From modeling clay to ICTs: Didactic sequence for the learning and teaching process of proteins in high school

Martinez-Aguilar, V.; Obaya, A.; Giammatteo, L.; Montaño Osorio, C. Vargas-Rodríguez, Y.M.;

Facultad de Estudios Superiores Cuautitlán Campo 1
Universidad Nacional Autónoma de México (UNAM) [1]
ymvargas@unam.mx*; obaya @unam.mx

Corresponding Author: ymvargas@unam.mx

Mëxico City +52 55 22995266

ymvargas@unam.mx*

obaya @unam.mx

Abstract

With the aim of improving the learning and teaching of proteins in the subject of "Interpreting the relationship of metabolic reactions in organisms" in high school, a didactic sequence is presented. This sequence includes the concepts of aminoacid and protein structure, function and classification, as well as the importance of proteins in teenagers' diet and their health related functions. The sequence is based on the following learning strategies: PBL, concept maps and playful strategies. The ICTs used were multimedia presentations, videos and documents extracted from websites. An evaluation was applied to the group of students to whom the protein topic was taught with the proposed didactic sequence (experimental) and results were compared to a control group. Results indicate a better understanding of the topic in the experimental group, compared to the control.

Keywords

Proteins, modeling clay, ICTs, learning strategies

Introduction

Chemistry is a subject of the second and third year of high school for students of dental assistants in Colegio Nacional de Estudios Profesionales (CONALEP) Campus Cuautitlan in Mexico. Relevant issues are proteins and biomolecules. However, it was found that they do not acknowledge this type of biomolecules. This represents an obstacle to move forward with the following topics. When the student does not have in his cognitive structure bridges that allow anchoring new knowledge to prior knowledge (Giammatteo and Obaya,2018), this turns into a mechanical, repetitive and unsubstantial process (Ausubel, Novak and Hanesian, 1978). Therefore, a learning strategy that facilitates the learning of protein structure, function and classification needs to be designed. It is important that students understand that proteins are the most abundant biomolecules in any organism and that they are found in every cell, since they are fundamental in every aspect of cell structure and function. It needs to be highlighted that each protein fulfills an important biologic function in all the living beings (Lehninger, 1985).

Methodology

The aim of this work is to design a didactic sequence for school students who are enrolled in the dental assistant program in CONALEP, Cuautitlán. The application of the strategy was carried out in an experimental group (EG). The evaluation of the didactic sequence took place in the EG and results were compared to a control group (CG), in which the topic was taught in a traditional way with a white board and markers.

1. Didactic Sequence Design

The study plan was revised so as to plan the activities within the sequence, taking into account the students learning styles (visual, auditive and kinesthetic) (Parrales, Obaya, Morales and Botello, 2017). Videos, digital presentations, concept maps, comparative charts, playful material and playful models were used to elaborate the didactic material and to express the content of the studies plan: a) aminoacid classification, structure identification and properties; b) protein structure, function and composition identification.

Moreover, ICTs were used as didactic tools for both teachers and students: a) internet sources (mobile data and broadband); b) terminals (computer, internet navigators, operative systems for computers and

cellphones, cellphones, audio and video portable players); and c) ICTs services (information searches to retrieve articles, videos and images).

2. Learning sequence application for the topic a) Aminoacid structure identification, properties and classification.

1. A previous knowledge questionnaire about aminoacids was applied initially to establish a starting point related to the topic's content. The questions included were: 1. What is an aminoacid?; 2. Indicate the parts of an aminoacid in the structure; 3. Define what a peptide bond is and indicate the existent aminoacids within a structure; 4. What are essential aminoacids?; 5. Draw L and D alanine; 6. Provide examples of three essential aminoacids and three non essential aminoacids, mentioning where they are found and they function; 7. Provide an example of acid-base properties in aminoacids.

2. Afterwards, the previous knowledge of the topic was activated by using a brainstorm and the aid of a scheme (figure 1).

