Active Biology - Senior Biology student worksheets part 2 **contains the following worksheets (including answer sheets):**

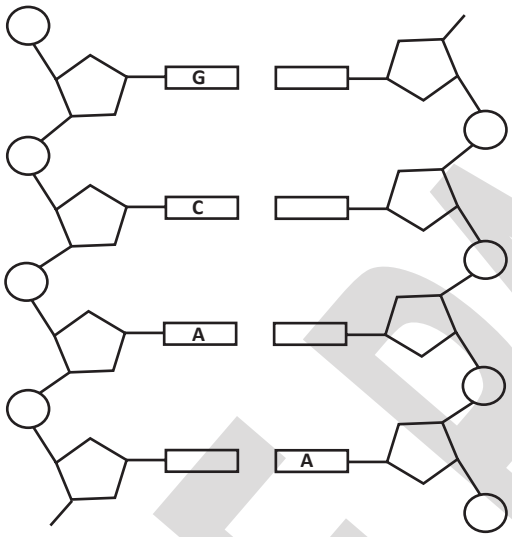
NUCLEIC ACIDS

1. DNA, or deoxyribonucleic acid, is a 'polymer'. What does this mean?

_____

_____

2. The following diagram shows part of a DNA molecule. It is unlabelled and not quite complete.



(a) Using two different colours, shade *and* label (i) the 'phosphate' part of each nucleotide (ii) the 'sugar' part of each nucleotide.

(b) Colour-code the four different types of nitrogen-containing bases and fill in any missing letters.

(c) Add hydrogen bonds (correct number) between each pair of complementary bases.

(d) Circle one complete nucleotide.

(e) For each chain, indicate the *5 prime* (5') and *3 prime* (3') end.

3. The two chains in a DNA molecule are said to run 'anti-parallel'. What does this mean?

_____

4. The two chains in a DNA molecule are actually arranged to form a double-helical structure, rather like a twisted rope ladder. In the space provided below, draw a simple diagram of a DNA double helix.

DNA double helix

(a) Which part of the double-stranded DNA molecule forms the 'rungs' of the ladder?

_____

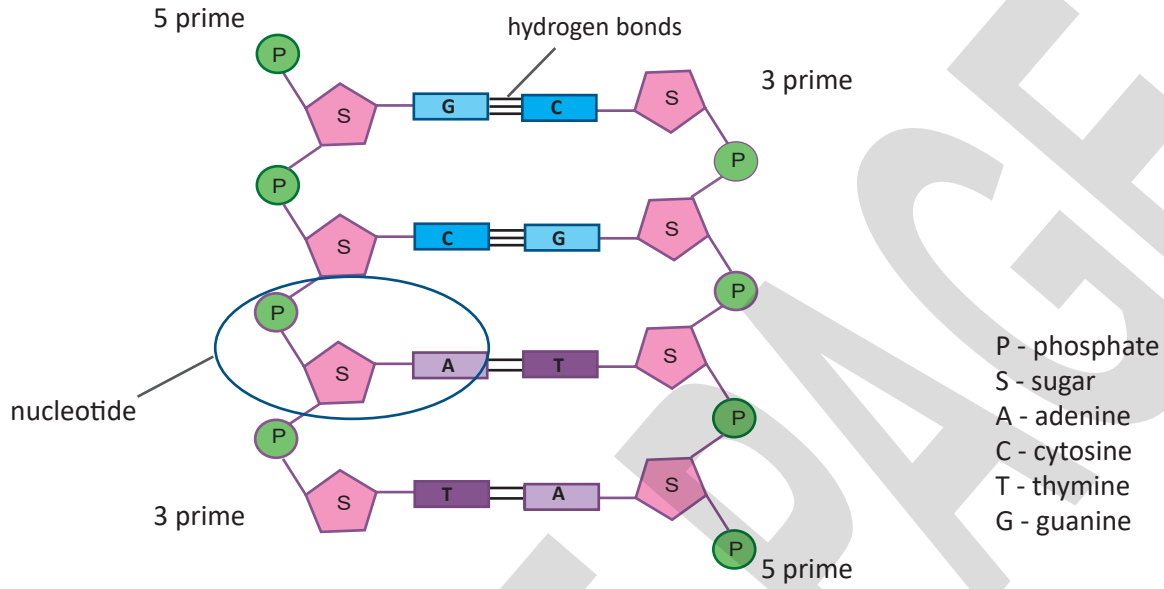
(b) Which part of the double-stranded DNA molecule forms the 'side rails' of the ladder?

_____

NUCLEIC ACIDS
(answers)

1. Being a *polymer* means that DNA is made up of similar sub-units called 'monomers'.

2.



(a) See above diagram.

(b) See above diagram.

(c) See above diagram.

(d) See above diagram.

(e) See above diagram.

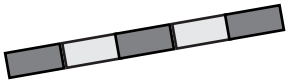
3. The two chains running 'anti-parallel' means that they run in opposite directions; one chain runs from the *5 prime* to *3 prime* end, while the other runs from *3 prime* to *5 prime*.

4.

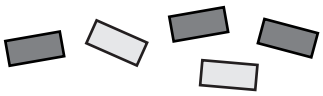
DNA double helix

(a) The nitrogen-containing bases form the 'rungs' of the ladder.

(b) The sugar-phosphate backbones form the 'side rails' of the ladder.



ALTERNATIVE SPLICING



1. What is meant by 'alternative splicing'?

_____

_____

2. What are the two ways in which alternative splicing can occur?

_____

MODELLING ALTERNATIVE SPLICING (activity)

MATERIALS: plasticine in four different colours, sharp pencil.

Part A

1. Cut 12 small rectangular pieces of plasticine in two different colours, with six pieces representing EXONS and six representing INTRONS

2. Number your introns and exons **1** - **6** by using the pencil to punch small holes into each piece.

3. Arrange all 12 pieces of plasticine to model a piece of pre-mRNA with 6 exons and 6 introns. This is your **base pre-mRNA** strand.

4. Use plasticine in two other colours to create a *cap* and a *poly-A tail.*

Part B

1. From your **base pre-mRNA** strand, remove all introns and then create four different, *complete* **mRNA** strands by:

    (a) removing exon 5
    (b) removing exons 2 and 6
    (c) removing exons 1, 2 and 4
    (d) removing exons 2, 3 and 5

2. Draw diagrams of your complete mRNA strands.

3. Use your **base pre-mRNA** strand to model INTRON RETENTION, where certain introns are retained rather than being cut out of the pre-mRNA. Create three different, *complete* mRNA strands of your own, removing some of the exons and retaining some of the introns. Draw diagrams of each of your mRNA strands.

The discovery of alternative splicing had profound implications in the science of genetics. How did it change what we believe about the way genes work?

_____

_____

_____

ALTERNATIVE SPLICING (answers)

1. Alternative splicing is a process in which genes are regulated so that they are able to produce more than one protein.

2. *Exon juggling* and *intron retention*.

