



YISHUN INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE
NAME

ANSWERS

CG

INDEX NO

BIOLOGY

9744/01

Paper 1 Multiple Choice

19 September 2025

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not use staples, paper clips, glue or correction fluid/tape.
Write your name, index no. and CG on this cover page and OTAS provided unless this has been done for you.

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.

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

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

1 Which row correctly describes a cell organelle?

	organelle	description
A	centriole	a hollow cylinder that generates spindle microtubules and is enclosed by a single membrane
B	lysosome	a spherical sac containing digestive enzymes that is formed by the smooth endoplasmic reticulum
C	mitochondrion	a single membrane enclosing an inner membrane folded into cristae to house electron transport chains
D	ribosome	two unequal subunits made of rRNA and proteins, attached permanently to the rough endoplasmic reticulum

A – Incorrect: A centriole is a hollow cylinder made of **nine triplets of microtubules** and is **not** surrounded by any membrane.

B – Incorrect: Lysosomes are spherical sacs containing digestive enzymes, but they are formed by the RER & Golgi apparatus, **not the smooth endoplasmic reticulum**.

C – Correct: A mitochondrion has a **double membrane** — an outer membrane and a folded inner membrane (forming cristae)

D – Incorrect: Ribosomal subunits are **unequal** in size (large and small subunit) and are found free in the cytoplasm or attached to the **rough ER**

ER: Poorly done. Only **28%** of candidates answered correctly.
Most chose **A (31%)** or **B (34%)** instead of the correct answer **C**.

2 The table compares some features of three different proteins, P, Q and R.

Of these proteins:

- one has a fibrous quaternary structure
- one has a globular tertiary structure
- one has a globular quaternary structure

protein	number of genes coding for the protein	% of protein composed of the commonest amino acid	% of protein composed of small amino acids	durability
P	2	46	77	less sensitive to changes in pH and temperature
Q	1	24	10	more sensitive to changes in pH and temperature
R	2	21	8	more sensitive to changes in pH and temperature

Which row correctly identifies each protein?

	fibrous quaternary structure	globular tertiary structure	globular quaternary structure
A	P	R	Q
B	P	Q	R
C	R	P	Q
D	R	Q	P

A – Incorrect: R is not the globular tertiary structure — it has 2 genes coding for it, which is more typical of a quaternary protein. Its low % of small amino acids (8%) also does not fit fibrous proteins.

B – Correct: P is the fibrous quaternary structure (2 genes, high % commonest amino acid, high % small amino acids, less sensitive to pH/temp), Q is the globular tertiary structure (1 gene, many amino acid types, more sensitive to pH/temp), and R is the globular quaternary structure (2 genes, more sensitive to pH/temp).

C – Incorrect: P is not a globular quaternary structure — its high % of small amino acids (77%) and repetitive sequence (46% commonest amino acid) fit fibrous proteins, not globular.

D – Incorrect: P is not a globular quaternary structure and R is not fibrous — R has many amino acid types and is more sensitive to pH/temp, which fits a globular protein.

ER: Well done

3

Which of the following statements below are correct?

1. During endocytosis, vesicles bud inwards from the cell surface membrane, leading to a loss of phospholipids.
2. During endocytosis, vesicle membrane fuses with the cell surface membrane, leading to a gain of phospholipids.
3. During exocytosis, vesicles fuse with the cell surface membrane, leading to a gain of phospholipids.
4. During exocytosis, vesicles bud off from the cell surface membrane, leading to a loss of phospholipids.

A 1 and 2

B 1 and 3

C 1 and 4

D 2 and 4

Statement 1 – Correct: In endocytosis, vesicles bud inwards from the plasma membrane. This removes a portion of the membrane, resulting in a net loss of phospholipids from the plasma membrane.

Statement 2 – Incorrect: Endocytosis does not involve vesicle membrane fusion with the plasma membrane — that occurs in exocytosis. Endocytosis decreases, not increases, the phospholipid content of the plasma membrane.

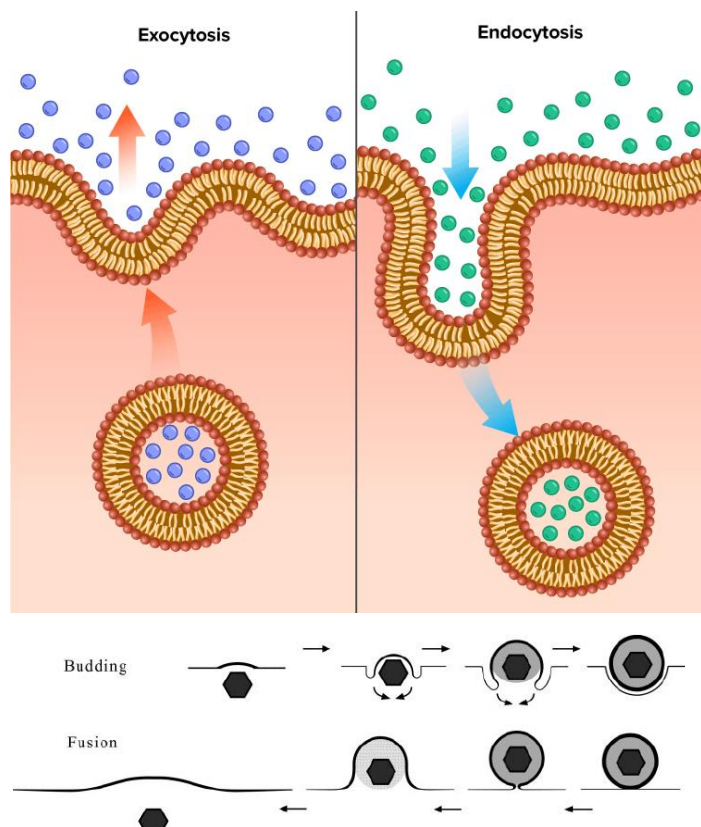
Statement 3 – Correct: In exocytosis, vesicles formed inside the cell (e.g., from the Golgi apparatus) fuse with the plasma membrane. This increases the plasma membrane surface area and results in a net gain of phospholipids.

Statement 4 – Incorrect: Exocytosis does not involve vesicles budding off from the plasma membrane — instead, they fuse with it. Therefore, there is no loss of phospholipids during exocytosis.

Take note!

HIV Entry: Direct fusion of the viral envelope with the host cell membrane.

