SURFING

VCE BIOLOGY UNIT 4

STUDY DESIGN 2022

How Does Life Change and Respond To Challenges Over Time?

Kerri Humphreys

Science Press

Contents

Science Press
ISBN 978-0-85583-8508

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VCE BIOLOGY UNIT 4

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Area Of Study 1

How Do Organisms Respond To Pathogens?

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Questions Scene 1

1. What causes:
   (a) Tetanus?
   (b) Diphtheria?
   (c) Dysentery?
2. How do each of these pathogens enter the human body?
3. How do bacteria reproduce?
4. Explain why Tetani has an identical twin.

SCENE 2 – IN THE BLOOD

(The three friends meet again in the blood)

Tetani Isn't this wonderful fun? Causing disease is SO, SO sick.

Histo How are you making this person sick?

Tetani I've produced a neurotoxin that binds to the synapses and interferes with nerve impulses to cause muscular spasms.

Diphtheriae Speak English, please.

Histo She means that she will try to make the jaw muscles lock up.

Diphtheriae Does that mean she's won our contest and will cause the most damage?

Histo Never. I've been very active and will cause terrible pain to this person.

Tetani Do tell. What have you been doing, Histo?

Histo I was licked off a finger with sugar from a donut and then I hatched in the intestine, invaded the intestine lining and fed on the blood and caused abscesses.

Diphtheriae That doesn't sound very impressive.

Histo I caused severe, continuous diarrhoea, and THAT was impressive.

Diphtheriae OK, you can have a few points for that. Are you going to do anything else?

Histo To get some points, I thought I may invade the liver and cause amoebic hepatitis.

Tetani What have you done, Diphtheriae?

Diphtheriae I released a toxin into the blood and will cause a fever, headache and vomiting all within 5 days.

Tetani Excellent, you certainly work fast.

Diphtheriae I sure do.

Macro Invaders, Invaders!!! Help! Help!

Diphtheriae Who's this?

Macro I'm Macro, a macrophage.

Tetani Well, diffuse off Macro. We are in the middle of a contest.

Macruu I came as fast as I could, Macro. What seems to be the problem?

Macro We have been invaded by these three antigens and the immune system must come to the rescue.

Histo Leave me alone Macro. What are you doing?

Macro Come on Histo, I have you now. I'm taking you to the nearest lymph node.

(Macro transports Histo away)

Macraa Hello, Hello. What do we have here, Constable Macruu?

Macruu Antigen invaders, Sir.

Macraa Well, what are you waiting for? You take the bacterium and I'll get the protozoan.

Macruu Right, Boss.

(Macruu and Macraa engage Tetani and Diphtheriae in a fierce struggle, but eventually the two antigens are taken into custody and taken to the nearest lymph node)

Questions Scene 2

1. Describe the symptoms caused by:
   (a) Tetanus bacteria.
   (b) Diphtheria bacteria.
   (c) Dysentery protozoans.
2. What happens when an antigen enters the body?
3. Where do macrophages take the antigens?

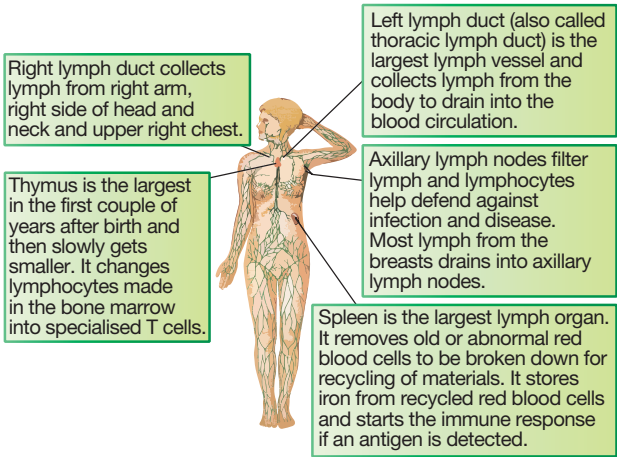

Figure 8.1 Lymphatic system.

SCENE 3 – THE LYMPH NODE

(The three friends meet again, this time in a lymph node. They are brought before Letty, the lymph node Commandant)

Histo They got you two also, did they?

Tetani They certainly did. They are very efficient, these white knights.

Letty Prisoners, be QUIET!

Tetani Yes, Madam.

Letty Step forward, prisoners, and be identified.

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17 MHC and Antigen Presentation

The **major histocompatibility complex** (MHC) molecule is a cell surface molecule that aids the immune system in recognising 'self' and 'non-self'. The molecules are found on the cell membrane of all nucleated cells of the body. MHC is found in all animals.

MHC molecules are divided into two main classes:

- **MHC class I** present intracellular self antigens and abnormal or non-self antigens to immune cells, e.g. natural killer cells in cellular immunity. MHC class I molecules are found on all nucleated cells and identify healthy cells as 'self'. These molecules are highly important in checking and ensuring the cells in the body are all healthy.
- **MHC class II** present abnormal or non-self (pathogen) antigens for the initial activation of T cells, e.g. helper T cells (CD4 cells). MHC class II are only found on dendritic cells, macrophages and B cells and are called **antigen presenting cells**.

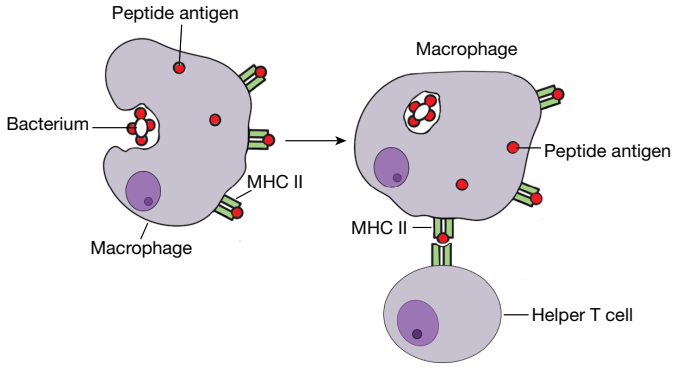

Figure 17.1 Antigen presentation.

Antigen presentation

Antigen presenting cells (APCs) are phagocytes that engulf and destroy pathogens. The breakdown of the pathogen and its products is called **antigen processing**. The MHC molecules are made within the cell and are transported in vesicles that intersect the broken down pathogen fragments. The **MHC-peptide complex** is formed and the APC 'displays' the MHC-peptide complex on its cell surface as in **antigen presentation**.

T cells, e.g. helper T cells recognise the displayed antigen peptide and are activated with the aid of cytokines, e.g. interleukin-1 secreted from the phagocyte. The T cell receptor does *not* bind to the antigen as do B cell receptors. T cell receptors recognise peptide antigens and signal transduction initiates a series of biochemical reactions, e.g. to produce interleukin-2.

The release of interleukin-2 by the helper T cells will activate and cause the cloning of particular cytotoxic T cells and B lymphocytes.

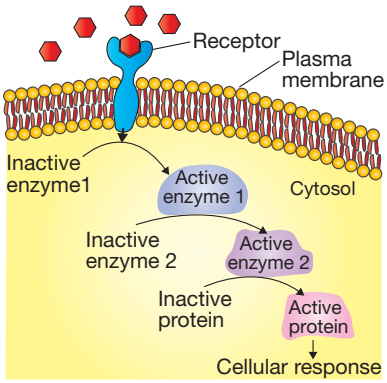

Figure 17.2 Signal transduction pathway.

QUESTIONS

1. What is the major histocompatibility complex?
2. Where is the major histocompatibility complex found?
3. Distinguish between the two types of major histocompatibility complex molecule functions.
4. (a) What are antigen presenting cells?
   (b) Which cells are antigen presenting cells?
5. What is antigen processing?
6. Describe antigen presentation.
7. (a) Which cells recognise the displayed antigen?
   (b) What happens when these cells recognise the displayed antigen?
8. In what way are B cell receptors different to T cell receptors?
9. Study the following leucocytes.

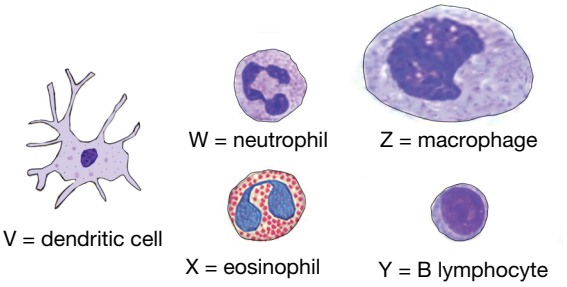

Figure 17.3 Different leucocytes.

Which lists antigen presenting cells?
(A) V, X, Y (B) W, X, Y
(C) V, Y, Z (D) X, Y, Z

10. Which of the following cells do *not* have major histocompatibility complex molecules in the cell membrane?
    (A) Natural killer cells. (B) T lymphocytes.
    (C) Neurons. (D) Red blood cells.

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20 Experiment – Microbes In Food and Water

Several biology students wished to discover if there were microbes in food and water. They decided to investigate food bought from their school canteen, food from the local shop and food brought from home.

