BioEPIC

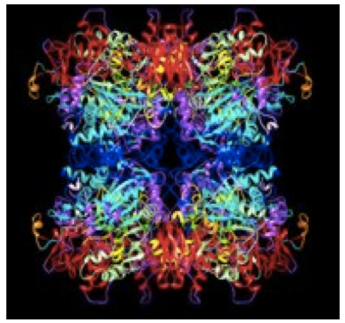
The Biological and Environmental Program Integration Center

BioSciences

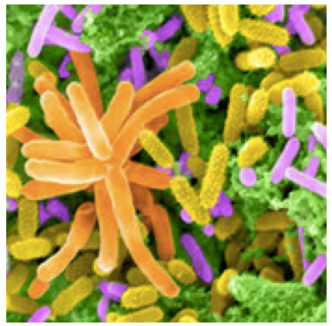
EARTH & ENVIRONMENTAL SCIENCES

DOE Biological and Environmental Research

MISSION: "The mission of the Biological and Environmental Research (BER) program is to support transformative science and scientific user facilities to achieve a **predictive understanding of complex biological, earth, and environmental systems** for energy and infrastructure security, independence, and prosperity."



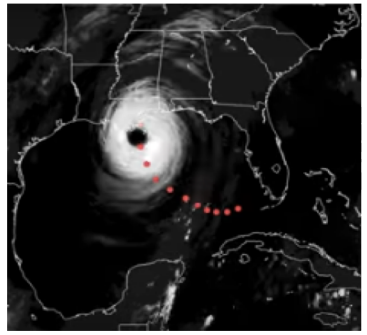
10^{-9} m



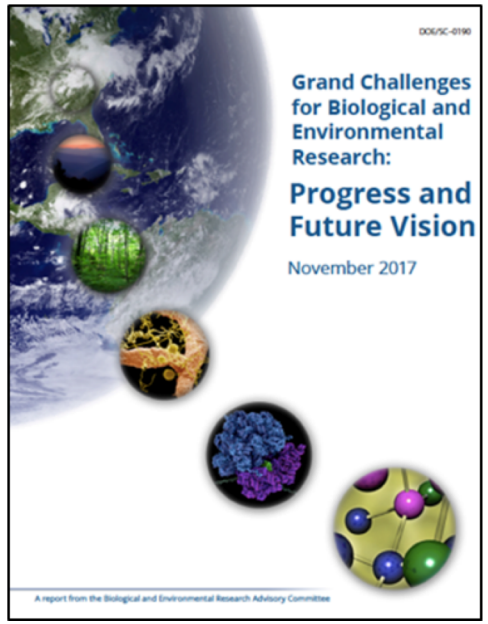
10^{-6} m

1m

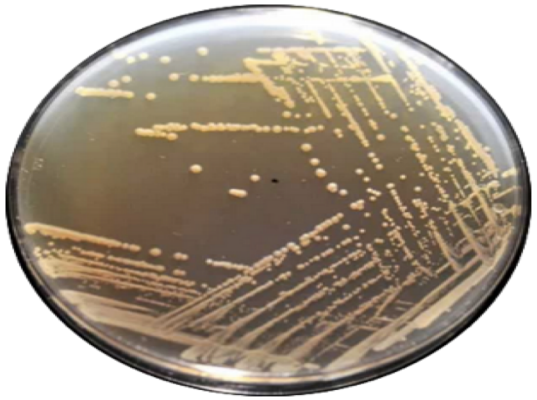
10^{3}m



10^{6}m



Microbes/plants in natural communities behave differently than those in lab culture



Lab Culture

≠

Communities

≠

Ecosystems

Current understanding of microbe-plant communities does not translate easily to the ecosystem level

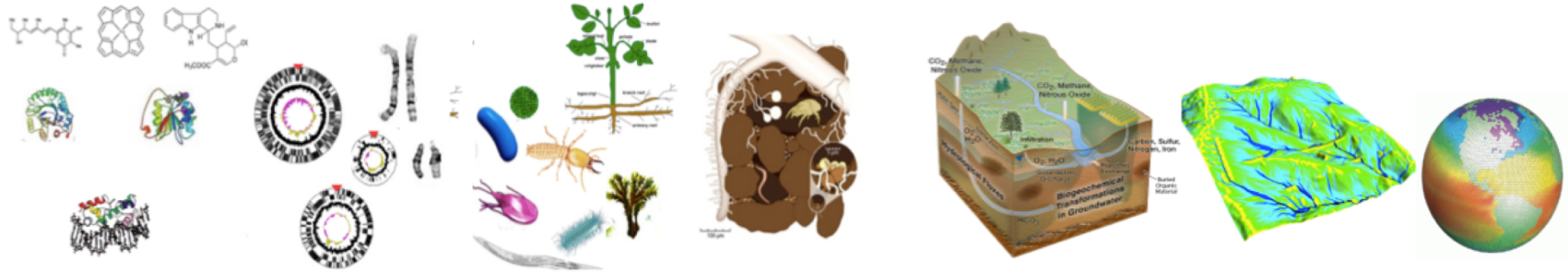
New tools to understand microbe-plant interactions in the environment

Isolate Culture | Communities | Ecosystems

for discovery/prediction of how the environment regulates plants and microbes and how they regulate the environment

