"The Singularity: Toward a Post-Human Reality"

Talk to UCSD's Sixth College
Honor's Course on Kurzweil's *The Singularity is Near*
La Jolla, CA
February 13, 2006

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

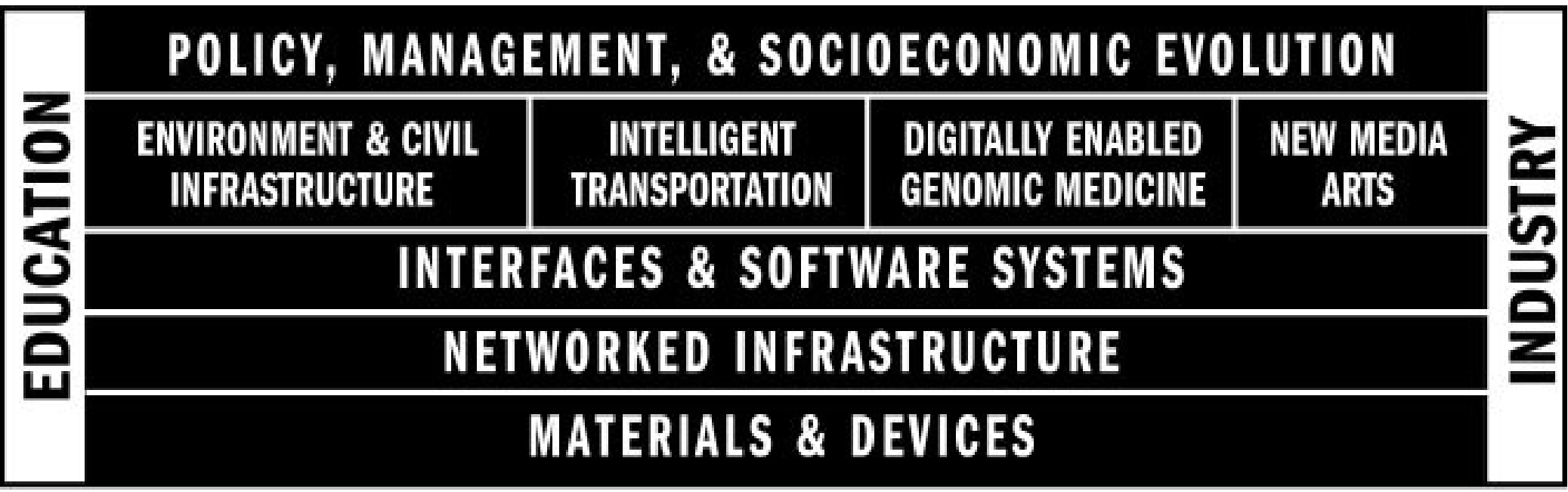
Jacobs School of Engineering, UCSD

UCSD
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Calit2 -- Research and Living Laboratories on the Future of the Internet

UC San Diego & UC Irvine Faculty
Working in Multidisciplinary Teams
With Students, Industry, and the Community



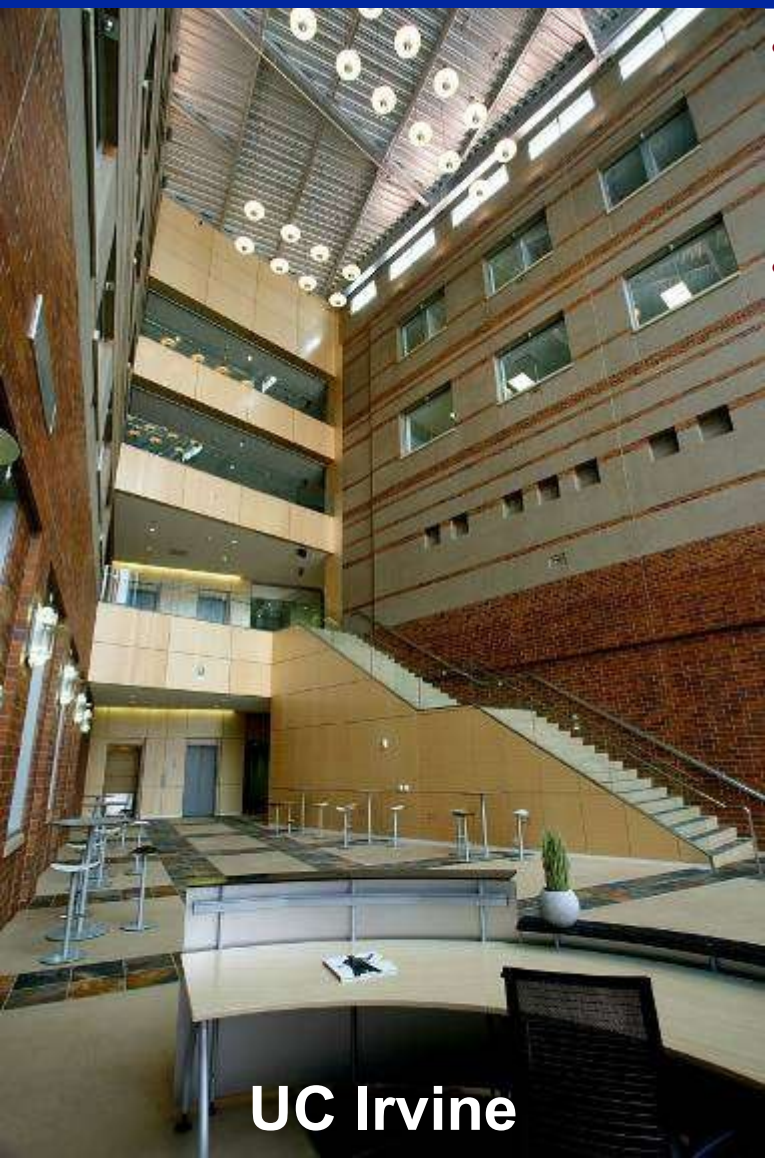
www.calit2.net

California Institute for Telecommunications and Information Technology . Cal-(IT)^2



Extending the Internet Throughout the Physical World

Two New Calit2 Buildings Will Provide Major New Laboratories to Their Campuses



- New Laboratory Facilities
  - Nanotech, BioMEMS, Chips, Radio, Photonics, Grid, Data, Applications
  - Virtual Reality, Digital Cinema, HDTV, Synthesis
- Over 1000 Researchers in Two Buildings
  - Linked via Dedicated Optical Networks
  - International Conferences and Testbeds

Richard C. Atkinson Hall Dedication Oct. 28, 2005



www.calit2.net

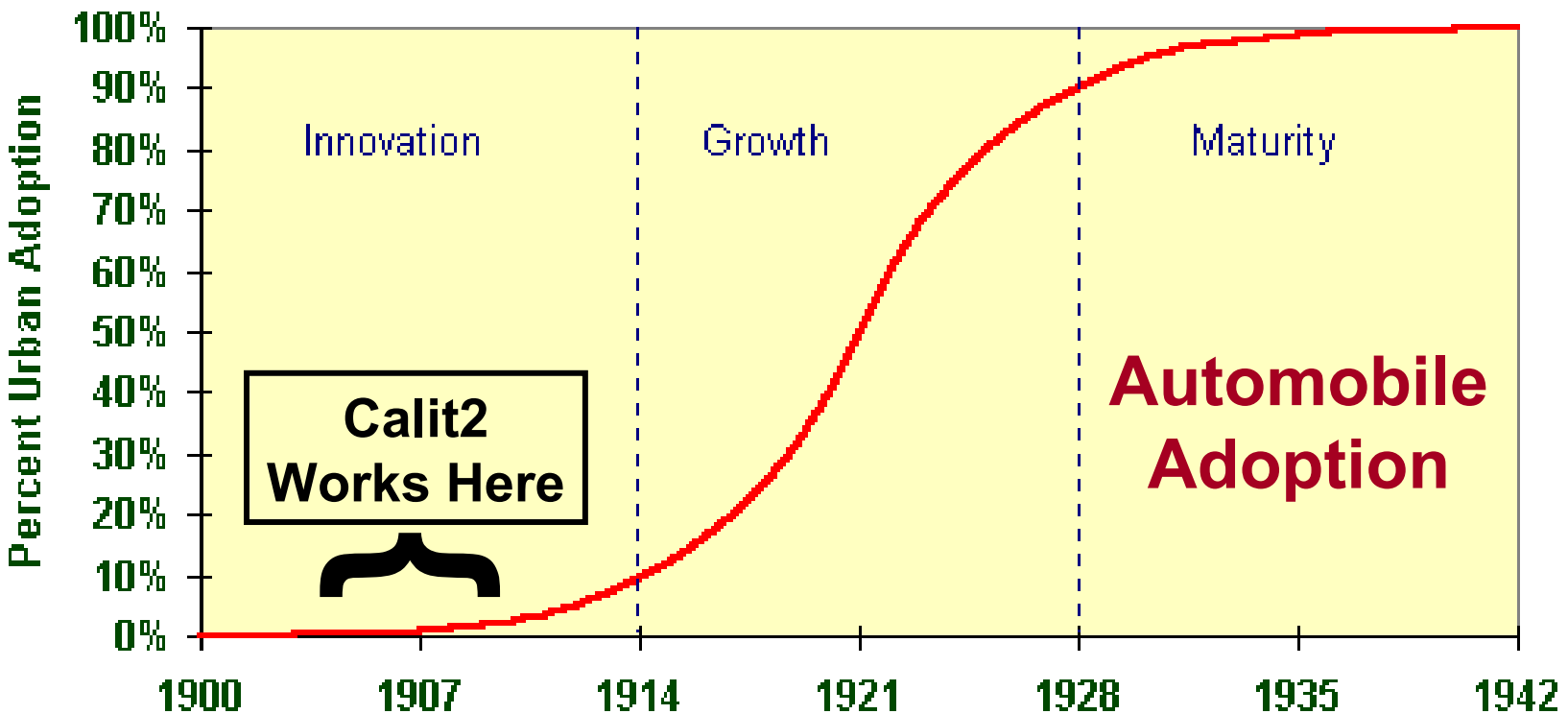
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Preparing for an World in Which Distance Has Been Eliminated…

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From Elite Science to the Mass Market

- **Four Examples I Helped "Mid-Wife":**
  - **Scientific Visualization to Movie/Game Special Effects**
  - **CERN Preprints to WWW**
  - **Supercomputers to GigaHertz PCs**
  - **NSFnet to the Commercial Internet**
- **Technologies Diffuse Into Society Following an S-Curve**



Source: Harry Dent, The Great Boom Ahead

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Science Fiction as a View into Possible Futures

- **Transhumanism and Posthumanism**
  - Neuromancer, Count Zero, Mona Lisa Overdrive by William Gibson
  - Matrix Trilogy
  - X-Files Kill Switch—by William Gibson
- **Androids and Robots**
  - Robot Series by Isaac Asimov
  - Blade Runner
  - Terminator Trilogy
  - Cherry 2000
- **Software Augmented Humans**
  - Aristoi by Walter Jon Williams
- **Nanotechnology**
  - The Diamond Age by Neil Stephenson

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Towards the Singularity-- Research on Kurzweil's Accelerators

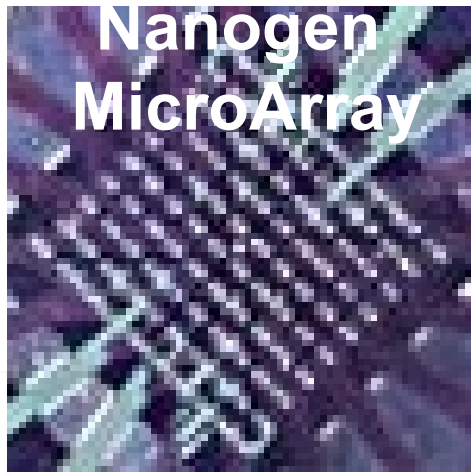
- Convergence of Info, Bio, Nano
- Reverse Engineering Brains
- Human Longevity
- Planetary Scale Computing
- Intelligent Interactive Robots
- Utilizing the Human Population Potential
- Eliminating Distance

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Accelerator: The Perfect Storm--
Convergence of Engineering with Bio, Physics, & IT

