Deliverable D1.1

Report on Common Ground Workshop

Work package number and title	*WP1: Mapping international microbiome activities and facilities along the food chain and beyond*
Lead-beneficiary	*AIT*
Work package Leader	*AIT*
Relevant Task	*Task 1.1*
Participants	*AIT, INRA, CSIC, VLO, FZJ, TEAGASC, TUT, AUA, UNITO, IAR, EUFIC, HMGU, CABI, WU, DLR, rtds, TUG, BRA, UEC, UW, UP, UWS, PU, WR and invited experts*
Dissemination Level	*Public*
Due Date (month)	*M6*

Microbiomesupport.eu – #MicrobiomeSupportEU
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

Common Ground Workshop – Report

Background

MicrobiomeSupport Common Ground Workshop united for the first time all project partners with the members of Advisory Groups and Expert Pool.
Together MicrobiomeSupport stakeholders worked on setting a basis for the mapping activities that are one of the major tasks of the MicrobiomeSupport project.

Aim

To collect and make available (database accessible through www.microbiomesupport.eu) information on microbiome related funding programmes, policies, research projects, experts and existing collaborations, facilities, know-how (incl. datasets and publications), educational programmes and applications (existing and in development). Furthermore, we want to explore the future of microbiome in the food systems and how these can contribute to global bioeconomy goals.

Date & Venue

4 – 5 March 2019, Vienna, Austria

Participants

Over 100 participants (Annex 1, Figure 4) from the MicrobiomeSupport consortium (partners and advisory group members), EC and IBF representatives and invited experts.

Countries

Austria, Australia, Belgium, Brazil, Canada, China, Denmark, Estonia, Finland, France, Germany, Greece, India, Ireland, Island, Italy, Netherlands, Poland, Portugal, South Africa, Spain, Sweden, UK, USA

Event Summary

MicrobiomeSupport Common Ground Workshop began with the introductory session that included presentation of the MicrobiomeSupport project (given by coordinator Angela Sessitsch, AIT) and other related innovation actions: CIRCLES (Marco Candela, University of Bologna), HoloFood (Anna Fotakis, University of Copenhagen), MASTER (Paul Cotter, TEAGASC) and SIMBA (Anne Pihlanto, Natural Resource Institute Finland). Furthermore, an overview presentation on the Microbiome R&I for Sustainable Food Systems was given by Carina Pereira (DG for Research & Innovation).

In the setting the scene session the status of microbiome R&I in Ireland (Paul Cotter, TEAGASC), Spain (Marta Olivares Sevilla, CSIC) and Canada (James Macklin, AAFC) was presented (Annex 2 – 4). In order to make these presentations comparable authors were provided a list of topics that should be covered. Nevertheless, the outcome was quite diverse, illustrating the considerable differences in the microbiome-related R&I strategies, policies and funding opportunities between these countries.

For example, in Spain there is no specific strategy governing microbiome R&I and the funds are mostly acquired from universal funding programmes and EU framework programmes. Primary focus of the nationally funded microbiome-related research projects lies in human health followed by food-systems. Interestingly, complete microbiome-related R&I is performed equally by academia and industry, but when only food-systems microbiome R&I is considered there is a significant shift to R&I activities in industrial sectors. This shift is apparently driven by the nature of available funding programmes (food systems microbiome R&I is principally funded through The Centre for the Development of Industrial Technology). Spain is also very successful in acquiring funding for microbiome-related R&I from EU framework programmes: a total of 69 projects with total funding volume for Spanish institutions of 46.5 M€ was reported.

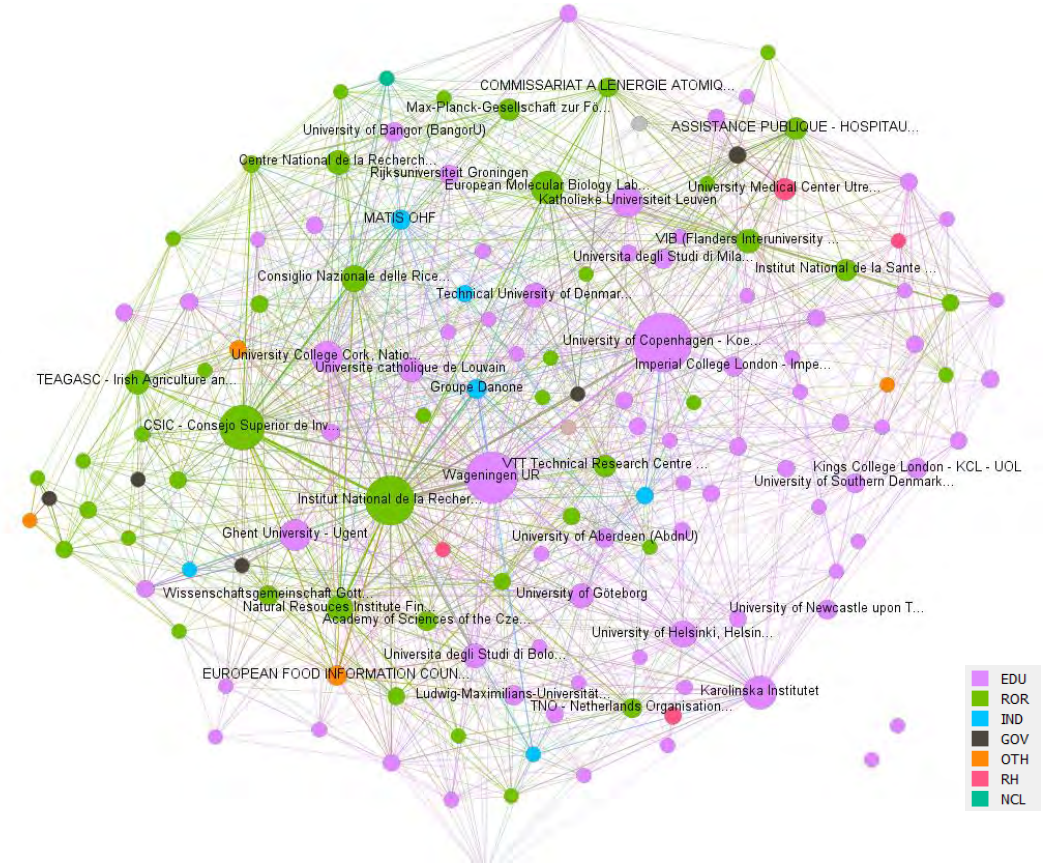
Ireland has a national strategy for microbiome R&I since 2016 (Teagasc 2035 Technology Foresight, https://www.teagasc.ie/media/website/publications/2016/Teagasc-Technology-Foresight-Report-2035.pdf), however there are also no dedicated funding schemes supporting this strategy, although the strategy influences budget across a variety of various funding streams. The focus of this strategy is on human, animal and soil microbiome. Additionally, Science foundation Ireland is funding APC Microbiome Ireland (http://apc.ucc.ie/) as one of the five Centres for Science, Engineering and Technology. This centre received 95 M€ since its establishment in 2013. Primary research focus is again human health, but there is continuous expansion of on other areas such as animal health and food-systems. Microbiome-related R&I in Ireland is mainly performed by academia (universities and RTOs), with smaller participation of industrial sector (15% in overall and 10% in food-systems microbiome R&I).

In Canada, microbiome-related R&I strategies are driven from different governmental bodies. The Canadian Institutes of Health Research is leading the Canadian Microbiome Initiative (http://www.cihr-irsc.gc.ca/e/39939.html) that focuses on human health. Through this initiative 77.7 M$ were invested in the microbiome-related R&I between 2013 – 2018. Agriculture and Agri-Food Canada (AAFC) has established Microbiome Advisory Group in order to maximize impact of agricultural microbiome research funded by AAFC (36 M$ invest in 2018 for microbiome-related R&I in animal, plant and soil systems).

Greater overlap between countries was observed when comparing available infrastructure and future needs. Basic infrastructure (sequencing and metabolomic facilities, biobanks and bioinformatic infrastructure) is available (to a certain degree) in all three countries. However, further investments in infrastructure and personnel resources was also identified as a universal need. Other identified needs included better networking, establishment of standardized approaches and clear regulation for potential applications.

The presentation of "Mapping of microbiome status-quo in EU Framework Programmes and Member States" (Michael Dinges, AIT) focused on 1) the identification of microbiome R&I actors and their constellations in the European Framework Programmes for R&I and 2) qualitative evidence on national strategies and funding instruments and key requirements of the policy community, which was operationalized by a survey among the advisory group members.

Figure 1: Microbiome R&I in FP7 and H2020 – Network of participating organisations



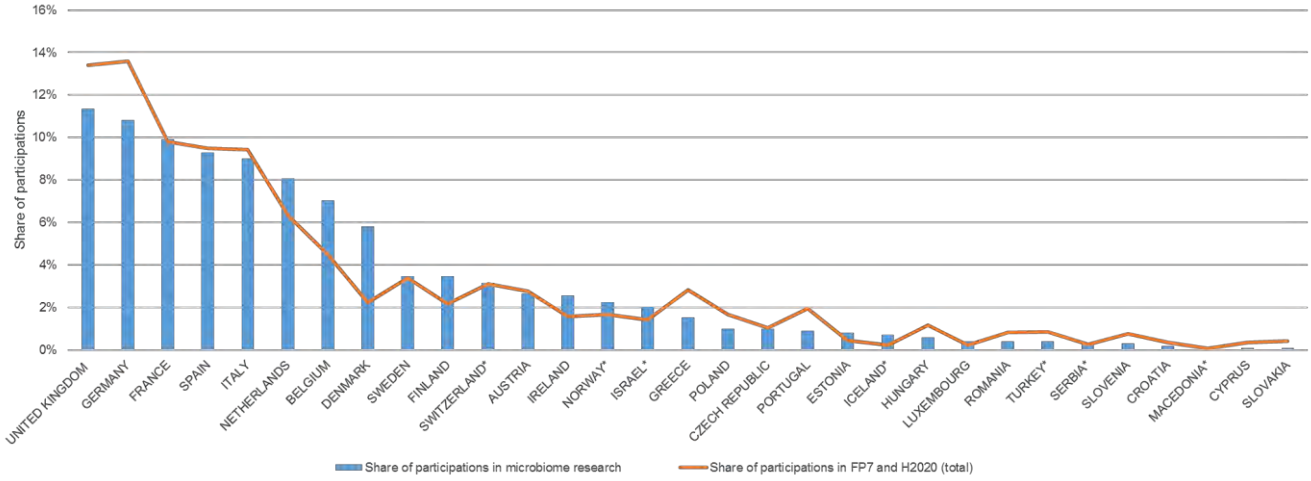
Source: AIT-Eupro Database, calculations AIT.

The analysis of the FP7 and H2020 project database revealed an European microbiome R&I research network which comprises 166 relevant projects with involvement of 650 organisations and more than thousand participations. Out of the participating organisations 144 organisations participated in more than one project (nodes) and 40 organisations in more than 3 projects (node size). The microbiome R&I actors (colour codes) are predominantly well linked Higher Education Institutes and Research Organisations.

While the United Kingdom, Germany, France, Spain and Italy exhibit the highest number of representation in microbiome R&I activities, above average participations in this area of research are being witnessed in particular in the Netherlands, Belgium, Denmark, Finland, Norway and Ireland.

In terms of EU-FP areas microbiome R&I is an integral part of the EU FPs. Microbiome R&I is concentrated in the societal challenges related to "Food, Agriculture, Forestry, Water" and "Health" but also ERC and MSCA actions play a relevant role.

Figure 2: Share of country participations in microbiome research compared to total

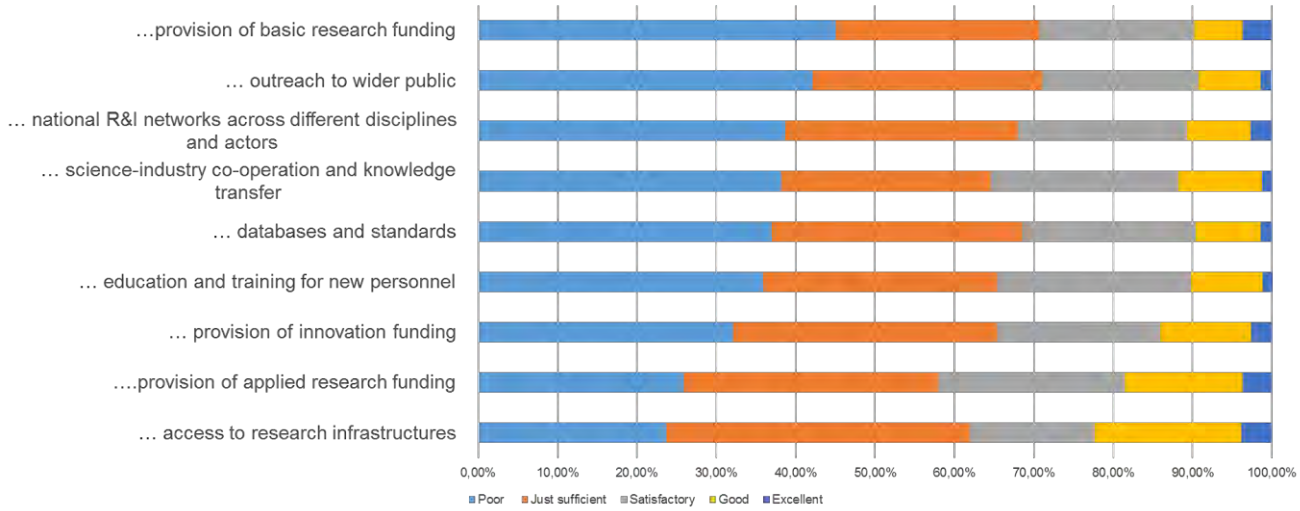


The majority of EU-MS have no national R&I strategies addressing microbiome R&I.

