

1 (a) In the space below, draw a sperm cell. On your diagram, label each of the following structures: **nucleus, mitochondria, flagellum** and **acrosome**.

(4)

(b) Explain the function of each of the following structures of a sperm cell.

(i) Flagellum

(1)

.....
.....

(ii) Mitochondria

(2)

.....
.....
.....
.....

(iii) Acrosome

(2)

.....
.....
.....
.....

(Total for Question 1 = 9 marks)

- 2 Infertility reduces the chance of successful fertilisation of the egg by a sperm cell. There are many causes of infertility in humans.

One cause of infertility is cigarette smoking. Men who smoke cigarettes have a 30% higher risk of infertility.

Cigarette smoke contains nicotine. The effects of nicotine on the quality of sperm cells have been studied in rats.

Male rats were given nicotine at levels of either 0.5 mg per kg of body mass or 1.0 mg per kg of body mass.

The sperm cells produced by these rats were compared with sperm cells produced by a control group of rats. The rats in the control group were not exposed to nicotine. The defects in the sperm cells produced were recorded and the results are shown in the table below.

Type of sperm cell	Percentage of each type of sperm cell (%)		
	Control	0.5 mg of nicotine per kg	1.0 mg of nicotine per kg
normal sperm cells	93.6	83.2	75.2
sperm cells with flagella defects	3.9		19.9
sperm cells with mid-piece defects	2.0	2.7	3.7
other defects, including missing heads	0.5	1.0	1.2

- (a) (i) Complete the table to give the percentage of sperm cells with flagella defects when the rats were given 0.5 mg of nicotine per kg of body mass.

(1)

(ii) Using the information in the table, calculate the difference in the percentage of sperm cells with defective flagella in rats given 1.0 mg of nicotine per kg of body mass compared with the control group.

(1)

.....%

(iii) Name the organelle that may be missing from the sperm cells with mid-piece defects.

(1)

.....

(iv) Using the information in the table, suggest why nicotine reduces the movement of the sperm cells.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

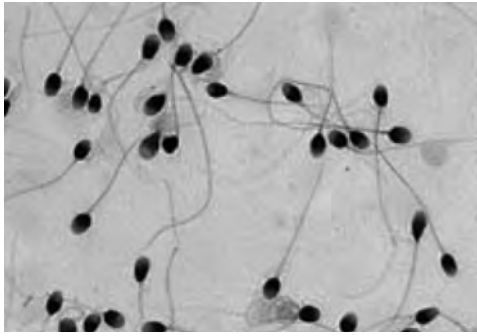
.....

.....

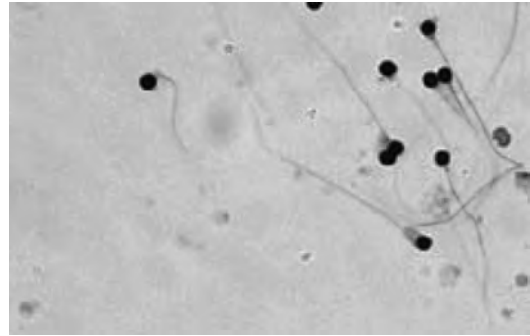
(b) A genetic cause of infertility is globozoospermia.

This condition results in round-headed sperm cells being produced. These sperm cells do not possess an acrosome.

Photograph **A** shows normal sperm cells and photograph **B** shows sperm cells from a man with globozoospermia.



A



B

Magnification $\times 500$

Suggest why the sperm cells in photograph **B** would not be able to fertilise an egg.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Suggest why a valid study on the effects of globozoospermia on fertility would have to be carried out on non-smokers.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 2 = 13 marks)

3 Mammalian gametes have specialised structures related to their function.

(a) The table below lists features found in egg cells and sperm cells. Complete the table by placing a cross (☒) in the appropriate box.

(4)

Feature	Egg cell only	Sperm cell only	Both egg cell and sperm cell	Neither egg cell nor sperm cell
Acrosome	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Cortical granules	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Flagellum	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Haploid nucleus	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

(b) Gametes contain mitochondria. Describe the function of mitochondria in sperm cells.

(2)

.....

.....

.....

.....

.....

.....

.....

(c) Explain the importance of meiosis in the production of gametes.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 10 marks)

4 Several processes lead up to fertilisation in animals and plants.

*(a) Describe and explain how, in mammals, events following the acrosome reaction prevent more than one sperm fertilising an egg.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Animals produce haploid gametes by meiosis.

Explain how meiosis gives rise to genetic variation in gametes.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

- (c) In flowering plants, the growth of pollen tubes is affected by many factors. An investigation was carried out to study the effect of the concentration of a chemical called methylpurine on pollen tube growth.

Pollen grains from lily flowers were exposed to 0.01 mol dm^{-3} methylpurine at pollination.



Lily flowers
Magnification $\times 0.2$

After 48 hours, the lengths of the pollen tubes formed were measured and the mean length calculated.

This was repeated with two other concentrations of methylpurine and a control with no methylpurine.

The results are shown in the table below.

Concentration of methylpurine / mol dm^{-3}	Mean length of pollen tube after 48 hours / mm
0.0000	94
0.0001	95
0.0010	90
0.0100	28

- (i) The investigation was carried out at a constant temperature of $22.5 \text{ }^\circ\text{C}$.

Suggest why the temperature was kept constant.

(2)

.....

.....

.....

.....

(ii) Using the information in the table, describe the effect of methylpurine concentration on the mean length of pollen tubes from lily flowers.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(iii) Methylpurine can inhibit messenger RNA (mRNA) synthesis.

Suggest how this can cause the change in mean pollen tube length.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 4 = 13 marks)