MODELLING ALTERNATIVE SPLICING (activity)

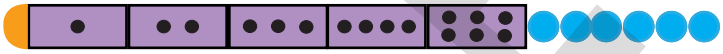
Part A

Base pre-mRNA strand (colours may vary):

 exon  intron

Cap:  Poly-A tail:  (shapes/colours may vary)

Part B

1. (a) 

(b) 

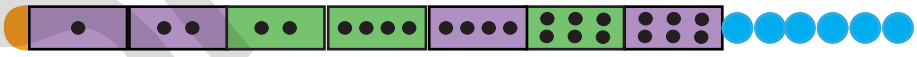
(c) 

(d) 

2. See diagrams 1 (a) - (d) above.

3. Student answers may vary. Examples of mRNA created as a result of intron retention could include:

(i) 
(remove exons 2, 4, 5 & introns 1, 4 - 6)

(ii) 
(remove exons 3, 5 & introns 1, 3 and 5)

(iii) 
(remove exons 1, 5 and 6 & introns 1, 3 and 5)

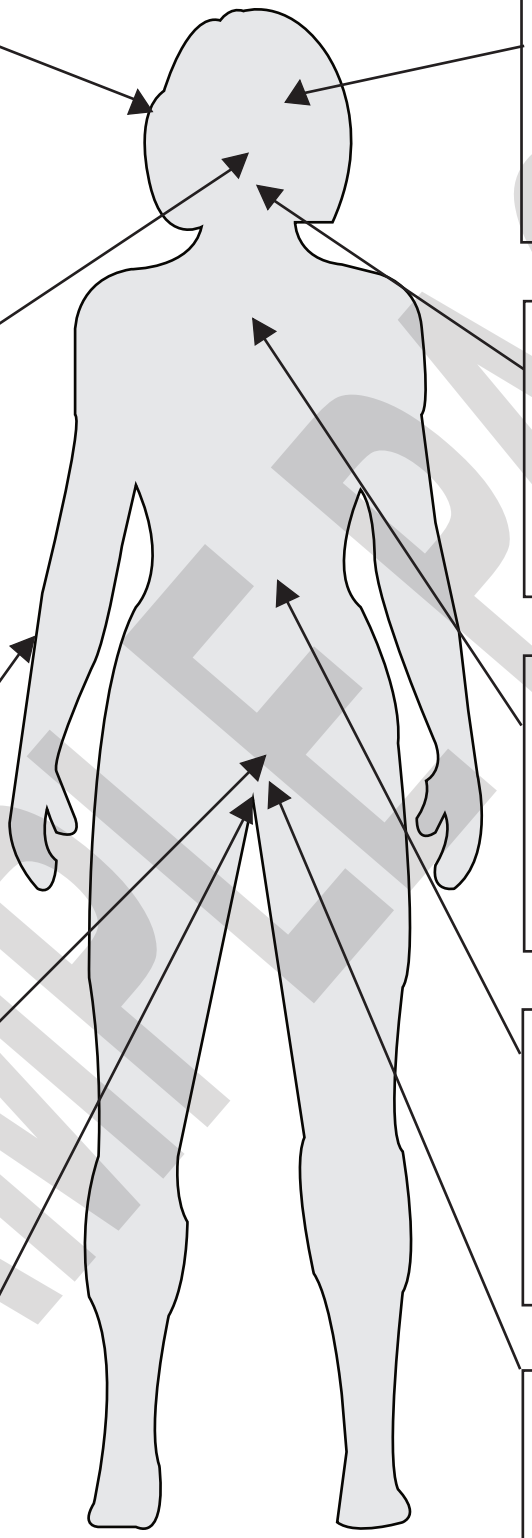
Previously, it was believed that genes produced only one protein each, that is, the 'one gene, one polypeptide concept'. The discovery of alternative splicing changed this thinking, as it became apparent that some genes are able to produce a variety of protein products. Alternative splicing also helps to explain why a relatively small number of genes (approximately 21,000) can account for the total number of different proteins that the human body can make, which scientists estimate could be as many as 2 million.

INNATE IMMUNITY: FIRST LINE OF DEFENCE

Describe the ways in which each body area provides protection from pathogens in the first line of defence:

EARS

EYES



NASAL CAVITY

MOUTH CAVITY

SKIN

AIRWAYS

URETHRA

STOMACH

GENITAL TRACT

ANUS

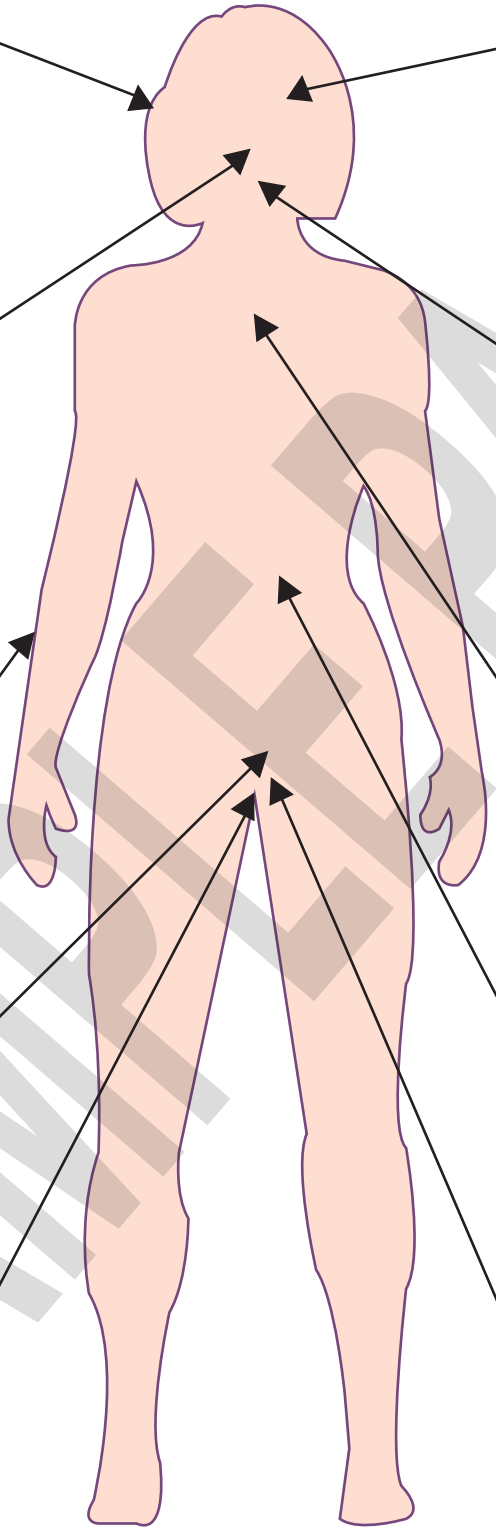
INNATE IMMUNITY: FIRST LINE OF DEFENCE
(answers)

EARS
* Produce cerumen (earwax) that helps to inhibit growth of bacteria.

EYES
* Produce tears which clean the eyes and contain lysozome, an enzyme that lyses bacteria.

NASAL CAVITY
* Contains hairs and mucus that trap microorganisms.

MOUTH CAVITY
* Produces saliva, which also contains lysozyme enzyme that lyses bacteria.
* Contains natural flora, harmless bacteria that can inhibit the growth of pathogenic bacteria.



SKIN
* Provides an impenetrable barrier against pathogens.
* Sebaceous glands secrete *sebum*, which contains fatty acids that have anti-bacterial properties.
* Produces sweat, which contains an anti-microbial protein called *dermcidin.*

AIRWAYS
* Have a layer of mucus that traps microorganisms.
* Hair-like structures called *cilia* help move mucus and the bacteria it contains to the back of the throat. Here, the mucus is either expelled by coughing, or swallowed.

URETHRA
* Flow of urine regularly cleanses surfaces, which can help prevent pathogens from becoming established.

STOMACH
* Produces strong stomach acid that kills bacteria.

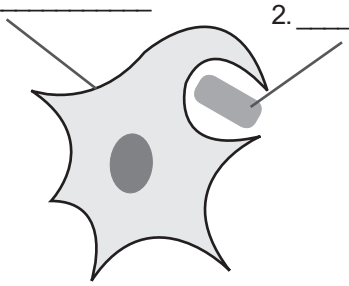
GENITAL TRACT
* Contains natural flora that inhibits growth of pathogenic bacteria.

ANUS
* Has mucous membranes that trap microorganisms.

