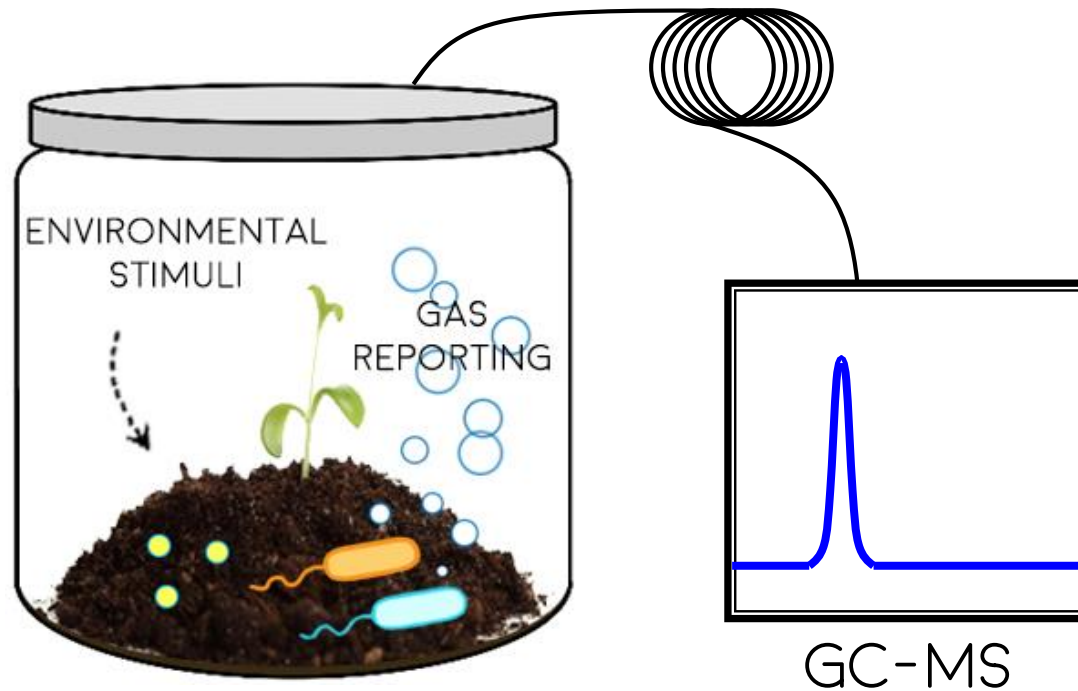


ENGINEERING SOIL MICROBES AS ENVIRONMENTAL BIOSENSORS

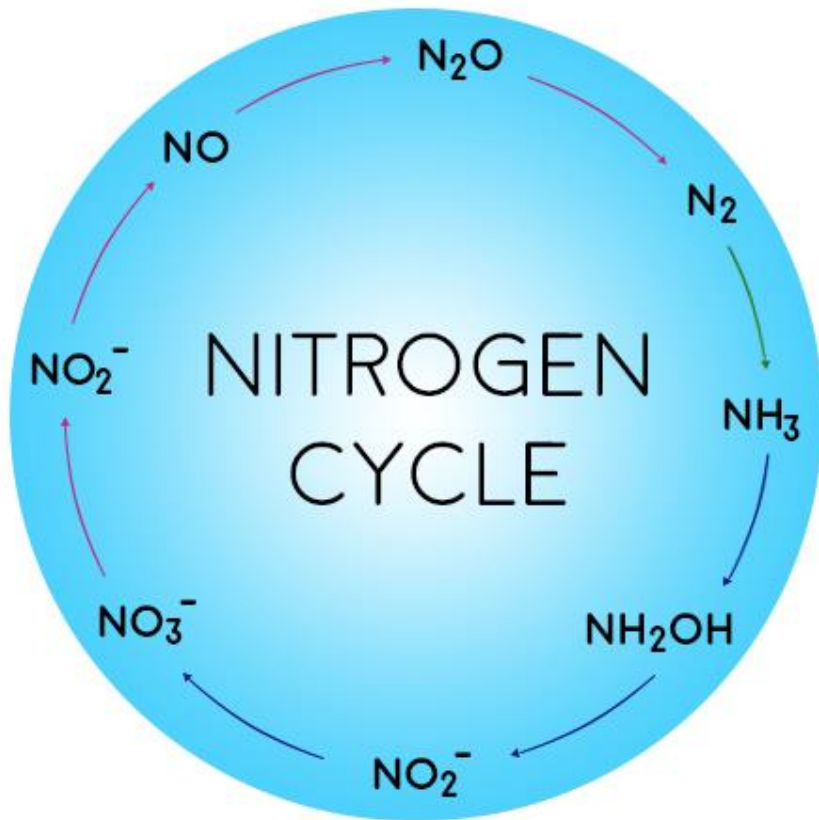
Synthetic biology can be used to develop tools needed to study the environmental microbiome and how it responds to biogeochemical change



Lin Boynton^{2,3}, Hsiao-Ying Cheng¹, Ilene Del Valle³, Joff Silberg^{1,3}, Caroline Masiello^{2,3}

¹Bioengineering, ²Earth Science and Chemistry, ³BioScience, Rice University, Houston, TX

