STATISTICS FOR BIOLOGY

QUESTIONSHEET 1

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Young pigs are frequently anaemic at birth due to iron deficiency. Iron injections are given to remedy this.An investigation was carried out to determine whether feeding an iron supplement to young piglets would increase their growth rate. Two similar groups of piglets were selected for the investigation. One group (A) was fed on normal pigfood with no iron supplement and the other group (B) was fed on the same pigfood but with an iron supplement added. The increase in weight of each piglet was measured after 21 days. The results are shown in the table below.

Group A. No iron supplement given		**Group B. Iron supplement given**	
Pig number	**Gain in weight/Kg**	**Pig number**	**Gain in weight/Kg**
1	2.1	1	3.6
2	3.7	2	4.2
3	4.1	3	7.9
4	3.9	4	9.1
5	2.8	5	6.5
6	5.6	6	6.6
7	8.9	7	2.9
8	7.6	8	3.1
9	8.2	9	4.7
10	2.8	10	3.9
11	3.4	11	3.7
Total	53.1	Total	56.2
Mean	4.83	Mean	5.11

(a) Calculate the differences in increase in weight of the two groups of pigs (x) and then calculate x^2. Write your answers in the table:

Pig number	1	2	3	4	5	6	7	8	9	10	11
B - A weight difference(x)											
x^2											

[2]

(b) The null hypothesis was proposed that 'supplementing the diet of the piglets with iron did not result in a greater increase in weight'. Perform a t-test on the data to assess whether the null hypothesis can be accepted or rejected.

The formula for a t-test is: $t = \dfrac{\bar{x}\sqrt{(n-1)}}{s}$

where $\bar{x}$ is the mean of the weight differences, n is the number of pigs in each group and s is found from the formula:

$$s^2 = \frac{\Sigma x^2}{n} - \bar{x}^2$$

(i) Calculate the values of $\bar{x}^2$ and Σx^2.

$\bar{x}^2$ .....

Σx^2 ..... [2]

(*Continued...*)

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(ii) Use your values from (i) to calculate the value of s. Show your working.

s = ... [2]

(iii) Calculate the value of t. Show your working.

t = ... [2]

(iv) The critical value for t at a 0.05 significance level is 2.201. Does this enable you to accept or reject the null hypothesis? Explain your answer.

.....

..... [2]

(c) (i) Suggest how a lack of iron could slow up the piglets' growth rate.

.....

.....

..... [2]

(ii) Suggest the best method for giving the piglets extra iron.

..... [1]

