

RAFFLES INSTITUTION

2025 Year 6 Preliminary Examination
Higher 2

BIOLOGY

9744/01

Paper 1 Multiple Choice

30th September 2025

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name and shade your Index Number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in 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.

Read the instructions on the Answer Sheet very carefully.

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.

Calculators may be used.

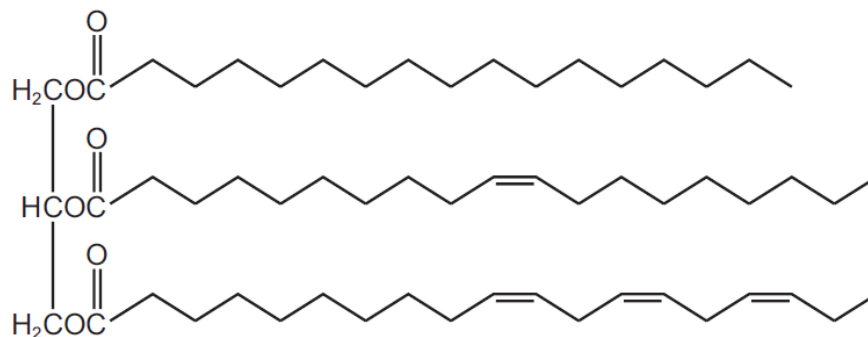
(Erase all mistakes completely. Do not bend or fold the OMR Answer Sheet).

This document consists of **22** printed pages.



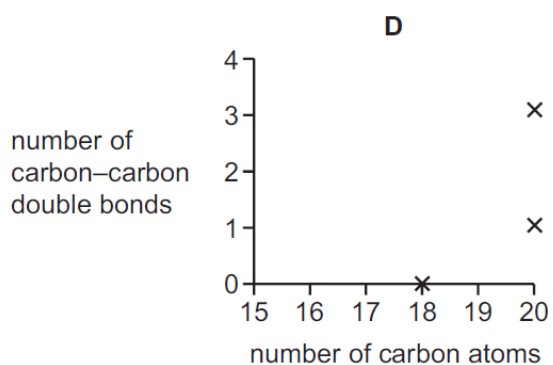
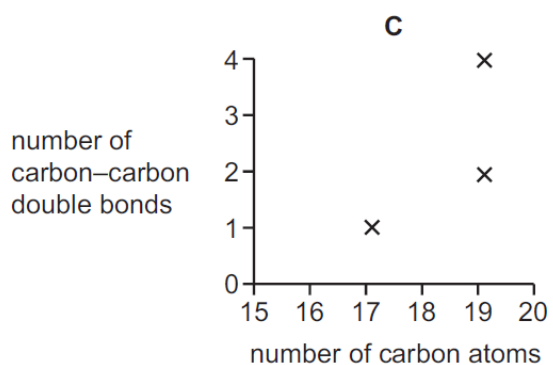
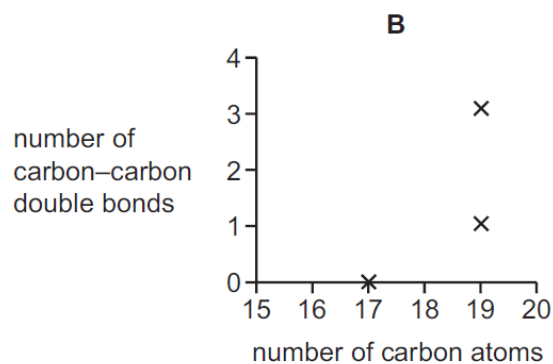
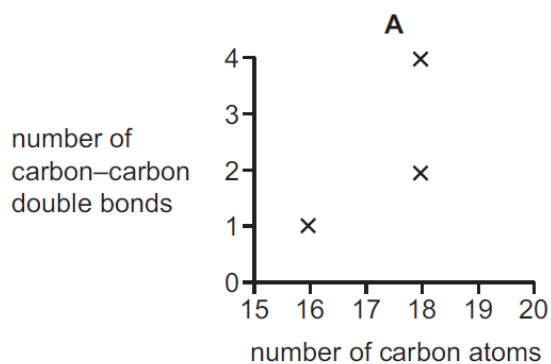
Raffles Institution
Internal Examination

1. The diagram shows a triglyceride.



An enzyme was used to digest this triglyceride into glycerol and fatty acids.

Which scatter plot correctly represents each fatty acid component of the triglyceride?

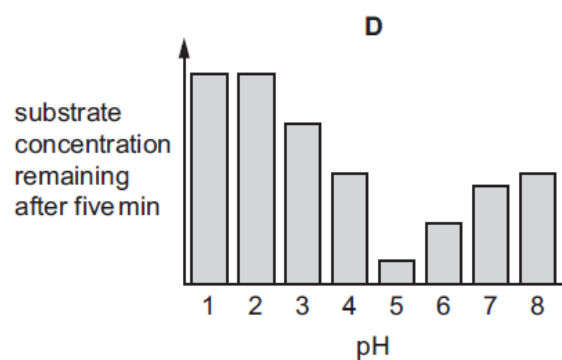
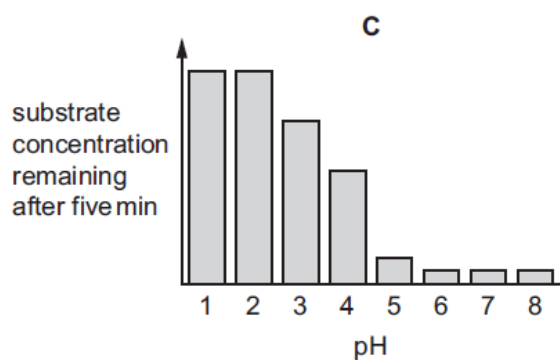
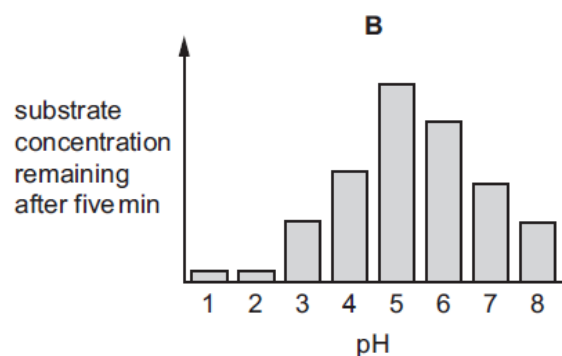
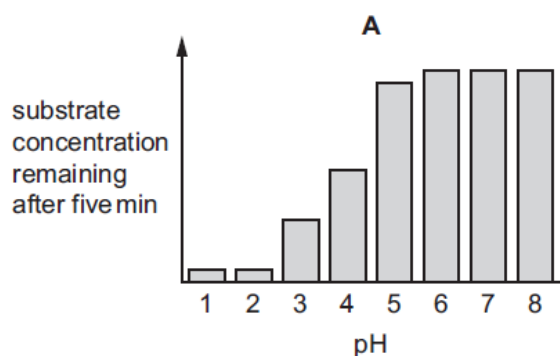


