The Future of Telecommunications and Information Technology

Talk to Warren College Scholars Seminar
UCSD
October 21, 2003

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

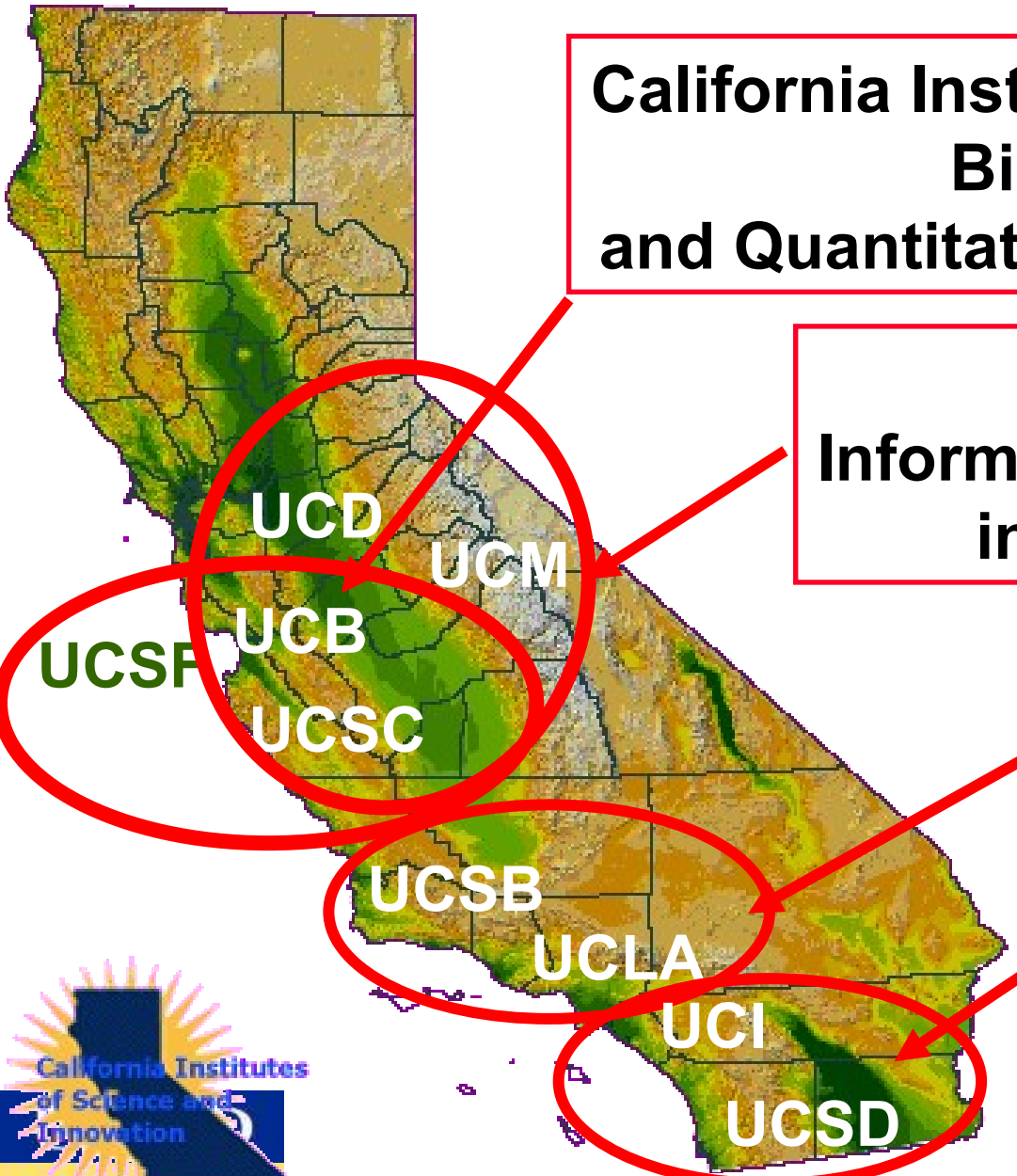
Jacobs School of Engineering, UCSD

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California's Institutes for Science and Innovation
A Bold Experiment in Collaborative Research



California Institute for Bioengineering, Biotechnology, and Quantitative Biomedical Research

Center for Information Technology Research in the Interest of Society

California NanoSystems Institute

California Institute for Telecommunications and Information Technology

California Institutes of Science and Innovation

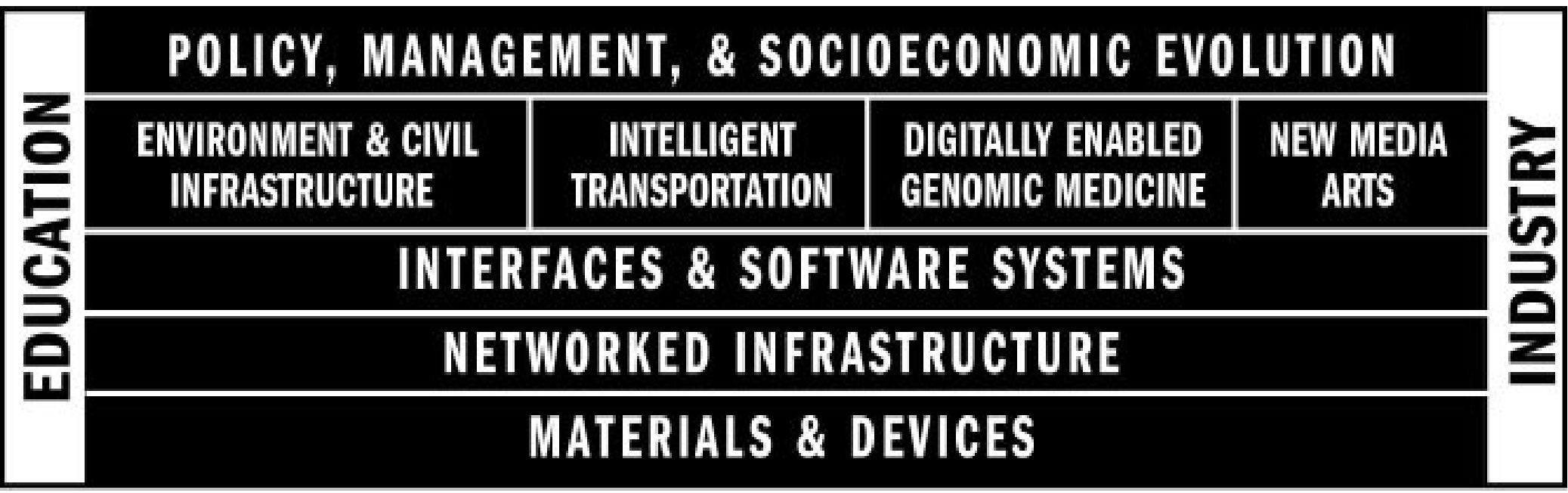
UCHV

www.ucop.edu/california-institutes

it²

Cal-(IT)^2--An Interdisciplinary Research Public-Private Partnership on the Future of the Internet

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



The State's $100 M

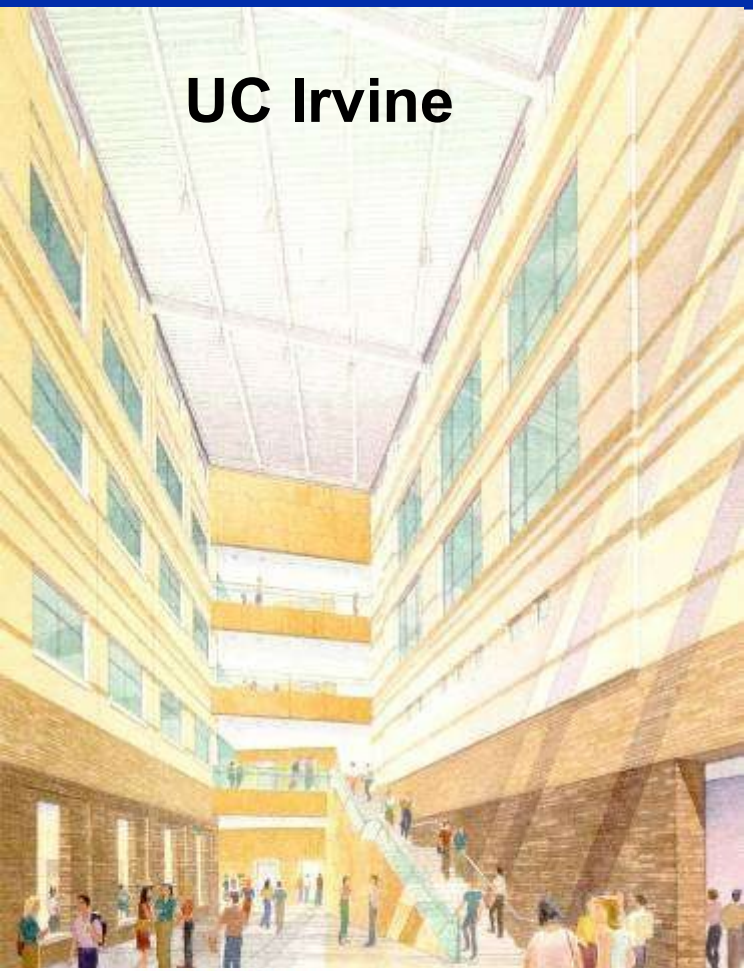
Creates Unique Buildings, Equipment, and Laboratories

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www.calit2.net

it^2

Two New Cal-(IT)^2 Buildings Are Under Construction



- **Will Create New Laboratory Facilities**
  - **Interdisciplinary Teams**
  - **Wireless and Optical Networking**
  - **Computer Arts Virtual Reality**
  - **Clean Rooms for Nanotech and BioMEMS**



UCSD Site



[Get Closer]

LIVE WEBCAMS ON CAL-(IT)^2 BUILDINGS!
[Read About]

UCI Site

[Get Closer]

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UCIrvine

See www.calit2.net for Live VideoCams

The UCSD Cal-(IT)^2 Building Will Be Occupied in January 2005

200 Single Offices
Hundreds
of Collaborative Seats

Virtual Reality
Cube

Digital Cinema
Auditorium



Nanotech
Clean Rooms

RF and Optical
Circuit Labs

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Watch us Grow! [www.calit2.net]

it^2

Cal-(IT)^2 Buildings Will Have Ubiquitous Tele-Presence



Falko Kuester, UCI, Laboratory with Smart Boards and Optically Connected Large Screens



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Cal-(IT)2 Undergrad Research Summer Research Program







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Bioengineering, Chemistry, Chemical Eng., Cog Sci, CSE, ECE, IR/PS, Music, Physics, SIO, Visual Arts

