Systems Biology from Single Species to Consortia

S&T Campaign: Materials Research
Biological and Bio-inspired
Technology from Biological Systems

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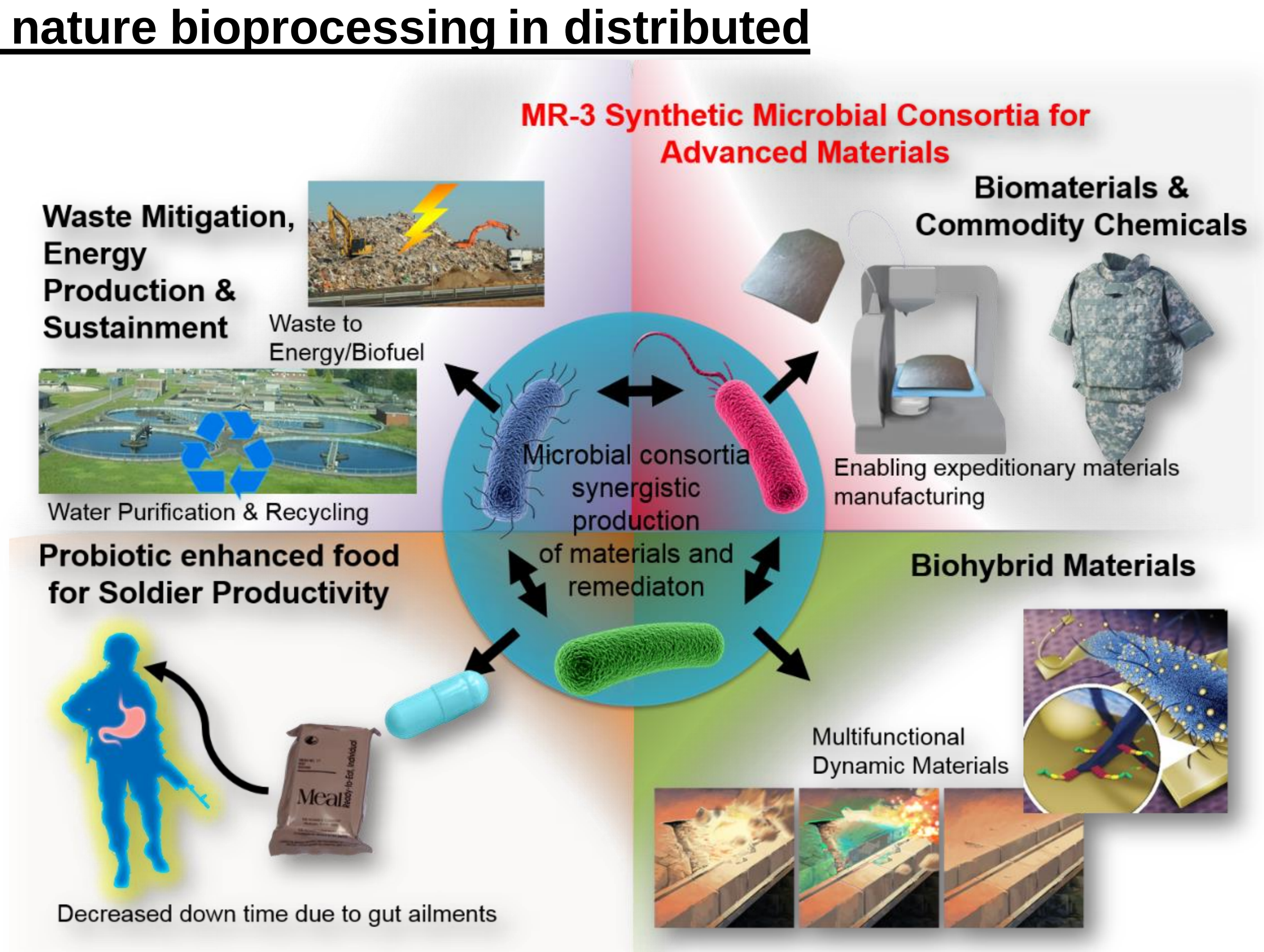
Research Objective

