Embracing Complexity to Achieve a New Vision for Agriculture

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Symposium: Phytobiome Research to Improve Agricultural Productivity
The Challenge

32 Growing Seasons

World Population: 1950-2050

Source: U.S. Census Bureau, International Data Base, August 2017 Update.
Agricultural Productivity is not rising fast enough to sustainably feed the world in 2050

TFP = Total Factor Productivity – the ratio of outputs to inputs
Declining Cereal Yields

How do we reverse the trend and achieve sustainable production in 32 growing seasons?


Source: IFPRI IMPACT simulations.
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 – the phytobiome**
Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds

Plant-Based Agriculture: A Complex System

A “Phytobiome”

Micro- and Macro-organisms
Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Algae
Fungi
Nematode

Plants

Soils

Arthropods, Other Animals and Plants
Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds

“Biome” – Site specific environment

Climate and Weather

“Phytobiome”
To understand, predict, and control emergent phenotypes within specific phytobiomes for the sustainable production of food, feed, and fiber

How do we get there?
INTERNATIONAL ALLIANCE FOR PHYTOBIOMES RESEARCH

A nonprofit consortium of industry, academic, and governmental scientists
Our **mission** is to establish a science and technology foundation for site-specific, phytobiome-based enhancement of sustainable food, feed, and fiber production.
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.
Why Now?

- Omics-enabling technologies and data
- Systems-level methods - convergence
- Advances in computational science
  - Machine learning, deep learning
  - Analytics
  - Predictive analytics
  - Quantum computing
- Precision Agriculture
  - Variable rate technology...seeding & input
  - Unmanned Aerial Systems (UAS)
  - Soil, plant, & weather sensors
  - Robots
Strategies

• Focus on pre-competitive science
• Determine research, resource, and technology gaps and develop roadmaps to fill them
• Coordinate and manage projects to address gaps
• Facilitate international and public-private collaborations
• Develop an interdisciplinary community of researchers committed to advancing phytobiomes science
• Empower industry growth and profitability
Fundamental Research Areas

- Universal, common, and environment-specific trends in microbiome composition
- Mechanisms by which distinct phytobiome components interact
- Genetic linkages that connect phytobiome components
- Impacts of phytobiome components on plant health
- Multidirectional feedbacks that influence phytobiome components
Short-term Priorities

• Databases that support correlation studies between biological and geophysical phytobiome components
  • Whole genome & 16S microbe sequences, metagenomics
  • **Metadata** to include crop, variety, soil characteristics, weather and climate, management practices

• Standards (minimum information, sampling, reference datasets...)

• Genome sequence-based classification system for microbes

• Preliminary crop models for several agroecosystems (cereals, vegetables, forage, trees...)

• Regulatory science roadmap for microbials

• 3 to 5 year strategic roadmap with specific deliverables
Longer-term Targets

- Simple, simulation models that are functionally accurate to real world complex conditions – e.g., greenhouse studies that reflect field conditions
- Validated and optimized models
- Trait- and gene-based microbial genomics datasets
- Integration of microbial data with databases and equipment used in precision agriculture
- Systems level predictive and prescriptive analytics for on-farm implementation
Phytobiomes Alliance Organizational Structure

**Board of Directors**
- Establishes overall vision

**Coordinating Committee**
- Financial sponsors
- Project leaders
- Establishes priorities, strategic plans, and roadmaps

**Topical Working Groups**
- Implements strategic plans

**Executive Office**
- Oversees and runs daily operations

**Members**

**Executive Director**
- Chief Operating Officer
- Communications Director

**Scientific Coordinating Committee**
- Data Working Group
- Standards Working Group
- Regulatory Working Group
- Climate/Weather Working Group
- New Working Group

**Executive Office**

- Establishes priorities, strategic plans, and roadmaps
• Phytobiomes Research Symposium, France (in planning for late 2018)
• Phytobiomes Database workshop (in planning)
• Regulatory Science workshop (2019)
• Keystone Symposium on Phytobiomes, 2019
Join Us!

Scientific Coordinating Committee

- Alliance sponsors
- Project leaders

Alliance working groups

- Overall topical leader
- Involved in projects aimed at filling gaps in knowledge, resources, or tools

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- www.phytobiomesalliance.org
Thank you for your attention!

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