Answer Key to the Experimental Tests

1. Animal and Plant Anatomy (100 points, 90 minutes)

Q.1.1. (1 point x 2 = 2 points)



(In the above figure, “B” and “O” were notes for black-and-white print, showing blue and orange, respectively)

Q.1.2. (3 points) 6

Q.1.3. (3 points) 9

* The answer "8" is scored as one point: the spiracles in the first thoracic segment is apt not to be noticed, because the first thoracic spiracles are unique in the insects.

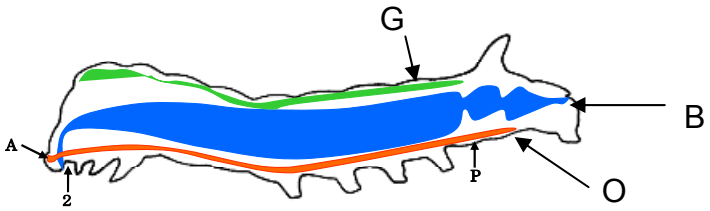
Q.1.4. (6 points +[name: 2 points + function: 2 point] ×3 points= 18 points)
Photograph of specimen (6 points)

* The students skillfully made a dissection exactly as shown in the photo prepared are given full marks. Even if the dissection is not so skillful, the dissection, which may be good enough for the students themselves to distinguish and identify the tubular structures concerned, is given 4 points. The dissection without sufficient quality is only given 3 points.

	name	Function
A	3	g
B	7	d
C	5	c

Q.1.5. (2 points × 3 = 6 points), Q.1.7. (4 points × 3 = 12 points)

* Q.1.5.: The students have to answer the questions, based on their own direct observations on the dissected and non-anesthetized caterpillars. As for the circulatory system, the students could observe only the heart beating in the dorsum of the abdomen, and this has to be clearly shown in the drawings: the other information is not evaluated. As for the central nervous system, the following points are important: 1) the crossing with the gut around the oesophagus, 2) the brain in the head, and 3) ventral localization. As for the digestive system, the anterior and posterior ends have to be clearly shown. For each structure, the answers missing only one of key points mentioned-above are given 1 point.
* Q.1.7. The anteriomost and the anterior-second gangia are clearly shown in the head and just posterior to the point crossing with the gut, respectively. The posteriormost ganglion shoud be shown in the seventh abdominal segment; the other answer is given 2 points, so far as it is shown in the range of the post abdomen.



(In the above figure, “B”, “G” and “O” were notes for black-and-white print, showing blue, green and orange, respectively)

Q.1.6. (4 points) 13

* The correct answer is "13", but the "12", "11" and "10 are respectively given 3, 2 and 1 points.

Q.1.8. (2 points) 2

Q.2.A.1. (3 point x 9 = 27 points)

Starch

seeds	Embryo	endosperm
I	±	+
II	±	N
III	±	++
IV	+	N

Protein

seeds	Embryo	endosperm
I	±	+
II	±	N
III	±	±
IV	+	N

Lipid

seeds	Embryo	endosperm
I	++	+
II	++	N
III	+	-
IV	+	N

I	barley	*Hordeum vulgare*
II	sunflower	*Helianthus annuus*
III	buckwheat	*Fagopyrum esculentum*
IV	azuki bean	*Vigna angularis*

Starch

seeds	correct combination of symbols		pattern of the correct answers
	embryo	endosperm	
I	-,±	+	<
	+	++	
II	± or +	N	± or +, N*
III	-, ±	+	<

	-,±,+	++	

* Partially point (1 point) are given to “-, N”, and “++, N” pairs.

Protein

seeds	correct combination of symbols		pattern of the correct answers
	embryo	endosperm	
I	-,±	+	<
	+	++	
II	+, ++, (+**)	N***	+, N*
III	±	±	=
	+	+	
	++	++	

* Two points are given to “+, N” pair.
** One point is given to “+” in II-embryo box.
*** One point is given to “N” in II-endosperm box.
No points are given when the both box of a seed are filled with “N”.

