Chapter 39
Gardening and Horticulture

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Abstract Gardening and horticulture are both activities concerned with the cultivation of plants. While there is much overlap between the two activities, the former refers to a leisure activity practiced by home or hobbyist gardeners, while the second refers to a scientifically underpinned, and highly specialised, professional occupation. Despite the undoubted similarities there are big differences in the techniques, technologies and scales of operation. Different types of cultivation, such as organic gardening, are used to highlight the differences in approach between gardening and horticulture, while garden styles or practices such as patio gardening or allotment gardening are used to show that while gardeners are the consumers of products and services, professional horticulturists are not only providers of the products and services, but have also developed the technology to make the style or practice possible. Commercial production and botanic gardens are examined as horticultural activities, while noting that some of the most skilled cultivators are, in the strict use of the word, amateurs, and are catered for by specialist societies. Techniques such as soil cultivation, propagation and pruning are examined for differences in approach and scale, and the chapter concludes with examples of the range of scientific endeavour underpinning plant breeding, glasshouse production and cultivation media.

Keywords Horticulture · Gardening · Cultivation · Horticultural technology

Introduction

Gardening and horticulture are both activities concerned with the cultivation of plants but the terms are usually applied in slightly different ways. Gardening normally refers to hobbyists or home gardeners while horticulture is usually applied to professionals who earn a living from their work. The terms are not precise and are often interchanged. Many people who work in the industry, particularly those in parks or botanic gardens, would informally describe themselves as gardeners but if they were being formal about it, then as horticulturists while amateur gardeners

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would virtually always describe themselves as gardeners and not horticulturists. In some dictionaries horticulture is defined as the art of gardening while gardening is defined as the act of cultivating or tending a garden, or the work or art of a gardener. This lack of precision is reflected in many societies and organisations that represent gardeners and horticulturists. The British Institute of Horticulture (Anon 2013a), the Horticultural Trades Association (Anon 2013b) and the International Society for Horticultural Science (Anon 2013c) very clearly represent professional horticulturists but so does the Professional Gardener's Guild (Anon 2013d) that represents paid, professional horticulturists who work in private gardens and estates. Likewise, the Worshipful Company of Gardeners represents professional gardeners (horticulturists), but uses the word 'gardeners', demonstrating that there are no clear established rules about how the words are used. First mentioned in City Corporation records in 1345, the Worshipful. Company of Gardeners is a survivor from the medieval craft guilds which exercised control over the practice of their particular 'mysteries' and ensured a proper training through the system of apprenticeship (Anon 2013e). In 1605, after existing for centuries as a "mystery" or "fellowship", the Guild was incorporated by a new Royal Charter. The Charter sets out the operations controlled by the Company: "The trade, crafte or misterie of gardening, planting, grafting, setting, sowing, cutting, arboring, rocking, mounting, covering, fencing and removing of plants, herbes, seedes, fruites, trees, stocks, setts, and of contryving the conveyances to the same belonging…". Apart from some old terminology and old fashioned spelling, these words are still a good description of what gardeners and some horticulturists do today, although the context within which each does it is very different.

The Royal Horticultural Society (RHS), one of the largest gardening societies and charities in the world, crosses the divide, with membership consisting mostly of amateur gardeners but with many professional horticulturists being members and the Society employs many horticulturists in their four gardens and its laboratories (Anon 2013f). The American Rhododendron Society is mainly populated by amateurs but has a considerable dimension of professionalism at which point it too, like many other similar organisation, bridges the divide (Anon 2013g). Many professional horticulturists are also passionate gardeners, with superb gardens at home, separate from their working lives. One characteristic that tends to prevail in this environment is a passion for growing plants and a very high level of job satisfaction meaning that many horticulturists continue to garden when they get home, often with little distinction between their day job and their preferred hobby or way of life. Likewise, many hobbyist gardeners develop their skills to such an extent that they can be more skilled than many trained, professional staff, spend considerable amounts of money on their enthusiasm, join specialist clubs and societies, take gardening holidays and attend gardening lectures, shows and events. Furthermore, while horticulture is regarded mostly as a science (but with art being an important component), gardening isn't considered a science, it's a leisure activity where one can garden for pleasure or garden at home, growing fruit and vegetables or derive pleasure from looking after the lawn, but it's not a profession for those people. In general all outdoor home care for plants can be brought together into gardening. The two terms are therefore very similar but if the terms are applied strictly then

they are clearly different with horticulture referring to those who cultivate or manage plants as their paid employment and gardening being used to describe hobbyist or home gardeners. Botany, on the other hand is the science of plant life, covering aspects such as physiology, morphology and reproduction but dealing in the main with plants as ecological entities, although there is a branch subject embracing "economic botany".

The shear diversity of activities that can be listed under gardening and horticulture is immense. In this chapter a selection of these activities, such as turf care and propagation, are examined from both a gardening and horticultural perspective to demonstrate the differences between gardening and horticulture.

The entry for Horticulture in Wikipedia describes it as the science, technology, and business involved in intensive plant cultivation for human use and continues by providing a very good and comprehensive description of what is entailed in horticulture (Anon 2013h).

The Diversity of Horticulture

Gardeners and horticulturists differ in the techniques and technologies they use and in the scale of their operations. There are also differences in philosophy when approaching gardening or horticulture (Hobhouse 2004; Taylor 2006). The forms of gardening selected for discussion may appear to simply be forms of garden design or style but they are actually different from these as they really emphasise the attitude, approach, background or thinking to garden making and plant cultivation and care.

Seven types of garden forms are described. The first two forms of gardening, organic gardening and wildlife gardening take a philosophical approach to gardening or the attitude taken by the gardener to horticulture while the second two describe allotment and patio gardening. These forms of gardening have largely been brought about by changing environmental, social, cultural and economic circumstances. The last three to be examined are botanic gardens, commercial horticulture and special interest gardening and this is where the enthusiast differs from the professional in the specific selection of plant material, their cultivation and financial motivation. All seven examples demonstrate both the differences and similarities between gardening and horticulture.

Organic Cultivation

Organic gardening is not one precise activity and many people practice it in different forms and to varying degrees of strictness. Essentially it is plant cultivation without the use of artificial pesticides or fertilizers, but it is really much more than that, it is a philosophy and a way of life, with those practicing it also being interested in composting, recycling, the promotion of wildlife in the garden and adhering to sustainability standards. Organic cultivation has its strict adherents who avoid any

artificial pesticides and who prefer to 'work with nature' in managing soil and controlling pests and diseases. Professional horticulturists who grow and sell products labelled as organic, or who have declared that their garden is organic, certainly have to operate within strict guidelines (although there is sometimes confusion about which guidelines are being followed), often established by government regulatory bodies. However, there are many home gardeners who generally work in this way, believing that it is 'a good thing' that not only benefits themselves and the environment, in producing wholesome, fresh and tasty produce but then occasionally revert to the use of some pesticides and herbicides when pests, diseases or weeds get out of hand.

Organic gardening has its roots back in the early to mid twenteeth century in tandem with the explosion in the use of artificial pesticides and fertilizers (Heckman 2005; Taylor 2006). Concern for the environmental and health effects of these materials, however, was only expressed by a minority of concerned individuals until people like Lawrence Hills, who is sometimes known as the father of organic gardening in Britain, started providing a scientific basis to what became known as 'the organic movement'. He and others were responsible for the foundation of the Henry Doubleday Research Association, HDRA, now known as HDRA- the organic organisation, which was established in 1954. The Soil Association, founded in 1946 and now with 27,000 members, is undoubtedly part of this story too. It is a membership charity campaigning for planet-friendly organic food and farming (Anon 2013i).

The organic movement is often associated with the social values and lifestyle of the 1960s with adherents often caricatured as long-haired, hippy, drop-outs and their produce thought of as small, badly shaped, pest and pathogen infested. But with concern for the environment becoming increasingly widespread from the 1980s onwards and coupled with good quality underpinning research, organic approaches to cultivation have become widely accepted in many parts of the world. Many important gardens are now run organically, for instance Prince Charles' garden at Highgrove (Wales and Lycett Green 2001) and many high profile celebrities such as Gwyneth Paltrow, Julia Roberts and Nicole Kidman also promote organic gardening.

