



2023 VCE Biology external assessment report

General comments

The 2023 Biology examination was the second for the *VCE Biology Study Design 2022–2026* accreditation period.

The multiple-choice Section A provided a variety of styles, formats, amounts of reading, and levels of difficulty.

In Section B, some questions, such as Question 6c.i., required a name, while others, such as Question 1b. (six marks) and 6a. (five marks), required students to formulate and set out an extended answer. Longer-response questions (three to six marks) made up a larger proportion of the examination, and generally required students to formulate and develop their response. Tables and graphs of data were given within the question, such as Questions 2, 3c. and 6b., and students were required to refer to these in their answers. It was important that students were familiar with specific task words, such as 'compare', 'justify' or 'outline', and could respond appropriately to them.

The length of the examination was suitable and gave students the opportunity to complete the paper in the time available. Students are advised to use the reading time to assess the Section B questions, identify the key requirements, and start formulating their answers.

The 'additional space' pages at the back of the question and answer book provided students with a designated place to continue their answer if they needed to elaborate further or provide a revised response to their original. On many pages, there was also blank space with no lines under the question, such as Questions 6a. and 11c., which students could use instead of or in addition to the space at the back. If students chose to use the extra space, they had to indicate this in their response. Occasionally, some students stated that their answer continued in the extra space section when, in fact, it did not. Notwithstanding handwriting size, the number of lines under a question gave an indication of the amount of space required to answer it.

The examination papers were scanned in colour and assessed online. Most students wrote in pen, which scanned well, and heeded advice not to use a pencil in Section B. Students should be reminded that if they use a pencil, it **must** be of a suitable quality to scan.

Specific information

This report provides sample answers or an indication of what answers may have been included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

The statistics in this report may be subject to rounding, resulting in a total of more or less than 100 per cent.

Section A

The table below indicates the percentage of students who chose each option. Grey shading and bold text indicate the correct answers.

Question	Correct answer	% A	% B	% C	% D	Comments
1	B	4	86	3	7	
2	D	6	20	3	71	
3	D	15	20	26	39	The term 'modified guanine molecule' is another name for what students commonly known as 'methyl cap'. Options A–C could have been ruled out to leave only D as the correct answer despite this term not being known by students.
4	C	24	4	33	39	One codon (three mRNA nucleotides) codes for one amino acid. The word 'codon' must not be confused with the word 'nucleotide' or 'base'.
5	B	15	74	8	3	
6	B	4	75	12	8	
7	D	5	21	3	71	
8	A	72	11	12	5	
9	B	14	82	1	2	
10	C	3	17	78	2	
11	D	3	18	13	66	
12	C	5	8	84	3	
13	B	3	69	2	26	
14	A	85	11	2	2	
15	D	6	9	11	74	
16	C	12	2	82	5	
17	C	19	4	68	9	
18	B	2	77	20	1	
19	D	6	24	9	61	
20	A	91	4	3	3	
21	A	91	3	4	2	
22	D	15	7	25	53	Students are required to recall the roles of different proteins involved in the immune response. 'Major histocompatibility complex proteins' is the full name for 'MHC proteins'. MHC proteins present antigens (and allergens) to specific T cells.

Question	Correct answer	% A	% B	% C	% D	Comments
23	B	13	70	9	8	
24	A	49	2	38	11	Interpretation of information presented in graphs is an important skill required of students. Here, many assumed the largest mean decrease in prescriptions between year 1 and year 2 meant it was most effective in this time. However, the treatment would be most effective when the mean decrease in prescriptions is the lowest (year 9). As this study is done over many years, no significant increase in the need for prescriptions signifies the long-term and sustained effects, hence option A.
25	C	17	3	77	3	
26	A	60	16	4	20	
27	B	8	75	14	2	
28	D	5	3	12	81	
29	A	71	16	10	3	
30	C	1	5	90	4	
31	A	78	3	3	15	
32	B	7	83	3	8	
33	A	89	2	9	0	
34	B	7	71	6	16	
35	C	2	38	55	5	Inaccuracy within experiments arises due to systematic errors. One main example of a systematic error is not calibrating measuring instruments, such as digital scales, thermometers, stopwatches, etc.
36	D	10	13	4	73	
37	D	6	3	2	89	
38	A	73	14	6	6	
39	B	2	77	5	16	
40	D	2	17	9	72	

Section B

Question 1a.

