Get Over the Insecurity!

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Key points

- Don't get hung up on trying to be a "pure science"
  - The fact that much of what we do is useful is *good*, not bad
  - Sure, the physicists did The Mother Of All Demos back in 1945, but they're in the crapper today – now, they envy us!
- We are at the center of everything

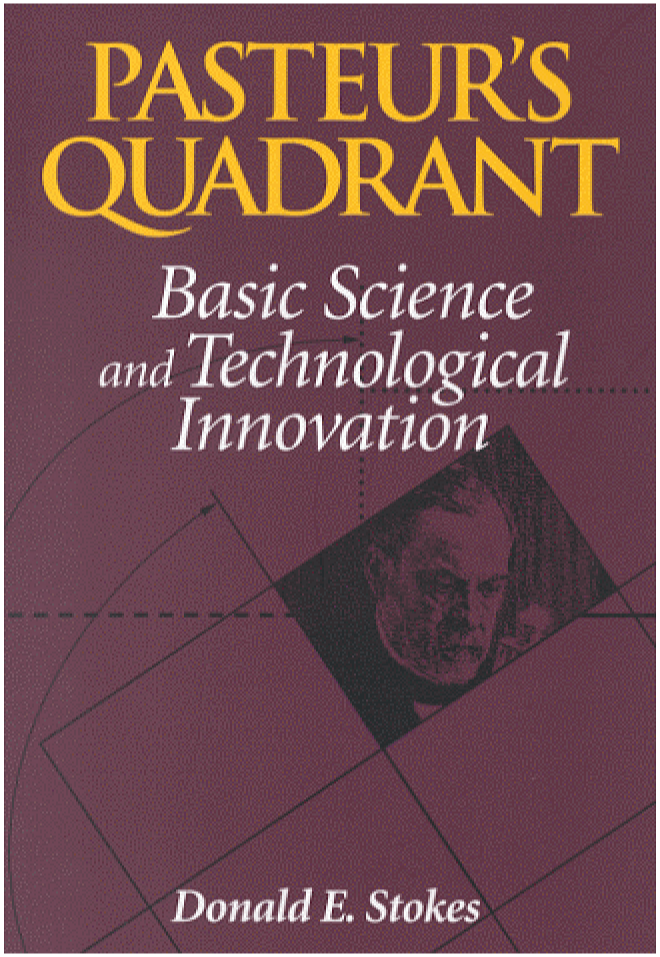
- There are incredible opportunities for "peer to peer" intellectual advancement
  - "Just say no" to those who want something else from you – corporate or academic
  - But recognize that every party in a collaboration needs to "pay some dues"
- Beware of having a narrow view of what constitutes computer science

Science vs. engineering

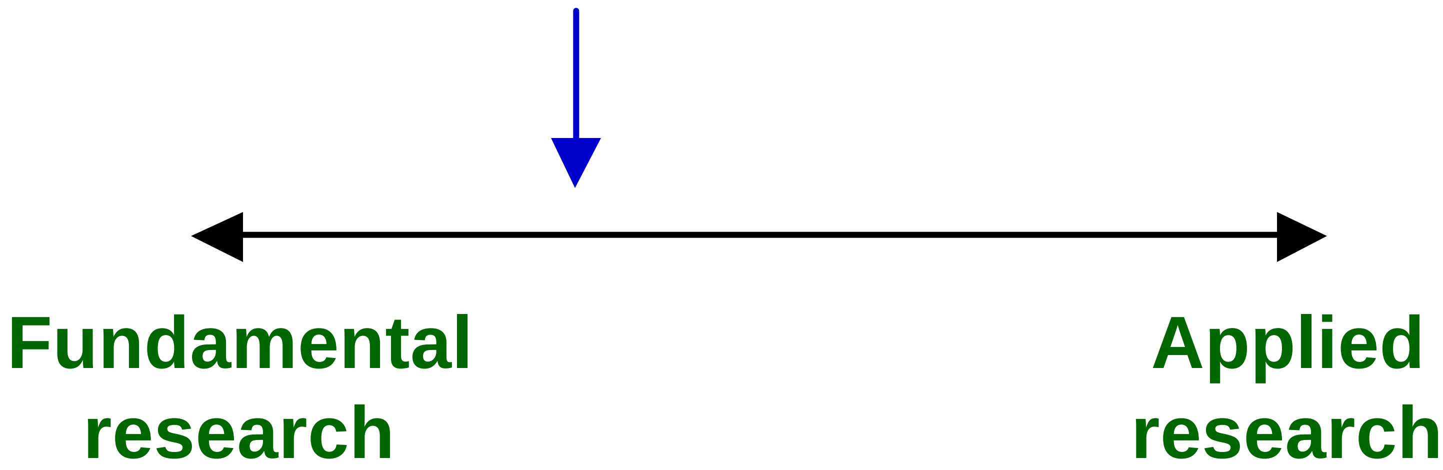
- Science
  - Describe, explain
- Engineering
  - Design, build, evaluate
  - “An engineer can do for a dime what any fool can do for a dollar”
- Much of computer science is engineering – celebrate this!