The survey among advisory group members showed that only a limited number of countries in Europe actually do have a microbiome R&I strategy and those countries, having target areas of microbiome R&I strategies focus predominantly on human, soil/plant and animal related microbiome R&I activities. The assessment of the national endowments for microbiome R&I has

been seen very critical among the advisory group members concerning a number of key factors relevant for pushing microbiome R&I (see figure below).

Figure 3: Key assessment of national R&I endowments for microbiome



Source: Advisory Group Survey, calculations AIT

The survey further revealed that available public support measures often do not provide ring-fenced, specific funding for microbiome initiatives, but microbiome R&I rather seems to be supported by bottom-up oriented funding measures, that to varying degrees allow for public-private co-operations, international R&I and/or transdisciplinary research.

The survey identified that the least developed measures comprise 1) Life-Long-Learning opportunities for researchers, 2) awareness measures in secondary education, 3) possibilities for international PhD training, 4) partnerships with developing countries and 5) measures for data sharing and access to global research communities.

Correspondingly, key needs for better R&I support in microbiome R&I funding comprised 1) measures to increase international co-operation, 2) measures promoting knowledge capacity building among researchers, and 3) the development of platform technologies.

The workshop continued in three parallel sessions discussing status quo (day 1) and visioning (day 2) of the microbiome R&I from perspective of different stakeholder groups (science, industry and funding/policy). Different discussion formats (one-to-one interviews, group

discussion, World Cafes) were applied. After each discussion round the feedback was given to the assembled plenum.

In the status quo session following questions were addressed

- Highlights in the last 5 years and their success factors
- Room for improvement
- Need for action

In the visioning session participants were asked to imagine that it was year 2030 (8 years after completion of the MicrobiomeSupport project) and the following was achieved:

- MicrobiomeSupport has created a collaborative international network and integrates know-how in plant, terrestrial, animal, human and aquatic microbiome R&I as well as expertise in bioeconomy applications
- MicrobiomeSupport has a main impact on the coordination of R&I agendas, which are integrated in regional, national, EU and global funding programmes related to microbiome in the food system
- Actors and experts from all stakeholder groups are integrated, have access to results and apply new research

Starting from this standpoint participants were asked to elaborate on following issues

- Expectations – Benefits for your group
- Trends and key topics
- Barriers
- Contribution from your stakeholder group

A comprehensive summary of the status quo and visioning discussions is available in Annex 5. As it could be expected the focus was slightly different between different stakeholder groups but some common denominators could be identified. Noteworthy is that all groups recognized the recent advancement in available technologies that drive the microbiome-related R&I, as well as increase of public awareness and funding opportunities. The bottlenecks identified by all three groups were: lack of collaboration between sectors (e.g. industry and science), accessibility and utilization of research data, fragmentation of microbiome-related R&I activities with strong focus on human health topics, missing regulation. In addition to actions directed against main bottlenecks there is a need to further improve public awareness and acceptance of microbiomes and microbiome applications as well as cross-sectorial expectations management. There is also unanimous requirement for more and better structured funding. In general, a universal need for more coherency could be elucidated. This is in agreement with the aims and working programme of the MicrobiomeSupport project, its next activity being the mapping survey (Task 1.2).

At the end of the workshop next steps (i.e. Task 1.2 Mapping survey) were presented (Christine Bunthof, WR)

In parallel to the workshop MicrobiomeSupport Ambassador Campaign was launched (coordinated by EUFIC). The aim of this campaign is to strengthen the commitment of MicrobiomeSupport stakeholders (project partners and advisory group members) with the project since they are instrumental for dissemination of project aims and achievements. In scope of this campaign participants were asked to provide their reasons for being a MicrobiomeSupport Ambassador. The first photos of the campaign are presented in Annex 6.

Figure 4: MicrobiomeSupport Common Ground Workshop participants

List of Annexes

Annex 1 – List of participants Common Ground WS
Annex 2 – Country presentation: Spain
Annex 3 – Country presentation: Ireland
Annex 4 – Country presentation: Canada
Annex 5 – Status Quo and Visioning Output
Annex 6 – MicrobiomeSupport Ambassador Campaign

MicrobiomeSupport Common Ground Workshop – participant list

First Name	Last Name	Email	Institution/Company
Wolfram	Allinger-Csollich	allinger@rtd-services.com	rtd services OG
Friederike	Bathe	friederike.bathe@dlr.de	DLR Project Management Agency
Gabriele	Berg	gabriele.berg@tugraz.at	Graz University of Technology
Elena	Biagi	elena.biagi@unibo.it	University of Bologna
Sigurður	Björnsson	sigurdur@rannis.is	Rannis
Martin	Borchert	mtbo@novozymes.com	Novozymes A/S
Davide	Bulgarelli	d.bulgarelli@dundee.ac.uk	University of Dundee
Christine	Bunthof	christine.bunthof@wur.nl	Wageningen UR
Marco	Candela	marco.candela@unibo.it	University of Bologna
Anirikh	Chakrabarti	anirikh_chakrabarti@cargill.com	Cargill R&D Centre Europe
Trevor	Charles	tcharles@uwaterloo.ca	University of Waterloo / Waterloo Centre for Microbial Research
Wen	Chen	wen.chen@canada.ca	Agriculture and Agri-Food Canada
Luca	Cocolin	lucasimone.cocolin@unito.it	University of Torino-DISAFA
David	Collinge	dbc@plen.ku.dk	University of Copenhagen
Paul	Cotter	paul.cotter@teagasc.ie	Teagasc
Don	Cowan	don.cowan@up.ac.za	University of Pretoria
Maria	De Angelis	maria.deangelis@uniba.it	University of Bari
Kathleen	D'Hondt	kathleen.dhondt@ewi.vlaanderen.be	VO-Dep. Economy, Science and Innovation (EWI)
Laurens	D'Huys	laurens.dhuys@kuleuven.be	KU Leuven

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

First Name	Last Name	Email	Institution/Company
Regina	Dick	reginadick@eurofins.com	Eurofins Genomics GmbH
Michael	Dinges	michael.dinges@ait.ac.at	AIT
Christophe	Dufour	christophe.dufour@mxns.com	Merieux NutriSciences
Lýður Skúli	Erlendsson	lydur@rannis.is	RANNIS
Kellye	Eversole	eversole@eversoleassociates.com	International Phytobiomes Alliance
Timothy	Evison	tevison@bio.ku.dk	Department of Biology, University of Copenhagen
Ilario	Ferrocino	ilario.ferrocino@unito.it	Università di Torino- DISAFA - sezione di Microbiologia
Rob	Finn	rdf@ebi.ac.uk	EMBL-EBI
Liam	Finnegan	liam.finnegan@agriculture.gov.ie	DAFM
Doreen	Fischer	doreen.fischer@helmholtz-muenchen.de	HMGU
Bruno	Fosso	bruno.fosso@gmail.com	IBIOM-CNR
Anna	Fotakis	holofood.eu@gmail.com	University of Copenhagen
Simone	Gatzke	s.gatzke@fz-juelich.de	Forschungszentrum Jülich GmbH
Arno	Greyling	arno.greyling@unilever.com	Unilever R&D
Robert	Gruninger	robert.gruninger@canada.ca	Agriculture and Agri-Food Canada
Gema	Herrero Corral	gema.herrero-corral@inra.fr	INRA
Sixing	Huang	sih13@dsmz.de	Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures
Carly	Huitema	carly.huitema@uwaterloo.ca	University of Waterloo
Richard	Jacoby	rjacoby@uni-koeln.de	University of Cologne
Hagai	Karchi	hagai@evogene.com	Evogene
Artem	Khlebnikov	artem.khlebnikov@danone.com	Danone Nutricia Research
Linda	Kinkel	kinkel@umn.edu	University of Minnesota

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

First Name	Last Name	Email	Institution/Company
Tanja	Kostic	tkostic@hotmail.com	AIT Austrian Institute of Technology
Gottfried	Lamers	gottfried.lamers@bmnt.gv.at	Ministry for Sustainability and Tourism
Lene	Lange	lene.lange2@gmail.com	LLa-BioEconomy, Research & Advisory
Jonas	Lazaro Mojica	j.lazaro-mojica@fooddrinkeurope.eu	FoodDrinkEurope
Lars	Leichert	lars.leichert@ruhr-uni-bochum.de	Ruhr University Bochum
Nelson	Lima	nelson@ie.uminho.pt	Micoteca da Universidade do Minho/CEB
Alexander	Loy	loy@microbial-ecology.net	University of Vienna
James	Macklin	james.macklin@gmail.com	Agriculture and Agri-Food Canada
Virginie	Maenhout	virginie.maenhout@eufic.org	EUFIC
Emmanuelle	Maguin	emmanuelle.maguin@inra.fr	INRA
Paula	Malloy	paula_malloy@yahoo.com.br	GCCRC - UNICAMP
Aleksandra	Malyska	Aleksandra.Malyska@plantetp.eu	Plant ETP
Julian	Marchesi	j.marchesi@imperial.ac.uk	Imperial College
Tim	Mauchline	tim.mauchline@rothamsted.ac.uk	Rothamsted Research
Ryan	McClure	ryan.mcclure@pnnl.gov	Pacific Northwest National Laboratory
Karin	Metzlaff	Karin.Metzlaff@epsomail.org	European Plant Science Organisation, EPSO
Birgit	Mitter	birgit.mitter@ait.ac.at	AIT Austrian Institute of Technology GmbH
Andreas	Moser	moser@rtd-services.com	rtd services OG
Rute	Neves	dkruns@chr-hansen.com	Chr. hansen
Louis Felix	Nothias	nothias@ucsd.edu	University of California San Diego
Marta	Olivares Sevilla	m.olivares@iata.csic.es	IATA-CSIC
Adrianna	Pawlik	adrianna.pawlik@ncbr.gov.pl	The National Centre for Research and Development

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

First Name	Last Name	Email	Institution/Company
Carina	Pereira	Carina.Pereira@ec.europa.eu	European Commission
Graziano	Pesole	graziano.pesole@uniba.it	University of Bari and CNR-IBIOM
Lori	Phillips	lori.phillips@canada.ca	Agriculture and Agri-Food Canada
Anne	Pihlanto	anne.pihlanto@luke.fi	Natural Resource Institute Finland
Laura	Plant	Laura.Plant@vr.se	JPIAMR/Swedish Research Council
Margaret	Rae	margaret.rae@marine.ie	Marine Institute
Simone	Rampelli	simone.rampelli@unibo.it	University of Bologna
Tom	Redd	tom.redd@jpi-oceans.eu	JPI Oceans
John	Ridley	john.ridley@converte.com.au	Converte Pty Ltd.
Hugo	Roume	hugo.roume@inra.fr	INRA
Matthew	Ryan	m.ryan@cabi.org	CABI
Daria	Rybakova	daria.rybakova@tugraz.at	Graz University of Technology
Mario	Salvi	mario@mariosalvinet.it	Fondazione IRCCS Cà Granda, University of Milan
Inga	Sarand	inga.sarand@taltech.ee	Tallinn University of Technology
Bettina	Schelkle	bettina.schelkle@eufic.org	EUFIC
Michael	Schloter	schloter@helmholtz-muenchen.de	Helmholtz Muenchen
Carolin	Schneider	schneider@inoq.de	Inoq GmbH
Sylvia	Schreiber	sylvia.schreiber@skynet.be	EUFIC
Ulrich	Schurr	u.schurr@fz-juelich.de	Forschungszentrum Jülich
George	Seghal Kiran	seghalkiran@gmail.com	Pondicherry University
Joseph	Selvin	josephselvinss@gmail.com	Pondicherry University
Angela	Sessitsch	angela.sessitsch@ait.ac.at	AIT
Colette	Shortt	cshortt@its.jnj.com	J&J Consumer
Brajesh	Singh	b.singh@westernsydney.edu.au	Western Sydney University

