Environmental biology of agaves and cacti

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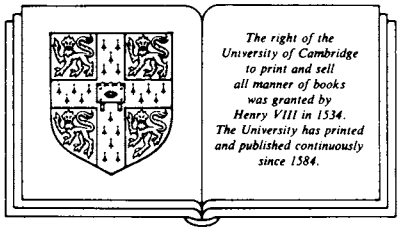

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Preface

Agaves and cacti capture the imagination of nearly everyone. Who can resist admiring their unique shapes or empathizing with their tolerance of droughts and high temperatures? How do these interesting and economically important desert succulents respond to specific environmental factors? We shall see that the monocotyledonous agaves are actually quite similar to the dicotyledonous cacti in their reactions to the environment. The aims of this book are quite ambitious: (1) to help interpret the environmental responses of agaves and cacti; (2) to consolidate the present level of our knowledge of these succulents for comparison with other plant groups; (3) to show how modeling can be used to analyze relations between morphology, microclimate, and productivity; (4) to serve as an example for the study of the environmental responses of relatively uninvestigated groups of plants; and (5) to provide a basis for evaluating whether certain arid, semiarid, and other regions can be successfully exploited for the cultivation of these succulents in the future. Although well over 600 references are cited, considerable emphasis is placed on research emanating from my laboratory since 1975.

To set the stage, we will describe the many uses of as well as early environmental research on agaves and cacti together with their taxonomy, morphology, and anatomy, including pictures of over thirty species that have played important roles in environmental research (Chapter 1). The physiological key to their ecological success is the water-saving consequences of Crassulacean acid metabolism (Chapter 2). The responses of agaves and cacti to three physical factors of the environment are discussed next: water relations, including a discussion of such topics as rain roots, capacitance, stomatal responses, C_3/CAM shifts, seedling establishment, and reproduction (Chapter 3); temperature aspects of gas exchange and survival limits, together with a model relating morphology, tissue temperature, and species distribution (Chapter 4); and photosynthetically active radiation, with a presentation of models describing radiation interception and the resulting morphological adaptations of agaves and cacti (Chapter 5). Nutrient responses are reviewed, and the importance of nitrogen is demonstrated (Chapter 6). To help integrate the environmental effects, an environmental productivity index is proposed and then used to discuss productivity and its morphological correlates for agaves and cacti; productivity is also predicted over wide geographical areas to help evaluate the agronomic potential of these succulent plants (Chapter 7).

The level of presentation is between that of an elementary textbook and the research literature. Approximately 100 photographs, over 200 figure panels, and about 30 tables are used to illustrate the state of our research knowledge for agaves and cacti. Because emphasis is on principles of wide biological applicability, certain aspects of universal appeal are developed in considerable detail. The book can therefore serve as a text for a course on

the environmental responses of organisms, as well as meeting the needs of plant physiologists, ecologists, and agronomists. Another intended audience is animal ecophysiologists and modelers. The succulent plant enthusiast/hobbyist should also find the material comprehensible and useful. To facilitate understanding by readers of such different backgrounds, every major scientific term is italicized and defined the first time used, and the first entry in the index indicates the definition of that term. We should also emphasize that much of the information on the environmental responses culminating in productivity predictions is pertinent to decision makers in Latin America as well as many other arid or semiarid regions where agaves and cacti can be grown. Thus, the book summarizes the present state of our knowledge and clearly points to the future, with respect to both needed research and authenticated utilization of these plants.

Thanks are due to many. First of all, my research on desert succulents has been generously supported by the Ecological Research Division (ERD) of the United States Department of Energy, the U.S. National Science Foundation, and the University of California at Los Angeles. Experiments specifically designed for this book and capably performed by Terry L. Hartsock were also supported by ERD. Many graduate students, postdoctoral fellows, and visiting scientists have contributed to the overall research effort of my laboratory, as detailed in the literature cited. A tremendous debt of gratitude is expressed to Marjorie Macdonald for her excellent typing. The figures were skillfully drawn by Hildy Heinkel, Amy Roberts prepared the references, and the photographs were taken by the person cited in the figure caption, or by me. The following individuals also made important critical comments that greatly enhanced the final manuscript: Dr. Wade L. Berry, Dr. Arthur C. Gibson, Dr. Barry A. Prigge, Dr. Paul J. Schulte, Augusto C. Franco, Loraine U. Kohorn, Michael E. Loik, Gretchen B. North, Mark T. Patterson, Cheryl C. Swift, and David T. Tissue. As you peruse this book, I hope you discover and share my enthusiasm for the special environmental responses of these remarkable plants.

Los Angeles
30 November 1987

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