HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**22S7___**

CENTRE NUMBER					**INDEX NUMBER**			

BIOLOGY

9744/01

Paper 1 Multiple Choice

20 September 2023

Additional Materials: Multiple Choice Answer Sheet

1 hour

INSTRUCTIONS TO CANDIDATES

1. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Multiple Choice Answer Sheet. Write your **NRIC number** and shade accordingly.
3. There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.

   Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.
4. At the end of the paper, you are to submit **only** the Answer Sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

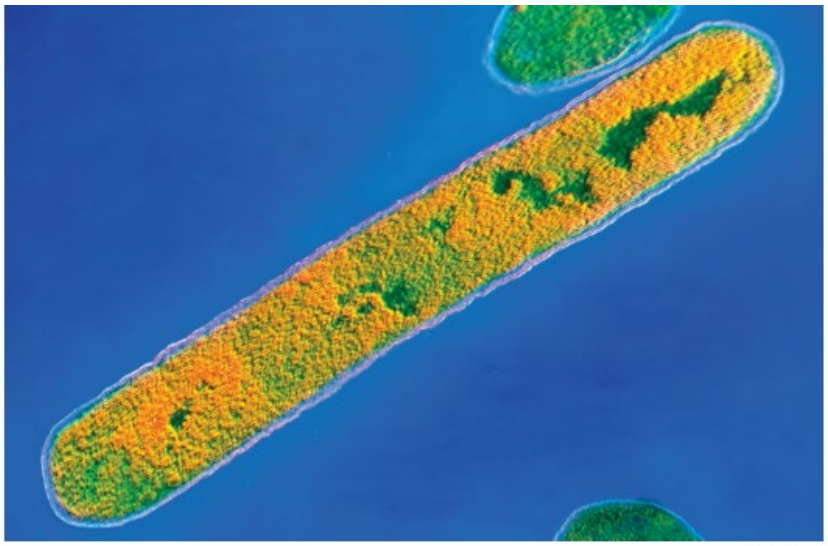
Any rough working should be done in this booklet.

The used of an approved scientific calculator is expected, where appropriate.

This document consists of **24** printed pages.

1 *Clostridium tetani* is the bacterium that causes the disease tetanus. Symptoms of the disease are caused by the release of a toxin, tetanospasmin.

The diagram shows a transmission electronmicrograph of cells of *Clostridium tetani*.



× 26 500

Which visible features suggest it is a prokaryote and not a eukaryote?

1 The presence of a cell wall surrounding the cell that is oval in shape.

2 The nucleoid region is not enclosed by a nuclear envelope.

3 The lack of membranous organelles within the cell.

4 The presence of 70S ribosomes that covered the cisternae of rough endoplasmic reticulum.

A 1 and 2 only **B** 1 and 4 only **C** 1, 2 and 3 only **D** 2 and 3 only

2 Four students were asked to match the function with the appearance of some cell structures in an animal cell.

The functions were listed by number.

1 mRNA passes through to the ribosome

2 produces the mitotic spindle during cell division

3 packaging of hydrolytic enzymes that will remain in the cell

The appearances were listed by letter.

V membranes which surround an enclosed inner cavity

W non-membrane-bound, spherical structures

X a double membrane interspersed with pores

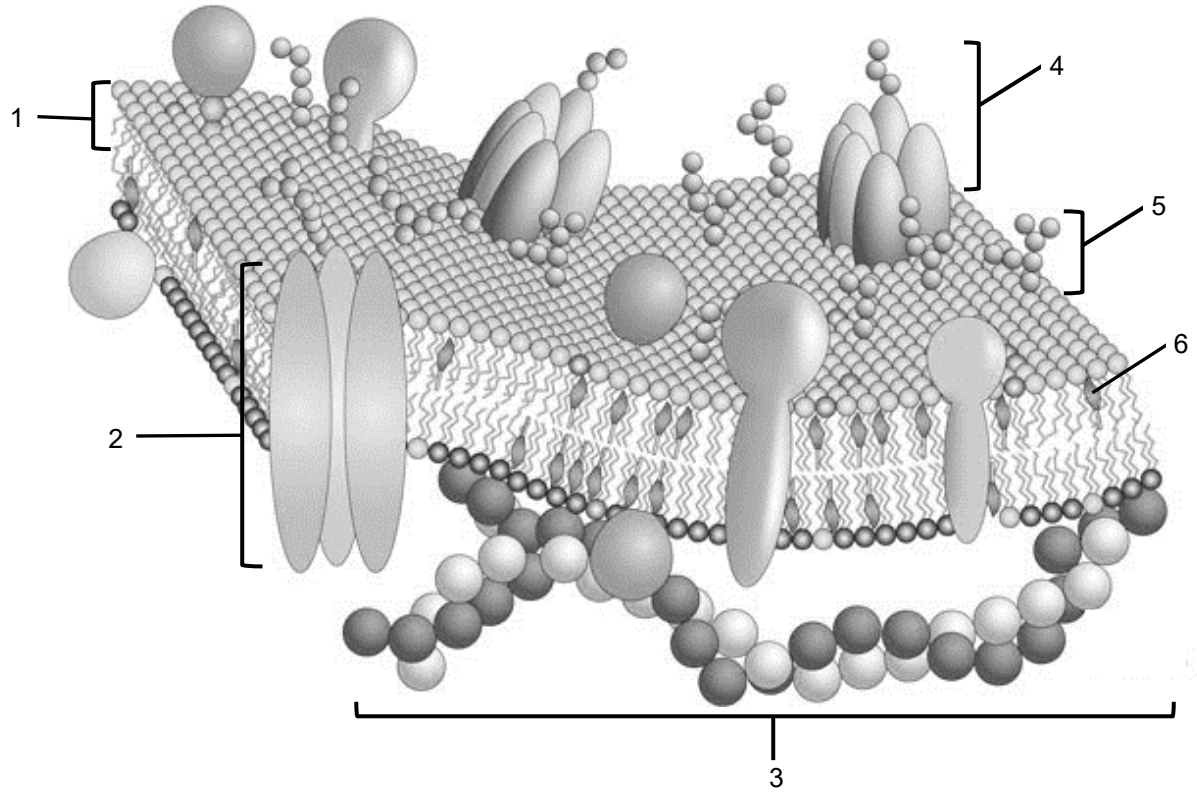
Y non-membrane-bound, cylindrical structures

Z membrane-bound sacs, arranged as a flattened stack

Which student correctly matched the numbered function with the appearance of the cell structure?

