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
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
5 Year Progress Report

An Institute Without Boundaries
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)
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
- 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
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 »
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
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
DEGREES OF INTEGRATION

These diagrams of scientific institutions were constructed by sorting over 16,000 academic journals into 554 different clusters, which were then grouped into 13 major fields. These major fields are shown as the 13 colored arcs comprising each circular figure. Arc lengths represent the number of journals in the corresponding fields. These circular diagrams can be used to display the disciplinary makeup of institutions. Take, for example, the Rensselaer Polytechnic Institute Center for Biotechnology and Interdisciplinary Studies. First, the papers authored by this center are mapped to their corresponding disciplines on the circle. Then the average position of these papers is calculated. Colored rays are drawn from this point (the institutional node) to each of the papers on the circle to show disciplinary makeup. The position of the institutional node and distribution of the colored rays give a measure of the interdisciplinarity of the institution. The closer the institutional node is to the center of the circle, and the greater number of colors it incorporates, the more interdisciplinary the institution.
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
Different
The Challenge of Building a New Organization in an Era of Accelerating Change:
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
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
Innovative Solutions for Major Global Challenges

Unifying Technology Platforms

Unique Signatures

Signature Detection

Actionable Information
Innovative Solutions for Major Global Challenges

Unifying Technology Platforms

Objective

Profile  Sense  Act
Integrated Functional Platforms to Exploit Technology Convergence

Identification of Unique Signatures

Detection of Signatures in Diverse Settings

Format and Transmit Actionable Information for Optimum Decisions

Profile

Sense

Act

Life Sciences and Mathematical/Statistical Tools for Complex Signal Analysis

Nanotechnology, Miniaturization Engineering, Materials Science

Large Scale Informatics and Information Architectures
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
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
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

Institutions and companies:
- Stanford University
- California Institute for Quantitative Biomedical Research
- UCSD
- Duke University
- Systems Biology
- Broad Institute
- UCSB
- CSBi
- Berkeley
- BP
- Agilent Technologies
- Advanced Technology Ventures
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
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
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
Understanding the Design Principles of Complex Adaptive Systems: An Ambitious Theme for Research Excellence at ASU
“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
Individual Interactions Lead to Complex Systems

Protein Interactions

Local Ecosystem

Internet Traffic

Networks

Systems of Systems
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
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
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Early Detection of Adverse Trends
Predict and Prevent Disease

A New Industrial Ecology

Initial Research Areas for CASI

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Synthetic Biology

Ubiquitous Sensing

CAS Modeling and Simulation
## Initial Research Areas for CASI

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### Dual-Use Complexity
Science and Industrial Policy, Regulation and Oversight
Socio-Cultural, Ethical and Legal Implications
Meta-Planning for Synthetic Biology

- metagenomics
- ecogenomics
- biobricks*
- biofoundry*

- biogeochemistry
- chemistry
- physics
- mathematics

- materials*
- bioengineering*

- pattern analysis
- simulation of complex systems

- sustainability initiatives*

- ethics/science policy/regulation

* major opportunity for 3M collaboration(s)
Analysis, Modeling and Simulation of CAS: New Computing and Knowledge Challenges

Volume

Global Networks

Integration

Aorta: Always on, Real Time Access: Interactive, Distributed and Customized
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 initiatives
Ever Onward!

Intellectual “Grand Challenges”

Pragmatic “Real World Challenges”

Competency, Courage and Commitment to Engage Complex Issues

“Urgency”

“Focus and Resolve”

“Passion and Purpose”
Five Year Accomplishments

THANK YOU