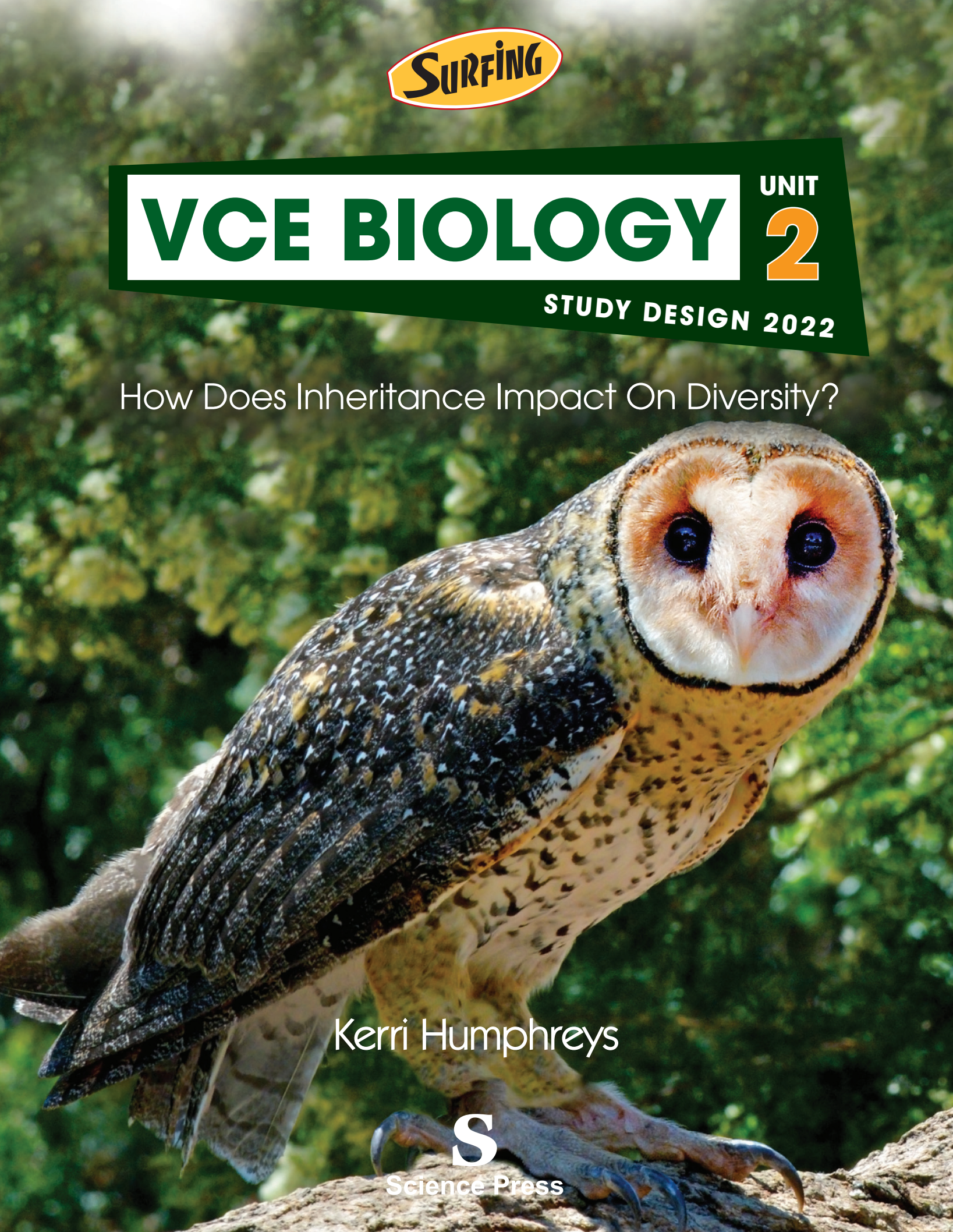
SURFING

VCE BIOLOGY UNIT 2

STUDY DESIGN 2022

How Does Inheritance Impact On Diversity?



Kerri Humphreys

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SURFING

VCE BIOLOGY UNIT 2

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Area Of Study 1

How Is Inheritance Explained?

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QUESTIONS

1. Define meiosis.
2. How many daughter cells are produced in meiosis?
3. Where does meiosis occur?
4. Describe the daughter cells produced by meiosis.
5. What are homologous chromosomes?
6. State the law of independent assortment.
7. What are linked genes?
8. Identify how linked genes can be inherited independently of each other and become part of different gametes.
9. State the law of segregation.
10. Draw a flow chart to show the process of meiosis.
11. The diagram shows a cross-section of a plant anther using low power of a light microscope.

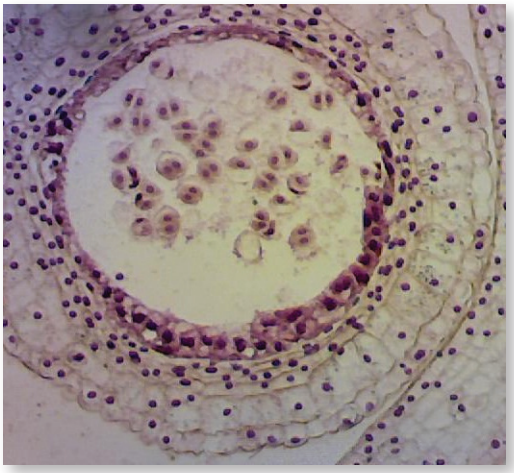
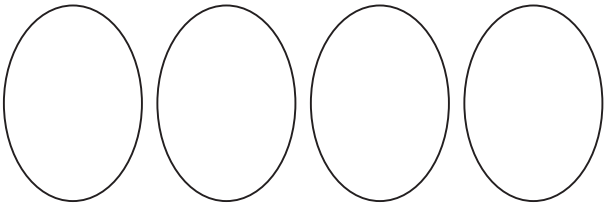


Figure 11.2 LP Plant anther.

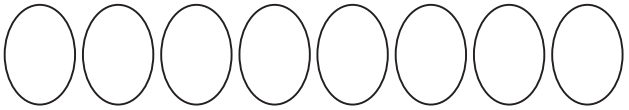
Explain why an anther was chosen to study the stages of meiosis and identify the stage in the diagram.

12. The diagram shows a cell with $2n = 6$. Copy the diagram and fill in the possible cell alignments for metaphase I and the possible gametes (no crossing over).

Possible alignments in metaphase I



Possible gametes



13. The diagrams show sections of anther with different stages of meiosis.

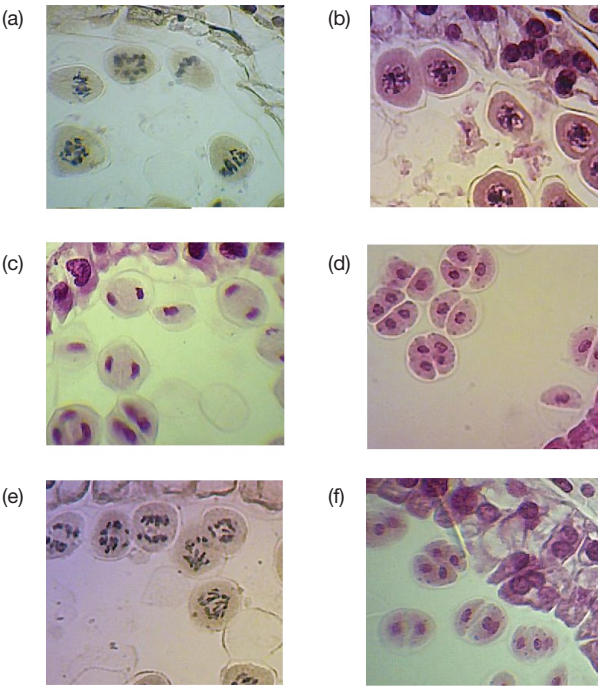
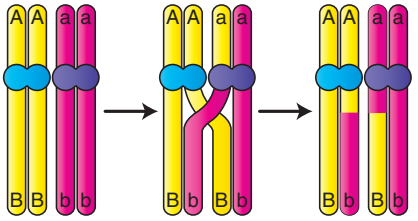


Figure 11.3 Different stages of meiosis.

Identify what is happening in each diagram.

14. The diagram shows crossing over with a pair of homologous chromosomes. Alleles A, a, B and b are indicated on each chromosome.



What are the genotypes of the daughter cells?

(A) AA, aa, BB, bb
(B) AB, Ab, aB, ab
(C) AB, AB, ab, ab
(D) AA, AB, bb, ab

15. In which stage of meiosis would you expect to see the homologous chromosomes separated and moving to opposite poles?

(A) Prophase I.
(B) Anaphase I.
(C) Prophase II.
(D) Anaphase II.

16. Which of the following occurs in meiosis but not in mitosis?

(A) Homologous chromosomes align.
(B) Chromatids line up at the equator.
(C) Spindle fibres move chromosomes to the poles.
(D) Chromatids joined at centromere.

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13 Experiment – Investigating Meiosis

A senior biology class was given the task of investigating meiosis. Each student had to present their work to the class and they were given a marking criteria which they would use to grade each other's work.

Some students decided that they would use a light microscope to view dividing cells. They collected a set of prepared stained slides of cross-sections of plant anthers and cross-sections of testis.

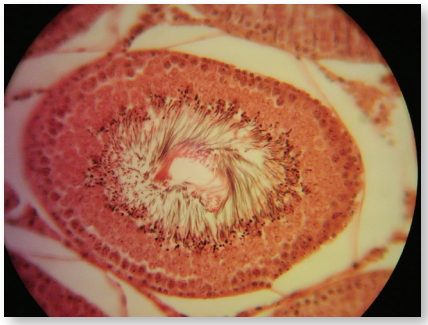

Figure 13.1 Cross-section of testis, low power.

The students took photos of the slides and drew diagrams of the cells they found at the different stages of meiosis. Using secondary sources of textbooks and reliable websites they collected data about what was happening at each stage of meiosis and annotated their diagrams.

Other students decided to use plasticine or other materials to construct models to show the sequence of events in meiosis. They also used secondary sources of textbooks and reliable websites to collect the data about what was happening at each stage of meiosis and used this data to make their models.

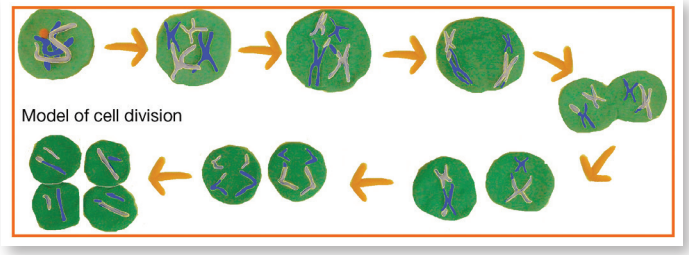

Figure 13.2 Student model of meiosis using plasticine.

After gathering the first-hand and secondary data, the students displayed their work around the classroom. They then graded each other's work assessing the 'correctness' and 'completeness' of information and evaluating each presentation for its appearance, its ability to be easily understood and its use as a model to convey scientific knowledge.

QUESTIONS

1. Explain why the students who used prepared slides and a light microscope to investigate meiosis chose to use slides of cross-section of plant anther and cross-section of testis.
2. In this task, what is the first-hand data collection and what is the secondary data collection?
3. Why do scientists make models?
4. When the students were using secondary sources to collect information, how could they determine if the secondary source was reliable?
5. When the students were using secondary sources to collect information, how could they determine if the source was accurate?
6. When the students were using secondary sources to collect information, how could they determine if the source was valid?
7. Discuss why the grading criteria assessed the 'completeness and 'correctness' of each student's presentation.
8. Explain why some would have chosen to make a model of meiosis for their investigation and presentation.
9. The diagram shows several steps in meiosis.

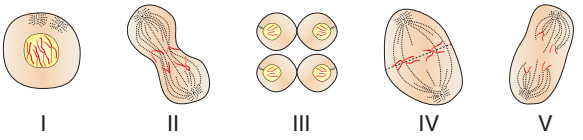

Figure 13.3 Steps in meiosis.

What is the correct order for these steps in meiosis?

(A) I, IV, V, II, III
(B) I, IV, II, V, III
(C) III, V, II, IV, I
(D) II, V, IV, III, I

10. The diagram shows a cross-section of *Lilium* anther.

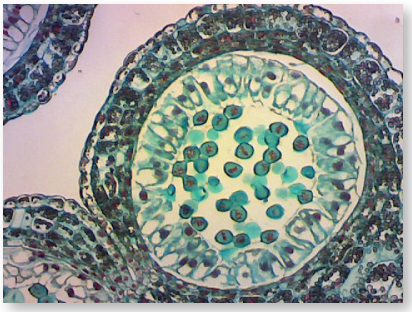

Figure 13.4 *Lilium* anther.

Why would this slide be studied when investigating meiosis?

(A) Meiosis in the anther produces pollen.
(B) Meiosis in the anther produces ovules.
(C) Meiosis in the anther produces the seed.
(D) Meiosis in the anther is needed for shoot growth.

