Position on

Horizon Europe

Initiative for Science in Europe

ISE Task Force on Horizon Europe

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The Initiative for Science in Europe (ISE) is an independent platform of 16 European Learned Societies and Research Organizations operating within different disciplines and across sectors. ISE supports all fields of research at a European level, involves researchers in the design and implementation of European science policies, and advocates strong independent scientific advice in European policy making.

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Glossary

COST European Cooperation in Science and Technology
DG Directorate-General
EC European Commission
ERA European Research Area
ERC European Research Council
ERDF European Regional Development Fund
ESIF European Structural and Investment Funds
ESF European Social Fund
EU-13 Member states added to the European Union on and after 1 May 2004 (The EU-13 comprises the following 13 countries - Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.)
EU-15 Member states in the European Union prior to the accession of ten candidate countries on 1 May 2004 (The EU-15 comprised the following 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.)
EU-28 The EU member states before the United Kingdom withdrew from the European Union in 2020 (The EU currently is 27 countries.)
EUA European University Association
FET Future and Emerging Technologies
FP Framework Programme
FP7 Seventh Framework Programme
FP9 Ninth Framework Programme, Horizon Europe
H2020 Horizon 2020
HE Horizon Europe
ISE Initiative for Science in Europe
LERU The League of European Research Universities
MSCA Marie Skłodowska-Curie Actions
NCP National Contact Points
R&I Research and Innovation
SDGs Sustainable Development Goals
STOA Science and Technology Options Assessment Panel
SwafS Science with and for Society
TRL Technology Readiness Level

Executive Summary: Position on Horizon Europe

With this document, the Initiative for Science in Europe proposes a set of recommendations to improve the implementation of the EU's research and Innovation Framework Programme, Horizon Europe (HE). ISE membership (European learned societies and research organisations) covers a vast spectrum of research and innovation expertise and activities, from academic, not-for-profit, and public service organisations, to collaborations with the private sector. The analysis of the framework programme we present here takes into account its impact on many sectors, disciplines, and geographies.

We consider that the positive advancements of HE, that are based on what was learned by its predecessor Horizon 2020 (H2020), make the overall structure of the programme good, and promising. At the same time, we believe that there are three main areas that need more consideration **to further enhance the effectiveness and pan-European societal impact of the programme**:

- foster interdisciplinary approaches within the programme
- increase the efforts towards supporting EU-13 countries improve their R&I system
- strengthen the R&I cycle in pillar 2

These three aspects are strongly interconnected and tackling them together will improve European Research and Innovation (R&I) capabilities well beyond the time span of this framework programme. Our analysis and recommendations also provide a useful tool for the European Commission to achieve the four strategic objectives set in the ERA Communication published in September 2020 (European Commission, 2020a).

Interdisciplinary perspective

To face the complexity of societal challenges, it is essential to have an interdisciplinary perspective. Understanding and solving systemic issues, questions, and problems can be achieved only through an approach that goes beyond disciplinary silos and synthesises and integrates research fields. Initial steps in this direction were taken in the previous framework programme; in fact, H2020 has encouraged some multidisciplinary (and at times interdisciplinary) approaches, for instance in the "Science with and for Society" programme (SwafS).

However, we argue for **developing a work programme where disciplinary, multidisciplinary, and interdisciplinary approaches coexist**. An interdisciplinary perspective is particularly important in

Horizon Europe's Global Challenges, including the missions. To facilitate the uptake of interdisciplinary approaches, we recommend*:*

1. enabling flexible budgets across intervention areas and across clusters with no additional administrative burden, and create calls across different clusters;
2. adapting reward systems that recognise interdisciplinary research;
3. supporting research programmes for interdisciplinary education;
4. combining more disciplines in one project.

