1 Wood as a Material

The very first thing to get absolutely clear at the start, is that there is no such thing as 'wood'! Of course, there is the stuff that grows on trees (or rather, the stuff that grows *inside* trees): but what I mean to say here, is that there is not one individual, unique and single substance that can simply be referred to just as 'wood'. There is no one, unique material that will do every single job without any problems and with no prior thought, no matter what you might require it to do for you.

The stuff that we know as 'wood' – and as most laymen are apt to use that term – is merely a catch-all word that covers a whole range of possibilities in terms of appearance and abilities. From the hard-wearing to the hardly worth bothering with: or from the very strong and durable to the very weak and rottable. So, in this book, I aim to show that any given species of wood is very different in its properties – and therefore in its usefulness – to some other vaguely similar sort of wood, but which happens to be of a different species.

An obvious comparison could be with the idea of what we mean by the word 'metal'. If you should go along to a stockist of metals, then the first thing you're likely to be asked is exactly what job you intend to do with that 'metal'. And the answer to that, in turn, will govern the likely properties that you will want that 'metal' to possess. Do you require it to have a high tensile strength, or a good degree of ductility, or a shiny surface, or something else? And if you don't specify more precisely what you need this particular 'metal' for, then you may be offered a whole range of possibilities: ranging from steel, to brass, to copper – or tin, or lead, or mercury (which is liquid at room temperature) or even calcium (yes, although it's in your bones, it's a metal!). All of these genuine 'metals' are very different from one another, with huge variations in their physical and chemical properties; but all of them fit that initial, vague and general description of being a sort of 'metal'. So why should the situation be any different when it comes to wood?

A good question to ask would be: 'Why do so many people assume that 'wood' is all that they need to specify'? Even those who take more care about what they do or write, often think that they've done enough by asking just for a 'hardwood' or a 'softwood' – as though that somehow defines more accurately

Wood in Construction: How to Avoid Costly Mistakes, First Edition. Jim Coulson.

the properties that they require in their material. But even that apparent improvement in the material's description is simply not enough, as I hope this book will show.

Every single, individual species of wood has certain very specific properties and therefore, it must follow, certain potential uses. But it also has certain other things about it that we might do best to avoid, or at least restrict: and those individual properties of this immensely variable material will then be subtly – or perhaps greatly – different from one species of wood to another. In essence, no two 'woods' are the quite same as one another; just as no two 'metals' are quite the same. And quite often, the differences in performance between different wood species can be very large indeed.

Sometimes, of course, these differences in properties are quite minor; and they will not significantly affect the outcome, where one species has been used instead of another. But sometimes, the differences between alternative wood species can be absolutely vast – such that it would be the equivalent of using chalk instead of cheese. (I know nobody builds with cheese – but sometimes, they might just as well, for all the good it does!)

There are at least 60 000 (and still counting) different species of wood in the world, which have so far been discovered and described by botanists or by Wood Scientists: so you should now begin to see that you really do need to know a whole lot more than perhaps you thought you needed to, in order to begin to understand exactly what *sort* of 'wood' you should be asking for. And, of course, what you should really be using.

But it's not *only* a question of the wood species – vitally important though that is. The Quality and the Grade of the timber that are to be used are also very significant factors in getting the best performance from timber, at the best price: as are a number of different processes and treatments that can (and quite often *should*) be done to the timber, once its wood species and final quality have been decided upon.

Some of these other processes are: moisture content (drying), treatment (preservation), finishes (paints and stains) and taking care of the timber during delivery and storage. All of these things are, in my humble opinion, quite essential factors in getting a good job done properly, when using timber. Not to mention all the additional complexities that are involved in specifying and using wood-based board products, such as plywood or chipboard or MDF. I will explain the most important of these different factors and different processes in greater detail, in some of the later chapters. But for now, I want to begin the process of your timber education by looking at what wood is actually made of.

1.1 Cellulose

All wood cells are made predominantly from cellulose. It's true that both the chemistry and physics of wood are somewhat more complex than this simple statement would imply; but I don't need to go too deeply into the chemistry

CELLULOSE = $C_6H_{10}O_5$

Light acts upon water and Carbon dioxide thus:-

Light $\Longrightarrow$ $H_2O + CO_2 .....^n$

This is photosynthesis

Therefore $5 \times H_2O + 6 \times CO_2 = H_{10} + O_5 + C_6 + 12O\ (= 6 \times O_2)$

In other words, 5 × Water + 6 Carbon dioxide = 1 × Cellulose + 6 × Oxygen molecules

Alternatively, 6 × Water + 6 × Carbon dioxide = $C_6H_{12}O_6$ (Sugar) + $6 \times O_2$

This changes in the growing tree to

$C_6H_{10}O_5 + H_2O$

(cellulose) (water) – absorbed into the tree

Figure 1.1 How trees make wood and oxygen

and physics here, in order to get you to appreciate the wonderful properties of this unique material. For now, suffice it to say that the main ingredient of wood – and therefore what gives this natural material most of its significant properties – is the organic substance called cellulose.

