Reaching for the Sun

How Plants Work

From their ability to use energy from sunlight to make their own food, to combating attacks from diseases and predators, plants have evolved an amazing range of life-sustaining strategies.

Written with the non-specialist in mind, John King's lively natural history explains how plants function, from how they gain energy and nutrition to how they grow, develop, and ultimately die. New to this edition is a section devoted to plants and the environment, exploring how problems created by human activities, such as global warming, pollution of land, water and air, and increasing ocean acidity, are impacting on the lives of plants.

King's narrative provides a simple, highly readable introduction, with boxes in each chapter offering additional or more advanced material for readers seeking more detail. He concludes that, despite the challenges posed by growing environmental perils, plants will continue to dominate our planet.

JOHN KING is Professor Emeritus of Biology at the University of Saskatchewan. He is a Past-President of the Canadian Society of Plant Physiologists and in 2001 he was awarded their highest honor, the Gold Medal, "in recognition of outstanding contributions to plant physiology in Canada." The first edition of *Reaching for the Sun* (Cambridge, 1997) was nominated for the Rhône-Poulenc (now Aventis) Prize for Science (General Category).

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Second Edition

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Contents

Preface to the Second Edition

The rationale for the 1997 edition was that, the more people that know about the lifestyle of plants, the more likely it is that they will appreciate what has to be done to preserve this component of the biosphere upon which our survival depends. A secondary aim was the hope that people would discover that knowing more about how plants work is not just useful but also fun.

This second edition is addressed primarily to an audience of students of plant sciences but also to keen gardeners, naturalists, or anyone with questions about why the Earth is green, how plants defend themselves against diseases and predators, how they combat the stresses of constant exposure to the environment, and how climate change is affecting plants.

The general alarm voiced in the 1997 edition about the deleterious effects humans are having on our environment through global warming, deforestation, overgrazing by domestic animals, overcropping of arable lands, and pollution of land, water, and the atmosphere, is now, more than 10 years on, more clearly focused. Thus, in addition to making the book's original contents consistent with the most recent knowledge, material has been added to educate students of all ages about how human activities are impacting the lives of plants – how plants are affected at the physiological level by changes to our environment, such as through increasing concentrations of greenhouse gases, higher temperatures, longer growing seasons, increasing ocean acidity, changing water economy of the Earth, and pollutants such as ozone. Knowledge of influences such as these on the lives of plants is an essential component in the education in the twenty-first century of anyone with an interest in the green component of our planet that is so critical to our survival as a species.

Chapters are grouped into five parts, the first four of which are made up of topics carried over from the 1997 edition. The original 17 chapters have been reduced to 14, mainly by merging and culling material. Each chapter has added to it a box containing additional, more advanced, or new information. This extra source was added for the benefit of the more advanced reader or for those seeking more detail.

Part V is entirely new and highlights, in two chapters, the state of the Earth's environment before and after the influence of human activities became increasingly globally significant. This approach is designed to make it easier for the reader to understand how the lives of plants are being affected, positively and negatively, by the accelerated changes to their environments caused by human actions.

Reference material is grouped at the end of each part, is much more extensive than in the 1997 edition, and each citation has beside it a guide as to how it might be useful in amplifying and enriching knowledge provided in the text.

The book ends with a discussion drawing attention to the importance that genetic engineering is likely to have in future in adapting crop plants to climate change and in transforming our world through a new field of human endeavor, synthetic biology.

I am particularly grateful to Marlynn Mierau for his expert help with the illustrations and to Drs. R. B. Horsch, B. R. Neal, and J. W. Sheard, for their critical reading of all or part of the chapters in part V. Their assistance and advice were of great value, but responsibility for the content of all chapters remains mine, alone. I also acknowledge Jacqueline Garget, Katrina Halliday, and Lynette Talbot, the staff members at Cambridge University Press, who, at various times, shepherded the project along with great expertise, patience, and tact.

John King,
Saskatoon, 2010

Preface to the First Edition

The idea for this book arose from a conversation I had one day with two of my neighbors. Neither is a plant specialist but both are keen gardeners. One has in his garden a number of large trees of which not everyone is an unqualified admirer, including the other neighbor. For one thing, the trees shade adjacent gardens from direct sunlight for much of the day, including that of the second neighbor, a somewhat sensitive matter at this northerly latitude where there is a relatively short growing season. In the autumn, immense numbers of leaves find their way into the general neighborhood, often late in the season since some of these particular trees continue shedding leaves even after the first snow. The task of cleaning up frozen, congealed, decaying leaves is not universally appreciated.

