FIRST SUPPLEMENT

TO THE SECOND EDITION OF

SEED GERMINATION THEORY AND PRACTICE

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Self-Published and Self-Distributed

First available March 1, 1996

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Every species has some mechanism for delaying germination until after the seed has been dispersed.

The Science of Seed Germination is the discovery and description of such mechanisms and the development of procedures for removing them so that the seeds can germinate.

FIRST SUPPLEMENT TO THE SECOND EDITION OF SEED GERMINATION THEORY AND PRACTICE

Published and distributed by Norman C. Deno
139 Lenor Drive, State College PA 16801
(Second Printing July 10, 1997)

TABLE OF CONTENTS BY SECTIONS

I INTRODUCTION

This is the First Supplement to the Second Edition of Seed Germination Theory and Practice. Contained herein are data on 40 new families, 518 new genera, 1117 new species, and updates of earlier work on 282 species. In general the principles and germination patterns presented in the Second Edition have been confirmed. There are two major new principles. The first is that many of the seeds in fruits have germination blocked because of lack of access to oxygen. This principle is presented in detail in Section IIa. The second is that Aril Iris appear to have germination blocked by some type of inner physical restraint. This is discussed in Section VI. There are also minor changes and updating of viewpoints. These are presented as a series of special topics in Section II. A separate chapter has been devoted to the extensive studies on Cactaceae (Section V). The extensive experiments currently in progress ensure that a Second Supplement will be published around April 1997. The price should be no more than $12 (postpaid anywhere).

The scope of the studies has been enlarged to include all types of plants from arctic to tropical and every type of seed bearing plant. Work on sedges, palms, cycads, etc. are now included. Naturally plants of horticultural interest have been emphasized because these are the species for which seeds were available and these are the species of most interest. An effort has been made to study any new species, but low priority is given to certain families. Most Fabaceae (legumes) have impervious seed coats. Most Asteraceae (composites), Caryophyllaceae (pinks), and Poaceae (grasses) have a D-70 pattern. A report on Orchidaceae was presented in the Second Edition and no further discussion is planned. A number of studies are currently in progress particularly on South African Liliaceae, Amaryllidaceae, and Iridaceae so that a second supplement will be issued in spring 1997.

The abbreviations and symbols used in the Second Edition are continued and summarized in Section IX. Two new abbreviations are introduced. These are OT for outdoors treatment and OS for oscillating temperature treatment. The OT treatment involves placing the seeds outdoors in a shed. The OS treatment involves shifting the samples between 40 to 70 (deg. F) back and forth each 12 hours.

An article has recently appeared entitled Germination of Fern Spores (V. Raghavan, American Scientist, March-April 1992, pp. 176-185) which shows that ferns have mechanisms for blocking development of the spores until the spores are dispersed analogous to the blocking mechanisms in seeds.

This introductory section closes with a most grateful acknowledgement to the many people, companies, botanical gardens, and other organizations who have cooperated in so many ways. Sending seed is perhaps foremost, but interactions of all kinds were also important. Abbott Laboratories and Sigma-Aldrich sent gibberellins. Seed companies sent seeds that had presented difficulties in germination. I continue to encourage all such interactions. Every communication that I receive including contrary points of view stimulates new thought, new experiments, and rethinking of old experiments. For all of this I am deeply grateful. Thank you, one and all.

II (a) Seeds in Fruits and Oxygen Blocks

It has long been obvious that seeds enclosed in fruits do not germinate while in the fruit. The past literature generally ascribed this to chemicals in the juice of the fruit which diffused into the seed and inhibited germination. Thus when the seeds were removed from the fruit and washed they germinated, sometimes immediately and sometimes after a series of time-temperature cycles or other treatments. In the Second Edition I accepted this view, but I now know that it is seriously in error. The following experiments on Citrullus melo clearly show that in this species it is lack of access to oxygen that blocks germination in the fruit.

Seeds of the Casaba (honeydew) form of Cucumis melo will not germinate while they are enclosed in the fruit. On removal and being placed in moist paper towels, germination is 100% in 2-8 days whether the seeds are rinsed or not. If the seeds are immediately placed under an inch of water in a cup after removal from the fruit, they will not germinate a single seed in at least 70 days even if the water is changed each day. The seeds can be removed at any time and placed in moist towels whereupon germination occurs in 2-8 days. However, there is slow dying of the seeds when under water so that after a two, four, six, eight and ten weeks under water, germination is reduced to 93%, 85%, 65%, 50%, and 35% respectively.

The above results show conclusively that the seeds have a high oxygen requirement for germination and that even an inch of water slows down the access to oxygen enough to block germination. This conclusion is reinforced by the absence of a physical connection between the seeds in the fruit and the juice of the fruit.

Germination of the seeds of Capsicum frutescens also appear to be blocked by lack of oxygen, but the evidence is not as conclusive. Like the Casaba melon, removal of the seeds from the fruit and placing them in moist towels leads to 100% germination in 2-8 days with or without washing or rinsing. However, in contrast to the melon, the oxygen requirement is much less so that germination under an inch of water is nearly as fast as in the more aerated moist paper towels. Like the Cucumis, the oxygen block interpretation is reinforced by the absence of significant physical connection between the seeds in the fruit and the juice of the fruit.

How can an oxygen block be distinguished from a chemical inhibitor? It is not as easy as might be thought. Where washing for seven days or washing in detergent gives germination more rapidly and in higher percentage than seeds simply rinsed, a chemical inhibitor can be presumed. In contrast the results with Cucumis melo are strong evidence for an oxygen block. However, there are many species with seeds in fruits where it would take far more sophisticated investigations than I have done to determine which blocking mechanism is in effect.

The one overriding conclusion is that an oxygen block must be added to the other physical mechanisms as a major mechanism for blocking germination before the seed is dispersed. This mechanism may be far more common in seeds in fruits than ever imagined before.

II (b) Time-Temperature Cycles and Extended Germinations

At the beginning of the program on seed germination it was decided to use just two temperatures, 40 and 70 deg. F, and to use three month time periods. The reasons for these choices were given in the Second Edition. All the data that have been accumulated demonstrate that these choices were most fortunate. There are a few species where temperatures above 70 are reported to give better germination such as several Passiflora and certain Rudbeckia as described under these genera in Section IV. For all the rest temperatures of 40 and 70 have given excellent germination providing the seeds were given the appropriate treatments. The conclusion that temperatures above 70 were required for germination of Gomphrena has been revised (see Gomphrena).

The choice of three month cycle times also proved to be a most fortunate choice. Where rates were carefully measured for the chemical process destroying germination blocks as in Eranthis hyemalis and Nemastylis acuta, three months was the time required to effect completion of these reactions.

This does leave an important question regarding species whose germination required a year or more of alternating three month cycles between 40 and 70. There were many examples of this such as Rosa and Halesia. There are two possibilities. One is that there could be multiple chemical blocking agents each requiring its own cycle for destruction. The other is that the three month cycles were not long enough to complete the destruction of the chemical blocking systems. Preliminary experiments with Halesia using longer cycle times have not been successful in shortening germination times, and outdoor treatments have been no more effective than three month cycles. However, more work needs to be done to resolve this question.

II (c) Dry Storage Effects

It has long been known that seeds of many species require dry storage before they will germinate and of course seeds are dying in dry storage. These subjects were discussed in the 2nd Ed. What was not fully appreciated was that dry storage can alter the germination pattern. The 2nd Ed. did give examples such as Citrullus vulgaris and Paulownia tomentosum where a light requirement for germination of fresh seed died out on prolonged dry storage. More examples of this have been found. In addition complex effects as exemplified by the following have been found.

Fresh WC seed of Opuntia tuna required gibberellic acid-3 (GA-3) for germination, but the percent germination even with the GA-3 was low (12%). After two years of dry storage at 70, the percent germination increased from 12% to 90% on treatment with GA-3, and 64% now germinated without GA-3.

It is evident that dry storage treatment of seed samples must be accurately known if consistent and reproducible germination results are to be obtained. To be complete this history should include the temperature of the dry storage and the relative humidity. Varying histories of dry storage are probably the commonest cause of inconsistent results.

In the 2nd Ed. many of the samples of seeds studied were received in midwinter, and this was not always carefully distinguished from freshly collected seeds. Seeds received in midwinter can be assumed to have received about six months of dry storage at 70. This could have led to significant dying and thus reduced the percent germination. It also could have led to partial disappearance of a light or GA-3 requirement so that although germination was best with light or GA-3 treatment, some germinated without this.

II (d) Time of Collection of Seeds

Another problem closely related to dry storage involves the time of collection of the seeds. It is possible albeit rarely to collect seeds before an impervious seed coat hardens such as in Sophora japonica or an inner membrane hardens such as in Juno bucharica. Time of collection was also critical in Acer pseudoplatanus where unripe seeds are superficially similar in appearance to ripe seeds.

A further concem involves seeds that require a period at 40 moist to destroy a system blocking germinaton. This can sometimes be replaced by a period at 40 with the seeds in the "dry" state. This was already shown for an Aesculus. It may be also true for some fruits that hang on through most of the winter such as Pyrus calleriana. More work is needed to clarify this question.

II (e) Calculation of Percent Germinations

In this Supplement more effort has been made to distinguish empty seeds coats and to discount them in calculating percent germinations. Many of the percent germinations reported in the 2nd Ed. would have been higher if this distinction had been made.

II (f) Light Requirements for Germination

Many species and particularly swamp species require light for germination. This requirement often disappears on extended dry storage. Many of the samples of seeds that were studied in the 2nd Ed. were received in midwinter and can be assumed to have been subjected to about six months of dry storage at 70. Thus when the seeds germinated best under light but also gave some germination in dark, it is always possible that fresh seed would have had an absolute light requirement.

A question arose as to whether the chemical blocking system that was destroyed by irradiation of moist seed could also be destroyed by irradiation of dry seed. To date such attempts have totally failed. Dry seeds of Catalpa bignonioides and Citrullus vulgaris were placed under light for up to fifty days under the same conditions of irradiation as used in irradiating the moist seeds. Such seeds failed to germinate when shifted to 70D anytime during the fifty days.

II (g) Impervious Seed Coats.

The group with impervious seed coats poses a problem for nurserymen and plant propagators. The most effective procedure, puncturing the seed coat, is labor intensive. It is bad enough with seeds of Gymnocladus dioica which require sawing through each seed coat. With the Asiatic maples it takes careful manipulation by hand to remove the tough outer seed coat without fatally damaging the seed after which the impervious inner seed coat must be nicked with a razor.

Certain species of Malvaceae cause trouble because the seeds are small, and it is easy to fatally damage the seed in an attempt to puncture the impervious seed coat. The seeds must be lightly drawn across sandpaper. The treatment is repeated on any seeds that do not germinate within five days.

Ingenious solutions to the above problems are needed. One idea was to puncture the seeds in winter when labor demands are low and then plant such punctured seeds in spring. This was tried on seeds of Acer pseudoplatanus, Acer pseudosieboldiana, Gymnocladus dioica, Tephrosia virginiana, and Thermopsis caroliniana. The punctured seeds were dry stored nine months at 70 and then placed in moist towels. The two Acer all rotted, but the three Fabaceae germinated nearly as well as freshly punctured seeds.

In the past work no precautions were taken to disinfect the seed coats or instruments. The studies with Erythrina show that this can be a factor.

II (h) Semipervious Seed Coats.

In the 2nd Ed. it was inferred that seed coats were either impervious or not. It now becomes apparent that some species have a semipervious seed coat. This can be detected by the seed ultimately germinating without puncturing the seed coat, but germination is faster if the seed coat is punctured.

This is a primitive mechanism for delaying germination and is found in some palms and cycads. With semipervious seed coats there is an induction period followed by a <u>gradual</u> onset of germination. This situation must be distiguished from induction periods in which a chemical blocking system is being destroyed. The latter have the characteristics of a chemical time clock wherein there is an induction period followed by a <u>sudden</u> onset of germination.

Examples of semipervious seed coats are Washingtonia filifera (2nd Ed.) where puncturing the seed coat caused germination to occur in the 2nd w rather than the 3rd w. G. Shannon Smith (Hort. Sci. <u>13</u>, 436, (1978)) showed that in the Cycad Zamia integrifolia germination was successively speeded up by removal of the pulp covering the seed coat, by clipping off one end of the seed coat, and by clipping off both ends of the seed coat. There is no significant induction period once the inner seed has access to oxygen and water. Zamia furfuracea displayed a similar semipervious seed coat, but in addtion there was a chemical blocking system which added on an induction period of 9-12 weeks. C. Forsyth and J. van Staden, S. African J. of Sci., <u>79</u>, 8 (1993), presented data showing a semipervious seed coat in Encephelartos natalensis.

Semipervious seed coats are distinct from the behavior where part of the seeds are pervious and part are impervious. This latter situation is found in certain legumes like Melilotus alba and Pelargonium hybrids (P. inquinans x P. zonale) as well as the mallow Hibiscus trionum. In these examples a certain percentage (usually of the order of 10-20%) of the seeds have an imperfection in the seed coat and germinate immediately. The remaining seeds will not germinate until the seed coats are punctured. Incidentally, Prof. Richard Craig at Penn State found that the percent of pervious seeds in Pelargonium hybrids could be increased from 40% to 55% to 88% in three generations by selective breeding.

II (i) Fire, Smoke, and High Temperatures

There have been reports that germinations were initiated by subjecting seeds to temperatures of 212 (100 deg. C) and even higher. What appears to have been done (personal communications) was to place the seeds in soils and then these insulated seeds were subjected to these temperatures in air ovens. Now air is a poor conductor of heat because of its very low heat capacity and soils heat up slowly because of their high heat capacities. As a result it is doubtful that the seeds ever reached temperatures above 140. The situation is identical to that in cooking and baking. Typically a five pound roast of beef can be placed in an oven at 250, and it takes hours for the temperature to reach 150 in the center as shown by a thermometer inserted into the center.

When the temperature of beef reaches 140 it is regarded as cooked rare, 150 is medium, and 160 is well done beef. Human skin scalds at temperatures above 140. All of this shows that most natural proteins undergo irreversible changes at 140 (denaturation) which leads to death of the tissue. Seeds of Gymnocladus dioica and a number of other species were found to quickly die when immersed in water at temperatures above 140 (2nd Ed.). While it is always possible that some species of plants will have seed that can stand higher temperatures (certain bacteria can stand boiling water), all present evidence is to the contrary.

The above arguments coupled with the anecdotal nature of past reports leads me to dismiss all claims that temperatures above 140 and particularly temperatures in the 210 region have any beneficial effect on seed germination. Of course it is possible for fires to cause seeds in the soil to reach temperatures up to 140 and lead to rupturing of impervious seed coats. This should be looked for in Fabaceae and Malvaceae and may be a factor in Australia and South Africa. It is doubtful that it is a factor in North America. Plants that colonize burned over areas in North America such as fireweed (Epilobium latifolium) do not have impervious seed coats and have germination patterns that do not require temperatures above 70 (2nd Ed.).

It is well known that certain pines from Southeastern United States are constructed in such a way that they resist brush fires both as adult trees and as seedlings. Their resistance is not because they survive temperatures above 140 but because they are physically constructed so that they do not reach these temperatures as brush fires sweep through. Seed germination is not involved.

A group at the Kirstenbosch Botanical Garden in South Africa (N. Brown, P. Botha, and D. Prosch) and a group under Jonathan Lidbetter at the Agricultural Station at Gosford, New South Wales, Australia, have reported that extracts of smoke promote germination. A paper in The Garden (pp.402-405, July 1995) summarizes the work of the Kirstenbosch group.

Lidbetter has conducted careful work on the germination of Goodenia scaevolina and shown that aqueous extracts of smoke can initiate germination. However, GA-3 has even a stronger effect in promoting germination so that at present GA-3 treatment would be preferred. Lidbetter found favorable effects with other species, and work is in progress to identify the chemical component(s) of the smoke that are responsible for the effect. A number of species native to dry regions of Australia were studied in my work and found to germinate without smoke or GA-3 so that I suspect that any smoke effect is a minor factor in Australia.

The Kirstenbosch group claim that 92 species of plants that are characteristic of burned over areas in South Africa have seeds which have improved germination when treated with smoke. A list of these 92 species appears at the end of this section. It would appear that smoke induced germination is a more important factor in species from burned over areas in South Africa than species from burned over areas in Australia or other continents.

The most convincing aspect of the Kirstenbosch work were data showing that aqueous extracts of smoke gave dramatic increases in percent germination of seeds of Rhodocoma capensis and Erica glauca v. glauca. However, there were unsettling aspects of the work. (a) The work relied entirely on percent germinations when rates of germination would have been more significant. (b) Much of the work was conducted in soils where other factors such as the gibberellin factor were not controlled. (c) Most of the work is in the form of unsupported claims giving just lists of species. (d) The work is written to promote the sale of smoke impregnated paper as a germination initiator.

Both groups have initiated studies designed to separate and identify the component(s) of the smoke responsible for promoting germination. When positive results come from such studies, the situation will be much clearer. Certainly it should be quickly determined whether nitrates or ammonium salts are the active components because they would be in aqueous extracts of smoke and they have been found to stimulate germination (see Chapter 12 of 2nd Ed.).

There are occasional claims that various unnatural treatments such as gravitational, electrical, or magnetic fields promote germination. In the early days of rate studies of chemical reactions the effects such fields were studied. None were found to have significant effects on rates. Of course extremely high fields will probably have some effect, but these are far beyond anything encountered in nature.

Comparison of 95% GA-3 with 30% Pro-Gibb

Species	Germination 95% GA-3	10% Pro-Gibb
Agastache occidentalis	74% in 5-8 d	71% in 4th w
Angelica archangelica(a)	80% in 2nd w	78% in 1-3 w
Aquilegia vulgaris (b)	25% in 3rd w	8% in 3-6 w
Calyptridium umbellatum	52% in 1-3 w	30% in 2-4 w
Cornus canadensis (c)	57% in 3-5 w	24% in 3-5 w
Empetrum nigrum	47% in 3-5 w	5% in 2-5 w
Papaver radicatum	80% in 2nd w	80% in 2nd w
Sambucus pubens (c)	34% in 4-6 w	none
(d)	77% in 4-6 w	4% in 3-7 w

(a) This sample germinated 40% in 3-5 w without GA-3. (b) Seed had been DS for 18 m. (c) Seed had been DS for 6 m. (d) Seed had been subjected to three months at 70 followed by three months at 40 before being treated with GA-3 at 70.

II (k) Two-Step Germinations

Many woodland species germinate in a two-step pattern in which the radicle and root system develop in one growing season and the leaf or leaves develop in the following growing season. Examples of this are Trillium and many Lilium. The question has been asked as to why a species would evolve such a two-step germination pattern. The survival advantage of such a pattern is that the seedlings get off to a fast start in spring as soon as the ground thaws. When the ground thaws the root system is already developed so that the seedlings can immediately direct their energy into producing the photosynthetic leaves above ground. Such species produce usually a single leaf, and this is produced before the trees leaf out. The seedling is thus able to get in a few weeks of photosynthesis before the leaf cover closes out further photosynthesis. Incidentally, Lilium canadense in Central Pennsylvania will survive for years in dense woodland producing a single short-lived leaf each year and waiting for some event to open the seedling to more light.

The survival value of the two-step pattern is related to survival value of the pattern where germination occurs at 40. The latter also has the advantage of allowing the seedling to get a fast start in spring. However, the germination at 40 pattern is largely restricted to species from cold desert areas where summer growth is closed out by dessication rather than a leaf cover.

The following species are reported (Kirstenbosch work) to have germination promoted by smoke.

Asteraceae: Edmondia sesamoides; Metalasia densa; Helichrysum patulum and H. foetidum; Othonna quinquedentata; Phaenocoma prolifera; Syncarpha speciosissima, S. vestita, and S. eximia; and Senecio grandiflorus.

Bruniaceae: Audouinia capitata; Berzelia lanuginosa.

Cupressaceae: Widdringtonia.

Ericaceae: Erica caffra, E. canaliculata, E. capensis, E. capitata, E.. cerinthoides, E. clavisepala, E. curvirostris, E. deflexa, E. diaphana, E. dilatata, E. discolor, E. ericoides, E. formosa, E. glauca, E. glomiflora, E. grata, E. hebecalyx, E. hirtiflora, E. junonia, E. lateralis, E. latiflora, E. longifolia, E. nudiflora, E. oatesii, E. perlata, E. phylicifolia, E. pinea, E. plukenettii, E. recta, E. sphaeroidea, E. spectabilis, E. simulans, E. sitiens, E. taxifolia, E. thomae, E. tumida, E. turgida, and E. vestita.

Fabaceae: Cyclopia intermedia.

Geraniaceae: Pelargonium auritum; P. capitatum and P. crithmifolium.

Proteaceae: Aulax cancellata; Protea compacta; Serruria florida and S. phylicoides.

Poaceae: Themeda triandra.

Restionaceae: Askidiosperma andreanum; Cannomois virgata; Chondropetalum hookerianum, C. mucronatum, and C. tectorum; Dovea macrocarpa; Elegia capensis, E. cuspidata, and E. fenestrata; Ischyrolepis sieberi and I. subverticellata; Restio brachiatus, R. festuciformis. R. praeacutus, R. simlis. R. tetragonus. and R. triticeus; Rhodocoma capensis and R. gigantea; Staberoha aemula, S. cernua, S. distachyos, and S. vaginata; Thamnochortus bachmannii, T. cinereus, T. ebracteatum, T. pellucidus, T. punctatus, T. spicgferus, and T. sporadeus.

Thymelaceae: Passerina vulgaris.

II (j) Gibberellins.

There are two important new results regarding the effects of gibberellins on germination. (1) Of 230 species of cacti that have germinated in the studies 64% required GA-3 for germination. (2) Several gibberellins, particularly GA-4 and GA-7, initiate germination of Sanguinaria canadensis. This confirms the proposal in the 2nd. Ed. that a gibberellin other than GA-3 is required for germination. Previously this species had failed to germinate under all controlled conditions although it readily self sows on our property. Experiments are in progress using K salt of GA-3, GA-4, GA-7, and iso GA-7. Kim Reasoner (a high school student) in Texas has conducted some precise experiments comparing GA-3, GA-4, GA-4/7, and GA-7. So far GA-3 seems to be the most effective except with the Sanguinaria.

Certain impure forms of gibberellins are commercially sold as Pro-Gibbs. The following experiments compare the effects of 95% crystalline GA-3 with 30% Pro-Gibb. The latter was used in three times the amount in order to give comparable concentrations of the gibberellin. The data in the following Table show that results were sometimes equivalent, but often the Pro-Gibb was less effective.

II (I) DEATH RATES

Ultimately all seeds die in storage either in dry conditions or in moist non-germinating conditions. The behavior from species to species varies enormously. Species such as Salix arctica (the arctic willow) have seeds that are totally dead after just two weeks of dry storage at 70. At the other extreme are species with seeds in impervious seed coats. These seeds sometimes retain viability for as much as 100 years or longer in dry storage. In general seeds with impervious seed coats have the slowest death rates in dry storage (DS), and seeds of species where the seeds are shed from green seed receptacles have the most rapid death rates in DS. Species that require dry storage (D-70 germinators) usually are viable for 2-5 years of DS.

The rate curve for dying has been studied for a number of species and both quantitative and qualitative data indicate that seeds die in dry storage by a chemical process that follows an inverse first order rate curve. The equation for this is $dn/dt = k/n$ where n is the number of viable seeds remaining after time t. This curve starts out flat with a very low rate of dying. The rate gradually increases and finally ends with the remaining 75% dying rather suddenly. Thus the tradition of giving a specific time for the seeds to remain viable is not far from the truth.

Moderately quantitative data were obtained for the following species. The half-life is given in parentheses after the name of each species: Allium karataviense (6 m), Aruncus dioicus (4 m), Aruncus sylvestris (15 m), Asclepias incarnata (18 m), Aster alpinus (12 m), Betulus populifolia (12 m), Catalpa bignonioides (18 m), Clematis grata (9 m), Clematis recta (12 m), Clematis virginiana (9 m), Elmera racemosa (2 y), Epilobium latifolium (8 m), Gaura biennis (12 m), Gentiana affinis (6 m), Heuchera richardsonii (12 m), Lathyrus latifolia (6 m), Lepidium sativum (6 m), Lobelia inflata (18 m), Meconopsis betonicifolia (6 m), Monarda citriodora (18 m), Salix arctica (6 days), and Thaspium trifoliatum (6 m).

It has been traditional to dry store seeds at 40 in a refrigerator on the presumption that the rates of dying of seeds will dramatically slow down at the lower temperature analogous to bacterial decay. **This may be completely in error.** Extensive studies in progress on storage of seeds of Eranthis hyemalis show that the seeds dry store much longer at 70 than in the refrigerator. With Hyacinthus orientalis the rate of dying was slower at 40 but only by a factor of about three (2nd Ed.).

Lifetimes in dry storage can be expected to depend (perhaps in a small degree) on the relative humidity. Most dry storage facilities have a relative humidity around 70%. The relative humidity in refrigerators varies, but in general there is a tendency to dry out material stored therein, and this may be a factor.

In addition there is the opportunity to store seeds in moist non-germinating conditions. An outstanding example is Salix arctica. Seeds can be held for at least three months moist at 40 with no effect on the germination at 70 whereas just two weeks dry storage at 70 is fatal. Seeds of Eranthis hyemalis can be also be stored for a year moist at 70 with little loss of viability whereas six months dry storage at 40 or 70 is largely fatal. Many other examples could be cited.

One critical precaution is that storage under moist non-germinating conditions must be kept aerobic. For example seeds of Eranthis hyemalis stored moist in tightly sealed polyethylene bags soon rot at either 40 or 70. This suggests that such seeds are still undergoing some type of respiration albeit at a slow rate.

II (m) Soaking of Seeds

A time-honored procedure in growing plants from seed is to soak the seeds in water before planting. There is no question that seeds must absorb water in order to germinate, but the following facts cast much doubt on the value of soaking. First of all in using my moist paper towel technique I have not found that a preliminary soaking gave significantly faster germination. This was true even for large seeds such as those of Aesculus hippocasteanum and Phoenix.

More alarming is the fact that many seeds die at a significant rates under water even if the water is changed every day and even if the seeds are under only an inch of water. What happens is that many seeds and particularly large seeds commence a rapid metabolism on moistening which has a large demand for oxygen. If placed under water the delivery of oxygen to the seed is inhibited, and the seeds start to die of asphyxiation. This was shown in detail for the honeydew form of Cucumis melo (see Section II a). This effect was even found in a swamp plant, Lysochiton camschaticum.

Presumably soaking for a day would have some minor value for large seeds if placed in certain media that transmitted water poorly. However, growers should be aware of the potential dangers of soaking. Possibly constant aeration of the water by bubbling air through it would make soaking less hazardous, but the minor benefits of soaking do not seem to warrant much effort in this direction.

II (n) PINACEAE

Several nurseries have expressed concern that germination in Pinaceae was low. The following is a possible (though not very helpful) explanation. Sixteen genera of Pinaceae have been studied. In general germination occurred in the first cycle at 70 or less often in a 40-70 pattern. However, many cones were collected that were either totally empty of seeds or had large numbers of empty seed coats or non-viable seeds that quickly rotted on exposure to moisture. If these are discounted, germinations were in high percentages, but such "empties" and "duds" are not readily recognized on visual examination.

II (o) Efficient Procedures in Germinating Seeds

This is more in the nature of a reminder that the paper towel and polyethylene bag procedures described in the 2nd Ed. are far more efficient than past procedures employing Petri dishes and other voluminous paraphanelia. Further, for many seeds with extended germinations it is far more efficient to conduct the treatments in the paper towels than in pots.

III FAMILIES AND GENERA NOT STUDIED BEFORE

Families: Agavaceae, Alangiaceae, Alstroemerikaceae, Bombaceae, Casuarinaceae, Cneoraceae, Cyperaceae, Elaeocarpaceae, Empetraceae, Epacridaceae, Fouquieriaceae, Franeniaceae, Globulariaceae, Goodeniaceae, Haemadoraceae, Hyacinthaceae, Juncaceae, Lecythidaceae, Martyniaceae, Meliaceae, Menispermaceae, Musaceae, Myopoaceae, Myrsinaceae, Nolanaceae, Ochnaceae, Orobanchaceae, Pedaliaceae, Pittosporaceae, Podocarpaceae, Puniaceae, Resedaceae, Saururaceae, Scheuchzerlaceae, Stachyuraceae, Sterculiaceae, Stylidaceae, Trochodendronaceae, Urticaceae, Zingiberaceae,

Genera: Acanthus, Acinos, Adenostoma, Aeonium, Aethiopsis, Aethiophyllum, Ageratina, Agrimonia, Agrostemma, Agrostocrinum, Akebia, Alangium, Albuca, Alcea, Alnus, Althaea, Amaranthus, Amethystia, Ammi, Amorpha, Anacampseros, Anagallis, Anigozanthos, Annona, Antigon, Apium, Arctium, Arctomecon, Ardisia, Argyreia, Argyroderma, Aronia, Asyneuma, Atractyloides, Atriplex, Azorina.

Banksia, Barbarea, Bartsia, Berardia, Berlandiera, Bertholletia, Beschorneria, Bessya, Biscutella, Bitium, Blephilia, Bloomeria, Boenninghausenia, Bomarea, Bombax, Brachiaria, Brachyglottis, Braya, Broussonetia, Bulbine, Butia.

Caesalpina, Cajanus, Calendula, Callitris, Calonycton, Calycocarpum, Cannabis, Capsicus, Cardamine, Carex, Carmichaelia, Carum, Carya, Casuarina, Catharanthus, Cautleya, Cedrela, Ceratotheca, Cercocarpus, Cerinthe, Cestrum, Chamaebatia, Chamaedaphne, Chamaemelum, Chimonanthus, Chordospartium, Cicer, Cicerbita, Clitoria, Cneorum, Cnicus, Cobaea, Cocculus, Collinsia, Coluteocarpus, Conimitella, Cordyline, Costus, Cotinus, Cotyledon, Cowania, Crambe, Crepis, Crinodendron, Criscoma, Cuminium, Cuscuta, Cyathodes, Cynanchum, Cypella, Cyperus, Cyphomandia, Cythomandra.

Daboecia, Daubenya, Davidia, Dendromecon, Delonix, Desmanthus, Desmodium, Dianella, Diascia, Dichelostemma, Dicranostigma, Dietes, Dipcadi, Diphylleia, Dirca, Dorotheanthus, Dracunculus, Draperia, Drosera, Duchesnea.

Eccremocarpus, Echinaceae, Echinops, Ehretia, Embothrium, Empetrum, Engelmannia, Eremophila, Eriastrum, Erinus, Eriophorum, Erythrina, Eschscholzia, Euceliopsis, Eucomis.

Fallugia, Fatsia, Fedia, Feijoa, Ficus, Foeniculum, Forskohlea, Fortunella, Fouquieria, Fragraria, Francoa, Frankenia, Fremontodendron, Fumaria.

Galega, Gamocheta, Gardenia, Globularia, Gloriosa, Glycyrrhiza, Glyphosperma, Godetia, Goodenia, Gossypium, Grayia, Grevillea, Guichenotia.

Hackelia, Haleria, Halimum, Hedeoma, Heliotropium, Herniaria, Hesperaloe, Hesperochiron, Heterodendrum, Hibbertia, Hieracium, Hierochloe, Hoheria, Honckenya, Hedyotis, Houttuynia, Humulus, Hunnemania, Hydrophyllum, Hymenosporum, Hyoscyamus.

Ibicella, Ipheion, Isatis, Isoplexis, Isotoma.

Jamesia, Jatropha, Jovellana, Juncus.

Kalopanax, Kedrastis, Kelseya, Kernera, Kigelia, Kitaibelia, Knautia, Koenigia.

Lachenalia, Lactuca, Lagopsis, Lagunaria, Lavatera, Lawsonia, Legousia, Leonotis, Leontodon, Leonurus, Lepechinia, Letptinella, Leptospermum, Leucaena, Leucocrinum, Leycesteria, Libertia, Ligusticum, Lippia, Lithocarpus, Livistonia, Loiseleuria, Lopezia, Luzula, Lycium, Lycopus.

Maackia, Macfadyena, Malacothamnus, Malope, Malva, Malvaviscus, Mandevilla, Mandragora, Mangifera, Marrubium, Margyricarpus, Matricaria, Maurandia, Medicago, Melia, Melissa, Menyanthes, Menziesia, Merremia, Micromeria, Mina, Mirabilis, Misopates, Modiola, Molospermum, Moltkia, Moluccella, Momordica, Montia, Moraea, Moricanda, Morina, Musa, Myoporum, Myrsine, Myrtus.

Nama, Nandina, Narthecium, Nectaroscordum, Nemesia, Nemopanthus, Nicandra, Nicotiana, Nigella, Nitraria, Nolana, Nolina, Notholirion, Nyctanthes.

Ochna, Olearia, Omalotheca, Omphalodes, Ononis, Onopordum, Orobanche, Orostachys, Orthrosanthus, Oryochophragmus, Oxypetalum, Oxyria.

Pancratium, Pandora, Parahebe, Parsonia, Patrinia, Peganum, Peltiphyllum, Perovskia, Petalonyx, Phaseolus, Phoenicaulis, Phormium, Phygelius, Pilosella, Pittosporum, Placea, Plantago, Pleiospilos, Pleurospermum, Plumeria, Podocarpus, Polanisia, Poliomintha, Polyxena, Porophyllum, Portulaca, Psathyrotes, Psychotria, Pterocephalus, Pterostyrax, Ptilotrichum, Pueraria, Punica, Purshia, Pyrola.

Rehmannia, Reseda, Rhinanthus, Rhodochiton, Rorippa, Rosularia, Roystonia, Ruta.

Sabal, Sagina, Sanicula, Sapindus, Sapium, Sarcopotorum, Sauromatum, Schivereckia, Schizopetalon, Scirpus, Scrophularia, Serenoa, Sesamum, Sesbania, Setaria, Shepherdia, Shoshonea, Silybum, Smyrnium, Sollya, Sparaxis, Spathodea, Specularia, Spergularia, Spilanthes, Stachyurus, Stapelia, Stephanotis, Stransvaesia, Strelitzia, Streptopus, Stylidium, Stylomecon, Stypandra, Succisa, Sutherlandia.

Tamarindus, Tecomaria, Tetragonolobus, Thaspium, Thespesia, Thunbergia, Thysanotus, Tibouchina, Tofieldia, Trachymene, Trachyspermum, Trichophorum, Triglochin, Trigonella, Triosteum, Tripterocalyx, Tritonia, Trochodendron, Tulbaghia, Turricula.

Ungnadia, Urtica.

Vaccaria, Valeriana, Veronicastrum, Vestia, Viguiera, Vincatoxicum, Vitaliana, Vitex.

Wachendorfia, Wahlenbergia, Withania.

Xanthoceras.

Zea, Zephyra, Zizania, Zizyphus, Zygophyllum.

IV DATA (in alphabetical order according to genera)

Data supplied by Ken W. Allan (KA), Alan D. Bradshaw (AB), Richo Cech (RC), Robert Charnock (RCh), Ann Crawford (AC), Carl Denton (CD), J. L. Hudson (JH), Darrell Kromm (DK), Vaclav Plestl (VP), Kim Reasoner (KR), Kristl Walek (KW), and Eugene Zielinski (GZ) has been included. When their data was used, it is indicated by their initials in parentheses. They are also included in the list of contributors. Negative results have been included to a greater degree because they do give some indication of the state of commercial samples. Generally the optimum treatment is given first.

Abies (Pinaceae). A. veitchii germ. 70D(15% in 2nd w)(2nd Ed.). Seeds DS 6 m were dead. It is possible that the low germination initially was because the seeds were already DS about 3 m.

Abutilon (Malvaceae). Impervious seed coats were not present.

A. sp. commercial hybrids germ. 70(2/12 on 3rd d) if punctured and 70(3/15 in 2nd w) if not.

A. vitifolium germ. 70(30% in 2-14 d). Punctured seeds all rotted.

Acacia (Fabaceae). All three species had an impervious seed coat.

A. cyanophylla germ. 70(12/13 on 3rd d) if punctured and 70(4/15 in 2nd w) if not.

A. dealbata germ. 70(16/18 on 3rd d) if punctured and 70(1/16 in 2nd w) if not.

A. iteophylla germ. only if the seed coat is punctured, and such seed germ. 50% in 3-12 d at 70 with the rest rotting. There was no significant change after 4 y DS.

Acanthus (Acanthaceae).

A. balcanicus germ. 70D(1/3 on 5th d). Removal of part of the seed coat gave the same 1/3 on 5th d. The remaining seeds rotted.

A. mollis germ. 70D(1/3 on 9th d) and 40(all 3 rotted).

Acer (Aceraceae). It was recognized by the fifth printing of the 2nd Ed. that it was the inner pliable seed coat that was impervious in a number of Asiatic Acer and not the hard tough outer seed coat. Data on Acer griseum, nikoense, pseudoplatanus, pseudosieboldiana, and truncatum now confirm this. What is confusing is that the outer seed coat is often so difficult to remove that in removing it the inner seed coat is inadvertently punctured. No highly efficient procedure has yet been devised for handling this troublesome group.

A. griseum has an impervious inner seed coat. The outer seed coat is tough and difficult to remove without injuring the inner seed. The only seeds that ever germinated were those that were removed from the outer seed coat followed by slicing off a small piece of the inner seed coat with a razor. Even then about half of the seeds developed within a few weeks while the remaining half required a 3 m period at 40 and a return to 70 before development proceeded. The sample of seed was probably stored several years, and this species needs reinvestigation.

A. nikoense had given some germination on opening the outer seed coat. It is now found that germination is 100% in 5-10 days if the inner seed coat (testa) is removed. Making a small nick in the testa with a razor blade also gives 90-100%

germination, but germination is slower taking 19-26 d. There is no doubt that the earlier germination resulted from an inadvertent nick in the testa. The seeds used in the study had been DS for 10 years followed by various moist treatments for 2 years. When the seeds were first opened, 90% of the seeds rotted within a month. These were not counted in computing the above percent germinations.

A. pseudoplatanus seeds were collected from the same single tree in Southeastern Pennsylvania on 10-2-93 and 11-20-93. The first collection rotted immediately, and all germination was from the second collection showing that the seed must be thoroughly ripe before collection. The seeds were soaked for several days in water to soften the outer seed coat before removing this outer seed coat by prying the two halves apart (fingernails work best). The brown leathery inner seed coat is impervious and must be ruptured to effect germination. Removal of the inner seed coat gives 30-50% germination on the 7th day. Germination occurred in the 3rd w if the seed coat was just nicked. Ungerminated seeds quickly rotted. Presumably seeds germinate eventually in OT, but none germ. in 2 y. Seeds DS 2 y were dead.

A. pseudosieboldiana was reported in the 2nd Ed. to give low germination on opening the outer seed coat. It is now found that it is the inner seed coat or testa that is impervious. Germination is 100% in 2-8 d if the testa is completely removed. Making a slight cut in the testa with a razor blade germ. nearly 100% in 8-15 d. Prior treatments including 6 m DS at 70 had no effect, but seeds DS 2 y were dead. In this species the outer seed coat is difficult to remove. The most effective method was to clamp the seed in a vice and slowly apply pressure along the keel until it had split enough to be pried apart.

A. rubrum was reported to die rapidly on DS at 70 so that the seed was all dead after two months. However, I have a report that DS seed still retained some viability. This question needs to be restudied.

A. saccharinum germ. 80-100% in 70D, 70L, or 40. The only difference was that in 70D opened seeds (outer seed coat removed) germ. in 2-6 d whereas unopened seeds germ. in 2nd w. Opened or unopened seeds germ. in 3rd w at 40. Seeds DS for just 3 m at 70 were all dead.

A. truncatum belongs to the group with an impervious inner seed coat. Germination was 25% in the 2nd w at 70 if the inner seed coat was peeled away. The rest rotted. If the inner seed coat is just nicked, the same percent germinated, but the seedlings quickly rotted. It also seemed important to remove the outer and inner seed coats at the same time. If the latter were delayed even one month, germination was reduced to around 10%.

Acinos (Lamiaceae). A. alpinus germ. 70L (32% in 3-16 d), 70 GA-3 (33% in 3rd w), 70D(14% in 8-11 w), and 40-70D(27%).

Aciphylla (Apiaceae). Based on small samples of seed, three species of Aciphylla were reported to germinate only with GA-3 (2nd Ed.). A sample of A. aurea was received that germ. 70D-40(4/8 on 10th w)-70(2/8 on 3rd d) and 70 GA-3-40(2/7 in 8th w). In this latter sample GA-3 had no effect which is inconsistent with the earlier work so that more work is needed on this genus. A small sample of A. monroi germ. 70-40-70-40-70(2/4 in 2-5 d).

Aconitum (Ranunculaceae). A. napellus seeds received in December were all dead and quickly rotted. A. vulparia received at the same time did germinate 2/33, but the seedlings quickly rotted as did the rest of the seed. These results confirm the conclusion that Aconitum seeds have high death rates in DS and that most of the seeds distributed are dead. Note that seed of A. wilsoni collected fresh from our own planting germ. readily at 40 in high percentage, but quickly died in DS.

Adenostoma (Rosaceae). Fresh seed of A. facsiculatum germ. best in 70 GA-3(27% in 3-14 w) and 70L(15% in 6-12 w)-40(9%)-70(8%) and less in 70D(2%)-40(6%). Seeds DS 6 m germ. similarly, but seeds DS 1 y germ. 12% in 2-5 w in either 70D or 70L indicating that the light requirement had died away. Seeds DS 2 y were all dead.

Adonis (Ranunculaceae). Generous amounts of seeds of A. vernalis have been received from a variety of sources. These have proved to be over 99% empty seed coats. My own plants set small amounts of viable seeds.