While private organic gardeners are at liberty to adopt any degree of rigour they wish, professional horticulturists producing fruit, vegetables and ornamentals for sale have to adhere to strict preparatory and marketing guidelines. The problem is in trying to produce a set of guidelines as there is no legally binding definition of the word 'organic'. Likewise, there are many similar, but strictly different, issues which could be incorporated into any definition such as the cultivation and sale of genetically modified cultivars, fair trade and the question of air miles, in other words the distance that harvested crops are flown to markets, such as Peruvian asparagus being flown to Europe. Indeed, while the incorporation of animal manure into soil destined for organic cultivation would generally be regarded as good organic practice, the use of manure from intensively produced cows cannot be used. Instead there are various guidelines, produced by different organisations which are subject to change and updating as knowledge and techniques evolve. So, while the market for organic produce continues to grow, the search for helpful definitions and clearly labelled food can be argued to be hampering progress.

Despite these problems, organic gardening and organic cultivation which have at their core the care of the soil, absence of the use of artificial pesticides and fertilizers and environmental sustainability issues, continues to progress and is increasingly regarded as mainstream. Detailed information on organic gardening can be found from the following reference sources: Taylor (2006), Kruger and Pears (2001), Marshall et al. (2009) and Anon (2013j, hh).

Wildlife Gardening

Wildlife gardening is mostly the preserve of home gardeners but many professional horticulturists working in large private gardens, botanic and heritage gardens often take a keen interest in promoting wildlife in and around their gardens too. Until the 1970s and 1980s the generally held view was that that the countryside was teaming with wildlife whereas the suburban landscape was devoid of many species except for a few common animals, birds and insects. Gradually, however, and supported by wildlife surveys it has become apparent that modern intensive agriculture with its monocultures, large-scale fields and heavy reliance on pesticides was not as full of wildlife as once thought (Carson 1963; Jameson 2012). In contrast, the mosaic of suburban gardens with their variety of flowers, shrubs, vegetables and fruit were surprisingly rich in wildlife.

Taken together gardens add up to a surprisingly large area of land and surveys of individual gardens have shown that they can contain large numbers of species. A 30 year study of a garden in Leicester, England, revealed that over 2,200 insect species had been recorded and it has been suggested that a typical garden probably exceeds 8,000 species of insect (Owen 2010). The single biggest factor in the value of gardens to wildlife is diversity, even on the very small scale. They don't have to be full of native species, but even a modest garden can accommodate a small tree, several shrubs, climbers, flowering plants, compost heaps, pond or water feature, vegetables, lawns, weeds and fruit and these, in turn provide shelter, nectar sources, natural habitats, food sources and water for different forms of wildlife. Gardens don't have to be left unkempt to encourage wildlife, as once thought, and even 'mini habitats' such as short runs of hedging, small ponds, natural stone walls and small piles of logs can support a diverse range of wildlife, while climbers provide nesting opportunities and shelter.

Encouraged by TV programmes, magazine articles, mass recording projects such as Big Bird Watch by the Royal Society for the Protection of Birds (RSPB) (Anon 2013k) and others, organic gardening, wildlife gardening, or wildlife-friendly gardening emerged as a legitimate type of gardening from the 1990s onwards. This does not mean that country gardens were not good for wildlife, (Fig. 39.1) or that all suburban gardens are good for wildlife or that many gardeners hadn't been wildlife friendly for many years. It simply meant that from the 1990s many urban and suburban gardeners have realised that their gardens could be important for wildlife and that with small adjustments, they could be increasingly rich in wildlife. In the professional environment it is no coincidence that many staff employed in both private

Fig. 39.1 Wildlife bluebell garden, Dorset England

and public gardens are also interested in wildlife and are therefore keen to preserve and promote it in conjunction with the garden in their care. Furthermore, in the UK as in many other countries, businesses (which include public gardens), public and local authorities have a duty to preserve and promote wildlife (under the Biodiversity Duty which came into force on 1 October 2006), and may be required by law to protect species on their property listed by Biodiversity Action Plans and will be required to survey and protect species if they hold an accredited environmental standard such as ISO 14001 (Anon 2013l), the international standard for environmental sustainability, which includes a small section on duty of care for wildlife. Detailed information on wildlife gardening can be obtained from the following reference sources: Thompson (2007), Tait (2006) and Baines (2000).

Allotment Gardening

Allotments or allotment gardens are plots of land set aside for non-commercial cultivation of fruit, vegetables and flowers and are therefore the preserve of amateur gardeners although the word ‘amateur’ in this context can be very misleading

because many allotment gardeners are highly skilled, effective and respected growers. In North America they tend to be called community gardens but in Britain, such a term would mean a garden where members of a community came together on an individual plot of land to garden it whereas allotments tend to be gardened by individuals, families or, sometimes, a small group of friends. Allotments range in size from about 50–400 m^2 and are usually grouped together, sometimes totalling a hundred gardens or more. Allotments tend to be found in cities, or peri-urban areas, where many people don't have individual gardens and are located in all sorts of place such as corners of public parks or adjacent to railway lines. In some Scandinavian countries and parts of western Russia it is traditional for elaborate allotment gardens with small dwellings to be located out of town and used by flat dwellers at weekends to get out of town, reconnect with nature and grow fruit and vegetables.

Many allotments are gardened very intensively, producing large quantities of high quality fruit and vegetables but, like all forms of gardening, there are no limits on production. Likewise, the structures found in allotments vary enormously from production glasshouses, polythene tunnels and frames to tool sheds, summer houses with verandas and children's play equipment. Either way, they are recognised as providing important socio-cultural and economic functions over and above the opportunity to enjoy the growing of plants. They provide opportunities for exercise, relaxation, social bonding and play, for the unemployed the feeling of being useful and not excluded as well as a supply of fresh vegetables at minimum cost, for immigrant families the possibility of communication and better integration in their host country and for the retired and elderly a sense of routine and purpose.

The history of allotments can be traced back to 1809 in the Wiltshire village of Great Somerford where the Free Gardens were created following a letter from Rev Stephen Demainbray to King George III in which he asked the king to spare, in perpetuity, 6 acres from the Enclosure Acts for the benefit of the poor of the parish. Other well recorded allotments include St Ann's Allotments in Nottingham, created in the 1830s. A brief history of allotments in the UK can be found at Anon (2013m), while Anon 2013hh provides an overview of allotments in countries such as Finland, France, Germany and the Netherlands. At the end of the nineteenth century there were about 250,000 allotments in the UK but this number rose to about 1,500,000 by 1918. Numbers dropped after this but rose again during World War II with the need for more locally produced food and the 'Dig for Victory' campaign. Numbers dwindled to about 600,000 by the late 1960s but interest started to rise again in the 1970s in tandem with the interest in organic, locally sourced food and the rise in environmentalism. Despite this growing interest numbers continued to decline as land was sold for development, dropping to less than 500,000 in 1977 and 265,000 in 1997. In 2008 330,000 people held allotments whilst 100,000 were on waiting lists. So, while demand was at an all-time high, pressure from development only decreased the number available. However, while less land is set aside for allotments, there is an increasing understanding of their value not just for the socio-economic and cultural benefits for food, exercise and relaxation gained by allotment holders, but also for the broader issues of climate change, food security, the encouragement of biodiversity and environmental sustainability. The cultivation of

fruit and vegetables is currently experiencing an upsurge in popularity and a recent England & Wales Department for Environment, Food and Rural Affairs (Defra) report has shown that many household foods which have been home grown in gardens or allotments have increased between 2007 and 2011, for instance beans, from 28 to 33 % and apples from 3 to 9 % over this period. Additionally, garden owners growing their own fruit and vegetables has increased from 34 % in 2007 to 43 % in 2011 (Anon 2011). Detailed information on allotment or community gardening can be obtained from the following reference sources: Anon (2013m), Akeroyd et al. (2010) and Clevely (2008).

Patio Gardening

Some might consider that 'patio gardening' is hardly a type of gardening but it is interesting to consider how a combination of circumstances can combine to create what at least is a 'way' of gardening. In this comparison between professional horticulture and the amateur or home gardener it is interesting to see how this form of gardening has been created by a combination of the demands of the gardener, the garden centre and modified technological developments of the professional horticulturist. Today a visit to the garden centre can provide the home gardener with a range of tools and equipment that is suitable for the smaller garden.

