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# Biotechnology

The OECD is the first international organization to have proposed a definition of biotechnology in 1982 as: "the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services". This technical definition reveals in practice that biotechnology applications are part of our everyday life and include a broad range of products. Indeed, one of the oldest applications of biotechnology is the use of micro-organisms for the production of foods such as yogurts, cheese, bear, and pharmaceuticals including antibiotics. Since 1980, modern biotechnology has emerged to complement these initial techniques, this time by using genetic manipulation.

As part of our everyday life, the issue of the potential impacts of biotechnology, and in particular of modern biotechnology, on the environment is important. Like any other kind of technical innovations, biotechnology applications present some risks as well as promises in the field of sustainable development.

Modern biotechnology is rather a tool - the manipulation of genes - than a product in itself. Three industrial sectors are therefore using biotechnology as an innovative tool: the agricultural sector, pharmaceutical companies and several small and medium size enterprises that develop innovative products for specialized markets - for instance in the domain of soil decontamination, recycling etc. The third sector is still in its early developments, while the pharmaceutical sector conducts researches on confined material that is not intended for release into the environment. On the contrary, modern agricultural biotechnology has been meant to develop new plant varieties that could better adapt to agricultural needs. The applications derived from modern agricultural biotechnology have consequently been the subject of a very intense debate regarding their impact on the environment.

In practice, the development of agricultural biotechnology applications has been uneven. On the one hand, the total surface of genetically modified crops has increased between 1995 and 2006 from a handful of field trials to more than 110 millions of hectares - with 13% growth between 2005 and 2006. On the other hand, most of the genetically modified plants concerns only four different varieties and two processes: soy resistant to weeds (60 millions of hectares); cotton resistant to caterpillars (10 millions hectares); corn varieties resistant to weeds and/or insects (25 millions of hectares); and canola seeds also potentially modified to resists to weeds or pests (2 millions of hectares). These varieties are cultivated in a handful of countries: the United States (55 millions of hectares), Argentina (18 millions), Brazil (11, 5 millions), India (3, 8 millions), China (3, 5 millions), Canada (6, 1 millions), Paraguay (2 millions) and South Africa (1, 8 millions hectares). The United States represent half of the worldwide production of transgenic plants.

As their properties show, the early development of modern agro-biotechnology products was initially meant to improve crop production, while using innovations that where more environmental friendly. Indeed, as genetically modified varieties where resistant to pests or weeds, their production was supposed to require less pesticides or insecticides. However, the

concern regarding the environmental impact of agricultural varieties grew over time. Progressively, the risks to see the development of "super bugs" or "super weeds", resistant to the new crop varieties emerged. The potential harmful effects of genetically modified species on the wild fauna were also mentioned, as well as the possible flows of genetic material to wild natural species. The main controversies started in 1999, when an American experiment demonstrated that one wild species of butterfly, the Monarch Butterfly, was disappearing consecutively to the introduction of genetically modified corn in the environment. The modified pollen was indeed suspected to kill the Monarch caterpillars. At the end of the same year, a Hungarian researcher, Arpad Pusztai, published in *The Lancet* his results concerning the dangers of modified potatoes on mice. These cases have brought the issue of genetic engineering to the forefront of the public consciousness worldwide.

Moreover, environmental critics were soon coupled with fears concerning the socio-economic impacts of biotechnology in general, and genetically modified varieties in particular. While developed with the aim to respond to the world's needs in terms of crop production, precisely in the developing world, these varieties only partially resolved the problem of hunger. The varieties of modified crops available on the market - soy, cotton, corn - were indeed poorly used in developing countries. These countries were moreover concerned about a technology they knew little about and that was mainly in the hands of northern countries and companies. The development of biotechnology applications required very specialized expertise and skills that limited its development in the South. While recognizing the potential benefits of the technology, developing countries asked for the global management of the potential risks related to agro-biotechnology applications.

At the international level, the Cartagena Protocol was adopted in 2000 under the Convention on biological diversity - an international regime related to the United Nations Environmental Program - and currently has 103 member states. This international agreement aims at managing the environmental and socio-economic risks related to agro-biotechnology applications. More precisely, the Cartagena Protocol deals with the transboundary movements of genetically modified organisms and recognizes the need for a precautionary approach to handle these organisms. It requires the documentation of genetically modified crops during their transport in order for countries to take informed decisions prior to the release of transgenic varieties into the environment.

At the national and the regional levels, several countries have adopted different regulations to balance the possible benefits of biotechnology applications with their risks. For example, the Indian government adopted in 2003 a special clause that requires that every new transgenic variety should respond to the Indian population's need in order to be accepted for commercialization nationally. In Europe, the European Commission has developed a strong regulatory policy concerning the deliberate release of genetically modified organisms into the environment. This legislation requires a full risk assessment and the agreement of numerous governments and agencies before the use of any novel transgenic variety. In countries where regulations have traditionally been favorable to the spread of agro-biotechnology applications, such as the United States, several practical measures have been introduced in order to manage the possible environmental damages of modified varieties. These measures can include the establishment of buffer zones between conventional crops and modified plantations or the need to mix modified varieties with a small percentage of non modified varieties, in order to avoid the development of resistant insects or weeds. The growing demand for organic foods and products also encourages countries to differentiate the different food supply chains for conventional, transgenic as well as organic productions.

Biotechnology firms also have made several steps towards the improvement of their products. Transnational corporations such as Monsanto, Syngenta or Bayer have put in place several international non governmental organizations - such as CropLife International - in order to inform the public about the benefits of agricultural biotechnology applications. Theses companies are also working on the elaboration of new plant varieties that could better answer to the needs of developing countries. For instance, in 2000, the private sector has started to develop a new variety of rice, known as "Golden rice", which has been enriched in vitamin A and is supposed to answer to food deficiencies' problems in African countries. Researches are also conducted on modified crops that could produce drugs, as well as on transgenic trees, or biofuel plantations. These innovations are often considered as the second generation of transgenic crop applications.

However, these developments are progressing at a slow pace and developing countries themselves start to engage in research in agricultural biotechnology. Whereas biotechnology has for a long time been perceived as a technological tool in the hands of the richer nations, several developing countries are encouraging today their national firms with the aim to find a compromise between national competitiveness and sustainable development objectives. This is particularly the case for emerging countries such as India, China or Brazil. These countries also aim at developing their skills in the development of biotechnology research in the field of pharmaceutical products and specialized industrial applications.

Even if the international debate on agricultural biotechnology has somehow tarnished the image of biotechnology, its applications in the three domains mentioned above - agriculture, pharmaceuticals and technological solutions - is currently progressing and looks promising in several ways.

Other entries: grains; green technology; Greenwashing; genetically modified products; precautionary principle.

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