The biogeochemical cycles are currently undergoing major change



Carbon Dioxide



Ammonia



Nitrogen Oxides



Nitrous Oxide

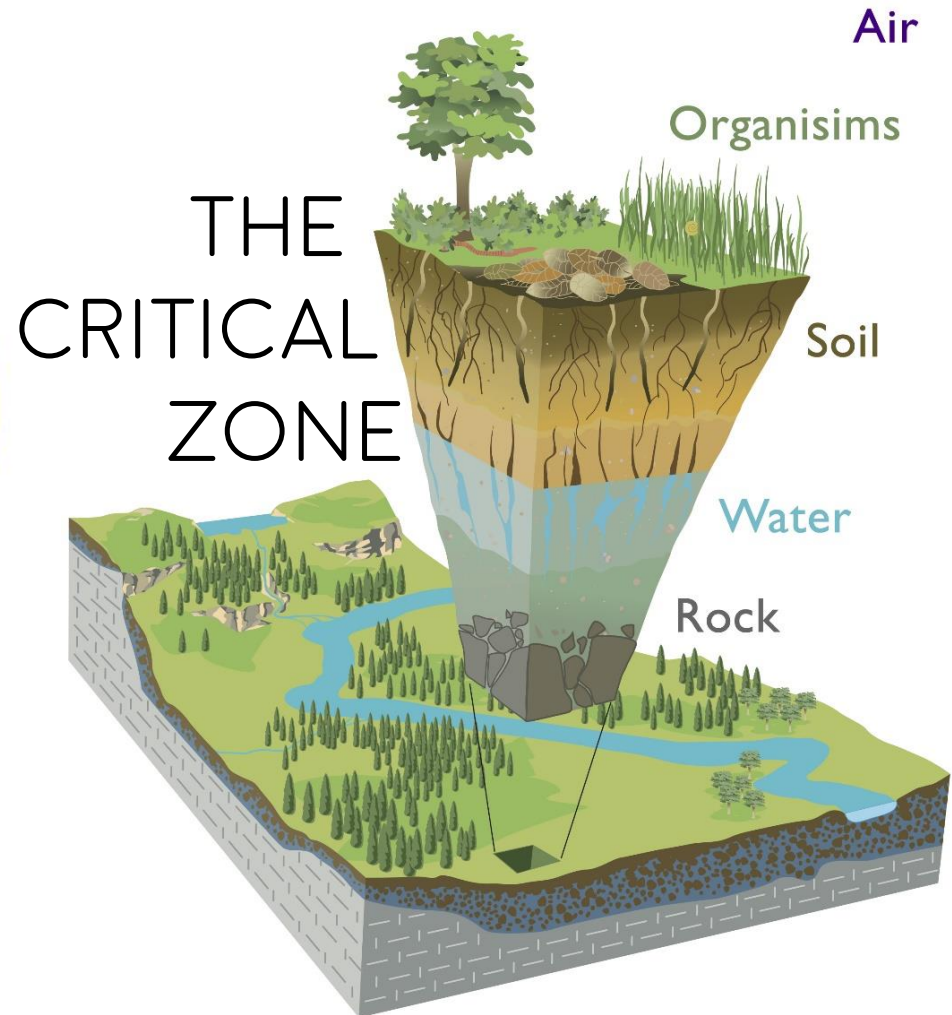
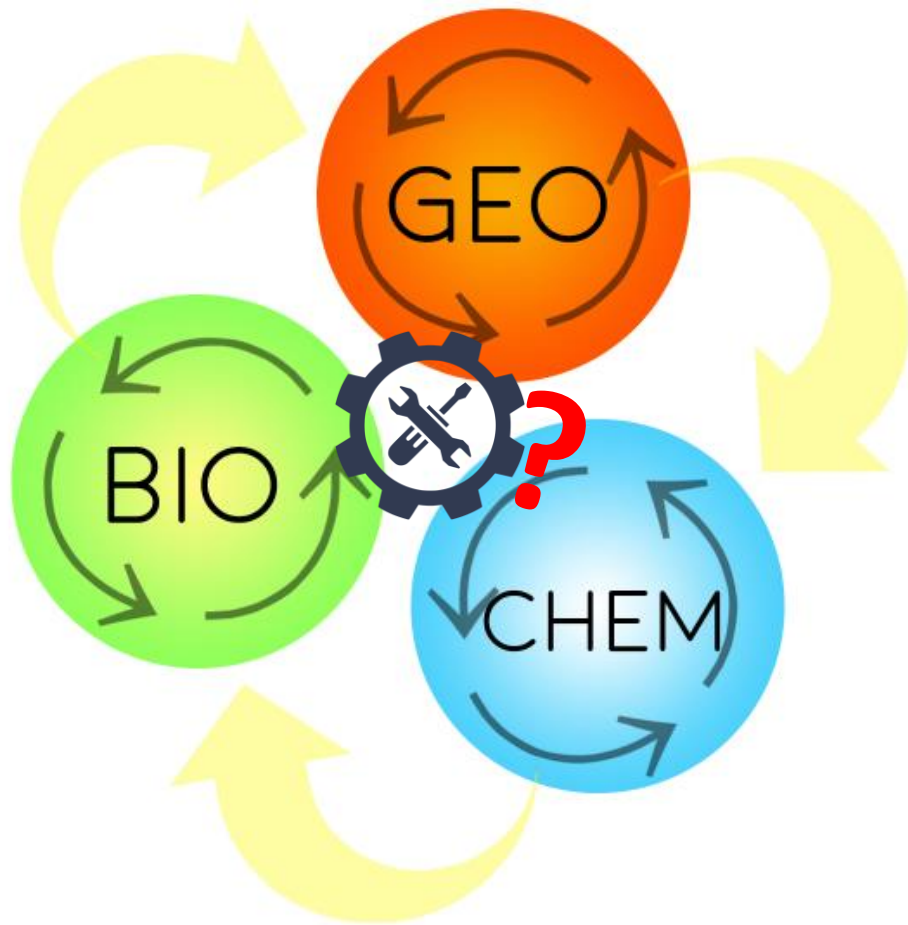


Ozone



Sulfur Dioxide

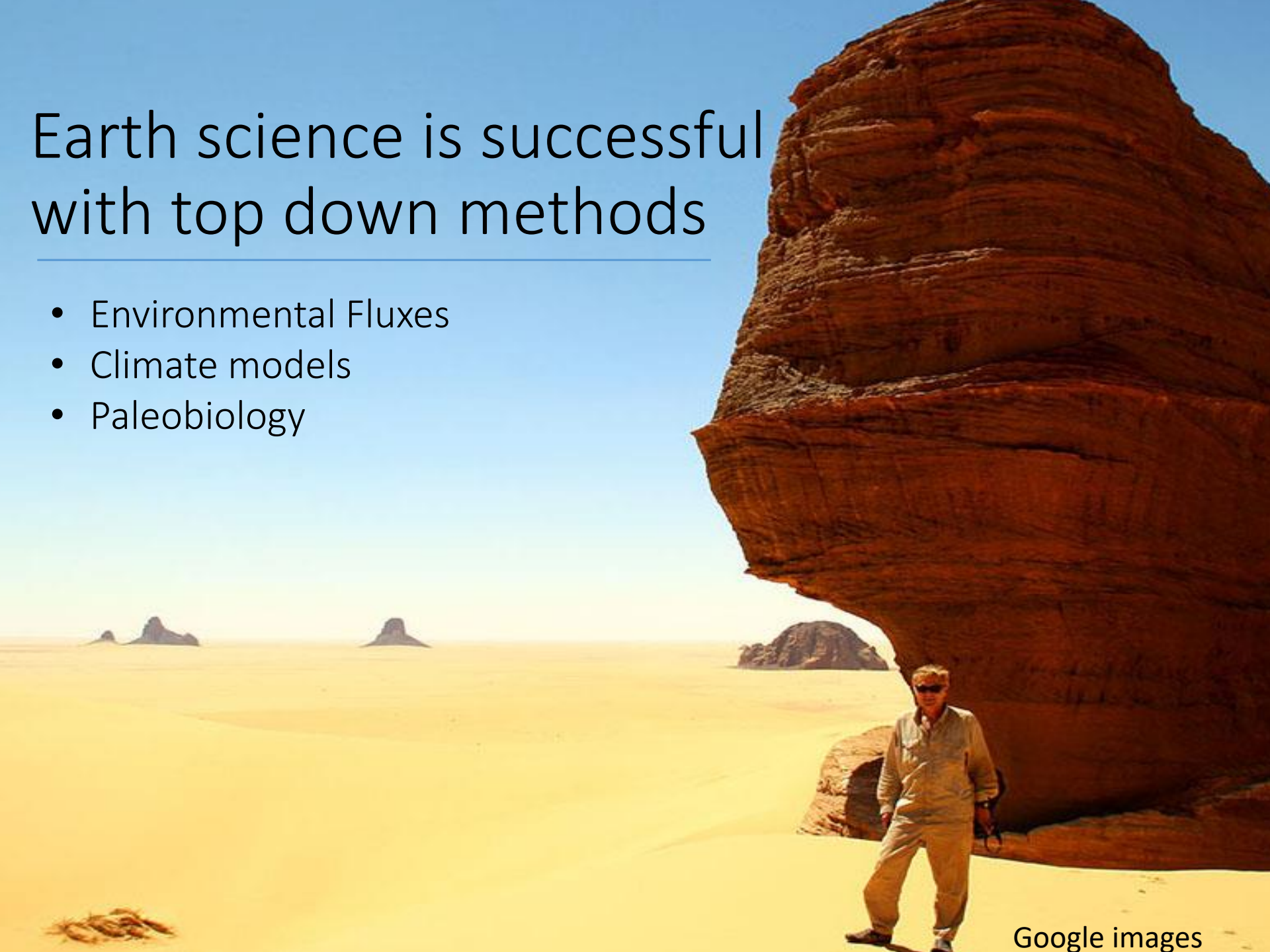
Interdisciplinary tools are needed to characterize biogeochemical interactions



