (phenotype) the same as a dwarf genotype (tt).

1.2.3.4 The range of phenotypic appearances for a trait is called the norm of reaction for a genotype. The norm of reaction can range from no breadth, e.g. for traits that have a specific genotype/phenotype such as ABO blood group or there can be a very broad norm of reaction, e.g. for human skin colour.

1.2.3.5 Pleiotropy occurs when a single gene has multiple effects, e.g. many genetic diseases caused by a single pair of alleles such as cystic fibrosis and sickle cell anaemia have multiple symptoms.

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1.2.3.6 A feature is multifactorial if many factors determine the final appearance of that feature. The development of cancers is usually multifactorial with many contributing factors, e.g. factors can include age (the older you are the more likely you are to develop a cancer), lifestyle (e.g. diet, exercise, alcohol intake, smoking cigarettes), DNA damage (e.g. by carcinogens in the environment), inheritance of a fault in one of the genes, infection by some types of virus (e.g. infection by human papilloma virus – HPV – is linked to cervical cancer, and problems with the immune system.

1.2.3.7 Gene expression means that information coded in the DNA in the gene directs the production of a particular polypeptide. The gene is 'switched on'.

1.2.3.8 Many metabolic pathways involve a series of reactions with each step catalysed by a different enzyme. Each enzyme is coded by a particular gene. This means that several genes need to be expressed for the complete metabolic reaction to occur. The appearance of a particular trait can thus depend on the products of several genes. For example, more than 12 pairs of alleles interact in various ways to produce coat colour in rabbits.

1.2.3.9 A mutation is a permanent change in the DNA. Gene expression of the changed code can form a protein that appears to have no observable effect or may be beneficial or may be harmful for survival. Phenotype is thus affected due to the change of a specific functional protein.

1.2.3.10 To carry out an investigation of the effect of environment on phenotype you could take 20 cuttings of equal size and 'healthiness' from a geranium plant. Each cutting needs to be placed in a pot of the same size, containing the same amount of soil, given the same amount of light and water and kept free from pests. The soil in 10 pots needs to be given all nutrients, while the soil in the other 10 pots is nitrogen deficient. The growth in height, number of leaves and the 'healthiness' of the leaves needs to be recorded over one term. As a safety precaution you need to always wear gloves when working with the soil to prevent contact with soil bacteria and make sure you are careful when using sharp gardening tools so you do not cut yourself which could lead to infection. Results need to be analysed and the 'average' result for the 10 pots that had full nutrient and the 10 pots that were nitrogen deficient need to be calculated. In this experiment the nitrogen deficient plants should show less growth, are smaller in overall size and the leaves are more yellow and pale in colour. This shows that environment (nitrogen deficiency) causes a different phenotype for genetically identical plants.

1.2.3.11 Hybridisation is the process of crossing two true breeding varieties, e.g. fertilising the flower of one species with the pollen of another species.

1.2.3.12 Humans use hybridisation in agriculture and horticulture to create products with specific phenotypes. The Labradoodle is an example of hybridisation within a species. It is produced by crossing a Labrador and a poodle. The hybrid is produced as they do not shed hair which is important for people who have asthma or are allergy sufferers. Labradoodles have no body odour, they do not need constant bathing and brushing and are easy to train, e.g. they are being trained as guide dogs. Artificial pollination is used to create plant hybrids, e.g. for particular flower colours.

1.2.3.13 In this example, the water temperature is an environmental factor that affects gene expression (epigenetics) changing the phenotype (sex of the fish).

1.2.3.14 (a) DNA methylation is a biological process where methyl groups are added to DNA.

(b) DNA methylation is an epigenetic mechanism that can control gene expression. The process does not change the nucleotide sequence but can change gene activity, e.g. if it occurs near a gene promoter gene transcription is stopped.

