THE VORTEX OF LIFE
SUPPLEMENT AND SEQUEL

LAWRENCE EDWARDS
Introduction

I believe that the remarkable results which follow from a systematic daily study of the buds as described in Chapter 15 of the Vortex of Life, can be seen as a discovery of a hitherto unknown phenomenon in the natural world. In a realm of such subtle forms where everything is so new to us, we are bound to find ourselves surrounded by unanswered questions, and a very great deal of further research is needed. This book is published with three main purposes in view—firstly in the hope that it will stimulate some others to take up this work practically; secondly that other readers will be able better to judge the value of the work—and lastly to make a permanent record of the results achieved so far, which will include much that has been subsequent to the publication of the Vortex of Life, hence the inclusion of the Word Sequel in the present title.

Basically the method employed is to gather a number of buds each day from the species being studied (normally 20 is found to be adequate), to find their mean λ and to count this as the λ of the day for that species. Doing this daily, this allows us to see how this species is varying through the weeks and months. Obviously if this work is to be in any way valid, the most rigorous care must be taken to ensure absolute comparability in all the conditions of working such as the gathering of the buds, their mounting for photography, the measuring and calculation—day by day. The following chapters give some indication of the general precautions which need to be taken; but each species presents its own problems, and these will be dealt with in the chapters devoted to such species.

Gathering

The task of gathering the buds is the most sensitive and vital one which the worker faces. For this provides the basic data on which the research is to be founded. The need for strict consistency in one's method of working, from day to day, and from week to week cannot be too strongly emphasized. Any carelessness or thoughtlessness can render the whole research invalid.

The buds should be picked at the same hour each day. There is some evidence that there may also be a circadian rhythm at work here, it has not yet been properly investigated. If one is looking for evidence of a rhythm stretching over a matter of weeks, any interference by a daily rhythm must be carefully excluded.

Before starting work on a tree one should study it carefully. Buds growing on its north aspect may have λ slightly, but consistently, different from those on its southern. Bud size and maturity may vary from one aspect and one branch to another. In some species one must distinguish between terminal buds, growing at the tips of their stem and lateral ones growing out of the side of the stem. It might seem best to be very restricted in one's choice—to confine oneself, let us say, to only the largest terminal buds growing on one particular
chosen branch. But this means imposing a severe restriction on the number of buds available. However, by confining oneself to four or five chosen branches, picking a fixed number of buds from each per day, with a fixed ratio of terminal to lateral, keeping as far as may be a constant mean size of bud for each daily set, it is feasible to maintain strict comparability, while using a wide range of buds from different parts of the tree.

A large and mature tree will be able to yield 1500 buds or sometimes even a few more, in the course of a season, without showing signs of subsequent impoverishment; and the graph which follows from this will be impressive-looking. But often, if the tree is smaller, or many of its buds are inaccessible, we have to be content with much less. These shorter graphs should not be despised. They have been made with the same care and give valuable information, specially for determination of the phase-shift.

After I have used a tree heavily for one season I do not return to it for several years. We must be careful not to injure those organisms which we are studying.

When we come to the flower buds we meet somewhat similar problems with regard to comparability. One of the difficulties here is the shortness of the budding season. We need to start work as early as possible, at a time when buds are few to find, and we have to go far afield to find as many as we need. But buds growing in a sheltered situation cannot be compared directly with those on an exposed hillside. However if we are careful to take exactly the same proportion each day from each situation, comparability can be retained.

In Chapter 7 of The Vortex of Life a description is given of the considerable variations in which the flower buds undergo during the course of their development and opening. Once this is realised it becomes obvious that such work with the flower buds will not be valid unless some way is found of gathering the buds always at the same exact stage of their development, week by week. With great many species this is a matter of considerable difficulty, but a few grow in such a way as to make it comparatively easy. These are the ones in which the buds start their life totally enclosed in their green sepals, but during the course of their development at a certain stage thrust through to the open air. The point at which the coloured tip of the bud first just appears is an easily identifiable moment of development, and this is the moment at which they should be picked.

Avoid picking any buds which are growing near to the high tension cables, either overhead or underground, or near to any other possible source of an electric or magnetic field, unless you are specifically aiming to investigate the effects of such a field.
Measurement and Calculation

As soon as they have been gathered the buds begin to lose moisture, very slowly to begin with, and at an increasing speed later, and in the course of this they gradually change their shape. It is therefore necessary to photograph them immediately after they have been picked.

For measuring they are laid out, side by side, on a glass measuring plate. I place them lightly on a strip of transparent sticky tape, lying sticky side up, so they do not roll about while being carried to and from the camera. There is probably no one single 'right' way of laying them out, but whichever way is adopted it must be adhered to strictly throughout any series of observations. In order to ensure absolute comparability I divide my twenty buds into two sets of ten, the larger buds going into the first set, and the smaller ones into the second. The mean $\lambda$ for each set is found, and the $\lambda$ for the day is taken as the mean of these two means. Working this way one is constantly aware of how much the size (i.e. the maturity) of the bud affects its $\lambda$; species, and even individual trees, vary much in this respect. If the correlation between bud-size and $\lambda$ is at all marked it is a warning to use extra special care to see that the mean size of each daily set of 20 remains absolutely constant throughout the series.

