Opportunities for patient-centered healthcare

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Outline

- How mature and how ready for deployment is this area?
- What are some of the emerging technologies and some of the driving biological problems?
- Summary comments about open systems and dedicated systems

Maxwell's Equations

VIII. *A Dynamical Theory of the Electromagnetic Field.* By J. Clerk Maxwell, *F.R.S.*

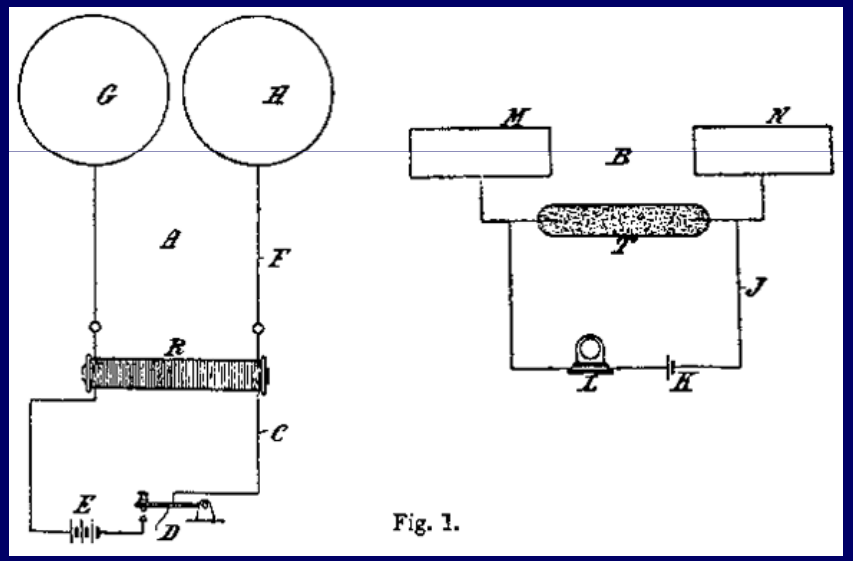
Received October 27,—Read December 8, 1864.

PART I.—INTRODUCTORY.

(1) The most obvious mechanical phenomenon in electrical and magnetical experiments is the mutual action by which bodies in certain states set each other in motion while still at a sensible distance from each other. The first step, therefore, in reducing these phenomena into scientific form, is to ascertain the magnitude and direction of the force acting between the bodies, and when it is found that this force depends in a certain way upon the relative position of the bodies and on their electric or magnetic condition, it seems at first sight natural to explain the facts by assuming the existence of something either at rest or in motion in each body, constituting its electric or magnetic state, and capable of acting at a distance according to mathematical laws.

In this way mathematical theories of statical electricity, of magnetism, of the mechanical action between conductors carrying currents, and of the induction of currents have been formed. In these theories the force acting between the two bodies is treated with reference only to the condition of the bodies and their relative position, and without

Marconi's Radio Telegraph System



Patient-Centered Healthcare

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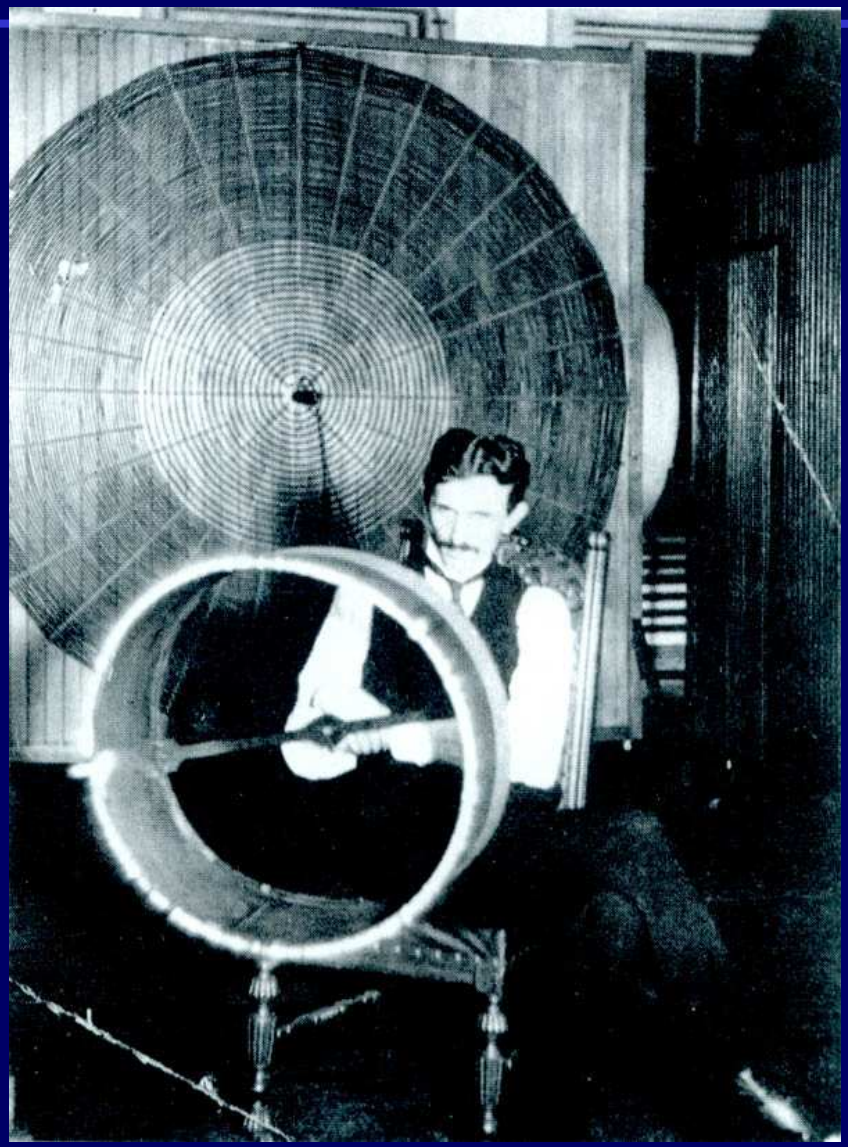
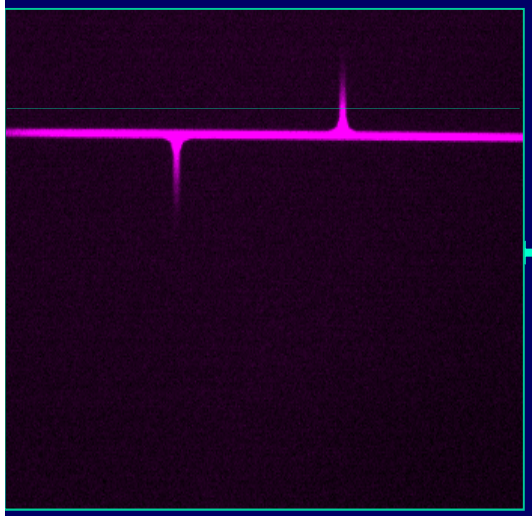
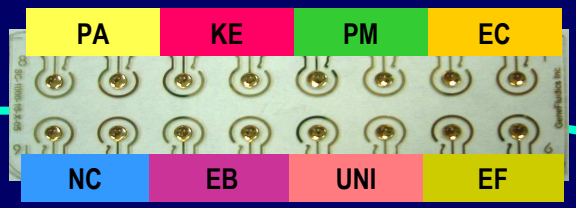
Technologies

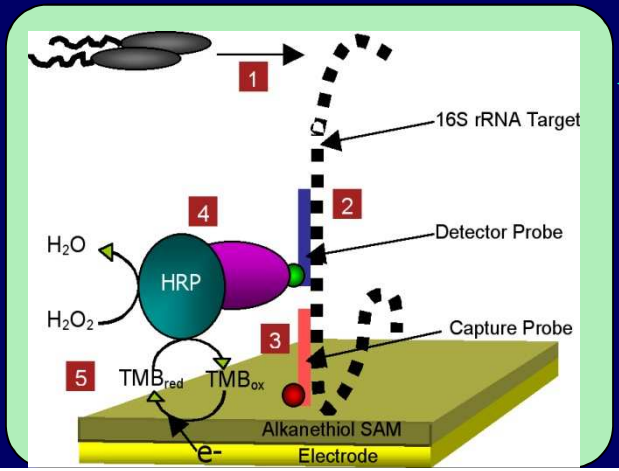


Uropathogen Detection Using DNA Biosensors

Microfluidic DNA based system for the rapid identification of pathogens in urine. **Detection in Minutes** (vs days by conventional cultures)







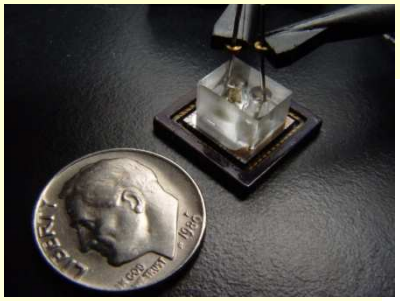
Features

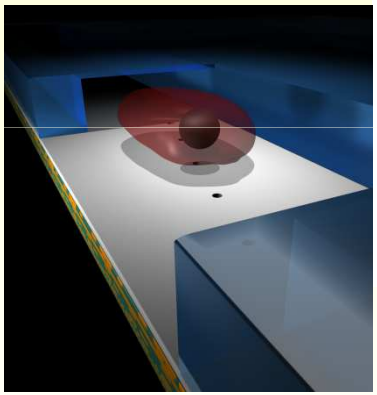
1. Ultra-sensitive, low cost sensor chip
2. Species-specific probes for RNA of Bacteria
3. Electrochemical signal when RNA detected