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

First Name	Last Name	Email	Institution/Company
Hauke	Smidt	hauke.smidt@wur.nl	Wageningen University
Zewei	Song	songzewei@outlook.com	BGI-Research
Argo	Soon	argo.soon@etag.ee	Estonian Research Council
Rafael	Souza	scs.rafael@gmail.com	Unicamp
Austin	Swafford	adswafford@ucsd.edu	Center for Microbiome Innovation, UC San Diego
Effie	Tsakalidou	et@aua.gr	Agricultural University of Athens
Kristof	van Emelen	kristof.vanemelen@prodigest.eu	ProDigest
Leo	van Overbeek	l.s.vanoverbeek@wur.nl	Wageningen University and Research
Claire	Veneault-Fourrey	claire.fourrey@univ-lorraine.fr	INRA
Isabel	Vercauteren	isabel.vercauteren@aphea.bio	Aphea.Bio
Gino	Vrancken	gino.vrancken@kuleuven.be	Rega Institute for Medical Research
Martin	Wagner	martin.wagner@vetmeduni.ac.at	Univeristy for Veterinary Medicine
Aaron	Walsh	aaron.walsh@teagasc.ie	Teagasc
Martin	Weigl	weigl.oevaf@boku.ac.at	ÖVAF/BIOS Science Austria
Guenter	Welz	guenter.welz@bayer.com	Bayer AG
Beatrix	Wepner	beatrix.wepner@ait.ac.at	AIT Austrian Institute of Technology GmbH
Stefanie Urimare	Wetzels	stefanie.wetzels@vetmeduni.ac.at	FFoQSI
Wieslaw	Wiczkowski	w.wiczkowski@pan.olsztyn.pl	Institute of Animal Reproduction and Food Research, Polish Academy of Sciences

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

Microbiome research in SPAIN

Marta Olivares, PhD

Microbial Ecology, Nutrition and Health

Institute of Agrochemistry and Food Technology (IATA-CSIC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

National Microbiome R&I Strategies

Any strategies available? Not specifically for the study of the microbiome

Microbiome is not a target area explicitly

No specific budget

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Spanish National Research Program

- Generation of knowledge
- Societal challenges

2013 — 2017

96 projects

Institute of Health Carlos III

Instituto de Salud Carlos III

2014 — 2018

90 projects

The Centre for the Development of Industrial Technology (CDTI)

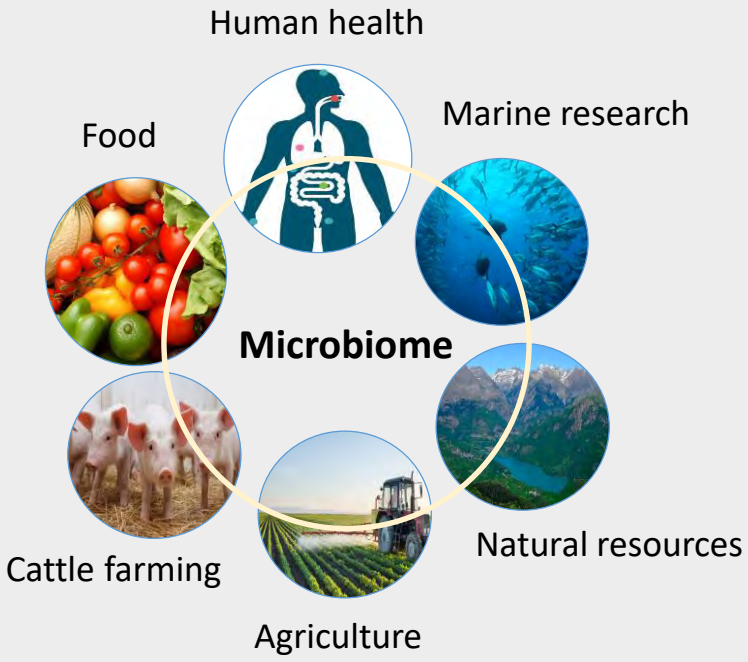
CDTI

2013 — 2017

32 projects

Microbiome R&I in SPAIN

Microbiome target areas:



96 projects

Spanish National Research Program

2013 — 2017

33 | 7 | 12 | 7 | 21 | 16

90 projects

Institute of Health Carlos III

2014 — 2018

32 projects

CDTI

2013 — 2017

23 | 1 | 8

Microbiome R&I in SPAIN

Percentage of microbiome R&I performed by academic or industrial bodies *:

- Spanish National Research Program
  - Generation of knowledge **0.85 M€**
  - Societal challenges **5.1 M€**
- Institute of Health Carlos III **2.4 M€**
- The Centre for the Development of Industrial Technology (CDTI) **7.8 M€**

51.7% ACADEMIA

- Research institutions
- Health Research Institutes
- Universities

48.3% INDUSTRY

* This data correspond to 2017

Microbiome R&I in SPAIN

Three R&I projects:

MetaHIT Project:

"Establishment of the methodology to characterize intestinal metagenomes and associate bacterial genes with human disease"

EU 7FP, 5 years, 21.2 M€
Coordinated by Prof. D. Ehrlich (France)
Two Spanish partners Hospital Vall d´Hebron and UCB Pharma

MyNewGut Project:

"Microbiome´s influence on energy balance and brain development/function put into action to tackle diet-related diseases and behaviour"

EU 7FP, 5 years, 9 M€
Coordinated by Prof. Y. Sanz.

MITOMAD Project:

"Functional characterisation of mitochondrial metabolic adaptations to innate sensing in dendritic cell subsets"

Consolitator Grant (ERC)
H2020, 5 years, 2 M€
Dr. David Sancho

Three achievements

Article:

Qin et al. "A human gut microbial gene catalogue established by metagenomic sequencing". **Nature**, 2010, 464, 59-70.

Series of Opinion Papers:

Dietary recommendation publised in **Clinical Nutrition** elaborated by the MyNewGut consortium

Potential of **probiotic strains:**

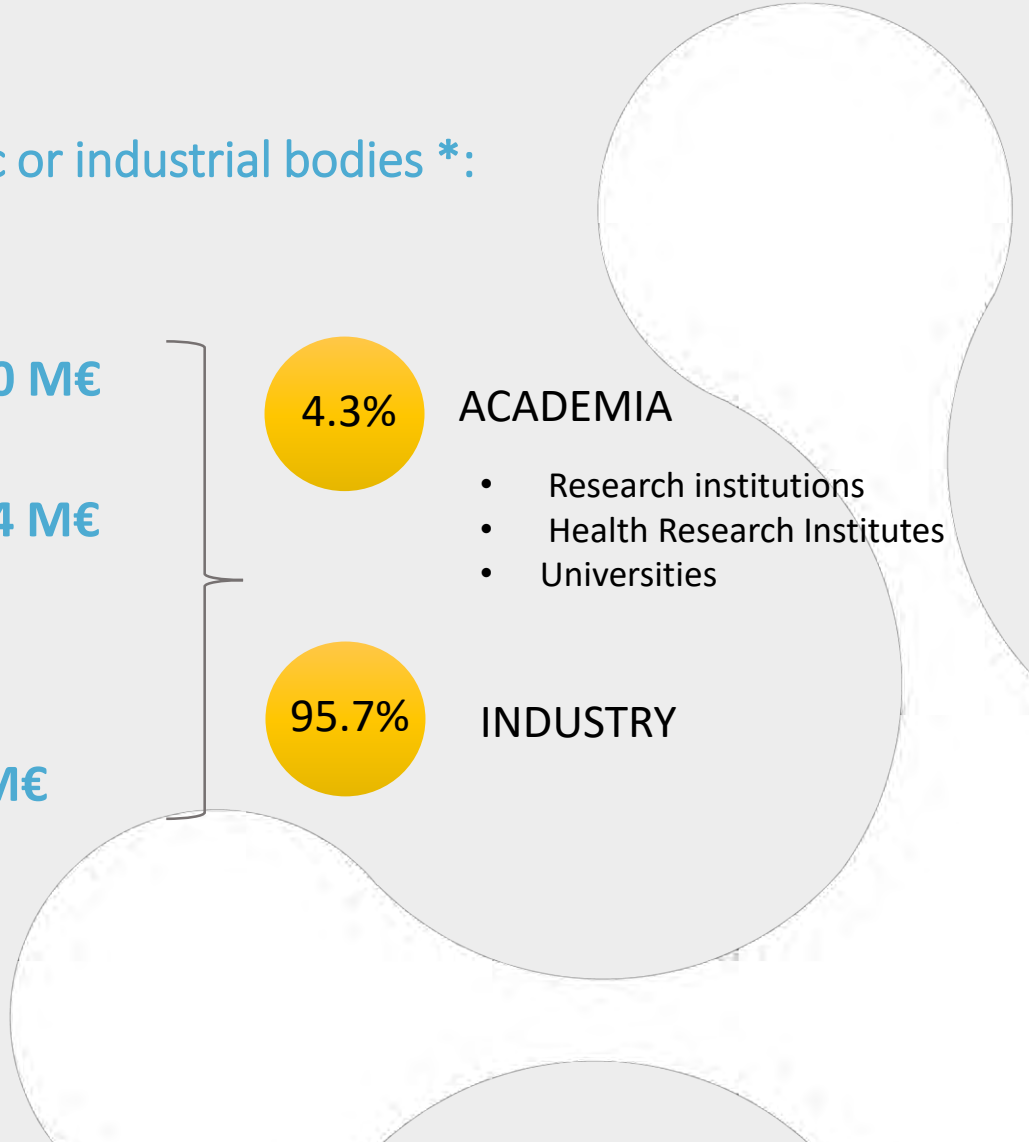
Clinical or preclinical efficacy on obesity complication and behavioural disorders

Food Systems Microbiome R&I SPAIN

Food systems microbiome R&I performed? **YES** ✓

Percentage of food system microbiome R&I performed by academic or industrial bodies *:

- Spanish National Research Program
  - Generation of knowledge **0 M€**
  - Societal challenges **0.24 M€**
- Institute of Health Carlos III **0 M€**
- The Centre for the Development of Industrial Technology (CDTI) **5.4 M€**



* This data correspond to 2017

Food Systems Microbiome R&I SPAIN

Three R&I projects:

CICLES Project:
"Controlling mIcRobiomes CircuLations for bEtter food Systems"

H2020, 5 years, 10 M€
Coordinated by Prof. M. Candela (Italy)
One Spanish partner (CSIC)

BacBio Project:
"Mechanistic and functional studies of *Bacillus* biofilms assembly on plants, and their impact in sustainable agriculture and food safety"
Starting Grant (ERC) H2020, 5 years, 1.5 M€, Dr. Diego F. Romero

Project:
"Study of variability based on the quality of the grape and the associated microbiota for the "tinto fino" and "cabernet sauvignon" varieties"
Centre for the development of Insdustrial Technology (Spanish Ministry). LEGARIS SL (Wine Cellar)

Top three achievements

Article: Kashiri et al. "Use of high hydrostatic pressure to inactivate natural contaminating microorganisms and inoculated *E. coli* O157:H7 on Hermetia illucens larvae. PLoS One. 2018; 13(3): e0194477.

Article: Cámara-Almirón et al. "Beyond the expected: the structural and functional diversity of bacterial amyloids". Critical Reviews in Microbiology, 2018, 44(6), 653.

Article: "Biofilm formation on abiotic and biotic surfaces during Spanish style green table olives fermentation". Int J Food Microbiol, 2012, 157, 230.

Funding of the Microbiome R&I in Spain

Public funding sources used for microbiome R&I in:

1-Programs with dedicated budget for microbiome R&I: There is not specific budget

2- Funding from Spanish Ministry of Science

- Spanish National Research Program
  - Generation of knowledge
  - Societal challenges
- Institute of Health Carlos III
- The Centre for the Development of Industrial Technology (CDTI)

		Nº microbiome projects	% budget versus total	Nº food system microbiome	% budget versus microbiome
Generation of knowledge	125.5 M€	6	0.7	0	0
Societal challenges	243.9 M€	38	2.1	2	4.7
Institute of Health Carlos III	68.5 M€	22	3.5	0	0
The Centre for the Development of Industrial Technology (CDTI)	104.2 M€	14	7.5	10	69.3

* This data correspond to 2017

Funding of the Microbiome R&I in Spain

Public funding sources used for microbiome R&I in:

3- Funding from European Union Framework programs

	Nº microbiome projects	Total for Spanish Institutions
European proyects	53	35.1 M€
European Research Council (ERC)	6	9.8 M€
Marie Curie (Individual Fellowships)	10	1.6 M€

4-Institutional funding/block funding

There is not

Infrastructure for the Microbiome R&I in Spain

Is there available…?