TOTAL / 13

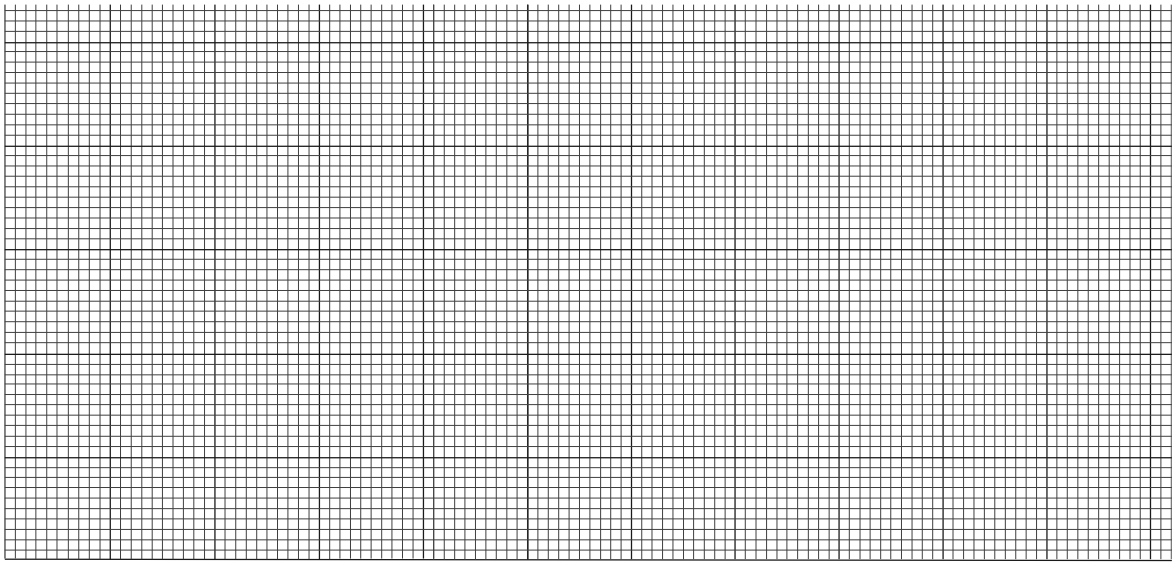
QUESTIONSHEET 2

The table shows gains in weight (pounds) of 97 young pigs over 21 days.

No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.
00	3	14	19	28	25	42	29	56	31	70	35	84	41
01	7	15	19	29	25	43	29	57	31	71	35	85	41
02	11	16	20	30	25	44	29	58	31	72	36	86	41
03	12	17	20	31	26	45	30	59	32	73	36	87	42
04	13	18	21	32	26	46	30	60	32	74	36	88	42
05	14	19	21	33	26	47	30	61	33	75	37	89	42
06	15	20	21	34	26	48	30	62	33	76	37	90	43
07	16	21	22	35	27	49	30	63	33	77	38	91	43
08	17	22	22	36	27	50	30	64	33	78	38	92	44
09	17	23	23	37	27	51	30	65	33	79	39	93	45
10	18	24	23	38	28	52	30	66	34	80	39	94	46
11	18	25	24	39	28	53	30	67	34	81	39	95	47
12	18	26	24	40	28	54	30	68	34	82	40	96	48
13	19	27	24	41	29	55	31	69	35	83	40	97	49

(a) (i) Construct a histogram from this data. Use groups of 5 pounds, writing the data on the table below.

Class (5 lbs)	No of pigs
0 - 4	
5 - 9	
10 - 14	
15 - 19	
20 - 24	
25 - 29	
30 - 34	
35 - 39	
40 - 44	
45 - 49	



[5]

(*Continued...*)