	1	2	3
A	V	W	Y
B	V	Y	Z
C	X	W	Y
D	X	Y	Z

3 The diagram shows the structure of the cell membrane with molecules labelled **1** to **6**.



Which row correctly matches the molecules with its role?

	contributes to fluidity of the cell membrane	contributes to cell recognition	contributes to stability of the cell membrane	contributes to movement of solutes across the cell membrane
A	1	3, 5	2, 4	6
B	1	4, 5	3, 6	2
C	2	4, 6	3, 6	1
D	2	3, 6	1, 4	3

4 The pandoraviruses are the largest known viruses to be discovered.

Some of its features are listed.

1 Its genome is double-stranded DNA consisting of over 2 million nucleotide pairs.

2 It is able to replicate only within an amoeba.

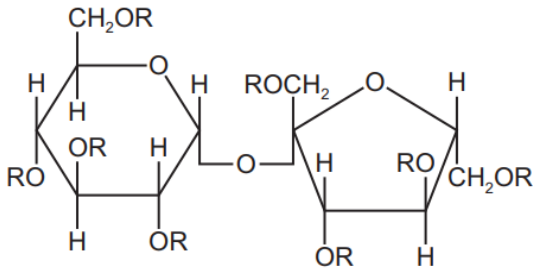
3 It causes pneumonia in humans.

Which features suggest that pandoraviruses are viruses?

A 1 only **B** 2 only **C** 1 and 3 only **D** 1, 2 and 3

5 Olestra is an artificial lipid. It is made by attaching fatty acids, by condensation, to a sucrose molecule.

A simplified diagram of olestra is shown. R represents the position where fatty acids would be attached.



Humans cannot hydrolyse olestra. However, other animals may be able to do so.

How many molecules of water would be needed to hydrolyse one molecule of olestra into fatty acids, fructose and glucose?

A 11 **B** 10 **C** 9 **D** 8

6 Insulin is a globular protein involved in cell signalling. It is transported in the blood plasma from the cells that synthesise it to its target cells. A molecule of insulin contains six sulfur-containing amino acids and has two polypeptide chains.

Which statements about insulin are correct?

1 An insulin molecule has a quaternary structure.

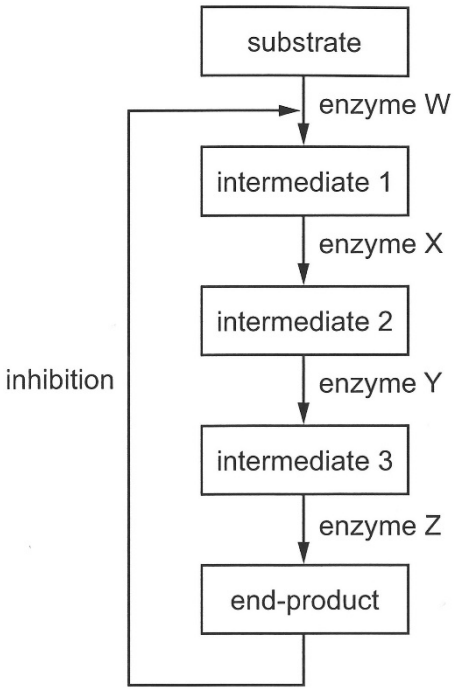
2 Insulin polypeptides are held together by six disulfide bonds.

3 Amino acid residues with non-polar R groups would be found in the centre of an insulin molecule.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

7 The end-product of a metabolic pathway can act as a competitive inhibitor. This is called end-product inhibition and allows a cell to control a metabolic pathway.

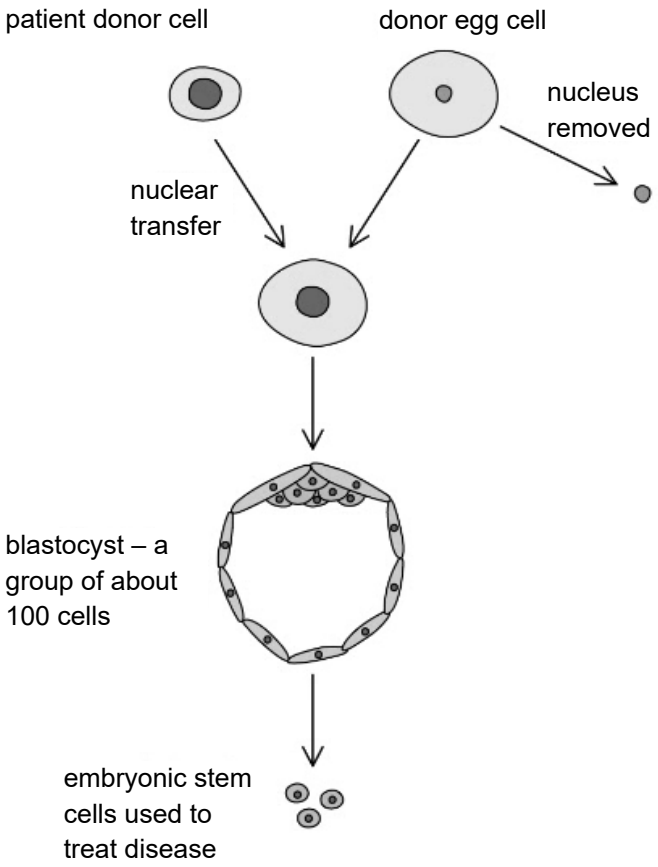
The diagram shows a metabolic pathway where the end-product could act as an inhibitor of enzyme W.



What would be the effect if enzyme Z was inhibited by the end-product instead of enzyme W?

	quantity of intermediate 1	quantity of intermediate 3	quantity of end-product
A	increase	increase	decrease
B	increase	decrease	unchanged
C	decrease	increase	decrease
D	decrease	decrease	unchanged

8 The diagram shows how embryonic stem cells are produced in therapeutic cloning for use in patients.



Which statements are possible ethical considerations of using such embryonic stem cells?

