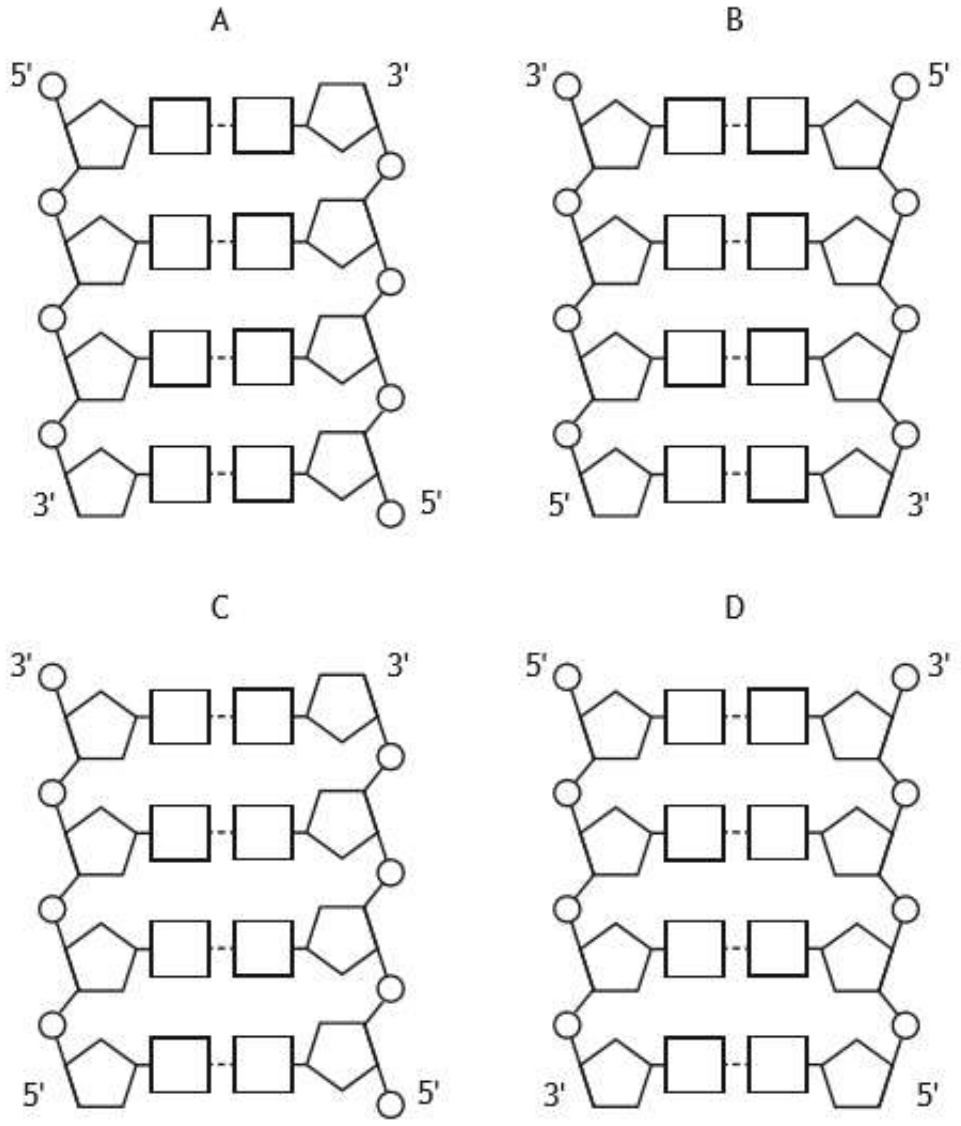
Higher Unit 1:

DNA and the Genome

Topic 1.1 The Structure and Organisation of DNA

1. Which of the following diagrams shows the correct structure of DNA?



1

2. A section of double stranded DNA was found to have 60 guanine bases and 30 adenine bases. What is the total number of deoxyribose sugars in this section?

A 30

B 90

C 180

D 270

1

3. The following terms describe different structures into which DNA can be organised within cells.

1 Linear chromosome

2 Circular chromosome

3 Circular plasmid

Which of these terms describe how DNA is organised within photosynthetic plant cells?

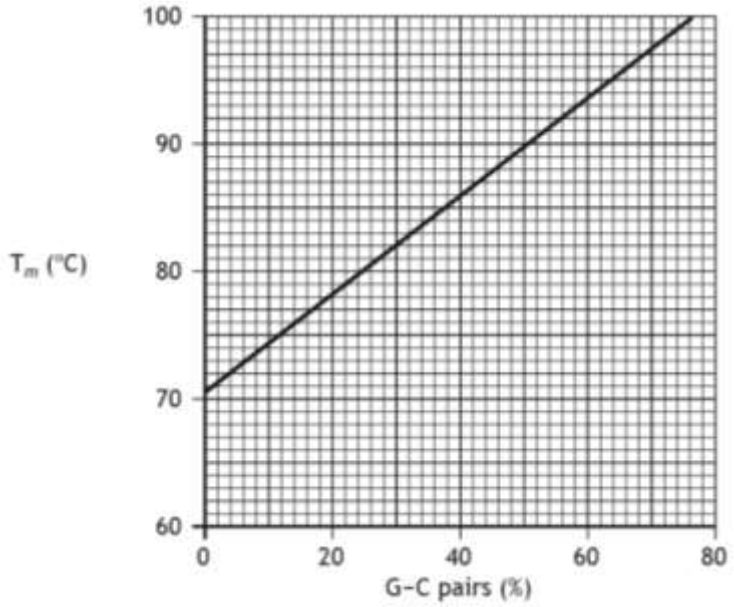
A 1 only

B 2 only

C 1 and 2 only

D 2 and 3 only **1**

4. The melting temperature of a molecule of DNA (Tm) is the temperature at which half of its base pairs separate. Tm is proportional to the percentage of the guanine to cytosine (G–C) base pairs in the molecule as shown on the graph below.



The numbers of base pairs present in a DNA molecule are shown in the table below.

Number of base pairs present	
A-T	**G-C**
1200	**800**

What is Tm for this molecule?

A 78 ºC
B 86 ºC
C 94 ºC
D 96 ºC **1**

5. The genetic material in human mitochondria is arranged as

A linear chromosomes
B circular plasmids
C circular chromosomes
D inner membranes **1**

6. DNA holds the genetic information in both prokaryotic and eukaryotic cells.

(a) (i) Describe one organisational difference between prokaryotic and eukaryotic chromosomal DNA.

_____

_____ **1**

(ii) Name the substance with which DNA is packaged in eukaryotes.

_____ **1**

(b) State one location, other than the nucleus, where DNA is found in eukaryotic cells.

_____ **1**

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Topic 1.2 Replication of DNA

1. Which of the following molecules are required in the replication of the lagging strand of a DNA molecule?

A DNA polymerase and ligase only
B DNA polymerase and primers only
C Ligase and primers only
D DNA polymerase, ligase and primers **1**