Student actions

The students took water samples from the school bubblers, from a tap in the school biology laboratory and from bottled water.

To culture the microbes they prepared agar plates with high protein nutrients, being careful not to expose the plates to the air. One plate was left unexposed to be used as a control.

For each of the 'water plates', the students inoculated the plates with 0.5 mL of the particular water sample and gently rocked the plate so that the water spread evenly over the agar surface.

For the food sample the students chose the bread from a cheese sandwich. They mashed the bread with distilled water and streaked the plate with a loopful of bread solution.

All plates were incubated at 25°C for 7 days.

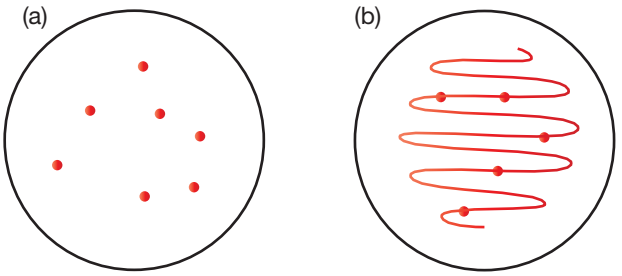
The plates were examined and the number and types of different colonies visible were recorded. The lids were not removed from the Petri dishes.

Problems encountered

The students encountered problems when they tried to identify and classify the different colonies on their plates. Most identification tests for different bacterial species are biochemical, physiological or immunological. Bacteriologists have a systematic identification procedure which allows them to quickly identify a pathogen, particularly useful in hospitals. For example, Gram stain with crystal violet, Jensen's iodine, alcohol and carbol fuchsin identifies if the bacteria is gram positive (purple) or gram negative (pink). Another identification procedure is growth tests on different food sources, for example sugars, proteins, nitrates and sulfur compounds. In the school laboratory, the students decided they would simply examine the size (mm), shape (circular, filamentous, irregular or rhizoid), texture (smooth, rough, shiny, matt, moist or dry) and colour of the bacteria. Fungi have a different appearance, being larger and cottony.

QUESTIONS

1. Explain why it is essential to use aseptic techniques in microbiology and give an example of one technique.



Tap water from biology laboratory

Bread from homemade sandwich

Figure 20.1 Experiment results.

Table 20.1 Student results.

Source	Bacteria		Fungi	
	Number of different types	Total number of colonies	Number of different types	Total number of colonies
Control	1	1	0	0
Bubbler water	3	17	0	0
Lab water	2	8	0	0
Bottled water	2	3	0	0
Canteen sandwich	3	25	1	1
Homemade sandwich	2	6	0	0
Local shop sandwich	2	22	0	0

2. Define the following terms – pure culture, colony, streaking.
3. Explain why the students were careful not to expose the plates to the air.
4. How could the control be used in this experiment?
5. Explain why a full nutrient agar was prepared and used.
6. From the student results, which sandwich was the most 'healthy'? Explain your results.
7. Suggest some possible ways in which the sandwich was contaminated.
8. Which 'water' was the most 'healthy'? Explain your answer.
9. Suggest some possible ways in which the water became contaminated.

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26 Macroparasites

Macroparasites are **cellular**.

Macroparasites can be seen with the naked eye and live either internally in the host (endoparasites) or externally (ectoparasites).

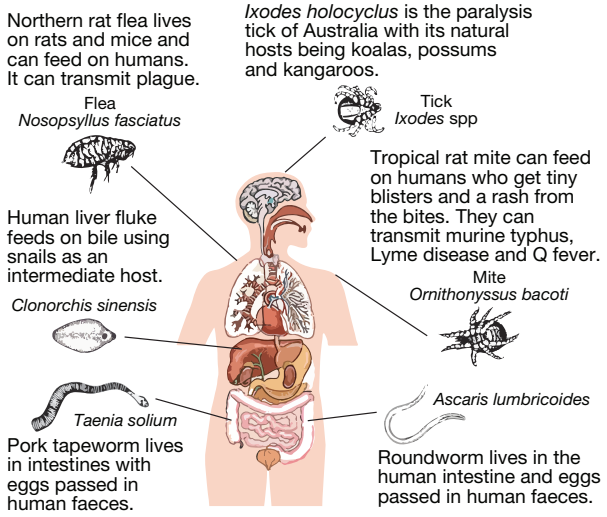

Figure 26.1 Macroparasites.

Endoparasites

Most endoparasites are flatworms or roundworms and have a long association with the host.

Trichinella spiralis is a roundworm normally parasitic in pigs and rats and infects humans when eaten in raw or uncooked pork. Small filarial nematode roundworms live in the human bloodstream causing filariasis and are passed from human to human by blood sucking vectors such as mosquitoes. The hookworm *Ancylostoma* inhabits the human gut with *A. duodenale* penetrating intact skin usually through the feet and travelling in the blood to alveoli where they move into the bronchi and trachea to be coughed up and reswallowed to eventually mature in the small intestine. *Ascaris* is a roundworm that can grow to 40 cm in length and infects the gut of pigs, cattle and sheep but can infect humans who eat uncooked vegetables that have been contaminated with faeces of infected animals.

Flukes are parasitic in or on the bodies of a wide variety of animals. *Fasciola hepatica* is the liver fluke that lives in the liver of sheep and the larvae in water snails.

Tapeworms have a long ribbon-like body with a small head with suckers and hooks for attachment in the intestines of its host. They have no mouth or alimentary canal as they absorb food through their body wall from the host's alimentary canal. *Echinococcus granulosus* is the hydatid tapeworm with the adult living in the intestines of dogs and the bladderworm invading any tissue in sheep, humans or other mammals.

Ectoparasites

Most ectoparasites are arthropods (e.g. lice, fleas, mosquitoes, ticks, leeches and mites) and have a brief association with the host.

Plant macroparasites are considered to be pests, for example aphids, mites, scale insects and borers. The dodder plant can be considered to be a parasite on its host tree. It wraps around the host and inserts haustoria into the vascular system of the host to take sugars and water from the host.

QUESTIONS

1. Define macroparasite.
2. Distinguish between ectoparasites and endoparasites.
3. The diagram shows the life cycle of *Echinococcus granulosus*.

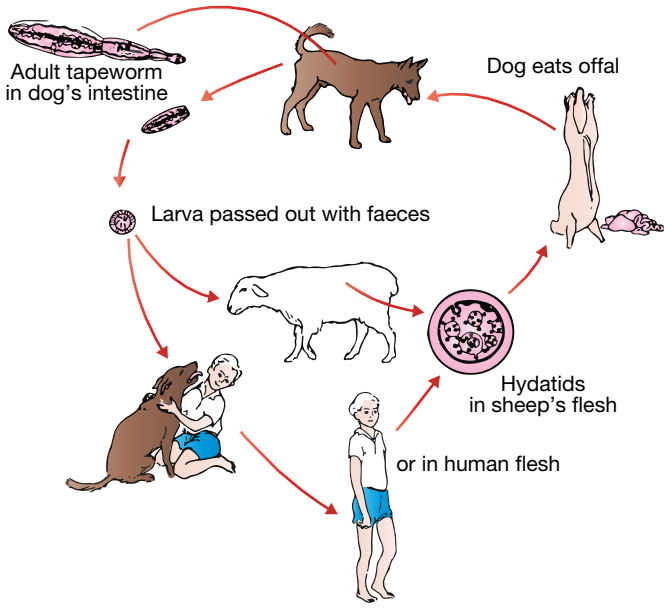

Figure 26.2 Life cycle of *Echinococcus granulosus*.

   (a) What type of parasite is *Echinococcus granulosus?*
   (b) Explain how a human can become infected by this parasite.
4. Use an example to show how an ectoparasite can act as a vector for another pathogen.
5. Explain why tapeworms do not need to have a mouth and an alimentary canal.
6. Endoparasites encounter specific problems. What feature of the endoparasite needs to be well developed for it to be successful in the human gut?
   (A) Digestive system.
   (B) Method of locomotion.
   (C) Exoskeleton.
   (D) Method of anchorage.

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10. Research the diseases listed in Table 49.1 and complete the table.

Table 49.1 Diseases.

Type of pathogen	Disease	Pathogen	Symptoms	Treatment/ prevention
Bacteria	Cholera	*Vibrio cholerae*		
	Tetanus	*Clostridium tetani*		
	Syphilis	*Treponema pallidum*		
	Whooping cough	*Bordetella pertussis*		
Virus	AIDS	HIV		
	Poliomyelitis	Poliovirus		
	Smallpox	*Variola major*		
	Influenza	Influenza A, B, C viruses		
	Rubella	Rubella virus		
Fungi	Tinea	Three genera: *Microsporum*, *Trichophyton*, *Epidermophyton*		
	Thrush	*Candida albicans*		
Protozoa	Malaria	Four *Plasmodium* species		
	Amoebic dysentery	*Entamoeba histolytica*		
	African sleeping sickness	*Trypanosoma gambiense*		
Macro-parasite	Human tapeworm	*Taenia saginata*		
	Threadworms	*Enterobius vermicularis*		
	Lice	*Pediculus humanus capitis*		
	Scabies	*Sarcoptes scabiei*		

11. Antibiotics are often prescribed by a doctor when you have a viral infection such as a cold because:
(A) Antibiotics are extremely effective against viruses.
(B) Colds are often accompanied by secondary bacterial infections.
(C) Antibiotics stimulate the production of antigens.
(D) The cell membrane of viruses is destroyed by antibiotics.

