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MATHEMATICS IN BIOLOGY

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Abstract

Mathematical biology is an interdisciplinary scientific research field in the midst of a variety of applications. Mathematical biology focuses on the exercise of mathematical tools to educate biological systems.It has both theoretical and practical applications in biological, biomedical and biotechnology research. Mathematics has been applied to biology since 19th century. Significance in the field has developed rapidly from 1960 onwards.Mathematics is applied in all most all essential fields of science, including biology.Because of quantifiable aspects of life science, mathematics plays a vital role in better understanding the natural world. **Mathematical biology** is a field of research that examines mathematical representations of biological systems.One important role of math in biology is the creation of **mathematical models**. These are equations or formulas that can predict or describe natural occurrences, such as organism performance patterns or population changes over time.The National Research Council [NAS (1989)] identified eleven major areas in biological research. Mathematics is used in all of these areas.These progresses are yielding new understandings of diseases and epidemics, ecological systems of our bodies, and essential life processes. Mathematics, along with the sciences and engineering, has played remarkable role in almost all these areas.There are important problems that require the attention of mathematicians in almost all areas of life and medical sciences. Some of these problems were solved by some researchers. Mathematicians and biologists were working successfully together and getting benefit from each other. It is one of the fastest growing research areas in mathematics and is contributing considerably to the biological world.

Key words: Mathematics, Biology,Interdisciplinary, Quantifiable, Formulas, research,

Introduction:

Mathematical biology is an interdisciplinary scientific research field with a variety of applications. Mathematical biology focuses on the use of mathematical tools to educate biological systems. It objects at the mathematical representation, treatment and modeling of biological processes, using techniques and tools of applied mathematics.It has both theoretical and practical applications in biological, biomedical and biotechnology research.

Relating systems in a quantitative manner means their behavior can be better pretended, and hence properties can be projected that might not be obvious to the experimenter. This requires accurate mathematical models.Mathematical biology employs many components of mathematics and has contributed to the development of new techniques.

HistoryMathematical biology:

Mathematics has been applied to biology since 19th century. Fritz Muller described the evolutionary benefits as Mullerian mimicry in 1879. It is the first practice of a mathematical argument in evolutionary ecology to demonstrate how natural selection is powerful. Malthus argued that growth would be "geometric" while resources might only grow arithmetically.

Recent growthin Mathematical biology:

Interest in the field has grown rapidly from 1960 onwards. Some reasons are-

- The rapid growth 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 facilitates calculations and simulations not previously possible.

Mathematical biology is interdisciplinary:

Mathematical biologythough highly interdisciplinary and intricate in all areas of mathematics such as real and complex analysis, integral and differential systems, met mathematics, algebra, geometry, number theory, topology, probability and statistics it is an area that challenges classification into the usual categories of mathematical research. It lies at the juncture of significant mathematical problems and fundamental questions in biology.The value of mathematics in biology comes partly from applications of statistics and calculus to quantifying life science phenomena. [6] proposed a system in which this study presented the implementation of two fully automatic liver and tumors segmentation techniques and their comparative assessment. The described adaptive initialization method enabled fully automatic liver surface segmentation with both GVF active contour and graph-cut techniques, demonstrating the feasibility of two different approaches. The comparative assessment showed that the graph-cut method provided superior results in terms of accuracy and did not present the described main limitations related to the GVF method. The proposed image processing method will improve computerized CT-based 3-D visualizations enabling noninvasive diagnosis of hepatic tumors. The described imaging approach might be valuable also for monitoring of postoperative outcomes through CT-volumetric assessments. Processing time is an important feature for any computer-aided diagnosis system, especially in the intra-operative phase.

Application of Mathematics in Biology:

Mathematics is applied in all most important fields of science, including biology. Unlike physics and chemistry, biology is not usually a science allied with mathematics.But because there are quantifiable aspects of life science, mathematics plays a critical role in better understanding the natural world. **Mathematical biology** is a field of research that examines mathematical representations of biological systems.