Cellulose is made by (and within) the tree itself, using as building blocks the sugars and starches that have recently been manufactured in the tree's leaves: and these chemicals in turn were obtained by harnessing the energy of sunlight, under the influence of chlorophyll (that green stuff). In fact, every tree (and almost every living plant, for that matter) is a fantastic, natural chemical factory.

Simply by utilising nothing more complex than water, drawn up from the ground via the tree's root system, and then adding to it some Carbon Dioxide that is literally sucked out of the air, this wonderful 'chemical plant' then combines those most basic of ingredients, by simply shuffling the atoms and molecules around to make completely new ingredients out of them.

To make cellulose, the tree uses six molecules of H_2O (water) plus six molecules of CO_2 (carbon dioxide) to fabricate – as a first step – a single molecule of sugar ($C_6H_{12}O_6$). An extremely useful by-product of this chemistry – certainly so far as we humans are concerned – are 12 'spare' atoms of Oxygen (see Figure 1.1), which are helpfully released into our atmosphere in the form of six molecules of O_2.

After making itself a supply of carbohydrates (that is, sugar plus starch – which is really quite similar in its chemical construction: using as it does, only the atoms of H, O & C), the growing tree then uses this newly-produced food supply to manufacture cellulose ($C_6H_{10}O_5$) for itself: and as it does so, it then releases one 'spare' molecule of water. To complete the picture, this excess molecule of water is simply absorbed into the tree, so that nothing is wasted.

Having seen that the tree can conveniently make its own cellulose, we should then perhaps try to learn something about that particular substance. And the most fantastic thing about cellulose is that it is strong: very strong indeed. It is, in effect, a natural type of Carbon Fibre, invented by Mother Nature, long before Mankind ever got clever with chemistry.

It is the hugely strong chemical bond between the atoms of Carbon in the molecules of cellulose that gives wood its high strength. (These molecules are called, by chemists, 'long chain' molecules, because of their highly-organised, elongated and linked-together structure.)

Cellulose (and therefore wood) has, as I've just said, very high strength, which comes from the linked atoms of Carbon in its molecular chains. This amazing strength was shown way back in the 1960s: where an experiment was carried out at a major university, to prove just how incredibly strong wood can be. The experiment consisted of pulling apart two equal-weight strands: one made of European pine and one made of a high-tensile steel wire, using a special machine, called a 'tensometer' (which pulls things apart in tension). Then they measured the force that it took to snap each strand: and from this experiment, it was demonstrated that (weight for weight) wood is actually *stronger* in tension than steel!

However, the picture is not quite as straightforward as perhaps I've implied, when it comes to establishing exactly why and how wood is so strong. As well as knowing its chemistry: that is, that wood is made up of very strongly-linked molecules of cellulose, we also need to consider the *physical* structure of wood when we are looking at how it performs when we actually try to use it to do any job with. So I now need to tell you about the way wood is – quite literally – put together, in order that you can properly understand how best to use it.

1.2 Grain

Trees (and therefore of course, wood) have an inherent 'grain' structure. Grain is one of those common yet very over-used words, that laymen love to bandy about all the time when referring to wood in all sorts of ways: not least when describing its appearance (which is wrong). The word 'grain' has a very specific meaning: so it is important that I should help you to use this term correctly from now on.

First of all, what grain is *not* is that nice, wavy (or sometimes stripy or curly), and thus often highly decorative pattern which we so often see on the surface of a piece of planed or sawn timber. I wouldn't mind betting that most of you have used the word 'grain' in that context: and I suspect that perhaps many of you still do.

But that's not right. The correct name for this nice, decorative surface pattern on a piece of timber is the word 'figure' (see Figure 1.2). Figure can often

