INTERNATIONAL BIOLOGY OLYMPIAD e. V. IBO

Question 1 = 23.5 marks

Task 1

Specimen	1: Species	2: Ploidy level of specimen
A	4 = Fern	**2n + n**
B	3 = Conifer	**2n + n + n**
C	2 = Liverwort	**n**
D	1 = Angiosperm	**2n + n + n**

[4 marks]

(1) ½ mark per correct answer (right or wrong) = 2 marks
(2) ½ mark per correct answer (right or wrong) = 2 marks

Task 2

Flower specimen	1: Family	2: Gynoecium position	3: Carpel structure
E – Arabidopsis	2=Brassicaceae	7=H	11=F
F - Bean	4=Fabaceae	7=H	10=S
G - Fuschia	5=Rosaceae	8=E	11=F
H - Ragwort	1=Asteraceae	7=H	12=M
I – Catmint	3-Lamiaceae	7=H	11=F

[7.5 marks]

(1) ½ mark per correct answer (right or wrong) = 2.5 marks
(2) ½ mark per correct answer (right or wrong) = 2.5 marks
(3) ½ mark per correct answer (right or wrong) = 2.5 marks

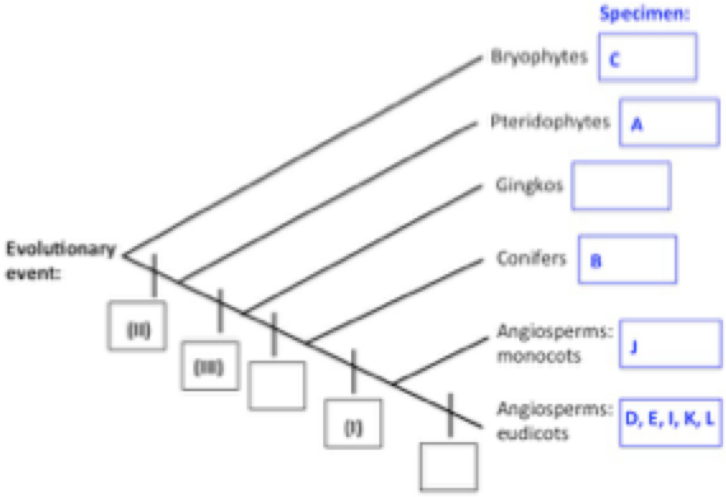
Task 3

Specimen	i: Vascular bundle type	ii: Vascular bundle organisation	iii: Stem rigidity enabled by
E - Arabidopsis	2=collateral	5=arranged in a ring	8=turgor pressure
I - Catmint	2=collateral	5=arranged in a ring	8=turgor pressure
J - Maize	2=collateral	6=scattered	8=turgor pressure
K* – *Helianthus*	2=collateral	5=arranged in a ring	9=secondary thickening
L*- Tilia	2=collateral	7=annual rings	9=secondary thickening
M*- *Curcubita*	1=bicollateral	5=arranged in a ring	8=turgor pressure

[9 marks]

(i) ½ mark per correct answer (right or wrong) = 3 marks
(ii) ½ mark per correct answer (right or wrong) = 3 marks
(iii) ½ mark per correct answer (right or wrong) = 3 marks

Task 4



[3 marks]

¼ mark per correct answer (right or wrong) = 3 marks

Question 2 = 10 marks

Task 5a

	1: Floral organ identity	2: Homeotic gene activity	3: Wild-type/mutant?
Specimen O (*apetala*)	3 (Stamens and carpels only)	10 (B, C)	15 (mutant)
Specimen P (wild-type)	1 (Sepals, petals, stamens and carpels)	7 (A, B, C)	14 (wild-type)
Specimen Q (*agamous*)	5 (Sepals and petals only)	8 (A, B)	15 (mutant)

(1) 1 mark per correct answer (right or wrong) = 3 marks
(2) 1 mark per correct answer (right or wrong) = 3 marks
(3) 1 mark per correct answer (right or wrong) = 3 marks

[9 marks]

Task 5b

Question	Answer
What would form in a homozygous BC double mutant?	2 (sepals in all 4 whorls)
What would form in a homozygous ABC triple mutant?	1 (leaves in all 4 whorls)

[1 mark]