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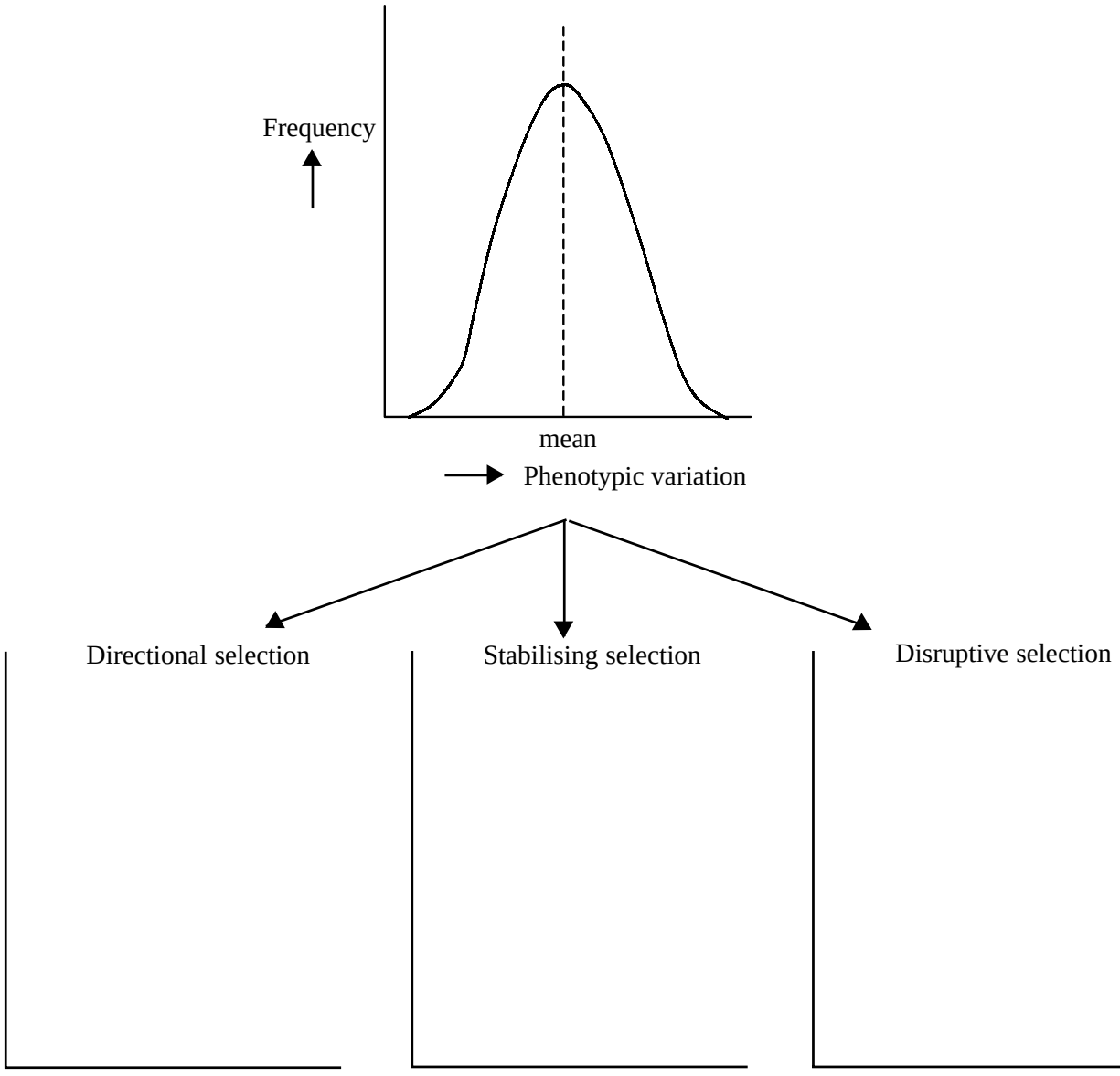
(ii) Comment about the distribution of the data.

..... [1]

(iii) Calculate the mean ($\bar{x}$) of the data. Show your working.

Answer: ..... [1]

(b) The distribution below shows phenotypic variation in a population before a selection pressure has acted on it. Draw distribution curves to illustrate how directional, stabilising or disruptive selection would alter the distribution. Show the position of the mean on each of your drawings.



[6]

TOTAL / 13

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QUESTIONSHEET 3

A student carried out an investigation to see if 20 people, when blindfolded, could distinguish between drops of distilled water and drops of an infusion of cinnamon placed on the tongue. In 200 tests the people were allowed to breathe normally and in another 200 tests their noses were clipped closed while they attempted to detect the cinnamon. In each test the person was asked to name the substance and their answer was recorded as correct or incorrect. The results are shown in the table.

	Answer		
	Correct	**Incorrect**	**Row total**
With nose closed	167	33	200
With nose open	112	88	200
Column total	279	121	400

The student suggested the hypothesis that 'the people could detect the substances better when they were allowed to breathe freely'. Perform a Chi^2 test to determine whether the figures support the hypothesis or not. The formula for finding the value of Chi^2 (χ^2) is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and E = expected results

(a) (i) Calculate the expected numbers and write them in the table below. The expected numbers may be calculated by the formula;

$$E = \frac{\text{Row total}}{\text{Total}} \times \frac{\text{Column total}}{\text{Total}} \times \text{Total}$$

	Correct	Incorrect
Nose closed		
Nose open		

[4]

(ii) Calculate the value of χ^2. Show your working.

Answer χ^2 = ... [2]

(iii) The number of degrees of freedom (n) is given by the equation

n = (no of rows – 1)(no of columns – 1)

How many degrees of freedom are there?

..... [1]

(*Continued...*)

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(iv) The critical value for χ^2 with these degrees of freedom is 10.83 at the 0.001 probability level. Does the calculated answer enable the hypothesis to be accepted or rejected? Explain your answer.

.....

..... [2]

(b) (i) Suggest three precautions the student should have taken to ensure the investigation yielded valid results.

1. .....

.....

2. .....

.....

3. .....

..... [3]

(ii) With reference to taste and smell receptors suggest an explanation for the experimental results.

.....

.....

..... [3]

TOTAL / 15

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QUESTIONSHEET 4

A particular variety of wheat has a recessive mutant gene, which in the homozygous state causes absence of chlorophyll. Such a condition is lethal, since plants without chlorophyll cannot photosynthesise and die soon after germination. Seeds from self-pollinated heterozygous plants were germinated, yielding 17 white plants and 49 normal green plants. According to Mendelian laws the two phenotypes should appear in the ratio 3 green : 1 white.

Use a χ^2 test to see if the result supports the hypothesis that the deviation of these results from the Mendelian ratio is significant. The formula for a χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and E = expected results

(a) (i) Calculate the expected values for the data and write them in the table.

	Number of plants	
	Green	**White**
O	49	18
E		

[2]

(ii) Calculate the value of χ^2. Show your working.

χ^2 = ... [2]

(iii) How many degrees of freedom(n) are there?

..... [1]

(iv) The critical value of χ^2 at these degrees of freedom and a 0.05 probability level is 3.84. Does the calculated result enable you to accept or reject the hypothesis? Explain your answer.

.....

..... [2]

(b) Illustrate the above cross by means of a genetic diagram.

[4]

TOTAL / 11

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QUESTIONSHEET 5

The plant known as Indian Mustard (Brassica juncea) will accumulate gold from gold salts in the soil in which it grows. It can be used to extract gold from impoverished mine wastes which still contain residual gold which is uneconomical to extract by traditional methods. Addition of ammonium thiocyanate to the mine waste growth substrate is thought to enhance the accumulation of gold by the plants. An investigation was carried out to test whether this was so. The results of the investigation are shown in the table below.

plant	**gold accumulated/mg gold Kg^{-1} dry mass**		**x = b - a**	**x^2**
	no thiocyanate(a)	**with thiocyanate(b)**		
1	1.01	0.99		
2	1.09	1.09		
3	0.98	1.25		
4	0.71	1.34		
5	1.15	1.22		
6	1.21	1.18		
7	1.18	1.23		
8	0.89	1.34		
9	1.26	1.21		
10	1.07	0.97		
11	1.30	1.18		
12	1.17	1.23		

The null hypothesis was proposed that 'the addition of ammonium thiocyanate to the mine waste did not improve the accumulation of gold by the Brassica plants'.

(a) Carry out a t-test to test the validity of the null hypothesis.

The formula for this t-test is: $\mathbf{t = \frac{\bar{x}\sqrt{(n-1)}}{s}}$

where $\bar{x}$ is the mean of the weight differences, n is the number of readings in each group and s is found from the formula:

$$\mathbf{s^2 = \frac{\Sigma x^2}{n} - \bar{x}^2}$$

(i) Calculate the value of $\bar{x}$. [3]

(ii) Calculate the value of $\sum x^2$. Show your working.

Answer: $\sum x^2$ = ... [2]

(iii) Calculate the value of $(\bar{x})^2$. Show your working.

Answer: $(\bar{x})^2$ = ... [1]

(*Continued...*)

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(iv) Calculate the value of s. Show your working.

Answer: s = ... [2]

(v) Calculate the value of t. Show your working.

Answer: t = ... [2]

(b) At 11 degrees of freedom the critical values for t at various probabilities are shown in the table.

Probability	**0.1**	**0.05**	**0.02**	**0.01**	**0.001**
Critical value	1.80	2.20	2.72	3.11	4.44

(i) Does the calculated value for t enable you to accept or reject the null hypothesis? Explain your answer.

.....

..... [2]

(ii) Suggest two precautions which should have been taken to ensure that the investigation yielded valid results.

1. .....