The word patio comes from Spanish where it means a courtyard or forecourt and in general terms patios are paved areas adjoining or close to a house. The degree to which many people now live in and around and adorn such areas with plant containers, space heaters and barbecues is remarkable and demonstrates that patio gardening is at least a fashion, if not a style, born from a combination of late twentieth century influences.

One of the joys of garden making, whatever the size of the garden, is the creation of places to sit and enjoy the garden or a view outside of the garden. Finding the perfect spot out of the prevailing wind or to catch the last rays of the evening sun to enjoy morning coffee, al fresco eating or an early evening drink is undoubtedly one of the pleasures of gardening. These favourite spots, known affectionately in Scotland as 'sitooteries', range in sophistication from a couple of logs to elaborate terraces with ornate outdoor furniture, pots, urns and planters. With the spread of suburban housing schemes, smaller gardens, greater affluence and more leisure time coupled with the joys of outdoor eating in paved and decorated courtyards brought back from Mediterranean holidays, the patio as a defined garden space has undoubtedly grown in popularity.

Developments in the professional horticulture industry also fuelled this type of gardening because patio gardening relied on recreating that 'Mediterranean' atmosphere and called for bright annuals that grew well in containers. While the elaborate bedding schemes that peaked in the Edwardian era continued as popular features in urban parks right up to the 1970s, the labour costs associated with manual sowing, pricking out, growing on and then planting meant that gardening with half hardy annuals almost became an extinct style. Even home gardeners found that the

time, skill and greenhouse space taken to produce these displays meant that they were becoming redundant. However, the advent of sowing machines, cellular or modular production and mass handling systems, which all brought down costs, allied to assured viability (that guaranteed no gaps in cellular trays), numerous new F_1 cultivars bred to be uniform, floriferous and shorter, and therefore suitable for patio containers, revived the cultivation of half hardy annuals, albeit in a different style. Hanging baskets, wall baskets, terracotta and other pots all leant themselves to patios and the requirement for regular watering and liquid nutrition was easily dealt with by adapting existing professional irrigation systems to the home gardening environment.

Patio gardening as a style or way of life has therefore been created from a combination of modern influences including package holidays to the Mediterranean and other idyllic locations, plant breeding, plant cultivation and handling systems, adapted intensive irrigation equipment, greater affluence, modern housing and the perennial desire to sit outside and enjoy the view.

Botanic Gardens

The title of 'Botanic Garden' covers a multitude of activities and designations but usually infers that there is at least some scientific basis to the arrangement of the plants on show. There are about 3,000 botanic gardens in the world with the largest concentrations being in developed counties such as Germany, France, the UK and USA and fewest being located in developing counties, where, ironically, biodiversity is often greatest, and in greatest need of conservation and protection (Rae 1995). Their activities usually include research, conservation, education and amenity or display and at their best they include both serious research institutions with a broad range of schools and public education and high quality visitor attractions. At the other end of the scale, unfortunately, many botanic gardens languish with virtually no research, minimal public education and gardens that are poorly maintained. Designations range from government and university botanic gardens to private foundation and local authority gardens. In the last forty years it is probably university botanic gardens that had declined in number and quality the most due to the change in the focus of teaching and research from whole plant biology to molecular approaches meaning that associated botanic gardens that supported anatomy, morphology and physiology teaching were judged to be no longer required. Fortunately this trend may be beginning to reverse. Universities are finding that students judge them at least in part by the quality of their green environment. This can have a significant impact on student choice when deciding which university shall receive a student's fees (I. Park, Estates Manager Exeter University, pers. comm.).

Whatever their focus, all botanic gardens at least have gardens and therefore employ horticulturists to maintain and develop them. Numbers employed and levels of training vary enormously. Entebbe Botanic Gardens, Uganda, for instance, employs three horticultural staff whereas King's Park and Botanic Garden, Perth, Australia, employs 68 (Anon 2013n). Horticultural training for botanic garden staff can vary

from one having little or no experience through to certificates, diplomas and botanic garden-validated courses, to undergraduate degrees and those with PhDs. All levels are valued in the establishment and maintenance of botanic gardens.

Botanic gardens in the modern era, meaning post Renaissance (there were gardens that could be termed 'botanic' before this period in countries such as Greece and Mexico) had their foundations in medicine, and therefore had a sound scientific basis. Generally described as physic gardens their purpose was to grow and distribute medicinal plants and train doctors and apothecaries in their use, so they also had an educational purpose. 'Classic' gardens of this period include Pisa, Padua, Bologna, Paris, Leyden and Montpellier, all founded before 1600. In the UK Oxford and Edinburgh Botanic Gardens and Chelsea Physic Garden were established in this tradition but were founded in 1620, 1670 and 1673 respectively. As plants became increasingly studied for interests beyond medicine, such as physiology, so botanic gardens adapted and supported teaching of these disciplines in universities. A good example of this is the research undertaken by Professor John Hope (1725–1786) at the Royal Botanic Garden Edinburgh in the latter part of the eighteenth century (the botanic garden having initially been founded as a physic garden in 1670). Again, there was a strong scientific basis for the garden and its collection of plants.

Botanic gardens have continued to evolve and develop reflecting the needs of society, with old gardens adopting new initiatives and new gardens being created for specific, new purposes. From those early days in medicine and physiology, botanic gardens have become involved in plant taxonomy and systematics, education, museum-like displays, acclimatisation of 'new' crops to different countries, plant discovery, conservation, biodiversity studies, interpretation and, most recently, well-being, social inclusion and food production. The most successful botanic gardens have maintained their effort in the most important traditional activities such as plant systematics but have also embraced the newer and frequently more public-focussed activities. The point is that for any of these activities, old or new, a plant collection maintained by trained horticultural staff is absolutely essential. This is why many botanic gardens concern themselves more with 'the collection', rather than the design or display of the plants, though the best gardens combine both successfully. It is the fundamental importance for such collections to be amassed and developed to support the scientific purposes of the garden, and for the requirement to have detailed and accurate records, that sets botanic gardens aside from purely ornamental gardens.

In selecting the most appropriate species to fulfil the needs of the collection, which are often documented in a Collections Policy, and ensuring that they've been correctly sampled from the wild and managed according to a plan we find the essence of curation, a word also used in museums and galleries. Few amateur gardeners would call themselves curators, but in the botanic garden world, the term is widely used and well understood and it is an important part of professional horticulture. Curators at the four gardens that make up the Royal Botanic Garden Edinburgh, for instance, follow the guidelines laid out in their Collections Policy for the Living Collection which includes sections covering national and international conventions and policies that apply, service provision to stakeholders, standards of

information, targets, reviews, audits, presentation and design, collection types and acquisition (Rae et al. 2006). These and other management issues such as verification and the wild origin content are the very essence of their jobs and it is a branch of professional horticulture that links the selection and cultivation of plants to their use by a vast range of stakeholders from molecular biologists through to school children, artists and the general visiting public.

Detailed information on botanic gardens and their histories can be obtained from the following reference sources: Oldfield (2007), Oldfield (2010), Johnson and Medbury (2007), and Taylor (2006) and also the following web sites: Wikipedia on botanic gardens – Anon (2013o) and Botanic Gardens Conservation International Anon (2013p).

Production and Commercial Horticulture

Both of these categories are exclusive to professional horticulturists rather than gardeners and, while they overlap considerably, the common link is they are business ventures with the intention of making money. In the UK the production horticulture industry consists of 7,700 businesses, with 95,000 people and is worth an estimated £3 billion (Anon 2013q). The industry splits into the distinct areas of ornamental plant, flower and tree production (including retail nursery outlets) and food production, also included are fruit, vegetable, salad, herb and potato production (Anon 2013q). Some might argue that the production of food crops is the preserve of agriculture. However, in this context the intensive cultivation of crops like fruit, vegetables, salads and herbs is regarded as horticulture while the more extensive production of crops such as wheat, barley, maize and soya beans is regarded as agriculture. While this division of terminology has been adopted for many years it is interesting to note that many vegetables, in particular, are now cultivated on such a scale that their cultivation is more akin to agriculture than horticulture. Pea growers in Lincolnshire and potato growers in East Lothian certainly consider themselves farmers rather than horticulturists, though the term 'grower' is a convenient way to avoid using either term. The precision required for the husbandry of many broadacre agricultural crops now closely resembles horticultural practice. Consequently, distinctions between "farmers" and "growers" is becoming blurred.

