Evaluate Validity PPQs

1. A response affected by plant hormones is phototropism.

A student completed an investigation into phototropism in cress seeds.

This was the method used:

- Place 50 cress seeds (*Lepidium sativum*) on a sterile paper towel in a petri dish.
- Water with 10 cm^3 of distilled water.
- Repeat for 3 different sets of seeds:
  – Set 1 is placed in a box to prevent light shining on the seeds.
  – Set 2 is placed in a box with light from above only.
  – Set 3 is placed in a box with light from the right hand side only.
- Keep all 3 sets at 25 °C.
- After 72 hours, remove 20 of the seedlings from each set and count how many have bent.

Identify **two** limitations of the student's method.

For each limitation, explain how it limits the validity of conclusions that can be drawn **and** suggest an improvement that would improve the validity of conclusions made.

limitation 1:

explanation:

improvement:

limitation 2:

explanation:

improvement:

[6]

2(a). The downy birch tree, *Betula pubescens*, produces varying numbers of leaf hairs.

These hairs are between 200 μm and 500 μm long in response to different environmental conditions.

A group of students investigated the relationship between the distance of different trees from a river and the mean leaf hair density.

Table 25 shows the results of their investigation.

Distance from river (m)	Rank of distance	Mean leaf hair density (number mm^{-2})	Rank of hair density	Difference in ranks *(d)*	Difference squared (d^2)
9.1	4	33.1			
13.7	1	34.8			
5.5	7	11.3			
0.3	10	3.4			
5.4	8	27.3			
11.5	3	30.3			
1.7	9	6.3			
6.0	6	22.9			
11.9	2	5.7			
6.8	5	23.2			

Table 25

i. Complete Table 25 by calculating the difference between the ranks and then squaring the difference.

[Answer on Table 25] **[2]**

ii. Use the formula below to calculate Spearman's rank correlation coefficient for this data.

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

[2]

(b). The students concluded that there is a positive correlation between distance of the tree from the river and mean leaf hair density.

i. Suggest reasons for this positive correlation.

[2]

ii. For this investigation, the students randomly selected leaves from ten downy birch trees at varying distances from the river.

Suggest **three** ways in which the students could improve the validity of their sampling method.

1

2

3

[3]

(c). Another group of students repeated this investigation and calculated $r_s = 0.589$. The critical value of r_s at the 5% level for 9 degrees of freedom is 0.600.

They concluded that their results showed a weak positive correlation between leaf hair density and distance of the tree from the river.

Evaluate the conclusion of this group of students.

[2]

3. Measles is a potentially fatal disease.

- Since 1988 children in the UK have been vaccinated against measles using the MMR vaccine.
- In 1998 a study was published which linked the MMR vaccine to the development of a condition known as autism. Some parents refused to have their children vaccinated with MMR.
- The study linking MMR to autism has since been discredited.

Table 3.1 shows some data about the percentage of children vaccinated with MMR and the incidence of measles in England and Wales.

Year	Proportion of children vaccinated with MMR (%)	Confirmed cases of measles
1997	92	177
1998	91	56
1999	88	92
2000	88	110
2001	87	70
2002	84	319
2003	82	437
2004	80	188
2005	81	78
2006	84	740
2007	85	990
2008	85	1370
2009	85	1144
2010	88	380

Table 3.1

i. Between 1997 and 1999 the mean percentage of children vaccinated with MMR was 90.3.

Calculate the mean number of confirmed cases of measles between 1997 and 1999.

Give your answer to one decimal place.

Answer..... **[1]**

ii. In 2005, despite relatively low vaccination rates, the number of confirmed cases of measles was only 78.

Use your answer to part **(i)** to calculate the percentage change in the number of confirmed cases of measles from the mean value of 1997–1999 to 2005.

Give your answer to one decimal place.

Answer..... **[2]**

iii. In early 2006, a newspaper claimed that the drop in MMR vaccination rates had not led to the predicted increase in measles cases.

Evaluate the validity of the newspaper's claim. Use processed data to support your argument.

[3]

4(a). Ebola is a viral disease that was first described in human populations in 1976.

Several thousand cases of the disease were recorded in 2014.

Table 5.1 shows the estimated number of Ebola cases and deaths that resulted from the disease.
Figures are shown for the world population and for nations located in West Africa.

Number of Ebola cases		**Number of deaths from Ebola**	
World	West Africa	World	West Africa
21 364	21 358	8 459	8 458

Table 5.1

Use the data to evaluate the validity of the following statements:

- the Ebola outbreak was a pandemic
- Ebola was more likely to result in deaths in West Africa than the rest of the world.

[3]

(b).

i. In 2014, the world's population was estimated to be 7.2 billion.

The total population of the West African nations that experienced Ebola was 231.4 million.

Using the information in Table 5.1, calculate the Ebola mortality rate (deaths per 100 000) for the world and for the West African nations.

World = ...