Mark	0	1	2	Average
%	31	16	54	1.3

Amino acids, such as tryptophan, contain an amine (NH₂) group OR carboxyl (COOH) group OR variable (R) group.

Question 1b.

Mark	0	1	2	3	4	5	6	Average
%	18	8	7	11	11	15	30	3.5

Students were required to compare the similarities and differences between the processes of repression and attenuation. However, students could also have answered this question by outlining the processes of both repression and attenuation as their way of comparing the two processes.

Key points included:

In repression, when tryptophan (*trp*) levels are high, two *trp* amino acids bind to the repressor, causing a conformational shape change in the repressor, enabling it to bind to the operator. This inhibits RNA polymerase from binding to the promoter to transcribe the structural genes.

In attenuation, when *trp* levels are high, RNA polymerase begins transcription of the leader or attenuator sequence. Within this sequence, there are two *trp* codons. As the ribosome does not stall here, a hairpin termination loop forms, resulting in the detachment of both RNA polymerase and the ribosome.

Both mechanisms occur to regulate *trp* levels, conserving energy in prokaryotic cells.

As both repression and attenuation occur when *trp* levels are high, students were not required to discuss these mechanisms in low *trp* environments.

Question 2a.

Mark	0	1	2	3	Average
%	11	15	39	34	2.0

The most likely type of plant is C₄ as it has high starch formation at 40 °C and at high humidity.

CAM was also acceptable if students made the link that they are suited to high temperature levels and low humidity, having higher starch formation in these.

No marks were awarded for choosing C₃.

Question 2b.

Mark	0	1	2	3	4	Average
%	18	24	27	20	10	1.8

Four valid points were required, such as:

- White light is made up of different colours, e.g. green and blue light, or different wavelengths.
- Green light is reflected / not absorbed.
- Blue light is absorbed.
- Light is absorbed in photosynthesis which produces glucose and then starch.

Question 3a.

Mark	0	1	2	3	Average
%	31	20	26	22	1.4

Antibodies bind to antigens, leading to agglutination OR neutralisation OR opsonisation OR activation of complement proteins. This triggers an increase in phagocytosis which reduces the number of pathogens OR the duration or severity of their effects on the body.

Students did not need to use the specific terms agglutination, neutralisation or opsonisation; instead, they could provide a description of the term.

Question 3b.

Mark	0	1	2	Average
%	5	16	80	1.8

Students could answer this question by referring to any ethical concept or approach with an appropriate and congruent explanation as to how this was violated in this study.

A common response was:

Principle violated: non-maleficence

Explanation: the scientists intentionally caused a sore throat in participants.

Question 3c.

Mark	0	1	2	3	Average
%	15	11	26	48	2.1

Participant 1.

Suitable justifications for Participant 1 included:

- This participant demonstrated a sore throat during the study.
- This participant had the lowest antibody (medium at stage 3) and lowest memory cell concentration (low at stage 2 and/or medium at stage 3) compared to all other participants in these stages.
- They had no prior immune response to the *S. pyogenes*, which would have occurred if they had been exposed to the vaccine or antigen OR antibody and/or memory cell concentration would have been higher if they were exposed to a vaccine.

Question 3d.

Mark	0	1	2	Average
%	12	39	49	1.4

Two valid points were required, such as:

- not enough research or development into new drugs or vaccines
- more time or money required to develop new drugs or vaccines
- doctors overprescribing new drugs or patients not completing the full course of treatment
- epidemics or pandemics more likely, making herd immunity difficult to achieve.

Question 4a.

Mark	0	1	2	3	Average
%	31	25	27	18	1.3

Coenzymes, such as NAD and FAD, carry hydrogen ions and/or electrons to the electron transport chain in aerobic cellular respiration. This enables ADP and Pi to join, forming ATP.

Question 4b.

Mark	0	1	2	3	Average
%	40	27	26	8	1.0

Red blood cells lack membrane-bound organelles such as mitochondria. As such, these cells only undergo anaerobic fermentation where glucose/pyruvate is converted to lactate at the same rate.

Question 5a.