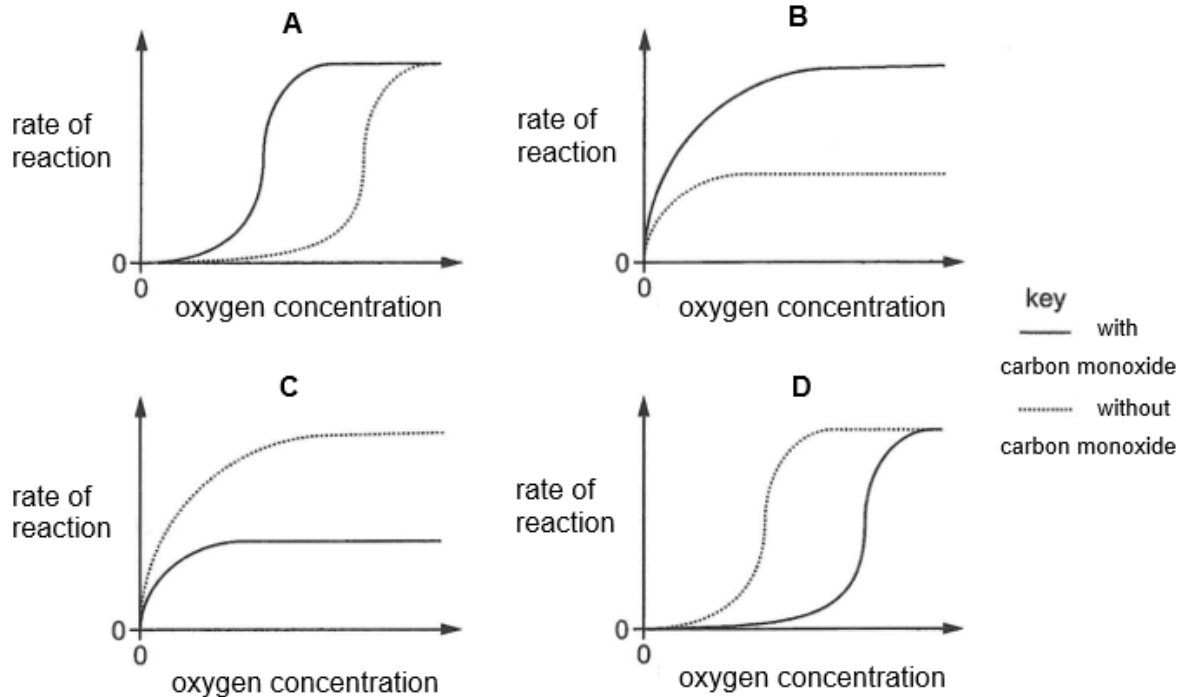
Influenza Entry: Receptor-mediated endocytosis followed by fusion within an endosome.



ER: Poorly done. Only 45% of candidates answered correctly. Most chose D (38%) instead of the correct answer C.

- 4 Carbon monoxide poisoning occurs when CO binds to haemoglobin with a much higher affinity than oxygen, reducing oxygen uptake.

Which graph shows the effect of oxygen concentration on the rate of oxygen binding to haemoglobin, with and without carbon monoxide?



Correct Answer: D

Haemoglobin shows sigmoidal (S-shaped) curves due to cooperative binding (binding of one O₂ results in the easier binding of other O₂ molecules).

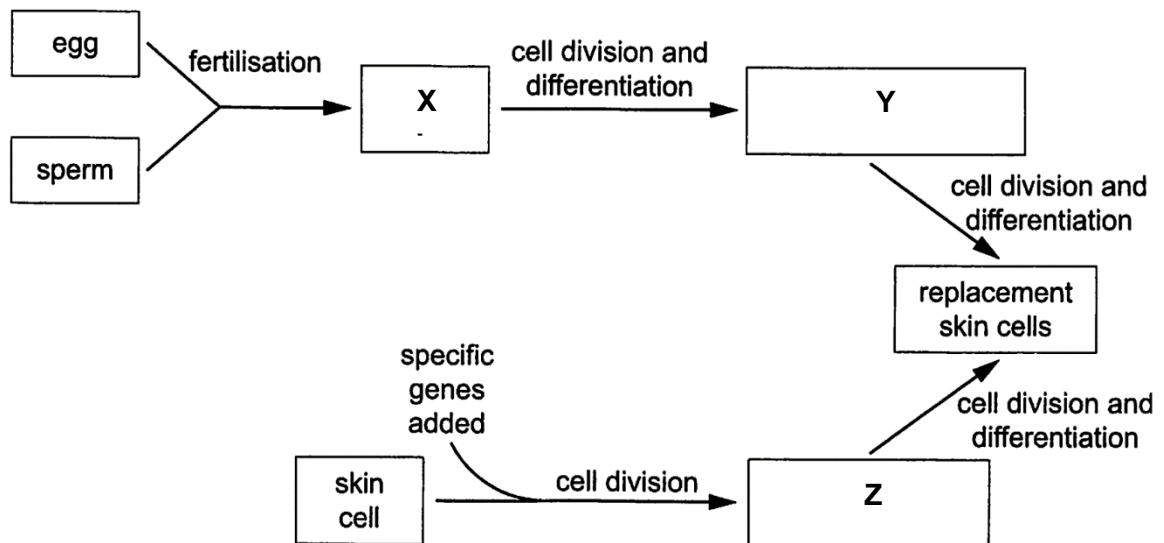
- CO acts as a **competitive inhibitor**, since it is **structurally similar to oxygen** and binds to the **active site** (haem group) of haemoglobin.
- With CO present, the curve shifts to the right, showing that a higher oxygen concentration is needed to achieve the same saturation (reduced apparent affinity).
- The maximum rate (V_{max}) is also reduced, because some haem groups are permanently occupied by CO and cannot bind oxygen at all.
- This matches graph D, where the "with inhibitor" curve is right-shifted and lower than the "without inhibitor" curve.

ER: Poorly done. Only **39%** of candidates answered correctly.

Most chose C (48%) instead of the correct answer D.

- 5 Stem cells can be used to replace cells in damaged tissues, such as skin.

The diagram shows two ways in which replacement skin cells can be produced.



Which row correctly describes the stem cells **P**, **Q** and **R**?

	X	Y	Z
A	pluripotent	multipotent	totipotent
B	pluripotent	induced pluripotent	induced pluripotent
C	totipotent	pluripotent	induced pluripotent
D	totipotent	totipotent	totipotent

X – Totipotent stem cell

- X represents the **zygote**, formed immediately after fertilisation.
- A zygote is **totipotent**, meaning it can give rise to all cell types in the body **and** extraembryonic tissues (e.g., placenta).

Y – Pluripotent stem cell

- Y represents **embryonic stem cells** derived from the early embryo.
- These cells are **pluripotent**

Z – Induced pluripotent stem cell (iPSC)

- Z is generated by adding **specific genes** to a differentiated skin cell, reprogramming it back to a pluripotent state.

ER: Well done

- 6** The structure of nucleic acids facilitates the accurate synthesis of proteins.
Which row describing the nucleic acid structure and its role is correct?

	structure	role
A	A mature mRNA has 997 nucleotides, including a 250-nucleotide poly-A-tail.	When translated, the polypeptide has a maximum number of 249 amino acids.
B	There are 61 different types of tRNA molecules, each with a different anti-codon, present in each cell.	During elongation, the activated tRNA brings the correct amino acid to the P-site of the ribosome.
C	rRNA are single-stranded but can fold to form double-stranded regions via A-T and C-G base-pairing.	rRNA has both structural and enzymatic functions in the ribosome.
D	The pentose sugar in DNA is deoxyribose, which lacks an –OH at the 2' carbon; in RNA it is ribose, which has –OH groups at both the 2' and 3' carbons.	Both have free 3' –OH groups that form phosphoester bonds with incoming nucleotides during condensation.