BioEPIC will co-locate existing science programs

BER Systems



Molecules Genomes Organisms Soil & Communities Watersheds Ecosystems Atmosphere

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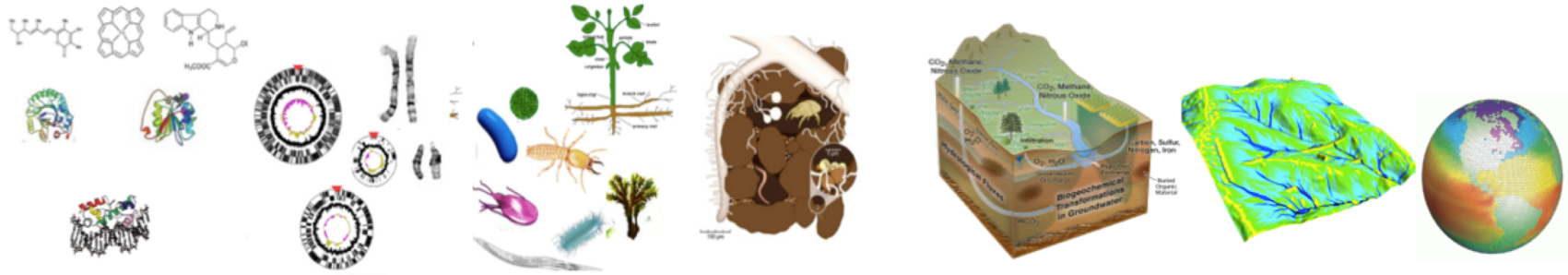
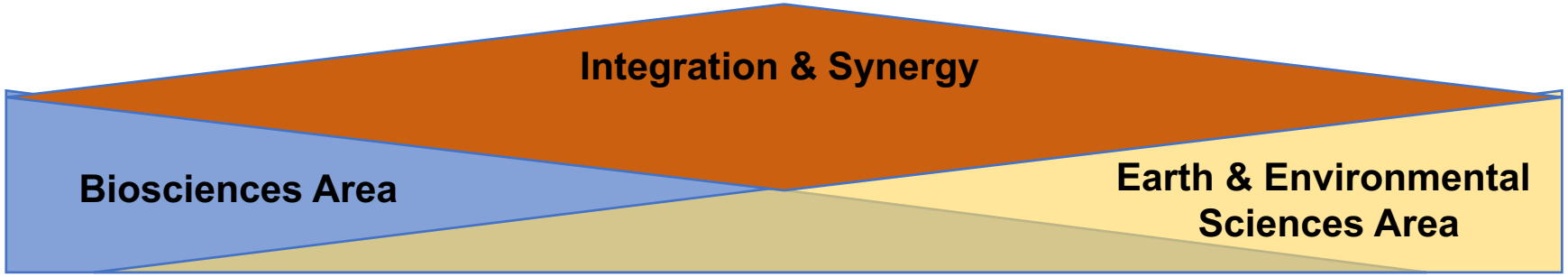
BioEPIC will co-locate existing science programs

BER Systems



Berkeley Lab Area

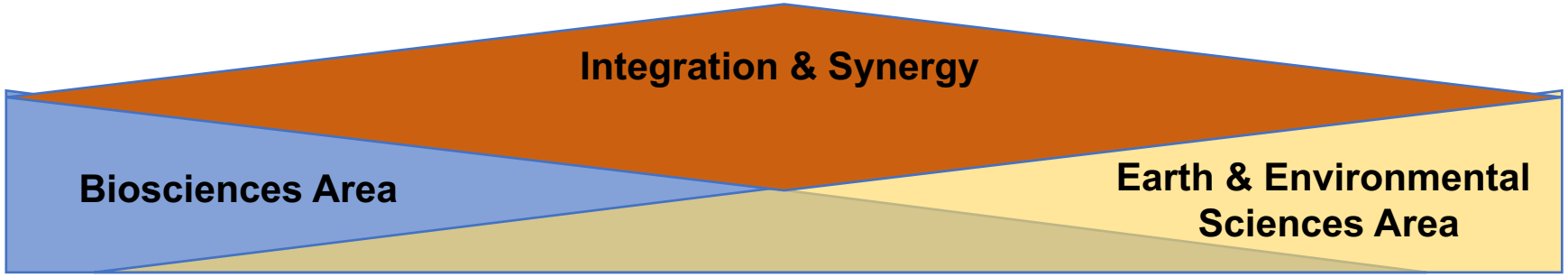


BioEPIC will co-locate existing science programs

BER Systems

Molecules | Genomes | Organisms | Soil & Communities | Watersheds | Ecosystems | Atmosphere

Berkeley Lab Area



BER SFAs In BioEPIC

ENIGMA — $12.3 M/yr

mCAFES — $1.6 M/yr

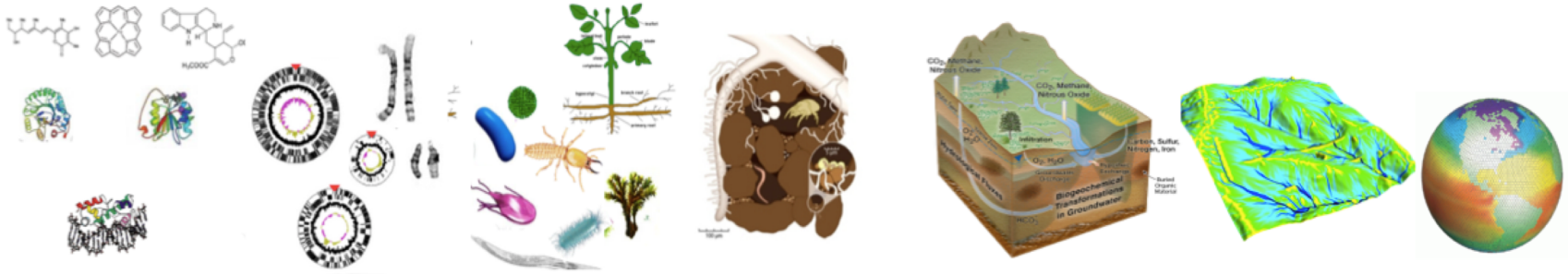
Belowground Biogeochemistry SFA — $1.1 M/yr

Watershed Scientific Focus Area — $6.8 M/yr

Total DOE BER funding to BioEPIC Scientific Focus Areas w/ Early Career Research Program (ECRPs): $23.8M/yr

