

اسم: مسابقة في مادة علوم الحياة  
الرقم: المدة: ثلاث ساعات

## Answer the following exercises:

### Exercise 1 (5 points)

### Dysuria

Dysuria is a disease that consists of a difficulty in urinating. It's related to excessive formation of urinary calculi ("stones" in urinary tracts). A family, which has twins suffering from dysuria, consults a doctor. He prescribed many tests whose results are represented in document 1.

Document 2 shows the reactions of metabolism of adenine related to the formation of calculi.

Measurements	Control	Twins
Quantity of adenine in urine excreted within 24h	1.5 mg	40 mg
Dihydroxyadenine (constituent of calculi)	Not detected	High quantity
Amount of active enzyme APRT	100 %	0 %

Document 1

1- Justify, by referring to documents 1 and 2, the dysuria detected in the twins.

In order to clarify the problem observed in the twins, a more detailed analysis concerning members of their family was performed. The pedigree of their family is shown in document 3.

2- Formulate, by referring to document 3, two hypotheses explaining the appearance of the disease in the twins.

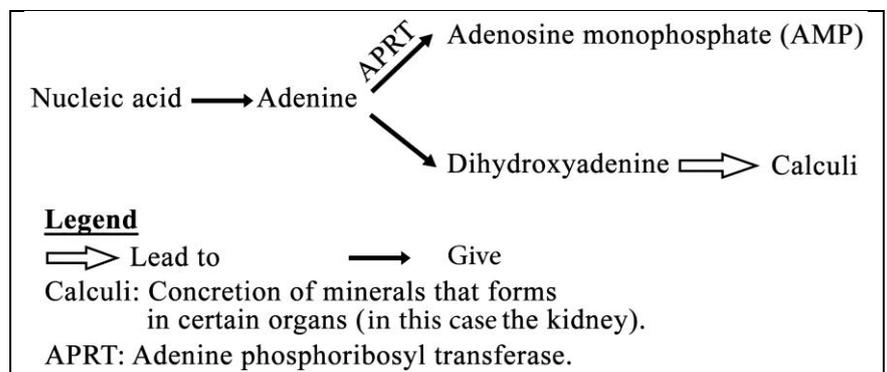
3- Knowing that the gene exists only in two allelic versions, specify if the allele responsible for the disease is dominant or recessive.

4- Show that this gene is not carried by a sex chromosome.

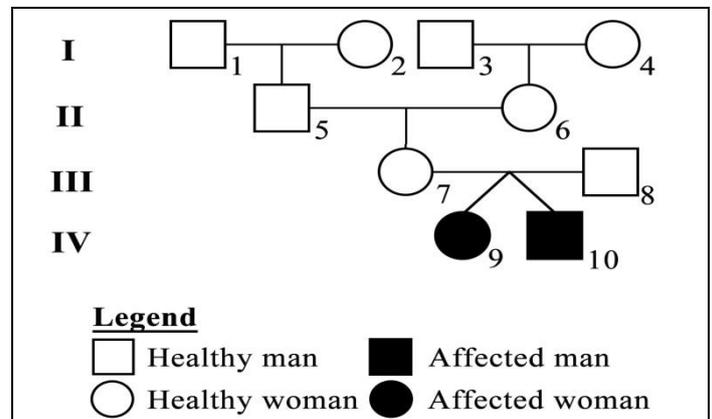
5- Indicate the possible genotype(s) of each of the individuals II and III8. Justify the answer.

Blood tests concerning the amount of active enzyme APRT were performed in members of this family. The results are represented in document 4.

6- Show, by referring to document 4, that at the molecular level, the two alleles are codominant.



Document 2



Document 3

Member of the family	Amount of active APRT
III7	50 %
III8	50 %
II5	50 %
II6	100 %
IV9	0 %
IV10	0 %

Document 4

**Exercise 2 (5 points)**

**AIDS and Treatments**

The human immunodeficiency virus (HIV) is responsible for the weakness of immune defenses in the organism, which leads to the death of affected persons. Document 1 shows the evolution of the concentration of T4 cells, measured in patients contaminated by HIV.

- 1- Analyze the results of document 1.
- 2- Draw out, from document 1, the cause of the appearance of opportunistic diseases.

