Arquivos Médicos
DOS HOSPITAIS E DA FACULDADE DE CIÊNCIAS MÉDICAS DA SANTA CASA DE SÃO PAULO

BRIEF COMMUNICATION

Arq Med Hosp Fac Cienc Med Santa Casa São Paulo. 2021; 66:e027
https://doi.org/10.26432/1809-3019.2021.66.027

Interactive biophysics platforms for healthcare courses

Plataformas interativas de biofísica para os cursos da área da saúde

Nilton da Silva Oliveira Jr [1], Eric Alexandre Brito da Silva [2]

Abstract

Introduction: *The teaching of biophysics for health sciences has always demanded great efforts on the part of the professors. Because of the computer systems advances, the simulators can enable students to turn something abstract (biophysical properties) into something intelligible. In order to adapt to the new technology, professors and large universities have acquired these tools and started using them to optimize the teaching of the subject. An undergraduate research project was created, as an alternative publicly available in Portuguese, where two computer simulators would be created, the first one elaborated in Excel spreadsheets and the second one in platforms with an interface for using it in internet browsers with the purpose of calculating bioelectric properties of cell membranes and facilitating the teaching and learning of this topic for students in health care courses.* ***Materials and Methods:*** *The elaboration of the project consisted of bibliographic survey, equation of biophysics calculations and systems programming in Visual Basic for Applications (VBA ®) and C # ® (both Microsoft ™ proprietary programming languages).* ***Results and Discussion:*** *The simulator of the electrical properties of cell membranes, named BioEletric9 has already been implemented and the tests carried out to ascertain its functionality and the coherence of the calculations were satisfactory, which has already validated it to be used in teaching activities.* ***Conclusions****: The Excel spreadsheet is already operational and allows the teacher to use it as an information resource in the classroom or computer lab. The BioEletric9 program is in its final stages of adjustment and will be subjected to a layout optimization after having its execution errors corrected.*

1. Santa Casa de São Paulo School of Medical Sciences. School of Medicine. Sao Paulo – SP – Brazil
2. Universidade Nove de Julho (UNINOVE). Health Care Department. Sao Paulo – SP – Brazil
Institution: *Santa Casa de São Paulo School of Medical Sciences. School of Medicine. Sao Paulo – SP – Brazil*
Universidade Nove de Julho (UNINOVE). Health Care Department. Sao Paulo – SP – Brazil
Correspondence address: *Nilton da Silva Oliveira Jr. Rua Maria do Nascimento Boz Vidal, 1449 - Vila Suissa – 08810-100 - Mogi das Cruzes – SP - Brasil*

Keywords: *Social media, Biophysics, Health sciences, Internet*

Resumo

Introdução: *O ensino da disciplina de Biofísica para as ciências da saúde desde sempre exigiu grandes esforços por parte dos docentes. Com o avanço dos sistemas computacionais, os simuladores permitiram tornar algo que é abstrato (propriedades biofísicas) aos alunos em algo inteligível. No intuito de adequar-se a essas novas tecnologias, os docentes e as grandes universidades adquiriram e iniciaram o uso dessas ferramentas para otimizar o ensino da disciplina. Pensando-se em uma alternativa disponível publicamente em língua portuguesa, o objetivo deste projeto de iniciação científica foi a criação de dois simuladores computacionais, o primeiro elaborado em planilhas do Excel e o segundo em plataformas com interface para uso em navegadores de internet com o intuito de calcular propriedades bioelétricas de membranas celulares e facilitar o ensino e o aprendizado desse tema para os alunos dos cursos da área da saúde.* ***Material e Métodos****: A elaboração do projeto compreendeu tarefas de levantamento bibliográfico, equacionamento de cálculos de biofísica e programação de sistemas em Visual Basic for Applications (VBA ®) e C# ® (ambas linguagens de programação proprietárias da Microsoft ™).* ***Resultados e Discussão:*** *O simulador de propriedades elétricas de membrana celular, nomeado de BioEletric9 já se encontra implementado e os testes realizados para averiguar sua funcionalidade e coerência dos cálculos foram satisfatórios, o que já permite utilizá-la em atividades didáticas.* ***Conclusões****: A planilha em Excel já é operacional e permite ao professor sua utilização didática como recurso informacional em sala de aula/laboratório de informática. O programa BioEletric9 encontra-se em seus últimos estágios de finalização e será submetido a uma otimização de layout depois de ter seus erros de execução corrigidos.*

