Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U20-1

Z22-A400U20-1

FRIDAY, 17 JUNE 2022 – MORNING

BIOLOGY – A level component 2

Continuity of Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**18**	
3.	**15**	
4.	**14**	
5.	**13**	
6.	**17**	
7.	**9**	
Total	**100**	

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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 or correction fluid.

You may use a pencil for graphs and diagrams only.

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 **7**.

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

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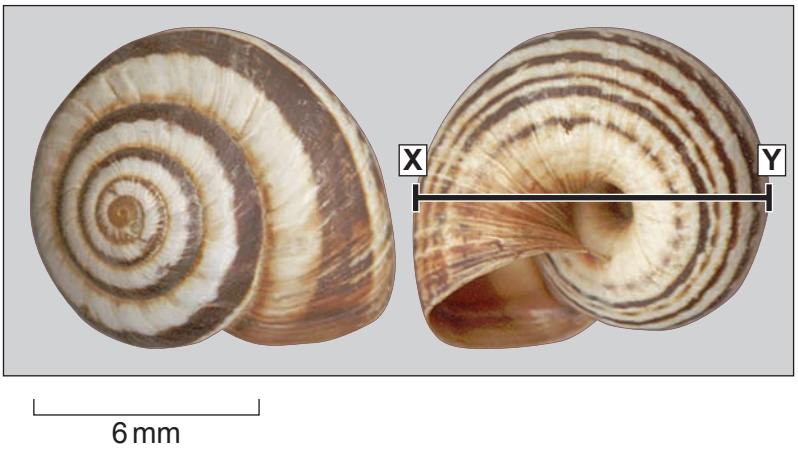
Answer **all** questions.

1. *Candidula intersecta* is a small snail found in coastal regions in the UK. It usually has a white shell with a varying number of brown bands. One form of the snail is shown in **Image 1.1**.

Image 1.1



(a) (i) Calculate the actual diameter of the snail along the line **X–Y** shown in **Image 1.1**. **Give your answer to the nearest millimetre.** [2]

Actual diameter = ... mm

(ii) Complete the table below to show the current classification of this snail. [2]

Domain	.....
Kingdom	.....
Phylum	Mollusca
Class	Gastropoda
Order	Pulmonata
Family	Hygromiidae
Genus	.....
Species	.....

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(b) The presence of a variable number of bands within a single population is an example of genetic polymorphism. It is believed that the variable number of bands is an adaptation to different environmental pressures.

(i) Explain what is meant by genetic polymorphism. [2]

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An investigation was carried out into the number of snails with different numbers of bands at two sites on either side of an estuary. **Image 1.2** shows the position of the sample sites and information about the vegetation and soil at each site.