2. ..... [2]

TOTAL / 14

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QUESTIONSHEET 6

Geranium seeds are sold in packets of sixty. It is claimed that each packet contains seeds that will produce plants with either red, white, yellow or pink flowers in the ratio 5:4:4:2. A randomly selected packet produced plants with flowers as shown in the table:

Colour of flower	**Red**	**White**	**Yellow**	**Pink**
Number of plants	15	20	10	15

Perform a Chi^2 (χ^2) test at the 5% level of significance to examine the claim made. The formula for a χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and E = expected results

(a) State a suitable null hypothesis to test the claim.

.....

..... [1]

(b) Calculate the expected values, showing your working and answers in the table:

Colour of flower	Red	White	Yellow	Pink
Working				
Expected numbers				

[2]

(c) Calculate the value of χ^2. Show your working.

Answer: χ^2 = ... [2]

(d) How many degrees of freedom are there? Answer: ..... [1]

(e) The critical value for χ^2 at these degrees of freedom at the 5% level of significance is 7.82. Does this enable you to accept or reject the null hypothesis? Explain your answer.

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..... [2]

(f) Comment about the possible genotype of the pink flowers.

.....

..... [2]

TOTAL / 10

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QUESTIONSHEET 7

Dandruff is when excessive skin flakes are lost from the surface of the scalp, possibly caused by an increased mitotic rate in the epidermis. The makers of a new type of anti-dandruff shampoo make the claim that 70% of users will be able to clear up their dandruff with only one application of the shampoo. To investigate this claim, 1000 people with dandruff were chosen at random, and randomely allocated to 200 groups of 5 people. Each person used the shampoo once, and the results are shown in the table below:

Number in group who reported dandruff cleared up	0	1	2	3	4	5
Number of groups	5	10	24	57	75	29

Perform a χ^2 test at the 1% level of significance to test the validity of the claim.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and E = expected results

(a) State a suitable hypothesis for testing the claim.

.....

..... [1]

(b) Some of the expected values are shown in the table. Calculate the remaining expected value and write it in the table. Show your working.

Number in group who reported dandruff cleared up	0 and 1	2	3	4	5
Number of groups	6.156	26.46		72.03	33.614

[2]

(c) Calculate the value of χ^2. Show your working.

Answer: χ^2 = ... [2]

(d) State the number of degrees of freedom in this investigation.

..... [1]

(e) The critical value for χ^2 with these degrees of freedom, at the 1% level of significance is 13.28. Does this enable you to accept or reject the hypothesis? Explain your answer.

.....

..... [2]

TOTAL / 8

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QUESTIONSHEET 8

A teacher believes that the mean height of the pupils in year 8 at his school is less than 1.53 metres. To test this, he chooses ten year 8 pupils at random and records their heights in metres. He obtains the data below:

Pupil Number	1	2	3	4	5	6	7	8	9	10
Height/m	1.50	1.57	1.49	1.46	1.53	1.62	1.53	1.51	1.57	1.44

Perfom a t-test at a 5% level of significance to assess whether the teacher is correct in his belief.

The formula for a t-test is: $\mathbf{t = \dfrac{\bar{x}\sqrt{(n-1)}}{s}}$

where $\bar{x}$ is the mean of the height differences, n is the number of readings in each group and s is found from the formula:

$$\mathbf{s^2 = \frac{\Sigma x^2}{n} - \bar{x}^2}$$

where Σx is the sum of the height differences.

(a) State a suitable hypothesis to test the teacher's belief.

.....

..... [1]

(b) (i) Calculate the differences between the actual heights of the pupils and the mean height 1.53 metres proposed by the teacher. Write your answers in the table: [2]

Pupil Number	1	2	3	4	5	6	7	8	9	10
Height difference/m										

(ii) Calculate Σx, $\bar{x}$, $\bar{x}^2$ and Σx^2.

Σx ..... $\bar{x}$ .....

$\bar{x}^2$ ..... Σx^2 ..... [4]

(iii) Calculate the value of **s**. Show your working.