½ mark per correct answer (right or wrong) = 1 mark

Question 3 = 10 marks

Task 6a

	Average number of seeds	% seeds at globular stage	% seeds at heart stage	% seeds at torpedo stage	% seeds at mature stage
Plant R	14	70%	30%	0	0
Plant S	14	70%	30%	0	0

[4 marks]

For both R and S there should be very similar answers (example (but not actual precise answer) above); scaling as:

(full) 2 marks for each if >60% recorded at globular stage with rest at heart stage

(partial) 1 mark for each if 40-60% recorded at globular stage with rest at heart stage

(partial) ½ mark for each if globular+heart stage <80%

'Average number of seeds' does not have a score; it is just a recording; this is an example

Task 6b

Question	Which plant has abnormal seed development?	In what way is seed development abnormal?	What is the approximate frequency of abnormal embyros?	Explanation for abnormal embryos:
Answer	R	3 = multiple embryos	0-33%	6

[6 marks]

1 mark for 'which plant' (right or wrong)

2 mark for 'what way' (right or wrong)

2 mark for 'abnormal %' (right or wrong)

1 mark for explanation (right or wrong)

Question 4 = 10.5 marks

Task 7a

Specimen	**Root hair phenotype**
U - *nph4-1 / arf19 -2*	8 = No lateral roots
V – *mlo4-4 / mlo11-4*	5/7= More root hairs /longer lateral roots (either is correct)
W– *RHD3*	1/6 = Short root hairs / shorter lateral roots (either is correct)
X – *rhd2*	2 = No root hairs

[6 marks]

1.5 marks each row for correct answer (right or wrong)

Task 7b

Choose one pattern by marking an X	**Root hair formation pattern**
	A – Root hairs are in rings of rows of epidermal cells
	B – Root hairs form from random cells
X	C – Root hairs are in files or columns of epidermal cells
	D – Root hairs form a checkerboard pattern on the epidermis

[2 marks]

2 marks for correct answer (right or wrong)

Task 8a

Choose one pattern by marking an X	Root hair phenotype
	Normal length root hairs
X	No root hairs
	Extra long root hairs
	Long root hairs

[0.5 marks]

0.5 marks for correct answer (right or wrong)

Task 8b

	Wild-type		
homozygote		B	B
	b	Bb	Bb
	b	Bb	Bb

[0.5 marks]

¼ mark for filling in the gametes correctly (must get all right)
¼ mark for filling in the F2 genotypes (must get all right)

What were the genotypes of the two plants that were crossed (in terms of B or b)?	Bb and Bb
How many plants would have the Bb genotype?	16
How many plants would have the BB genotype?	8

[1.5 marks]

½ mark for correct answer in each row (right or wrong)

Note for all questions: if more than one code is entered when only one is asked for, the answer will be marked as 0.

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Write the numbers in Table 3.

Table 3 (4 marks) {one mark is given for each complete row of data; 0.33 of a mark is given for each correct value in a row. Marks are given for correct number, +/- 0.5 of a whole number}

	Sample F	Sample M	Sample D
Haematocrit (%)	42.3 %	32.8 %	25.5 %
MCV (fl)	79.2 fl	90.7 fl	83.7 fl
MCH (pg)	26.9 pg	28.7 pg	28.2 pg
MCHC (g/dl)	34.0 g/dl	31.7 g/dl	33.7 g/dl

Task 1c

For each patient, show your workings for each parameter, in Box 1a (for Father (F)), Box 1b (for Mother (M)) and Box 1c (for Daughter (D)).

Box 1: Workings for patient F (Father) (4 marks) {Marks are given for correct number, +/- 0.5 of a whole number; no marks are given for correct calculation but incorrect number}

Element	Show your working here
Haematocrit (%)	RBC fraction/Total plasma x 100 (58/137) x 100 = 42.3 %
MCV (FL)	Hct/RBC or 1l/RBC x Hct $0.424/5.35x10^{12} = 7.9x10^{-14} = 79.3x10^{-15}$ l (fl)
MCH (pg)	Hb/RBC 14.4 g/dl x 10 = 144 g/l $144/5.35x10^{12} = 2.69x10^{-11} = 26.9x10^{-12}$ g (pg)
MCHC (g/dl)	Hb/Hct 14.4/0.424 = 34.0 g/dl

Task 1d

Using the values you have obtained (included in Table 3), establish the classification in terms of size of blood cells and levels of haemoglobin of the blood of sample F, M and D.

