

Preface

“Physiology,” which is the study of the function of cells, organs, and organisms, derives from the Latin *physiologia*, which in turn comes from the Greek *physi-* or *physio-*, a prefix meaning natural, and *logos*, meaning reason or thought. Thus *physiology* suggests natural science and is now a branch of biology dealing with processes and activities that are characteristic of living things. “Physicochemical” relates to physical and chemical properties, and “Environmental” refers to topics such as solar irradiation and wind. “Plant” indicates the main focus of this book, but the approach, equations developed, and appendices apply equally well to animals and other organisms.

We will specifically consider water relations, solute transport, photosynthesis, transpiration, respiration, and environmental interactions. A physiologist endeavors to understand such topics in physical and chemical terms; accurate models can then be constructed and responses to the internal and the external environment can be predicted. Elementary chemistry, physics, and mathematics are used to develop concepts that are key to understanding biology—the intent is to provide a rigorous development, not a compendium of facts. References provide further details, although in some cases the enunciated principles carry the reader to the forefront of current research. Calculations are used to indicate the physiological consequences of the various equations, and problems at the end of chapters provide further such exercises. Solutions to all of the problems are provided, and the appendixes have a large list of values for constants and conversion factors at various temperatures.

Chapters 1 through 3 describe water relations and ion transport for plant cells. In Chapter 1, after discussing the concept of diffusion, we consider the physical barriers to diffusion imposed by cellular and organelle membranes. Another physical barrier associated with plant cells is the cell wall, which limits cell size. In the treatment of the movement of water through cells in response to specific forces presented in Chapter 2, we employ the thermodynamic argument of chemical potential gradients. Chapter 3 considers solute movement into and out of plant cells, leading to an explanation of electrical potential differences across membranes and establishing the formal criteria for distinguishing diffusion from active transport. Based on concepts from irreversible thermodynamics, an important parameter called the reflection coefficient is derived, which permits a precise evaluation of the influence of osmotic pressures on flow.

The next three chapters deal primarily with the interconversion of various forms of energy. In Chapter 4 we consider the properties of light and

its absorption. After light is absorbed, its radiant energy usually is rapidly converted to heat. However, the arrangement of photosynthetic pigments and their special molecular structures allow some radiant energy from the sun to be converted by plants into chemical energy. In Chapter 5 we discuss the particular features of chlorophyll and the accessory pigments for photosynthesis that allow this energy conversion. Light energy absorbed by chloroplasts leads to the formation of ATP and NADPH. These compounds represent currencies for carrying chemical and electrical (redox potential) energy, respectively. How much energy they actually carry is discussed in Chapter 6.

In the last three chapters we consider the various forms in which energy and matter enter and leave a plant as it interacts with its environment. The physical quantities involved in an energy budget analysis are presented in Chapter 7 so that the relative importance of the various factors affecting the temperature of leaves or other plant parts can be quantitatively evaluated. The resistances (or their reciprocals, conductances) affecting the movement of both water vapor during transpiration and carbon dioxide during photosynthesis are discussed in detail for leaves in Chapter 8, paying particular attention to the individual parts of the pathway and to flux density equations. The movement of water from the soil through the plant to the atmosphere is discussed in Chapter 9. Because these and other topics depend on material introduced elsewhere in the book, the text is extensively cross-referenced.

This text is the third edition of *Physicochemical and Environmental Plant Physiology* (2nd ed., Academic Press, 1999; 1st ed., 1991), which evolved from *Biophysical Plant Physiology and Ecology* (Freeman, 1983), *Introduction to Biophysical Plant Physiology* (Freeman, 1974), and *Plant Cell Physiology: A Physicochemical Approach* (Freeman, 1970). The text has been updated based on the ever-increasing quality of plant research as well as comments of colleagues and especially students. The goal is to integrate the physical sciences, engineering, and mathematics to help understand biology, especially for plants.

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