MIRRI
MICROBIAL RESOURCE RESEARCH INFRASTRUCTURE

MICROBIAL RESOURCES FOR A GREEN, HEALTHY AND SUSTAINABLE FUTURE

Strategic Research & Innovation Agenda
2021 - 2030

Strategic Research & Innovation Agenda 2021 - 2030

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Foreword & Executive Summary

The Microbial Resource Research Infrastructure (MIRRI) is the pan-European distributed Research Infrastructure for the preservation, systematic investigation, provision and valorisation of microbial resources and biodiversity. MIRRI fulfils the role as research support infrastructure for the biosciences scientific community and bioindustries, by facilitating the access, through a single point, to the broadest range of high-quality microorganisms, their derivatives, associated data and services. MIRRI holds microbial resources matching every demand from bioresearchers and bioindustries. These include strains supporting basic research and taxonomy and those producing antimicrobials or other bioactive compounds and enzymes for the pharmaceutical industry, to others that can be used in the production of healthier food and feed products (including ingredients), upgrading residues, processing side-streams and organic wastes, in the biological management of agricultural soils and crops, in the bioremediation of polluted sites or contaminated effluents, or in the production of renewable, biobased chemicals, materials and fuels, to mention a few examples. Besides, MIRRI also makes available a vast, diverse portfolio of high-quality services, ranging from general services to more application-specific ones – including pipelines of integrated, product-oriented services made available as tailor-made, turnkey solutions – based on its partner organisations' state-of-the-art facilities and top-level expertise.

A priority of MIRRI is alignment with the most relevant global and European strategic agendas and the needs of user communities, to enable them deliver the maximum value and impacts from their projects, technologies and products. This priority has been the main motivation behind the present MIRRI's Strategic Research & Innovation Agenda 2021-2030. Resulting from an exhaustive and comprehensive exercise of self-analysis, on one hand, and of landscape analysis and horizon scanning, on the other, this Agenda serves the fundamental purpose of placing the strategic focus of MIRRI, for the decade ahead, over a selected group of areas, within the broad domains of Health & Food, Agro-Food, and Environment & Energy, namely:

Research on pathogenic microorganisms and human / human-animal infectious diseases.

Research & Development of new (bio)pharmaceuticals / therapeutic solutions (including antimicrobials, vaccines, phage therapies and microbiome therapeutics – for human use).

Research & Development of new, safe, healthy and sustainable food and feed products.

Resources and methods for biological management of soils and crops.

Resources and methods for biomonitoring and/or bioremediation of microbial pathogens, persistent organic pollutants and plastics in soils and waters.

Research & Development of renewable biobased chemicals, materials and bioenergy sources.

Rescuing and preserving microbial biodiversity.

These are highly relevant areas, from a socioeconomical point of view. They are aligned with UN Sustainable Development Goals, EU Horizon Europe and many of its clusters, missions and partnerships, several national/ regional Research and Innovation Strategies for Smart Specialisation (RIS3), and with the ESFRI Roadmap, Strategy Report and Landscape Analysis (including the scope of action of other ESFRI Research Infrastructures). MIRRI assumes a pivotal role as a preferred partner for research and innovation projects targeting the goals and impacts pursued by these strategic referentials.

At MIRRI, we see the collections of microbial resources that we hold as treasures, in the sense that their true value comes not solely from its "possession", rather from its use. We have an open innovation-oriented culture, and we strive to contribute to strengthening the European Research Area (ERA) and the EU's industrial competitiveness and strategic autonomy. The MIRRI's Strategic Research & Innovation Agenda 2021-2030 unveils our vision for taking the best out of "our" treasures. It is intended to be a "living document", to be revised and updated at the rhythm that the global challenges, the research and innovation landscape and our users' needs will dynamically change and evolve. We trust that MIRRI's Strategic Research & Innovation Agenda 2021-2030 will serve as an inspiration for our users, for other Research Infrastructures, and for public authorities and policy makers, based on our common mission of solving current and future global societal challenges towards a green, healthy and sustainable world.

MIRRI: a pan-European Research Infrastructure for making microbial science & innovation happen

MIRRI, at a glance

The Microbial Resource Research Infrastructure (MIRRI) is the pan-European distributed Research Infrastructure for the preservation, systematic investigation, provision and valorisation of microbial resources and biodiversity. It currently brings together around 50 microbial domain Biological Resource Centres (mBRCs)*, culture collections and research institutes from ten European countries and one associated country. In the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap since 2010, now on its Health & Food domain, MIRRI is striving to soon establish the European Research Infrastructure Consortium (ERIC).

MIRRI serves the bioscience and the bioindustry communities by facilitating the access, through a single point, to the broadest range of high-quality microorganisms, their derivatives, associated, harmonised and standardised data and services, with a special focus on the domains of Health & Food, Agro-Food, and Environment & Energy. Within the ESFRI landscape, MIRRI is a cornerstone Research Infrastructure to interact and explore synergies among a plethora of other ESFRI Research Infrastructures forming a single ecosystem for advanced research and interdisciplinary analysis of complex scientific problems. These interactions are emphasised later in this Agenda for each strategic area.

By serving its users, by collaborating with other Research Infrastructures and by working with public authorities and policy makers, MIRRI contributes to the advancement of research and innovation in life sciences and biotechnology, for a competitive and resilient bioeconomy. It is worth mentioning that the global market for microbes and microbial related products was estimated at €150 billions in 2015 and an expected annual growth rate of >10% until 2023.

*What are Biological Resource Centres and why are they important?

According to the definition by the Organisation for Economic Co-operation and Development (OECD), Biological Resource Centres (BRCs) are an essential part of the infrastructure underpinning biotechnology. They consist of service providers and repositories of the living cells, genomes of organisms, and information relating to heredity and the functions of biological systems. BRCs contain collections of culturable organisms (e.g. microorganisms, plant, animal and human cells), replicable parts of these (e.g. genomes, plasmids, viruses, cDNAs), viable but not yet culturable organisms, cells and tissues, as well as databases containing molecular, physiological and structural information relevant to these collections and related bioinformatics. BRCs must meet the high standards of quality and expertise demanded by the international community of scientists and industry for the delivery of biological information and materials. They must provide access to biological resources on which R&D in the life sciences and the advancement of biotechnology depends.

Why a Strategic Research & Innovation Agenda?

High-quality bioscience research and innovative bioindustries are key contributors to tackle global societal challenges, today and in the future, leading towards a green, healthy and sustainable world.

MIRRI strives to achieve these goals, and by matching the resources, capabilities and expertise of all its partner organisations with global and European strategic agendas, MIRRI is placing its strategic focus, for the decade ahead, over a selected group of socioeconomically relevant areas.

MIRRI continuously analyses the landscape and scans the horizon in these areas, in order to systematically anticipate gaps and opportunities, aiming at better addressing the effective needs of its user communities, and helping them deliver the maximum value and impacts from their projects, technologies and products.

These are the bases for MIRRI's Strategic Research & Innovation Agenda 2021-2030, a "living document" to be revised and updated at the rhythm that the global challenges, the research and innovation landscape and the users' needs will dynamically change and evolve.

Countries and Partner Organisations

BELGIUM

BCCM - Coordination cell - Belgian Science Policy
BCCM/DCG - Diatoms Collection
BCCM/GeneCorner - Plasmid Collection
BCCM/IHEM - Fungi Collection: Human and Animal Health
BCCM/ITM - Mycobacteria Collection
BCCM/LMG - Bacteria Collection
BCCM/MUCL - Agro-Food and Environmental Fungal Collection
BCCM/ULC - Cyanobacteria Collection

FRANCE

CIRM - CFBP Plant associated bacteria collection
CIRM - BIA Food associated bacteria collection
CIRM - BP Pathogenic bacteria collection
CIRM - CF Filamentous fungi collection
CIRM - Levures Yeasts collection
CRBIP - National Collection of Cultures of Microorganisms
CRBIP-CVIP Collection of Viruses of the Institut Pasteur
CRBIP-CIP Collection of bacteria of the Institut Pasteur

GREECE

CCUoA-NKUA - Culture collections of the National and Kapodistrian University of Athens
ACA-DC - Agricultural College of Athens - Dairy Collection
BPIC - Benaki Phytopathological Institute Collection

ITALY

TUCC - Turin University Culture Collections
DBVPG - Industrial Yeasts Collection
UMCC - University of Modena and Reggio Emilia Microbial Culture Collection
CNR-PLAVIT - National Research Council-Plant Viruses Italy
CNR-ITEM - National Research Council-Agro-Food Microbial Culture Collection
USMI - University Hospital (Ospedale Policlinico) San Martino

