

- Importance
- Areas of research
- Evolutionary biology
 - Computer models and automata theory
 - Modelling cell and molecular biology
 - Modelling physiological systems
 - Molecular set theory
 - Complex systems biology
- Mathematical methods
- Simulation of mathematical biology
- Mathematical biophysics
 - Deterministic processes (dynamical systems)
 - Stochastic processes (random dynamical systems)
- Spatial modelling
- Relational biology
- Algebraic biology
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- Theoretical biology

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:

- ## AREAS OF RESEARCH

STOCHASTIC PROCESSES (RANDOM DYNAMICAL SYSTEMS)

SPATIAL MODELLING

RELATIONAL BIOLOGY

- knowledge involved, bio-mathematical research is often done in collaboration between [mathematicians](#), bio mathematicians, [theoretical biologists](#), [physicists](#), [biophysicists](#), [biochemists](#), [bioengineers](#), engineers, biologists, [physiologists](#), [research physicians](#), biomedical researchers, [oncologists](#), [molecular biologists](#), [geneticists](#), [embryologists](#), [zoologists](#), [chemists](#), etc.

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

Evolutionary biology has been the subject of extensive mathematical theorizing. The traditional approach in this area, which includes complications from genetics, is **population genetics**. Most population geneticists consider the appearance of new **alleles** by **mutation**, the appearance of new **genotypes** by **recombination**, and changes in the frequency of alleles and genotypes by **selection**. In the case of a single gene, the frequency of alleles in a population of given size and number of generations can be calculated, together with the assumption of **linkage equilibrium** or **quasi-linkage equilibrium**, 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 that led to the extensive use of molecular biology in evolutionary biology is **phylogenetic systematics**, which deals with the reconstruction and analysis of phylogenetic (evolutionary) trees and networks based on inherited characteristics. Traditional population genetic models deal with alleles and genotypes, and are frequently **stochastic**.

Many population genetics models assume that population sizes are constant. Work in population sizes, often in the absence of genetic variation, are treated by the field of [population dynamics](#). Variable in this area dates back to the 1st century, and even as far as 1914 when [Thomas Malthus](#) formulated the first principle of population dynamics, which later became known as the [Malthusian growth model](#). The [Lotka–Volterra predator–prey equations](#) are another famous example. Population dynamics overlap with another active area of research in mathematical biology: [mathematical epidemiology](#), the study of infectious disease affecting populations. Various models of the spread of [infections](#) have been proposed and analyzed, and provide important results that may be applied to health policy decisions.

In [evolutionary game theory](#), developed first by [John Maynard Smith](#) and [George R. Price](#), selection acts directly on inherited phenotypes, without genetic complications. This approach has been mathematically refined to produce the field of [adaptive dynamics](#).

A monograph on this topic summarizes an extensive amount of published research in this area up to 1987, and including subsections in the following areas: **computer modeling** in biology and medicine, **artificial system models**, **neuron models**, biochemical and **oscillation networks**, **quantum automata**, **quantum computers** in **molecular biology** and **genetics**, cancer modelling, **neural nets**, **genetic networks**, abstract categories in relational biology, metabolic-ecosystem systems, **category theory** applications in biology and medicine, **automata theory**, **cellular automata**, **teleconnection models** and **complete self-reproduction**, **chaotic systems** in **organisms**, relational biology and organismic theories. This published report also includes ^{†1} references to peer-reviewed articles by a large number of authors.

This area has received a boost due to the growing importance of [molecular biology](#).

1. Mechanics of biological tissues
2. Theoretical enzymology and [enzyme kinetics](#)
3. **Cancer** modelling and simulation
4. Modelling the movement of interacting cell populations
5. Mathematical modelling of scar tissue formation
6. Mathematical modelling of intracellular dynamics
7. Mathematical modelling of the cell cycle

- 17. [Protein folding](#)
- 18. [Simulated reality](#)
- 19. [Statistical genetics](#)
- 20. [Systems biology](#)
- 21. [Theoretical ecology](#)
- 22. [Quantum Biology](#)

