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# New perspectives on the knowledge-based bio-economy

## Conference report



Transforming  
life sciences knowledge into  
new, sustainable, eco-efficient  
and competitive products



SIXTH FRAMEWORK PROGRAMME



**This report sums up the main findings of an event organised by the European Commission's Research DG with the support of the Interpretation DG, Conference Directorate and in close collaboration with the UK Presidency of the EU 2005.**



# Foreword

Many of you will have heard of the knowledge-based economy, but the concept of a knowledge-based bio-economy is likely to be new to you. But it is a concept that will doubtless become familiar over the coming years as Europe steps up its efforts to become a world-leading economic and scientific powerhouse.

Why all this interest in knowledge? Because knowledge has become an extremely valuable economic resource, one that Europe is good at producing and will rely on increasingly to maintain its competitive edge. In a global economy, knowledge is the best way to increase productivity and competitiveness and improve our quality of life, while protecting our environment and social model. This is what the EU's Growth and Jobs initiative and Lisbon Strategy are about.

The knowledge-based bio-economy will play an important role in this emerging reality. It is a sector estimated to be worth more than €1.5 trillion per year. The life sciences and biotechnology are significant drivers of growth and competitiveness here. These sciences will help us to live in a healthier and more sustainable fashion by finding more environmentally friendly production methods and pushing forward the frontiers of science.

It is this economic, social and environmental potential that has thrust the knowledge-based bio-economy to the top of the policy agenda in many countries, such as the United States, Japan, China, India and Brazil. This should prompt us to redouble our efforts in order to remain competitive.

The life sciences and biotechnology can help find solutions to many of the most pressing challenges facing humanity and answers to some of the most fundamental questions about life and its meaning.

To reflect this global importance, delegates from around the world, including India and South Africa, joined their European colleagues at the Brussels conference. In addition, China held a sister conference at the same time as the Brussels gathering and the Chinese Minister of Science and Technology Xu Guanhua and myself delivered a joint welcome address.

Europe's success requires a long-term and coherent vision. But the bio-economy is complex. It involves different sciences and technologies, different industries, and different policy areas. Achieving a common vision among such a diversity of stakeholders is no easy task. This conference was an important step in that direction.



Janez Potočnik

*EU Science and Research Commissioner*

# Setting the scene

*The bio-economy is one of the oldest economic sectors known to humanity, and the life sciences and biotechnology are transforming it into one of the newest. We have always depended on nature's bounty. In fact, human civilisation is firmly rooted in agriculture. Without the invention of farming, we would not have had the necessary basis for civilisation to bloom.*

However, it is more than a question of food. Natural and biological resources are the raw materials for the majority of the products on which we depend: from the paper you are reading this document on to the clothes on your back.

But the bio-economy should not be written off as some outdated notion – the 'primordial soup' from which the modern economy emerged. It is also leading the charge into the 21st century and is at the vanguard of the emerging knowledge-based economy. "As citizens of planet Earth, it is not surprising that we turn to Mother Earth – to life itself – to help our economies to develop in a way which should not just enhance our quality of life, but also maintain it for future generations," said EU Science and Research Commissioner Janez Potočnik.



**“As citizens of planet Earth, it is not surprising that we turn to Mother Earth – to life itself – to help our economies to develop in a way which should not just enhance our quality of life, but also maintain it for future generations.”**

“The knowledge-based bio-economy (KBBE) is a desirable path to tread. It will enhance Europe’s competitiveness, rural development, sustainability and the environment,” argued Christian Patemann, director of Biotechnology, Agriculture and Food Research at the European Commission.

In recognition of the growing importance of the bio-economy, the European Commission – in collaboration with the UK Presidency of the EU (second half of 2005) – organised this international conference in Brussels, Belgium, on 15-16 September 2005.

## The fruits of a revolution

The KBBE would not be possible without massive advances in the life sciences and biotechnology, which have surged ahead in leaps and bounds in the half-century since the double helix structure of DNA was discovered. They are swiftly transforming the agri-food and pharmaceuticals sectors and creating new bio-resource industries.

Scientists have already painstakingly mapped the entire human genome and those of a rapidly increasing number of animals, plants and micro-organisms. Our growing knowledge of the molecular mechanisms of organisms will soon yield health, societal and economic rewards.

This cutting-edge sector can lead to applications and products in a wide range of fields, such as new agricultural products and practices, novel foods, biodegradable plastics, as well as sustainable, environmentally friendly biofuels.

Biotechnology is opening up new possibilities in terms of tailor-made foods targeted at specific consumer needs. In addition, industrial biotechnology is breaking new ground in understanding microbial biodiversity and bio-processes that could lead to valuable bio-products and bio-materials.

“Renewable materials derived from agricultural feedstocks and used for industry and energy can make a positive contribution to sustainable development, deliver improved industry competitiveness and benefits to the rural economy,” observed UK Minister of State for Industry and the Regions, Alun Michael.

**“The bioscience sector is a vibrant part of the European economy and, in the years to come, will play an increasing role in bringing prosperity to the citizens of Europe.”**



## Towards a sustainable bio-economy

The bio-economy generates a turnover of some €1.5 trillion per year in Europe. “The bioscience sector is a vibrant part of the European economy and, in the years to come, will play an increasing role in bringing prosperity to the citizens of Europe,” said Michael.

The EU’s ambition is to build the world’s most competitive knowledge-based economy implies the existence of an efficient and effective knowledge-based bio-economy: a sustainable economy based on renewable resources. This will help wean Europe off its dependence on diminishing oil supplies and will enable it to better compete with fossil-fuel rich areas of the world by levelling the energy playing field. It will also lead to the creation of new and innovative goods and services that will enhance Europe’s competitiveness and meet the needs of its citizens.

Although Europe enjoys huge potential in the KBBE, it requires proactive action on the scientific, economic and political fronts to realise it. “The European bio-economy cannot compete on a global level by delivering only basic agricultural commodities,” Potočník pointed out. “We must look to providing a sound institutional and financial framework, based on a rational consideration of the issues at stake.”

And this is where the Union can do much to complement and stimulate Member States to work together in a cohesive and coherent fashion. “The European Union has a major role to play in championing the biosciences sector,” argued Michael.

But science is not the end of the story. “Investment in science is necessary, but not sufficient,” Potočník commented. “All participants in the chain – farmers, industry, regulators and consumers – will need to get together to make the bio-economy work.”

