Biotechnology worldwide and the ‘European Biotechnology Thematic Network’ Association (EBTNA)

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The European Biotechnology Congress 2011 held under the auspices of the European Biotechnology Thematic Network Association (EBTNA) in conjunction with the Turkish Medical Genetics Association brings together a broad spectrum of biotechnologists from around the world. The subsequent abstracts indicate the manner in which biotechnology has permeated all aspects of research from the basic sciences through to small and medium enterprises and major industries. The brief statements before the presentation of the abstracts aim to introduce not only Biotechnology in general and its importance around the world, but also the European Biotechnology Thematic Network Association and its aims especially within the framework of education and ethics in biotechnology.

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‘EBTNA’ – European Biotechnology Thematic Network Association – a brief history

The European Biotechnology thematic network Association (EBTNA) (http://www.ebtna.net/home.htm) was created in 2007 by Mariapia Viola-Magni with a formal statute signed by the notary in Perugia. The partners are listed below:

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<td>GR – Greece</td>
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<td>University of Maribor – Faculty of Agriculture University of Lubiana</td>
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The aims of the Association are to:

a. implement, consult or supervise programs for the assessment of skills and knowledge in sciences with an emphasis on biotechnology,
b. undertake programs concerning education and training, especially those concerning innovative approaches,
c. operate as a consultant or assessor in programs concerning education and training,
d. provide certification of achievement when assessments have been carried out under appropriate conditions,
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e. co-operate with established professional or other associations in the furtherance of its objectives,
f. extend the reach of all aspects of education in biotechnology beyond national and European borders.

The partners participating in this Association have collaborated for a long time within European projects and especially Thematic Network projects.

In 1996 the Socrates Programme proposed the creation of a Thematic Network (TNP). These projects were intended to create a network of European Universities in order to analyse and discuss the formation of students through the comparison of European curricula. Many networks were created in scientific and humanistic disciplines.

A Biotechnology network was proposed by Perugia University and was coordinated by Professor M.P. Viola-Magni. A number of different projects have been developed as follows:

Biotechnology formation in the University
The first project was approved in 1996 (BIOTECH – Biotechnology Thematic Network Agreement No. 26036-CP-1-96-1-IT-ERASMUS-ETN) (1996–1999) and was dedicated to the analysis of Biotechnology formation in European Universities. Each country produced a booklet with the description of the development of this discipline in a particular country showing if there are separate courses or whether biotechnology forms a part of other courses, for example Medicine, Pharmacy, Biology. Hence, a specific biotechnology curriculum was designed that also included courses such as Business and Patent Law.

The second project (BIOTECHNOLOGY DISSEMINATION – Results, Dissemination by means of a Website of European Biotechnology Network Agreement No. D26036-CP-1-99-1-IT-ERASMUS-ETN) (1999–2000) was dedicated to the dissemination of the results acquired in the first project and to the consolidation of the network.

The updating of worker formation
The third project (BIOTECHNET – BIOTECHnology Thematic NETwork Agreement No. 10051-CP-1-00-1-IT-ERASMUS-ETN) (2000–2003) was mainly directed to continuous formation and to updating the knowledge of workers, many of whom work in enterprises yet have only a general formation and lack the many technologies developed during the recent times. To this end, some distance learning modules were prepared choosing subjects for which the requests for updating were more numerous. A specific, interactive software was prepared to facilitate the participation in learning of the student or worker. Some exercises and sets of questions were also prepared both for the student to determine if they have understood a subject and also for distance evaluation. The ODL modules were tested on biotechnology students from different countries and an evaluation made by students was taken into consideration in order to improve the ODL modules.

The relation between University/Enterprise
The fourth project (BIOTECHUNTE – Biotechnology University Formation for Enterprises Development Agreement No. 110769-CP-1-2003-1-IT-ERASMUS-TNPP) (2004–2007) was mainly dedicated to the implementation of the relationship between Universities and enterprises. Enterprise representatives have little participated in the network but in 2003, the European Commission permitted them to be included in the network so leading to an increased number. The European dimension gives the possibility of greater cooperation by using a large area of competences and experiences. The Universities have the opportunity to collaborate and to reinforce the social roles in a cultural and linguistically different Europe.

The most recent project is concentrated on Lisbon priorities: formation, research and innovation.


The fifth project approved in 2007 intends to implement the collaboration between Universities and enterprises by favouring the development of common research projects, the development of more innovative courses, the implementation of distance learning and the application of the Tuning methodology to formation in biotechnology. We intended also to promote an internal debate on the most important bioethic problems especially on Consumerism in European and non-European countries.

