Intro to ‘BioEngineering’ 196B

manner engineering can interact with biology

to develop ‘new solutions’

“… biology will define scientific progress in the 21st century.”

Business Week, March 10, 1997

Introductions

- Your Name
- Academic background
- Why are you taking this course?
- Expectations

Course Schedule

Week	Lecture Topic
1	Course organization; Introduction to BioEngineering Application in living systems
2	Cell and molecular biology of living systems
3	Engineering analysis of living systems
4	Biomaterials & Biocompatibility
5	**First Midterm Examination**
6	Human systems - Bioengineering approaches to Disease
7	Human systems - Bioengingeering approaches to therapeutic Interventions
8	Intro to FDA and Regulations, GMPs & QSRs
9	Overview of Clinical trials process
10	**Second Midterm Examination**
11	Diagnostic & Therapeutic Instrumentation
12	Class Presentations
13	Tissue engineering & Stem Cells
14	Bioinformatics & Genomics
15	Topics in Bioethics, the industry and career pathway
16	**Final Examination**

What is a 'Engineer'?

- "Engineer" comes from word engine which means "to create".

- Engineers are different than scientists in that scientists use their knowledge to acquire new knowledge...

- ...whereas engineers apply knowledge to design and develop usable devices, structures and processes

Engineer

- Uses science & math to solve people's problems – great at problem solving
- Creates and invents new things
- Improves and makes things better
- Creativity
- Like to figure things out, solve problems
- Good at Maths

BioEngineering

- ***"Bioengineering integrates physical, chemical, mathematical, and computational sciences and engineering principles to study biology, medicine, behavior, and health.***

- ***It advances fundamental concepts; creates knowledge from the molecular to the organ systems levels; and develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health***

Source: NIH Working Definition of Bioengineering - July 24, 1997)."

What makes Bioengineers different?

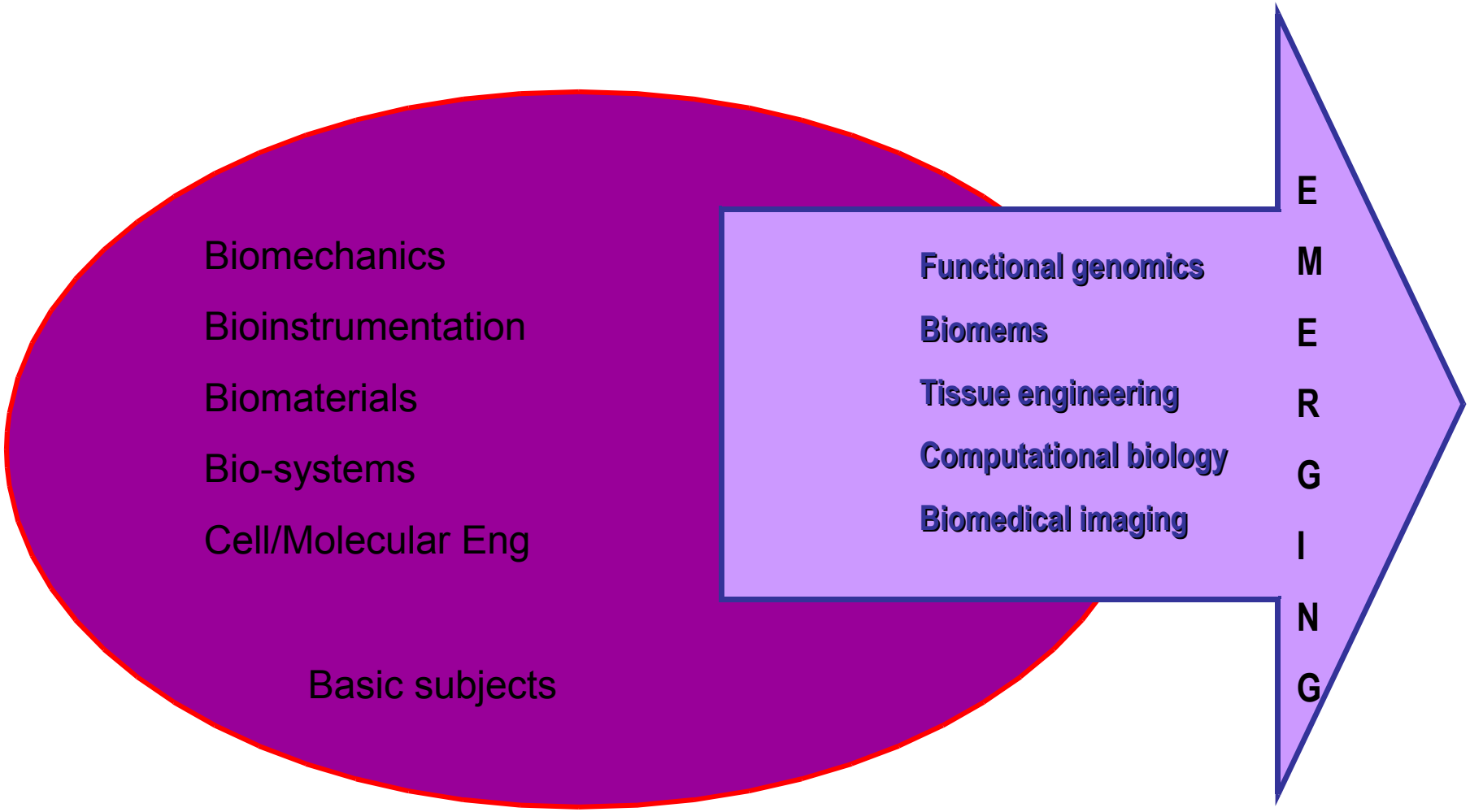
Bioengineers understand/use a core of ideas essential to living systems
(which other engineers typically will not)

