Service Leadership for Science Technology and Society

Sung-mo Kang

KAIST President

July 15, 2014

KAIST

An Early Korean Church in Reedley, CA

Paying Tribute to Early Koreans in Reedley, CA

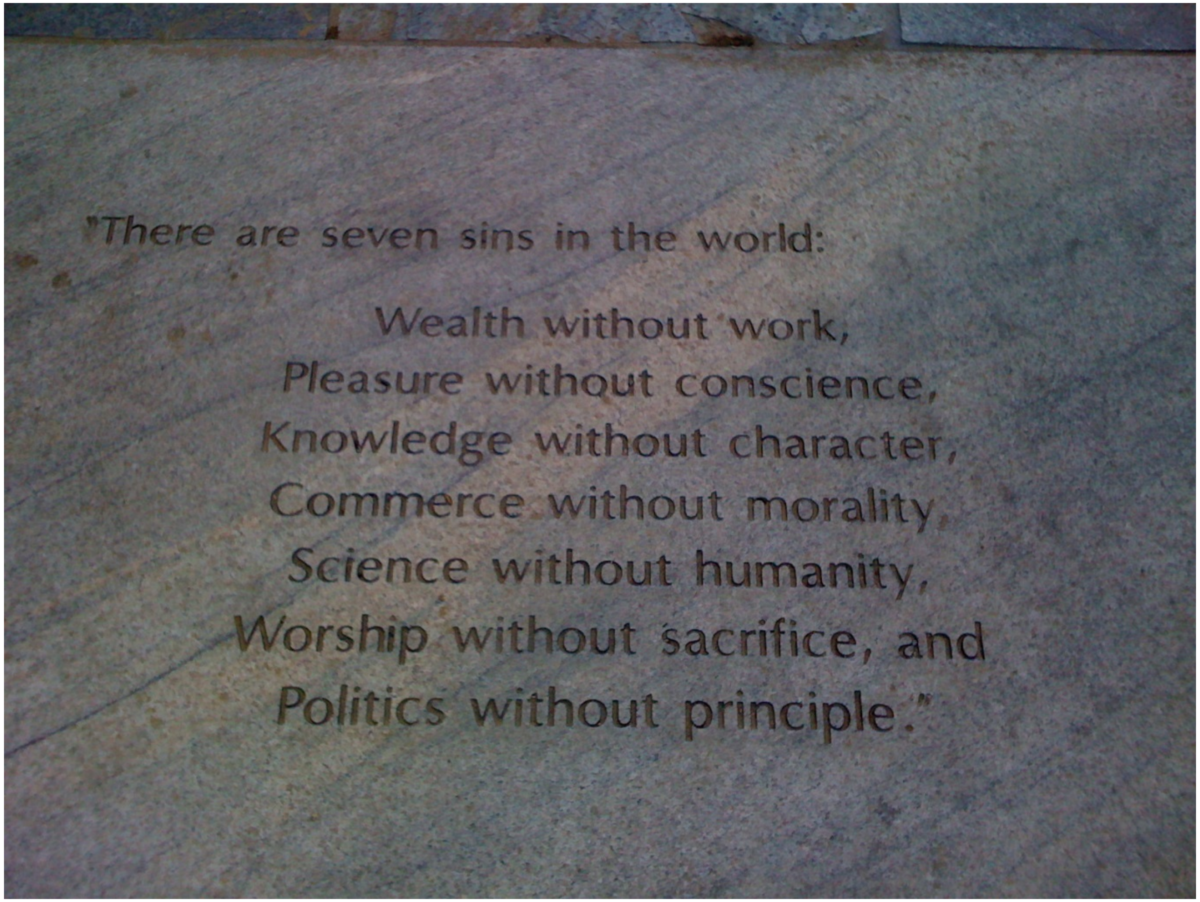
Kim Brothers became first Korean-American Millionaires Through Farming

President Syngman Rhee and Ahn Chang-Ho in Reedley, CA

Three Statues in Riverside, California

M. L. King, Jr.; Dosan Ahn Chang-Ho; Mahatma Gandhi

Gandhi's 7 Deadly Sins



Outline of the Talk

I Globalization as Social Interaction

II Global Economy: Now and New Future

III 21st Century Grand Challenges

Globalization in the 21st Century

- Globalization denotes the impact of transcontinental flows and patterns of social interaction that impacts
  - Culture
  - Education, Science and Technology
  - Policy and Economy
  - Increased Licensing, Joint Ventures, Co-Production, Corporate Alliances

- With Internet, work flow is revolutionized.
- Population increases from 6.67B in 2007 to 9.2B in 2050.
  - The number of megacities with > 10M people : 5 in 1975 to 26 in 2015.
  - Champagne glass inequality- Richest 20% own 82.8% world income while poorest 20% own 1.4% (Source Wade 2001)

"The convergence of global warming, global flattening, and global crowding is the most important dynamic shaping of the world."

21st Century's Grand Challenges

Sustainability
- Energy- solar, wind, biofuel, etc.
- Clean water, air
- Carbon sequestration
- Nature conservancy

Quality of Life
- Personalize learning
- Improve urban infrastructure
- Tools for scientific discovery
- Enhance virtual presence

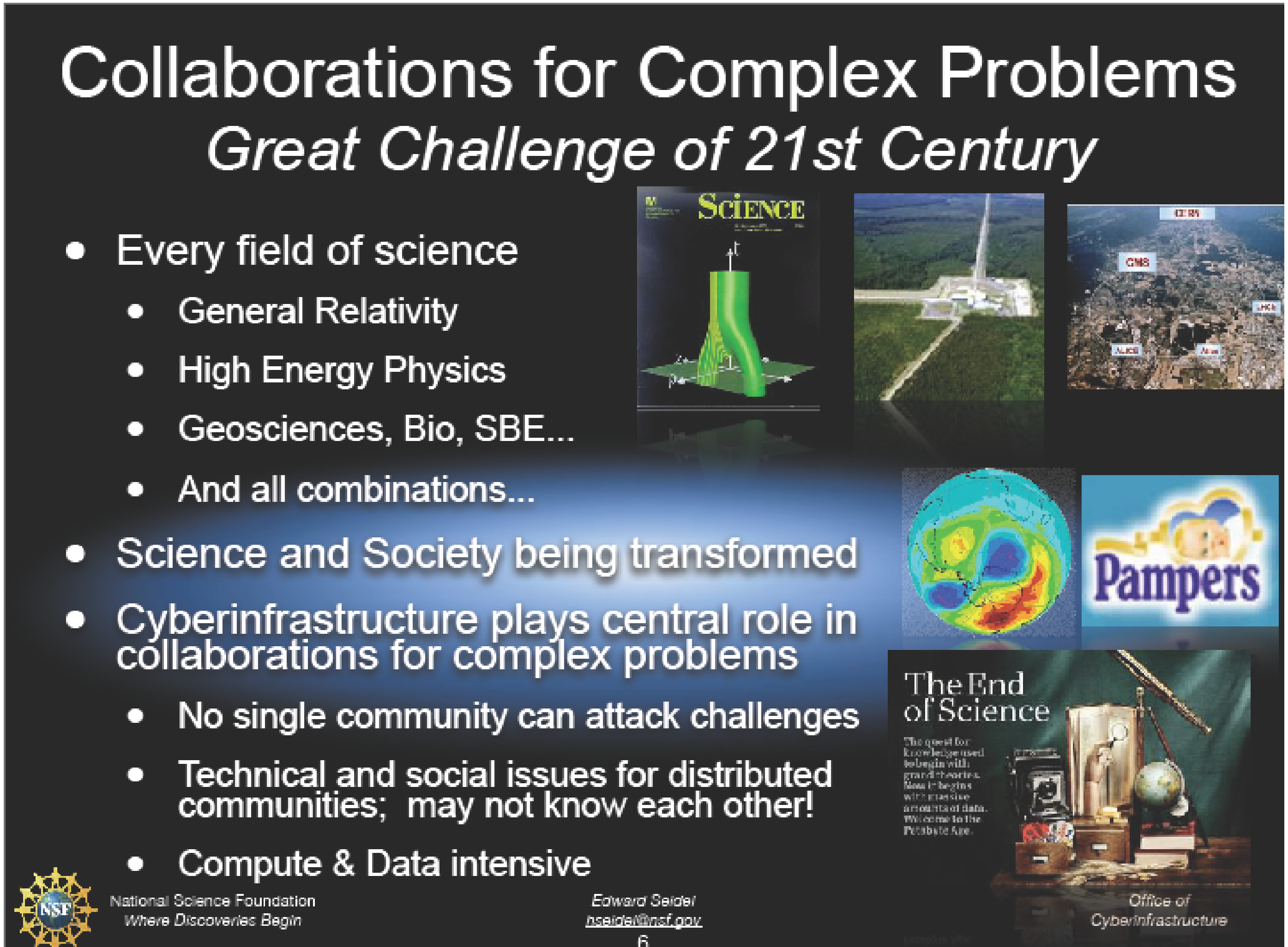
Health
- Advance health informatics
- Customize medicine
- Telemedicine
- Affordable health care

Vulnerability
- Prevent nuclear terror
- Prepare for disasters (earthquake, tsunami, fire)
- Secure cyberspace

Grand Challenges of the 21st Century (NAE)

1. Make Solar Energy Economical
2. Manage the Nitrogen Cycle
3. Advance Health Informatics
4. Prevent Nuclear Terror
5. Advance Personal Learning
6. Provide Energy from Fusion
7. Provide Access to Clean Water
8. Engineer Better Medicine
9. Secure Cyberspace
10. Engineer the Tools of Scientific Discovery
11. Develop Carbon Sequestration Methods
12. Restore and Improve Urban Infrastructure
13. Reverse-engineer the Brain
14. Enhance Virtual Reality

Global S&T Collaborations



© MAPQUEST.
Asia
0 1,000 Miles
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60° N
40° N
Bering Sea
Tropic of Cancer
180°
20° N
EUROPE
Russia
Ural
Georgia
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Turkey
Azerbaijan
Cyprus
Kazakhstan
North Korea
Japan
Lebanon
Mongolia
Israel
Syria
Uzbek.
Jordan
Turkmen.
Iraq
Kyrgyzstan
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Iran
Tajikistan
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Bahrain
Afghan.
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Qatar
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Saudi Arabia
Himalayas
U.A.E.
Nepal
AFRICA
Hong Kong (China)
Yemen
Oman
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India
Laos
Macao (China)
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Bangladesh
Thai.
Myanmar
Vietnam
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AUSTRALIA


North America
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Greenland (Denmark)
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Beaufort Sea
Baffin Bay
Alaska (U.S.)
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0 1,000 Kilometers
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Canadian Shield
Great Plains
Rocky Mts.
Coast Ranges
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Tropic of Cancer
20° N
United States
Appalachian Mts.
Hawaii (U.S.)
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40° W
PACIFIC OCEAN
Gulf of Mexico
CARIBBEAN
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Haiti
Puerto Rico (U.S.)
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Dominican Republic
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160° W
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Nicaragua
SOUTH AMERICA
Costa Rica
Panama
© MAPQUEST
140° W
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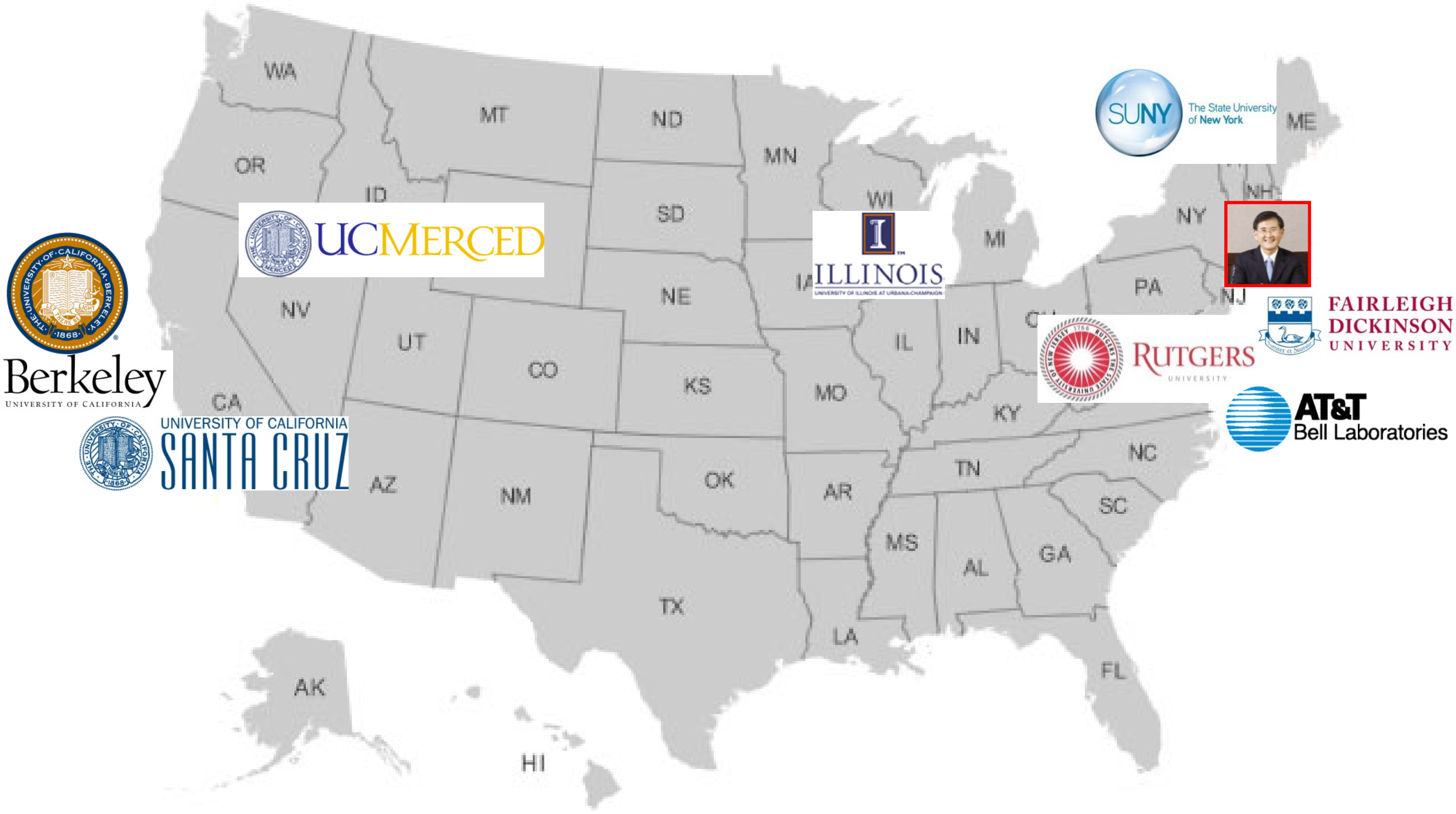
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SUNY The State University of New York
UC MERCED
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Berkeley
UNIVERSITY OF CALIFORNIA
UNIVERSITY OF CALIFORNIA
SANTA CRUZ
RUTGERS
UNIVERSITY
FAIRLEIGH DICKINSON UNIVERSITY
AT&T
Bell Laboratories

VIP Leadership

Vision

- Global Vision
- Leadership as Integrator, Diplomat, Cross-Fertilizer, Deep Thinker [source: The Leader of the Future, The Drucker Foundation]
- Great Cause - Eric Liddell ran for glory of God in “Chariots of Fire”

