Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

A400U20-1

S18-A400U20-1

BIOLOGY – A level component 2
Continuity of Life

MONDAY, 11 JUNE 2018 – AFTERNOON

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**23**	
2.	**15**	
3.	**17**	
4.	**19**	
5.	**17**	
6.	**9**	
Total	**100**	

A400U201
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

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Answer **all** *questions.*

1. Lysosomal storage disorders are a group of about 50 diseases that are characterised by an accumulation of waste products in the lysosomes. Two examples are Fabry disease and Tay-Sachs disease. Sufferers of Tay-Sachs disease die in childhood.

(a) The electron micrograph above shows the cell organelle responsible for producing lysosomes. Name the organelle, **draw an arrow labelled L** on the micrograph to identify a lysosome and describe a general function of lysosomes in normal cells. [3]

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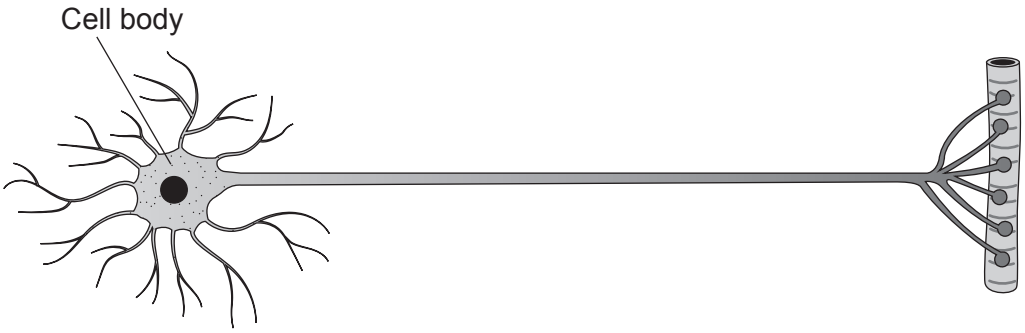
(b) The symptoms of Tay-Sachs disease are a consequence of abnormal accumulation of fatty substances in neurones.

(i) **Complete the diagram** of a neurone below to show how this fatty substance is usually distributed, your labels should include the name of the fatty substance. [2]



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(ii) Explain how the arrangement of the fatty substance affects the transmission of nerve impulses. [3]

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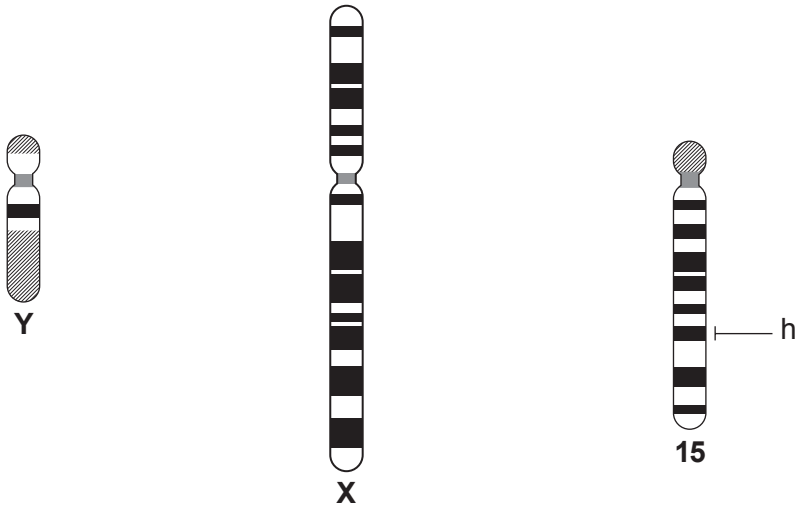
(c) The diagrams below show gene maps of human sex chromosomes and chromosome **15**. The recessive allele **(f)** that causes Fabry disease is carried on the **X** chromosome. The recessive allele **(h)** that causes Tay-Sachs is carried on chromosome **15**, in the locus labelled h.



(i) **Mark, by placing the letter f on the diagram,** a possible locus for the gene that causes Fabry disease. [1]

(ii) With reference to the positions of the gene loci explain the following observations: [2]

I. Males with the **f** allele always suffer Fabry disease but females can have the **f** allele without suffering the disease.

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II. Males and females can have the **h** allele without suffering Tay-Sachs disease.

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(d) Complete the genetic diagram below to show how Fabry disease might be inherited from parents neither of whom suffers from the condition and state the probability of this couple producing a child with Fabry disease. [4]

	male		female
Parental phenotype:	.....		.....
Parental genotypes:	.....	x	.....
Gametes:	.....	x	.....

Probability of this couple producing a child with Fabry disease = ...

(e) A genetic counsellor advised a woman with Fabry disease in her family to have an amniotic fluid test, ten weeks into her pregnancy, in order to determine the sex of the embryo.

(i) Explain the function of amniotic fluid. [1]

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(ii) Why might it be important for the woman with Fabry disease in her family to know the sex of the embryo and what ethical issues might this cause? [2]

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The Hardy-Weinberg Principle states that the frequency of alleles for a given gene remains constant from generation to generation, providing the population is large and no selection takes place.