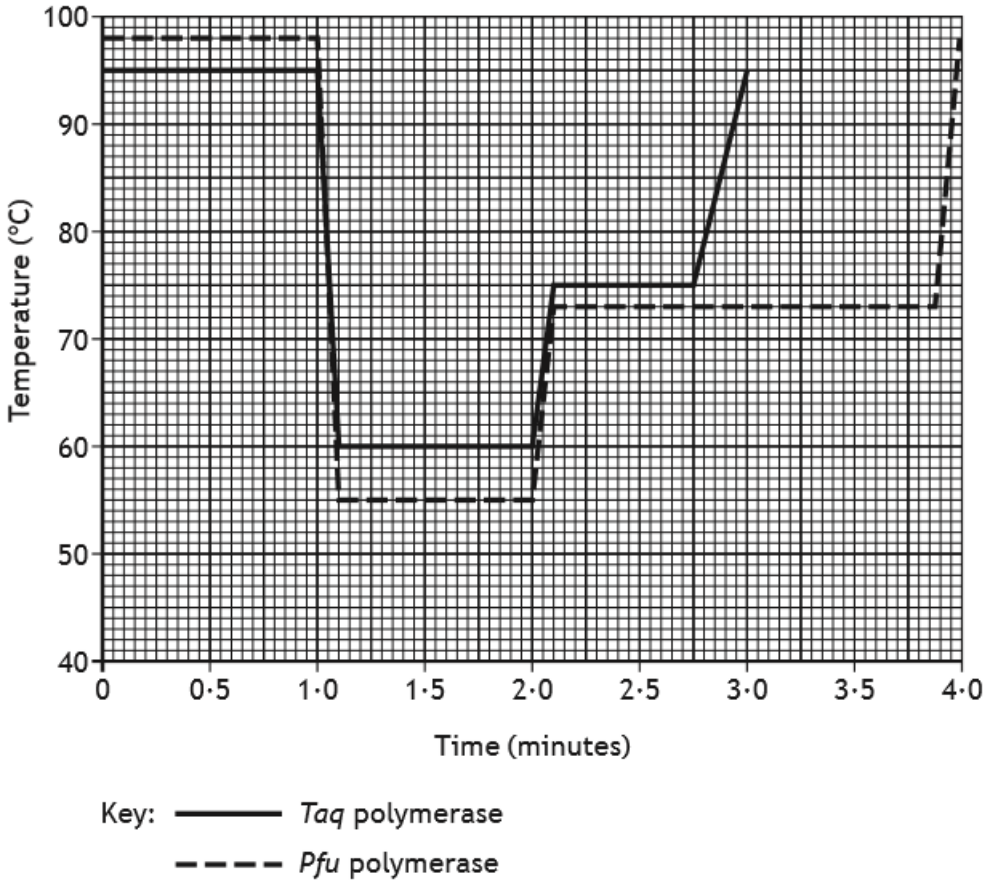
2. Which of the following are required in a polymerase chain reaction (PCR)?

A DNA polymerase, template strand and primers
B RNA polymerase, template strand and primers
C DNA polymerase, template strand and ligase
D RNA polymerase, ligase and primers **1**

3. Each cycle of a polymerase chain reaction (PCR) takes 5 minutes. If there are 1000 DNA fragments at the start of the reaction, how long will it take for the number of fragments produced by the reaction to be greater than 1 million?

A 15 minutes
B 35 minutes
C 50 minutes
D 55 minutes **1**

4. Two heat-tolerant DNA polymerases used in polymerase chain reactions (PCR) are Taq and Pfu. Pfu has "proof reading" activity. It checks that the correct nucleotides are inserted during replication of a target sequence and then corrects any errors. The graph shows the temperatures during a single PCR cycle required to amplify a target sequence using Taq and Pfu.



(a) (i) Calculate the time taken for 16 copies of the target sequence to be made from one DNA fragment using Taq polymerase.

Space for calculation

_____ minutes **1**

(ii) Identify the time period during which primers bind to the original DNA fragment.

from _____ to _____ minutes. **1**

(b) A scientist was planning to amplify DNA using PCR. State which DNA polymerase should be used and describe the advantage of using this polymerase.

DNA polymerase _____

Advantage _____

_____

_____ **1**

(c) Explain the importance of using heat-tolerant DNA polymerases in PCR.

_____

_____ **1**

5. During DNA replication two new daughter strands are synthesised using the original strands as templates.

(a) (i) State why the antiparallel nature of the DNA molecule results in one of the strands being synthesised in short fragments.

_____

_____

(ii) Template DNA, enzymes and ATP are necessary for DNA replication. State one other substance required.

_____ **1**

(b) Explain why cells need to carry out DNA replication.

_____

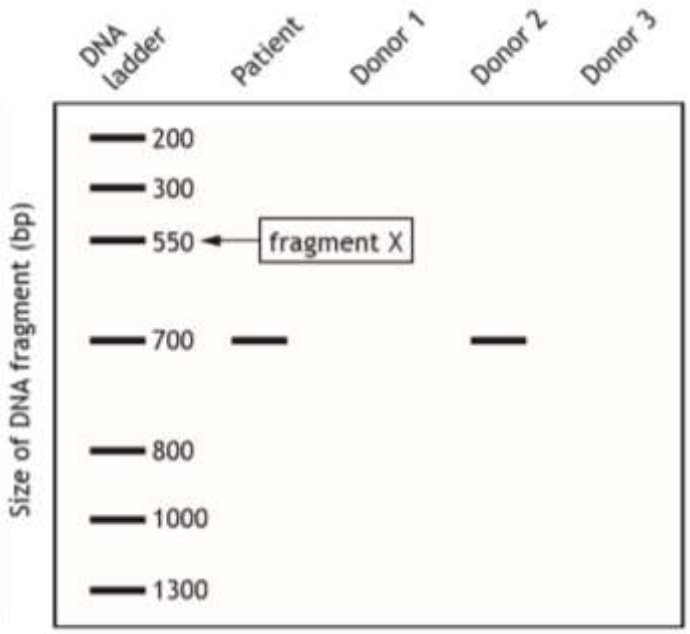
_____ **1**

6. Patients requiring an organ transplant are tissue typed to match with potential donors. Polymerase chain reaction (PCR) and gel electrophoresis are used to compare DNA sequences of the patient with those of donors. Gel electrophoresis separates mixtures of DNA fragments according to size. The presence of a specific DNA band indicates that a donor is a suitable match.

Patient and potential donor samples were compared with a DNA ladder.

The DNA ladder contains fragments of DNA, separated by gel electrophoresis, which are of a known size and measured in base pairs (bp). The distances the DNA fragments travelled were measured and are shown in the table below. The diagram below shows the result of the gel electrophoresis.

Size of DNA fragment (bp)	*Distance travelled* (mm)
200	72
300	58
550	32
700	18
800	12
1000	10
1300	8



(a) The gel used for electrophoresis contains agarose. Calculate the mass of agarose required to make 30 cm3 of a 0·8% agarose gel.

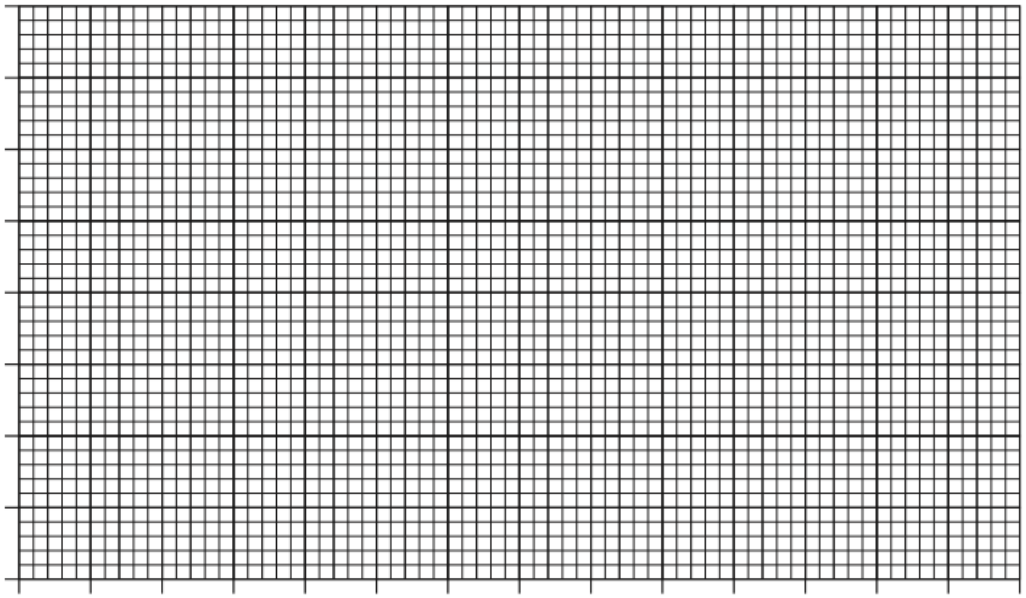
Space for calculation

_____ g **1**

(b) Using information in the table and the diagram give the distance travelled by fragment X in the DNA ladder.

