# Mathematics for Biosciences: Biology and Medicine as an Example Area of Applications

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***Abstract*—**This paper discusses the important role that Mathematics and mathematical models play in the recent revolution of learning, with the aid of technology and computational power. The paper outlines the reasons behind considering the application of mathematics to the field of Biology and Medicine as an urgent need. The paper also highlights the aims and objectives of this branch of disciplines indicating that Mathematics is a rich area of inquiry ranging from pure abstractions to concrete applications. The mentioned examples prove that: The language of Mathematics is remarkably powerful and flexible, and the modes of thinking learned in mathematics can yield remarkable insight into many phenomena that pervade modern life. This branch of disciplines uses mathematical methods and techniques to provide insights into biological and biomedical phenomena with the aid of advanced computational power.

***Keywords*—** Mathematics for Biosciences, Biology, Medicine.

## I. Introduction

### *A. The Important Needed Field of Discipline: Why?*

This branch of disciplines uses mathematical methods and techniques to simulate the biological systems and biomedical phenomena, with the aid of advanced computational power.

It has grown from a small flied, containing relatively few concepts and theorems, to a major branch of applied mathematics. Mathematics for biosciences helps us understand many biological and medical phenomena, from that: topics such as population growth, biological oscillations and pattern formation, the spread of disease, human physiology, systems and organs, the growth of tumors...ect. With a considerable emphasis on models building and development.[2,5].

### *B. What is Mathematical Biology?*

Mathematical Biology is the application of mathematical concepts, modeling and techniques to solve problems in biology and physiology. It is one of the fastest growing research areas in mathematics and is contributing significantly to our understanding of the biological world. It also produces new mathematical questions.[8].

Reflecting the use of mathematics in modern biology, the computational approaches can be applied to probe biological questions, and makes extensive use of computer support to help researchers [1,6] develop intuitive mathematical skills - both through graph-plotting software, and interactive programs. Within the next few years all fields of mathematical biology will be impacted by large amounts of complex data. Because of this, there are many new mathematical questions to be addressed:

Should old simple models be thrown out and should we begin again with newer complex models? Or are there mathematical ways to use the new data to determine parameters in the old models more accurately and thus allow their parameters to be updated automatically in real time as the data stream iin.

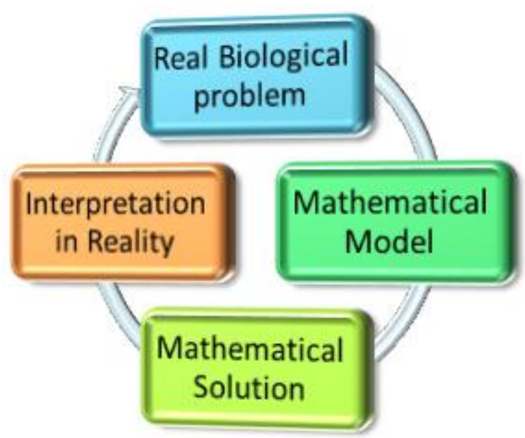
These questions are fundamental to the followings examples:

- Medical practice in acute crises.
- The dynamical behavior of living organisms.
- Cell physiology.
- The policy decisions about epidemic spread, vaccination and controlling mechanisms.
- the effects of climate change on ecological niches,

Understanding of brain function, and many others ………

### *C. Detailed Biological problem:*

The detailed biological and medical problems solving process via, mathematical tools and techniques can be illustrated by the following diagram:




### *D. Why should we shift to this field of Discipline?*

Mathematics is a rich area of inquiry ranging from pure abstractions to concrete applications.

The language of Mathematics is remarkably powerful and flexible, and the modes of thinking learned in mathematics can yield remarkable insight into many phenomena that pervade

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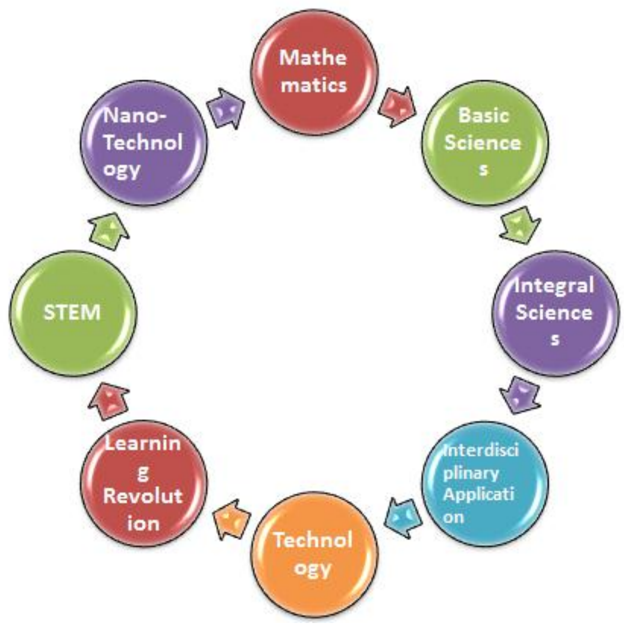
modern life. By many measures, the mathematical sciences community has responded robustly and productively to the biological revolution. This because most undergraduate math majors really like mathematical biology. So, they are excited to see the techniques that they are learning in their mathematics courses, whether calculus, graph theory, ODEs or probability, applied to questions that they are interested in. There's nothing wrong with the traditional applications to physics and engineering, but most of the applications that we can, get at with undergraduate mathematics are nineteenth (or eighteenth) century applications, and students can see that. But in biology we can see mathematics being used to gain understanding in situations where the full scientific picture is not understood by anyone. So, there are always barriers to communication between mathematics, biology, other disciplines and technology. These communications can be illustrated by the following diagram.




