

AICE Biology Problem Set: Human Reproduction

Complete the following questions on human reproduction and human reproductive strategies. This problem set is worth 30 points and is due the day of your quest.

1. A recent development in fertility treatment is called in-vitro maturation (IVM). This is both cheaper and safer than the standard procedure used in in-vitro fertilisation (IVF), especially for women with polycystic ovaries. Hormone treatment can be dangerous for women with this condition, in which a number of ovarian follicles mature at the same time.

IVF and IVM are compared in Fig. 3.1.

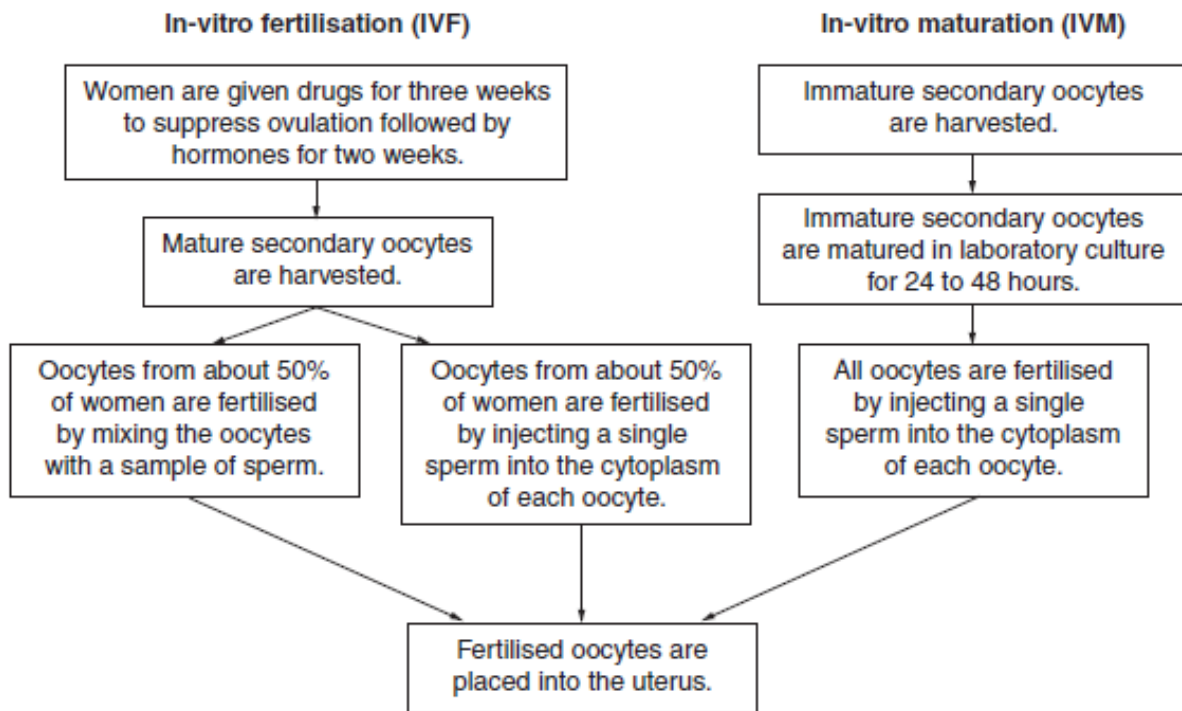


Fig. 3.1

- (a) With reference to Fig. 3.1, explain why women are treated with hormones for two weeks after being given drugs to suppress ovulation at the beginning of IVF treatment.

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(b) State the roles of mitosis and meiosis in producing an immature secondary oocyte.

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..... [3]

(c) Suggest one advantage and one possible disadvantage of fertilising an oocyte by injecting a sperm into its cytoplasm instead of mixing the oocyte with a sample of sperm.

advantage
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disadvantage
..... [2]

[Total: 7]

2.

(a) Describe the maturation of a spermatid into a spermatozoon (sperm).

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- (b) A method of sorting damaged from undamaged sperm has undergone trials at an *in vitro* fertilisation (IVF) clinic in Australia. It is hoped to use the procedure when attempting IVF with sperm from men with fertility problems.

The sorting process is shown in Fig. 2.1.