In order to find a treatment that limits the consequences of opportunistic diseases, a series of studies is performed, some of which are represented below:

**Study 1:** Lymphocytes are removed from a monkey and B, T4 and T8 cells are separated.

- B cells are placed in chambers of culture 1 (1a, 1b and 1c) where molecules of antigen X are present at their bottoms. Only 0.01% of B cells remains fixed to the bottom of each chamber and is not eliminated by rinsing.
- T8 cells are placed in chambers of culture 2 (2a and 2b) where monkey cancerous fibroblasts are present at their bottoms. Only 0.01% of T8 cells remains fixed to the bottom of each chamber and is not eliminated by rinsing.
- Then, lymphocytes activated by the same antigens (X or cancerous fibroblasts) are added to certain chambers.

Document 2 shows the experimental conditions as well as the results.

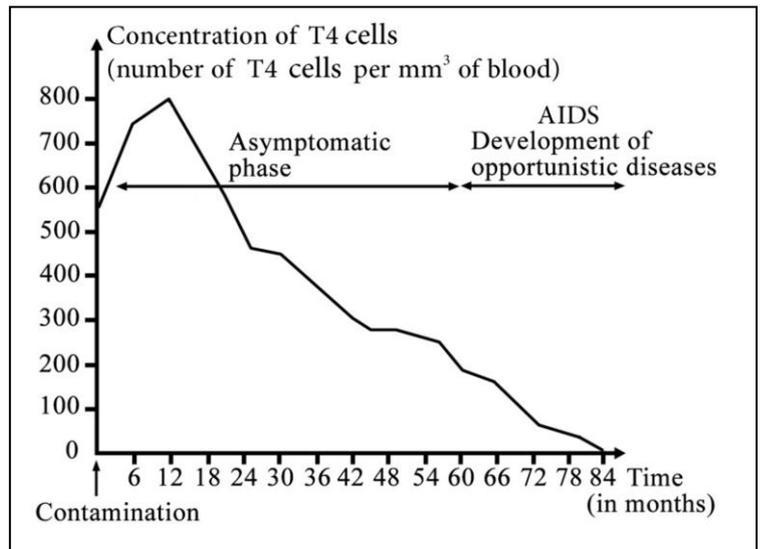
- 3- Interpret the results obtained in document 2.
- 4- Explain, by referring to all what precedes, the appearance of opportunistic diseases observed in document 1.

**Study 2:** Two groups of researchers have produced two treatments.

The first treatment is based on the principle of vaccination against some opportunistic diseases such as pneumonia. This treatment was tested on two categories of patients having a different number of T4 cells. The results are represented in document 3.

In the second treatment, three medicines are administered during 5 years to individuals whose number of T4 cells, at the beginning of treatment, is between 200 and 350 T4 cells/mm<sup>3</sup> of blood. The results are shown in document 4.

- 5- Explain the importance of vaccination.
- 6- Determine if the first treatment is efficient against the development of opportunistic diseases.
- 7- Show that the second treatment may delay the AIDS phase.



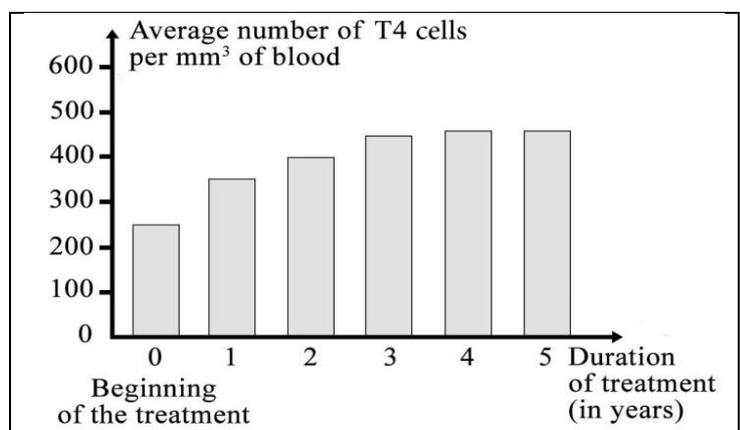
*Document 1*

Chamber	Existing lymphocytes	Added lymphocytes	Result
1a	B cells retained by antigen X	-	No antibodies
1b		Activated T4 cells	Presence of antibodies
1c		Activated T8 cells	No antibodies
2a	T8 cells retained by monkey cancerous fibroblasts	-	No lysis of fibroblasts
2b		Activated T4 cells	Lysis of fibroblasts