The frequency of Tay-Sachs disease is 1 in 360 000 births in the general population of the USA. However, the frequency is 1 in 40 000 in certain populations, which isolate themselves culturally. One such population is the Old Order Amish of the Kishacoquillas Valley, Pennsylvania, USA. Recent estimates put the size of this population at 40 000.

(f) (i) Use the Hardy Weinberg equations, given below, to calculate the number of people in the Amish community in the Kishacoquillas Valley that carry the Tay-Sachs allele without suffering the disease. [3]

$p + q = 1.0$ $\qquad$ $p^2 + 2pq + q^2 = 1.0$

Number of people who are carriers of Tay-Sachs allele = ...

(ii) Explain why the frequency of Tay-Sachs is higher in isolated populations and predict, with a reason, what is likely to happen to the frequency of the Tay-Sachs allele in the general population. [2]

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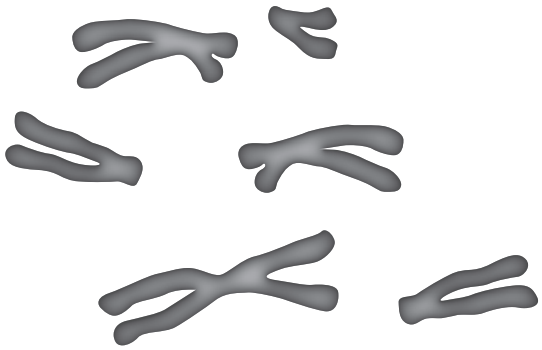
2. The photograph shows all the chromosomes from a blood cell of a mammal.



(a) (i) Explain why red blood cells could not have been used to produce the photograph of the chromosomes. [1]

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(ii) Use the photograph to deduce the sex of the mammal and explain your choice. [1]

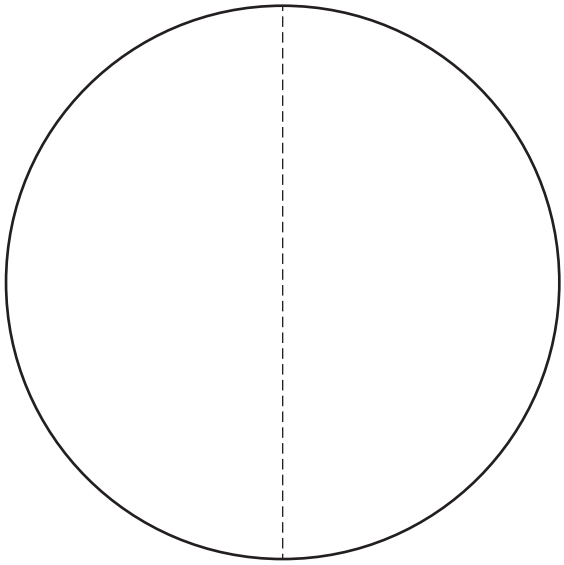
.....

(iii) In this mammal, how many chromosomes would be present in [1]

I. a kidney cell; .....

II. gametes? .....

(iv) The circle below represents the outline of the mammal cell at metaphase I of meiosis, and the dotted line the equator of the cell.
Complete the drawing to show the spindle and how **the sex chromosomes** as shown above would be arranged. [2]



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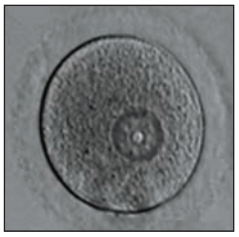
(b) Starfish, *Asterias rubens*, reproduce sexually by spawning. When starfish spawn, the males release spermatozoa and the females release oocytes in large numbers.

The oocytes are suspended at early prophase of the first meiotic division.



The nuclei of early oocytes are called germinal vesicles.

Breakdown of the germinal vesicle indicates resumption of meiosis (re-initiation).

Re-initiation is naturally stimulated by contact with spermatozoa. Scientists have shown that it is possible to stimulate re-initiation by exposing the oocytes to suitable concentrations of calcium ions (Ca^{2+}).

Sea water has a typical calcium concentration of 400 mg dm^{-3}.

Suggest a suitable hypothesis for this investigation and design an experiment to investigate how calcium ion concentration affects meiosis in starfish. Make sure you suggest suitable values for the independent variable as well as identifying the dependent variable and **two** controlled variables. [6]

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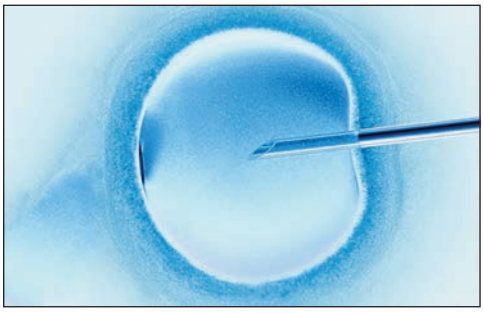
(c) Some human fertility problems are due to poor morphology (abnormal shape) or poor motility (not moving normally) of spermatozoa. These causes of infertility can be treated by a special type of In Vitro Fertilisation (IVF) called Intra-Cytoplasmic Sperm Injection (ICSI). It differs from conventional IVF in that a single spermatozoon is injected directly into a secondary oocyte, instead of fertilisation taking place in a dish where many spermatozoa are placed near a secondary oocyte.