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14 Comparing Meiosis and Mitosis

Meiosis is a type of cell division that produces gametes. **Gametes** are sex cells and have half the normal number of chromosomes. **Mitosis** is the process in which the cell nucleus divides into two.

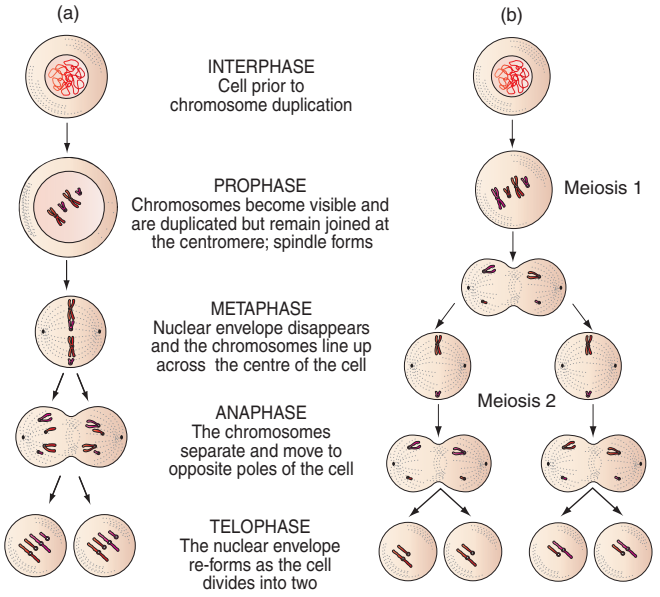

Figure 14.1 Meiosis and mitosis cell division. (a) Mitosis produces cells genetically the same as the parent. (b) Meiosis produces gametes with half the number of chromosomes.

Stages in mitosis

Mitosis begins with the chromosomes becoming visible as two identical chromatids. The nuclear membrane disappears and the chromatids line up at the equator. The chromatids separate and move to the poles carried by spindle fibres. A nuclear membrane forms around each new nucleus and cytokinesis occurs forming two identical daughter cells.

Stages in meiosis

Like mitosis, the cell division begins with the chromosomes becoming visible as long thin threads which condense until they are double strands called chromatids joined at the centromere. The nuclear membrane disappears. However, in the first division, the chromosomes line up in homologous pairs and crossing over can occur increasing the variation in genetic material in the gamete unlike mitosis where the chromosomes line up singly. The spindle apparatus forms and the sister chromatids remain attached and are pulled as a unit toward opposite ends of the cell. The spindle disappears and the cell divides into two. In the second division, the chromosomes do not duplicate. A spindle forms and the sister chromatids line up along the equator. The sister chromatids separate and each moves to an opposite pole. The spindle disappears, the nuclear membrane re-forms and there are now four daughter cells.

There are some similarities between meiosis and mitosis. However, meiosis involves two cell divisions and produces four haploid daughter cells while mitosis involves one cell division and produces two identical daughter cells. Mitosis occurs in all living things while meiosis only occurs in organisms that sexually reproduce. In multicellular organisms mitosis occurs in body cells (somatic cells) and is needed for growth, repair and maintenance while meiosis occurs in the gonads (testes and ovaries) and is needed for sexual reproduction.

QUESTIONS

1. Define meiosis, gamete and mitosis.
2. Construct a table to show the differences between meiosis and mitosis.
3. Explain why meiosis is often called the 'reduction division' while mitosis is called the 'equating division'.
4. What is meant by the diploid number and haploid number of chromosomes?
5. Explain what a homologous pair is using the chromosomes found in humans as an example.
6. If the diploid number of chromosomes for a species is 64 chromosomes. How many chromosomes are found in a gamete of this species?
   (A) 64 (B) 32 (C) 16 (D) 8
7. How is mitosis different to meiosis?
   (A) Mitosis involves two divisions.
   (B) Mitosis forms four daughter cells.
   (C) Meiosis has daughter cells identical to the parent cell.
   (D) Meiosis has the chromosomes line up in homologous pairs.
8. Where does meiosis occur?
   (A) In any somatic cell.
   (B) In the gonads.
   (C) In sperm and ova.
   (D) In any living cell.
9. If a gamete contains four chromosomes, what is the haploid number for this species?
   (A) 8
   (B) 4
   (C) 2
   (D) Not enough information has been given to determine the haploid number.
10. What type of cell division forms sperm?
    (A) Meiosis. (B) Mitosis.
    (C) Parthenogenesis. (D) Differentiation.

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22 Epigenetic Factors

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.

Epigenetics maintains tissue identity by controlling the expression of different sets of genes. Epigenetic dysregulation can cause diseases, e.g. cancer with the activation of oncogenes.

Epigenetic silencing occurs when genes are 'turned off' leading to differential expression, e.g. one reason why genetic twins can have slightly different phenotypes.

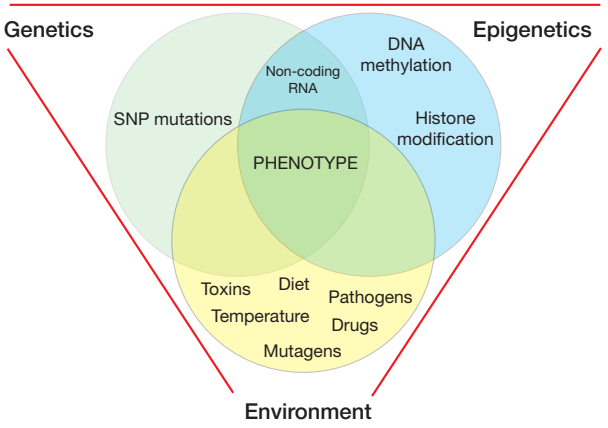

Figure 22.1 Relationship between environment and expression of genes.

DNA methylation

DNA methylation occurs when a methyl group (CH_3) is added to DNA. It is very specific adding in a region where a cytosine nucleotide is next to a guanine nucleotide that is linked by a phosphate (CpG site). This alters the appearance and structure of DNA and transcription. Near a promoter region where there is a high frequency of CpG sites (CpG islands) DNA methylation is associated with gene silencing.

The addition of the methyl group at the 5-carbon of the cytosine ring causes 5-methylcytosine (5-mC). In humans this is found in approximately 1.5% of genomic DNA.

Histone modification

Histones are small proteins that are the main part of chromatin and help compact DNA into a smaller volume. DNA winds around the histones. If histones are modified after they are translated into proteins they can change the arrangement of chromatin. A change can affect transcription of the associated DNA. If chromatin is not in its compact form it is active and the associated DNA can be transcribed.

Epigenetics and disease

In 1893 researchers found that diseased tissue of patients with colorectal cancer has less DNA methylation than normal tissue from the same patients. Loss of DNA methylation can cause high gene activation.

In some tumour there is **hypermethylation** of CpG sites in regions near promoter sites which causes genes that should not be silenced to be turned off. Hypermethylation can also cause instability of microsatellites – making them longer or shorter, which is also linked to many cancers.

QUESTIONS

1. Define epigenetics.
2. What is epigenetic silencing?
3. What is DNA methylation?
4. Outline the importance of differential gene expression.
5. The diagram shows an epigenetic factor.

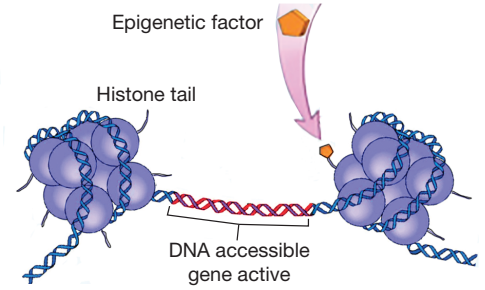

Figure 22.2 Epigenetic factor.

What is happening in this diagram?

6. What proportion of the human genome has the 5-methylcytosine?
7. What happens in CpG island hypermethylation?
8. The diagram shows a section of DNA.

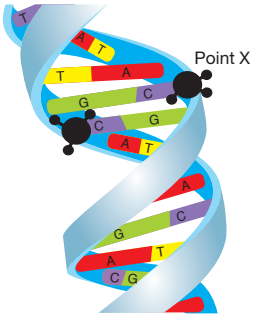

Figure 22.3 Section of DNA.

What has happened at point X?

(A) Methylation at an adenine.
(B) Methylation at a cytosine.
(C) Enzyme binding to histone tail.
(D) Covalent bond broken between the sugar and phosphate.

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23 SNP Mutations and Phenotype

SNP variations can lead to different phenotypes for a trait. SNP databases are used to examine phenotypic differences, e.g. physical and biochemical differences in traits, disease resistance and to identify individuals in DNA profiling.

Single nucleotide polymorphisms are variations in an allele at a single nucleotide, e.g. a SNP can replace the thymine (T) with an adenine (A) at a certain section of DNA. A particular variation needs to be in more than 1% of the population to be a SNP.

SNP mutations occur at a rate of one in every 100 to 300 nucleotides and are the most common type of variation of variation in humans.

Functional bioinformatics studies SNP mutations analysing the roles of SNPs in healthy people and those with a genetic disease.

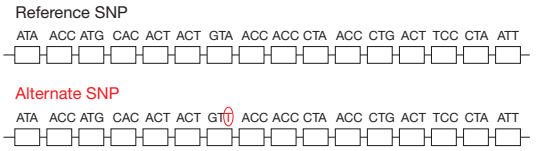


Figure 23.1 SNP variation.

SNP mutations and allele frequency

SNP patterns are used to identify different groups of people, e.g. different ancestral races and are used as biological markers for disease in genetic screening.

There are several databases that contain frequency data for SNPs found in the human population.

Allele frequency is the incidence of a gene variant in a population. The **reference allele** (Ref) refers to the base that is found in the reference genome (this not always the major allele) and the **alternative allele** (Alt) is any base, other than the reference, that is found at that locus on the chromosome.

QUESTIONS

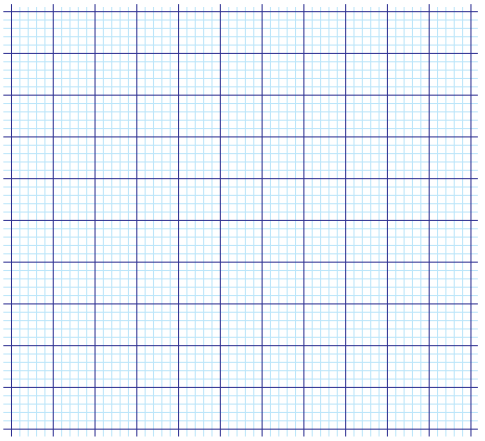
1. What is a SNP?
2. What is the rate of SNP mutation in humans?
3. How common are SNP variations in the human genome?
4. Define allele frequency.
5. Distinguish between the reference allele and the alternative allele.
6. Case study.
   A SNP variation occurs for a structural protein with a base change from C to T.

   The frequency of the reference allele (with C) and the alternative allele (T) was investigated for five groups of people who live in different geographical areas. The results are shown in the following table.

Table 23.1 SNP variation in five groups.

Group	Ref allele	Alt allele
A	0.62	0.38
B	0.51	0.49
C	0.92	0.08
D	0.43	0.57
E	0.78	0.22

   (a) Graph the frequency data for the reference allele for the five groups.



   (b) Does the data show that the reference allele is the most common allele? Explain your reasoning.
   (c) With the five groups geographically separated, which two groups are most likely to have the *least* gene flow due to migration?
7. The diagram shows part of the normal β-globin gene and the mutant β-globin gene and their appearance.

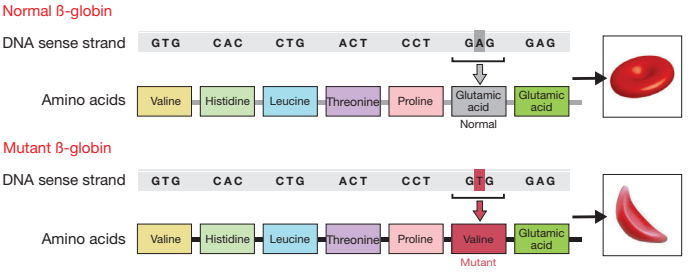


Figure 23.2 SNP variation of β-globin gene.

   (a) Explain why this variation is a SNP.
   (b) How does the change affect phenotype?
   (c) Identify the disease associated with the mutant allele.
   (d) If two parents are heterozygous for this trait, what is the probability of their offspring having the disease?

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24 Pedigrees

Pedigrees are graphical ways of picturing the ancestry of living things. They assist the study of the inheritance of genes by showing the genetic family history of specific traits.

Pedigrees track hereditary diseases

For families that carry genetic diseases, pedigrees are used by doctors to help advise these families about the chance of future children having a particular disease. A study of pedigrees has given valuable information about specific diseases, e.g. breast cancer, albinism and haemophilia.