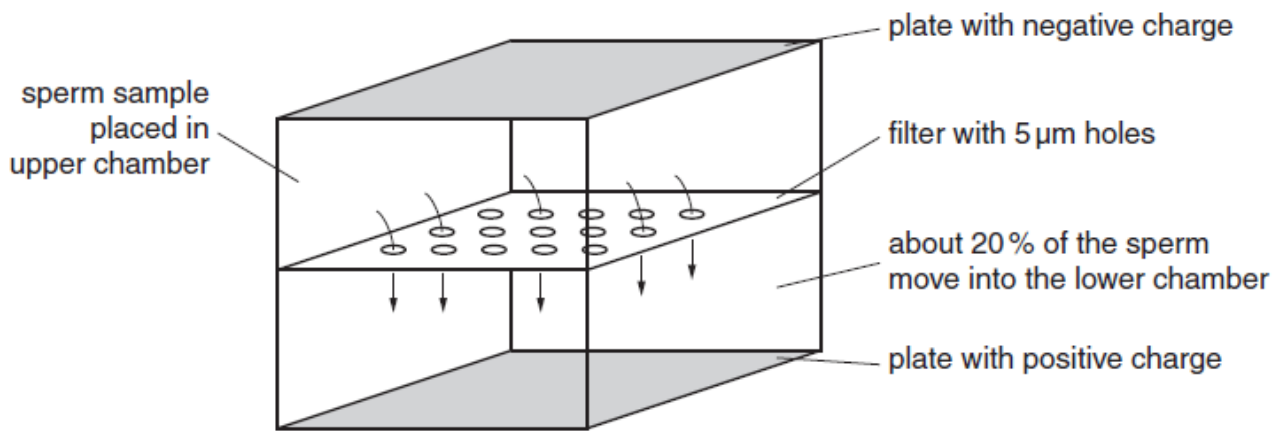


Fig. 2.1

Sperm left in the upper chamber have, on average, twice as much damage to their DNA as those that move into the lower chamber.

In the body, sperm which mature normally move slowly through the epididymis, gradually accumulating molecules of a negatively charged protein in their cell surface membranes. Other sperm move more quickly through the epididymis.

With reference to the information given, including that in Fig. 2.1, explain why only some of the sperm move into the lower chamber.

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[Total: 7]

3. (a) Fig. 4.1 shows the stages in spermatogenesis in a mammal.

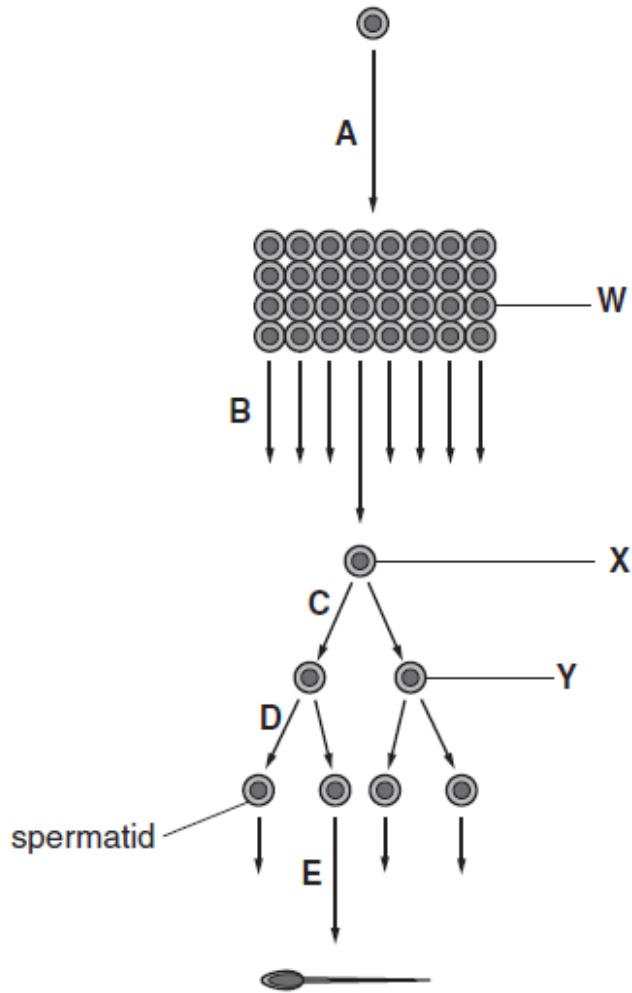


Fig. 4.1

(i) State the letter(s) of the arrow or arrows that represent mitosis.

.....[1]

(ii) Name the cells W, X and Y.

