Surname	StemUp Model Solution	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

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Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**18**	
3.	**15**	
4.	**14**	
5.	**13**	
6.	**17**	
7.	**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 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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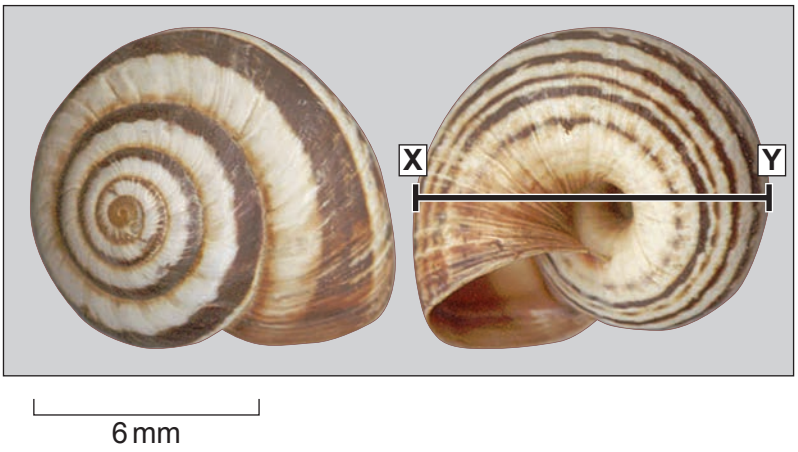
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Answer **all** questions.

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]

Length of X–Y on image = 47 mm

Scale bar (6 mm) = 29 mm on image

Actual diameter = 47 ÷ 29 × 6 = 9.72 mm

Actual diameter = ..10.. mm

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

Domain	*Eukarya*
Kingdom	*Animalia*
Phylum	Mollusca
Class	Gastropoda
Order	Pulmonata
Family	Hygromiidae
Genus	*Candidula*
Species	*intersecta*

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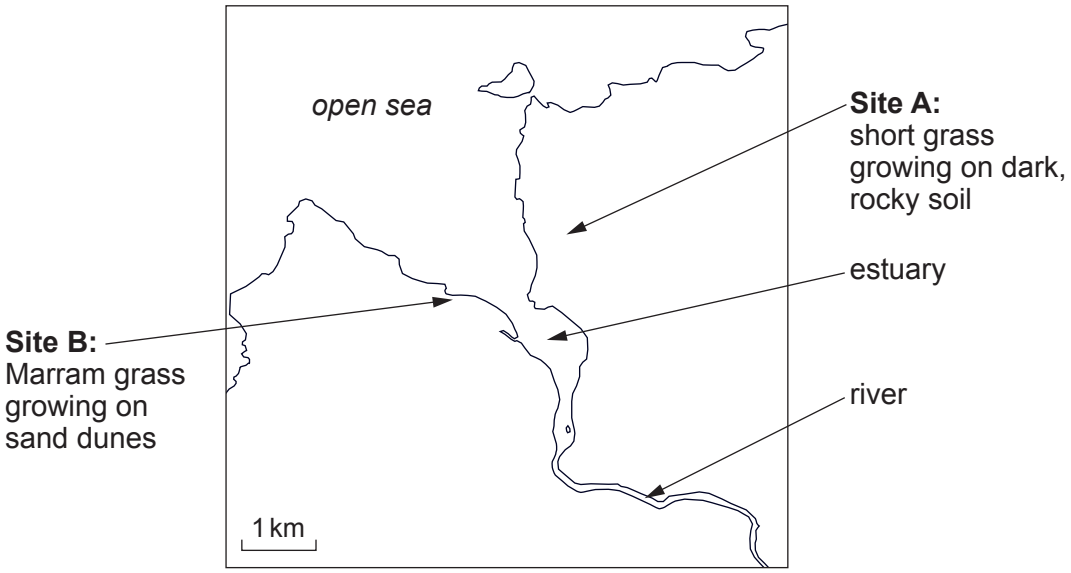
(b) The presence of a variable number of bands within a single population is an example of genetic polymorphism. It is believed that the variable number of bands is an adaptation to different environmental pressures.

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

The existence of two or more distinct forms (phenotypes) in one population, due to many alleles of the same gene at the same locus, at frequencies too high to be maintained by mutation alone.