"Engineering research": oxymoron?

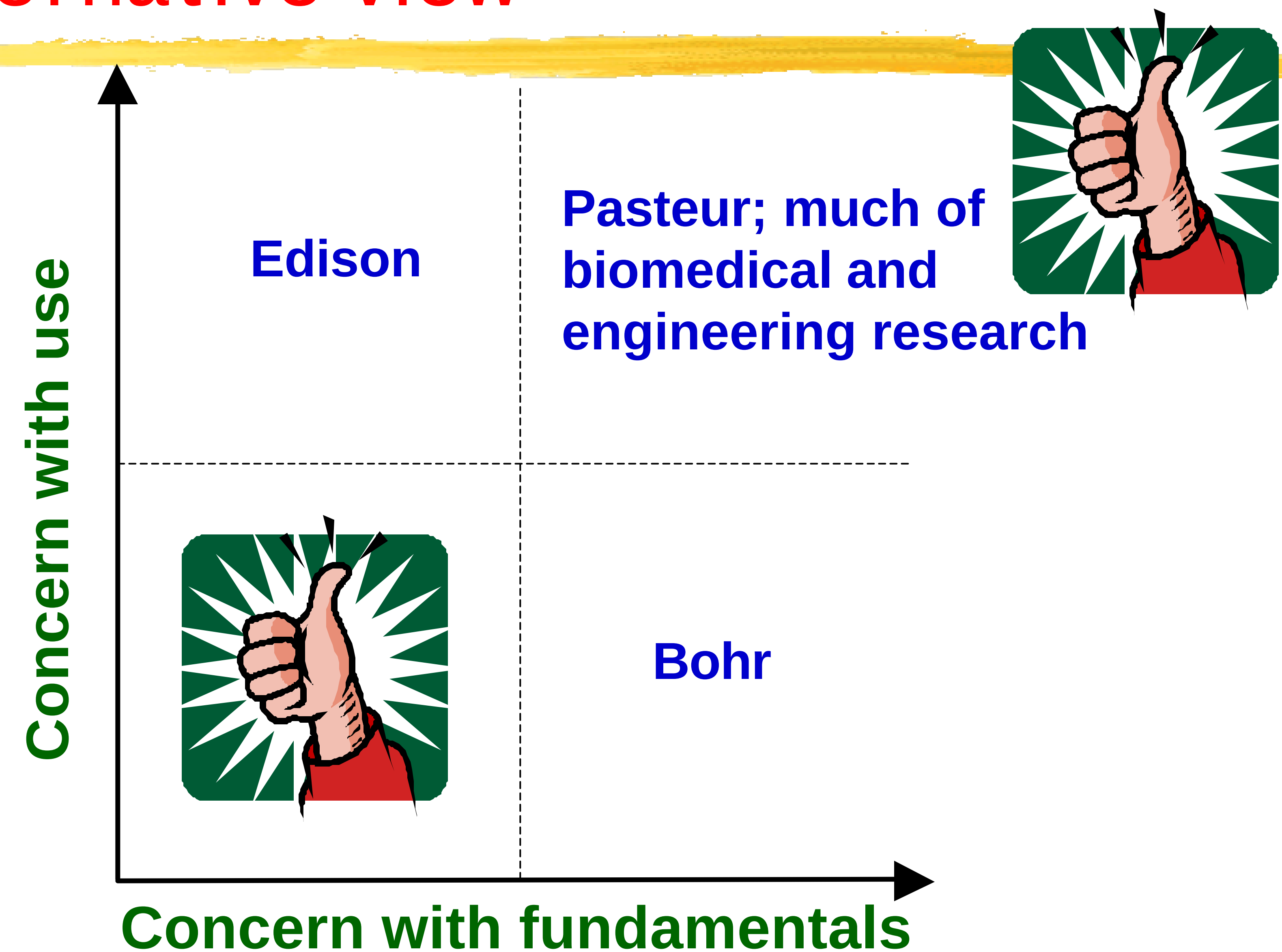
- "Fundamental research" and "application-motivated research" are compatible



Traditional view



Alternative view



Some UW examples in the bio space

- Computational molecular biology
- LabScape – embedded systems to instrument biotech laboratories
- Neurally-inspired computing