Aeonium (Crassulaceae). Small samples of A. simsii and A. tabuliforme both gave a single germination in 70L and none in 70D. After 1 y DS at 70 the sample of A. simsii germ. 70L(2 in 5-9 d) and none in 70D. Neither species germ. any after 18 m and 2 y DS. The samples were too small for definitive conclusions.

Aeniopsis (?). A. cabolica germ. 70D(3/4 in 6-12 d).

Aesculus (Hippocastanaceae). Thanks to data from Darrell Kromm (see contributor list), it is now clear that this genus divides into two groups. One group germinates immediately at 70, and the seed is killed by winter temperatures in Wisconsin. This group consists of A. x carnea, A. discolor, A. sylvatica, A. parviflora, and A. parviflora serotina. The second group are 40-70 germinators, and the seed survives winters in Wisconsin. This group consists of A. glabra, A. hippocastanum, A. octandra, A. turbinata, and A. turbinata tomentosa (A. chinensis). It was shown with A. hippocastanum that there is enough moisture in the bulky seed so that 3 m at 40 in a loose polyethylene bag gives as good germination on the shift to 70 as did 3 m moist at 40, and this may be true for the rest of this group.

A. pavia has a confusing situation. The first sample (2nd Ed.) germ. 40-70(100% in 1-7 d). A sample of three seeds from my own tree germ. 40(3/3 in the 2nd w) which is a remarkably rapid germination for any species at 40. However, Kromm lists this species as one of those germinating at 70. It is possible that the three samples were not all the same species.

Aethephyllum (?). A. pinnatifidum germ. 70D(5/10 on 10th d).

Agastache (Lamiaceae). Light was required for the two species studied.

A. nepetoides germ. 70L(57% in 2nd w) (2nd Ed.) and 70D(none). This pattern and the rate were unchanged after 2 y of DS, but the germination declined to 28% (still in 2nd w), and seeds DS 3 y were all dead.

A. occidentalis germ. 70L(68% on 5th d), 70 GA-3(74% in 5-8 d), 70D(none), 40(14%)-70D(11%), and 100% in late March in OT. It is unusual for OT and 70L to be the two treatments to give germination. Seeds DS 2 y germ. 70L(26% in 4-8 d) and 70D(none) showing significant dying of the seeds and retention of the light requirement.

A. scrophulariaefolia gave somewhat confusing results with two samples (2nd Ed.). The general pattern was that seeds germ. better after 1 y DS and that light or GA-3 was required. Seeds DS 1 y germ. 70L(80% in 5-11 d), 70 GA-3(80% in 1-4 w), and 70D(none) whereas fresh seed germ. 70L(16% in 3-17 d), 70 GA-3(38% in 3-8 d), and 70D(none). A prior 3 m at 40 led to lower percent germinations.

Ageratina (Asteraceae). A. occidentale germ. 5/5 in 10-14 d in 70D.

Agrimonia (Rosaceae). A. eupatoria germ. 70D(1/7), 70L(2/5), and 70 GA-3(2/5), all in the 3rd w. It also germ. 40(3/7 in 10th w)-40(1/7).

Agrostemma (Caryophyllaceae). A. tinicola germ. 100% on 3rd d in 70D using either seed DS 6 m or 1 y.

Agrostocrinum (Liliaceae). A. scabrum were all empty seed coats.

Akebia (Lardizabalaceae). A. quinata germ. at 70 after a prior one month at 40 (JH).

Alangium (Alangiaceae). A. platanifolium along with Cornus canadensis are the two species with seeds in a fleshy fruit that require GA-3 for germination. Seeds germ. 70 GA-3 (100% in 3-5 w). A year under various moist conditions or DS 6 m had no effect, and the seeds still germ. immediately on treating with GA-3. Seeds were dead after DS for 1 y.

Albuca (Liliaceae). A. aurea germ. 100% in 4-6 d in either 70D or 70L. S. canadensis germ. 70D(11/20 in 6-12 d) and 70L(0/10). A. humilis germ. 75% in 6-10 d in either 70D or 70L. A. sp. germ. 60% in 2nd w in either 70D or 70L.

Alcea (Malvaceae). A. rosea is a D-70 germinator, and A. ficifolia germ. 70D(4/6 in 6-10 d).

Alchemilla (Rosaceae). In retrospect it is likely that OS may be the best treatment for the five species studied although, unfortunately, OS was not tried initiallly on any of the five. In the 2nd Ed. A. mollis and A. saxatilis were shown to require either light or OT (regarded as equivalent to OS) for germination. A. alpina, A. faeronensis, and A. vulgaris germ. best in OS, but the OS treatment was applied only after prior 70D-40 and 70L-40 treatments.

A. alpina germ. 70D-40-OS(36% in 4th w), 70L-40-OS(15% in 3rd w), 70D-40-70D(15% in 4th w), 70 GA-3-40(10%), 40-70D-40-70D(10% on 6th d), and none in OT after one y.

A. faeronensis germ. 85% in March in OT from seeds placed outdoors the previous October. None germ. in 70D-40, 70L-40, 70 GA-3, or 40-70D. When seeds from 70L-40-70L and 70D-40 were shifted to OS, respective germinations were 85% in the 3rd w and 20% on 8th d. Curiously shifting seeds to OS after 70D-40-70D treatment did not give any germination. Seeds DS 1 y were dead.

A. vulgaris germ. 44% in March in OT from seed placed outdoors the previous October and none in the other treatments after two cycles. Similar to A. faeronensis, when seeds from 70L-40-70L and 70D-40 wre shifted to OS, germination was 70% on the 3rd w and 58% on the 8th d. Also similar to A. faeronensis, seeds from 70D-40-70D treatment shifted to OS failed to germinate. Seeds did germinate 40-70-40-70(56% in 3-7 d), but this extended treatment is approaching OS treatment. Seeds DS 1 y were dead.

Allium (Liliaceae).

A. alba germ. 70D(97% in 1-8 w), 70 GA-3(100% in 2nd w), 70L(100% in 2-5 w), 40-70D(93% in 3 d-2 w), and OT(100% in first 2 w of Nov. from seeds placed outdoors in mid-Oct.). The data suggest that OS and GA-3 gave a modest increase to the rate of germination.

A. albopilosum germ. 40(87% in 5-13 w) and 70-40(87% in 6th w)(2nd Ed.). Seeds DS 6 m and 1 y germ. the same, but seeds DS 2 y were dead.

A. aff. farreri germ. 70D(25% in 4-6 d) and 40(50% in 5-8 w).

A. karataviense germ. in a long extended manner. It is now found that germination is somewhat faster under outdoor conditions with 36% germinating in March from seed placed outdoors in July. However, this result was on seed DS 1 y. Seeds DS 2 y were dead.

A. moly germ. 40(28%)-70(33%) (2nd Ed.). Seeds all died after DS for 18 m.

A. schubertii germ. 70D(64% in 1-3 w), 70L(6%), 40(61% in 4-8 w), and 28% in April in outdoor treatment. Light inhibits germination.

A. vulgaris seeds required GA-3 to germinate when fresh, but this requirement died off on DS. Superimposed on this was a dying in DS (2nd Ed.). After 1 y of DS germination in 70 GA-3 had fallen to 88% (fresh seed was 100%). It is now found that the seed is dead after 2 y of DS.

Alnus (Betulaceae). All samples were received in March, and had already undergone at least 6 m of DS and probably more. Since DS was clearly detrimental in A. crispa and A. rugosa (but not A. glutinosa), the low germinations in A. rugosa and A. serrulata and the total failure of A. japonica and A. maritima to germinate (despite normal looking seeds that resist rotting) may be due to the seeds having been subjected to DS for a year or more. Light and/or GA-3 generally promoted germination.

A. crispa (DS 6 m) germ. 70L(80% in 2nd w) and 70D(none). A prior 3 m at 40, OT, or GA-3 had little effect. Seeds DS 1 y germ. 70L(12% in 3rd w) and 70D(none) suggesting half life of about 9 m in DS.

A. glutinosa germ. 70L(65% in 7-9 d) and 70D(20% in 1-4 w). A prior 3 m at 40, OT, GA-3, or DS 6 m had little effect.

A. hirsuta v. hirsuta (DS 6 m) germ. 70L(6% in 3rd w), 70 GA-3(5% in 2nd w), 70D(1%)-40-70D(4% in 2nd w), 40-70D-40-70D(none), and 11% in May and June in OT. Seeds DS 1 y gave about the same results in 70L.

A. rugosa germ. 70L(1%), 40-70D(2%), and 3% in May and June in OT. None germ. in 70D or 70 GA-3.

A. serrulata germ. 70L(18% in 2-7 w), 70 GA-3(18% in 2-6 w), 70D(none), 40-70D(20% in 4-10 d), and 23% in May and June in OT.

Althaea (Malvaceae). A. officinalis is a D-70 germinator (RC).

A. hirsuta has an impervious seed coat and seeds DS 6 m germ. 100% on 4th d at 70 if punctured and none otherwise. Seeds DS 1 y germ. 70(6/8 in 2-4 d if punctured and 2/13 on 2nd d if not punctured). Larger samples are needed, but there is some indication that DS may induce cracking of the seed coats.

Amaranthus (Amaranthaceae). KR reported that A. cruentus and A. hypochondriacus germ. 50-90% in 2-3 d at 70. There were some differences if treated with GA-3, GA-4, and GA-7 but the samples were too small and the effects not large enough to attach much significance.

Amelanchier (Rosaceae). All seeds were WC 7 d, all experiments were conducted in the dark, and neither GA-3 or OT initiated germination. A. grandiflora and A. stolonifera germ. best in a 40-70 pattern and A. sanguinea germ. best in a 40-70-40-70 pattern. A preliminary 3 m at 70 delayed these germination for two additional cycles, and this is one of the rare examples where a treatment seemed to produce addtional blocks to germination.

A. grandiflora germ. 40-70(37% in 2-14 d)-40-70-40-70(8%) and 70-40-70-40-70(28% in 2-14 d)-40-70(40% in 2-10 d). Seeds DS 1 y were dead.

A. laevis germ. 70-40-70-40(100% in 10-12 w). Seeds started at 40 or 70 GA-3 largely rotted and did not germinate. Seeds DS 6 m were 97% dead and seeds DS 1 y were all dead.

A sanguinea germ. 40-70(3%)-40-70(56% in 2-30 d)-40-70 and 70-40-70-40-70(3%)-40-70(26% in 1-7 w)-40(37%)-70(24% in 2-6 d).

A. stolonifera germ 40-70(40% in 2-20 d)-40-70-40-70 and 70-40-70-40-70(60% in 2-4 d)-40. Seeds DS 1 y were dead.

Amethystia (Lamiaceae). A. caerulea germ. in 3 w in 70D (JH).

Ammi (Apiaceae). A. majus germ. in 7 d in 70D (JH), and A. visnaga was a D-70 germinator (RC).

Amorpha (Fabaceae). A. fruticosa has an impervious seed coat. The thin leathery seed coat can be punctured in two ways. Either grind the seeds against sandpaper or cut off the end with a scissors. Either leads to 100% germ. in the 2nd w. About 20% of the seeds have an imperfection in the seed coat and germ. without treatment. When the seeds are DS for 18 m, about half the seeds were found to have been internally infected with a weevil which ate the seed and emerged through a hole in the seed coat. The remaining half germ. 50% in the 2nd w with or without puncturing the seed coat indicating that the extended DS had killed about half of the seeds and had cracked all the seed coats. Overall only 25% of the seeds survived 18 m of DS between the weevils and natural dying.

Amsonia (Apocyanaceae).

A. jonesii germ. 70L(3/5 on 10th d), 70D(none), 40-70D(5/6 on 10th d), and 4/5 in April in OT. The 40-70D treatment is best, and it is remarkable that either 3 m at 40 or light initiate germination.

A. tomentosa germ. 70D(5/5 in 2-4 d) and 40(2/5 in 2-6 w)-70D(3/5 on 2nd d).

Anacampseros (Portulacaceae). A. ruffescens germ. 100% on 4th d in 70L and 70 GA-3 and 100% on 14th d in 70D.

Anagallis (Primulaceae). A. arvensis germ. in 3-6 w at 60-65 (JH), and A. linifolia germ. 100% in 4-8 d in 70D.

Anchusa (Boraginaceae).

A. angutissima germ. 70L(100%) if DS for 6 m and only 30% without the DS (KW). Expts. were not conducted in 70D, but light is probably not required.

A. azurea extensively self sows suggesting immediate germination at 70 (KW).

A. officinalis seeds had been DS for 18 m when received. These germ. 70D(70% in 2-6 d) and 40(6%)-70. Light, GA-3, or an additional 6 m DS had no effect. Note that starting at 40 was nearly fatal.

Anemone (Ranunculaceae).

A. japonica fails to set seed here, and two commercial samples did not seem to have any viable seed in the abundant cotton in which the seeds are enmeshed.

A. nemorosa germ. 70-40(59% in 9th w)-70-40(15% in 11th w) and 40-70(3%)-40(10% in 3rd w)-70-40(20% in 7th w). All rotted in OT and 70 GA-3. Germination is hypogeal and on shifting to 70 most of the seedlings develop a true leaf within a month. No further leaves develop the first year.

A. ranunculoides germ. 70-40-70-40(2/17 in 7th w)-40-70(1/17) and none in under all other conditions. A radicle developed at 40. A leaf emerged on a shift to 70.

Angelica (Apiaceae). A. archangelica germ. 70L (98% in 10-18 d), 70 GA-3 (97% in 11-15 d), 70D (5%)-40(10%)-70D(33% in 4-15 d)-40(5%), 40-70D(18%)-40(2%), and 46% in Nov.-Dec. and 31% in March-April in OT. The light requirement is similar to the two species reported in the 2nd Ed., and 70L is the best treatment. The seeds were all dead after 1 y of DS.

Anigozanthos (Haemadoraceae).

A. flavidus germ. 70D(100% largely in 4th w), 70 GA-3(100% largely in 3rd w), and 70L(none). The empty seed coats, about 50%, were not counted. Seeds DS 1 y showed no evidence of dying.

A. manglesii had over 90% empty seed coats. The limited data were 70D(1/1), 70L(2/2), and 70 GA-3(1/1) over a 2-6 w period suggesting that light or GA-3 had no effect.

Annona (Annonaceae). A. cherimola has failed to germinate under all conditions including puncturing the seed coats.

Anthericum (Liliaceae). A. racemosum germ. 70 GA-3 (70% in 2-8 w), 70L(8%)-40-70D(40% in 2-14 d)-40(24% in 7th w)-70D(16% in 2nd w), 70D-40-70D(none), and 40-70D(43% in 2-5 d plus 25% in 13th w)-40-70D(4%). At the suggestion of Grimes (the seed donor) the seeds were given 70(for 3 w)-40(for 8 w)-70(78% in 2nd w). These erratic results parallel earlier erratic results with A. racemosum and two other species. There does seem to be stimulation by GA-3 on top of a basic 40-70 pattern.

Antigon (Polygonaceae). A. leptopus germ. in 2-4 w at 70 (JH).

Anthriscus (Apiaceae). A. cerefolium seeds DS 6 m germ. 4-12% in 70D, 70L, and 40 (2nd Ed.), and seeds DS 1 y were dead. The low percentages of 4-12% may be due to extensive dying in the 6 m DS.

Apium (Apiaceae). A. graveolens seeds DS 6 m germ. 100% in 6-14 d in 70D or 70L and 40(90% in 7-11 w)-70(4%). After 2 y DS seeds germ. 70D(47% in 1-4 w), and after 3 y DS seeds germ. 70D(3% in 10-18 d).

Aquilegia (Ranunculaceae). In general Aquilegia require GA-3 for germination, but this can sometimes be replaced by light or DS.

A. canadensis was shown to have a GA-3 requirement for fresh seed, but this disappeared after 6 m and 12 m DS. Seeds DS 2 y at 70 germ. 9% in 3rd w showing that dying of the seeds had now become severe.

A. discolor germ. 70 GA-3 (81% in 5th w) and 70D-40-70D(32% in 2-4 w).

A. fragrans germ. 70L(6/10 in 2-4 w), 70 GA-3(3/10 in 2nd w), and 70D(none).

A. scopulorum was shown to germinate 100% in 2nd w in 70 GA-3 and none in 70D. This has now been confirmed in a second sample from a different source. The latter also germ. 40-70D(2/8 in 3rd w) and 70D-40(none).

A. vulgaris had germ. similar to A. canadensis. Seeds DS 18 m and 2 y germ. only 1% in 70D and were almost completely dead.

Aralia (Araliaceae).

A. californica (seeds received after 6 m DS) germ. 70D-40-70D(100% in 3-9 d), and 70L-40-70D(95% in 3-16 d), 70 GA-3(54% in 3rd w)-40-70D, and 40-70D(20% on 4th d)-40-70D(80% in 1-3 d). It is interesting that the 70-40-70 pattern is slowed down by an initial 3 m at 40.

A. elata (seeds received after 6 m DS) germ. 70 GA-3(35% in 3-9 w)-40(1%)-70D(3%) and 2% in OT. None germ. in 70D-40-70D, 70L-40-70D, or 40-70D. Seeds DS 1 y showed no deterioration and germ. 70 GA-3(40% in 5th w)-40-70d(4%), and 70D(none).

A. nudicaulis failed to germinate under all treatments despite the seeds being freshly collected.

Arbutus (Ericaceae). A. menziesii germ. 40(98% in 8th w). A prior 3 m in 70D or 70L and DS for 6 m or 1 y had little effect. Seeds germ. 70 GA-3(45% in 3-11 w)-40(55% in 3-6 w), but this is of no advantage in view of the excellent germination at 40. Seeds DS 2 y germ. 40(78% in 11th w) indicating some minor deterioration.

Arctium (Asteraceae). A. lappa is a D-70 germinator (RC).

Arctomecon (Papaveraceae). A. californica germ. 70 GA-3(3/8 in 5th w), OT(2/7 in Jan.), and none in 70D, 70L, or 40. OS needs to be tried. There was no further germination in the 70 GA-3 treatment after a shift to 40 for 3 m and a return to 70. Samples of A. californica and A. humilis seed that were 3 y old failed to germinate under all treatments.

Arctostaphylos (Ericaceae). Studies on A. crustacea, A. patula, A. pungens, and A. uva-ursi indicated that GA-3 causes some increase in the rate of germination, but germination was still low and occurred over extended periods. Results with A. pungens suggest that more extensive WC is needed.

A. crustacea germ. 70(GA-3)-40(2%)-70(2%) and 70-40-70-40(2%). None germ. in 70L, 40-70-40-70, or OT.

A. patula germ. 70 GA-3(4%)-40(9%)-70(13%) and none in 70-40-70-40-70.

A. pungens was divided into two lots, one WC for 7 d and the other WC for 14 d. The latter gave better germination and germ. 70(GA-3)-40(31% in 5-14 w)-70(20% in 2 d-2 w)-40-70(1%) and 70-40(1%)-70(6%). The seeds WC 7 d germ. 70GA-3(3%)-40(12%)-70(12%) and 70-40-70(3%). Light had no effect.

A. uva-ursi seeds placed in OT in Dec. 1991 germ. 2% in summer 1993 and 4% in summer 1994. A sample was treated with GA-3 after a year of alternating cycles whereupon it germ. 70(GA-3)-40(2%).

Ardisia (Myrsinaceae). A crenata seed 2 or 3 y DS failed to germinate under all treatments.

Arenaria (Caryophyllaceae). Nine species were D-70 (2nd Ed.). This is not true for A. norvegica.

A. hookeri germ. 70D(24% in 2-10 d).

A. norvegica germ. only in 70 GA-3 (87% in 1-5 w) and none in 70D or 70L. Changes occur in the seed in DS so that seed DS 6 m at 70 germ. 70 GA-3(100% in 4-6 d), 70L(30% in 1-4 w), and 70D(1%), and seeds DS 1 y germ. 70 GA-3(45%) and none in 70D. Seeds DS 2 y were dead.

Argemone (Papaveraceae). A. pleicantha was studied earlier and germ. in high percentage only under outdoor conditions, but GA-3 was not tried. The following three show disparate behavior between themselves and A. pleicantha. Such differences in germination behavior between different species have been frequent in Papaveraceae.

A. grandiflora germ. 70D(100% in 6-11 d).

A. hispida germ. 40(30% in 11th w)-70D(10%), 70 GA-3(50% in 3rd w), and 70D-40-70D(none).

A. munita germ. 70 GA-3(98% in 2-4 w). No other treatment gave any germination. The results were identical for fresh seeds or seeds DS up to 2 y.

Argyreia (Convolvulaceae). A. nervosa germ. 70D(3/4 in 3-10 d).

Argyroderma (Aizoaceae). A. congregatum germ. in 3rd d at 70 (KR).

Arisaema (Araceae). A. amurense germ 70D(2/6 in 16 d). The pattern for A. quinata (misnamed A. quinquifolium previously) has been confirmed.

Aristolochia (Aristolochiaceae). A. macrophylla germ. 70L(65% in 3rd w), 70 GA-3(25%), 70D-40-70D(14%), 44% in May in OT, and 40-70D(none). Seeds DS 1 y germ. 70L(10%) indicating a half life in DS of the order of 3 m.

Armeria (Plumbaginaceae). A. maritima seeds DS 1 y germ. 70D(50% in 10-20 d) and 40-70D(50% in 2nd w). Germination was lower in fresh seeds which germ. 70D(15% in 2-6 w)-40-70D and 40-70D(38% in 3-20 d).

Aronia (Rosaceae). Germinations were extended over a number of cycles which is typical of many of the Rosaceae.

A. arbutifolia has failed to germinate after one year in all treatments despite self-sowing on our property and fruiting abundantly.

A. melanocarpa seeds DS 6 m germ. in higher percentage (90%), but the germination did not occur until the sixth cycle whereas fresh seed gave significant germination in the first and third cycles. Fresh seeds germ. 70L(6%)-40-70L(60% in 2nd w), 70D(6%)-40-70D(24% in 2-4 w), OT(58% in April from placing outdoors the previous September), and none in 70 GA-3 or 40. Seeds DS 6 m at 70 germ. 70D-40-70D-40-70D(90% in 6-10 d), 40-70-40-70-40-70(71% in 4-12 d), and OT(43% in March and April from placing outdoors in March a year earlier).

Artemisia (Asteraceae). A. pamirica still germ. 70D(100% in 3-5 d) after 2 y of DS.

Arthropodium (Liliaceae). A. cirrhatum germ. only with GA-3. Data for this treatment is now complete: 70 GA-3(25% in 3-11 w)-40-70(10%)-40(10%).

Aruncus (Rosaceae). A. dioicus and A. sylvestris germ. only in 70L (2nd Ed.). The seeds rapidly die on DS. For A. dioicus the percent germination was 61%, 19%, 6%, and zero for seeds DS 0, 6 m, 1 y, and 2 y. For A. sylvestris the percent germination was 100%, 85%, 68%, and 2% for seeds DS 0, 6 m, 1 y, and 2 y. Although the data is limited and there were difficulties in counting the fine seed, the death rates follow an inverse first order rate law.

Asarina (Scrophulariaceae). A. barclaiana germ. 70L(100% in 2ndw) and less in 70D(37% in 2nd w) and OS(57% in 3-7 w). However, after DS 1 y these differences disappeared and the seeds germ. 100% in 6-12 d in either 70D or 70L.

Asclepias (Asclepiadaceae). A. cryptoceras germ. OT(5/8 in April), 70D(4/8 in 3rd w), and 40-70(6/7 in 1-3 d) using fresh seed. A second sample DS 3 m germ. OT(6/6 in April), 40-70(5/7 in 1-4 w), and 70-40-70-40-70(2/6 on 4th d), but after DS 6 m, it germ. 40-70(1/6 on 2nd d, rest rotted) and 70(all rotted) indicating that nearly all had died after 6 m DS.

Asimina (Annonaceae). A. triloba germ. 40-70(76% in 0-5 w). It is now found that germination will take place in 70 GA-3(50% in 4-6 w).

Asparagus (Liliaceae). A. sprengeri germ. 100% in 1-3 w in 70D for seeds WC for one d. Further WC or puncturing seed coats had little effect.

Asphodeline (Liliaceae). A. lutea germ. 70D(100% in 2-5 w). This was unchanged by DS for 1 y. A. brevicaulis germ 2/2 on 10th d in 70D. A liburnica germ. 2/4 in 2nd w in 70D.

Asphodelus (Liliaceae).

A. albus germ. 40-70D(3/6 in 1-4 w). Although none germ. in 70D, there were only 2 seeds. A second sample collected in the wild was entirely empty seed coats.

A. fistulosus was studied again and germ. 70D(3/4 on 4th d).

Aster (Asteraceae). A. alpinus germ. 100% in 5-13 d in 70D (2nd Ed.). The percent germination in 70D declined on DS to 70% after 6 m, 40% after 12 m, and 2% after 2 y DS. Presumably the blocking mechanism is destroyed in a few weeks of DS.

Asteromoa (Asteraceae). A. mongolica germ. 100% in 5-7 d in 70D. This was unchanged after 6 m and 1 y of DS, but dropped to 41% in 10-20 d after 2 y DS.

Astragalus (Fabaceae).

A. glycophyllus has an impervious seed coat and seed coats must be punctured to germinate. However, germination of the punctured seeds was unusual in that it occured over an extended period. Punctured seeds germ. 70(30% in 3-12 w)-40(4%)-70(32% in 2nd w) and 40-70(60% in 1-7 w). If the seed were given 70-40 first and then a hole made in the seed coat, the seeds germ. 51% in 2-4 w.

A. membranaceous has an impervious seed coat (RC).

Astrantia (Apiaceae). A. major and A. minor germ. 3-5% in 70-40 patterns with seeds DS several months. A new freshly collected sample germ. 40(1/8)-70(4/8 in 2-4 d) and none in 70D or 70L. A rapid death rate in DS is suspected.

Asyneuma (Campanulaceae). A. limonifolium germ. 70D(68% in 1-3 w) and 70L(33% in 2nd w).

Atractyloides (Asteraceae ?). A. japonica from seed exc. was all chaff.

Atriplex (Chenopodiaceae).

A. hymenolytra seed is enclosed in a capsule centered in a circular membrane. The seeds germ. 100% in the 2nd w either in 70D or 40 providing the seed was removed from the capsule. Otherwise germination was of the order of 20-50% and occurred over longer times. DS for 6 m or 1 y and light or GA-3 had no effect.

A. longipes germ. 70 GA-3 (20% in 2-4 w)-40-70(50% in 3rd w), 70D (3%)-40-70D(7%), 70L-40-70D(12%), 40-70(37% in 1 d-6 w)-40-70(5%), and 90% in April and May in OT. Seeds DS 2 y were dead.

Aubrietia (Brassicaceae). A. grandiflora seeds DS 6 m germ. 70D(65% in 4-8 d) and 40(26% in 4-12 w)-70D(1%). Light had no effect. Germination dropped to 10% in 4-12 d in 70D after 1 y DS. It is likely that fresh seeds would have germ. significantly higher than 65% in view of the high death rate in DS.

Azorina (?). A. vidallii germ. 70L(100% on 8th d) and 70D(38% on 14th d).

Banksia (Proteaceae). Three species of B. had impervious seed coats (JH).

Baptisia (Fabaceae).

B. australis seeds DS 1 y germ. 100% if punctured and 10% if not punctured, both on 2nd d and in 70D.

B. viridis germ. 100% on 3rd d if punctured and 1% if unpunctured.

Barbarea (Brassicaceae). B. vulgaris germ. 70L(78% on 4th d) and 70D(25% in 6-10 d). Germination in 70 GA-3 was similar to 70L.

Bartsia (Schrophulariaceae). B. alpina (fresh seed) germ. 70 GA-3 (90% in 1-8 w, first order kinetics, ind. t of 4 d, and a half-life of 16 d), 70D-40-70D(86% in 1-3 w), 70L-40-70D(88% in 1-3 w), 33% in April in OT, and 40-70D(none). Seeds DS 6 m at 70 germ. 70 GA-3(36%, ind. t 4 d, half-life about 3 d). Thus the rate is faster but the percent germination much lower. Seeds DS 1 y were dead.

Begonia (Begoniaceae). B. suffruticosa germ. 100% in the 2nd w in either 70D or 70L like others in this genus. DS 6 m or 1 y had no effect.

Berardia (Asteraceae). B. subacaulis germ. 70D(3/4 in 1-3 w). About 90% of the seed coats were empty, many due to having been eaten out by a weevil.

Berlandiera (Asteraceae). B. lyrata germ. 70D(5/6 on 3rd d) and 70L(3/7 on 5th d).

Bertholletia (Lecythidaceae). B. excelsa are the large nuts sold in stores as Brazil nuts. These have rotted within a month either opened or unopened indicating that some processing of the nuts led to total death despite the kernel of the nut being full and solid.

Beschorneria (Agavaceae). B. bracteata germ. 70D(100% in 6-10 d) and 40(100% in 8th w). Light or GA-3 had little effect.

Bessya see Synthyris.

Betula (Betulaceae). Light and/or 40-70 patterns were best.

B. glandulosa germ. best in a 40-70D pattern although light and GA-3 gave some direct germination at 70. Seeds DS one m germ. 40-70D(19% in 4-8 d), 70L(8% in 3rd w)-40-70D(1%), 70 GA-3(4%), 70D-40-70D(9% on 8th d), and 7% in April in OT. Seeds in DS had a half life of about one year as shown by 40-70(19%), 40-70(18%), and 40-70(8%) respectively for seeds DS one m, 6 m, and 12 m.

B. nana germ. 70L (20%, zero order kinetics, ind. t 2 d, 10%/d), 70 GA-3 (34%, zero order kinetics, ind. t 2 d, 20%/d), 70D-40-70D(24% in 1-4 w), 40-70L(2%), 40-70D(none), and 5% in OT. After 3 m DS seeds germ. 70L(38% in 2nd w) and 70D(none). The seeds were difficult to count so that the percent germinations in 70L could have been equal for seed fresh and DS 3 m. Seeds DS 1 y germ. 70L(none) and 70D(3%) and are nearly dead, but the light requirement may have disappeared.

B. platyphylla japonica germ. best in a 40-70 or a 70L pattern. Seeds DS 6 m germ. 40-70D(8% in 6-10 d), 70L(9% in 7-11 d), 70 GA-3(6% on 9th d), 70D(none), and 10% in April in OT. Seeds DS 1 y gave about the same results, but seeds DS 2 y germ. only 3% in 2nd w in 70L.

B. populifolia germination in 70L was 11% (in 1-3 w) and none in other treatments. The percent germination in 70L declined on DS to 9%, 4%, and 1% for seeds DS 6 m, 1 y, and 2 y respectively.

B. pubescens germ. 70L(13% on 6th d), 70D(8% in 4th w), and none in 70 GA-3 or 40.

Biscutella (Brassicaceae). B. coronopifolia germ. 70D(5/5 in 1-3 w) and 40-70(1/5).

Bitium. See Chenopodium.

Bixa (Bixaceae). B. orellana germ. 10% in 3rd w in 70D, 70L, or 70 GA-3 (2nd Ed.). This was unchanged after 6 m DS.

Blephilia (Lamiaceae). B. hirsuta germ. 70L(60% in 1-4 w), 40-70D(22% in 4-6 d), and 70D-40-70D(60% in 5th w).

Bloomeria (Liliaceae). B. crocea germ. 40(4/4 in 5th w) and 70D(2/4 in 2nd w)-40(1/4 in 3rd w).

Boenninghausenia (Rutaceae). B. albiflora germ. 70D(3/3 on 7th d), 70L(2/4 on 13th d), and 40-70D(none).

Bomarea (Alstroemeriaceae). B. sp. DS 2 y germ. 70 GA-3(25% in 10th w, rest rotted), 70-40-70-40-70(15% on 1-4 w)-40-70(30% in 4-8 w), and 40-70-40-70-40-70(24% in 4th w).

Bombax (Bombaceae). B. malabaricum germ. 70D(2/6 in 3rd w). Puncturing the seed coat led to total rotting and GA-3 had no effect.

Borago (Boraginaceae). B. officinalis has germination much improved by DS at 70 for 12 m. Such seeds germ. in 80-95% in 1-3 w in 70D, 70L, or 70 GA-3 whereas fresh seeds germ. 90% in 70 GA-3 and only 20% in 70D or 70L.

Brachiaria (Poaceae). B. dictyoneura seeds germ. best in OS treatment, but with DS the germination in 70D gradually approached that in OS treatment. Seeds DS 4 m germ. OS(28% in 3rd w), 70L(9% in 2nd w)-40-70D(4%), 70D(6%), 70 GA-3(6%), OT(11% in Nov. from seed placed outdoors in October), 40-70L(10%), and 40-70D(none). Seeds DS 6 m germ. OS(68% in 2nd w) and 70D(36% in 2nd w), and seeds DS 1 y germ. OS(46% in 5-9 d) and 70D(36% on 5th d). Seeds DS 1 y germ. 70D(36% on 5th d) and OS(46% in 5-9 d).

Brachyglottis (Asteraceae). B. bellidioides germ 70L(2/8 in 4th w) and 70D(all rotted). The sample was to small to conclude that light was required.

Braya (Brassicaceae). B. alpina germ. 70L(100% on 5th d), 70D(80% in 5-17 d), 40(68% in 2-8 w)-70D(24% in 3-7 d), and OT(100% in March started in Feb.).

Brimeura (Liliaceae).

B. amethystina optimum conditions can now be completed: 40-70(3%)-40(92% in 5-7 w)-70-40-70-40(5%).

B. amethystina alba germ. 70L-40(90% in 4-9 w), 70D-40(20% in 2nd w), 70 GA-3(10%)-40(15%), 40-70D-40(100% in 3rd w), and 40-70L-40(70% in 3rd w).

B. pulchella data is now complete: 40(97% in 2nd w) and 70(5%)-40(95% in 3-8 w) for fresh seed and 40(98% in 3-6 w) and 70(53% in 1-4 w)-40(34% in 6th w) for seeds DS 6 m at 70.

Broussonetia (Moraceae). B. papyrifera seeds DS 6 m germ. 70D(10% in 1-7 w)-40-70D(10% in 1-5 w). Germination of seeds DS 1 y was similar.

Buddleia (Loganiaceae). B. davidi seeds collected in 1992 and 1995 gave different behaviors. The 1992 seeds required light for germination, but this light requirement disappeared on DS. Fresh seeds or seeds DS 2 y germ. 100% in 2nd w in 70L. Seeds DS 0, 6 m, 1 y, and 2 y germ. 4%, 4%, 30%, 90% in 70D. Seeds DS 3 y were all dead. In contrast the 1995 sample germ. within a week in both 70D and 70L. It was already shown that the blocking system is readily removed by limited exposure to light. It is possible that the 1995 seed had already had sufficient exposure to light in the seed capsule as the seed was collected in the last week of November whereas the 1992 seed had been collected the last week of October. The two samples were collected from different plants, and this could also account for the difference. B. davidi naturalizes here and sets abundant seed.

Bulbine (Liliaceae). B. bulbosa, B. caulescens, and B. frutescens all germ. 100% in 4-8 d in either 70D or 70L. B. annua germ. 70L(100% on 4th d) and 70D(6/7 in 3rd w).

Bupleurum (Apiaceae).

B. longifolium DS 6 m germ. 70-40(10% in 9th w)-70(10%)-40(60% 9th w) and none in 40-70-40. Light had no effect.

B. ranunculoides DS 6 m germ. 70D(67% in 3-8 w), 40-70D(21% in 1-4 w), and none in OT. When a sample was shifted to 70D after 8 w in 70L, 24% germ. in 2-4 w. This is one of the rare species in which germination is inhibited by light.

B. rotundifolium germ. best at 40. Seeds DS 6 m germ. 40(90% in 4th w), 70D(77% in 1-3 w)-40(4% in 3rd w), 70L(48% in 1-7 w)-40(12%), and 70 GA-3(13%). Seed DS 1 y gave the same germination. A second sample also DS 6 m germ. 40(92% in 4th w), 70D(14% in 1-8 w)-40(27% in 4th w), 70L(11%)-40(52% in 4th w), and OT(87% in March, started in Feb.). The OT treatment was in effect germination at 40. About half the seeds died after 2 y DS as shown by 40(38% in 5-7 w).

Butia (Palmaceae). B. capitata v. odorata has failed to germinate after 8 m.

Caesalpina (Fabaceae). C. pulcherrima seeds (commercial) all rotted despite being large and full of endosperm.

Cajanus (Fabaceae). C. cajon germ. 70D(60-70% in 2nd w)(KR).

Cajophora (Loasaceae). C. acuminata germ. 70D(100% in 2nd w). Light or GA-3 had little effect.

Calendula (Asteraceae). C. officinalis was a D-70 germinator (RC).

Callistemon (Myrtaceae). The sample of C. speciosus contained two kinds of seeds. Both were small. The smaller was light brown and the larger was nearly black. Both germ. 50-70% in 70D or 40 whether fresh or DS up to 2 y. An unidentified Callistemon sp. showed no dying after 1 y of DS.

Callitris (Cupressaceae). C. rhomboidea germ. in 1-14 w at 70 (JH).

Calochortus (Liliaceae). C. kennedyi germ. 40(100% in 4th w) and 70D(none).

Calonycton (Convolvulaceae). C. aculeatum has an impervious seed coat (JH).

Calothamnus (Myrtaceae). C. quadrifidus seeds DS 0, 1 y, and 2 y germ. 30%, 20%, and 2% in 70L and 8%, 3%, and 6% in 70D.

Caltha (Ranunculaceae). C. palustris seeds were received from N.E. U.S. and from Iceland. The U.S. seed germ. only with GA-3, but the Iceland seed germ. in both 70 GA-3 and 70L albeit in higher percentage with GA-3. The U.S. seeds were given varying amounts of time in 70D (moist) before applying the GA-3, and the effects were remarkable. For times of 0, 17 d, 32 d, and 10 w in 70D; the percent germinations were 60%, 92%, 70%, and 0% after addition of the GA-3. The 17 d period at 70D increased percent germination, but then a rather rapid death rate set in so that all seeds were dead after just 10 w in moisture at 70. In all the germinations with GA-3, germination occurred 8-10 d after applying the GA-3. The seeds die rapidly on DS, and both U. S. and Iceland seeds were dead after just 3 m of DS at 70.

The Iceland seeds germ. 70 GA-3(100% in 3-11 d), 70L(55% in 1-9 w)-40-70D(6%), 70D-40-70L(95% on 6th d), 70D-40-70D(10% in 2nd w), and 40-70L(50% in 2-6 w). However, Haraldsson in Iceland found that seeds kept moist for 2 y under varying temperature treatments ultimately gave 45% germination.

Calycocarpum (Menispermaceae). C. lyoni germ. 40-70D-40(2/2 in 3rd w). None has germ. as yet in 70D-40-70D, 70L-40-70D, or 70 GA-3.

Calylophus (Onagraceae). C. lavandulifolius germ. 70D(100% in 3-15 d) (2nd Ed.). This was unchanged after 18 m DS, but the seeds suddenly died thereafter so that after 2 y of DS the seeds germ. 70D(5%).

Calyptridium (Portulacaceae). C. umbellatum has now been completely studied and C. monospermum has been added.

C. monospermum germ. 70L(82% in 1-4 w), 70 GA-3(75% in 2nd w), 70D(31% in 1-4 w), and 40-70D(74% in 4-18 d). Outdoor treatment reduced germination to 12% probably because the -20 deg. was largely fatal.

C. umbellatum germ. 70L(12% in 1-4 w), 70 GA-3(52% in 1-3 w), 70D(none), and 40-70D(11% in 4-6 d). Outdoor treatment was largely fatal as with the above. Seeds DS 1 y and 2 y germ. 70L(6%) and 70D(none).

Campanula (Campanulaceae). C. latifolia germ. 95% in 5-11 d in either 70D or 70L, and C. latifolia alba germ. 70D(1/36 in 2nd w).

Cannabis (Moraceae). C. sativa seeds DS about 8 m germ. 90% in 2-4 d in 70D, 70L, or 70 GA-3. Seeds DS 18 m germ. 70D(57% on 4th d) and seeds DS 2 y germ. 70D(9% on 6th d) indicating a half-life of about 20 m.

Capparis (Capparidaceae). The data on C. spinosa is now complete. Seeds germ. 70 GA-3(19% in 2-8 w)-40(3%)-70(6%), 70L-40-70L(10% in 2nd w), and none in 70D-40-70D. A second sample were all empty seed coats.

Capsicum (Solanaceae). It was reported in the 2nd Ed. that seeds of the green, yellow, and red forms all germ. in 9-11 d after removing from the fruit and after a WC as brief as 2 hours. It was proposed that possibly a germination inhibitor was somehow being transmitted into the seed inside the fruit. <u>This has now been shown to be incorrect</u>. What happens is that the fruit simply blocks access of oxygen to the seed. Thus the seed germ. 100% in 2-8 d in 70D with all three forms after removing from the fruit and placing in the moist paper towels. It made no difference whether the seeds were taken directly or WC for various times up to 8 d. In fact the seeds germ. under water in the WC treatment almost as fast as when in the more aerated paper towels. This result is in contrast to the behavior of the Casaba melon (cucumis melo) where seeds totally fail to germinate under water. The difference is attributed to the melon seeds requiring large amounts of oxygen whereas the Capsicum seeds are smaller and require less oxygen and are able to extract the needed oxygen from the water. Seeds of the yellow form showed no significant deterioration after 2 y DS.

C. annuum germ. 70L(100% in 2nd w) and 70D(70% in 2nd w). GA-3 had no effect. Presumably germination is prevented inside the fruit by blocking access to oxygen as described above for C. frutescens. Seeds DS 1 y germ. 70D(29% in 2nd w) indicating a fairly high death rate on DS.