Commercial horticulture would include production horticulture but to their numbers, in the UK, would be added the 172,000 people employed in the landscaping and sports turf industries which include those involved in landscape construction, from initial earthworks, through hard landscaping and on to final planting, grounds men who manage sports turf from racing tracks to golf courses, and those managing parks, botanic and historic gardens (Anon 2013q), see also the Commercial Horticulture Association website, (Anon 2013r).

While home gardeners certainly grow ornamental plants, fruit, vegetables and herbs and while they also landscape their gardens and manicure their lawns, the scale of operation is completely different, the range of machinery and equipment is different, the training is different and the motivation is different,- production and

commercial horticulture being done for financial profit and home gardening being done, essentially, for pleasure.

The scale of many horticultural enterprises is considerable and at the upper end certainly eclipses anything that any enthusiast gardener could do. Three examples illustrate this point. Van Heyningen Brothers Ltd (VHB), a Sussex-based company growing fresh herbs and seedlings have 230 full time employees and produce 14 million fresh potted herbs and 12 million punnets of salad cress per year (Anon 2013s). The Green Pea Company is a co-operative formed in 2006 and covering a wide geographic area in East Yorkshire and North Lincolnshire. They include 230 growers, each of which have up to 1500 ha and collectively they grow nearly 10,000 ha of vining peas. The scale of the operation is vast, being the largest pea cooperative in the world, producing around 45,000 t of high quality peas per year. Pea viner harvesting machines can harvest 1 ha per h and cost £ 300k (Anon 2013t).

The third example demonstrates landscape construction and horticulture on a massive scale. The London Olympic Park, created for the venue of the 2012 Olympic Games was the largest new urban park to be developed in Europe for 150 years. The 100 ha site is situated in Stratford, East London and the master plan was developed by a consortium of the British landscape architecture practice, LDA Design, with the American landscape architecture practice, Hargreaves Associates. Professors James Hitchmough and Nigel Dunnett of the Department of Landscape, University of Sheffield were appointed in 2008 as principal horticultural and planting design consultants for the Olympic Park, working with LDA/Hargreaves. Their role has been to develop a whole-site planting strategy, and to produce concepts and detailed proposals for the herbaceous vegetation in the park. The planting approach is highly ambitious and revolutionary for a major UK urban park, being driven by biodiversity and sustainability objectives, whilst also providing for an outstanding aesthetic experience. The Olympic Park comprises two different character areas: the North Park which has a more extensive and informal character, and the South Park, which includes the main Olympic Stadium and has a more urban character. Plantings in the North Park largely represent designed versions of native UK habitats and celebrate native biodiversity. They include species-rich meadows of different types; wetland plantings, including rain gardens and bioswales; woodland underplantings, and dramatic perennial ‘lens plantings’. Plantings in South Park focus on visual drama and have a strong horticultural basis. They include the 2012 Gardens, Display Meadows and the ‘Fantasticology’ art installation (Anon 2013u).

Created over four years, work on the Park included extensive demolition and the decontamination of nearly two million tonnes of soil (the largest ever soil-washing operation in the UK), the creation of vast areas of concourse, spectator lawns and landscape features like the London 2012 Gardens and Great British Garden, the largest wildflower meadow ever planted in the UK, more than 4,000 semi-mature trees planted, wetland planting on a massive scale—more than 300,000 plants, including reeds, rushes and grasses grown from cuttings taken before construction began, created new wildlife habitats, regeneration of the rivers and canals that weave through the site and transformation of the River Lee into wetland, swales, wet woodland, dry woodland and meadow to form crucial sustainable flood defences.

Fig. 39.2 Eden Project, relaxation and education

The Eden project in Cornwall could equally well illustrate landscape construction and horticulture on a massive scale (Anon 2013v) (Fig. 39.2).

While it is difficult to tease out the number of horticultural staff and purely horticultural costs from all the engineers and construction staff there is no doubt that this was a massive horticultural project measured by any parameter but landscaped by professional horticulturists.

Special Interest Garden Societies

Many botanic gardens certainly hold large numbers of species (RBGE 13,300, Botanischer Garten, Berlin-Dahlen, 16,865, (Rae 2012)) and they often have staff with very specialist knowledge in particular plant groups such as succulents, ferns or carnivorous plants. However, when it comes to the minutely detailed cultivation of specialist groups of plants there is no doubt that talented enthusiasts can outperform even the best botanic gardens. In this example of contrasting professional horticulturists with 'amateur' (which is not a good word to use in this context) gardeners the latter are every bit as professional as the former, the only difference being that it's not their full time, paid job. Many of the clubs and societies representing these special interests are so professional-looking in the quality of their publications, shows and cultivation knowledge that many professional horticulturists are members. Good examples of this level of expertise can be found in specialist societies such as the Alpine Garden Society (AGS) (Anon 2013w), Carnivorous Plant Society (Anon 2013x), International Dendrology Society (Anon 2013y) and the National Vegetable Society (Anon 2013z).

Membership numbers and activities vary but most include web sites giving detailed help and advice, produce publications and newsletters, arrange garden tours and distribute seeds. Many also take an active interest of their particular plants in the wild and arrange tours to view them growing in their native habitats. However,

when it comes to the skilled cultivation of plants no other activity compares with the competitive shows that most of these clubs and societies arrange. At these events individual entries are grouped together and judged by skilled judges who look for excellence and deduct points for the most minute of defects. The ensuing discussion, advice and swapping of cultivation details is where younger or less experienced members gain invaluable help in cultivating their plants. Garden tours to visit others members' gardens and collections also facilitates this knowledge exchange.

The Alpine Garden Society (AGS) is a good example of all of the activities mentioned above. Started in 1929, and now with 7,000 members, the AGS describes itself as an "international society for the cultivation, conservation and exploration of alpine and rock garden plants, small hardy herbaceous plants, hardy and half-hardy bulbs, hardy ferns and small shrubs". In pursuing these goals, they have a seed distribution scheme, very high quality journal, arrange numerous competitive shows with many entry categories and award a wide range of cups and medals, have local and special interest groups and a slide and reference library. They hold national and regional meetings and conferences and arrange workshops to demonstrate and discuss the cultivation of particular plant groups or cultivation techniques/structures such as alpine bulbs, saxifrages, scree gardens or alpine houses. They also arrange three or four tours a year to mountainous regions to see alpine plants in the wild and organise garden visits to both other members' gardens and botanic and heritage gardens.

While the AGS concentrates mostly on flowering plant species the National Vegetable Society promotes the cultivation of edible vegetables. They were founded in 1960 and have 3,000 members. Their objectives are two-fold: "to advance the education of the public in the cultivation and improvement of vegetables" and "to advance knowledge of and further public interest in vegetables by the publication of information, by exhibition, by stimulating research and experiment and by awarding prizes open to public competition". In pursuing these objectives they have numerous national and regional shows, a web site packed full of helpful advice, maintain a network of local clubs, have an on-line shop selling books, leaflets and DVDs and arrange tours and demonstrations. While showing vegetables is not as popular as it once was, many shows are still well supported with numerous entries for each category. Competitors regularly produce vegetables of the highest quality and experienced judges are needed to select the very best from a range of entries that would be the envy of the average vegetable grower.

These examples of different types of approach, philosophy and motivation to gardening and horticulture demonstrate both the similarities and differences of the two vocations.

Horticultural Practices

The successful cultivation of plants, be they in a garden, orchard or glasshouse, requires a diverse range of skills or techniques. Considering the fact that wild plants have grown and survived unaided by human intervention for thousands of years, it

is remarkable that so many techniques to manipulate plants and the environments in which they grow have been developed to obtain so many different outcomes. These manipulations at their simplest include soil cultivation, propagation, environmental adaptations and pruning and training, mulching, composting and plant protection from pests and diseases. Their inclusion here along with a small selection of applications on turf care are not intended to provide a text book description of the techniques, but a sufficiently inclusive account to demonstrate the different manipulations possible and the degree of difference between skilled craftsmanship delivered by gardeners and the professional approach developed by horticulturists and to further demonstrate the differences between horticulture and gardening.

