M. Iosifescu · P. Tăutu

Stochastic Processes and Applications in Biology and Medicine II

Models

Stochastic Processes And Applications In Biology And Medicine Part 2

D.L. Solomon,C.F. Walter

Stochastic Processes And Applications In Biology And Medicine Part 2:

    Diffusion Processes and Related Topics in Biology Luigi M. Ricciardi,2013-03-13 These notes are based on a one quarter course given at the Department of Biophysics and Theoretical Biology of the University of Chicago in 1916 The course was directed to graduate students in the Division of Biological Sciences with interests in population biology and neurobiology Only a slight acquaintance with probability and differential equations is required of the reader Exercises are interwoven with the text to encourage the reader to play a more active role and thus facilitate his digestion of the material One aim of these notes is to provide a heuristic approach using as little mathematics as possible to certain aspects of the theory of stochastic processes that are being increasingly employed in some of the population biol ogy and neurobiology literature While the subject may be classical the nov elty here lies in the approach and point of view particularly in the applica tions such as the approach to the neuronal firing problem and its related dif fusion approximations It is a pleasure to thank Professors Richard C Lewontin and Arnold J F Siegert for their interest and support and Mrs Angell Pasley for her excellent and careful typing I PRELIMINARIES 1 Terminology and Examples Consider an experiment specified by a the experiment s outcomes forming the space S b certain subsets of S called events and by the probabilities of these events

    The Belousov-Zhabotinskii Reaction J.J. Tyson,2013-03-13 In 1958 B P Belousov discovered that the oxidation of citric acid by bromate in the presence of cerium ions does not proceed to equilibrium methodically and uniformly like most chemical reactions but rather oscillates with clocklike precision between a yellow and colorless state See Fig 11 1 p 30 A M Zhabotinskii followed up on Belousov s original observation and in 1964 his first investigations appeared in the Russian journal Biofizika Though H Degn in Copenhagen at the time knew of Zhabotinskii s work and published his own account of the mechanism of oscillation in Nature 1967 this interesting reaction attracted little attention among Western scientists until 1968 when Zhabotinskii and his coworkers and Busse from Braunschweig W Germany reported on their work at an international conference on biological and biochemical oscillators held in Prague Shortly thereafter appeared a flurry of papers on temporal oscillations and spatial patterns in this reaction system Vavilin and Zhabotinskii 1969 and later Kasperek and Bruice 1971 studied the kinetics of the oxidation 3 of Ce by Br0 and the oxidation of organic species by Ce 4 Busse 1969 3 reported his observation of colored bands of chemical activity propagating up and down in a long tube of unstirred solution Zaikin and Zhabotinskii 1970 observed circular chemical waves in thin layers of solution   **Complexity, Language, and Life: Mathematical Approaches** John L. Casti,Anders Karlqvist,2012-12-06 In May 1984 the Swedish Council for Scientific Research convened a small group of investigators at the scientific research station at Abisko Sweden for the purpose of examining various conceptual and mathematical views of the evolution of complex systems The stated theme of the meeting was deliberately kept vague with only the purpose of discussing alternative mathematically based approaches to the modeling of evolving processes being given as a guideline to the participants In order to limit the scope to some degree it

was decided to emphasize living rather than nonliving processes and to invite participants from a range of disciplinary specialities spanning the spectrum from pure and applied mathematics to geography and analytic philosophy The results of the meeting were quite extraordinary while there was no intent to focus the papers and discussion into predefined channels an immediate self organizing effect took place and the deliberations quickly oriented themselves into three main streams conceptual and formal structures for characterizing sys tem complexity evolutionary processes in biology and ecology the emergence of complexity through evolution in natural lan guages The chapters presented in this volume are not the proceed ings of the meeting Following the meeting the organizers felt that the ideas and spirit of the gathering should be preserved in some written form so the participants were each requested to produce a chapter explicating the views they presented at Abisko written specifically for this volume The results of this exercise form the volume you hold in your hand

Mathematics and the Life Sciences D.E. Matthews,2013-03-13 For two weeks in August 1975 more than 140 mathematicians and other scientists gathered at the Universite de Sherbrooke The occasion was the 15th Biennial Seminar of the Canadian Mathematical Congress entitled Mathematics and the Life Sciences Participants in this inter disciplinary gathering included researchers and graduate students in mathematics seven different areas of biological science physics chemistry and medical science Geographically those present came from the United States and the United Kingdom as well as from academic departments and government agencies scattered across Canada In choosing this particular interdisciplinary topic the programme committee had two chief objectives These were to promote Canadian research in mathematical problems of the life sciences and to encourage co operation and exchanges between mathematical scientists biologists and medical re searchers To accomplish these objective the committee assembled a stim ulating programme of lectures and talks Six principal lecturers each delivered a series of five one hour lectures in which various aspects of the interaction between mathematics and the life sciences were considered In addition researchers working in the areas of health population biology physiology and development biology and disease processes were invited to give more than 25 hours of complementary talks