Widening participation

Aware of the European Commission's willingness to address the issue of widening participation, we point out that there is still a significant gap between the EU-13 and EU-15 countries in terms of participation and success rates in the FPs. We reckon that, while Horizon Europe should uphold the principles of excellence, cooperation, and impact, for a sustainable future of the EU's research ecosystem it is necessary to **diminish the R&I gap between member states**. Based on the study by the European Parliament Research Services and on the feedback from our member organisations, we recommend the following actions that will synergistically benefit both EU-13 and EU-15 countries:

1. provide incentives for both EU-15 and EU-13 to collaborate more closely and foster international links between institutions.
2. advance from the exchange networks for research results and ideas (COST actions) to actual research collaborations (RIA, IA).
3. extend the MSCA widening fellowships concept to other programmes.
4. enable a central role for National Contact Points (NCPs).
5. link national funding in EU-13 to peer review process in EU-15.
6. exploit synergies with other EU programmes.

The R&I cycle in pillar 2 of Horizon Europe

We consider that the Research and Innovation cycle in pillar 2 of the HE programme should be designed to achieve a balanced representation of basic and applied research in addition to demonstration and innovation actions. This will strengthen the effectiveness of the European innovation ecosystem by allowing a continuous flow between advancement of knowledge and technologies at different technology readiness levels (TRLs), thus as well addressing the needs of the industrial sector and private companies. To this end, we strongly **recommend including collaborative basic research as an intrinsic component and occasional focus of R&I actions**, particularly for funding that addresses Global Challenges.

Introduction

The Initiative for Science in Europe (ISE) is an independent platform of 16 European Learned Societies and Research Organisations within different disciplines and across sectors. ISE constitutes a unique voice in Europe representing the research community; indeed, its wide geographical distribution, disciplinary breadth, diverse demographics and, collectively, a very large membership across Europe, allows ISE to provide novel and complementary insights compared to universities, academies, and funding agencies. In addition, ISE covers a vast spectrum of research and innovation expertise and activities, from academia, not-for-profit, and public service to collaborations with the private sector. This guarantees a nuanced approach to R&I policies that takes into account their impact on many sectors.

This paper was prepared by the ISE Task Force on Horizon Europe and presents the shared views of ISE members on the EU's Research and Innovation Framework Programme, Horizon Europe (HE). In particular, we lay out what European learned societies consider to be the priorities for the development of HE Work Programmes: interdisciplinary research, widening participation, and balancing the R&I cycle within pillar 2. The three are closely related to each other and we view our recommendations as enabling better scientific and societal impacts of the entire framework programme (FP) with an efficient use of the budget available.

Considering the relatively low funding budgeted for Horizon Europe (i.e., no substantial increase with respect to H2020), it is important to address from the beginning structural features to make it effective and balanced among the three pillars.

This introduction is followed by three sections, one for each identified area of intervention. Within each section, we describe the main issues identified by our analysis and then provide a set of recommended actions to address those issues. We also provide a few examples of interdisciplinary approaches and of collaborative basic research respectively in Appendices 1 and 2.

Interdisciplinary perspective

Interdisciplinary research integrates separate disciplines in one project, including their various data methods; tools; concepts; and theories, in order to create a better understanding of a complex issue; question; or problem. The critical indicators of interdisciplinarity in research include evidence that the integrative synthesis is different from, and greater than, the sum of its parts.

This is in contrast to multidisciplinary research that juxtaposes disciplinary and professional perspectives, adding breadth and available knowledge, information, and methods. In multidisciplinary approaches, researchers speak in separate voices. Disciplinary elements retain their original identity. In short, the multidisciplinary research product is generally the simple sum of its parts. Multidisciplinary approaches often occur in separate projects towards one goal and can be visualised as parallel pathways.

Interdisciplinary research requires a higher degree of integration and interaction of different disciplines inside of one project to solve problems and can be visualised as a matrix of pathways. This approach is particularly advantageous to address complex challenges. Therefore, conducting interdisciplinary research is the best way to take on global challenges and achieve, for instance, the Sustainable Development Goals and to help implement the European Green Deal.

