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مسابقة في مادة علوم الحياة
المدة: ثلاث ساعات

الاسم:
الرقم:

Exercise 1 (4.5 points) **Patau Syndrome**

Patau syndrome is caused by an excess of genetic material of chromosome 13 in the cells of the body. It affects one newborn in 10000 births. The affected children show certain abnormalities: small head, malformation of the hands and eyes, as well as various perturbations in the functioning of the organs.

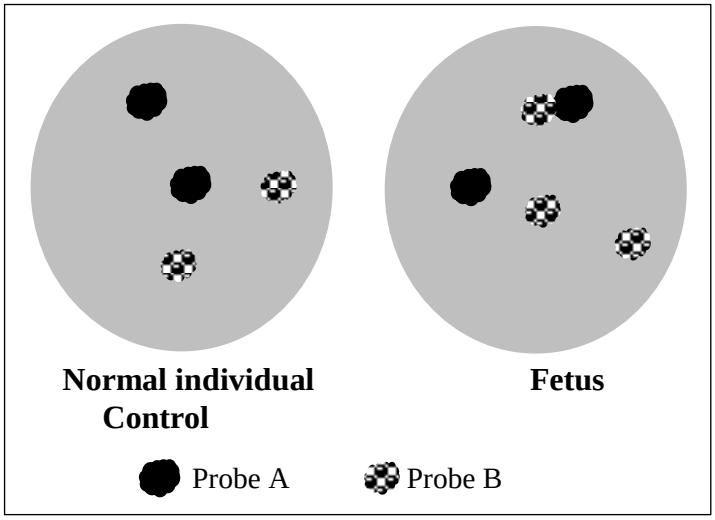
1. Formulate a hypothesis explaining the presence of the excess genetic material in individuals affected by Patau syndrome.

Mr. and Mrs. H, a healthy couple who already have a child affected by Patau syndrome, are expecting another child. They are worried that the fetus might be affected by this syndrome.

The doctor requests certain tests to be performed.

Test 1: The fluorescent in situ hybridization technique (FISH) is applied on fetal cells.
In this prenatal diagnosis technique, two fluorescent single-stranded molecular probes are used:

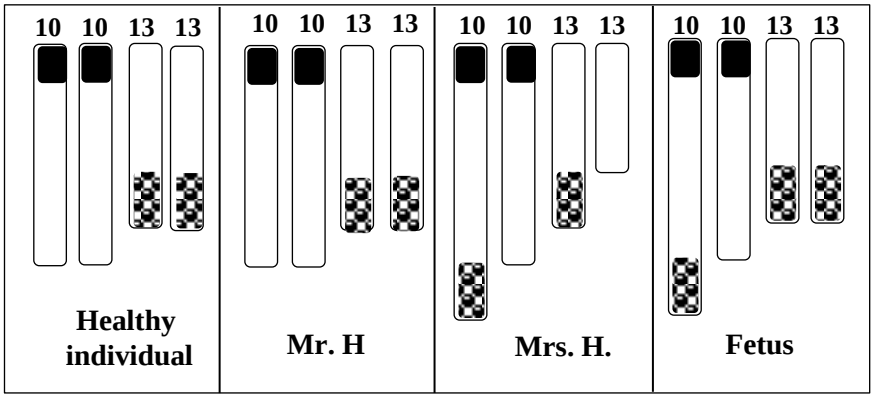
- Probe A complementary to a specific DNA sequence of chromosome 10.
- Probe B complementary to a specific DNA sequence of chromosome 13 that is involved in Patau syndrome.



Document 1

The obtained results are shown in document 1.
Based on the analysis of the results, the doctor assures for the parents that their expected child is affected by Patau syndrome.

2. Justify, by referring to document 1, the doctor's diagnosis.



Document 2

Test 2: The doctor orders additional tests for each of the two parents and their fetus. Document 2 shows only the pairs of chromosomes 10 and 13 of the mother, the father, the fetus and those of a healthy individual. The other pairs are all normal.