*Document 2*

Category	Average number of T4 cells/ mm <sup>3</sup> of blood	production of antibodies
1	> 500	Strong
2	< 200	Weak

*Document 3*



*Document 4*

### Exercise 3 (5 points)

## Analgesia without Morphine

Morphine is an analgesic substance (pain-killer) that acts at the level of enkephalin and endorphin synapses. The latter substances are neurotransmitters that are naturally produced in the brain and in the spinal cord, while morphine is exogenous. Its excessive usage causes physical and psychological dependence as well as respiratory and digestive troubles.

1- Explain how morphine acts at the level of enkephalin synapses.

In order to avoid the secondary effects of the use of morphine, researchers have tried to find other endogenous analgesic substances. Some of their studies are represented in the following experiments.

**Experiment 1:** Researchers have injected serum to rats without or with analgesic, morphine or endorphin.

Then, they put each rat in zone P of a box whose surface is divided into two zones: zone P (periphery) that is covered by sharp ends causing intense pain, and zone S (center) without sharp ends. Then, during three minutes, they measured the average duration during which the rats stayed in zone P. This duration indicates the analgesic effect of the studied substance. Document 1 shows the conditions as well as the results of the experiment.

Animals	Injections	Duration of staying in zone P (sec)
A	-	5
B	Morphine (6 mg/kg)	72
C	Endorphin (6 mg/kg)	5

*Document 1*

2- What can you deduce from experiment 1?

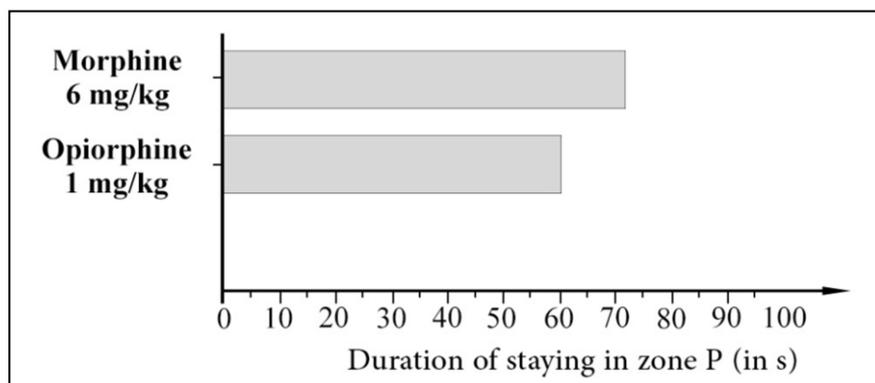
3- Formulate a hypothesis explaining the result obtained upon the injection of endorphin.

**Experiment 2:** Researchers have injected endorphin marked by radioactive tritium in the blood of a group of animals. The performed tests reveal the absence of radioactivity in the brain and in the spinal cord. Moreover, even in blood, endorphin disappears rapidly, but other radioactive molecules appear.

4- Show that experiment 2 explains the result obtained in rats C.

**Experiment 3:** Other researchers of Pasteur institute have identified a new analgesic substance, secreted naturally in the saliva of humans, the opiorphine. They have tested opiorphine on rats. They repeated experiment 1 but they injected opiorphine instead of endorphin. The experimental conditions as well as the results are represented in document 2.

Document 3 shows information concerning opiorphine.



*Document 2*

5- Show, by referring to document 2, that opiorphine is an effective analgesic.

6- Explain how opiorphine acts as an analgesic.

7- Draw out two reasons why opiorphine seems to be a molecule whose therapeutic value is more important than that of morphine.

Opiorphine has an analgesic power for thermal and mechanical pain as well as chronic pain. Opiorphine seems to protect enkephalin from the effects of the enzyme NEP present in the cleft of enkephalin synapses. It is not necessary to increase the doses of opiorphine to obtain the same anti-nociceptive effect. It doesn't cause constipation and its addictive effect is much reduced.