Lipid

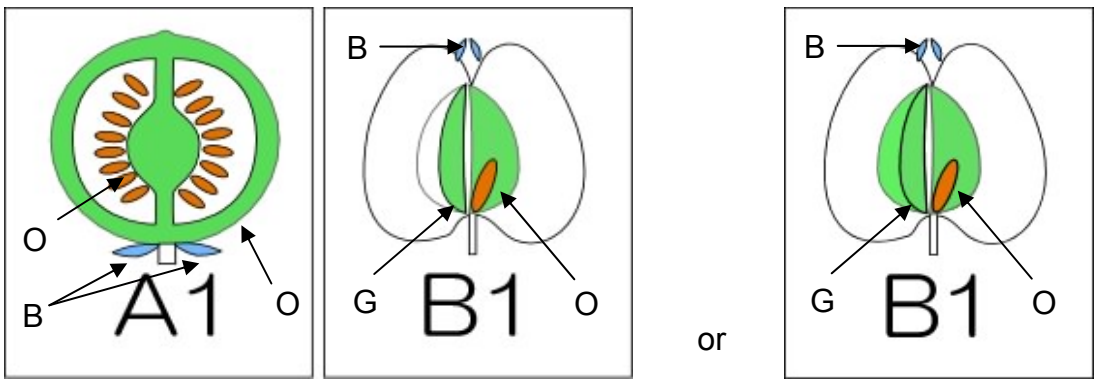
seeds	correct combination of symbols		pattern of the correct answers
	embryo	endosperm	
I	±	-	>
	+	±	
	++	+	
II	+	N**	+, N or ++,N*
	++	N**	
III	+	- , (+**)	+,- or ++,-
	++	-, (+**)	

* One point is given to “N” in II-endosperm box.
** Partially points (2 points) are given to “+, +” or “++, +” pairs.
No points are given when the both box of a seed are filled with “N”.

Q.2.B.1. (2 points x 2 = 4 points)

Fruit	Flower
A	I
B	II

Q.2.B.2. (1 point x 11 = 11 points)

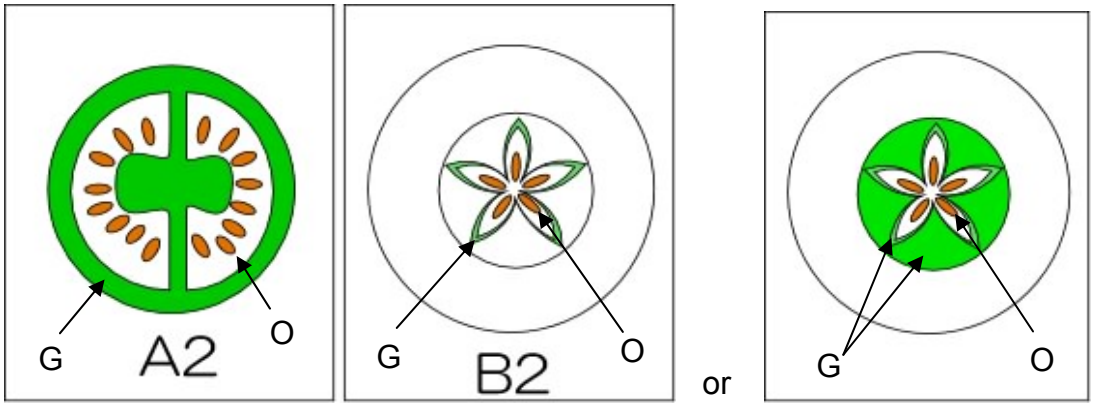


(In the above figure, “B”, “G” and “O” were notes for black-and-white print, showing blue, green and orange, respectively)

A1: 1. Sepals are drawn.
2. Sepals are painted in blue
The point is given when a student color the edible part of an apple in blue.
3. Ovules (or seeds) are drawn
4. Ovules (or seeds) are painted in orange
5. Carpels (and/or tissue derived from carpel) are painted in green

B1: 6. Sepals are drawn.
7. Sepals are painted in blue
8. Ovules (or seeds) are drawn
9. Ovules (or seeds) are painted in orange
10. A line indicating the border of carpels are drawn
11. Carpels (and/or tissue derived from carpel) are painted in green
(The answer shown below is also acceptable)

Q.2.B.3. (2 points x 4 = 8 points)



(In the above figure, “G” and “O” were notes for black-and-white print, showing green and orange, respectively)

