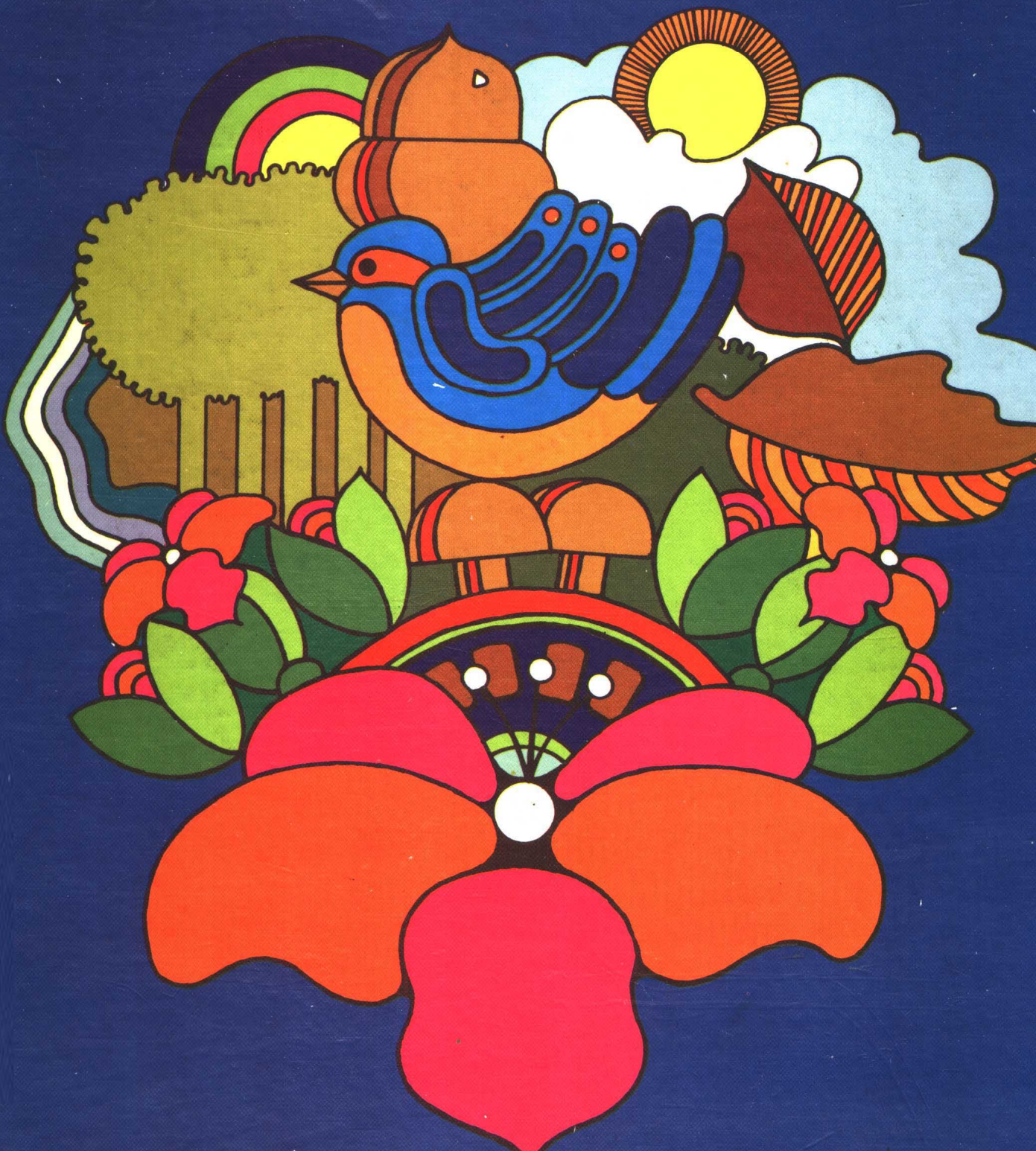
PLANTS and LIFE

ALAN W. HANEY



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Alan Haney
February 1977

Preface

Plants and Life is different from most botany texts in two principal ways. First, ecology is the integrating theme. Second, emphasis is shifted from factual details to biological models and concepts. The result is a unique organization that begins with discussions of ecosystems and moves systematically to populations, genetics, development, and physiology. Each section is written with sufficient detail and autonomy for the text to be used in a course presented in the more traditional fashion. Experience at the University of Illinois, however, clearly demonstrated greater student acceptance and learning when the organization described here was used.