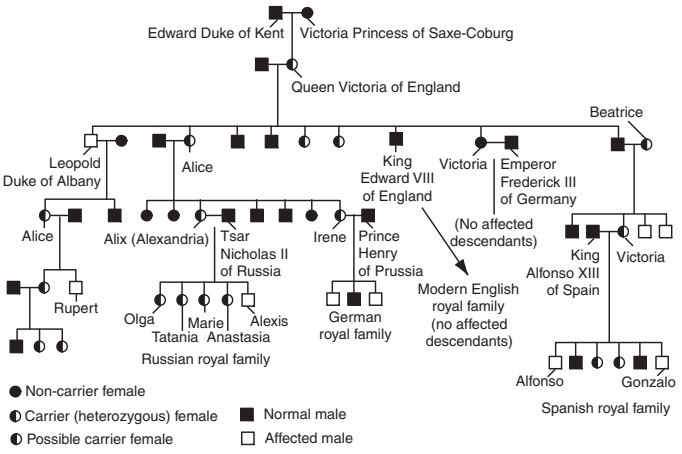

Figure 24.1 Pedigree of Queen Victoria.

Queen Victoria was a carrier for the blood clotting disease haemophilia and a study shows that it must be sex-linked as it only appears in males.

How to draw pedigrees

In a pedigree chart males are represented by squares and females are represented by circles. Shading indicates the particular phenotype being investigated.

Figure 24.2 Males and females in pedigree charts.

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.

Interpreting pedigree charts

A pedigree chart can be drawn for a recessive trait, e.g. inheritance of albinism or it can be drawn for a dominant trait, e.g. brown eyes.

If you are not told if the trait represented in a pedigree chart is dominant or recessive you can work it out by analysing the inheritance patterns. You need to look for two parents that are the same and have a child that is different.

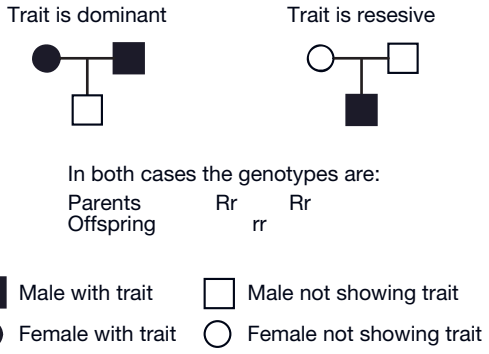

Figure 24.3 Determining if a trait in a chart is dominant or recessive.

QUESTIONS

1. Outline the rules for drawing pedigree charts.
2. In humans, the gene for red hair is recessive to the gene for brown hair. A man with red hair marries a woman with brown hair and they have two children – a daughter with red hair and a son with brown hair. His mother and his mother's father have red hair. His wife's father and sister have red hair.
   (a) Draw a family tree for red hair in this family.
   (b) Draw a Punnett grid and predict the probability of future children of the couple having red hair.
3. Explain how you would draw twin sons in a family tree. Draw a diagram to show this on a pedigree.
4. The diagram shows a family tree for a particular characteristic.

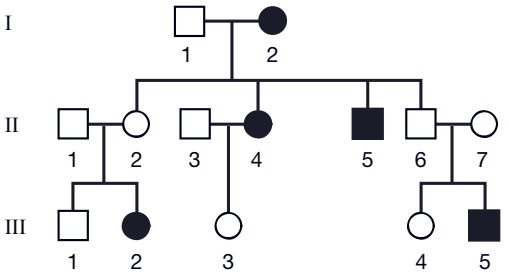

Figure 24.4 Pedigree for a particular characteristic.

   (a) Identify each person with the trait.
   (b) Is this trait dominant or recessive? How did you draw this conclusion?
5. Explain why pedigree charts are drawn.
6. Outline why doctors and counsellors may draw pedigree charts for couples who are hoping to start a family.
7. Explain why a family tree of the British royal family is often used to show how pedigrees provide important information.

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29 Dihybrid Crosses

Mendel began his experiments looking at a single characteristic at a time, e.g. height of pea plants. He then began to study two characteristics in one cross – **dihybrid crosses**.

Mendel investigated the inheritance of seven characteristics and it was very fortunate for him that each of these characteristics was on a different chromosome. From his investigation into dihybrid crosses he worked out the **law of independent assortment** – which states that pairs of factors independently segregate of other pairs of factors when forming reproductive cells.

The law has since been modified to state that two or more pairs of alleles segregate separately of each other as a result of meiosis provided that the genes concerned are not linked by being on the same chromosome.

Producing F_1

Mendel looked at the height of pea plants and the shape of the seed in a dihybrid cross. If he took a pure breeding (homozygous) tall plant with round seeds and a dwarf plant with wrinkled seeds, he found that all the first generation (F_1) were tall with round seeds. He concluded that tall was dominant to dwarf and round seed was dominant to wrinkled seed. You can represent this cross by the following symbols:

Genotype	TTRR	×	ttrr
Phenotype	tall, round seed	×	dwarf, wrinkled seed
Gametes	TR, TR		tr, tr

	TR
tr	TtRr

F_1

All offspring are TtRr genotype.

All offspring are tall with round seed phenotype.

Producing F_2

If you cross two of the offspring you can use a Punnett square to predict the percentages of different offspring produced.

Genotype	TtRr	×	TtRr
Phenotype	tall, round seed	×	tall, round seed
Gametes	TR, Tr, tR, tr		TR, Tr, tR, tr

	TR	**Tr**	**tR**	**tr**
TR	TTRR	TTRr	TtRR	TtRr
Tr	TTRr	TTrr	TtRr	Ttrr
tR	TtRR	TtRr	ttRR	ttRr
tr	TtRr	Ttrr	ttRr	ttrr

There are 16 different possible genotypes and four possible phenotypes in the second generation (F_2). When Mendel carried out his dihybrid cross experiments with pea plants, he used a test cross to determine if a plant that showed the dominant characteristic was homozygous or heterozygous. In a test cross you breed the plant in question with the homozygous recessive. If any of the offspring show the recessive characteristic, then the parent must be heterozygous and carrying the recessive gene.

Table 29.1 Ratio of phenotypes in F_2.

Phenotype	Genotype	Ratio
Tall, round seed	TTRR, TtRR, TtRr, TTRr	9
Tall, wrinkled seed	TTrr, Ttrr	3
Dwarf, round seed	ttRr, ttRR	3
Dwarf, wrinkled seed	ttrr	1

QUESTIONS

1. What is a dihybrid cross?
2. What is the law of independent assortment?
3. In pea plants, if yellow seed colour is dominant to green seed colour and round seed shape is dominant to wrinkled seed shape, identify the genotypes and phenotypes of the F_1 and F_2 generations if a pure breeding plant with yellow wrinkled seeds is crossed with a pure breeding plant with green, round seeds.
4. What is a test cross?
5. (a) Outline why Mendel's second law was determined by his investigations into dihybrid crosses.
   (b) Explain why Mendel's second law has since been modified.
6. In guinea pigs, if you cross a homozygous black, short hair guinea pig with a homozygous white, long hair guinea pig, all the offspring have black, short hair.
   (a) Which characteristics are dominant and which are recessive? Explain your answer.
   (b) If a homozygous white, long hair guinea pig is mated with a guinea pig that is heterozygous for both characteristics and is black with short hair, what is the probability of an offspring being white with long hair?
7. In a cross between a maize plant homozygous for both coloured kernel (C) and shrunken kernel (s) and a plant homozygous for colourless kernel (c) and heterozygous for smooth kernel (Ss), give the ratios of the genotype and phenotype of the possible offspring.
8. An organism that is heterozygous dominant for two characteristics of the F_1 generation is crossed with a dominant homozygous individual for the same characteristics. What will be the ratio of the phenotypes of the offspring for these two characteristics?

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VCE BIOLOGY UNIT 2

STUDY DESIGN 2022

Area Of Study 2

How Do Inherited Adaptations Impact On Diversity?

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30 Asexual Reproduction in Animals

Many animals, especially the invertebrates have the ability to reproduce asexually. Asexual reproduction only involves one parent. Since the Australian environment is particularly arid, asexual reproduction is a means of using less energy to produce offspring.

Sponges

Sponges are very simple animals that are basically a colony of cells with very little division of labour between the cells. They do not have any type of nervous system. Australia has 25 species of freshwater sponges. Sponges can reproduce both sexually and asexually. They can reproduce asexually in several ways. Adult sponges produce 'buds' which are clones of the parent. The buds break off and grow into new sponges. Sponges can also regenerate from fragments that have been broken off. When rivers dry up during droughts, the sponges form gemmules which are drought-resistant buds. These remain dormant until immersed in water again when they will return to life.

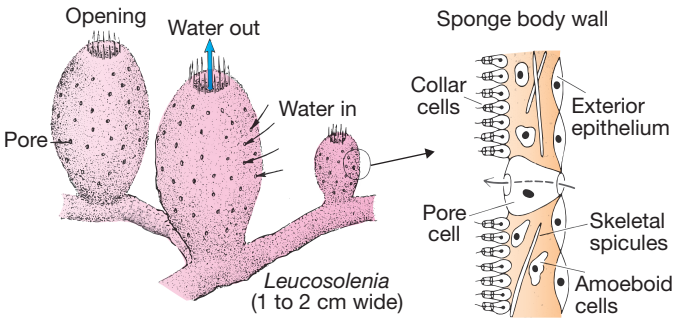

Figure 30.1 The calcareous sponge *Leucosolenia* looks like curved vases.

Cnidarians and budding

Cnidarians are aquatic animals with a simple body plan with one opening for the digestive system. Their body is basically a hollow container that is a polyp and vase shaped or a medusa and bowl shaped. The polyp is usually sessile and the medusa is usually motile.

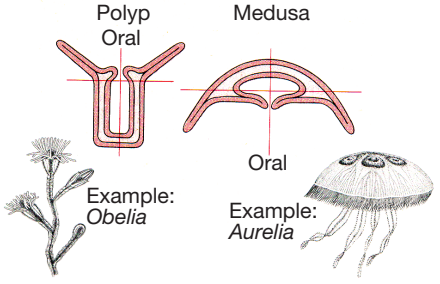

Figure 30.2 Cnidarian body shape and examples.

Cnidarian polyps typically reproduce asexually by **budding** where a new animal is formed as an outgrowth of the parent polyp and the division of the animal into two is unequal. Medusa always reproduce sexually.

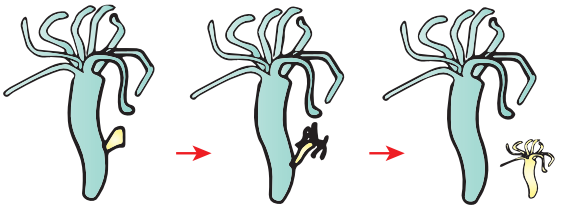

Figure 30.3 Hydra asexually reproducing by budding.

In ideal conditions more than one bud may develop at a time until the bud is pinched off at the base to form an independent organism.

Regeneration

Regeneration occurs when a parent organism splits and the parts of the organism develop into mature, fully grown individuals. The fragments regenerate into new complete individuals by mitosis and differentiation.

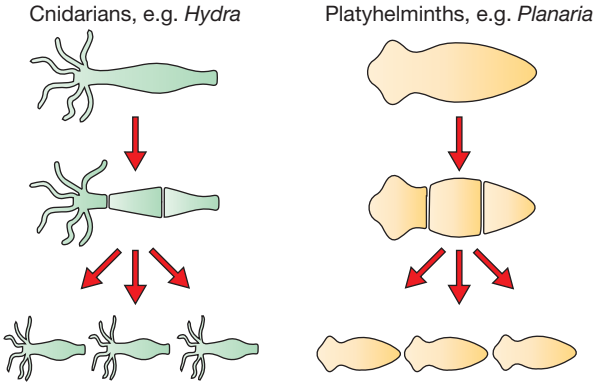

Figure 30.4 Hydra asexually reproducing by budding.

Parthenogenesis

Parthenogenesis is the development of unfertilised eggs into adults, e.g. in ants, wasps and bees. In honey bees every egg laid by the queen will develop whether or not they are fertilised. Most of the eggs are fertilised eggs and develop into sterile worker females, while the few eggs which are not fertilised develop parthenogenetically into male drones. The males are involved in mating and do not help in the nest. In parthenogenesis the offspring are identical to the parent, which is an evolutionary disadvantage in a changing environment, but it allows the build-up of a large population in a short time without the need to find a mate. For example, aphids can produce several generations of female young when conditions are favourable in summer. A newly hatched female can produce new females within days and thus millions of aphids can be produced in a very short time frame.

