



Phytobiomes Alliance: Convergent Research & Regulatory Science Activities

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5 November 2019

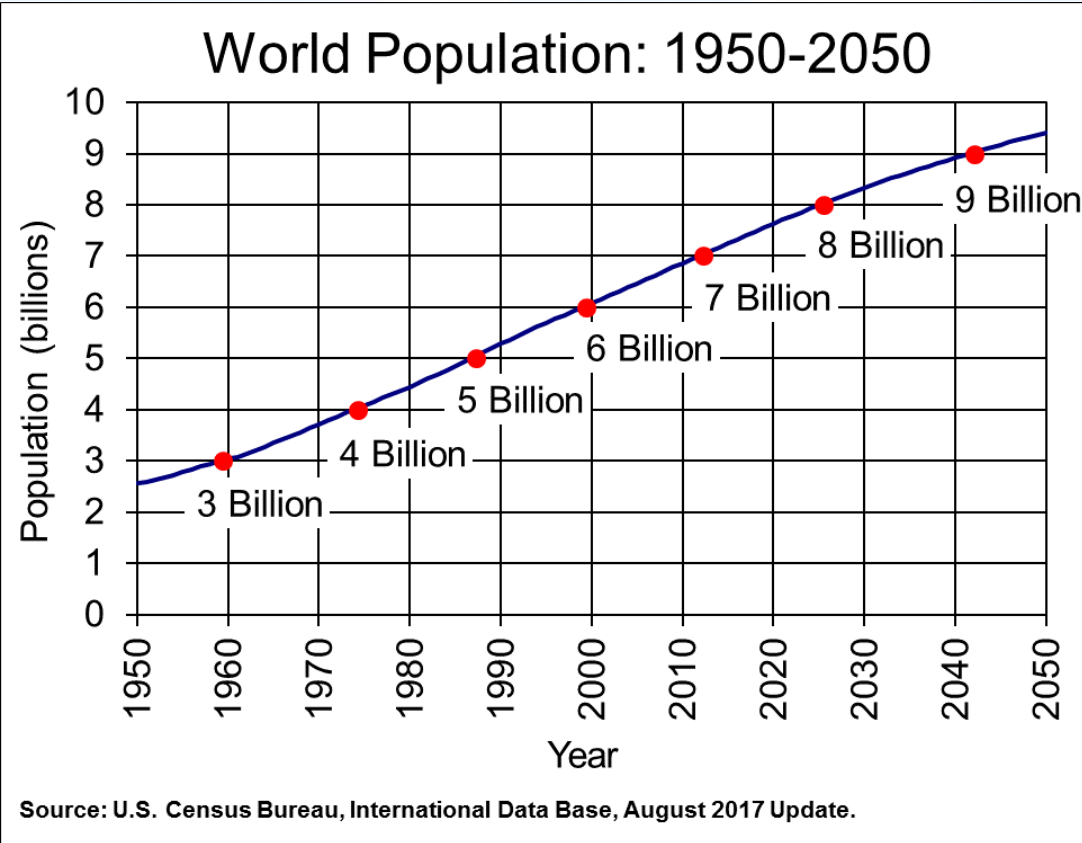
4th PARTNERSHIPS IN BIOCONTROL, BIOSIMULANTS
& MICROBIOME CONGRESS: USA
Raleigh, North Carolina



INTERNATIONAL ALLIANCE FOR PHYTOBIOMES RESEARCH

*A nonprofit consortium of industry,
academic, and governmental
scientists*

The Challenge



Realities:

- **Insufficient productivity growth**
- **Limited land**
- **30 Growing Seasons**



Holy Grail for Plant Production

To understand, predict, and control emergent phenotypes within specific sites for the sustainable production of food, feed, and fiber

How do we get there?



Moving From Simple to Complex

Traditional science approach

- Reductionist
- World is linear and can be understood by focusing on individual components
 - Soils
 - Plant genetics
 - Microbiomes or
 - Weather

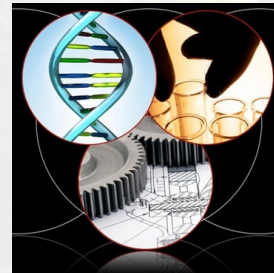
Reality – agriculture is a **complex system**

- non-linear organization
- governed by multiple non-linear interactions and environmental variables
- adaptation via learning or evolution
- it can be influenced

Paradigm shift to a systems approach

Why Now?