1 A potential life is being destroyed.

2 Embryonic stem cells are pluripotent in nature.

3 These embryonic stem cells can produce cells of any type.

4 These embryonic stem cells contain both the patient's nuclear genome and the donor's mitochondrial genome.

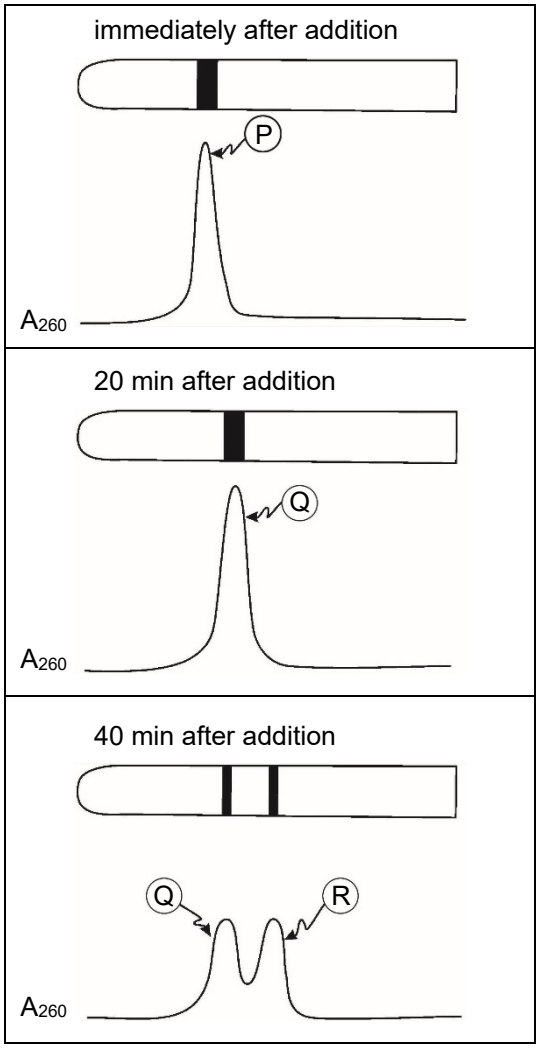
A 1 and 2 only **B** 1 and 4 only **C** 3 and 4 only **D** 1, 3 and 4 only

9 Bacteria were cultured in the presence of ^{15}N for several generations, until most of the natural ^{14}N atoms in their DNA were replaced by the ^{15}N isotope.

A large excess of ^{14}N was then added to the culture and samples were taken immediately after the addition, as well as 20 min and 40 min later.

Cell extracts of the samples were subjected to caesium chloride density-gradient centrifugation.

The diagram shows three distinct DNA bands. The amount of DNA in each band was determined by absorbance of UV light at 260 nm and are represented by peaks **P**, **Q** and **R**.



Which statement correctly characterises the DNA molecules of the three peaks?

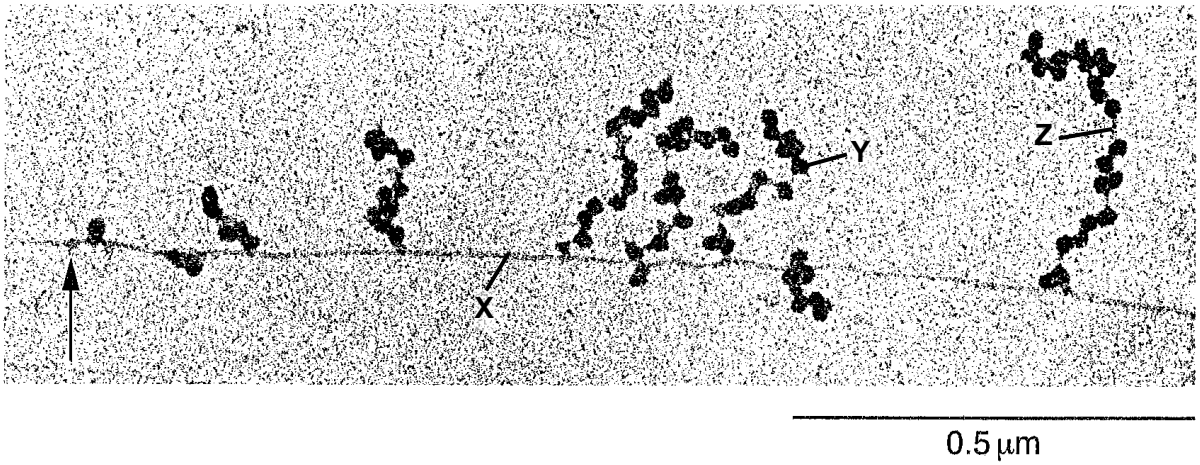
A Peak **P** DNA contains mostly ^{14}N

B Peak **Q** DNA contains approximately equal amounts of ^{14}N and ^{15}N

C Peak **R** DNA contains mostly ^{15}N

D Peak **R** DNA contains approximately equal amounts of ^{14}N and ^{15}N

10 The electronmicrograph shows simultaneous transcription and translation of a single gene in the bacterium *Escherichia coli*.



Which row is correct?

	polarity of **X** at arrow	**X**	**Y**	**Z**
A	3’	DNA	RNA polymerase	mRNA
B	3’	DNA	ribosome	mRNA
C	5’	DNA	ribosome	polypeptide
D	5’	mRNA	ribosome	polypeptide

11 The table shows a comparison of some aspects of the genomes of eukaryotes and prokaryotes.

organism	complexity	estimated genome size (base pairs)	estimated number of genes	gene density (genes/Mb)
Human	↑	3 billion	25,000	6.5
Mouse		2.9 billion	30,000	10
Fruit fly		165 million	14,000	100
Rice plant		400 million	40,000	100
Roundworm		97 million	19,000	200
Yeast		12 million	6,000	520
Bacteria		4.6 million	4,400	950

Which statement can be concluded from the table?

A Biological complexity of an organism is correlated to the number of genes.

B Gene density is proportional to the biological complexity of an organism.

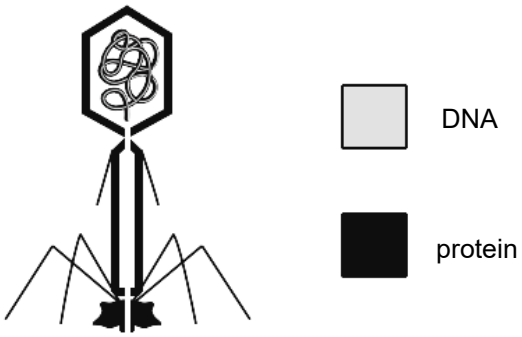
C More complex organisms tend to have larger genome sizes.

D More complex organisms have more introns.

12 Which row correctly describes the transfer of DNA from one bacterium to another?

	binary fission	conjugation	transformation	transduction
A	only bacterial chromosome passes to daughter cells	single strand of F plasmid transferred from donor to recipient cell	bacterial cells take up foreign plasmid from culture medium	DNA transferred by prophage from donor to recipient cell
B	only bacterial chromosome passes to daughter cells	double strand of F plasmid transferred from donor to recipient cell	bacterial cells take up naked DNA from culture medium	DNA transferred by bacteriophage from donor to recipient cell
C	bacterial chromosome and plasmids pass to daughter cells	single strand of F plasmid transferred from donor to recipient cell	bacterial cells take up naked DNA from culture medium	DNA transferred by bacteriophage from donor to recipient cell
D	bacterial chromosome and plasmids pass to daughter cells	double strand of F plasmid transferred from donor to recipient cell	bacterial cells take up foreign plasmid from culture medium	DNA transferred by prophage from donor to recipient cell

13 Phages are viruses that consist of DNA contained within a protein head.



Phages inject their DNA into a host bacterial cell, but leave the protein heads (called phage ghosts) on the outside of the infected cell.

