ASU BIODESIGN INSTITUTE

ARIZONA STATE UNIVERSITY

Building Interdisciplinary Research Excellence for Innovative Solutions to Global Challenges

Presentation to PCAST Subcommittee

President's Council of Advisors on Science and Technology
Executive Office of the President

25 August 2008

New Challenges for the Academy

Technology Convergence

- life sciences
- engineering
- computing
- scale
  - funding
  - teams

Academic Culture

- fundamental reforms for sustained competitiveness
- broadened horizons
- relentless change

Broadened Collaboration Networks

- global horizon scan and sourcing
- proactive capture of innovation
- IP
- regulatory issues

Scale

- 3M projects
  - multi-investigator, multi-institution, multi-million

Use-Inspired Research

- real world engagement
  - understanding industry's needs
  - proof-of-concept and translational research
  - IP

New Partnerships and Funding Sources

NEWS FEATURE

NATURE | Volume 446 | April 26 2007

nature International weekly journal of science

Arizona State University's president Michael Crow wants to shake up the hierarchy of American universities.

THE ARIZONA EXPERIMENT

"ASU is the most radical experiment going on in American higher education."
-George Poste

"It is a wonderful thing to be part of a place that is becoming, rather than a place that has been."
— Kip Hodges

Five Year Strategic Objectives

Building an Entirely New Organization in an Era of Accelerating Change

Use-Inspired Research

Implementing a New Organizational Model for Cross-Disciplinary Academic Research: The Evolution of the 'Tightly-Coupled' Institute

His test for Addison's disease come back negative. Because his blood tests keep coming back hypercalcaemia, elevated calcium they are also going to run tes

The Challenge of Building a New Organization in an Era of Accelerating Change

- blurring of boundaries between traditional intellectual disciplines
- mastery of technology convergence
  - science, engineering and computing
- escalating funding requirements to support large scale, inter-disciplinary research
- new funding sources to counter anticipated constraints on USG agencies
- aggressive ROI and progression to economic independence
- globalization of research and intensifying competition

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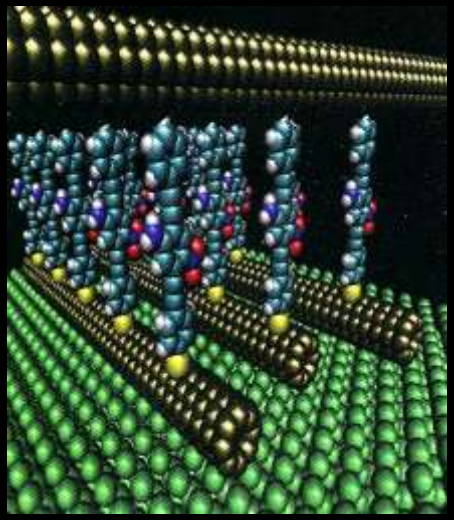
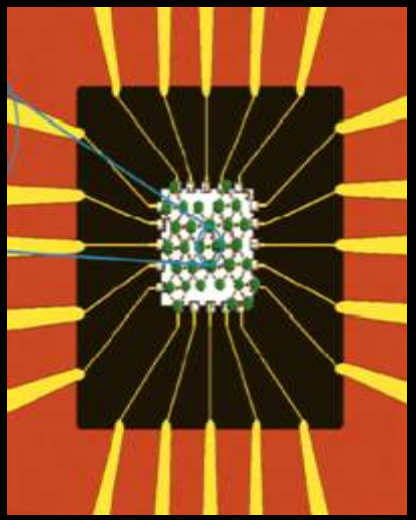
Technology Convergence

Biotechnology,
Systems Biology and
Synthetic Biology



Nanotechnology
Materials Science
and
Miniaturization
Engineering



Advanced
Computing
and
Knowledge
Management

• technologies with radical, pervasive and enduring impact

THE IMPERATIVE TO ADDRESS MAJOR GLOBAL CHALLENGES

The Challenge of Building a New Organization in an Era of Accelerating Change: Strategic Goals

- use-inspired research to address major global challenges
- high impact research
  - transforming advances versus timid incrementalism
- funding scale: 3M grants-multi-institution, multi-investigator, multi-million dollar
- become self-supporting with funding from external sources
- accelerate technology transfer and commercial development of innovative discoveries
- create new education and training capabilities

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A "Tightly Coupled" Research Institute

- interdisciplinary
- integrated
- aligned
- high risk: high reward projects
- competitive

RETURN ON INVESTMENT

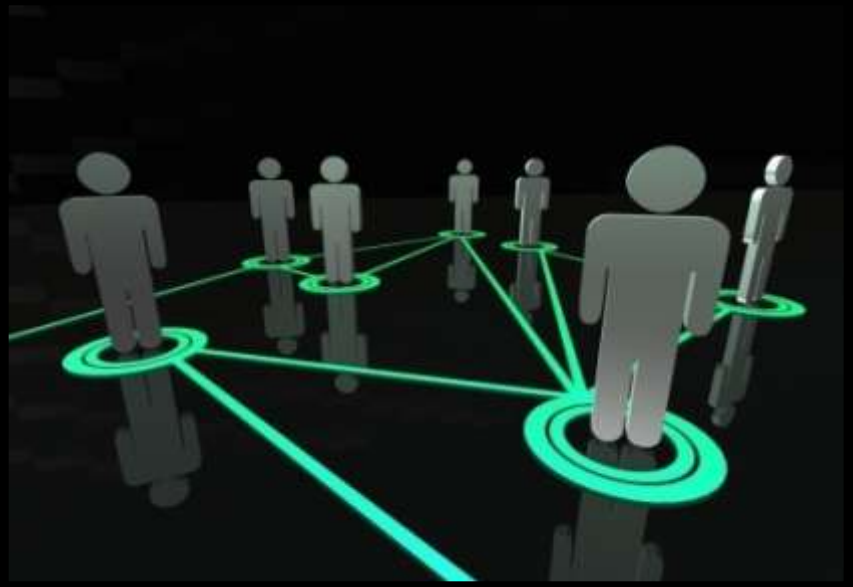
DELIVERY and ACCOUNTABILITY

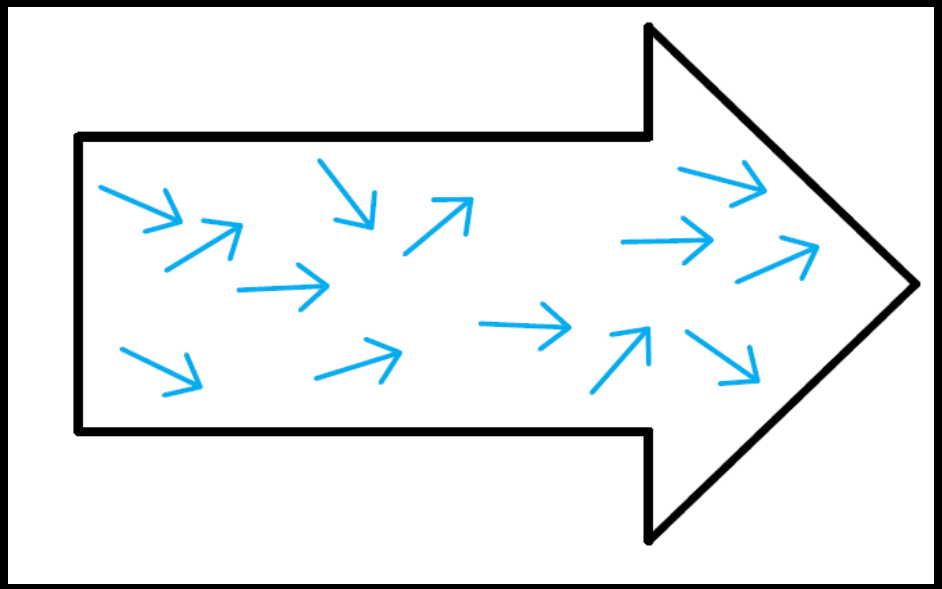
IMPACT

A Tightly Coupled Institute

- new concept for academic research
- progressive evolution from traditional “loose federation” of collaborating units to increasingly coordinated integration
- alignment (tightly) around shared goals
- integration of diverse skills from specialized research centers (coupled)
- significant cultural and management transitions
- new governance mechanisms for oversight and coordination of project portfolio
- performance milestones

Progressive Alignment, Shared Goals and a Collective Ethos for Success





The Challenge of Radical Change

- radical change is disruptive
- radical change is threatening
- radical change places great demands on individuals
  - engaging with unknown/unproven
  - adoption of new methods and acquisition of new skills
  - mastery of constant ambiguity and doubt
  - relentless, and often hostile, opposition from status quo defenders
  - untiring advocacy in the face of naysayers, the petty and the malignant
  - generosity to commit to activities that don't benefit individuals alone

Reed Business Information

May 2006 Vol. 48, No. 5

R&D

Where Innovation Begins

DEPARTMENTS

www.rdmag.com

Interdisciplinary Science + Technology II

CDC's Emerging Infectious Diseases Lab

Wellcome Trust Sanger Institute

40th Anniversary

2006 Lab of the Year

Also in this issue:

Lab of the Future Report

Exclusive

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...titute, Arizona State Univ.

Facilities

- on-time, on-budget construction
- building A (opened Dec. 2004)
  - 172,000 sq. ft; $73 million
- building B
  - 175,000 sq. ft; $78.5 million
- specialized capabilities
  - low vibration/electromagnetic field zones
  - BSL-3 biocontainment
  - femtosecond laser laboratory
  - vivariuim and surgical suites
- high security
  - CDC Select Agent regulations
- LEED Gold (Bldg A) and Platinum (Bldg B) Awards
- over 26 national awards for facility excellence

Five Year Accomplishments: Information Technologies

- scale, specialization and sophistication
- largest IT research infrastructure on ASU campus
- 53 servers with 238TB total storage
- full backup and disaster recovery
- adoption as best practices elsewhere in ASU
- comprehensive AV capability
  - videoconferencing, podcasting, full HD studio
- expanding web-based applications
  - Institute web site
  - intranet services

Five Year Accomplishments: Competitive Funding and Return on Investment

- received $71 million in TRIF funds from ASU
- generated $199 million in external funding
- 2.8X return-on-investment in 3.7 years
- 12 patents, 45 patents filed, 122 provisional patent filings, 212 records of invention
- catalyzed major reorganization of Arizona Technology Enterprises (AzTE)


Agilent Technologies


BOEING


CORNING


bp


edison


APS


Honeywell


GENERAL DYNAMICS
Strength On Your Side®


MOTOROLA


SONY


CH2MHILL


iOMED


COMBIMATRIX


Applied
Applied Process Technology, Inc.


VAXX Inc.


VIRIONICS
CORPORATION

Five Year Accomplishments: Robust Administrative Systems and Support Systems

- set quantitative performance metrics
- parameters for continuous improvement
- customer-centric responsiveness
- standardization and automation
- electronic tracking systems
- electronic laboratory notebooks and IP

Five Year Accomplishments: Robust Administrative Systems and Support Systems

- Office of Strategic Integration and Research Management
- establish comprehensive framework to support cross-disciplinary research teams
- significant reform/refinement of ASU policies
  - personnel, budgeting, purchasing, audit,
  - animal welfare, biosafety
  - sponsored research
  - standardized CDA/MTA procedures
  - clinical trials
- employee training and orientation programs

Five Year Accomplishments: Education

- design/participate in 10 new ASU courses
- new post-doctoral fellowship scheme
  - 108 fellows
- expand research opportunities for ASU students
  - 316 undergraduates
  - 174 graduate students
- new Ph.D. program in Biological Design
- launch new K-12 educational program

Five Year Accomplishments: External Review

- crucial importance of external assessment
  - quality of research
  - progress in meeting performance goals
  - rational use of expensive resources
  - operational barriers/problems
- established worldclass Institute Advisory Board (IAB)
  - 11 members of National Academies
  - 1 Nobel Laureate in Physiology and Medicine

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Advisory Board

★ = National Academy Member
✪ = Nobel Laureate

Chairman:

★ Dr. Stephen Benkovic, Professor; Eberly Chair in Chemistry — Penn State

Members:

★ Dr. Allen J. Bard, Director, Laboratory of Electrochemistry — UT at Austin

★ Dr. Carolyn Bertozzi, T. Z. & Irmgard Chu Distinguished Professor, Department of Chemistry
University of California, Berkeley

★ Dr. Charles R. Cantor, CSO — Sequenom, Inc.

★ Dr. John Donoghue, Professor of Neuroscience
Division of Biology & Medicine — Brown University

★ Dr. David Eisenberg, Director, Institute for Genomics and Proteomics — UCLA

★ Dr. Larry Gold, Chairman and CSO — SomaLogic, Boulder, CO

✪★ Dr. Lee Hartwell, President and Director — Fred Hutchinson Cancer Center, Seattle, WA

★ Dr. Daniel Nocera, W. M. Keck Professor of Energy & Professor of Chemistry — MIT

★ Dr. James Rothman, Director, Department of Cell Biology, Yale Univ.

★ Dr. Lucy Shapiro, Director, Beckman Center for Molecular and Genetic Medicine; Ludwig Professor of Cancer Research — Stanford University School of Medicine

★ Dr. James Wells, President and CSO — Sunesis Pharmaceuticals

Five Year Accomplishments: An External Critique

- Institute Advisory Board Reports

"The Institute has made excellent progress,
far more than many would have dreamed possible at ASU"

December, 2007

"The achievements of the Institute in these initial years
has been remarkable."

March, 2008

Making a Difference by Being Different

- vanguard initiatives that differentiate us from the current ‘leaders’
- mastery of cross-disciplinary research
  - organizational, financial and cultural transitions
- use-inspired research that excites us plus new sponsors
- audacious goals
- relentless focus on few high profile target areas in which we can attain worldclass status

High Impact Research on Major Global Challenges and Unmet Needs

personalized medicine

outpacing infectious diseases

energy and environment

securing a safer world

synthetic biology

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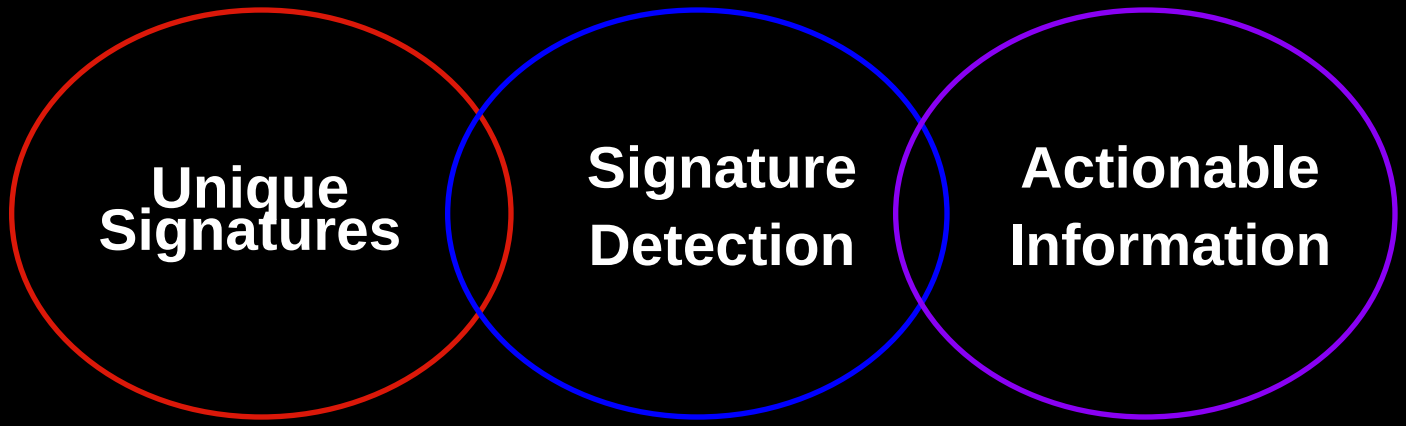
Leveraging Technology Convergence for Diverse Applications

Personalized Medicine	Outpacing Infectious Disease	Energy and Environment	Securing a Safer World	Synthetic Biology

Innovative Solutions for Major Global Challenges




Unifying Technology Platforms



Innovative Solutions for Major Global Challenges




Unifying Technology Platforms

Unique Signatures

Signature Detection

Actionable Information

Objective

Profile

Sense

Act

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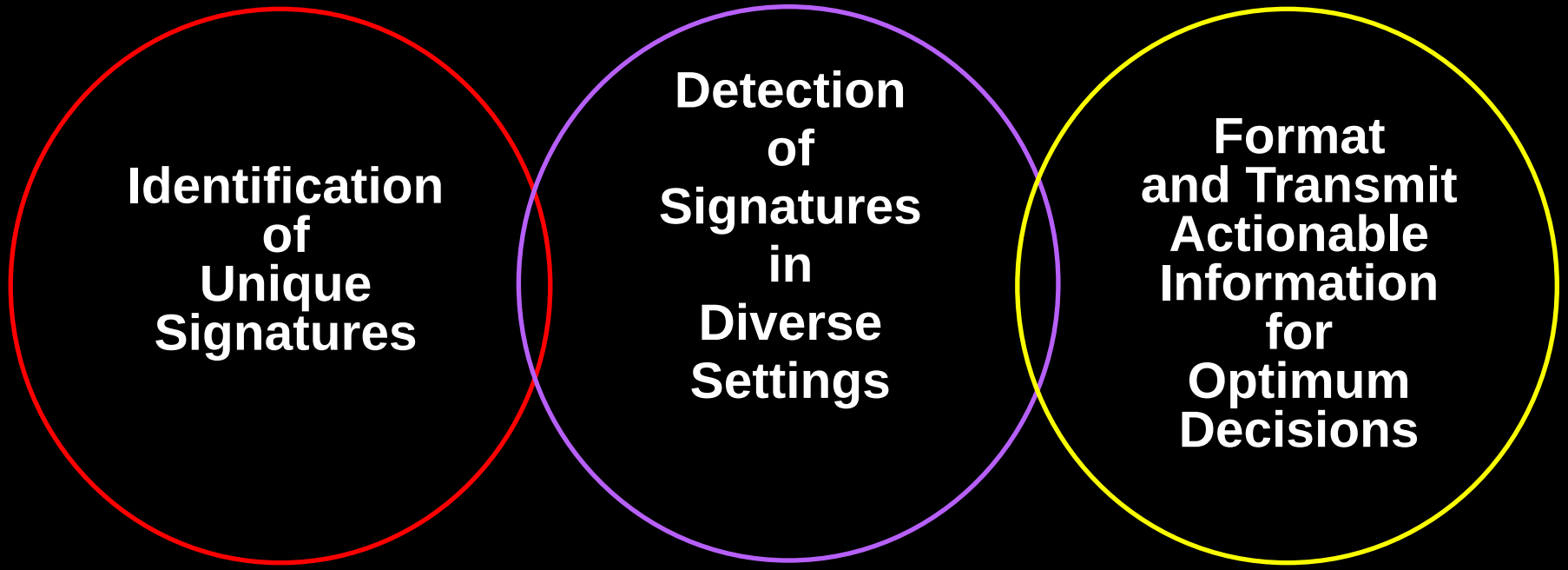
Integrated Functional Platforms to Exploit Technology Convergence



Profile

Life Sciences and Mathematical/Statistical Tools for Complex Signal Analysis

Sense

Nanotechnology, Miniaturization Engineering, Materials Science

Act

Large Scale Informatics and Information Architectures

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Leveraging Common Technology Platforms for Diverse Applications

Personalized Medicine	Outpacing Infectious Disease	Energy and Environment	Securing a Safer World	Synthetic Biology
				

Unique Signatures

Molecular Detection Systems: Diagnostics, Sensors & Taggants

Remote Monitoring: Wireless and Network Architectures

Personalized Medicine	Vaccines Safe Water	Bioremediation Bioenergy	Tag, Track, Locate	Bio-inspired Mfg.

Informatics: Complex Signal Deconvolution, Data Formatting & Visualization

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Building a Project Portfolio of Graded Maturity

Apollo Projects

- major projects and significant interdisciplinary collaboration
- dedicated project management resources
- supported by significant external funding

Gemini Projects

- maturing high profile projects with anticipated progression to Apollo status 18-24 months
- mixture of internal (TRIF) and external funding

Frontier Projects

- highly innovative concepts that require confirmatory data to attract external funding
- ‘seed’ funding for one year

Core Technologies

- advanced technologies that support multiple Apollo and/or Gemini Projects

Innovative Solutions for Global Challenges

Personalized Medicine	Outpacing Infectious Disease	Energy and Environment	Securing a Safer World	Synthetic Biology
				

Apollo Projects

- Point-of-Care Molecular Diagnostics
- Partnership for Personalized Medicine
- Cancer Vaccines
- New Era Vaccine Technologies
- Tubes-in-the-Desert
- Forensic Profiler
- Living Systems Engineering
- Bio-inspired Design, Assembly and Manufacturing

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Innovative Solutions for Global Challenges

Personalized Medicine	Outpacing Infectious Disease	Energy and Environment	Securing a Safer World	Synthetic Biology
				

Gemini Projects

- DNA Scaffolding*
- Next Generation DNA sequencing*
- Population Proteomics*
- Dark Genome

- Synthetic Genomics for Immunization*

- Biohydrogen*
- Molecular Photovoltaics*
- Biomimetic Fuel Cells*

- Dirty Bomb DX*
- Nanowires*
- Sensors for Explosives Detection*
- On Body: In Body Sensors (OBIBs)

- Ecogenomics*
- Metagenomics *
- Dark Genome

* = external funding to supplement TRIF

Technology Core Platforms

Sophisticated Planning and Integration for End-to-End Solutions

New Expertise in Project Management

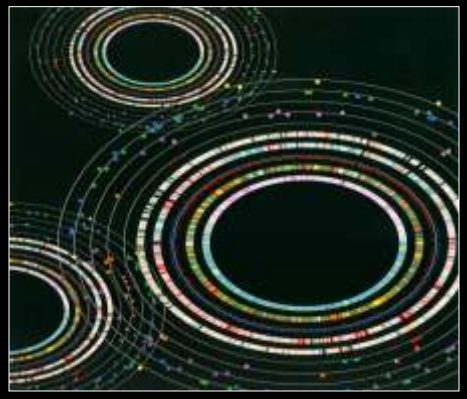
R&D Competencies for Bioinspired Energy Production and Bioremediation

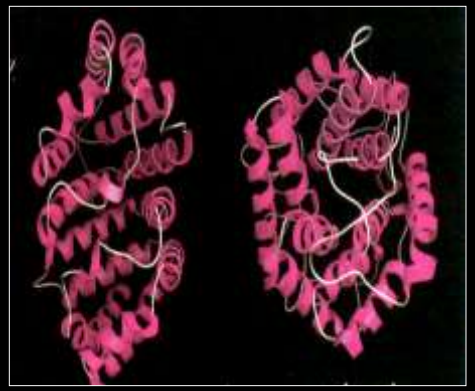
systems biology and synthetic biology

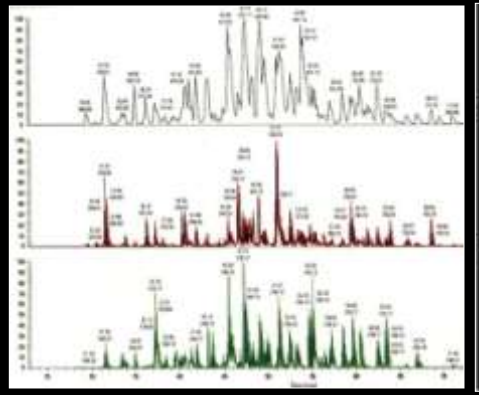
protein engineering, directed evolution and enzymology

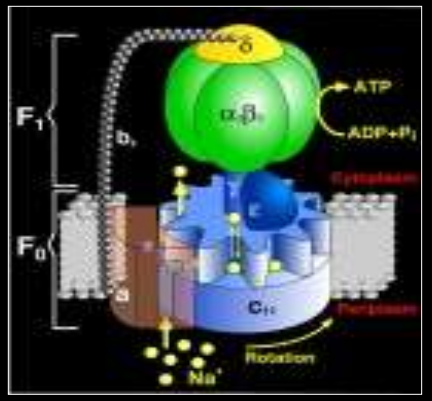
high throughput assay automation

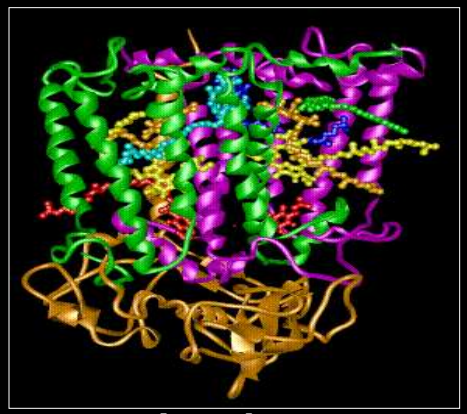
computing and systems modeling











molecular bioenergetics and biological physics

directed molecular assembly

bioprocess engineering

proof-of-concept for industrial interest

Systems-Based R&D: Obligate Focus on End-to-End Solutions

Intellectual Property (IP): Building an IP Fortress

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Impact on Global Challenges

The Changing Environment for Research Success

ASU Arizona State University

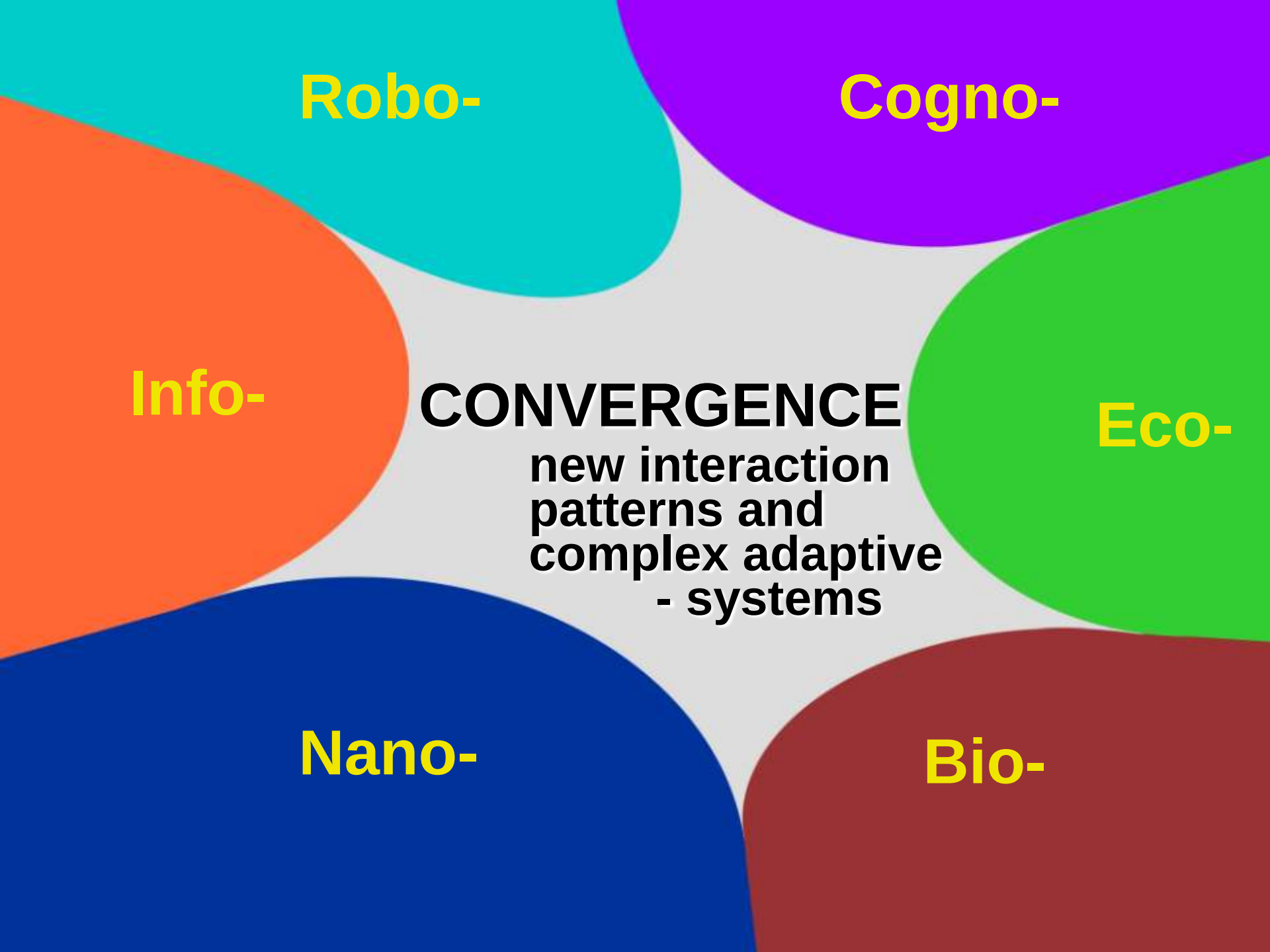
ASU Home | ASU A-Z Index | ASU Interactive | My ASU | Colleges & Schools | Directory | Map

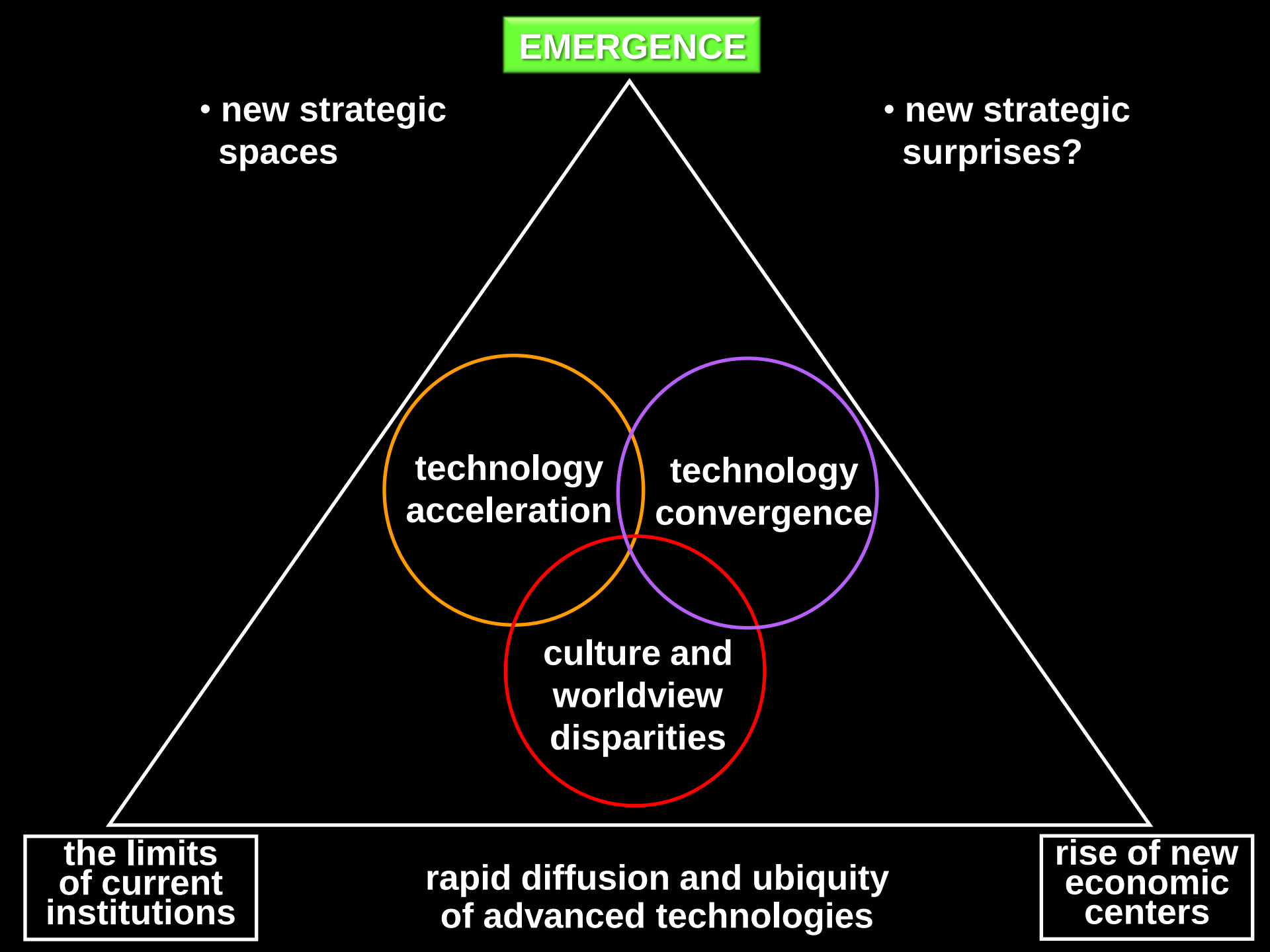
The Complex Adaptive Systems Initiative (CASI)

- both exemplar and a catalyst to expand use-inspired, cross-disciplinary research more broadly at ASU
- leveraging Biodesign's success to launch additional research initiatives in which ASU can achieve worldclass status
  - focus on nascent, emerging areas arising from the 'convergence' of previously distinct research domains
- draw upon substantial but dispersed expertise at ASU

Design Principles in Complex Adaptive Systems

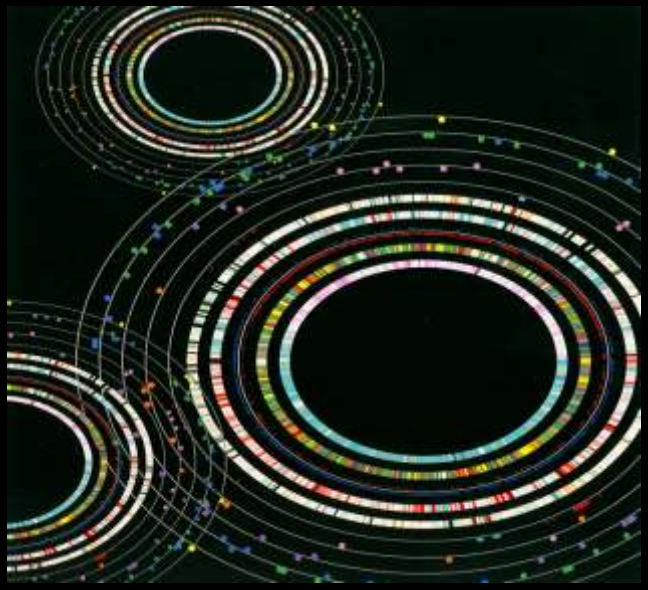
- understanding connectivity patterns and unitary organizational principles in seemingly highly different entities
- ultimate resolution as patterns of information flow
  - "it from bits"
  - "the ecology of information networks"
  - "the ecology of knowledge"
- overarching and unifying concept for the integration of knowledge
  - science, technology, humanities, law, social sciences, business

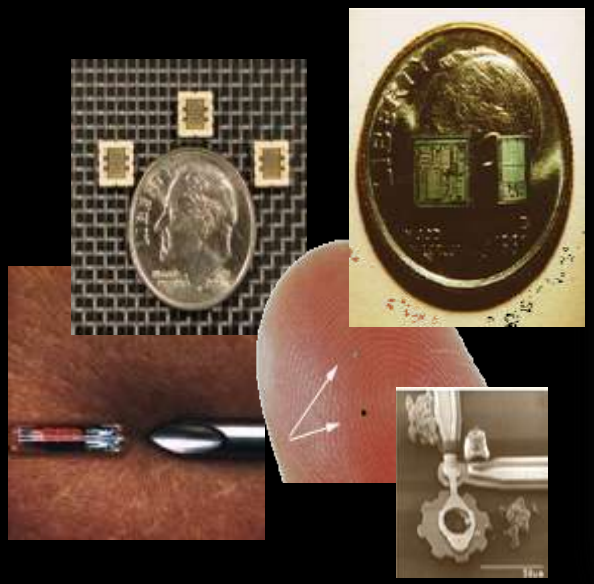

Robo-
Cogno-
Info-
CONVERGENCE
new interaction patterns and complex adaptive - systems
Eco-
Nano-
Bio-

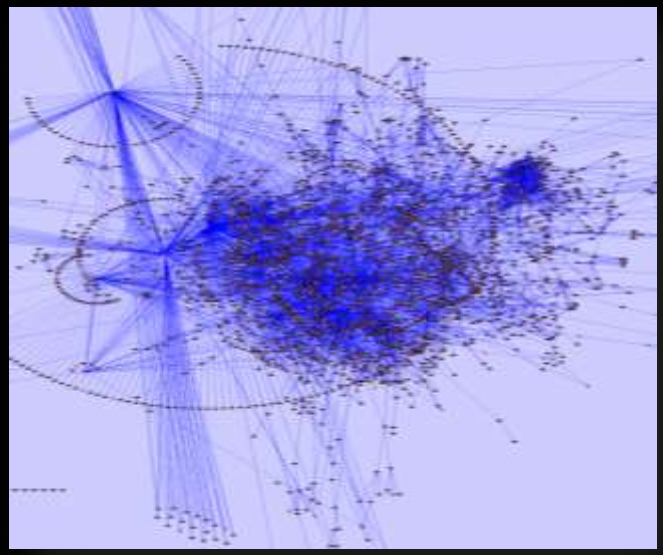

EMERGENCE
• new strategic spaces
• new strategic surprises?
technology acceleration
technology convergence
culture and worldview disparities
the limits of current institutions
rapid diffusion and ubiquity of advanced technologies
rise of new economic centers

Initial Research Areas for CASI

Synthetic Biology	Ubiquitous Sensing	CAS Modeling and Simulation





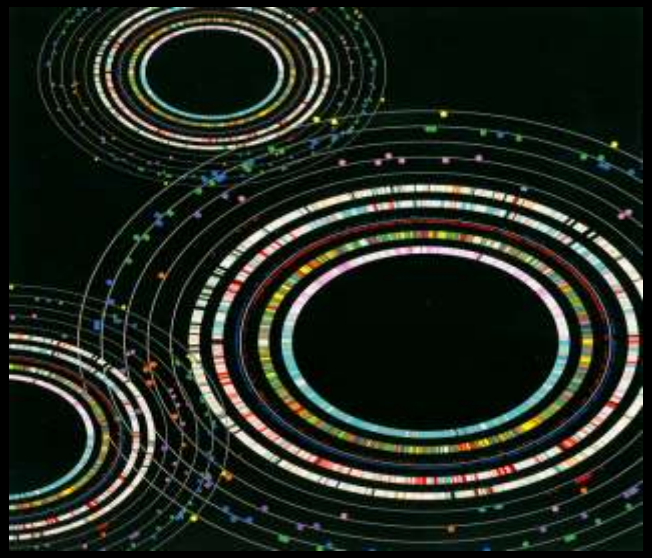


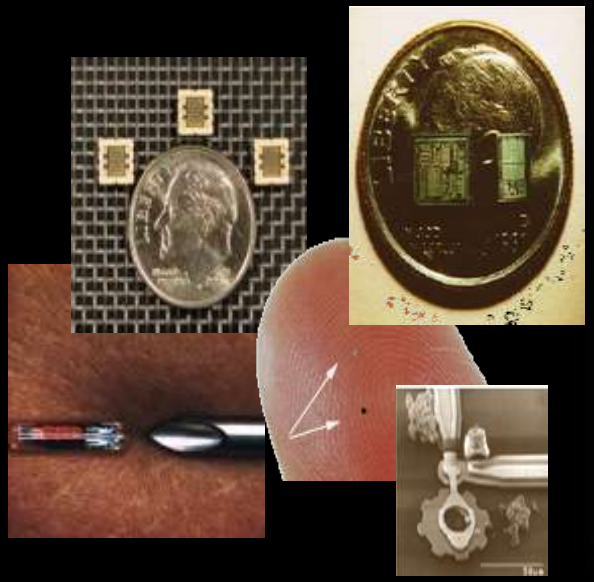
- Engineering of Biological Networks
- Remote Monitoring for Healthcare and Environmental Sustainability
- Advanced Medical Diagnostics and Healthcare Information Systems

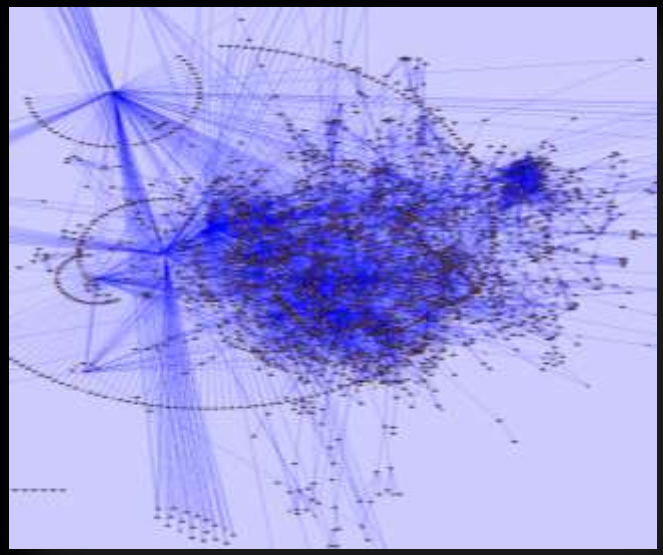
ASU Complex Adaptive Systems Initiative
Arizona State University

Initial Research Areas for CASI

Synthetic Biology	Ubiquitous Sensing	CAS Modeling and Simulation







- Engineering of Biological Networks
- Remote Monitoring for Healthcare and Environmental Sustainability
- Advanced Medical Diagnostics and Healthcare Information Systems

Dual-Use Complexity
Science and Industrial Policy, Regulation and Oversight
Socio-Cultural, Ethical and Legal Implications

Synthetic Biology

- emerging technology with myriad applications across diverse industrial sectors

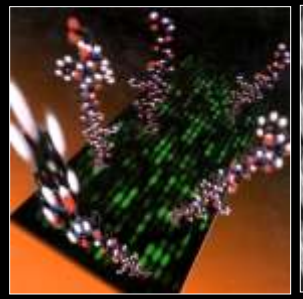
Healthcare

Public Health

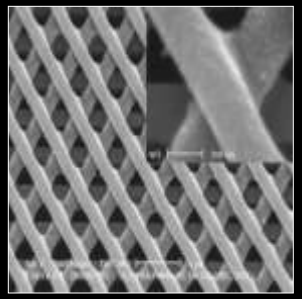
Agriculture

Functional Foods

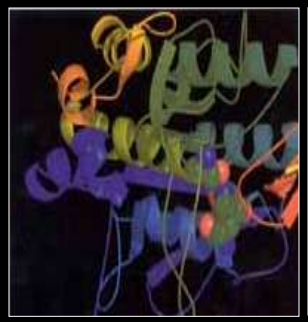
Novel Materials



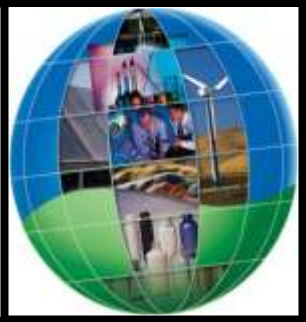
Textiles



Bioenergy and Biofuels



Industrial Enzymes



'Green' Mfg

Bio-remediation

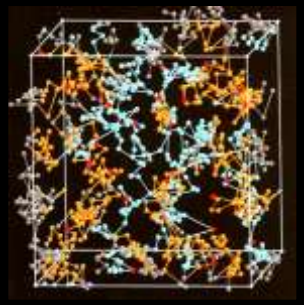
Clean Water

Ubiquitous Sensors

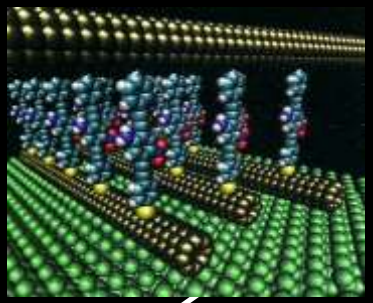
Synthetic Biology:
Inter-disciplinary Convergence and Complex Policy Issues

Systems Biology

Computational Biology

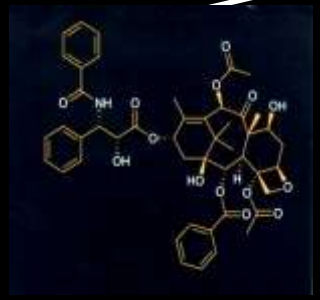


Materials and Nanobiotechnology



Industrial Bioprocess Engineering

Specific Applications



Occupational Safety

Dual-Use Applications

Public and Media Responses

Public Policy and Regulatory Oversight

Meta-Planning for Synthetic Biology

- metagenomics
- ecogenomics
- biobricks*
- biofoundry*

Astrobiology*

biogeochemistry

- materials*
- bioengineering*

- chemistry
- physics
- mathematics

- pattern analysis
- simulation of complex systems

sustainability initiatives*

ethics/science policy/regulation

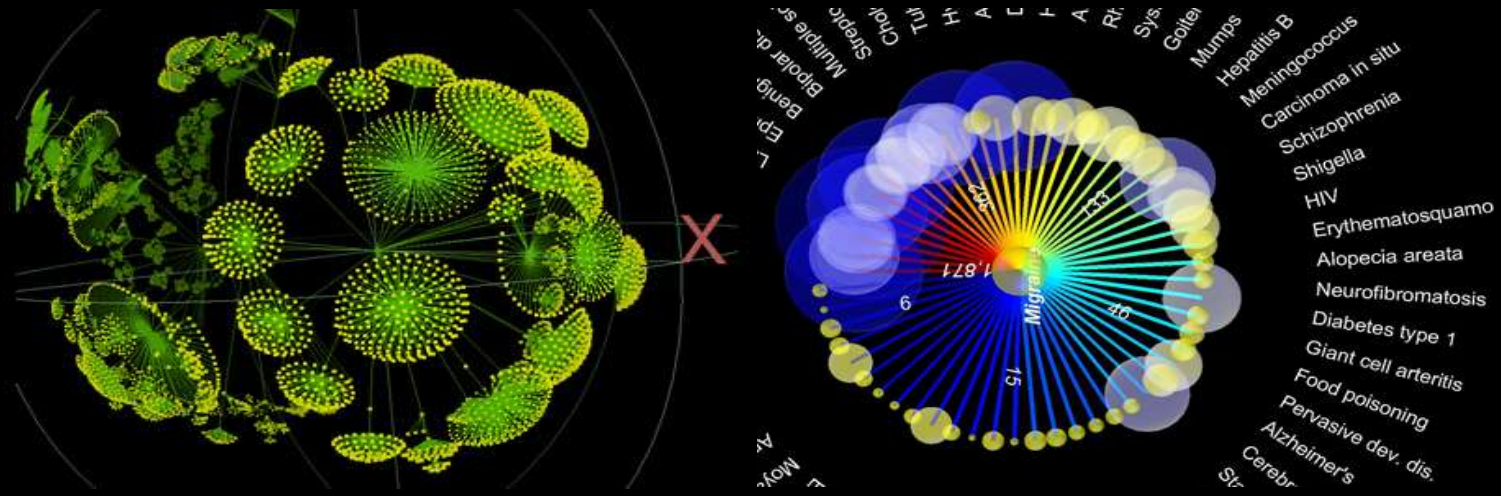
* major opportunity for 3M collaboration(s)

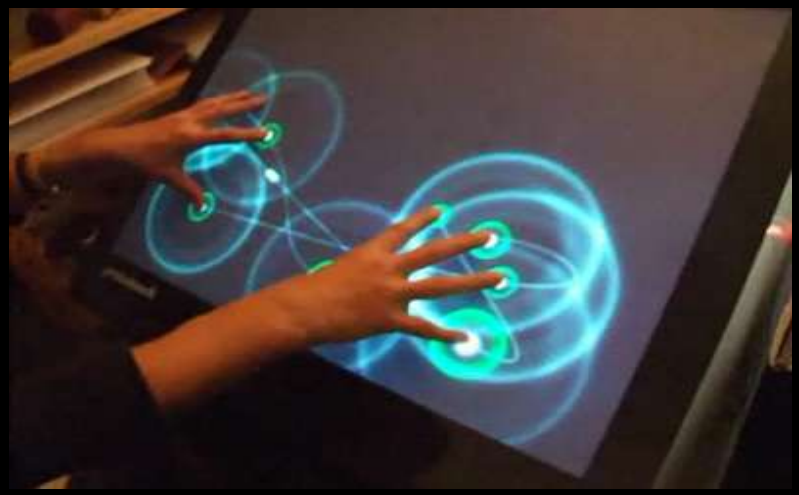
The Infocosm: Emerging Networks of Global Connectivity

Ubiquitous Sensing and Ambient Intelligence: A Burgeoning Infocosm and An Expanding Metaverse

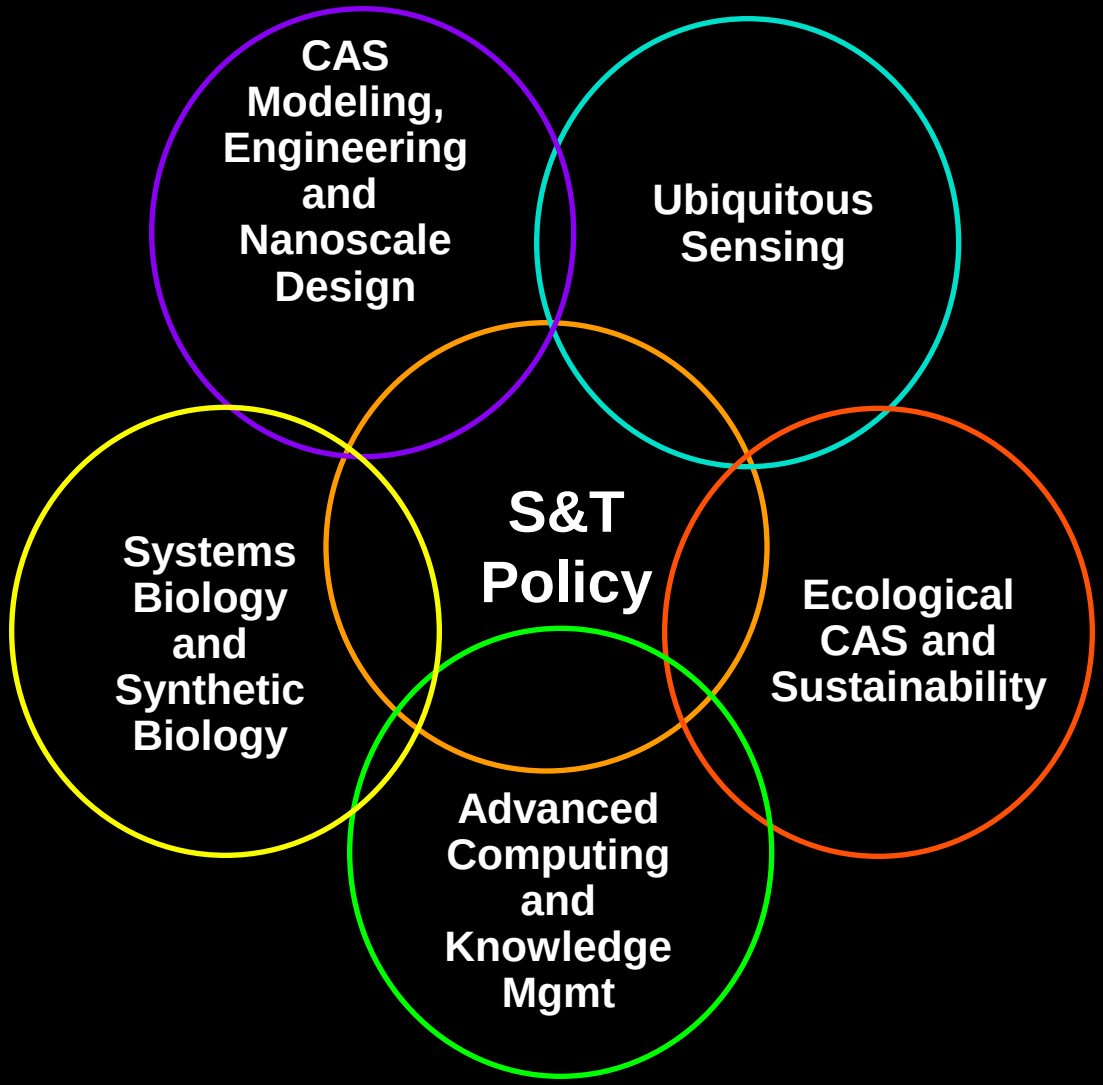
- everything is a reporter
- everything goes everywhere
- everybody sees everything
- everything moves fast

Design of Context-Dependent Data Mining and Visualization Tools and Integration with Advances in Cognitive Biology