Intra-Cytoplasmic Sperm Injection

However, fertilisation does not always proceed to completion. A solution of a 'calcium ionophore' may be used to stimulate gated calcium ion channels in the oocyte plasma membrane. Ionophores are molecules that facilitate ion passage in or out of cell membranes.

(i) Use your knowledge of the structure of the plasma membrane to state what is meant by the term *'gated calcium ion channel'*. [2]

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(ii) In humans, before fertilisation the oocytes are suspended in metaphase II. Explain how the ionophore molecules might improve the success rate of ICSI. [2]

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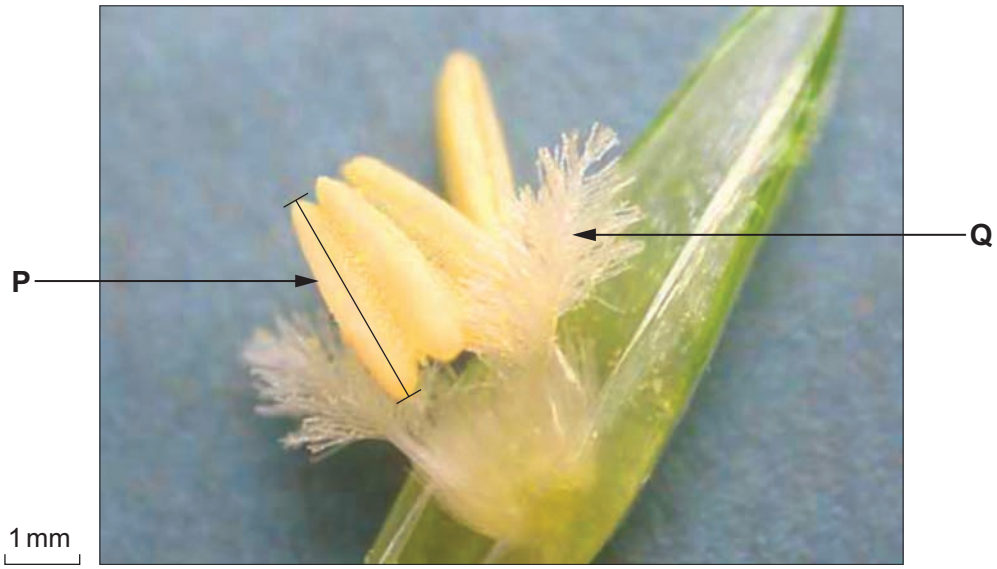
3. *(a)* The photograph below shows a flower of the wheat plant, *Triticum aestivum*.



(i) Name the parts labelled **P** and **Q**. [1]

P .....

Q .....

(ii) Calculate the actual length of structure **P**. [2]

Size = ... mm

(iii) Describe **two** features of the flower shown in the photograph which suggest it is wind pollinated. [1]

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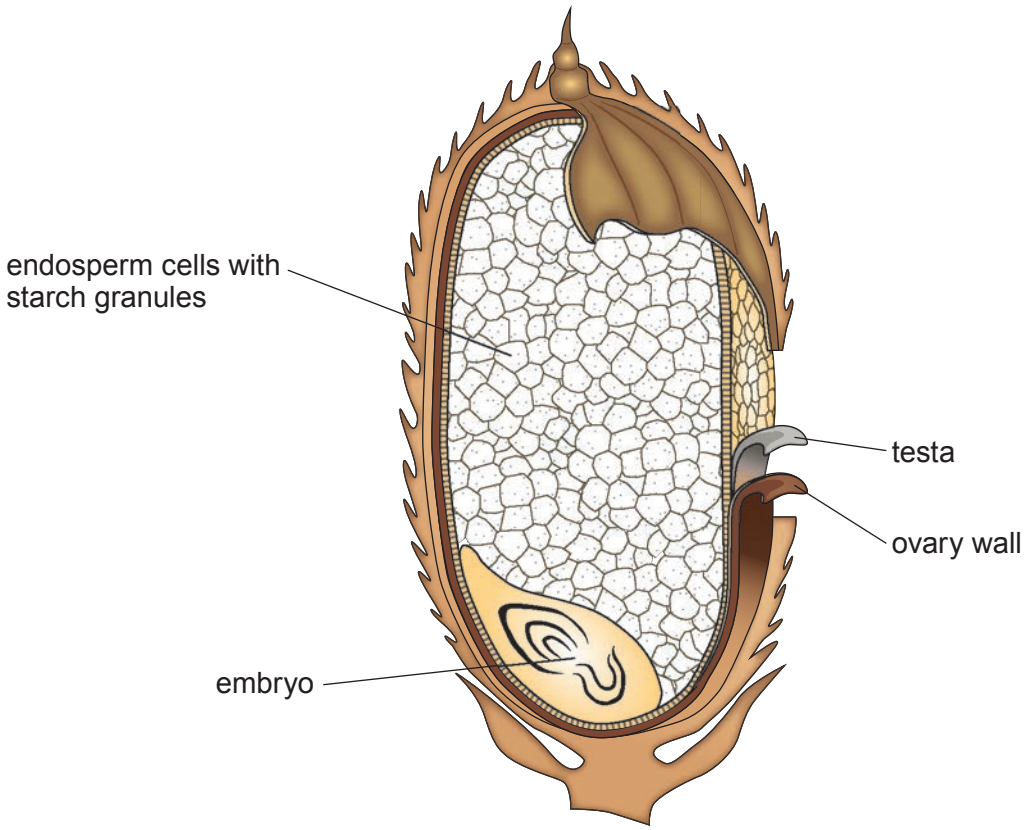
(b) The diagram below shows a wheat grain.