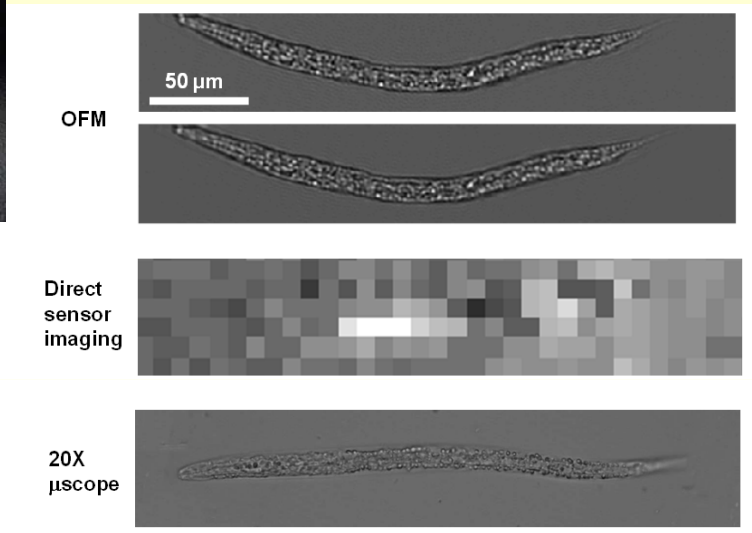
$10 On-Chip Microscope System – High-resolution, Cheap, and Compact

conventional microscope

optofluidic microscope







floaters in our eyes

The optofluidic microscope (OFM) enables high-resolution (~ 1 micron) on-chip cell and micro-organism imaging by drawing inspiration from the 'floater' phenomenon. The system is lensless, high-resolution and cheap to mass-produce.

X Cui, L Lee, X Heng, W Zhong, PW Sternberg, D Psaltis & C Yang, PNAS Vol 105, 10670 (2008)

GAS CHROMATOGRAPHY: Separation and Identification of Complex Gaseous Mixtures

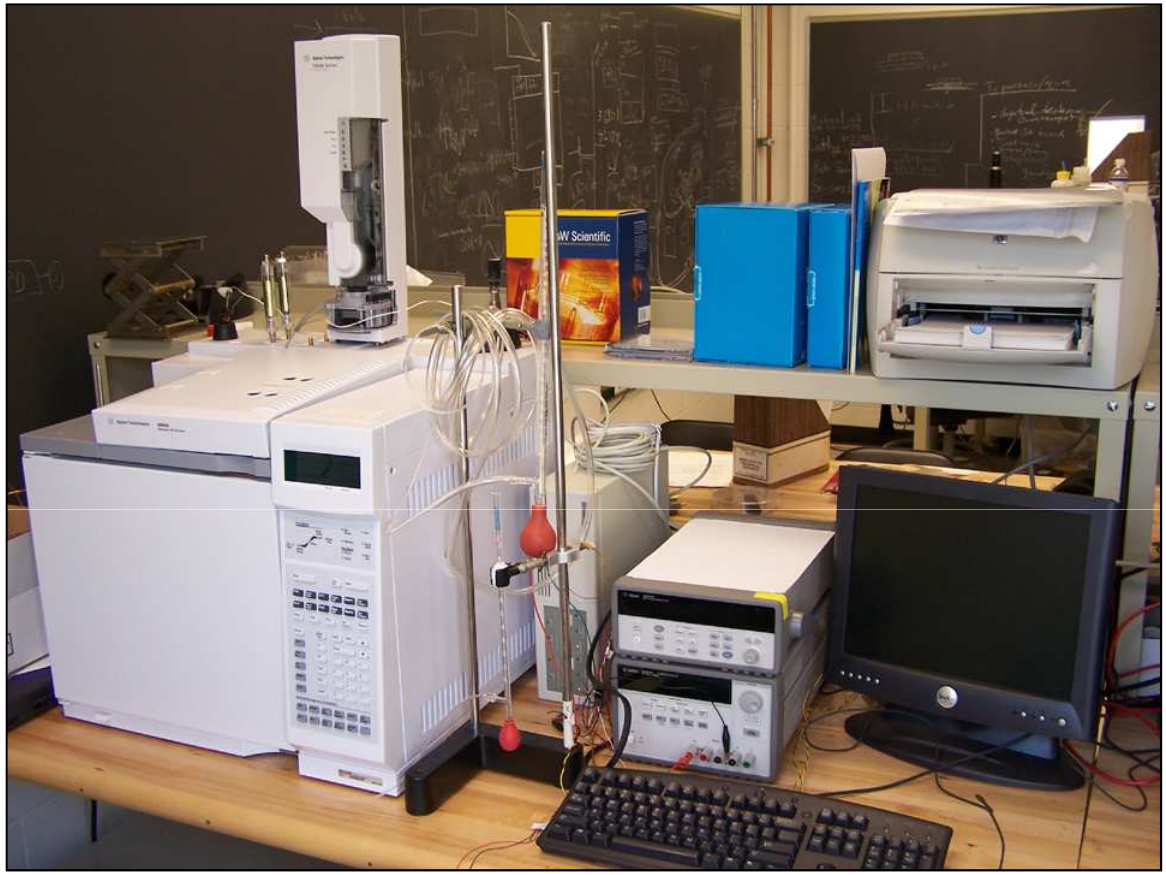


Table-top instruments that offer precision analysis but are relatively expensive, slow, and not portable enough for field use