12. Which is *not* a means of transmission of an infectious disease?
(A) Airborne droplets.
(B) Water supply.
(C) Malnutrition.
(D) By a vector.

13. The diagram shows testing for drug sensitivity of *Staphylococcus aureus*. The agar plate was completely covered with *Staphylococcus aureus* colonies. The antibiotic discs A, B, C and D were then added. The antibiotics that were effective destroyed the bacteria around them, leaving a clear ring.

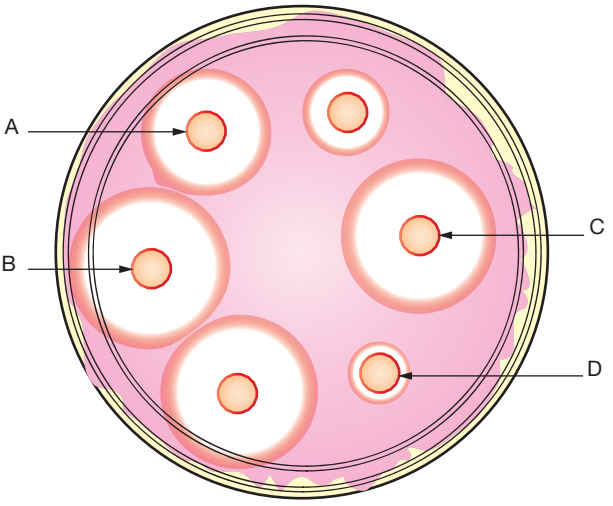

Figure 49.2 Drug sensitivity testing of *Staphylococcus aureus.*

Which drug would be least effective against *Staphylococcus aureus*?
(A) A
(B) B
(C) C
(D) D

14. The lower section of the male and female urethra can be colonised by *Mycobacterium smegmatis*, *Corynebacterium* spp, *Streptococcus* spp and *Staphylococcus epidermidis*. Identify the specific conditions needed by commensal bacteria which inhabit a specific region of the human body.
(A) Nutritional conditions.
(B) pH.
(C) Temperature.
(D) All of the above.

Science Press
ISBN 978-0-85583-8508
Surfing VCE Biology Unit 4

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STUDY DESIGN 2022

Area Of Study 2

How Are Species Related Over Time?

Science Press
ISBN 978-0-85583-8508

58 Point Mutations

A mutation is a permanent change in the genetic information and is a cause in genetic diversity. A gene mutation is a permanent change in the genetic information in a gene. The mutation can involve one or more base pairs and can be anywhere in the gene.

A point mutation is a change in one base in a single nucleotide in a gene. If the point mutation occurs in a gamete or zygote the change will affect every cell in the developing organism and will be passed to future generations. If the point mutation occurs in the developing embryo or foetus the change will affect tissues and cells that descend from this cell and may be passed to future offspring depending on the location of the mutation, e.g. in reproductive organs. If the point mutation occurs in an adult somatic cell the change will not be inherited by future generations and the effect on the person will depend on the specific mutation and how the body detects and responds to the error.

There are four basic types of point mutation – base pair substitution, insertion, deletion and inversion.

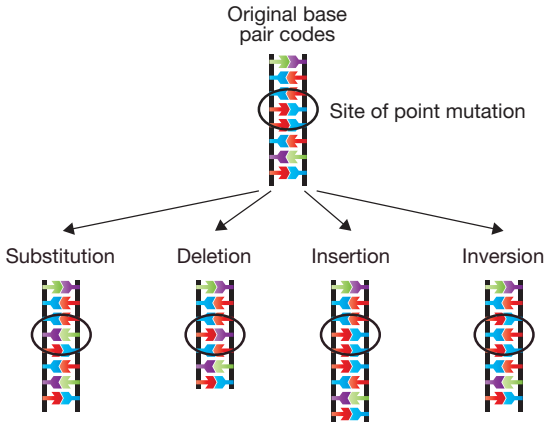

Figure 58.1 Point mutations.

Base pair substitution

In a base pair substitution one nucleotide and its complementary partner replace another pair of nucleotides. Sometimes this change is a **silent mutation** as the change has no effect on the protein being produced. For example, using the mRNA codes from Table 58.1 a base pair substitution from CUU to CUC will be a silent mutation as both code for the amino acid leucine. Other silent mutations may change the amino acid but have little effect on the protein. This can occur when the new amino acid has properties similar to the amino acid it replaced or the substitution has occurred in an area of the protein that is not an important determinant of the shape of the protein and its function.

Silent mutations occur fairly frequently but are hard to detect as they are not easily observed. Occasionally the change can be beneficial and can increase variation.

If the base pair substitution affects the shape of the protein or is at the active site of an enzyme, the change can seriously affect the functioning of the protein. For example, disulfide bridges are formed when two cysteine amino acids are brought close together with their sulfhydryl groups (–SH) on their side chains in close proximity due to the folding of the protein and a change in the code from UGC (cysteine a polar amino acid) to UUC (phenylalanine a non-polar amino acid) can affect the structure and functioning of the protein. Disulfide bridges are important in maintaining the structure of immunoglobulins (antibodies) and the antigen receptor sites on lymphocytes.

Table 58.1 mRNA codes.

UUU Phe	UCU Ser	UAU Tyr	UGU Cys
UUC Phe	UCC Ser	UAC Tyr	UGC Cys
UUA Leu	UCA Ser	UAA Stop	UGA Stop
UUG Leu	UCG Ser	UAG Stop	UGG Trp
CUU Leu	CCU Pro	CAU His	CGU Arg
CUC Leu	CCC Pro	CAC His	CGC Arg
CUA Leu	CCA Pro	CAA Gln	CGA Arg
CUG Leu	CCG Pro	CAG Gln	CGG Arg
AUU Ile	ACU Thr	AAU Asn	AGU Ser
AUC Ile	ACC Thr	AAC Asn	AGC Ser
AUA Ile	ACA Thr	AAA Lys	AGA Arg
AUG Met	ACG Thr	AAG Lys	AGG Arg
GUU Val	GCU Ala	GAU Asp	GGU Gly
GUC Val	GCC Ala	GAC Asp	GGC Gly
GUA Val	GCA Ala	GAA Glu	GGA Gly
GUG Val	GCG Ala	GAG Glu	GGG Gly

U – uracil (thymine)	Cys – cysteine	Met – methionine
C – cytosine	Gln – glutamine	Phe – phenylalanine
A – adenine	Glu – glutamine	Pro – proline
G – guanine	Gly – glycine	Ser – serine
Ala – alanine	His – histidine	Thr – threonine
Arg – arginine	Ile – isoleucine	Trp – tryptophan
Asn – asparagine	Leu – leucine	Tyr – tyrosine
Asp – aspartic acid	Lys – lysine	Val – valine

Most base pair substitution mutations cause a missense mutation. A **missense mutation** is a changed codon that codes for an amino acid but does not necessarily make the correct sense. A **nonsense mutation** is a point mutation that changes a codon for an amino acid into a stop codon. The stop codon causes translation to stop shortening the polypeptide chain that is being synthesised. In most cases a nonsense mutation creates a non-functional protein. For example, a change in the code UCA for serine to UAA will create a stop at this point in translation and process of protein synthesis.

Science Press
ISBN 978-0-85583-8508

59 Block Mutations

A block mutation is a permanent change to a segment of a chromosome that rearranges, deletes or disrupts many loci. Many block mutations are harmful changing the structure of the chromosome, though some are neutral especially if genes remain intact and sometimes the change can be beneficial, e.g. the change links genes that together now produce a positive effect.

Block mutations can be caused by **transposons** (transposable genetic elements) which are DNA segments that can move from one position to another in the chromosome. Transposons are sometimes called 'jumping genes' which is not how they move as they do not 'jump'. When the folding of the DNA molecule brings segments near each other transposons follow a 'cut and paste' mechanism to move to a new location or follow a 'copy and paste' mechanism replicating a section of DNA and adding it to another area. Transposons were discovered by Barbara McClintock when studying corn in the 1940s and she was awarded the Nobel Prize in Physiology or Medicine in 1983 for her discovery of 'mobile genetic elements'. She was the first female to receive this prize unshared. It is estimated that about 44% of the human genome is **repetitive DNA** which is multiple copies of DNA sections.

Types of block mutations include duplications, inversions, deletions, insertions and translocations.