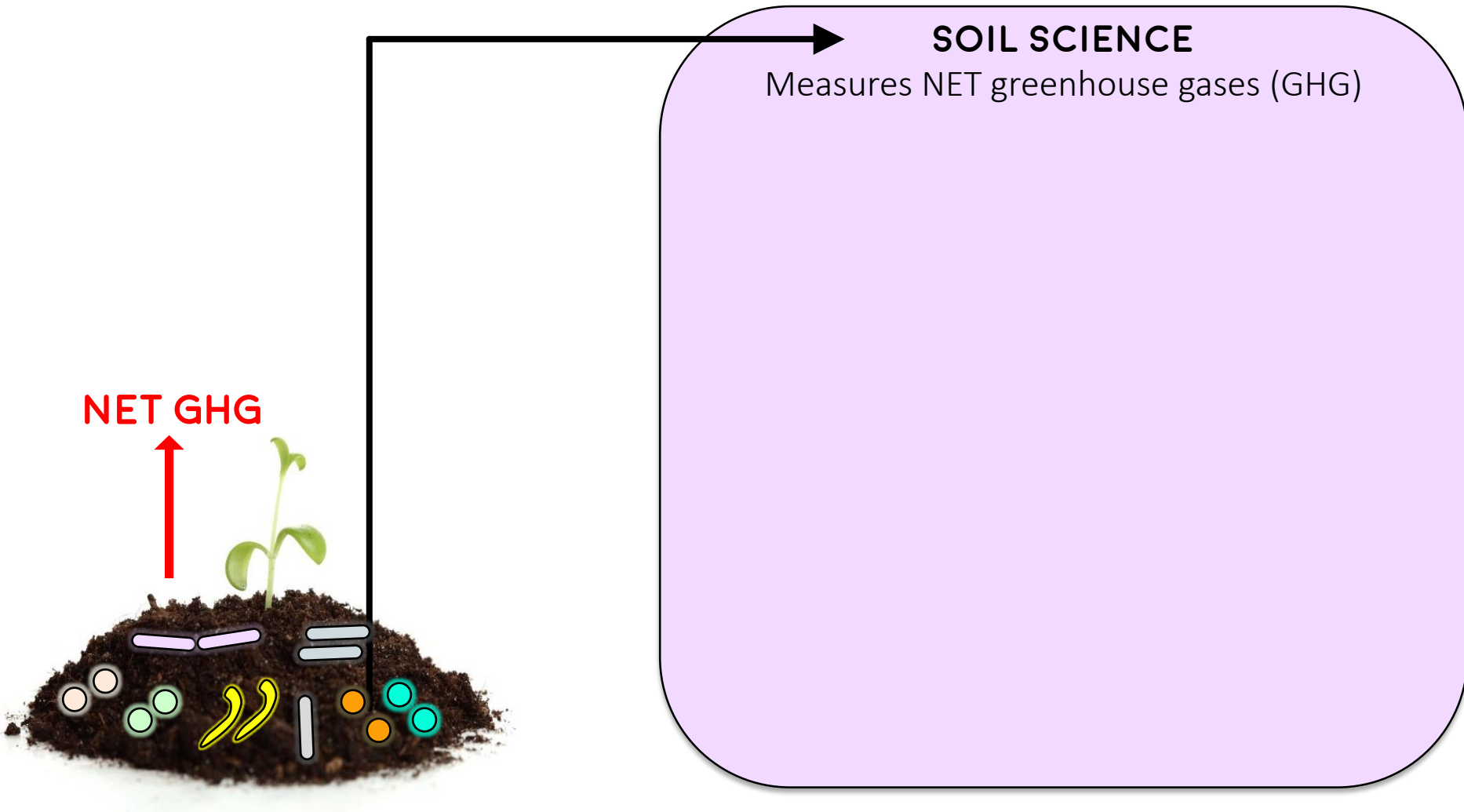
After Chorover et al, Catalina-Jemez CZO

Earth science is successful with top down methods

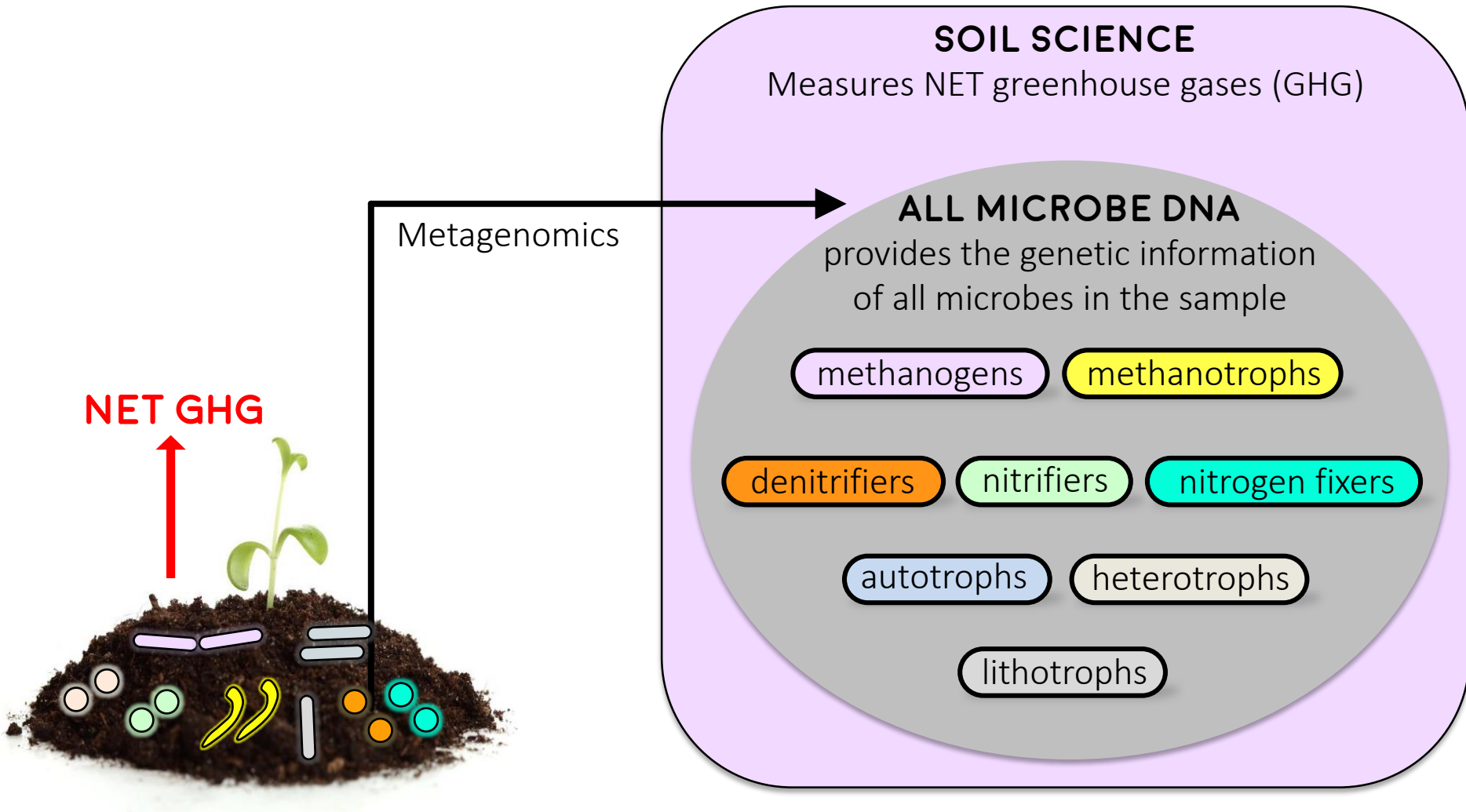
- Environmental Fluxes
- Climate models
- Paleobiology