W

X

Y[3]

- (b) Fig. 4.2 is a light micrograph of a transverse section through a seminiferous tubule in a mammalian testis.

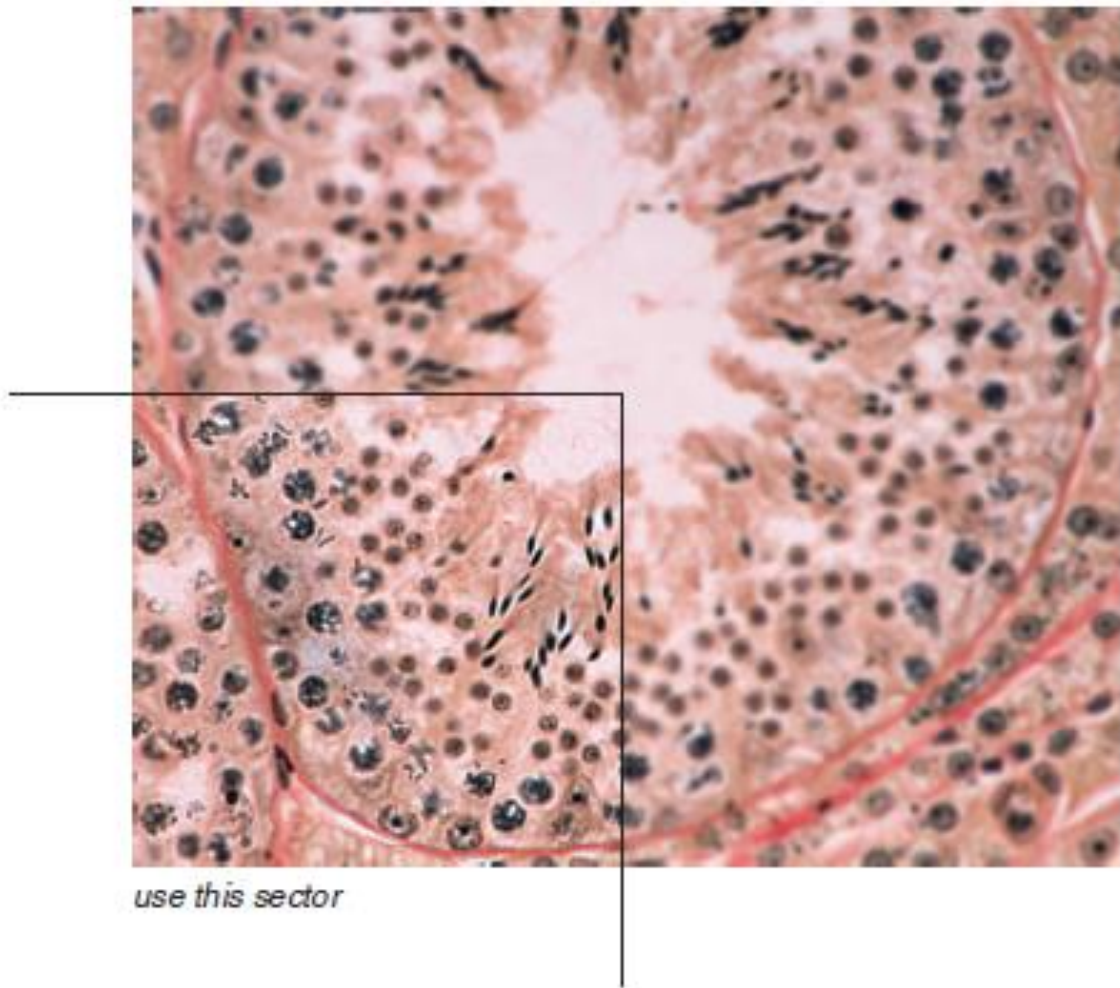


Fig. 4.2

On the sector indicated on Fig. 4.2, use label lines and letters to label:

- G** a cell in the germinal epithelium
- M** a maturing sperm cell
- Y** an area where spermatids are found.

- (c) In all animals so far studied, the production of fully functional sperm is sensitive to temperature.

In the nematode worm, *Caenorhabditis elegans*, spermatogenesis takes place in a similar way to mammals. Two proteins known as argonaute proteins are important in the development of sperm. They are coded for by the genes *alg-3* and *alg-4*.

Table 4.1 shows the effect of mutations in one or both of these genes on the fertility of male worms, at temperatures of 20 °C and 25 °C.

