Development and Characterization of 3D, Nano-Confined Multicellular Constructs for Advanced Biohybrid Devices (130813)

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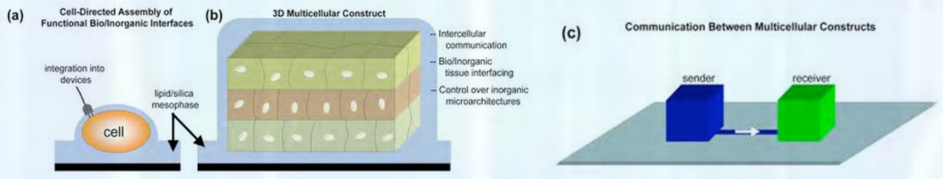
Problem

Purpose/Goals

To develop a robust platform bridging biological systems to device applications using recent advances to interface living and non-living components.

Revisions to R&D Goals and Milestones

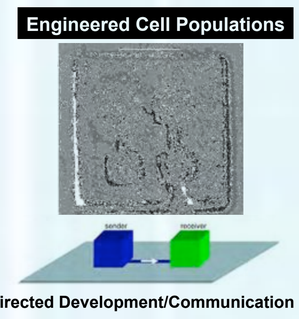
- Integration of multicellular assemblies to lipid-silica nanoconfinement.
- Directed communication between cell modules
- Integration of biometallization strategies to 3D patterning



Approach

Goal: To develop a robust platform bridging biological systems to device applications using recent advances to interface living and non-living components, and employ biological processes to build functional materials

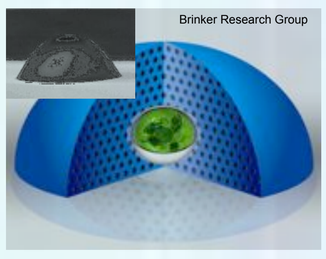
Engineered Cell Populations



Directed Development/Communication

Some features of multiphoton protein microfabrication:
•Arbitrary 3D structures
•"Breathable" and functional architectures.

Nano-confinement



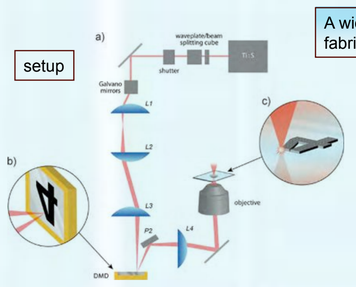
Some features of cell-directed assembly:
•Interface to inorganic materials
•Detachment from external fluidics
•Extended viability

These breakthroughs provide a platform to integrate complex cell behaviors to device materials

NATURE News and Views, August 2008

Defining 3D Microenvironments using Dynamic-Mask Multiphoton Protein Lithography

setup



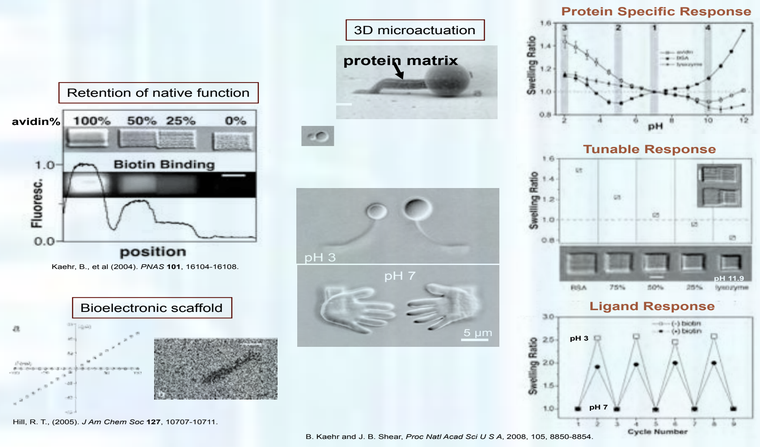
A wide range of Mask Inputs can be used to fabricate complex 3D structures including:

Nielson, Kaehr and Shear, *Small*, 2009, **5**, 120-125

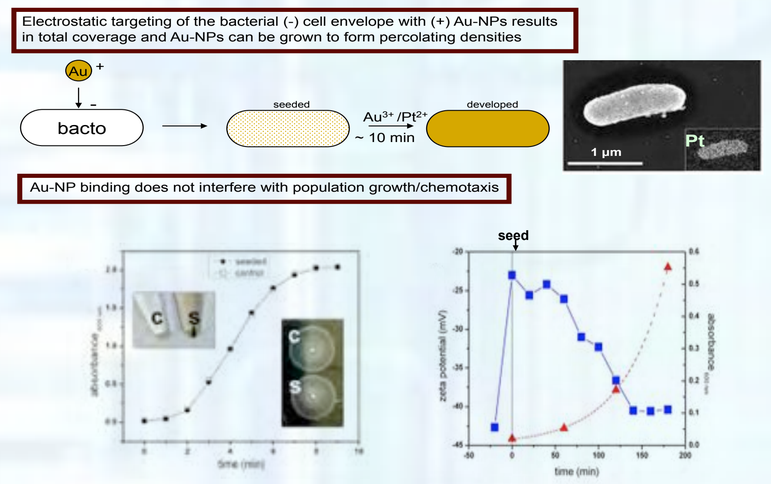
Sensitizers	*Reactive Residues*	*Proteins*
Rose Bengal, Methylene Blue, Porphyrins, Flavins	Tyr, His, Lys, Cys, Trp	**BSA**, avidin, lysozyme, cytochrome c, GDH, GOx, AP, Con A, Catalase

Results

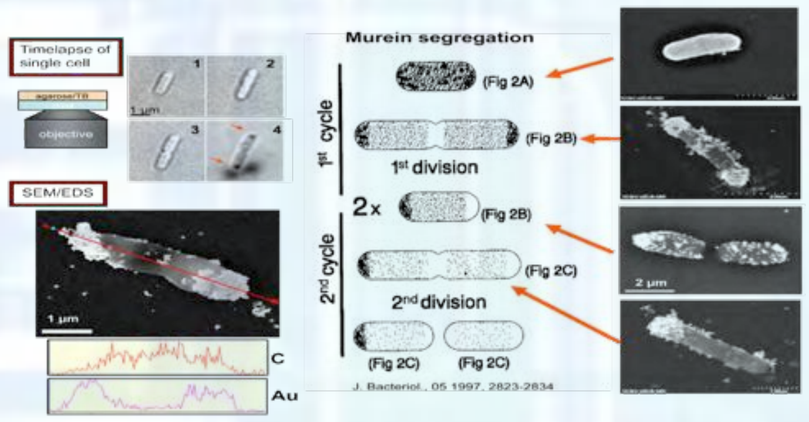
Characteristics of Protein Matrices



Using bacterial growth to develop asymmetric metallic particles

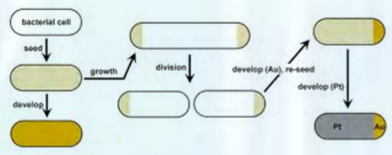


Gold 'seeds' localize to cell poles during cell growth

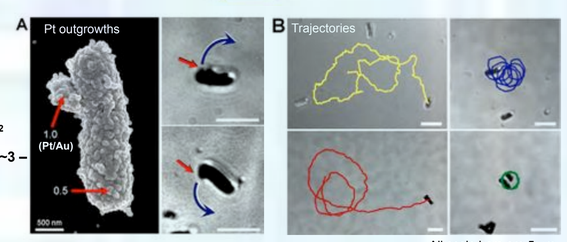


Using motile cell templates to develop bimetallic motile particles

Scheme



Mechanism of motility



•Pt/Au bimetallic particles
•1.0% H_2O_2
•Linear velocities ~3 – 6 µm s^{-1}

All scale bars are 5 µm

Angew. Chem. Int. Ed. 2006, 45, 5420 –5429

Significance

Some Key Accomplishments

- Completion of biological multiphoton fabrication facility integrated into BSL2 certified laboratory at the AML.
- Integration of proteinaceous materials to lipid-silica self-assembly process. Demonstration of bacterial behavior modification via nanoconfinement.
- Development of new biotemplating strategy employing cell growth to organize catalytic materials.

Significance of Results

Development of a new class of biohybrid materials proposed here will impact a wide range of applications (e.g., micro-sensors and actuators, biocomputers, biomedical and bionic technologies), while benefiting basic research regarding confined living systems — crucial for human health and disease.

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