Two different types of phage were developed by growing the phages in cultures of bacteria in two separate media:

- medium **P** contained radioactive phosphorus (^{32}P)
- medium **S** contained radioactive sulfur (^{35}S).

Type P phage had DNA that was labelled with ^{32}P.
Type S phage had proteins that was labelled with ^{35}S.

Fresh cultures of the bacteria *E. coli* were infected with either type P or type S phage.

After infection, the empty phage heads (phage ghosts) were separated from the bacterial cells. Each was tested for radioactivity.

Which table correctly shows where radioactivity was present (Y) or absent (N)?

A

Phage type	Bacterial cells	Phage ghosts
P	Y	N
S	Y	N

B

Phage type	Bacterial cells	Phage ghosts
P	Y	N
S	N	Y

C

Phage type	Bacterial cells	Phage ghosts
P	N	Y
S	N	Y

D

Phage type	Bacterial cells	Phage ghosts
P	N	Y
S	Y	N

14 Different strains of the influenza virus have formed as a result of mutations. Each strain of the virus contains the enzyme neuraminidase. In each strain of the influenza virus, the primary structure of the active site of the neuraminidase enzyme remains unchanged.

Which statement correctly accounts for the unchanged primary structure of the active site of neuraminidase in each strain of the influenza virus?

A Antigenic shift occurs at the third base of the DNA triplets in the gene for neuraminidase resulting in the same amino acids coded for.

B Viral replicase has proofreading mechanisms to correct the mutations occurring in the gene for neuraminidase.

C The gene for neuraminidase is essential for the influenza virus to enter host cell to replicate.

D Those strains of influenza virus, which have a different conformation of the active site of the neuraminidase enzyme, are selected against.

15 A student attempted to integrate the concepts that he learnt about the cell cycle and the control of eukaryotic gene expression at the chromatin level, namely histone modifications and DNA methylation.

The student made the following statements:

1 DNA methyltransferase is more active during S phase of interphase to facilitate DNA replication and intensive gene expression.
2 Histone acetyltransferase is more active during interphase to facilitate intensive gene expression.
3 DNA methyltransferase is less active during mitosis to facilitate proper chromosome segregation.

Which statement made by the student is correct?

A 1 only **B** 2 only **C** 1 and 2 only **D** 2 and 3 only

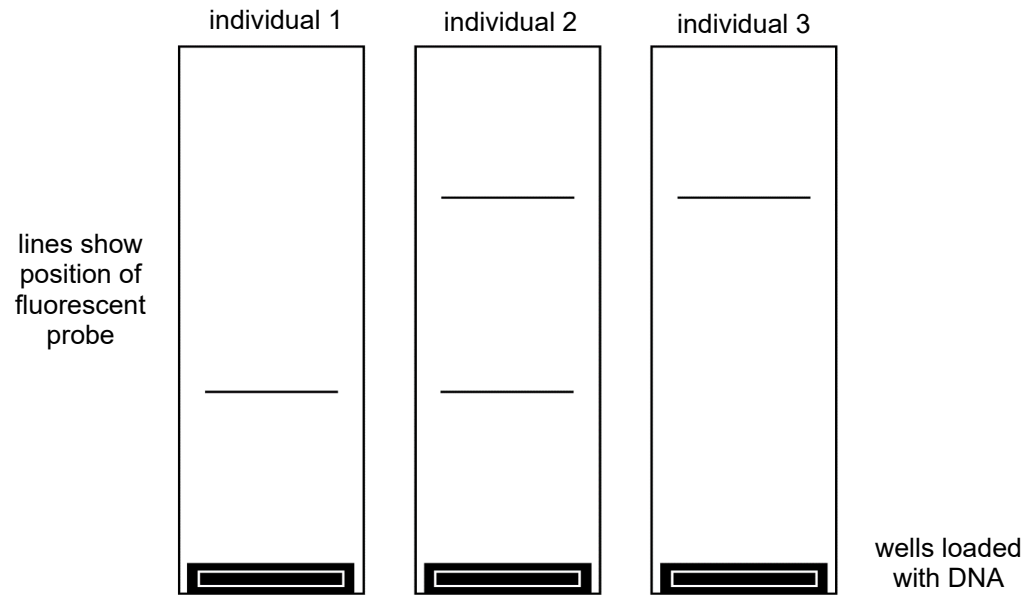
16 The *β-globin* gene codes for a polypeptide in haemoglobin. An individual with sickle cell anaemia has two copies of a recessive allele of this gene. A genetic test can distinguish between the normal and sickle cell alleles.

DNA is extracted from three individuals and cut with a restriction enzyme. The restriction digestion will yield:

- 7.6 kilobase pairs long fragments from the normal *β-globin* allele
- 13 kilobase pairs long fragments from the sickle cell allele.

The DNA fragments are separated by electrophoresis. A fluorescent DNA probe is used to show the location of the fragments on the gel.

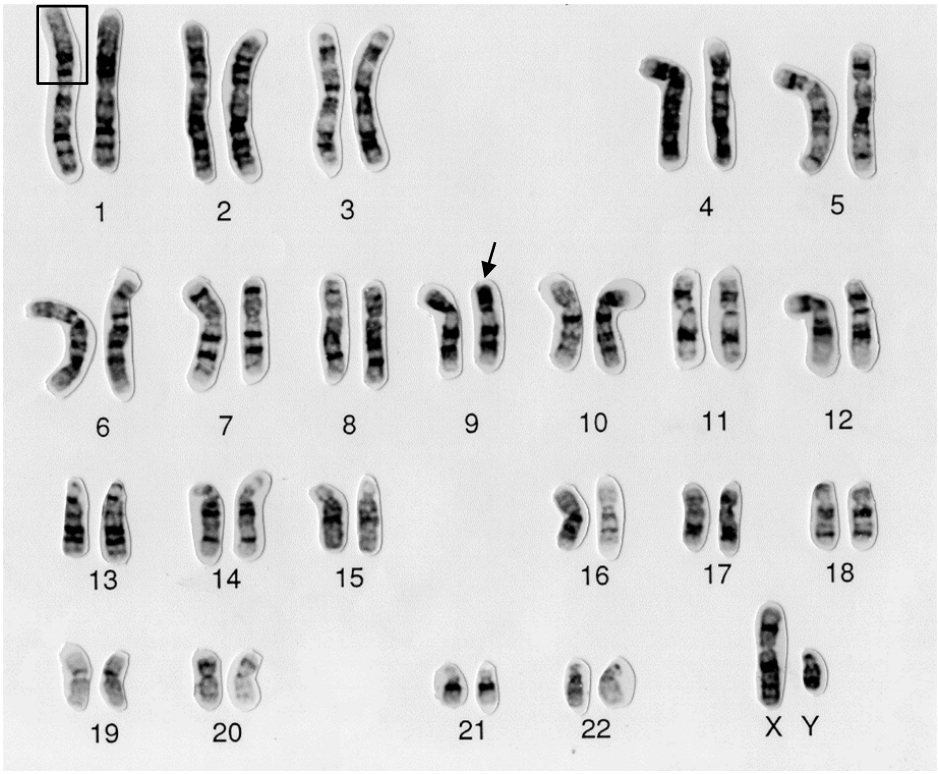
The diagram shows results for three individuals.