Capsicus (Solanaceae). C. pubescens germ. in high percentage at 70 when fresh, but germination dropped to 5% after 3 m DS (KA). It is not clear whether there is a high death rate or whether the seed coat becomes impervious.

Cardamine (Brassicaceae). C. pennsylvanica germ. 70L(100% in 1-6 w, ind. t 10 d, zero order, 2%/d), 70D(none), 40-70D(none), and 40-70L(20%).

Cardiocrinum (Liliaceae).

C. cordatum v. glehnii failed to germinate in alternating 3 m cycles after 4 y although the seeds were full and failed to rot. Presumably like C. giganteum they will ultimately germinate.

C. giganteum, further expts. confirm the extended germinations. It is of interest to compare the following two samples which were from the same source and received at the same time, but which must have had different storage conditions in some way before being received on 2-2-1992. One sample germ. 40-70-40-70(2%)-40(93% in 5-12 w)-70-40-70(1%) and the other germ. 40-70-40-70-40(5%)-70-40-70(61% in 2-8 d). KW has found the same basic behavior.

Carex (Cyperaceae). C. lurida and C. retrorsa were received as fresh seed and the other six were received as seeds DS 6 m. Germination occurred only in light with all eight species and none germ. in dark or with GA-3. Germination was essentially unchanged after 2 y of DS in the six species tested. A prior 2 m in 70D had no effect with C. arenaria, C grayi, and C. pendula, but in C. comans germination was reduced to 20% in 4-9 w.

C. arenaria germ. 70L(100% in 1-5 w) and 70D(none). After 2 y DS there was a little germination in 70D(9% in 2-4 w) with germination in 70L still 100%.

C. comans germ. 70L(85-100% in 2-5 w) and 70D(none) for seeds DS up to 2 y.

C. grayi seeds DS 6 m germ. 70L(50% in 2-14 w) and 70D(none), and seeds DS 2 y germ. 70L(4/11 in 7-12 w) and 70D(none).

C. lurida fresh seeds germ. 70L(95% in 2nd w if husk removed, 50% in 3-9 w if husk left on) and 70D(none), and seeds DS 1 y germ. 70L(95% in 8-20 d) and 70D(none).

C. muskingumensis seed DS 6 m germ. 70L(100% in 8-10 d) and 70D(none).

C. pendula germ. 70L(100% in 2-4 w) and 70D(none) for seeds DS up to 2 y.

C. retrorsa had very low viability and germ. 70L(3%)-40-70L(3%) and 70D(none). Seeds DS 6 m or 1 y germ. none in either 70D or 70L.

C. stricta seed DS 6 m germ. 70L(100% in 16-26 d) and 70D(none).

Carica (Caricaceae). C. papaya germ. 70L(50% in 6-27 d) and 70D(none) for either fresh seed or seed DS 1 y or 2 y. The light requirement is interesting in view of the jet black color of the seed coats.

Carmichaelia (Fabaceae). C. apressa and C. monroi had impervious seed coats. Seeds germ. 100% on the 4th d at 70 if a hole was made in the seed coat and none germ. otherwise.

Carum (Apiaceae). C. caryi germ. 70L(76% in 2nd w), 70D(24% in 1-7 w), 70 GA-3(36% in 3rd w), and 40(44% in 6-12 w)-70D(17% on 4th d).

Carya (Juglandaceae). C. pecan seeds sold for food have all rotted.

Castanea (Fagaceae).

C. sativa germ. 70(4/4 on 6th d) if the outer and inner seed coats were removed, 70(4/4 in 3rd w) if only the outer shell is removed, and 70(2/5 in 4-6 w) in the control. Nicking the inner seed coat had little effect.

C. sinensis germ. 100% at 70(100% in 3rd w). Germination is a little faster (2nd w) if the outer seed coat is removed and the innner seed coat removed or nicked. Soaking for 7 d had no effect.

Castillea (Scrophulariaceae). C. parviflora germ. 70D(15% in 1-5 w) for seed DS 6 m. This dropped to 9% for seeds DS 2 y.

Casuarina (Casuarinaceae). Three sp. of C. germ. in 1-3 m at 70 (JH).

Catalpa (Bignonicaceae). C. bignonioides fresh seeds germ. only in light or GA-3 treatment, but this slowly disappeared on DS (2nd Ed.). Experiments were conducted to see if Irradiating the seeds while dry would destroy the system blocking germination, but this was totally unsuccessful. Seeds irradiated eight inches under 40 watt fluorescent light for up to 50 d germ. germ. 70L(100% in 5-12 d) and 70D(none) the same as seeds not irradiated.

Catharanthus (Apocyanaceae). C. roseus germ. in 10-20 d at 70 (JH).

Caulophyllum (Berberidaceae). Although C. thalictroides self sows here, not a single germination has been obtained in sterile conditions. The gibberellins

GA-3, K salt of GA-3, GA-4, GA-7, and iso GA-7 have all failed to initiate germination.

Cautleya (Zingiberaceae). C. spicata germ. 70D(6/6 on 10th d), 70L(5/6 in 12-18 d), and 40-70D(1/6).

Cedrela (Meliaceae). C. sinensis germ. 2/3 in 7-9 d in 70D.

Centaurium (Gentianaceae). C. muhlenbergii germ. 80% in 6-8 d in 70D, 70L, or 70 GA-3. A prior 3 m at 40 had no effect. The seed had been DS at 40 for 2 y. An additional DS for 1 y had no effect on germination in 70D.

Cerastium (Caryophyllaceae). C. fontanum germ. 70L(90% in 1-9 w) and 70D(15% in 1-9 w)-40-70D(54% in 4-8 d). DS not only increased the rate of germination, but it also decreased the effect of light. Seed DS 6 m at 70 germ. 70L(100% in 1-3 w) and 70D(79% in 2nd w), and seed DS 1 y germ. 70D(88% in 2nd w). However, seeds DS 2 y germ. 70D(32% in 3rd w) showing significant dying. The five species studied previously germ. in 70D, but it is possible that the seeds had extensive DS which had removed the light requirement.

Ceratotheca (?). C. triloba germ. 100% in 8-10 d in either 70D or 70L. GA-3 had little effect.

Cercocarpus (Rosaceae). C. intricatus germ. 70D(10%)-40(5%)-70D(17%) and 40(50% in 8-12 w). A second sample germ. 40(60% in 1-3 w) and 70D(12% on 2nd w). The patterns are similar.

Cerinthe (Boraginaceae). C. major germ. 70 GA-3(5/5 in 10-14 d), 70L(3/7 on 8th d), and 70D(5/12 in 6-10 d).

Cestrum (Solanaceae). C. nocturnum germ. 70L(100% in 8-10 d), 70D(12% in 1-6 w)-40-70L(88% in 6-18 d), and 70D(12% in 1-6 w)-40-70D.

Chaenomeles (Rosaceae). C. sinensis is the commercial quince. It germ. 70(4/8 in 2-14 d) for seeds WC 7 d and 70(1/10 in 4th w) for seeds simply rinsed.

Chamaebatia (Rosaceae). C. millefolium germ. 100% in 4-8 d in either 70D or 70L, 40-70D(70% in 1-3 d), and none in 70 GA-3. Seeds also germ. 100% in the first 2 w of Nov. from seed placed outdoors in mid-Oct., but this was essentially germination in 70D. DS for 6 m had no effect.

Chamaecytisus (Fabaceae). C. austriacus has an impervious seed coat (100% germ. in 2-3 d if punctured), but 28% had an imperfection and germ. in 1-8 w without puncturing the seed coat. This was unchanged after 2 y DS, but after 3 y DS germination in 70D (unpunctured) dropped to 15% in 2nd w.

Chamaedaphne (Ericaceae). C. calyculata germ. 70L(16% in 9-17 d), 70 GA-3(38% in 9-17 d), and none in 70D, 40, or OT.

Chamaemelum (Asteraceae). C. nobile was a D-70 germinator (RC).

Chenopodium (Chenopodiaceae). Based on meagre data, C. ambrosiodes was reported to have germination somewhat promoted by light. This general trend continues in the three additional species now studied.

C. bonus seeds DS 6 m, 18 m, and 2 y germ. 100% in 3-7 d, 86% in 4-8 d, and 94% in 1-4 w in 70L and 60% in 1-11 w, 62% in 4-12 d, and 43% in 3rd w in 70D.

C. (Bitium) virgatum DS 6 m, 18 m, and 2 y germ. 100% in 3-7 d, 88% in 4-6 d, and 92% in 5-9 d in 70L and 80% in 3-11 w, 67% in 6-12 d, and 43% in 2-4 w in 70D. The seeds DS 2 y also germ. 40(20% in 6-12 w)-70(40% in 2-15 d).

C. vulvaria seeds DS 6 m, 18 m, and 2 y germ. 100% in 3-5 d, 48% in 4-14 d, and 24% in 1-4 w in 70L and 5% in 10th w, 21% in 4-20 d, and 1% in 70D. The dying on DS is more pronounced than in either of the two previous species.

Chimonanthus (Calycanthaceae). C. praecox has an impervious leathery seed coat, but 25-50% of the seed coats have an imperfection and an opening so that they germinate immediately. If the ungerm. seeds have their seed coats opened, they germinate in 6-10 d in 70D. This was true for both fresh seeds and seeds that had hung on the tree for a year. The latter seeds were about 25% dead.

Chionanthus (Oleaceae). C. virginica germ. 50% in August in outdoor treatment after starting in November nearly two years earlier. This parallels the germination in 70-40-70 treatment but takes longer and offers no advantage. After the seeds germinate, a period of time at 40 is necessary before stem and leaf growth will occur on returning to 70. It was indicated in the 2nd Ed. that 3 m at 40 may not be long enough. The optimum has not yet been determined, but it has been found that seedlings that had not developed stems and leaves after 3 m at 40 and a shift to 70 would do so after 3 m at 70, a second 3 m at 40, and a shift to 70.

Chordospartium (Fabaceae). C. muritai germ. 50% in 2nd w at 70 with or without a hole in the seed coat.

Cicer (Fabaceae). KR reported that C. arietinum germ. 70(2/18) and 70 GA-3(5/18) both in 4-15 d. Neither GA-4 or GA-7 had a significant effect..

Cicerbita (Asteraceae). C. alpina germ. 70L(20% in 1-3 w), 70D(14% in 4-6 w), and 70 GA-3(all rotted). A prior 3 m at 40 reduced germination to 5%.

Circaea (Onagraceae). C. lutetiana had germ. best in OT with fresh seed (2nd Ed.). It is now found that seeds DS 6 m were dead.

Citrullis (Cucurbitaceae). Further work on C. vulgaris verifies that fresh seed requires light to germinate and that this light requirement disappears on DS. After 3 m DS 13% germ. in 70D and after 6 m DS 100% germ. in 70D. These interesting results have been confirmed on two further samples. An experiment was conducted to see if irradiating the seeds while dry (same conditions as with Catalpa) would destroy the system blocking germination. As with Catalpa, it does not and the germination remains unchanged after up to 50 d of such irradiation.

Cladastris (Fabaceae). C. lutea was shown to develop an impervious seed coat on DS (2nd Ed.). After 5 y DS a peculiar result was observed which was that the unpunctured seeds germ. 2/7 at 70 whereas 10 seeds that were punctured all rotted.

Clematis (Ranunculaceae).

C. addisonii showed a marked difference between fresh seed received in October and the same seed DS 6 m at 70. The fresh seed germ. 70 GA-3(65% in 7-11 w) and none in 70L or 70D. The DS seed germ. 70 GA-3(100% in 4-8 w), 70L(65% in 3-6 w), and 70D(50% in 9-11 w). The DS eliminates the GA-3 requirement.

C. coactilis germ. 70D(1/3 in 11th w) and 70L(1/4 in 10th w). All 4 rotted in 70 GA-3. The cotyledons are slow to expand and did not open completely until 4 w after germination.

C. columbiana, the two best germinations were 91% in May-June from outdoor treatment starting the previous November and 70L(50% in 2-10 w).

C. grata seeds DS 0, 6 m, 1 y, and 2 y germ. 63%(in 6-8 w), 55%(in 2-4 w), 7%, zero in 70L. None germ. in 70D. The death rate is an inverse first order curve.

C. orientalis germ. 70L(90% in 5 d), 70D was not done. The seed was of unknown DS. After and additional year of DS the seed germ. 70L(20%). Another sample germ. 70L(95% in 10 d) and 70L(65% in 1 m) after and additional 1 y DS. All of this indicates a significant death rate in DS. The data is all from KW.

C. recta germ. 43% in 9th w in 70D (2nd. Ed.). This dropped to 19%, 17%, and 0% after 6 m, 1 y, and 2 y of DS. The half-life is about 1 y.

C. virginiana seeds DS 0, 6 m, 1 y, and 2 y germ. 98%, 98%, 27%, and zero in 70L. All germinations in 2nd w. None germ in 70D. The death rate is an inverse first order curve with half-life of about 1 y.

Cleome (Capparaceae). C. hassleriana seeds DS about 8 m germ. 100% in 3-5 d in 70D or 70L and 40(70% in 7-9 w)-70(15%). The seeds largely rotted in 70 GA-3. Seeds DS 18 m germ. only 1% in 70D, and seeds DS 2 y were all dead.

Clethra (Cletharaceae). C. fargesii seeds DS 0, 6 m, 1 y, 2 y, and 3 y germ. 15% (2-11 w), 22%(3-6 w), 20%(3-5 w), 8%(3-5 w), and 0% in 70L and 0, 0, 0, 5%(5th w), and 0% in 70D. The data suggests the usual inverse first order curve for the death rate with a half life of about 2 y on top of a disappearance in the light requirement. However, the death rate is too fast to make the disappearance of the light requirement of any practical use.

Clianthus (Fabaceae). C. formosa germ. 70(100% on 3rd d) if punctured and 70(15% in 3rd d) if not. Having an impervious seed coat with a small percentage imperfect is typical of many Fabaceae and similar to C. puniceus (studied before).

Clitoria (Fabaceae). C. ternatea germ. 70(100% in 3-5 d) if punctured and 70D(75% in 5-12 d) if not.

Cneorum (Cneoraceae). C. tricoccon seeds DS 6 m germ. 70 GA-3(28% in 6th w), 70L(10%), 40(6%)-70(3%), and 70D(none). Seeds DS 2 y germ. 70 GA-3 (3/7 in 10-12 d) and 70D(1/6 in 7th w).

Cnicus (Asteraceae). C. benedictus is a D-70 germinator (RC).

Cobaea (Polemoniaceae). C. scandens germ. 70D(7/11 in 5-12 d). Light had no effect. Ungerm. seeds soon rotted.

Cocculus (Menispermaceae). C. carolinus germ. 70D (JH).

Cochlearia (Brassicaceae). C. officinalis germ. 70L(60% largely in 3-5 d), 70D(2%), and 40(10% in 4-7 w)-70-40. Seeds DS 1 y germ. 32% in 4-8 d in either 70L or 70D indicating both some dying and disappearance of the light requirement.

Codonopsis (Campanulaceae). C. pilosula is a D-70 germinator (RC).

Colchicum (Liliaceae). C. luteum continued to give an occasional germination after 2 y of alternating 3 m cycles between 40 and 70.

Collinsia (Scrophulariaceae). C. bicolor germ. 70(100% in 2-8 d) and 40(73% in 3-6 w). Light or GA-3 had no effect.

Collomia (Polemoniaaceae). C. grandiflora had been studied before. A new sample germ. 70D(70% in 2-14 d)-40(30%) and 40(90% in 2-4 w). This is in essential agreement with the earlier work. Two other species studied earlier require GA-3 for germination, but GA-3 caused total rotting in C. grandiflora.

Coluteocarpus (Brassicaceae). C. vesicaria germ. 70D(100% in 1-8 w) and 40(1/5 in 10th w)-70D(4/5 in 5th w).

Conimitella (Saxifragaceae). C. williamsii germ. 70D(3/8 in 4-8 w) and none in 70L-40 or 40-70D.

Convolvus (Convolvulaceae). C. tricolor germ. 70(80% in 1-3 d). Light had no effect.

Cordyline (Liliaceae). C. indivisa were all empty seed coats.

Coriaria (Coriariaceae). C. terminalis xanthocarpa germ. 70L(100% in 2-4 w) and 70D(none). A prior 2 m in 70D did not affect the germination in 70L.

Cornus (Cornaceae).

C. amomum, studies on a new sample confirmed that germination occurred only in outdoor treatment. The new sample germ. 72% in April (30% in the earlier sample).

C. canadensis germ. 70 GA-3 (100% in 3-17 w) and 40-70 GA-3(45% in 6-11 w). None germ. in 70D-40, 40-70, or outdoor treatment. A prior 3 m at 40 or 70 was detrimental and such treatments reduced germination to 35-40%. This is the first member of this family to require GA-3, and the second species with seeds in a fruit that required GA-3 (the other was Alangium platanifolium). Seeds that had been WC and cleaned germ. 70 GA-3(85% in 2-5 w) and 70D(none) after 2 y DS showing that GA-3 was still required and that there had been little dying of the seeds. The same seeds DS 2 y in the dried berries germ. 70 GA-3(44% in 5-7 w) and 70D(none) showing that it is actually less preferable to store the seed in the dried berries. Incidentally, there are efforts to change the name to Chamaeperidymenum. To replace an old established name with a new name and such a cumbersome one at that only harms communication. Anyone can see that the growth habit is somewhat different than other Cornus, but this in no way justifies an intellectually vacuous publication.

Corydalis (Fumaraceae).

C. caseana ssp. brandegei germ. 70 GA-3(50%) and none in the other treatments. The seeds split in the 3rd w but it is another week or two before the radicle develops and the cotyledons do not start developing until the 10th w. A prior 4 w of OS had little effect on the germination in 70 GA-3, but a prior 4 w at 70 was fatal.

C. nobile was found to germinate best in OT. KW reports that seed placed at 40 as soon as collected in June had germ. about 25% when examined in October. It is possible that my seed would have done the same if the seed started at 40 had been kept at 40 for 4 m.

Corylus (Betulaceae). C. avellana was studied in detail (2nd Ed.) because my interpretations were so much at odds with previous work and a book. It was reinvestigated and my earlier results completely confirmed. Placing Corylus in a new family, Corylaceae, has not been adopted herein.

Costus (Zingiberaceae). C. guanaiensis germ. 70L(1/26 in 5th w)-40, 70D(1/27 in 10th w)-40, and none in 70 GA-3. The ungerm. seed coats appeared to be all empties so that the germination could approach 100% if these are discounted.

Cotinus (Anacardiaceae). C. coggyria seed germ. 70D-40-70D(1 on 10th d). The rest of the sample appeared to be empty seed coats.

Cotoneaster (Rosaceae).

C. divaricata data is now complete. Germination extends over many cycles and always occurred in 2-6 d after shifting to a cycle at 70. Studies should be conducted on varying the length of the cycles to see if faster germination could be achieved. The data are 40-70-40-70-40-70(14%)-40-70(19%)-40-70(26%) and 70-40-70-40-70(6%)-40-70-40-70-40-70(10%) for fresh seed WC 7 d and 40-70-40-70(12%)-40-70(27%)-40-70(23%) and 70-40-70-40-70(2%)-40-70(40%) for seed DS 6 m in the WC state. Outdoor treatment is no better. Fresh seed set outdoors in October germ. 3% in the April 1.5 years later, 13% in March 2.5 years later, 4% in March 3.5 years later. Seeds DS 6 m set outdoors in April germ. 22% in April a year later.

C. microphyllus v. cochleatus experiments are now complete, and it is found that there are alternatives to GA-3. The seeds germ. 70 GA-3(40% in 4-10 w)-40-70(3%), 70D(2%)-40-70D, and 40-70(29% in 2-11 w)-40-70(2%). Seeds DS 2 y germ. 40-70(46% in 1-9 w) and 70 GA-3(40% in 4-10 w).

Cotyledon (Crassulaceae). C. orbiculata germ. 70(3/7 in 2nd w). GA-3, GA-4, and GA-7 had no significant effect (KR).

Cowania (Rosaceae). C. mexicana germ. 40(1/1 in 9th w). On examination the several seeds in 70D and 70L were empty so that all that can be said is that the seeds will germinate at 40.

Crambe (Brassicaceae). C. cordifolia germ. 6/10 in 7 d in 70L if fresh. Unfortunately 70D was not tried on this sample. A second sample germ. 70L(1/2 on 3rd d) and 70D(0/2). A commercial sample germ. 10-20% in 70L over 2 m with some further germination over an extended period. This was unchanged by a further 1 y DS. C. maritima gave similar results (KW).

Crataegus (Rosaceae). C. monogyna germination is extended over a number of cycles. Data is now complete. The seeds were WC for 7 d. Fresh seeds germ. 70-40-70(31% in 2nd w)-40-70(4%), 40-70(4%)-40-70-40-70(56% in 1st w), and 15% in March and April from seed set outdoors the previous October. Seeds DS 6 m at 70 germ. 70-40-70(17% in 2nd w) and 40-70-40-70(70% in 1st w)-40-70(20% in 5th d). It is evident that longer and shorter cycle times and DS times should be investigated, particularly since fresh and DS seed did not give identical behaviors.

Crepis (Asteraceae). C. sibiricus germ. 70D(20% in 1-3 w)-40(5%)-70D(32% in 3-5 d). Seeds DS 1 y germ. 70D(3% on 10th d) showing much dying.

Crinodendron (Elaeocarpaceae). C. hookerianum seeds were all dead.

Criscoma (Asteraceae ?). C. coma-aurea was all chaff.

Crocosmia (Iridaceae). C. aurea germ.70L(93%) and 70D(56%) (2nd Ed.). These were unchanged after DS 1 y, but after 2 y they dropped to 15% and 14%.

Crowea (Rutaceae). C. angustifolia v. dentata has been reported to have germination benefited by light, WC, and hot water treatments (JH). A sample of one hundred seeds appeared to be all empties.

Cryptantha (Boraginaceae). C. paradoxa germ. 70D(100% in 1-7 w) and 40(2/6 in 6-10 w)-70(2/6 on 2nd d).

Cucumis (Cucurbitaceae).

C. melo (Casaba, honeydew form) has lack of access to oxygen (in the fruit) as the mechanism blocking germination, see Section II (a). The seeds still germ. 100% in 4-6 d in 70D after 3 y of DS.

C. melo (netted form) showed remarkable effects of DS. The DS increased the percent germination, the rate of germination, and eliminated the promoting effect of light. Fresh seeds germ. 70L(61% in 1-4 w) and 70D(8%). After 2 m DS at 70 the seeds germ. 70L(87%) and 70D(35%), both in 2-6 d. After 12 or 18 m of DS the seeds germ. 70D(100% on the 3rd d). These results are all on the same sample of seeds.

Cucurbita (Cucurbitaceae).

C. maxima (Acorn squash) showed dramatic effects of DS with the effect of light disappearing on DS. Fresh seeds germ. 70L(100% in 10-27 d), 70D(26% in 2-4 w), and 70 GA-3(62% in 9-19 d). Seeds DS 2 m at 70 germ. 70D(80% in 4-6 d) and 70 GA-3(50% in 7-9 d). Seeds DS 12 or 18 m germ. 70D(100% on 3rd d). After 3 y of DS there is significant dying and such seeds germ. 70D(30% in 2-8 d). Note not only the lower percentage but the slower rate of germination. Possibly the seedlings were weaker but this was not studied. The effect of GA-3 is confusing, but suffice to say it is of no benefit to germination.

C. mixta germ. 100% in 4-6 d at 70 (KR).

C. pepo (pumpkin) germ. 70L(85% in 4-14 d) and 70D(none). The results were the same whether the seeds were just rinsed or WC for 1 d. The seeds die rapidly if kept under water and germ. 70L(10% on 8th d) after 17 d under water. The light requirement dies off with DS, and seeds DS 6 m germ. 100% in 70D. Presumably lack of access to oxygen is a factor in blocking germination of the seeds inside the fruit.

C. sativus (horned melon) still germ. 100% in 2-4 d after 2 y DS.

Cuminium (Apiaceae). C. cyminum germ. in 1-2 w at 70 (JH).

Cupressus (Cupressaceae (Pinaceae)). C. lusitanica germ. in a 40-70 pattern (JH).

Cuscuta (Convolvulaceae). C. sp. from Pennsylvania germ. 70D(100% in 1-4 w), 70L(100% in 2-4 w), and 70 GA-3(11% in 4th w). A prior 3 m at 40 and OT were totally fatal. This is surprising and suggests that this species must germinate in the fall and overwinter as a young seedling. Seeds DS 1 y germ. 70D(6% in 3rd w) showing that they were largely dead.

Cyathodes (Epacridaceae). C. empetrifolia germ. 1/5 in a 70 cycle after two years of 3 m cycles alternating between 70 and 40. GA-3 needs to be tried.

Cymbalaria (Scrophulariaceae). C. muralis germ. 70L(12% in 3-8 w) and 70D(2% in 4th w).

Cymopterus (Apiaceae). C. aboriginum germ. 40(1/8 in 7th w) and 70D(none). Despite the limited data the germination at 40 is similar to other members of this genus.

Cynanchum (Asclepediaceae). C. acutum germ. 70D(3/7 in 2nd w) and 70L(4/5 in 8-14 d).

Cynoglossum (Boraginaceae). C. grande germ. 40(100% in 6-9 w) and none in 70D or 70L. The seeds all rotted in 70 GA-3. A prior 3 m in 70D or 70L speeded up the germination at 40 so that it occurred in the 4th w after the shift to 40. Seeds DS 6 m, 1 y, or 2 y still germ. 100% at 40. All rotted in OT, and the seeds are probably killed by winter temperatures here.

Cypella (Iridaceae).

C. amosa germ. 70D(50% in 2-11 w), 70L(96% in 2-4 w), and 40(4%)-70D-40.

C. coelestis germ 70D-40(6/9 in 12th w)-70D(2/9 on 5th d) and 40(2/11 in 12th w)-70D-40-70D(2/11 in 2nd w).

Cyperus (Cyperaceae). C. papyrus germ. 100% in 5-7 d in 70L and none in 70D or 70 GA-3. Germination was the same for seeds DS 2 y.

Cyphomandia (Solanaceae). C. betacea germ. in 4th w at 70 (JH), presumably the seeds had been WC.

Cythomandra (Solanaceae). C. betacea is the fruit marketed under the name Tamarillo. The seeds when removed from the fruit are jet black but turn to light brown in one day of WC in either bright or subdued light. Seeds WC 7 d germ. 70L(94% in 2-4 w), OS(88% in 3rd w), 70 GA-3(97% in 2nd w), and none in 40 or 70D. A second sample was studied to determine the effect of various amounts of washing. A single rinse seemed to be as effective as the 7 d WC. Further, the seeds germ. under water in light almost as fast as in the more aerated moist paper towels, but there was significant dying so that seeds kept under water 1 m were 25% dead.

Daboecia (Ericaceae). D. cantabrica germ. 70D(8% in 7-12 w)-40-70D(2%), 70L(100% in 5-9 w), and none in 70 GA-3 or 40-70D.

Daphne (Thymelaceae). D. mezereum and its alba form gave somewhat different germination patterns. The seedlings from GA-3 treatment developed a stem and leaves a few weeks after germination, but the seedlings from a 40-70 pattern were slower to develop a stem and leaves and some had to go through 3 m at 40 before such development occurred. The 40-70 and 40-70-40-70 treatments were best.

D. mezereum germ. 40-70(26%)-40-70(74% in 1-6 w), 70 GA-3(60% in 5-10 w), and 70D(15%)-40(8%)-70(15%).

D. mezereum alba germ. 40-70(100% in 6-11 w), 70 GA-3(55% in 3-5 w), and 70D(10%).

Datura (Solanaceae). The seeds are sometimes enclosed in a berry. Commercial samples sometimes had the dried berry still intact. It was always removed in the following experiments, and germination was poor without this removal.

D. innoxia is a D-70 germinator (RC).

D. metaloides germ. 2/6 in 2nd w in either 70D or 70L.

D. sanguinea germ. 70L(4/5 in 3rd w) and 70D(2/8 in 3-7 w).

Datura sp. (from Bahamas Is.) germ. 70L(4/4 in 5-10 w)-40-70L(8/14 in 2-6 w) and 70D(none).

D. suaveolens germ. 70L(5/11 on 4th d) and 70D(1/8 on 4th d) providing the remnants of the dried berry are removed. None germ. otherwise.

D. tatula is a D-70 germinator (RC).

Daubenya (Hyacinthaceae). D. aurea germ. 70D-40(4/7 on 12th d) and GA-3 had no effect on this pattern.

Davidia (Nyssaceae). D. involucrata presented some new problems. First of all I am much indebted to Mrs. James D. Lawrey of Washington VA for 95 fruits of D. involucrata (received 11-27-93), particularly since I have found no other source. The fleshy fruits are ellipsoidal in shape and pointed at the ends. The pulp (similar to a Kieffer Pear in taste and texture) was removed with a knife, and the enclosed nut WC for 7 d. The elongated nut is corrugated, and is much the size and shape of a butternut. The seeds were so large that they were placed in moist Perlite in a polyethylene bag instead of the usual paper towels.

Each nut contains from one to five seeds which germinate intermittently over an extended period of time. In alternating 3 m cycles between 40 and 70, germination commenced after the 2nd cycle (6 m) and continued at a constant rate up to the present (2 y). There does seem to be more germination in a cycle at 40 than in the 70 cycles. At the end of two years the number of nuts in which 5, 4, 3, 2, 1, and 0 germinations had occurred are 2, 3, 8, 15, 31, and 36 respectively. This gives a net total of 107 seedlings from the 95 nuts.The question arises as to whether longer or shorter times at 40 and 70 would have led to more rapid and more efficient germination. It would take an extensive study to determine the answer to this question. Presumably OS are not much of a factor because OT gave no significant increase in rates of germination. GA-3 had no effect.

It is difficult to calculate a percent germination because the number of seeds in any particular nut cannot be determined without damaging the seeds. The smaller nuts had one seed and this seed occupied most of the nut. The nuts that failed to give any germination after two years ranged randomly from the smaller to the largest nuts so that there was no relation of viability to size at least for a single germination.

Germination consists of a wedge falling away revealing the expanding seed. Where germination occurred at 40, the seedling must be kept at 40 until the radicle is well developed and the cotyledons begin to extricate themselves from the nut. When shifted to 70 too quickly, development ceases. When the seedling has extricated itself from the nut, it is removed from the perlite and planted.

The seedlings are sensitive to direct sunshine and to lack of moisture so that the seedlings must be slowly conditioned to direct sunlight. It is best to grow them initially under fluorescent lights, and then slowly condition them to direct light. Once conditioned they grow vigorously in direct sunlight and reach a height of over a foot the first year. They develop large leaves and look somewhat like a mallow.

Questions have been raised regarding the hardiness of D. involucrata and whether plants in the northernmost limit of the hardiness will flower. With the germination pattern now solved, the way is paved for growing large numbers from seed and selecting for better flowering and hardiness.

Delonix (Fabaceae). D. regia germ. 70(3/4 on 4th d) if punctured and 70D(1/4 in 2nd w) if not. This is interpreted to be an impervious seed coat with about 25% having an imperfection in the seed coat.

Delphinium (Ranunculaceae).

D. consolida germ. 70D-40(20% in 3-5 w), 70L-40(10%), and 40-70D-40(13% in 3rd w). None germ. in 70 GA-3, 40-70D, or 40-70L.

D. tricorne, the extended germinations have been confirmed repeatedly. A typical result is 70-40-70-40-70(1%)-40(5%)-70(10%)-40(14%)-70(6%)-40-70(4%)-40(5%)-70(5%).

Dendromecon (Papaveraceae). D. rigida germ. 70 GA-3(20% in 4-7 w)-40(40% in 3-6 w) and none in 70L, 70D, 40-70, or OT (after one y). The seeds expand and split first. The radicle does not appear until a week later followed by expansion of the cotyledons in two days. Seeds that had been DS at 40 for 3 y were dead.

Dentaria (Brassicaceae). The remarkable results with D. lacinata have been confirmed with somewhat higher percent germinations in samples from later years, the best being 70 GA-3-40(50% in 6-11 w).

Desmanthus (Fabaceae). D. illinoensis germ. 70 GA-3(2/20 in 3-4 d) and 70(none)(KR). Neither GA-4 or GA-7 gave any improvement over GA-3 (KR).

Desmodium (Fabaceae). D. candense germ. 100% in the 2nd d at 70 if the seed coat was punctured. No germination occurred otherwise. This impervious seed coat is typical of many Fabaceae. Seed DS 1 y and 2 y gave the same result.

Deutzia (Saxifragaceae). D. staminea germination dropped from 100% to 20% in 70D after 3 years of DS at 70.

Dianella (Liliaceae). D. intermedia germ. 70L(5/13 in 12-14 w)-40-70L(1/13)-40-70-40(1/13)-70L, 40-70L-40-70L(3/13 in 2-11 d)-40(1/13)-70L(4/13)-40(2/13), 70D-40-70D-40-70L(6/12 in 8-10 w)-40-70L, and 70 GA-3(none). There are three unusual features. (a) There is a long induction period in 70L. (b) Prior cycles starting at 70 have little effect, but prior cycles starting at 40 delay germination in 70L. (c) It is unusual to find photostimulation of germination in a member of the Liliaceae.

Dianthus (Caryophyllaceae). Twenty species were found to be D-70 germinators with only D. armeria being an exception and showing a light requirement (2nd Ed.).

D. superbus alba germ. 70L(97% in 3-5 d) and 70D(71% in 5-9 d). The remaining seeds from the 70D treatment were shifted to 70 whereupon 20% germ. on the 4th d. It is likely that the seeds require light for germination when fresh and that the light requirement dies off on DS.

D. barbatus germ. 100% in 2-5 d in 70D. This was unchanged after 1 y DS.

Diascia (Scrophulariaceae). D. barberae germ. 100% in 4-6 d in either 70D or 70L.

Dicentra (Fumariaceae). D. uniflora germ. 70D(1/1 in 4th w) using seed DS 6 m at 70. The same seed in the fresh state failed to germinate under all conditions. However, there were many empty seed coats so that it is not certain if any viable seed was present in many of the expts.

Dichelostemma (Liliaceae). In all three species neither GA-3 nor outdoor treatment stimulated germination. All germ. at 40, and a prior 3 m at 70 had no effect other than speeding up germination at 40 in D. multiflorum from 9-14 w to 4-8 w.

D. capitatum germ. 40(100% in 3-6 w).

D. ida-maia germ. 40(90% in 4-10 w). A prior 3 m in 70D or 70L or a prior DS of 6 m or 1 y had little effect on the germination at 40, but seeds DS 2 y germ. 40(54% in 8-13 w) showing both a slowing and a reduction of percent germination.

D. multiflorum germ. 40(90% in 9-14 w). DS 6 m, 1 y, or 2 y had little effect.

Dicranostigma (Papaveraceae). D. franchetianum germ. 100% in 6-10 d in 70D, 70L, or 70 GA-3.

Dietes (Iridaceae). D. grandiflora germ. 70L(100% in 2-5 w) and none in 70D and 40.

Diospyros (Ebenaceae).

D. virginiana, germination was satisfactory in a 40-70 pattern, but it is now found that GA-3 will initiate germination directly at 70. Seeds germ. 70 GA-3(100% in 5-10 d). The seedlings were elongated but appeared to be able to survive.

D. texana germ. 40-50% in 5th w at 70, and GA's had little effect (KR).

Dipcadi (Liliaceae). D. fulvum and D. serotinum germ 100% in 4-8 d in either 70D or 70L.

Diphylleia (Berberidaceae). D. cymosa seed was all dead.

Dipsacus (Dipsacaceae).

D. fullonum germ. 70 GA-3(93% in 1-7 w) and 70L(5% in 2nd w) and none in 70D-40 or 40-70D.

S. strigosus germ. 40-70-40-70-40(38% in 4th w)-70(16% in 2-4 d) and none in 70D, OS, and OT over two years. Light had no effect. Seeds DS 1 y germ. 40(6%)-70D(24% on 2nd d).

Dipcadi (Liliaceae). D. fulvum and D. serotinum germ. 100% in 4-8 d in either 70D or 70L.

Dirca (Thymelaceae). D. palustris seed was WC for 20 minutes and the outer coat removed. This seed germ. 70L(1/8 in 11th w) and 40-70-40-40-70-40-70(2/2 on 5th d). None germ. in OT, and all rotted in 70 GA-3. Seeds DS an additional year all rotted. The seeds were received in July, and it is suspected that they were at least a year old and had largely died already.

Dorotheanthus (Aizoaceae). D. bellidiformis germ. in 1-3 w at 70 (JH).

Dracocephalum (Lamiaceae). D. tanguticum germ. 70 GA-3(1/5 in 9th w)-40-70-40-70(3/5 in 4th w), 70L-40(2/5)-70(1/5)-40, 70D-40-70D(1/6)-40(1/6), and none in 40-70D-40-70D-40. No clear pattern emerges from these results except that germination is extended.

Dracunculus (Araceae). D. canariensis germ. 3/5 in 3rd w in 70D.

Draperia (Hydrophyllaceae). D. systyla seeds DS 6 m germ. 70 GA-3(70% in 5-8 w)-40(30% in 5-11 w) and none in 70D or 40 confirming AB's report. Seeds DS 1 y were dead.

Drosera (Droseraceae). The effect of light varied from no effect to promoting germination to being an absolute requirement for germination. Germination in 70 GA-3 was always poor and often zero. Except for D. aliceae (which germ. in either 70D or 70L), a period of 10 w in 70D was fatal, and the seeds failed to germinate on shifting to 70L.

D. aliciae seeds DS 6 m germ. 50-100% in the 3rd w in either 70D or 70L. Seeds DS 2 y were dead.

D. angelica germ. 40-70L(16%) and none in 70D or 40-70D.

D. binata seeds DS 8 m germ. 70L(100% in 10-12 d) and 70D(15% in 5th w). This declined to 14% for either 70L or 70D after 18 m DS (note elimination of the light requirement along with the dying) and seeds DS 2 y were dead.

D. binata v. multifida germ. 70L(100% in 10-12 d) and 70D(40% in 3rd w). Seeds DS 18 m were 85% dead, and seeds DS 2 y were all dead.

D. burkeana germ. only in 70L and none in 70D. Seeds DS 8 m, 18 m, and 2 y germ. 8% in 2-4 w, 17% in 2-4 w, and 2% respectively. Note that seeds DS 18 m germ. best.

D. capensis germ. 70L(100% in 10-12 d) and none in 70D for seeds DS either 8 m, 18 m, or 2 y.

D. spathulata seeds DS 8 m germ. 70L(100% in 12-20 d) and none in 70D. Seeds DS 2 y were largely dead and germ. 70L(6%) and 70D(none).

Dryandra (Proteaceae). D. serra germ. 40-70(2/6 in 3rd w) and none in 70D or 70 GA-3 using seed DS only 3 m. After 2 y DS the seeds now germ. 40(12/12 in 6th w) showing the favorable effect of lengthy DS. Seeds DS 3 y germ. 40-70(4/5 in 3rd d). These results are somewhat inconsistent, but they do show that the seed remains viable for 3 y of DS.

Dryas (Rosaceae). Much larger samples of D. octapetala germ. 90-95% in 1-4 w in 70D or 70L confirming the earlier results on a very small sample. A prior 3 m at 40 reduced germination to 37% on shifting to 70. DS for 6 m at 70 reduced the germination in 70D to 60% (in 2nd w), and seeds were dead after 1 y DS.

Duchesnea (Rosaceae). D. indica germ. 70L(100% in 1-4 w), 70 GA-3(5%), and 70D(none). A prior 3 m at 40 had little effect.

Dudleya (Crassulaceae). D. brittonii and D. pachyphytum germ. in the 2nd w in 70D or 70L.

Eccremocarpus (Bignoniaceae). E. scaber germ. 70L(90% in 2nd w) and 40(20% in 10th w)-70(5%). None germ. in 70D or 70 GA-3.

Echinaceae (Asteraceae). E. angustifolia and E. purpurea were D-70 germinators (RC).

Echinops (Asteraceae). E. spaerocephalum germ. 70D(76% in 3-5 d) and 70D(5% on 6th d) for seeds DS 6 m and 1 y. This shows a high death rate on DS.

Ehretia (Boraginaceae). E. anacua seeds DS 1 y germ. 70D(5/6 in 3-6 w), 70L(4/9 in 3-6 w), OS (3/7 in 3-6 w), and 40-70(3/7 in 3-9 d). Puncturing the seed coats had no effect. Germination was best in 70D.

Eleaganus (Eleaganaceae). E. angustifolia seed DS 6 m and WC 7 d germ. 70D(60% in 4th w), 40-70D(50% in 3-5 d), OT(50% in March and April from seed set outdoors in January), and 40-70(50% in 3-5 d). GA-3 strongly inhibits germination as indicated by 70 GA-3-40(1/10)-70(2/10). These results do not agree with a previous claim cited in the 2nd Ed. that this species is a 40-70 germinator. Seeds DS 1 y were dead.

Elmera (Saxifragaceae). E. racemosa germ. in 70 GA-3 and 70L with either fresh seed or seed DS 2 y (2nd Ed.). Seeds DS 4 y were dead.

Embothrium (Proteaceae). A sample of seed of E. coccineum were all empty seed coats so this may be a problem with this species.

Empetrum (Empetraceae). E. nigrum germ. best in 70 GA-3 and OT. The data are 70 GA-3(37%, ind. t 25 d, zero order rate, 2.5%/d), 36% in May-August and 24% the following April in OT, and 70-40-70(8%). Light, a prior 3 m at 40, or DS 6 m had no effect, however, the seeds were dead after 1 y DS.