LATVIA

MSCL - Microbial Strain Collection of Latvia

NETHERLANDS

CBS - Collection of yeasts and filamentous fungi
NCCB - Netherlands Culture Collection of Bacteria

POLAND

IAFB - Collection of Industrial Microbial cultures of the Prof. Wacław Dąbrowski Institute of Agricultural and Food Biotechnology
KPD - Collection of Plasmids and Microorganisms at the University of Gdansk
PCM - Polish Collection of Microorganisms

PORTUGAL

MUM - Micoteca da Universidade do Minho, CEB/UMinho
PYCC - Portuguese Yeast Culture Collection, UCIBIO/UNLisboa
ACOI - Algoteca de Coimbra, UCoimbra
LEGE-CC - Blue Biotechnology and Ecotoxicology Culture Collection, CIIMAR/UPorto
UCCCB - University of Coimbra Bacteria Culture Collection
CIMOCC - Mountain Research Centre Culture Collection, CIMO/IPBragança
VFMCC-INIAV - Agronomic, Veterinary and Food Microbial Culture Collections
Biotropical Resources - GHTM-IHMT/Global Health and Tropical Medicine, UNLisboa
CDB - Coleção do Departamento de Biologia, CBMA/UMinho
IVDP - Instituto dos Vinhos do Douro e Porto, I.P.
LRV/DRAg - Laboratório Regional de Veterinária dos Açores, Direção Regional da Agricultura

RUSSIA

VKM - All-Russian Collection of Microorganisms
IEGM - Regional Specialised Collection of Alkanotrophic Microorganisms
UNIQEM - The Collection of Unique and Extremophilic Microorganisms
VKPM - Russian National Collection of Industrial Microorganisms

SPAIN

CECT - Spanish Type Culture Collection
BEA - Spanish Bank of Algae

ROMANIA (Observer)

IBB - Institute of Biology Bucharest
MCUB - Microbial Collection of the University of Bucarest
CMII-ICCF - Culture Collection of Industrial Importance Microorganisms-National Institute for Chemical Pharmaceutical Research and Development
MIUG-DJUG - Industrial Microorganisms Collection of "Dunărea de Jos" University of Galati, (DJUG)
CNBC - IC Cantacuzino National Institute for Research in Microbiology and Immunology

Why and how to join MIRRI

The offer of microbial genetic resources is dispersed and no single country can offer a complete coverage of microbial diversity and associated services, which makes the case for an overarching organisation to make best use of current capacity, bridge gaps and address the needs of biotechnology.

Under the framework of the ESFRI Roadmap, the objective of MIRRI is to establish, operate and develop a pan-European distributed Research Infrastructure that provides facilitated access to high-quality microorganisms, their derivatives, standardised associated data and services to underpin research, development and innovation in microbiology, life sciences and biotechnology.

For each Member country participating, MIRRI will enable them to coordinate and mutualise a comprehensive set of resources and services for the benefit of the European Research Area (ERA) and its scientific community. MIRRI will stimulate the scientific and technological development of the European regions, boost the competitiveness of product and service development in the different sectors of biotechnology and will act as a catalyst for investment and job creation in the European countries.

For individual organisations – mBRCs, culture collections or research institutes – the participation in MIRRI may bring many benefits, such as: become more competitive, provide improved harmonised services as a result of the exchange of knowledge, including quality control / quality assurance and best practices; improve sustainability, enlarge holdings in a coordinated, standardised and coherent manner, in line with their major expertise; improve the standardised data offer associated to the microbial resources, by connection to the MIRRI Information System; increase the accessibility to their capacities taking advantage of the higher profile conferred by the MIRRI brand.

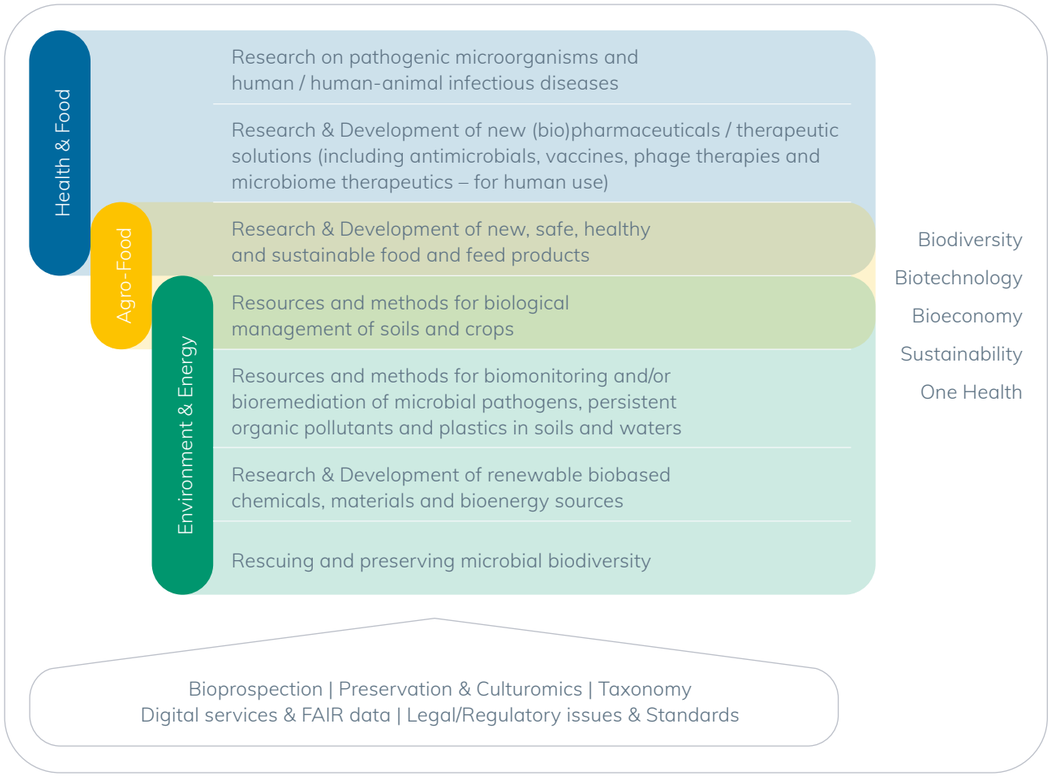
EU Member States, associated countries, third countries other than associated countries and intergovernmental organisations may become a Member or an Observer of MIRRI. In wishing to do so, they shall issue a written request to the Chair of the Assembly of, in English, describing how they would contribute to MIRRI tasks and activities and how they will respect the obligations of Members or Observers. The application will then be examined by the proper MIRRI bodies and a decision issued.

MIRRI is continuously engaged in enlarging its geographic coverage in Europe and beyond. If you would like to know more about participation in MIRRI, please contact us: info@mirri.org.

To find more information about MIRRI and its partner organisations, please visit www.mirri.org.

MIRRI: a preferred partner for Research & Innovation in the domains of Health & Food, Agro-Food and Environment & Energy

Overview of MIRRI's strategic domains/areas



From microbial collections to real-life innovations

From a "demand" point of view, global and European strategic agendas – such as the UN Sustainable Development Goals and the EU Horizon Europe, besides the ESFRI Roadmap, Strategy Report and Landscape Analysis –, and national/regional Research and Innovation Strategies for Smart Specialisation (RIS3), along with the identified users' needs, set the framework for MIRRI's strategic domains/areas of intervention.

In response to those demands, MIRRI proposes the broadest range of microbial resources, characterised with cutting-edge technologies, some being unique, and makes their associated data accessible through FAIR approaches. These resources are the bases for multiple biotechnological applications and offer multiple potential uses.

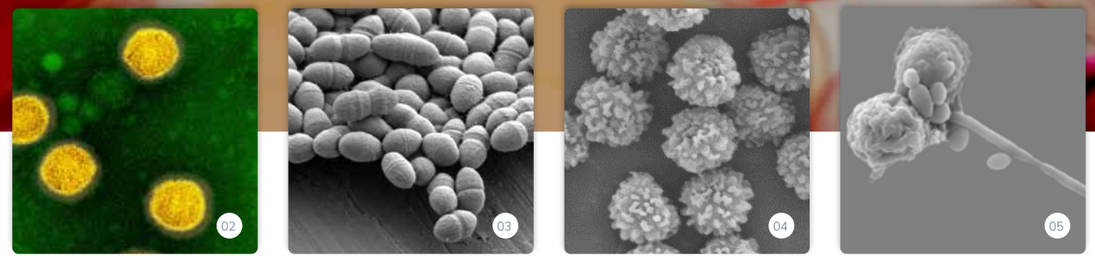
MIRRI mobilizes hundreds of scientists and other experts from about 50 research and innovation organisations, from 11 different countries, thus bringing together a pool of expertise that covers a broad and diverse range of scientific fields and application domains, such as: fundamental and applied research; environmental, industrial, food and clinical microbiology; environmental, human, animal and plant health; pharmacology and toxicology; agricultural and food sciences; biotechnology food industry; food safety; biological soil and crop management; environmental management and bioremediation; marine biotechnology; biofuel production and microbial fuel cells; microbial biodiversity and taxonomy; microbiomes and culturomics; molecular biology and biotechnology; bioinformatics and data management; and legal/regulatory affairs, amongst others.

