Candidate Name	Centre Number					Candidate Number				

A LEVEL BIOLOGY

COMPONENT 2

Continuity of Life

SPECIMEN PAPER

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**12**	
3.	**12**	
4.	**18**	
5.	**13**	
6.	**12**	
7.	**14**	
8.	**9**	
Total	**100**	

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.

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 8.

*Answer **all** questions.*

1. Species richness is one measure of biodiversity providing information on the number of species found in a particular area.

Simpson's Diversity Index is a different measure of biodiversity. It is calculated as shown below:

Simpson's Diversity Index = $1-D$

where D = $\frac{\Sigma n(n-1)}{N(N-1)}$

N = the total number of organisms of all species
n = the total number of organisms of a particular species

(a) (i) Which measure provides better information regarding biodiversity? Explain your answer. [1]

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(ii) There are 288 known species of mammal on the island of Borneo. Explain how you could obtain the data required to calculate a Simpson's Diversity Index for the biodiversity of mammals on this island. [2]

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(iii) Suggest one problem associated with this method. Explain how it could affect the validity of any conclusions based on the calculated diversity index. [2]

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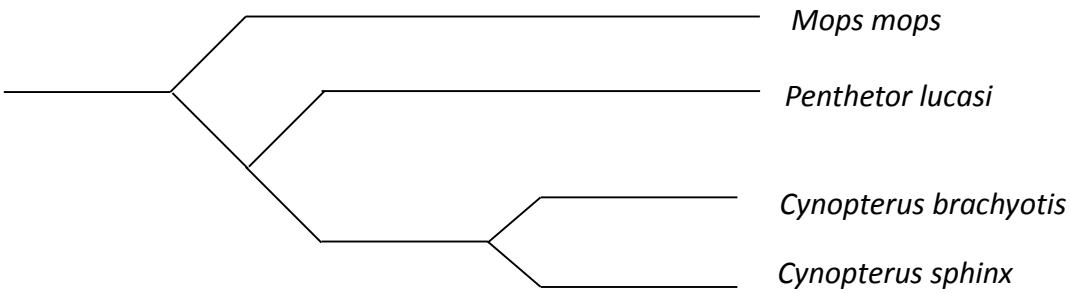
(b) Of the 288 species of mammals in Borneo, 102 are bats. The following diagram is a phylogenic tree showing the evolutionary relationship between some of the bats.



Amino acid sequences of cytochrome oxidase from blood samples from each species were prepared. The sequences for the other three bats were compared with the sequence for *Cynopterus brachyotis.* The number of positions at which there was a different amino acid is recorded in the table below.

Bat	**A**	**B**	**C**
Number of amino acids different to *Cynopterus brachyotis*	**19**	**7**	**13**

(i) Mark clearly on the phylogenic tree, with the letter **X**, the position of an ancestor common to *Penthetor lucas*i and *Cynopterus sphinx* but not common to *Mops mops*. [1]

(ii) Use the information in the table and the phylogenic tree to identify the bats. [1]

A .....

B .....

C .....

(c) *Mops mops* is a fruit-eating bat while *Cynopterus sphinx* feeds on insects. The table below shows the approximate nutritional composition of the food of these species.

	% composition	
	fruit	**insects**
carbohydrate	**23.4**	**2.5**
fat	**0.7**	**16.0**
protein	**2.2**	**18.0**

With reference to respiratory pathways, explain why *Cynopterus sphinx* eats a lower mass of food than *Mops mops* but is able to synthesise more ATP. [3]