Which individual(s) suffer from sickle cell anaemia?

A 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3

17 The karyotype of a normal human male is shown.



One part of chromosome 1 (highlighted in the box) is translocated to chromosome 9 (shown by the arrow) during meiosis.

Which statement is correct?

A Translocation can occur in a blood stem cell at prophase I of meiosis.

B Bivalents of chromosome 1 and chromosome 9 fail to separate during anaphase I of meiosis, giving rise to polyploidy upon fertilisation with a normal female gamete.

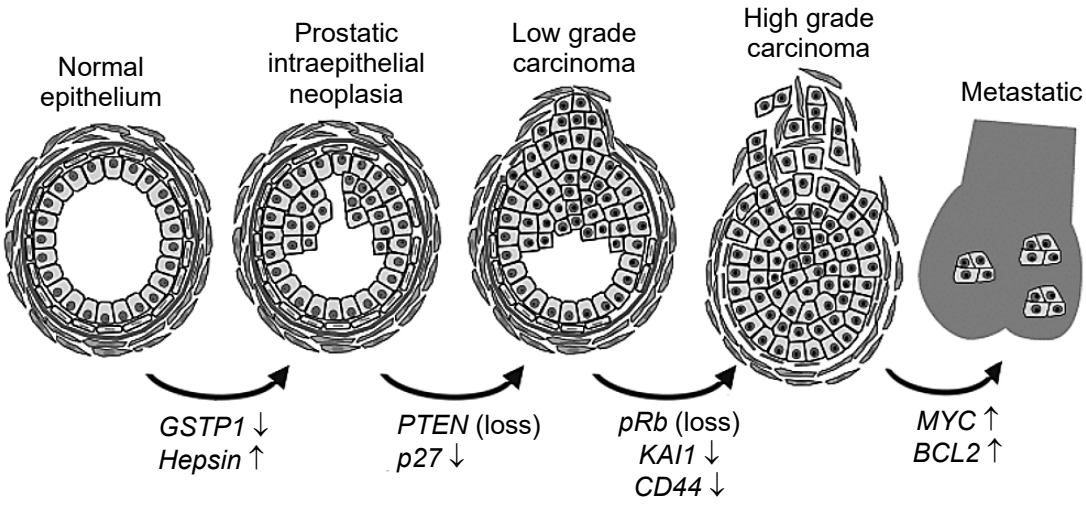
C The resultant gamete gives rise to a trisomy-1 or trisomy-9 child upon fertilisation with a normal female gamete.

D The resultant gamete may give rise to an abnormal embryo upon fertilisation with a normal female gamete.

18 The diagram shows a model of prostate cancer progression. Morphological features of different stages of prostate cancer progression correlate with specific genetic events. The prostate epithelial cells are on the innermost layer.

The genes involved in prostate cancer progression could be

- deleted, denoted as (loss)
- upregulated, denoted with an up-arrow (↑)
- downregulated, denoted with a down-arrow (↓).



Which statements can be inferred from the diagram about prostate cancer and the genes involved?

1 *GSTP1* and *PTEN* are tumour suppressor genes.

2 Upregulation of *Hepsin* gene causes *p27* gene to be downregulated.

3 Gain-of-function mutation must occur in several genes before the low grade carcinoma can progress into high grade carcinoma.

4 Prostate cancer is a multi-step process because no single genetic event can result in the tumorigenic and metastatic states.

A 1 and 4 only **B** 2 and 3 only **C** 1, 2 and 4 only **D** 1, 2, 3 and 4

19 Normal (wild-type) goats have a gold and black coat colour pattern, known as bezoar, and are also horned (have horns). Domestic goats may have a white coat and may be hornless (do not have horns).

These variations are coded for by two unlinked genes:

- white coat colour, coded for by the dominant allele of the gene A/a
- hornless, coded by the dominant allele of the gene H/h.

A first cross between a white hornless goat and a bezoar horned goat produced offspring of four different phenotypes. A second cross between a bezoar hornless goat and a white horned goat also produced offspring of four different phenotypes.

Which row correctly shows the possible genotypes involved for each cross?

	first cross	second cross
A	AaHH x aahh	aaHh x Aahh
B	AaHh x aahh	aaHH x Aahh
C	AaHh x aahh	aaHh x Aahh
D	AaHh x AaHh	AaHh x AaHh

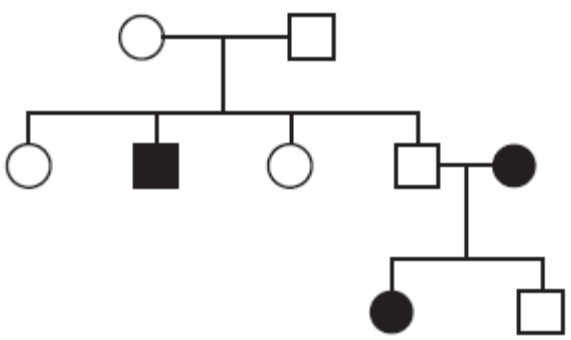
20 A man has normal red-green colour vision. His blood group is rhesus negative (homozygous recessive). His wife also has normal vision but is rhesus positive. She is heterozygous at both the red-green colour vision locus and the blood group locus.

What is the probability that their first child will be rhesus negative, red-green colour blind boy?

