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

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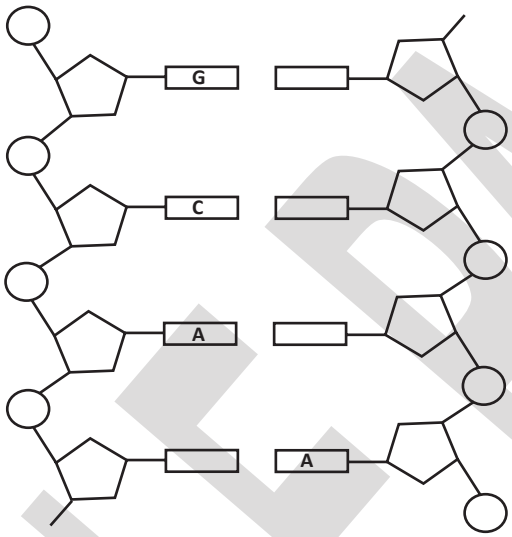
NUCLEIC ACIDS

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?

_____

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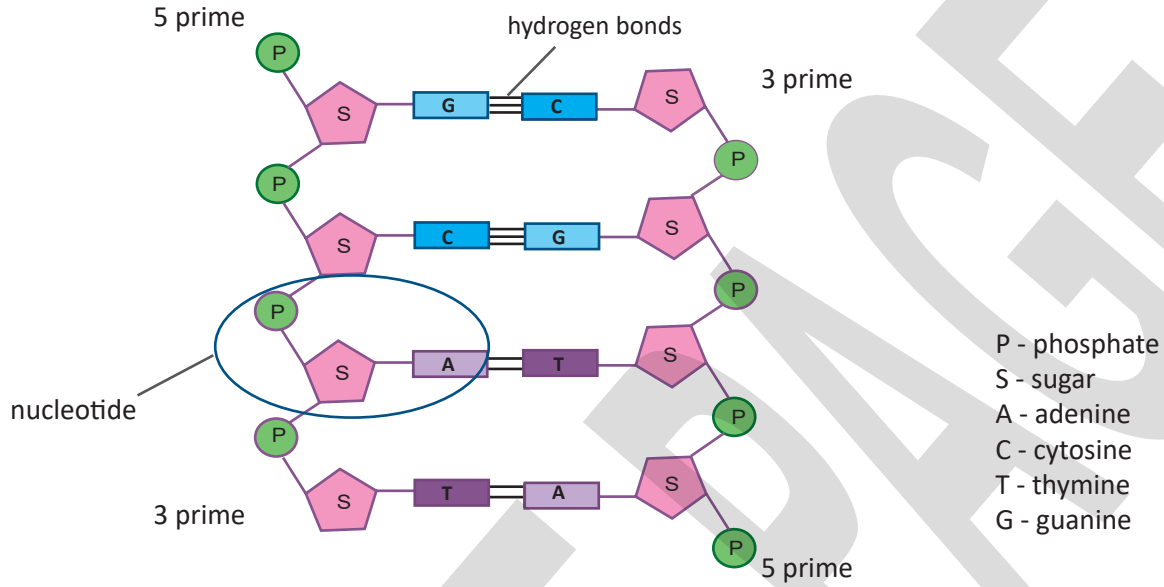
NUCLEIC ACIDS
(answers)

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.

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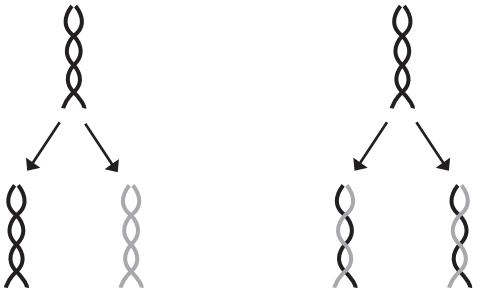
DNA REPLICATION

1. Give examples of where DNA replication would probably be occurring in your body right now.

_____

_____

2. The following diagram shows two models of DNA replication:



conservative model semi-conservative model

(a) What is the major difference between the two models?

_____

_____

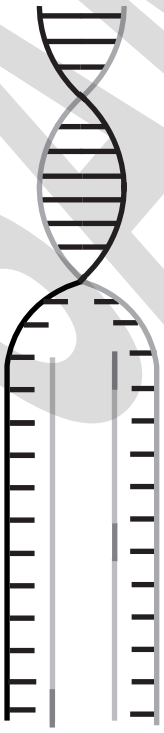
_____

_____

(b) Which is the correct model? _____

(c) In the space below, complete the next round of replication for both models:

3. The following diagram shows the process of DNA replication:



(a) On the diagram, label each of the following: **replication fork** - **leading strand** - **lagging strand** - **RNA primer** - **new strands**.

(b) Show the direction of movement of the replication fork.

(c) Indicate which is the **5'** and **3'** end of (i) the leading strand (ii) the lagging strand (iii) new strands.

(d) Show the direction of replication for each of the two new strands.

(e) Name the enzyme that (i) separates the two strands (ii) builds the two new strands (iii) controls the binding of the primers.

_____

_____

_____

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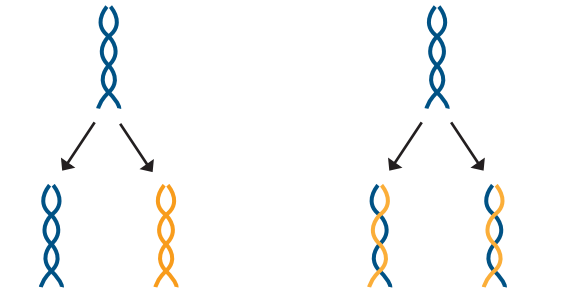
DNA REPLICATION
(answers)

1. DNA replication would be occurring in areas where cells are constantly dividing, such as the bone marrow, hair, fingernails, skin, stomach and small intestine.