Palavras chave*: Mídias sociais, Biofísica, Ciências da saúde, Internet*

Introduction

The teaching of the biophysics subject for health sciences has always demanded great effort from the

professors since the physical properties of several organic systems were not actually viewable or any other form of direct contact for the students, making it hard for them to learn the topic.

The references which carry the Biophysics designation end up in its great majority being assigned to the exact sciences public, leaving the physiology references destined to the health care students when a biophysics support is needed. This fact is due to the complexity of the physics application on biology. In order to respond to the diverse phenomena that living beings are susceptible to, many mathematical equations are required and sometimes sophisticated mathematical treatment is essential. Therefore, even though Biophysics books are focused on the health care area, it is impossible not to have a mathematical approach[1-6].

However, on account of the advances of computer systems, simulators have enabled the students to turn something abstract (biophysical properties) into something intelligible, whether as videos or calculation tools for these properties, with real-time display of results. One example is the PhysioEx9,0[7] software. Its latest version possesses 66 lab activities which can be simulated using just an internet browser. Undoubtedly, it is very instructional and useful program to aid the covered concepts though it doesn't have a Portuguese version nor it is a free software.

There are some simulation and animation websites online regarding physics concepts applied to biology or just physiology that seem interesting and bring some interactivity to the classroom[8]. Those are only related to a single specific topic, for instance, rest and action potential genesis or circulatory system biophysics[9]. The English language simulation websites offer some kind of interactivity, where the student can alter the concentration levels of intracellular and extracellular components which induces a change in the membrane electrical potential. In some cases, these virtual environments of simulation present themselves in a confusing and not very instructive manner. In the Portuguese language it is difficult to find these types of simulations applied to biophysics.

In 2010, a master's degree course conclusion work named "Biofísica Aplicada a Enfermagem"[10] was published. The teaching material available on the internet has the theoretical approach and gathers several links from well-known television programs, such as National Geographic and Discovery Channel, as well as scientific paper texts in the area. It is definitely good material but it lacks interactivity[11].

In the intention of adapting to new technology, professors and large universities alike acquired these tools and started using them to optimize the teaching of biophysics and improve the comprehension of the subject from their students, allocating financial resources to their acquisition. Nevertheless, it was wondered why the development of customized software which met the local needs in the academic environment and as such, for being academic in purpose, it was free platform and widely available for educational ends.

The answer emerged in the form of a course conclusion work and a scientific research project, both part of the line of research of the guide professor from these works[12], initially carried out in Universidade Nove de Julho (UNINOVE)[12].

In 2015, work focused on the same topic was accomplished, yet using the Delphi platform for the development of a computer system applied for biophysical calculation and teaching that encompassed the hemodynamics theme to be used as support material for the health area professors[13].

Two computational simulators were created, the first one elaborated in Excel spreadsheets and the second one in platforms with an interface for using it in internet browsers, which opens for the possibility of running it in any computer, with the purpose of calculating bioelectric properties of cell membranes and facilitating the teaching and learning of this topic for students in health care courses.