it²

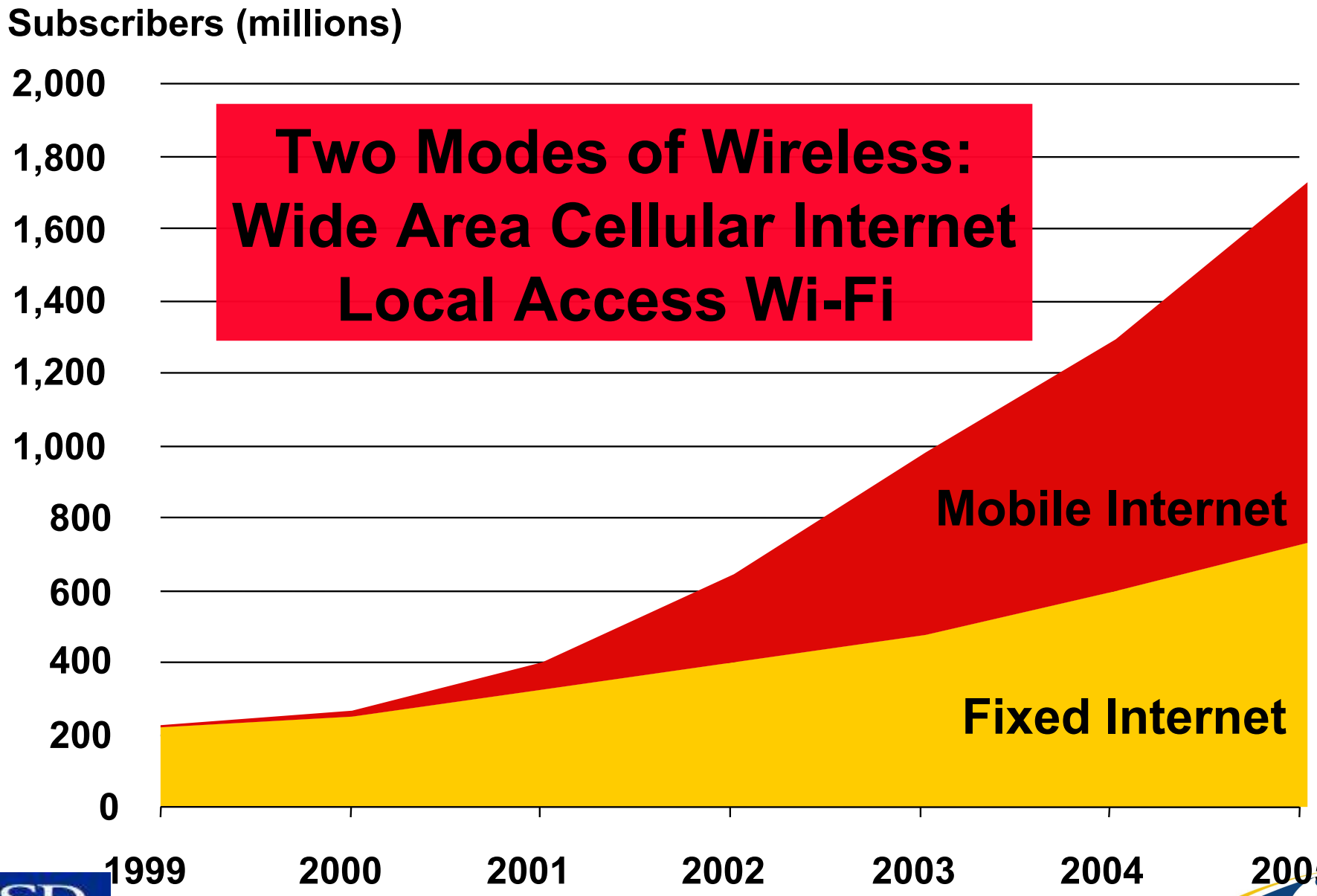
Major Internet Technology Trends That Will Have Major Impact on Medicine

- **Wireless Access--Anywhere, Anytime**
  - Broadband Speeds
  - Cellular Interoperating with Wi-Fi
- **Billions of New Wireless Internet End Points**
  - Information Appliances (Including Cell Phones)
  - Sensors and Actuators
  - Embedded Processors
- **Enormous Capacity Core Network**
  - Multiple Wavelengths of Light Per Fiber
  - Linking Clusters, Storage, Visualization
  - Massive Distributed Data Sets

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Transitioning to the "Always-On" Mobile Internet



Source: Ericsson

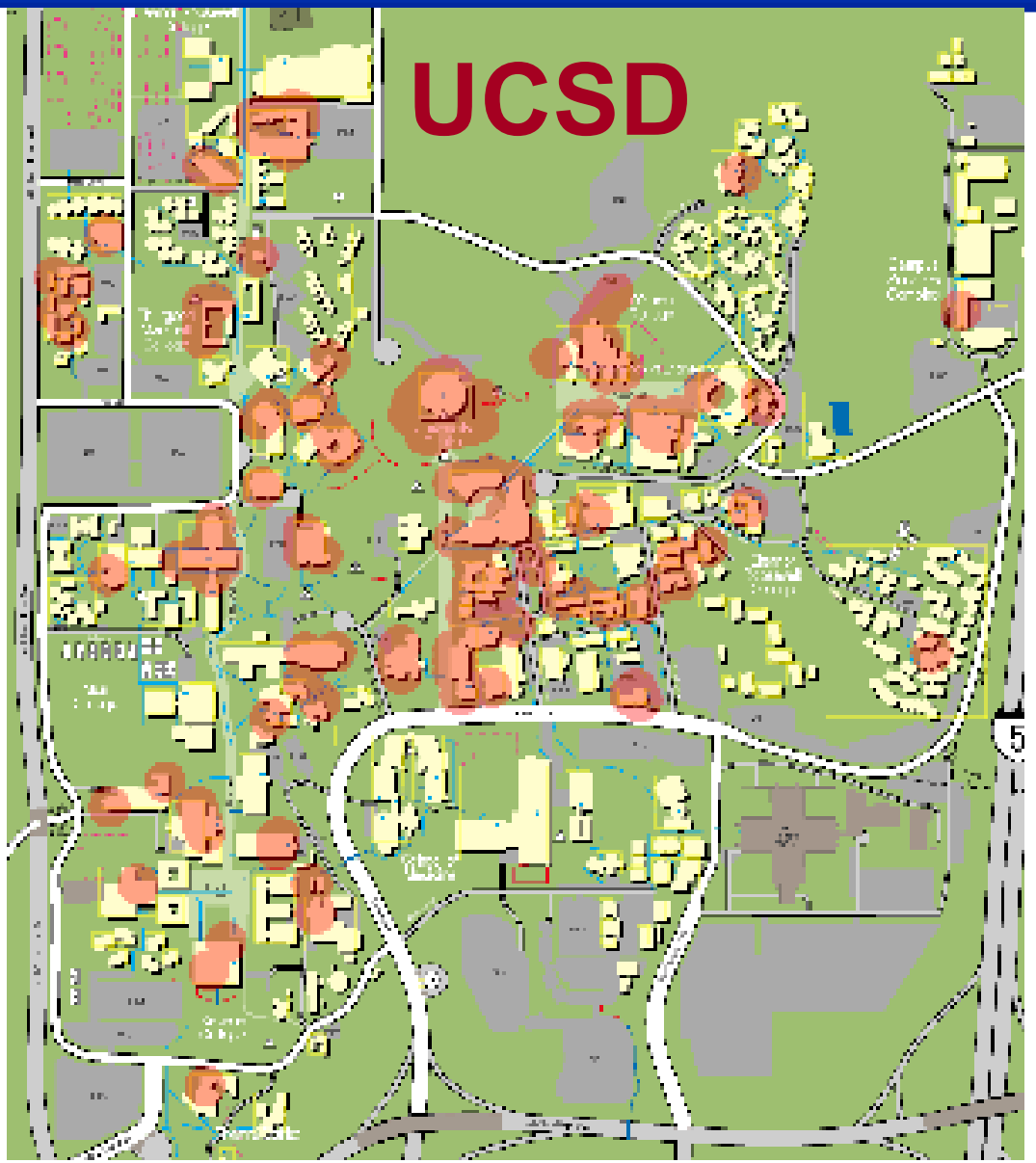
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There Are Two Major Classes of Wireless Internet

- **Wi-Fi**
  - Or IEEE 802.11
  - Range Roughly 100 Feet
  - 11 Mbps going to 54 Mbps
  - Installed in Ground-Up Fashion by Individuals
- **Cellular Internet**
  - "Always-On" Internet Addition to Voice
  - Provided by Telecom Vendors Like Verizon
  - A "Cable Modem" in the Sky
    - Two Standards
      - CDMA 2000 (US and Korea)
        - Now available as 1XRTT (~100 kbit/s)
        - Oct. 1 1xEVDO in San Diego (~700kbit/s)
      - WCDMA GPRS (Europe and Asia)

Campuses Are Increasingly Covered With High Bandwidth "Wi-Fi" Wireless Internet Zones



- **UCSD Wireless Projects**
  - ActiveClass
  - ActiveCampus
  - Explorientation
  - CyberShuttle
- **UCI Wireless Projects**
  - GPS PDAs
  - Intelligent Transportation
  - Wearables

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http://activecampus2.ucsd.edu/acelaunch/coverage.php

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Using Students to Invent the Future of Widespread Use of Wireless Devices

- **Broadband Internet Connection via Wireless Wi-Fi**
  - **Over 600 Access Points on the Campus**
- **Year- Long "Living Laboratory" Experiment 2001-02**
  - **500 Computer Science & Engineering Undergraduates**
- **300 Entering UCSD Sixth College Students—Fall 2002**
- **Experiments with Geo-Location and Interactive Maps**

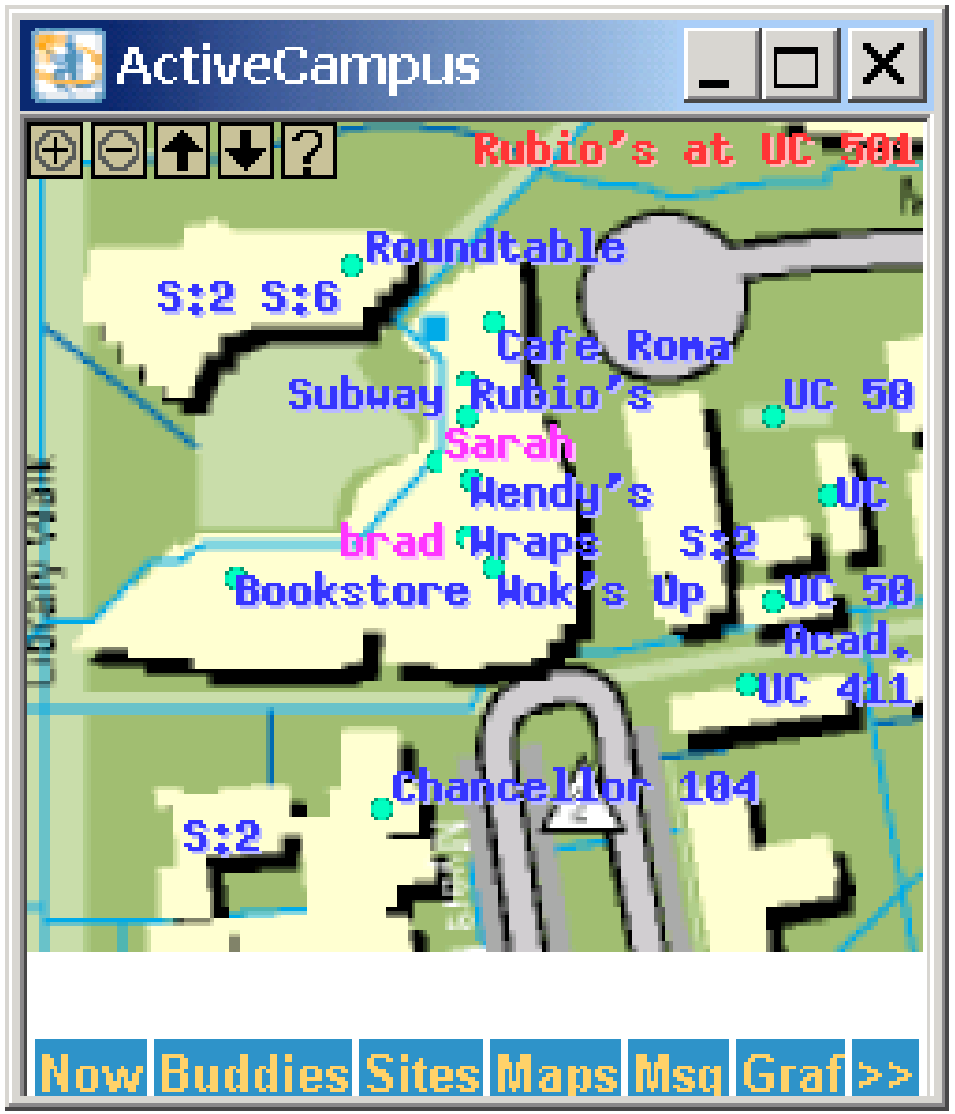




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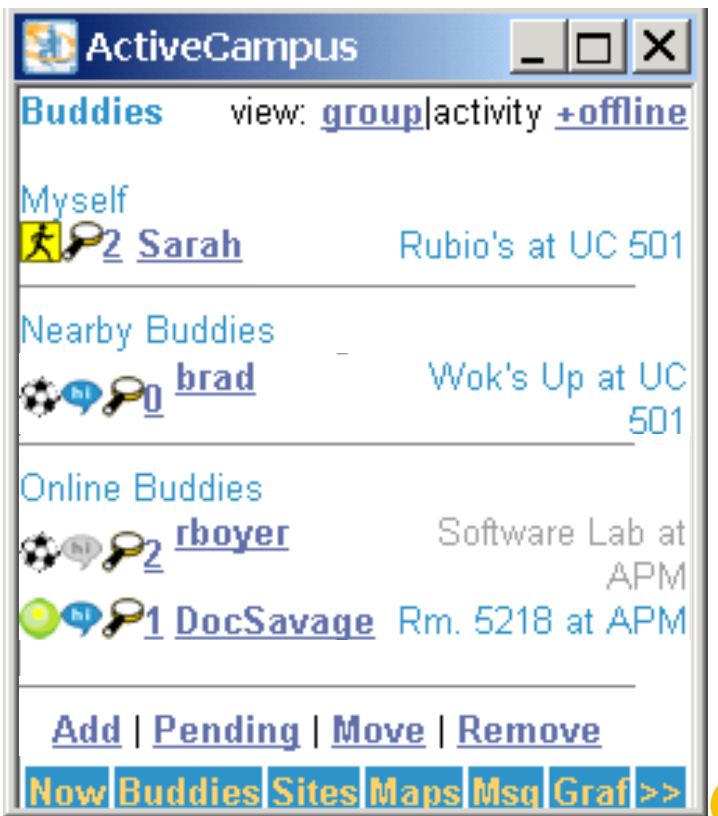
Cal-(IT)^2 Team: Bill Griswold, Gabriele Wienhausen, UCSD; Rajesh Gupta, UCI