HUMORAL IMMUNITY FLOWCHART

Complete the following flowchart by labelling the various cells/structures and providing brief captions:

1. _____



_____

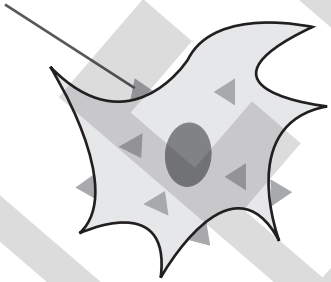
_____

2. _____

_____

_____

3. _____



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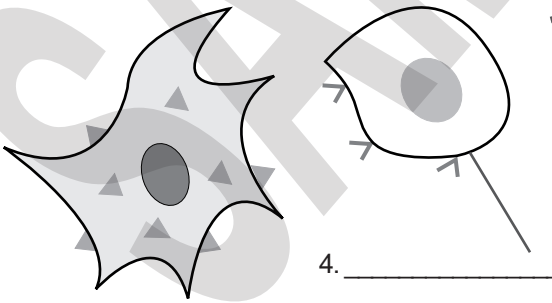
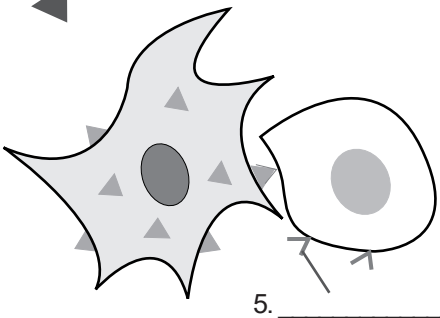


4. _____

_____

_____



5. _____

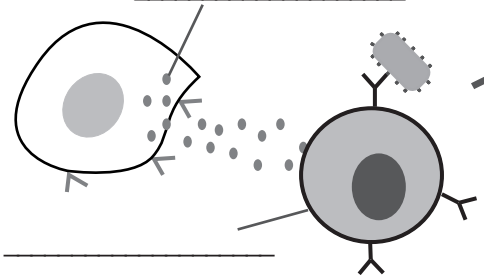
_____

_____

HUMORAL IMMUNITY FLOWCHART

(Cont.)

6. _____



7. _____

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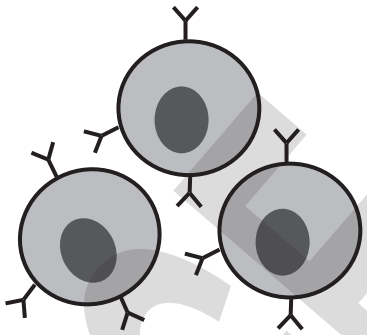

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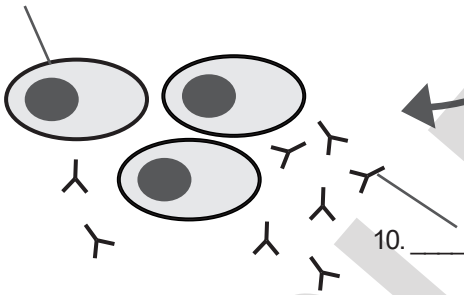
8. _____



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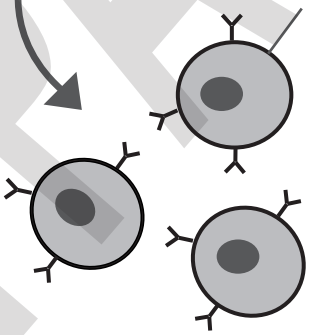
9. _____

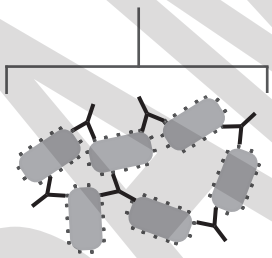


_____

_____

10. _____

11. _____



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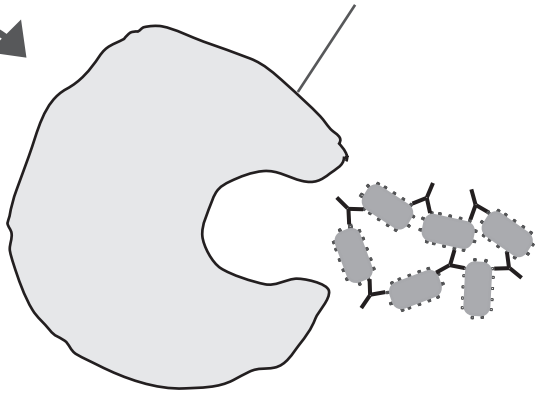
_____

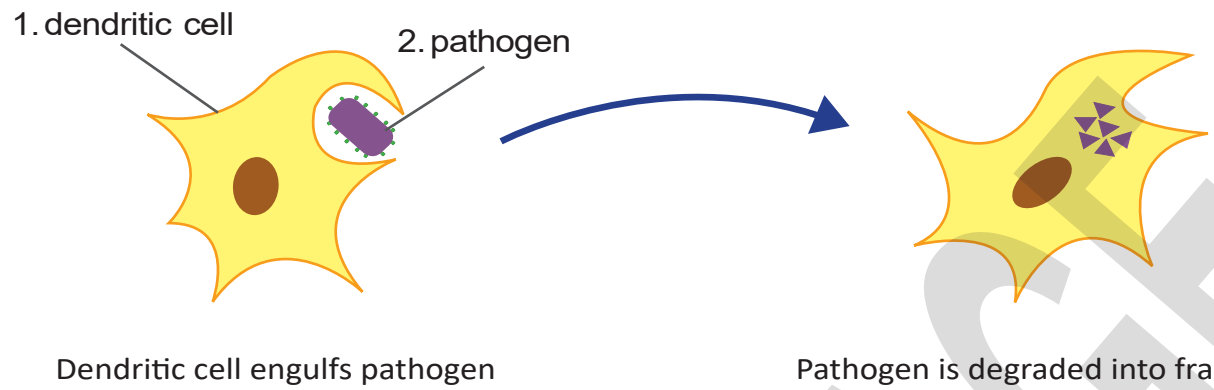
12. _____



_____

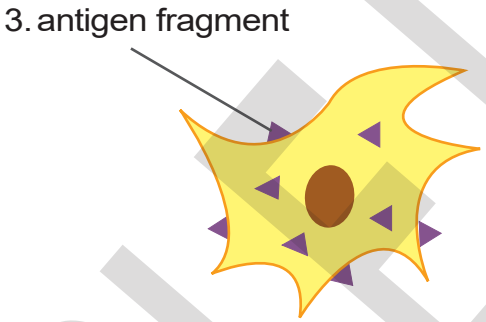
_____

HUMORAL IMMUNITY FLOWCHART (answers)

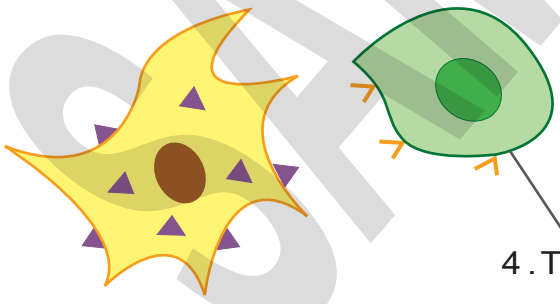


Dendritic cell engulfs pathogen

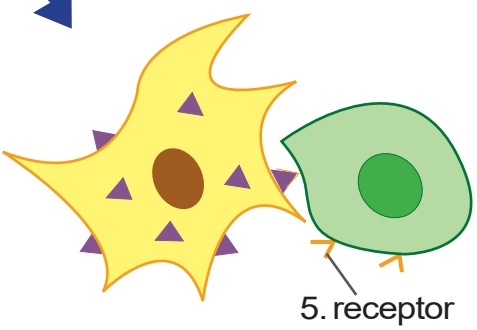
Pathogen is degraded into fragments



Some fragments are transferred to the surface of the dendritic cell



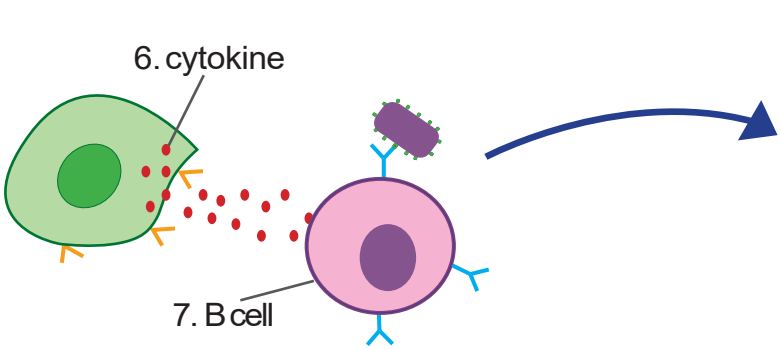
Dendritic cell presents antigen fragments to T helper cell



