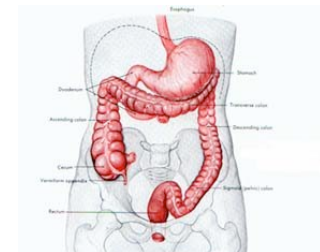
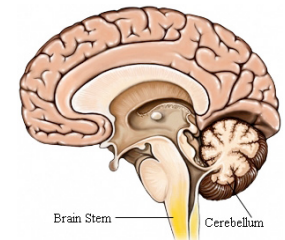


BiInspired Neuromodulation of Obesity: The return of the Wandering Nerve (Vagus)

Imperial College
London

Prof Chris Toumazou FRS, FEng, FMedSci
Regius Professor of Engineering
Imperial College London

Chief Executive & Chairman, DNA Electronics
Chairman Toumaz Healthcare

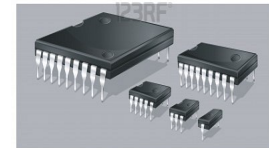
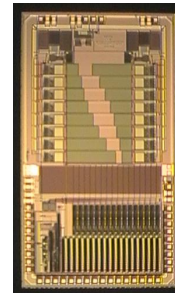
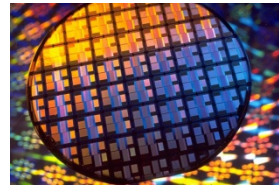


Brain Forum, Lausanne 2015

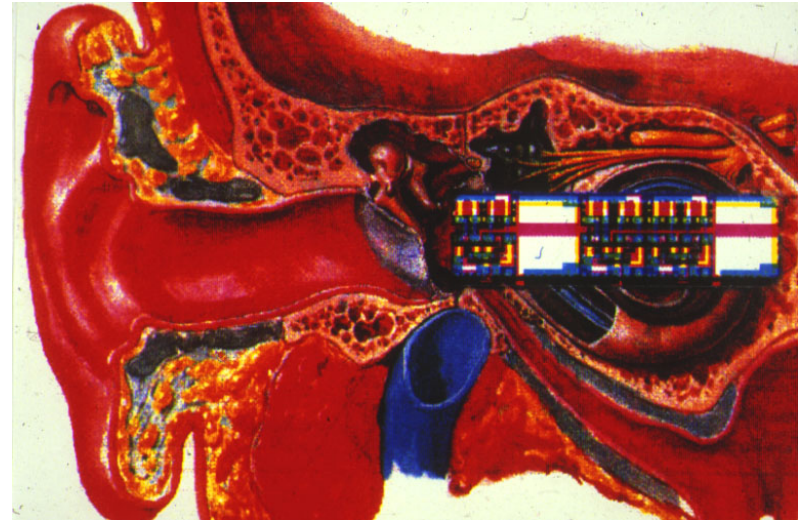
Radio Chips for Mobile Communications



Ultra Low Power Analogue RF

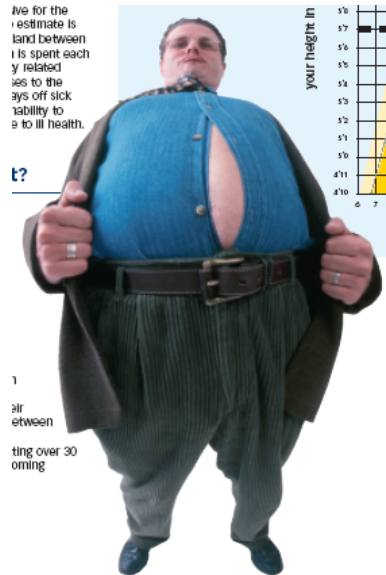


Silicon Ear- 2001 Lowest power



The Challenges

Uninformed and Poor Lifestyle Choices



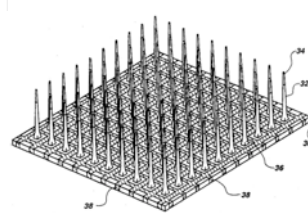
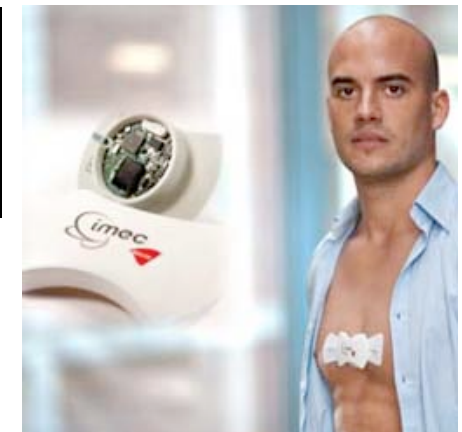
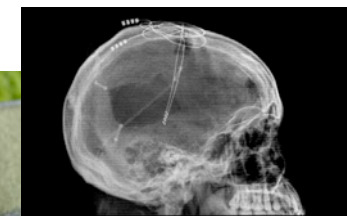
Obesity ~25% of
population (UK)

Poor Diet

Sedentary
Lifestyle

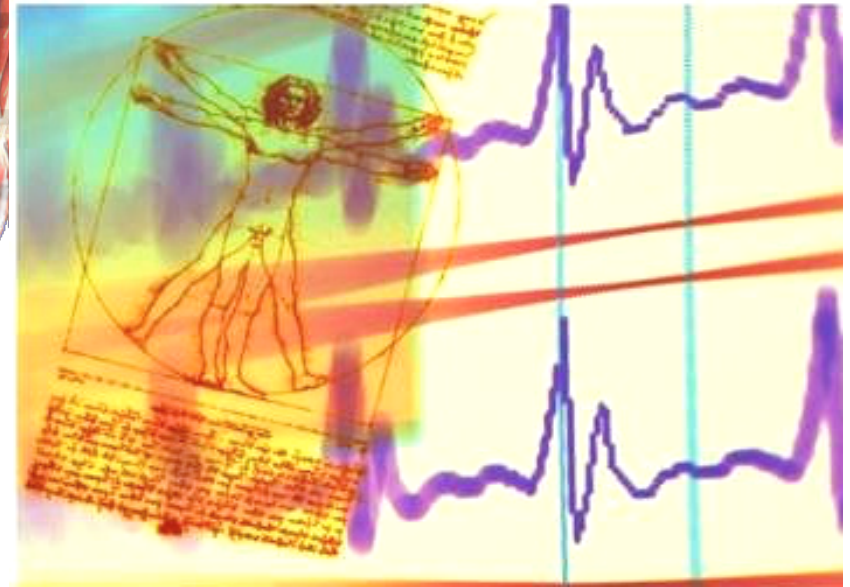
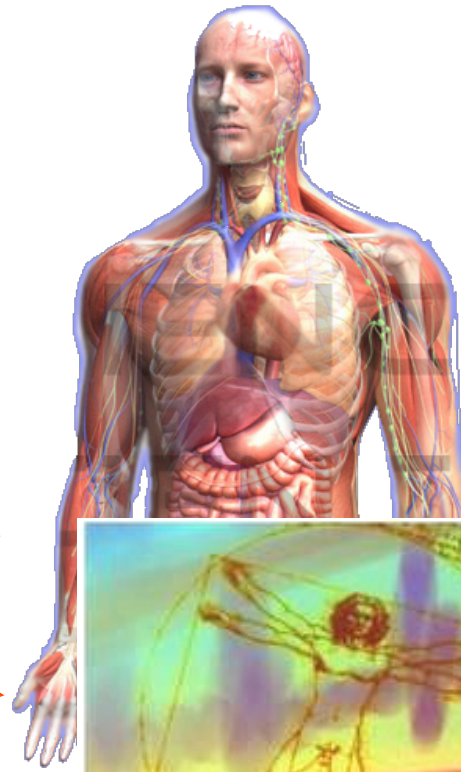
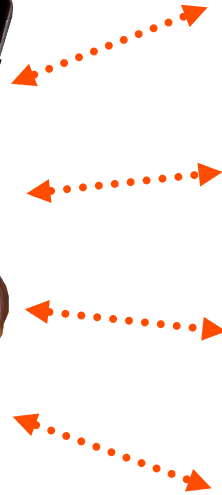
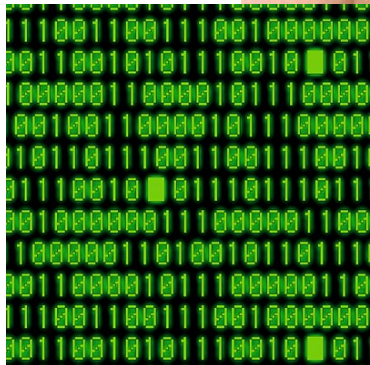
Chronic diseases such as diabetes and heart disease

GOOD NEWS



Health on the Go !!