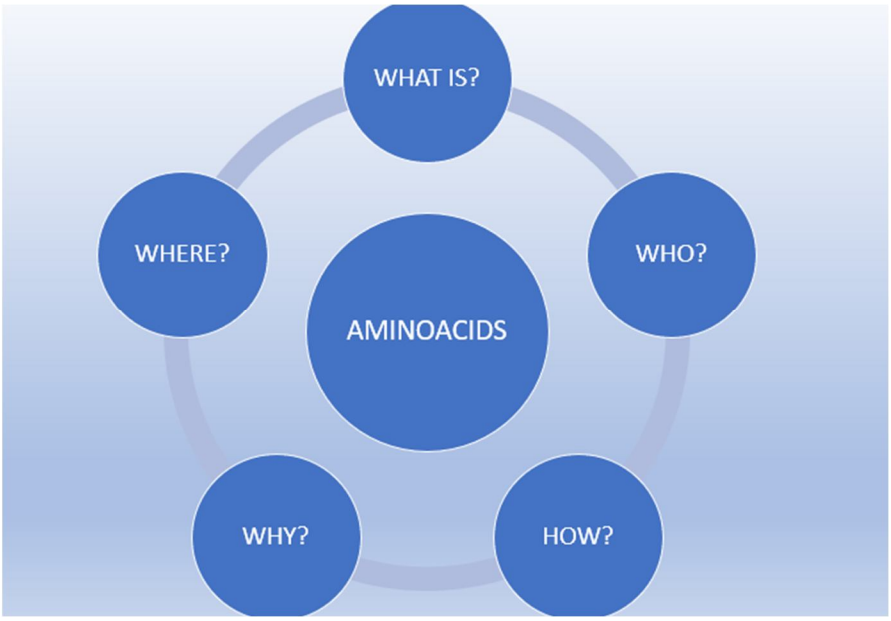


Figure 1. Guiding questions

3. By using a digital presentation, the topic was developed by linking students' daily life experiences to create bridges and connect new knowledge, making it significant to students (Figure 2).

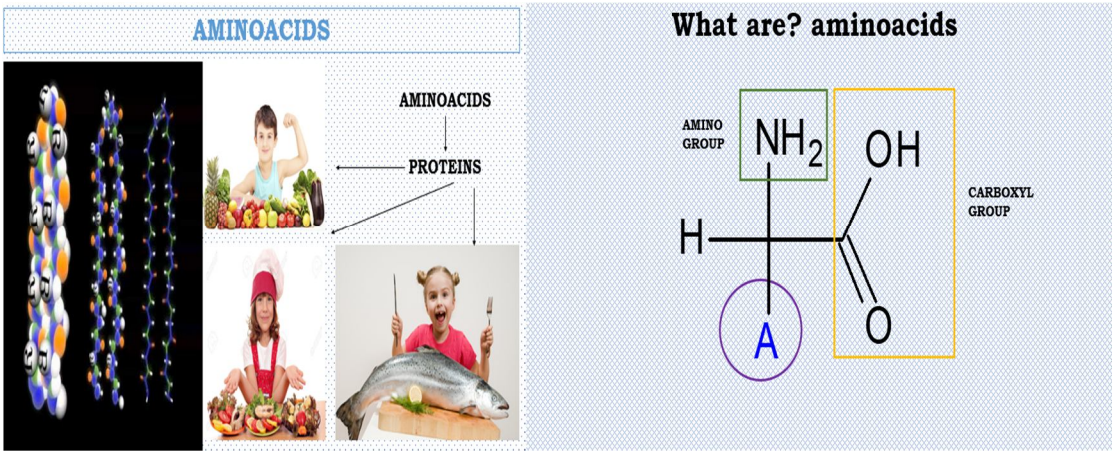


Figure 2. Aminoacids Digital Presentation

4. Students solved an exercise in which aminoacids' structure was identified, as well as peptide bonds based upon the digital presentation that was previously shown.

5. Subsequently, students searched online using their mobile devices to solve an exercise of twenty aminoacids in which they had to complete four to five aminoacid structures per team. Besides, they looked for their classification and their organism function. Later, they presented their investigation per team and solved the exercise as a group until the activity was completed.