_____ mm **1**

(c) On the grid below, draw a line graph to show the distance travelled against the size of DNA fragment.



2

(d) Give a conclusion about the suitability of the donors.

_____ **1**

(e) (i) The base sequence of a primer used in the PCR procedure is shown below.

A T G A C A A A T C G

Give the base sequence of a DNA fragment to which this primer would bind.

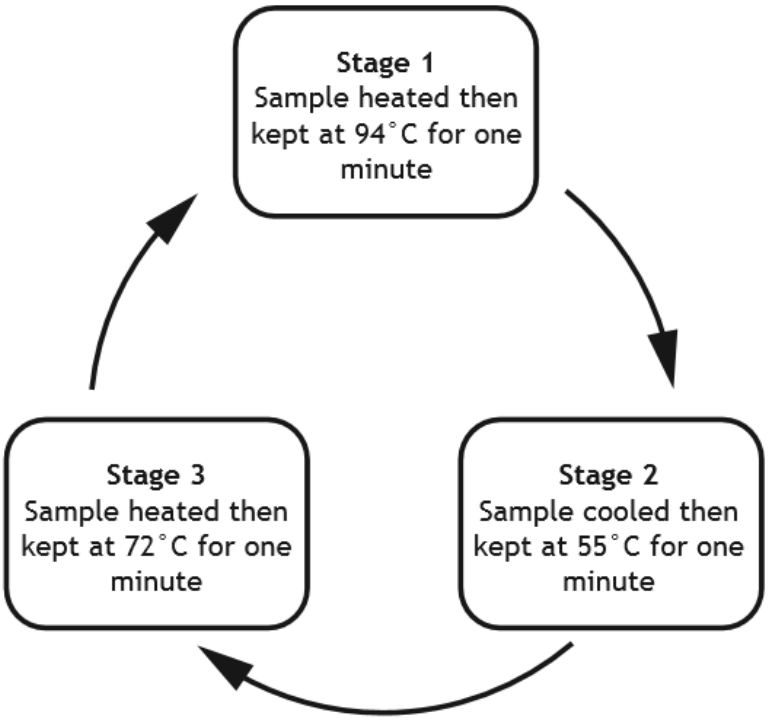
_____ **1**

(ii) Complete the table below to show the temperatures used in two stages of the PCR procedure and the reasons for using these temperatures.

Temperature (ºC)	*Reason*
94	
	Allows primer to bind to target sequence

2

7. The polymerase chain reaction (PCR) amplifies specific sequences of DNA. The flow chart below shows how a sample of DNA was treated during a cycle of the PCR procedure.



(a) Explain the purpose of the different heat treatments in Stage 1 and Stage 2.

_____

_____

_____ **2**

(b) The number of DNA molecules doubles during each cycle of the PCR procedure. Calculate the number of cycles needed to produce 128 copies of a single DNA molecule.

Space for calculation.

_____ cycles **1**

(c) The diagram below shows the contents of a tube used in PCR.

Contents of tube

– DNA
– DNA nucleotides
– primers
– enzyme and buffer

Describe the contents of a suitable control tube designed to show that primers are needed in the reaction.

_____

_____

1

(d) State one practical application of PCR.

_____ **1**

Higher Unit 1:

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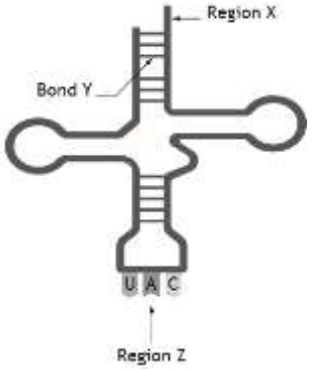
Topic 1.3 Control of gene expression

1. The diagram shows a molecule of tRNA.

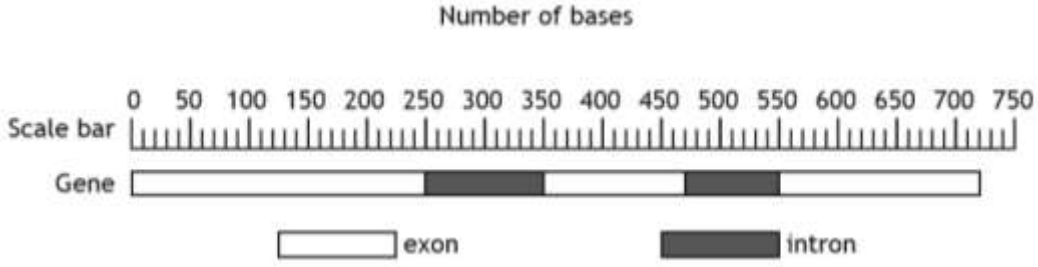


Which row in the table identifies Region X, Bond Y and Region Z?

	Region X	*Bond Y*	*Region Z*
A	amino acid attachment site	hydrogen	Anticodon
B	anticodon	hydrogen	amino acid attachment site
C	amino acid attachment site	peptide	anticodon
D	Anticodon	peptide	amino acid attachment site

1

2. The diagram below shows a eukaryotic gene containing introns and exons and a scale bar representing the number of bases in the gene.



How many bases will there be in the mature mRNA formed from the primary transcript of this gene?

A 180

B 540

C 560

D 720

1

3. The main components of a ribosome are

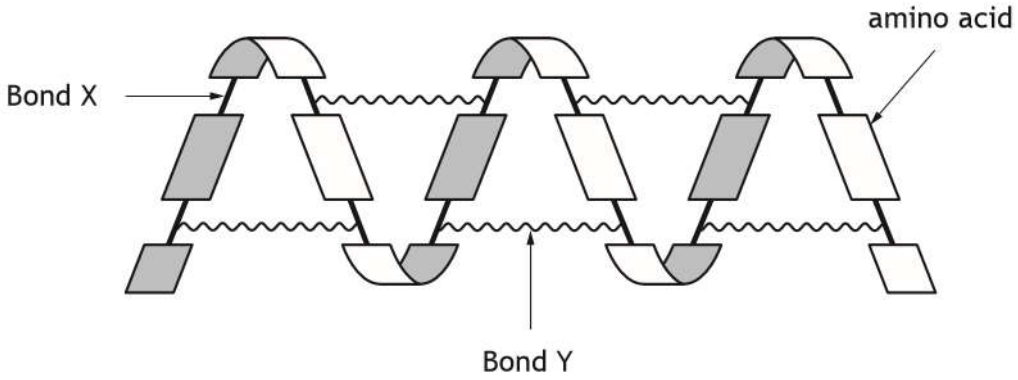
A mRNA and tRNA

B rRNA and protein

C mRNA and protein

D rRNA and mRNA. **1**

4. The diagram below represents part of a protein molecule.

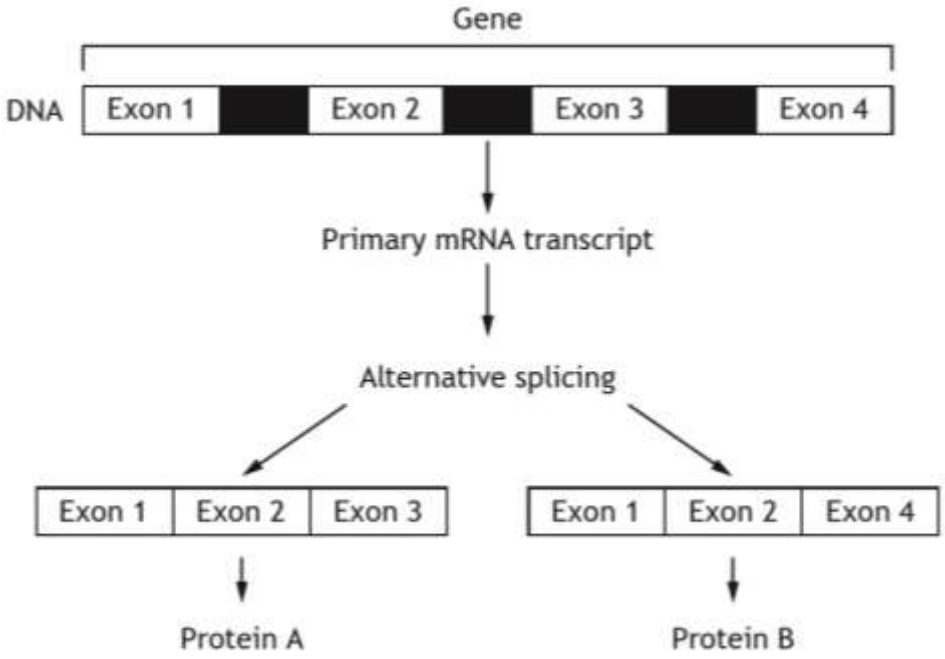


Which line in the table below identifies bonds X and Y?