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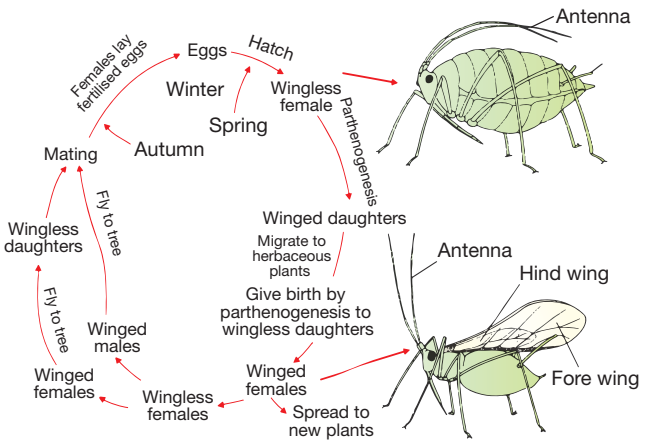

Figure 30.5 Parthenogenesis in aphids.

Although parthenogenesis is more common in insects than vertebrates, some species of lizard have been found to reproduce asexually. Bynoe's gecko (*Heteronotia binoei*) is one of the most widespread lizards in Australia found everywhere except the dampest areas in the south-east and south-west. In Central and Western Australia several populations that only consist of females have been found existing next to populations that contain both sexes. Parthenogenesis has been artificially induced in laboratory experiments using the unfertilised eggs of several different species.

QUESTIONS

1. Describe three ways in which Australian freshwater sponges can reproduce asexually and explain why this is suited to the Australian environment.
2. The diagram shows the development of a sponge.

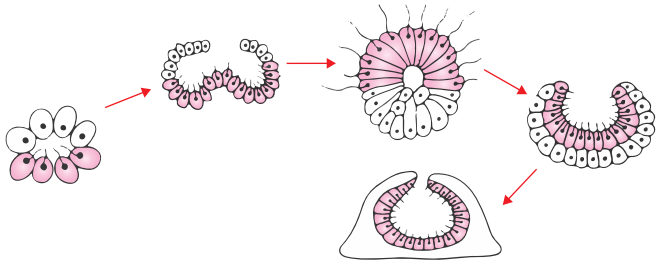

Figure 30.6 Stages in sponge development.

If the body of a living sponge is pushed through a sieve to separate into individual cells and small clumps of cells within a short time, e.g. 30 minutes for some species, the isolated sponge cells will start to aggregate to form the recognisable form of a sponge with an outer surface of epithelial cells, pores and channels and flagellated chambers. Explain why scientific research into this feature of sponges could help solve issues in the treatment of human diseases and injuries.

3. What is budding?
4. Outline what happens in regeneration.
5. Define parthenogenesis and give an example.
6. Outline an advantage and a disadvantage of parthenogenesis.
7. Aphids show facultative parthenogenesis, that is, they can reproduce by either parthenogenesis or sexually. Explain why agriculturalists study the life cycle and reproductive features of aphids.
8. Discuss why the reproduction of Bynoe's gecko is interesting for a vertebrate.
9. All individuals in populations of the mourning gecko (*Lepidodactylus lugubris*) are female. Each female usually lays two soft, sticky eggs which hatch and grow into adult females.

Figure 30.7 Mourning gecko.

What type of reproduction must occur in the mourning gecko?
(A) Sexual reproduction.
(B) Budding.
(C) Regeneration.
(D) Parthenogenesis.

10. In laboratory experiments it has been found that the unfertilised eggs of frogs and the unfertilised eggs of rabbits can be made to develop into adults by giving them a mild electric shock or by pricking them with a needle dipped in blood or by changing the osmotic pressure by changing the salt concentration.
What would be the sex of the adults produced in this manner?
(A) Male.
(B) Female.
(C) 50% chance either male or female.
(D) Sex cannot be predicted.
11. Compared with European honey bees Australian honey bees are smaller and have no sting. Which of the following shows a type of reproduction in honey bees?
(A) Males produced parthenogenetically.
(B) Females produced parthenogenetically.
(C) Males produced from fertilised eggs.
(D) Queens produced asexually.
12. What process involves the formation of a new individual with a smaller 'daughter' individual breaking from the larger 'mother' individual?
(A) Sexual reproduction. (B) Budding.
(C) Regeneration. (D) Parthenogenesis.

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31 Asexual Reproduction In Australian Plants

In asexual reproduction there is only one parent and the offspring are clones of the parent. Some plants, fungi and animals use asexual reproduction as their main form of reproduction. Asexual reproduction is advantageous as it does not involve the time and energy needed to find a mate. However, it reduces genetic variation which can be a disadvantage for natural selection in a changing environment.

Many plants are able to reproduce asexually by **vegetative propagation**. In vegetative propagation parts of the parent plant detach and will grow into new individuals. The advantage of vegetative propagation is that less time and energy is needed to produce new individuals – the need for pollinators and pollination, fertilisation, the production of seeds and seed dispersal is removed. The disadvantage of vegetative propagation is the lack of genetic diversity. This is not a problem when the environment is stable but lack of variation reduces survival chances for evolution if the environment changes.

When people take cuttings from a plant and grow a new plant from the cutting, it is a form of vegetative propagation. Cuttings can be from the stem, roots, leaves or petals of the flower, though few plants will grow from petal cuttings. The new plant will be identical to the parent plant. The cells that can give rise to all parts of an organism are called **totipotent**. Plants that live in harsh environments often reproduce by asexual reproduction. They have features that suit that habitat and if conditions are not changing they will survive and multiply, all with identical features.

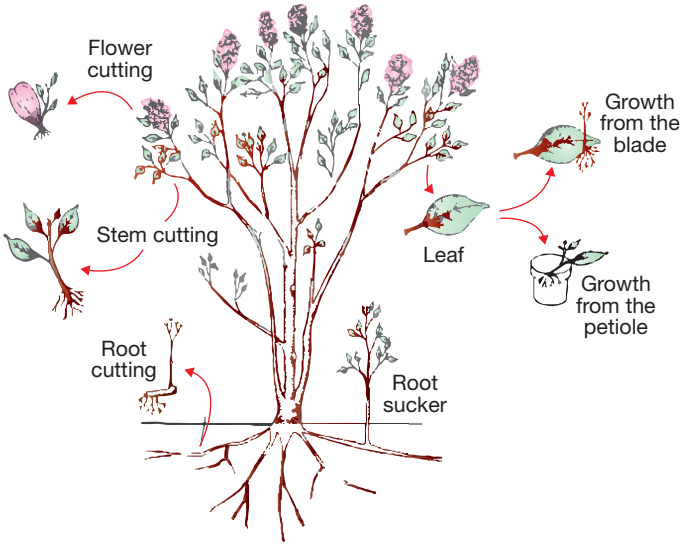

Figure 31.1 Cuttings can be taken from many parts of a plant to grow new individuals that will be identical to the parent plant.

Plants have meristematic tissue of undifferentiated cells that can divide to produce new growth. This process can continue indefinitely. Parenchyma cells which are found in many tissues and are usually drawn as the 'typical plant cell' can divide and differentiate to form specialised cells to repair damage, maintain plant tissues or regenerate lost parts. Parenchyma cells are found in stems and roots and can store starch.

In vegetative propagation a plant fragment will grow roots to obtain nutrients and water and a new plant begins to form. **Adventitious** roots grow from an atypical location, e.g. roots growing from the stem. Adventitious shoots arise when the root system produces so many new growths that some become shoot systems. The oldest known plant clone, King's lomatia, is aged at 43 600 years old.

Stem modifications for asexual reproduction

There are several ways in which a stem can be modified leading to new individuals – stolons, tubers, rhizomes, and suckers.

Stolons – many plants, especially the grasses have long stems called **stolons** or 'runners' that grow along the surface producing new roots and leaves at nodes, e.g. spinifex grass.

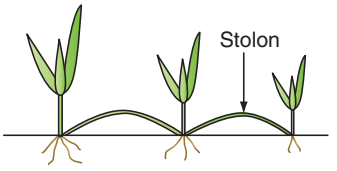

Figure 31.2 Stolon.

Tubers are swollen underground stems that store food and new plants can grow from the tuber. For example, a potato is a tuber and the 'eye' of the potato are buds which can each grow into a new potato plant.

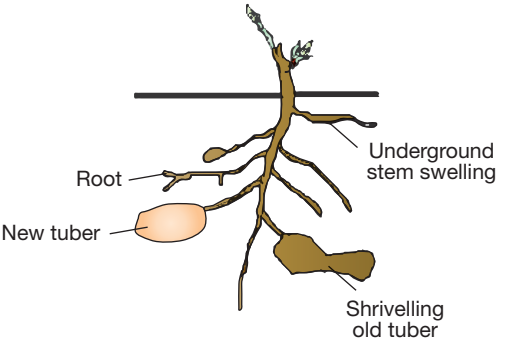

Figure 31.3 Tuber.

Rhizomes are underground stems that give rise to new roots and shoots at the nodes, e.g. ferns, kangaroo paws *(Anigozanthos)*, native ginger *(Alpinia coerulea)* and grasses. Couch grass is considered to be an Australian native and is often used as a lawn grass.

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It will spread by stolons (runners) and also has underground rhizomes which aid its spread across an area. Couch is found in wetlands and river edges.

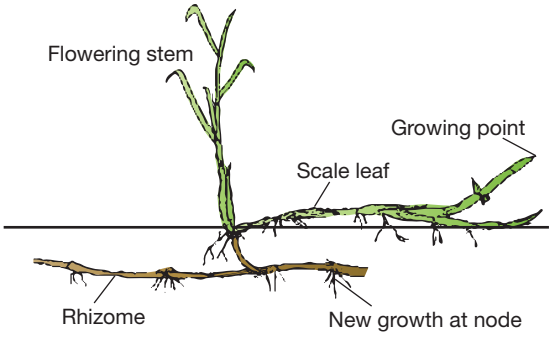

Figure 31.4 Couch grass.

Suckers are new shoots that arise from roots or underground stems, often after fires. Several Australian plants reproduce by suckers, e.g. several *Dampiera* spp, *Scaevola striata* (type of fan flower) and *Goodia lotifolia* (type of pea plant).

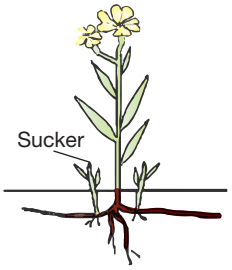

Figure 31.5 Suckers.

Leaf modifications for asexual reproduction

Bulbs consist of a modified stem which is the base plate and on top of this there are a number of leaves. The leaves form a sheath, are non-photosynthesising and are surrounded by a papery bract. An onion is a bulb. Not many Australian plants are bulbs. Examples include *Crinum*, *Calostemma* and *Proiphys* which all belong to the lily family (Liliaceae).

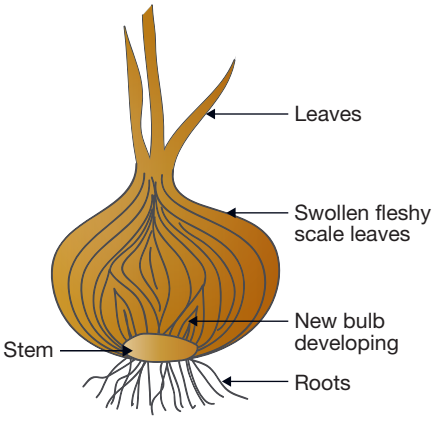

Figure 31.6 Structure of a bulb.

QUESTIONS

1. Define asexual reproduction.
2. What is vegetative propagation?
3. Outline an advantage and a disadvantage of vegetative propagation.
4. Define totipotent.
5. Name a type of plant cells that is totipotent.
6. Explain why plants are capable of regeneration while few animals have such an ability.
7. What are adventitious roots?
8. The photo shows the native violet, *Viola hederacea*. Explain how it reproduces asexually.

Figure 31.7 Native violet.

9. Explain why reproduction from suckers is advantageous in the Australian environment.
10. The diagram shows a structure that assists asexual reproduction. Identify the structure and explain how it aids asexual reproduction.

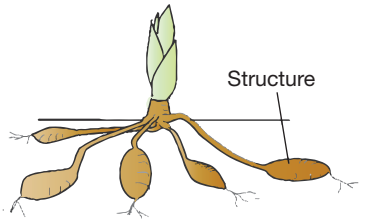

Figure 31.8 Structure Involved in asexual reproduction.

11. Discuss how a plant clone can live for extremely extended periods of time.
12. Many new fresh fruit products on shelves are 'seedless', e.g. seedless grapes and seedless watermelon. Explain how these fruit originated and how they now create new plants for other farmers.
13. Which of the following is the best description of a tuber?
    (A) An underground stem-like runner that will send out new shoots and roots at nodes.
    (B) A swollen underground stem that stores food.
    (C) Small stem base with a sheath of fleshy, non-photosynthesising leaves.
    (D) Underground fruit.
14. A lignotuber is the woody base of a plant stem and can be either partially or wholly underground. The lignotuber is fire resistant and is found in many eucalypts and banksias. How would lignotubers function after a fire?
    (A) New shoots sprout from the lignotuber.
    (B) Lignotuber releases seeds into the air.
    (C) Lignotuber opens up to release spores.
    (D) The lignotuber releases pollen.