These ideas revolve around the
concepts of self-organization,
self-replication,
non-linearity,
and emergent properties that arise from the
assembly of cells and tissues into complex living systems.

Source: Bioengineering Department at SUNY Binghamton

Typical Bioengineering projects/pursuits

- Detection, measurement/monitoring of biosignals –Biosensors/Bioinstrumentation
- Therapeutic and rehabilitation procedures and devices- Rehabilitation engineering
- Devices for replacement or augmentation of bodily functions- Artificial organs
- Development of new diagnostic instruments for blood analysis
- Computer modeling of the function of body parts
- Development of new diagnostic imaging systems
- Design of telemetry systems for patient monitoring
- Developments of expert systems for diagnosis of diseases
- Design of closed-loop control systems for drug administration
- Modeling of the physiologic systems of the human body
- Development of new dental materials
- Design of communication aids for the disabled
- Design of new pharmaceuticals.
- Design of fermentation equipment to produce medically relevant products
- Design of novel polymers for drug delivery etc.
- Source: Robert Nerem

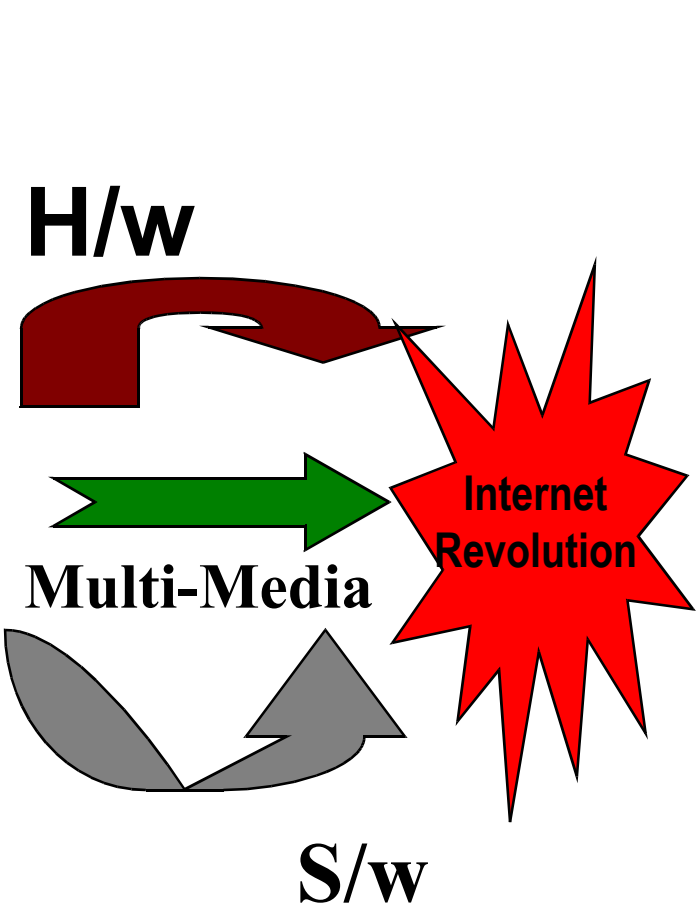


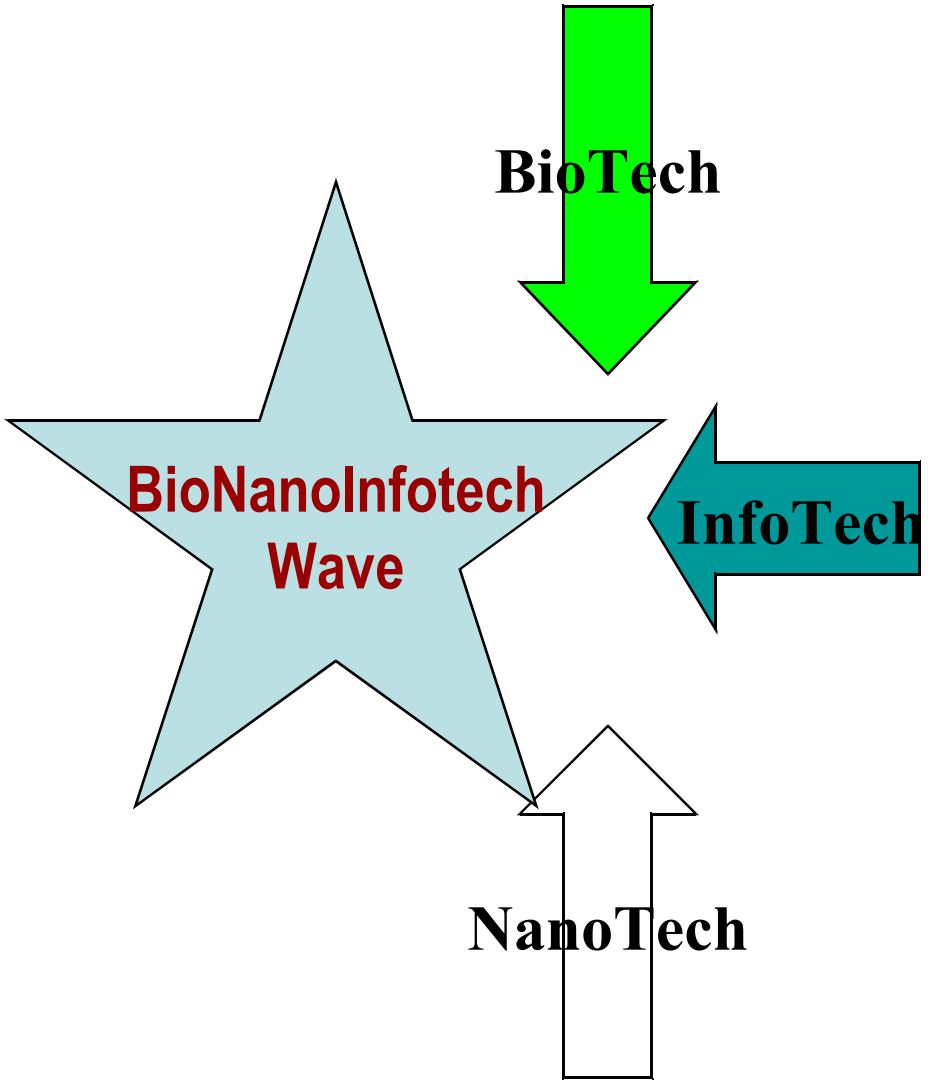
BIOENGINEERING

Basic Engineering Concepts

- Thermodynamics
- Engineering mechanics
- Instrumentation/circuits
- Signal analysis
- Materials science
- Fluid mechanics
- ??