- Sequencing facilities ✓
- Metabolomic facilities ✓
- Biobanks ✓
- Bioinformatics infrastructure ✓

Important infrastructure for microbiome R&I:

Spanish Type Culture Collection

CECT
COLECCIÓN ESPAÑOLA DE CULTIVOS TIPO

The headquarters of Kimitec:
Largest European center for probiotics applied to agriculture

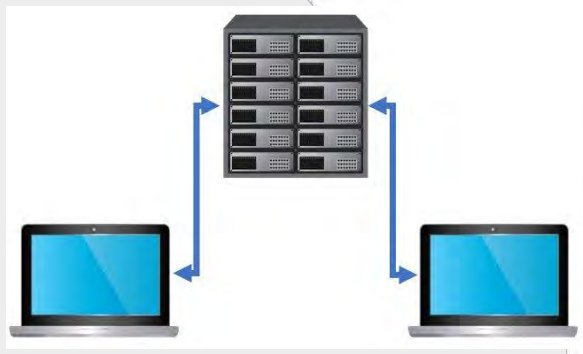
kimitec group

CSIC sequencing service

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Future Needs for the Food Systems Microbiome R&I in SPAIN

- More infrastructures and equipment
- Increase the potential for the computational analysis of data
- More economic resources to hire trained staff



Thank you for your attention

Marta Olivares, PhD

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

References

http://www.ciencia.gob.es/

http://www.isciii.es/

https://www.cdti.es

https://www.uv.es/uvweb/coleccion-espanola-cultivos-tipo/es/coleccion-espanola-cultivos-tipo-1285872233521.html

Microbiome research in Ireland

Paul Cotter,

Teagasc Food Research Centre, Moorepark

APC Microbiome Ireland

Twitter: @pauldcotter

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

Microbiome R&I in Ireland

Refreshed Priority Areas 2018 – 2023

Theme	Priority Area
ICT	Future Networks, Communications and Internet of Things
	Data Analytics, Management, Security, Privacy, Robotics and Artificial Intelligence (including Machine Learning)
	Digital Platforms, Content and Applications, and Augmented Reality and Virtual Reality
Health and Wellbeing	Connected Health and Independent Living
	Medical Devices
	Diagnostics
	Therapeutics
Food	Food for Health
	Smart and Sustainable Food Production and Processing
Energy, Climate Action and Sustainability	Decarbonising the Energy System
	Sustainable Living
Manufacturing and Materials	Advanced and Smart Manufacturing
	Manufacturing and Novel Materials
Services and Business Processes	Innovation in Services and Business Processes

2016

Theme 2: Human, Animal and Soil Microbiota

Abundant evidence shows that particular aspects of human health and disease are attributable to the trillions of microbes that inhabit our gastrointestinal tract, collectively referred to as the gut microbiota. Consider that the number of unique genes contributed by the gut microbiota is greater than 150-fold that encoded within the human genome and that the vast number of metabolites produced by these organisms allows effects on distant organs. The composition of the gut microbiota is complex and in addition to bacteria includes viruses, fungi, protozoa, and Archaea. These organisms contribute not only to each other's function and survival but humans have evolved to depend on the extended physiology and metabolism that the microbiota provides[33].

While the study of microbiota in various living organisms is not new, one of the generally surprising recent discoveries in biology concerns not just the diversity and complexity of these microscopic life-forms that inhabit the human body, in particular the human gastrointestinal tract (GIT), the bodies of farm animals and every other corner of the biosphere, but the discovery of the vitally important role they play in the general health and well-being of the individual, the animal and the planet. Specific examples, by no means exhaustive, of the importance of microbiota for food and agriculture are summarised in Table 3.1.

Table 3.1: Role of Microbiota in Humans, Livestock and the Environment

Biome	Role
The human GIT	General health and well being Digestion Protection against infection by pathogens Allergies Food intolerances
The rumen and the GIT of all domesticated farm animals	General animal health Digestion and feed conversion Production of methane
Soils	Plant health and productivity Nutrient availability Water purification and storage Carbon storage Provision of antibiotics, pharmaceuticals, etc.
Water bodies	Water quality Bioremediation Biodiversity, algae, aquatic-plant, fish and insect populations Water management, intense weather and flood control
Bioreactors	Fermentation systems to produce foods and beverages (beer, cheese, yoghurt, tofu and "soon-to-be-discovered" new food categories… this is a major focus for research in countries such as South Korea) Conversion of organic matter (waste or non-waste) into fuels Conversion of organic matter into feeds (silage, insects…) Conversion of organic matter into industrial chemicals and precursors.

National Microbiome R&I Strategies – Slide 1

- Are there any strategies available and if yes since when?

Teagasc 2035 Technology Foresight (2016)

- Who developed/decided on these strategies? Were scientific experts involved?

National and international scientific experts

- Are any microbiome target areas explicitly defined and if yes which ones (human, animal, aquatic, soil/plant, food systems, …)?

Human, animal and soil

- What are the main aims of these strategies and till when should these be achieved?

Various ‘real world’ applications; 2035

- Is there a specific budget allocated to the implementation of these strategies? If yes please provide more info on this (€ in total, duration of the programs, etc.)

No specific budget but does influence budget across a variety of funding streams (including internal Teagasc recruitment)

National Microbiome R&I Strategies – Slide 2

- Are there any strategies available and if yes since when?

SFI Centres for Science, Engineering and Technology In 2003, SFI allocated over €110 million to fund the first five Centres for Science, Engineering and Technology (CSETs).

Alimentary Pharmabiotic Centre (APC) ….Now APC Microbiome Ireland

Since then €95 million has come from SFI to APC

- Who developed/decided on these strategies? Were scientific experts involved?

A grant application by scientists

- Are any microbiome target areas explicitly defined and if yes which ones (human, animal, aquatic, soil/plant, food systems, …)?

Initial focus on human…expansion to include animal and foods/food chain

- What are the main aims of these strategies and till when should these be achieved?

Initial focus on IBD, IBS and gut microbiota. Considerable expansion since across 3 rounds of funding

- Is there a specific budget allocated to the implementation of these strategies? If yes please provide more info on this (€ in total, duration of the programs, etc.)

Primary focus of the Centre is the Microbiome

APC Microbiome Ireland

15 Senior PIs

29 Junior PIs

75 APC Faculty

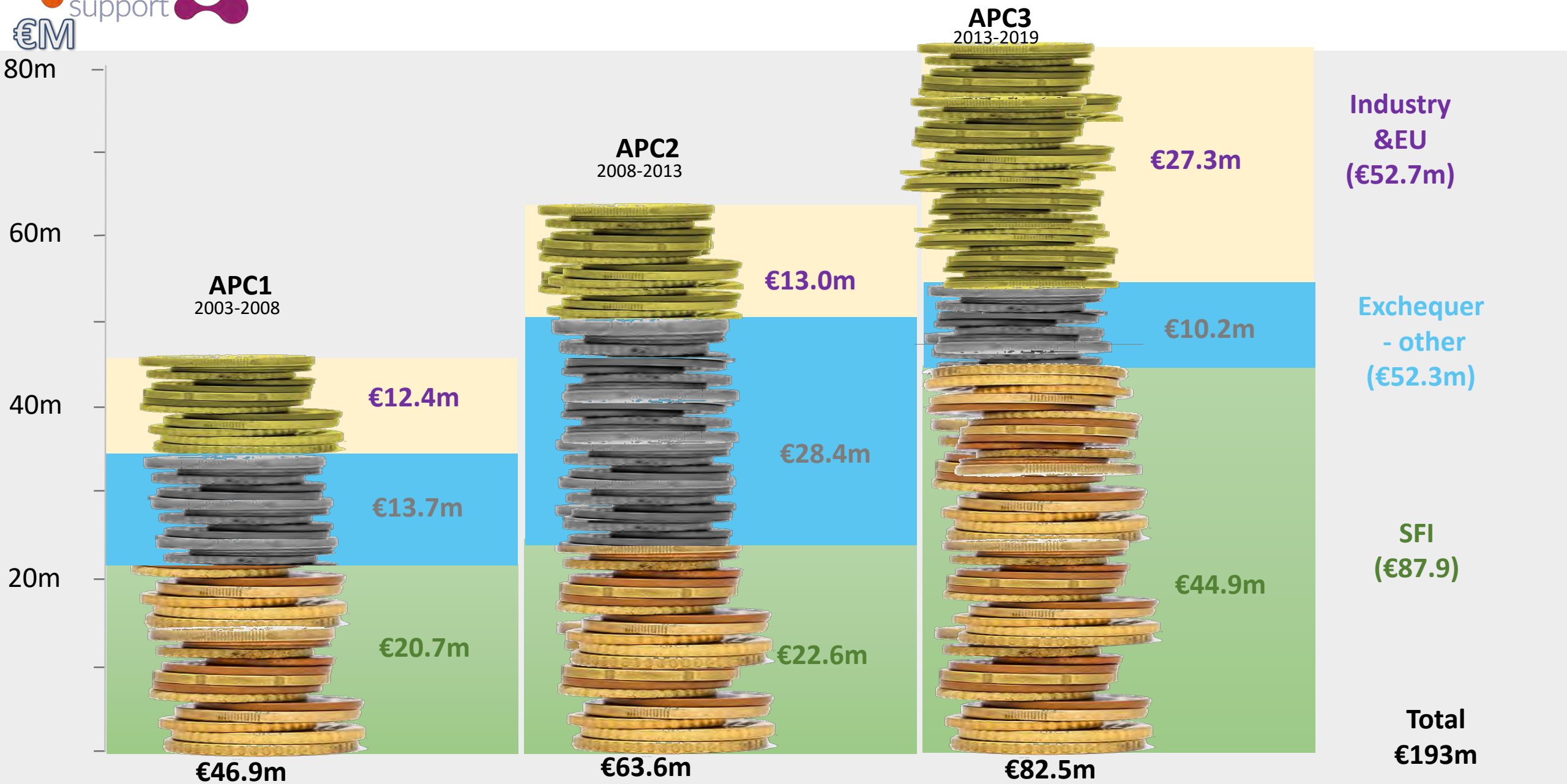
300 APC-Institute Staff

Multiple scientific and clinical disciplines applied to same problem

Microbiology, immunology, pharmacology, neuroscience, food science, nutrition, biochemistry, medical microbiology, pharmacy, physiology

Gastroenterology, psychiatry, cardiovascular health, rheumatology, radiology, oncology, pathology, gerontology, neonatology, metabolic health

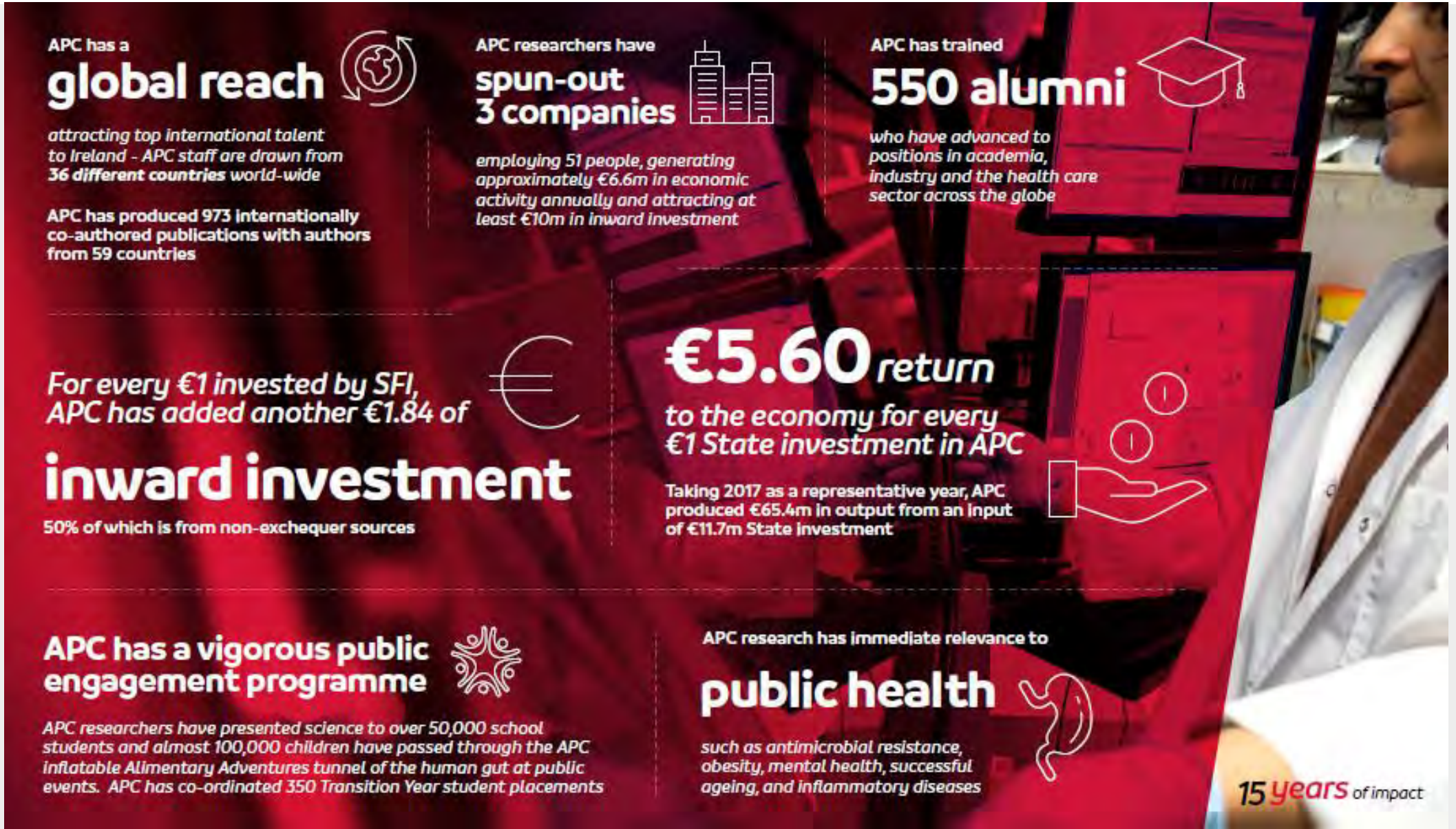
APC Research income (including overheads)