Geolocation Will Be an Early New Wireless Internet Application



UCSD ActiveCampus – Outdoor Map

- **Technologies of Geolocation**
  - GPS chips
  - Access Point Triangulation
  - Bluetooth Beacons
  - Gyro chips



Source: Bill Griswold, UCSD

Students Are Creating New Uses of the "Always-On" Internet









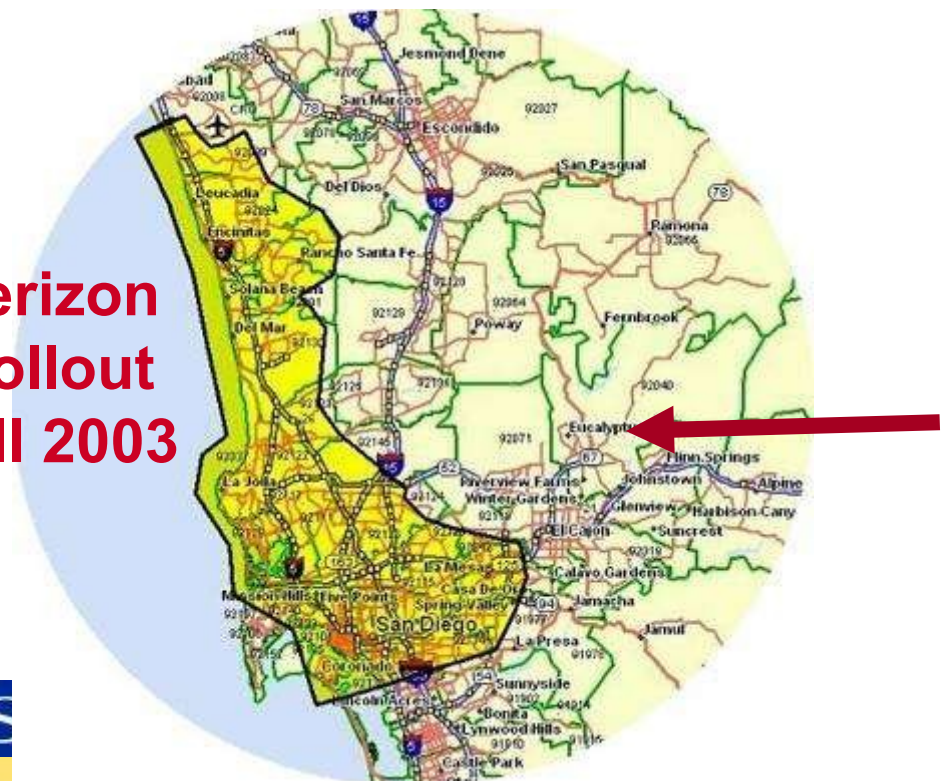
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Only Three Years From Research to Market
New Broadband Cellular Internet Technology

- First US Taste of 3G Cellular Internet
  - UCSD Jacobs School Antenna
    - Three Years Before Commercial Rollout
- Linking to 802.11 Mobile "Bubble"
  - Tested on Campus CyberShuttle
- Verizon is Now in Final Tests



Rooftop Qualcomm
1xEV Access Point



Verizon
Rollout
Fall 2003



CyberShuttle March 2002

www.calit2.net/news/2002/4-2-bbus.html

UCI UCIrvine

High Resolution, Low Jitter Video Diagnosis Tool

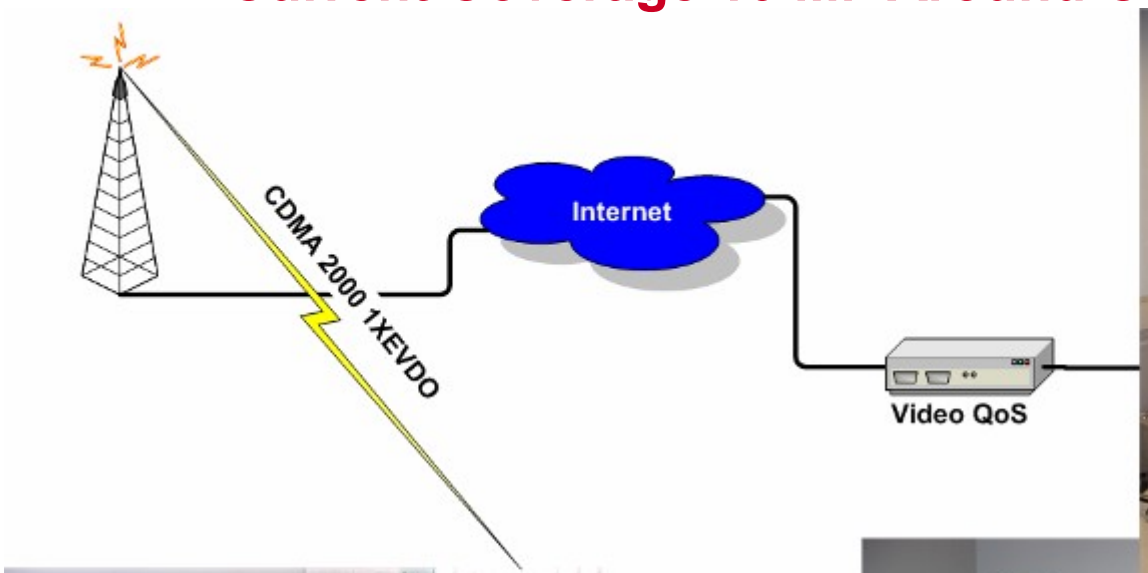
Cal-(IT)², Qualcomm, Path 1, & UCSD Stroke Center

End-to-End QoS Management

Video Delivered Over CDMA 2000 1x EV-DO To Specialists

Viewing Station –Standard Laptop With 1xEV-DO Modems

Current Coverage 10 Mi. Around Campus









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Prototype Led to a $5-million, 5-Year Grant from the National Institute of Neurological Diseases and Stroke

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Building Materials Were Chosen To Maximize Radio Penetration

- **Exterior Wall**
  - Clear Glazing
  - Trespa Wall Panels
- **Interior Walls**
  - Glazed Office Walls
  - Clerestory



Experiments That Will Influence Building Design in the Future

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nbbj

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SDSU Santa Margarita Field Station is a SensorNet Living Laboratory

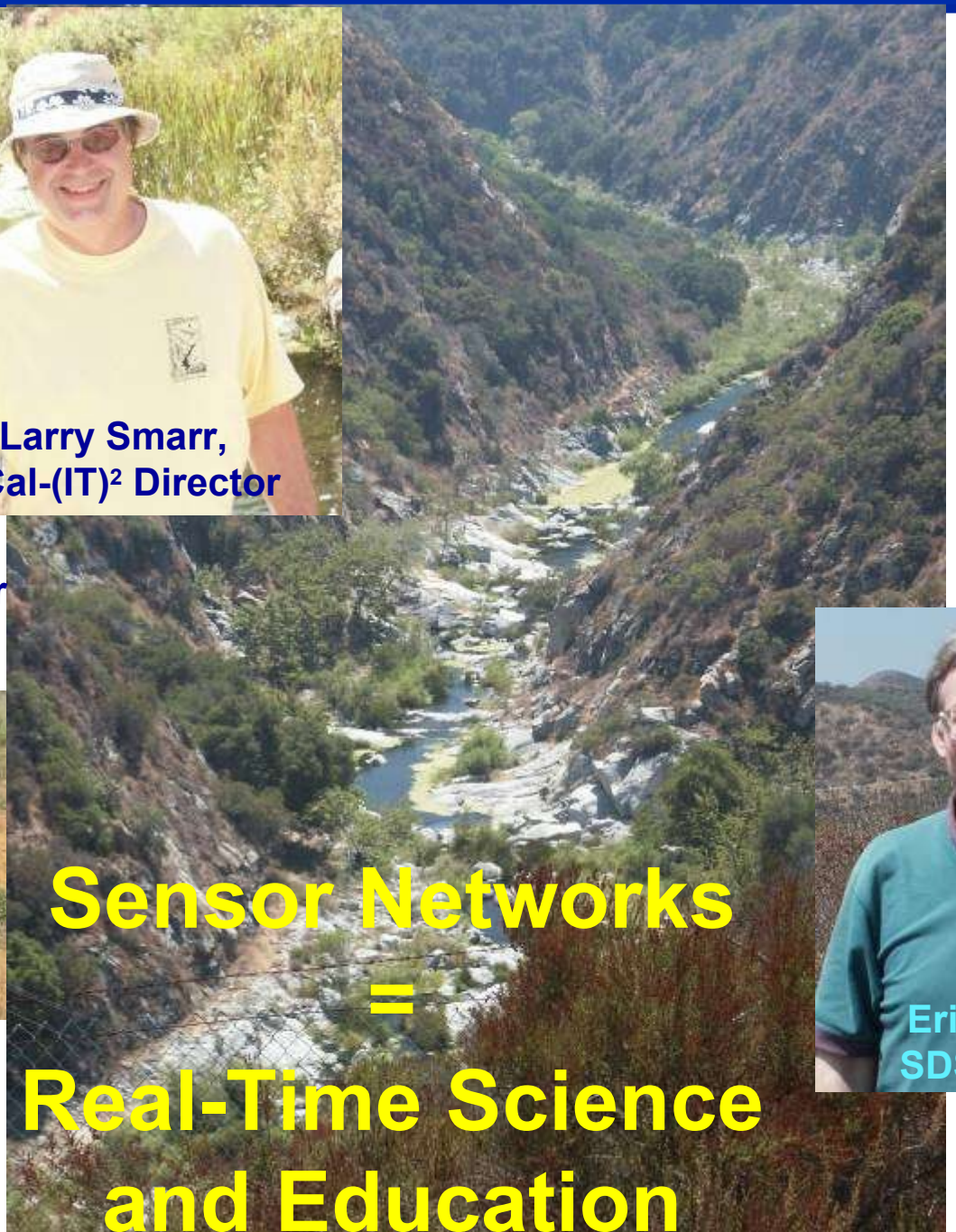


Larry Smarr,
Cal-(IT)² Director

Sedra Shapiro,
Field Stations Director



Pablo Bryant,
FS Technical Lead



Sensor Networks
=
Real-Time Science and Education



Dan Cayan, SIO
Installing
Water Sensors



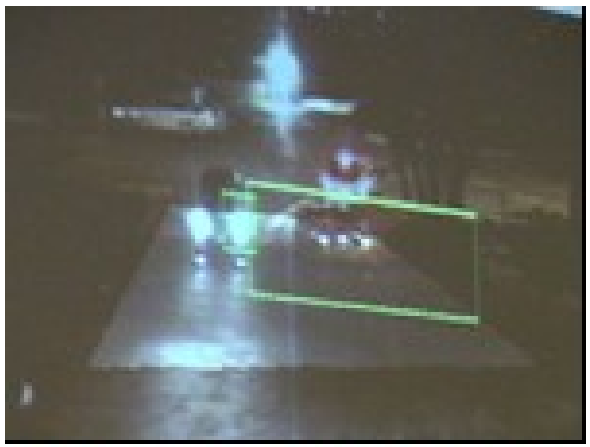
Eric Frost,
SDSU Prof.