6. Stereoisomerism and optical properties were addressed with the video called “the horror of thalidomide” from youtube: https://www.youtube.com/watch?v=LNCWO05LeW8 (Figure 3).

7. After the video, the students read the article called “The case of Thalidomide” (Figure 4) to complement the topic. The article was obtained from: http://www3.uah.es/edejesus/lecturas/curiosidades/cur005.htm.

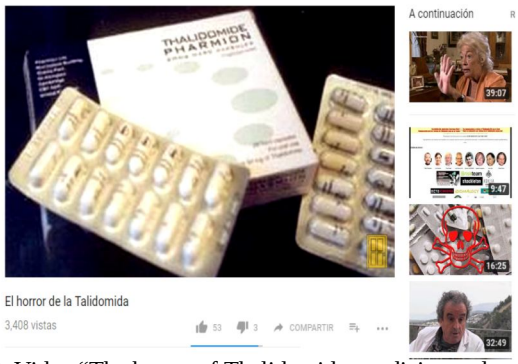


Figure 3. Video “The horror of Thalidomide, medicine and illness”,

Figure 4. The case of Thalidomide in 1962. Source: http://www3.uah.es/edejesus/lecturas/curiosidades/cur005.htm

8. A group discussion took place about the topic and the relationship it has with thalidomide. The concepts that were not understood were explained through a digital presentation (Figure 5).

9. Students made playdoh models to understand Stereoisomerism and optical properties (Figure 6). Structure was reviewed once more.

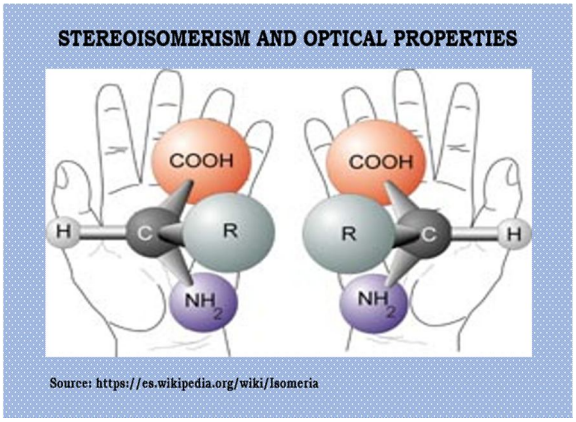


Figure 5. Stereoisomerism and aminoacids optical properties presentation.

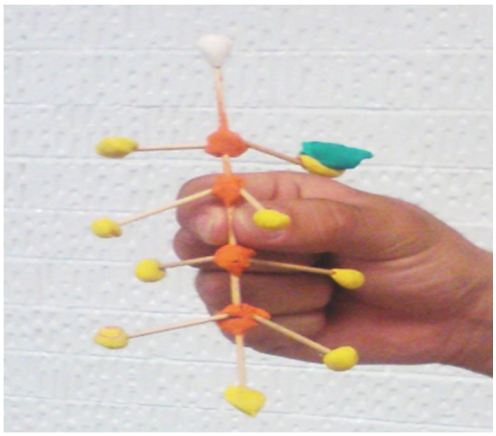
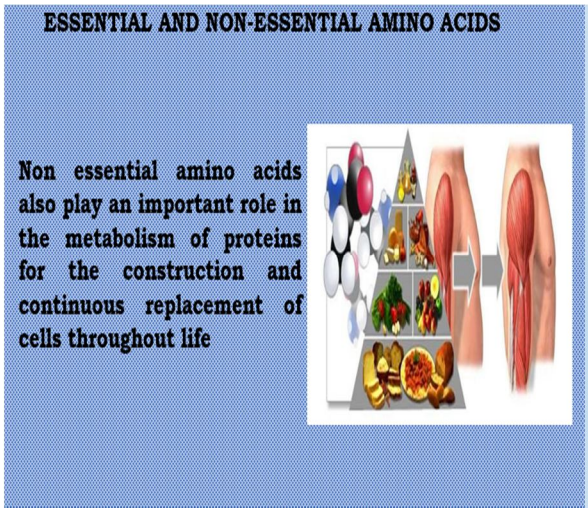
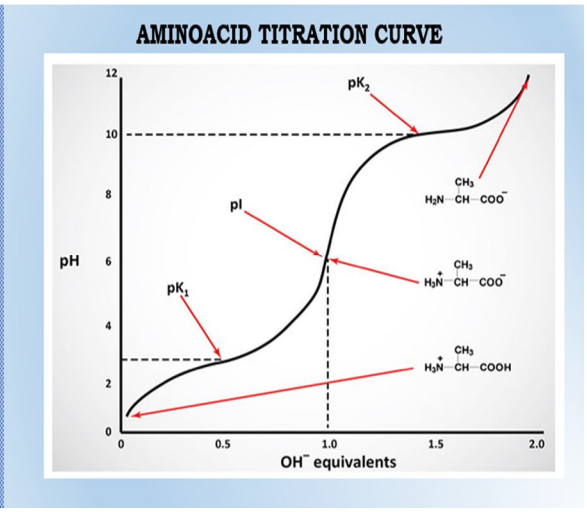


