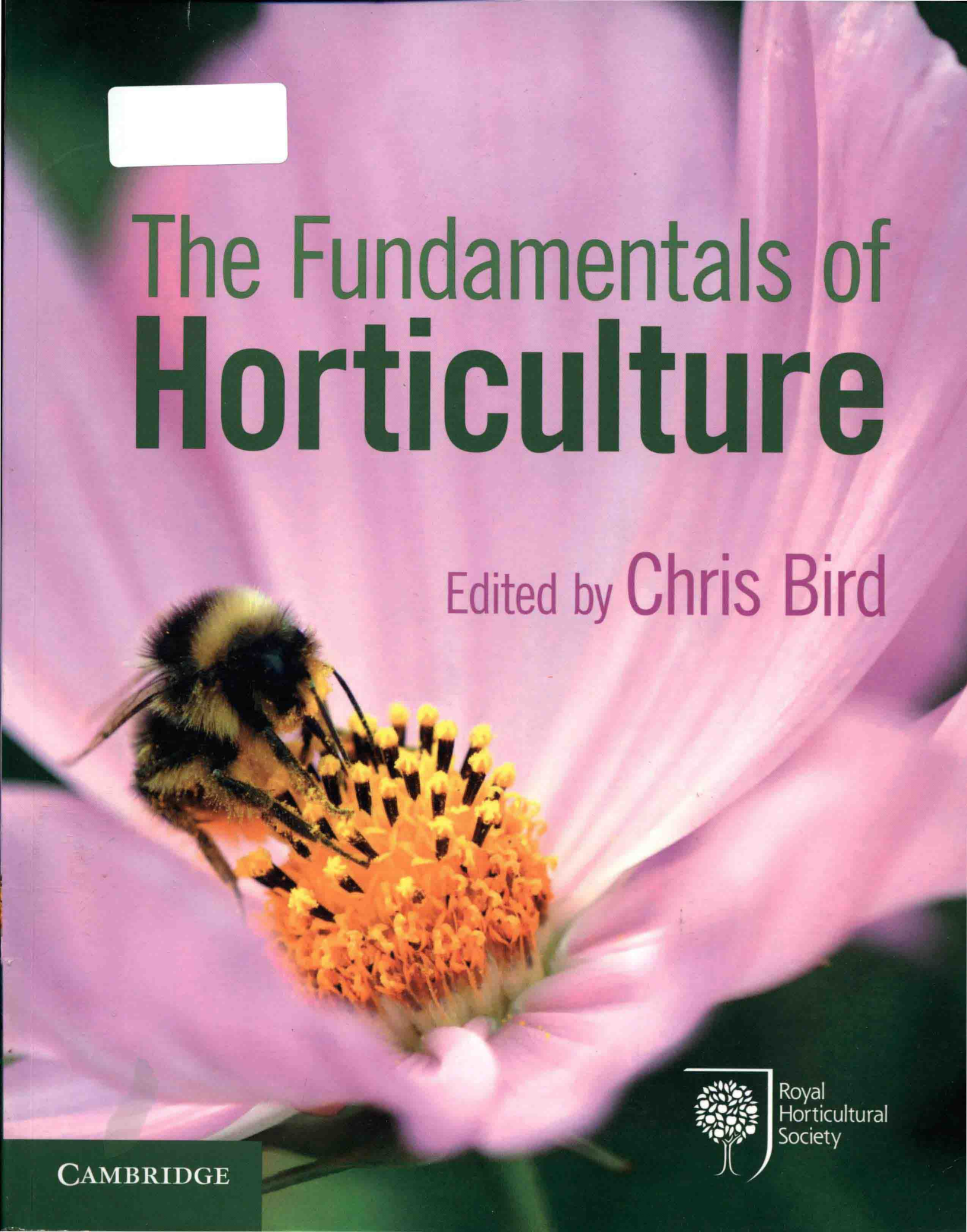
The Fundamentals of Horticulture

Edited by Chris Bird



Royal Horticultural Society

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The Fundamentals of Horticulture

Theory and Practice

Edited by **Chris Bird**
Sparsholt College, Winchester

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The Fundamentals of Horticulture

Theory and Practice

Essential reading for all studying horticulture and keen gardeners. This clear introduction to the principles underlying the practical applications of horticulture opens up the excitement of growing plants and garden development without readers wading through complex information. Written by a team of highly motivated and experienced horticultural tutors, the text supports the newly restructured RHS Level 2 qualifications with related Level 3 topics in boxes and sign-posting to Level 4 topics, together with other horticultural qualifications at these levels.

