Integrating conventional and molecular genetics

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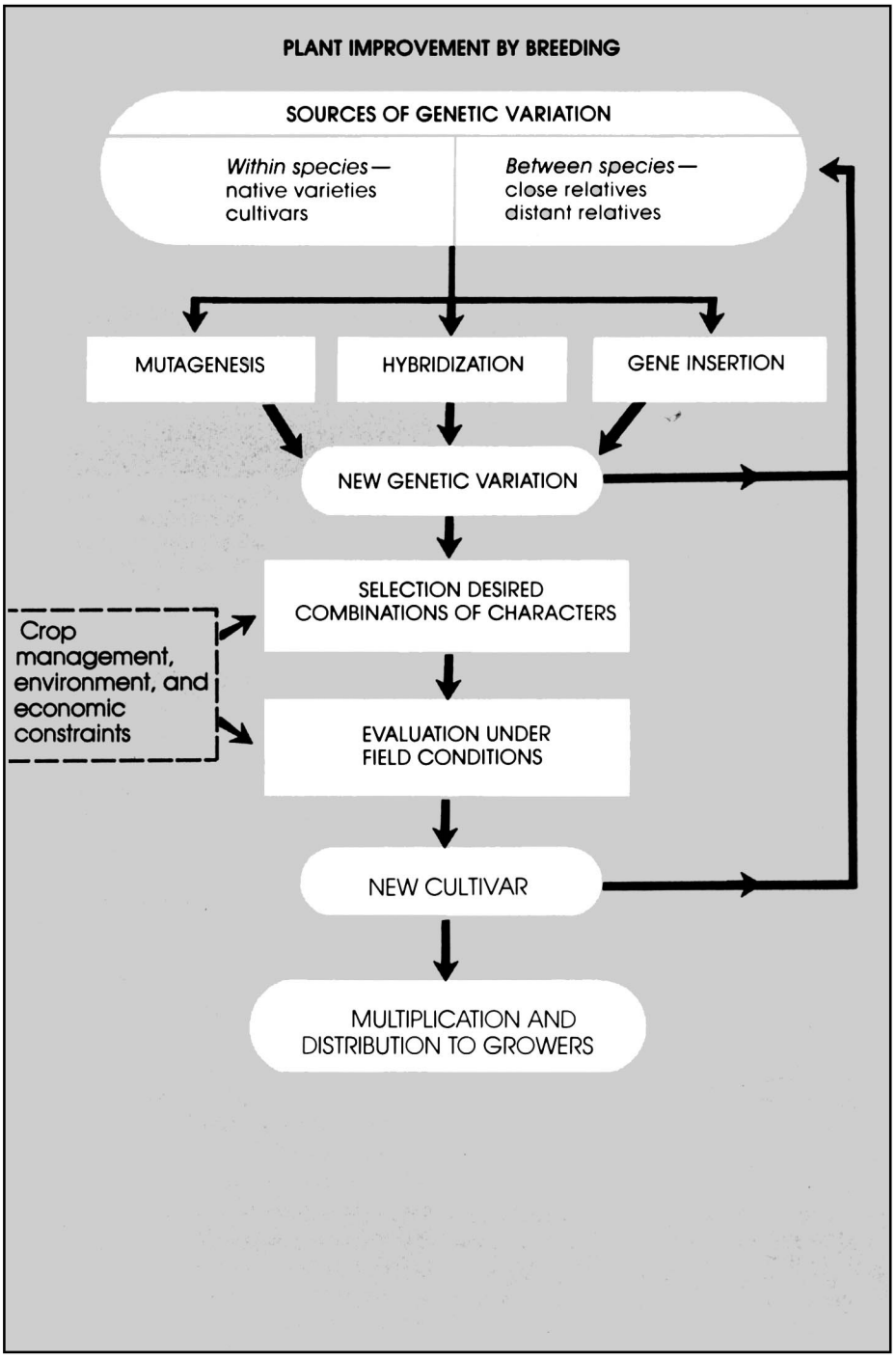
Molecular genetics offers entirely new methods for manipulating and introducing genes into plants, as has been described throughout this special issue. These are generally gene insertion methods, by which genes or larger units of genetic material are extracted from one species or cultivar and transferred into another.

