ASU BIODESIGN INSTITUTE
ARIZONA STATE UNIVERSITY

The State of the Institute Review
14 July 2008

Building Interdisciplinary Research Excellence for Innovative Solutions to Global Challenges

Agenda

- five year progress report
- launch next phase in the Institute's evolution
- remarks by President Crow

Five Year Accomplishments: Meeting the Challenges

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

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

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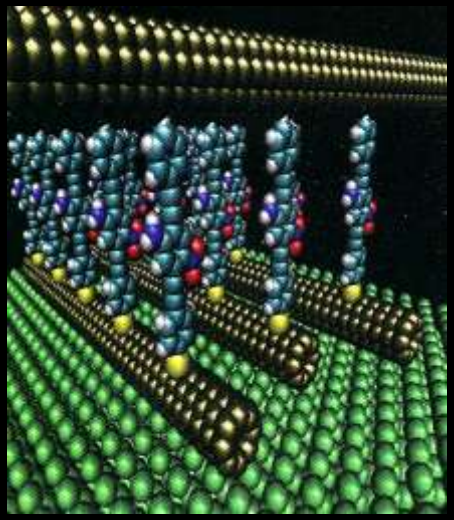
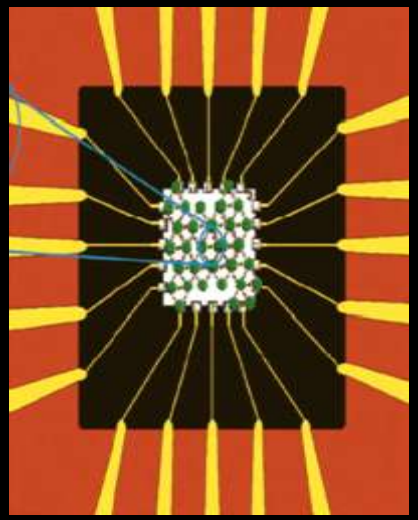
Technology Convergence

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

- 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
- globalization of research and intensifying competition

Building an Entirely New Organization in an Era of Accelerating Change: The Intangibles

- seeing a bigger vision
- rising to the challenge
- creating a great place to work
- being part of something special
- making an impact on real world problems
- courage to say “I don’t know” and “I need your help”
- rejoice in collegial and collective accomplishments
- everyone is an ambassador

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5 Year Progress Report

An Institute Without Boundaries

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

Biodesign Institute, Arizona State Univ.

Five Year Accomplishments: Facilities and Staffing

- on-time, on-budget construction and commissioning of 400,000 sq. ft. of superb facilities
- 20 facilities awards
- first LEED Platinum certification for any AZ facility
- recruitment of over 60 faculty and 500 other research and support staff

Big Science Requires a Big Engine

Five Year Accomplishments: Competitive Funding and Return on Investment

- received $71.26 million in TRIF funds from ASU
- generated $199 million in external funding
- 3.5X return-on-investment
- 12 patents, 45 patents filed, 122 provisional patent filings, 212 records of invention
- catalyzed major reorganization of Arizona Technology Enterprises (AzTE)


BILL & MELINDA GATES foundation
Bringing innovations in health and learning to the global community


W. M. KECK FOUNDATION


The Wallace Foundation™


sfaz
SCIENCE
FOUNDATION
ARIZONA


VIRGINIA G.
PIPER
CHARITABLE TRUST


FLINN
FOUNDATION
Biosciences IMPROVING THE
COMPETITIVENESS OF ARIZONA'S
BIOMEDICAL RESEARCH ENTERPRISE


Agilent Technologies


BOEING


CORNING


bp


edison


APS


Honeywell


GENERAL DYNAMICS
Strength On Your Side®


MOTOROLA


SONY


CH2MHILL


iOMED


COMBIMATRIX

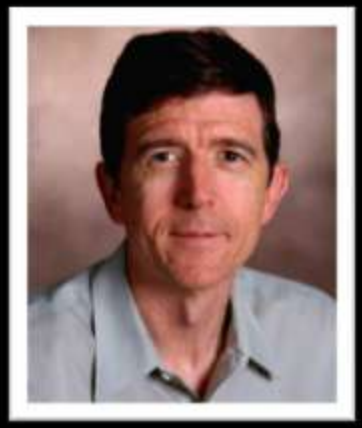

Applied
Applied Process Technology, Inc.


VAXX Inc.


VIRIONICS
CORPORATION

Five Year Accomplishments: Recognition of Research Excellence

- 460 papers in leading journals
- 286 presentations at national/international meetings
- faculty service on 56 national level review panels/advisory groups
- faculty membership on editorial boards of 32 journals and 23 corporate/foundation boards



“This is not your grandfathers science and it can no longer be taught that way”

Dr. Neal Woodbury

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: Honors and Awards

- faculty recipients of numerous prestigious awards
- Regents Professorships (2)
- ASU Faculty Achievement Awards (3)
- Arizona BioIndustry Researcher of the Year Awards (2)
- Governors Innovator of the Year Award (2)
- Fellowships, American Association for Advancement of Science (3)
- major professional society awards (4)
- R&D Magazine Researcher of the Year (1)
- Einstein Prize: Global Business Leadership Council (1)
- Sloan Foundation Fellowship (1)
- NIH Eureka Award (1)
- DOD Distinguished Career Award (1)

Five Year Accomplishments: Strengthening State-Wide Research and Economic Development

- productive collaborations with AZ-based research institutions
  - TGen, Mayo, Bio-5, Banner, Barrows Neurological Institute, Carl Hayden VA, Scottsdale Health
  - 70 adjunct faculty
- participation in new state-wide initiatives
  - Arizona Proteomics Alliance, Health Research Alliance Arizona, Arizona Bioindustry Association, Arizona Bioscience Roadmap
- successful capture of competitive funding from Science Foundation Arizona
- support civic and legislative initiatives in economic development
  - GPEC, GPL, Gubernatorial initiatives, Arizona Department of Commerce

Five Year Accomplishments: Communications and Public Relations

- diverse target audiences
  - legislature, media, industry, philanthropy
  - professionals, employees, students
  - public
- community relations
  - hosted 733 tours for 4693 visitors
  - monthly e.newsletter to over 1000 subscribers
- media relations
  - 292 major news hits/26 wire stories from 170 press releases
  - high-profile coverage by Nature and Washington Post
  - KAET series on Institute's focus on global challenges

THE biodesign INSTITUTE

ARIZONA STATE UNIVERSITY

keyword SEARCH

FEATURE STORY

From foe to friend: Researchers use salmonella as a way to administer vaccines in the body

Researchers at the Biodesign Institute at Arizona State University have made a major step forward in their work to develop a biologically engineered organism that can effectively deliver an antigen in the body. The researchers report that they have been able to use live salmonella bacterium as the containment/delivery method for an antigen.

Read More »

NEWS & EVENTS

Can microorganisms be a solution to the world's energy problems?

Biodesign collaborative mettle leads to new SARS vaccine project

ASU Leads the Nation with Largest University Solar Installation

AT THE BIODESIGN INSTITUTE, WE STRIVE TO:

- PREVENT AND CURE DISEASE
- OVERCOME THE PAIN AND LIMITATIONS OF INJURY
- RENEW AND SUSTAIN OUR ENVIRONMENT
- SECURE A SAFER WORLD

RESEARCH CENTERS AT THE BIODESIGN INSTITUTE

- Applied NanoBioscience
- Bioelectronics and Biosensors
- BioEnergetics
- BioOptical Nanotechnology
- Ecogenomics
- Environmental Biotechnology
- Evolutionary Functional Genomics
- Infectious Diseases and Vaccinology
- Innovations in Medicine
- Single Molecule Biophysics

NEW INITIATIVES

GET INTO SCIENCE 90-SECOND VIDEO

GREEN INITIATIVES

PH.D. PROGRAM IN BIOLOGICAL DESIGN

RESOURCES

GLOSSARY

HISTORY

CAREER TRACKS

Five Year Accomplishments: Communications and Public Relations

- launched Institute web site
- average over 700 hits/day
- pending major redesign of web site
- variety of intranet sites

Five Year Accomplishments: Institutional Advancement

- $18 million in philanthropic donations
- Virginia G. Piper Trust*
  - $10 million for Professorial appointments in personalized medicine research
- private philanthropist
  - $5 million for new Ph.D. program in Biological Design
- next challenge for the Institute to capture major donations for facilities expansion

*additional $35 million in collaboration with Partnership for Personalized Medicine

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

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

THE ARIZONA EXPERIMENT

Nature (2007) 446, 968

"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

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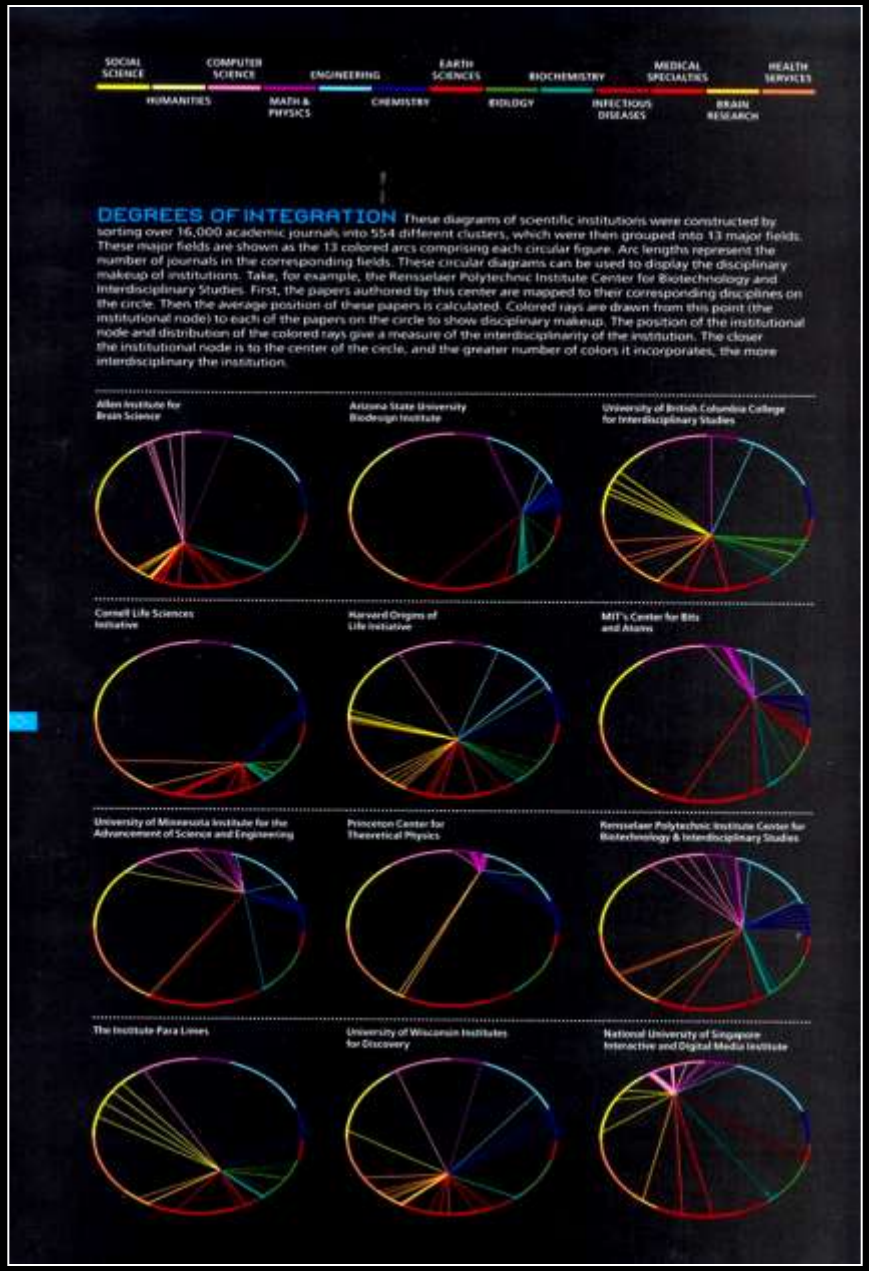
The Evolution of Inter-disciplinary Academic Research Centers (Seed Jan. 2008)