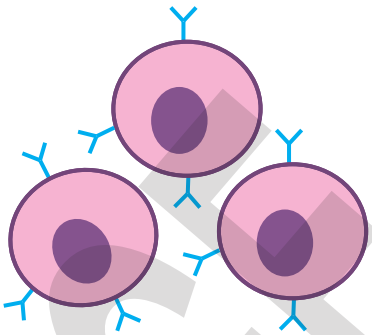
T helper cell binds to the antigen via receptors on its surface; this activates the helper cell

HUMORAL IMMUNITY FLOWCHART (answers)

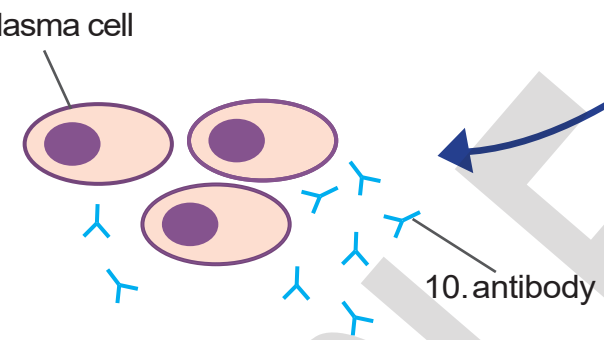
(Cont.)



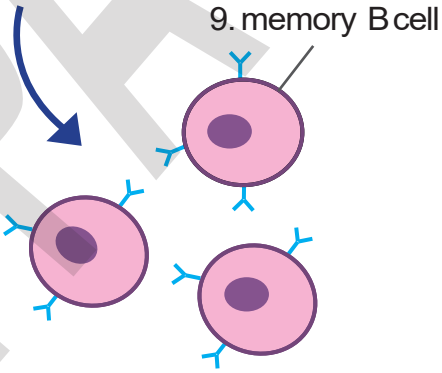
T helper cell releases cytokines that activate B cell



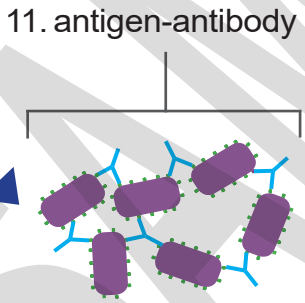
B cell undergoes clonal expansion to produce a clone of B cells



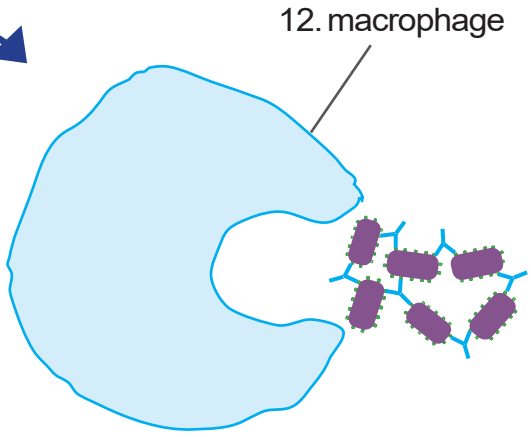
Most of the cloned B cells differentiate into antibody-producing plasma cells



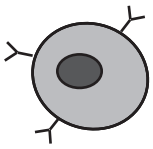
Some of the cloned B cells differentiate into memory B cells



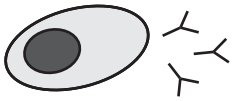
Antibodies bind to antigens on the surface of extracellular pathogens, forming an antigen-antibody complex



Macrophage engulfs and destroys antigen-antibody complex by phagocytosis



TYPES OF WHITE BLOOD CELLS



Using a system of colour-coding, match the name of the cells to their correct function:

B lymphocytes

Release histamines during inflammation

Plasma cells

Memory B cells

Destroy intracellular pathogens in 3rd line of defence

Main antigen-presenting cells

T helper cells

Can 'remember' an antigen; involved in cellular immunity

Monocytes

NK cells

Basophils

Release histamines during the allergic response

Suppressor T cells

Differentiate into plasma cells

Neutrophils

Produce cytokines that stimulate B and T cells

Dendritic cells

Mast cells

Differentiate into macrophages

Can 'remember' an antigen; involved in humoral immunity

Memory T cells

Eliminate pathogens by degranulation

Produce antibodies

Cytotoxic T cells

Type of phagocytes involved in 2nd line of defence

Limit or stop an immune response

TYPES OF WHITE BLOOD CELLS
(answers)

B lymphocytes

Release histamines during inflammation

Plasma cells

Memory B cells

Destroy intracellular pathogens in 3rd line of defence

Main antigen-presenting cells

T helper cells

Can 'remember' an antigen; involved in cellular immunity

Monocytes

NK cells

Basophils

Release histamines during the allergic response

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Differentiate into plasma cells

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Produce cytokines that stimulate B and T cells

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Can 'remember' an antigen; involved in humoral immunity

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Eliminate pathogens by degranulation

Produce antibodies

Cytotoxic T cells

Type of phagocytes involved in 2nd line of defence

Limit or stop an immune response

THE COVID 19 VACCINE: HOW IT WORKS

1. The Oxford-AstraZeneca COVID 19 vaccine uses a modified chimpanzee *adenovirus* to carry a gene that codes for the coronavirus 'spike protein' into a cell (this gene has been inserted into the adenovirus).

   (a) What is an 'adenovirus'?

   _____

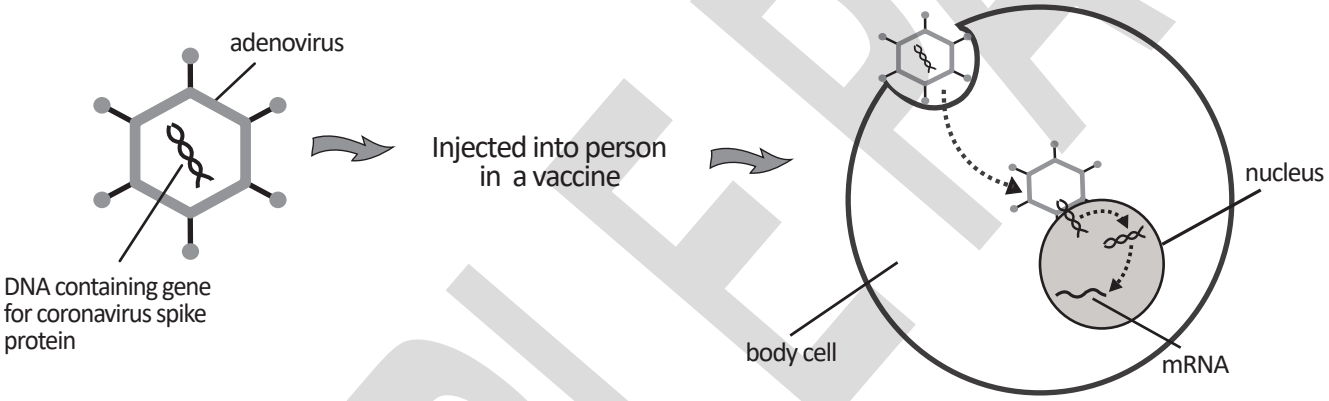
   (b) Why does the adenovirus need to be modified?

