Executive summary

Micro-organisms including bacteria and viruses are probably best known as pathogens causing disease in plants, man and other animals. At the same time, many microbial species also play a fundamental role in the functioning of the environment, being instrumental, for instance, in mineralization processes, nitrogen fixation and an array of other geochemical processes. Life on earth would not be possible without micro-organisms and the services that they provide.

The precise role of specific micro-organisms is, however, not clear in many cases. In 1990, the first evidence became available that the micro-organismal environment is much more complex than had been thought until then. The years that followed saw the development of novel concepts about the population structure of micro-organisms and how micro-organisms co-operate in a community or "microbiome". These innovative ideas and developments in environmental microbiology have had large impacts on biotechnology.

The purpose of the OECD conference was to inform policy makers, regulators and specialists in the use of transgenic micro-organisms (also known as genetically modified micro-organisms) and of the environmental aspects (biosafety and risk assessment), by drawing an overview of the current situation and relevant developments in environmental microbiology, as well as its potential applications. This is important if policy makers and others are to be proactive in ensuring the responsible use of such organisms.

The conference covered the state-of-the-art of environmental microbiology as it is applied for biotechnological purposes, and the role of genetic engineering of micro-organisms intended for use in the environment, now and in the near future. The conference programme addressed the following themes: i) the Use of Micro-Organisms in Agriculture; ii) the Use of Microalgae for Production Purposes; iii) the Use of Micro-Organisms for Bioremediation; iv) the Use of Micro-Organisms in Cleaning Products; v) Environmental Applications of Microbial Symbionts of Insects; and vi) Environmental Risk Assessment of the Deliberate Release of Engineered Micro-Organisms.

Micro-organisms are important in agriculture especially as biofertilizers, which are growth-promoting micro-organisms. Presently, there are about a hundred companies involved in the development of growth-promoting micro-organisms, and around 500 products have been registered. Another agricultural application involves the use of micro-organisms as biocontrol agents, that is, as plant protection products to control disease and attack by insects and other herbivores. It is likely that transgenic micro-organisms will appear in these types of application in the future.

A second application discussed in this publication is the use of microalgae for production purposes, including the production of biofuels. Algae, with photosynthetic cyanobacteria, offer ideal solutions because they can be cultivated year round,

on non-arable land, alleviating the pressure on farmland and freshwater resources that would be exerted by crops grown for biofuel purposes. Many algal strains are suitable for producing renewable fuels (biodiesel, bioethanol and kerosene). They may also become a promising source of food and feed. The production of algae, in particular microalgae, has therefore become a focus area in biotechnology development. Research on the use of transgenic algae is expanding, and commercial applications are likely in the coming period.

The use of micro-organisms for bioremediation is also addressed in this document. Bioremediation uses living organisms for removing contaminants from the environment, for example polluted land. To date, there have been few cases of bioremediation involving transgenic micro-organisms. This is probably due to the current lack of knowledge concerning the risks and benefits of releasing them into contaminated soils.

The development of cleaners, detergents and other similar products containing micro-organisms has increased over recent years. In many cases, detailed knowledge of their composition is lacking. As far as is known, it is unlikely that any such products currently available contain transgenic forms of micro-organisms, though this remains a possibility for the future.

A more surprising use of micro-organisms discussed in this publication is the use of *Wolbachia* species to control the spread of disease transmitted by insects. For example, cases are described of the potential control of dengue fever by mosquitoes as well as the control of malaria. While these techniques may be promising, no transgenic organisms have been used in large scale practice yet.

In terms of the **major findings and conclusions** of the conference, the following should be noted:

- In recent years, there has been a considerable increase in knowledge as to how micro-organisms function in nature and co-operate in a communities or the "microbiome".
- Certain micro-organisms are currently used (or have the potential to be used) in a variety of products and applications such as biofertilisers, plant protection products, biofuel production, bioremediation, cleaners, detergents as well as in the control of disease transmission.
- To date, there have been few uses of transgenic micro-organisms in such products and applications, though that might change in the future.
- In order that products involving transgenic micro-organisms are used in a responsible way, it is important that regulatory oversight involves a rigorous risk/ safety assessment.

It is clear that the uses of micro-organisms in agriculture and of microalgae for production purposes are significantly increasing. These developments could involve important economic impacts in their respective sectors. At the same time, they could well contribute to the OECD's work on green growth and sustainable development. As a final recommendation, therefore, it would be timely to consider the development of tools which would assist in a scientifically-sound approach to risk assessment of transgenic organisms in these two areas of applications.