MNK Publication

International Journal of Latest Research in Science and Technology **ISSN (Online):2278-5299**
Volume 4, Issue 6: Page No.65-68, November-December 2015 (Special Issue Paper)
http://www.mnkjournals.com/ijlrst.htm
Special Issue on International conference on Methematics Sciences-2015(MSC-2015)
Confernece Held at Sadguru Gadage Maharaj College, Karad ,Maharastra,(India)

MATHEMATICS FOR BIOLOGY: NOVEL TREND IN TECHNOLOGY.

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Abstract- ***Mathematics has always benefited from its contribution with developing biological sciences. Each successive interaction revitalises and enhances the field. Biological science is clearly the premier science of the advanced future. In this paper our review focuses on an integrated introductory education for quantitatively oriented biologists really is an experiment in a more general problem: science education in the modern world. This is a problem whose solution will require collaborations among scientists who now reside in quite different departments and cultures; enthusiastic as we are, we also are cognizant of the difficulties that will no doubt arise. We have focused on the biology in the view of mathematics, by discussing with some of the research fields like evolutionary biology, mathematical models, algebraic biology and mathematical physics.***

Keyword: Evolutionary biology, mathematical models, algebraic biology, mathematical physics.

I. INTRODUCTION

Mathematical and theoretical biology is an interdisciplinary scientific research field with a range of applications in biology, biotechnology, and medicine.[1] The field may be referred to as mathematical biology or biomathematics to stress the mathematical side, or as theoretical biology to stress the biological side.[2] Mathematical biology aims at the mathematical representation, treatment and modeling of biological processes, using a variety of applied mathematical techniques and tools. It has both theoretical and practical applications in biological, biomedical and biotechnology research. For example, in cell biology, protein interactions are often represented as "cartoon" models, which, although easy to visualize, do not accurately describe the systems studied. In order to do this, precise mathematical models are required. By describing the systems in a quantitative manner, their behavior can be better simulated, and hence properties can be predicted that might not be evident to the experimenter.

Mathematical biology is a fast-growing, well-recognised, albeit not clearly defined, subject and is, to my mind, the most exciting modern application of mathematics. The increasing use of mathematics in biology is inevitable as biology becomes more quantitative. The complexity of the biological sciences makes interdisciplinary involvement essential. For the mathematician, biology opens up new and exciting branches, while for

the biologist, mathematical modelling offers another research tool commensurate with a new powerful laboratory technique but *only* if used appropriately and its limitations recognised. However, the use of esoteric mathematics arrogantly applied to biological problems by mathematicians who know little about the real biology, together with unsubstantiated claims as to how important such theories are, do little to promote the interdisciplinary involvement which is so essential.

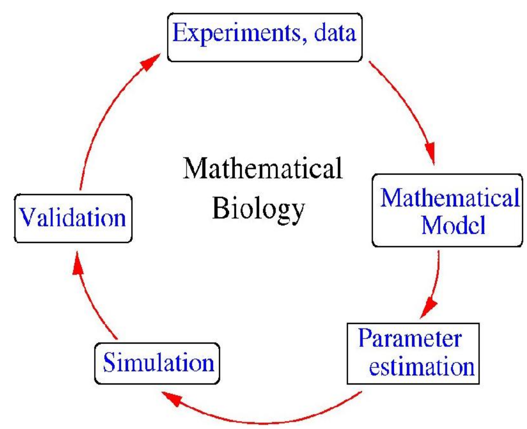


Fig1: Mathematical biology concept.

Mathematical biology research, to be useful and interesting, must be relevant *biologically*. The best models show how a process works and then predict what may follow. If these are not already obvious to the biologists *and* the predictions turn out to be right, then you will have the biologists' attention

[3].Such mathematical areas as calculus, probability theory, statistics, linear algebra, abstract algebra, graph theory, combinatorics, algebraic geometry, topology, dynamical systems, differential equations and coding theory are now being applied in biology.[3] Some mathematical areas, such as certain methodologies in statistics, were developed as tools during the conduct of research into mathematical biology.
A paradigmatic account of the uses of mathematics in the natural sciences comes, in deliberately oversimplified fashion, from the classic sequence of Brahe, Kepler, Newton: observed facts, patterns that give coherence to the observations, fundamental laws that explain the patterns.

These days, mathematics enters at every stage: in designing the experiment, in seeking the patterns, in reaching to understand underlying mechanisms. In biology, of course, every stage in this caricature is usually vastly more complex than in the early days of physics. But the advent of computers, and the extraordinary doubling of their capability roughly every 18 months for the past several decades, permits exploration—and sometimes understanding, we could not have dreamed of 50 years ago.

IMPORTANCE

Applying mathematics to biology has a long history, but only recently has there been an explosion of interest in the field. Some reasons for this include:

- the explosion of data-rich information sets, due to the genomics revolution, which are difficult to understand without the use of analytical tools,
- recent development of mathematical tools such as chaos theory to help understand complex, non-linear mechanisms in biology,
- an increase in computing power which enables calculations and simulations to be performed that were not previously possible, and
- an increasing interest in in silico experimentation due to ethical considerations, risk, unreliability and other complications involved in human and animal research.

Several areas of specialized research in mathematical and theoretical biology[5-9] as well as external links to related projects in various universities are concisely presented in the following subsections, including also a large number of appropriate validating references from a list of several thousands of published authors contributing to this field.