Computational Molecular Biology

- Collaborators: Lee Hood, Maynard Olson, Phil Green
- Faculty: Dick Karp, Martin Tompa, Larry Ruzzo, Rimli Sengupta
- Postdocs: Amir Ben-Dor, Benno Schwikowski
- Completed Ph.D. students: Brendan Mumey (U Montana), Jeremy Buhler (WashU), Ka Yee Yeung (UW Microbiology), Agatha Liu (IBM), Saurabh Sinha (Rockafeller U), Mathieu Blanchette (McGill), Emily Rocke (UW Genome Sciences)
- Corporate interactions: Zymogenetics, Immunex, Rosetta, Institute for Systems Biology

The Portolano Expedition in Invisible Computing

portolano.cs.washington.edu

Gaetano Borriello
Department of CS&E
University of Washington

Seattle SAGE Group

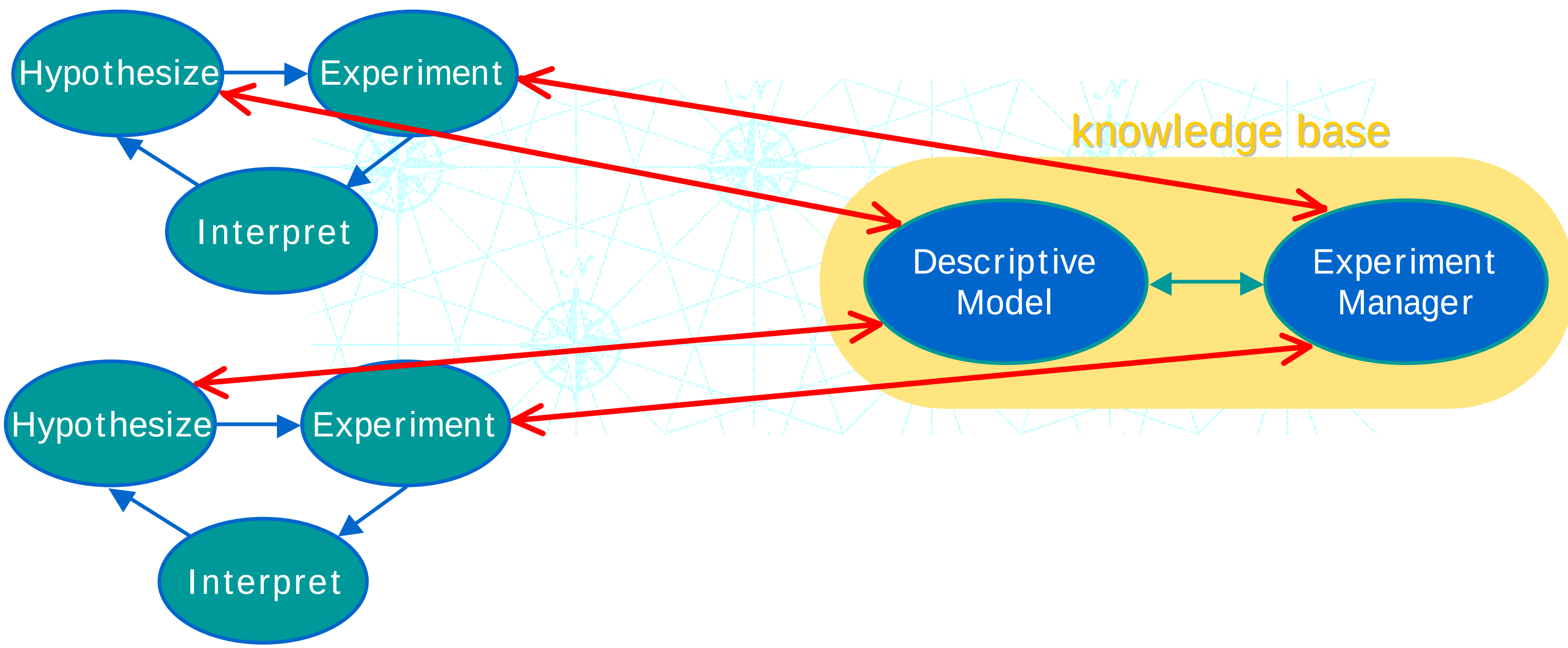
14 September 2000

Principal Themes

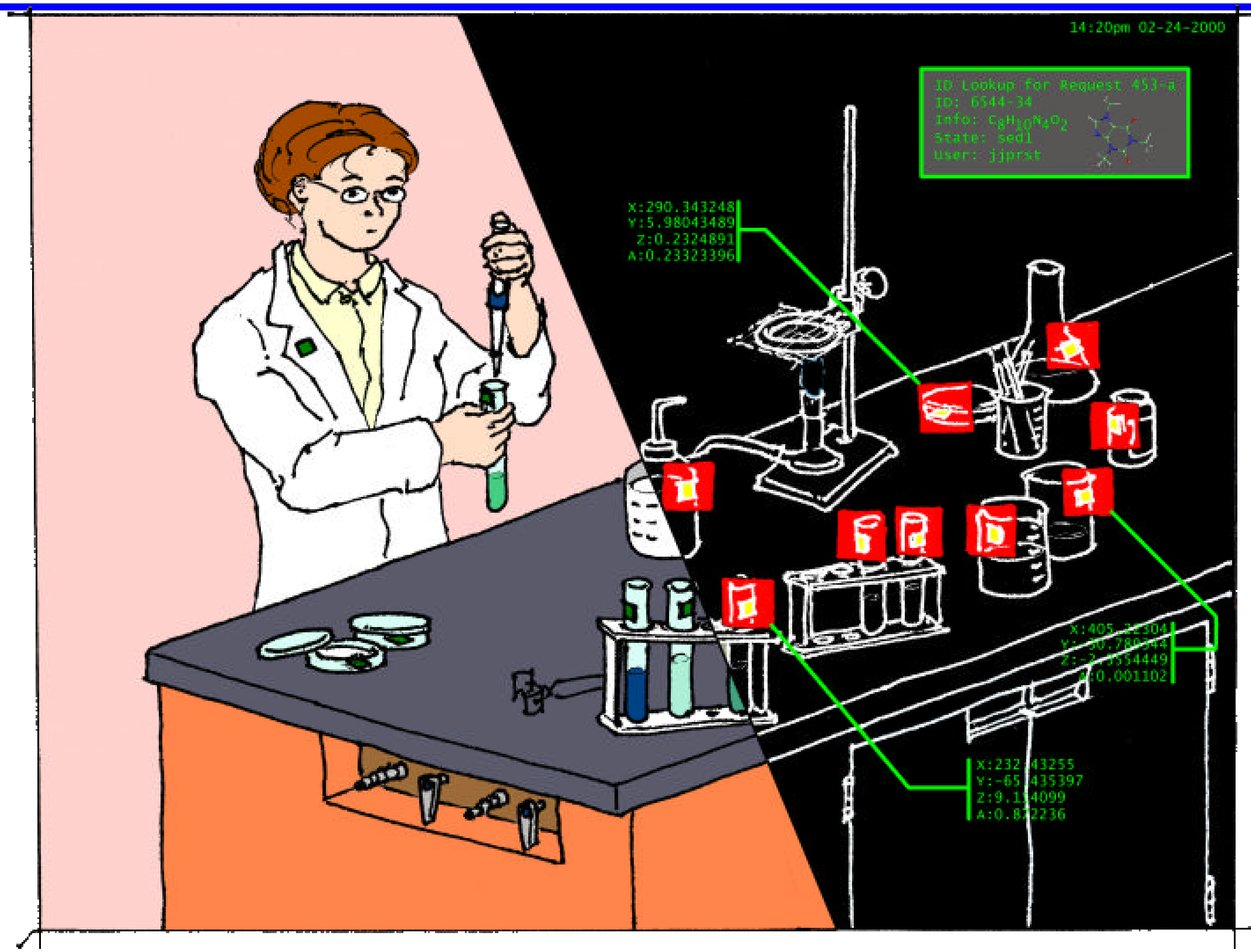
- Invisibility
  - not enough to be mobile, pervasive, ubiquitous, etc.
  - user's attention is the valuable resource
  - minimize user configuration/maintenance/interaction
  - robust, reliable, safe, and trustworthy
  - devices, middle-ware, and "applications" ⇨ services
- Active fabric
  - plug-and-play, discovery, composability
  - data-centric, heterogeneous, active networking
  - data and code mobility
  - self-organizing, self-updating, self-monitoring systems
  - active databases and information management
- External user community

LabScape - one of our driver applications

- Biology is a hard science with a soft infrastructure
  - capture and use of knowledge is key
  - from loosely connected to highly integrated collaboration
  - invisible infrastructure for building knowledge base