2. A student carried out an experiment to investigate the effect of pH on an enzyme-catalysed reaction.

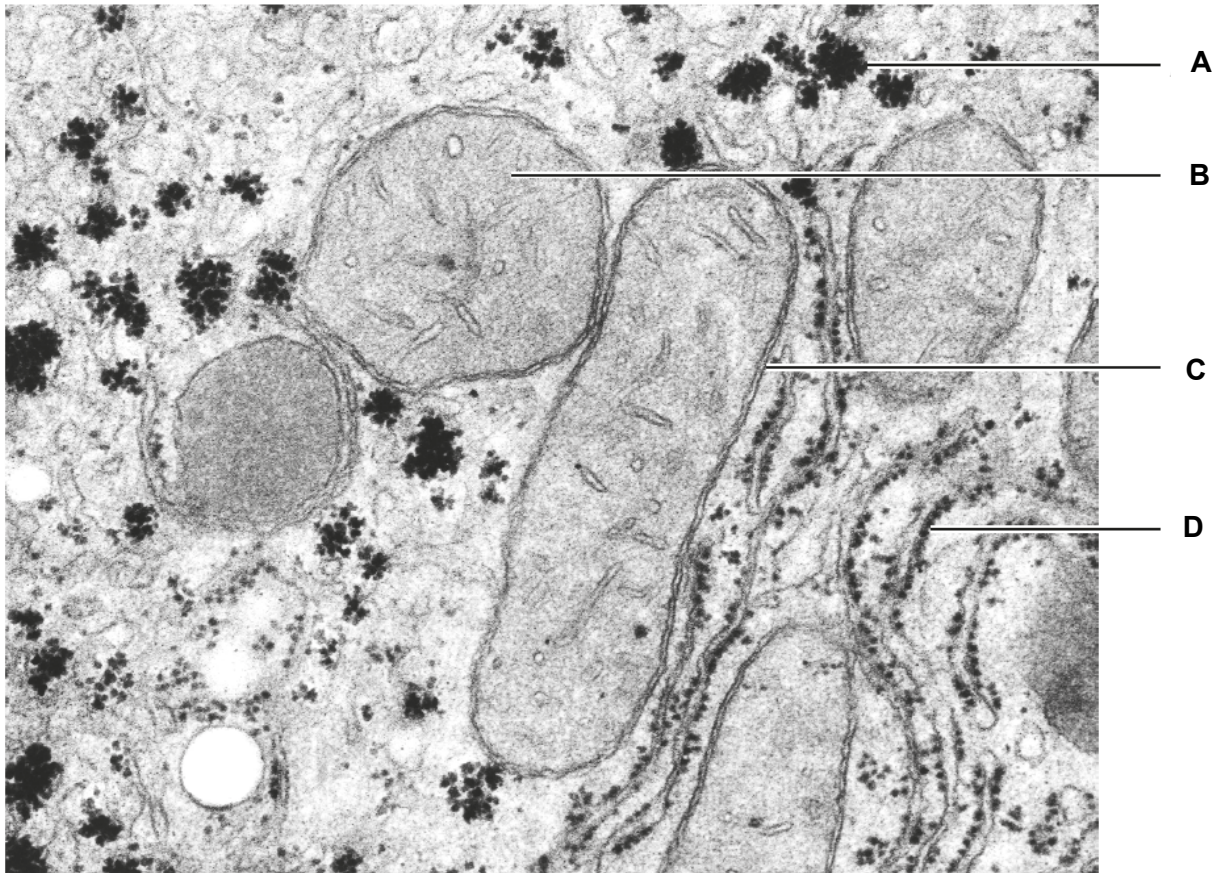
The optimum condition for this enzyme is the acidic environment of the stomach at pH 1-2.

The remaining substrate concentration was measured after 5 minutes at each different pH.

Which graph shows the effect of increasing pH on substrate concentration remaining after five minutes?



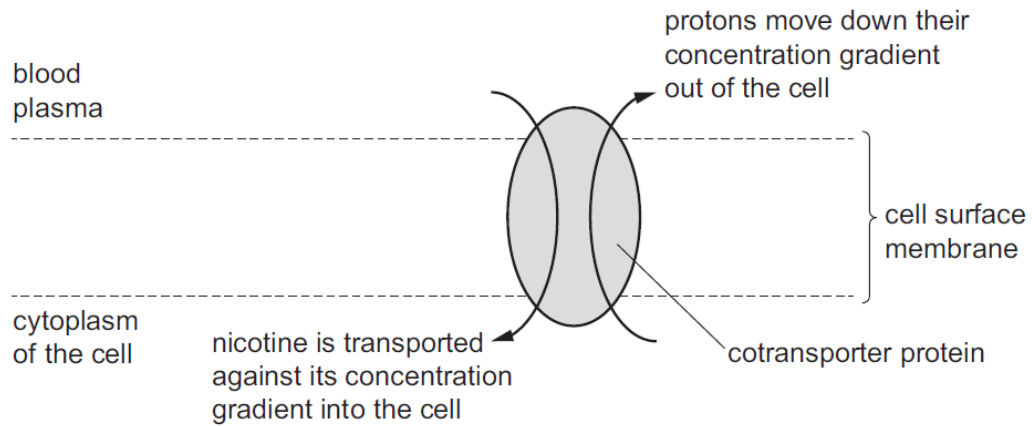
3. The micrograph below shows some organelles and storage molecules in a mammalian liver cell.



Which of the following statements about the labelled structures/ molecules is incorrect?

- A** Biomolecule **A** is a storage polysaccharide, glycogen.
- B** Structures **B** and **C** are the same organelle, just sectioned at different planes.
- C** Structure **D** is attached to a membrane and responsible for protein synthesis.
- D** The inner membrane of **C** has an identical composition as the membrane that **D** is attached to.

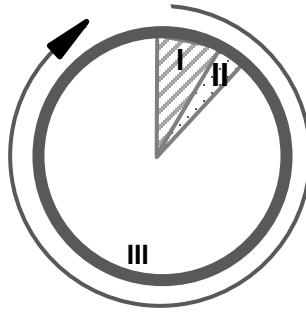
4. The diagram shows how nicotine is transported from the blood plasma into a cell using a type of cotransporter mechanism.



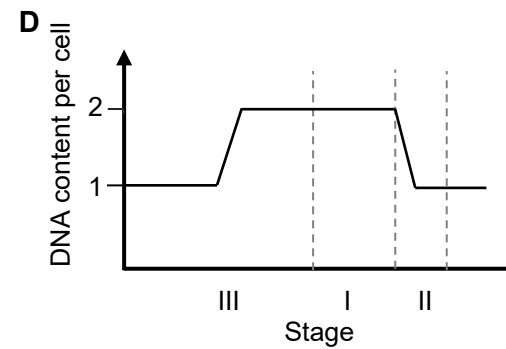
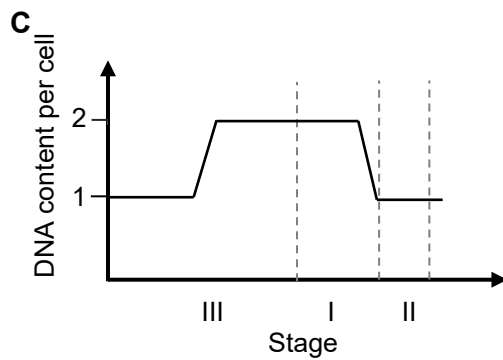
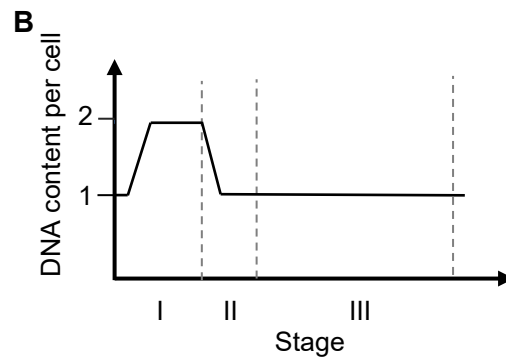
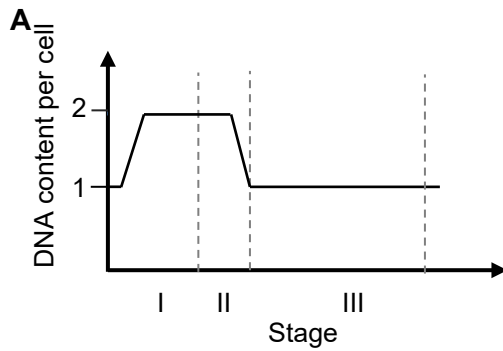
With reference to the figure above, which statement best describes the transport of nicotine?