Material and Methods

The Project elaboration consisted of bibliographic survey, equation of biophysics calculations and systems programming in Visual Basic for Applications (VBA ®) and C # ® (both Microsoft ™ proprietary programming languages). It was carried out in three phases:

1st STAGE

1.1 Bibliographic survey for collecting quantitative data to be used in biophysical formulas and simulation applying;

1.2 Collection of quantitative data;

1.3 Microsoft Excel platform familiarization;

2nd STAGE

2.1 Creation of spreadsheets for each topic;

2.2 Developed spreadsheets application in na interactive platform used in classes;

3rd STAGE

3.1 Software elaboration for internet platform.

3.2 For the third stage the Visual Studio.NET Companion 2015 compiler was used, available in the partnership between UNINOVE and Microsoft ™ which allows the creation of dynamic and interactive sites serving the purposes of the aforementioned projects.

Results e Discussion

The cellular membrane electrical properties simulator has been already implemented and the tests carried out to ascertain its functionality and the coherence of the calculations were satisfactory, which has already validated it to be used in teaching activities.

The 2016 version of Microsoft Excel was used for its elaboration since it is distributed freely for UNINOVE students in an agreement with the company itself.

In picture 1 the graphic spreadsheet interface of the membrane electrical properties is presented, which allows users to alter the calcium, potassium and sodium values and enter data of internal and external concentrations of ions and conductivity in the David Goldman equation[14]. The software also indicates if the means are in a state of hypoconcentration (lower than average), normal concentration (average) or hyperconcentration (higher than average). From that the membrane potential is calculated.

There is still the possibility of calculating the membrane potential through the Conductivity equation, with its use similar to the previous method.

The Excel platform has as advantages its easy-to-use interface from the part of both students and professors, as well as the fact that the Excel program

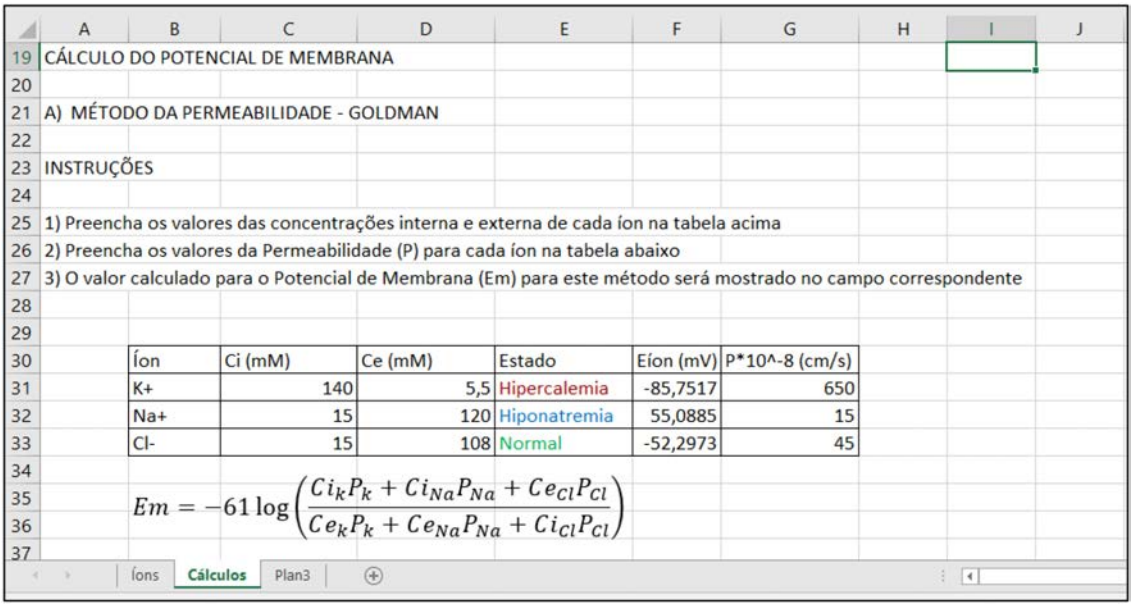

Figure 1 – Excel spreadsheet for the calculation of membrane bioelectrical properties – Goldman method.