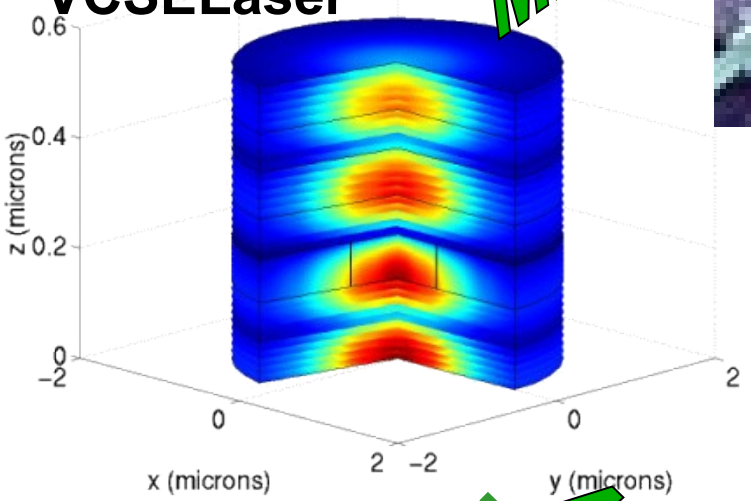
500x Magnification

MEMS



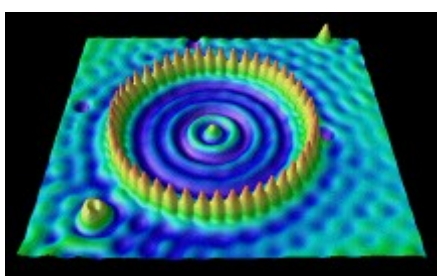
2 mm

VCSELaser

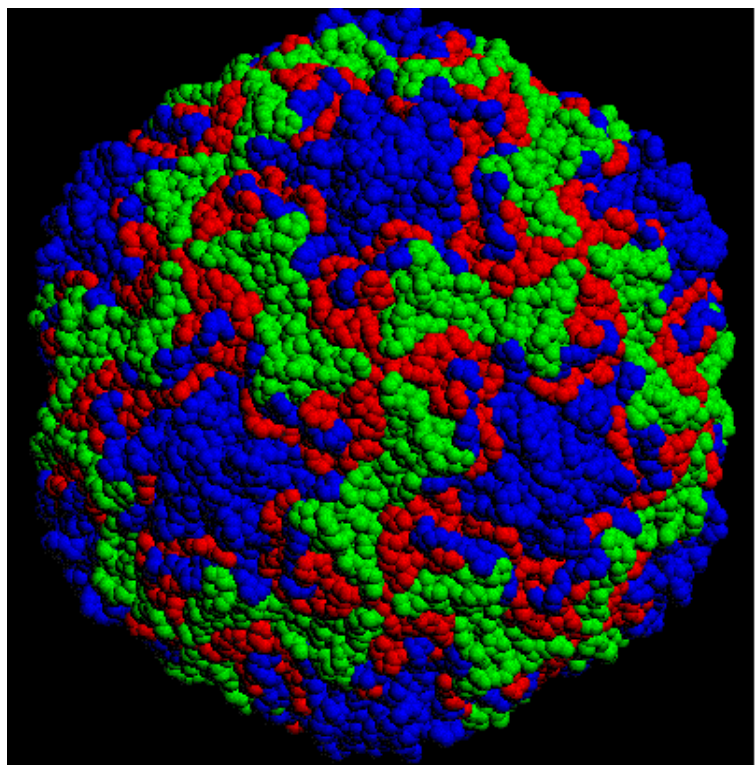


NANO

400x Magnification



IBM Quantum Corral
Iron Atoms on Copper



Human Rhinovirus

5 nanometers

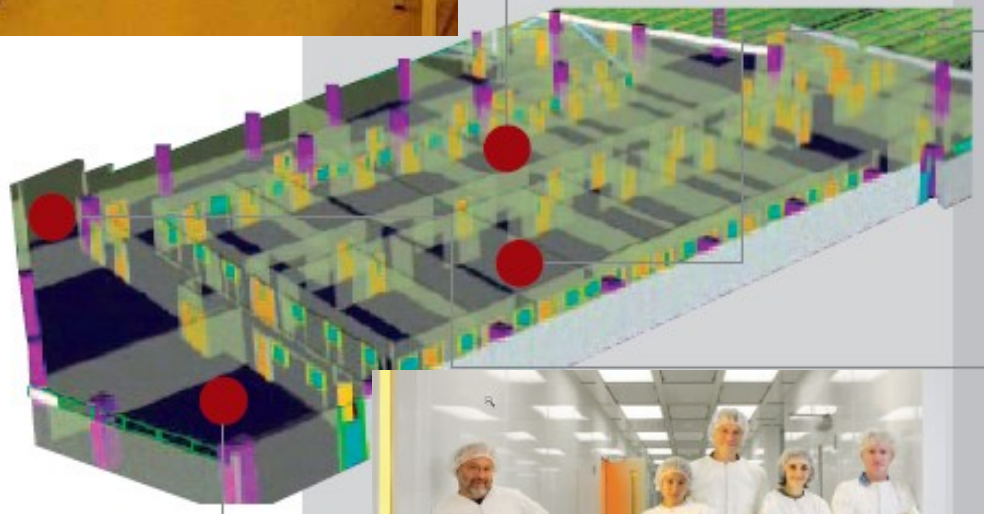
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Nanobioinfotechnology

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Calit2@UCSD Creates a Dozen Shared Clean Rooms for Nanoscience, Nanoengineering, Nanomedicine







Class 100 Clean Room Modules: Nano/microlithography

Areas with no more than 100 particles larger than 0.5 microns per cubic foot of air. Facilities include e-beam lithography and photolithography modules.

Class 1000 Clean Room Modules: Nano/microfabrication

No more than 1,000 particles larger than 0.5 microns per cubic foot of air. Areas include metallization/thin film deposition, advanced dry etching, metrology, thermal and back-end processes.

Advanced Structural Characterization

Techniques include scanning electron microscopy (using electrons rather than light to form an image) and scanning probe microscopy. Ultrahigh vacuum surface analysis. Optical characterization.

OTHER FACILITIES INCLUDE:

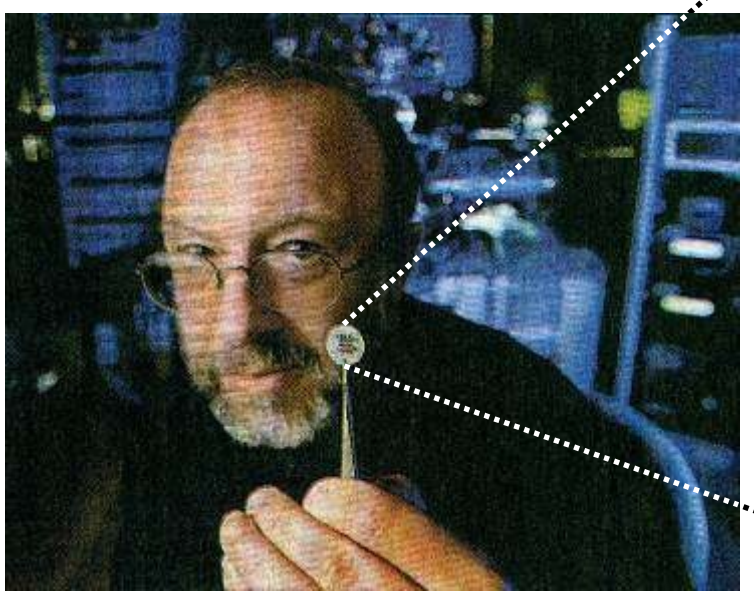
Metal-Organic Chemical Vapor Deposition Facility

MOCVD technique used for thin film growth in advanced, compound semiconductors and nanostructures.

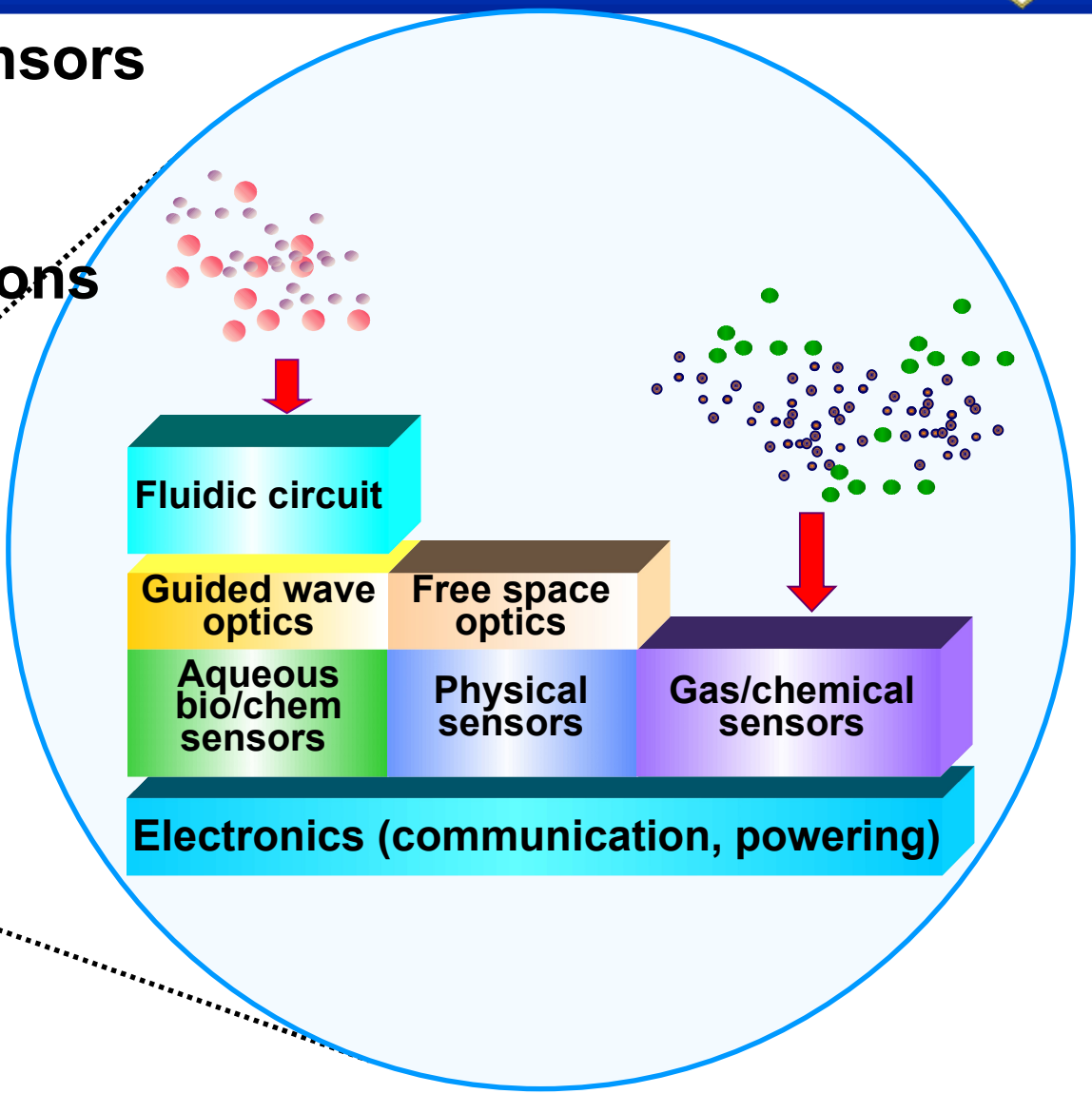
Photo Courtesy of Bernd Fruhberger, Calit2

A World of Distributed Sensors Starts with Integrated Nanosensors

Developing Multiple Nanosensors on a Single Chip, with Local Processing and Wireless Communications



I. K. Schuller holding the first prototype

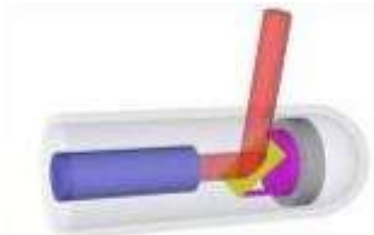


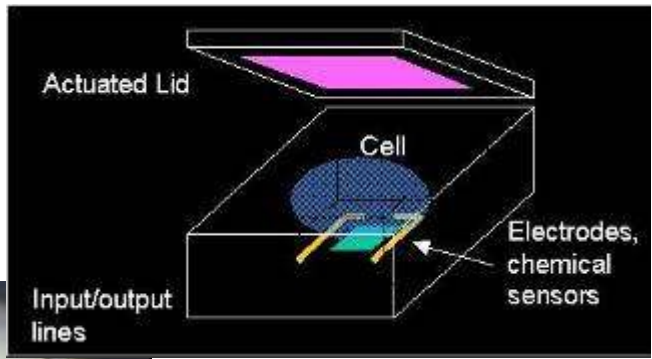
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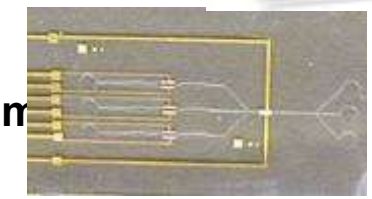
I. K. Schuller, A. Kummel, M. Sailor, W. Trogler, Y-H Lo

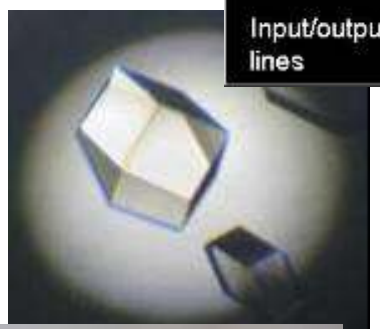
Research Topics of INRF / Calit2@UCI BioMEMS Team