This requires a holistic approach that transcends the narrow confines of scientific disciplines – blending, for example, the bio- and nano-sciences – and cuts across policy areas: from research and innovation, to trade and health and consumer affairs.

In addition, it involves bringing all stakeholders on board to chart a common course into the future. We must not focus exclusively on the science to the detriment of social dialogue to ensure that science delivers what people need and complies with an acceptable ethical consensus.

# Plotting a course for Lisbon

*In March 2000, European leaders gathered in the Portuguese capital to plot a course ahead for the new millennium. At that meeting, the European Union set itself the ambitious goal of becoming “the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010”.*



**“I have to deal with the Lisbon Strategy regularly.”**

This Lisbon Strategy explicitly recognises the central role of knowledge as a motor of economic prosperity and social welfare in our fast-paced, technology-driven world. In fact, the Commission estimates that R&D investment is responsible for up to 50% of economic growth in Europe.

Consequently, the landmark strategy covers an incredibly complex range of policy areas and inter-related issues. This means that policy-makers and experts need to keep a constant eye on the ever-evolving terrain. “I have to deal with the Lisbon Strategy regularly,” admitted Peter Ludlow, a leading expert on the politics and institutions of the European Union and the founding director of the Brussels-based think-tank the Centre for European Policy Studies. “However, I suspect that, like the head of state and government themselves, I end up more convinced about my ignorance rather than my knowledge.”

Despite this complexity, there is no doubt that the life sciences and biotechnology are an important component of Lisbon. “Biotechnology was singled out as playing a key role in this strategy,” pointed out MEP John Purvis, who is a member of the European Parliament’s Committee on Economic and Monetary Affairs. “[It is] an industry that has the potential to be one of the largest growth sectors in our economy for decades to come.”

## Low on fuel

But the EU’s road to Lisbon has not run entirely smoothly. Despite some progress, the Union still lags behind its major competitors in terms of R&D investment.

In Barcelona in 2002, EU leaders committed themselves to boosting research investment to 3% of the Union’s collective gross domestic product. It has remained sluggish at just over 2%. “In monetary terms, the EU is spending roughly €100 billion a year less than the USA,” Purvis explained. He puts the US success down to its ability to encourage private industry to invest heavily in R&D.

In concrete terms, reaching the 3% target by 2010 will require the public sector to raise its R&D investment by 6% a year and the private sector by 9%. Such investment in knowledge would help the EU economy grow by an additional 0.5% and create 400 000 jobs every year from 2010 onwards.

## Milestones on the road from Lisbon

- 2000:** EU leaders agree landmark Lisbon Strategy
- 2002:** Union sets itself the ‘Barcelona’ target of investing 3% of GDP in research
- 2004/2005:** Mid-term review of Lisbon. Relaunch of Strategy with focus on growth and jobs. ‘Knowledge for growth’ becomes focus of European research policy



**“Biotechnology was singled out as playing a key role in the Lisbon Strategy.”**

But low investment is not the only challenge facing EU life science research. “Biotechnology is an R&D-intensive sector and vulnerable to waves of popular antipathy,” Purvis said. “The use of biotech does raise controversial issues, but are we approaching them correctly or leaving them to scaremongers?”



## New road to Lisbon

A mid-term review of Lisbon prompted EU leaders to commit themselves to redoubling their efforts so as to achieve its ambitious objectives in a timely fashion. With a renewed focus on jobs and growth, the landmark strategy was relaunched in March 2005. To underline the importance of R&D, Science and Research Commissioner Janez Potočnik launched his ‘knowledge for growth’ initiative at around the same time.

The Commission’s proposal for the forthcoming Seventh Framework Programme (FP7), which will run from 2007 to 2013, seeks to set the wheels of knowledge spinning faster through a proposed doubling of the Union’s annual research budget.

## Rethinking the CAP

Launched in the early 1960s, the common agricultural policy (CAP) is one of the Union’s oldest policy areas. At €43 billion per year, it represents about four-tenths of EU spending. Its aims have traditionally been to enhance food security in Europe, ensure that farmers and less-privileged rural areas enjoy a fair standard of living, and provide consumers with affordable food.

**“The CAP has to be adapted to the objectives of the Lisbon Strategy.”**

In recent years, the CAP has been subject to increasing criticism owing to its market-distorting effects on farmers in developing countries and the cost of maintaining the policy. In response, the policy has evolved in recent years to decouple subsidies and agricultural output, and to open European markets more to agricultural producers in poorer countries.

But where to take the CAP from here has been a subject of heated public debate across Europe. “The importance of the CAP is not diminishing. It remains young despite its age,” said László Vajda, director-general at the Hungarian Ministry of Agriculture and a member of the Standing Committee on SCAR.

“The CAP has to be adapted to the objectives of the Lisbon Strategy,” he proposed. This, he explained, involves exploiting the ‘multifunctionality’ of agricultural areas, i.e. striking a balance between the various functions of rural areas. In addition to the countryside’s role as a ‘food factory’, it could be used to grow renewable bio-resources as sustainable raw materials for our energy needs and for industry.

However, others believe more radical reform is needed. Some Member States, such as the UK, argue that European funds should be used in areas that enhance European competitiveness. Certain participants at the conference suggested that some CAP funds should be diverted to funding European biotech research. “The CAP is not a subsidy to production... But it is effectively a social transfer,” said Patrick Cunningham of Trinity College, Dublin (IE).

“We [as Europeans] have to agree what the EU budget is about,” Commissioner Potočnik explained. “Is it predominantly a redistributive one, or one for facing up to common challenges?”





**“Life sciences and their applications have formed an important, if understated, component of European industry and its success.”**

Drinks Industries of the EU (CIAA), which represents 24 national food industry federations, 20 large food companies and 33 sector associations. “Yet life sciences and their applications have formed an important, if understated, component of European industry and its success.”

Many of these innovations have been driven by the changing needs of consumers and society. “Without analysing societal trends, we find it would be difficult for us in the food and drink industry to fulfil our roles,” Kettlitz noted.

A wealthier society assigns more functions to food than simple subsistence. We also savour our food, use it as an opportunity to socialise, even as a status symbol. In addition, our changing lifestyles affect the sort of food we demand.

Busy careers have created a large market for ready-made and semi-prepared food and more people are eating out at restaurants than ever before. Moreover, an ageing population and the growing obesity epidemic caused by unhealthy diets and sedentary lifestyles have placed increased emphasis on healthier food products.