This does not mean that disciplinary research is no longer necessary. In fact, good interdisciplinarity relies on disciplinary science performed at the highest standards of each discipline, and scientists from different disciplines ready to combine forces to address new challenges. As their work progresses on the new challenges, unexpected disciplinary questions may need to be answered. Building on strong disciplinary research, the two approaches (multi- and interdisciplinary) will coexist and are optimally applied to different cases. Examples of the benefits of interdisciplinary research are provided in Appendix 1.

In H2020, multidisciplinary approaches increased compared with FP7 by addressing challenges from different perspectives through different projects. In many cases, several disciplines started gradually to work together in one project. Depending on the ambition and skills of the coordinators, as well as the partners, some projects have already developed interdisciplinary approaches. This assures the integration of the different areas into the common goal, rather than the disciplinary contributors to function in silos. Such integration has been successfully achieved, for example, in natural sciences projects that have included social science researchers and multidisciplinary approaches within SwafS.

Horizon Europe should be ambitious and encourage the step change from multidisciplinary to interdisciplinary approaches. The missions seem to fit this view, but we believe that

interdisciplinarity should be more strongly encouraged in and across the various clusters addressing the Global Challenges. This will complement disciplinary and multidisciplinary projects.

We note that interdisciplinary learning and thinking should be systematically fostered at all stages of education (Kahn and Zeidler, 2019). Systematically integrating interdisciplinary aspects into the curriculum and learning activities will likely help prepare researchers to be more open and readily able to incorporate different perspectives in their work.[i]

These attitudes and skills are essential for the citizen of modern societies: if deliberately and effectively strengthened in the sense of the present suggestion, Horizon Europe will succeed to respond to its societal commitment both by working on specific global challenges and by contributing to ensure essential components of scientific literacy in European societies.

Recommended actions

- Enable flexible budgets across intervention areas and across clusters. The EC's Implementation Strategy (2020b) has as its second objective to increase transparency and simplification. Since to date there is not much flexibility in handling the budgets across different Directorates-General (DGs), we strongly suggest including a concerted, simplified, and flexible approach of the budgetary responsibilities in Horizon Europe. For example, call budgets from different clusters could be allocated in turns by different DGs to a joint call covering several years. Furthermore, DGs could test funding joint budgets across clusters.

- Create calls across different clusters. Interdisciplinary research should not only be encouraged across intervention areas (European Commission, 2018) in the same cluster, but also across clusters to better address Global Challenges. The EC's final version of the "Orientations towards the first Strategic Plan for Horizon Europe" (2019b) already indicates contributions from various clusters, by true interaction between various disciplines inside the same project, will achieve a step-change compared to H2020.

- Adapt reward systems that incentivise interdisciplinary research in order to incentivise prospective partners to pursue involvement in projects not directly related to their main field of research or interest.

[i] Note that it is suggested to *enhance* disciplinary science content by interdisciplinary aspects, and not to *replace* it; without a solid basis in different disciplines, there would be nothing to be integrated in an interdisciplinary perspective.

- Support research programmes to ensure the necessary background knowledge towards interdisciplinary education, integration of interdisciplinary thinking in academia, and development of higher order skills like creativity, critical thinking, and problem solving.

- Combine more disciplines in one project. Encourage true interaction between disciplines in one project by stating the challenge and the goals, and by giving examples of which disciplines could be combined to achieve the goal(s). This is equally relevant for research and for innovation partners.

Widening participation

The European Research Area (ERA) is a unified research area where support for cooperation among the Member States in research and innovation is a significant element and is mostly achieved through the FP for R&I. Most of the EU-13 countries began participating in FP5 (1998 – 2002) via specific association agreements. However, after more than 20 years, the EU-13 are still lagging behind the EU-15 in terms of participation and success rates. While the EU-13 represent about 20% of the EU population, their participation in FP7 and H2020 projects represents less than 10% of total EU-28 participation and less than 4% of EC´s financial contributions. They usually do well in COST Actions and in Coordination and Support Actions (CSA), while they struggle in the European Research Council (ERC), Marie Sklodowska-Curie actions (MSCA), R&I Actions (RIAs) and Innovation Actions (IAs)[ii].

Results of the first four calls within the H2020 programme "Spreading Excellence and Widening Participation" show that there is considerable variation among EU-13 countries in their participation in the three key instruments of this programme (TEAMING, TWINNING and ERA-Chairs). This demonstrates that the participation gap can only be overcome if Member States are more ambitious in their spending and in creating better conditions for excellent researchers to flourish.

[ii] EU-13 underperformance is a complex problem, and no single indicator can adequately provide a complete picture of FP participation. In FP7 about 21% of all projects involved at least one EU-13 organisation. In Horizon 2020 this percentage has fallen to about 17%. On the other hand, about 90% of all projects involve one or more organisations from the EU-15. In FP7, the average EU-13 organisation took part in just over three projects compared to five projects for the average EU-15 organisation. In Horizon 2020, these averages were approximately two and three projects respectively. In FP7 and Horizon 2020, EU-13 participation is below average in funding schemes that focus on excellence and innovation (ERC, MSCA, and IA/RIA). It is particularly low in the ERC. CP/IA/RIA projects, on the other hand, comprise about 45% of all EU-13 participations. EU-13 participation is also relatively strong in CSA-projects. CSA projects represent 17% of EU-15 participations in FP7 and 15% in Horizon 2020; for EU-13 organisations, these shares are 33% and 35%, respectively.

European Research and Innovation Framework Programmes alone are not enough; national determination is fundamental to successfully achieve the goals. **National authorities should take the necessary measures to reform, invest and implement at home**. In addition, they could make use of other EU instruments available to achieve this, for example, the European Structural and Investment Fund (ESIF) to build research capacity; the Policy Support Facility and European Semester process to analyse the national R&I systems and produce recommendations; and the EU Reform Support programme to fund these reforms.

A recent study from the Science and Technology Options Assessment (STOA) Panel of the European Parliament (EPRS, 2018) has identified the main causes of the research divide between EU-13 and EU-15 (outlined below). Given the heterogeneity of the R&I landscape in EU-13, not all of the causes apply to the same extent to each country, but they provide a good guidance to policy[iii]. Our recommendations are based on identifying the most prominent causes of the division:

i. Prospective participants from the EU-13 have weaker connections to the collaboration network in FPs than participants from the EU-15 who have more connections and are often stronger members of the network
ii. Low rates of participation in the FPs reflect the relative weakness of the research and innovation systems of the EU-13 compared with the EU-15.
iii. The success rate of proposals involving participants from the EU-13 is lower than that of proposals not involving participants from the EU-13.
iv. Funding opportunities at EU level are not fully attractive to prospective participants in the EU-13 and, therefore, EU-13 organisations are less active in the framework programme than EU-15 organisations.

In the upcoming framework programme, "Widening participation and strengthening the ERA" is a cross-cutting action across all pillars, to which at least 3.3% of the Horizon Europe budget will be invested. This is a significant leap compared to 1% in H2020 (European Parliament, 2019), but slightly less than the 4% the European Parliament suggested. It consists of two strategic lines: "widening participation and spreading excellence" and "reforming and enhancing the European R&I system". In addition to the core widening measures of TEAMING, TWINNING, ERA Chairs and COST, and to the recently introduced ad hoc Widening Fellowships tied to the MSCA Individual Fellowships, there would be a new matchmaking service. This advisory service provided by NCPs will help find partners to improve proposals and will provide a budget enabling EU-13 to join existing projects in midstream as a "hop-on" provision. Details on how the hop-on provision will be implemented are awaited.

[iii] STOA makes the following policy recommendations: (1) Creating and exploiting the existence of pockets of excellence; (2) improving the governance of national research and innovation systems; (3) improving the use and exploitation of FP research and development projects; (4) strengthening national contact points (NCPs); expanding Spreading Excellence and Widening Participation.

While we maintain that "Excellence" should be the principle on which EU research should focus, we strongly believe that several actions are necessary to widen participation and thereby create the proper environment to facilitate the growth of a cohesive pan-European research community that will be internationally competitive.