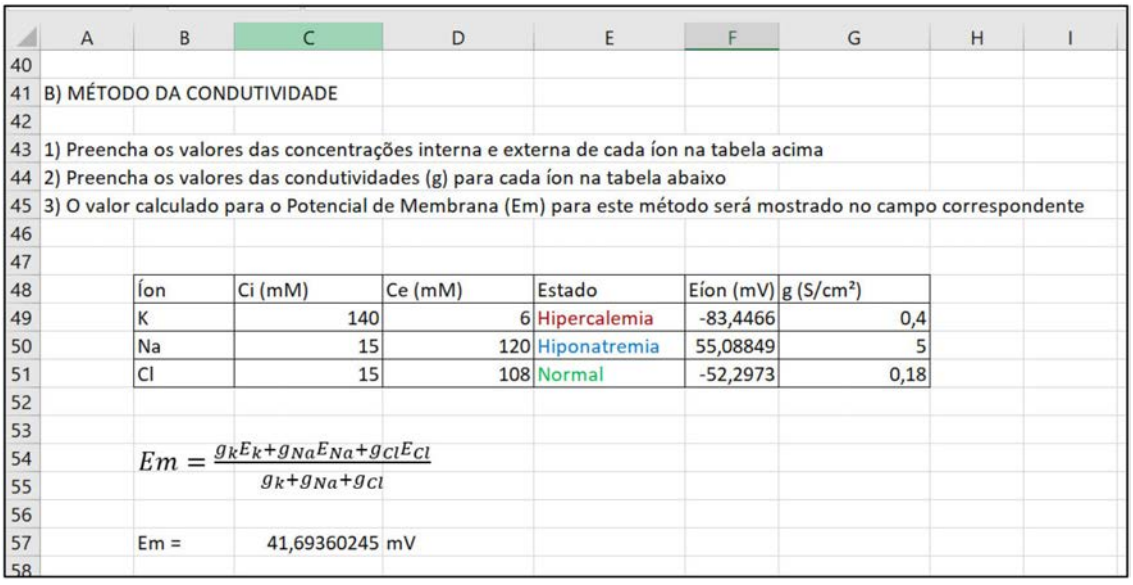

Figure 2 – Excel spreadsheet for the calculation of membrane bioelectrical properties – Conductivity method.

has numerous built-in mathematical functions which optimize the calculation of all the biophysical properties in question. However, it has disadvantages such as the fact of Excel being ownership software and its presence being required in the user's personal computer (or the user possessing an online office 365 account).

Regarding the internet software, the Microsoft Visual Studio.NET Community 2015 platform was chosen, in C# language, due to the availability of this tool for the students. We named it BioElectric9.

The calculation resources of the bioelectrical properties of membranes from the internet software have already been developed, presenting some operational errors (bugs), which are normal in this stage of development of any computational software.

After the correction of these bugs, we aimed to install the website in the university's internet provider itself, which would allow remote access from students and professors alike, starting out its educational use in biophysics activities.

In Figures 3 to 5, the program's graphic interface images are presented.

One property, in its final stage of implementing is the graphic Generation of the physical properties of membranes. This is already possible, indirectly, through the Excel spreadsheet, as presented in Figure 6 and is the objective of further implementation in the

