

Implantable microelectronic systems

Julio C Palmaz, MD

Palmaz Scientific Co

Implantable electronic devices

Pacemakers (1930)

Defibrillators (1969)

Cochlear implants (1950)

Movement disorder management

Muscle stimulator

Urinary incontinence

Pain management

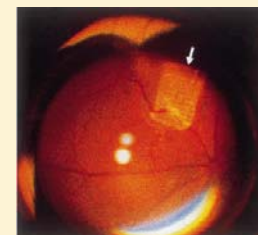
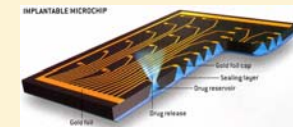
Drug delivery

AAA pressure monitoring

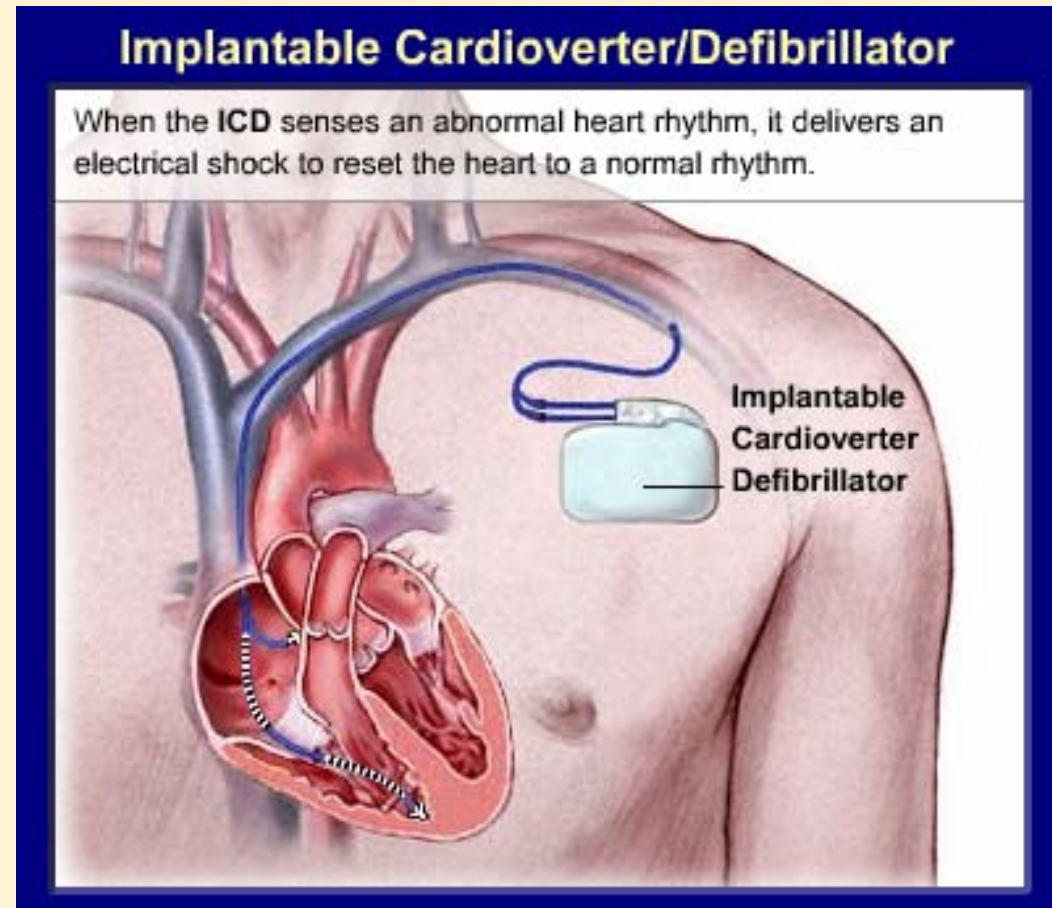
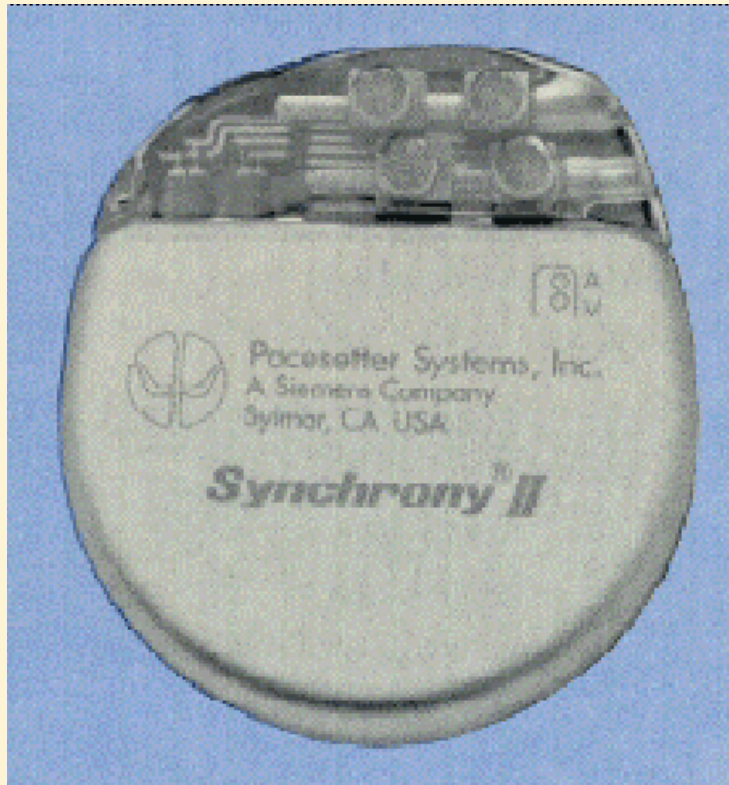
Retinal stimulation