Image 1.2

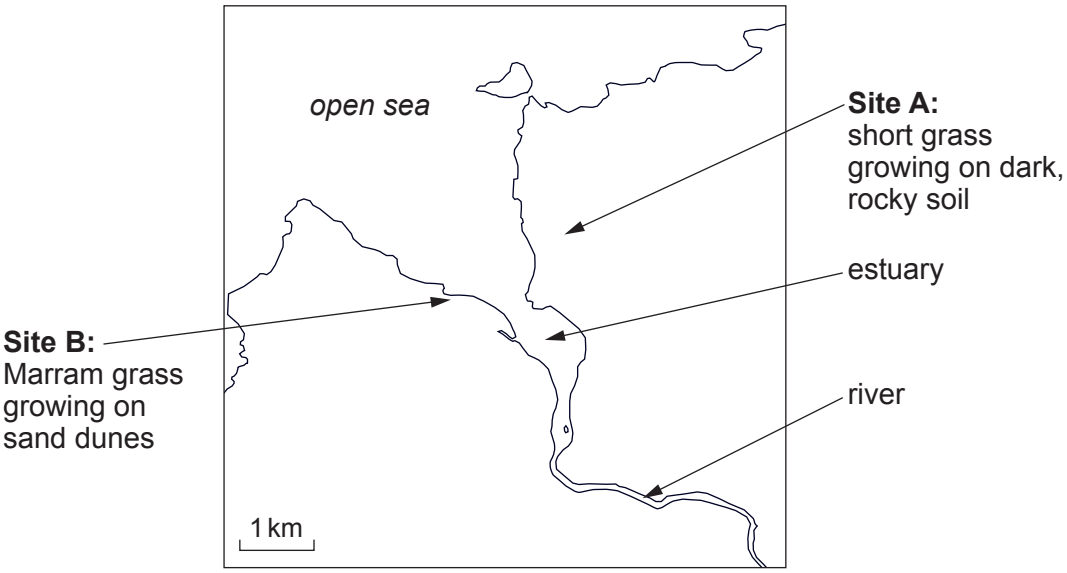

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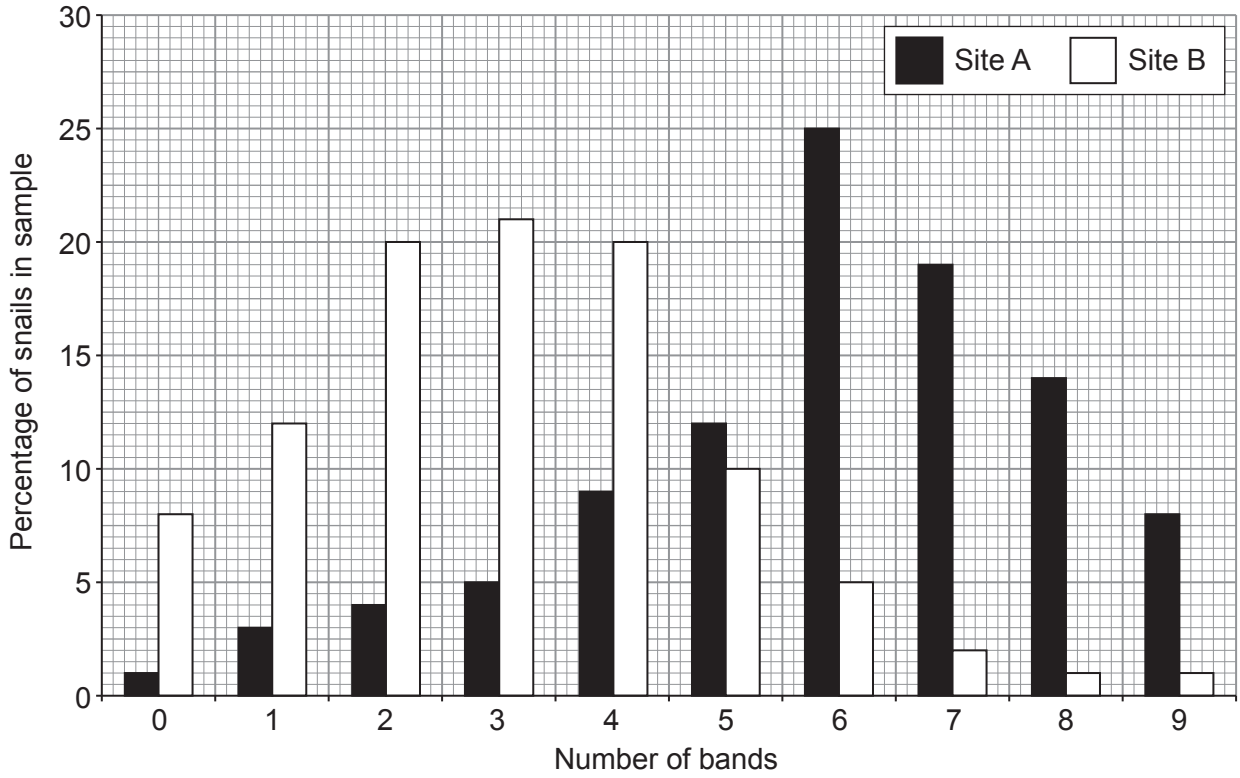
Image 1.3 shows the percentage of snails in each sample with different numbers of bands.

Image 1.3



(ii) The data collected from each site were analysed separately using a type of chi^2 test.
State the null hypothesis that would have been tested. [1]

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Statistical analysis of the data showed that there was a highly significant difference in the distribution of snails with different numbers of bands between Sites **A** and **B**.

(iii) Use **Image 1.3** to determine the modal number of bands on snails at sites **A** and **B**. [1]

A .....

B .....

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(iv) Explain how the vegetation and soil type at sites **A** and **B** shown in **Image 1.2** could have caused the difference in banding of the snails at the two sites. [3]

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(v) Suggest how the location and habitat of the sites has led to a significant change in the frequency of the alleles between the two populations of this species of snail. [3]

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2. Students carried out an investigation to determine how amylase activity in barley seeds changes during germination. The method followed is outlined below.

1. 100 barley seeds were soaked in 50 cm^3 of distilled water for 24 hours. They were then removed from the water and allowed to germinate.
2. After one day of germination, 10 of the barley seeds were homogenised in 5 cm^3 of distilled water.
3. Three discs of filter paper were soaked in the barley seed extract and placed on the surface of a starch agar plate.
4. The plate was incubated for 24 hours at 25 °C.
5. The paper discs were removed and the surface of the agar covered with iodine / potassium iodide solution.
6. The maximum diameter of the clear area around each disc was measured and the mean diameter calculated.
7. Steps 2 to 6 were repeated for barley seeds after 2, 4, 5, 8, 9 and 10 days of germination.

(a) (i) Describe how the production of amylase was triggered in the barley seeds. [4]

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(ii) Explain why it was important that the same concentration of agar and the same concentration of starch were used in all Petri dishes. [2]

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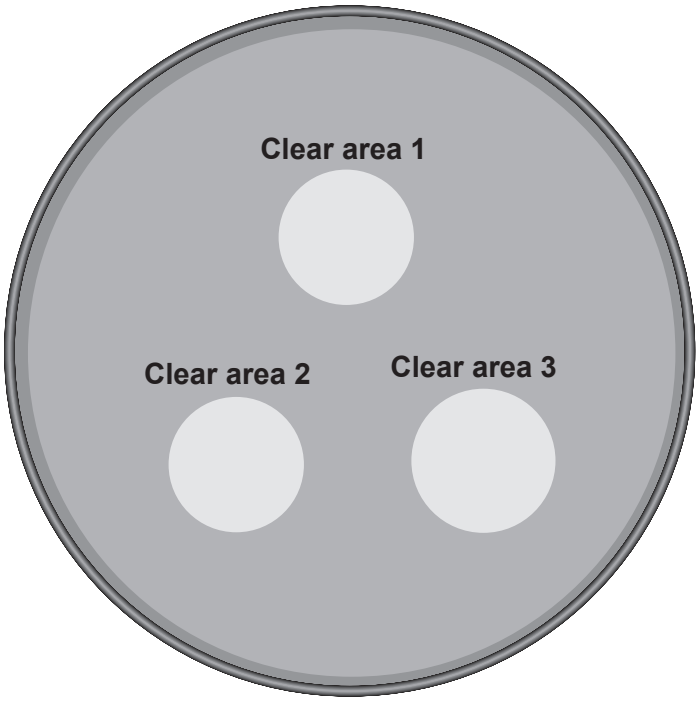
(b) **Image 2.1** shows the plate produced using barley seeds that had been germinating for **9 days**.