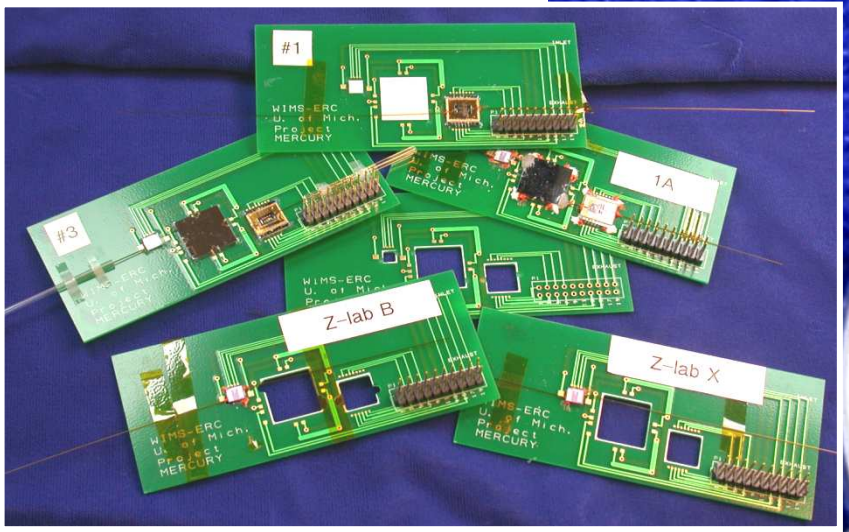
The WIMS µGC

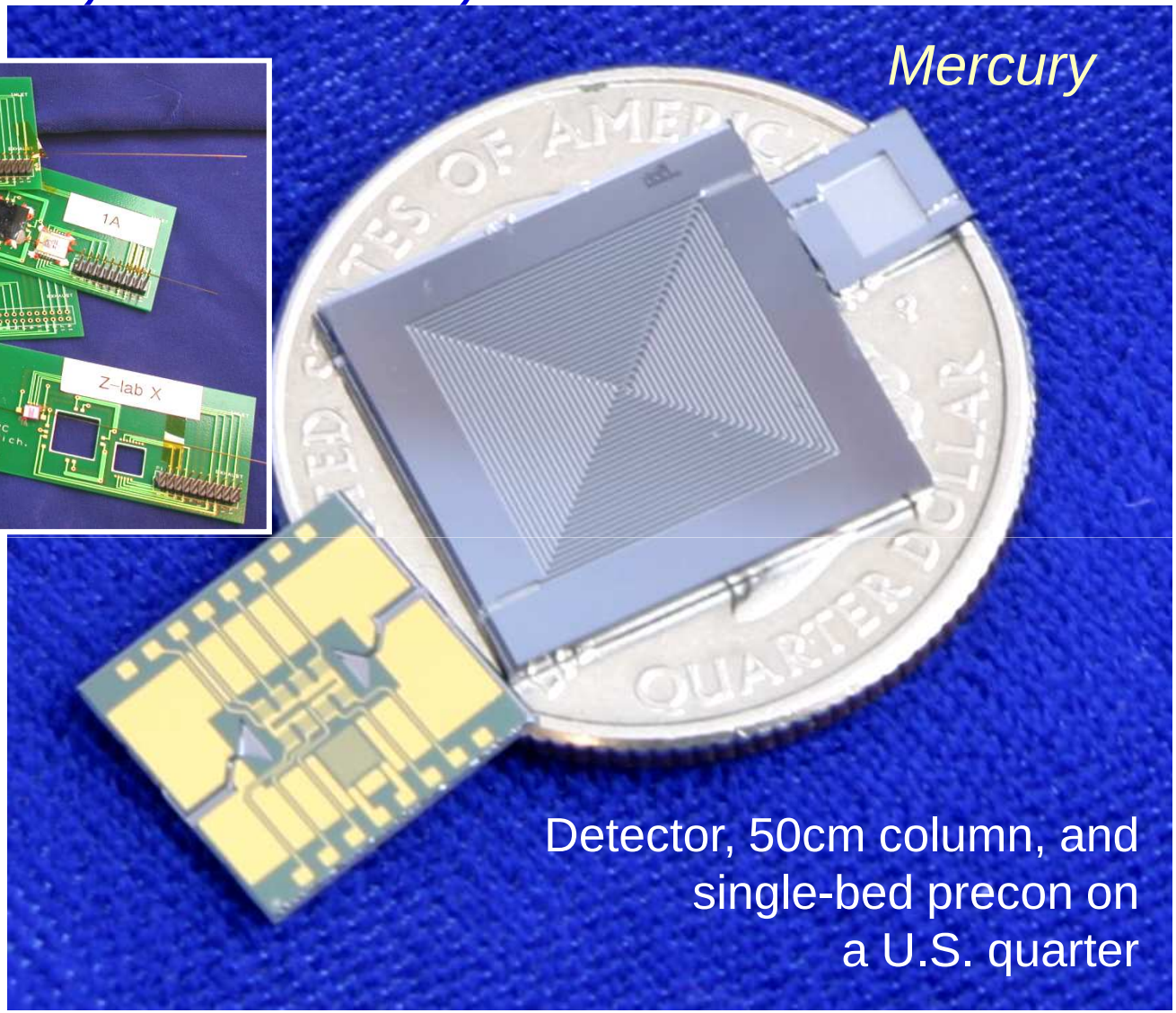
100X Smaller
100X Cheaper
100X Faster

TARGETED PERFORMANCE:

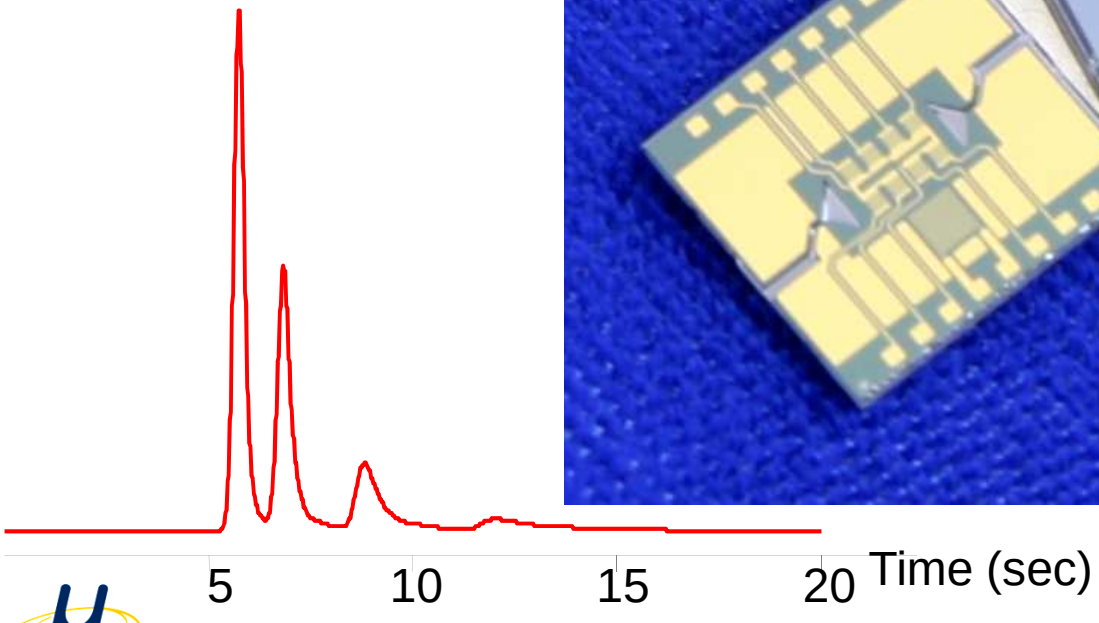
- 30-50 Organic-Vapor Pollutants per Analysis
- Detection Levels: <1ppb per analyte
- Analysis time: 5-50sec
- Size: 5-50cc

µGC PRECONS, COLUMNS, AND DETECTORS

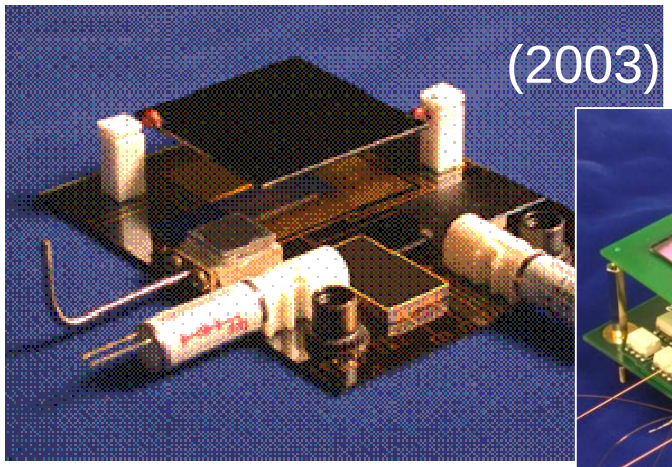




Detector, 50cm column, and single-bed precon on a U.S. quarter

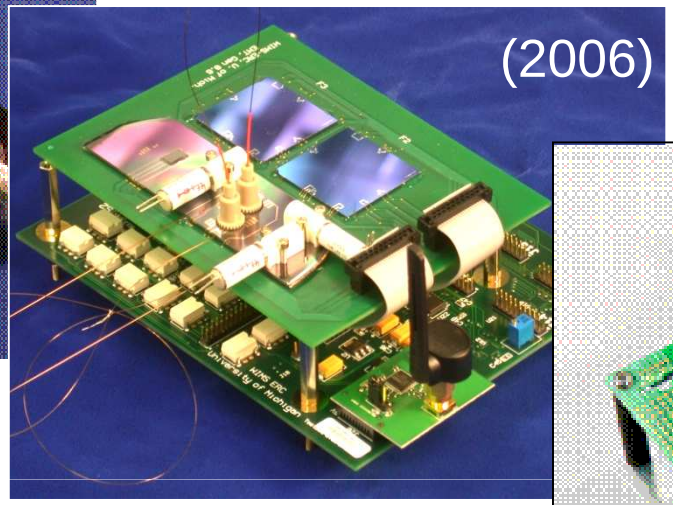


µGCs FOR COMPLEX GASEOUS MIXTURES

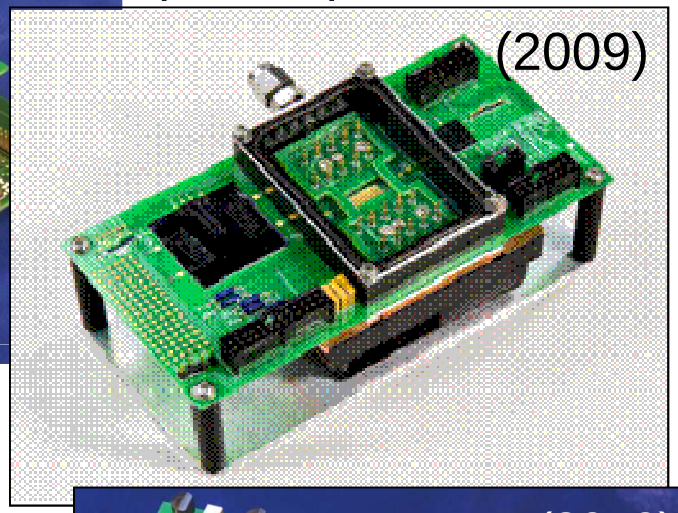


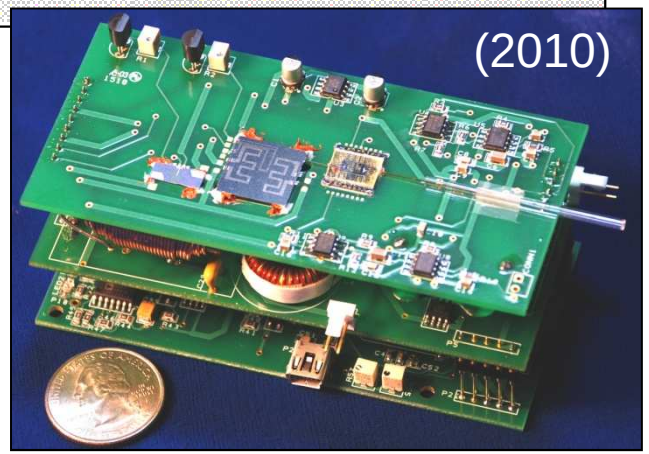
Single column

Dual-column (tunable)