Event Capture in Labscape



Neurally Inspired Computation

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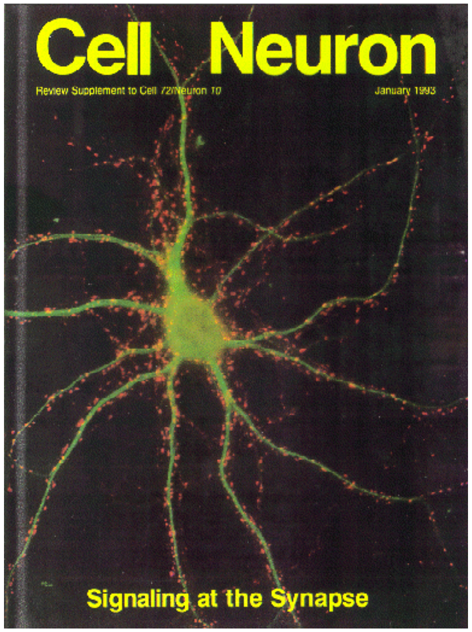
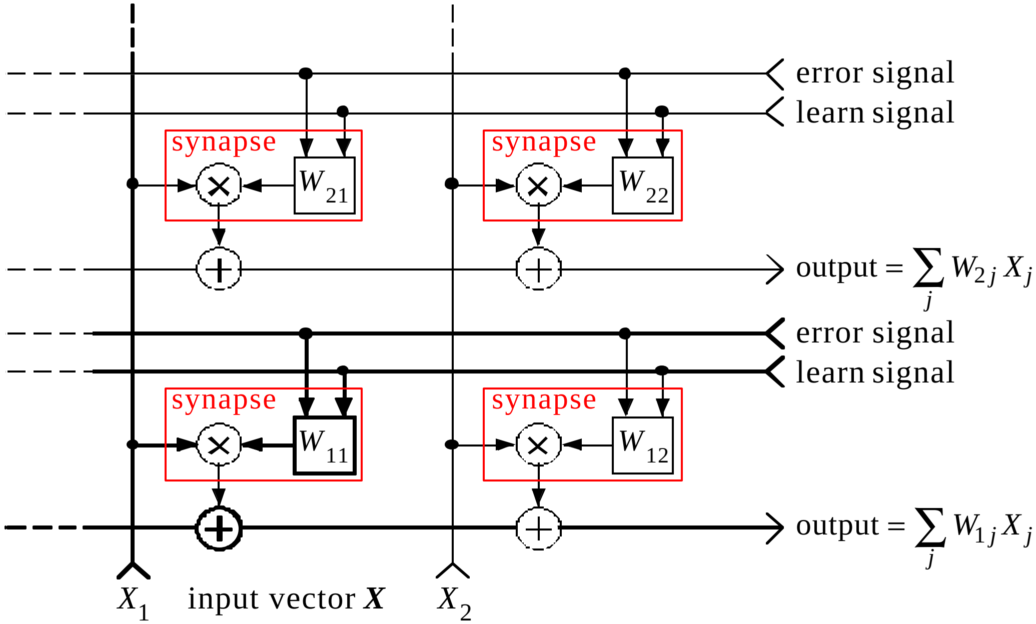
Nature is telling us something...

- Can add numbers together in nanoseconds
  - Hopelessly beyond the capabilities of brains
- Can understand speech trivially
  - Far ahead of digital computers
  - …and Moore's law will end