2.



conservative model semi-conservative model

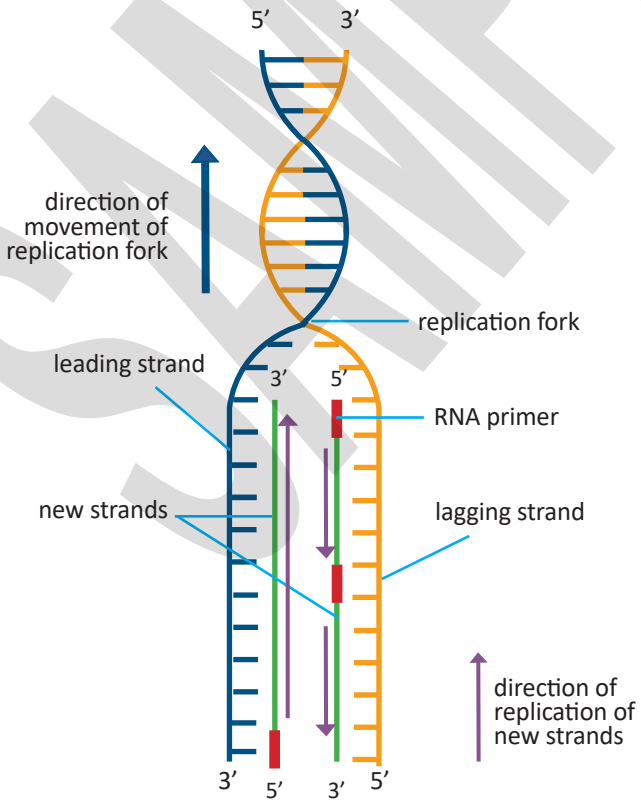
(a) The major difference between the two models is that in conservative replication, the end result is two double-stranded DNA molecules, one made up of two 'old' strands and the other made up of two 'new' strands, while in the semi-conservative model both molecules are made up of one 'new' strand and one 'old' strand.

(b) The correct model is the semi-conservative model.

(c) The next round of replication would look as follows:

conservative model semi-conservative model

3.



(a) See diagram on the left.

(b) See diagram on the left.

(c) See diagram on the left.

(d) See diagram on the left (DNA replication can occur only in the **5'** to **3'** direction).

(e) (i) Helicase.
(ii) DNA polymerase.
(iii) DNA primase.

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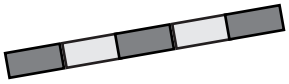
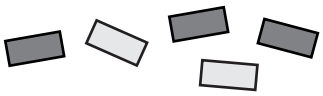
ALTERNATIVE SPLICING





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?

_____

_____

_____

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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)

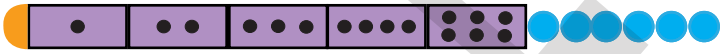
Part A

Base pre-mRNA strand (colours may vary):

 exon  intron

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

Part B

1. (a) 

(b) 

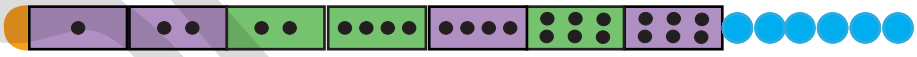
(c) 

(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.

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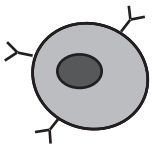
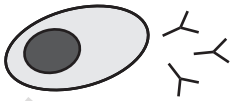


TYPES OF WHITE BLOOD CELLS



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

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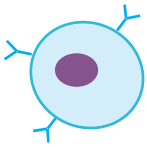
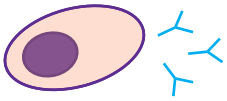
TYPES OF WHITE BLOOD CELLS
(answers)





B lymphocytes

Release histamines during inflammation

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Memory B cells

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Main antigen-presenting cells

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Type of phagocytes involved in 2nd line of defence

Limit or stop an immune response

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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'?

   _____

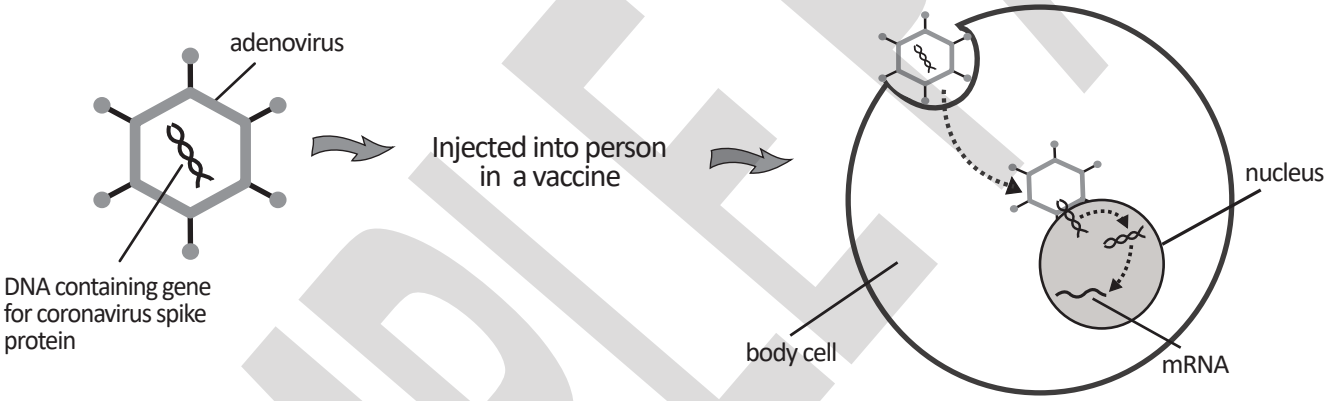
   (b) Why does the adenovirus need to be modified?