Full colour images tied closely to the text and practical case study boxes inspire readers by making topics relevant to their own horticultural experiences. A comprehensive glossary helps build confidence in the use of classical horticulture language as well as new developing terms, and end-of-chapter questions encourage readers to apply what they have learned. Extensive online supporting material includes mind maps showing the relationship of topics and aiding students in revision, and can be found at www.cambridge.org/horticulture.

Chris Bird has over 25 years of horticultural teaching experience in guiding learners through the complete suite of Royal Horticultural Society (RHS) qualifications, together with other horticultural qualifications including the BTEC National Diploma and City & Guilds Subsidiary, Diploma and Extended Diploma. He has co-ordinated Sparsholt College's Chelsea Flower Show educational gardens for the past 14 years, winning 14 RHS show medals including five at gold level, and has written articles for a number of gardening magazines.

Royal Horticultural Society

Sharing the best in Gardening

The RHS is the UK's leading gardening charity, dedicated to advancing horticulture and promoting good gardening. Its work includes training the next generation of gardeners and creating hands-on opportunities for children to grow their own plants. For more information visit www.rhs.org.uk or call 0845 130 4646.

One of the current buzz-phrases of education is 'distance travelled'. Think of this also within a garden context. How far have you travelled on these subjects?

- Environmental concerns
- Sustainable developments
- Reducing waste
- Offsetting climate change
- Promoting the balance of wildlife

This book is divided into three parts: developing a sequential progression of interest and knowledge. Part 1, entitled **The foundations**, as the name suggests provides an introduction to the background techniques and topics that underpin the whole process of the successful growing of plants. Part 2, **The adjustments**, consists of the developmental topics that having mastered, or at least understood, the foundations lead on to.

Finally, Part 3, **The applications**, shows the diversity that horticulture encompasses, including chapters on landscape design; plant use; pest, diseases and disorders; and commercial production. These provide an increased understanding of your plot and build on its history, providing a balance of conditions to aid your improved success, whatever your starting point.

HOW TO USE THIS BOOK

Do you wish to enjoy or endure your studies? This new, full colour, textbook has been developed to balance the need for an understanding of technical language with full descriptions of traditional and modern, fully illustrated, practical techniques, all designed to enhance the joy of study.

Each chapter begins by listing the key concepts that the chapter covers and features an opening case study showing the practical applications of the theory covered.

The main text is supported by a comprehensive glossary with key terms clearly highlighted in **bold** in the text. Within the chapters themselves, given within boxed sections, are extra details or further examples, which provide information to support RHS Level 3 qualifications, and boxed case studies show the real-life applications of the theory.

Chapters are rounded off by summaries, further reading lists and some revision questions for you to confirm your knowledge or to highlight where further study time is required.

All the major horticultural syllabuses have been considered and the main text is aimed at the RHS Level 2 learner, but will also inform the keen gardener or those seeking some information to get started. Clear signposting to the RHS Level 3 areas of information are highlighted within boxes at the end of each chapter, helping students to organise their learning. However, it should be noted that some topics have been re-allocated into Level 4 and these are covered in Chapters 9 and 15. Where comprehensive tables have been developed these are provided as appendices to maintain the smooth flow of the text: they make excellent revision notes. The text also supports NPTC (National Proficiency Test Council) City & Guilds horticultural qualifications, such as Extended Diploma, Diploma and Subsidiary Diploma in Horticulture at Level 3 and Level 2, together with BTEC National Diploma and Certificate in Horticulture.