Personalised Medicine



Analogue



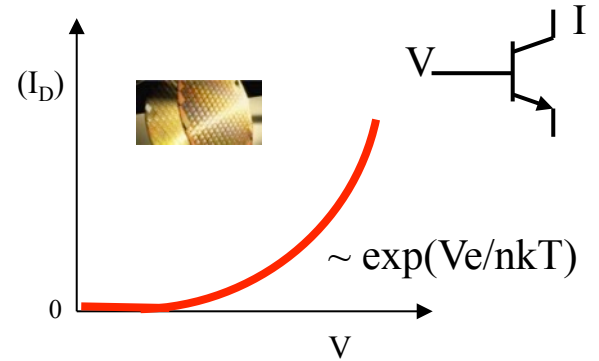
Where's the monkey???



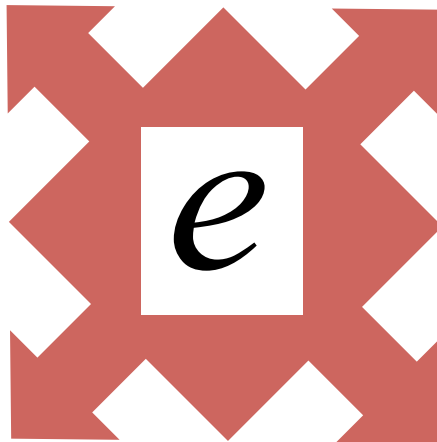
PHYSICS



Boltzmann
1844-1906



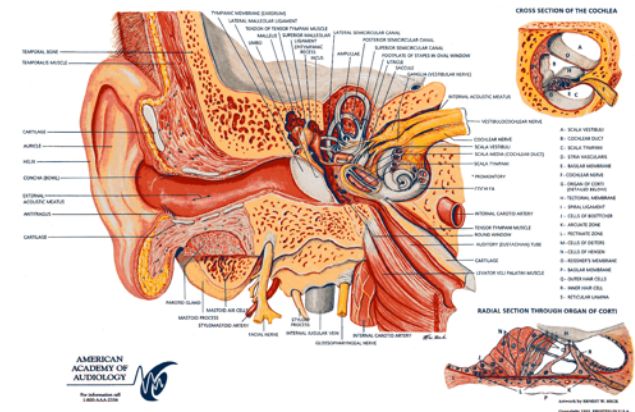
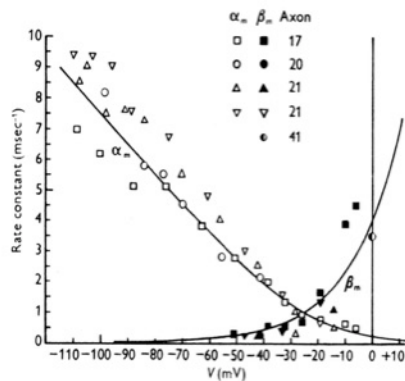
Microchip



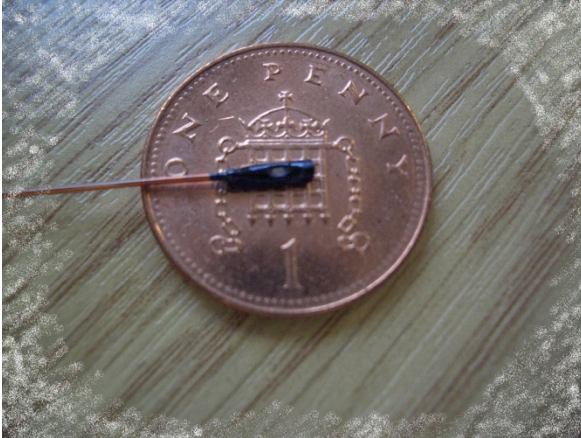
Nervous Tissue



Hodgkin-Huxley
Nerve Axon -1963
NERNST

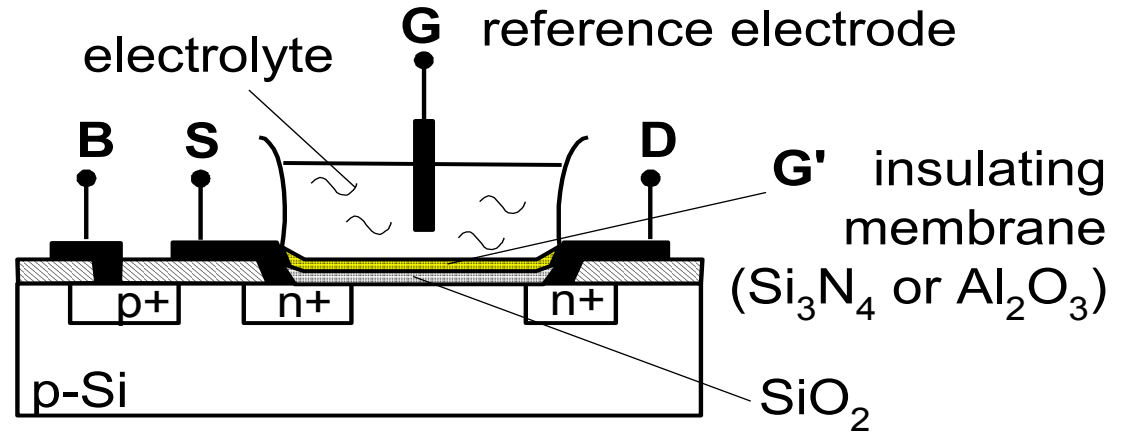
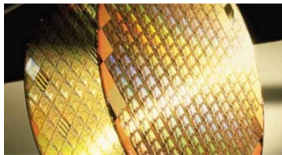


Chemical Transistors (ISFETs)



Opportunities

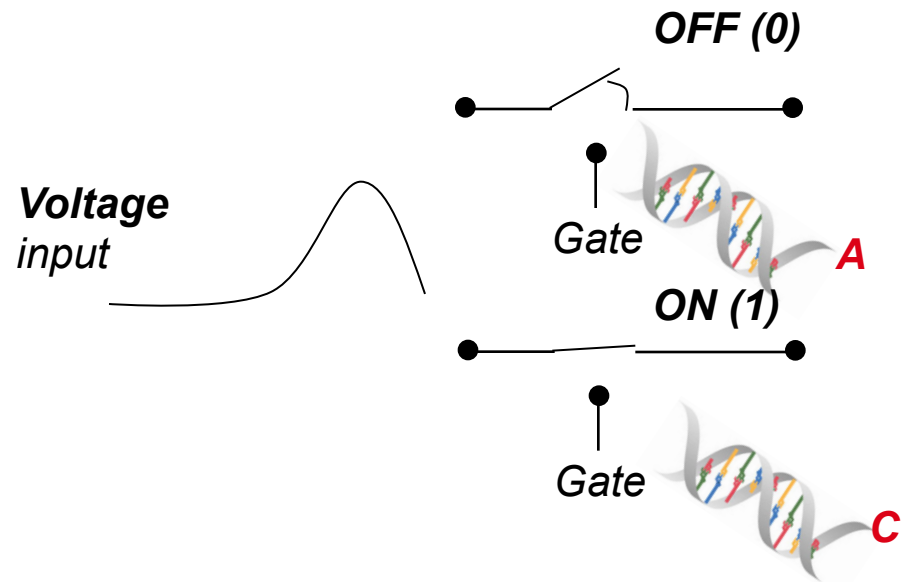
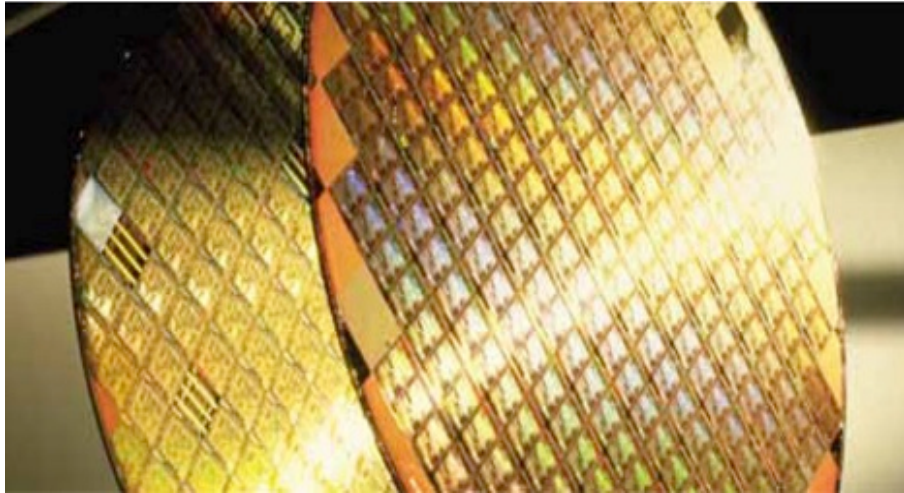
- low-cost
- mass-fabrication
- small, fast
- integration of electronics



pH to voltage converter

Eureka Moment

Semiconductor DNA detection



Toumazou et al., US AND PATENTS WO2003073088, Chemical Reaction Monitoring and Semiconductor Genome Sequencing. Priority 2001