   _____

   (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.

_____

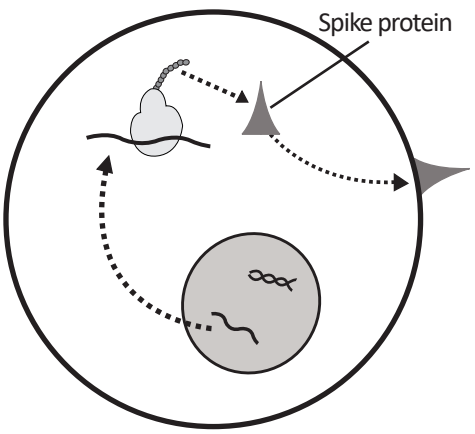
_____

_____

_____

_____

_____



(iii)

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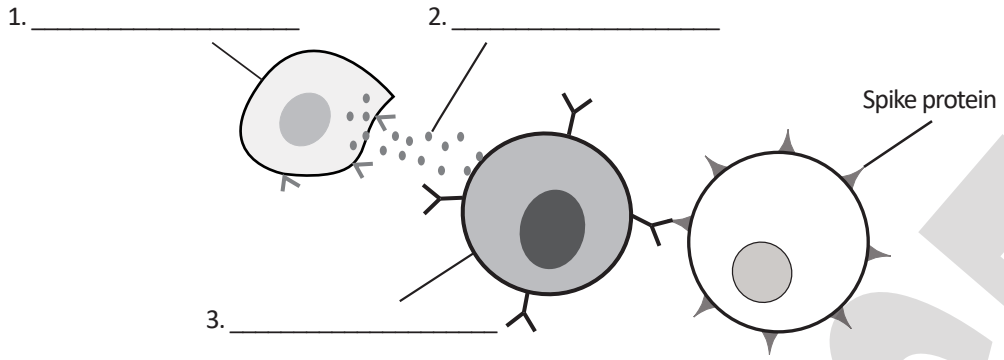
4. The following diagram **(iv)** shows the next stage, in which the body's immune cells become involved:



(a) Label the structures **1** - **3** on the above diagram.

(b) Using your knowledge of the immune system, describe what is happening.

_____

_____

_____

(c) Following stage (iv) shown above, what will **structure 3** do?

_____

_____

5. The following diagrams show the fate of a coronavirus particle after it infects a vaccinated person:

(a) What is the importance of the coronavirus' spike proteins?

_____

_____

(b) Explain what ultimately happens to the coronavirus particle after it infects a vaccinated person.

_____

_____

(c) What would happen in an *unvaccinated* person?

_____

_____

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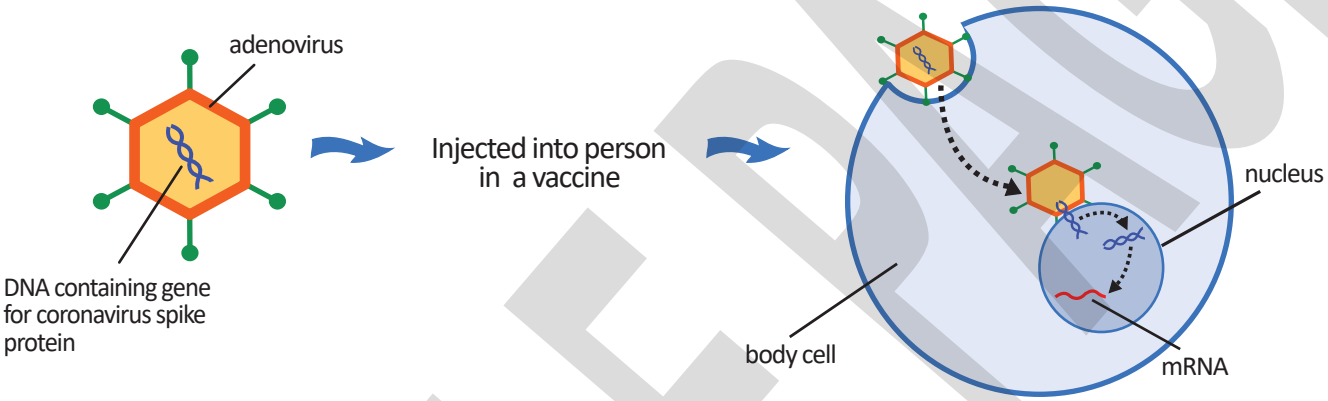
THE COVID 19 VACCINE: HOW IT WORKS
(answers)

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

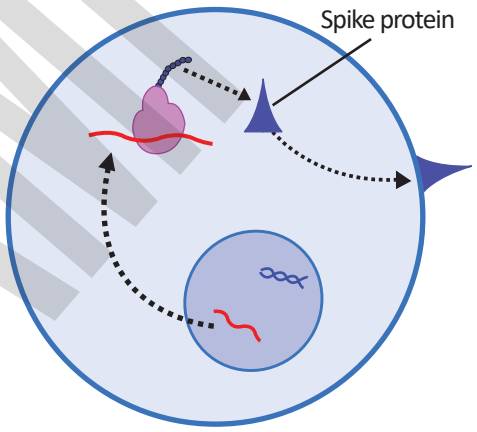
   (b) The adenovirus needs to be modified so that it cannot itself replicate inside the body of the person being vaccinated and cause disease.

   (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.