The New Convergence Wave

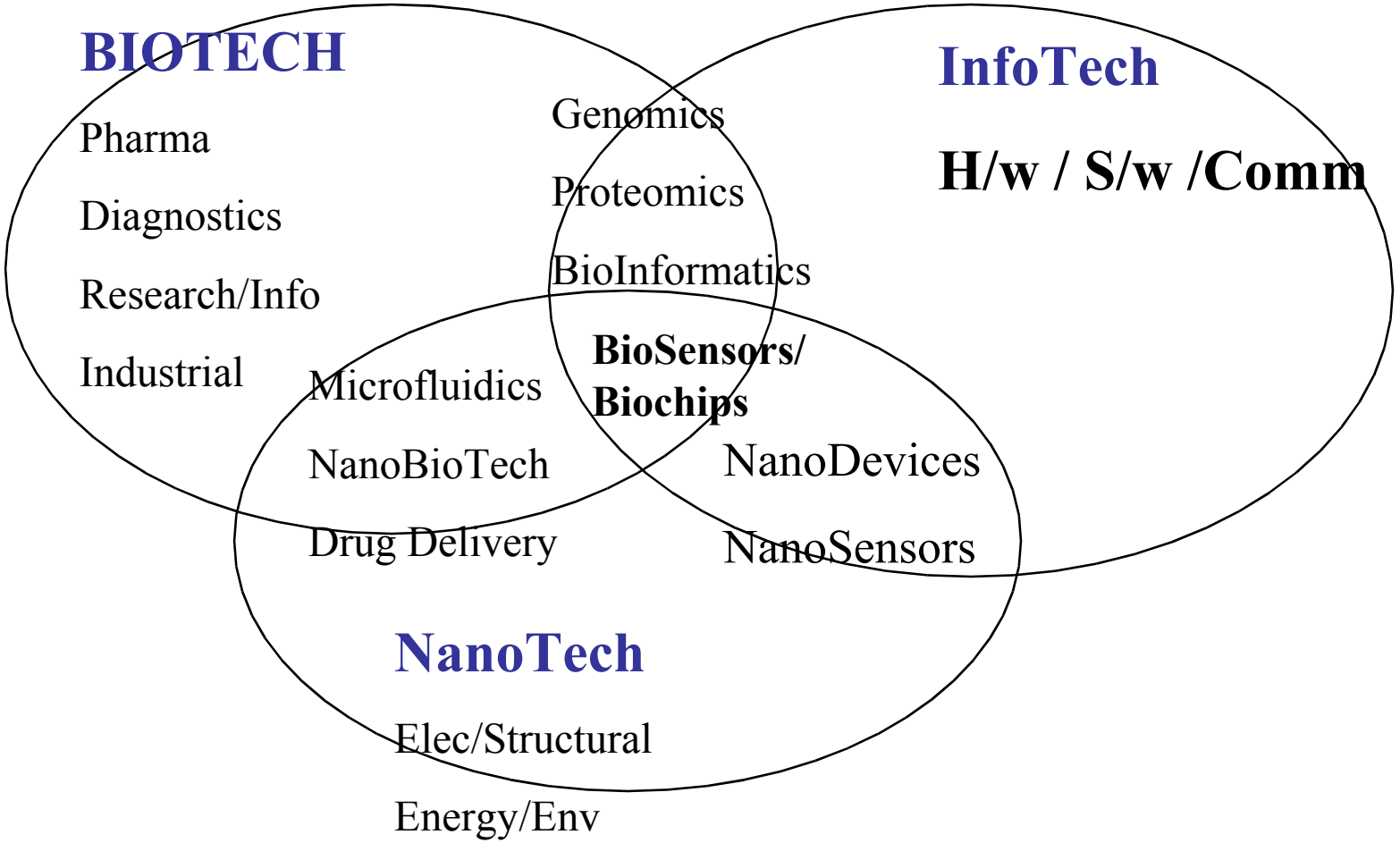




Source: Collaborative Economics, Inc

Restructuring away from Semiconductors, Software toward the Biomedical Industry

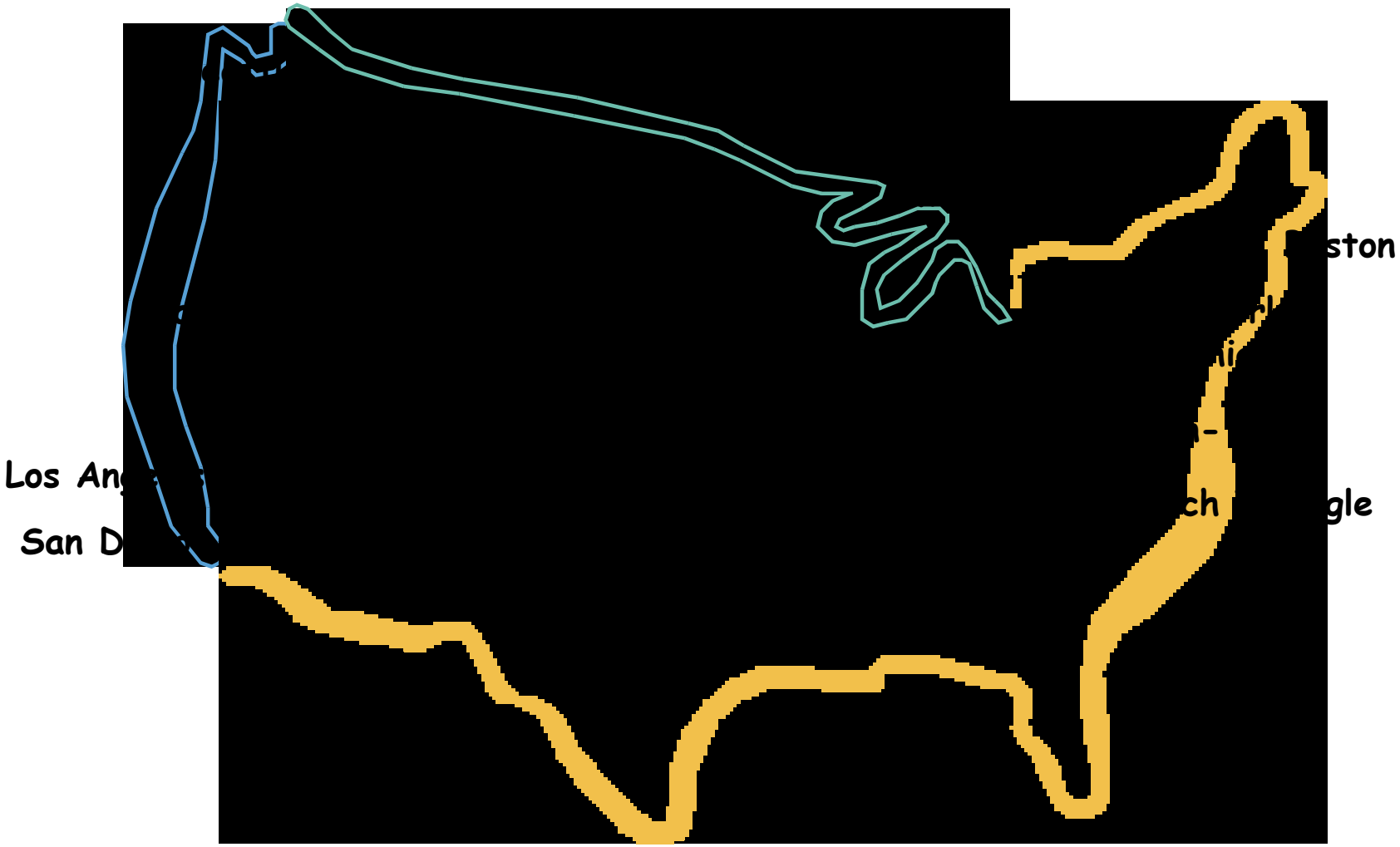
Three Converging Revolutions



Source: Collaborative Economics, Inc

Market potential: > 1 trillion in 10 yrs

9 Metros Dominate BioMedical



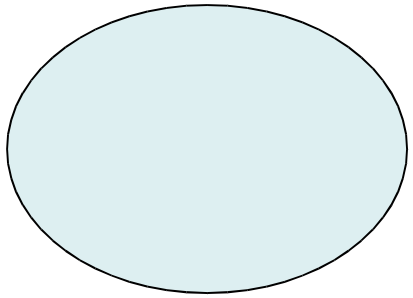
California

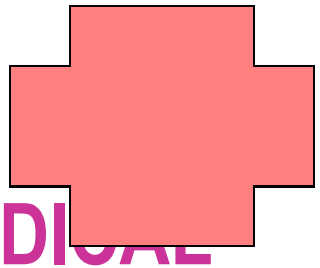
- Total Biomedical Companies – 2,600
- Total Employment – 230, 000
- 7 Biomedical industry clusters
- Bay Area - 700 companies, 85,600 employees
- 31 academic research institutions - companies have spun off from Stanford (117), UCB (87), UCSF(115)
- Scaramento/Vacaville –growing into BioMfg center)
- 650 drugs in R & D pipeline (2/3 in Clinical trials stage) 70 devices under development in 30 companies currently

WHAT DO WE MEAN BY BIOMEDICAL ?

