

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

Answer the following exercises

Exercise 1 (5 points)

Origin of Mental Retardation

Alain, son of Riad and Samar, is affected by a mental retardation. This couple who has no family history concerning mental retardation is expecting a second child and wishes to know whether he will be affected like his brother.

1- Formulate a hypothesis explaining the appearance of this retardation in Alain.

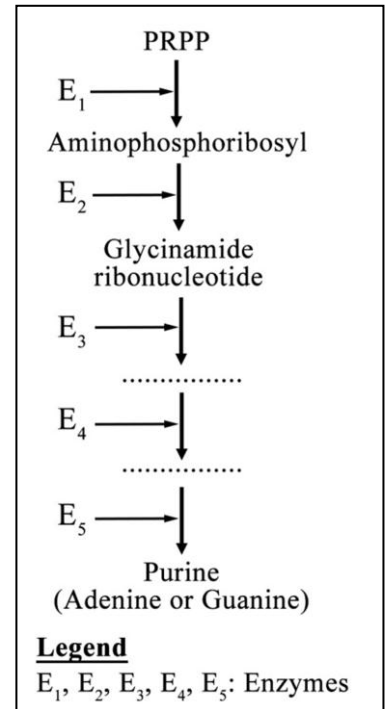
In order to understand the possible origin of this mental retardation, the following studies are performed.

Blood analysis of Alain concerning substances involved in mental retardation shows a high amount of purines of 118 mmol/L with respect to the normal level of 79 mmol/L.

The synthesis of purines is controlled by 5 enzymes. The pathway of this biosynthesis in the body is presented in document 1.

Three cell cultures are performed.

- **Culture 1:** nerve cells are cultured in a medium rich in purines. These cells degenerate.
- **Culture 2:** cells of CHO mice are cultured in a medium without purines. In these mice, the gene coding for enzyme E2 which is homologous to that of humans, is inactive. These cells degenerate.
- **Culture 3:** human cells are fused with cells of CHO mice and Hybridoma are obtained. These hybridoma are cultured in a medium without purines. Spontaneously, some hybridoma lose with time their human chromosomes. Those that lose their chromosome n° 21 degenerate and those that conserve the chromosome n° 21 remain in the medium.



Document 1

2- Interpret the results obtained in cultures 1 and 2.

3- Determine the location of the gene studied in this mental retardation.

The karyotype of Alain consists of 46 chromosomes. Document 2 shows the blood level of purines as well as the karyotype of Alain, those of his parents, and that of the fetus. In these karyotypes only the pairs of chromosomes 14 and 21 are schematized; the other pairs of chromosomes are normal.

| Alain's Family | Mother : Samar | Father : Riad | Alain | Fetus |
|------------------------------------|----------------|---------------|-------|-------|
| Karyotype | | | | |
| Blood level of purines (in mmol/L) | 79 | 79 | 118.5 | ? |

Document 2

4- Determine, from all what precedes, the origin of the mental retardation revealed in Alain.

5- Specify the diagnosis for the fetus.

6- Make the factorial analysis to determine the phenotypic proportion of this couple's children who will suffer from a mental retardation identical to that of Alain.

Exercise 2 (5 points)