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



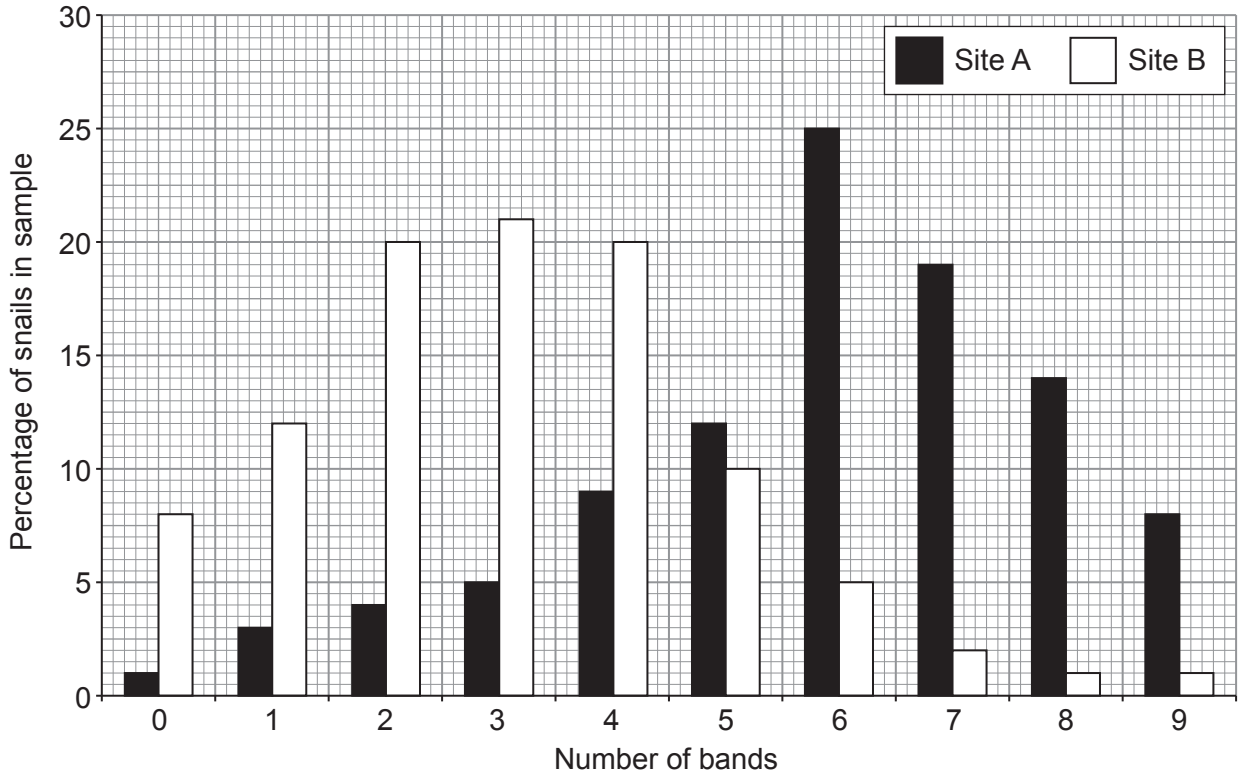
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Image 1.3 shows the percentage of snails in each sample with different numbers of bands.

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]

There is no significant difference between the observed and expected numbers of snails with each number of bands; any difference is due to chance.

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 6

B 3

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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]

Vegetation and soil type act as different selection pressures at each site.

At Site A (short grass on dark, rocky soil) more bands give better camouflage; at Site B (Marram grass on sand) fewer bands give better camouflage.

Better camouflaged snails have a selective advantage: less chance of predation, so an increased chance of survival.

So they reproduce and pass on their advantageous banding alleles to their offspring.

(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]

The estuary and river act as a geographical barrier, so the two populations are isolated: no interbreeding, so no gene flow (no exchange of alleles).

Different selection pressures act at each site, so different alleles are selected for; snails with advantageous alleles are more likely to survive.

Random mutations and genetic drift also differ in each population.

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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]

Soaking caused absorption of water (imbibition) by the seed.

This activated the embryo to release gibberellins, which diffuse to the aleurone layer.

Gibberellins trigger transcription and translation (protein synthesis) in the aleurone layer; stored proteins are hydrolysed (food reserves mobilised) to release amino acids.

These amino acids are used to synthesise amylase, which is secreted into the endosperm.

(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]

Agar: no effect on the rate of diffusion, i.e. the same resistance for amylase to diffuse through the agar.

Starch: the same number of starch molecules to digest in each dish.

Both are controlled variables, so results are due to amylase activity only.

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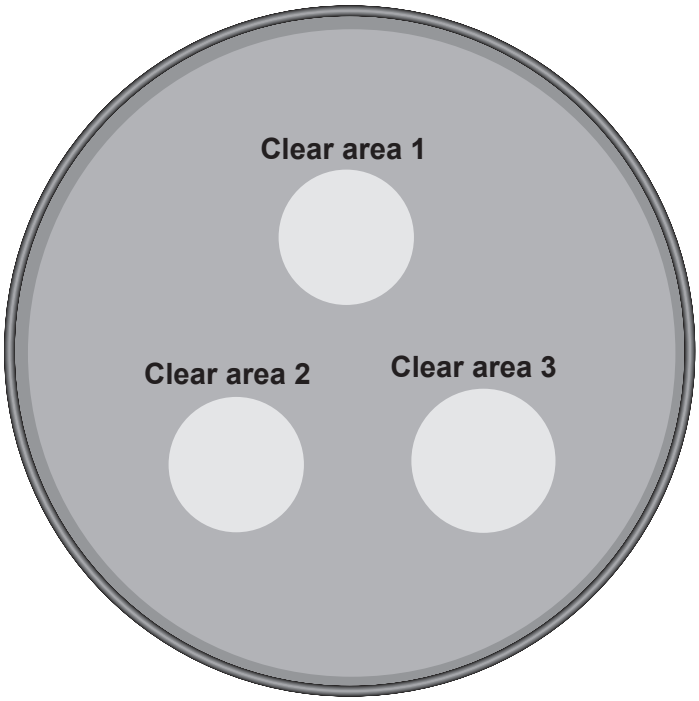
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(b) **Image 2.1** shows the plate produced using barley seeds that had been germinating for **9 days**.