Claudia Luke,
SMER Manager

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Cal-(IT)² Homeland Security Experiments During Super Bowl 2003



Vehicle detection software running on Seaport Village video feed







Super Bowl XXXVII sign from Seaport Village Command Center



Crane deploys cameras across from QUALCOMM Stadium



UCSD Triton sign on top of crane across from QUALCOMM Stadium

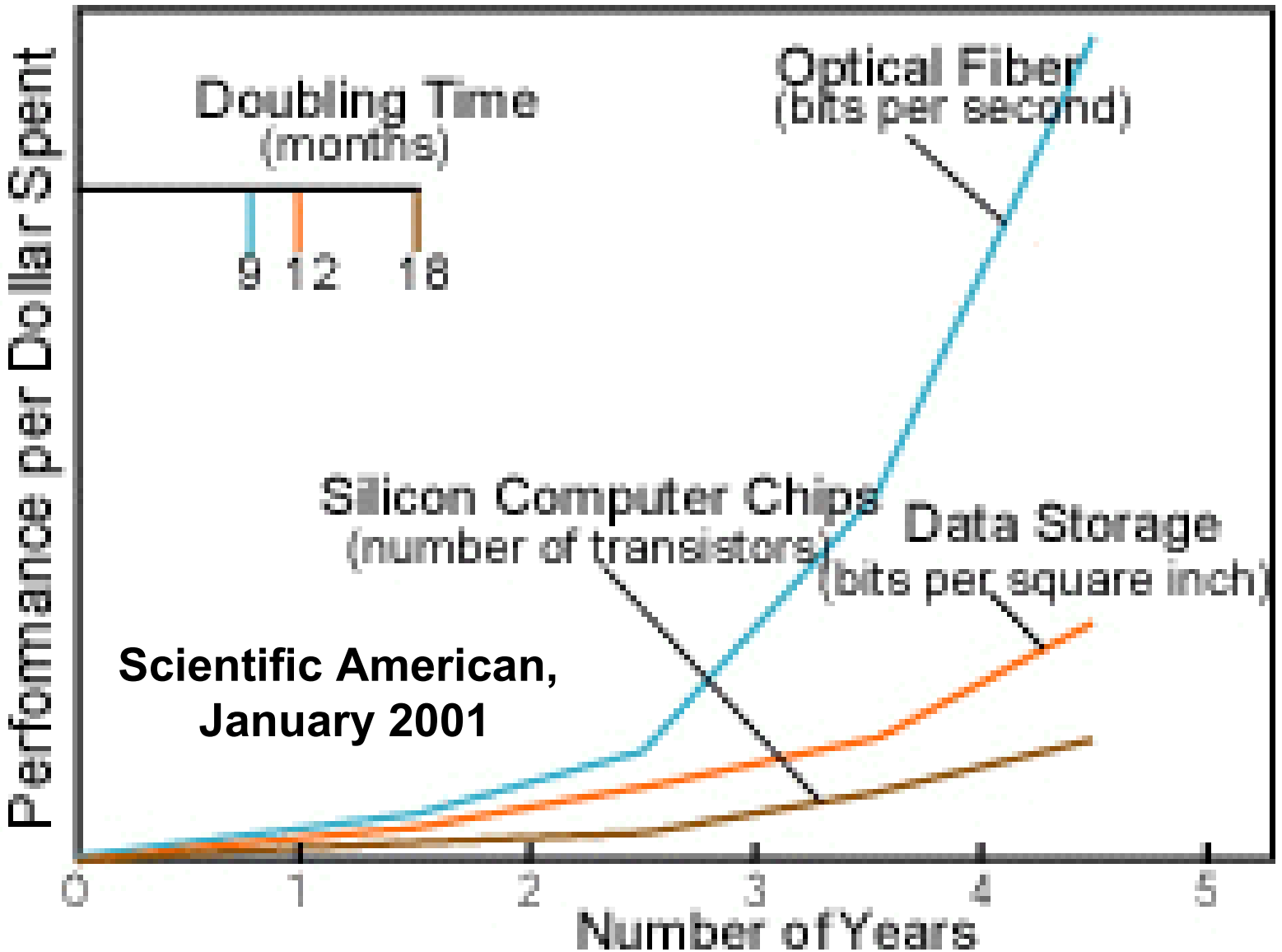
CVRR
Computer Vision and Robotics Research Laboratory

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Led to $12M NSF Award to UC Irvine and UC San Diego Announced This Week—"Responding to the Unexpected"

it²

Why Optical Networks Are Emerging as the 21st Century Driver for the Grid

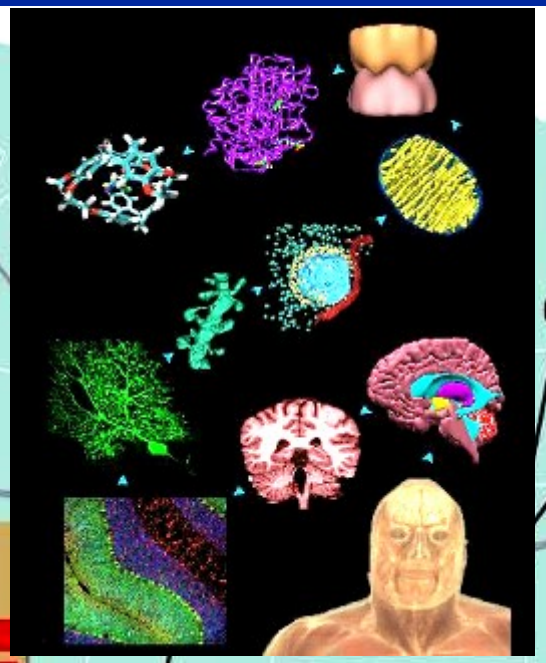


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Parallel Lambdas Will Drive This Decade
The Way Parallel Processors Drove the 1990s

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The Biomedical Informatics Research Network: a Multi-Scale Brain Imaging Federated Repository



Average File Transfer ~10-50 Mbps

Northern Lights Network
University of Minnesota

Abilene
University of Iowa

Nox
Harvard I
Harvard II

Abilene
Stanford

CalREN-2
Caltech
UCLA
Irvine
NCMIR
UCSD II

BIRN Central NOC
SDSC

Abilene
LANL
University of New Mexico

NCNI
Duke I
Duke II
UNC

Mouse
Brain Morphology
Functional Imaging/Human
Abilene Backbone

UCSD is IT and Telecomm Integration Center

National Center For Research Resources

Part of the UCSD CRBS
Center for Research on Biological Structure

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NBCR NPACI

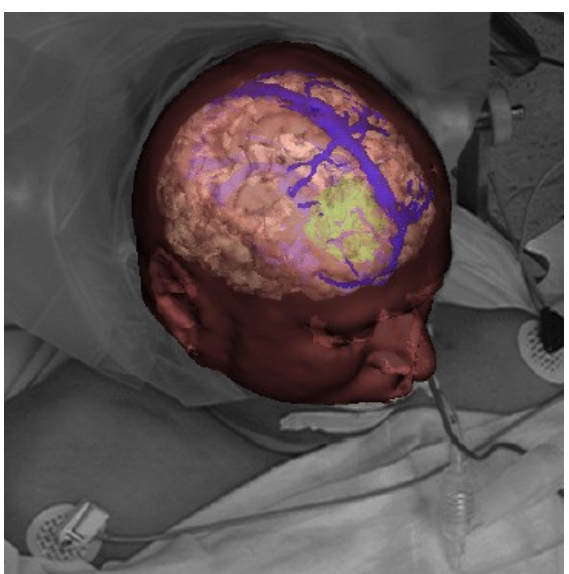
NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

it2

Interventional MRI Requires Tight Coupling of Infrastructure



- **Open MRI and Surgical Theater**
  - **Overlay of Graphics from**
    - **Computed Data & Simulation**
- **Feedback To Surgeon Regarding**
  - **Change in Location of Landmarks**
    - **and Target Tumor**
- **Feedback To MRI Controls**
  - **and Radiologist to Modulate**
    - **Instrument and Improve Image**



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OptIPuter

it²

Why Not Constantly Compute on Federated Repositories?



- **Currently**
  - Transformations to Organ Coordinates
    - Surgical View of Body
    - Define Differences in Organs
    - Eg. UCLA Human Brain Mapping Project—Art Toga
  - Fly Through Organs
    - Virtual Colonoscopy (www.vitalimaging.com)
- **Future**
  - Train AI Software on
    - Millions of Human Image DataSets
    - Define Distribution Functions
    - Thresholds for Medical Attention
  - Life Cycle of Single Individuals
    - Automatic Early Warnings

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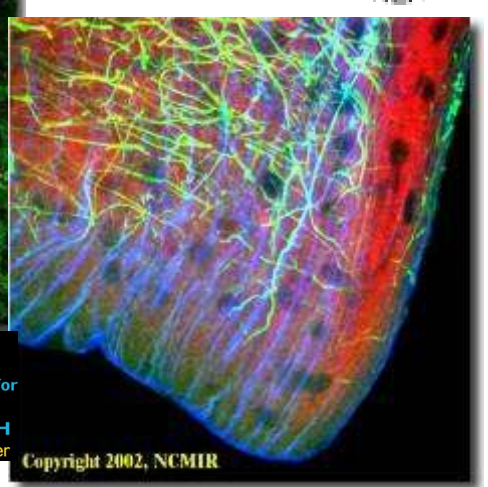
it²

The OptIPuter Project –
Removing Bandwidth as an Obstacle In Data Intensive Sciences

- **NSF Large Information Technology Research Proposal**
  - **UCSD and UIC Lead Campuses—Larry Smarr PI**
  - **USC, UCI, SDSU, NW Partnering Campuses**
- **Industrial Partners: IBM, Telcordia/SAIC, Chiaro, Calient**
- **$13.5 Million Over Five Years**
- **Optical IP Streams From Lab Clusters to Large Data Objects**

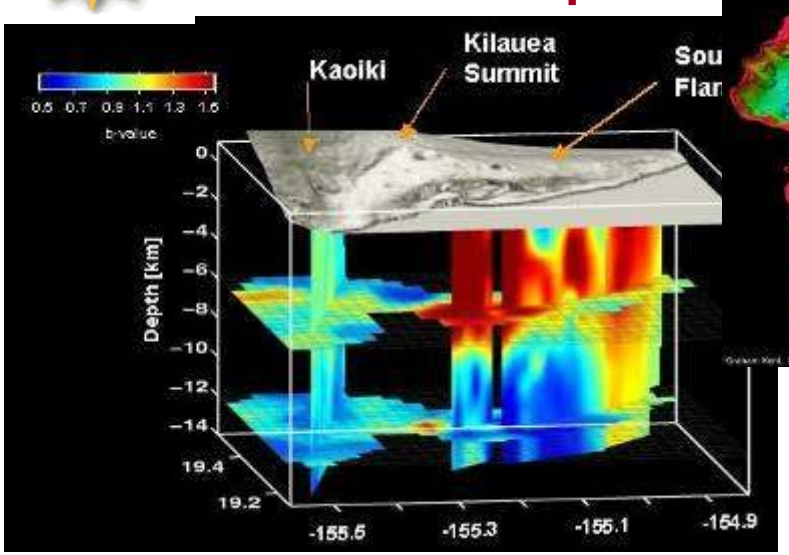
NIH Biomedical Informatics Research Network