The philosophy of this ecological-conceptual approach developed over many years of teaching a large, introductory botany course and grew from problems encountered while trying to meet the heterogeneous needs and interests of students in the same class who were majoring in agriculture, nonscience liberal arts, and botany. A classical approach that emphasized phylogenetic relationships was found to be too esoteric for liberal arts students who came to the course with little background or interest in botany. More recently, a molecular approach was used in an attempt to capture the excitement of modern biology. That, too, proved unpopular and impractical because of the limited background and lack of interest in chemistry evidenced by the majority of students. An objective evaluation of the needs of nonmajors also leads one to question the phylogenetic and molecular approaches. Beginning students who are not majoring in botany need concepts and principles, with enough facts to understand and apply them.

The choice of ecology as the integrating theme was made for a number of reasons. By its very nature, ecology represents an integration of biology. The principles of ecology are of direct use to all types of students, whether they are agriculture majors or simply someone wishing to grow houseplants, or, more importantly, nonbiologists who will participate in future decisions that will determine the ultimate direction and fate of life on this planet. In a recent national survey of biology educators, a list was compiled of 110 concepts important for inclusion in introductory biology courses. These were ranked by the panel in order of importance. Of the 35 concepts ranked as the most

important, 55 per cent were ecological; and over a third of all the concepts were ecological in nature.

By beginning with a discussion of ecology, students enter botany from the point of greatest familiarity. They are far more familiar with communities than with atoms or molecules. As they gain an understanding of ecosystems, students see a need for understanding the populations and organisms within these systems. Concepts of population biology lead logically to evolution and genetics, and these concepts prepare the student for a better understanding of the organism. Likewise, an understanding of the organism requires familiarity with organs, cells, and, ultimately, molecular biology. Where previously students were pushed to learn about protein synthesis, they now ask how organisms respond to environmental stimuli.

This approach is primarily intended for students who will take no advanced botany courses, although those who do, in our experience, have met with no difficulty. This text is designed for a one semester course. The goal is to leave students with the maximum understanding and appreciation of botany, particularly as it may be useful to nonmajors. This approach is more demanding for most students, especially when examinations are designed to stress conceptual understanding rather than factual recall. A semester that begins with ecosystems and includes molecular concepts must move rapidly. The rate at which material can be presented is faster with this ecological approach. Students seem much more willing to push ahead when the ecological organization is used. They see more easily where the course is going and enter each new area with an overview already in mind.

This approach emphasizes less the form of plants and more the function and interactions of biological systems. It begins with the ecosystem, the ultimate organization, and works toward the details. Analogously, to obtain a functional understanding of a car, one begins with a working car and takes it apart to examine the relationship of each subunit to the whole. Particularly where self-education is encouraged, as in most college courses, beginning with the parts and trying to fit them together is less efficient and pedagogically more difficult.

Once students have learned the broad models and their supporting concepts, it is easier for them to continue educating themselves. This eases the burden of trying to teach everything in one semester. Rather than teach the function of each "nut and bolt," examples and principles are provided to serve as models in understanding. This has led quite naturally to decreased emphasis on factual detail and greater emphasis on concepts. Factual detail, however, is not omitted from this text. Obviously, it is impossible to present conceptual relationships without facts. Moreover, a basic foundation of factual detail is essential for students to make good use of concepts. Emphasizing facts, however, seems particularly ill-starred when one recognizes that scientific knowledge doubles about every ten years. The conceptual framework of biology, however, changes much more slowly. It is rather rare for new facts to lead to totally new concepts.

In a one-term, introductory course, it is impossible to develop all the major

areas of botany. Most texts do so in order to provide a choice of emphasis, but they also provide, at the expense to the student, a larger and often more confusing book appropriate for a two-semester course. This expense does not seem justified for students of one-semester courses. The scope of this text is limited to material necessary to follow the central ecological theme. Consequently, much of the classical botany, especially that related to detailed descriptions and life cycles of major groups, is not treated. Additionally, emphasis in the growth and development chapters focuses on angiosperms, which are the plants with which most students are most familiar. With the basic concepts given, students are amply prepared to enter advanced courses in taxonomy and morphology. From these intermediate courses, students have had no difficulty moving on to mycology, anatomy, paleobotany, phycology, or other more specialized courses, which further develop their understanding of the almost endless variation within the plant kingdom.

Jargon, so prevalent in biology, has been avoided in this text. A working vocabulary is necessary, of course, and I have given careful thought to what terms are needed. As they are introduced, terms are defined or appear in boldfaced print to indicate that they are defined in the glossary. Italicized words or phrases denotes special emphasis.

A knowledge of elementary college chemistry and physics is not needed for students using this text. Students with high school chemistry and physics will have sufficient understanding. Students with no background should study the simple reviews in Appendix A and Appendix B, as necessary.