	Bond X	*Bond Y*
A	hydrogen	peptide
B	hydrogen	hydrogen
C	peptide	hydrogen
D	peptide	peptide

1

5. The diagram illustrates steps in the transcription and translation of a gene.



(a) Name the regions always removed from a primary mRNA transcript.

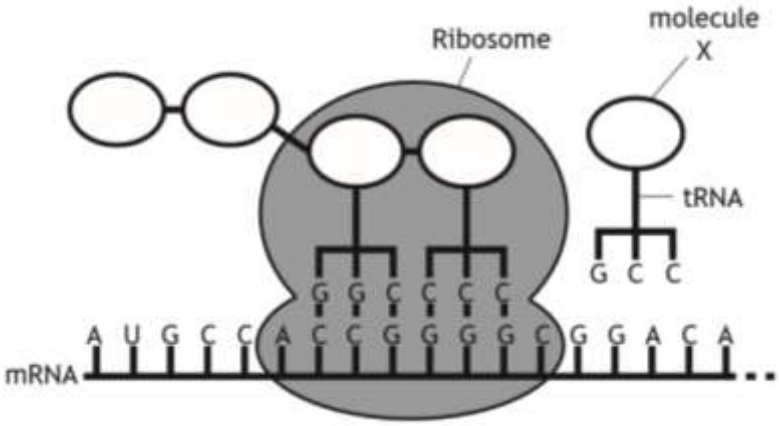
_____ **1**

(b) Insert numbers in the boxes below to show the three exons in the gene shown above which could be translated to produce a protein which is different from proteins A and B.

Exon _____	Exon _____	Exon _____

1

6. The diagram below shows a process involved in the production of a polypeptide in a cell.



(a) Name molecule X

_____ **1**

(b) State one substance, other than ribosomal RNA (rRNA), that makes up the ribosome.

_____ **1**

(c) Many polypeptides are modified in order to produce functional proteins. Describe one way in which a polypeptide could be modified.

_____

_____ **1**

(d) In some eukaryotic cells, different mRNA molecules, and therefore different proteins, can be expressed from a single gene.

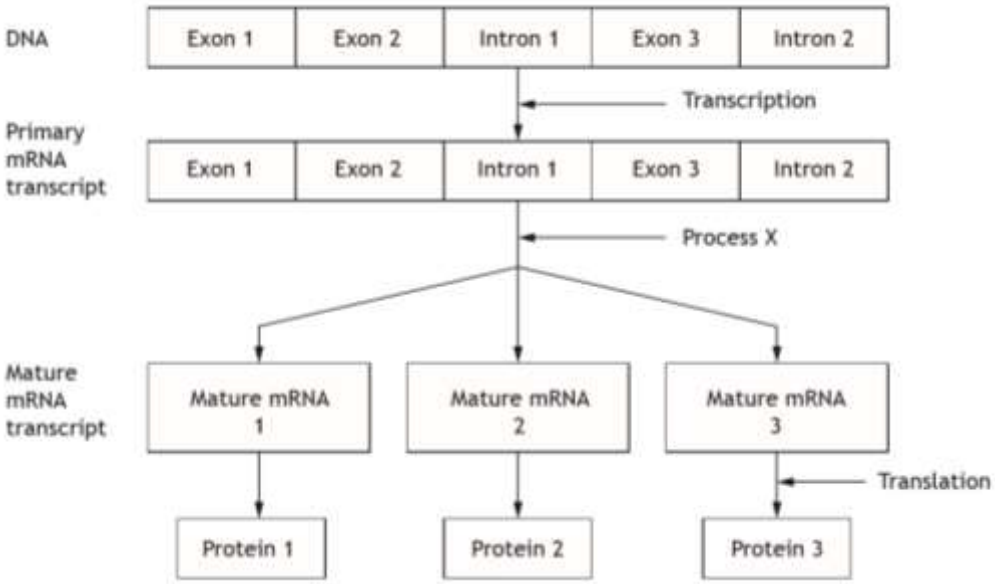
Name and describe the process which results in different mRNA molecules being expressed.

Name _____

Description _____

_____ **2**

7. The diagram below shows stages in the production of three different proteins that are coded for by one gene.



(a) (i) Identify a non-coding region of DNA.

_____ **1**

(ii) Name process X.

_____ **1**

(iii) Explain how process X can produce different mature mRNA transcripts.

_____

_____

_____ **2**

(b) Some proteins undergo post translational modification to make them functional. Give one example of post translational modification.

_____ **1**

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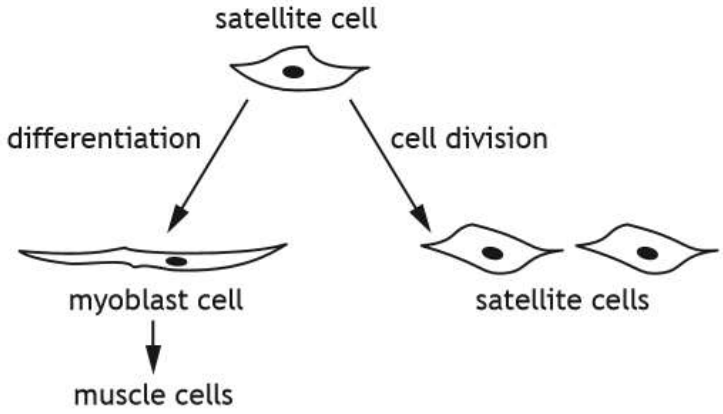
Topic 1.4 Cellular Differentiation

1. Which line in the table below describes meristems.

	Found in	*Type of cell present*
A	animal	specialised
B	animal	unspecialised
C	plant	Specialised
D	plant	unspecialised

1

2. Human muscles contain satellite cells within the muscle tissue. The diagram illustrates the division and differentiation of satellite cells.



(a) (i) Using information from the diagram explain why satellite cells are an example of tissue (adult) and not embryonic stem cells.

_____

_____ **1**

(ii) State one benefit to the human body of satellite cells differentiating into myoblast cells.

_____

_____ **1**

(iii) Satellite cells could be used to treat muscle diseases. Give one ethical reason for using satellite cells instead of embryonic stem cells in order to treat such diseases.

_____

_____

1

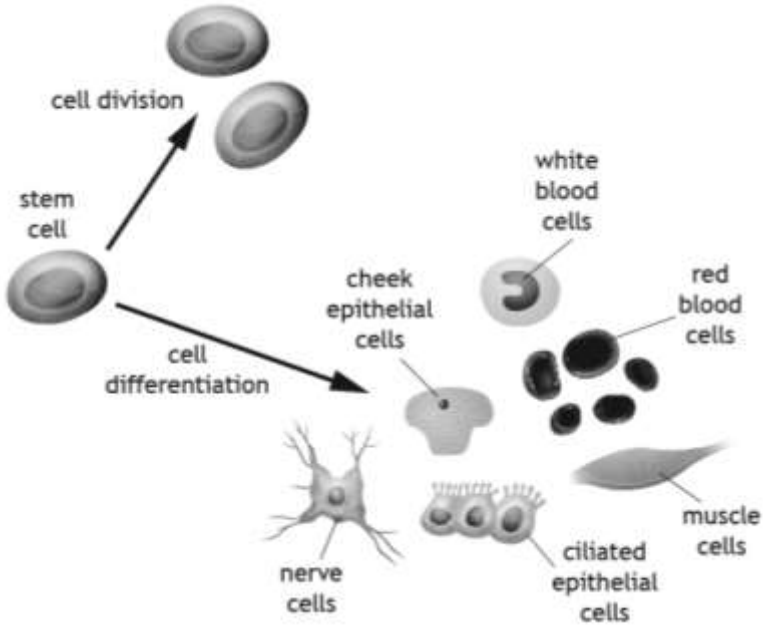
(b) Give one example of how stem cells are used as model cells in medical research.