- **Stable, predictable multi-organism systems**
- **Advanced non-consolidated bioprocessing**

Most bioprocessing approaches attempt to adapt a single organism to perform the function of many

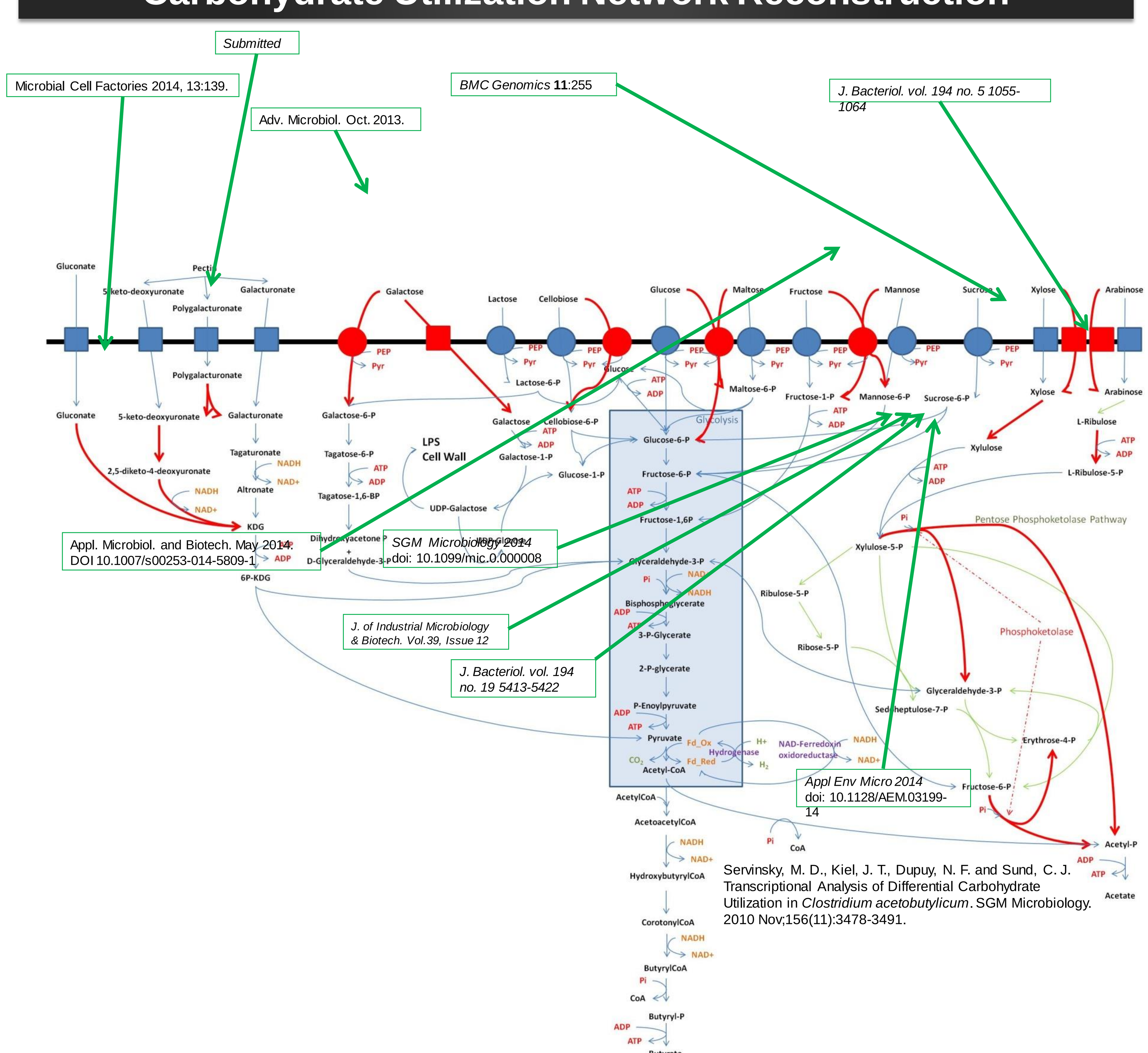
<u>In nature bioprocessing in distributed</u>