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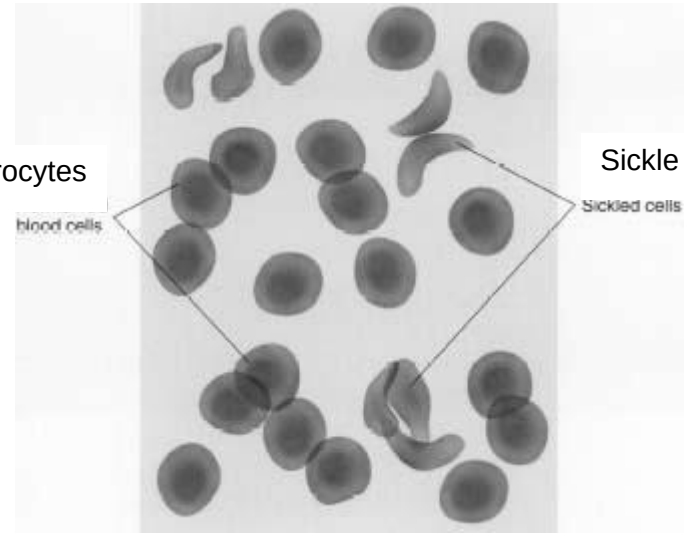
2. Sickle cell anaemia is an inherited disease. People who have the disease inherit two genes for sickle haemoglobin—one from each parent.

Sickle haemoglobin causes red blood cells to develop a sickle shape. These block blood flow in the blood vessels causing pain and organ damage. It leads to much reduced life expectancy. The photograph below shows the shape of normal and sickle cells.



People who inherit a sickle haemoglobin allele from one parent and a normal allele from the other parent have **sickle cell trait**. They usually have few symptoms and lead normal lives.

Plasmodium falciparum is one of the organisms that cause malaria in humans. When it infects erythrocytes it uses oxygen and causes the haemoglobin of people with sickle-cell trait to change its tertiary structure and the erythrocytes to take on the classic sickle cell shape.

(a) A survey was conducted into the relationship between sickle-cell trait and the incidence of malaria. Patients were tested for the presence of the malarial parasite *P.falciparum* and if they were positive for sickle-cell trait. The results of the survey of 150 people are shown below.

percentage of people in the sample			
sickle-cell trait		**normal haemoglobin**	
infected with *P.falciparum*	**not infected with *P.falciparum***	**infected with *P.falciparum***	**not infected with *P.falciparum***
4.7	**12.4**	**58.2**	**24.6**

(i) What conclusion can be drawn from these results? [1]

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(ii) Suggest how the survey could be modified to improve the validity of your conclusion. [2]

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(b) In the United States, the sickle cell disease occurs in 1 out of every 625 African-Americans.

The Hardy-Weinberg formula states that if alleles **A** and **a** are present in a population with the frequencies of *p* and *q*, the proportion of individuals homozygous for the dominant allele (**AA**) will be p^2, the proportion of heterozygotes (**Aa**) will be $2pq$, and the proportion or homozygous recessives (**aa**) will be q^2, where $p + q = 1$.

Use the Hardy Weinberg formula to estimate the number of African Americans from a population of 1000 people that would have **sickle cell trait**. [4]

Estimation of African Americans with sickle cell trait = ...

(c) The Hardy-Weinberg Principle states that allele frequencies remain the same from generation to generation in the absence of natural selection.

In the nineteenth century, many sub-Saharan Africans were taken as slaves to America. In 2007 fewer than 2000 cases of malaria were reported in the USA while over 150 million were affected in sub-Saharan Africa in the same year.

Predict how the proportion of people with sickle cell trait could have changed in the USA and sub-Saharan Africa since the nineteenth century. Explain the basis for your prediction. [5]