The book has been designed so that you can dip in and out of the different parts and chapters as you wish, to experience new information or remind you of forgotten facts, methods or solutions. Enjoy your time becoming informed and guided around the fantastic role we can play in the growing and caring for the natural world, and especially the parts we may own or have responsibility for and can influence.

ONLINE RESOURCES

To continue your studies supporting material is available from www.cambridge.org/horticulture. This includes:

- an extended glossary of common horticultural terms
- mind maps serving as study aids to show the structure and relationship of topics
- all figures from the book as JPEG files and PowerPoint slides
- plant photographs for identification purposes
- exam techniques for those taking the RHS exams
- example questions with outline answers
- video demonstration of chip budding technique.

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Thank you to all our families who have borne the brunt of our trials and tribulations in the development of this work, especially to my wife Wendy; tea and cake always came at the right time.

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PREFACE

WHY ANOTHER HORTICULTURAL TEXTBOOK?

Well, the world of horticulture is constantly changing, and the Royal Horticultural Society, one of the major guardians of excellence in this area, has rethought and restructured the information required to obtain its highly regarded qualifications. These changes make the transition through the levels of knowledge more logical and smoother for anyone wishing to know more about plant selection, propagation, growing, use and design.

This is the first textbook written to take account of these latest adjustments and provide sequential development over a wide range of topics, arranged in three broad parts, allowing quick access to an appropriate starting point for readers to move forward in their quest for horticultural knowledge and understanding.

Most people start learning about plants through their families, especially grandparents: the techniques and dates of practical operations have been handed down from one generation to the next, over time, but the reasoning and science behind these events has become confused or totally lost. Therefore with changes such as the advent of climate change, the expanded plant palette at our disposal, the re-awakening of interest in the natural world and the joy of feeding our families by home production of fruit and vegetables, we need to revisit our timings and methods and ensure maximum success with minimum inputs of resources, including the efficient use of valuable time.

Also the mental and spiritual wellbeing found within the activities of plant growing and use can not be understated at this time, with the continued rapid development of horticulture as a successfully method of therapy: an antidote to busy, sometimes stressful, lives. Many people are looking to enhance, or produce, their own green oasis; the chapters on the selection and use of plants will assist this process.

This textbook is not only for students wishing to study for examinations leading to valuable qualifications, but also for all those who have any interest, or an emerging puzzlement, of how plants grow, develop and can be used.

Structured in three parts, Part 1 The foundations, Part 2 The adjustments and Part 3 The applications, the book provides a clear development of the material provided by an experienced team who have between them amassed over 250 years of horticultural and 150 years of teaching experience; and are still learning.

STRUCTURE OF THE BOOK

With the resurgence of interest in the 'green agenda' and grow-your-own campaigns, such as the National Trust's 'Plot to Plate', the Royal Horticultural Society's 'Grow your Own' and a number of major supermarkets leading national campaigns (also related to encouraging uptake by school children and their wider families) there has never been a better opportunity to spend some time exposed to the **foundations** of growing; being reminded of the **adjustments** that can be undertaken and introduced to the **applications** that can be achieved within your own community. Also, with the publication of a new syllabus emerging from the RHS and other horticultural qualifications, we have taken a fresh look at the fundamentals of horticulture, remembering to include an emphasis on the first syllable of fundamentals.

CONTENTS

PART 1
The foundations

INTRODUCTION

As with every complex endeavour it is always best to learn, or at least appreciate, the foundations of that subject or topic. Horticulture provides one of the most challenging but rewarding mixtures of endeavours, encompassing, but not limited to: art, chemistry, design, faith, frustration, health, history, languages, patience, physical effort, relaxation, religion, science, social development, therapy and wildlife.

This part comprises the chapters that relate to the background of growing and using plants. Answering those perennial horticultural questions: How does a plant work? What situation should it grow in? Where can I use it for maximum effect? Why was it so good last year/month/week?

Please use it to introduce, re-acquaint or remind yourself of the wonders that are found in the natural world and that you can tap into to provide a lasting and satisfying result: be it food production for the family, a wildlife haven, or a green oasis away from the busy world of today.