   _____

   (c) Where on a coronavirus particle would you find the spike proteins?

   _____

2. The following diagrams show early stages in the workings of the Oxford-AstraZeneca vaccine:



(i) **(ii)**

Once a person receives the vaccine, the adenoviruses make contact with body cells. Look carefully at diagram **(ii)** and describe what happens.

_____

_____

_____

3. The diagram on the right shows the next stage. Explain what is happening.

_____

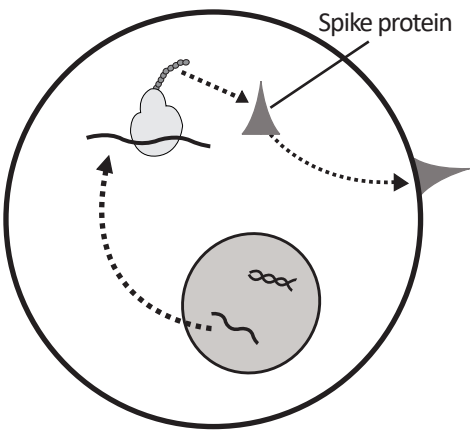
_____

_____

_____

_____

_____



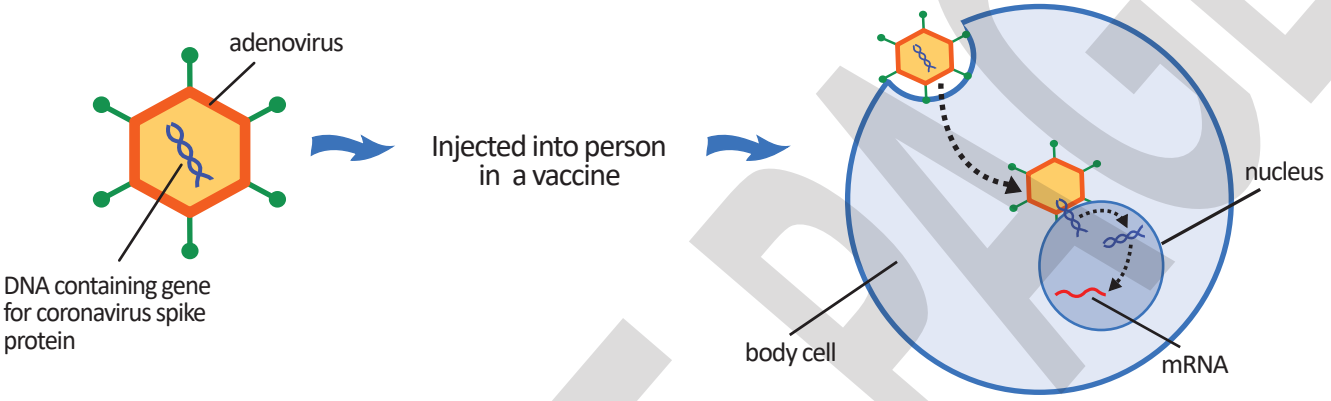
(iii)

THE COVID 19 VACCINE: HOW IT WORKS
(answers)

1. (a) An 'adenovirus' is a type of DNA virus that tends to cause respiratory disease.

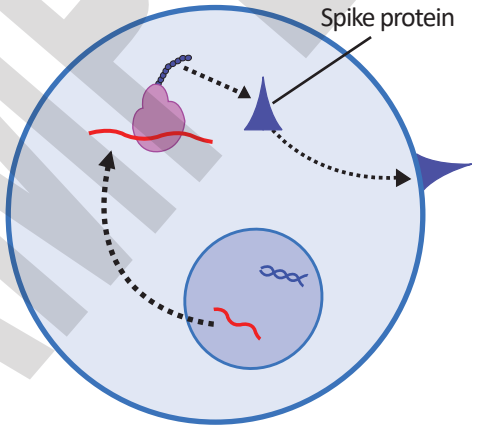
   (b) The adenovirus needs to be modified so that it cannot itself replicate inside the body of the person being vaccinated and cause disease.

   (c) The spike proteins are found on the surface of the coronavirus.

2. 

(i) **(ii)**

The diagram shows that the adenovirus carrying the gene for coronavirus spike protein is engulfed by the body cell. It then makes its way towards the nucleus and injects the DNA into it. The gene is then transcribed into mRNA.

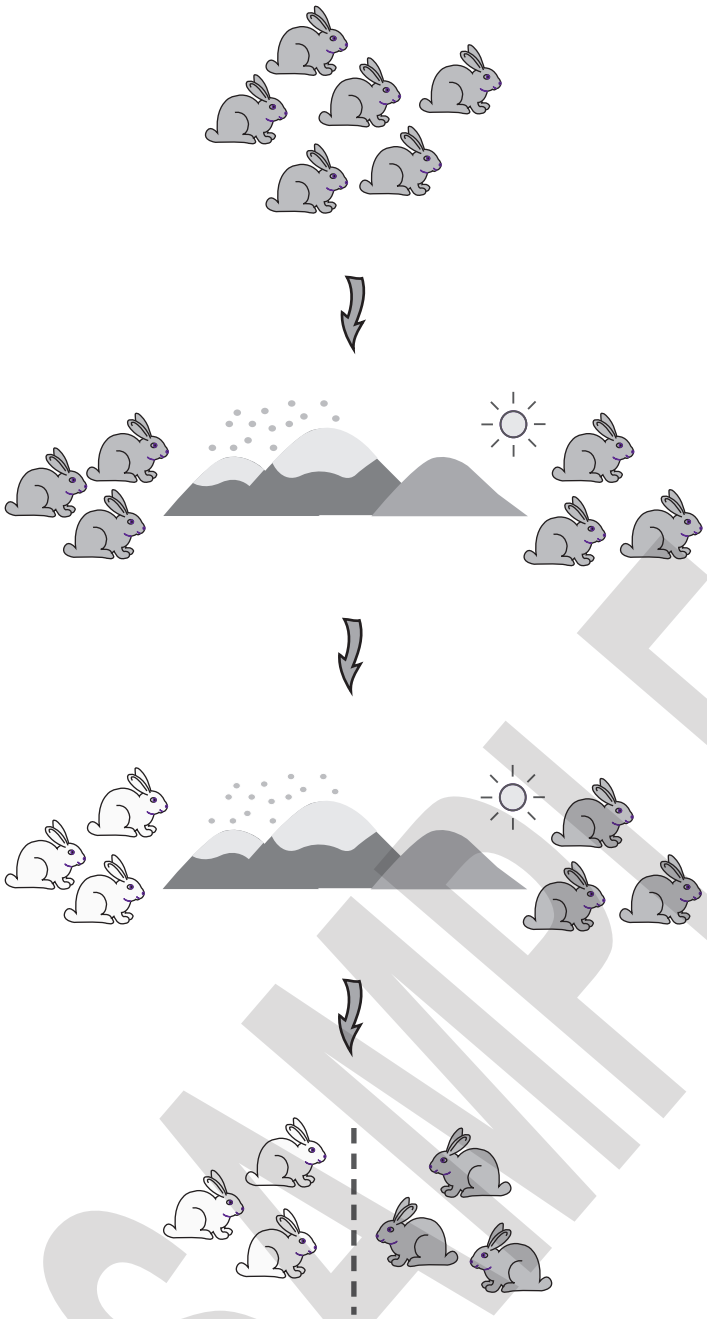
3. 

(iii)

The mRNA leaves the nucleus and moves into the cytosol. Here, at a ribosome, it is translated into a polypeptide which is then folded into a spike protein. The spike protein migrates to the surface of the cell.