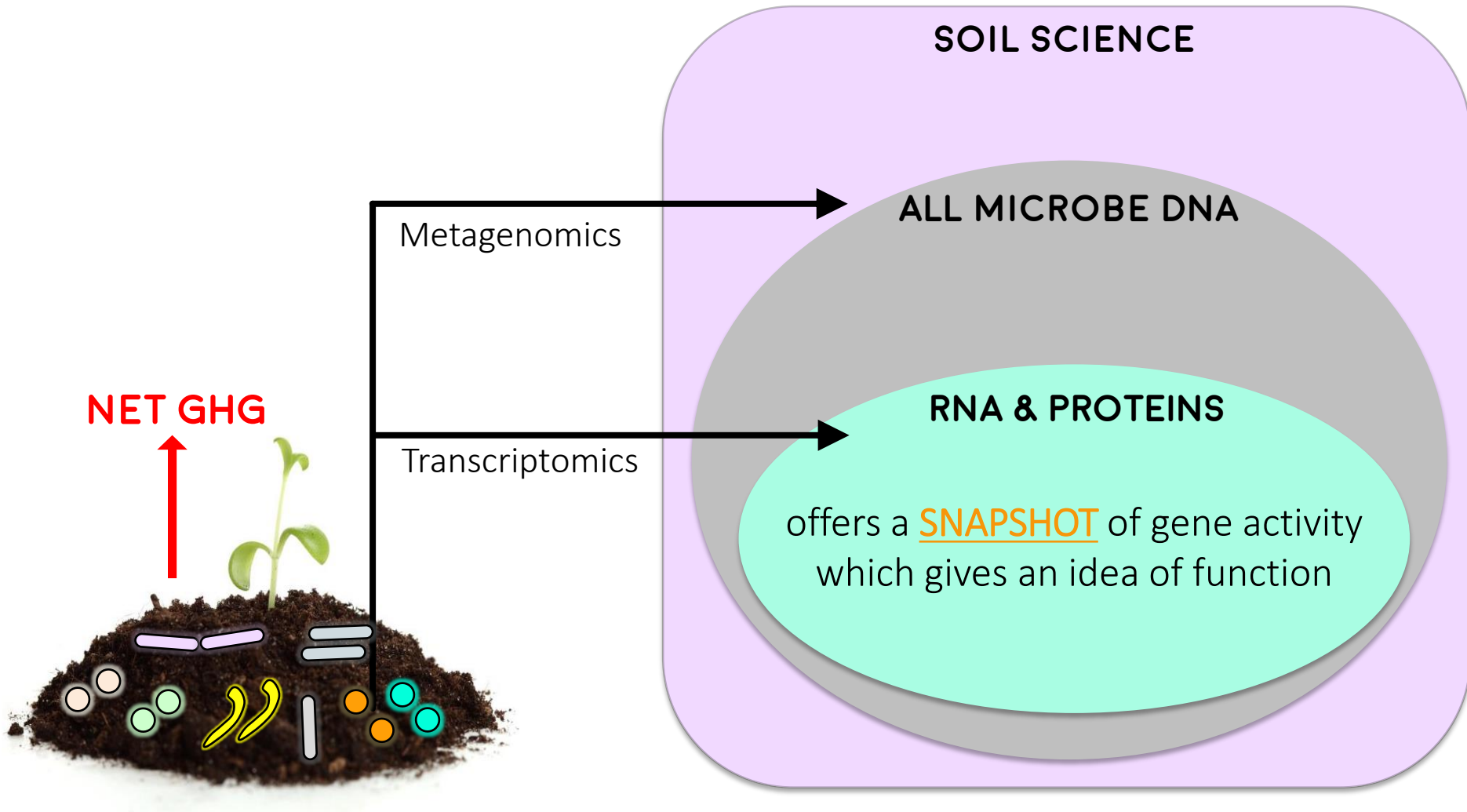
Metagenomics has begun to address environmental microbiology questions



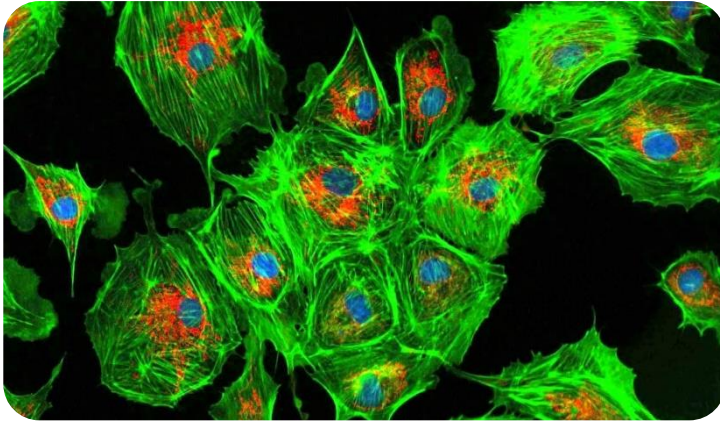
Metagenomics has begun to address environmental microbiology questions



Metagenomics has begun to address environmental microbiology questions



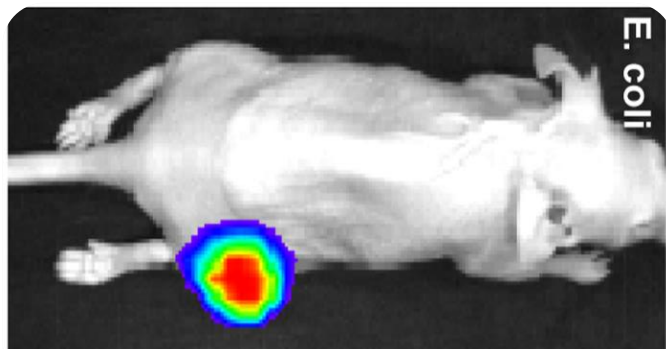
Visual reporting methods not useful for nontransparent environmental samples