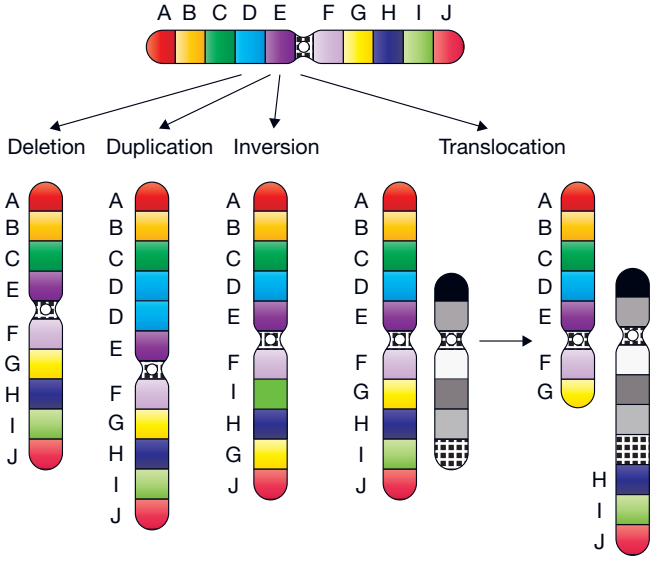

Figure 59.1 Types of block mutations.

Some sections of DNA are called **hot spots** as they are places that are more likely to undergo mutation than other places with an observable higher mutation frequency. Hot spots can be single nucleotides or short stretches of repeated nucleotides that have some basic instability or chemical tendency for nucleotide substitution.

Deletions

Deletions occur when a section of DNA is removed from a chromosome. The effect of a deletion depends on the size and location of the removed block sequence. Large deletions can involve several genes and have greater effect on phenotype and the health of the individual. Cri du chat syndrome is a deletion disorder that is caused by a deletion on the short arm of chromosome 5.

Duplications

Duplications occur when sections of DNA are replicated making the chromosome longer. Repetitive DNA can occur during DNA replication or recombination in crossing over and segregation during mitosis or meiosis. If the copies of a repeat sequence lie adjacent to each other they are called **tandem repeats**. Tandem repeats can vary in length with the large repeat units called satellites. Satellite DNA was first discovered when DNA was centrifuged and the repetitive units appeared as a distinct band in the tube. **Satellite DNA** (also now called simple sequence DNA) is a section of tandem, non-coding DNA that can be thousands of base pairs long. Microsatellite DNA is a short region of repeats that are used as genetic markers in DNA fingerprinting. In humans some microsatellites have 20 or more alleles which provides the variation to assist in identifying particular individuals by their DNA. **Trinucleotide disorders** occur when there are too many trinucleotide repeats in a gene, e.g. Huntington's disease occurs when there are more than 35 CAG repeats on the gene coding for the protein HTT. A genetic disorder due to duplication is Charcot-Marie-Tooth disease type 1 with duplication of 17p12 – a large section on the short arm of chromosome 17.

Inversions

Inversions occur when a section of DNA breaks and is reattached in the reverse orientation and order. This changes chromosome structure. Inversion is a cause for haemophilia A with an inversion in the factor VIII gene on X chromosome. The inversion within this gene stops protein production which means that testing for this disorder often involves measuring protein activity rather than a genetic test for the inversion.

Translocation

In translocation a section of one chromosome moves to a non-homologous chromosome. In a **reciprocal translocation** the non-homologous chromosomes exchange segments. Myeloproliferative syndrome is a genetic disorder caused by translocation of genetic material from chromosome 8 to other chromosomes, e.g. t(8;13)(p11;q12) which involves translocation of chromosomes 8 and 13 in lymphoma cells.

Science Press
ISBN 978-0-85583-8508

61 Chromosome Abnormalities

There are several types of chromosome abnormalities. Some individuals can have extra or missing chromosomes and some individuals have a different number of whole sets of chromosomes.

Polyploidy is the possession of more than two sets of chromosomes per nucleus, e.g. hexaploid (6*n*).

Monoploidy is the loss of an entire set of chromosomes. It is the haploid number of chromosomes.

Aneuploidy is the addition of all or part of a chromosome, e.g. in humans there could be 45 or 47 chromosomes instead of the normal 46 chromosomes in the nucleus.

Monosomy is the lack of one chromosome from the normal number of chromosomes.

Trisomy means there are three copies instead of the normal two copies of a particular chromosome.

Non-disjunction

The change in the number of chromosomes can be due to non-disjunction during cell division. Non-disjunction is an error during mitosis or meiosis when both members of a pair of homologous chromosomes or both sister chromatids fail to separate properly.

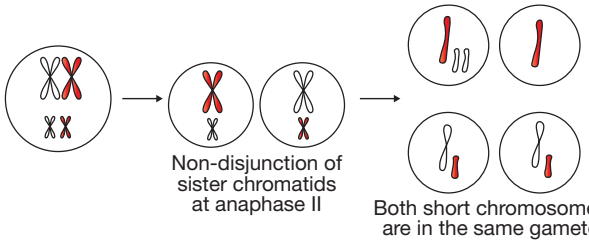

Figure 61.1 Non-disjunction in anaphase II in meiosis.

Non-disjunction leads to an abnormal number of chromosomes in a gamete. If it occurs in anaphase II there will be two affected daughter cells – one with two copies of the chromosome and the other with no copies of that chromosome.

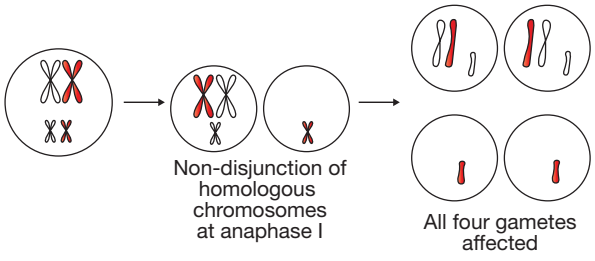

Figure 61.2 Non-disjunction in anaphase I in meiosis.

If the homologous chromosomes do not separate during anaphase I then all four daughter cells are affected – two daughter cells will have an additional chromosome and two cells will be missing one chromosome.

During fertilisation the fusion of an abnormal gamete with a normal gamete will create a zygote with an incorrect number of chromosomes, e.g. missing a chromosome or having an additional chromosome. Many cases of trisomy 21 (Down syndrome) are due to non-disjunction.

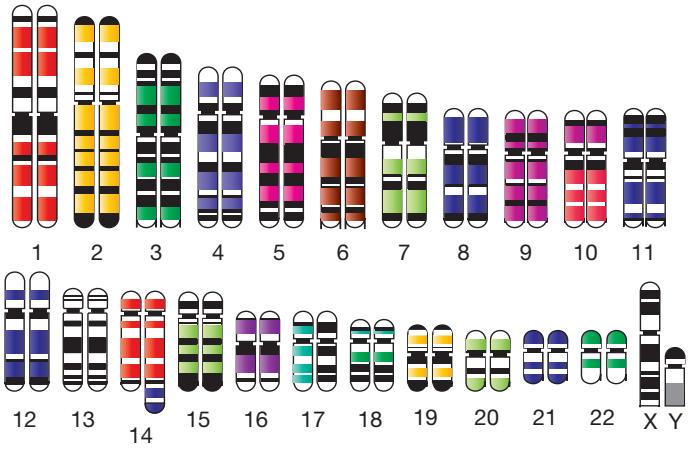

Figure 61.3 Trisomy 21 with translocation to chromosome 14.

Non-disjunction can also occur during mitosis. If the error occurs during early embryonic development then a large number of cells will have the aneuploidy condition. In mosaic Down syndrome the person has some cells with trisomy 21 and some cells with the normal 46 chromosomes in a cell.

Unequal crossing over in meiosis

Chromosome abnormalities can occur when crossing over between adjacent non-sister chromatids in the tetrad in prophase I if meiosis is unequal. In the resulting gametes one cell may have a chromosome with a gene deletion and another cell will have a chromosome with a gene duplication. Transposable elements in the chromosome provide the sites for crossing over in non-sister chromatids.

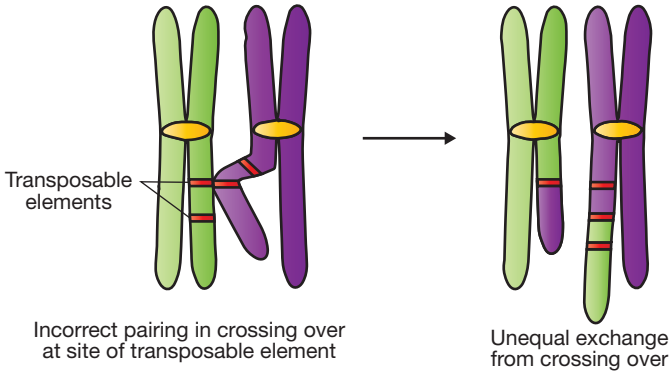

Figure 61.4 Unequal crossing over.

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65 Speciation

Speciation is the evolution of a new species. Speciation involves the reproductive isolation of a group from the rest of its species with no genetic interchange.

Allopatric speciation involves geographical separation, e.g. mountain ranges form, rivers change course, land bridges form/disappear, deserts form or dynamic Earth movements such as earthquakes and volcanic eruptions occur.

Sympatric speciation occurs when the new species develops within the same geographical region as the parent species, e.g. by polyploidy.