Challenges

- **High-throughput methods to study individual cells and single species of multi-specie consortia need to be developed**
- **Current metabolic models do not sufficiently account for interactions with the environment**
- **Current models do not account for phenotypic heterogeneity**

Carbohydrate Utilization Network Reconstruction



ARL Facilities and Capabilities Available to Support Collaborative Research

- **Facilities and experience in systems biology of anaerobes**
- **Advanced capabilities in metabolic network reconstruction**
- **12-vessel bioreactor with off gas analysis and in situ metabolite analysis**
- **Next generation sequencing – ordered**
- **Multi-Scale Biological Modeling**

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

Near-term goals (FY15-FY19):

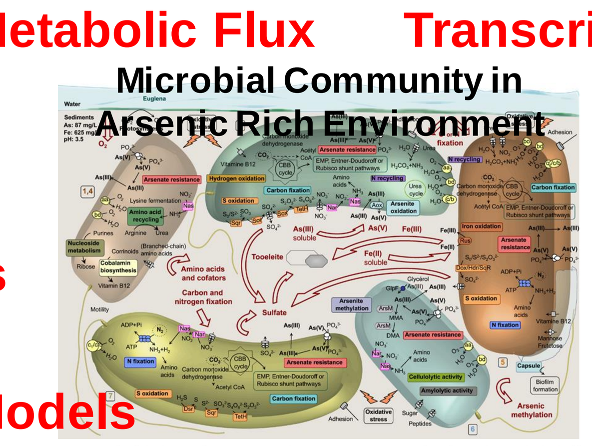
- Develop methods to measure metabolic flux from individual species in multi-organism systems
- Leverage existing state-of-the-art and develop new transcriptomic and proteomic methods to measure individual species in multi-organism systems
- Systematically study designed consortia via bottom up assembly to understand and develop universal design principles for artificial ecology engineering
- Advance state-of-the-art in modeling multi-organism systems to include interactions with other organisms and ecological parameters
- Iteratively develop and validate advanced models with increasing organism and ecological complexity
- Examine mechanistic responses of natural and engineered bacterial consortia to stress and environmental stimuli including feed stocks, pH, and temperature
- Use understanding of stress response to improve robustness of ecological systems

Mid-term goals (FY20-FY25):

- Characterize genetic circuitry used in natural and artificial consortia to determine mechanism through which individual species modulate responses to ecological conditions such as location in ecology, presence of other organisms, and nutrient levels.
- Develop advanced tool sets for studying individual cells in ecologies to better understand the impacts of natural phenotypic heterogeneity on complex multi-organism consortia and systems.
- Develop genetic engineering and synthetic biology tools to alter organisms in ecologies.
- Manipulate ecologies through genetic modifications of individual species using newly developed synthetic biology tools.
- Determine minimal metabolic pathways for desired function of ecologies
- Develop a-cellular systems based on minimal metabolic pathways to reduce system complexity.
- Explore synthetic systems to produce critical polymer precursors from renewable starting materials.
- Iteratively develop and validate advanced models with increasing organism and ecological complexity.
- Develop advanced design principles for ecologies and a-cellular systems
- Determine critical criteria for scaling the processes

Metabolic Flux · Transcriptomics · Genomics · Proteomics · Metabolomics · Competition · Multi-organism Models · Population Stability

Microbial Community in Arsenic Rich Environment



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Intercellular Communication