## The food chain and the research menu

But health and quality are not the only issues on the consumer menu. With the spate of food scares in recent years – such as mad cow disease (BSE), avian flu, dioxine and salmonella – food safety has risen high among public concerns. Despite high-tech procedures to ensure the integrity of the food we consume, the concentration of the food production and distribution chain means that a contaminant which creeps in can spread at an alarming rate. For that reason, the Commission first adopted a ‘farm-to-fork’ and then a ‘fork-to-farm’ approach to food quality and safety research.

Kettlitz also explored the role of research in the food and drinks industry. The first step is the basic research usually carried out by universities and state-owned laboratories which lasts five to ten years. This provides the foundation for the applied research carried out in public-private partnerships which typically lasts for four to eight years. The final stage is product development which is carried out by industry to create innovative new products and processes, or improve current products.

However, Europe, which has an admirable track record in basic research, does not always manage to capitalise on the application and product development stages – something is often lost in translation.

To address this, Kettlitz explained that industry was willing to engage more closely in the research process and that is why European companies have joined forces with one another and with other stakeholders to create the Food for Life Technology Platform.

## Food for thought on the bio-economy

The knowledge-based bio-economy may be a fledgling idea, but the life sciences and biotechnology have been fuelling innovation in several industrial sectors, particularly the food and drinks industry.

“The concept of the bio-economy is still rather new,” maintained Beate Kettlitz, director of Scientific and Regulatory Affairs at the Confederation of the Food and



“It’s not always easy for industry to come together and share knowledge. But the food industry has done just that,” she noted.

Food for Life has formulated a strategic vision for the food and drink sector and has been working on a Strategic Research Agenda to take the sector forward over the next 20 years (see next section).

## Factoring in the international dimension

The knowledge-based bio-economy and the promises and challenges it throws up stretch far beyond Europe’s shores. Naturally, given the fierce nature of the global market place, it will spark a lot of competition, not only between traditional rivals, such as the EU, the USA and Japan, but also emerging economic powerhouses, including China, India and Brazil.

However, the KBBE also represents massive opportunities for valuable international co-operation that can provide all sides with a win-win formula. This potential manifested itself practically in the fact that China held a parallel conference on the subject in Beijing at the same time as the Brussels gathering. In addition, delegates from as far afield as South Africa and India attended the Brussels conference.

“Although there are many differences between China and the 25 EU Member States, we face many of the same challenges,” Commissioner Potočnik and China’s Science and Technology Minister

Xu Guanhua said in a joint statement. “We are both very interested in finding solutions that lie in the life sciences and biotechnology, because these are sustainable solutions that can help us find a balance between the needs of our economies and our environment.”

**“For India, biotechnology must fulfil practical ambitions and be more than a Utopian concept.”**

International co-operation is useful for Europe in that it helps spread the costs of expensive research and tap into a more diverse pool of expertise. It also allows the EU to fulfil its role as a responsible member of the international community by assisting developing countries to boost their scientific capacity so that they can better address the unique challenges confronting them independently.

“The biosciences in India have the potential to improve public health, enhance food security, lead to more efficient and greener industrial technologies, and enhance environmental conservation and utilisation,” explained Maharaj Kishan Bhan, secretary to the Indian government’s Department of Biotechnology. India and other large developing countries can benefit greatly by investing in biotech research targeted at their specific needs, he pointed out.

“For us, biotechnology must fulfil practical ambitions and be more than a Utopian concept,” he added. To deliver on these ambitions, he noted, India is pushing ahead to create an environment conducive to innovation in the sector, and these efforts are already bearing fruit.

But countries like India cannot go it alone, and international co-operation can help them boost their capacity. Such co-operation could also be very profitable for European partners. “Research partnerships between Europe and developing countries give real opportunities to reduce R&D costs and expand potential markets for new products,” he stressed. India, for instance, has a huge pool of affordable and highly educated scientists and technicians who can help make R&D and its applications cheaper.



# The bio-economy and its life science and biotech pistons

*The tree of human knowledge in the life sciences has grown remarkably. Our understanding of life's basic mechanisms has reached unprecedented heights, and it is branching out further and higher at a dizzying pace. When we speak confidently of the knowledge-based bio-economy, it is a tacit acknowledgement of our expectations that applying this new knowledge through biotechnology will bear massive fruit for society and the economy.*

**“Europe needs a flywheel project to bring Europeans together in a common vision.”**



But to bring this process to complete fruition and to profit from Europe's longstanding lead in this sector requires renewed commitment and investment. European scientists and researchers were at the vanguard of this field in its formative years. In recent years, other parts of the world have caught up and are overtaking a slowing Europe in the innovation stakes. If the EU and its Member States do not shift up a gear in the life sciences and their biotechnological applications, we risk stepping aside and allowing others to reap the rewards of our earlier efforts.

European policy-makers, governments, industry, public and private research bodies and civil society need to recognise that our life science and biotech potential has to be carefully nurtured if it is to continue to grow.

The KBBE will not only help us enhance our material prosperity, it will also allow us to do so sustainably, in a way that is less damaging to the environment, empowering us to become more responsible custodians of the Earth for future generations. The KBBE will also help us preserve and protect Europe's coveted social solidarity and cohesion model by contributing to the creation the necessary resources to sustain it.

“Europe needs a flywheel project to bring Europeans together in a common vision,” said MEP Jerzy Buzek from Poland, who is the European Parliament's rapporteur on FP7. “Could KBBE be the flywheel for the Lisbon Strategy?”

## A complete spectrum of biotech possibilities

To the uninitiated, the biotechnology field sounds like a veritable kaleidoscope of colours and shades: there is red, green, grey and white biotech. But these colourful tags are more than just surface gloss and each represents a major sector of burgeoning possibility in its own right.

Red biotechnology encompasses biotech in the pharmaceuticals and medical sector. The life sciences are pushing back the frontiers of medicine, and solutions to the challenges that have foiled the best efforts of medical science for decades suddenly appear to be within our reach. ‘Regenerative medicine’, ‘gene therapy’, ‘therapeutic cloning’, and the more precise and targeted use of organic matter to build better drugs promise to uncover cures and treatments for a plethora of degenerative and hereditary diseases and conditions, including Parkinson's and Alzheimer's disease, cancer, and more.