Mature technology:
DNAe's semiconductor sequencing technology
is being used in laboratories around the world



ion torrent
by *life* technologies™



Clearly Needs an IP Address



1933

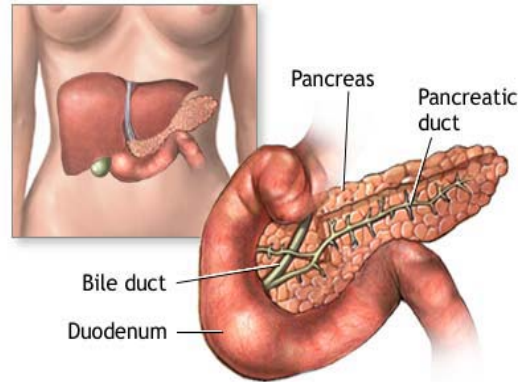
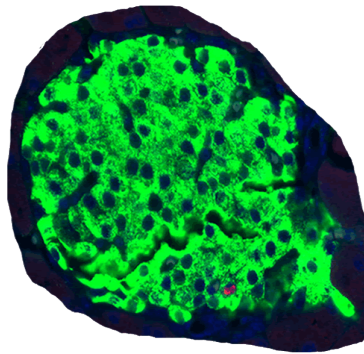


2011

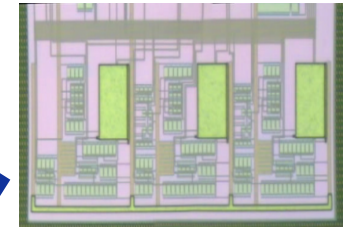
Brain Forum, Lausanne 2015

Silicon Beta Cell

Biological Beta Cell

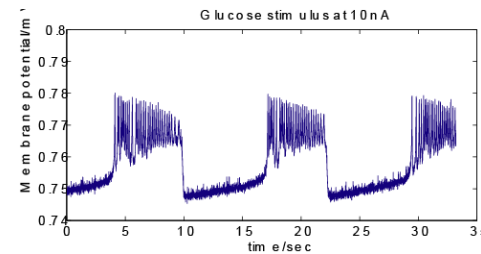
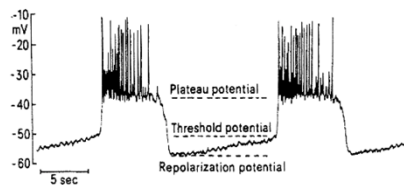


Silicon Beta Cell Chip



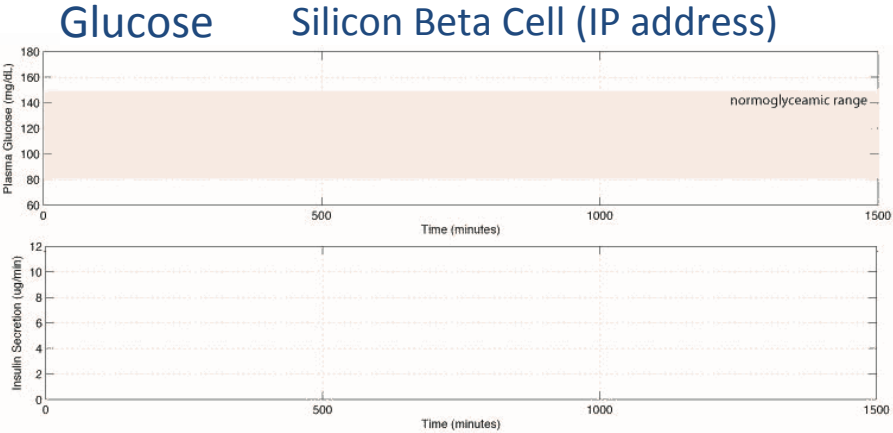
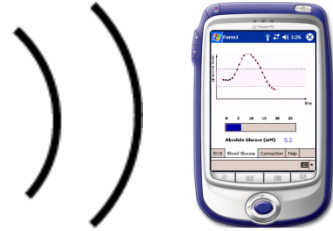
Size: 5x5 mm

Power Consumption: 2.6 μ W



Georgiou,P, Toumazou,C: A Silicon Pancreatic Beta Cell for Diabetes. *IEEE Transactions on Biomedical Circuits and Systems*, 1:39-49, 2007

Worlds first Bio-inspired Closed Loop Artificial Pancreas

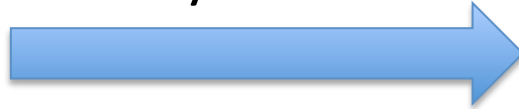


Obesity:

A European and Worldwide problem



Last 20 years in EU



– Current treatments ineffective

- No drug available – all are banned
- Bariatric surgery is expensive with mortality rates

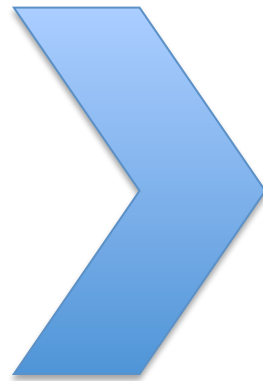
Obesity: *A World Epidemic*

- 1 in 3 Adults Obese
- 1 in 3 Children Obese or Overweight.



Obesity

- Increased diabetes, cancer, heart disease
- Being overweight doubles risk of death
- Causes 1,000,000 deaths/year in EU (7%)



Anti-obesity Drugs

- Fenfluramine
 - **Banned**
- Rimonobant
 - **Banned**
- Sibutramine
 - **Banned**



Need alternative approach

Current therapies

- Diet and Exercise
 - Ineffective



"Hundreds of years of medical progress, and all you can tell me to do is *eat less?*"

