

I. Respondent's profile

Further development of the bioeconomy is essential if Europe is to address the grand challenges that face not only European but also global societies and economies. European plant sciences are willing and able to actively participate in this process by playing a leading role in research, education and innovation that will lead to the sustainable bioeconomy of the future.

EPSO – the European Plant Science Organization (www.epsoweb.org) – is an independent academic association with more than 220 research institutes and universities from 30 countries mainly in Europe, and 2 800 individuals, as members, representing over 28 000 people working in plant science.

EPSO has been actively involved in the development of strategies and has provided some of the initial impetus for the implementation of the bioeconomy in Europe. Since its founding 10 years ago, EPSO and its members have actively fostered collaboration between the scientific and industrial communities across disciplines and sectors of the bioeconomy, e.g. as a founding member of the European Life Science Forum and the Initiative for Science in Europe. These groupings supported the creation of the European Research Council (ERC), which became one of the success stories of FP7. Beyond this support for frontier research, EPSO fosters collaborative research across stakeholders and disciplines as a key member of the European Technology Platform “Plants for the Future”. EPSO has also had a central role in the establishment of the Strategic Research Agenda of the ETP and its links to the bioeconomy of the future. On behalf of the Plant ETP, EPSO coordinated the BECOTEPS-project linking 9 ETPs active in bioeconomy, developing joint perspectives and recommendations for research, education and innovation to make the Bioeconomy in Europe a reality.

II. Potential benefits and risks of the Bioeconomy

Europe can only maintain its position in the global development of the bioeconomy, if society is open and supportive to all relevant technologies and innovations. The implementation of technologies must be considered relative to their contribution in addressing global societal challenges and needs. Of particular relevance for the bioeconomy are global food security, sustainable use of natural resources, public health, climate change and clean energy production.

The bioeconomy must become an integral part of the overall economy benefitting from synergies with other industrial sectors, including renewable energy production, synthesis of novel/new materials, development of novel chemicals and pharmaceuticals. This can result in diverse mid- and long-term production routes, including bio-based as well as non-biobased processes. For example, power for energy-intensive processes could be provided by non-bio-based renewable energy sources or waste heat and bio-catalysis could be combined with non-biological catalysis.

It will not be possible to build a bioeconomy on a “European Island”. Novel global interactions need to be actively facilitated and developed addressing the emerging potential of societies on a global scale. For example, it is expected that new trade routes will be needed. Such developments must be actively fostered, especially with emerging countries, according to their production and contribution to the market potential for the bioeconomy. This provides significant opportunities for research and innovation. These global perspectives must also be accompanied by suitable education actions and initiatives to ensure researcher mobility.

III. European bio-based economy today

Today several activities for research and innovation have been initiated. None of them is fully established and implemented at the level required to build a successful and competitive European bioeconomy. More general as well as specific actions must be taken at all levels from research, through education to innovation.

IV. European strategy on a sustainable bio-based economy: advantages and possible future actions

The European strategy towards the future bioeconomy must combine curiosity-driven and agenda-driven research approaches to both develop as well as foster innovative ideas and the capability to transform them into society-relevant solutions. There also needs to be the establishment of appropriate mechanisms for knowledge-transfer, and the establishment of pilot and demonstration plants, experimental farms and industrial installations, all of which are indispensable tools for transforming knowledge into marketable products. This phase has been largely neglected in the past, but needs to be developed in a balanced manner with continued support for the research that will provide the necessary knowledge based information. The major amount of resources for the Bioeconomy in the European Research and Innovation Program should therefore be used for European research projects, with a smaller amount to further advance the relevant European Research Area using instruments such as ERA-NETs and JPIs.

Industrial participation clearly needs to be fostered: for collaborative, agenda-driven research projects, industry must be involved in defining the research needs and have access to research results in an effective manner. In projects ranging from pilot to demonstration plants, industries must be directly involved for their implementation and should provide an increasing share of the financial resources required for near-market products. Establishing a “KIC Bioeconomy” within the European Institute of Technology with a strong industry perspective would open new routes to effectively bridge the gap between invention and market - a goal of extraordinary importance for the emerging bioeconomy.

The bioeconomy would consequently be an excellent focus for the establishment of European Innovation Partnerships, accelerating the research, development and market deployment of innovations directed at major societal challenges, and providing a basis for the pooling of expertise and resources for enhancing the competitiveness of the EU bioeconomy industry. An “Innovation Partnership on Agricultural Productivity and Sustainability” would be an excellent first step in this direction. This would strongly benefit from and support the alignment of the future EU research and innovation program for bioeconomy with the new Common Agricultural Policy.