Fertility was measured as the mean number of offspring produced when the male worms mated with normal females.

Table 4.1

male worms	mean number of offspring produced	
	at 20 °C	at 25 °C
normal at both gene loci	280	150
mutation in <i>alg-3</i> only	125	95
mutation in <i>alg-4</i> only	220	85
mutations in both <i>alg-3</i> and <i>alg-4</i>	90	0

- (i) Describe the effect of increased temperature on the fertility of normal male worms.

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- (ii) Compare the effect of increased temperature on the fertility of *alg-3* mutant male worms with the effect on fertility of *alg-4* mutant male worms.

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- (iii) An investigation showed that at 20 °C the number of spermatids produced in worms with both mutations, in *alg-3* and *alg-4*, was the same as in normal worms.

However, at 25 °C, these mutant worms produced 29% fewer spermatids than the normal worms. Microscopic examination of their testes showed that many of the secondary spermatocytes had failed to complete meiosis.

Use this information to state the letter of **one** arrow on Fig. 4.1 that represents a stage of spermatogenesis affected by mutations in **both** the *alg-3* and *alg-4* genes.

..... [1]

- (iv) Table 4.2 shows the effect of temperature on the percentage of spermatids that developed full motility at 20 °C and 25 °C in normal worms and in worms with mutations in **both** *alg-3* and *alg-4*.

Table 4.2

male worms	percentage of sperms with full motility	
	at 20 °C	at 25 °C
normal	57	54
mutations in both <i>alg-3</i> and <i>alg-4</i>	10	2

With reference to Table 4.2, and the information in (iii), state the cause or causes of reduced fertility in these mutant worms at each temperature.

at 20 °C

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at 25 °C

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 [2]

[Total: 14]

- 4 (a) Blood samples were taken from a 29 year old woman each day for a period of 43 days. The concentrations of oestrogen, progesterone and luteinising hormone (LH) in each sample were measured. The results are shown in Fig. 4.1.