Problem: How do we build circuits that learn

- One approach: Emulate neurobiology
  - Dense arrays of synapses

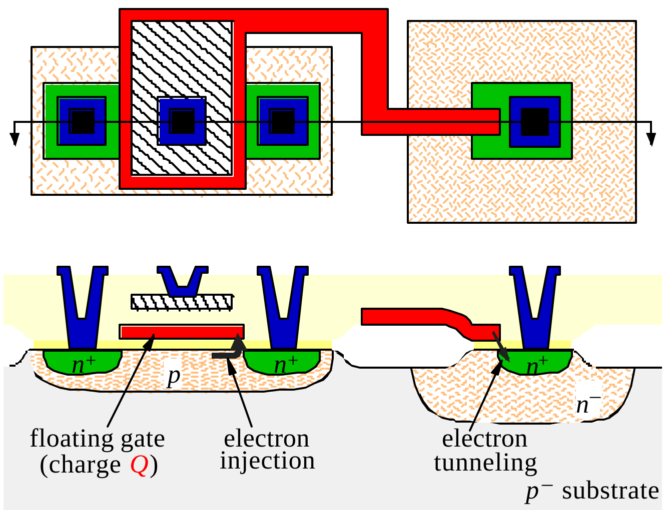




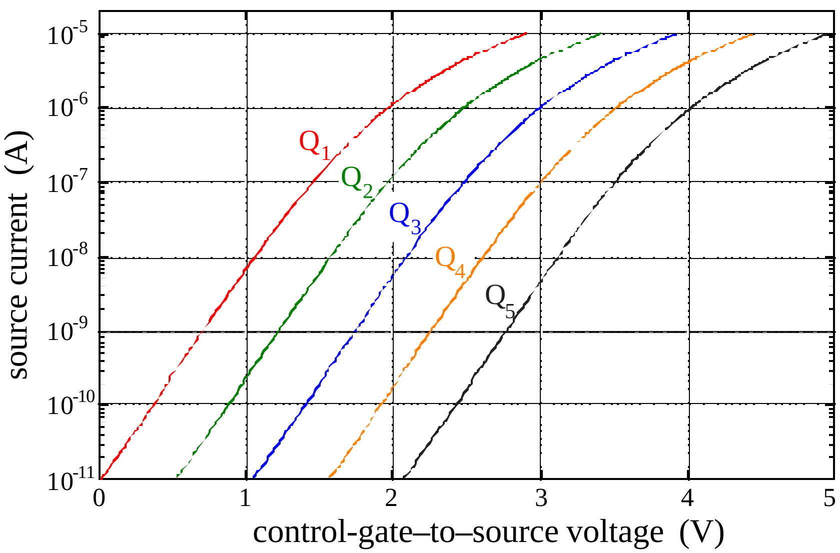
Silicon synapses

- Use the silicon physics itself for learning
  - Local, parallel adaptation
  - Nonvolatile memory

Silicon Synapse Transistor



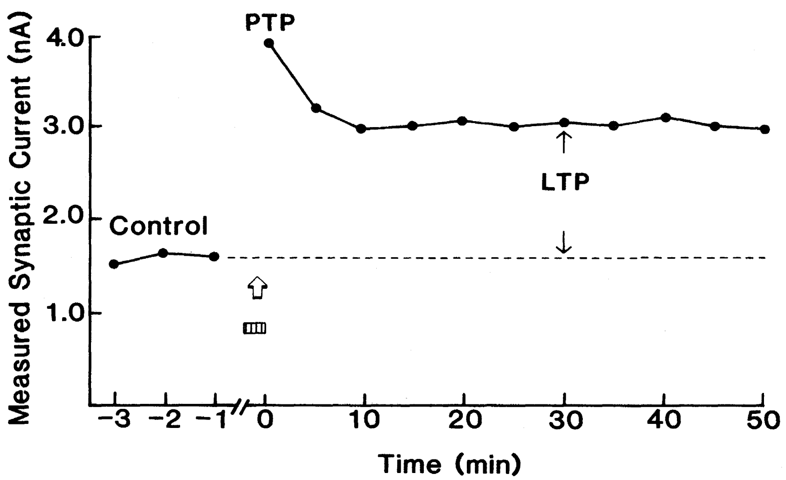
Charge *Q* Sets the Weight



Silicon synapses can mimic biology

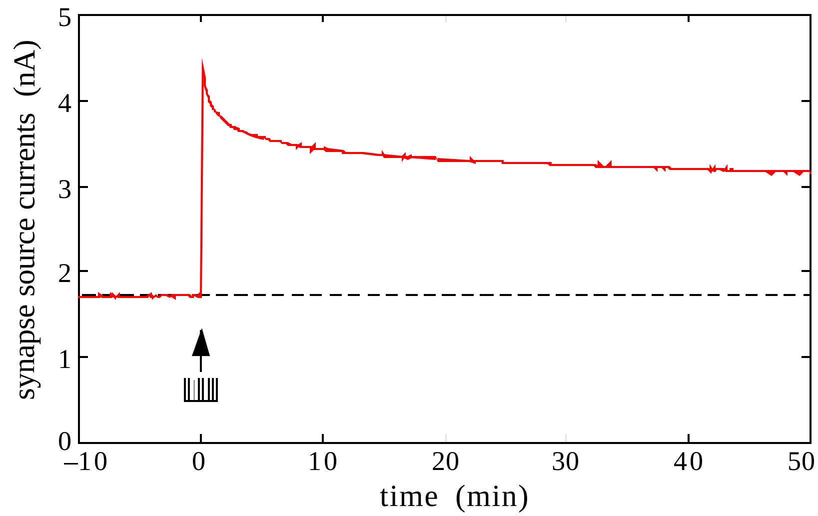
☞ Local, autonomous learning

Biological Synapses



Mossy-fiber EPSC amplitudes plotted over time, before and after the induction of LTP. Brief tetanic stimulation was applied at the time indicated. From Barrionuevo et al., J. Neurophysiol. 55:540-550, 1986.

