- ***Cephalotaxus*** spp. (Plum yew). Crush fruit in polythene bag to separate plum-like seeds from the fleshy fruit. When deposited in water, the good seeds will sink and the rubbish will float. Air-dry the seeds on newspaper and sow.

Once the seed collector has experienced the various fruit types, it will soon become apparent which cleaning treatment will be the ideal and quickest.

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An extensive hand-out was given out which is printed in the IDS yearbook 2007, pp. 148-152.
See also the report by Lloyd Kenyon on the seed collecting study day at Hergest in the IDS Yearbook 2006, pp. 149-151.
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Tree pruning

HUGH MORRIS writes about the history of tree pruning and describes the CODIT model which arose from scientific research carried out during the final quarter of the twentieth century by Alex Shigo in the United States.

I have thought of writing an article on pruning for quite some time. This is due to my concerns over how trees are pruned and how often they are pruned using various incorrect pruning methods. Unfortunately, it is a subject seldom written about in the mainstream of horticultural publications, and perhaps as a consequence so seldom done correctly. I first learned how to prune at Hillier Tree Farm in Liss, Hampshire, but I never considered why it was I pruned using a particular method. It was only when I trained in the practice of arboriculture at the RHS garden, Wisley that I began to explore the subject and query why we used this adopted approach. This approach was known as Natural Target Pruning, a new method born in the 1980s that replaced a method known as the flush cut, which was advocated by De Courval and Des Cars in the late nineteenth century and was used for more than a century. To understand how the art and science evolved to this current method, we must go back to the start. As Alex Shigo, the father of modern tree biology and the advocate of Natural Target Pruning, said, “Pruning is one of the oldest agricultural treatments”.

The earliest mention of pruning was in the bible “Every branch in me that does not bear fruit, he takes away; and every branch that bears fruit, prunes it so that it may bear more fruit – John 15:2 (AD 80 - 100)”. Of course this is a metaphor, but it tells you how advanced we were at that time, where a method to increase the fruit bearing capacity of a fruit tree was already in practice. Pictorial records dated from as far back as around 4000 BC showed evidence of pruning in the form of Bonsai (though obviously not referred to as such) in early Egyptian culture where Pharoah Rhamesses III donated various pot-bound plants to temples throughout his kingdom. However, there is only an assumption they were pruned but no written evidence of such. The first written evidence of dwarfing trees was in China during the Jin dynasty (AD 420 - 265), which involved the pruning of roots and crown. The term for this was Penzai and was later translated to Bonsai by the Japanese who embraced and continued the art during the Heian period (modern Kyoto) AD 794 - 1185. So, until only recently, pruning was for aesthetics and fruit production and carried out by gardeners for kings and the ultra-rich (Duval, 1982); the art and craft was born, but not the science. The science evolved in response to our understanding of trees and their physiology (Sargent, 1884). A moment of observation and clarity evolved when we began to piece together what happens inside a tree and this helped us understand how a tree might respond when pruned. It was within the discipline of forestry that pruning using a scientific approach evolved to increase the wood quality and yield of timber. The advantage of pruning forest trees, to increase their yield of timber, was recognised in Germany as early as the seventeenth century (Sargent, 1884). This practice was seen as unfavourable and later abandoned until two French foresters, De Courval and Des Cars, revived the practice by introducing a scientific method based on the fundamental laws of plant physiology. In Belgium, where more than in any other country the subject of forest management had occupied the public mind, the two legislative chambers of government discussed the subject of pruning at great length in 1884 without reaching any satisfactory conclusion; in France authorities did not agree, – some condemned all pruning, while others believed in its advantage, but without agreeing on the best methods to adopt (Des Cars,

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Oak (*Quercus robur*) with large wound caused by a flush cut. The operator used a tar-based wound dressing to help seal the wound. Both the flush cut and the wound dressing are bad practices and not recommended. The large open wound caused by the flush cut has allowed the entrance of pathogens, as the Branch Protection Zone (branch collar) has been removed. The Branch Protection Zone (BPZ) forms part of wall 1 of the CODIT model.