You should answer from one of the following options for each patient (N.B. you can use any of the options more than once):

A. Macrocytic, normochromic
B. Microcytic, hypochromic
C. Normocytic, normochromic

Patient	Classification
Father (F)	C
Mother (M)	C
Daughter (D)	C

(3 marks: one mark for each correct answer) {Marks are given for correct letter only; one mark for each correct answer}

Box 2 (one mark) {Marks are given for a correct calculation (appreciating there is more than one way to derive the correct answer)}

Show an example of your workings for the calculation of volumes to be used of the highest PEP concentration.

Options/examples of method include:

To make 1.5 mM PEP from 10 mM PEP

10 mM/1.5 mM = 6.667 (a dilution factor)

1000 µl/6.667 = 150 µl of concentrated PEP in 1000 µl

OR

C1V1 = C2V2

10 mM * x = 1.5 mM * 1000

x = (1.5 * 1000)/10 = 150 µl in 1000 µl

Table 5, Reaction Volumes. You should write the substrate concentrations, PEP [S], you have decided to use in the first row at the top of each column, and the volumes of each solution in the respective boxes. (3 marks) {Marks are given for the correct numbers depending on the choice of PEP concentration; examples are shown in this marking crib. Marks are given for rows for A, B and C with each correct cell awarding 0.2 marks. The PEP concentrations used must be included in the top row but carry no marks, however failure to include this results in zero marks.}

	Concentration 1 e.g. 0.2 mM	Concentration 2 e.g. 0.4 mM	Concentration 3 e.g. 0.8 mM	Concentration 4 e.g. 1.0 mM	Concentration 5 e.g. 1.5 mM
Solution A (µl)	500	500	500	500	500
Solution B (µl)	430	410	370	350	300
Solution C (µl)	20	40	80	100	150
Plasma	50 µl	50 µl	50 µl	50 µl	50 µl
Final volume	1000 µl	1000 µl	1000 µl	1000 µl	1000 µl

Task 2c

Perform the experiment as described and record the absorbance readings using the tables provided (Tables 6.1, 6.2 and 6.3).

{Example of Table 6.1. Marks are awarded for a correct orientation of numbers, i.e. descending from approximately 1.2 to approximately 0.02 for higher concentrations and the inclusion of a correctly calculated rate. The column includes the calculation of initial change (rate) in absorbance per minute, which the students are asked to highlight (there are no marks for highlighting the numbers, but this will aid marking). 1 mark is awarded per column of data with a further 0.2 marks per calculated rate. 0.2 marks for each rate will be awarded in the rate is within +/- 10% of the known value}.

Table 6.1 Sample F (6 marks)

Concentration	**1**	**2**	**3**	**4**	**5**
[S]	0.2	0.4	0.8	1.2	1.5
Absorbance at 0 s	1.036	0.990	0.959	1.009	1.000
Absorbance at 30 s	0.872	0.732	0.664	0.710	0.708
Absorbance at 60 s	0.712	0.475	0.358	0.402	0.398
Absorbance at 90 s	0.570	0.227	0.069	0.162	0.098
Rate (ΔA/Δt min)	0.313	0.520	0.609	0.616	0.610

Task 2d

Calculate the initial velocity (v_0) and write your answers in the tables below for each patient (Father (F), Mother (M) and Daughter (D)). Your values should be given to the nearest 3 decimal places (d.p.).

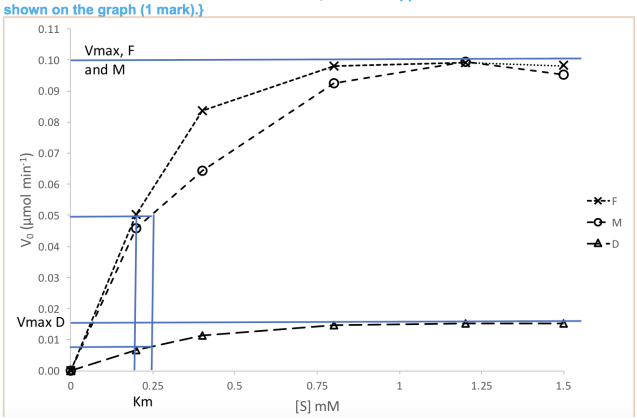
{Marks are awarded for the inclusion of correctly calculated numbers for V_0. 1 Mark is given for each F, M and D sample. Example data give for the Father (F)}

Table 7.1 Patient F (1 Mark)