BIOTECH

HEALTHCARE

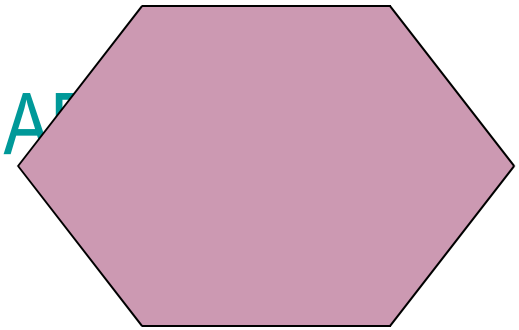


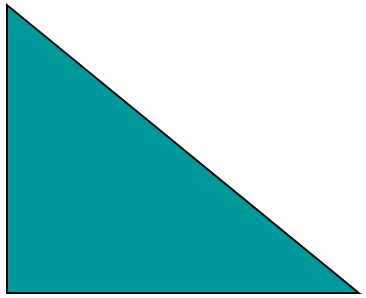


MEDICAL

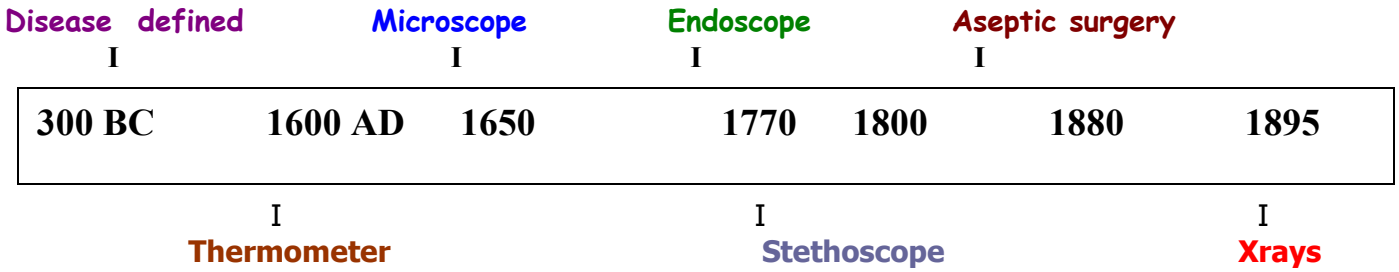
DEVICE

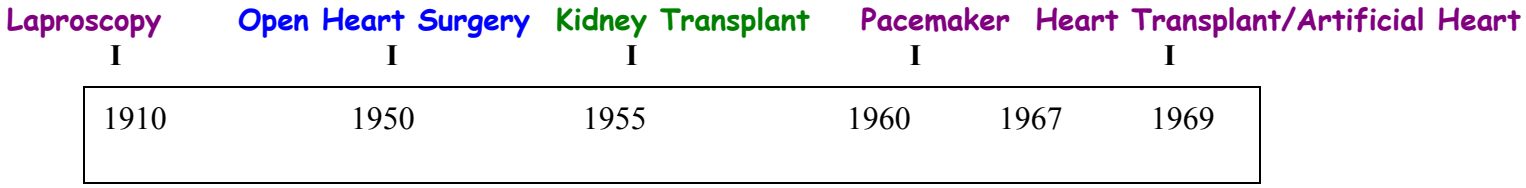
BIOPHA

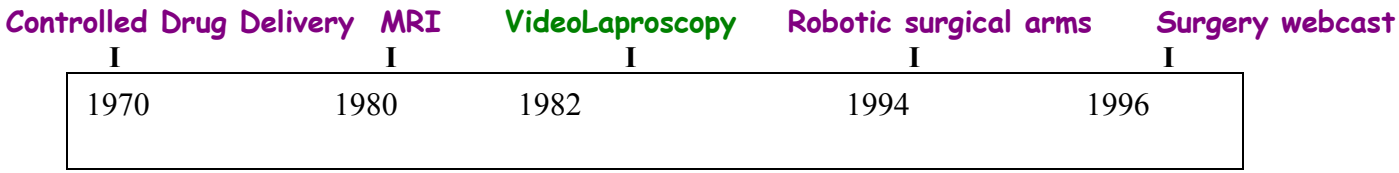




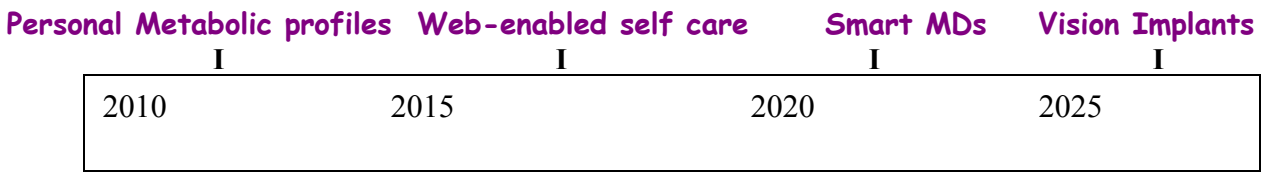
MEDICAL DEVICES – HISTORICAL



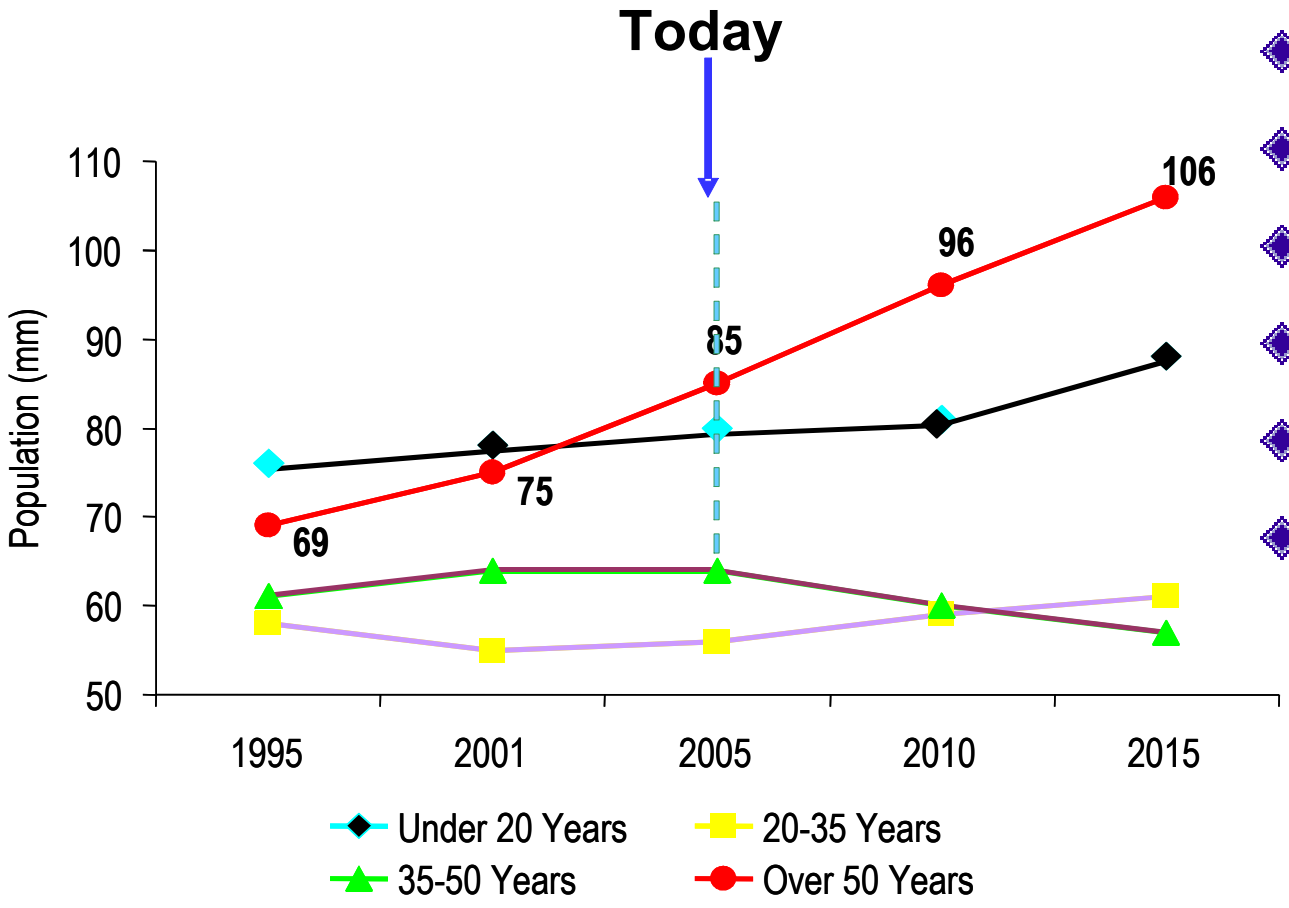