Figure 6. Modelling clay for Stereoisomerism and optical properties.

10. Students created a mindmap about essential and non essential aminoacids, based on a PowerPoint digital presentation.

11. By using a digital presentation, the topic of acid and basic aminoacids was presented, as well as titration





curves. Students made simple exercises about this (Figures 7-8).

Source: http://masmusculomurcia.es/2016/07/09/aminoacidos-esenciales/

Figure 7. Essential aminoacids presentation

https://themedicalbiochemistrypage.org/es/amino-acids-sp.php

Figure 8. Aminoacids titration curves

Learning sequence application for the topic b) Proteins' Composition identification, structure and function.

1. A previous questionnaire to know the students' starting point was applied for the topic of proteins' composition identification, structure and function.

2. With the aid of a brainstorm, proteins' previous knowledge was activated by discussing the following questions: What is a protein? Where are proteins found? What is the use of proteins? What is the proteins' structure?

3. By using their mobile devices, students downloaded recent outreach articles from the website: https://www.muyinteresante.es/resultados-google?cx=partner-pub-8023226614373997%3A5w8v7rqe5v1&cof=FORID%3A10&ie=UTF-8&q=proteinas&sa=, (see figure 9). With this, proteins were related to their environment to create significant knowledge and relate it to something they already know. A brief presentation of their readings was carried out, providing group feedback.

Figure 9. Internet readings about proteins.

4. Composition classification (Figure 10) and conformation of proteins (Figure 11) was presented in PowerPoint. Students created a comparative chart and a letter soup.

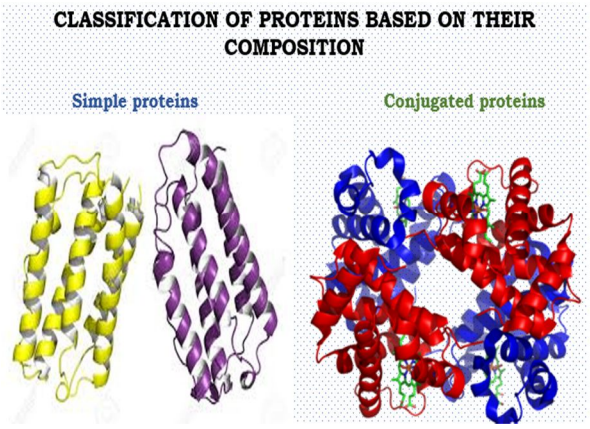


Figure 10. Protein classification based on their composition.

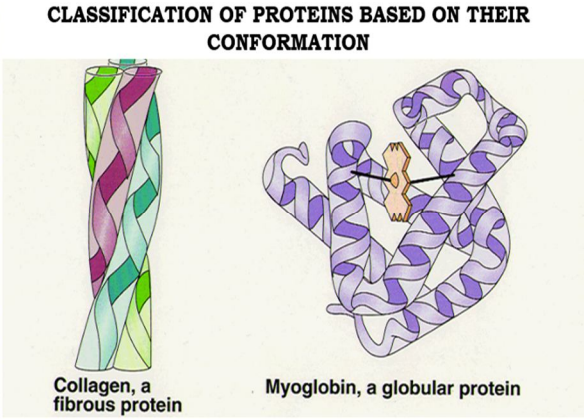


Figure 11. Classification according to their conformation.