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Oak (*Quercus robur*). This is an example of good practice. You can clearly see how the wound has completely sealed. Providing you carry out Natural Target Pruning as shown here, callus will form equally from all sides and eventually seal the wound. Also, as a result of the Branch Collar being kept intact, the ingress of pathogens will be restricted.

Oak (*Quercus robur*). Here is another example of a flush cut. You can see how the callus has formed disproportionately, with greater callus formation from the laterally than axially. Also, the decay appear quite extensive here. Due to the branch collar being removed, there was nothing to restrict the movement of decay towards the main trunk.

1886). The objections were endless: some believed that a branch removed would kill a root directly influencing that branch; practicing foresters, with a respected authority on the subject, claimed that pruning led to spoiled timber due to the ingress of decay. However, as noted by Des Cars (1886), this was due to the use of an incorrect pruning method and not the act of pruning in general. So many reasons arose from diverse disciplines to discourage the act of pruning that a definitive work was needed to evaluate the process in general and to provide a consensus based on scientific theory. This was achieved by the works of De Courval and Des Cars leading to an evolution in the practice of pruning that is, however, still hotly contested today.

Pruning is carried out within many of the land-based sciences, including pomology, agriculture, horticulture, forestry, and arboriculture. However, of recent times arboriculture has become the discipline most associated with pruning and has pushed the science and art to new heights. To achieve a universal standard of pruning takes a multidisciplinary approach, and to this day this has not happened to a satisfactory level. There are various reasons for this and it all points simply at confusion. Because different methods of pruning arose from different disciplines, both amateurs and in many cases professionals applied their techniques from one discipline to that of another. An example of misguided methodology is where the principle of pollarding on young trees is applied to big trees where it is still regarded as pollarding, except it is really mutilation. This misguided perception may have arisen from general gardening books on the pruning of shrubs etc, or from topiary. Also, there is a lack of understanding of the anatomy of branch attachment and of the trees active natural defence system. Another problem is our view of the tree as an indestructible large organism and because of this we feel that it should tolerate more than it actually can. However, the greatest problem that leads to improper pruning is planting the wrong tree in the wrong place, which places pressure to have its growth curtailed, resulting in mutilation followed by the ingress of decay.

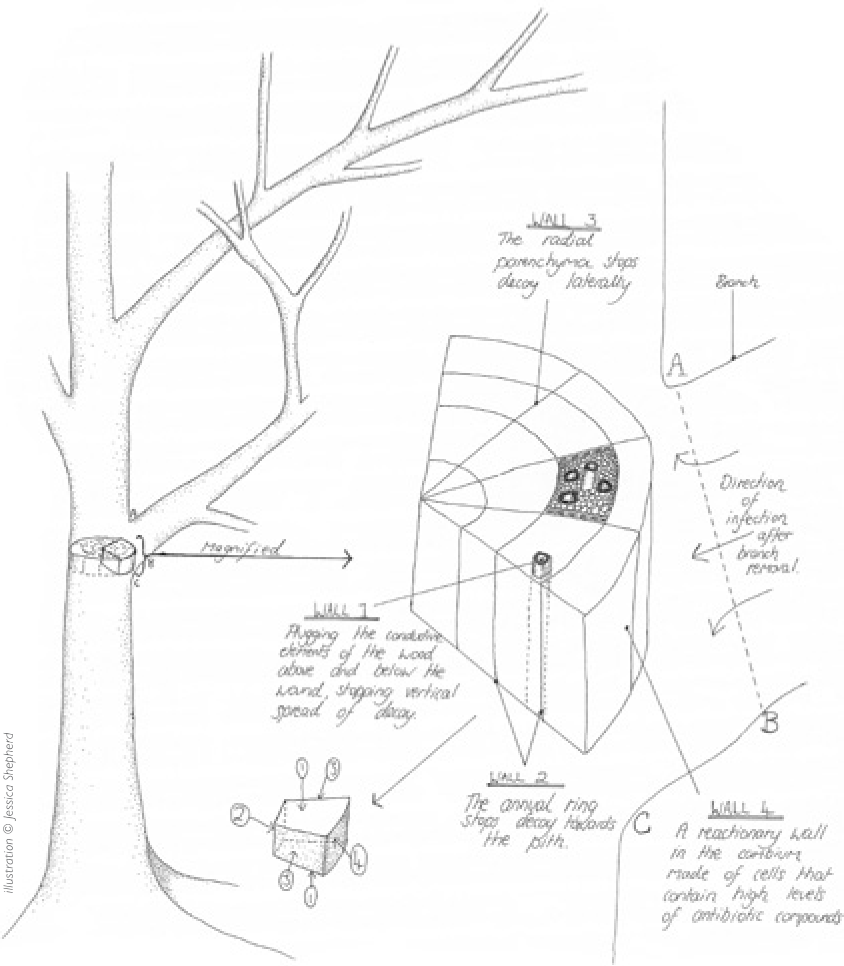
This paper will explore how the science of pruning evolved and will explore the general physiology of a tree and how it responds to pruning. An arboricultural perspective will be used in most cases, as it is the science that encompasses the pruning of trees in parks, arboreta, urban forests, towns, and people's homes.