- A** The cotransporter protein generates a proton gradient by moving protons out of the cell by active transport.
- B** The protons are transported through the cotransporter protein by facilitated diffusion.
- C** The cotransporter protein uses the energy stored in the proton gradient to drive the movement of nicotine.
- D** The cotransporter protein uses energy from ATP to transport protons with nicotine.

5. The simplified schematic diagram below shows 3 stages in a cell cycle.

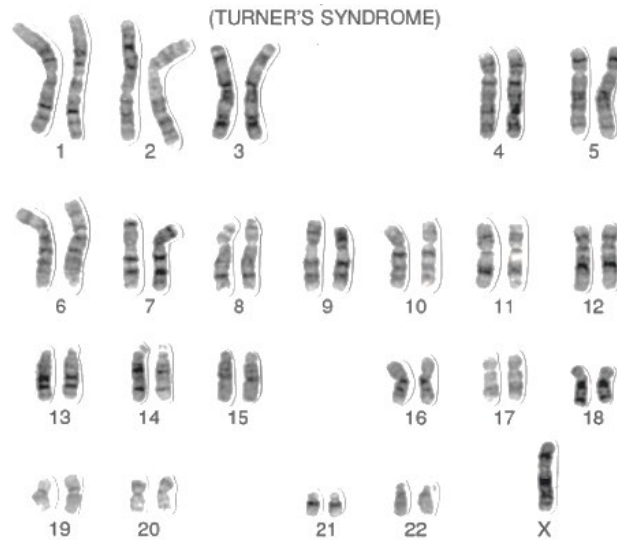


Which of the following graphs best matches the changes in the DNA content per cell, in the three stages?



6. Turner syndrome is a genetic disorder affecting only females. It causes symptoms such as short stature, elbow deformity and sterility.

A girl with Turner syndrome produced the following karyogram.



[Credit: Wessex Reg. Genetics Centre. Attribution 4.0 International (CC BY 4.0)]

This condition resulted from non-disjunction occurring in anaphase I of meiosis in an egg cell. Two cells resulted from the first division. One of the cells led to Turner syndrome. Which chromosomes will be in the other cell (polar body) at the end of meiosis I?

- A 44 autosomes and X
- B 44 autosomes and XX
- C 22 autosomes and X
- D 22 autosomes and XX

7. The following sequence of template DNA is taken randomly from a bacterial genome.

5' TTACGCTTCGAAATAGGAATATCATAGGCT 3'

What would be the first four amino acids of a polypeptide generated from this sequence?

The mRNA codons for some amino acids are shown in the table below:

Arg	CGA, CGG, AGA, AGG	Leu	CUU, CUC, CUA, CUG
Asp	GAU, GAC	Lys	AAA, AAG
Ile	AUU, AUC, AUA	Phe	UUU, UUC
Start	AUG	Ser	UCA, UCG, AGU, AGC
Stop	UAG, UGA, UAA	Tyr	UAU, UAC

- A** Met-Arg-Ser-Phe
B Met-Arg-Ser-Lys
C Met-Ile-Phe-Leu
D Met-Tyr-Lys-Asp

8. The table describes different types of mutations in DNA.

mutation	name
from purine to other purine	transition
from pyrimidine to other pyrimidine	transition
from purine to pyrimidine	transversion
from pyrimidine to purine	transversion

The diagram represents part of a DNA molecule.

A – T
A – T
C – G
C – G

Which diagram shows the DNA molecule after a transition has occurred?

T – A
A – T
C – G
C – G

I

A – T
A – T
C – G
G – C

II

A – T
A – T
T – A
C – G

III

A – T
G – C
C – G
C – G

IV

- A** I only **B** I and II only **C** III only **D** III and IV only

9. Which set of statements correctly describes the transfer of DNA from one bacterium to another?

	binary fission	transduction	conjugation
A	only plasmids pass to daughter cells	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
B	only plasmids pass to daughter cells	bacterial cell takes up foreign DNA from culture medium	double strand of F plasmid transferred from one bacterium to another
C	daughter cells inherit bacterial chromosome and plasmids	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
D	daughter cells inherit bacterial chromosome and plasmids	bacterial cell takes up foreign DNA from culture medium	double strand of F plasmid transferred from one bacterium to another

10. The *trp* operon is an example of a repressible operon found in the *E. coli*.

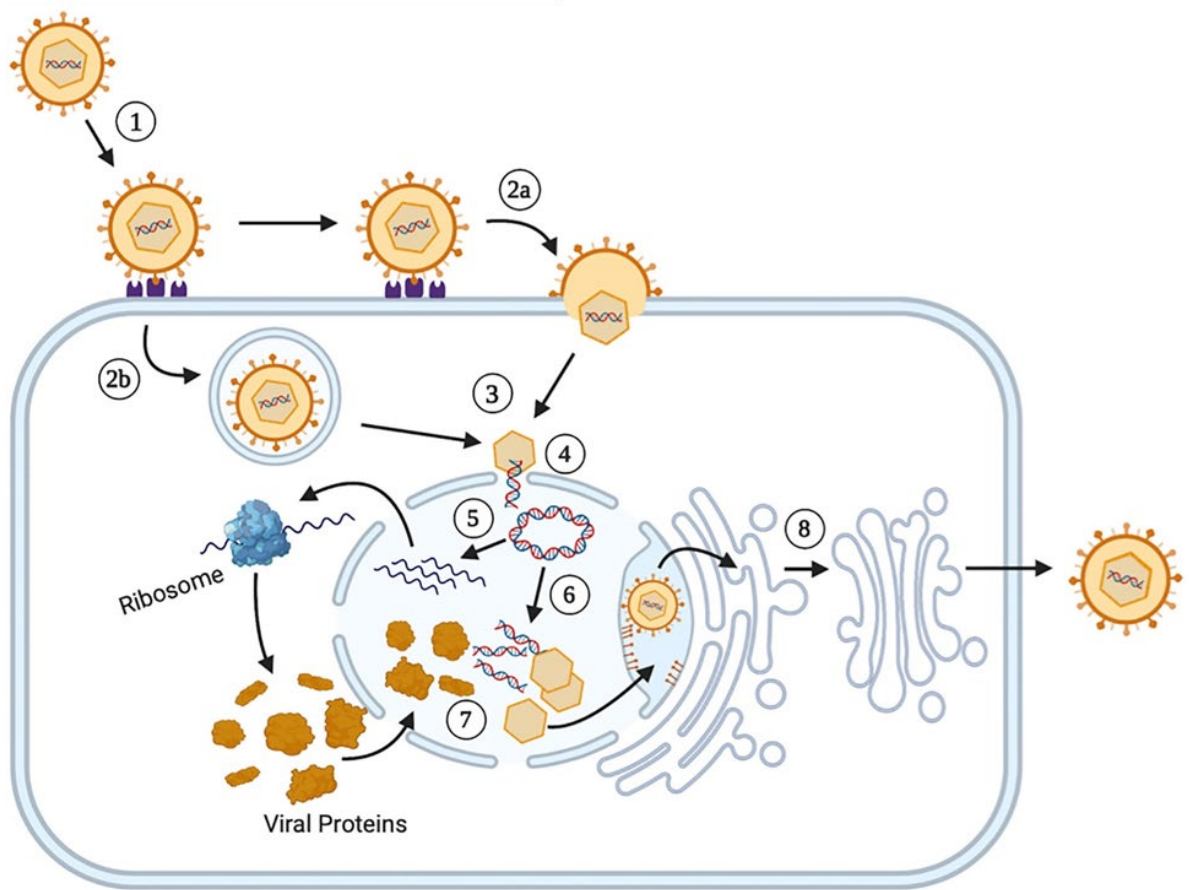
E. coli cells were irradiated by UV light, leading to mutations in their genomes. In some of these cells, mutated *trp* R regulatory genes led to the constitutive expression of active repressor proteins, due to a conformation change in their DNA binding sites.