Accordingly, new courses were developed in innovative applications, for example Omics applied to Biotechnology, Biosensor Application in Medicine, New Application of Polymers in Medicine, Biotechnology Application in Immunology, Microbial Adaptation to Environmental Changes and Molecular Diagnostics of Micro-organisms.

For distance learning, a platform was developed to utilise the existing ODL modules and to develop new modules. Currently, the partners have produced 40 ODL modules covering many sectors of Biotechnology. It is intended to increase this number and to give the possibility to persons who have difficulty in following regular University courses to complete their preparation through these modules and the use of a laboratory. Some modules are dedicated to technical aspects thus permitting the stu-
dent to use experimental methods, for example PCR and sequence analysis.

Special attention has been devoted to evaluation. Tests prepared for each module permit student self-evaluation or, if needs be, an objective evaluation that may be used for distance learning courses. We intend to export these systems outside Europe in the more disadvantaged areas, using the courses to aid the development of enterprises in this sector.

The relevance of biotechnology in different curricula is also taken into consideration and a special course in Veterinary Medicine has been designed.

As outlined previously, we intend to stimulate research collaboration between Universities and enterprises; to this end, two projects are proposed. One concerns food safety through the identification of plant products by using a PNA platform. The influence of diet and alimentary products on gastrointestinal diseases will be studied by comparing the experimental results from various European countries.

In order to favour contact with enterprises, a deeper analysis of their needs will be made through a questionaire already present on our web-site and by direct interviews. We intend to explore more deeply the kind of formation that may help a young person to work successfully in an enterprise. The results obtained from the interviews will help the network in elaborating didactic material and in revising the current curricula.

Particular attention is also dedicated to the quality evaluation of formation and of the development of biotechnology in different fields. Currently, there are no established indicators at the European level in this field as happens in other sectors like Chemistry. The network intends to dedicate efforts to elaborate and propose general outlines for such common quality criteria concerning many problems especially in the bioethics area. Many techniques used in diagnostics are standardised, but there is a need to implement these applications to stimulate the use of new methods and, consequently, new products from enterprises. Since the results can vary between different laboratories, we intend to analyse the differences and to establish a quality assessment so as to establish common criteria towards helping enterprises in programming their products.

The innovative aspects of our project are, therefore:

1) creation of an education system that favours employability at a European level and the attractiveness for this system in other third countries;
2) implementation of cooperation in formation between enterprises and the academic world thus also favouring research development. Our work contributes to reaching the aims established in Lisbon and in the subsequent meeting by the European Commission.

The creation of the Association permitted continuity for the activities already made and to stabilise and diffuse the results obtained. The association will take care of the web-site and of the organisation of the platform containing ODL modules that we intend to increase in number and quality to favour distance learning for worker updating as well as for students who do not have the possibility to follow regular courses.

**Biotechnology in the world**

Biotechnology is the application of technologies to living organisms or biological systems in order to develop new products and/or to change existing processes for specific uses. On the contrary, modern technology can be defined as the application of modern science and technology. Biotechnology is related to many scientific disciplines including microbiology, biochemistry, molecular biology, cell biology, immunology, protein engineering, enzymology, and bioprocess technologies.

The biotechnology industry has become such an important sector nowadays with its global value estimated to be almost 500 billion dollars. In comparison, its global value was only 54 billion dollars in 1999 and 101 billion dollars in 2003 [1]. The North American share is almost 50% while the European Union contributes about 30 billion Euros to this industry. Among European Union countries, the United Kingdom, Germany, and France invest the most in research in the biotechnology industry. In other parts of the world, Japan, Israel, and Brazil are noticeable as countries accelerating their investments in biotechnology. In addition, India has especially developed research environments in the field of biotechnology. According to data from the year 2009 [2], the number of companies operating in the field of biotechnology was 1699 in the USA of which 313 were public and 1386 private companies. However, the European Union (EU) has a total of 1790 companies with 171 public and 1619 private companies. Interestingly, there were 4% fewer US companies (1771) and 2% fewer companies in the EU (1819) than in 2008. The market value of American companies was 340.7 billion dollars in 2008 but this value dropped to 270.4 billion dollars in 2009. By contrast, during the same period, there was an increase of 33% to 33.426 billion euros in the EU. There was a corresponding decrease in the number of biotechnology employees in the USA down from 120,300 in 2008 to 109,100 in 2009 yet with a 1% increase in the EU to 49,120 in 2009.