MIRRI's partner organisations have a proven track-record of successful research and innovation projects in collaboration with startups, SMEs and large companies.

MIRRI and its partner organisations have a privileged position to collaborate with the bioscience and the bioindustry communities on delivering the maximum value and impact from their projects, technologies and products, most remarkably in the strategic domains/areas (see table on page 16).

Strategic Area 1

Research on pathogenic microorganisms and human / human-animal infectious diseases



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The resources, capabilities and expertise of MIRRI within Strategic Area 1 | Research on pathogenic microorganisms and human / human-animal infectious diseases are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 3 | Good Health and Well-being SDG 6 | Clean Water and Sanitation
Horizon Europe Clusters	Health
Horizon Europe Missions	A Climate Resilient Europe
Horizon Europe Partnerships	Health: European Partnership for EU-Africa Global Health European Partnership for Innovative Health (Initiative) European Partnership for Personalised Medicine European Partnership for One Health/AMR Antimicrobial Resistance (AMR) Food, Bioeconomy, Natural resources, Agriculture and Environment: European Partnership for Animal health (PAH)
Other ESFRI Research Infrastructures	Health & Food: EU-IBISBA; BBMRI ERIC; EATRIS ERIC; ECRIN ERIC; ELIXIR; ERINHA; Euro-Bioimaging; INFRAFRONTIER; INSTRUCT ERIC

Infectious diseases and the growing concern for human and animal health

With globalisation, Europe and the world are exposed to various infectious diseases which threaten the public health. This global issue is a huge concern for health and economic development. The current Covid-19 pandemic underlines what is at stake. Zoonotic infections are likely to increase as people contact with carrier species with diseases that humans have not previously encountered. These infections spread by international travel. The EU needs to be prepared for these likelihoods. Implementation of prevention and mitigation measures is required to avert global health and economic crises.

Furthermore, the World Health Organization (WHO) estimated that 420,000 people die every year after eating contaminated food, resulting in the loss of 33 million healthy life years (DALYs). What is more, despite increased access to improved water supplies, water-related infectious diseases continue to pose a threat to public health in the pan-European region and worldwide. Pathogens that induce infectious diseases in livestock represent an additional economic and health threat and a challenge for food safety and security. Animal pathogens are of major concern to agriculture as well as to global health, since it is estimated that approximately 60% of human infections are associated to zoonoses.

Besides the global emerging infectious diseases, there are the neglected infectious diseases (NIDs). According to the European Commission, the NIDs affect around 1 billion people in the world's poorest countries. Therefore, urgent actions must be taken to develop effective and relevant prevention, early diagnosis and treatments to fight such diseases. Combating infectious diseases necessitates the preparedness in research facilities, technologies, services, and resources.

The urge in combating outbreaks stimulated the European Commission to launch several actions related to infectious diseases. The actions addressed the readiness to face outbreaks, development of diagnosis, treatments and vaccines and support of clinical trials through the European and Developing countries Clinical Trials Partnership (EDCTP) which was launched for a second time for the period 2014-2024 to cover the NIDs with a budget of €1.3 billion. Moreover, Europe is addressing the infectious diseases through research infrastructures and resources to enhance the research such as ECRAID (European Clinical Research Alliance on Infectious Diseases) and ERINHA (European Research Infrastructure on Highly Pathogenic Agents).

MIRRI commitment in the fight against infectious diseases

The resources available from MIRRI form a rich asset capable of supporting research and innovation on infectious diseases. MIRRI conserves and distributes well-characterised strains of pathogenic agents, and encompasses research facilities, high-quality services, and expertise to contribute to deliver new treatments, prevention and research findings on human and animal infectious diseases, in the frame of respecting scientific and regulatory policies. MIRRI offers expertise and technologies to build workflows to characterise pathogens in terms of their precise taxonomic position, virulence and antimicrobial resistance, allowing to model their evolution and predict their virulence potential, their biological activities and their capacity for resistance to antimicrobial agents. The vision of MIRRI is to secure the basic necessities to respond to infectious diseases through the deep knowledge on the biology of pathogens that needs to be achieved by applying new technologies. MIRRI thereby supports research on interactions between infecting pathogens and the immune system, on the role of healthy microbiota in preventing pathogens development and pathogenesis routes. MIRRI can also support research on pathogens evolution including the development of resistance to the host's defense mechanisms or to antimicrobial agents. This provides the scope to promote the development of new therapeutic measures and medications.

MIRRI helps facing existing and emerging diseases by providing resources to quickly develop infectious disease diagnostics (e.g. by providing the needed control strains for emerging pathogens diagnostic tests set-up, as was the case for SARS-CoV-2), setting new strategies for pathogens monitoring and developing treatments and vaccines.

Strategic Area 2

Research & Development of new (bio) pharmaceuticals / therapeutic solutions

(including antimicrobials, vaccines, phage therapies and microbiome therapeutics – for human use)


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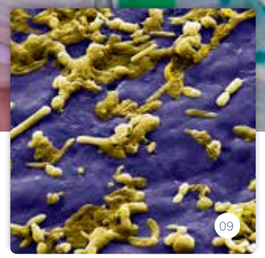
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The resources, capabilities and expertise of MIRRI within Strategic Area 2 | Research & Development of new (bio) pharmaceuticals / therapeutic solutions (including antimicrobials, vaccines, phage therapies and microbiome therapeutics – for human use) are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 3 | Good Health and Well-being
Horizon Europe Clusters	Health
Horizon Europe Missions	A Climate Resilient Europe Conquering cancer: mission possible Mission Starfish 2030: Restore our Ocean and Waters
Horizon Europe Partnerships	Health: European Partnership for EU-Africa Global Health European Partnership for Innovative Health (Initiative) European Partnership for Personalised Medicine European Partnership for One Health/AMR Antimicrobial Resistance (AMR)
Other ESFRI Research Infrastructures	Health & Food: EU-IBISBA; BBMRI ERIC; EATRIS ERIC; ECRIN ERIC; ELIXIR; EMBRC ERIC; ERINHA; EU-OPENSCREEN; Euro-Bioimaging; INFRAFRONTIER; INSTRUCT ERIC

The need for innovative medicines and the role of microbial resources

Oncology, autoimmune and inflammatory diseases, diabetes and metabolic disorders, infectious diseases (including neglected infectious diseases, NIDs), neurological and cardiovascular diseases, are the focus of intensive research and innovation to deliver new therapeutic solutions, such as monoclonal antibodies, recombinant growth factors, purified proteins, recombinant proteins, enzymes or hormones, cell and gene therapies, vaccines, immunomodulators, phage therapies, microbiome therapeutics, and many other product types.

Part of these solutions may come from the use of living organisms to create and produce biopharmaceuticals. This includes not only products from mammalian cells but also bacteria, filamentous fungi, yeasts and other microbial groups. The current flourishing biopharmaceuticals market is driven by various factors, such as an increase in the elderly population, the surge in prevalence of chronic diseases, growing levels of resistance to antimicrobial agents, the response to any emergent epidemic or pandemic disease, etc.

The global biopharmaceuticals market is highly competitive and is projected to grow by 9% through to 2025, reaching €360-440 billions. Alongside with this scenario, the pharmaceutical industry, together with academia, start-ups, and supported by governments, non-governmental organisations and charities have been developing new drugs and therapeutic solutions, including for NIDs, to operate in financially less attractive markets. Several initiatives and programs are: 1) the Special Program for Research and Training in Tropical Diseases (http://www.who.int/tdr/en/), 2) the Medicines for Malaria Venture (https://www.mmv.org), 3) the Global Alliance for Tuberculosis Drug Development (https://www.tballiance.org) and, 4) Drugs for Neglected Diseases Initiative (https://www.dndi.org).