Innovation

- Lifelong Learning – No Learning, No Job
- Moore’s Law, a driving force for microelectronics world for decades

Perseverance

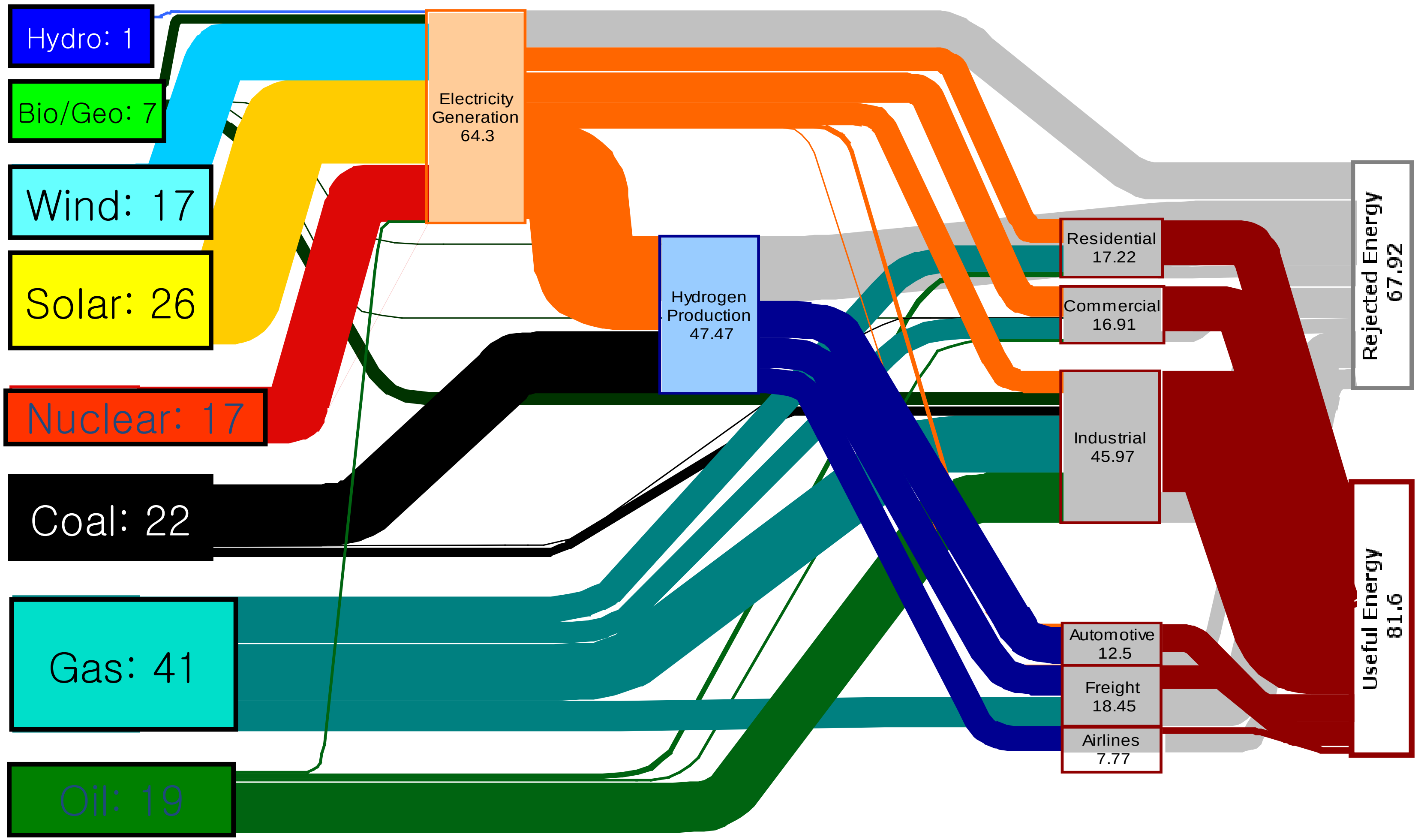
- Edison’s 1% Inspiration, 99% Perspiration
- Resilience

Passion for Lifelong Learning
Art in Hess Select Museum, Napa Valley, CA

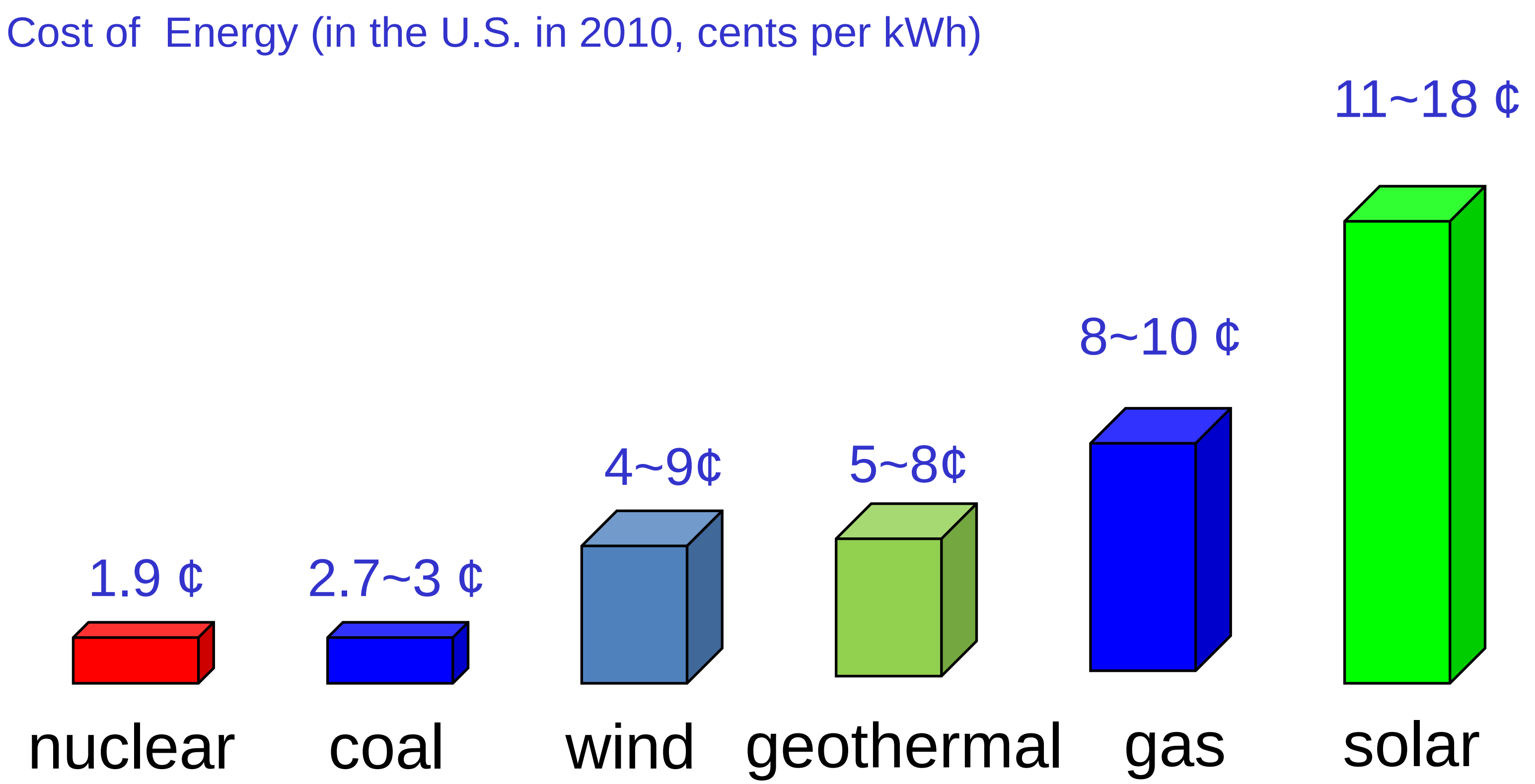
Working Hard Persistently – 99% Perspiration

U.S. 2050 Energy Scenario (Ref. Berry & Lamont)

(~150 EJ/yr ~ 4.8 TW) reduces carbon emissions to 1995 Levels (~1.4 GtC/yr)

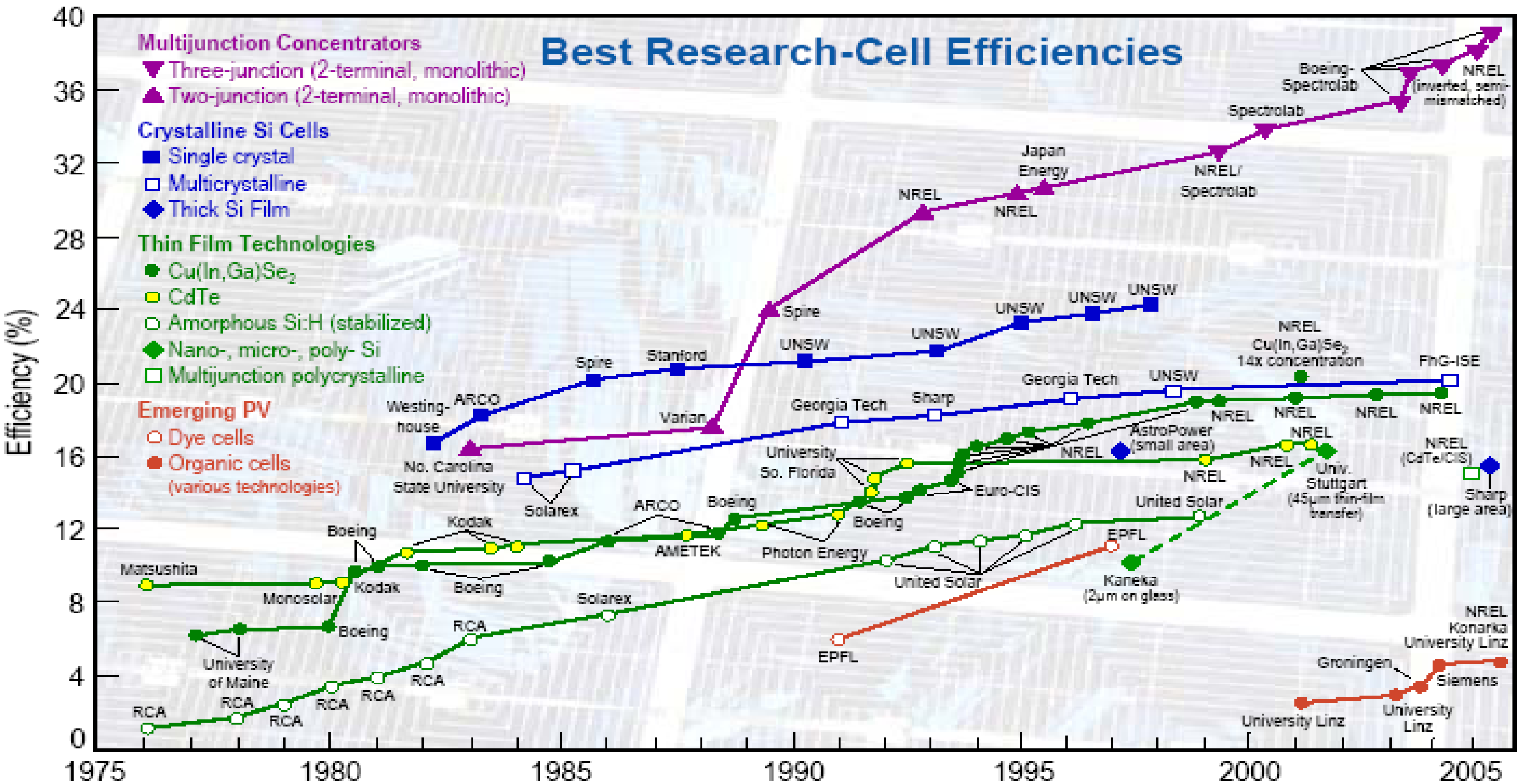


Electric Energy Cost



[Source] Nuclear Energy Institute, American Wind Energy Association, American Solar Energy Society, NREL, DOE

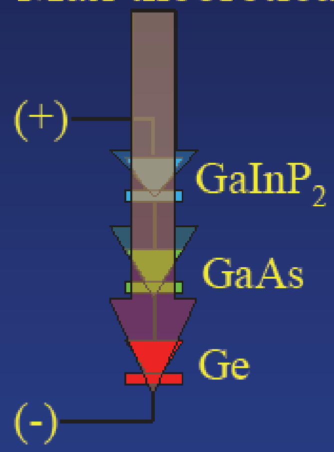
Photovoltaic Cell Efficiency

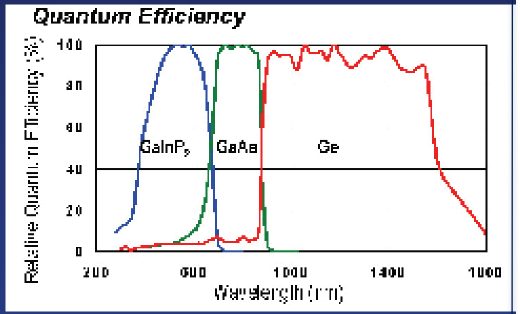


Research on Triple Junction Cell

The triple junction cell

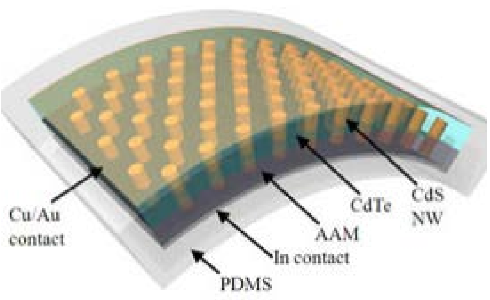
- Efficiency:
  - Currently 35% - 40%
  - Max theoretical 86%, multi-junction





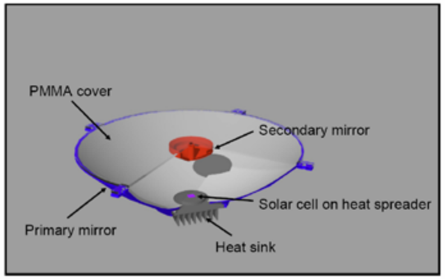
UC Solar- Calif. Advanced Solar Technology (CAST)