A – Incorrect: the mature mRNA should have $997 - 250 - 3$ (stop codon) = $744/3 = 248$ amino acids, not 249 amino acids

B – Incorrect: During elongation, the activated tRNA delivers its amino acid to the **A-site** of the ribosome.

C – Incorrect: rRNA is single-stranded and forms secondary structures via base pairing, but in **RNA pairing is A–U (not A–T)**. This structural error makes the description inaccurate, even though the role is correct.

D – Correct: DNA contains deoxyribose, which contains a H atom at the 2' carbon; RNA contains ribose, with –OH groups at both the 2' and 3' carbons.

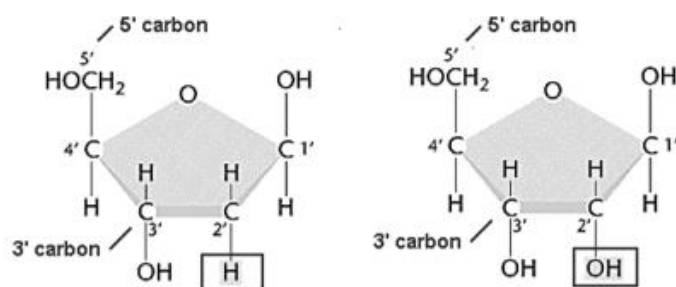
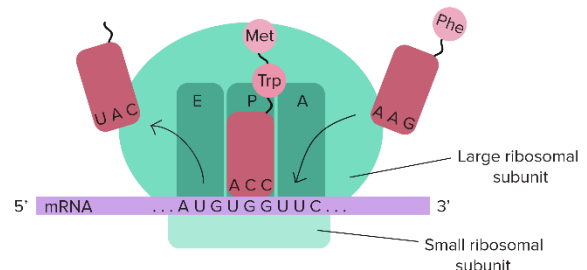
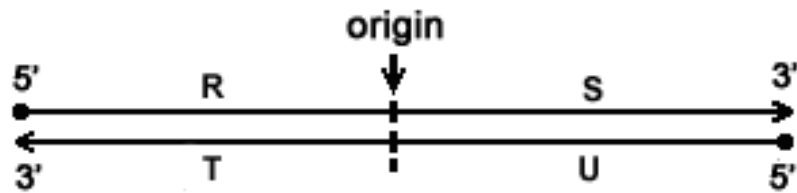


Fig. 2.1.2: Deoxyribose (left) and ribose (right)

ER: Poorly done. Only **29%** of candidates answered correctly.

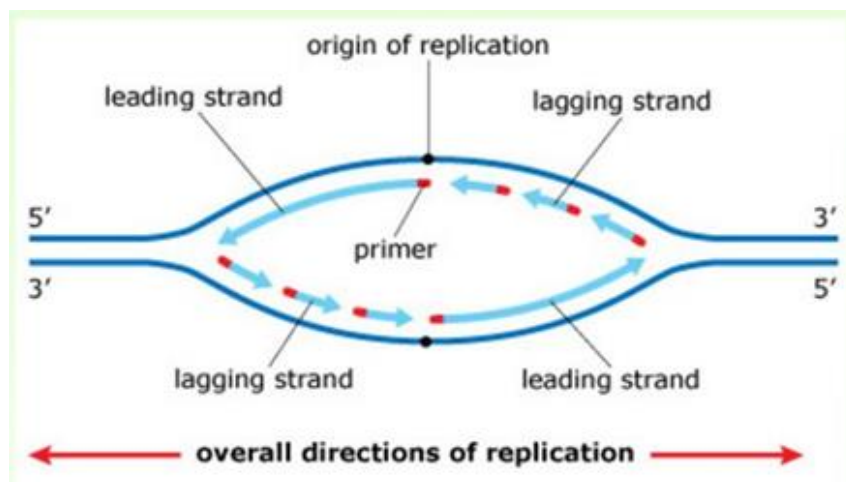
Most chose **B (27%)**, **C (22%)** or **D (29%)** instead of the correct answer **D**.

- 7 DNA synthesis is initiated at the origin of replication as shown in figure below.



Which segments of single-stranded DNA are templates for the synthesis of the following strands?

	Leading Strands	Okazaki Fragments
A	S and T	R and U
B	R and U	S and T
C	S and U	R and T
D	R and T	S and U

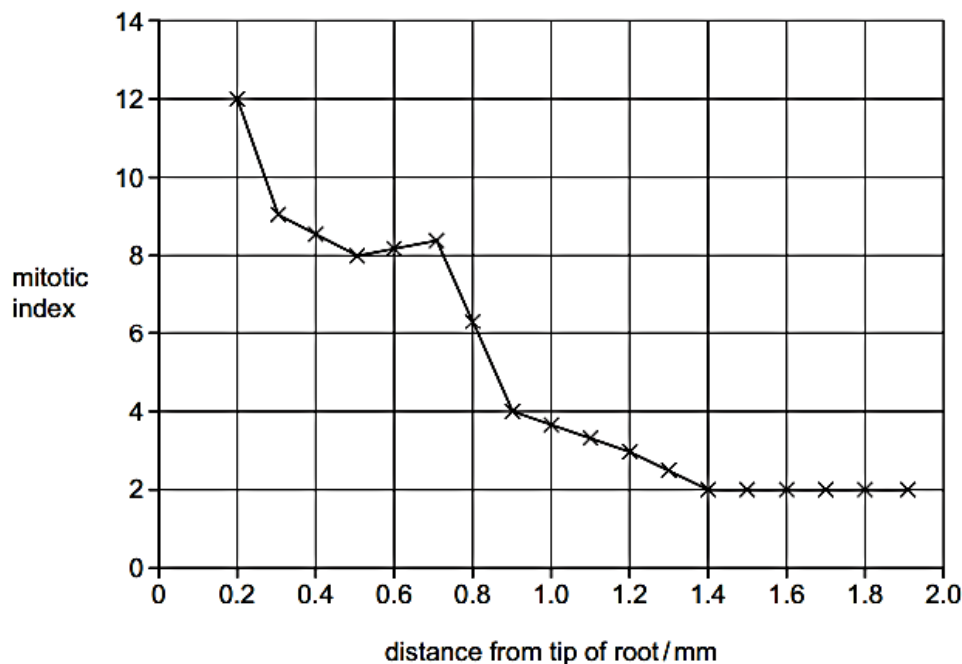


ER: Well done

- 8 The mitotic index is a measure of the proportion of cells that are undergoing mitosis in an area of tissue. It is calculated using the formula shown.

$$\text{mitotic index} = \frac{\text{number of cells undergoing mitosis}}{\text{total number of cells}} \times 100$$

A scientist calculated the mitotic index of areas of onion root at different distances from the tip of the root. The results are shown.



- A** No cell division occurs further than 1.4 mm from the tip of the root.
- B** The rate of cell division decreases as the distance from the root tip decreases.
- C** Most of the cells undergoing cell division are further away from the tip of the root.
- D** For a sample of 200 cells 0.2 mm from the tip of the root, 24 would be undergoing mitosis.

A – Incorrect: The graph shows a mitotic index of about 2% from 1.4 mm to 2.0 mm from the root tip. This means some cell division is still occurring beyond 1.4 mm, so saying “no cell division” is wrong.