Which of the following modification(s) could restore the normal regulation of the *trp* operon?

- I Induce a loss of function mutation in the promoter site of the existing mutated *trp* R gene.
- II Induce a loss of function mutation in the promoter site of the existing *trp* R gene and insertion of a functional *trp* R gene with its own promoter.
- III Replace, via homologous recombination, the existing operator sequence with a mutated operator sequence, without affecting the promoter region.
- IV Culture the mutated *E. coli* cells in a tryptophan deficient medium for several generations.
- V Transform the bacterial cells with recombinant plasmids, each containing a functional promoter sequence of the *trp* R and the *trp* structural genes.

- A** I and III only
- B** II only
- C** II, III and V only
- D** I, II and IV only

11. The diagram below shows the life cycle of Herpes virus.



Which of the following statements is incorrect?

- A** The virus enters the cell by fusion.
 - B** The viral genome replicates using reverse transcriptase.
 - C** Budding occurs at the nuclear membrane.
 - D** Assembly of the viral components occurs in the nucleus.
12. Which statement best reflects what we know about antigenic shift?
- A** An avian flu virus undergoes several mutations such that it can be transmitted to other birds.
 - B** A flu virus from a human epidemic or pandemic infects birds; the birds replicate the virus differently and then pass it back to humans.
 - C** An influenza virus gains new sequences of DNA from another virus, such as a herpesvirus; this enables it to be transmitted to a human host.
 - D** An animal such as a pig is infected with more than one type of flu virus, genetic recombination occurs, the new flu virus mutates and is passed to a new species such as a bird, the flu virus mutates and can be transmitted to humans.

13. The following table shows the genome size, number of genes and chromosome number for a variety of organisms.

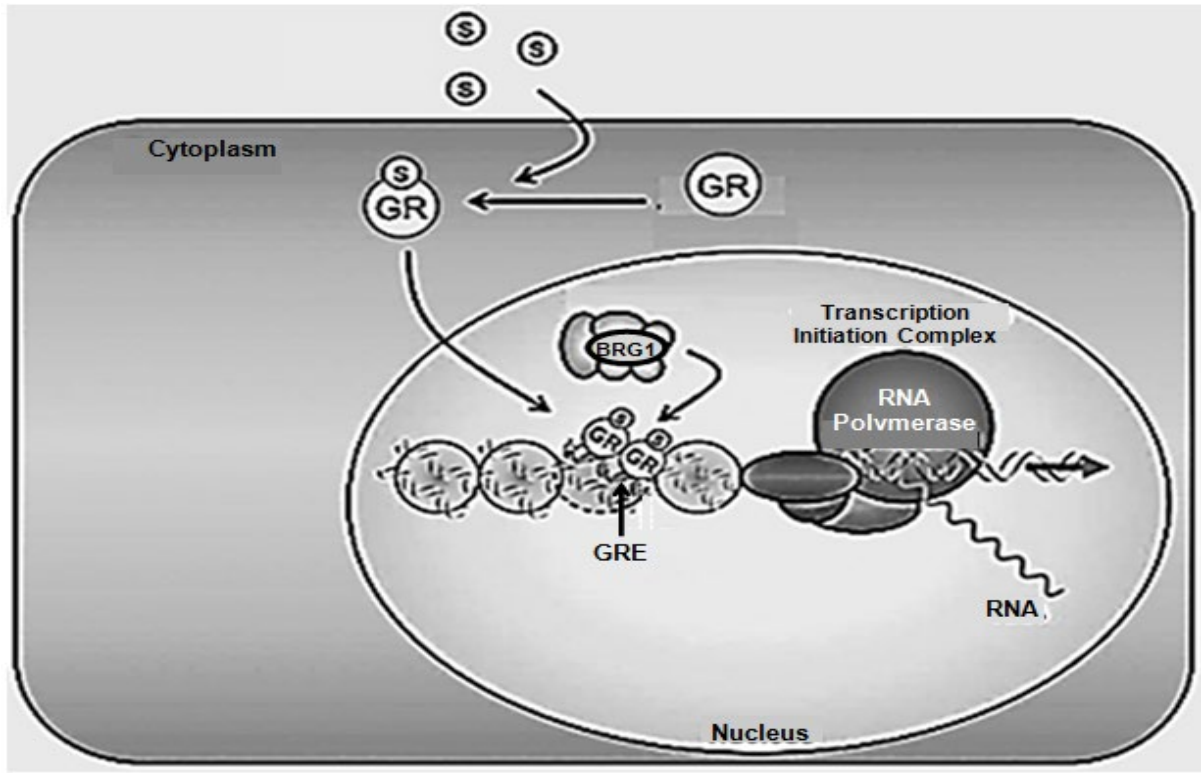
organism	genome size (kilo bp)	number of genes	chromosome number
<i>E. coli</i>	4,000	4,000	n = 1
Yeast	12,000	6,000	2n = 12
Amoeba	290,000,000	No data	500-1000 (possibly polyploid)
Mouse	3,000,000	No data	2n = 64
Rhesus monkey	3,000,000	No data	2n = 42
Fruit fly	137,000	14,000	2n = 8
Humans	3,000,000	30,000	2n = 46

From this data it is possible to conclude that

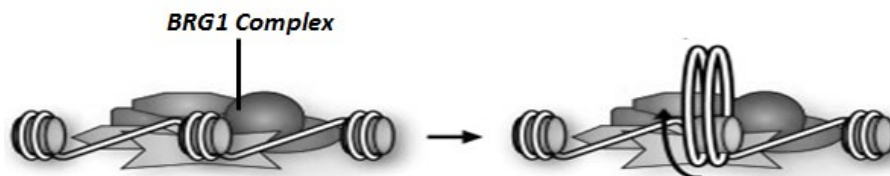
- A** there is more non-coding DNA in humans than in the bacterium.
- B** as chromosome number increases, so do the number of genes.
- C** the mouse and the rhesus monkey will have the same number of genes.
- D** the genome size relates to the complexity of an organism.