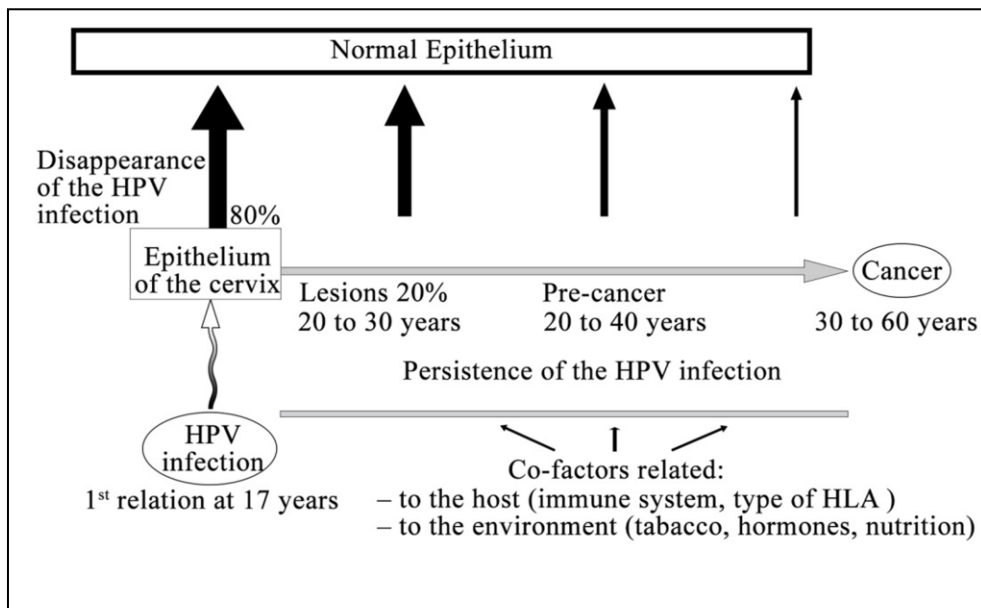
Cervical Cancer and the HPV Virus

Cervical cancer is considered to be the second cancer that affects women in the developing countries, and the eighth in the developed ones.

To better understand the cause of this cancer and in order to prevent it efficiently, researchers performed different studies.

- A study involving thousands of women suffering from cervical cancer shows that 75% of these women have encountered the human papillomavirus (HPV) during their sexual life.

Document 1 shows the evolution of the state of the cervical epithelium after HPV infection.



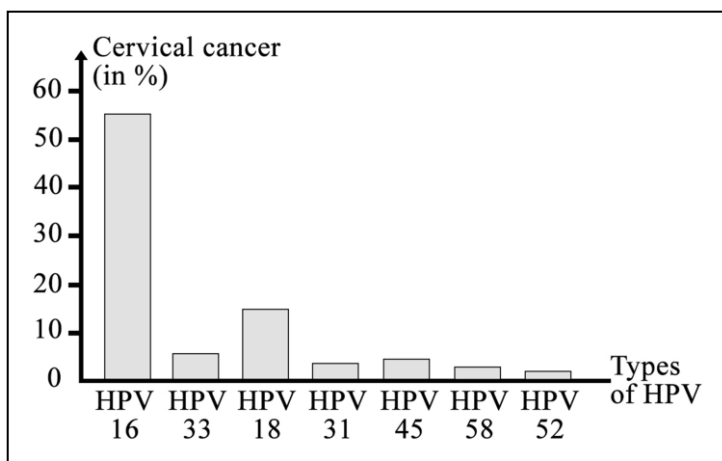
Document 1

1- Justify the following statement: « Cervical cancer is a slowly induced viral cancer ».

2- Pick out, from document 1, two other risk factors for the development of cervical cancer.

3- Indicate the type of specific immune response triggered to fight against a viral infection. Justify the answer.

- In a second study, 150 types of HPV have been identified, some of which are qualified as being of “high-risk“, induce a genetic mutation which causes cervical cancer. Document 2 shows the percentages of women having cervical cancer as a function of the types of HPV that have infected them.



Document 2

4- Deduce from document 2 the two types of HPV of high risk .

- Researchers have elaborated prophylactic vaccines aiming to ensure a preventive protection of individuals against the infection. These vaccines stimulate the production of antibodies directed against certain types of HPV viruses. The characteristics of two of these vaccines are regrouped in document 3.

| | Vaccine | |
|---|---|----------------------------------|
| | Gardasil | Cervarix |
| Types of targeted HPV | Quadrivalent Vaccine HPV6, HPV11, HPV16 and HPV18 | Bivalent Vaccine HPV16 and HPV18 |
| Suggested amount | Almost 20 µg | 20 µg |
| Vaccination Schedule | 0, 2 and 6 months | 0, 1 and 6 months |
| Amount of antibodies produced compared to that of the natural infection | 8 times higher | 100 times higher |

Document 3

5- Determine the most efficient vaccine.

6- Explain how the antibodies produced during this vaccination allow protection against cervical cancer.