3. Justify why the mother presents no phenotypic abnormalities.
4. Show that the chromosomal abnormality of the fetus is an abnormality in structure and not in number.
5.1. Schematize chromosomes 10 and 13 in the gametes produced by each of the two parents.
5.2. Indicate the two parental gametes that are at the origin of the karyotype of the fetus**.**

Exercise 2 (5 points) Therapy against an autoimmune disease

Type 1 diabetes (T1D) is due to an autoimmune disease. The current treatment that is based on insulin injection attenuates the symptoms of type I diabetes disease without curing it. For this reason, a research is carried out to verify the effectiveness of a new therapeutic approach to stop the progression of the autoimmune disease which is at the origin of this type of diabetes.

Measurements of the mass of certain components of the pancreas are performed during autopsies in healthy individuals and in individuals suffering from type 1 diabetes. Document 1 shows the obtained results.

1.1. Compare the obtained results.

1.2. Draw out the cause of type 1 diabetes.

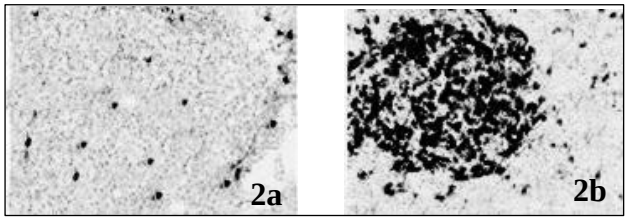
	Healthy individual	**Individual suffering from type 1 diabetes**
Mass of the islets of Langerhans (mg)	1400	415
Mass of alpha cells (mg)	220	200
Mass of beta cells (mg)	850	0

Document 1

The NOD mice (Non Obese Diabetic) develop a disease similar to T1D starting from the age of 10 weeks.

Document 2 represents islets of Langerhans of NOD mice at two different stages of diabetes: an early stage of diabetes (2 a) and a more advanced stage (2b). In this document, T8 lymphocytes appear in the form of black spots.

Note that these mice are not subjected to any viral infection.



Document 2

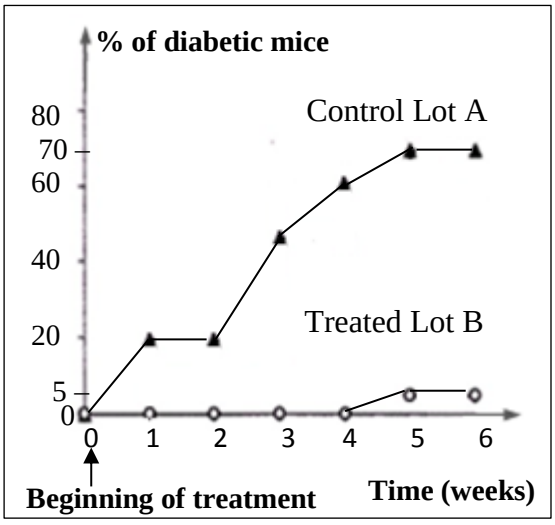
2. Identify the type of the immune response involved in this autoimmune disease.

3. Explain the mode of action of T8 Lymphocytes on their target cells.

A new treatment for T1D is tested on two lots of NOD mice at the age of 4 weeks, before the onset of the disease:

- Lot A receives an injection of a saline solution that has no effect (control lot).
- Lot B is subjected to this new treatment.

Document 3 shows the occurrence of diabetes in these two lots of NOD mice.

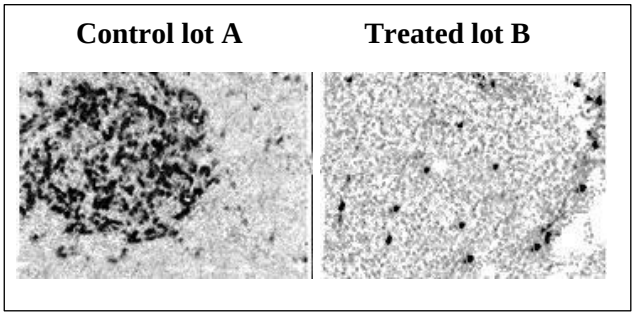


Document 3

4. Draw a table representing the results of document 3.

5. Verify if this new treatment is effective against type 1 diabetes.

Document 4 presents the results of labeling cytotoxic T8 lymphocyte in the pancreas of beginning of treatment. T8 lymphocytes appear in form of black spots inside the islet of Langerhans.