To ensure innovation in the public sector needed for humanitarian aid in developing countries – Joint Research and Innovation Activities for Humanitarian Aid - it should be considered how the EU wants to support and coordinate future innovation that has to be done in the public sector, such as food security and pharmaceuticals for developing countries. This could become an exception in the innovation programme, as not only hurdles but as well the innovation itself needs to be addressed by the public sector.

A scheme similar to the Joint Programming Initiatives could be envisaged that would not only address research, but as well innovation in the public sector. Funding at EU level should include the coordination of research and innovation across the Member States and EU initiatives, as well as some research and some innovation activities in addition to those funded by the Member States. One could call these ‘*Joint Research and Innovation Initiatives for Humanitarian Aid*’. They could be supported by

better aligning strategies and resources from the research, the innovation and the development programmes.

To provide an incentive for foundations or other entities to invest in humanitarian aid, EU programmes could offer matching funds to relevant/appropriate topics where some financial support has already been secured (e.g. 10 million € from the Gates foundation or other PPPs) to foster further product development, establishment of pilot plants and preparations required for market introduction.

Creative and novel financing mechanisms need to be developed between the European Commission, the Member States and the EIB, as the existing equity and debt-based financing available for innovation in the private sector is only possible for fully operational companies and is absolutely a no go for academic institutions as well as research organizations who are the main actors for innovation in the public sector in relation to humanitarian aid.

Case example 1: Innovation in the public sector for food security for developing countries

Current demographic, energetic and climatic threats make food security a widely recognized concern. It is a complex matter that does not rest only on technical matters, but food certainly comes from plants and from agriculture, which must also produce fibre and fuel and provide economic growth, preserve environment and natural resources and contributes to reduce poverty. Near 2 billion small producers depend on agriculture for their living but moreover, they will be responsible to feed 9 billion people in 2050 in a sustainable way. Hence, improving agriculture efficiency on economic, environmental and social levels becomes a tremendous challenge for humanities.

The "green revolution" in the 60s and the 70s was based on a mix of new high yielding varieties and high inputs levels and allowed the food crop yields to jump and, especially in Asia, to tackle efficiently food insecurity at that time. The new varieties were essentially based on public research on the main food crops, rice, wheat and maize, which were widely spread. Yet large parts of the world, Africa in particular, remained untouched by high yielding varieties. During the 80s and the 90s, agriculture in the developing countries knew a massive disinvestment on different levels, including research. Progressively, in most less developed countries, the research capacities eroded and in some cases disappeared.

Plant sciences have a key role in that challenge, and their central impact channel is plant breeding. Public international agricultural research covers some of it but not all and not everywhere. There is a huge gap between those crops that mobilise multinational private actors, often at the expense of local specific crop adaptation, and those globally minor but locally essential crops that receive no investment. The global capacity in this area requires urgent action, targeting emergence of a new generation of breeders that can deploy a global effort for plant improvement and make the best use of novel methods and tools. These include a broad range of situations: diverse selection approaches (from simple marker-assisted selection to gene-based selection or genome-wide selection); diverse crops (from major cereals to diverse orphan, locally essential, crops); diverse types of plant population (species associations, genotype mixtures, hybrids, ...); diverse marginal areas with specific, often sporadic, constraints; diverse modes of partnership (from public-based participatory breeding to private proprietary varietal development).

Supporting plant research to impact on food security requires many, highly-trained, technology-enabled plant specialists and breeders. Critical mass and qualification being prerequisites to the proper use of technology, a training component requires specific action and massive support, with exposure to and practice of advanced methodologies.

Access to technology must be carefully thought of. Mutualising common facilities that serve a broad community is rather recent in 'advanced' countries, and it is not an easy process; there are still important barriers between sectors of biology, for instance health and agriculture. Emergence of such advanced laboratories in developing countries is both critical and challenging. As a step towards it, it is essential to reserve free access to large facilities in Europe for partners in the developing world, with procedures that facilitate sense of ownership and

autonomy for those partners. This effort is to parallel and synergize a global effort towards the conservation and equitable use of genetic resources, most of which comes from currently developing countries.

Case example 2: Innovation in the public sector needed for Plant Made Pharmaceuticals for developing countries
Biopharmaceutical proteins are typically produced in cultivated mammalian cells that are costly, require dedicated fermentation and downstream processing facilities, and run the risk of contamination with human pathogens. For all these reasons, pharmaceutical products such as antibodies are among the most expensive on the market, so that the world's poorest people are deprived of access. The world's poorest people are also the most likely to suffer from diseases such as HIV/AIDS, tuberculosis, malaria and rabies as well as other tropical and infectious diseases because of the low educational and health standards in developing countries and the high cost of prophylaxis and therapy.

