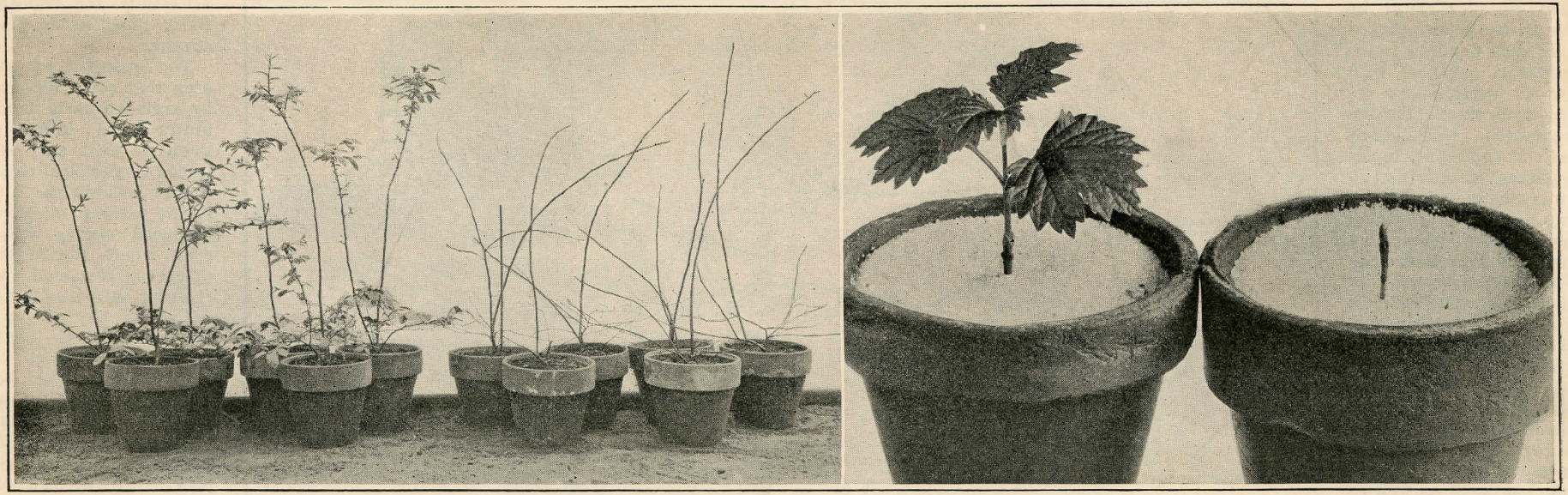

Left: The six blueberry plants at the left of this group spent the winter outdoors and were brought into the greenhouse early in the spring; one month later they had developed as shown in the picture. The plants at the right spent the winter in the greenhouse, escaping the natural chilling; and these specimens were still completely dormant when the photograph was staged. *Right:* Two yearling seedlings of the grouseberry which had been similarly treated

Demonstrating the necessity for a period of winter chilling as a prerequisite to the spring growth of plants

How Jack Frost Stimulates Plant Growth

Novel Experiments Which Go to Show That Chilling Governs All Vegetable Growth

By D. H. Georgian

ACCORDING to common belief, cold weather causes plants to become dormant during the fall, while warm weather the succeeding spring again incites new growth. Intensive investigations of Dr. Frederick V. Coville of the Federal Department of Agriculture, which have been conducted over a period of ten years and which have covered every phase of this subject, demonstrate that both of these traditional theories are erroneous. Dormancy in our native trees and shrubs begins some time before the start of cold weather each winter; the appearance of Jack Frost is not necessary for the establishment of complete dormancy. Furthermore, after such a condition of dormancy has developed exposure of the plants to the ordinary growing temperature thereafter does not arouse them from their lethargy so that they begin growth anew.

Interestingly enough, the Coville experiments show that plants which have responded to the lure of autumnal and winter dormancy will not react properly and resume normal growth the following spring unless they are subjected during the interim to a period of chilling. A certain amount of cold is essential to stimulate the plant growth—despite the old-fashioned idea that retarded growth and low temperatures were synonymous. Dr. Coville removed healthy blueberry plants during the research showed him that the plants required only exposure to prolonged chilling for a period of two or three months at a temperature reasonably close to zero. Where this chilling does not occur plants will remain dormant for periods as long as one year under circumstances where the heat, light and moisture environments are ideal for expeditious and robust growth.

The stimulating effect of cold is limited to such portions of the plant as are subjected to chilling. For example, a single blueberry plant 44 inches high which had shed its leaves and become dormant in a warm greenhouse where the average temperature was about 65 degrees, was repotted and placed in a position of southern exposure. A small opening was made in the glass of the greenhouse through which one or two of the stems of the plant were projected. The opening around the stem was then carefully plugged up with moss. Henceforward, throughout the winter, part of the plant was exposed to winter weather outside the greenhouse, while the remainder was carefully sheltered and kept warm within the plant residence. The following spring the outdoor branch grew rapidly and luxuriantly while the indoor branch continued dormant. Another test of this description was carried out, in this instance the plant being placed on a shelf out-

burst into bud under the influence of the warm weather of Indian summer and subsequently would be killed by the first heavy freeze. But our native trees and shrubs are so intimately adjusted to the changes of climate to which they have been long exposed that they are almost completely protected from injury by freezing. On the other hand, cultivated species of plants introduced from sections of the world having a climate radically different from ours are only imperfectly adapted to our climatic changes. These foreign plants attempt to grow at times when our native plants have "learned" that it is desirable to remain dormant, with the result that the majority of such venturesome trees and shrubs are killed.