MIRRI, a key resource for new (bio)pharmaceuticals / therapeutic solutions

Antimicrobial (antibacterial, antiviral, antiparasitic and antifungal) drugs are critical tools to fight infections in humans. Nevertheless, a constantly increasing level of resistance to these drugs is placing a century of progress in human health and life expectancy at risk. This is a matter of great concern expressed, for instance, in the EU4Health programme, the European One Health Action Plan against AMR or the Pharmaceutical Strategy for Europe. New, effective antimicrobials are a pressing need, and the availability of new, improved, accessible vaccines would provide a cost-effective preventive measure against the health threat of antimicrobial-resistant pathogens and epidemics.

The current Covid-19 pandemic illustrates only too clearly the need for novel antiviral drugs and pharmaceuticals to alleviate the symptoms of the infection. In addition, the scientific innovation results also from the use of holdings preserved in microbial culture collections or isolates to develop non-conventional antimicrobials, such as phage therapy, microbial silver nanoparticles, microbial quorum sensing inhibitors, biosurfactants, and production of functional foods (probiotics / prebiotics / synbiotics) and nutraceuticals.

The use of microbiomes, such as the faecal microbiome transplantation (bacteriotherapy) to treat diarrhoea induced by chemotherapy is recognised, as well as it is a highly effective treatment against recurrent *Clostridioides difficile* infections. In the United States, *C. difficile* causes about half a million infections and 29,000 deaths, while in Europe it is estimated that around 153,000 infection cases and more than 8,300 associated deaths occur every year. The potential of microbiome therapeutics is still in its infancy and the microbiome samples long-term preservation in mBRCs needs to be investigated. New regulations to deposit and supply microbiomes need a global coordination effort where MIRRI has a pivotal role.


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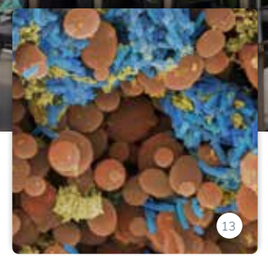
Strategic Area 3

Research & Development of new, safe, healthy and sustainable food and feed products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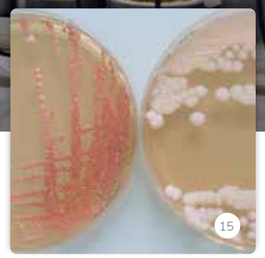
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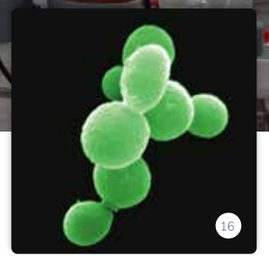
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The resources, capabilities and expertise of MIRRI within Strategic Area 3 | Research & Development of new, safe, healthy and sustainable food and feed products are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 2 | Zero Hunger SDG 3 | Good Health and Well-being
Horizon Europe Clusters	Health Food, Bioeconomy, Natural Resources, Agriculture and Environment
Horizon Europe Missions	A Climate Resilient Europe Conquering cancer: mission possible Mission Starfish 2030: Restore our Ocean and Waters Caring for soil is caring for life
Horizon Europe Partnerships	Health: European Partnership for One Health/AMR Antimicrobial Resistance (AMR) Food, Bioeconomy, Natural resources, Agriculture and Environment: European Partnership accelerating farming systems transition European Partnership for Animal health (PAH) European Partnership for Safe and Sustainable Food Systems Partnerships across themes: EIT Food-KIC
Other ESFRI Research Infrastructures	Health & Food: EU-IBISBA; METROFOOD-RI; ECRIN ERIC; ELIXIR; ERINHA

Future of food innovation in balance with a resilient food system

Innovation in the food sector is oriented towards healthy lifestyles and disease prevention. There is a growing demand for organic and healthy diets, with special attention on more nutritious and low-calorie food, directed to specific population groups i.e. children, the elderly or even to customized food products, but also for food with health-promoting effects.

Functional food is an emerging solution representing a huge market of €147 billions (2021) that is expected to grow to €225 billions in 2027. In addition, food products need to meet the safety regulations to guarantee consumers' health. Alternatives to the use of chemical additives in food applications, for food safety and extended shelf life, are of a great concern to ensure the food system sustainability.

The European Commission is committed to a fair and equitable transition of the food system that considers consumers' health (One-Health approach) and planetary limitations (Circular Biobased Economy concept) which is reflected in the Farm to Fork Strategy and the Food 2030 policy, both aligned with the Green Deal priorities.

Microbial solutions in line with the 2030 EU food policy

Some microbes can be used directly for consumption, such as mushrooms. Others can be used to produce single cell protein (SCP) as animal feed, such as yeasts. In the course of fermentative processes, traced as far back as 7000 BC, bacteria and/or fungi convert the chemical composition of raw materials, allowing food preservation, pathogens inhibition, transformation of some matrices into edible food with enriched nutritional value as well as conferring health-benefits to the consumers. Many food-fermentative microbial species are categorized as Qualified Presumption of Safety (QPS) by the European Food Safety Authority (EFSA) and therefore their use is a good strategy for the design of new, safe and healthy functional food. At present, probiotics and prebiotics represent more than 40% of the ingredients and 65% of functional foods are elaborated with the help of microbes (i.e. bakery, dairy, novel vegetal fermentations).

Understanding the food microbiome and the interaction between food and the gut microbiome will provide new opportunities in the design of novel functional food i.e. plant-, algal- and fungal-based products for alternative proteins and dietary shift or substrates with health-promoting properties. In addition to the design of novel functional foods, there is a plethora of microbial solutions that will support the transition to a sustainable food system. In fact, the agro-food chain generates about 700 million tons of waste each year in Europe. They are secondary raw materials which, in line with the transition towards a circular biobased economy, can be exploited as carbon and nitrogen sources for microbial fermentation. Therefore, challenges such as agro-industrial by-products management and valorisation or foodborne-pathogen mitigation can also be addressed with the aid of microbes.

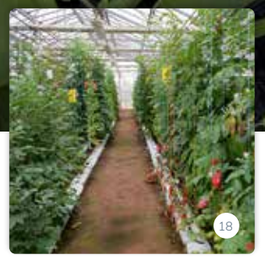
The EU's food safety policy covers also animal feed, high standards of animal health and welfare and plant protection. Seventy five % of all EU land is used for feed production, which challenges MIRRI to contribute to the development of biopesticides and biofertilizers to reduce the use of hazardous pesticides and nutrient losses, while ensuring on soil fertility. Reducing by 50% the sale of antimicrobials for farmed animals and in aquaculture, and achieving 25% of total farmland under organic farming by 2030 are also EU targets that will potentially halt biodiversity losses. Finally, cultivated meat (cellular agriculture) and new sources of proteins, such as from edible unicellular microorganisms, are to be used as protein supplement in human foods or animal feeds.

MIRRI, a key resource for the food system revolution

MIRRI provides an unprecedented centralised access to a huge diversity of high-quality, legally compliant, microbial resources and their metadata, thus accelerating their valorisation. In addition, backed by strong and complementary expertise of its partner organisations in microbiomes, physiology, genomics and functional analysis of microorganisms, MIRRI is able to propose characterisation workflows (metabolism, genomics, anti-pathogenic properties, anti-inflammatory activity), enabling product developers a fast-track in microbe search and selection.

Strategic Area 4

Resources and methods for biological management of soils and crops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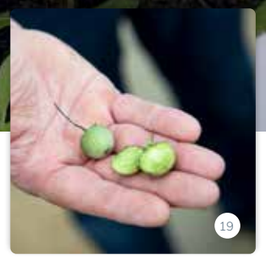
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The resources, capabilities and expertise of MIRRI within Strategic Area 4 | Resources and methods for biological management of soils and crops are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 2 | Zero Hunger SDG 3 | Good Health and Well-being SDG 6 | Clean Water and Sanitation SDG 12 | Responsible Consumption and Production SDG 13 | Climate Action SDG 15 | Life On Land
Horizon Europe Clusters	Food, Bioeconomy, Natural Resources, Agriculture and Environment
Horizon Europe Missions	A Climate Resilient Europe Caring for soil is caring for life
Horizon Europe Partnerships	Food, Bioeconomy, Natural resources, Agriculture and Environment: European Partnership accelerating farming systems transition Agriculture of data European Partnership for Safe and Sustainable Food Systems Partnerships across themes: EIT Climate-KIC
Other ESFRI Research Infrastructures	Health & Food: AnaEE

Healthy soil - healthy microbial ecosystem

Healthy soils are essential to sustain plant and animal productivity, to provide food and clean water, to mitigate climate change, to maintain biodiversity and to support human health and habitation. However, the European Commission's Joint Research Centre has estimated that approximately 60-70% of EU soils are unhealthy. Soil is an ecosystem containing large numbers of bacteria, fungi and other microbes; these contribute to 80-90% of the soil's biological activity and play a critical role in maintaining soil's health, ecosystem functions and crop production. Soil biological properties are of vital importance for its quality and for plant growth and are better indicators of soil health than its physical and chemical properties.