Not for the first time, then, the owner of one of the shaded gardens was trying to persuade the tree-loving neighbor to remove his trees which, to the former, were obstacles to productive gardening. As the conversation developed, it became obvious that the aggrieved party thought the main bulk of a tree came from the soil since he made repeated reference to the fact that the offending trees were taking in significant quantities of nutrients through their roots. Of course, plants do absorb many essential minerals and water from soil but we have known for a long time, for more than 200 years in fact, that air, not soil, is the source of the main building block (carbon) from which the bulk of green plants is manufactured.

This experience led me to wonder how many other aspects of the ways in which plants grow and develop are less than well known to non-specialists. Green plants (in particular, those growing on land rather than in water) have a highly specialized lifestyle due to the fact that they are generally fixed in one location throughout

their lives. In addition, they contain a unique molecule, chlorophyll, which sets them apart from all other living organisms and gives them the option of manufacturing enormous quantities of their own food through photosynthesis.

Their general dependency on soil as an anchor and for essential mineral nutrients, as well as water, has led to the development of an elaborate root system with many unique functions. Like all living things, plants need water but, unlike many other organisms, they are not able to go searching for it beyond their immediate location. Thus, green plants have evolved a range of devices to obtain, transport, and conserve water as well as ways to combat the effects of excessive wind, drought, cold, heat, and light from which they cannot hide.

Green plants face serious challenges connected to the changing seasons. Flowering, seed production, dormancy, germination, leaf fall, and death, to name some of the more important milestones in the life cycle of plants, all are related to the seasons. Ways to measure time have evolved so that the activities of plants fit into the pattern of seasonal changes in their environment.

Green plants produce an enormous array of elaborate chemicals for only some of which a purpose is known. Plants use them to add color, fragrance, and flavor to their flowers and fruits, to wage war on predators and disease organisms, and to out-compete near neighbors. We make use of many of them ourselves, as cosmetics and pharmaceuticals for example.

These, and other features of green plants, together constitute what biologists would recognize as plant physiology – how plants work. My purpose here is to try to create an interest in and explain in straightforward language to the inquisitive layperson how plants function.

Green plants are all around us. They are the most successful of all living things evidenced by the fact that they are overwhelmingly the most abundant kinds of organisms on earth. We are absolutely dependent on them for food; we cultivate them for our pleasure; and we have used them in a vast number of ways down the centuries to our advantage. There is growing concern that we are following

practices that are a serious threat to green plants. For example, we do not know what effect depletion of the ozone layer in our atmosphere will have on plants (or other creatures for that matter); the so-called "greenhouse effect" is also an unknown quantity. We do know that we are destroying vast numbers of plants through practices such as the burning of forests, overgrazing by our domestic animals, and overcropping. The advent of biotechnology and its use in agriculture is causing concern that we may be manipulating natural plant genetic processes in ways of which we are alarmingly ignorant. Overpopulation and the parallel outcome of more intensive agricultural and industrial practices (such as pollution) that go hand in hand with our burgeoning world population are a growing threat to the green plant world. Such problems should concern us all.

Here, I have tried to provide examples of some of the important aspects of how plants work with the rationale that the more people know about the lifestyle of plants, the more likely it is that they will appreciate what has to be done to preserve this component of the biosphere without which we, ourselves, could not survive on our Earth. I also hope that people who read this will discover that knowing more about how plants work is not just useful but also fun.

I would like to acknowledge, with gratitude, the fact that much of the reading and writing for this project were accomplished during a sabbatical leave granted by the University of Saskatchewan during 1994–95. In addition, among those who helped along the way, I wish to make special mention of two: Dr. Timothy Benton, Popular Science Editor at Cambridge University Press, who gave thoughtful guidance at every step with great good humor and tact; and my wife, Myrna, who not only read and commented on each chapter but also provided ideas to help dispel the kinds of mental vapors that, surely, shroud the minds of most writers from time to time.

John King,
Saskatoon, 1997