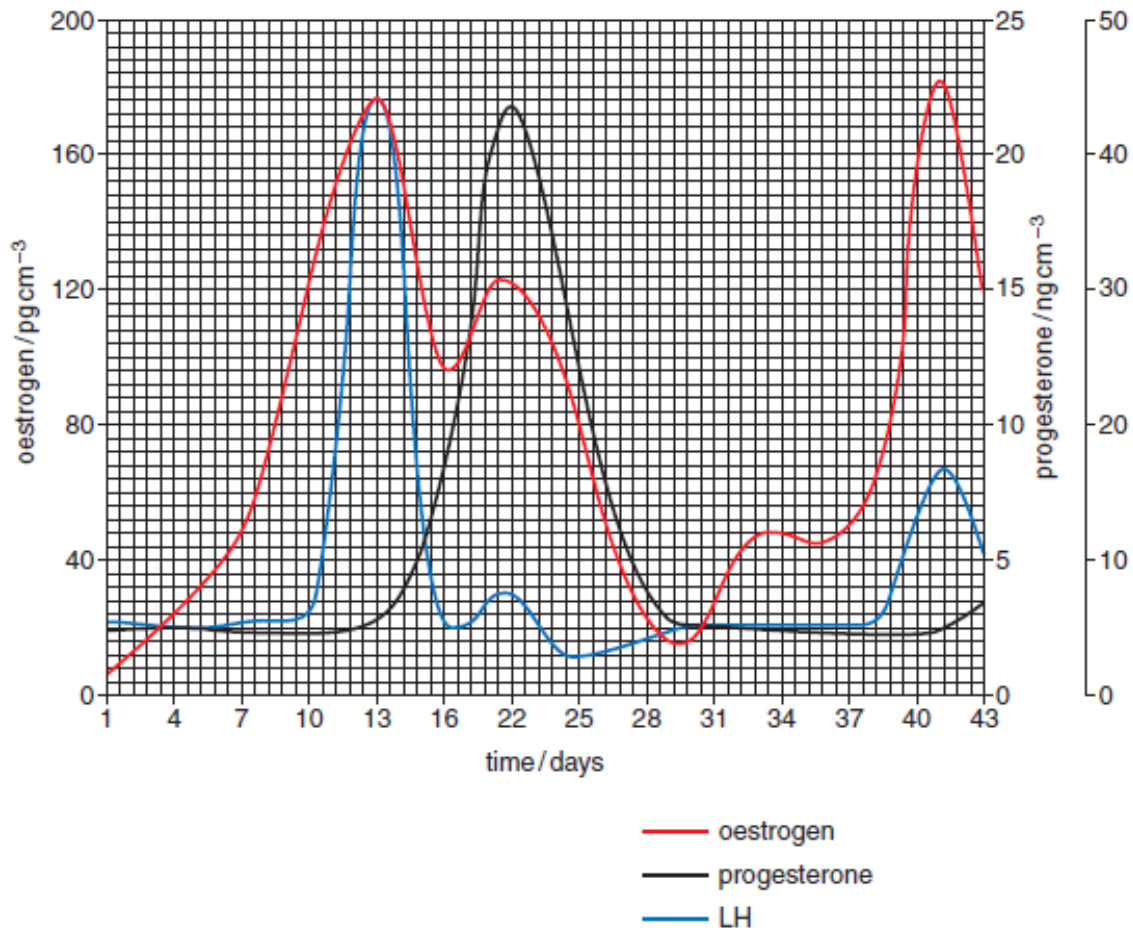


Fig. 4.1

- (i) Estimate the length of the woman's menstrual cycle. Show how you worked out your answer.

answer (days) [2]

- (ii) The luteal phase is the part of the cycle when a corpus luteum is present in the ovaries. It begins immediately after ovulation, and ends when menstruation starts. Use Fig. 4.1 to suggest when the luteal phase began and ended.

began ended [2]

(iii) Name the organ that secretes LH.

..... [1]

(iv) Describe the roles of LH in the menstrual cycle.

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(b) An investigation was carried out to determine whether the ability of a woman to perform a task involving spatial ability varied at different times of her menstrual cycle.

The investigation involved 12 women. They each performed 24 similar spatial tasks on day 2 and day 22 of their menstrual cycle, for six successive cycles. The tasks involved mentally rotating 3-D shapes.

The researchers used two methods to determine the phase of the menstrual cycle.

- Each woman was asked when her previous menstrual period had begun.
- After each test, a blood sample was taken and the concentrations of oestrogen, progesterone and LH were measured.

(i) Suggest why the researchers used two methods to determine the phase of the menstrual cycle.

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(ii) The mean score for women taking the tests on day 2 of their cycle was 10.50 out of 24. The mean score for women taking the tests on day 22 of their cycle was 7.38 out of 24.

Discuss whether or not these results support the hypothesis that the concentration of oestrogen in the blood affects the ability to perform spatial tasks.

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[4]

[Total: 14]

5.

(a) Outline the differences in the process of gametogenesis in a man compared with that in a woman.

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[3]

(b) The hormone testosterone is secreted by Leydig cells in the testis. These cells form an endocrine gland.

Explain what is meant by an *endocrine gland*.

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[2]

- (c) In 2009, a research laboratory for family planning in Beijing announced that it had injected 1000 healthy, fertile men with testosterone over a two-year period and found that only 10 of the men were then able to father a child. The men's normal fertility was restored six months after their last injections.

The injections, each of 500mg of testosterone, resulted in a reduced production of follicle stimulating hormone (FSH) and of luteinising hormone (LH) in the injected men.

Describe the **similarities** between the effect of these testosterone injections on a fertile man with the effect of the oestrogen/progesterone contraceptive pill on production of FSH and LH by a fertile woman.

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..... [3]

[Total: 8]

6.

- (a) Hormones are secreted by endocrine glands.

Explain what is meant by the term *endocrine gland*.

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..... [2]

- (b) Fig. 5.1 shows the changes in concentration in the blood of follicle stimulating hormone (FSH) and luteinising hormone (LH) during the first half of the menstrual cycle.

