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INNOVATION IN BIOMATHEMATICS

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Abstract

The human anatomy is very complex structure created by God in which various organs and systems play their different roles. These processes are so complex that they cannot be easily studied wholly. Biomathematics is a field of study that helps indevelopment of predictive and analytical models of biological and medical systems. It has been used in many areas, including: Cellular neurobiology, Epidemic modelling and Population genetics. Innovation in Bio-mathematics can be a powerful tool for biological sciences. It can be useful for testing hypotheses, especially when a direct experiment cannot be conducted.

Keywords : Biomathematics, innovation, modelling, medicine.

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Introduction

Man has involved in unveiling the mysteries of the universe and environment by exploration due to his curiosity and continuous enhancement of knowledge. He has been always trying to comprehend the mysteries i.e. the beginning of life itself and various mechanisms involved in making the life self-sustaining inadequately optimised manner. However, there is a lot be done to fully understand the mechanism of function of this superstructure created by nature and when tries to understand by physico-mathematical point of view, the study is called Bio-mathematics. In the other language, Bio-mathematics is that branch of scientific knowledge which involves mathematics with biology or it is the study of mathematical aspects with the structure and working of the biological system. This branch of science includes studies regarding morphology and growth of biological systems and mechanism of their parts and their engagement with the surroundings of the environment.

Fig.1. Going from models to innovation

2. The role of Bio-mathematics in Biology:

The term biomathematics has used first time in 1923 by Dr William Moses Feldman when he used he used this term in the title of an assay. 100 years later it has become highly relevant discipline for current development such as bio-informatics, biostatistics and computational biology. Today Bio-mathematics has essential choice for academicians and researchers. Biomathematics has been used to examine a wide range of biological sciences including the human genome, population level genetics, cancer cells, ecologically invasive species, the immune system, etc [L. A. Segel, (1980)] Biomathematics is the branch of mathematical sciences in which we use mathematical numerical methods are used to solve types of problem related to biology. From the year 1922 the mention of this branch is seen in literature. It was broadly used in 1930's and today it is in front of us as futuristic mode of interdisciplinary study in which we are finding out the mysteries of this super structure using mathematical models and computers [Tripathee and Mishra (2023)]. The human body one of the most significant bio-mechanical system itself where physiological fluid dynamics plays a crucial role during bio-rheological research. Physiological fluid dynamics is an multi-disciplinary field which has been developed through collaboration of scientist and researchers working in engineering, medical and science. During the last five decades, this interaction (Collaboration) has resulted in improving our knowledge not only in functional aspects of various biological systems but also for the development of devices which have helped in alleviation of sufferings [S M Tripathee and Lokesh Mishra (2023)].

3. Different types of mathematical modelling (MM):

Mathematical modelling in biology encompasses various approaches to describe and enhance the complex processes in living organisms [L. A. Segel, (1980)]. Here are some different types of mathematical modelling (MM) in biology:

1. Deterministic Models: Description: Deterministic models use precise mathematical equations to represent biological processes. They consider that the system's behaviour is entirely predictable with no randomness. Example:Population and population growth models by using differential equations.

2. Stochastic Models: Description: Stochastic models incorporate randomness or probabilistic elements into the mathematical representation of biological systems. They are helpful when considering uncertainties or random events. Example: Stochastic simulation models of biochemical reactions.

3. Compartmental Models: Description: Compartmental models divide a system into compartments, representing different states or stages of a biological process. These mathematical models (MM) are often used in epidemiology and population biology.

Example: SIR (Susceptible-Infectious-Removed) model for disease spread.

4. Agent-Based Models: Description: Individual entities (agents) and their interactions within a system can be simulated by agent-based models. These mathematical models (MM) are generally useful for studying complex systems with decentralized components. Example: Simulating the behaviour of individual organisms in an ecosystem.

5. Network Models: Description: Network models represent biological entities as nodes and their interactions as edges in a graph. This approach is commonly used in research of genetic regulatory networks models and protein-protein interaction models. Example: Mathematical modelling on gene regulatory networks using graph theory.

6. Dynamic Systems Models: Description: Dynamic systems models focus on understanding the variations in a system over time. They sometimes include differential equations to describe (to evaluate) the rates of change of variables. Example:Modelling the dynamics of biochemical pathways.