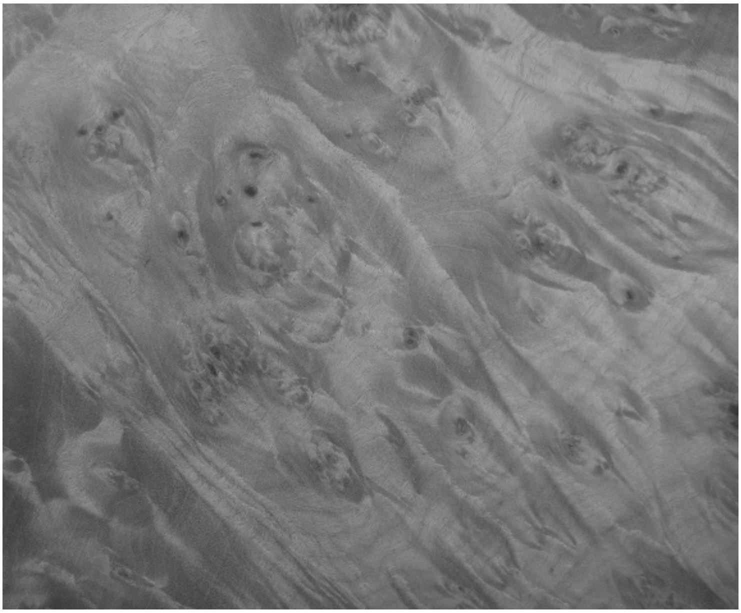

Figure 1.2 Example of figure (pattern) on the surface of timber

(although not always) show us what the *real* grain is up to; but it is decidedly *not* the same thing as the 'grain' of the wood. Sometimes, mis-reading the figure and thinking it is the grain can lead to physical damage: and sometimes it can lead to unnecessary rejection of the timber, for example when undertaking strength grading (a topic that I will discuss in a later chapter).

So, if it is not the pattern that you can see on the surface of the wood, then what exactly *is* grain?

Well, in my book (literally, as well as metaphorically!) the term 'grain' specifically relates to the direction of the wood fibres: that is, the way they grow up and along the trunk of the tree; or the way they are aligned along the length of a board or a plank of wood (see Figure 1.3). The principal vertical (or longitudinal) cells in the tree trunk – which for now, we'll refer to simply as 'fibres' – are relatively long (a few millimetres in softwoods) but they are very narrow, and they generally grow quite straight: along the main axis of the tree's trunk or stem.

These basic wood cells grow in the form of hollow tubes: which have a relatively thin cell wall, and with a hole (known as the cell 'cavity' or 'lumen') that runs all the way down their middle. In the living tree, this lumen or cell cavity is full of sap. But when a tree is cut down, the sap dries out (sooner or later), leaving the 'dry' wood essentially as a network of relatively long but narrow, hollow tubes, full of air. (I want to come back to the detail of the correct drying of timber later.)

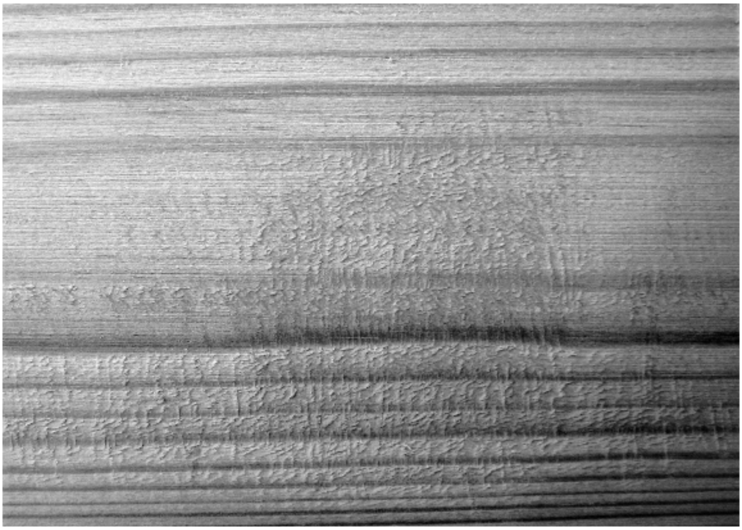

Figure 1.3 Wood surface showing grain (wood fibres)

These tube-like 'wood fibres' all point more or less in the same direction (along the tree trunk). So please remember from now on, that you should (and I definitely will!) only use the word 'grain' to mean one thing: 'the direction of the wood fibres'.

You should now see that, if we cut up a tree in a good and efficient way, such as in a sawmill, we will (hopefully) find that the wood fibres that were in the tree will line up so that they are more or less parallel with the long axis of the board or the plank of wood that we cut out of that tree. And if the cutting has been done well, then the grain will run pretty straight along the length of that piece of timber. I hope that you can now understand that those strong molecular 'chains' of cellulose (which, as I said earlier, make up the main substance of the wood-fibre walls) are then able to contribute their very high 'chemical-bond' strength to the physical 'along-the-grain' strength performance of the wood. So it is immediately possible to state one certainty about wood, and that is: 'the straighter the grain, the stronger the piece of timber'.

Unfortunately, though, there is always a plus and minus where wood is concerned (as you will see several times in the course of this book). The 'plus' is that the cellulose makes wood very strong when loaded along the grain. But the 'minus' with wood is that all of those long, thin wood cells that are in the tree or along the plank of timber, are stuck together, side-to-side, by a natural sort of glue, known as 'lignin'.