Concentrating Photovoltaics

- Concentrating ratio : 500~1000
- Dual-axis tracking
- SolFocus



Solar Thermal

- Oil-based media
- Up to 400º F without tracking
- Solar cooling

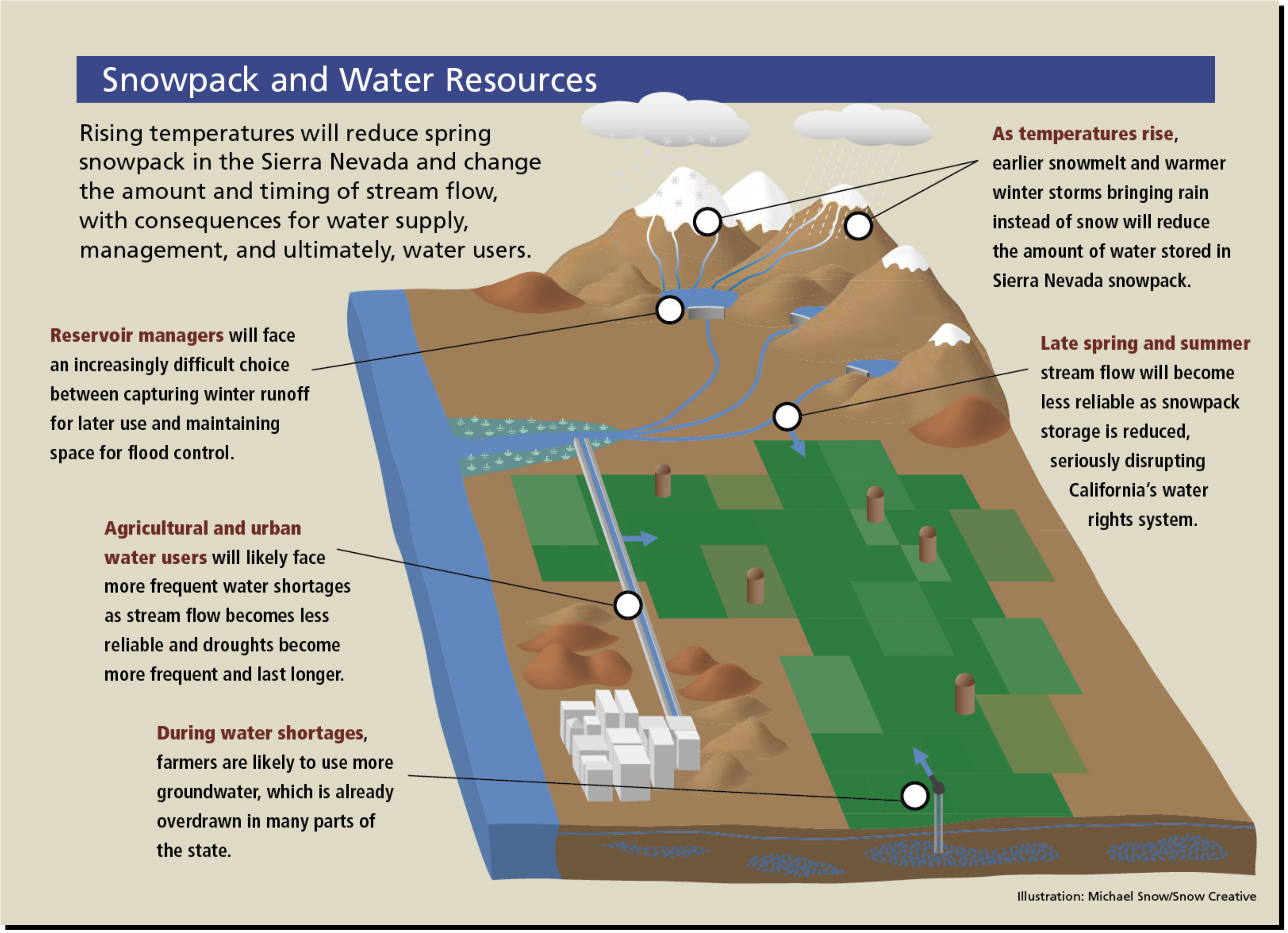
Daylighting

- 1" diameter light pipe =100 watt light bulb
- 100 of these light pipes on a single tracker

Nanopillar Photovoltaics

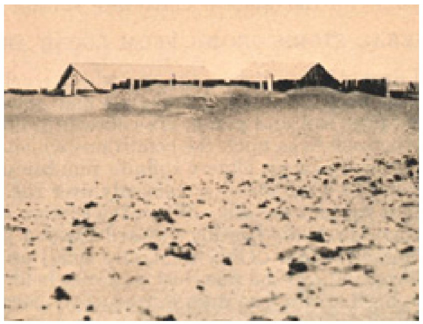
- Highly regular, single crystalline nanopillar (NPL) arrays
- Wide range of semiconductor materials

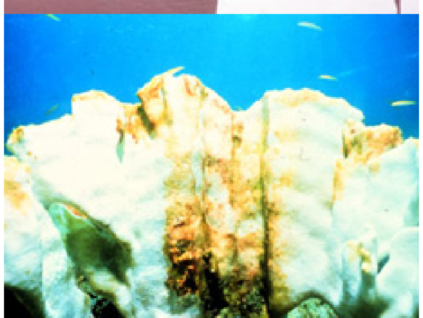
Impacts of Climate Change

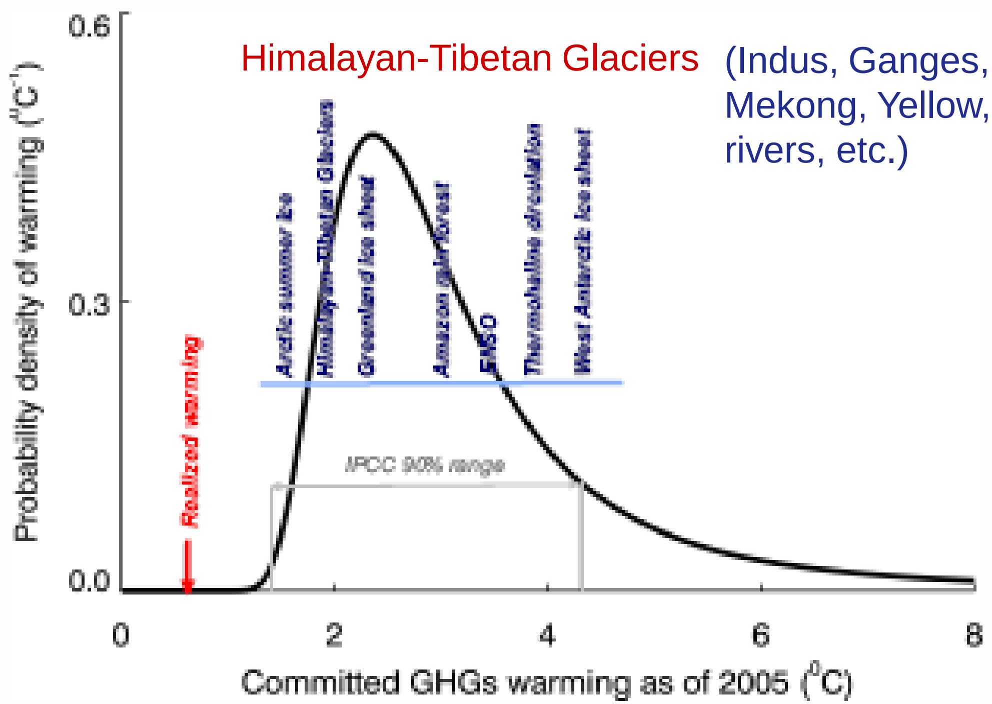


Water Towers of Asia Are Melting

Additional Warming over the Year 1750 Level







(Indus, Ganges, Brahmaputra, Mekong, Yellow, Yangtze rivers, etc.)

Source: V. Ramanathan & Y. Feng, PNAS, vol.105, pp. 14245-14250, 2008

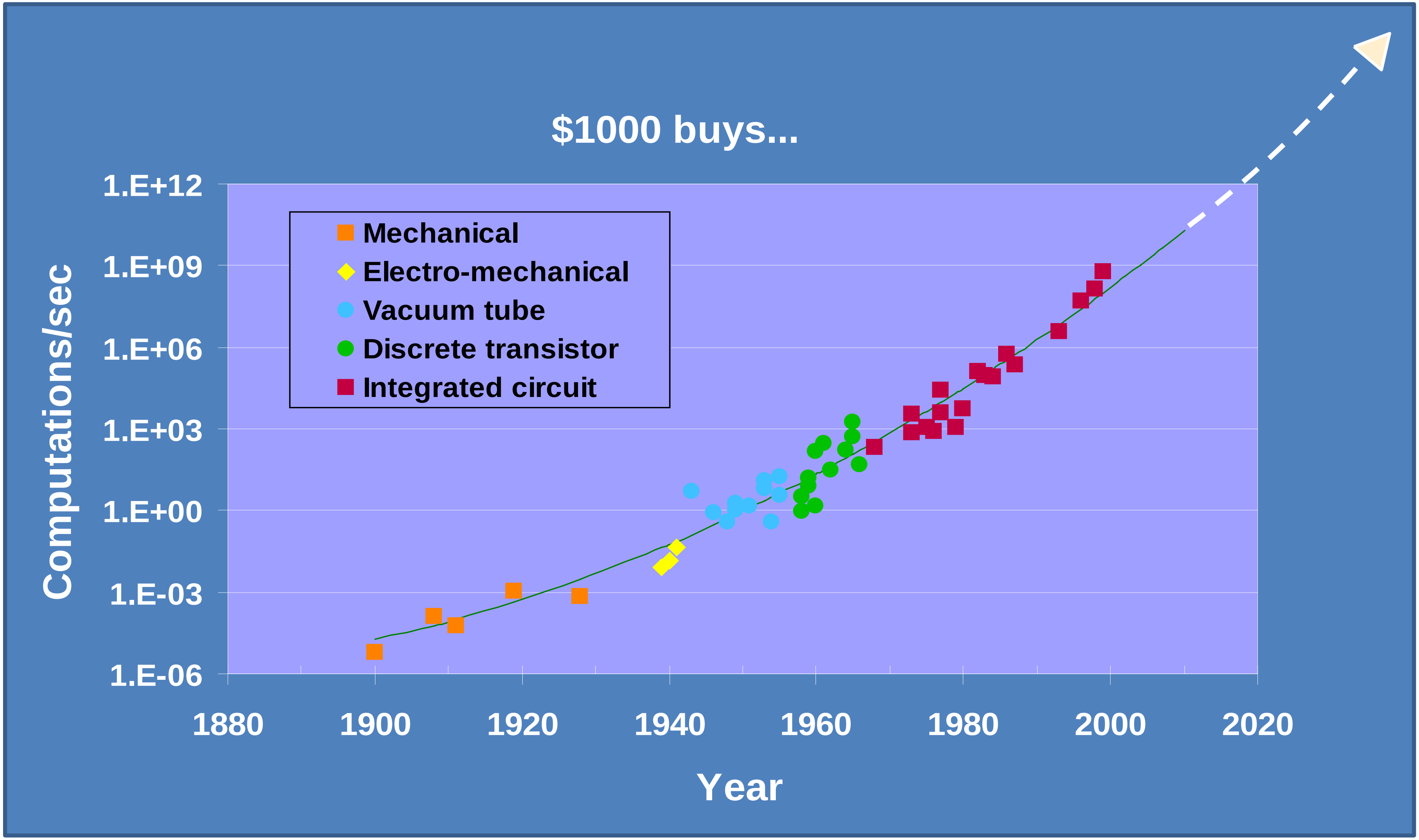
NASA's Aqua Satellite's MODIS Instrument Provided "Situational Awareness" of the 14 SoCal Fires

Calit2, SDSU, and NASA Goddard Used NASA Prioritization and OptIPuter Links
to Reduce Time to Receive Images from 24 to 3 Hours

Moderate Resolution Imaging Spectroradiometer (MODIS)

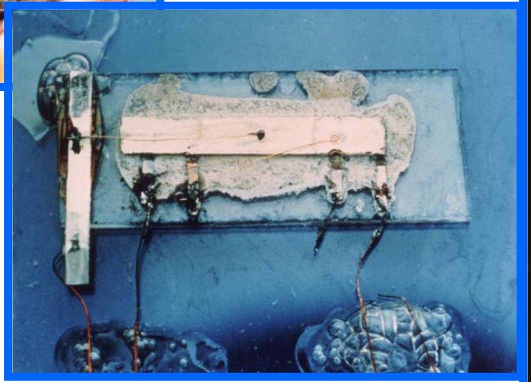
www.nasa.gov/vision/earth/lookingatearth/socal_wildfires_oct07.html

Computing History- From Mechanical to Nano (T. Theis, IBM)



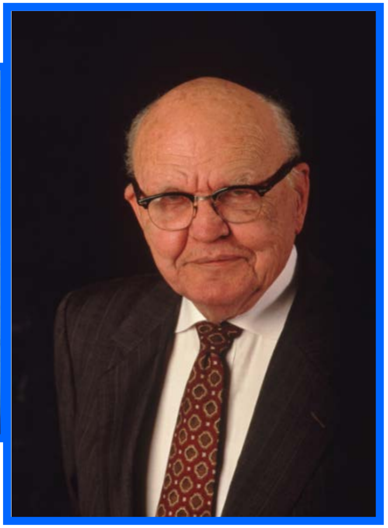
Transistor Invention (1956) to Integrated Circuit (1958)

1956 Nobel Prize, Physics
(J. Bardeen, W. Shockley,
W. Brattain)



Germanium,1T, 1C, 3R, Oscillator,
0.04 inch X 0.06 inch

2000 Nobel Prize, Physics
(Jack Kilby)



Jack Kilby's Nobel Lecture (Dec. 8, 2000)

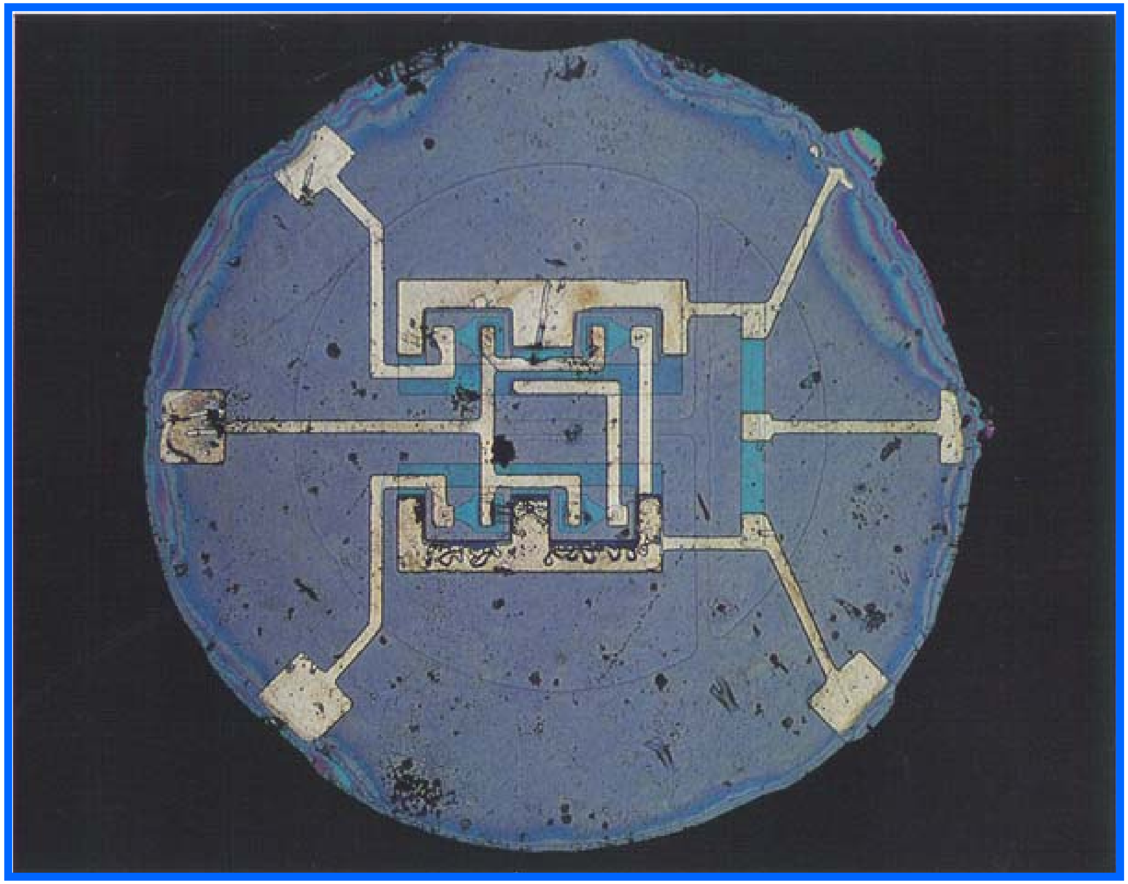
"In 1958, my goals were simple: to lower the cost, simplify the assembly, and make things smaller and more reliable. And although I do not consider myself responsible for all the activity that has followed, it has been very satisfying to watch the IC's evolution. I'm pleased to have had even a small part in helping turn the potential of human creativity into practical reality."