West Africa = ...

[2]

ii. Suggest **one** reason for the difference in mortality rates calculated in **(b)(i)**.

[1]

(c).

i. What problems will medical professionals need to overcome when treating diseases caused by pathogens such as the Ebola virus, which has only recently evolved to infect humans?

[2]

ii. A patient diagnosed with Ebola in the UK was treated with blood plasma from a person who had recently recovered from the disease.

This is known as convalescent plasma therapy (CPT).

Suggest why CPT can be effective in the treatment of patients with Ebola.

[2]

iii. Suggest **one** precaution that must be taken when using CPT.

[1]

(d). Ebola is an example of a notifiable disease.

What is meant by a *notifiable disease*?

[1]

5. Icefish live in very cold water.

Icefish contain biological molecules that allow them to tolerate cold temperatures.

A group of students investigated the effect of temperature on the activity of two forms of trypsin: human trypsin and icefish trypsin.

Part of their method is shown below:

- use 10 cm^3 of 5% trypsin solution for all trials
- measure enzyme activity at 10, 20, 30, 40 and 50 °C for both enzymes
- carry out each trial in the same pH buffer
- repeat the experiment 5 times at each temperature
- measure enzyme activity by recording the area of gelatine on a photographic film that is broken down over a set time period
- calculate the rate of enzyme activity at each temperature.

i. Suggest **and** explain two improvements that would increase the validity of the students' investigation.

Improvement
Explanation

Improvement
Explanation

[4]

ii. Suggest appropriate units to use to represent the rate of enzyme activity in this investigation.

[1]

iii. The students recorded the temperature that produced the fastest reaction rate in each of the five replicates. These results are shown in Table 3.

Replicate	Temperature that produced the fastest reaction rate (°C)	
	Human trypsin	Icefish trypsin
1	40	20
2	10	10
3	30	20
4	40	30
5	40	30
Mean =	32.0	22.0
Mode =	40	20 and 30
Median =	40	20

Table 3

One of the students made the following statement:

I think the mean is a more accurate measure than the median or mode for these results.

Evaluate the student's statement.

[2]

iv. The students wanted to know whether there was a difference between the reaction rates of the two forms of trypsin at 30 °C.

They performed a statistical test on the mean of the five replicates for human trypsin and the five replicates for icefish trypsin.

Suggest the most appropriate statistical test for the students to use **and** explain why this test is appropriate.

[2]

6. A program has been developed for vaccinations against the influenza virus and is updated yearly. It is recommended that the vaccination be given to adults aged 65 years and over and those under 65 years with 'at-risk' health conditions. However, not all the people in these groups take up the offer of the influenza vaccination.

The data in Fig. 4.1 show the number of influenza cases in four different environments within a single city during three consecutive winter periods from 2015–2018.

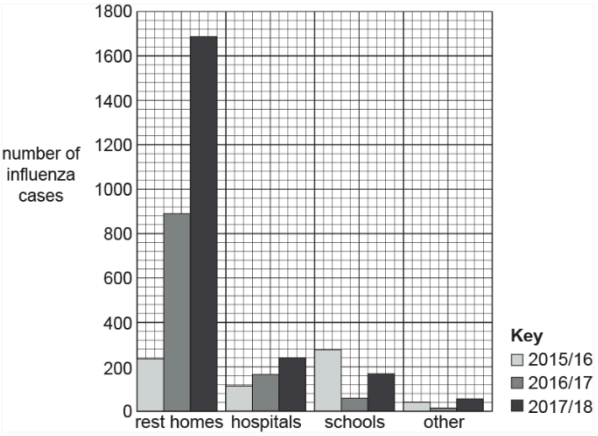


Fig. 4.1

The data in Fig. 4.2 show the percentage uptake of the influenza vaccine in four different environments in the same city during three consecutive winter periods from 2015–2018.

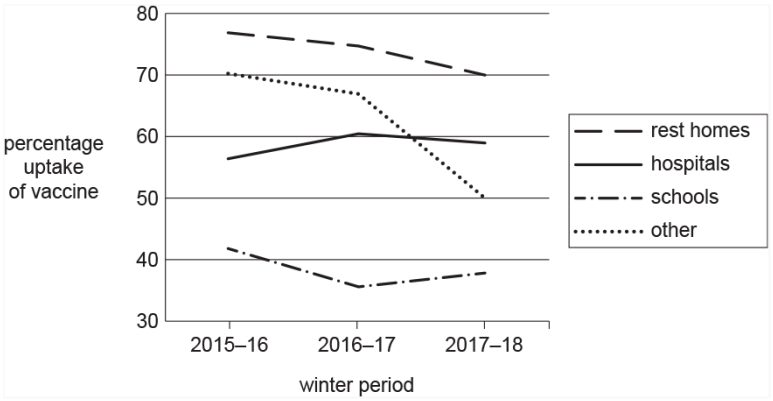


Fig. 4.2

A student looking at the data in Fig. 4.1 and Fig. 4.2 made the following conclusion:

'The data shows that a vaccination program is a successful way of reducing influenza cases in this city, as there is a direct correlation between uptake of the influenza vaccine and the number of influenza cases.'