Lignin is a very complex chemical, whose structure is still not fully understood: but one thing that we *do* know about it, is that it is not very strong in tension. Therefore all of the wood fibres can be pulled apart relatively easily

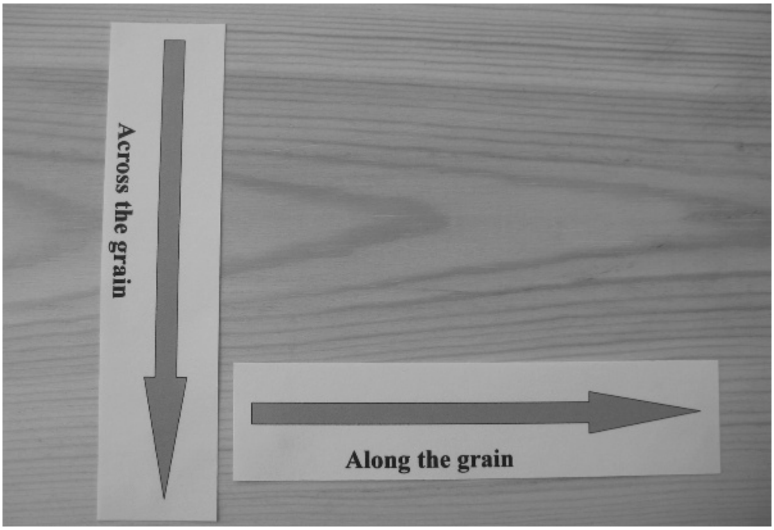

Figure 1.4 Directions, along and across the grain

in their side-to-side direction: and this sideways orientation is what we usually refer to as being 'across the grain'.

So, because of both its chemical make-up (the cellulose and the lignin) and its very particular physical structure (a whole bunch of long, very strong, tube-like 'fibres', which point along the line of the grain, but which are nonetheless stuck together relatively weakly) wood ends up being a very unusual material, in terms of its strength performance. We say that wood is *anisotropic* – which is a posh word, that basically means: 'it behaves differently under different directions of loading' – as I'll now explain.

Consider a brick, perhaps, or a block of concrete. Load either of them (by, for example, squashing them beneath the weight of a wall in a building) and they will resist that load – which is a compressive force – to the best of their ability. And, as you might reasonably expect, the brick or the concrete block is capable of resisting that load pretty equally, in all the three usual directions of width, breadth and depth. By the same token, a steel joist will be more or less equally strong when it is loaded in bending or in tension, in each of those three directions. In fact, just about all of our building materials, by and large, behave more or less equally in terms of their strength, in all of the different directions of loading. All of them, that is, except for wood: and that is because of wood's highly 'anisotropic' nature, which it gets on account of its special 'grain' structure.

Compared with our other building materials, wood really *is* very unusual. It is – as I've just explained – incredibly strong *along* the grain (and remember, that is along the direction of its fibres). But wood is very weak *across* the grain (that is, sideways, across both the width and the breadth of a timber member) (see Figure 1.4). This strength difference – taken as an average amongst most common wood species – is about 40 times greater in tension *along* the grain than it is *across* the grain. Now just think about that for a second: 40 times! That's an incredible difference in the behaviour of one single material: and one that is dependent only upon its direction of loading.

So that's why everyone who uses timber should always try to use it in a way in which they can capitalise on its long-grain strength; whilst at the same time, trying to minimise its cross-grain weakness. And they should do that by making sure that any imposed loads are carried as much as possible along the grain; and never, as far as possible, across the grain. However, strength alone is not the only property of wood that may be influenced by the direction of the grain.

1.3 Dimensional change in wood

Wood reacts with moisture: or to put it more accurately, it reacts to *changes* in its moisture content; which in turn are influenced very strongly by the relative humidity of the atmosphere that the wood may be used or stored in. I will talk about water in wood in a great deal more detail later; and I will explain the vital need to get things right, in Chapter 3. But for the moment, I want to touch on just one essential concept, that is related directly to grain orientation: and this is known as 'movement' (see Figure 1.5).

When wood loses or gains moisture from within its microscopic cell structure, the wood fibres will either come together a little bit, or shift apart a little bit, in their side-by-side relationship. (Don't worry at this stage *why* that happens: I'll explain it fully in Chapter 3. For now, concentrate on the fact that it really *does* happen.) Therefore, please take it as a fact that wood swells or shrinks, depending upon whether it respectively gains or loses moisture.

But this change of dimension (and that's essentially what it is) only happens to any appreciable extent *across* the grain. Wood does not swell or shrink to any significant extent *along* the grain (at least, not under normal circumstances of use and with 'normal', healthy wood). But neither does wood change dimension – in any direction – in response to any normal changes in temperature: so that is also a very useful property possessed by this unique material.