First Successful Operation of MOS Transistor

by Dr. Dawon Kahng (May 4, 1931- May 13, 1992)

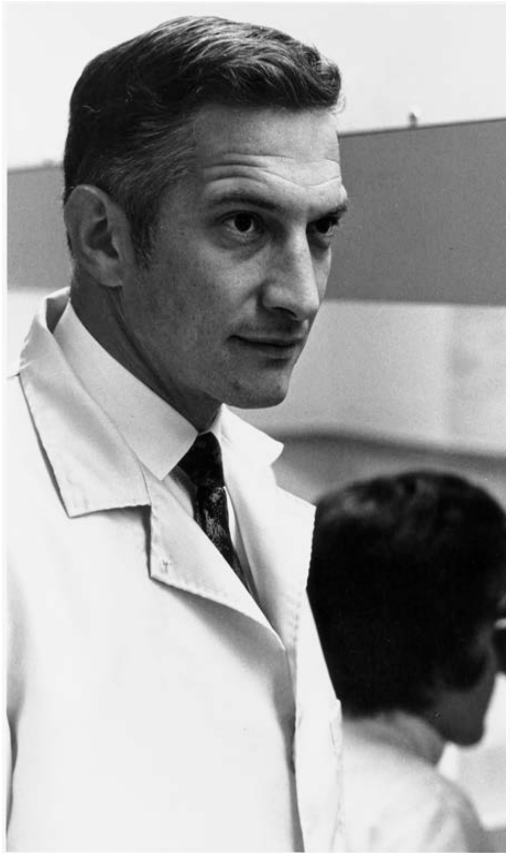
- **SNU (BS), Ohio State Univ. (Ph.D. 1959)**
- **Dr. Kahng, with M. Atalla, fabricated a MOSFET using a gate insulator formed from high quality SiO_2 grown by a new high-pressure steam oxidation process at Bell Labs (1960)**
- **First successful demonstration of MOSFET was a major milestone in semiconductor technology**
- **Invented in 1967 a field effect memory, the first nonvolatile silicon memory (floating gate memory)**
- **Became Founding President of NEC, Princeton, NJ in 1988**

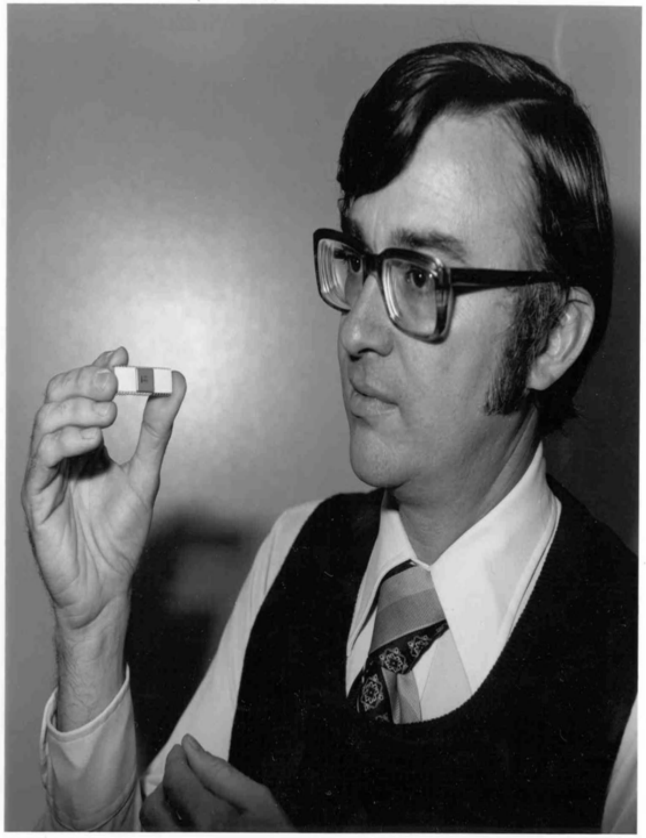
1961 Fairchild Flip Flop



4T 5R result from Planar process which was soon used to fabricate RTL.
The volume production era started, both at TI and Fairchild.