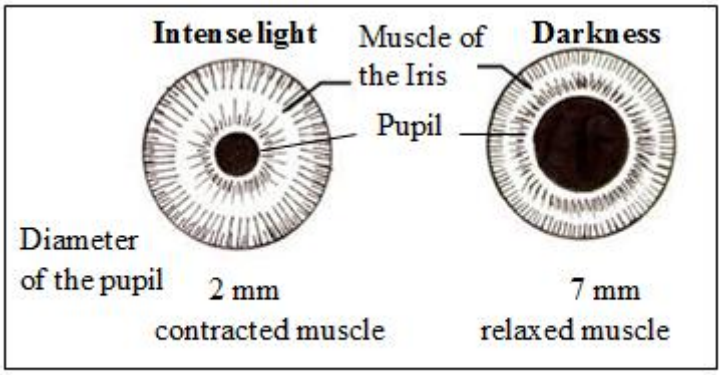
Document 4

6. Draw out how this new treatment slows down the progression of T1D.

Exercise 3 (5 points)

Action of Atropine

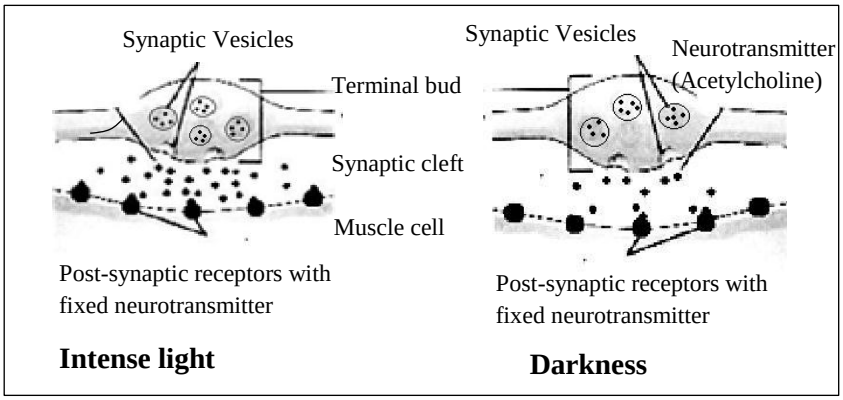
The diameter of the pupil, an orifice in the eye through which the light penetrates, is controlled by a muscle (the iris) .This diameter varies with light intensity, document 1.
Ophthalmologists use medicine such as "atropine" which allows the examination of the eye.
A study is performed to determine the mode of action of atropine.



Document 1

1.1. Compare the aspect of the pupil and the muscle of the iris in light and in darkness.
1.2. Draw out the effect of light on the muscle of the iris.

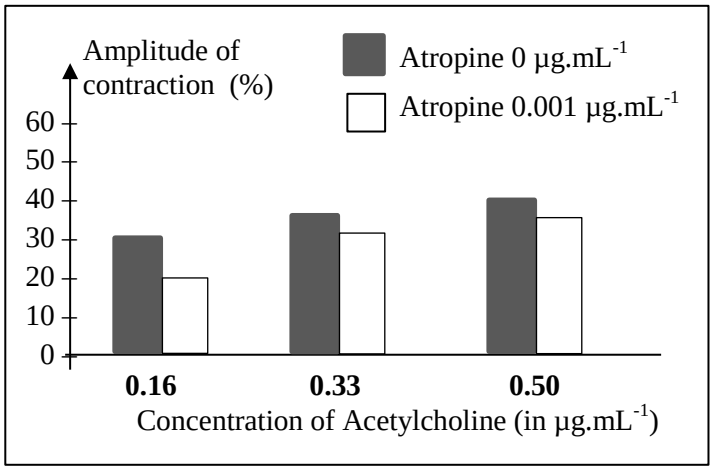
At the level of the iris, the muscle fibers form excitatory cholinergic synapses with the ends of motor neurons.
Document 2 shows the functioning of these neuromuscular synapses in intense light and in darkness.



Document 2

2. List the steps of the synaptic transmission.
3. Justify, referring to document 2, the amplified muscle contraction in the presence of light.