When a tree is pruned an open wound is created. No matter where the pruning cut is made, the arborist severs directly through living parenchyma cells and active vessel elements, with the latter being responsible for the uptake of water. This wound immediately makes the tree vulnerable to an attack of decay from a number of different decay-causing fungi. Decay will naturally occur, but it is how to limit or prevent that decay from proceeding to the central column next to where the wound was made that has been the subject of such debate for hundreds of years. It was only in 1886 that a German pathologist called Robert Hartig discovered that decay was caused by a fungus, until then it was believed that decay created the fungus (one must consider that De Courval and Des Cars would not have been aware of this discovery). A simple switch in understanding caused a completely different thinking towards fungi and wood dynamics. This switch in mode of thinking gave rise to a new tree biology where thousands of trees were dissected using at first axes and hand saws and then the chainsaw. The lightweight powerful chainsaw was the first major tool that made it possible to dissect and study thousands of trees (Shigo, 1986). Although Alex Shigo is revered as being the father of modern tree biology, this is perhaps not the case. As Shigo (1986) himself acknowledged, "The early dissection work of Dr George Henry Hepting in the 1930s set the stage for a new tree biology". However, Shigo pursued the studies with a total of 15,000 dissections allowing him to make unique observations of the internal structure of a tree by viewing entire longitudinal sections only made possible with the chainsaw.

From the physically demanding outdoor lab work, Shigo observed very interesting patterns in wood that led to a concept changing the urban tree industry and our mode of thinking, which was likening trees to people. This concept became known as CODIT, an acronym for Compartmentalisation of Decay in Trees. Until these extensive timber studies, it was believed that trees healed in response to pathogens, now, as a result of his astute observations, we know they seal or compartmentalise, or to put it another way, they isolate diseased areas. The CODIT model is a simple concept to help us think about the processes (Shigo, 2008), but the biology behind it is complex. When a wound is inflicted on a tree, it causes a localised reaction. This reaction is an attempt to stop the decay in its tracks so the least possible harm is caused to the tree. This is carried out by forming a reaction zone around the decay preventing it from moving any further into the wood in any direction.

Both natural barriers and a reactionary barrier form the CODIT model. It is made up of two parts: the first part composed of three walls 1, 2, and 3; the second part, wall 4. Wall 1 resists vertical spread of decay; wall 2 resists inward spread; and wall 3 resists lateral spread. These walls are natural barriers. The annual ring is an example of a natural barrier and this can prevent or halt the movement of decay towards the pith (Shigo, 1986). Another example of a natural barrier are the parenchyma ray cells or radial parenchyma, which form a tissue laid down in a radial direction that prevents or curtails the movement of decay laterally (see diagram 1). Wall 4 of part two is a reactionary wall that occurs after wounding where a barrier zone made of chemical compounds is formed. The cambium forms cells that differentiate to form the barrier zone (Shigo, 1986). This is the barrier we are most interested in: it is the strongest of the 4 walls and it is the zone that forms between the decayed tissue and the new tissue formed by the cambium. It is also an anatomically distinct zone, in that the cells can undergo suberisation, an airtight layer that inhibits fungal movement.