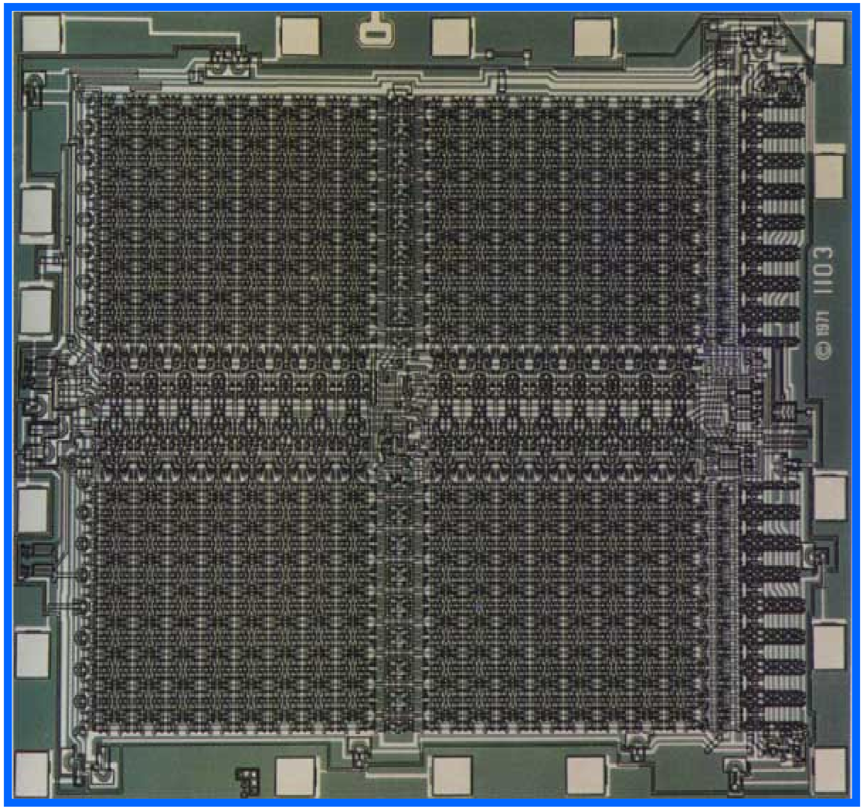
Intel's Trio In the Beginning

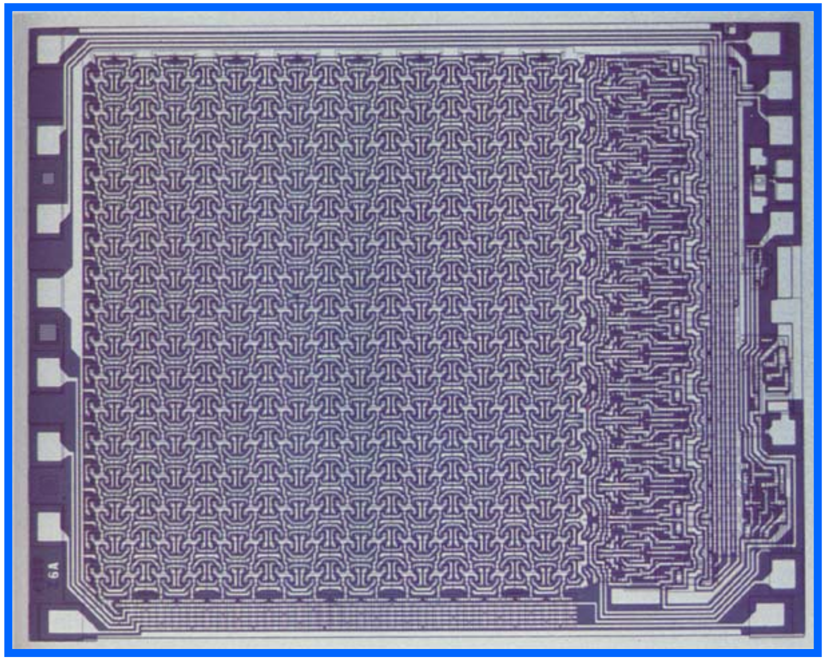




Gordon Moore Bob Noyce Ted Hoff

First Memory Chips

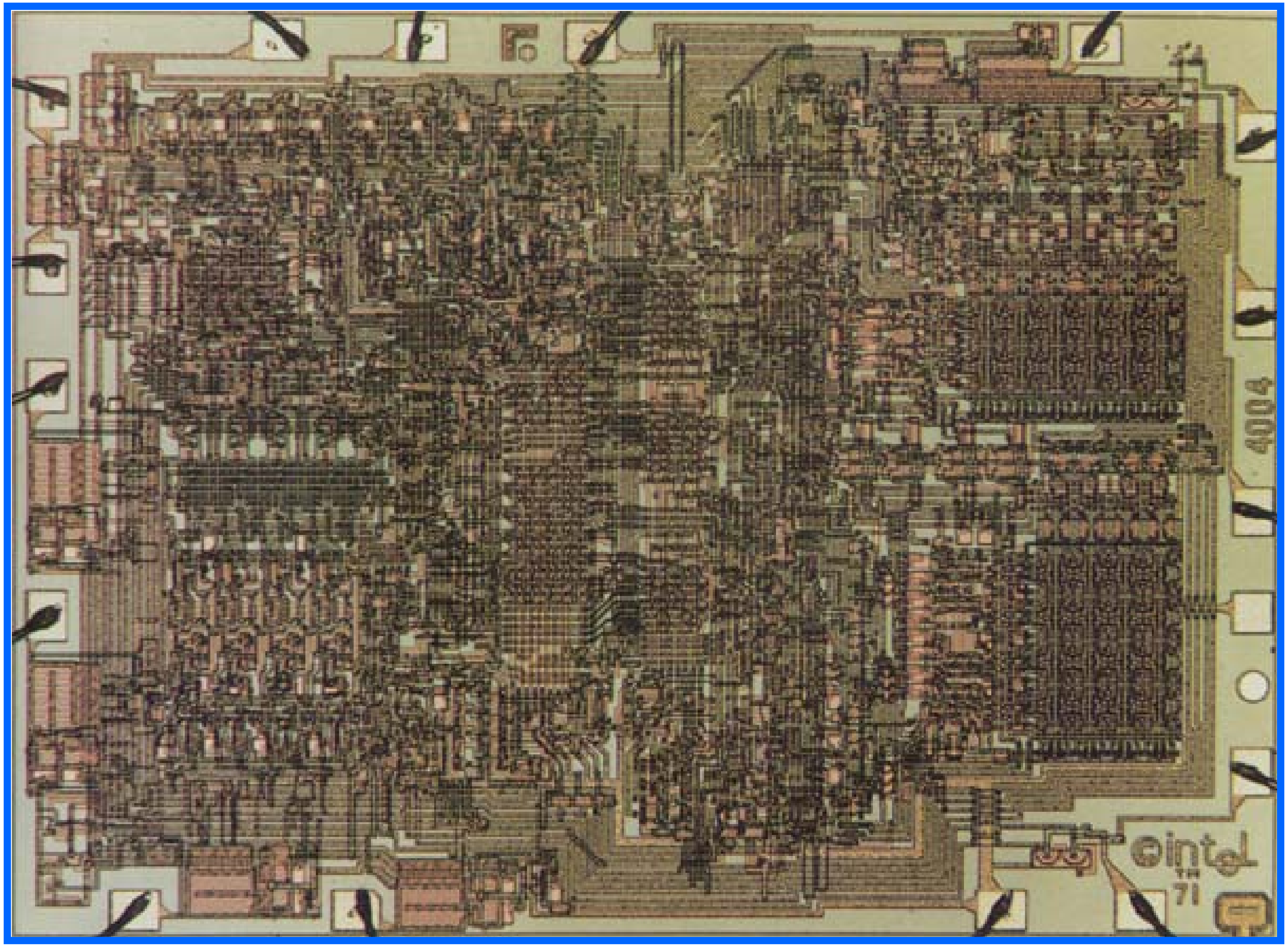




1103,1K DRAM, INTEL, 1970

256Bit SRAM, FC4100, 1970

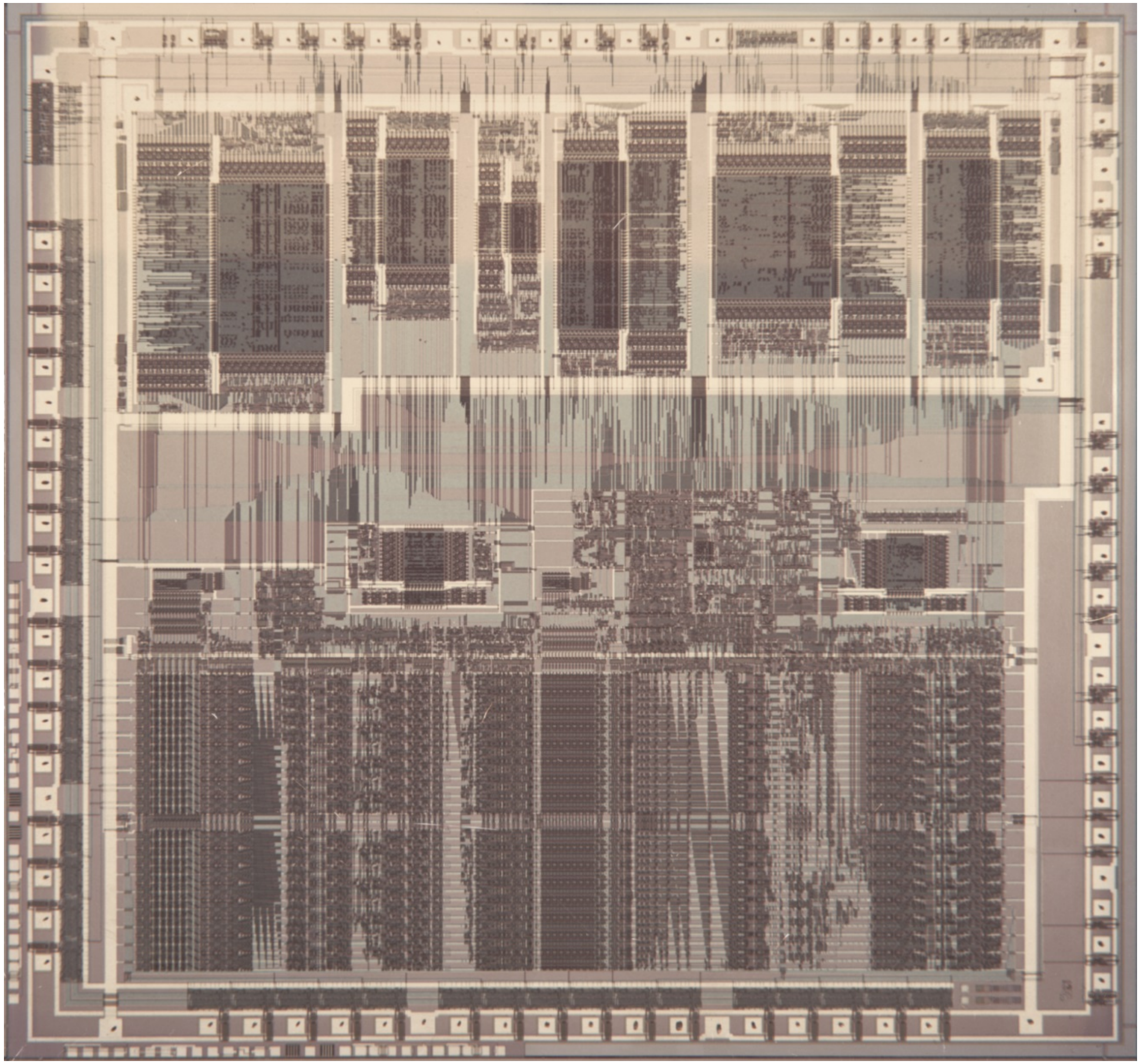
Intel Microcomputer 4004 in 1971



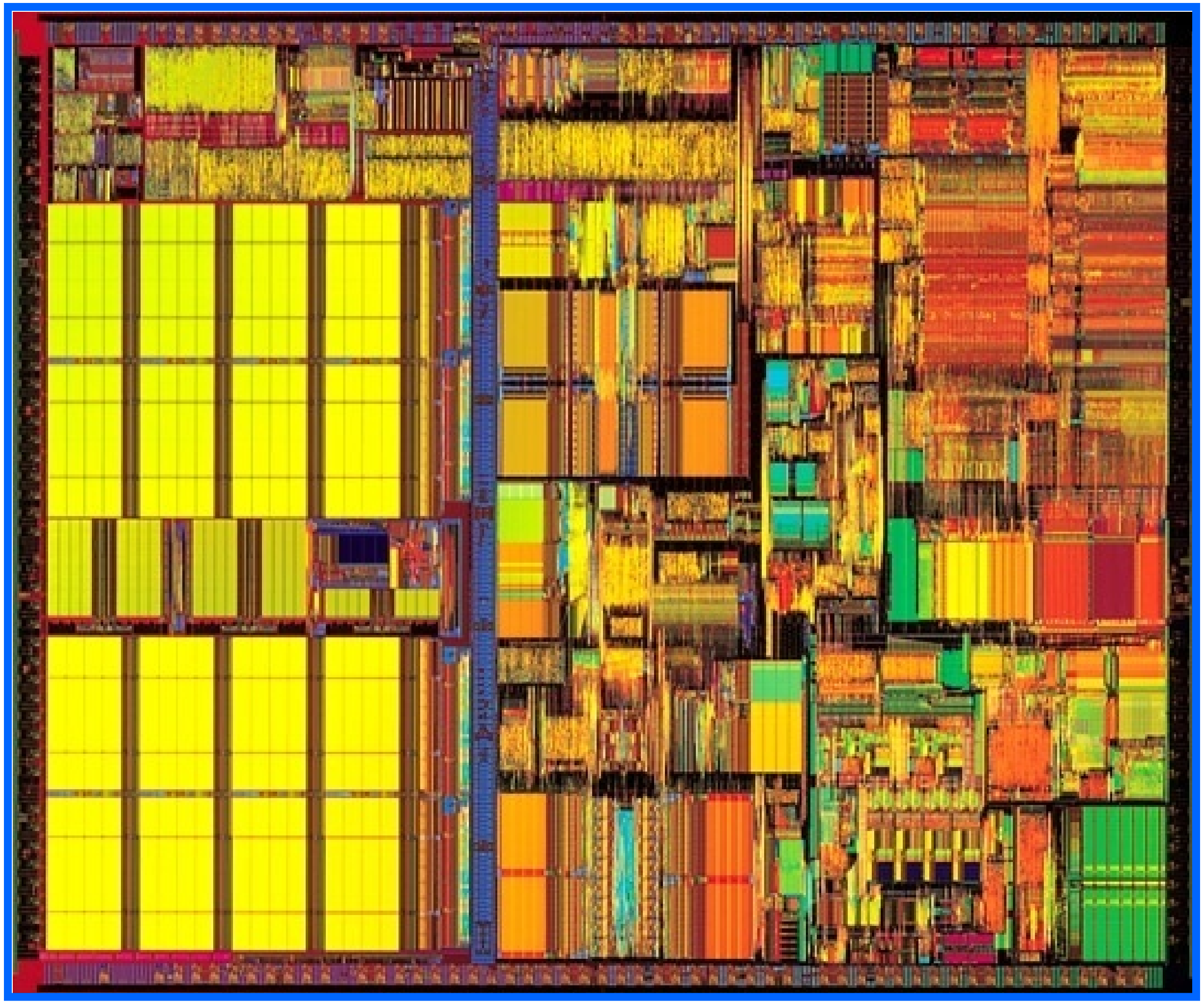
AT&T BELLMAC-32 TEAM at MH LOBBY (1981)

When CAD Tools Are Not Ready

World's First 32Bit CMOS Microprocessor BELLMAC-32

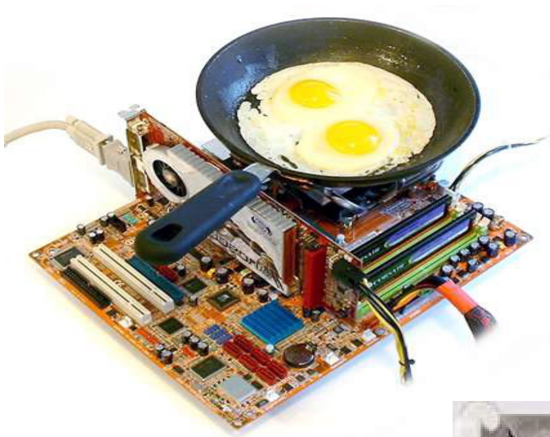


Intel Pentium 3B (1999)

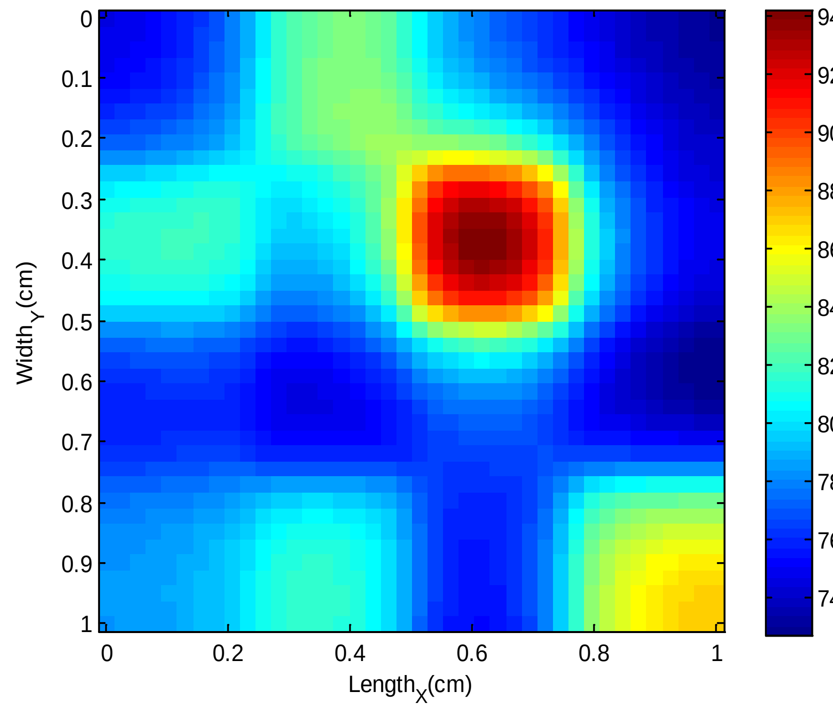


On-Chip Electro-Thermal Engineering

- **Increased Chip Temperature**



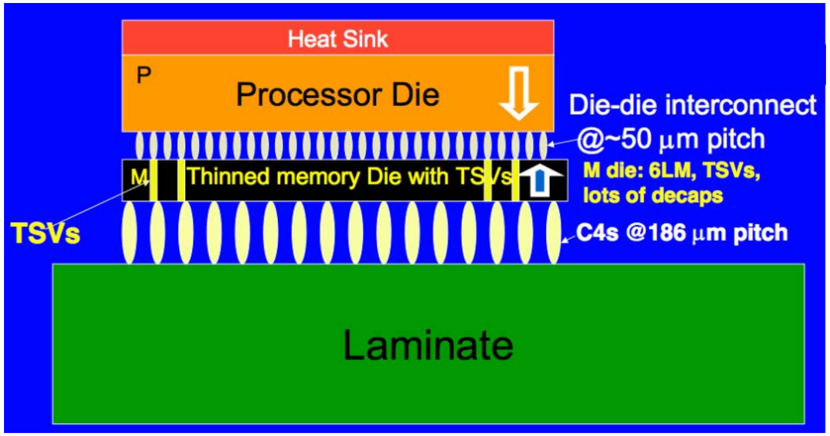
- **Non-uniformity (Hot Spots)**

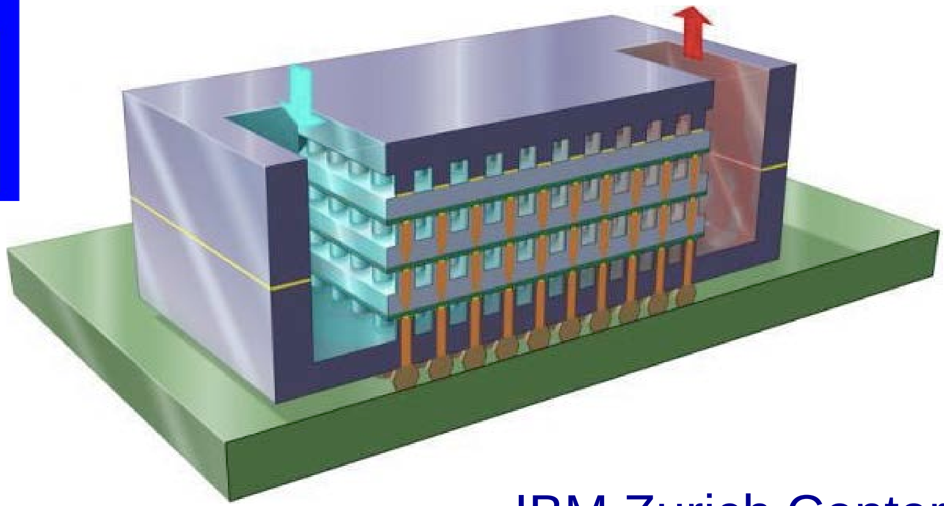


- Degrades chip performance and reliability (physical failure).
- Accurate chip temperature profile is required.