(i) Use information shown in the diagram to explain why the grain is more correctly described as a fruit rather than a seed. [2]

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(ii) Explain why the events taking place in the embryo sac of a wheat flower are described as a double fertilisation. [2]

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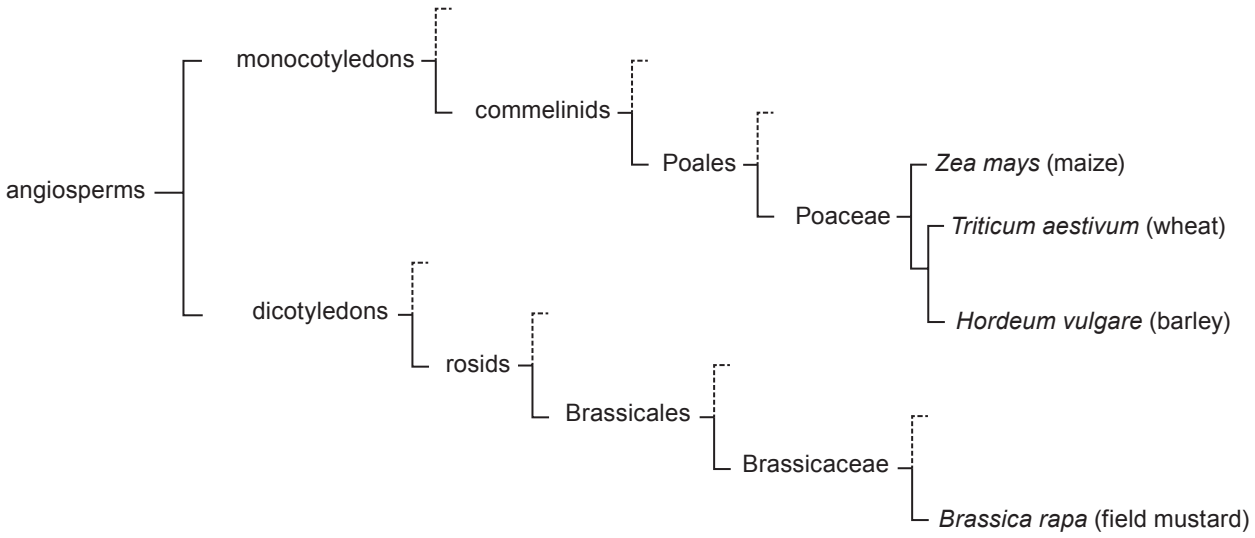
(c) The photograph below shows a flower of the field mustard plant, *Brassica rapa*.

Diagram **1** below shows the classification of wheat and field mustard and their evolutionary relationship.

Diagram 1



Each branch on the diagram represents a clade, i.e. an ancestor together with all its descendants.

(i) **Mark with an X**, the position on the diagram where wheat and field mustard share a common ancestor. [1]

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(ii) In modern plant classification systems hierarchical groups like Divisions and Classes have been replaced with unranked clades, but orders and families have been retained and have names ending in **~ ales** and **~ aceae** respectively.

Use the diagram opposite to complete the classification of field mustard and wheat. [2]

Kingdom:	Plantae	Plantae
(unranked):	angiosperms	angiosperms
(unranked):	.....	monocotyledons
(unranked):	Rosids	.....
Order:	.....	Poales
Family:	Brassicaceae	.....
Genus:	*Brassica*	*Triticum*
Species:	***B. rapa***	***T. aestivum***

(iii) Using the information given and your own knowledge, describe how the seed of field mustard differs from the wheat grain in terms of where it stores nutrients. [2]

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(d) The amino acid sequence of the protein cytochrome C has been used to investigate the evolutionary relationship between organisms. The table below shows the amino acid sequences of parts of the protein from three sources, wheat, barley and maize. The amino acids are represented by using a single letter code, e.g. G = glycine.