5. In order to study the topic “protein classification” according to their structure, a video from Youtube was used: https://www.youtube.com/watch?v=qBRFIMcxZNM,

6. Students modelled protein structures with playdoh and styrofoam, so as to have a better understanding of the classification. They then explained their model to the group (see figure 12).

Figure 12. Protein models made by students

7. A comparative chart of protein classification and a concept map were made by students, with the aid of a digital presentation of the protein functions.

8. Two videos were presented: https://www.youtube.com/watch?v=VDEPrUJq_Vo&t=1s (Figure 13) and “Proteins: what are they and how many do we need?”, from https://LlWMwww.youtube.com/watch?v=yuV6rKX. With the aid of these tools, the importance of proteins in teenagers' development was studied, and students made a summary with cardboard and markers which they afterwards presented to the group. Last, they solved a letter soup to reinforce the topic.

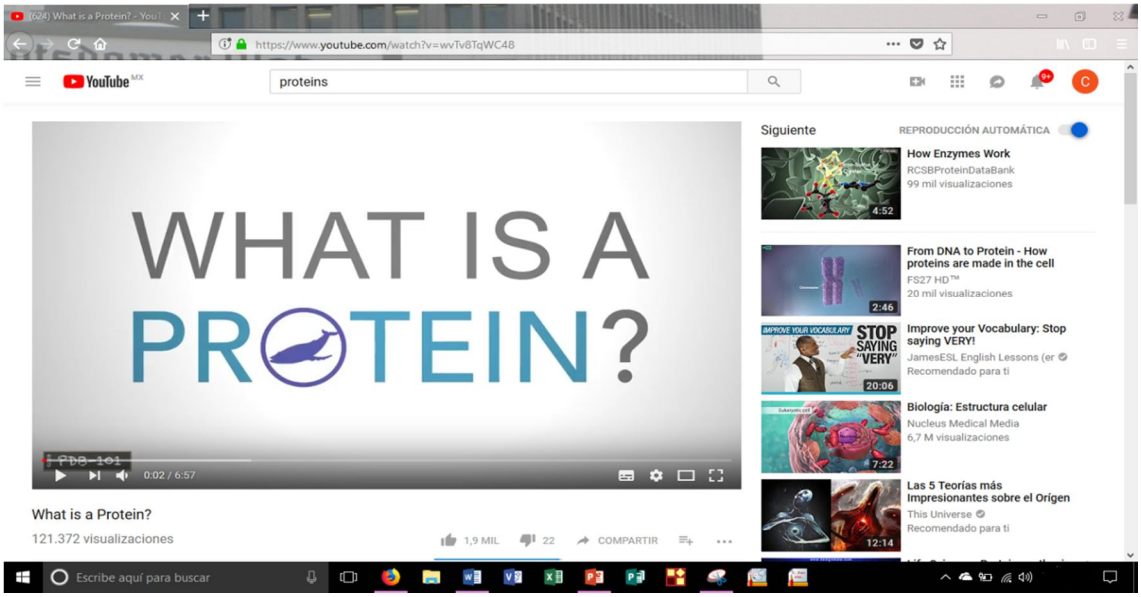


Figure 13. Protein Videos

9. The topic of proteins purification and denaturing was presented by using a digital presentation and students made a concept map. At the end, an evaluation was made.

10. Evaluation instrument: In order to evaluate the effectiveness of the designed didactic strategy, an evaluation instrument was designed (annex 1) with four learning dimensions as shown in Table 1 (Marzano, 2001).