Five Year Accomplishments: A Critique

- Institute Advisory Board Reports

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

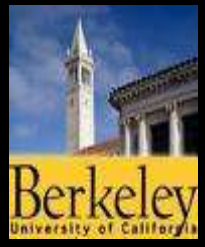
December 2007

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

March 2008

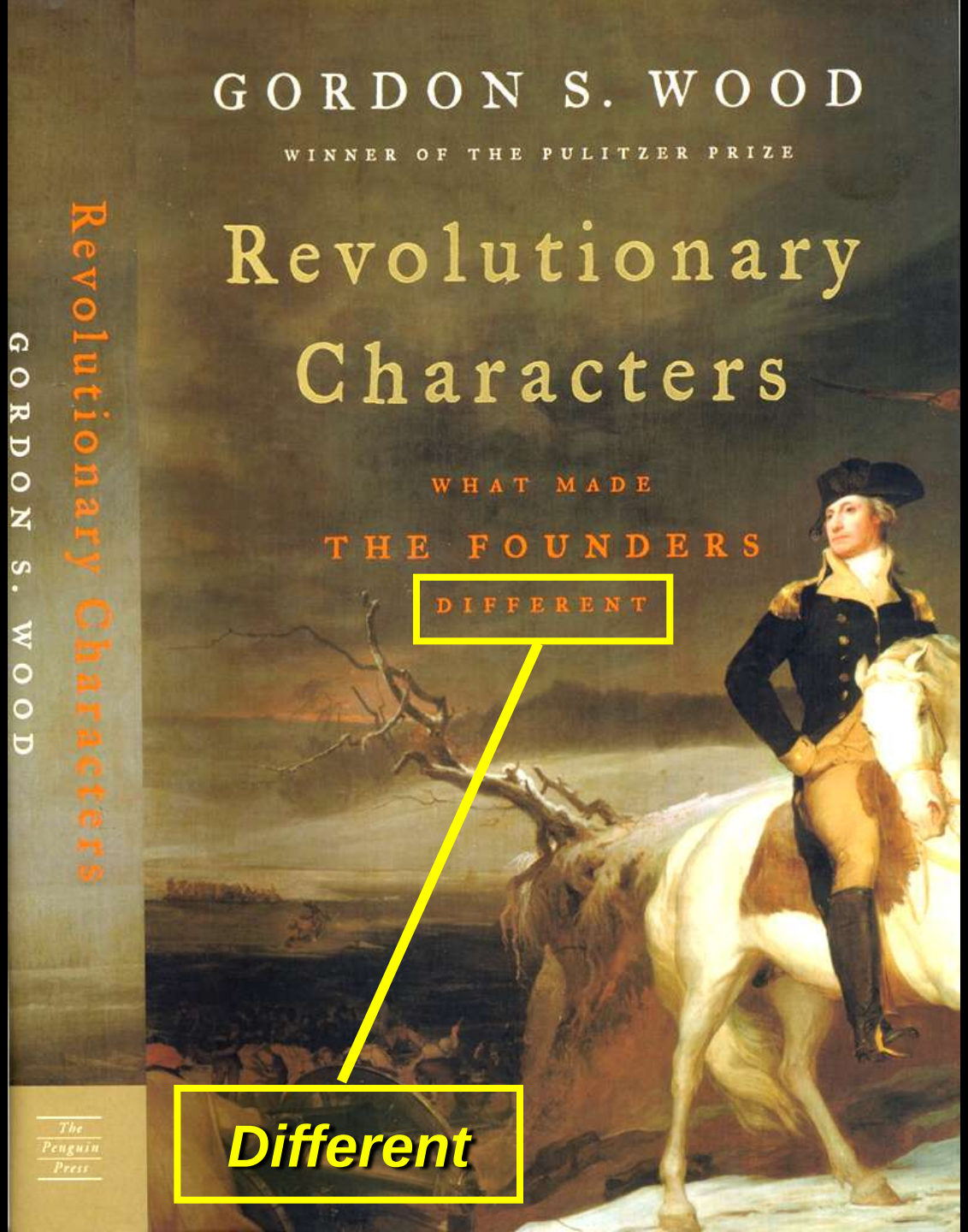
It Doesn’t Just Happen!

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



Five Year Accomplishments: Strategy and Competitiveness

- how can we prosper in an era of rapid and substantial change?
- purposeful proactive planning versus ad hoc and passive reactivity
- how can we do things differently to achieve worldclass recognition?
  - short timeframe to success
- emulation of today's leading institutions is neither realistic nor a guaranteed roadmap for success


GORDON S. WOOD
WINNER OF THE PULITZER PRIZE
Revolutionary Characters
WHAT MADE
THE FOUNDERS
DIFFERENT
Different
Revolutionary Characters
GORDON S. WOOD
The Penguin Press

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

ASU BIODESIGN INSTITUTE
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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 and attracts new sponsors
- audacious goals
- relentless focus on a few high profile target areas in which we can attain worldclass status

IMPACT

The Challenge of Building a New Organization in an Era of Accelerating Change: Organizational and Cultural Transitions

- from a predominant focus on single discipline to multi-disciplinary teams
- from limited funding of individual investigators to formidable funding needs of large scale research
  - 3M grants: multi-investigator; multi-institution; multi-million dollar
- from largely autonomous research units to sophisticated orchestration of resources from multiple centers
  - progressive evolution of a “tightly-coupled” Institute

Five Year Accomplishments: Meeting the Challenges

- highly aggressive timetable and performance metrics
- cultural hurdles
  - ambiguity, skepticism, fear, hostility
  - greater collegiality and cooperation
  - ‘heavy lifting’ for the collective good
  - accountability and deliverability

Creation of a Portfolio of Competitive Research Programs to Address Major Global Challenges

Use-Inspired Research

High Impact Research on Major Global Challenges and Unmet Needs

personalized medicine

outpacing infectious diseases

energy and environment

securing a safer world

synthetic biology

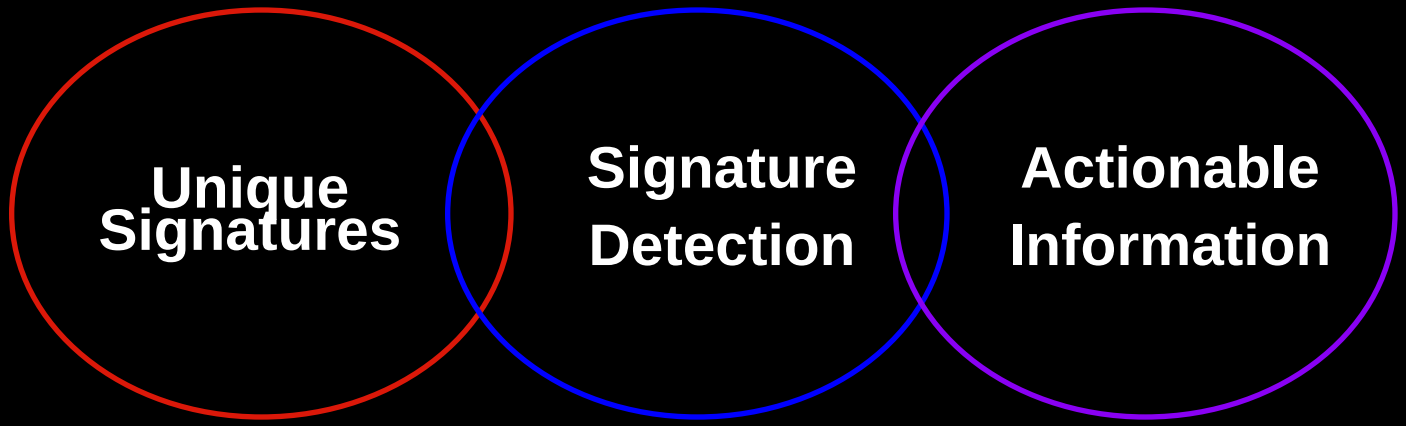
Leveraging Technology Convergence for Diverse Applications

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

Innovative Solutions for Major Global Challenges




Unifying Technology Platforms



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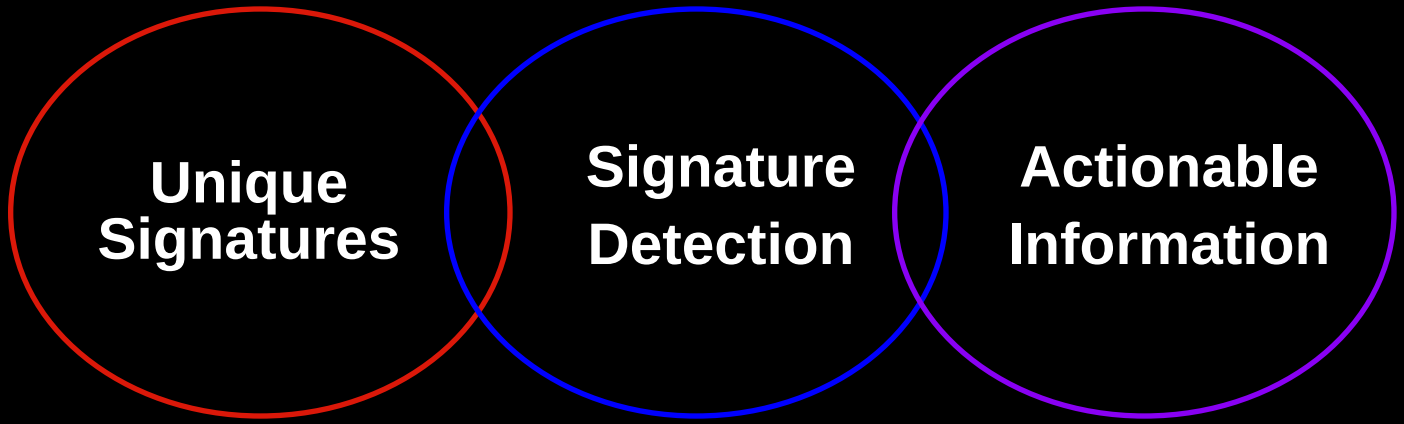
Innovative Solutions for Major Global Challenges




Unifying Technology Platforms



Objective

Profile | **Sense** | **Act**

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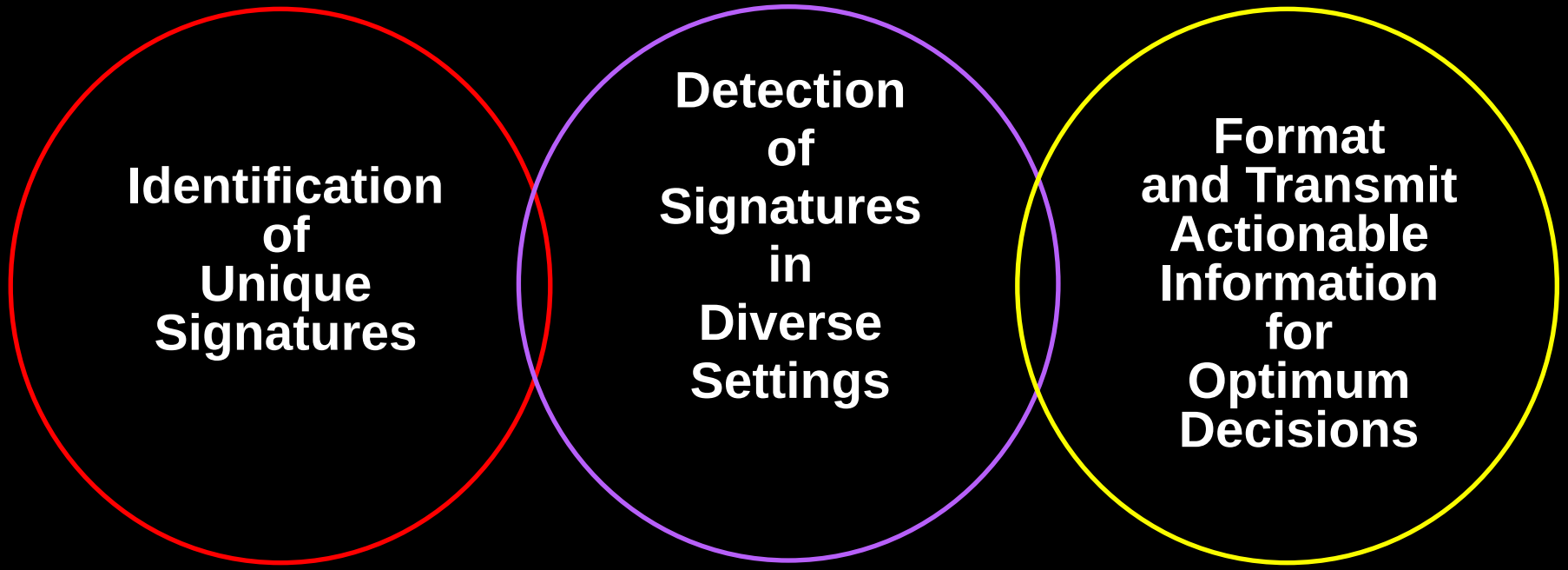
Integrated Functional Platforms to Exploit Technology Convergence



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

Assembling a Competitive Portfolio of Projects at Different Levels of Scientific and Technological 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

- Synbodies and Molecular Diagnostics (Doc-In-a-box)
- 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

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*
- 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

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A "Tightly Coupled" Research Institute