Answer: s = ... [2]

(iv) Calculate the value of **t**. Show your working.

Answer: t = ... [2]

(v) How many degrees of freedom are there?

..... [1]

(c) The critical value for t at a 5% level of significance, with these degrees of freedom, is 2.26. Does this enable you to accept or reject the hypothesis? Explain your answer.

.....

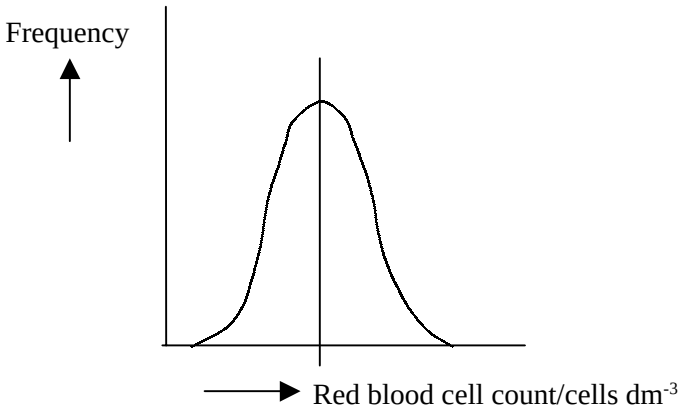
..... [2]

TOTAL / 14

QUESTIONSHEET 9

The graphs below show the distribution curves of certain biological values. Answer the questions that relate to each distribution.

(a) The red blood cell counts of normal human males.



On the graph draw and label, and then explain, the distributions which would be shown by the following:

(i) the red blood cell counts of normal human females.

..... [2]

(ii) the red blood cell counts of a large group of hospital patients suffering from anaemia.

.....

..... [3]

(iii) The red blood cell counts of a large group of athletes who have acclimatised to be able to compete at high altitude.

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..... [3]

(*Continued...*)

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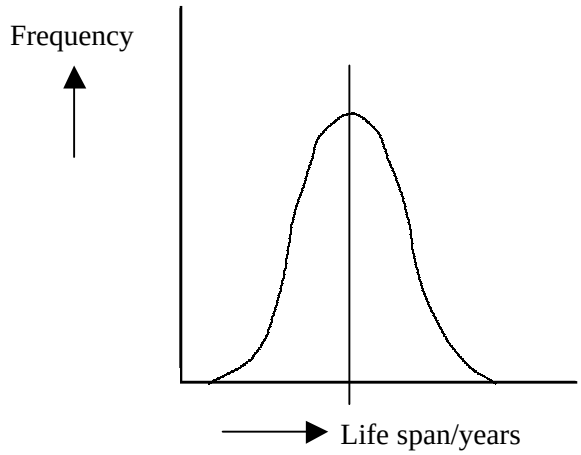
(b) The life span of modern men.



On the graph draw and label, and then explain, the distributions which would be shown by the following:

(i) the life span of modern women.

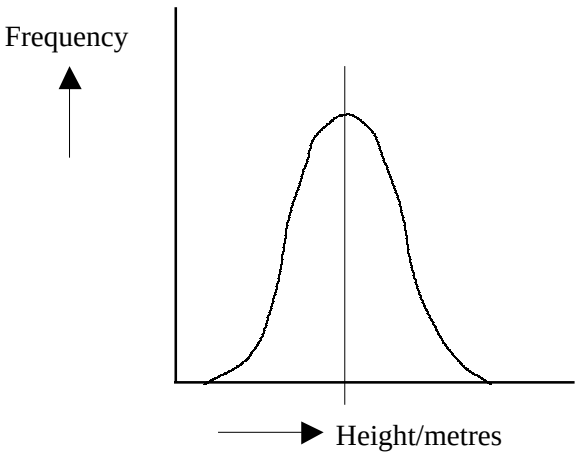
..... [2]

(ii) the life span of paleolithic (old stone age) humans.

.....

..... [3]

(c) Height in humans.



On the graph draw and label, and then explain, the distribution which would be shown by Mendel's pea plants:

.....

