

People, Plants, and Genes

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The Story of Crops and Humanity

Denis J. Murphy

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This book is the story of the untold generations of agriculturalists who
largely created the world as we know it—for both good and ill.
It is especially dedicated to the long-suffering people of Warka/Iraq,
which was once one of the most important cradles of our civilization.
They surely deserve better.

Ad agricolis
Mundus noster fecistis
Dum aetas fugax

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Preface

This book has been a particularly challenging endeavour. My aim was to write a reasonably scholarly text that could also provide an accessible synthesis of up-to-date knowledge across some very diverse academic disciplines. It is aimed at a wide range of audiences, including anybody with an interest in how people and societies have evolved together with the crops upon which we now depend. While addressing a relatively broad spectrum of readers, it also seeks to deal with technical topics, from genetics to archaeology, in sufficient depth to satisfy most academic specialists. Such a balancing act is always difficult and there are inevitable simplifications and generalizations, especially when describing complex processes such as societal development or plant/human coevolution. In addressing other areas, such as molecular genetics or climatology, a scientific background would be an advantage for the reader but not absolutely essential to grasp the main points. As in the majority of academic discourse, some of the issues covered in the book are still vigorously disputed by experts. Examples include thorny topics such as human cognitive modernity and the impact of climatic change on societal development. In such cases, I have either remained neutral in the controversy or have explicitly agreed with a particular viewpoint, while drawing attention to the wider picture by citing alternative perspectives in the endnotes.

In order to meet the challenge of such wide-ranging and at times technical subject matter, the main text is supplemented by over 1200 detailed endnotes. These are linked in turn to a comprehensive bibliography of over 1460 citations, mostly from the peer-reviewed, primary literature. This should enable the interested reader to delve more deeply into the many complex and fascinating topics, many of them at the cutting edge of scientific

discovery, that are perforce discussed more concisely in the main text. Wherever possible, I have provided web links to articles that are now available online. Many of the more enlightened scientific journals make their articles freely available on the Internet either immediately or within a year or so of initial publication. Such primary research articles are often surprisingly accessible to the interested layperson, and I recommend readers to consult at least a few examples. Secondary literature, for example scholarly reviews, government reports, conference papers, etc., is also often available on the Internet and can be a useful resource, especially for a more general reader or a technical specialist from a slightly different field. I have used relatively few 'tertiary' sources, such as popular magazines or newspapers, because while these tend to be more immediate in their content and often a 'good read', they are often less reliable, less accessible, and much more ephemeral in their Internet locations.

We often think about the history of humankind in terms of its 'progression' from a relatively simple and supposedly 'primitive' Palaeolithic past, to the sophisticated technological societies of today. It is normally assumed that one of the major defining features of this process was the 'invention' of agriculture a little over ten thousand years ago. One of my purposes here is to challenge this viewpoint and to present an alternative perspective based on a great deal of recent research, especially relating to human-plant interactions. Over the past decade or so, discoveries in fields as diverse as molecular genetics, palaeoanthropology, climatology, and archaeology, have immensely improved our understanding of human biological and societal development over the past two million years. Of course there are still many gaps in our knowledge of this complex process. Nevertheless, we are now beginning to appreciate more clearly how the course of

human development has been modulated by a whole range of contingencies arising just as much (or sometimes more) from our biological and abiotic environments, as from internal societal factors.

The book is divided into four parts that cover the broad canvas of plant and human evolution, from 90 million years ago until the present day, and beyond into the medium-term future. In Part I, People and plants: two hundred millennia of coevolution, the three chapters are focussed mainly on the development of humankind from the emergence of *Homo sapiens* in Africa and its subsequent spread around the world. The interactions of early humans with the animals and plants upon which they depended were greatly affected by the hyper-variable climate of the Pleistocene Era. We will see that people in different regions interacted in many contrasting ways with plants and animals, and that in some cases these partnerships were as enduring and complex as agriculture has been. In a (very) few cases, human–plant partnerships became much more intimate, eventually favouring the evolution of different types of plant that were specifically adapted to growing in association with new forms of human management. These new management methods developed into what we now call agriculture and the new types of plant became our first crops. The first known case of plant domestication occurred about 12,000 years ago, at the village of Abu Hureyra in present day Syria. However, agriculture was neither inevitable nor necessarily enduring, and we will see how some societies either never adopted farming or later abandoned it in favour of more reliable and rewarding strategies of food acquisition.