Nearly half of employees worked in R&D units with the USA spending 17.2 billion dollars in 2009 on R&D activities as opposed to 22.6 billion dollars in 2008, a 24% decrease.
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According to OECD data [1], the greatest number of biotechnology companies per million people is found in Sweden, Switzerland, and Canada. Most of these firms operate in the health industry where, consequently, the maximum number of biotechnology-associated workers is employed.

The G7 countries took the top six ranks for patents issued in the biotechnology sector during 1990–1997 with the United States Patents and Trademark Office (USPTO) and the European Patent Office (EPO). Among the G7, Italy was the only country failing to enter to this top list. During 1990–1999, the number of patent applications to EPO increased by 10% annually, while the number of patents granted by USPTO has increased by 11% annually. This is an indication of how advanced the develop countries are in comparison to developing countries. In 1995, developing countries paid 60 billion dollars for the right to use patents and licenses.

Biotechnology in Europe and EBTKNA
The European Biotechnology Thematic Network Association has as its main characteristic the symbiosis between science and the biotechnological industry. In the future, EBTKNA will develop in different ways that are briefly illustrated below.

International courses
During this year the International first level degree and master program in ‘biotechnology oriented to job development’ will open in Erciyes University (Turkey). In this location, the experience of the first International Course based previously in Perugia (Italy) will be followed and implemented. EBTKNA will collaborate with these Courses by providing teachers who will move from different European countries to Erciyes University in order to teach the students studying the degree modules.

European projects
The Association, profiting from a well-established network of members present in most European countries, will participate in the different calls for European Union projects, especially those relating to lifelong learning projects where EBTKNA has accumulated an important experience during the previous years. Finally, it will participate in calls in the field of biotechnology for scientific projects financed by the EU.

Event organization
Following the Conference in Istanbul, EBTKNA will organize new events in the field of biotechnology, profiting from the experience accumulated from that occasion where national competences, in this case those of Turkish colleagues, have been implemented by the expertise of different members of EBTKNA involving the different fields of biotechnology including Medical Genetics, Industrial Biotechnology, Food and Feed, Nanobiotechnology, Animal Biotechnology, Dysmorphology, Pharmaceutical Biotechnology, Bioinformatics, Plant Biotechnology, Regenerative Medicine and Stem Cells, Environmental Biotechnology, Assisted Reproductive Methods in Biotechnology, Human Present Consumerism and Its Impact On the Earth Ecosystem, Functional and Structural Genomics, Proteomics and Metabolomics.

Open Distance Learning (ODL) module production
The ODL modules are a resource of the Association with the first being generated in the framework of the BIO-TECHNET project. Now, over 40 modules are available on the e-learning platform in the field of biotechnology covering an entire first level degree course. In the future, EBTKNA intends to support and implement technically both the hardware and software infrastructures and to disseminate the available modules.

Expansion of the network
At present EBTKNA is composed of members from Austria, Italy, France, Germany, UK, Latvia, Spain, Hungary, Slovak Republic, Bulgaria, Sweden, Portugal, Poland, Greece and Turkey. The future intent is to extend participation to researchers and teachers coming from other countries not only within the European Union, but also from other countries belonging to the geographical region of Europe including Israel and countries of the former U.S.S.R.

Education and biotechnology
The need for education
The 21st century will see biotechnology and the life sciences become the most important global industry, overtaking information technology in economic importance. The size of this market is immense, with US publicly traded biotech companies alone having a total value in excess of $400 billion. Biotechnology enhances health, feeds ever growing populations and fuels our everyday needs [3]. Each year biotech products prevent >2.5 million childhood deaths globally by immunisation alone [4], while 2.35 billion acres of biotech crops were grown between 1996 and 2009 [5]. Use of biotech detergents allows European and US consumers alone to save $4.1 billion and >32 million tons of CO₂ emissions annually, the equivalent of 8 million cars [1,6]. Preparing new graduates and re-skilling existing graduates to meet the needs of the biotechnology and life sciences sector is among the most important tasks for Europe’s Universities and higher education institutions as the benefits of true lifelong learning become realised and workers need to upskill or retrain at various points throughout their economically productive lives [7]. Failure to do so will hand advantage to our competitors, often with low wage economies, and risk soaring unemployment at a time of great fiscal uncertainty around the world.
Throughout Europe, for example, populations are ageing, leading to increased healthcare science needs, costs and expectations. Health economics demonstrates that the highest costs associated with patient treatments tend to be in the first two and last two years of life. Increasingly citizens demand higher quality healthcare, while global competition demands greater use of innovation and entrepreneurship to develop more environmentally friendly products and services. These pressures mean that our Universities face greater responsibilities and pressures to educate, train and develop the current and future workforce to meet these needs, at a time of increasing financial difficulties, frequently with declining budgets while being expected to deliver much more with less resource. In this context, reflecting upon the attributes and skills graduates are expected to attain and demonstrate during their working lives becomes increasingly important.