Speciation is likely to occur if the isolated group is a small population. Genetic drift and the founder effect will lead to changes in the gene pool of the separated group so that allele frequencies will differ from the original parent population and there will be genetic divergence.

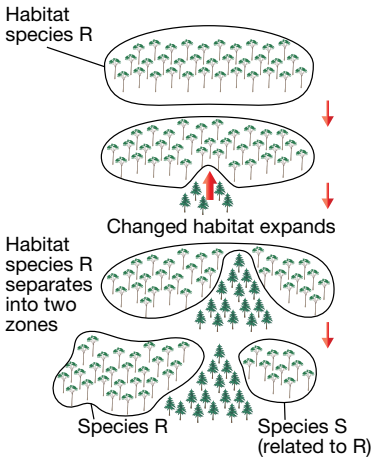

Figure 65.1 Speciation by geographic isolation.

If the barrier disappears in allopatric speciation

If the barrier that separated the parent population and the small population disappears then:

- Speciation had led to sufficient changes that the two groups can no longer interbreed to produce fertile offspring and there are two distinct species.
- Speciation had not occurred and the two groups can interbreed to produce fertile offspring making them one species.
- The two groups have distinct differences and there is limited gene flow which can lead to sympatric speciation or a cline can develop when the differences change with location.

Speciation by polyploidy

A **polyploid** is an individual or a species whose chromosome number is a multiple, other than a doubling of the haploid number, e.g. triploid, tetraploid, hexaploid. Polyploid formation is common in many plant species, though relatively rare in animals.

An **allopolyploid** is a common type of polyploid species which forms when two different species interbreed and produce a hybrid. If the plant hybrid is sterile it can propagate asexually and in many instances various mechanisms in future generations occur that change the sterile hybrid into a fertile allopolyploid.

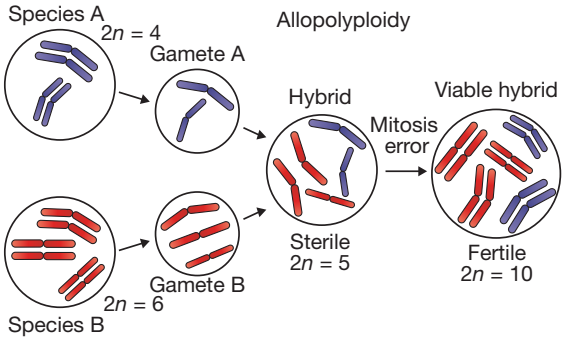

Figure 65.2 Formation of an allopolyploid.

Many crop plants, e.g. wheat, oats, potato, cotton and tobacco are allopolyploids that have been created to combine specific traits from different species.

An **autopolyploid** is an individual with more than two sets of chromosomes that came from a single species. An autopolyploid can occur when there is non-disjunction in cell division.

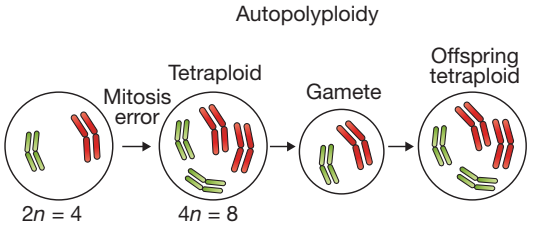

Figure 65.3 Formation of an autopolyploid.

If the chromosome number doubles to form a tetraploid then the offspring will not be able to breed with the diploid parent population. Triploids are sterile and unable to complete a normal meiotic division.

QUESTIONS

1. Define speciation.
2. Distinguish between allopatric speciation and sympatric speciation.
3. If the barrier in allopatric speciation is removed, what possible outcomes could occur?
4. What is a polyploid?
5. What is an allopolyploid?
6. What is an autopolyploid?
7. Explain why allopolyploids cannot interbreed with the diploid parent population.
8. Discuss why it is believed that allopolyploidy is a mechanism that could explain the rapid appearance of flowering plants in the fossil record.

Science Press
ISBN 978-0-85583-8508

SURFING

VCE BIOLOGY UNIT 4

STUDY DESIGN 2022

Topic Test

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ISBN 978-0-85583-8508

Topic Test

Section A – Multiple Choice (40 marks)

1. What term best describes the engulfing and destruction of bacteria or foreign bodies?
   (A) Phagocytosis.
   (B) Exocytosis.
   (C) Vaccination.
   (D) Immunisation.
2. What is the role of histamine in the inflammatory response?
   (A) Vasodilation of blood vessels.
   (B) Produce pus.
   (C) Prevent clotting.
   (D) Increase the rate of meiosis.
3. The lymphatic system is a collection of vessels which carry a fluid called lymph. The lymph rejoins the circulatory system at the heart.

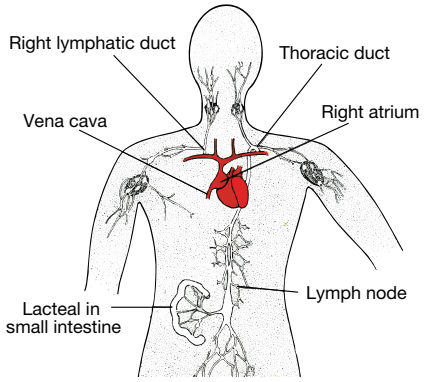

Figure TT.1 Lymphatic system.

How would the concentration of blood change due to the inflow of lymph from the lymphatic system at the heart?
   (A) Increase in oxygen.
   (B) Increase in lipoproteins.
   (C) Decrease in carbon dioxide.
   (D) Decrease in urea.
4. Which of the following produces antibodies?
   (A) Cytotoxic T cells.
   (B) Plasma cells.
   (C) Helper T cells.
   (D) Macrophages.
5. Which of the following describes the relationship between a parasite and its human host?
   (A) Causes the human to produce antigens.
   (B) Stimulates the production of interleukins by the parasite.
   (C) Initiates the inflammatory response in the human.
   (D) Benefits the parasite but harms the host.
6. Haemolytic anaemia is a disease in which antibodies are manufactured to destroy the body's own red blood cells. Normal red blood cells live approximately 120 days, while people with this disease have red blood cells which only live for a few days. This type of disease is best described as an example of:
   (A) Inflammatory response.
   (B) Allergic reaction.
   (C) Malfunction of the immune system.
   (D) Phagocytosis.
7. Many ancient cultures recognised the relationship between the survival from a disease and that person's immunity for that disease. For example, after a typhus epidemic in Athens, Thucydides (460-400 BC) wrote '... none was ever attacked [by the pathogen] a second time or with a fatal result.' Which of the following gives current understanding of this relationship?
   (A) Exposure to antigens results in the production of antibodies and memory cells.
   (B) Antigens entering the body induce phagocytosis at higher levels of activity.
   (C) Antibodies of pathogens stimulate immune response and increased phagocytosis.
   (D) Complement proteins cause the release of histamine which prevents the pathogen reproducing.
8. The diagram shows the defences against infection.

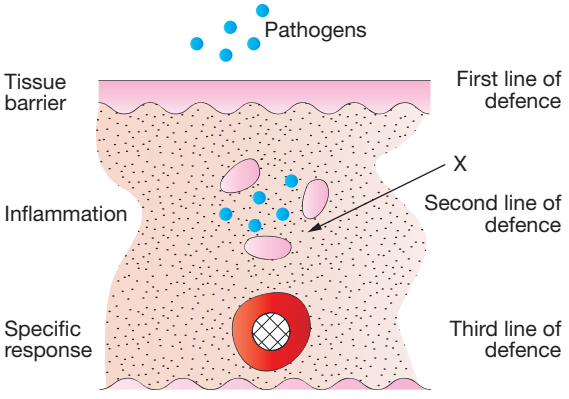

Figure TT.2 Lines of defence against infection.

Which of the following is most likely to occur at the point labelled 'X'?
   (A) Secretion of mucus.
   (B) Lysosomes of phagocytes release enzymes toxic to micro-organisms.
   (C) Killer T cells secrete interleukins which modulate the function of the immune system.
   (D) Plasma cells synthesise antibodies which move into the bloodstream and tissue spaces.

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15. Certain chemicals are known to inhibit the action of specific enzymes, e.g. penicillin prevents bacteria making their cell walls. Which of the following offers the best explanation for this inhibition?
    (A) Penicillin is made of cellulose in a form which cannot be used by bacteria.
    (B) Penicillin reacts with cellulose so there is no substrate to make cell walls.
    (C) Penicillin blocks the active site of an enzyme involved in making the cell wall.
    (D) Penicillin changes the pH increasing the acidity so enzymes cannot function.
16. Comparing the blood of sheep that had died of anthrax with the blood of healthy sheep, Robert Koch (1843-1910) found that the blood of the diseased sheep contained small rod shaped organisms. This discovery became the first step in Koch's postulates. What is this first step in Koch's postulates?
    (A) The organism must be grown in pure culture.
    (B) The organism must be seen under the microscope in all organisms.
    (C) The microbe causing the disease must be isolated and grown in pure culture.
    (D) The microbe causing the disease must be found in each diseased organism.
17. Which group only relates to specific immune responses?
    (A) Vaccination, antibody production.
    (B) Phagocytosis, stomach acid production.
    (C) Immunisation, cilia.
    (D) Mucous membranes, complement.
18. The diagram shows the processes occurring in a white blood cell after infection with dengue virus.