By now you should see that, as well as needing to know which direction of the grain is orientated, in order to use wood in its best (strongest) direction, you also need to know which way its grain is oriented, in order to make allowances for any swelling or shrinkage that may happen to timber components in service. So by understanding wood better, and by looking at it with a more experienced eye, if you can tell when you're dealing with timber in its 'long-grain' orientation, then you won't need to leave any expansion or 'movement' gaps in that direction. But if you find that it is being used in its 'cross grain' orientation, then you'll now know that you – or someone – must leave adequate movement gaps in that direction, to avoid later problems. (As I have said, the exact details of all this will be explained

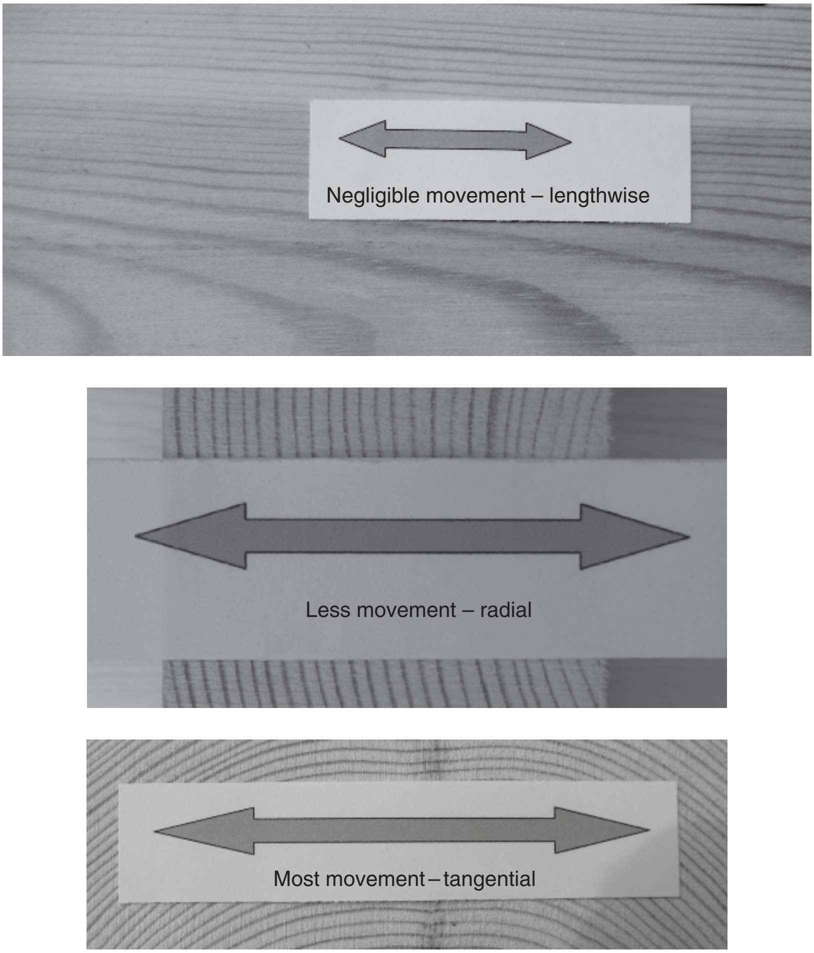

Figure 1.5 Movement

in Chapter 3 when we discuss Water in Wood: but at the moment, I am simply concentrating on the essential properties that are common to the grain of all wood, regardless of species.)

Before I leave the subject of grain – at least for the time being – there is another important property of wood related to grain orientation that I'd like to cover: and that is its ease or difficulty of machining.

Straight-grained timber (as you should now know, that is a piece of wood whose fibres are all nicely parallel with the long straight edge of the board or plank) will be much easier to machine than will be timber whose fibres 'stick up' out of the surface at an angle (see Figure 1.6). If they come up to the surface at a relatively steep angle (or sometimes even at several different angles!), then these fibres will more easily catch on the cutters of a planer, or on the teeth of a

Figure 1.6 Two pieces of timber: one straight-grained, showing smooth surface and another with a grain problem, showing a 'splintery' surface

saw; and so they will make lots of splinters and give the timber a very rough finish. That is yet another reason to appreciate just exactly what the grain of wood is, and to find out where it's going and what it's doing, within any piece of timber that you are hoping to use.

But that's not all you should know: not by a long way. Apart from its grain structure, there are a good many other things to know about wood in general, which can help you to understand its unique properties. So let's now take a closer look at the cut end of a log.

1.4 Heartwood and sapwood

In many wood species (but be warned: not in all of them, by any means) you may see a distinct change in the colour of the wood tissue at the tree's centre – or heart. This central zone of wood tissue is known as the 'heartwood' and it forms the oldest part of the tree. That's because trees grow bigger by adding on layers of wood on the outside of the stem, just underneath the bark (that's the reason why trees have 'growth rings' in the first place). So therefore, the *newest* wood tissue is that wood which has recently formed just under the bark; whereas the *oldest* wood tissue is to be found right in the log's centre – dating back to when the tree was just a sapling. After a few years (and of course, exactly how long this 'few years' may be depends on various factors: the tree's particular species, the local climate where it is growing, its local forest habitat, and many other things), this central zone at the heart of the tree trunk simply shuts down; and after that, the heartwood takes no further part in the day-to-day growing life of the tree.

