MR. HALWARD: I would like to mention the names of the fellow Canadian members who contributed information to this paper: Mr. Constant deGroot of the Sheridan Nurseries, Jens Pederson from Rose Arbor Industries, Oakville: William Vanderkruk, from Waterdown, John Cannon Nurseries; George Leiss from Erindale; Robert Fleming, Vineland Experiment Station and also Louie Forester from the Royal Botanical Gardens, Hamilton. If it hadn't been for these fellows, I wouldn't be up here today.

MODERATOR LEACH: Gentlemen, we are far enough behind schedule that I am afraid we are going to have to track down Mr. Mackay and Mr. Halward in the recess that is coming up in a moment and address your questions to them personally. In the meantime I want to thank Dr. Widmoyer, Professor McDaniel, Mr. Davis, Mr. Jaynes, and Mr. Mackay and Mr. Halward, for their fine contributions this morning.

The next session on the program this morning relates to the propagation of Plants by Seeds. The first speaker is Ken Reisch, of the Department of Horticulture in Ohio State University, who will talk on After Ripening as Related to Germination and Seedling Growth.

AFTER RIPENING AS RELATED TO GERMINATION AND SEEDLING GROWTH

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Seeds of many plant species do not germinate readily for various reasons or combinations of reasons and to introduce the subject I will define some common terms relating to this.

Seed Dormancy is an all inclusive term indicating that seed will not germinate and produce seedlings due to unfavorable environmental or internal conditions (the inhibitory factors may be external, internal or a combination of both).

Quiescence relates to the fact that seed will not germinate and produce seedlings due to unfavorable external conditions. Contributing factors are moisture, temperature, oxygen, light, or others such as pH, nutrients, carbon dioxide, or toxic conditions. This can be overcome by simply supplying the contributing factors at optimum for germination.

Rest or Internal Dormancy describes the situation where seed will not germinate and produce seedlings due to unfavorable factors or conditions specific to the seed. These may be classified in the following eight areas. Seed coat, endosperm, embryo development, embryo rest, epicotyl rest, root and epicotyl rest, cotyledons, and combinations of these. The inhibitory action of these factors or conditions can be overcome by seed coat treatments, furnishing food materials, cold temperatures, warm temperatures, combinations of warm and cold temperatures, the use of light, leaching, and possible chemical treatments.

After Ripening is basically a series of physiological or chemical changes occurring within the seed which bring to a close the rest period and make germination possible. Conditions favoring after-ripening include cold temperature, warm temperature, alternating temperatures, ample oxygen, moist stratification and probably light.

Important changes which have been found to occur in some seed during after ripening are increased water holding capacity, increased acidity, increased enzyme activity (specifically catalase, perioxidase, and oxidase), increase in sugar content, decrease in fat content, translocation of food materials from endosperm to embryo, increase in respiration,and in increase in the vigor of the seed which is believed to reduce susceptibility to fungal incidence.

Many workers have studied these problems, although much of the research dates back many years. An excellent review of the subject of seed dormancy was presented by Dr. Dale Kester at the first Western Propagator's Conference in 1960 and I refer you to his thorough article in the 1960 Proceedings of the Plant Propagator's Society. Because of this, the material in this paper will be restricted to one aspect of dormancy which is very perplexing and at the same time somewhat fascinating.

This relates to epicotyl rest, which is a major factor giving rise to many so-called two year seed. The epic work on this subject dates back to 1933 when Barton (3) reported that seed of Tree Peony exhibited epicotyl dormancy and that seed planted outdoors in May, June or July did not give good seedling production until the following spring. She indicated that if earlier production was desired it was necessary to sow seeds in flats and hold them in a warm greenhouse for three months until root production was complete and then transfer the flats to temperatures of 1-10°C for 2½ to 3 months to overcome epicotyl dormancy and then again to a greenhouse, at which time shoots grew.

Epicotyl dormancy or correctly, epicotyl rest, simply refers to the fact that the terminal growing point of the embryo will not grow unless special treatment is given to overcome the rest condition. Seeds with this type of rest are unique in that only the radicle or root will grow under warm stratification, and a further cold treatment is necessary to overcome the rest of the epicotyl. If the latter treatment is not given, the root will continue to grow until the food supply is exhausted and the seed dies. Some hypotheses have been proposed to explain this phenomenon and several workers indicated that the inhibition in Viburnum seed may be seated in the cotyledons, the waxy coat, or in the integument; however, to my knowledge, no one has ever discovered a proven satisfactory explanation for epicotyl rest.

Reports on research, much of it from the Boyce Thompson Institute, have described seeds of a number of plant types having epicotyl rest in addition to the Tree Peonies mentioned earlier. In 1936 Barton (1) reported that seed of six lily species required warm plus cold temperature stratification to produce seedlings. Fordham (8) speaking at the Plant Propagator's Society Meeting in 1960 pointed out that this type of dormancy existed on Chionanthus retusus and Davidia involucrata. Barton (4) in a later work, also included in this category seed of Asarum canadense, Sanguinaria canadensis, Polygonatum commutatum, Trillium grandiflorum, and Caulophyllum thalictroides. She indicated that another, more complex condition, was found in the Trillium and Caulophyllum seed, where both roots and epicotyl are dormant and two separate cold treatments were necessary to bring about seedling production. After working with Convallaria majalis and Smilacina racemosa, Barton and Schroeder (6) reported another unique and different aspect. Low temperature treatment was required for shoot growth after root growth had occurred. However, it was only effective if given after the shoot had started to grow and had broken through the cotyledonary sheath. The recommended treatments were given as follows. Three months at cold temperature to after ripen the partially dormant roots; two months at greenhouse temperature to grow the root system and develop the first leaves; three to five months at cold temperature to after ripen the shoot bud; and then a transfer to the greenhouse for seedling production.