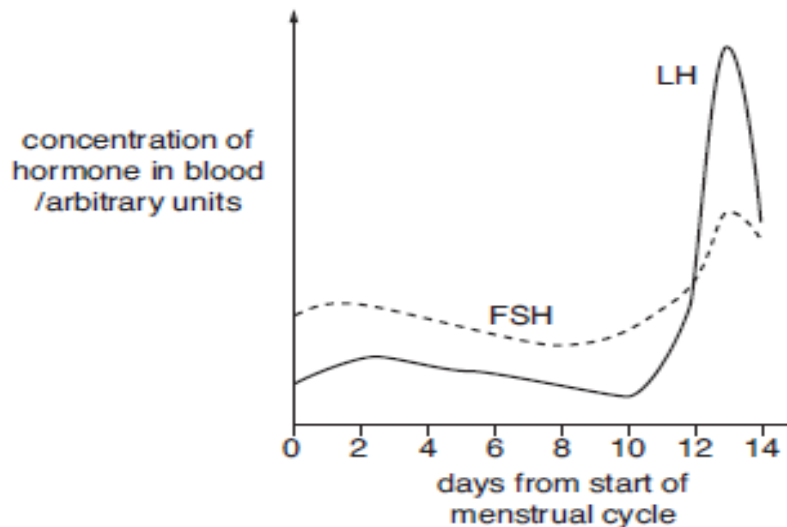


Fig. 5.1

With reference to Fig. 5.1, describe,

- (i) the changes that take place in the ovary during this time, as a result of the action of FSH

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..... [2]

- (ii) the role of LH.

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..... [1]

- (c) In preparation for in-vitro fertilisation (IVF), women are injected with FSH. Explain why treatment with FSH is a necessary preparation for IVF.

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..... [2]

- (d) The standard treatment with FSH and clomiphene (clomifene) causes significant side-effects. Clomiphene occupies oestrogen receptors, blocking a negative feedback mechanism.

- (i) Explain briefly what is meant by *negative feedback*.

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..... [1]

- (ii) Outline the feedback mechanism that is blocked by clomiphene.

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..... [1]

- (e) Recently a so-called 'mild' treatment has been introduced in the hope of avoiding the side-effects of the standard treatment. This treatment does not use clomiphene. Instead, an antagonist to LH secretion is used.

The days in the first half of the menstrual cycle on which injections of FSH and clomiphene are given in the two treatments are shown by asterisks (*) in Fig. 5.2.

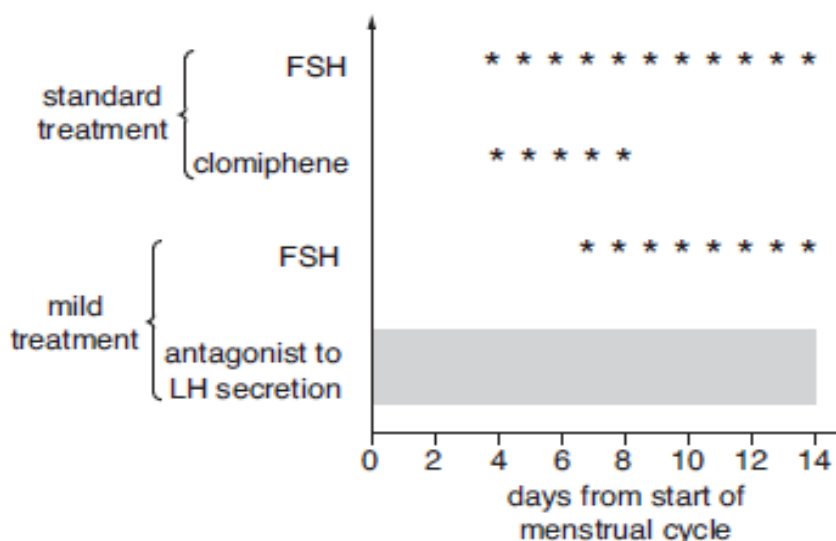


Fig. 5.2

- (i) With reference to the concentrations of LH shown in Fig. 5.1, show, using an asterisk on Fig. 5.2 when the antagonist to LH secretion should first be given.

Put your asterisk into the grey area on Fig. 5.2. [1]

- (f) The average dose of FSH given in the mild treatment is 1300 international units (IU), compared with an average dose of 1800 IU in the standard treatment. This could lead to the mild treatment being less effective.

The outcomes of an investigation into the two treatments are shown in Table 5.1.

Table 5.1

	mild treatment	standard treatment
mean number of oocytes harvested per treatment cycle	6.7	8.5
mean number of embryos produced per treatment cycle	2.8	3.8
percentage of pregnancies resulting in live birth	43.4	44.7

With reference to Table 5.1, compare the effectiveness of the two treatments.

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- (g) FSH consists of two polypeptide chains which are encoded by genes on different chromosomes. The two genes, together with their promoters, have been inserted into bacteria to produce the hormone used in fertility treatments.

Explain briefly why promoters need to be transferred into the recipient bacteria together with the two genes for the FSH polypeptides.

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..... [2]

[Total: 16]

7.