Below, we provide some recommendations to meet these needs by addressing the main causes identified above. We notice that, since there are substantial differences between EU-13 countries, the policies we recommend should be implemented differently for each country depending on (i) where it stands in the gap and (ii) the institutional effort it requires already to bridge that gap. Naturally, some recommendations address not only the EU level, but as well the Member States to act at national level.

Recommended actions

- Provide incentives for both EU-15 and EU-13. Integrate the talents and infrastructure of lower performing regions in mutually beneficial (and sustainable) networks and consortia. This will require shared efforts, national reforms and synergies between funding schemes. We recommend designing the programme and the selection process to avoid the danger that institutions in EU-13 not apply for projects in advance because "hopping on" would be easier.

  As for coordinating institutions in EU-15, institutions should be rewarded with additional funding when EU-13 institutions are included in the consortium - this would be an incentive to actively seek EU-13 partners. In addition, we recommend fostering international links in areas such as recruitment, co-authored publications, PhD mobility, and representation at international organisations by enhancing collaborative R&I networks with top-performing organisations in excellence-based funding (for example, through joint proposals).

- Advance from the exchange networks for research results and ideas (COST actions) to actual research collaborations (RIA, IA). To promote research collaborations across all 27 EU countries, HE should provide instruments to connect the best EU expertise and to foster collaboration in EU R&I projects (RIA, IA) between researchers and research institutions from different countries. In addition, strong synergies between different sources of funding must be created. Increasing national funding for R&I will also help build a much-needed research infrastructure and ensure appropriate salaries, and eventually address the innovation gaps between EU's Member States.

- Extend MSCA widening fellowships. After the success of the programme in H2020, we recommend that 3.3% of the MSCA budget be made available for widening fellowships for EU-13. In addition, we recommend developing novel concepts to extend the impact of these actions

to other programmes, in particular to the ERC, Future and Emerging Technologies (FET), and Research Infrastructures, without compromising the criteria that made those programmes successful.

- Enable a central role for National Contact Points (NCPs). One of the objectives of the EC's Implementation Strategy is to provide special support to NCPs in widening countries, but no further details are provided. We recommend enabling them through further training and additional resources to encourage, facilitate, and support a cultural change in EU-13; in addition, being the frontline in contact with the local research and innovation ecosystems, the EU Commission should use the NCPs feedback to adapt and improve its programmes, thus enhancing their impact.

- Strengthen use of peer review processes. EU-13 should link national funding opportunities to peer review processes similar to those used in the EU-15, thus tackling structural causes of underperformance such as remuneration rules and biased evaluations. This should include speeding funding for proposals that receive the Seal of Excellence (European Commission, NDa). For example, some countries fund research projects of individual researchers who have been given the seal of excellence within the MSCA and/or ERC programmes.

- Synergise with other EU programmes. To support flexibility in the pursuit of ERA objectives and accounting for the diversity of national R&I systems, Member States should be incentivised to use European Structural and Investment Funds (ESIF) (European Commission, NDb) to advance national R&I systems. For example, ESIF could be used to support the mobility of researchers to Widening countries, modernise research infrastructures and/or contribute to the creation of new ones, and the creation of new jobs. This should be complemented by an increase of the national R&I funding to turn the brain-drain into a brain-circulation process.

The R&I cycle in pillar 2 of Horizon Europe

Pillar 2 of the upcoming framework programme is of utmost importance to tackle Global Challenges and enhance European Industrial Competitiveness. Since it constitutes a translational bridge between the Excellent Science and the Innovative Europe pillars, its actions should support basic and applied research together with the demonstration and innovation aspects in a balanced way. We envision this pillar as closure of the R&I cycle, where research and innovation outcomes grow through a positive feedback loop.