Game Theory Models: Description: Game theory models are employed to study interactions between entities in a strategic environment. This approach is used to understand evolutionary dynamics and cooperative behaviours. Example: Evolutionary game theory in the research of cooperation among individuals.

7. Optimization Models: Description: The goal of optimization models to find the best solution to a given problem. In biology, these models are used to optimize biological processes or parameters. Example: Optimal foraging theory in ecology.

8. Statistical Models: Description: Statistical models involve the use of statistical methods to analyze and interpret biological data. They are essential for understanding variability and making inferences from experimental observations. Example: Linear regression mathematical models to detetermine the relationship between variables.

9. Hybrid Models: Description: Hybrid models combine different modelling approaches to capture the strengths of each. For instance, combining deterministic and stochastic elements. Example: Hybrid models in systems biology combining ordinary differential equations and stochastic simulations These different types of mathematical modelling in biology cater to the diverse nature of biological systems and help researchers gain insights into their behaviour, dynamics, and interactions.

4. Branches of Biomathematics:

Biomathematics can be categorized as:

1. Mathematical Biomechanics :
   1.1. Bio fluid Mechanics
   1. 2. Bio-fluid Dynamics

2.Mathematical Zoology and Mathematical Botany
3.Mathematical Ecology
4.Mathematical Epidemiology / Disease Mapping
5. Mathematical Biochemistry
6. Mathematical Biophysics
7.Mathematical Bioengineering
8. Mathematical Theory of Diseases
9.Mathematical Bio-economics and many more

Mathematical and computational models are increasingly used to help interpret biomedical data. The application of advanced computer models enables the simulation of complex biological processes, which generates hypotheses and suggests experiments [Briefings in bioinformatics]

Conclusion

This research of mathematical models on biosciences includes many mathematical innovative ideas. The primary mathematical tools used in this field are fluid mechanics, which deals with the behaviour of fluids in motion. Specifically, researchers use the principles of fluid dynamics to enhance the movement of bio-fluids[[Lucas, Douglas (1934), Wilkision (1960), Weibel (1963), Barton, Raynor (1967), Schroter, Sudlow (1969), Pedley et al.(1970), Blake(1971a, 1971b, 1973, 1974, 1975), Clarke et al. (1970), Clarke (1973), Ross. Corrsin (1974), Sleigh (1977,1990), Scherer and Burtz (1978), Blake and Winet (1980), Winet and Blake (1980), Yeats et al.(1980,1981), Wanner (1981)]. There are several mathematical models [Blake and Fulford (1984), Puchelle et al.(1980), Sleigh et al. (1988), Zahm et al. (1989,1991), Agarwal et al. (1989), King et al. (1982,1985,1989,1993,1995), Bennet et al. (1990), Mogami et al. (1992), Tomkiwicz et al. (1994), Agarwal and Verma (1997,1998), Kim (1997), Rubin (2002), Satpathi (2007), Smith et al.(2008), Polak (2008), Benjamin (2011), Shivesh Mani Tripathee (2017)] used to describe bio fluids. One of the most common is the two-phase model, which considers fluid as a non-Newtonian fluid. This model takes into account the complex rheological properties of fluid, which makes it difficult to move through the narrow airways. Other mathematical models include the continuum model, which assumes that the air and mucus are continuous fluids, and the discrete particle model, which treats bio fluids as a collection of discrete particles. Researchers use these models to study different aspects of bio fluids such as mucus transport, such as the effects of cilia movement and mucus composition on transport rates. In addition to fluid mechanics, mathematical tools such as computational fluid dynamics (CFD) and finite element analysis (FEA) are used to simulate the transport of Bio fluids. These tools allow researchers to visualize and analyse bio fluids under different conditions and to test different hypotheses about the underlying mechanisms. Overall, the mathematical study of fluid dynamics in biology is a complex and interdisciplinary field that requires the integration of multiple disciplines, including mathematics, physics, biology, and engineering. However, advances in mathematical modelling and simulation techniques are helping researchers gain a better understanding of this crucial biological process and develop new treatments for respiratory diseases.

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