_____

_____

1

`3. Stem cells are unspecialised cells which can be found in embryonic and adult tissue.



(a) Explain how the diagram above indicates that the stem cell shown is an embryonic and not a tissue (adult) stem cell.

_____

_____ **1**

(b) After a stem cell differentiates, only certain genes are expressed. Explain how this results in different cell types.

_____

_____ **1**

(c) Give one therapeutic use of stem cells.

_____

_____ **1**

(d) State one ethical issue relating to the use of embryonic stem cells.

_____

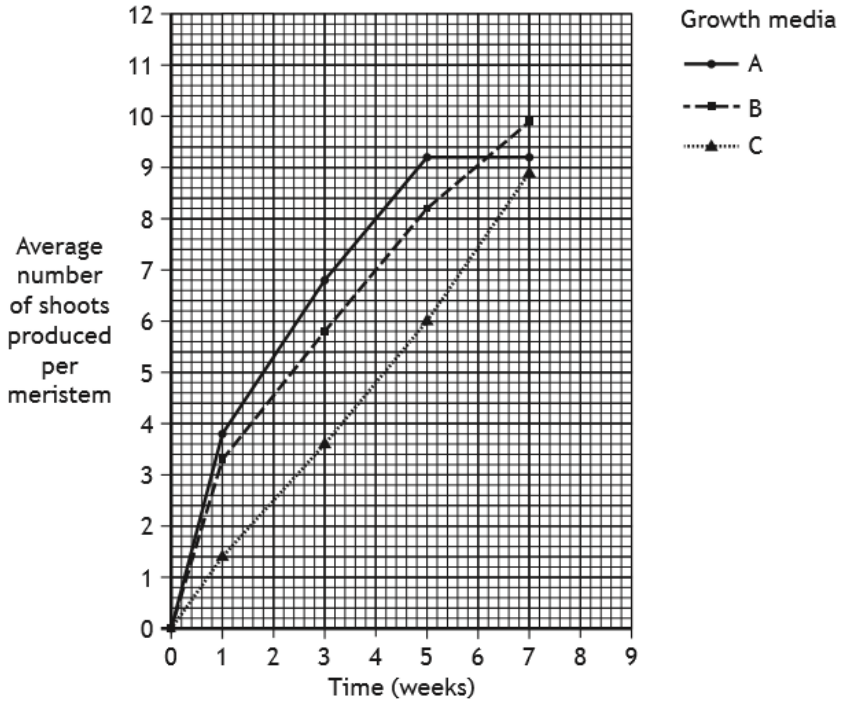
_____ **1**

4. Meristems can be cultured in growth medium to produce new plants.

An experiment was carried out to investigate the effects of three different growth media (A, B and C) on the production of shoots by meristems of African violet plants.

Five meristems were removed and cultured in each medium for a period of seven weeks. The average number of shoots produced per meristem was recorded at specific times during the investigation.

The results are shown in the graph below.



(a) (i) Use values from the graph to describe the average number of shoots produced per meristem over the seven week period in medium A.

_____

_____

_____ **2**

(ii) Calculate the percentage increase in the average number of shoots produced per meristem between week 1 and week 7 in medium B.

Space for calculation.

_____ *%* **1**

(iii) Table 1 below shows the number of shoots produced per meristem at three weeks in one of the media.

Table 1

Meristem	***Number of shoots produced per meristem***
1	**4**
2	**5**
3	**7**
4	**7**
5	**6**

Using information from Table 1 and the graph, state the medium in which these meristems were cultured.

Space for calculation

Medium _____ **1**

(b) Predict which medium would produce plants with the greatest number of shoots after nine weeks growth. Give a reason for your answer.

Medium _____

Reason _____

_____ **2**

(c) In a further experiment, the average number of roots and average root length at 7 weeks were recorded in each of the media.

The results are shown in Table 2 below.

Table 2

Medium	***Average number of roots produced per meristem***	***Average root length (mm)***
A	**12**	**12**
B	**11**	**19**
C	**12**	**17**

After analysing the results, medium B was used for the commercial production of plants.

Use the information in Table 2 to explain why plants cultured in medium B would grow best.

_____

_____ **2**

5. An investigation was carried out involving a number of patients with heart disease. A group of volunteer patients was treated with adult stem cells and a control group was not given this treatment.

Six weeks after the treatment, the average heart rate and the average volume of blood pumped out per heartbeat (stroke volume) was determined for each group.

The results are shown in the table below.

	Patients given stem cell treatment	*Patients not given stem cell treatment*
Average heart rate (beats per minute)	70	70
Average stroke volume (cm^3)	45	28

(a) Give two conclusions which can be drawn about the effect of the stem cell treatment on the patients.

1 _____

_____

2 _____

_____ **2**

(b) Another important measure of heart performance is cardiac output.

Cardiac output = heart rate × stroke volume

(cm3 per minute) (bpm) (cm3)

Calculate the average increase in cardiac output in those patients given the stem cell treatment compared to those in the control group.

Space for calculation

_____ cm^3 per minute **1**

(c) (i) Describe how tissue (adult) stem cells differ from embryonic stem cells.

_____

_____

1

(ii) Describe how the heart cells produced by the patients as a result of the stem cell treatment in this investigation developed their specialised functions.

_____

_____

1

(d) Much stem cell research is related to the therapeutic value of stem cells. Give one other reason for carrying out stem cell research.

_____

_____

1

Higher Unit 1:

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Topic 1.5 The Structure of the Genome

1. Which line in the table below shows features of the human genome?

	Contains base sequences that regulate transcription	*Contains base sequences transcribed to RNA but never translated*	*Contains base sequences from which primary transcripts are produced*
A	X	√	X
B	X	X	√
C	√	√	X
D	√	√	√

1

Higher Unit 1:

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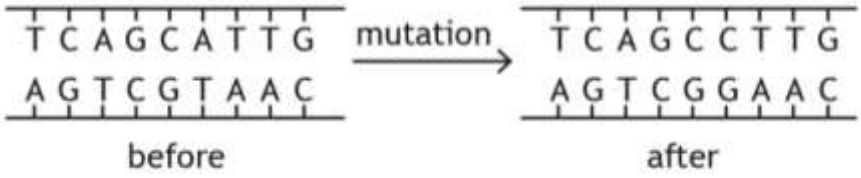
Topic 1.6 Mutations

1. The diagram below shows part of a DNA molecule before and after a mutation.



The type of mutation shown is

A deletion

B substitution

C insertion

D inversion **1**

2. Types of single gene mutation are given in the list below.

1 substitution

2 insertion

3 deletion

Which of these would affect only one amino acid in the polypeptide produced?

A 1 only

B 2 only

C 3 only

D 2 and 3 only **1**

3. The table below provides information about ancestral and modern Brassica species. The modern species have been produced by hybridisation of two ancestral species followed by a doubling of the chromosome number in the hybrids.

Brassica species	*Ancestral or modern species*	*Crop*	*Diploid chromosome number (2 n)*
B. oleracea	ancestral	cabbage	18
B. nigra	ancestral	black mustard	16
B. rapa	ancestral	turnip	20
B. juncea	modern	Indian Mustard	36
B. carinata	modern	Ethiopian Mustard	34
B. napus	modern	oilseed rape	38

Which of the following shows the ancestral hybridisation and the modern species produced?