Deterministic Aspects of Mathematical Demography J. Impagliazzo,2012-12-06 Mathematical Demography the study of population and its analysis through mathematical models has received increased interest in the mathematical com munity in recent years It was not until the twentieth century however that the study of population predominantly human population achieved its math ematical character The subject of mathematical demography can be viewed from either a deterministic viewpoint or from a stochastic viewpoint For the sake of brevity stochastic models are not included in this work It is therefore my intention to consider only established deterministic models in this discussion starting with the life table as the earliest model to a generalized matrix model which is developed in this treatise These deterministic models provide sufficient de velopment and conclusions to formulate sound mathematical population analy sis and estimates of population projections It should be noted that although the subject of mathematical demography focuses on human populations the development and

results may be applied to any population as long as the preconditions that make the model valid are maintained Information concerning mathematical demography is at best fragmented *Stochastic Processes and Applications in Biology and Medicine* Marius Iosifescu,Petre Tăutu,1973 Vol 1 **Selection in One- and Two-Locus Systems** T. Nagylaki,2012-12-06 Most of these notes were presented as part of a two quarter course on theoretical population genetics at The University of Chicago Almost all the students were either undergraduates in mathematics or graduate students in the biological sciences The only prerequisites were calculus and matrices As is done in these notes biological background and additional mathematical techniques were covered when they were required I have included the relevant problems assigned in the course My aim in these notes is to formulate the various models fairly generally making the biological assumptions quite explicit and to perform the analyses relatively rigorously I hope the choice and treatment of topics will enable the reader to understand and evaluate detailed analyses of specific models and applications in the literature No attempt has been made to review the literature or to assign credit Most of the references are to papers directly germane to the subjects and approaches covered here Frequency of reference is not intended to reflect proportionate contribution I am very grateful to Professor James F Crow for helpful comments and to Mrs Adelaide Jaffe for her excellent typing I thank the National Science Foundation for its support Grant No DEB76 01550 *Mathematical Models in Biological Discovery* D.L. Solomon,C.F. Walter,2013-03-13 When I was asked to help organize an American Association for the Advancement of Science symposium about how mathematical models have con tributed to biology I agreed immediately The subject is of immense importance and wide spread interest However too often it is discussed in biologically sterile environments by mutual admiration society groups of theoreticians many of whom have never seen and most of whom have never done an original scientific experiment with the biolog ical materials they attempt to describe in abstract and often prejudiced terms The opportunity to address the topic during an annual meeting of the AAAS was irresistable In order to try to maintain the integrity f the original intent of the symposium it was entitled Contributions of Mathematical Models to Biological Discovery This symposium was organized by Daniel Solomon and myself held during the 141st annual meeting of the AAAS in New York during January 1975 sponsored by sections G and N Biological and Medical Sciences of the AAAS and the North American Regions of the Biometric Society and supported by grant BMS 75 0280 from the National Science Foundation What follows in this volume are papers by nine of the participants who not only felt that they had something to say in a symposium entitled Contributions of Mathematical Models to Biological Discovery but who falso were willing to record their ideas in more detail here *Antigen Antibody Interactions* C. Delisi,2013-03-13 1 1 Organization of the Immune System One of the most important survival mechanisms of vertebrates is their ability to recognize and respond to the onslaught of pathogenic microbes to which they are conti ously exposed The collection of host cells and molecules involved in this recognition 12 response function constitutes its immune system In man it comprises about 10 cells 20 lymphocytes and 10 molecules immunoglobulins Its