It has been my experience that devoting a portion of the course to applied topics offers an opportunity for students to relate basic knowledge to real problems. This not only helps students in their understanding, but also shows how basic science relates to vocational or avocational interests. Moreover, applied plant science fits nicely into the ecological theme. Section V is devoted entirely to applied plant science and relates especially closely to the background and interests of forestry and agriculture students. To tie this section to the interests of others, the ecological and evolutionary aspects have been emphasized, and the chapters are written on a more general level. Students are more likely to retain what they learn if they can apply it, even if the application is maintaining a collection of plants around the house.

This book represents a philosophy of teaching that has been developed over many years of trial and error. Throughout this developmental period I have carefully examined the factors affecting the attitudes of students. I am confident of this approach from the success in my classes, term after term. The most important factor in any teaching effort, however, is neither the text nor the organization of the course. It is the human element, above all the enthusiasm of the instructors for what they are teaching. I know this approach to introductory botany is a great improvement over the previous approach used, but its success for other teachers in other situations will depend upon many factors. I can only hope that it meets with as much success for others as it has for me.

A. W. H.

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Prologue

Have you ever watched a spider spinning its web? It is infinitely patient and meticulous, an artist without emotions. Life is much the same. The spider ensnares and kills its prey with no more emotion than a plant feels for the light it uses or for the rabbit who eats it. There is no greed, no guilt, no right or wrong. There are no legal regulations, yet order is implicit at every level. The balance of nature is largely achieved by each species pulling against the others, each individual striving to live and reproduce. Placed in a finite environment, the struggle for survival becomes extreme, but it is the very struggle that creates the order in ecological systems.

One may wonder at the seemingly miraculous perfection in life. How did each species, each individual come to be so well suited to its environment, and how did the myriad species come to be so attuned to one another that a near perfect balance is attained? The answer is partly time. Over three billion years have elapsed since life on Earth began. The second part of the answer is "try and try again." The natural tendency for all living creatures, plant and animal, is to reproduce. No two individuals are identical. Some live and reproduce, others do not. Through generations, countless forms and processes appear. Most do not survive, but those that do are testimony to their own success, and their offspring continue to represent that success through the generations, until such time as they are replaced by even more successful forms and processes. Third, perfection in life was attained by close and continual interactions among individuals of the same and different species. Success, in fact, is determined largely by the ability of an individual to deal with other individuals through competition for limited resources, through predator-prey relationships, through parasite-host interactions, and through mutually beneficial associations.

Plants perform the key functions in this finely tuned system we call life. They provide the energy, obtain the basic compounds or elements from the air, soil, and water, and convert them to forms that can be used by other living creatures; they also build and hold the soil. Plants directly interact with all other forms of life. Were it not for plants, the spider would have nothing upon which to hang its web. Nor would it have anything to catch, since in-

sects feed directly or indirectly on plants. Plants are the most finely attuned members of the living communities. Without them, there would be no life. We and every other animal owe our existence directly to the green plants that form the nucleus of living systems as surely as the sun is the nucleus of our solar system.

There is only one flaw in life—ourselves. If we were to condense the three billion years that life has existed on Earth to one day, a twenty-four-hour period, "people" would seem to have been here for less than half a minute. Our species as we know it would seem to have shared this planet with other life for only the past few seconds of this twenty-four-hour period. Yet during these few seconds we have directly exploited hundreds of species to extinction and have modified the environments of Earth so drastically that thousands of others are endangered. In doing so, we have upset or seriously disrupted the intricate balances of nature so severely that most species have been affected, some to their benefit but most to their detriment.

Human beings are subject to precisely the same checks and balances as any other species. We differ only in having the mental capability to develop the technology that permits us to manipulate our environment, including other species. In so doing, we have unintentionally and perhaps unknowingly removed ourselves from the normal checks and balances that prevent other species from disrupting the ecological systems upon which survival of all life depends. The checks and balances of nature can temporarily be averted, but never ignored for long. Any species that tends to exploit its environment will ultimately render the environment less suitable for its own survival, thus bringing into play the ultimate check. This is inevitable. No species can survive in isolation; we now know that the ultimate success of any depends on parallel success of others. Consequently, it is extremely narrow-minded and short-sighted to think that people have risen above nature, that we can control our own destiny while ignoring nature.

If we are to use our mental capability to control our destiny, we must do so through nature, not in spite of nature. We must strive to understand nature and learn how to adapt our needs. To continue in any other way will bring us ever closer to the demise of our species. Education is no longer a privilege, it is a necessity. Too often our education is devoted only to learning the ways and means of exploitation. Our welfare now requires that we learn the ways and means of survival. An individual may survive by exploitation, but a species can only survive by maintaining harmony with other species. This should become the goal of every human being. It is hoped that this book may contribute to this essential process.