B – Incorrect: The statement reverses the trend. The graph shows the mitotic index **decreases** as the distance from the root tip **increases**, not decreases.

C – Incorrect: The mitotic index is highest (around 12%) close to the root tip and declines with distance. This means most actively dividing cells are located near the tip, where growth occurs.

D – Correct: At 0.2 mm from the root tip, the mitotic index is about 12%.
12% of 200 cells = 24 cells undergoing mitosis, not 6.

ER: Well done

- 9 Scientists can reprogram differentiated somatic cells into induced pluripotent stem cells (iPSCs) by introducing certain transcription factors.

Which statements correctly describe the action of these transcription factors?

1. It acts as a repressor for pluripotency genes
2. It acts as an operator for pluripotency genes
3. It acts as an activator for pluripotency genes
4. It regulates the processing of pre-mRNA coded by pluripotency genes
5. It acts as a repressor for genes involved in cell maturation
6. It acts as an activator for genes involved in cell specialisation

A 1 and 6

B 3 and 5

C 1, 2, 4 and 6

D 3, 2, 4 and 5

Statement 3 – Correct: These transcription factors bind to promoter or enhancer regions of pluripotency genes (e.g., OCT4, SOX2, KLF4, c-MYC), increasing their transcription and sustaining the stem cell state.

Statement 5 – Correct: They also act as repressors for genes involved in cell maturation, preventing differentiation and allowing the cell to retain potency.

Why the others are incorrect:

- **1:** Repressing pluripotency genes would cause the cell to lose potency.
- **2:** “Operator” is a term from prokaryotic gene regulation (operons), not relevant to eukaryotic transcription factors.
- **4:** Regulation of pre-mRNA processing is not a primary role of these transcription factors; their main function is DNA binding to control transcription initiation.
- **6:** Activating genes for specialisation would promote differentiation, the opposite of maintaining pluripotency.

ER: Well done

- 10** Edeine is a polypeptide antibiotic that inhibits bacterial protein synthesis. When added to a mixture containing fully intact organelles, protein production decreased significantly within 3 hours.

Analysis of the edeine-treated mixture revealed the absence of polyribosomes. Instead, mRNA was found accumulated with the 30S ribosomal subunit bound to initiator tRNA.

What is the mechanism of action of edeine?

- A** It inhibits aminoacyl-tRNA synthetases
- B** It prevents the formation of the translation initiation complex, which contains the initiator tRNA and both ribosomal subunits.
- C** It blocks the translocation of peptidyl-tRNA from the A-site to the P-site of the ribosome.
- D** It interferes prevents the release factor from binding to the stop codon.

A – Incorrect: Aminoacyl-tRNA synthetases act before ribosome assembly. Inhibition here would stop charging of all tRNAs, but the evidence specifically shows mRNA bound to initiator tRNA and the small subunit.

B – Correct: Absence of polyribosomes indicates possible failure of assembly of translation initiation complex.

C – Incorrect: Translocation occurs during elongation; the absence of polyribosomes shows elongation never started.

D – Incorrect: Termination cannot occur in the absence of polyribosomes

ER: Well done

- 11 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid	property
AAA AAG	lysine	polar
AGA AGG CGG	arginine	polar
GGU GGA GGC GGG	glycine	non-polar
CCU CCA CCC CCG	proline	non-polar
UGG	tryptophan	non-polar
UAU UAC	tyrosine	non-polar

The base sequence of mRNA coding for part of a polypeptide is shown below.

U A U A A G A G G C C U U G G
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
 ↑
 start reading

From the information provided, which of the predictions stated below is **not** true?

- A** The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.
- B** The substitution of the nucleotide at position 7 with G will result in a misfolded protein
- C** The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.
- D** The substitution of the nucleotide at position 3 with C will result in a misfolded protein

Polypeptide sequence: Tyr – Lys – Arg – Gly – Pro – Trp

A – True: Degeneracy of genetic code

B – True: Missense mutation, Arg → Gly

C – True: Frameshift mutation at earlier nucleotide should result in greater change

D – False: Silent Mutation, UAU and UAC both code for Tyr

ER: Well done

- 12 The table identifies the condition associated with a variety of ploidy changes.

chromosome number	condition name
monosomy 5	Cri du chat syndrome
trisomy 21	Down syndrome
trisomy X	Klinefelter syndrome
monosomy X	Turner syndrome

For a person who has 47 chromosomes ($2n + 1$) due to a non-autosomal condition, which condition do they have?

- A Cri du chat syndrome
- B Down syndrome
- C Klinefelter syndrome**
- D Turner syndrome

C – Correct Answer

A person with **47 chromosomes** has a **trisomy condition** ($2n + 1$).

The question specifies **a non-autosomal condition**, which means the extra chromosome is a **sex chromosome** (not chromosomes 1–22).

According to the table:

- **Trisomy 23** (chromosome 23 = sex chromosomes) → **Klinefelter syndrome**

Therefore, the correct condition is **Klinefelter syndrome**, which results from an extra sex chromosome (e.g., XXY).

ER: Well done

13 Researchers studied two genes, HER2 and BRCA1, which are both involved in regulating cell division.

- Rapidly dividing cells show high levels of HER2.
- Cells with BRCA1 mutations are more prone to genetic instability
- Individuals with a BRCA1 mutation have a higher lifetime risk of developing breast and ovarian cancers.
- When both HER2 and BRCA1 are mutated, cancers tend to develop earlier and spread more rapidly.

Which statements are supported by these findings?

1. HER2 acts as a tumour suppressor gene when highly expressed.
2. BRCA1 mutations contribute to cancer by preventing DNA repair .
3. BRCA1 mutations alone are more dangerous than mutations in HER2
4. Cancer may develop due to changes in genes that regulate DNA repair or cell division

A 2 and 4 only

B 1, 2 and 3 only

C 2, 3 and 4 only

D 1, 2, 3 and 4

Statement 1 – False: HER2 is a proto-oncogene; high expression promotes, not suppresses, tumour growth.

Statement 2 – True: BRCA1 mutations → Non-functional BRCA1 protein → lack of DNA repair → genetic instability