Recently, various works from ISE, LERU, Science Europe and EUA have suggested that the focus towards high Technology Readiness Levels (TRLs) in H2020 has caused a steady increase in support for applied research and demonstration actions, and a steep increase in support for innovation actions. Although we agree that increases for those actions were due, we notice that it has been unbalanced and that support for basic research has dropped dramatically. As a consequence, the Societal Challenges aspects in H2020 missed out on the benefits from projects feeding questions and knowledge between innovation and basic research. This has caused the weakening (and at times breaking) of the R&I cycle, thus slowing down (and at times hindering) the identification and deployment of ground-breaking solutions for current and future challenges.

This view is shared by a study from UNESCO (2017) reviewing approaches across the globe: *"the focus of scientific discovery has shifted from basic research to 'relevant' or big science, in order to solve pressing developmental challenges, many of which have been identified as SDGs [Agenda 2030] by the United Nations. […] an adequate investment in* ***both basic sciences and applied research and development (R&D)*** *will be critical to reaching the goals of Agenda 2030"* (emphasis added). Applied to Europe today this requires a better balance in the support of research actions compared to innovation actions by completing and strengthening the R&I cycle.

LERU (2016) analysed H2020 Work Programmes from Societal Challenges and from Industrial Leadership regarding TRLs and found that there is a quantitative trend towards supporting higher TRLs in Societal Challenges, with peaks in TRLs 3-6 (2014-2015), moving to TRLs 4-6 (2016-2017). Early analyses made by ISE suggest that in 2018-2020 most peaks (except the transport challenge) moved even further to TRLs 5-7. Contrary to the Societal Challenges general trend, the trend in Industrial Leadership is moving from peaks in TRLs 4-6 (2014-15) to TRLs 3-5 (2016-2017 and 2018-2020). We find that while most Societal Challenges miss out on the benefits from basic and applied research, Industrial Leadership and the Transport Challenge show a more balanced distribution of TRLs and should be used as example for the Global Challenges in Horizon Europe.

While we see a high potential in bottom-up basic research in pillar 1, e.g., in the ERC and MSCA, we also believe that basic research contributions should be included in pillar 2 of HE to maximally

benefit innovation within the R&I cycle. We acknowledge that there are dedicated Innovation Actions in pillar 2, complementing the innovation focus of pillar 3. Similarly, we call for dedicated basic and applied research actions in pillar 2, complementing the research focus on pillar 1. The unique position of pillar 2 to cover and thereby complete and strengthen the R&I cycle in a balanced way has the potential to become one of the strengths of the Horizon Europe programme – a step change compared to H2020 (see, e.g., ISE 2016). In Appendix 2, we show a few examples of collaborative basic research.

Recommended action

- Make collaborative basic research an intrinsic part and occasional focus of R&I Actions. The EC's Implementation Strategy has as its first objective to maximise impacts and refers to level of TRLs in collaborative research. We strongly suggest providing funding that addresses Global Challenges through the encouragement of collaborative basic research as an intrinsic component and occasional focus of R&I Action projects. The collaborative work will sometimes emphasise basic and applied research and at other times the demonstration and innovation aspect. When all actions are considered together, they will end up supporting the four components in a balanced way.

This recommendation will have two additional positive impacts that we deem worth considering:

- Meets the needs of private companies by embedding programmatic basic research requirements in all clusters of pillar 2. Designing programmes with basic and strategic research will help meet the needs of private companies with limited in-house capacity for applied R&I. It will also help soften the lack of financial motivation for exploratory research that lays the groundwork for further improved innovation activities.

- Indirectly facilitates widening participation. Supporting projects encouraging basic and applied research that includes participants from EU-13. Enabling research groups across Europe to collaborate within the European Research and Innovation Programmes will advance economies across Europe, increase social stability, and help build a more inclusive and equal Europe.

References and additional reading

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Appendix 1: Interdisciplinary approaches

The need for an interdisciplinary perspective in research long pre-dates the difficult times that we are currently facing. There are several other examples of this need and the importance of interdisciplinary research for society. Here, we provide some examples that demonstrate the impact of interdisciplinary approaches.