Graduate and post-graduate skills
Recent evidence from surveys of senior academics suggests that the three most desirable graduate attributes to be developed among life sciences undergraduates are [8]:

- Becoming self-confident achievers.
- Evaluating, critically appraising and synthesising novel concepts.
- Ability to work flexibly, independently or as part of a team.

These life sciences graduate attributes, align closely with the generic set of graduate attributes identified by the Quality Assurance Agency for Higher Education [9,10] and perhaps because of the highly practical, frequently laboratory-based nature of the life sciences, lead on to desirable Master’s level attributes emphasising:

- Conceptual understanding enabling crucial evaluation of current research and advanced scholarship.
- Originality in application of knowledge.
- Ability to deal with complex issues and form conclusions based on incomplete data sets.

To these attributes, adding an international dimension is becoming increasingly important, either through immersion in the laboratories or industries of another country or through working with international students, to gain a greater appreciation of the diversity of cultures and approaches that can be focused on key challenges. Increasingly, all of these attributes are becoming essential for graduates to gain employment, or become successful entrepreneurs and contribute to sustainable growth [11].

Together, these undergraduate and postgraduate attributes provide a highly valuable framework for educators in the life sciences. Discipline-based graduate attributes can be used to help ensure that we adequately prepare scientists, leaders, entrepreneurs and policy makers to develop solutions to tomorrow’s questions, of which many have not yet even been thought of. This framework should prepare our students not just to learn facts by rote, but instead, to know how to find information, assess and manipulate it to devise new and innovative solutions to increasingly complex challenges. This must now be the ultimate imperative for all University educators. Investing now in our Universities is essential to realising future benefits for everyone. In return, our seats of learning must foster the development of enquiring minds, if we are to recover from economic shocks, rebuild economies and continue to enhance our quality of life.

Ethics and biotechnology
The rapid progress in Biotechnology has resulted in Ethics of Biotechnology becoming a subdiscipline of Bioethics dealing with the ethical implications of the different fields of biotechnology research and its applications. The interdisciplinary nature of ethics has great and unpredictable social consequences as people, in general, re-evaluate their conventional ideas about moral standards and legal responsibility not just in Western law and morality, but on a global basis. Biotechnology has already generated crucial and open ethical thinking in the academic and public worlds about the social aspects of increasing sophistication in techniques as well as the possible new ways in which biotechnology might provide solutions to many human problems and contribute to the environmental sustainability of the Earth.

Populations, food and health
Various assumptions exist about the future population trends, resource availability, industrial output, food supplies and population levels around the world. It is estimated that, today, some 800 million people suffer from chronic food shortages and there are 40,000 hunger-related deaths every day. Poor people suffer worse health and die younger. A report by the WHO and UNICEF warns that ill-health and poverty could defeat human development efforts with children being the first to suffer. According to the United Nations, food production will have to rise by 50% by the year 2030 to meet the demands of growing population.

Biotechnology opened new areas in health care with better methods for detecting, preventing and treating diseases; the use of recombinant DNA technology to produce pharmaceutical products for humans; the introduction of advanced techniques in agriculture and in food science to increase food production and to protect the environment; invested research in industrial biotechnology and bioenergy; and much more. These are important benefits not only for the developing countries but also for the entire human population today and in the future.
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Ethical and societal moral considerations
However, like any research and technology, biotechnology not only provides benefits and helps people, but has inherent risks as well. Therefore, all potential risks, ethical and moral questions should be approached and properly assessed before research begins. Although there are particular ethical positions commonly shared by leading scientists around the world, that all biotechnology products must be safe for humans and the environment, there is considerable public concern about the potential risks posed by certain aspects of modern biotechnology, such as the possible harm to human populations on using cloning technology; changing genes by genetic engineering technology far beyond the changes that occur naturally during evolution; the impact of releasing genetically modified organisms into both the human population and the environment; the possible damage to biodiversity; genomic medicine, issues of enhancement, including the selection of genes for intelligence, the use of smart drugs to enhance brain performance; synthetic biology; the use of enzymes and bacteria in a wide range of applications, bioinformatics; advanced nanotechnology and others.