Visual cortex stimulation

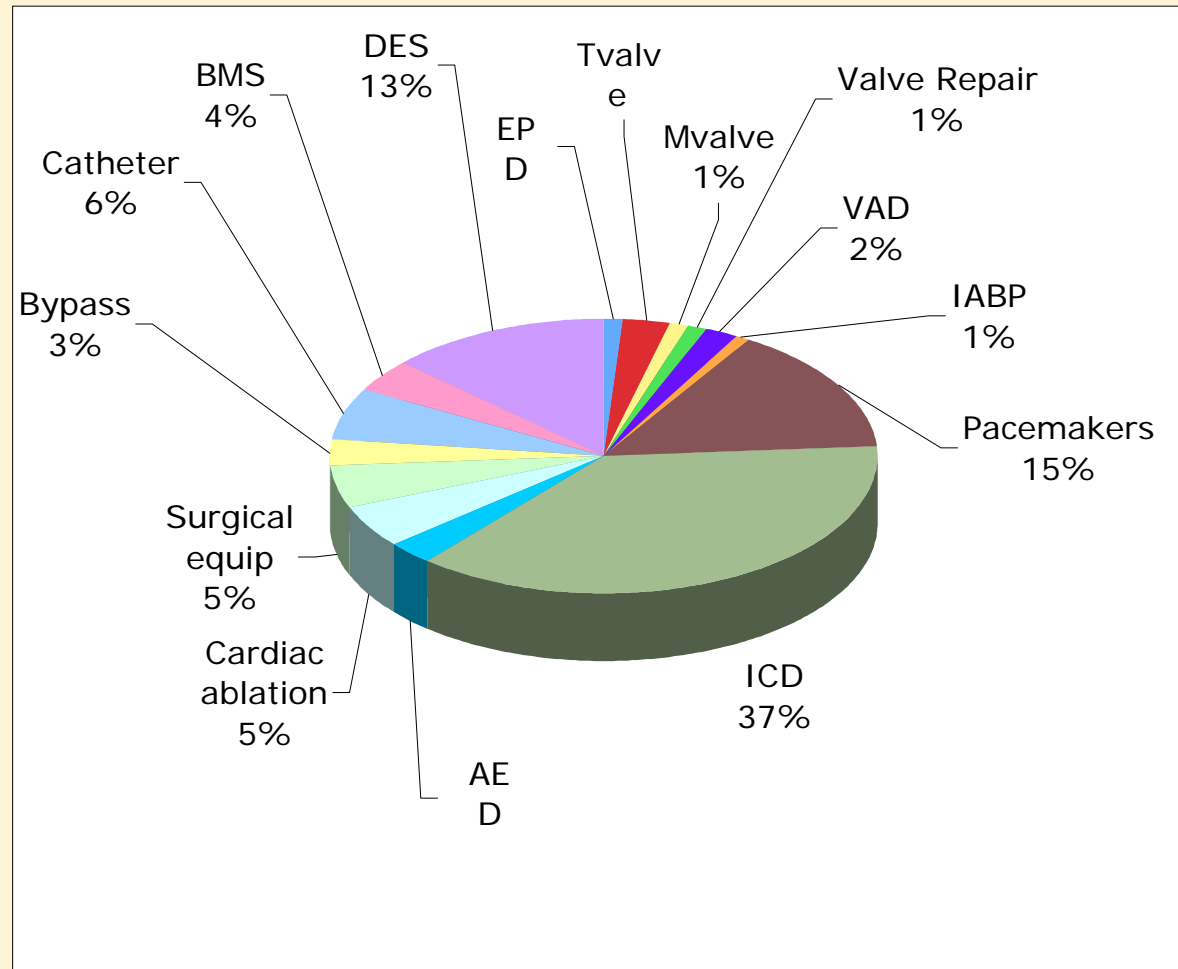
Motor cortex interface



Implantable pacemaker and defibrillator