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Young females have a spur, but it is shed during her first year. The spur on the males is retained throughout its life and connects with a poison gland which secretes a toxin during the breeding season. It is believed the spurs are used in fights among males over territories and females. The poison can kill a dog and causes massive pain in humans. The bill is an elongated snout that has sensitive nerve endings and is covered in a soft leathery skin. The bill has electroreceptors to detect small amounts of electricity produced by its aquatic invertebrate prey as well as various pressure detectors to help navigate underwater. For example, freshwater shrimp when prodded with a wooden stick use a 'tail-flick' motion to escape which discharges 1 to 2 millivolts over 200 milliseconds. The platypus can detect this electrical output. Their large tail is broad and paddle-like and able to store up to 50% of the platypus' body fat. A 'squeeze test' by researchers on the platypus' tail provides information about the healthiness of the platypus.

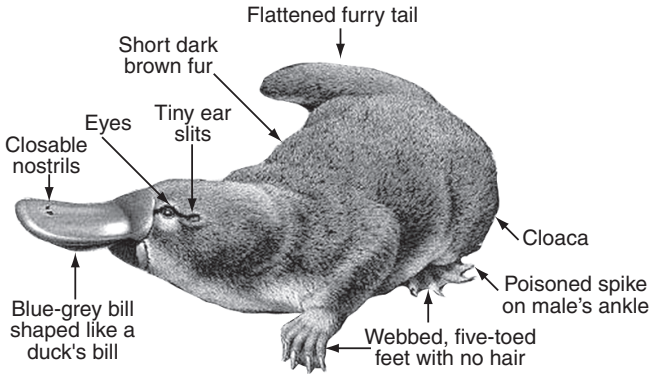

Figure 42.2 Platypus features.

Reproduction

Monotremes produce leathery-shelled eggs with relatively large yolks. The uterus and excretory systems join before reaching the outside at the cloaca. Only one ovary functions in the platypus, whereas both function in echidnas. The genetic information of the platypus is interesting. Researchers at the Australian National University in 2004 found that the platypus has ten sex chromosomes compared with the two sex chromosomes of most other mammals. Platypus genes have both mammalian and reptilian elements. There is also some similarity to some bird genes. Continued research into the platypus genome will clarify the relationship of this monotreme to mammals, birds and reptiles.

There is usually a single breeding season with mating from June to October. Females become mature in the second year. She builds a deep burrow, makes it into a nest and looks after the young on her own.

Behaviour

During the day, the platypus usually rests in its burrow which is in the bank of a river or a lake. It will often bask in the sun at the entrance to the burrow and spend lengths of time grooming its thick woolly fur. When underwater it is continuously diving downwards using its front webbed feet as paddles and its back webbed feet for steering and braking. It usually forages for food between sunset and sunrise and although it can be seen carrying out activities in the daytime, it is considered to be a nocturnal animal. When diving for food the platypus usually only stays underwater for up to 2 minutes. However, platypuses have been known to rest for 10 to 14 minutes underwater underneath logs. An analysis of the blood of platypuses shows that it is very rich in haemoglobin and red cells and this helps explain how it can stay underwater for so long. It has been found that a platypus can lower its heart rate from over 200 beats/min to less than 10 beats/min and this also would assist in allowing it to remain underwater for longer periods.

Diet

Platypuses eat all kinds of insect larvae, molluscs, crustaceans, e.g. freshwater shrimp, fish eggs and sometimes frogs. It uses its bill to search for food and once caught holds the food in cheek pouches until it reaches the surface where it will grind the food and eat. Only juveniles have teeth.

Brain structure

Recent studies, e.g. using microelectrode recordings have investigated the structure of the brain of the platypus and found that previous theories need to be revised. For example, the frontal cortex is less developed than previously thought while the sensory neurocortex is larger than previously thought. This means that theories about the large frontal cortex of monotremes needs revision.

QUESTIONS

1. How is the platypus classified?
2. Where is the platypus found?
3. Discuss why the platypus is classified as a mammal.
4. Describe one Aboriginal legend about the origin of the platypus.
5. What is the first recorded account of the platypus by Europeans?
6. Describe some of the physical features of the platypus.

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43 Specialised Digestive Systems

The diet of the animal determines several features of their digestive system. Plant material has fewer concentrated nutrients than meat so herbivores need to eat more food each day compared to carnivores. Since plant cells have a cellulose cell wall and cellulose is hard to digest the plant material needs to stay longer in the digestive tract so there is more time for the cellulose to be digested. This means that, generally, herbivores have a longer alimentary canal relative to their body size than carnivores.

Many herbivores have special chambers where bacteria and protists live and make enzymes that can break down cellulose into usable sugars. These fermentation chambers can be before the stomach and the animals are known as foregut fermenters or the chamber can be after the small intestine and the animals are called hindgut fermenters.

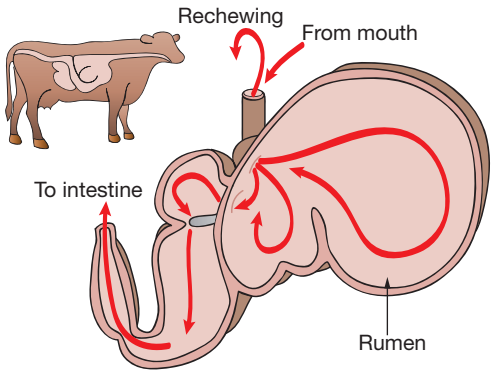

Figure 43.1 Ruminant herbivore.

Foregut fermenters

Ruminant herbivores, e.g. cows, goats and sheep are foregut fermenters. They have a stomach with four chambers. Food is passed into the first chamber called the **rumen**, where it is broken into smaller pieces. Usually it cannot leave the rumen until it is about 1mm long. The length of time spent in the rumen depends on microbial digestion and the type of plant eaten, e.g. young green shoots are easier to digest than tough fibrous stems. The contents of the rumen can be regurgitated into the mouth as 'cud' so it can be rechewed, mixed with more saliva, which is needed to maintain correct conditions in the rumen for digestion, and then reswallowed. The micro-organisms ferment the food, turning the plant tissue into a form that can be used by the host. They also produce amino acids which are not part of the ruminant's diet. This is a symbiotic relationship between the ruminant and the micro-organisms as both benefit from the association. The eastern grey kangaroo is a foregut fermenter.

Hindgut fermenters

Hindgut fermenters have an enlarged caecum, e.g. koalas and rats. The caecum usually forms a blind-ended sac between the small and large intestines. The caecum contains micro-organisms which ferment the cellulose in the plant material. Some of the products of digestion can pass directly through the wall of the caecum to the bloodstream but many hindgut fermenters, e.g. rats and rabbits, have to eat some of their faeces so that the food passes twice through their system and they can thus absorb the vitamin B12. In hindgut fermenters, e.g. possums the microbes are found posterior to the acid secreting region which means they can use the sugars and proteins in their diet but are unable to digest microbial protein, unless they eat their faeces (coprophagy).

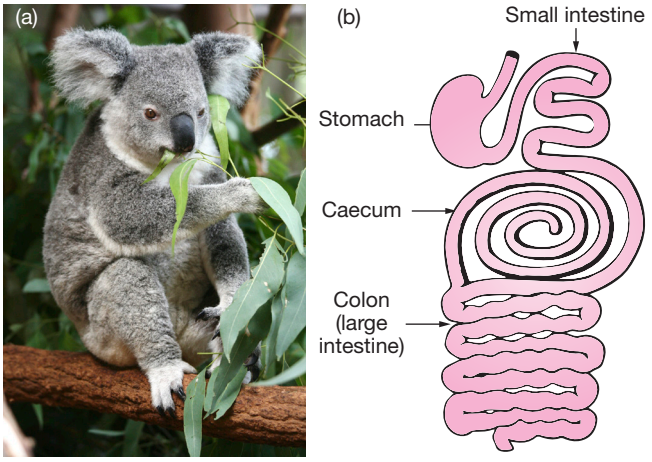

Figure 43.2 Koala digestive system. (a) Koala. (b) The digestive system of a herbivore with large caecum.

Koalas eat eucalyptus leaves which are tough and contain high concentrations of tannins which are very hard to break down. The bacteria T-PCDE live in the koala's caecum, and are able to break down these tannins. The long length of the intestines means that food stays in the gut of the koala for extended periods of time, allowing greater time for digestion. The high surface area allows for increased absorption rates.

Carnivores eat meat, which is predominantly protein and requires less digestion. The acid in the stomach breaks down some muscle tissue and the protease digestive enzyme, e.g. pepsin breaks down the peptide bonds in the protein. The fats in the meat are not broken down until the food reaches the small intestine, where bile from the liver and lipase enzymes from the pancreas and the walls of the small intestine break down the lipids. Protein and fat also contains a higher amount of energy per gram than most plant material. This means that the carnivore can eat less to gain the same amount of energy.

Small **insectivores** use sharp molar teeth to pierce the touch cuticle of their prey. They then use their molars to crush the exoskeleton and shear the inner tissues to release the nutrient rich haemolymph. **Omnivores** eat a variety of food types.

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47 Utilising Indigenous Ecological Knowledge

Aboriginal and Torres Strait Islander people have an extensive history of caring for country.

Many programs and projects have been established to support and help preserve indigenous knowledge and understanding of the adaptations and interdependencies between species in Australian ecosystems, e.g. National Landcare Program, DVDs, books and images produced by the Central Land Council, and the Gunditj Mirring Partnership Project in south-west Victoria.

The Aboriginal and Torres Strait Islander people have the oldest continuous culture in the world making their knowledge of their land thorough and extensive.

Intellectual property is the property of your mind or privately owned knowledge. It is very important when working with indigenous Australians and recording traditional ways, medicines and ecological knowledge that intellectual property is properly acknowledged and protected.

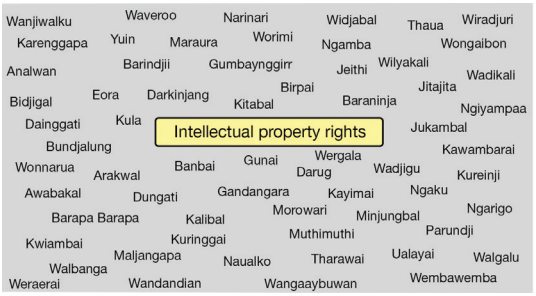

Figure 47.1 Indigenous intellectual property.

Guidelines have been written to provide a framework for the management of indigenous ecological knowledge ensuring the preservation of intellectual property rights and cultural integrity. The collection and use of information recognises the need for respect and the informed consent for those who hold the knowledge. Attribution needs to be given to indigenous stakeholders with equitable benefit sharing.

Linking IEK to science

Accumulated understanding of the environment, of species present in particular areas, of weather patterns, of seasonal changes and of water courses has been handed down over thousands of years from generation to generation by indigenous people about their land. Scientists have realised the importance of linking indigenous land and sea management practices that have conserved and maintained biodiversity for so many generations to the current situation. This involves co-designing and assessing new management procedures with greater indigenous participation and producing culturally appropriate information, including in indigenous languages.

The Atlas of Living Australia (ALA) is involved with many projects that are helping to link traditional and contemporary indigenous knowledge with Western science.

Enterprise activities

Collaborative projects involving traditional owners and the scientific community allow the transfer of knowledge and skills. Enterprise activities have produced many benefits – there is a range of published literature which aids education and increases understanding, there are new bush medicine and bush tucker industries and there are many conservation and rehabilitation projects that are restoring ecosystems.

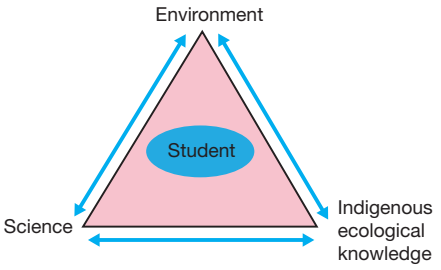

Figure 47.2 IEK triangle.

The triangle shows the links between indigenous ecological knowledge, scientific knowledge and the environment. The student learns about each, their inter-relatedness and can then apply their understanding to conserve biodiversity and help maintain sustainable ecosystems.

Increased awareness of the complexities of ecological interdependencies, the particular adaptations and requirements of species within dynamic communities and relationships with the land and seasonal changes require the monitoring, the recording and the analysis of observational data and then educational programs that disseminate knowledge.

QUESTIONS

1. What is intellectual property?
2. The Traditional Ecological Knowledge (TEK) Project involves Torres Strait communities to collect, protect and control the sharing of cultural and natural resource information. Suggest why one of the key outcomes for development plans for the Torres Strait involves community sustainability, resilience and ability to adapt to climate change.
3. How does the IEK triangle shown in Figure 47.2 represent integrated student learning?

