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BILL FLEMER: Thank you very much, Ted. As you can see this is a rather complex subject and one which is not conducive to being handled by a 10-minute talk.

Our next speaker is well known to us all — Dr. Sidney Waxman. Sid is going to discuss another aspect of the environment which we must manipulate in propagating plants, and that is light, its duration, its quality and its intensity; Sid.

LIGHT: DURATION, QUALITY, INTENSITY

SIDNEY WAXMAN
University of Connecticut
Storrs, Connecticut

Before discussing any of the various aspects of light or its influences on plant growth, it must first be understood that there are three basic factors: light intensity, light quality and light duration which all interact with each other. The overall influence on vegetative growth, flowering or some other response is the product of these three factors operating simultaneously. There are many other factors that may alter a plant's response to light; the most important one is temperature.

I. LIGHT INTENSITY

Jan Ingen-Housz, in articles dating back to 1779, was among the first to recognize that light was an important factor in photosynthesis. He reported on experiments in which he found that "plants purified the air only in light, whereas in the dark the same tissues made the air impure". He also noted that this process became more active with a higher intensity of light and that under heavily shaded conditions "the plants acted upon the air just as animals." In 1800 it was first considered by Jean Senebier, that the oxygen given off during photosynthesis came from the carbon dioxide absorbed by the plant. Senebier also reported, when using stained glass of various colors, that it was the red rays of the spectrum that were chiefly effective in the photosynthetic process.

In 1804, Nicolas de Saussure, in his classic work "Chemical Researches on Plants" showed that water was fixed in the plant at the same time as the carbon and that this resulted in an increase in the plant's weight (7). He suggested that the process was probably of some nutritional value to the plant. More recently, radioactive isotope techniques have shown that all the oxygen released in photosynthesis is derived from the water molecule. It took a long time for the early botanists to recognize the significance of photosynthesis. This was probably due, in part, to their lack of interest in or knowledge of chemistry and, in part, to the great emphasis that was then placed on the naming and classification of plants.

One of the first to recognize that photosynthesis was a fixing of light energy was Robert Mayer who reported in 1845 that "plants form a container in which the fixed immaterial rays of the sun . . . . . . are stored" (33).

Over the years it has become apparent that the photosynthetic process is a highly complicated one and that it is the primary source of all organic substances.

In rooting cuttings we are concerned with providing an environment that will keep them in a healthy condition until they are lined out. The early propagator needed considerable experience and knowledge in the area of plant growth to furnish such an environment. He had to allow enough sunlight for photosynthesis and yet not so much that the cuttings wilted; a temperature high enough to encourage root initiation, but not high enough to cause an excessive rate of respiration and thus weaken the cutting, and a level of moisture both in the medium and in the air that would provide water as well as oxygen to the cutting. In creating this environment, he had to consider the levels of stored carbohydrates in the cutting, the stage of development at the time the cutting was taken, and the amount of leaf area it should retain. Another factor that would determine the amount of sunlight needed by a particular species is its ability to carry out photosynthesis under low light intensities. Some species such as the flowering dogwood, hemlock and American holly are able to photosynthesize at low intensities while others like the red pine, paper birch and sweet gum, are intolerant of low light intensities and would suffer if held there over a period of time (20).

The contemporary propagator, however, can enjoy the benefits of the mist system. He can now provide more than enough light to improve the carbohydrate content of the cutting without fear of its wilting. Hess demonstrated in 1956 that, under mist, cuttings propagated under full or nearly full sunlight actually accumulated seven times more sugars than cuttings placed under double glass and shaded (16).

The plastic tent, on the other hand, requires considerable shading to prevent excessively high temperatures from occurring. For rooting under plastic it may be wise to limit the species to those that are shade-loving, i.e., those that can carry on photosynthesis efficiently under relatively low intensities.

II. LIGHT DURATION

The duration of light or photoperiod has a considerable influence on the pattern of growth of a large number of trees and shrubs. It plays a part in the propagation of seed as well as of cuttings.

Although reports of daylength influencing plant growth were written as early as 1891 by Liberty Hyde Bailey (1) and 1914 by Klebs (19), it was not until the more comprehensive report of Garner and Allard in 1920 that it was clearly shown that the number of hours of light and darkness a plant received daily could actually effect its ability to flower (14). Since then there has been a considerable number of papers written on the various effects that photoperiodic treatment has on animals as well as plants.