Water Cooling of Stacked 3D VLSI

Vertical stacking 3D shortens 2D wire lengths by 1000 times

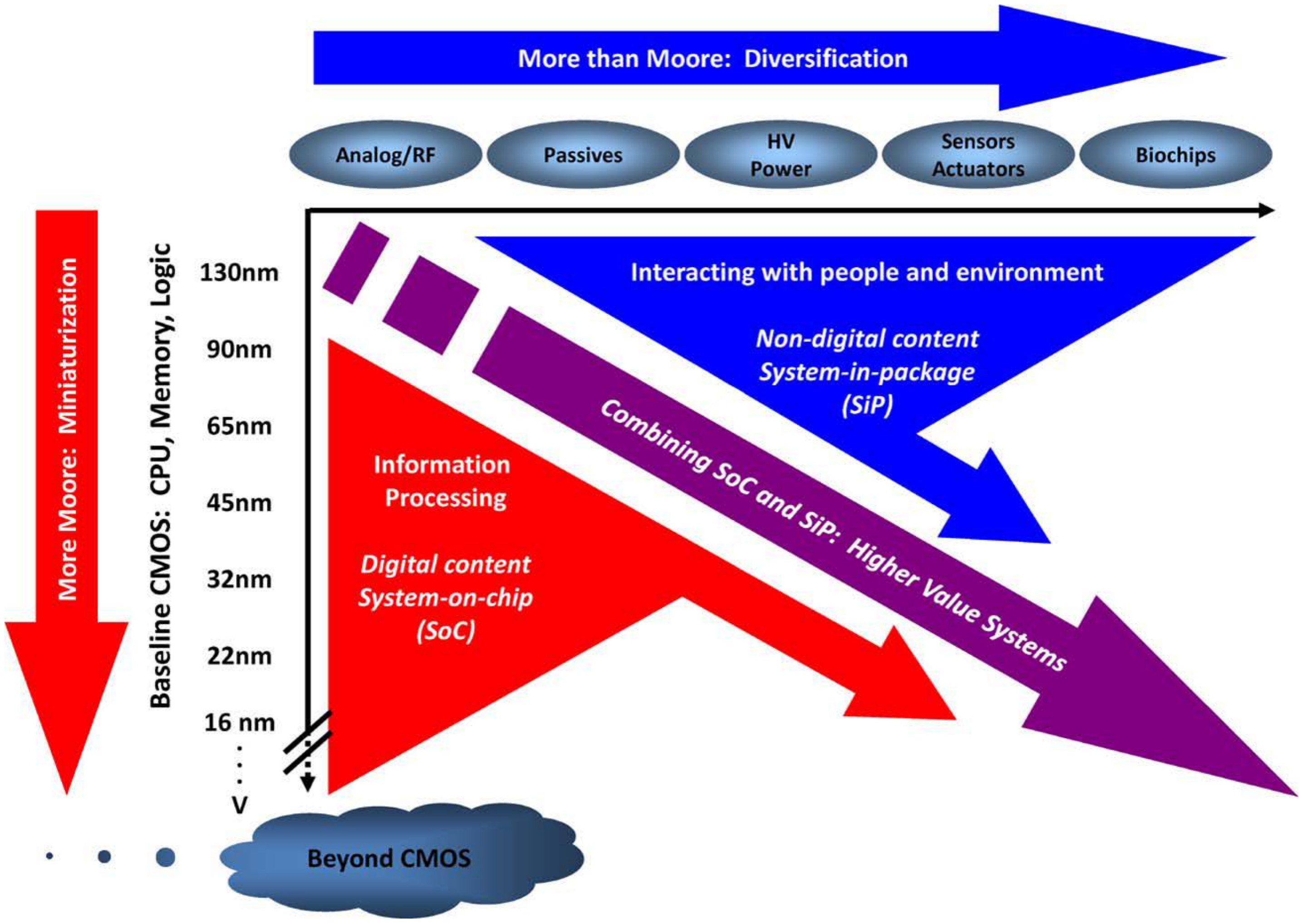




IBM Zurich Center
50um pipes
Cooling 180W/cm2

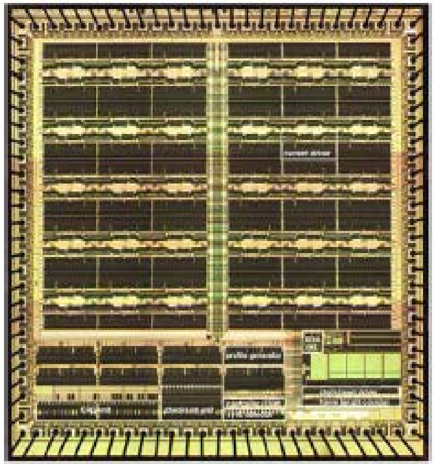
Source: IBM

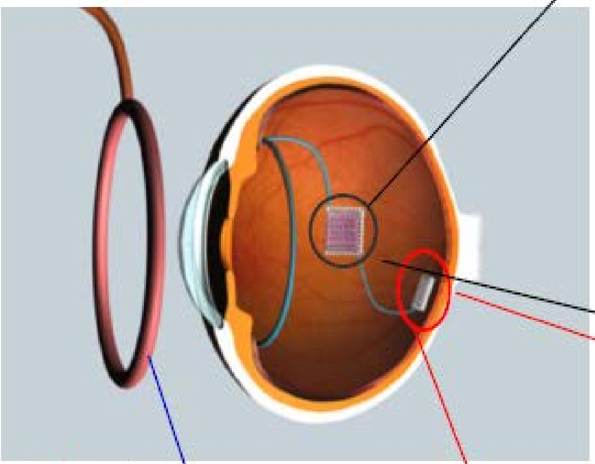
Beyond the Moore's Law

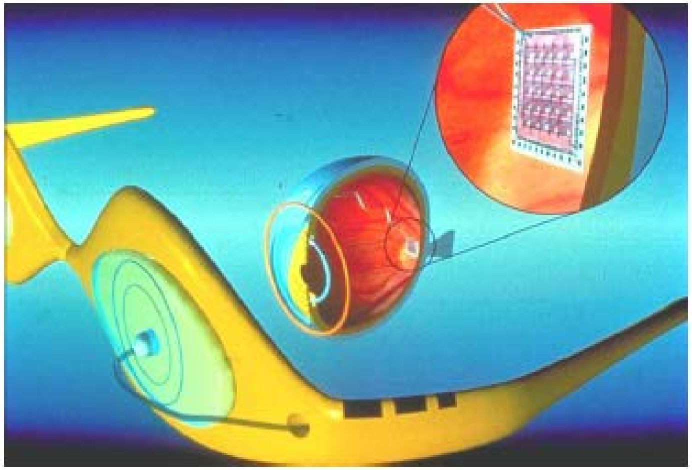


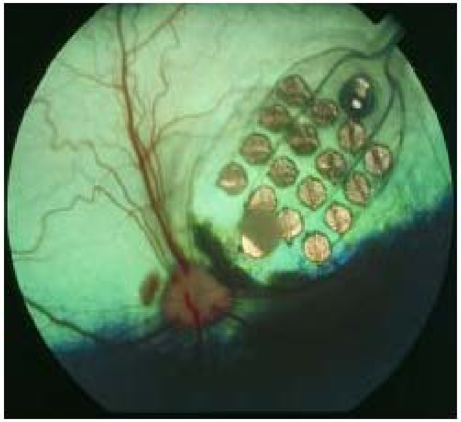
A Biochip for Retinal Prosthesis

- 17 patients participate in the research
- Mobility vision has been achieved
- A permanent implant has been done on Feb 19, 2002

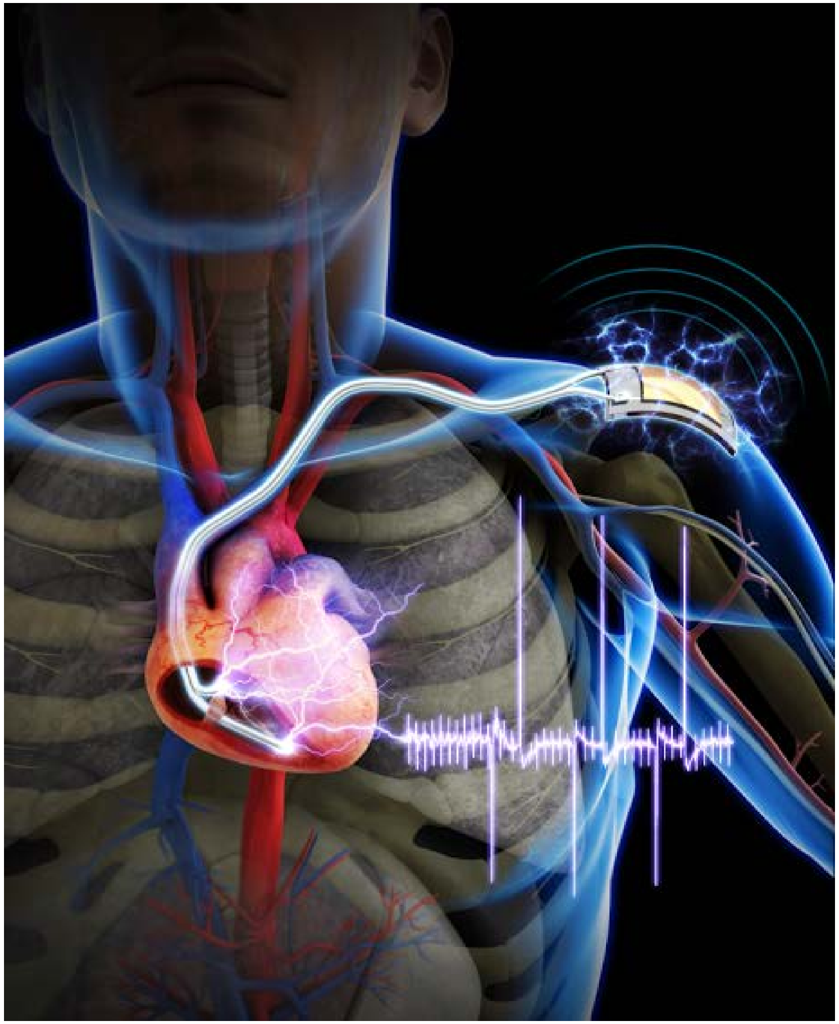




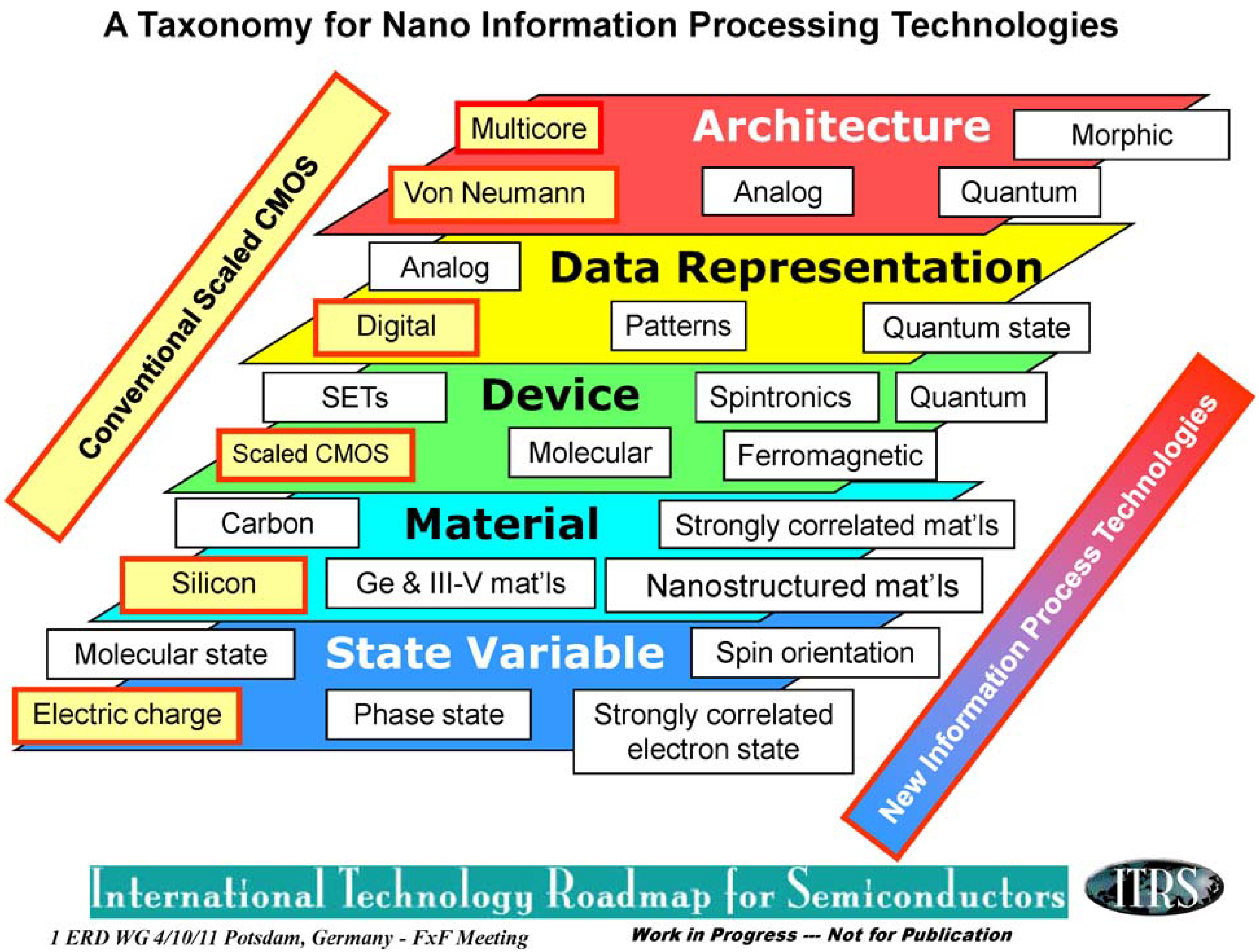




Regenerative Powering of a Pacemaker

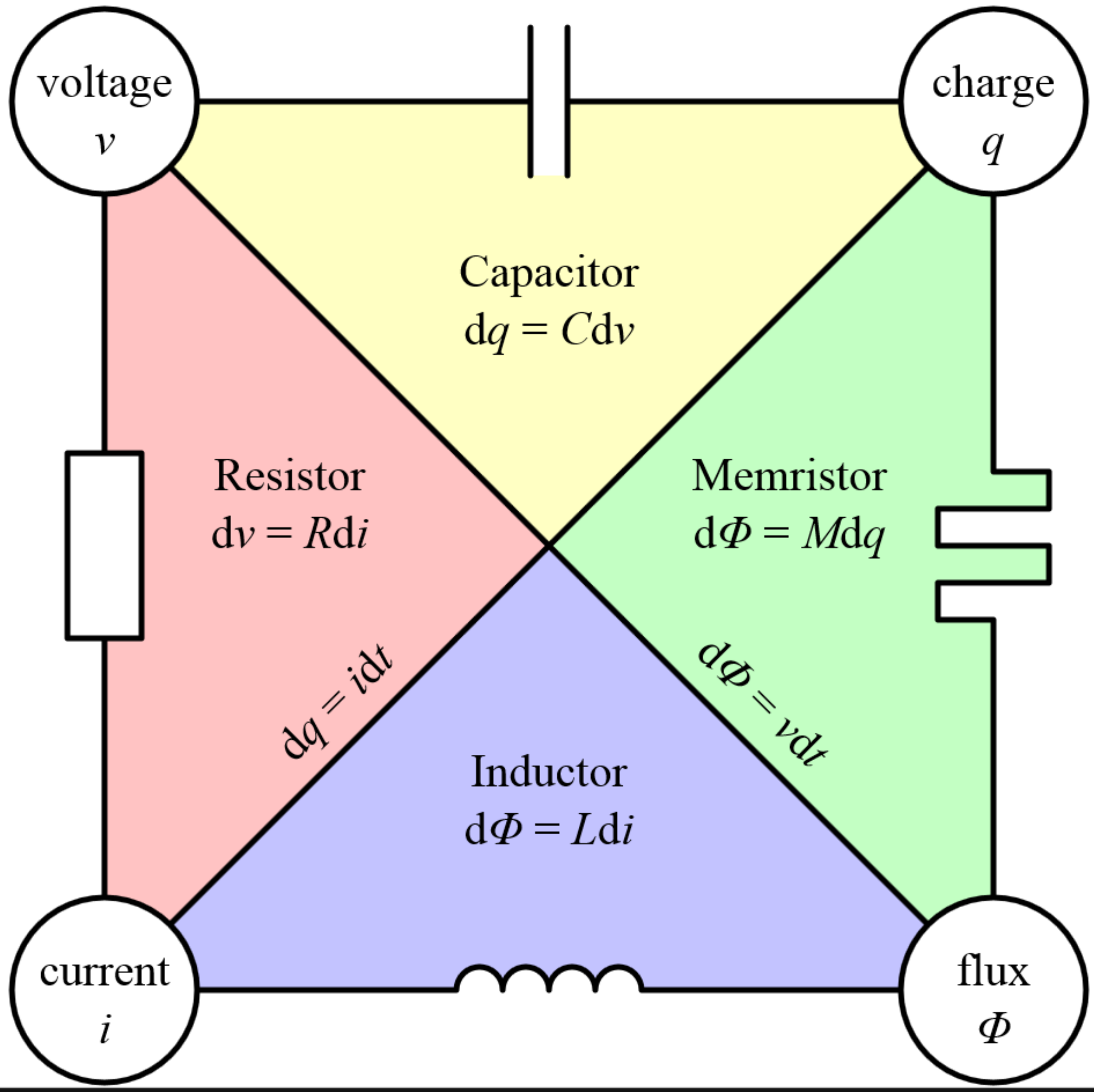


From VLSI Architecture to State Variables



Ref. www.itrs.net

CONSTITUTIVE RELATIONS OF R , L , C , AND M



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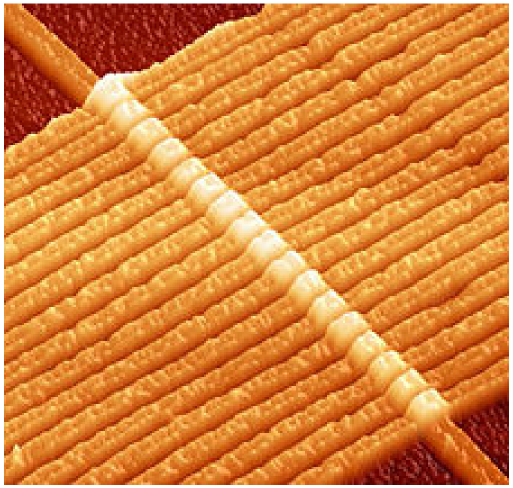
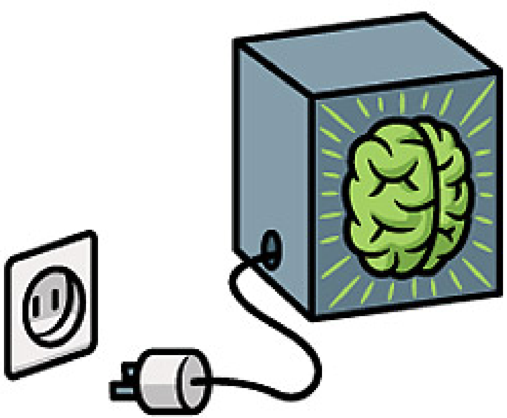
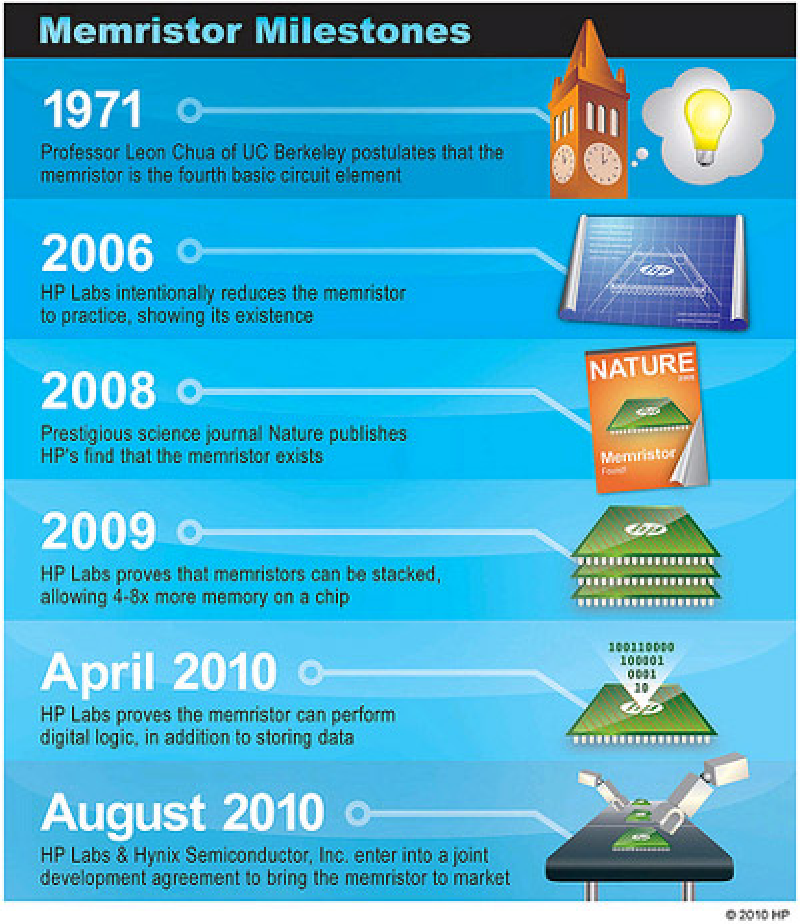
HP's 2008 Nanoscale Solid-State Memristor (Memristive Devices)