Our growing understanding of how our bodies function, and how they are affected by food and the environment, will also aid scientists to act on the edict that prevention is better than cure by helping detect the early signs of certain complications and finding ways of making our lifestyles healthier.

Green biotechnology relates to agri-food applications, such as the development of genetically modified crops and plants with certain enhanced characteristics, including drought resistance or salt tolerance. It also covers the application of life science knowledge to improve plant breeding techniques and to select wild plant candidates for domestication.

**“White biotechnology is the application of nature’s toolset to industrial production.”**



White biotechnology is also known as industrial biotechnology and refers to the processing and production of chemicals, materials and energy. “It is the application of nature’s toolset to industrial production,” explained Alfred Oberholz, a member of the board at German chemicals giant Degussa AG.

Grey biotechnology, which was once indistinguishable from white biotech, refers to environmental applications. This means creating sustainable technological solutions to protecting the environment. Examples of such technologies include the development of biological enzymes which can help to clean up the effects of manmade environmental disasters, such as oil spills, and micro-organisms that absorb and filter waste matter in sewage water as part of the purification process.

“As the third wave in the field of biotechnology, white biotech follows the red and green or agricultural applications of biotechnology.” It means employing the life sciences and biotechnology in the production process itself to find more efficient and sustainable ways of manufacturing products.

“Red, grey and white biotechnology are strong in Europe,” pointed out Oberholz. The reason why green biotech is relatively weak is due to the years of deadlock caused by the controversy surrounding genetically modified organisms (GMOs) which led to a slowing of research in the field and the migration of European green biotech researchers and research facilities to other parts of the world, mainly the United States.

## Finding the right chemistry for white biotech

The European chemicals industry – the world’s largest – has traditionally been associated with the creation and use of synthetic chemicals. But with the advent and growth of white biotech, coupled with rising concern over the environment and the sustainability of current production processes, this paradigm is shifting.

White biotech employs micro-organisms, such as yeasts, moulds and bacteria as so-called ‘cell factories’ and enzymes to produce goods and services. This implies developing and producing chemicals at the cellular level by exploiting and adjusting natural processes in living organisms to generate the substances and enzymes needed by industry. Examples include environmentally friendly detergents and enzymes that replace the use of stones in stonewashed jeans.

Oberholz outlined the main drivers and sectors of white biotech. “The three fields of activity in industrial biotechnology are biorenewables as feed stock, bioprocesses for production, and bioproducts for the market,” he noted. “The drivers are selectivity, diversity, evolvability, robustness, sustainability, and biocompatibility.”

“White biotechnology... serves sustainability in industry... [and] can play a vital role in encouraging cleaner industrial processes,” maintains Europabio, the European Association for the Bioindustries.

White biotechnology is stirring up both interest and concern in the chemicals industry. Some firms are worried about the erosion of their current markets, the disruptive nature of major technological change and competition from newcomers. Other companies see it as a singular opportunity to reinvent current processes and practices, wean the chemicals industry off petroleum-based raw materials, and create new and exciting products and markets.

## Cell factories of the future

Together, a wide range of stakeholders from the research community, industry and policy-making circles set up the EU-backed Sustainable Chemistry Technology Platform. “White biotechnology, although already successfully established in some sectors, is still in its infancy,” the Platform observes in a working document. “Significant challenges still lie ahead if its power is to be fully harnessed to the needs of industrial sustainability while maintaining European industry’s global competitiveness.”

To meet these challenges, the Platform hammered out a vision for white biotech over the next two decades. By 2025, industry is likely to be using biotechnology in at least one of the processing steps used to produce a huge number of chemicals and materials. Industrial biotech will enable a range of industries – and not just the chemicals industry – to shift to an economically and environmentally sustainable way. Biomass-derived fuel will cover an increasing amount of our energy needs and rural bio-refineries will increasingly replace port-based oil refineries.



## Ingredients of a successful food research pie

The food and drink sector is the EU’s largest manufacturing sector. Yet related R&D has been hampered by public suspicion of GMOs and other food-related biotech applications. “We need to change the public understanding of biotechnology. We have been successful in the health sector but we are facing difficulty in the food industry,” explained Daniele Rossi, co-chair of the Food For Life Technology Platform.



**“We need to change the public understanding of biotechnology.”**

Under the slogan ‘adding life to years’, the Platform seeks to address this reticence and build commitment among the various stakeholders to invest in research which will bolster the future of this ‘bread and butter’ sector for Europe.

The Platform aims to provide European consumers with the food and drink products they need to lead healthier lives and improve their quality of life. It will seek to sharpen the competitiveness of Europe’s largest manufacturing sector. Through targeted activities, it will help maintain the Union’s global business leadership.

“A coherent research strategy for the future must be developed based upon the shared vision of the diverse stakeholders,” a vision document which charts the road to 2020 and beyond urges. “A step-change in research intensity and investment, together with effective technology transfer, is a prerequisite for ensuring that the European agri-food sector remains innovative and competitive.”



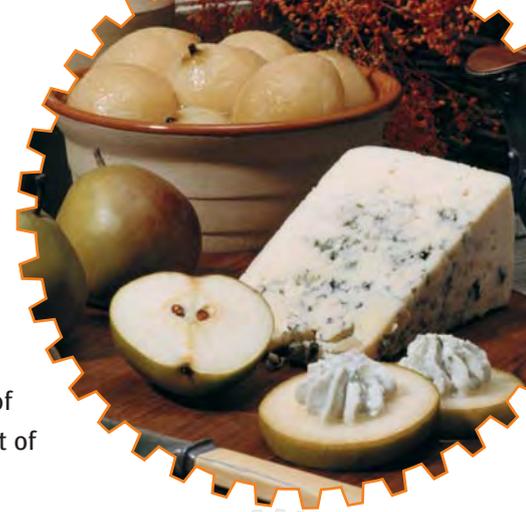
## Plotting the industry food chain

According to the European Commission, future EU-backed food, agriculture and biotech R&D under the forthcoming Seventh Framework Programme (2007-2013) should focus on the sustainable production and management of biological resources, ensuring the integrity of the food chain, the development of sustainable non-food bio-products.

The European food and drink industry is going through a period of profound change as it moves to better exploit life sciences and biotechnology. This industry in the midst of far-reaching restructuring is dominated by small and medium-size enterprises (SMEs) which presents both opportunities and challenges.