It is important to recognize how this methodology fits into the general scheme of crop improvement through plant breeding. Of special note are the three methods of generating and releasing genetic variability upon which selection for desired characteristics can be applied. Mutagenesis and hybridization are well-known, effective methods that have been the cornerstones of plant breeding. Gene insertion techniques, the subject of modern or molecular plant genetic engineering (MPGE), are evolving rapidly as gene vectors are constructed and plant cell and protoplast culture techniques perfected.

It is too early to say definitely whether this new method of gene manipulation will become important in plant improvement, but there are sufficient reasons to believe it is well worth pursuing. In the accompanying box (page 30), I have itemized eight opportunities for plant breeders that may be realized by MPGE. Obviously plant breeders will show little interest in a new and complex method, if they can accomplish the same goal with existing methods. In each of the examples listed, MPGE would provide a new approach to an important plant breeding problem.

It must be emphasized that plant breeding involves extensive evaluations and selection for "fine-tuning" genotypes to the environments in which they will be used. Genetic variation released by MPGE is subject to these same evaluations. For simply inherited characteristics, the selection and evaluation phases can be rather simple, but for complexly inherited characters, they can be very time-consuming and may involve several cycles of hybridization and selection. MPGE might not be more efficient than conventional methods for complex characters such



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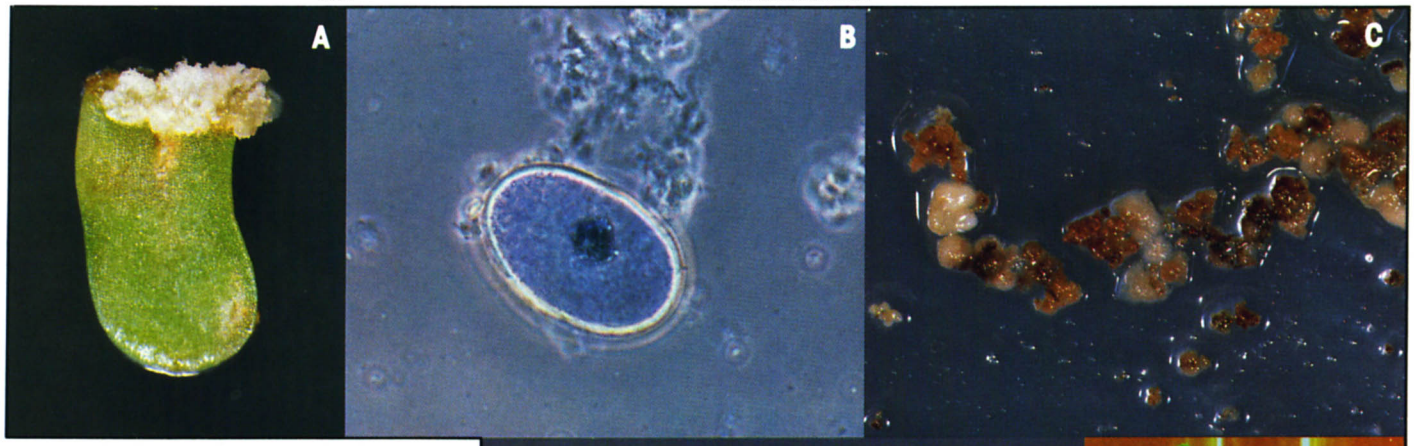