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SURFING

VCE BIOLOGY UNIT 1

STUDY DESIGN 2022

Topic Test

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Topic Test

Section A – Multiple Choice (35 marks)

1. The diagram shows part of a process that occurs in cells.

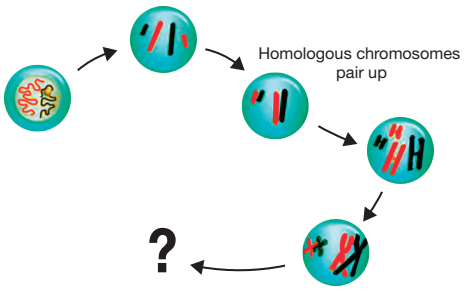

Figure TT.1 Cellular process.

What process is occurring in this diagram?
(A) First steps in mitosis.
(B) First steps in meiosis.
(C) First steps in binary fission.
(D) Gene expression.

2. What are histones?
(A) Small proteins that bind to DNA.
(B) A chemical that causes dilation of blood vessels.
(C) An iron-containing pigment that carries oxygen.
(D) Proteins that coat fats for lipid transport.

3. The diagram shows a biological process.

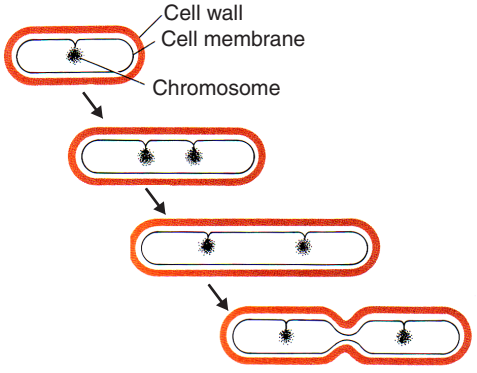

Figure TT.2 Biological process.

What is this process?
(A) Binary fission in bacteria.
(B) Mitosis in an animal cell.
(C) Binary fission in plant cell.
(D) Mitosis in plant cell.

4. What would be an example of alleles?
(A) Red hair and freckles linked close together.
(B) Adenine/thymine and cytosine/guanine.
(C) A set of three bases with the code for a specific amino acid.
(D) White and black fur colour.

5. What is the genome?
(A) The study of heredity and the variation of inherited characteristics.
(B) The complete set of proteins that can be expressed by a cell, tissue or organism.
(C) The visual appearance of chromosomes of a cell or organism.
(D) The complete set of genes or genetic material present in a cell or organism.

6. The diagram shows a biological strategy used by the cnidarian Hydra.

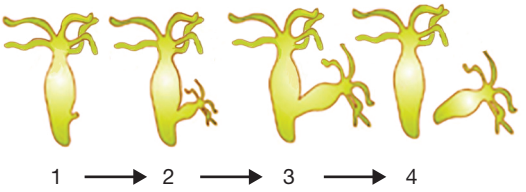

Figure TT.3 Biological strategy.

What is this strategy?
(A) Asexual sexual reproduction by binary fission.
(B) Asexual reproduction by budding.
(C) Sexual reproduction by binary fission.
(D) Sexual reproduction by budding.

7. Which of the following is an example that shows how the environment may affect the expression of a gene in an individual?
(A) Many people with red hair also have freckles and green eyes.
(B) Homozygous snapdragon plants have red or white flowers but hybrids have pink flowers.
(C) Black fur develops under a cold pack placed on the white fur of a Himalayan rabbit.
(D) Identical twins brought up in different areas show many physical similarities.

8. When does Mendel's second law of independent assortment not apply? When:
(A) Both genes are on the same chromosome.
(B) There is incomplete dominance.
(C) Environmental factors change phenotype.
(D) Codominance produces a new phenotype.

9. What is the name of the process that causes cells with the same genotype to become specialised with distinct structures to carry out particular functions?
(A) Transcription and RNA processing.
(B) Directional selection.
(C) Differential gene expression.
(D) Tissuisation.

10. A researcher investigating ear width in native animals found that large ear (L) is dominant over small ear (l). Which of the following have the different genotype by the same phenotype?
(A) Ee, Ee
(B) EE, Ee
(C) EE, ee
(D) Ee, ee

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30. The diagram shows an emperor penguin and a fairy penguin.

Figure TT.14 Emperor and fairy penguins.

Which statement correctly explains why fairy penguins are found in Australia and emperor penguins are found in Antarctica?

(A) Fairy penguins have smaller SA : V and lose heat more easily.
(B) Fairy penguins have larger SA : V and lose heat more easily.
(C) Fairy penguins have smaller SA : V and lose heat less easily.
(D) Fairy penguins have larger SA : V and lose heat less easily.

31. Which of the following would be a structural adaptation for low temperature?

(A) Muscles shivering.
(B) A thick layer of fur.
(C) Living underground in a burrow.
(D) Going into torpor for hibernation.

32. The western pygmy possum *(Cercartetus concinnus)* is known to dig holes to live in during hot conditions, coming out at night to look for food.

Figure TT.15 Pygmy possum.

Which of the following is this an example of?

(A) A selection pressure.
(B) A structural adaptation.
(C) A behavioural adaptation.
(D) A physiological adaptation.

33. Which of the following explains why elephants are considered to be a keystone species of African savannahs?

(A) They eat roots, grasses, fruit and bark.
(B) They are the main primary consumer.
(C) They are migratory with an annual route depending on dry and wet seasons.
(D) They modify the landscape, e.g. pull down trees and dig waterholes.

34. What is parthenogenesis?

(A) Development of unfertilised eggs into adults.
(B) An entire adult organism splitting itself lengthwise producing a clone.
(C) A parent body splitting into fragments and each part developing into a fully grown identical individual.
(D) The formation of internal buds that eventually detach from the parent body.

35. The diagram shows a process used to clone animals, e.g. for agriculture.

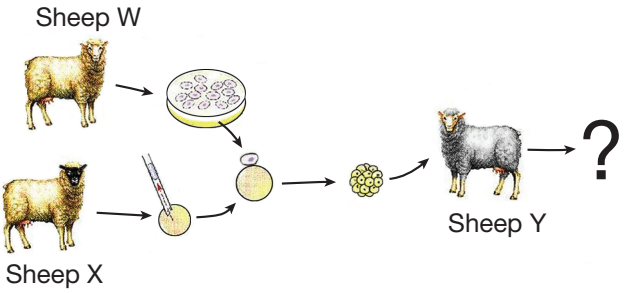

Figure TT.16 Cloning process.

Which of the sheep will the resulting lamb resemble?

(A) Sheep W.
(B) Sheep X.
(C) Sheep Y.
(D) It will be a hybrid of sheep W and sheep X.

Section B – Written Response (65 marks)

36. Relatively simple organisms, such as cnidarians, can use both sexual and asexual reproduction.

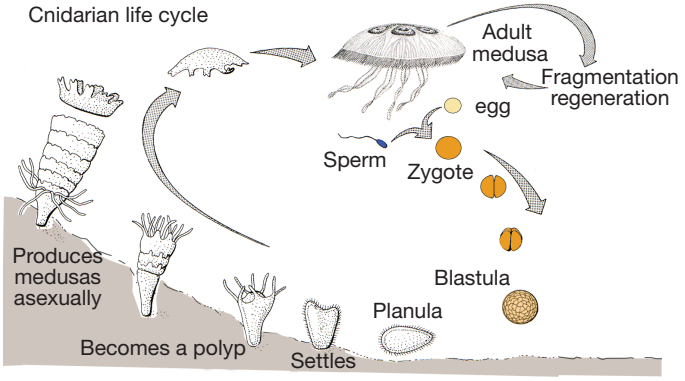

Figure TT.17 Cnidarian life cycle.

Explain three advantages for these organisms to reproduce both sexually and asexually. (3 marks)

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37. (a) What is a clone? (1 mark)
(b) Explain how cloning could affect the genetic diversity of a species. (2 marks)
(c) Many people believe that 'cloning is a new technological development'. Use examples to evaluate this statement. (3 marks)
(d) In 2001 scientists cloned a gaur, a wild ox which is an endangered species; although it died 48 hours later. In the same year a mouflon, an endangered wild sheep was successfully cloned. Discuss the importance of these programs. (2 marks)

38. The diagram shows a food web of an Australian rainforest.

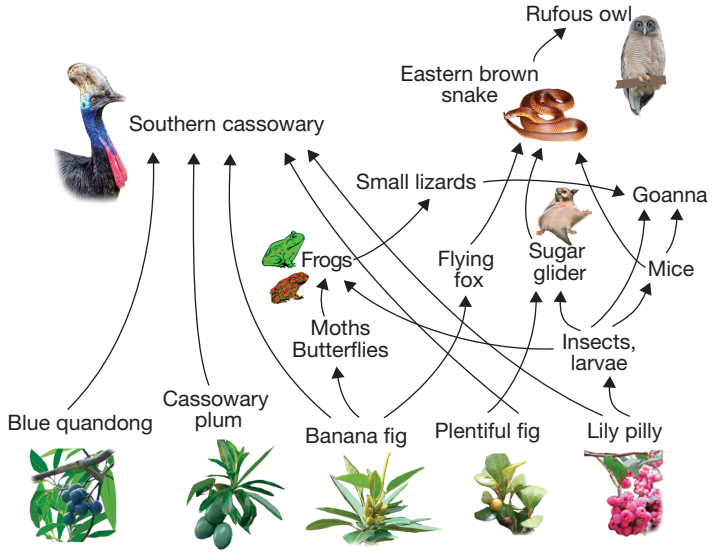

Figure TT.18 Food web of an Australian rainforest.

(a) Identify the keystone species. (1 mark)
(b) Suggest an outcome of removing the keystone species. Explain your reasoning. (2 marks)
(c) How could genetic diversity change if the rainforest was logged and some regions made into farmland? (3 marks)

39. (a) Scientists often refer to 'Mendel's ratios'. Explain what is meant by this term. (2 marks)
(b) Describe two situations where Mendel's ratios are not produced. Use an example for each. (4 marks)

40. Transposable genetic elements or transposons are DNA segments that can move from one position to another in chromosomes. Discuss the impact of transposable genetic elements on the genome. (2 marks)

41. The human ABO blood group system is an example of codominance and multiple alleles. The table shows inheritance of different ABO blood group alleles.

Table TT.1 Table for human ABO blood groups.

Blood group	Allele	Dominant/recessive
A	Allele I^A	Codominant with I^B
B	Allele I^B	Codominant with I^A
O	Allele i	Recessive to both I^A and I^B

(a) Explain what is meant by codominance and multiple alleles. (2 marks)
(b) Use a Punnett grid to explain how it is possible for two parents, one with blood type A and one with blood type B to have four children each with a different blood type. (2 marks)

42. Female cats may be yellow, black or tortoiseshell while male cats can only be yellow or black. The alleles are X-linked.
(a) Outline why there is an extra colour possibility for females. (2 marks)
(b) Calculate the phenotypes you would expect between a mating of a black male and a tortoiseshell female. Show all working. (3 marks)

43. A person constructing family trees for two families forgot to label the trees. The Smith family had a history of Huntington's disease and the Lyle family had a history of phenylketonuria (PKU).
The diagram shows the two trees.

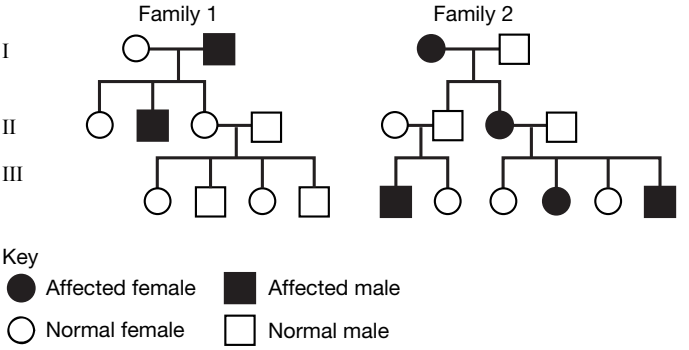

Figure TT.19 Two family trees.

(a) If Huntington's disease is caused by a dominant allele and PKU is caused by a recessive allele, identify which family tree is the Lyle family and which is the Smith family giving reasons for your decision. (2 marks)
(b) Read each of the following descriptions of the two diseases.