SMEs often do not possess the resources individually to carry out extensive R&D and, often being family businesses, are prone to intergenerational differences of opinion regarding the need for change. But their closeness to their markets and their expertise can be extremely valuable in the research process.

“SMEs are central to job creation. These are firms that are still growing and, if we want to trigger more innovation, we need to involve them more closely [in the R&D process],” noted Rossi.



## Strengthening the roots of the bio-economy

Although plants are not most people’s idea of high technology, much of the knowledge-based bio-economy is firmly rooted in the plant sciences. Plants have helped humanity to blossom, and they will be every bit as essential in the future.

**“In Europe, plant bioscience is not unanimously perceived as being beneficial.”**

“Plants are the engines of the agricultural value chain,” said Marc Zabeau, president of the European Plant Science Organisation (EPSO).

Humans have depended on plants since the inception of civilisation for a large proportion of their food and raw materials (oils, fibres, energy, and wood). But it is only now, at the beginning of the 21st century, that we are starting to construct a profound understanding of the basic mechanics of plant life – and this offers us enormous potential for the future.

“This is the golden age of the life sciences and it presents us with unprecedented applications,” Zabeau maintained.

However, owing to the public debate surrounding agricultural biotechnology, particularly GMOs, this field has been relatively neglected compared with other promising emerging disciplines. “In Europe, plant bioscience is not unanimously perceived as being beneficial.”



## Sowing the strategic seeds for future growth

To bridge the perception gap relating to plant genomics and biotechnology and to reap the rewards of this budding field, stakeholders from the research community, industry, policy-makers and consumer organisations formed the Plants for the Future Technology Platform. “To take advantage of this area, we need to get our science and research organised in Europe. We need to reach a consensus between stakeholders,” Zabeau noted.

Drawing on the expertise of 290 people in 30 countries, the Platform drew up a Strategic Research Agenda for the next 20 years addressing four main challenges:

- Healthy, safe and sufficient food and feed
- Sustainable agriculture, forestry and landscape
- Green products
- Competitiveness, consumer choice and governance

## The fertile forestry sector

The European forestry-based industry represent up to €600 billion a year (some 8% of manufacturing added value), employing about 16 million forest owners and 4 million in manufacturing. But the importance of the forestry sector does not stop there, as forests are important recreational facilities, repositories of wildlife and biodiversity, as well as natural regulators (i.e. carbon sinks, protectors against soil erosion, etc.).

“Europe enjoys global technological leadership and occupies a leading research position at the international level,” said Björn Hägglund, chair of the EU-backed Forest-based Sector Technology Platform.

The Platform has formulated a vision and a Strategic Research Agenda that aims to meet the multifunctional demands on forest resources and their sustainable management, and help to improve the environment. It will also seek to reinforce Europe’s position as the global technology leader and enhance the efficiency of European R&D.

Many of these goals can be achieved through the development of high-end forest-based products, pointed out Hägglund, such as ‘intelligent’ packaging that react to touch or light, or sterilise food, etc. “But the most exciting applications are the ones we don’t know yet,” he suggested.

## Down on the modern farm

Idyllic as the traditional image of farming might be, modern agriculture is a massive industry. The application of modern technologies in the farming sector has enabled us to enjoy an unprecedented abundance of affordable food using a smaller workforce.

“In the 1800s, most people were involved in food production and the food distribution chain was short. In 2005, food production employs less than 5% [of the workforce] and the food chain has become greatly elongated,” observed Patrick Cunningham of Trinity College, Dublin (IE).



**“The most exciting applications are the ones we don’t know yet.”**

But this bounty has come at a price. Contemporary agricultural practices are energy intensive, burning huge amounts of fossil fuels in the management of larger farms and the transportation of food products along an elongated food chain. This longer distribution chain has had its benefits, such as ensuring high quality and safety standards, but its main problem is that contaminants, such as foot and mouth disease, can spread rapidly. The Mad Cow disease, or BSE, epidemic alone cost the EU more than €90 billion and the lives of millions of cows.

In addition, modern farming techniques use a lot of fertilisers and pesticides which has led to increasing phosphorous concentrations and other contaminants across Europe.

## Harvesting the fruits of knowledge-based agriculture

In the future, our agricultural system will be called upon to become more sustainable, to supply food for a growing world population and to provide a growing range of non-food products from medicines to biomaterials. To achieve this, Cunningham suggested, we need to move towards a knowledge-based agricultural system. “The importance of any industry is based on the substitution of knowledge for other resources,” he explained.

**“We need to move towards a knowledge-based agricultural system.”**



Fuel production will be an important function of future agriculture and it will have to be balanced against growing demand for food. “One of the great challenges facing agriculture is to produce renewable energy resources, i.e. exploiting today’s solar energy rather than yesterday’s.”

But climate change, pollution and the rapid depletion of fossil fuels will have far-reaching implications for farming in itself. “Modern agriculture is not as sustainable as it used to be before oil dependency.” In the coming decades, farmers will have to use more efficient farming techniques.

## Real-life ‘micro’ computers

**“A cell behaves like a computer that programmes other computers.”**

Microbes are microscopic biological structures which make up about half of the Earth’s biomass. They represent an untapped treasure trove of biological ‘parts’ and ‘components’, i.e. cells which can be used to perform new functions and create new materials.

Cells are a lot like living computers in the way they read and process the information stored in their genes. “A cell behaves like a computer that programmes other computers,” described Antoine Danchin of the Institut Pasteur in Paris (FR).

These natural computers can be reconfigured by taking away or adding genes to create something new, effectively turning them into ‘cell factories’.

Danchin argued that the sequencing of individual genes to discover their functions was perhaps not the best approach, since there are too many variations and individual gene sequences, due to evolutionary convenience, perform different functions in different circumstances. “If I’m reading a book, it functions as a book. But if I use it to stop the papers on my desk getting carried away in a draught, then it becomes a paperweight,” he explained metaphorically.

This, he posited, would make it more worthwhile to pursue an approach that focused on structural genes since regulation in cells evolves much faster than any other process.



# Staking a claim to the future

*The knowledge-based bio-economy can deliver benefits for everyone and, owing to its size and growth potential, it will have far-reaching implications for the whole of society. For that reason, it is important for all stakeholders – researchers, academics, company executives, policy-makers, consumers and members of the public – to express clearly what they want from the life sciences and biotechnology, and to help chart a course for the future. In short, the various stakeholders need to stake their claim to the future.*

This section features the diverse views of various stakeholders and their vision for the future. It reflects the discussions held in the ‘Stakeholders’ vision’ session of the conference, which was capably moderated by Nico van Belzen, the executive director of ILSI

Europe, the European branch of the International Life Sciences Institute, who managed to call on his experience to help sharpen the focus of the debate. “At ILSI Europe, our job is to provide a stakeholder dialogue with scientists from academia, government and industry,” he noted.