Statement 3 – False: Inconclusive from evidence provided

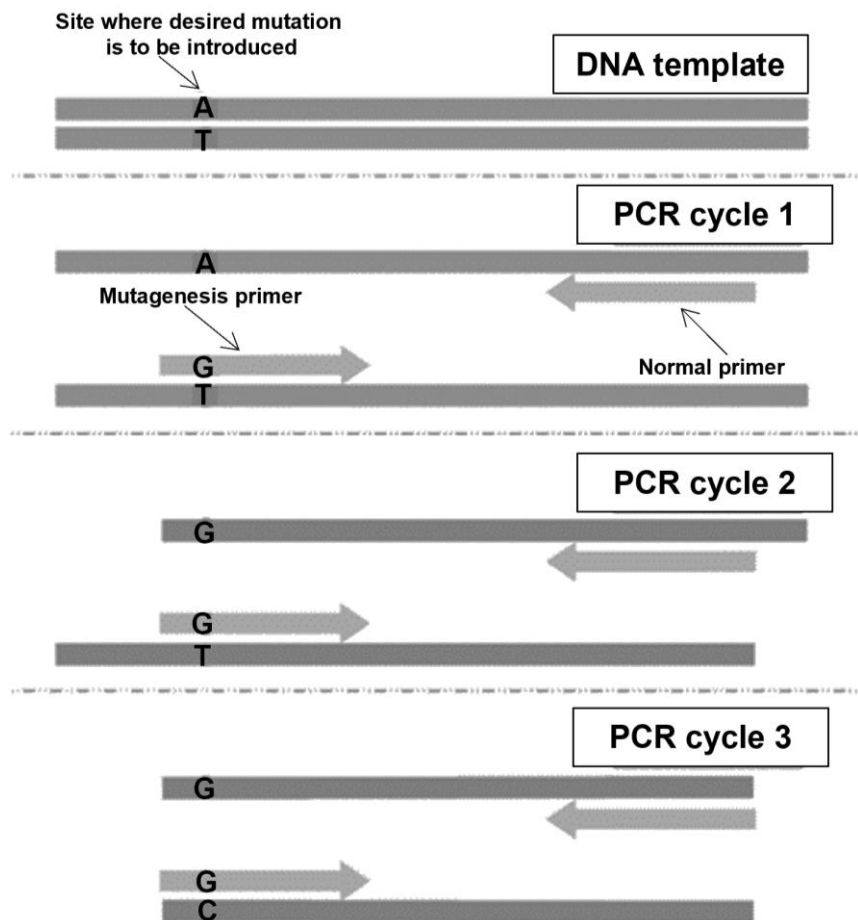
Statement 4 – True: Directly reflected by BRCA1 (DNA repair) and HER2 (cell division) roles.

ER: Poorly done. Only 41% of candidates answered correctly.

Most chose C (49%) instead of the correct answer A.

14

Mutagenic oligonucleotide-directed polymerase chain reaction (MOD-PCR) is a modified version of PCR in which base substitution mutation is introduced into the amplified DNA sequences. The diagram shows the steps involved in MOD-PCR.



Which statement is **not consistent** with the information about MOD-PCR?

- A** MOD-PCR only causes mutations in the regions that the forward and reverse primers can anneal to.
- B** MOD-PCR allows for mutations to occur at precise locations in the amplified DNA sequence.
- C** The mutagenesis primer is the primer that contains the intended base to be substituted to.
- D** If the primer contains a nucleotide which cannot base pair with the template strand, annealing is affected.

A,B,C – True

D – False: PCR cycle 1 shows that the primer can still bind to the template strand even though it is mutated, which allows for PCR cycle 2 (and the amplified DNA in PCR cycle 2 to have the mutation)

ER: Poorly done. Only 45% of candidates answered correctly.

Most chose **A (26%)** or **C (16%)** instead of the correct answer **D**.

- 15 Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infects and replicates human cells. SARS has a positive sense single stranded RNA genome, and its reproductive cycle does not involve integration into host genome.

Which protein complexes are most likely needed for SARS-CoV-2 replication?

- 1 DNA-dependent RNA polymerase
- 2 reverse transcriptase
- 3 ribosomes
- 4 RNA-dependent RNA polymerase

A 2 and 3

B 3 and 4

C 1, 2 and 3

D 1, 3 and 4

- **SARS is a positive-sense RNA virus** → its RNA can be directly translated by **ribosomes** (3).
- It replicates using **RNA-dependent RNA polymerase** (4) to make more RNA.
- It does **not use DNA** or integrate into the host genome → so **1** and **2** are not needed.

ER: Well Done

16 Which features of viruses account for them being obligate parasites?

- 1 Nucleic acids in viruses can be cut into small fragments by bacterial restriction enzymes.
- 2 Each contains only 1 type of nucleic acid.
- 3 They can be crystallised.
- 4 They cannot synthesise ATP.
- 5 They have no cellular structure.
- 6 They have no enzymes involved in metabolism outside a host cell.

A 1, 3 and 5

B 1, 4 and 6

C 2, 3 and 5

D 2, 4 and 6

Statement 1 – Incorrect:

Being cut by bacterial restriction enzymes is about DNA/RNA susceptibility, not why viruses must live inside a host.

Statement 2 – Correct:

Having only one type of nucleic acid means they lack the full genetic information needed for independent life, making them host-dependent.

Statement 3 – Incorrect:

Ability to be crystallised is a structural property, not related to their dependence on a host for reproduction.

Statement 4 – Correct:

Cannot synthesise ATP, so they must use the host cell's energy supply.

Statement 5 – Incorrect:

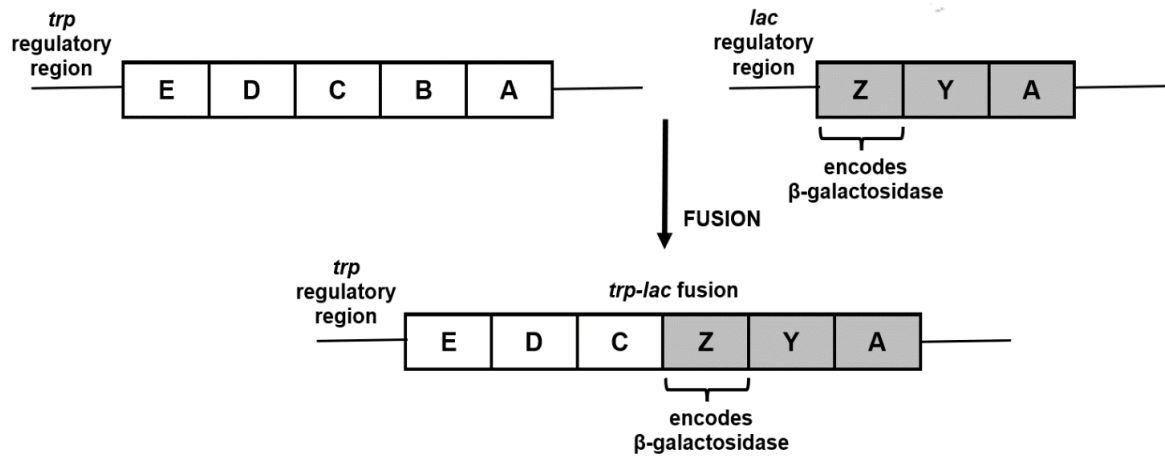
Lacking cellular structure alone does not directly explain obligate parasitism; the key is absence of metabolic and energy-generating systems.

Statement 6 – Correct:

No enzymes for metabolism outside a host cell, so they cannot carry out life processes independently.

ER: Well Done

- 17** The diagram shows the process of fusion between some components of the *trp* and *lac* operons.



Which statement explains the proper functioning of the *trp-lac* hybrid operon?

- A** In the absence of tryptophan, β-galactosidase will be synthesised.
- B** In the presence of tryptophan, enzymes needed for lactose hydrolysis are synthesised.
- C** The lac repressor protein is unable to bind to the operator if lactose is present.
- D** When both lactose and tryptophan are present, the hybrid operon will be transcribed at a very high rate.