SOURCE	Position of amino acid in polypeptide chain																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-60	61	62	63	64	65	66	67	68	69	70	71	72-112
1	M	D	S	F	A	E	A	P	A	G	N	P	T	T		V	I	W	E	E	N	T	L	Y	D	Y	
2	M	A	P	F	D	E	A	P	P	G	K	S	K	A		V	E	W	E	E	K	T	L	T	D	Y	
3	M	A	S	F	D	E	A	P	P	G	K	P	K	A		V	E	W	E	E	K	T	L	Y	E	Y	

(i) Explain why determining the amino acid sequence of proteins from different organisms can be used to show evolutionary relationships. [1]

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(ii) Count the differences between the amino acid sequences from sources **2** and **3**. Enter your answer in the table below. [1]

Between sources	No. of differences
1 and 2	11
2 and 3	.....
1 and 3	9

(iii) Use the table above and diagram **1** on page **12** to conclude which source came from which species. [2]

Species	Source
Maize (*Zea mays)*	.....
Wheat *(Triticum aestivum)*	.....
Barley *(Hordeum vulgare)*	.....

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4. Wheat grain size is determined by the plants' genetics (i.e. variety), and the length of the grain filling period (time between fertilisation and harvesting). Plant breeders cross varieties of wheat in order to increase grain size. The photograph below shows the results of one such cross.

Parental variety A

Extreme phenotypes from the hybrids

Parental variety B

(a) Distinguish between **continuous** and **discontinuous** variation. You should give an example, which is visible in the photograph, for each one. [3]

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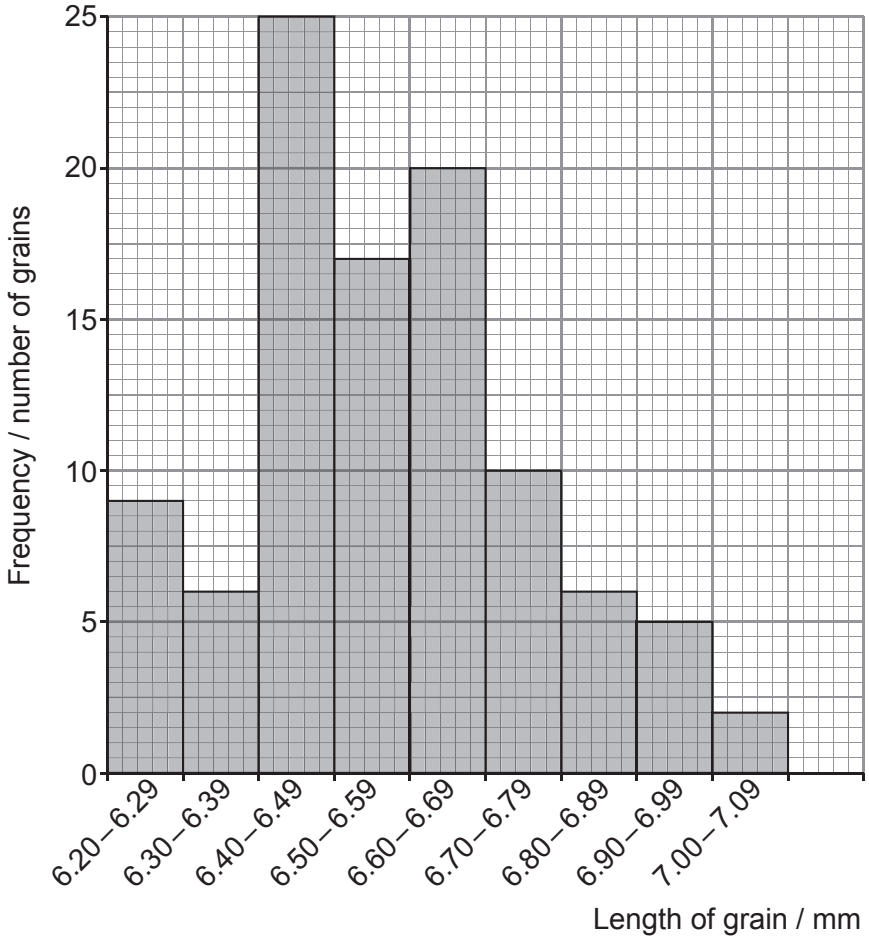
The graph below shows the distribution of grain length in a sample of the hybrid wheat variety. The grains were measured to the nearest 0.01 mm.



(b) (i) What is the total number of grains in the sample? [1]

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(ii) The student calculated three different averages for the length of hybrid grains. The mean was 6.57 mm. The other two values were 6.45 mm and 6.52 mm. With reference to the graph, state which of these values is more likely to be the mode and give a reason for your choice. [2]

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(iii) What evidence is there from the graph that the length of hybrid grains is not normally distributed? [1]