SPECIATION

1. The following flow diagram shows *speciation*, the process of formation of new species. In the spaces provided, write captions to explain, in scientific terms, what is happening at each step.



2. What type of speciation is that which occurs as the result of two populations becoming geographically isolated from one another?

_____

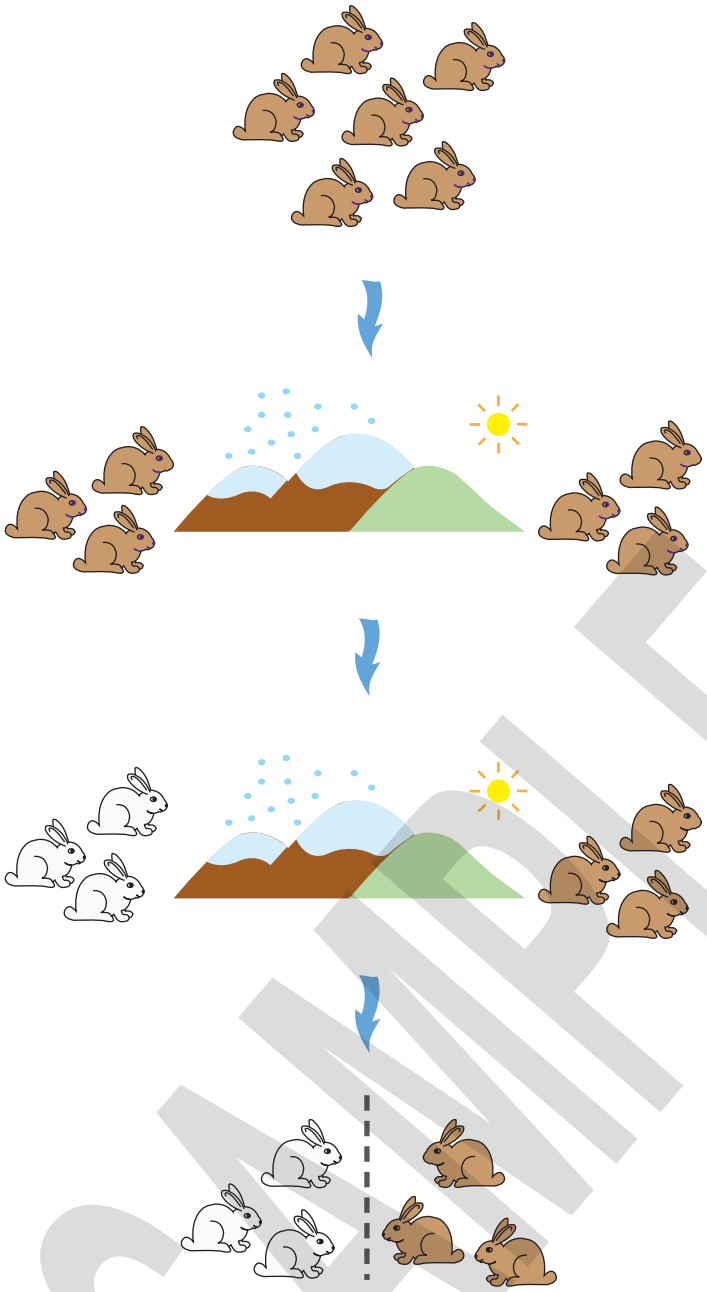
3. If two different populations are considered to be *subspecies*, what does this mean?

_____

_____

SPECIATION
(answers)

1.



In the beginning there is one rabbit population, with all its members belonging to the same species.

Two populations of the rabbit species become geographically isolated by a mountain range (formed by uplift in extremely slow geological processes).

The isolated populations are subjected to different selection pressures because of the differences in environmental conditions. They start to become less and less alike, evolving in different directions.

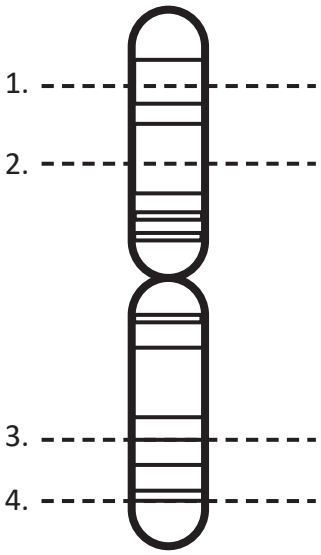
If the two rabbit populations are later brought back together they can no longer interbreed; they have become two different species.

2. Allopatric speciation.

3. If two populations are considered subspecies, this means that while they might look quite different to each other, they are still capable of interbreeding and producing healthy, fertile offspring. They therefore still belong to the same species.

BLOCK MUTATIONS

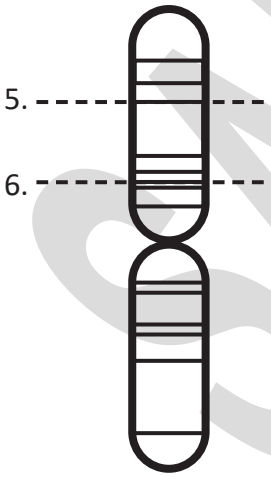
1. Colour in the different segments of chromosomes **A** and **B** as shown on the screen (see next page).
2. Redraw chromosome **A** showing a *duplication* of the segment between lines 1 and 2.
3. Redraw chromosome **A** showing a *deletion* of the segment between lines 3 and 4.
4. Redraw chromosome **B** showing an *inversion* between lines 5 and 6.
5. Draw the chromosomes that would result from a *reciprocal exchange* between the segments 1 - 2 of chromosome **A** and 5 - 6 of chromosome **B**.



Normal Chromosome **A**

Chromosome **A** with duplicated segment

Chromosome **A** with deleted segment



Normal Chromosome **B**

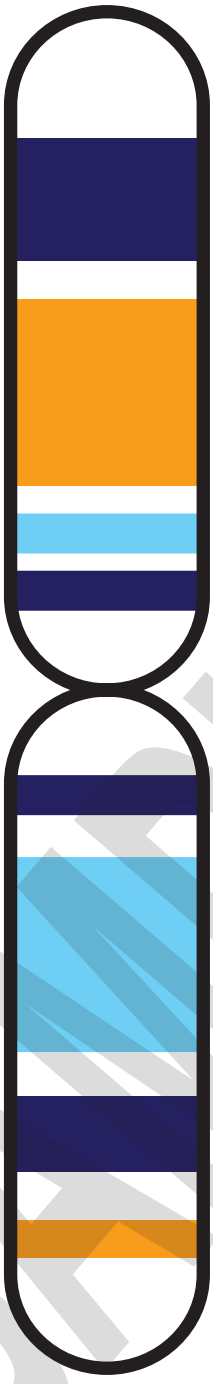
Chromosome **B** with inversion

Chromosome **A** following reciprocal exchange

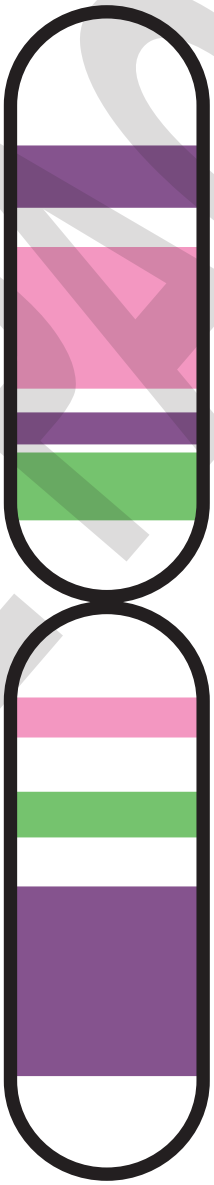
Chromosome **B** following reciprocal exchange

BLOCK MUTATIONS

Give chromosomes **A** and **B** the following colours:



Chromosome A



Chromosome B

BLOCK MUTATIONS
(answers)

Normal Chromosome **A**

Chromosome **A** with duplicated segment

Chromosome **A** with deleted segment

Normal Chromosome **B**

Chromosome **B** with inversion

Chromosome **A** following reciprocal exchange

Chromosome **B** following reciprocal exchange

DATING ROCKS

1. A person's age can be described in either *relative* or *absolute* terms. Explain, using an example.

_____

_____

_____

2. The relative age of rock strata (layers) can be determined using the *stratigraphic method*. What does this mean?

_____

_____

3. The following diagrams show rock strata containing various types of fossils in South America and Africa.

(a) Which layer in South America is (i) the oldest? (ii) the youngest?

