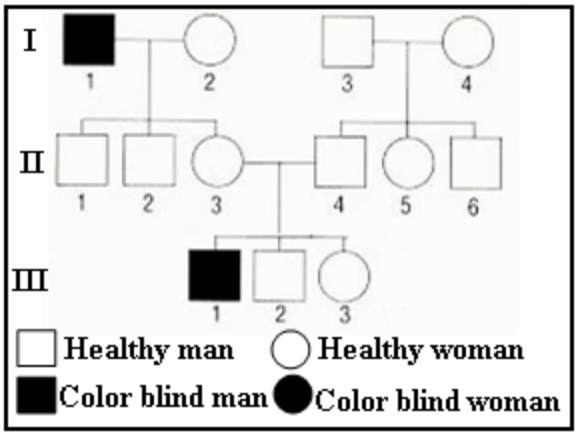
المركز التربوي للبحوث والإنماء	الهيئة الأكاديميّة المشتركة قسم : العلوم	المادة: علوم الحياة- لغة إنكليزية الشهادة: الثانوية العامة الفرع: علوم الحياة نموذج رقم ٢٠١٩/١ المدّة : ثلاث ساعات

Answer the following four exercises.

Exercise 1 (5 points) **Case of Two Phenotypic Abnormalities**

Color blindness or Daltonism, a hereditary abnormality, is characterized by difficulty in distinguishing certain colors. This abnormality is due to a gene located on X chromosome. Document 1 shows the genealogical tree of a family where a couple with normal vision (II_3-II_4) has a color blind boy (III_1), a normal vision boy (III_2) and a normal vision girl (III_3).

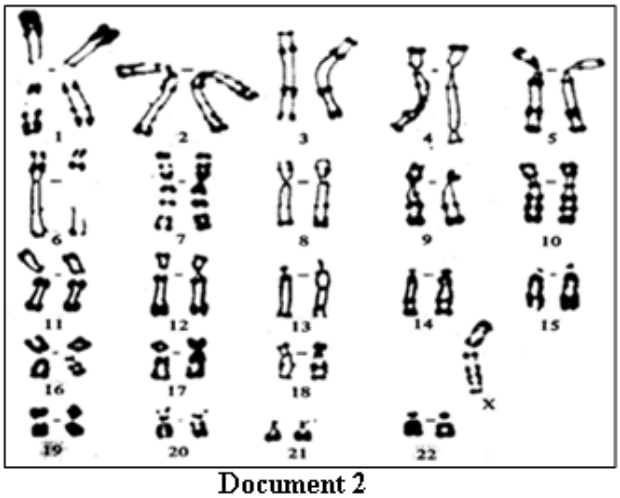


Document 1

1. Specify if the allele coding for this abnormality is dominant or recessive.
2. Indicate the genotypes of the individuals II_3, II_4, and those of their children.
3. Determine the risk for this couple to have:
   3.1. A color blind girl.
   3.2. Another color blind boy.

This couple gave birth to another girl who is color-blind.

4. Explain why the birth of this color blind girl from this normal couple is unexpected.


Document 2

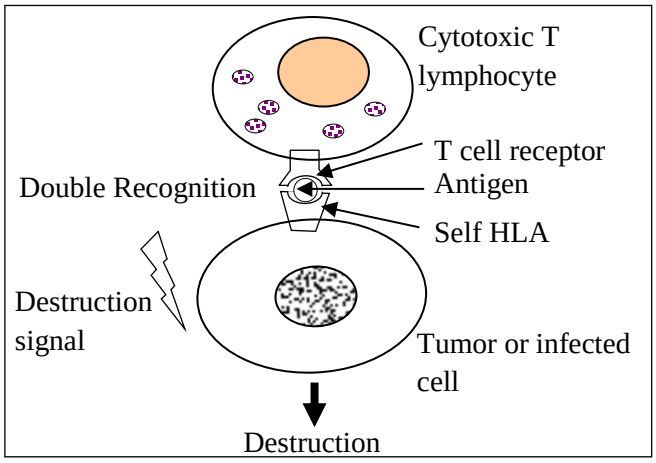
Document 2 shows the karyotype of this color blind girl.