Image 2.1



(i) Measure the maximum diameter of each clear area and **add the results to Table 2.2**. Calculate the mean diameter of the clear area after 9 days of germination. [2]

Table 2.2

Time after germination / days	Maximum diameter of clear area / mm			
	clear area 1	clear area 2	clear area 3	mean
1	0	0	0	0
2	5	5	5	5
4	32	37	35	35
5	48	51	39	46
8	29	34	47	37
9	.....	.....	.....	.....
10	11	8	12	10

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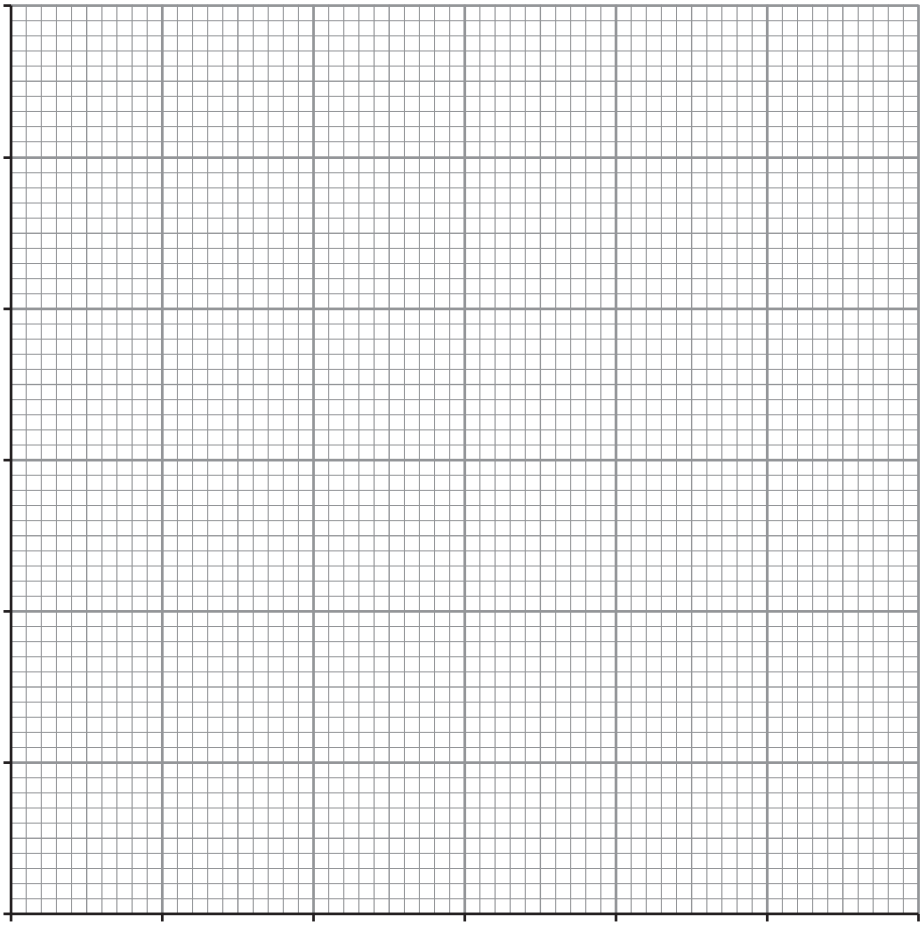
(ii) Plot the mean results from **Table 2.2** on the grid below. Include range bars for each set of results.

[5]



(iii) Explain why range bars are drawn on a graph. [2]

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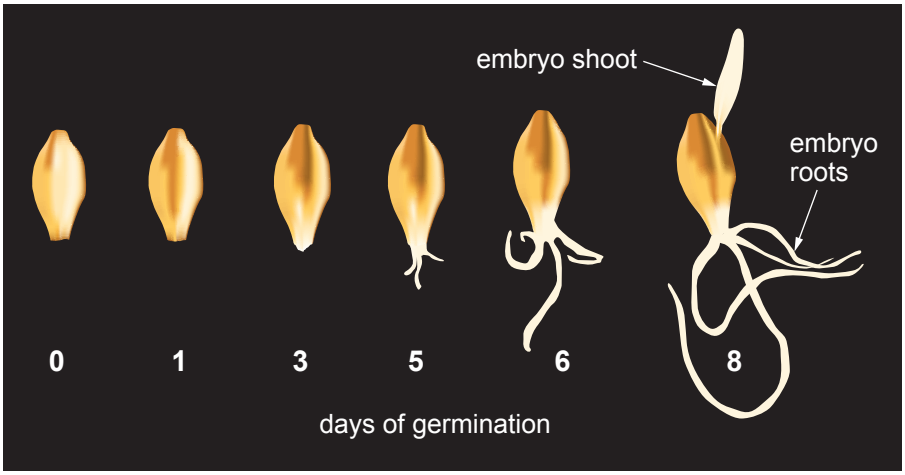
(c) **Image 2.3** shows barley grains at different stages of germination.

Image 2.3



Using the information provided and your own knowledge and understanding of germination in endospermic seeds, suggest a reason for the decrease in amylase activity after eight days of germination. Explain your answer. [3]