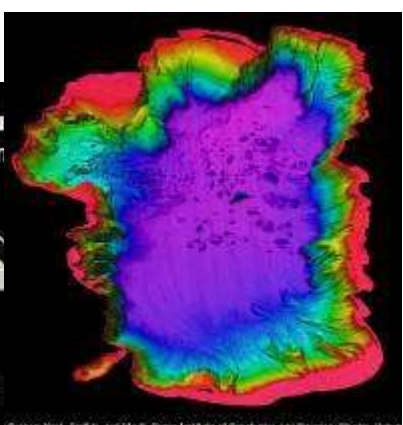




NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

NSF EarthScope





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http://ncmir.ucsd.edu/gallery.html

siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

it²

Prototyping a Campus-Scale OptIPuter



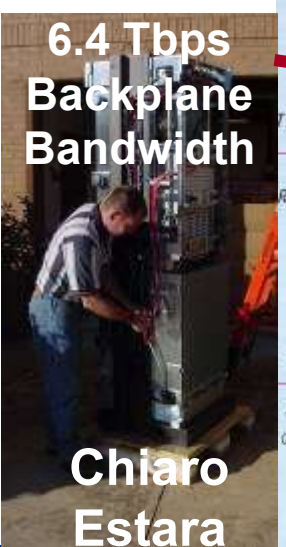
0.320 Tbps Backplane Bandwidth

To CENIC

Juniper T320

20X

6.4 Tbps Backplane Bandwidth



SDSC

SDSC Annex

Engineering

High School

Medicine

Collocation

Earth Sciences

½ Mile

Forged a New Level Of Campus Collaboration In Networking Infrastructure

2 Miles
0.01 ms

Source: Phil Papadopoulos, SDSC; Greg Hidley, Cal-(IT)²

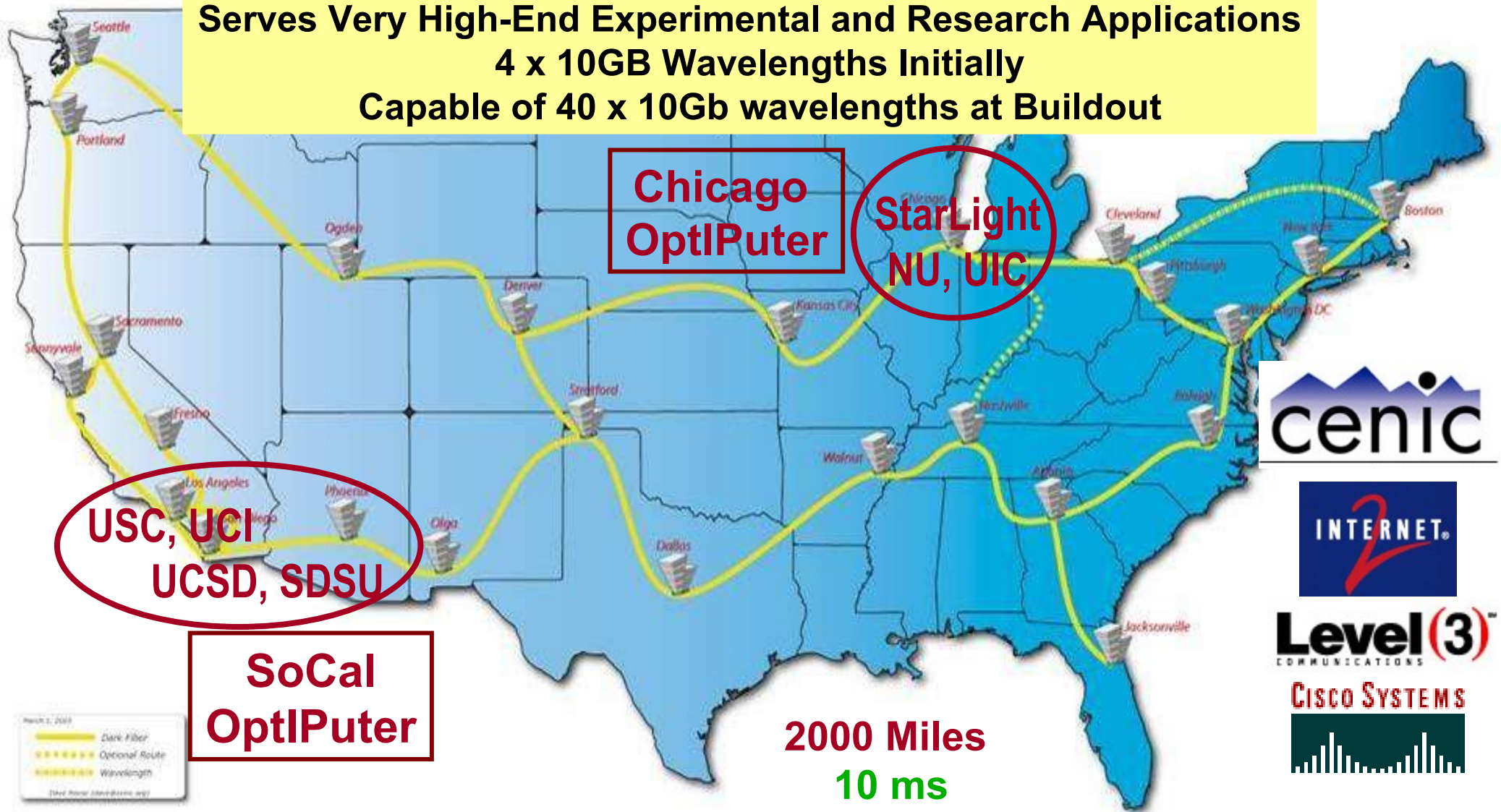
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Multi-Latency OptIPuter Laboratory
National-Scale Experimental Network

"National Lambda Rail" Partnership

Serves Very High-End Experimental and Research Applications
4 x 10GB Wavelengths Initially
Capable of 40 x 10Gb wavelengths at Buildout



cenic

INTERNET 2

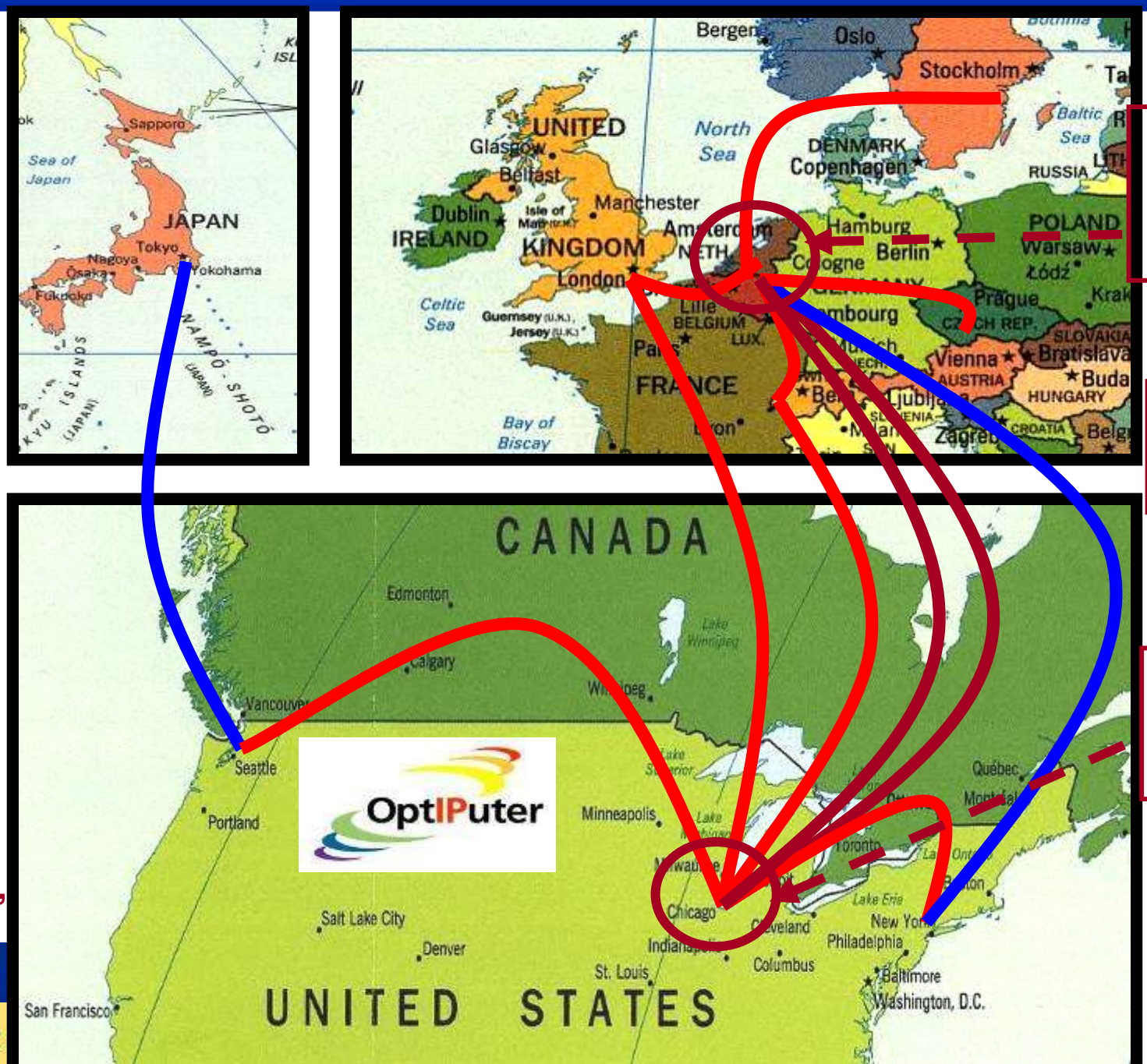
Level (3) COMMUNICATIONS

Cisco Systems

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UCIrvine

Source: John Silvester, Dave Reese, Tom West-CENIC

OptIPuter Uses TransLight Lambdas to Connect Current and Potential International-Scale Partners



The OptIPuter Was Born Global!

Univ. of Amsterdam NetherLight

Current OptIPuter

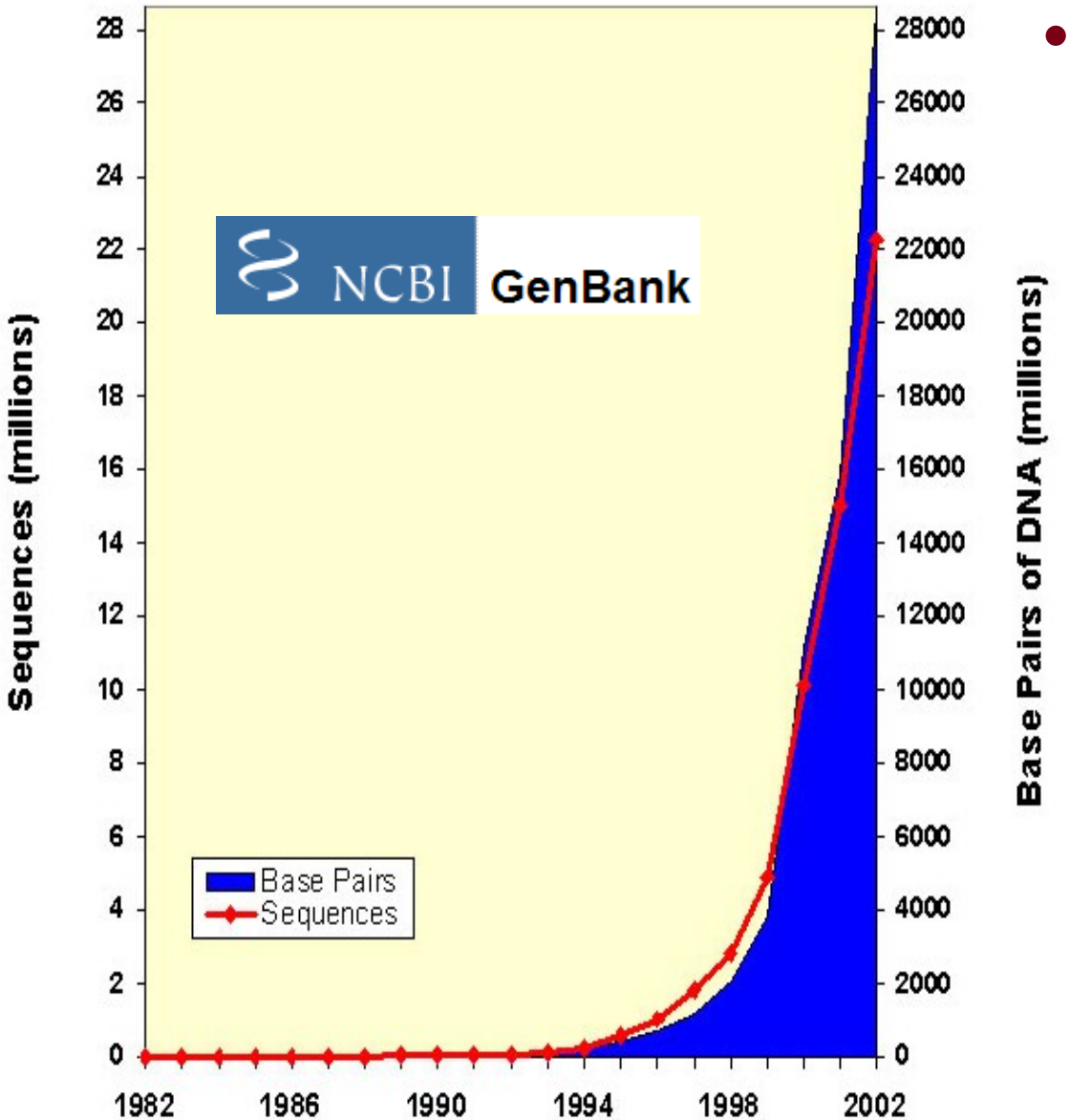
Starlight NU, UIC

Source: Tom DeFanti, UIC

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Exponential Growth in the Number of Genetic Sequences