- Micro Resonators for Wireless Communications
- Optical Coherence Tomography
- Mechanosensitivity Microplatforms
- Micro- and Nano- Fluidics
- Protein Crystallization in Nanovolum
- Nano-Biosensors
- Catheter-Based Microtools
- Silicon-Based HF Ultrasonic Atomizer
- Smart Pills
- Bionic Ear





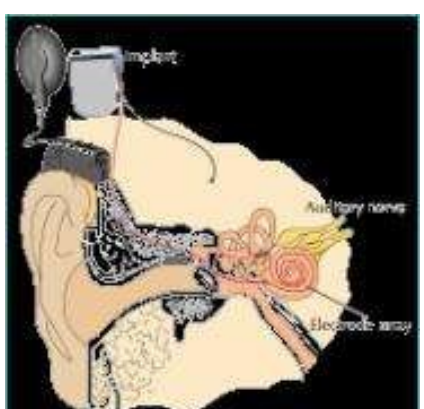


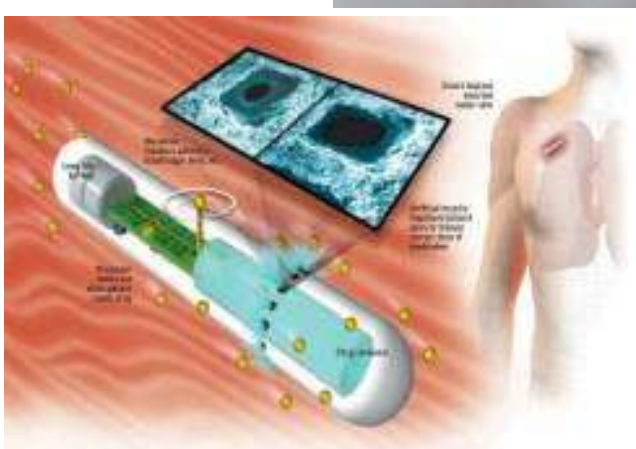










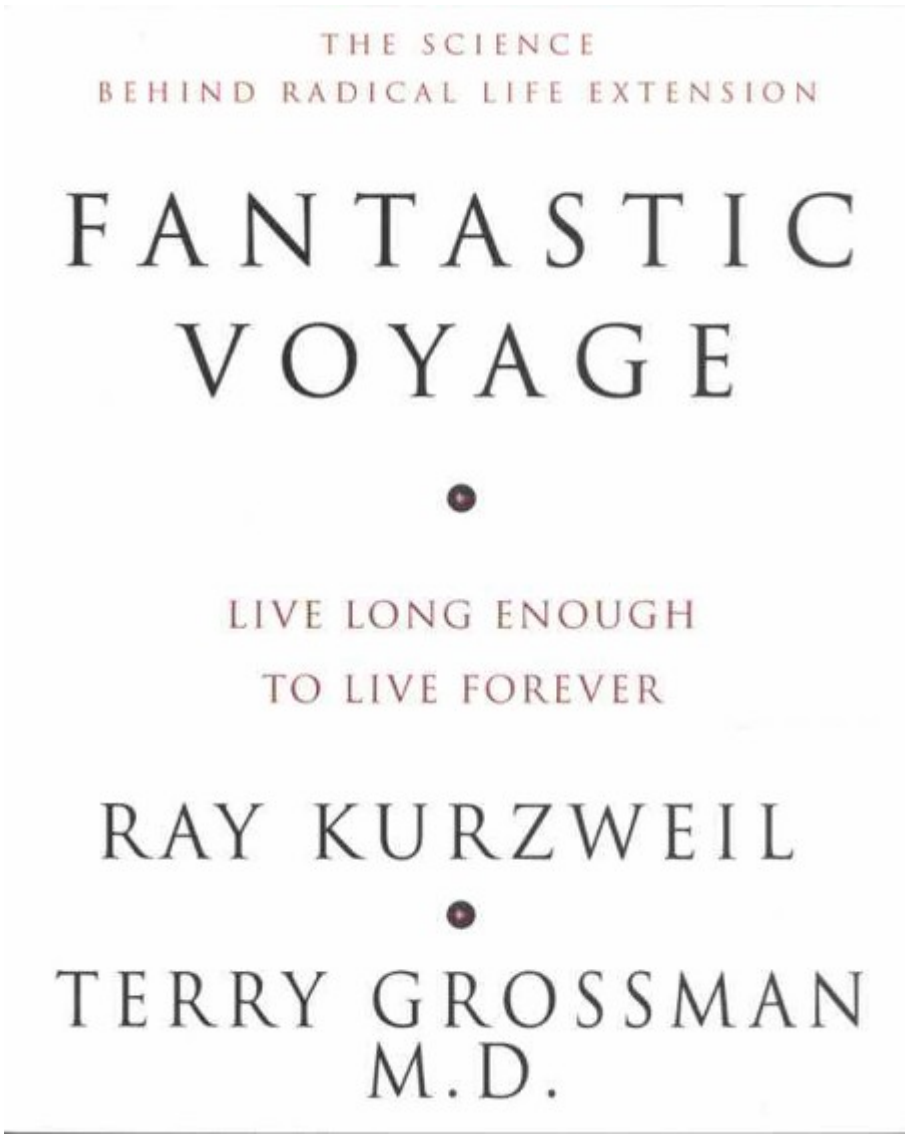


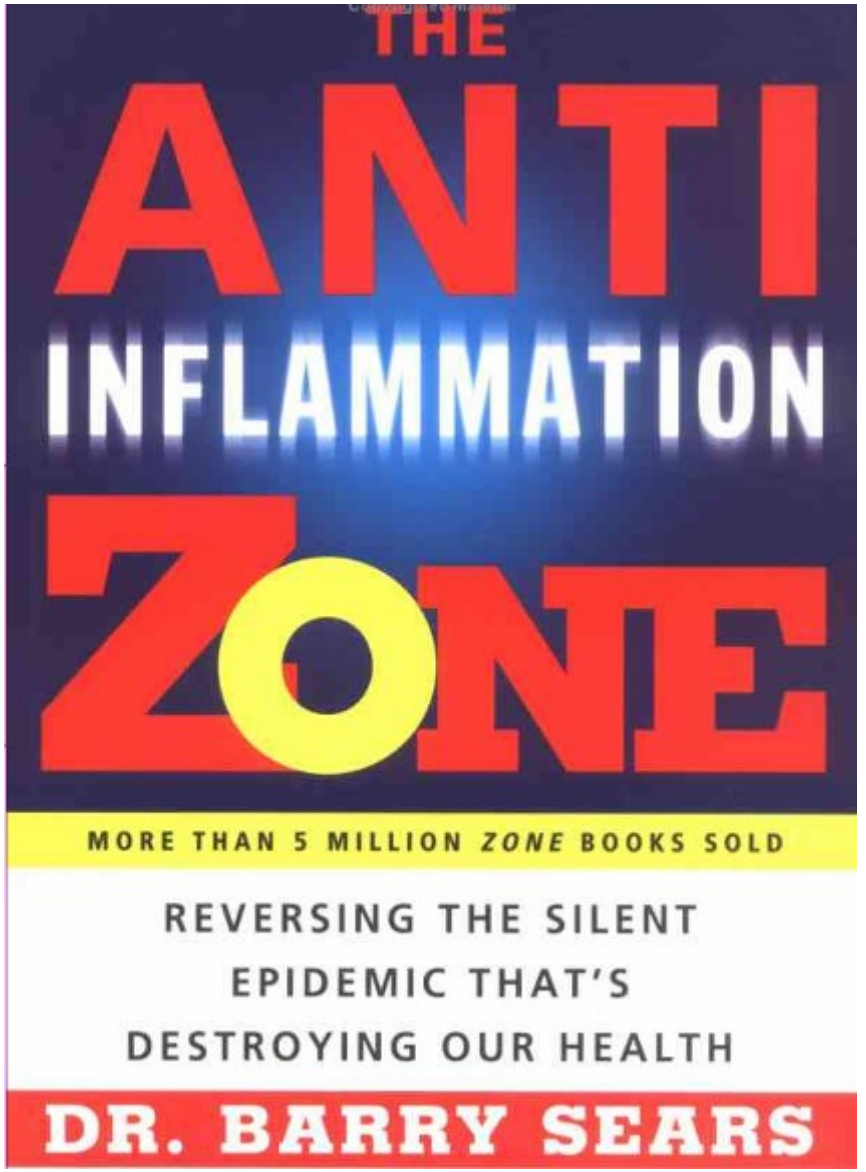
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Accelerator: Learn Your Body's Biochemical Systems to Live Longer and Healthier





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Treatment, Understanding, and Monitoring of Cancer
(UCSD, Burnham Institute, UCSB, UCR, UCI --PI: Sadik Esener)

OBJECTIVE: Use of nanotechnology towards eliminating suffering and death due to cancer

- Detect cancerous tumors at the earliest stage
- Treat cancerous cells selectively and effectively
- Understand their progression
- Monitor and destroy residual cancer cells

APPROACH: Delivery via stealth porous mother ships with multi functional payloads

- smart nano sensors and
- tumor activated nano platforms for therapeutics and imaging

KEY AREAS OF RESEARCH FOCUS

- Avoiding RES and retain particles in circulatory system: stealth mother ships
- Reducing other organ pollution: increase targeting specificity and ability to go in an out of organs
- Penetration of tumors for therapeutics and imaging: release and self-assembly of ultra small payload on specific cues
- Enabling longitudinal studies: novel nano sensors
- Ex vivo genetic analysis enabled by nano-platforms



Porous mother ship In vasculature



Targeting early tumor formations

Release of payload



Impact of treatment

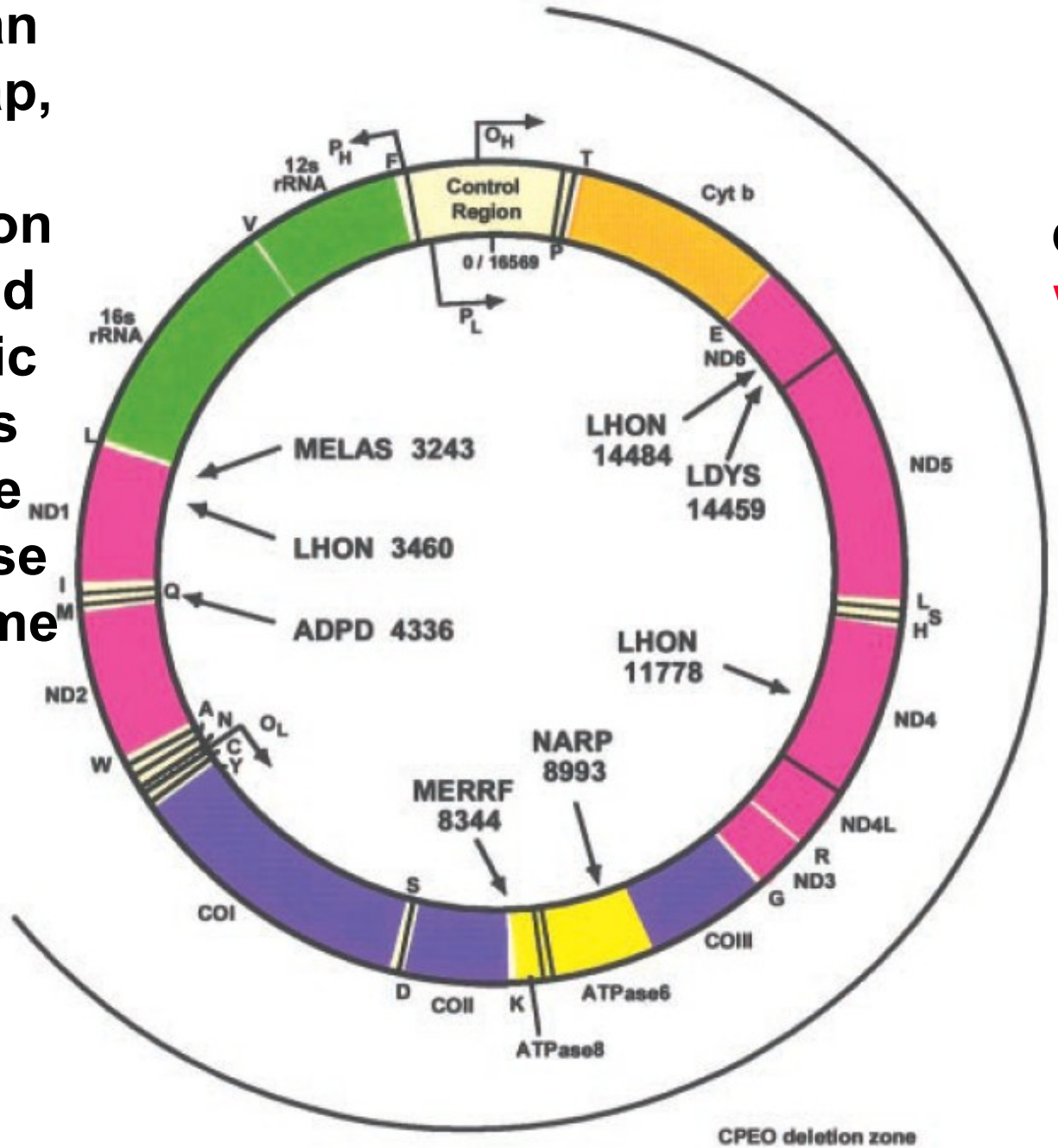
NCI Alliance for Nanotechnology in Cancer

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Calit2 is Collaborating with Doug Wallace Planning to Bring MITOMAP into Calit2 Domain

The Human mtDNA Map, Showing the Location of Selected Pathogenic Mutations Within the 16,569-Base Pair Genome



MITOMAP: A Human Mitochondrial Genome Database. www.mitomap.org, 2005



5 March 1999

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For Mitochondrial Diseases It Has Been More Productive
to Classify Patients by Genetic Defect Rather than by Clinical Manifestation

Over the past 10 years, mitochondrial defects have been implicated in a wide variety of degenerative diseases, aging, and cancer… The same mtDNA mutation can produce quite different phenotypes, and different mutations can produce similar phenotypes. …The essential role of mitochondrial oxidative phosphorylation in cellular energy production, the generation of reactive oxygen species, and the initiation of apoptosis has suggested a number of novel mechanisms for mitochondrial pathology.