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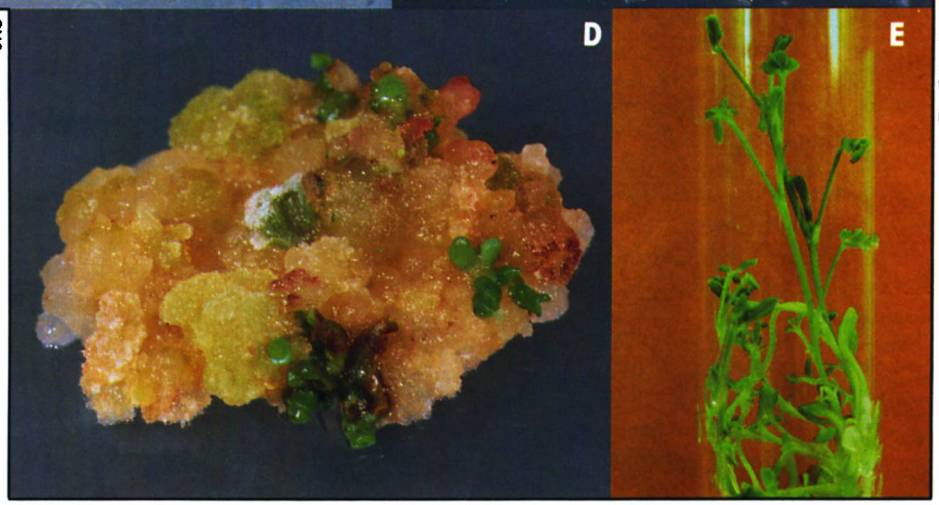

Selecting for salt tolerance: (A) Alfalfa cotyledon produces callus from cut portion. (B) A single alfalfa cell has potential to regenerate into a complete alfalfa plant. (C) Cells are challenged with salt in nutrient medium; light-colored areas are living and presumably salt-resistant; brown and black areas are dead. (D) Resistant cells, on new medium, begin to differentiate into plantlets. (E) Regenerated alfalfa plant, when hardy enough, will be transplanted into soil for further study.

as yield, stress resistance, or nutritional quality, but it may present methods to release previously unavailable variability for such traits. Clearly, MPGE does not stand alone in plant improvement; integration with conventional methods is absolutely necessary.

In considering agricultural applications of genetic engineering, some requirements should be mentioned that are the subjects of current and future research. (1) Cell or tissue culture systems are needed to select for the target characteristic (gene). (2) Systems must be developed to regenerate plants from cell cultures rapidly and in large numbers. (3) Gene expression in cell cultures must also be sustained at the stage of growth in which the plants will be utilized. (4) Good vectors and probes must be developed to transmit and identify the desired genes. These are substantial criteria for utilizing MPGE, but they are certainly not beyond the scope of plant biology research.

Some opportunities for using molecular plant genetic engineering in plant improvement

- ☐ To make transfers of genes from one species to another that would not be possible with nonmolecular methods.
- ☐ To transfer genes at a single step, rather than through repeated crosses or backcrosses.
- ☐ To transfer only the target gene, without detrimental genes linked or otherwise associated with it.
- ☐ To transfer genes rapidly in species with long generation times.
- ☐ To transfer genetic information to plants that will facilitate new end-products.
- ☐ To conserve plant genes in cloned DNA gene banks.
- ☐ To assess genetic variation and genetic relationships among species by molecular methods.
- ☐ To capitalize on "spinoff" technology for use in conventional gene transfer systems — for instance, tissue, cell or protoplast culture methods.

Developing salt tolerance

D. William Rains

Salinity and its potential influence on plant productivity can be managed either by physically manipulating the environment in which the plant grows or by biologically manipulating the plant to reduce the harmful effects of excess salt. The concept of biological manipulation is based on the observation that salt tolerance appears to be genetically controlled and that plants vary widely in their sensitivity to high levels of salt.

Sometimes traditional breeding methods cannot be used to develop salt-tolerant crops. Natural genetic variability in tolerance to salinity may be lacking or not accessible by usual breeding methods. In these cases, it is appropriate to apply new techniques to achieve this goal.

Plant cell culture techniques may be used to obtain salt-tolerant cell lines. This use of cell cultures is based on the application of mutant selection techniques developed in microbial and fungal systems (see articles by Z. R. Sung and G. E. Jones in this issue). The general selective strategy is to produce a cell culture of a crop plant and to challenge these cells with an inhibitory salt concentration by incorporating the salt into the nutrient medium in which the cells are grown. The rare cells that can survive and divide under these conditions are candidates for further study. By inducing the survivors to regenerate whole plants, it is possible to determine whether the salt tolerance observed in the selected cells is stable and transmitted genetically.

In our laboratory we have obtained a line of salt-tolerant alfalfa cells by this means. The salt-selected line grows better than unselected cells at a high level of salt (1 percent sodium chloride), indicating that the selection isolated variant cells with an increased capacity for growth in the presence of high