Table 1. Learning dimensions of the evaluation reagents

Learning dimensions	Learning indicator	Items
1	Recognizes the classification of proteins	multiple choice questions (1,2,3, 4,5,6,7 and 8)
2	It understands some functions of proteins in the human body and can relate them to its structure	column relationship (9, 10, 11, 12 and 13)
3	Classify and outline the different structures of proteins	Scheme identification (14, 15, 16 and 17))
4	Apply your protein knowledge to determine the importance of them in the adolescent's diet.	Open answer questions (18, 19 and 20)

Population sample

The application of the didactic sequence took place in a high school named "CONALEP plantel 108", located in Avenida Primero de Mayo, Cuautitlán Izcalli, Estado de México with students enrolled in fifth semester in the "Interpretation of metabolic reactions in organisms" module. The didactic strategy was evaluated in an experimental group (EG) of 41 seventeen to eighteen year old students. The results were compared to a control group (CG) of 51 seventeen to eighteen year old students where the didactic strategy was not used, and the topic was taught in a traditional way with a white board and markers.

Results

A written test was applied which consisted of 20 reagents (*Appendix*), divided in four sections according to the learning level (Marzano, 2001). Correct answers results from EG and CG are shown in Figure 14.

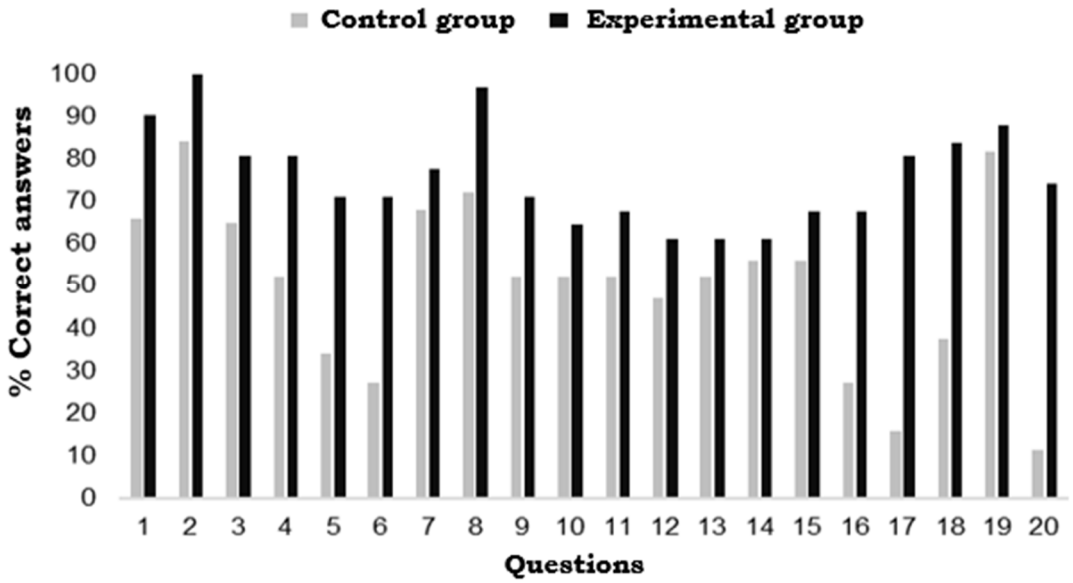


Figure 14. Correct answers in experimental and control group. Yellow (CG: Group); black (EG: Experimental Group)

In the first section, definitions and concepts were evaluated (questions one to eight). In the second section, the understanding of some of the proteins functions in the human being in relation to their structure were evaluated (questions nine to thirteen). In the third section, the ability of the student to schematize protein structures was assessed (questions 14 to 17). The last section considers the ability of the student to apply acquired knowledge of protein importance in a teenagers' diet (questions 17 to 20). Globally speaking, results show that EG students have more correct answers compared to the CG students in the four learning levels. Averages per section were determined: 83.42, 65.06, 69.25 and 81.85 % in the EG, and 54.80, 51.00, 36,47 y 45%) in the CG, respectively. It is important to observe that the evaluation in all the learning levels from the group in which the didactic strategy and the ICTs were applied is passing.

Conclusions

The didactic sequence, based on using different learning strategies such as problem-based learning, concept maps, playful strategies and didactic models, generated a better understanding of the protein topic, as well as motivating students since they related it to their environment and their interests in a more profound way. This enabled students to take action with the conceptual knowledge acquired to solve real problems and transforming the classroom into a pleasing enviroment where students acquire abilities and skills.