14. Glucocorticoids (S), are a class of steroid hormones that bind to the glucocorticoid receptor (GR), and are crucial in regulation of many genes. S binds to GR, activating GR. Activated GR binds to glucocorticoid response elements (GREs) within the promoter regions of target genes. This results in the recruitment of the chromatin remodelling complex, BRG1 complex.

The figure below shows the effect of GR-mediated gene expression.



The effect of BRG1 complex binding to the promoter region of the target gene is shown in the diagram below.



Which of the following about gene expression can be concluded from the information provided?

- A glucocorticoid receptor is regulated at the translational level
- B glucocorticoid receptor regulates gene expression at the transcriptional level
- C BRG1 complex brings about an effect similar to that of methylation of DNA
- D BRG1 is an activator

15. The statements below are about genes and proteins that are involved in breast cancer.
- The protein coded by the *BRCA1* gene inhibits the growth of breast cancer cells.
 - The protein coded by the *p53* gene suppresses tumours.

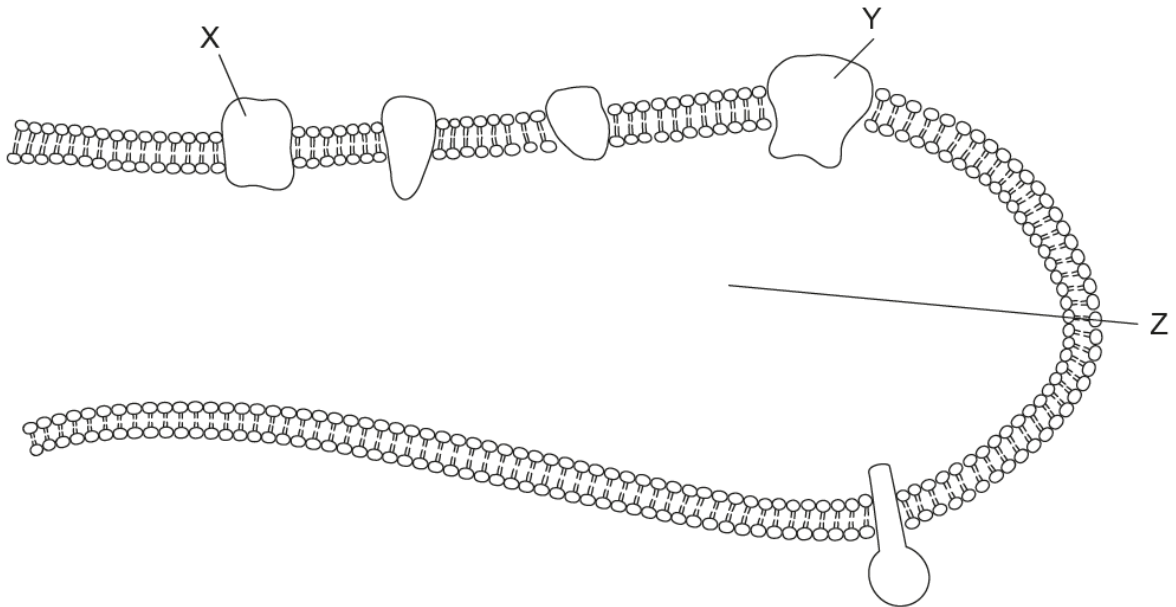
Which combination of genes is most likely to result in breast cancer?

	<i>BRCA1</i>	p53
A	✗	✗
B	✗	✓
C	✓	✗
D	✓	✓

✓ = normal active gene

✗ = mutated gene

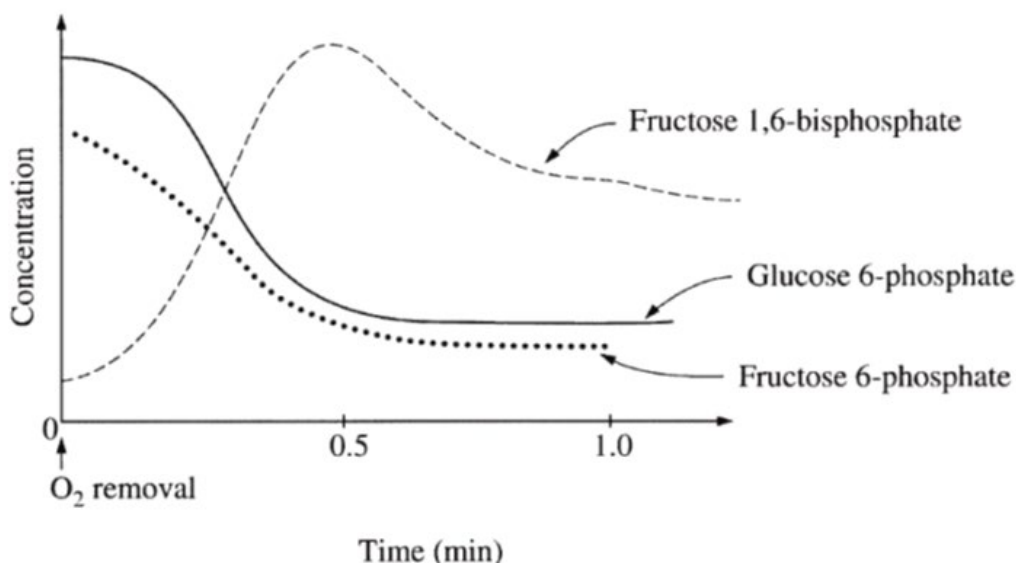
16. The diagram shows a section of an organelle in a plant cell. Electrons move from Y to X.



What do the letters **X**, **Y** and **Z** represent?

	X	Y	Z
A	Photosystem I	Photosystem II	Thylakoid space
B	Photosystem II	Photosystem I	Thylakoid space
C	ATP synthase	Photosystem II	Stroma
D	Photosystem II	ATP synthase	Stroma

17. Muscle cells were incubated in the presence of oxygen. Concentrations of various metabolites were measured immediately following the removal of oxygen. The results are shown below



The change in the concentration of glucose 6-phosphate can be best explained by

- A** increased demand for ATP in the cells.
B increased rate of glycolysis.
C decreased synthesis of glucose 6-phosphate.
D increased enzymatic inhibition by fructose 1,6-bisphosphate.
18. A variety of *Pelargonium* has yellow leaves. When plants of this variety are crossed, the resulting seeds produce green, yellow and white seedlings in the ratio 1:2:1. If plants with yellow leaves are crossed with plants with green leaves, what would be the expected ratio of phenotypes in the offspring?

	Green	Yellow	White
A	1	2	1
B	3	1	0
C	2	2	0
D	2	1	1

19. Two pure-bred lines of different plant varieties, which differed markedly in bean seed mass, were crossed. The mass of bean seeds produced by the two parental varieties and their offspring were measured to the nearest gram. The number of bean seeds in each mass category was counted.