Comprehensive µGC x µGC

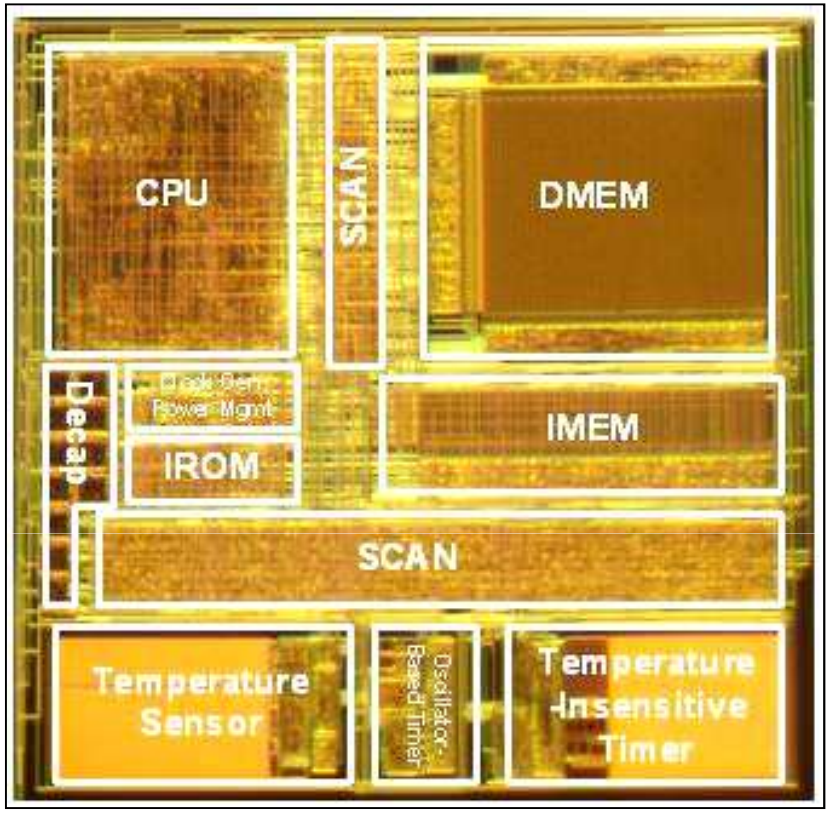




Mercury

PHOENIX: A 30pW Platform for Sensing Applications

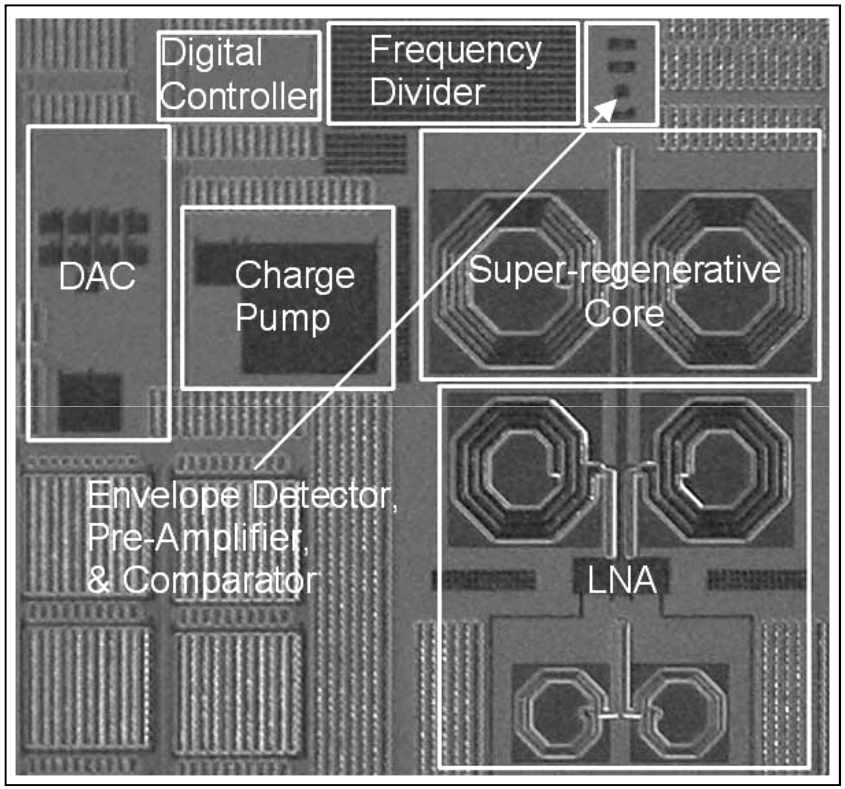
- Minimizes sleep energy to realize the world's lowest-power processors
- The Phoenix microprocessor has been designed with comprehensive sleep strategy
  - Unique power gating approach
  - Event-driven CPU with compact instruction set
  - H/W supported compression
  - Low leakage SRAM cell
  - Adaptive leakage management in DMEM
- Measurements
  - $P_{sleep,avg}$= **30pW**
  - E_{active}= **2.8pJ/Inst** at 0.5V
  - P_{sram} = **10.9fW/bit** (retentive)
  - 915 x 915µm^2 in TSMC 0.18µm
  - 10 yr lifetime with 1mm^2 thin-film battery



Professor Dennis Sylvester

AN 0.13µM CMOS 2.4GHZ ISM BAND SUPER REGENERATIVE RADIO

The first fully integrated super-regenerative radio



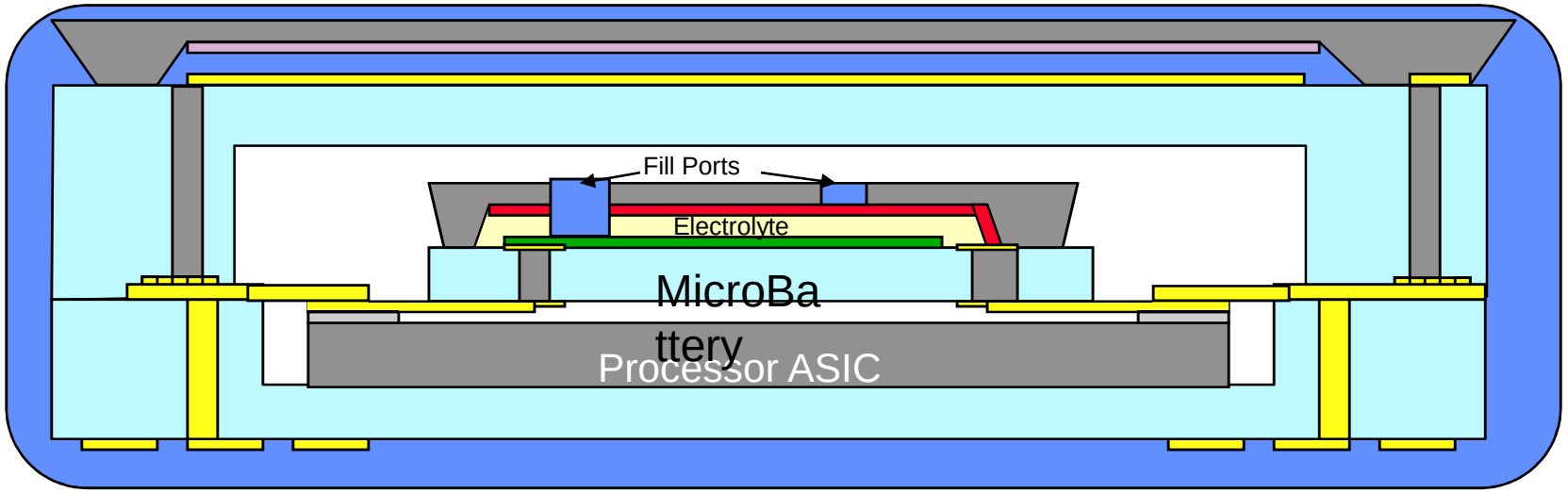
Supply	1.2 V
Supply current	2.5 mA
Area	1mm^2
Sensitivity	-90 dBm
Data rate	< 500 Kbits/s
Channel spacing	10 MHz
BER	< 1/1000