Plants provide an alternative platform for the production of biopharmaceutical proteins, and, because this can be scaled up to agricultural levels, they are ideal for the economical supply of pharmaceutical proteins, and secondary metabolites that are in great demand in developing countries; these include HIV microbicides, rabies antibodies for post-exposure prophylaxis and malaria vaccine candidates. In addition, transient plant-based platforms allow the rapid production of pharmaceutical products, including vaccines that can be produced rapidly in response to a pandemic disease outbreak.

However, there is a significant innovation gap between the technological development of plant-based production platforms and their deployment on the ground in developing countries. What is required is a unique combination of agricultural and medical translational research in developing countries to identify and accelerate the supply of plant-derived pharmaceuticals that would address societal needs most rapidly and effectively. Next to an ethno-pharmaceutical approach, the development process would include the selection and adaptation of plant varieties that would be suitable hosts for pharmaceutical production in regions such as sub-Saharan Africa, the introduction of inexpensive processing facilities and a move away from the fixed equipment concept used in the industrialized world towards less expensive facilities with disposable processing equipment, and the development of publicly funded clinical networks to take the most promising candidates into clinical development.

Research and innovation is currently focused on the early R&D stages and must be more evenly distributed along the value chain in order to bring inexpensive drugs, vaccines and microbicides within the reach of the people who need them the most.

To fully benefit from the potential of bioeconomy, deregulation needs to be better addressed to not hinder innovation. For example in the plant sector one instrument to continue the high safety standard and at the same time reduce the effort for deregulation to a manageable level as well for SMEs in Europe would be the introduction of the familiarity principle. Large companies could take the lead in getting approval for a certain transgenic plant family or species, with SMEs then having fewer hurdles to overcome when bringing related products to the market.

Many discoveries in plant science over the last 15 years have the potential to improve crop performance. A better understanding of plant gene function helps breeders to identify alleles that are linked to traits of interest in a breeding population; for example, resistance genes, regulatory genes or genes that regulate starch accumulation. However, in addition to this approach, there is considerable scope for GM approaches in which plant genes are fused to non-wild type regulatory sequences to improve their spectrum of activity or expression levels. New alleles of plant genes could be generated in vitro and after insertion into a plant, creating crops with an improved performance. Genetic variation in wild relatives can be identified, cloned and moved into crops.

University and other public sector labs, in particular, host creative individuals with the flair and appetite for innovation in this sector. However, the current regulatory burden is such that funding for any GM based innovation is extremely difficult. The problem is not technical risk, but rather, regulatory risk and regulatory costs. As Northern Europe will have a crucial role to play in food production as climate change increases drought and heat stress for southern European, the US corn belt, China and South America it is essential that GM regulation is rational, restricted to assessing scientifically plausible risks, and that it is based on science rather than politics.

The rest of the world is moving quickly to adopt GM methods- 15M farmers planted 150M hectares of GM crops in 2010- but currently Europe is being excluded from either leading or benefiting from GM innovation, despite the many \$B of value created each year by GM crops. This challenge to innovation must be addressed.

The provision of a trained and educated workforce is essential for the research, and farming communities as well as industries. Training should be carried out in dedicated training programs following-on from successful schemes such as Marie-Curie at the European level and the corresponding ones at the national level. Already today there is a shortage of the relevant skills required for the nascent but rapidly growing bioeconomy. Following the success of the joint research agendas, European Technology Platforms should be strongly involved in defining appropriate education targets. The EC might facilitate these activities through e.g. a conference on education and training in cooperation with the responsible national stakeholders, including those responsible for education, for example the respective ministries.

Socio-economic impacts and foresight activities are also important. In most cases the continuations of existing activities is sufficient and only in exceptional cases are additional ones required.

All activities in research, innovation and education need to be supported for their disciplinary excellence within each sector of the bioeconomy. This is the basis for proactive multi-sectorial research and innovation actions that need to be supported across all the relevant sectors that are required to build the bioeconomy web and beyond linking for instance with the environment, the health and the energy sectors.

In addition we provide EPSO views on four questions asked by the Questionnaire for future EU research and innovation funding programmes that are most relevant to bioeconomy:

Q1. How should the Common Strategic Framework make EU research and innovation funding more attractive and easy to access for participants?