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	18	18	19	18
10	11	8	12	10

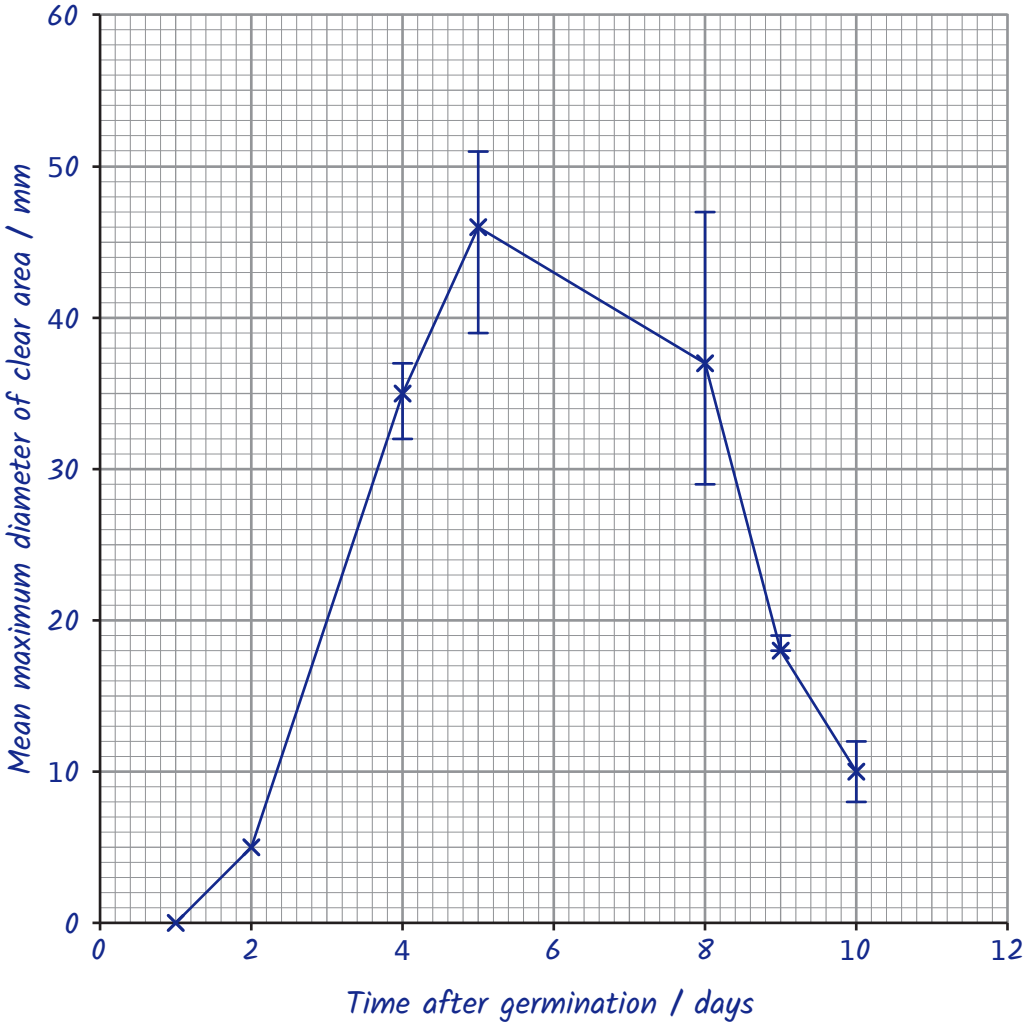
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(ii) Plot the mean results from **Table 2.2** on the grid below. Include range bars for each set of results.

[5]



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

To show the range (spread) of results around the mean, from the maximum to the minimum value.

This gives information on the repeatability (consistency) of the data and shows whether the data for different days overlap.

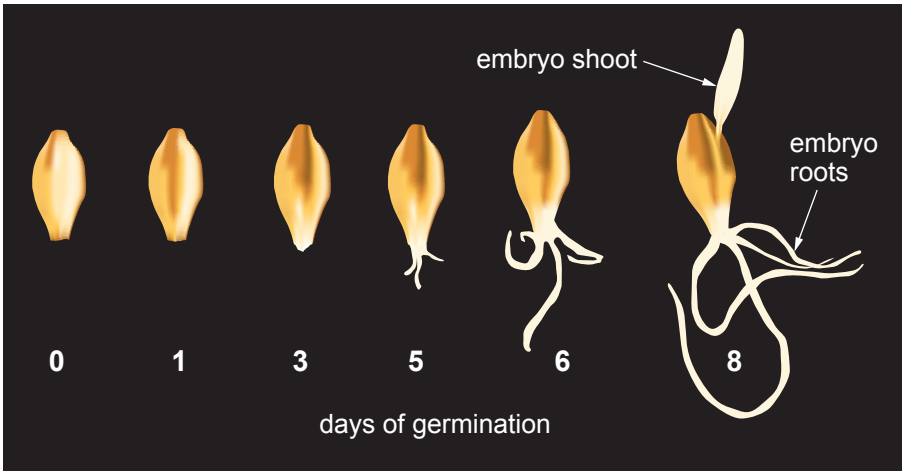
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(c) **Image 2.3** shows barley grains at different stages of germination.

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]

Image 2.3 shows that by 8 days the embryo shoot (leaves) has grown and appears above the soil.

The leaves are able to photosynthesise, so the plant can produce its own glucose.

Therefore less starch needs to be broken down (most of the endosperm starch has already been broken down), so less amylase is produced and its activity decreases.