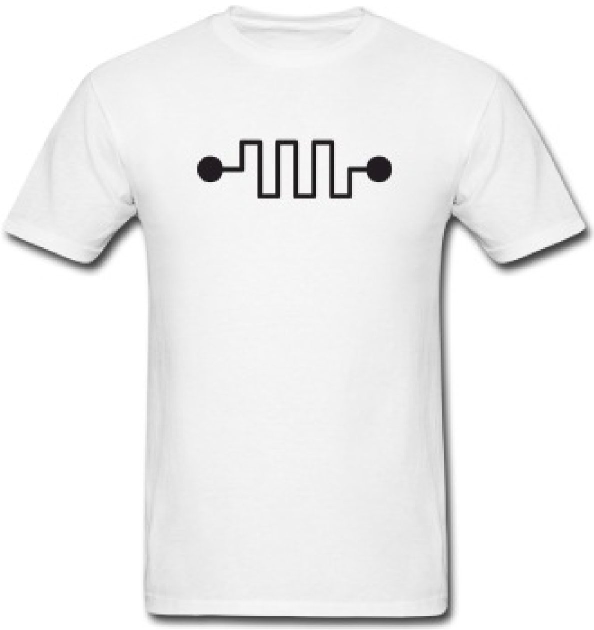




J. Yang, D. Pickett, X. Li, Ohlberg, D. Stewart, R. S. Williams, Nature Nanotech. (2008)

HP and Hynix Team on Universal Memory? (G. Russell, Sept 1, 2010)





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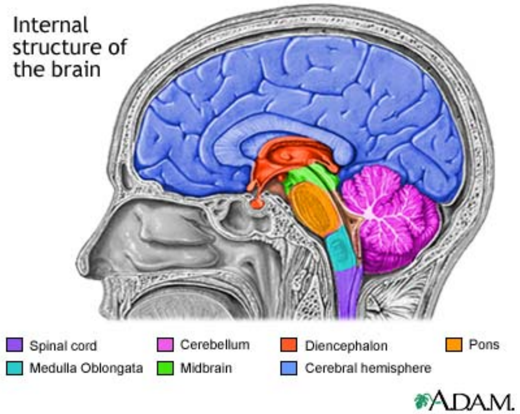
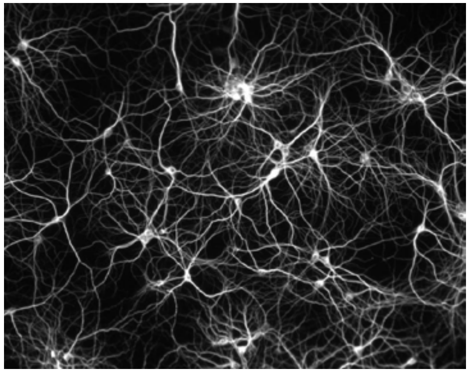
Cognitive Computing

With Neuroscience, Supercomputing, and Nanotechnology





Cognitive Computing may lead to

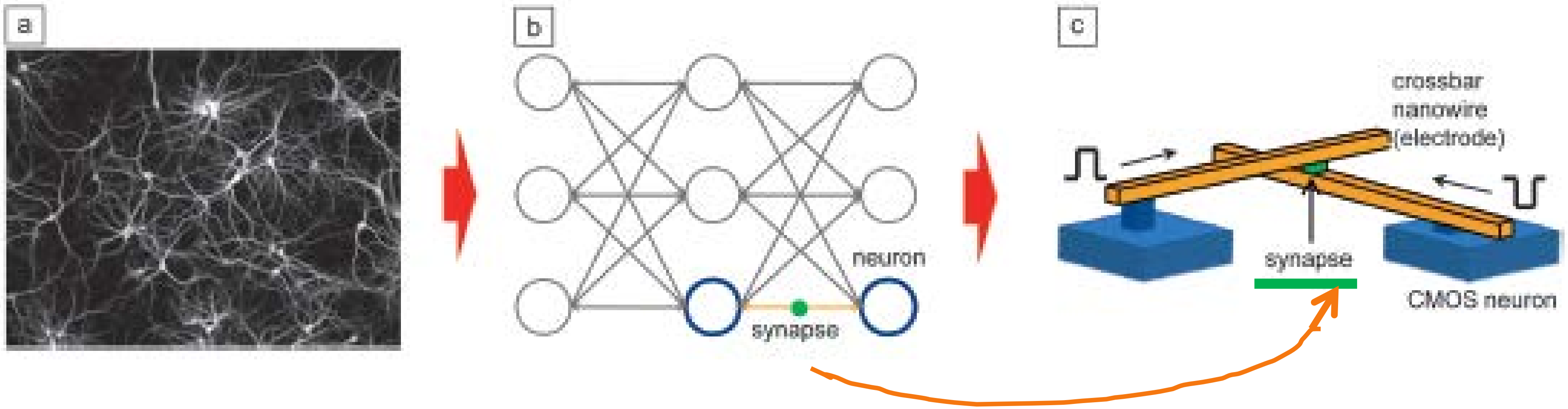
- novel learning systems
- Non Von Neumann architectures
- new programming paradigms
- integration, analysis and action on vast amounts of data from many sources at once

Ref. D. Modha, et al., Communications of ACM, Aug. 2011

	Mouse	Rat	Cat	Monkey	Human
Neurons (B)	0.016	0.055	0.763	2	20
Synapses (T)	0.128	0.442	6.10	16	200

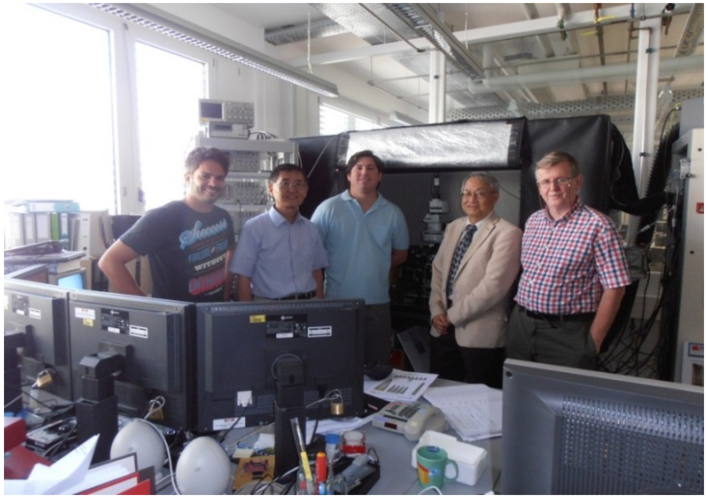
Memristive Synapse for Neuromorphic Computing

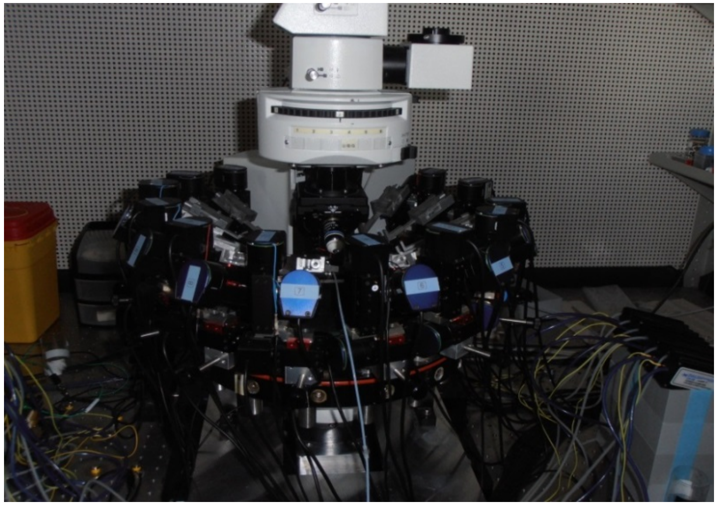
Neuromorphic VLSI Circuits



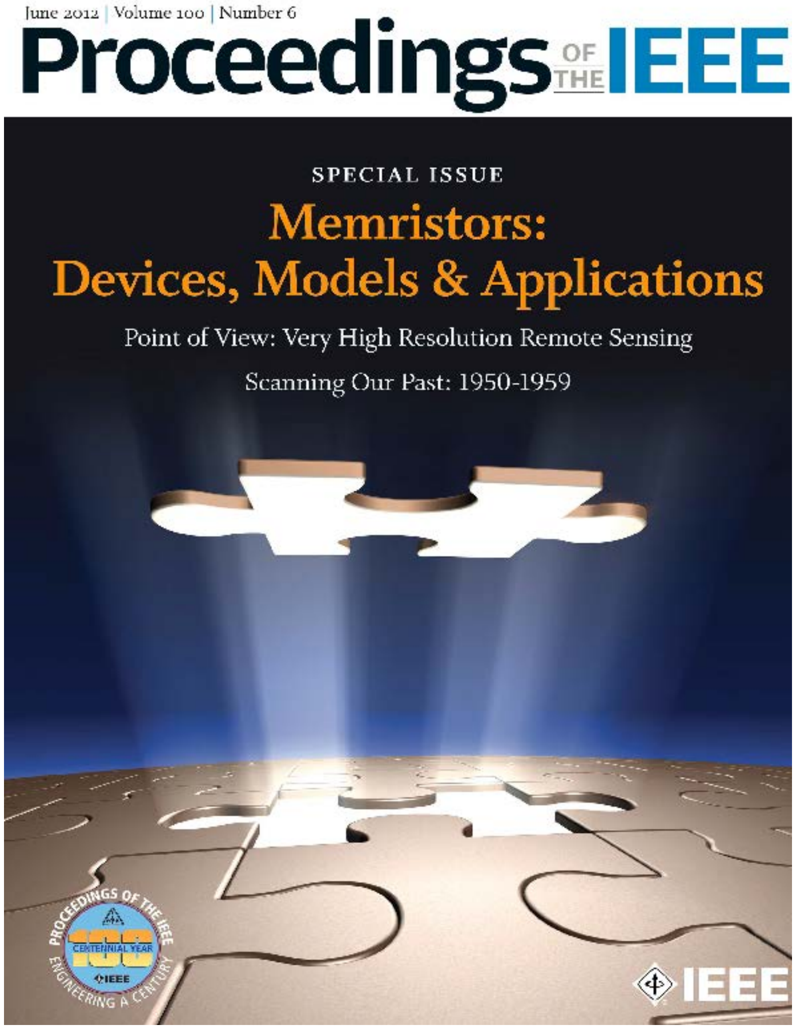
Ref. D. B. Strukov, *Nature* 476, 403 (2011)

Brain Modeling at EPFL- Swiss Federal Institute of Technology



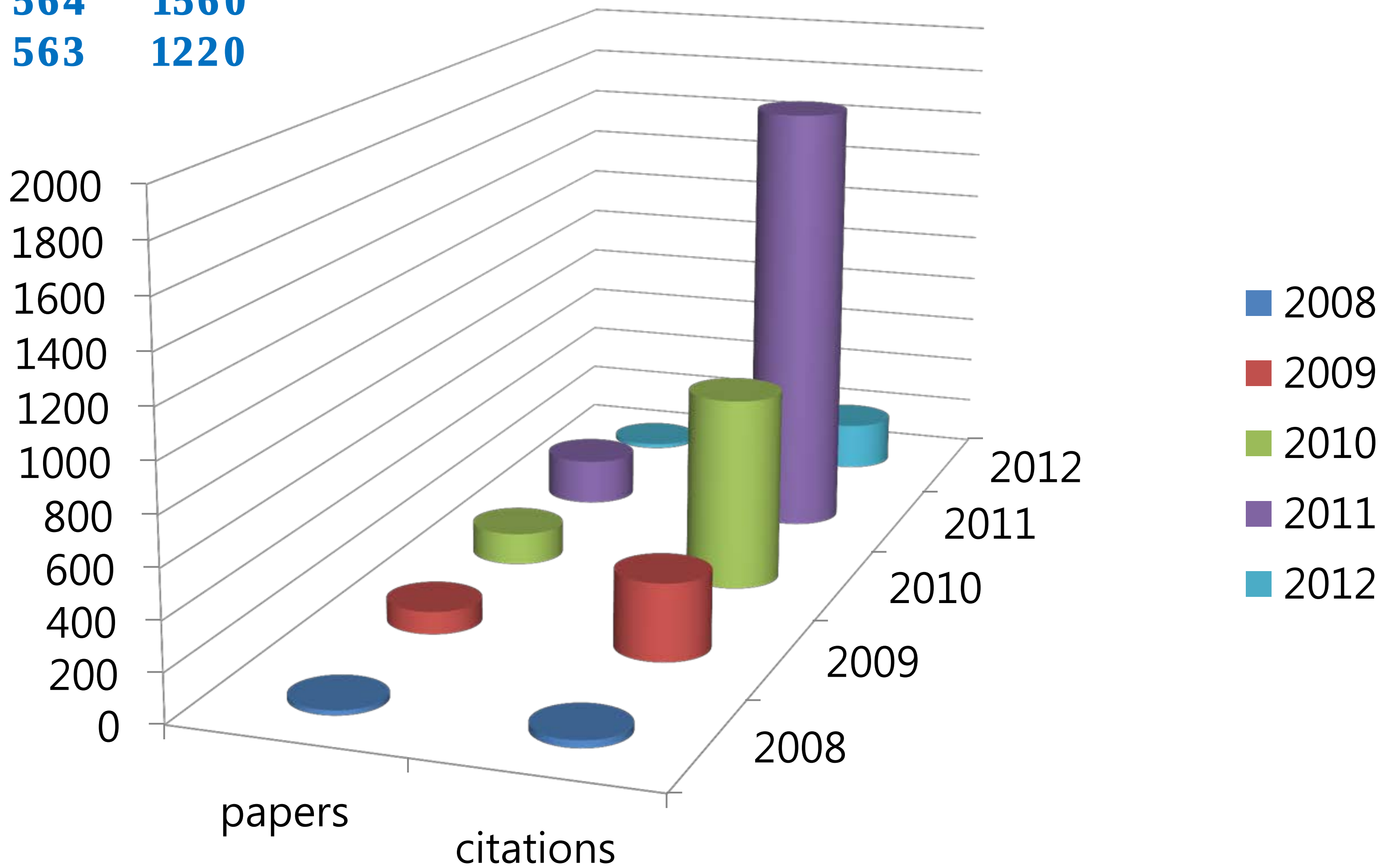


Special Issue on Memristors (June 2012)