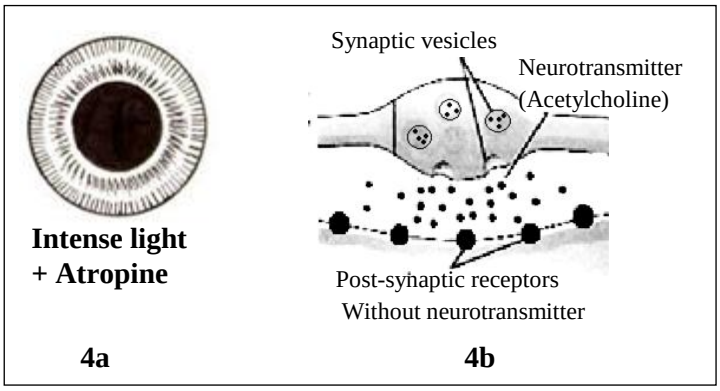
Document 3 shows the amplitude of contraction of the muscle of the iris, in the presence and absence of atropine, as a function of the concentration of acetylcholine in the synaptic cleft.



Document 3

4.1. Analyze the obtained results.
4.2. Conclude the effect of atropine on muscle contraction.

Document 4 shows the aspect of the pupil (4a) and the functioning of the neuromuscular synapse (4b) in intense light, after the application of a droplet of atropine in the eye of an individual.



Document 4

5. Compare the aspect of the pupil in document 4a to each of the two aspects shown in document 1.

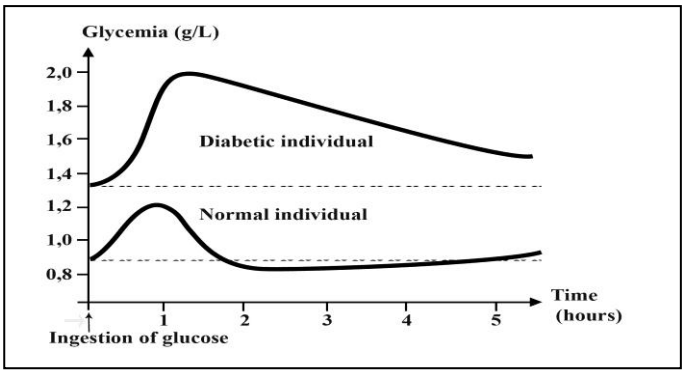
6. Draw out the step of the synaptic transmission at the level of which atropine acts.

7. Explain, based on what precedes, the use of atropine by ophthalmologist to provoke dilation of the pupil even in the presence of intense light.

Exercise 4 (5.5 points) **Hypoglycemic Treatment**

According to a predicting study performed recently by the World Health Organization (WHO), the number of the individuals affected by diabetes will become 300 million in 2025. The results of this study lead to the research for new medicines for diabetes.

Document 1 shows two major characteristics of diabetes by comparing the development of glycemia in two individuals, one is diabetic and the other is non-diabetic, after the ingestion of glucose solution.

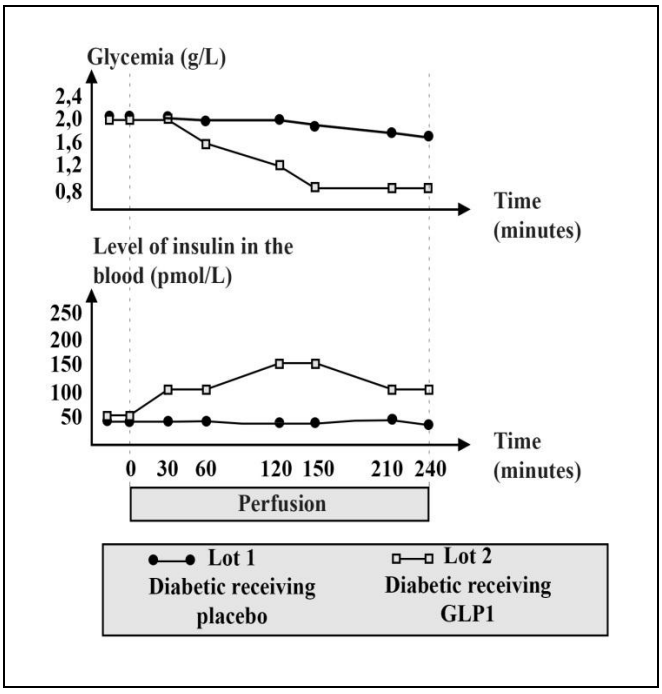


Document 1

1. Interpret the results of document 1.

Researchers have discovered a hormone, GLP1, secreted into the blood by the intestinal cells after a meal. In the framework of studying the action of GLP1, the following experiments are carried out:

Experiment 1: Diabetic individuals are divided into two groups. One group receives a perfusion (continuous injection) of GLP1during 240 minutes. The other group receives a placebo perfusion, a neutral substance that has no action. The results are represented in document 2.



