CPQ Medicine (2021) 12:2
Conceptual Paper

Next-Generation Education: Incorporating Bioinformatics into Biological Science Education

Stavroula Koulocheri, A.

Department of Biological Chemistry, Medical School, National and Kapodistrian University of Athens, NKUA, Greece

***Correspondence to:** Dr. Stavroula Koulocheri, A., Department of Biological Chemistry, Medical School, National and Kapodistrian University of Athens, NKUA, Greece.

Copyright

Received: 29 June 2021

Published: 02 July 2021

Keywords: *Bioinformatics; Undergraduate Course Design; Interdisciplinary Curriculum; Problem-Based Learning; Biomedical Sciences*

Abstract

Bioinformatics is rapidly becoming an integral part of the biological sciences and is considered an essential research tool over the last few years. The ability to search and extract information from large databases has continually become of great importance to various aspects of biomedical sciences. It is important that undergraduates be exposed to the available information and procedures. Broadening the undergraduate biological sciences curricula with data-mining exercises is a perfect way to expose the students to the existing databases and tools in an integrated manner, thus taking advantage of this plethora of biological information.

Introduction

Bioinformatics is a new field and of multidisciplinary character, encompassing biological sciences, mathematics and computer science. The pressing need to process and analyze the cataclysm of data created by proteomics and genomics works showed the important role that bioinformatics can play in recent world. The fast technological achievements have led to a vast increase of biomedical data in recent years. The

advances in the biomedical sciences and information technologies resulted in the design of big biological data management and organization. The National Center for Biotechnology Information (NCBI) relating to this field is focusing on the "*analysis and interpretation of various sets of data, as nucleotide and amino acid sequences, protein domains, and protein structures" investigating the relationships among the large data sets* [1].

This necessitated the further processing of translational bioinformatics in education and teaching. With the aid of the internet and the plethora of online resources, teaching bioinformatics is important for a well structured education. Infusion of bioinformatic methodologies and application of on line tools into the classroom is very important for future students in biomedical sciences.

Bioinformatics Constitutes an Integral Part of a Biomedical Undergraduate Course

The multidisciplinary nature of bioinformatics is associated with biomolecules, thus essential biochemistry, biology, molecular biology, mathematics, and computer science are subjects correlated. There is a need to incorporate new sequence technologies and bioinformatics into undergraduate education and training [2].

It is known that web-based bioinformatics includes tutorials and background information. Bioinformatics exercises can be mixed with biomedical subjects such as chemistry with biological emphasis, biochemistry and biology. Thus students with the aid of exercises can learn the essential principles and make use of online literature sources, various databases (Genbank), information retrieval (OMIM, PubMed, FASTA format, NCBI Structure/PDB Viewer) and alignment (BLAST). Further, the European Bioinformatics Institute (EMBL-EBI) is very helpful for users interesting in eLearning. This institute maintains the world's most broad, freely available and up-to-date molecular data resources and training courses [3].

Students enrolled in small groups can do practice in cooperative mode in problem-solving, and be involved in various projects. The subjects of the assignments given to students may involve literature searches, database queries, sequence alignments, BLAST searches. Dealing with data sets and interpreting sets from various on line bioinformatics sources is very constructive for further understanding [4].

The focus is on the Central Dogma, the encoding within the genome, translation to protein and protein function. Prerequisites are genetics, gene sequences, protein structure and function. Students should learn to apply various computational tools, and perform analysis on biological and medical data.

Infusion of bioinformatics into existing courses (Genetics, Molecular Biology and Biochemistry) is a very practical approach to teach the basics of bioinformatics. The simultaneous teaching with the essential of bioinformatics enhances and interconnects each field. This can be done by sharing exercises through linking of biology, chemistry of biomolecules, biochemistry and computer science topics. The focus on teaching this basic course must be more biological than computational. For three-dimensional structure analysis and visualization of proteins, Swiss-PDBViewer is a very usuful tool with accompanying online tutorials. The introduction of exercises and projects on biomolecules using online visualization tools such as Protein Explorer or software PyMOL is very helpful. Another option is the use of RasMol intended for the 3D visualisation of proteins, nucleic acids and small molecules.

It is worth of note that emphasis on group-teaching and cooperation among the other disciplines is very important and can result in a better organization and understanding of the basic principles of these tools. Bioinformatics exposure and training is an indispensable part of a biomedical education. This exposure enhances biomedical education and understanding. Further this leads to a gradual transition from traditional passive learning to a more creative instructional transmission.

It is very important that many software packages and bioinformatics tools are free and available through internet. This early integration supplements and enhances biomedical education and understanding [5]. It is essential that students search and explore literature in PubMed, a fundamental bioinformatic expertise for future researchers and medical doctors. Freshmen-level and sophomores can be familiarized with bioinformatics tools in exercises and projects [6].

Students of biomedical sciences can be practiced and be familiarized with data analysis and tools because there are practical tutorials and relative information available through the web [7,8]. So far, many universities have incorporated bioinformatics in the biomedical sciences [9,10].