A Cabbage × turnip → oilseed rape

B Turnip × black mustard → Ethiopian mustard

C Turnip × cabbage → Indian mustard

D Cabbage × black mustard → Indian mustard **1**

4. Single gene mutations can occur which may affect the structure of the proteins produced.

(a) (i) Describe the effect of a nonsense mutation on Protein A and give a reason for your answer.

Description_____

_____

Reason_____

_____ **2**

(ii) A deletion mutation occurred in Exon 2.

Explain why this would have a major effect on the structure of proteins A and B.

_____

_____

_____ **1**

5. Polyploidy can lead to speciation.

(a) (i) State what is meant by the term polyploidy.

_____

_____

1

(ii) Describe one example of the importance of polyploidy in evolution.

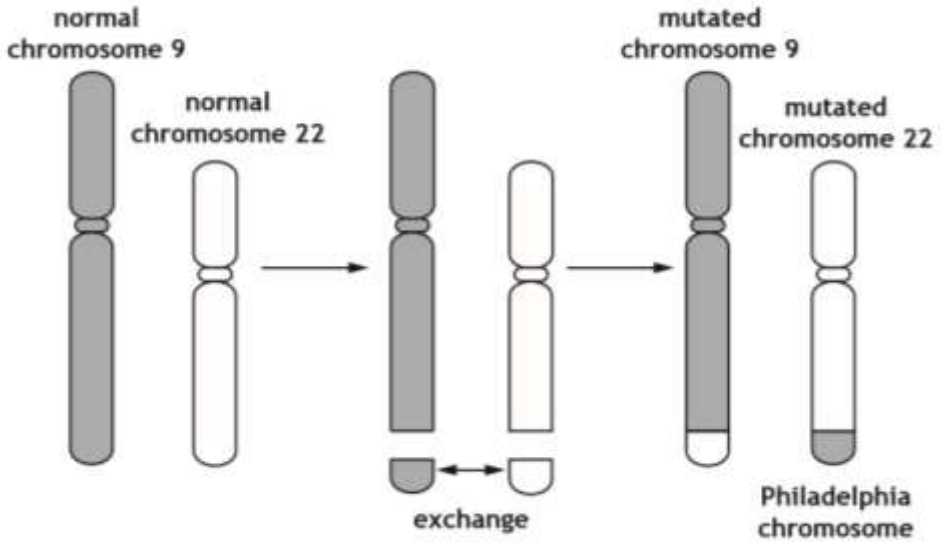
_____

_____

1

6. A chromosome mutation in humans can result in the formation of the Philadelphia chromosome, which is associated with a form of leukaemia.

The stages leading to the formation of a Philadelphia chromosome are shown in the diagram below.



(a) Name the type of chromosome mutation, shown in the diagram, which results in the formation of a Philadelphia chromosome.

_____ **1**

(b) (i) The presence of a Philadelphia chromosome causes a form of leukaemia through the over-production of an enzyme.

A drug has been used to successfully treat this form of leukaemia by blocking the active site of the enzyme.

Name the type of enzyme inhibition shown by this drug.

_____ **1**

(ii) White blood cell counts in humans normally range from 5000 to 10 000 cells per µl of blood.

The table below shows the white blood cell counts from a patient with leukaemia before and after treatment with this drug.

	Number of white blood cells (per µl blood)
Before treatment	150 000
After treatment	7500

Calculate the percentage decrease in the number of white blood cells after treatment with this drug.

Space for calculation

_____ % **1**

(iii) Explain how the results suggest that the type of leukaemia in this patient was a result of the presence of a Philadelphia chromosome.

_____

_____

_____ **2**

Higher Unit 1:

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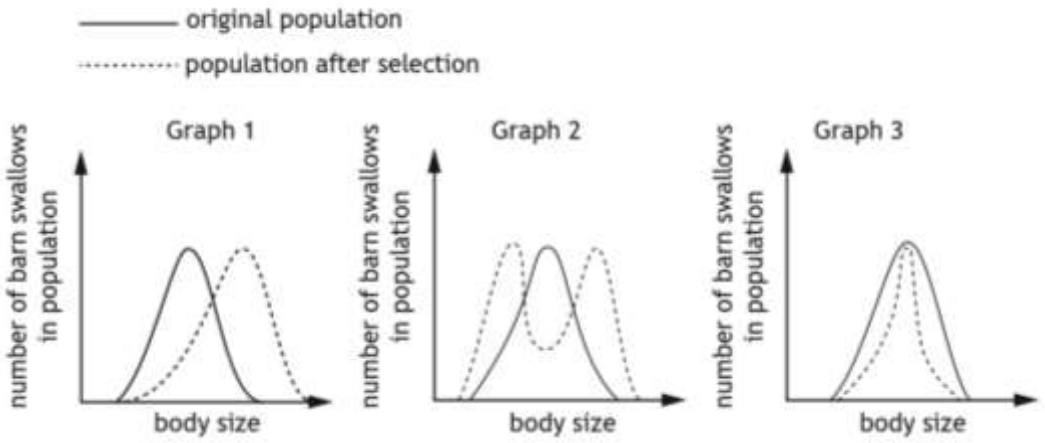
Topic 1.7 Evolution

1. The graphs below show possible changes in the body size of a population of barn swallows, Hirudino rusticana, in response to a selection pressure.



Which row in the table below matches each graph with the type of selection taking place?

	Graph		
	1	***2***	***3***
A	disruptive	directional	stabilising
B	directional	disruptive	stabilising
C	stabilising	disruptive	directional
D	directional	stabilising	disruptive

1

2. Which of the following would not explain loss of genetic diversity in a population?

A Inbreeding

B The founder effect

C The bottleneck effect

D No barriers to gene flow **1**

3. The herbicide glyphosate is used to control the annual weed charlock (Sinapis arvensis) in cereal fields.

An investigation was carried out into the effect of glyphosate on the development of glyphosate resistance in charlock plants in a cereal plot.

The charlock plants were treated with glyphosate from 2009 to 2016 and the percentage of glyphosate resistant plants in the plot was recorded every year.

The results are shown in the table.

Year	*Charlock plants resistant to glyphosate (%)*
2009	10
2010	18
2011	32
2012	42
2013	53
2014	58
2015	66
2016	66

(a) Using values from the table describe the change in glyphosate resistance over the time of investigation.

_____

_____

_____

_____ **2**

(b) Explain how natural selection resulted in the change in glyphosate resistance.

_____

_____

_____

_____ **2**

(c) Another investigation was carried out into the development of antibiotic resistance in bacteria. It was observed to be more rapid than the development of glyphosate resistance in charlock.
Explain this observation in terms of gene transfer.

_____

_____ **1**

4. In the North Pacific Ocean there are two different populations of killer whales Orcinus orca. One population feeds mainly on fish while the other feeds mainly on sea mammals.

This behavioural barrier has led to considerable genetic variation between these populations.

(a) (i) Name the type of speciation which could occur as a result of this barrier.

_____ **1**

(ii) State the importance of isolation barriers in speciation.

_____

_____ **1**

(iii) Scientists believe that these two populations are still the same species. Suggest how they could confirm this.

_____

_____

1

Higher Unit 1:

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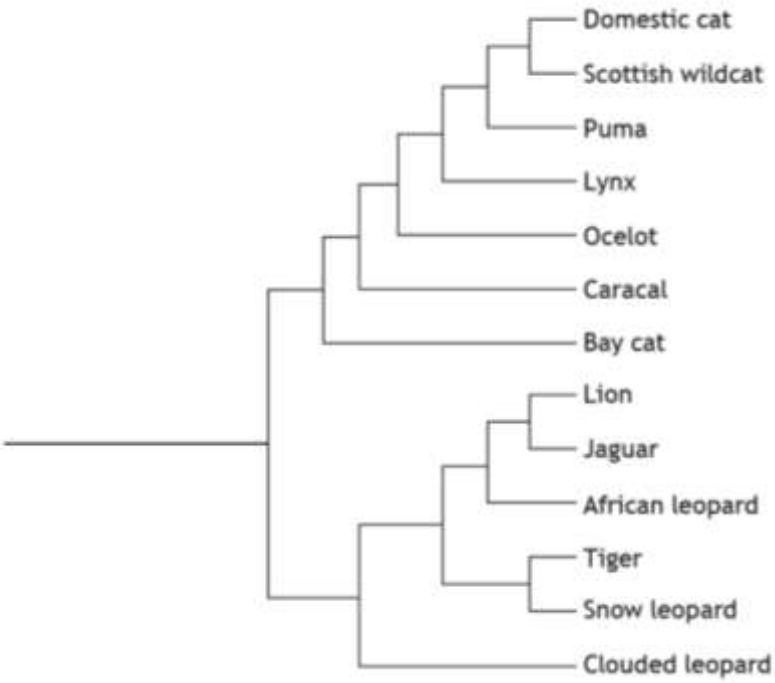
Topic 1.8 Genomic Sequencing

1. The diagram below represents a phylogenetic tree showing the evolutionary relatedness of several species of cat.



With how many species does the African leopard share a common ancestor in this phylogenetic tree?