Evaluate the validity of this statement, based on the data in Fig. 4.1 and Fig. 4.2.

[4]

7. *Heliamphora*, shown in Fig. 18.1, is a genus of carnivorous plant. Its leaves are adapted to form water-filled traps for insects. The insects are attracted by nectar, then fall into the traps and drown. The plants digest the insects and absorb the mineral ions produced. This allows *Heliamphora* to survive in soils with low mineral content.

Fig. 18.1

A student prepared slides of *Heliamphora* vascular tissue for viewing under a light microscope.

The method the student used is outlined below:

1. Select a blade.
2. Cut *Heliamphora* tissue.
3. Select best pieces.
4. Place on slide.
5. Add cover slip.

i. Suggest **three** improvements to this method. For each improvement, explain how it would increase the **validity** of the slides produced.

Improvement 1:

Explanation:

Improvement 2:

Explanation:

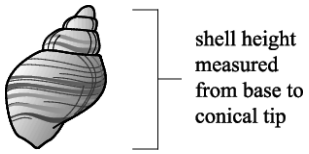
Improvement 3:

Explanation:

ii. Discuss the benefits of using stains when making slides for light microscopy.

[3]

8. The effect of wave action on the height of the shells of the dog whelk *(Nucella lapillus)* was investigated by comparing an exposed shore and a sheltered shore.



- A random sampling technique was used to collect 50 shells from an exposed shore.
- The shell height was measured from the base to the conical tip. The whelk was returned to its location.
- The process was repeated for the sheltered shore.
- All the results were recorded in **Table 3.1**.

Location	Height of shell (mm)										Range	Mean	SD
Sheltered shore	26	28	27	26	28	23	28	23	26	28			
	29	29	29	29	29	28	29	29	29	29			
	30	31	30	29	32	29	30	29	30	32			
	33	35	34	32	35	32	34	32	33	35			
	37	39	38	37	39	35	38	36	37	39	16	31.3	4.1
Exposed shore	15	17	16	15	23	15	23	16	13	15			
	17	24	18	17	17	14	17	18	16	17			
	19	19	20	24	18	20	19	20	18	20			
	23	14	24	14	21	20	23	17	21	23			
	25	25	28	26	25	27	25	28	25	27	15	20.0	4.2

Table 3.1

a. The t test can be used to determine the significance of the differences between shell height on the exposed shore and the sheltered shore.

i. Calculate the *t* value for the data using the formula:

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

where, $|\bar{x}_1 - \bar{x}_2|$ is the difference in mean values of sample 1 and sample 2

s_1^2 and s_2^2 are the squares of the standard deviations of the samples

n_1 and n_2 are the sample sizes.

Give your answer to **two** decimal places.

Answer..... **[2]**

ii. The null hypothesis is that there is no difference between the means of the two shell populations.

The critical values at 98 degrees of freedom are shown in **Table 3.2**.

Degrees of freedom	p **= 0.10**	p **= 0.05**	p **= 0.01**	p **= 0.001**
98	1.67	2.00	2.64	3.41

Table 3.2

Using the table of critical values, explain whether the student would be able to accept or reject the null hypothesis as a result of the *t* value you calculated in part **(i)**.

[1]

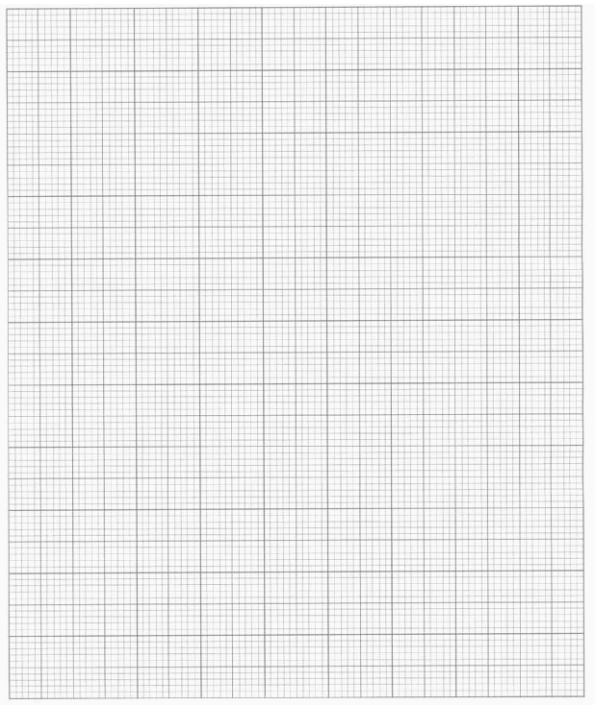
b. The students organised the data from **Table 3.1** into classes.