5. Show that this karyotype reveals in this girl an abnormality other than color blindness.
6. Determine, in this girl:
   6.1. The parental origin of daltonism.
   6.2. The parental origin of her other abnormality.

7. Schematize, taking into consideration only one pair of autosomes and the sex chromosomes:
   7.1 The karyotype of the color blind girl.
   7.2 The karyotypes of the parental gametes which are responsible for the birth of this color blind girl.

Exercise 2 (5 points) **Pregnancy and Immune Defense**

The fetus is a kind of temporary allograft that survives for nine months. However, fetal cells should be non-self for the mother's immune system because they express protein markers different from those of the mother. A research is performed to discover some mechanisms that allow the fetus to escape the mother's immune system during pregnancy.



Document 1

The fetus is surrounded by a tissue called trophoblast, which isolates it from the maternal immune system. The trophoblast cells do not express HLA class I proteins that are mainly involved in the cytotoxicity of certain lymphocytes against the non-self (Document 1).

1. Explain the mechanism of cellular cytotoxicity of Tc lymphocytes.

2. Determine the cause of ineffectiveness of Tc lymphocytes against the fetal cells.

Moreover, the trophoblast cells carry on their surface and secrete in the medium a protein called HLA-G, a non-polymorphic molecule. A hypothesis assumes that this HLA-G protein prevents trophoblast cells from being recognized by the immune system as non-self-cells.

In order to validate this hypothesis, experiment 1 is performed. The conditions and the results of this experiment are presented in document 2.

Experiment 1:

Medium	**A**	**B**	**C**
Conditions	Immune cells of the mother	Immune cells of the mother	Immune cells of the mother
	Non-self cells	Trophoblast cells carrying HLA-G molecules	Trophoblast cells carrying HLA-G molecules blocked by a chemical substance
Results	Lysis of the non-self cells	No Lysis of trophoblast cells	Lysis of trophoblast cells

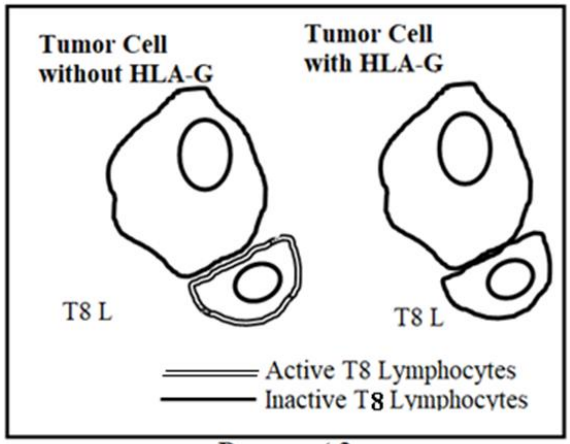
Document 2

3. Do the obtained results validate the tested hypothesis? Justify the answer.

Some cancer cells also produce HLA-G protein. In an attempt to find out if this molecule allows the cells to escape the action of the T lymphocytes, the following experiments, 2 and 3, are performed.

Experiment 2: Macrophages are placed in contact with the non-self cells carrying HLA-G. Their capacity to activate T4 lymphocytes becomes reduced.

Experiment 3: T8 lymphocytes are cultured in the presence of two types of cancer cells. The results are shown in document 3.



Document 3

4. Determine, by referring to each of the experiments 2 and 3, how the HLA-G contributes to making the specific immune response less effective.

Exercise 3 (5 points) Maintaining Resting Potential

Nerve cells have a potential difference (pd) of -70 mV across the plasma membrane. This resting potential is correlated with differences in ion concentrations on either side of the plasma membrane, ECM and ICM, (Document 1).