- interdisciplinary
- integrated
- aligned
- competitive

DELIVERY and ACCOUNTABILITY

IMPACT

A Tightly Coupled Institute

- organizational model adopted in US National Laboratories
  - complex, multi-disciplinary projects
  - constant changes in skill/resources as projects evolve
- alignment (tightly) around shared goals
- integration of diverse skills and centers (coupled)
- performance milestones for high impact outcomes

A Tightly Coupled Institute

- new concept for academic research
- progressive evolution from traditional “loose federation” of collaborating units to increasingly coordinated integration
- significant cultural and management transitions
- new governance mechanisms for oversight and coordination of project portfolio

Creation of a New Governance Framework for Managing Large Scale, Cross-Disciplinary Projects

The Biodesign Directorate

George Poste
Institute Director

Michael Tracy
Director, California Collaboration Initiative

Jeffrey Darbut
Director, Finance & Operations

Kimberly Ovitt
Director, Communication & Institutional Advancement

Heather Anderson
Director, Strategic Integration

Roy Curtiss
Director, Infectious Diseases and Vaccinology

Neal Woodbury
Director, BioOptical Nanotechnology

Stephen A. Johnston
Director, Innovations in Medicine

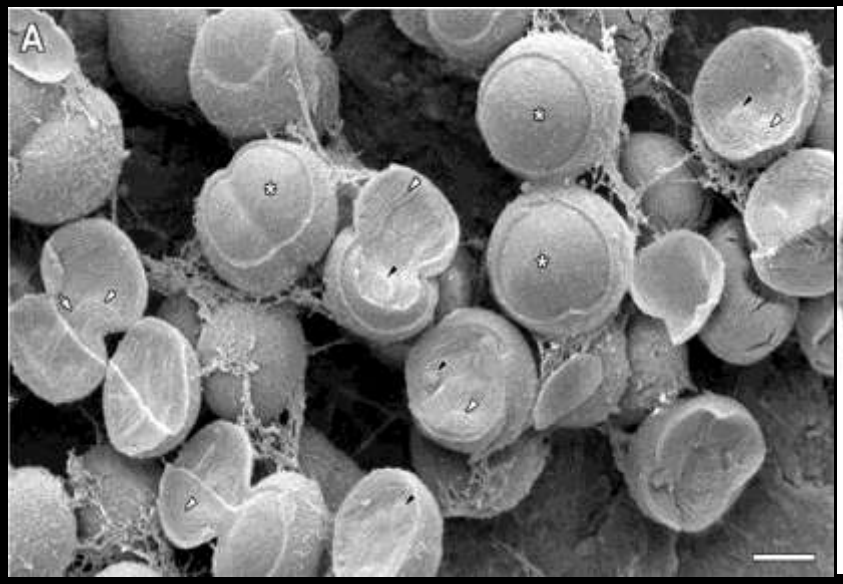
Stuart Lindsay
Director, Single Molecule Biophysics

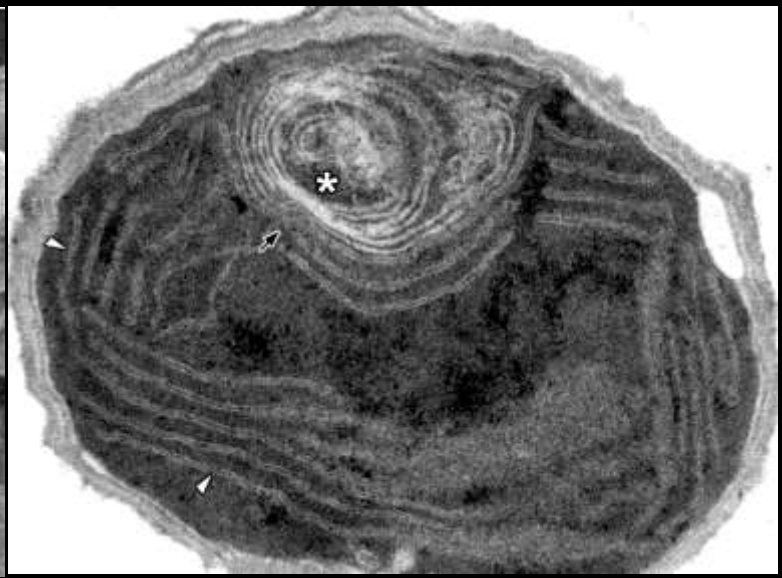
Deirdre Meldrum
Director, Ecogenomics

Apollo Projects

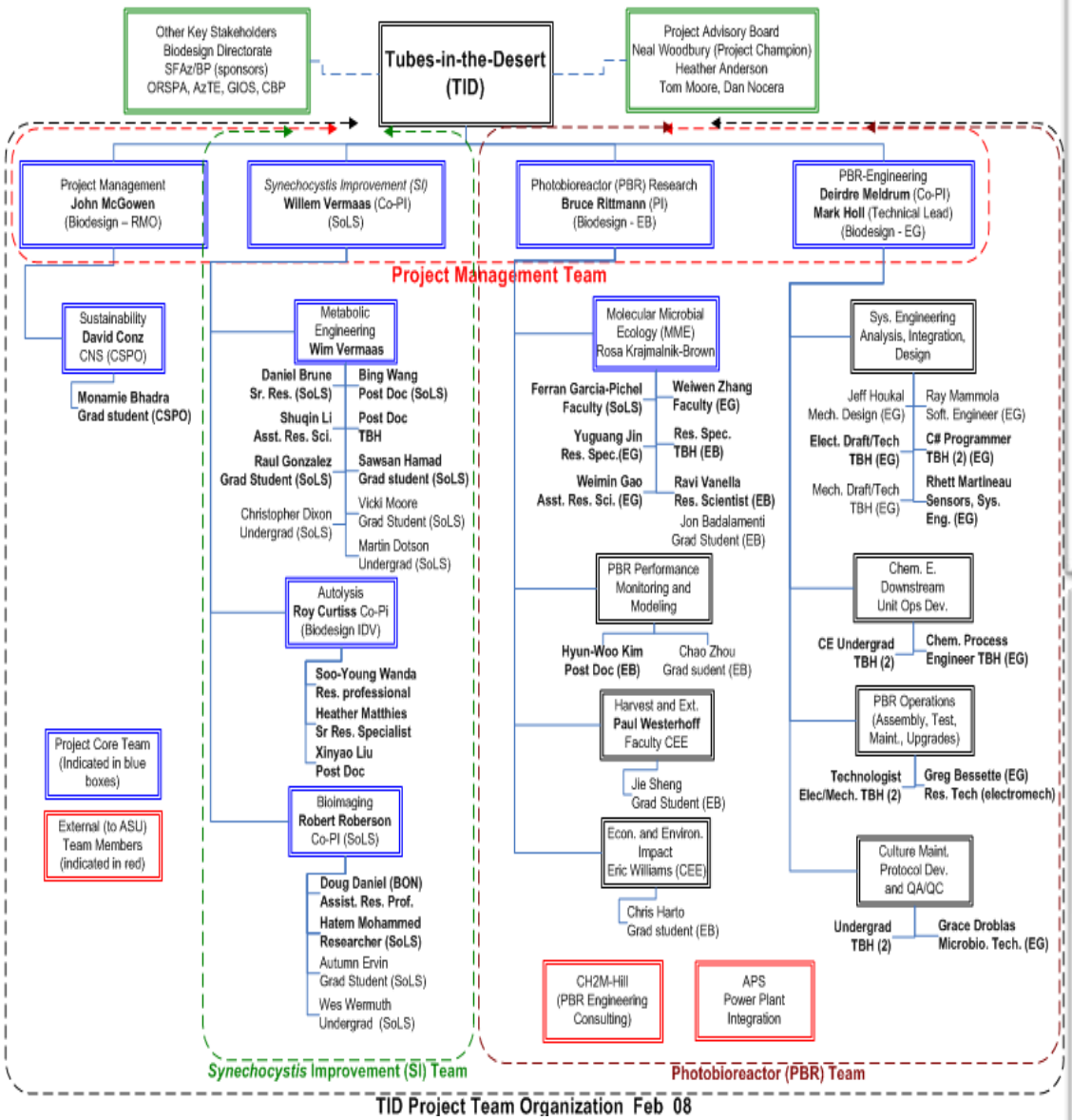
Tubes-in-the-Desert

- high yield bacterial biomass and biodiesel production





UCLA bp CORNING APS®


Other Key Stakeholders
Biodesign Directorate
SFAz/BP (sponsors)
ORSPA, AzTE, GIOS, CBP
Tubes-in-the-Desert (TID)
Project Advisory Board
Neal Woodbury (Project Champion)
Heather Anderson
Tom Moore, Dan Nocera
Project Management
John McGowen
(Biodesign – RMO)
Synechocystis Improvement (SI)
Willem Vermaas (Co-PI)
(SoLS)
Photobioreactor (PBR) Research
Bruce Rittmann (PI)
(Biodesign - EB)
PBR-Engineering
Deirdre Meldrum (Co-PI)
Mark Holl (Technical Lead)
(Biodesign - EG)
Project Management Team
Sustainability
David Conz
CNS (CSPO)
Monamie Bhadra
Grad student (CSPO)
Metabolic Engineering
Wim Vermaas
Daniel Brune
Sr. Res. (SoLS)
Bing Wang
Post Doc (SoLS)
Shuqin Li
Asst. Res. Sci.
Post Doc
TBH
Raul Gonzalez
Grad Student (SoLS)
Sawsan Hamad
Grad student (SoLS)
Christopher Dixon
Undergrad (SoLS)
Vicki Moore
Grad Student (SoLS)
Martin Dotson
Undergrad (SoLS)
Autolysis
Roy Curtiss Co-Pi
(Biodesign IDV)
Soo-Young Wanda
Res. professional
Heather Matthies
Sr Res. Specialist
Xinyao Liu
Post Doc
Bioimaging
Robert Roberson
Co-PI (SoLS)
Doug Daniel (BON)
Assist. Res. Prof.
Hatem Mohammed
Researcher (SoLS)
Autumn Ervin
Grad Student (SoLS)
Wes Wermuth
Undergrad (SoLS)
Molecular Microbial Ecology (MME)
Rosa Krajmalnik-Brown
Ferran Garcia-Pichel
Faculty (SoLS)
Weiwen Zhang
Faculty (EG)
Yuguang Jin
Res. Spec.(EG)
Res. Spec.
TBH (EB)
Weimin Gao
Asst. Res. Sci. (EG)
Ravi Vanella
Res. Scientist (EB)
Jon Badalamenti
Grad Student (EB)
PBR Performance Monitoring and Modeling
Hyun-Woo Kim
Post Doc (EB)
Chao Zhou
Grad sudent (EB)
Harvest and Ext.
Paul Westerhoff
Faculty CEE
Jie Sheng
Grad Student (EB)
Econ. and Environ. Impact
Eric Williams (CEE)
Chris Harto
Grad student (EB)
CH2M-Hill
(PBR Engineering Consulting)
APS
Power Plant Integration
Sys. Engineering Analysis, Integration, Design
Jeff Houkal
Mech. Design (EG)
Ray Mammola
Soft. Engineer (EG)
Elect. Draft/Tech
TBH (EG)
C# Programmer
TBH (2) (EG)
Mech. Draft/Tech
TBH (EG)
Rhett Martineau
Sensors, Sys. Eng. (EG)
Chem. E. Downstream Unit Ops Dev.
CE Undergrad
TBH (2)
Chem. Process Engineer TBH (EG)
PBR Operations (Assembly, Test, Maint., Upgrades)
Technologist
Elec/Mech. TBH (2)
Greg Bessette (EG)
Res. Tech (electromech)
Culture Maint. Protocol Dev. and QA/QC
Undergrad
TBH (2)
Grace Droblas
Microbio. Tech. (EG)
Project Core Team
(Indicated in blue boxes)
External (to ASU) Team Members
(indicated in red)
Synechocystis Improvement (SI) Team
Photobioreactor (PBR) Team
TID Project Team Organization Feb 08


GROVE

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

The Increased Emphasis on Business Development & Strategic Alliances

Understanding and learning from our competitors

Creating new collaborative networks

The California Collaboration Initiative (CCI)

- unmatched scale and sophistication of California academic and industrial research plus venture capital resources
- strategic imperative for Biodesign/ASU to increase collaborations/3M awards
- initial focus on synthetic biology
  - UCB, UCSF, Stanford, QB3
  - ‘bio-fab’ consortium
  - venture capital investments
- led by M. Tracy

Five Year Accomplishments: Competitive Intelligence

- Strategy and Research Alliance Unit established December 2005
- 24 major analyses of emerging technical areas
- 57 profiles of organizations of interest
- 16 detailed biographies of researchers of interest (recruitment/collaboration)

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: 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