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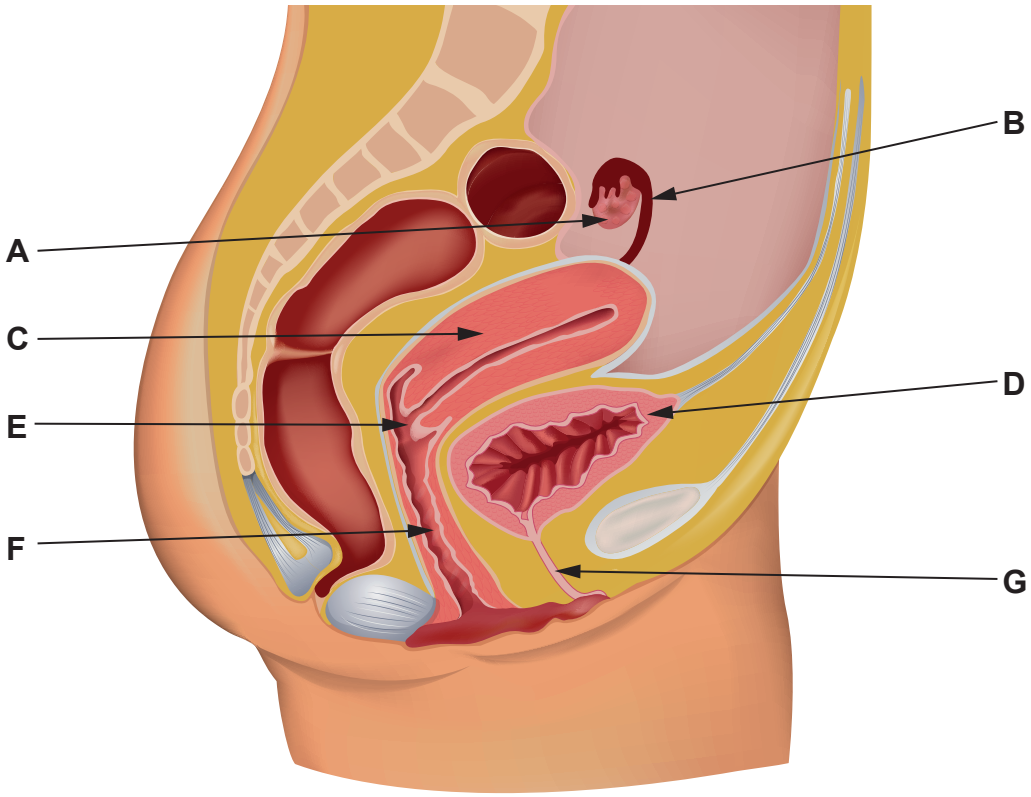
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3. Advances in human fertility treatment involve an understanding of reproductive anatomy and physiology. **Image 3.1** shows a vertical section through a human female reproductive system.

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	A
meiosis I takes place before birth to produce about 100 000 primary oocytes	A
secretions are neutralised by alkaline seminal fluid during intercourse	F
oxytocin has a positive feedback effect during birth	C

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

In males G (the urethra) carries both urine and semen, but in females it only carries urine.

(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]

Ciliated epithelium.

In B (oviduct) the beating cilia move the secondary oocyte, or the fertilised ovum (zygote / blastocyst), along to the uterus.

In the trachea the cilia move mucus, with trapped dust and pathogens, up and out of the breathing system.

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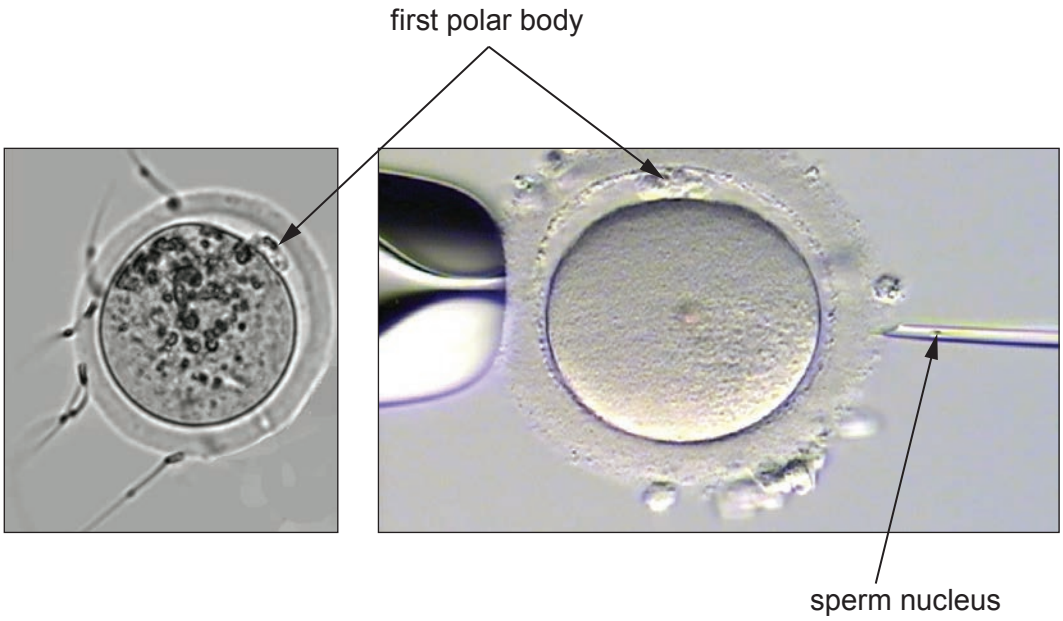
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In vitro fertilisation (IVF) is an option that can enable women who cannot conceive (become pregnant) naturally to have a child. In this process, a secondary oocyte is harvested before ovulation and fertilised outside the body. Two forms of IVF are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

It has not completed meiosis: it is suspended in metaphase II, and meiosis II is only completed on entry of (fertilisation by) a sperm. Its chromosomes still have two chromatids; only the first polar body has been produced, not the second.