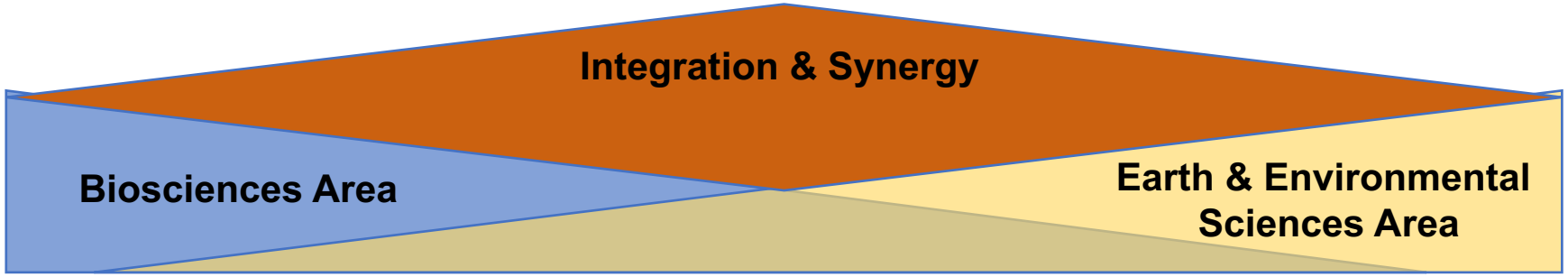
BioEPIC will co-locate existing science programs

BER Systems



Molecules | Genomes | Organisms | Soil & Communities | Watersheds | Ecosystems | Atmosphere

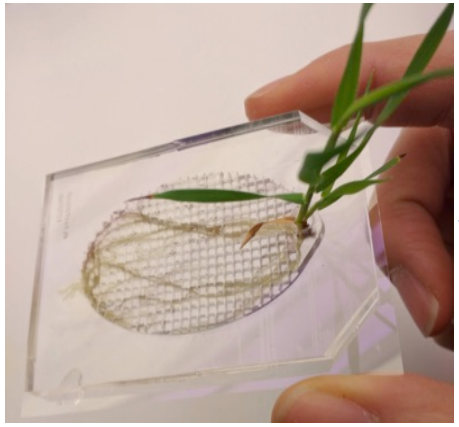
Berkeley Lab Area



BioEPIC Platforms

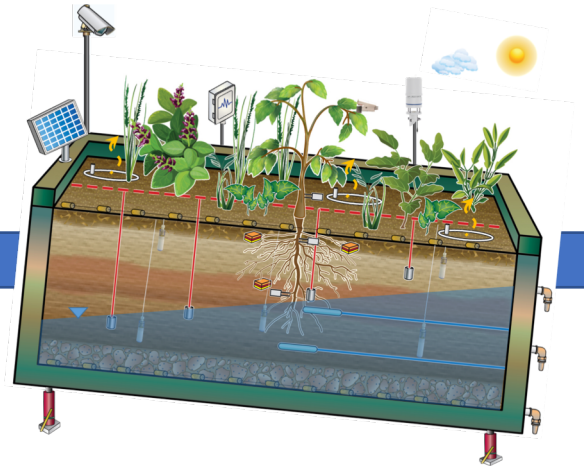
Mass Spec | CryoEM | EcoFABs | EcoPODs | SMARTsoils | Telemetry to/from Field

Interconnected experimental, sensing and simulation capabilities needed for predictive understanding of environmental-biological feedbacks across scales