Once a set is photographed each bud is lifted off the plate, rotated through 90 degrees about its long axis, replaced on the plate, and the whole set is re-photographed. Thus a set of ten buds gives us twenty pictures to analyse, and the figure for each day is the mean of no less than forty sets of measurements. Each bud is, as it were, seen from two directions of space. The photographs next have to be measured. The methods for this, and the subsequent calculations, are described in Chapter 5 and Appendix 3 of The Vortex of Life. They involve measuring the diameter of the bud at a series of equally-spaced levels along the long axis of the bud. These calculations are time consuming and tedious, and these days it is better to use a computer. On a following page we give a simple basic program LAM which does this calculation for us. LAM demands as input first the number of levels which we have decided to measure (7 is usually found to be adequate), and after that we have to input one by one the measured diameters starting with the lowest one (i.e. nearest the base) upwards. The computer then delivers to us, $\lambda$, as calculated by four different methods described in Appendix 3. If the form which we are measuring is a perfect path curve these four answers will of course be identical. But when working with living nature there will be small differences. The relative virtues of these four methods are discussed in that appendix. Apart from the morphological method, it seems that there is not much to choose between them, but of course whichever method is chosen must be adhered to throughout any given series of observations. In my own work I normally use the projective method, more for aesthetic reasons than any other; it goes in a very direct way straight to the heart of the whole processes we are using.
At this point we are faced with two alternatives. We may proceed by
the method known as ML (the mean of the lambdas). For this we calcu-
late A separately for each bud and find the mean of these 40 values,
each having of course been photographed twice. Or we may use
that known as LM (the lambda of the means). In this case we find the
mean value for the diameter at each level, giving us the dimensions
of what we may call the mean bud of the whole set, and we find the
\lambda of this. These two methods are both valid, and it does not very
much matter which one we use, but of course once a choice has been
made it must be adhered to for the whole of any one set of observa-
tions. It is found by experience that the values given by LM are nor-
ally very slightly below those given by ML, and that from day to day
and week to week they tend to be rather more consistent, i.e. less
erratic; and it is for this latter reason that I always use LM in my
work.

It is possible, simply and at very small expense, to construct a cam-
ena which makes the photography speedy and economical, dispensing
altogether with the use of negative material. It is illustrated at
the right of this column. L is a light en-
closed in a box with a translucent screen,
G, below it. S is a slot into which the
glass measuring plate on which buds are
laid out, will fit. H is a lens; a normal
camera lens works very well for this job.
P is a plate on which the photographic pa-
per will be laid. An image of the bud is
thrown on to the paper and is recorded on
it. The lens, H, needs to be moveable, up
and down, for the purposes of focussing,
and the plate, P, similarly for the purpose
of getting the right size of image. The
camera in my darkroom is about seven feet
tall, and with this one can get, within
reason, an image of any size one wishes.
The image, which is a white silhouette on
a dark ground, is crisp and clear and is
perfectly adapted for precise measuremenet.
Apart from the light within its light box,
one of the apparatus needs to be boxed in;
one simply works in a darkened room. The
taking of the photographs is easy and very
quick. The time consuming part is when one
comes to measure them afterwards! All my
work up to the summer of 1967 was done on
this machine which is why up to that date
most of it was done with only ten buds per
species (i.e. twenty pictures) per day.
This proves just sufficient for signifi-
cant results, but twice that amount is much
to be desired.
Since the summer of 1987 I have taken no more photographs. At that time I was gifted by the Margaret Wilkinson Research Fund with an electronic scanner which eliminates the necessity for photography. This remarkable machine not only does all one's calculations but also makes the measurements on which they are based. It consists essentially of a computer with a wide range of memory, an extra monitor screen and a T.V. camera. When the buds, mounted on their glass measuring plate, are put into the machine, an enlarged image of them appears on the monitor screen, and from there a message is sent to the computer giving, firstly, the x-y co-ordinates (as seen on the monitor screen) of the tip of the bud, then of the base of the bud, and thereafter of the left- and right-hand ends of each diameter, working from the base end upwards. This data goes into a fresh file for each bud, numbered from 1 to 20. The program, procedure, then goes from file to file picking up all the data, converts co-ordinate pairs into distances (i.e. levels upwards from the base to the tip, and diameters at each of these levels), finds from these the dimensions of the mean bud of the whole set, and delivers its λ, calculated according to the original projective method and also according to the regression method described in appendix 3.

When the machine arrived it was found to give results satisfactorily consistent with those which were already being achieved by the most careful hand measurement and of equal reliability and accuracy. But where the machine really scores is in its speed of working. By using it I was able to do between four to five times as much work in a set time as previously. After this nearly all the work has been done with twenty buds per day (i.e. forty pictures) instead of the previous ten, thus giving greatly increased reliability, whilst covering twice as many species. Program, L, also printed here, works from the same data but delivers the λ for each separate bud. I should like to record here my very great thanks to the Margaret Wilkinson Research Fund for the great help to the work that this has meant.

In the Autumn of 1991 the Fund bought another such machine, and this is now in use in the south of England. Just about the same time my friend, Graham Calderwood, of Campfield, Aberdeen, completed the construction of another similar machine, with which he has since been doing most useful work. So since the beginning of 1992 we can hope to have results from at least three independent observers separated by five hundred miles of countryside.
The Graphs

As far as it has been found possible and convenient all the graphs have been drawn to the same scale in order to make comparison between different years and different species easier; but necessarily there have been a few exceptions to this.