But the wood in the heart of the tree doesn't rot, or do anything strange (unless the tree is very, very old and thus over-mature: in which case the heart may eventually rot out). Normally, the heartwood simply closes itself off and takes no active part in conducting the sap up the tree; and it then leaves that job to the outermost few layers (that is, the most recent few years) of wood-cell growth.

So what about this outer zone or band of wood tissue? Well, this is the bit of the tree that still plays a full part in its day-to-day life: and it is known as the 'sapwood' (because it conducts the sap, of course!). Please note that the sapwood of any tree is generally pale in colour and in many wood species it is visibly distinct and separate from the heartwood in any tree. But – importantly – the sapwood in any tree has precisely the same basic cell structure as the heartwood: because it will one day become heartwood; when and if the tree carries on growing outwards and closes down more layers, as it gets bigger and bigger if allowed to keep on growing (see Figure 1.7).

The principal difference between sapwood and heartwood is that the heartwood has been deliberately shut down by the tree, in order to conserve its energy. But this one functional difference is nevertheless vitally important to us as wood users, because it can affect the properties (and therefore the potential behaviour) of each and every piece of timber. Every single piece of timber can potentially contain varying amounts of either sapwood or heartwood within it – and this is especially true of softwoods, whose structure will be described in Chapter 2.

Sapwood – by its very name and nature – contains (or in dried-out wood, it once contained) the 'sap' – which is the juice of the tree – and which carries both the tree's essential foodstuffs and its waste products. Sap is (or was, if we're talking about dried-out wood) very wet, and it is very rich in carbohydrates – those sugars and starches – which other living things really like to eat. Other living things, that is, like moulds, stains and rots. And sometimes, even other things like beetles and 'woodworm' (which, you'll not be surprised to hear, is not actually a worm).

Therefore you need to be aware of the fact that sapwood – under any adverse circumstances, such as very high levels of moisture – will be extremely prone to discolouration, or worse, if the high moisture level continues for some time: because then it is seriously at risk of being eaten by decay fungi. (Not to mention insects.)

Heartwood, on the other hand, because it has been closed down by the tree, contains much less moisture and (depending on the species) it also contains much less appetising stuff for those nasty organisms to eat. But here's the rub: and I hope you noticed that I used that simple but all-important phrase, 'depending on the species'. Different individual species of trees can manage to do quite amazingly different things when laying down their heartwood.

Figure 1.7 Log ends, showing heartwood and sapwood

Some species (such as the White Oaks, or American Mahogany, for example) manage to convert the residues that were left behind within the heartwood into quite different and more complex organic chemicals – such as the Tannins in Oak. Or they may accumulate deposits within the heartwood, made up from the chemicals and other things that the tree picks up out of the ground – such as the Silica deposits in Iroko. And yet, some wood species do nothing of the sort; and so they have no fancy chemicals stored within their heartwood to help them resist potential attack by bugs, beetles and rot.

The heartwood of certain particular wood species will contain what we Wood Scientists call 'extractives' (because they can be extracted from the timber by means of solvents, or steam, or some other process). And the presence of these extractives will very often change the colour of the heartwood: sometimes making it a shade or two darker, or even changing its colour completely.

But the really clever bit, as I hinted at above, is that those timbers which contain particular extractives within their heartwood end up being resistant to (or sometimes, virtually immune from) attack by decay fungi, and in some cases, even by wood-eating insects. And when a timber has such chemicals or deposits stored within its heartwood that help it to resist being attacked and eaten, we say that the timber has some level of 'Natural Durability' – and this is another of the fundamental properties of wood, which varies from species to species.

1.5 Natural durability

Please be careful with this term 'durable'. In the context of wood, it does not mean 'hard wearing' or 'strong': it *only* means that the timber *may* have a level of resistance to (usually) rot, which can then help it to last longer under adverse conditions, such as when exposed to high levels of moisture for long periods. And I make no apologies for labouring the next point, because I need you to be really clear about it.

The heartwood of certain wood species *may* have a degree of natural durability (decay resistance): but this will be entirely dependent upon the particular species of wood (and *not* whether it is a 'Hardwood' or a 'Softwood' either – as I'll discuss in Chapter 2). And this Natural Durability will not be directly related, in any obvious way, as to how dark the colour of the heartwood is. For example, the heartwood of Oak is a light, honey-coloured timber, yet it is rated as being in the second-best rank of rot resistance; whereas Scots Pine heartwood is red-brown, but it is only in the fourth-best rank of Natural Durability.

Remember that the sapwood, as I stated just a little while ago, has no great amount of natural durability whatsoever. None. Not in *any* species. And that can sometimes give us quite a headache: because of the very real possibility of there being a fundamental difference in the durability of the sapwood (i.e. hardly any) and the heartwood (perhaps very high) *within the same piece of timber*.

So you will need to consider very carefully the conditions under which you are intending to use any specific timber. And after having done that, you may then have to decide that it is best not to use any of its sapwood; and so you may have to specify the *heartwood only*, of this timber that has a good natural durability. And that will mean that an additional process is needed, to remove all of the sapwood from the finished product. ('What about Preservation Treatment?' I can hear you asking. And I will answer that, I promise you: but in a later chapter. Remember, I'm dealing only with the fundamental properties of different wood species, in this chapter.)