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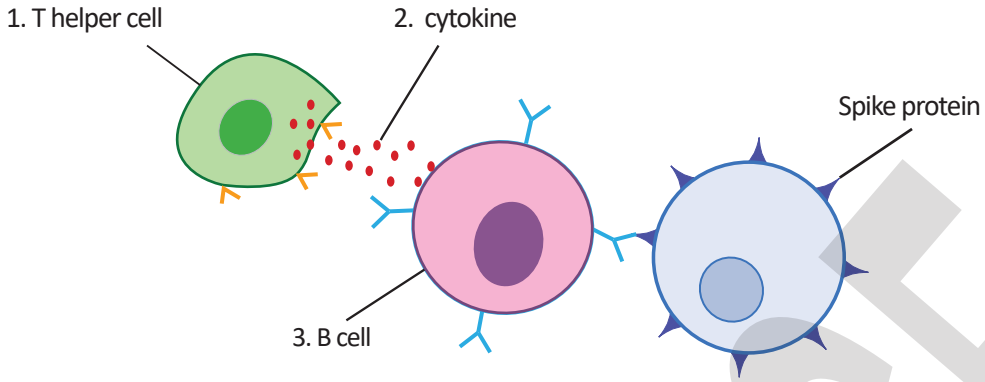
4.

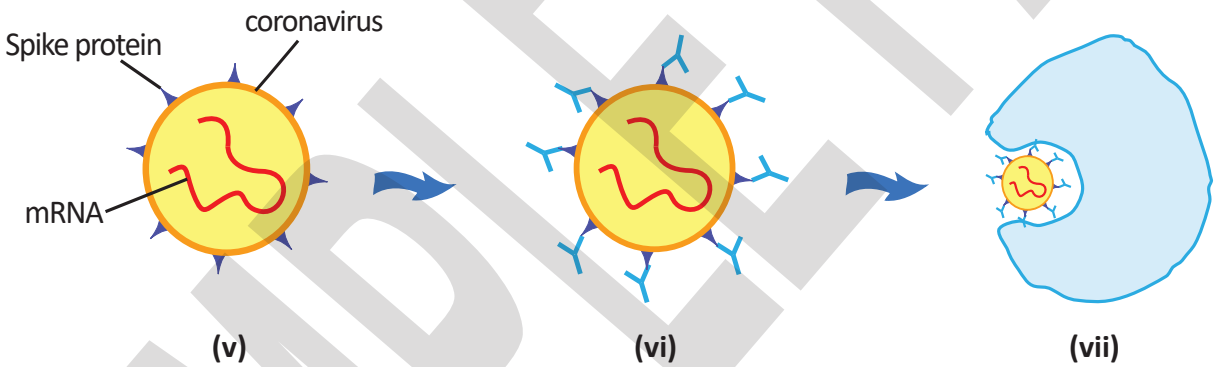


(a) See above diagram.

(b) The B cell has recognised and attached to the spike protein on the surface of the body cell. Before the B cell can respond, it must await activation by the T helper cell, which does so through the release of chemical signalling molecules known as cytokines.

(c) Structure 3, the B cell, will carry out clonal expansion, producing a large clone of cells. These B cells will then produce and release antibodies against the coronavirus (memory B cells may also be produced).

5.



(a) The spike proteins bind to receptors on the host cell surface and allow the virus to enter the cell.

(b) The coronavirus particle is attacked by antibodies, which bind with the spike proteins and block them, preventing them from attaching to other body cells. This also marks the virus for destruction by macrophages, which engulf the virus and destroy it in the process of phagocytosis.

(c) In an *unvaccinated* person, no antibodies are available to bind with the spike proteins on the surface of the virus. The virus is therefore free to bind with the person's cells and infect them.

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CHANGES IN POPULATIONS WORD FIND

Work out each of the 20 clues below, then find and highlight those words in the following word find.

S C E M I G R A T I O N A W Z S B V
D R V Y A U G F O M U O L R E O F B
I P A G L C P X P X F I L L T C D T
V S R T L D T A Y D C T E T A I I H
E S I F O U N D E R N C L S G H D Y
R U A I P F Z M N O T E E L E P A T
G B T R A X S C I I N L F O N R R N
E S I D T L E T N E E E R O E O T E
N P O C R B A G C C O S E P F M I G
T E N I I I A K T A S L Q E L Y F R
S C E T C G E I R E H A U N O L I E
R I J E E F V U N D I R E E W O C V
G E P N F E C T G F S U N G G P I N
F S T E B G I U X Y H T C B Q R A O
G T C G P F V B Y I F A Y P Q M L C
B T A C I H P R O M O N O M M C C X

Clues:

1. Process in which organisms that are better adapted to their environment survive and reproduce.
2. Any factor that affects survival or fertility in a biological population.
3. The formation of new and distinct species through evolution.
4. Transfer of genetic material from one population to another.
5. Refers to changes that occur in allele frequency in a population purely due to chance.
6. Describes a population in which all members are identical with respect to a particular trait.
7. The 'raw material' of natural selection.
8. Describes the type of speciation that occurs as a result of populations becoming geographically isolated from each other.
9. This is expressed as a number between 0 and 1.
10. Type of evolution that results in closely related species becoming less similar.
11. Species more likely to survive and reproduce have this type of advantage.
12. Describes a population in which there is more than one variant in a particular trait.
13. Occurs when the size of a population is drastically reduced due to some sort of disaster, such as a flood or fire.
14. Migration out of a region.
15. This value will be higher for species that make a greater contribution to the gene pool.
16. Effect that occurs when a small group of individuals leaves an area to begin a new colony somewhere else.
17. Taxonomic category or grouping that ranks below species.
18. Describes a type of selection whereby farmers or breeders choose individuals to become the parents of the next generation.
19. Sum total of the entire genetic information present in a population.
20. Type of evolution in which unrelated species begin to develop similarities.