Interdisciplinary education projects

"Physics/Chemistry/Biology in Context" were three German science education programmes with a focus on application and interdisciplinarity from 2000 to 2010. The most important objectives of these programmes were (i) to develop and strengthen interest and attitudes of pupils towards science, and (ii) to induce the capability of transfer of knowledge – applying science knowledge outside the classroom in different situations instead of reproducing facts. Indeed, it is difficult to imagine how the R&I cycle could function without a sufficient workforce well capable of knowledge transfer, and this shows again the need of a systematic integration of science education.[iv]

COVID-19/SARS-CoV-2 crisis

In this most recent example policy makers ask scientists to clarify the structure, function and thereby mode of action of the interaction between this coronavirus and humans. In addition, policy makers make use of advice from ethics experts, sociologists, and economists on how to cope with the crisis without giving up on the fundamental values of their political systems. More needs to be done to understand a new paradigm for assuring human health and safety. For example, the wearing of face coverings has been historically rejected in most parts of Europe. It is unclear if the current mandates for face coverings in certain public spheres will simply become the norm, or if after a few months the issue will need to be revisited more thoroughly. Ongoing decisions on mask use will of course hinge primarily on health issues. But as well research on how masks become acceptable, or, for a technological work-around (for example, an inexpensive see-through mask), will continue to be necessary. Research in these areas has already started and will need interdisciplinary approaches to determine the best approaches, and how implementation of mask mandates can then be changed as needed.

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Phytonutrient research

Current knowledge has highlighted the importance of the positive impact of phytonutrients on human health. For instance, many classes of bio-compounds can provide a substantial contribution to the human gut microbiomes shaping, which in turn is an important factor influencing our immunity response and general wellbeing.

Several studies have shown the importance of phytochemicals consumption for the human immune system and the prevention of inflammation-associated conditions, including cardiovascular, neurodegenerative and bowel diseases. Scientists across disciplines are discussing the importance of addressing the link between specific sets of phytochemicals and the impact on a specific pathology. Only if we can get robust and scientifically sound results on these important issues, we will be able to develop respective crops and propose their consumption for sub-groups of consumers at higher risk of specific diseases.

The European Plant Science Organization proposed such a concept in the mission idea '*1001 Crops - Diverse crops for diverse diets, human health and resilient production*'. In the medium-term, related interdisciplinary projects could be clustered and actions taken forward always by those currently receiving funding so as to not miss benefits from ongoing projects or those nearing completion.

Appendix 2: Examples of collaborative basic research

The cases based on collaborative research mentioned in this Appendix highlight the relevance and advantages of boosting interdisciplinarity in the European research system.

Plant and microbiome interactions

Following recent microbiome research and innovation, companies have placed products on the market with microbiota mixtures which can be used as fertiliser or protection against pests. Sometimes, these products do not work, but the reason is unknown. Therefore, some companies have reached out to researchers to clarify which components and mechanisms in microbiotas and mixtures of microbiotas actually cause in association with which crops, with which other microbiota, under which environmental conditions benefits for crop production. In this example, a question from industrial needs is fed back to basic and applied research to sustain product innovation, closing the R&I cycle.

New materials for medical devices

One aim of both the Minamata Convention and the respective EU regulation is to abandon mercury-added products, such as different medical devices including dental amalgam [v]. The development of new materials for the treatment of cavities is thus necessary and despite the introduction of new materials for that purpose in the past, so far, no overall replacement for amalgam has been found. The development of such a new material is a classic example of close cooperation (interdisciplinary and multidisciplinary) between basic research (e.g., developing new chemistries for such materials) and applied research (e.g., evaluating the necessary technical, biological and clinical characteristics). Such a cooperation is an integrated process in order to develop new materials and products as quickly as possible.

[v] Mercury discharge into the environment has been identified as a global societal challenge by the UNEP (United Nations Environmental Programme) since the 70s. A legally binding document was finalised (Minamata Convention) in 2013, which by now has been ratified by more than 120 countries including the EU. The aim is to significantly reduce mercury discharge into the environment. Within the EU, this has led to the EU mercury regulation of 2017.

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