I'm soon going to leave the properties of wood behind (though only for the time being, I assure you, since they are going to feature in every decision you make about wood from now on!). But before I do, there is one other basic property of wood that I'd like to mention, since it also affects the use of timber when it comes to applying preservatives. And in order to do that, I first need to tell you about another very special type of wood cell that is found within all trees: and that cell is known as a 'ray'.

1.6 Rays

I said, some pages earlier, that the main wood cells in a tree (and which I have for the moment referred to simply as 'fibres') are lined up vertically along the tree trunk, and – hopefully – more or less straight along the length of a piece of wood. And whilst that is true for the fibres, all trees need to have other, more specialised cells, which can help them to move the foodstuffs and waste products about, in and out of the trunk, in a horizontal direction as well. That is, from the point just under the bark to all the way inside: right to the very edge of the heartwood, within the 'active' sapwood zone.

And these horizontal cells 'radiate' out into the curvature of the tree trunk, just like the spokes do in a cartwheel: from the centre, towards the outside of the tree. That is why they are given the name 'rays' (see Figure 1.8). (By the way, I hope you can see that the heartwood was, once upon a time, sapwood itself, at an earlier stage in life of the tree: and so these ray cells can be found right throughout the tree trunk, and not just in the present-day sapwood.)

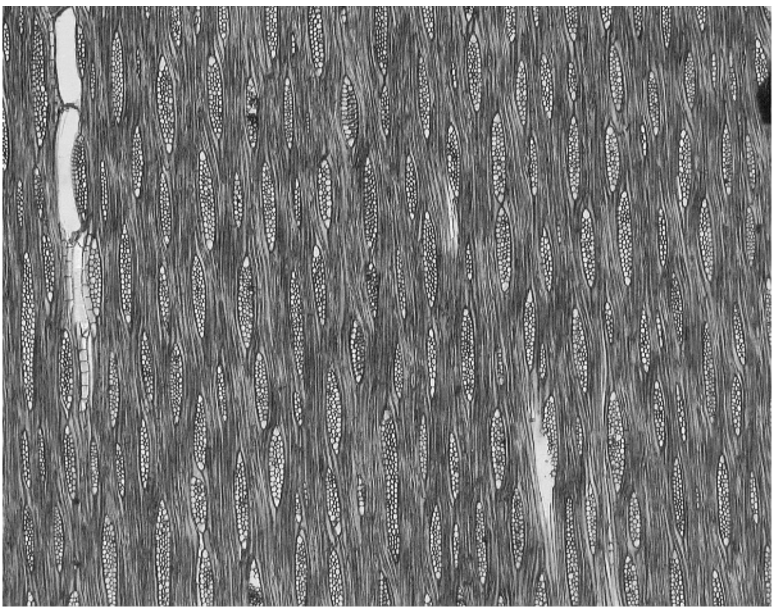

Figure 1.8 Rays, viewed end-on

As I have just said, these ray cells radiate out horizontally *across* the tree trunk, thus providing some very handy pathways in and out, in a sideways direction, *across* the grain. And now at this stage, I also ought to tell you the correct name for the two different versions of 'across the grain' – because they will become quite important in later chapters.

1.7 Radial and tangential directions

The direction across the tree trunk which goes the same way as the rays – that is, at right-angles to the growth rings – is called (for obvious reasons) the 'radial' direction.

But there is another way to travel across the grain; and that is by traversing a line which goes at right-angles to the radial: striking the growth rings across their curvature. Because this direction hits the circular rings at a tangent (remember your school geometry?) it is called the 'tangential' direction (see Figure 1.9). Please keep these definitions tucked away at the back of your mind: they will come in very useful later on, when we discuss moisture movement in greater detail.

But now back to what the rays help the tree to do. These ray cells, which radiate across the tree trunk, help to contribute to another property of wood, known as 'permeability'.