The organised data is shown in **Table 3.3**.

Sheltered shore			**Exposed shore**		
Height (mm)	**Tally**	**Total**	**Height (mm)**	**Tally**	**Total**
23–26	𝍸	5	11–14	IIII	4
27–30	𝍸 𝍸 𝍸 𝍸 II	22	15–18	𝍸 II	18
31–34	𝍸 𝍸 I	11	19–22	𝍸 𝍸 II	12
35–38	𝍸 IIII	9	23–26	𝍸 𝍸 II	12
39–42	III	3	27–30	IIII	4

Table 3.3

Plot the most suitable graph of the data given in **Table 3.3**.



[4]

c. Use the data and graph to discuss any correlation between the height of the whelk shell and the type of shore.

Suggest explanations for your findings.

[3]

d. Suggest a limitation of the procedure used to gather the data in this experiment and recommend how you could improve this.

[2]

e. How could the students improve the accuracy of their data?

[1]

f. Discuss the validity of the conclusions you have made during this experiment.

[3]

END OF QUESTION PAPER

Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			***related to light (L)*** **L1** light intensity / brightness, is not, controlled / specified **OR** size of hole in box not specified ✔ **L2** different, light intensities / brightness, could lead to variation in, phototropism / bending ✔ **L3** *idea that* light intensity / brightness, stays the same ✔ ***related to selection of seedlings (S)*** **S1** no method for, selecting / AW, (20) seedlings ✔ **S2** could lead to biased results ✔ **S3** *idea of* random selection ✔ ***related to measuring bend of seedlings (B)*** **B1** degree of bending (of seedlings) not considered ✔ **B2** *idea of* a (reproducible) comparison is not possible **OR** could lead to biased results ✔ **B3** measure angle of bend ✔	**6 max**	*Mark limitation, explanation and improvement as continuous prose within each numbered prompt. If marks come from more than one letter within either numbered prompt, award that which gives the highest mark* **IGNORE** reference to any other variables **ALLOW** wavelength / colour instead of intensity throughout (***L)*** *For L3 if statement not used other examples may include* e.g. use of, light meter / photo sensor e.g. use lamps of same bulb wattage e.g. use same distance from lamp e.g. use same, wavelength / coloured bulb *For S1* **IGNORE** only 20 seedlings selected *For S3* **ALLOW** count, all / more / 50, seedlings **ALLOW** reasonable method of selection e.g. photograph and allocate numbers e.g. mini grid then select random numbers *For B1* **ALLOW** bending judgement**,** not quantitative / is subjective *For B3* **ALLOW** descriptions of method e.g. use of protractor e.g. use a, standard / model (for comparison)

			related to replicates (R) **R1** experiment / trial, was not repeated ✔ **R2** cannot, calculate mean / identify anomalies / carry out statistical analysis ✔ **R3** repeat (experiment at least) twice **OR** carry out (at least) three trials ✔ ***related to size of dish (D)*** **D1** size of petri dish not, controlled / specified ✔ **D2** different sized dishes could affect, spacing of seeds / access to light ✔ **D3** specify, size / volume / diameter, of petri dish ✔		*For R2* **IGNORE** reference to, fair test / accuracy / reliability *For D3* **ALLOW** use the same sized dish **Examiner's Comments** **Q21(b)** proved challenging and candidates seemed to have had little preparation in analysing and redesigning experiments. The majority of marks awarded pertained to the control of light and selection of seedlings. Very few achieved maximum marks and Examiners commented on the fact that some candidates gave responses that included aspects of the experiment that had already been taken into account in the method provided.
			Total	**6**	
2	a	i	differences completed correctly ✓ squares of differences completed correctly ✓	2	**IGNORE** all negative signs in Difference of ranks column **DO NOT ALLOW** negatives in Difference squared column **ALLOW ECF** for mp 2 **Examiner's Comments**

Rank of hair density	Difference in ranks (*d*)	Difference squared (d^2)
2	2	4
1	0	0
7	0	0
10	0	0
4	4	16
3	0	0
8	1	1
6	0	0
9	(-)7	49
5	0	0

