the mailing. The breakown was 100 from Commercial members and 64 from Non-commercial and Juniors. In the returns we had 46 papers offered for the meeting; 36 kind people offered to be moderators; and 6 offered to have some type of an exhibit. This is a response that is very heart warming — and almost unbelievable. As a consequence we have represented at this meeting, 24 states, 3 Canadians and one paper from England. The 46 participants at this meeting include 24 Non-Commercial, 19 Commercial and 3 Junior and 1 guest. Because of the afore-mentioned data, the program was 98% completed by April 30, 1967. My deep and heartfelt thanks to everyone who made my responsibility for this meeting a joy.

Now to get our 17th annual meeting underway, it is with a great deal of pleasure that I introduce the first moderator of our program this year. There is no-one better qualified to moderate a Seedage Symposium than Hugh Steavenson, Forrest Keeling Nursery, Elsberry, Missouri. Hugh is a Past - President of the Eastern Region and of the International Plant Propagators' Society. In 1953 I attended my first I.P.P.S. meeting as Hugh's guest — no other gentleman in the nursery community has given so much to me in guidance, understanding and compassion than your first moderator of our 17th meeting — I present to you my mentor and dear friend — Hugh Steavenson!

MODERATOR STEAVENSON: As Ralph knows I am here substituting for that eminent gentleman and friend of ours, Dr. F. L. O'Rourke, Department of Horticulture, Colorado State University. Unfortunately, Steve is unable to be here today and Ralph has asked me to read his paper.

SEED PROPAGATION REVIEW

F. L. STEVE O'ROURKE
Department of Horticulture
Colorado State University

Plant propagation from seed is an ancient art. It had its beginnings when primitive man first established permanent sites and relinquished a nomadic existence. Throughout the ages seed propagation has developed with mankind and in the modern world is basic to man's need for food and clothing.

In our time plant propagators are interested in seed propagation for several primary reasons:

1. Many homozygous seed strains (pure lines) of various species of both woody and herbaceous plants come "true from seed", that is, the seedlings are relatively uniform and resemble their parents in practically all characters.

2. Plants from heterozygous parents are quite variable, nonuniform, and seldom resemble their parents. However, certain individual plants may show superior or desired characteristics.

Thus selections may be made and the chosen plant may thereafter be propagated vegetatively as a clone.
3. Combinations between two pure lines may produce seedlings of exceptional quality. An example is "hybrid corn".
4. Rootstocks needed as stocks for grafting and budding are obtained to a large degree from seed.
5. Seed, which is relatively light in weight and resistant to injury during shipment, is a means of securing new or desired plants from far-off places.

Propagation by seed has been a matter of concern to members of the International Plant Propagators Society since its organization in 1951. The sixteen volumes of the Proceedings, 1951 to 1966, contain 27 articles on seeds and seedage. Some of these papers are broadly basic and comprehensive, some quite narrowly specific, while others treat of practical measures to insure economic stands of seedlings. All of the articles, however, have contributed to a broader knowledge and fuller understanding of seed problems and how to overcome them. Any enthusiastic prospective plant propagator may, by reading these articles, obtain a knowledgeable background of the factors involved and learn how practical plant propagators effectively and economically produce plants from seed.

The physiology and basic underlying causes of germination problems have been adequately discussed in the Proceedings by Barton 1956 and 1958, Bergh 1960, Heit 1964, Kester 1960, and Reisch 1962. The problems and solutions affecting seeds of specific plants have been reported by Barton 1958, Fennichia 1966, Fordham 1960, Galle 1953, Kern 1952, Mitiska 1954, Morey 1960, Nordine 1952, Stuke 1960, and Warner 1954. Nursery operations and practical propagation procedures with seeds of conifers and deciduous woody plants have been thoroughly explained by Fordham 1962, Holmason 1963, Pinney 1957, 1962, 1964, Schneider 1960, Steavenson 1959, 1960, Stoutemyer 1960, Strong 1951, and Vuyk 1956, 1961.

Heit, 1966-67, a in a series of articles in the American Nurseryman, has emphasized the wide variation in germination and subsequent seedling performance among seeds from various geographical races (ecotypes) within the established range of a species. Scots pine is a notable example. Thus the response from one lot of seeds may be quite unlike another lot from the same species. Each lot should be specifically tested under laboratory conditions before planting in order that the propagators may know how thickly to sow to achieve the desired density in the seed bed.

The most perplexing problem affecting practical plant propagators in the temperate zone is "delayed germination" which may be caused by "internal dormancy" (rest period), a hard seed coat, an underdeveloped embryo, biochemical inhibitory substance within the seed, or the need of certain temperature, moisture, or light conditions to initiate the germiniation process.

Delayed dormancy of seed is a survival factor which has been developed under natural conditions of the environment. If seeds which normally ripen in the fall would germinate immediately the resulting seedlings would be killed by cold. Thus the seeds of many of these species are internally dormant when the fruit is ripe and must be "after-ripened" by "stratification" in a cool moist environment for a period of one to four months depending upon the particular seed strain involved. Under natural conditions internal dormancy keeps the seed from germinating during the late fall and early winter and the winter cold or external dormancy prevents it from germinating until the warm moist days of spring have arrived.

The seeds of some plants are "double dormant". These are often termed "two-year seeds" because a cold period (first winter) is needed to stimulate the radical (root) to emerge, a warm period (first summer) to allow root growth, another cold period (second winter) to "after-ripen" or stimulate the epicotyl (stem) into growth, and a subsequent warm period (second summer) for the shoot to emerge above ground and develop the new plant. Each species or even individual seed strains within the species follow somewhat different patterns as indicated by the papers presented in past volumes of the Proceedings.