--Douglas Wallace, Science, Vol. 283, 1482-1488, 5 March 1999

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Calit2 Researcher Eskin Collaborates with Perlegen Sciences on Map of Human Genetic Variation Across Populations



"We have characterized whole-genome patterns of common human DNA variation by genotyping 1,586,383 single-nucleotide polymorphisms (SNPs) in 71 Americans of European, African, and Asian ancestry."

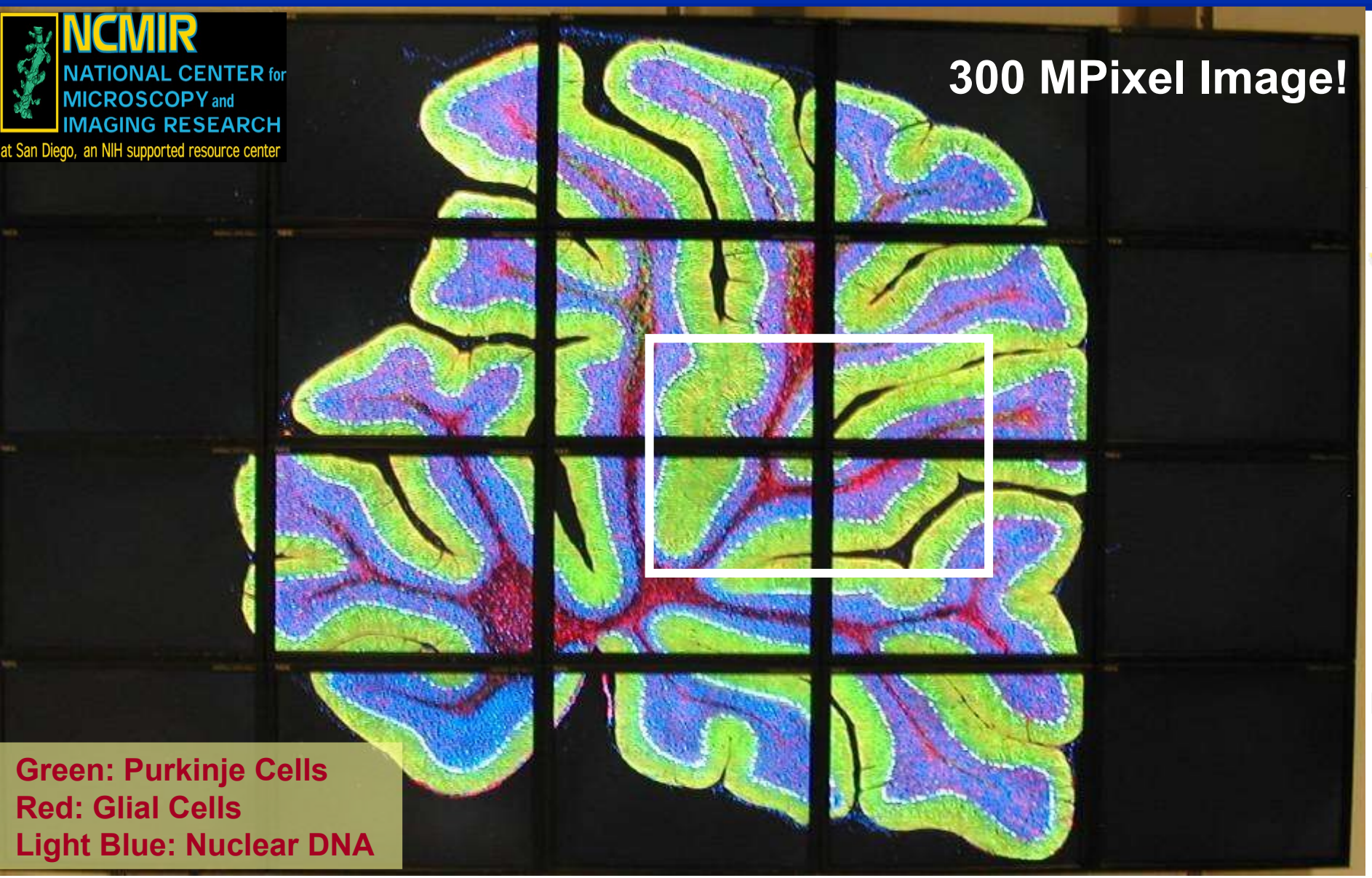
David A. Hinds, Laura L. Stuve, Geoffrey B. Nilsen, Eran Halperin, **Eleazar Eskin**, Dennis G. Ballinger, Kelly A. Frazer, David R. Cox.
"Whole-Genome Patterns of Common DNA Variation in Three Human Populations"
Science 18 February, 2005: 307(5712):1072-1079.

"Although knowledge of a single genetic risk factor can seldom be used to predict the treatment outcome of a common disease, knowledge of a large fraction of all the major genetic risk factors contributing to a treatment response or common disease could have immediate utility, allowing existing treatment options to be matched to individual patients without requiring additional knowledge of the mechanisms by which the genetic differences lead to different outcomes ."

"More detailed haplotype analysis results are available at http://research.calit2.net/hap/wgha/ "

Accelerator: Reverse Engineering the Brain

NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center



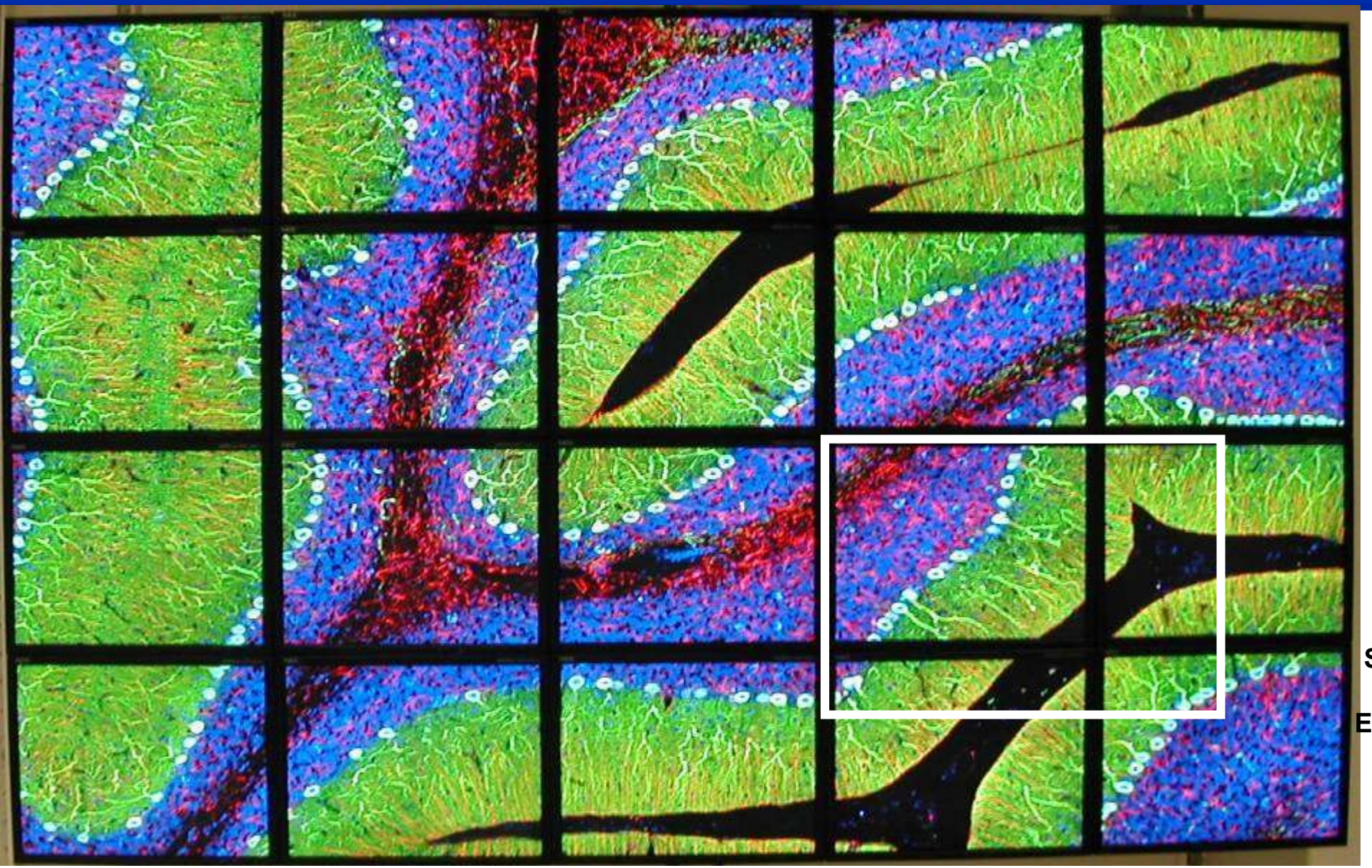
Green: Purkinje Cells
Red: Glial Cells
Light Blue: Nuclear DNA

Source: Mark Ellisman, David Lee, Jason Leigh

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Calit2 (UCSD, UCI) and UIC Lead OptIPuter Campuses—Larry Smarr PI
Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST

Scalable Displays Allow Both Global Content and Fine Detail



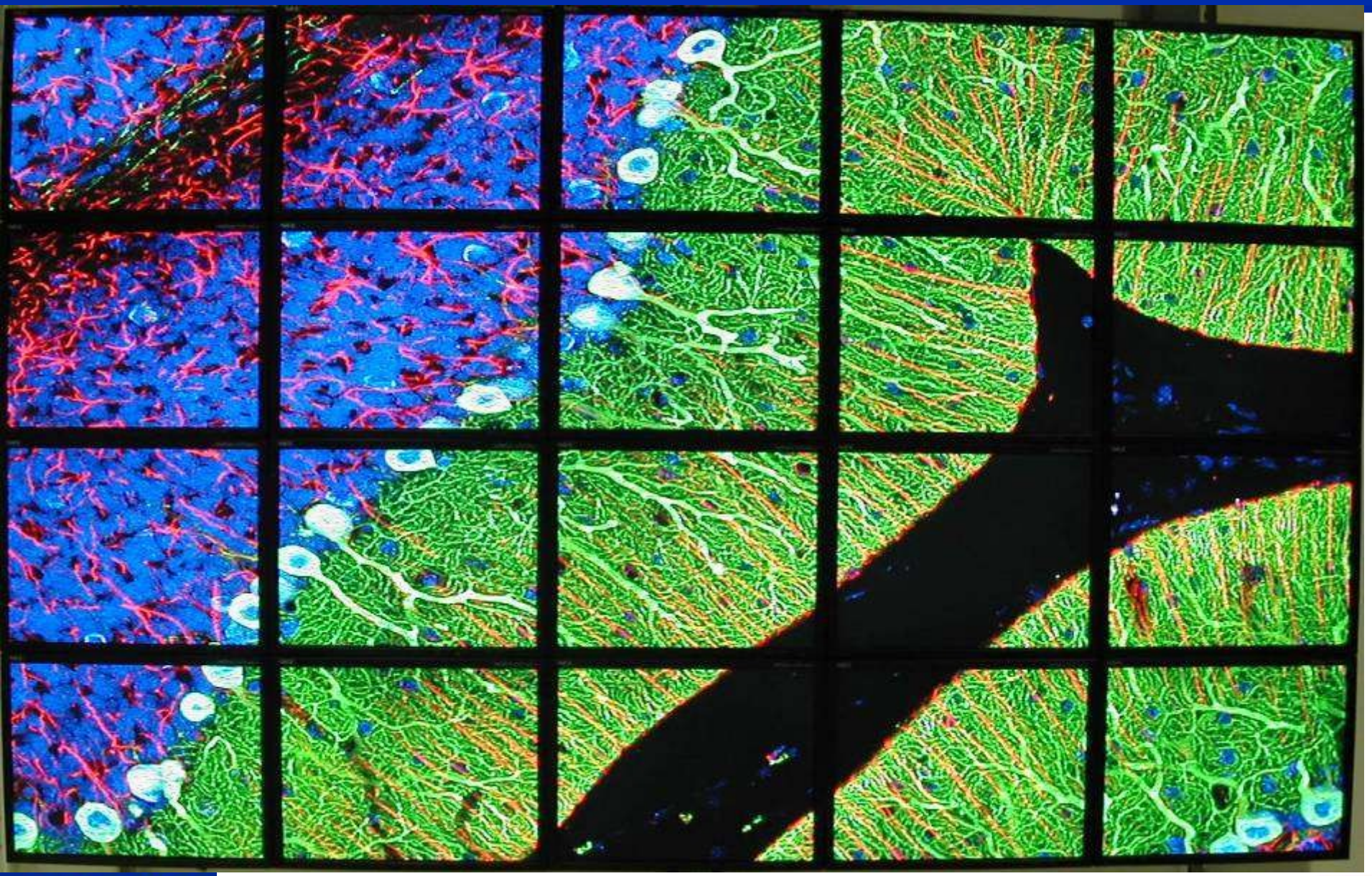
Source: Mark Ellisman, David Lee, Jason Leigh

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30 MPixel SunScreen Display Driven by a 20-node Sun Opteron Visualization Cluster

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Allows for Interactive Zooming from Cerebellum to Individual Neurons

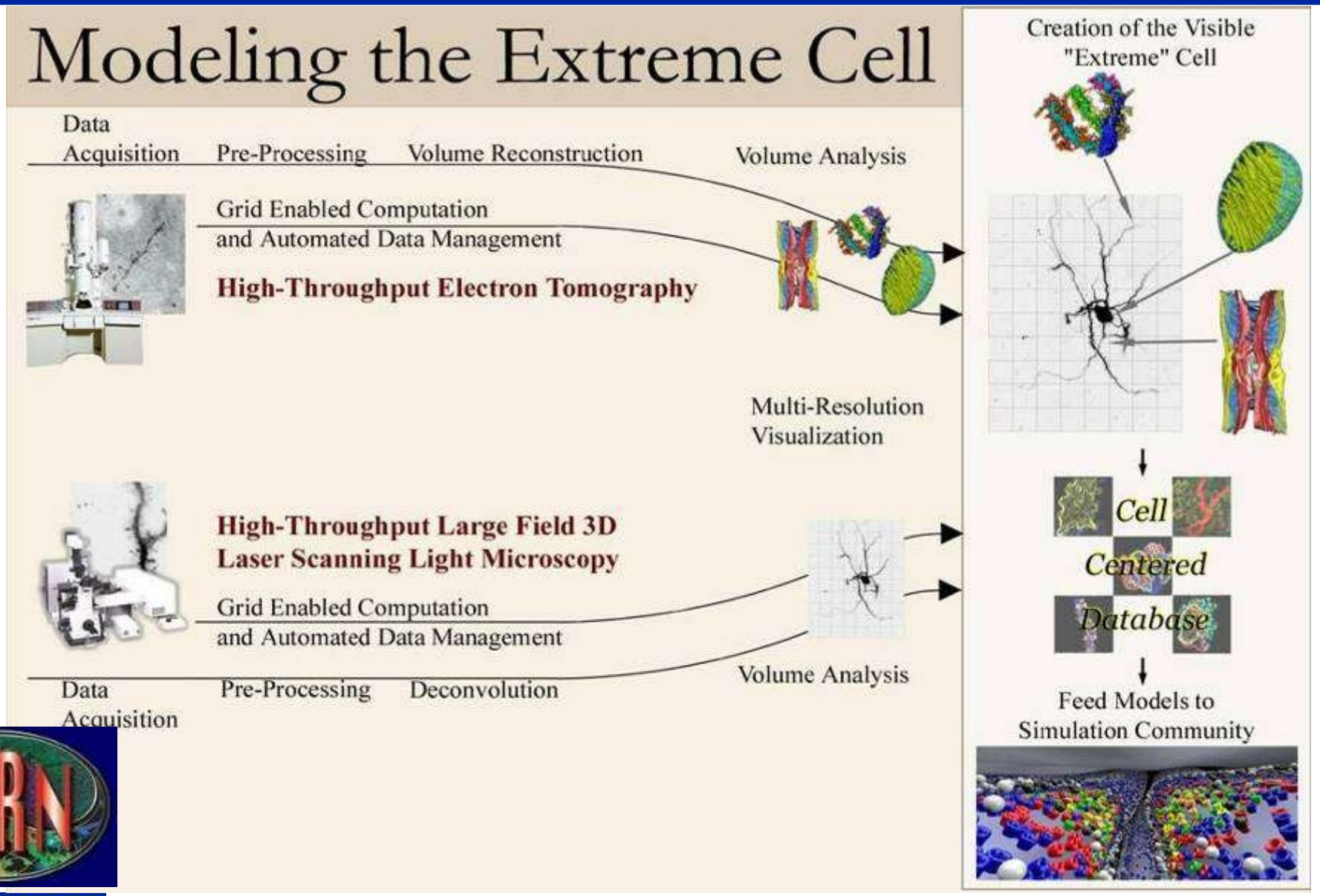


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Source: Mark Ellisman, David Lee, Jason Leigh

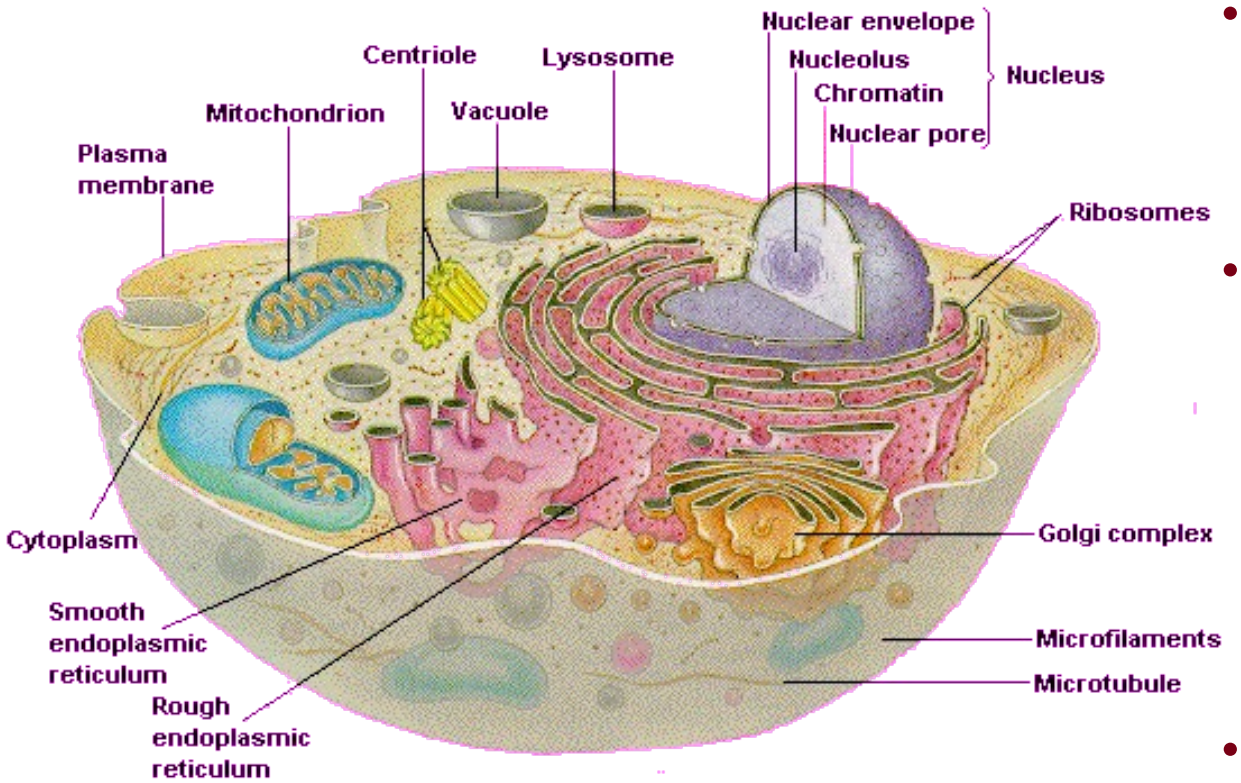
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The "Visible Cell" Project Will be Housed in the Calit2@UCSD Building



Source: Mark Ellisman, UCSD

But Don't Underestimate the Complexity of Living Cells



Taken from *Human Biology* by Daniel Chiras

www.people.virginia.edu/~rjh9u/cell1.html

Viscosity	≈ 1000 x H_2O
Pressure (osmotic)	≈ 500 atm
Electrical gradient	≈ 300,000 V/cm

Source: Bernhard Palsson, UCSD

- **Organelles**
  - 4 Million Ribosomes
  - 30,000 Proteasomes
  - Dozens of Mitochondria
- **Macromolecules**
  - 5 Billion Proteins
    - 5,000 to 10,000 different species
  - 1 meter of DNA with Several Billion bases
  - 60 Million tRNAs
  - 700,000 mRNAs
- **Chemical Pathways**
  - Vast numbers
  - Tightly coupled
- **Is a Virtual Cell Possible?**

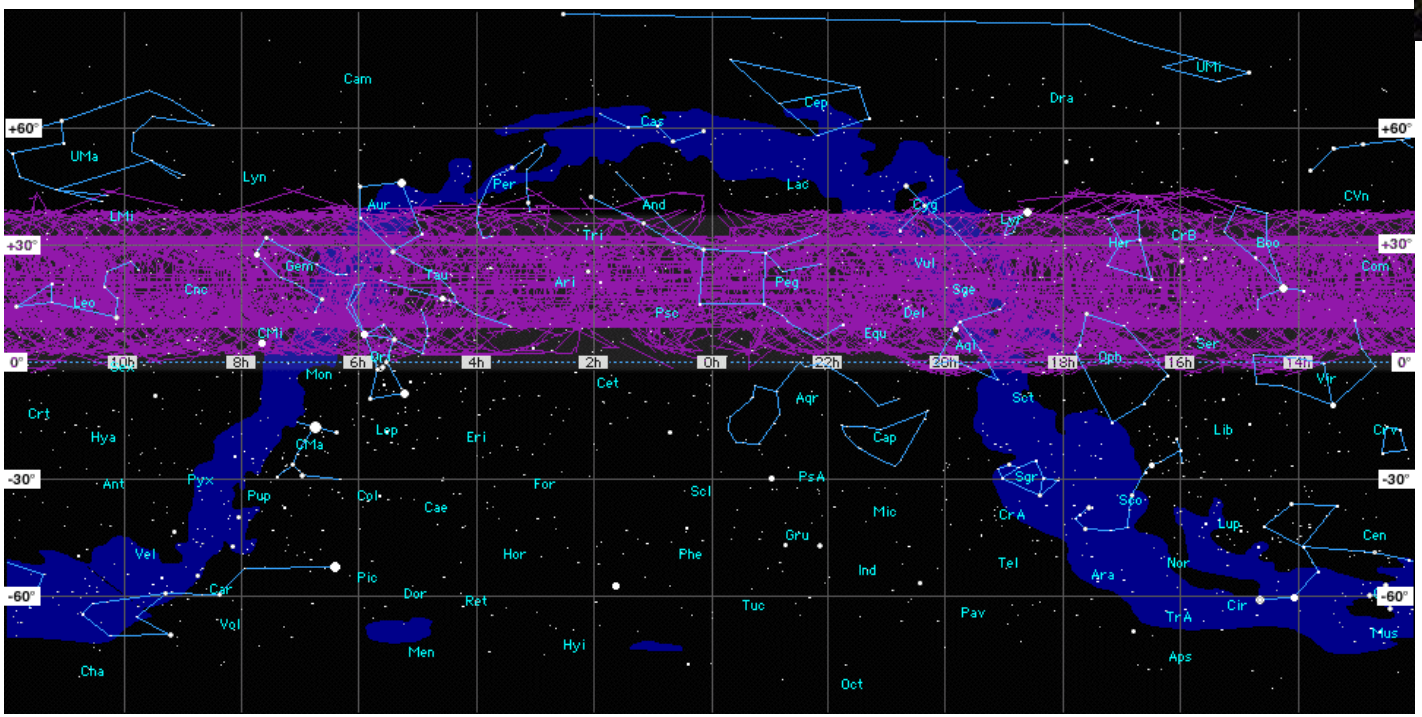
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Accelerator: Utilizing the Planetary-Scale Distributed Computing Capability

- Running on ~500,000 PCs, ~3000 CPU Years per Day
  - 2,500,000 CPU Years So Far
- Sophisticated Data & Signal Processing Analysis
- Distributes Datasets from Arecibo Radio Telescope