Engelmannia (Asteraceae). E. pinnatifida germ. 38% in 5-12 d at 70 (KR).

Epilobium (Onagraceae).

E. anagallidifolium germ. 70D(55% in 3-6 w), 70L(61% in 4th w), and 40-70D(41% on 3rd d). Seeds DS 6 m germ. similarly.

E. angustifolium germ. 70D(3%), 70L(12% in 3-5 w), and 40-70D(8%). Seeds DS 6 m germ. 70D(8%) and 70L(4%). The seeds were small and difficult to count so it may be that light or 6 m DS have no significant effect.

E. latifolium seeds DS 0, 6 m, and 1 y germ. 49%, 33%, and zero in 70D.

E. palustris germ. 70D(77% in 1-11 w), 70L(72% in 2nd w), 40-70L(95% in 4-6 d), and 40-70D(18%). Seeds DS for 1 y germ. 70D(25% in 3rd w) indicating that 67% had died.

Eranthis (Ranunculaceae). Extensive studies are in progress on storage of seeds of E. hyemalis, see Section II (I).

Eremophila (?). RCh reports that the seeds must be removed from the woody fruits in order for germination to occur.

Eremurus (Liliaceae). E. robustus has now been studied on a much larger sample. This fresh seed germ. 40(7% in 1-8 w)-70-40(7%)-70-40(47% in 1-11 w), 70D(1%)-40(25% in 3-12 w)-70D(3%)-40(22% in 2-10 w)-70-40(7/83), and OT(6%). Light, GA-3, or DS for 1 y had little effect. Germination is largely at 40. The seedlings are programmed to grow at temperatures around 40. If young seedlings are shifted to 70, the cotyledon develops quickly and dies.

Eriastrum (Polemoniaceae). E. densifolium v. austromontanum germ. 70 GA-3(100% in 3-5 d), 70L(20%), and 70D(83% in 5-11 d) using fresh seeds. Like all D-70 germinators there is an optimum length of DS which is a compromise between time for destruction of the blocking mechanism and dying of the seeds. This is evident in this species both in the percent germination and rate of germination. Germination in 70D for seeds DS 3 m, 6 m, 1 y, and 2 y were 83% in 5-11 d, 100% on 2nd d, 19% in 4-19 d, and all dead.

Erigeron (Asteraceae). E. flettii germ. 70D(100% in 5-7 d) for either fresh seed or seed DS 2 y.

Erinus (Scrophulariaceae). E. alpinus germ. 70D(67% in 1-3 w).

Eriogonum (Polygonaceae).

E. allenii (fresh seed) germ. 72% in late March from seed placed outdoors in November. It also germ. 70D(12%) and 40-70D(30% on 2nd d). Light and GA-3 were injurious. Seeds DS 6 m at 70 germ. 70D(1%) and 40(38% in 10-12 w). The results are not as inconsistent as might appear. The fresh seed in the 40-70 pattern was almost ready to germinate after 12 w at 40 and might have germ. at 40 if the time at 40 had been extended.

E. bicolor germ. 40(2/9 in 2-8 w)-70D(4/9 on 2nd d) and 70D(1/7 in 2nd w). All ungerm. seed rotted, and the 3 m moist at 70 was injurious.

Eriophorum (Cyperaceae). Both species showed the unusual pattern of germination occurring only in light or OT. Seeds of both species germ. the same for fresh seed or seed DS 6 m, but seeds DS for 1 y were dead.

E. angustifolium germ. 70L(74% in 6-12 d) and none in 70D or 70 GA-3. A prior 3 m at 40 had no effect. Seed placed outdoors in Oct. germ. 20% in Oct. and 70% in April.

E. scheuzeri germ. 70L(80% in 6-12 d) and none in 70D or 70 GA-3. A prior 3 m at 40 or had no effect. Seed placed outdoors in Oct. germ. 20% in April.

Eritrichum (Boraginaceae). E. rupestre v. pectinatum germ. 70D(70% in 4-12 d).

Erythrina (Fabaceae). E. crista-galli germ. 70(3/4 in 4-6 d) if punctured and if the seeds and the saw used for puncturing had been sterilized with 2% aqueous sodium hypochorite. When the sterilization was not used 1/4 germ. and the other three rotted. None germ. without the puncturing of the seed coat.

Erythronium (Liliaceae).

E. grandiflorum has now been studied with a much larger sample. As expected germination does not require light. The data are 70D-40-70D(12% in 1-4 w)-40(8%) and 40-70D-40(13% in 12th w)-70(23% in 2 d-7 w)-40-70(4%). Germination was speeded up by GA-3 as shown by 70-40 GA-3(35% in 7-11 w).

E. hendersonii x citrinum germ. 40(86% in 9-12 w) and 70-40(87% in 8-12 w). This is identical to the pattern for E. hendersonii.

Eschscholzia (Papaveraceae). E. californica germ. D-70 (RC).

Eucalyptus (Myrtaceae). E. leucoxlyn seeds DS 1 y germ. 100% on the 4th d in 70D the same as fresh seeds.

Euceliopsis (Asteraceae) E. covillei germ. 70D(3/9 in 2nd w) and 40(4/6 in 2-4 w). The rest rotted.

Eucomis (Liliaceae). E. bicolor germ. 4/4 in 3rd w in 70D.

Euonymus (Celastraceae). It had been found that with both E. alatus and E. europaeus that seeds germ. best in outdoor treatment and only after WC with detergents. Presumably the efficacy of the OT is due to the oscillating temperatures. The detergent washes remove the oil soluble germination inhibitor(s). Although OT (and possibly OS) are the optimum treatments, some germination occurs after several years in treatments where temperatures are shifted back and forth between 40 and 70.

Although GA-3 does not initiate immediate germination (2nd Ed.), it does speed up the long extended germinations as shown by the following data. The data for E. alatus seed WC 7 d in detergent are 70 GA-3-40-70(12%)-40-70(85% in 3-20 d), 70-40-70-40-70(13%)-40-70-40-70(5%), and 40-70-40-70-40-70(58% in 4-18 d)-40-70(2%). The data for E. europaeus seeds WC 7 d in detergent are 70 GA-3-40-70-40(8%)-70(50%)-40-70(8%), 70-40-70(8%)-40-70-40-70(58%), and 40-70(7%)-40-70-40-70-40-70-40-70(7%).

DS is not tolerated and seeds of E. alatus DS 6 m were about half dead and seeds DS 12 m were all dead.

Eupatorium (Asteraceae). E. perfoliatum (DS 6 m) germ. 100% in 8-13 d in either 70L or 70 GA-3. None germ. in 70D or 40. A prior 3 m in 70D or 3 m at 40 had little effect. Seeds DS 1 y were all dead.

Euphorbia (Euphorbiaceae).

E. myrsinites germ. 70 GA-3(5/5 in 2-4 w), 70L-40(1/3 in 3rd w), and none in 70D-40 or OS.

E. wulfenii fresh seeds germ. 70-40-70(3/3 on 2nd d). Light, GA-3, or OS did not initiate germination.

Fallugia (Rosaceae). F. paradoxa germ. 100% in 4-8 d in 70D, 70L, or 70 GA-3 and 40(73% in 8-12 w)-70D(20% on 2nd d). Seeds DS 1 y were all dead.

Fatsia (Araliaceae). A commercial sample of seeds were all dead.

Fedia (Valerianaceae). F. cornucopiae seeds were all empty seed coats.

Feijoa (Myrtaceae). F. sellowiana fruits were purchased as (a) fruits 3 inches long and (b) fruits half that length. Seeds were rinsed and WC 7 d. Seeds from either treatment germ. 70L(100% in 8-16 d) counting from the beginning of the WC. Germinations in 70D were a little slower. Treatment with GA-3 had little effect. A commercial sample of seed germ. 1/6 in 70L with the rest rotting suggesting that there is a short lifetime in DS.

Ficus (Moraceae). F. carica seeds were obtained from commercial dried figs. The seeds germ. 70L(40% in 3-7 w), 70 GA-3(20% in 4th w, rest rotted), and 70D(5% in 4-8 w).

Foeniculum (Apiaceae). F. vulgare germ. 70 GA-3(82% in 7-11 d), 70L(100% on 9th d), 70D(45% in 3rd w), and 40(10%)-70D(25%). RC reported that it germ. at 70, but it is evident that light and GA-3 cause higher percent germination.

Forskohlea (Urticaceae). F. angustifolia DS about 8 m germ. 70L(100% on 4th d). All rotted in 70D or 70 GA-3. The light requirement disappeared on further DS and seeds DS 2 y and 3 y germ. 100% on the 4th d in 70D.

Fortunella (Rutaceae). F. crassifolia is the kumquat. Seeds from fruits germ. in 70D, 36% in 3-6 w if rinsed and 27% in 3-7 w if WC 7 d.

Fouquieria (Fouquieriaceae). F. splendens germ. 70D(100% in 2nd d), 70 GA-3(40% on 2nd d, remainder rotted), and 40 (all rotted).

Fragraria (Rosaceae). F. chiloensis (strawberry) was WC for 7 d. Seeds germ. 70L(43% in 1-3 w), 70 GA-3(34% in 1-4 w), 70D(4%), and none in 40-70D.

Francoa (Saxifragaceae). F. sp. germ. 100% in 10-14 d in 70D or 70L.

Frankenia (Frankeniaceae). F. thymifolia germ. 70D(100% on 3rd d), 40(80%), and OT(100% in March). Light or GA-3 had no effect.

Franklinia (Theaceae). F. alatahama is now found to require light for germination. Portions of a large sample were periodically shifted from 70D to 70L over a two month period. Germination always occured in the 3rd w after the shift to 70L. There are large amounts of empty seed coats which are not easy to differentiate so that percent germinations (estimated to be about 100%) are inaccurate.

Frasera (Gentianaceae). F. fastigiata was still showing an occasional germination two years after starting the expts. Data were 70-40-70-40-70(20% in 1-3 w)-40-70(38% in 2nd w)-40-70(2%).

Fraxinus (Oleaceae).

F. americana seeds were collected in December. It is possible that seeds collected earlier would have given somewhat different results. Seeds were studied both with the winged outer coat left on and with it removed (stripped). Stripping the seeds gives better exposure to light and better germination. The stripped seeds germ. 70L(82% in 5-11 d), 70 GA-3(91% in 1-6 w), 70D(11%)-40(11%)-70D(57% on 4th d), OS(20%), 40-70D(72% in 2-24 d), and OT(76% in March, started in Dec.). The unstripped seeds germ. 70L(20%) and 70D(8%). Two more samples from neighboring trees gave similar results but with more germination in 70D(20%)-40(45%)-70D(25%). About 20% of the seeds contained a weevil, and such seeds were not counted. Many trees in this genus set vast amounts of normal size seed coats that are empty. Snipping off the end of the seed coat or puncturing the side did not initiate germination so that impervious seed coats are not present.

F. anomala germ. 40-70D(2/10 on 2nd d) and none in 70D-40.

Fraxinus quadrangulata seeds DS 18 m germ. 70-40-70-40-70-40(7/34 in 4-12 w)-70(7/34 in 2-23 d). It is anticipated that more will germinate on further treatment since the seeds show no sign of rotting. There was no change in this pattern if the seeds were started in a 70L cycle. Both OT and GA-3 failed to initiate germination.

Fremontodendron (Bombaceae). Two samples of F. californicum had failed to germinate under all treatments until a sample that had been DS 2 y had the seed coats punctured. These germ. 4/14 in 6-8 w. This experiment was repeated, and the result confirmed. An impervious seed coat is present. It is unfortunate that the seeds were not punctured when fresh.

Fritillaria (Liliaceae).

F. graeca v. thessalica germ. 70-40(40% in 12th w)-70-40(20%) and 40-70(10%)-40-70(10%). This updates earlier work.

F. imperialis is now studied on a much larger sample. Seeds DS 1 y germ. better than fresh seeds and germ. 40(40% in 12-17 w) and none in 70D. Fresh seeds germ. 70D-40-70D(15% in 1-4 w) and 40-70D(4%)-40(5%)-70D(15% in 3-9 d). There was extensive loss of seeds through rot in the fresh seeds. GA-3 led to rotting of all the seeds, and light had no effect. The seedlings must be grown under cool conditions.

F. pallida was reported in the 2nd Ed. to germinate in a 70-40-70-40 pattern. It is now found that germination is faster if the initial period at 70 is 6 m instead of the standard 3 m. Germination is now 70-40(26% in 12th w)-70(29% in 2-11 d) relative to 70D-40-70D(11%)-40-70D(22%) when the initial period at 70 was the usual 3 m. Further variations in time periods need to be studied.

Fumaria (Papaveraceae). F. officinalis germ. 1/26 in May in outdoor treatment and none in any other treatment suggesting that it may not tolerate DS.

Galega (Fabaceae). G. officinalis germ. D-70 (RC).

Gamocheta (Asteraceae). G. nivals germ. 100% in 8-10 d in 70D.

Gardenia (Rubiaceae). G. jasminoides germ. 70D(90% in 3rd w) confirming a past report (JH). This dropped to 70D(20% in 3rd w) for seeds DS 1 y.

Gaultheria (Ericaceae). G. shallon germ. 70D(30% in 2-4 w), 70L(85% in 3rd w), 70 GA-3(16% in 3rd w), and 40-70D(1%).

Gentiana (Gentianaceae).

G. affinis, seeds of a third sample germ. 70 GA-3(100% in 9-19 d), 70L(31% in 1-4 w), 70D(13% in 1-4 w), 40(80% in 9th w), and 80% in April in OT. This confirms that their is stimulation by GA-3, light, and oscillating T, but there is still significant germination in 70D. About half the seeds died after DS 6 m and 95% after DS 1 y.

G. asclepiadea germ. 70L(1/30) and none in 70D or 70 GA-3.

G. calycosa seeds were all dead after 1 y DS.

G. cruciata germ. 70 GA-3(100% in 10-18 d), 70L(84% in 3rd w), and 70D(2%)-40-70D(90% in 4th w). Unfortunately 40-70D was not tried.

G. nivalis germ. 70 GA-3(73% in 2-6 w, ind. t 14 d, first order, half life 5 d) and none in 70D, 70L, 40-70D, or 40-70L. DS at 70 for 3 m raised germination in 70 GA-3 to 96%, but otherwise had little effect.. A small amount (10%) germ. in OT. Seeds DS 1 y were dead.

G. paradoxa, a second sample germ. 70D(20% in 3-5 w) and 40-70D(20%) with light or GA-3 having no effect. This is inconsistent with results from the earlier sample.

G. scabra, further samples confirm that light or GA-3 are required for germination.

Gentianella (Gentianaceae).

G. campestris germ. 70 GA-3(56% in 5-11 w) and 10% in April in OT. None germ. in 70D, 70L, 40-70D, or 40-70L. Seeds DS 1 y were dead.

G. germanica germ. 70 GA-3(79%% in 1-3 w), 70L(3%), and 70D(none).

G. turkestanorum germ. 70 GA-3 (25% in 4-6 w) and little or none under other conditions using seeds DS 6 m. Seeds DS 2 y were dead suggesting that the 6 m DS on the seed originally received could have been detrimental

Geranium (Geraniaceae). G. sylvaticum germ. 70D-40-70D(1/10 on 4th d)-40-70D(1/10 on 6th d), 70L-40-70D(4/10 in 3-5 d)-40-70D(1/10 on 5th d), and 40-70D-40-70D(1/9 on 5th d)-40(1/9).

Geum (Rosaceae).

G. montanum was reported (2nd Ed.) to germinate in April from seeds placed outdoors in January. A new sample has now germ. 40-70D(52% in 2-4 d), 70L(13% in 3-7 w), 70 GA-3(6%), and 70D(21% in 3-8 w).

G. rivale germ. 70L(100% in 2-7 w), 40-70L(41% in 2nd w), and none in 70D, 70 GA-3, 40-70D, or OT. Seeds DS 6 m germ. 70L(42% in 1-5 w) and 70D(6%), and seeds DS 1 y were dead.

G. urbanum germ. D-70 (RC).

Gilia (Polemoniaceae). G. formosa germ. 40(2/5 in 3rd w) and 70D(none).

Gillenia (Rosaceae). DS had a marked effect on germination of G. trifoliata. Fresh seed germ. 70 GA-3(24% in 4-12 w)-40-70(32% in 1-3 w), 70% in April in outdoor treatment, and none in 70D or 70L. Seed DS 6 m at 70 germ. 40(50% in 8-10 w)-70(4%), 70 GA-3(4%), and 70D(none). Seed DS 12 m at 70 germ. 40-70D(67% largely in 3rd w) and 70D(none). These results are not consistent.

Glaucium (Papaveraceae). G. elegans germ. 70D(17% in 3rd w) for either seed DS 6 m or 2 y, but seeds DS 3 y were dead.

Globularia (Globulariaceae). Samples of G. bellifolia, G. bisnagarica, G. cordifolia, G. cordifolia purpurea, and G. incanescens were all chaff.

G. punctata germ. 70L(100% on 8th d) and none in 70D.

G. sp. germ. 70D(4/8 on 10th d).

G. trichosantha germ. 70L(75% in 8-14 d) and 70D(45% in 8-14 d).

Gloriosa (Liliaceae). G. superba germ. 70D(100% in 3rd w). Light or GA-3 had no effect.

Glycyrrhiza (Fabaceae). G. glabra has an impervious seed coat (RC).

Glyphosperma (Liliaceae). G. palmeri germ. 3/4 on 11th d in 70D.

Godetia (Onagraceae). G. grandiflora seed probably DS 1 y germ. 100% in either 70D or 70L although it was faster in 70L, 3rd d relative to 3-11 d. This could have been simply a heat effect.

Gomphrena (Amaranthaceae). G. haagena seeds DS 4 y germ. differently than the fresh seeds reported in the 2nd Ed. The fresh seeds germ. best when diurnal temperatures were shifted between 70 and 90 each day with less germination in 70L and least in 70D. Removing the seed from the husk did not make a difference. The seeds DS 4 y germ. 70-90% in 2nd w but only if removed from the husks. A prior 4 w moist in the husk made no difference. More work is needed to clarify this confusing situation. Temperatures over 70 are not needed for seeds DS 4 y.

Goodenia (Goodeniaceae). A sample of G. scapigera were all empty seed coats. Jonathan Lidbetter of Australia reports that germination is initiated by gibberellins and by components of smoke.

Gossypium (Malvaceae). G. herbaceum germ. D-70, but G. thurberii had an impervious seed coat (RC).

Grayia (?). G. spinosa germ. 70 GA-3(2/11 in 2 d), 70L(1/8 in 4th w), 70D(0/8), and 5/9 in April in OT.

Grevillea (Proteaceae). Two sp. germ. in 2-10 w at 70 (JH).

Guichenotia (Sterculiaceae). G. sterculiaceae has an impervious seed coat. Making a hole in the seed coat by sandpapering gives 100% germination in 4-6 d at 70. No germination occurs otherwise.

Gunnera (Halorgidaceae). In earlier work samples of seeds of four species had all immediately rotted. Now G. densiflora germ. 70 (GA-3)-40-70(2/4 in 3 w), 70D-40-70D(1/4 in 5th w)-40-70-40-70(1/4)-40-70(1/4), and 40-70-40-70(1/4 in 3rd w). Germination is much extended, and GA-3 probably has little effect. JH reported that G. chilensis and G. manicata germ. in about 40% if soaked in running water for 6-24 hours first. WC for various time periods needs to be tried.

Hackelia (Boraginaceae). H. bella germ. 40(2/9 in 12th w). The remaining seeds rotted and seeds all rotted in all other treatments. H. nervosa germ. 40(1/5 in 7th w) and 6/8 in April in outdoor treatment. The samples of 5 seeds each in 70D or 70 GA-3 rotted within a month. Despite the meagre data, there is a clear indication that the seeds germinate only at 40 and best if placed immediately at 40.

Haleria (?). H. corniculata germ. 70L(85% on 9th d) and 70D(60% on 12th d).

Halesia (Styracaceae). H. caroliniana seeds subjected to alternating 3 m at 40 and 70 did not start germinating until after 2 y. Germinations were largely complete after 4 y and were as high as 90% providing the empty seed coats were not counted. These empty seed coats were generally 70-90% of the total seed coats of normal size. The germinations generally occur within a week after a shift from 40-70. This pattern was confirmed on twenty different samples. Germination was little affected by DS for 6 m or GA-3. Puncturing the seed coat led to rapid rotting. Seeds did not germinate until the third spring in OT. It would appear that more than one blocking mechanism is present and periods at both 40 and 70 are needed. Experiments are in progress in which the periods at 40 and 70 are lengthened to see if the number of cycles can be reduced.

Halimium (Cistaceae). H. ocymoides germ. 70D(1/25 on 6th d) and 70L(none).

Hamamelis (Hamamelidaceae). H. virginiana seeds DS 5 y were dead.

Hardenburgia (Fabaceae). H. comptoniana seeds punctured germ. 100%, 50%, and 0% for seeds fresh, DS 1 y, and DS 2 y. None germ. unless the seed coats are punctured. It is unusual for seeds with an impervious seed coat to have such a high death rate on DS.

Hebe (Scrophulariaceae). H. epacridea germ. 70 GA-3(100% in 2nd w), 70L(75% in 3rd w), 70D(30% in 3rd w)-40-70D(10%), and 40-70D(80% in 8-10 d). Although GA-3 speeds up germination, the 40-70D treatment insures healthy seedlings and is preferred.

Hedeoma (Lamiaceae). H. hispida germ. 70L(80% in 8-12 d) and 70D(70% in 1-3 w).

Heliotropium (Boraginaceae). H. arborescens germ. in 2-6 w at 70 (JH).

Helleborus (Ranunculaceae). The data for H. argutifolius is now complete. It germ. 70-40(57% in 7-11 w)-70-40(21% on 2nd d)-70-40(3%) and none in 40-70 or 70 GA-3.

Helonias (Liliaceae). Fresh seeds of H. bullata have now been subjected directly to 70L, and 95% germ. in 10-16 d. The same seeds in 70D germ. 29% in the 4th w. If the seeds in 70D are shifted to 70L after 6 w, the remaining seeds germ. in the 2nd w after the shift. This confirms the earlier less definitive results that light initiates germination.

Herniaria (Caryophyllaceae). H. glabra germ. D-70 (RC).

Hesperaloe (Liliaceae or Agavaceae). H. parviflora germ. 70D(100% on 4th d), 70L(6/7 in 6-8 d), and 40-70D(94% in 1-3 d).

Hesperochiron (Hydrophyllaceae). H. californicum germ. 70 GA-3(76% in 2 d-4 w), 70D(none), and 40(6%)-70D(53% in 1-4 w).

Heterodendrum (Sapindaceae). H. oleifolium seeds DS either 6 m or 1 y germ. 70D(50% in 4-8 d). The orange aril was removed for convenience, and it is not known whether this had any effect on the germination.

Heuchera (Saxifragaceae).

H. cylindrica seeds DS 0, 2 y, and 4 y germ. 13% in 3rd w, 43% in 2-5 w, and none, all in 70L. In 70D the respective germinations were 5%, none, and none.

H. richardsonii seeds DS 0, 2 y, and 4 y germ. 94% in 1-3 w, 17% in 3rd w, and none in 70L and 89% in 1-3 w, none, and none in 70D.

Hibbertia (Dillenaceae). H. dentata seeds DS 6 m germ. 70 GA-3(1/4 in 9th w)-40(1/4 in 8th w)-70(1/4 on 2nd d), 70D(1/4 in 9th w)-40-70D, and 70L(1/2 in 12th w)-40-70D.

Hibiscus (Malvaceae). H. trionum germ. 70D(100% on 3rd d) if the seeds were punctured and 71% on 3rd if unpunctured. These numbers fell to 65% and 30% (about the same proportional decrease) if the seeds were DS 1 y.

Hierochloe (?). H. odorata was all chaff.

Hieracium (Asteraceae).

H. maculatum germ. 70L(1/7 in 4th w) and 70D(1/14 in 5th w).

H. olafii germ. 70L(100% in 1-3 w) and 70D-40-70D(none). After 1 y DS the light requirement largely disappeared, and the seeds germ. 70D(71% in 2nd w).

Hoheria (Malvaceae). H. lyalli was all empty seed coats.

Honckenya (Caryophyllaceae). H. (Ammadenia) peploides germ. 70 GA-3(95% in 2-8 d), 70L(23% in 2nd w)-40-70D, 70D(27% in 2nd w)-40-70D, 40-70D(none), and OT(23% in Nov. and March). The same percentages and patterns were shown by seeds DS 6 m. Seeds DS 1 y germ. 70 GA-3(64% in 8-10 d). 70L(20% on 20th d), and 70D(none).

Houstonia (Hedyotis pygmaea)(Rubiaceae). H. rubra germ. 70D(100% in 4-8 d), 70L(30%), 70 GA-3(25%), and OT(40% in Nov. from seed placed outdoors in October and none the following spring).

Houttuynia (Saururaceae). H. cordata germ. 70L(45% in 4-6 w) and none in 70D, 70 GA-3, 40-70D, or OT.

Humulus (Moraceae). H. lupulus germ. 70 GA-3(23% in 1-4 w), 70L(none), 70D(2%)-40-70D(20% in 1-3 d), and 40(6%)-70D(53% in 1-4 w).

Hunnemania (Papaveraceae). H. fumariefolia germ. in 2-3 w at 70 (JH).

Hydrangea (Saxifragaceae). The seeds of both species were received in March and had 6 m of DS.

H. arborescens germ. 70L(100% in 1-3 w), 70 GA-3(100% in 2nd w), 70D(none), 40-70L(100% in 3rd w), 40-70D(12% in 3rd w), and 2% in May in OT.

H. panniculata germ. 70L(2%), 70 GA-3(100% in 2nd w), 70D(none), 40-70L(100% in 3rd w), and 40-70D(4% in 2nd w). Seeds were dead after 1 y DS.

Hydrophyllum (Hydrophyllaceae). H. capitatum germ. 40(43% in 4-10 w), 70 GA-3-40(80% in 2nd w), and 70D-40(4%). About half the seeds died in DS 6 m, 80% were dead after 2 y DS, and all were dead after 3 y DS.

Hymenosporum (Pittosporaceae). H. flavum germ. 70L(83% in 3-6 w), 70 GA-3(50% in 4th w), and 70D(9%) using seeds DS 6 m. Seeds that had been given 6 m of other treatments germ. 3/4 in 4th w after treating with GA-3.

Hyoscyamus (Solanaceae). H. niger was reported to be a 40-70 germinator (RC). It is now found to germinate 70 GA-3(100% in 1-3 w) and none in 70D, 70L, 40, or OT. Seeds were over 95% dead after DS 6 m.

Hypericum (Hyperiaceae).

H. olympicum germ. 70 GA-3(91% in 3rd w) and none in 70L,70D, or 40-70D. Seeds DS 6 m were dead.

H. spathulatum seeds germ. 70L(44% in 1-7 w) and 70D(2%) for fresh seeds. Seeds DS 6 m germ. 70L(63% in 1-6 w) and 70D(7%).

Hysoppus (Lamiaceae). H. officinalis germ. 70D (RC).

Iberis (Brassicaceae). I. umbellata germ. 70D(95% in 4-20 d), 70L(70% in 4-28 d), OS(100% in 6-17 d), OT(100% on 7th d in Oct.), and 40(86% in 3rd w).

Ibicella (Martyniaceae). I. lutea has a tough black seed coat, and the seeds were studied with the coat on and off (peeled). Peeled seeds germ. 70D(1/5 in 2nd w), 70L(1/4 in 4th w), and 70 GA-3(all rotted). Seeds DS 1 y and peeled germ. 70L(1/4 in 4th w) and 70D(1/8 in 6th w). Unpeeled seeds did not germinate.

Ilex (Aquifoliaceae).

I. glabra data is more complete now. Germination is best in OT. Seeds started in January germ. 16% in May-September and 23% the following May.

Impatiens (Balsamaceae). I. balsamina germ. D-70 (RC).

Inula (Asteraceae). I. helenium germ. 70L(50% in 5-10 d) and 70D(none) using seeds DS either 6 m or 1 y.

Ipheion (Liliaceae). I. uniflorum germ. 70D(1/10 in 16 d)-40-70 and 40-70D-40(3/8 in 4-6 w).

Ipomoea (Convolvulaceae).
I. batatas has an impervious seed coat (KA).
I. tricolor germ. D-70 (RC).

Iris (Iridaceae). The Aril Iris including Juno have been one of the most difficult groups to germinate. Section VI is devoted to this problem. Alternating cycles means alternating between 3 m at 40 and 3 m at 70 (just a reminder).

I. attica germ. 1/4 in 70D after 4 y of alternating cycles and 1/4 at 40 a year later.

I. bulleyana germ. 70L(2/9 in 3rd w) and 1/6 after 1 y of alternating cycles in dark.

I. darwasica germ. 1/3 in the 9th w at 40 after 3.5 y of alternating 3 m cycles starting at 70.

I. stolonifera seeds DS 1 y germ. 2/5 at 40 after 2 y of alternating cycles.

I. trojana germ. 70(1/5). A 2nd seed germ. at 40 after 4 y of alternating cycles. Both seedlings were vigorous.

I. typhifolia germ. 70L(7/8 in 12-22 d) and 70D(none).

I. versicolor germ. 70L(55% in 3-11 w). A second sample germ. 70L(32% in 4-9 w)-40-70L(36% in 1-4 w), 40-70L(42% in 2-5 w), 70D-40-70L(30%), and none in all other treatments. Seeds of this 2nd sample DS 1 y germ. 70L(17% in 9th w)-40-70L(58% in 2nd w) and 70D(none).

I. xiphoides germ. 70 GA-3(1/5 in 6th w)-40(2/4 in 7th w) and none in 70D, 70L, or 40.

Isatis (Brassicaceae). I. tinctoria germ. 40(96% in 2nd w) and 5% in 2nd w in 70D or 70L. Removing the outer husk increased the percent germination in 70D to 15%. Seeds DS 2 y germ. 70D(100% in 2-4 d) and 40(55% in 3-11 w)-70D(28% on 3rd d). The DS for 2 y seemed to change the germination pattern, but the seeds were still completely viable.

Isoplexis (Scrophulariaceae). I. canariensis germ. 70L(100% on 9th d) and 70D(100% in 8-16 d). Germination was fewer and slower in 70 GA-3.

Isotoma (Lamiaceae). I. axillaris germ. 70L(85% in 8-12 d) and 70D(74% in 8-14 d). Germination was fewer and slower in 70 GA-3.

Jamesia (Saxifragaceae). J. americana germ. 70L(67% in 1-3 w), 70 GA-3(32% in 2nd w), and 70D(none) confirming a report (JH) that light is required.

Jatropha (Euphorbiaceae). J. curcas germ. 100% on the 5th d in 70D or 70L. It failed to germinate in 70 GA-3.

Jovellana (Scrohulariaceae). J. repens was all chaff.

Juglans (Juglandaceae). J. regia was obtained as commercial nuts. The only germination was 70D(1/4 in 4th w). Soaking was no help and led to rotting.

Juncus (Juncaceae). J. compressus, J. effusus, and J. tenuis seeds DS 8 m required light and germ. 100% in 70L in 1-8 w, 1-4 w, and 5-9 d respectively. None germ. in 70D or 40-70D. DS for 2 y had no effect on the germination of seeds of J. effusus and J. tenuis, but seeds of J. compressus were dead.

Juniperus (Pinaceae). J. horizontalis germ. 70-40-70-40-70(1/250)-40-70(1/250) similar to the extended germination shown by J. virginiana (2nd Ed.).

Juno (Iridaceae). See Section VI.

Kalopanax (Araliaceae). K. pictus germ. 70D-40(16% in 9-12 w)-70D(53% in 2-6 d) and none in 40-70D-40 and 70 GA-3-40-70D. Light had no effect. All rotted in OT. Seeds DS 1 y germ. 70D-40-70D(22% in 2-8 d), and seeds DS 2 y were dead.

Kedrostis (?). K. africana germ. 100% on 6th d in 70D.

Kelseya (Rosaceae). K. uniflora, first sample DS 6 m germ. 70 GA-3(100% in 1-3 w), 70D(none), 40(10%)-70(40% in 1-5 w), and 100% in April in outdoor treatment. A second sample of fresh seeds germ. 70D(2/4 in 3rd w), 70D(4/4 in 1-6 w) if preceded by 4 w of OS, 40-70D(2/4), and none in the other treatments. The discrepancies may be due to differences in the amount of DS.

Kernera (Brassicaceae). K. saxatilis germ. 70L(100% in 1-3 w), 70D(77% in 1-7 w), and none in 40-70D or OT.

Kigelia (Bignoniaceae). K. pinnata germ. 3/18 in 3rd w at 70 with or without GA-3 (KR). Other GA's did not improve the percent germination.

Kitaibelia (Malvaceae). K. vitifolia germ. 100% in 4th d in 70D if the seed coats were punctured and 2/6 in 1-10 w if unpunctured. There is an impervious seed coat, but some of the seed coats have an imperfection that allows germination.

Knautia (Dipsaceae). K. macedonica germ. 70L(65% in 1-3 w), 70 GA-3(62% in 1-3 w), 70D(21% in 1-5 w), and none in 40-70D or 40-70L.

Koenigia (Polygonaceae). K. islandica germ. 100% in 4-8 d in 70D, 70L, or 70 GA-3. OT had no effect. Curiously a prior 3 m at 40 was fatal.

Kunzea (Myrtaceae). K. baxteri continued to germinate around 50% in 70D after 2 y of DS, and K. vestita continued to germinate 70-80% after 2 y of DS.

Lachenalia (Liliaceae). Light inhibited germination.

L. gilleti germ. 70D(21/24 in 8-15 d) and 70L(none).

L. latiflora germ. 70D(5/14 in 10-15 d) and 70L(none).

L. mediana germ. 70D(8/10 in 10-15 d) and 70L(none).

L. postulata germ. 70D(100% in 6-10 d) and 70L(1/30).

L. postulata (blue) germ. 70D(75% in 6-14 d) and 70L(none).

L. unicolor germ. 70D(100% in 8-12 d) and 70L(none).

Lactuca (Asteraceae). L. sativus germ. 100% in 2nd w at 70 (KR).

Lagopsis (Lamiaceae). L. marrubiastrum were all empty seed coats in a commercial sample and empty seed coats may be a problem with this species.

Lagunaria (Malvaceae). L. patersonii germ. 70D(2/5 in 4-10 d) if punctured and 2/5 in 2-7 w if not. Seeds DS 1 y germ. 70D(4/8 in 8-18 d) indicating no dying.

Larrea (Zygophyllaceae). L. tridentata germ. 70D(80% in 1-5 d). Light had no effect and GA-3 lowered the percent germination (confirmed with a 2nd sample). Germination was unchanged after DS for 6 m and 1 y.

Lathyrus (Fabaceae). L. latifolia germ. 70D(100%) for fresh seed (2nd Ed.), but this dropped to 91% after 6 m DS, 25% after 2 y DS, and 7% after 3 y DS.

Lavandula (Lamiaceae). L. sp. germ. 80% in 4-6 d, 48% in 2nd w, and none (all dead) in 70D after 6 m, 2 y, and 4 y of DS. The seeds DS 2 y also germ. 40(70% in 4-10 w) and light or GA-3 had no effect.

Lavatera (Malvaceae). L. thuringiaca DS about 4 m germ. 100% on 3rd d in either 70D or 70L. A second sample was nearly all dead suggesting that there may be a significant death rate in DS.

Lawsonia (Lythraceae). L. inermis v. alba seeds have failed to germinate in 70D, 70L, and 70 GA-3.

Legousia (Campanulaceae). L. patagonia germ. 70L(100% on 5th d), 70D(38% in 1-3 w), and 40(50% in 6th w).

Leonotis (Lamiaceae). L. leonurus germ. readily at 70 (JH)(RC).

Leontodon (Asteraceae). L. autumnalis germ. 70L(100%, zero order, ind. t. 3 d, 20%/d), 70D(78% in 4-10 d), and 40-70(3%) using seed that had been DS about 3 m. The 3 m at 40 is largely fatal. When the sample in 70D was shifted to 70L after 4 w, the last 22% germ. in 6-12 d. The effect of light disappeared on DS so that after 2 y of DS the seeds germ. 70D(100% in the 2nd w). It is possible that the fresh seed had a light requirement for germination, but that this had largely disappeared in 3 m DS.

Leonurus (Lamiaceae). L. cardiaca and L. sibiricus germ. D-70 (RC).

Lepechina (Lamiaceae). L. calycina germ. 70D-40-70D(1/5 on 2nd d) and none in 70 GA-3, 70L, 40, or OT.

Leptinella (Asteraceae). L. pyrethifolia germ. 70L(2/6) and 70D(1/13) both on 14th d. L. (Cotula) atrata luteola was all chaff.

Leptodactylon (Polemoniaceae). L. watsonii germ. 70D(4/8 in 2nd w) and 40(4/10 in 8-10 w)-70D(4/10 on 2nd d).

Leptospermum (Myrtaceae). L. lanigenum and L. scoparium were largely empty seed coats. In both species 1 to 5 germ. in 8-10 d in 70D and 70L.

Leucaena (Fabaceae). L. leucocephala had an impervious seed coat and germ. 70D(100% on 6th d) if punctured and none otherwise.

Leucocrinum (Liliaceae). L. montanum germ. 40-70D(1/8 on 10th d) and none in 70D or 70 GA-3.

Leucopogon (Epacridaceae). L. colensoi failed to germinate despite the seeds being collected fresh and not rotting.

Levisticium (Apiaceae). L. officinale is now studied on a much larger sample starting with seeds that had been DS for 6 m. These germ. 70D(75% in 2nd w) and 40(76% in 3-8 w). Light, GA-3, or DS for 1 y did not effect germination in 70D, but seeds DS 2 y were dead.

Leycesteria (Caprifoliaceae). L. formosa germ. 70D(1/4 in 7th w).

Libertia (Iridaceae). L. formosa germ. 70D(6/20 in 3-7 w) and 70L(6/14 in 5-7 w).

Libocedrus (Pinaceae). L. decurrens still germ. around 15% in 70D after 1 y of DS.

Ligularia (Asteraceae). L. japonica germ. 70D-40(2/4 in 5-9 w)-70D(2/4 in 1-3 d), similar to the two Ligularias reported before. KW reports that in most gardens Ligularias produce very little if any viable seed, and that is the experience here.

Ligusticum (Apiaceae). L. scoticum germ. OT(22% in March), 70D-40-70D(3/16 on 7th d), 70L-40-70D(1/10 on 9th d), 40-70D(1/ in 8th w), and 70 GA-3(1/8 in 3rd w). Seeds DS 6 m germ. 70D(3%)-40-70D(15% in 1-10 d).

Lilium (Liliaceae). Past work did not study the effect of light. It is now found that light mildly inhibits the germination of L. auratum, L. canadense, and L. martagon. Light had no effect on the germination of L. centifolium, L. pumilum, and L. szovitsianum.

L. auratum germ. 70D(67% in 1-12 w) and 70L(48% in 12th w).

L. canadense v. editorum seed was subjected to a number of experiments. Effect of 3 m at 40: seeds collected 9-23-92 germ. 70D(85%, ind. t 25 d, rate 1.3%/d) and 40-70D(90%, ind. t 61 d, rate 6%/d) showing that the 3 m at 40 accelerated the rate markedly, but also lengthened the induction time which compensated for the rate increase. A sample of seed collected a year later on 11-2-93 germ. 70D(85%, ind. t 61 d, rate 5.0%/d). It is likely that this seed was exposed to low temperatures around 40 in October so that its rate of germination was similar to seed collected the year before in September and given 3 m at 40 first. Effect of light: Light slows down the germination so that it takes 11-16 w at 70 instead of 8-10 w, but the final percent germination is about the same. Effect of DS: seeds DS 6 m or 12 m germ. about the same as fresh seeds, but seeds DS 2 y germ. 0-20% and the rates were significantly slower.

L. columbianum germ. 70-40(1/7 in 4th w) and 40-70-40-70-40(4/6 in 4th w).

L. humboldtii v. ocellatum germ. 70-40(100% on 4th w) and 40-70-40(100% in 3rd w). The true leaf began emerging at 40 four w after germination.

L. martagon germ. 70D(88% in 3-9 w) and 70L(35% in 3-12 w).

L. occidentale germ. 40(56% in 9th w)-70(4%)-40-70(4%) and 70-40-70(all rotted).

L. pardalinum was studied in OT treatment. It is likely that it is a 70-40 germinator like its variety wigginsii, see next entry. The seedlings require more than a 3 m cycle at 40 in order for the true leaf to develop on a shift to 70.

L. pardalinum v. wigginsii germ 70-40(100% in 6th w) and 40-70-40(3/5 in 7th w)-70-40(2/5 in 4-9 w).

L. parryi germ. 70-40(4/4 in 7th w) and 40-70-40(1/4)-70(1/4). The true leaf emerges after 3 m at 40 and the shift to 70.

L. superbum seeds DS 6 m germ. 70(93% in 10-22 w)-40-70 and 40-70(57% in 12-22 w). Note the extended cycle at 70.

L. szovitsianum germ. in two steps , the first step is formation of the radicle and small bulb and this germination is 70D(95% in 2-12 w), confirmed by a second sample. The seedling has to be subjected to 3 m at 40 before a leaf develops on the return to 70.

Linanthrastum (Polemoniaceae). L. nuttallii germ. 70 GA-3(3/6 in 2 d-4 w), 70L(2/8 in 2nd w), 70D(none), and 40(1/6)-70D(2/6 on 2nd d) similar to an earlier sample (2nd Ed.).

Linum (Linaceae).