Medical Devices – the future



US is witnessing Demographic Shifts



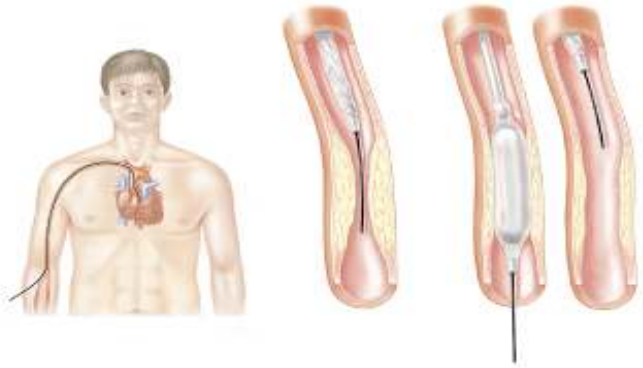
> 50s

- 27% of U.S. pop
- Consume $615 HC
- Utilize 74% pharma
- 65% hospital bed days
- 42% of physician visits
- Number ~85 Million

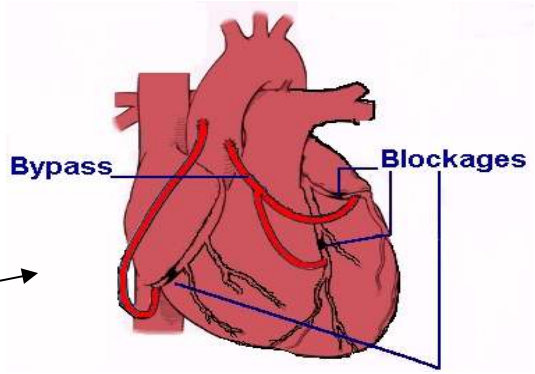
- **Baby boomers are descending upon the US HC infrastructure**