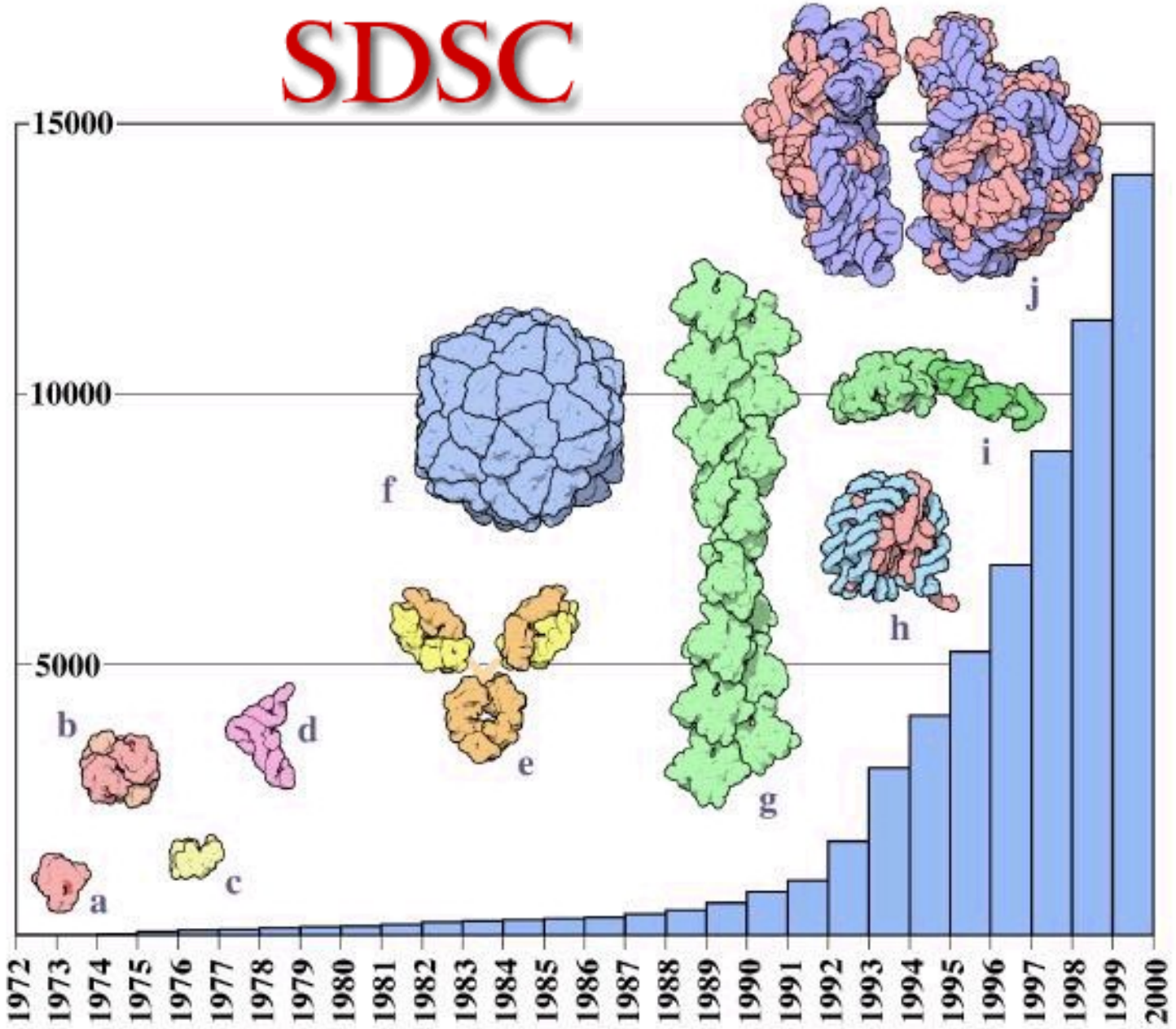


- **Currently (Feb 2003)**
  - **28 Billion Base Pairs**
  - **22 Million Sequences**
  - **50,000 species**

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www.ncbi.nlm.nih.gov/Genbank/GenbankOverview.html

The Protein Data Bank is Growing Rapidly



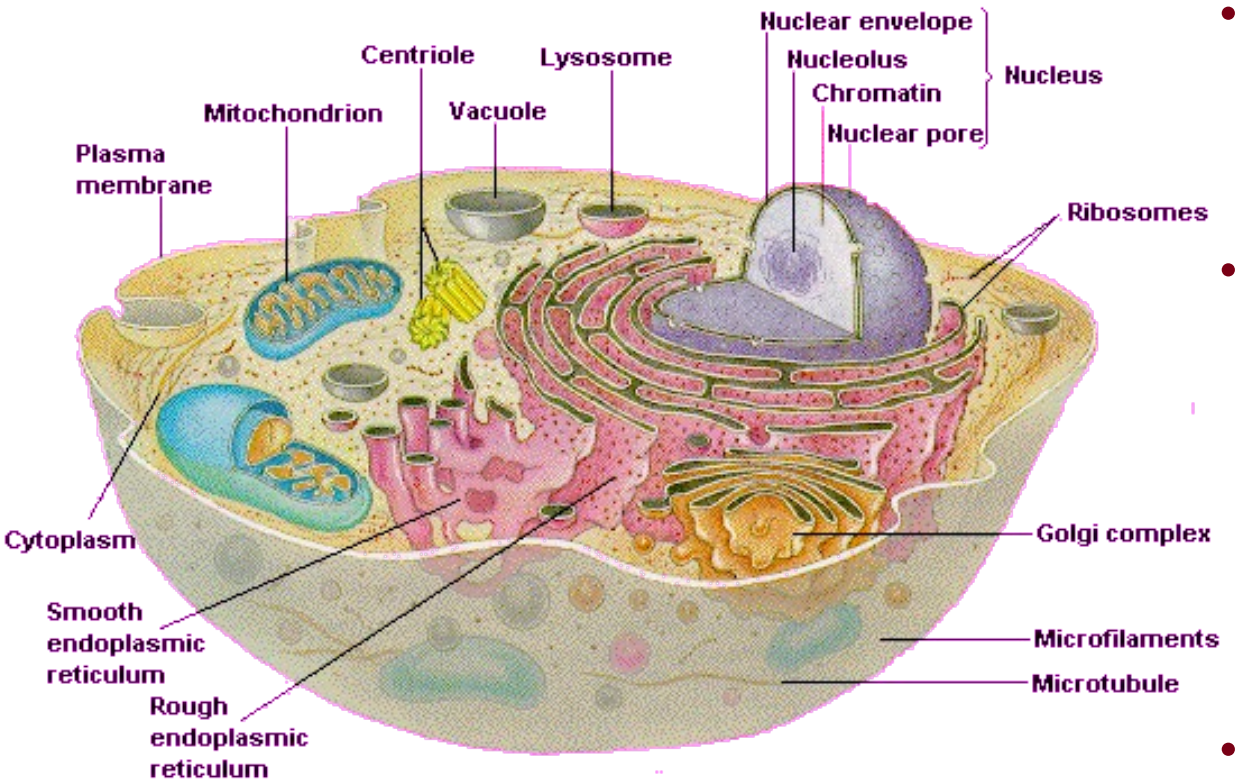
- The Single International Repository for 3-D Structure Data of Biological Macro-molecules
- More Than 150,000 Web Hits Per Day,
- > 1 Hit Per Second, 24/7

UCIrvine

Source: Phil Bourne, SDSC. UCSD

it²

Hard Far Can We Go in the Re-Integration of a Single Eukaryotic Cell?



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

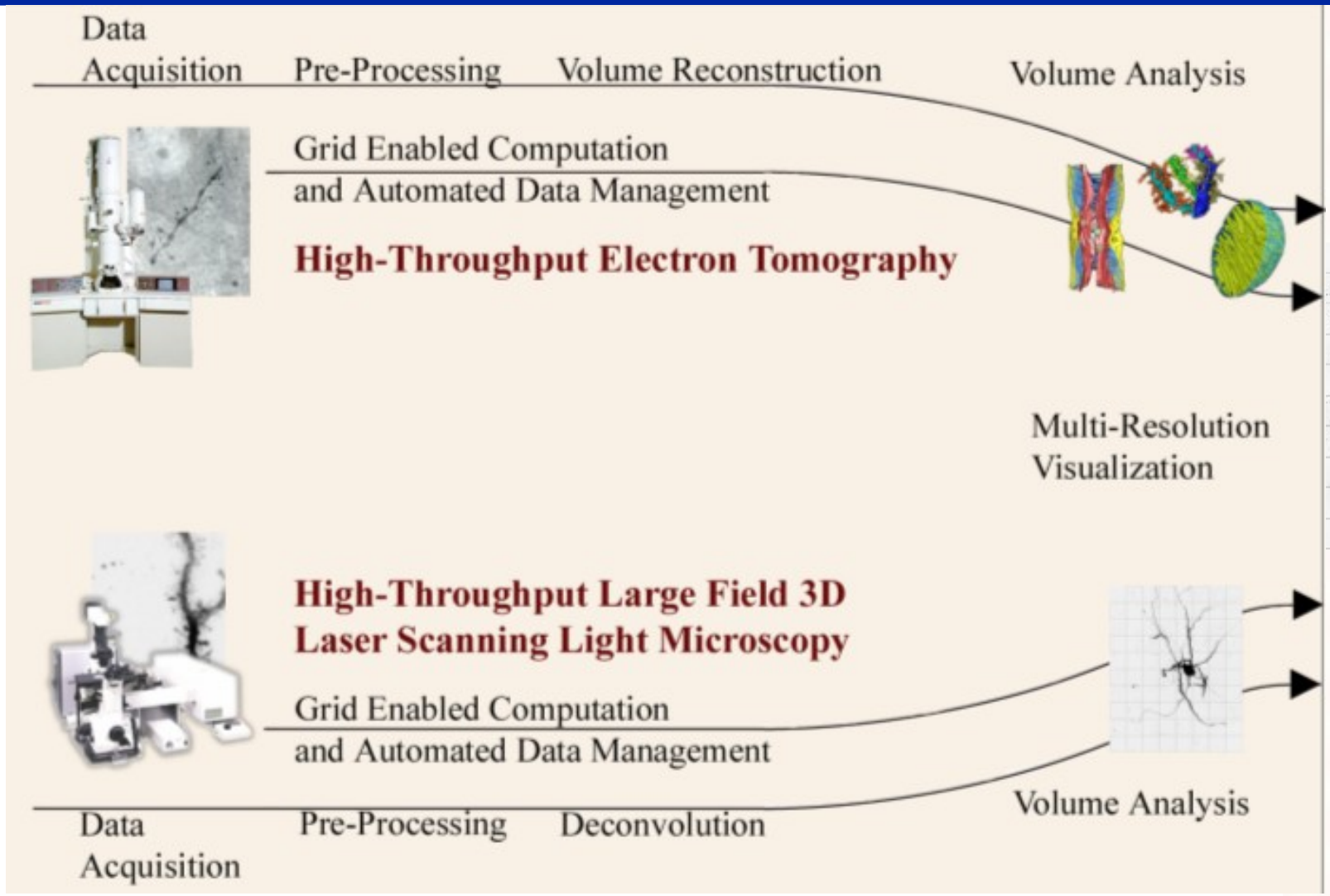
Source: Bernhard Palsson, UCSD

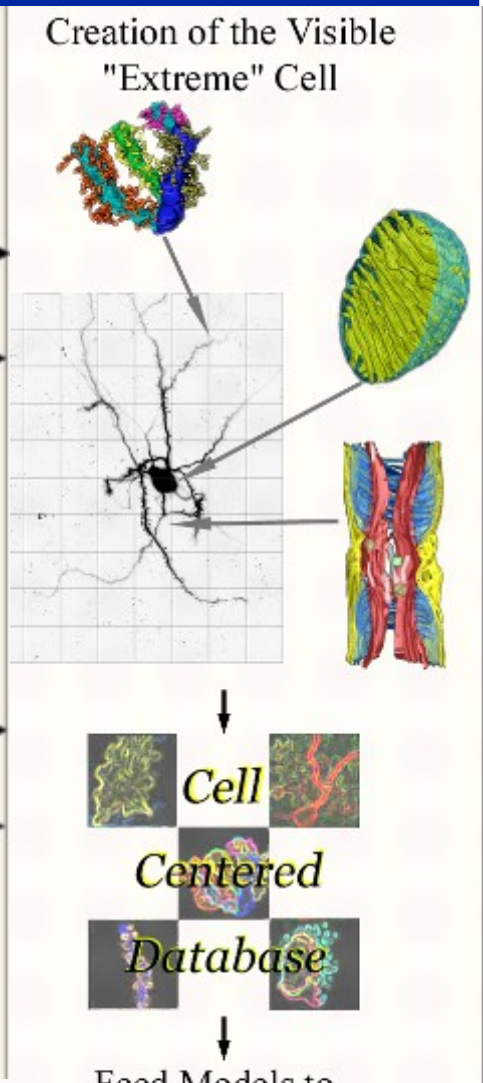
- **Organelles**
  - 4 Million Ribosomes
  - 30,000 Proteasomes
  - Dozens of Mitochondria
- **Macromolecules**
  - 5 Billion Proteins
    - 5,000 to 10,000 different species
  - 1 meter of DNA with Several Billion bases
  - 60 Million tRNAs
  - 700,000 mRNAs
- **Chemical Pathways**
  - Vast numbers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