*Document 3*

### Exercise 4 (5 points)

### Female Infertility

Fertilization is not an automatic phenomenon. Only 25% of the sexual intercourses occurring during the fertile period are followed by pregnancy.

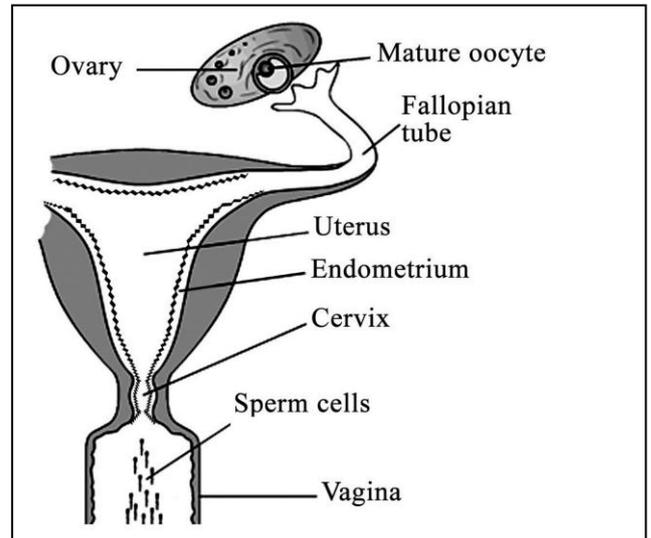
Document 1 shows a part of a female genital duct.

- 1- Indicate the site of fertilization and the role of the uterus.
- 2- Explain briefly the process of fertilization.

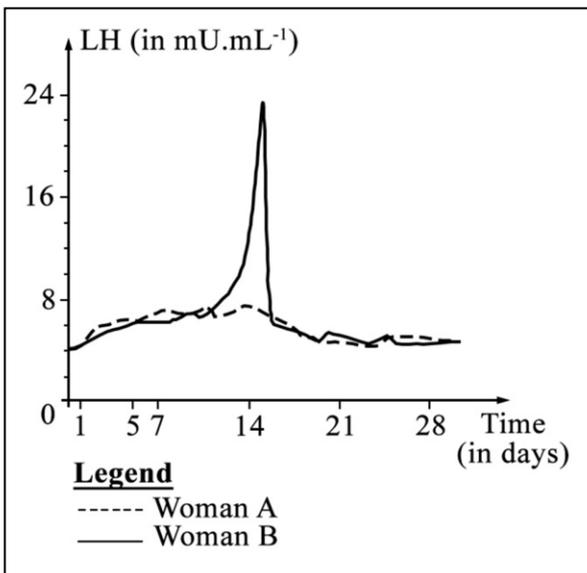
Two women, A and B, consult a gynecologist because of their infertility. In order to determine the origin of their infertility, the doctor prescribed the following tests:

- Measurement of the plasma concentration of LH hormone
- A radiologic exam of the genital duct after introducing an opaque liquid in the genital duct of each of the two women.

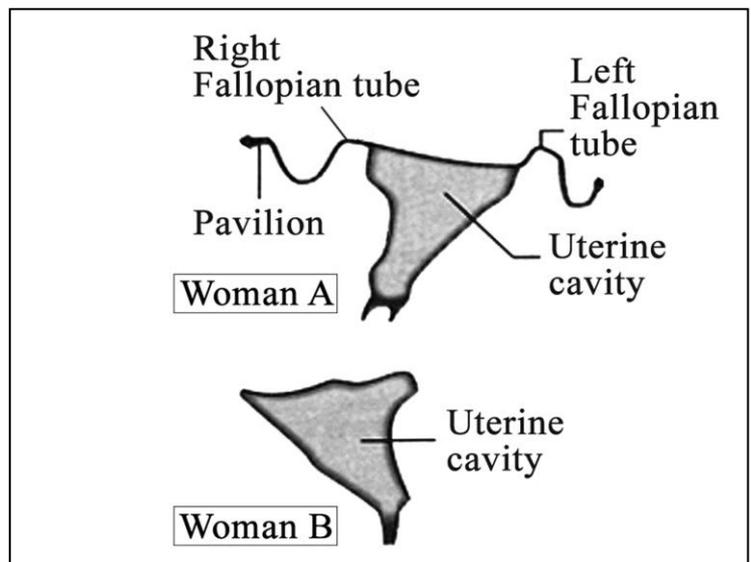
The results are shown respectively in documents 2 and 3.