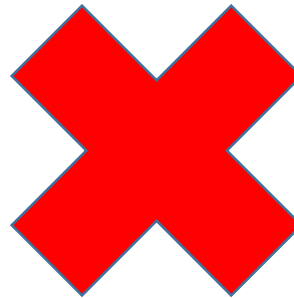
FLUORESCENCE



SOIL SAMPLES



BIOLUMINESCENCE

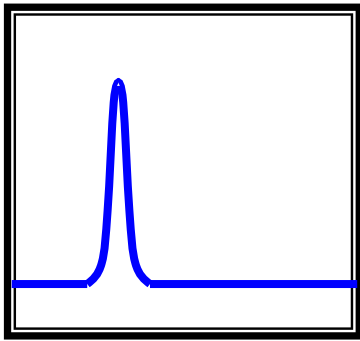


usgs.gov

WATER SAMPLES

Microbial biosensors are a solution to biogeochemical challenges

GC-MS



CHEMISTRY



Trace Gas

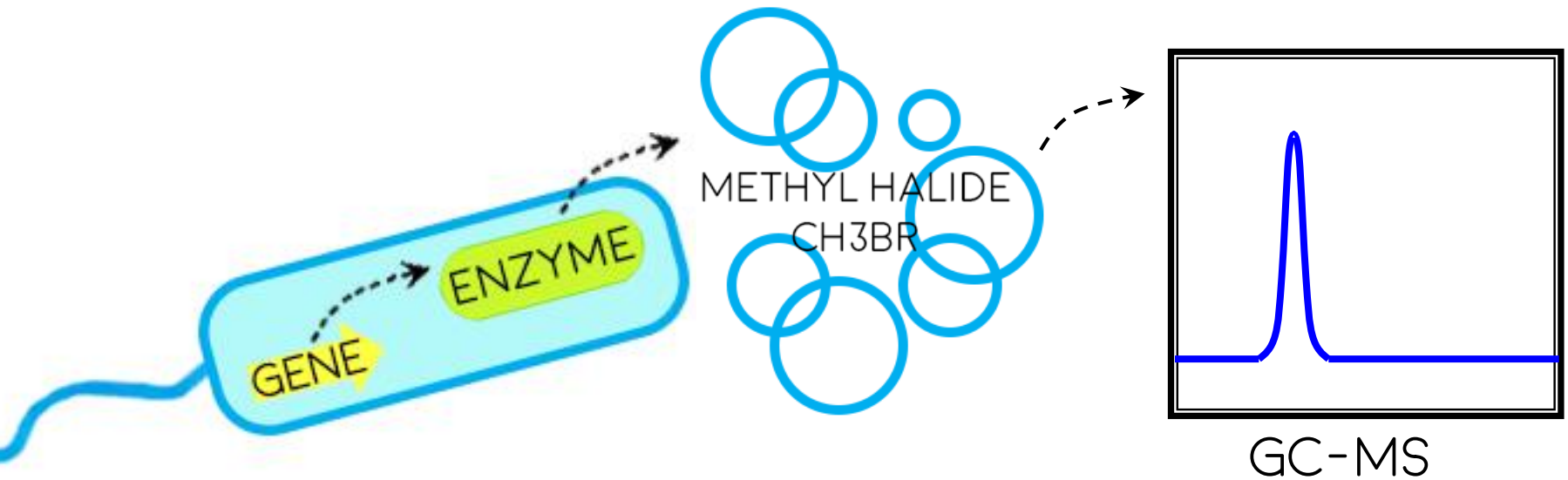
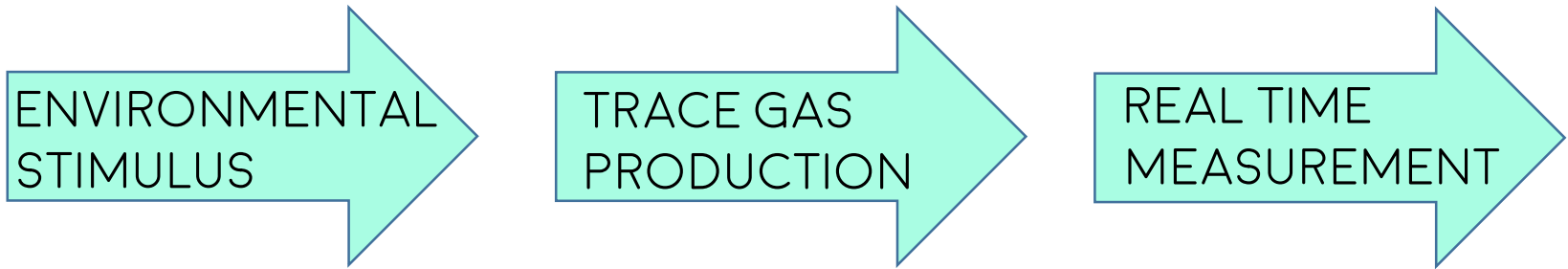
METHYL HALIDE
 CH_3Br