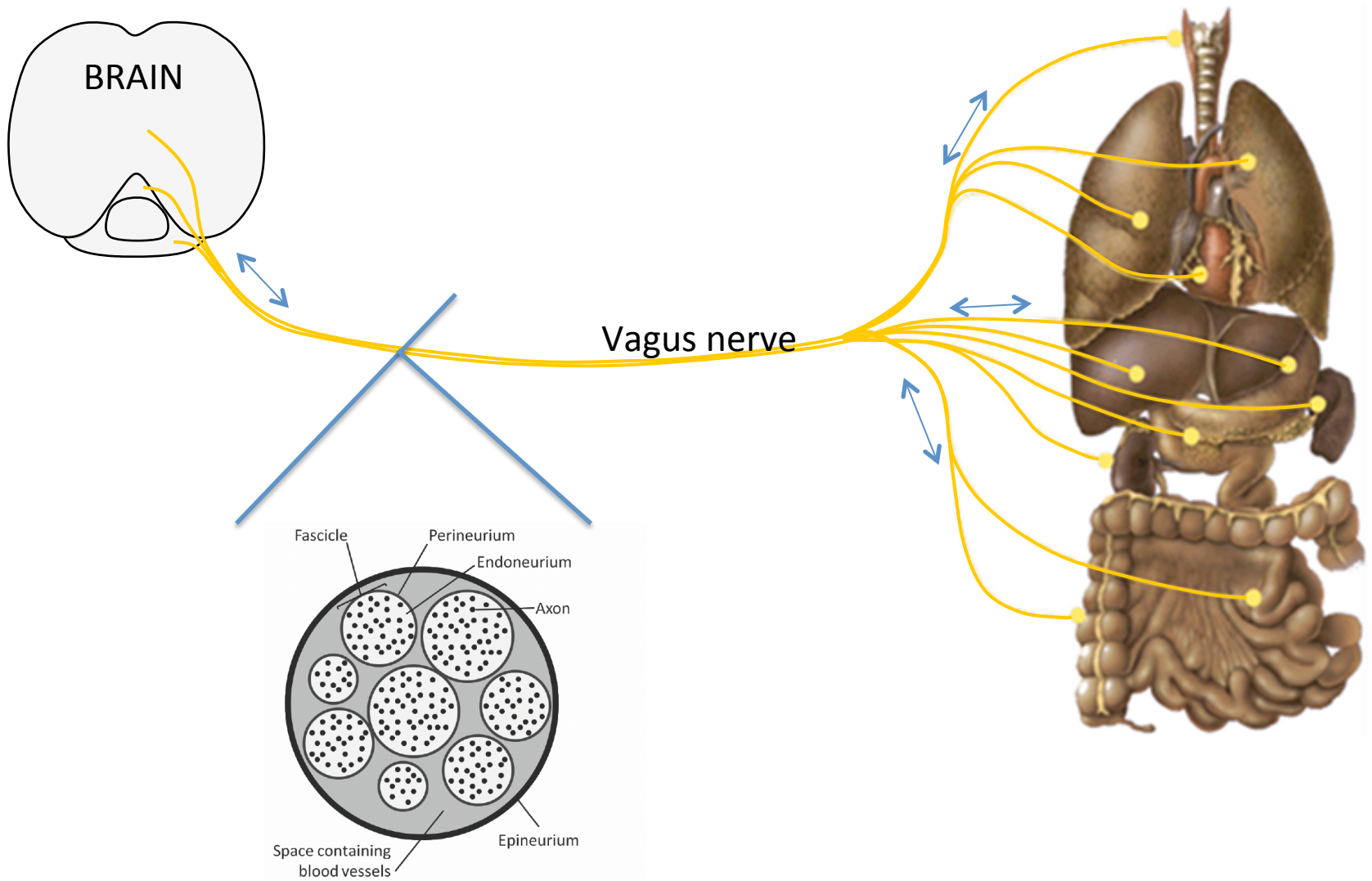


Current therapies

- Bariatric surgery
 - Effective but cost prohibitive (€30 000+/patient)
 - Surgery related morbidity and mortality

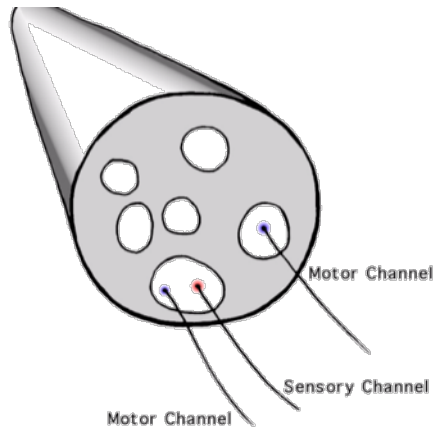
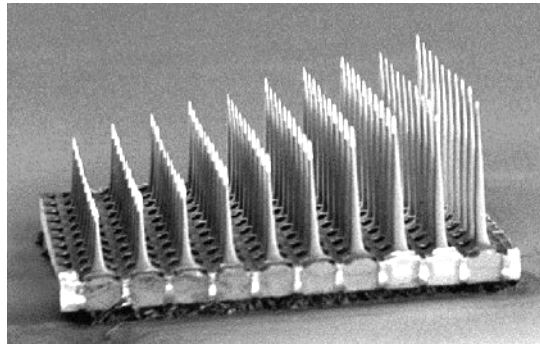


Vagus Nerve



Interfacing Nerves: *Electrodes*

Spike Electrodes



Cuff Electrodes



Current Nerve Interfacing

No Intelligence!

Cyberonics®

Fiscal 2010

VNS therapy – 70 countries, 60,000 patients

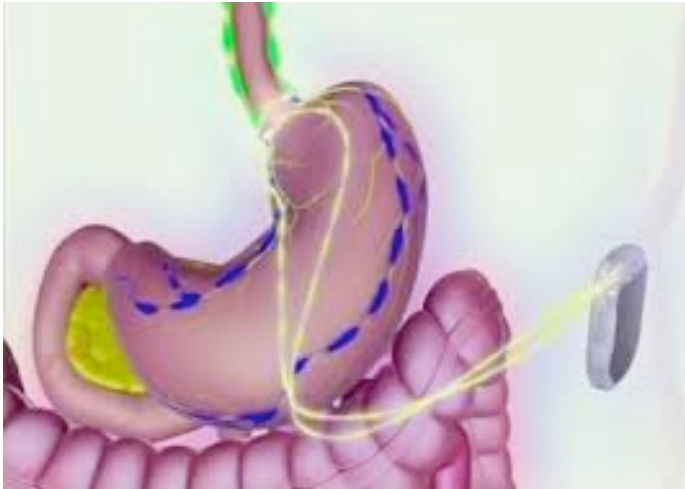


Application to Epilepsy and Depression

Adverse side effects:

Hoarseness of voice, cough, neck pain, shortness of breath

Obesity-Specific Solution

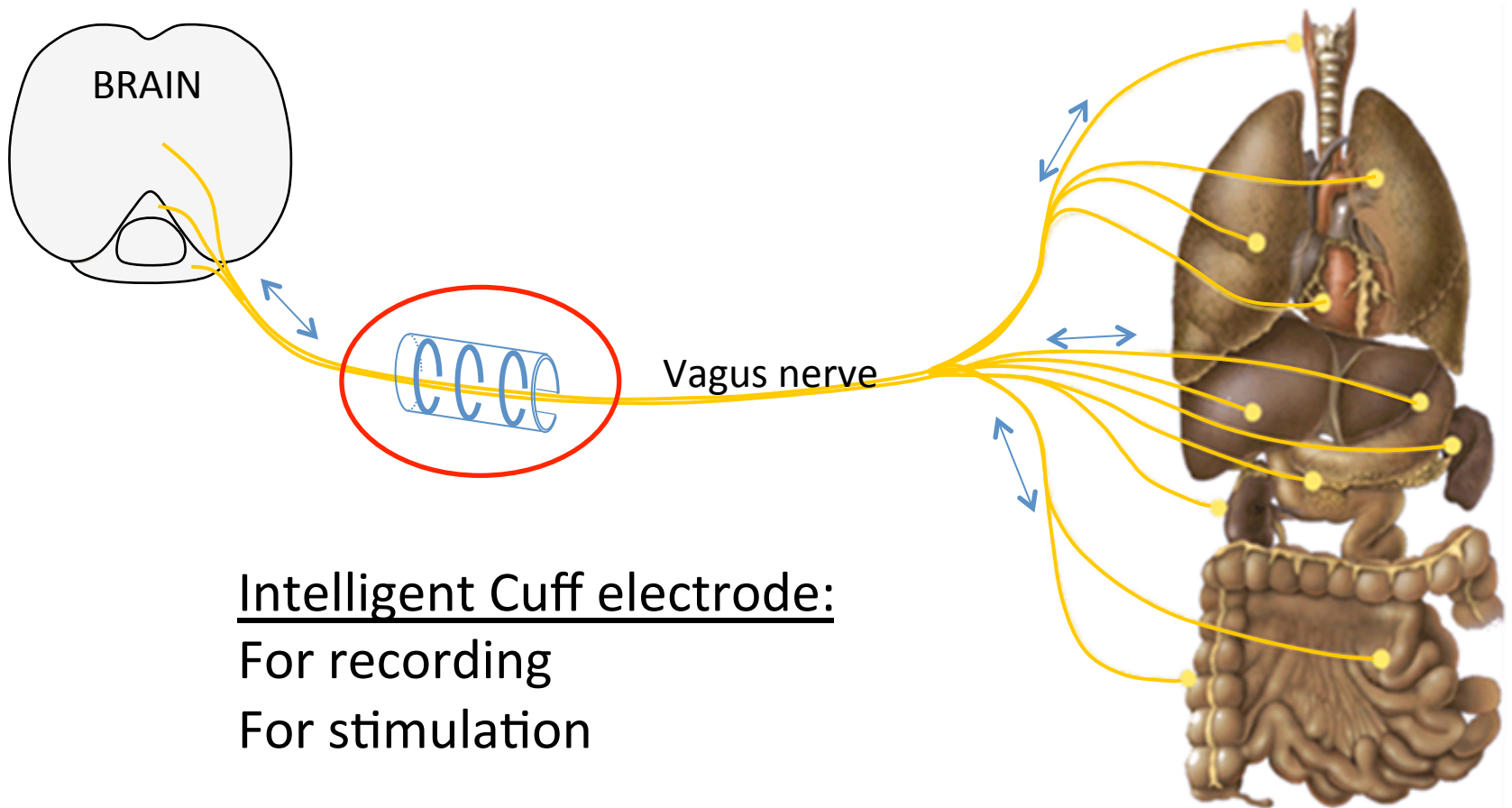


Enteromedics VBLOC

Blocks Nerve with *non-intelligent* high frequency stimulation

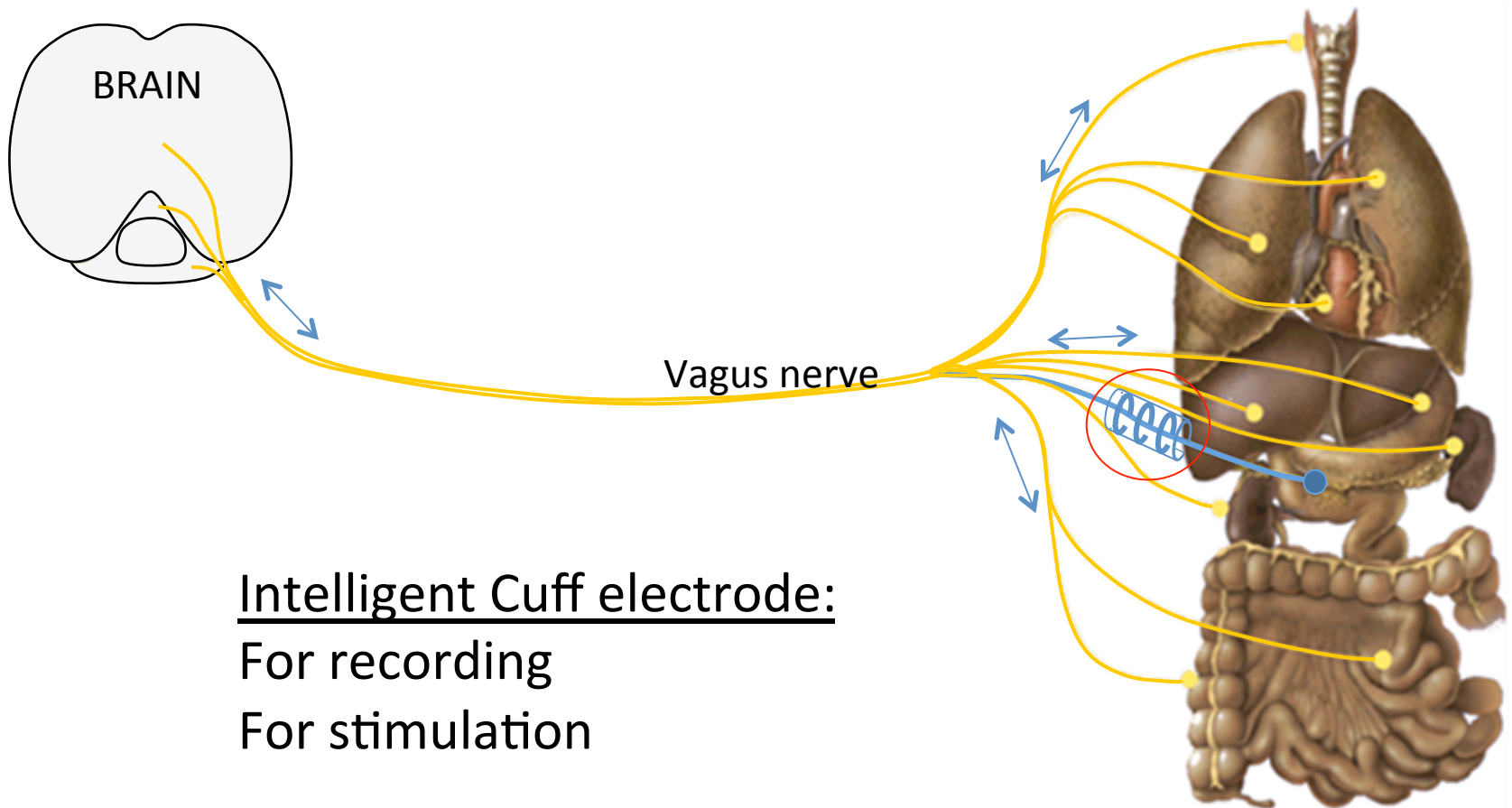
FDA Approved

Intelligent Vagus Nerve Interface



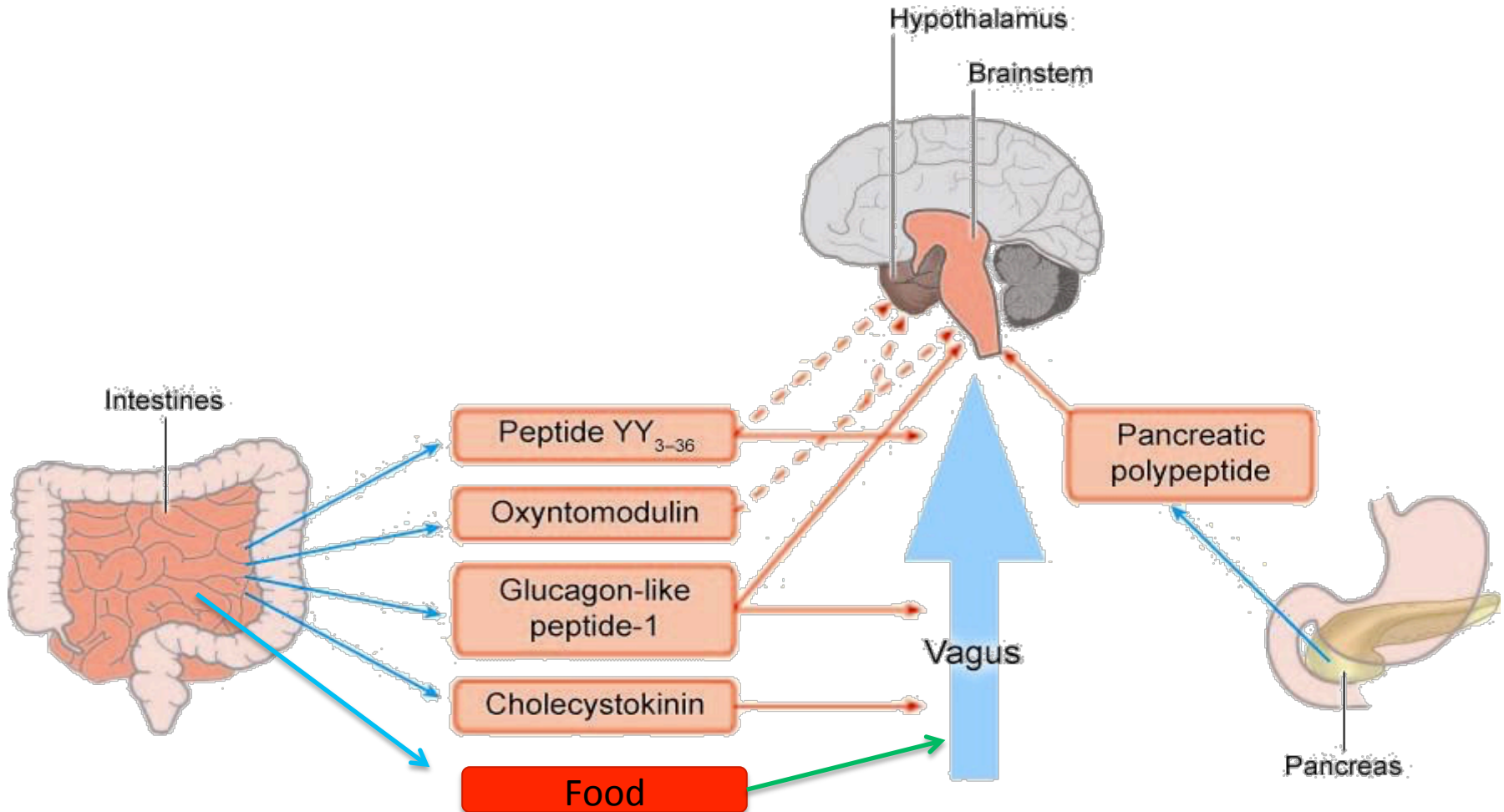
Intelligent Cuff electrode:
For recording
For stimulation