Next to the regulation of flowering, the most dramatic influence daylength has is on the control of vegetative growth, i.e., on the induction and prevention of dormancy.

Long photoperiods prevent or delay the onset of dormancy and thereby encourage vegetative growth while short photoperiods either induce dormancy or merely slow down the rate of growth.

Several reports have been published in which various species were placed into certain categories according to how they responded to long and short photoperiods (4, 28, 40). For a great many species, short days will stop growth and long-days will produce continuous growth. Some of the species that fall into this category are *Weigela florida, Cornus florida, Cornus kousa, Betula paprifera, Acer palmatum,* and *Populus sp.*

Some species such as *Quercus borealis* (27, 40) and *Ilex opaca* (27) do not grow continuously but produce a series of flushes of growth under long photoperiods and under short photoperiods stop growth. However, not all photoperiod-sensitive species fall neatly within these categories. The European cranberry bush *(Viburnum opulus)* could fit into either the first or the second category depending on how long the long-day treatment was. If they were given 15 hours of light daily, they would grow in a series of flushes each of which would end with the development of a dormant terminal bud (40). The frequency of the development of the flushes would increase with the increase in the number of hours of light. The flushes occur more frequently under an 18-hour-day than under a 15-hour-day. Under continuous light, there are no obvious cycles of growth; no dormant terminal buds develop, and growth appears to be continuous (40). Such species as *Juniperus horizontalis* and *Thuga occidentalis* fall into a third category in which short photoperiods do not stop growth but reduce its rate. With these species, growth occurs under all photoperiods from 9 to 24 hours, but the greatest amount develops in the longest daylengths.

Although grouping various species into such categories is convenient, it is not accurate, There are many environmental factors which interact with the photoperiod and, consequently, could cause some confusion as to which category a particular species fits into.

It is not uncommon to hear of propagators, as well as researchers, who have experimented with photoperiodic treatments, and have come forth with different and sometimes conflicting results. The author, after having experimented with various light treatments on woody species for several years, all of which were carried out in greenhouses, decided to run a series of tests in the field. In the greenhouse, long photoperiods usually brought about spectacular increases in growth, while short photoperiods prevented it. Differences in growth between long-day and short-day-grown plants were sometimes tenfold after one year's treatment. In the field, however, there were hardly any differences in growth among the treatments. The plants given natural daylengths grew about as well as those given long-days. What happened was totally unexpected. The plants given light during the night were expected to continue growth long after the natural day plants became dormant, but they didn't because the night temperatures were very low. The mean night temperatures were from 50° to 60°F during the summer months of 1958 and 1959. There were no appreciable differences in growth even though the light treatments were continued through October, but there were differences in survival the following spring. Most of the species given continuous light or flashing light were injured or killed outright during the winter. The group that received natural daylengths had no serious winter damage. Apparently, the long-day treatments did have an effect on the plants, but the low temperatures that prevailed prevented their expression.

In another test, weigela plants were grown in four greenhouses having minimum night temperatures of 50°, 55°, 60°, and 65° F.There were considerable differences in the rates of growth among the groups of plants, all of which were illuminated with continuous light (Table 1). The weekly rate of growth at a minimum temperature of 65° F almost doubled the rate at 55° F.

Another factor that can be the cause of conflicting data is the origin of the species being tested. Vaartaja, in 1954, reported that he obtained differences in the growth of seedlings of *Alnus incana* (L.) under identical photoperiods because they came from two widely separated latitudes (34).

Table 1. **Effect of temperature on the rate of growth of weigela exposed to continuous light.**

[1]Temperature (degrees F.)	Growth (cm per week)	Number of leaves produced per week.
65	8.12	2.10
60	6.65	1.96
55	4.13	1.68
50	2.45	1.40

[1] Minimum night temperatures.