Next Step-
Allen Telescope Array



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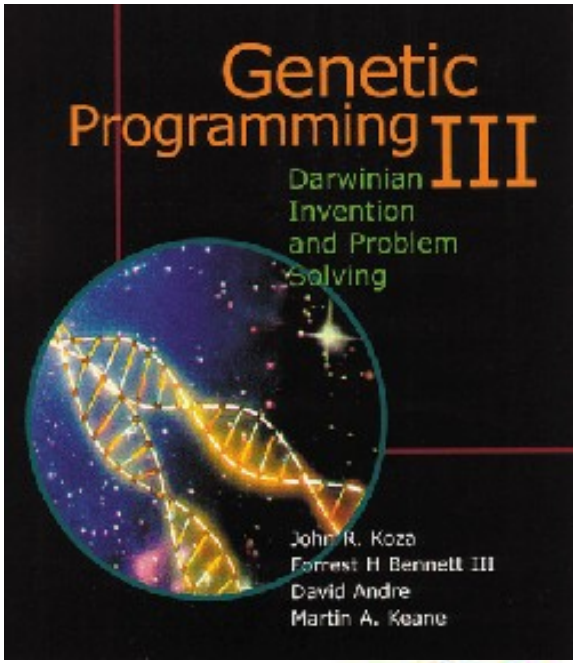
From Software as Engineering to Software as Biology

- Stanford Professor John Koza
- Uses Genetic Programming to Create a Working Computer Program From a High-Level Problem Statement of a Problem
- Starting With a Primordial Ooze of Thousands of Randomly Created Computer Programs, a Population of Programs Is Progressively Evolved Over a Series of Generations
- Has Produced 21 Human-Competitive Results





1,000-Pentium Beowulf-Style Cluster Computer for Genetic Programming



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www.genetic-programming.com/

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Human Brains Compute at ~ PetaFLOP with an I/O of a Gigabit/s

- **Napster Meets Entropia**
  - Distributed Computing and Storage Combined
  - Assume Ten Million PCs in Five Years
    - Average Speed Ten Gigaflop
    - Average Free Storage 100 GB
  - Planetary Computer Capacity
    - 100,000 TeraFLOP Speed
    - 1 Million TeraByte Storage
- **1000 TeraFLOPs is Roughly a Human Brain-Second**
  - Morovec-Intelligent Robots and Mind Transferral
  - Kurzweil-The Age of Spiritual Machines
  - Joy-Humans an Endangered Species?
  - Vinge-Singularity

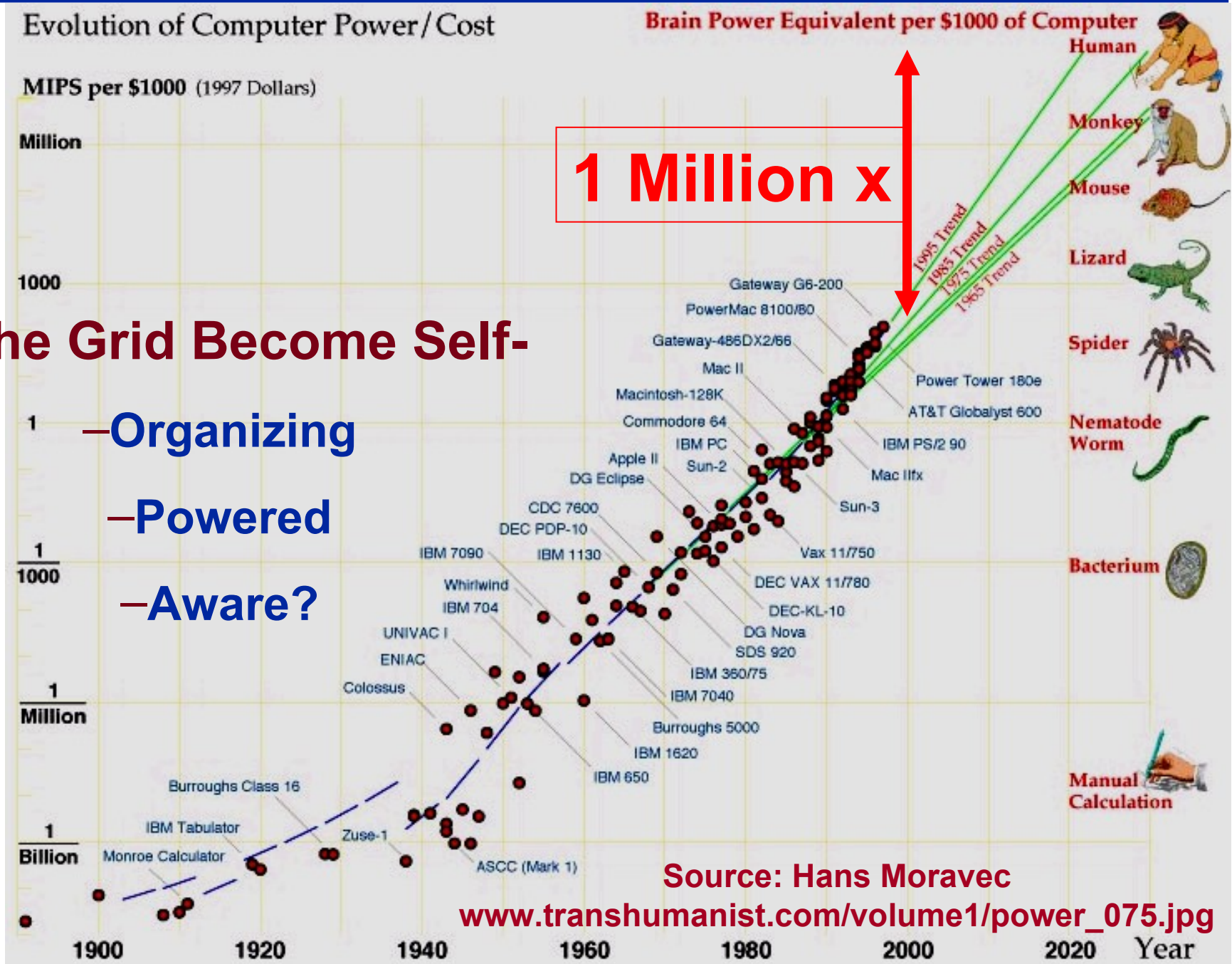
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Source: Larry Smarr Megacomputer Panel
SC2000 Conference

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The Planetary Computing Power is Passing Through an Important Threshold

- Will the Grid Become Self-
  - Organizing
  - Powered
  - Aware?

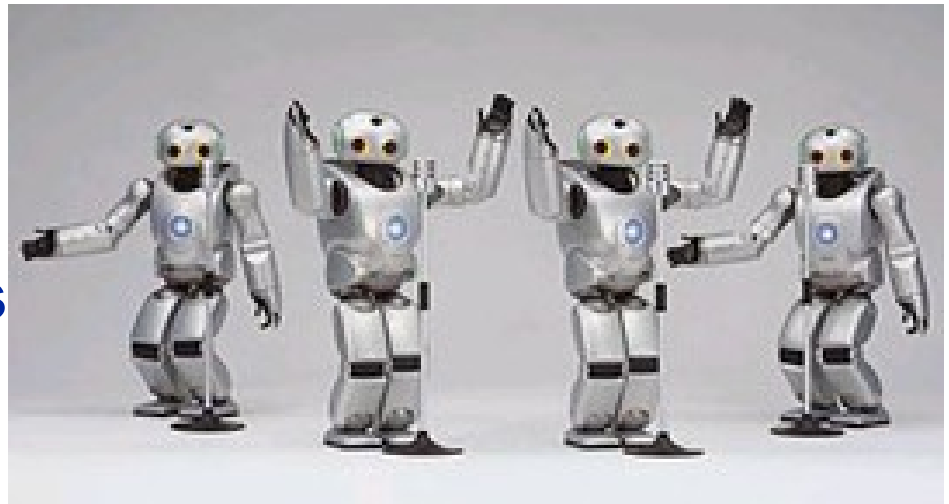


Source: Hans Moravec
www.transhumanist.com/volume1/power_075.jpg

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Accelerator: Robots Tap the Power of the Planetary Computer

- **Sensors**
  - Temperature
  - Distance
  - Speed
  - Accelerations
  - Pressure
  - IR
  - Vibration
  - Imaging





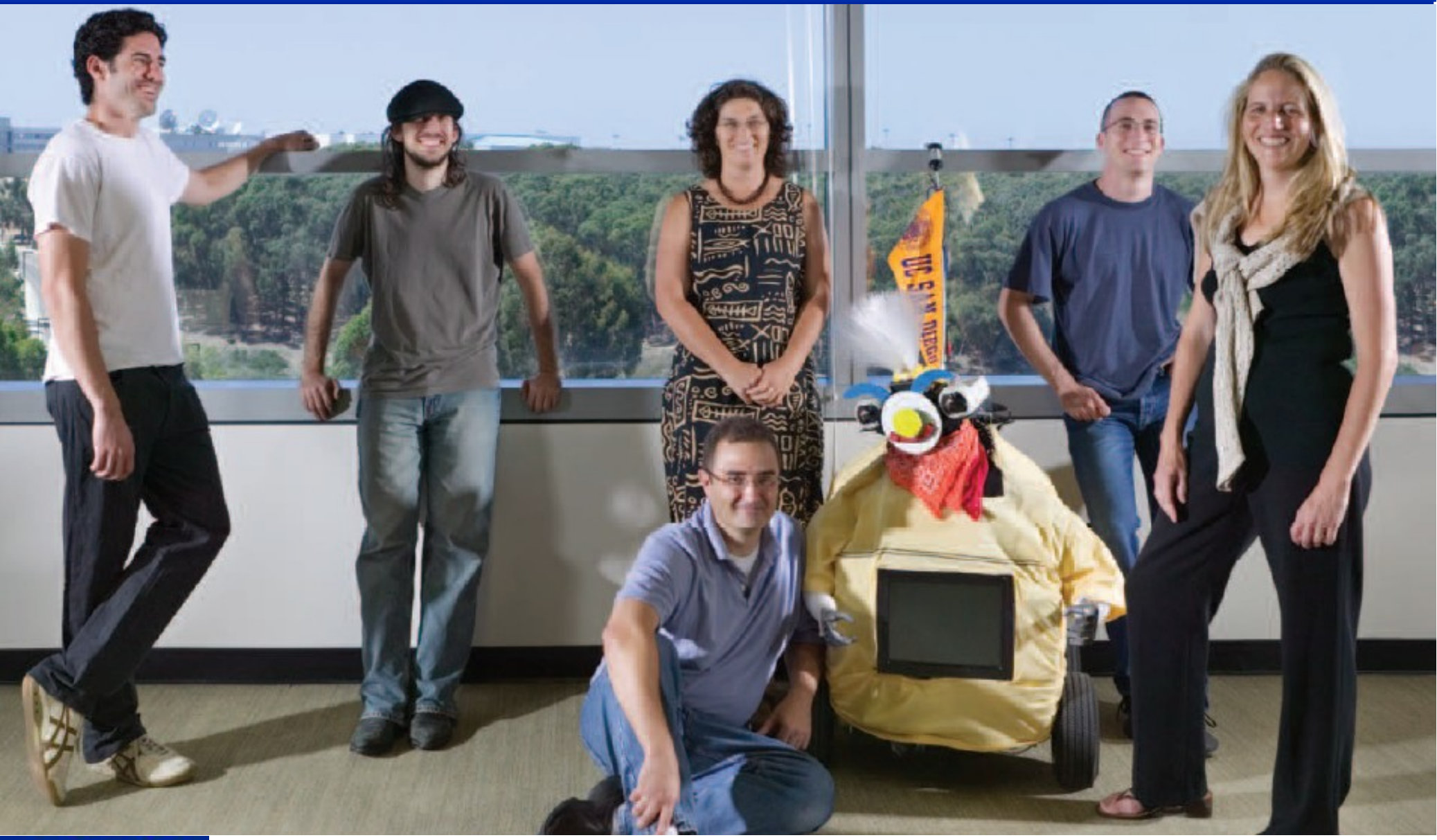
Sony's AIBO and SDR-4X

- **Linked to Internet by Wi-Fi Wireless Br**
  - Completely Changes Robotics Architecture
  - Access to Nearly Infinite Computing, Storage, Software
  - Marriage of Net Software Agents to Physical Probes
  - Ad Hoc Teams of Interacting Intelligent Robots

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UCSD's MPLab Observes How Pre-Schoolers Interact With and Learn From RUBI (Robot Using Bayesian Inference)