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

Entry of the first sperm triggers the cortical reaction: exocytosis (release of the contents) of the cortical granules. This modifies (thickens) the zona pellucida, forming a fertilisation membrane, so no other sperm can enter.

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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]

In B the nucleus is injected directly into the secondary oocyte, ensuring it enters. In A the sperm may not be able to penetrate the corona radiata or zona pellucida; in B no acrosome reaction is needed.

(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]

The zygote contains (nearly) all of the cytoplasm and organelles of the oocyte.

So it has enough nutrients and organelles for cell division and can divide rapidly, with less time needed between divisions.

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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]

Nitrate: a source of nitrogen for synthesis of amino acids / proteins, nucleic acids and chlorophyll.

Phosphate: needed to make nucleic acids (DNA, RNA), phospholipids and ATP.

(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]

Endodermis.

Cadmium ions have to be actively transported into the endodermis cells by these carrier proteins, which requires ATP.

So oxygen is needed for aerobic respiration in the root cells to synthesise ATP for active transport.

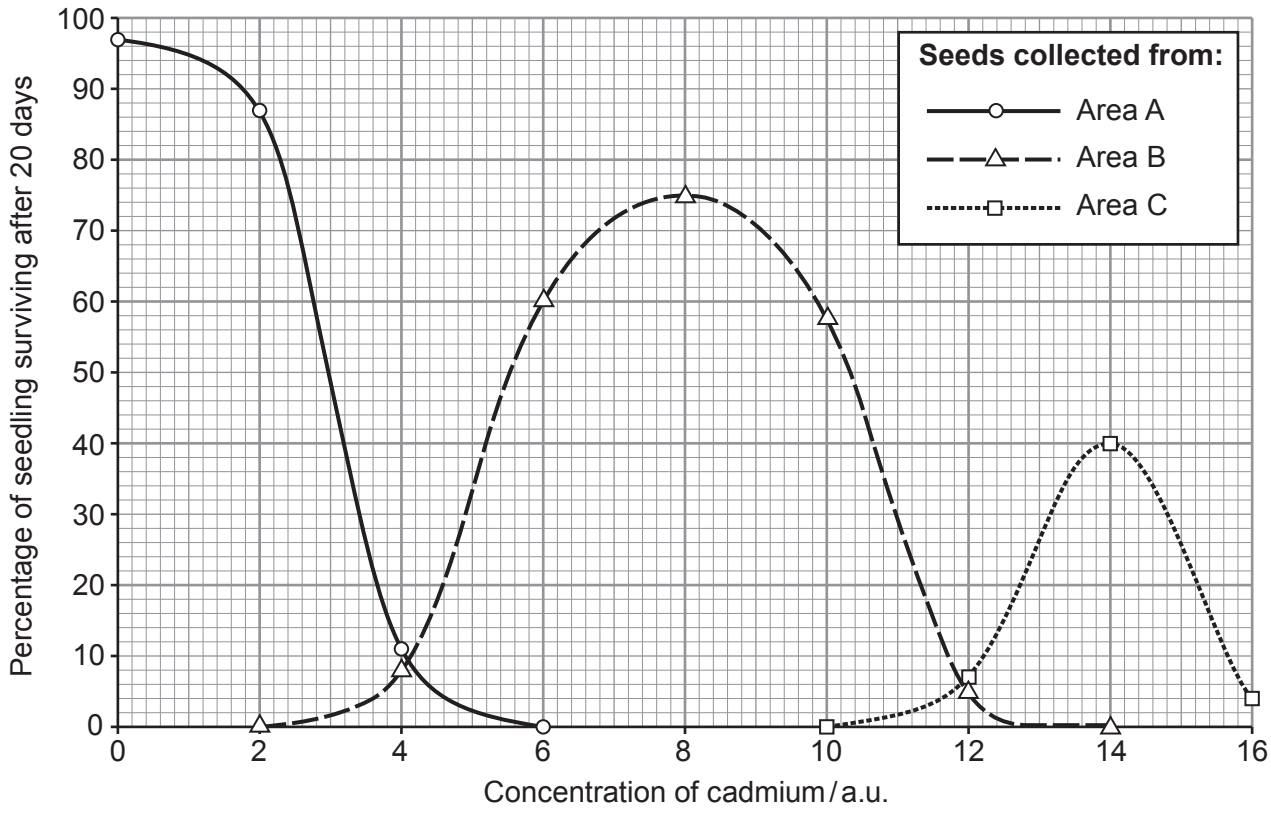
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Seeds were collected from three areas of a habitat contaminated with cadmium and then grown at different cadmium concentrations. The percentage of seedlings surviving after 20 days was recorded. **Image 4.1** shows the results of the investigation.

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]

Even, symmetrical distribution about the mean (bell-shaped curve); the mean, median and mode are the same.

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

Continuous variation.

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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]

Chi^2 cannot be used because the data are continuous (not categoric), so expected results cannot be calculated.

A t-test cannot be used because the data (e.g. Area A) are not normally distributed.

(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]

At the start (15 a.u.) it is a sensible choice, as at high concentrations only seedlings from Area C can survive.