**“At ILSI Europe, our job is to provide a stakeholder dialogue with scientists from academia, government and industry.”**



## Establishing sustainable biotech firms

The European biotechnology sector has scored many notable successes and the number of biotech firms in Europe compares favourably with the figure across the Atlantic. However, European biotech firms tend to be smaller, do not last as long, and do not invest as much in R&D and innovation as their American counterparts, according to John Hodgson, director of Critical I, a UK-based biotech consultancy.

Nevertheless, such generalisations mask a huge diversity within the EU, with Hodgson classing countries like Finland, Belgium, France and the UK in ‘biotech heaven’ for their R&D investment levels, technology transfer capabilities, policy incentives and financing respectively.

Part of the problem is that biotech firms need a sustained commitment from investors before they become self-sufficient and viable entities. This is because they differ significantly from conventional companies in that they invest a disproportionate amount of their funds in R&D and, in the early years, have little to no market potential.

Europe needs to create biotech firms that grow bigger and live longer, because these are the type of enterprises that create the most jobs, invest the most in research and generate the highest revenues. For instance, companies that are more than 16 years old employ more than half the biotech workforce. And it is more of these mature companies that the EU needs to catch up with the United States.

## Sustained effort

Hodgson prescribed a number of solutions to this dilemma and build sustainability through innovation and through efficiency. The first was to create larger companies to ensure that they do not use a disproportionate amount of their resources carrying out ‘maintenance’ functions. Another was to encourage venture capitalists to commit long term to a company to avoid the split in revenue streams demanded by ‘unadventure capitalists’ to try to reduce risk. Finally, he recommended that biotech firms avoid ‘stop-go’ product development by securing contingent financing structures.

In addition to the need for European investors to become more adventurous, biotech companies should redouble their efforts to attract more foreign direct investment. “Sustaining innovation in Europe would require a bigger cake of foreign direct investment, a bigger slice of the cake for European companies, and better use of that slice,” he suggested. “We also need to deliver funds in larger packages and venture capitalists should become more involved in the running of companies.”

**“Sustaining innovation requires more foreign direct investment for European companies.”**



On the policy front, Hodgson recommended that governments stimulate R&D investment by industry through tax incentives and streamline the regulatory burden to encourage more innovation and, hence, tax revenue. Industry should also commit to doubling its research budgets.

## Tackling the education enigma

In the long term, more research investment will be of little benefit if there are not enough scientists to carry out the research and not enough laypeople who understand and appreciate its benefits and put them to good use.

**“We have to get young people interested.”**

Although Europe remains the world’s largest ‘brain factory’ and has a well-educated citizenry, graduating the highest proportion of S&T students, the number of young people pursuing scientific studies and careers is tailing off. This trend is particularly worrying in light of the increasing number of qualified researchers the EU needs as it moves to construct a fully functioning knowledge-based economy.

This requires us to rethink our approach to science education and curricula. “Education is a cornerstone of the knowledge-based economy,” explained Lene Lange, who is an advisor to the Danish ministries of Science and Technology, Food and Agriculture, and Transport and Energy. “We have to get young people interested.”

Motivation is part of the problem. Many students and schoolchildren cannot see the link between the science they learn in school and the ‘real world’ they live in outside and the issues they care about. “Many young people want to make a difference. We need to show them that they can make a difference as biotech researchers.”

## Gaining new momentum

Young people are often concerned about the state of the environment and the sustainability of our way of life. If they realise that the shift towards a knowledge-based bio-economy offers a sustainable alternative to the fossil-fuel economy, they are more likely to become a part of it, suggested Lange.

In addition, the bio-economy could act as a good equaliser, creating a more egalitarian global trading system. “Fossil fuels and petrochemistry give only a few countries a strong advantage,” she noted, “biological resources are widespread, giving all countries – even newcomers to the field – a more ‘equal’ chance.”

According to Lange, the science education system needs to be redirected, and teachers retrained, to serve three purposes: empower citizens to have a good general grasp of S&T so that science can function democratically; nurse and stimulate the interests, skills and qualifications of young people to create the top scientists of the future; ensure that a broad spectrum of professional understand S&T and how it affects their work.



## Towards consumer-led innovation

Any knowledge-based economy of the future should be clearly geared towards delivering goods and services that consumers need and want, and providing them with freedom of choice. Consumers should have a free choice,” asserted Jim Murray, director of the European Consumers’ Organisation. “I do not necessarily oppose any new technologies, but consumers should have the right to choose.”

**“Consumers should have the right to choose.”**



In addition, innovation should be consumer-led. “The purpose of production is consumption and not the other way around,” Murray stressed. “We need to learn from the CAP and find a way of delivering what consumers want.”

Biotech and GM food are not one and the same thing, he noted, because GMOs are only a small part of the biotechnology spectrum. But the field as a whole has been somewhat tainted by the controversy surrounding GMOs. “Few people who know something about the subject now believe that there is a significant health risk from GM technology,” he noted.

Nevertheless, as countless opinion surveys reveal, Europeans are concerned about the health consequences. The answer could lie in promoting more coexistence between different types of crops. “Coexistence is a way of providing consumers with a choice. But we have to see whether it provides them with a real choice, or will it be like the choice between crossing the Atlantic by liner or plane when air travel took off,” Murray said.

## Virtuous circles to break vicious cycles

In order to break out of the deadlock surrounding GMOs and other controversial biotechnologies, the benefits of the field need to be demonstrated materially. “We need to look at the immediate benefits from biotech to consumers, whether it is new products or improved environmental management,” Murray suggested.

Such benefits, and any associated risks, need to be evaluated objectively. “Assessment of benefits must be science and evidence-led. But whose science?” he asked. In certain cases, particularly if left unsupervised and unregulated, industry-led research can lead to less transparency by gearing the research agenda towards commercial concerns rather than purely scientific goals. “Scientific disinterest and impartiality can be compromised under such pressure,” he said.

The solution lies in striking a careful balance between the needs of the various stakeholders. “With the right focus, we can get a virtuous circle of biotechnology delivering economic, environmental and social benefits,” he concluded.