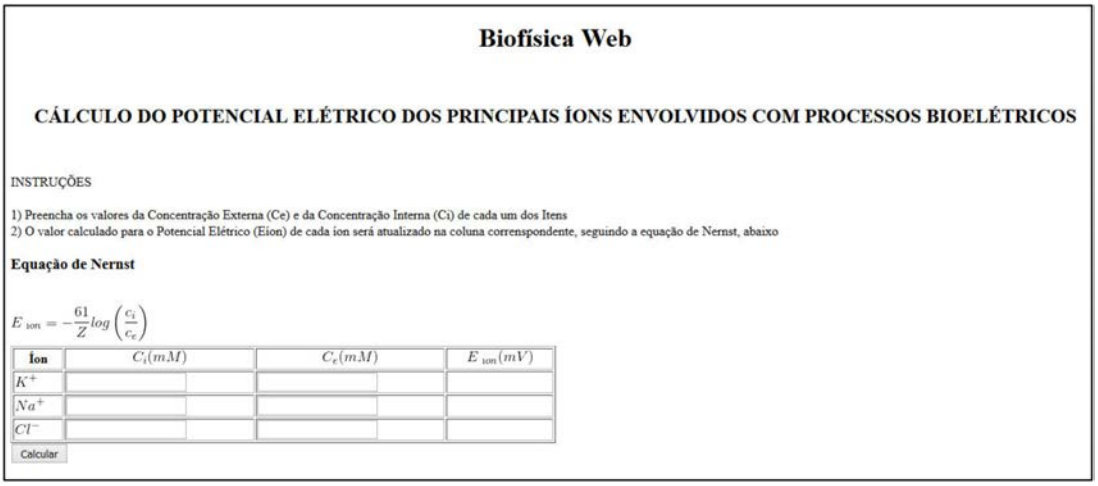

Figure 3 – Internet software for the calculation of bioelectrical properties of membranes and ion potential. Similar to the Excel spreadsheet, the values of internal and external ion concentrations are here inserted for the calculation of their Nernst potential.

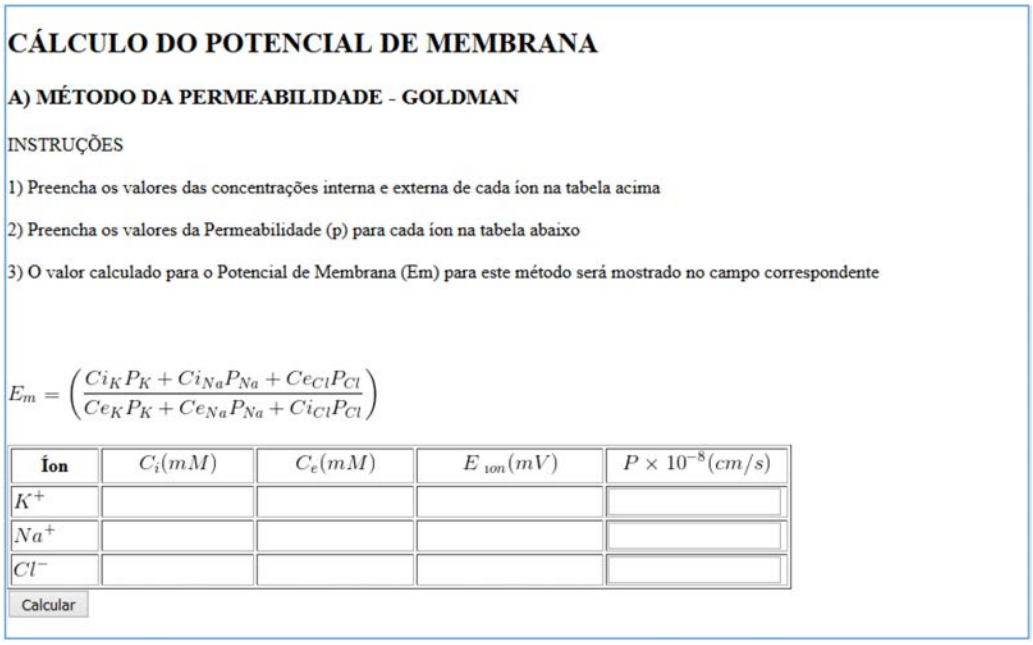

Figure 4 – Software BioEeltric9, internet version. This is the screen for membrane potential calculation using the Goldman method, in which input data are internal and external concentration of the ions, their Nernst potential and their permeability values.