(a) Complete Table 5.1 to show, for each of the two hormones, follicle stimulating hormone (FSH) and progesterone,

- the site of secretion
- the target tissue(s)
- the action of the hormone during the human menstrual cycle.

For
Examine
Use

Table 5.1

hormone	site of secretion	target tissue(s)	action during human menstrual cycle
FSH

progesterone

[6]

(b) Explain the biological basis of the oestrogen/progesterone contraceptive pill.

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[Total: 9]

8. (a) Fig. 5.1 shows a section through part of a human testis.

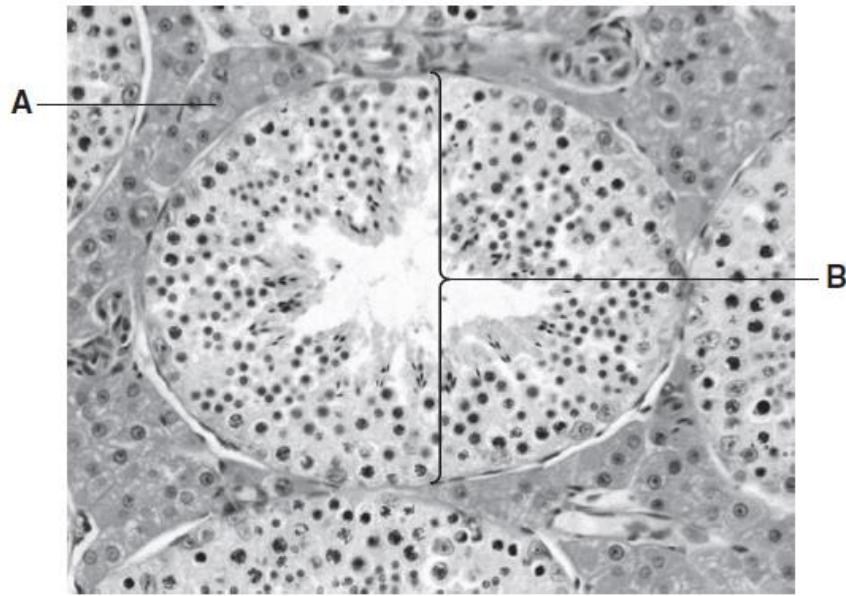


Fig. 5.1

Name structures **A** and **B**.

A

B

[2]

- (b) Spermatogenesis, the production of sperm, begins in the testes of a boy around the age of 11 and can continue for the rest of his life.

Fig. 5.2 outlines the sequence of events that occur during spermatogenesis.

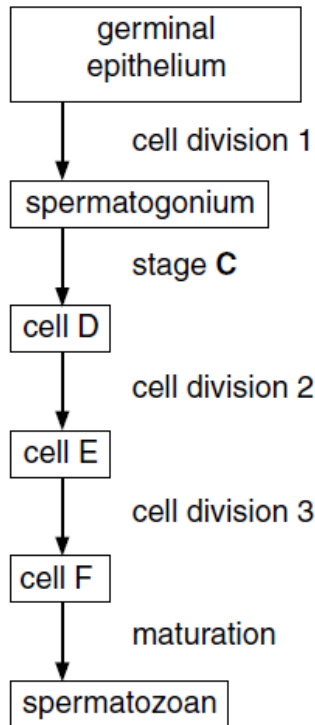


Fig. 5.2

With reference to Fig. 5.2,

- (i) state which cell division is mitotic,
 [1]

- (ii) state which cells are haploid,

 [2]

- (iii) state what is happening to the cell during stage C.
 [1]

- (c) The middle piece of a spermatozoan contains many mitochondria.
 Suggest why a spermatozoan needs so many mitochondria.

 [2]

(d) Some couples have difficulty in conceiving. This could be due to a problem with either the male or female reproductive systems.

(i) Suggest reasons why a man may be infertile.

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..... [3]

(ii) *In vitro fertilisation (IVF)* is a widely used treatment for infertility.

Explain what is meant by the term *in vitro fertilisation*.

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(iii) At one IVF clinic, over 1000 treatment cycles were monitored. The number of live births was recorded as a percentage of the number of treatment cycles for each age group. The results are shown in Table 5.1.

Table 5.1

age of women/years	percentage of live births per treatment cycle
under 34	27.6
34 to 36	22.3
37 to 39	18.3
40 to 42	10.0
above 42	less than 5.0

The data in Table 5.1 show that there is a decrease in the percentage of live births per treatment cycle with increasing age.

Explain this trend.

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..... [3]