More advanced modules will introduce research topics in biomedical mathematics and theoretical neuroscience, Mathematical physiology, Epidemiology, Biostatistics.

Much of the research undertaken in the modern knowledge revolution is multidisciplinary and it crosses traditional boundaries. So, what we need is to introduce mathematics to biologists in the language of their fields. Some updated branches of applied Mathematical models include areas like: drug delivery; biological growth rate mechanisms , and treatment of tumors; bacterial infections; DNA modeling; tissue engineering; biomechanics; cell signaling; gene networks; mathematical neuroscience; stem cell biology; plant growth; physiological modeling; metabolism; regenerative medicine……ect.

*E. Collaborations with Biology-Mathematics-Computational sciences:*

Times are changing, and it is rapidly becoming apparent that applied mathematics and biology and computational power have a great deal to offer one another as one body. The main target for this goal is to realized the fact that : applied mathematicians who know little biology will have an easier time to understand the biological problem under study and analysis , but the biologists with little mathematical training will face a problem. So in the recent time, advanced mathematical tools have been emerged to deal with this problem. We choose the following example to explain the goal:

**Chaste Examples:**

Chaste (Cancer, Heart and Soft Tissue Environment)

Is a general purpose simulation package designed at a multi-scale , computationally, to simulate problems arising in biology and physiology , for biologists without strong base of Mathematics.

Current functionality includes tissue and cell level electrophysiology, discrete tissue modeling, and soft tissue modeling. Software engineering (COMPUTATIONAL BIOLOGY), mathematical modeling and scientific computing.

**Chaste has focused primarily on two distinct application areas:**

1- Continuum modeling of cardiac electrophysiology (**CADIAC CHASTE**);

2- individual-based modeling of cell populations, with specific application to tissue homeostasis and carcinogenesis (**Cell-based Chaste**).

## II. Conclusion

We aim to promote the application of mathematical modeling to Biology and the biomedical sciences, and to stimulate multi-disciplinary study and research within the University and beyond.

Introducing of applied interdisciplinary concepts of applied mathematics, in the foundation of our curriculum of mathematics is an urgent need to allow students to shape their degree program according to their interests and goals.eg (material of freshman program).

Students will learn relevant parts of biology and the application of mathematics to medicine and biology or any other branch of health related disciplines.

Students will also have the opportunity to engage in discovery-based research program in coming post- graduation study.

The integral sciences experience will help students apply the critical thinking and problem-solving skills they learn in the classroom to real-world situations. We know that mathematics is beautiful, that it is fundamental l, and that it is important for applications. And, here, mathematical biology is making and will continue to make real contributions. . The general public can't understand the mathematics, but they certainly can understand the applications. So, let us remember that Mathematics does not mean calculation, start learning mathematics and let the tools do the calculations.

## REFERENCES


[1] P. Agarwal, H. Edelsbrunner, J. Harer, and Y. Wang, Extreme elevation on a 2-manifold, Discrete Comput. Geom. 36 (2006), 553–572.

[2] D. Anderson, A proof of the global attractor conjecture in the single linkage class case, SIAM J. Appl. Math. 71 (2011), no. 4, 1487–1508.

[3] D. Anderson, J. Mattingly, H. F. Nijhout, and M. Reed, Propagation of fluctuations through biochemical systems, Bull. Math. Biol. 69 (2007), 1791–1813.

[4] Z. Arai, W. Kalies, H. Kokubu, K. Mischaikow, H. Oka, and P. Pilarczyk, A database schema for the analysis of global dynamics of multiparameter systems, SIAM J. Appl. Dyn. Sys. 8 (2009), 757–789.

[5] G. Carlsson, Y. Dabaghian, F. Memoli, and L. Frank, A topological paradigm for hippocampal spatial map formation using persistent homology, PLoS Comp. Biol. 8 (2012), no. 8, e1102581.

[6] G. Carlsson, T. Ishkhanov, V. deSilva, and A. Zomorodian, On the local behavior of spaces of natural images, Int. J. Comput. Vision 76 (2008), 1–12.

[7] R. Coifman, I. Kevrekides, S. Lafon, M. Maggioni, and B. Nadler, Diffusion maps, reduction coordinates and low dimensional representation of stochastic systems, SIAM J. Mult. Mod. Sim. 7 (2008), 842–864.

[8] C. Curto and V. Itskov, Cell groups reveal structure of 9--Y. Wenjuan, L. H. Xingsheng, and L. Xiaoqing, “The vibration equation’s establishment and solution of the eardrum,” Journal of Vibration and Shock, vol. 27, no. 3, pp. 63–66, 2008.