## Mapping the gene landscape

Microbes may live below our visible consciousness, but they contain most of the planet’s biodiversity. “How do we access biodiversity, if we assume that microbes are its main repositories?” asked Victor de Lorenzo of Spain’s National Centre of Biotechnology. “Ideally, the more individual genomes we sequence, the more we sequence of the global genome.”

However, the law of diminishing marginal returns does not only apply in economics, it also applies in genomics. “Statistically, we should reach a plateau at which the cost of discovering new genes becomes prohibitive,” he asserted. The answer? A rethink of our approach to sequencing, suggested de Lorenzo.

“Perhaps we need to think of genes not as DNA sequences but as gene landscape,” he proposed. This would mean taking a more functional approach to genomics and grouping genes together according to what they do.

## From genetic engineering to synthetic biology

For two decades, genetic engineering has been about adding or taking away individual genes from existing biological systems. “This is becoming a thing of the past. The next big leap is synthetic biology,” opined de Lorenzo.

Synthetic biology borrows heavily from classical engineering and revolves around the notion of designing complete bio-based systems from scratch. “Why take the whole cell? Why not extract just the parts we need for our purposes?” he asked.

This would work more effectively than conventional genetic engineering because cells have not always evolved to perform functions in the most efficient way possible and they usually contain code for tasks that are redundant for scientific or industrial purposes.

**“The next big leap is synthetic biology.”**

But this raises the thorny issue of whether such use of biological matter could constitute a form of ‘life’. No, believes de Lorenzo, because such organic systems would lack the very essence and mission of life: multiplication and self-propagation. “We will build biological systems, not living organisms, not life.”

Synthetic biology presents an endless range of possible applications, including the design of better catalysts, artificial chromosomes, microbial fuel cells, and much more.

## Biopolicing of food quality

Numerous EU public surveys have revealed that food quality and safety are of utmost importance to many Europeans. This concern is reflected in Union regulations that set some of the world’s highest standards.

These include general quality and safety legislation and directives targeted at specific food types, such as meat, as well as clear labelling requirements. Maximum residue limits are set for many hazardous compounds. In addition, the EU oversees a large network of national safety laboratories and runs a rapid alert system to check the spread of contaminants that enter the food chain.

Enforcing such regulation and underwriting the safety and quality of food is no mean task. It requires sophisticated feats of technical competence and expensive high-tech equipment. “Laboratories need to determine simultaneously multiple unrelated residues and contaminants in complex samples, while meeting requirements for the quality of generated data,” said Jana Hajslova of the Czech Republic’s Institute of Chemical Technology.





**“Biotech testing methods can offer real alternatives to biological and radioactive assays.”**

## Complementing current methods

Currently, such testing depends on sophisticated off-site approaches, such as gas and liquid chromatography. Although such physio-chemical systems are very accurate and can detect extremely low concentrations, they are expensive and often time-consuming to run and require highly trained personnel. “Biotech testing methods can offer real alternatives to biological and radioactive assays,” suggested Hajslova.

Biotechnology solutions are often more portable, cheaper to run, do not require the same level of training and can be used on site. One current example of this is ELISA (enzyme linked immunosorbent assays), which are kits based on microplates containing antibodies specific to a particular analyte. Emerging biotech testing systems include biosensors, transcriptomics and proteomics.

An EU-backed research project called BioCop is currently exploring ways of developing new biotechnologies to screen multiple chemical contaminants in food.

## Nano-sleuths and nano-culprits

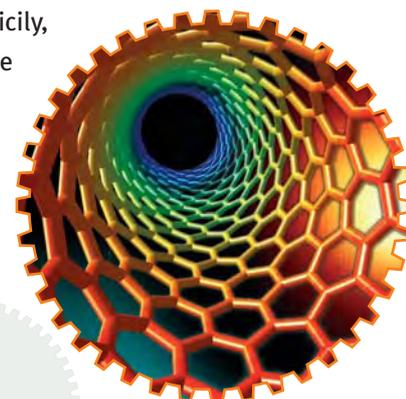
Another emerging way of detecting microscopic threats to our health is the fledgling field of nanopathology. Rising pollution levels in recent decades have meant that an increasing number of toxic nano-particles, from basalt to lead, are finding their way into our food and drink. They are usually in concentrations that are harmless, unless exposure to them is sustained over a large part of a person’s lifetime.

**“Nanotools can help us to fight the war against contamination.”**

We need to be able to detect these contaminants effectively in order to assess the risk they pose and trace their origins, a task which is made the more complicated by the global nature of modern trade. “If we eat polluted food, there is a chance that the inorganic element will pass through into our organs,” explained Antonietta Morena Gatti of the Laboratory of Biomaterials at the University of Modena and Reggio Emilia in Italy. “For example, a toxic particle inhaled can reach the lung within an hour.”

Her expertise and concern lead her to become a veritable nano-sleuth and she has become a leading light in the emerging field of nanopathology. For instance, Gatti traced the minute traces of basalt found in cauliflower from her local supermarket to a volcanic eruption in Sicily, and uranium particles found in a secretary’s stomach to an organic farm near a tile factory which used a uranium-based substance in its glazing process.

Such early detection is invaluable in avoiding long-term health problems and in stemming contamination at the source. “Nanotools can help us to fight this war against contamination,” she noted. But that, in itself, would not be enough. “Is growth still sustainable?” she asked. “Not according to the current model, but I think the bio-economy can offer truly sustainable solutions.”



# Conclusions

As can be gleaned from the breadth of the discussions and ideas covered in this brochure, the Brussels conference represented a prime opportunity to present new and emerging knowledge and consider a path forward for the knowledge-based bio-economy.

“This gathering has shown that we now need to focus on the four Fs (food, fibre, fuel and feed) and the four Cs (changes, challenges, complexity and compliance),” noted Christian Patermann, director of Biotechnology, Agriculture and Food Research at the Commission.