The understanding and management of soil biological properties and microorganisms is therefore a key area of concern to ensure that soil can maintain sustainable crop production, store and purify water, capture carbon, cycle nutrients and preserve biodiversity. Soil microorganisms can also affect human health, either directly via infection or by acting as reservoirs of antibiotic and antifungal genes than can be acquired by pathogens – for example, resistance to antifungal azoles administered to humans for treating aspergillosis has been linked with azoles used in agriculture.

To address this, the Horizon Europe mission 'Caring for soil is caring for life' has been proposed with the goal to ensure that, by the year 2030, 75% of the EU soils will be healthy and able to provide essential ecosystem services. Healthy soils are required to fulfil the European Green Deal, the Common Agricultural Policy, the Water Framework Directive, the Habitats Directive, the Circular Economy Action Plan and the Soil Thematic Strategy.

Plant-microbe interactions for plant health and crop management

Plant-microbe interactions have dramatic effects on crop yield and economic viability. Microbes are important in nutrient transfer, nitrogen fixation, soil litter decomposition, solubilisation of inorganic minerals, stimulation of plant growth through phytohormones, antagonism towards pathogenic microorganisms, and mitigation of salt stress. Chemical fertilizers increase the cost of agricultural production and deteriorate soil quality. Use of beneficial microbes has a low cost and can reduce a crop's requirement of nitrogen by 50-70% and increase its yield by up to 20%. It is estimated that employing beneficial microbes could potentially reduce the usage of chemical fertilizers by half. Biocontrol is the use of microbes or secondary metabolites produced by microbes to control pathogens; these can cause large reductions in pathogen numbers or pathogen virulence and thus reduce the dependence of farmers on harmful pesticides. The potential of microbes to reduce the reliance on pesticides and fertilizers, as well as their ability to remediate contaminated soils means that they can have a major role in the development of sustainable farming systems and can thus play a major role in achieving UN Sustainable Development Goals such as Zero Hunger.

MIRRI, a key partner for the improvement of soil health and fertility and crop management

MIRRI can assist by the study of soil microbiomes to unravel the microbial populations supporting healthy ecosystems as the basis for monitoring soil biodiversity, to assess soil health, as it is strongly recommended by FAO's The State of the World's Biodiversity for Food and Agriculture report, published in 2019. Agricultural soils can be improved by the addition of nitrogen-fixing bacteria in soil or on seeds or by introducing microbes harmful to pest organisms. MIRRI can isolate, identify and provide microbial strains able to improve soil biogeochemical cycles and thus contribute to the development of biofertilizers as an alternative to chemicals for an ecological agro-food production in line with the Green Deal and the Circular Biobased Economy.

Strategic Area 5

Resources and methods for biomonitoring and/or bioremediation of microbial pathogens, persistent organic pollutants and plastics in soils and waters

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The resources, capabilities and expertise of MIRRI within Strategic Area 5 | Resources and methods for biomonitoring and/or bioremediation of microbial pathogens, persistent organic pollutants and plastics in soils and waters are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 2 | Zero Hunger SDG 3 | Good Health and Well-being SDG 6 | Clean Water and Sanitation SDG 12 | Responsible Consumption and Production SDG 14 | Life Below Water SDG 15 | Life On Land
Horizon Europe Clusters	Health Food, Bioeconomy, Natural Resources, Agriculture and Environment
Horizon Europe Missions	A Climate Resilient Europe Mission Starfish 2030: Restore our Ocean and Waters Caring for soil is caring for life
Horizon Europe Partnerships	Health: European Partnership for Chemicals Risk Assessment Food, Bioeconomy, Natural resources, Agriculture and Environment: European Partnership Water Security for the Planet (Water4All)
Other ESFRI Research Infrastructures	Environment: DANUBIUS-RI, AnaEE Health & Food: EMBRC ERIC, EU-IBISBA, EMPHASIS

Global environmental issues require immediate action

Pollution is one of the main causes of soil and water degradation and loss of ecosystem services: the accumulation of persistent pollutants from agriculture (e.g., agrochemicals), industry (e.g., hydrocarbons, plastics, dyes), and civil society (e.g., pharmaceuticals, personal care products) led to negative consequences on climate change, alteration of water cycle, soil quality, and biodiversity with a strong impact on human health. Accordingly, Europe aims to implement the Action Programme to 2030 to support the environment in the scope of the European Green Deal through protection and preservation of biodiversity.

Therefore, to reduce the European ecological deficit there is a pressing need to invest in new sustainable products and processes and to restore the ecological functions of lands, surface waters and oceans. The European Environment Agency (EEA) estimates more than 2.5 million potentially contaminated sites; 340,000 sites already identified and require remediation intervention. Managing contaminated land in Europe costs an estimated €6.5 billions per year.

The growing role of microorganisms in natural environments preservation and bioremediation

Microorganisms are primary players in ecosystem functioning; they control the main biogeochemical cycles supporting the existence of all higher trophic life forms and contribute with half of the global net O_2 production, being at the same time one of the major sinks for CO_2. Investigation of climate change and pollution impact on microbial life is essential to assess the risks and consequences associated to changing environmental conditions and to the release of chemicals in the environment. On the other hand, the environmentally safe and relatively inexpensive biotechnological methods of pollution control involving microorganisms (bioremediation) allow solving the environmental issues in a sustainable way taking into consideration the high number of sites that have to be treated.

Attempts at remediating contaminated environments continue to be managed using conventional chemical-physical and often costly approaches. These methods are time consuming, invasive, disruptive to natural habitats and usually result in causing other problems. Moreover, they are not applicable to tackle the problem of diffuse pollution of micropollutants (including microplastics) in soil and water. This dictates to expand and intensify the research on microorganisms in polluted environments, which act as a primary response system to adverse or potentially harmful environmental changes and initiate the adaptive responses. Native or genetically engineered microorganisms are serving to overcome the challenges and threats imposed on the environment. Emerging technologies such as ecogenomics offer new horizons for research and development in environmental biotechnologies, including bioremediation – applied to contaminated environments, for example, may determine the presence of useful microorganisms and/or enzymes indicating treatability by bioremediation. Moreover, there is a growing interest in the in-depth study of genomes, proteomes, and metabolomes of previously unexplored microorganisms, including those non-culturable in traditional media. Advances in functional metagenomics support the identification of versatile and unique microbial resources involved in the biodegradation of persistent pollutants, which will be used in environmental biotechnology and also in improving waste management and recycle according to circularity criteria.

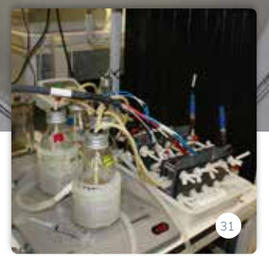
MIRRI resources for environment protection

MIRRI is a key resource for environmental biotechnology: it provides optimal ways of constructive human-microbes' world interaction, opening up the prospects for predicting and managing the environmental changes, for developing and implementing advanced ecobiotechnologies as a result of improved interaction among mBRCs, biotechnological companies and policy makers. MIRRI microbial catalogue encompasses all ecologically significant types of microorganisms useful for xenobiotics' biodegradation and contaminated ecosystem bioremediation, and related information for specialists in various fields of science and bioindustry.

The current EC ambition (Zero Pollution Action Plan) of creating a toxic-free environment requires action to prevent pollution as well as strategies to clean and remedy it. MIRRI will contribute to the reduction of the environmental impact of food (including food packaging), agriculture and industrial production. MIRRI resources are currently applied in research improving microbial biosensors for pollution monitoring, bioremediation of soil and water from organic and inorganic contaminants, innovative wastewater processes and management of different kind of wastes in view of their valorisation in the production of energy or in new added value materials.

Strategic Area 6

Research & Development of renewable biobased chemicals, materials and bioenergy sources



The resources, capabilities and expertise of MIRRI within Strategic Area 6 | Research & Development of renewable biobased chemicals, materials and bioenergy sources are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 7 | Affordable and Clean Energy SDG 12 | Responsible Consumption and Production
Horizon Europe Clusters	Digital, Industry and Space Climate, Energy and Mobility
Horizon Europe Missions	A Climate Resilient Europe 100 Climate-neutral Cities by 2030 – by and for the Citizens Mission Starfish 2030: Restore our Ocean and Waters
Horizon Europe Partnerships	Climate, Energy and Mobility: European Partnership on Clean Hydrogen European Partnership for Clean Energy Transition Partnerships across themes: EIT Climate-KIC EIT InnoEnergy-KIC EIT Manufacturing-KIC
Other ESFRI Research Infrastructures	Health & Food: EU-IBISBA; EMBRC ERIC

Urgent need for renewable energy to tackle climate change

Development of technologies to utilise renewable sources for the production of bioenergy enable energy security and help reduce national and global greenhouse gas (GHG) production. In addition, the efficient utilisation of agricultural and forestry resources is considered as part of a circular biobased economy. Renewable energy sources are derived ultimately from the power of the sun's radiation in the form of plant material, and technologies for harnessing this power require, in some cases, the exploitation of natural microbial resources for breakdown and conversion to utilisable bioenergy products.

