AgriMicrobiomics promise and challenges.

Date: Wednesday 20th - Thursday 21st, September 2023

Venue: **In-person** | at EMBL-EBI, Hinxton, Cambridge CB10 1SD Cambridge, UK

Online | By Zoom. Link will be sent to registered participants

Registration: **Free** for EMBL-EBI Industry Programme members and invited speakers.

Registration is required.

Event logistics will be managed by Emily Pomeroy (epomeroy@ebi.ac.uk)

Day 1: Wednesday 20th September 2023

Time	Presentation	Speaker / moderator
09:00-09:30	**Arrival/Registration**	
Local time LINK	**Welcome and introductions**	
09:30-09:50	Opening remarks	Effie Mutasa-Gottgens
09:50-09:55	Motivation & desired outcomes	Mark Ott
Local time LINK	**Session 1 | Keynote**	**Chair – Vanessa King**
09:55-10:55	Biological context is critical to understanding soil health as an emergent property. **Abstract** General concepts of health are directly related to maintaining the dynamical state of life-sustaining functions via homeostasis and/or homeorhesis. In soil, favourable attributes such as plant productivity, microbial activity, nutrient cycling, carbon dynamics, and reduced greenhouse gas emissions arise as emergent outcomes of soil's capacity to preserve a mixture of air and water in interconnecting pathways across a range of environmental conditions. This essential trait stems from the volume and interconnectedness of soil pore space at scales below 100 µm, which hold water against gravitational forces. Drawing conclusions about soil health solely from biological measures, such as biodiversity, that neglect this context may be flawed. Pore space in soil exhibits scale-free properties that can be modelled using	Andy Neal

Time	Presentation	Speaker / moderator
	fractal geometry. This implies that the fraction of connected pores follows a power law and has important implications for the functioning of soil systems at the microbial scale. Evidence from long-term experiments at Rothamsted suggests that pore connectivity in clay-rich soils is influenced by variations in organic inputs and that the soil-microbe system is in a state of self-organised criticality, responding to the input and turnover of plant-derived organic carbon. This adaptive self-organisation is an intrinsic property of clay-rich soils that influences the soil extended composite phenotype. At high carbon input rates, the self-organised state allows maximum microbial metabolism, increasing nutrient and water fluxes to plants and water storage, while reducing greenhouse gas emissions. However, the soil stores less carbon than it would without self-organisation. Under reduced organic inputs, the preferential accumulation of low oxidation state organic compounds is favoured due to their comparatively poor thermodynamic yield compared to more oxidised compounds during anaerobic respiration. Consequently, the soil is likely to sequester more carbon at lower input rates than would be the case in the absence of self-organised criticality. This adaptation is not an intrinsic property of sand-rich soils, which do not exhibit self-organised criticality. Understanding and discussing soil health within this context of whole system behaviour presents a more intuitive and easier to convey message regarding how to manage soils in a positive and sustainable manner.	
10:45-10:55	**Andy Neal** | Q&A – 10 min	
10:55-11:25	**Break**	
Local time LINK	**Session 2 | Soil sampling and biobanking**	**Chair | Rob Finn**
11:25-11:55	Preserving the microbiome and curating meta-data for Phytobiomes research **Abstract** Culture Collections have a history of supporting microbiological research, primarily through the accession, preservation and supply of axenically cultured microorganisms. However, in nature microbes do not exist on their own, they interact with many millions of other microbes. With developments in technology, microbiome research is changing the way culture collections and biobanks need to support their user communities through the optimal preservation of samples and the curation of associated meta-data. In this talk an overview will be provided of how 'state-of-the-art; technologies are being applied to complex microbial samples and synthetic consortia through two ongoing projects, the EU Microbiome Biobanking Enabler and the UK Crop Microbiome Cryobank.	Matthew Ryan
11:55-12:05	**Matthew Ryan** | Q&A - 10 min	
12:05-12:35	Fit for purpose: building a sequence-based resource for the UK Crop Microbiome Cryobank **Abstract** The UK Crop Microbiome Cryobank is a bioinformatics and biological resource to facilitate research towards optimising plant yield in an integrated	Nicola Holden