Pacemakers and ICD's in 2007: 4.1 billion \$/yr



CV therapy devices

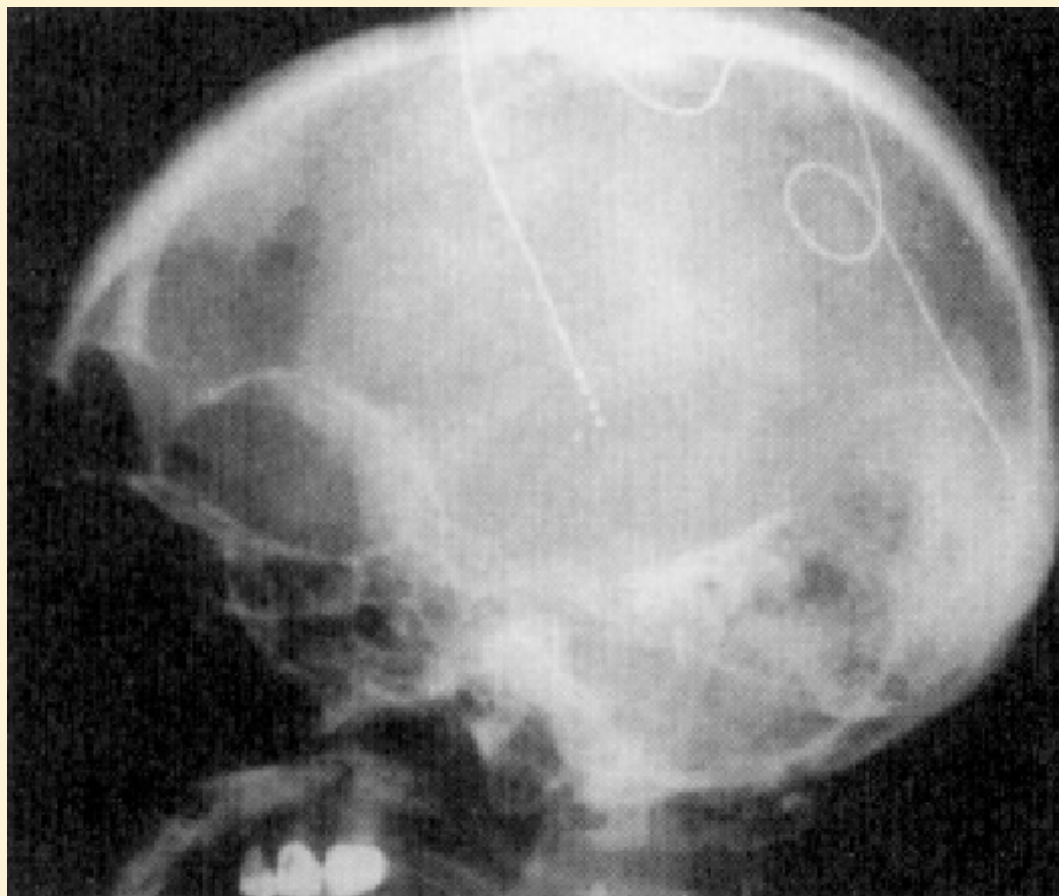
Choclear implant for neural deafness