APC Impact


15 impacts for 15 years
APC is ranked as a
global leader
#1 worldwide for research in anti-microbials and therapeutic microbes
APC helps to support
526 jobs
in Ireland each year
APC helps to generate
€1.2 million
for the Irish Economy each week, including expenditure and taxation impact
In 2018, 10 APC Principal Investigators were ranked in the
Top 1%
of researchers worldwide
APC is a flagship SFI Research Centre which expands the R&D capabilities of Ireland Inc.
To date APC researchers have won over
€200 million
in competitive funding
APC is a leader in
knowledge generation and transfer
APC researchers have authored more than 2,500 publications which have been cited more than 80,000 times
APC
commercialises its knowledge
successfully
APC inventors have filed 54 new patent applications, and signed 47 license, assignment and option agreements
APC researchers have secured over
€50million
in R&D funding from industry
for collaborative research projects
4
apc Microbiome Ireland

APC Impact


APC has a
global reach
attracting top international talent to Ireland - APC staff are drawn from 36 different countries world-wide
APC has produced 973 internationally co-authored publications with authors from 59 countries
APC researchers have
spun-out 3 companies
employing 51 people, generating approximately €6.6m in economic activity annually and attracting at least €10m in inward investment
APC has trained
550 alumni
who have advanced to positions in academia, industry and the health care sector across the globe
For every €1 invested by SFI, APC has added another €1.84 of
inward investment
50% of which is from non-exchequer sources
€5.60 return
to the economy for every €1 State investment in APC
Taking 2017 as a representative year, APC produced €65.4m in output from an input of €11.7m State investment
APC has a vigorous public engagement programme
APC researchers have presented science to over 50,000 school students and almost 100,000 children have passed through the APC inflatable Alimentary Adventures tunnel of the human gut at public events. APC has co-ordinated 350 Transition Year student placements
APC research has immediate relevance to
public health
such as antimicrobial resistance, obesity, mental health, successful ageing, and inflammatory diseases
15 years of impact

microbiome support

Industry Partners

Microbiome R&I in Ireland

- Top three microbiome target areas R&I primarily focuses on in your country

Human, Animal, Food/Food chain

- Three representative microbiome R&I projects (incl. basic info on duration, funding, lead, aims/outcome)

Eldermet - Gut microbiota as an indicator and agent of nutritional health in elderly Irish subjects (2007; €15 m)

Spin Outs - Alimentary Health, Atlantia, Artugen, 4D Pharma Cork,

Atlantia Food Clinical Trials Ltd was spun out of the APC Microbiome Institute in 2012 to design and execute food interventional clinical studies for the food industry. Atlantia now employs 35 people and is enjoying strong business and revenue growth and will expand its operations in the USA in 2019 by opening a site in Chicago

SFI Spokes - Jansson, Abbvie, Alimentary Health, DSM

Microbiome R&I in Ireland

Top three achievements (e.g. publications/patents/prizes/applications/ products/…) coming from the microbiome R&I performed in your country (not necessarily from the above mentioned projects)

- 10 APC researchers on Clarivate 2018 list of highly cited researchers (155 awards)
- EPE – including World Microbiome Day (interact with >80,000 individuals per year)
- Total number of Pubs =>2500 (>81,000 citations);
  Average cites per publication: 32

- The share (%) of microbiome R&I performed by
  Academic institutions (Universities etc.) 65%
  Research & Technology Organization 20%
  Industry 15%

Food Systems Microbiome R&I in Ireland

- Is food systems microbiome R&I performed in your country? YES
- The share (%) of food systems microbiome R&I performed by
  - Academic institutions (Universities etc.) 40%
  - Research & Technology Organization 40%
  - Industry 10%
- Three representative food systems microbiome R&I projects (incl. basic info on duration, funding, lead, aims/outcome)

Dairybiota – Microbiota of dairy foods (Teagasc €150,000; 2009 -4 years)

NIHAM Foods - Generation of Functional Foods to Promote the Growth of Newly Identified Health Associated Microbes in the Gut (DAFM €600,000; 2015 -4 years)

Systems microbiology applied to the reduction and control of bacterial transmission in the powdered infant formula (PIF) production environment – towards scientifically validated improvements in food safety (DAFM €600,000; 2013 -4 years)

Food Systems Microbiome R&I in Ireland

- Top three achievements (e.g. publications/patents/prizes/applications/ products/…) coming from the food systems microbiome R&I performed in your country (not necessarily from the above mentioned projects)

Cheese pinking – identification of causative agent & patent

Collaborations with industry to improve FCE and methane mitigation in ruminants

Probiotics for infants (infant milk formula)

Funding of the Microbiome R&I in Ireland

Please provide information/estimate on the share (%) of public funding sources used for microbiome R&I in your country using following categories

SFI Ireland 'Microbiology' = €85 mill; DAFM 'Microbiota' = €11.2 mill

- Programs with dedicated budget for microbiome R&I

No

- Funding from research councils / foundations

Some e.g. IRCSET

- Funding from European Union Framework Programs (e.g. H2020, ERA-NETs)

Multiple H2020, JPI and COST Networks

Marie-Curie = APEX (€4.4 m), Individual Fellowships

- Institutional funding / block funding

Some - Teagasc

Please provide information/estimate on the share (%) of whole public funding sources used for microbiome R&I that is used on the food systems microbiome R&I 33%

Funding of the Microbiome R&I in Ireland DAFM = €11.2 mill

DAFM Reference	Project Title	Institution	Award
15F635	Generation of Functional Foods to Promote the Growth of Newly Identified Health Associated Microbes in the Gut (NIHAM Foods)	Teagasc (ITT, UCC)	€603,909
15F698	Seaweed-Microbe Interactions to enhance bioactive yields for food applications (SMO-BIO)	NUIG (UCC, Teagasc)	€824,992
15F721	The relation between the Human Milk Microbiome, Composition and Infant Nutrition (INFAMILK)	UCC (Teagasc)	€600,308
15F747	Enzymes for efficient milk oligosaccharide production (EFFICIenz)	NUIG (Teagasc)	€98,877
14/F/821	Foods solutions for replenishing disrupted microbiota in toddlers	Teagasc MFRC, (UCC, CUMH)	€597,246
14/F/828	Dietary manipulation of microbiota diversity for controlling immune function	UCC, (Teagasc, UCD, UL)	€1,246,995
14/F/845	Application of novel food processing and microanalytical technologies to identify and control spores, in dried food ingredients, and of biofilms in food processing environments-a systems microbiology approach to ensuring quality and safety	UCD, (DCU, Teagasc)	€879,348
13/F/423	Systems microbiology applied to the reduction and control of bacterial transmission in the powdered infant formula (PIF) production environment – towards scientifically validated improvements in food safety	UCD (Teagasc)	€604,308
13F511	Seaweeds as a source of non-digestible complex polysaccharide components for the development of novel prebiotic ingredients for the functional food industry.	Teagasc (NUIG, UU, UCC)	€601,078
13F516	The anti-inflammatory and microbial modulating effects of marine derived laminarin and omega-3 fatty acids on inflammatory bowel disease in an experimental porcine model.	UCD, UCC	€493,064
11F023	Novel prebiotics from plant-derived sugars using bifidobacterial enzymes	UCC (Teagasc)	€234,250
11F053	Novel food ingredients for the elderly consumer	UCC (Teagasc)	€500,098
10RDTMFRC705	Infant Nutrition for Programming the Gut Microbiota in Neonates	Teagasc (UCC)	€398,858
07FHRIUCC3	Gut microbiota as an indicator and agent of nutritional health in elderly Irish subjects	UCC (Teagasc)	€4,956,490

Infrastructure for the Microbiome R&I in Ireland

- Is following large infrastructure available in your country (yes/no)
  - Sequencing facilities YES (Teagasc/APC)
  - Metabolomic facilities SOME (UCC/UCD)
  - Biobanks YES (APC/Teagasc)
  - Bioinformatics infrastructure ICHEC (servers at national centre shared by public bodies)

- Please list other important large infrastructure (max 3) available in your country that you regard to be relevant for the microbiome R&I (basic microbiology and molecular biology laboratories excluded)
  - Germ free mouse facility
  - Food biotest (pig and animal) facility
  - Pilot scale food production plant

Future Needs for the Microbiome R&I in Ireland

- What is needed to further promote microbiome R&I in your country (e.g. in terms of funding, infrastructure, education, collaboration (between different sectors e.g. academia/industry or international cooperation, strategies, policies, legal frameworks, …)

Standardized approaches

Regulation/Accreditation (FMT, Phage, Food safety, Probiotics/Biotherapeutics/Inoculants)

Rapid outputs

Future Needs for the Food Systems Microbiome R&I in Ireland

What is needed to further promote food systems microbiome R&I in your country (e.g. in terms of funding, infrastructure, education, collaboration (between different sectors e.g. academia/industry or international cooperation, strategies, policies, legal frameworks, …)

Standardized approaches

Regulation/Accreditation (Food safety, Strains)

Rapid outputs

Acknowledgements

Jill Haynes (APC)

Ruairi Colbert and Liam Finnegan (DAFM)

Michael Ryan (SFI)

Thank you for your attention

Paul

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

Main points are as follows:

· Since its foundation in 2003, APC has leveraged 3 successive phases of seed funding from SFI with matching funds from Industry Collaborators and NENC sources (EU, International Agencies, Philanthropy, Charity) namely: APC 1 (2003-2008), APC 2 (2003-2013), APC 3 (2013-2019).

· Table 1 below shows the funding secured under the "SFI Funding Model" for APC 1, APC 2, APC 3.

· In addition, to the SFI funding model (SFI + matching funds from NENC & Industry), we also have funding model for APC Institute (Table 2) which includes TABLE 1 PLUS the funding from Irish Exchequer, and PI salaries and space costs.

· For APC 4 we are moving from the current SFI funding model (70% SFI & 30% Matching funds) to a new SFI model of (33% SFI & 67% Matching funds) (See slides attached from close out review).

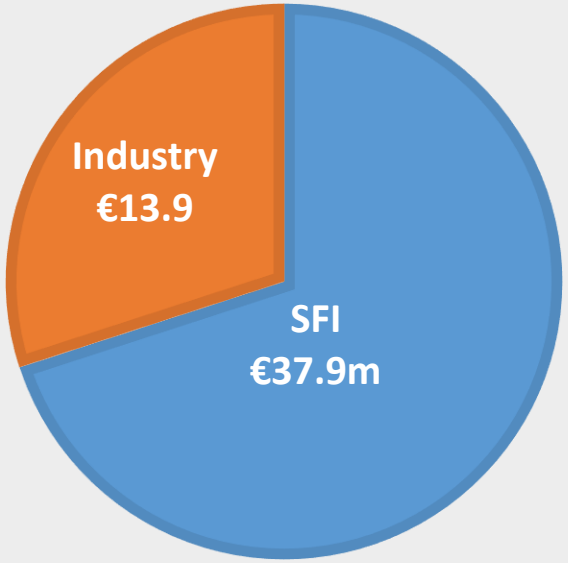
References

Please provide any references that might be useful for exploring this issue further, e.g.