					Candidates were asked to complete the table by making a number of simple calculations. Most able candidates did this successfully. A number of candidates were unable to rank the hair density correctly and therefore the difference in ranks was incorrect. These candidates could still achieve a mark if they correctly squared the difference they had calculated. A few made errors in calculating the square of the difference.
		ii	rs = 0.576 / 0.58 ✓✓	2	**ALLOW** ECF from table **ALLOW** one mark for working e.g. n(n2-1) = 990 ✓ 6x70/10(99) ✓ 0.57 = one mark (incorrect rounding) 0.580 = one mark (for incorrect rounding) 0.6 = one mark (rounding too far) **Examiner's Comments** Candidates were asked to calculate Spearman's rank correlation coefficient. Many candidates managed to do this successfully. If the values in the table were incorrect the error was carried forward to enable candidates to achieve these marks using their own data from the table in part (i). Less able candidates often struggled to carry out this calculation correctly. Sometimes this was because they did not transfer data accurately into the table.
	b	i	further away from the river less water (available) / ORA ✓ transpiration causes water loss ✓ hairs, trap water vapour / reduce transpiration / reduce loss of water (vapour)✓ reduced water (vapour) potential gradient from inside to outside leaf ✓	2 max	**DO NOT ALLOW** 'further from source' 'no source' **DO NOT ALLOW** hairs prevent water (vapour) loss **Examiner's Comments** This question asked candidates to explain how leaf hairs enabled the plant to conserve water in the context of differing water availability at different distances from the river. More able candidates had a good idea that leaf hairs could reduce water loss. They also understood that this was required because there was less water available further from the river. Less able candidates often became confused and wrote about leaf hairs absorbing water from the less humid environment. Some even seemed to think that leaves closer to the river had more hairs which helped the leaf to lose water. **Exemplar 7**

					(d) The students concluded that there is a positive correlation between distance of the tree from the river and mean leaf hair density. (i) Suggest reasons for this positive correlation. As you get further from the river, less water is available from the soil so the plan trees would need hairy leaves so as to reduce the rate of transpiration by trapping water & to stop it from leaving via stomata as vapour. [2] In this exemplar the candidate has written a clear and concise response. It shows a clear understanding that water is less available further away from the river and that the leaf hairs will reduce transpiration. The candidate goes on to explain that transpiration is loss of water vapour via the stomata.
		ii	same / similar, size / age, trees ✓ same / similar, size / age, leaves ✓ repeated leaves from each tree **and** calculate mean ✓ record results at same, time of year / day ✓ ensure leaves selected are from, same side / same height / evenly distributed around tree ✓ systematic sampling / sample at set distances (from river) / described ✓	3 max	**Examiner's Comments** This question asked for candidates to describe ways to improve the validity of their sampling techniques. Validity is all about controlling the variables around the collection of data so that the data are not affected by inconsistencies. The technique is valid if it measures what it is supposed to measure. There was a wide range of responses. It was clear that many candidates did not really understand the meaning of the term 'validity'. Few candidates achieved full credit and many responses described ways to improve repeatability. In many cases the responses were not well phrased. **Exemplar 8** Suggest **three** ways in which the students could improve the validity of their sampling method. 1 Use leaves from the same height from the trees 2 Use similar size trees 3 Use similar ~~&~~ leaves of a similar area. [3] In this exemplar the candidate has given three clear statements. Each statement describes a way to remove a variable to ensure the data collected are comparable. This makes the sampling techniques valid.
	c		their conclusion is incorrect ✓ reject (the student's), hypothesis / H1 ✓ there is no, relationship / correlation, (between leaf hair density and distance from river) / the pattern seen is due to chance ✓	2 max	**ORA** accept the null hypothesis / H_0 **Examiner's Comments** Candidates were asked to evaluate a conclusion. It was clear that many candidates did not really know how to interpret the results of a statistical test. If the calculated value of Spearman's rank is below the critical value then we can say that there is no correlation. Many candidates seemed to suggest that because the calculated value was close to the critical

					value that was OK. Less able candidates become very confused and compared the calculated value to 5% or even to 9. Definitions of the terms associated with practical work are available in the practical skills handbook. **Exemplar 9** Evaluate the conclusion of this group of students. The rs value is blow the critical value so there isn't a no significant correlation and it may be due to chance so their conclusion is wrong. [2] This exemplar shows a rare case where the candidate has a good understanding of how to interpret the results of a statistical test. The candidate makes clear that the calculated result is below the critical value and states that this means there is no significant correlation.
			Total	**11**	
3		i	108.3	1	**IGNORE** all other responses.
		ii	28.0 (1)(1)	2	**ALLOW** 1 mark if correct answer given to incorrect number of decimal places. *If answer is incorrect* **ALLOW** 1 mark for any number divided by the candidate's answer to part **(i)**. *If the candidates answer to part **(i)** is incorrect apply ecf.*
		iii	*max two from:* *idea that* lowest year has been cherry-picked (1) *idea that* average of several years would have been a better indicator (1) *idea that* level might fluctuate (1) *plus:* use of processed data to support any of the above (1)	3	
			Total	**6**	
4	a		not pandemic; only 6 cases / few cases, originating outside West Africa; use of data to show that probability of dying from Ebola is greater in West Africa; *idea of* data too limited for validity statement;	3 max	**e.g.** 39.6% **and** 16.7% or 1 in 2.5 **and** 1 in 6 (die) **Examiner's Comments** This question required analytical skills on very topical, epidemiological data and thus centred around AO2 with maths. Many candidates understood why the first statement was not valid and could also develop their response further by commenting on the data, but very few