..... [3]

TOTAL / 16

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QUESTIONSHEET 10

In Drosophila (fruit flies) grey body is dominant to black body and normal wings are dominant to vestigial wings. A student expected the characteristics to behave in a Mendelian manner, (9:3:3:1 ratio), but obtained the following results when flies heterozygous for both sets of characteristics were interbred:

Phenotypes	No of flies
Grey winged	180
Black vestigial	52
Grey vestigial	14
Black winged	12

Perform a χ^2 test to see whether the observed results deviate from the expected results.
The formula for a χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and E = expected results

(a) (i) State a suitable null hypothesis for the investigation.

.....

..... [1]

(ii) Calculate the expected values, the values of $(O - E)$ and $(O - E)^2$ and write them in the table below:

Phenotype	Observed	Expected	(O – E)	$(O - E)^2$
Grey winged	180			
Black vestigial	52			
Grey vestigial	14			
Black wild	12			

[6]

(iii) Calculate the value of χ^2. Show your working.

χ^2 = ... [2]

(iv) State the number of degrees of freedom.

..... [1]

(v) The critical value of χ^2 with these degrees of freedom is 11.35 at a 1% level of significance. Does this enable you to accept or reject the null hypothesis? Explain your answer.

.....

..... [2]

(b) Suggest an explanation for the results the student observed.

.....

.....

..... [3]

TOTAL / 15

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QUESTIONSHEET 11

A biologist suspected that two species of plant, dandelion (Taraxacum officianale) and ribwort (Plantago lanceolata) tended to grow in association with one another in a meadow. To investigate this, 200 quadrats were randomly placed in the meadow and the presence or absence of the two species was noted. The results are shown in the contingency table below:

		Dandelion		
		present	absent	row total
Ribwort	present	O 88 E	O 52 E	140
	absent	O 36 E	O 24 E	60
	column total	124	76	200 (grand total)

Perform a χ^2 test to assess whether the biologist's suspicions were confirmed by the results.
The formula for a χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results and
E = expected results

(a) Propose a suitable null hypothesis for this investigation.

.....

..... [1]

(b) The expected reults can be calculated by the formula:

$$E = \frac{\text{Row total x Column total}}{\text{Grand total}}$$

(i) Calculate the expected results and write them in the table above. [4]

(ii) Calculate the value of χ^2. Show your working.

Answer: χ^2 = ... [2]

(iii) Calculate the degrees of freedom. (no of rows – 1) x (no of columns – 1)

..... [1]

(iv) With these degrees of freedom, the critical value for χ^2 at a 5% level of significance is 3.84. Does this enable you to accept or reject the null hypothesis? Explain your answer.

.....

..... [2]

