New Chemical Tools for Control and Imaging of Cellular Processes
David Chenoweth
Dept of Chemistry, University of Pennsylvania

Chemical tools are invaluable for modulating, probing, manipulating, and imaging biological systems. Our laboratory is developing new small molecule and peptide based chemical tools to probe and monitor biological systems in a spatially defined and temporally controlled manner. Recent results from our laboratory describing modular chemical tools to control protein localization in living cells have paved the way for several recent advances aimed at controlling cellular processes. This work will be discussed in the context of new chemical tools for studying and imaging biology at the single cell level.

Translating the Properties of Single Cells into Collective Behaviors in Tissues
Zev Gartner
Dept of Pharmaceutical Chemistry, University of California, San Francisco

The structure and function of tissues arises through the collective behavior of their constituent cells. I will describe my lab’s efforts to relate the physical properties of individual cells to their collective behaviors during the process of self-organization, with a focus on the human mammary gland as a model system. Time permitting, I will also describe a new tool developed in the lab for reconstituting complex 3D tissue architecture in vitro from dissociated cells.

Single Cell Sensors
Deirdre Meldrum
Center for Biodesign Discovery Automation, Arizona State University

The evolving myriad of sensors enhance our ability to perceive and measure the world. For example, they enable measurements in the environment for weather prediction, water quality, and health of the Earth. They enable diagnostics to measure the health status of humans, to predict future health challenges, and to effectively treat disease. This presentation will review the forefront of microsensor technology in the context of measuring biosignatures for quality of life. Our laboratory has been developing a suite of polymer thin film sensors and molecular sensors to perform extracellular and intracellular metabolic measurements of single cells, cell clusters, and tissue to discover predictive biosignatures of human health or to perform biochemical measurements of ocean processes. Our current breadth of sensor technology includes: extracellular pH, oxygen, potassium, dual pH and oxygen, dual oxygen and glucose, as well as intracellular glucose and potassium. These optical-chemical sensors may be used in innovative platforms including 3D single-cell optical computed tomography, the Cell-CT, and a
high-throughput microfluidic array for single-cell metabolic measurements, the Cellarium. Examples will be provided for esophageal cancer and inflammation. Successful implementation of biosignatures in emerging health care programs will require high-throughput automation for biosignature discovery, clinical validation, standardization, and qualification for use in pre-symptomatic diagnoses, drug development research, commercialization, and patient management for healthy patient outcomes. Our sensors are also being leveraged by the ocean sciences community to discover rare and exotic chemical or biological entities or to perform spatiotemporal monitoring of ocean processes.

**Tumor Evolution and Diversity at Single Cell Genomic Resolution**
Nicholas Navin  
Dept of Genetics, Bioinformatics and Computational Biology, and Biomedical Sciences, University of Texas

Tumors evolve from single cells. As they evolve they acquire complex genomic mutations and diverge to form multiple subpopulations, resulting in intratumor heterogeneity. This genomic heterogeneity plays an important role in clonal evolution during the growth of the primary tumor and during invasion, metastasis and the evolution of chemoresistance in breast cancer patients. In this talk I will provide an overview of the experimental and computational methods we have developed for performing single cell DNA sequencing to measure copy number profiles, point mutations and indels in individual tumor cells. I will also discuss our efforts in applying these methods to study punctuated copy number evolution in triple-negative breast cancer patients and metastatic dissemination in colorectal cancer.

**Single Cell Approach to Unravel the Mystery of Olfaction**
Ron C. Yu  
Stowers Institute for Medical Research

The mammalian olfactory systems is consist of the vomeronasal organ, which detects pheromone cues, and the main olfactory epithelium, which detects odors at large. In both sensory organs, individual sensory neuron expresses a specific receptor gene. Neurons expressing the same receptor converge onto stereotypic targets in the brain to form internal representation of the pheromones and odors. We have taken single cell approaches to identify from the vomeronasal organ cognate receptors for sex pheromones and to reveal their functional contribution to mating and aggressive behaviors. We also using transcriptome analyses to identify candidate genes associated with specific targeting of the olfactory sensory neurons during development.

**Illuminating Biochemical Activity Architecture of the Cell**
Jin Zhang  
Dept of Pharmacology, University of California, San Diego

It has become increasingly clear that cellular biochemical activities are compartmentalized in nanoscale domains that define the biochemical architecture of the cell. Despite advances in molecular sensors and optical imaging, direct interrogation of any minute activity domains at the molecular length scale remains a challenge. In this talk, I will focus on cAMP and Ca²⁺ regulated signaling activities and present studies where we combined genetically encoded fluorescent biosensors, superresolution imaging, targeted biochemical perturbations and mathematic modeling to probe the biochemical activity architecture of the cell.