					were able to gain more than two marks as they could not manipulate the data to support their answer. Some candidates did not appreciate that the World data included the data from West Africa.
	b	i	*The world* 0.1 (per 100,000); *West Africa* 3.7 (per 100,000);	2	**ACCEPT** 0.12 or 0.117 **ACCEPT** 3.66 **Examiner's Comments** Very few candidates knew how to calculate the mortality rates and of those who did complete the calculation there were some who used an inappropriate number of decimal places. Clearly candidates struggled with working out the values per 100,000.
		ii	*idea of* differences in access to therapies and medical care **OR** spread of disease contained within West Africa **OR** *idea that* infected people / contaminated material, not isolated in West Africa;	1	**ACCEPT** ref to remote areas in West Africa having no hospitals **Examiner's Comments** The majority of candidates answered this in terms of less health care facilities in West Africa although a few candidates felt the difference was solely due to the difference in population size, not appreciating the relevance of calculating a mortality rate and not relating it to the previous part question.
	c	i	no (reliable or fully?tested), cure / treatment; no vaccine; (so) no herd immunity; *Idea of* how, pathogen / virus, is transmitted; *idea that* identification of, virus / pathogen / symptoms, might be difficult;	2 max	**Examiner's Comments** There were some good responses seen which demonstrated that candidates were aware of the problems such as the need to create new treatments and vaccines. Answers included a need to know how the virus was spread and how to prevent contaminating others. However weaker candidates considered this simply in terms of wearing protective clothing which was not credited. A few candidates were distracted by the 'recently evolved' part of the question and discussed their answer in terms of the virus constantly evolving and showing antigenic shift/drift.
		ii	antibodies against Ebola (virus) present; passive immunity; AVP;	2 max	e.g. *idea that* lack of blood cells avoids the need to match blood groups **Examiner's Comments** Although many candidates stated that antibodies would be present in the plasma they also stated that memory cells would be present and did not appreciate that this is passive immunity. Some

					candidates felt that memory cells would be present and then would form antibodies when injected into the recipient.
		iii	*idea of* screening for, other (named) pathogens / red blood cells / ABO antibodies;	1	**IGNORE** disease **Examiner's Comments** Screening for other pathogens was the most commonly seen correct response. Candidates need to be aware of not stating that we are 'screening for the disease' which could not be credited.
	d		disease for which cases are reported to the, local / health, authority;	1	**Examiner's Comments** Examiners saw wide variation in what is considered to be a 'local authority' and credit was given to suitable suggestions. Many candidates read notifiable as noticeable, stating that it is a disease that has clear, definable symptoms or can be spotted quickly.
			Total	**12**	
5		i	*I*: another named control variable (not mentioned in text) ✓ *E*: *idea of* prevent other factors (other than temperature) affecting results ✓ *I*: *idea of* standardised method ✓ *E*: minimises experimental error ✓ *I*: temperature intervals closer together ✓ *E*: (gives a more) accurate estimate of optimum temperature ✓ *I*: control group / tube with no trypsin / tube with boiled trypsin ✓ *E*: to see if gelatine breaks down without trypsin (at different temperatures) / to allow comparison (with experimental data) ✓	4 max (AO3.4)	*Read as prose as improvement mark could be found in explanation e.g. 'I; substrate concentration E; should be kept constant' gets I mp* *Marks for explanation can be awarded if the linked improvement mark is attempted but not given* e.g. area of film / volume of pH buffer / source of trypsin thickness / volume / concentration, of, gelatine / substrate **IGNORE** amount e.g. thickness may affect rate of breakdown of gelatine e.g. film is placed in the solution in the same way each time / measure time for set volume of gelatine to be broken down / use a thermostatically controlled water bath **ALLOW** improves, accuracy / reproducibility/ repeatability / precision **IGNORE** improves reliability **ALLOW** extend temperature range below 10°C **ALLOW** shows the optimum / best temperature (for trypsin) **ALLOW** improves precision **DO NOT ALLOW** improves, reproducibility/reliability **ALLOW** to show trypsin is needed to break down gelatine **ALLOW** to see if heat breaks down gelatine **Examiner's Comments**

