APPLICATIONS ON SPERMATOGENESIS

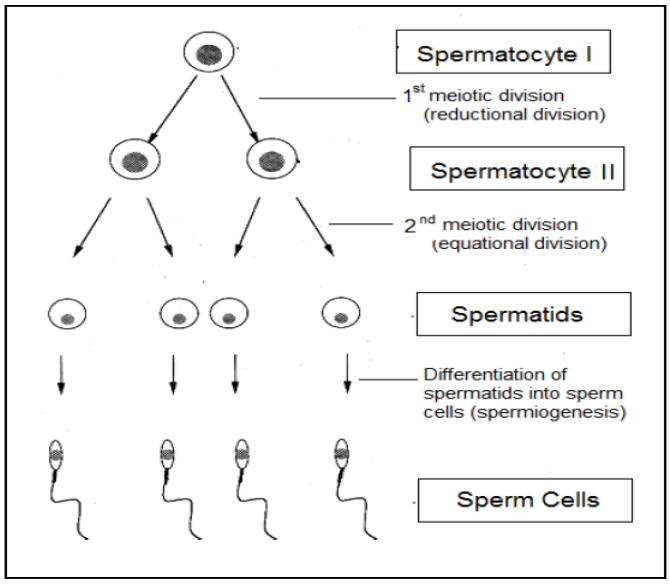
Exercise 1

Mr. X and Mr. Y are two adult sterile men. We perform different tests to specify the origin of this defect. Document 1 shows certain stages of spermatogenesis. The germ cells, whose names are framed in boxes, are found in the wall of the seminiferous tubules.

1- Describe the different stages of spermatogenesis represented in document 1.

We perform a quantitative study for the amount of DNA of the germ cells extracted directly, by biopsy, from a fragment of the testicles of these two sterile men and that of a fertile man Mr. Z. Three different populations of germ cells are obtained. The number of each cell population, as well as the amount of DNA in each of them are shown in document 2.

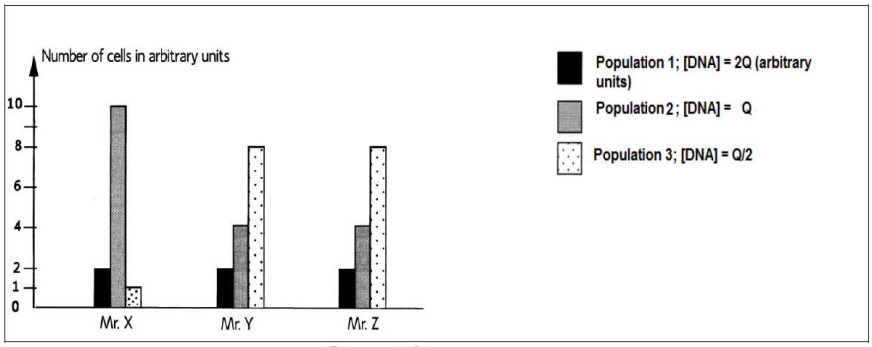
2- Indicate the germ cells corresponding to each of the three populations shown in document 2. Justify the answer.



Document 1

3- Explain the variation of the number of germ cells of the three populations in the fertile man Mr. Z.

4- Determine, by referring to document 2, the cause of sterility of Mr. X.