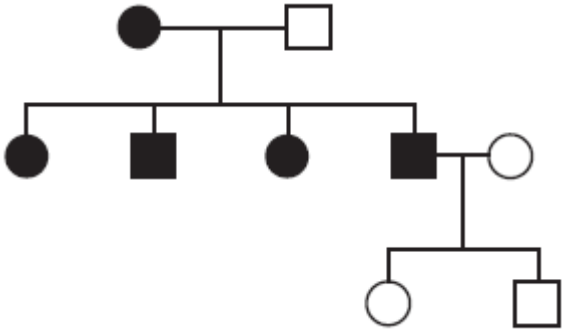
A 0 **B** 0.0625 **C** 0.125 **D** 0.25

21 Which pedigree shows a sex-linked dominant pattern of inheritance of a genetic disorder?

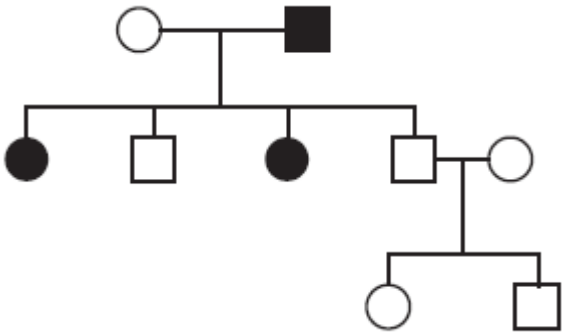
A



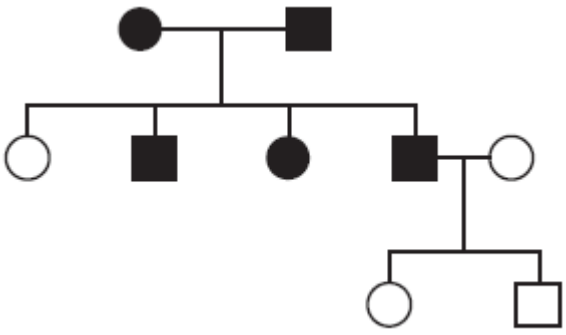
B



C

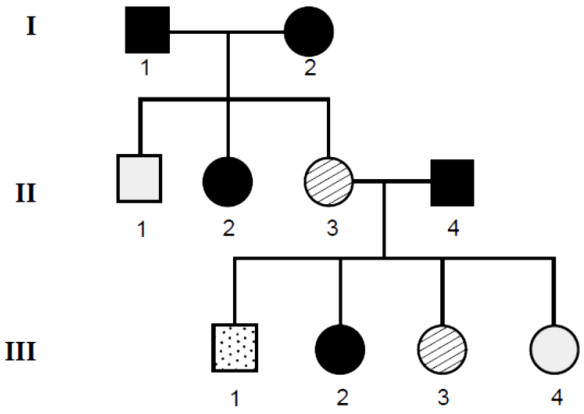


D



22 Coat colour in cocker spaniel dogs varies. Four of these colours are black, liver, red and lemon. These four colours result from the interaction of two specific autosomal genes found on different chromosomes.

The pedigree shows the inheritance of coat colour in a group of cocker spaniels.



phenotype	generalised genotypes
black	R_B_
liver	rrB_
red	R_bb
lemon	rrbb

R_ can be either RR or Rr
B_ can be either BB or Bb

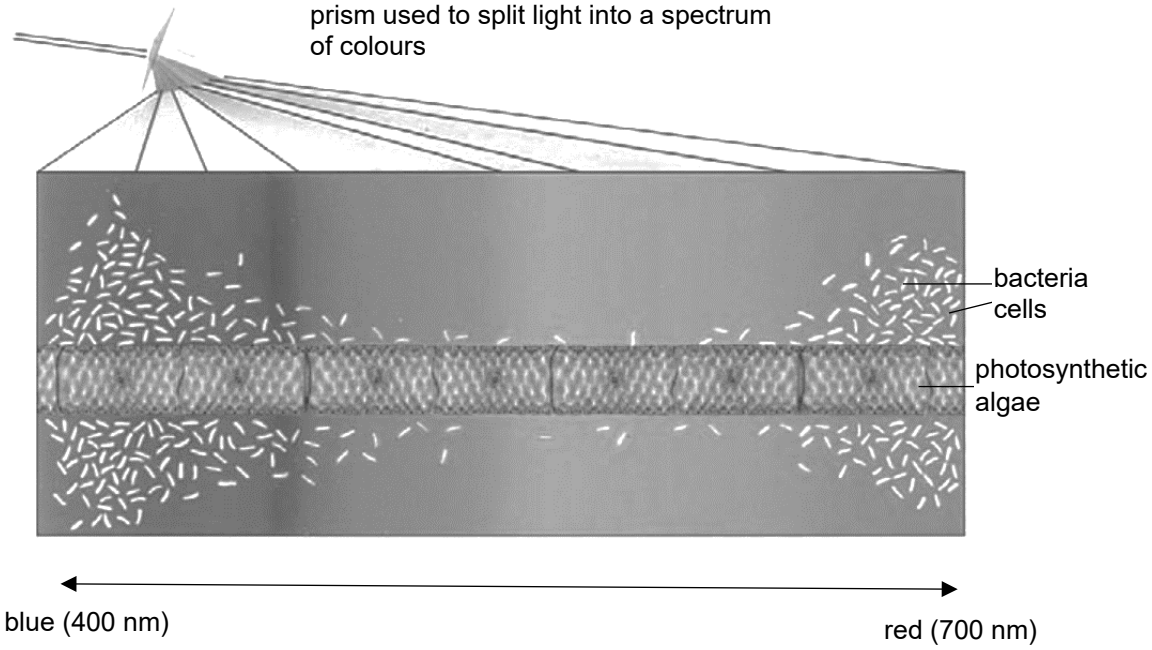
Which row correctly shows the genotypes of individuals I-1, II-4 and III-4?

	I-1	II-4	III-4
A	RrBb	RRBb	rrBb
B	RrBb	RrBb	rrBb
C	RrBb	RrBb	rrBB
D	RrBB	RrBb	rrBb

23 Engelmann's experiment investigates the effect of different wavelengths of light on the rate of photosynthesis for a suspension of photosynthetic algae.

A prism was used to split a beam of light and the different wavelengths were directed at equal intensity towards the immobilised algae. Aerobic bacteria were then introduced and allowed to move freely in the suspension.

After some time, the bacteria were observed to accumulate as follows.



Which statement **cannot** be concluded from the experiment?

A Reduction of light intensity would likely reduce the accumulation of bacteria in the setup.