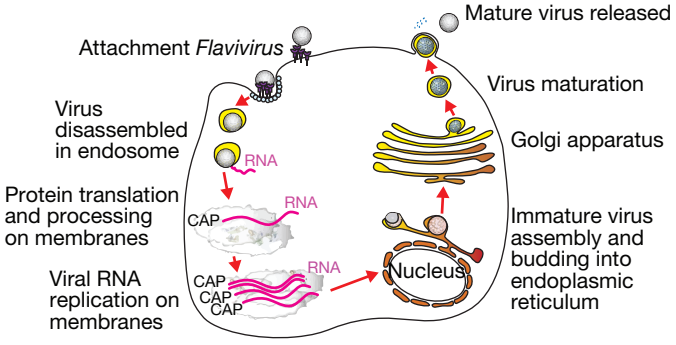

Figure TT.5 White blood cell infected with dengue virus.

How is the Golgi apparatus involved in viral replication?
    (A) Reverse transcription of viral RNA.
    (B) Translation of viral mRNA into polypeptide.
    (C) Transports viral proteins to the cell membrane.
    (D) Process and packages viral proteins and lipids.

19. Many bacteria are found on the skin. The genera *Staphylococcus, Micrococcus, Corynebacterium* and *Propionibacterium* are considered 'normal' flora. Which of the following could be used as a safety measure to temporarily dispose of this normal flora to prevent infection as is needed during an operation or surgery?
    (A) Expose all vital areas to gamma radiation.
    (B) Wash all areas with antimicrobial preparation such as an iodine-containing preparation.
    (C) Cover all areas with petroleum jelly to form an artificial impenetrable covering.
    (D) Ingest an antibiotic such as penicillin.
20. Creutzfeldt-Jakob disease (CJD) was independently observed in the 1920s by two German physicians, Hans Creutzfeldt and Alfons Jakob. This disease is a mental degenerative disease where the patient gradually loses memory and intellect, and has increasing difficulty performing simple tasks. The disease causes microscopic vacuoles to form in neurons so that they appear 'sponge-like', hence the name of spongiform encephalopathy disease. What type of pathogen is believed to be the cause of CJD?
    (A) Virus.
    (B) Protozoan.
    (C) Prion.
    (D) Bacteria.
21. A gene from the soil microbe *Bacillus thuringiensis* has been artificially inserted into some crops. The gene produces a pest-killing toxin and the crops are now able to produce this toxin, which acts as a natural insecticide. What is one biological concern about the use of genetic engineering to produce such crops?
    (A) All the insects may perish due to food shortage.
    (B) The gene may pass to a closely related wild species which could become a serious weed pest.
    (C) The gene will mutate into a disease-causing variety which will spread to other species.
    (D) The cost of producing the new crop will make it too expensive for commercial markets.

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22. The genome of the two chromosomes of *Vibrio cholerae* has been completely sequenced. One locus allows the bacteria to take genes from other organisms, e.g. viruses and this feature makes it highly adaptive. It has taken genes from viruses to increase its ability to stick to the intestinal wall and also genes for its toxin. How could this information be used to aid the fight against cholera?

(A) It will assist making antibiotics which target genome areas for parasitism.
(B) It will assist finding a predator for *Vibrio cholerae*.
(C) It will allow gene splicing to remove the locus that gives the bacteria the ability to take genes from viruses.
(D) We can make mutant cholera bacteria that are not soluble.

23. It is believed that cockroaches first appeared on Earth 300 million years ago. Some species have changed little in millions of years. What is this lack of change most likely due to?

(A) Their strong exoskeleton which is immune to fire and nuclear radiation.
(B) Living in a relatively unchanging habitat.
(C) Their small size making them hard to catch by most predators.
(D) Lack of competitors for the same food resources.

24. Which instrument would be most useful to see the earliest fossils of life on Earth?

(A) Light microscope.
(B) Electron microscope.
(C) Mass spectrometer.
(D) Deep sea submersible.

25. The diagram shows two stratigraphic columns taken from nearby areas. Index fossils have been indicated in some of the layers.

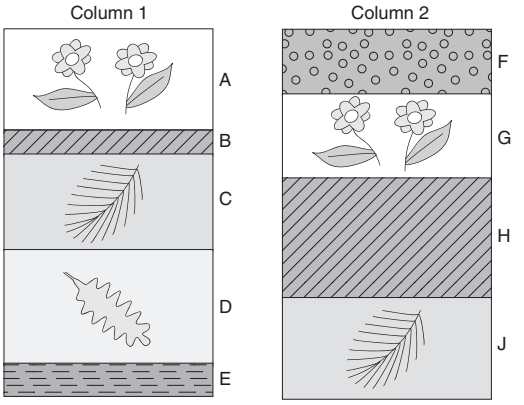

Figure TT.6 Two stratigraphic columns.

What can be concluded from these columns?

(A) Column 2 location was more favourable to fossil formation than column 1 location.
(B) Layer C and layer J are the same age.
(C) Layer B is older than layer J.
(D) Layer E is the youngest layer in the two sequences.

26. A Neanderthal fossil was dated by DNA extracted from the bone at approximately 35 000 years old. Which of the following methods was most likely used to date this fossil?

(A) Potassium-argon dating.
(B) Stratigraphy.
(C) Carbon-14 dating.
(D) Fluorine analysis.

27. The diagram shows the lower jaws of three different primates – a gorilla, an australopithecine and a human.

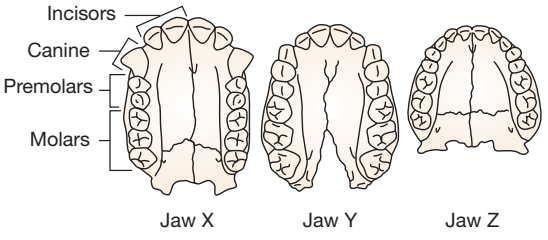

Figure TT.7 Primate jaws.

Which of the following would be the most likely match of jaw and species?

	Gorilla	Australopithecine	Human
(A)	Jaw Z	Jaw Y	Jaw X
(B)	Jaw Z	Jaw X	Jaw Y
(C)	Jaw X	Jay Y	Jaw Z
(D)	Jaw Y	Jaw X	Jaw Z

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48. The Pleistocene epoch began around 1.75 million years ago. During the Pleistocene there were periods with abundant rain and high humidity and periods of low humidity with ice ages forming ice sheets, e.g. in Antarctica and Greenland. During this time there were many instances in Australia of forms adapted to wet and semi-arid conditions becoming fragmented and isolated in refuges around the periphery of the continent.

(a) Explain why this is an example of allopatric speciation in Australia during the Pleistocene epoch. (2 marks)

(b) Research has suggested that the Lake Eyre Basin and the Flinders Ranges formed the 'Eyrean Barrier'. The presence of this barrier has been used to help account for the divergence of southern Australian birds, e.g. populations of the mulga parrot, *Psephotus varius* and the red rumped parrot *Psephotus haematonotus* which are found in arid scrublands and grasslands in inland southern Australia.

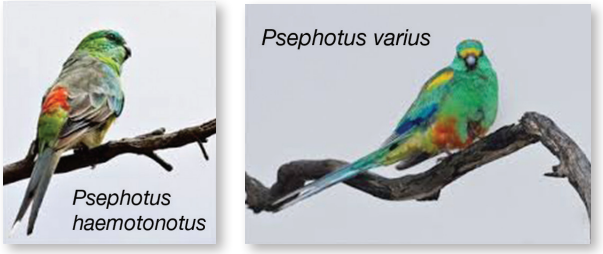

Figure TT.14 Inland Australian parrots.

Explain why such an investigation into speciation of Australian avifauna needs to include both a study of phylogenetic relationships as well as morphological features. (4 marks)

49. The diagram shows one suggested timeline for several different hominins.

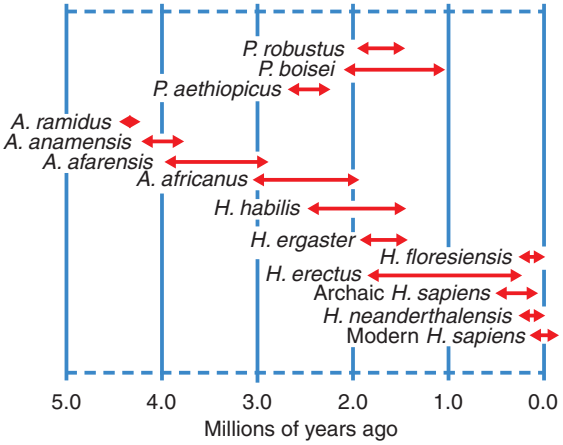

Figure TT.15 Timeline for several hominins.