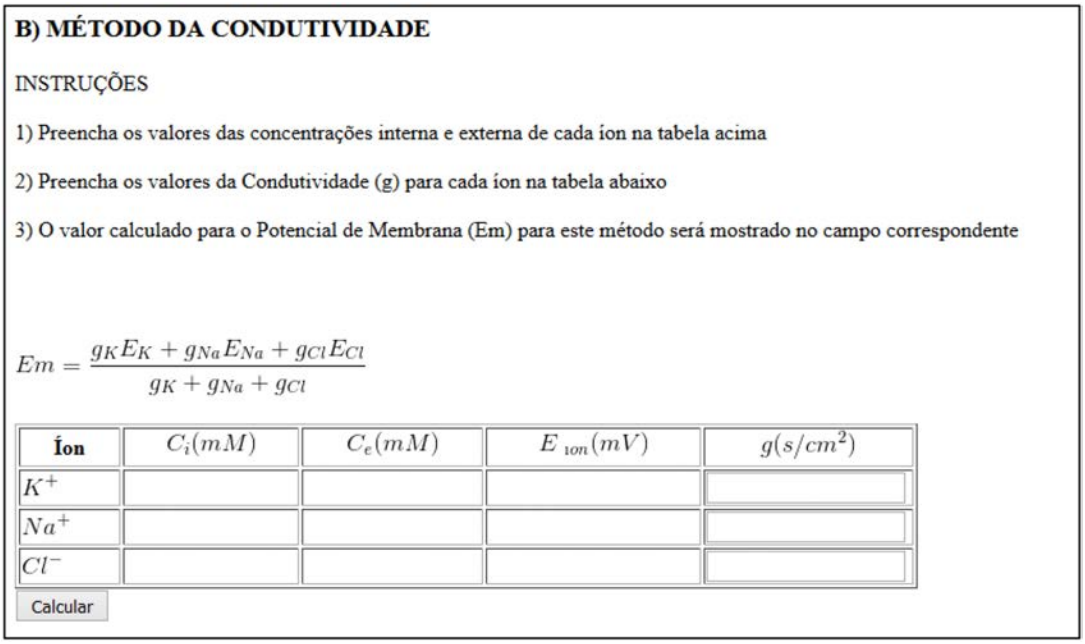

Figure 5 – Software BioEeltric9, internet version. This is the screen for membrane potential calculation using the conductivity method. The internal and external ion concentration and Nernst potential values are also inserted here, as well as their conductivity values.

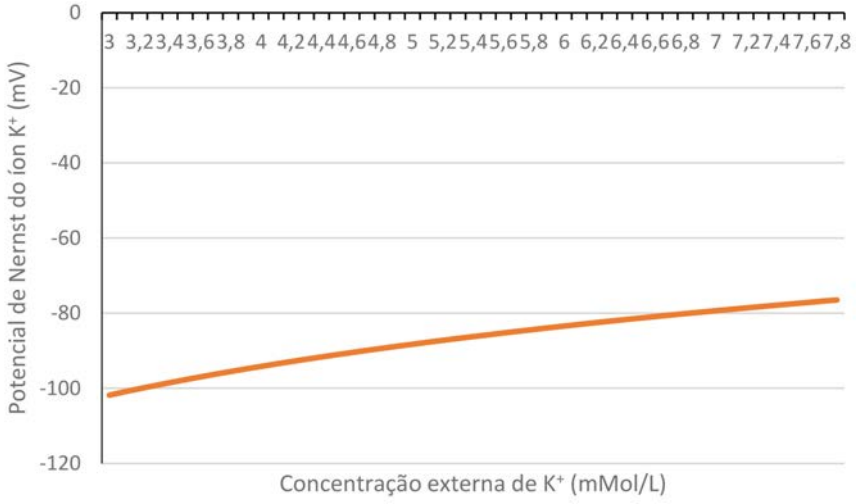

Figure 6 – Table relating potassium concentration in the extracellular fluid to the Nernst potential of the aforementioned ion. The states of hypokalemia (lower than average), normal kalemia (average) and hyperkalemia (higher than average).

web version. In this application, it is possible to better analyze the influence of ionic concentration variations in the genesis of the membrane potential and investigate the applications in several clinical cases.