- Omics-enabling technologies and data
- Advances in computational science
 - Machine learning, deep learning
 - Network analyses
 - Predictive analytics
 - Quantum computing
- Precision Agriculture
 - Variable rate technology...seeding & input
 - Unmanned Aerial Systems (UAS)
 - Soil, plant, & weather sensors
 - Robots
- Convergence science
 - Systems level methods
 - Move from multi- to trans-disciplinarity



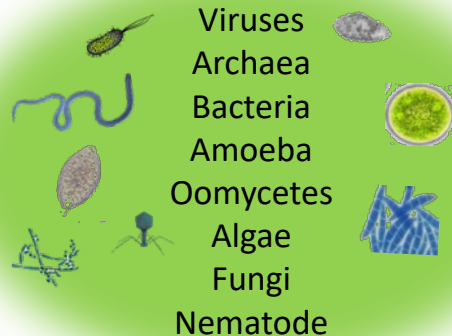
➤ **For plants: Phytobiomes approach**

Phytobiomes: Complex Systems of Plant-based Agriculture



“Biomes”: Site specific environments

Climate,
Weather,
Water



**Microbiomes and
Macroorganisms/Macrofauna**

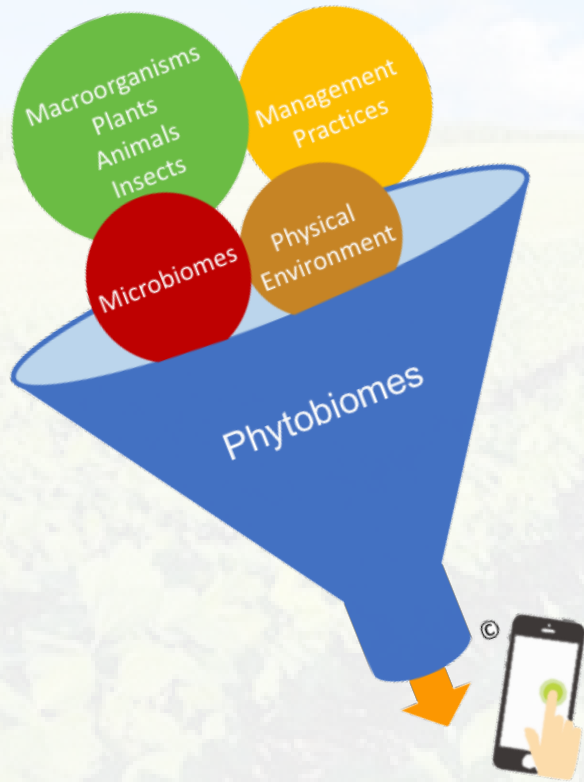


**Arthropods, Other
Animals and Plants**



All influenced by Management Practices

Phytobiomes Alliance Vision



By 2050, all farmers have the ability to use predictive and prescriptive analytics based on geophysical and biological conditions for determining the best combination of crops, management practices, and inputs for a specific field in a given year.



Phytobiomes Alliance

Our **mission** is to establish a science and technology foundation for site-specific, phytobiome-based enhancement of sustainable food, feed, and fiber production



Strategies

- Determine research, resource, technology, and commercialization gaps or problems
- Focus efforts on the pre-competitive space
- Find or assemble the right teams and individuals
- Identify specific project objectives with input from Alliance partners and stakeholders to ensure translation
- Coordinate and manage projects
- Involve industry sponsors and academic/governmental leaders at national and international levels to revise and update strategies
- **Empower industry growth and profitability**



Short-term Priorities

- Enhance understanding of the interactions between plants, microbiomes, and other components of phytobiome systems
- Link site-specific and temporal geophysical and biological data
- Develop databases that support correlation studies between biological and geophysical phytobiome components
- Draft standards, protocols, check-lists (minimum information, sampling, reference datasets, regulatory requirements...)
- Deploy genome sequence-based classification system for microbes
- Design preliminary models for several agroecosystems (crops, forage, trees...)
- Draft regulatory science roadmap for microbials



Short-term Regulatory Science Priorities

- Genome sequence-based classification system for microbes
- Databases that facilitate regulatory science and regulatory review: public & private microbial genome and metagenomic sequences (WGS, 16S, ITS)
- Standards (minimum information, sampling, reference datasets)
- Census of microbes by state and by country
- Develop a “risk prediction” method for beneficial plant bacteria



Alliance LINS Project: Whole Genome Sequence-Based Classification & Identification Platform

Model: *Ralstonia solanacearum*



Database of sequences coupled to pathogenicity data



Precisely circumscribe the strains that should be designated as “Select Agents”