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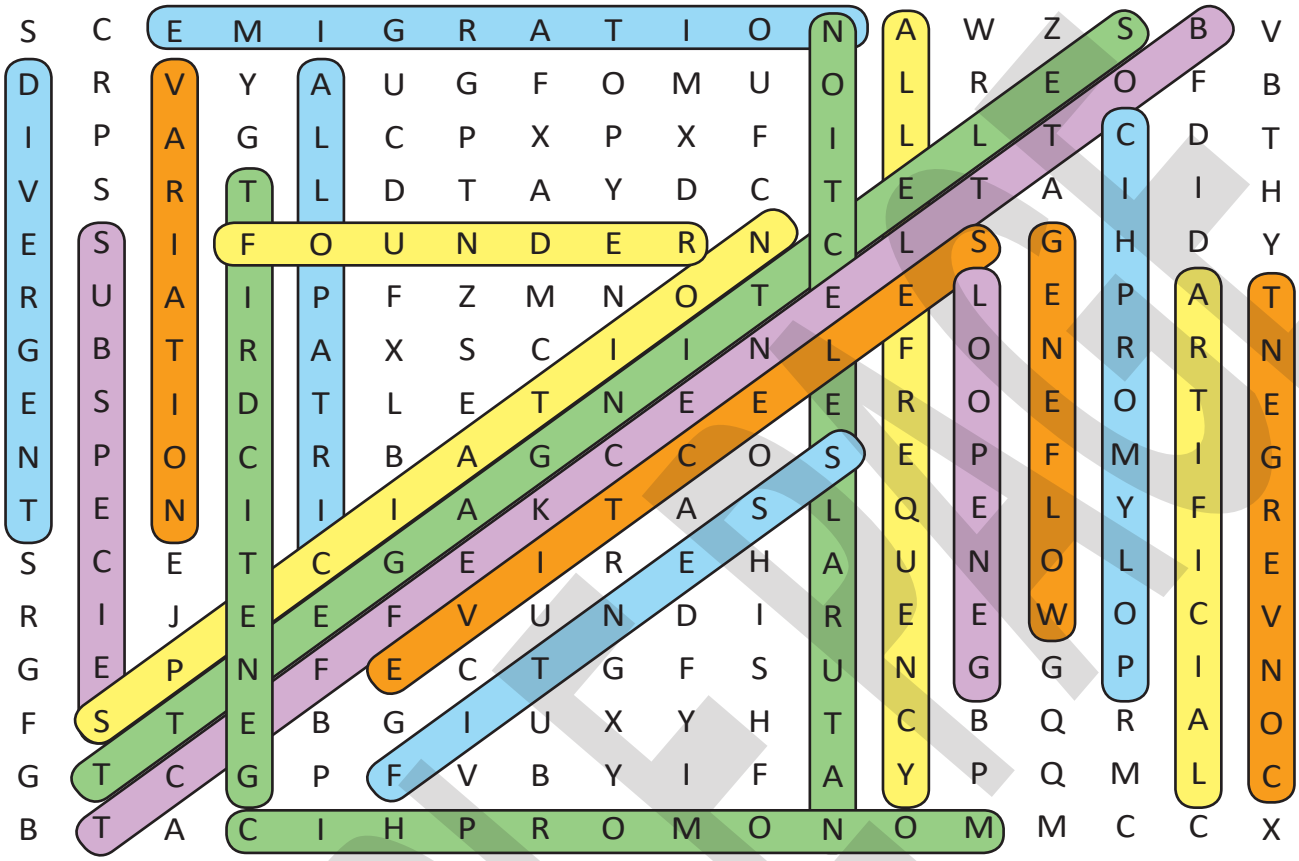
CHANGES IN POPULATIONS WORD FIND
(answers)



Answers to clues:

1. Natural selection
2. Selecting agent
3. Speciation
4. Gene flow
5. Genetic drift
6. Monomorphic
7. Variation
8. Allopatric
9. Allele frequency
10. Divergent
11. Selective
12. Polymorphic
13. Bottleneck effect
14. Emigration
15. Fitness
16. Founder
17. Subspecies
18. Artificial
19. Gene pool
20. Convergent

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VARIATION IN POPULATIONS: POLYPLOIDY

1. 'Polyploidy' is a condition that is rare in animals, but not unusual in plants. What is polyploidy?