Document 1



Document 2



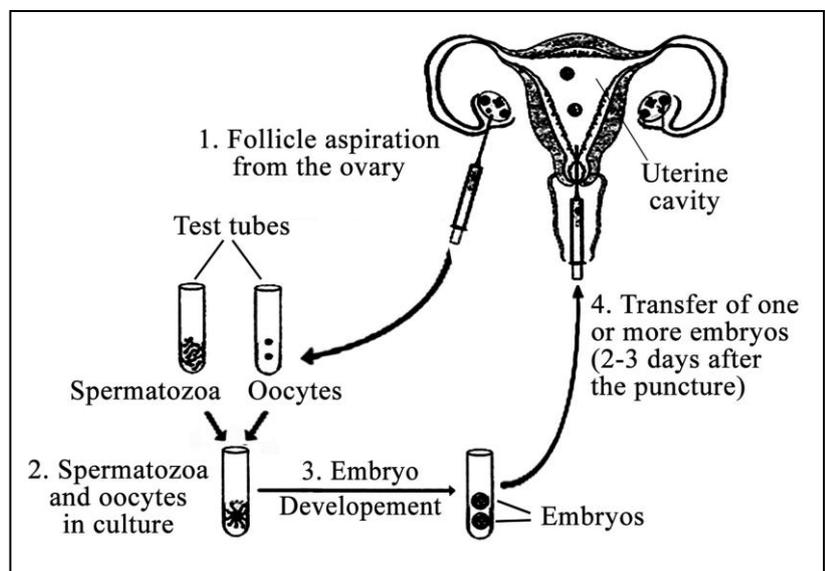
Document 3

- 3- Determine the cause of infertility of each of the women A and B.

After analyzing the results of the performed tests, the gynecologist decides to perform IVF and ET technique in order to solve the problem of one of the two infertile women.

Document 4 shows the different steps of this technique.

- 4- Describe, in a text, the IVF and ET technique.
- 5- Indicate which infertile woman A or B, the IVF and ET technique can solve her problem. Justify the answer.
- 6- Formulate a hypothesis explaining the probable origin of infertility in the second woman.



Document 4

Part of the ex.	Exercise 1 Dysuria	Grade 5 pts
1	The difficulty of urinating in the twins is due to the presence of urinary calculi. The result shows that the amount of active APRT enzyme necessary for the transformation of adenine into adenosinemonophosphate is null (document 1). This blocks the transformation and leads to the accumulation of adenine and its elimination in high amounts in the urine, 40 mg > 1.5 mg (in control). The absence of APRT provokes the formation of dihydroxyadenine in high amounts (not detected) forming calculi leading to urinary difficulties in the twins.	1
2	Hypothesis : The disease is due to a recessive allele carried by the parents. The disease is due to congenital malformation. The disease is related to the mutation of the gene coding for APRT in the twins. The disease is due to a chromosomic aberration	1
3	Individuals IV9 and IV10 suffer from dysuria and descend from normal parents III7 and III8. So, the allele responsible for the disease is carried by the parents but it is masked. Therefore, the allele responsible for the disease is recessive, whose symbol is d, with respect to the normal allele whose symbol is N.	3/4
4	If the gene is located on the non-homologous part of Y, then the disease is transmitted from the father to son, but the male IV10 is diseased while his father is normal. Therefore, the gene is not located on the non-homologous part of Y. If the gene is located on the non-homologous part of X, then the diseased female IV9 having 2X chromosomes should carry 2 alleles for the disease. She should inherit one allele from each parent. So, her father III8 should be carrying the allele responsible for the disease and would be sick but this is not the case. Therefore, the gene is not located on the non-homologous part of X. If the gene is located on the homologous part of X and Y, then parent III8 must be sick and his genotype must be $X^dY^d$ in order to give his daughter IV9 $X^d$ and his son IV10 $Y^d$ . But he is not sick. Therefore, the gene is not located on the homologous part of X and Y. Therefore, this gene is not carried by a sex chromosomes.	3/4
5	The possible genotypes of I1 is N//N or N//d since the normal allele is dominant and can be expressed in the homozygous or heterozygous state. The genotypes of III8 is N//d since the diseased twins IV9 and IV10 who exhibit the recessive phenotype have genotype dd. The recessive allele is only expressed in the homozygous state. They have surely inherited one allele for the disease d from their father III8 and since he is normal he has the allele N.	1
6	Since the gene is carried by an autosome and it has only two allelic versions then the presence of three different amounts of APRT, 100%, 50% and 0% shows the presence of three molecular phenotypes indicating codominance.	1/2