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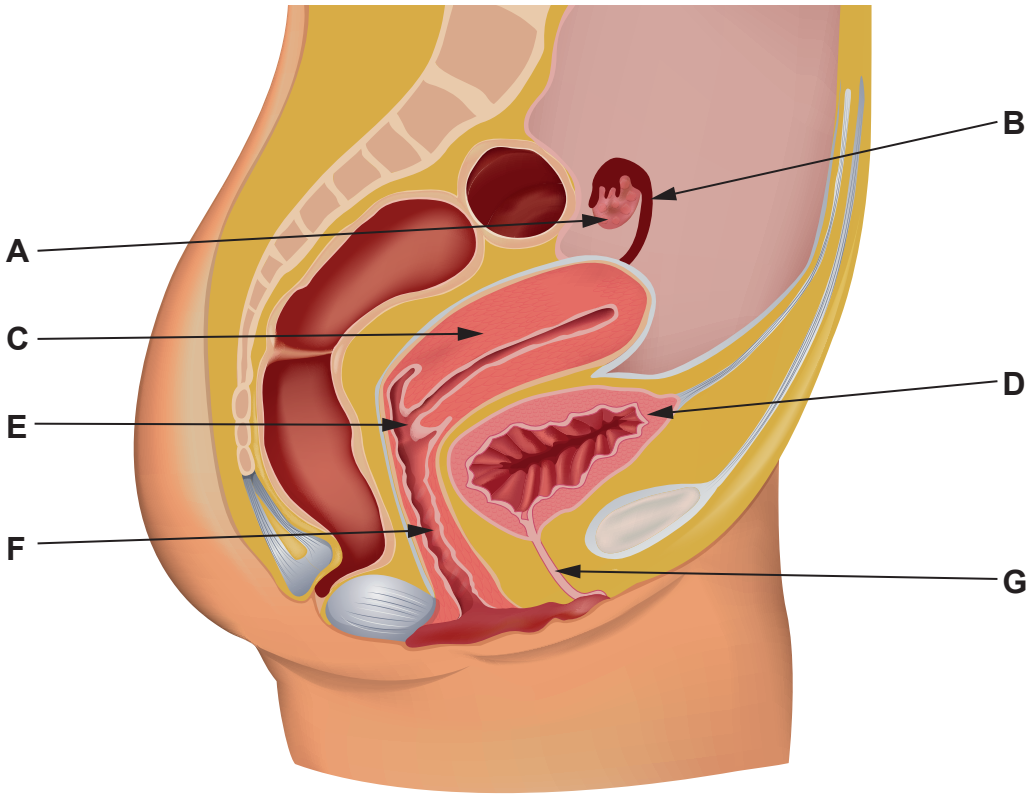
3. Advances in human fertility treatment involve an understanding of reproductive anatomy and physiology. **Image 3.1** shows a vertical section through a human female reproductive system.

Image 3.1



(a) (i) Using some of the letters **A – G** from **Image 3.1** complete the table below to identify the site of the following: [3]

	Letter
FSH and LH control the development and release of a secondary oocyte	
meiosis I takes place before birth to produce about 100 000 primary oocytes	
secretions are neutralised by alkaline seminal fluid during intercourse	
oxytocin has a positive feedback effect during birth	

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(ii) Explain how the function of the structure labelled **G** is different in male and female mammals. [1]

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(iii) Structure **B** contains epithelial tissue similar to that found in the trachea. Name the type of epithelium found in both **B** and the trachea and describe the function of this tissue in **both** locations. [3]

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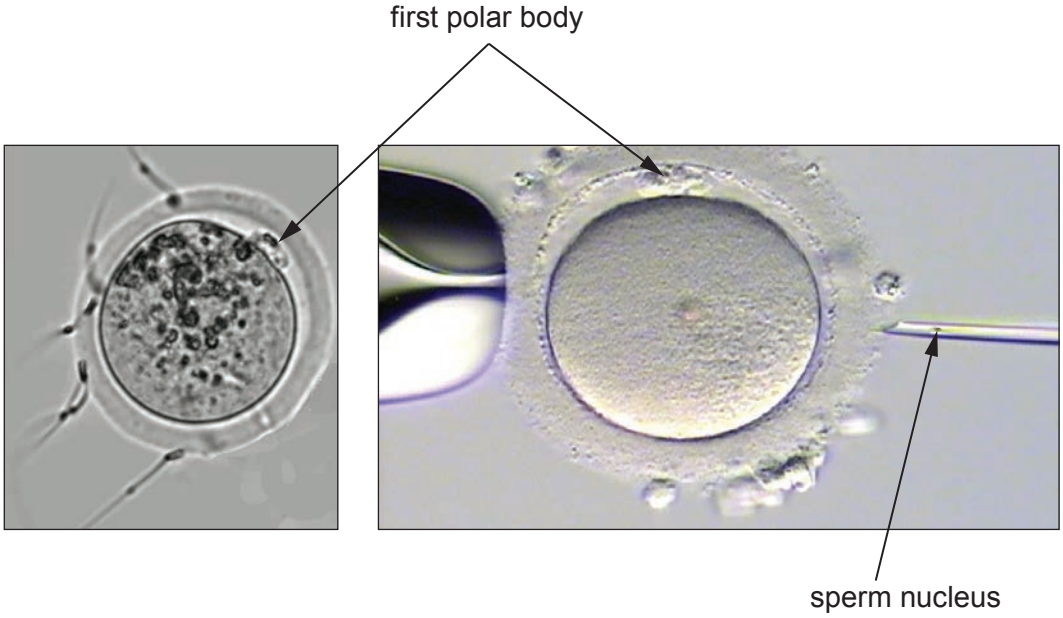
In vitro fertilisation (IVF) is an option that can enable women who cannot conceive (become pregnant) naturally to have a child. In this process, a secondary oocyte is harvested before ovulation and fertilised outside the body. Two forms of IVF are shown in **Image 3.2**.

- **Image 3.2 A** shows a secondary oocyte exposed to many sperm cells
- **Image 3.2 B** shows a single sperm nucleus being injected into a secondary oocyte.

Image 3.2 A **Image 3.2 B**



(b) (i) Explain why the cell harvested from the Graafian follicle is a secondary oocyte and not a female gamete (ovum). [2]

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(ii) Describe how the entry of more than one sperm nucleus into the secondary oocyte (**Image 3.2 A**) would be prevented. [2]

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(iii) In some cases, IVF using the method shown in **Image 3.2 A** is not successful. Suggest why the type of IVF shown in **Image 3.2 B** has a higher rate of success in producing an embryo. [2]

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(iv) The first polar body contains the same number of chromosomes as the secondary oocyte, but hardly any cytoplasm. Explain the advantage to the zygote of this unequal division of cytoplasm during the formation of the secondary oocyte. [2]

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4. The process of phytoremediation involves growing plants that are tolerant to heavy metals on contaminated land. As they grow, the plants absorb the heavy metals. At the end of the growing season, the plants are harvested and removed from the habitat. In this way, the concentration of heavy metals in the soil is reduced.