In Part II, Crops and genetics: 90 million years of plant evolution, the focus switches to considering human–plant associations from the plant perspective. The four chapters in this section are probably the most technical in the book, dealing with plant genetics and its key role in enabling a few species to become domesticated into crops. Unlike humans, plant behaviour is solely determined by a combination of genetics and environment (i.e. there is no social component) so the analysis of plant genomes is of great interest and significance. Recent advances in molecular biology have given us a fascinating new view of plant genomes and the ways

in which only a few of them have lent themselves to domestication. We will examine the remarkably fluid nature of plant genomes, with DNA constantly moving to and fro, both within and between species, sometimes to the extent that it becomes difficult even to define a particular plant species or genus. Unlike most animals, plants can also duplicate their genomes, often after hybridization with other species, and many of our most important crops are descended from such polyploid ancestors. The final two chapters of Part II deal specifically with the genetics of our major crops, and the ways in which their unusual genomic architecture, especially the clustering of certain genes in a few chromosomal regions, predisposed these plants to become domesticated by humans. One of the conclusions that may surprise some readers is that crop domestication in the Neolithic period almost certainly owed its success more to the structure of plant genomes than to the botanical skills of early protofarmers. Indeed, it is now widely accepted by geneticists that most or all of the ancient crop domestications were unconscious processes of plant–human coevolution, rather than deliberate strategies based on knowledge and foresight by the people involved.

In Part III, People and plants in prehistoric times: ten millennia of climatic and social change, the focus returns to humankind, and particularly the development of the early farming-based cultures that went on to create the dominant agrourban societies of Asia, Africa, Europe, and the Americas. The first two chapters describe the emergence of crops in various parts of the world over several millennia during the early to mid part of the Neolithic period. The decidedly mixed benefits of agriculture are discussed in the context of its sometimes-adverse effects on individual human health, especially compared to many of the better-nourished hunter-gatherers of the time. Despite often leading to a reduction in individual human fitness, farming was generally a highly adaptive strategy at the population level. In particular, farming enhanced the competitiveness of the growing agrarian societies compared to the smaller groups of hunter-gatherers. We will also see how people have become modified genetically in response to farming, and how most of us carry relatively recent mutations that are directly

attributable to our intimate associations with plant and animal domesticants.

The next three chapters of Part III deal in turn with the development of farming-based, agrourban cultures of varying size and complexity in the Near East, east and south Asia, Africa, Europe, and the Americas. Recent research shows how agrarian societies evolved independently in all of these regions, and also reveals many interesting similarities and differences between them. In particular, the speed of urbanization and development of complex, stratified social organizations varied considerably in different parts of the world, as did societal responses to vicissitudes such as climate change or resource depletion. One important point that emerges from these three chapters is the manner in which most (but by no means all) agrourban cultures have repeatedly and successfully modulated their size and complexity in response to environmental and social stresses. In particular, over the past twelve millennia, there have been many instances of retreat from complexity and often drastic population downsizing that sometimes involved considerable loss of knowledge and skills. However, such episodic setbacks were often, but not inevitably, followed by resumption of what used to be termed 'progress' towards increasing complexity, both in terms of social structures and technologies.

In Part IV, People and plants in historic times: globalization of agriculture and the rise of science, we move through the classical and medieval periods and the many ups and downs of technosocial evolution, particularly as related to agriculture. In Europe, the period after the Renaissance witnessed what I term a 'neonaissance' that involved more powerful paradigms for the discovery, dissemination, and exploitation of knowledge, with the rise of science and a vast suite of new technologies. In particular, during the post-Enlightenment era, there was a flowering of investigation into matters botanical and agronomic that underpinned a quantum leap in agricultural productivity. This was the era of 'imperial botany', with European explorer-entrepreneurs scouring the world for useful and profitable plants. It also set the scene for the industrial revolution of the eighteenth and nineteenth centuries; the twentieth century globalization of

agriculture and technourban cultures; and the most recent population explosion that is only now beginning to level off.

Associated with these developments was the rise of a new and more evidence-based form of scientific plant breeding that by the twentieth century was benefiting from discoveries in genetics and physiology, and new technologies, from X-rays to tissue culture. Some of the subject matter in Chapters 14 and 16 overlaps with the more detailed discussions about the institutional context of modern plant breeding in my forthcoming book: *Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture* (Murphy, 2007). Contemporary plant breeding is fast becoming a high-tech activity that uses the latest robotic and bioinformatic tools, often based on DNA and other sophisticated molecular marker methods. Modern scientifically-informed plant breeding has enabled food production to increase even faster than population growth. This has enabled the emergence of the impressive new megaeconomies of India and China, both with populations of over one billion people who, thanks to the 'Green Revolution' of the 1960s and 1970s, are now largely self-sufficient in crop production.

New methods of advanced plant breeding should enable us to keep pace with the predicted population growth over the next century, providing there is sufficient climatic and social stability to enable the research to bear fruit. Molecular tools may also enable us to domesticate some of the thousands of potentially useful plants that have hitherto proved genetically recalcitrant to all the best breeding efforts of our predecessors. In the final chapter, we finish with a brief retrospective and prospective glance at the broader context of plant-human interactions. Here, we will see how our new-found knowledge of genetics and human agrosocial development can do much to inform the choices that may be faced by our descendants. In particular, it gives us some ground for optimism for the ability of humanity to survive and prosper in the uncertain times that lie ahead, albeit perhaps with different societal models to those that currently prevail.

I am indebted to those who have inspired and helped me in various ways during writing of this book, especially the many colleagues with whom I

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