But C seedlings can only survive at cadmium concentrations above 10 a.u., so they would die out as the cadmium concentration falls.

So they need to use all the types of seeds: grow C, then B, then A as the concentration falls.

B would also die out when the concentration falls below 2 a.u.; only A can survive to reduce cadmium to < 1 a.u., so C alone cannot reach safe levels.

(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]

Proximal convoluted tubule (PCT).

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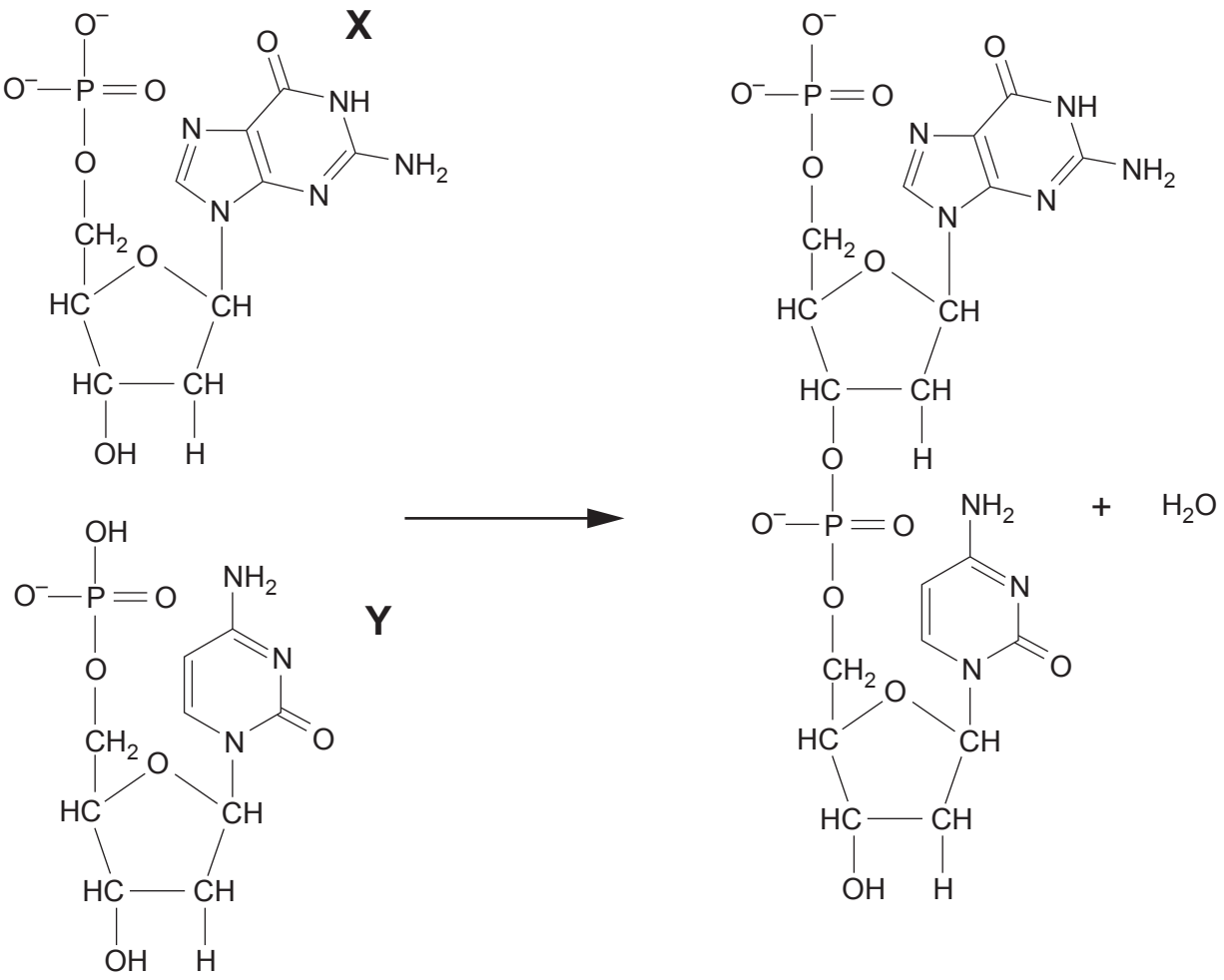
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5. The main aim of the Human Genome Project was to sequence the DNA of each chromosome and to identify the location of each gene. Sanger sequencing was one technique used. It involved replicating and then sequencing short fragments of DNA.

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: Condensation

Bonds: Glycosidic (bond)

Peptide (bond)

(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** guanine Base **Y** cytosine

Reason

X is a purine (double ring) and Y is a pyrimidine (single ring), so they are complementary.

They cannot be adenine and thymine because thymine (T) is not found in RNA.