Alpine pennycress, *Thlaspi caerulescens*, is able to absorb cadmium ions from contaminated soils. Plants from some populations of this species can survive in concentrations of cadmium over 75 times greater than plants of other species.

Seeds of alpine pennycress were collected from a habitat contaminated with cadmium. They were grown hydroponically (soil-free) with their roots submerged in an oxygenated solution containing all the minerals required for growth.

(a) (i) Explain why **nitrate** and **phosphate ions** each need to be included in the solution used in the hydroponic system. [2]

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(ii) Cadmium ions are only able to pass into the xylem due to the presence of specialised protein molecules in the cell membranes of one tissue layer in the roots.

Name the tissue in the plant where these specialised protein molecules would be found and explain why the solution used in the hydroponic system needs to be oxygenated. [3]

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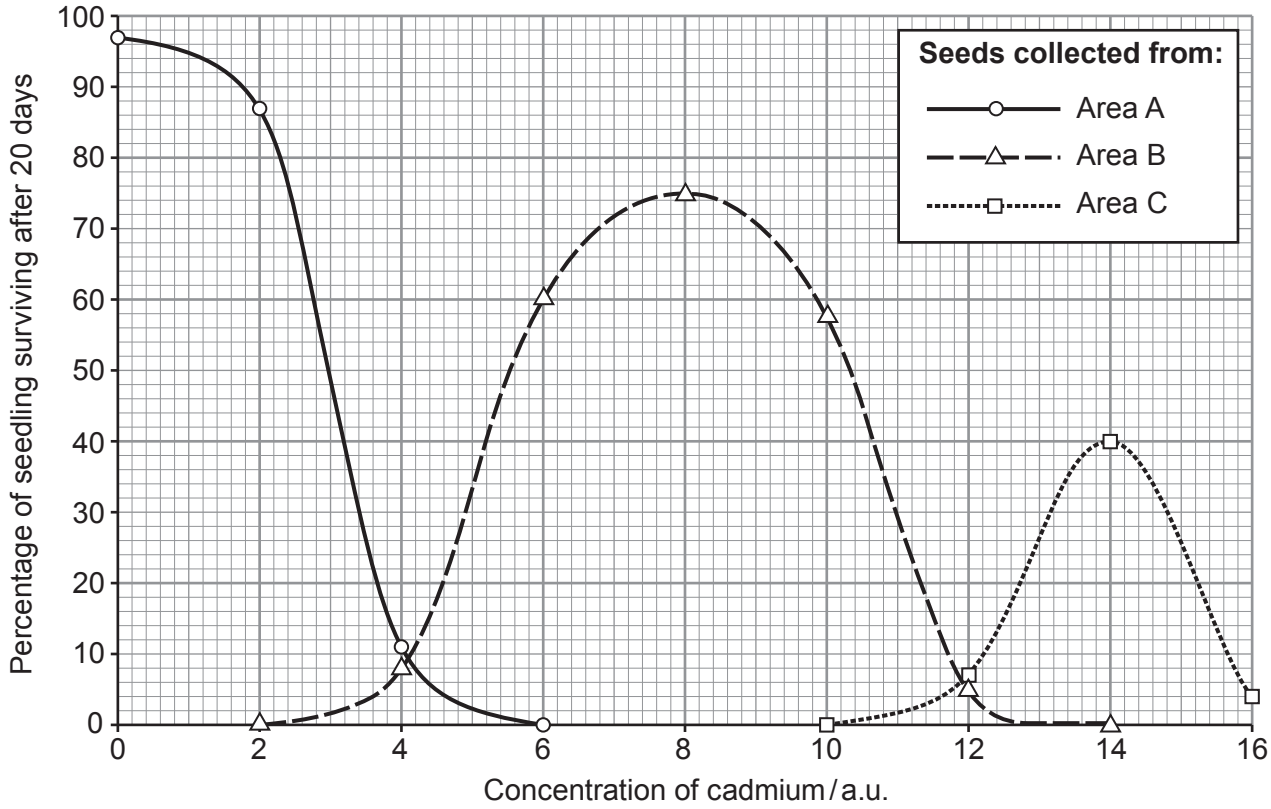
Seeds were collected from three areas of a habitat contaminated with cadmium and then grown at different cadmium concentrations. The percentage of seedlings surviving after 20 days was recorded. **Image 4.1** shows the results of the investigation.

Image 4.1



(b) (i) The percentage of seedlings from Area **B** surviving after 20 days showed a normal distribution. Explain what is meant by normal distribution. [1]

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(ii) State the **type** of variation shown in all three populations. [1]

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(iii) Explain why it would be inappropriate to use either a Chi^2 test or a Student's t-test to determine if there was a significant difference between the survival of seedlings grown from seeds collected from Areas **A** and **B**. [2]

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(iv) Scientists conducted a long-term project to reduce cadmium concentration to safe levels (< 1 a.u.) in a habitat with a cadmium concentration of 15 a.u.. They decided to use only seeds collected from Area **C**. With reference to **Image 4.1**, evaluate their decision. [4]

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(c) One symptom of cadmium poisoning in humans is the loss of high levels of glucose, phosphate ions and amino acids in the urine. Suggest which part of the nephron is affected by cadmium poisoning. [1]