Two curves appear on each graph. One is made of thin lines joining those points which represent the actual daily observations as they were made. The other, thicker, curve joins those points which have been calculated by the method of three-day-means. We call this the 'trend curve' because it iron out the accidental variations which are always liable to appear in observations made in this way, but shows us the true general trend of the way that X is varying. The usual way of calculating three-day-means is to take the sum of yesterday's, to-day's and to-morrow's observations and to divide it by 3. But in order to be really fair one feels that extra stress should be given to to-day's result, over and above those of yesterday and to-morrow. So the method employed here is to take once yesterday's result, twice to-day's and once to-morrow's and to divide the sum by 4. This gives results which are very close indeed to those of the more ordinary method but, one feels, a somewhat truer picture. It is instructive to watch the difference between these two curves. Sometimes the thin line lies closely along the trend curve, indicating that the tree or species was growing consistently (harmoniously one might say?) at that time; but at other times it may oscillate wildly above and below the trend curve giving us the feeling that some kind of disturbing factor has entered into the growth of the plants we are studying.

On each graph arrows are planted showing us where dips (downward-pointing) and peaks (upward-pointing) might be expected in the curve according to past experience. The position of each arrow is calculated according to the moment of the lunar alignment with that planet which has proved to have connection with the species in question. Adjoined to each arrow is a number which shows the phase-shift at which this arrow has been placed. This phase-shift is taken from the phase-shift chart, printed at the end of this section, which shows the average phase-shift of all the species being studied, at this particular moment. The arrow is simply there to guide one's eye. To determine the actual phase-shift of the specimen being studied one must notice the position of the dip or peak in the trend curve in relation to the position of the arrow. If it coincides with the arrow then of course the phase-shift is the same as the number with which that arrow is labelled.
A Statistical Consideration

It is important to bear in mind that nearly all the figures involved in work of this kind are mean numbers, and by the very nature of the case such mean numbers can never be considered to have very exact values. In the course of the days and weeks, due to the random collection of the buds there are bound to be accidental rises and falls in our curve, which are not significant for the life of the tree. If we believe that we have found such a significant change, it is important to be able to know whether it is larger than any probable accidental change which may have been registered.

To do this we must keep a check on the general level of the standard deviation of our results. This standard deviation gives us a measure of how far the numbers arrived at by measuring our forty pictures of buds spread on either side of their mean value. Obviously if the spread is very large then the resulting mean value will be less reliable and the chances of accidental change will be all the greater. It can be shown statistically that in any such set of numbers, we can expect to find 95.4% of them crowded within the space of 2 standard deviations plus and minus of their mean value.

But we are not concerned here, directly, with the variation of the actual \( \lambda \) values of our individual buds, but rather with the variation of their mean values from day to day and week to week. Clearly we need a way to find the effective standard deviation of our mean values; and equally clearly, the greater the number of buds we are dealing with each day, the more reliable these means are likely to be. Statistically it can be shown that if \( s \) is the standard deviation of a set of \( n \) buds then their mean has a standard deviation of \( \frac{s}{\sqrt{n}} \).

We consider now the trend curve on our graphs. The accidental variations on this curve have been smoothed out by joining points which have been arrived at by taking the mean of three days' observations i.e. 120 bud pictures. Their standard deviation will therefore be found by dividing the standard deviation of the buds themselves by the square root of 120, for practical purposes, by 11. If we double this we find the spread plus and minus of the central mean value, within which 95.4% of our points ought to lie by probability. Any point lying outside this zone does so with 95.4% probability of significance rather than accidentally. That is to say that the points lying outside this zone probably number about 4.6% of the total. But in our work we are normally only concerned with variation in one direction. If on any particular day we are concerned to know whether a significant dip has occurred in the trend curve we are interested only in those points which fall below the limit set by the two-standard-deviation threshold, i.e. in 2.3% of the total. Therefore we can say that any point lying below this threshold does so with a probability of at least 97.7% And this, as we shall see later, gives us a good measure of the significance of our results.
The Phase-shift

The strange and unexpected phenomenon of the changing phase-shift and the method of its charting have been described in Chapter 15 of The Vortex of Life, and full details will not be repeated here. We should remember that the rhythm of the plants has shown itself, over the years, to be getting slowly and consistently out of step with that of the planetary alignments, the dips in the \( \lambda \)-curves coming earlier than the corresponding alignments. When the bud is responding 2 days early we say that it has a phase-shift of -2; clearly by the time that the phase-shift has increased to -14 the rhythms are 'on time' again and the phase-shift has returned to zero; 2 days before that the buds will have been responding 2 days late, and the phase-shift will have been +2, while half way in between these two times there will have been a moment when the phase-shift was \( \pm 7 \). Owing to the fact that the periods between alignments vary for different planets from about thirteen and a half to nearly fifteen days the matter is more complicated than this and as the work progresses more sophisticated methods of presentation will no doubt be needed; but by ensuring that the numerical value of the phase-shift never increases beyond 7 any inconsistencies are reduced to a minimum and the present simple method of notation can be a valuable tool for mapping the general form of the phenomenon.

On page 810 we print the phase-shift chart made to the latest date. Each point shows the phase-shift for a whole species in the particular season where it is marked. Owing to the fact that a phase-shift of -2 is of very nearly the same significance as one of +12, etc., each point, and of course the whole curve, appears in a series of positions along the vertical axis of the chart, but only the one in the middle needs to be considered. It will be a long time before all the complications of this phenomenon are understood but a few things can be said immediately:

1) The curve appears to be repetitive, i.e. cyclic.
2) The gradient is never positive, and almost all the time negative, i.e. the earthly part of the phenomenon is nearly all the time running a little ahead of the celestial part.
3) It appears to have a periodicity of about seven years.
4) The phenomenon seems to cut right across the difference between one species and another, and between one planet and another, e.g. the point representing Mars and the mighty Oak lies on the same curve as that for the Sun and the delicate Primrose.
5) The latest observations seem to indicate that the symmetry is not exact, the curve running downhill a little less steeply between the beginning of 1983 and the end of 1984, then between the beginning of 1990 and the end of 1991. The curve appears to have been horizontal about December 1982 and again in December 1989 indicating a period of seven years, but whereas the phase-shift had become about -3 by January 1985 it was fully -4 by January 1992 giving a period of only six and a half years. We must watch for the possibility that although this is basically seven year periodicity it may vary a little over and under that figure in the course of long periods of time.
Consideration of no 4 above which shows that planetary bodies are different from one another as Saturn, Mars and the Sun all seem to be treated alike by the phase-shift phenomenon has led to a doubt being expressed as to whether it will be possible to find a true celestial correlation for it, and to the suggestion that it might possibly be an effect of terrestrial origin which is superimposed on the astronomical one. One of the next important steps to take is to test this possibility. If it should prove to be true it would mean making a fresh phase-shift chart for each locality on the surface of the earth. For this reason, the phase-shift chart printed here contains only points arising from observations made at Strontian, and, until further evidence accrues, must be judged as valid only for that locality.

Except those labelled otherwise, every graph in this book was made near Strontian, and in all these the arrows mark the current phase-shift of the generality of buds at that time, as taken from this phase-shift chart. They are there in order to assist the reader's eye in judging quickly and easily just how accurately the species under consideration was conforming to the general behaviour. Clearly this could not be so for the graphs made at other places since no phase-shift charts have yet been made for them. Therefore in these other graphs the arrows have been put in, and labelled, at places which seem most appropriate to the behaviour of that graph. One day, if it is found to be needed, these arrows may assist in making a phase-shift chart for that locality.

The chart printed on page a10 is central to everything in this book and all the graphs need to be carefully studied in relation to it.
PHASE-SHIFT CHART
The Beech provides buds which are some of the most fruitful for this kind of work. A mature tree will bear, literally, millions of buds, and many of these are usually easily accessible. They are well adapted for accurate measurement, and they turn out to be good path curve forms, with MVDs usually between 1% and 3% and their λ-values have a satisfactorily low standard deviation to give accurate mean values. Nevertheless the most consistent results will not be achieved unless very great care is observed in their collection and handling.

A cursory examination of the tree reveals what, at first sight, seem to be both terminal and lateral buds. However if one returns to the same tree a few months later one finds that many of the buds which one had supposed to be lateral are now clearly terminal, growing out of their own little side stems. It is probably correct to say that in essence all beech buds are terminal but that at any particular moment some of them are not mature enough to show themselves in this form. Nevertheless these less mature buds are growing in the lateral situation and are subject to the restraints in form which are due to their closeness to the main stem, and it is not fair to compare them directly with the ordinary terminal buds. Therefore in this text we shall continue to refer to them as either 'terminal' or 'lateral'.

It is usual to find that the lateral buds give rather higher λ than the terminal ones. It is therefore essential, after an initial examination of the tree, to decide on a fixed ratio of terminal to lateral which one will pick each day, and to stick to this rigidly all through any one series of measurements.

The next point at which great care must be exercised is in the cutting of the buds from their stem. Most terminal buds will be found to have a small asymmetrical placed notch near their base, and this is a useful place at which each bud can be cut from its stem. If on an occasional tree this notch is not easily seen, then one can usually find a faint horizontal ring round the base of the bud where the cut can be made. The lateral buds usually do not show these things, and in their case the cut should be made just at that point where the bud emerges from the main stem.

The buds are formed of countless exceedingly thin scales, placed one over the other, in spiral formation. They are so thin that if one of them is carefully removed it does not make any significant difference to the form of the bud. However in the course of cutting and mounting it occasionally happens that one of these scales becomes loosened forming a bulge in the side of the bud, and it can then seriously deform the shape of the bud. In the course of the work one must always watch out for this, and remove the offend-
Another feature of these buds which has to be paid careful attention to is their curvature. Close examination of these buds is, I think, enough to convince one that their essential nature is to be straight. Nevertheless, owing to certain asymmetries in the process of their growth (for instance the light falls more strongly on them from above than from below), they do often tend to exhibit a slight degree of curvature along their long axis. On most trees this curvature is very slight indeed, but it is there, and since it affects their λ, it is important that all buds should be mounted in exactly the same way with respect to this feature. The surest way to do this is to lay each bud down on the glass measuring plate with its curve facing directly away from the camera. They will thus be seen on the photo or the monitor screen as though they are completely straight, in what I call their straight aspect. Then when they are lifted and turned through 90° they are seen in their maximum curved aspect and the mean between these two is the figure accepted. This is a more consistent way to deal with them than to have them in various intermediate aspects. In general a curved aspect tends to give a slightly higher λ than the straight. I have the definite impression that the curvature of the buds is increased when the tree is growing under the high tension cables but this is something which has not been subject to exact research yet.

A very important feature to deal with is the size, i.e. the length of the buds. On the same branch one will find larger and smaller buds growing side by side. By choosing with the greatest care the same kind of buds from the same parts of each branch, each day, one can ensure a good degree of uniformity, but for really consistent results one needs to do more than this. My method is to choose my 20 buds as carefully as possible, and then to take two extra ones, one larger than average and the other smaller. When the 20 buds are laid out on the measuring plate, they are first measured for length, and the mean length of the set calculated. If this mean length comes greater than the standard length which I have already adopted for this particular tree then the smaller of the extra buds is substituted for one of the larger ones in the set, but if the value comes out too small, then the larger extra one is substituted for one of the smaller ones. In this way one is able to keep the mean length of each daily set constant to within one fifth part of a millimetre. Only then is the measurement for λ proceeded with. This extra precaution definitely adds to the consistency of one’s results. In general one usually finds the smaller buds yielding rather higher figures than the larger.