In addition, because several results of modern Biotechnology are unfamiliar and mysterious to the public, some segments of society have doubts, anxieties and concerns about their usefulness. In order to respond and overcome the concerns of society, educational programs for a wide range of audiences must be organized to elevate the level of public knowledge on biotechnology issues and to provide basic information about how biotechnology works, as well as raising awareness of the benefits and risks. To successfully inform the public about biotechnological issues, the knowledgeable teaching of young people at every level of education must be a first priority. It is also important to develop active interactions between biotechnology and the diverse belief systems that co-exist in Europe, especially considering the impact on the ethics and traditions of the general public. Through placing emphasis on education it will be possible to materialize a productive interplay between biotechnological discoveries and the societal and humanistic values embodied in the various belief systems and cultural heritages of Europe.

Due to such efforts, the public could become more and more involved in identifying the key ethical questions and formulating regulations, policies, guidelines and principles for Biotechnology that are scientifically relevant and sensitive to our societies.

The ‘Golden Age’ of biotechnology
The twenty-first century is called the ‘golden age’ of biology. The same can be said about one of its branches: biotechnology.

Biotechnology is one of the key areas of quality of technological development in a variety of industries. Biotechnology refers to the collection of methods and techniques to produce useful products for mankind and the phenomena with biological agents. At the same time it should be noted that the development and achievements of biotechnology are closely related to the complex knowledge not only of biological sciences, but also of many other disciplines. The potential opportunities and range of applications of biotechnology have transformed the industry, along with nanotechnology as the leading factor in the development of the economies of individual nations and the world community as a whole.

The expansion of the practical sphere of biotechnology is also due to problems facing humanity such as shortage of clean water and nutrients, environmental pollution, lack of raw material and energy resources, the need for new environmentally friendly materials. Therefore, for human life support, the quality of life and its duration, it is becoming increasingly necessary to develop fundamentally new methods and technologies. Scientific and technological progress, leading to enhanced rates of material and energy resources, unfortunately, leads to an imbalance in the biosphere processes. Polluted water and air basins in cities and reduced reproductive function of the biosphere are due to the accumulation of dead-end products.

Growth of biotechnology
The reason for the rapid growth of biotechnology in the past 5–10 years is its potential to solve global challenges:

- Health biotechnology effectively works towards the establishment of funds for the treatment of previously considered incurable diseases as well as most modern vaccines;
- Environmental use of biomass fuels in power generation and automobile engines;
- Food – increasing productivity by protecting plants from pests and weeds.

The global biotech market
The largest biotech market in the world is the U.S. followed by the Asia-Pacific region and Europe. Red biotechnology accounts for more than half of the worlds production with green biotechnology accounting for 12% and the rest as white biotechnology.

Biotechnology in the U.S.
This high capital-intensive and knowledge-intensive biotechnology industry identifies key factors of sustainable U.S. leadership in global development of biotechnology: high levels of industry funding; a large number of specialized educational and research institutions; considerable resources of qualified personnel; long experience of entre-
Biotechnology in Japan

Japan ranks second in the world after the U.S. in terms of the development of biotechnology. In the traditional areas, particularly in the production of enzymes, antibiotics and amino acids, the position of Japan is very strong. However, there is a noticeable lag behind the U.S. in applying modern biotechnology. To overcome this gap, Japan opted for the revolutionary development of biotechnology by the practical use of scientific and technical information and purchased licenses and patents for genetic engineering technology together with a fast-track preparation of Japanese professionals through an internship abroad. Their own research on genetic engineering was expanded in laboratories both in universities and industrial firms.

Currently about 5% of the costs of R&D in Japanese pharmaceutical industry is spent on research in the field of genetic engineering. There is close cooperation between public and private sectors in Japan. A number of ministries are involved in the implementation of individual biotech programs. Universities in Japan are actively engaged in research on gene and cell engineering so contributing to the level of development in biotechnology that brings them to the level of research conducted in U.S. universities.

Biotechnology in European countries

The main centres of biotechnology in Europe are Britain and Germany. Britain is the leader in terms of funding attracted into the industry that is about a third of that invested across Europe [12]. Germany is ahead of its neighbours on investments of venture capital in the biotech sector, a figure twice the average level in the region. In addition, Germany is ahead of other countries by virtue of the number of institutions, research institutions and universities that specialize in biotechnology.