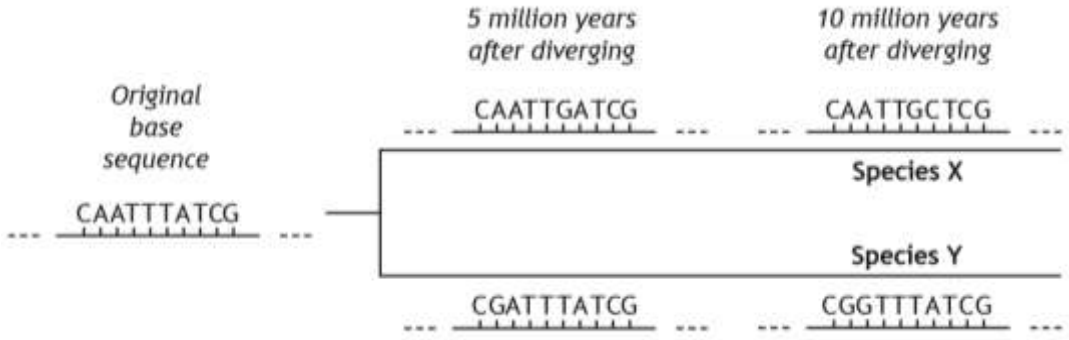
A 2 only

B 5 only

C 12 only

D 13 **1**

2. Over millions of years of evolution, mutations occur at a broadly constant rate within a gene. This allows genes to be used as molecular clocks. The diagram below shows how the base sequence in part of a gene changed as two evolutionary lineages diverged from an original base sequence. The base sequence in the gene has changed at a rate of 1 base per 5 million years as shown.



Assuming this rate of mutation continued, by how many bases would this part of the gene differ in Species X compared with Species Y 20 million years after diverging from the original base sequence?

A 4

B 8

C 16

D 20 **1**

3. The following are events in the evolution of life on Earth.

1 Animals appear

2 Vertebrates appear

3 Land plants appear

In which order are these events thought to have occurred?

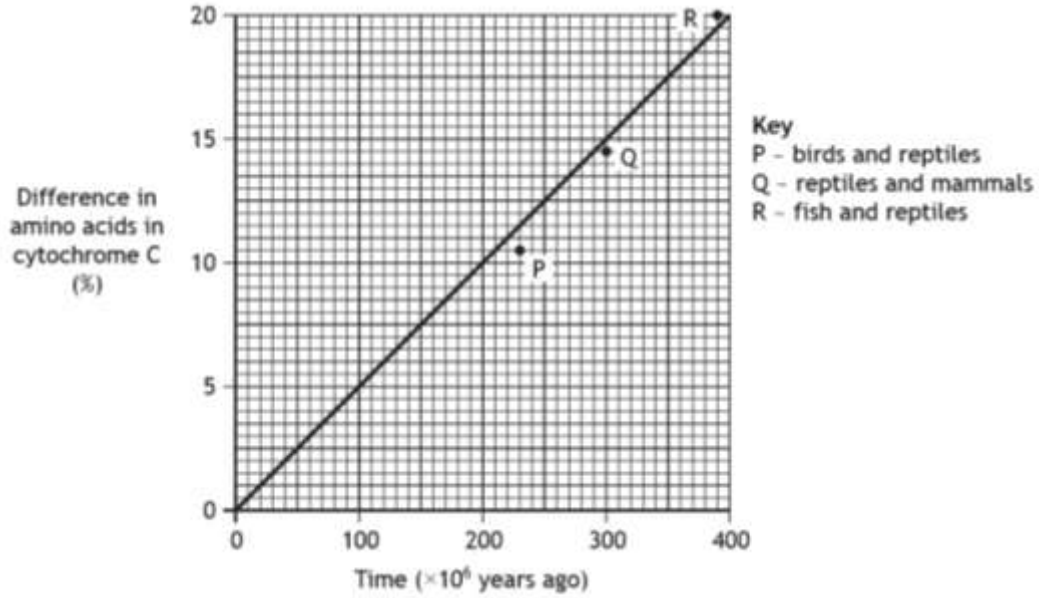
A 1 2 3

B 1 3 2

C 3 1 2

D 3 2 1 **1**

4. The graph below shows a molecular clock which compares the amino acid sequences in the protein cytochrome C in various vertebrate groups.



From the information in the graph, which vertebrate groups shared a common ancestor most recently?

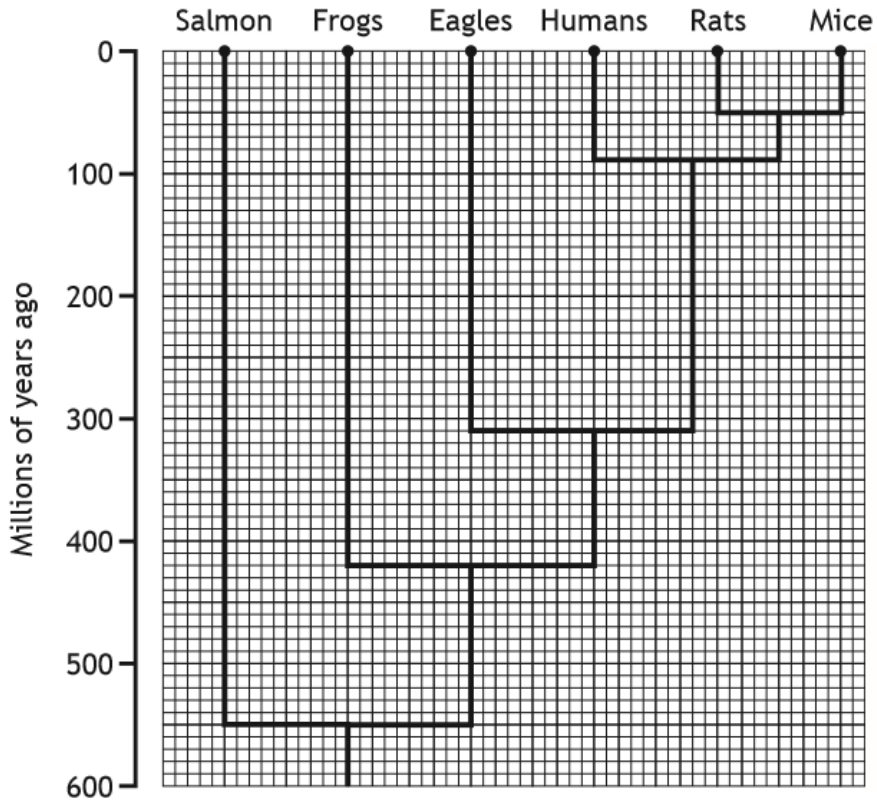
A Fish and reptiles

B Birds and mammals

C Reptiles and mammals

D Birds and reptiles **1**

5. The phylogenetic tree illustrates the evolutionary relatedness of six groups of animals.



(a) (i) Using information from the phylogenetic tree state when the last common ancestor of salmon and frogs lived.

_____ million years ago **1**

(ii) Calculate how many million years separate the divergence of eagles and humans from the divergence of rats and mice.