Time	Presentation	Speaker / moderator
	framework. The material is generated from six major UK crop types grown in nine different soil types from across the UK. It is a multi-partner project, led by CABI, for which SRUC and the James Hutton Institute are generating and analysing the sequence-based data. In this presentation I will outline the project, share preliminary results, and describe how the work fits in the wider context of plant & soil microbiome work. I will then discuss how these types of resources can best be used to maximise their impact.	
12:35-12:45	**Nicola Holden** | Q&A (10 min)	
12:45-14:00	**Lunch break – 1h 15min**	
Local time LINK	**Session 3 | Soil health – Part 1: Technology tools & translation**	**Chris Sweeney**
14:00-14:30	**Virtual presentation** | Soil Microbiomes and One Health **Abstract** Soils are of pivotal importance for food production and sustainable ecosystems. Over 50% of Earth's biodiversity is thought to live in the soil. However, intensive agricultural practices often reduce the abundance of particular groups of beneficial soil microbes. Hence, there is much interest to search for ways to enhance soil health. Here we demonstrate that soil microbiome engineering and alteration of agricultural management are suitable tools to promote soil health. In particular we observed that inoculation with biologicals (e.g. arbuscular mycorrhizal fungi - AMF) is a viable tool for soil microbiome management and to promote crop yield.	Marcel van der Heijden
14:30-14:40	**Marcel van der Heijden** | Q&A – 10 min	
14:40-15:10	Challenges and opportunities in manipulating the soil microbiome to promote soil health and productivity. **Abstract** Our understanding of the soil microbiome is rapidly expanding due to ongoing methodological and conceptual advances. We now have unique opportunities to leverage the soil microbiome to improve soil functioning and the monitoring of soil health. However, there are important barriers that limit the practical applications of soil microbiome research. These barriers include knowledge gaps associated with the large percentage of soil microbial diversity that remains uncharacterized and the challenges associated with directly manipulating the soil microbiome for desired outcomes. I will discuss why these barriers exist and strategies to overcome these limitations, using examples from recent research conducted by my group.	Noah Fierer
15:10-15:20	**Noah Fierer** | Q&A – 10 min	
15:20-15:50	Climate and management impacts on mycorrhizal function in crops **Abstract** Fungi and plants have formed symbiotic relationships known as mycorrhizas for over 500 million years. These associations help plants access nutrients from the soil while providing plant-fixed carbon to the fungi. Enhanced access to soil nutrient pools is likely to have been critical for the	Katie Field

Time	Presentation	Speaker / moderator
	success of the earliest plants on land and today forms the basis for the exploitation of soil fungi in sustainable approaches to food production and soil management. Shifts in atmospheric CO2 concentration, together with biotic factors such as plant and fungal identity, have been shown to impact exchanges of carbon for nutrients between plants and their mycorrhizal fungi across plant and fungal lineages, including food crops. This has critical implications for application of mycorrhizal fungi in sustainable agriculture, particularly in a rapidly changing climate. Crop access to soil nutrients can also be improved through application of wastewaters, slurries, and sludges as a means of recycling nutrients back into the soil. This approach has many advantages but can also be a source of emerging contamination, including human and animal-use pharmaceuticals. These contaminants are seldom removed by treatment prior to use, with unknown effects on soil microorganisms and plants. Our findings show environmentally relevant concentrations of human- and animal-use pharmaceuticals can have dramatic impacts on mycorrhizal function and emphasises the need for regulation of human and animal-use pharmaceutical chemicals entering the soil environment. Our research highlights the significant contribution mycorrhizal fungi can make to sustainable crop production and identifies substantial potential for enhancing crop mycorrhizal function and responsiveness to rising atmospheric CO2 concentrations in the future. It emphasizes the importance of broadening our understanding and consideration of the impacts of sustainable soil management strategies on soil health and functionality to maximize the potential benefits of soil microorganisms.	
15:50-16:00	**Katie Field** | Q&A – 10 min	
16:00-16:30	**Break**	
Local time LINK	**Session 4 | Soil health – Part 2: Technology tools & translation**	**Marc Roell**
16:30-17:00	**Virtual presentation** | Delivery of relevant, actionable functional information on the soil microbiome and soil system – **Provisional title.**	Duncan Cameron
17:00-17:10	**Duncan Cameron** | Q&A – 10 min	
17:10-17:40	Expansion of novel biosynthetic gene clusters from terrestrial environments using SanntiS **Abstract** Microbial-synthesized natural products are vital in ecology. Discovering the biosynthetic gene clusters (BGCs) responsible for these compounds is crucial. However, the imbalanced distribution of BGC classes in existing databases restricts the generalisation of detection patterns and limits the ability of mining methods to recognise a broader spectrum of BGCs. This problem is amplified in metagenomic datasets where BGC genes may be fragmented. The talk will introduce SanntiS, a machine learning-based approach that effectively identifies BGCs with high accuracy. Applying SanntiS to MGnify's metagenomic assemblies led to 1.1 million BGC predictions, including contextual data from diverse biomes. Experimental validation of a novel BGC detected solely by SanntiS showcases its potential for uncovering new bioactive compounds. This talk highlights the significance of metagenomic datasets in understanding BGC diversity in soil	Santiago Fragoso