[S]	V_0
0.2	0.050
0.4	0.084
0.8	0.098
1.2	0.099
1.5	0.098

Task 2e

Use your data to construct a Michaelis-Menten plot of v_0 over [S] for each patient (F, M and D) on the graph area below. You should draw one graph with three data plots; one each for Father (F), Mother (M) and Daughter (D). Use a cross (X) to mark data from the Father (F), a circle (O) to mark data from the Mother (M) and a triangle (Δ) to mark data from the Daughter (D).**{Example of plot. Two marks are awarded for each correctly labelled axis. Two marks are awarded for each data plot; two each for Father, Mother and Daughter. Markers will look for an approximation of the curve following the data points to make an approximation of the best fit (1 mark). In addition, the students are asked to indicate their estimations, where an approximation of V_{max} and K_M are shown on the graph (1 mark).}**



Task 2f

Using the three data plots, estimate V_{max} and K_M; write the estimates in the table below using the correct units and to the nearest 2 decimal places (d.p.), for each sample from the graph you have drawn.

(6 marks)

Patient	V_{max}	K_M
Father (F)	0.10 µmol min^{-1}	0.20 mM
Mother (M)	0.10 µmol min^{-1}	0.25 mM
Daughter (D)	0.02 µmol min^{-1}	0.25 mM

{(6 marks: one mark for each value) **{Calculations, derived from numbers generated from the plots are expected to be shown here. Marks are awarded for figures that are within a range of +/- 10% of values calculated by the staff team. It is expected that there will be some variation across the cohort.}**

Task 2g (3 marks: one mark for each completed table)

Determine [S]/v_0 for each substrate concentration and each sample and write your answers in the tables below for each patient (Father (F), Mother (M) and Daughter (D)). Your values should be given to to the nearest 1 decimal places (d.p.).

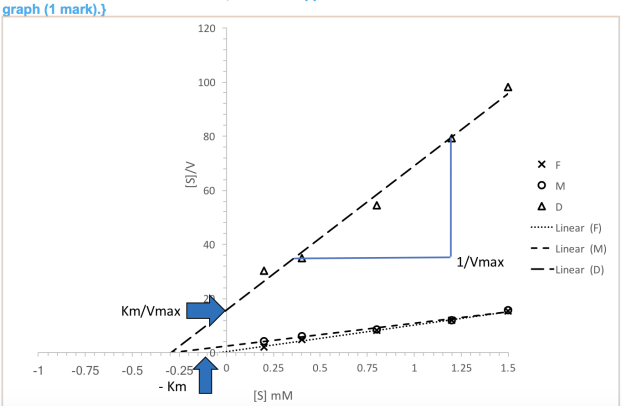
{Marks are given for each correct table, one mark for each table ((3 total) example for Patient F shown. Marks are not awarded for completing the [S] column as these figures (where correct) are awarded in previous questions.}

Patient F

[S]	S/V_0
0.2	2.0
0.4	4.8
0.8	8.2
1.2	12.1
1.5	15.3

Task 2h

Plot [S]/v_0 over [S] for each patient (F, M and D) on the graph area below. You should draw one graph with three data plots; one each for Father (F), Mother (M) and Daughter (D). Add a line of best fit for each data plot. Use a cross (X) to mark data from the Father (F), a circle (O) to mark data from the Mother (M) and a triangle (Δ) to mark data from the Daughter (D). **{Example of plot. Two marks are awarded for each correctly labelled axis. Two marks are awarded for each data plot; two each for Father, Mother and Daughter. Markers will look for an approximation of the curve following the data points to make an approximation of the best fit (1 mark). In addition, the students are asked to indicate their estimations, where an approximation of V_{max} and K_M are shown on the graph (1 mark).}**



Task 2i

Calculate V_{max} and K_M for each patient and include in the table below using the correct units to two decimal places (d.p.).

(6 marks)

Patient	V_{max}	K_M
F	**0.10 µmol min^{-1}**	**0.04 mM**
M	**0.12 µmol min^{-1}**	**0.35 mM**
D	**0.02 µmol min^{-1}**	**0.34 mM**

(6 marks: one mark for each value) **{Calculations, derived from numbers generated from the plots are expected to be shown here. Marks are awarded for figures that are within a range of +/- 10% of values calculated by the staff team. It is expected that there will be some variation across the cohort.}**

Task 3a

Complete the table below, indicating which size protein bands are visible for each patient (F, M or D), as either 'present' or 'not present'. Use the letter P to mark present, and NP to mark not present.