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Answers

1 Assumed Knowledge

1. A gene is a heritable factor that determines a specific characteristic, e.g. gene for stem height in pea plants.
2. (a) Meiosis is cell division to produce haploid daughter cells.
   (b) Meiosis produces four daughter cells and in the anther will produce four pollen grains.
3. Information is transferred as DNA on chromosomes when cells reproduce themselves.
4. (a) Structure X is the centromere.
   (b) The P region is the shorter arm and the Q region is the longer arm of a chromosome from the centromere.
5. The basic unit of DNA is the nucleotide.
6. The genome is the complete genetic information of an organism. It usually refers to the haploid genome of an organism.
7. Homologous chromosomes are pairs of chromosomes of the same length and centromere position with one being inherited from the father and one from the mother.
8. A gene is a certain length of DNA that has the code for one characteristic.
9. An autosome is any chromosome that is not a sex chromosome.
10. A mutation is a change in the chemical structure of the DNA.
11. Sex chromosomes in humans are an X chromosome and a Y chromosome.
12. A pedigree is a graphical way of picturing the ancestry of living things. It shows genetic history.
13. The diploid number is the number of chromosomes present in the body cells of a diploid organism (2 copies of each chromosome).
14. The table shows that the different species – aloe vera, koalas, dolphins, magpies, fruit flies and humans have different diploid numbers from each other in their genetic make-up.
15. Asexual reproduction involves only one parent and the offspring have the exact same set of chromosomes as the parent, whereas sexual reproduction involves two parents and the offspring have chromosome sets different from those of either parent.
16. A somatic cell is a body cell.
17. Genetic diversity refers to the total number of genetic characteristics in the genetic make-up of a species.
18. Both genes and environmental factors determine the features of an organism.
19. Many different examples can be used to show how the environment influences the appearance of an organism. In plants, e.g. pea plants, the environment can have a great influence on the appearance of an organism. If the plant has the genetic code to be tall, but is grown in poor soil which has few nutrients, then the plant will not reach its full height potential and may appear to be a dwarf plant.
20. In pea plants there are two alleles for plant height – tall (T) and dwarf (t). Given that all other environmental factors are the same, a plant with the genetic code TT or Tt will be tall, while a plant with the code tt will be dwarf.
21. Genotype is the genetic make-up of an organism, or a set of alleles of an organism.
22. Fertilisation is the union of two gametes.
23. Gametes fuse to form a zygote. It is essential that gametes contain only half the number of chromosomes to maintain the chromosome number of the species. Otherwise the number of chromosomes would double every generation.
24. The male part of the flower is the stamen and it consists of the anther and the filament. The female part of the flower is the carpel and it consists of the ovary, with ovules, the style and the stigma.
25. Gregor Johann Mendel studied the inheritance of different characteristics in pea plants in 1856. He started with many strains and bred them for several years to find easily recognisable traits that bred true. Mendel crossed pure breeding round seeds with pure breeding wrinkled seeds and found that the first generation (F_1) were all round seeds. When he crossed two of the offspring he found that the ratio was 3 round : 1 wrinkled in the second generation (F_2). Mendel concluded that there were two factors for a character and one (e.g. round seed shape) was dominant over the other (e.g. wrinkled seed shape).
26. A clone is an organism that has the identical genetic make-up to the parent cell.
27. An adaptation is any feature or characteristic which helps the organism survive in its environment.
28. (a) Structural adaptations are those concerned with the anatomy of the organism – the size, shape or appearance of its body or part of its body.
    (b) Behavioural adaptations are those concerned with how an organism behaves – how it moves around or acts.
    (c) Physiological adaptations are those involved with the internal functioning of the body's metabolism.

2 Genome, Gene and Allele

1. The genome is the complete genetic information of an organism.
2. Genomics is the study of whole sets of genes and their interactions, e.g. it includes how particular genes are expressed, how they are regulated, their interactions with other genes and how gene expression affects growth, development and evolution.
3. In many cases the genome of prokaryotes is a single DNA molecule not bound by a membrane while the genome of eukaryotes usually consists of a number of DNA molecules in the nucleus which is surrounded by a membrane.
4. A chromosome is a cellular structure that holds genetic information in the coding of the DNA molecule.
5. A gene is a heritable factor that determines a specific characteristic, e.g. gene for stem height in pea plants. It is a section of DNA coding for proteins that expresses itself as the phenotype for that trait.
6. An allele is an alternative for a particular trait, e.g. there are two alleles for height in pea plants – tall (T) or short (t).
7. If two alleles at a locus differ then one will be the dominant allele and will show in the phenotype and the other will be the recessive allele and will only show in the phenotype if there is no dominant allele present.
8. (a) PKU is phenylketonuria, an autosomal recessive genetic disorder that causes problems with brain development.
   (b) The gene involved with PKU is the PAH gene on chromosome 12. This gene codes for the enzyme phenylalanine hydroxylase which is needed for the reaction that breaks down the amino acid phenylalanine into the amino acid tyrosine.
   (c) PKU is detected by screening newborns 2 to 7 days after birth with tests for PKU and if a child is diagnosed with PKU it is prescribed a diet that is low in phenylalanine and high in tyrosine for the rest of their life, e.g. diet low in meat, chicken, nuts, cheese and potatoes with tyrosine supplements.
9. B
10. C

3 Genome, DNA and Bioinformatics

1. The genome is the sum total of an organism's DNA measured in the number of base pairs contained in a haploid set of chromosomes.
2. DNA stands for deoxyribose nucleic acid.
3. DNA is a double helix or twisted ladder shape.
4. A nucleotide is the basic unit of DNA. It consists of a sugar, a phosphate and a nitrogenous base.
5. Part X is phosphate, part Y is sugar.
6. The base pairs of DNA are A-T (adenine always pairs with thymine) and C-G (cytosine always pairs with guanine).
7. A genome map is less detailed than a genome sequence identifying short DNA sequences as markers in a genome. A genome sequence is the complete order of the As, Ts, Cs and Gs in the DNA code.

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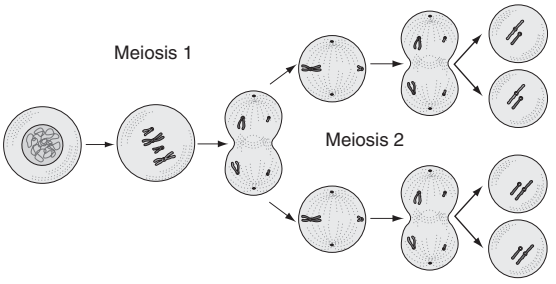
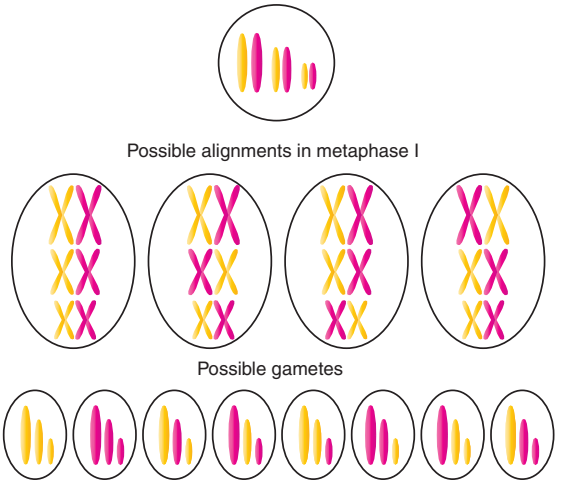
5. The father determines the sex of the child. The mother is XX, which means all eggs contain one X, while the sperm carry either an X or a Y. X sperm will form daughters while Y sperm will form sons.
6. Females are XX which means they would require two recessive alleles to show the trait, while males are XY and only need one recessive allele to show the trait. Thus males are more likely to show a recessive trait on the X chromosome, e.g. haemophilia, than females.
7. Parthenogenesis is a type of reproduction in which females produce offspring from unfertilised eggs.
8. The *SRY* gene is the sex-determining region on the Y chromosome. If this gene is present the gonads develop into testes. If this gene is not present the gonads develop into ovaries. The protein made by the *SRY* code starts male sex determination and regulates other genes which are also involved in developing fully functioning sex organs.
9. B
10. A
11. C

10 Karyotyping

1. A karyotype is an arrangement of chromosome pairs according to size and shape. It is a property of a cell giving the number and type of chromosomes present in the nucleus and not a photograph or diagram of them.
2. A karyotype is prepared by collecting cells, culturing them and then halting cell division at metaphase. The cells are stained and then the chromosomes are sorted according to size and structure.
3. Karyotyping is carried out using cells that are dividing as this is when the chromosomes are clearly visible under the microscope.
4. A karyogram is a photograph or diagram of the chromosomes in a cell. The chromosomes are arranged in homologous pairs of decreasing length in a karyogram. The longest pair are chromosome 1.
5. Karyotyping is useful to look for chromosome anomalies, e.g. trisomies where there is an extra copy of a chromosome making three copies instead of two, or translocations where part of a chromosome has duplicated and been added to another chromosome. Karyotyping is also carried out if a female has recurrent miscarriages.
6. Klinefelter syndrome is a chromosomal disorder that occurs when males have two or more X chromosomes, e.g. a male has XXY. It is a congenital disorder detected by karyotyping. The additional X chromosome can come from the egg or the sperm or can be added during the early stages of embryo development. The additional X causes sterility and the male may have weaker muscles, poor coordination, less body hair, smaller genitals and breast growth.
7. Turner syndrome (TS) is a chromosomal disorder that occurs when females are missing part or a whole X chromosomes, e.g. a female has XO. The lack of the second X chromosome often causes low-set ears, low hairline, reduced breast development, heart defects, lack of menstrual periods and inability to produce children. There is no cure for Turner syndrome but treatments, e.g. hormone replacement therapy can aid growth development and breast development.
8. There is no cure for Turner syndrome but treatments, e.g. hormone replacement therapy can aid growth development and breast development and plastic surgery can remove the webbing on the neck.
9. Edwards syndrome is a chromosomal disorder when there is three copies of chromosome 18.
10. The three types of Edwards syndrome: 1. Full trisomy 18 with every cell in the body having the extra chromosome. 2. Partial trisomy 18 with only part of chromosome 18 additional and attached to another chromosome. 3. Mosaic trisomy 18 with some cells having the additional chromosome and some cells having the normal number of 46 chromosomes per cell.
11. (a) Trisomy 2 means that there is three copies of chromosome 2 present in cells.
    (b) A mosaic means that some cells have an additional chromosome and some cells have the normal number of 46 chromosomes per cell.
12. Chromosome 2 is the second longest chromosome with many genes. The presence of the additional chromosome disrupts normal development, cell functioning and cell metabolism. Thus full trisomy 2 leads to a spontaneous abortion during pregnancy. Mosaics do not have the additional chromosome in every cell and the number and distribution of cells with the additional chromosome means they can survive and have a live birth.
13. C
14. B

11 Meiosis

1. Meiosis is cell division to produce gametes – egg and sperm.
2. Four daughter cells are produced by meiosis
3. Meiosis occurs in the gonads, e.g. testes and ovaries in animals, ovaries and anther in flowering plants.
4. The daughter cells formed by meiosis are haploid and not identical to the parent cell.
5. Homologous chromosomes are pairs of the same length and centromere position with one being inherited from the father and one from the mother.
6. The law of independent assortment states that alleles of genes on nonhomologous chromosomes sort independently during gamete formation.
7. Linked genes are on the same chromosome.
8. Linked genes can be separated and inherited independently of each other if crossing over occurs during prophase I.
9. The law of segregation states that the two alleles for each gene separate during meiosis and gamete formation.
10. 

11. An anther would have been chosen to study meiosis as the anther is the male part of a plant where meiosis occurs to form pollen. The diagram shows the end of meiosis I with the dividing cells consisting of two cells (in the centre).
12. 

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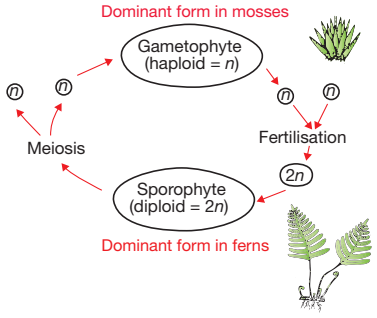
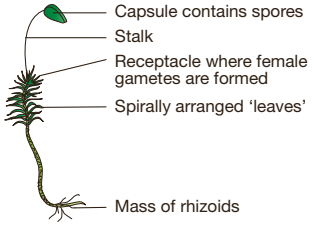
11. Many plant clones can live for extremely extended periods of time as new growth is produced from roots or shoots by asexual reproduction, e.g. the oldest known plant clone, King's lomatia, *Lomatia tasmanica*, is aged at 43 600 years old. If the parent plant ages and dies, the new growths can appear as separate individuals even though they are all genetically identical and came from the same parent.
12. The original 'seedless' fruit would have been a mutated form that had less seeds than the normal fruit. The farmers and research workers would have carried out artificial selection while these plants could still reproduce sexually. If a plant is seedless or the seeds are not viable, the way to obtain more plants for other farmers is to use cuttings and vegetative propagation. This means all plants from the cuttings will be genetically identical to that parent plant.
13. B
14. A

32 Spore Formation

1. Spores are produced by many different types of organisms as a means of asexual reproduction, e.g. by plants such as ferns and mosses, by fungi, by algae and by bacteria.
2. Alternation of generation means that the life cycle has both diploid and haploid multicellular stages.
3. In the life cycle of a plant or alga that has alternation of generation a spore is a haploid cell that is produced by meiosis and itself divides by mitosis forming a multicellular individual, the gametophyte without fusing with another cell.
4. The sporocyte is the spore mother cell that produces spores by dividing by meiosis.
5. 

6. Mosses show a variety of forms and do not have true vascular tissue – veins. The gametophyte has a green, leafy stem with rhizoids (thread-like structures) growing from the base.
7. Moss plant.