Time	Presentation	Speaker / moderator
	microbial communities.	
17:40-17:50	**Santiago Fragoso** | Q&Q – 10 min	
17:50-18:00	**Final discussion/Wrap-up Day 1**	Organisers
	Networking dinner	
18:30-21:00	Drinks Reception & Dinner at Hinxton Hall	
21:00	**End Day 1 – Transport back to hotels / home**	

Day 2: Thursday 21st September 2023

Time	Presentation	Speaker / moderator
08:30-09:00	**Arrival/Registration**	
09:00-09:05	Welcome - Day 2	
09:05-09:15	Overview of Day 1	Edgardo Ferran
Local time LINK	**Session 5 | Regulatory challenges - delivering impact**	**Mark Ott**
09:15-09:35	**Bayer** | Predicting Fate of Plant Protection Products **Abstract** Soils provide key services for human and ecosystem health. The protection and restoration of soil biodiversity requires the definition of soil health in terms of microbial composition. Incorporating soil health into the regulatory framework provides clear guidance for industry-wide efforts to deliver novel plant protection products with a sustainable profile and reduced environmental impact. This presentation will outline the current regulatory framework for assessing the environmental fate of plant protection products. The consideration of microorganisms within this framework is outlined and a perspective is given on the predictive role of microorganisms in shaping the next generation of sustainable and green chemistry.	Marc-Sven Roell
09:35-09:45	**Marc Roell** | Q&A – 10 min	
09:45-10:05	**Syngenta** | Challenges of utilising complex microbiome data in a regulatory context using plant protection products as an example. **Abstract** Soil microorganisms are afforded protection from adverse impacts from plant protection products through regulatory frameworks via an environmental risk assessment. There is increasing interest in	Christopher Sweeney

Time	Presentation	Speaker / moderator
	expanding the scope of these regulatory requirements. It has been suggested to explore the inclusion arbuscular mycorrhizal fungi and amplicon sequencing approaches as testing requirements to monitor the impacts of plant protection products on the soil microbiome. However, it is incredibly challenging to do this in a robust, reliable, and standardised manner, as required by regulatory guidelines. During this talk, we will explore these challenges and define key knowledge gaps to provoke discussion as to how novel and higher resolution techniques to study the microbiome can be utilised in a regulatory context.	
10:05-10:15	**Christopher Sweeney** | Q&A – 10 min	
10:15-10:45	**Break**	
10:45-11:15	**Virtual presentation** | Setting the scene for a novel tiered risk assessment for pesticide effects on soil microorganisms: from single species to ecosystem level testing **Abstract** Upon their application pesticides end up in soil where they interact with the soil microbiota. Despite the key role of soil microorganisms in soil ecosystem functioning, we still lack a scientifically robust and methodologically advanced scheme to determine the potential toxicity of pesticides on the soil microbiota. In the frame of the EU project ARISTO we develop a novel risk assessment scheme and furnish this with all necessary elements and tools like (i) microbial bioindicators like ammonia-oxidizing microorganisms and arbuscular mycorrhizal fungi, and (ii) novel testing systems spanning from standardized single species tests to, soil tests and eventually to ecosystem level approaches with and across trophic levels.	Dimitris Karpouzas
11:15-11:25	**Dimitris Karpouzas** | Q&A – 10 min	
11:25-11:45	**BASF |** Recipes for modeling biodegradability: Can we really cook this? A summary, in the context of current knowledge and exchanges at this workshop, of what would be needed to model biodegradability in soil.	Averina Nicolae
11:45-11:55	**BASF** | Q&A – 10 min	
12:00-13:00	**LUNCH BREAK**	
Local time LINK	**Session 6 | AgriTech Consortium: pre-competitive space & projects**	**Organisers**
13:00-13:10	**Digital Soil Platform** – introduction to ideas from the Environmental fate of pesticides workshop	Mark Ott / another TBC