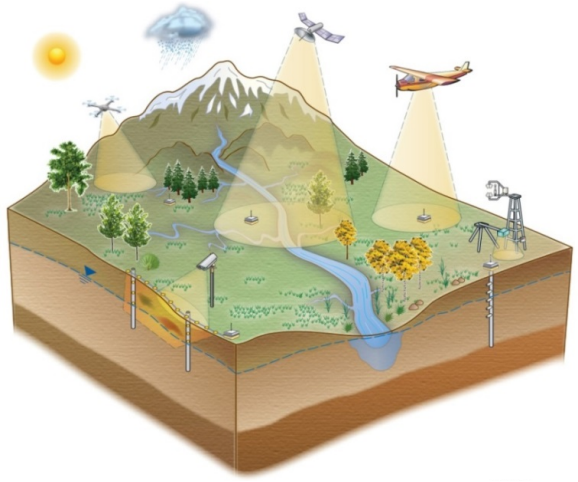


EcoFABs

EcoPODs

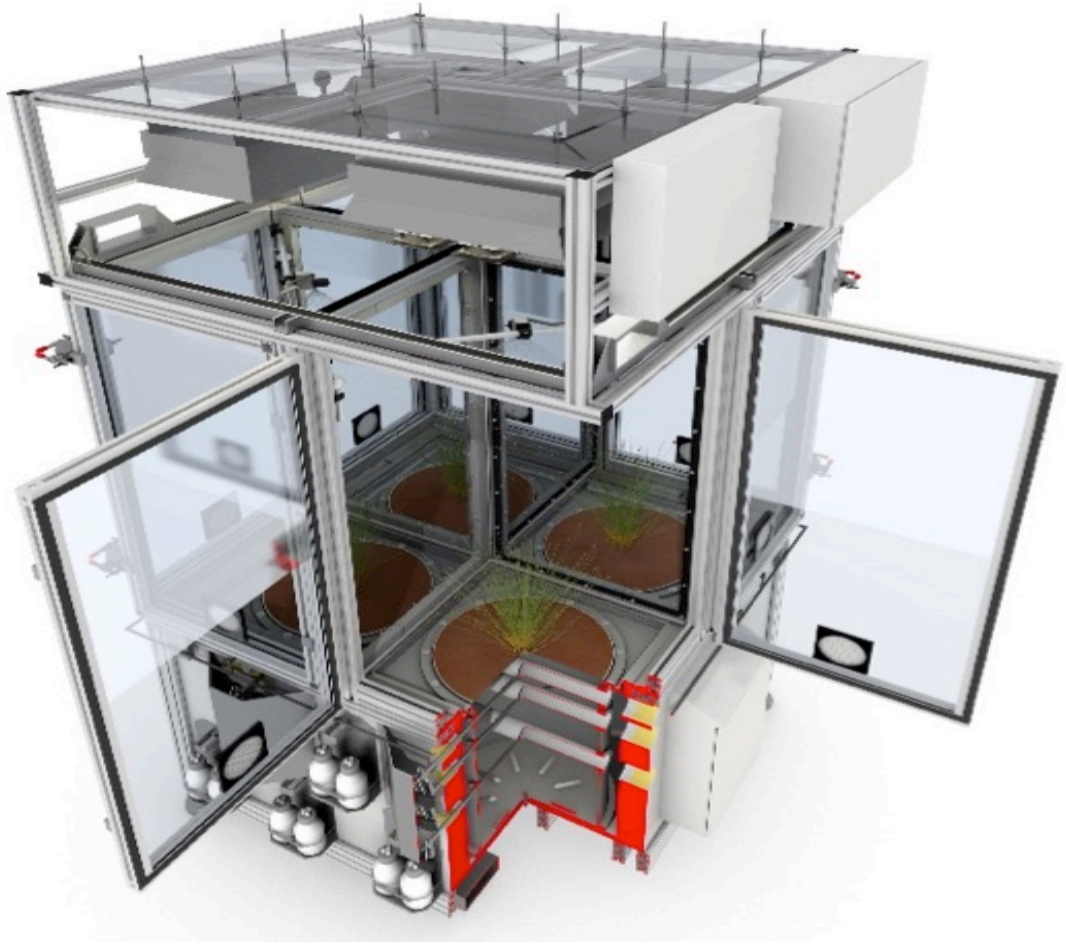


EcoSENSE
SMARTsoils
testbed



Field Testbeds

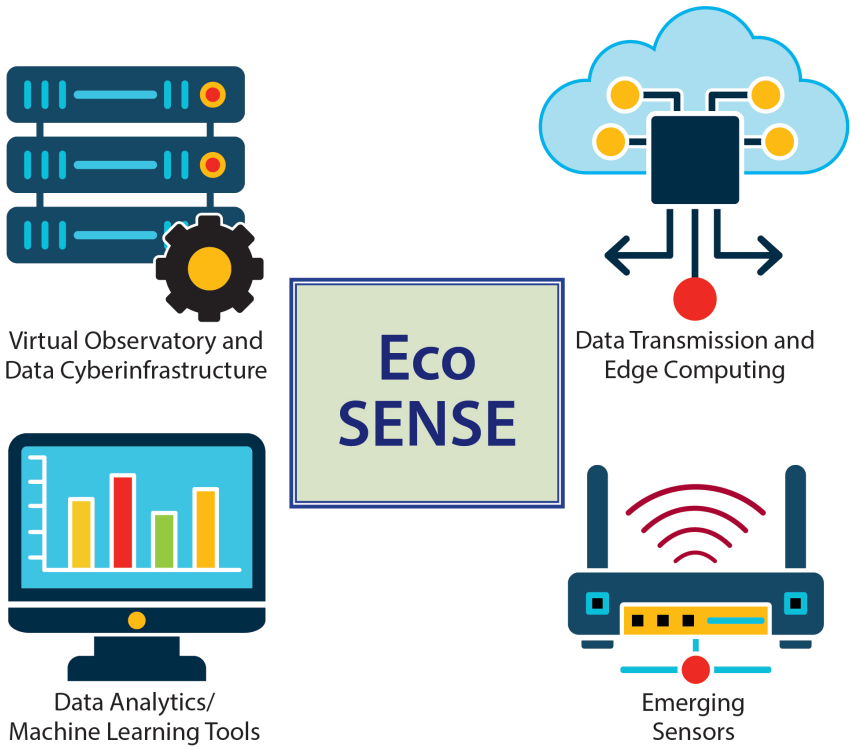
The EcoPod Program

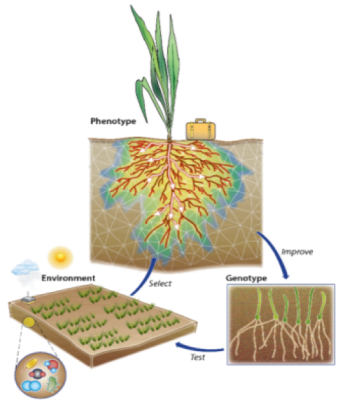


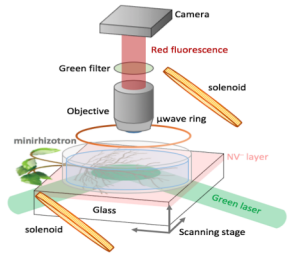
EcoPOD: Highly controlled environment for reproducible investigations of soil-microbe-plant systems that bridges between lab and field scales

The ECOSENSE Program

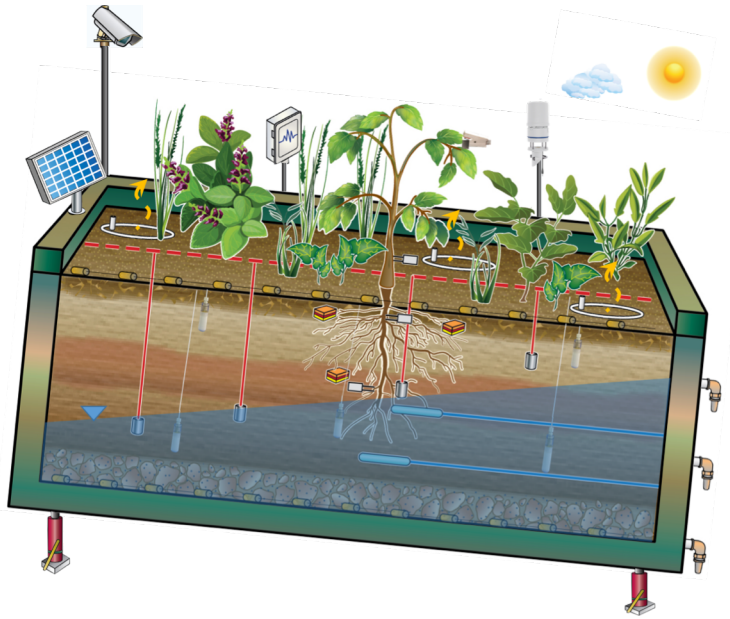
- **New sensing capabilities**
- **Data capabilities**
- **Analysis capabilities**
- World –first instrumented **‘Mesoscale’ SMART Soils** testbeds to explore soil-microbe-plant interactions under realistic yet controlled hydrobiogeochemical conditions and gradients