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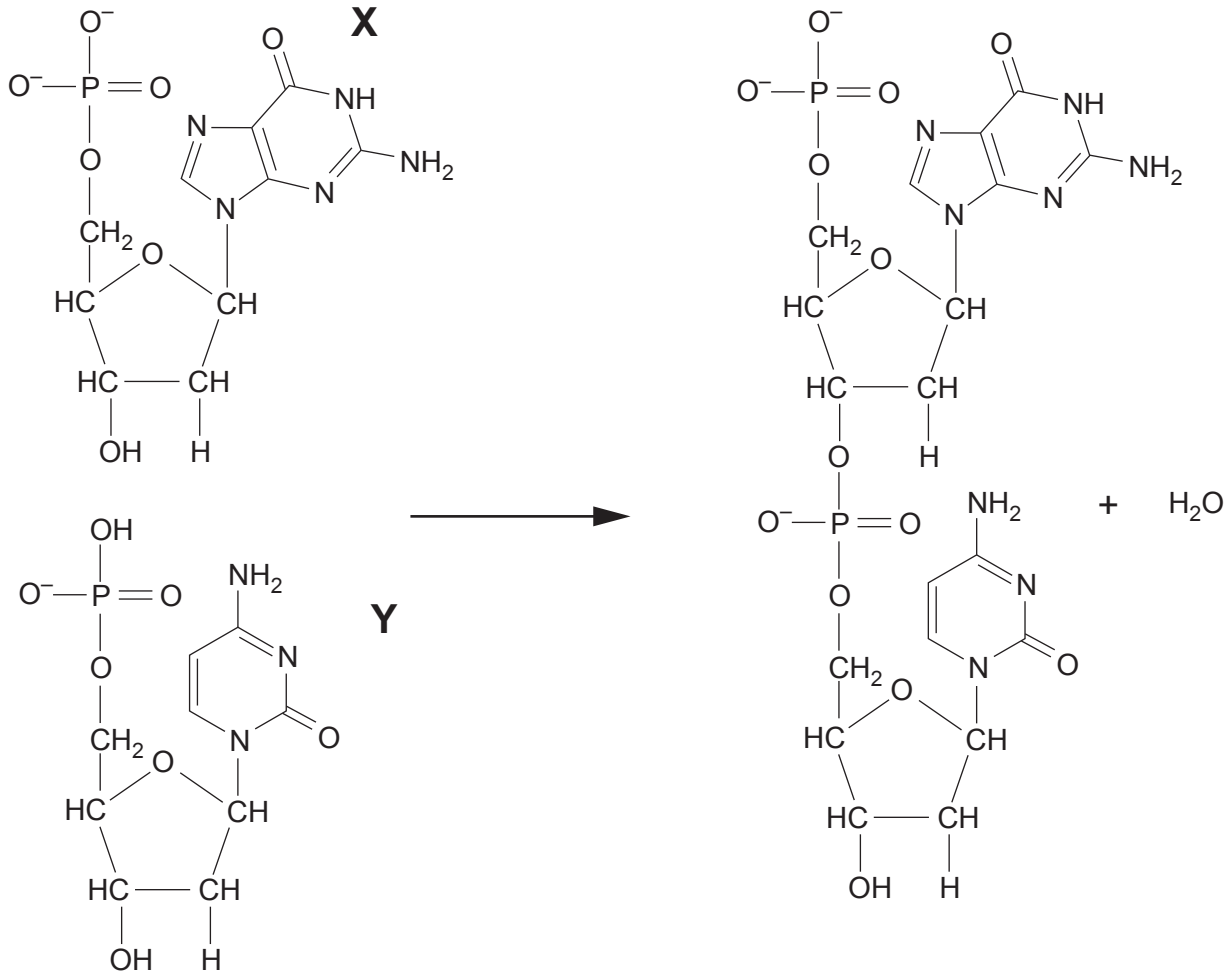
5. The main aim of the Human Genome Project was to sequence the DNA of each chromosome and to identify the location of each gene. Sanger sequencing was one technique used. It involved replicating and then sequencing short fragments of DNA.

A new base is added to the chain of nucleotides by a reaction between two nucleotides as shown in **Image 5.1**.

Image 5.1



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(a) (i) Identify the type of reaction shown in **image 5.1** and name **two** other bonds found in biological molecules that are formed by the same type of reaction. [2]

Type of reaction: .....

Bonds: .....

.....

(ii) The bases labelled **X** and **Y** could form a complementary base pair. Both bases are found in DNA **and** RNA. Deduce the identity of these bases giving reasons for your answer. [3]

Base **X** ..... Base **Y** .....

Reason .....

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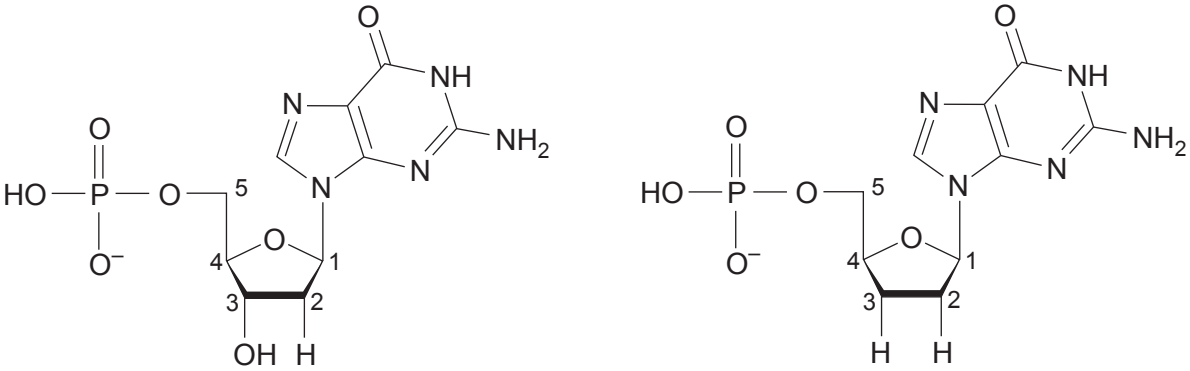
Sanger sequencing uses nucleotides that contain dideoxyribose which stops further nucleotides being added to a strand of DNA. **Image 5.2** shows nucleotides containing deoxyribose and dideoxyribose.