Part of the ex.	Exercise 2 AIDS and Treatments	Grade 5 pts
1	During the asymptomatic phase, the concentration of T4 cells/mm <sup>3</sup> of blood increases from 550 up to 800 just within 12 months after the contamination. On the contrary, this amount decreases from 800 to 200 at the 60 <sup>th</sup> month, the beginning of the appearance of opportunistic diseases until it becomes nil at the 84 <sup>th</sup> month.	1/2
2	The cause of appearance of opportunistic diseases is the low amount of T4 cells, less than 200/mm <sup>3</sup> of blood.	1/2
3	<p>The presence of antibodies is observed in culture medium 1b containing B lymphocytes activated by antigen X and LT4 activated by the same antigen. On the contrary, neither antibody are produced in culture medium 1a containing only B cells activated by antigen X or culture medium 1c containing B cells activated by the antigen and activated T8 cells. This implies that the cooperation only between T4 cells and B cells is indispensable for the secretion of antibodies.</p> <p>Lysis of monkey cancerous fibroblasts is observed in medium 2b containing T8 cells and T4 cells activated by the same antigen. On the contrary, no lysis is observed in culture medium containing only activated T8 cells. This implies that cooperation between T4 and T8 cells is indispensable for cellular lysis.</p>	1
4	<p>Document 2 shows the importance of T4 cells in the activation of specific humoral immune responses whose effectors are B lymphocytes and in cellular immune responses whose effectors are T8 cells.</p> <p>Document 1 shows that the opportunistic diseases appear when the concentration of T4 cells decreases to an amount inferior to 200/mm<sup>3</sup>. Thus, this low amount of interleukin secreted is insufficient to activate proliferation of activated B and T8 cells. This blocks specific immune responses and reduces general immunity of the organism, which renders the environment favorable to the development of opportunistic diseases.</p>	3/4
5	Vaccine ensures the first contact with this antigen and triggers immunological memory. Consequently, the body, after a second contact, develops a secondary response which is more amplified, more rapid and more durable against this antigen.	3/4
6	<p>In the first treatment, the vaccine isn't effective unless the amount of T4 cells/mm<sup>3</sup> of blood is superior to 500 T4 cells/mm<sup>3</sup> (document 3).</p> <p>But opportunistic diseases develop only when the amount is less than 200 T4 cells/mm<sup>3</sup> (2.5 times less than 500). The first treatment is only efficient against pneumonia, one of the multiple opportunistic diseases. Thus this treatment isn't efficient against the development of the opportunistic diseases.</p>	3/4
7	The second treatment ensures the increase in the concentration of T4 cells in blood from 250 to 480 T4 cells/mm <sup>3</sup> between the beginning of treatment and the 5 <sup>th</sup> year (document 4). This doesn't lead to a concentration less than 200 T4 cells/mm <sup>3</sup> characterizing the AIDS phase which prolongs the asymptomatic phase and delays the AIDS phase.	3/4