If all these precautions are carefully followed the Beech buds will give us excellently consistent results, usually with a standard deviation of about 7% to 10%. Next we should consider the individual graphs.

Graph cl. Although in the two previous years I had acquired some evidence linking Saturn with the Beech this was the first time that I had been able to do a really long series on this species, and this
marked something of a turning point in the work, as this was the first time that the phase-shift was so strongly shown as to force itself on my attention. The arrows on this graph are showing the actual dates of the alignments, i.e. at phase-shift zero, because at that time I was not expecting the dips in the curve to come at any other times. However a glance at the graph shows that the dip which I had been expecting on October 12th had come about one and a half days early, and the following dip fully two days before expected. In fact during the whole of that Autumn the phase-shift varied between minus one and a half, and minus two days. With hindsight now we can see that this graph was already demonstrating the varying speed of change of the phase-shift, although I did not become aware of it at the time. By the end of February and in early March we see that the dips are coming two and a half and finally fully three days ahead of time thus showing a rate of change in the phase-shift of about a day in six months, a rate which has since proved to be fairly general in the middle part of the phase-shift chart.

Another point of interest that winter was the general form of the graph. We see a strong variation during the Autumn getting gradually weaker as midwinter approaches. From the middle of December until the first week of February, apart from one dip about January 13th, the fortnightly variation has almost completely ceased. Then in the Spring months the variation resumes, quite strongly, although perhaps not quite as strongly. The arrows on this graph are shifting the lines on the graphs which I had arrived at two years earlier for the Oak and the Cherry trees almost exactly the same general form portrayed. These similarities were so striking that this led me to believe that this is a quite general form for the midwinter months, so much so that I was led to give the phenomenon a name—the Midwinter Sleep. Since then, as will appear in the following pages, a number of Beech trees have been found which have contrived to retain their variation right through the winter, with considerable strength, although even with those I think the amplitude of the variation tends to get smaller round about the turn of the year. So I think that we must say that although the general form of Diagram c1 may be fairly general it is by no means universally so.

Any doubts as to what the phase-shift was doing were resolved some seven months later with the making of Graph c2. Here we see a firm fortnightly rhythm with a clear phase-shift of minus four days; in fact the dip of October 24th comes at nearer minus five. This means a change in phase-shift of fully a day, or maybe even a little more, in the course of the preceding six months.

One year following, graph c4, proved to be one of the most unsatisfactory ones that I have made. Starting very early in the season the buds were immature and still growing towards their final size and form; and I had no means of knowing whether work with them in this state would be at all valid. My circumstances during that period prevented me from working as regularly as I would have wished. The record is broken and rather thin. At the end of six weeks work all
I could honestly say was that the results could be considered consistent with a fortnightly rhythm of dips but could certainly not be brought forward as strong evidence to prove it. However, experience of several further years of work has shown that this graph was in fact foreshadowing future tendencies with remarkable truth. Compare this graph with graphs c8, c11, c14, c16 and c17 and one finds five independent trees in four different years all behaving in almost exactly the same way as the tree of c4. When one starts so early in the season, A starts high, and then undergoes a progressive period of decrease, punctuated by fortnightly dips correlated with the Moon/Saturn alignments. Examining these graphs with care one finds that they do not significantly differ from one another except in the phase-shift which, of course, varies from year to year. Of particular interest is a comparison of c16 and c17; these two trees, growing 150 miles apart, yielded graphs of almost identical form, the chief difference being that the Aberdeen tree gave a more lively performance, varying with greater amplitude.

A somewhat unusual phenomenon is shown by graph c7. This was at the time when the electronic scanner had just arrived and for the first time I felt able to observe two trees of the same species side by side. The first of these yielded graph c6, an absolutely typical result for the very early weeks of the Beech season. The other, c7, growing a few hundred yards away, in, as far as one could see, identical conditions, started identically, showing a well-marked dip on September 18th. However, from the last week of September this variation went into abeyance. The next two alignments are not acknowledged at all; but just beyond the middle of October, after a short period of some agitation, the next dip, of October 29th, is strongly shown.

A somewhat similar thing had happened the previous Spring,—graph c5. It started with a well-marked dip on January 18/19th, and another, not so well-marked, on January 31st. The following rise failed to take place satisfactorily and after a period of some agitation in the first week of February, the next dip failed to materialise completely. I had to be away from home after this, but on my return was able to resume work on this tree. Doing so I found, with relief that the next dip, of March 12th, was clearly shown. Since this rhythm had thus been called in question I selected yet another tree for observation at this time, just to make sure. The results from this are shown in the top part of the righthand section of c5. It had a somewhat higher A, but otherwise was behaving identically.

An even more striking example happened the following year, shown in graph c10. Here I was following two Beech trees, one down by the valley and the other on the hill, over a considerable period of time. The first is shown in the upper part of c10. Notice that the first dip, of October 2nd, is distinctly higher than any of the others. The usual period of decreased at the beginning of the season was just coming to an end. Thereafter the next three dips in the curve come impeccably, but then, again after a moment of some agitation, about November 20th, the usual rhythm ceases. The second tree shows the rhythm complete and unbroken right through to the end of the series.
This phenomenon of a tree which follows the planetary rhythms with quite strict accuracy for a considerable period and then, for no ascertainable reason, ceases to do so is one that I have only found with the Beech, and even there but rarely—in fact for three times in nearly ten years work. The fact that in two of these cases I was following a second tree in parallel, and that this further tree continued with the planetary rhythm unbroken, gives me to believe that the cause of this phenomenon is not celestial. I think we must realise that we are dealing with subtle and very delicate reactions here and there may be many interfering factors, both terrestrial and celestial which have yet to be explored.