Mark	0	1	2	3	4	Average
%	31	20	15	20	14	1.7

The following key points were required:

- sgRNA is designed to be complementary to CsWRKY22 OR CsLOB1.
- sgRNA is combined with Cas9 OR guides Cas9.
- Cas9 binds to PAM and cuts the gene. As a consequence, CsWRKY22 protein is not produced or can't bind to the CsLOB1 gene OR CsLOB1 gene is not transcribed, so proteins that cause citrus canker are not produced.

Question 5bi.

Mark	0	1	Average
%	50	50	0.5

At 250 °C most cells are ruptured and the most glucose is released.

Question 5bii.

Mark	0	1	Average
%	48	52	0.5

One of the following:

- At 35 °C, yeast produces ethanol.
- This is the optimum temperature for the enzymes responsible for anaerobic respiration.

'The optimum temperature for the yeast' was not an acceptable answer.

Question 6a.

Mark	0	1	2	3	4	5	Average
%	29	9	12	12	20	18	2.4

Students were required to identify that human insulin genes for chains A and B are isolated and that Insulin A gene is placed in one plasmid and Insulin B gene is placed in a different plasmid.

Other key steps students may have identified included:

- Restriction endonucleases are used to cut, e.g. the plasmid or human DNA.
- DNA ligase joins the DNA sequences into the plasmid.
- The plasmid is inserted by heat shock into the bacteria which is transformed OR each plasmid is inserted into separate bacteria.
- Antibiotic selection or another suitable method (e.g. insulin genes inserted next to a gene coding for beta-galactosidase protein) is used to determine success.
- Processing of the protein such as joining insulin polypeptide chains A and B occurs to create functional insulin.

Question 6b.

Mark	0	1	2	3	Average
%	2	4	58	36	2.3

- Lispro
- Compared to regular insulin, lispro acts immediately / it peaks quickly at 2 hours instead of 5 / at 7 arbitrary units instead of 6.
- Its duration is shorter / 5 hours compared to 12 hours.

The correct name was given by nearly every student and most gave one valid reason for their choice. Those who correctly interpreted the graph gained the third mark available.

Question 6ci.

Mark	0	1	Average
%	31	69	0.7

Insulin is a quaternary protein.

Question 6cii.

Mark	0	1	2	Average
%	56	32	12	0.6

Consideration: the tertiary structure of insulin does not change.

Justification: insulin remains functional.

Question 7a.

Mark	0	1	2	3	Average
%	37	20	23	20	1.3

Genetic drift causes a decrease in genetic diversity.

Suitable explanations included:

- It is a random change in allele frequency and is more pronounced in small, isolated populations.
- Genetic drift may cause an allele of a particular gene to disappear altogether purely by chance OR may lead to a bottleneck in future populations.

Question 7b.

Mark	0	1	2	Average
%	30	42	28	1.0

Genetic diversity is maintained as birds bred in captivity have different genetic diversity. When gene flow occurs between the populations, these differences enter the wild population.

Question 7c.

Mark	0	1	2	3	Average
%	18	28	40	14	1.5

A consequences-based approach places central importance on the consideration of the consequences of an action, with the aim to maximise the positive outcomes and minimise the negative effects.

As part of their response, students were required to consider possible positive outcomes and negative effects of the work by Zoos Victoria in preventing the extinction of the helmeted honeyeater.

Positive outcomes Zoos Victoria may have sought to maximise included an increase in the total number of birds OR an increase in genetic diversity in the wild which may prevent extinction.

Negative effects Zoos Victoria may have sought to minimise included not having a negative effect on the bird's health OR not enough food available OR space for nesting.

Question 8a.

Mark	0	1	2	Average
%	23	51	26	1.0

Possible ways that people with African ancestry could have Neanderthal DNA in their genomes included:

- Ancestors of modern Africans could have interbred with Neanderthals before migrating from Africa.
- Ancestors of modern Africans left Africa and interbred with Neanderthals already in Europe and Asia, before returning to Africa.
- Modern-day Africans still carry Neanderthal DNA that was shared DNA from their common ancestor.

Question 8b.