					Candidates did not gain marks for describing improvement aspects of the experiment that were already in place on the exam paper (e.g. controlling pH using a buffer) or variants of this (e.g. saying that the set time period should be stated exactly). The most common correct answers concerned controlling another variable such as the thickness, volume or concentration of the gelatine substrate. Not all could match this improvement with the explanation that variation in this variable would affect the rate being measured. Candidates also sometimes attempted to describe a way of standardising the method, such as using a thermostatically-controlled water bath, although again correct explanations relating to improved precision and reproducibility or repeatability were not always forthcoming. Few candidates considered running a control experiment. Candidates who realised that accuracy could be improved by testing at more temperatures often did not state 'within the range' or to make clear that the more temperature intervals they suggested would be smaller intervals between 10°C and 50°C. Some students did not understand that this question was about practical measurement and talked about improvements relating to calculations and statistical analysis. Correct use of terms such as accuracy, precision, reproducibility and repeatability were important in answering this question. Many candidates justified their suggested improvements by simply repeating the term 'validity' from the question.  **AfL** The word 'amount' is not specific enough and should be avoided by candidates.  **OCR support** Appendix 4 of the Practical Skills Handbook, provides information on terms used in measurement and conventions for recording and processing experimental measurements. This is in line with the 'The Language of measurement' booklet: https:/www.ocr.org.uk/Images/294468-biology-practical-skills-handbook.pdf
		ii	mm^2 / cm^2 **and** s^{-1} / min^{-1} ✓	1 (AO2.4)	**ALLOW** /s /min **DO NOT ALLOW** 'per' or 'sec' or 'minute'

					Examiner's Comments A few answers provided correct units for area per unit time such as $mm^2\ s^{-1}$ or cm^2 / min. Errors included giving measures of volume (mm^3 and cm^3), combining two conventions such as using a slash and '$^{-1}$' after the time term, and writing in the format of area unit 'per' the time unit. Correct abbreviations of units were needed as opposed to words like 'minutes' or 'sec'.
		iii	*I agree / yes, because…* two mode values exist (for icefish trypsin) ✓ *I disagree / no, because…* outlier / anomaly, included in the mean (for human trypsin) ✓ median / mode, not / less, affected by outliers ✓	2 max (AO3.2)	**IGNORE** references to decimal places **Examiner's Comments** Many candidates provided descriptions of the terms mean, mode and median, but these gained no marks, as they were not related to the question. Some candidates showed awareness that the mean calculation included an outlier though not all reasoned that, as a result the student's statement was incorrect. Similarly not all considered that a strength of the median or mode is that they are unaffected by outliers. Very few noticed that the existence of two values for the mode for icefish trypsin was a problem. Some candidates are demonstrating their understanding of the command term 'evaluate' by trying to provide a balanced answer, in this year's exams.
		iv	(Student's)(unpaired) t-test ✓ (they are) comparing **means** (of two data sets) / AW ✓	2 (AO3.1)	**IGNORE** standard deviation **DO NOT ALLOW** paired / dependent / related, t-test e.g. 'finding the difference between 2 means' **ALLOW** 'compare averages of 2 data sets' **Examiner's Comments** Many candidates referred to the correct answer which was t-test. . However, most candidates scored only one mark as they did not explain that this allows comparison of two means (they often just stated two data sets, which is too vague). Some candidates showed extended knowledge of the application of statistics to experimental design with the use of terms like unpaired, unrelated and independent. Incorrect answers included the χ^2 test, standard deviation and Spearman's rank correlation. **OCR support** 'Mathematical skills statistics booklet' can help to develop the correct use of statistical tests: https:/www.ocr.org.uk/Images/338621-mathematical-skills-statistics-booklet.doc

<table>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
<tr><td>6</td><td></td><td></td><td>1 data (as a whole) do not show, direct / positive / indirect / negative / any, <u>correlation</u> ✓

2 direct / positive, correlation is opposite to, conclusion / trend, student describes ✓

3 rest home time trend supports negative correlation / as % vaccination decreases number of flu cases increases in rest homes / when vaccination higher flu cases lower ✓

4 schools trend supports positive correlation / as % vaccination decreases number of flu cases decreases in schools / when vaccination higher flu cases higher ✓

5 hospitals / other, trends show no correlation / as % vaccination decreases number of flu cases may increase or decrease or stay the same ✓

6 idea that need to plot % vaccination against number of flu cases to judge correlation / uptake and cases highest in rest homes ✓

7 compare figures from 2 years for one group OR from 2 groups for one year OR rest homes and other both at 70% uptake ✓

8 limitation of data ✓</td><td>4 max
(AO3.1)
(AO3.2)</td><td>max 3 if do not state mp1

ALLOW ora conclusion / trend, student describes is, indirect / negative correlation

ALLOW ‘flu case figures + / – 20 for mp 7

<table>
<tr><td></td><td colspan="3">Number of ‘flu cases</td></tr>
<tr><td></td><td>2015-16</td><td>2016-17</td><td>2017-18</td></tr>
<tr><td>rest homes</td><td>240</td><td>890</td><td>1690</td></tr>
<tr><td>hospitals</td><td>120</td><td>170</td><td>240</td></tr>
<tr><td>schools</td><td>280</td><td>60</td><td>170</td></tr>
<tr><td>other</td><td>40</td><td>20</td><td>60</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">Percentage uptake of vaccine</td></tr>
<tr><td></td><td>2015-16</td><td>2016-17</td><td>2017-18</td></tr>
<tr><td>rest homes</td><td>77</td><td>75</td><td>70</td></tr>
<tr><td>hospitals</td><td>57</td><td>60</td><td>59</td></tr>
<tr><td>schools</td><td>42</td><td>36</td><td>38</td></tr>
<tr><td>other</td><td>70</td><td>67</td><td>50</td></tr>
</table>