Intelligent Vagus Nerve Interface



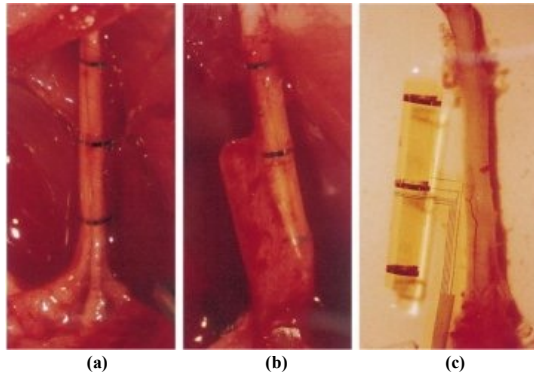
Intelligent Cuff electrode:
For recording
For stimulation

Appetite & *The Vagus Nerve*

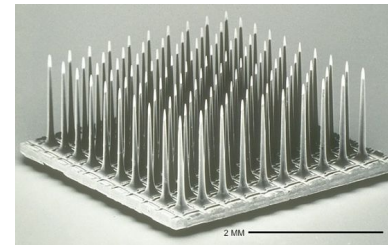


Intelligent Neural Stimulation: Ultralow-Power Ion Sensitive Microchips

Multi-Contact Cuff Electrode



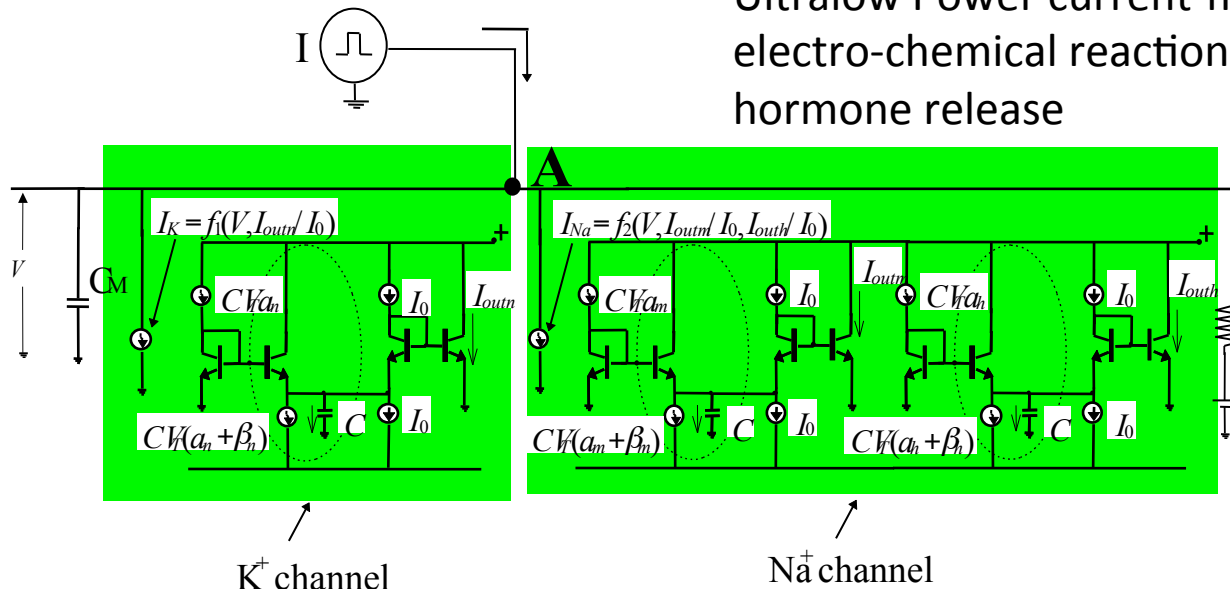
Intrafascicular Probes



Therapy

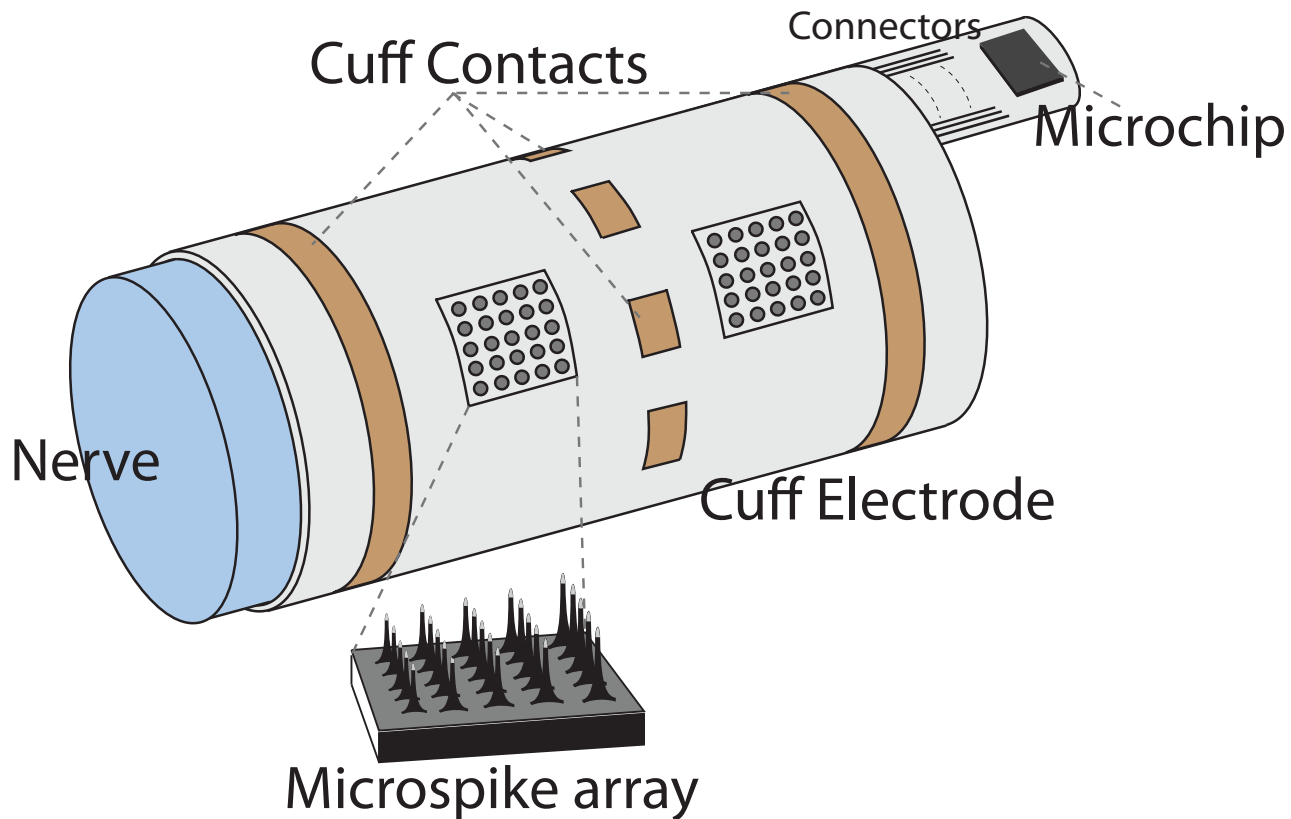
Diagnosis

Ultralow Power current-mode Circuits to monitor electro-chemical reactions representative of hormone release