Space for calculation.

_____ million years **1**

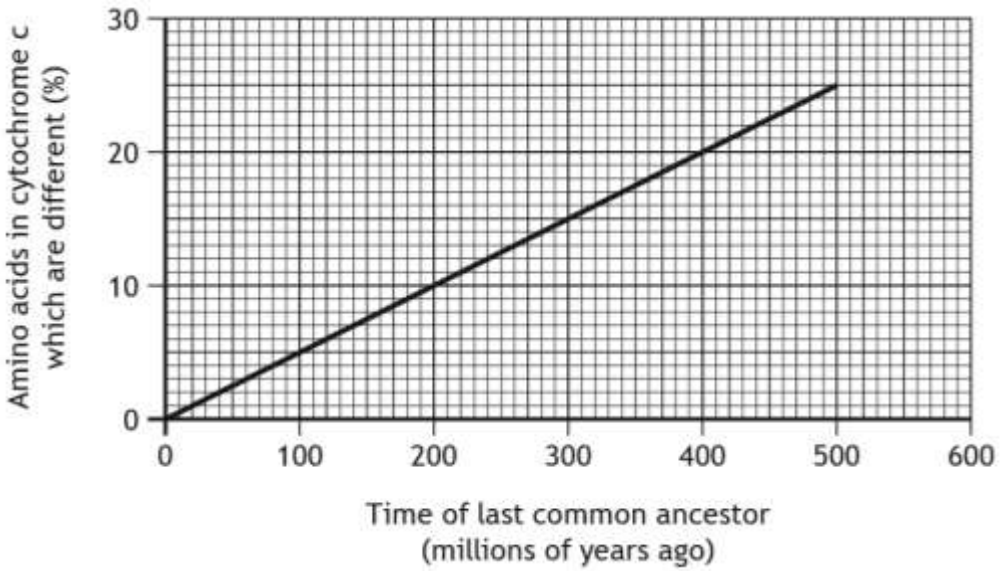
(iii) Rats are more closely related to humans than they are to frogs. Use evidence from the phylogenetic tree to justify this statement.

_____

_____

_____ **1**

(b) The graph shows a molecular clock which compares the amino acid sequence of the protein cytochrome c between a range of species.



(i) Cytochrome c is a protein containing 112 amino acids.

Calculate the number of amino acids in cytochrome c that are different between two species whose last common ancestor lived 500 million years ago.

Space for calculation

_____

1

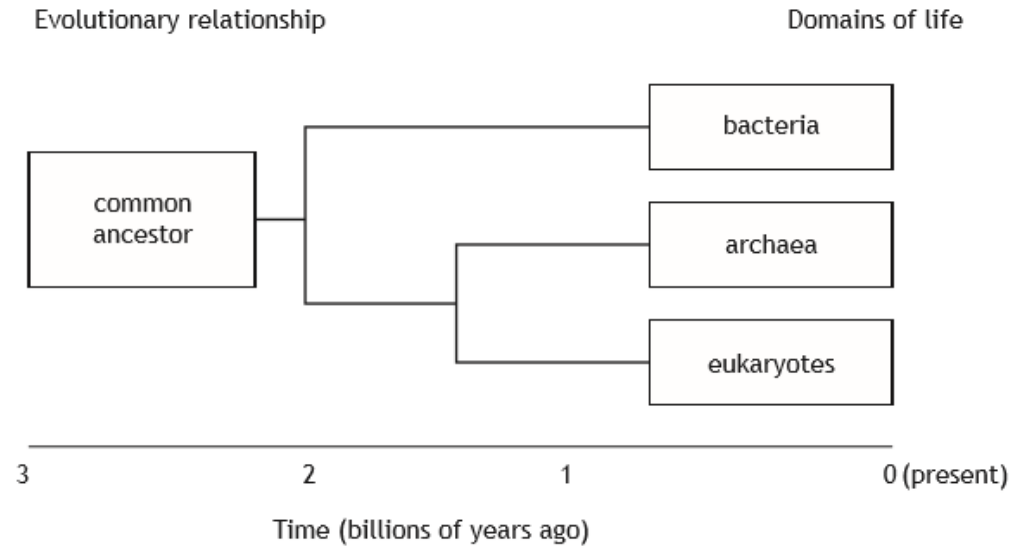
(ii) Predict the percentage of amino acids in cytochrome c which would be different between two species who shared a common ancestor 550 million years ago.

_____ % **1**

(c) Using information from the phylogenetic tree and the graph, state the percentage of amino acids in cytochrome c that are different between rats and frogs.

_____ % **1**

6. The phylogenetic tree below shows the evolutionary relationship between the three domains of life into which all present day living things can be divided.



(a) Name the type of data that can be used to confirm the evolutionary relationships between the domains of life shown on the diagram.

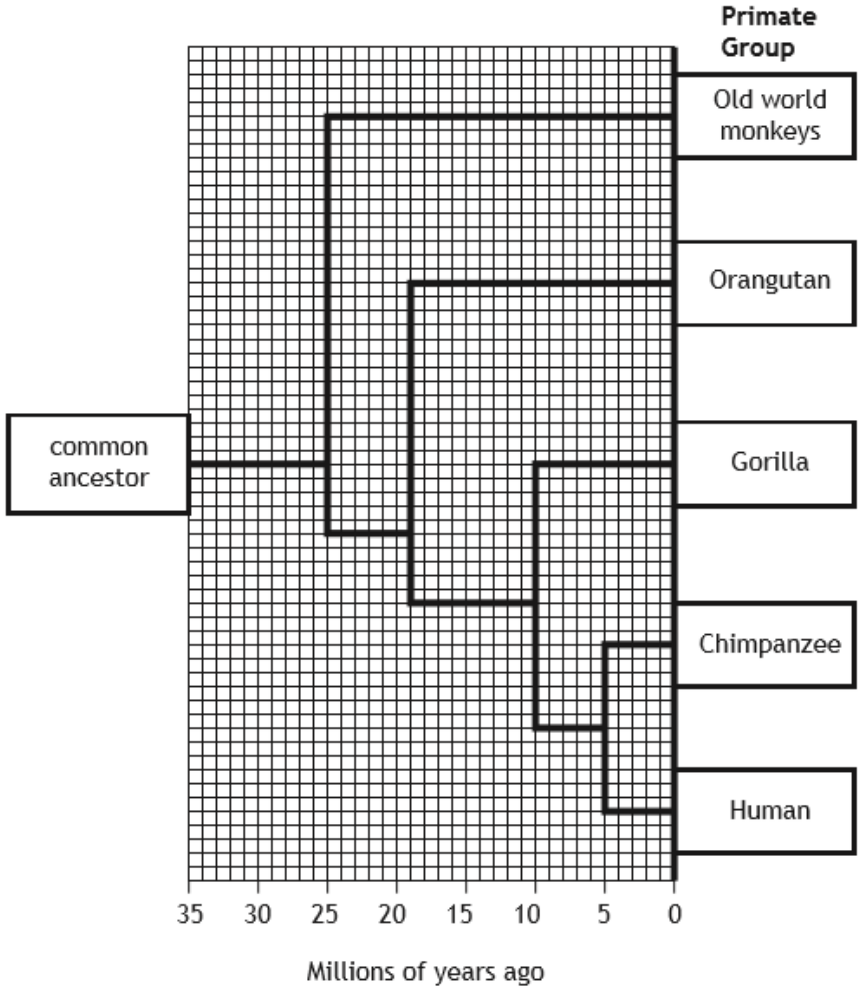
_____ **1**

(b) Around one billion years ago genes were transferred between archaea and bacteria.

Give the term that describes this form of gene transfer.

_____ **1**

(c) The phylogenetic tree below illustrates the evolutionary relationships between primate groups.



(i) State how long ago the last common ancestor of gorillas and old world monkeys existed.

_____ million years ago **1**

(ii) Humans are more closely related to chimpanzees than to orangutans. Explain how this is known, using information from the phylogenetic tree above.

_____

_____

_____ **2**