Image 5.2



deoxyribonucleotide dideoxyribonucleotide

(b) (i) State the difference between the two nucleotides shown in **Image 5.2**. [1]

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(ii) Explain why the addition of a dideoxyribonucleotide to the end of a DNA strand prevents further bases being added to the chain. [1]

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(c) Using DNA polymerase, a short fragment of DNA was copied in four separate experiments including a mixture of unlabelled A, T, C and G deoxyribonucleotides and one of radio-labelled A, T, C or G dideoxyribonucleotides.

The DNA chains produced in each experiment were then separated using gel electrophoresis as shown in **Image 5.3**.

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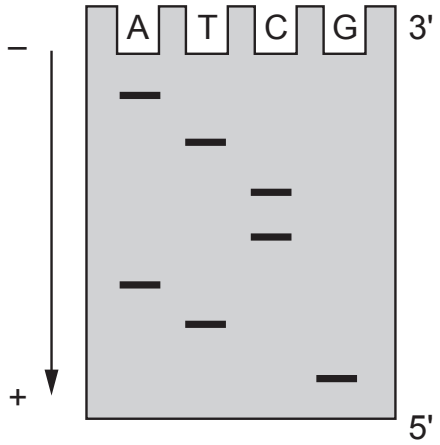
Image 5.3

DNA samples from experiments with radiolabelled dideoxyribonucleotides



(i) The arrow shows the direction of movement of the DNA fragments in the electrophoresis gel. Explain why the fragments have separated as shown in **Image 5.3**. [3]

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(ii) Using information from **Image 5.3** complete the table below to show the base sequence of the original double stranded DNA. [2]

	5´						**3´**
sequence of bases from gel electrophoresis							
complementary strand							
	3´						**5´**

(iii) Sanger sequencing took several months to sequence a genome but Next Generation Sequencing (NGS) can sequence a whole genome in less than five hours. State **one** medical advantage of using NGS rather than Sanger sequencing. [1]

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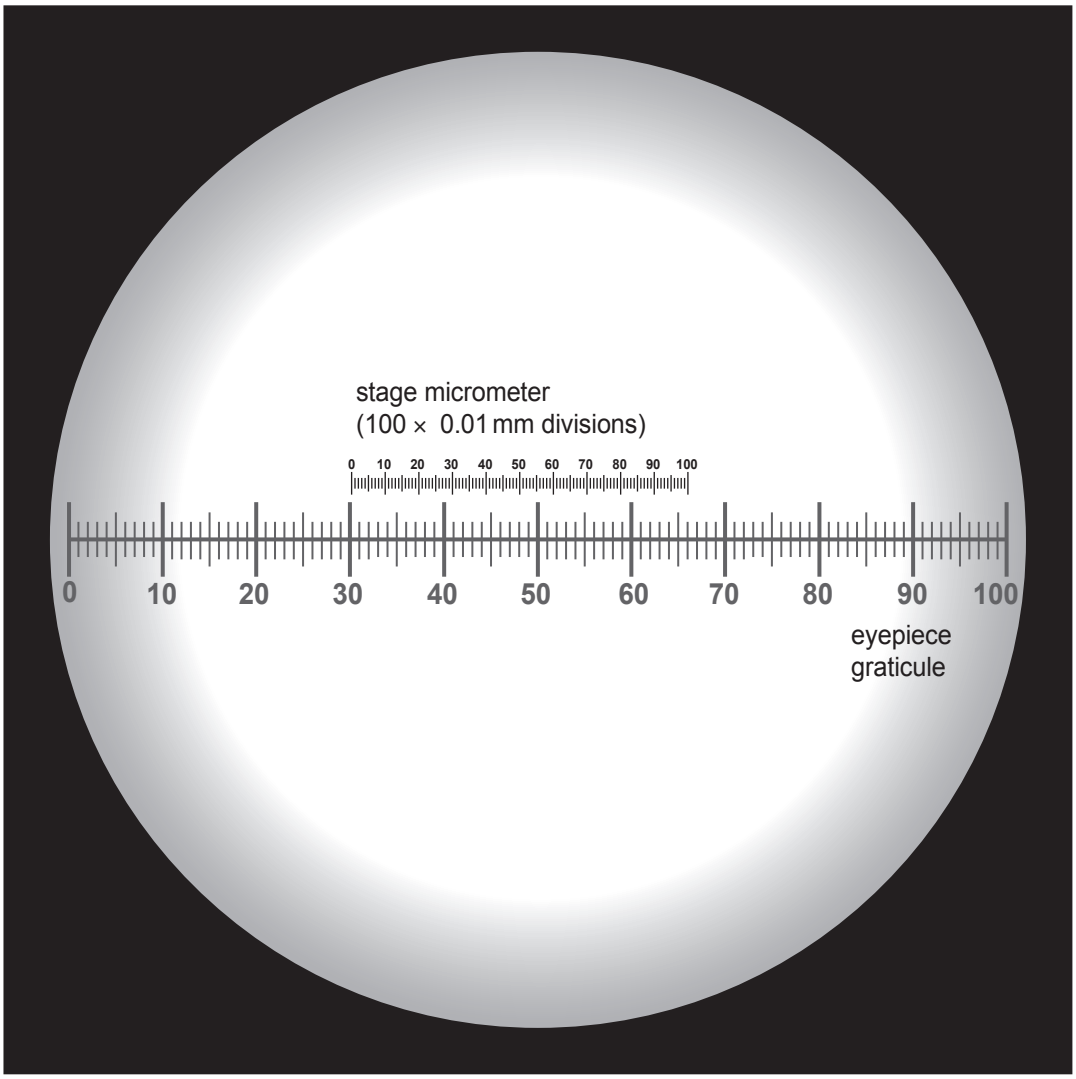
6. Using a ×4 objective lens, a student calibrated her microscope using the eyepiece graticule and stage micrometer shown in **Image 6.1**.

Image 6.1



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(a) (i) Calculate the size of one eyepiece unit (epu) at this magnification. **Give your answer to the nearest micrometre.** [2]
[1 stage micrometer division = 0.01 mm]

1 epu using a ×4 objective lens = ... μm

(ii) Explain why the microscope would need to be recalibrated before calculating actual size when using an objective lens of a different magnification. [1]

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Using the same microscope, the student examined a slide of a section through the ovary of a cat as shown in **Image 6.2**.