Soil Cultivation

Soil cultivation includes primary and secondary cultivation, soil amelioration, mulching and physical forms of weed control. The purpose of primary cultivation is to bury weeds by inverting the soil to provide a weed free (and therefore competition free) environment to promote successful seedling emergence. Ploughing is the main form of primary cultivation in horticulture and agriculture but has traditionally taken the form of hand digging in small scale gardening. While both may seem mundane to some, cultivation is almost an art form when executed skilfully. Ploughing with horses certainly required skill but so too does ploughing with powerful tractors and both traditions have their enthusiastic followers who take part in fiercely contested competitions. Digging certainly requires skill, not to mention muscle power but, done by an experienced gardener, can appear almost effortless, resulting in straight lines, a level surface, a well prepared seedbed and absence of green material. As well as inverting the soil to give a clean weed free surface, digging also provides the opportunity to incorporate organic matter such as garden compost or horse manure to improve structure, retain moisture and increase soil fertility. This is usually accomplished by double digging where the top spade's depth is inverted to one side leaving a trench into which the organic material is added and incorporated with a fork (Brickell 2007). While ploughing, organic matter can be incorporated if it has first been spread over the surface with a 'muck spreader' but it is never incorporated to the same depth or with the same degree of amelioration achieved with hand digging.

Traditionally, and especially with heavy clay soils, primary cultivations are undertaken in the autumn to allow the soil to settle over the winter and provide an opportunity for frost action to break down the lumps of soil making it easier to work with a 'frost tilth' later. In contrast, the use of powerful machinery and the rapid cycling of crops can usually render this traditional approach unnecessary or unaffordable in intensive horticulture.

The purpose of secondary cultivation is to break down the large lumps of soil left from primary cultivation into a finer tilth, ready for sowing. Again, there is a clear difference between intensive horticulture where powered and non-powered harrows are used and gardening where hoes and rakes are used. Either way, the purpose is to

create a fine tilth so that seeds can more easily come into contact with water-providing soil particles and also so that they are evenly buried thereby ensuring even germination. Hoeing and harrowing are also used for mechanical weed control, leaving the soil weed free if done frequently enough although the mechanical action of both approaches can cause considerable damage to roots and stems if not done carefully.

Propagation

Seed sowing is an ancient horticultural and agricultural technique going back to biblical times and beyond. To the untrained layperson the simple act of scattering seeds on the ground may seem basic but the opportunities for failure are great, ranging from factors such as poor seedbed preparation and wrong time of year to wrong sowing rate, depth and aftercare. Vegetable gardeners will quickly learn that one rule does not apply to all as some plants are more cold hardy than others and can therefore be sown earlier, some require deeper sowing than others, some are best grown in broad drills whilst other are best in single lines, some require thinning soon after emergence, and they all have different emergence rates and irrigation requirements and more. And that is just for direct sown vegetables and can well apply to the wider range of horticultural crops.

Again, the approach taken by horticulturists and gardeners is different and driven by scale, economics and training. Vegetables grown by a home or allotment gardener would always be sown by hand and with considerable time and trouble taken over sowing depth and density. The treatment of field grown vegetables is far more akin to agriculture with the use of precision sowing machines or planters pulled by tractors.

Half hardy ornamental annuals require sowing and early cultivation under protection before planting and, commercially, have undergone a revolution in production during the last 20 years. Traditionally, both in commercial horticulture (probably parks and heritage gardens in this example) and home gardening the technique was quite similar, the only difference being one of scale and operator speed. The task was often painstakingly undertaken by skilled gardeners who relished the challenges offered and attained deep satisfaction in sowing or planting their gardens. For commercial horticultural staff the task might not have been regarded as quite so special but it was none-the-less undertaken with skill and precision but probably at a much faster pace than home gardeners. For both sectors seeds would initially be sown into pots or containers, pricked out to allow growth and development followed by further growing under protection, hardening off to promote acclimatisation, and eventual planting out. Half hardy bedding displays in parks and heritage gardens almost ceased at the end of the last century due to the high costs associated with the process. In home gardening their popularity declined due to the sheer amount of work required or the costs involved in purchasing appropriate seedlings from a nursery. Half hardy bedding plant displays are once again popular due to a combination of factors including smaller home gardens, so-called ‘patio’ or container gardening but most of all because the cost has reduced both for public gardens

and also for home gardeners. This is because production techniques have become so automated that home gardeners can now buy relatively cheap half hardy bedding plants from garden centres or supermarkets, and parks and heritage gardens now buy in such plants from specialist professional growers or nurseries rather than producing them themselves. The reason for this is that the whole process has been streamlined by precision sowing, modular production and automated handling and irrigation. This, in turn, has been made possible by improvements in plant breeding which have increased uniformity of size, not only in visual attributes, but also in seed and seedling viability.

For plants that don't produce a lot of seeds or where germination is slow or erratic or for cultivars with complex percentage, then vegetative propagation techniques, which maintain parental genetic integrity, are used. These techniques, typically cuttings, grafting or layering, are ideal for woody shrubs, trees and half hardy perennials such as *Pelargonium* cultivars. Simple division or splitting is easiest for herbaceous plants. There are sound scientific principles underpinning propagation by cuttings and grafting including an understanding of callus production, rooting hormones, transpiration control, propagule maturity and root zone heating. The approaches adopted by gardeners and horticulturists do not differ greatly in their principles, but certainly differ in their scale, use of equipment and speed of propagation. Propagation by cuttings requires skill and dexterity to accomplish the task carefully and effectively but a gardener is likely to propagate fewer plants, taking a lot of time in the process, using pots, bought compost, domestic propagators and then relying on small domestic often poorly environmentally controlled glasshouses. The success of the task then relies on skill and judgement with experienced gardeners able to control temperature, humidity and the outbreaks of diseases while those without such skills often failing to root a single plant. Horticulturists, by contrast, deal in tens of thousands, combine skill with speed, use specialist modules and rely on climate controlled glasshouses where temperature and humidity are carefully controlled and where outbreaks of disease are rare because of the precautions taken and the attention paid to climate control. All aspects of the environment are likely to be carefully controlled, from air temperature and humidity, air circulation, root zone temperature and substrate moisture content (Hartman et al. 2010).

Grafting requires skilful knife craft, knowledge of the different techniques available and which is best for different species, time of year and aftercare experience to maximize the union of the scion with the rootstock. While simple in theory, competence only comes with long-term practice and experience and the names of the techniques used provides ample testament to the degree of 'craft' involved- whip and tongue, cleft and saddle grafting, budding, bridge grafting, awl, veneer and stub grafting (Garner and Bradley 2013; Alexander and Lewis 2008). While rootstock selection for ornamental plants such as *Sorbus* and *Rosa* is usually confined to seed-grown wild species, that is not the case with cropping apples (*Malus*) and pears (*Pyrus*) where there has been a huge amount of research into the effect of rootstocks on the scion, particularly as it affects vigour (Garner and Bradley 2013). The same scion material can be grafted onto numerous different rootstocks which control the plant's vigour in varying degrees from dwarfing to vigorous. While some enthusi-

Fig. 39.3 Espalier trained rose

astic gardeners may occasionally graft a few apples, *Sorbus* cultivars, or bud some rose (*Rosa*) cultivars, this is an area of propagation that is predominantly the preserve of horticultural specialists. Detailed information on propagation can be obtained from the following reference sources: Hartman et al. 2010, Macdonald 2000, Toogood 2006 as well as the International Plant Propagator's Society (IPPS) web site at Anon (2013aa).

Pruning and Training

Pruning has a sound scientific basis although for some it seems to be shrouded in myth and mystery. Pruning controls and balances plant growth regulators within the plant. In the cultivation of fruit trees such as apples and pears, pruning both promotes flower-bearing shoots and regulates the amount of flower buds (and hence fruit) on stems (Fig. 39.3). This avoids the otherwise typical boom and bust cycles where trees flower and fruit heavily one year followed by a year of poor fruiting. Removal of section of stem removes flower buds and thus regulates fruiting. In flowering shrubs, such as *Philadelphus* and *Deutzia*, pruning after flowering pro-

Fig. 39.4 Arboriculture

motes the production of new, flower-bearing shoots for the following year whereas pruning roses (which flower on shoots produced in the current year) well before flowering stimulates vigorous new growth which supports good flowering. Severe pruning of all stems down to the ground, or stooling, on species such as coloured stem willows (*Salix*) and dogwood (*Cornus*) promote vigorous one year stems of a metre or more to sprout from the base. Since the colour, typically reds, oranges and yellows, are only produced on one year stems, this treatment produces thickets of coloured stems.