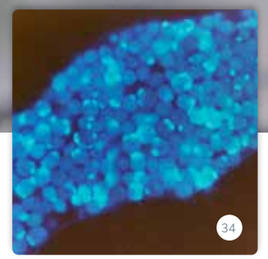
The natural resources, in terms of fermentable sugars, malleable phenolics, and transformable lipids, can be extensively and selectively transformed into a range of desired products, many currently finding their place as replacements to chemicals, materials and fuels derived from fossil fuel reserves, as well as in the production of bioalcohol (current bioethanol for automobiles and future longer chain alcohols for jet aircraft, for example), biochar and syngas. Renewable purpose-grown energy biomasses and organic wastes are the main inputs into the bioenergy process. Specifically developed bacterial consortia, simultaneous and selective-degrading filamentous fungi, highly sugar-specific fermentative yeast strains, microalgae and, more recently, co-cultivation methodologies have been developed to systematically remove high value components of the biomass for transformation into biobased chemistry precursors. These high value components find their application in the pharmaceutical, food and specialised chemicals industry.

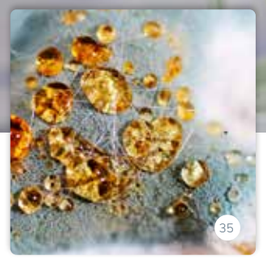
MIRRI microbial resources for biobased chemicals

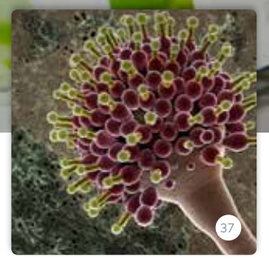
The culture collections within MIRRI are extremely rich sources to develop the next generation of green, environmentally-friendly and sustainable tools required to more efficiently replace fossil resource-derived materials for today's and future industries. More efficient microbes from nature's diverse pantry, as maintained within the growing collections within MIRRI, can be utilised, either as whole cells or from a better understanding of their metabolic processes and/or from understanding more about the function and applicability of their individual and collective enzymes as both degradative and synthetic catalysts. Furthermore, the genetic and biochemical knowledge gleaned from the MIRRI partner organisations' collections can be utilised to design synthetic microbes more efficient than the wildtype ones.

Strategic Area 7

Rescuing and preserving microbial biodiversity







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The resources, capabilities and expertise of MIRRI within Strategic Area 7 | Rescuing and preserving microbial biodiversity are aligned with or can be linked to (non-exhaustive list):

UN Sustainable Development Goals	SDG 14 | Life Below Water SDG 15 | Life On Land
Horizon Europe Clusters	Food, Bioeconomy, Natural Resources, Agriculture and Environment
Horizon Europe Missions	A Climate Resilient Europe Mission Starfish 2030: Restore our Ocean and Waters Caring for soil is caring for life
Horizon Europe Partnerships	Food, Bioeconomy, Natural resources, Agriculture and Environment: European Partnership for rescuing biodiversity to safeguard life on Earth European Partnership for Safe and Sustainable Food Systems Partnerships across themes: EIT Climate-KIC
Other ESFRI Research Infrastructures	Environment: DANUBIUS-RI; DiSSCo; eLTER; EMSO ERIC; LifeWatch ERIC Health & Food: AnaEE; EMBRC ERIC

mBRCs, key players for microbial biodiversity investigation and preservation

Europe is a stronghold for ex-situ conservation of living microbial resources, some of which have been preserved for over a century. Collection staff and other users continuously study the properties of these strains, update identification, and generate new data that is published or kept in databases associated with the strain catalogues. Many of the holdings are considered unique or known to originate from habitats that have since disappeared or were seriously affected by human activity. The Horizon Europe Missions “Caring for soil is caring for life” and “Mission Starfish 2030: Restore our Ocean and Waters” appropriately address the crises of ecosystem deterioration and biodiversity loss. These missions will not be effective without improving our basic understanding of composition and functioning of the microbial communities in terrestrial, marine and freshwater ecosystems.

MIRRI approach for the preservation of biodiversity of endangered environments

Microbial communities play a key role in supporting all biota, ecosystem stability and services.

However, as underpinned by the United Nations for Sustainable Development Goal 15, there is still a huge gap in our knowledge on the composition of microbial communities and the specific properties of individual taxa therein, and methods for preserving them ex-situ. To address the acute threat of losing unique or pristine habitats, MIRRI research will focus on improvement of ex-situ conservation methods for environmental samples and understudied biodiversity (taxa). Further, MIRRI will use its expertise to discover, describe and preserve ex-situ new microorganisms from natural and arable environments in Europe, and to characterise individual strains as well as microbiome samples at phenotypic and genomic levels. Field sampling efforts will target soils and waters being under threat, but also the existing microbial biobank holdings – currently 400,000+ strains are preserved in MIRRI partner biobanks in Europe – will be further characterised. To cover all biota (macro- and microbiota) and make available other key ecosystem parameters, MIRRI will collaborate with other Research Infrastructures, to more efficiently integrate and disclose scientific harmonised and standardised data and materials for research. Such data and knowledge will be important for soil and water sanitation and remediation approaches, and for sustainably restoring and using ecosystem services.

Soil biodiversity is one of the key parameters for effectively monitoring soil health. It depends heavily on the knowledge-base from existing studies and new efforts to isolate and characterise undescribed microbes and their preservation for future reference. Data on soil microbes from culture-based studies and available reference materials in ex-situ collections will be indispensable for the Living Labs envisaged for the EU Horizon Mission for monitoring soil health, develop solutions and identify gaps.

Linking Biodiversity to Bioprospection

Green and Blue biotechnology depend on well-characterised and high-quality ex-situ materials for research and development, and can be boosted by successful partnerships with MIRRI through its expert clusters and services.

The exploration of the microbiomes in soil and in continental and sea water, and the preservation of their biodiversity in ex-situ collections will further enrich and widen the MIRRI catalogue with well-characterised microorganisms. Soil microbes are one of our most promising sources of new therapeutic drugs, while marine microbiota is already used for pharmaceuticals and nutraceuticals, food and feed, textiles, polymers, bioplastics and other biomaterials, biofuels and bioremediation. The exploration of environmental microbes has provided recently key microbial resources for fermented foods, and it will provide genetic material for the study of the emergence of new pathogens either for plants or for animals.

MIRRI: a single point of access to high-quality microbial resources, data, services, expertise and training

Microbial resources (and associated data)

MIRRI offers its users a single point of access to 400,000+ high-quality microbial resources, an ever-growing number made available by its about 50 partner biorepositories, covering all types of microorganisms, such as bacteria (and their cognate bacteriophages), archaea, fungi (including yeasts), eukaryotic viruses, microalgae and other microbiological material such as cell lines, natural or constructs carrying plasmids, DNA libraries, and genomic DNA.

The acquisition of MIRRI resources and the data obtained from their characterisation relies on the use of cutting-edge technologies. The use of molecular identification with barcodes, and the growing trend of genome sequencing provide an ultimate characterisation of microbes. The development and application of the MALDI-TOF MS technology for strain identification among MIRRI partner organisations offer support for a unique and wide base of spectra allowing a rapid, robust and high-throughput microbe characterisation. This pairs with the growing importance of culturomics in MIRRI that will offer a distinctive ability of collecting rare microbial resources. The MIRRI Information System will also provide users with all relevant information and associated contextual data (metadata) about the microbial resources, as available – e.g. taxonomy, ecology, pathogenicity, morphology, physiology, chemical characterisation, DNA barcoding or genomics.

From strains supporting basic research and taxonomy and those producing antimicrobials or other bioactive compounds and enzymes for the pharmaceutical industry, to others that can be used in the production of healthier food and feed products (including ingredients), upgrading residues, processing side-streams and organic wastes, in the biological management of agricultural soils and crops, in the bioremediation of polluted sites or contaminated effluents, or in the production of renewable, biobased chemicals, materials and fuels, to mention a few examples, MIRRI is very likely to hold microbial resources matching every demand from bioresearchers and bioindustries in the sectors of Health & Food, Agro-Food, and Environment & Energy.