	Na^+(mmol/L)	K^+ (mmol/L)
Extracellular medium(ECM)	140	5
Intracellular medium(ICM)	14	140

Document 1

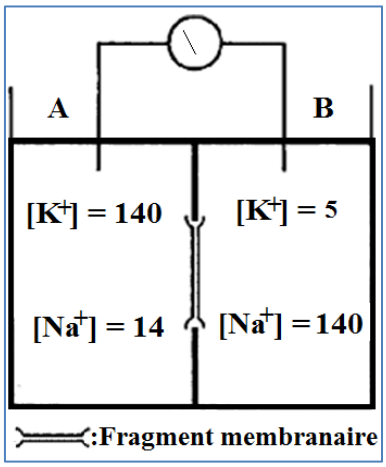
1. 1.1. Compare the ionic composition of the two media (Document 1).

1.2. What can you draw out?

It is hypothesized that the plasma membrane is impermeable to ions. In order to test this hypothesis, experiments 1 and 2 are performed.

Experiment 1: Two compartments A and B are separated by an impermeable teflon membrane pierced with a hole. This hole is covered with a fragment of plasma membrane (Document 2). Initially, the Na^+ ions in compartment B are radioactive. After time "t" a quantity of radioactive Na^+ "Q1" is detected in in compartment A.

Experiment 2: The above experiment (experiment 1) is repeated but radioactive K^+ is initially placed in compartment A. After time "t" "Q2" of radioactive K^+, is detected in compartment B, where Q2 is greater than Q1.



Document 2

2. Is the tested hypothesis valid? Justify the answer.

3. Justify the direction of ion diffusion through-this membrane.

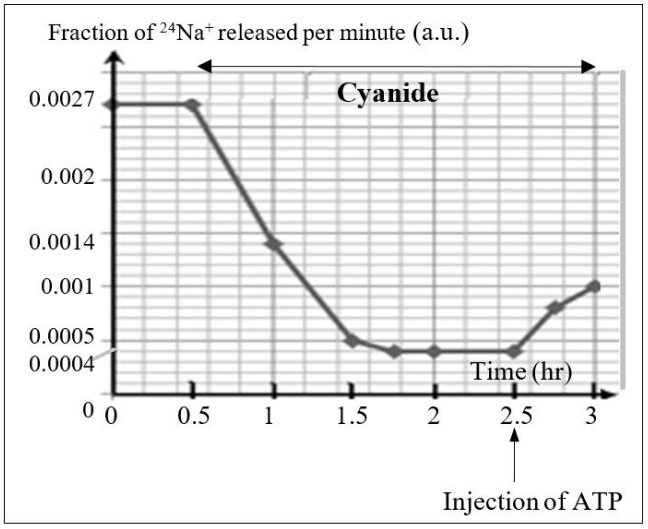
4. Draw out the origin of membrane resting potential.

If in the previous setup, the diffusion continues; the differences in ionic concentrations should disappear and the resting potential too. However, in living cells, the resting potential is maintained. In order to understand the mechanism that is responsible for maintaining this resting potential, experiments 3 and 4 are performed.

Experiment 3:

An axon is injected with radioactive $^{24}Na^+$ ions. Then, it is immersed in a solution containing cyanide, a poison that blocks all reactions that require energy (ATP) in the cell. At time 2.5hrs the axon is injected with ATP, energy molecule used by the cells. The level of $^{24}Na^+$ ions released by the axon is measured (Document 3).

Experiment 4: An axon is placed in a medium enriched with radioactive $^{40}K^+$ ions. Radioactivity appears rapidly in the cytoplasm of the axon. Later, this same experiment 4 is repeated in the presence of cyanide. Radioactivity is not detected in the cytoplasm of the axon.