BERKELEY QUANTUM



SMART SOILS TESTBED

BioEPIC

The Biological and Environmental Program Integration Center

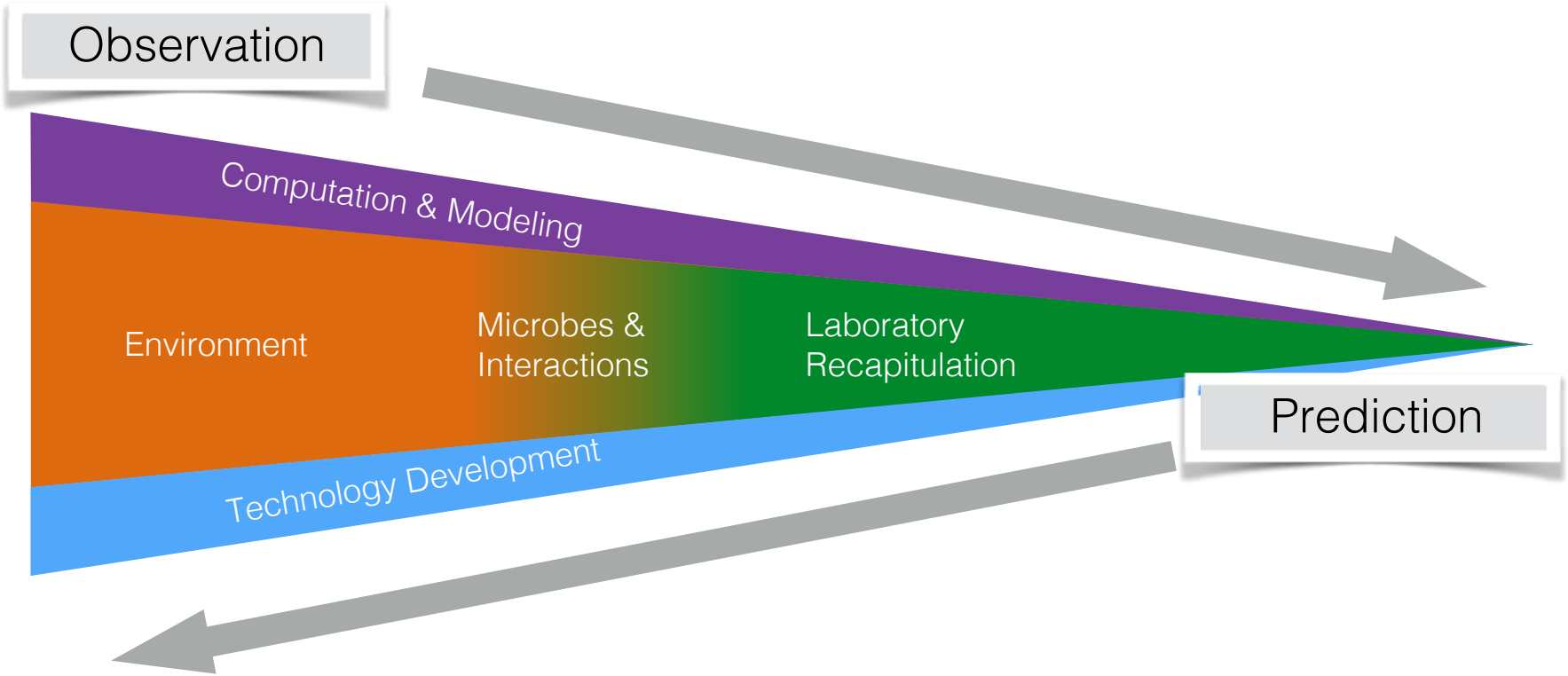
BioEPIC will transform scientists' ability to quantify how complex microbial interactions influence the environment across scales of space and time to solve critical national issues in **energy production, water resources, carbon cycling, and environmental stewardship**


Thank you

BioEPIC would transform scientists' ability to quantify how complex microbial interactions influence the environment across scales of space and time.

ENIGMA Science Focus Area Approach

- Microbes live in complex communities (microbiomes) whose activities play an essential role in many DOE-relevant environments
- How do microbial communities interact with environment to effect the movement/immobilization of toxic metal contaminants at the Oak Ridge Field Research Center?



mCAFEs Program Vision

Plants select and interact with microbes from soil communities in ways that are essential for plant growth, health and response to stresses.

VISION: *To develop foundational tools and understanding required to predict, alter, and design grass rhizosphere communities impacting DOE missions*

Overarching Science Question: *How do molecular factors determine grass rhizosphere community structure, spatial organization, activities, and responses to perturbations?*

Watershed Function SFA:

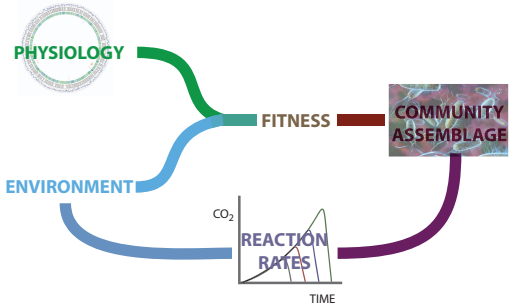
How do plant-microbe-mineral interactions influence how mountainous watersheds retain and release water, nutrients, carbon and metals?

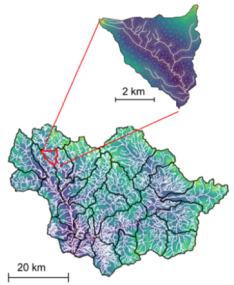
When, where and how fine-scale processes drive hydrobiogeochemical cycles?