An overview of MIRRI's offer of microbial resources is provided n the table on pages 34-35, organised by major groups, type of application and correspondence to strategic areas.

For more information, please visit www.mirri.org.

Microbial Resources

		Strategic Area 1	Strategic Area 2	Strategic Area 3	Strategic Area 4	Strategic Area 5	Strategic Area 6
		Health & Food		Agro-Food	Environment & Energy		
Archaea	Archaea for bioactive compounds		●	●			●
	Archaea for agro-environmental applications					●	●
	Archaea for biotech applications	●	●	●	●	●	●
Bacteria	Pathogenic bacteria (for humans, animals, plants and crops)	●	●	●	●	●	●
	Bacteria for bioactive compounds		●	●			●
	Foodborne bacteria		●	●			●
	Bacteria for agro-environmental applications (e.g. bioremediation, biofertilizers, biopesticides, etc.)				●	●	●
	Bacteria for biotech applications	●	●	●	●	●	●
	Bacteria as reference strains for bioassays' controls	●	●	●	●	●	●
Cyanobacteria	Toxic cyanobacteria (for humans and animals)	●	●	●		●	●
	Cyanobacteria for bioactive compounds		●	●			●
	Cyanobacteria for food (e.g. dietary supplements)			●			●
	Cyanobacteria for agro-environmental applications (e.g. biofertilizers)				●	●	●
	Cyanobacteria for biotech applications	●	●	●	●	●	●
Filamentous Fungi	Pathogenic fungi (for human, animal, plants and crops)	●	●	●	●		●
	Fungi for bioactive compounds		●	●			●
	Foodborne fungi		●	●			●
	Fungi for agro-environmental applications (e.g. bioremediation, biofertilizers, biopesticides, etc.)				●	●	●
	Fungi for biotech applications	●	●	●	●	●	●
	Fungi as reference strains for bioassays' controls	●	●	●	●	●	●
Yeasts	Pathogenic yeasts (for human, animal, plants and crops)	●	●	●			●
	Yeasts for bioactive compounds (e.g. mycocins)		●	●			●
	Yeasts for biotech applications	●	●	●	●	●	●
	Yeasts as reference strains for bioassays' controls	●	●	●			●
Microalgae	Microalgae for bioactive compounds		●	●			●
	Microalgae for food (e.g. dietary supplements, food additives, etc.)			●			●
	Microalgae for agro-environmental applications (e.g. bioremediation, biofertilizers, etc.)				●	●	●
	Microalgae for biotech applications	●	●	●	●	●	●
Viruses	Pathogenic viruses (for humans, animals, plants and crops)	●	●	●		●	●
	Viruses for therapies		●				●
	Viruses as vectors		●				
	Viruses for agro-environmental applications				●	●	●
	Viruses for biotech applications	●	●	●	●	●	●
	Viruses as reference strains for bioassays' controls	●	●	●		●	●
Cell Lines & Genetic Constructs	Human, animal and plant cell lines	●	●	●	●	●	●
	Plasmids	●	●	●	●	●	●
	Bacteriophage vectors	●	●	●	●	●	●
	Microbial DNA/RNA	●	●	●	●	●	●

Services, Expertise & Training

Based on its partner organisations' state-of-the-art facilities and top-level expertise, MIRRI makes available for its users a vast, diverse portfolio of high-quality services. These range from general services to more application-specific ones – including pipelines of integrated, product-oriented services made available as tailor-made, turnkey solutions; strain tool boxes can be made available to specific bioindustrial R&D or training programmes.

The offer of technical and analytical services is to be complemented with the access to a wide selection of experts in different topics related with the use of microbial resources – e.g. microbial taxonomy; microbial cultivation; preservation of strains, DNA/RNA, consortia and microbiomes; applications and technologies; legal issues; IT / data management; mBRC Quality Management –, as well as with the access to training courses and e-learning webinars covering different aspects of the use of microbial resources. MIRRI is able to advise on the precautionary conditions to produce bioactive compounds and enzymes in safety bioreactors, avoiding natural or engineered antibiotic-resistant and pathogenic strains that must not be released to the environment in any circumstances. MIRRI is best placed to legally assist the bioscience and bioindustry communities' compliance with the Convention on Biological Diversity (CBD) and the Regulation (EU) No 511/2014 on access to genetic resources and sharing of benefits arising from their utilisation by part of the Nagoya Protocol, as well as being a stakeholder to the European Commission on this area.

MIRRI's services and expertise can help researchers and bioindustries delivering the maximum value and impacts from their projects, technologies and products.

Non-exhaustive lists of MIRRI's services are provided in the next pages.
For more information, please visit www.mirri.org.


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General services
(non-exhaustive list)

DEPOSIT
- Public Deposit
- Patent Deposit
- Safe Deposit

MICROORGANISM ISOLATION, PRESERVATION AND CULTIVATION
- Isolation and purification of strains
- Freeze-drying
- Optimisation of preservation conditions (including consortia and microbiomes)
- Optimisation of cultivation/fermentation
- Microbial counting/titer (phages, viable cells, spores, MPN...)

MOLECULAR IDENTIFICATION
- Identification from pure cultures
- Virus diagnostics
- Cell line authentication

PHENOTYPIC CHARACTERISATION
- MALDI-TOF MS
- Image analysis (optical, fluorescent, CLSM, TEM and SEM microscopies)
- Biochemical tests (classical or miniaturised i.e. API, Biolog ...)
- Analysis of the cellular fatty acid composition
- Analysis of cell wall sugars
- Analysis of peptidoglycan structure
- Analysis of polysaccharide degrading enzymes
- Analysis of the cellular polar lipid composition
- Analysis of volatile metabolites
- Analysis of ligninolytic enzymes
- Analysis of mycolic acids
- Analysis of respiratory quinones
- Immunochemical analysis

MOLECULAR CHARACTERISATION, MOLECULAR TYPING AND PHYLOGENETIC ANALYSIS
- Gene sequencing and analysis (housekeeping/rRNA/virulence/drug-resistance genes, MLSA/MLST...)
- PCR-typing (RAPD, DGGE, TTGE, AFLP, Microsatellites, rep-PCR, Inter-LTR)
- RFLP (genomic, mt-RFLP, ARDRA, ribotyping...)
- MALDI-TOF MS
- Karyotyping
- Determination of ploidy
- Plasmid profile analysis

NGS RELATED SERVICES
- Draft/complete genome sequencing and analysis (assembly, annotation, G+C...)
- Overall genome relatedness index (ANI, DDH...)
- Metagenomic analysis

SCREENING, TESTS AND BIOASSAYS
- Growth promoting / antimicrobial bioassays
- Screening (targets depend on the provider mBRC)
- Characterisation of technology abilities
- Characterisation of bioproducts (analytical, pharmaceutical)
- Analysis of adhesive activity
- Analysis of biosurfactant-producing activity
- Analysis of hydrocarbon-oxidizing activity
- Quality control and sterility testing of raw materials and products
- Material resistance testing

MISCELLANEOUS
- Assessment of Virus presence within fungal cultures
- Cell sorting applications (Flow cytometry)
- Construction of interspecific hybrids
- Determination O_2 consumption / CO_2 production
- DNA extraction
- Down-streaming processing (metabolite purification)
- House fungi diagnostic (e.g. *Serpula*)
- Mycoplasma testing
- Mycotoxin analysis
- Plasmid copy number quantification (Droplet digital PCR)
- Preparation of competent cells
- Provision of inactivated strains
- Safety assessment of strains for food and feed
- Virus resistance assays

TAXONOMIC DATABASE TOOLS
- MycoBank
- YeastIP
- FungalDC
- Yeast-ID
- Phylosearch

CONSULTANCY, TRAINING AND CONTRACT RESEARCH
- Consultancy (taxonomy, handling and preservation of strains)
- Consultancy (topics related to the mBRC expertise, including legal and safety issues)
- Training courses (content depends on the provider mBRC)
- Contract Research (content depends on the provider mBRC)

Application-specific and integrated services

(non-exhaustive list)

HEALTH & FOOD

Diagnostic

Bacterial and fungal pathogens detection, isolation, characterisation and preservation under controlled conditions

Selection of reference pathogenic strains for bioassays and diagnostics

Bacterial genome scanning for investigation of virulence factors and antimicrobial resistance

Biopharmaceuticals

Identification of taxonomically related *Streptomyces* strains with antimicrobial activity using mass spectrometry profiles