To make the correct pruning cut you have to use vital clues in the language of trees. There are two indicators that guide the operator: 1, the branch collar, and 2, the branch bark ridge ~~(diagram here)~~. One or both of these may not be present at the time of pruning, though in most cases they are, especially in more mature branches. When making the cut it must be done in two stages, unless the branch being cut is particularly small. The first cut is known as a 'step cut', and this should leave a stub. With this cut you must make an under score (perhaps 50cm long), and then place your cut on the top of the branch slightly to the inside of the bottom cut. This removes the branch cleanly and does not leave a vulnerable tear along the underside of the branch union. The next cut is the final one, where it removes the stub just outside the branch collar and at 45° to the branch bark ridge. It is crucial that this is done with precision, as the removal of too much results in the flush cut while the removal of too little leaves a stub. This immediately prompts the two questions: why not leave a stub and why not flush cut? Are there two schools of thought in conflict? These questions are the basis for this paper and a dispute lasting for hundreds of years. Des Cars (1884) quoted in the famous work 'Tree Pruning'



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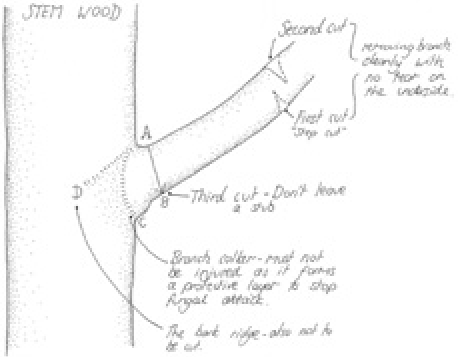
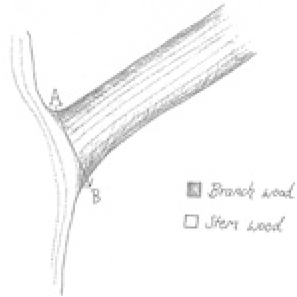
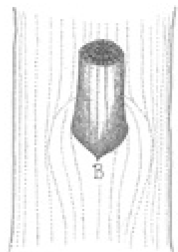
that as descending sap alone forms the new bark and wood that heal the wound, it follows that if the cut is made in the manner represented by the line A-B, the new growth cannot cover over the lower part, B-C, which is cut off from the communication with the leaves; so that the wood included in the lines A-B, A-C, is not covered with new growth must soon begin to decay, and in time destroy the trunk of the tree. This shows the scientific reasoning at that time – science progresses as we learn new things and put old theories through rigorous examination to prove or disprove a theory. This is what Shigo did here, as he showed that the correct pruning cut is indeed from A-B and not A-C as postulated by Des Cars. A-C results in a breach of the branch protection collar, which forms the protective layer against the ingress of fungi. Des Cars







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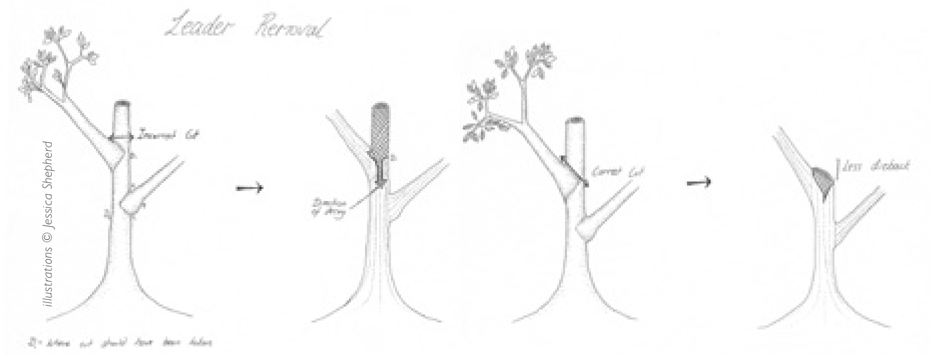
postulated that callus would not develop evenly inwards from the cambium at the outer edge of the wound, as it would not be able to grow over the lip from B-C where decay could spread rapidly. Des Cars was probably referring to stem wood here or annual incremental growth and not callus wood – two different types of wood development. Callus wood produced in response to a stimulus such as pruning or other injury, whereas stem wood is the normal wood laid down as the annual growth rings.