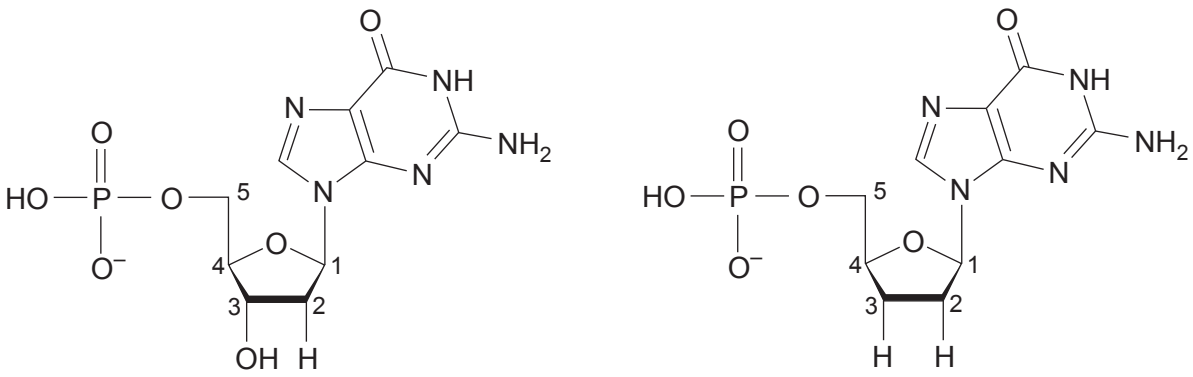
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Sanger sequencing uses nucleotides that contain dideoxyribose which stops further nucleotides being added to a strand of DNA. **Image 5.2** shows nucleotides containing deoxyribose and dideoxyribose.

Image 5.2



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

On carbon 3 there is no OH group: the OH is replaced by H.

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

Without the OH on carbon 3 no condensation reaction can occur, so no bond can form with another nucleotide.

(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**.

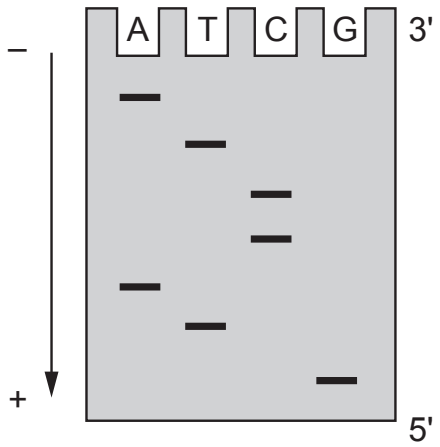
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Image 5.3

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]

The DNA fragments are negatively charged, so they move towards the positive electrode.

Smaller (shorter) fragments move further and faster, because they can move through the pores in the gel more easily.

(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	*G*	*T*	*A*	*C*	*C*	*T*	*A*
complementary strand	*C*	*A*	*T*	*G*	*G*	*A*	*T*
	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]

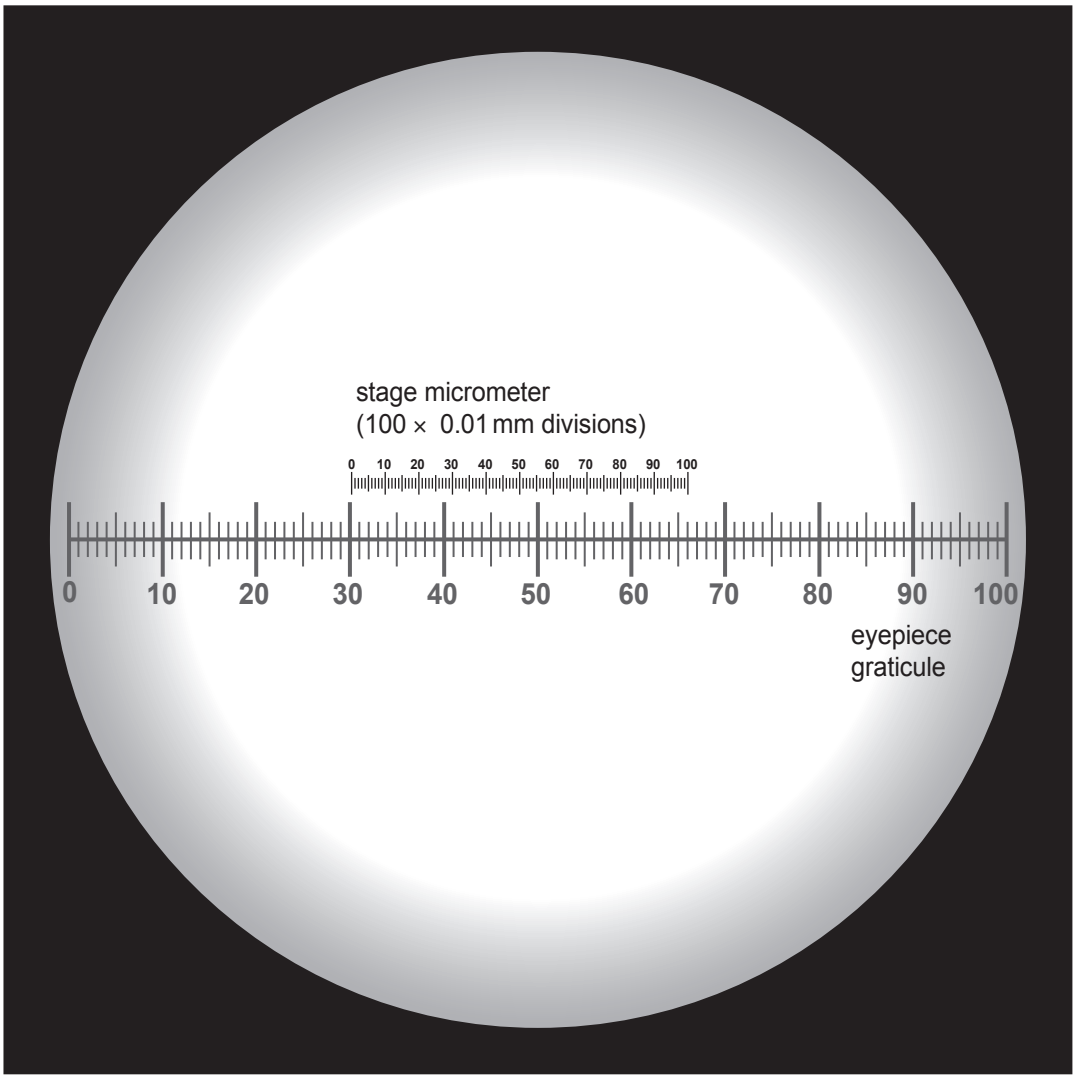
Faster diagnosis, so treatment can be tailored to the individual patient sooner.