Document 2

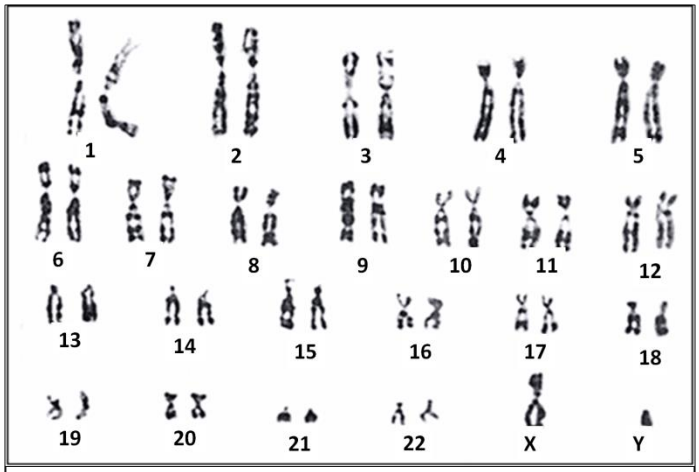
II-) Sex determination

The acquisition of a phenotypically differentiated and functional sex in done in many steps starting from the embryonic life until the puberty.

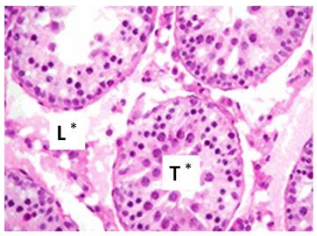
A study is done on an individual who has a particular abnormal phenotype: his external genital organs are feminine but his breast is not developed and he does not show menstruations (cycles).

The internal exam reveals the absence of female gonads (ovaries) and genital tracts. In contrary, he has 2 male gonads (testicles) in an internal position and a reduced male genital tracts.

Document 1 shows the karyotype of this individual.

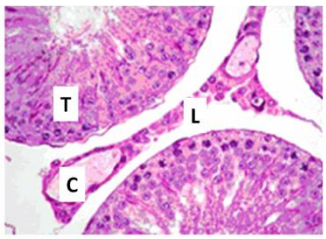


Document 1



L *: Leydig cells of low activity
T *: seminiferous tubule

Cross section of testicles having the same structure as the studied individual



L : Leydig cells
T : seminiferous tubule
C: blood capillaries

Cross section of testicles having normal structure

Observations are done at the same magnification (x 200)

Document 2

1- Specify the genetic sex of this individual.

Document 2 shows a microscopic observation of sections of testicles of an individual having the same abnormality and another of a normal individual .

2- Compare the 2 sections.

To study the functioning of testicles, we measure the concentration of testosterone then we induce a variation of this concentration by injection of a high dose of LH (a pituitary hormone). The results are shown in **document 3**.

	Measurements of the individual	**Measurements of an adult male**
Concentration of testosterone in the plasma (nmol/L) without stimulation	0.69	10 to 38
Variation of testosterone in the plasma (nmol/L) due to the stimulation by injection of LH	Weak increase in the concentration of testosterone	Strong increase in the concentration of testosterone

Document 3

3- Interpret the results of **document 3**.

4- Explain the results using **documents 2** and **3** and the acquired knowledge.

Document 4 summarizes the role of testosterone.

The testes are endocrine glands that are specialized in the production male hormones. These hormones are synthesized by Leydig cells located between the seminiferous tubules. The most active hormone is testosterone which is responsible for the maturation of genital organs at puberty, the activation of spermatogenesis, and the appearance and maintenance of secondary sexual characteristics (barb, muscle development, voice maturation …).

Document 4

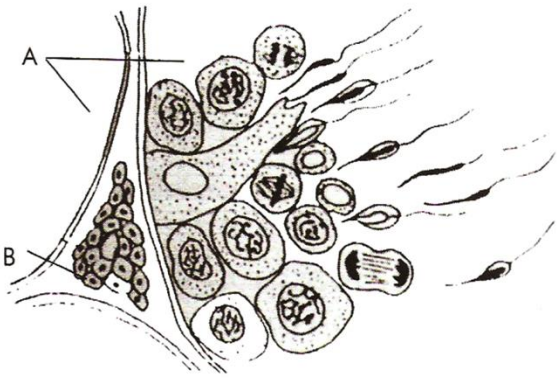
5- Using documents **3** and **4**, determine whether the individual has a normal spermatogenesis and presents male sexual characteristics.