When the plant propagator knows the particular conditions under which each seed lot may best be after-ripened he may "stratify" the seeds by mixing them with two or three times their volume of moist, but *not wet,* sand, peat, sawdust or other moisture-holding material. Polyethylene bags are usually used for containers. These may be placed in storage, usually from 32°F to 50°F (optimum 41°F) for a period ranging from 30 to 120 days depending upon the particular requirement of the species or seed strain. The moisture content of the medium should be checked at intervals. If too dry, the seeds will not after-ripen, if too wet, molds will kill the seeds.

Hard seed coats impermeable to water and air, occur in many species, notably with legumes. Under natural conditions in the soil the seed coats break down gradually due to bacterial and microbial action and thus may germinate over a period of years. This again is an instance of a survival factor for the species as some years may be more favorable for germination and plant growth than other years.

Immediate germination of these hard-coated seeds may usually be secured by "scarification", the term applied to the partial breakdown of the seed coat by either chemical or mechanical means. Immersion in concentrated sulfuric acid for periods ranging from 5 minutes to over an hour, depending upon the type of seed, is a common practice to insure prompt germination. Mechanical methods of scarification range all the way from nicking the seed with a file or rubbing on sandpaper, to large concrete mixer types of machines equipped with erosive surfaces.

The thickness and relative resistance of the seed coat to erosion determines the time and degree of force to be exerted. Embryos may be injured if either the chemical or mechanical processes of scarification are carried on for too long a period.

The temperature and moisture requirements most favorable for the development of embryos which are immature at the time of seed ripening varies with the species but apparently proceeds well at temperature from 40°F to 50°F. The time period also varies with the species but usually requires a year of more. Thus seeds of hollies may be termed "double dormant" from an entirely different cause than that of other two-year seeds.

Some seeds are "light sensitive". These must have light in some degree to initiate germination, but the intensity and the duration of the light varies widely among the species involved. Other seeds germinate well only in total darkness.

Seeds of other species may remain dormant due to a combination of factors. Thus a seed may have a hard seed coat, a need for after-ripening, and perhaps an immature embryo as well. The propagator therefore must resort to several treatments in proper sequence to obtain maximum germination.

"Secondary dormancy" is another disturbing condition which often confronts the propagator. Even after all the after-ripening requirements of a seed have been satisfied and the germinative process has started, a sudden lack of moisture, oxygen, or even light may cause it to return to a state of deep dormancy. This secondary dormancy can only be broken by another series of after-ripening treatments which means that another year must pass until the seed is again ready to germinate.

Apparently all the factors of internal dormancy and other influences that affect germination are controlled by the genetic structure of the plants which produce the seed. Different geographical races or even different individual trees, within the same species, may produce seeds with different pregermination requirements. Each seed source must be investigated so that the propagator may determine the optimum treatments for the particular lot of seed.

After the pregermination requirements have been satisfied a favorable combination of optimum temperature for the species, adequate moisture, and a goodly supply of air should provide the conditions for satisfactory germination and subsequent seedling growth. The optimum temperature will vary with the species. Most warm area plants germinate better at a relatively high temperature, more northern plants at a cooler one. Some plants germinate best in total darkness, others in varying degrees of light intensity. Both water and oxygen are needed in adequate quantities, so the seeding medium should be both retentive of moisture and highly aerated.

When seeds are sown in the greenhouse or cold frame, coarsely shredded sphagnum moss will provide the best medium for the seeds of most woody plants as all the factors for germination and growth can be definitely controlled. Seedlings may be held in "living storage" in sphagnum moss for long periods without harm. In addition the anti-biotic qualities of sphagnum moss will prevent infection by fungus diseases.

Sterile substances such as vermiculite, arcillite, or perlite have value as media for seeds which germinate rather quickly and are transplanted soon thereafter. The seed may be treated with a fungicide before sowing as a precaution against diseases which may be carried in or on the seed coat.

Soil should not be used indoors but is necessary for large lots of seeds out of doors. A good soil for sowing seed should be light in texture, well drained, well aerated, and contain a fair degree of organic matter to prevent rapid loss of moisture. Treatment with steam or chemicals to control weeds, nematodes, insects, and diseases is important before the seed is sown.

Since seeds vary so widely in their pregermination and germination requirements, the need for accurate observation and research with each particular species or seed strain is evident. Every plant propagator can assist in this endeavor. Accurate records of every operation and environmental factor should be kept and reported thereafter in the Proceedings or quarterly journal of the International Plant Propagators Society. Thus, bit by bit, the information will accrue so that the plant propagator of future years may be the recipient of more definite and detailed instructions for each type of seed than is available at present.

MODERATOR STEAVENSON: Before we have any discussion we will hear our next paper presented by another old friend of the Society, Mr. Al Fordham of the Arnold Arboretum.

HASTENING GERMINATION OF SOME WOODY PLANT SEEDS WITH IMPERMEABLE SEED COATS

ALFRED J. FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

Germination of many seeds is hindered only by seed coats that retard the admission of water. If these impervious coats are not modified by pretreatment, germination can be erratic and sometimes extended over many years. Three hundred seeds of *Gymnocladus dioicus*, the Kentucky coffee tree, were placed in a tray of water in April 1963 and since that time have been kept at room temperature. Each week the seeds were examined, those which had germinated were removed, and the results recorded. In the first 10 days, 13 seeds imbibed water and the produced radicles. These, no doubt, had fissures in their seed coats at the outset. Twenty-one months later, in January 1965, three more imbibed water and germinated. The following table shows how many more have done so since that time: