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Topics selected in the

2021 call for Proposals on Strategic Lines

From topics to successful proposals

This document contains the title, scope and expected impact of the topics selected in this call for proposals. In addition to the extensive description of each topic, some additional traits may apply. These should also be considered when preparing proposals in response to this call:

- Proposers should consider other research and innovation actions (i.e., projects, platforms or networks) currently in execution on the topic or related to the topic. These actions may be performed at national or international level. Proposals should consider the need for coordination or complementarity of efforts.
- Regulatory aspects may be important in some proposals concerning specific topics. If this is the case, proponents are requested to address these regulatory issues and to abide with them, to outline the need to overcome the current regulatory framework and/or to provide support to regulatory developments.
- The term "interdisciplinary" is used in this document to refer to the combination (intersection) of disciplines. In some cases, the union of disciplines may be adequate to respond to a topic.
- All proposals must include companies. The call provides additional detail on the nature and degree of implication of the companies in the proposals. All consortium members are expected to contribute to the project tasks under the principle of collaboration.

List of topics

1. Emerging animal diseases and zoonoses: from pathogen biodiversity to sustainable livestock food production
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14. New strategies of biofabrication: from current organ-on-a-chip, organoid or 3D bioprinting strategies, to clinical application
15. Nanomaterials and nanotechnology for the diagnostics of human diseases
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19. Strategies for addressing depopulation and socio-spatial inequalities
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21. Predictive maintenance of infrastructures through intelligent systems
22. Harnessing and modelling complexity in risk forecast scenarios
23. Plastics in the open environment

1 Emerging animal diseases and zoonoses: from pathogen biodiversity to sustainable livestock food production

Scope:

Safe and sustainable livestock food production depends on animal health, disease prevention and control. The rising numbers of zoonoses in recent years represents a serious threat to these sectors and to public health in general. At least, 75% of the pathogens responsible for emerging infectious diseases are of zoonotic origin. Likewise, climate change and globalization create favourable conditions for the spread of pathogens, their animal reservoirs and vectors. Infectious diseases at the wildlife–livestock interface threaten the health and wellbeing of animal and human populations. Wild animals are regarded as a "zoonotic pool" and a source of pathogens that can jump the species barrier. Consequently, a key challenge is the fostering of research and innovation in animal health through a 'One Health' approach. Developing interdisciplinary strategies for the prevention, treatment and control of animal diseases will have a positive global impact on the livestock industry and food production systems, improving sustainability, food safety and quality food availability.

This topic encompasses, among others, the following areas of research and innovation:

- Identification of "hot-spots" for disease emergence and the discovery of new pathogens in unexplored organism groups.
- Early detection and prevention strategies; development of rapid response tools to emerging threats.
- New technological solutions in the development of vaccine platforms and diagnostic tools with animal and human application.
- Surveillance programs, development of predictive epidemiological models and the identification of risk factors responsible for disease transmission.
- Rational use of antimicrobials.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Development of a new territorial model that will be resilient to new diseases and pests, being especially important for rural areas, including protected areas.
- Building new solutions to prevent zoonotic diseases while sustaining primary production systems and economic prosperity on a global scale.
- Develop sustainable livestock practices that improve animal health, minimize the effects of climate change and produce zero waste.
- Improved efficiency and competitiveness in the livestock sector, while reducing the environmental impact and improving social perception.

2 Sustainable enhancement of plant productivity: development of innovative plant health programs and products

Scope:

Along with the ever-growing world population comes the need to produce increasing amounts of safe food, as expressed in United Nations Sustainability Development Goal 2: End Hunger. The productivity of agroforestry systems is under the serious threat of constantly changing climate conditions accompanied by emerging pests and diseases. Food losses due to abiotic stresses, pests and infections represent 20 to 40% of the annual crop production and may even increase if no urgent actions are taken. Moreover, the negative impacts of some currently used agricultural practices require the development of new innovative sustainable strategies. In this context, the European "Farm to Fork" strategy seeks a 50% reduction in the use of xenobiotic phytosanitary products by 2030 and aims at implementing new innovative techniques, including biotechnology and the development of bio-based products.

The overall aim of this topic is to develop interdisciplinary, translational approaches for innovative plant health programs and products to enhance sustainable production of healthier feeds and foodstuff, while reducing the environmental impact in agriculture. This should be achieved by addressing some of the following activities:

- Study of the biology of plant-insect, plant-microbes and crop-weed interactions for the design of sustainable agricultural applications.
- Development of bio-based products to improve sustainable plant health programs.
- Improved monitoring of plant health status; decision making for traditional and emergent risks.
- Biological assessment of plant adaptation to changing conditions, pests and diseases.
- Conventional and biotechnological approaches to improve plant health.

Expected impact:

This topic will enhance sustainable agriculture while having a positive economic and social impact. It will open innovative avenues for the future of the agroindustry. This research and development action will preserve natural resources and will improve the health standards and wellbeing of society. Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Better use of natural resources in the context of sustainable agriculture.
- Increased farmer knowledge and awareness on agroecological principles, facilitating the spread of preventive and/or remedial management systems for plant protection.
- New genes or genotypes conferring resistance to pests, diseases, weeds, and abiotic stresses.
- New bioproducts and evaluation of their effectiveness.
- Healthier food for consumers.

These activities are directly related to the objectives indicated in the Spanish Action Plan (2018-2022) on Sustainable Use of Plant Protection products promoted by the Ministry of Agriculture, Fisheries and Food.

3 Novel systems for observation, modelling and management of marine ecosystems

Scope:

Long-term observations are essential for documenting the state, variability and changing conditions of the oceans under climate change and other anthropogenic pressures, as well as the effect of such changes on ecosystems. This knowledge is crucial to fully understand, predict and, ultimately, mitigate and adapt to present and future adverse impacts. The aim of this topic is the development of technologies and platforms for observing the marine environment, which includes both in-situ measurements and remote sensing observations (sensors, cameras, control systems, AUV (autonomous underwater vehicles), USV (unmanned surface vehicles), remotely piloted aircraft systems, satellites, etc.), together with big data analysis and artificial intelligence techniques to process the data obtained. The increase in precision and spatial coverage and resolution will provide valuable information to tackle environmental issues such as ocean acidification, biodiversity loss, sea level rise, overfishing and degradation of coastal habitats or pollution, among many others. Aquaculture activities could also benefit from these approaches.

Proposals should involve different disciplines and address several of the following aspects:

- Development of a framework and a plan for defining the observations intended and their exploitation.
- Development of the techniques, artefacts and tools needed for capturing the intended data and for monitoring its evolution.
- Development of communication systems that can cope with the difficulties posed by the marine environment.
- Development of techniques for processing different kinds of data, which may include physical-biogeochemical data, biological data and audio and image to detect biomass levels, movement patterns, presence or absence of species, etc.

Expected impact:

Sustained aerial and marine monitoring efforts will distinctly improve our understanding of the functioning of marine ecosystems and their ongoing changes. Information and communication technologies, marine science and technologies and aquaculture, are disciplines potentially involved.

More specifically, proposals should address one or several of the following impact criteria and provide metrics to measure and monitor the success:

- Combined *in situ* and remote sensing observations, delivering the information needed for the management and protection of marine ecosystems.
- Improved data retrieval, storage and processing. Development and application of tools to assess data robustness and to model uncertainty, critical aspects to gather the information required to effectively manage natural systems.
- Develop sustainable aquaculture exploitations, improving the quality of their products.

4 Plastic sustainability: synthesis, recycling and valorisation

Scope:

Despite plastics have transformed our lives, the durability of plastic materials, combined with their widespread littering and mismanagement, have resulted in extensive, global environmental pollution and high associated economic costs. Plastic circularity requires the development of new plastic production processes, as well as plastic (bio)degradation, recycling and valorisation, through new and innovative mechanical, chemical and biotechnological strategies (2018 EU Plastics Strategy). Therefore, this topic sets out to transform the plastics value chain by addressing some or all of the following aspects:

- Smart and innovative approaches to address plastic degradation, recycling and valorisation of waste byproducts.
- Preparation of advanced materials from recycled plastics through different modification and functionalization methods.
- Novel sustainable plastics from renewable monomers to replace current recalcitrant petroleum-derived plastics.
- Novel bio-based polymers and composite materials with enhanced properties for strategic industrial sectors, from high technology sectors, such as aeronautic, automotive, construction, energy, or sports to manufacturing packaging and mulch films.
- Turning carbon emissions into environmentally friendly plastics (synthesis and properties of CO_2-based plastics).

The topic should be addressed through an interdisciplinary approach that will require the interaction of biologists and biotechnologists, physicists, chemists, and chemical and environmental engineers.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Sustainable options for the management of plastic waste, promoting recycling, using energy recovery as a complementary option, and restricting the plastic deposit in landfills to reduce its negative environmental impact.
- Novel bio-based plastics with enhanced properties for strategic industrial sectors; generation of new (bio)degradation and recycling processes acting as key drivers for the production of added-value building blocks for the chemical industry.
- Strong interaction between the scientific community, companies and research platforms to reinforce the plastic value chain and to accelerate the commercialization of project developments.
- Establish training and outreach activities in order to generate scientists specialized in this research area.
- Improve social perception and sustainability of plastics by transmitting information, guidance and training to citizens.

5 Next generation batteries

Scope:

As the current generation of batteries is approaching their performance limits, novel ideas enabling the creation of more efficient, long-lasting and sustainable batteries are required.

The objective of this topic is to develop and validate the next-generation of batteries (based on, e.g., sodium-ion, metal-air, all solid-state, organic, flow, multivalent metal-ion, dual-ion, supercaps, among others) aiming at achieving performance levels beyond the state-of-the-art established for current technologies.

Research will focus on developing advanced materials and/or technologies for such disruptive storage systems, considering circular economy aspects such as the substitution and/or more efficient use of critical materials (e.g. cobalt, vanadium, lithium, natural graphite, etc.), the reduction of their environmental impact, sustainability and recycling. The work plan must include technology demonstration at least at cell level, as well as the evaluation of the upscaling potential, including integration in battery packs.

Interdisciplinary proposals, which may include expertise from materials research, nanotechnology, electrochemistry, engineering and environmental science fields, are expected.

Expected impact:

This development of the next generation of high performance, safe, and more sustainable batteries is expected to have an impact on both existing and emerging markets. Societal and environmental impacts are also expected at many levels.

More specifically, proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Have clear relevance for specific targeted applications in industrial sectors such as energy, transport, aerospace, information technology, robotics, medical devices, internet of things, chemistry or electronics, among others.
- Contribute to the reduction of emissions and decarbonisation of economy.
- Promote the use of environmentally friendly materials and components.
- Facilitate recycling, reuse and disposal of materials and components.
- Consolidate a knowledge-based society through the training of researchers and technologists.
- Provide clear coordinated dissemination and exploitation plans that will help to bring the new scientific and technological outputs to the battery community.
- Provide an outreach plan aiming at enhancing the awareness of the public of the need for more sustainable energy storage and its economical and societal implications.
- Performance indicators and estimated cost targets should be guided by those indicated in the European Strategic Energy Technology Plan (SET-Plan), which stablishes different parameters depending on the target application.

6 Efficient solar light conversion to fuels and chemicals

Scope:

Photovoltaics converting sunlight into electricity is a mature commercial technology. In contrast, the use of solar light as primary energy to promote endergonic processes is much behind. Innovative approaches and disruptive technologies are needed to make use of solar energy to produce fuels and chemicals. Aviation, marine transportation and long-distance heavy vehicles consume about 30 % of the total energy, and their electrification is full of challenges. Renewable fuels with zero CO_2 footprint are needed in the transportation sector. The production of bulk chemicals is an energy intensive process, accounting for over 10 % of fossil fuels consumption, there being a necessity of implementing sustainable alternatives, among which those based on solar light for the production of chemicals are very appealing. CO_2 capture and utilization should have an impact on the mitigation of global warming and climate change, being necessary life cycle assessments to quantify the benefits of the novel technologies for the environment.

This topic aims at developing sunlight responsive materials based on Earth abundant, non-toxic elements with high light harvesting ability throughout the entire solar spectrum, from UV to near IR and solar energy conversion efficiency into the target chemical over 5 %. Chemicals to be targeted include, but are not limited to, hydrogen, ammonia, methane, methanol, formic acid. Durability of the material activity should be longer than 1,000 h of solar irradiation with an activity decay no larger than 25 %. The optimization of reactors and systems integrating these materials is also included in this topic. The rationalization of the structure-activity should be based on calculations on models and characterization of physical, textural and photophysical properties.

Proposals should involve different disciplines and aim to the understanding of the reaction mechanism and the nature of the active sites. Benefits and impacts for the environment of the novel technologies should be supported by the corresponding lifecycle analyses.

Expected impact:

The conversion of solar energy into fuels and chemicals can break its current low efficiency and can serve for hydrogen production from fresh and sea water, CO_2 utilization and biomass-derived product upgrading and transformation, among other processes. This could provide clean and renewable fuels, but also primary industrial products such as alcohols, alkenes and aromatics. A hydrogen generation technology based on photocatalysis could have a large economic impact, with better societal acceptance. The South and East parts of Spain have a solar irradiance much higher than other European countries, making this technology widely applicable in Spain. This is particularly suited for rural and depopulated areas, providing them with an additional opportunity as energy providers for *on site* consumption or commercialization.

More specifically, proposals should address at least one of the following impact criteria and provide metrics to measure and monitor the success:

- To contribute to decentralized energy production, chemicals to power fuel cell hybrid vehicles, and novel green synthesis.
- To complement electrolysis in hydrogen generation, being applicable in remote places not connected to the electrical grid and with lesser capital and operation investment.

7 Smart building technologies

Scope:

Buildings can produce a large amount of data from a wide range of sources. Internet of Things (IoT) and smart buildings solutions use this information to increase energy savings and create more sustainable buildings. The energy Performance of Buildings Directive 2018/844/EU states that smart buildings will play a crucial role in the future energy systems and one of the focal points is to improve Smart Ready Technologies (SRT) in the building sector implementation. Smart capabilities can effectively assist in creating healthier and more comfortable buildings, while having a lower energy consumption, lower carbon impact and more effectively water management.

The goal of this topic is to significantly improve the energy efficiency of the building stock, upgrading the energy management smartness level and changing traditional energy consuming role of buildings. To achieve this goal, an interdisciplinary and holistic analysis of buildings should be considered taking into account all processes, operations, and the whole-building performance.

Different technologies can be contemplated such as digital twin, BIM modelling, IoT and big data solutions. Synergy with aspects like involved materials that allow monitoring and automation improvement, sustainable urban mobility (building-cross-activities) or smart water management are also relevant.

Proposed solutions are expected to increase in smartness readiness indicator (SRI) and to increase in energy efficiency and flexibility, including Renewable Energy Systems (RES) generation and storage. Recharging points for electric vehicles, vehicle-to-grid and other forms of energy storage should also be incorporated in demonstrators, including the development of innovative storage and consumer/prosumer strategies.

Proposals are expected to cover some or all of the following aspects:

- Develop new or enhance existing solutions for smart building systems, ensuring integration to Smart Cities.
- Allow integration and optimization of Renewable Energy Systems (RES), energy efficiency and storage.
- Demonstrate the sustainability of the solutions in the following aspects: environmental, social, and economic.
- Aim and demonstrate building performance improvement in terms of efficiency and cost.
- Evaluate the contribution to the enhancement of the smart readiness indicator (SRI).

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Improvement of smart buildings technologies rollout.
- Reduction of the embodied energy in buildings without concessions with respect to energy consumption and comfort.
- Development of novel smart technical solutions to achieve quantified improvements in energy efficiency while reducing environmental impact. Contribute to the integration of buildings into Smart Cities development and into future energy systems and markets.
- “Transition to energy positive buildings (producing electricity, covering their heating and cooling needs and contributing to the grid stability) with sustainable, renewable energy technologies”. Green Deal LC-GD-4-1-2020.
- Increase collaboration between ICT companies, industry and research teams.
- Raise awareness about Smart Buildings benefits and disseminate the advantages both at the level of carbon footprint reduction and reduction of energy consumption to encourage investments.

8 Smart urban and metropolitan mobility strategies

Scope:

Urban mobility has been established through the last decades as one of the key pillars of sustainability. European programs have been focused on the development of a smart, green and integrated transport. There are currently different factors that point to a new concept of mobility that needs to be developed taking into account technological, legal, social and environmental issues. Among these factors, Mobility as a Service (MaaS), the rise of new personal mobility devices, the arrival of the cooperative, connected and automated mobility (CCAM), the availability of big-data for planning and managing mobility, the specific problems of the boom in urban freight logistics with the e-commerce or the new mobility patterns associated with teleworking and flexible work schedule.

Mobility in urban areas must interconnect private and public transport and must be coordinated with interurban and periurban connected corridors. The generalized use of centralized and decentralized information will provide solutions oriented to better coordination and organization of mobility and to increase the whole transport system performance.

The aim of this topic is to boost the development of applications based on new technologies in vehicles, management and infrastructure oriented to mobility that takes into account sustainability, safety, social cohesion and use of urban space. Proposals can include, but not be limited to, the following technologies: short and long-range communication, autonomous mobility at levels 3 or above (perception, decision-making and information exchange), real time information and decisions or Big-Data analysis. Proposals should be interdisciplinary and address one or several of the following aspects:

- Intelligent Transport Systems, models, tools and data for planning, testing and managing the new mobility.
- Transport and information technologies for more efficient solutions of intermodal mobility, new operating and business models in public and shared transport and development of mobility as a service.
- New mobility paradigms based on connected and automated vehicles, including infrastructure adaptation to connected and automated vehicles.
- Periurban connected corridors for coordinated use of information in main urban transport nodes.
- New smart and sustainable solutions to reduce impact of urban freight distribution.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- New capacities to design and manage efficient and environmentally friendly vehicles and transport solutions.
- Intelligent transport solutions that integrate intermodal public and shared transport in urban and metropolitan areas.
- Use of information for a connected mobility, providing updated and complete information in real time and fostering higher levels of automation.
- Development and evaluation of urban freight distribution solutions efficient for operators, clients and citizens.
- Impulse in the adoption of more sustainable mobility and a better use of urban space through offering more efficient, seamless and user friendly solutions for private and public transport, considering intermodality.
- Promotion of new mobility models and behaviours with less impact to the environment and the urban landscape, taking advantage of new technologies applied to transport and other areas that lead to people mobility.
- Improved safety, reduced congestion and reduced exhaust emissions, without large investment in new conventional infrastructures.
- A gender-sensitive approach to urban mobility.

9 Cultural heritage

Scope:

Cultural heritage is the expression of our way of living, including values, behaviours, customs, practices, places, objects, texts and artistic expressions that are transmitted from one generation to the next. Heritage has an extraordinary economic and symbolic value, and constitutes a significant factor of social cohesion. Safeguarding and valorisation of our cultural, textual and artistic heritage is a key European policy priority that needs solid research to generate historical knowledge, produce evidence for future policy making, and improve access to and engagement with our cultural and artistic assets. Research and innovation results will contribute to European integration and will provide better, wider and more equal access to culture and the arts.

Examples of areas that could be addressed by interdisciplinary proposals responding to this topic include:

- The analysis of the tangible and intangible remnants, traces and spaces of the past in the present; heritage and historical knowledge.
- Heritage preservation and restoration, material culture, conservation and management.
- The recovery and analysis of lost, forgotten, neglected and disperse heritage (in Spain).
- The remaking of pasts into heritage, and the processes of appropriation and restitution, musealisation and mediatisation.
- The building of the cultural and textual archive.
- Critical edition and digitization of textual and musical heritage and technologies to exploit them.
- Heritage policy and law-making processes.
- Implementation and enforcement of heritage laws.
- The economic potential of cultural heritage; legal and economic valuation of heritage assets.
- The impact of environmental change in immovable heritage.
- The creation of risk management models and the promotion of quick damage assessment.
- Physical and chemical analysis of materials and processing techniques employed in cultural and artistic expression.
- The use and design of ITC tools and 3D reconstruction methods.
- The development of critical thinking about cultural heritage in education.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Improve knowledge of the social construction, quality and usage of cultural heritage at the national, European and international levels; research in old and new forms of cultural and artistic expression to promote tangible and intangible heritage.
- Recover and analyse lost cultural heritage.
- Increase capacities for the protection of endangered cultural heritage.
- Promote preventive measures against pillage and the illicit trade of cultural goods and design better public policies and heritage laws.
- Develop cutting-edge conservation and restoration technologies and methods and provide innovative, sustainable and participative management models.
- Support the use of digitized collections and new methodologies of digital humanities for new interpretations of the past.
- Increase access to and participation in cultural heritage through innovative approaches and new and emerging technologies; increase cultural literacy.
- Develop sustainable and inclusive cultural tourism and support Spanish and European policies for cultural and creative industries contributing to sustainable growth and job creation.

10 Experimental implementation of quantum technologies

Scope:

We are currently in the midst of the so-called second quantum revolution, a field that can profoundly transform science and technology this decade. This topic aims to support the development of technologies based on the control of individual quantum systems. Quantum properties will be exploited to improve: (i) computation, by using quantum effects to drastically accelerate certain calculations such as numerical factorization, data searching and optimization problems; (ii) communications, where individual or interlaced photons are used to transmit data securely; and (iii) sensing, where the high sensitivity of quantum systems to external disturbances is used to improve the accuracy of physical magnitude measurements.

The topic will support experimental consortia dedicated to quantum technologies, having the knowledge (nanotechnology, materials science, nanofabrication and accurate measurements) and the required infrastructure.

Different platforms will be explored before finding the best physical implementation for the possible applications of quantum technologies, which will generate many opportunities for new knowledge from the fundamental to the applied level, where the contribution of interested companies is key for the development of instrumentation.

Expected impact:

Selected proposals will strengthen the Spanish quantum community at the experimental hardware level, including interdisciplinary research groups, to gain international competitiveness in a context in which countries and companies are strongly investing in the second quantum revolution.

More specifically, proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Developing quantum applications to computation, communications and sensing.
- Developing unique infrastructures in the field of quantum technologies in a community that has the know-how on the complex quantum phenomena.
- Strengthening collaboration between academia and companies to foster developments and technologies.
- Outline benefits to society from Quantum technologies in terms of contributions to wellbeing, connectivity and quality jobs, contributing to the societal acceptance of these technologies.
- Create the right environment for the practical training of quantum researchers and technologists, who will be key for the required industry transformation in the medium-long term.

11 Robots to help people

Scope:

The main goal of this topic is the development of robots and robotic systems that help people. This is a new area of robotics that is at an early stage of development, and not so mature as others, like industrial robotics. The use of robotics in applications related to improving people's health, well-being and development will foreseeably be one of the elements that will transform our society and our future life style. As an example, some of these applications of robotics are exoskeletons, educational robots, robots for helping the elderly, entertainment robots, surgical robots, rehabilitation robots or artificial organs.

The involved technologies are multiple and include, among others, mechatronics, control, telematics, machine learning, natural language understanding, perception, human-robot interaction, wearable devices, etc. All these technologies must be integrated to produce robots or robotic systems that offer relevant benefits to users. The development from an interdisciplinary perspective is essential, taking into account - in addition to technical aspects - psychological, legal, communication, medical or security aspects.

Robots and robotic systems must be designed to interact in a friendly and safe way with people. In some applications of robotics (e.g., industrial robotics) it is possible to adapt the work environments to the needs of the robots, making the robots carry out their activities in relatively simple and predictable conditions. In the case of robots to help people this is not possible. Robots must act in environments that are not adapted for them (such as homes) and in conditions with a high degree of unpredictability, since each person is different and behaves at all times in a way that is difficult to predict. To take this into account and to show the benefits for users, proposals should include tests with end users in conditions that are as real as possible. The use of these systems must extend to all society: it is important that the cost is as low as possible.

Expected impact:

Proposals should be interdisciplinary, address several of the following impact criteria and provide metrics to measure and monitor success:

- Improved user well-being. For example, robots can be designed to meet the physical limitations of their users.
- Improved user health. An example of this are the robots dedicated to rehabilitation.
- Personal development, such as educational robots.
- Mitigate the problems of ageing population. Robotics can help elderly people, allowing them to live independently in their private homes for as long as possible. Robots can entertain, assist, keep company or stimulate elderly people.
- Economic benefits, contributing to the development of companies operating in this sector. Markets for this kind of robots are expected to grow dramatically in the coming years.

12 Sustainable fuels

Scope:

The efficient use of renewable feedstocks derived from biomass, waste oils and fats as a source for fuels and as alternative carbon-based chemicals in the future has become a key concern in today's society, together with the challenging objective of achieving a more sustainable planet. Moreover, in a more industrialized society and thinking in alternatives to limited petroleum sources, reducing the emission of greenhouse gases and searching for sustainable, unlimited sources of energy have led to recent research in this pivotal topic. Additionally, new fuels must meet the technical regulations mandatory for specific uses.

These feedstocks normally contain a large amount of oxygen functional groups that must be transformed into other functional groups by means of successive and different catalytic processes to produce cleaner fuels and manageable chemicals.

The goal of this topic is to design new processes to produce a new generation of economically and environmentally sustainable biofuels. An interdisciplinary approach is required for the production of innovative technologies for the industrial production of biofuels. These technologies should develop novel catalytic reaction mechanisms or process more sustainable, efficient and economically viable. Proposals should aim at translating this concept to scalable processes, at least at pilot plant scale.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Develop innovative approaches that allow the use of renewable feedstocks as sustainable biofuel sources.
- Design new economically viable biofuels to increase their use.
- Take advantage of interdisciplinary approaches for this challenging society concern.
- Strengthen collaboration between academia and industry to accelerate development and commercialization research products.
- Disseminate novel technologies to facilitate industrial adoption and to expand social awareness.

13 Digital twins: modelling and design

Scope:

Digital modelling provides computational tools to mimic the behaviour of general systems, allowing their computer-assisted design and optimization. Its main tool is the Digital Twin (DT), digital replica of the system. The DT system allows testing its weaknesses and improve/optimize its design without building expensive prototypes, thus providing large cost reductions to companies. At the same time, digital twins open opportunities to compete through new business models as well as to challenge traditional product management practices throughout a product's life cycle.

The scope of the topic is twofold: On the technical side, there is an opportunity to apply digital modelling to solve challenging problems regarding the way we manufacture products. Classical mechanistic models and data-based models together with optimization and model predictive control techniques are essential tools in this fast developing field. This topic is guided by the certainty that a high level approach on DT, enriched by data analysis (DA), deep learning (DL) and high performance computing (HPC), will make a decisive contribution to improving many industrial processes and significantly reducing manufacturing costs. On the management side, there is a need to understand how organizations should revamp product development, manufacturing, service and customer-engagement routines to generate new value from the use of DTs. Likewise, it is highly important to understand how DTs, being a new type of asset, affect competition, firm survival and market dynamics.

Advances in this field are linked directly to developments in strongly intersecting disciplines such as mathematics, computer science, industrial and production engineering and economics.

Expected impact:

The expected impact of this topic is to facilitate the development and commercialization of software tools for the creation of DTs by research groups and companies. Moreover, the transversal feature of DTs should impact any industrial sector contributing to digitalization of product design and process control. Digital modelling generates long-term improvements in production processes, which are associated with the creation of high-level employment.

More specifically, proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Energy efficiency in industry, transport and households.
- Water resource management. DTs enable utilities to simulate events such as pipe failure, power outages, fires, and contamination.
- Battery design and battery management systems (BMS) for electric vehicles.
- Healthcare industry. DTs make possible to build personalized models for patients, continuously adjustable based on tracked health and lifestyle parameters.
- Managing of integrated electric and gas transportation networks involving renewable sources, biogas and hydrogen.
- Prediction of natural disasters such as floods.
- Support services to connected products & machines. Environmental and social challenges like the current climate crisis or Logistical challenges related to sorting and redistributing products.

14 New strategies of biofabrication: from current organ-on-a-chip, organoid or 3D bioprinting strategies, to clinical application

Scope:

At the intersection of the fields of tissue engineering (TE), regenerative medicine (RM) and biofabrication (BF), computer-assisted cell deposition pursues the design and use of biocompatible materials and devices to support the growth and assembly of relevant cell types. These technologies are aimed at the regeneration of a deficient tissue/organ in a patient (organ scale) or mimicking specific organs *in vitro* (organ-on-a-chip scale) suitable for multiparametric monitoring at micro/nanoscale.

The challenges of identifying and creating multicellular constructs, devices or organoids with the correct cells, materials, designs and signals necessary to mimic their development and differentiation remain central to BF research. Technologies associated with TE and BF are especially relevant in drug screening platforms & personalized medicine, toxicology & efficacy testing, biosensor approaches, and associated commercial products.

The aim of this topic is the development of technologies based on 3D BF (from organ-on-a-chip to organoid and tissue/organ generation) with a clear biomedical and clinical application. An interdisciplinary approach should be proposed addressing the discovery of new methodologies: new micro/nanofluidics, new bio-inks, new organoid technologies and organ-on-a-chip platforms. Advances in this field are directly linked to developments in strongly intersecting disciplines such as materials science, nanotechnology, biomedicine or bioengineering.

Proposals should focus on developing these strategies under joint efforts of research laboratories and the industry, to be finally transferable to clinic applications.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Combined development of new innovative approaches based on additive bioengineering for tissue/organ biofabrication and replacement in a higher 3D cell resolution, leading to new organoid platforms and organ-on-a-chip devices simulating the complex structure/function of healthy and damaged human organs, specially aiming at drug discovery and related-applications.
- New technologies and protocols available for all society in an equal, safe and personalized basis following the N3CR strategy of experimental research.
- Promoting bridges between the laboratory and the market through innovation and interdisciplinarity to accelerate the development and the clinical use of the new constructs and devices.
- Strengthening contacts and collaborations between the scientific community and industrial sectors in Spain, enhancing the interaction between the private sector, academia and research and clinical centres.
- Training and outreach activities to foster scientists' specialization in this research area.

15 Nanomaterials and nanotechnology for the diagnostics of human diseases

Scope:

This topic aims at contributing to the development of quick, inexpensive and accurate biomedical detection devices, with high sensitivity, simplicity of manufacture and use, and amenable for production at a low cost.

Approaches based on a wide diversity of technologies (e.g. nanosystems, functional materials, biophotonics), for the development of *in vitro* and *in vivo* diagnostic systems for the detection and/or prognosis of pathologies are expected. The discovery of novel biomarkers, sample processing methods, transduction systems, self-powered detection devices with the potential to be connected through Internet of things (IoT) protocols, are examples of the kind of strategies that may be adopted to obtain the targeted diagnostic platforms. Proposals should focus on developing these platforms aiming at a clinical environment and should be easily transferable from the laboratory to the industry.

Advances in the field of clinical diagnosis based on nanomaterials and nanotechnology are expected to arise from the intersection of disciplines such as materials, biomedicine and biotechnology, photonics, electronics, and information and communication technologies.

Expected impact:

The overall impact of the selected proposal(s) will be to improve the quality of life of the population by advancing the diagnostic capacity of human diseases. Reducing the time required to obtain test results will allow anticipating, adjusting and improving the treatment of various pathologies.

More specifically, proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Consider priority needs for the diagnosis and/or monitoring of pathologies in a more effective way.
- Use innovative approaches based on novel materials and technologies that will allow the diagnosis of pathologies in a more straightforward, cheaper and/or more precise way.
- Increase the competitiveness of the sensing technology and diagnostics industrial sectors, especially in SMEs.
- Bring developments in sensing technology and new diagnostic methods to the clinical setting.
- Increase the dissemination efforts of the results to expand social awareness about novel technologies applied to health.
- Strengthen the industrial value chain and accelerate the commercialization of these developments.
- Standardization issues and involvement of regulatory bodies should be taken into consideration.

16 Novel approaches to understand mechanisms and establish new strategies for cancer immunotherapy of solid tumours

Scope:

Exploit research in new mechanisms that could underlie ground-breaking agents and strategies in the field of cancer immunotherapy of solid tumours. Precision treatments in cancer require the development of novel advanced therapies. Immunotherapies have taken therapy of many prevalent solid tumours to a new level of success, resulting not only in extended life expectancy, but also in curation.

Tumour microenvironment cell populations, including myeloid derived cells, fibroblasts and others, may mediate immune evasion. These mechanisms of immune evasion promote T-cell exclusion from solid tumours and block acquisition of the T cell-effector phenotype preventing function of immunomodulatory antibody therapies. These novel therapeutic approaches in immunotherapy (as single or combined treatment) should investigate ground-breaking mechanisms involved in the immune response against tumours and new immunotherapy strategies that should go beyond current approaches (e.g. beyond CAR-T or immunomodulatory therapies directed to PD-(L)1). It is also of interest innovative follow-up and methodology for early identification of those patients that are non-responsive and hyperprogressors upon cancer immunotherapy treatment. These advances should establish the basis for potential new pharmacological targets and strategies for next generation cancer immunotherapy of solid tumours. This is the case of antibody-drug conjugates, novel immune checkpoint targets or the stem cell secretome as a cell-free alternative to cell based-therapies. Complementarily, the discovery and evaluation of novel therapy predictive biomarkers that prompt patient therapeutic stratification are to be pursued.

These new approaches should be achieved through interdisciplinary collaboration between research areas, including biotechnology (gene editing, RNA technology), materials (nanotechnology), bioengineering (novel medical devices and bioimaging technologies), bioinformatics, mathematics (machine learning and artificial intelligence) and physics (characterization of immune impact of other innovative treatments, such as new uses of radiotherapy).

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Improved knowledge on the molecular mechanisms driving the immune response against solid cancers.
- Identification of novel pharmacological targets for intervention in immune response against cancer and development of new therapeutic tools.
- Understanding the role of tumour microenvironment in immune response modulation in solid cancers.
- Develop new technologies combining genomic, transcriptomic, and immune cell repertoire analyses to gain insight into the dynamic interplay between solid tumours and the immune system.
- Delivery of companion stratification biomarkers.
- Exploitation of artificial intelligence advances for bioimaging analysis as a strategy for precise therapies.
- Technology transfer to companies for clinical validation of therapeutic targets and companion stratification biomarkers.
- Increased medical awareness of cancer immunotherapy for precise treatment.
- Innovative ways to increase safety in immunotherapy while preserving and enhancing efficacy.

17 Innovative approaches to better understand and identify novel therapeutic targets for atherosclerosis

Scope:

Cardiovascular diseases (CVDs) are the number one cause of death globally. Atherosclerosis is the underlying cause of many forms of CVD, and responsible for a big proportion of healthcare costs. Despite years of research, the mechanisms leading to atherosclerosis initiation and progression are only partially understood. The transition from asymptomatic to clinical stages is hardly predictable. A better understanding of these aspects will open the venue for new therapeutic targets complementary to current ones.

The scope of this topic is the application of ground-breaking approaches based on novel technologies and concepts to advance on the knowledge of the pathophysiology of atherosclerosis. Research consortia are expected to integrate fundamental and innovative knowledge on blood vessel biology (e.g. endothelial and smooth muscle cell functional diversity, vascular aging or blood flow sensing, among others), low-grade, chronic inflammation of the arterial wall, lipid metabolism and transport, advanced lipidomic and proteomic screenings, diagnostic methods (including molecular imaging-based approaches, nanosensors and functionalized nanomaterials), personalized theranostic strategies, and computer-based predictive modelling. Results should lead to the translation of new knowledge in the field of atherosclerosis, fostering the future development of innovative treatments and protocols for the management of this condition (early diagnosis and prognosis) and theranostic approaches.

These approaches will require interdisciplinary interactions of research teams in the biomedical field (molecular mechanisms in disease) with groups from other areas such as biotechnology, or biophysics for the investigation in novel mechanisms, bioengineering or materials for the design of novel diagnostic/therapeutic devices, and bioinformatics or mathematics for machine learning and artificial intelligence aiming at the stratification and optimal application of findings.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Improved knowledge on the molecular mechanisms of atherosclerosis initiation, progression and transition to clinical stages.
- Identification of new aetiologic factors, including inflammatory signatures, that promote atherosclerosis in vulnerable societal groups.
- New public policies on the management of patients and the prevention of atherosclerosis.
- New potential therapies based on the discovery and characterization of novel pharmacological targets not yet exploited by current treatments.
- Transdisciplinary collaborations between research groups and companies.
- Technological progress in advanced therapies for CVD.

18 Addressing disinformation, hoaxes and fake news through public and private channels

Scope:

Disinformation and conspiracy theories impact significantly in contemporary societies in domains such politics, health, education, environment, etc. Misinformation and disinformation occur on both ordinary situations (like elections or public policies like health related issues) and emergencies such as natural disasters, humanitarian crises (refugees), national and international conflicts, terrorism and armed conflicts. Interdisciplinary proposals in social sciences and relevant humanities should cooperate with technical areas such as computer science, health and engineering in addressing one or several of the following headings:

- Identifying the models of "influence spread" and malicious networks.
- Analysing the processes that lead to a standardised *infodemic*.
- Studying the building of political polarisation using cyber-scams.
- Reviewing the impact of health misinformation and disinformation on perceptions and specifically on vulnerable people (minorities, impaired, elderly, etc.).
- Measuring the impact of disinformation and misinformation on social inequalities.
- Examining and mapping case studies (general elections, pandemics, pseudoscientific theories, health claims, and conspiracy theories via social networks (Facebook, Twitter, Instagram, Tik-Tok, etc.) or private message (via WhatsApp, Telegram, etc.).
- Reviewing the use of fiction (audiovisual, digital, literary) as disinformation instruments and identifying language resources and technologies to support the identification of mis-/disinformation.
- Studying "fake history" and historical disinformation as a political instrument to shape identities in contemporary societies.
- Describing cognitive persuasion mechanisms and identifying intervention strategies to minimize the impact of disinformation on individuals and societies.
- Developing techniques to detect image, audio, or video manipulation, social network monitoring and content attribution.
- Addressing the legal challenges posed by disinformation and fake news.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Policy recommendations for media practitioners, educators, researchers and general audience.
- Ethic and transparency. Public information management. Support to public authorities with the guidelines, protocols and standards produced and derived by the research.
- Strategies and instruments to identify and refute fake history, accessing the media.
- Dissemination of the results focused on targets. Public Information Management. Support to public authorities in policies to contain the spread and the impact of disinformation. Support in engaging civil society organisations (associations and foundations).

19 Strategies for addressing depopulation and socio-spatial inequalities

Scope:

How can public policies and private initiatives contribute to fixing population to territories or bringing new migrants to those depopulate areas? How to address inequalities of gender, age, ethnicity, and class in depopulated areas? Public policies may contribute to enhance supply and demand matching in regional labour markets or the territorial cohesion via the provision of public service (education, health, social, gender equality, and integration policies). Research can also explore how the digital revolution, accelerated by the COVID-19 pandemic, may incentive workers in big cities to move to smaller cities, with less costly housing and often a better work-life quality balance. This move requires the development of appropriate infrastructure of all kinds (reliable internet connection, good quality health and educational services, retail stores, provision of care for children and dependent people and good transport connections) among other factors. A critical analysis of the urban planning of these rural localities will be necessary, especially in the capacity of their water distribution, sewage, and electricity networks, among others.

Novel ways to provide cost-effective public services in these small areas are a challenge as environmental impacts should be minimized to preserve rural attractiveness. In addition, specific types of social protection would be required in order to guarantee workers' rights in this new environment (work schedule, pay, work-life balance policies, etc.). Research must also address the conditions that make decision makers more prone to preferences for certain geographical areas and the effects of these decisions in wealth concentration. Interdisciplinary projects in social sciences and humanities will engage with technical areas such as engineering, earth sciences, urbanism or agriculture in several of the following subjects:

- Identification of the main driving forces of demographic change and the consequences of the outmigration of young qualified population towards growing cities (both in origins and destinies) and the impact of labour market changes in preferences for rural and urban areas.
- Assess the gender, ethnicity, age and class profile of workers that could move to repopulate declining areas and make a diagnosis of their needs
- Model the potential preferences reversal brought by the COVID-19 sanitary and social crisis.
- Assess the capacity of existing social infrastructures to provide health and social services to new members of the population.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Assist in designing and implement environmentally friendly public policies to make the moving to depopulated areas attractive and sustainable (labour rights for tele-workers, work-life balance policies, migrant integration policies) at the human-wildlands interface.
- Contribute to the development of territorial planning in which urban planning, communication and transport networks facilitate mobility with unpopulated areas.
- Promote the exchange of knowledge, pointing out cases of success and failure of governance in terms of rural revitalization.
- Improve training programs and the employability of workers in declining areas
- Identify local development opportunities (i.e., tourism, cultural heritage, environmental preservation, ecosystem goods and services)
- Identify market opportunities for institutions and private companies in charge of the provision of (tele)infrastructures and services in different territories
- Increase the protection and enhance the economic potential of cultural heritage in unpopulated areas and in rural areas in decline.

20 Demographic change and the future of public services: health and pensions

Scope:

As many countries in Europe, Spain's population is getting older: birth rates are low, life expectancy is increasing and immigrant flows are not able to compensate for the aging of the population. This transition of the demography brings new challenges for the society, labour markets, and welfare state.

Proposals should analyse, from an interdisciplinary perspective, the impact of the demographic change in the society, labour markets and the welfare state, and/or provide solutions (i.e. policy changes) to mitigate these effects, by addressing some or all of the following aspects:

- The composition of the population is changing, both regarding age, as well as, regarding the importance of migration flows. The growing segment of elderly people demands new services (i.e. health) and migration flows might lead to political conflict. Which policies can have an effect on the demographic changes?
- In labour markets, the productivity over the working life is affected by the changes in demography and therefore this will affect how individuals decide on their labour supply and financial decisions: savings and investments. How should regulation of labour markets and retirement change?
- The welfare state is based mainly on intergenerational solidarity, so the age structure of the population is crucial for its sustainability in a way that the speed of the ageing process determines how successfully the welfare state can adapt to the new demographic dynamic. Basic public services, such as health and pensions, require new funding. How should public policy react to sustain the welfare state?