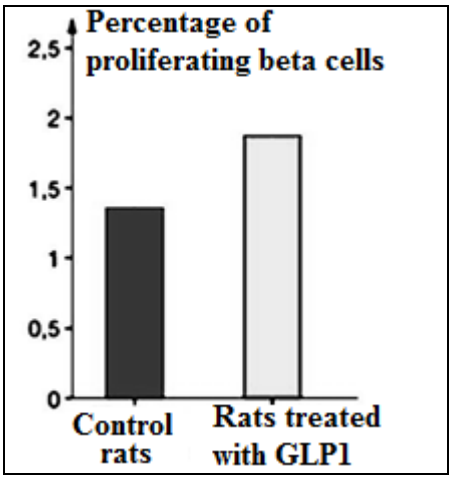
Document 2

2.1. Analyze the results represented in document 2.
2.2. What can you conclude?

Experiment 2: Zucker rats are obese rats that develop diabetes. Document 3 shows the effect of GLP1 on pancreatic beta cells of two groups of Zucker rats, one treated with GLP1, while the other is a control which is not treated with this hormone.

3. Deduce the effect of GLP1 on Beta cells of the pancreas.

The hormone GLP1 is degraded in the body within two minutes by an enzyme, DPP4. It is thus transformed into inactive substances. Sitagliptin, a new medicine, is an inhibitor of DPP4: When Sitagliptin is administered, it blocks the action of DPP4.

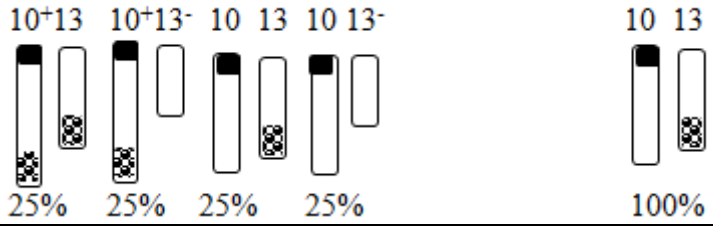
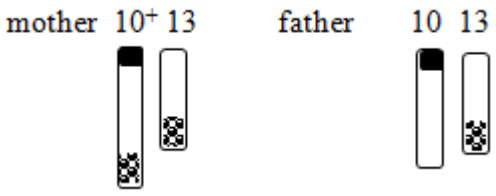


Document 3

4. Draw out the effect of the administration of Sitagliptin on the blood level of GLP1.

5. Explain how Sitagliptin molecule can improve the health state of certain diabetic individuals.

مسابقة في مادة علوم الحياة

Q.	Exercise 1 Patau syndrome	Mark
1	Hypothesis: - The excess of genetic material might be due to trisomy 13 (linked or free). - The excess of genetic material might be due to a translocation of part of chromosome 13. - The excess of genetic material might be due to a certain mutation at the level of chromosome 13 (duplication of a fragment of a chromosome).	**0.5**
2	Document 1 shows that each of the healthy individual and the fetus possesses two fluorescent probes A which correspond to the two chromosomes 10. However, the fetus presents three fluorescent probes B corresponding to three chromosomes 13 , unlike the healthy individual who presents two fluorescent probes B (two chromosomes 13). Moreover, one of the three probes B is attached to probe A. The fetus thus has an excess of genetic material of chromosome 13. Since this excess of genetic material of chromosome 13 in the cells causes Patau syndrome, then the doctor's affirmation that the fetus will be affected by Patau syndrome is justified.	**0.75**
3	Since one of the pair of chromosomes 13 of the mother shows a missing part , and one of chromosomes 10 has an excess of the same part, and since all the other chromosome pairs are normal; then the mother presents neither gain nor loss in the genetic material and her DNA mass is conserved. As a result, the mother has a normal phenotype.	**0.75**
4	The fetus only presents abnormalities in chromosomes 10 and 13. Document 2 shows that the fetus possesses a pair of chromosomes 10 and a pair of chromosomes 13; so the exact total number of chromosomes is normal. Therefore, the fetus' abnormality in not in number. However, one of the chromosomes 10 of the fetus is longer than the pair of chromosomes 10 of the healthy individual, but the other copy of chromosome 10 and both copies of chromosome 13 of the fetus have equal lengths as those of the healthy individual. It is therefore the structure of the chromosomes that is abnormal.	**1**
5.1	Scheme showing the types of the parental gametes Types of gametes of the mother gamete of the father Gametes: 	**1**
5.2	The gametes at the origin of the karyotype of the fetus are: 	**0.5**