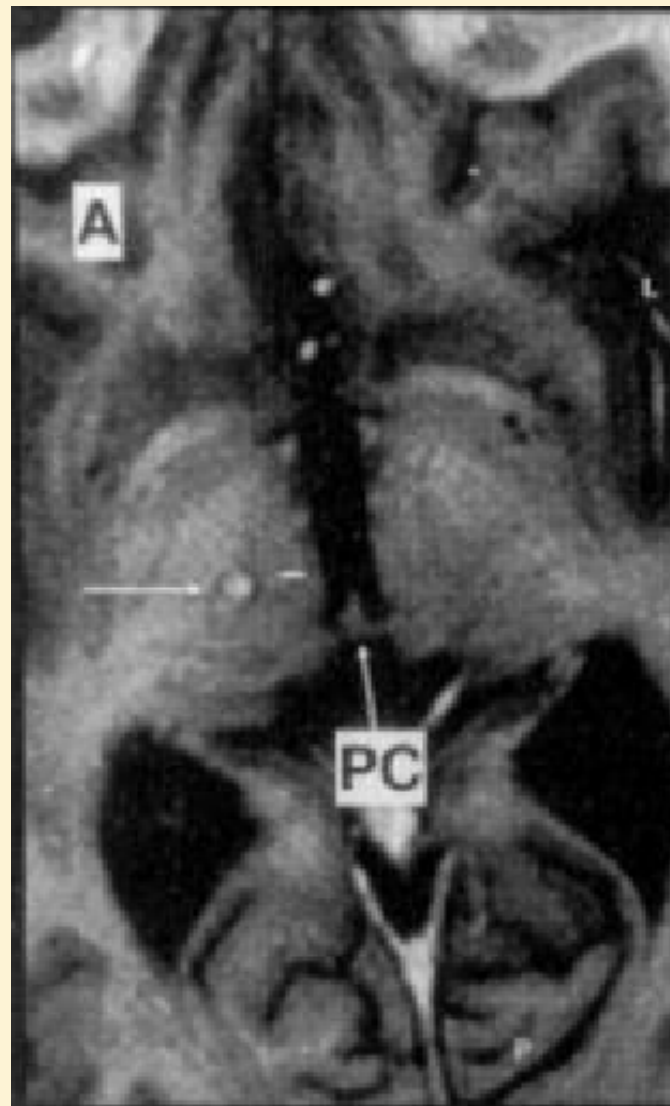
Advanced Bionics Co



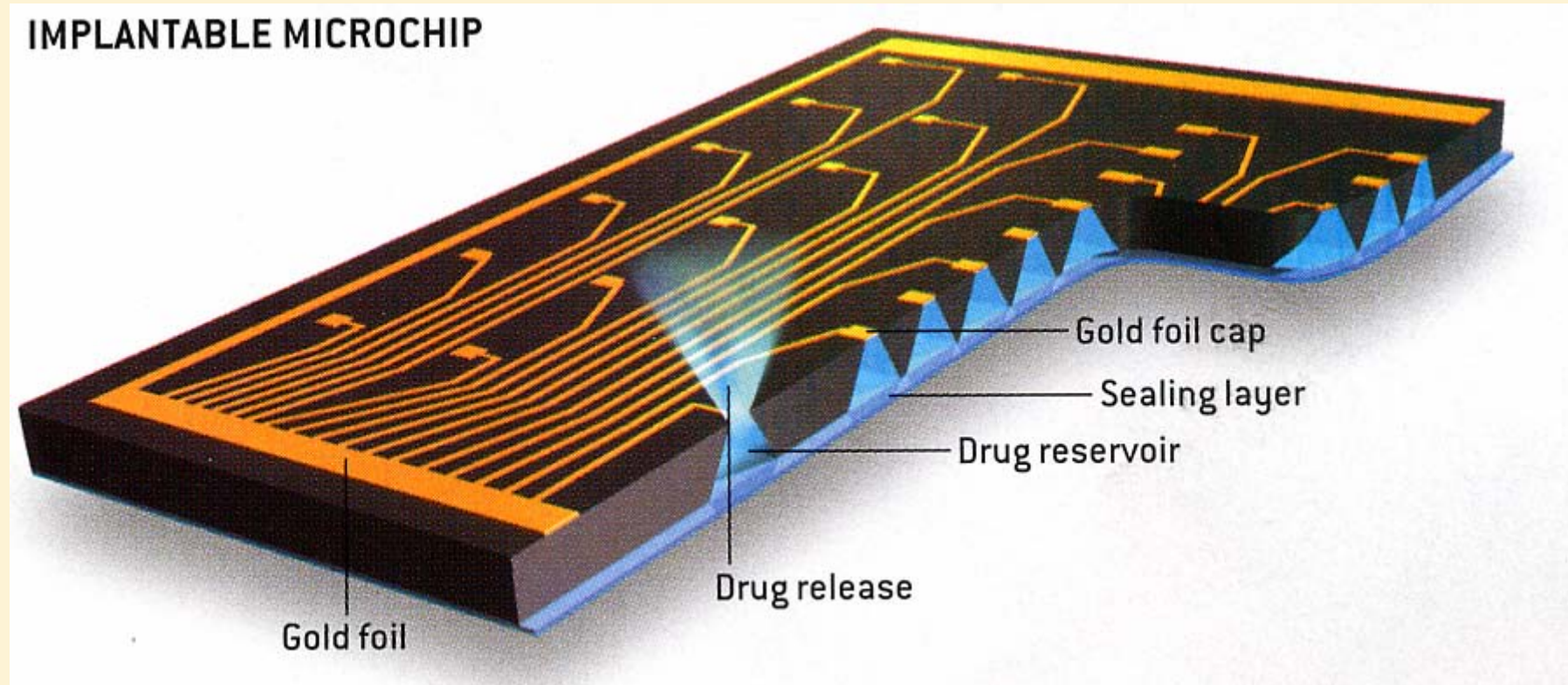
Medtronic quadripolar deep brain stimulator for movement disorders



