Preface

This book was written with a broad readership in mind. Students as well as working biologists in the fields of physiology, morphology, zoology, evolutionary biology, and ecology, especially those interested in or who are actively engaged in the area of comparative respiratory biology will particularly find it of significance. Scientists in the fields of Earth Sciences who are interested in how the physical world has interacted and influenced the biological one and therefore determined the development of life forms, states, and physiological processes will find the book interesting and hopefully stimulating. A section of the treatise deals with the origin, the dynamics, and the physicochemical properties of the respiratory gases and fluid media, with specific focus on molecular oxygen (O_2). By designating O_2 as "the molecule that made the world" and observing that "if water is the foundation of life, then oxygen is its engine," Lane (2002) absolutely summed it up. Large-scale anoxia and hypoxia, especially in the oceans, is commonly cited as having been the foremost driver of mass extinctions as well as a long-term limiting factor of evolutionary radiation of life on the early Earth, particularly during the Cambrian. Insights into the mechanism(s) of the inauguration and innovation of the respiratory means and processes and understanding of the basis of the high fidelity of living entities, especially from a comparative perspective, are lacking. This is because of the dearth and even lack of a clear grasp of the physical backdrop in which the changes occurred, the prevailing limitations, and the adaptive stratagems adopted, i.e., the solutions by which the challenges were surmounted as animals not only strived to survive but also to conquer, occupy, and advance to new ecological niches.

I utterly believe that in order to most incisively explicate the essence of the structure and function of the gas exchangers, it is vital to interrogate and integrate, at the broadest and deepest possible levels, the pertinent details and facts from as many relevant disciplines as possible. Among others, these fields include astronomy, astrophysics, geology, atmospheric science, aquatic chemistry, marine biology, sedimentology, oceanography, ecology, physics, chemistry, plant physiology, evolution, adaptation, physiology, and morphology. While fragmentation of science into smaller disciplines has historically been necessary and has laudably advanced many fields as investigators/researchers have focused on narrower questions, the downside to it has been the unintended creation of artificial barriers that have stymied perception of the "broad picture," leading to myopic scientific concepts, themes, and principles. This has lead to wanting answers to far-reaching questions. In both the physical and the biological sciences, awareness of this negative aspect has seen and continues to see erosion of boundaries and merging of traditional disciplines and proliferation of more encompassing ones like paleogeography, geochemistry, paleoclimatology, biochemistry, biophysics, paleogeology, ecophysiology, paleoecology, chemical geology, evo–devo (evolutionary developmental biology), genetic and molecular biology, bioinorganic chemistry, chemical physics, and geoengineering. For example, erosion of the "cultural barriers" between biologists, mathematicians, and engineers, awareness of the complementarity of scientific enterprises, and the huge rewards reaped from collaboration across disciplines has seen the emergence of fields such as bionics and synthetic biology and more powerful modeling of biological events, states, and processes.

Inauguration of O_2 utilization for energy production is an ancient process. Its development and progression was underpinned by events and dynamics of the biological, physical, and chemical worlds. While some of the perspectives presented in this book may on casual glance appear to fall outside the conventional realm of biology and in particular that of respiratory morphology and physiology, horizontal and vertical integration of pertinent aspects has been made to adduce more compelling answers regarding the basis of the functional design of gas exchangers. Many of the books that have broached the subject of comparative functional respiratory biology have only described the form and function of the "end-product" (the gas exchanger), on outcome of a long and highly dynamic process. They scarcely delve into the factors and conditions that motivated and steered the development from the incipient to the modern states. Here, broad questions have been posed and multidisciplinary data and facts synthesized and critically analyzed to better clarify previously cryptic aspects of respiratory biology. The foremost questions include the following: Where did O_2, the primary respiratory gas, come from? How have its levels in the biosphere (water and air) changed during the existence of life on Earth and what specific role(s) has it (O_2) played in the functional designs of the gas exchangers? Regarding water and air, the only two naturally occurring fluid respiratory media at the biological range of temperature, the following question has been asked: How have their physicochemical properties shaped the form and function of the gas exchangers? The far-reaching question is: Can we identify the underpinnings and make sense of the range of the phenotypes of gas exchangers that have formed? I have not hesitated from speculating or offering views where resolute data are lacking.

This book encapsulates over three decades of my work on comparative functional respiratory morphology. I am most grateful to the many colleagues that I have had the good fortune of collaborating with and who have given me their precious time and ideas unreservedly. I cannot list all of them: they know themselves and understand the depth of my appreciation. I should, however, mention

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