8 only three years studied /
small sample sizes /
not a comparison of standardised groups /
case numbers not per 100, 000 / percentages /
age / gender / other health problems, not controlled

<u>Examiner’s Comments</u>

This question provided a challenge as candidates needed to integrate two graphs and evaluate their findings in the light of a student statement that included a contradiction. A general exam technique tip is to use all the classes of data in the answer. In this question that would mean commenting on results from rest homes, schools, hospitals and other. A teaching tip is to show candidates examples of positive (direct) and negative (indirect) correlations on scattergraphs. Dose response curves illustrate that effective medical interventions produce a negative correlation when drug dose is plotted against disease incidence or prevalence or against mortality.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
</table>

7		i	sharp blade (should be selected) (1) so slide is thin enough, individual cells are visible / resolution is high (1) method for slicing pieces of tissue (thinly) (1) so slide is thin enough, individual cells are visible / resolution is high (1) select thin(nest) slides (1) to ensure maximum light can penetrate sample (1) wet mount (1) prevents dehydration / distortion of tissue (1) squash slide (1) easier to see individual cells / allows light to penetrate tissue more easily (1)	6	**ALLOW** any reasonable method (e.g. microtome) **ALLOW** quantified thickness (e.g. measured with a micrometer) **ALLOW** description **ALLOW** description
		ii	contrast is high(er) (1) more (internal) structures visible (1) some (named) organelles / cell components more visible, because they bind to stain (1) clearer image can be obtained (1)	3	
			Total	**9**	
8	a	i	t = 13.61 (1)(1)	2	**ALLOW** correct working for 1 mark. $\frac{[31.3 - 20.0]}{\sqrt{\frac{4.1^2}{50} + \frac{4.2^2}{50}}} = \frac{11.3}{\sqrt{\frac{16.81}{50} + \frac{17.64}{50}}} = \frac{11.3}{\sqrt{0.3362 + 0.3528}} = \frac{11.3}{\sqrt{0.689}}$ $= 11.3 / 0.830 = 13.61$
		ii	probability is highly significant, calculated t value is greater than the critical value at 0.001 / there is a chance (probability) of below 0.001 that the differences in the shell height seen can be due to chance **and** the null hypothesis can be rejected (1)	1	
	b		histogram correctly plotted for the values (1) two sets of data distinguished by a key or other suitable method to identify them (1) x axis labelled 'height (mm)' **and** y axis labelled 'number of dog whelks / *Nucella lapillus* / shells / class' (1) makes good use of the graph paper **and** both axes are correctly scaled with ascending equidistant intervals (1)	4	**DO NOT ALLOW** a bar chart or a line graph as neither would represent the data correctly. **ALLOW** a correlation scattergram. **ALLOW** '% of the sample' for the y axis if this has been calculated.
	c		three from positive correlation between the height of the whelk shell and the type of the shore (1)	3	**ALLOW** correlation is strong or a reference to relationship such as:- taller shell height and sheltered shore or shorter shell height and exposed shore.

			correct calculation of the correlation coefficient (1) (histogram / data, indicates that) shore exposure has an impact on height (1) Nucella show adaptation to harsher wave action (1) shells measured may not all be exposed to wave action (1)		**ALLOW** little overlap on the histogram bars. **ALLOW** the idea that the differences may be due to direct wave action or adaptation.
	d		no detail for the random sampling technique was given / *Nucella* from the whole population may not have been sampled (1) **and** use (two) metre tapes to set out a grid and use randomly generated coordinates (1) no measuring instrument specified (1) **and** use vernier callipers with a precision of more than 0.5 mm (1) incorrect identification of *Nucella* / several types of shelled molluscs that are similar to *Nucella* (1) **and** use a sea shore key to correctly identify the whelk (1) classification of the shore as sheltered or exposed was subjective (1) **and** use an approved shore classification (such as Ballantine's) (1)	2	**Limitation and improvement must be linked for 2 marks.**
	e		*one from* increase the number of, *Nucella* used in the data collection / samples (1) replicate / repeat, the entire experiment again (1)	1	**ALLOW** a value given such as increasing number to 100 from each shore. **ALLOW** an understanding of the *idea* that the procedure has only been carried out once for each shore.
	f		*not valid* a small percentage of N*ucella* sampled and some areas not sampled at all which would lead to skewed data (1) human interpretation of the measurement causes accuracy of the data to be questioned (1) genetic variations or sub species not taken into account (1) *valid* random sampling techniques mean no bias in collection (1) 100 *Nucella* sampled in total (50 in each	3	**ALLOW** reverse arguments made. *idea that* conclusion will be distorted

			area) so large sample size (1) precise instructions for consistent measurement of shell height (1)		
			Total	**16**	