Starr PA. Neurosurg 1998;43:989



Remote release valve actuated by electrocorrosion



R Langer
Scientific American 2003

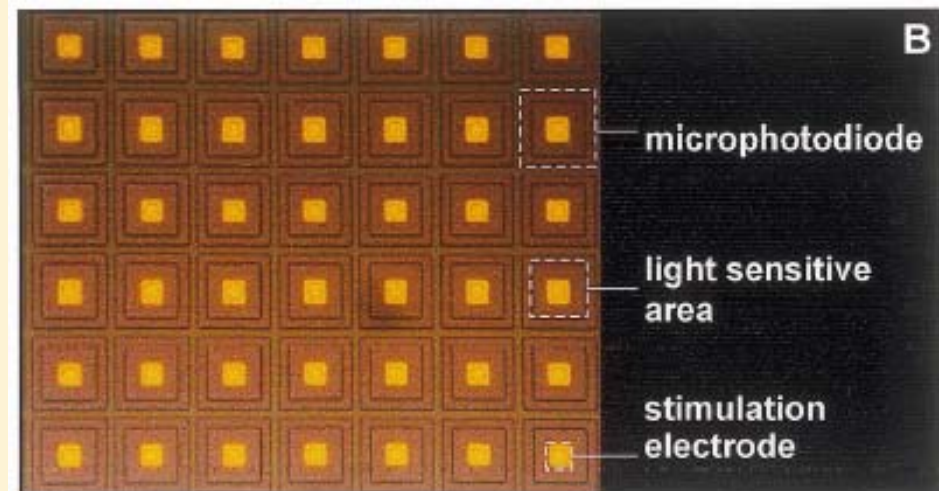
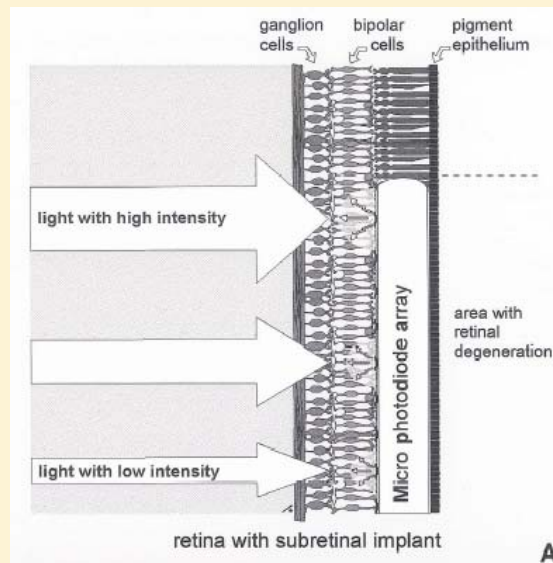
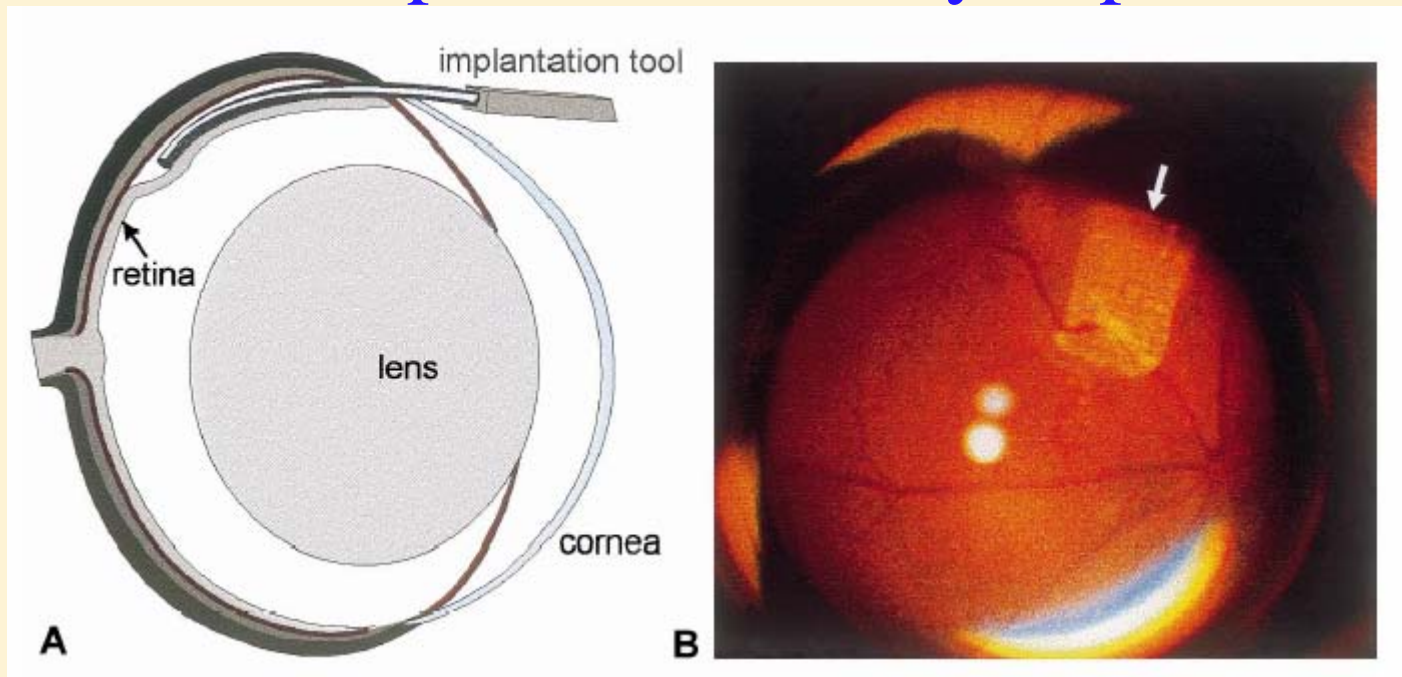
Needle / deliverable muscle stimulator for spinal cord damage patients



Bion injectable electronic stimulator

A. Mann Foundation, Ca and the Pritzker Institute, Il

Retinal photodiode array implant



Zrenner E. Vision Research 1999;29:2555

Basic components of electronic implantable systems

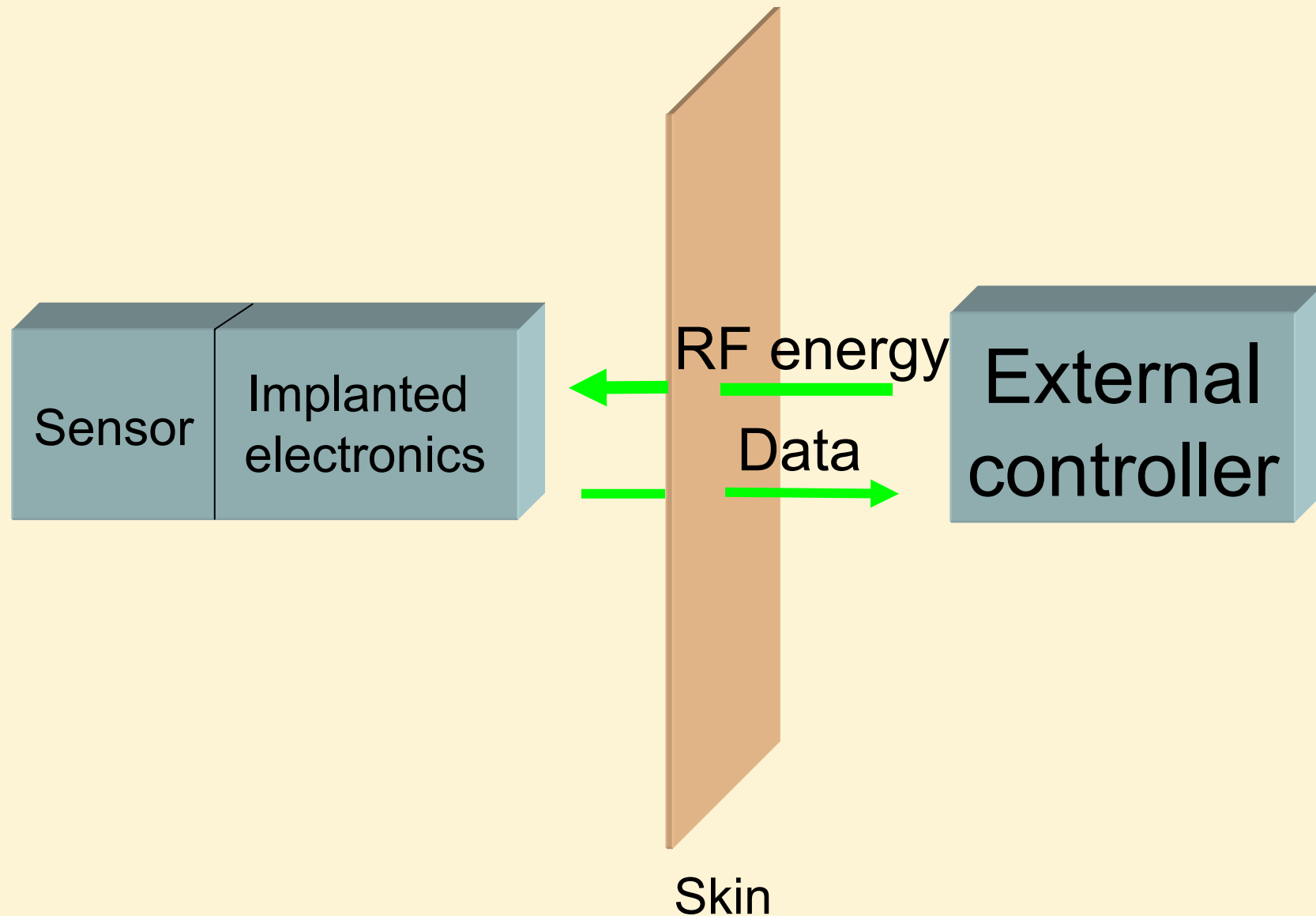
ASIC

(application-specific integrated circuit)