To test out all this, one may during mid-autumn bring into the house and place in water freshly cut, dormant and leafless branches of a few early spring blooming plants such as the alder, hazelnut, pussy-willow, yellow bush jasmine, Japanese quince, peach or plum. They will not bloom. Repeat the performance during mid-winter and the branches cut at the later dates will bloom. The period of winter at which these plants will respond in this way depends on the time which they, respectively, require for their annual chilling. Thus the period of chilling for the peach in

which have covered every phase of this subject, demonstrate that both of these traditional theories are erroneous. Dormancy in our native trees and shrubs begins some time before the start of cold weather each winter; the appearance of Jack Frost is not necessary for the establishment of complete dormancy. Furthermore, after such a condition of dormancy has developed exposure of the plants to the ordinary growing temperature thereafter does not arouse them from their lethargy so that they begin growth anew.

Interestingly enough, the Coville experiments show that plants which have responded to the lure of autumnal and winter dormancy will not react properly and resume normal growth the following spring unless they are subjected during the interim to a period of chilling. A certain amount of cold is essential to stimulate the plant growth—despite the old-fashioned idea that retarded growth and low temperatures were synonymous. Dr. Coville removed healthy blueberry plants during the late summer from their outdoor beds and placed them in a greenhouse, where the plants were maintained at ordinary growing temperatures such as would have kept the plants in luxuriant growth during the spring and summer months. Despite these ideal environments the refractory blueberry plants refused to continue to grow, but instead shed their leaves and shortly lapsed into a condition of complete dormancy.

Subsequently these practical tests were repeated again and again with many different kinds of plants, and without exception all trees or shrubs which were natives of northern, cold climates fell asleep in the late fall and early winter irrespective of the temperature. Comparative studies of the susceptibility of indoor and outdoor specimens of the same families of plants indicated that dormancy develops a little more quickly in the plants exposed outside, evidently because their foliage is injured by freezing weather and because they drop their leaves earlier than do the indoor plants. In fact, unnatural warmth is a detriment to plant growth, inasmuch as trees and shrubs that are kept continuously warm during the winter take up their ordinary growth much later the following spring than their mates which are exposed to a period of chilling and freezing weather.

Doctor Coville's detailed tests show that the indoor plants which are not exposed annually to an era of cold weather thereafter will not bloom. On the other hand, plants which spent the cold-weather period outdoors burst into leaf and flowered luxuriantly in the spring when they were subjected to proper growing conditions. In the early stages of his investigations this scientist assumed that the plants had to be frozen to stimulate them to growth, but later on more detailed

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On one occasion Dr. Coville made 286 cuttings from dormant outdoor blueberry plants, which he stored in bundles, some in moist moss, others in birch sawdust at a temperature of about one or two degrees below freezing. He allowed these cuttings to remain in cold storage for nine months and at the end of that time, except in the case of several cuttings which mildewed and died, one or more buds had begun to swell on every cutting. This indicates that growth had begun to occur even at this low cold storage temperature. On another occasion he placed 58 cuttings from dormant outdoor blueberry plants in moist birch sawdust at a commercial cold storage temperature of about 34 degrees. Nine months later buds on every cutting had begun to grow. None of the cuttings gave a starch reaction, indicating that their transformation of stored starch into sugar was completed despite their subjection to freezing exposures.

According to Doctor Coville, the establishment of a dormant condition before the advent of freezing weather and the continuation of this dormancy through warm periods in late fall and early winter are protective armors adapted for the use of the native plants and shrubs. The principle of chilling is of the utmost importance to plant growth. If plants were constituted so that they would start growth readily in the fall under the influence of a few warm days—without the need of several months of chilling—as they do in the spring, many of our plants would begin to grow and

sections of the world having a climate radically different from ours are only imperfectly adapted to our climatic changes. These foreign plants attempt to grow at times when our native plants have "learned" that it is desirable to remain dormant, with the result that the majority of such venturesome trees and shrubs are killed.

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Chilling is a necessary event in the annual cycle of the cold-winter trees and shrubs. It is so essential that it limits the geographical distribution of such varieties of plant life. The common northern fruit trees such as apples, pears, peaches and cherries when introduced to tropical countries grow well for a while but ultimately develop dormancy and finally die because they are divorced from the customary chilling for several months a year to which they have long been accustomed. To produce fruit of this description under tropical conditions necessitates the artificial chilling of the plants at stated intervals. Uncle Sam has actually tested out various laboratory contrivances to be used in this artificial chilling.

Doctor Coville suggests that the field of investigation concerning the chilling of plants is still fertile for more comprehensive investigations as he feels that his studies have only lifted the lid which heretofore has concealed scientific facts of immeasurable importance. He believes that scientific research should now be directed toward such practical goals as the determination of the proper temperatures for the storage of seeds, bulbs, cuttings and grafting wood; the proper temperatures for the treatment of plants which are to be forced from dormancy to growth at unusual seasons; and proper temperatures for the storage of nursery stock so that the nurserymen may have the plants in proper condition for shipment on any dates satisfactory to the purchasers.