BIOLOGY

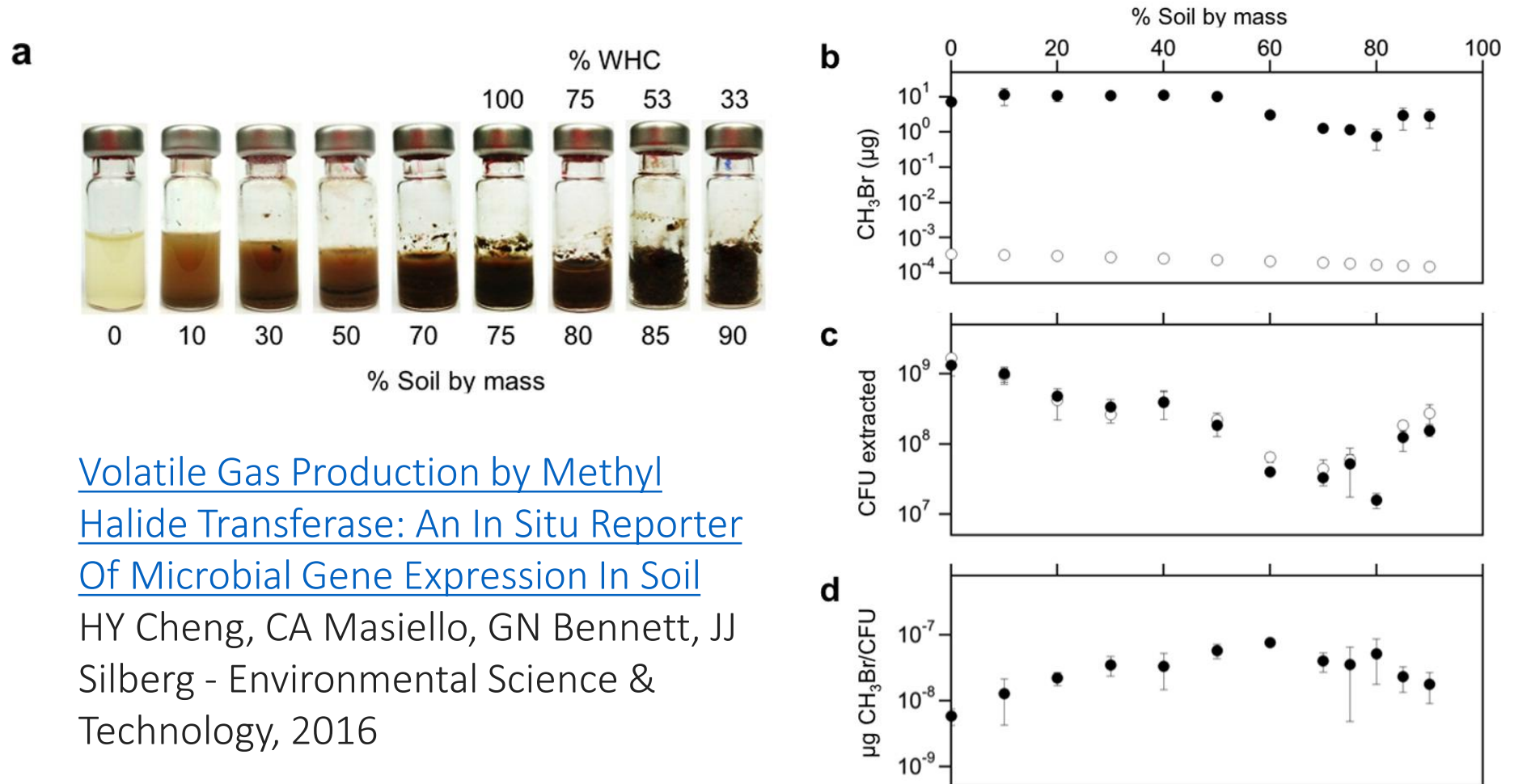
GEOLOGY



Microbial biosensors use gas reporting



POC in *E. coli* shows good signal in environmentally relevant conditions



[Volatile Gas Production by Methyl Halide Transferase: An In Situ Reporter Of Microbial Gene Expression In Soil](#)

HY Cheng, CA Masiello, GN Bennett, JJ Silberg - Environmental Science & Technology, 2016

THE
DESIGN

POC

THE
MICROBE

IT WORKS

THE IDEA

THE
FUTURE

Pseudomonas stutzeri is ideal for engineering a biogeochemically important biosensor

- *P. stutzeri* is a gram negative, denitrifying bacterium
- Important in the N cycle



- Quick and easy to culture and manipulate
- Common in soil environments



THE
DESIGN

POC

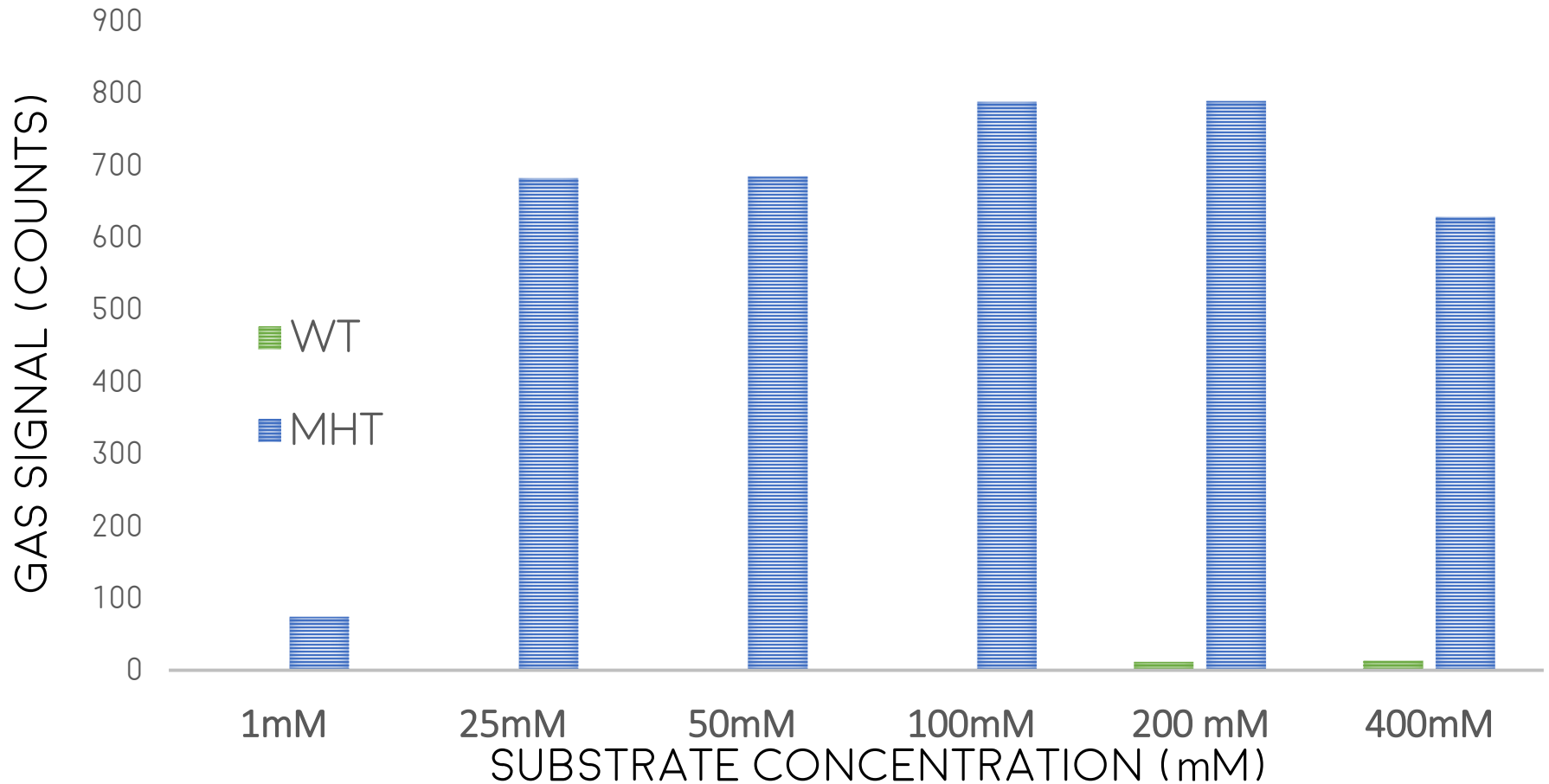
THE
MICROBE

IT WORKS

THE IDEA

THE
FUTURE

Good signal at environmentally relevant concentrations of substrate in *P. stutzeri*