A Multi-Tiered System for Planning and Oversight of the Research Portfolio

Internal

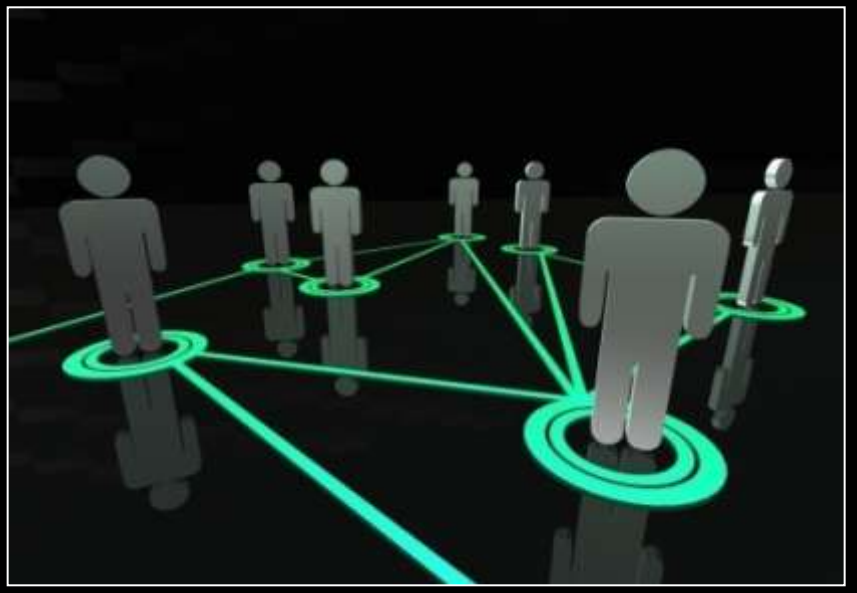
- Institute Director and Deputy Director
- Institute Center Directors
- Apollo and Gemini Project Leaders/Team Members
- Office of Strategic Integration and Management
- Government and Industry Liaison Office

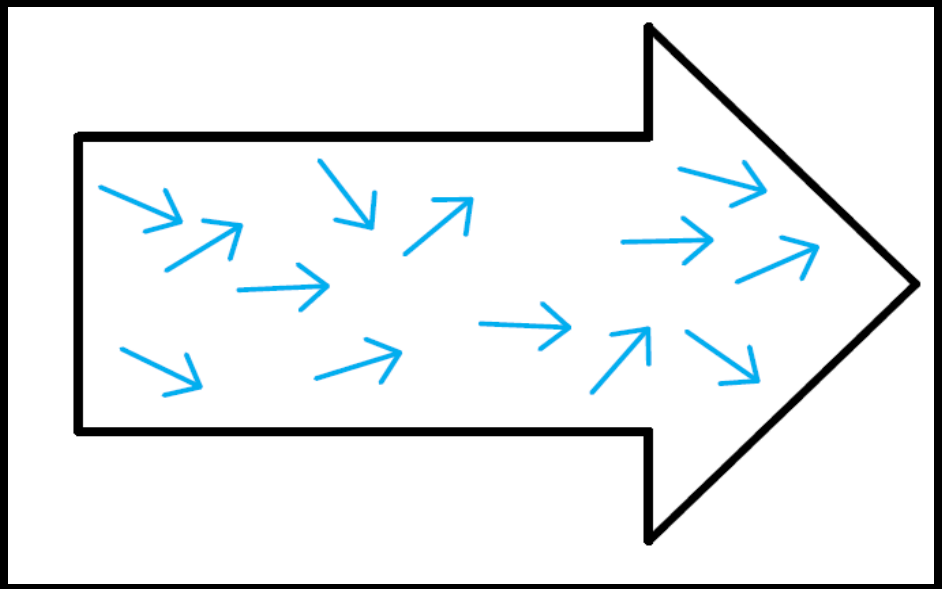
External

- Office of the President
  - WGB
- Institute Advisory Board
- Success in competitive funding
- Publications and citations
- Major conferences and board invitations


Impact on Global Challenges
vision and purpose
use-inspired solutions
ASU and Institute Leadership
IAB
global challenges
personalized medicine
outpacing
infectious disease
energy and environment
securing a safer world
Directorate
project portfolio
Apollo and Gemini projects
New Frontiers projects
core platforms
Program Leaders
competitiveness
sustaining competitive discipline-based expertise and collaborations
aggressive pursuit of external funding
education and training
Research Centers
Leveraging Technology Convergence
Cross-Disciplinary Research
Expanded Collaboration Networks
3M Funding
The Changing Environment for Research Success

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

The Next Phase in the Evolution of the Institute

The Next Phase in the Evolution of the Institute

- sustain momentum of current project portfolio
- continue to refine application of tight-coupling to optimize cross-disciplinary research goals
- expand external revenue streams to achieve economic self-sufficiency by 2012
- diversify funding sources and increase fraction of 3M revenues
- increase private-public partnerships
  - diversify funding sources
  - expand licensing revenues from IP and related assets

The Next Phase in the Evolution of the Institute

- launch of the Complex Adaptive Systems Initiative (CASI) at ASU
- opportunity for ASU to be in the vanguard of research scholarship in emerging areas of science that will demand broad integration of intellectual resources across the entire university

The Launch of the Complex Adaptive Systems Initiative (CASI)

Chief Scientist,
Complex Adaptive Systems Initiative,
Arizona State University

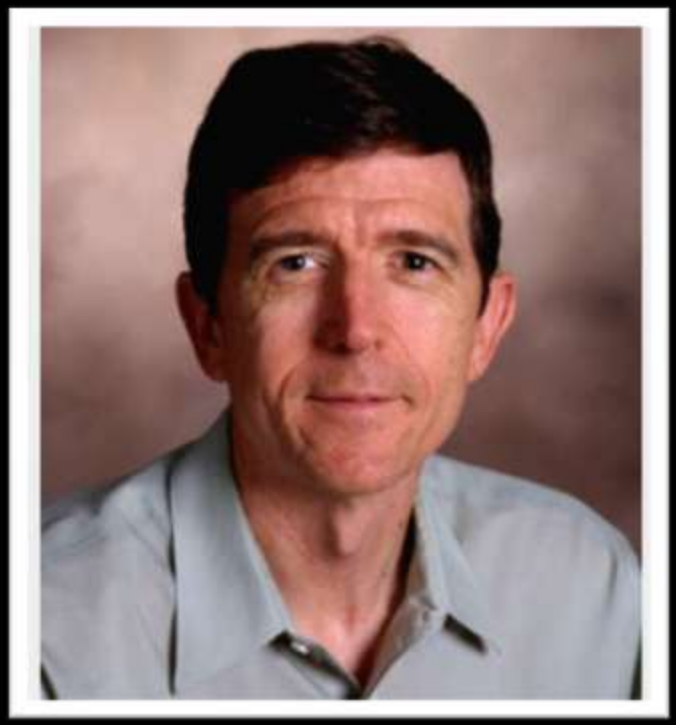
ASU BIODESIGN INSTITUTE
ARIZONA STATE UNIVERSITY

Leadership Transition

Leadership Transition for the Institute

- G. Poste to assume new role as Chief Scientist, CASI
- international search to be launched for successor with worldclass credentials
- G. Poste will remain Institute Director until successor is recruited
- crucial importance of continuity and providing new Director with access to ongoing experience and insights into the Institute's goals and operations

Leadership Transition for the Institute



Appointment of
Dr. Neal Woodbury
as Deputy Director,
The Biodesign Institute

ASU BIODESIGN INSTITUTE
ARIZONA STATE UNIVERSITY

Understanding the Design Principles of Complex Adaptive Systems:

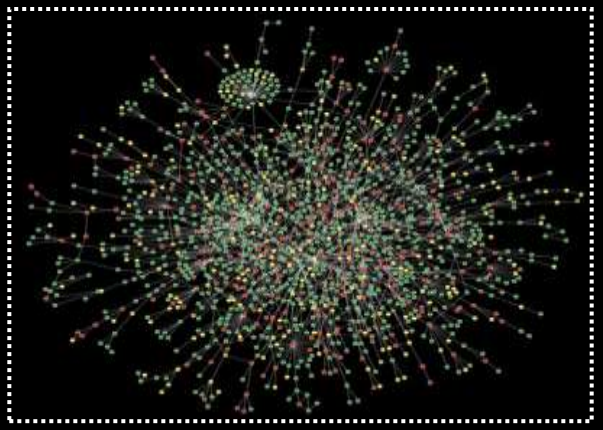
An Ambitious Theme for Research Excellence at ASU

ASU COMPLEX ADAPTIVE SYSTEMS INITIATIVE
ARIZONA STATE UNIVERSITY

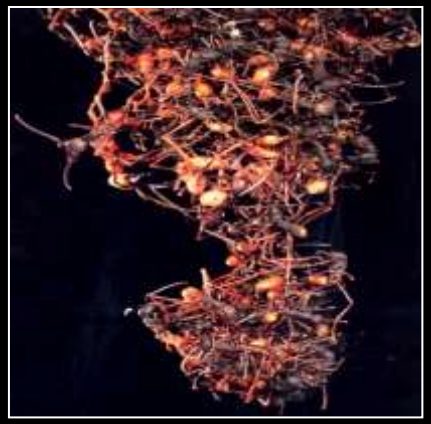
"Complexity is the new science.
Everything is complex.
Every problem in the world is a system.
The disciplines are classified by people,
but nature never recognizes them."

C. S. Kiang
Founding Dean,
College of Environmental Sciences
Beijing University
Cited in Seed January 2008, p. 56

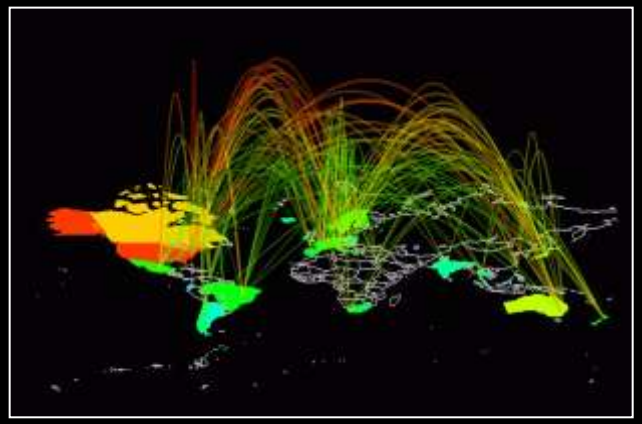
Protein Interactions



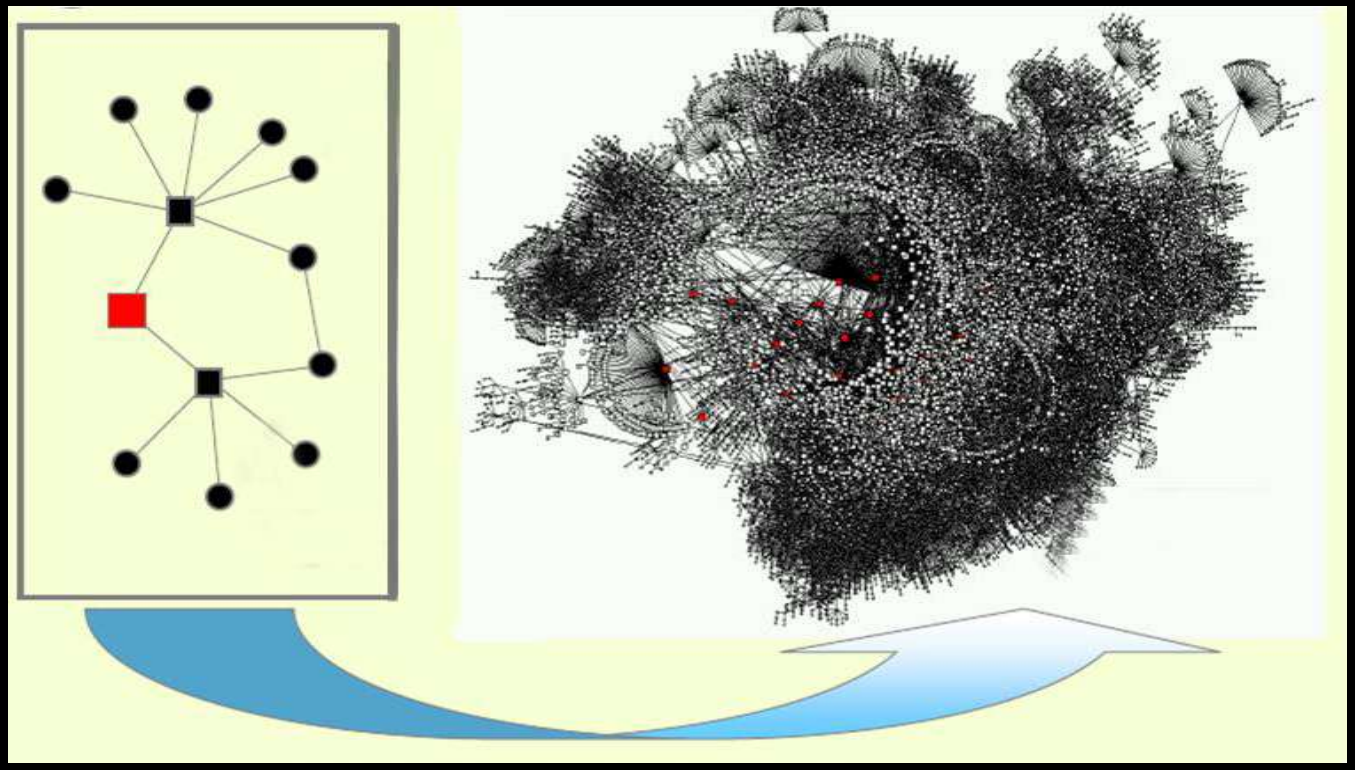
Local Ecosystem



Internet Traffic



Networks

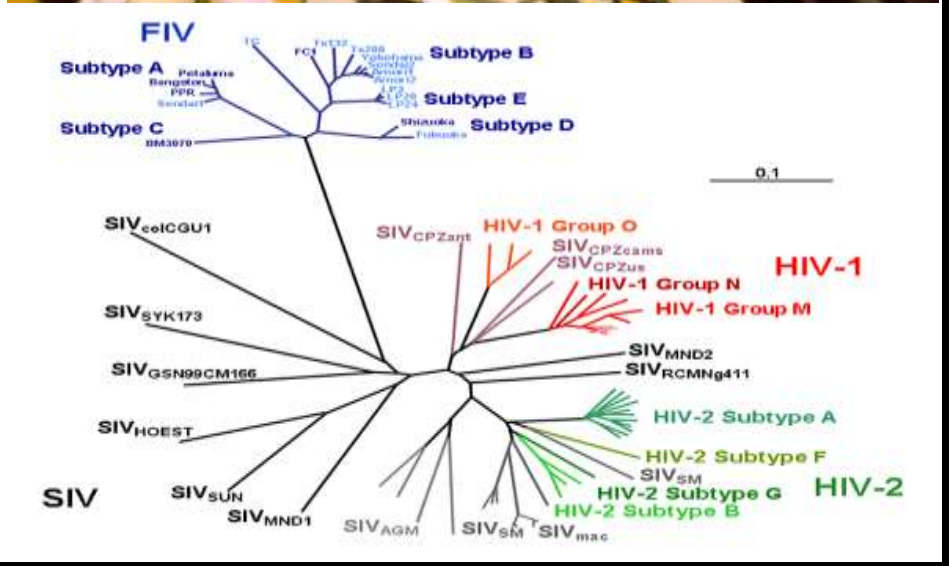


Systems of Systems

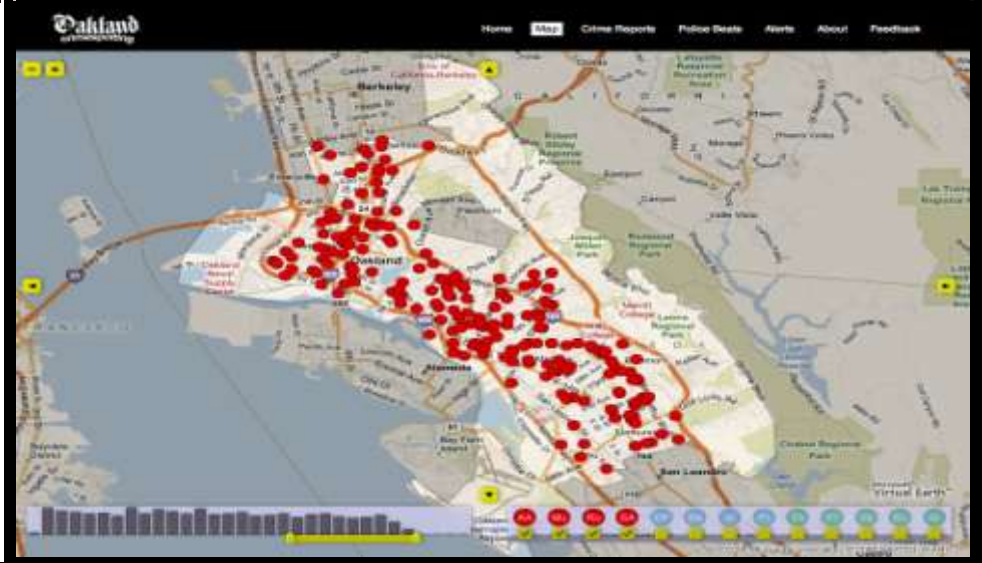
Individual Interactions Lead to Complex Systems

National Power Grid

Global Financial Markets

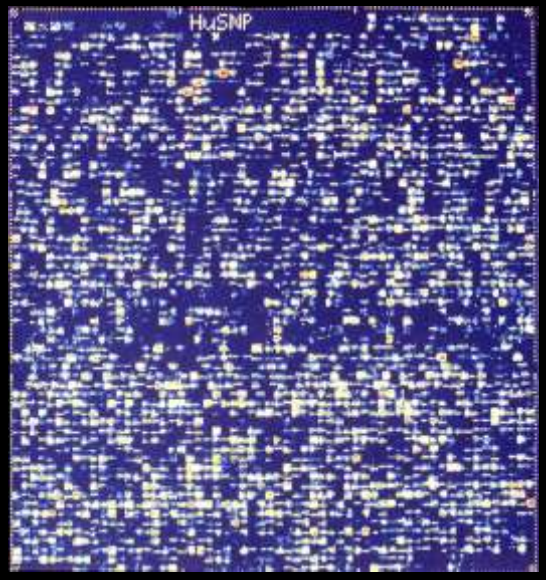


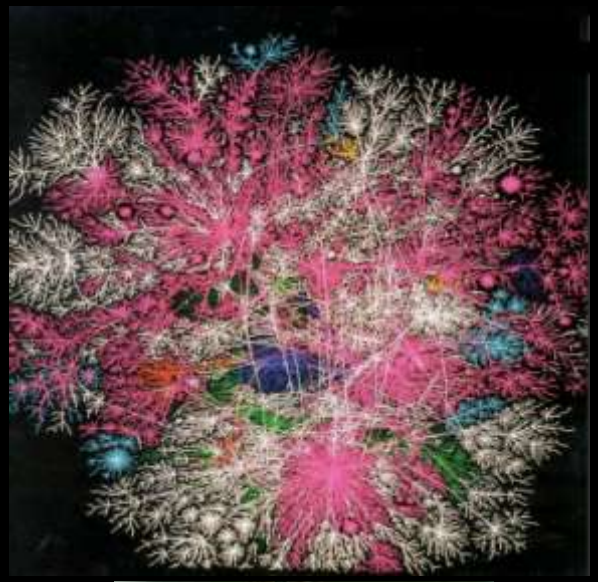
Viral Epidemiology

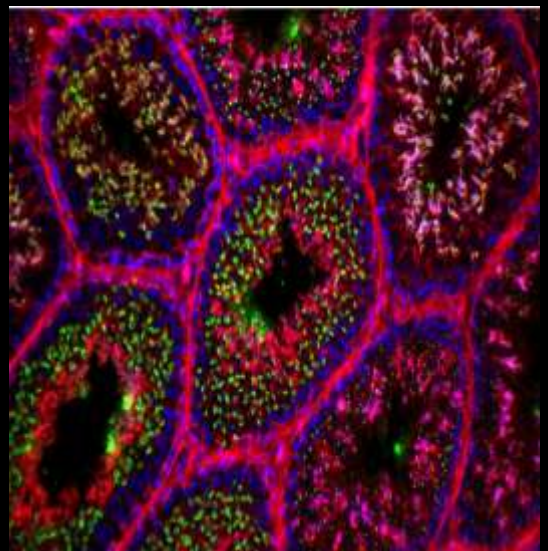


Urban Crime Patterns

Comprehending Biological Design: The Design of Complex, Adaptive Networks of Increasingly Higher Structural Order







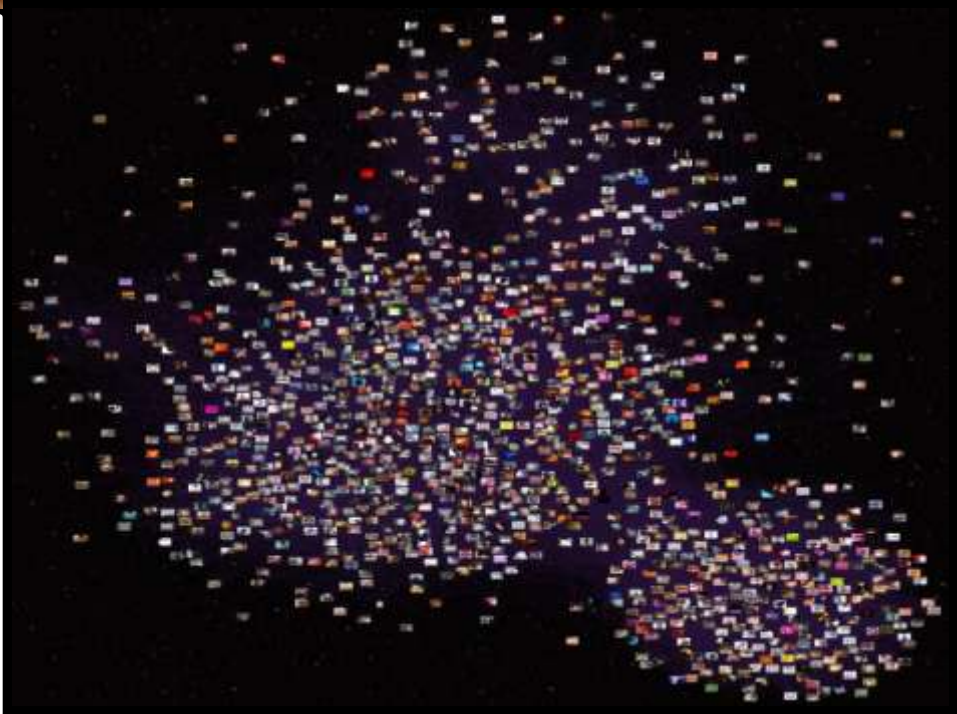
Principles of Design

- 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, business

The Elegance of Design: Combinatorial Assembly of Complex Adaptive Systems

- assembly of higher order complexity/functional diversity
  - components
  - circuits
  - networks
  - system
  - connectivity of systems
- connectivity of systems
- system of systems