Starting with the range and development of the 'five kingdoms' classification and naming of plants, this leads on to the structure of plants in their many forms, and the new and developing language, such as eudicots, providing valuable technical updating for all those with an interest in plants. Also covered are the basic environmental conditions required for successful plant establishment and growth, this is encompassed within the requirement and effect of light, water and its importance for plants, and the ever-changing and most talked about topic: climate, weather and seasonal effects. This must be one of the most challenging aspects of modern gardening. With no growing season being the same as any other, and the range of temperatures within a 24-hour period being so wide, this continues to focus the mind of everyone growing plants.

Underpinning all of this is an understanding of soils and plant nutrients, covering the usual questions: How are soils formed? What type of soil have I got? What can I use, if not soil? What are nutrients, and how can I supply them without harming the environment?

By studying all of these aspects, in balance, the maximum reward can be obtained from your situation and whatever plant palette you personally wish to develop, using whatever timescale you wish, resulting in successful production of flowers, seeds and fruits: how to aid in their formation, storage and germination.

Please also use this part as a quick reference, when required, for the clarification of lapsed memories or positive re-inforcement of mis-remembered facts and details.

Also remember that plants are very forgiving and usually possess unlimited fortitude and patience, even if we do not.

CASE STUDY A living fossil

The Maidenhair tree, *Ginkgo biloba*, is regarded as a 'living fossil' and is the only living example of *Ginkgoales*, which is a plant order. This plant was thought to be extinct in the wild for many years (surviving wild plants are now known in SE China) but the species was kept alive by Buddhist Monks in their monasteries as a sacred tree particularly in China and Japan. Increasingly it is valued as a long-lived street tree in urban situations due to its abilities to prosper in high temperatures, elevated levels of atmospheric pollution and resistance to pests. It is also regarded as an international symbol of peace because of established specimens growing next to the epicentre of the atom bomb site at Hiroshima, Japan survived the bomb and were the first living things to re-grow afterwards.

Another feature is its use as a medicinal plant to promote the flow of blood over the cranium thereby improving memory. However, without this plant being found, recognised, valued and reintroduced all these features would not be available for us to use.

The fallen leaves and fruits of a female Maidenhair tree, *Ginkgo biloba*. One of the oldest living lineages of seed plants alive today.

Chapter 1

Plant diversity

Michael Buffin and Tim Upson

INTRODUCTION: DIVERSITY AND EVOLUTION

In planting a garden, we celebrate diversity. There are the plants that we deliberately cultivate for our own benefit, but also the vast and often unseen array of microscopic organisms as well as the obvious birds and butterflies that we may actively encourage.

If you study nature, or are just intrigued by the diversity in the garden, it can perhaps at first be puzzling. Looking more closely at the range of diversity you soon realise there are patterns that when pieced together help to create a picture of life, which we can classify into a system that can be communicated. This pattern is the result of almost 4 billion years of organic evolution on Earth from a common ancestor that we all ultimately share. In sharing common ancestry, whether from millions of years ago or more recently, we have shared characteristics, such as the details of our cellular structure and chemistry or the form of a flower. These shared characteristics are the raw data that enable us to discover these patterns and ultimately build a classification. This provides a structure within which to name organisms and recognise their evolutionary relationships, a system that can be understood worldwide and without ambiguity. This is the science of systematics, which helps bring order and sense to this diversity, and an understanding of it is key knowledge in horticulture.

Diversity exists at a number of different levels, not just among the organisms that we may identify and name around us. Differences exist between individuals: the genetic diversity that gives the variation providing new garden plants. This is also the raw material for breeding or finding resistance to pests and diseases. It also exists in a wider sense beyond the garden, into the urban landscape and countryside beyond, and the underlying soil, geology and prevailing climate, which all ultimately dictate what can be successfully cultivated.

This diversity does not exist in isolation but has evolved together creating interactive and often complex relationships between organisms, which are further influenced by the physical environment around them – the ecosystem. Gardens are ecosystems in their own right, albeit ones artificially created and manipulated by their creators.

