DOWNLOAD PDF MODELING DIFFERENTIAL EQUATIONS IN BIOLOGY

Chapter 1 : Mathematical and theoretical biology - Wikipedia

A text on the mathematics of diffusion, classical ecology, geology and epidemiology. The back cover of Modeling Differential Equations in Biology explains that, as college level science students only take the rudiments of calculus, this book fills a gap in teaching the biology students how to use differential equations in their research.

This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. April Learn how and when to remove this template message Interest in the field has grown rapidly from the s onwards. Some reasons for this include: 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 An increasing interest in in silico experimentation due to ethical considerations, risk, unreliability and other complications involved in human and animal research Areas of research[edit] Several areas of specialized research in mathematical and theoretical biology [9] [10] [11] [12] [13] 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. Evolutionary biology[edit] 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 frequencies of existing alleles and genotypes at a small number of gene loci. When infinitesimal effects at a large number of gene loci are considered, 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 development of coalescent theory is phylogenetics. Phylogenetics is an area that deals with the reconstruction and analysis of phylogenetic evolutionary trees and networks based on inherited characteristics [14] Traditional population genetic models deal with alleles and genotypes, and are frequently stochastic. Many population genetics models assume that population sizes are constant. Variable population sizes, often in the absence of genetic variation, are treated by the field of population dynamics. Work in this area dates back to the 19th century, and even as far as when Thomas Malthus formulated the first principle of population dynamics, which later became known as the Malthusian growth model. The Lotkaâ€"Volterra predator-prey equations are another famous example. Population dynamics overlap with another active area of research in mathematical biology: Various models of the spread of infections have been proposed and analyzed, and provide important results that may be applied to health policy decisions. Price , selection acts directly on inherited phenotypes, without genetic complications. This approach has been mathematically refined to produce the field of adaptive dynamics. Computer models and automata theory[edit] A monograph on this topic summarizes an extensive amount of published research in this area up to , [15] [16] [17] including subsections in the following areas: It was introduced by Anthony Bartholomay , and its applications were developed in mathematical biology and especially in mathematical medicine. 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. 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. The following is a list of mathematical descriptions and their assumptions. Deterministic processes dynamical systems [edit] 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.

Chapter 2 : Differential Equations and Mathematical Biology - CRC Press Book

This is a good book on the use of differential equations in modeling in biology. However, the book is written by a mathematician not a biologist and the papers that are featured are now about 10 years out of date.

This is the problem of determining a curve on which a weighted particle will fall to a fixed point in a fixed amount of time, independent of the starting point. Lagrange solved this problem in and sent the solution to Euler. This partial differential equation is now taught to every student of mathematical physics. Example[edit] For example, in classical mechanics , the motion of a body is described by its position and velocity as the time value varies. In some cases, this differential equation called an equation of motion may be solved explicitly. An example of modelling a real world problem using differential equations is the determination of the velocity of a ball falling through the air, considering only gravity and air resistance. Finding the velocity as a function of time involves solving a differential equation and verifying its validity. Types[edit] Differential equations can be divided into several types. Apart from describing the properties of the equation itself, these classes of differential equations can help inform the choice of approach to a solution. Commonly used distinctions include whether the equation is: This list is far from exhaustive; there are many other properties and subclasses of differential equations which can be very useful in specific contexts. Ordinary differential equations[edit] Main articles: Ordinary differential equation and Linear differential equation An ordinary differential equation ODE is an equation containing an unknown function of one real or complex variable x, its derivatives, and some given functions of x. The unknown function is generally represented by a variable often denoted y , which, therefore, depends on x. Thus x is often called the independent variable of the equation. The term "ordinary" is used in contrast with the term partial differential equation , which may be with respect to more than one independent variable. Linear differential equations are the differential equations that are linear in the unknown function and its derivatives. Their theory is well developed, and, in many cases, one may express their solutions in terms of integrals. Most ODEs that are encountered in physics are linear, and, therefore, most special functions may be defined as solutions of linear differential equations see Holonomic function. As, in general, the solutions of a differential equation cannot be expressed by a closed-form expression , numerical methods are commonly used for solving differential equations on a computer. Partial differential equations[edit] Main article: Partial differential equation A partial differential equation PDE is a differential equation that contains unknown multivariable functions and their partial derivatives. This is in contrast to ordinary differential equations , which deal with functions of a single variable and their derivatives. PDEs are used to formulate problems involving functions of several variables, and are either solved in closed form, or used to create a relevant computer model. PDEs can be used to describe a wide variety of phenomena in nature such as sound , heat , electrostatics , electrodynamics , fluid flow , elasticity , or quantum mechanics. These seemingly distinct physical phenomena can be formalised similarly in terms of PDEs. Just as ordinary differential equations often model one-dimensional dynamical systems , partial differential equations often model multidimensional systems. PDEs find their generalisation in stochastic partial differential equations. There are very few methods of solving nonlinear differential equations exactly; those that are known typically depend on the equation having particular symmetries. Nonlinear differential equations can exhibit very complicated behavior over extended time intervals, characteristic of chaos. Even the fundamental questions of existence, uniqueness, and extendability of solutions for nonlinear differential equations, and well-posedness of initial and boundary value problems for nonlinear PDEs are hard problems and their resolution in special cases is considered to be a significant advance in the mathematical theory cf. Navierâ€”Stokes existence and smoothness. However, if the differential equation is a correctly formulated representation of a meaningful physical process, then one expects it to have a solution. These approximations are only valid under restricted conditions. For example, the harmonic oscillator equation is an approximation to the nonlinear pendulum equation that is valid for small amplitude oscillations see below. Equation order[edit] Differential equations are described by their order, determined by the term with the highest derivatives. An equation containing only first derivatives is a first-order differential equation, an equation containing the second derivative is a second-order differential equation, and so on. Two broad classifications of both ordinary and partial differential equations consists of distinguishing between linear and nonlinear differential equations, and between homogeneous differential equations and inhomogeneous ones. Inhomogeneous first-order linear constant coefficient ordinary differential equation:

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Chapter 6 : Differential equation - Wikipedia

Ordinary differential equations (ODEs) provide a classical framework to model the dynamics of biological systems, given temporal experimental data. Qualitative analysis of the ODE model can lead to further biological insight and deeper understanding compared to traditional experiments alone.

Chapter 7 : Modeling Differential Equations in Biology by Clifford Taubes

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Chapter 8 : Is differential equation modelling in molecular genetics useful? - Biology Stack Exchange

Suitable for courses on differential equations with applications to mathematical biology or as an introduction to mathematical biology, Differential Equations and Mathematical Biology, Second Edition introduces students in the physical, mathematical, and biological sciences to fundamental modeling.