Preface

The theory of evolution is generally accepted as *the* explanation of the Earth's present biodiversity. However, since Darwin first proposed natural selection as the leading mechanism of evolution, a series of other mechanisms have been periodically advanced to explain the observed variability. Some of these are proposed as complementary to natural selection but others constitute alternative explanations. The purpose of this book is to analyse some of the most widely publicized of these mechanisms in the context of our present genomic understanding.

The ever-increasing knowledge of whole genome sequences is unveiling a variety of structures and mechanisms that impinge on current evolutionary theory. The origin of species, the evolution of form, and the evolutionary impact of transposable elements are just a few of the many processes that have been revolutionized by ongoing genome studies. These novelties, among others, are examined in this book in relation to their general significance for evolution, emphasizing their human relevance. For example, the assessment that most of the human genome (and of other higher organisms as well) does not encode proteins demands an evolutionary explanation. Moreover, a high fraction of this non-coding DNA (almost 50% in humans) belongs to a class of mobile, repetitive sequences that has been qualified as 'junk DNA' ever since its inception. However, a more thorough analysis of parts of this mobile fraction is revealing their long-term adaptive role in the evolution of new functions. On the other hand, the small genomic differences between humans and chimps (about 1.2%) challenges our understanding of what makes us humans in terms of genetic differences. Certainly, neither the increase in number of genes nor, probably, the changes in coding sequences are the key evolutionary differences that define our humanity. Most probably the relevant steps towards the evolution of higher forms, humans among them, have arisen in regulatory and assembling processes that decide when, where, and in which combination the already existing genetic blocks operate. These are just a few glimpses of these controversial issues that this book examines in the context of Darwinian evolution.

Genome studies generate information, often dispersed in different disciplines, that deserves a continuous effort of synthesis if we are to understand its basic significance. Evolution provides the perfect framework to focus this synthesis. This book aims to provide a synthetic, readable account of some widely debated evolutionary issues in the context of our growing understanding of functional genomics. Recently, this debate has centred on arguments extracted from genomic and molecular information that have been intended to 'deconstruct' the Darwinian Theory. The purpose of this book is to show that whilst genome dynamism is providing new, and previously unanticipated, sources of variability, there is no reason to dismiss the role of natural selection as the mechanism that sorts out these potentialities. In other words, this genome potential provides new possibilities (and also constraints) for evolution, but the realization of this potential is driven by natural selection.

There are many examples to justify the argument to 'reconstruct', rather than to 'deconstruct', the Darwinian Theory. Exploration of whole genomes has allowed us to depict the genome as an ecosystem-like landscape where gene factors are species-like elements to be adapted (if not domesticated) to the genome environment. This analogy has revived old evolutionary controversies, such as the role of internal constraints as leading factors in evolution

versus the pre-eminence of the external environment in Darwinian organismal selection. Perhaps the case for genome level selection is nowhere more relevant than in the role of mobile elements as selfish units operating in genomes. Evolution of form is another arena where the old Darwinian gradualist processes are being challenged. Goldschmidt's 'hopeful monsters' have been brought back to life by those that see developmental changes elicited by big-leap mutations of developmental genes. These are only a few of many instances in which the new understanding of genomes has been interpreted by some as supportive of non-Darwinian processes. I argue, however, that most (if not all) of these contentions can be shown to be inconsistent because Darwinian reasoning continues to provide a sufficient explanation for our new genomic knowledge.

While I was writing this text I realized how much I and most of my generation fellows were influenced by the ideas from those extremely bright evolutionists that produced the Modern Synthesis of Evolution. Without their ability to synthesize the evolutionary knowledge from their time the theory of evolution would never have experienced the current advance. Yet, as time went by, I developed a sense of critical admiration that led me to appraise the tenets of the synthesizers and also, in view of the new scientific advances, their shortcomings. In this book I have often impinged on some principles of the Modern Synthesis in an attempt to incorporate the current wisdom that stems from the genome studies. This endeavour may seem at times rather misleading, if not presumptuous, something that I never mean to be. On the contrary, I intend to give all the credit to the Modern Synthesis without disregarding how the new genome evidence obliges to change, enlarge, or modify some of its tenets. The discussion of the concept of species is an example of how, in my opinion, the new evidence of gene transfer impinges on the concept of biological species, an iconic concept in the Modern Synthesis.

Currently, the science of evolution emerges as a new synthesis waiting for the synthesizers. From the ashes of many old tenets, like some that underpinned the Modern Synthesis, new pillars will certainly emerge that are largely bolstered by the genome understanding. There is no doubt that some principles will have to be reshaped or even removed, introducing new concepts, but the fundamental question remains whether Darwin's principle of 'descent with modification' by natural selection as the main driving force withstands the thrust of genome studies. This book is an abridged answer to this. Many fundamental lessons learnt from the genome are presented and their evolutionary significance is discussed. When all these contentious issues are taken together a picture emerges which shows, although many mechanisms need to be updated and new concepts need to be incorporated to the theory of evolution, that there is no reason to debunk Darwin's fundamental principles. In fact, the genome shows the same fingerprints of the action of natural selection as other organism structures do: that is, a force working like a tinkerer for immediate survival.

The Dynamic Genome addresses a wide range of readers. Firstly, it is intended to fill the gap that many graduate students in evolutionary biology experience between their general interests in evolution and their specific research work, helping them to focus the present controversies within both a historical and a conceptual framework. I have often been aware in discussions with students that they lack the historical background of many controversial issues, which gives them an incomplete understanding of their conceptual roots. Secondly, any scientist with a background and interest in evolution will find much insight through learning about the new contributions of genome studies to the more controversial issues of the present evolutionary debate and how they apply to anti-Darwinian arguments. I use a precise and not overly academic language, and provide a comprehensive glossary to clarify every scientific term. An understanding of the more complex concepts is enhanced by a number of illustrations. In summary, this book is intended to be of value to graduate (as well as senior undergraduate) students not only by providing them with putative solutions on controversial issues in Darwinian Theory but also, and more importantly, by explaining why and how these controversies exist. But it will also find its way to a postgraduate and scholar readership (evolutionists and non-evolutionists alike), especially those interested in the present wave of attempts at discrediting Darwinian arguments under allegations of contradictory genomic data.