Time	Presentation	Speaker / moderator
13:10-13:15	Instructions for breakouts	Effie Mutasa-Gottgens
13:15 14:15	Breakout session	All
14:15-14:30	**Short break**	All
14:30-14:50	Reporting back from breakout discussions	
Local time LINK	**Session 7 | Next steps**	**Moderators**
14:50-15:55	Final discussion	
14:55-15:00	**Wrap-up and next steps**	
15:00	**End of workshop**	

EMBL-EBI organisers

Effie Mutasa-Gottgens (effie@ebi.ac.uk), Matt Hall, Edgardo Ferran, Rob Finn

Industry organisers

Mike Csukai, **Syngenta** (proposer) | Vanessa King, **Unilever** | Mark Ott, **Bayer** (proposer) | Ben Oyserman, **Syngenta** | Lauren Ray, **Syngenta |** Marc-Sven Roell, **Bayer** | Christopher Sweeney, **Syngenta** | Katherine Karberg, **Bayer** | Irina Shilova, **Bayer**

Background & Motivation

- There has been a step change in Microbiomics in the last few years but plant holobiome and particularly soil metagenomics is still a challenge.
- Healthy soil is a hot topic in agriculture and the soil microbiome is a significant contributor to soil heath.
- Now is a good time to review the Agri-Microbiomics landscape to get a clearer understanding of current state of the science, and in particular relative to industry challenges.

Scope

The workshop will focus on soil microbiomes in the context of soil health and impact on agricultural productivity. Climate and agronomic practice are expected to impact soil microbiomes, and this will also be considered during the workshop. Key to developing actionable hypotheses will be the collection of the "correct" data sets at the different scales (landscape to rhizosphere), with choices driven by use cases. The workshop offers a timely opportunity during the early development of soil microbiomics methods, for public-private collaboration to develop core pre-competitive data sets and approaches to encourage the use of common data standards. In summary, the workshop aims to:

- explore relationships between soil health and soil microbiomes.
- Develop core pre-competitive data sets and influence best practice for common data standards in public repositories.
- learn how climate and agronomic practices impact soil microbiomes and the associated consequences for soil health.
- begin to develop a pre-competitive data strategy for soil (agri) microbiomics.

Anticipated workshop outcomes

- Bring together key opinion leaders from Agri Industry, biotech, and academia.
- Share key knowledge and experiences:
    - Peer to peer learning – industry use case presentations/interactive discussions.
    - Cutting edge technologies - academic presentations.
    - Data sources, tools, platforms & computational methods.
    - Identify high priority issues and challenges.
- Provide opportunities for networking and collaborations between industry members and academic partners.

About EMBL-EBI and the EMBL-EBI Industry Programme

EMBL-EBI (European Bioinformatics Institute) is part of EMBL and is an intergovernmental not-for-profit organisation whose primary mission is to freely provide data and resources to all aspects of the scientific community.

The EMBL-EBI Industry Programme is a subscription-based programme for global companies that make significant use of the data and resources provided by EMBL-EBI as a core part of their R&D. Member companies represent most of the top 20 pharmaceutical companies as well as several major agri-food, nutrition and healthcare companies. The programme is unique, providing regular quarterly strategy meetings, expert-level workshops on topics prioritised by the members, webinars and other activities.