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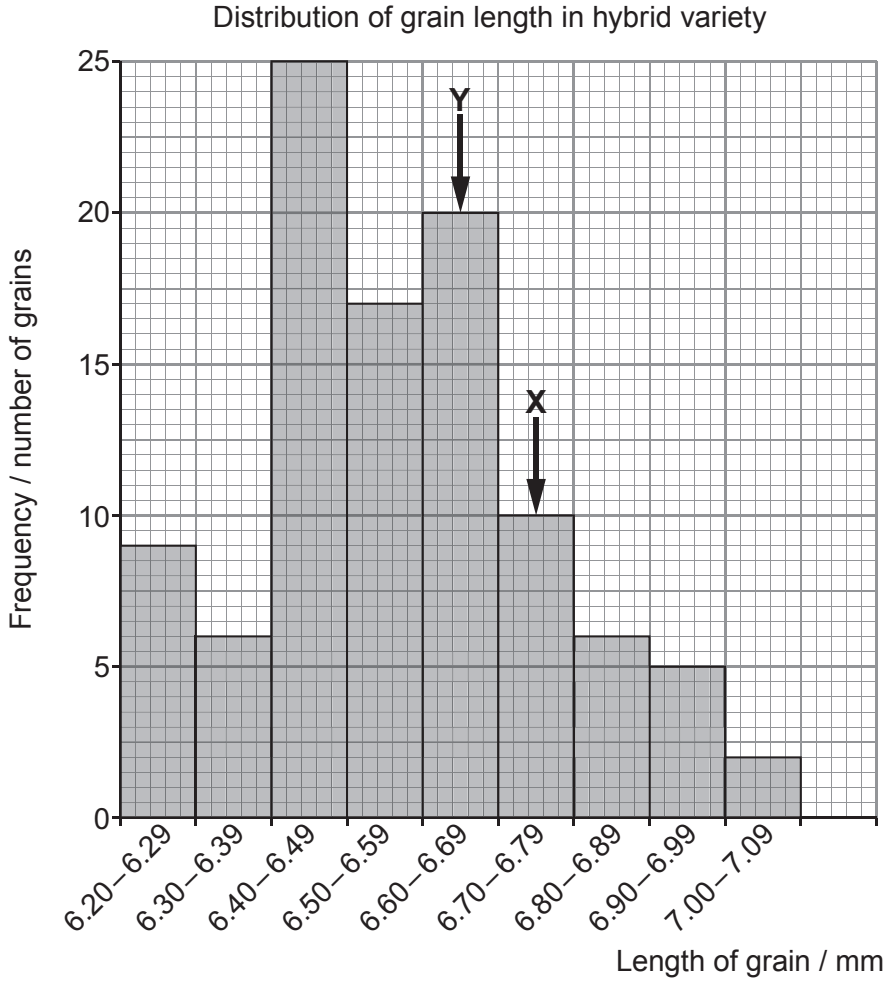
For each parental variety the mode and median were the same. Arrow **X** shows the mode and median for parental variety A and Arrow **Y** shows the mode and median for parental variety B.



(iv) Consider the following statement:

'There is no significant difference in the length of the hybrid grains and the length of the grains of parental type B.'

Describe any evidence from the graph above to support the statement and name the terms used to describe; the type of hypothesis represented by the statement and the statistical test that could be used to test the hypothesis. [3]

Evidence .....

.....

Type of hypothesis .....

Statistical test .....

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As soon as fertilisation has occurred, the embryo and endosperm begin to develop with the plant redirecting products of photosynthesis to the developing grains. The longer the period of grain fill the larger wheat grain size. Grain size can be influenced by the availability of water and nutrients, and disease management.

(c) With reference to the information provided above, explain the following:

(i) there is a saying amongst farmers, "When you think the crop is ready to harvest, take a holiday"; [1]

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(ii) the use of nitrate fertiliser to increase grain size; [3]

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(iii) the use of fungicide to increase grain size. [2]

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(d) In the USA wheat prices are quoted per bushel, (a unit of volume). In Europe wheat prices are quoted per kg. Rex Ryder is a Kansas farmer who harvests his wheat into a truck that holds 998 bushels. During the harvest in 2015 he filled the truck 22 times. His farm covers 492 acres.

Estimate how many bushels of wheat he produced per acre to the nearest bushel and suggest **one** advantage and **one** disadvantage of using prices per kg rather than per bushel. [3]