A – Correct: In the absence of tryptophan, the *trp* repressor is inactive, allowing transcription of the hybrid operon. Since *lacZ* is now under *trp* control, β-galactosidase will be synthesised.

B – Incorrect: Tryptophan activates the *trp* repressor, which blocks transcription. Therefore, enzymes like β-galactosidase will not be synthesised, even if lactose is present.

C – Incorrect: The lac regulatory region is not present in the hybrid operon. Thus, the lac repressor protein is irrelevant and cannot affect transcription.

D – Incorrect: Tryptophan will repress transcription via the *trp* repressor. The presence of lactose has no effect on the hybrid operon since lac regulatory region is not present.

ER: Poorly done. Only 43% of candidates answered correctly.

Most chose **C (23%)** and **D (18%)**, instead of the correct answer **A**.

- 18** Two mutant strains of *Escherichia coli* were mixed in a suspension. One strain was unable to synthesise biotin and the amino acid threonine, the other was unable to manufacture the two amino acids leucine and lysine. The genes coding for the synthesis of these essential metabolites are separated from the bacterial chromosome.

After sixty minutes the bacteria were plated onto a growth medium deficient in all four metabolites. Three hundred colonies grew.

Which process would result in bacteria that are able to grow on a growth medium deficient in these metabolites?

- A** conjugation
- B** transformation
- C** transduction
- D** conjugation and transformation

A – True: Conjugation allows direct transfer of plasmid-borne genes between bacteria via a pilus, enabling one cell to acquire all missing genes synthesise all 4 metabolites

B – False: Transformation involves uptake of naked DNA from the environment; less likely here because no free DNA source is provided

C – False: Transduction requires bacteriophages to transfer DNA; not applicable as no phages are present in the experiment.

D – False: Conjugation alone is sufficient; there is no mention of free DNA source/competence factors/heat shock/ electroporation, rather two strains of bacteria are present, which makes conjugation more likely.

ER: Poorly done. Only **29%** of candidates answered correctly.

Most chose **D (33%)** instead of the correct answer **A**.

- 19 Mendel crossed plants homozygous for yellow, round seeds with plants homozygous for green, wrinkled seeds. All the first generation (F1) had yellow, round seeds. Mendel then crossed two F1 plants.

What proportion of the offspring would be homozygous for one of the recessive alleles?

- A 1/2
B 3/4
C 3/8
D 7/16

parental: $YYRR \times yyrr$
genotype
gametes: YR yr
punnett square:

	YR
yr	$YyRr$

F1 genotype: $YyRr$

F1 selfing: $YyRr \times YyRr$
gametes: YR Yr yR yr
punnett square:

	YR	Yr	yR	yr
YR	$YYRR$	$YYRr$	$YyRR$	$YyRr$
Yr	$YYRr$	$YYrr$	$YyRr$	$Yyrr$
yR	$YyRr$	$YyRr$	$yyRR$	$yyRr$
yr	$YyRr$	$YyRr$	$yyRr$	$yyrr$

* homozygous for one recessive allele
→ yy or rr ⇒ 6 out of 16
 $\frac{6}{16} = \frac{3}{8}$ #

ER: Well Done

- 20 In mice, the allele for black colour (**B**) is dominant and brown hair colour (**b**) is recessive.

The agouti allele (**A**) causes banding on hairs so that the colour of the coat appears paler, black hair appears grey and brown hair appears beige. The recessive, non-agouti allele (**a**) gives a continuous pigment in the hairs so that the coat appears uniform in colour.

What would be the expected ratio of black : grey : beige : brown offspring if the parents had the genotypes **Aabb** and **aaBb**?

A 9 : 3 : 3 : 1

B 12 : 0 : 3 : 1

C 1 : 1 : 1 : 1

D 9 : 3 : 0 : 4

① Understanding the Context

2 traits, $\rightarrow$ Colour : (B) for black, (b) for brown
 2 genes $\rightarrow$ Banding pattern : (A) for agouti, (a) for non-agouti

② Parental Cross

Parental Genotype : **Aabb** $\times$ **aaBb**
 gametes : (Ab) (ab) (aB) (ab)
 Punnett's square :

	(Ab)	(ab)
(aB)	AaBb	aaBb
(ab)	Aabb	aaabb

genotypic & phenotypic ratio :

1 **AaBb** : 1 **Aabb** : 1 **aaBb** : 1 **aaabb**
 1 grey : 1 beige : 1 black : 1 brown

Use the context above to deduce the phenotypes

ER: Well Done

21 A weed-killer works by preventing the formation of RuBP.

Which statements about the effect of this weed-killer on photosynthesis are correct?

- 1 Carbon fixation is prevented in the light dependent phase
- 2 Carbon fixation is prevented in the light independent phase
- 3 ATP from the light dependent phase is unable to catalyse the regeneration of RuBP
- 4 ATP from the light independent phase is unable to catalyse the regeneration of RuBP

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

Statement 1 – Incorrect: Carbon fixation occurs in the **light-independent phase**, not the light-dependent phase, so Statement 1 is wrong.

Statement 2 – Correct: Without RuBP, CO₂ cannot be fixed, so carbon fixation in the light-independent phase stops.

Statement 3 – Correct: ATP from the light-dependent phase cannot be used to regenerate RuBP if its synthesis pathway is blocked.

Statement 4 – Incorrect: ATP is produced in the light-dependent phase, not the light-independent phase, so this statement is wrong.

ER: Well Done

- 22** In the Krebs cycle, ATP and reduced coenzymes are produced. The reduced coenzymes are subsequently used in oxidative phosphorylation to generate ATP.

2.5 molecules of ATP can be made from each reduced NAD and 1.5 molecules of ATP from each reduced FAD.

What is the maximum number of ATP molecules that can be made from the Krebs cycle per molecule of glucose?

- A** 8
B 12
C 18
D 20

Steps in Krebs Cycle

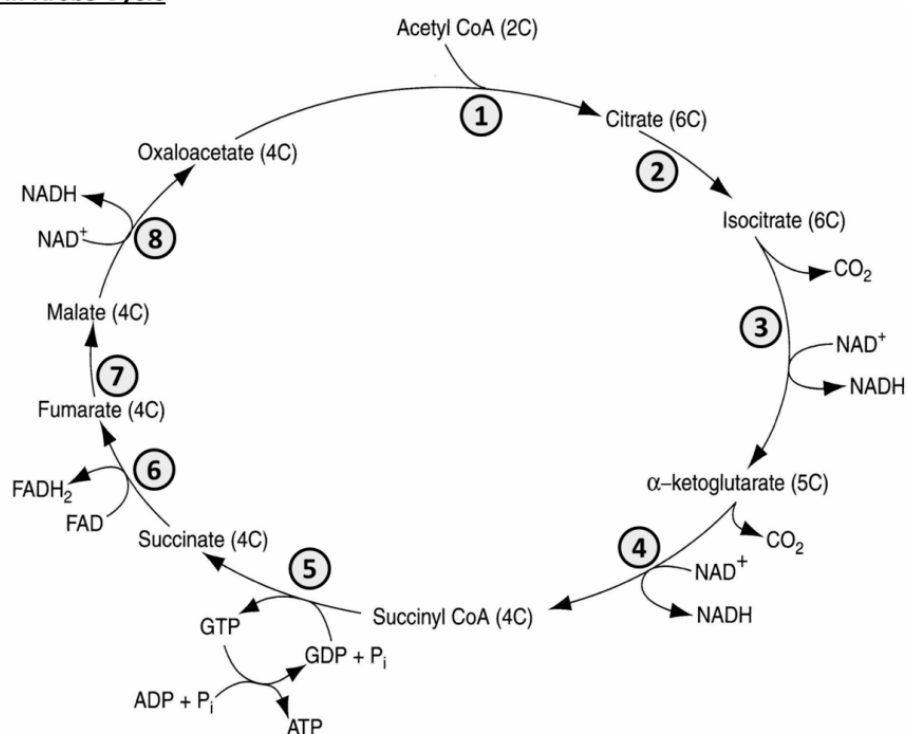


Fig. 2.3.2: Krebs cycle
 (names of intermediates are not required)