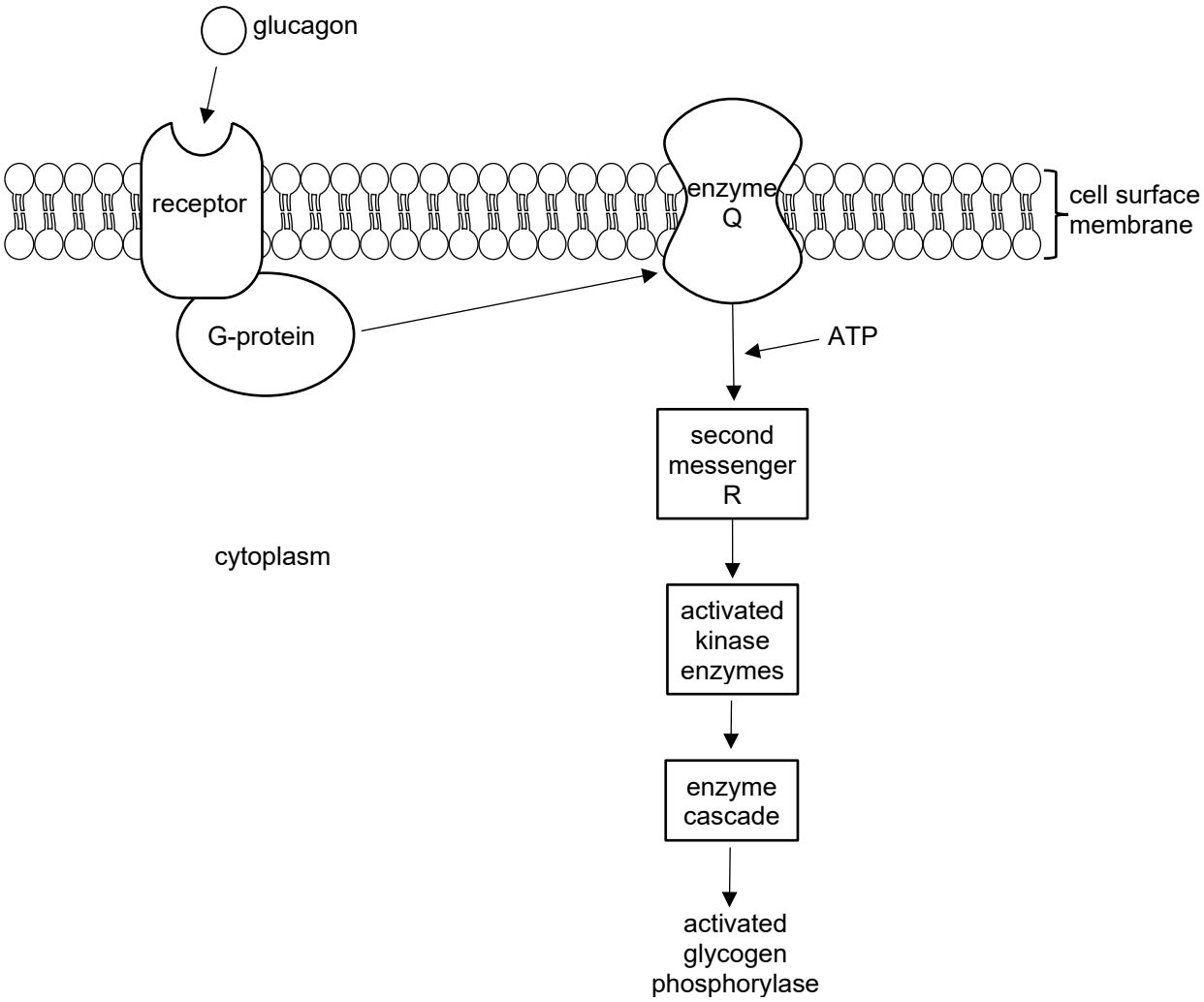
B Bacteria cells most readily utilise red and blue light for photosynthesis and hence accumulate there.

C Red and blue light are most efficient for photosynthesis in algae.

D The results of bacteria accumulation would be different if anaerobic bacteria were used.

24 Glucagon is released by the alpha cells of the pancreas when the blood glucose concentration decreases below the set point.

The diagram outlines the response of liver cells to glucagon.



Which row is correct?

	enzyme Q	second messenger R	enzyme cascade	activated glycogen phosphorylase
A	adenylyl cyclase	calcium	involved in signal transduction	promotes glycolysis
B	adenylyl cyclase	cyclic AMP	amplifies signal	promotes breakdown of glycogen
C	protein kinase A	cyclic AMP	amplifies signal	promotes glycolysis
D	protein kinase A	calcium	involved in signal transduction	promotes breakdown of glycogen

25 In his book 'On the Origin of Species', Charles Darwin made the following four observations.

1 Offspring generally appear similar to their parents.

2 No two individuals are identical.

3 Organisms have the ability to produce large numbers of offspring.

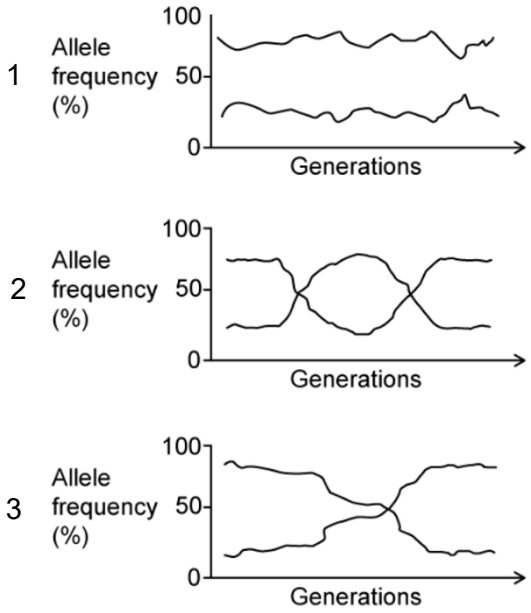
4 Populations in nature tend to remain relatively stable.

From these observations he made a number of deductions, listed in the table below. The deductions are supported by **one or more** of the observations (1, 2, 3 or 4).

Which row is correct?

	Characteristics are passed on to the next generation	There is struggle for existence	Individuals with beneficial characteristics are among the few who survive
A	1	3 and 4	2, 3 and 4
B	2	1 and 3	2 and 3
C	2 and 3	2 and 4	1
D	1	2 and 3	1, 3 and 4

26 The three graphs show how the allele frequencies of two alleles in three different populations changed over several generations.



Which of the graphs show changes in allele frequency that suggest that evolution is taking place?

A 1 and 2 only **B** 2 and 3 only **C** 3 only **D** 1, 2 and 3

27 *Petrogale lateralis* is an Australian marsupial, commonly known as the black-footed rock-wallaby.

Evidence suggests that about 30 000 years ago it spread to an island 55 km away from the mainland. Since then, the island and the mainland populations have remained isolated from each other.

Conservationists recently investigated the populations. They measured the male : female ratio and the percentage of females that had reproduced and were carrying offspring. They also took blood samples from rock-wallabies in both populations.