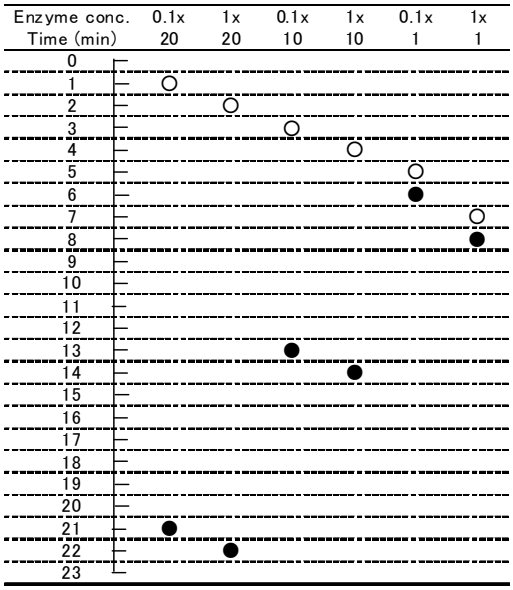
A2: 1. Two carpels are shown (there are three carpels in some fruits)
Carpels are shown (1 point), and painted in green (1 point).
2. Ovules (or seeds) are drawn
Ovules are shown (1 point), and painted in orange (1 point).
B2: 3. Five carpels are shown (there are more or less carpels depends on fruits)
(The answer shown below is also acceptable)
Carpels are shown (1 point), and painted in green (1 point).
4. Ovules (or seeds) are drawn
Ovules are shown (1 point), and painted in orange (1 point).

**********END OF PRACTICAL TEST 1**********

2. Biochemistry (100 points, 90 minutes)

Q.1.1. (10 points)

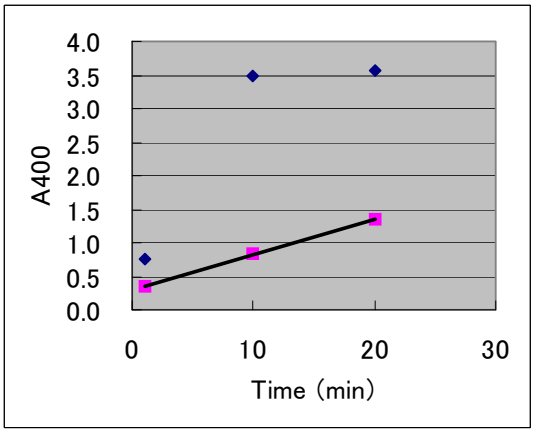
Taking a time course of enzymatic reactions is time-consuming if individual reactions are performed in series. Thus, this kind of time schedule is necessary to save time. The key points are that the 1-min reactions are done within the time of a 10-min reaction and the 10-min reactions are done within the time of a 20-min reaction.



Q.1.2. (15+10 points)

When new samples are tested for an enzymatic reaction, it is necessary to perform the reaction at different enzyme concentrations. In the case of Q.1.2., one cannot estimate the initial rate of the reaction from the data of 1x enzyme; one cannot linearly link the 1-min point and the 10-min point, because the 20-min point is not on the line projected from the 1-min and 10-min points. The saturation of absorbance observed with 1x enzyme is due to inability of spectrophotometers towards too much concentrated samples. The reaction with 0.1x enzyme proceeded linearly within the time range, and the initial rate of the reaction is calculated from these data. In this case, time is the independent variable, which must be plotted on the X-axis, while absorbance is dependent variable, which must be plotted on the Y-axis. Principally, both axes should be labeled with unit, but absorbance is an absolute number having no units.

Time (*min*)	Enzyme concentration	
	1x	0.1x
1	0.766	0.338
10	3.491	0.825
20	3.578	1.342



Q.1.3. (15 points)

Linearity : 1x (0.1x)

Slope = (1.342 - 0.338)/(20 - 1)=0.053 min^{-1}

The slope is calculated from the data point as described in the above box or directly read

from the graph.

Q.1.4.(5 points)

ΔA = Ans (Q.1.3.) x (1/0.24) x 10 = 0.053 x 4.17 x 10 =2.2 ml^{-1} min^{-1}

The slope obtained with 0.24 ml of 0.1x enzyme is proportionally converted to what would be obtained with 1 ml of 1x enzyme solution.

