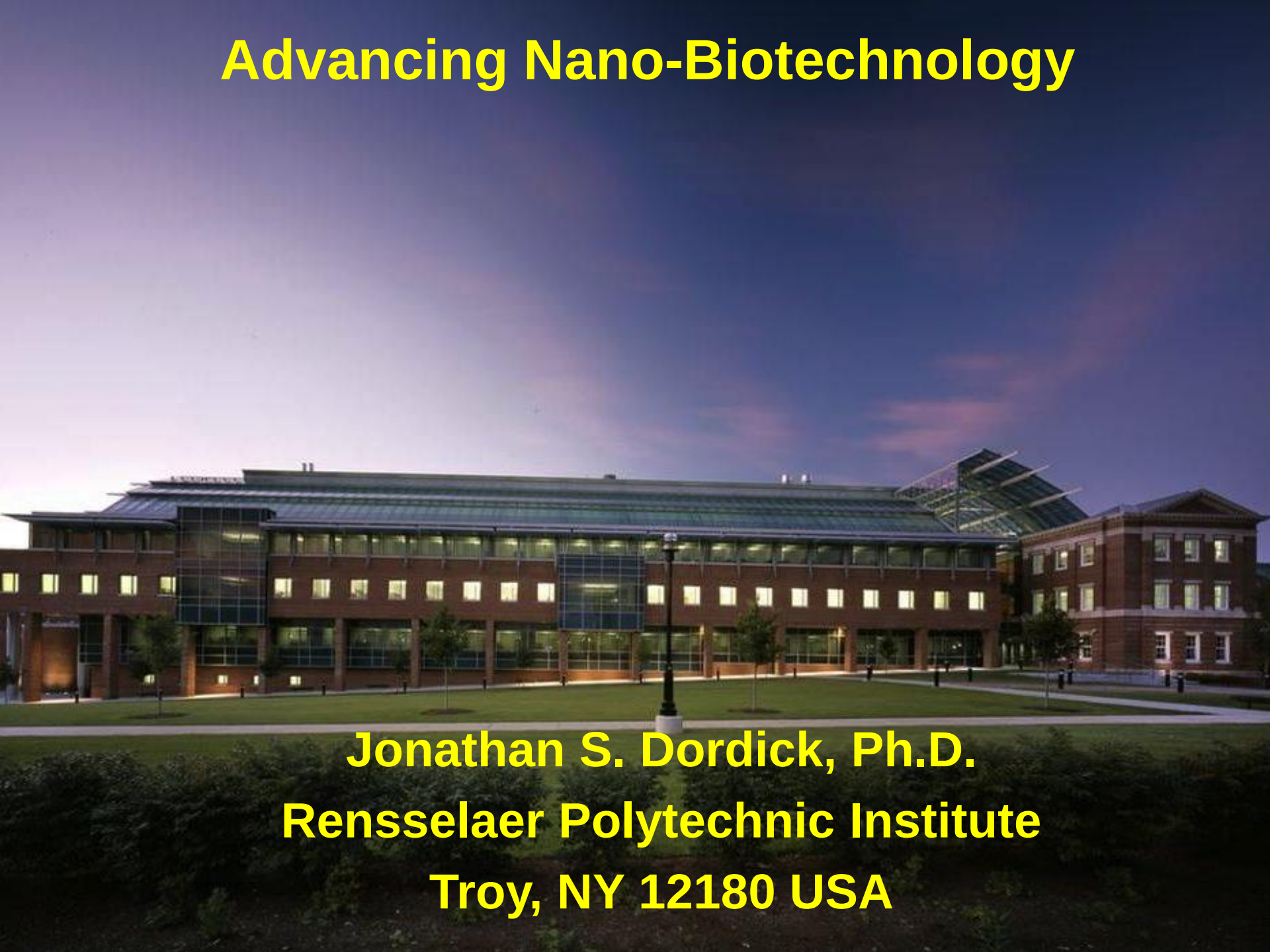
Advancing Nano-Biotechnology



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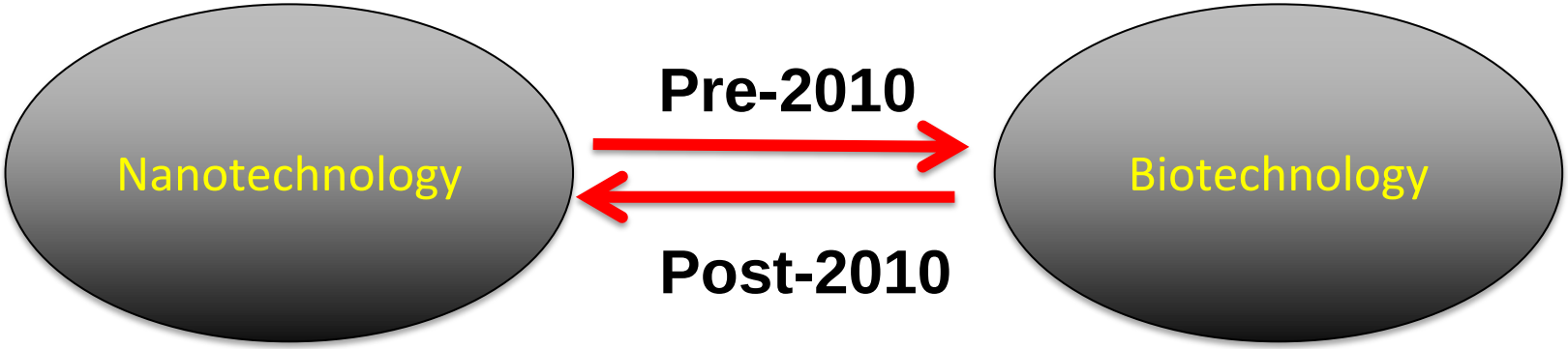
New York's Nanotechnology Model at Work in Biotechnology

- Tremendous leveraging of NIH, NSF, DOE, and DOD funding
- Opportunities for upstate engineering and downstate biomedical research collaborations
- Entry of "big data" into the nano-biotechnology research space
- Innovation occurs by exploring new ways to use biotechnology and leading to new products, processes, and businesses
- NY State has a unique opportunity to extend its "nanotech model" to biotechnology, and engage more the federal government and a broader range of industries

Contrasting Nanotechnology and Biotechnology



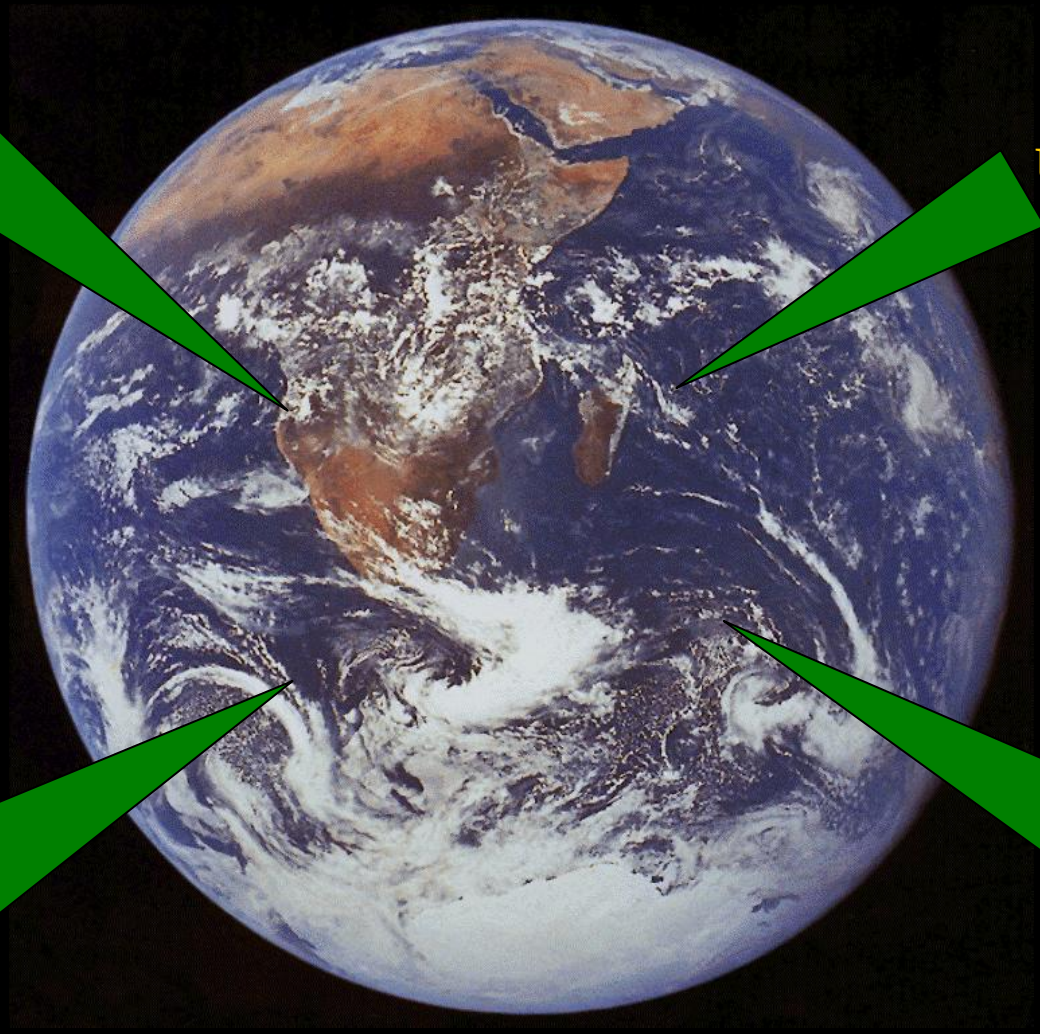
Advantages:
- Processing/Manufacturing
- Man-made
- Collaboratively established

Disadvantages:
- Difficult to control < 50 nm
- Limited compatibility with biological systems
- Not environmentally benign

Advantages:
- Exquisite selectivity in shape, size, biochemistry
- Nature "invested" billions of years to develop
- Environmentally benign and biocompatible

Disadvantages:
- Nature is smarter than us
- Isolationism with little collaboration

Nature: The Ultimate Nanotechnologist



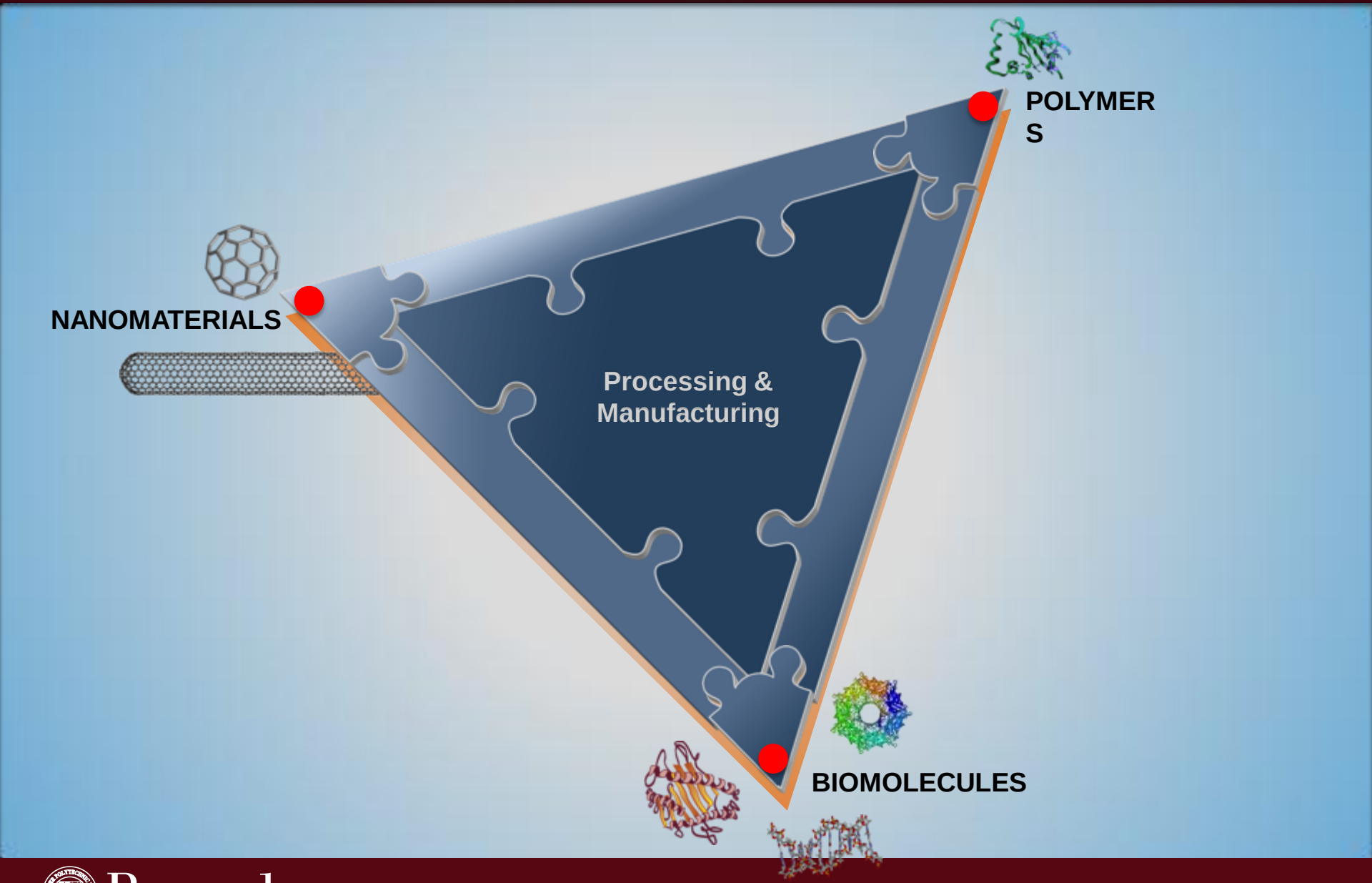
Structures & Architectures

Unique Functions

Bioactive Products

???

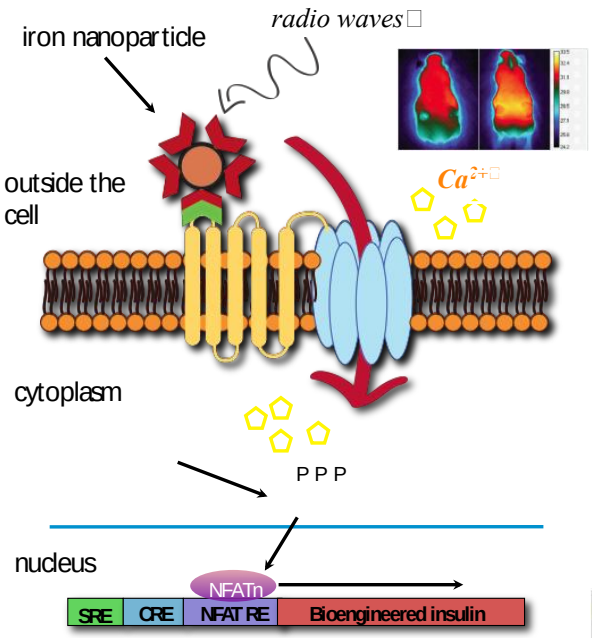
Nanotechnology Enables us to Break Away from Nature's Boundaries



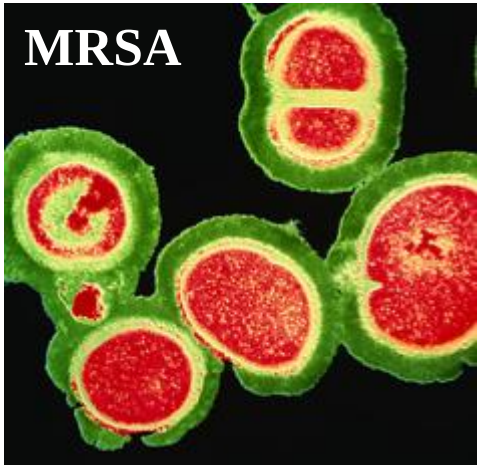
Support through NSF and the NSEC Program

Opening Up New Opportunities: Collaborations are Required

Biomedicine



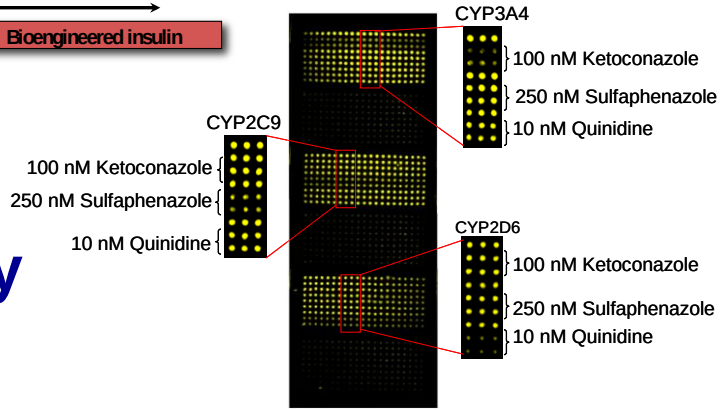
Pathogen Decontamination



Affordable Healthcare Technologies

thesignaltonoise.com

Drug Discovery



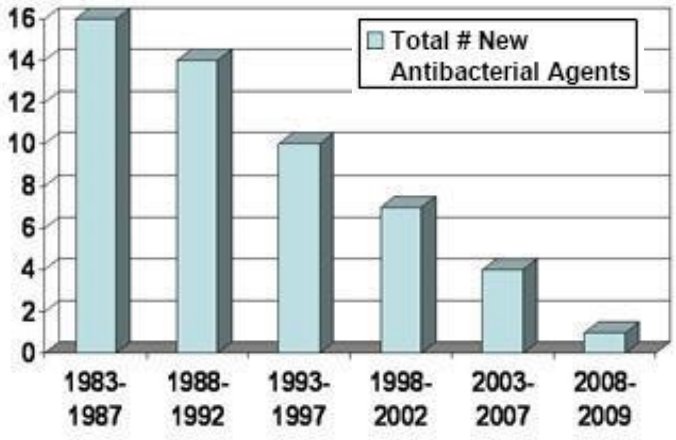
Societal Drivers for Bioengineered Safe Environments

Safe and Sustainable Healthcare Infrastructure

Safe Food Processing and Packaging

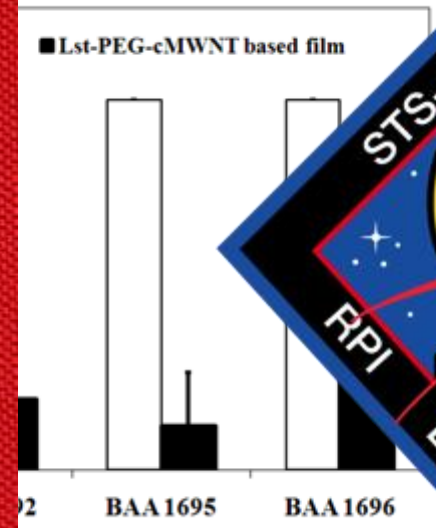
- **Community infrastructure susceptible to antibiotic-resistant microorganisms**
  - Hospital-acquired infections are the 4th/5th leading cause of preventable death in the U.S.
  - WHO → we are headed back to the early 20th Century where many infections were lethal
  - Routine surgeries may go undone
  - Antibiotic use in food industry is literally killing us
- **Nearly 50 million cases of food poisoning annually in the U.S. alone.**
  - Economic impact of $7B annually and 1/4 of all freshwater use
  - Annual energy waste equivalent to ca. one month of petroleum use
- **Lack of clean water devastates society**
  - Developing world
  - Developed world following natural/man-made disasters

Declining Antibacterial Approvals



Antistaphylococcal Paints: From Hospitals to Mars

Effectiveness against methicillin-
***ureus* (MRSA)**



gainst all MRSA
strains tested
- ***>99% bactericidal activity in 2 h***

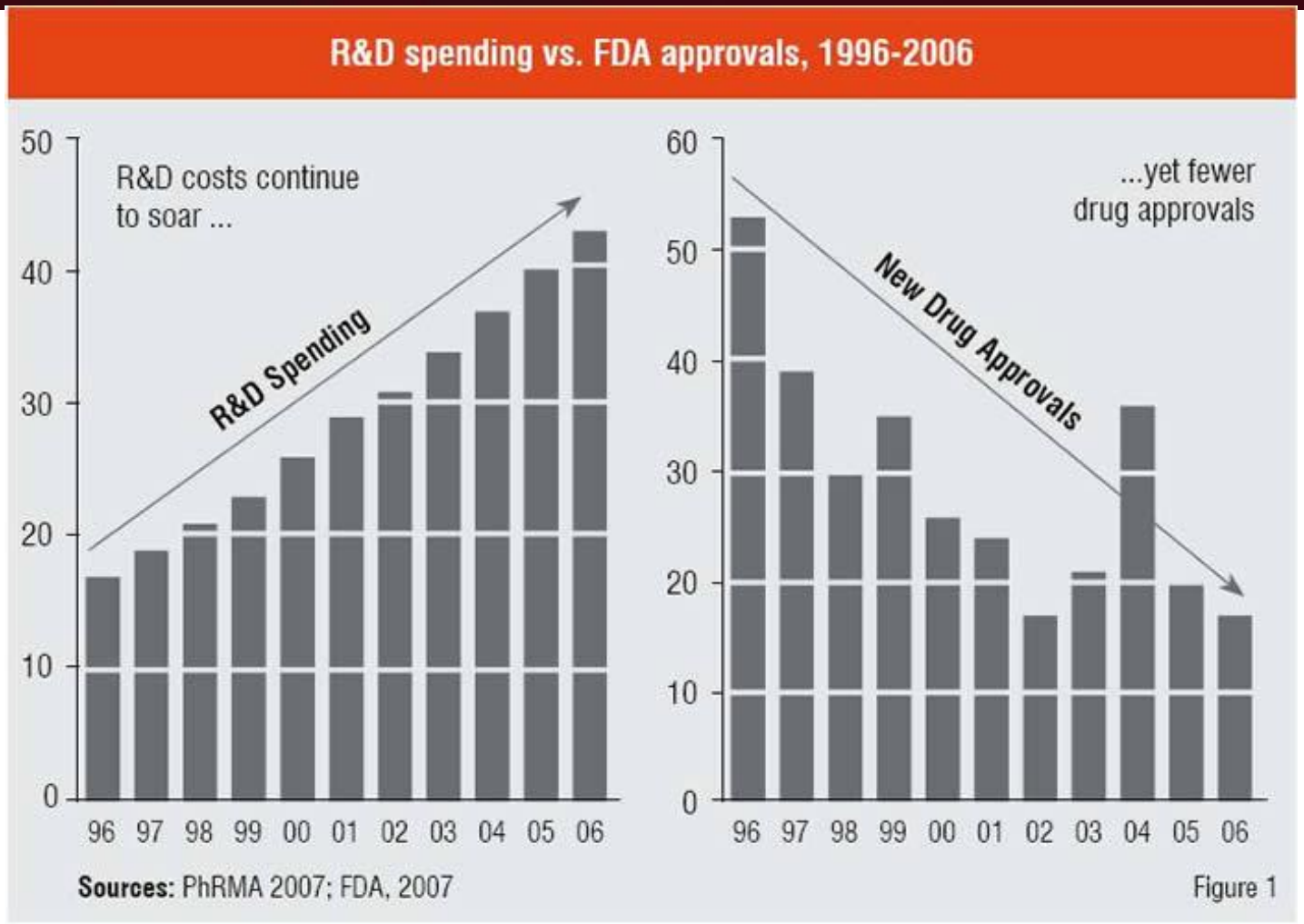
J.S. Dordick, R.S. Kane, C. Collins, D. Metzger, R. Pangule

“Doctors pour drugs of which they know little, to cure diseases of which they know less, into human beings of whom they know nothing.”

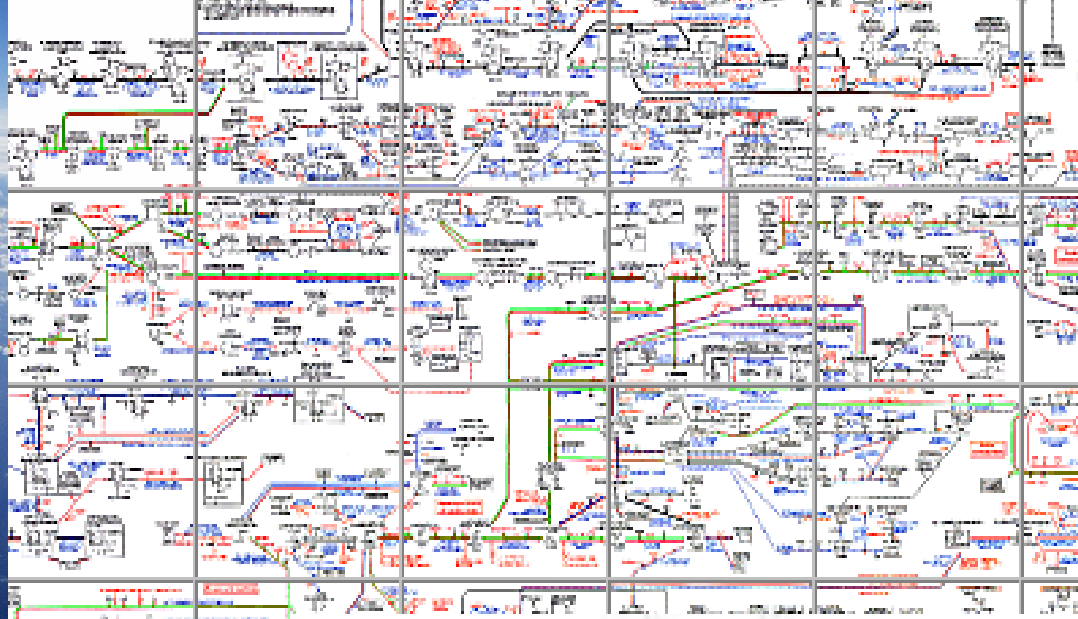
Voltaire
(1694-1778)

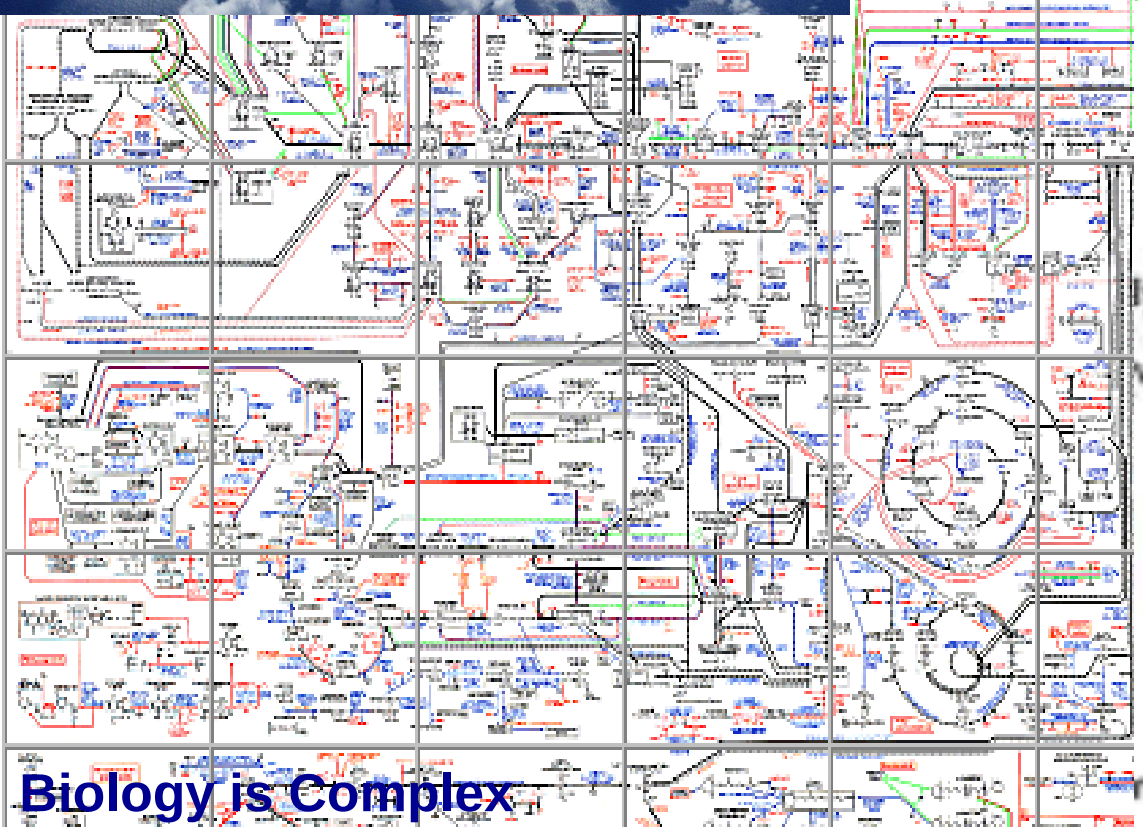
Drug Discovery: More Knowledge, Yet More Failure

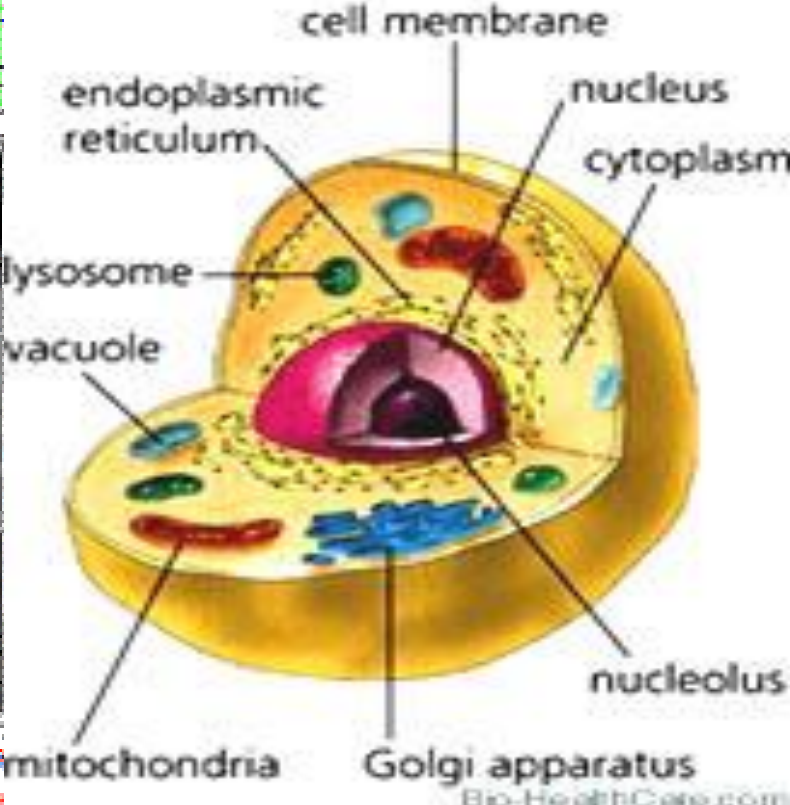
- **Total small molecule approvals = 58 in 2009-2011**
- **Cost for drug approval now close to $2 billion**
- **Patents covering > $50 billion in blockbuster drug revenue expired in 2010**



Innovation Barrier







Biology is Complex

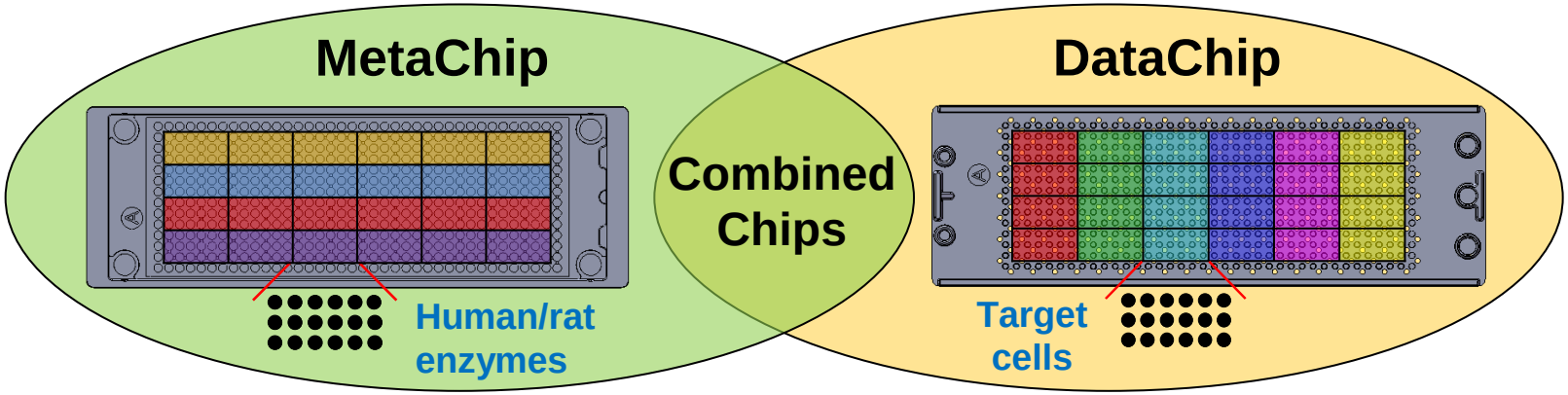
Drug Discovery and Toxicology Screening

Your Liver's Function

Metabolizing **e**nzyme
toxicology **a**ssay **C**hip

Your Body

Data **a**nalysis
toxicology **a**ssay **C**hip



Rapid and Early Removal of Bad Drugs
Before Going to Clinical Trials

Interface of Nano-Bio-Big Data for Effective and Affordable Healthcare

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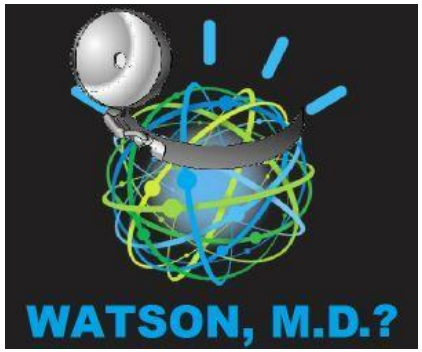
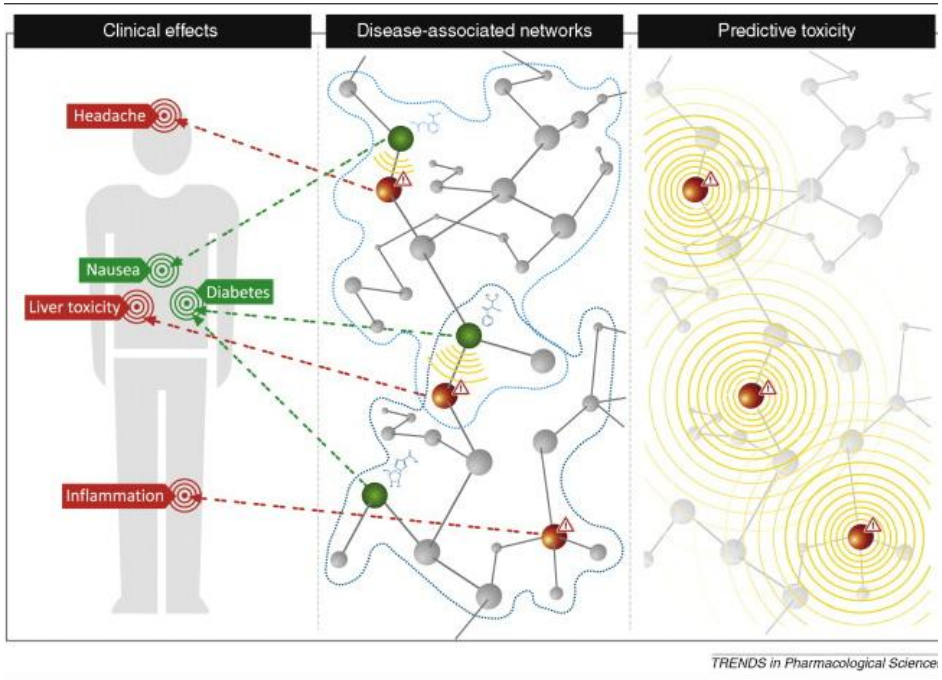
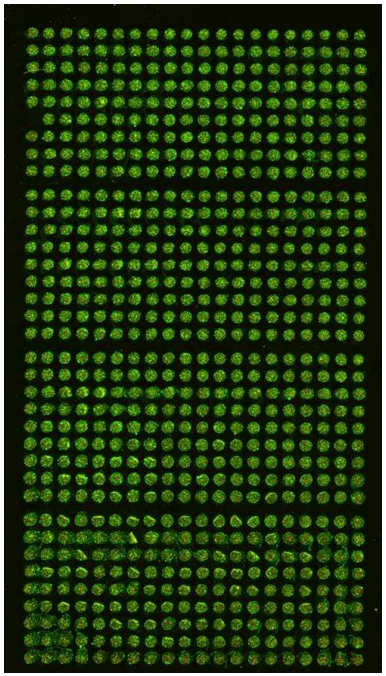




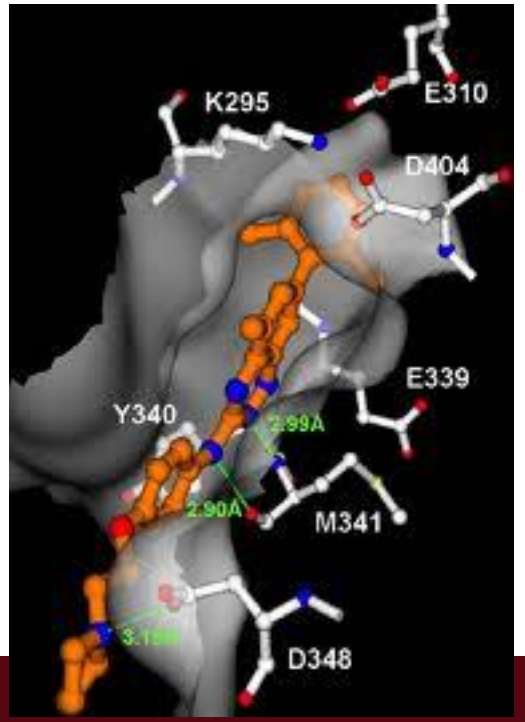


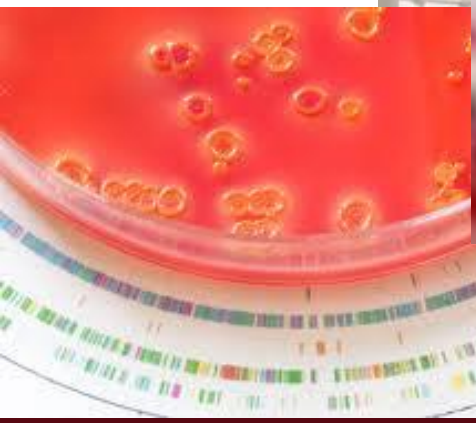
The Emerging Opportunity: Interface of Nano-Bio-Big Data for Effective and Affordable Healthcare

Research & Development	Clinical/Translational	Healthcare Infrastructure
Therapeutics and Diagnostics Discovery	Whole Body "Sensors"	Networks of Sensors
Biochips & Miniaturization	Personalized Clinical Trials	Big Data
"Omics"	Big Data	Patient Treatment Regimens
Analytical Methodologies		Reduced Delivery Costs • Payers • Hospitals • Patients • Government
Big Data		

- NY State can leverage its investment in microelectronics to build the "new" biotechnology
- The expertise exists in biotechnology, nanotechnology, biomedical research, and emerging big data
- Investment must include support to bring VC investors to NY and foster pre-competitive investments

On-Demand Pharmaceuticals: Tailoring Drugs to YOUR Genetic Makeup



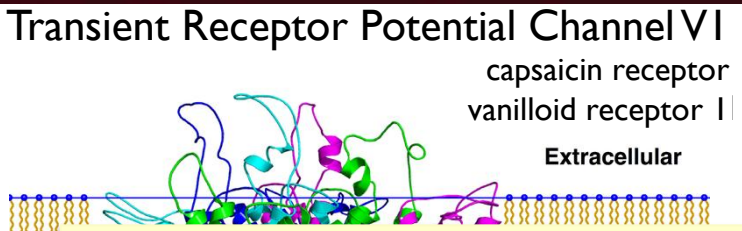


NY State Has Fostered the Nano-Bio Infrastructure at Rensselaer

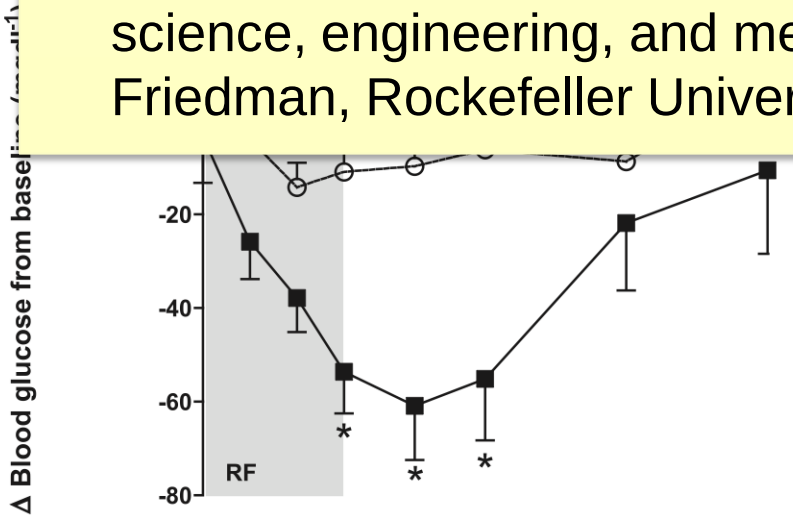
RCSCR

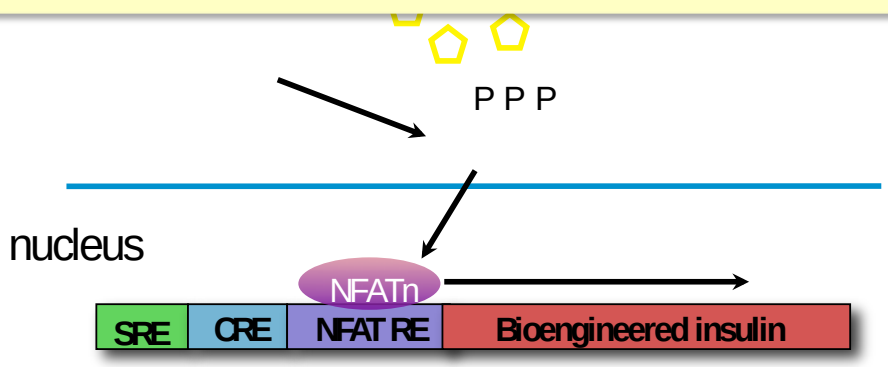
RENSSELAER CENTER
FOR **STEM CELL RESEARCH**

Biomolecule-Nanomaterial Formulations in Biomedical Therapies



- Using nanotechnology and microelectronics to achieve therapeutic outcomes
- Possible impact in neurodegenerative diseases (e.g., Alzheimer's, Parkinson's, etc.), diabetes, others
- Could not have been achieved without collaborative, multidisciplinary science, engineering, and medicine (collaboration with Dr. Jeffrey Friedman, Rockefeller University)



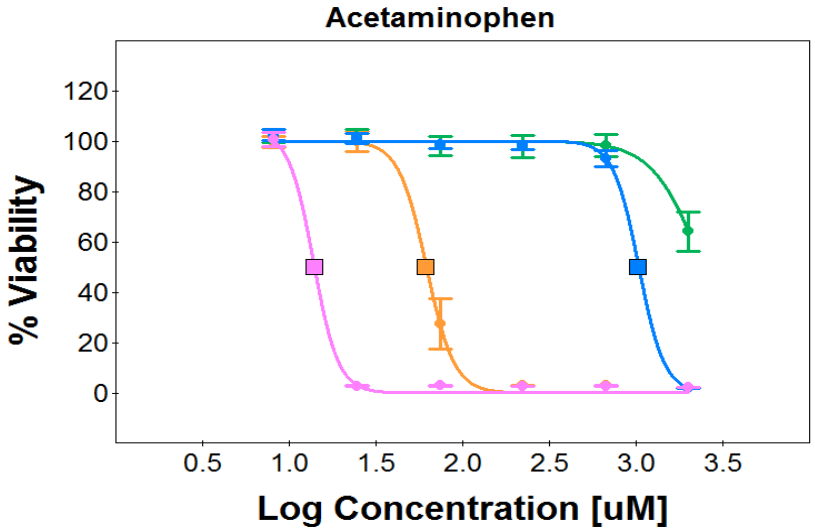


Stanley et al. *Science* 336, 604 (2012).

Opportunities at the Nano-Bio Interface in Advancing Drug Discovery

- Mimicking the human body requires cell-based and protein-based materials
- These materials are effective due to nanoscale matrix components that provide optimum environments for biological activity
- Can be applied to rapid drug discovery and toxicity screening, control of stem cell biology, and regenerative medicine
- Ideally suited to personalized medicine

Drug Toxicity



Stem Cells Biotechnology