Mark	0	1	2	Average
%	32	35	33	1.0

Possible reasons why modern Europeans and Asians show a greater percentage of Neanderthal DNA included:

- *Homo sapiens* coexisted with Neanderthals for a longer period of time in Europe and Asia, so more opportunities existed for interbreeding.
- *Homo sapiens* who originated in Africa did not coexist or interbreed with Neanderthals, as Neanderthals did not live in Africa.

Question 9a.

Mark	0	1	2	Average
%	30	54	16	0.9

Two factors contributed to speciation in the *Howea* palms:

- *H. forsteriana* and *H. belmoreana* palm species have different flowering times.
- Between the opposite genders of different species, their peak flowering frequency is different.

Question 9bi.

Mark	0	1	Average
%	16	84	0.9

	pH	Altitude range (m)
<i>H. forsteriana</i>	8	31–60
<i>H. belmoreana</i>	6	greater than 121 / > 121

All data included in the table had to be correct to receive the mark.

Question 9bii.

Mark	0	1	2	Average
%	35	34	31	1.0

Any two of the following:

- The common ancestor was well adapted to acidic soils and/or high altitudes.
- *H. forsteriana* was well adapted to basic soils and/or low altitudes. Different nutrients / soil type / pH caused different flowering times.
- Alleles for different pH and/or altitude were favoured or selected for by natural selection.
- These differences caused different flowering times leading to no gene flow OR reproductive isolation.

Many students incorrectly discussed the *H. belmoreana* palm species, when the question required them to discuss how the differences in pH and altitude led to speciation between *H. forsteriana* and the common ancestor.

Question 10a.

Mark	0	1	2	Average
%	20	12	68	1.5

Two of: fur, skin, saliva, venom, urine, faeces.

Some students incorrectly gave a location instead of a source, which was not acceptable.

Question 10b.

Mark	0	1	2	Average
%	28	52	19	0.9

Two possible factors included:

- prevent contamination of DNA from other sources by using gloves
- label the samples with date, time and location to ensure the correct sample details are recorded / equipment calibrated
- use consistent sampling conditions, e.g. water temperature, and consistent sampling methods such as collecting a suitable number of samples and volume of water to increase reliability and validity.

Question 10c.

Mark	0	1	2	Average
%	21	25	54	1.4

PCR is used to amplify the platypus DNA to produce enough sample DNA to be tested.

Question 10d.

Mark	0	1	2	Average
%	41	25	34	1.0

Students were required to give a difference and a justification.

Difference: platypus occurrences (circles) are found in areas of predicted absent OR unknown occurrences (grey shading).

Justification: circles are in grey shading areas OR platypus are elusive animals and may not have been sighted or trapped in the predicted absent areas.

OR

Difference: platypus occurrences (triangles) are not found in areas of predicted occurrences (no shading).

Justification: triangles in white, unshaded area OR platypus may not be present during the time of sampling OR are no longer in the predicted area due to habitat destruction.

Question 11a.

Mark	0	1	2	Average
%	14	40	46	1.3

Examples of factors that were controlled in this experiment included:

- the volume (10 mL) of bacterial growth medium
- the sample volume (0.1 mL) of each population transferred to next growth medium
- incubation time (24 hours)
- incubation temperature
- species of *E. coli*
- initial amount of citrate and/or glucose in growth medium.

Question 11b.

Mark	0	1	2	Average
%	18	29	52	1.4

Effect of mutation on subsequent generations: Bacteria carrying the mutation had an increased rate of reproduction OR an increased frequency of the allele for citrate metabolism was present in future generations.

Reason why: *E. coli* now have an additional food source OR greater energy availability.

Students could also have answered this question from the perspective of a negative effect on the *E. coli* population which would not survive due to a disadvantage in using citrate or no longer being able to use glucose as an energy source.

Question 11c.

Mark	0	1	2	3	Average
%	25	30	28	17	1.4

In conducting an experiment, students needed to include one point from each of the following:

Examples of appropriate controlled variables:

- volume of nutrient broth or sample added to different flasks
- incubation time or incubation temperature
- volume of citrate added

Examples of an appropriate control group:

- *E. coli* provided 0% glucose
- *E. coli* provided only citrate

Repeatability:

- large sample size
- incubate *E. coli* over many generations

As both the independent and dependent variables were provided in the question stem, students who referred to either one of these correctly could receive a maximum of one mark for either of these variables. They then only required any appropriate answer from two of the above listed points.