- Links to relevant strategies, calls, etc.
- Contact information of responsible public bodies/organizations
- …

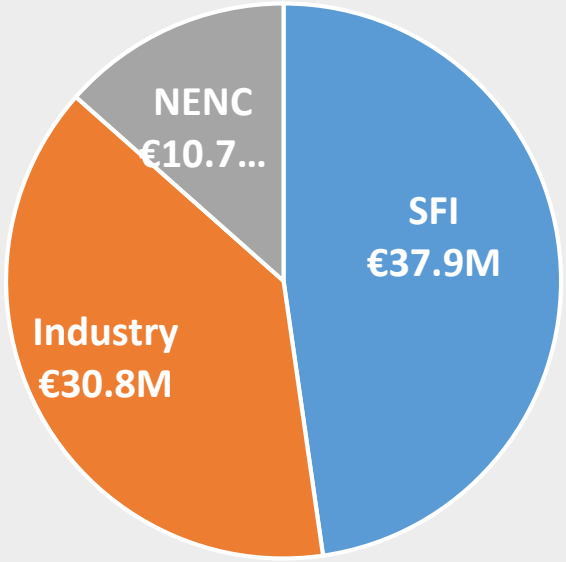
Funding	APC 1, 2003-2008	APC 2, 2008-2013	APC 3, 2013-2019	Total APC 1, 2 &3
SFI Core Funding	€17.6M	€17.3M	€37.9M	€72.8M
NENC (incl. EU/Charity/Philanthropy/International)	€2.5M	€2.4M	€10.7M	€15.6M
Irish Exchequer (DAFM, HRB, EI, SFI non core awards)	€12.7M	€28.7M	€21.7M	€63.1M
Institutional contribution (PI space & time)	€3.5M	€4.2M	€4.8M	€12.5M

Current Phase:
What we were asked to do



TOTAL TARGET DIVERSIFICATION= €46.5

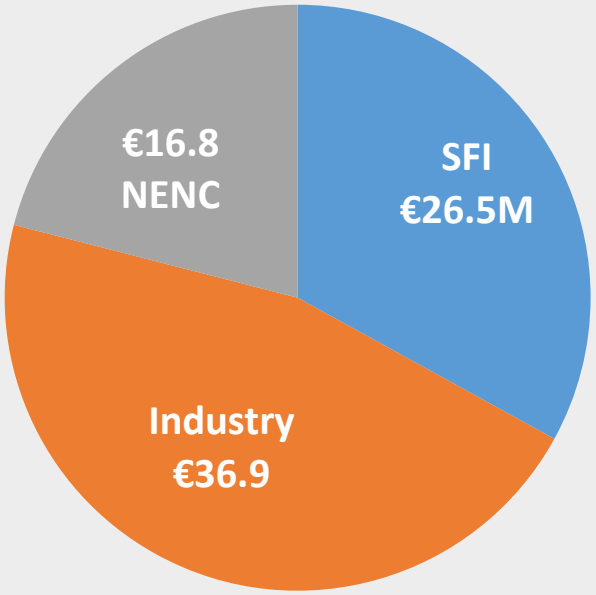
Current Phase:
Where we are now



TOTAL SECURED DIVERSIFICATION: €79.4M

)

Next Phase:
What we are asked to do



TOTAL TARGET DIVERSIFICATION: €80.3M

Microbiome research in Canada

James A. Macklin, PhD

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

Microbiome Research in **Canada**

Shared Activity

- Government of Canada
  - Agriculture and Agri-Food Canada (AAFC)
  - Canadian Institutes of Health Research (CIHR)
  - National Research Council of Canada (NRC)
  - Natural Sciences and Engineering Research Council (NSERC)
- Academic Institutions (e.g., Universities)

Funding of Microbiome R&I in **Canada**

Canadian Institutes of Health Research (CIHR)

- Canadian Microbiome Initiative
  - $77.7 M total funding (2013-2018)
  - 2018: 88 projects led by 72 principal investigators
    - $25 M investment
  - Research conducted at Universities and Hospital Research Institutes/Agencies across Canada
  - Focus: development of effective preventative and therapeutic interventions through deeper understanding of microbiome on human health

Funding of Microbiome R&I in **Canada**

Natural Sciences and Engineering Research Council (NSERC)

- Primary funding agency supporting science and engineering community
- 2018: $3 M investment
- 75 projects led by 70 principal investigators
- Focus: pursuing a greater understanding of the microbiome's potential for improving human and animal health, and plant systems

Drivers for **Canada**

Industry and Trade

- Consumer demand for safe, sustainably-produced and high-quality food

Government Priorities

- Budget 2017: $75B export target
- Climate change, water and soil conservation
- Innovation

AAFC Science

- Building Agro-Ecosystem Resiliency
- Antimicrobial Resistance, One Health, national and international collaborations
  - Genomics Research & Development Initiative (GRDI); International Bioeconomy Forum (IBF)

Funding of Microbiome R&I in **Canada**

Agriculture and Agri-Food Canada (AAFC)

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

- Microbiome research key to achieve agriculture science priorities:
  - **Productivity** – improve yields and efficiencies towards enhancing plant and animal health
  - **Environment** – soil/water conservation; adaptation to climate change
- 2018: $36 M investment
- 76 projects led by 61 principal investigators (animal, plant, soil)

Microbiome R&I Strategy in **Canada**

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Capacity mapping

- Lead development of Gov't of Canada microbiome capacity mapping
- Update AAFC microbiome capacity
- Further develop AAFC microbiome network

Investment

- Continued investment in microbiome initiatives

Collaboration

- Interdepartmental consultation
- International Bioeconomy Forum: positioning a global agricultural microbiome initiative
- Tetrapartite (Canada, France, UK, USA)

INTERNATIONAL BIOECONOMY FORUM

Microbiome R&I Strategy in **Canada**

Agriculture and Agri-Food Canada (AAFC)

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

- **Strategy:** maximize impact of agricultural microbiome researched funded by AAFC includes:
  - **Microbiome Advisory Group**
    - Multidisciplinary approach to research
    - Workshops to initiate discussion, exchange knowledge, and provide recommendations to senior management
    - Engage international partners to further goals

Future Needs for Microbiome R&I in **Canada**

AAFC – 2017 Microbiome Working Group Findings

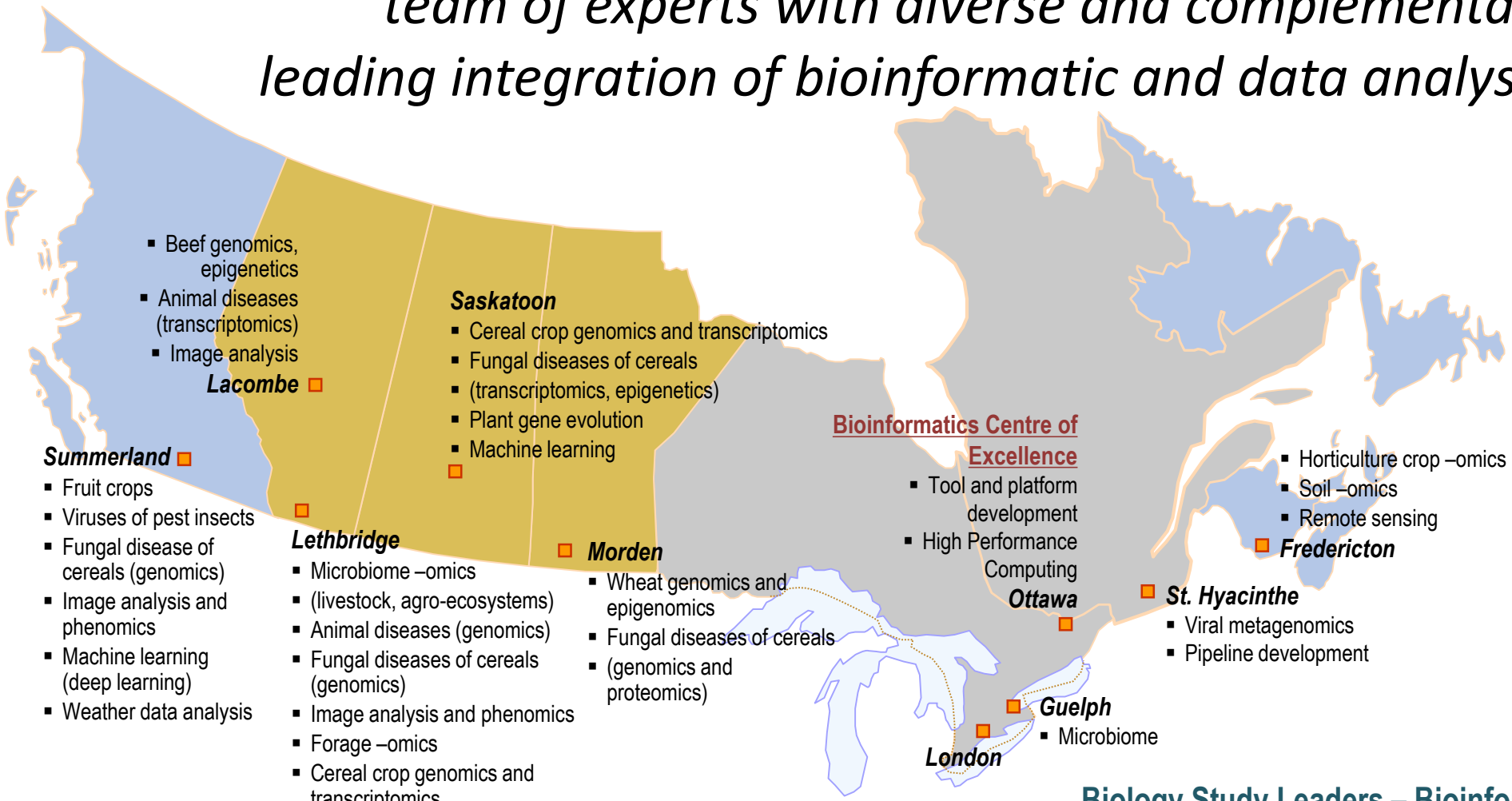
- **Microbiome research is cross-cutting**
  - coordinated, multidisciplinary, whole microbiome approach required
- **Canada needs to**
  - align with and participate in international microbiome research initiatives
  - add microbiome data to existing collections, explore new collections (especially bacterial), build linkages to international collections
- **Trade considerations:** assess datasets before open release for potential trade barriers
- **Regulations considerations:** initiate dialogue with regulatory bodies to prepare for microbiome field applications

Canada-AAFC – Microbiome Working Group Recommendations

- Forages and Beef: Exploit benefits of microbiome-assisted strategies in beef cattle to enhance health and feed efficiency to increase resiliency of cow-calf and feedlot production systems
- Agro-Ecosystem Resilience: Understanding soil microbiomes and how management practices impact soil biodiversity and function
- Biodiversity and Bioresources: Provide comprehensive information on soil and plant microbiome using high throughput sequencing-based metagenomics and integrate meta-barcoding environmental abiotic and biotic parameters, land use and climate changes

AAFC Bioinformatics / Big Data Research Support Network

*Building support for science programs through **Nationwide** team of experts with diverse and complementary skill sets leading integration of bioinformatic and data analysis methods*



Biology Study Leaders – Bioinformatics Specialists working with Computer Science Specialists

Future Needs for Microbiome R&I in **Canada**

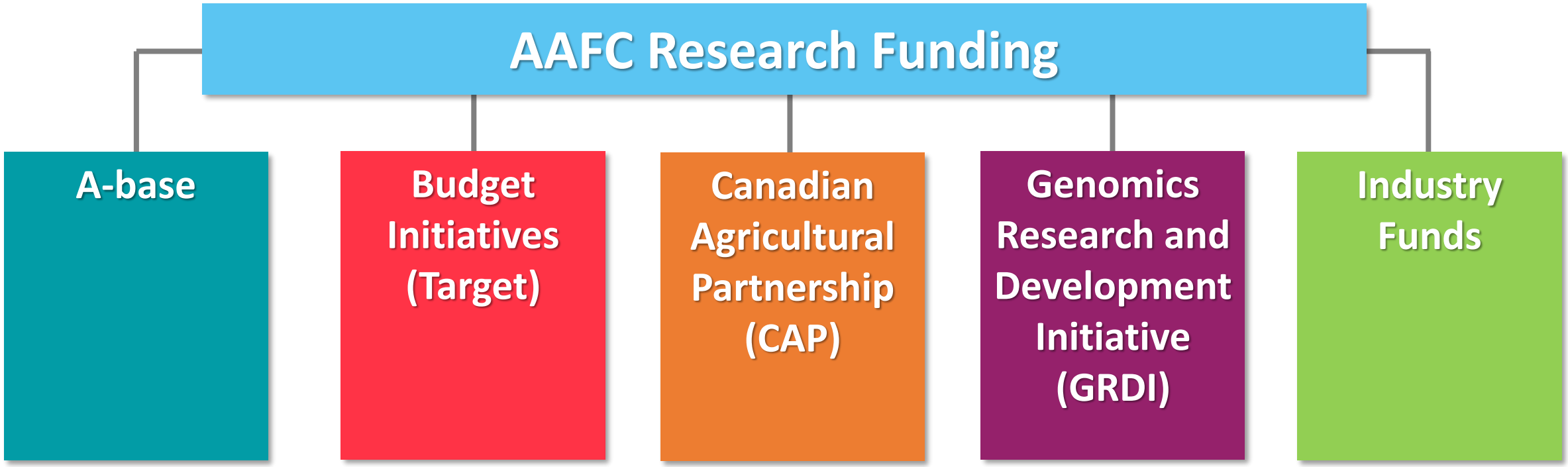
Agriculture and Agri-Food Canada

- **Capacity mapping**
  - Lead development for Gov't of Canada
  - Further develop AAFC microbiome network
- **Investment**
  - Continue to pursue increase in initiatives and required resources
- **Collaboration** (increase and enhance)
  - Interdepartmental (CFIA, CIHR, NRC, NSERC, Genome Canada)
  - International Bioeconomy Forum and Tetrapartite