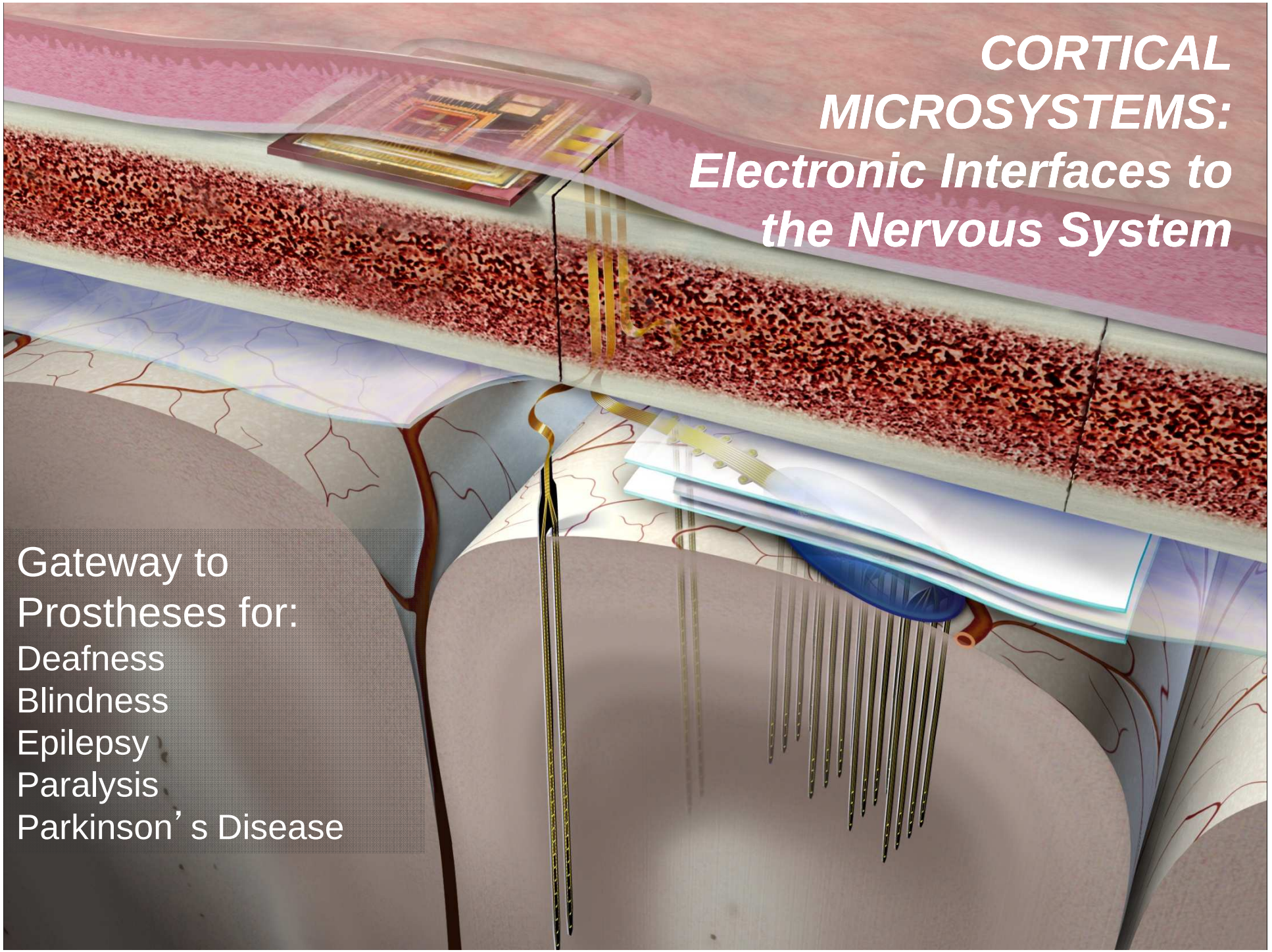
Professor Michael Flynn

- Record energy efficient ~ **5.8nJ/bit**
- New multi-channel architecture with excellent selectivity

A WIRELESS INTRAOCULAR PRESSURE SENSOR FOR TREATING GLAUCOMA

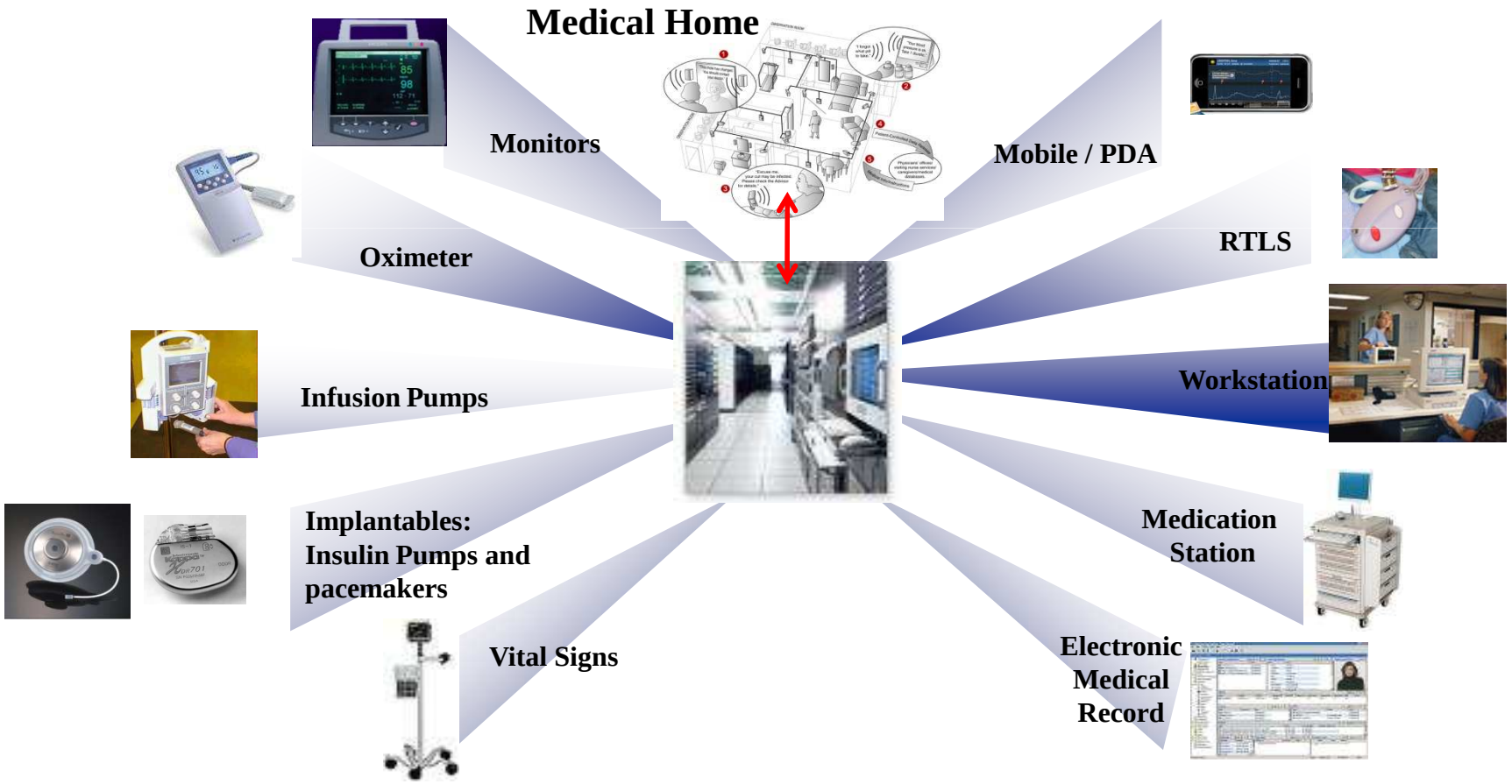
- Intraocular pressure is a significant key in treating glaucoma, the second-leading cause of blindness, affecting 65 million worldwide
- Sensor will take readings every 15min, storing them in memory
- Powered by energy scavenging; read out once a day over an UWB link
- Integrates the pressure sensor, rechargeable microbattery, wireless link, and embedded processor in a parylene-covered glass package
- Size: 0.5mm x 1mm x 2mm
- Phoenix processor holds data at 30pW; operates at 300nW.




CORTICAL MICROSYSTEMS:
Electronic Interfaces to the Nervous System
Gateway to Prostheses for:
Deafness
Blindness
Epilepsy
Paralysis
Parkinson's Disease

Applications

Proliferation of Wireless Devices



Monitor Diet / Electrolyte Intake in ESRD

DIMA

Dietary Intake Monitoring Application

PDA :

- ***Renal Failure:***
  Monitor dietary nutrients
- **Input:**
  Visual Interface, scan bar code
- **Output:**
  Visual display of nutrients
- **Dietary Hx:**
  Recall of previous meals

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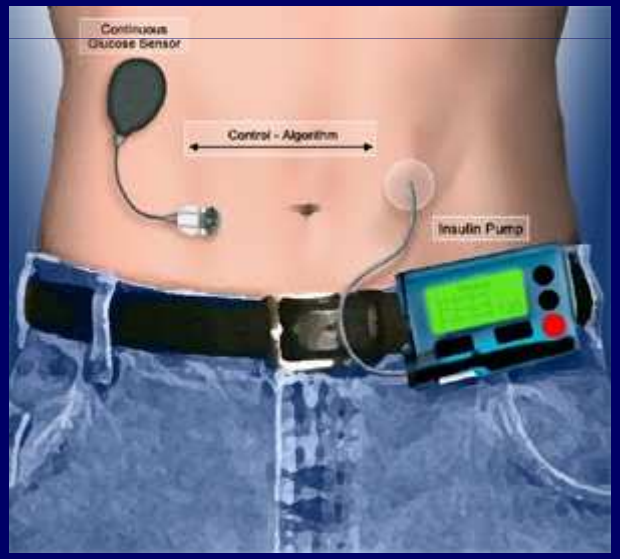
Artificial Pancreas