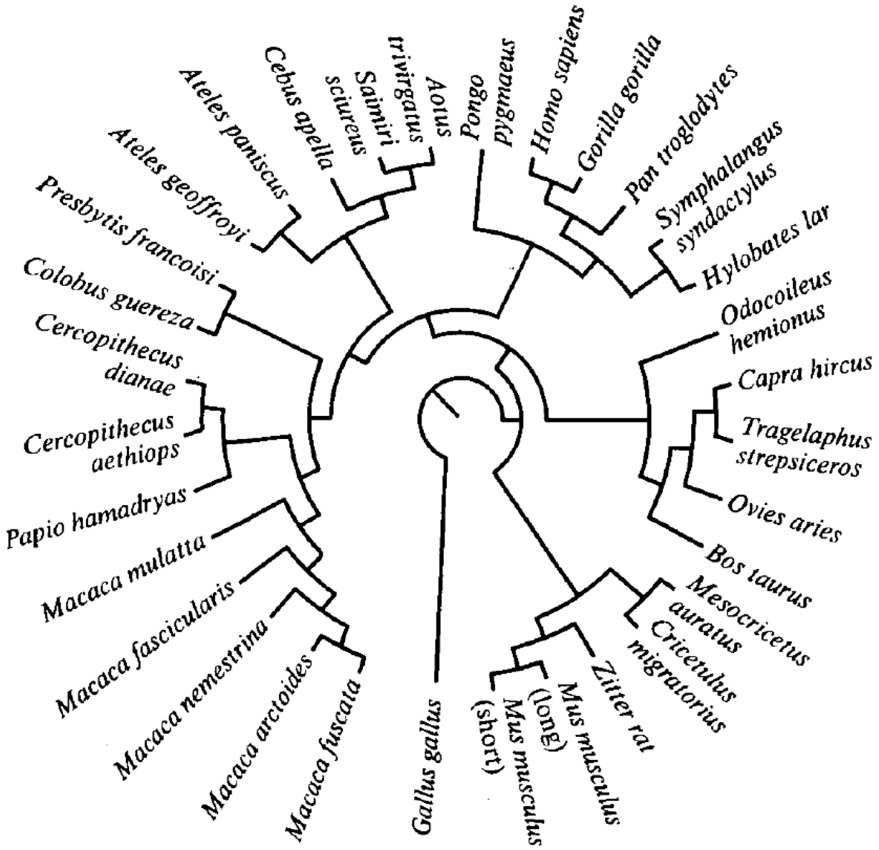
Tests on these samples allowed the genotype of each of the rock-wallabies to be deduced for 14 different genes. If more than one allele of a gene is present in a population, the population is **polymorphic** for that gene. If only one allele is present, the population is **non-polymorphic**. The results of the investigations are shown in the following table.

	island population	mainland population
male : female ratio	1: 2.5	1 : 1.5
percentage of females carrying offspring	52	89
polymorphic genes	1 of the 14 genes is polymorphic	10 of the 14 genes is polymorphic

Which row correctly predicts the population that would be more vulnerable to extinction if there was a period of rapid environmental change?

	population that is more vulnerable to extinction	reason
A	island	fewer genes are polymorphic and so there is less genetic diversity, reducing chance for adaptation and survival
B	island	small population with fewer males per females leads to appearance of deleterious alleles that decrease fertility
C	mainland	more genes are polymorphic and this allows better chance for adaptation and survival
D	mainland	there is heterozygote advantage observed as more genes are polymorphic

28 Prion protein is found on the surface of neurons in vertebrates. The gene coding for this protein has been sequenced in 33 species of vertebrates. The differences in base sequence have been used to construct a phylogeny for these 33 vertebrates. The phylogeny is shown in the diagram below.

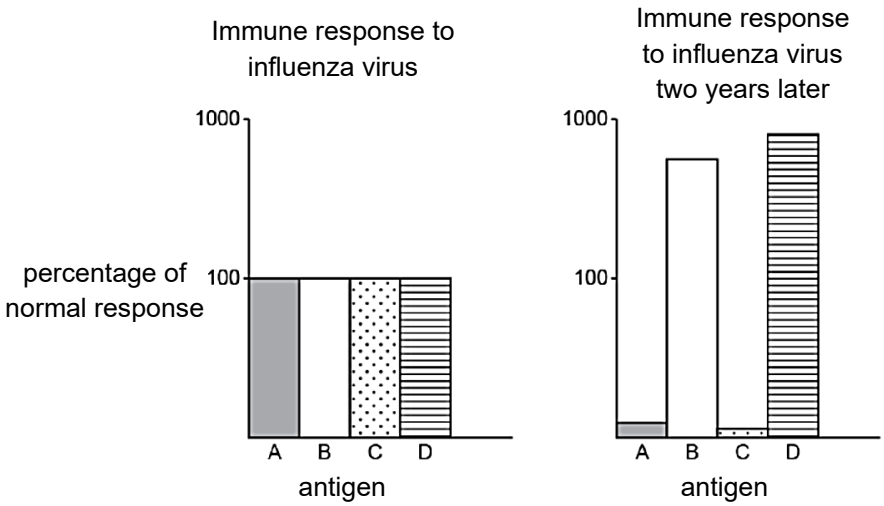


Which row correctly deduces the evolutionary relationships stated according to the base sequence of the prion gene?

	the species most similar to that of *Homo sapiens*	the species most different from that of *Homo sapiens*
A	*Pan troglodytes*	*Gallus gallus*
B	*Pongo pygmaeus*	*Bos taurus*
C	*Gorilla gorilla*	*Macaca fuscata*
D	*Gorilla gorilla*	*Gallus gallus*

29 An individual's immune responses can change throughout their lifetime.

The diagram shows one person's immune response to four antigens (A – D) of the influenza virus when they were first infected and when they were infected two years later by a new, mutated strain of the virus.



Which statement is consistent with the results of the second infection?

A Antigens B and D evoked a larger immune response.

B The genes encoding antigens B and D had mutated.

C Memory cells produce a secondary response to antigens A and C.

D The mutated strain of the virus caused a more severe infection.

30 Reef-building corals are marine invertebrates found in shallow, clear, tropical oceans. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef ecosystem.

Zooxanthellae are a group of unicellular algae from the genus *Symbiodinium* that live within the cells of reef-building corals. The relationship has been described as mutualistic since it is beneficial to both coral and zooxanthellae.

Evidence shows that the mutualistic relationship between zooxanthellae and reef-building corals has evolved by free-living algae invading corals that did not contain algae.

1 The mutualistic relationship between zooxanthellae and reef-building corals evolved because the zooxanthellae benefits from physical support from the corals to obtain light.

2 Corals that do not need zooxanthellae can live at a greater depth than reef-building corals.

3 Under conditions of stress such as increased temperature, the relationship between the reef-building corals and the zooxanthellae can break down.

4 Corals are susceptible to change in temperature because shallow bodies of water are more susceptible to extreme temperature fluctuations than deeper bodies

How many statements are correct regarding reef-building corals?

A 1 **B** 2 **C** 3 **D** 4

--- END OF PAPER---

BLANK PAGE