Another example here of science progressing is Des Cars notion that it is descending sap alone that forms the new bark and wood, which seal the wound. By descending sap, he was referring to phloem sap, and quite correctly the greatest source of such sap descends from the leaves. However, another source is that with the largest capacity: the storage site or sink in the wood and bark parenchyma. So phloem sap can descend and ascend. Examples of phloem sap ascending are in birch and the maple in early spring before the leaves emerge. The source of maple syrup is from ascending phloem sap. The source from where wounds seal by the formation of callus comes directly from the sink – the sink being the site where phloem sap is transferred to and held as a local source of reserve energy. The local centre for healing a stem or branch injury would be the cambium – a tissue specialised for the production of new cells, and the necessary nutrients would be translocated into it through the phloem. Conifers and angiosperm trees differ in how they react to a wound. Conifers produce copious amounts of resin from the resin glands after injury and this hardens to act as an impenetrable shield. However,



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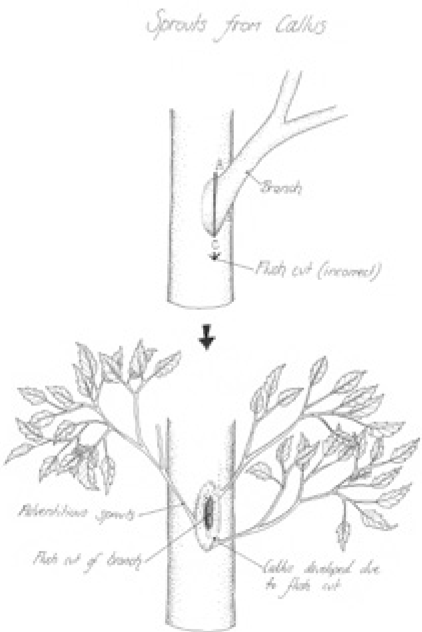
conifers still require the correct pruning techniques as they to have a collar with a protective layer of cells, as outlined in the CODIT model.

Shigo used three words to describe the reactionary processes after injury – stimulus, recognition, and response. Survival of any system depends on its ability to recognise a stimulus that threatens it, and then respond rapidly and effectively (Shigo, 2008). Of course, the response time depends on the size of the reserve of potential energy and this directly relates to the vigour and vitality of the affected tree. The vigour of the tree is its genetic propensity to safeguard the system for a long life. The vitality of a tree is essentially the tree's immune system and how it copes with injury. An old tree has less vitality than a young tree and therefore has less energy reserves to cope with injury. Another example of reduced vitality is where a tree is growing in the wrong soil type or location, and fails to thrive making it more susceptible to decay.

Understanding the genetics of different species means understanding their wood properties and their ability to compartmentalize. Species of tree such as willow and poplar put most of their energy reserves into growth so they tend to have shorter life spans. They spend life in the fast lane: 'grow' fast and 'go' fast. Oak trees put huge investment into defence and grow slowly, dying at great ages.

Writing about the different species and their ability to cope with pruning wounds is a paper in itself, but this paper describes the basic process. Pruning done correctly is a science and an art form. The method is easy once understood and practiced. The science can be complex but it is necessary to demonstrate why we prune in a certain way and in doing so attempt to diminish confusion and old myths. We are stubborn by nature and don't like to change old ways, being creatures of habit. Alex Shigo, the father of modern arboriculture, was the first to make these changes after years of arduous experiments out in the forest. We are now following in his footsteps, however gradually. Shigo followed in the footsteps of Des Cars and many other great scientists, and made amendments along the way. But for scientists just as Des Cars and De Courval, Shigo would have had no footsteps in which to follow, hence the reason why science is progressive and constantly progressing. With urbanisation a growing concern, trees are more precious to us than ever before and more trees must be planted amongst us in order to maintain a balanced dynamic system. Trees have never been more under threat. Knowing how and when to prune can allow us to co-exist in harmony. Trees were never viewed as importantly as they are today and we should give them appropriate treatment so that they continue to thrive and provide their inestimable benefits to us and the whole environment. We owe them this much.



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