A. **Critical Daylength.** In determining a particular species' response to daylength, the question arises, what is its critical daylength? In other words, what is the demarcation line in time between a long-day and short-day? An experiment was conducted in which four groups of weigela plants, all in active growth while under continuous light, were transferred to photoperiods of 8, 12½, 13, and 13½ hours. The plants in the eight hour photoperiod produced two pairs of leaves and then became dormant after 18 days. It was easy to determine that the terminal was becoming dormant because the two uppermost leaves would always recurve at this stage. The plants in the 12½ hour photoperiod produced a third pair of leaves which recurved on the 21st day. In the 13 hour photoperiod four pairs of leaves developed, the last pair recurving on the 23rd day. The plants in this group, however, did not remain dormant because two additional pairs of leaves were produced, each of which recurved. By the 48th day the plants finally became dormant and remained so with the development of dormant terminal buds. The critical daylength for weigela probably is close to 13 hours, for at 13½ hours, leaf development continued long after the experiment was terminated. The fact that a weigela will stop growth in a 13 hour photoperiod and continue to grow in a 13½ hour photoperiod suggests that the plant can measure the length of day or night with an accuracy of 30 minutes or even less.

For most species subjected to various photoperiodic treatments, continuous light appears to be the most effective. Wareing, however, has demonstrated that the most effective daylength for *Pinus sylvestris* was 20 hours (35). He found that seedlings of this species grew taller under 20 hours of light, and four hours of dark than either 22 or 24 hours of light.

Long photoperiods can be provided in various ways:

1. Natural daylength plus artificial illumination to accumulate a total of approximately 14 hours or more followed by darkness for the remainder of the day.

2. Natural daylight followed by the dark period which is interrupted with two to four hours of light during its mid point, e.g. 10 pm until 2 am.

3. Natural daylight followed by the dark period which is continuously "flashlighted", i.e. illuminated with brief exposures of light throughout the night (42).

B. Rates of growth in long photoperiods. Many species can be grown continuously under long photoperiods in a greenhouse without the need for chilling temperatures to break the "rest period". *Cornus florida* (39), and *Betula paprifera* (unpublished), have been maintained in continuous growth for more than 18 months without having been chilled, The dogwoods during their most rapid period of growth grew at the rate of ⅜ inch daily, while the paper birches grew at a rate of ¾ inch per day. Seedlings of *Acer palmatum* were variable in their rates of growth. Some of the most rapidly growing ones maintained rates of ½ inch per day.

The pattern of growth was especially whip-like for the Japanese maple and the paper birch. Plants growing steadily over long periods of time at these rates usually require staking. Not all daylength-responsive species can be grown continuously, however. Some species will eventually set a dormant terminal bud after a certain period of growth. Wareing reported that seedlings of *Pinus sylvestris* and *Acer pseudoplatanus* responded well to long photoperiods but eventually formed terminal resting buds even while under continuous illumination (35).

Newly-germinated seedlings are relatively slow in their response to lights. The paper birch seedlings, for example, grew rapidly only after the plants were about 4 - 8 inches tall. Probably the young seedlings' food reserves were not sufficient to support a more rapid rate of growth.

C. Germination of seed. Another aspect of the photoperiodic influence on plant growth is the effect it has on the germination of seed. Ingen-Housz and Senebier, near the end of the 18th Century, wrote of the possible effect of light on seed germination (2). It has since been definitely proven that light does regulate the germination of many seeds. A paper published in 1908 by Kinzel records over 600 species of seed which were found to be light sensitive (18). Since then a considerable amount of work has been published mostly concerning the effect of light on the germination of seeds of herbaceous plants (6, 11, 12, 13). Relatively little research has dealt with the germination of ornamental trees and shrub seeds. Black and Wareing reported that *Betula pubescens* seeds could be germinated without chilling provided they were exposed to long photoperiods when held at a temperature of 59° F. At this temperature 95 percent of the seeds germinated in a 20-hour photoperiod, while only 30 percent germinated in an eight hour photoperiod (3). They might thereby be classified as long-day seed except that raising the temperature from 59° F to 68° F changed their response. At the higher temperature they germinated equally well in long or short photoperiods (3). Even a single exposure to light will cause them to germinate at a temperature of 68° F. If, on the other hand, the seeds are kept in darkness, germination will not occur unless the seed are first chilled for three to four weeks at 41° F (37).

The eastern hemlock also changes its critical photoperiod with changes in temperature. At 70° F the most effective photoperiod for germination was 8 to 12 hours, while at 80° F 16-hour photoperiods were most effective (32). Both the birch and the hemlock seed offer a good example of how temperature can interact with the photoperiod.

The germination of umbrella pine *(Sciadopitys verticillata)*differs from most other photoperiod-sensitive seed studied as of this date because it germinates most rapidly and at highest percentages in short photoperiods or darkness (40, 41).