_____

2. Define the following:

(a) Tetraploid: _____

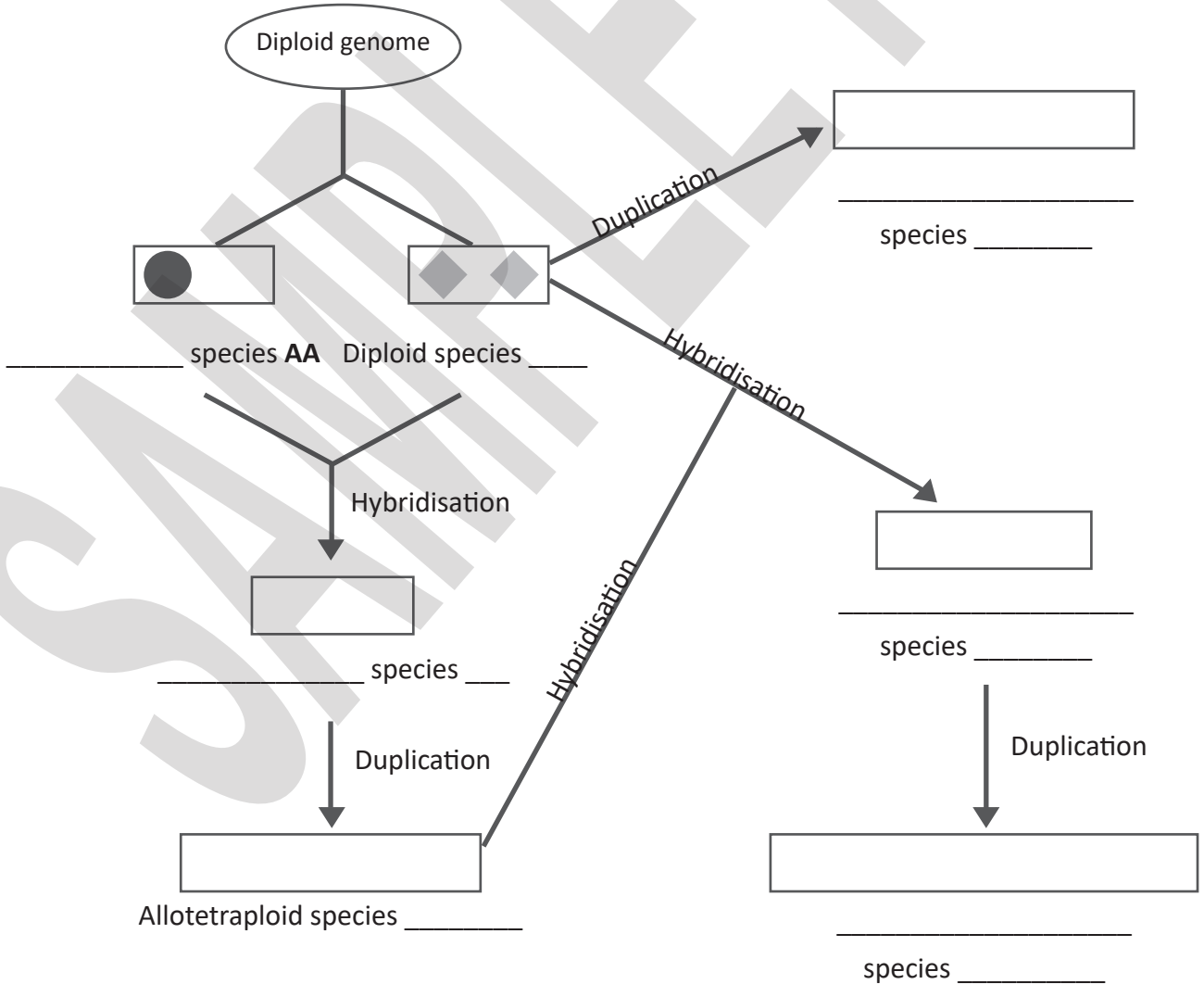
(b) Hexaploid: _____

(c) Autopolyploid: _____

(d) Allopolyploid: _____

3. It is possible to create polyploid plants by (i) *hybridisation*: crossing two parents from different species and (ii) *duplication*: doubling the number of chromosomes by using chemical treatment.

Complete the following diagram showing how polyploid plants can be created using two species, **A** and **B**.



haploid chromosome set for species **A**

haploid chromosome set for species **B**

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VARIATION IN POPULATIONS: POLYPLOIDY
(answers)

1. Polyploidy is a condition in which an organism has more that two matching sets of chromosomes.

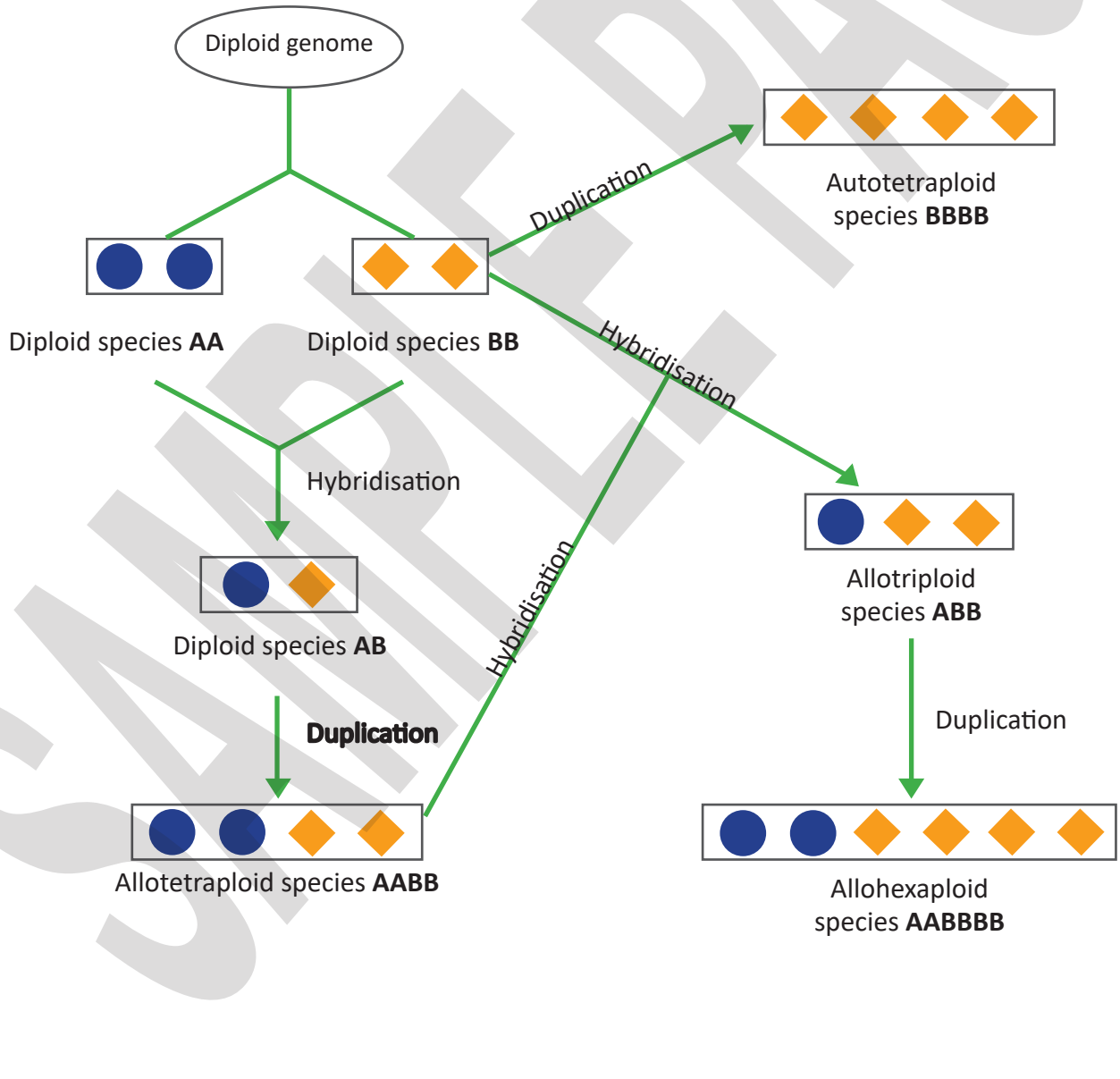
2. (a) Tetraploid: describes an organism that has four sets of chromosomes.