_____

(b) Which of the fossils is most likely to be classed as an 'index' fossil? Indicate this on the diagram.

(c) Explain your answer to (b).

_____

_____

(d) What important piece of information does the index fossil provide about the rock strata in South America and Africa?

_____

_____

4. The absolute age of rock can be determined using *radiometric dating*. Describe what this involves.

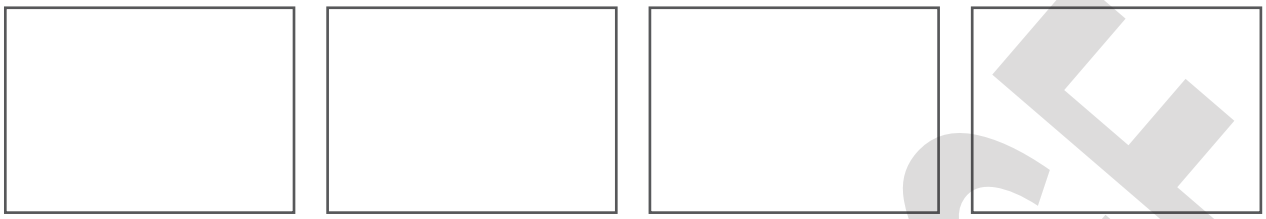
_____

_____

_____

5. In radiometric dating, the rate of decay of radioactive isotopes present in the rock is measured in 'half-lives', with one half-life being the time taken for 50% of the original parent isotope to decay.

   (a) The following shapes each represents a slab of igneous rock at different ages, or half-lives. Use shading (or some other method) to show what happens to the amounts of parent/daughter isotopes over time.



0 half-lives | 1 half-life | 2 half-lives | 3 half-lives

   (b) The parent isotope potassium-40, which decays to form argon-40, has a half-life of 1300 000 000 years, while carbon-14, which decays to form nitrogen-14, has a half-life of only 5730 years. What implications does this have for the use of these isotopes in radiometric dating?

_____

_____

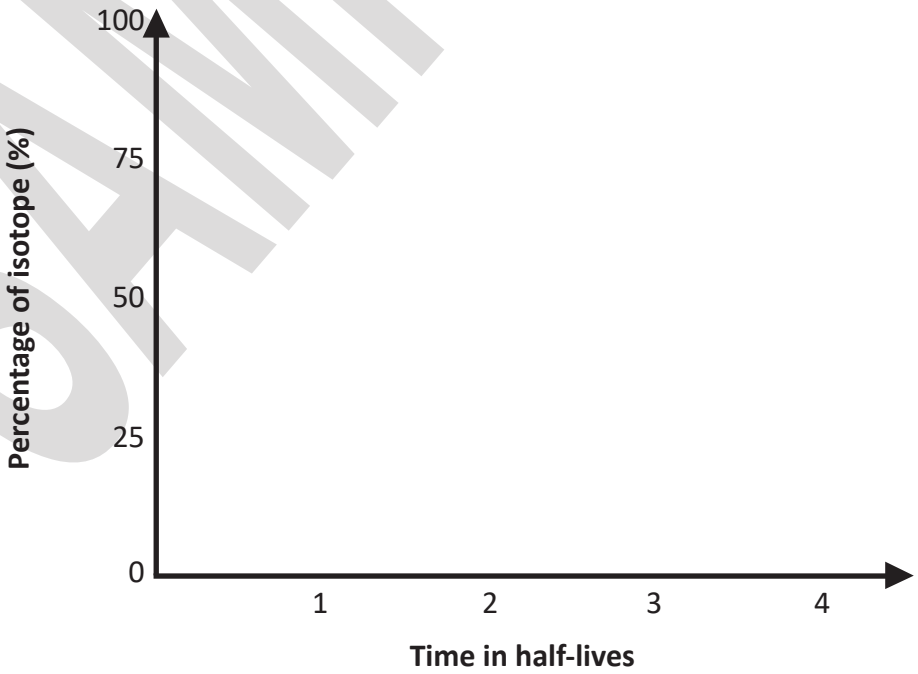
   (c) Explain why radiometric dating cannot be used for sedimentary rock.

_____

_____

_____

6. The following set of axes is for a line graph showing the percentages of (i) parent isotope and (ii) daughter isotope in ageing rock. Complete the graph by adding both sets of data.

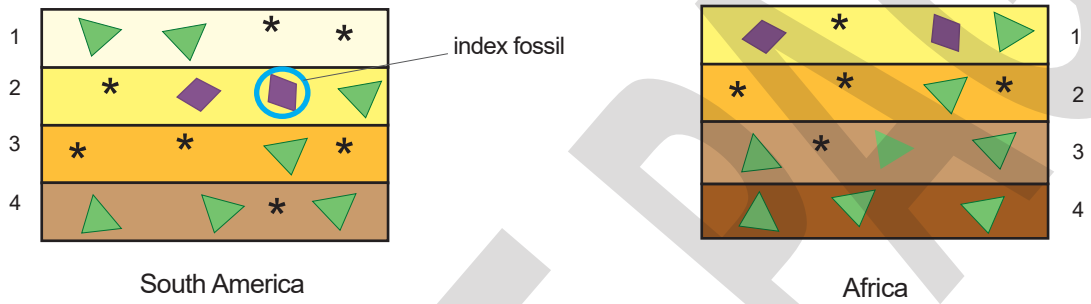


DATING ROCKS
(Answers)

1. When describing the *relative* age of a person, you are comparing them to another person, for example, *Sarah is older than Tom*. When describing a person's *absolute* age, however, you are giving the actual figure in years, for example, *Sarah is eighteen*.

2. The stratigraphic method of determining the relative ages of rock strata is one based on the *principle of superposition*, which simply states that the oldest layer occurs at the bottom, with layers above becoming progressively younger.

3.



(a) (i) Layer **4**. (ii) Layer **1**.

(b) See above diagram.

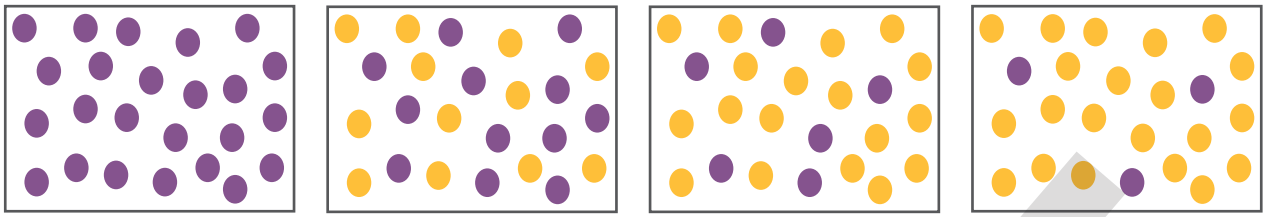
(c) Index fossils are those formed from species that existed on Earth for only a short time, and are therefore usually restricted to just one or two layers of rock. The fossil indicated is found in only one rock layer in both South America and Africa.