Explain how the construction of timelines shows the difficulty in determining the exact pathway of the evolution of humans. (6 marks)

50. (a) Outline some of the areas of evidence that show there has been a change in diet during the evolution of humans. (4 marks)

(b) Relate the change in diet during the evolution of humans to increase in brain size. (3 marks)

51. Use a named example to show how an advance in technology has changed scientific thinking about evolutionary relationships. (2 marks)

52. Evaluate the impact of one human activity on the interactions of organisms with their environment in the search for measures to treat and manage human diseases. (8 marks)

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Answers

1 Assumed Knowledge

1. Disease is any condition that impairs or interferes with the normal functioning of the body.
2. An infectious disease is caused by pathogens which invade the body. They are contagious diseases often able to be passed from one person to another.
3. A pathogen is an agent that causes disease.
4. Macroparasites can be seen with the naked eye, e.g. worms, ticks, while microparasites cannot be seen with the naked eye, e.g. bacteria.
5. An antibiotic is a chemical which inhibits or destroys micro-organisms such as bacteria.
6. An antigen is a substance that triggers the immune response, e.g. a virus, part of a bacteria or part of a toxic molecule.
7. Immunisation is a process which stimulates the immune system to produce lymphocytes or antibodies for a particular antigen.
8. Epidemiology is the study of disease and its prevalence in the community.
9. Red blood cells transport oxygen in the body to needy cells for respiration. Neutrophils are a type of white blood cell that are the first cells to migrate to a site of infection and are phagocytes. Monocytes are large white blood cells and differentiate into macrophages and are involved in adaptive immunity. Lymphocytes are white blood cells involved in the immune response and are B cells and T cells. Basophils are white blood cells involved in the inflammatory response and allergic symptoms. Platelets are cytoplasmic fragments involved in blood clotting.
10. Phagocytosis is a type of endocytosis where large, particulate substances are taken into a cell.
11. Response A is dilation of blood vessels which allows an increased flow of blood to the area bringing phagocytes, nutrients, antibodies, increased temperature and also makes the area appear red. Response B is an increase in permeability of the walls of the capillaries which allows the needed substances to move from the bloodstream into the tissues that have been invaded by the pathogen. Response C is the migration of phagocytes to the area which will engulf and destroy the pathogens by phagocytosis.
12. The reaction of the body to the presence of a substance identified as non-self.
13. An antibody (or immunoglobulin) is a protein secreted by plasma B cells in response to a particular antigen.
14. Vaccination programs in the National Immunisation Program include: hepatitis B (at birth, 2, 4 and 6 months), the triple antigen (diphtheria, tetanus and whooping cough) at 2, 4, 6, and 18 months, poliomyelitis at 2, 4, and 6 months and 4 years, chickenpox at 10 to 15 years, human papillomavirus (HPV) at 10 to 15 years and measles at 12 and 18 months.
15. (a) Skin is an intact, tough outer layer that is a physical barrier preventing the entry of pathogens.
    (b) The stomach secretes gastric juice which contains hydrochloric acid and is a chemical barrier that destroys pathogens that enter the digestive system through the mouth.
16. The photograph shows leaves with holes and missing sections that indicate a plant pest, e.g. caterpillar has been eating the leaves and some of the leaves show leaf curl which could be due to insects laying eggs on the leaves or incorrect growing conditions of the soil.
17. An index fossil is a distinctive organism that lived for a short time and is found over a wide area.
18. The law of superposition states that the oldest layers are on the bottom and the youngest layers are on top, unless there has been folding or faulting or another form of dynamic Earth movement.
19. Relative dating uses the law of superposition determining if something is 'older than' or 'younger than' whereas absolute dating gives a date in years with the experimental error of the method used in determining the date.
20. Trilobite D (Redlichids) are suitable as an index fossil as they only existed for a short time and are indicative of the Cambrian period. However, trilobite H was present in the Cambrian through to the Permian which is a very long time frame and is thus particularly useful as an index fossil – it simply indicates the Palaeozoic era.
21. Natural selection is a process that leads to a change in a population over time due to some phenotypes having more success surviving and reproducing in particular environmental conditions.
22. An example of fossil evidence that shows present day organisms have developed from different organisms in the past is the fossil history of the horse. The modern day horse *Equus* has evolved from *Hyracotherium* which was much smaller, had more toes, and smaller teeth and lived around 60 million years ago.
23. Evolution occurs when natural selection causes changes in relative frequencies of alleles in the gene pool.

2 Infectious Disease

1. A disease is any condition that impairs or interferes with the normal functioning of the body.
2. Infectious diseases differ from other diseases, e.g. genetic and lifestyle diseases in that they are caused by the invasion by a pathogen and can be transmitted from one host to another.
3. In the past infectious diseases have affected human populations by causing the death of many individuals which can affect the politics and economics of an area, e.g. by the death of prominent citizens, leaders, insurgents. In the 14th century nearly one third of the world's population died from bubonic plague – the Black Death which is an infectious disease caused by the bacteria *Yersinia pestis*.
4. Diseases can be classified in many ways, e.g. by the major categories of infectious disease and non-infectious disease or by the body part/system that is mainly affected, e.g. cardiovascular diseases, heart, lung and other organ diseases or endocrine system diseases or by the way the disease is acquired, e.g. genetic diseases, injuries and environmental diseases.
5. The invention of the light microscope and developments in its design to improve resolution and magnification enabled scientists to observe micro-organisms and then to link particular organisms to particular infectious diseases. For example, in 1845-1846 Louis Pasteur showed that a mystery disease that threatened the silkworm industry was caused by micro-organisms that were only visible under a microscope and only found in the tissues of diseased silkworms, moths and eggs.
6.

Technology	Used by	Scientific understanding of infectious disease
Light microscope	Anton van Leeuwenhoek	Observed micro-organisms under the microscope which led to other scientists searching for microbes in different substances.
Swan neck flasks	Louis Pasteur	Showed microbes caused decay giving rise to the germ theory and refuting the theory of spontaneous generation.
Petri dish with agar jelly	Robert Koch	Identified the causative pathogens for tuberculosis and cholera and proposed a systematic method that will identify the pathogen causing a particular infectious disease.

7. A

3 Barriers — The First Line Of Defence

1. The first line of defence of the human body involves barriers that prevent the entry of pathogens, such as skin, mucous membranes, cilia, chemical barriers and other body secretions.
2. Natural immunity refers to the defence mechanisms present at birth, for example mucous membranes.
3. Skin provides an intact, outer tough layer with keratin to stop penetration; its dryness prevents growth, and glands secrete antibacterial and antifungal chemicals.

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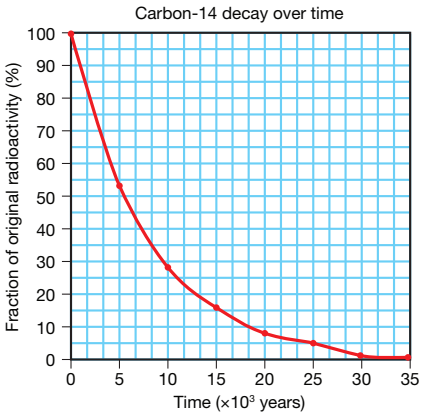
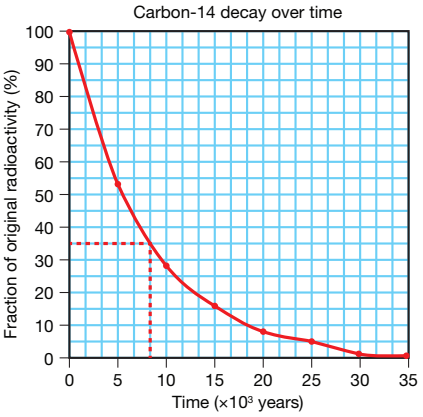
13. Geological absolute dating requires long half-lives while medical applications requires short half-lives causing different radioisotopes to be useful for different time frames and for different purposes.
14. Useful geological radioisotopes include carbon-14, potassium-40, rubidium-87, samarium-147, uranium-238 (^{238}U to ^{206}Pb) and uranium-235 (^{235}U to ^{207}Pb).
15. Uranium is very useful for dating rocks as almost all igneous and metamorphic rocks contain enough uranium and lead for accurate dating and dating methods can be used on powdered whole rocks, mineral concentrates or single grains.
16. The oldest rocks of terrestrial origin dated so far come from Jack Hills, Western Australia dated at 4.4 billion years old.
17. As carbon-14 has a half-life of 5730 years the oldest date reliably measured by radiocarbon is around 50 000 years. This means that carbon-14 has limited use in dating fossils and is restricted for organisms that lived within the last 50 000 years.
18. Fission tracking occurs when uranium-238 decays (in fission process) and the released high speed atoms cause damage to nearby rocks and minerals (fission tracks). In a rock containing uranium-238 the number of fission tracks will increase over time at a rate that depends on the uranium content. The age of the rock can be calculated by measuring the uranium content and the density of the fission tracks.
19. D