   (b) Hexaploid: describes an organism that has six sets of chromosomes.

   (c) Autopolyploid: describes an organism that has extra sets of chromosomes from its own species.

   (d) Allopolyploid: describes an organism that has extra sets of chromosomes from a different species.

3.



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DNA PROFILING

1. What is DNA profiling? Briefly describe what it involves.

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2. DNA profiling requires the use of special regions of DNA known as *short tandem repeats* (**STR**s). What are STRs and what makes them so useful in DNA profiling?

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3. The following table shows the number of repeats found at three different STR loci in person **A** and person **B**. The three STRs are known as *D3, FGA* and *D13.*

	Person A	**Person B**
STR locus	No. of repeats	No. of repeats
D3	12, 16	18, 30
FGA	40, 65	25, 50
D13	7, 10	10, 10

(a) Why does each person have two lots of repeats at each STR locus?

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(b) Is person **A** homozygous or heterozygous at the three STR loci? How can you tell?

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_____

(c) Is person **B** homozygous or heterozygous at (i) STR D3 (ii) STR D13?

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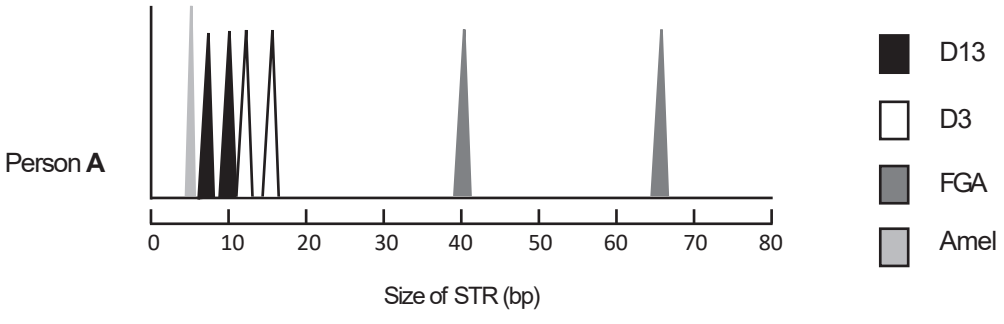
4. The following diagram shows the DNA profile of person **A**:



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(a) Is person **A** male or female? How do you know?

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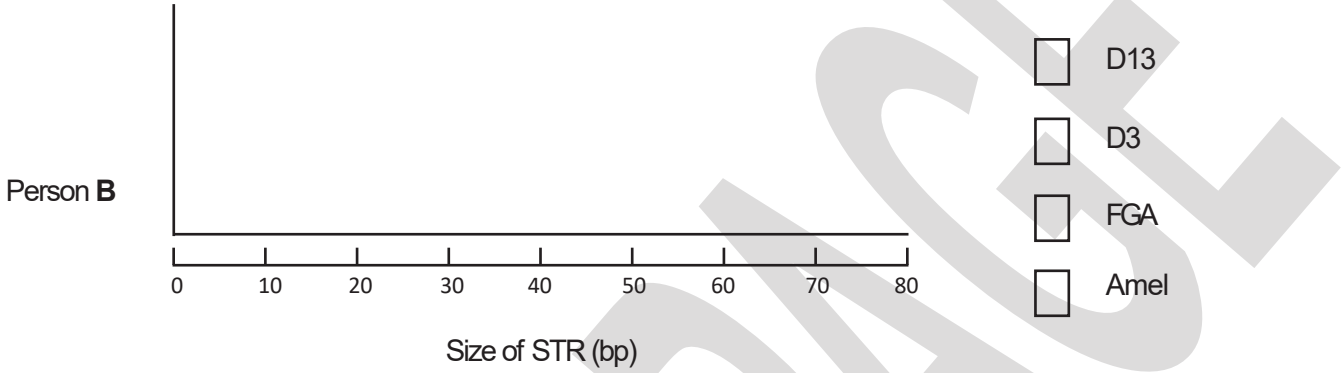
(b) Using information from the table in question 3, complete the DNA profile for the three STR loci from person **B** (use your own colours):



(c) Person **B** is a male. Add this information to the DNA profile above.

(d) In reality, many more than three STRs are used to create a DNA profile. In Australia, for example, 18 STRs are used. What is the advantage of using so many?