Pruning is also carried out on field grown trees or nursery stock to provide the necessary specification for a tree's eventual landscape purpose, such as standard trees for street planting or feathered or multi stem stock for more natural planting situations. It also affords the opportunity to remove diseased stems and, undertaken with an artistic eye, allows shrubs to be kept within their allotted space, keeping them compact and well balanced. Pruning can therefore be regarded as both an art and a science, with the art more the preserve of gardeners and the science more the preserve of horticulturists. Taken up a level and applied to trees, pruning becomes arboriculture with the opportunity for crown reduction to reduce wind drag and crown lifting to allow more light to penetrate beneath the canopy (Fig. 39.4). These arboricultural operations are almost exclusively the domain of skilled and highly trained horticultural arborists.

Training, which virtually always requires pruning to accomplish, refers to the practice of forcing plants into particular shapes. This is sometimes done to increase production as in the case of fruit trees grown against sunny walls, or to make the most of restricted space, such as training the stems of a grapevine up the inside of a glasshouse or conservatory or in espalier grown apples. On other occasions it can make protection from predating birds easier such as when cherries are grown against a wall to make netting easier, or because it's the most effective way to manage climbing plants such as *Wisteria*, climbing roses or C*lematis*. Often, plants are trained into particular shapes for design or aesthetic purposes such as cloud pruned box plants or climbing roses trained over a pergola. Sometimes art and science come together such as the traditional practice of growing espalier pears on the gable

ends of cottages which is both scientifically valid and aesthetically pleasing. The same is the case with step over and cordon grown fruit trees. In each case the training provides for efficient production and is visually pleasing.

Plant training might therefore be considered purely an aesthetic pursuit and therefore a home gardening technique rather than an operation carried out by commercial horticulturists. Professional horticulturists employed in heritage or botanic gardens, however, spend considerable amounts of time training plants to create aesthetic displays and professional horticulturists at famous display gardens such as Longwood in Pennsylvania, USA (Anon 2013b) deploy considerable time and skill into training species from *Chrysanthemum* to *Wisteria* into dazzling shapes and spectacles. Going back in history, famous garden designers such as André le Notre (1613–1700), relied on training to achieve spectacular garden creations. Training is therefore the preserve of both gardeners and horticulturists with, again, scale of operation being the major divide. Detailed information on pruning and training can be obtained from the following reference sources: Brickell and Joyce (2011), Brown and Kirkham (2009) and Joyce and Lawson (1999).

Composting

The process of organic matter decomposition and nutrient cycling (the carbon cycle) is a natural process in the environment and both gardeners and horticulturists have harnessed this biological activity for their benefit for generations. In the wild dead leaves and other plant and animal remains are colonised by fungi and bacteria resulting in the liberation of heat, water, carbon dioxide, a reduction in volume, the liberation or recycling of some nutrients, and leaving a by-product, humus, that slowly continues to further decompose and reduce in size. In the garden situation, any organic material such as weeds, leaves, vegetable peelings, mown grass clippings and unwanted herbaceous plants can be stacked in a heap and allowed to decompose. Undertaken with skill, the waste heat produced kills pathogens and weed seeds and the humus remaining (which will have reduced to about a quarter of its original bulk) can then be incorporated back into the garden where it increases fertility but, perhaps more importantly, helps improve soil structure making the soil easier to work and less prone to wind or water erosion.

Composting is frequently described as an art and it is certainly a craft, at least, with many gardeners lacking the necessary skills finding success difficult to achieve. Composting fits very well with organic and wildlife gardening and is very popular at the moment, often featuring very prominently in garden society lecture programmes and demonstrations.

In the professional horticulture environment, while composting has always been practiced to a greater or lesser extent over the last 50 years and more, the rise in popularity of organic production, along with public pressure and coupled with imposed environmental legislation has forced up the usage and importance of composting and, with it, the machinery necessary to handle large quantities of material. In the recent past many parks and public gardens would collect and burn leaves, or throw organic

matter onto rubbish tips rather than compost heaps and there was certainly no thought that local authorities would collect domestic garden waste and compost it in municipal compost heaps. Today progressive large botanic gardens now feature their massive compost heaps as educational opportunities allowing the public to see the tractors turning the heaps and witness the clouds of steam rising into the air. Composting on this scale is subject to strict legislation to promote public safety, monitor transportation and guard against environmental damage such as pollution of ground water. This and the size and cost of the machinery involved contrasts clearly with the home gardening approach. Detailed information on composting can be obtained from the following reference sources: Scott (2010) as well as Anon (2013bb).

Environmental Manipulations

While gardening itself is sometimes described as the art of plant manipulation, it is probably fair to say that gardeners manipulate the environments in which they cultivate plants almost as much as they manipulate plants themselves. Probably the most obvious way to benefit plants in northern temperate regions is to grow them on south facing slopes to benefit from the extra warming that provides as opposed to growing them on north facing slopes. The Romans understood this when they cultivated cherries in the Scottish Borders but it was well known long before that. On a smaller scale, Victorian gardeners would grow peaches and nectarines on south facing walls for the same reason and, apart from the benefit for fruit growing, gardeners growing ornamental plants know well the value of seeking out sunny spots for Mediterranean species while retaining cooler shaded spots for understory ferns and large leaved herbaceous plants. The use of microclimates in this way to benefit from extra warm or avoid frost pockets is all part of both the art and science of gardening.

Not only do gardeners seek to benefit from small differences in site microclimate but they invest in numerous types of structure and equipment, all in the name of gardening and the benefit, financial or for pleasure, in producing bigger, or earlier or more cold intolerant plants in places where they would not naturally grow. Different styles of greenhouses, cloches, cold frames, fleece, polythene, bell jars and heavy mulching are all ways to protect non hardy plants from frost, or to produce fruit such as tomatoes in places where they would not naturally ripen well. Wind breaks, both natural and synthetic provide shelter and tree tubes do this for individual plants aiding their establishment by reducing exposure. Mulching with both organic and inorganic materials smothers weeds, thereby reducing competition, and helping to retain moisture while all types and scales of irrigation equipment provide plants with extra water to help establishment or increase growth and yield.

The practices listed above are just a small insight into the craft or practice of gardening but demonstrate the intricate nature of what skilful plant cultivation at the amateur level can entail. Horticulturists employed in public gardens often adopt the same types of approaches and this is perhaps best seen in botanic gardens where a wide range of the world's biodiversity is being grown on a single location. Every opportunity to manipulate the environment so as to cultivate plants that naturally

grow in deserts, shade, alkaline soils, waterlogged situations or on shallow mountain tops, for instance, are taken to successfully grow plants from other environments. The sophistication of professional horticulturists in adapting and controlling the environment is, perhaps, demonstrated to its extreme in glasshouse cropping. Here computer controlled environments manipulate day and night temperature, humidity, carbon dioxide levels, nutrient applications, pest and disease control, pollination, light levels and day length, while also maximising opportunities for environmental sustainability through rainwater harvesting, thermal insulation and renewable energy sources. Detailed information on environmental manipulations can be obtained from Cockshull et al. (1998).

Mulching

Mulches, to smother weeds and retain moisture, are traditionally composed of organic matter such as garden compost, leaf mould or farm yard manure. Inorganic materials do much the same job and are often used in intensive crop production, even if they are aesthetically less pleasing. Black polythene, woven geotextile membranes, gravel and even decorative, coloured recycled glass aggregates can all be used but don't add to the soil's fertility or improve its structure. In collections-based gardens, such as botanic gardens, different types and depths of mulching can help diversify the range of species it's possible to cultivate at a particular site. For instance, heavy applications of moisture retaining garden compost allow the cultivation of rhododendrons on the east coast of Scotland where the annual rainfall amounts to only 650 mm whereas such applications are unnecessary on the west coast where precipitation can reach 3,000 mm.

