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H. Atlan I.R. Cohen (Eds.)

Theories of Immune Networks

With 23 Figures

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Preface

For a long time, immunology has been dominated by the idea of a simple linear cause-effect relationship between the exposure to an antigen and the production of specific antibodies against that antigen. Clonal selection was the name of the theory based on this idea and it has provided the main concepts to account for the known features of the immune response.

More recently, immunologists have discovered a wealth of new facts, in the form of different regulatory cells (helpers, suppressors, antigen presenting cells), genetic determinations of immune responses such as those involved in graft rejections, different molecular structures responsible for intercellular interactions such as interleukins, cytokins, idiotype-antiidiotype recognition and others. While furthering our understanding of the local interactions (molecular and cellular) involved in the immune response, these discoveries have led to a questioning of the simplicities of the classical clonal selection theory. It is clear today that every single immune response is a cooperative phenomenon involving several different molecular and cellular interactions taking place in a coupled manner. In addition, cross reactivity to different antigens has shown that responses of the whole immune system to different antigens are not completely isolated from one another and that the history of encounters with different antigens plays a crucial role in the maturation of the whole system. Thus, problems of complexity, generation of diversity and self-organization have entered the field of immunology. Increasingly, an analogy has been drawn between the central nervous system and the immune system, both being viewed as networks of interacting cells producing cooperative behavior with the collective properties of memory and learning. It was realized that the immune system, like the central nervous system, could be studied as a computing network endowed with cognitive capabilities.

In the meantime, powerful computation methods have been developed in artificial intelligence and in the physics of complex systems; these have facilitated much improved simulations of such networks. (Some of them have already been presented in previous volumes of the Springer Series in Synergetics.) The above developments were the motivation for the symposium in Jerusalem in May, 1988, where physicists, computer scientists and mathematicians met with experimental immunologists. The goal was to review network approaches to the study of the immune system from different viewpoints corresponding to different levels of organization. Hence the title "Theories of Immune Networks".

The first part of the book presents empirical data on some molecular and cellular interactions, mainly idiotypic-antiidiotypic, which constitute the basis of the connections between different cell populations. Automata network behavior can be used to model not only idiotypic-antiidiotypic interactions, but also other specific and less specific interactions between different classes of lymphocytes as well as receptor-antigen interactions. Thus, the otherwise rather general concept of an immune network takes on a more precise meaning, depending on which level of description is used. Two different approaches are discussed in parts two and three respectively: The large network approach consisting of all possible idiotypic-antiidiotypic interactions with cross-reactivity between antigenic structures; and the small network approach, better fitted to represent and analyze specific data on limited interactions involved in the response to a single antigen as provided by experimental models.

Through the different contributions to the book, we hope that the reader will become familiar with the variety of formal approaches available today to analyze the behavior of such networks. Presented among them are the first applications of neural network computation to immunology.

Jerusalem
July 1989

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