Students need to remember that 1 molecule of glucose rises to 2 molecules of Acetyl CoA.

- Krebs Cycle produces 3 NADH, 1 FADH₂, 1 ATP per Acetyl CoA molecule.
- That makes it 6 NADH and 2 FADH₂, 2 ATP per glucose molecule.
- Hence there will be a total of $6 \times 2.5 + 2 \times 1.5 + 2 = 15 + 3 + 2 = 20$ molecules

ER: Poorly done. Only **18%** of candidates answered correctly, which shouldn't be the case as this question is modified from the 3.2 Respiration Tutorial question!

Most chose **C (34%)** or **B (28%)** instead of the correct answer **D**.

23

Six tubes were set up as shown in the table.

tube	contents
1	glucose and homogenised yeast cells
2	glucose and yeast mitochondria
3	glucose and yeast cytoplasm lacking organelles
4	pyruvate and homogenised animal cells
5	pyruvate and animal mitochondria
6	pyruvate and animal cytoplasm lacking organelles

After incubation under aerobic conditions, each sample was analysed to determine the presence of lactate.

In how many tubes is lactate likely to be present?

A 0

B 1

C 2

D 3

Tube 1 – glucose + homogenised yeast cells

✓ Yeast perform **alcoholic fermentation**, not lactate fermentation.

✗ No lactate

Tube 2 – glucose + yeast mitochondria

✓ No cytoplasm, so no glycolysis → no pyruvate to feed mitochondria

✗ No lactate

Tube 3 – glucose + yeast cytoplasm lacking organelles

✓ Yeast cytoplasm → alcoholic fermentation → ethanol, not lactate

✗ No lactate

Tube 4 – pyruvate + homogenised animal cells

✓ Mitochondria present → aerobic respiration possible

✗ No lactate under aerobic conditions

Tube 5 – pyruvate + animal mitochondria

✓ Mitochondria + aerobic conditions → full respiration

✗ No lactate

Tube 6 – pyruvate + animal cytoplasm lacking organelles

✓ No mitochondria → can't do aerobic respiration

✓ Animal cytoplasm → **has enzymes for lactate fermentation**

☑ **Lactate produced**

ER: Poorly done. Only 19% of candidates answered correctly.

Most chose C (54%) instead of the correct answer B.

24

Which statements correctly describe the second messengers that are involved in cell signalling?

- 1 They are small, water-soluble proteins.
- 2 They are produced by enzymes.
- 3 They induce cellular response through change in concentration.
- 4 They cause a long-term cellular response.

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

Statement 1: X Second messengers are **not proteins**; they are **small, non-protein molecules** (e.g. ions, nucleotides).

Statement 2: ✓ Second messengers like **cAMP** and **IP₃** are **produced by enzymes** (e.g. adenylyl cyclase, phospholipase C).

Statement 3: ✓ They work by **rapid changes in concentration**, which triggers cellular responses (e.g. Ca²⁺ spikes).

Statement 4: X Incorrect — **long-term responses** are usually mediated by **transcription factors** or hormonal pathways, not second messengers.

ER: Poorly done. Only 38% of candidates answered correctly.

Most chose A (37%) instead of the correct answer C.

25

The Eco-Link@BKE is a wildlife bridge in Singapore that allows animals to safely cross the Bukit Timah Expressway (BKE). This ecological bridge connects the Bukit Timah Nature Reserve and the Central Catchment Nature Reserve.

Which of the following statements are likely to be true due to the presence of this wildlife bridge.

- 1 allows for gene flow between different species living in the initially separated nature reserves
- 2 allows for genetic drift to occur, population in separated nature reserves do not undergo genetic drift
- 3 prohibits founder's effect from taking place as populations in separated nature reserves are now merged
- 4 prohibits change in the allelic frequency as populations are now subjected to the same natural selection pressure in the merged nature reserve

A**3****B**

2 and 3

C

1, 2 and 3

D

All of the above

Statement 1: Incorrect – Gene flow occurs between populations of the same species, not between different species.

Statement 2: Incorrect – Genetic drift is a random process due to small population size, resulting in bottleneck effect/ founder's effect. Genetic drift should occur less due to the bridge as it increases population size and gene flow;

Statement 3: Correct – The wildlife bridge connects populations, reducing isolation and preventing small, separated groups from experiencing founder's effect by maintaining the variety of alleles in the gene pool.

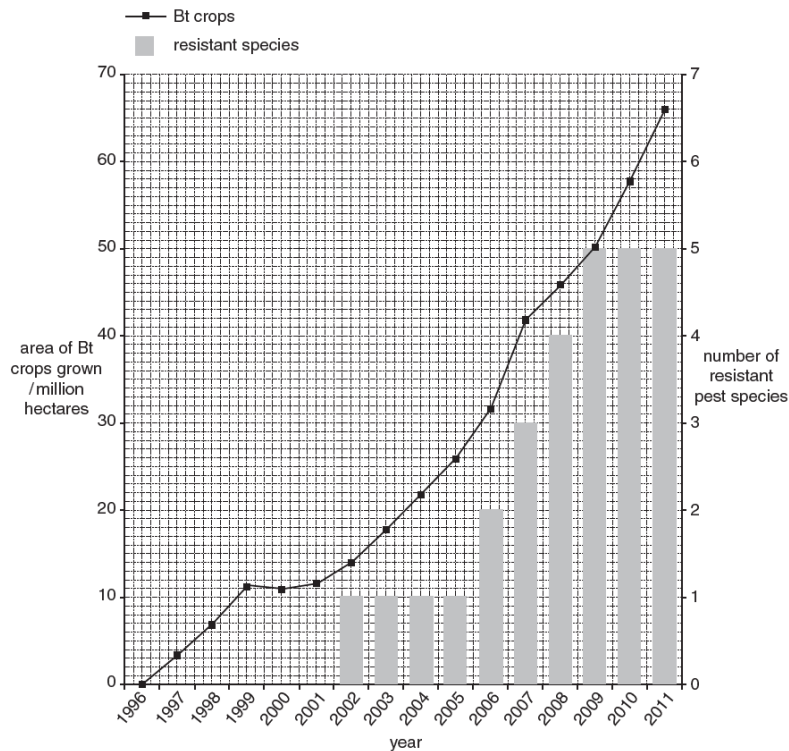
Statement 4: Incorrect – Natural selection still causes changes in allelic frequency; the change in allelic frequency in both populations will be similar now since they are subjected to same selection pressures

ER: Poorly done. Only 29% of candidates answered correctly.