Thank you! / Merci!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 818116

Agriculture and Agri-Food Canada – **Research Funding**



MicrobiomeSupport
COMMON GROUND WORKSHOP
Vienna, 4-5 March 2019

STATUS QUO – INDUSTRY

Think of Microbiome R&I landscape in the last five years

- What have been the key highlights? Which factors contributed making them successful?
    - Sequence-driven progress, solutions have higher TRL
    - Public awareness rose, better networking like COST, MicrobiomeSupport
    - From "human" to "ecology" / other environments
    - Large private investments, more funding, PPP good, good support from government
    - Lower sequencing costs, various tools and bioinformatics have improved
    - High interest in biocontrol / agriculture
    - Demand from consumer for high quality food, from farmers for microbiome solutions, export market demand – generally increased interest from industry

- What is not going well at the moment?
    - Public knowledge must improve
    - Data access from industry to science
    - Regulations unclear, too slow
    - Applied science: delivery and formulation of products, reproducibility under field conditions
    - ONE technology (sequencing) limits solutions
    - Approaches too risky for industry, return of investment
    - Translation of research to products, lack of competences for translation
    - Limited knowledge for discovery
    - Metadata not standardized
    - Lack of innovative products
    - High expectations

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818116

- Science: Move to causation, evidence of effects

- Where is a need for action? Why?
  - Delivery and formulations
  - Data access, cross-sectorial
  - Consumer acceptance, education, networking
  - Creative funding – more funding needed for translation to practice
  - Knowledge-based products
  - Science for pre-competitive stage
  - Clear regulatory path + international
  - Knowledge + investment in pharma is high, farm to fork still low
  - Industry need to collaborate
  - Standardized terminologies (e.g. biocontrol, biostimulants)
  - Art of dealing with different agencies
  - Education and training – intermediate between silos and experts
  - Collaboration between stakeholders

STATUS QUO – POLICY

Think of Microbiome R&I landscape in the last five years

- What have been the key highlights? Which factors contributed making them successful?

There is an increasing Momentum in Microbiome R&I policy"

  - Increase in research activities
  - Interdisciplinary approaches are taken more often
  - Collaboration between science, government and industry is increasing
  - Projects funded through structural funds lead to more application orientation
  - Microbiome is recognized as an "own scientific field"
  - Some national strategies already exist
  - Recognition of the "microbiome" in diverse fields: high level of recognition
  - Increased funding to microbiome projects
  - Leveraging
  - EC specific funds increased
  - Improved technologies accelerate scientific findings (e.g. sequencing)

- Increased collaboration between countries (e.g. DE, FR, ES) and increased international networking and projects e.g. in JPI HDHL
- Increased public awareness in particular on health issues

What is not going well at the moment?

Core weaknesses are: 1) fragmentation of R&I, 2) predominance of research in silos of health/animal/plant related microbiome, 3) a lack of experimental approaches (lot of observational research), 4) shortcomings in methodologies (low number of samples taken from at different places a", limited emphasis on validation), 5) Lack of knowledge: who is doing what, and 6) lack of awareness.

- Strategies might block curiosity-driven research, but also no clear strategy: no/not much dedicated microbiome research strategies; funding; collaboration infrastructures
- Silos exist between 1) plant/health/animal, 2) national/EU/international, 3) industry / research & funding – fragmented research landscape; lack of trans-sectorial dialogue (policy)
- Many observational and inventory data, but few functional data, lack of understanding, also in regard to societal relevance
- Lot of parameters and data but from relatively small amount of sample points; the data is "thick and short"
- Models and cohorts missing: important/relevant, longer-term, alignment (EU/international)
- Microbiome-related collections: -> towards testable hypothesis, concepts of standardization
- Difficult to define a common focus (synergies)
- Need an overview of existing knowledge infrastructures, funding etc. (national and international)
- Data sharing & Data standards: aligning between fields, projects, exchange of samples
- Too much time for applying for research resources
- Need of better methodologies: validation, sample points vs. analysis
- No dedicated microbiome training at universities

Where is a need for action? Why?

Against the main obstacles identified, there is need for: 1) clear strategies, 2) collaborations within countries of the EU and on international level, 3) creation of

awareness /think to work trans-sectoral, 4) more samples-increase data standards, meaningful curricula, 5) Mapping of program, actors, infrastructures 6) overall – a masterplan for microbiome funding which ensures balance between basic and applied research

- Update / revision of national strategies (e.g. Ireland), embedding microbiome into national strategies (e.g. bioeconomy)
- Cross-cutting funding incentives to overcome silos
- Cross-cutting fora for exchange (adaptation to various sectors)
- Balanced approach between curiosity driven research and applied research
- Experimental approaches to functional microbiomics
- Standards, which are developing/adapt to state-of-the-art technology
- Cross-regulatory frameworks made for different applications/sectors
- Translational research between 1) academia and industry and 2) different sectors
- Communication / Outreach (public / progress rel. for industry)
- Embedding of microbiome into circular economy concepts / implementation
- Establishing models
- Communication and public awareness: What is the microbiome? What can it be used for? The microbiome could help for…
- Improved international cooperation (currently going slowly)
- Increased targeted funding – potentially through increased international cooperation
- Member States need to act to affect national policies / strategies and to align between Member States for increased coherence
- COST Actions for microbiome research
- Budget for education, knowledge transfer, implementation (involve users early on, and adapt current practices)
- Communication with users and stakeholders: farming, industry commercialization (going against traditional patterns)
- Masterplan: mapping landscape, identify research principles, stakeholders, metrics, roadmap and timeline; Need of dedicated strategy
- Technological infrastructure: Standards, Openness, Exchange and Sharing
- Need of more alignment / coordination between science and policy decisions
- Preserving evidence: bio-collections, data stores, standardization, reproducibility, provenance
- Programs for more multi- and transdisciplinary research (less sectoral)
- Better methodologies for development of experiments in terms of validation and sampling sources

- Need to raise awareness for policy stakeholders – e.g. on the benefits for society
- Need more budget

STATUS QUO – SCIENCE

Think of Microbiome R&I landscape in the last five years

- What have been the key highlights? Which factors contributed making them successful?
  - Public engagement leveraged – human microbiome
  - Microbial genomes, proteomics, metabolomics, linked to reference genomes
  - Advance in understanding link between host and microbiome and environment and human activities (e.g. climate change) – paths for modulating microbiomes
  - Methodological capacities to analyze diversity across kingdoms, ecological considerations of inter-kingdom interactions
  - General interest in microbiomes, in only few years it has become a major theme, in some countries funding is very strong
  - Successful products
  - Public awareness
  - Funding and collaboration increased - from basic to collaborative research
  - Common methods, e.g. bioinformatics

- What is not going well at the moment?
  - Standardization of data depository in the public space; DOI: to increase citation rate – motivator
  - Standards, references
  - Disconnect between data collection and interpretation of multi-omics data
  - Communication between different scientific disciplines
  - Dialogue between academia and industry needs improvement
  - Fragmentation
  - Human microbiome dominates – need to expand to other areas
  - Quantitative data on microbiome functioning is lacking
  - Microbiomics is often not connected to other taxa (than bacteria) / trophic tiers
  - What is egg, what is chicken? Hypothesis-driven research, replication, what is a healthy microbiome?

- Linking lab to field; rational design of synthetic communities

- Where is a need for action? Why?
  - Standards, metadata, information, data provision
  - Make data more user-friendly + better toolkits
  - Open access to raw data
  - Artificial intelligence
  - Quality standards for methods/producers; for meta-data
  - Difficulty to translate science to forestry – data and databases needed
  - Replication, time and space issues
  - Tools for understanding the relationship between microbiome and its ecosystem; focus on understudied environments (e.g. marine)
  - Include the quantitative role of microbiome
  - Big gap between what we can measure and what we can deliver – involve industry, manage expectations
  - Communication – across sectors; avoid Hype
  - Clear strategies
  - National and international collaborations
  - Think and work asectoral
  - Need for more samples and data, standards, education etc.
  - Need for mapping programs & actors & infrastructures
  - A masterplan for funding, ensure balance between basic and applied

VISIONING – INDUSTRY

Expectations

- Core achievements in 2030
  - Technical advances, incl networks for transfer, data sharing
  - Forum for funding at pre-competitive level
  - Treat more diseases
  - More products on the market

- Implementation?
  - Impact assessment for funding and outputs
  - Do not oversell, but elaborate
  - Disconnect to other problem > connection needed
  - Guidelines across programs
  - Clear regulations needed
  - Improve customer acceptance
  - Education
  - PPP for early-middle stages
  - WHO? – all stakeholders

- Best practices known?
  - Good practice: labelling, connect with consumers, risk management, microbiome ambassadors

Trends and key topics

- Most important trends?
  - Methodology & technology, systems approach
  - Artificial intelligence, computing power, big data
  - Development of new business models
  - Economic trend – change in nature of business structure, start-ups have good chances
  - Increasing consumer awareness
  - E-commerce
  - Lack of confidence in establishments
  - Diversification / personalization

- Opportunities arising from these trends?
  - Opportunity to positively influence public awareness by industry meeting consumer demand
  - Growing market
  - "Solution packages" by industry > products, education
  - Customized products driven by e-commerce and big data
  - Mechanistic evaluation - knowledge-driven products with proven efficacy
  - To better identify and target yet unmet consumer / patient needs
  - Growing blue market

- Associated risks?
  - Mismanagement/failure of expectations
  - Misunderstanding in public / public perception / unacceptance by consumer
  - viability
  - Time to market (too) long (delayed because of public perception)

- Best practices known?
  - Organic farming
  - Biomin in AT, microbial detoxification
  - Cell-based therapy

Barriers

- Most important barriers?

1) Public awareness, training; 2) Technical barriers– standardization, data management, bioinformatics, phenomics; 3) Translational barriers - regulatory issues, culturomics and up-scaling; gap between knowledge generation in academia (TRL 1-3) and market access (TRL 7-9) – funding for proof-of-concept phase (TRL 4-6; start-ups, PPP) - regulatory support, guidance; 4) Product side: beneficial effect, risk management, return of investment

  - Lack of incentives
  - Lack of understanding to access / translate the data
  - Lack of tools to handle complexity
  - Nature of the innovations / solutions
  - Lack of funding for PPP (to take risk for riskier opportunities)

- communication of uncertainty
- Customization / personalization increase ultimate costs
- Public perception of microbes / lack of knowledge
- Solutions may not always be efficacious > new business models

- Measures to mitigate these barriers?
  - Faster regulatory approval (fast track)
  - PPP to manage risks
  - Proactive education / information
  - Professional outreach

Contributions from your stakeholder group

- What can your group do to contribute to microbiome R&I?
  - Commercializing

- What is needed?
  - Public / consumer awareness
  - How to define different products
  - Requirement of industry for guidelines how to place product on the market
  - Innovations – how can academia and industry work together? Spin-offs?
  - Reference catalogue for industrial microbes, nomenclature
  - New/improved regulatory frameworks needed (e.g. on biopesticides)
  - Interface needed between regulatory body and industry, PPP facilitated
  - Multi-stakeholder dialogues
  - New knowledge to be shared, co-innovation, framework to allow industry access to science results
  - Microbiome needs to go wider, collaboration

- Which collaborations are needed?
  - Better collaboration between academia and industry

- Best practices known?
  - IBMA (Biocontrol), EBIC (Biostimulants), ELF (Eur. Lead Factory), PISTOIA Alliance (Pharma)

VISIONING – POLICY

Expectations

- Core achievements in 2030, why important?
    - Public Health improved due to microbiome-based applications (policies for targeted preventive strategies)
    - Food system more sustainable: e.g. through precision farming, less pesticides by improved pathogen surveillance in crop production, less antibiotics for life stock, pre-, probiotics)
    - Improved waste streams treatment
    - Conservation of biodiversity
    - Improved processes for food security and safety (production of healthy and nutritious food for everyone)
    - Carbon/Climate change
        - Green chemistry/Blue chemistry
        - Alternative energy sources: biofuel cells
        - CO2-Reduction/Sequestration/ bio-innnovations such as making bricks with bacteria mimicking coral formation (zero-carbon bricks)
        - Etc., e.g. enlarging storage capacity of solar cells, marine organisms …
    - Knowledge advancements – understanding causation
    - Education and Awareness Programs
    - Science advice to policy on risks/benefits
    - Economic benefits, cost efficiency, new markets

- Implementation?
    - WHO? – stakeholders and actors including: doctors, pharmacies (for health-related), farmers, educators, consumers, advertisers, industry, extension services farm advisors, etc.), innovators, entrepreneurs, regulators, investors

- Best practices known?
    - Innovation Radar (including data about technological progress and about awareness and perception, requiring input form natural sciences and social sciences)
    - Effective communication techniques (learn from some NGO's campaigns!)