Key concepts

- Patterns and nature of diversity on Earth
- The major groups of plants
- Organising, naming and communicating diversity
- Interaction of diversity in the garden
- Plant collecting: how our diversity of garden plants arose
- Understanding diversity through different types of plant collections

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THE FIVE KINGDOMS – THE DIVERSITY OF LIFE

The vast diversity of life that has evolved on Earth can be perplexing, but major groupings of organisms can be recognised. Initially split into animals and plants, we now recognise other groupings or kingdoms that reflect both the early forms of life and progress through to the more complex groups that have evolved. These five kingdoms are bacteria, representing the earliest forms of life, protists, fungi, plants and animals.

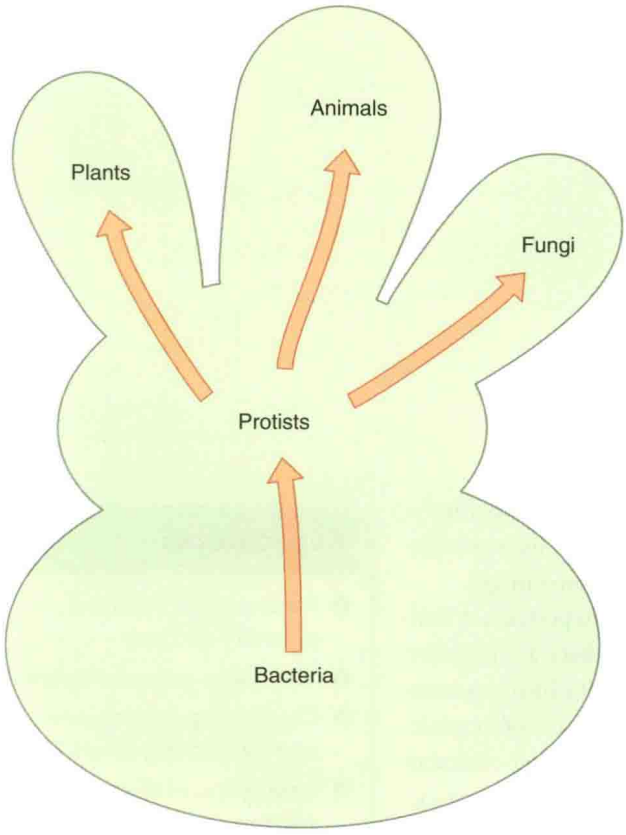

Figure 1.1 Diagrammatic representation of the five kingdoms.

Within these five kingdoms the most fundamental split is in the single-celled organisms, which lack a nucleus – the prokaryotes, meaning 'first kernals', and form the kingdom bacteria. The other four kingdoms contain organisms with more complex cells, containing a nucleus and other membrane-bound organelles – they are called the eukaryotes, meaning 'true kernals'. This division of prokaryotic and eukaryotic cells represent two distinct levels of cellular organisation and a fundamental distinction.

Kingdom bacteria

The most basic form of life, the kingdom bacteria comprises all organisms with prokaryotic cells and is further divided into the true bacteria (*Eubacteria*) and the *Archaebacteria*. The *Archaebacteria* represent the oldest living organisms on Earth today and are typically found in some of the most inhospitable environments, including oceanic volcanic vents and salt pans, reflecting their early origin when the Earth's atmosphere consisted of poisonous gases, was very hot and lacked oxygen.

The true bacteria are more complex and common, and are found everywhere around us. Many are familiar to our everyday lives as they can cause disease, are used to help ferment milk and form important relationships with both plants and animals. Nitrogen-fixing bacteria convert nitrogen in the atmosphere to ammonia, the form of nitrogen that can be used by plants.

One of the important groups, the cyanobacteria (once called the blue-green algae), were one of the first organisms to produce energy through photosynthesis: by harnessing the energy of the sun to produce sugars and releasing oxygen. Over time the gradual build up of oxygen changed the early atmosphere and led to the near extinction of oxygen-intolerant organisms including the *Archaebacteria*.