ontogenic development is c strained by the requirement that it be capable of responding to an almost limitless variety of molecular configurations on foreign substances while simultaneously remaining inert to those on self components It has thus evolved to discriminate with exquisite precision between molecular patterns The foreign substances which induce a response called antigens are typically large molecules such as proteins and polysaccharides The portions of these with which immunoglobulins interact are called epitopes or determinants A typical protein epitope may consist of a configuration formed by the spatial arrangements of four or five amino acids and have an average linear dimension of about 20 A **A Stochastic Model for Immunological Feedback in Carcinogenesis: Analysis and Approximations** N. Dubin,2013-03-13 Stochastic processes often pose the difficulty that as soon as a model devi ates from the simplest kinds of assumptions the differential equations obtained for the density and the generating functions become mathematically formidable Worse still one is very often led to equations which have no known solution and don t yield to standard analytical methods for differential equations In the model considered here one for tumor growth with an immunological re sponse from the normal tissue a nonlinear term in the transition probability for the death of a tumor cell leads to the above mentioned complications Despite the mathematical disadvantages of this nonlinearity we are able to consider a more sophisticated model biologically Ultimately in order to achieve a more realistic representation of a complicated phenomenon it is necessary to examine mechanisms which allow the model to deviate from the more mathematically tractable linear format Thus far stochastic models for tumor growth have almost exclusively considered linear transition probabilities **Integrodifferential Equations and Delay Models in Population Dynamics** J. M. Cushing,2013-03-08 These notes are for the most part the result of a course I taught at the University of Arizona during the Spring of 1977 Their main purpose is to inves tigate the effect that delays of Volterra integral type have when placed in the differential models of mathematical ecology as far as stability of equilibria and the nature of oscillations of species densities are concerned A secondary pur pose of the course out of which they evolved was to give students an at least elementary introduction to some mathematical modeling in ecology as well as to some purely mathematical subjects such as stability theory for integrodifferentia1 systems bifurcation theory and some simple topics in perturbation theory The choice of topics of course reflects my personal interests and while these notes were not meant to exhaust the topics covered I think they and the list of refer ences come close to covering the literature to date as far as integrodifferentia1 models in ecology are concerned I would like to thank the students who took the course and consequently gave me the opportunity and stimulus to organize these notes Special thanks go to Professor Paul Fife and Dr George Swan who also sat in the course and were quite helpful with their comments and observations Also deserving thanks are Professor Robert O Malley and Ms Louise C Fields of the Applied Mathematics Program here at the University of Arizona Ms Fields did an outstandingly efficient and accu rate typing of the manuscript The Genetic Structure of Populations A. Jacquard,2012-12-06 It is part of the ideology of science that it is an international enterprise carried out by a community that

knows no barriers of nation or culture But the reality is somewhat different Despite the best intentions of scientists to form a single community unseparated by differences of national and political viewpoint they are in fact separated by language Scientific literature in German is not generally assimilated by French workers nor that appearing in French by those whose native language is English The problem appears to have become more severe since the last war because the ascendance of the United States as the preeminent economic power led in a time of big and expensive science to a pre dominance of American scientific production and a growing tendency at least among English speakers to regard English as the international language of science International congresses and journals of world circulation have come more and more to take English as their standard or official language As a result students and scientific workers in the English speaking world have become more linguistically parochial than ever before and have been cut off from a considerable scientific literature Population genetics has been no exception to the rule The elegant and extremely innovative theoretical work of Malecot for example is only now being properly assimilated by population biologists outside France It was therefore with some sense of frustration that I read Prof   *Modeling and Control in the Biomedical Sciences* H.T. Banks,2013-03-12 These notes are based on i a series of lectures that I gave at the 14th Biennial Seminar of the Canadian Mathematical Congress held at the University of Western Ontario August 12 24 1973 and li some of my lectures in a modeling course that I have cotaught in the Division of Bio Medical Sciences at Brown during the past several years An earlier version of these notes appeared in the Center for Dynamical Systems Lectures Notes series CDS LN 73 1 November 1973 I have in this revised and extended version of those earlier notes incorporated a number of changes based both on classroom experience and on my research efforts with several colleagues during the intervening period The narrow viewpoint of the present notes use of optimization and control theory in biomedical problems reflects more the scope of the CMC lectures given in August 1973 than the scope of my own interests Indeed my real interests have included the modeling process itself as well as the contributions made by investiga tors who employ the techniques and ideas of control theory systems analysis dif ferential equations and stochastic processes Some of these contributions have quite naturally involved application of optimal control theory But in my opinion many of the interesting efforts being made in modeling in the biomedical sciences encompass much more than the use of control theory   **Mathematical Problems in Biology** P. van den Driessche,2013-03-08 A conference on Some Mathematical Problems in Biology was held at the University of Victoria Victoria B C Canada from May 7 10 1973 The participants and invited speakers were mathematicians interested in problems of a biological nature and scientists actively engaged in developing mathematical models in biological fields One aim of the conference was to attempt to assess what the recent rapid growth of mathematical interaction with the biosciences has accomplished and may accomplish in the near future The conference also aimed to expose the problems of communication bet een mathematicians and biological scientists and in doing so to stimulate the interchange of ideas It was recognised that the topic spans an enormous breadth and little