L. alpinum germ. 70 GA-3(6/10 in 10-18 d), 70L(1/9 on 10th d), and 40(3/8 in 9-12 w)-70D(2/8 on 2nd d). None germ. in 70D or OT.

L. catharticum germ. 70L-40-70D(71% in 2-10 d) and 70D-40-70D(17% on 3rd d). Germination in 70 GA-3, 40-70D, and OT were under 5%. Seeds DS 6 m germ. 40(14% in 12th w) and 70D(none).

L. usitatissimum germ. D-70 (RC).

Lippia (Verbenaceae). A seed exch. sample of L. (Phyla) nodiflora was all chaff.

Liriodendron (Magnoliaceae). L. tulipifera germ. 70D-40-70D(2%)-40-70(4%). This may be the optimum pattern for germination. The low percent germinations are largely if not completely due to the high percentage of empty seed coats that are not detectable from outer appearance.

Lithocarpus (Fagaceae). L. densiflorus v. echinoides germ. 70D(5/10 in 2-12 w)-40(4/10 in 3rd w) and 40(4/7 in 12th w)-70D(3/7 in 2-12 d). Probably the rest would have germ. at the initial temperature if given longer times. L. densiflorus v. densiflorus germ. similarly in an even smaller sample. Seeds of both species were dead after 6 m DS at 70.

Lithospermum (Boraginaceae). L. officinale germ. 70L(91% in 1-7 w), 70 GA-3(23% in 3-12 w), 40-70L(95% in 2-5 w), and none in 70D or 40-70D.

Livistonia (Palmaceae). L. chinensis germ. 70(8/10 in 2-4 w). Puncturing the seed coat had little effect. About 80% of the seeds lying on the ground had a hole in the side due to the emergence of a weevil that had eaten the seed.

Lobelia (Lobeliaceae).

L. anatina germ. 70L(13% in 2-4 w), 70 GA-3(40% in 1-4 w), and 70D(none).

L. boykinii germ. 70 GA-3(33% in 3rd w), 70L(1%), 70D-40-70L(12%), and none in 40-70D or 40-70L. The 3 m at 40 appears to be fatal which is unusual.

L. cardinalis germination in 70L follows zero order kinetics. The rate (ind. t 8 d, 2.8%/d) is unchanged by DS of the seed, but the percent germination goes through a maximum and then falls as the seed dies. The percent germinations in 70L are 14%, 79%, 77%, and zero for seeds DS 0, 6 m, 1 y, and 2 y.

L. inflata seeds DS 0, 1 y, and 2 y germ. 74%, 66%, and zero in 70L and zero, 11% and zero in 70D. All germinations were in 2-5 w.

L. pendula germ. 100% in 3-5 d in either 70D or 70L. Germination was slightly inhibited by GA-3. Seeds DS 6 m germ. 70D(100% in 6-15 d) which shows some slowing of the rate of germination.

Loiseleuria (Ericaceae). L. procumbens germ. 70L(30% in 5-8 w), 70 GA-3(33% in 6th w), 70D(none), 40-70L(62% in 2-4 w), 12% in May in outdoor treatment, and 40-70D(none). A 3 m DS at 70 had no effect on the germination in 70L, but seeds DS 1 y were dead.

Lomatium (Apiaceae). L. nuttallii germ. 40(100% in 7-9 w), 70 GA-3(none), and 70-40(7%)-70-40(80% in 3-11 w). The germination at 40 is typical of this genus. It is of interest that starting the seeds at 70 slows down the germination at 40.

Lopezia (Onagraceae). L. racemosa germ. in 6 d at 70 (JH).

Luzula (Juncaceae). Seeds of the following three species had been DS about 8 m. L. luzuloides and L. nivea germ. in 1-5 w in either 70D or 70L. The percents were 50% and 20% respectively. They also germ. 40(27%)-70D(27%) and 40(1%)-70D(11%) respectively. L. pilosa germ. 70L(42% in 1-4 w), 70D(16% in 5-7 w), and 40-70D(none) suggesting that light promoted germination somewhat, and that possibly the light effect was disappearing on DS. All three failed to germinate a single seed in 70 GA-3. Seeds of all three were dead after 2 y DS.

Lychnis (Caryophyllaceae).

L. alba germ. 70L(100% in 4-9 d) and 70D(1-10%) (2nd Ed.). This was unchanged after 2 y DS.

L. flos-cuculi germ. 100% in 4-15 d in either 70D or 70L and 40-70(64% in 3-8 d). Neither GA-3 or DS 6 m had any effect. Seeds DS 2 y germ. 70D(18% in 3rd w) showing extensive dying.

Lycium (Solanaceae). L. chinense germ. in 2nd w at 70 (JH), presumably the seeds had been WC.

Lycopersicon (Solanaceae). L. esculentum seeds DS 6 m germ. 100% in 3-5 d in 70D. A zero order rate law (30%/d) was followed from 10-90% germination. After 2 y DS germination was unchanged with seeds of the strains Big Girl and Beefsteak. In contrast germination in seeds of Rutgers dropped to 67%, and the rate was slower (4-13 d). After 3 y DS Rutgers germ. 55% in 4-12 d and Beefsteak germ. 85% in 6-12 d. An experiment was conducted on seeds fresh from the fruit involving WC for various times. Seeds WC from a simple rinse to WC 17 d showed little difference in germination suggesting that the mechanism blocking germination is simply protection from oxygen of the air rather than any specific inhibitor in the fruit. The seeds under water in the WC treatment continued to germinate and at a rate only slightly slower than seeds in the moist paper towels indicating that the seeds have only a modest demand for oxygen which is met by the oxygen dissolved in the water.

Lycopus (Lamiaceae). L. europaeus germ. D-70 (RC).

Lysichiton (Araceae). Germination is much faster and in higher percentage in light, but there is significant germination in the dark.

L. americanum germ. 70L(100% in 2-6 w) and 70D(63% in 2-12 w). This clarifies the peculiar results reported in the 2nd Ed. A second sample collected a year later germ. 70L(100% in 2-7 w) and 70D(25% in 1-8 w) confirming the general pattern.

L. camschatense germ. 70L(100% on 12th d), 70D(90% in 2-6 w), 70 GA-3(30% in 3rd w), and 40(8%)-70L(84% in 2-5 w). A second sample germ. 70L(68% in 3-15 w)-40-70D(22% in 3-12 w)-40-70D(1%), 70D-40-70L(2%), and 40-70L(1%). This second sample had been DS for a month which may explain its somewhat different behavior. The optimum treatment is 70L. The second sample was also put in 70D and 70L under one inch of water with curious results. The sample under water in 70D was shifted to 70L onto a moist towel after 11 w whereupon 60% germ. in the 3rd w. The sample under water in 70L germ. 2% in 8 w. It was then shifted to 70L onto a moist towel whereupon 5% more germ. over the following 3-6 w. The 2-3 m under water are clearly detrimental, but immersion in dark is less detrimental than immersion in light.

Lysimachia (Primulaceae). L. punctata germ. 70L(100% in 1-4 w), 70 GA-3(86% in 2nd w), and 70D(none). Seeds DS 1 y germ. 70L(83% in 1-4 w) and 70D(none).

Maackia (Fabaceae). M. amurensis has an impervious seed coat. Seeds punctured by grinding against sandpaper germ. 100% in 2-3 d in 70D. The seed coats break down readily so that 10% of the controls germ. in 70D in 2-12 w. Seeds DS for 6 m germ. 40% in 3-9 d if punctured and 30% in 2-10 w in the controls. This is interpreted to mean that DS caused microfissures in the seed coats, but it also was fatal to 60-70% of the seeds.

Macfadyena (Bignoniaceae). M. unguis-cati had germination promoted by light, but light was not essential. Seeds DS 1 y germ. 70L(5/6 in 3rd w), 70D(4/8 in 4-6 w), and 70 GA-3(1/4 in 4th w).

Magnolia (Magnoliaceae).

M. kobus v. stellata has germination initiated by GA-3, but 40-70 is satisfactory and probably preferable. Seeds WC 7 d germ. 70 GA-3(50% in 3rd w), 70-40-70(50% in 10-17 d), and 40-70(54% in 1-3 w)-40-70(12% in 2-4 w).

M. grandiflora germ. best if the seeds were WC 7 d, given 6 w of OS, and 70D(40% in 1-3 w). None germ. without the preliminary OS treatment. The expts. are only 3 m old so that other treatments may work, but the OS-70D was for seeds from two different trees and WC 7 d. WC in detergent gave lower germinations.

Malacothamnus (Malvaceae). M. densiflorus germ. 70D(3/3 in 2-4 d) if punctured and 1/35 if not. Light had no effect. There were 70% empty seed coats that were not counted. After 1 y DS punctured seeds germ. 2/17 and none if unpunctured.

Malope (Malvaceae). M. trifida germ. 100% in 3-12 d in either 70D or 70L.

Malva (Malvaceae).

M. alcaea had an impervious seed coat. Producing a hole in the seed coat led to 100% germination on the 5th d. None germ. otherwise.

M. moschata, KW confirms that seed germ. 100% in 2-4 d, and further that seeds DS up to 4 y gave identical behavior.

Malvaviscus (Malvaceae). M. arboreus seeds DS 1 y germ. 70L(2/6 in 2nd w). The samples in the other treatments turned out to be empty seed coats.

Mandevilla (Apocyanaceae). M. suaveolens germ. 70D(90% in 1-3 w). Light or GA-3 had no effect.

Mandragora (Solanaceae). M. officinalis germ. 40(1/6)-70-40(2/6)-70(1/6) and none in 70D, 70L, or 70 GA-3.

Mangifera (Anacardiaceae). M. indica (mango) has the large seed enclosed in a clam shaped seed coat. When pressure is applied to the keel in a vice, the seed coat splits and can be pried apart. After rinsing the seeds they germ. on the 7th d. The radicle develops and branches rapidly and a stem with true leaves emerges about two weeks after germination. The cotyledons turn green, but do not develop. Treating one seed with GA-3 led to immediate rotting, and this is not recommended.

Marrubium (Lamiaceae). M. vulgare germ. D-70 (RC).

Margyricarpus (Rosaceae). M. setosus 70D(100% on 3rd d).

Matelea (Asclepediaceae). M. obliquus germ. only with GA-3 with fresh seed. It is now found that DS for 6 m at 70 reduces the percent germination in 70 GA-3 from 26% to 10%, but it also causes 10% germination in 70L. The DS reduces the GA-3 requirement, but simultaneously caused significant death of seeds.

Mathiola (Brassicaceae). M. incana germ. 70L(84% in 2nd w) using either fresh seeds or seeds DS 1 y. Fresh seeds also germ. 70D(60% in 2nd w) and 40(61% in 3-7 w).

Matricaria (Asteraceae).

M. maritima germ. 70L(100% in 2nd w), 70 GA-3(100% in 3rd w), 70D(55% in 2-4 d), OT(10% in April), and 40-70D(none). The effect of light declined on DS, and seeds DS 6 m germ. 70D(80% on 3rd d) and 70L(100% on 3rd d).

M. recutita germ. D-70 (RC).

Maurandya (Scrophulariaceae). M. (Asarina) petrophila germ. 70L(1/3 in 3rd w), 70D(2/19 in 10th w), and 40(2/5 in 10th w).

Meconopsis (Papaveraceae). M. betonicifolia germ. 70% in 3rd w in 70D (2nd Ed.). It rapidly died in DS and germ. 19% and 0% after 6 m and 1 y of DS.

Medicago (Fabaceae). M. achinus germ. 100% in 2nd w in 70D.

Melaleuca (Myrtaceae).

M. diosmafolia seeds are very small, and it is difficult to distinguish viable seeds from chaff. Germination at 70D was near 100% for seeds DS 0, 1 y, 2 y, and 3 y. Seeds also germ. in 5-7 w at 40. Light or GA-3 had no significant effect.

M. huegeri seeds DS 0, 1 y, and 2 y germ. zero, 42% and 69% in 70D. Both germinations were in the 2nd w. This is a typical D-70 pattern.

Melia (Meliaceae). M. azederach gem. 70 GA-3-40-70(4/6 in 2-4 w), 70L(1/5 in 3rd w), and 70D-40-70D(2/8 in 8-18 d). This last sample was shifted to 70L after the 9 m whereupon 5/12 germ. in the 6th w after the shift. Puncturing the seed had no effect. Seeds DS 1 y germ. 70L(2/3 in 3rd w), 70 GA-3(2/3 in 4th and 12th w), and 70D(none). Both light and GA-3 stimulate the erratic pattern of germination.

Melilotus (Fabaceae). After 2 y of DS M. alba still germ. 70D(100% in 2 d) if the seed coat is punctured and 2% if not.

Melissa (Lamiaceae). M. officinalis germ. somewhat differently for two samples. The first sample germ. 70L(100%) and 70D(74%) both on the 4th d and 40(30%)-70D(3%). The second sample germ. 70L(100% in 4-12 d), 70D(10%), 40(10%)-70L(63% in 4-15 d), and 40(10%)-70D(none). Shifting this second sample from 70D to 70L after 3 m caused 56% to germinate in 1-3 w. The 70L treatment is best but not obligatory. DS is detrimental, and seeds DS 1 y germ. 70L(32% in 1-3 w) and 70D(3%), and seeds DS 2 y germ. 70L(25% in 4-10 d) and 70D(none).

Melospermum (Apiaceae). M. peleponnesius germ. 70D-40-70D(3/4 in 1-4 w). The seedlings were vigorous so that these are not stray germinations.

Mentha (Lamiaceae).

M. microphylla germ. 70L(35% in 2nd w), 70 GA-3 (20%), and none in 70D, 40-70D, or OT.

M. sp. germ. 70 GA-3(84% in 2nd w), 40-70D(5%), and none in 70D, 70L, or OT. DS for 1 y caused no change in this pattern.

M. spicata germ. best in light, and this light requirement intensified on DS for 1 y. Fresh seed germ. 70L(85% in 1-4 w), 70D(34% in 1-3 w), 40-70L(42% in 1-4 w), and 40-70D(none) whereas seed DS 1 y germ. 70L(80% in 2nd w) and none in 70D.

Menyanthes (Gentianaceae). M. trifoliata germ. 70L(1/8), 70 GA-3(1/28), and none in 70D, 40, or OT. After 6 m DS it germ. 70 GA-3(1/16) and none in 70D or 70L. The ungerm. seed appeared to be all empty seed coats so in fact germination was virtually 100%, but the amount of viable seed was too small to establish any pattern with confidence.

Menziesia (Ericaceae). M. pillosa (DS 6 m or 1 y) germ. 70L(100% in 2nd w), 70 GA-3(90% in 4th w), 40-70D(15% in 4th w), and none in 70D.

Mentzelia (Loasaceae). M. (Bartonia) aurea germ. 70D(30% in 2-10 d) and none in 70L.

Merremia (Convolvulaceae). M. tuberosa germ. 70D(1/3 on 8th d), and the other two ultimately rotted. Two seeds in which the hard seed coat was punctured rotted immediately. Seeds DS 1 y also germ. 70D(1/3 on 6th d).

Mertensia (Boraginaceae). M. maritima germ. 70L(50% in 5-9 d), 70 GA-3(25% in 5-12 d), OS(43% in 2nd w), OT(15% in October), 70D(none), and 40-70D(20% on 6th d). It is remarkable that light, GA-3, 40-70D, and oscillating temperatures initiate germination, but none germ. in 70D. The seeds are enclosed in a black loose outer seed coat. The thin narrow seeds were laboriously removed from the outer seed coat before treatment.

Micromeria (Lamiaceae).

L. juliana germ. 70D(70% in 10-12 d), 70L(85% in 9-12 d), and 70 GA-3(6%).

M. thymifolia germ. 70 GA-3(18% on 10th d) and none in 70D or 70L.

Mimulus (Scrophulariaceae).

M. "Calypso Hybrids" germ. 100% in 4-5 d in 70D, 70L, or OS and 40(100% in 4th w).

M. ringens germination in 70L increased with DS. The data for germination in 70L for fresh seed, seed DS 6 m, and seed DS 18 m were 15% in 1-5 w, 70% in 4-9 d, and 100% in 10-12 d. Germination in 70D remained zero and germination in 70 GA-3 remained at 80-100%. Seeds DS 3 y were dead.

M. rupicola germ. 70L(100% on 4th d), 70D(7%), and 40(7%)-70(11%).

Mina (Convolvulaceae). M. (Quamoclit) lobata germ. 70(60% on 3rd d). Neither light or GA-3 has any effect.

Minuartia (Caryophyllaceae). M. sp. Iceland germ. 72% in 2nd w in either 70D or 70L for either fresh seed or seed DS 6 m. Seeds also germ. 40-70D(25%). Seeds DS 1 y germ. 72% in 1-4 w in 70D, and seeds DS 2 y were dead.

Mirabilis (Nyctaginaceae). M. multiflora germ. 50% in 5-7 d in 70D. Light, GA-3, or a prior 3 m at 40 had no effect. OT killed the seed.

Misopates (?). M. oronticum germ. 70L(100% on 9-12 d) and 70D(23% in 7-9 d). Germination in 70 GA-3 was similar to 70D.

Modiola (Malvaceae). M. caroliniana germ. 70D(34% in 3-5 d), 70L(70% in 3-13 d), 70 GA-3(20% in 3-9 d), 40(10%)-70D(7% in 1-3 d), and OS(60% in 3-5 d). After 1 y DS germination decreased to 70D(24% in 4-8 d) and 70L(21% in 6-10 d).

Moltkia (Boraginaceae). M. petraea germ. 70D(17% in 3rd w), 40(35% in 10th w)-70D(30% in 3-12 d), and OT(40% in April from seeds placed outdoors in Feb.). Light or GA-3 had no significant effect.

Moluccella (Lamiaceae). M. laevis germ. 70D(38% on 2nd d), 70L(38% in 2-6 d), 70 GA-3 (60% on 2nd d), and 40-70D(54% in 1-3 d).

Momordica (Cucurbitaceae). M. rostrata germ. 70L(65% on 6th d) and none in 70D. This light requirement disappears on DS. Seeds DS 6 m or 2 y germ. 100% on the 2-6 d in 70D. This beharior is similar to that of Citrullus vulgaris.

Monarda (Lamiaceae).

M. fistulosa required light with fresh seed, but this light requirement diminishes on DS. Seeds DS 0, 6 m, 1 y, and 2 y germ. 73%, 80%, 61%, and 30% in 70L and 0, 15%, 26%, and 25% in 70D. All germinations were in 1-3 w.

M. menthifolia germ. 100% in 10-12 d in either 70D or 70L.

M. punctata seeds DS 6 m germ. 70L(51% in 2nd w), 70 GA-3(3%), 70D(4%), 40(4%)-70L(35% in 2-14 d), and 40(4%)-70D(4%). After an additional 6 m DS (1 y total) the seeds germ. 70L(33% in 4-17 d) and 70D(5%), and after 2 y DS the seeds germ. 70L(11% in 6-22 d) and 70D(none) .

Montia (Portulacaceae). M. (Claytonia) sibirica germ. 70 GA-3(45% in 3rd w), 70L(80% in 2-10 w), 70D(10% in 1-8 w), and 40-70D(75% in 1-11 w)-40(18%). The promotion of germination by light died away on DS so that seeds DS 1 y germ. 70L(40% in 1-3 w) and 70D(45% in 1-8 w)

Moraea (Iridaceae). M. sp. germ. 70L(5/8 in 4th w), 70D(1/11)-40-70L(2/6), 70D(1/6)-40-70D(none). After 1 y DS the seeds germ. 70L(2/18 in 4th w) and 70D(2/15 in 6-12 w). The promotion of germination by light disappears on DS.

Moricanda (Brassicaceae). M. arvensis germ. 30% in 3-22 d in either 70D or 70L and 40(20% in 4th w).

Morina (Dipsicaceae). M. longifolia germ. 100% in 5-7 d in either 70D or 70L and 40(20% in 2nd w), confirmed in a second sample.

Musa (Musaceae). M. velutina and M. violacea have impervious seed coats and germinate in 3 w to 4 m after puncturing (JH).

Myoporum (Myopoaceae). M. debile germ. 70D(1/2 in 11th w). One seed was punctured and it failed to germinate.

Myrica (Myricaceae). M. gale (DS 6 m) germ. 70L(30% in 11-16 d), 70 GA-3(90% in 1-3 w), and none in 70D or 40-70D. DS for 1 y had no effect, but seeds were dead after DS for 2 y.

Myrsine (Myrsinaceae). M. nummularia germ. 70-40-70(1/3 in 11th w)-40-70(1/3 on 8th d) and none in 70L or 70 GA-3.

Myrtus (Myrtaceae). M. communis seeds DS about 8 m germ. 70D(100% on 2nd d) and 40(90% in 8th w). Light, GA-3, or DS for 3 y had no effect on the germination at 70.

Nama (Hydrophyllaceae).

N. hispidum germ. 100% in 2-6 d in either 70D or 70 GA-3.

N. rothrockii germ. 70 GA-3(28% in 4-9 w)-40(11%) and none in any other treatment.

Nandina (Berberidaceae). N. domestica seeds received in March showed effects not seen before. Seeds placed in 70L for 8 w and then shifted to 70D germ. 52% in 1-4 w after the shift to 70D. Seeds kept at 70D for 5 m failed to germinate but germ. 50% in 1-3 w after a shift to 40. Seeds kept 3 m in 70D, shifted to 70L for 2 m, then shifted back to 70D germ. 30% in 4-9 d after the last shift. Seeds germ. 40-70D(25% in 12-15 w) and 40-70L(none), but when this last sample was shifted to 70D after 3 m in 70L, 50% germ. in 1-3 w. Seeds also germ. 70 GA-3(18% in 10th w) and 17% in September in OT. All of this needs more study, but there does seem to be a pattern of seeds germinating after a 3 m in 70L followed by a shift to 70D. Germinations in two clones (nana purpurea and Harbor Dwarf) were similar.

Narthecium (Liliaceae).

N. californicum germ. 40-70D(57% in 2nd w), 70D-40-70D(60% in 3rd w), 70L(22% in 3-12 w), 70 GA-3(16% in 4-11 w), and OT(none perhaps because low T killed the seeds).

N. ossifragum germ. 70L-40-70L(100% in 2nd w), 70D-40-70D(9%), and 40-70-40-70(8% in 3-6 w). Seeds DS 1 y were dead.

Nectaroscordum (Liliaceae). N. siculum seeds were all dead suggesting that this species may not tolerate DS.

Nemesia (Scrophulariaceae).

N. sp. germ. 70L(54% in 6-9 d) and 70D(28% in 8-10 d).

N. strumosa germ. 100% in 4-6 d in either 70D or 70L.

N. umbonata germ. 100% in 6-10 d in either 70L or 70D.

Nemopanthus (Aquafoliaceae). N. mucronatus germ. 4/8 at 70 after two years of 3 m cycles alternating between 70 and 40. Light had no effect

Nepeta (Lamiaceae). N. nepetalla germ. 70L(19% in 1-3 w) and 70D(none).

Nerium (Apocyanaceae). N. oleander germ. 97% in 4-6 d in 70D after 3 m and 1 y DS. A previous sample germ. 15%. A prior 3 m at 40 had little effect. Seeds DS 2 y were dead.

Nicandra (Solanaceae). N. physalodes germ. 70D(26% in 4-6 d) and 70L(59% on 6th d).

Nicotiana (Solanaceae). N. langsdorfii and N. trigonophylla germ. D-70 (RC). N. langdorfii germ. 70D(95% in 18 d), but N. sylvestris required light for germination (KW).

Nigella (Ranunculaceae).

N. damascena germ. 70D(88% in 6-8 d) and 70L(30% in 9-12 d). A second sample germ. 70D(33% in 6-12 d) and 70L(10% on 9th d).

N. hispanica germ. 70L(45% on 9th d) and 70D(6% in 6-8 d).

N. orientalis germ. 85% on 10th d in either 70D or 70L.

Nitraria (Zygophyllaceae). N. schoberi germ. 70D(2/4) if punctured and 1/5 without, both in 3rd w.

Nolana (Nolanaceae).

N. paradoxa germ. 70D(9/10 in 2-4 d), 70L(6/11 in 4-6 d), OS(3/10 on 6th d), and 40(2/11 in 2nd w)-70D(5/12 in 2-6 d). The lower germination in 70L needs to be checked. Germination at 40 was more rapid with GA-3(7/7 on 6th d).

N. sp. germ. 70D(33% in 2-4 d) and 70L(50% in 1-3 w).

Nolina (Agavaceae). N. parryi germ. 70D(44% in 2-4 w)-40(56% in 3rd w), 70 GA-3(21%), 40(90% in 8th w), and 70% in April in OT. Seeds DS 6 m or 1 y gave similar patterns with 40(90% in 2-4 w) and 70D(5%)-40(80% in 3rd w). Seeds DS 2 y germ. 40(52% in 8-12 w)-70(24% in 3-7 d) showing that germination was less and slower after the 2 y DS.

Notholirion (Liliaceae). N. bulbiferum germ. 70D(85% in 5-8 w) and 40-70D(85% in 8-11 w)-40-70D(15% in 8th w).

Notothlaspi (Brassicaceae). N. rosulatum can be updated. Seeds germ. 70D(2/7 on 15th d)-40-70(1/7) and none in 40-70D.

Nyctanthes (Oleaceae). N. arbor-tristis germ. 70L(80% in 3-5 d), 70 GA-3(1/4, other three rotted), and 70D(none). The seeds were removed from the wafer like outer seed coat.

Nyssa (Nyssaceae). The literature reported that a 40-70 pattern was effective for N. sylvatica (2nd Ed.). AC reports that seeds were collected from a wild stand at various times every year from 1987 to 1994. The seeds were subjected to various temperature and light treatments. Only four germinations have been observed from large numbers of seeds, and these occurred at 70 after 3-5 m at 40. In my work a large commercial sample of seeds failed to germinate under all conditions including GA-3 treatment. Wild collected seeds proved to be all empty seed coats.

Ochna (Ochnaceae). O. serrulata seeds failed to germinate in 70D with or without puncturing.

Oenothera (Onagraceae).

O. argillicola seeds DS 0, 6 m, 1 y, and 2 y germ. 58%, 80%, 73%, and 3% in 70D. Germination in 70L was 80-90% in 0-1 y DS. All germinations were in 4-10 d.

O. biennis seeds DS 0, 6 m, 1 y, 2 y, and 3 y germ. 44%, 30%, 54%, 13%, and 14% in 1-3 w in 70L and none of the seeds germ. in 70D.

O. caespitosa germinations varied with different samples. The original sample germ. 70L(4/8 in 2-9 w) and 70D(none). A new sample identified as O. caespitosa v. caespitosa germ. 5% in either 70D, 70L, or 70 GA-3 and 10% in 70D if DS 6 m.

O. speciosa germ. 70D(100% on 4th d) and 40(70% in 5-10 w)-70D(9% in 1-3 d). Light or DS 1 y had no effect.

Olearia (Asteraceae). Two samples were both all chaff.

Omalotheca (Asteraceae).

O. norvegica germ. 100% in 2nd w in 70D, 70L, or 70 GA-3. It also germ. 40-70D(32%). After 1 y DS seeds germ. 70D(83% in 8-12 d).

O. (Gnaphalium) supina had a light requirement, unusual in Asteraceae, and more unusual, this light requirement partially disappeared after 3 m at 40. Seeds germ. 70L(100% in 1-3 w), 70 GA-3(100% in 5-7 d), and 70D(none). When the seeds in 70D were shifted to 70L after 4 w, 100% germ. on the 4th d. Seeds also germ. 40-70D(41% in 3-5 d). It is remarkable that an initial 3 m at 40 removed part of the light requirement, but 70L is still the best treatment. Seeds DS 1 y germ. 70D(56% in 10-20 d) showing disappearance of the light requirement.

Omphalodes (Boraginaceae). O. linifolia, O. linifolia alba; O. luciliae, and O. sp. all germ. 100% in 4th d in either 70D or 70L.

Ononis (Fabaceae). O. natrix had an impervious seed coat and germ. 100% on 3rd d if punctured and none otherwise.

Onopordum (Asteraceae). KW reports that O. nervosa and O. sylvestris gave very low germination in 70L with or without 2 y DS. Samples from seed exchanges gave no germination.

Ornithogalum (Liliaceae). O. pyrenaicum, the original sample had been DS 6 m and germ. best in 40(89% in 5-11 w). Seeds DS 2 y were dead.

Orobanche (Orobanchaceae). Tanos Hage reported that this genus requires specific chemicals from the host plants in order to germinate. In accord with this germinations failed in all the standard treatments with O. minor.

Orostachys (Crassulaceae). O. iwarenge germ. 100% in 4-6 d in either 70L or 70 GA-3, 70D(17%), and 40-70D(30% in 3-9 d).

Orthrosanthus (Iridaceae). O. chimboracensis v centroamericanus germ. 70L(88% in 3-11 w) and and none in 70D or 70 GA-3. Neither a prior 8 w in 70D or DS for 1 y had any effect on this pattern.

Orychophragmus (Brassicaceae). O. violacens germ. 70D(2/10 in 1-3 w) and 70L(4/10 on 1-5 w).

Oxypetalum (Asclepediaceae). O. caeruleum germ. 2/3 in 70D and 2/2 in 70L both in 2nd w.

Oxyria (Polygonaceae). O. digyna germ. 100% in 2-4 d in 70D or 70L Neither GA-3 , a prior 3 m at 40, or DS 6 m had any effect. However, after 1 y DS germination dropped and slowed to 70D(66% in 1-3 w), and after 2 y DS seeds were dead.

Oxytropis (Fabaceae). O. chiliophylla germ. 70D(100% in 3-5 d) if punctured and 10-20% if unpunctured for either fresh seed or seed DS 2 y.

Pachystegia (Asteraceae). P. insignis minor seeds DS 2 y germ. 70D(87%) and 40(90%), both in 2nd w, which is similar but faster than fresh seed.

Pancratium (Amaryllidaceae). P. maritimum germ. 70D(100% in 2nd w), 70L(100% in 2-4 w), and 40(none).

Pandorea (Bignoniaceae). P. jasminoides germ. 6/12 in 1-4 w in either 70D or 70L.

Paonea (Ranunculaceae).

P. broteri, two further samples gave more extended germination than the earlier sample and showed some modest stimulation of germination by GA-3. The most remarkable result was a sample that germ. 70-40-70-40-70-40(2/9 in 5th w)-70-40-70-40(6/9 in 3rd w).

P. suffruticosa has been studied on a large sample collected the last week of November. This sample germ. 70D(48% in 5-10 w). The seedlings must be shifted to 40 for several months before they will develop a leaf at 70. GA-3 had no effect on the germination at 70, but it did stimulate leaf development directly at 70. It is suspected that the time of collection of the seeds may be important.

Papaver (Papaveraceae). KW reports that many species show no sign of dying after 5 y of DS.

P. amenum germ. 70 GA-3(100% in 4-10 d) and 70D(50% in 4-14 d).

P. degenii germ. in 2nd w at 70; 57% in GA-3 and 30% in 70D or 70L.

P. ecoanense germ. 70D(35% on 6th d), 70L(56% in 2nd w), and 70 GA-3(15%).

P. faurei germ. 100% on the 7th d in 70L or 70 GA-3 and none in 70D-40-70D.

P. julicum germ. 70 GA-3(100% in 6-10 d) and 70D(50% in 4-10 d).

P. kluanense has failed to germinate in 70D.

P. pilosum germ. 70 GA-3(100% in 6-10 d) and 70D(94% in 4-8 d).

P. pyrenaicum v. rhaeticum germ. 70 GA-3(100%) and 70D(44%) both in 2nd w.

P. radicatum germ. 70 GA-3(100% in 3rd w) and 30% in April in OT. None germ. in 70D, 70L, or 40-70D. Seeds DS 1 y were dead.

P. somniferum seeds germ. 70D(none) but after 6 m DS they germ. 70D(30% on 4th d). Germination in 70D stayed at 30% after 1 y and 2 y of DS but declined to 1% after DS for 3 y. There were some strange effects of light and GA-3. Seeds DS 6 m germ. 70L(60% on 4th d) and 70 GA-3(60% on 4th d) whereas fresh seed germ. none in either 70L or 70 GA-3. However, if fresh seed is given 3 m in 70 GA-3, 62% germ. in 2-10 w on shifting to 40. Obviously there is interesting chemistry taking place other than the destruction of the blocking system by DS.

Paradisea (Liliaceae). P. liliastrum germ. 1/12 in April from seed placed outdoors in February and also 40-70-40-70(1/10). A second sample germ. 70 GA-3(1/7 in 10th w) and none in 70D or OT. The results are similar to A. racemosum where there was a much larger sample.

Parahebe (Scrophulariaceae). P. linifolia germ. 70L(100% on 11th d) and 70D(13% in 3rd w). P. lyalli germ. 70L(100% on 11th d) and 70D(50% in 3rd w).

Parnassia (Parnassiaceae). P. palustris seeds DS 6 m germ. 70 GA-3(88% in 5th w), 70L(48% in 1-3 w), and 70D(16% in 3rd w). Seeds DS 2 y germ. 70L(18% in 3rd w) and 70D(2%). Seeds DS 3 y were all dead.

Parsonia (Apocyanaceae). P. capsularis germ. 70D(6/7 in 2nd w).

Passiflora (Passifloraceae). P. edulis had been found to germinate in a 70-40-70 pattern (2nd Ed.). Thelma Norman of Mena, Arizona, now reports some interesting results. Commercial seeds of P. edulis, P. antiquiensis, P. malformis, P. mollissima, and P. vitafolia were inadvertently exposed to temperatures of 125 for several days shortly after sowing. All germinated in 6-10 days. Presumably the chemical system blocking germination can be destroyed not only by 70-40 treatments, but also by high temperatures in the 125 region. P. cinnabarina and P. coccinea failed to germinate in the above treatment.

Patrinia (Valerianaceae).

P. gibbosa germ. 70L(44% in 2nd w), 70 GA-3(64% in 2nd w), 70D(29% in 4-10 w), and 40-70D(15%).

P. scabiosifolia germ. 70D(73% in 3-13 d), 70L(84% in 5-11 d), 40-70D(36% in 3-7 d), and OT(40% in April). GA-3 led to total rotting. Seeds DS 1 y were dead.

Paulownia (Scrophulariaceae). P. tomentosum required light for germination and the seeds were about 50% dead after 2 y DS (2nd Ed.). It is now found that seeds are all dead after 3 y DS.

Pedicularis (Scrophulariaceae). P. rainierensis germ. only in 70 GA-3(72% in 1-4 w)(2nd Ed.). It is now found that seeds are dead after 2 y DS.

Peganum (Apiaceae). P. harmela germ. D-70 (RC).

Peltiphyllum (Saxifragaceae). P. peltatum germ. 70L(100% in 2nd w), 70D(80% in 3rd w), and 40-70D(2%). Seeds largely rotted in 70 GA-3.

Penstemon (Scrophulariaceae).

P. ambiguus germ. 44% in 4-14 d in 70D confirming earlier results.

P. centranthifolius germ 70D(30% in 2nd w). Light, OT, or a prior 3 m at 40 had little effect.

P. corymbosus (syn. Keckiella corymbosus) germination was improved by DS 6 m at 70. The DS seed germ. 70L(50% in 1-3 w), 70D(15%), and 40(30% in 8th w). Fresh seed germ. 70D(13% in 1-11 w), 70L(40% in 1-7 w), 70 GA-3(63% in 1-3 w), and 40-70D(22% in 8th w)-70(20% on 3rd d). Seeds DS 1 y germ. 70D(35% in 2-4 w) and 70L(29% in 2-4 w).

P. duchesnensis germ. 40(3/13 in 7th w)-70D(2/13 on 2nd d), 70L(1/14 in 12th w)-40(1/13), and none in 70D or OS.

P. flowersii germ. 40(7/12 in 5-10 w)-70D(2/12 on 2nd d), and none in 70D-40 or OS.

P. harbouri germ. 70L(100% in 6-20 d) and none in 70D-40, 40-70D, or OS.

P. heterophyllus germ. 70D(66% in 2nd w), 70L(67% in 1-3 w), and 40(none).

P. monoensis germ. 40(2/9 in 6th w) and none in 70D, 70L, and OS.

P. ophianthus seeds DS 0, 2 y, and 3 y germ. 44%(2nd w), 24%(1-3 w), and 2% in 70D. Light or GA-3 had little effect on germination of the fresh seed.

P. pachyphyllus data is now more complete. Seeds germ. 70 GA-3(75% in 1-5 w), 70D-40(40% in 1-12 w), and 40(56% in 1-11 w).

P. pinifolius germ. within 2 w at 70 (KW) and does not need the OT inferred in the 2nd Ed.

P. retrorsus germ. 40(1/7 in 6th w) and none in 70D-40, 70L-40, or OS.

P. scapoides germ.40-70D(2/15 on 2nd d) and none in 70D, 70L, 40, or OS.

Pernettya (Ericaceae). P. macrostigma seeds DS 6 m germ. 70L(45% in 4-8 w), 70 GA-3(30% in 4-8 w), 70D(2%)-40-70L(33%), and 70D(2%)-40-70D(none). Seeds DS 2 y germ. 70L(7%) and 70D(none), and seeds DS 3 y germ. 70D(7% in 7-11 w) and 70L(9% in 4th w).

Perovskia (Lamiaceae).

P. abrotanoides germ. 70D(50% in 4-14 d) and 70L(70% on 6th d).

P. atriplicifolia germ. 75% in 3-5 d in either 70D or 70L.

Petalonyx (Loasaceae). P. nitidus germ. 40-70D(4/7 on 2nd d), 70D(1/5 in 4th w), and none in 70L or 40.

Petroragia (Saxifragaceae). P. (Tunica) saxifraga germ. 70L(100% in 3-7 d) and 70D(15% in 2nd w).

Phacelia (Hydrophyllaceae). P. purshii germ. 70D(90% in 12th w) and 40(15%)-70D. Light had no effect and GA-3 led to total rotting of the seed.

Phaseolus (Fabaceae). P. acutifolius germ. 100% in 3-4 d at 70. GA-3 had no effect (KR).

Phlomis (Lamiaceae). P. samia germ. 70D(1/8 in 5th w).

Phlox (Polemoniaceae). Several species germinated over a number of cycles. Phlox glaberrima was one of these. It is now found that P. glaberrima germ. 100% in 1-4 w in 70 GA-3. It is possible that other species would have germ. immediately in 70 GA-3, and this has to be tested in this genus. P. glaberrima seed is dead after 1 y DS.

P. speciosa data is now more complete. Seeds germ. 70-40(50% in 3-7 w).

Phoenicaulis (Brassicaceae). P. cheiranthoides germ. 70D(3/4 in 2nd w).

Phoenix (Palmaceae). P. dactylifera seeds were obtained from commercial dates. Seeds germ. 70D(4/5 in 3-8 w) if WC 3 d and 2/5 in 4th w if just rinsed.

Phormium (Liliaceae). P. tenax purpureum germ. 70L(1/12 in 2nd w), 70D(1/26 in 3rd w), and 40(none).

Photinia (Rosaceae). P. villosa has been restudied and germ. 40-70D(100% in 2nd w) in contrast to an earlier sample that germ. 40(90% in 10-12 w). The two patterns are not that different as both show that the blocking mechanism requires 2-3 m at 40 to be destroyed.

Phygelius (Scrophulariaceae).

P. aequalis germ. 70L(100% on 8th d) and 70D(60% in 2nd w).

P. capensis germ. 70L(100% on 8th d) and 70D(90% in 2nd w).

Physalis (Solanaceae).

P. alkekengi seeds DS for 3 y were dead.

P. ixocarpa germination is blocked in the fruit by lack of access to oxygen plus a minor light effect. Seeds germ. 70L(100% in 1-6 d) and 70D(77% in 1-6 d) when removed from the fruit and either placed directly in moist towels, rinsed, or WC 1 d. Like Lycopersicon, the seeds do not have a large oxygen requirement so that they continue to germinate under water in the WC treatment although at a much slower rate. They are also dying in the WC treatment, and after about 20 d they are nearly all dead.

Physoptychis (Brassicaceae). P. gnaphlodes germ. 70D(100% on 6th d).

Picea (Pinaceae).

P. abies seeds DS 0 and 2 y germ. 45%(6-8 d) and 6%(9-13 d) in 70D.

P. mariana seeds germ. 15-20% in 70D in 5-10 d for seeds DS up to 2 y, but this drops to 3% in 3rd w for seeds DS 3 y.

Pilosella (Asteraceae). This genus should probably be condensed into Hieracium. P. islandica germ. 90% in 4th w in 70D. Light, GA-3, or DS for 3 m or 1 y at 70 had no effect., but seeds DS 2 y were dead. The fresh seeds also germ. 40(22% in 12th w)-70(71% in 1-7 d).

Pimelea (Thymelaceae). P. prostrata data is now complete. It germ. 40-70(4/6 in 4 d-9 w) and 70D-40-70D(4/4 on 2nd d).

Pinguicula (Lentibulariaceae). P. vulgaris germ. 70 GA-3(92% in 2nd w), 70L(18% in 3-12 w), 40-70L(100% on 10th d), and none in 70D or 40-70D using fresh seed. Seed DS 3 m germ. similarly, but seeds DS 1 y were dead.

Pinus (Pinaceae). P. elliottii germ. 70D(80% in 2nd w) (KR).

Pittosporum (Pittosporaceae). P. crassicaule germ. 70-40-70-40-70(30% in 2nd w)-40-70(20%)-40-70(10%)-40-70(10%) and 40-70-40-70-40-70(20% in 3rd w). The two patterns are in accord. Light did not initiate germination, and GA-3 led to total rotting of the seed.

Placeae (Amaryllidaceae). P. ornata all rotted, DS intolerant ?