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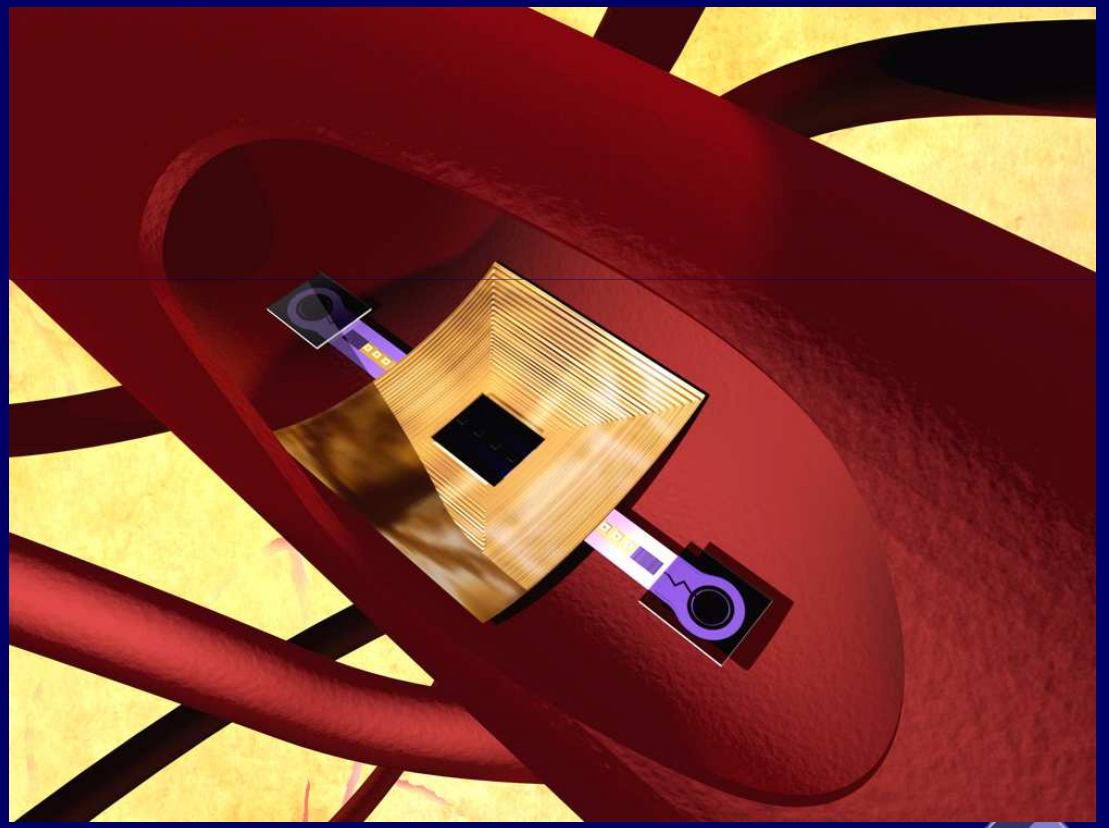
Hypertension management



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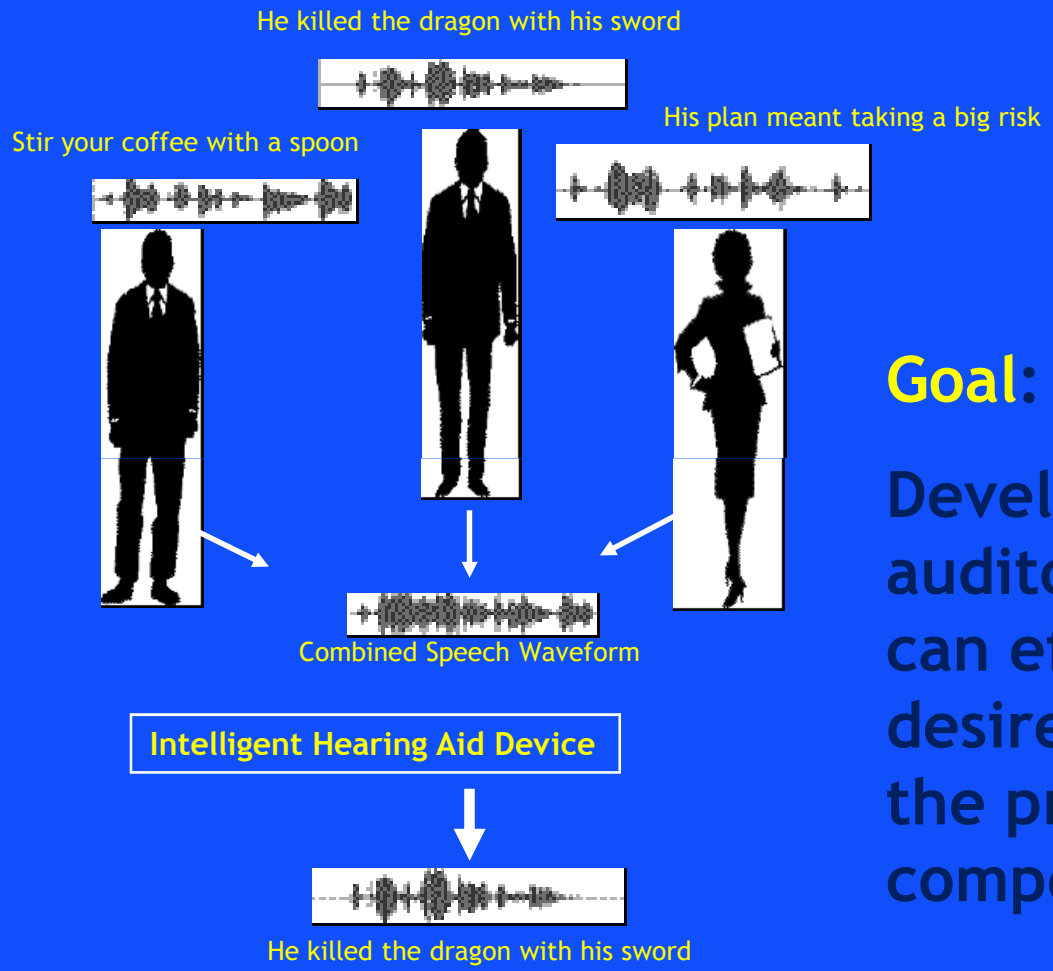
Directional Hearing Aid



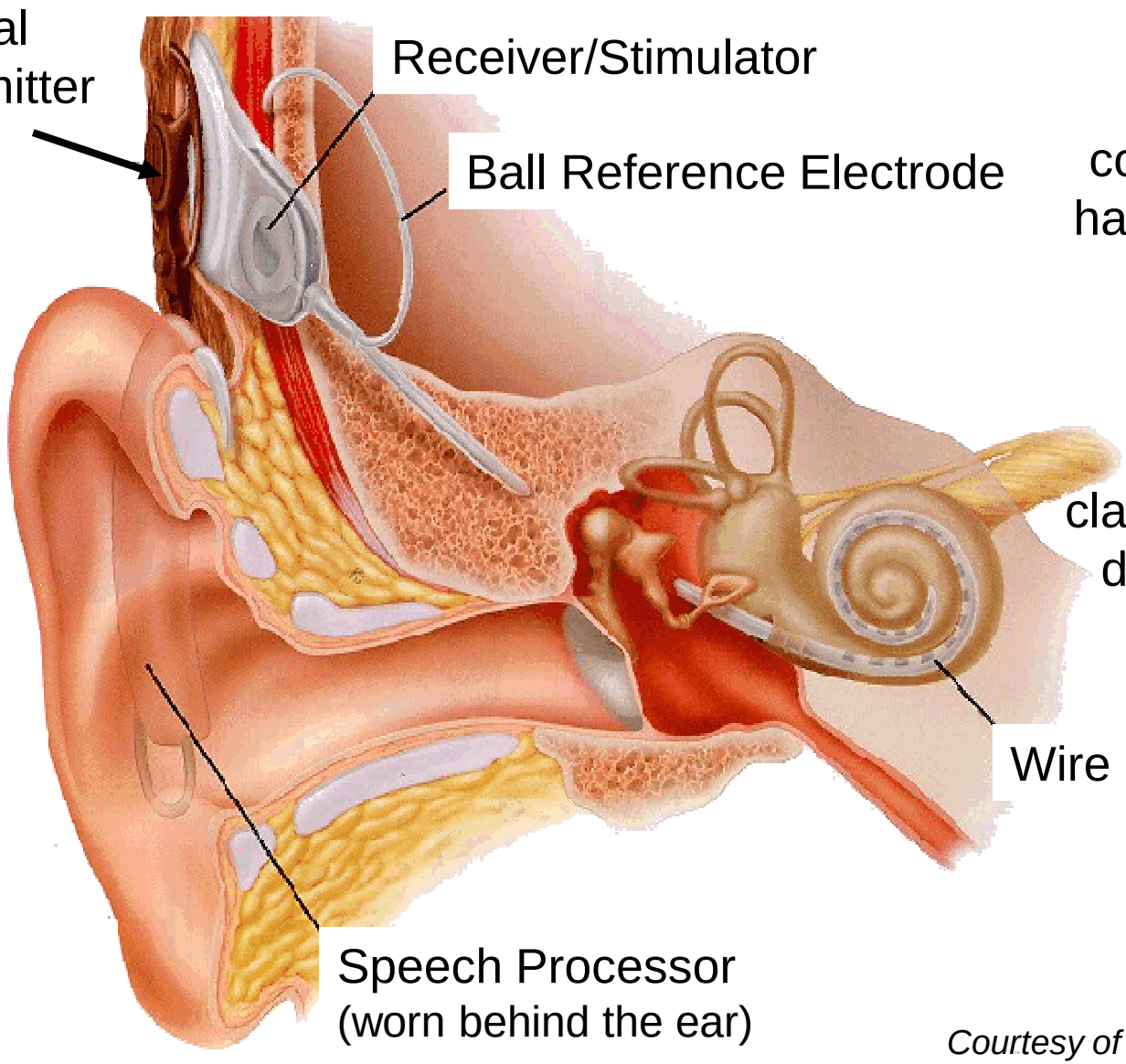
Goal:

Develop high performance auditory processors which can effectively extract a desired speech signal in the presence of multiple competing sounds.