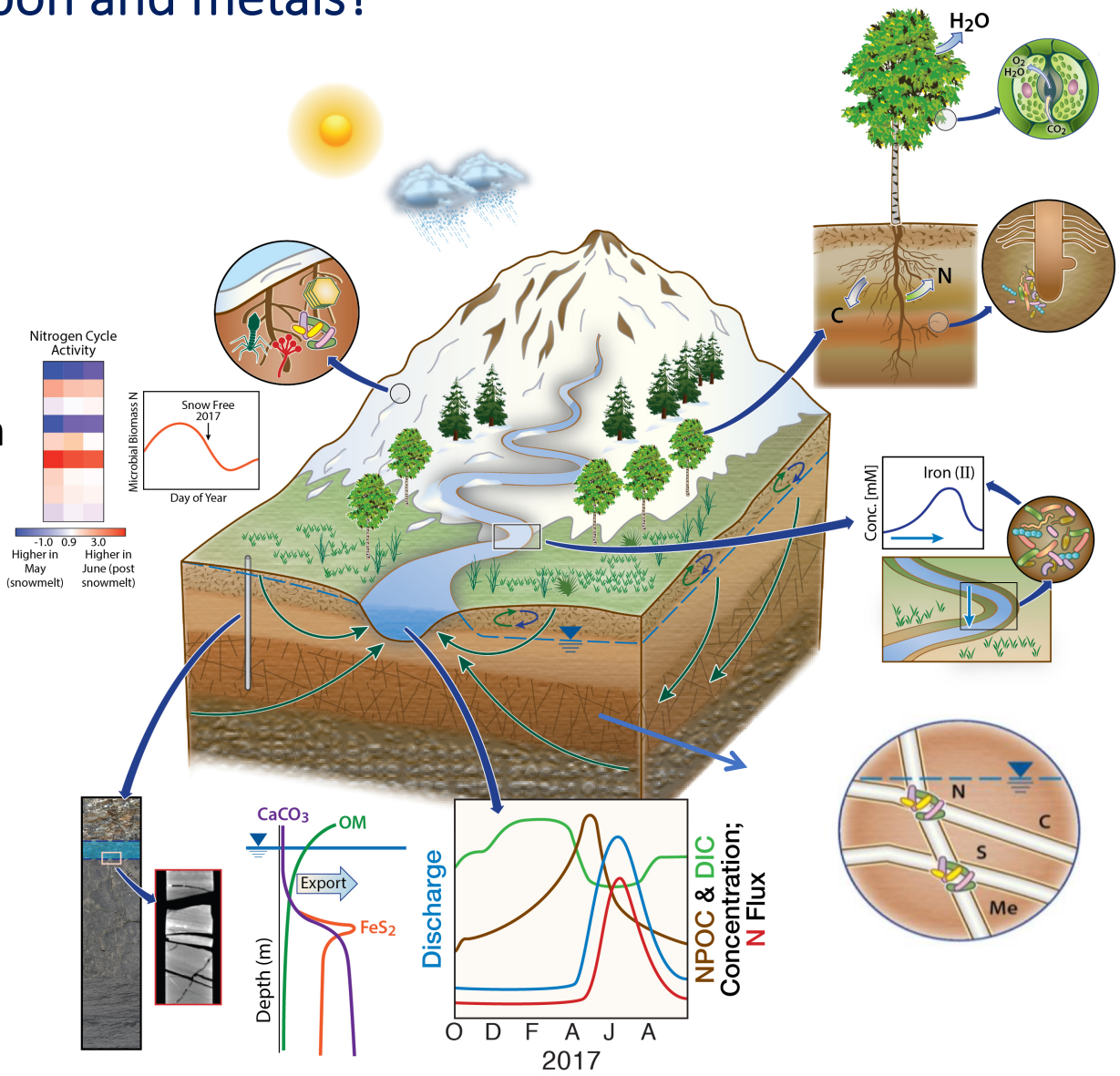
How will interactions change with perturbation?

Approaches:

- **New Laboratory Technologies** to quantify interactions in fine detail and under controlled environmental stress
- **4D Watershed: Omics to Satellites –** extreme scale sensing, from bedrock to canopy and from molecular to watershed scales
- **Toward exascale watershed modeling and AI** to rapidly simulate biological-environmental feedbacks and aggregation