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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]

36 epu = 100 stage micrometer divisions

100 × 0.01 mm = 1 mm = 1000 µm

1 epu = 1000 ÷ 36 = 27.78 µm

1 epu using a ×4 objective lens = ..28.. 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]

The eyepiece graticule is a fixed scale, but the stage micrometer appears a different size at different magnifications, so the number of smd per epu (value of 1 epu) changes.

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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]

97 epu × 28 µm = 2716 µm

2716 ÷ 1000 = 2.716 mm

Diameter of Graafian follicle = 2.7 mm

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

Several (three) Graafian follicles are visible in the ovary at the same time.

(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]

The primary oocyte undergoes meiosis I.

This produces a secondary oocyte and the first polar body; the secondary oocyte then starts meiosis II and stops at metaphase II.

(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]

Mitosis.

In males this continually produces large numbers of sperm, which increases the chance of fertilisation.

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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]

The gene (allele) is carried on the X chromosome (and not on the Y chromosome).

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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 Carrier (normal) female × Affected male

Parental genotype X^DX^d × X^dY

Gametes X^D X^d × X^d Y

gametes	X^D	X^d
X^d	X^DX^d	X^dX^d
Y	X^DY	X^dY

X^DX^d = carrier female

X^dX^d = affected female

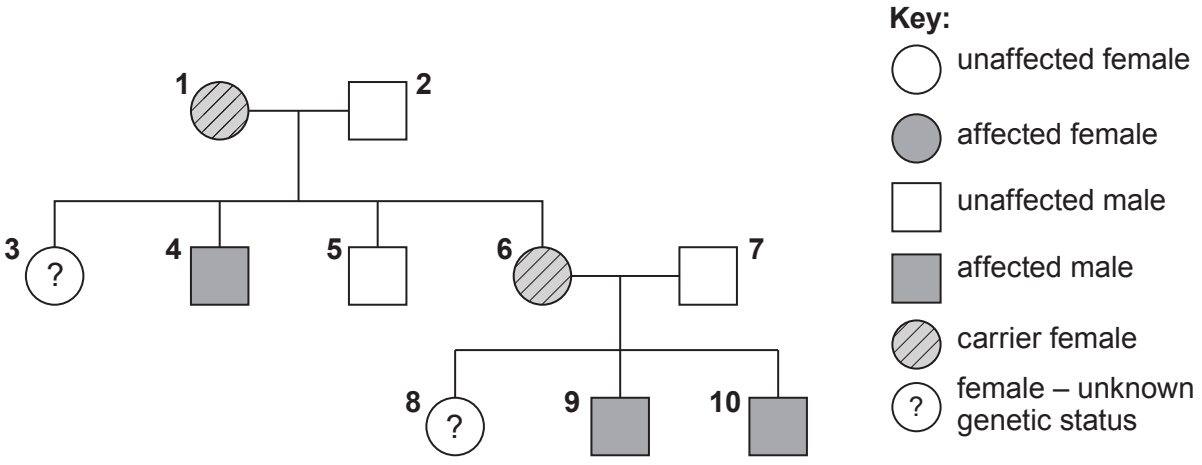
X^DY = normal male

X^dY = affected male

Genotype of female cat with muscular dystrophy X^dX^d

(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]

To find out if they are carriers, as their mothers (1 and 6) are carriers. If so, to know the risk of their sons inheriting DMD or daughters being carriers, and whether to screen the embryo in pregnancy.

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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.

1 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
5 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.

10 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]

Dandelions are insect-pollinated and show both cross-pollination and self-pollination.

Insect pollination increases the chance of pollination, as insects carry pollen from anthers to stigmas. The flowers are brightly coloured (bright yellow) to attract insects, and they open fully during the day, when more insects are around, closing at night.

Cross-pollination increases genetic variation, so the population is more likely to contain individuals that survive environmental change. In each flowerhead the stigmas mature before the anthers, so the flower cannot be self-pollinated at that time, and the anthers mature only after the stigmas have degenerated, so their pollen must pollinate other plants.

Self-pollination ensures pollination when few or no insects are available, e.g. in spring and autumn, and preserves successful combinations of alleles. When insect numbers are low the anthers mature earlier and the filaments grow longer, pushing the anthers against the stigma so pollen is transferred directly.

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Other strategies make dandelions effective weeds. Each flowerhead produces 125 to 300 seeds, a large number, increasing the chance that some survive, and seeds are produced over a long period (March to November), so dandelions can colonise for most of the year.

The seeds are lightweight with feathery fibres, so they stay in the air longer and are carried by the wind over long distances; wind dispersal lets them colonise other habitats and reduces competition with the parent.

The seeds germinate quickly and the plant becomes established quickly with a deep taproot. The plant can also regrow from the taproot (as well as from seeds): as little as 2 mm^3 of taproot forms a new plant, so digging or cutting rarely eradicates it.

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