- To attract the best applicants topics should be broad enough (currently too narrow in food, agriculture and biotech; same in environment) and supported with sufficient grants (that only one project has a chance to be funded is deterring applicants) to achieve a critical mass of funding in related research areas. Consequently greater impact is achieved.
- Procedures and administrations need to be based on trust with reasonable control rather than with heavy work load for application, contract negotiation, management and reporting (the procedures of the ERC are a good starting point). Otherwise national funds would need to be available to support the time-consuming proposal preparation and contract negotiation.
- FP structure should enable multi-disciplinary and multi-sectorial approaches in research and innovation, to facilitate the creation of new research alliances and focus
- FP structure should include a fast track for certain applications, e.g. small / medium sized projects with SMEs

Q2. How should EU funding best cover the full innovation cycle from research to market uptake?

- EU funding should cover activities that encompass performing curiosity driven research, strategic research, demonstration projects and pilot plants in research programmes. In general the public contributions should be highest (100%) for ERC and decrease towards the pilot plants stage, whereas the private contributions should increase, the only exception being innovation in the public sector for humanitarian aid. In addition EU funding should be used to identify and address barriers for innovation in the innovation programmes.
- Research and innovation programmes should be able to absorb at any stage results from national and multi-national and global initiatives. Linkages between national programmes and FP research should be facilitated to leverage EC funding
- Research and innovation programmes should allow for some projects to start with research and take them further to pilot and demonstration. In such case the length of the funding/continued funding will be important to ensure that the results are translated into commercial activities. Flexibility is required in both

the initial duration of the project (3 years are too short) and an ability to extend the original work. Continuity is important.

Q3. What are the characteristics of EU funding that maximise the benefit of acting at the EU level? Should there be a strong emphasis on leveraging other sources of funding?

- The potential of EU programmes supersedes those of national programmes to address challenges at the European or global scale, striving to maximise the potential of European research by facilitating long-term integration in key research sectors.
- In EU research programmes, it is crucial to provide most resources to achieve critical mass (grants at least as high as in national programmes) to perform excellent frontier research (ERC) as well as collaborative open ended and collaborative strategic research (Cooperation Programme). In addition a smaller amount of resources needs to be provided to carry out a set of coordination and support actions to bring national activities closer together to maximise their impact, to ensure more efficient transfer of generated knowledge towards products for the market.
- In EU education programmes, continued focus should be on training and mobility across countries – clearly not the remit of national programmes. More encouragement for mobility from academia to industry AND back to academia should be provided – one shortcoming in Europe compared to the US and other major economies. Similarly encouragement for moving between academia / industry and policy, regulatory and media environments. In addition, EU programmes could start coordination and leverage activities towards the Member States discussing existing or future gaps in education and how to address at national and regional level. These coordination activities would only need a small amount of the resources available in the EU programme.
- In EU innovation programmes, hurdles for innovation can be addressed at the European level followed by support actions creating the links to develop and implement the solutions at national levels. European Innovation Council could be established to promote entrepreneurship, achieving a similar effect in the innovation arena as the European Research Council is achieving at the European research level.
- For all approaches mentioned above, it is important to focus on performing research, performing training, and addressing innovation hurdles, and use only a limited percentage of the budget for coordination activities leveraging other sources of funding, such as the ERA-Net, joint programming initiatives, European Technology Platforms and public-private partnerships.
- Along the same lines focusing on the activities, part of the research and innovation funds could be used to top up national funds and / or foundation funds to quickly react to and participate in major global initiatives.

Q8. How should EU research and innovation funding relate to regional and national funding? How should this funding complement funds from the future Cohesion policy, designed to help the less developed regions of the EU, and the rural development funds?

- We consider the EU research and innovation programmes, the relevant programme under the EU cohesion policy and relevant parts of the EU development programmes, to complement each other in terms of activities as well as amounts of funding. In addition, one could consider using part of the cohesion funds earmarked for research purposes to finance participation of scientists from less developed regions in ongoing EU research projects. This would help these regions to access established networks and become a natural part of this network over time. This exceptional use of the cohesion funds should decrease over several years (max of 7 years and then stop) after which the scientists of these regions should be able to compete for funding with scientists from more established regions.
- In particular CAP needs to be aligned with the increased innovation requirement of agriculture in an increasingly competitive market for agricultural goods and services in Europe and globally. The increasing needs of agricultural raw materials require a more rapid transfer of information based on knowledge-driven research to application-oriented science for agriculture and further to candidate products / management practices that lead to commercialisation. Sustainable intensification is required as an over-arching concept that is generated from a joint commitment. It needs to be implemented by closing the ranks between agricultural practice and research, based on incentives for both sides - research to orient itself towards the urgent questions of agriculture and agriculture and industry to benefit from the world-class knowledge generated in European sciences. The urgency of the huge tasks ahead demands an open-minded approach, which does not exclude technologies that have potential to overcome major bottlenecks.