THE
DESIGN

POC

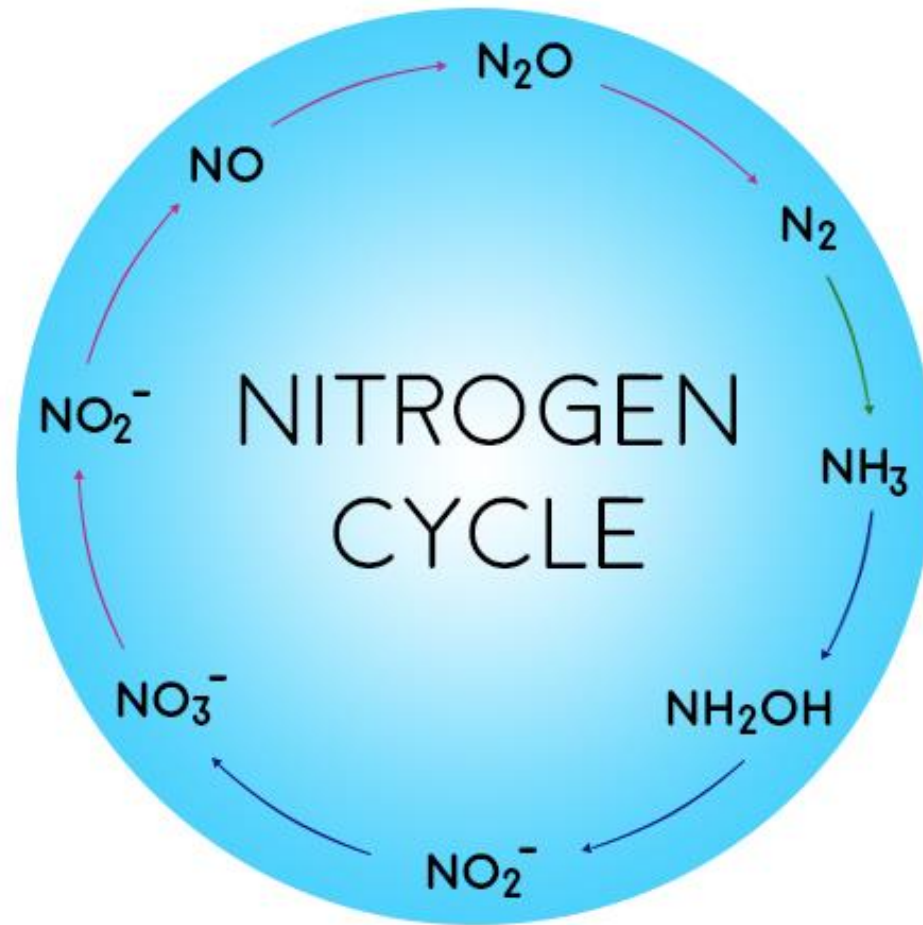
THE
MICROBE

IT WORKS

THE
IDEA

THE
FUTURE

Microbial biosensors are a way to trace biogeochemical processes in the N cycle



THE
DESIGN

POC

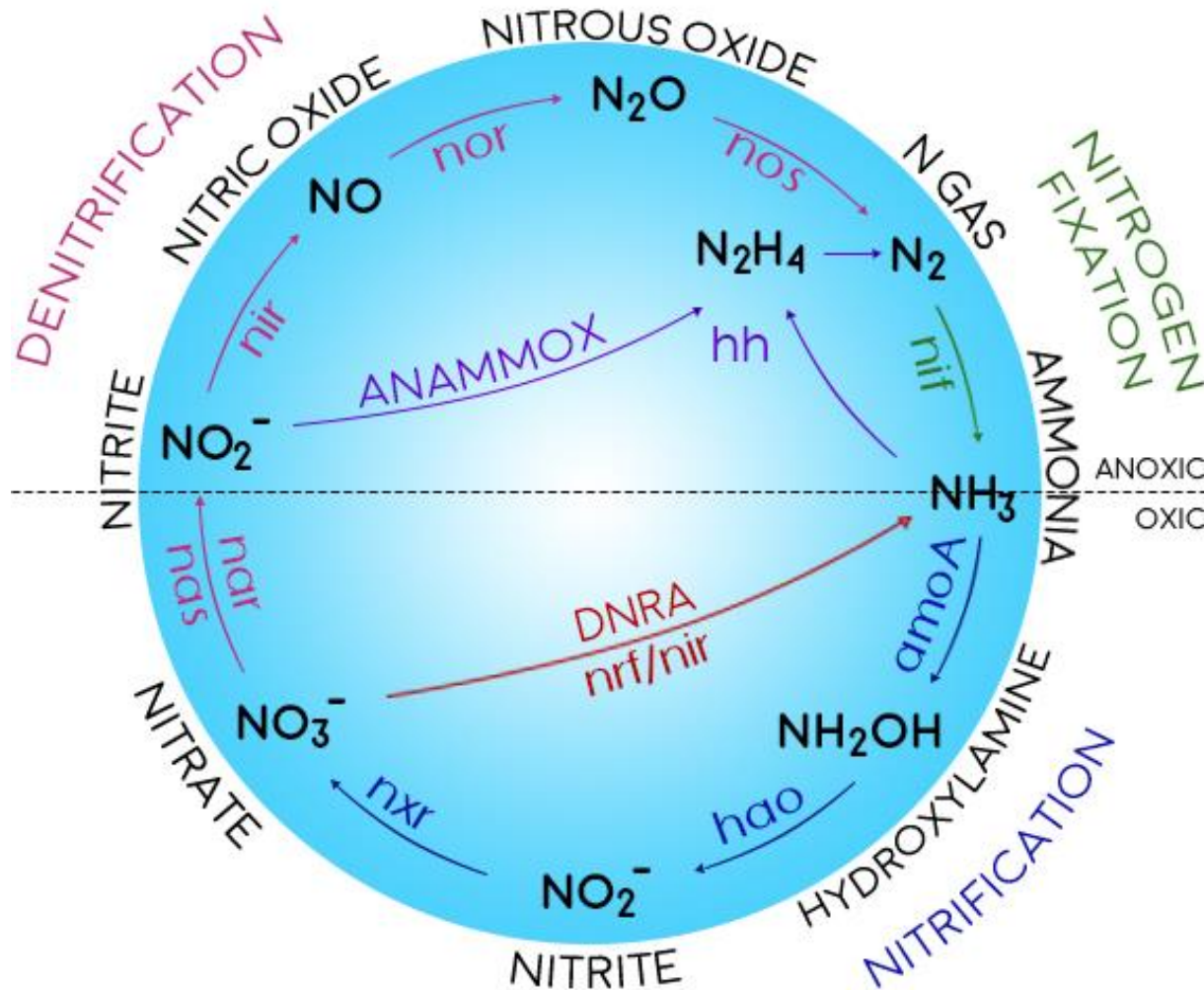
THE
MICROBE

IT WORKS

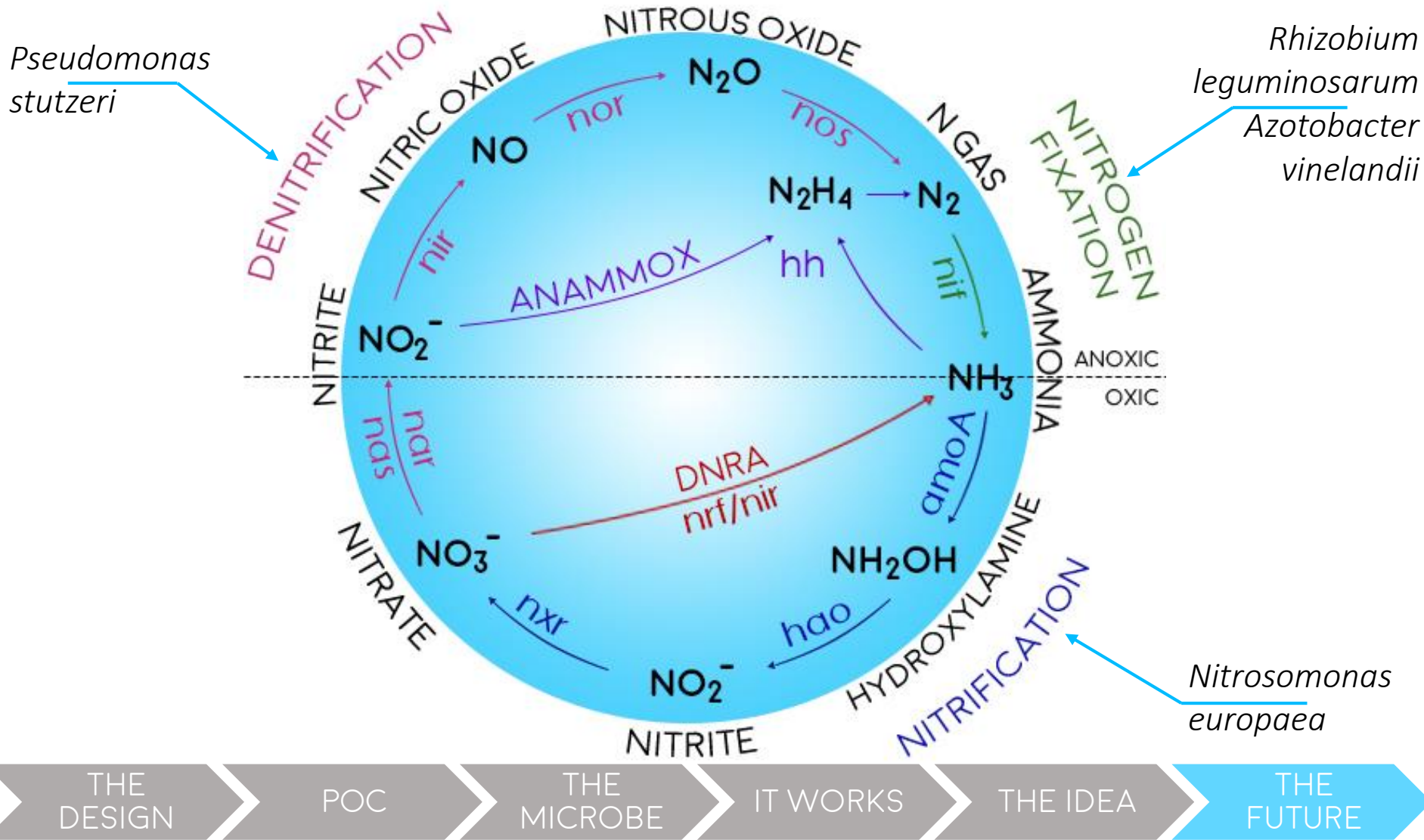
THE IDEA

THE
FUTURE

The chemistry of the N cycle is well studied;
biology beginning to be better understood



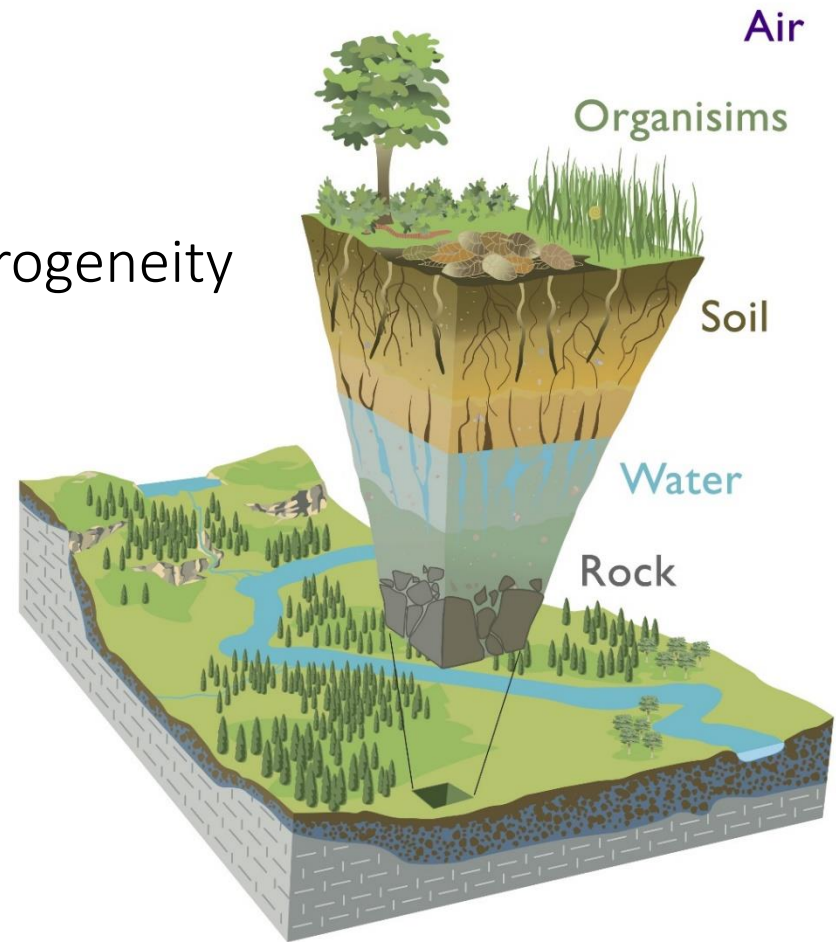
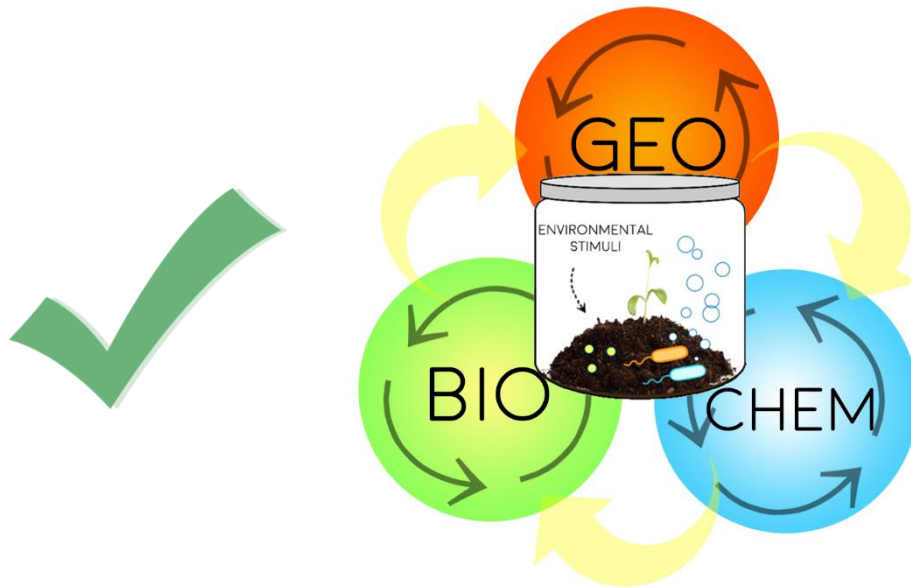
We are targeting a comprehensive microbial tool kit for the N cycle



System is working – possibilities for a nitrogen specialist microbial biosensor

Future directions:

- Broad host expression
- C, N, P nutrient limitation/ heterogeneity
- Critical zone field experiments



THE
DESIGN

POC

THE
MICROBE

IT WORKS

THE IDEA

THE
FUTURE

Thank you



Silberg lab:

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Shirley Liu
Josh Atkinson
Emily Thomas
Ian Campbell

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Xiaodong Gao
Valérie Huguet
Zuolin Liu
Lacey Pyle
Loredana Suci