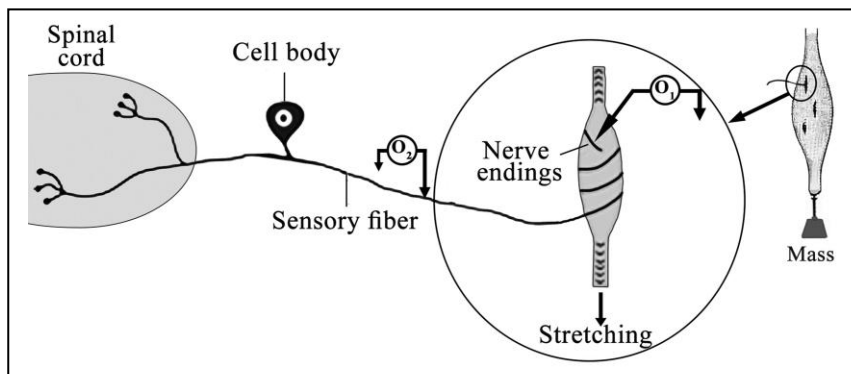
7- Suggest two preventive means against cervical cancer.

Exercise 3 (5 points)

Nervous Coding of Sensory Information

When a dog is kept on a leash, the muscles of the arms react immediately to all the traction variations they undergo. This is a reflex.

In order to study the coding of the message involved in this reflex, the following experiments are performed using the experimental set up presented in document 1.



Document 1

Experiment 1: The arm muscle is stretched five times using increasing masses. The obtained responses are recorded by oscilloscope O1 at the level of the neuromuscular spindle (document 2) and by oscilloscope O2 at the level of the sensory nerve fiber (document 3). Meanwhile more and more important contractions are observed at the level of the stretched muscle.

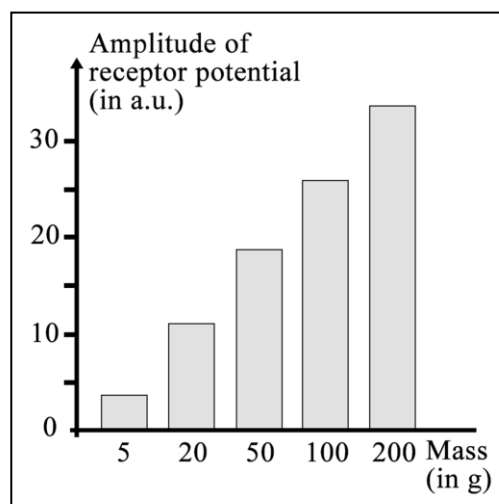
- 1- Show that this is a “myotatic reflex”.
- 2- 2-1- Analyze the results of each of the documents 2 and 3.
2-2 Conclude the type of coding of the nerve message at the level of the neuromuscular spindle and at the level of the sensory fiber.

Experiment 2: This muscle is subjected twice to the same effective stretching of 750 μm at different velocities. The response for each stretching is recorded at the level of the sensory fiber. The obtained results are presented in document 4.

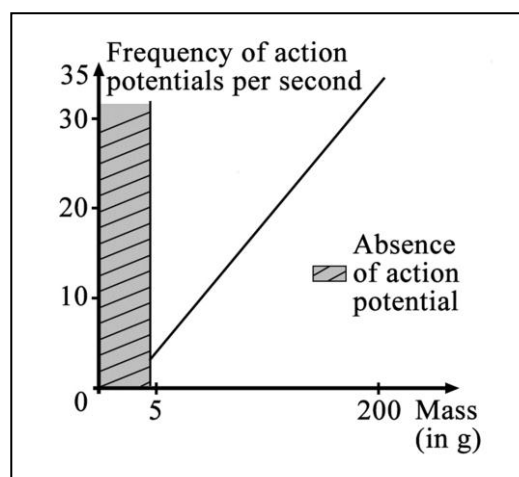
- 3- What can you draw out from document 4?

Experiment 3: The arm muscle, like in experiment 1, is stretched five times using increasing masses. The amount of the neurotransmitter (acetylcholine) that is released at the level of the synapse involved in the neural circuit of this reflex is measured. The obtained results are shown in document 5.

