Preface

Immune system functions require energy. Energy availability is not indefinite and the immune system is not the only component requiring energy resources. As a consequence, the degree of energy allocated for the functioning of the immune system will depend on the total amount of available energy and the energy simultaneously required by other systems. The tight interconnection between energy availability and immune response is one of the main focuses of eco-immunology and it has been receiving an increasing attention in the last decade, with relevant implications for immunological studies. This book wants to give an "all-round" perspective of the possible approaches and ideas that may be included in, or may stem from, the eco-immunology.

Introducing the concept of energy allocation and redistribution, and describing the challenges presented by the on-field research, the first Chapter of this book poses one of the most relevant questions of the eco-immunologists. Is the lab-research a good and faithful representation of the diversity and the variety of immune challenges that an organism have to face daily in order to survive and reproduce? The answer is far from being obvious, and Chap. 2 makes the reader aware of the increasing complexity of the variables that must be considered by eco-immunologists, illustrating that population dynamics and mathematical models are ineludible instruments for investigating immune responses against infectious diseases. Thanks to this perspective, the interactions between host and pathogens may be analyzed and described using also ecological models leading in some cases to the unobvious conclusion that a less responsive immune system may in some cases improve the survival.

The cultural fundament of eco-immunology describing the immune response as a physiological activity that must be controlled in order to avoid an excessive energy consume is analyzed in depth throughout Chap. 3. The interactions between immunity and reproduction are analyzed, with a special attention towards the fundamental role played by trade-offs, a further concept representing a cornerstone of eco-immunology. Considerations on the Hamilton-Zuk hypothesis, an hypothesis formulated in 1982 and linking host-parasite dynamics with reproductive success, represent a trait d'union between Chaps. 3 and 5. In the latter, Owen and Hawley focused on host-parasite interactions, one aspect that, though fundamental, is frequently

overlooked in the eco-immunological studies aimed at understanding how ecological components intervene in shaping the immune system and its evolution.

The evolution of the immune system becomes the major topic in Chap. 5, where the concepts of trade-offs are extended to the immune-neuroendocrine system, here described as an integrated component both in terms of functions and evolvability. In Chap. 5 the principle differences between jawed vertebrates and other metazoans are analyzed in light of eco-immunological considerations. One of the principle elements of discontinuity observed in the immune systems of jawed vertebrates is represented by the lymphocyte, a cell with immune-neuroendocrine functions and the major component of the "mobile brain" described in 1986 by Blalock and Smith. The environment in which T lymphocytes mature is represented by the thymus, an organ that notoriously undergoes relevant changes during growth and aging. As evidenced in Chap. 6, thymus commonly hosts a great energy investment in childhood even in absence of important immune challenges, in order to provide a more efficient immune system in the adulthood. The redistribution of energy allocation implies programmed structural changes which, accordingly to Quaglino and coauthors, may not be finalized to the simple disposing of the thymus, but rather to its reutilization as energy storage and endocrine component. Chap. 6 also represents a transition point of the book, where evolutionary and ecological considerations derived from animal models give room to aspects of eco-immunology more connected with human immunology and translational medicine. The new and suggestive concept of "antigenic eco-space" is proposed in Chap. 7, in which the importance of the immunological biography of individuals is analyzed for its role in determining the quality of immuno-senescence. Of relevance, Franceschi and colleagues hypothesize that human genetic variants selected by evolution are probably unfit to the present-day environment of developed countries. mTOR- and NF-κB-mediated pathways are the mentioned examples of molecular routes that have been selected as adaptations to limited resources and whose action may reveal deleterious in aged people of wealthy countries. The alternative between immuno-senescence and the related state of chronic inflammation (inflammaging) versus an healthy aging is the main topic of Chap. 8. Interestingly, the role of geographical and cultural environment seems relevant in determining the prevalence of a detrimental inflammaging versus a positive one, and it is proposed the concept of "population immunology" to emphasize the importance of the environment in modeling the individual immune system and its functioning during post-reproductive age.

The reliability of laboratory models, the importance of mathematical analyses, the evolutionary response of adaptive immune systems to resource availability and the health problems suffered by humans in consequence of immuno-senescence are recollected in an integrated view within the Chap. 9. In this last Chapter, human and mouse immune systems are comparatively analyzed in the light of the directionality theory, a mathematical model of evolutionary dynamics. The evolutionary-driven differences between human and mouse immune systems, especially in their adaptive components, may have relevant consequences on immunological researches. More precisely, using Alzheimer's disease as principle reference, Chap. 9 introduces the discrimination between early- and late-onset diseases and it explains that

mice can be reliable models for the early-onset diseases, but they are unreliable guides for late-onset inflammatory diseases. As a consequence, therapies developed in mice and utilized for counteracting late-onset diseases will most probably be ineffective in humans.

Throughout the book it emerges the wideness of concepts that can be embraced by eco-immunology. Despite the different perspectives and expertise of the contributors, one of the most important leit-motif is the continuous and combined appeal to mathematical models, evolutionary theories and immunological competences. Much more than the combination of ecology and immunology, eco-immunology is progressively revealing itself as a self-standing discipline, a way of thinking and approaching numberless biological problems, which may have reflections on diverse fields extending from environmental and evolutionary analyses to therapeutic strategies and welfare politics.

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