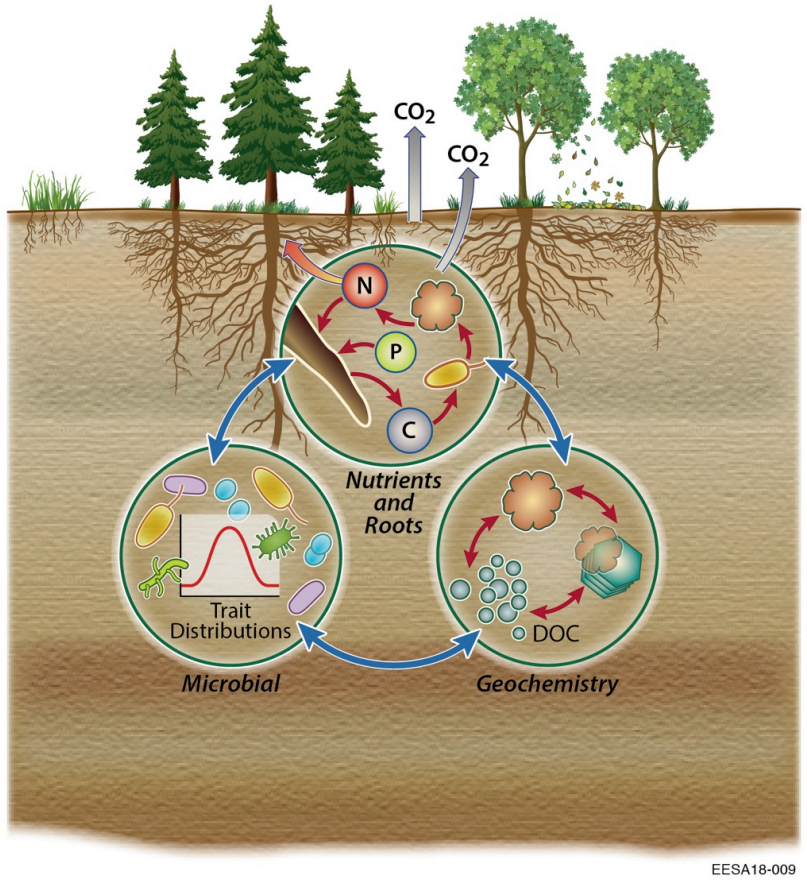






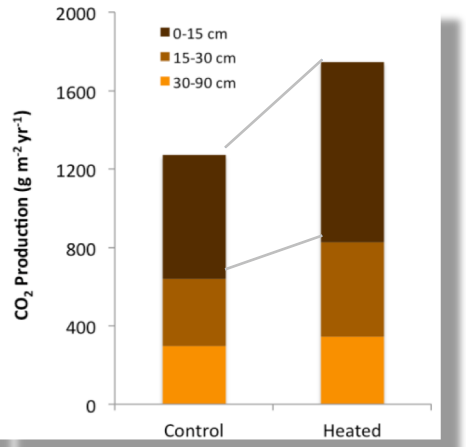
Belowground Biogeochemistry SFA: Scaling complexity

What will be the role of soils in terrestrial feedbacks to atmospheric and climatic changes over the next 100 years?



Deliverables & Approach.

- Integrated lab and field experiments and modeling
- Development of robust, generalizable tools for understanding and predicting soil biogeochemical response to global change across spatial and temporal scales



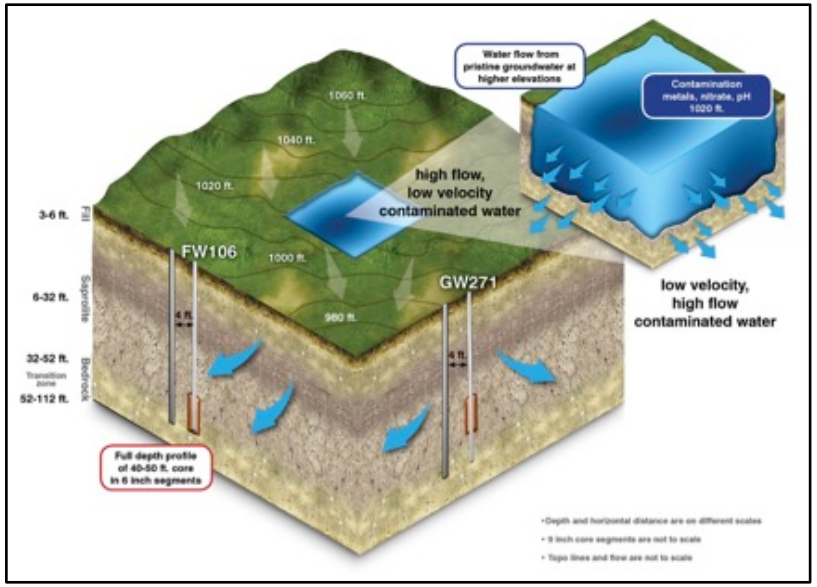
ENIGMA Science Infrastructure

ENIGMA has created a unique research platform to construct predictive computational models of microbiome assembly and activity

Field | Laboratory | Computation/Modeling

Take groundwater samples from the
Oak Ridge Field Research Center

Determine microbial genomic information



Characterize microbes and molecules using high throughput technologies

Use computational tools to develop predictive computational models to develop hypotheses for further testing to understand microbial ecology

BioEPIC will:

Co-locate DOE BER's Biological and Environmental SFA researchers and Early Career Research Program PIs with each other and near other Berkeley Lab facilities and expertise

Enable the development of world-first **interconnected experimental, sensing and simulation infrastructure** to quantify and manipulate biological and environmental processes

- from molecules to ecosystem
- from nanoseconds to decades

Cultivate an interdisciplinary Next Generation of BioEPIC Scientists

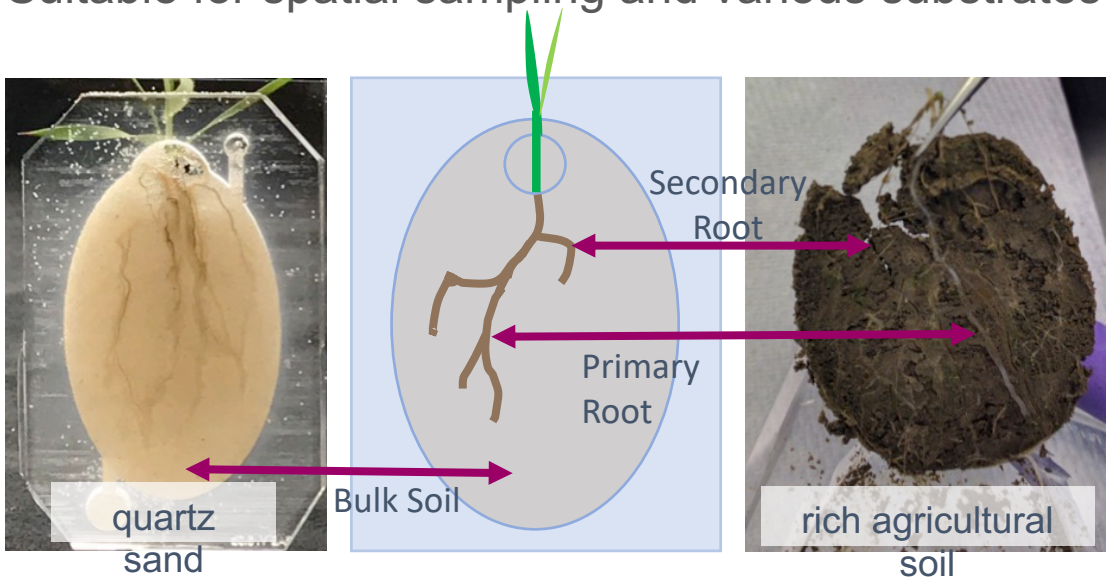
Enable transformative discoveries about how biology shapes the environment and how the environment shapes biology

Thank You

Questions?