Principles For Binaural Directional Hearing Aids

- Two microphones (placed on the lateral side of the head).
- Integrate outputs to compute directional information
- Single unified output.
- Allow listeners to actively steer toward the target sound.
- Real-time Operation
- Highly directionally selective over short distances
- Separately adaptive in each frequency band

ANATOMY OF A COCHLEAR PROSTHESIS

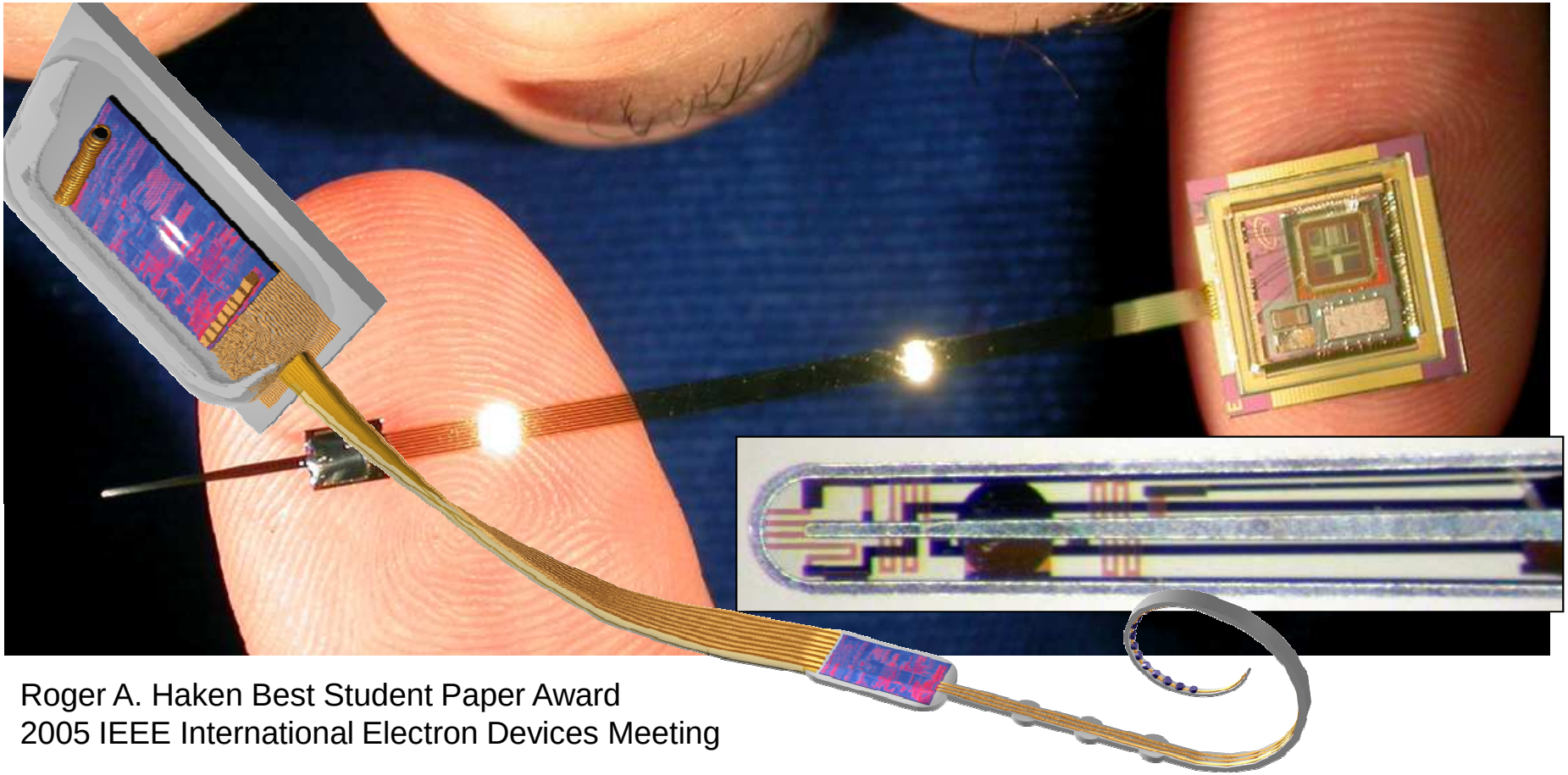


Over 150,000 cochlear prostheses have been implanted to date.

250 million people worldwide are classified as *disabled* due to hearing loss.

Courtesy of Cochlear Corporation

A HIGH-DENSITY COCHLEAR MICROSYSTEM



Roger A. Haken Best Student Paper Award
2005 IEEE International Electron Devices Meeting

Thin-film electrode technology; up to 128 high-density IrO sites
Embedded sensors for array position and wall contact
Biocompatible silicon-quartz-parylene structure; integrated 8-lead microcable
Articulated insertion tools being developed to allow deep placement

Monitoring movement disorders

Assisted Walking

(Medication is Working)

<CLICK on Image>

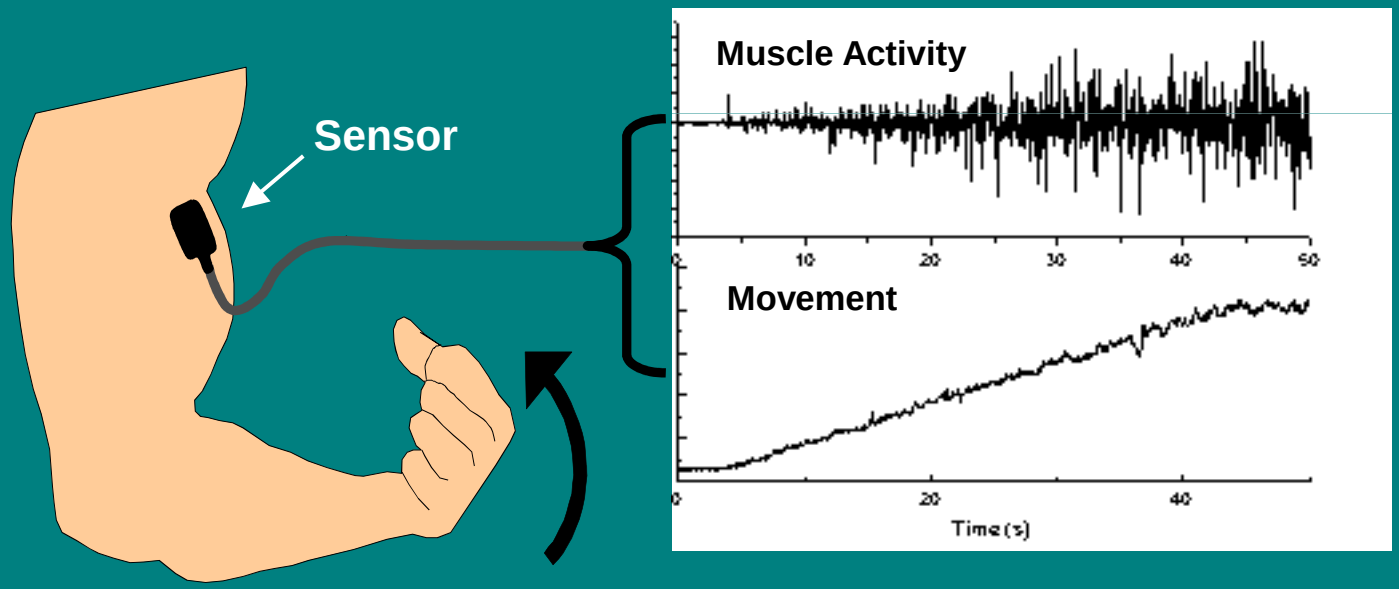
Freezing Gait

(Medication has Worn Off)

<CLICK on Image>

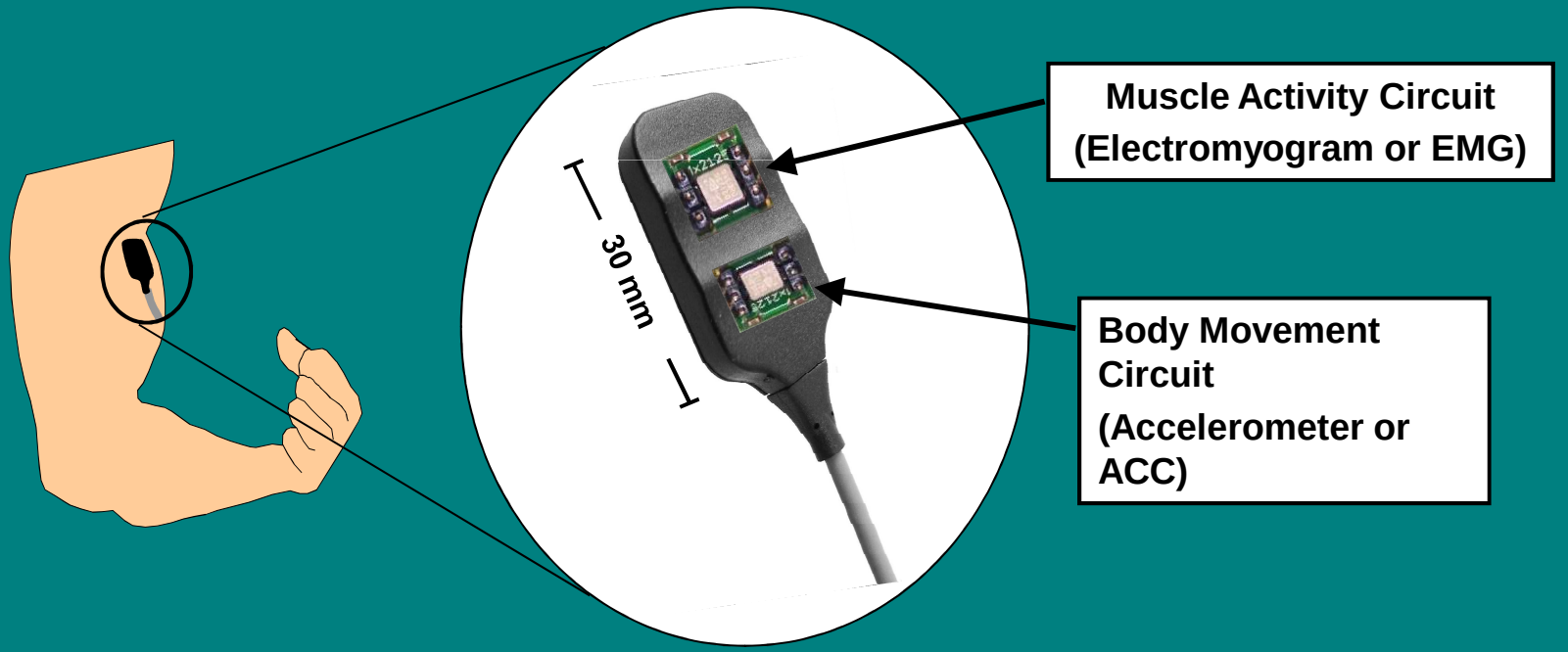
Monitoring movement disorders

- The patient's mobility status, motor disorders, and "On-Off" medication states are monitored by sensors placed on the body.
- These sensors detect **muscle activity** and **body movement/position** .