Another fact of considerable importance is shown by graph c12. In some previous years (see for instance the Stitchwort and Geranium) evidence had been found to show that when Mars and Saturn are aligned with one another they have a mutually inhibiting effect, but it was not until the Spring of 1938 that there was a chance to test this with the Beech. Consulting the phase-shift chart we find that the shift for the generality of species in that spring was plus three and a half days. In the normal way therefore we might have expected a dip in the curve about February 1st to 2nd. However Mars was already approaching Saturn: there was in fact a dip but it came two days late and showed only feebly. A fortnight later, when the two planets were only three and a half degrees apart no significant dip was recorded at all.

Much stronger evidence was to come later. Graph c12 shows the result of a long series of observations almost throughout a whole winter. By calculating 7-day means one can smooth out all the local variations, and this has been done to produce the central continuous curve showing a very slow rise and fall throughout the whole period. Above and below this, and parallel with it, are dotted curves showing the two-standard-deviation limits for these buds. On any particular day, a dip coming below the lower curve has a probability greater than 97.7% of statistical significance. These limits are calculated for the heavy, trend, curve, not for the lighter one showing the actual daily observations. We see that between October 19th and the first week of February there were, during the periods when observations were being made, eight occasions when dips might have been expected, and on every one of these a dip was actually recorded, no fewer than seven of them reaching down to or below the two-standard-deviation limit. It is interesting to note that the two dips which fail to go below this limit both occur during the time which we have designated as that of 'winter sleep'. But on February 28th Saturn and Mars came into conjunction. The numbers on the graph show the distance separating these two bodies; and we see that from the moment when they are less than about five degrees apart no more dips are to be found. Indeed almost all statistically significant variations cease.

This is not to say that such variation as still seems to show is not real, but that it is so small that, with the frequency of observations which were being made, it could not be statistically verified. Had this been all that I had to go upon I would have been inclined
to consider the apparently residual variation in the graph as just 'noise' without any real significance. However I was at that time running another Beech tree similarly, in parallel with this one. The result of this is seen in graph c13, and it is very instructive to compare this with graph c12. Again we see that of the eight alignments which fall within the periods of observation between the middle of October and mid-February every single one is marked with a dip in the curve and again no less than seven of these dips fall well below the lower two-standard-deviation limit, the only exception being the dip of Nov 3rd. And again, as with graph c12, from the middle of February onwards there are no further dips coinciding with the alignments of Moon and Saturn. Furthermore it is noticeable that what variation remains stays for the most part well within the two-standard-deviation limits; little of it can really be said to be statistically significant. Nevertheless the surprising thing is that these two cases of residual variation are quite remarkably similar, so much so that one is driven to ask whether there is perhaps some significance here. We see dips, common to the two graphs, round about February 23rd and March 15th, and peaks on March 5th and 18th. The dips are separated by twenty days and even if they are significant cannot possibly have any lunar correlation. But the peaks are just thirteen to fourteen days apart and our attention therefore is bound to fall upon it. It happens that they coincide closely with alignments of Moon and Jupiter. One has to ask whether, once the influence of Saturn has been annulled, it would be possible to find another influence, from Jupiter, working softly in the background. Well, of course it would! But just two cases like this are certainly not enough to establish a fact. It is a possibility that has to be held in mind for future consideration only.

Just a year later we have a set of observations which gives a graph, c15, which is at first glance very similar to the two we have just been studying. The curve for the 7-day-means shows a gradual rise and fall. The first three alignments are strongly marked by dips and the fourth rather less markedly. Thereafter all significant variation again ceases. This time the interfering influence seems to be coming from Jupiter. In the last week of February Jupiter moved to within five degrees of alignment with Saturn and thereafter, for the remainder of the graph, stayed closely in opposition. It would seem that we have to enunciate the rule that Saturn works in this way on the Beech only when unencumbered by alignments with other heavenly bodies.

In the winter and spring of 1982 we had three observers working on this. Ada Ruth Dobson near Stroud in the south west of England, Graham Calderwood in Aberdeen some 500 miles to the north, and myself in Strontian, some 140 miles west of him, and also 500 miles north of Stroud. The preliminary results of dual working can be clearly seen in graphs c16 and c17. As has been already described on page 44 the very early development of the Beech buds had been followed in a whole number of previous years and had been found to run in quite a definite pattern. It is pictured in graphs c7, c8, c11 and c14. The earliest measurements show comparatively high values for $\lambda$. 
particularly at the beginning of September, and then, during the succeeding weeks this value undergoes a progressive decrease until about the middle of October when it reaches a more steady value, this decrease being punctuated by the usual fortnightly dips in the curve correlating with the alignments of Moon and Saturn. The Autumn of 1931 was no exception in this respect and examination of Graph c16 reveals a result absolutely typical of past years. It is unfortunate that illness prevented me from getting actual measurements for the last dip (October 13th), but the results for October 14th, 15th and 16th were enough to assure me that the dip had really occurred. Having had results similar to this in a number of past years it was a matter of very great interest to see what would eventuate from a different environment and a different observer. Graph c17 shows the result. Although at first sight it appears to be rather different, careful examination shows that this Aberdeen tree was in fact behaving very similarly to its sister tree growing 140 miles to the west,—a long progressive decrease punctuated by fortnightly dips which were almost simultaneous with those at Strontian. An unexpected difference was that the Aberdeen tree was more 'lively', the amplitude of the variation being much greater. The phase-shift for both places seemed to be the same, at about -3 days.