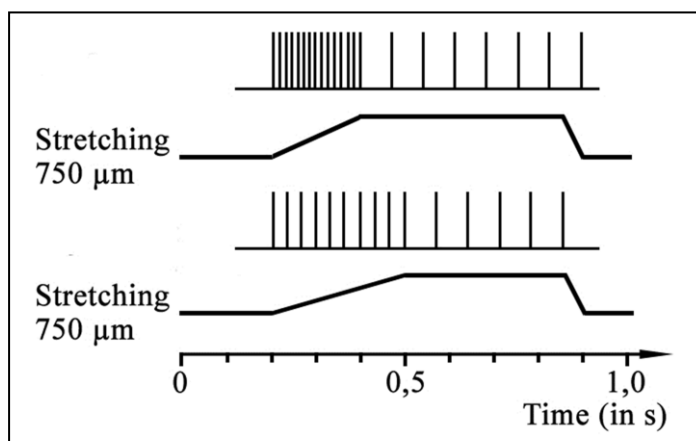
- 4- Draw the curve showing the variation of the amount of released acetylcholine as a function of the intensity of stretching.
- 5- Deduce the type of coding of the nervous message at the level of a synapse.
- 6- Show how the arm muscles react in an adapted way to each traction.



Document 2



Document 3



Document 4

| Intensity of stretching (in a.u.) | 5 | 10 | 15 | 20 | 25 |
|--|----|----|----|----|----|
| Amount of released acetylcholine (in a.u.) | 20 | 30 | 40 | 50 | 60 |

Document 5

- 7- Schematize the neuronal circuit and the structures involved in this reflex.

Exercise 4 (5 points)

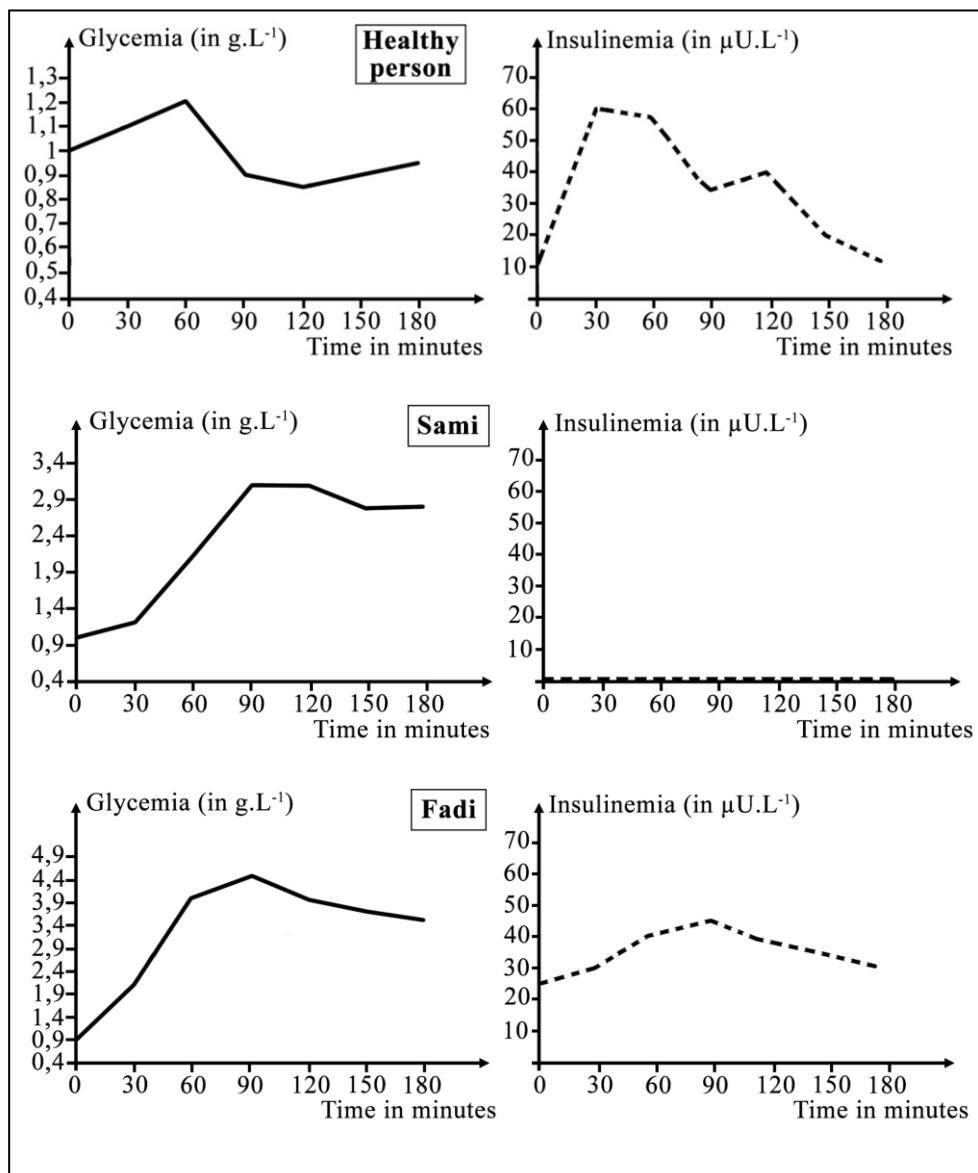
Diabetes: Type I or Type II?