(d) Being an index fossil, it tells us that layer **2** in South America is the same age as layer **1** in Africa, which also contains the fossil.

4. Radiometric dating of rock is based on the rate of decay of certain radioactive isotopes found in igneous rock. These 'parent' isotopes are unstable and decay over time to form stable 'daughter' isotopes. By measuring the relative amounts of parent and daughter isotope present in a rock, its absolute age can be determined.

5. (a)
(shading method):

(dot method)

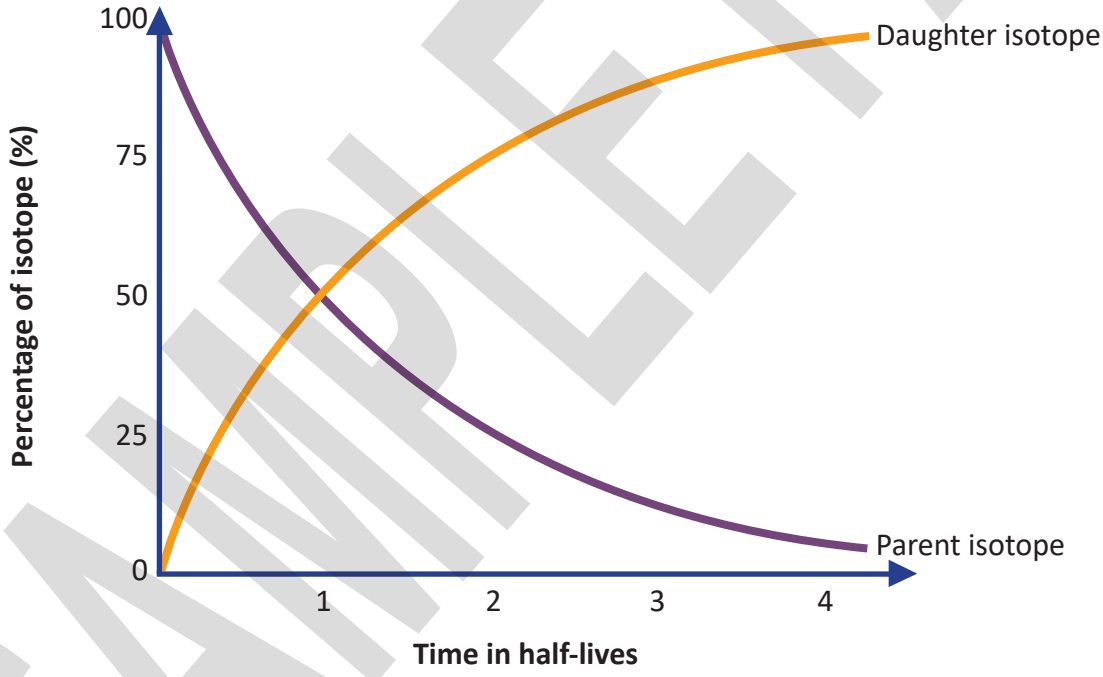


0 half-lives | 1 half-life | 2 half-lives | 3 half-lives

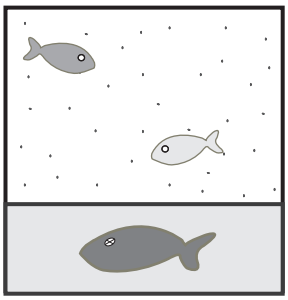
(b) The longer the half-life of a radioactive isotope, the older the material that can be dated using that particular method (because carbon-14 has a relatively short half-life, it cannot be used to date material older than around 60 000 years, while potassium-argon dating has been used to date rocks up to 4 billion years old).

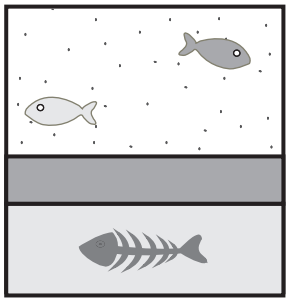
(c) Radiometric dating cannot be used to date sedimentary rocks because they have formed from *pre-existing* rocks following the processes of weathering and erosion, which in turn means that the minerals - or any radioactive elements - found in these rocks are actually older than the rock itself.

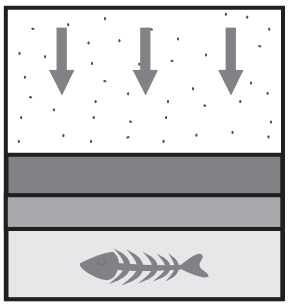
6.

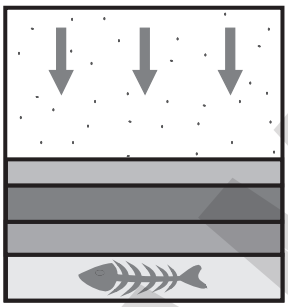


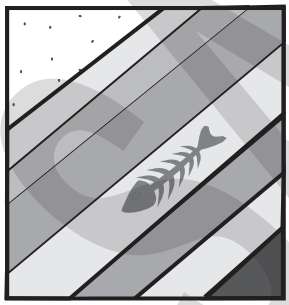
Processes involved in the fossilisation of a fish.

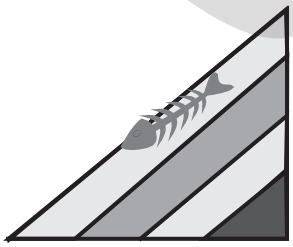




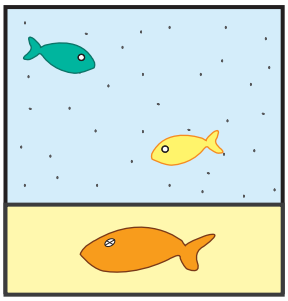




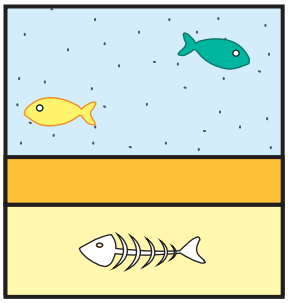




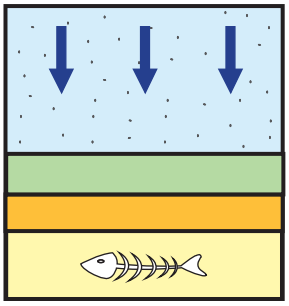
Processes involved in the fossilisation of a fish.



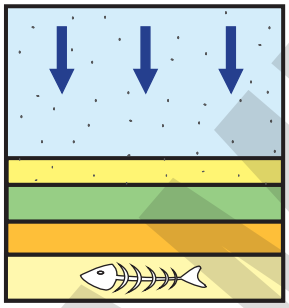
Fish dies and is quickly buried by sand at the bottom of the sea, protecting it from being eaten by other animals.



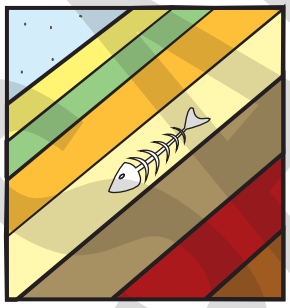
Over time, more sediment is deposited on the sea floor, forming a new layer. Softer parts of the animal decay, leaving the hard skeleton.



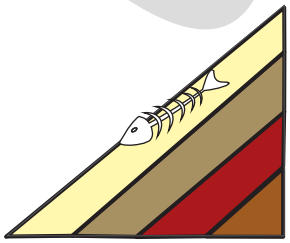
As more layers of sediment are deposited, the added weight puts great pressure on the original layer containing the dead fish. Layers of sediment are squeezed together.



New layers of sediment continue to form, increasing the pressure on the deeper layers. This pressure causes the sediments to become compressed and eventually turn into rock.



After millions of years, the sedimentary rock layers may be thrust upwards by great geological forces, and become part of a mountain range.



Processes such as weathering and erosion may eventually wear away the top layers of rock, exposing the fossil fish.