75 Radiometric Dating

1. Radiometric dating uses radioisotopes to determine the absolute age of fossils or rocks plus or minus the experimental error involved in the particular method used.
2. Radiocarbon is used to date organic material such as bone, shell, charcoal, linen, wood, paper, and cave paintings which have pigments from honey, milk, or oil seed.
3. The half-life of carbon-14 is 5730 ±30 years.
4. The use of particle accelerators as mass spectrometers means it is possible to measure the number of carbon-14 atoms directly rather than waiting for their decay allowing dating up to 70 000 years ago.
5. When using radiocarbon dating for artefacts made by people the date of the use needs to be distinguished from the date the material being used was harvested or gathered. For example, with writing on paper such as the Dead Sea Scrolls, the radiocarbon dates give the time the flax was cut and the leaves died which is not necessarily the exact age of when the scrolls were written.
6. It has been discovered that the ratio in the atmosphere of one atom of carbon-14 to every million million (10^{12}) carbon-12 atoms is not a totally fixed ratio. The study of growth rings on trees and gas analysis of ice cores from glaciers and Antarctica has required corrections to be made to allow for fluctuations in the carbon-14 content of the atmosphere.
7. Potassium-40 has a half-life of 1.26×10^9 years.
8. Potasium-40 has a long half-life which means it is used in dating volcanic rocks and minerals older than 200 000 to 300 000 years and is limited to a small range of rocks past a certain age.
9. Many of the hominid fossils in East Africa have been found in layers associated with volcanism and sedimentation and potassium-argon dating has been used to date the volcanic ash deposits and thus the fossils in these deposits. For example, the footsteps at Laetoli were made by three hominin individuals walking in powdery volcanic ash from a nearby eruption and the tuff was dated using potassium-argon dating and stratigraphy.
10. (a) Zircon is a mineral ($ZrSiO_4$) that has no tracks when it forms in a volcanic eruption. As nearby uranium undergoes fission, the high speed atoms that are released leave fission tracks in the zircon. The number of tracks depends on the amount of uranium and the time of exposure. Zircon fission tracks can thus be used to date rocks.
    (b) Zircon grains from Jack Hills, WA are dated 4.4 billion years ago and the oldest known rocks in the world of terrestrial origin.
11. Rb-Sr dating uses rubidium-87 which has a half-life of 48.8×10^9 years. With a long half-life it is usually only used to date rocks older than about 100 million years old, e.g. Moon rocks and is not suitable for a recent ice age 12 000 years ago.
12. (a)



    (b) 8300 years



13. Fission tracking can be used on minerals and glass in a range from 100 years to 4500 million years before the present.
14. D
15. D

76 Other Dating Methods

1. Absolute age gives a date for a rock or a fossil, e.g. 50 million years ago, while relative age compares the age with another rock or fossil, i.e. older than or younger than the other rock/fossil.
2. Stratigraphic correlation looks at the index fossils found in each rock layer. Since the index fossils are known to have lived at a certain time, you can correlate two layers from different areas. If they have the same index fossil, then the two layers were laid down at the same time, even though they were in different areas.
3. For many years scientists used stratigraphic correlation and the law of superposition to work out the relative ages of different rocks and fossils to indicate time frames. The discovery of radioactive isotopes and the invention of instruments to measure the amount of radioisotope present in a sample has enabled scientists to work out the absolute age of rocks and fossils. This gives a more precise date and age for the sample.

Science Press
ISBN 978-0-85583-8508
Surfing VCE Biology Unit 4

7.

Feature	New World monkey	Old World monkey	Ape
Examples	Spider monkeys, squirrel monkeys, howler monkeys and capuchins	Baboons, leaf monkeys, Rhesus monkeys and vervets	Gibbons, gorillas, chimpanzees, orangutan and bonobo
Arboreal and/or terrestrial	Arboreal	Arboreal and/or terrestrial	Arboreal and/or terrestrial
Platyrrhine or catarrhine	Platyrrhine	Catarrhine	Catarrhine
Tail	Many have long prehensile tail	None have prehensile tail	No external tail

8. Structural features that would identify a fossil as a primate include – opposable thumb that allowed objects to be grasped and manipulated and forward facing eyes that enabled stereoscopic binocular vision.
9. Captive breeding programs are extremely important for orangutans as it not only ensures survival of the species as humans can breed individuals but reduces the need for poaching and smuggling and hence there will be less interference with free orangutans living in native forests.
10. Diagram (a) shows the platyrrhine – flat nose nose with widely spaced nostrils of New World monkeys while diagram (b) shows the catarrhine – downward facing nose and close nostrils of Old World monkeys, apes and humans.
11. (a) Spider monkeys are New World monkeys and are found southern Mexico and South America, e.g. Brazil.
    (b) Baboons are Old World monkeys found in Africa.
    (c) Orangutans are apes and are found in western Borneo and the top of Sumatra.
    (d) Gorillas are apes and are found in Africa, e.g. west central Arica and east central Africa.
12. Social groups with group bonding provides protection for the mother and child, e.g. against predators and increases the chances of finding food and increases the chances of infant survival to adulthood. This aids evolution by securing the next generation to live in that area.
13. An opposable thumb means the thumb can be moved around to touch the other fingers. This allows the hand to grasp objects. Similarly an opposable toe can touch other toes. These features aid an arboreal lifestyle allowing branches to be grasped. Being able to grasp and manipulate objects has been an important feature in the development and evolution of the primates.
14. A prehensile tail acts as a fifth limb and aids movement through the trees as arms and legs may be free to grab food or other branches while the monkey 'hangs' by its tail. The reduction in size of the thumb of the spider monkey allows for greater brachiation as a thumb grasping a branch in the opposite direction to the fingers could be broken and would get in the way during the swinging motion of brachiation.

94 The Hominidae

1. The Hominidae is a family in the primate order.
2. The ending '-idae' is given to the 'family' taxon in biological classification.
3. The definition of 'hominid' has changed over time with the term now having a broader meaning than it did in the past. Hominids now include the great apes and their ancestors which means it includes the modern humans, chimpanzees, gorillas and orangutans.
4. Changes in classification are due to improved technologies and increased knowledge and understanding about evolutionary relationships. Classification is a human construct which is used to show how we believe organisms should be grouped.
5. Technological advances include the use of DNA-DNA hybridisation to compare the DNA of different species, DNA sequencing to find differences in either nuclear or mitochondrial DNA (mtDNA) between two species to determine their likely time of divergence from a common ancestor and karyotype analysis to compare the number, shape and banding of chromosomes of different species to determine their degree of similarity.
6. The number of incisors, canines and molars are the same but the New World monkeys have three premolars while hominids only have two premolars.
7. Hominids are the largest primates and have – 1. No tail and no ischial callosities. 2. Upright or semi-upright stance. 3. Same dental formula $\frac{2,1,2,3}{2,1,2,3}$ with broad incisors. 4. Prominent face and prognathous jaw, 5. Arms shorter than legs. 5. Only the orangutan has an arboreal lifestyle. 6. Sexual dimorphism with males larger than females. 7. Large brain relative to body size.
8. Nails are a feature of primates and would have aided grasping ability for an arboreal lifestyle. Flattened nails improve grasping ability. Broader fingertips with tactile pads not only gives unique fingerprints in humans but also aids holding and manipulating objects for tool making to help food gathering and protection against predators.

95 The Hominins

1. The hominins refers to the human branch of the evolutionary tree. It includes bipedal humans and extinct ancestors and close relatives, e.g. other species in the genus *Homo* and the australopithecines.
2. The earliest hominins were small in size, had brains similar in size to modern apes and had a set of characteristics that allowed both upright bipedal walking and climbing.
3. Fossils of *Sahelanthropus tchadensis*, e.g. skull, jawbones and teeth show several hominin features, e.g. flatter face than apes and position of the foramen magnum, the opening for the spinal cord is oval, downward pointing and near the front of the skull suggesting an erect spine.
4. (a) Derived characters are features that evolved in the lineage leading up to a clade that sets the members of that clade apart from other individuals.
   (b) Shared derived characters of hominins include – reduced canine teeth, relatively flat face, bipedalism and more upright stance.
5. (a) Bipedalism means usually walking on two legs.
   (b) Bipedalism is advantageous in woodlands and grasslands as it raises the line of sight for seeing predators, it is an efficient way of travelling long distances, it minimises exposure to the Sun aiding temperature regulation and it frees the hands for carrying food and manipulating tools and objects.
6.

Suggested theory	Adaptive advantage
Carrying theory	Those that could carry more food had better survival chances. Weapons could also be carried for defence and food gathering and tools held and manipulated.
Hunting theory	Those that could make weapons, e.g. spears and throw spears and catch prey had better survival chances. Upright walking is slower but long distances can be travelled to find food.
Better vision theory	Upright posture gave better vision over tall grasses and they could see approaching prey or predators giving better survival chances.
Eating grass seed theory	Freeing the hands to gather grass seeds means more food can be collected and carried ensuring a more permanent food supply and increased survival chances.
Feeding from bushes theory	Freeing the hands combined with taller reach means more food sources can be used and the different foods can be carried ensuring a more permanent food supply.

Science Press
ISBN 978-0-85583-8508