Combinatorial Assembly and Complexity

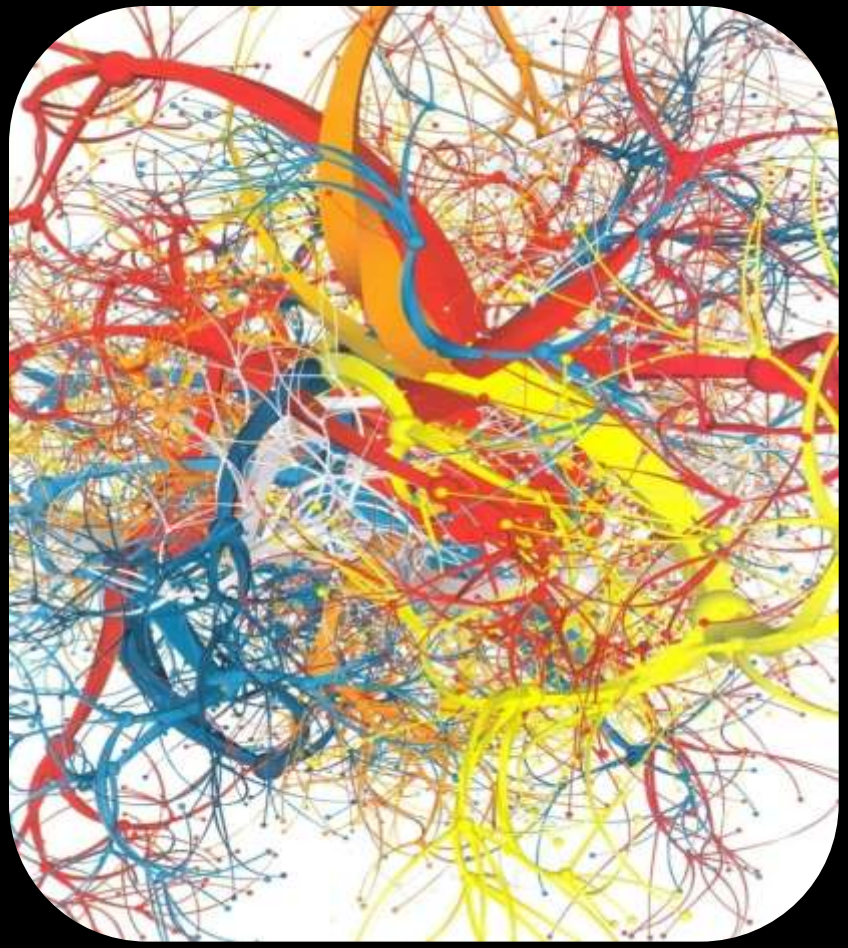


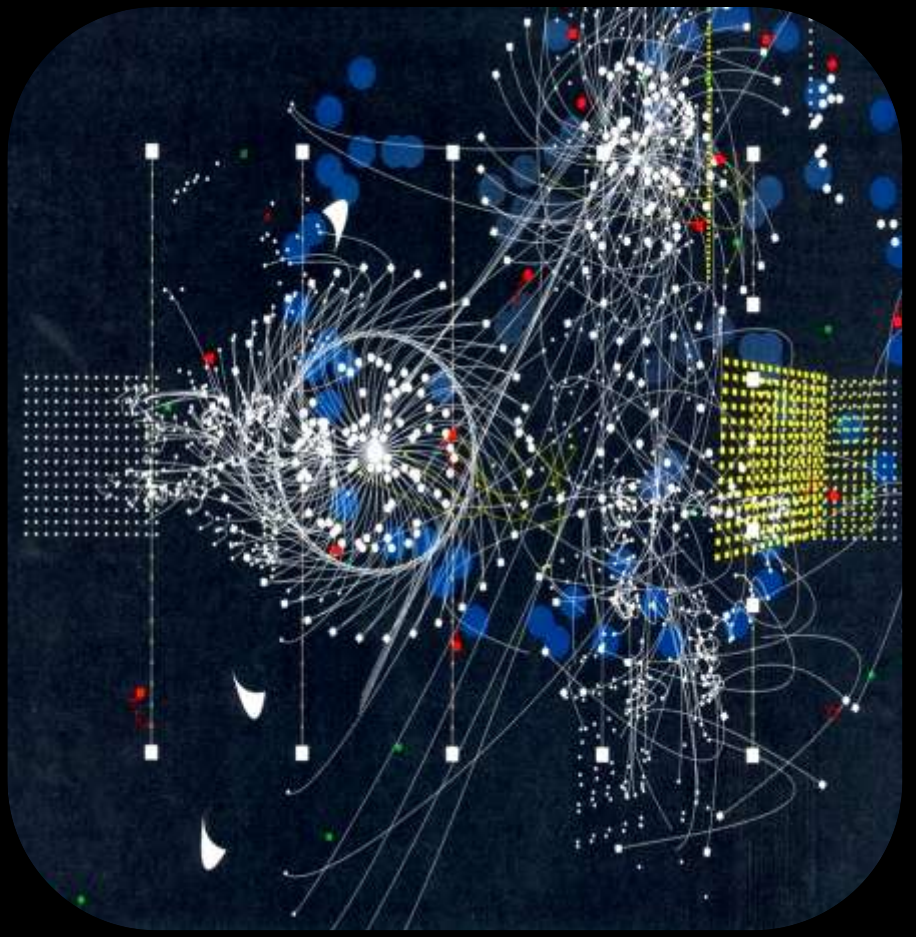
Biological Design: "Endless Forms Most Beautiful": Limitless Diversity From Combinatorial Assemblies of Limited Building Blocks

"Simplicity is the ultimate sophistication"

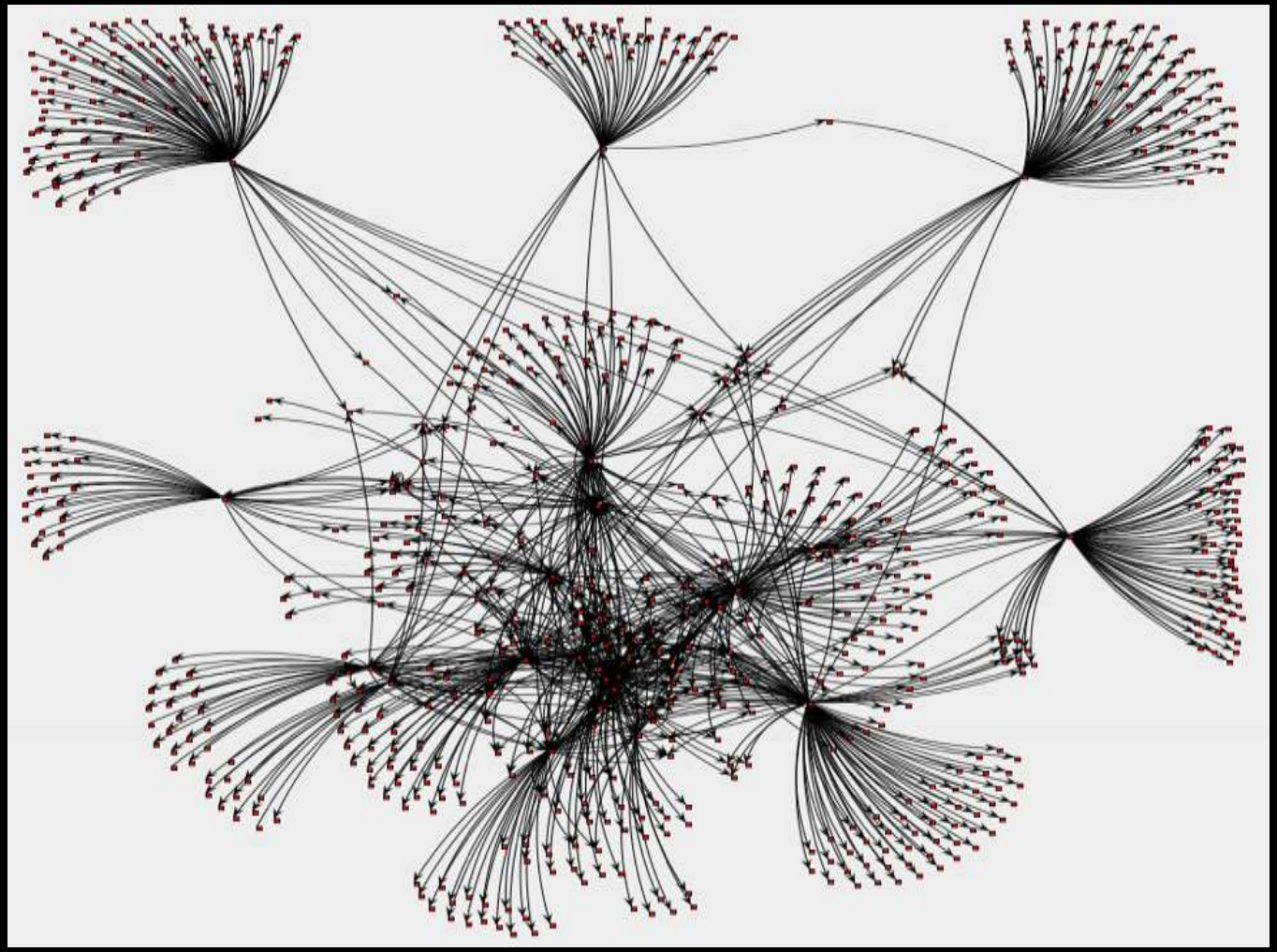
Leonardo de Vinci

Elucidation of the Structure of Scale-Free Networks and Interaction Patterns

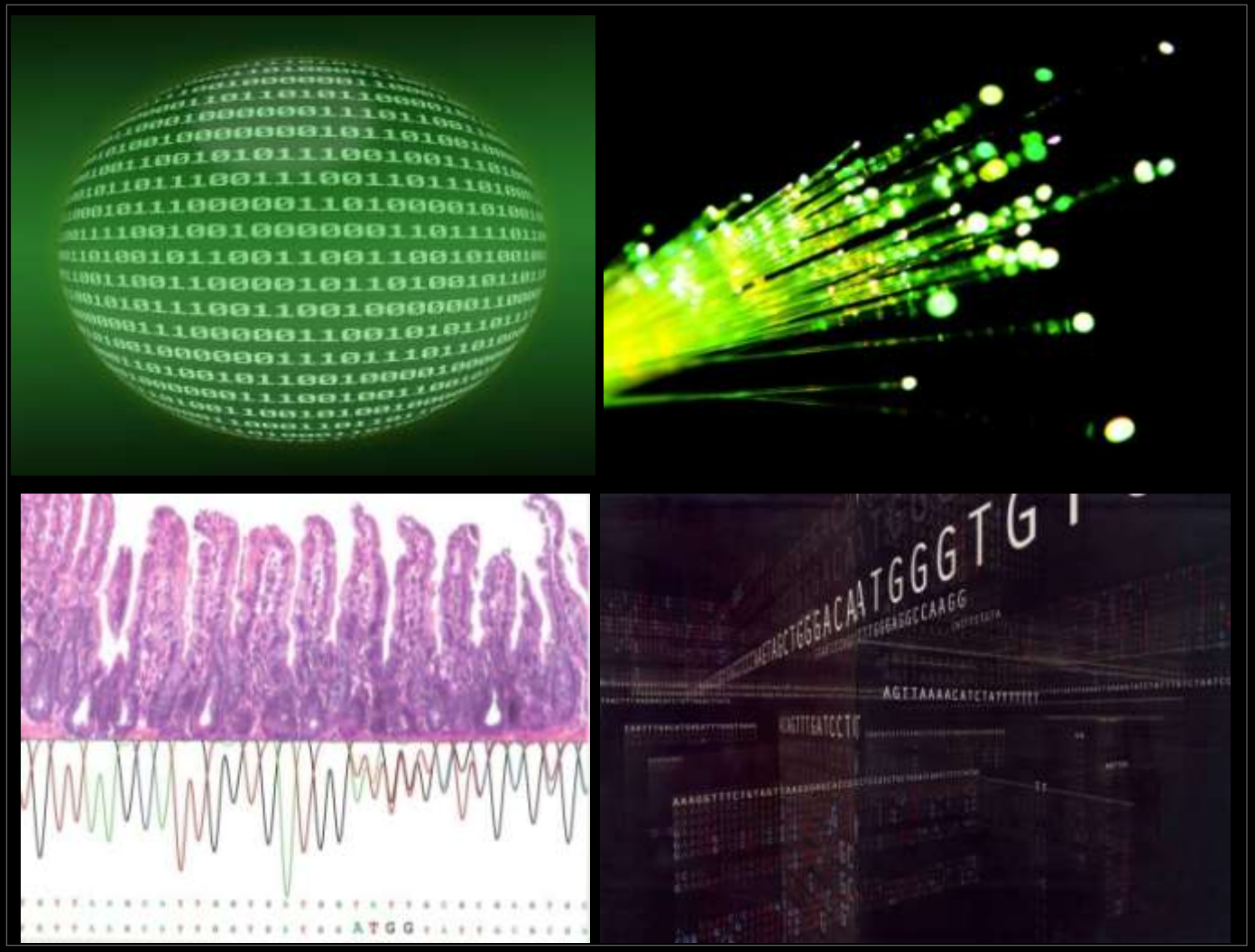




The Elegance of Design: Scale-Free Networks: a Ubiquitous Design Principle



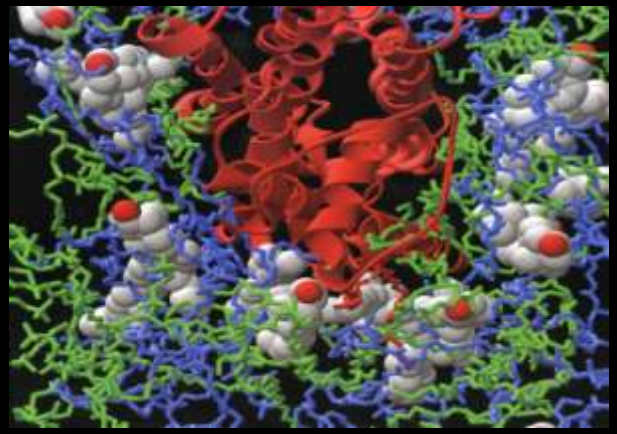
The Elegance of Design: Unitary Codes for the Assembly and Interaction of Networks and Systems