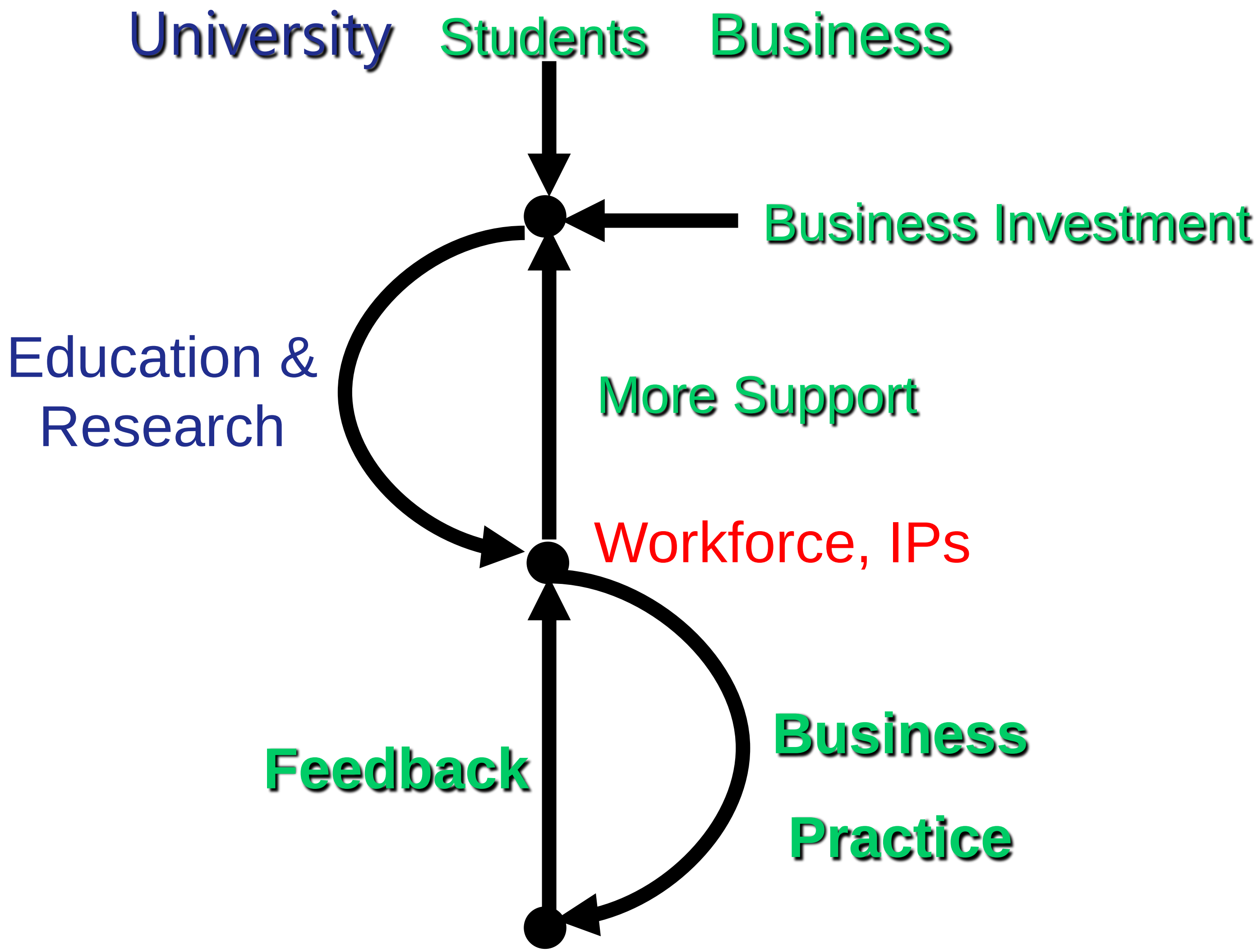


Memristor Papers and Citations (2008 - early 2012)

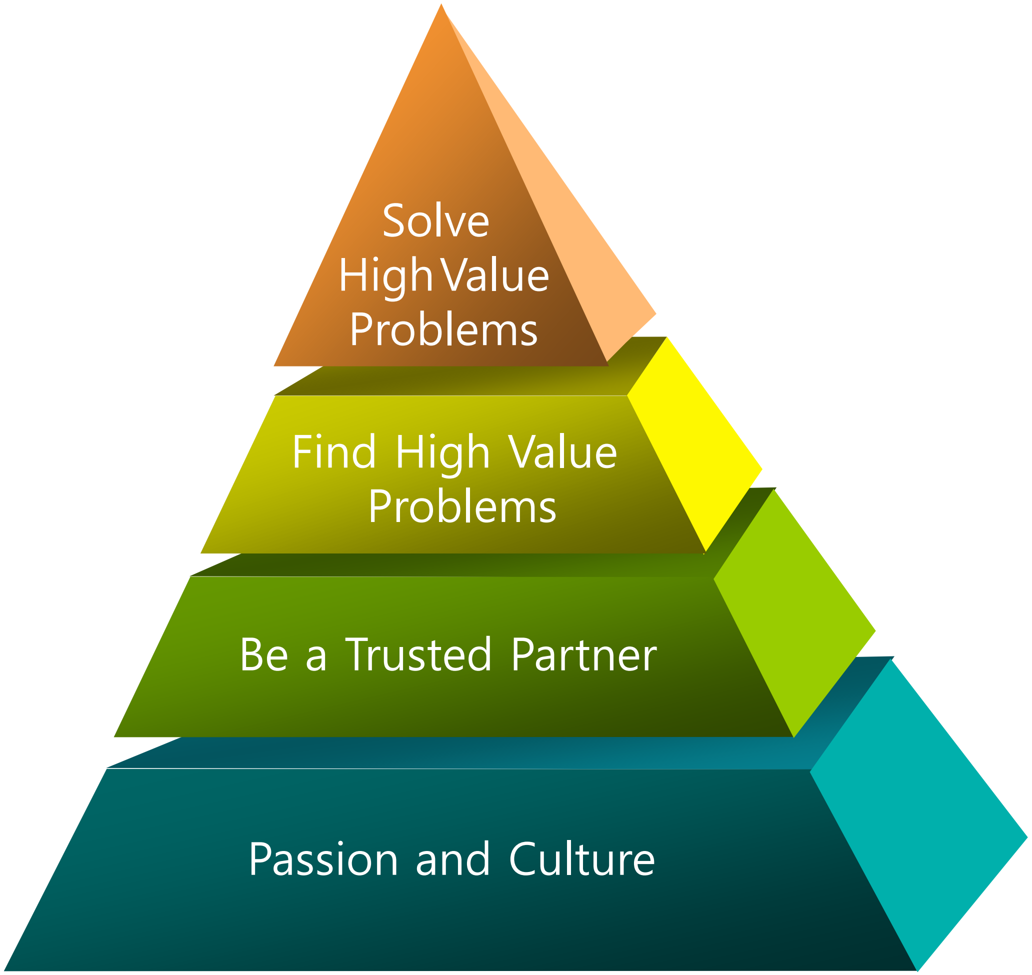
2012 : 564 1560
2013 : 563 1220



Education-Business Synergy (S Curve)



In Search of Excellence

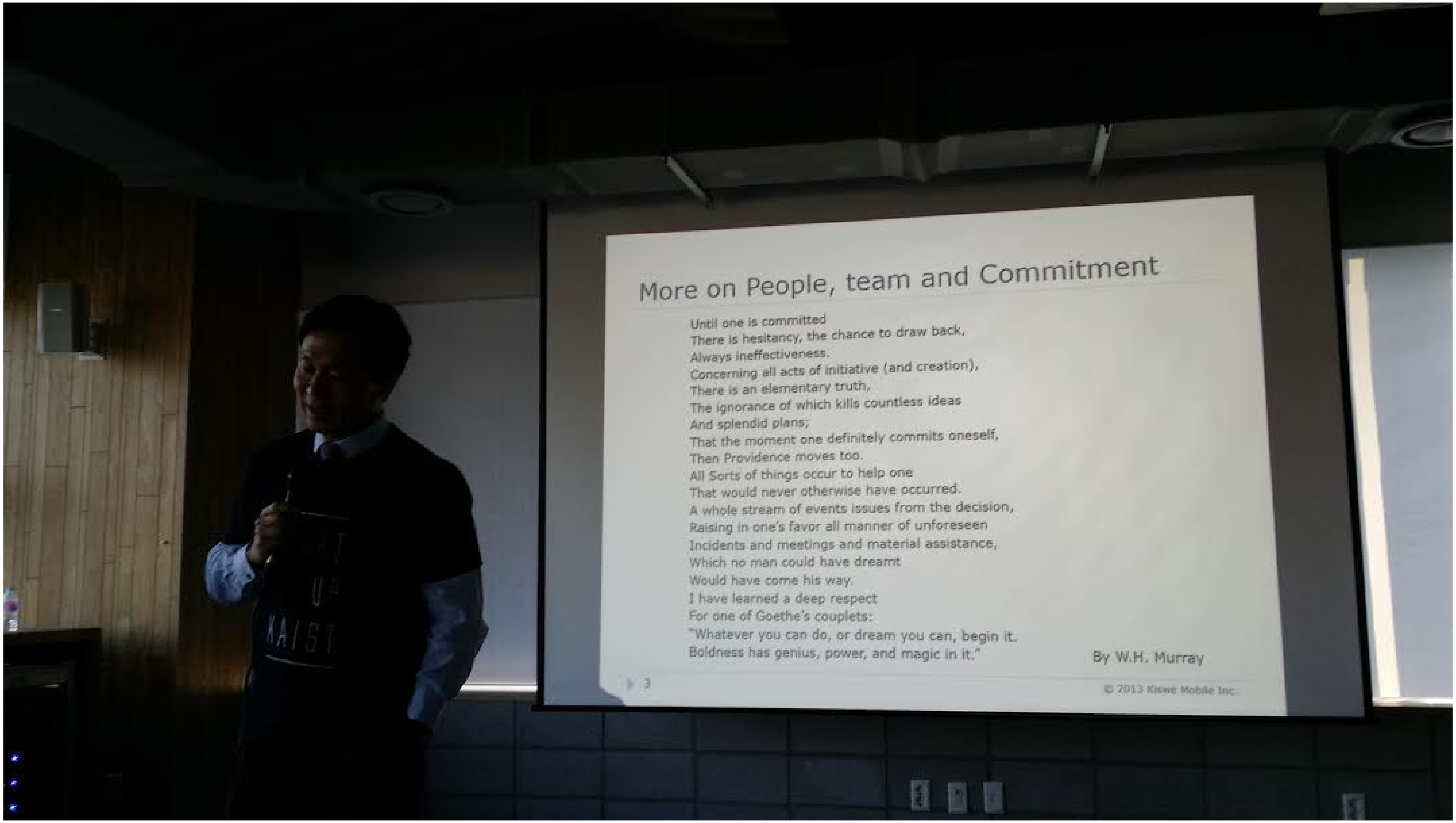


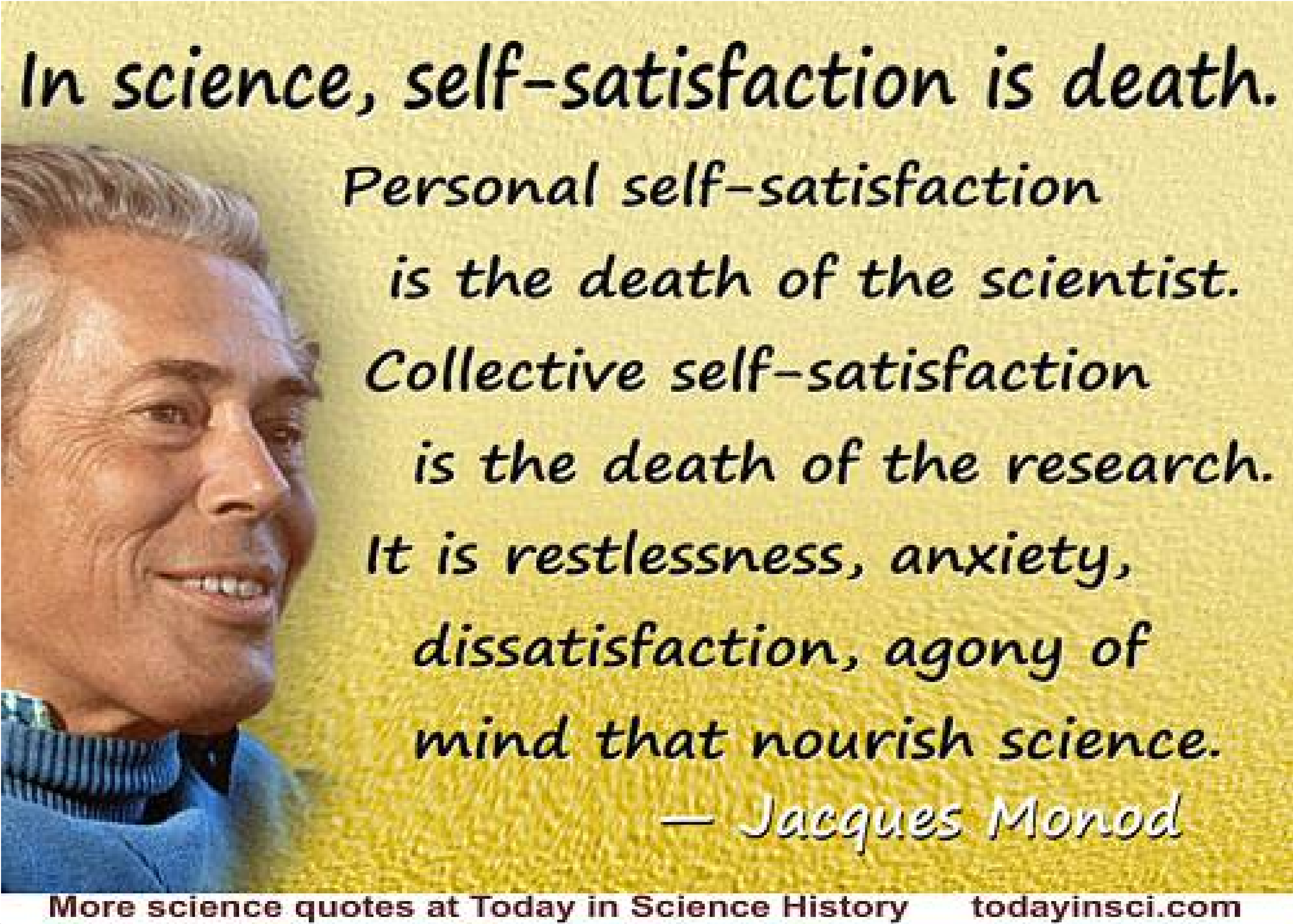
source : Applied Materials

Utricularia Captures Bugs

Tree Grows on Rocks

People, Team and Commitment




In science, self-satisfaction is death.
Personal self-satisfaction is the death of the scientist.
Collective self-satisfaction is the death of the research.
It is restlessness, anxiety, dissatisfaction, agony of mind that nourish science.
— Jacques Monod
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Social Value Creation