A major goal is to train students to be effective users of the huge information deposited in biomedical databases [11]. It is important to gain knowledge and skills as described below in bioinformatics learning outcomes [12].

Bioinformatics Learning Outcomes

Knowledge

- Understanding the role of bioinformatics as a topic
- Familiarity with structure of biomolecules and how structure determines function
- Understanding of information flow in biomolecular systems
- Basics of molecular evolution
- Experience with biological databases and with sequence search and alignment
- Gaining literacy in the basic methodology and applications of bioinformatics
- Gaining a deeper and critical perception of bioinformatics methods and their applications
- Showing the impact that genomics and proteomics is having on the field of biochemistry.

Skills

- Critical thinking, evaluation of information
- Practicing with bioinformatics software and tools
- Data analysis and extracting biologically correct results
- Gaining the skill to work from DNA sequence to protein structure and function and reversely

• Searching and organization of information obtained

• Using online bioinformatics resources to solve biological problems

• Using of online literature -online sources

Summary

The life sciences are transformed by the rapid growth of data of diverse types. Accessing and exploitation of these data means strong dependance on computational methodology. The future medical students must access and analyze this information. The role of bioinformatics is very important. No biomedical science curriculum can remain modern without the integration of bioinformatics. In silico dry labs based on bioinformatics methodology and virtual lab exercises can be very beneficial in the field of genetics, biology, and biochemistry. Exercises using on line tools freely available on the internet can help students in obtaining skills. A strong recommendation is a demand for students to be involved and worked with the existing data and tools that reflect the biomedical research in the 21st century.

Dr Alan Bleasby (coauthor of the EMBOSS sequence analysis package) said:

«half a day on the web, saves you half a month in the lab!» -if you do your software analysis in the correct manner! [10].

Besides traditional laboratory work, the future demands a modern, virtual biomedical science.

Infusion of bioinformatics with biological sciences is becoming a multidisciplinary field. Bionformatics analyses are also transformed from the DNA sequences towards more complex fields such as metabolic networks and the communication among different proteins and functions. With the aid of bioinformatics in curriculum, students can follow the current scientific developments.

The essence of bioinformatics is based on the assumption that the genomics sequence data contain information to complex diseases and examining these sequences would lead to the various diseases with the goal of treatment using therapies or drugs. Thus, this exposure of medical students to these resources, helps to a deeper understanding and perception toward computer-assisted learning of biochemistry and biomedical sciences.

Undergraduate life sciences education needs a modernization.

It is certain that we are at the beginning of an interesting era of biomedical sciences and bioinformatics will contribute strongly to the deep understanding of the molecular basis of life in the years ahead.

Bibliography

1. Dooley, E. E. (2004). TXGnet: National Center for Biotechnology Information. *Environ Health Perspect., 112*(12), A674.

2. Hotaling, S., Slabach, B. L. & Weisrock, D. W. (2018). Next-Generation Teaching: A Template for Bringing Genomic and Bioinformatic Tools into the Classroom. *Journal of Biological Education, 52*(3), 301-313.

3. On-demand training.

4. Wightman, B. & Hark, A. T. (2012). Integration of Bioinformatics into an Undergraduate Biology Curriculum and the Impact on Development of Mathematical Skills. *Biochemistry and Molecular Biology Education, 40*(5), 310-319.

5. Boyle, J. A. (2004). Bioinformatics in undergraduate education: Practical examples. *Biochemistry and Molecular Biology Education, 32*(4), 236-238.

6. Shamsir, M. S., Hussein,H., Mohd Hashim, S. Z. & Salim, N. (2013). *Educating the educators: Incorporating bioinformatics into biological science education in Malaysia*.

7. Claverie, J. M. & Notredame, C. (2007). *Bioinformatics for Dummies*, 2nd Edition. Hoboken, USA: Wiley Publishing Inc., (Pp. 1-464).

8. Hack, C. & Kendall, G. (2005). Bioinformatics: Current Practice and Future Challenges for Life Science Education. *Biochemistry and Molecular Biology Education, 33*(2), 82-85.

9. Maloney, M., Jeffrey Parker, J. & LeBlanc, M. (2010). Bioinformatics and the Undergraduate Curriculum Essay. *CBE Life Sci Educ., 9*(3), 172–174.

10. Luo, J. (2013). Teaching the ABCs of bioinformatics: A brief introduction to the Applied Bioinformatics Course. *Briefings in Bioinformatics, 15*(6) 1004-1013.

11. BIO2010: 2010: Transforming Undergraduate Education for Future Research Biologists (Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century). The national academies press, Washington, D.C.

12. Chapman, B. S., Christmann, J. L. & Thatcher, E. F. (2006). Bioinformatics for undergraduates: steps toward a quantitative bioscience. curriculum. *Biochem Mol Biol Educ 34*(3), 180-186.