Task 3b

Indicate on the table whether any of the three patients (F, M or D) contain a PK tetramer by marking as either 'present' or 'not present'. Use the letter P to mark present, and NP to mark not present.

(5 marks) {1 mark for each correct complete row, the correct answers are shown in the table.}

		Patient F	Patient M	Patient D
	Molecular Weight	Present (P) or Not Present (NP)		
	232 kDa	P	P	NP
	58 kDa	P	P	NP
	40 kDa	NP	NP	P
	18 kDa	NP	NP	P
	PK tetramer	P	P	NP

Task 3d (1 mark for the correct answer; you cannot gain a mark for Task 3e unless you have answered Task 3d correctly).

Wild type alleles are designated **A**; mutant alleles are designated lower case **a** followed by a subscript.

Indicate, by drawing a circle around your choice of either A, B or C, father III-4's genetic PK gene arrangement in terms of:

A. Simple Heterozygote (Aa_1, Aa_2, Aa_3)
B. Compound Heterozygote (a_1a_2; a_1a_3; a_2a_3)
C. Homozygous (AA

Task 3e (1 mark for the correct answer; you can only receive a mark if you have answered Task 3d correctly).

Indicate, by drawing a circle around your choice of either A or B, brother IV-5's genetic PK gene arrangement in terms of:

A. Simple Heterozygote
B. Compound Heterozygote

{The correct answer for Task 3d is A; the correct answer for Task 3e is B. No marks are given for either Task 3d or 3e if the answer of Task 3d is incorrect; One mark is given for the correct answer to Task 3d, even if Task 3e is incorrect.}

INTERNATIONAL BIOLOGY OLYMPIAD e. V. IBO

IBO2017 – Practical 3

Developmental Physiology marking crib and justification

Question 1 – Identifying tissues of a fly larva

Tasks 1a & 1b – Identify the axes of a larva. **(7 Marks)**

Tasks 1c, 1d & 1e – Dissect *Calliphora vicina* larva to isolate identified tissues. **(38 Marks)**

(45 marks in total)

Question 2 – Physiological responses of a larval heart

Task 2a, 2b & 2c – Dissect a *C. vicina* larva to reveal beating dorsal vessel (larval heart) **(10 Marks)**

Task 2d, 2e & 2f – Design and perform an experiment to identify the activity of pharmacological agents acting on the dorsal vessel **(45 Marks)**

(55 marks in total)

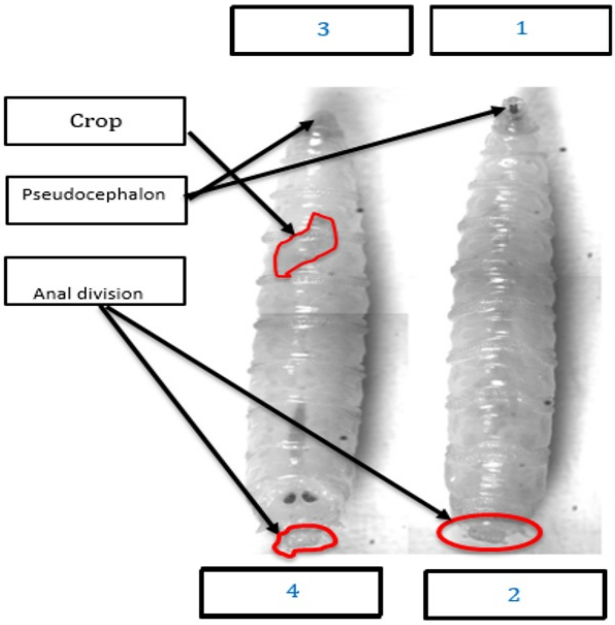
Examination total = 100

The overarching aim of this examination is to test fine dissection skills, attention to detail and understanding of the scientific principles of experiment design and procedure. There is no assessment of prior academic knowledge.

As the exam progresses the complexity and time pressure increase. We have structured this examination in a very specific way to allow some skills development and so candidates should follow the chronological order of the exam tasks.

Question 1: Identifying tissues of a fly larva

Task 1a & -b Identify the body axes of a fly larva



7 Marks

Figure 5. External morphology of *C.vicina* 1

The images given in Fig 2 and -3 are to guide the students; there are subtle differences between species such as size of salivary gland, exact position of crop and number of teeth on the mouth hooks. A possible difference is alluded to in the legend of Fig. 3B. If candidates simply copy from the figures provided, they will get incorrect answers.