TOTAL / 10

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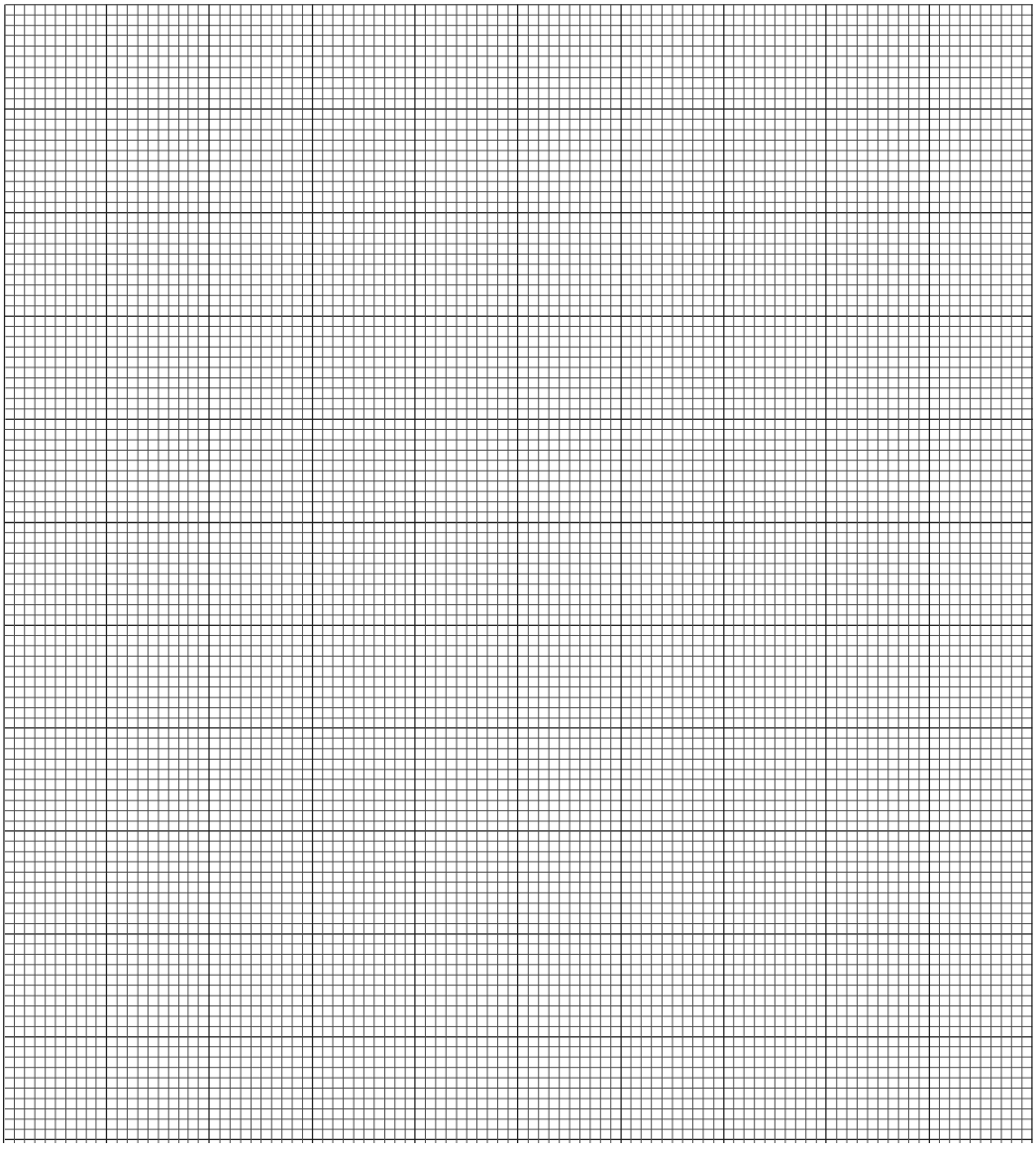
QUESTIONSHEET 12

When planning statistical investigations it is necessary to decide how many samples to collect. To help in making a decision it is a good idea to calculate a 'running mean'. For instance, when measuring plant populations in two areas A and B using 1 m^2 quadrats, the following data might be collected:

Area A		**Area B**	
No of plants/m^2	**Running mean**	**No of plants/m^2**	**Running mean**
110		80	
80	95.0	78	79.0
72	87.3	77	78.3
54	79.0	85	80.0
90	81.2	84	80.8
104	85.0	79	80.5
102	88.3	75	79.7
95	89.1	81	79.9
82	87.7	79	79.8
71	86.0	82	80.0

(a) (i) Plot these results in a suitable graphical form.



[5]

(*Continued...*)

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(ii) Which area would require the larger number of samples? Explain your answer.

.....

.....

..... [3]

(iii) Suggest two other criteria which may be important in deciding how many samples to take.

1. .....

2. ..... [2]

(b) Suggest which statistical test would be suitable for use with each of the following investigations. In each case state a reason to support your answer.

(i) An analysis of inheritance patterns in fruitflies.

Test: .....

Reason: .....

..... [2]

(ii) The percentage cover of mosses on a damp and a dry rockface.

Test: .....

Reason: .....

..... [2]

(iii) The effect of increased shading on the distribution of bluebells in an oakwood.

Test: .....

Reason: .....

..... [2]

TOTAL / 16