8. A fungal mycelium is a densely packed network of hyphae, e.g. mushroom.
9. Spores are usually microscopic, light and surrounded by a protective wall which allows them to survive difficult environmental conditions. Spores of many organisms can travel thousands of kilometres by wind and can remain dormant for many years. This aids survival of the species as it provides a mechanism for survival through harsh conditions and also provides a means for wide dispersal which can increase the distribution with some spores migrating to new areas to start new colonies far from the location of its parent.
10. Asexual reproduction is a disadvantage as all offspring from one parent will be clones of the parent with identical genetic information. This is a problem in a changing environment as they not have features favourable to the new selective pressures which will enable the population to survive. This can lead to extinction where these new pressures exist.
11. The diagram shows the formation of an endospore by a bacterium. In this process a copy of the bacterial chromosome is surrounded by a tough wall to form the endospore. Water is removed from the endospore and metabolism inside the endospore stops. The rest of the cell breaks down leaving the endospore to survive the harsh conditions. When favourable conditions return the endospore germinates and the bacterium emerges or the spore contents can immediately divide into two cells.
12. A
13. B
14. C

33 Sexual Reproduction

1. Sexual reproduction is a type of reproduction where two parents give rise to offspring that have a unique combination of genes from the gametes of the two parents.
2. A gamete is a sex cell with a haploid number of chromosomes.
3. Gonads are the sex organs in males and females.
4. A zygote is a fertilised egg formed by the union of haploid gametes.
5. In many species the ovum is a large, inactive cell containing a store of food to provide energy for the zygote until it grows to a stage where it can feed itself.
6. In many species the sperm is a microscopic cell that swims using a relatively long tail. The nucleus in the sperm is in a small head piece with an acrosome at the tip which contains enzymes that help the sperm penetrate the egg. Behind the head the sperm has a middle piece with large numbers of mitochondria which provide the energy needed for the movements of the tail.
7. Fertilisation is the union of two haploid gametes to produce a diploid zygote.
8. Hermaphrodites are individuals that have both male and female gonads. They can function as both male and female in sexual reproduction by producing both sperm and eggs. Some examples are certain cnidarians, flatworms, annelids and molluscs.
9. Fertilisation in animals takes place in a fluid, e.g. sea water, fresh water or body fluid of the female parent.
10. Most animals have reproductive cycles that are often related to different seasons. Offspring are likely to be born when there is plentiful food and resources to help aid survival of the young.
11. Advantages of sexual reproduction include: 1. In a changing environment variation in genotypes means that some individuals may have gene combinations that are favourable to the new environmental selective pressures leading to natural selection, evolution and survival. This is particularly beneficial if the population is small in size and the mutation rate is relatively high. 2. Sexual reproduction allows for multiple numbers of offspring which increases variation for natural selection in a changing environment. 3. The recombination of genes in sexual reproduction may lead to harmful genes being removed from a population.
12. D

34 Fertilisation

1. Fertilisation is the union of two gametes.
2. A gamete is a sex cell and is haploid containing only one set of chromosomes.
3. A zygote is a fertilised egg.
4. When two haploid gametes fuse the result is a zygote with the diploid number – two sets of chromosomes. This means that fertilisation maintains the diploid number of a species.
5. Internal fertilisation occurs when the sperm and ovum unite inside the female's body while external fertilisation occurs when the sperm and ovum unite outside the female's body.

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14. Wetland areas are important as areas of human settlement with the establishment of towns and cities, as areas for food production and harvesting, as areas for recreation, for water supply management, for transport and commercial activities for both international and domestic shipping, for industrial development and as important areas for maintaining biodiversity.
15. B

40 Adaptations In Invertebrates

1. Invertebrates are animals without backbones.
2. In cnidarians transport between cells is slow as they do not have a blood system to aid circulation. Movement of substances by diffusion relies on the concentration gradient between two points.
3. (a) Platyhelminths have a flat body. This means they have a large surface area to volume ratio. This minimises the distances for diffusion of substances and gases into and out of the flatworm and compensates for the lack of a blood system. The gut is highly branched and divided which also minimises the distances the digested food needs to travel.
   (b) The flame-bulb system of flatworms is important in water balance and in removing wastes from the flatworm. It is especially important in freshwater flatworms as the difference in osmotic pressure means water moves into the worm by osmosis and the worm needs a way to regulate its internal body fluid concentration for osmoregulation.
4. All cells in a multicellular organism need to have nutrients provided and wastes removed. An increase in size means the organism needs a transport system to deliver and remove substances from cells. In animals, the blood carries oxygen and digested food to cells and removes wastes, e.g. carbon dioxide and nitrogenous compounds. Having a blood system, e.g. in the annelids, arthropods, molluscs and echinoderms means there can be rapid transport of substances around the body and there can be division of labour with cells specialised to carry out particular functions. Thus having a blood systems allows an increase in body size.
5. The tracheal system is an important adaptation for insects as it is a ventilation system that brings oxygen into the body and lets carbon dioxide out of the body. In small insects the gas exchange occurs purely by diffusion. However, active large insects, e.g. grasshoppers have a greater requirement for oxygen for increased respiration and increased metabolism. Thus these larger insects need to use the pumping action of movements of the abdomen to ensure there is sufficient gas exchange for the basic requirement for survival.
6. Tapeworms have many features and adaptations that help them obtain the basic requirement for survival. 1. They lack a gastrovascular cavity and nutrients are absorbed across the tapeworm's body surface from the host's intestine. They do not need a complex digestive system as they rely on their host to obtain food and break it down into usable substances. 2. On their scolex they have hooks and suckers that attach to the host and prevent the worm from being passed out of the host. 3. Behind the scolex are the proglottids which each contain both male and female reproductive organs. The mature proglottids containing fertiolised eggs are released from the end of the mature tapeworm moving with faeces out of the host. Thus there is no need to find a mate and the requirements for reproduction are met.
7. The radula is an important feature for snails as it is used for feeding. The radula of herbivorous snails is used to scrape and cut plant material and algae. The radula of carnivorous snails is used with an acidic secretion to bore through the shell of other snails to get to the soft tissues of their prey.

41 Adaptations In Vertebrates

1. Vertebrates are animals with backbones.
2. Vertebrates include the jawless fish, the cartilaginous fish, the bony fish, the amphibians, the reptiles, the birds and the mammals.
3. (a) Vertebrates belong to phylum Chordata.
   (b) All members of the phylum Chordata at some stage in their development have a rod-like notochord running under the dorsal surface of the body and a hollow dorsal nerve cord just above the notochord.
4. A swim bladder has great adaptive advantages for bony fish. It gives buoyancy so that secreting gases into the bladder changes the fish's density allowing it to rise in the water or absorbing gases from the bladder allows the fish to go deeper in the water. The swim bladder can also store oxygen.
5. Dissolved oxygen transport pigments increase the viscosity of the blood and limit the oxygen-carrying capacity of the blood. Having haemoglobin in red blood cells that travel in the blood increases the oxygen-carrying capacity of the blood and the organism can have a higher metabolic rate. It also enables the organism to control its own body temperature by internal mechanisms and be endothermic. Endotherms can stay active in cold weather and thus having haemoglobin in red blood cells is more advantageous than having dissolved oxygen transport pigments in the plasma.
6. The double circulation of mammals means the deoxygenated blood coming from the body on the right side of the heart does not mix with the oxygenated blood from the lungs on the left side of the heart. This maximises the amount of oxygenated blood going to the tissues and maintains blood pressure. The single circulation of fish means fish cannot maintain a high blood pressure and thus cannot maintain a metabolic rate for prolonged periods of time.
7. (a) During drought there is less water. When there is high temperatures the water holds less oxygen. And at night oxygen levels can drop as there is less photosynthesis releasing oxygen into the water. Thus at the times mentioned when the lungfish rises to the surface and gulps air into its lung there can be less oxygen in the water and the behaviour is a way the lungfish can supplement its supply of oxygen from its gills.
   (b) The heart of a lungfish has a fibrous plug in its heart that nearly fully separates the right side of the atrium from the left side of the atrium. This means that there is less mixing of oxygenated blood and deoxygenated blood compared with the heart of other fish. This is a more efficient system for maximising the amount of oxygen that can be delivered to tissues for a prolonged period of time.
8. Ventilation in lungs is tidal as the incoming air goes along the same pathway as the outgoing air. In fish the flow of water over the gills is unidirectional. Unidirectional ventilation is more efficient than tidal ventilation as tidal ventilation always has some 'stale' air in the lung and the lung is never completely emptied. Gills need to be more efficient than lungs as there is less oxygen in water than in air and fish need a greater surface area for the respiratory surface, e.g. fish can extract nearly 80% of dissolved oxygen from the water.
9. The high concentration of urea in the body fluid and blood of cartilaginous fish makes their internal environment isotonic or slightly hypertonic to the external environment, the sea water. The concentration of urea is higher than can be tolerated in most other vertebrates but has the advantage in that little water will be absorbed by osmosis through the gills. This means that there is less pressure on the kidneys for osmoregulation.
10. Migratory fish such as eels and salmon need to change the flow of ions across their gills in or out of body fluids depending on their external environment. When they are in fresh water salt is lost in urine and salt needs to be absorbed across their gills into their body. When they are in marine environments salts need to be pumped out of their body across the gills. In marine environments sea water is taken in to counterbalance water lost by osmosis.

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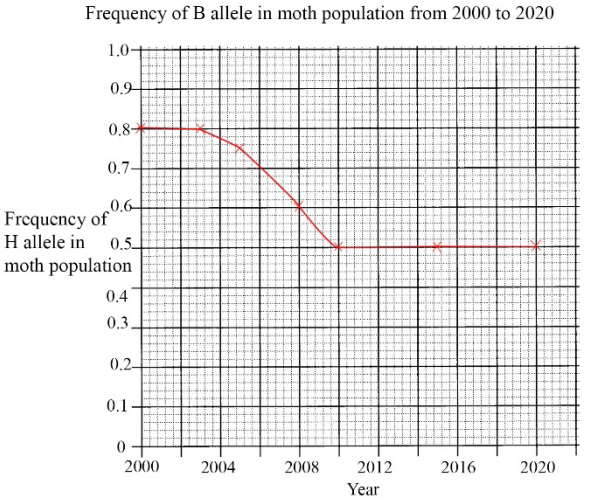
45. (a) Marking Guidelines

Criteria	Marks
Correctly plots graph checking for H = heading Y1 = *y*-axis correctly scaled Y2 = *y*-axis with correct name label Y3 = *y*-axis with correct unit label X1 = *x*-axis correctly scaled X2 = *x*-axis with correct name label X3 = *x*-axis with correct unit label S = scale fills graph paper P = points correctly plotted J = points correctly joined ID = independent and dependent around correct way With 10 to 11 correct	4
8 to 9 correct	3
6 to 7 correct	2
1 to 5 correct	1

Sample answer:



(b) Marking Guidelines

Criteria	Marks
Provides a possible reason AND gives an explanation with reference to the data	3
Provides a possible reason with reference to the data	2
Provides a possible reason	1

Sample answer:
From 2003 to 2010 there was a drop from a frequency of 0.8 to 0.5, which would result in fewer brown moth phenotypes. This could be due to emigration of brown moths (decrease H allele frequency) or an immigration of beige moths (increases hh genotypes). This gene flow would decrease the frequency of the B allele.

OR

A new selection pressure favoured the beige moths. The brown moths died/were eaten and the B allele would decrease.

46. (a) Marking Guidelines

Criteria	Marks
Provides a possible reason for advantage of larger body size AND smaller mouths of snakes	2
Provides a possible reason for advantage of larger body size OR smaller mouths of snakes	1

Sample answer:
Cane toad toxin acts as a selective pressure on native snakes. Snakes with a smaller head and mouth gape are less able to grab a large adult cane toad and thus rely on other prey. A longer body length means the snake is more able to digest the toxin. Thus being longer with larger body and smaller head gives a survival advantage. These snakes survive and reproduce passing their features to the next generation.

(b) Marking Guidelines

Criteria	Marks
Fully completes table	6
Partially completes table	1 to 5

Sample answer:

Type of adaptation	Feature in cane toad	Advantage
Structural	Longer hind legs compared to their bodies	Longer legs allow faster hopping which means the toad can travel further in one night
Behavioural	Very directional in their hopping in north-west straight line	The 'front line' toads can invade new areas in shorter time
Physiological	Faster growers	Faster developmental growth means the 'front line' toads can outcompete smaller toads and take over and dominate new areas

(c) Marking Guidelines

Criteria	Marks
Uses given information to give suitable explanation of why fast and directional hopping is innate/genetic and not learned behaviour or due to environmental conditions	2
Relates fast directional hopping to innate behaviour/ genetics	1

Sample answer:
Raising the toads and their offspring from two different areas then releasing them in the same area near Darwin showed that the toads from the invasion front were still fast directional hoppers while the toads from Queensland were still slow meanderers. Since they were raised and released in the same area and there is no parental care, the difference in hopping behaviour must be due to innate behaviour/genetics and not a response to environmental conditions.

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