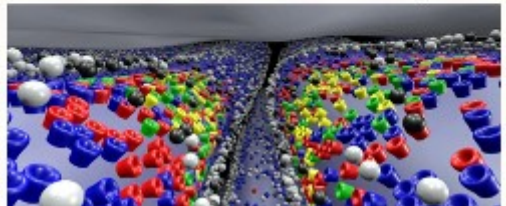
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Toward a Model of the Neuron
An "Extreme" Cell





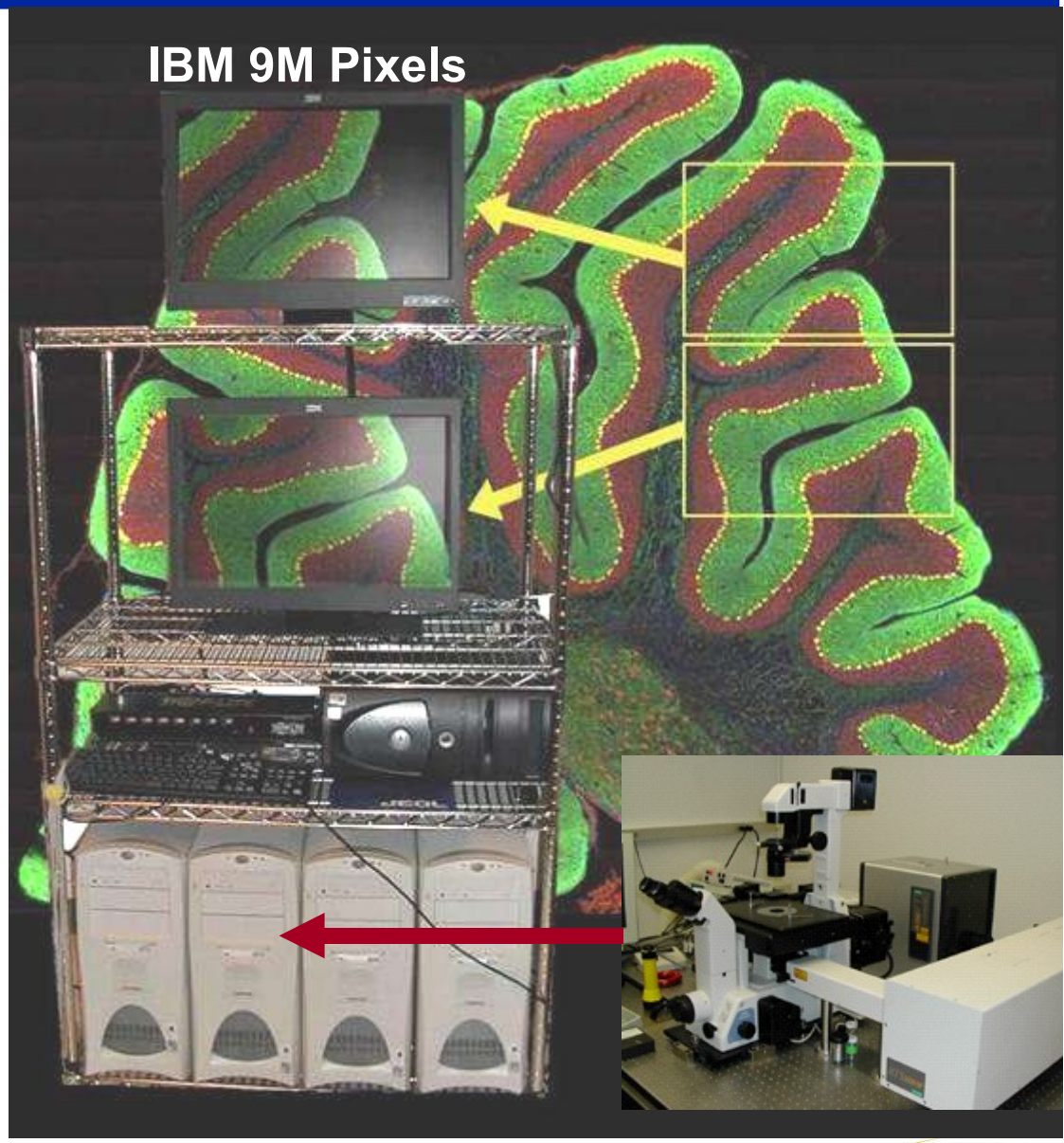


UCSD UCIrvine it²

Source: Mark Ellisman, NCMIR, UCSD SOM

OptIPuter Includes On-Line Microscopes Creating Very Large Biological Montage Images

- 2-Photon Laser Confocal Microscope
  - High Speed On-line Capability
- Montage Image Sizes Exceed 16x Highest Resolution Monitors
  - ~150 Million Pixels!
- Use Graphics Cluster with Multiple GigEs to Drive Tiled Displays



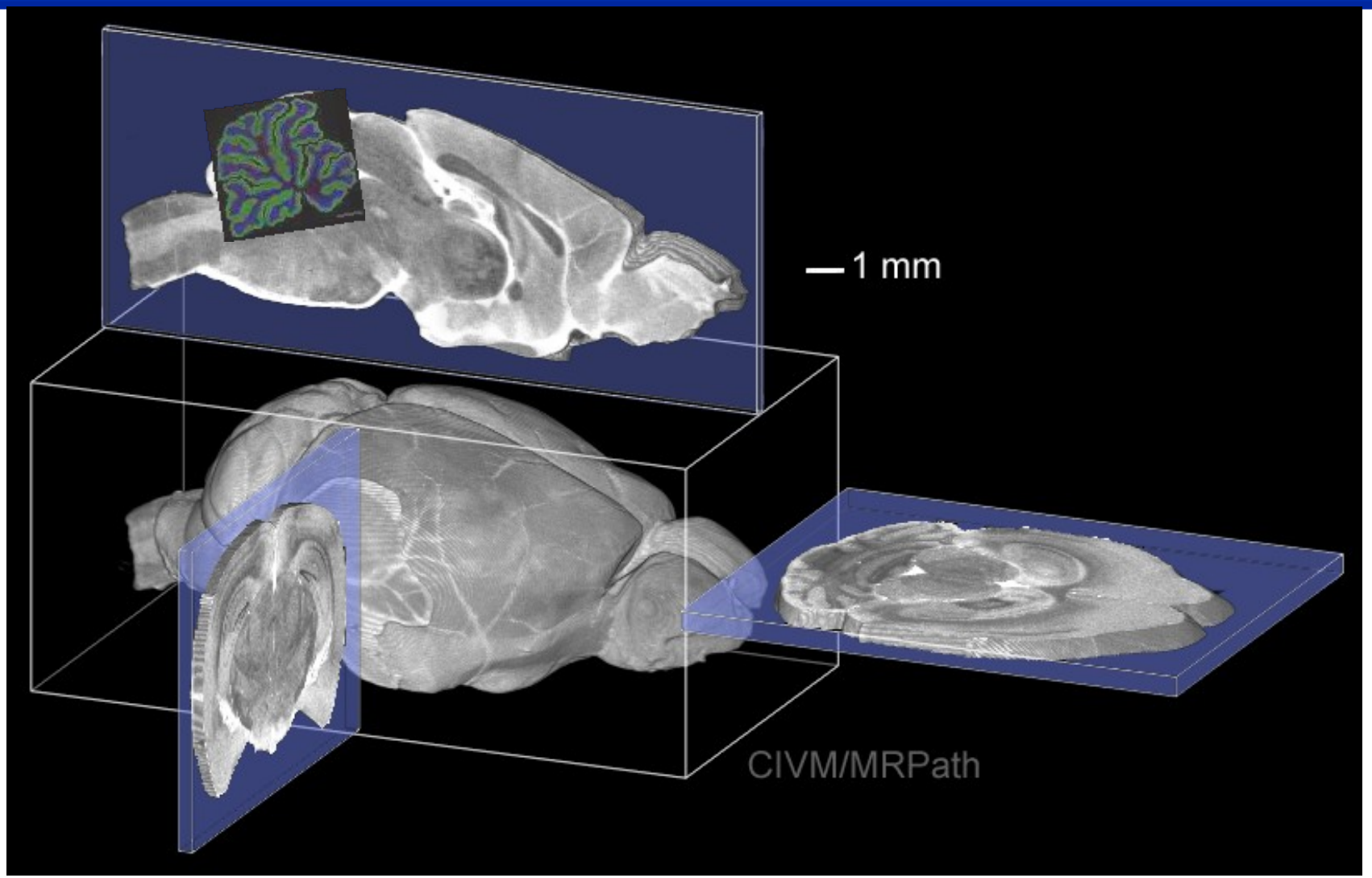
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NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH at San Diego, an NIH supported resource center

Source: David Lee, NCMIR, UCSD

it2

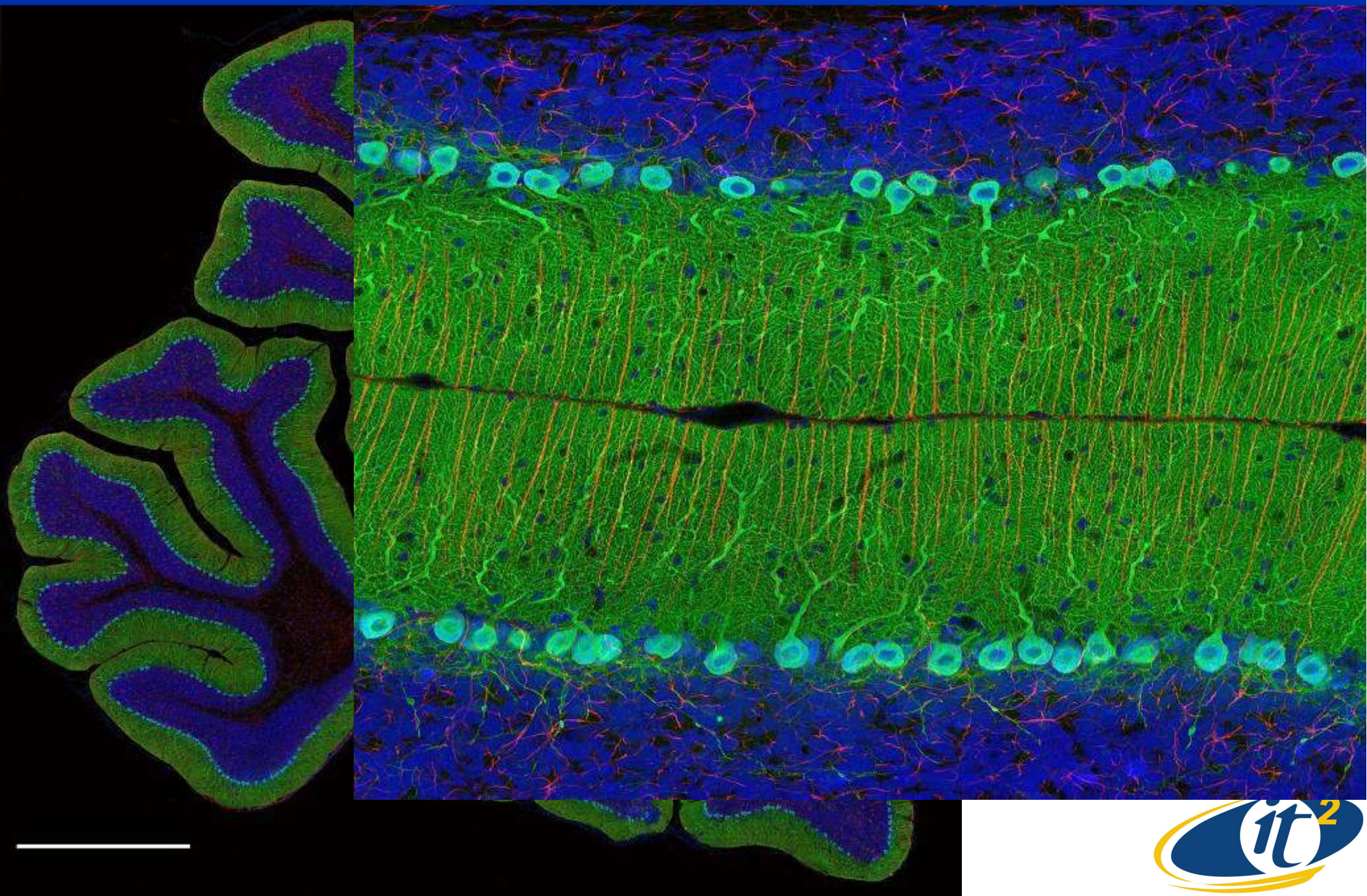
Mouse BIRN--Integration of Multi-Resolution Data