Studies with Viburnum have probably been of greatest interest to the woody plant propagator and to review briefly I refer to Giersbach's (9) original work in 1937. She indicated that seed of some Viburnum species such as nudum and scabrellum offered no germination problems but that seed of V. acerifolium, dilatatum, lentago, opulus, prunifolium, and rufidulum, had to be exposed to warm temperature stratification for germination and root development, followed by a cold period to force epicotyl development. This work was reviewed by Barton (2) in the 8th Annual Proceedings of the Plant Propagator's Society.

Fordham (8) reported that five months warm stratification treatment on seed of Viburnum sargenti flavum was more than necessary for radical emergence and that the seed could have been placed in the cold temperature treatment after three months.

Smith (10) found that maximum germination of Viburnum lantana occurred after fifty-six days treatment at 40° F. He also noted that percentages as high as 47 per cent germination occurred after only 14 days of 40° F storage. The recommendations in the Woody Plant Seed Manual (11) indicate considerable variation between treatments for different Viburnum species, however, the basic treatment is stratification at warm temperature of approximately 70° F, or possibly fluctuating warm temperatures, followed by a storage period at cold temperature of approximately 40° F. The other alternative recommended is to sow seed outdoors in the spring or early enough in the summer so that sixty warm days will elapse before winter. Seedling production will occur the following spring.

Barton and Chandler (5) found that gibberellic acid was effective in overcoming epicotyl rest of Tree Peony, replacing the need for low temperature treatment, however, they indicated that abnormal growth with spindly stems and small leaves resulted.

The use of controlled storage temperature treatment raises some practical problems. If, as Barton indicated at the 1958 meeting of the Plant Propagator's Society (2), the radicle must protrude before the cold treatment is given, the seed should be sown in flats and carried through the treatments in this way. If this is not done the radicle will be broken off when the seeds are sown after the warm temperature treatment. On the basis of observations by Chadwick (7), this may not be an absolute rule with most species of Viburnum, since some types appeared to produce epicotyls even though radicles were not protruding at the time of exposure to cold temperature.

Research with Viburnum seed was begun at the Ohio Agricultural Experiment Station in 1961. The results at this time are only of the most preliminary nature, however, some of the general observations will be presented. The primary objective of the research was to determine whether it is absolutely necessary that the radicle of Viburnum seed protrude before the cold temperature treatment will be effective, and also to study in greater detail the elongation of the embryo. Species studied included V. dentatum, latana, lentago, opulus, dilatatum setigerum, and trilobum. The treatments were 1, control — greenhouse; 2, 70° F storage only; 3, 40°F storage only; 4, 70°F storage followed by 40°F storage for varying periods ranging from six weeks to fifteen weeks.

General observations of results to-date include the following.

Germination of Viburnum lantana seed was very low, however, after no warm treatment and ten weeks of 40°F treatment, fifteen percent of the seed which germinated produced seedlings. Smith (10) indicated this in earlier work and it appears that V. lantana may be one of the exceptions to the rule that the radicle must protrude before seedling production will result.

No benefit was found from re-exposure to cold temperature treatments if these were interrupted with a warm temperature. This supports results of earier work indicating that the cold treatment effects are not additive. In some instances it appeared that the total period in warm temperature stratification plus the cold temperature treatments may be as important as the time in each individual temperature treatment. Measurements of the embryo — radicle length of Viburnum trilobum seed indicated that in seed stratified at 70°F. the radicle did not protrude until after eight weeks at which time the length was approximately 5 mm. The embryo-radicle increased gradually to approximately 20 mm at 12 weeks storage time and then rapidly to over 37 mm. between the 12 and 13 week storage period.

With Viburnum trilobum seed stored at 11, 12 and 13 weeks at 70°F, radicle emergence increased, embryo-radicle length increased, and ultimate epicotyl emergence increased with time. In contrast to this, 8, 9, and 10 week periods of 40°F treatment resulted in no increase in radicle emergence, no increase in embryo-radicle length. and an increase in epicotyl emergence with time.

These studies are being continued and final results will be published later.

In summary, the germination problems with Viburnum seed appear to be due to a number of factors. There is considerable variation between species, variation between individual plant seed sources, variation due to environmental effects, as well as variation due to the time seed is collected. In this study, as in others, it was found that the use of short periods in the warm and cold temperature treatments resulted in low germination percentages; however, the fact that a small percentage of seed did germinate, indicates a variation that exists even within individual seed from the same plant.

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MODERATOR LEACH: Thank you, Dr. Reisch.

The subject of Stimulating Germination by Chemical and Mechanical Means has been divided into two discussions, the first by Thomas S. Pinney, Jr., of Evergreen Nursery Company, Sturgeon Bay, Wisconsin, who is going to talk to us about Commonly Propagated Ornamentals.

STIMULATING GERMINATION OF SEED BY CHEMICAL AND MECHANICAL MEANS

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There have been a number of techniques developed to overcome the problem of rest or internal dormancy of various seeds. Chemical and mechanical treatments may be helpful in overcoming internal dormancy that is caused by: (1) seed coat (i.e.) *Gleditsia, Gymnocladus* (2) hard endosperm which acts as a seed coat (i.e.) *Tila* and (3) when seed coat is one of the factors which contribute to the in-