Preface

The theme of this book is the history of life in New Zealand through geological time. The origins of the plants and animals have been controversial for over a century, but a vast amount of new information on the topic is now available thanks to recent work in molecular biology. The effects of the molecular revolution on biology resemble the tidal wave of new knowledge that followed the invention of the microscope; all fields of biology have changed in fundamental ways. The classifications, or phylogenies, of biological groups are now often based on molecular data, the DNA sequences. Wide-ranging, geographic surveys of DNA sequences in different species have revealed an unsuspected, new world of organic structure that exists at all scales, from submicroscopic to intercontinental, and have highlighted the significance of life in New Zealand.

New Zealand is home to bizarre creatures such as the kiwi and the tuatara, and the country's flora and fauna have always been recognized as distinctive and unusual. Jared Diamond (1997: 3) thought that "New Zealand is biologically the closest thing we can come to exploring another planet," and the new molecular work has confirmed this. It has revealed that many large groups of plants and animals are composed of two subgroups, with one made up of the "normal" members that are widespread and diverse around the world, and the other restricted to New Zealand. For example, the parrots comprise two main groups: the New Zealand group Strigopoidea (*Nestor* and *Strigops*) and all other parrots. Likewise, the passerines—the group of small, perching birds that make up more than half of all birds—comprise two groups: the New Zealand wrens (Acanthisittidae) and all the others. Many other examples of "globally basal endemics" are now known from New Zealand, and there are probably more than in any other region, except perhaps Madagascar. This suggests that the ancestors of many groups, such as parrots and passerines, had a widespread, global distribution and then differentiated in and around the region that became New Zealand. In this way, the new molecular phylogenies show that New Zealand can be recognized as a biological "parallel universe," one that can shed light on global evolution.

As well as examining the geographic affinities of New Zealand groups outside the country, this book focuses on the groups' distributions within the area. Apart from having so many globally basal endemics, the New Zealand biota is of special interest because many of the marine, freshwater, and terrestrial groups have such localized distributions. Groups of related species and populations also display distinctive ranges, and often these do not correlate with ecological factors. In many cases the distribution patterns can be related, not with the present environment, but with ancient landscape features. As with the globally basal endemics, the patterns appear to have been caused by large-scale, geological changes and evolutionary divergence.

The New Zealand biota has a special importance in the history of ideas about biogeography. In 1863, Darwin wrote: "I really think there is hardly a point in the world so interesting with respect to geographical distribution as New Zealand" (Burckhardt et al., 1999: 542), and since then, New Zealand has been a test case for theories of biogeography and evolution. One key question is whether most differentiation has been caused by chance, transoceanic dispersal in individual organisms, or by geological and climatic changes that have fragmented the ranges of many widespread species at the same time, a process termed "vicariance." The American ichthyologist Gareth Nelson developed the concept of vicariance in the 1970s, and it has now gained wide acceptance. In a well-known passage, Nelson (1975: 494) wrote:

> With regard to general problems of biogeography, the biota of New Zealand has been, perhaps, the most important of any in the world... all notable authorities have felt obliged to explain its history: explain New Zealand and the world falls into place around it.

One of the most important general conclusions of molecular studies is the idea that geographic distribution has an even closer relationship with evolution and phylogeny than was thought. When molecular classifications of groups began to be published, no one knew which morphological features, if any, would agree with the new groupings of species. Would the molecular classifications be compatible with variation in features used in traditional classifications, such as flowers in angiosperms, genitalia in insects, or teeth in mammals? Or would the key features instead be characters that had been neglected by earlier workers, such as microscopic structure, biochemistry, or behavior?

Some molecular groupings of plants and animals have turned out to correspond well with traditional taxonomic arrangements, but many molecular groups are new. These new groups often do not coincide with variation in traditional taxonomic characters or even with more cryptic features. Instead, another feature has proved to be of unexpected relevance: geographic distribution. Almost all of the molecular groups have distinctive geographic ranges and well-defined spatial structures; the precise, dovetailing distributions of related genetic groups are indicated in the molecular work with even more clarity than they were in morphological studies. Sequencing studies show that precise geographic structure occurs in most organisms, even in marine groups and microbes.

The general phenomenon of deep geographic structure in molecular phylogenies only started to become apparent around the year 2000, and as yet it has seldom been discussed. Nevertheless, it is seen across all the molecular work. No one expected geography to be "the character," but the fact that it is constitutes one of the most striking results of the whole molecular research program, and it raises many new questions. Why does the molecular variation exhibit such deep spatial structure, even in organisms such as microbes and marine groups? What does this tell us about phylogeny, speciation, and evolution in general? How can this new observation be utilized in practice, for example, in estimating the ages of groups or in conserving biodiversity?

If distribution patterns were the result of chance dispersal, there would be no reason to expect such clear-cut geographic structure in so many groups. As it is, the observed patterns suggest that evolution proceeds by phases of geographic differentiation (vicariance) alternating with phases of range expansion and geographic overlap (dispersal). In this model, both processes are determined, not by chance, but by geological and climatic changes that have affected whole communities. This would also explain another interesting fact: the repetition of the same distributional breaks and centers of endemism in many groups that have different ecologies and means of dispersal. Distribution is related to and caused by evolution, and so it can be used to tell us about evolution.

The interpretation of the New Zealand biota has been controversial ever since the first modern studies. While the new molecular data have answered many questions, several old problems remain unresolved, and there are many new ones. This book attempts to provide answers to these by integrating the strongest results of the molecular genetics—the new classifications—with the latest results from tectonic geology. This integration produces conclusions about the factors of space and time in the evolution of New Zealand groups, and these are then combined with recent ideas on mutation to produce a new synthesis of evolution in the region.

This book concludes that for most plants and animals, New Zealand is neither a "sink" for dispersal from elsewhere nor a "center of origin" of groups that have dispersed to other regions. The biota instead reflects differentiation that has developed in widespread or even global groups, by vicariance between New Zealand and other regions. The modern New Zealand biota is much older than was thought—Mesozoic, rather than Cenozoic—and has developed in tandem with geological change.

The first two chapters of this book outline general aspects of analyzing evolution in time and space. Chapter 3 introduces some main aspects of New Zealand geology; more detailed references to regional aspects of geology are made in later chapters. Chapter 4 introduces the New Zealand biota and its global significance. Chapters 5 through 9 provide a regional treatment of New Zealand biogeography and highlight localities of particular significance. Chapters 10 through 12 analyze case studies of particular groups of plants and animals, with reference to the localities discussed earlier. Chapters 13 and 14 discuss general morphological trends, and Chapters 15 and 16 consider the morphological evolution of New Zealand birds and mammals in their biogeographic context. Chapter 17 presents general conclusions and indicates some applications to conservation practice.