Later the same year we have, on graph c18, results for two Beeches in Strontian. Of the five dips shown, two, (on November 6th) came at a phase-shift of -4 days and those of December 30th would seem to be at about minus three and a half days, and this final result should probably be taken as correct for the end of that year. These results can now be compared with both Aberdeen and Stroud, on graph c19. The dip of December 6th does not show on the Aberdeen graph but is strongly marked on the Stroud one, although one day later than at Strontian. The dip of December 20th is clearly shown by all four trees.

Coming now to graph c20 we have a long series of observations on a Strontian beech. This graph is remarkably similar to those of some previous years; compare it with those of pages c12, c13 and c15. There is a long slow increase in $\lambda$, followed by the beginning of a decline towards the end of the season. I have marked, as before, the mean value obtained by taking 11-day means, and above and below it, in dotted curves the two-standard-deviation limits of 97% confidence. We see the curve coming well below the lower limit at each of the first three alignments and at no other time. On February 27th Mars approached to within 6 of Saturn, and the conjunction was complete on March 6th. We see the curve apparently approaching another dip round about February 25th, falling to do so and thereafter ceasing to show any further variation outside the confidence limits. It is of great interest to compare this with the results for a Beech taken in Aberdeen at the same time, shown in graph c21. Again we see a gradual rise from the beginning of the year, culminating about the middle of February. Again we see the fortnightly dips, although here the mean phase-shift would appear to be nearer -5 days than the -4 of graph c20. Again, although this was a different tree from that
of graph c17 it also shows the mark of greater liveliness, the amplitude of variation being nearly twice as large as at Strontian. This should also be compared with graph c22, of two further trees taken at the same time in Aberdeen. It was not possible to obtain such an unbroken record of these two trees but apart from the dip of January 4th/5th, which for some reason got displaced from agreement with all the others, this graph confirms in all respects the qualities seen in graph c21. The fact that this wider amplitude of variation appears in all of four separate cases prompts the question whether this quality ought not to be associated with the individual trees themselves, but rather with the locality in which they were growing; and this point must be born in mind with further research.

At this point we should remind ourselves that whereas in all the Strontian graphs the arrows mark the phase-shift for the generality of buds at that time, taken from the phase-shift chart, with these Aberdeen graphs it is different. The arrows are marked in at the points which seem most appropriate to the observations under consideration, and these may one day form part of a basis for making a phase-shift chart appropriate for the neighbourhood of Aberdeen. Such a chart, it is clear, would bear points at minus three to minus three and a half days for the Autumn of 1991 and -5 days for the Spring of 1992.

Thus we see that the correspondence between the measurements made in Aberdeen and in Strontian has so far been remarkably good, and the difference in phase-shift (almost negligible in Autumn 1991 and at the very most one day in Spring 1992) is not great enough to be certain of significance. However if this small difference continues consistently in future years it will have to be taken into account.

With the observations made at Stroud (the lower part of graph c19, and graphs c23, c24 and c25) the situation is not quite so clear. During the period from the end of November 1991 to the end of February 1992 when Mars moved into conjunction with Saturn, we have ten alignments to consider for these three trees and if we adopt a figure of -2 days as their phase-shift at this time, no less than eight of these alignments are represented by dips in the curve with a moderate degree of regularity; arrows have therefore been marked into the graphs at these points. However the curves show many other dips at points which cannot possibly correspond to any alignments. Indeed the overall impression one gets from these graphs is not of a 14-day but rather of a 7-day rhythm, the intermediate dips corresponding fairly regularly with the square aspects of Moon and Saturn, i.e. when they are 90° apart. Against this we have to set the fact that in ten years of work at Strontian, and also recently at Aberdeen, such a phenomenon has not been observable. It seems that at this early stage we can only return an open verdict— not proven; but that if it eventually proves significant to interpret these results in this way then we must attribute to Stroud, for the Spring of 1992, a phase-shift of -2 to -3 days. We can only come to a final decision as to what these results mean, on the basis of much more work in the south of England.
COPPER BEECH 1986

Graph showing the temperature trends for copper beech in 1986.

-5°C markers on January 18th and February 2nd.
BEECH  1987
BEECH 1988

Distance between $a^\prime$ and $b^\prime$

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<th>9°</th>
<th>8°</th>
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2.8
2.7

1 6 Feb 11 16
Oak

The leaf buds of the Oak provide excellent examples for this kind of work. They are, for the most part, very good path curves and are ideally shaped for precise and easy measurement. At first sight it would seem that they are hardly well adapted for our purposes, being usually rather small, and always very hard and woody. It is not easy to imagine them undergoing these subtle rhythmic variations which we are finding in other species; and each Autumn I am astonished afresh when I find them indeed responding again so strongly and regularly.

But there are difficulties. There are many different types of oak and several of these produce buds which are too small for accurate measurement. When one finds a tree producing good-sized buds all too frequently one finds that most of them are high up and quite out of reach. After only a few weeks of working the supply of accessible buds runs out, and one has to start work on another tree. This is why we have so many short graphs charting the behaviour of the oak.