D. Photoperiodic influence on the induction and breaking of dormancy and related phenomena. Long photoperiods can break dormancy in addition to preventing its onset. Many species that become dormant under natural conditions during the summer can be forced to renew growth by exposing them to long photoperiods. This can be accomplished provided there are functional leaves present (40).

Breaking dormancy in the autumn, however, would be very difficult because the buds would be in deep rest and would require a period of chilling temperatures before their rest could be broken. There are a few exceptions to this; some species in deep rest can be induced to renew growth without chilling. Wareing reported that unchilled buds of *Fagus sylvatica, Betula pubescens,* and *Larix decidua* could be induced to grow by exposing them to long-days (37). Bud-break of rhododendron also appears to be determined by the photoperiod (9).

The shortening daylength that occurs in late summer and fall is one of the most important environmental factors that bring about the induction of dormancy. Along with the stoppage of vegetative growth, short days have been found to bring about aging, fall coloration, and abscission of the foliage (15, 27, 29, 40). Daylength, too, has a strong influence on the growth of conifers. Long days have been reported to increase stem growth, needle length, and growth in diameter, i.e., increased development of early wood (22).

Winter hardening is another condition attributed to short days. Moshkov (25), in 1935, reported that artificial short photoperiods could bring about winter hardening provided it was done at a particular time. He reported that *Robinia pseudoacacia* of southern origin was regularly killed by early frosts in northern Russia unless it was given artificially short photoperiods. He found that 20 days of short-day treatment could increase hardiness considerably, provided they were given during July and August. In September, the 20 short-days were not effective because the 40° F temperatures that prevailed then were too low to permit a photoperiodic response (25). Irving and Lanphear recently reported that hardiness was induced in *Acer negundo, Viburnum plicatum* var. *tomentosum,* and *Weigela florida* by short photoperiods followed by low temperatures (17). They also found that hardiness could even be induced under long-days and natural fall temperatures if the leaves were first removed. This latter treatment, however, was not as effective as short days with leaves intact.

E. Effect on root initiation. Relatively little has been published concerning the effect of daylength on root initiation of cuttings. Moshkov and Kocherzhenko reported that long days caused an increase in both the speed and numbers of roots produced (26). The author found that the percentage rooting of *Salix blanda, Cornus florida* 'Rubra', and *Weigela florida* was similar in all photoperiods. However, the numbers of roots produced per rooted cutting were much larger under long-day than under short-day treatment (40). He also found that these differences occurred only on cuttings taken in the spring and early summer from actively growing shoots. Cuttings of *Cornus florida* taken late in September from dormant wood did not exhibit any differences in rooting percentage or in numbers of roots in either long or short photoperiods (40).

Lanphear and Meahl (21) made comparisons of the rooting of cuttings taken in the fall with cuttings taken during the winter. They reported that among the cuttings taken in the fall, the largest root systems developed on the cuttings given long photoperiods, while among those taken during the winter the largest root systems developed on the cuttings given short photoperiods. The species they experimented with were *Ilex opaca, Juniperus horizontalis* 'Plumosa' and *Rhododendron mucronatum.* Earlier, Snyder reported no differences in the rooting of *Taxus cuspidata* under long and short photoperiods on cuttings taken during November (3).

It appears that for some species rooting can be improved by long-day treatment if the cuttings are taken early in the season before the onset of dormancy. However, on cuttings taken during the winter, when the buds are at rest, long-day treatment may be wholly ineffective and even detrimental. Generally, species reported to exhibit improved rooting under long-days, in addition to those already mentioned are: *Rhododendron mucronulatum, Magnolia soulangeana* (40), *Camellia, Ilex crenata, Ilex glabra* (43), *Rhododendron caucasicum* 'Boule de Niege', *Rhododendron catawbiense* 'Album' (30). Species not affected by photoperiodic treatment are *Pieris japonica, Pyracantha coccinea* 'Lalandi', and *Buxus sempervirens* (40).

Another way in which the rooting of cuttings may be influenced although indirectly, by photoperiodic treatment, is by treating stock-plants before the cuttings are taken. Cuttings of *Cornus florida* 'Rubra' which were taken from stock plants that were given long photoperiods for 45 days had a rooting percentage and root number twice as great as that of cuttings taken from short-day-grown stock plants (40). Similar results were reported for *Salix undulata* which rooted 100 percent from long-day grown stock plants and 0 percent from 9-hour-day plants. The opposite response occurred in a different variety: *Salix pieroti* rooted best from short-day-grown stock plants, while *Salix babylonica* rooted best from stock plants grown under a 14-hour photoperiod (26).