Task 1c – Dissection; Task 1d Isolation of organs/tissue; Task 1e complete the table.

Table 1 Recording of identified larval tissues

Candidates will be scored on the correct intact tissues being in the wells, as well as the answers in the table below

Slide Position:	Tissue	Observations to record WRITE YOUR ANSWERS IN THIS COLUMN	MARKS
1	Crop	(1) for crop tissue (evidence of crop tissue, can be partly damaged) Or (2) for whole intact undamaged tissue (1) = Anterior	/3
2	Salivary glands	(1) for one salivary gland (evidence of tissue, can be partly damaged) Or (2) for whole intact undamaged tissue, this is very delicate tissue so holds a bigger value (2) for correct ratio = 1/3 or 3:1 (should be measured in situ, tissue will shrink a little when in gelvitol)	/4
3	Brain	(1) for brain (evidence of tissue, can be partly damaged) Or (2) for whole brain with some nerve roots attached. Or (3) for whole intact undamaged brain with all nerve roots attached.	/6
		This is very delicate tissue and secured by a number of connections, removing intact is difficult so holds a bigger value. (1) for total number of nerves = 20 (has to be exact) (1) for dorsally originating = 12 (1) for ventrally originating = 8 **Justification for three counts**: the correct dorsal/ventral count combination can be difficult if the tissue is not manipulated well. It is still however possible to count the total root projections.	
4	Spiracle and Trachea	(1) for number of slits within a spiracle = 3. (This can be counted on an un-dissected larva). (1) for spiracle (evidence of tissue, can be damaged) with no trachea. It is almost impossible to not have trachea attached, therefore a separate free floating piece from another part of the preparation will not be accepted. Or (2) for spiracle (evidence of tissue, can be damaged) with trachea	/7

		attached. Or (3) for whole spiracle with attached trachea with all three slits damaged. Or (4) for whole spiracle with attached trachea with 2 slits damaged. Or (5) for whole spiracle with attached trachea with 1 slit damaged. Or (6) for whole spiracle with attached trachea no slits damaged.	
5	Mouth hooks	(1) for the correct number of teeth = 1 tooth Localization. (1) for on the nub = 1 (1) for anterior to the nub = 0 (1) for posterior to the nub = 0 (1) for each mouth hook with damage and or not cleared of all muscle. (2 marks) Or (a combination of) (2) for each mouth hook intact and cleared of muscle. (**4 marks**)	**/8**
6	Wing disc	(1) for the isolation of any other imaginal disk (not wing disk) can be damaged. (2) for isolation of any other imaginal disk (not wing disk) intact. (5) for wing disk can be damaged (10) for intact wing disk with no damage **Justification:** imaginal disks are difficult to find and differentiate between, they are also difficult to pick up and transfer effectively they therefore hold a much bigger value.	**/10**

38 Marks **Total Marks for Experiment 1** **45 Marks**

Question 2: Physiological responses of the insect heart.

Task 2a,-b & -c Dissect *C. vicina* larva to reveal beating dorsal vessel.

Here the candidates are required to dissect an lethally anesthetised larva, this time in a ventral plane in order to open the larva up gently move aside the internal organs to reveal the two dorsal tubes. The larva needs to be pinned out carefully, not twisted or too stretched and the internal organs moved gently, this will minimise any disruption of the connections from the brain to the dorsal vessels which can cause the heart to stop. Candidates are given 10 larvae, if they have not managed to expose a beating heart after ~5 attempts they will run out of time before they run out of larvae.

Correctly exposed dorsal vessel **(5 marks)**

Dorsal vessel beating **(5 marks)**

Justification: This mark will not be broken down further to assess quality of dissection/dorsal vessel exposure as this could lead to subjectivity between markers.

Any amount of dorsal vessel exposed and beating is suffice for the candidate to continue. This will be evidenced by a demonstrator who will write a standardised code on the exam paper. This will stop students from continuing with the experiment without the correct tissue being exposed. Or simply continuing with no viable tissue and making up their results. If there is no official code and the student has attempted to continue with the exam, any further work beyond 2d and 2e will not be recognised. The marker will strike through these answers.