Most chose C (41%) or D (26%) instead of the correct answer A.

- 26** Maize and other crops have been genetically modified since 1996 to produce the Bt toxin to kill insect pests.

The figure below shows the area of Bt crops grown (plotted points) and the number of insect pest species in which resistance to Bt has been reported (bars).



Based on your biological knowledge and **inferences from the information above**, which of the following statements is valid?

- A** The more the area of Bt crops grown, the more the number of resistant pest species.
- B** Resistance to Bt toxin among insect pests could arise from a spontaneous chromosomal aberration event.
- C** The farming of Bt crops exerted a selection pressure that caused mutations resulting in resistance to Bt toxin among insect pests.
- D** The allele for resistance to Bt toxin is likely to have spread from one pest species to another.

A: Correct – Conclusive from the evidence provide (graph)

B: Incorrect – Not conclusive from the evidence provide (graph)

C: Incorrect – Not conclusive from the evidence provide (graph)

D: Incorrect – Not conclusive from the evidence provide (graph)

ER: Poorly done. Only **23%** of candidates answered correctly.

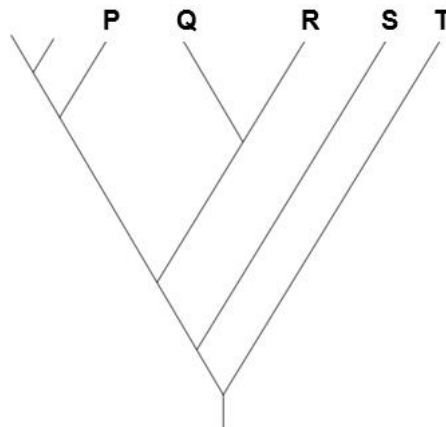
Most chose **C (47%)** instead of the correct answer **A**.

- 27 Information about two species of seals and their habitats is shown in the table below.

Name of seal species	Mean adult body mass/kg	Mean adult height/cm	Endemic to
<i>Neomonachus schauinslandi</i> (Caribbean Monk Seal)	170 - 270	240	Caribbean Sea and Gulf of Mexico
<i>Ommatophoca rossii</i> (Ross seal)	120 - 210	200 - 250	Antarctic Ocean

Molecular phylogeny suggests that the Caribbean Monk Seal split off from a branch which led to the evolution of all other living seal species. This split happened about 12 million years ago.

The diagram below indicates the evolutionary relationships between the main species of seals. The letter Q indicates the position of the Ross seal.



Based on the information given above, which of the following is correct?

	Position of the Caribbean Monk Seal on the diagram	Position of the species most closely related to the Ross Seal on the diagram
A	S	P
B	T	R
C	R	S
D	P	R

ER: Well Done

- 28 Studies suggest that climate-driven phenological mismatches between flowering plants and their pollinators are becoming more frequent. What is the most likely consequence of such mismatches for fruit crop production, and why might this impact be uneven across crop types?

- A Fruit production will uniformly decline across all crop types because pollinator absence directly halts floral development.
- B Self-pollinating fruit crops will exhibit greater yield loss than insect-pollinated crops due to their reliance on stable temperatures for fertilization.
- C Fruit crops reliant on abiotic pollination are more likely to suffer than biotically pollinated crops due to increased atmospheric carbon dioxide interfering with pollen dispersal.

D Insect-pollinated fruit crops with narrow flowering windows are more vulnerable to yield loss, as asynchronous pollinator activity limits fertilisation opportunities.

A – Incorrect: Not all crops rely on **insect pollinators**, and some have **broader flowering periods** or use **wind/self-pollination**, so the impact **won't be uniform**.

B – Incorrect: Self-pollinating crops are **less reliant on pollinators**, so they are **less vulnerable** to phenological mismatches than insect-pollinated crops.

C – Incorrect: The question is about **timing mismatches** (phenology), not **CO₂ levels** or abiotic pollination (e.g. wind).

D – Correct: If a plant has a narrow flowering window and the pollinators are not active at the same time, fertilization fails, especially in crops that depend on insects for pollination.

ER: Well Done

- 29 A vaccine can be used to create artificial active immunity to influenza.

People at risk of complication from influenza are advised to have a vaccination against influenza annually. Each year, a new vaccine is developed and used that is different to the previous vaccine.

Which reason explains why a new vaccine is needed annually?

- A B lymphocytes are short lived and do not survive to recognise the viral antigens in the next year
- B Vaccination stimulates class-switching in B cells, allowing an improved immune response
- C Immunoglobulins induce somatic recombination, hyper-mutation and class switching to recognise the viral antigens

D Viral antigens may vary due to antigenic drift

A – Incorrect : Memory B cells can **persist for years**, maintaining immune memory.

B – Incorrect: While class-switching does enhance immune response, it's not the reason **new vaccines are needed annually**

C – Incorrect: They **enhance antibody diversity**, but do **not explain the need for a new vaccine**.

ER: Well Done

30 An antibody specific for a virus was produced by identical plasma cells.

This antibody was treated with an enzyme to break the bonds between the variable and constant regions.

The separated variable and constant regions were then added to cells infected with the virus.

With regard to the experiment carried out, which statements are correct?

- 1 the constant regions would bind to different parts of the virus epitope
- 2 the variable regions would all bind to the same part of the virus epitope
- 3 the separated constant and variable regions cannot bind to the virus epitope

A 2

B 3

C 1 and 2

D 1 and 3

Statement 1: Incorrect – Constant regions do not bind to viral epitopes

Statement 2: Correct – Variable regions bind to viral epitopes, + highly specific

Statement 3: Incorrect – Constant domains are required in the formation of both heavy chain and light chains

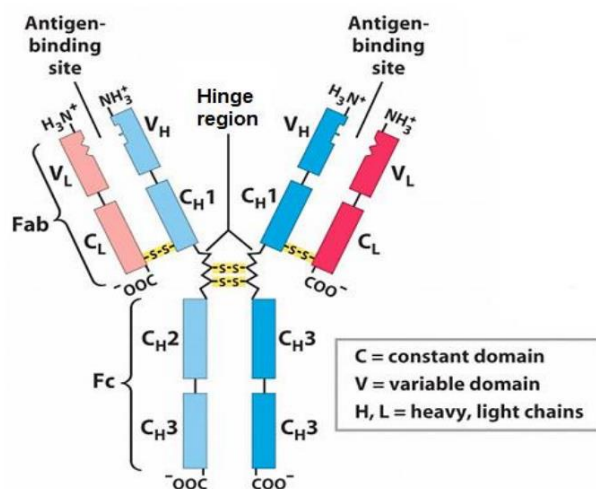


Fig. 3.1.3: Structure of IgG (2)

ER: Poorly done. Only **30%** of candidates answered correctly.

Most chose **B (47%)** instead of the correct answer **A**.

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