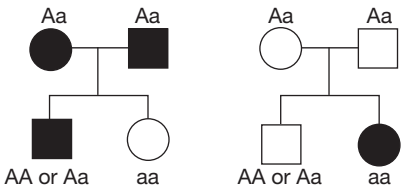
(c) Histone modification is another epigenetic process that affects phenotype.

1.3.1.1 In a pedigree chart males are represented by squares and females are represented by circles. Shading indicates the particular phenotype being investigated. Each generation is set out in one line and the birth sequence in a family is read from left to right. The next generation will be on the line below.

■ Male with trait □ Male not showing trait

● Female with trait ○ Female not showing trait

1.3.1.2 If two parents have the same trait and an offspring has a different trait, then the parents are heterozygous. If the parents possess the trait, then the trait is dominant, if the offspring has the trait then the trait is recessive.



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1.3.1.3 The chromosomes that determine the sex of an individual are called the 'sex chromosomes'. In humans females are XX and males are XY. Any feature on the X chromosome or Y chromosome is referred to as sex-linked inheritance trait, e.g. red-green colour blindness is sex-linked in humans.

1.3.1.4 (a) The diagram shows that the X chromosome has more genes than the Y chromosome. This means that males only have one allele for many traits that are on the X chromosome and will have different inheritance patterns compared to autosomes where both males and females have two alleles.

(b) Since males only have one allele for many traits on the X chromosome, they will show a recessive genetic disorder more frequently than females for that disorder.

1.3.1.5 (a) *Drosophila melanogaster* is suitable as: 1. They are small flies less than 3 mm long, requiring little space, can be easily handled and can be maintained in small glass containers. 2. They breed easily in captivity, e.g. females lay up to 200 eggs just 2 weeks after mating. 3. Sexual dimorphism – the two sexes can be readily distinguished. 4. *Drosophila* have a small number of chromosomes ($2n = 8$) so that their chromosomes can be readily examined and identified. 5. Low culture and maintenance cost and can be bred at room temperature. Can be easily anaesthetised and manipulated individually with unsophisticated equipment.

(b) Morgan's results showed that white eye/red eye was a gene on the X chromosome and thus was the first person to link a specific trait to a specific chromosome – and is credited with identifying sex-linkage. He also showed that the Mendelian ratio (i.e. 3 dominant : 1 recessive in a hybrid cross) does not always apply (e.g. in reciprocal cross of white eyed female with red eyed male gives one half red eye and one half white eyes of both sexes in F_2).

(c) Let X^R = X chromosome carrying red eye allele

X^r = X chromosome carrying white eye allele

Y = Y chromosome (does not carry eye colour allele)

Parents	White eyed female	Red eyed male
	X^rX^r	X^RY
Gametes produced	X^r or X^r	X^R or Y

Fertilisation

	X^R	Y
X^r	X^RX^r	X^rY

Offspring genotype: 1 X^RX^r : 1 X^rY

Offspring phenotype: All females are red eyed : all males are white eyed

1.3.1.6 (a) PKU is autosomal recessive – shown by two heterozygous parents have a child of either sex with the disease.

(b) Let T = normal gene and t = PKU gene

Parents	Heterozygous normal Tt	Heterozygous normal Tt
Gametes produced	T or t	T or t

Fertilisation

	T	t
T	TT	Tt
t	Tt	tt

The grid shows that there is a 3 : 1 chance (25%) that two parents who are heterozygous normal will have a child with PKU.

1.3.1.7 (a) Let L = long eyelashes and l = short eyelashes. Person (I, 2) has genotype ll (recessive, short eyelashes).

(b) Person (III,1) could be either LL or Ll. His sister has short eyelashes which means she must be ll, while both parents have long eyelashes and must be Ll. You cannot determine if he is homozygous or heterozygous until he has children.

(c) Person (III,3) must be heterozygous Ll with long eyelashes. If they marry a person homozygous for long eyelashes, the probability can be shown with a Punnett grid.

LL (homozygous long) x Ll (heterozygous long)

	L	L
L	LL	LL
l	Ll	Ll

Offspring genotypes are 2LL : 2 Ll. The probability is 100% long eyelashes for offspring.