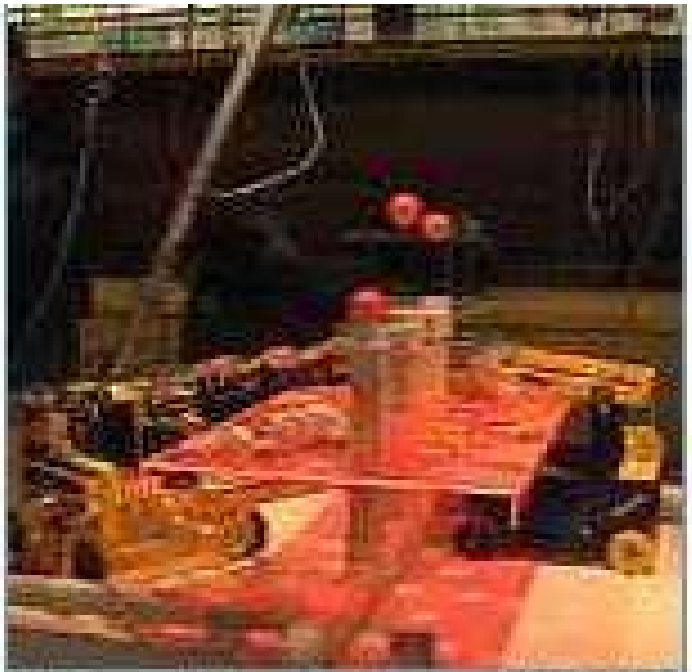
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RUBI Can Detect Six Basic Facial Expression and Distinguish Voices by Combining Spatial & Temporal Processing

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Calit2 Supports UCSD Undergraduate Robotics Outreach and Design Contest

- Mechanical and Aerospace Engineering Lecturer Nathan Delson
- Collaboration with Preuss School was Sponsored by Calit2
- The Object of the Contest is to
  - Collect the Balls from the Air Vent and
  - Bring the White Ones Back to the Bin and
  - Bring the Orange Ones Back to the Triangular Corals



Final contest on "center court": at right is the ultimate winner, designed to slide under the playing field

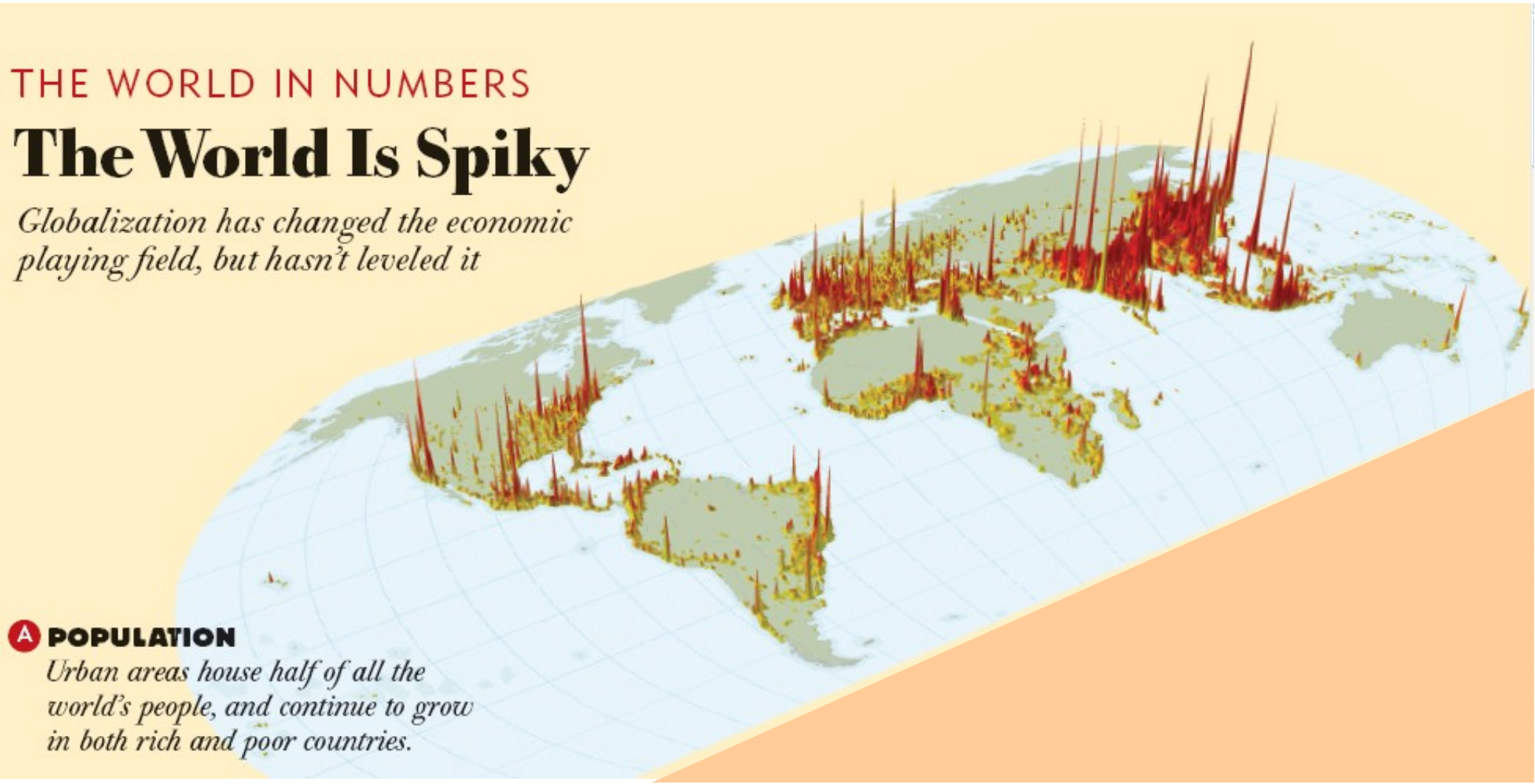


Preuss students working on projects

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www.calit2.net/newsroom/article.php?id=242

Accelerator: Use the Whole Human Population's Innovation Potential

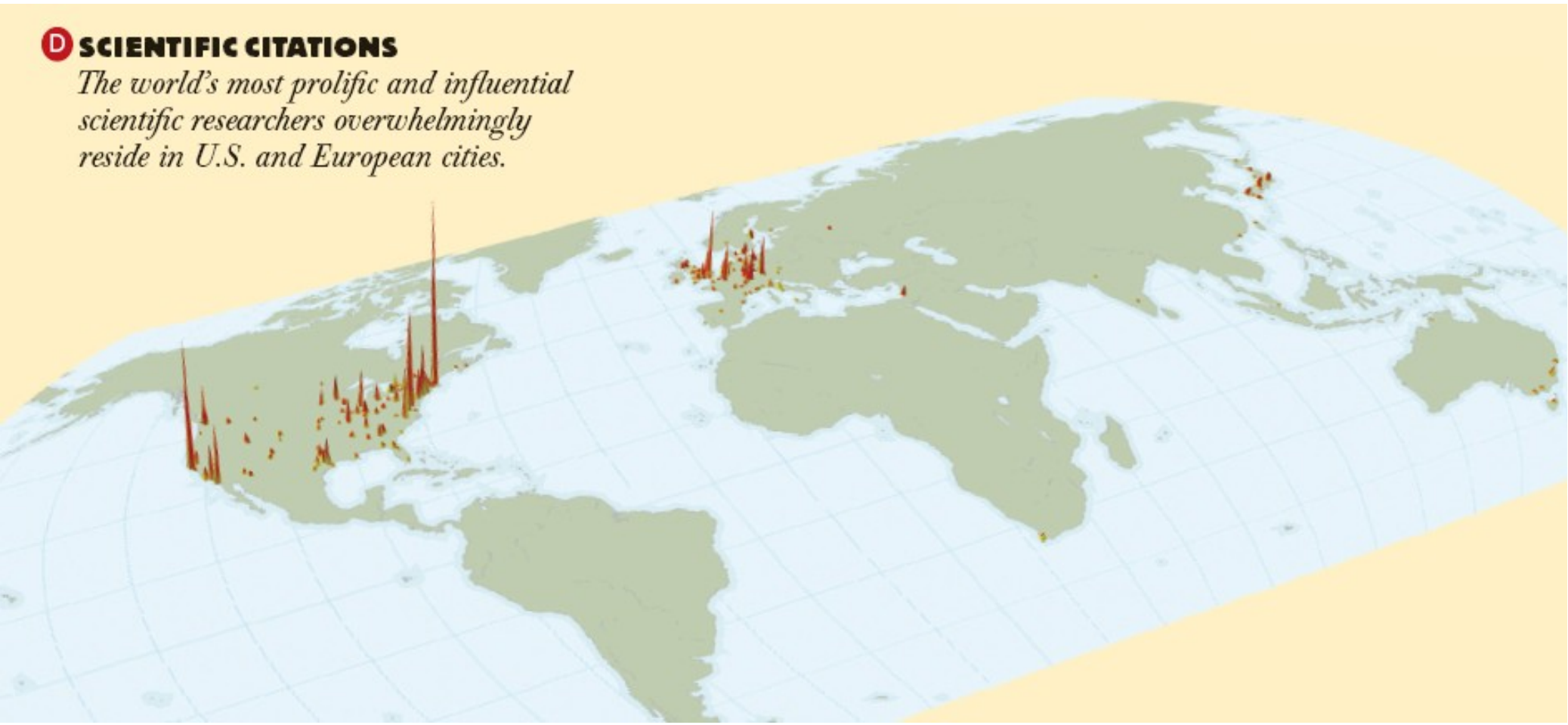


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Source: Richard Florida October 2005 Issue of Atlantic Monthly

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Basic Research Spread From Europe to US Only 50 Years Ago—Next is Asia and the Americas

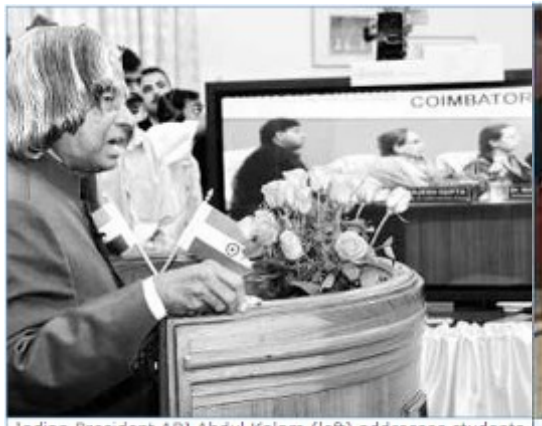


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India Partners with US Universities to Establish Satellite e-Learning Collaboration

- **Goals**
  - Enhance Science and Engineering Education at Indian Universities
  - Boost Supply of World-Class Engineers Available for Corporate and Academic Research in Both Countries
- **Industry Partners**
  - QUALCOMM, Microsoft and Cadence Design Systems
  - Pay for U.S. Professors to Spend Part of their Sabbaticals Teaching at the E-Learning Facility
  - Their Lectures will be Beamed via Edusat, India's First Satellite Devoted Exclusively to Educational Programming
  - Lectures will Eventually Reach Classrooms on 100 Indian Campuses



Indian President APJ Abdul Kalam (left) addresses students and faculty, including UCSD computer scientist Rajesh Gupta (on video monitor at left) in Coimbatore.


Indian and U.S. participants on hand for the launch in New Delhi of the education and research collaboration.

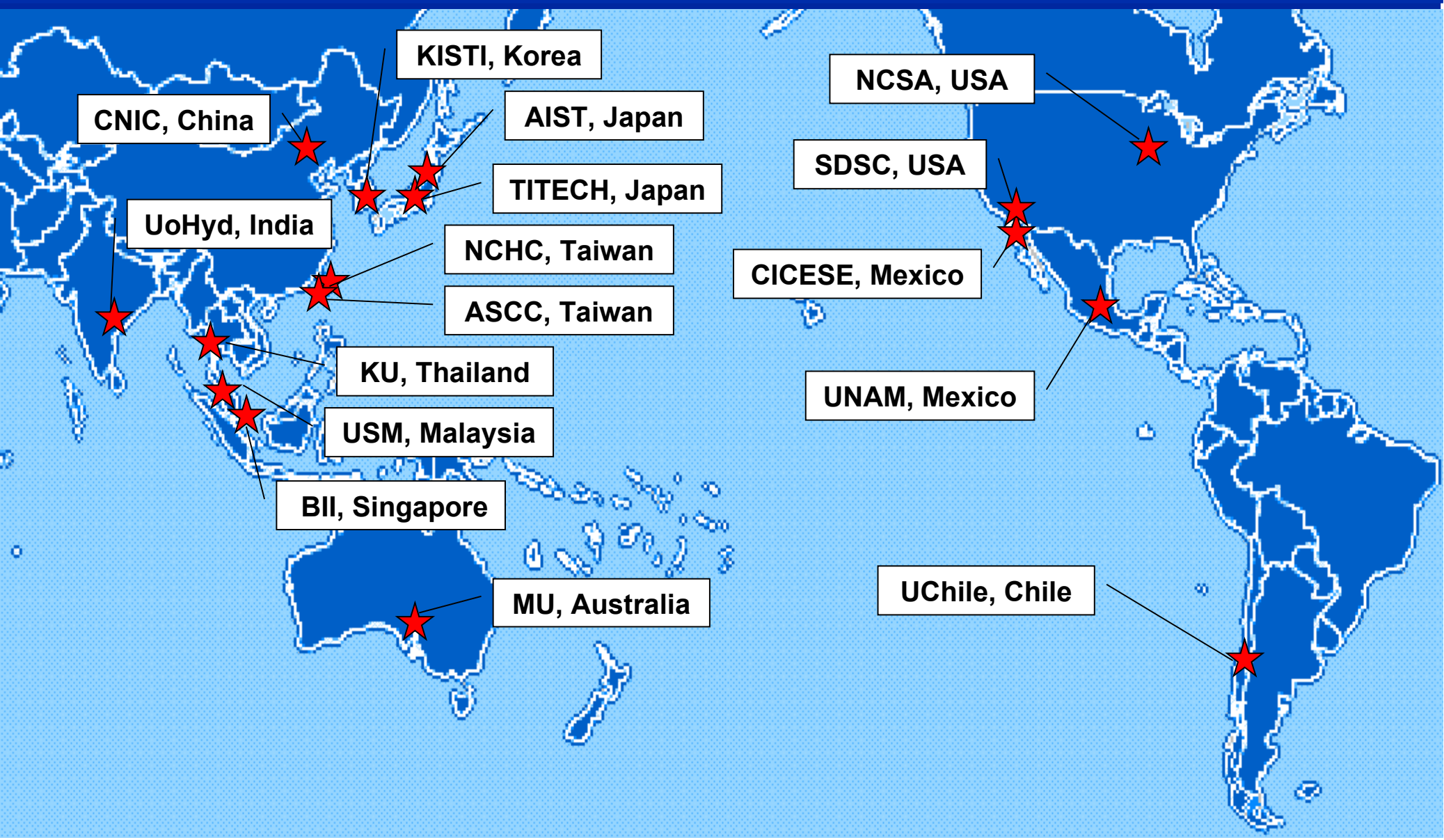
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Pacific Rim Undergraduate Experiences PRIME 2005