- Community of experts webpage, fostered and hosted by EC DG's (e.g. DG SANTE ensuring sustainability of food experts webpage after lifetime of project REFRESH)
- International science network

Trends and key topics

- Most important trends and opportunities?
  - Biological / SMART solutions
  - Public perception and demand for these products
  - Climate Change: Reducing GHG emissions, Reduced impact on environment
  - Need for safe food and nutrition
  - Human health and well-being
  - New scientific advances allowing for new applications in microbiome: Block-Chain
  - Technological progress supporting microbiome R&I
  - Probiotics
  - Increased awareness: e.g. first take-up of 'microbiome' in commercials

- Associated risks?
  - Lobby-Groups pushing in different directions
  - Regulation
  - Unknown impact of microbiome in the field
  - Public acceptance and acceptance of end-users: demand vs. chemical solutions (big potential exists)
  - Over-Promising: Careful management of expectations needed; Engagement of public early in the process

Barriers

- Most important barriers?
- Consequences?
- Measures to mitigate these barriers?
- Best practices known?

Barriers	Consequences	Mitigation	Good practices
Focus of policy Public trust in science Overselling Regulatory barriers IP issues / Nagoya / CBD Infrastructure	Claims of product efficacy due to absence of regulatory regimes (comment: there are products on the market which destroy trust)	Mapping which type of policy and regulation is needed = regulatory framework Common standards on quality and compliance Harmonization – don't reinvent the wheel	Science media hubs for QC (?)
Still limited understanding of causal relationships Mechanisms / Mode of Action Climate change Policy understanding of scientists	Low quality products due to lack of confidence Legal criteria Lack of innovation Lack of uptake and trust	Early engagement of stakeholders / MicrobiomeSupport Incentives Information and exchange: development of key messages	There are many: evaluate what is there and identify gaps Information Virtual /common platforms Joint Programming Initiatives
Duplication Understandable communication	Limited impact due to silos Duplication of efforts Problems with reproducibility Lack of compliance Lack of clarity: investment and regulatory environment	Alignment of research policy: expert platform > Science policy draft Life-long learning Media/Communication	
Lack of people submitting data and metadata Fundamental vs. Applied		Science information Active role of scientists in the media	

Contributions from your stakeholder group

- What can your group do to contribute to microbiome R&I?
  - Risk – fragmentation – need coordination
  - Better integration of microbiome in existing bioeconomy strategies: identification of areas
  - Define the actors: set up working groups, structured, don't allow communication breakdowns
  - Policy co-created with all stakeholders
  - Integrate knowledge generation into regulatory body / government
  - Policy makers develop supportive policy evidence based / policy development with an interactive approach

- What is needed?
  - Policy development inclusive, well designed
  - Improve mechanisms for involving different stakeholder groups
  - Consistency in regulations
  - Understand the role of different actors
  - Policy alignment: identify relevant policies
  - Overcome silos
  - Put microbiome on the education agenda
  - Now – consider form of databases, future integration into other platforms
  - Not target the history of past projects (continuous monitoring, AI tools)
  - Research and innovation should not be linear, balance basic and applied, demonstration and innovation
  - Minimal levels of meta-data to allow for databases to be inter-operable in the future
  - Long-term commitment to maintain databases, standardization, rich metadata/structured
  - Long-term support of network
  - Store data and generated knowledge – make use of AI

- Best practices known?
  - Case studies of what did not go well
  - USA: National microbiome data-center – NMDC, interagency budget for initiative ($ 10 Mio per year)
  - Centre of Microbial innovation: hub for interdisciplinary research; location close to innovators / San Diego

- Innovation Radar – 5-10 years monitoring tool > active follow-up of projects
- Ireland: APC microbiome since 2003 / have programs including school education

VISIONING – SCIENCE

Expectations

- ### Core achievements in 2030, why important?
  - Knowledge: deep understanding of microbiomes at a global scale for important topics such as food security, climate change etc.; predictive models and indicators to modulate microbiomes; biomarkers associated with healthy hosts / ecosystems
  - Knowledge transfer: feedback between the groups – public, stakeholders, policy makers
  - Open schemes collaborations
  - Technology: flagship of goals, policy makers, overarching goals and objectives

- ### Implementation?
  - Repertoires of benchmarks, samples/DNA/RNA banks, bioinformatics
  - Platforms, funding support
  - Biomarkers, genomic / microbiome information – ensure privacy

Trends and key topics

- ### Most important trends?
  - Technical advances
  - Multi-omics, combination of techniques
  - Defining healthy microbiomes
  - Diversity to function
  - Better cultivation, synthetic communities
  - Better pipelines
  - Translation of microbiome research
  - Open access

- Topics: climate change, food security, ONE health, horizontal gene transfer, antimicrobial resistance, plant breeding, microbiome swapping, bioprospecting, bioremediation

- Opportunities?
  - Technology: cheaper, faster, better?
  - Data validation
  - Reduce impact on environment
  - Synthesis of new compounds

- Associated risks?
  - Over-interpretation
  - Data overload
  - Bad data - Poorly validated data
  - Over-hyping of microbiome

- Best practices
  - Move to hypothesis-driven research
  - Defining SOPs for data, meta-data
  - Open access
  - Public awareness
  - Communication with stakeholders – public, policy makers

Barriers

- Most important barriers?
  - Funding
  - Standards (datasets, strains, reference genomes, metadata)
  - Regulation (over- or under-regulated, ethics, GDPR, Nagoya, EFSA)
  - Infrastructure (servers, computer power, culture/ biobanks)
  - Tools (integration of multi-omics)
  - Need for culturomics and mechanistic understanding
  - Training (bioinformatics)
  - Overemphasis of bacteria

- Measures to mitigate these barriers?
  - Benchmarked datasets, de novo sequences

- Communication - lobbying with stakeholders
- Funding schemes to bridge gaps, e.g. translational aspects
- Long-term funding of infrastructure
- Training
- Efforts to standardize approaches (where realistic)

- Best practices known? Role of MicrobiomeSupport
  - Peer-reviewed opinion papers
  - White papers for regulators, funders, politicians
  - Guidance on ethics and regulation
  - Define achievable goals
  - Identify flagship challenges, e.g. global warming and microbiome

Contributions from your stakeholder group

- What can your group do to contribute to microbiome R&I?
  - MicrobiomeSupport can support availability of (standard) protocols (wet and dry)
  - MicrobiomeSupport could provide policy information to stakeholders / politicians
  - MicrobiomeSupport can bring messages to society

- What is needed?
  - Shared data as a policy objective
  - Standards should be available, e.g. mock communities; MicrobiomeSupport could list verified standards
  - MicrobiomeSupport can bring best practices, ideas to conferences, journals, schools etc.
  - More international regulations; MicrobiomeSupport can influence this
  - Data – fair interoperability, machine readable
  - Share protocols etc. with licenses, track changes like GitHub
  - Funding and journals require FAIR – MicrobiomeSupport can help people to use it - OK

- Which collaborations are needed?
  - Funding collaborations with right skills, including industry

MicrobiomeSupport Motivations

#1	One Health Approach
#2	Improve awareness of R&I initiatives, research trends & issues to be solved
#3	To understand science priorities, focus areas and objectives. To meet network partners. To source opportunities for collaborations
#4	To see if my knowledge is up to date. To network. Not to miss any changes. To be inspired!
#5	Involvement in Microbiome EU project. Intent to network with other scientists
#6	"Fermentation microbiome" reveals improved food quality, taste, aroma and texture.
#7	Curiosity in science. Problems in agriculture production. Benefits for humans
#8	I entered the microbiome field about 4 years ago by coordinating H2020 Marie Curie ETN. My motivation is to maintain those connections and to increase my network in the area
#9	Networking. Information gathering. Help to set an agenda
#10	To join the EU initiative and interact with WU and non-EU groups active on microbiome (food and health)
#11	Networking. Spreading knowledge of microbiomes. Obtain some knowledge of the network
#12	Learning about perspectives and views in other countries/stakeholders. Connecting human microbiome field with other microbiome research areas
#13	To learn more about MicrobiomeSupport and understand strategic approach to develop recommendation towards future R&I. To meet and network with relevant stakeholders in the field
#14	Gain an overview of the CSA
#15	Networking. Synergies. How the microbes are used and how useful are to the Microbiome era. Discussions with WP members
#16	Re-definition "microbiome" – what is all included? Networking/Synergies with all different actors
#17	Traditional Microbiology" has transformed into "Microbiome Biology". All microbial processes are population driven not by single organism. Seeking partnering opportunities which can be leveraged through our in-house know-how and technology
#18	Science understanding. Industry motivation exchange
#19	Seeking partnering opportunities which can be leveraged through our in-house know-how and technology
#20	Bayer CropScience would like to collaborate with microbiome research teams in order to develop novel products for Ag and crop protection

MicobiomeSupport Expectations

#1 Inspiration. Networking

#2 Microbiome definitions and standards to transform microbiome research outcomes in clinical/agriculture/other practices

#3 Microbiome standards in fermented food products

#4 Connecting microbiomes. Understanding how microbiomes in diverse ecosystems interfere with each other

#5 Cross-sector knowledge sharing. Personal contact with project carriers

#6 To be able to situate opportunities at the interface of food and health (disease prevention or ???)

#7 Have not been detailed before. Activities from the various very good + intensive discussions. PDCA-circle, maybe needed permanently, not only 3 years project

„...European and global networking and cooperation is needed to unfold the opportunities of the microbiome.“

[Andreas Moser, rtd services]

„...I am convinced that the microbiome can be applied in multiple beneficial ways to enhance humankind and the planet in general.“

[Paul Cotter, TEAGASC]

„...Microbiome is EVERYWHERE!! (90% of biosphere diversity).“

[WP3 team, AIT, DLR, INRA, CSIC]

„...it is important to spread knowledge about microbiome. Microbiota are everywhere and affect basically everything. Thus we need to understand who is there and what do they do. And better networking is good anyways.“

[Stefanie Urimare Wetzels, FFoQSI]

„...of the marine microbiome and the immense opportunity this holds for us to understand our ocean and help us predict and protect it, our people and their livelihoods.“

[Margaret Rae, AORA-CSA]

„...we are running out of fungicides.“

[David B Collinge, University of Copenhagen]

„... People are really interested and that means we have an amazing opportunity to get #sciencecommunication right this time round!“

[Bettina Schelkle & Virginie Maenhout, EUFIC]

„...we think communicating science is a key aspect to be considered by us scientists.“

[Rafael Souza & Paula Malloy, GCCRC-Unicamp]

„....we need to understand them.“

[Tim Mauchline, Rothamsted research]

„...MICROBES ROCK!!!.“

[Davide Bulgarelli, University of Dundee]

„...microbiomes are crucial for human health, well-being and more or less all environmental processes. Therefore, we have to increase the awareness of the importance of microbiomes for our planet“

[Angela Sessitsch, AIT]

„...of my experience in microbial ecology.“

[Ilario Ferrocino, University of Torino]

„....the world of microbiomes is just fascinating“

[Andreas Moser & Wolfram Allinger-Csollich, rtd services]

„...understanding behaviour of microbiomes is key to improving human, animal and environmental health, and thus the quality of life.“

[Hauke Smidt, Wageningen University]

„....I believe in the power of microbes to improve and contributre to a more sustainable world.“

[Rute Neves, Chr. Hansen]

„...microbiome universe needs to be explored.“

[Artem Khlebnikov, Danone Nutricia Research]