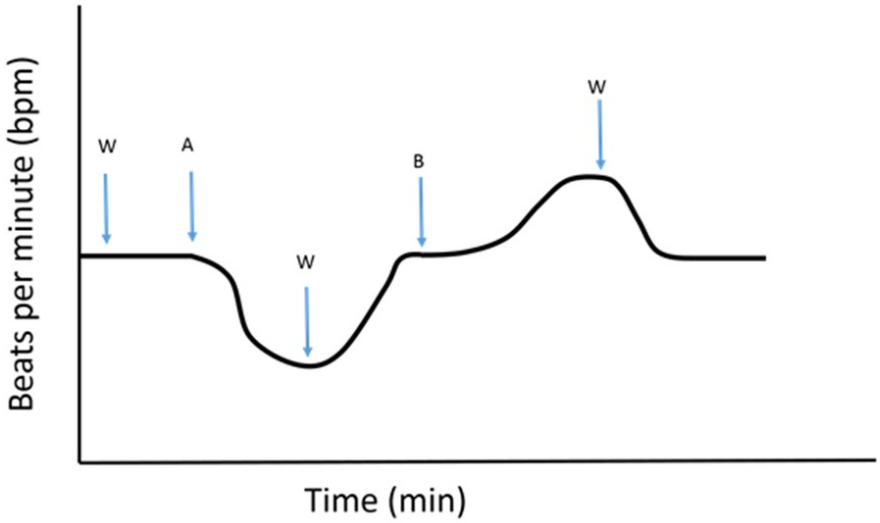
Task 2d, -e & -f Design and perform and experiment to identify three pharmacological agents' activity on the dorsal vessel.

Task 2d

We are looking for candidates to consider appropriate experimental design and representation of experimental data, in addition, to demonstrating their expectations of the action of acetylcholine and adrenaline on one tissue preparation. This will help them to consolidate their expectations of the pharmacology of the experiment and will prepare them for the Task 2e.

They must design their experiment for just one preparation to test multiple agents, using a robust methodological approach. For example, identifying baseline data, initiating a response i.e. adding a reagent, washing to bring bpm back to resting, before continuing with either a repeat of the same agent or the next agent.

The ideal expected sketch is shown below.



If a candidate misinterprets the instructions and draw two sets of data overlaid on one graph this will be recognised and will be scored similarly using the below criteria.

(1) for not starting at 0
(1) for an initial resting phase
(1) for annotations for the addition of each agent A and B
(1) for a decrease with A (Acetylcholine)
(1) for back to resting
(1) for an increase with B Adrenalin
(1) for last wash and back to resting

(7 marks)

Task 2d cont... Experimental design

Candidates will be required to divide an experimental timeline into the relevant number of blocks. Then assign an appropriate letter to each block to represent the addition of solutions (A, B or C) or PBS wash (W) to their single specimen. This will be their experimental design.

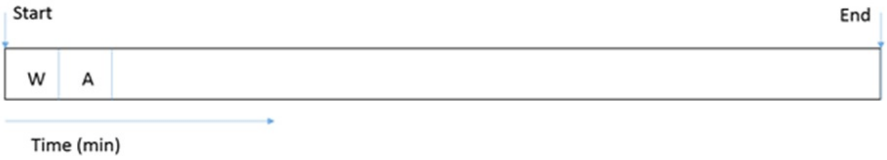


Figure 7 – Experimental design. *Relative times of the addition of PBS washes (W) and agents A, B and C*

Candidates will be specifically judged on **application** of all three agents taking into consideration repetitions, **washing** and **interleaving**.

(A) Application of Agents:

(i) (1) for the application of each agent x1

E.G W A W B W C W (or variations of)

(ii) (2) for the application of each agent x2

E.G. W A W B W C W A W B W C W (or variations of)

(iii) (3) for the application of each agent x3

E.G. W A W B W C W A W B W C W A W B W C W (or variations of)

BUT NOT W A A A W B B B W C C C W. This will be classes as option (i) =1 mark

(W) Application of Washes:

(iv) (1) for the application of wash but not after each agent

E.G. W A B C W A B C W

(v) (2) for application of wash after each class of agent

E.G W A A A W B B B W C C C W

(vi) (3) for application of washes after individual agent applications

(vii) (+1) for having end wash

(I) **Interleaving:**

(viii) (1) for interleaving agents (x3)

E.G. W A A A W B B B W C C C W

(ix) (5) for interleaving individual agents (x1)

E.G W A W B W C W

(**Maximum marks** = 12)

Examples

#1

W	A	W	B	W	C	W

A = 1: W = 3+1; I = 5 (Total 10). If the student write X2 or x3 next to it to represent repetitions this will not be recognised as this would indicate more than one larvae preparation (experimental repeats) which in this instance has not been requested.