<table>
<tr><th>Q</th><th>Exercise 2 Therapy against an Autoimmune Disease</th><th>Mark</th></tr>
<tr><td>1.1</td><td>The mass of the islets of Langerhans in a healthy individual is 1400mg which is greater (3.38 times more) than 415mg in individual suffering from T1D.
While the mass of alpha cells in a healthy individual is 220mg which is slightly greater than that of alpha cells in the affected individual (200 mg).
However, the mass of beta cells in a healthy individual is 850mg which is greater than 0mg in the affected individual.</td><td>0,5</td></tr>
<tr><td>1.2</td><td>Type 1 diabetes is due to a lack of beta cells.</td><td>0,25</td></tr>
<tr><td>2</td><td>Document (2a) shows few T8 lymphocytes which appear in the form of black spots in islets of Langerhans of NOD mice at an early stage of diabetes.
At a more advanced stage of diabetes (document 2b), the concentration of T8 lymphocytes represented by black spots in the islets of Langerhans of NOD mice increases.
As T8 cells have a cytotoxic action against cells, these results show that beta cells are being attacked by T8 cells causing their disappearance in the individual affected by T1D (document 1). Since T8 cells are the effector cells involved in cell mediated immune response, then the immune response involved is specific cell mediated.</td><td>1</td></tr>
<tr><td>3</td><td>During a cell mediated specific immue response:
- TL8 recognizes the antigenic peptides presented by MHC found on the membrane of target cells, through its TCR.
- They are then activated by double recognition.
- Once activated, and under the action of IL-2, T8 cells profilerate and form a clone.
- Activated T8 cells diffferentiate into killer cells or cytotoxic TL which :
• Secrete perforin which forms hollow channels through the plasma membrane of target cells.
• Secrete granzymes that penetrate the polyperforin channels, leading to the degradation of its DNA.
This leads to apoptosis of target cells.</td><td>1</td></tr>
<tr><td>4</td><td>
<table>
<tr><td colspan="2">Time (weeks)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td rowspan="2">% of diabetic mice</td><td>Control Lot A</td><td>0</td><td>20</td><td>20</td><td>50</td><td>60</td><td>70</td><td>70</td></tr>
<tr><td>Treated Lot B</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>5</td><td>5</td></tr>
</table>
↑
Beginning of treatment
Title: Table showing the variation of percentage of T1D in NOD mice with or without treatment, as a function of time.</td><td>1,25</td></tr>
<tr><td>5</td><td>The results of document 3 show that the percentage of diabetic mice in control lot A (injected with a saline solution that has no effect) increases between 0 and 6 weeks from 0% to reach 70% which is a value much greater than that of treated lot B (subjected to the new treatment), where the percentage of diabetic mice remains null till 4 weeks, and then increases slightly to 5 % between 4 and 6 weeks.
The new treatment has thus reduced the risk of developing type 1 diabetes, which confirms its effectiveness against this disease.</td><td>0,75</td></tr>
<tr><td>6</td><td>This treatment seems to protect the beta cells of islets of Langerhans from the cytotoxic action of T8 lymphocytes; consequently slowing down the occurence of type 1 diabetes in individuals at risk.</td><td>0,25</td></tr>
</table>