Eg: Imagine a biologist studying butterfly migrations. He goes into the field and count a sample population in a confined region and then multiply the sample numbers by the total geographical range to get a population estimate. Then he go back to lab and review other researcher's reports of butterflies over the span of their migration pattern and use vector calculations to predict their future path. Finally he examine previous years' data on the butterfly numbers and location to establish a probable error margin for his prediction. At every step of this process, he depend upon mathematics to measure, predict, and understand natural phenomena.

The unit of life is a cell.Thecell is extremely more complex. A cell in mammals characteristically contains 300 million molecules. Some are very large, such as the DNA molecules, which consist of many millions of atoms. But a cell is not just a huge collection of molecules. A cell absorbs nutrients and generates biomass to perform specific functions.A cell replicates when

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surroundings are favorable.Consequently, mathematical modeling of cellular processes is quite challenging.The human body approximately contain 1013 cells of diverse types and functions continuously. Hence mathematical models of biological processes are extremely challenging.

Creating Models

One important role of math in biology is the creation of **mathematical models**. These are equations or formulas that can predict or describe natural occurrences, such as organism performance patterns or population changes over time.

Work in mathematical biology is naturally a collaboration between a mathematician and a biologist. A biologist will describe a set of experiments, while the Mathematician will improve a model and simulate it.In order to develop a model the mathematician needs aconnections among the biological variables and rate parameters.Some of these parameters are not institute in the literature and need to be estimated. They are determined in an iterative process of simulations with the experimental data. This process may take many repetitions.

For scientists, mathematical models make it much easier to view and describe a measurablephenomenon without having to stay fixed in the raw numerical data. Most fields of medicine are also very reliant upon mathematical models, especially with respect to the frequencies of gene expression and the spreading rates of diseases.When the model simulations finally agree with experimental results, the model may be considered useful for signifying new hypotheses that are biologically testable.

Uses of Mathematical biology

The National Research Council [NAS (1989)] identified eleven major areas in biological research. Mathematics is used in all of these areas. They are

- Cell organization
- Ecology and ecosystems
- Evolution and diversity
- Genome organization and expression
- Growth and development
- Immune system, pathogens and host defenses
- Integrative approaches to organism function and disease

- Molecular structure and function
- Neurobiology and behavior
- New technology and industrial biotechnology
- Plant biology and agriculture
- Medical sciences-tomography and models of physiological systems.
- Radiology-fMRI and PET imaging.
- Computational biology and bioinformatics-structure and analysis of genomes.
- Systems biology-metabolic pathways in cells
- Brain science-derivation and study of canonical models of neuronal systems.

These progresses are yielding new understandings of diseases and epidemics, ecological systems of our bodies, and fundamental life processes. Mathematics, along with the sciences and engineering, has played noteworthy roles in almost all these areas.

Need of mathematical Biology:

There are remarkable problems that require the attention of mathematicians in almost all areas of life and medical sciences. Some of these problems were solved by some researchers. They are-

- Rene Thom developed and used topology and singularity theory to investigate problems in developmental biology. He took the approach of deriving and analyzing canonical mathematical models that capture certain fundamental aspects of developmental phenomena. It clarified understanding of the underlying biological processes.
- Investigations of pattern formation in nature, which began with work by d'Arcy Thompsondirected to the introduction of suitable mathematical models for reaction-diffusion systemsand continues today to assist studies in various other fields.
- Stochastic processes have been established and practicedonmultiple problems in all areas of biology, predominantly population genetics and molecular genetics.

There are many more refined mathematical results that have contributed and benefited for biology investigations.

Conclusion:

Both the disciplines mathematics and biology, benefit from each other. Mathematicians and biologists were working successfully together. Sophisticated mathematical results and statistical methods have been used to solve a variety of population problems in ecology, genetics etc. Scientists from mathematics, physics, chemistry, engineering, and medicine have developed and used mathematical methods in biology investigations. Mathematical Biology is the application of mathematical modelling to solve problems in biology and physiology. It is one of the fastest growing research areas in mathematics and is contributing considerably to the understanding of biological world.

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