Biotechnology in China

The main sector of the Chinese biotechnology industry is biopharmaceuticals, the sector operating 580 companies [13]. Chinese manufacturers yield some 7% of the worldwide market in medicinal biological products. The government provides the most funds that are focused on research funding in the early stages of R&D and the application of development and commercialization of the products.

‘Green’ Biotechnology is also the subject of significant investment in China, the research in agricultural biotechnology accounting for about 40% of public investment in the industry. According to the National Program for the Development of Science and Technology, the state will invest U.S. $112 billion in R&D in 2006–2020, biotechnology having the highest priority over other areas.

Biotechnology in Brazil

The market for biotechnology products of Brazil is estimated at U.S. $14 billion and is the largest in Latin America. Brazil has a recognized competence in the field of genomics, vaccines and stem cell research. The country attaches great importance to the use of renewable sources of energy, Brazil being today world’s second largest producer of ethanol after the United States [15].

Biotechnology in India

India ranks among the top three countries in biotechnological development in the Pacific region – after Australia and China. India leads the world in terms of pharmaceutical production facilities approved by the U.S. Food and Drug Administration outside the U.S., and became a centre for conducting clinical trials for many international pharmaceutical companies [14]. The Indian market for contract research in biopharmaceuticals is estimated at U.S. $250 million and growing by 30–40% annually.

The biotech industry in India enjoys the active support of the state, which is now the main source of funding for biotech R&D, especially for small businesses. The National Biotechnology Development Strategy sets the basic problems and their solutions in order to create the country’s enabling environment for the development of bioindustry.

Biotechnology in Turkey

Turkey has remained behind in biotechnology, because of inadequacies in research opportunities, trained personnel, and laboratory infrastructure. Although funds allocated to research and development in biotechnology is insufficient, there has been a remarkable increase in recent years. Among the reasons preventing the increase in the number and quality of researches in Turkey, the
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high cost of materials used in research is the most important one.

Studies in the field of biotechnology in Turkey have accelerated in 1980s. In the 2000s, the development of biotechnology has noticeably gained momentum in Turkey as in other parts of the world. Currently, many universities, technology institutes, centres, and various sized public and private enterprises employ qualified personnel in the field of biotechnology. Turkey has the potential to create a variety of industries specializing in, for example, the processing of renewable biomass, providing food and the production of modern medicines.

Conclusions

The foregoing brief statements have not only introduced EBTNA but have shown the need for both research and specific, basic education and training as well as continuing education in the field of biotechnology. It is also important that the field of bioethics is brought to the fore especially in the light of developments in medicine, agriculture and food production. With continuing developments and the role of the biotechnology industry in a free market economy, it is also important that governments take a balanced and ethical view of the way in which biotechnology is permitted to advance.

An example may be made with the development of biofuels where some governments have decided to establish a fixed quota of biofuel production so as to reduce the dependence upon oil. Unfortunately, the easy way is to use plant material that is produced on a large scale. This has led to the use of, for example wheat, maize and sorghum as a biomass of choice. Hence there is a conflict between using the resource as food and as a biofuel source. The knock-on effect is food shortage and increased prices, an aspect exacerbated by the effect on the production of these grains by drought in Australia, Africa, the USA, Russia and China. The exploitation of Jatropha as an alternative biofuel source has met with mixed reviews although it has been suggested that it could be planted on a large scale in marginal areas from which subsistence farmers will need to be displaced.

A second example where biotechnology plays a role that may not be always to the advantage of the general public is in drug development. For a new drug to be marketed, the manufacturer has to demonstrate that it produces a substantial effect on the particular disorder that is way above that of a placebo. It does not have to be better than products already on the market.

These are two examples where governments need to control the way in which biotechnology can aid the general public rather than just to provide profits for the market regardless of the outcomes. Moreover, it demonstrates the need for longer-term government decisions on an international basis to ensure that, as in the case of biofuels, their support for industrial profit is not at the expense of feeding the poorest.

Biotechnology can provide many benefits for mankind, but there are also negative aspects that need to be controlled. It is here that ethical considerations are involved. In addition, the need to educate about biotechnology concerns not just those people who will be employed in the biotechnology sector, but also the general public who need to be aware of the positive and negative aspects of biotechnology so that a non-emotional and balanced debate can occur on a variety of topics such as the use of GM crops and stem cells.

References