Kingdom *Protista* (the protists)

The protists are one of the most diverse kingdoms, a rather loose grouping of different lineages that have a relatively simple organisation, and if multicellular show no differentiation into distinct tissues. All protists evolved from a symbiosis between at least two different kinds of bacteria. Endosymbiosis is the term given when an organism lives within another: cellular organelles such as chloroplasts and mitochondria were originally free-living bacteria that became engulfed within other cells.

Protists include a range of organisms with which we are familiar, including many seaweeds. The various groups of algae also belong here, including the green algae (*Chlorophyta*) although some authors include them with plants. Others, such as the diatoms, are often studied by botanists and known for their beautifully sculpted hard coats and are commonly found in ponds and lakes. Perhaps one of the most puzzling organisms encountered in gardens, the cellular slime moulds belong here, and are encountered in the autumn where they live in damp soils and rotting vegetation. They live as independent feeding and dividing amoebas and only become visible when they aggregate into a slimy mass puzzled over by many.

For the horticulturist, the protists include some of the most serious disease-causing organisms. These include the genus *Plasmodiophora*, which live within plants and are the cause of club root in cabbages, *Brassica oleracea* (Capitata Group), and powdery scab of potato, *Solanum tuberosum*. Another group are the Oomyceta, known as the water moulds and once included with the fungi. These organisms extend fungus-like threads into plant tissues causing white rusts and downy mildews. *Phytophthora* causes some of the most serious plant diseases including late blight of potatoes due to *P. infestans*, which most famously caused the Irish potato blight, famine and emigration of the population. Currently sudden oak death, caused by *P. ramorum* and others, is reshaping landscapes and is a threat to major timber crops such as *Larix* (larch).

Kingdom fungi

The fungi are an essential group of organisms in the garden, often unseen until betrayed by their fruiting bodies – mushrooms and toadstools. The study of fungi, known as mycology, has often been undertaken by botanists as they were once considered to be primitive or degenerative plants that lacked chlorophyll. They are now recognised as being a distinct life form more closely related to animals – containing chitin in their cell walls as do some animals (arthropods). Over 100,000 fungi have been described and it is estimated that the total number of species may exceed 1.5 million, placing them second only to insects in their diversity.

Fungi consist of small filamentous structures known as hyphae, which collectively form a mass called a mycelium that can be extensive in spread. They are primary decomposers using enzymes to break down organic compounds from other organisms, which are absorbed for nutrition, the hyphae spreading to seek new food supplies. A few fungi familiar to us, such as the single-celled yeasts, obtain energy by fermentation and are most notably used in bakers' and brewers' yeast – to make bread rise or to produce alcoholic drinks.

Fungi reproduce through the formation of microscopic spores that can be produced sexually or asexually. Dry and very small, they are easily dispersed through air currents or in free-flowing water and rain splash. In some of the major groups of fungi sexual reproduction leads to the formation of reproductive structures, the familiar mushrooms, which consist of tightly packed mycelium and a remarkable range of forms.

Important for plants are the mycorrhizal fungi, literally fungus roots. These are of major ecological importance, forming a mutualistic relationship with the roots of vascular plants. This association provides the fungi with sugars produced by the plant; the plant in return benefits from the higher absorptive capacity of fungi for water and minerals, due to the large surface area of mycelium. This association is key for good plant growth and to increase crop yields. While only a small proportion of mycorrhizal fungi have been described, they are widespread. A huge number are yet to be named and they form an association with 95% of those vascular plant families examined. They can be important in allowing plants to colonise nutrient-poor soils.

One of the largest groups of fungi are the ascomycetes, or sac fungi, most familiar in the garden for the cup- or sac-like mushrooms and moulds that cause food spoilage, powdery mildews and several devastating diseases, including Dutch elm disease, *Ophiostoma novo-ulmi*, which devastated and reshaped the English countryside in the 1970s. Others produce the healing penicillin from *Penicilliums* – the first antibiotics that were effective against serious diseases. The most distinct and familiar group of fungi are the basidiomycetes, which include mushrooms, toadstools, puffballs and bracket fungi. These reproductive structures are spore-producing structures or basidia. Members of this group are particularly important in the decomposition of plant litter and the recycling of nutrients. In trees they form part of the natural cycle in decomposing wood, but in the garden this can be problematic if it leads to structural weakness. Plant pathogens, most notably the rusts and smuts, are included here.