Biomedical Eng Interventions- CVS

Angioplasty

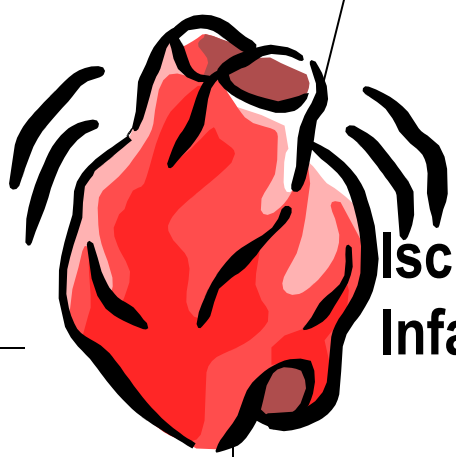


CAD

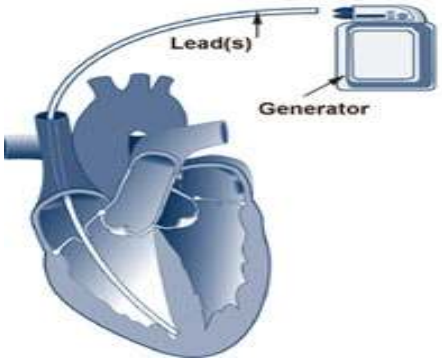


CABG

Robotic CABG



Ischemia / Infarction



arrhythmia

Pump Failure

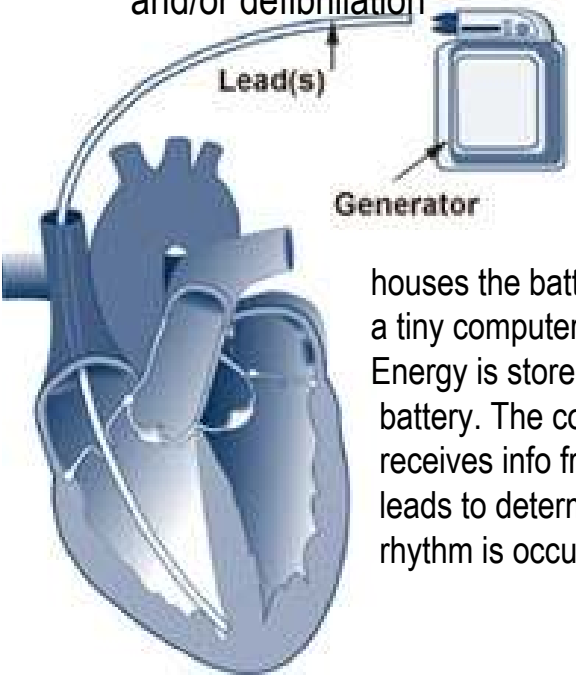
Artificial Heart

Left side - VAD

ICD (Implantable Cardioverter Defibrillator)