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(e) The USA uses 13 STRs to create a DNA profile. What is the maximum number of peaks that a person's profile can show based on 13 STRs? Explain your answer.

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The following table shows the DNA profiles of two parents and their three children based on four STRs.

STR locus	Father	Mother	Child 1	Child 2	Child 3
D5	7, 12	10, 15	10, 12	12, 15	12, 15
D13	6, 11	8, 14	8, 11	8, 14	6, 14
D18	16, 20	22, 27	16, 27	18, 22	20, 22
D21	25, 30	27, 30	30, 30	30, 31	25, 30

5. Which of the three children is *not* the father's biological child? Explain.

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DNA PROFILING
(answers)

1. DNA profiling is a method of identifying people - or even animals - based on *hypervariable* regions of DNA, that is, DNA that varies greatly between individuals (except for identical twins).

2. Short tandem repeats (**STR**s), also known as *microsatellites*, are hypervariable regions of chromosomes consisting of sequences of two to five base pairs that are repeated many times. They are useful in DNA profiling because they are unique to the individual (except identical twins) and can therefore be used for identification with a high degree of accuracy.

3.

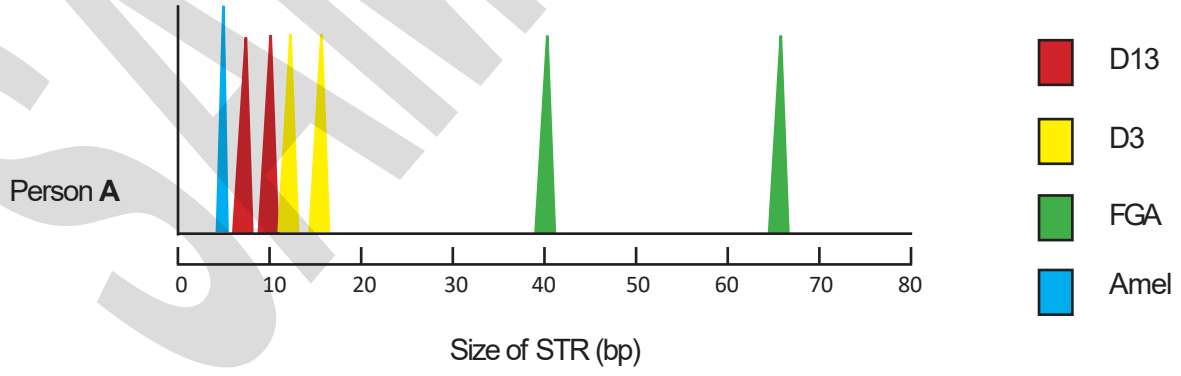
	Person A	**Person B**
STR locus	No. of repeats	No. of repeats
D3	12, 16	18, 30
FGA	40, 65	25, 50
D13	7, 10	10, 10

(a) Each person has two lots of repeats at each STR locus because there are two chromosomes with that particular STR, one that comes from the mother and one from the father.

(b) Person **A** is heterozygous at all three STR loci because in each case, the number of repeats on one chromosome differs from that on the other (each variation acts as a distinct allele).

(c) (i) Heterozygous. (ii) Homozygous.

4.



(a) Person **A** is female because only one Amel gender marker is seen. This is because there are two X chromosomes and the Amel gene is the same size on each.

(b) See diagram on the next page.

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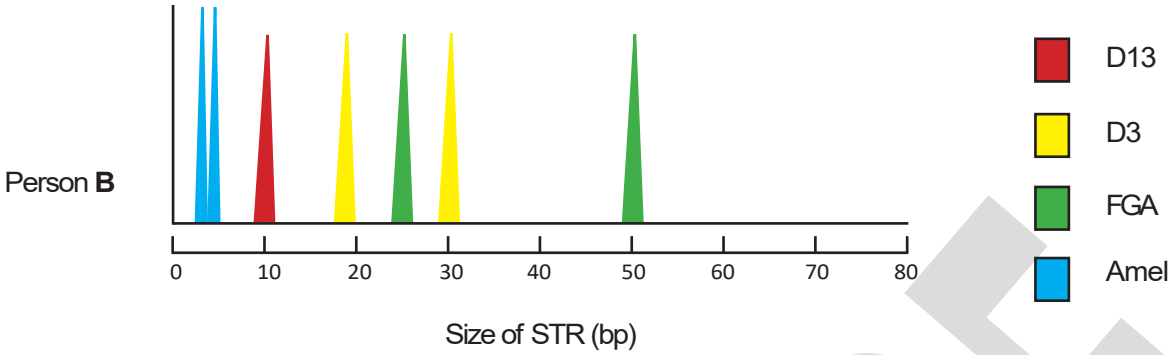

(c) See above diagram.

(d) The higher the number of STRs used, the more accurate the profile because the chance that two unrelated people will have the same pattern of peaks becomes very low (with 18 STRs, the chance is one in many billions).

(e) Based on 13 STRs, the maximum number of peaks that any person can have is 26, meaning that the individual is heterozygous at all STR loci. If he/she is homozygous at any STR locus, the number will be less than 26.

STR locus	Father	Mother	Child 1	Child 2	Child 3
D5	7, 12	10, 15	10, 12	12, 15	12, 15
D13	6, 11	8, 14	8, 11	8, 14	6, 14
D18	16, 20	22, 27	16, 27	18, 22	20, 22
D21	25, 30	27, 30	30, 30	30, 31	25, 30

5. Child **2** is *not* the father's biological child because he/she has inherited repeats at certain STR loci that are not present in the father, for example, at D13 and D18 (biological children always inherit the same number of repeats as those found on at least one of the chromosomes of the parent).

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