#2

W	A	W	B	W	C	W	A	W	B	W	C	W

A = 1; W = 3 +1; I = 5 (Total = 11)

#3

W	A	W	B	W	C	W	A	W	B	W	C	W	A	W	B	W	C	W

A = 1; W = 3 +1; I = 5 (Total = 12)

#4

W	A	W	A	W	A	W	B	W	B	W	B	W	C	W	C	W	C	W

A = 3; W = 3 +1; I = 0 no interleaving (Total = 7)

#5

W	A	A	A	W	B	B	B	W	C	C	C	W

A = 1; W = 2 +1; I = 0 (Total = 4) Effectively the same as #1 but with no washes in between each application

Task 2e. Conduction of the experiment and completion of Table 2

The candidates must ensure that they make the correct dilutions; it is a simple 1 in 4 dilution and they will only be awarded marks for the first set of volumes entered in the table below. They need to conduct their experiment following their experimental design or a version of this depending on time. They need to calculate the average BPM for each treatment in order to select the appropriate descriptor for the effect that they identify.

Agent	Resting W	A	B	C
Working concentration volumes	-	Stock: 250 µl PBS: 750 µl **(2)**	Stock: 250 µl PBS: 750 µl **(0)**	Stock: 250 µl PBS: 750 V **(0)**
Record your raw data counts here				
Average bpm	Average = **(1)**	Average = **(1)**	Average = **(1)**	Average = **(1)**
Select the appropriate descriptor	Increase No change within 10% Decrease	Increase No change within 10% Decrease	Increase No change within 10% Decrease	Increase No change within 10% Decrease
	(1)	**(2)**	**(2)**	**(2)**
Identify active receptors	-	1 **(1)**	0 **(1)**	1 **(1)**

(16 marks)

Table 2: BPM of resting tissue, effect of agents A, B and C and identification of agents.

This is where they get credit for the generation of their data.

Task 2f Line graph of their experimental data.

We are looking for a reflection of their experimental design or a suitable adaptation of this depending on the time they have left. We have asked them to record their raw data in the table, we would expect to see evidence of a number of counts taken for each solution. They should plot these on their graph paper using the appropriate annotations. It could look something like the sketch graph in **Task 2d** with the addition of Octopamine data. Alternatively, if they record their data discreetly then they may produce a histogram.

If students conduct their experiment and collect data but run out of time and do not complete the graph they can still be awarded credit for the generation of their data set if they are able to enter this into the table.

Discrete

Histogram using average data – **(4)**
Histogram showing variation **(6)**
Or Box and Whisker – **(6)**

Continuous
Line graph using average data – **(2)**
Line graph using all raw data counts – **(6)**

Annotation – A, B, C and W and labels – **(2)**
(8 Marks)

Task 2f cont...

The two hypotheses (H1 and H2) for this experiment were that the *C.vicina* dorsal vessel will respond to acetylcholine negatively chronotropically (H1) and second, will respond to adrenaline positively chronotropically (H2), as would a mammalian heart.

From their data, they are required to accept or reject these hypotheses.

H1 should be accepted, if their data supports this (we will check their Table 2 answers) and they accept H1 they will get 1 mark, if they go against their data for any reason and reject H1 they will be negatively marked. If their data refutes the hypothesis and they also reject the hypothesis they will get 0 marks because they have conducted the experiment incorrectly.

H2 should be rejected and the marking follows the same rules as above.

Therefore **2 marks** for correctly accepting/rejecting the hypotheses.

H1 (Accept)	Data accepts H1	H1 Accept selected by student	H1 Reject selected by student
		(1)	**(-1)**
	Data rejects H1	H1 Accept selected by student	H1 Reject selected by student
		(-1)	**(0)**

H2 (Reject)	Data accepts H2	H2 Accept selected by student	H2 Reject selected by student
		(0)	**(-1)**
	Data rejects H2	H2 Accept selected by student	H2 Reject selected by student
		(-1)	**(1)**

(2 marks) Total marks for Question 2 = 55 **Examination total marks = 100**