- **Preparing Students for the Global Workplace of the 21st Century**
  - **14 UCSD Undergrads**
    - **NSF- Funded with Calit2**
  - **Students Work With Researchers During Summer in:**
    - **Australia, Japan, Taiwan, China and Thailand**
  - **Chemistry, Biomedical, Ecology, Networking**



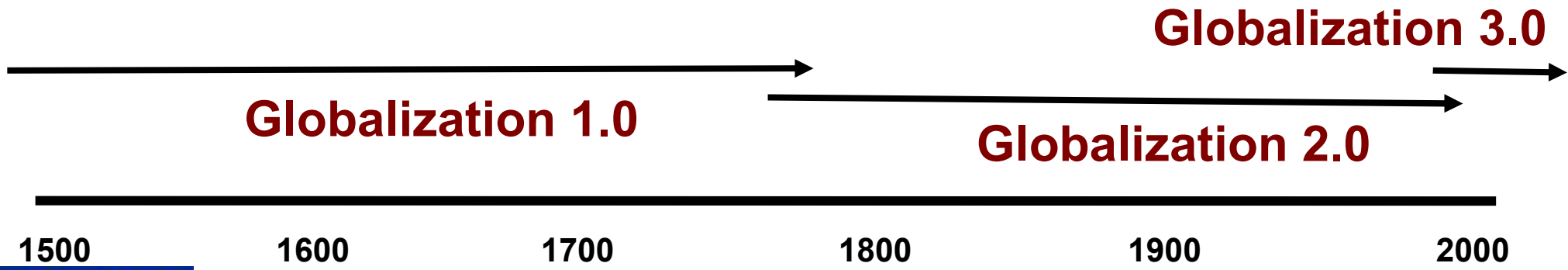
Calit2/PRAGMA International Grid Testbed



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We Stand at the Beginning of the Globalization 3.0 Era

Globalization 1.0 was about countries and muscles. In Globalization 2.0 the dynamic force driving global integration was multinational companies. The dynamic force in Globalization 3.0 is the newfound power for individuals to collaborate & compete globally. And the lever that is enabling individuals and groups to go global is software in conjunction with the creation of a global fiber-optic network that has made us all next-door neighbors."



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Accelerator: Global Connections Between University Research Centers at 10Gbps

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org



the UC Discovery Grant

September 26-30, 2005
Calit2 @ University of California, San Diego
California Institute for Telecommunications and Information Technology



21 Countries Driving 50 Demonstrations
1 or 10Gbps to Calit2@UCSD Building
Sept 2005

CICESE, CONACYT, CUDI, and Telmex at iGrid2005

Opening a University Fiber Highway between Mexico and the USA

http://iGridMX.cicese.mx

contact

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CUDI, Mexico, and San Diego State University (SDSU), USA
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collaborators

CUDI, Mexico: Carlos Casasus • SDSU, USA: Eric Frost, Bob Welty, John Graham • CICESE, Mexico: Javier Mendieta Jiménez, Luis Farfán, Edgar Pavia, Tereza Cavazos, Raúl Hazas Izquierdo, Salvador Castañeda, Julián Delgado, José Luis Rodríguez • CONACYT, Mexico: Jaime Parada, Juan Milton Garduño, Carlos Duarte • Telmex, Mexico: Benjamin Podoswa • Stanford University, USA: Milton Chen • University of California, San Diego, USA: Peter Arzberger, Cindy Zheng



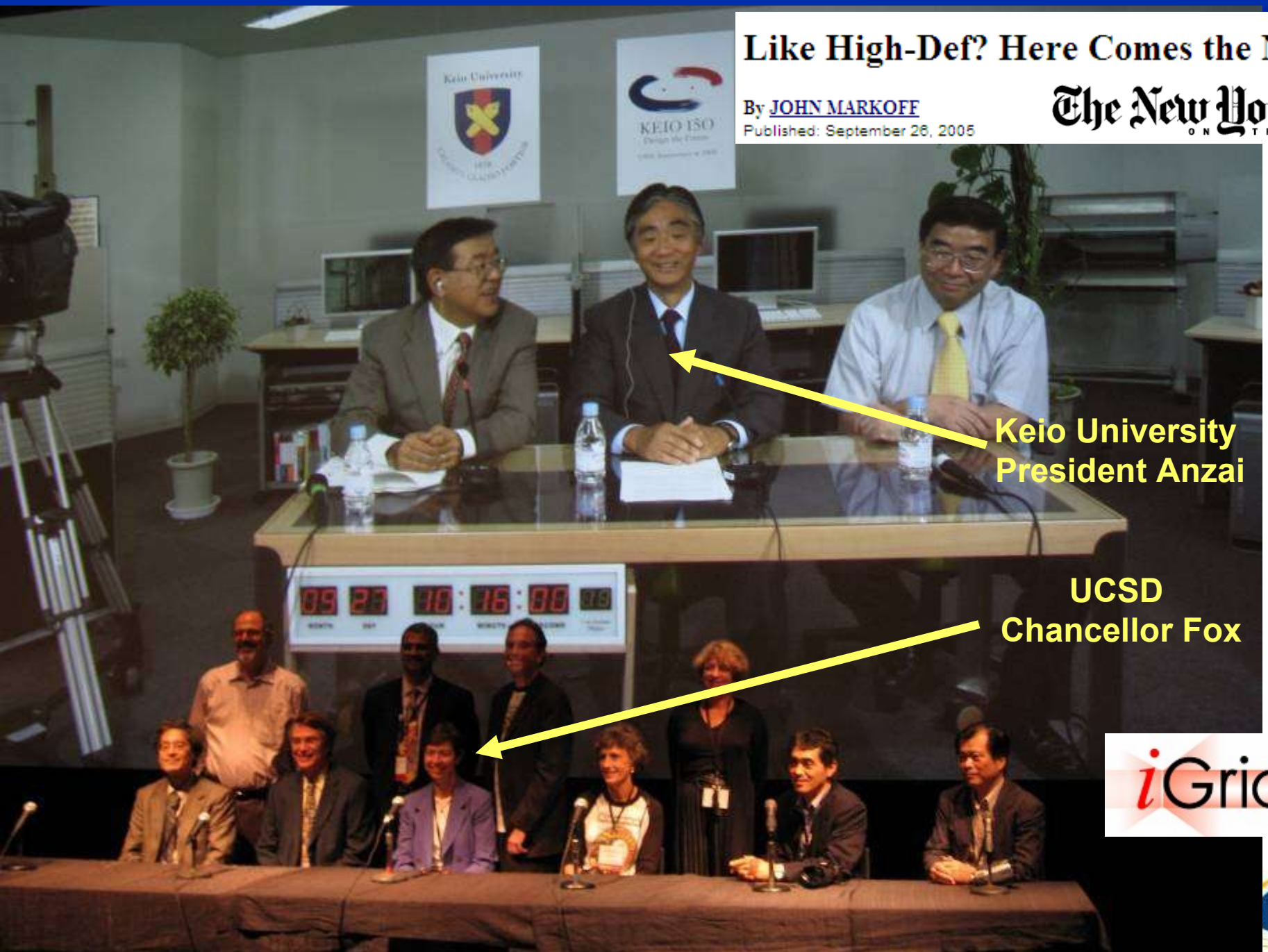
Optical fiber newly installed between San Diego and Tijuana, and ultimately extending down to CICESE in Ensenada in the Baja California Peninsula, is enabling collaborative USA/Mexican research in Earth, oceanographic and atmospheric sciences. At iGrid, 3D visualizations of shared terrain enable scientists to better understand the consequences of fires, floods, and earthquakes, which have no geographical boundaries. Environmental modeling and simulation visualizations fed by real-time sensor information combined with legacy visualizations provide hybrid visualizations for situational awareness for public safety, economic effect assessment, and shared Homeland Security.

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September 26-29, 2005

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First Trans-Pacific Super High Definition Telepresence Meeting in New Calit2 Digital Cinema Auditorium



Like High-Def? Here Comes the Next Level

By JOHN MARKOFF
Published: September 26, 2005

The New York Times ON THE WEB

Keio University President Anzai

UCSD Chancellor Fox

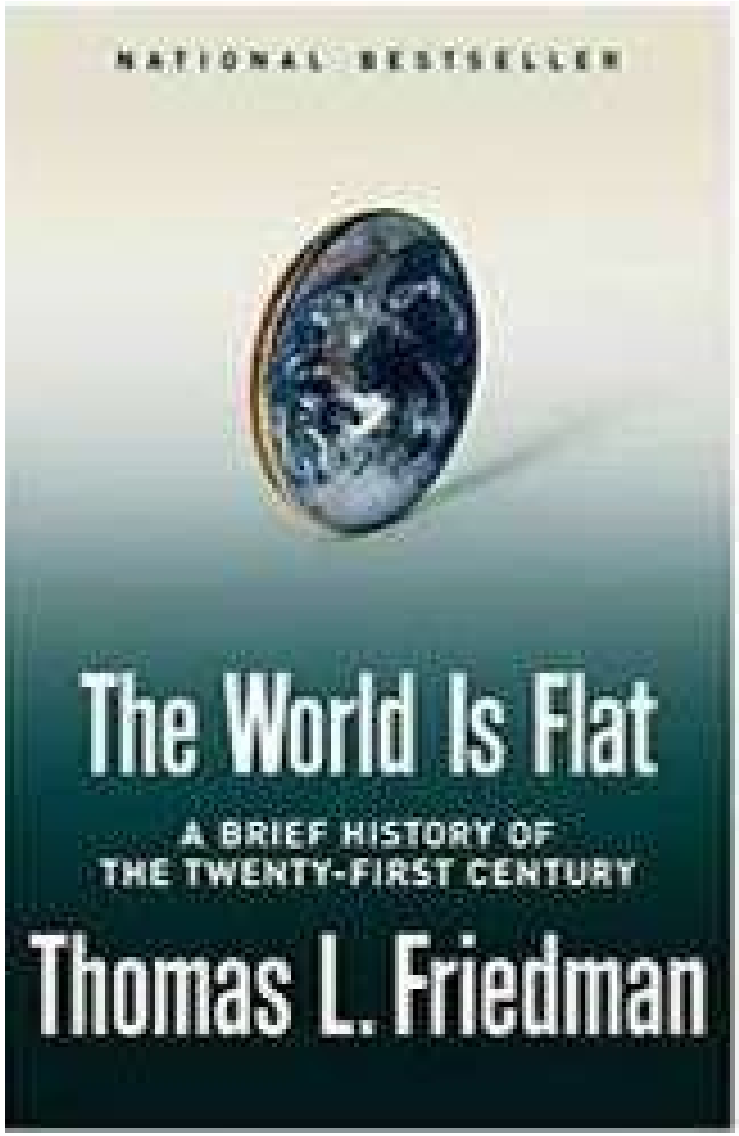
Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

it²

The Technology Innovations of Ten Years Ago-the Shared Internet & the Web-Have Been Adopted Globally



- **But Today's Innovations**
  - **Dedicated Fiber Paths**
  - **Streaming HD TV**
  - **Ubiquitous Wireless Internet**
  - **Location Aware Software**
  - **SensorNets**
- **Will Reduce the World to a "Single Point" in Ten Years**

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