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2.1.1.3

Prokaryotes Bacteria Archaea	Fungi	Protists	Plants	Animals
Binary fission.	Budding. Sporulation.	Budding. Binary fission.	Sporulation. Vegetative propagation.	Budding. Fission (transverse or longitudinal). Fragmentation/regeneration. Parthenogenesis.

2.1.2.1 Sexual reproduction involves two parents producing offspring which have sets of chromosomes that are different to those of either parent.

2.1.2.2 The diagram shows the production of offspring from two parents in sexual reproduction. Each parent produces haploid gametes that have only one set of chromosomes (*n*). Males produce sperm and females produce eggs. The egg is large and inactive while the sperm is smaller with a long tail for locomotion. In fertilisation two gametes fuse to produce a zygote with diploid number (2*n*). The zygote will develop into a child which will be born having a unique combination of genes from the gametes of the two parents.

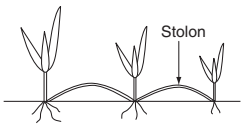
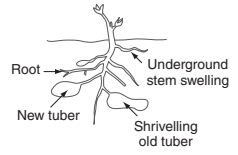
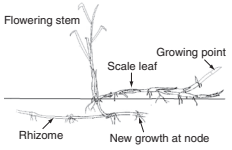
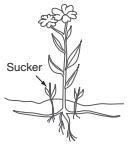
2.1.2.3

Process	How genetic diversity occurs
Crossing over during meiosis	Crossing over is the exchange of certain sections of chromosomes producing new linkage groups. This means that individual chromosomes will carry genes from two different parents and the new combination provides genetic diversity.
Random segregation of chromosomes during meiosis	Each chromosome of the homologous pair sorts independently and randomly so that the gametes can have different combinations of chromosomes. In humans with 23 pairs of chromosomes the number of possible combinations is 2^{23} which is around 8 million different types of chromosome combinations able to be produced by one person.
Fertilisation	Fertilisation involves the union of two haploid gametes. This forms a new combination of genes not identical to either parent. If each male and each female can produce around 8 million possible chromosome combinations due to random segregation then the union of a particular male with a particular female could produce (2^{23} x 2^{23}) = about 64 trillion different possible combinations of chromosomes.
Mutation	A mutation is a permanent change in the genetic information. This is the only process that also occurs in asexual reproduction to produce variation in the offspring.

2.1.2.4 Various processes in sexual reproduction, e.g. crossing over and random segregation in meiosis, and fertilisation results in variability in offspring. This genetic diversity is particularly important in a changing environment as survival relies on some individuals in the population having features favourable for the new conditions. The higher the genetic diversity the greater the chance of the survival of some individuals that will reproduce and pass the favourable features to the next generation. Sexual reproduction aids the survival and evolution of a species.

2.1.3.1 A clone is an organism or cell that has the identical make-up of the parent cell.

2.1.3.2

Cloning method	Diagram	Features and uses
Stolon		A stolon is a long stem or 'runner' that grows along the surface producing new roots and leaves at nodes. Stolons are used to propagate many grasses, e.g. Spinifex grass to bind sand dunes near beaches and other plants such as strawberry plants.
Tubers		A stem tuber is a swollen underground stem that stores food and new plants grow from the tuber. Potatoes are a tuber and the 'eye' of the potato is a bud from which a new potato plant can grow.
Rhizome		Rhizomes are underground stems that give rise to new roots and shoots at the nodes. Couch grass is used as a lawn grass and propagation uses both stolons and underground rhizomes. Other plants that propagate with rhizomes include ginger, irises and lily of the valley.
Suckers		Suckers are new shoots that arise from roots or underground stems, e.g. after fires. Root suckers usually emerge from the ground some distance from the parent plant and can appear after the parent plant has been cut down. Horticulturalists use suckers to propagate kangaroo paws, lilies, some Dampiera and Lechenaultia.

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