Objective: Enable rapid and precise taxonomic identification of microbes



Expand model to other agriculturally relevant bacteria



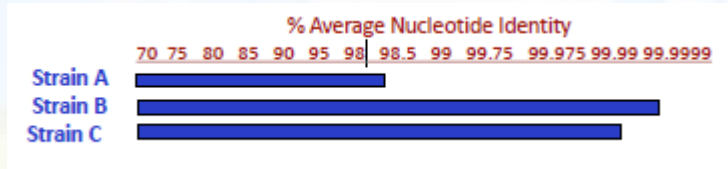
Expand to include plant-associated fungi

Life Identification Number[®] (LIN[®])

- Stable and unique codes that are:
 - assigned to individual organisms/genomes (for example, bacterial isolates)
 - based on a measure of genome similarity, such as average nucleotide identity (ANI)
 - informative of the similarity of an organism's genome to the genomes of all other organisms
- Codes consist of a series of positions, each expressing a different threshold of genome similarity
- The more similar the genomes of two organisms are, the more similar the LIN[®]s of the two organisms

Whole Genome-Based Classification & Identification Platform: APHIS Project

- Enable rapid and precise identification of microbes



- Assess rapidly relatedness of new strains to existing strains for which phenotypic and geographic data are available
- Involve government and industry in planning the data, metadata, and user needs and outputs to improve regulatory process for research and commercialization of agricultural microbes
- Embed data privacy options for contributors to the database



Risk Prediction Classification (Submitted)

- Develop a “risk prediction” method for beneficial plant bacteria
- Initial focus on *Bacillus*, *Pseudomonas*, and *Burkholderia* with plant growth promoting activity and biocontrol activity
- Objectives include:
 - ✓ Developing a precise genome sequence-based classification and genome sequence-based phylogenetic trees of the strains
 - ✓ Identifying genetic markers associated with beneficial and pathogenic strains belonging to the genus *Bacillus*
 - ✓ Precisely circumscribe strains that are, and are not, pathogens and plant beneficials



Database for rapid assessment of geographic distribution of microbes

- Expand/create database to include WGS, 16S, ITS, metagenomic sequences coupled with geographic metadata
- Controlled vocabulary for phytobiome-associated metadata
- Identify best practices, reference materials, and standards for characterizing phytobiome microbes



Longer-Term Regulatory Science Priorities

- Develop machine learning methods for microbial annotation
- Determine science needed to support commercialization of microbial communities and genetically engineered microbes
- Explore artificial intelligence, machine learning, and deep learning (AI, ML, DL) approaches which could support research, regulatory review, and commercialization of microbes, microbial communities, and genetically engineered microbes



Next Steps towards Regulatory Science Roadmap

- Identify problems and design potential solution
- Engage international, national, & state regulatory officials
- Workshop on classification system & standards – Raleigh – Feb 2020
- Spring 2020 - Workshop with regulators
- Phytobiomes Conference – Dec 2020 – regulatory session & working group meeting
- Publish regulatory science roadmap
- Develop science basis for regulatory improvements



Join Us!

Scientific Coordinating Committee

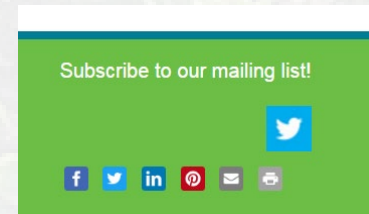
- ✓ Alliance sponsors
- ✓ Project leaders

Alliance working groups

- ✓ Two Working Groups: Regulatory and Controlled Environment Agriculture
- ✓ Involved in projects aimed at filling gaps in knowledge, resources, or tools

Subscribe to Mailing List

- ✓ www.phytobiomesalliance.org



Phytobiomes Conference 2020



1-4 December 2020

Denver, CO, USA

www.phytobiomesconference.org

Main Scientific topics

- Plant fitness
- Microbial community assembly and function
- Network analyses within the phytobiome system
- Modeling
- Data – framework, tools and resources, big data
- Genetic linkages
- Engineering to improve carbon sequestration
- Interactions within phytobiomes for abiotic stress
- Engineering microbes and microbial communities
- Precision agriculture
- Controlled environment agriculture
- Fertilizer, nutrient, and chemical input efficiency
- Product development
- Regulatory requirements
- Greenhouse & Field trials
- Industry research needs

International Alliance for Phytobiomes Research Sponsors



BioDiagnostics





Thank you for your attention!

www.phytobiomesalliance.org