Estimate

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Advantage

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Disadvantage

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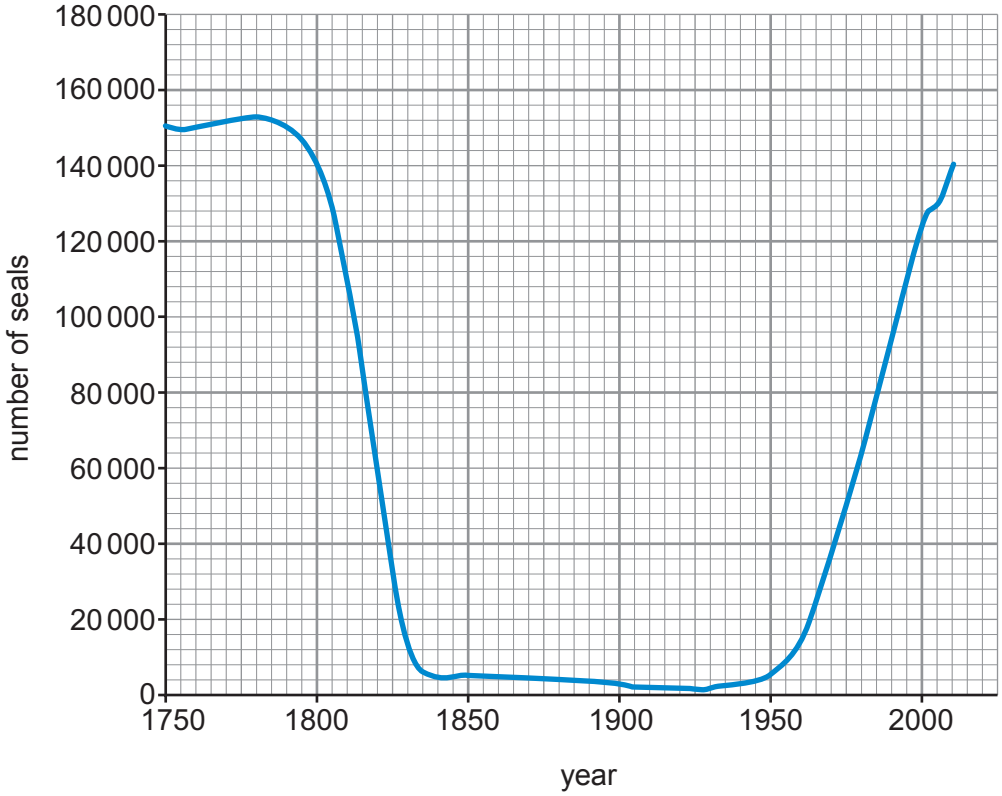
5. The northern elephant seal, *Mirounga angustirostris*, is named because the male has a large nose that resembles an elephant's trunk. They feed on squid, octopus and fish. They have a thick layer of blubber which was used by humans in the nineteenth century to produce lamp oil.

The population curve below shows estimates of the population of northern elephant seals from 1750 to 2010.



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(a) Factors affecting population size are described as density dependent or density independent. Use the graph to identify when density dependent and density independent factors would have been acting, between the years 1750 and 1830, and suggest what these factors may have been. [4]

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(b) An event in which the size of an existing population is drastically reduced is called a **population bottleneck**.

By 1910, Northern Elephant Seals were only found on Guadalupe Island off Baja California, Mexico. The species was protected under U.S. and Mexican law early in the twentieth century.

Explain how the graph illustrates an example of a *'population bottleneck'* and describe evidence from the graph which suggests that conservation measures were successful. [2]

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(c) Today, all Northern Elephant Seals are descended from the 50 or so Guadalupe seals.

In order to assess the impact of the population bottleneck on the genetic diversity of northern elephant seals a group of scientists compared nucleotide sequences of DNA. Samples were taken from 185 present day northern elephant seals and compared with 22 museum samples of northern elephant seals collected in the nineteenth century.

Five different base sequences have been identified at the same point in the same gene locus. The results table below shows the number of specimens showing each of these alternative base sequences.

Base sequence at a particular point in the gene locus.	Number of specimens showing this sequence	
	present day	nineteenth century
GTA	50	8
GAA	0	8
GAG	0	4
AAG	135	1
AAA	0	1

[A. Rus Hoelzel *et al*; J. Evol. Biol. **15** (2002) 567-575)]

(i) Name a technique that the scientists could have used to amplify the DNA available from the museum specimens. [1]

.....

(ii) Give **one** limitation of the experiment that produced the results in the table. [1]

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(iii) With reference to the data, draw a conclusion about the impact of population bottlenecks on genetic diversity of northern elephant seals. [2]

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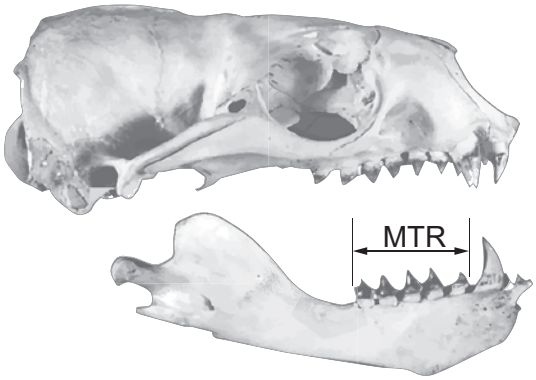
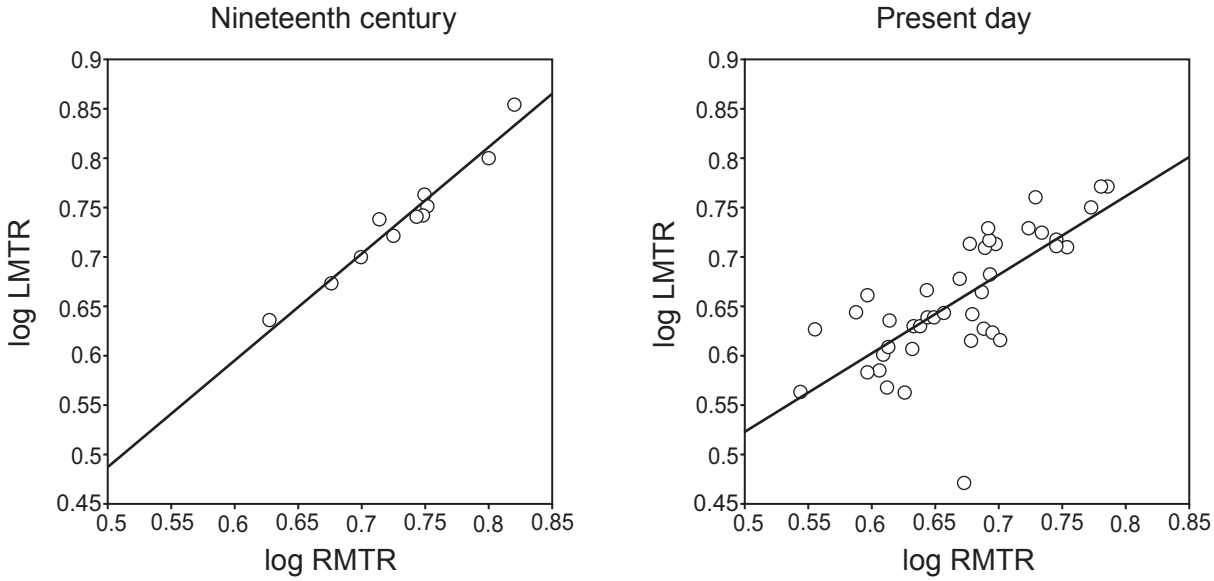
In order to investigate the impact of the population events on development in the northern elephant seals, the same group of scientists also compared the skulls of present day seals with the museum specimens. They measured the length of the Mandibular Tooth Row (MTR) shown in the diagram below. By comparing the lengths from the right and left sides of each skull they were able to assess their symmetry.