- [National Institute for Mathematical and Biological Synthesis](#)
- [Society for Mathematical Biology](#)
- [ESMTB: European Society for Mathematical and Theoretical Biology](#)
- [The Israeli Society for Theoretical and Mathematical Biology](#)
- [Société Francophone de Biologie Théorique](#)
- [International Society for Biosemiotic Studies](#)

- Y. [Acta Biotheoretica](#)
- Y. [Bioinformatics](#)
- Y. [Biological Theory](#)
- E. [BioSystems](#)
- o. [Bulletin of Mathematical Biology](#)
- E. [Ecological Modelling](#)
- Y. [Journal of Mathematical Biology](#)
- E. [Journal of Theoretical Biology](#)
- E. [Journal of the Royal Society Interface](#)
- E. [Mathematical Biosciences](#)
- Y. [Mathematical Biosciences and Engineering](#)
- Y. [Medical Hypotheses](#)
- Y. [Rivista di Biologia-Biology Forum](#)
- E. [Theoretical and Applied Genetics](#)
- E. [Theoretical Biology and Medical Modelling](#)
- Y. [Theoretical Population Biology](#)
- Y. [Theory in Biosciences](#)

D. Barnes; D. Chu (eds.), *Introduction to Modelling for Biosciences*, Springer Verlag, ISBN 1-4419-7702-4.

Y. Israel G. (1984), "On the contribution of Volterra and Lotka to the development of modern biomathematics". *History and Philosophy of the Life Sciences*, 1 (1-3), pp. 27-43. PMID 7122442.

Scudo FM (March 1997), "Vito Volterra and theoretical ecology", *Theoretical Population Biology*, 51 (1): 1-17. PMID 9125125.

S.H. Hoggatz, *Nonlinear dynamics and Chaos: Applications to Physics, Biology, Chemistry, and Engineering*, Perseus, 1997, ISBN 0-207-45561-5.

N.G. van Kampen, *Stochastic Processes in Physics and Chemistry*, North Holland, 7rd ed., 1993, ISBN 0-444-31515-0.

I. C. Baianu, "Computer Models and Automata Theory in Biology and Medicine", *Monograph*, Ch.11 in M. Winter (Editor), *Mathematical Models in Medicine*, vol. V, Vol. 5, 1972-1973 (1974), Pergamon Press, New York.

Y. Izumi, edited by Hsiao Chen Lin in C.U.P., 1st ed., ISBN 0-471-77931-3.

P.G. Drizin, *Nonlinear systems*, C.U.P., 1988, ISBN 0-521-33331-3.

L. Edelstein-Keshet, *Mathematical Models in Biology*, SIAM, 1988, ISBN 0-89603-424-7.

G. Forgacs and S. A. Newman, *Biological Physics of the Developing Embryo*, C.U.P., 1998, ISBN 0-521-34877-9.

- Modelling of **arterial** disease
- Multi-scale modelling of the **heart**

Molecular set theory (MST) is a mathematical formulation of the wide-sense chemical kinetics of biomolecular reactions in terms of sets of molecules and their chemical transformations represented by set-theoretical mappings between molecular sets. It was introduced by **Anthony Bartholomew**, and its applications were developed in mathematical biology and especially in mathematical medicine. In a more general sense, MST is the theory of molecular categories defined as categories of molecular sets and their chemical transformations represented as set-theoretical mappings of molecular sets. The theory has also contributed to biostatistics and the formulation of clinical biochemistry problems in mathematical formulations of pathological, biochemical changes of interest to Physiology, Clinical Biochemistry and Medicine.

An elaboration of [systems biology](#) to understanding the more complex life processes was developed since 1997 in connection with molecular set theory, [relational biology](#) and algebraic biology.

A model of a biological system is converted into a system of equations, although the word 'model' is often used synonymously with the system of corresponding equations. The solution of the equations, by either analytical or numerical means, describes how the biological system behaves either over time or at equilibrium. There are many different types of equations and the type of behavior that can occur is dependent on both the model and the equations used. The model often makes assumptions about the system. The equations may also make assumptions about the nature of what may occur.

Computer with significant recent evolution in performance acceraretes the model simulation based on various formulas. The websites [BioMath Modeler](#) can run simulations and display charts interactively on browser.