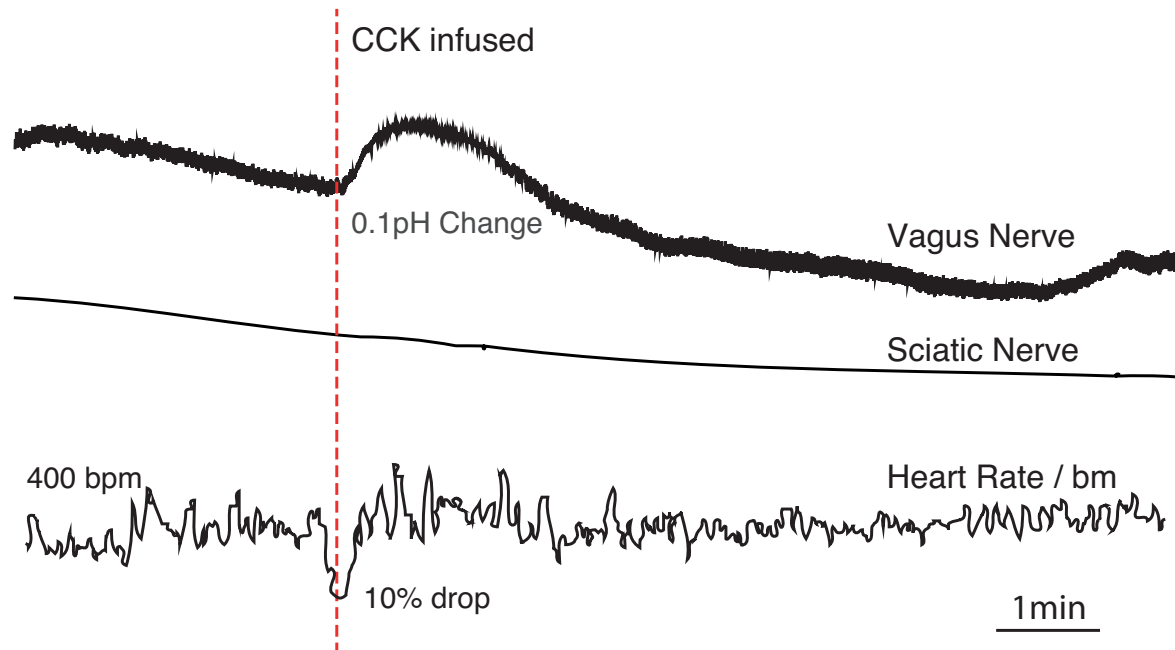
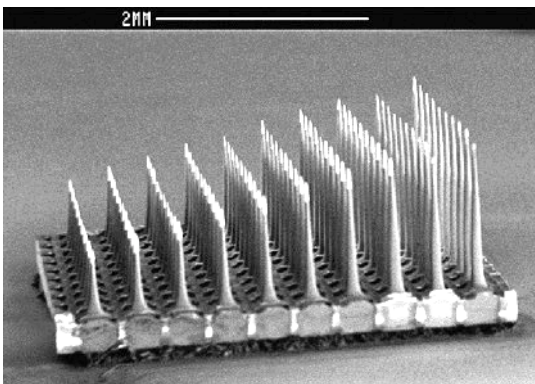
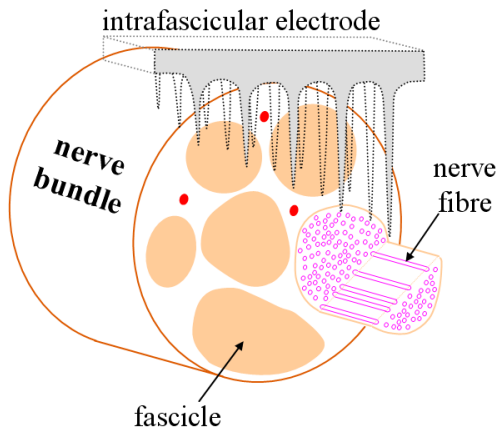
Vision: *New Paradigm*

BINGE: Bio-Inspired Neural-Gut Expert

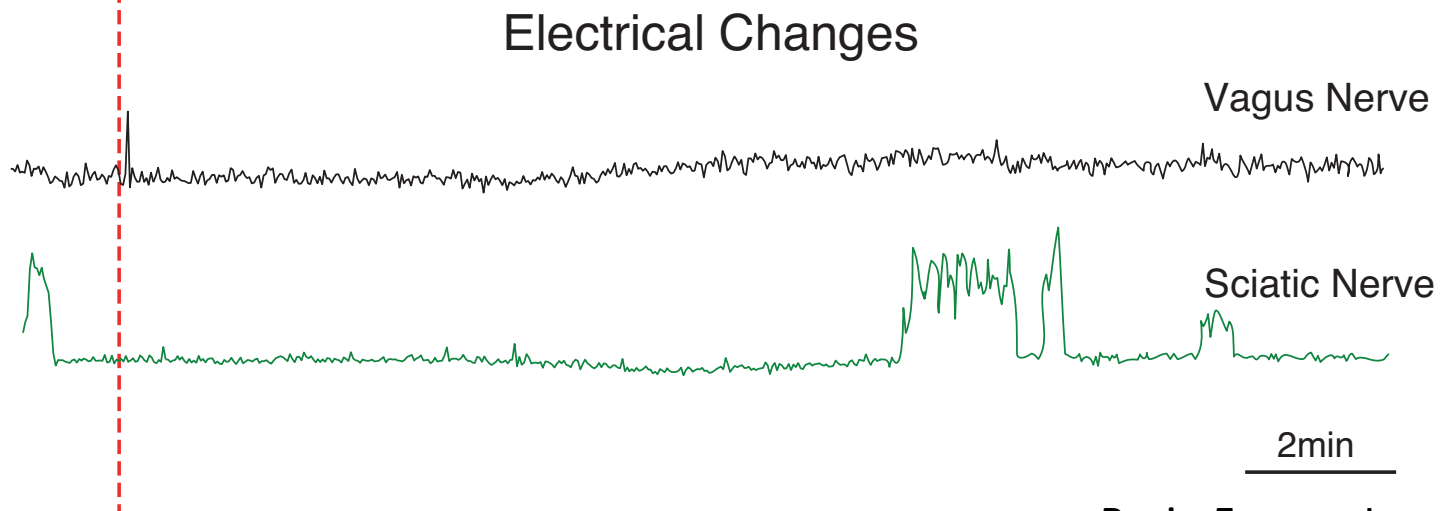
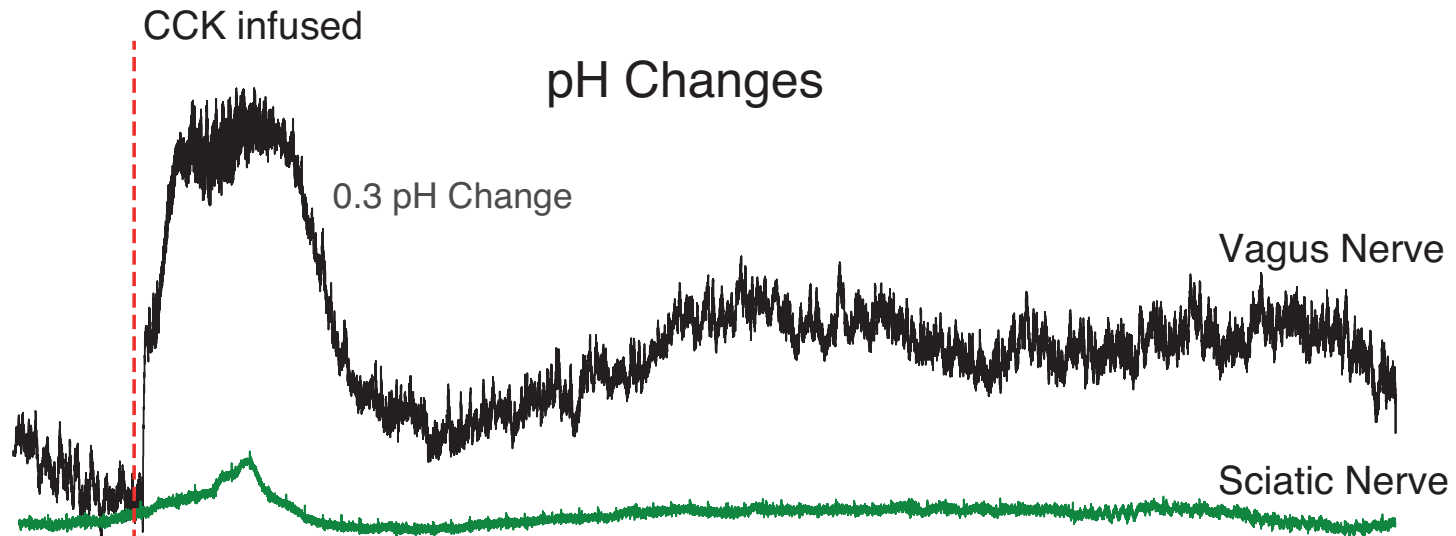