**“We now need to focus on the four Fs (food, fibre, fuel and feed) and the four Cs (changes, challenges, complexity and compliance).”**

He went on to outline the six basic conclusions that can be drawn from the conference:

1. The timing of the conference was good as it will provide food for thought for the preparations for the forthcoming Seventh Framework Programme (2007-2013). It was also a good time to bring together 400 key players from 40 countries
2. There is no doubt that the KBBE is an integral part of the Lisbon Strategy
3. Combining biotechnology with other technological fields is the right way forward
4. Industry is active in pursuing the goals of the KBBE. Even though many developments have still not made it to market, Europe is moving ahead. Technology Platforms are doing a good job, but related ones need to cluster more closely
5. International co-operation is becoming an integral component of the biotechnology landscape
6. Biotechnology needs to comply closely with the wishes and needs of society, with regulations and with the requirements of the research system

The Commission is planning to establish a network of senior government officials to pursue the further development of the KBBE in Europe. It will facilitate the exchange of views on different practices and experiences, with the ultimate aim of establishing a strategic framework for the knowledge-based bio-economy.



# Conference agenda and useful links

This report and its conclusions are drawn from the presentations and discussions which took place at The knowledge-based bio-economy conference in Brussels (15-16 September 2005). The gathering revolved around the following three themes:

## THE POLICY CONTEXT

This session explored numerous policy-related issues, including the knowledge-based bio-economy in the context of the Lisbon Strategy and the changing focus of the common agricultural policy. It also examined the interaction between education, science and values.

## LIFE SCIENCES AND BIOTECHNOLOGIES DRIVING THE BIO-ECONOMY

Biotechnology and the life sciences are the recognised motors driving the knowledge-based bio-economy. This session examined the vital role of these disciplines and how scientific knowledge can be transformed into valuable applications. Several EU-backed Technology Platforms presented their vision for the future.

## STAKEHOLDERS' VISIONS

This session enabled various stakeholders to outline their visions for sustainable and environmentally friendly growth, industrial competitiveness and consumer satisfaction. It also considered biotech applications and the implications of the nanotechnology revolution in the context of the bio-economy.

### Conference website:

[www.europa.eu.int/comm/research/conferences/2005/kbb](http://www.europa.eu.int/comm/research/conferences/2005/kbb)

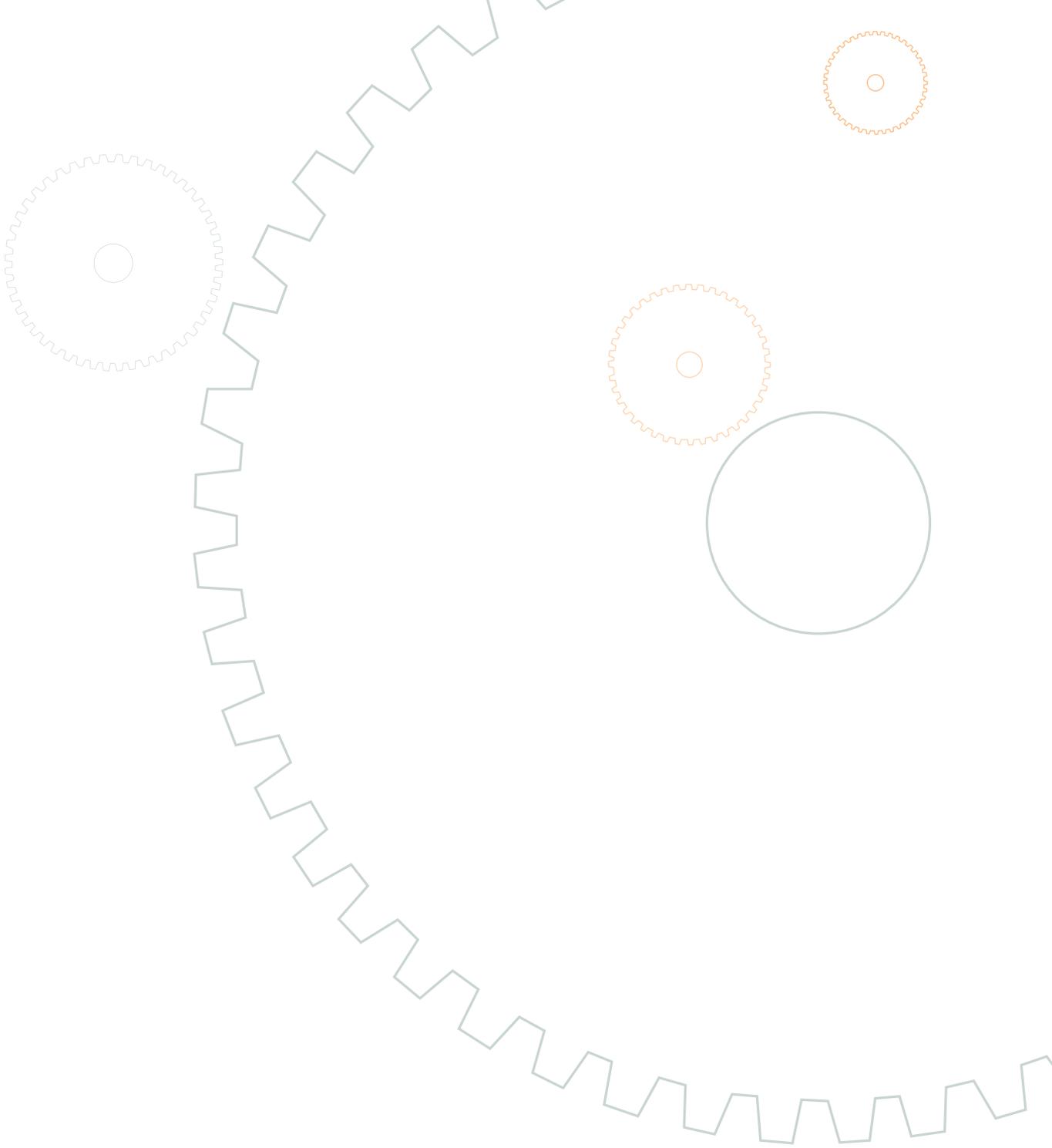
### Further information on the conference topics is provided at:

[www.europa.eu.int/comm/research/fp6](http://www.europa.eu.int/comm/research/fp6)

[www.europa.eu.int/comm/research/future](http://www.europa.eu.int/comm/research/future)

[www.europa.eu.int/comm/research/biosociety](http://www.europa.eu.int/comm/research/biosociety)

[www.cordis.lu/fp7/](http://www.cordis.lu/fp7/)





**“As citizens of planet Earth, it is not surprising that we turn to Mother Earth – to life itself – to help our economies to develop in a way which should not just enhance our quality of life, but also maintain it for future generations.”**

Janez Potočnik  
*EU Science and Research Commissioner*