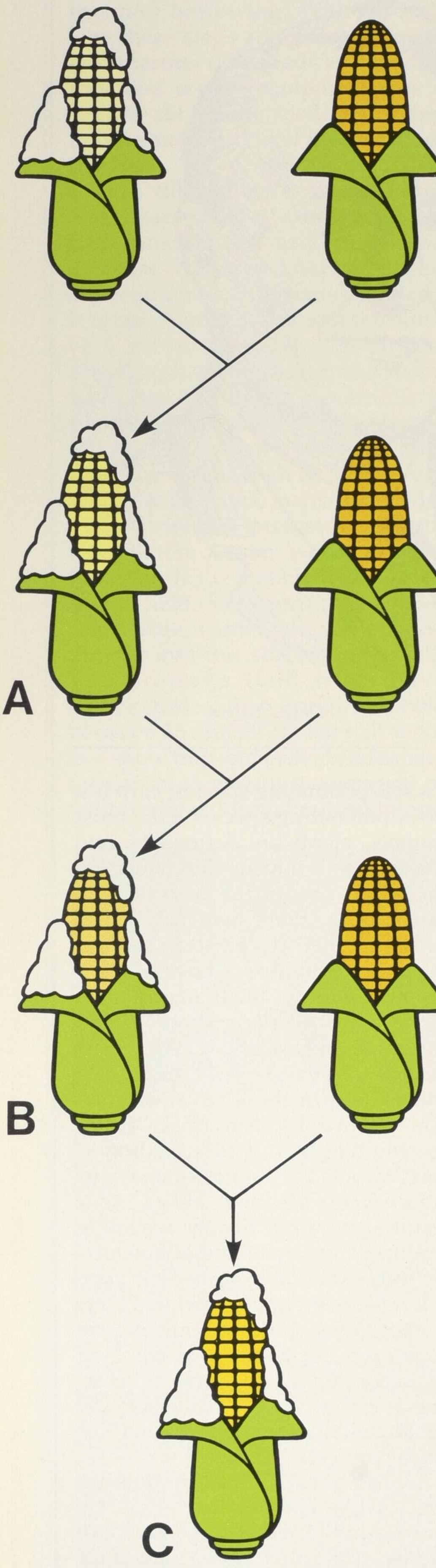

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heterozygous plant community. Offspring genotypes will not resemble parental ones, and therefore the breeder cannot predict offspring characteristics. To produce homozygous or inbred lines, artificial self-fertilization is required. In corn, the pistillate flowers (female) in the ears must be covered to exclude pollination from other plants. Pollen is collected from the plant's staminate tassel (male) and artificially applied to the pistillate flowers. Repeated application of this process over a number of generations eventually produces inbred or homozygous lines where offspring do resemble parents. This makes it possible to identify and breed varieties with desirable characteristics.

Unfortunately, inbreeding in cross-pollinating species like corn also leads to "inbreeding depression" or reduced vigour in the offspring. However, when plants from two such inbred lines are crossed, the resulting hybrid is likely to exceed in vigour even the progenitors of the original lines — a phenomenon known as 'heterosis' or hybrid vigour. Both inbreeding depression and heterosis have long been known and were in fact very clearly described by Charles Darwin in *The Origin of Species* (1859):

...there is the clearest evidence that a cross between individuals of the same species, which differ to a certain extent, gives vigour and fertility to the offspring; and that close interbreeding continued during several generations between the nearest relations, if these be kept under the same conditions of life, almost always leads to decreased size, weakness or sterility.

This knowledge, however, did not receive widespread application to agriculture until the 1940's when hybrid corn produced by crosses between inbred lines was introduced in the United States. The extremely vigorous hybrids have since come to dominate corn production in the developed world where corn yields have almost tripled in the past 40 years.

Given these modern corn breeding methods, Dr. Larter's first step in breeding cold tolerant, high-yielding corn has been to develop a number of cold tolerant inbred lines. Corn was originally domesticated from its wild ancestors in Central America and numerous types of corn are still grown in this area. Larter has acquired corn from Central American highland areas which, his tests confirm, is able to grow under cold climate conditions. The Central American corn is highly heterozygous so Larter has inbred it to produce cold tolerant homozygous lines. Currently he has about 250 inbreds to work with and he continues to develop more.

Tests for cold tolerance are carried out in growth chambers where circulating cold water baths keep soil temperatures of the immersed potted plants at a constant 10°C. Plants which perform well at such temperatures, comparable to early spring, are then subjected to field tests.

Since Larter's cold tolerant inbreds are relatively low-yielding, the second step in his breeding program is to cross these cold tolerant lines with more high-yielding hybrids currently used in commercial corn production. As in the wheat project, Larter is back-crossing progeny of these crosses to the high-yielding varieties to maintain cold tolerance while improving yields.

Backcrossing . . . pooling the best traits

The simplest way to understand what is happening in this breeding process is to take the case of two corn varieties, one with all kinds of valued traits — good weight, nutritional value, and so on — and another that has few or none of these, but, it does have one highly valued trait that the other lacks — cold resistance. The plant breeder's aim is to transfer only the cold resistance trait to the valued variety. If these two plants are crossed, and we assume that both are 'homozygous' (i.e., both chromosome sets are identical in each parent), then the first generation (A) will contain on average 50 per cent of the genetic traits of each parent. The plant breeder then searches through the members of this generation, picks out plants close to the desired parent and with cold resistance (not all will have it), and 'backcrosses' this with the desired parent (B). The B generation contains 75 per cent of the desired parental genetic traits. The breeder next searches for members of this generation with cold resistance, and again backcrosses them with the desired parent. The C generation contains on average about 88 per cent of the desired traits from the parent generation. The breeder simply repeats this process until he or she obtains a plant with all the desired characteristics of the original parent and cold resistance.