Pest, Weed and Pathogen Control

Pests of all sorts including insects, molluscs, pathogens and weeds have been the scourge of gardeners and horticulturists for as long as husbandry has been practiced. Killing, trapping, removing, scaring, shooting and burning have been traditional ways of trying to remove the source of the problem and there is even evidence of chemical control using sulphur, for example, as an insecticide and fertilizer going back more than 4,000 years. As a result of the agricultural revolution machinery became more effective and more widely adopted leading to massive changes in cultivation techniques which in turn led to more intensive cropping creating the conditions for some pests to become even more of a problem. Combating pests became consequently more serious with solutions being found in plant breeding and the production of resistant cultivars, cultivation techniques such as crop rotation and intercropping, more efficient chemical sprayers and machinery and, as the green revolution dawned, so the manufacture of more and more sophisticated and highly effective pesticides. Since the latter part of the twentieth century concerns regarding the damaging effect on human health and

the environment have caused a gradual shift away from chemical treatment to other forms of control using biological agents, physical techniques such as mulching for weed control, organic pesticides, holistic approaches and integrated techniques.

Possibly nowhere else is the difference between home gardening and professional horticulture more widely exhibited than in the control of pests and diseases but there are not simply two scenarios at different ends of the scale but three:- home gardeners, public ornamental gardens, such as botanic and heritage gardens and commercial horticultural crops. Many gardeners and horticulturists adopt an Integrated Pest Management (IPM) approach which combines minimal use of pesticides with physical and cultural techniques of pest control (Radcliffe et al. 2008).

Turf Culture

Possibly no other area of plant cultivation more amply demonstrates the divide between horticulturists and gardeners than turf culture or lawn care. While they might have been regarded as only of a different scale in the past, the science and technology now applied to sports turf in particular, now places them far apart, at least at their extremes. Modern sports turf cultivation now requires a thorough understanding of soil texture, irrigation, draining, cultivar selection, aeration, topdressing, plant nutrition and disease and weed control. The perfect-looking swards achieved at famous sporting locations such as Wimbledon, Pebble Beach, Lords or Old Trafford Cricket Grounds each have very specific characteristics required from each sport and are managed with skill, backed by science and technology. The equipment required to create and maintain these surfaces includes not only numerous cutting and irrigation types of machinery but also technique such as sand and vibro slitting, overseeding, scarification, topdressing, rolling and a means of alleviating compaction.

The Science of Horticulture

Horticulture is both an art and a science. The art is expressed from the smallest urban garden right the way through to the grandest of designs such as Peterhof Palace, west of St Petersburg, Russia while the science underpins every stage of cultivation from plant selection right the way through to post harvest storage. Horticultural research has resulted in new cultivars, with greater pathogen resistance, greater colour range, longer cropping season, higher yield, better flavour, different sizes and shapes and more. Cultivation research has led to improvements in propagation and handling, irrigation techniques, soil cultivation, urban tree survival, organic cultivation, effective pest, disease and weed control, cost effective harvesting, and post harvesting procedures to extend shelf life. In addition there is considerable art and science in amenity horticulture when we are dealing with the design, construction and maintenance of different landscapes.

Science Associated with Growing Media

Sometimes known as potting composts or just compost for short (but not to be confused with garden compost and composting), growing media describes the range of materials used to cultivate plants in containers, as opposed to plants growing in the open ground. Plants have been grown in pots or containers for many centuries, even if it was only to transfer them from one place to another. Using a predominantly mineral soil for this purpose is unsatisfactory because the frequent and heavy watering required when plants are containerised leads to a loss of structure. This in turn causes the loss of natural air spaces that would normally allow free drainage resulting in a material that does not drain leaving waterlogged conditions in which roots eventually die.

Up until the middle of the last century gardeners used mixtures of all sorts of materials to overcome this problem in the physical structure of growing media, along with a vast array of chemical additives to try and promote healthy plant grow. The main problem was that these materials had to withstand daily watering which is detrimental to soil structure and answers lay in a combination of organic matter and coarse sand or grit– the former have an extraordinary combination of high porosity, large surface area capable of retaining moisture and strong physical structure able to withstand the destruction of the hose or watering can. The latter add weight and improve porosity. Sources of organic matter usually consisted of garden compost or leaf mould. To these two basic material were usually added a certain amount of garden soil and a plethora of other ingredients such as charcoal, sawdust, broken up clay pots or river washed sand. Ingredients to provide plant nutrients consisted mostly of organic products such as ground bone meal, hoof and horn meal, dried blood and manure but also some mineral components like limestone. Mixed carefully and used skilfully there is no doubt that such materials could grow satisfactory crops and plants. The main problems, however, lay in procurement, consistency, sterility and the time taken in preparation. In commercial production and large municipal parks, in particular, it became difficult and time consuming to source the materials, although this was less of a problem in estates and private gardens. Consistency of product, which is so important in commercial production, was probably the main issue with the variable quality of each of the materials giving inconsistent results in terms of crop size, quality and harvest date. Finally, many of these materials contained sources of pathogens leading to high levels of pest and disease infestation and they took a long time to prepare.

Many of these problems were at least partially overcome following research undertaken in the 1930s by William Lawrence and John Newell working for The John Innes Horticultural Institution which demonstrated that a reasonable degree of uniformity could be obtained by using just three components– loam, peat and grit, supplemented by a standard combination of chemicals added at stated weights per volume and increasing in amount with type of plant and the likely length of time that they would remain in the growth media (Anon (2013cc). Interestingly, this uniform approach to making compost was initially developed to remove the variables from crop experiments at the institute and were only commercialised at a later date.

This was true also of the University of California standardised peat and sand mixes which were developed first for standardisation demanded from research and were then commercialised (Flegman and George 1979).

While these composts marked a substantial advance in the science of plant cultivation and were used by gardeners and professional horticulturists for many years (and are being revived today as part of moves to reduce the use of peat), the problems of procurement and standardisation remained, albeit at a reduced level, particularly with the use of loam which was supposed to be sourced from stacked turves, left to decompose 6 to12 months, then riddled to create an evenly sized product before steam sterilization to kill pests and pathogens. But, while the procurement, standardisation and use of the loam were problems, the procurement and use of peat was a revelation to many. While it was acid in reaction and devoid of any nutrients, its ease of procurement, superb physical composition and sterile nature made it an ideal constituent and led to further research on the possibility of using peat only, or peat with added grit for potting composts. More careful attention had to be paid to plant nutrition but these were easily added by readily available inorganic fertilizers, while the acid reaction was countered by the addition of ground limestone.

Peat-based composts were suitable for commercial and home use and were easily supplied in bulk to the former, particularly for its use in the nursery stock and garden centre industry, and conveniently in bags for home use. The product was clean, easily used and uniform, giving good, healthy growth and a uniform product. Many peat-based composts were only composed of peat with added nutrients but sometimes this was supplement with sand or grit to add weight or, for instance, perlite or vermiculite to increase aeration even more, particularly for use in propagation. Unfortunately, the supply of peat is not sustainable and there have been increasing pressures put on the use of peat due to concerns about the loss of valuable wildlife habitats. Since the turn of the century alternative materials, such as coir and bark, have been sought and have been the subject of research but it has proved to be very difficult to find a product as good as peat. Today a variety of materials are available on the market but are arguably not as easy to use as peat-based composts. However, with an understanding of their nutritional requirements and, especially, irrigation needs, good results can be obtained.

The 1960s and 1970s also saw experimentation of the cultivation of plants without soil at all, but in nutrient enriched water (Douglas 1976; Anon 2013dd). This generally took two forms, types of hydroponics, which found popularity in the commercial specimen pot plant industry, particularly for interior landscapes such as hotel lobbies, shopping malls and corporate board rooms (Manaker 1996). This type of cultivation involved containers with water reservoirs which could easily be topped up by unskilled staff and with plants supported by light expanded clay aggregate (LECA), a light material looking like gravel but with a pumice-looking internal structure. The other form of cultivation, commonly termed nutrient film technique (NFT), first found its outlet in the commercial production of tomatoes, aubergines and peppers but is now applied to many other vegetables produced for the supermarket such as lettuce and strawberries. Production involved plants growing in shallow channels of nutrient enriched water with the advantages of a very clean, soilless product which never experiences drought and in which the nutrient supply

is constantly monitored and automatically topped up. Add to this an almost sterile environment with the floor covered with polythene, ideal environmental conditions in controlled glasshouses and biological pest control, adding up to a commercially successful growing 'package'.