Q	Exercise 3 Action of Atropine	Mark
1.1	In darkness, the diameter of the pupil is more dilated, 7mm , a value greater than 2 mm obtained in intense light. Furthermore, the muscle of the iris is contracted in the presence of intense light, but it is relaxed in darkness.	**0, 5**
1.2	Light stimulates the contraction of the muscle of the pupil.	**0,25**
2	The steps of the synaptic transmission are : 1. Arrival of the nervous message to the terminal bud of the presynaptic neuron. 2. Opening of the voltage dependent calcium channels and entrance of calcium ions into the terminal bud. 3. Exocytosis of the neurotransmitter from the synaptic vesicles. 4. Fixation of the neurotransmitter on its specific receptors found on the post-synaptic membrane. 5. Generation of PSP. 6. Recapture or degradation of neurotransmitter.	**1,25**
3	In the presence of intense light, the quantity of neurotransmitter found in the synaptic cleft and that fixed on the post-synaptic receptors is much higher than the quantity observed in darkness. Since these synapses are excitatory, then the muscle will be more contracted in light.	**0, 5**
4.1	In the presence of atropine, the amplitude of muscle contraction increases from 20% to 36% as the concentration of acetylcholine increases from 0.16 $\mu g.mL^{-1}$ to 0.50 $\mu g.mL^{-1}$, which is less than the amplitude recorded in absence of atropine which increases from 31% to 41%.	**0,5**
4.2	Thus, atropine reduces (attenuates) the muscle contraction.	**0,25**
5	In the presence of atropine and intense light, the pupil shows a diameter similar to that obtained in darkness, and which is larger than that obtained in intense light without atropine.	**0,5**
6	The step of the synaptic transmission at the level of which atropine acts is the binding (fixation) of acetylcholine on its post-synaptic receptors.	**0,25**
7	Atropine is antagonistic with acetylcholine (document 3), it prevents the fixation of acetylcholine on its specific receptors (document 4). Consequently, the muscle of the iris does not contract in the presence of light. When it is relaxed, the pupil dilates, allowing the passage of more light which permits the ophthalmologist to examine the eye even in the presence of intense light.	**1**

Q	Exercise 4 Hypoglycemic treatment	Mark
1	At time 0 hours, upon ingestion of glucose, glycemia in normal individual is 0.9 g/l which is less than that in diabetic individual which is 1.3 g/L. One hour after the ingestion of glucose, glycemia increases in both individuals; however it increases in the normal individual to 1.2 g/L which is less than 2 g/L obtained in diabetic individual. This shows that the ingested glucose is absorbed in the blood which provokes a hyperglycemia. However, glycemia in the normal individual decreases rapidly after 40 minutes to regain its initial value (0.9 g/L), unlike the glycemia in the diabetic individual which decreases slowly from 2g/L to 1.6 g/L during a longer duration of time (around 4 hours) and remains higher than its initial value (1.3g/L). This shows that these individuals have a hypoglycemic system that permits the regulation of glycemia, but this system is slower in diabetic individuals than in normal ones.	**1,25**
2.1	**Before the perfusion of GLP1**, the level of glycemia and the level of insulin are constant at 2g/L and 50 pmol/L respectively in both lots 1 and 2. While **during the perfusion**, the level of insulin remains almost constant at 50 pmol/L in diabetics of lot 1 receiving placebo which is less than the level of insulin in diabetics of lot 2 receiving GLP1 which increases to 150 pmol/L after 120 minutes, and then it decreases to reach 100 pmol/L which is higher than its initial value between 210 and 240 minutes. However, glycemia decreases slightly in diabetics of lot 1 after perfusion of placebo to reach 1.8g/L after 240 minutes, which is higher than the glycemia in diabetics of lot 2 receiving GLP1, which decreases to reach a constant value of 0.8g/L after 210 minutes.	**1**
2.2	GLP1 stimulates the secretion of insulin, and it has a hypoglycemic effect.	**0,5**
3	The percentage of proliferating beta cells in rats treated with GLP1 is 1.85 % which is greater than that in control rats which is 1.4%. Therefore, GLP1 favors the proliferation of beta cells.	**0,75**
4	Sitagliptin increases the level of GLP1 in blood.	**0, 5**
5	Sitagliptin inhibits the degradation of GLP1 by DPP4, resulting in the increase of the level of GLP1 in the blood. This hormone stimulates rapidly the secretion of insulin, a hypoglycemic hormone, thus presenting a hypoglycemic action. On the long term, GLP1 leads to an increase in the number of beta cells. Since these cells secrete insulin, the production of insulin by the pancreas of diabetics will increase. This hypoglycemic property allows the use of Sitagliptin as a treatment of diabetes.	**1.5**