Lichens – Included within the kingdom are the lichens, a mutualistic partnership between a fungal partner (the mycobiont) and a population of a photosynthetic algae or cyanobacteria (the photobiont). The fungi receive carbohydrates and nitrogen from their photosynthetic partners while providing a place to grow.

Lichens are able to live in some of the harshest places on Earth, and hence in gardens they are able to colonise rocks, roofs and the trunks of trees and shrubs, where their presence can cause concern – but they are completely harmless. One aspect of their ability to survive inhospitable places is their capacity to dry out very quickly, cease photosynthesising and enter a state of suspended animation. They also produce lichen acids that play a role in the weathering of rock and consequently soil formation. Lichens are also useful as environmental indicators. They are unable to secrete elements absorbed so are sensitive to toxic compounds, particularly sulphur dioxide found in polluted air and are used to monitor atmospheric pollution in cities.

Kingdom *Animalia* (the animals)

Animals form one of the best known and recognised kingdoms, a diverse assemblage including the most complex organisms on Earth. Most animals are multicellular, with a definite body plan and tissues that form organs and the systems that sustain them. They are all motile, able to move spontaneously and independently, even if this is only at certain stages in their life. Unable to make their own food, they generally ingest nutrients into a digestive chamber and are thus reliant on other kingdoms, especially plants, as a food source. They are also distinguished from plants, protists and fungi by their development, which is progressive and can involve different stages in their life cycle. Nearly all animals undergo some form of sexual reproduction with motile sperm and a larger, non-motile egg that fuse to form zygotes and develop into new individuals.

One of the basic and fundamental divisions within animals is whether they possess an external skeleton (invertebrates) or an internal skeleton (vertebrates). Those with an internal skeleton (vertebrates) have a backbone, which is made up of a column of vertebrae. During development, the internal skeleton forms a relatively flexible framework upon which cells can move about and be re-organised, making complex structures possible.

The most numerous and diverse animals found in gardens are the invertebrates, these are important within the soil biota, as key pollinators of flowers and often encouraged for their interest and beauty. They can also be destructive pests and a major cause of plant losses. The nematodes or eelworms are usually tiny soil-living species found almost everywhere in the world, but also include large animal parasites such as hookworms. Some are serious pests invading the root systems of plants and include potato cyst nematode, *Globodera pallida*, stem and bulb nematodes affecting daffodils, *Narcissus* spp., onions, *Allium cepa*, and beans, e.g. *Phaseolus coccineus*. Others are vectors for viruses, while predatory nematodes are increasingly being used as biological

controls attacking soil-dwelling pests such as wireworm, *Agriotes* spp., and vine weevil, *Otiorhynchus sulcatus*.

The annelids (or segmented worms) include leeches, possible inhabitants of ponds, but also one of the most important garden animals, the earthworms. There are many different species ranging from those living in the leaf litter in composting bins to those that enrich the soil by mixing and allowing air and water to penetrate. In this respect they are perhaps one of the most important garden organisms ensuring a healthy soil, essential for good plant growth. They are also key prey species for birds, shrews, e.g. *Sorex araneus*, and badgers, *Meles meles*.

While the gastropods are most diverse in marine environments and include clams, mussels and other seashells, in the garden they are principally represented by the terrestrial slugs and snails. Both feed on plant material using their file-like tongue or radula, causing large amounts of damage, moving by means of a large muscular foot and leaving a tell-tale slimy trail. Slugs are one of the most serious pests in the garden, feeding on plant material including roots, tubers and bulbs in the soil and are a major reason for the failure of plants. Snails differ in bearing a protective shell and often feed on dead organic matter, but can also be problematic, particularly for young seedlings and some crop plants.