attempt was made to balance the very diverse areas Widespread active interest was shown in the conference and just over one hundred people registered The varied departments and institutions across North America from which the participants came made it both academically and geographically mixed The chief activity of the conference was the presentation of papers Nine invited guest speakers see table of contents each gave a one hour talk These covered a wide range of topics There were twenty five shorter twenty minute contributed papers and almost all papers l rere followed by a five minute question and discussion period Duplicated abstracts of presented papers were available at the meeting An evening informal discussion meeting of participants chaired by Dr A B Tayler and led by Drs E M Hagmeier E C **Ion Transport through Biological Membranes** M.C. Mackey,2013-03-13 This book illustrates some of the ways physics and mathematics have been and are being used to elucidate the underlying mechan isms of passive ion movement through biological membranes in general and the membranes of excltable cells in particular I have made no effort to be comprehensive in my introduction of biological material and the reader interested in a brief account of single cell electro physlology from a physically oriented biologists viewpoint will find the chapters by Woodbury 1965 an excellent introduction Part I is introductory in nature exploring the basic electrical properties of inexcitable and excitable cell plasma membranes Cable theory is utilized to illustrate the function of the non decrementing action potential as a signaling mechanism for the long range trans mission of information in the nervous system and to gain some in sight into the gross behaviour of neurons The detailed analysis of Hodgkin and Huxley on the squid giant axon membrane ionic conductance properties is reviewed briefly and some facets of membrane behaviour that have been revealed since the appearance of their work are dis cussed Part II examines the foundations of electrodiffusion theory and the use of that theory in trying to develop quantitative expla nationsof the observed membrane properties of excitable cells in particular the squid giant axon In addition an ad hoc formulation of electrodiffusion theory including active transport is presented to illustrate the qualitative nature of cellular homeostasis with respect to intracellular ionic concentrations and membrane potential and cellular responses to prolonged stimUlation *Measuring Selection in Natural Populations* Freddy Christiansen,T.M. Fenchel,2012-12-06 **Zoobooks** ,1974 **Deterministic Threshold Models in the Theory of Epidemics** P. Waltman,2013-03-08 These notes correspond to a set of lectures given at the Univer sity of Alberta during the spring semester 1973 The first four sec tions present a systematic development of a deterministic threshold model for the spraad of an infection Section 5 presents some compu tational results and attempts to tie the model with other mathematics In each of the last three sections a separate specialized topic is presented The author wishes to thank Professor F Hoppensteadt for making available preprints of two of his papers and for reading and comment ing on a preliminary version of these notes He also wishes to thank Professor J Mosevich for providing the graphs in Section 5 The visit at the University of Alberta was a very pleasant one and the author wishes to express his appreciation to Professors S Ghurye and J Macki for the invitation to visit there Finally thanks are due to the very competent secretarial staff at the

University of Alberta for typing the original draft of the lecture notes and to Mrs Ada Burns of the University of Iowa for her excellent typescript of the final version TABLE OF CONTENTS 1 A Simple Epidemic Model with Permanent Removal 1 2 A More General Model and the Determination of the Intensity of an Epidemic 10 21 3 A Threshold Model 4 A Threshold Model with Temporary Immunity 34 5 Some Special Cases and Some Numerical Examples 48 A Two Population Threshold Model 62 6 **Positive Feedback in Natural Systems** Donald L. DeAngelis,Wilfried M. Post,Curtis C. Travis,2012-12-06 Cybernetics a science concerned with understanding how systems are regulated has reflected the preoccupations of the century in which it was born Regulation is important in twentieth century society where both machines and social organizations are complex Cybernetics focused on and became primarily associated with the homeostasis or stability of system behavior and with the negative feedbacks that stabilize systems It paid less attention to the processes opposite to negative feedback the positive feedback processes that act to change systems We attempt to redress the balance here by illustrating the enormous importance of positive feedbacks in natural systems In an article in the American Scientist in 1963 Maruyama called for increased attention to this topic noting that processes of change could occur when a deviation in anyone component of the system caused deviations in other components that acted back on the first component to reinforce of amplify the initial deviation The deviation amplification is the result of positive feedback among system components Maruyama demonstrated by numerous examples that the neglect of such processes was unjustified and suggested that a new branch of cybernetics the second cybernetics be devoted to their study **Stochastic Processes and Applications in Biology and Medicine: Theory** Marius Iosifescu,Petre Tăutu,1973 A stray dog is constantly frustrated in her quest for a bone Turning the narrower pages reveals hidden portions of the illustrations

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