Two persons Sami and Fadi show the following symptoms: frequent urination, severe thirst, sensation of intense hunger, loss of weight and intense fatigue. They consult a doctor who monitors their glycemia and insulinemia after an ingestion of 50g of glucose at $t=0$ min. The results obtained for Sami and Fadi as well as those of a healthy person are presented in document 1.

- 1- Specify, for the healthy person, the factor that determines the secretion of insulin on one hand, and the role of insulin on the other hand.
- 2- Determine the type of diabetes diagnosed for each of the two diabetic persons: Fadi and Sami.

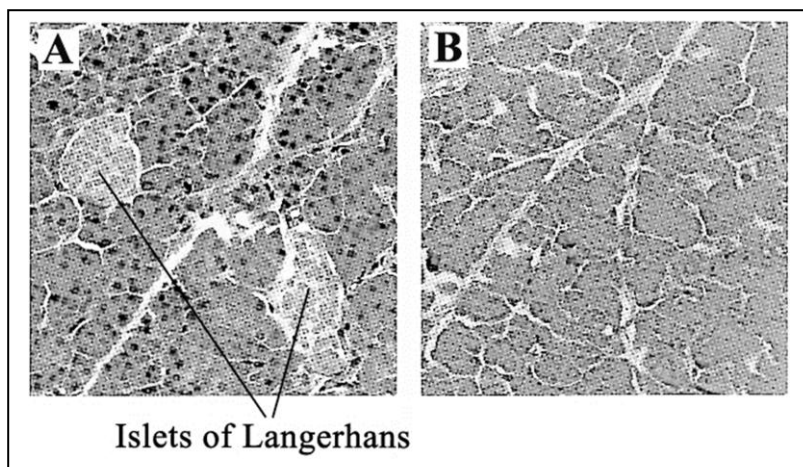
Histological examination of the pancreas of each of the two diabetic persons, Sami and Fadi, shows the results presented in document 2.

- 3- Match each of the sections A and B to each of these persons. Justify the answer.



Document 1

Nowadays a treatment by artificial monohormonal pancreas is prescribed to some diabetic patients. It consists of an apparatus inserted under the skin. This apparatus ensures a continuous automatic measurement of blood glucose and sends the data to a control programmed module. This module calculates the necessary amount of insulin and sends commands to an insulin pump to deliver the calculated amount.

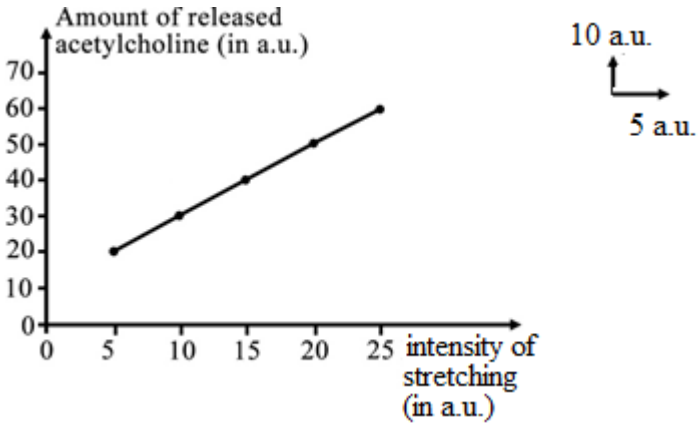
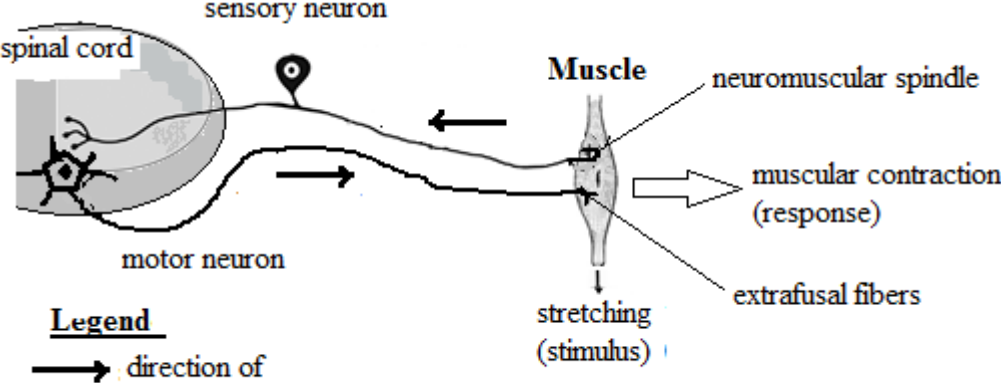