Didactic strategies and the use of ICTs favoured the creation of a productive and interesting learning environment for Millenial students, taking advantage of their potential towards new technologies and improving the learning outcomes.

The implementation of ICTs as well as the creation of modelling clay made a change in students, since they don't perceive the subject and abstract and intangible because they are able to be creative in the classroom. This led to the application of learning and knowledge technologies (LKTs).

References

Ausubel, D.P, Novak, J. D. and, Hanesian, H. (1978). *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart & Winston.

Giammatteo, L. and Obaya, A. (2018) Assessing Chemistry Laboratory Skills Through a Competency‐based Approach in High School Chemistry Course. *Science Education International* Volume 29, Issue 2, 103-109.

Lehninger, A. L. (1985) *Bioquímica. Las bases moleculares de la estructura y función celular*. Barcelona: Ediciones Omega.

Marzano, R.J. (2001). Designing a new taxonomy of educational objetives. *Experts in Assessment Series.* (T.R. Guskey, Ed.) CA: Corwin.

Mihaela-Gabriela Păun (2013) Pedagogical Strategies in Instructional Design. *International Journal of Education and Research* Vol. 1 No. 10, 1 – 8.

Parrales, D., Obaya, A. V., Morales, M. and Botello, J. (2017). Estudio exploratorio Aplicaciòn del sistema 4mat de estilos de aprendizaje, en la enseñanza de biomoléculas*. Enseñanza de las ciencias: Revista de Investigaciòn y Experiencias Didàcticas* Nº Extraordinario 1883 – 1889.

Appendix: Evaluation

I. Instructions: place in the parenthesis the letter of the correct answer

( ) 1. What is a protein?
a) Biopolymers formed from high molecular weight amino acids
b) They are the monomers of proteins, consisting of an amino group and a carboxyl
c) Set of organic biomolecules composed of carbon and hydrogen

( ) 2. The primary structure is constituted mainly by?
a) A chain of amino acids linked by peptide bonds
b) It is formed from the condensation of two monosaccharides
c) Constituted by phospholipids and polar lipids

( ) 3. The secondary structure of proteins is constituted by?
a) Formed by polypeptide chains, can be folded into α-ellipse and β-folded
b) Long chain of amino acids, linked by peptide bonds
c) It is a globular structure linked by peptide bonds, covalent bonds and hydrogen bonds.

( ) 4. How is a tertiary structure defined?
a) It consists of an α-ellipse folding on itself, unit by means of hydrogen bonds and ionic interactions, covalent bonds, hydrogen bonds, disulfide bridges and may contain prosthetic groups.
b) Proteins can associate with each other and can be linked by covalent bonds
c) Components of organic or inorganic origin called prosthetic groups

( ) 5. How a quaternary structure is defined?
a) Consists in the folding of alpha-ellipse on itself, linked by hydrogen bonds and ionic interactions, covalent bonds, disulfide bridges and may contain prosthetic groups
b) Proteins can associate with each other and can be linked by covalent bonds
c) Components of organic or inorganic origin called prosthetic groups

( ) 6. They are examples of the classification of proteins according to their biological function
a) Enzymes, globular proteins and metalloproteins
b) Lipoproteins, fibrous proteins, non-fibrous proteins
c) Structural proteins, defense proteins and hormones

( ) 7. They are examples of proteins according to their solubility
a) Nucleoproteins and glycoproteins
b) Globular and fibrous
c) Transport and defense proteins

( ) 8. Examples of conjugated proteins (fractions of non-protein components)
a) Primary and secondary protein
b) Lipoproteins, glycoproteins
c) Contractile and structural proteins

II. Instructions: Relate the columns correctly

9. Insulin is an example	Tertiary structure protein
10. Good cholesterol is part of lipoproteins and is	Quaternary structure
11. The keratin found in the skin and hair is	Are a secondary and fibrous proteins?
12. Hemoglobin is a globular protein responsible for the transport of O_2 and CO_2, in an example of structure	A conjugated protein
	Of a protein of primary structure
13. Myoglobin, roanesa, papain and immunoglobulins are examples of	