mCAFEs' Technology: EcoFABs Fabricated Ecosystems for testable ecology in the laboratory

Suitable for spatial sampling and various substrates



Fabricate using 3D printer

↓

Add/subtract soil, microbial, plant components

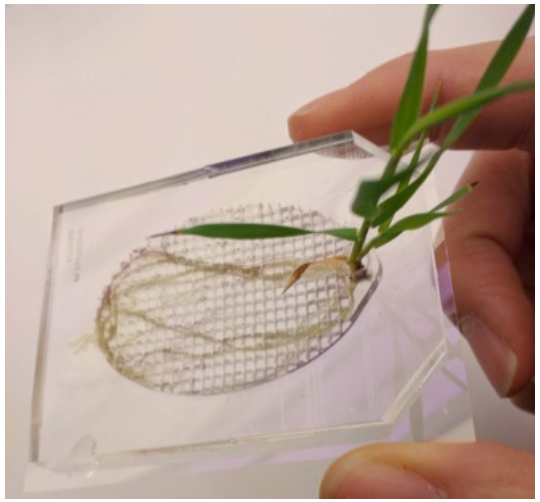
↓

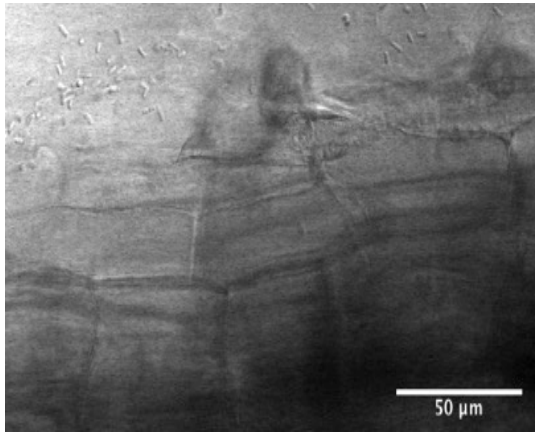
Analyze

↓

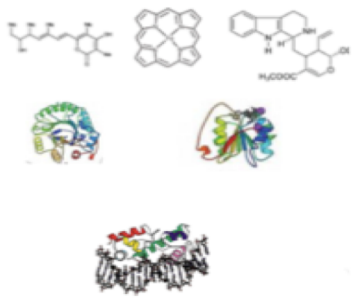
Discover microbial ecology insights

High-resolution imaging of plant roots/ microbes

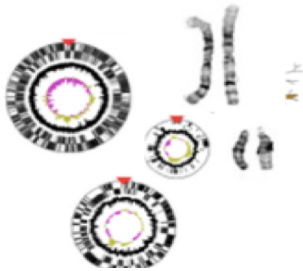




BioEPIC: Specialized space to house new capabilities



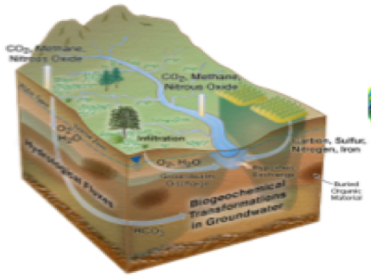
Molecules



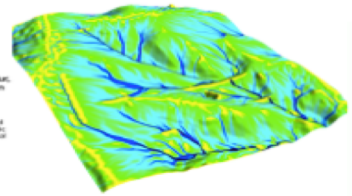
Genomes

Organisms

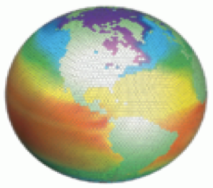
Communities



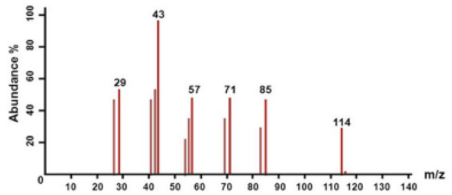
Watersheds



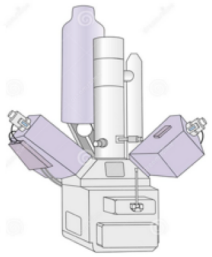
Ecosystems



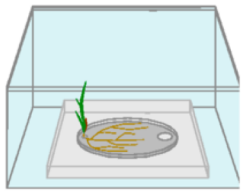
Atmosphere



Mass Spec

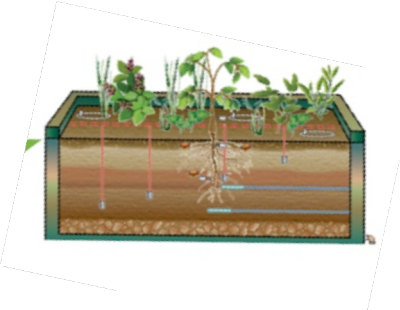


CryoEM

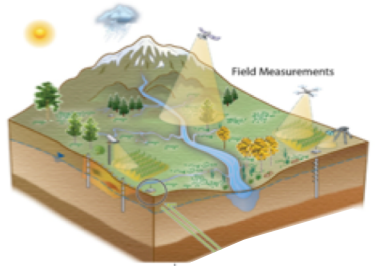


EcoFABs

EcoPODs



SMARTsoils



Sensors & Telemetry

BioEPIC Summary

Co-location, co-location, co-location!

- SFA Principal Investigator lab groups all together with BER Early Career Research Program PIs
- Potential interactions between SFAs and ECRPs
- Strengthens Berkeley Lab's bio-environmental-computing concentration

Proximity to other Berkeley Lab assets and expertise

- *Joint Genome Institute, National Energy Research Scientific Computing, Advanced Light Source, Molecular Foundry*

Development of specialized & interconnected capabilities in BioEPIC and with Field Sites

- *Sensor development, EcoSENSE including SMART Soils, EcoFABs, EcoPODs, EcoSim, Virtual Field Testbeds*

Purpose-built laboratory spaces

- Biosafety Level 2 lab, high throughput robotic systems, cryoEM

Platform for enabling transformative discoveries *about how biology shapes the environment and how the environment shapes biology*