Plantago (Plantaginaceae). The curious results that some species required light and others did not may be due to the light requirement dying off on DS as found for P. virginica coupled with the seeds having been subjected to varying degrees of DS before being received.

P. coronopus seeds DS 6 m and 2 y germ. 100% in 4-10 d in 70L. The seeds DS 6 m also germ. 70D(65% in 1 d-4 w), 40(19% in 3-10 w)-70D(72% in 1-25 d), and 40(19% in 3-10 w)-70L(73% in 1-11 d).

P. lanceolata seeds DS 6 m germ. 70L(75% in 1-9 w), 70D(45% in 2-6 w), 40(8%)-70L(91% in 3-7 d), and 40(8%)-70D(71% in 2-4 w). After 2 y DS the seeds germ. 70L(77% in 1-4 w).

P. major seeds DS 6 m germ. 70L(100% on 3rd d), 70D(none), 40-70L(100% on 5th d), and 40-70D(4%). Seeds DS for 2 y germ. the same.

P. maritima germ. 70L(100% in 4-8 d), 70 GA-3(100% in 2-8 d), 70D(75% in 2-9 w), 40-70D(95% in 2-8 d), and OT(none). Seeds DS 6 m were dead.

P. purshii germ. 100% on 2nd d at 70 and 100% in 12-15 d at 40. Light or GA-3 had no effect. After 1 y or 2 y of DS germination in 70D dropped to 40%.

P. serpentina seeds DS 6 m germ. 70L(100% in 4-15 d), 70D(30% in 1-6 w), and 40(100% in 7-12 w).

P. virginica germ. 70L(91% in 6th w), 70 GA-3(81% in 3rd w), and none in 70D or 40-70D. A prior 6 w in 70D had no effect. Seeds DS 6 m at 70 germ. 70L(90% on 5th d) and 70D(32% in 1-5 w) suggesting that DS is eliminating the light requirement.

Pleiospilos (Aizoaceae). P. bolusii germ. 70L(85% in 2-8 w), 40-70L(80% in 4-6 w), and none in 70D, 70 GA-3, 40-70D, or OS. When the sample in OS was shifted to 70L after 9 w, 85% germ. in the 3rd w.

Pleurospermum (Apiaceae). P. brunonis germ. 70D(1/1 on 7th d).

Plumeria (Apocyanaceae). P. emarginata germ. 70D(3/3 on 4th d). All 4 rotted in 70L, but the sample is too small to conclude that light is detrimental.

Podocarpus (Podocarpaceae). P. nivalis seed 6 m old failed to germinate in 70D or in a shift to 70 GA-3 after a year in moist dark treatments.

Polanisia (Capparaceae). P. dodecandra DS 8 m germ. 70D(50% in 2-4 d) and 40(50% in 4-6 w). Light or GA-3 had no effect. Seeds DS 20 m germ. 70D(16% on 4th d) indicating extensive dying, and seeds DS 3 y were dead.

Polemonium (Polemoniaceae).

P. coeruleum alba germ. 70L(84% in 1-4 w) and none in 70D. This contrasts with the results reported for P. coeruleum where light if anything was slightly inhibitory. This needs to be reinvestigated particularly in light of a report from KW that P. coeruleum usually germ. at 70 but some forms were 40-70 germinators.

Poliomintha (Lamiaceae). P. incana germ. 100% in 2-6 d in either 70D or 70L. A prior 3 m at 40 had little effect.

Polygala (Polygalaceae).

P. paucifolia ripens both the normal seeds and the cleistogamous seeds in early July. The former germ. 70D(50% in 4-7 w), 70L(35% in 4-6 w), and 70 GA-3(60% in 3rd w). The latter germ. 70D(72% in 6-11 w), 70L(93% in 4th w), and 70 GA-3(100% in 3rd w).

P. senega germ. 70D(2/45)-40(3/45)-70D, 40(5/30)-70(4/30 in 2 d-3 w), and 70L-40-70D(11/27 in 2-6 d), and none in 70 GA-3. The seeds that germ. at 70 were vigorous whereas the seeds that germ. at 40 failed to develop on shifting to 70.

Polygonatum (Liliaceae). P. humile germ. 70D(2/8 in 10th w). The radicle developed an extensive root system, but a stem and leaves did not develop until the seedling had been subjected to 40-70-40-70 (a year of alternating cycles), and the leaf and stem did not develop until the 4th w in the last cycle at 70. Probably longer times at 40 and/or 70 would hasten leaf development, but it is clear that the rate of destruction of the growth inhibitors is slow.

Polygonum (Polygonaceae). Previous samples of P. orientale had given very low germinations of 3-5% (2nd Ed.). A new commercial sample has failed to give any germination. An intensive study is needed.

Polyxena (?). P. corymbosa germ. 4/7 in 2-8 d in 70D. P. ensifolia germ. 7/14 in 6-8 d in 70D. P. odorata germ. 9/11 in 4-8 d in 70D.

Porophyllum (Apiaceae). P. rudicale germ. D-70 (RC).

Portulaca (Portulacaceae). P. mundula germ. 70 GA-3(3/6 in 4-6 d) and 70D(none) (KR).

Potentilla (Rosaceae). P. recta has a complex behavior. Fresh seeds germ. 70 GA-3(64% in 3-10 w) and none in 70L or 70D. Seeds DS 6 m germ. 70 GA-3(60% in 5-11 d), 70L(61% in 5-10 d), and 70D(5% in 5-10 d). Seeds DS 1 y germ. 70L(90% in 4-6 d) and 70D(17% in 2nd w). Seeds DS 2 y germ. 70L(100% in 5-7 d). Seeds DS 3 y germ. 70L(50% in 4-6 d) and 70D(38% in 4-8 d). What is happening is that GA-3 seems to eliminate immediately the system blocking germination and fresh seed germ. in 70 GA-3. The system blocking germination in 70L is being removed by DS and more rapidly than the system blocking germination in 70D. Superimposed on this is a rate of dying which becomes significant by the 3rd y of DS.

Primula (Primulaceae).

P. dowensis germ. 65% in 2nd w in either 70D or 70L. OT or GA-3 had little effect on the basic pattern.

P. forrestii, a prior 3 m moist at 40 had no effect on germination.

P. kisoana DS for 2 y was dead.

P. nevadensis germ. 70D(50% in 4-10 d). A prior 3 m at 40 had little effect.

P. rotundifolia, a prior 3 m moist at 40 was largely fatal.

P. specuicola germ. 40-70D(60% in 2nd w) and 70D-40(none).

Prunella (Lamiaceae). P. vulgaris germ. 70L(100% in 2nd w), OT(40% in Nov. from seeds placed outdoors in Oct. and 20% in April), 40-70D(53% in 3-8 d), 70D-40-70D(38% on 5th d), and 70 GA-3(none). This is an unusual pattern with the blocking system being destroyed by either light or a period at 40. DS also destroys the blocking system, and seeds DS 6 m germ. 27% in 1-11 w in 70D. Seeds are also dying at a moderate rate in DS so that seeds DS 1 y germ. 70D(3%), 70L(15% on 8th d), and 40-70D(20% in 4-8 d).

Prunus (Rosaceae).

P. armenaica is the apricot. Seeds from Mongolia germ. 40(100% in 3-7 w) and 70(50% in 1-7 w). Seeds from Europe germ. 70D(100% in 5-9 w) and 40(25%)-70(75%). Seeds from commercial apricots germ. 40(7/7 in 3-6 w) and 70(2/4 in 1-7 w)-40(1/4 in 6th w). Different amounts of DS may account for the difference. All seeds had been removed from the shell and rinsed before treating.

P. communis is the common almond. Both removing the shell (opened seeds) and OS treatment improved germination. Opened seeds germ. OS(6/6 in 13-15 d), 40(5/6 in 10th w), and 70D(4/8 in 2-4 w). Unopened seeds germ. 70D(1/5 in 4th w, rest rotted). A WC for 2 d had little effect.

P. "Golden Beauty" was studied both as opened seed and unopened. The opened seeds germ. 40(3/5 in 12th w) and 70-40-70(4/4 on 3rd d). Unopened seeds germ. 40(1/4 in 12th w)-70(3/4 in 1-3 d) and 70-40-70(1/4 on 3rd d). None germ. directly at 70.

P. sp. (PA) germ. 70-40-70(8%)-40-70(5%) and 40-70-40-70(12%). Cracking the seed coat, GA-3, or light had no effect. DS improved germination, and seeds DS 1 y germ. 40-70(3/24 in 4-10 d).

Psathyrotes (Asteraceae). P. pilifera germ. 40(2/3 in 9th w), 1/6 in outdoor treatment, and 70D(none).

Psychotria (Rubiaceae). P. nervosa germ. 70(6/7 in 6-23 w), 40-70(3/6 in 5-12 w), and 70 GA-3(none). Seeds punctured on the base germ. 4/6 in 9-15 w, and seeds punctured on side all rotted. The data indicate a semipervious seed coat.

Ptelea (Rutaceae). P. trifoliata germ. 70 GA-3(70% in 1-3 w), 40-70D(10%)-40-70D(6%), 70D-40(12% in 12th w)-70D-40-70D(19% on 2nd d), 70L-40(14%)-70L, 70L-40(10%)-70 GA-3(90% in 5-7 d), and 40% in April in OT. Seeds DS 1 y germ. 70 GA-3(50% in 2nd w) and 70D-40-70D(1/5), and seeds DS 2 y germ. 70 GA-3(2/5 on 8th d) and 70D(none) indicating little change in the seeds in 2 y DS.

Pterocephalus (Dipsacaceae). P. perennis germ. 70D(2/4 in 2nd w) and 70L(2/2 in 2nd w).

Pterostyrax (Styracaceae). P. hispidus germ. 70 GA-3(2/6 in 5th w), 70L(1/6 in 4th w), 70D-40-70D-40-70D-40(none), and 40-70D-40-70D-40-70D(1/6 on 7th d).

Ptilotrichum (Brassicaceae). P. coccineum germ. 2/2 on 4th d in 70D. P. macrocarpum germ. 70D(100% in 2-4 d). P. spinosum were all empty seed coats.

Pueraria (Fabaceae). P. lobota has an impervious seed coat (RC).

Punica (Puniaceae). P. granatum is the pomegranate fruit, and the seeds were obtained from commercial fruit. The seeds are enclosed in juicy capsules which can be crushed and rinsed. However, there is a further membrane that adhers to the seed and can be removed only by scraping the seeds. Both scraping the seeds and WC for 7 d improved germination. The best germination was with seed that had been scraped and WC 7 d. These germ. 70D(55% in 3-7 w). Germination dropped to 22% if unscraped, 10% if just rinsed and scraped or unscraped. Puncturing the seed does speed up germination, but it is difficult to do this without injuring the seeds.

Purshia (Rosaceae).

P. mexicana v. stansburyana germ. 70L(88% in 2-4 w), 70 GA-3(30%), 70D(46% in 3-8 w), and 40(61% in 7-12 w)-70(15%). Winter temperatures killed all the seed in OT. DS for 6 m had little effect.

P. tridentata germ. best at 40 as shown by 40(100% in 7-12 w), 70L(20%)-40(80% in 8th w), 70 GA-3(50% in 10th w), 70D-40(25% in 8-12 w)-70D(6%)-40(6%)-70D(6%)-40(6%)-70D(6%), and 60% in April in OT. Seeds DS 6 m, 1 y, and 2 y germ. 40-70D(70% in 2-4 d), 40-70D(60% in 1-4 d), and 40(8/12 in 5-11 w). These results are not entirely consistent, but they do indicate that the seeds are largely viable after 2 y of DS.

Pycnanthemum (Lamiaceae). P. incanum germination in 70L increased from 30% in 2-8 w for fresh seed to 56% in 1-4 w for seed DS 6 m at 70. This indicates that seed should be DS for 6 m or more. There was still no germination in 70D.

Pyrola (Ericaceae). P. minor was received as fresh seed, but it failed to germinate in 70D, 70L, 70 GA-3, or 40.

Pyrus (Rosaceae).

P. "Buerre Bosc" germ. 70D(40% in 2-4 d)-40(10%)-70-40-70D(30% on 3rd d) and 40(100% in 4th w). Placing the seeds initially at 40 is best, and It is interesting that an initial 3 m at 70 causes germination to extend over a number of cycles.

P. calleriana seeds collected in October and WC 7 d germ. 40(100% in 7-12 w) and 70(3%)-40(74% in 8-12 w) (2nd Ed.). This declines to 95% after 6 m DS and 73% after 18 m DS. A sample collected in mid-December a year later germ. 70D(95% in 3-7 d) and 40(95% in 5-7 w). The interpretation is that the blocking mechanism is destroyed by allowing the fruit to experience the cold of Nov. and Dec.

P. "Kieffer" germ. 40(50% in 2-8 w)-70(50% in 3-9 d) and 70D(10%).

Quercus (Fagaceae). This genus was written badly in the 2nd Ed. It is restated here. Q. alba germinates immediately on contacting moisture and Q. borealis and Q. coccinea are germinated most efficiently in a 40-70 pattern although there is some germination directly at 70.

Q. alba germ. 70(100%, ind. t 6 d, first order rate, half life 2 d) and 40(70%, ind. t 12 d, first order rate, half life 8 d). The germination rate at 70 is four times that at 40. A stem with true leaves develops in the 2nd w after germination at 70. Grubs infested 20% of the seed coats, and these were not counted.

Q. borealis germ. 40-70(100%, ind. t zero, first order rate, half life 2.5 d) and 70(10%)-40(80% in 8-10 w). The seedlings develop a 4-6 inch radicle followed by a stem with true leaves within a month of germination. Soaking the seeds for a week, making a hole in the seed coats, or removing the seed coats did not increase the rate of germination or the percent germination showing that impervious or semipervious seed coats were not present nor was there any inhibitors in the seed coats.

Q. coccinea germ. 40-70(61%, ind. t 4 d, zero order rate, 7%/d) and 70(8%)-40-70(28% in 2nd w). The 50% of the seeds with densities less than one were not viable and were not counted. It is possible that they are infested with grubs.

Q. virginiana germ. 70(4/11 in 4th w) and 40-70(2/8 in 2nd w). Removing the seed coat led to rotting of the seed. Seeds DS 1 y were dead.

Ranunculus (Ranunculaceae).

R. asiaticus germ. 65% in 4-6 w in 70D or 70L and 60% in the 11th w at 40. All rotted when treated with GA-3.

R. bulbosus germ. 70D(8% in 7-11 w), 70L(13% in 7-11 w), 40-70(4%), OS(10% in 7-12 w), and none in OT or 70 GA-3.

R. glacialis germ. 70 GA-3(100% in 3rd w) and none in 70D, 70L, 40, or OT. Seeds DS 1 y were dead.

R. lyalli required GA-3 when fresh (2nd Ed.). Seeds are dead after 2 y DS.

Ratibida (Asteraceae). R. columnifera (yellow form) seeds DS 1-3 y germ. 70D(50% in 3-15 d). The red form DS 1 y germ. 80% in 3-9 d. After 3 y DS germination was still 80% but in 2-4 w which is a little slower.

Rehmannia (Scrophulariaceae). R. elata germ. 70D(90% in 6th d) and 70L(100% on 7th d). All rotted in 70 GA-3. Seeds DS 1 y germ. 70D(70% in 6-16 d) showing both a decline in percent germination and a slowing of rate.

Reseda (Resedaceae). R. odorata grandiflora germ. 70D(82% in 2-10 d). Light had no effect. Germination dropped to 40% in 4-6 d in 70D after DS 1 y.

Rhinanthus (Scrophulariaceae). Two samples of R. minor collected in succesive years failed to germinate under all the standard treatments except for two seeds that germ. in OT in April. It is concluded that some specific chemical emulating from the host or possibly some gibberellin other than GA-3 is required for germination. The seeds appear to be alive as they do no rot in moisture in up to a year. Seeds DS 1 y rot in a month in moisture indicating that they are dead.

Rhinephyllum (?). R. broomii germ. 70D(25% in 8-14 d) and 70L(30% in 6-14 d). GA-3 had little effect.

Rhodochiton (Scrophulariaceae). R. atrosanguineum germ. at 70 (JH).

Rhodophiala (Amaryllidaceae). Eight samples of this genus have been received since the studies reported in the 2nd Ed. Germination was at 40 or in a combination of 40 and 40-70. It is clear that an inhibitor is destroyed at 40 followed by germination at 40, but germination at 40 is slower than at 70 after the inhibiting system has been destroyed. This is the same pattern as Nemastylis acuta.

R. andicola (2 samples) germ. 30% in 7-10 w and 20% in 3rd w both at 40.

R. elwesii (2 samples) germ. 40(90% in 3rd w) and 40(35% in 2-12 w)-70(60% in 1-3 d). In this second sample germination would undoubtedly have continued at 40 if the sample had been kept beyond 3 m at 40.

R. montanum (3 samples) germ. 100% in 2-7 w, 76% in 2-5 w, and 63% in 2-4 w, all at 40. None germ. at 70.

R. sp. germ. 40(50% in 10-12 w)-70(50% in 1-3 d) and none at 70.

Ribes (Saxifragaceae). R. lacustre germ. best in OT(53% in March and April from seeds started 13 m earlier) similar to other Ribes. Seeds also germ. 70 GA-3(9% in 4-7 w), 40-70D(5% in 3-5 w), and none in 70D and 70L

Romneya (Papaveraceae). R. trichocalyx germ. only with GA-3 (as with R. coulteri), but DS had a marked effect. Germination was 70 GA-3(10%)-40(74% in 2-7 w) for fresh seed, 70 GA-3(100% in 4-10 w) for seeds DS 6 m, and 70 GA-3(100% in 2-4 w) for seeds DS either 2 y or 3 y. None germ. in any other treatment. Note that DS improved the germination. All the seeds were killed by temperatures around zero.

Rorippa (Brassicaceae). R. islandica germ. 70L(90% in 4th w), 70 GA-3(80% in 3rd w), and none in 70D or 40. DS at 70 for 3 m had no effect, but DS for 1 y lowered germination in 70L to 8%.

Rosa (Rosaceae). Germination in the six species studied earlier and the following three extends over a number of cycles. Varying the time of each cycle from three months to other time periods should be tried. Recently two papers (H. Kuska, Rose Hybridizers News Letter 25, 7 (1994) and Y. Yambe and K. Takeno, HortScience 27, 1018 (1992) have reported that germination is speeded up by treating the seeds with a variety of macerating enzymes. Since pericarp removal gave immediate germination, the results were interpreted to mean that the enzymes digested and opened the seed coat along the suture line where the seed coat is thinnest. Such interpretations are not in accord with my own experiments where puncturing the seed coat had no effect. Light was not expected to have any effect and was not tried, and GA-3 treatments were without effect.

R. canina seeds DS 6 m germ. 70-40-70-40-70(17% in 3-5 d)-40-70(11%)-40-70(27% on 2nd d)-40-70(16% in 3-5 d) and 40-70-40-70-40-70(13% in 2 d-2 w)-40-70(5%)-40-70(1%). Neither OT, GA-3, a further 6 m DS, or puncturing the seeds speeded up germination.

R. carolina germ. 40-70(18% in 2-4 d)-40-70(43% in 3-14 d)-40-70(12% on 4th d)-40-70(2%), 70-40-70(60% in 2-8 d)-40-70(26% on 2nd d)-40-70(1%), and 38% in April-May in OT.

R. palustris germ. 40-70(60% almost all in 2-4 d)-40-70(10%)-40-70(4%), 70-40-70(32% largely in 2-6 d)-40-70(31% in 2-6 d)-40-70(3%), and 38% in April-May in OT. Seeds DS 1 y germ. similarly.

R. hybrid "Sheilers Provence" germ. 70(2/9 in 8th w)-40-70(2/9 on 2nd d).

Rosularia (Crassulaceae).

R. pallida DS 8 m germ. 70D(45% in 1-11 w), 70L(51% in 1-6 w), 70 GA-3(none), and 40-70D(14%). Seeds DS 18 m were dead.

R. sempervivum seeds DS 6 m germ. 100% in 3-13 d in 70D or 70L.

Roystonia (Palmaceae). Two samples of R. regia seed were collected in Florida. Sample A had seeds identical in shape and texture to a small coconut one inch long. Sample B had smoother seeds and more rounded and is likely another species. Sample A germ. 40-70D(8/10 in 3-11 w and one more 3 m later). When kept continuously at 70, 1/5 germ. in the 26th w. Puncturing the seeds on the side, the obtuse end, or on both ends did not initiate germination. It is surprising that this species required a period at 40 to initiate germination although where it grew in Florida it did experience temperatures near freezing in winter. Sample B germ. 40-70(1/10 in 11th w) and none in 70 after 6 m with or without puncturing. A variety of further treatments failed to give a single additional germination with either sample.

Rubus (Rosaceae). R. argutus requires DS followed by outdoor treatment. The most effective treatment is to DS the seed 6 m and start the seed outdoors March 15. Such seeds germ. 41% two months later in May (8 m after collecting the seed). Seeds DS 12 m and started in September germ. 32% the following May, but this was 18 m after collection. Fresh seeds started in September germ. 1% the following May and 28% the second May a year later. Germination was not stimulated by GA-3. When seeds were subjected to alternating 3 m cycles between 40 and 70, germination of the order of 5% began after a year of such cycles, but this is time consuming.

Rudbeckia (Asteraceae). Margaret Shore of Denver CO has written that the popular Rudbeckia hybrid Goldsturm requires temperatures of 90 to germinate. A study has been reported (Fay, Still, and Bennett, see American Nurseryman Dec. 1995, p. 92 for an abstract) on R. fulgida in which germination was studied as a function of temperature from 66-96. The optimum temp. was 82-90, but germination did occur at 70.

Rumex (Polygonaceae). Some species require light and others do not. The seeds were DS 8 m when received. They were studied when received. They were also studied after DS for 2 y except for R. longifolius and R. venosus.

R. acetosa DS 8 m germ. 100% in 3-5 d in either 70D, 70L, or 70 GA-3. A prior 3 m at 40 or DS 2 y had little effect.

R. acetosella germ. 70D(60% in 4-6 d). Light or GA-3 had little effect, but a prior 3 m at 40 was fatal. DS for 2 y germ. similarly.

R. alpinus germ. 70D(81% in 1-4 w), 70L(86% in 5-11 d), 40(4%)-70L(96% in 1-3 w), and 70 GA-3(2%). This was not significantly changed after 2 y DS.

R. crispus DS 8 m germ. 70L(94% in 5-11 d), 70D(1%), and 70 GA-3(2%). A prior 3 m at 40 or DS 2 y had little effect.

R. longifolius was mostly empty seed coats, but the single germinations for both fresh seed and seed DS 6 m occurred in 70D.

R. obtusifolius DS 8 m germ. 70L(100% in 7-11 d) and none in 70D. Seeds DS up to 3 y showed little change.

R. patientia DS 8 m germ, 70L(100% in 5-11 d), 70D(5%), and 70 GA-3(none). The germinatiion in 70L was unaffected by a prior 10 w in 70D and only slowed some by a prior 3 m at 40. Seeds DS 2 y germ. 70L(100% in 4-12 d) and 70D(32% in 3-13 d) indicating that the light requirement was disappearing.

R. scutatus DS 8 m germ. 100% in 3-5 d in 70L or 70 GA-3 and 70D(38% in 3-6 w). After 10 w the sample in 70D was shifted to 70L whereupon the remaining 62% germ. in 4-6 d). A prior 3 m at 40 and DS for 2 y had no effect.

R. venosus germ 70 GA-3(43% in 2nd w), 40(70% in 4-9 w), and 65% in April in OT. A prior 3 m in 70D or 70L was fatal and none germ. on shifting to 40.

Ruta (Rutaceae). R. graveolens germ. 70D(95% in 2-4 d).

Sabal (Palmaceae). S. palmetto was obtained as a commercial sample and as a sample collected near Sarasota FL. Both germ. 70-90% in 5-28 w in 70D either fresh or DS 1 y. Puncturing the seed coat speeded up the germination so that it took place in 4-24 w. A prior 3 m at 40 caused the germination at 70 to be faster so that it took place in 3-8 w. These results indicate a semipervious seed coat. Both of the above samples had seed that were 1/4 inch in diameter. A third sample collected in FL had seeds only 1/8 inch in diameter. It gave similar germination results.

Sagina (Caryophyllaceae).

S. procumbens seeds fresh or DS 3 m germ. 70D(54% in 4-13 w), 70L(67% in 3-6 w), 70 GA-3(61% in 3-9 w), 40-70D(80% in 1-5 w), and 100% in April in outdoor treatment. Seeds DS 2 y germ. 70L(57% in 10-18 d) and 70D(24% in 2nd w).

S. selaginoides germ. 70D(54% in 1-5 w), 70L(100% in 2-6 w), and 40-70D(77% in 2nd w). Seeds DS 1 y germ. 88% in 2nd w in either 70L or 70D.

Salix (Salicaceae). Fresh seed of four species were received by air mail from Iceland and all germ. on the 2nd d at 70. The four species were S. arctica, S. herbacea, S. lanata, and S. phylicifolia. Light and GA-3 had no effect. The first two germ. 100%, but the latter two had much chaff so that percent germinations could not be readily determined. After just 3 w of DS at 70 the seeds were all dead. However, the seed can be stored moist at 40 for some time. Seeds of S. arctica and S. herbacea were kept up to 12 w moist at 40, and they germ. 100% in 2 d on shifting to 70. This opens up a way for storing and distributing such seeds.

S. calcicola was received only a few weeks after collection, but it had all died by that time.

Salvia (Lamiaceae). S. hispanica (RC) and S. pratensis (KW) germ. immediately at 70 in accord with many other species (2nd Ed.).

Sambucus (Caprifoliaceae). S. canadensis, S. pubens, and S. racemosa all required GA-3 for germination. With all three species not a single germination occurred under any other condition. This is particularly significant because samples of over 1000 seeds were used with all three species. The seedlings were healthy.

S. canadensis (a second sample) germ. 70 GA-3(93% in 2-5 w) similar to the first sample (2nd Ed.). After 1 y DS germination in 70 GA-3 dropped to 53% and germination in 70D was still none. Seeds treated to alternating cycles between 40 and 70 failed to germinate after 2 y. Seeds DS 2 y were dead.

S. nigra germ. 70-40-70(1/28 on 7th d). Light or GA-3 failed to initiate germination. It is possible that this sample had received a long period of DS and was virtually all dead.

S. pubens germ. 70% in 1-5 m in 70 GA-3. A prior 70-40 had no effect. DS for 1 y had little effect, but seeds were all dead after 2 y DS. Margot Parrot of MA confirmed the GA-3 requirement for germination of this species.

Sandersonia (Liliaceae). S. aurantiaca had germ. a single seed in 70L and none in 70 GA-3 or 40. It is now found (GZ) that seeds placed outdoors in mid-March germ. in July indicating that OS is required.

Sanguinaria (Papaveraceae). S. canadensis had given a rare germination after a year or more in various treatments. In contrast the species self sows abundantly here. Fresh seeds have now been treated with GA-3, K salt of GA-3, GA-4, GA-7, and iso GA-7. The GA-3 was obtained from Aldrich Chemical Company whereas the remaining gibberellic acids were from Sigma Cell Culture.

The GA-7 was the most effective. Seeds were collected and treated on June 20. By Sept. 9 15% had developed a radicle, 41% had split, and 4% rotted. Seedlings were shifted to 40 for five months during which all of the split seeds developed the radicle. On shifting to 70 half of the germ. seeds developed the single true leaf. The results were half as good with the K salt of GA-3. The GA-4 gave as good development of the radicle, but the seedlings failed to develop the leaf on shifting to 70. Only a few percent germ. with GA-3 and iso GA-7. One curious result was if the seedlings in the first stage (radicle developed) were placed outdoors, all were killed by the winter temperatures indicating that they need to be in soil to survive the winter.

Sanguisorba (Rosaceae). S. minor seeds were received after 6 m DS. They germ. 70D(90% in 3-6 d)(2nd Ed.). This was unchanged after 3 y DS.

Sanicula (Apiaceae). S. arctopoides germ. 100% in April in OT. All other treatments gave lower percentages. Seeds germ. 70D(7% in 3rd w), 70L(37% in 4-12 w), 70 GA-3(20% in 3-5 w), and 40(16%)-70(10%). DS for 6 m was fatal.

Sapindus (Sapindaceae). S. saponaria v. drummondi was received from a commercial source and failed to germinate after 6 m in all treatments.

Sapium (Euphorbiaceae). S. sebeferum germ. 70 GA-3(3/8 in 5-8 w)-40-70(1/8), 70-40-70(1/10 on 8th d), and 70-40-70(2/10 on 10th d) if punctured.

Saponaria (Caryophyllaceae).

S. chlorifolia germ. 70 GA-3(100% in 3rd w), OT(5/8 in March), and none in 70D, 70L, or 40.

S. ocymoides seeds DS 6 m germ. 70L(86% in 4-20 d) and 70D(50% in 4-8 d). Seeds DS 1 y germ. 70D(50% in 1-3 w).

Sarcopotorum (Rosaceae). S. spinosum failed to germinate after 6 m starting either at 70D or 40. The sample started at 70 was then shifted to 70 GA-3 whereupon 2/3 germ. on the 15th d. It is likely that this species requires GA-3.

Sarracenia (Sarraceniaceae). S. alabamensis germ. best in 40-70L (2nd Ed.). Seeds DS 6 m were dead.

Sassafras (Lauraceae). It was noted in the 2nd Ed. that seeds of S. verifolium failed to germinate under all treatments. Similar experiences were reported by AC. This species remains one of the very few that have failed to germinate except under conditions in the wild.

Sauromatum (Araceae). S. venosum germ. 100% in 3rd w. Light or GA-3 had no effect. Seeds also germ. 40-70D(1/5) indicating that a prior 3 m at 40 was deleterious.

Saxifraga (Saxifragaceae). Where death rates were measured it was found that the seeds died rapidly in DS. Thus many of the past failures in this genus can possibly be the result of old seed.

S. aizoides germ. 70-40-70(2%) and failed to germinate in all other treatments. Seeds were dead after 1 y of DS.

S. caespitosa germ. 70 GA-3(95% in 2-6 w), 70D(20% in 5-11 w)-40(5%)-70(47% in 3-10 w), 70L(4%), 40-70D(31% in 4-11 w)-40(4%), 40-70L(30% in 4-7 w), and 64% in April-June in OT. Seed DS 6 m gave a similar behavior in 70D, 70L, and 70 GA-3, and seeds DS 1 y gave the same behavior in 70D. Seeds DS 2 y were dead.

S. cotyledon germ. 70L(2%) and failed to germinate in all other treatments. Seeds were dead after 1 y of DS.

S. nivalis germ. 70D(44% in 3rd w), 70L(58% largely in 2nd w), 70 GA-3(95% in 2-4 w), 40-70D(40% in 2nd w), and none in OT. After 1 y of DS seeds germ. 70L(2% in 4th w) and 70D(none) indicating that they were virtually all dead.

S. oppositifolia germ. 70 GA-3(18% in 3-5 w), 70L(12% in 5th w)-40-70L(38% in 2-4 w), 70D(2%)-40-70L(20% in 3rd w), 70D(2%)-40(2%)-70D(16% in 3rd w), and 40-70D(none). Although light and GA-3 increased percent and rate of germination, germination is still satisfactory in a 70-40-70 pattern in dark. Seeds DS 4 y were dead.

S. stellaris germ. 70L(37% in 1-3 w), 70 GA-3(75% in 2nd w), 40-70D(10%), 70D-40-70D(100% in 4-8 d), and none in OT. Seeds DS 1 y were dead.

Scabiosa (Dipsacaceae).

S. ochraleuca germ. 100% in 1-3 w in either 70D or 70L. A prior 3 m at 40 reduced percent germination to 20%.

S. vestita germ. 70L(3/8 in 2-5 w). The seeds put in 70D treatment were found to be all empty seed coats so that the results do not as yet indicate a light requirement.

Schivereckia (Brassicaceae). S. doerfleri germ. 70D(100% in 2-4 d).

Schizopetalon (Brassicaceae). S. walkeri germ. 70D(56% in 3-14 d), 70L(28% in 4-20 d), and 40(10% in 4th w).

Scilla (Liliaceae). S. chinensis germ. 70D(60% in 4-9 w), 70L(90% in 3-6 w), 70 GA-3(50% in 2-6 w), and 40(15%)-70(85% on 2nd d).

Scirpus (Cyperaceae). S. holoschoenus DS 8 m germ. 70L(100% in 7-9 d) and none in 70D, 70 GA-3, or 40. A prior 3 m at 40 had no effect. Seeds DS 2 y germ. 70L(86% in 2nd w) indicating some dying and a slowing of rate of germination. The seeds still failed to germinate in 70D.

Scrophularia (Scrophulariaceae).

S. lanceolata germ. 70 GA-3 (89% in 1-3 w), 40(4%)-70D(40% on 4th d), and 73% in April in outdoor treatment. Germination was 5-10% in 70D and 70L.

S. nodosa germ. 70L(100% on 4th d), 70 GA-3(100% in 4-9 d), and 70D(19% in 1-3 w). When the seeds in 70D were shifted to 70L after 3 m, the remaining 81% germ. in 4-6 d. A prior 3 m at 40 was fatal. After 1 y DS the light requirement disappeared, and the seeds germ. 92% in 4-8 d in either 70D or 70L. After 2 y DS the seeds germ. 70D(22% in 4-10 d) indicating extensive dying.

Scutellaria (Lamiaceae). Samples of S. elliptica and S. ovata were all empty seed coats.

S. laterifolia and S. baicalensis germ. D-70 (RC).

S. novae-zealandiae germ. 70D(1/10)-40-70(3/10 in 3rd w).

S. integrifolia were received as two samples both DS 1 y. One sample germ. 70D(21% in 2nd w), 70L(54% in 2nd w), and 70 GA-3(all rotted). The second sample germ. 70D(none), 70L(83% in 1-3 w), and 70 GA-3(4/7 in 2nd w). The data suggest that fresh seeds require light for germination and this requirement dies off on DS.

Sedum (Crassulaceae).

S. pilosum germ. 70L(34% in 5-18 d), 70 GA-3(15% in 2nd w), and 70D(none).

S. villosum seed collected in the wild in Iceland failed to germinate.

Senecio (Asteraceae). Death rates in DS are rapid, and this may be the cause of the failure to germinate in S. abrotanifolius.

S. abrotanifolius failed to germinate either with fresh seed or seed DS 1 y.

S. abrotanifolius v tirolensis germ. 70(75% in 1-3 w), but seed DS 1 y was dead.

S. aureus is remarkable in two respects. The seed requires light and the seed is all dead after DS for 6 m at 70. Both are unusual for Asteraceae. The seeds germ. 70L(100% in 6-10 d) and none in 70D.

Sequoiadendron (Pinaceae). S. giganteum germ. 70D(22% in 2-4 w) and 40-70D(38% in 3-10 d). Seeds DS for 6 m at 70 germ. 70D(50% in 2-12 w) indicating that the seeds received in March still had not had enough DS, but seeds DS 2 y germ. 70D(4%) and were largely dead.

Serenoa (Palmaceae). S. repens germ. 70D(1/4 in 20th w)-40 and 40-70(none). Seeds all rotted if the seed coats were punctured.

Sesamum (Pedaliaceae). S. orientalis germ. 100% in 2-4 d in 70D or 70L for either seed DS 6 m or 1 y.

Sesbania (Fabaceae). S. tripetii and S. triquetri had impervious seed coats and germ. 100% on 3rd d if punctured and none otherwise.

Setaria (Poaceae). S. italica germ. 85-100% in 3-6 d at 70 with or without GA-3 (KR).

Shepherdia (Eleaganceae). S. canadensis germ. 70D(4%)-40-70D(20% in 2nd w)-40-70D(70% in 2-16 d), 70L-40-70D(25% in 1-6 w)-40-70D(45%), 40-70D(4%)-40-70D(48% on 5-7 d), and 35% in August-October in OT from seeds started in February. There was no further germination the following spring in OT. GA-3 had little effect, and light had only a minor effect.

Shoshonea (Apiaceae). S. pulvinata germ. 40(40% in 10th w)-70-40(50% in 5th w)-70(5%), 70D-40(50% in 3-12 w)-70-40(5%), and 70 GA-3(none).

Shortia (Diapensaceae). S. soldanelloides germ. 70D(1/20 in 8th w) and none in 70L or 70 GA-3. The viability of the seed was too low for significant results, probably the result of a rapid death rate in DS.

Sibbaldia (Rosaceae). S. procumbens germ. better after 3 y DS. This germ. 70D(100% in 12-14 d) and 70L(100% on 10th d). Fresh seed (2nd Ed.) had germ. 70D(14% in 7-9 d) and 70L(67% in 3-5 d).

Silene (Caryophyllaceae).

S. caroliniana germ. 100% in 2-7 d in either 70D or 70L.

S. californica germ. 100% in 2-7 d in either 70D or 70L.

S. colorata germ. 100% on 3rd d in either 70D or 70L and 40(30% in 3rd w).

S. delavayi germ. 100% in 4-6 d in 70D or 70L and 40(30% in 6-11 w)-70(60% in 2-6d). GA-3 was detrimental.

S. gallica seed DS 6 m germ. 70L(100% on 5th d), 70D(75% on 5th d), OT(31% in March), and 40(5%)-70D. After 1 y DS the seeds germ. 100% in 3-5 d in either 70L or 70D. It is suspected that fresh seeds had a light requirement which had largely disappeared in the seeds DS 6 m and had completely disappeared in seeds DS 1 y. The prior 3 m at 40 was largely fatal which is surprising.

S. laciniata seeds DS 6 m germ. 70D(81% in 3-9 d) but after 2 y DS germination dropped to 15% and seeds DS 3 y were all dead. Light and GA-3 had little effect. The seeds DS 6 m also germ. 40-70D(60% in 2-10 d).

S. uniflora germ. 70 GA-3(100% in 3rd w), 20% in 2-10 w in either 70D or 70L, and OT(13% in March). Seeds DS 6 m germ. similarly, but seeds DS 1 y germ. 70 GA-3(20% ion 6th d) and 70D(40% in 3rd w).

Silybum (Asteraceae). S. marianum germ. D-70 (RC).

Sisyrinchium (Iridaceae). S. inflatum germ. 40(70% in 8th w) and none in 70L or 70D. A prior 3 m in 70D or 70L had no effect on the germination at 40.

Smyrnium (Apiaceae). S. perfoliatum germ. 70L-40(2/5 in 11th w)-70(2/5 in 2nd d), 70D-40(2/5 im 12th w), 40-70(1/6 on 4th d) and none in 70 GA-3 or OT. It is doubtful that the light really had any effect considering that the seeds did not germinate while in light but only after the shift to 40.

Solanum (Solanaceae).

S. aculeatissimum germ. D-70 (RC).

S. capsicastrum germ. 70D(6/8) and 70L(3/4) both in 2nd w.

S. dulcamara seeds DS 0, 6 m, 1 y, 2 y, and 3 y germ. 55%(2-5 w), 80%(1-3 w), 88%(1-4 w), 84%(1-3 w), and 20% in 3rd w respectively, all in 70L. There was no germination in 70D in any of these seeds.

S. sisymbrifolium germ. 70D(4/8 in 2nd w) and 70L(4/8 in 2-6 w).

Soldanella (Primulaceae). S. carpathica germ 70D(65% in 3rd w) which is similar to two species studied earlier.

Sollya (Pittosporaceae). S. heterophylla were empty seed coats.

Sophora (Fabaceae). Both species have an impervious seed coats and germinate only if the seed coats are punctured.

S. microphylla (the New Zealand Kowhai) germ. 70(100% in 5-7 d).

S. tomentosum germ. 100% on 4th d at 70.

Sorbus (Rosaceae). S. aucuparia germ. only in OT (2nd Ed.). This has been confirmed on further samples, but direct OS treatment has not been tried as yet.

Sparaxis (Iridaceae). Three different color forms of S. hybrids all germ. 100% in 10-12 d in 70D. A prior 3 m at 40 reduced germination to 15-70%.

Spathodea (Bignoniaceae). S. campanulata seeds DS 6 m or 1 y germ. 70L(100% in 2nd w) and none in 70D or 70 GA-3.

Specularia (Campanulaceae). S. speculum-veneris seeds DS 6 m germ. 70D(30% in 4-6 d), 70L(50% in 4th d), 70 GA-3 (none), 40(71% in 3-7 w), and OT(100% in March). Seeds DS 1 y were dead.

Spergularia (Caryophyllaceae). S. rupicola germ. 70L(100% on 4th d), 70D(10% in 2nd w), and 40(90% in 2-5 w).

Sphaeralcea (Malvaceae).

S. incana germ. 70L(100% in 2 d-6 w), 70D(50% in 2-14 d), and 40(8%).

S. (Illimna) remota has an impervious seed coat. However, the seed is easily damaged. It is best to abrade very lightly. Those seeds in which the seed coat is punctured will germinate 100% in 2-6 d at 70. The remaining seeds are then retreated and this continued until all germinate. About 15% of the seeds have a fracture in the seed coat, and will germinate without treatment.

Spilanthes (Apiaceae). S. acmella germ. D-70 (RC).

Spiraea (Rosaceae). S. ulmaria requires light (RC).

Stachys (Lamiaceae).

S. alpina germ. 70D(1/9), 70L(2/10), OT(1/11 in March), and 40(none). The low germinations are probably the result of DS since seeds DS a further 1 y were dead.

S. officinalis germ. D-70 (RC).

Stachyurus (Stachyuraceae). S. chinensis germ. 70L(41% in 5-11 w)-40-70L(32% in 2-7 w) and 70 GA-3(36% in 4-7 w). A prior 70-40 in dark had little effect. Seeds did germinate small amounts (8%) after 2.5 y in dark under alternating 3 m cycles at 40 and 70.