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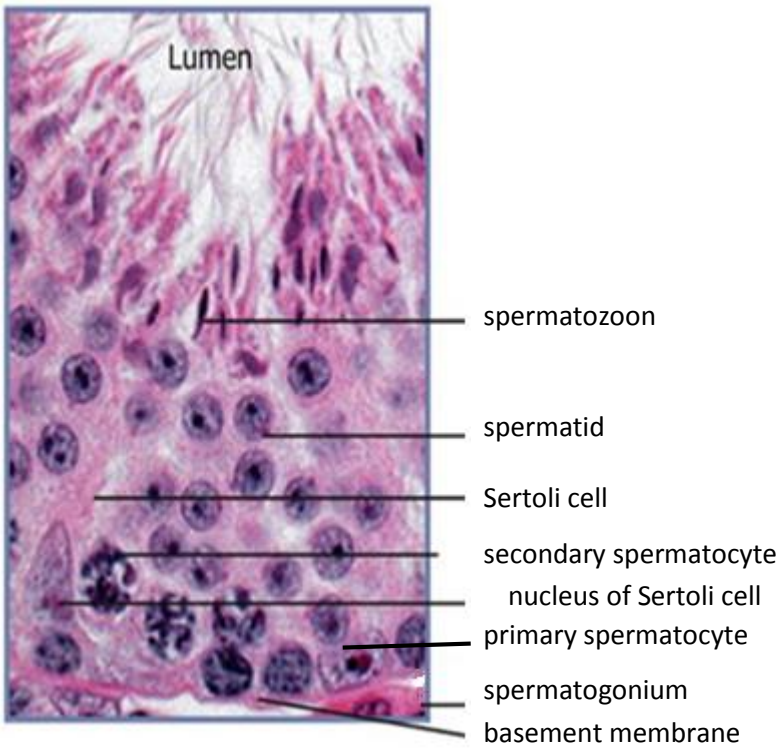
3. Spermatogenesis takes place in the seminiferous tubules of male mammals. The image below shows a transverse section of mouse seminiferous tubule.



(a) (i) Identify cells in the section that match the descriptions listed in the table below. The cells can match more than one description or none. [4]

Description	Name of cell(s)
undergoing meiosis	
will produce more cells by mitosis	
provides protection from the male immune system	
will undergo differentiation to produce a fully functional cell	

(ii) Explain why there will be more spermatids than spermatogonia. [1]

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(iii) The Sertoli cell contains a prominent nucleolus and large numbers of ribosomes. It is known that these cells are involved in providing nourishment to developing sperm cells.
Suggest what nutrients the Sertoli cells provide to the developing cells? Give reasons for your answer. [2]

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(iv) Another function of Sertoli cells is to remove debris from the lumen of the seminiferous tubule. Name the process by which Sertoli cells carry out this function. [1]

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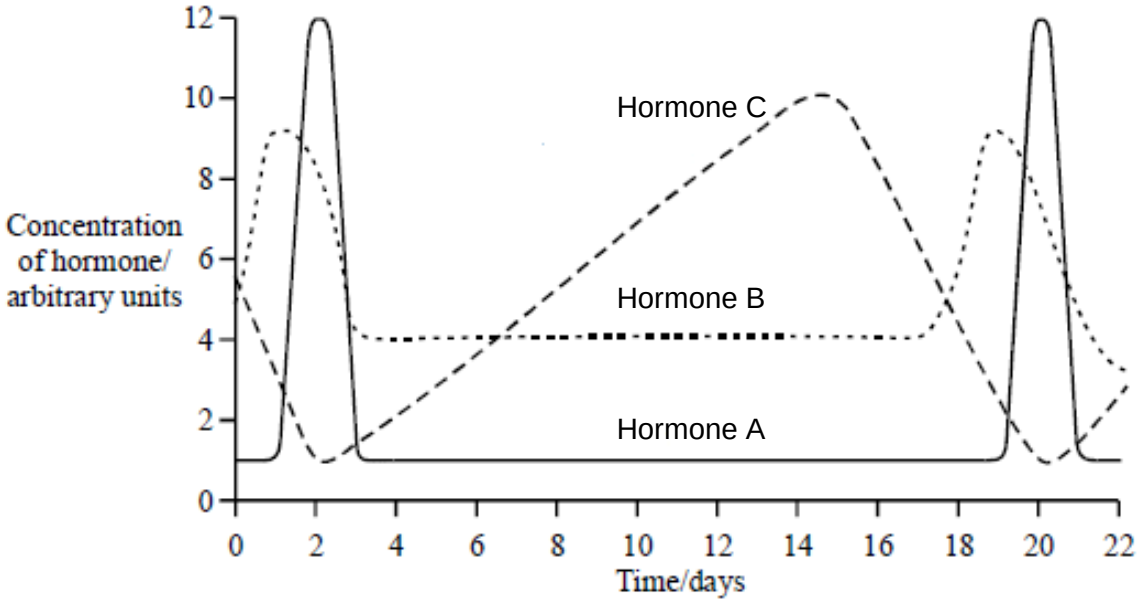
(b) The menstrual cycle in cows is controlled by the same hormones as women. The diagram below shows the changes in the levels of some hormones of a cow over a 22 day period.



(i) Identify hormones **A**, **B** and **C** shown in the graph above. [3]

A .....

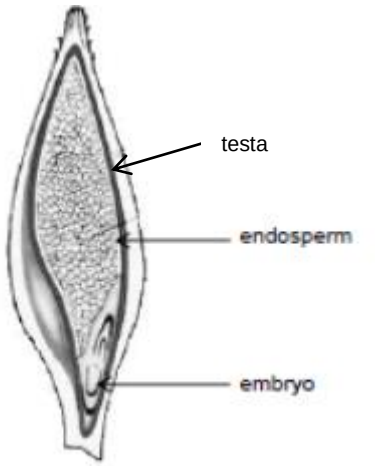
B .....

C .....

(ii) Estimate the length of the menstrual cycle shown. [1]

..... days

4. Barley (*Hordeum vulgare),* is an important cereal grown in the UK. It is used widely for animal fodder and as a source of maltose when brewing beer. The diagram below is a cross-section through a grain of barley, *Hordeum vulgare*.



(a) Explain why a barley grain is technically a fruit and not a seed. [2]

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(b) The endosperm cells contain 21 chromosomes. Calculate how many chromosomes there are in the cells of the embryo. Explain how you arrived at your answer. [4]

Number of chromosomes in embryo cells = ……

Explanation: .....

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(c) The table below shows the results obtained from a study of the germination and early growth of barley grains.

Time after sowing (days)	Dry mass of endosperm (mg)	Dry mass of embryo (mg)
0	42	2
2	41	2
4	32	8
6	20	16
8	9	24
10	6	34

What can be concluded from these results? [2]

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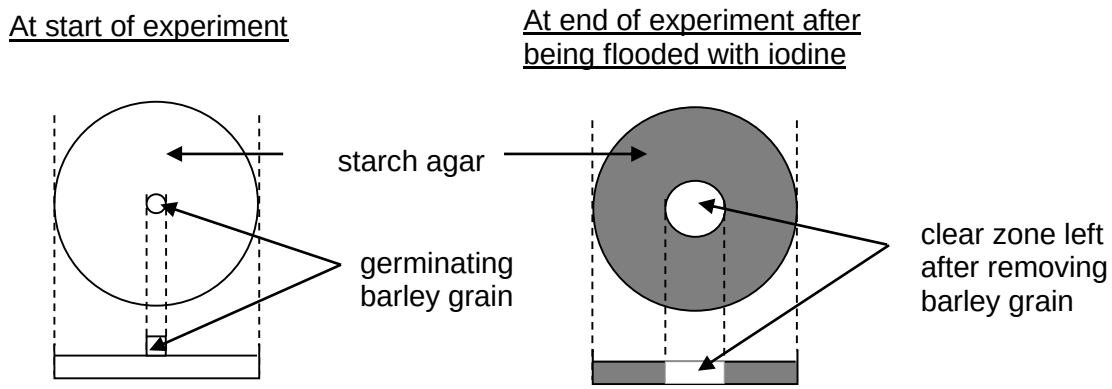
(d) The diagram below shows a view from above and from the side of an experiment demonstrating the presence of amylase in a germinating barley grain.



(i) The agar contained 1g starch per 100cm^3 of agar. The agar in each plate was 5mm deep and the clear zone left after removing the barley grain was 25mm in diameter. The volume of agar in the clear zone can be calculated as follows:

Volume = $\pi r^2 h$ (π = 3.142)

Calculate the mass of starch digested by the germinating barley grain. Show your working and give your answer in standard form. [3]

Mass of starch digested = ... g

(ii) During germination the amylase is synthesised from amino acids from protein stored in the barley grain. Name the tissue where the protein is stored and name the hormone responsible for mobilising the amino acids. [2]

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(iii) It is important that brewers know how the age of their barley affects the concentration of amylase produced so that they can obtain the best yield of malt.
Using the apparatus shown, design a method to investigate the effect of age of seed on the concentration of amylase produced. [5]

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5. Bacteria and Archaea produce restriction enzymes that cleave DNA that is foreign to their own DNA. These enzymes recognize and cut DNA molecules at or near specific sequences of nucleotides called restriction sites. One theory is that these enzymes have evolved as a defence mechanism against viruses called bacteriophages that can infect bacteria.
More than 3000 different restriction enzymes have been discovered to date and over 600 are available commercially for use in genetic engineering.

(a) Explain why these enzymes could be effective as defence mechanisms against these viruses. [1]

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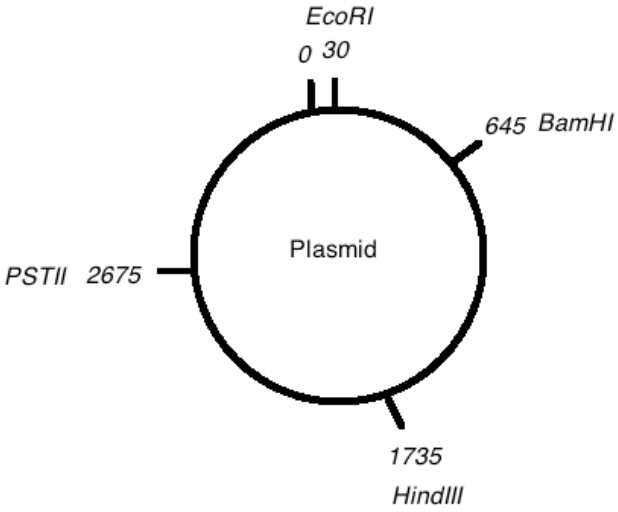
(b) The diagram below is of a bacterial plasmid 3 450 base pairs in length with the restriction sites of four different enzymes, EcoRI, BamHI, HindIII and PSTII shown.



Total length = 3450 base pairs (bp)
NOT drawn to scale

(i) If the plasmid was cut using EcoRI and PSTII **only**, what would be the size of the smallest fragment? Show your working. [2]

Answer ……..

(ii) A gene was present between 550 and 1 699 base pairs. Which two enzymes would be needed to cut out the gene leaving the smallest number of additional bases? [1]

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(c) "D7S280" is a short tandem repeat (STR) sequence of "GATA" found on human chromosome 7. This STR was sequenced and found to lie between 126 and 177 base pairs within the 341 base pair sequence shown below (**GATA shown in bold**).

Starting base number						
1	AATTTTTGTA	TTTTTTTTAG	AGACGGGGTT	TCACCATGTT	GGTCAGGCTG	ACTATGGAGT
61	TATTTTAAGG	TTAATATATA	TAAAGGGTAT	GATAGAACAC	TTGTCATAGT	TTAGAACGAA
121	CTAAC**GATAG**	**ATAGATAGAT**	**AGATAGATAG**	**ATAGATAGAT**	**AGATAGATAG**	**ATAGATA**GAT
181	TGATAGTTTT	TTTTTATCTC	ACTAAATAGT	CTATAGTAAA	CATTTAATTA	CCAATATTTG
241	GTGCAATTCT	GTCAATGAGG	ATAAATGTGG	AATCGTTATA	ATTCTTAAGA	ATATATATTC
301	CCTCTGAGTT	TTTGATACCT	CAGATTTTAA	GGCC		

The STR was then extracted and amplified using PCR.

(i) Explain why each stage of the PCR is conducted at the following temperatures: [3]

I 95°C .....

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II 50 – 60°C .....

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III 70°C .....