Conclusions

The Excel spreadsheet is already operational and allows the professor its educational use as an information resource in classroom or computer lab. The **BioEletric9** program is in its last stages of development and will be submitted to a layout optimization after having its execution errors corrected.

As inherent attributes to this program, the free distribution, the customization possibility, the adaptable layout to mobile platforms and the fact of being entirely in Portuguese can be highlighted.

The development of this project has reached and met the needs of the proposed objectives in a satisfactory way. From its implementation there will be a significant gain in academic simulations referring to the bioelectric properties of cellular membranes. Using this platform through any compute will allow the educational unit to no longer depend on a specific lab or

paid licenses. The simultaneous use among professor and students makes it possible to alternate between the theoretical and the practical parts at the same educational moment, even in case of distance learning, allowing this teaching "structure" to be maintained.

The next steps will be making available the support texts and educational activities to be explored with the software, the matters of study related to the biophysics of membrane potentials and the elaboration of clinical case studies in which the software could be applied, creating a connection between the theoretical basis of the subject to the clinical reality of a health care professional.

References

1. Cameron J, Skofronick J. Medical physics. New York: John Wiley & Sons; 1978. 615p.
2. Hall S. Biomecânica básica. 3a. ed. Rio de Janeiro: Guanabara Koogan; 2000. 417p.
3. Heneine I. Biofísica básica. São Paulo: Atheneu; 1990. 311p.
4. Okuno E, Caldas I, Chow C. Física para ciências biológicas e biomédicas. São Paulo: Harbra; 1986. 490p.
5. Garcia E. Biofísica. São Paulo: Sarvier; 2002. 387p.
6. Rodas Durán JE. Biofísica: fundamentos e aplicações. São Paulo: Person Prentice Hall; 2003. 318p.
7. Physiology LLSi. PhysioEx9,0. Pearson Education; 2011.
8. UNICHIG. Electrophysiology and the molecular basis of excitability. [Internet]. Chicago (Il)University of Chigago. [citado 2020 Dez 12]. Disponível em: http://nerve.bsd.uchicago.edu/nerve1.html.
9. Nave R. Poiseuille's law. [Internet]. Atlanta(GA): Georgia State University, Department of Physics and Astronomy; 2012. [citado 2020 Dez 12]. Disponível em: http://hyperphysics.phy-astr.gsu.edu/hbase/ppois2.html.
10. Guimarães FSP. Biofísica: Elaboração de um material didático para o curso de enfermagem. Dissertação [Mestrado]. Belo Horizonte: Pontifícia Universidade Católica de Minas Gerais; 2010.
11. Guimarães FSP. Biofísica aplicada à enfermagem 2010. [Internet]. [citado 2020 Dez 11]. Disponível em: http://www.biofisica.xpg.com.br/.
12. Silva E, Grosso A. Elaboração de uma plataforma interativa de biofisica e fisiologia para aplicação didática nos cursos da área da saúde. Iniciação Científica (Graduação em Medicina). São Paulo: Universidade Nove de Julho; 2016.
13. Arçari P. Elaboração de uma plataforma interativa de biofisica e fisiologia para aplicação didática nos cursos da área da saúde. Monografia [Trabalho de Conclusão de Curso]. São Paulo: Universidade Nove de Julho; 2015.
14. A Equação de Hodgkin-Katz-Goldman. [Internet]. [citado 2020 Dez 11]. Disponível em: http://www.bioinfo.ufc.br/obj/gal/hodgkin.php.

Article received: December 14, 2020
Article approved: August 19, 2021
Article published: September 14, 2021

Responsible Editor: Prof. Dr. Eitan Naaman Berezin (Editor–in-Chief)