Document 2

- 4- Justify the following statement: “the artificial monohormonal pancreas is a treatment that is more efficient than the treatment based on insulin injections”.
- 5- Determine to which person the doctor will suggest the treatment with artificial pancreas.
- 6- Suggest an advice that the doctor will give to the second person. Justify the answer.

| Part of the ex | Exercise 1 Origin of Mental Retardation | Grade 5 pts | | | | | | | | | | | | | | | |
|----------------|---|-------------------|---------------------------------|---------------------------------------|----------------------|-------------------------|--------|-------------------|-------------------|---------------------------------|----------------------------------|--|--|--|--|---------------------------------------|-------|
| 1 | Hypothesis: The mental retardation of Alain is due to a recessive allele masked in parents. Or The mental retardation of Alain is due to the mutation of a gene implicated in the mental development and that occurred during his conception. Or The mental retardation of Alain is due to a chromosomal aberration (that occurred during meiosis in one or in both parents). | 3/4 | | | | | | | | | | | | | | | |
| 2 | Nervous cells degenerate in the culture medium rich in purines (culture 1). Similarly cells which are unable to synthesize purines degenerate in the medium lacking purines (culture 2). This shows that the synthesis of purines in amounts far from its normal range is responsible for the degeneration of cells. | 1/2 | | | | | | | | | | | | | | | |
| 3 | Culture 2 shows that the cells of CHO mice having inactive E2 are unable to synthesize purines and degenerate. Culture 3 shows that the hybridoma having lost their chromosome 21 degenerate. And since the degeneration of nervous cells may lead to a mental retardation, this allows us to say that the gene coding for E2 is localized on the chromosome 21 and that its inactivation is responsible for the mental retardation. | 1/2 | | | | | | | | | | | | | | | |
| 4 | Culture 1 shows that cells degenerate in a medium rich in purines, and Alain possesses a high purines level of 118mmol/L. This excessive synthesis is due to an additional allele. However the karyotype of Alain shows two free chromosomes for each of the pairs 14 and 21 with one chromosome 14 that is longer than its homologous. And since the allele coding for E2 is carried by the chromosome 21. This can be explained by the presence of an additional chromosome 21 linked to the chromosome 14. Thus the origin of the mental retardation of Alain is a linked trisomy 21 leading to a high enzymatic activity of E2. | 1 | | | | | | | | | | | | | | | |
| 5 | The fetus is normal, since as his normal father he possesses a free chromosome 21 and another chromosome 21 linked on the chromosome 14. He has conserved his genetic material, he has two alleles coding for the enzyme E2 and consequently will have a normal amount of purines of 79 mmol/l indicating a normal mental activity. | 3/4 | | | | | | | | | | | | | | | |
| 6 | Factorial analysis Phenotype : normal mother X normal father Genotype : 14//14 21//21 14//14 ²¹ 21// Gametes and proportions : 14 21 14 21 , 14 , 14 ²¹ , 14 ²¹ 21 1 1/4 , 1/4 , 1/4 , 1/4 Table of cross : <table border="1" style="margin-left: 20px;"> <tr> <td></td> <td>14 21 1/4</td> <td>14 1/4</td> <td>14²¹ 1/4</td> <td>14²¹ 21 1/4</td> </tr> <tr> <td>1421 1</td> <td>14//14 21//21 1/4</td> <td>14//14 21// - 1/4</td> <td>14//14²¹ 21// - 1/4</td> <td>14//14²¹ 21// 21 1/4</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>Mental retardation like that of Alain</td> </tr> </table> <p>The Phenotypic proportion of children suffering from mental retardation like that of Alain is 1/4</p> | | 14 21 1/4 | 14 1/4 | 14 ²¹ 1/4 | 14 ²¹ 21 1/4 | 1421 1 | 14//14 21//21 1/4 | 14//14 21// - 1/4 | 14//14 ²¹ 21// - 1/4 | 14//14 ²¹ 21// 21 1/4 | | | | | Mental retardation like that of Alain | 1 1/2 |
| | 14 21 1/4 | 14 1/4 | 14 ²¹ 1/4 | 14 ²¹ 21 1/4 | | | | | | | | | | | | | |
| 1421 1 | 14//14 21//21 1/4 | 14//14 21// - 1/4 | 14//14 ²¹ 21// - 1/4 | 14//14 ²¹ 21// 21 1/4 | | | | | | | | | | | | | |
| | | | | Mental retardation like that of Alain | | | | | | | | | | | | | |