III. Schematize the following protein structures

14 Primary structure

15 Secondary structure

16 Tertiary structure

17 Quaternary structure

IV. Answer correctly

18 What are the sources of protein and where are they mainly found?

19. Why are proteins important for adolescent development?

20. How many calories does one gram of protein provide?

ANNEX: Evaluation

I. Instrucciones, coloca en el paréntesis la letra de la respuesta correcta.

( ) 1.-¿Qué es una proteína?

a) Biopolímeros constituidos a partir de aminoácidos de alto peso molecular
b) Son los monómeros de las proteínas formados por un grupo amino y un grupo carboxilo
c) Conjunto de biomoléculas orgánicas, compuestas por carbono, hidrogeno

( ) 2.-La estructura primaria está constituida principalmente por:

a) Una cadena de aminoácidos unida por enlaces peptídicos
b) Se forma de la condensación de dos monosacáridos
c) Constituido por fosfolípidos y lípidos polares

( ) 3.-La estructura secundaria de las proteínas están constituidas por

a) Formada por cadenas polipeptídicas, se puede plegar en alfa elipse y beta plegada.
b) Cadena larga de aminoácidos, unida mediante enlaces peptídicos
c) c)Es una estructura globular unida mediante enlaces peptídicos, covalente y puentes de hidrogeno

( ) 4.- ¿Cómo se define a la estructura terciaria?

a) Consiste en el plegamiento de α-elipse sobre sí misma, unidas mediante puentes de hidrogeno e interacciones iónicas, enlaces covalentes, puentes de disulfuro, pueden contener grupos prostéticos
b) Las proteínas pueden asociarse entre ellas y se pueden unir mediante enlaces covalentes
c) Componentes de origen orgánico o inorgánico llamados grupos prostéticos

( ) 5.- ¿Cómo se define la estructura cuaternaria?

a) Consiste en el plegamiento de α-elipse sobre sí misma, unidas mediante puentes de hidrogeno e interacciones iónicas, enlaces covalentes, puentes de disulfuro, pueden contener grupos prostéticos
b) Las proteínas pueden asociarse entre ellas y se pueden unir mediante enlaces covalentes
c) Componentes de origen orgánico o inorgánico llamados grupos prostéticos

( ) 6.-Son ejemplos de la clasificación por su función biológica de las proteínas

a) Enzimas, proteínas globulares, metaloproteínas.
b) Lipoproteínas, proteínas fibrosas, proteínas fibrosas.
c) Proteínas estructurales, proteínas de defensa, hormonas.

( ) 7.-Son ejemplos de proteínas según su solubilidad

a) Nucleoproteínas y glucoproteínas.
b) Globulares y fibrosas.
c) Proteínas de transporte y defensa.

( ) 8.-Son ejemplos de proteínas conjugadas (fracciones de componentes no proteicos

a) Proteína primaria y secundaria.
b) Lipoproteínas y glucoproteínas.
c) Proteínas contráctiles y proteínas estructurales.

II.- Relaciona las columnas correctamente

9.-La insulina es un ejemplo	Proteína de estructura terciaria
10.-El colesterol bueno es parte de las lipoproteínas y es	Estructura cuaternaria
11.-La queratina que se encuentra en la piel y el cabello es	Es una proteína secundaria y además fibrosa.
12.-La hemoglobina es una proteína globular encargada del transporte de O_2 y CO_2 es un ejemplo de estructura	Una proteína conjugada
13.- La mioglobina, roanesa, papaína e inmunoglobulinas son ejemplos de	De una proteína de estructura primaria.

III.- Esquematiza las siguientes estructuras de proteínas primaria, secundaria, terciaria y cuaternaria.

14.- Estructura primaria

15.- Estructura secundaria

16.- Estructura terciaria

17.-Estructura cuaternaria

IV.- Contesta correctamente

18.- ¿Cuáles son las fuentes de proteínas y principalmente en donde se encuentran?

19.- ¿Porque son importantes las proteínas para el desarrollo de los adolescentes?

20.- ¿Cuántas kilocalorías aporta un gramo de proteína?