The table below shows the results.

mass of bean/ mg		51 - 150	151 - 250	251 - 350	351 - 450	451 - 550	551 - 650	651- 750	751 - 850	851 - 950
number of beans	parental	5	375	177				352	955	10
	offspring			13	544	974	48	2		

Which statement incorrectly explains these experimental data?

- A** The range of phenotypes for the characteristic of bean seed mass is continuous and is due to several different nucleotide sequences at different chromosomal positions controlling the characteristic.
- B** The greater variation in bean seed mass observed in the offspring generation as compared to the parental generation is due to crossing over between homologous chromosomes, random fusion of gametes, different survival rates of the gametes and zygotes.
- C** The phenotypic effects of different nucleotide sequences at different chromosomal positions can be summed up to determine the bean seed mass in each plant.
- D** Various environmental factors affect the mass of bean seeds in plants.
20. The inheritance of flower colour in sweet pea plants is controlled by the interaction between two different genes. The biochemical pathway below illustrates the synthesis of purple pigments in these sweet pea plants.



Which of the following statements are false?

- 1 Recessive alleles at either gene loci in the homozygous recessive condition produce the same phenotype without a cumulative effect.
- 2 Inheritance of flower colour in sweet pea is an example of dominant epistasis.
- 3 Self-pollination of a double heterozygous sweet pea plant results in three different phenotypes.
- 4 Self-pollination of a double heterozygous sweet pea plant results in an offspring phenotypic ratio of 15:1.

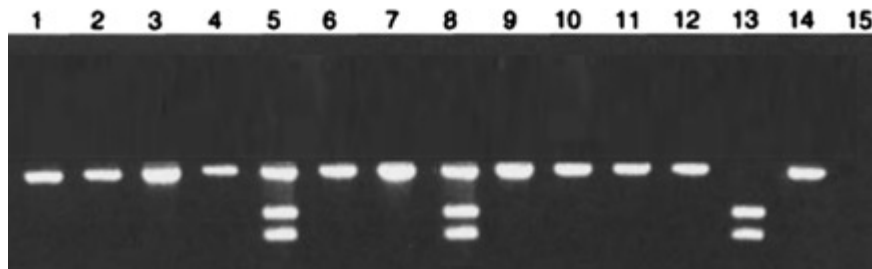
- A** 1 and 3 only **B** 2 and 4 only **C** 1, 2 and 4 only **D** 2, 3 and 4 only

21. Cystic fibrosis (CF) is one of the most common life-threatening recessive genetic diseases. It is a complex multisystem disorder, caused by different mutations of the gene encoding for the cystic fibrosis transmembrane conductance regulator (CFTR).

Cystic fibrosis mutation is the G551D mutation. This mutation creates a recognition site for the restriction enzyme *Mbo*I at codon 551 and results in a non-functional CFTR protein. This recognition site is not present in the normal allele.

The *CFTR* gene is amplified and digested with *Mbo*I. The diagram below shows the results of agarose gel electrophoresis of *Mbo*I digest products.

	...	549	550	551	552	553	...
	...	S	G	G	Q	R	...
Normal	...	AGT	GGA	GGT	CAA	CGA	...
	...	S	G	D	Q	R	...
Mutant	...	AGT	GGA	<u>GAT</u>	<u>CAA</u>	CGA	...
				<i>Mbo</i> I			
				recognition site			



Which of the following can be concluded from the results above?

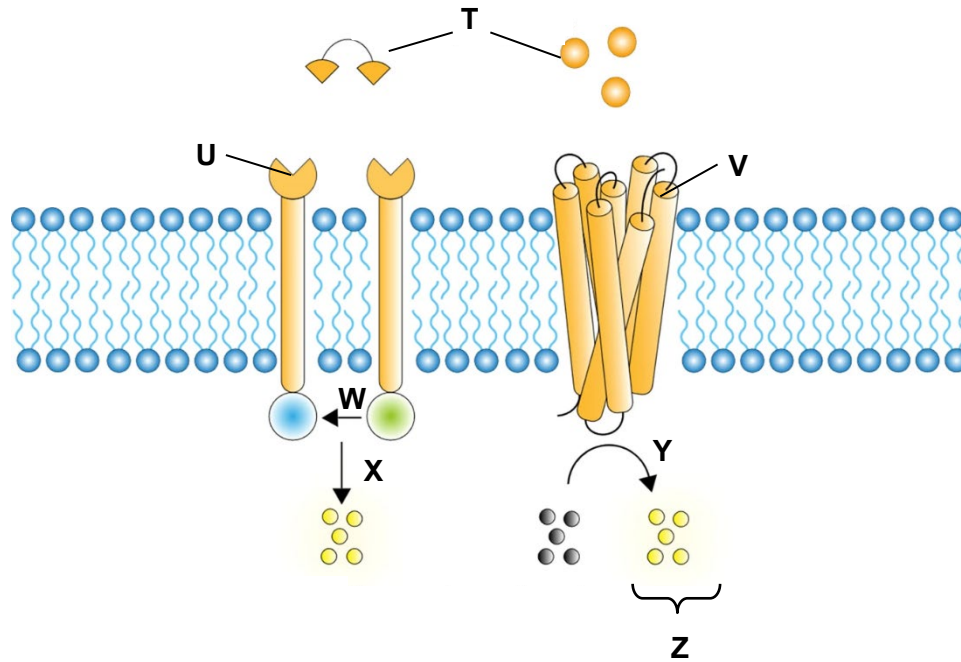
- Individuals 5 and 8 do not suffer from the cystic fibrosis.
- The probe used binds to region spanning and corresponding to codons 552 and 553.
- The recessive allele is represented only by the lowest band.

A 1 only **B** 1 and 3 only **C** 2 and 3 only **D** All of the above

22. Which is a correct statement about obtaining human embryonic stem cells for research?

- Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
- The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
- The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
- The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

23. The diagram shows two types of prominent transmembrane protein receptors involved in living cells.



[image: [Engineering receptor-mediated transmembrane signaling in artificial and living cells | Communications Materials](#)]

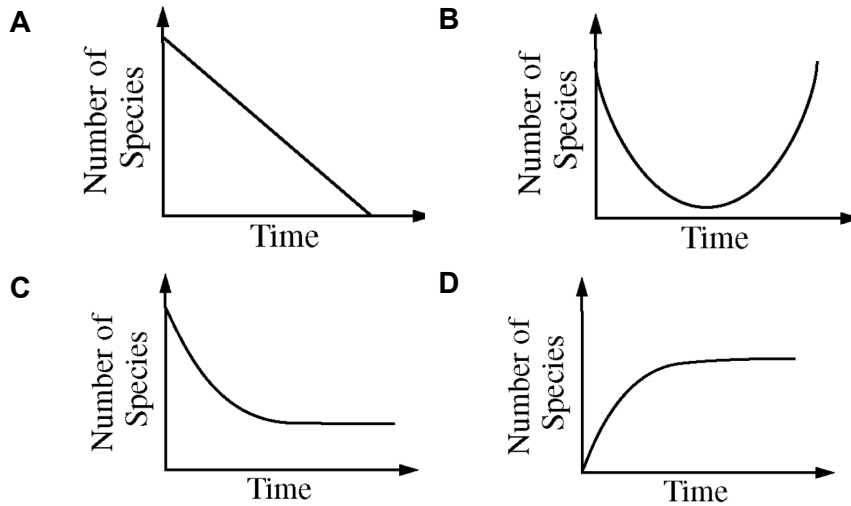
The following statements describe the series of reactions that involve these receptors in cell signalling pathways.