Sensor

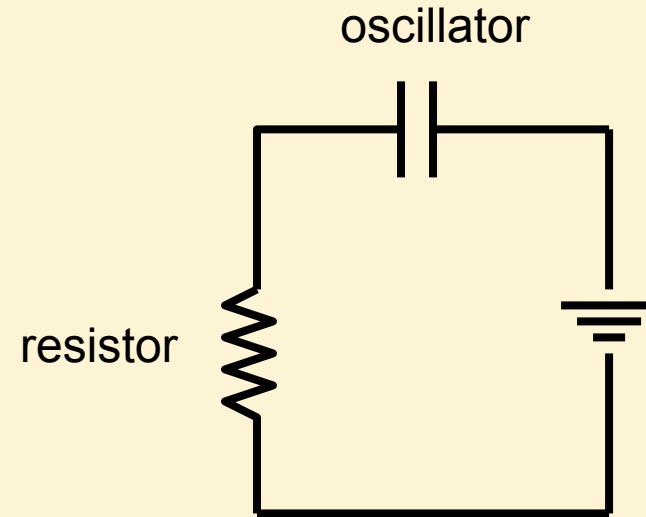
Energy source

Implanted electronic monitoring system

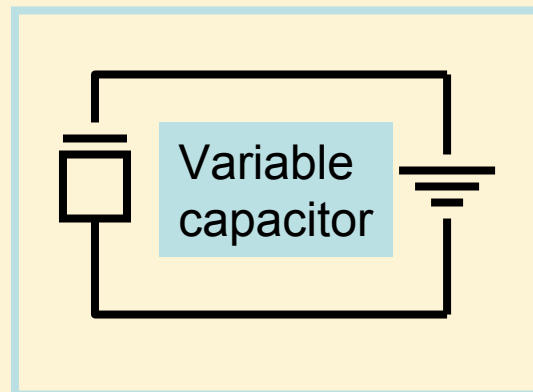


Variably resonant circuit

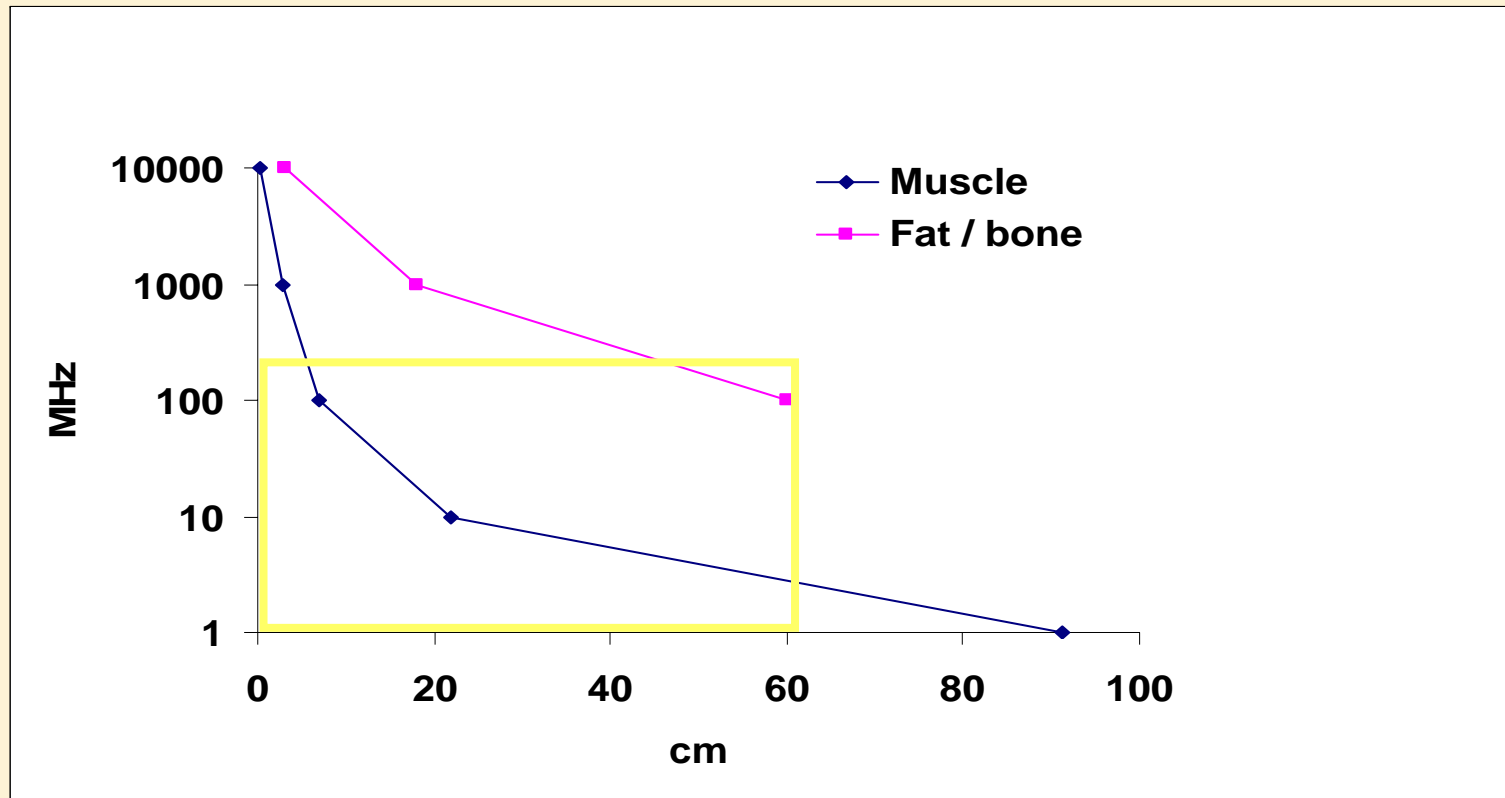
**External
controller**



Implant



RF energy penetration in tissues



Useful range of RF frequency : 0.1 - 200 MHz

Safety standards for RF exposure

ANSI standard 1990, IEEE mod 1991

Any RF source $\leq 7 \text{ W}$ at $\leq 2.5 \text{ cm}$ from skin is acceptable

Safe **SAR** (specific absorption rate) : 0.4 W / kg
(human metabolic rate: 1 W / kg)

Implantable sensors / actuators

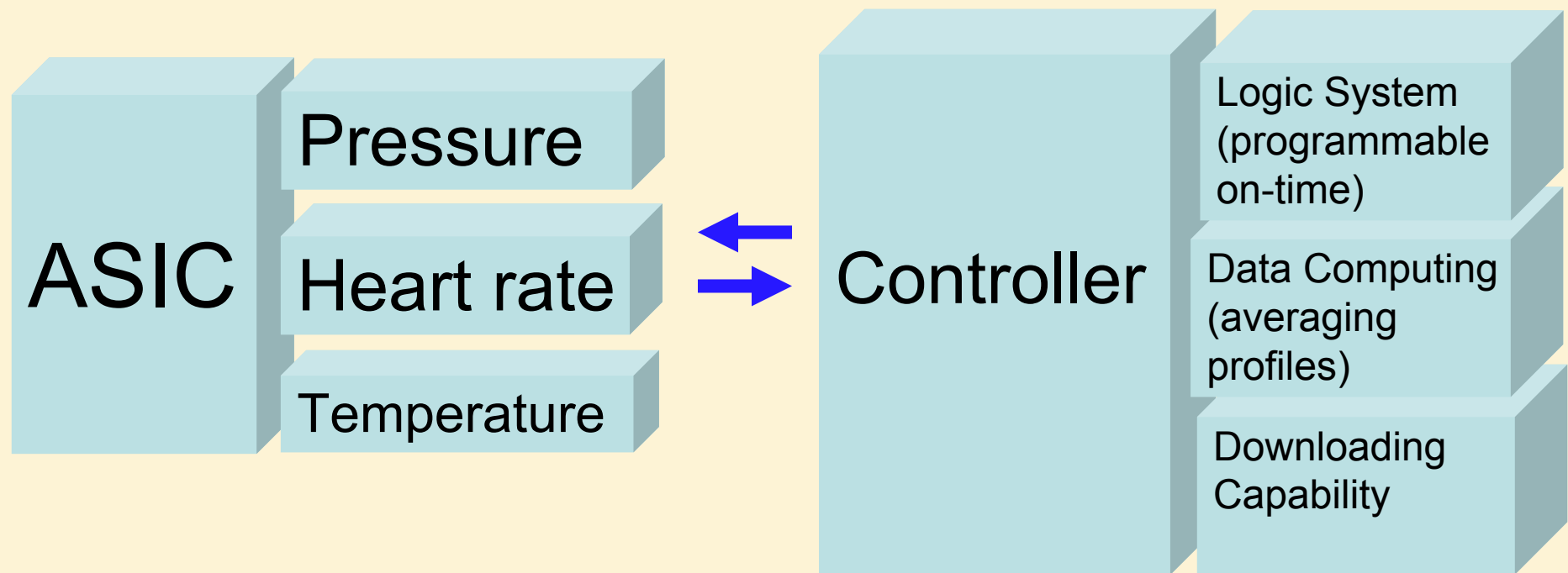
Sensing:

- Pressure, flow, local temperature
- Electrophysiological activity of the heart, brain
- Kinetic information of the heart
- Blood chemical analysis
- Local tissue analysis

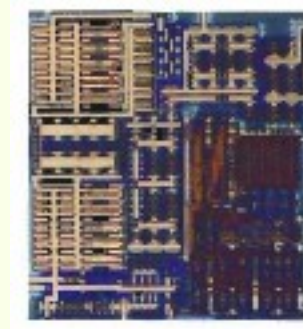
Actuating:

- Muscle e-stimulator
- Micropump drug delivery
- Robotic stents

Basic vascular physiological monitor



RFID “powder”



50X50 micron

T Horniak
Sci Am 08

Dispersed implantable electronics

- Very small area communication
- Cluster communication system
- Cluster computing

Conclusion

- Implantable electronics is the largest vascular device industry at present time
- Fast development in microelectronics and small area communications will make micro-implantable systems a reality