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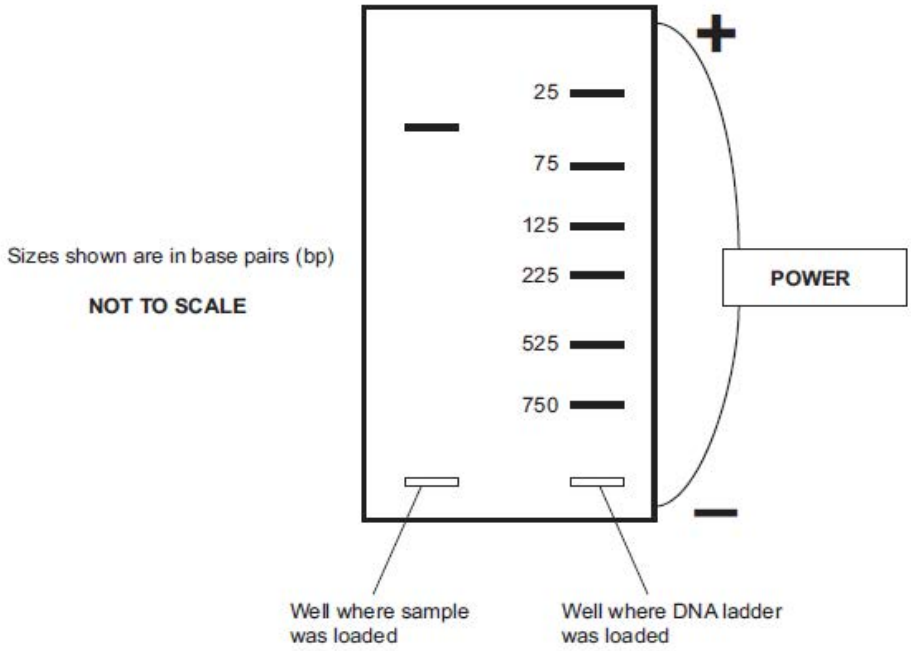
(ii) The amplified STR was run on an agarose gel using gel electrophoresis. The result is shown below.



Describe and explain how electrophoresis produced the results seen in the gel result. [3]

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(iii) Evaluate how well the results of the electrophoresis match the sequencing results. [2]

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(iv) How could the gel result be made more accurate? [1]

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6. In peas, the allele for wrinkled seeds (R) is dominant to that for smooth (r) and the allele for yellow seed colour (Y) is dominant to green (y).

A plant breeder has developed a new variety of wrinkled, yellow peas but thinks that his new variety is a hybrid. In order to confirm this, he crossed his new variety with a plant that produced smooth, green peas.

When the F_1 generation grew, he recorded the phenotype of the seeds they produced. His results are shown below.

Number of plants	Phenotype of seeds produced
31	yellow, wrinkled coat
22	green, wrinkled coat
29	yellow, smooth coat
26	green, smooth coat

(a) Complete the genetic diagram below to show how F_1 inherited the phenotypes shown in the table. [5]

Parental genotype ..... x .....

Gametes ..... x .....

F_1 genotypes .....

F_1 phenotypes .....

Phenotype ratio .....

(b) Based on the results of this cross he concluded that the new variety was pure-breeding.

(i) Calculate χ^2 for the results of this cross. A table is provided below for you to use. [3]

Phenotype of seeds produced	**Observed O**	**Expected E**			
yellow, wrinkled coat	31				
green, wrinkled coat	22				
yellow, smooth coat	29				
green, smooth coat	26				

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

= .....

(ii) Use your calculated value of χ^2 and the probability table to justify whether the plant grower's conclusion was valid. [4]

Degrees of freedom	**Probability**		
	P = 0.10	**P = 0.05**	**P = 0.02**
1	2.71	3.84	5.41
2	4.61	5.99	7.82
3	6.25	7.82	9.84
4	7.78	9.49	11.67
5	9.24	11.07	13.39

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7. In 2011, over 330,000 cases of cancer were diagnosed in the UK of which, cancer of the kidney was the eighth most common..

(a) With reference to the structures involved in the production of urine, explain how a kidney tumour could result in the presence of blood in the urine. [2]