Image 6.2

(b) (i) Structure **X** is a mature Graafian follicle with a diameter of 97 epu at the point indicated by the line on the image. Using your calibration of the microscope at this magnification (from (a)(i)), calculate the actual diameter of the Graafian follicle. **Express your answer in mm to 1 decimal place.** [2]

Diameter of Graafian follicle = ... mm

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(ii) Describe the evidence from **Image 6.2** that cats produce multiple offspring during each pregnancy. [1]

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(iii) Structure **Y** is a primary follicle. Describe the stages in oogenesis that occur during the maturation of a primary follicle into a Graafian follicle. [2]

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(iv) Before the birth of cats and other female mammals, several thousand of structure **Z** are formed. These are called primordial follicles and each contains a single primary oocyte. No further primary oocytes are produced after the birth of a female mammal.

In male mammals primary spermatocytes are produced on a continual basis following puberty.

State the type of cell division that produces both primary oocytes and primary spermatocytes and explain the significance of this process in male mammals. [2]

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(c) Cats can suffer from a muscle wasting disease similar to muscular dystrophy in humans and have been used as an animal model for human muscular dystrophy.

To investigate the inheritance of muscular dystrophy in cats, a breeding colony was established from a single affected male. The 1st generation (F_1) was obtained through breeding the original affected male with two unaffected female cats. The F_1 females were then bred back to their father to obtain the F_2 generation.

Table 6.3 shows the number of normal and affected male and female cats in the F_1 and F_2 generations.

Table 6.3

Phenotype	Number of cats	
	F_1 generation	F_2 generation
Female normal	7	8
Female affected	0	5
Male normal	6	7
Male affected	0	5

Based on these results it was concluded that cat muscular dystrophy is inherited as an X-linked recessive condition.

(i) State what is meant by an X-linked condition. [1]

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(ii) There are three possible gametes that can be produced by the male and female cats: $\mathbf{X^D}$, $\mathbf{X^d}$, and **Y**, where **D** = unaffected and **d** = muscular dystrophy. Complete the genetic diagram below to show how female cats with muscular dystrophy were produced in the F_2 generation. [4]

Parental phenotype ..... × .....

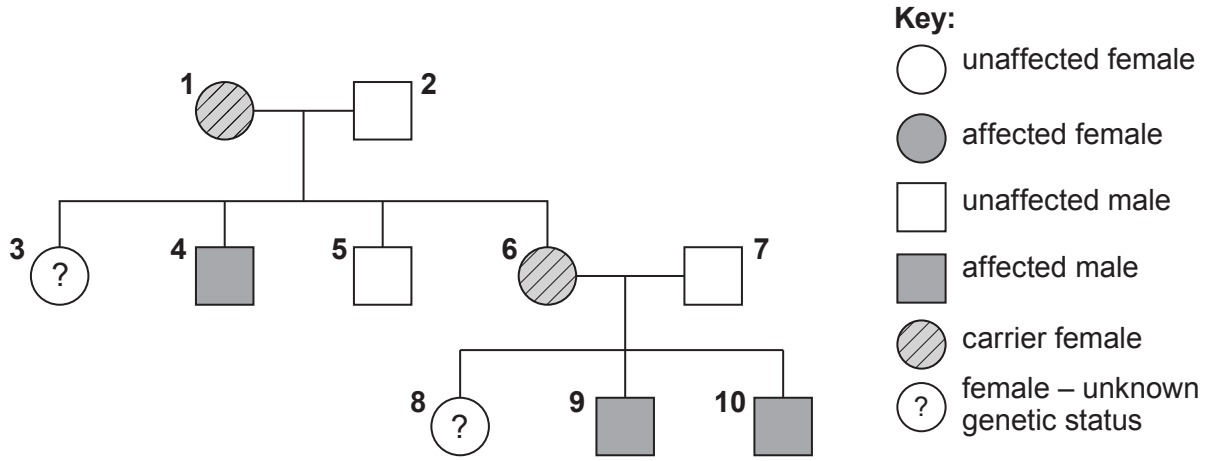
Parental genotype ..... × .....

Gametes ..... × .....

Genotype of female cat with muscular dystrophy .....

(d) One form of muscular dystrophy in humans is called Duchenne muscular dystrophy (DMD). It is also inherited as a recessive, sex-linked condition. The inheritance of DMD in one family is shown in **Image 6.4**.

Image 6.4



Suggest why individuals such as **3** and **8** may want genetic counselling before having children. [2]

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7. The dandelion *(Taraxacum officinale)* is a common plant in the UK. It is classified as a weed as it can spread easily and quickly and is very difficult to eradicate.

The passage below describes the reproductive strategies of the dandelion.

The flowers are bright yellow and open fully during the day and close at night. They contain both male and female reproductive organs. In each flowerhead, the stigmas mature before the anthers and degenerate before the anthers begin to produce pollen. However, in spring and autumn when insect numbers are low, the anthers mature earlier, the filaments grow longer and push the anthers against the stigma.

Each dandelion flowerhead produces between 125 and 300 seeds and this can happen from March to November. Once formed, the lightweight seeds are attached to white fibres and are easily detached by the wind. They can be carried for long distances before landing.

If conditions are suitable, the seeds germinate and quickly grow a taproot that penetrates deep into the soil. Dandelions can regrow the whole plant from the taproot; as little as 2 mm^3 of taproot tissue is needed to form a new plant.

Using your knowledge of plant reproduction and the information from the passage above, identify the types of pollination found in dandelions and explain the advantages of each. Describe and explain how the flowers are adapted for each type of pollination. Identify and explain the other reproductive strategies that make dandelions such effective weeds. [9 QER]

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END OF PAPER

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