The earlier stages of mathematical biology were dominated by mathematical [biophysics](#), described as the application of mathematics in biophysics, often involving specific physical/mathematical models of biosystems and their components or compartments.

The following is a list of mathematical descriptions and their assumptions.

A fixed mapping between an initial state and a final state. Starting from an initial condition and moving forward in time, a deterministic process always generates the same trajectory, and no two trajectories cross in state space.

- [Difference equations/Maps](#) – discrete time, continuous state space.
- [Ordinary differential equations](#) – continuous time, continuous state space, no spatial derivatives. *See also:* [Numerical ordinary differential equations](#).
- [Partial differential equations](#) – continuous time, continuous state space, spatial derivatives. *See also:* [Numerical partial differential equations](#).
- [Logical deterministic cellular automata](#) – discrete time, discrete state space. *See also:* [Cellular automaton](#).

11. A. Goldbeter, *Biochemical oscillations and cellular rhythms*. C.U.P., 1995. ISBN: 0-01-39542-7.
12. L.G. Harrison, *Kinetic theory of living pattern*. C.U.P., 1957. ISBN: 0-01-39543-1.
13. F. Hoppensteadt, *Mathematical theories of populations: demographics, genetics and epidemics*. SIAM, Philadelphia, 1976 (reprinted 1957). ISBN: 0-896-0313-1.
14. D.W. Jordan and P. Smith, *Nonlinear ordinary differential equations*, 2nd ed. O.U.P., 1969. ISBN: 0-19-250613-9.
15. J.D. Murray, *Mathematical Biology*. Springer-Verlag, 1989 ed. in 2 vols: *Mathematical Biology: I. An Introduction*, 1989. ISBN: 0-387-90133-2; *Mathematical Biology: II. Spatial Models and Biomedical Applications*, 1991. ISBN: 0-387-90134-1.
16. E. Renshaw, *Modelling biological populations in space and time*. C.U.P., 1991. ISBN: 0-01-39540-7.
17. S.I. Rubinow, *Introduction to mathematical biology*. John Wiley, 1987. ISBN: 0-471-91452-4.
18. L.A. Segel, *Modelling dynamical phenomena in molecular and cellular biology*. C.U.P., 1988. ISBN: 0-01-39540-7.
19. L. Preziosi, *Computational Modelling and Simulation*. Chapman Hall/CRC Press, 1997. ISBN: 0-04-434411-4.

1. Bertalanffy, L. v. 1935. *Theoretische Biologie. Band I: Allgemeine Theorie, Physikochemie, Aufbau und Entwicklung des Organismus*. Berlin: Gebürder Bontraeger.
2. Bonner, J. T. 1988. *The Evolution of Complexity by Means of Natural Selection*. Princeton: Princeton University Press.
3. Hertz, H. 1957. *Structure, Form, Movement*. New York: Reinhold Publishing Corp.
4. Mangel, M. 1989. *Special Issue, Classics of Theoretical Biology (part 1)*. Bull. Math. Biol. 51(9/10): 175-8.
5. Mangel, M. 2007. *The Theoretical Biologist's Toolbox. Quantitative Methods for Ecology and Evolutionary Biology*. Cambridge University Press.
6. Prusinkiewicz, P. & Lindenmeyer, A. 1999. *The Algorithmic Beauty of Plants*. Berlin: Springer-Verlag.
7. Reimke, J. 1959. *Einleitung in die theoretische Biologie*. Berlin: Verlag von Gebürder Paul.
8. Schaxel, J. 1959. *Grundzüge der Theoriebildung in der Biologie*. Jena: Fischer.
9. Thompson, D.W. 1957. *On Growth and Form*. 2nd ed. Cambridge: Cambridge University Press. 1. vols.
10. Uexküll, J. 1957. *Introduction to Theoretical Biology*. Berlin: Springer-Verlag.
11. Vogel, S. 1988. *Life's Designs: The Physical World of Animals and Plants*. Princeton: Princeton University Press.
12. Waddington, C.H. 1958-1959. *Towards a Theoretical Biology*. 2 vols. Edinburgh: Edinburgh University Press.

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