Work in mathematical biology is typically a collaboration between a mathematician and a biologist. The latter will pose the biological questions or describe a set of experiments, while the former will develop a model and simulate it. In order to develop a model, for instance in terms of a system of differential equations, the mathematician needs to determine a diagram of relationships among the biological variables and specify rate parameters. Typically some of these parameters are not found in the literature and need to be estimated. They are determined in an iterative process of simulations aimed at achieving good fit with the experimental data. This process may take much iteration. Hence it is crucial that each simulation does not take too much computational time. When the model simulations finally agree with experimental results, the model may be considered useful for suggesting new hypotheses that are biologically testable. It may suggest, for example, a particular therapy that is represented, in the model, in the form of an increase in one or several rate parameters

[10]. AREAS OF RESEARCH

Due to the wide diversity of specific knowledge involved, biomathematical research is often done in collaboration between mathematicians, biomathematicians, theoretical biologists, physicists, biophysicists, biochemists, bioengineers, engineers, biologists, physiologists, research physicians, biomedical researchers, oncologists, molecular biologists, geneticists, embryologists, zoologists, chemists, etc.

1) Evolutionary biology

Ecology and evolutionary biology have traditionally been the dominant fields of mathematical biology.

Evolutionary biology has been the subject of extensive mathematical theorizing. The overall name for this field is population genetics. Most population geneticists consider changes in the frequencies of alleles at a small number of gene loci. When infinitesimal effects at a large number of gene loci are considered, one derives quantitative genetics. Ronald Fisher made fundamental advances in statistics, such as analysis of variance, via his work on quantitative genetics. Another important branch of population genetics concerns phylogenetics. Phylogenetics is an area that deals with the reconstruction and analysis of phylogenetic (evolutionary) trees and networks based on inherited characteristics

[11]. The modern evolutionary synthesis involved agreement about which forces contribute to evolution, but not about their relative importance [12]. Current research seeks to determine this. Evolutionary forces include natural selection, sexual selection, genetic drift, genetic draft, developmental constraints, mutation bias and biogeography.Computer models and automata theory

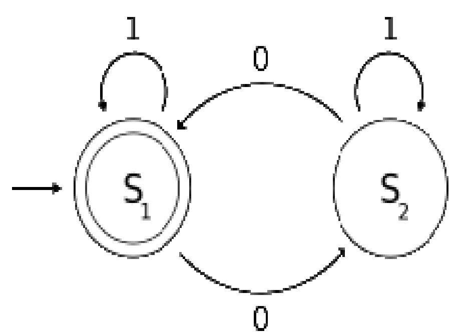


Fig2: Computer models

A monograph on this topic summarizes an extensive amount of published research in this area up to 1986,[13-15] including subsections in the following areas: computer modeling in biology and medicine, arterial system models, neuron models, biochemical and oscillation networks, quantum automata, quantum computers in molecular biology and genetics,[16] cancer modelling[17].The Logistic Equation $\frac{dN}{dt} = rN(1 - \frac{N}{K})$

Where r, is the population growth rate; t is time; N is the population abundance; and K is the carrying capacity.

This is a model of a single population's growth—exponential at first and then flattening out as it approaches carrying capacity.

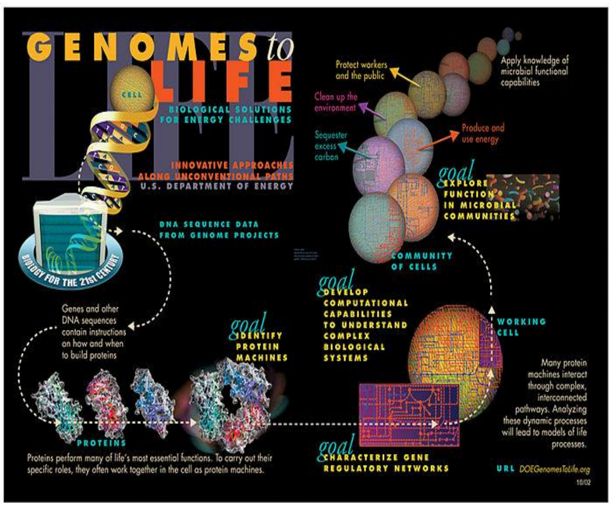
Modeling cell and molecular biology

- Mechanics of biological tissues[18]

- Theoretical enzymology and enzyme kinetics
- Cancer modelling and simulation[19,20]
- Modelling the movement of interacting cell populations[21]
- Mathematical modelling of scar tissue formation[22]
- Mathematical modelling of intracellular dynamics
- Mathematical modelling of the cell cycle

2) Mathematical biophysics

Mathematical biophysics is a subfield of both biophysics and mathematical biology focusing of physical and physico-chemical mechanisms involved in physiological functions of living organisms, as well as the molecular structures supporting such physiological functions. The earlier stages of mathematical biology were dominated by mathematical biophysics, that was then described as the application of mathematics in biophysics, often involving specific physical/mathematical models of biosystems and their components or compartments.



***Specific research areas* of current interest in mathematical biophysics are, for example:**

- Complex systems
- Quantum biophysics and biochemistry
- Automata theory,
    - Cellular automata,
    - Tessellation models
- complete self-reproduction, * chaotic subsystems of organisms,
- Relational biology and organismic theories

3) Algebraic biology

Algebraic biology (also known as symbolic systems biology) applies the algebraic methods of symbolic computation to the study of biological problems, especially in genomics, proteomics, analysis of molecular structures and study of genes [23-25]

CONCLUSION:

Historically, science and technology have been a driving force for new mathematical theories. The great alliance between the physical and the mathematical sciences is recognized universally: both disciplines thrived by supporting each other. To conclude, we believe there is a great opportunity to construct a unified, mathematically sophisticated introduction to physics and chemistry, which draws on examples from biology wherever possible. Such a course would provide a coherent introduction to quantitative thinking about the natural world, and invite all students, including biologists of the future, to partake of the grand tradition, which flows from Galileo's vision.

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