Stapelia (Asclepediaceae). S. leendertzii germ. 100% on 4th d in either 70D or 70L.

Stellaria (Caryophyllaceae). S. media germ. D-70 (RC). See Stellera (next entry) for an error in the 2nd Ed.

Stellera (Thymelaceae). In the 2nd Ed. the data for S. chamaejasme was by error given under Stellaria. Hopefully readers will have caught this error because the species name and the family name were correct.

Stenanthium (Liliaceae). S. occidentale germ. 2/9 in 2nd w in either 70D or 70L.

Stephanotis (Asclepediaceae). S. floribunda germ. 70D(5/9 on 8th d). Light or GA-3 had no effect.

Stransvaesia (Rosaceae). S. nitakaymensis germ. 40(1/4 in 8th w)-70D(3/4 on 2nd d), 70D-40-70D(1/4), and none in 70D, 70L, or 70 GA-3.

Strelitzia (Musaceae). Both S. nicolae (JH) and S. reginae have impervious seed coats. The latter germ. 70D(1/4) if punctured and none if not.

Streptopus (Liliaceae). S. rosea germ. 70D-40-70D(2/6 on 8th d) and none in 40 or OT. Treatment with GA-3 after a y of moist treatments failed to initiate germination.

Stylidium (Stylidaceae). S. graminifolium germ. 70 GA-3(100% in 3rd w), 70L(70% in 3rd w), 70D(55% in 3-7 w), and 40-70D(none). RCh reports similar results with several species. Germination rates and percentages are increased with GA-3 treatment.

Stylomecon (Papaveraceae). S. heterophylla germ. 70D(40-50% in 1-3 w). Light or GA-3 had little effect.

Stypandra (Liliaceae). S. glauca germ. 70L(1/24 in 2nd w) and none in 70D or 70 GA-3.

Styrax (Stryracaceae). S. obassia has been restudied on a much larger sample. None have germ. after 3 m under all treatments including GA-3 and puncturing the seed coats.

Succisa (Dipsacaceae).

S. inflexa germ. 70L(8/10 in 2-9 w) and 70D(1/5 in 3rd w).

S. pratensis germ. 70L(1/1 in 3rd w).

Sutherlandia (Fabaceae). S. montana germ. 70D(100% in 4-6 d) if punctured and 2/8 on 4th d if not.

Symplocarpus (Araceae). S. foetidus is now found to require light like most swamp plants. This clarifies the previous confusing results. Seeds germ. 70L(100% in 2-8 w), 70 GA-3(80% in 2-4 w), and none in 70D.

Synthyris (Scrophulariaceae). S. alpina (syn. Bessya alpina) germ. 70D(54% in 1-9 w)-40-70D(23% in 2-4 d), 70 GA-3(3%), and 40(65% in 4-7 w)-70D(11%). Light had no effect. Seeds DS 1 y were dead.

Talinum (Portulacaceae). A T. sp. was reported in the 2nd Ed. to germinate 40-70(12% in 2nd w) and none in other treatments. After 2 y and 3 y of DS the pattern was the same and germination was still in the 2nd w, but the percent germination dropped to 38% and 10% respectively.

Tamarindus (Fabaceae). T. indica has an impervious seed coat. When the seed coat is punctured and such seeds placed in 70D, the seeds swell to about four times their volume within a day. Germination is 100% in 3-12 d.

Tanacetum (Asteraceae). T. parthenium germ. D-70 (RC). A sample of T. turcomanicum was all chaff, a frequent problem in Asteraceae.

Tecomaria (Bignoniaceae). T. capensis germ. 100% on 7th d in either 70D or 70L.

Tellima (Saxifragaceae). T. grandiflora seed after 3 y DS at 70 had germination in 70L reduced from 72% to 24%, but germination in 70 GA-3 was still 90% in 2-4 w showing that the effects of DS were more complex than just dying of seeds. Seeds DS 5 y were dead.

T. alexanderi germ. one in 70 GA-3 and none in 70D or 40.

T. articulatus germ. one in 70 GA-3 and none in 70D or 40.

Taxus (Taxaceae). The extended germinations found for T. baccata have been confirmed. No way has been found to shorten germination times.

Tephrosia (Fabaceae). T. virginiana has an impervious seed coat (2nd Ed.). There was no change in germination behavior after 1 y DS, but seeds DS 3 y were dead.

Tetragonolobus (Fabaceae). T. maritimus had an impervious seed coat and germ. 100% on 3rd d if punctured and only 5% if not.

Thalictrum (Ranunculaceae). Most of the species in this genus have a GA-3 requirement for germination and most die quickly in DS.

T. lucidum germ. 70 GA-3(100% in 2nd w) and 70(none). Seeds DS 1 y were dead.

T. minus germ. 70 GA-3(14% in 2nd w) and 70(none). Seeds DS 1 y were dead.

T. rochebrunianum will ultimately germinate without GA-3 if given sufficient cycles. The data are 70 GA-3(81% in 2nd w), 70-40-70(80% on 6th d), and 70% in April in OT from sowing the previous September. DS for 6 m at 70 did not affect the germination in 70 GA-3.

T. tuberiferum had been reported to germ. 1% in OT, but it is now found that when the expt. is continued germination is 85% in April-May from seed placed outdoors a year earlier in April. This treatment is more certain of producing healthy seedlings than the GA-3 initiated germination reported earlier. It is possible that seeds placed in OT in the fall would have germ. the following spring.

Thaspium (Apiaceae). T. trifoliatum germ. 25% in 4-8 w in 70D or 70L and 12% in 70 GA-3. A prior 3 m at 40 had no effect. DS 6 m reduced germination to 5% and seeds DS 1 y were dead.

Thermopsis (Fabaceae). T. caroliniana has an impervious seed coat (2nd Ed). There was no significant dying in DS up to 2 y, but seeds DS 4 y were dead.

Thespesia (Malvaceae). T. populaea seeds fresh or DS 1 y germ. 4/4 in 4-6 d at 70 if punctured and 1/4 otherwise.

Thuja (Pinaceae). T. occidentalis seeds DS 0, 6 m, 1 y, and 2 y germ. 50%, 33%, 6%, and zero in 70D, all in 2-5 w.

Thunbergia (Acanthaceae). T. alata germ. in 3rd w at 70 (JH).

Thysanotus (Liliaceae). T. multiflorus germ. 70 GA-3(2/9 in 5th w) and none in 70D, 70L, or OS. Seeds DS 6 m were dead.

Tibouchina (Melastomaceae). T. grandiflora germ. 70L(4/17 in 3rd w) and 70D(none). The seeds are very small, and all of those in 70D may have been empty seed coats.

Tofieldia (Liliaceae). T. pusilla germ. 70L(72% in 1-3 w), 70 GA-3(70% in 2-4 w), and 40-70D(72% in 2nd w). Germ. declined and slowed in 70D(53% in 3-7 w).

Trachymene (Apiaceae). T. caerulea germ. 70L(95% in 2nd w) and 70D(7% in 2nd w).

Trachyspermum (Apiaceae). T. ammi germ. 70D(85% in 4-10 d) in either 70D or 70L. There was little change after 1 y DS.

Tradescantia (Commelineaceae). T. bracteata germ. 40-70D(50% on 10th d) and 70D-40-70D(35% in 2nd w) and none in 70D, 70L, 70 GA-3, or OT.

Trichophorum (Cyperaceae). T. alpinum DS 8 m germ. 70L(95% in 2nd w), none in 70D or 70 GA-3, 40-70L(100% in 2-4 d), and 40-70D(9% in 1-11 d). Seeds DS 3 y germ. the same.

Trichostema (Lamiaceae). T. dichotomum is best germ. in 70 GA-3, 88% in 5-15 d for fresh seed and 100% in 4-8 d for seed DS 6 m. However, significant germination is obtainable in 40-70L(31% in 4-13 d), 70L-40-70L(66% in 3rd w), 70D-40-70D(4%), and 10% in OT. DS 6 m or 12 m had little effect, but seeds DS 3 y were dead.

Trifolium (Fabaceae). T. repens has an impervious seed coat but 5-10% of the seeds have an imperfection that allows them to germinate in 1-4 w in 70D. Seeds that have been punctured germ. 100% on the 3rd d.

Triglochin (Scheuchzeriaceae). T. maritima DS 8 m germ. 70L(100% in 4-6 d), 70 GA-3(100% on 8th d), 70D(38% largely in 4-6 d), 40(1%)-70L(100% in 2-4 d), and 40(1%)-70D(25% in 5th d). Seeds DS 20 m germ. 70L(60% in 6-12 d) and 70D(14% in 8-20 d) showing that significant dying had occurred, and seeds DS 2 y were dead.

Trigonella (Fabaceae). T. foenum-graecum germ. D-70 (RC).

Trillium (Liliaceae). This genus has now been extensively studied by Carl Denton in England and by myself. Denton used a 40-65 cycle which is comparable to my 40-70 cycle. In 40-65 experiments Denton applied the GA-3 at the beginning of the 65 cycle whereas my expts. started at 70 and the GA-3 was applied at the start. Taking these procedural differences into account, our results generally are in agreement. The overall conclusion is that some species require GA-3 for germination and others do not. All species have two-step germination, and a period at 40 is necessary after the first step before the cotyledon will develop on shifting to 70. Germination was always epigeal (cotyledon photosynthesizing) despite reports to the contrary. Data on T. flexipes, T. luteum, and T. ovatum from the 2nd Ed. remain unchanged.

T. albidum germ. 70 GA-3(64% in 10-16 w), 40-70D(83% in 8-11 w), and 70D-40-70D(70% in 6-10 w). Denton found 40-65(50% in 12th w). The 40-70 cycle is best although germination will occur directly at 70 with GA-3. In the 2nd Ed. germination was listed as 40-70(100% <u>largely on 3rd d</u>). The underlined part is an error, it should have read 100% in 9-16 w, which is in accord with the later data.

T. apetalon germ. 70 GA-3(80% in 12th w)-40(20% in 4th w) and none in 70-40.

T. chloropetalum (Denton's data) germ. 40-65(75% in 13th w) and 40-65 GA-3(86% in 11-13 w) showing little difference with GA-3. T. chloropetalum rubrum gave similar results.

T. erectum (Denton's data) germ. 40-65 GA-3(75% in 7th w) and 40-65(none). T. erectum alba germ. 40-65 GA-3(100% in 5-7 w) and 40-65(none). This confirms that GA-3 is necessary for germination (as surmised from imperfect expts. in the 2nd Ed.), but it is not yet clear whether a preliminary 3 m at 40 is necessary.

T. grandiflorum and T. grandiflorum roseum, Denton's data is in agreement with my earlier work.

T. kamschaticum (Denton's data) germ. 40-65(100% on 12th w) and 40-65 GA-3(71% in 12th w). It is still possible that GA-3 would have initiated germination in an initial cycle at 70.

T. nivale (Denton's data) germ. 40-65(50% in 12th w) in accord with my earlier data. Denton also found 40-65 GA-3(none). I have not yet tried GA-3.

T. pusillum germ. 70 GA-3 (95% in 9th w), 70-40(68% in 3rd w), and 40-70(78% in 8-11 w). These results are curious. The seedlings slowly expanded the cotyledon after a month or two at 40 independent of whether the germination had taken place at 40 or at 70. On shifting to 70 the cotyledon completed development.

T. recurvatum (Denton's data) germ. 40-65 GA-3(90% in 12th w) and 40-65(none).

T. rugeli (Denton's data) germ. 40-65 GA-3(55% in 8th w) and 40-65(none).

T. tschonoski is the one species where our results differ. I had found 70 GA-3(80% in 8-10 w), 40-70 GA-3(50% in 7th w), and none in other treatments. Denton finds 40-65(40% in 9-11 w) and 40-65 GA-3(40% in 9-11 w) showing no effect of GA-3.

T. vaseyi (Denton's data) germ. 40-65 GA-3(58% in 5-8 w) and 40-65(none). I had found some germination in other cycles but had not tried GA-3.

Triosteum (Caprifoliaceae). T. perfoliatum failed to germinate in either 70-40 or 40-70 after 6 m. Puncturing had no effect.

Tripterocalyx (Nyctaginaceae). T. cyclopetris failed to germinate in 70D, 70L, 70 GA-3, 40, and OT after 9 m.

Tritonia (Iridaceae). T. crocea germ. 70D(3/9 in 2-6 w) and 40-70-40(none).

Trochodendron (Trochodendronaceae). T. aralioides germ. 70L(48% in 4th w), 70D(18% in 4th w), 70 GA-3(80% in 4th w), 40-70D(25%), and 46% in May in OT starting March 1.

Trollius (Ranunculaceae). T. laxus is now found to germ. 70 GA-3 (80% in 3-5 w). The treatments reported earlier are still to be preferred because the seedlings did not survive indicating that the exposure to GA-3 will have to be precisely controlled.

Tropaeolum (Tropaeolaceae).

T. minus germ. D-70 (RC).

T. pentaphyllum germ. 70D-40(1/6)-40-70(1/6), and T. speciosum germ. 70D-40-70D-40(1/9). These patterns are similar to those of the three species studied earlier.

Tsuga (Pinaceae). T. canadensis showed a curious effect on DS at 70. Fresh seeds germ. 70D-40(5%)-70(31% in 1-5 w) and 40(68% in 12th w)-70(11%). Seeds DS 6 m germ. 70D(10% in 12th w)-40(none) and 40(70% in 12th w). Seeds DS 12 m germ. 70D(all rotted) and 40-70D(23% in 3rd w). Seeds DS 2 y germ. 40-70D(4%) and 70D-40(4%)-70D(23% in 3rd w), and seeds DS 3 y were dead. The interpretation is that the seeds are dying in DS. After 12 m of DS the seeds require increasing times at 40 before they will germinate.

Tulbaghia (Liliaceae). T. galpinii germ. 70D(100% in 4-6 d) and 40(50% in 4-7 w)-70(8%).

Tulipa (Liliaceae).

T. chrysantha germ. 70D-40(50% in 6th w) and none in 40-70 or OT.

T. sprengeri germ. 40(60% in 11th w)-70(20%)-40-70(2%)-40(18% in 6-8 w), and 70D-40(34% in 11th w)-70(51% on 2nd d), and none in OT.

Turricula (Hydrophyllaceae). T. parryi germ. 70 GA-3(100% in 4-10 w) and none in 70L, 70D, 40-70D, 40-70L, or OT. A prior 6 m DS at 70 was fatal.

Ungnadia (Sapindaceae). U. speciosa germ. OS(1/1 on 12th d) and none after 3 m in 70D, 70L, 70 GA-3, or 40.

Urtica (Urticaceae).

U. membranacea DS 8 m germ. a single seed in 3rd w at 40 and none in 70D, 70L, or 70 GA-3. None germ. when DS 20 m. A more viable sample is needed.

U. piculifera DS 8 m germ. 70L(100% in 4-18 d), 70D(82% in 2-4 w), 40(82% in 2-4 w), and 70 GA-3(none). Seeds DS 20 m germ. 70L(100% in 4-12 d) and 70D(88% in 4-8 d) indicating little change on this further DS, but seeds DS 3 y were dead.

Vaccaria (Caryophyllaceae). This genus is a variant of Saponaria. Both species germ. at the same rate at 40 as at 70.

V. hispanica DS 8 m germ. 40(30%) and 70(10%) both in the 2nd w. The ungerminated seed rapidly rotted. The higher germination at 40 may be due to a slowing down of the rate of rotting. Light or GA-3 had no effect. Seeds DS 20 m germ. 70D(4%) indicating extensive dying, and seeds DS 3 y were all dead.

V. pyrimidata germ. 70D(100% on 3rd d) and 40(100% on 6th d). Seeds DS 1 y germ 70D(100% on 2nd d).

Vaccinium (Ericaceae). With fresh seed light promotes germination but is not essential. The effect of light was eliminated by DS for 6 m in V. globulare and reduced in V. myrtillus.

V. globulare germ. 70L(83% in 2-4 w), 70 GA-3(100% in 2nd w), 70D(10%), 40-70D(47% in 2-8 w), and 14% in May in OT. The stimulation by light disappeared after DS, and seeds DS either 6 m or ! y germ. 50% in 2-5 w in either 70D or 70L.

V. macrocarpum germ. 70L(95% in 1-3 w)(2nd Ed.). This was unchanged after 6 m DS.

V. myrtillus (fresh seed) germ. 70L(90% in 3rd w), 70 GA-3(83% in 1-3 w), 70D(5%), 40-70L(86% in 2-5 w), and 40-70D(16% in 2-5 w). DS for 6 m reduces the effect of light, and the DS seed germ. 70L(85% in 2-8 w) and 70D(56% in 2-7 w). Seeds DS 1 y were dead.

V. uliginosum germ. 70L(10% in 2-4 w), 70 GA-3(5% in 4th w), 70D(none), 40-70L(62% in 1-5 w), and 40-70D(21% in 1-4 w) using either fresh seed or seed DS 6 m. Seeds DS 1 y germ. 40-70D(12% in 1-3 w), and seeds DS 2 y were dead.

V. vitis-idaea germ. 70L(68% in 4-7 w) and 70D(none).

Valeriana (Valerianaceae). V. officinalis requires light (RC).

Veltheimia (Liliaceae). V. bracteata germ. 10/17 in 6-8 d in 70D.

Veratrum (Liliaceae). V. californicum germ. 70 GA-3(60% in 3-10 w), 70D-40-70D(25% in 2nd w), 70L(none), 40(13%)-70(53% in 2-16 d), and none in OT.

Verbascum (Scrophulariaceae). V. thapsus requires light (RC) similar to reported for V. blattaria (2nd Ed.). KW reported that V. bombyciferum, V. chaixi album, V. nigrum, V. nigrum album, V. olympicum, and V. phoeniceum all germ. over 90% in 5 d in 70L. It is likely that at least some of these would have germ. equally in 70D since V. phoeniceum germ. 100% in 3-4 d in 70D (2nd Ed.).

Verbena (Verbenaceae). V. macdouglii germ. 45% in 2nd w in either 70L or 70 GA-3 and none in 70D or 40. A prior 3 m in 70D was fatal, and a prior 3 m in 40 reduced percent germination to 10%. After 1 y and 2 y DS light was still required, but germination was reduced to 33% and 20% respectively.

Vernonia (Asteraceae). V. altissima germ. 70L(32% in 7-18 d), 70 GA-3(70% in 4-15 d), 70D(5%), and 40-70D(17% in 2-12 d). The results are similar but not identical to those found with V. novaboracencis. The germination in 70L increased on DS, and seeds DS 0, 6 m, 12 m, and 16 m germ. 32%, 48%, 63%,and 72%, all in 1-3 w. Germination in 70D remained in the 2-5% range. Seeds DS 30 m were dead.

Veronica (Scrophulariaceae).

V. fruticans germ. 40-70D(80% in 1-8 d) and none in 70D or 70L.

V. serpyllifolia germ. 70L(50% in 2nd w), 70 GA-3(95% on 7th d), 40-70L(100% in 4-8 d), and none in 70D, 40-70D, or OT. Seeds DS 1 y were dead.

Veronicastrum (Scrophulariaceae). V. virginica germ. 70L(62% in 6-12 d), OT(33% in April from seed placed outdoors in February), 40-70D(4%), and none in 70D or 70 GA-3. It is curious that light and OS are the two effective treatments as this combination is rare.

Vestia (Solanaceae).

V. foetida germ. 100% in 6-10 d in 70D, 70L, and 70 GA-3.

V. lycioiodes germ. 70D(80% in 8-10 d), 70L(90% in 8-12 d), and 70 GA-3(100% in 8-10 d).

Viburnum (Caprifoliaceae). All seeds were WC for 7 d first.

V. carlesi germ. 40-70(80% in 9-14 w) and 70D-40-70D(100% in 8-13 w). The seedlings developed their cotyledons at 40 in 1-3 w after germination.

V. sargenti germ. 70(92% in 8-12 w) (2nd Ed.) with no change after 1 y DS.

V. trifolium germ. 40-70(65% in 7-11 w), 70 GA-3(64% in 8th w), 70D-40-70D(24% in 9-11 w), and 70% in July and August from seed placed outdoors in the previous September.

V. trilobum germ. 70D(95% in 5-8 w) and 40-70D(100% in 9-14 w). A prior 3 m at 40 had no effect. Germination consisted of forming a radicle. The seedlings then required 3 m at 40 and a return to 70 in order for formation of a stem and leaves.

Vicia (Fabaceae). V. cracca collected in Michigan and a sample collected in Iceland gave different behaviors. The Michigan sample germ. 95% in 3-5 w in 70D without puncturing the seed coat, but the Iceland sample (fresh or DS 3 y) had an impervious seed coat and germ. 100% on 3rd d in 70D but only if the seed coat was punctured.

Viguiera (?). V. porteri germ 70D(70% in 6-14 d) and 70L(70% in 8-12 d).

Vincatoxicum (Asclepiadaceae). Seeds of both of the following species were received in April and presumably had been DS for about 8 m. Germination was faster and in slightly higher percentage when treated with GA-3. Seeds DS 21 m gave about the same overall percent germination for both species, but in both species the pattern was shifted from a 40 germinator to more of a 40-70 germinator.

V. hirundinaria (DS 8 m) germ. 70 GA-3(93% in 4-14 d), 70L(34% in 5-11 d)-40-70D(38% in 2nd w), 70D(12%)-40-70D(53% in 2nd w), and 40(82% in 7-11 w)-70D(3%). Seeds DS 21 m germ. 70D(54% in 1-3 w)-40-70D(31% in 1-3 w) and 40(2%)-70(94% in 1-7 d).

V. nigrum (DS 8 m) germ. 70 GA-3(95% in 4-8 d), 70L(62% in 1-9 w)-40-70D(28% in 2nd w), 70D(41% in 1-8 w)-40-70D(50% in 4-6 d), and 40(53% in 7-11 w)-70D. Seeds DS 21 m germ. 70D(48% in 1-8 w)-40-70D(44% in 5-7 d) and 40(33% in 3-11 w)-70(39% in 1-3 d).

Viola (Violaceae). Four species of rosulate Violas from the Andes germ. only in 40 GA-3 (2nd Ed.). A most important new result is that all four samples germ. identically after fours years of DS. This shows that these have considerable longevity in DS in contrast to species native to Eastern U.S. which die quickly in DS.

V. adunca germ. 70 GA-3(78% in 1-7 w), 70L(64% in 7th d), 70D(15% in 3rd w), 40(12%)-70D(66% on 2nd d), and 64% in April-June in OT.

V. canina germ. 70 GA-3(54% in 3-5 w), 70L-40-70D(58% on 4th d), and none in 70D, 40, or OT. Seeds DS 1 y were dead.

V. cuneata germ. 70 GA-3(5/7 in 2nd w), 40(4/7 in 7-13 w)-70D-40, 70L-40(2/6)-70D(1/6), and none in 70D-40-70D.

V. glabella germ. 70 GA-3(35% in 3rd w) and none in 70L, 70D, 40-70, or OT.

V. nuttallii germ. 40(60% in 8-10 w), 70 GA-3(30% in 7th w), and 70% in April in OT. The seeds all rotted in 70D and 70L.

Vitaliana (Primulaceae). V. (Douglasia) primuliflora germ. 70D(100% in 12-14 d).

Vitex (Verbenaceae). V. agnus-castus germ. 70L(40% in 2-10 w), 70 GA-3(46% in 2-5 w), 70D(none), 40-70L(38% on 4th d), and 40-70D(6%). When the sample in 70D was shifted to 70L after 3 m, 83% germ. in 6-17 d. Light (or GA-3) is a requisite for germination despite the hard black seed coat. After 1 y DS seeds germ. 70L(40% in 1-4 w) and 70D(none) indicating no significant deaths as yet.

Wachendorfia (Haemodoraceae). W. thrysiflora germ. 70L(2/2 in 10-16 d) and 0/2 in 70D.

Wahlenbergia (Campanulaceae).

W. congesta germ. 70L(93% in 8-10 d), 70 GA-3(100% in 8-12 d), and 70D(10%).

W. gloriosa germ. 70D(43% in 8-16 d), 70L(34% in 8-16 d), and 70 GA-3(31% in 8-16 d).

Washingtonia (Arecaceae). W. filifera, a prior 3 m at 40 moist had no effect on the germination at 70.

Watsonia (Iridaceae).

W. beatricis germ. 3/4 in 4-6 d in 70D and 0/4 in 70L.

W. sp. germ. 5/6 in 4-6 d in 70D and 0/6 in 70L.

Withania (Solanaceae). W. somnifera germ. 70L(90% in 1-3 w), 70D(4%), and 70 GA-3(26% in 1-3 w).

Xanthoceras (Sapindaceae). X. sorbifolium germ. 70(70% in 1-3 w) and 40(80% in 8-10 w). Puncturing the seed coat had little effect, but soaking the seeds for 3 d lowered the germination in 70 to 43%. Seeds DS 6 m germ. 40(88% in 4-12 w)-70(4%) and 70D(15%)-40(24% in 8-12 w)-70(28% on 2nd d).

Zantedeschia (Araceae). Z. ethiopeca germ. 70D(100% in 4th w) if the seed capsule is removed (2nd Ed.). There was no change after 6 m DS.

Zea (Poaceae). Z. mays germ. 100% in 2-6 d in 70D when fresh, but this dropped to 35% in 2-9 d after 3 y DS.

Zephyra (?). Z. minima germ. 70D(1/2 on 6th d) and 70L(2/3 on 10th d).

Zizania (Poaceae). Z. aquatica germ. in spring underwater as soon as the temperature of the water rose above 40 from seed sown underwater in the fall (D. Goldman, Waynesboro PA).

Zizia (Apiaceae). Z. aptera germ. 44% in 2-6 w in either 70L or 70 GA-3 and none in 70D. The percent germination in 70L dropped to 10% for seeds DS 6 m.

Zizyphus (Rhamnaceae). Several samples of seeds of Z. jujuba have failed to germinate, and the seeds soon rot.

Zygophyllum (Zygophyllaceae). Z. atriplicoides germ. 70 GA-3(9/9 in 1-3 w), 70D(2/7 on 4th d), and 40-70D(6/11 on 10th d).

V CACTACEAE

Studies on seeds of 273 species (101 genera) of Cactaceae are reported herein. Ten of these species and eight of the genera were studied before, and this is an update on these. Germinations in Cactaceae have the following characteristics. (1) Germinations occur either in 70D or 70 GA-3 and never at 40. (2) Light requirements, requisite cold treatments, or impervious seed coats **are not found.** (3) Dry storage has profound effects.

Of the 273 species studied, (a) 84 germinated only in 70 GA-3, (b) 46 germinated far better in 70 GA-3 relative to 70, (c) 18 gave a single germination and that was in 70 GA-3, (d) 79 germinated about equally in 70 GA-3 or 70, (e) 2 gave a single germination in 70 and none in 70 GA-3, (f) 4 germinated in 70 but not 70 GA-3, and (g) 41 failed to germinate. If groups (a), (b), and (c) are combined as the species essentially requiring GA-3 for germination and group (g) is discounted, **65% of the species studied can be regarded as essentially requiring GA-3 for germination.**

However, the situation is more complex because the GA-3 requirement often disappears on extended dry storage (at 70) as exemplified by Opuntia tuna. Most of the samples studied were from commercial sources. The seeds were received usually in midwinter and had been dry stored for at least six months and possibly several years. This is no criticism of the commercial sources because many cacti germinate much better after two years of dry storage as exemplified again by Opuntia tuna. It is only to point out that the seeds when fresh might have had an even more pronounced GA-3 requirement for germination than was observed.

Varying amounts of dry storage are also the cause of divergent results. Any changes in germination pattern with dry storage are superimposed on the death rates in dry storage. Generally cacti seeds have slow death rates in dry storage; but deterioration was evident in Opuntia tuna after three years of dry storage at 70.

Kim Reasoner in Texas has studied germination of fifteen cacti with GA-3, GA-4, GA-7, and GA-4/7 in concentrations of 5 ppm and 1000 ppm. The overall result is that GA-3 in 1000 ppm concentration is generally the best, and in no species did one of the other gibberellins give significantly superior results.

The GA-3 requirement for germination is unusually common in Cactaceae, and an effort was made to study every species of cacti for which seed was available. The reason why cacti have evolved this requirement is explained in detail in the Second Edition. Incidentally, subjecting the seeds to prior moist cycles before treating with GA-3 was generally injurious to the seeds and sometimes fatal.

Cacti seeds are generally enclosed in a juicy fruit. The seeds were removed from the fruits and washed and cleaned for one to seven days before commencing the experiments. It is presumed that the fruits block access to oxygen and delay germination by this mechanism. Also cleaning the seeds was a convenience in the experiments. It is not known whether there are any chemical inhibitors in the fruit.

The fruits on Opuntias are held on the plant for over a year, and the question arises as to when to collect the fruits and does collection at different times give differing germination patterns. This is being investigated with Opuntia humifusa, but only preliminary results are available for this supplement.

The raw data are reported because even when only one or a few germinated or the sample was small, the results are indicative. The data on cacti differ from all other data in this supplement in that empty seed coats were counted, and some of the failures were due to empty seed coats.

There have been reports that germination in cacti were stimulated by treatment with concentrated (95%) sulfuric acid. It has usually been presumed that this treatment was effective because it weakened or opened the seed coat. This is most doubtful in Cactaceae because no evidence was ever found for an impervious seed coat. If the sulfuric acid does have any favorable effect (and this has not been definitively shown to my satisfaction), it seems more likely that any such effects are due to the sulfuric acid drawing water out of the seed and thus mimicing the effects of dry storage or the acid destroying the chemical system blocking germination.

Significant amounts of the following data were provided by Kim Reasoner (a high school student) in Bridgeport, Texas, and Eugene Zielinski (a chemist) in Milesburg, Pennsylvania.

Acanthocalycium. A. peitscherianum germ. 70 GA-3(8/15 in 6-14 d) and 70(3/6 in 8-24 d). A. spiniflorum germ. 70 GA-3(17/18 in 4-18 d) and 70(4/11 in 8-10 d). A. violaceum germ. 70 GA-3(3/10 on 5th d) and 70(9/10 in 5-9 d) (KR), but GZ found 70 GA-3(3/6) and 70(0/6).

Ancistrocactus. A. brevinamatus germ. 70 GA-3(12/18 in 12-33 d) and 70(4/7 in 10-22 d). A. scheeri germ. 70 GA-3(10/12 in 4-7 d) and 70(10/12 in 4-8 d)(KR).

Arequipa. A. erectocylindrica germ. 70 GA-3(8/12 in 10-16 d) and 70(4/9 in 8-10 d). A. weingartiana germ. 70 GA-3(10/19 in 6-30 d) and 70(6/8 in 8-30 d). A. sp. Tacna germ. 70 GA-3(10/14 in 6-14 d) and 70(5/8 in 8-22 d).

Ariocarpus. A. agavoides germ. 70 GA-3(4/5 in 8th d) and 70(4/5 in 8-10 d). A. kotschoubeyanus germ. 70 GA-3(5/5 in 10-12 d) and 70(0/4). A. retusus germ. 70 GA-3(2/6 in 10-12 d) and 70(1/4 on 10th d). A. trigonus failed to germinate (both 0/5).

Armataocereus. A. matulanensis germ. 70 GA-3(5/13 in 14-30 d) and 70D(1/7 on 20th d).

Astrophytum. A. asterias germ. 70 GA-3(5/5 on 8th d) and 70(2/5 on 6th d). A. capricorne crassispinum germ. 70 GA-3(10/15 on 8thd) and 70(5/8 on 6th d). A. coahuilense germ. 70 GA-3(15/15 on 4th d) and 70(5/6 on 6-12 d). A. hyb. Sen-As germ. 70 GA-3(20/20 in 4-8 d) and 70(6/6 on 6th d).

Austrocactus. A. bertinii germ. 70 GA-3(3/6) and 70(0/6)(GZ). A. bertinii 'Patagonicus' failed to germinate (0/15 and 0/6 in two separate samples).

Austrocylindropuntia. A. shaferi germ. 70 GA-3(1/13 in 3rd w) and 70(none), and seeds DS 1 y germ. 70 GA-3(2/8 in 2-6 w) and 70(none). There was no germination with A. inarmata (confirmed by GZ), A. floccosa (KR), A. haematacantha, and A. weingartiana.

Aztekium. A. ritteri germ. 70 GA-3(5/8) and 70(1/8)(GZ), but a second sample failed to germinate (0/17 and 0/6).

Blossfelldia. B. iliputana failed to germinate (0/18 and 0/11).

Buiningia. B. aurea (0/16 and 0/6) and B. brevicylindrica (0/14 and 0/7) failed to germinate.

Carnegia. C. gigantea germ. 70 GA-3(75% in 3-5 d) and 70(75% in 3-9 d). A second sample germ. 70 GA-3(1/12 on 30th d) and 70(4/7 in 2-4 w). KR also found that GA-3 was not beneficial for germination.

Cephalocereus. C. alensis germ. 70 GA-3(0/13) and 70(1/8 on 20th d). C. royenii germ. 70 GA-3(6/14 in 16-30 d) and 70(4/7 in 26-42 d). C. senilis germ. 70 GA-3(0/10) and 70(3/10 in 5th d).

Cereus. C. aethiops germ. 70 GA-3(6/15 in 10-34 d) and 70(0/5). C. validus germ. 70 GA-3(15/16 in 16-28 d) and 70(5/7 on 32nd d).

Cleistocactus. C. aureispinus germ. 70 GA-3(6/14 in 10-24 d) and 70(2/5 in 12-14 d). C. baumannii failed to germinate in either 70 GA-3 or 70 (both 0/8). C. smaragdiflorus germ. 70 GA-3(14/21 in 20-28 d) and 70(0/5).

Coleocephalocereus. C. goebelianus germ. 70 GA-3(8/18 in 30-50 d) and 70(0/7).

Copiapoa. C. barquitensis germ. 70 GA-3(11/19 in 10-28 d) and 70(0/5). C. humilis failed to germinate (0/15 and 0/6). C. hypogaea failed to germinate (0/15 and 0/7). C. magnifica germ. 70 GA-3(3/5 in 1-5 w) and 70(3/5 in 5th w)(KR). C. tenuissima failed to germinate (0/18 and 0/7).

Corryocactus. C. urmiriensis germ. 70 GA-3(15/18 in 28-30 d) and 70(2/5 on 20th d). C. tarijensis failed to germinate (0/14 an 0/7).

Coryphantha.

C. echinoides germ. 70 GA-3(9/10 in 5-8 d) and 70(8/10 in 5-12 d)(KR).

C. palmeri germ. 70 GA-3(28/36 in 4-7 d) and 70(35/36 in 5-7 d)(KR).

C. vivipara seeds DS 6 m germ. 70 GA-3(60% in 6-10 d), but it also germ. 70(10%)-40-70(40%). A second sample DS 6 m germ. 70 GA-3(85%, zero order rate, ind. t 11 d, 11%/d) and 70D-40-70D(2/5 on 6th d). After 1 y DS this second sample germ. 70 GA-3(none) and 70D(50% in 3rd w). These somewhat confusing results suggest that GA-3 is required for germination of fresh seed, but that this requirement slowly disappears.

Cumarinia. C. odorata germ. 70 GA-3(3/17 on 10th d) and 70(0/4).

Denmoza. D. rhodacantha germ. 70 GA-3(12/17 in 8-30 d) and 70(3/5 in 22-50 d) in two separate samples. The pattern was confirmed by KR who found 70 GA-3(8/11 in 6-16 d) and 70(3/11 in 6th w).

Disocactus. D. alteolens germ. 70 GA-3(2/6 in 16-20 d) and 70(0/4). D. boomianus germ. 70 GA-3(5/6 in 16-30 d) and 70(0/4). D. crystallophilus germ. 70 GA-3(2/5) and 70(1/5)(GZ). D. pugionacanthus germ. 70 GA-3(1/5 in 3rd w) and 70(0/7).

Echinocactus. E. horizonthalonius germ. 70 GA-3(4/5 in 1-4 w) and 70(0/5). E. ingens germ. 70 GA-3(13/15 in 10-24 d) and 70(0/7). E. platyacanthus germ. 70 GA-3(13/16 in 8-30 d) and 70(0/6).

E. texensis germ. 70 GA-3(16/18 in 8-30 d) and 70(0/7). A second sample germ. 5/6 in 4-6 d in either 70 GA-3 or 70 in accord with GZ who found 70 GA-3(4/6) and 70(2/6). Presumably the latter samples had more DS.

Echinocereus. E. engelmanni germ. in both 70 GA-3 and 70D, and a prior 2 m in 70D before treating with GA-3 was fatal to the seeds. E. engelmanni v. chrysocentrus germ. 70 GA-3(83%, zero order rate, ind. t 8 d, 4%/d) and 70(none), and a prior 2 m at 70D was fatal to the seeds. E. fendleri germ. 70 GA-3(91%, zero order rate, ind. t 8 d, 15%/d) and 70D(none), and a prior 2 m in 70D before treating with GA-3 was fatal to the seeds. E. ferreiranus germ. 70 GA-3(1/5 on 13th d) and 70(4/5 in 20-23 d) (KR). E. pectinatus germ. 70 GA-3(6/33 in 6th w) and 70(1/33 in 6th w) (KR). E. pectinatus hybrids required GA-3, and the data followed a first order rate plot to eight half-lives (see 2nd Ed). E. pectinatus v. wenigeri had germination improved by GA-3 (KR). E. reichenbachii germ. 70 GA-3(85%, zero order rate, ind. t 15 d, 16%/d) and 70D(none), and a prior 2 m in 70D before treating with GA-3 was fatal to the seeds. E. reichenbachii v. albispinus germ. 70 GA-3(95% in 1-5 w) and 70D(none), and a prior 2 m in 70D had no effect on the germination in 70 GA-3. E. reichenbachii v. baileyi germ. 70 GA-3(6/6) and 70(1/6)(GZ). E. reichenbachii v. caespitosus germ. only with GA-3(95% in 1-3 w). E. reichenbachii v. perbellus GA-3 improved germination (KR). E. x roetteri failed to germinate (both 0/5) (KR). E. spinigemmatus failed to germinate (both 0/6)(GZ). E. triglochidiatus germ. only in 70 GA-3. E. triglochidiatus v. mojavensis germ. 70 GA-3(85%, zero order rate, ind. t 17 d, rate 13%/d) and 70-40-70(10%, ind. t 7 d, 4%/d), and if given a prior 70-40-70 treatment, the germination in 70 GA-3 dropped to 50% and the rate dropped to about 6%/d. E. viridiflorus germ. only with GA-3(10/12 in 4-21 d).

Echinofossulocactus. E. dichroacanthus germ. 70 GA-3(17/17 in 4-14 d) and 70(1/4 in 6th w). E. erectocentrus germ. only in 70 GA-3(13/15 in 4-20 d). E. heteracanthus germ. 70 GA-3(7/20 in 4-16 d) and 70(0/7). E. sp. CSD 19 germ. 70 GA-3(14/17 in 8-14 d) and 70(0/7). E. zacatecasensis germ. 70 GA-3(14/18 in 8-14 d) and 70(6/8 in 6-16 d).

Echinomastus. E. dasyacanthus germ. 70 GA-3(4/9 in 8-10 d) and 70D(0/7) in one sample and 70 GA-3(13/13 in 7-15 d) and 70(1/10 on 8th d) in the other sample. E. laui germ. 70 GA-3(16/16 in 6-12 d) and 70(4/7 in 10-26 d).

Echinopsis. E. ancistrophora hamatacantha germ. 70 GA-3(13/16 in 8-30 d) and 70(6/9 in 12-26 d). E. mirabilis germ 70 GA-3(13/13 on 6th d) and 70(7/8 in 4-8 d). E. rhodotricha germ. 70 GA-3(10/12 in 6-14 d) and 70(8/9 in 6-14 d). E. tapecuna tropica germ. 70 GA-3(7/15 in 8-42 d) and 70(2/8 in 10-14 d).

Epithelantha. E. micromeris germ. only with GA-3(70% in 1-3 w).

Epostoa. E. mirabilis germ. 70 GA-3(11/22 in 8-14 d) and 70(1/8 on 15th d). E. nana germ. 70 GA-3(18/20 in 8-12 d) and 70(4/6 in 8-12 d).

Erdisia. E. quadrangularis germ. 70 GA-3(13/14 in 6-12 d) and 70(4/8 in 6-14 d).

Eriocereus. E. jusbertii germ. 70 GA-3(10/18 in 10-24 d) and 70(0/8).

Eriosyce. E. ihotzkyana germ. only with GA-3(39% in 1-6 w) and if preceded by a 70-40-70 treatment, germination in 70 GA-3 dropped to 10%.

Escobaria. E. minima germ. 70 GA-3(1/6) and 70(0/6) (GZ). E. vivipara germ. 70 GA-3(1/6) and 70(0/6) (GZ).

Escontria. E. chiotilla germ. 70 GA-3(15/17 in 12-14 d) and 70(11/11 in 8-28 d).

Eulychnia. E. acida germ. 70 GA-3(6/18 in 6-10 d) and 70(4/7 in 6-14 d). E. castanea germ. 70 GA-3(14/14 in 4-12 d) and 70(7/7 in 6-12 d).

Ferocactus.

F. acanthoides seeds DS 6 m, 1 y, 2 y, and 3 y germ. 14% in 1-10 w, 14% in 1-10 w, 45% in 3-7 w, and 62% in 1-4 w respectively in 70 GA-3 treatment. None germ. in 70 D until DS 3 y, and then only 5% germ. However, seeds DS 6 m germ. 70 GA-3(37% in 2-4 w) if they were given 3 m at 70 first. It is possible that this is due to a different effective concentration of the GA-3 since the seeds given 3 m at 40 first would be more moist reducing the concentration of the GA-3 reaching the seeds.