Q.1.5. (5 points)

$\Delta C = \Delta A/\varepsilon L$ = Ans(Q.1.4.)/ε = 2.2/19000 = 1.2 x 10^{-4} M min^{-1} ml^{-1}

The rate obtained as the absorbance change per min per ml of 1x enzyme is converted to a concentration change by using the absorption coefficient of pNP, 19000 M^{-1} cm^{-1}. Note that L is 1 cm, as described in the box in the Question paper.

Q.1.6. (5 points)

ΔN = ΔC x 0.0012 (L) = Ans(Q.1.5.) x 0.0012 = 1.4 x 10^{-7} (mol min-1 ml-1)

Mol number is calculated by multiplying the concentration change by the volume of mixture that was subjected to the measurement of absorbance, that is 1.2 ml. Remember that M (molar) is mol/liter, and the unit of the volume must be liter, not milliliter.

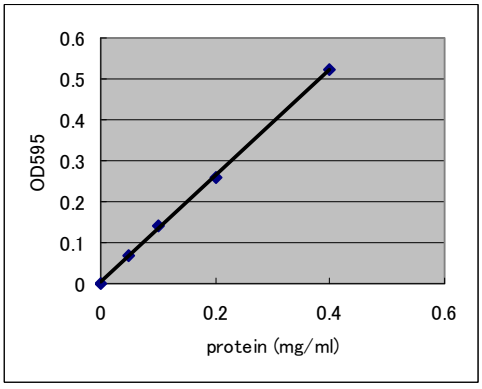
Q.1.7. (5 points)

Total activity = Ans(Q.1.6.) x 4 = 5.6 x10^{-7} (mol min^{-1})

Total activity is calculated by multiplying the activity per ml of 1x enzyme solution by the volume of 1x enzyme solution.

Q.2.1. (10 points)

Optical density is the 'absorbance' of suspension, and can be treated like absorbance in Task 2*. Protein concentration is the independent variable, which must be plotted on the X-axis, while optical density is the dependent variable, which must be plotted on the Y-axis. Both axes should be labeled with unit, but optical density is an absolute number having no units like absorbance.



*Absorbance is a term for solutions, but cannot be used for suspensions. In the Bradford method, mixing of soluble proteins with the Bradford dye yields insoluble materials that absorb 595-nm light and are precipitated by low speed centrifugation.

Q.2.2. (10 points)

Concentration of 0.1x enzyme solution = 0.135 mg ml^{-1} Concentration of 1x enzyme solution = -1.35 mg ml^{-1}

The plot of 5 point gives a straight line. The intersection of the straight line and an OD=0.18 line shows that the concentration of 0.1x enzyme is 0.135 mg ml^{-1}. The concentration of 1x enzyme solution can be obtained by multiplying the concentration of 0.1x enzyme by 10.

Q.2.3. (10 points)

Specific activity= Ans(Q.1.6.)/Ans(Q.2.2.)
$=1.4 \times 10^{-7}$ (mol min^{-1}) (1.35 mg protein) $^{-1}$
$=1.0 \times 10^{-7}$ (mol min^{-1} mg^{-1}protein)

Specific activity is the activity per unit weight (mg) of protein. The 1x enzyme solution has the activity of 1.4×10^{-1} (mol min^{-1} ml^{-1}) and the protein concentration of 1.35 mg ml^{-1}. Thus, the specific activity is calculated by dividing the former by the latter.

**********END OF PRACTICAL TEST 2**********

3. Genetics (98 points, 90 minutes)

Q.1.1. (3 points x 3 = 9 points)

(2)	C
(3)	B
(4)	I

Q.2.1. (8 points)

	red females	white females	red males	white males
(5a)	10	0	0	0
(5b)	0	0	10	0

No points if other numbers for “0” is written.

Q.2.2. (8 points)

	red females	white females	red males	white males
(6a)	10	0	0	0
(6b)	0	0	0	10

Four points for each complete row.
Two points if other numbers for “10” is written.
No points if other numbers for “0” is written.

Q.2.3. (2 points x 4 = 8 points)

	red females	white females	red males	white males
(7)	10	0	5	5

For “red females”, one point for the numbers 8, 9, 11 or 12.
For “white females”, only zero is acceptable and other numbers receive no point.
For “red males” and “white males, one point for 4 or 6.

Q.2.6. (3 points x 3 = 9 points)

(5a) and (5b)	A, C
(6a) and (6b)	D
(7)	E

For “(5a) and (5b)”, one point if only one answer is chosen.

Task 3 (18 points)

Criteria

1. At least one sample spot is confirmed on the sheet (4 points).

2. Solvent front is moved as specified (~3 cm) (4 points).
3. Pigments are migrated in near straight line (4 points).
4. At least two pigment spots are separated (6 points).

Q.4.1. (5 points)

Spot No.	Pigment (A-G)	WT	*w*	*se*	*bw*	*cn*
1	E	+	-	+	-	+
2	B	+	-	+	-	+
3	A	+	-	+	-	+
4	D	+	-	++	-	+
5	F	+	-	+	-	+
6	G	+	-	+	-	+
7	C	+	-	-	-	+

One point for each column with correct answers for all

Q.4.2. (3 points x 3 = 9 points)

se	D
bw	B
cn	A

Photograph of the gel (18 points)

Criteria
1. Loading of the molecular weight marker and two samples (3 x 3 points).
2. Separation of the molecular weight marker with several bands visible (3 points).
3. BPB dye bands are well migrated for the two samples (2 x 3 points).

Q.5.1. (3 points)

M1	M2	M3
A	C	B

3 points only when all answers are correct. No partial points.

Q.5.2. (3 points)

M1	M2	M3
C	B	A

3 points only when all answers are correct. No partial points.

**********END OF PRACTICAL TEST 3**********

4. Cell Physiology (91 points, 90 minutes)

Q.1.A.1. (4 (2 x 2) points)

1	b
2	a

Q.1.A.2. (6 points)

e.g. 4.8×10^6 cells/ml

1. Actual length of cell is $4.79 \pm 0.60 \times 10^6$ cells /ml. This value is determined in two

independent experiments by 10 graduate students.
2. Full point is given for 2.4 x 10^6 x 9.6 x 10^6 cells /ml.
3. 3 point is given for answer between 1 x 10^6 x 9.9 x 10^6 cells /ml except range prescribed in 2.
4. 1 point is given for answer between 1 x 10^5 x 9.9 x 10^7 cells /ml except range prescribed in 2 and 3.

Q.1.A.3. (5 points)

Total cells counted e.g. 120	19 %

1. Actual percentage of cells undergoing cytokinesis is 19.4 ± 5.1%. This value is determined in two independent experiments by 10 graduate students.
2. To fill in a number more than 100 is required for the mark. In the case of under 100 or no entry, 2 points are subtracted.
3. Points are given as follows,
   For 5 points, 0.1-38%*
   3 points, 39-50%
   · Minimum value 0.1% is provided. Because, students who are not familiar with adjustment of iris in microscope may underestimate a percentage of cells undergoing cytokinesis because they tend to miss a cell containing thin septum. Under 0.1% may not be acceptable because students are unable to practically count more than 1,000 cells.
   · Maximal value for full marks is twice 19%.
   · 50% is a limit for marks because it has never occurred more than half of cells are undergoing cytokinesis in an asynchronous culture in wild-type of *S. pombe*.

Q.1.A.4. (4 points)

Formula	solution
e.g. 100% / 19% x 25 min	132 min

1. Formula or calculation process must be shown for fill marks.
2. Value found in Q.1.A.3 must be applied.
3. Miscalculation is subtracted 2 points.

Q.1.A.5. (3 points)

B (C, D, E are also possible*)

*More than half of cells in culture medium c are forming spores. But a few percentages of cells are conjugating or undergoing meiosis. Moreover, some dead cells are included there. Answer of B, C, D, or E with A is given 1 point because there is no cell vigorously growing.