| Part of the exercise | <p style="text-align: center;">Exercise 2 Cervical Cancer and the HPV Virus</p> | Grade 5 pts |
|----------------------|---|----------------|
| 1 | <p>Studies involving thousands of women suffering from cervical cancer shows that 75% of them have encountered the human papillomavirus (HPV) at some point of their sexual life. Thus this cancer is induced by a virus. The development of this cancer is slow it requires the persistence of the HPV infection for more than 13 years before inducing a genetic mutation at the origin of the cancer (document 1). Thus, this cancer is induced by a virus and its development needs time.</p> | 3/4 |
| 2 | <p>The environment: tobacco, nutrition... Status of the host: immune system, type of HLA</p> | 1/2 |
| 3 | <p>The specific immune response is cell mediated. Since the virus integrates its DNA into the genome of infected cells and modifies their immunological self. This modified self is only recognized by the T8 which are the effectors of the cell mediated response.</p> | 3/4 |
| 4 | <p>Document 2 shows that the highest percentage of cancers is 54,5% due to HPV 16 and 16% due to HPV 18. These percentages are higher than those of cancers induced by all the other types of HPV (more than 100 type of HPV). Thus the two types HPV 16 and HPV 18 are of high risk.</p> | 3/4 |
| 5 | <p>Both vaccines, Cervarix and Gardasil , requires the same amount and the same number of repetitions (3times) and immunize the body against the two types of HPV of high risk(HPV16 and 18). On the contrary, the level of produced antibodies induced by the vaccine Cervarix (100 times higher) is more important than that induced by the vaccine Gardarix that is 8 times higher than that produced in the case of natural infection. Thus the more efficient vaccine is Gardarix.</p> | 1 |
| 6 | <p>The antibodies produced due to vaccination neutralize the viruses before they bind to the membrane receptors of the target cells of the cervix and inhibit the viruses from infecting them. The viruses are thus eliminated (the formed immune complexes will be phagocyted by macrophages) and the lesions leading to cancer do not appear . Thus antibodies inhibit the HPV infection and protect the epithelium from genetic mutations that are at the origin of cervical cancer.</p> | 3/4 |
| 7 | <p>Get vaccinated before the first sexual intercourse. Do not smoke, have balanced healthy nutrition.</p> | 1/2 |

| Part of the exercise | <p style="text-align: center;">Exercise 3 Nervous Coding of sensory information</p> | Grade 5 pts |
|----------------------|---|----------------|
| 1 | A myotatic reflex is the contraction of a muscle in response to its own stretching, in this case (exp 1) the stretching of the muscle of the arm leads to its contraction. Thus it is a myotatic reflex. | 1/2 |
| 2.1 | Document 2 shows that the amplitude of the receptor potential increases from 4 to 35 a.u. when the used mass increases from 5 to 200g. Document 3 shows that the frequency of APs per second increases from 4 to 35AP/s when the used mass increases from 5g to 200g. | 1/2 |
| 2.2 | The coding of the nervous message at the level of the neuromuscular spindles is modulated in amplitude. The coding of the nervous message at the level of the fiber is modulated in frequency of APs. | 1/2 |
| 3 | The response is modulated in frequency of APs as a function of the velocity in which the stretching is performed. | 1/2 |
| 4 | <p>Curve showing the variation of the amount of released acetylcholine as a function of the intensity of stretching.</p>  | 1 |
| 5 | The amount of the released neurotransmitter increases from 20 to 60 a.u. when the intensity of stretching increases from 5 to 25 a.u. Hence, the coding at the level of the synapse is modulated in concentration of neurotransmitters. | 1/2 |
| 6 | The traction performed by the dog stretches the neuromuscular spindles of the arm muscle ensuring the contraction of the same stretched muscle (it's a myotatic reflex). Since the response of the sensory neuron: the receptor potential and the APs as well as the response at the level of the synapse, the amount of neurotransmitters, are modulated in function of the intensity and the velocity of the traction. This allows to adapt the response to each traction. | 3/4 |
| 7 |  <p>The neuronal circuit and the structures involved in this reflex.</p> | 3/4 |