- 1 Ligand molecules **T** have a specific shape that binds to respective receptors **U** and **V**.
- 2 **W** involves the dimerisation of two units of **U** that activates the tyrosine residues in each subunit to phosphorylate tyrosine kinase on the subunit.
- 3 Binding of **T** to **V** causes a conformational change in the extracellular domain that will set off a cascade of reactions.
- 4 **U** consists of a transmembrane unit that passes through the membrane once but **V** consists of a transmembrane region that passes through the membrane seven times.
- 5 The second messenger molecules **Z** are activated when **Y** occurs, which is the exchange of bound GTP for GDP.

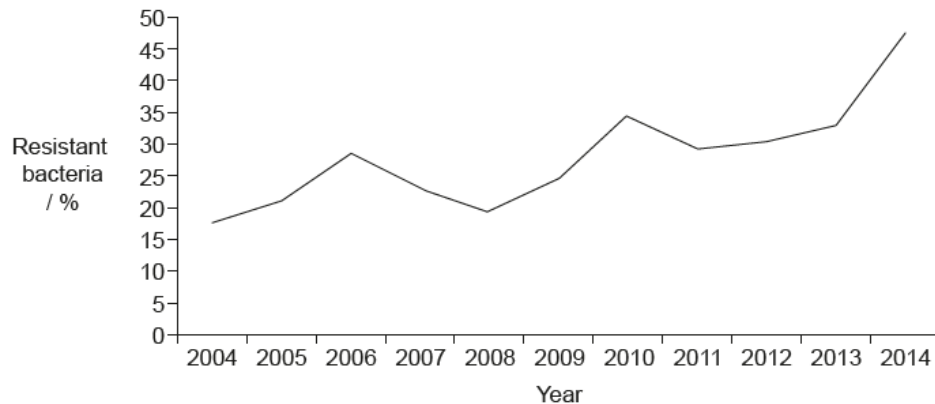
Which of the above statements are correct?

- A** 1 and 2 only **B** 1 and 4 only **C** 1, 3 and 4 only **D** All of the above

24. Which of the following graphs most likely represents how the number of bird species would change from the time of an island's formation? Assume the island remains constant in size, isolation and environmental conditions.



25. The graph shows the proportion of a bacterial population of *Neisseria gonorrhoeae*, displaying resistance to the antibiotic tetracycline. This bacteria commonly causes a sexually transmitted infection.



[Source: © All rights reserved. *Canadian Antimicrobial Resistance Surveillance System Report, 2016*. Public Health Agency of Canada. Adapted and reproduced with permission from the Minister of Health, 2022.]

What can be deduced from this graph?

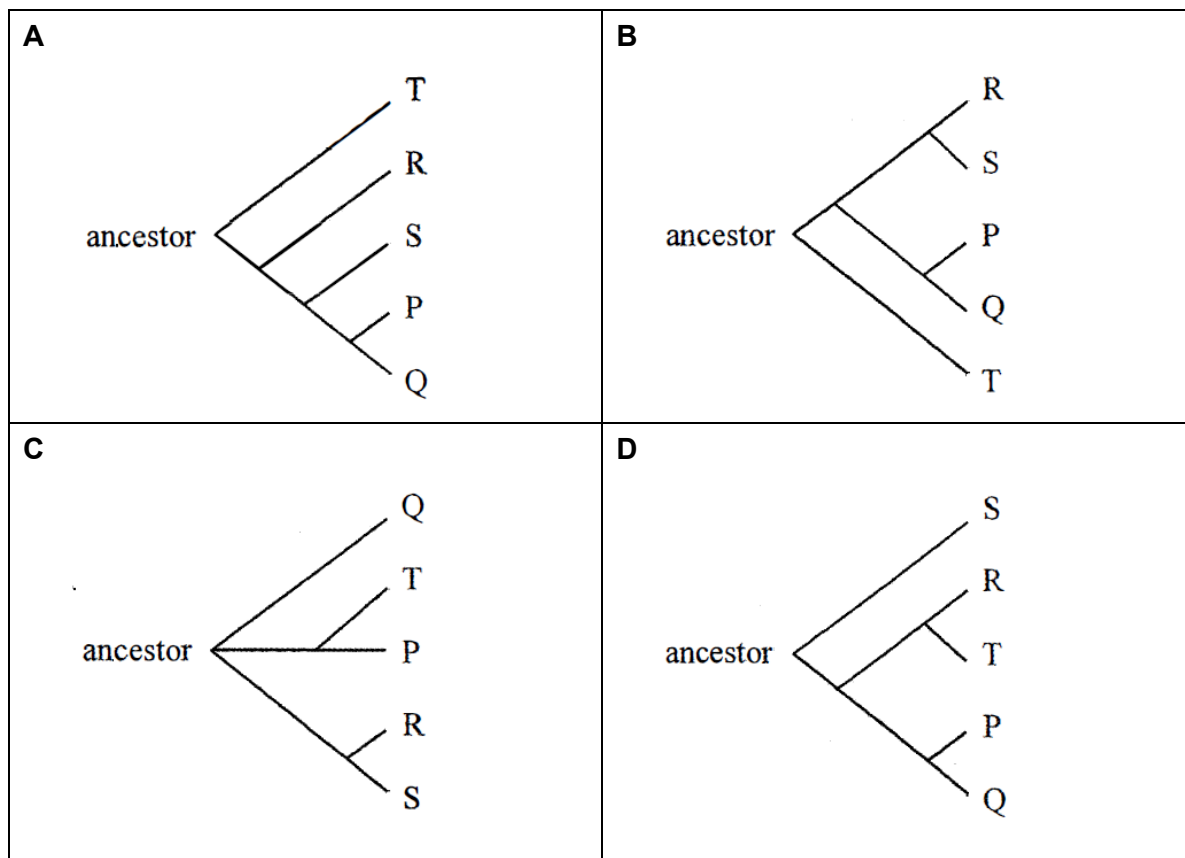
- A Bacteria with beneficial traits against tetracycline survive and pass on their alleles.
- B Immunity to tetracycline is triggered by over-use of the antibiotic.
- C Genetic variation in the bacteria is increasing.
- D Use of antibiotics exerts a selection pressure on pathogens.

26. Five new species of eubacteria were discovered in Antarctic ice core samples. The nucleotide sequences of the gene that codes for an essential protein were compared.

The nucleotide differences between the species is shown below:

Species	Number of nucleotide differences				
	P	Q	R	S	T
P	-	4	12	11	22
Q		-	12	11	19
R			-	4	22
S				-	22
T					-

Which of the following evolutionary trees best illustrates the phylogenetic relationship of the five species?