Perhaps the most important group are the arthropods, characterised by their jointed limbs and hard, protective exoskeleton or cuticle. This hard cuticle is inflexible and thus prevents growth, meaning they need to moult their skin to grow. Included in this large and diverse group are many familiar aquatic organisms such as crabs and shrimps, but they are equally diverse in the garden environment. Familiar garden arthropods include woodlice, millipedes and centipedes, which can occasionally cause damage. Mites can be found on plants where they cause mottling and distortion, while soil mites are generally beneficial to the soil biota. Spiders also belong here, not always welcomed by some, but important in helping to control pest levels with their webs providing autumnal interest.

By far the most diverse and important group of arthropods in the garden are the insects, recognised by their six legs and jointed body plan divided into three parts – head, thorax and abdomen. Many are pest species either sucking on plant sap or are chewing insects capable of attacking all plant parts including stored seeds. Others are beneficial, for example wasps, which feed on other pest species. While their presence in the garden in summer and autumn is unwelcome, as they search for sugary foods, they are the gardener's friend in spring, preying on larvae using their sting to paralyse the prey used to feed their own grubs. Others such as butterflies and the related moths, *Lepidoptera*, may be actively attracted into gardens with specific plantings of nectar-rich flowers, yet their larvae may actively feed on our garden plants. Perhaps the greatest benefit in the garden is pollination, one of the most important relationships between flowering plants and insects. Pollinating insects, such as the various species of bees and hoverflies, are essential for ensuring seed set and without which many of our cultivated fruit plants would be sterile.

Vertebrates are among the most familiar animals in gardens. Those most obviously associated with water bodies are fish. Water is also required by amphibians such as toads, frogs and newts to breed, their egg-containing spawn is an indication of spring; at other times they seek damp moist places, under logs or stones, and can be useful predators of garden pests. Of the reptiles, the most likely to be encountered is the grass snake, *Natrix natrix*, often seen swimming in water or utilising the warmth of compost heaps to incubate their eggs.

One group often deliberately encouraged are birds, for which gardens have become increasingly important habitats. They are important predators, particularly in spring, eating vast amounts of larvae to feed their young. A good population of birds can be vital in controlling numbers of pest species and reducing or even eliminating the need for chemical controls. They can, however, also be pests: wood pigeons, *Columba palmus*, being notorious for stripping leaves from plants and devastating crops.

Mammals are perhaps the largest animals found in gardens and, although rarely encouraged, are enjoyed by many despite the fact that some can cause immense damage. Common native garden mammals include hedgehogs, *Erinaceus europaeus*, which help control slugs and insects, and foxes, *Vulpes vulpes*, now frequent in urban gardens. Less welcome can be mice, eating young plants and seeds, tunnelling moles, *Talpa europaea*, which can ruin lawns with piles of earth, and badgers, *Meles meles*, which can damage borders and lawns in search of worms. Introduced mammals such as grey squirrels, *Sciurus carolinensis*, can be particularly problematic barking trees, eating shoots and even predating young nesting birds. Large herbivores, such as various species of deer, can cause devastation: in extreme cases requiring often expensive fencing to exclude them. These animals might seem to cause endless damage but this can often be at tolerable levels, and sharing our space with them can equally bring endless joy and interest.

Viruses

The organisms classified within the five kingdoms are all cellular but there is one group that does not fit this description, the viruses. They are composed of just DNA (deoxyribonucleic acid) or RNA (ribonucleic acid) enclosed in a protein coat and much smaller than any cell. Viruses replicate but can only do so by entering a cell and using its living mechanism. Outside the cell viruses cannot reproduce, feed or grow but can be incredibly tough and able to survive for long periods in extreme conditions. For the horticulturist they are, however, an important disease-producing organism causing yield loss in crops and even plant death.

THE DIVERSITY OF PLANTS IN THE GARDEN

Over the last 500 million years, plants have undertaken an evolutionary journey that has ultimately altered the planet to one dominated by green plants that are fundamental to supporting