F. gracilis germ. 70 GA-3(23/32 in 8-12 d) and 70(26/32 in 8-16 d) (KR).

F. wislizeni germ. 70 GA-3(11% in 3-11 w) and 70(none). However, seeds DS 6 m germ. 70 GA-3(19% in 2-4 w) if they were given 3 m at 70 first. This is similar to F. acanthoides and the same remarks apply.

Frailea. F. alacriportana fulvispina germ. 70 GA-3(11/15 in 4-8 d) and 70(3/8 on 12th d). F. aureinitens germ. 70 GA-3(5/14 in 6-10 d) and 70(2/8 on 8th d). F. gracillima germ. 70 GA-3(5/13 in 8-16 d) and 70(2/9 in 16-42 d). F. grahliana germ. 70 GA-3(0/17) and 70(1/10 on 13th d).

Glandulicactus. G. uncinnatus germ. 70 GA-3(9/11 on 8th d) and 70(6/9 in 8-12 d). G. wrightii germ. 70 GA-3(11/14 in 8-22 d) and 70(3/8 in 12-44 d).

Grusonia. G. bradtiana cuatrocienagas germ. 70 GA-3(6/21 in 13-50 d) and 70-40-70(1/11 in 4th w)

Gymnocactus. G. beguinii germ. 70 GA-3(3/15 in 12-14 d) and 70(0/7). G. beguinii senilis germ. 70 GA-3(16/16 in 8-10 d) and 70(5/7 in 8-12 d). G. calochorum proliferum germ. only with GA-3 (GZ). G. knuthianus germ. 70 GA-3(9/15 in 10-14 d) and 70(0/8). G. subterraneus zaragosae germ. 70 GA-3(14/17 in 8-14 d) and 70(3/7 on 10th d).

Gymnocalycium. G. ambatoense germ. 70 GA-3(10/17 on 6th d) and 70(3/9 on 6th d). G. anisitsii germ. 70 GA-3(18/25 in 7-18 d) and 70(1/11 on 15th d). G. baldianum germ. 70 GA-3(15/20 in 6-24 d) and 70(4/9 on 6th d). G. bodenbenderianum germ. 70 GA-3(1/10 on 11th d) and 70(0/6). G. calochorum proliferum germ. 70 GA-3(2/6) and 70(0/6). G. gibbosum germ. 70 GA-3(3/6 in 5-6 d) and 70(1/6 in 4th d) (KR). G. gibbosum nigrum failed to germinate (both 0/6) (GZ). G. multiflorum DS either 2 or 3 y germ. 70 GA-3(100% in 3rd w) and 70(20% in 2nd w).

Haageocereus. H. chosicensis germ. 70 GA-3(15/18 in 6-18 d)and 70(4/8 in 6-14 d). H. pseudomelanostele germ. 70 GA-3(9/14 in 12-16 d) and 70(3/10 in 12-14 d).

Hamatocactus. H. sp. germ. 70 GA-3(16/16 in 6-16 d) and 70(4/8 in 10-18 d).

Harrisia. H. bonplandii germ. 70 GA-3(11/17 in 6-12 d) and 70(9/11 in 4-12 d). H. brookii germ. 70 GA-3(9/14 in 12-28 d) and 70(3/9 in 14-41 d).

Leuchtenbergia. L. principis germ. 70 GA-3(13/14 in 6-14 d) and 70(5/9 in 12-20 d).

Lobivia. L. acanthophlegma oligotricha germ. 70 GA-3(11/20 in 8-33 d) and 70(1/8 on 15th d). L. aurea germ. 70 GA-3(4/12 in 8-16 d) and 70(0/10). L. aurea leucomalia germ. 70 GA-3(13/14 in 6-14 d) and 70(1/10 on 7th d). L. backebergii germ. 70 GA-3(3/6) and 70(1/6) (GZ). L. bruchii fresh or DS 1 y germ. 70 GA-3(95% in 1-4 w) and 70(95% in 1-4 w). L. chrysantha germ. 70 GA-3(3/6) and 70(3/6) (GZ). L. einsteinii aureiflora germ. 70 GA-3(5/8 in 10-18 d) and 70(0/7). L. saltensis nealeana germ. 70 GA-3(2/6) and 70(0/6) (GZ). L. wrightiana winteriana germ. 70 GA-3(3/6) and 70(4/6) (GZ).

Lophophora. L. decipiens germ. 70 GA-3(5/5 in 5-9 d) and 70(4/4 in 5-7 d).

Lophocereus. L. schottii germ. 70 GA-3(0/8) and 70(1/6 on 11th d).

Loxanthocereus. L. seniloides germ. 70 GA-3(5/20 in 8-12 d) and 70(2/5 in 12th d).

Machaerocereus. M. gummosus germ. 70 GA-3(6/16 in 8-10 d) and 70(0/5).

Maihuenia. M. patagonica seeds DS 2 y or 3 y germ. 70 GA-3(6/7 in 3rd d), 70-40-70 GA-3(5/6 in 2-7 w), 40-70(2/7 on 5th d), and 70-40-70(2/26 on 2nd d). Note that the prior 70-40 treatment markedly slowed down the rate of germination in 70 GA-3 although the percent germination was the same. A prior 3 m at 40 also removes some of the chemical block but is not as effective as GA-3. Another sample failed to germinate (both 0/3) (GZ).

Maihueniopsis. M. glomerata germ. only in 70 GA-3(2/3 in 4-8 w), and none germ. (0/4) in 70 GA-3 if preceded by a 70-40 treatment. M. sp. Yocalla failed to germinate.

Mamillaria. M. apamiensis pratensis germ. 70 GA-3(9/16 in 8-10 d) and 70(3/11 in 50th d). M. apozolensis saltensis germ. 70 GA-3(6/8 in 8-12 d) and 70(9/13 in 20-50 d). M. aurihamata germ. 70 GA-3(26/40 in 8-12 d) and 70(4/8 in 10-50 d). M. backebergiana germ. 70 GA-3(0/15) and 70(1//7 in 25th d). M. bocasana f. roseiflora germ. 70 GA-3(17/38 in 5-12 d) and 70(11/38 in 7-17 d) (KR). M. carnea failed to germinate (0/15 and 0/9). M. gueizowiana germ. 70 GA-3(3/6) and 70(0/6) (GZ). M. lasiacantha germ. 70 GA-3(3rd d) and 70(4th w)(KR). M. melacantha germ. 70 GA-3(2/7) and 70(0/7) (GZ). M. senilis germ. 70 GA-3(2/6) and 70(1/6) (GZ). M. theresae germ. 70 GA-3(4/5 in 8-12 d) and 70(0/5) (KR).

Matucana. M. formosa germ. 70 GA-3(6/21 in 8-10 d) and 70(0/7). M. haynei germ. 70 GA-3(11/14 in 9th d) and 70(1/5 in 25th d). M. roseo-alba germ. 70 GA-3(13/16 in 8-10 d) and 70(0/9).

Melocactus. M. amoenus failed to germinate (0/16 and 0/7). M. bahiensis failed to germinate (both 0/6) (GZ). M. concinnus germ. 70 GA-3(1/17 in 30th d) and 70(0/6). M. loboguerreroi germ. 70 GA-3(4/14 in 8-30 d) and 70(0/9). M. oaxacensis germ. 70 GA-3(1/3 in 6th w) and 70(0/10).

Micranthocereus. M. auri-azureus failed to germinate (0/16 and 0/11). M. strekereii germ. 70 GA-3(1/14 in 22nd d) and 70(1/8 in 18th d).

Mila. M. fortalezensis germ. 70 GA-3(2/21 in 11th d) and 70(1/7 in 26th d). M. pugionofera germ. 70 GA-3(1/21 in 11th d) and 70(1/9 in 24th d).

Morawetzia. M. sericata germ. 70 GA-3(14/16 in 8-10 d) and 70(5/10 in 20-24 d).

Myrtillocactus. M. geometrizans germ. 70 GA-3(13/13 in 9-11 d) and 70(3/8 in 20-26 d).

Neobessya. N. missouriensis ripens and exposes the fruit, a red berry, in April from the previous years bloom. After WC seeds collected April 27 germinated 80% in 8-10 d and seeds collected April 1 germinated 65-80% in 3-6 w.

Neobuxbaumia. N. tetetzo germ. 70 GA-3(3/14 in 4th d) and 70(0/7).

Neocardenassia. N. herzogiana failed to germinate (0/12 and 0/5).

Neoevansia. N. diguetii germ. 70 GA-3(1/7 in 9th d) and 70(0/4).

Neolloydia. N. conoidea germ. 70 GA-3(4/14 in 4-10 d) and 70(1/8 in 15th d). A second sample germ. 70 GA-3(7/17 in 5-11 d) and 70(0/8). These results are in agreement with GZ who found 70 GA-3(4/6) and 70(0/6).

Neoporteria. N. chilensis albidiflora germ. 70 GA-3(16/19 in 8-14 d) and 70(5/7 in 9-27 d). N. coimasensis germ. 70 GA-3(5/13 in 8-14 d) and 70(6/8 in 12-33 d), and a second sample germ. 70 GA-3(13/17 in 9-25 d) and 70(2/5 in 14-19 d). N. curvispina kesselringianus germ. 70 GA-3(11/15 in 10-16 d) and 70(4/6 in 12-20 d). N. sp. germ. 70 GA-3(11/15 in 8-24 d) and 70(4/7 in 8-45 d).

Neoraimondia. N. roseiflora germ. 70 GA-3(6/15 in 12th d) and 70(0/5).

Neowerdermannia. N. worwerkii failed to germinate (0/14 and 0/6).

Notocactus. N. agnetae germ. 70 GA-3(8/13 in 12th d) and 70(2/2 in 12th d). N. ampliocostatus germ. 70 GA-3(2/12 in 12th d) and 70(4/8 in 6-16 d). N. bueneckeri failed to germinate (0/12 and 0/5), and this was confirmed by GZ. N. purpureus meugelianus germ. 70 GA-3(4/14 in 12-16 d) and 70(0/7). N. rutilans failed to germinate (both 0/6) (GZ).

Obregonia. O. denegrii germ. 70 GA-3(4/7 in 4-16 d) and 70(2/5 in 12-18 d), but GZ found it germ. 70 GA-3(2/4) and 70(0/4).

Opuntia.

O. basilaris "double dark pink from Utah" germ. 70 GA-3 (55% in 1-7 w), 70D(13% in 8-10 d)-40-70(17% in 2nd w), 40-70D(20% in 6-8 d), and 10% in April in outdoor treatment. The amount of DS on the above seeds was unknown. Seeds given an additional 10 m DS germ. 70 GA-3(36% in 2nd w) and 70D(20% in 2nd w). Seeds given an additional 2 y DS germ. 70 GA-3(5/14 in 2nd w) and 70(5/25 in 2nd w). The DS for 3 additional years had little effect.

O. basilaris v. woodburyii "double dark pink" germ. 70D(55% in 8-12 d)-40-70(10%), 70 GA-3(73% in 1-7 w)-40(7%)-70(20% on 5th d), 40-70D(26% in 1-6 w), and 88% in April in outdoor treatment. The amount of DS on the above seeds was unknown. Seeds given an additional 10 m DS germ. 70(4/16 in 2nd w). Seeds given an additional 2 y DS germ. 70 GA-3(6/9 in 2-6 w) and 70(2/12 in 1-5 w). The behavior in 70 GA-3 treatment indicates that DS for an additional 3 y had little effect.

O. basilaris (pink from Utah) failed to germinate.

O. basilaris (pale yellow) germ. 70 GA-3(3/15 in 6-11 w) and 70(none).

O. chisosensis failed to germinate.

O. clavata germ. 70 GA-3(1/6 on 10th d) and 70(none).

O. cyclodes failed to germinate in two samples.

O. engelmannii failed to germinate.

O. erinacea germ. 70 GA-3(6/24 in 3rd w) and 70(1/11 on 14th d), and a second sample germ. 70 GA-3(4/10 in 9-17 d) and 70(4/10 in 9-17 d) (KR).

O. erinacea ursina (KR) germ. 4/10 in 2nd w in either 70 or 70 GA-3.

O. fragilis, KW reports that seed of Opuntia collected in the wild in Alberta germ. immediately at 70. Presumably this Opuntia is O. fragilis.

O. gilvescens failed to germinate.

O. gregoriana failed to germinate.

C. imbricata germ. 70 GA-3(70% in 1-4 w) and 70D(40% in 3rd w).

O. nicholii germ. 70-40-70(2/4 in 2nd w) and none in 70 GA-3.

O. humifusa seeds from my plantings germ. only in 70 GA-3 and none in any other treatment so that all data refers to 70 GA-3 treatment. All seeds were WC for 7 d before further treatment. This was necessary to remove the water soluble viscous gum that encloses the seeds inside the fruit. Fruits collected in spring (10 months after flowering) gave better germination than fruits collected in the fall (5 months after flowering), however, this difference disappeared after 1 y of DS.

Seeds of O. humifusa collected in spring germ. 70 GA-3(25% in 4-6 w)-40-70D(20% in 2nd w) when fresh and 70 GA-3(84% in 3-11 w) after 6 m DS. This data is for seed DS in a cleaned and washed state. If the seeds are DS 1 y in the dried fruits, germination is only 5% showing that this is detrimental.

Seeds of O. humifusa collected in the fall will not germinate fresh, but after 1 y DS in the cleaned state they germ. 70 GA-3(92% in 2-5 w).

A sample of O. humifusa seed collected in Colorado germ. 70 GA-3(12% in 7-11 w), 40-70D(7% in 3rd w), and 70-40-70(5%). It is not known whether this germination in both 70 GA-3 and 70D was because the seeds were from a different strain or whether the pattern had been altered by extensive DS.

O. joconosiele germ. 70 GA-3 (2/8 in 4th and 6th w)-40-70. After these three cycles more GA-3 was added whereupon 1/8 germ. on 8th d. After a 70D-40-70D treatment GA-3 was added whereupon 3/9 germ. 2-4 w.

O. macrocentra failed to germinate.

O. phaecantha (Oklahoma pancake opuntia) germ. 40-70-40-70(1/70) and none in 70 GA-3 or OT and none in 70 GA-3 or 70 after 2 y DS. O. phaecantha Oklahoma failed to germinate both when received and after an additional 2 y DS.

O. polycantha hyb. germ. 40-70(2/9 in 1-5 w) and none in 70D or 70 GA-3. Seeds given a 70-40-70 treatment followed by GA-3 germ. 1/6 in 4th w.

O. polyacantha "Crystal Tide" germ. 70 GA-3(5/14 in 2-6 w)-40-70(1/14 on 8th d) and 70-40-70(1/12 on 10th d).

O. polyacantha hystricina germ. 70 GA-3 (1/6 in 3rd w) and none in other treatments.

O. pottsii germ. 70D-40-70D-70 GA-3(1/7 in 4th w)-40-70(1/7 in 12th w) and none in four cycles starting with70 GA-3, 70D, or 40.

O. sanguinicula failed to germinate.

O. tuna seeds DS 0, 2 y, and 3 y germ. 12% in 7th w, 90% in 1-3 w, and 74% in 1-4 w in 70 GA-3 and 0%, 64% in 1-6 w, and 33% in 1-4 w in 70D. It is evident that two processes are occurring in DS. One is the disappearance of the GA-3 requirement, but superimposed on this is a dying of the seeds.

O. woodsii failed to germinate.

Oreocereus. O. celsianus seeds DS 2 y germ. 70 GA-3(8/12 in 10-16 d) and 70(3/12 in 12-18 d), and after 3 y DS it germ. 70 GA-3(1/20 on 17th d) and 70(4/36 in 5th w). O. hendriksenianus germ 70 GA-3(7/19 in 10-18 d) and 70(1/7 in 25th d).

Pachycereus. P. pectin-aboriginum germ. 70 GA-3(5/10 in 9-21 d) and 70(0/6).

Parodia. P. amblayensis germ. 70 GA-3(4/14 in 8th d) and 70(0/7). P. aureispina germ. 70 GA-3(6/16 in 14-20 d) and 70(0/15). P. cabracoraliensis germ. 70 GA-3(4/13 in 12th d) and 70(0/8). P. comarapana germ. 70 GA-3(8/15 in 8-12 d) and 70(0/8). P. laui germ. 70 GA-3(1/7) and 70(0/7) (GZ). P. mazanensis failed to germinate (0/14 and 0/7). P. microthele germ. 70 GA-3(4th w) and 70(5th w). P. minuta germ. 70 GA-3(2/7 and 70(0/7) (GZ).

Pediocactus. The following results indicate that the GA-3 requirement for germination of fresh seed disappears on several years DS.

P. peeblesianaus that had been DS perhaps 2 y (not known exactly) germ. 70 GA-3(2/3 in 4th w) and 70D(1/2 in 4th d).

P. simpsoni seeds that had been DS for several months germ. 70 GA-3(21/30 in 1-4 w) and 70D-40-70(2/11 in 2-10 w). A sample that had been DS for perhaps two years (not known exactly) germ. 70 GA-3(2/6 in 2nd w) and 70D(1/4 in 2nd w).

Pelecyphora. P. aselliformis germ. 70 GA-3(3/6 in 9-13 d) and 70(1/4 in 17th d).

Peniocereus. P. greggii transmontanus germ. 70 GA-3(6/8 in 8th d) and 70(2/4 in 18-24 d).

Phytolace. P. dioica seeds DS 1 y germ. 70 GA-3(2/12 in 13th w) and none in 70. Fresh seeds failed to germinate in either 70D or 70 GA-3.

Polaskia. P. chichipe germ. 70 GA-3(14/25 in 8-20 d) and 70(5/7 in 26-50 d).

Pyrrhocactus. P. bulbocalyx germ. 70 GA-3(1/16 in 11th d) and 70(0/7). P. sanjuanensis germ. 70 GA-3(6/15 in 8th d) and 70(1/7 in 21st d). P. umadeave seeds DS 12 y germ. only in 70 GA-3.

Rathbunia. R. alamosensis germ. 70 GA-3(9/12 in 8-33 d) and 70(3/8 in 8-16 d).

Rauheocereus. R. riosaniensis germ. 70 GA-3(1/15 in 11th d) and 70(0/11).

Rebutia. R. hybrids germ. 70(28-42 d). R. marsoneri germ. 70 GA-3(2/7) and 70(0/7) (GZ). R. narvaecensis germ. 70 GA-3(2/6) and 70(0/6) (GZ).

Rhipsalis. R. baccifera failed to germinate (0/18 and 0/6).

Sclerocactus. S. glaucus germ. 70 GA-3(3/4 in 1-3 w), 40-70(1/3) and 70(none). S. nevadensis germ. 70 GA-3(1/4 in 10th w) and 70(0/3). S. parviflorus failed to germinate, confirmed by GZ. S. pubispinus germ. only with GA-3(1/4 in 8th w). S. spinosior failed to germinate (both 0/4) (GZ). S. whipplei v. roseus germ. 70 GA-3(4/15 in 12-18 d) and 70(0/15).

Schlumbergera. S. truncata germ. 70 GA-3(8/15 in 14-20 d) and 70(0/12).

Seticereus. S. icosagonus germ. 70 GA-3(11/21 in 8-20 d) and 70(1/7 in 19th d).

Stenocereus. S. griseus germ. 70 GA-3(14/15 in 4th d) and 70(0/5). S. stellatus germ. 70 GA-3(7/20 in 8th d) and 70(0/7). S. thurberi germ. 70 GA-3(7/9 on 4th d) and 70(9/9 on 4th d) (KR).

Stephanocereus. S. leucostelie germ. 70 GA-3(10/14 in 26th d) and 70(0/6).

Stetsonia. S. coryne germ. 70 GA-3(14/19 in 8-14 d) and 70(0/7).

Strombocactus. S. disciformis failed to germinate (both 0/10).

Sulcorebutia. S. totorensis lepida germ. 70 GA-3(2/5) and 70(0/4) (GZ).

Tephrocactus. T. alexanderi bruchii germ. 70 GA-3(1/8 on 8th d) and 70(0/8), and a second sample failed to germinate (both 0/5). T. articulatus campana germ. 70 GA-3(6/14 in 17-29 d) and 70(0/5), and a second sample failed to germinate (both 0/5). T. articulatus Chilecito germ. 70 GA-3(1/6 on 15th d) and 70(0/6), and a second sample failed to germinate (both 0/10). T. (T. A. B. Pomen) germ. 70 GA-3(4/8 in 14-18 d) and 70(0/12). T. rauhii failed to germinate in 70D or 70 GA-3.

Thelocactus. T. bicolor germ. 70 GA-3(13/19 in 8-12 d) and 70(4/9 in 26-33 d). T. conothele germ. 70 GA-3(6/17 in 6-10 d) and 70(8/14 in 8-26 d). T. hexaedrophorus germ. 70 GA-3(2/6) and 70(2/6) (GZ). T. leucacanthus schmollii germ. 70 GA-3(3/15 in 8-12 d) and 70(0/8). T. tulensis failed to germinate (both 0/6) (GZ).

Thrixanthocereus. T. blossfeldiorum germ. 70 GA-3(14/14 in 4th d) and 70(12/13 in 8-12 d).

Toumeya. T. papyracantha germ. 70 GA-3(4/6 in 11-15 d) and 70(0/13), and a second sample failed to germinate (both 0/5).

Trichocereus. T. bridgesii germ. 70 GA-3(6/7 in 8-10 d) and 70(6/13 in 12-44 d). T. bruchii nivalis germ. 70 GA-3(9/14 in 8-10 d) and 70(2/8 in 32-55 d). T. formosus germ. 70 GA-3(12/14 in 8-16 d) and 70(10/10 in 16-42 d). T. pachanoi germ. only with GA-3(12th d).

Turbinocarpus. T. lophophoroides germ. 70 GA-3(13/17 in 8-14 d) and 70(1/8 in 21st d). T. polaskii germ. 70 GA-3(7/13 in 8th d) and 70(2/10 in 14-18 d).

Uebelmannia. U. gummifera germ 70 GA-3(1/5 in 21st d) and 70(0/6).

Vatricania. V. guentheri germ. 70 GA-3(12/16 in 8-16 d) and 70(4/10 in 14-30 d).

Weberbauerocereus. W. johnsonii germ. 70 GA-3(12/12 in 8-10 d) and 70(12/14 in 10-16 d).

Weingartia. W. hediniana germ 70 GA-3(1/14 in 12th d) and 70(1/8 in 14th d). W. longigipba germ. 70 GA-3(3/13 in 8th d) and 70(3/12 in 16-28 d).

Zygocactus. Z. truncatus germ. 70 GA-3(1/50 on 5th w) and 70(4/60 in 4th w). The remaining seed coats appeared empty so that germination was really 100%.

SECTION VI. ARIL IRIS

This Chapter could not have been written without the help of Sharon McAllister of Fairacres, New Mexico, and Samuel N. Norris of Owensboro, Kentucky. Both communicated unpublished results, and both sent reprints of critical papers that had been published in the Yearbooks of the Aril Society International (ASI), the Quarterly Bulletins of the American Iris Society (AIS), and the semi-annual Newsletter of the Species Iris Group of North America.

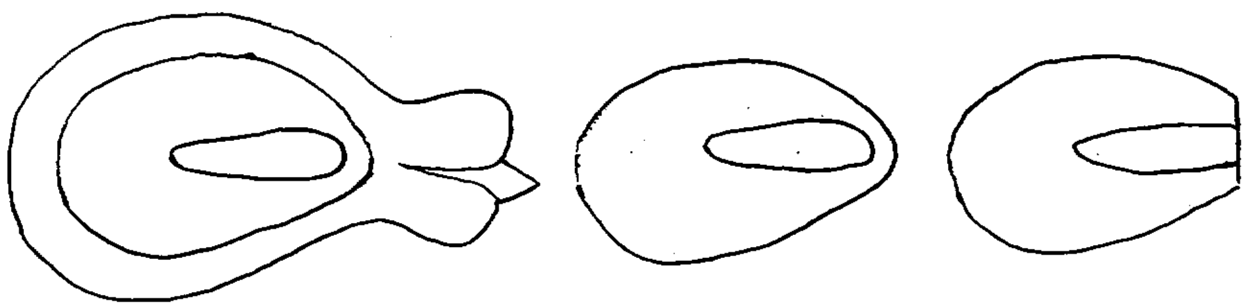
Seeds of Juno, Oncocyclus, and Regelia Iris are characterized by having a fleshy aril attached to the seed giving them the name Aril Iris. It has been known for a long time that seeds of this group have germinations which extend over a number of years under natural conditions. There are reports that natural germination can extend for up to ten and even twenty years. This coupled with the susceptibility of Aril Iris to rot has made them rare in cultivation despite their fantastic beauty.

David Shahak (AIS Yearbook 1991) extensively studied ten species of Oncocyclus Iris. There is some germination the first year under outdoor conditions, but this is generally of the order of 1-10% and only rarely is it higher. The amount of germination in the first year depends not only on the species but it varies with crops from different years and from different seed pods in any one year. Neither soaking the seeds nor gibberellin treatments initiate germination, and this agrees with my work. In summation, germination of Aril Iris can be characterized as erratic and extended under traditional procedures.

Four treatments have been found to speed up germination. These four are termed slicing, embryo culture, green seed, and OS (oscillating temperatures). The success of all four treatments is interpreted as being due to a physical barrier at the micropylar end of the seed. This barrier prevents growth of the embryo. A remarkable aspect of this barrier is that it can reheal and reform the barrier if the slicing of it is not deep enough. It is doubtful that any chemical inhibitor is involved to any significant extent.

Treatment 1. Two papers by Samuel Norris (ASI Yearbooks 1975 and 1980) presented the first detailed description of this technique. A sketch taken from the 1980 paper is shown below to illustrate where the cut is made. The cut is made with a razor blade usually with the help of magnification of some sort. If a more shallow cut is made, it appears to heal and reestablish the barrier (such seeds can be resliced). If significantly deeper cuts are made, the embryo attempts to germinate but is fatally injured. This technique was first reported in 1906 (W. Crocker, Bot. Gazette), but the species of Iris that was studied was not identified.

SEED: Untreated Peeled Peeled and Sliced



The success of this slicing technique has been confirmed by John and Kay Tearington (ASI Yearbook 1979), David Shahak (ASI Yearbook 1991), and Sharon McAllister (ASI Yearbook 1994). In addition Poljakoff-Mayber and Coworkers (ASI Yearbook 1992) conducted extensive physiological experiments that supported the concept that there was a physical barrier at the micropylar end of the seed.

There is some question as to how to treat the seeds before and after making the surgical slice. Norris suggests holding the seeds for at least five weeks warm and moist followed by peeling the seed and surface sterilizing the seed with 2% aqueous sodium hypochlorite. The seeds are then sliced and placed in moist vermiculite at about 40 for three to nine weeks, and returned to 70. After a week the radicle and cotyledon will be developing.

McAllister reports that the seeds need to be peeled only at the end where the slice is made and that the the hypochorite wash was not necessary. My own suggestion would be to conduct all treatments in moist paper towels and polyethylene bags up to the stage where leaf formation begins. This would reduce problems of rot. Of course the bags must be kept aerobic by keeping them slightly open as discussed in Chapter 3 of the Second Edition.

Both McAllister and Norris found that pricking with a pin was ineffective. This would be expected for the same reason that shallow cuts fail.

The slicing technique requires careful manipulation generally under some kind of magnification. It is not convenient for most growers and is not applicable to commercial production.

Treatment 2. There are several papers (Holden, ASI Yearbook 1986 for example) reporting success in germinating Aril Iris seeds using embryo culture. Embryo culture has been used for a long time for the germination of seeds of Lilium that were derived from wide crosses. It has been shown with Lilium that a specific chemical in the endosperm destroys the embryo or prevents its growth. Readers interested in embryo culture are referred to the articles that have appeared in the Bulletin of the North American Lily Society. Embryo culture is difficult and tedious and would not be convenient for commercial or amateur growers. For this reason embryo culture has not received much treatment in the Second Edition or in this Supplement.

Treatment 3. The seed capsules of Juno Iris become dry and tan while the cluster of seeds inside are still green. Seeds of Juno bucharica collected on 6-14-95 at this green stage germinated 70-40(5/6 in 9-12 w) whereas seeds from the same plants collected two weeks later on 7-1-95 failed to germinate in six months under identical treatment or any other treatment. The most attractive interpretation is that such green seeds had not hardened the impervious membrane inside the seed.

This treatment has been tried only on Juno bucharica and on small samples. Much wider trials are needed using larger samples, more variations in the time of collection, and a wider variety of Aril Iris species. However, this method will always suffer because such green seeds are not generally available from collectors, commercial sources, or seed exchanges. It also requires a careful timing for the collection of the seeds.

- 100 -

Treatment 4. This treatment involves oscillating temperatures (OS). The following recent result illustrates the method.

Seeds of Juno bucharica were collected on 7-1-95. These were subjected for three months to temperatures oscillating between 40 and 70 every twelve hours. They were then shifted to 40 whereupon 6/18 germinated in 9-12 weeks. All other treatments including 70-40 gave more extended germinations.

McAllister has conducted several variations of the oscillating temperature technique and found that it promotes germination and gives healthier seedlings (ASI Yearbook 1994 and Fall 1995 Bulletin of the Species Iris Group of North America). Her recommended treatment is to keep the seeds moist at 70 for a month, then shift them to 40 for at least a month and generally several months, then give them oscillating temperatures. An additional advantage of this treatment is that it give healthier seedlings as often happens when the optimum conditions for germination have been found.

Oscillating temperatures have long been known as a method of rupturing impervious inner and outer seed coats. They could thus be expected to be effective in rupturing internal impervious membranes. However, McAllister reports that subjecting seeds to two oscillations between 32 and about 120 was ineffective. Experiments are in progress on Juno bucharica where the seeds were given four or ten oscillations between 32 and 120. The upper limit of 120 is suggested since temperatures above 140 are generally fatal (see Section II i).

Conclusions. The presence of an impervious barrier within the seed seems to be established as the primary barrier to germination in Aril Iris. The ability of this barrier to reheal minor punctures has confused the problem. Much more work is needed in using oscillating temperatures (McAllister's enhanced germination) because such a non-invasive technique would be adaptable to commercial production and easy application by horticultural enthusiasts.

VII CONTRIBUTORS

The following people contributed seeds that were particularly important to this supplement of the second edition of Seed Germination Theory and Practice.

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VIII SOURCES FOR SEEDS

In the course of my studies on rates of germination of over 4000 species, seeds have been received from over 150 sources. Three generalization have emerged. (a) The seeds are remarkably true to name from all sources. (b) The seeds are viable over 95% of the time. (c) The information on germination has been inadequate. What is often taken for dead seed was in fact lack of knowledge of the germination pattern.

There is only a small percentage of commercial seeds that are distributed dead. As expected these are species with high death rates in dry storage. Aconitums and Corydalis are examples, and these are perhaps the two genera whose seed are most often dead when sold. Probably one should avoid purchasing seeds of these genera unless special provisions have been made for immediate delivery.

A few genera are noteworthy for producing large amounts of empty seed coats. This can readily be ascertained by opening the seed. Adonis vernalis is a classic example. Many Pinaceae also have this characteristic.

Several seed companies are making a strong effort to cooperate with my program and to upgrade their information on germination. Noteworthy are Alan D. Bradshaw of Alplains, Bob and Brigitta Stewart of Arrowhead Alpines, Kristl Walek of Gardens North, Richo Cech of Horizon Herbs, J. L. Hudson of J. L. Hudson Seeds, Ron Ratko of Northwest Native Seeds, Gwen and Panayoti Kelaidis of Rocky Mountain Rare Plants, and Keith Sangster and Lisa Crowning of Thompson and Morgan. It is my view that if the public receives accurate information on germination, they will have more success, and interest in growing plants from seeds will increase.

The following problem will not have much effect on your growing plants from seed, but it deserves comment. Seeds are said to be tested under rules and guidelines of the Association of Official Seed Analysts and the International Rules for Seed Testing. This sounds official, but it is doubtful that any testing procedure was used that involved either gibberellic acid-3 or some of the other complex patterns that have been found necessary for germination of many species. Some states require all commercial seed to be tested. What have they been doing? In many instances they have depended on the well-known test with tetrazolium salts and not on actual germination tests. One has to be sympathetic with their position because often it would take a year or more to conduct a true germination test even if the germination pattern were known. Nevertheless growers should be aware that the phrase "tested seeds" is not quite what might be inferred.

To turn to a more positive note, the following is a list of seed sources with a few comments about some of the sources. Most of the commercial seed sources ask one to two dollars for their catalog or seed list so that it is probably appropriate to send this to them when making inquiries.

Seed Exchanges of International Horticultural Societies. Most of the international horticultural societies maintain seed exchanges. By far the most extensive are the seed exchanges of the American Rock Garden Society, The Alpine Garden Society, and the Scottish Rock Garden Club. Each of these three lists contain about 6000 entries. While some of these entries are named clones and hybrids, there are over 5000 botanical species represented. The American Rock Garden Society has instituted a seed exchange for species whose seed dies quickly in dry storage where the seed is distributed shortly after collection. You must be a member of these societies to participate in these seed exchanges. If there is any complaint about seeds from these exchanges it is that the amounts of seed are often small, sometimes being as few as three seeds per packet. The addresses of some of these societies are as follows. If your society conducts a seed exchange and is not listed below, contact me and it will be included in the next supplement.

American Rock Garden Society, Jacques Mommens, Secretary, P. O. Box 67, Millwood NY 10546, U.S.A.

The Alpine Garden Society, Mike Hall Seed Chairman, AGS Centre, Avon Bank, Pershore, Worcestershire WR10 3JP ENGLAND

American Rhododendron Society, George Woodward Seed Chairman, Box 531, 55 Post Road, Westbury NY 11590

The Cycad Society, c/o William Tang, Fairchild Tropical Garden, Miami FL 33156

The Rock Garden Club of Prague, Mrs. Eva Hajkova Mimonska, 12/639, 190 00 Prague 9, CZECHOSLOVAKIA

Scottish Rock Garden Club, Hon. Treasurer Ian Aitchison, 20 Gorse Way, Formby, Merseyside, L37 1PB United Kingdoms

Cactus and Succulent Society, Mindy Fusaro, CSSA, Box 35034, Des Moines IA, U. S. A. 50315-0301

Cyclamen Society, Vic Asplund, 12 Davis Avenue, Tipton, West Midlands DY4 8JZ ENGLAND

Commercial Seed Sources. This list is far from complete. If your company is not listed, please notify me and I will include it in a further supplement. An asterisk signifies that I have not dealt with this source.

Alplains, 32315 Pine Crest Court, Kiowa CO 80117, U. S. A. (An extrensive list largely of seed collected in the Rockies)

Androsace, Massimo Bruatto, via G. Garibaldi 57, 10122 Torino, ITALY

Jim and Jenny Archibald, "Bryn Collen", Ffostrasol, Llandysul, Dyfed, Wales, United Kingdoms SA44 5SB (a remarkable list of seeds offered nowhere else that are largely derived from collecting expeditions to the Andes and to Turkey)

*Dr. A. N. Berkutenko, c/o Lois Ann Zurbrick, P. O. Box 210562, Anchorage, Alaska, U. S. A. 99521 (A list of 120 rare species from Russia)

*Box-74, 70800-Ostrava-8, CZECH REPUBLIC (seeds collected from several countries in Europe and Northwest China)

Burpee Seed Company (common garden annuals and vegetables)

Chris Chadwell, 81 Parlaunt Road, Slough, Berks., SL3 8BE ENGLAND

*Chiltern Seeds, Bortree Stile, Ulverston, Cumbria LA12 7PB ENGLAND (Claims to offer 4000 items)

Jim and Jenny Archibald, 'Bryn Collen', Ffostrasol, Llandysul, Dyfed, SA44 5SB, Wales, United Kingdoms

*Cook's Garden, P. O. box 535, Londonderry VT 05148

Doug Elsasser, Parkland Botanicals, Box 175, Togo, Saskatchewan CANADA S0A 4E0

Gardens North, Kristl Walek, 5984 Third Line Road North, RR #3, North Gower, Ontario, K0A 2T0 CANADA (excellent germination instructions and a focus on seeds of plants hardy in Canada)

Horizon Herbs, P. O. Box 69, Williams OR 97544 (largely herbs and medicinal plants)

J. L. Hudson, Seedsman, P. O. Box 1058, Redwood City CA 94064 (a fine list of unusual species from all over the World)

Ion Exchange, Howard and Donna Bright, 1878 Old Mission Drive, Harpers Ferry IA 52146-7533 (Wild collected seed from Midwest U. S.)

*V. Jane, P. O. Box 1, 78961 Bludov, CZECH REPUBLIC (Seeds collected in the wild in Europe)

Jellitto, Postfach 1264, D-29685 Schwarmstedt, GERMANY (A long list of a variety of species); North American Office, Allen W. Bush, 125 Chenoweth Lane, Louisville KY 40207

*Karmic Exotic Nursery, Box 146, Shelburne, Ont. LON I5O CANADA

*Larner Seeds, P. O. Box 407, Bolinas CA 94924

Mesa Garden Seed List, P. O. Box 72, Belen NM 87002 (a remarkably long list of seeds of species of cactus and other succulents)

*Missouri Wildflowers Nursery, 9814 Pleasant Hill Road, Jefferson City MO 65109 (Seeds of Midwest U. S. native plants)

Natural Legacy Seeds, R.R. 2, C-1 Laird, British Columbia, VOE 1BO CANADA

Northwest Native Seeds, Ron Ratko, 915 Davis Place South, Seattle WA 98144 (Another excellent list of seeds collected in the Rockies)

Of the Jungle, Box 1801, Sebastopol CA 95473

The Onion Man, Mark McDonough, 30 Mount Lebanon Street, Pepperell MA 01463 (extraordinarily complete list of seeds of the genus Allium)

Park Seed Company, Cokesbury Road, Greenwood SC 29647-0001 (limited list of common garden annuals and vegetables)

*Mojmir Pavelka, P. O. Box 95, 74101 Novy Jicin, CZECH REPUBLIC

Plants of the Southwest, 930 Baca Street, Santa Fe NM 87501 (an extensive list of seeds of species from Southwest U. S.)

Prairie Nursery, P. O. Box 306, Westfield WI 53964 (a complete collection of native midwestern U. S. wildflowers)

Rocky Mountain Rare Plants, P. O. Box 200483, Denver CO 80220 (An excellent list of seeds collected in the Rockies)

*Seederama, P. O. Box 3, Charlestown, New South Wales 2290, AUSTRALIA
*Seed Savers Exchange, 3076 N. Winn Road, Decorah IA 52101
Southern Business Express, Seeds Division, 3421 Bream Street, Gautier MS 39553
*Southern Seeds, The Vicarage, Sheffield, Camnterbury, NEW ZEALAND (Seeds collected in New Zealand)
*Stokes, Box 548, Buffalo NY 14240
Thompson and Morgan, (Largely common garden plants but some unusual ones)
John Watson, 24 Kingsway, Petts Wood, Orpington, Kent, BR5 1PR ENGLAND
Wildginger Woodlands, P. O. Box 1091, Webster NY 14580 (small list of wildflowers and ferns native to Eastern U. S.)

Botanical Expeditions. These are usually advertised in the Bulletins of International Horticultural Societies and are on a year by year basis. One buys shares and the harvest of collected seeds is distributed to the shareholders.

Botanical Gardens. Generally these gardens will send seed lists to nurseries. They often contain species that are unavailable elsewhere. In my work I have received much seed from these sources and am much indebted to them. However, it probably not proper to suggest them as a general source of seeds. Further, the recent political changes in USSR have eliminated botanical gardens from this area as a source for the moment.

VIII REVIEW OF SYMBOLS AND ABBREVIATIONS

Letter Abbreviations

DS	dry storage, at 70 deg. F (unless otherwise noted) and with a relative humidity in the 50-80% range
WC	Cleaned and washed in water with three rinses daily usually for a period of seven days
GA-3	Gibberellic acid-3 (GA-4, GA-7, and iso GA-7 are other gibberellic acids).
Times:	d days, m months, and y years
T	temperature in degrees Fahrenheit
t	time
germ.	germinated
ind. t	This is the induction time, the time between the seeds being shifted or started in a particular cycle and the time the seeds start to germinate <u>in that same cycle</u>.
percent/d	For example 25%/d means that 25% of the seeds germinate in each day once germination starts. This is applicable to a zero order rate process where a <u>constant amount</u> germinates in each time period.
half life	This is the time for half of the seeds to germinate starting from the time that germination starts. This applicable to a first order rate process where a <u>constant fraction</u> germinates in each time period.

Number Abbreviations

D-70	A species in which the seed requires dry storage before the seeds will germinate at 70.
40-70	Seeds were subjected to 3 m at 40 followed by a shift to 70 (which typically initiated germination). This system can be extended indefinitely. For example 70-40-70-40 means that the seeds were subjected to 3 m at 70, 3 m at 40, 3 m at 70, and shifted to 40.
70D	means that the seeds were at 70 in the dark.
70L	means that the seeds were at 70 in the light (see Chapter 3, 2nd Ed. for exact conditions).
70 GA-3	means that the seeds were treated with GA-3 (see Chapter 3, 2nd Ed. for exact conditions).
40%	In referring to germination any percentage such as 40% means the percentage of normal sized seed coats that germinated. In the 2nd Ed. attempts were made to discount undersize seed coats, seed coats that readily crushed and were obviously empty, and overly thin seed coats that were empty of endosperm. A greater effort has been made in this First Supplement to discount such empty seed coats. As a result percent germinations in this First Supplement are somewhat higher for what was actually equivalent percent germinations in the Second Edition.
6-10 w	In referring to germination such time intervals indicate the time period during which germination occurred. For example 6-10 w means that germination started at the end of the 6th week and ended at the end of the 10th w.