Document 3

5. Construct a table showing the results of document 3.

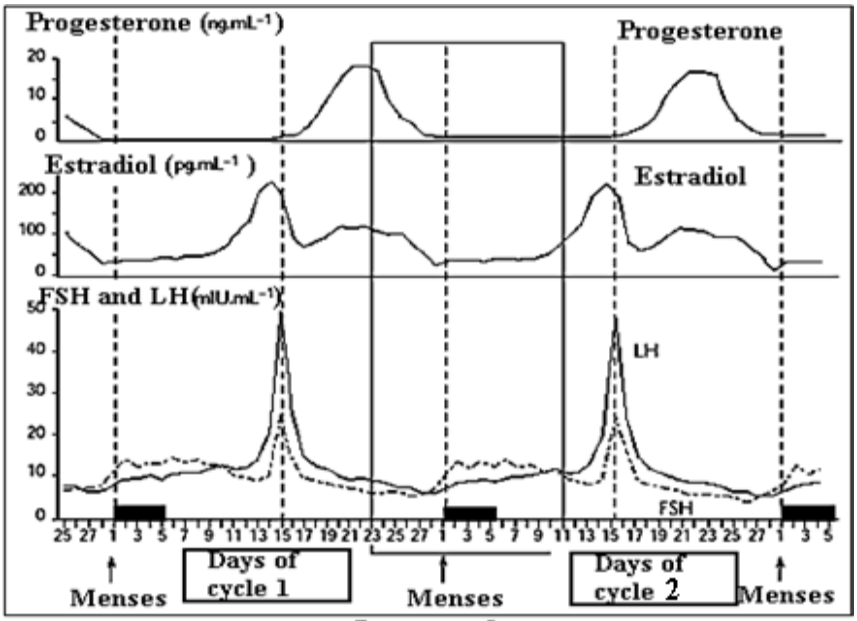
6. Interpret the results of the experiments 3 and 4.

7. Name the protein molecule involved in the active transport of ions across the plasma membrane.

Exercise 4 (5 points) Hormonal Influence on the Renewal of Sexual Cycle

A research is performed to explain the hormonal mechanisms involved in the renewal of the ovarian cycle, on the first day of the menses.
In fact, in women, the beginning of each cycle is marked by the appearance of menses (document 1). This menses results from the sloughing off of the uterine mucosa that occurs if no embryo implantation takes place during the luteal phase (day 15-day 28) of the preceding cycle.

Document 1 shows the evolution of the secretion of the anterior pituitary hormones, FSH and LH, and ovarian hormones, estrogen and progesterone, during two consecutive cycles in the woman.

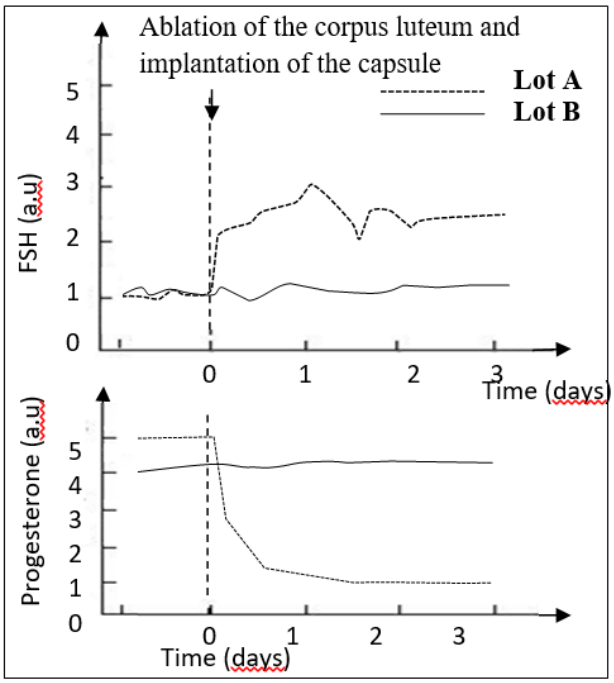


Document 1

1.1 What are the characteristics of the luteal phase concerning hormone secretions, document 1?
1.2 Draw out the type of feedback control exerted by the ovarian hormones on the pituitary gland during the luteal phase.

In order to show the effects of progesterone during the luteal phase of the cycle, the following experiment is performed.

Few days before the end of the cycle, ewes in lots A and B are subjected to the ablation of their corpus luteum followed by the implantation of a capsule under the skin of each of them according to the following conditions:
- For each ewe in lot A, an empty capsule.
- For each ewe in lot B, a capsule containing progesterone, releases continuously and slowly their content in the body.
The concentrations of FSH and progesterone in the plasma are measured during the days following the implantation of the capsules (Document 2).
Note: The evolution of the plasma concentration of LH and FSH hormones is synchronized during the experiment.



Document 2

2. What can you deduce from the obtained results, document 2?
3. Explain, by referring to the acquired knowledge, the mechanism that permits the renewal of an ovarian cycle.

The implantation of the capsule containing progesterone can be used as a contraceptive method.

4. Explain the mode of action of this contraceptive capsule.

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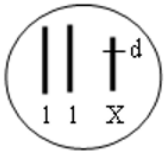
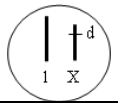
أسس التصحيح:

Ex	Part	Exercise 1 (5 points) Case of Two Phenotypic Abnormalities	Mark
1	1	The allele coding for color blindness is recessive since the normal parents $II_3$and II_4 have a color blind boy III_1. Since this gene is located on the sex chromosome X and since this latter chromosome is inherited from his mother who is normal, thus the mother possesses the allele responsible for colorblindness which is masked by the allele responsible for normal vision. N: normal dominant allele d: recessive color blind allele	0.5
	2	The genotype of the father II_4 and that of the boy III_2 is : $X^N//Y$ The genotype of the mother II_3 is : $X^N//X^d$ The genotype of the color blind boy III_1 is: $X^d//Y$ The genotype of the girl with normal vision III_3: $X^N//X^N$ or $X^N//X^d$	1
	3.1	The mother II_3 is heterozygous, of genotype $X^N//X^d$, since she gave birth to a color blind boy III_1. The genotype of the father II_4 is $X^N//Y$. He transmits the sex chromosome Y to his sons and X^N to his daughters. Since all daughters inherit X^N from their father and since allele N is dominant over allele d, then all the girls will have normal vision. Hence, the risk for this couple to obtain a color blind girl is null.	0.5
	3.2	For this couple to obtain a color blind son having a genotype X^d // Y, this son should inherit X^d from his mother and Y from his father. Since the mother II_3 have the genotype $X^N//X^d$, thus she might transmit either X^N or X^d to her sons. The risk of the mother to transmit X^d to her son is ½. Therefore, the risk to have a color blind boy is ½.	0.5
	4	Color blindness is a recessive abnormality due to a gene carried on the sex chromosome X. So, a color blind female should have the genotype X^d //X^d (a recessive allele is only expressed phenotypically when it is present in two copies). Therefore, this girl should get X^d from her mother, II_3, and X^d from her father, II_4. Consequently, her father should have the genotype X^d //Y and should be colorblind; However, he has normal vision of genotype X^N //Y. Hence, this is why the birth of this color blind girl from this couple is unexpected.	0.5
	5	This karyotype shows the presence of only 1sex chromosome instead of two. This sex chromosome is X. Therefore, the other abnormality revealed by this karyotype is monosomy X or Turner syndrome.	0.5
	6.1	The girl is affected with monosomy X and is color blind. Her unique sex chromosome X carries the allele d. Since, her father is of normal vision then he doesn't have X^d. Consequently, this girl has certainly inherited X^d from her mother. Hence, the origin of daltonism in this girl is maternal.	0.5
	6.2	Since the origin of the only sex chromosome X in this female is of maternal origin, this means that this female results from the fusion a female gamete having one X chromosome	0.25

		and a male gamete lacking any sex chromosome. Hence, the origin of this abnormality (monosomy X) is paternal.	
	7.1	Karyotype of the color blind girl: 	**0.25**
	7.2	karyotypes of the parental gametes Maternal gamete Paternal gamete  	**0.5**

Ex	Part	**Exercise 2 (5 points)** **Pregnancy and Immune Defense**	Mark
2	**1**	The T cell receptor (TCR) on the membrane of Tc lymphocyte binds to HLA-I – nonself-peptide complex on the target cell membrane, tumor or infected cell. Then, Tc lymphocyte releases its perforin molecules which assemble into polymers that form a hollow channel through the target cell membrane. Then, the Tc releases granzymes that penetrate into the target cell through the polyperforin channels triggering an enzymatic chain reaction within the cell leading to DNA degradation. This causes cell death by apoptosis.	**1.5**
	2	The action of Tc lymphocyte on the target cell necessitates the double recognition of the nonself peptide associated to self HLA-I protein. The trophoblast isoltes the fetus from the maternal immune system. The cells of this trophoblast do not express the self HLA- class I proteins; thus, these cells are not recognized by Tc lymphocyte. This makes Tc lymphocyte unable to reach and destroy the fetal cells.	**1**
	3	The hypothesis is validated since the mother's immune cells lyse the non-self cells (medium A) but not the trophoblast cells that carry HLA-G molecules (medium B). This shows that HLA-G prevents the action of maternal immune cells on trophoblast cells. This is also confirmed by the result obtained in medium C, where the trophoblast cells carrying blocked HLA-G molecules are lysed by maternal immune cells.	**1**
	4	Experiment 2 shows that the capacity of macrophages to activate T4 lymphocytes is reduced when placed in contact with the non-self cells carrying HLA-G . Furthermore, the activation of the T4 cells is a step necessary for the induction of the specific immune response, humoral and cellular mediated. Hence, this immune response becomes less effective. The results of experiment 3 show that T8 lymphocyte remains inactive when it binds to a tumor cell which carries HLA-G molecules. However, it becomes active if HLA-G molecules are absent. Thus, T8 lymphocyte are not activated by tumor cells carrying HLA-G molecules. Hence, the specific immune response triggered by lymphocytes is less effective.	**1.5**

<table>
<tr><th>Ex</th><th>Part</th><th>Exercise 3 (5 points)
Maintaining Resting Potential</th><th>Mark</th></tr>
<tr><td rowspan="7">3</td><td>1-1.</td><td>The extracellular medium is more concentrated in Na^+ ions than the intracellular medium (140 mmol.L^{-1}> 14 mmol.L^{-1}). However, the intracellular medium is more concentrated in K^+ ions than the extracellular medium (140 mmol.L^{-1}> 5 mmol.L^{-1}).</td><td>0.5</td></tr>
<tr><td>1-2.</td><td>Resting potential is due to an uneven distribution of Na^+ and K^+ ions on either side of the plasma membrane, where excess Na^+ ions are present towards the ECM with respect to ICM, and excess K+ ions exists towards ICM with respect to ECM.</td><td>0.5</td></tr>
<tr><td>2</td><td>The formulated hypothesis is not valid because in experiment 1, the appearance of radioactivity in compartment A shows that an amount Q1 of radioactive Na^+ ions diffuses from compartment B to compartment A through the membrane fragment during time t.
Similarly, the result of experiment 2 shows a diffusion of an amount Q2 of K^+ ions from compartment A to compartment B (Q2> Q1) during the same time interval.
This means that the plasma membrane is permeable to Na^+ and K^+ ions.</td><td>0.75</td></tr>
<tr><td>3</td><td>The diffusion of ions across the plasma membrane takes place with concentration gradient, from a medium of higher concentration to a medium of lower concentration for the same ions.
Na^+ ions diffuse from compartment B to compartment A because the concentration of Na^+ ions in compartment B is 140 mmol.L^{-1} which is higher than that in compartment A (14 mmol.L^{-1}).
Similarly, K^+ ions diffuse from compartment A to B because the concentration of K^+ ions in compartment A is 140 mmol.L^{-1} which is higher than that in compartment B (5mmol.L^{-1}).</td><td>0.5</td></tr>
<tr><td>4</td><td>The origin of the resting potential is the selective permeability of the membrane, which is more permeable to K^+ ions than to Na^+ ions.</td><td>o.25</td></tr>
<tr><td>5</td><td>Title: The variation of the fraction of radioactive $^{24}Na^+$ released across the plasma membrane of the axon as function of time within different conditions.
Cyanide
<table>
<tr><td>Time (hour)</td><td>0</td><td>0.5</td><td>1</td><td>1.5</td><td>2</td><td>2.5</td><td>3</td></tr>
<tr><td>Fraction of $^{24}Na^+$released /min (a.u)</td><td>0.0027</td><td>0.0027</td><td>0.0014</td><td>0.0005</td><td>0.0004</td><td>0.0004</td><td>0.001</td></tr>
</table>
Injection of ATP</td><td>1</td></tr>
<tr><td>6</td><td>Between 0 and 0.5 hours, and in the presence of ATP, the fraction of $^{24}Na^+$ ions released by the axon is 0.0027 a.u.
However, between 0.5 hrs and 2.5 hrs and in the presence of cyanide that inhibits ATP production, the fraction of released $^{24}Na^+$ ions decreases from 0.0027 to 0.0004 a.u. at 1.3 hours and then remains constant. Hence, the release of $^{24}Na^+$ from ICM to ECM requires energy.</td><td>1.25</td></tr>
</table>