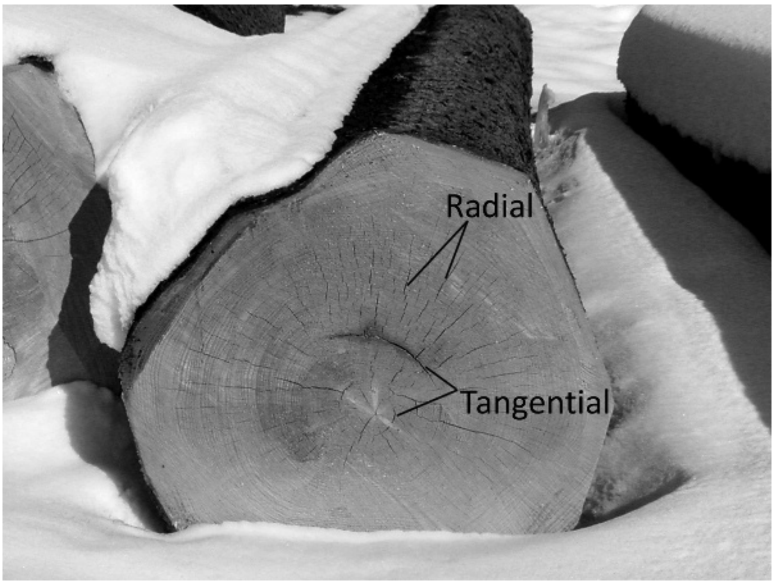

Figure 1.9 Log showing radial and tangential directions

1.8 Permeability in timber

The free movement of liquids in and out of the tree trunk is greatly helped by the rays. (There are also special openings – a bit like trapdoors – in the walls of the vertical cells; and these are called 'pits' and they are very important, especially in softwoods. But that's a bit too much like serious Wood Science for this book; so we'll leave things with just the rays, for now.)

Although we mostly use wood when the majority of the water from the sap has been removed (and I will cover Water in Wood in Chapter 3, as I said), there are occasions when we have a definite need to re-introduce a different type of liquid back into the wood cells. I am of course talking about Preservation Treatment. (I promised to tell you more about that later, also – and I will. But don't forget, we're still talking here about basic wood properties; and we're trying now to get to grips with the notion of permeability.)

So: imagine trying to pump some liquid back into the wood cells, without a series of helpful pathways to achieve it. Done that? Now imagine trying to pump liquid back into the wood cells, but this time with a whole series of wide-open pathways to help you to achieve it. Done that too?

Then you've successfully imagined the concept of permeability. All that this property involves is the ease or difficulty of penetrating the wood's surface and getting it to take up as much liquid (in this case a Wood Preservative) as we would like it to. And that is another basic property of wood.

But by now, it should come as no surprise to learn that some timbers are quite easy to treat, whereas others are frightfully difficult to penetrate. Some timbers are therefore classed as 'permeable' whilst others are classed as 'impermeable'. The varying levels of either the straightforwardness or difficulty in getting preservative treatment into wood, are subdivided into categories: ranging from 'easy to treat', to 'resistant to treatment' and right up to 'extremely resistant to treatment'.

As I've been saying to you all along: no two species of timber are the same, when it comes to their properties, or to using them: even to do exactly the same job with. Therefore, you really need to know what those differences between species are, if you're going to use wood successfully, time after time. So now, before I finally close this section on the Basics of Wood as a Material, I'd better just remind you what we've discovered about the properties of wood, so far.

1.9 Chapter summary

Wood is quite unlike most of the other materials that we use for building with. It is 'anisotropic' (it has unequal strength when loaded in different directions); and its principal strength lies along the *grain* – which I have defined as being the longitudinal direction of the main wood fibres. Wood gets this great strength (which, weight-for-weight, is stronger than steel) from the main constituent of its cell walls: which is a natural 'carbon fibre' called *cellulose*, and which has its extremely strong, long-chain molecules lined up along the main lengthwise axis of each long, thin wood cell.

This very special and unique grain structure of wood also affects its property of *movement*: which refers to the dimensional changes that occur in response to any changes in the wood's moisture content. Remember: wood only 'moves' (that is, changes its dimension) *across* the grain, and not *along* the grain: which is another unique thing about this material. (Steel and concrete, for example, expand by very large amounts, due to changes in temperature, and so structures made from these materials require expansion gaps every so often along the length of, say, a bridge or a railway track: whereas timber requires no longitudinal expansion joints at all.) And remember, too, that there are two different cross-grain directions: radial and tangential.

The nature of the wood's grain also influences how easily or otherwise we can work a length of timber. Straight-grained timber is much easier to finish well; whereas timber with wild or twisted grain will tend to machine more roughly and to splinter more easily; and thus it will require more time and effort to achieve a good finish. (You should realise too, that having a 'wild' grain will also result in the piece of timber distorting more, when it dries out.)

The next thing we learned about was that all trees have sapwood and heartwood: and it is the 'extractives' in the heartwood which sometimes (but not always!) help to give some timbers a greater resistance to rot and 'woodworm' attack. And we called this decay-resistant property its 'natural durability'. Another vital point to remember is that whilst the heartwood of certain species *may* have an increased level of durability, the sapwood of *all* species is *always* susceptible to such attack, whilst it is wet.

Finally, I told you about *rays* and the job they do within the tree trunk in a sideways direction. Since they form pathways in and out of the tree, *across* the trunk, they can either help or hinder us in impregnating timber with preservatives: and this property of any wood is what we call its 'permeability'. That's what makes different woods either easy to treat, or difficult to treat.

For the moment, that's enough about the basic properties of wood as a material. Now instead, it's time I explored the essential features of some of the different timbers that you're likely to use.