It's apparent that much is to be learned in order to clarify the sometimes conflicting responses obtained in the rooting of cuttings under various photoperiodic treatments.

F. Applications of photoperiodic control. The various effects photoperiodic treatment has on growth suggest that there may be several ways in which it could be used as a tool to suit the needs of the propagator.

1) Hastening the growing of seedlings. The length of time required to produce seedlings large enough to line out could surely be shortened by subjecting them to long photoperiods. It would be practical to light those species that develop slowly and require a considerable period of time before they can be lined out. Rhododendron seedlings have been reported to make up to five spurts of growth during one year instead of the usual two.

Two propagators in Connecticut use lights from mid-winter through spring to hasten the growth of second year seedlings of rhododendron, deciduous azaleas, as well as leucothoe. The long photoperiod forces earlier bud-break and increases the amount of growth produced over unlighted seedlings.

2) Increasing growth of rooted cuttings.

Cuttings of deciduous species taken in the spring could benefit by an additional burst of growth after rooting to increase size and ensure survival the following spring.

A Rhode Island propagator has been using long photoperiods on deciduous azaleas to force the development of growth immediately after rooting to guarantee survival the following spring. Cuttings of Exbury hybrids taken at the end of May are rooted by late August at which time they are given long photoperiods until the end of September. The cuttings are lighted for 30 seconds every 6 minutes from nine in the evening until five the next morning. The cuttings then are over-wintered in frames held at a minimum temperature of 55° F.

Rooted rhododendron cuttings are given long photoperiods by two propagators, one in Pennsylvania and the other in Connecticut. Both place the rooted cuttings in cool temperatures for about one month after which they are given long photoperiods from January to April. Two, and occasionally three, bursts of growth are obtained by spring.

3) **Lighting of stock plants.**

Another application of photoperiodic treatment is the lighting of stockplants to keep them actively growing and producing new stems and leaves. This would be of value if one wanted to build up a large number of plants from a limited number of stockplants. The few stockplants being lighted have the potential to be a continuous source of cuttings. In a paper previously presented to the Society it was shown that within a two-year period, it was possible to produce 1200 dwarf arborvitae starting with only two cuttings (42). The original cuttings after having been rooted were maintained in continuous growth under long photoperiods. In a relatively short period of time the cuttings developed enough branches to provide additional cuttings which were then rooted. Throughout the two years, cuttings were constantly taken from rooted cuttings all the while being exposed to long photoperiods.

This species was well suited for this type of treatment because it grew rapidly and rooted easily under the long photoperiods.

III. WAVELENGTH

The major processes that go on in green plants are directly dependent on light. The sun provides a fantastic range of wavelengths, but of this wide range only a small portion is used by the plants. Within this narrow range are wavelengths of red, orange, yellow, green, blue and violet which, together, appear to us as white light. However, because of the pigments present in green leaves, plants have the ability to differentiate between the various wavelengths and can be highly selective in which ones they absorb. Once the pigments absorb their preferred bands, they are then able to carry out their particular role in the growth of the plant.

The relation between light and the rate of plant growth is extremely complex and is by no means dominated by its effect on photosynthesis. There are other light-dependent processes that play a part by using the substances produced in photosynthesis to direct the pattern of plant growth. Briefly, certain wavelengths are known to be absorbed by certain pigments which in turn activate specific processes. The wavelengths in the blue region are effective in phototropism. These are the wavelengths that cause plants to bend or grow towards light. If a series of plants are placed in black boxes and each is illuminated with a different color of light from one side only, the plants would bend and grow toward blue light, but would not be affected by red light. The pigments involved here are either carotenoids or flavins or both (23). Another pair of pigments called phytochromes absorb the longer wavelengths of red and — what is referred to as — far red. These two pigments which are close together in the spectrum oppose each other in their effects on plant growth. The germination of seed as well as the various photoperiodic responses of plants are mediated through these pigments.