Home gardeners have certainly benefitted from the research undertaken on composts and are easily able to buy bags of ready-mixed high quality compost from garden centres and supermarkets. To this extent they are using very similar materials, backed by the same research and development, as commercial horticulturists, the only difference being in the scale of delivery and use with gardeners buying modest sized bags and commercial users purchasing their compost in cubic metre sacks or in bulk by the trailer load. When it comes to fruit and vegetable production, while it is possible to by home-scale hydroponic kits, commercial scale production, along with its technology and equipment is very much the preserve of the commercial horticultural producer and is poles apart from home gardening.

Science Associated With Plant Breeding

Forms of plant breeding have existed for as long as humankind has been domesticating agricultural and horticultural plants, probably for at least ten thousand years. The earliest application was probably the simple selection of useful characteristics such as size or disease resistance and the subsequent use of seeds from plants exhibiting these features. Over time such selections would have reduced the genetic variability within the species to a more uniform (but still genetically diverse) appearance leading, eventually, to recognised landraces. With an understanding (or at least observation) of how pollination resulted in seed production so the opportunity for deliberate hybridisation resulted in the possibility of combining desirable characteristics from two related species. However, this was still well before Gregor Mendel's (1822–1884) time and deliberate hybridisation was the preserve of farmers and growers who had no knowledge or understanding of genetics. It was Mendel's methodical approach to hybridising peas that eventually lead to the new science of genetics and an understanding that there was a rational underlying explanation of what was being observed (Mawer 2006).

Traditional plant breeding uses crossing and backcrossing to combine useful traits such as high yield, increased quality and disease resistance and these techniques were in use by commercial, mostly agricultural, seed producers in the latter part of the nineteenth century. In 1908 heterosis, the superiority of heterozygous genotypes with respect to one or more characters in comparison with the corresponding homozygous, the phenomenon of hybrid vigour (Rieger et al. 1991), was described and explained and this ability of the progeny of a particular cross to outperform both parents was used widely in crop development. However, while scientists were steadily working away understanding the science of genetics and applying this gradually to crop development and improvement, large numbers of Edwardian Head Gardeners and commercial nurserymen were busy hybridising and selecting a vast array of ornamental plants, fruit and vegetables. Everything from

Fig. 39.5 Display of flowering plants for hobby gardeners at the Chelsea Flower Show, London

violets, antirrhinums, sweet peas and delphiniums to plums, pears, potatoes, cabbages and beans were the subject of breeding and selection and nursery catalogues bulged with vast lists of the cultivars available (Fig. 39.5).

The era when both the scientific and 'gifted amateur' approach to plant breeding and selection continued for many years with the former concentrating on more commercial crops and the latter on ornamentals. However, with the increasing application of technology such as protoplast fusion, mutagenesis, genetic modification and exploiting somaclonal variation to increase diversity that would not normally occur naturally, and the trend of chemical companies buying seed houses with the intention of 'harmonising' the cultivation of specific cultivars with the use of particular pesticide, so the day of the amateur plant breeder has declined, but has certainly not disappeared.

Science Associated with Glasshouse Production Technology

The purpose of glasshouse production is normally to raise the growing temperature to permit the cultivation of warm temperate or tropical crops like tomatoes, aubergines and peppers in northern latitudes. This is not always the case, however, and in some tropical countries glasshouse temperatures are cooled to enable these same crops to grow successfully. Glasshouse, or protected, cropping does more than simply heat or cool the temperature, it makes possible the complete control of all growing parameters within an almost closed, and therefore controllable, environment. This, in turn, makes possible the cultivation of high volume, high quality crops matched to precise harvest and sale schedules. The costs associated with both the infrastructure and on-going production are considerable but, given the value and profits possible, are considered to be worth it. Like any industry though, to keep ahead of competition and to make a profit requires investment in new technology, and this new technology needs to be underpinned by sound research. More research

Table 39.1 World greenhouse vegetable production area (ha) (2002)a

Country	Production area (ha)
Canada	876
United States	395
Netherlands	4,300
Mexico	1,520
Spain	70,000

Note: When comparing relative size of operations between countries the different production technologies should be taken into account. For example, production in Mexico and Spain consists of a variety of production systems ranging from low to high technology greenhouses. Spain consists mostly shade cloth production not glass production. 1 ha = 2.471 acres. Source: BC Vegetable Marketing Commission.

Table 39.2 North American greenhouse vegetable production area (ha) of major crops (2002). (Source: BC Vegetable Marketing Commission)

Production area (ha)				
Crop	Canada	US	Mexico	Total North America
Tomatoes	482	350	790	1,622
Cucumbers	199	25	118	342
Bell Peppers	174	20	210	404
Total	855	395	1,118	2,368

has probably been devoted to protected cropping than any other aspect of the horticultural industry.

Selected statistics demonstrate the scale of glasshouse production. Worldwide, the main greenhouse vegetable production areas include: Spain, the Netherlands, Mexico, Canada and the United States (Table 39.1). Production in Mexico and Spain consists of a variety of production systems ranging from low to high technology greenhouses. Spanish production consists mostly of shade cloth production, not glass production. Production in the Netherlands, Canada, and the United States consists primarily of high technology greenhouses with significantly higher yields. Table 39.2 shows the production area of the major greenhouse crops in North America (Anon 2013ee). The Netherlands has around 9,000 greenhouse enterprises that operate over 10,000 ha of greenhouses and employ 150,000 workers, efficiently producing € 4.5 billion worth of vegetables, fruit, plants, and flowers, 80 % of which is exported (Anon 2013ff). In the 1950s, the global flower trade was less than US$ 3 billion. By 1992, it had grown to US$ 100 billion. In recent years, the floral industry has grown six percent annually, while the global trade volume in 2003 was US$ 101.84 billion. While production has traditionally been centered around the main centres of population in North America and Europe and with Dutch growers leading production technology and volume, in recent years other countries such as Kenya and Ethiopia have been developing their capacity, based on cheap labour and efficient air transportation (Anon 2013gg).

Every aspect of infrastructure and cultivation technique impact on quality and yield and have been the subject of research and innovation. Many glasshouse companies, university departments and governments carry out this research and whole research institutes are or have supported the industry. In the UK the Glasshouse Crops Research Institute was created for this very purpose and, in its heyday, employed over 200 scientific staff. In the northern hemisphere a lot of research has been devoted to maximising light levels and reducing heat loss as these two factors influence heating costs, and therefore production costs, the most. Even a 1 to 2% increase in light intensity can make a difference to profitability and roof and crop orientation are both significant factors in these studies (Nelson 2011). In terms of reducing heat loss, cladding material (e.g. glass, polythene or plastics such as polycarbonate sheets) side wall insulation and thermal blankets are all important while the source of heat (e.g. gas or oil), the efficiency of combustion and distribution systems all have a role to play in glasshouse efficiency (McCullagh 1978; Nelson 2011; Boodley 2008).

The cost of energy is such a major influence on cost and yield that even small deviations from ideal temperatures can have an impact. As a result electronic control systems and environmental management are important components of glasshouse cropping, while sustainable forms of heating such as ground source and air source heat pumps and the use of deep geothermal energy are being vigorously investigated. If CO_2 enrichment and supplementary lighting systems are used, the interplay of light intensity (not just from supplementary lighting but also dawn, dusk and ambient intensity), temperature and CO_2 can all be controlled for maximum effect. Temperature is affected naturally by outdoor temperature and light radiation penetrating the house but can be controlled by a combination of ventilation and water temperature within heating pipes.

When it comes to cultivation, crop layout to maximise space by minimising walkways or using mobile bench systems, ensures that as much of the expensive glasshouse space is used for cropping as possible. Breeding programmes to increase yield and improve disease resistance have also made a major contribution as has research into plant nutrition and cropping systems such as hydroponics, nutrient film technique (NFT) and modular systems of cultivation (Fig. 39.6).

Conclusions

While gardening and horticulture are both concerned with cultivating plants, this chapter has served to show that the motivation, scale and technology between the two is different. Gardening is primarily a leisure activity while horticulture is a paid, professional occupation. While gardeners pursue their hobby in gardens and allotments, however large, horticulture is often on a large scale such as parks, botanic gardens and production nurseries. Finally, while gardeners however skilled, and many are exceptionally skilled, reply on domestic-based technology, horticulturists work in or with sophisticated machinery and equipment and in high-tech, highly controlled environments, backed by advanced scientific research.

Fig. 39.6 Container grown trees for landscaping and amateur gardens

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