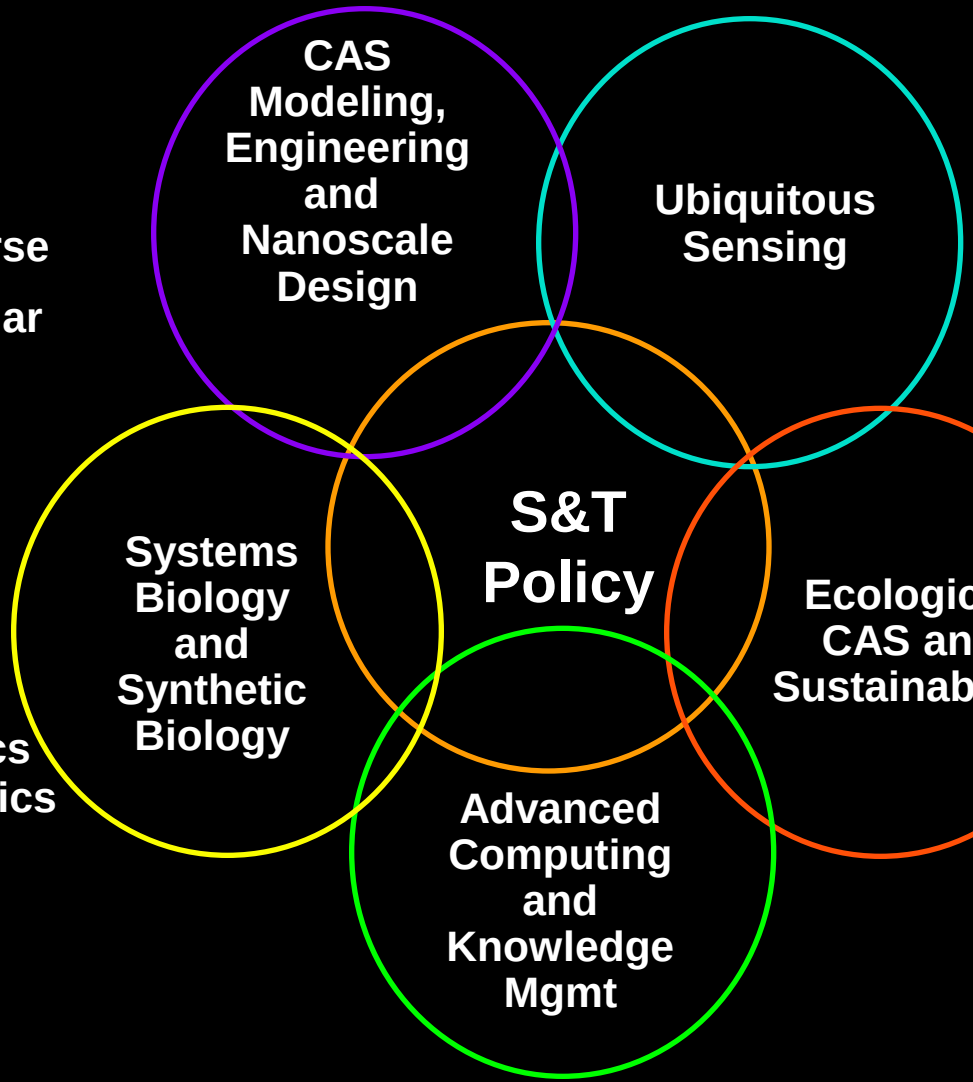




Integrated Components for Understanding the Design Principles of Complex Adaptive Systems (CAS)



Integrated Components for Understanding the Design Principles of Complex Adaptive Systems (CAS)



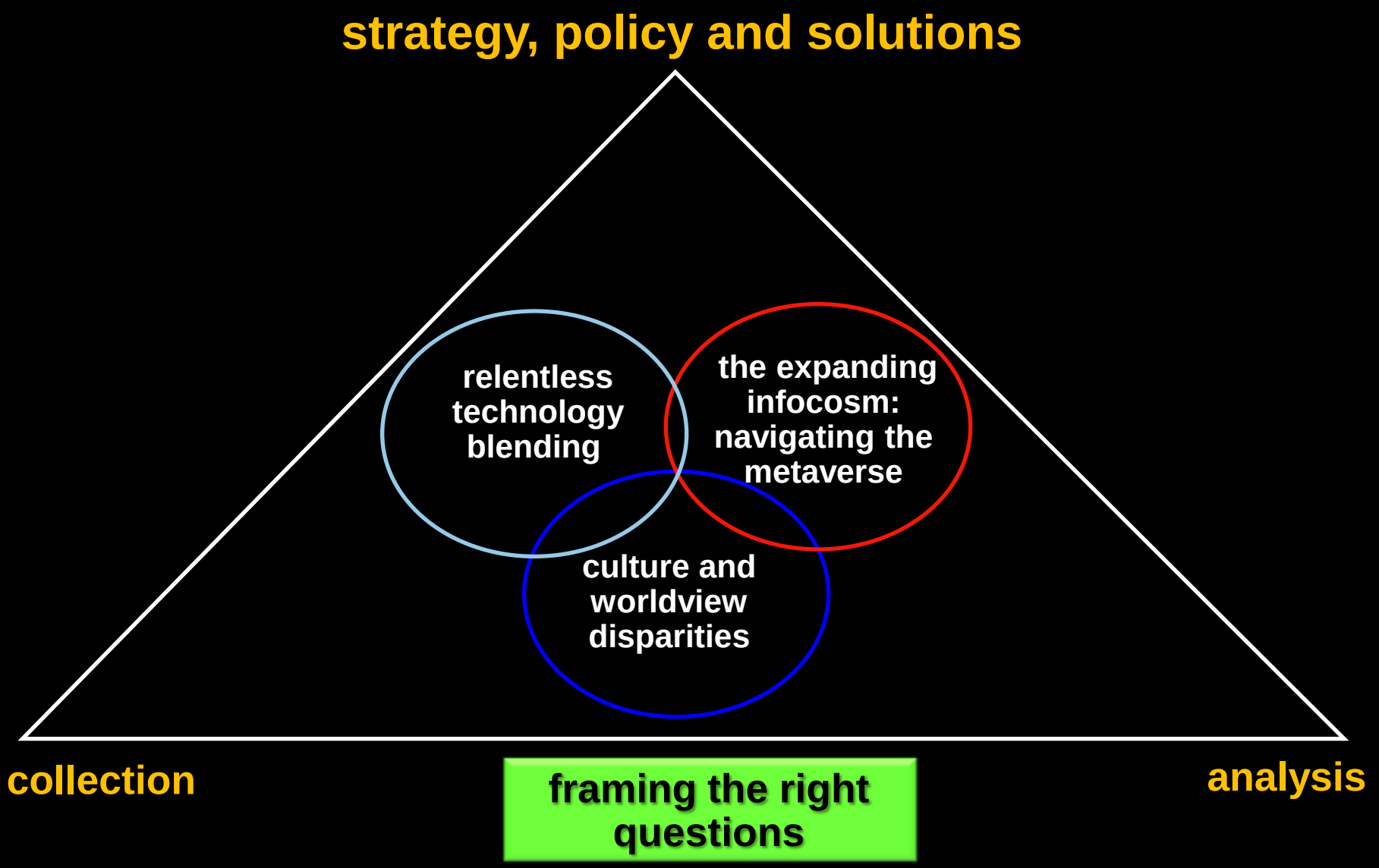
- multi-scale analytics
  - -nm to universe
- directed molecular assembly and nanofabrication
- systems and subnetworks design
- synthetic biology
  - ecogenomics
  - metagenomics

- bio-inspired products/materials services
- synthetic biology and novel mfg
- biomimetic materials
- environmental
  - urbanization
  - infectious diseases
  - water
  - energy
  - ecosystem modeling
- national security

- complex signal deconvolution
- novel data visualization
- novel IA for dynamic sensor networks
- large scale simulation
- cognitive neuroscience and optimized analysis / learning

ASU Complex Adaptive Systems Initiative
Arizona State University

Leadership in Research on Complex Adaptive Systems: ASU can be Ahead of the Curve



Future Thinking for Thinking About the Future

- what is possible?
- what is probable?
- what is preferable?
- what is preventable?

- how do we develop and apply new tools to understand complex systems
  - scientific research
  - technological solutions
  - institutional reform
  - education and training

"Urgency"

"Focus and Resolve"

"Passion and Purpose"