| Part of the exercise | <p style="text-align: center;">Exercise 4 Diabetes: Types I or Type II?</p> | Grade 5 pts |
|----------------------|---|----------------|
| 1 | <p>The factor that determines the secretion of insulin is the hyperglycemia. Since after the ingestion of glucose, glycemia increases from 1g/L to 1,2 g/l within 60 minutes. And insulinemia also increases from 10 $\mu\text{g.L}^{-1}$ to reach a maximum of 60 $\mu\text{g.L}^{-1}$ within 30 min. 1/2pt</p> <p>Insulin is hypoglycemic. Since glycemia decreases from 1,2 g/L to 0,85 g/L between 60 and 120 min, when insulinemia reaches its optimum 60 $\mu\text{g.L}^{-1}$ between 30 to 60 min. 1/2pt</p> | 1 |
| 2 | <p>In Sami, there is an important increase of glycemia following the ingestion of 50g of glucose from 1g/L to 3g/L (superior to the 1,2 g/L in the healthy individual), whereas insulinemia remains nil during the 90 min after the ingestion . This shows that Sami doesn't produce insulin that is indispensable for the decrease of hyperglycemia. Thus Sami has type I diabetes or insulin-dependent diabetes. 1/2pt</p> <p>In Fadi, there is an increase of glycemia following the ingestion of 50g of glucose from 0,9 g/L to 4,4 g/L 3 times higher than healthy individual. Similarly, Insulinemia increases from 25 $\mu\text{g.L}^{-1}$ ($> 10 \mu\text{g.L}^{-1}$ in healthy individual) to 40 $\mu\text{g.L}^{-1}$ ($< 60 \mu\text{g.L}^{-1}$ in healthy individual) during 90 min (> 30 min)</p> <p>This shows that Fadi secretes insulin more slowly than the healthy individual and in an amount that is insufficient to induce a decrease of the provoked hyperglycemia. Hence, Fadi has diabetes of type II, "non-insulin-dependent" that can be due to abnormal insulin or the absence or lack in insulin-receptors at the level of the target cells. 1/2pt</p> | 1 |
| 3 | <p>Section A corresponds to Fadi. It shows the presence of islets of Langerhans responsible for the secretion of insulin, which explains the secretion of insulin after the increase of glycemia.</p> <p>Section B corresponds to Sami. It shows the absence of islets of Langerhans, which are responsible for the secretion of insulin, which explains the nil insulinemia after the increase of glycemia.</p> | 1 |
| 4 | <p>The artificial monohormonal pancreas is more efficient than insulin injections. It permanently detects in an automatic manner the variation of glycemia allowing the administration of insulin in amounts adapted to this variation. This is not the case with injections done at specific times and constant doses that are sometimes inadequate to the needs.</p> | 3/4 |
| 5 | <p>The artificial pancreas administrates insulin as a function of glycemia that is controlled constantly by a programmed module. It is only prescribed to persons who have a problem in insulin secretion: absence or insufficient amount of insulin or abnormal insulin. This corresponds to the case of Sami who has no insulin secretion and no islets of Langerhans.</p> | 3/4 |
| 6 | <p>The doctor prescribes to Fadi a diet that does not induce hyperglycemia. Since Fadi has normally (in absence of provoked hyperglycemia), an insulin secretion higher than that of the normal individual that allows him to maintain a normal constant glycemia. And the increase in this secretion in case of hyperglycemia is not efficient and doesn't lower glycemia.</p> | 1/2 |