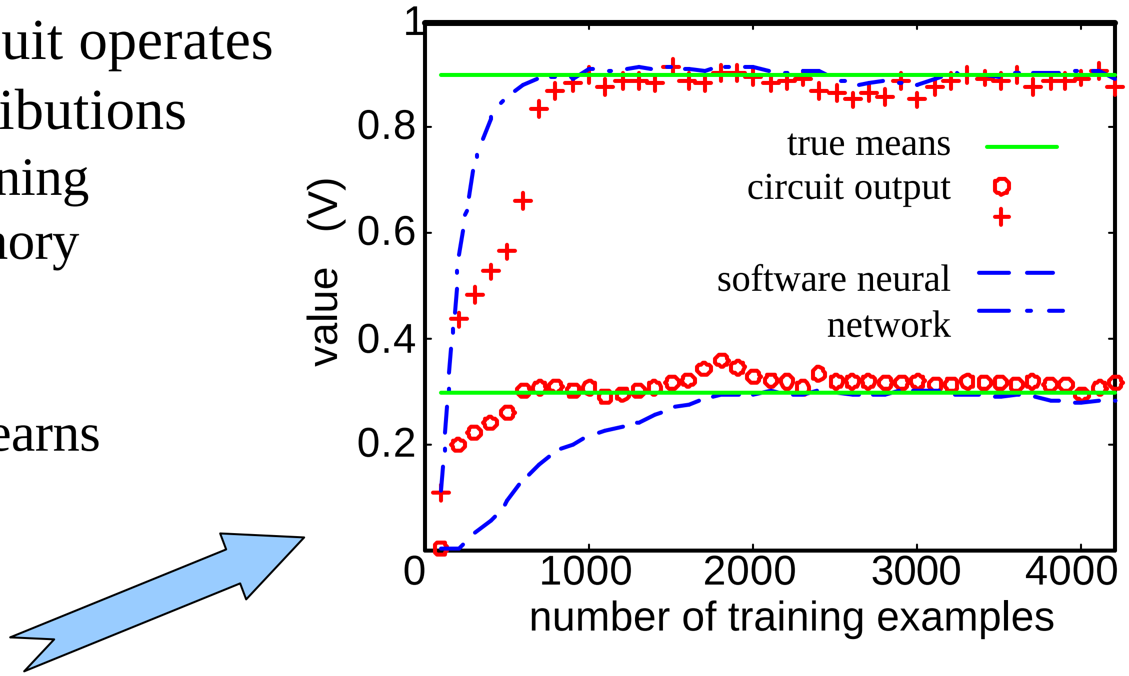
Silicon Synapses



Synapse transistor source currents plotted over time, before and after we applied a tetanic stimulation of 2×10^5 coincident (row & column) pulses, each of 10 μs duration, at the time indicated.

Synaptic circuits can learn complex functions

- Synapse-based circuit operates on probability distributions
  - Competitive learning
  - Nonvolatile memory
  - 11 transistors
  - 0.35µm CMOS
  - Silicon physics learns "naturally"

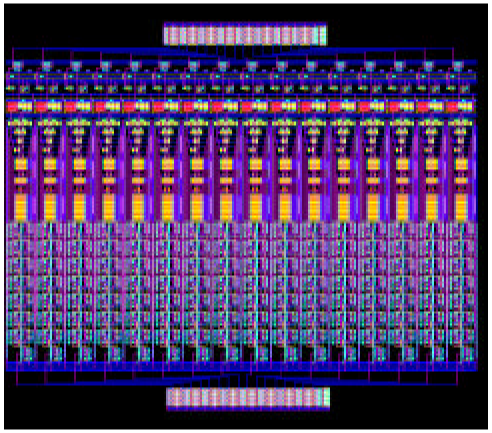


- Silicon learning circuit versus software neural network
  - Both unmix a mixture of Gaussians
  - Silicon circuit consumes nanowatts
    - Scaleable to many inputs and dimensions

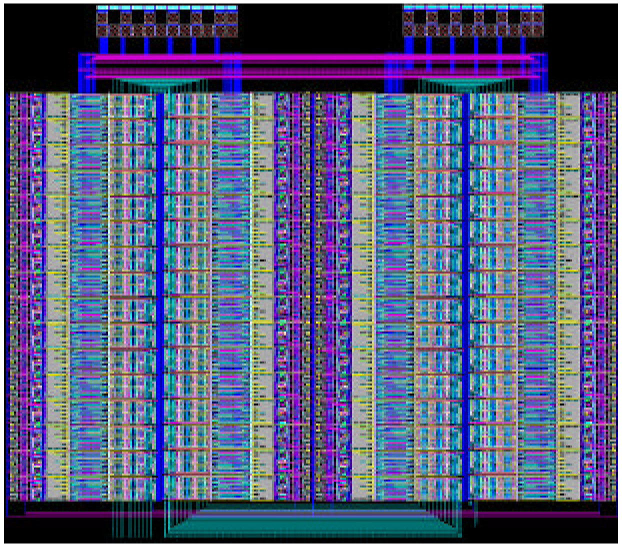
Technology spinoff: Adaptive filters

- Synapse transistors for signal processing
  - ~100× lower power and ~10× smaller size than digital

Mixed-signal FIR filter
16-tap, 7-bits 225MHz, 2.5mW
Built and tested in 0.35µm CMOS
Adjust synaptic tap weights off-line



FIR filter with on-chip learning
64 taps, 10 bits, 200MHz, 25mW
In fabrication in 0.35µm CMOS
On-line synapse-based LMS