The graphs below show the results of plotting logs of values for the Left Mandibular Tooth Row (LMTR) against logs of values for the Right Mandibular Tooth Row (RMTR).



(d) Use the graphs above to draw a conclusion about the impact of population bottleneck of the nineteenth century on the symmetry of skulls in northern elephants seals. [2]

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The scientists also measured the skulls of present day southern elephant seals, *Mirounga leonina*, which did not suffer as badly from the population bottleneck of the nineteenth century.

(e) (i) Using the information, what is the evidence that the northern elephant seal is closely related to the southern elephant seal? [1]

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(ii) How does measuring southern elephant seals improve the validity of the conclusion? [1]

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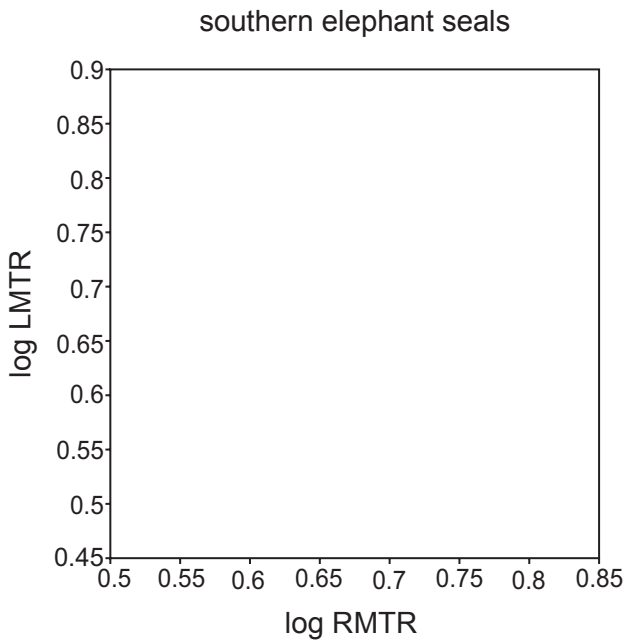
(iii) **Draw a line on the grid below** to represent the expected relationship between the LMTR and RMTR for the southern elephant seals. [1]



(f) How might the effects of the population bottleneck of the nineteenth century on the DNA described in part *(c)* and the development described in part *(d)* affect the survival of northern elephant seals in the future? [2]

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6. In April 2003 one of the most significant scientific breakthroughs of modern times was announced. After years of painstaking research carried out by thousands of dedicated scientists across the world, the complete genetic code of a human being – their genome – could now be made freely available on-line.

The Human Genome Project, as this work was known, was the largest international collaboration ever undertaken in biology with British scientists leading the global race to read the human genome using a technique called sequencing.

To bring the predicted benefits of genomics to NHS patients the 100 000 Genomes Project was launched in late 2012 and by 2017 had sequenced the genomes of 100 000 NHS patients. The project focussed on patients with a rare disease and their families, and on patients with cancer.

Scenario:

> It is 2025 and Sharon has a painful skin infection that she just can't get rid of. Her doctor would like to prescribe an antibiotic called phenyloxacillin, since it is especially effective against the bacteria *(Staphylococcus aureus)* that are causing the infection. However, her doctor knows that in a small number of cases phenyloxacillin can cause serious liver damage so suggests a genome test. She tells Sharon that there is a law giving people the right not to disclose the results of genetic tests to insurers.

Explain what is meant by 'sequencing' the human genome and describe the type of data that might be made available on-line.
Explain how the extra information provided by the '100 000 Genomes Project' might be used in medicine, and describe how the scenario above illustrates one possible beneficial application and an ethical dilemma of genome sequencing. [9 QER]

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