Access to high quality administrative data should greatly facilitate future research in these crucial issues.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor the success:

- Models for the understanding of the evolution of the demography of the population (birth and migration rates).
- Strategies to alleviate the political, social and economic costs of the growth in the number of elderly, decline in the number of youth and of migration flows.
- Understanding of the dynamics and prospects of health and pension expenditure, generosity and coverage across the EU.
- Solutions to the challenge for achieving the sustainability of the welfare state.
- Examining of active retirement policies and provision of new solutions: making pensions compatible with work.
- Understanding of the individuals' reaction to changes in the public policies: insights from behavioural sciences and applications to health and pension systems.
- Analysis of gender differences: whether men and women are affected differently.

21 Predictive maintenance of infrastructures through intelligent systems

Scope:

The power grid, the transport network and information and communication systems are among the so-called "critical infrastructures", which are essential to maintain vital societal functions. Damage or destruction of critical infrastructures by natural disasters, high degrees of deterioration due to its age, terrorism and criminal activity, may have negative consequences for security and for citizen well-being.

This topic aims to leverage the interdisciplinary synergies of academia-industry partnerships towards the development of novel sensor technologies and advanced analysis methodologies leading to procedures with higher functionality and operating capacity. Proposals should focus on new applications, new technologies and the incorporation of new smart technologies in risk assessment and decision-making. Activities conducted under the umbrella of this priority also include listed heritage constructions with high level of governmental protection.

This topic is fully integrated into the United Nations Sustainable Development Goal No. 9: "*Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation*".

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Increased security in critical infrastructures that have a limited useful life.
- Development and implementation of technologies that guarantee the monitoring of the structural and functional health of critical infrastructures.
- Innovation in new technologies, methodologies and procedures that guarantee the extension of the useful life of critical infrastructures.
- Reduction of the response time due to the application of methodologies for automated decision-making based on smart technologies.
- Promote leadership in the use of smart technologies to develop smart predictive maintenance infrastructures.
- Monitor infrastructures in a smart way to predict the end of its useful life before reaching catastrophic situations.
- Disseminate the advantages of smart predictive maintenance in infrastructures to encourage investments.

22 Harnessing and modelling complexity in risk forecast scenarios

Scope:

We are currently under a revolution in our ability to generate massive amounts of data in fields as diverse as sociology, economics, biomedicine, climate, and public health. This data should help us predict and control humankind-level threats such as pandemics and climate change. However, the complexity of the underlying systems limits our ability to harness data to our advantage. The current bottom-up approach used by machine learning, in which we find patterns in the data for prediction purposes, must be complemented by top-down methods that leverage our knowledge of the fundamental mechanisms that generate this data.

The aim of this topic is to bring together academic researchers working at the forefront of complex systems research in all areas of science and technology, with companies interested in extracting the maximum advantage out of existing large-scale datasets. Proposals should advance the fundamental knowledge of complex systems research by focusing on specific applications. Applications envisaged include, but are not limited to, malware spreading in computer networks, disease spreading in human populations, network approaches in economics, and explainability of artificial intelligent agents. Proposals must be designed from an interdisciplinary perspective.

Expected impact:

Proposals should address the following impact criteria and provide metrics to measure and monitor the success:

- Leveraging massive amounts of real-world data in the short- to mid-term. This will require advances in computational information acquisition, storage and processing, which should be tailored to the specific applications being addressed.
- Besides leading to scientific impact, results should inform the design and implementation of information-processing products to qualitatively change the industries in which they are embedded. Illustrative examples of high-impact results include progress in our ability to assess the robustness of large-scale computer networks to both randomly injected and targeted malware, and to forecast new pandemics from public-health and sociological data.

23 Plastics in the open environment

Scope:

The accumulation of end-of-life plastic items as litter in the open environment is a worldwide environmental issue. In this context, open environment refers to natural ecosystems, ranging from pristine systems to those impacted by a wide range of human activities. Massive accumulation of micro-plastic particles has been reported all around the world. Plastic additives increase risks to the environment (e.g., endocrine disruptors such as phthalate esters). Biodegradation of a plastic material in the open environment differs from composting it in waste management plants. In fact, the course of biodegradation in open environments depends on both plastic material properties that allow for mineralization, and suitable (uncontrolled) conditions in the receiving environment. Targeted biodegradation of plastics in the open environment has shown benefits in specific applications. However, providing consumers with clear information by standardised labelling is crucial to avoid the unintended fate of plastics, including pollution of recycling streams, improper composting, and an increased risk of materials ending up in the open environment through littering.

This topic sets out to assess and diminish plastic pollution due to human activities in the open environment by addressing some or all of the following aspects:

- Evaluation of the environmental impact of biodegradable and non-biodegradable plastics, (nano)micro-plastics pollution and additives at the ecosystem level.
- Assessment of the impact of (bio)plastics and micro-plastics pollution on wildlife.
- Detection and elimination of (nano)micro-plastics from different ecosystems.
- Ecodesign and biodegradation studies of plastics and additives for medium- and large-scale open environment applications.
- Biodegradability in natural ecosystems of marketed biodegradable plastic products, which may bring environmental benefits because collection from the environment is not cost-effective or not possible.

The topic should be addressed through an interdisciplinary approach that will require the interaction of environmental scientists, toxicologists, physicists, analytical and material chemists, biochemists, biotechnologists and biologists.

Expected impact:

Proposals should address several of the following impact criteria and provide metrics to measure and monitor success:

- Reduce the environmental harm resulting from plastic pollution.
- New testing and certification schemes for evaluating biodegradability of plastics in the context of their application in a specific open environment.
- Novel biodegradable plastics and additives to be applied in specific applications in open environment for which reduction, reuse, and recycling are not feasible.
- Driving biodegradable plastic market developments in the right direction by avoiding “greenwashing” strategies, which could convey misleading information.
- Establish training and outreach activities in order to generate scientists specialized in this research area.
- Improve social perception on the biodegradability of plastics by transmitting information, guidance and training to citizens.