27. Which of the following rows regarding the roles of cells of the immune system are correct?

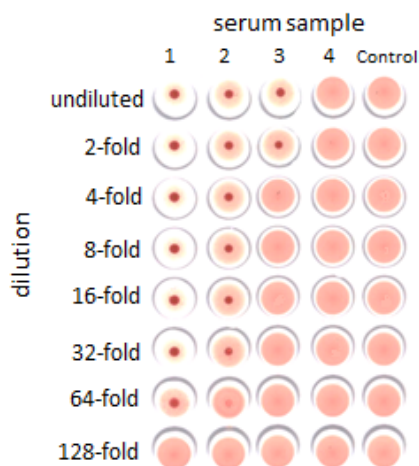
	macrophages	T lymphocytes	B lymphocytes
I	antigen processing and presentation	antigen recognition	antigen presentation
II	phagocytosis	antigen presentation	antigen processing
III	antibody binding	production of memory cells	antigen recognition
IV	antigen presentation	activation of B lymphocytes	production of antibodies

- A** I and II only **B** II and IV only **C** I, III and IV only **D** All of the above

28. The effectiveness of a vaccine is measured by the concentration of antibodies produced that can bind to specific antigens in the vaccine.

Blood from a man is taken at different times after vaccination and the blood serum containing antibodies is extracted. The serum is then subjected to a serial dilution where the concentration is halved with each step of the dilution. Each diluted blood serum is added to a well containing a fixed concentration of antigens. At a sufficiently high antibody concentration, a visible dark spot is formed due to a high level of antigen-antibody agglutination.

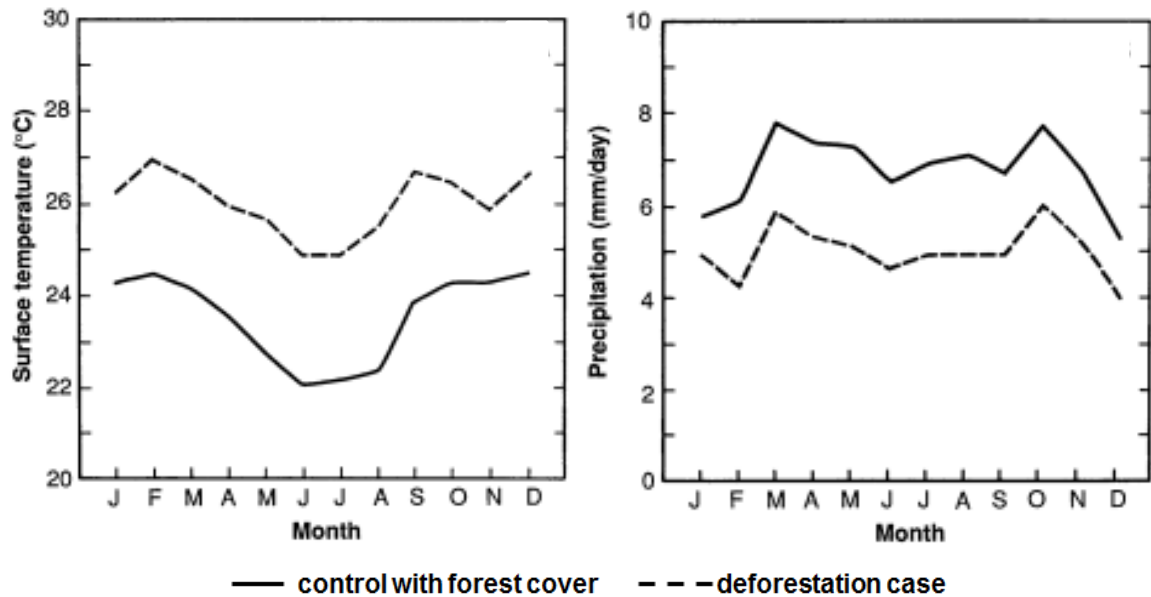
The diagram shows the results of an investigation on the effectiveness of the initial dose of the vaccine and its booster given after six months. Four serum samples were taken at different time points.



Which serum samples correspond to the different time points after the initial dose and the booster were given?

	2 nd day after initial dose is given	Before booster is given (6 months after initial dose)	2 nd day after booster is given	6 months after booster is given
A	1	2	4	3
B	4	2	3	1
C	4	3	1	2
D	1	4	2	3

29. Scientists created a simulation of the effects of Amazon deforestation on the climate. In the simulation, an area of the tropical forest was replaced by a pasture of grass. The simulation provided monthly data on the temperature of the ground surface (surface temperature) and rainfall (precipitation) over a year-long period.

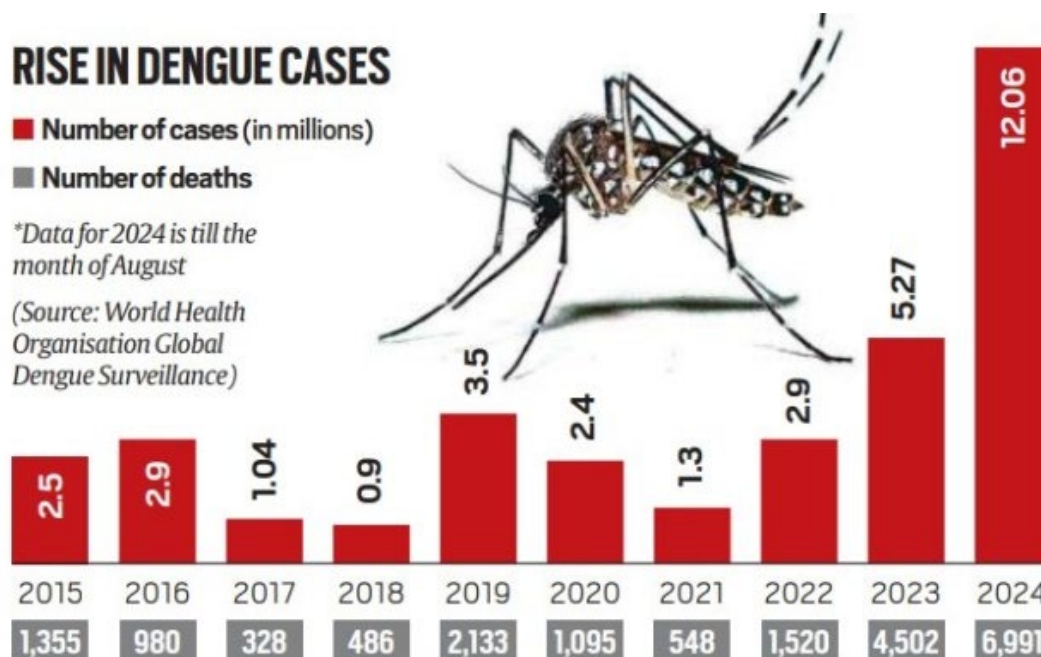


Which statements could explain these data?

- 1 Grass is a more effective carbon sink than trees.
- 2 The removal of forest cover disturbed the soil layers and resulted in carbon emissions.
- 3 Without the trees, the reduced transpiration rate resulted in less water vapour released into the atmosphere.
- 4 Increase in surface temperature could lead to increase in the rate of evaporation.

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

30. The number of cases of dengue and number of deaths due to dengue have risen over the years.



Which of the following is not a possible cause for the steep increase in the number of cases seen from 2021 to 2024?

- 1 Higher temperatures allowed mosquitoes to increase their range.
 - 2 Modern technology allowed better detection of dengue infection.
 - 3 More patients are being tested for dengue infection.
 - 4 More international human travel.
- A** 2 and 3 only **B** 1 and 4 only **C** All of the above **D** None of the above

- End of Paper -