Sensor Technology

A novel sensor technology was developed to integrate the electronic components for recording muscle activity and body movement into a single compact design



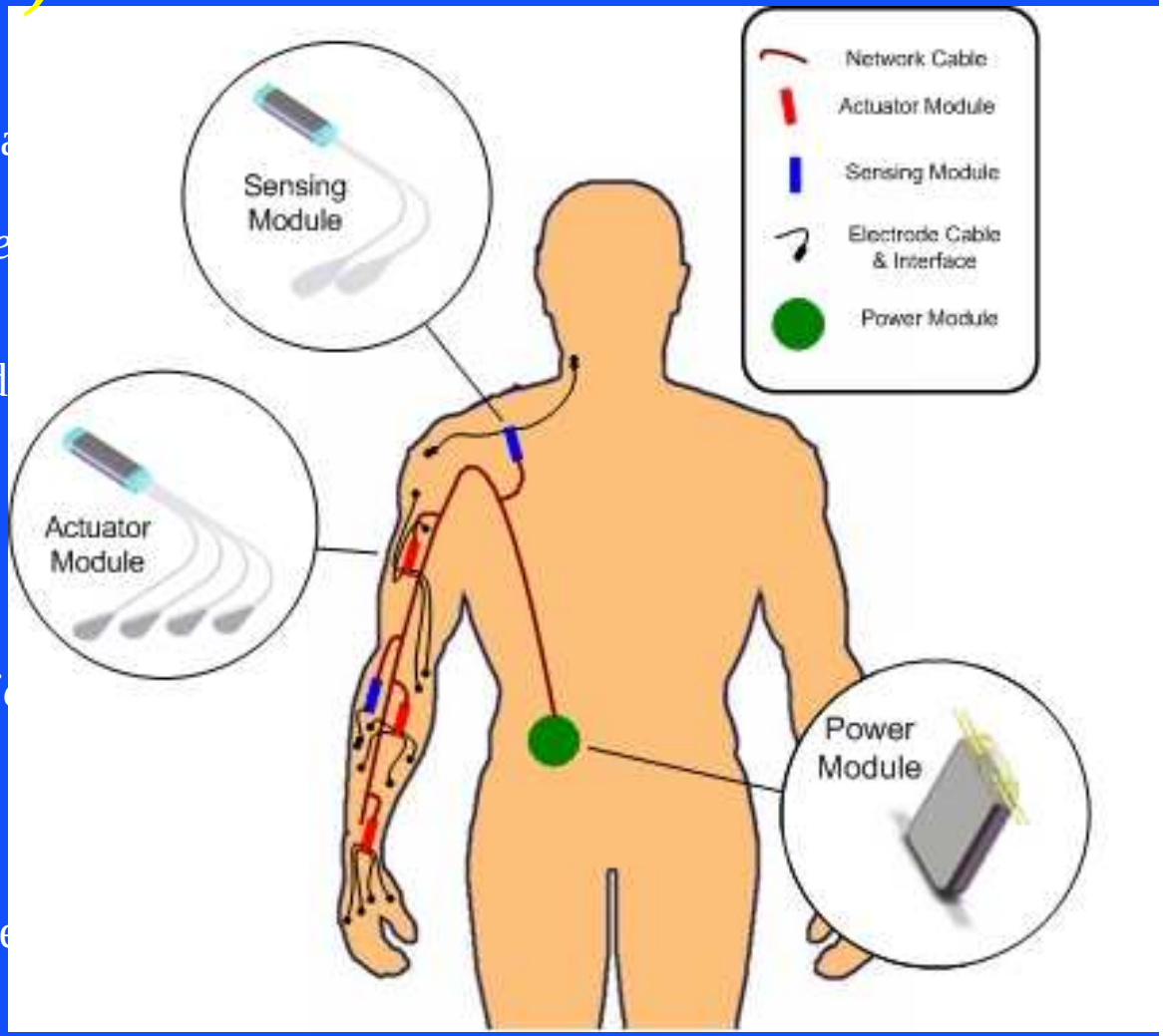
DELSYS®

Crowded Clinical Environments

GENERAL DESCRIPTION

The Networked Neuroprosthetic System (NNPS)

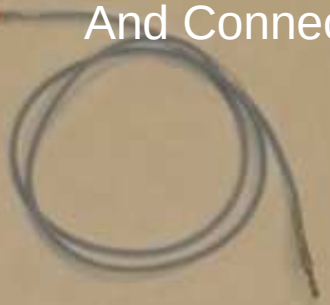
- *Network infrastructure* between implanted *functional modules* via *network cable*;
- Modules are *small* and *distributed* remotely throughout the body, local to their target area (minimizing leadwire length and bulk);
- Actuator Modules: Muscle Stimulators, Nerve Stimulators;
- Sensor Modules Transducer, Biopotential;
- Power Module: *Power distribution* to each module from a *central* rechargeable battery via the network cable;
- Network cable also provides the *communication backbone* between modules of all types.

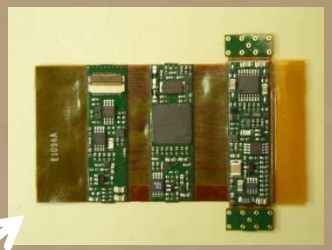


Networked Neuroprosthesis Components

Power Module

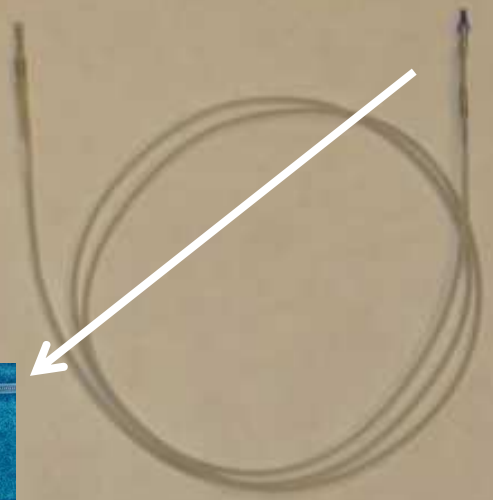
Network Cable
And Connector

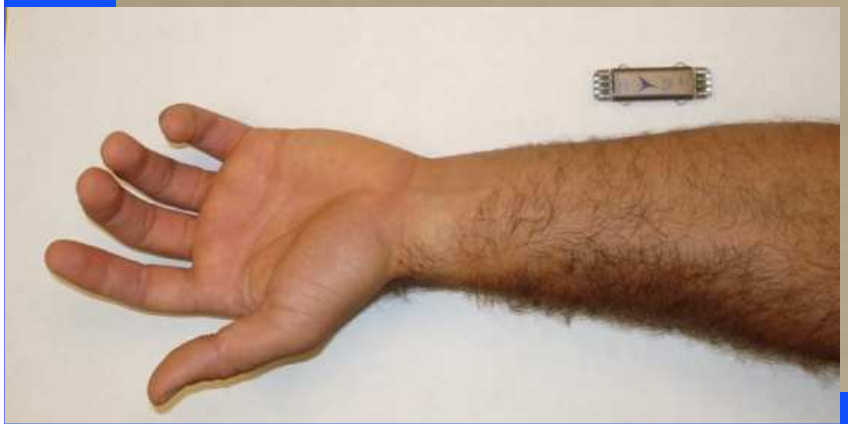


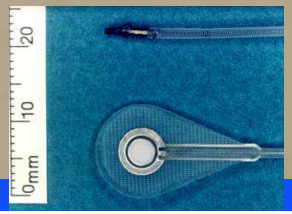


Remote Modules
4 Channel Stimulator
2 Channel Myoelectric
Signal

Stimulating
And
Recording
Electrodes







Targeted Clinical Applications

- Restoration of sensorimotor system function
- Systems that require interaction between sensors and actuators
- Systems expected to be permanent
- Systems with a long life-expectancy
- Fully implanted (including power)

Moving forward

- Industry is active
- Government is active
- Academia is active
- The next step is systems
- The area will flourish whether work is done collaboratively or in isolation but
- Identifying precompetitive areas for work is critical
- The need and opportunities are great

Thank You