III-Secondary sexual characteristics of roosters (6 pts)

In order to specify the secondary sexual characteristics of roosters, the following experiments are performed.

Experiment 1:

We irradiate the testicles of a rooster. The **zone A (document 1)** is destructed and the animal becomes sterile while the **zone B** is not destructed and secondary sexual characteristics (morphological, physiological and behavioral differences between males and females) persist.



Document 1

Experiment 2:

We castrate (ablation of testicles) a rooster before reaching the sexual maturity, we obtain a capon which presents the following characteristics:

- The erected organs remain of small size.
- The sexual instinct does not appear.
- The capon cocks as a hen.
- The animal becomes fat, it conserves the body of a rooster, and the plume is not modified.

Experiment 3:

We graft fragments of testicles on the capon. We obtain, after few weeks, the results of **document 2**.

Mass of the graft (g)	Results
0.15	Normal erected organs
0.25	Normal erected organs and singing
0.3	Normal erected organs, singing, and sexual instinct
0.35	All the characteristics of the rooster
Document 2	

1- Interpret the experiments 1 and 2.
2- What can you deduce from experiment 3. ?

Experiment 4:

We isolate a substance, the testosterone, from the testicles of a fertile rooster.

Document 3 shows the variation of the length of the crest as a function of the injected testosterone dose.

Dose of testosterone (mg)	0.45	1.2	2.5	5
Length of the crest (mm)	5	10	15	20
Document 3				

3- Draw the curve showing the variation of the length of the crest as a function of the injected testosterone dose.
4- Interpret the results.

CORRECTION

Exercise 1 (5 Pts)

1- During the first meiotic division (reductional division), spermatocyte I produces two spermatocytes II that are subjected to the second meiotic division (equational division) , each producing two spermatids. Then, the spermatids differentiate into sperm cells (spermiogenesis). **(1/2 pt)**

2- Population 1 corresponds to spermatocytes I because the quantity Q is duplicated during the S phase of interphase and becomes 2Q in spermatocyte I that has 2n chromosomes of 2 chromatids each**.(½ pt)** Population 2 corresponds to spermatocytes II because after the reductional division of meiosis we obtain spermatocytes II that have n chromosomes each of 2 chromatids corresponding to the quantity Q of DNA**.(½ pt)** Population 3 corresponds to spermatids or sperm cells because after the equational division of meiosis, we obtain 4 cells (spermatids) each having n chromosomes of one chromatid each corresponding to the quantity Q/2 of DNA. This same quantity remains constant after spermiogenesis that gives sperm cells. **(½ pt.) 3-** In the fertile man, the number of germ cells is doubled from 2 to 4 then to 8 passing from population 1 to population 3 because the number of cells is doubled after each meiotic division. Each spermatocyte I produces 2 spermatocytes II and each spermatocyte II produces 2 spermatids (1-2-4) **(1/2 pt)**

4- In the sterile man X, the number of spermatocytes I is the same as in the fertile man (2 a.u.), but the number of spermatocytes II in the sterile man is much higher than that in the fertile man (10 a.u >4 a.u) . On the other hand, the number of spermatids or sperm cells in the sterile man is abnormally lower than that in the fertile man (1 AU < 8 AU). Therefore, not all spermatocytes II had divided into spermatids during meiosis. Hence, the cause of sterility in man X is an abnormal meiosis, which is blocked at the stage of spermatocytes II leading to an insufficient number of sperm cells (oligospermy) **(1 pt)**

5- Document 2 reveals that in the sterile man Y, the number of cells of the three populations is the same as in the fertile man Z; this indicates that meiosis took place normally in man Y, that is why he has a normal number of spermatids and sperm cells, therefore, oligospermy did not happen . **(1/2 pt)** On the other hand, document 3 reveals one type of sperm cell that has a normal flagellum and a normal head, but the middle piece is larger than in the normal sperm cell. This is due to the non elimination of residual cytoplasm **.(½ pt)** Hence, the origin of sterility of man Y is the abnormal spermiogenesis **(1/2 pt)**

II-) The individual is male since it has X and Y as sex chromosomes.