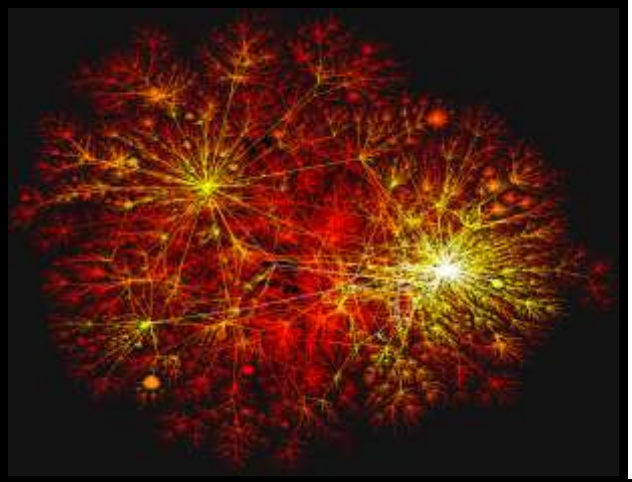
Systems Biology: Mapping the Assembly, Control and Perturbation of Molecular Networks in Health and Disease

Genes

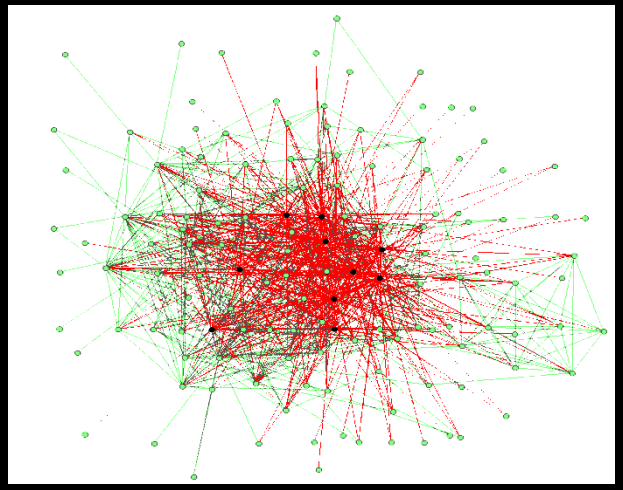
Proteins



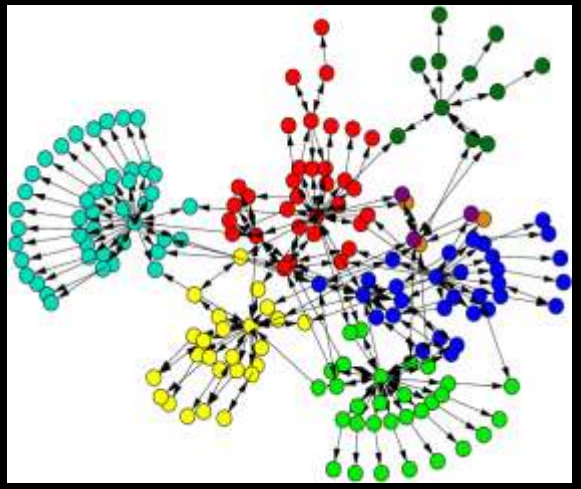
Circuits



Scale-free Networks



Protein Interactions



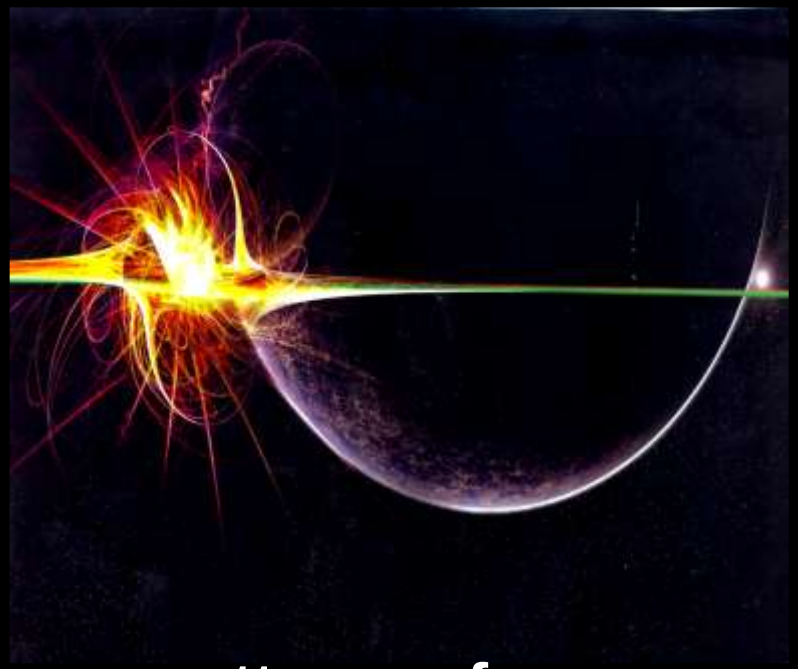
Network Pharmacology

Features of Complex Adaptive Systems: Highly Optimized Tolerance and Far-From Equilibrium States

Convergence

- novel interactions between previously distinct networks/systems

Emergence

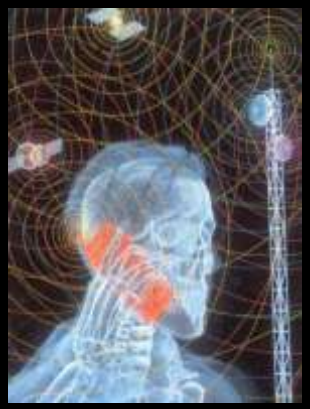
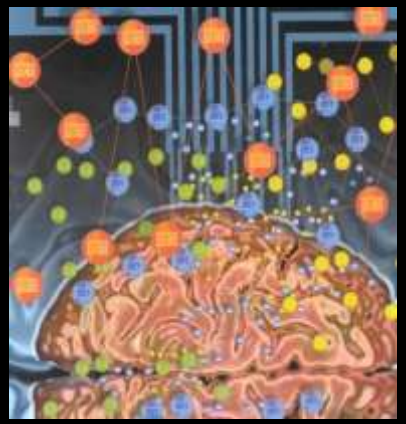


- new patterns of convergence trigger new system with highly different and unexpected features

“For most of us design is invisible. Until it fails” Bruce Mau. Massive Change. 2004

Convergence and Radical Shifts in Complex Adaptive Systems (Emergence)

Convergence in Complex Adaptive Systems and the Emergence of Discontinuities

Ubiquitous Sensing	Synthetic Biology	Brain: Machine Interactions	Infocosm and Metaverse	Cosmology
				
"Connected Space"	"Exploring Biospace"	"Cognitive Space"	"Cyberspace"	"Outer Space"

Ever Shifting, Multi-Dimensional Matrices in the Ecology of Knowledge

The Complex Adaptive Systems Initiative (CASI)

- intellectual foundation for increasingly accurate prediction of CAS behavior and directed design of desired CAS dynamics
- the ecology of information
- the ecology of knowledge

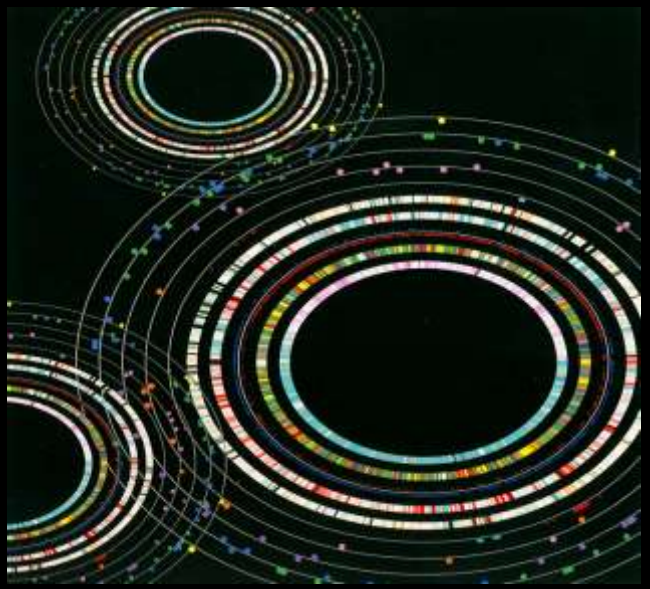
ASU Arizona State University

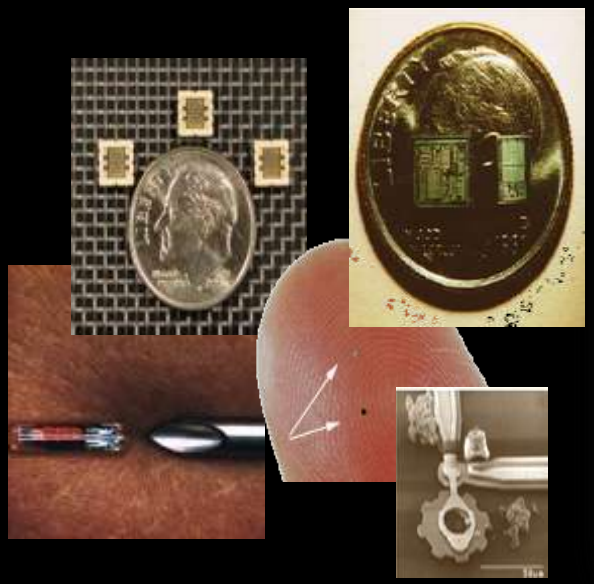
The Complex Adaptive Systems Initiative (CASI)

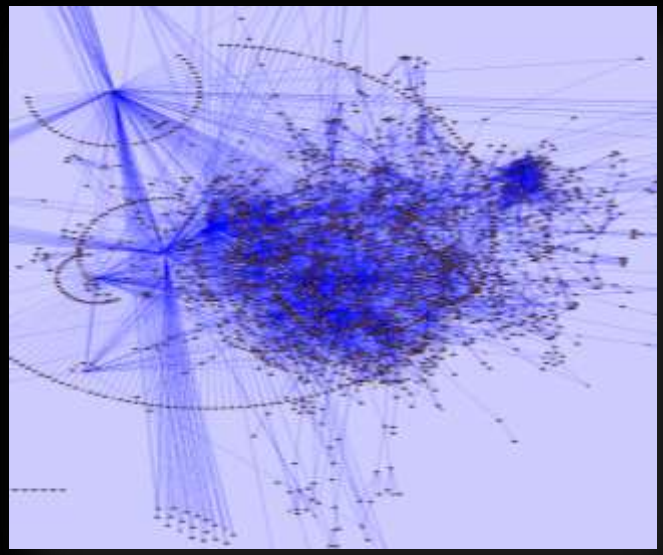
- both exemplar and a catalyst to expand use-inspired, cross-disciplinary research more broadly at ASU
- leveraging Biodesign's success to launch additional research initiatives in which ASU can achieve worldclass status
  - focus on nascent, emerging areas arising from the 'convergence' of previously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

Initial Research Areas for CASI

Synthetic Biology	Ubiquitous Sensing	CAS Modeling and Simulation



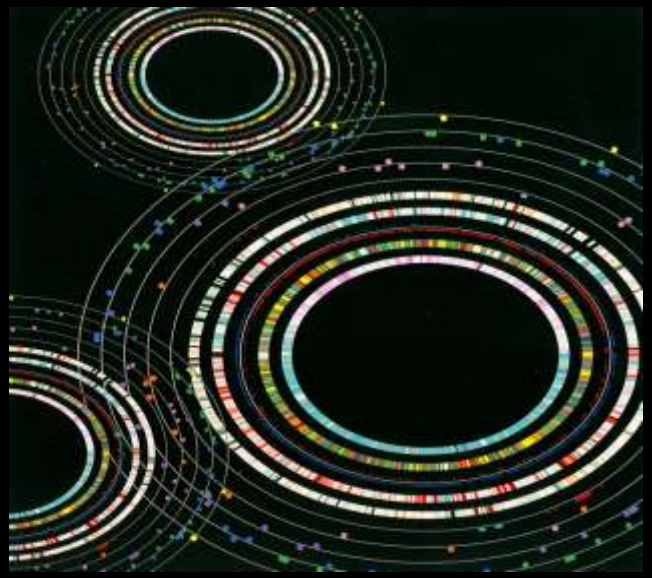


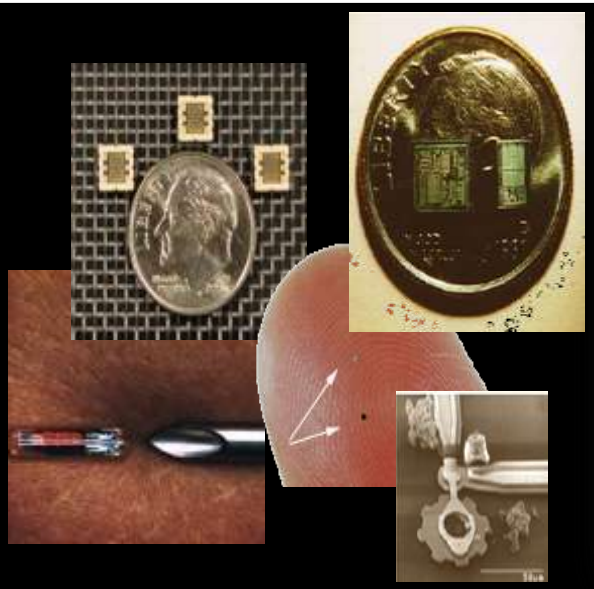


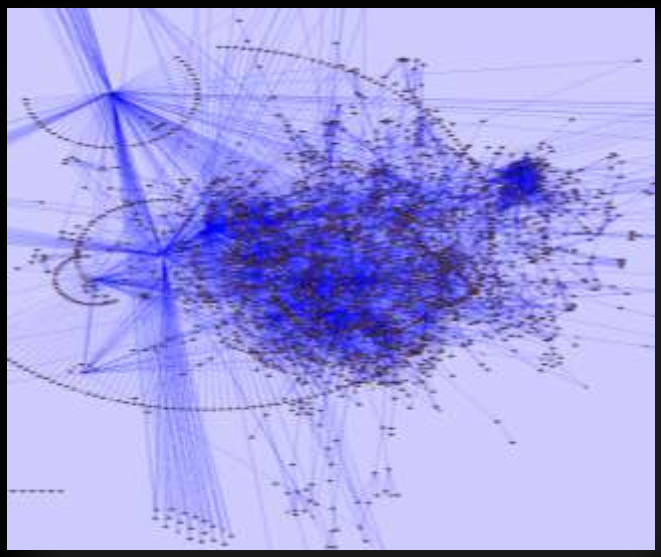
- Engineering of Biological Networks
- Remote Monitoring for Healthcare and Environmental Sustainability
- Advanced Medical Diagnostics and Healthcare Information Systems