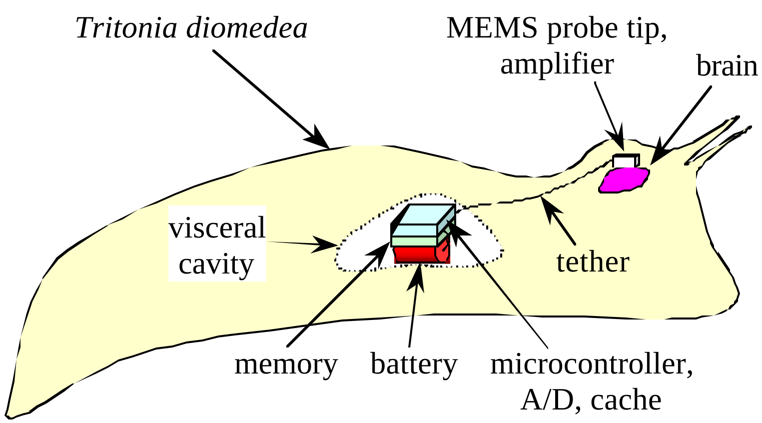


Startup company: Impinj

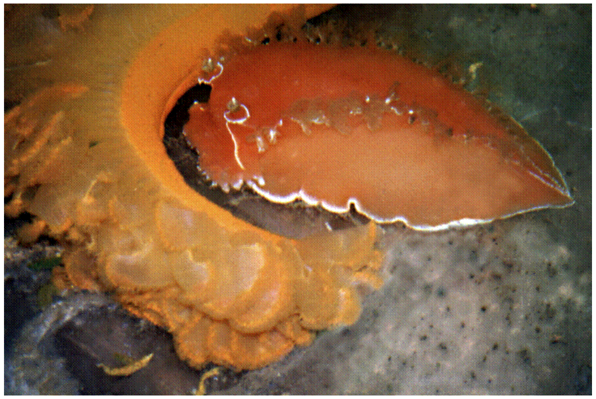
- Chris Diorio (UW) and Carver Mead (Caltech)
- Self-tuning analog computing implemented in standard digital CMOS processes (e.g., TSMC) for telecommunications applications (filtering, DSP, etc.)
- Potentially a factor of 500 power savings, plus the ability to fully integrate analog and digital on the same die

Problem: How to study neural basis of behavior

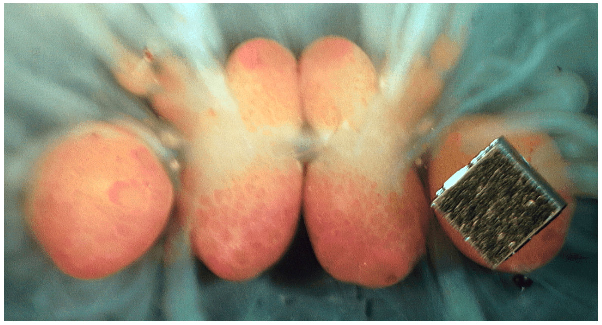
- Measure neural signaling in intact animals
  - Implant a microcontroller in *Tritonia* brain
- *Tritonia* is a model organism
  - Well studied neurophysiology
  - 500µm neurons; tolerant immune response
  - Work-in-progress



A. Tritonia and seapen



B. Brain with implanted chip: Dorsal view

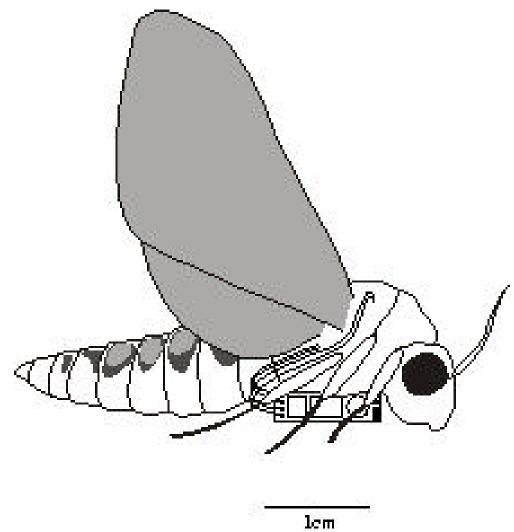


Images courtesy James Beck & Russell Wyeth

An in-flight data recorder for insects

- An autonomous microcontroller "in-the-loop"
  - Study neural basis of flight control

*Manduca Sext*a or "hawk moth"



Participants

- Chris Diorio and students from CSE
- Karl Bohringer and students from EE (MEMS probes)
- Tom Daniel and students from Zoology
- Dennis Willows and students from Friday Harbor Labs
- Funding from Packard, DoD MURI, NSF, DARPA, many others

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