Q.1.A.6. (8 (2 x 4) points)

a	b	c	d
I	II	IV	III

Q.1.B.1.(3 points)

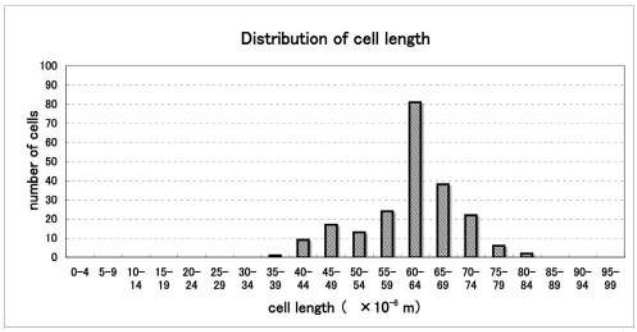
C	Plural choice is null.

Q.1.B.2.(4 points)

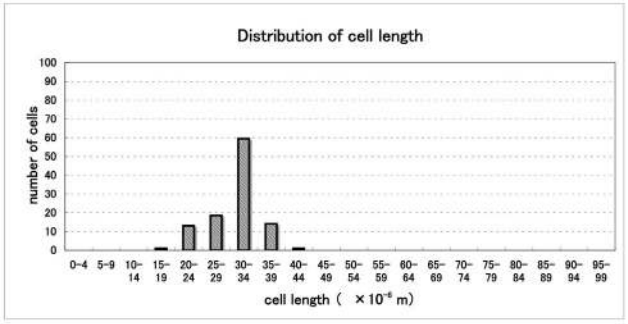
3.85 μm Two points are given for 3.7-4.0.

Q.1.B.3.(12 points)

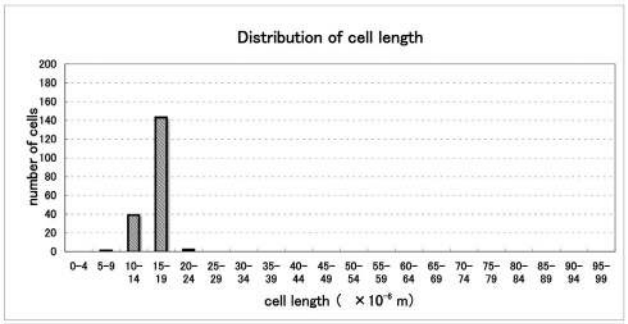
1. It is essential for full mark that students make a graph similar to one of above four. Top is a summarized result by 10 graduate students when they used objective lens (x40). Three lower graphs may be possible if x4, x10, or x20, are applied. Because, there is no description which objective lens should be used for experiment in the problem.
2. 3 points are subtracted if student does not fill the appropriate unit in the bottom bracket.



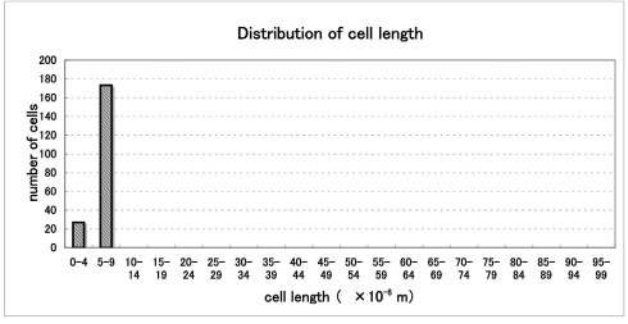
×40



(×20)



(×10)



(× 4)

Q.1.B.4.(2 points)

A Plural choice is null.

Q.1.C.1. (10 (2 x 5) points)

1	2	3	4	5
D	C	A	E	B

Q.2.A.1. (6 points)

D Plural choice is null.

Q.2.A.2. (2 points)

A Plural choice is null

Q.2.B.1. (6 points)

C Plural choice is null

Q.2.B.2. (2 points)

C and/or D

Q.2.C.1. (8 (4x2) points)

A	B
e.g. 95 %	0 %

1. In A 4 points are given for value more than 70% since almost all cells contain flagella. Value under 70% is subtracted 2 points because of miss probably caused by inadequate technique for observation.
2. In B 4 points are given for 0%. Because effect of acetic acid on removal of flagella is absolute in this experimental condition. Other value smaller than A is subtracted 2 points.

Q.2.D.1. (4 (1x4) points)

	Supported	Not-supported
1		x
2		x
3	x	
4		x

Q.2.D.2. (2 points)

A Plural choice is null

**********END OF PRACTICAL TEST 4**********