<b>Part of the ex.</b>	<b>Exercise 3 Analgesia without morphine</b>	<b>Grade 5 pts</b>
<b>1</b>	Morphine is agonist to enkephalin. Morphine has a shape complementary to that of enkephalin receptors. It binds to the enkephalin receptors and inhibits the release of substance P. Thus, it stops the transmission of nerve message associated with pain.	<b>1/2</b>
<b>2</b>	The duration of staying in zone P by animals that haven't received any injection or by animals that have received 6 mg/kg of endorphin is the same 5 sec. This duration is 14 times less than 72 sec which corresponds to the duration of staying in zone P of animals that have been injected by morphine. Therefore, endorphin seems not to have an analgesic effect in comparison with morphine which is a strong analgesic.	<b>3/4</b>
<b>3</b>	Hypothesis: Endorphin cannot cross the blood brain barrier to act at the level of endorphin synapses. OR Endorphin is decomposed rapidly before reaching the endorphin synapse. OR Endorphin has a short term effect.	<b>1/2</b>
<b>4</b>	Experiment 2: shows a rapid transformation of endorphin into other substances. This leads to its rapid disappearance in blood and prevents its arrival to the spinal cord and the brain. Similarly, it shows that the radioactivity remains at the level of the blood which explains the inability of endorphin to cross the blood brain barrier that is neither permeable to this substance nor to its products. This explains the ineffectiveness of endorphin as an administered exogenous analgesic.	<b>3/4</b>
<b>5</b>	The duration of staying in Zone P of animals injected by opiorphine is 62s which is less than 72s which is the duration of staying of animals injected by morphine, despite the injection of 1 mg/kg of opiorphine. This quantity is 6 times less than 6 mg/kg which corresponds to the amount of injected morphine. Thus opiorphine even in small doses is an efficient analgesic.	<b>3/4</b>
<b>6</b>	Since opiorphine seems to protect enkephalin from the effects of the enzyme NEP that is present in the cleft of enkephalin synapses, this analgesic decreases the degradation of this neurotransmitter after its fixation on its corresponding postsynaptic receptors. This leads to an increase in the concentration of enkephalin and its persistence in the synaptic cleft and on the receptors. Thus, the action of enkephalin that consists of inhibiting the transmission of pain messages is enhanced. That is why, the analgesic effect, observed in doc 2, revealed by the duration of staying, 62s, is close to that of morphine, 72s.	<b>3/4</b>
<b>7</b>	Opiorphine acts at small doses (6 times < than that of morphine) to have a certain analgesic effect. The secondary effects of opiorphine are reduced compared to that of morphine: no constipation, no addiction... Opiorphine is a natural substance secreted by the body unlike morphine which is exogenous. It acts by amplifying the natural analgesic capacities of the organism (amplifies the action of enkephalin that is also a natural endorphin), contrary to morphine which reduces them.	<b>1</b>

Part of the ex.	Exercise 4 Female Infertility	Grade 5 pts
1	Fertilization occurs at the level of the fallopian tubes. The uterus is the site of implantation of the embryo and the development of the fetus.	1/2
2	One of the spermatozoa that surround oocyte II blocked at metaphase II arrives to the zona pellucida. Pendunculated cells retract. The release acrosomal enzymes digest the zona pellucida. The head of the sperm binds to the oocyte membrane. Then, oocyte II gets activated and liberates the content of cortical granules thereby forming the fertilization membrane. Oocyte II continues the second division and releases the second polar body. The sperm is totally absorbed. Male and female pronuclei are formed and then they unite (karyogamy). The zygote is formed.	1
3	Document 2 shows that woman A has an amount of LH almost constant, fluctuating between 4 and 7 mU/mL without any peak on the 14 <sup>th</sup> day necessary for ovulation. However, document 3 shows that woman A has a uterus and 2 open tubes (oviducts) allowing opaque liquid to pass through. Thus this woman doesn't have any problem in her genital duct. Hence, Mrs A problem is the absence of ovulation due to the absence of LH peak. Document 2 shows that woman B has a normal variation of the amount of LH with a peak of 24 mU/mL in the middle of the cycle thereby provoking ovulation. On the contrary, document 3 shows a uterus without fallopian tubes. These tubes are invisible when radiology was performed, they didn't allow opaque liquid to pass through. Hence, the problem of woman B is blocked fallopian tubes and not hormonal.	1 1/2
4	Follicles are aspirated from ovaries; they are put in one test tube. Sperm cells are put in another one. Then, sperm cells and oocytes are cultured together. Embryos are obtained after embryo development. Two to three days after the puncture, one or more embryos are transferred to the uterine cavity.	1
5	Woman B can be treated by IVF and ET technique since this woman undergoes ovulation but her fallopian tubes are blocked, so sperm cells can't reach oocytes. This technique allows the sperm cells to fertilize the oocyte outside the woman's body.	1/2
6	Hypothesis : GnRH Receptors on pituitary cells are deficient. OR Amount of estradiol is not enough to exert a positive feedback on pituitary cells. OR Pituitary cells have a small number of estradiol receptor.	1/2