Summary

The list of cultivated plants that can be genetically modified is lengthy and there are numerous methods available for introducing exogenous DNA into a plant of interest. The most frequently used transformation system is based on the natural properties of a soil bacterium, *Agrobacterium tumefaciens*. *A. tumefaciens* is naturally able to transfer into plants a part of its genome in the form of a fragment called T-DNA which is harbored by the Ti plasmid. Two 25-nucleotide sequences border the T-DNA on either side, called *Left border*, LB, and *Right border*, RB. The T-DNA bears genes involved in the synthesis of plant growth hormones in target cells. The rest of the Ti plasmid codes all the proteins involved in the T-DNA transfer mechanism. The activity of transformed cells is thus stimulated and the bacteria benefit from an important source of carbon and nitrogen. The mechanism is perfectly natural and results in the transfer of genes between considerably distant species, from a bacterium to a plant. The mechanism is based on the fact that it is possible to separate the transfer machinery and the T-DNA sequence that gets transferred. Any gene sequence (transgene) encoding a protein of interest that is placed between the LB and RB borders will be transferred to the plant genome. Most plant species can now be transformed by Agrobacteria.

Transgenesis represents an efficient tool and is often indispensable for studying plant function and development. Inserting a foreign gene into an unknown sequence may inactivate a previously unidentified gene or stimulate its expression. The gene thus revealed can be isolated from the complexity of the genome. Likewise, the use of techniques based on gene transfer can be used to study how a gene is expressed and the properties of the protein it encodes.

In the context of present controversy regarding genetically modified organisms (GMOs), an effective defense of fundamental research by the public authorities is necessary. Maintaining financial support for

research, which ensures its independence from economic pressures, is indispensable to preserve the credibility of risk evaluation. Furthermore, the GMO controversy must force researchers to place themselves at the interface of science and society where communication will be a determining factor.

The search for new methods of plant breeding has led in the 1980s to the elaboration of plant transformation techniques. These have resulted in the last six years in the cultivation of transgenic varieties. In 2001, transgenic crops, mainly in America, occupied 50 million hectares. Transgenic varieties have been rejected in Europe, although there has never been a health problem regarding consumers or damage to the environment. The precise understanding of genomes and gene function makes it possible to glimpse at the considerable possibilities for crop improvement by various methods, among which transgenesis will become increasingly important. The French position, characterized by an alarming absence of research on the application of plant transformation, leaves this field of investigation completely open to others. Therefore, a relative depreciation of our cultivated varieties may be feared for the long term, which will be detrimental to our agricultural economy.

The risks associated with transgenic plants (herbicide tolerance, resistance to predators and diseases, sterility, antibiotic resistance, allergenic properties) are currently under analysis. This analysis shows that all the criticisms against GMOs can be set aside based for the most part on strictly scientific criteria. Furthermore, any generalization on the potential risks linked to GMOs is impossible since scientific rigor can only proceed from a case by case analysis.

Europe has just adopted one of the most strict regulations concerning the dissemination and the commercialization of transgenic plants, especially in the areas of biosafety, labeling and traceability. A hiatus in the writing of regulatory measures will be necessary to assess existing regulations. It will be necessary to reform measures which have not functioned correctly. Finally, with the implementation of new regulations, there will be no objective reason to continue the moratorium on market approval authorizations of GMOs. If this situation continues, the imminent risk is the eradication of GMOs from the European soil and the banishment of all commercial exchanges of seeds and agricultural material with countries where GMO crops are cultivated.

From the beginning, developing countries have participated in the debates on the use of GMOs. They have been pushed to the forefront of the media by the awkward publicity campaigns of big firms. Transgenesis methods should be oriented towards the resolution, at least in part, of some of the problems encountered by developing countries with the aim of securing quantity and safety of food production. For example, transgenesis could be used to solve agronomic problems such as virus and nematode resistance. On the long term, genetic engineering may even address problems of tolerance to abiotic stresses (cold, drought, salt). Genetic engineering associated with new practices should permit to better reconcile increase in productivity, preservation of main ecological equilibria and social acceptability.

It is recommended that the necessary tools be implemented as part of a judiciously chosen large-scale pilot project to demonstrate the usefulness of genetic engineering to help disadvantaged populations, especially in underdeveloped countries. It is also recommended that research be strengthened – for example in the area of population dynamics – with the aim of increasing indispensable knowledge in evaluating the risks in tropical situations. An international initiative should be encouraged to prevent industrial intellectual property from dissuading uses in non-commercial areas that are of general interest. An ethics charter for biotechnology issues should be formalized which would apply to public research institutes in their relations to developing countries.

Genetic engineering of yeast strains for academic and applied purposes essentially concerns three areas: the production of proteins of therapeutic (hormones, vaccines) or industrial (enzymes) interest, the biosynthesis of chemical products and finally traditional fermentation processes. *Saccharomyces cerevisiae* is the most studied and industrially used yeast. Advanced genetic tools have been developed for it that allow excellent control of genetic modifications introduced into the strains. The use of different genus and species of yeast has also led to the production of therapeutic and industrial proteins. Expression systems have been optimized for a small number of these species and are at the heart of many remarkable industrial success stories. In two other domains of application, there is a strong hesitation from industry to use GMOs. The use of yeasts in the production of chemical compounds (bioethanol, organic acids, vitamins, etc.) has been the focus of much research leading to the construction of many GMOs. The yeasts used in bread-, beer- and wine-making, essentially all belong to the *Saccharomyces* genus. Although many GMOs presenting different improved technological parameters have been developed by academic and industrial groups, their future use in Europe appears completely blocked for the moment.

Five years after the *Saccharomyces cerevisiae* genome was completely sequenced, several sequencing projects of fungi genomes have been announced. Themes that will enhance the value of the data obtained from these massive sequencing projects as well as further our understanding of yeast diversity should be encouraged and developed within the yeast community in France.