2- The Leydig cells of the individual have a low activity compared to those of the normal individual while the seminiferous tubules of this individual have a diameter smaller than that of the normal individual. In addition, the section of this individual shows the absence of blood capillaries that are present at the normal individual

3- Without stimulation, the concentration of testosterone in the abnormal individual is 0.69 nmol/L while that in the normal individual is 10 to 38 nmol/L. Due to the stimulation by injection of LH, the concentration of testosterone increases weakly in the abnormal individual and strongly in the normal individual.

This indicates that LH stimulates the production of testosterone and this not the case of the abnormal individual.

4- Document 2 shows that the abnormal individual has Leydig cells of low activity. Document 3 shows that the production of testosterone is weak after the stimulation by LH injection. This is explained by the fact that Leydig cells, that secrete testosterone, produce a weak quantity of this hormone in response to the stimulation.

5- Document 4 shows that testosterone is responsible for the maturation of genital organs at puberty, the activation of spermatogenesis, and the maintenance of secondary sexual characteristics. Document 3 shows a weak amount of testosterone even after the stimulation by LH. This indicates that the abnormal individual does not have spermatogenesis or present male sexual characteristics.

III-)1- The irradiation of testicles of the rooster provokes the sterility and the persistence of the secondary sexual characteristics. **This indicates that** zone A is responsible for production of sperm cells while zone B is responsible for secondary sexual characteristics.

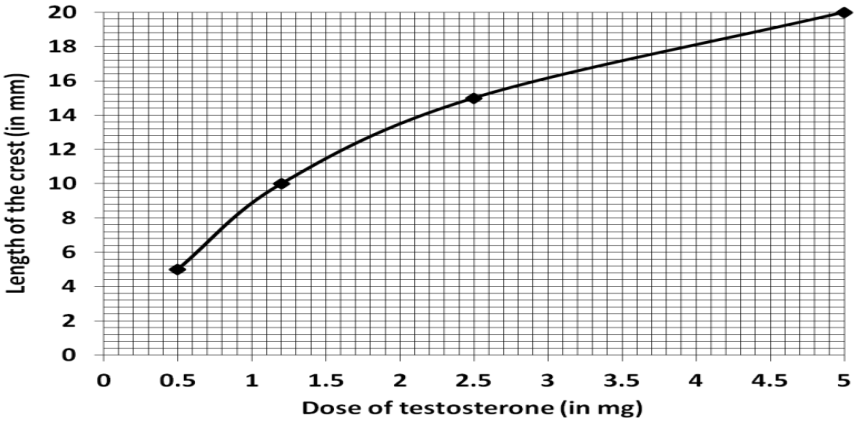
The ablation of testicles provokes the disappearance of the sexual instinct, the reduction of size of erected organs, the animal becomes quiet and cocks as a hen, it becomes fat and it conserves the body and the plume of a rooster.**This indicates that** zone B is responsible for the disappearance of the sexual instinct, the reduction of size of erected organs, and the voice of the animal.

2- The grafting of 0.15 g of fragments of testicles restores the normal erected organs. While, the grafting of 0.25 g restores in addition the singing. Whereas, the grafting of 0.3 g restores also the sexual instinct but the grafting of 0.35 g restores all the characteristics of the rooster.

Then as the mass of grafted fragments increases, the number of restored characteristics increases.

3- Title: variation of the length of the crest (in mm) as a function of the dose of testosterone (in mg)

Scale: vertically: 1 cm → 5 mm; horizontally: 1 cm → 0.5 mg.



4- The length of the crest is 5 mm for 0.5 mg of testosterone, it increases to 20 mm with the increase of the dose of testosterone to 5 mg.

This indicates that the length of the crest increases with the increase of the dose of testosterone.