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

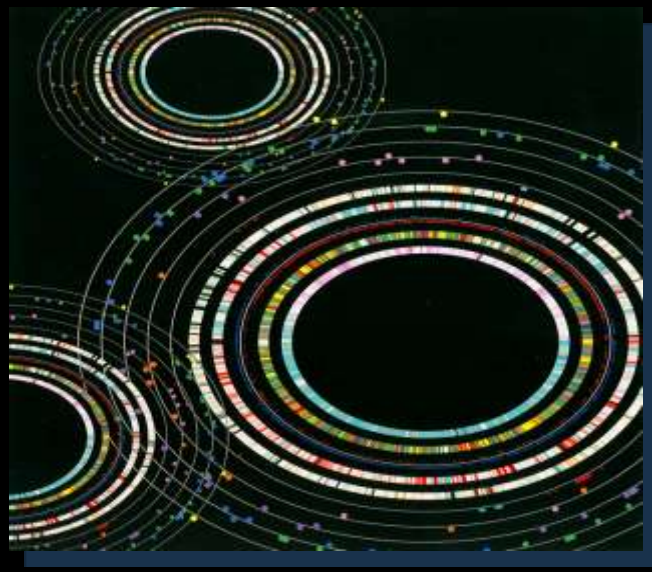
A New Industrial Ecology

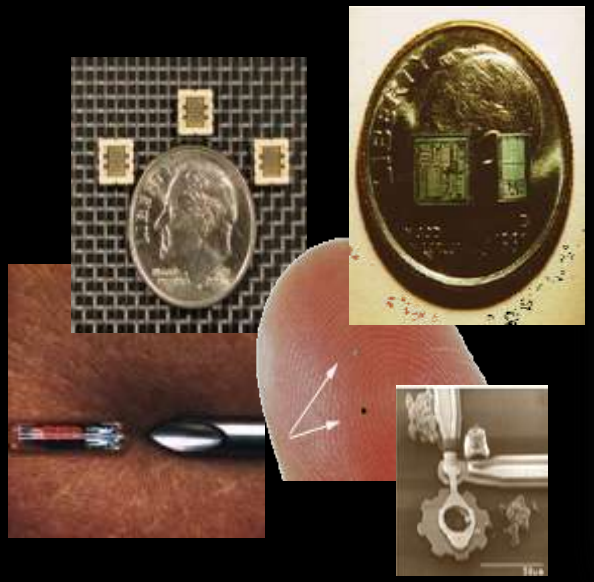
Early Detection of Adverse Trends

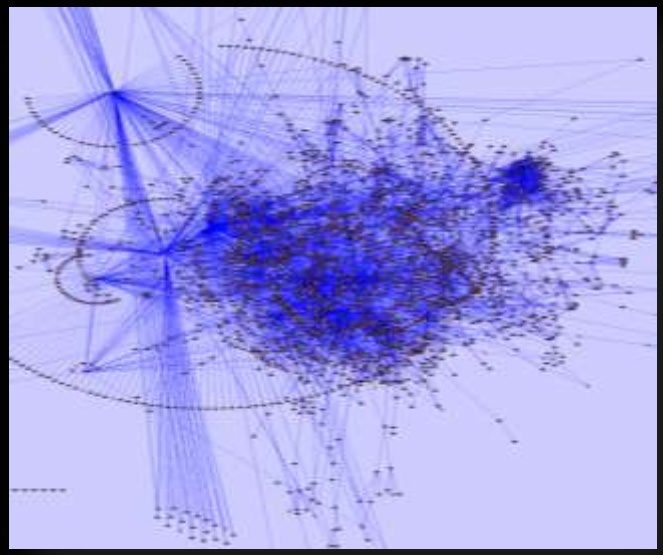
Predict and Prevent Disease

Initial Research Areas for CASI

Synthetic Biology	Ubiquitous Sensing	CAS Modeling and Simulation



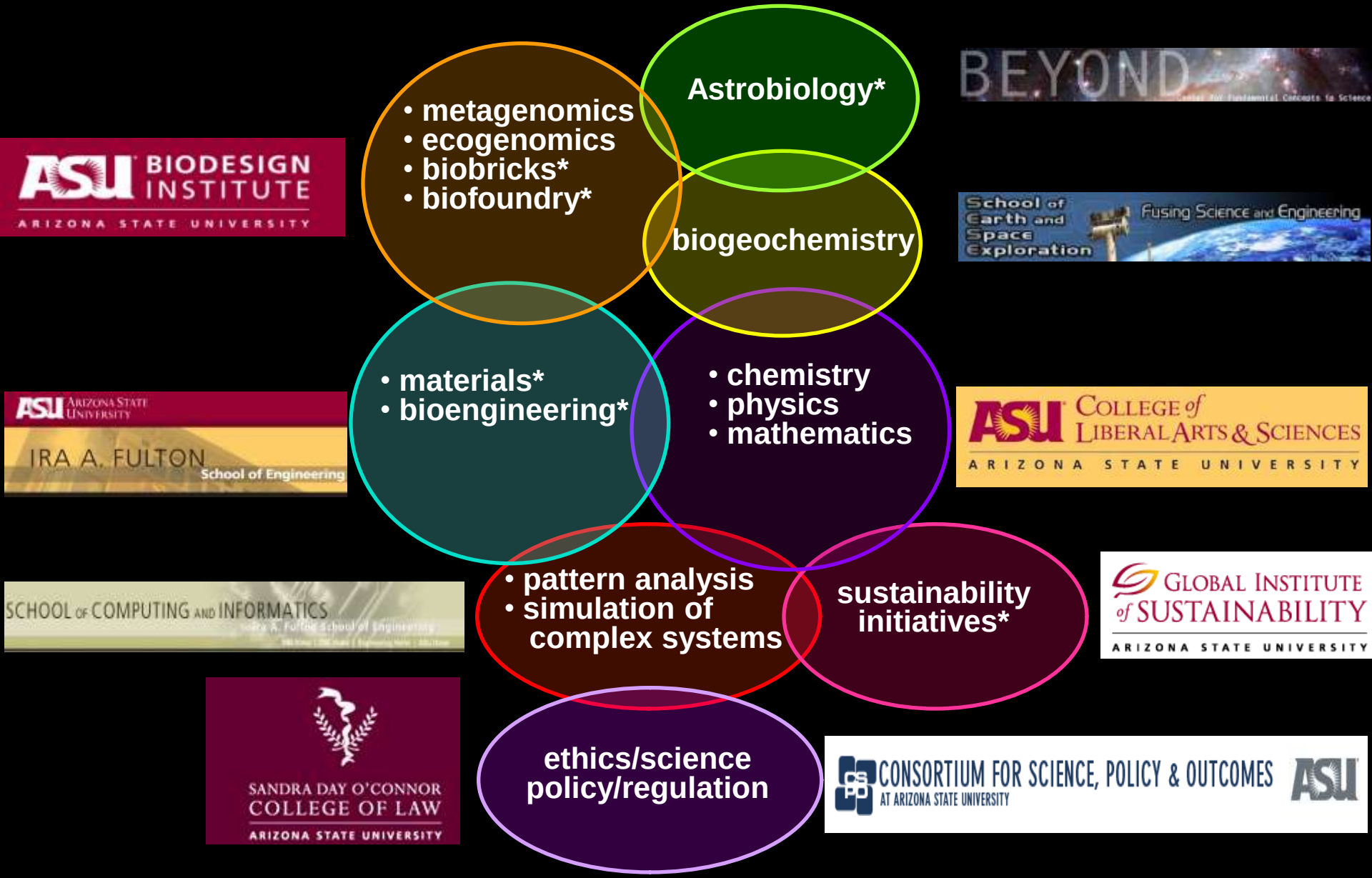




- Engineering of Biological Networks
- Remote Monitoring for Healthcare and Environmental Sustainability
- Advanced Medical Diagnostics and Healthcare Information Systems

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

Meta-Planning for Synthetic Biology



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BEYOND

School of Earth and Space Exploration
Fusing Science and Engineering

ASU Arizona State University
IRA A. FULTON School of Engineering

ASU College of Liberal Arts & Sciences
ARIZONA STATE UNIVERSITY

SCHOOL OF COMPUTING AND INFORMATICS

GLOBAL INSTITUTE of SUSTAINABILITY
ARIZONA STATE UNIVERSITY

SANDRA DAY O'CONNOR COLLEGE OF LAW
ARIZONA STATE UNIVERSITY

CSPO CONSORTIUM FOR SCIENCE, POLICY & OUTCOMES
AT ARIZONA STATE UNIVERSITY
ASU

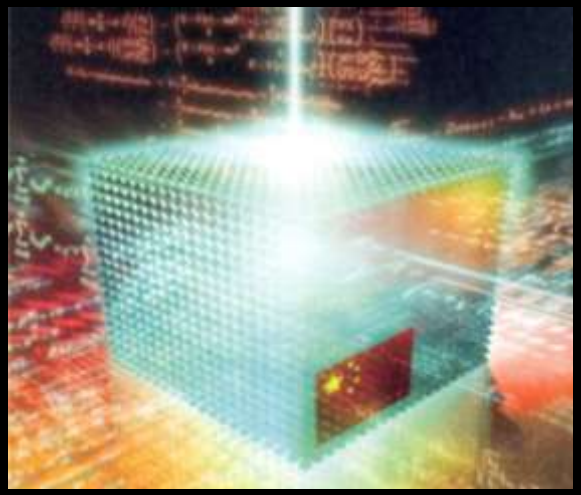
* major opportunity for 3M collaboration(s)

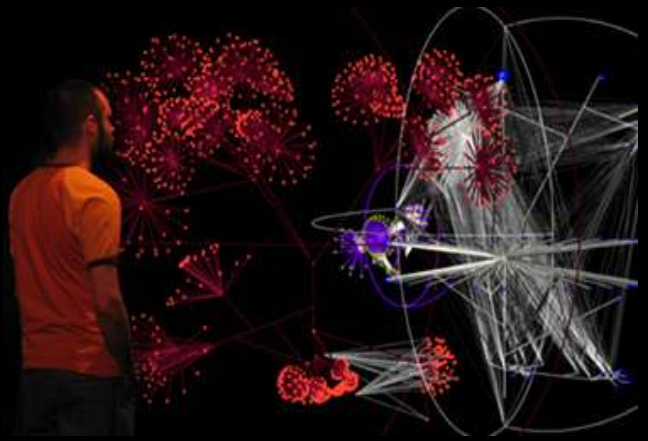
Analysis, Modeling and Simulation of CAS: New Computing and Knowledgement Challenges

Volume

Global Networks

Integration





Aorta: Always on, Real Time Access: Interactive, Distributed and Customized

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The Complex Adaptive Systems Initiative (CASI)

- provide a strategic template for integration of diverse intellectual capabilities across ASU to achieve worldclass status in CAS research
- catalyst for ASU's new 'meta-planning' exercise to map future focus, resource needs and applications
- thematic signature for ASU research excellence
- networks of expertise versus dedicated "institute" infrastructure
- Biodesign as vital component of several CASI intiatives

Ever Onward!

"Urgency"

"Focus and Resolve"

"Passion and Purpose"

Five Year Accomplishments

THANK YOU

ASU BIODESIGN INSTITUTE
ARIZONA STATE UNIVERSITY