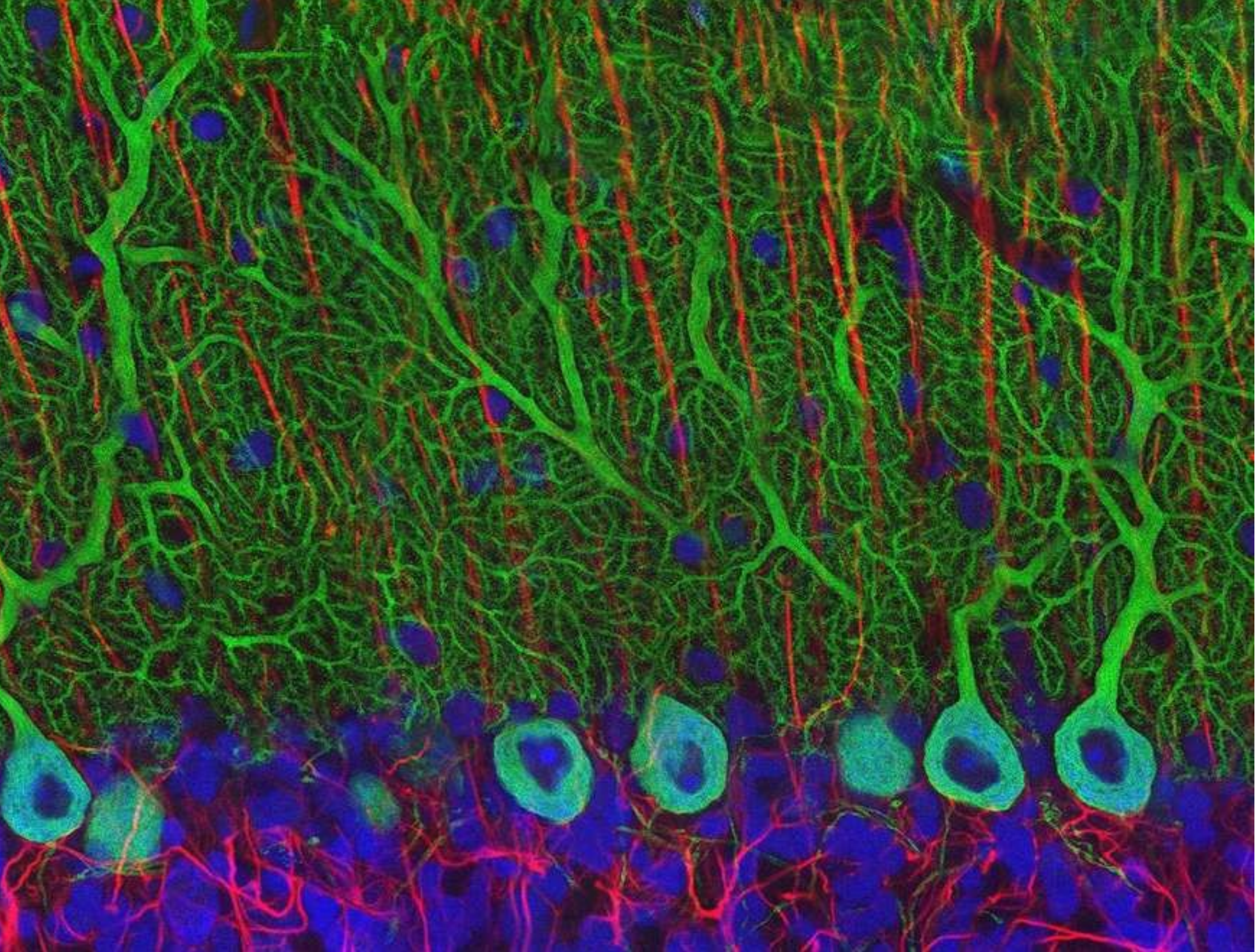


Microscopic MRI of Rodent Brain - Duke Univ and Caltech
Linked with High Resolution Laser-Microscopy Data-UCSD NCMIR

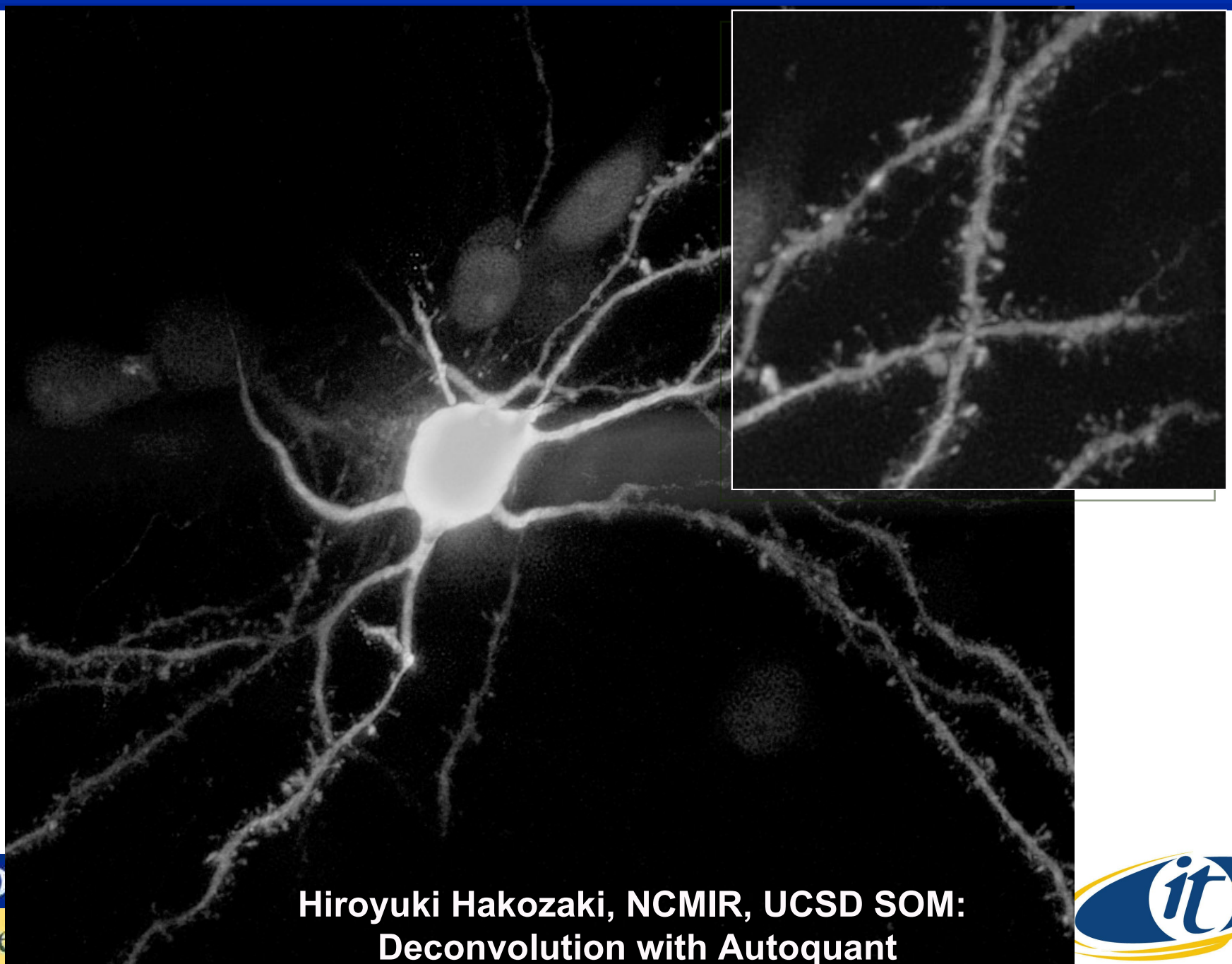
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Large Microscope Images Allow Both Fine Detail and Global Context





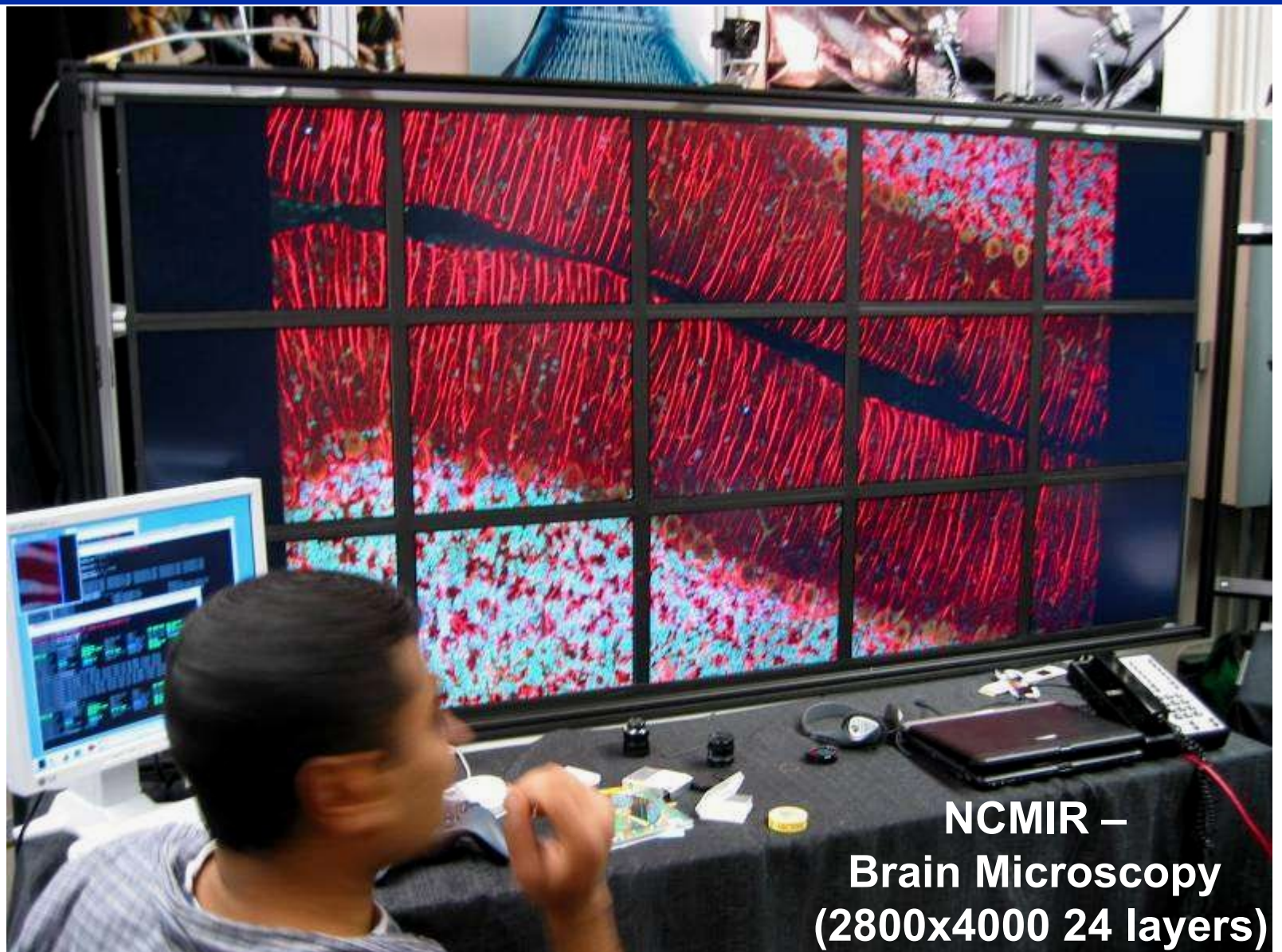
Single Neuron Cell Reconstructions



Hiroyuki Hakozaki, NCMIR, UCSD SOM:
Deconvolution with Autoquant

UCSD
UCIrvine

Toward a Hundred Million Pixel Flat Display



UCSD
UCIrvine

it²