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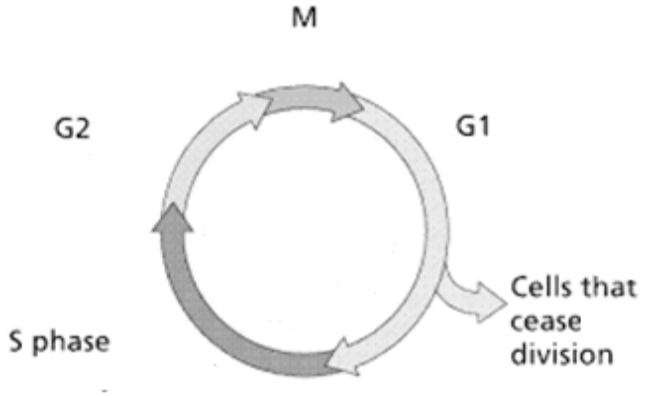
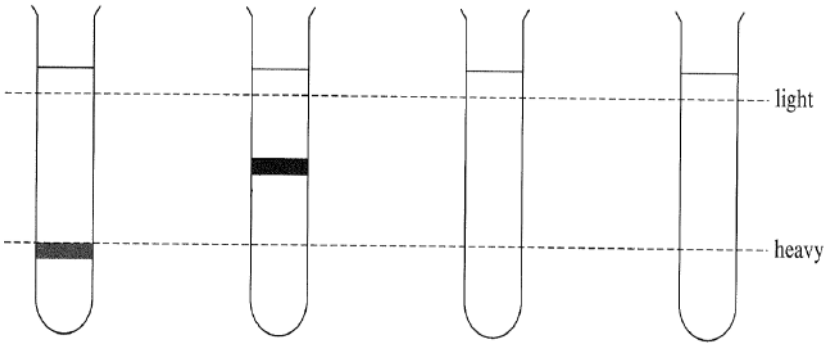
Cancer has been described as the uncontrolled, abnormal proliferation of cells and involves disruptions to the control of the normal cell cycle, as shown in the diagram below.



(b) During the S phase, cells that are undergoing cell division carry out DNA synthesis. In 1958, Meselson and Stahl carried out experiments to test which of three different theories did indeed describe the mechanism of DNA replication. Here is a brief description of their experimental method.

> The bacterium *Escherichia coli* (E. coli) was cultured in a nutrient broth, containing the heavy isotope as a source of nitrogen, ^{15}N, instead of the normal ^{14}N. After several generations all of the DNA in all of the bacteria contained the heavy isotope ^{15}N. They were then washed and transferred to a ^{14}N medium and allowed to replicate. After each generation, bacteria were removed and spun in a centrifuge. The position of the DNA in the medium was then determined.

(i) The diagram shows how the position of the DNA changed after successive cell divisions.



Initial position after growing in ^{15}N culture medium	After 1 division in ^{14}N culture medium	After 2 divisions in ^{14}N culture medium	After 3 divisions in ^{14}N culture medium

Complete the diagrams to show the pattern and relative proportions of DNA you would expect after 2 and 3 divisions in ^{14}N culture medium. [2]

(ii) Name the theory of DNA replication supported by the results of this experiment. [1]

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(iii) Explain how their results before and after the first division in ^{14}N culture medium support this theory and not the other theories proposed. [2]

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(c) p27 is a protein that is involved in the control of the cell cycle. High levels of this protein block the initiation of the S phase. This results in cells remaining in the G_1 phase for longer. In cells taken from breast cancers, it has been found that the levels of p27 are abnormally low.

(i) Suggest why it would be an advantage for normal cells to have: [2]

I high levels of p27 .....

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II low levels of p27. .....

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(ii) Suggest why abnormally low levels of p27 could result in the development of a tumour. [2]