		On the other hand, following ATP injection at 2.5 h and in the presence of cyanide, the release of $^{24}Na^{+}$ ions out of the axon is resumed and its rate increases from 0.0004 to 0.001 a.u. within half an hour. Therefore, the release of $^{24}Na^{+}$ ICM to ECM , against the concentration gradient, is an active mechanism that requires the supply of energy in the form of ATP. In Experiment 4, the radioactivity appears rapidly in the cytoplasm of an axon placed in a medium enriched in radioactive $^{40}K^{+}$ ions in the presence of ATP. However, it ceases only in the presence of cyanidet that inhibits ATP production. Therefore, the movement of $^{40}K^{+}$ ions from ECM to ICM against the concentration gradient is an active mechanism too.	
	7	The protein molecule involved in the active transport of ions across the plasma membrane is the Sodium-Potassium pump (Na^{+}/K^{+} Atpase pump)	**0.25**

Ex	**Part**	**Exercise 4 (5 points)** **Hormonal Influence on the Renewal of Sexual Cycle**	**Mark**
3	**1.1**	The luteal phase is characterized by an increase in the secretion of progesterone and estrogen but with higher level of progesterone compared to estrogen. However, this phase is characterized by a fall in the levels of FSH and LH.	**1**
	1.2	The high levels of ovarian hormones, progesterone and estradiol exert a negative feedback on the activity of the pituitary gland during the luteal phase.	**0.5**
	2	Before removal of the corpus luteum, the FSH level is about 1 au. in both lots ,A and B and that of progesterone is 5 a.u. for lot A and 4 a.u. for lot B. After the ablation of the corpus luteum and the implantation of capsule at day 0, the level of FSH increases in lot A having an empty capsule to 3 au at day 1 then fluctuated around 2a.u till day 3, but the level of progesterone decreases from 5 a.u. to 1a.u after 0.5 day and then remains constant till day 3. However, the level of FSH in Lot B where the implanted capsule contains progesterone, fluctuates around 1 a.u. till day 3 and that of progesterone remained constant at 4 a.u. during the same interval of time. Hence, progesterone inhibits the secretion of FSH.	**1** **1**
	3	The renewal of an ovarian cycle is manifested by the ~~initiation of menses~~ resuming the increase in production of estrogen hormone by the developing follicles(at the level of the theca interna and granulosa). At the end of the luteal phase of the previous cycle the corpus luteum degenerates leading to a drop in the levels of the ovarian hormones. This drop leads to an increase in the level of GnRH and pituitary hormones, mainly FSH. FSH stimulates the growth and development of the cavitary follicles as well as the secretion of estrogen by follicular cells.	**1**
	4	Progesterone capsules continually and slowly diffuse this hormone into the body. This hormone will block the pituitary function, thereby inhibiting the secretion of pituitary hormones LH and FSH and consequently ovulation.	**0.5**