In fact, when we come to actually work with them, we find these buds to be more, not less, strongly variable than most other species; and the range of $\lambda$ on any one day is often rather high. This introduces another problem which has to be coped with. In all the other species described in this book I come away from my gathering not having, for one reason or another, any idea whatever whether the average $\lambda$ of the day’s set is significantly high or low. This is partly due to the very subtle nature of the forms we are dealing with and, in the case of the flowers, to the fact that the buds are still hidden in their separae. Once the buds are mounted on the measuring plate, and their image is blown up large on the monitoring screen, I have, with the experience of years, a fairly good idea of the approximate value which the machine will deliver to me; but by then the die is cast: all subsequent operations are in the hands of the computer: nothing I can do will affect them. And this is how I like it. It is easy to have confidence that the complete objectivity which we must strive for is being maintained. But with the oak the differences between one bud and another are sufficiently great for me, at least sometimes, to gain some kind of estimate, approximately, of their $\lambda$ at a glance while they are still on the tree. How can I be sure that I am not, quite unconsciously, affecting the issue by selective choosing of the buds? The best way to cope with this is to take the buds from the branch, not singly, one by one, but by the twigful. It is simply not possible to assess, at a glance, the mean $\lambda$ of a set of fairly tightly-packed buds on a twig; and thus one comes away again without any knowledge of what one has gathered. I take each day a twig from each of four chosen branches and use from each twig the four largest laterals, and the single terminal buds which it contains, thus preserving a constant ratio, lateral to terminal, of four to one. Normally the terminal buds have a rather higher $\lambda$ than the lateral, so the preservation of such a ratio unchanged during a complete set of observations is important.

Graph 45 was made differently from the others in this book, being a record of measurements of a single bud photographed while it was
actually growing on the tree. It was a method which was very cumbersome to follow and which proved to have some serious disadvantages; and I have not followed it since. It did, however, enable me to make a long graph stretching right through the winter, the only such that I have been able to make for the oak, and it proved in a way historic in this branch of the work being the first one to show a clear planetary relationship. Especially during the autumn one finds the dips in the curve co-inciding exactly with the days of the alignments of Moon and Mars, marked with arrows. Notice how the variation almost disappears during the end of December and the first half of January, to be resumed, rather less certainly, thereafter. I had to be away from home during March, but returned in time to record the beginning of the final dip which marked the opening of the bud in April. Notice that all the dips co-incide punctually with the arrows except the last one (February 28th) which came one day early. Was this the first manifestation of the phase-shift? If so it went unnoticed by me at the time. After this all arrows shown on the graphs of the Oak mark Moon/Mars relationships.

The top graph on page 62 shows a typical Oak development during the Autumn of 1965. The generality of buds at that time were showing a phase-shift of about -4 days but this particular tree was running slightly ahead of schedule. Notice the tendency for a steadily increasing A during the period of observation, something that seems to be fairly common with this species.

Some four months later we have the lower graph of page 62. At that time Mars had just passed conjunction with Saturn and the numbers on the graph show the degrees which then separated the two planets. The general phase-shift had then increased to -5 days but we see that the 'expected' dip about February 28th completely failed to happen, and the following one came, rather uncertainly, nearly three days late. Just how close together these two bodies need to be to inhibit one another seriously is yet to be determined. The figure of 5 which I have been working with is an arbitrary one, and this graph goes to confirm the impression given by graphs 12 and 13 that at any rate the after-effects of such a conjunction last considerably longer.

The graph of 63 should be compared with that of 64, made at the same time. We see the Oak and the Beech behaving in opposite ways, the one increasing while the other decreases, which seems to be quite common behaviour for them early in the season. The right hand end of this graph is repeated in graph 64 showing the two- and three-standard-deviation limits for the probability of significance, and we see that the two dips, as well as the intervening peak, reach well to 99%.

Both in graphs 65, 66, the lower right-hand graph of 67, and 68 we notice the tendency for a general increase in A during the period of observation. This was something which was not expected, and, I think, hardly noticed at the time, but which later on, when one compares the results together, becomes very clear. Only in the upper
graph of page e9 do we see a case in which this phenomenon does not show itself. When one finds such mutual consistencies which, although unnoticed at the time, show themselves regularly year by year, it helps to give one confidence in the reliability of one's measurements.

If we look back to graphs e1 and e3 we see a very big difference in their quality. In the former, where the phase-shift was about zero, the dips in the curve are short and sharp, lasting barely more than a day each. In the latter, where the phase-shift has become as large numerically as possible, 17, the form of the dips has become open and gradual. The curve coming somewhat to resemble a sine curve. But when we come to graph e5, taken at a time when the phase-shift has again become numerically very small, 10 and approaching zero, the form of the dips has again become, seven years later, very short and sharp. This is so much so that the dips are almost obscured in the heavy trend, curve, and one has to look to the lighter daily lines in order to see that the dips are really there. There is not enough evidence yet to show that this is a general rule, but it may be. The graphs of the Primrose, taken over the same period, seem to show a similar trend. They are well worth comparing with these of the Oak. A somewhat similar, though perhaps less well-marked trend, can be seen in the case of the Stitchwort; see the upper graph of page 44. More research is needed here.

Graphs e7, e9 and e10 are all short, due to the sparsity of accessible buds on those trees, and perhaps no single one of them, taken by itself, can be considered highly significant. But taken all together they add up to a considerable body of evidence; in no single case did a dip fail to materialise at the time appropriate to the current phase-shift.

Graph e11 shows an Oak for the spring of 1922 and is interesting as it shows yet another case where Mars comes into alignment with Saturn. The alignment was exact on March 6th, and the numbers printed above the graph show the number of degrees of longitude separating these two bodies. The phase-shift has now grown to 4 and we see the alignment of January and February strongly marked by dips in the curve, but the March alignment, coinciding closely with the conjunction of the two planets, comes punctually but with very much reduced strength. This confirms well what has been previously observed; the alignment of these two planets inhibits their activity but does not always completely eradicate it. We compare this with the graph of c20 where we see the effect of this same conjunction on the working of Saturn.