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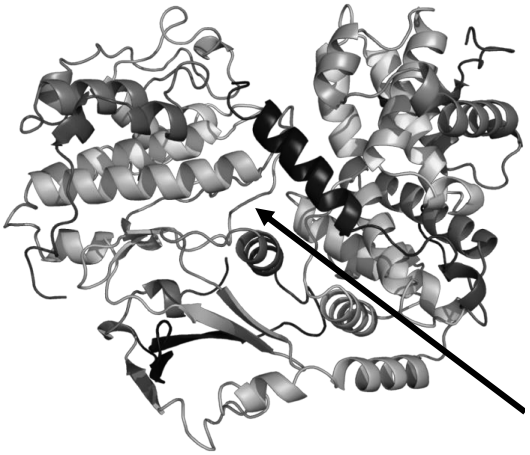
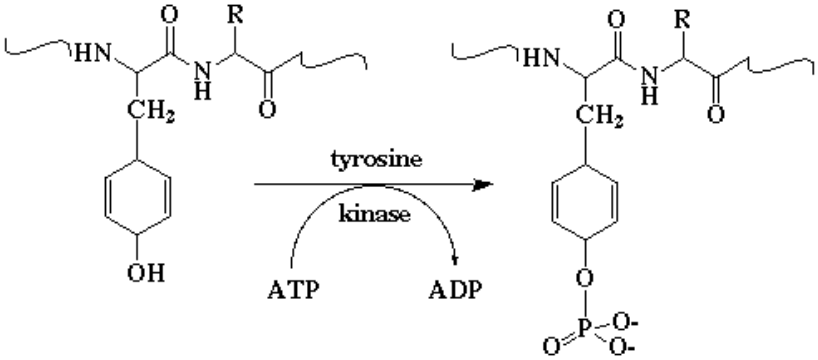
(d) The structure of the p27 protein is shown in the diagram below.



Research has shown that p27 acts as a competitive inhibitor of one of the enzymes responsible for the initiation of DNA replication.
The enzyme tyrosine kinase can phosphorylate a tyrosine molecule at position 88 in the p27 polypeptide chain as shown in the diagram below.



Explain how this could reduce p27s ability to inhibit its target enzyme. [3]

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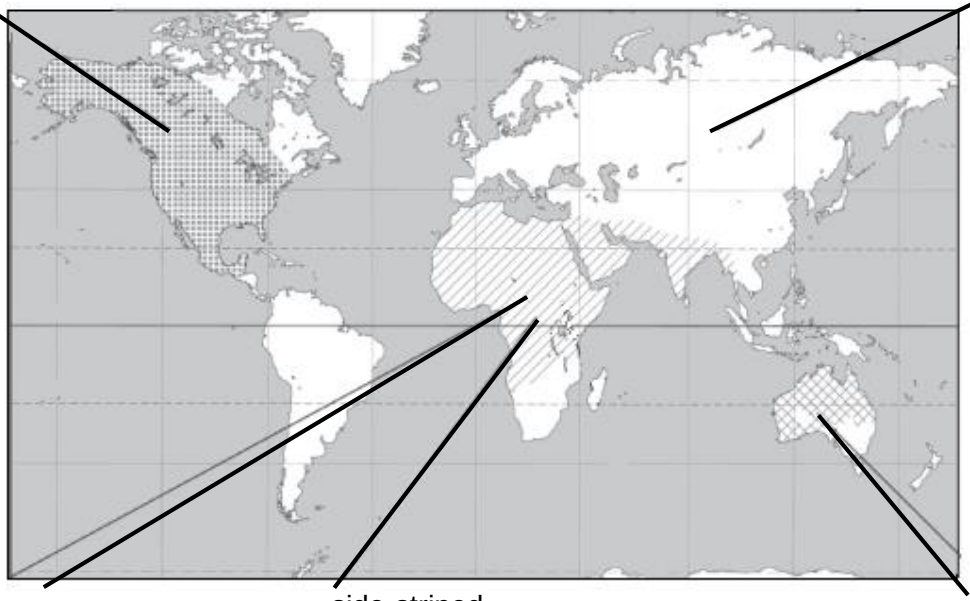
8. It is believed that the canine (dog) family evolved from a common ancestor about seven million years ago. The map below shows the world distribution of some members of the canine family.

coyote

wolf



black-backed jackal

side-striped jackal

dingo

In order to determine whether all the examples shown on the map were the same species, mating experiments were carried out. The results are shown in the table below.

	Coyote	Wolf	Dingo	Black backed Jackal	Side striped jackal
Coyote	✓	✓	✓	×	×
Wolf	✓	✓	✓	×	×
Dingo	✓	✓	✓	×	×
Black backed jackal	×	×	×	✓	×
Side striped jackal	×	×	×	×	✓

Using the information given, determine how many different species are shown on the map. Explain how you arrived at your conclusion and suggest how the different species could have arisen.
(The quality of your extended response will be assessed in this question.) [9QER]

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