A third group of pigments, the chlorophylls and the accessory carotenoid pigments are effective in photosynthesis (23). All the wavelengths that make up the visible part of the spectrum; the red, orange, yellow, green, and blue bands are all absorbed and used as sources of energy for the manufacture of sugars. Although blue and red light are more effective than yellow, orange and green, the latter ones do contribute a good share of the energy absorbed. There is no reason why fluorescent light manufacturers should concentrate on the removal of these wavelengths from lamps to be used for the growing of plants. The variability among species in absorption of the different wavelengths is so great, that it is doubtful those fluorescent lamps emitting certain portions of the spectrum will prove more beneficial to plant growth than those having all the visible bands.

Until there is new evidence that the spectral energy of the sun can be improved upon, it appears that the overall growth of all species would, under artificial light, suffer the least if the fluorescent light sources were similar to the sun in their spectral distribution.

IV. SUMMARY

We are learning more and more about the control daylength has on plant growth. We know that not all photoperiod-sensitive species react as uniformly as we would prefer. The different responses can be attributed to the genetic background of the species. Over the centuries, through natural selection, plants have become adapted to the peculiarities of the environment in which they originated. Many of the trees and shrubs we now propagate have been introduced from different latitudes and elevations throughout the world and therefore it is not surprising that their reactions to daylength and temperature are often different from one another.

All this leads to the fact that we have much to learn, not only about plants in general, but about their specific responses. We have to learn more about the mechanisms within plants that operate for their survival in order to know how to control their growth.

In order to obtain predictable patterns of growth, it would be necessary to reduce fluctuations of moisture, temperature and light. Controlling such factors in a greenhouse is extremely difficult but not so in an insulated building. A propagation house, well insulated and with an artificial source of light would enable the propagator to better manage the environment around the cuttings. Regulation of the amount of light would result in more uniform levels of temperature and moisture in the air, the cuttings, and the medium.

The problems that now exist in the use of an insulated structure are: (1) the cost of providing a high intensity of light for those species that require it and (2), the build-up of high temperatures that would occur as a result. The development of a more efficient lamp, one which would emit more energy as light and less as heat, would solve this problem.

In the not-too-distant future, problems in propagating woody plants by tissue culture may be solved. If and when this does occur, there will, no doubt, be specialists who will do custom propagation, producing large numbers of clonal material on order as it is now being done for the orchid growers.

In conclusion, I believe that future developments will lead to a more precise control of the environment which, along with the success of the tissue culture technique, will bring plant propagation to a point where it is dependable and predictable.

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BILL FLEMER: Thank you, Sid. It should be immediately apparent from this very interesting presentation that there are practical effects which can be obtained by applying to plant propagation the results of theoretical investigations of the effects of light duration and quality.

Our next speaker is better known to the Eastern Region members as an author than as a lecturer because he is the co-author of a very excellent text on plant propagation. It gives me a great deal of pleasure to present to you Dr. Dale Kester, who will give us some of his observations and conclusions on the effects of temperature in plant propagation.

TEMPERATURE AND PLANT PROPAGATION

DALE E. KESTER

Department of Pomology
University of California
Davis, California

The pattern of temperature exposure resulting from radiation from the sun to the earth is perhaps the most significant environmental factor that controls plant growth and development and thereby determines what kinds of plants grow and where they grow (26). Likewise, control of temperature is one of the most important tools of the plant propagator. Or perhaps, we could better say that lack of temperature control can be the major limiting factor for plant propagation and subsequent growth of the plant for whatever use we make of it.

Temperature control is achieved by propagators in many ways, utilizing either the natural environment, artificial environments, or both. We can achieve control by locating our operations where the natural temperature regime is favorable and grow plants adapted to that location. We time our operations during the year when proper temperatures are available. We use many artificial methods to control temperature for both heating and cooling: greenhouses, phytotrons, coldframes, hotbeds, bottom heat, refrigerators, mulches, shading, mist systems, sprinkling, reflective materials, such as whitewash, etc.

To exploit these potentials of temperature control we need to know a great deal about engineering aspects of heat production, heat transfer and heat loss. We also should know something about the effects of temperature on the basic biology of the plant. As practical propagators, we need, most of all, to know the temperature requirements of particular plants and plant processes.

PLANT ADAPTATION

My purpose is to discuss some effects of temperature on the basic biological processes of plants as a background for more detailed discussions concerning individual kinds of plants and procedures that will be covered in other parts of these meetings. First, let us recognize