Replicating Satiety

World's first Results: *CCK a satiety hormone*

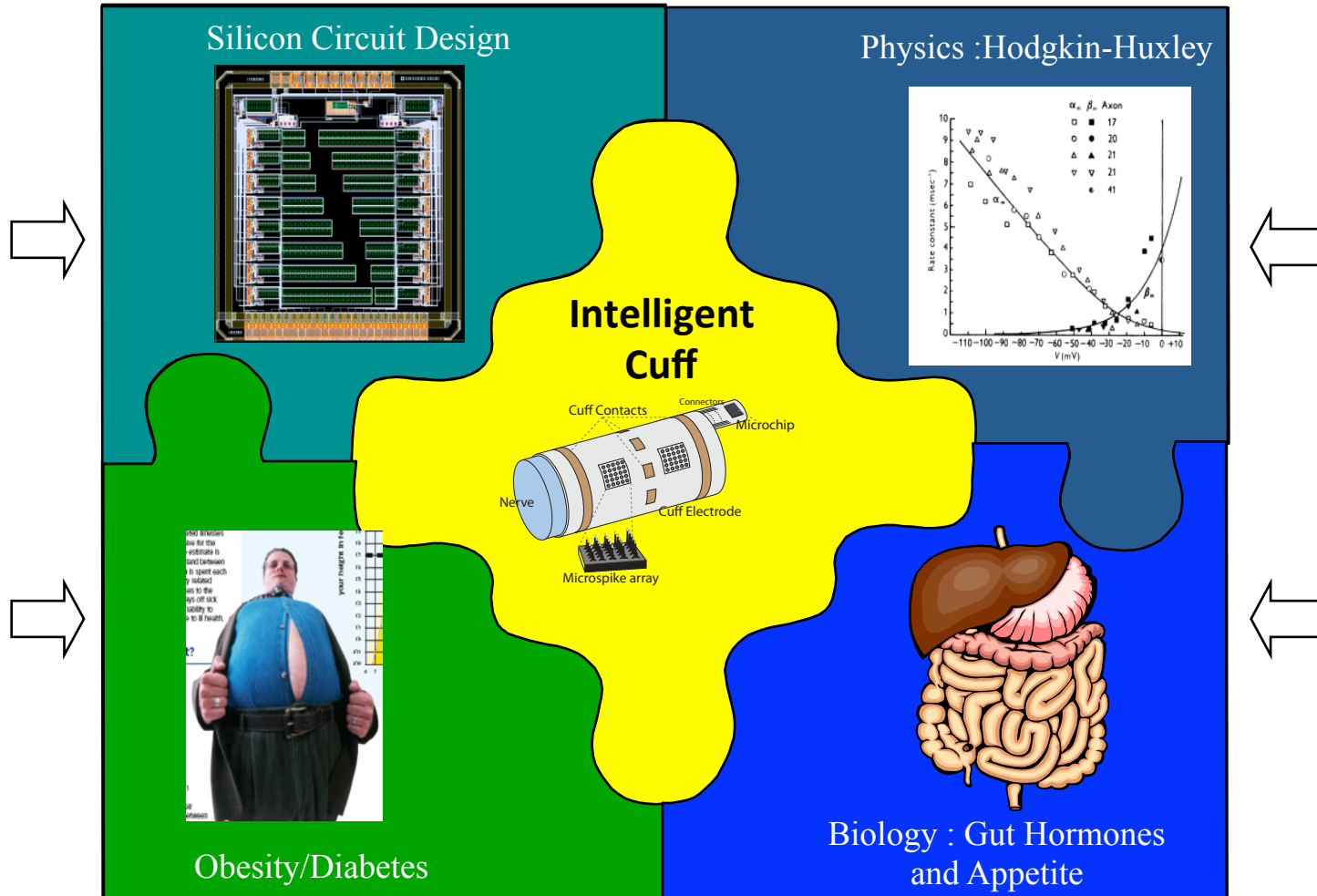


Physiological pH Changes

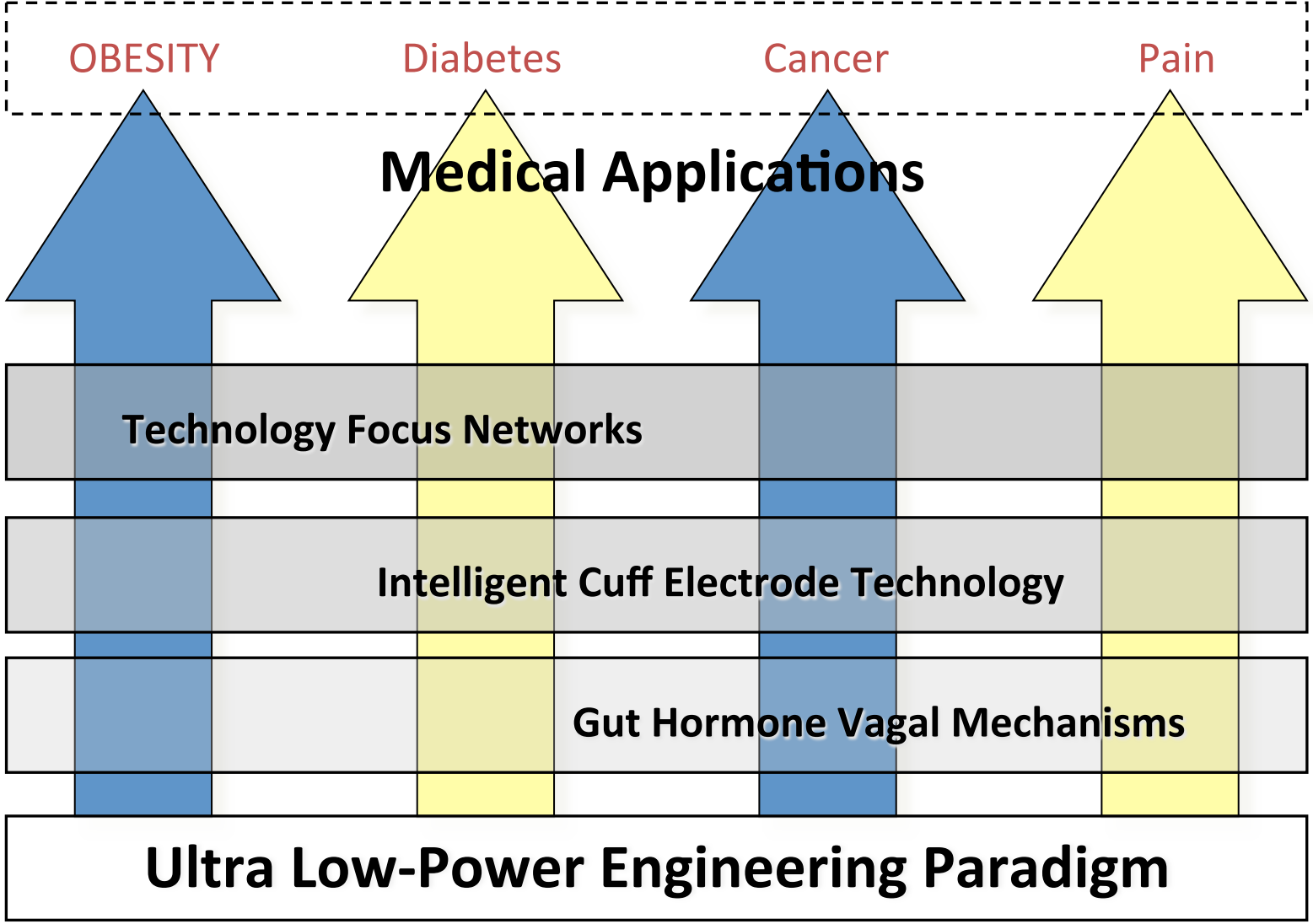


i2MOVE

cuts across traditional disciplines



The Vision: *Technology Synergy*



*“The future’s already arrived;
it’s just not evenly distributed yet.”*

William Gibson