rapidly at this time and are usually strongly-rooted one month from the date of insertion.

Once rooted the cuttings are hardened off; we like to lift and pot just as the terminal bud begins to show signs of movement. They are then placed in coldframes under shaded glass until established, when the glass is removed. At the end of the first flush of growth the plants are stopped to encourage side branch. As with rhododendrons, vine weevil can be a serious problem in the pots and aldrin is used as a control.

LIGHT INTERLUDE — PHOTOPERIODISM

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The title of this talk is taken from the chapter heading of a book that I have just written but which has not, I am afraid, yet found a publisher. The book deals with *inventors;* not so much what they invent but the manner in which their minds work and how they come to have their inspirations. One of the points I try to make is that the inventor's mind is quite unlike that of, say, a designer or a research worker. A designer may be a very clever fellow indeed, as also are research workers such as biologists and chemists, but they suffer from one great fault which absolutely precludes them from being inventors . . . they cannot see the wood for the trees! Examples are given below to illustrate this allegation and it so happens that they are all about photoperiodism, hence the title.

Since photoperiodism was discovered in 1911, thousands of researchers have studied the effect in detail, making painstaking observations on hundreds of thousands (if not millions) of plants to determine whether they are long-day plants or short-day plants, or to study the effects of night breaks, etc. I have recently read two very erudite books on the subject, both by English authors; Harry Smith (Phytochrome and Photomorphogenesis, — McGraw-Hill, 1975) and Daphne Vince-Prue (Photoperiodism in Plants, — McGraw-Hill, 1975). They both quote about 500 references and Harry Smith actually draws attention to the fact that there were some 2,000 papers on the subject, so it can hardly be said to be an uncharted sea. It would appear that very clever people have now isolated the actual element responsible for performing the act of photoperiodism, — a molecule called *phytochrome.* Like other complex organic molecules, such as *chlorophyll* and the hormones, there is every

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chance of being able to synthesise it artificially, although I'm not sure what good this will be to anybody.

Now, the main point about phytochrome is that the molecule can take two forms: it "flip-flops" from one form to the other under the influence of particular narrow wavebands of light; "far-red" makes it take one form and "red" makes it take the other. One mode *initiates* certain biological responses and the other mode *inhibits* biological responses; i.e., it acts as a switch. There is no "in between" state; it has to be one or the other. Naturally, the researchers have done countless experiments to prove that this is so, subjecting different plants to sequences of far-red and red lights, finding the exact wavelengths to which they are sensitive and observing the subsequent biological responses, not only of bud initiation but other things like dormancy of seeds, leaf fall, etiolation, etc. All are dependent on the mode of the phytochrome, i.e., whether it is P_r or P_{fr}.

This is most exciting and fills in most of the detail of what was known in the general sense about short-day and long-day plants but nobody seems to have asked the question: how *long* is a day . . . or night? That is not strictly true; Dr. Vince-Prue got near to asking the question when she headed a sub-section, "How dark is dark?" but it turned out to be a dissertation on whether passing clouds had an effect on day-length or whether moonlight reduced the effective length of the night. In other words, she was concerned with the *intensity* of the light source and it didn't seem to worry (or even surprise) her that the plant didn't appear to notice variations in intensity . . . it made up its own mind when day began and ended!

So when *does* day begin and end? You can look it up "officially" in Whittaker's Almanac, of course, but the plant hasn't got this advantage. Also, the transition from day to night, and vice versa, varies enormously in different latitudes. At the equator, it is very rapid, lasting only a few minutes. As we move towards either Pole, the "twilight" period gets longer until, at the Poles, there *is* no 24-hour day . . . their "day" lasts for 6 months, followed by a 6-month "night." Apart from this extreme, plants seem able to cope with twilights ranging from minutes to hours and, as our blinkered researchers have pointed out, it is not a question of light intensity. The plant behaves exactly as though the daylight were switched on and off . . . just like an electric light.

It is at this point that the difference between an inventor and a researcher begins to show! I am an electrical engineer and the moment the switching of an electrical circuit is mentioned, I cannot help but visualise the switch itself. I won't go into technical reasons but the fact is that the "make-and-break" action of a switch has to be very fast, however slowly you move the operating lever, or knob. It is known as a "toggle" action and there are many ways of achieving it; the type you find in a thermostat is probably familiar to you but the simplest is any spring that is in an unstable position. It doesn't matter how slowly one moves the operating lever, the spring can only occupy one of two positions . . . it cannot rest "in between." And that is precisely the behaviour of our phytochrome molecule . . . it can be P_r or P_{fr}, but nothing else.

Putting the sun in the place of the operating lever, we can see that it moves fast (in terms of change of intensity) at the equator but more slowly at latitudes towards the Poles but it is *not* the intensity that causes the switching action. What, then, is it? You have to get up pretty early in the morning to discover the secret; yes, it is the beautiful red *dawn* (or red *sunset*, if you're the lazy type). As the sun's rays appear at the horizon, they start by having to pass through a very great depth of the earth's atmosphere and this has the maximum filtering effect on the shorter wavelengths, leaving only the *far-red* band of light. As the earth rotates (i.e., the sun "rises"), the rays have less depth of atmosphere to penetrate and the far-red gives way to ordinary *red*. This is the trick; the *change*, in that order, from a predominance of *far-red* to a predominance of *red* in the spectrum. Nothing to do with intensity. The reverse happens at sunset, of course; the *red* burst precedes the *far-red*, causing the phytochrome molecule to switch from P_r to P_{fr}, where it remains until morning. Thus, the plant has measured daylength whether it has a twilight lasting a few minutes or several hours.

Lastly, let us take a look at what clever man has done with his brilliant knowledge of photoperiodicity. To those whose interest is in horticulture, the obvious use is his manipulation of daylength to produce all-year-round flowers and fruit, i.e., "out of season." Personally, I can think of no more depressing sight than acres of absolutely uniform blooms at the "wrong" time of the year. The real wonder of this world is the infinite *variety* of plant life, brought about by the variations of environment over the world's surface and the ever-changing seasons. Does it not seem strange that man should use his cleverness to obliterate this glorious diversity and achieve dull uniformity?