Scanning of fungal genomes, identification of pathways for synthesis of biomolecules with pharmaceutical interest and heterologous expression of silent fungal gene clusters for bioactive compounds production

In vitro screening of anti-inflammatory and anti-infectious activities (antibacterial, antiviral, antifungal and antiparasitic) of newly isolated strains or strains preserved in mBRCs (including archaea, bacteria, cyanobacteria, yeasts and fungi isolated from untapped environments)

Preparation of inactivated strains to be used for the development of vaccines

Microbial based therapeutics and health promoting solutions

In vitro screening of phages for phage therapy as alternative to antimicrobials

In vitro screening for health-promoting properties i.e. production of organic acids, vitamins, aminoacids, GABA

Isolation and/or selection of strains with probiotic activity, screening of probiotic potential and analysis of resistance to gastrointestinal conditions

AGRO-FOOD

Food production processes

Food microbiome: metagenomic & culturomic analysis, fungal/yeasts/bacterial species isolation and identification

In vitro screening of food preservation activities: antifungal, antibacterial

Analysis of relevant metabolites for food production (e.g. exopolysaccharide, esters, superior alcohols, volatile compounds in wine production)

Microalgae strain selection and mass culture optimisation for aquaculture feed and food ingredients production

Food-waste products recycling: isolation, identification and characterisation of degrading strains

Food safety

Genome analysis for food safety strain requirements i.e. antimicrobial resistance (AMR), antimicrobial production, toxigenicity and pathogenicity

Food safety assessment based on genomic information (according to EFSA)

Analysis of mycotoxin profiles

Investigation of food contamination and identification of bacteria and fungi applying an integrated polyphasic approach (e.g. identification of *Alicyclobacillus* sp., frequent spoiler of fruit juices)

Agriculture

Selection and characterisation of arbuscular mycorrhizal fungi strains for application in agricultural and horticultural crops

Biofertilizers: identification and quantification for registry purposes

Biocontrol agents: identification and characterisation of strains used as biocontrol agents (e.g. *Trichoderma harzianum*)

Investigation of microbial activities with impact in soil nutrients (e.g. siderophore production, phosphate solubilisation)

ENVIRONMENT & ENERGY

Bioremediation

Compositional and functional characterisation of microbiomes from metal contaminated sites, strain isolation (cyanobacteria, bacteria, fungi, yeasts, microalgae) and taxonomic characterisation. Screening of tolerance to heavy metals

Screening of existing microbial resources (cyanobacteria, bacteria, fungi, yeasts, microalgae) for biotransformation of organic pollutants (e.g. phthalates, polycyclic aromatic hydrocarbons)

Characterisation of microbial communities, isolation of autochthonous strains or selection of strains in mBRC (bacteria, cyanobacteria, fungi, microalgae) for application in wastewater treatment processes

Biomass valorisation and bioenergy production

Assessment from genome annotation of specific enzymatic activities for biofuel production (e.g. hydrolytic activities) and *in vitro* validation in bacteria

Characterisation of microbial communities and/or screening and isolation of autochthonous strains for enzymatic activities aimed at biomass degradation and waste-to-energy valorisation

Microalgae strain selection, ecophysiology, growth and mass culture for biofuel production

Biomaterials and bioindustry

Bioplastics: production of polyhydroalkanoates

Self-healing concrete: strain for microbial calcium carbonate deposition and counselling for processes development

Analysis of relevant enzymatic activities with environmental and industrial interest (alginase, chitinase, lignolytic activity, agarase, amylase, β-glucanase, protease...)

Counselling for microbial bioprocesses: growth and productivity, screening of tolerances under technological conditions, analysis of biotechnological relevant behaviour (e.g. flocculation, foaming)

How to access to and collaborate with MIRRI

Access modalities and conditions

MIRRI's digital material targeted to broad audience and the catalogue of microbial resources is to be freely accessible and searchable online, therefore open to any interested user. Access to the other MIRRI services is to be restricted to users from academia, business, industry, and public service recognised institutions, and requires registration in the MIRRI platform and/or application for requesting access.

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Contacts

For specific queries about how to access to MIRRI's resources or services, please contact:

Liliana Avila Ospina
Access Officer
access@mirri.org

For generic questions about MIRRI's Strategic Research & Innovation Agenda 2021-2030, please contact:

Luís Soares
Executive Director
info@mirri.org

MIRRI European Headquarters
University of Minho
Campus of Gualtar
Pedagogic Complex 3, Floor 0
4710-057 Braga
Portugal

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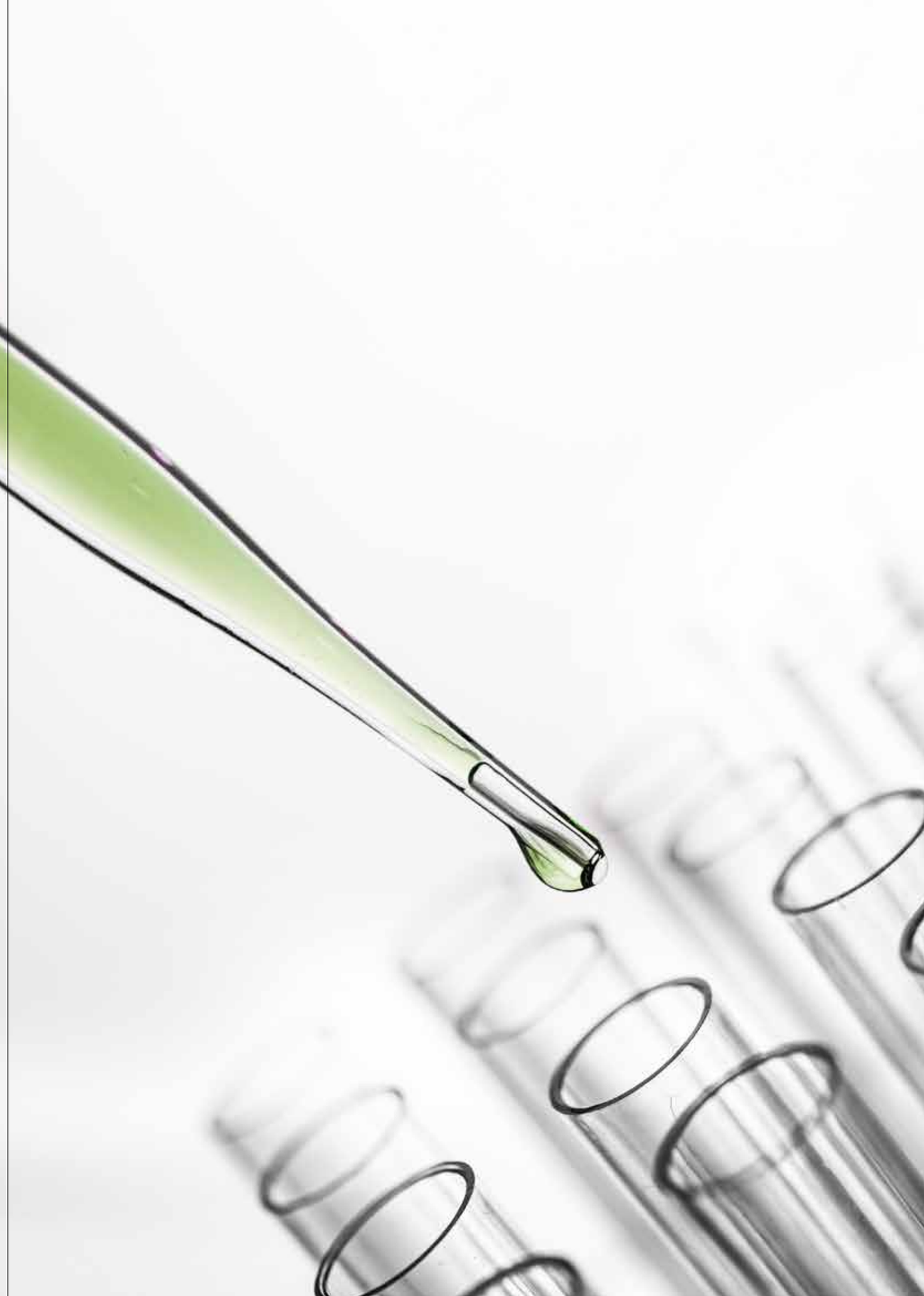

MIRRI IS21
IMPLEMENTATION AND SUSTAINABILITY FOR THE 21ST CENTURY
MICROBIAL RESOURCE RESEARCH INFRASTRUCTURE

The project "Implementation & Sustainability of Microbial Resource Research Infrastructure for 21st Century" (IS_MIRRI21) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 871129. This document reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.