- **An electronic device that constantly monitors your heart rate and rhythm.**
- **If it detects an abnormal heart beat it delivers energy to the heart muscle**

monitors heart rhythm,
delivers energy used for pacing,
and/or defibrillation



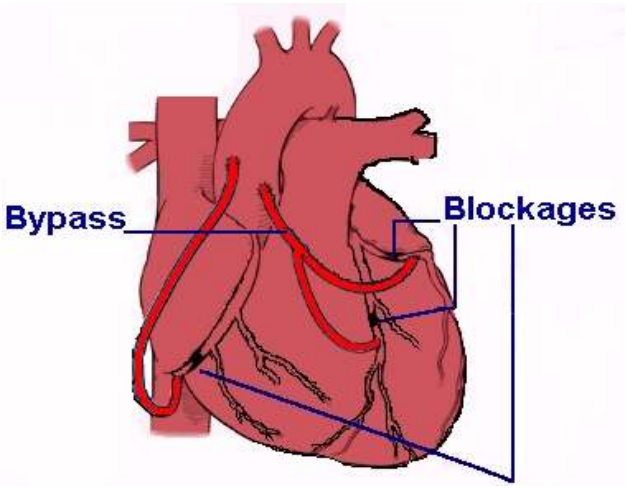
houses the battery and a tiny computer. Energy is stored in the battery. The computer receives info from the leads to determine what rhythm is occurring.

- Small incision is made under the collar bone
- Lead is placed into a vein and guided inside your heart chamber
- Generator is placed under skin in upper chest and attached to the lead(s).

Heart Rhythm Market = 10.8 Billion

Medtronic's InSynch Sentry

Coronary Artery Bypass Graft (CABG) using Robotic Surgery

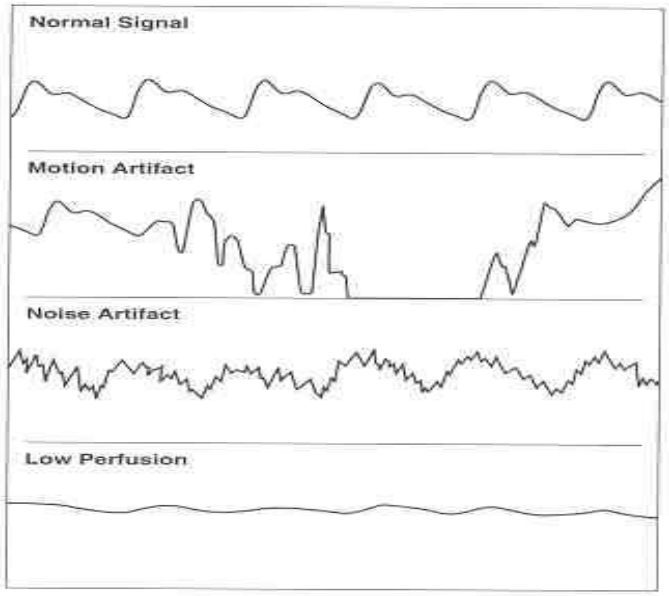


Pulse oximetry

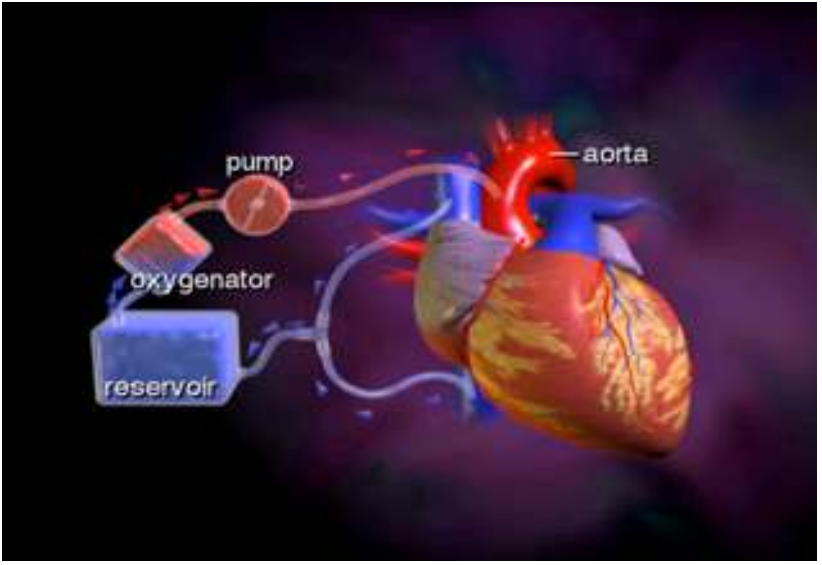
Light source on a finger senses light transmission at 650nm and 805nm

These wavelengths are absorbed selectively by oxygenated/de-oxygenated blood

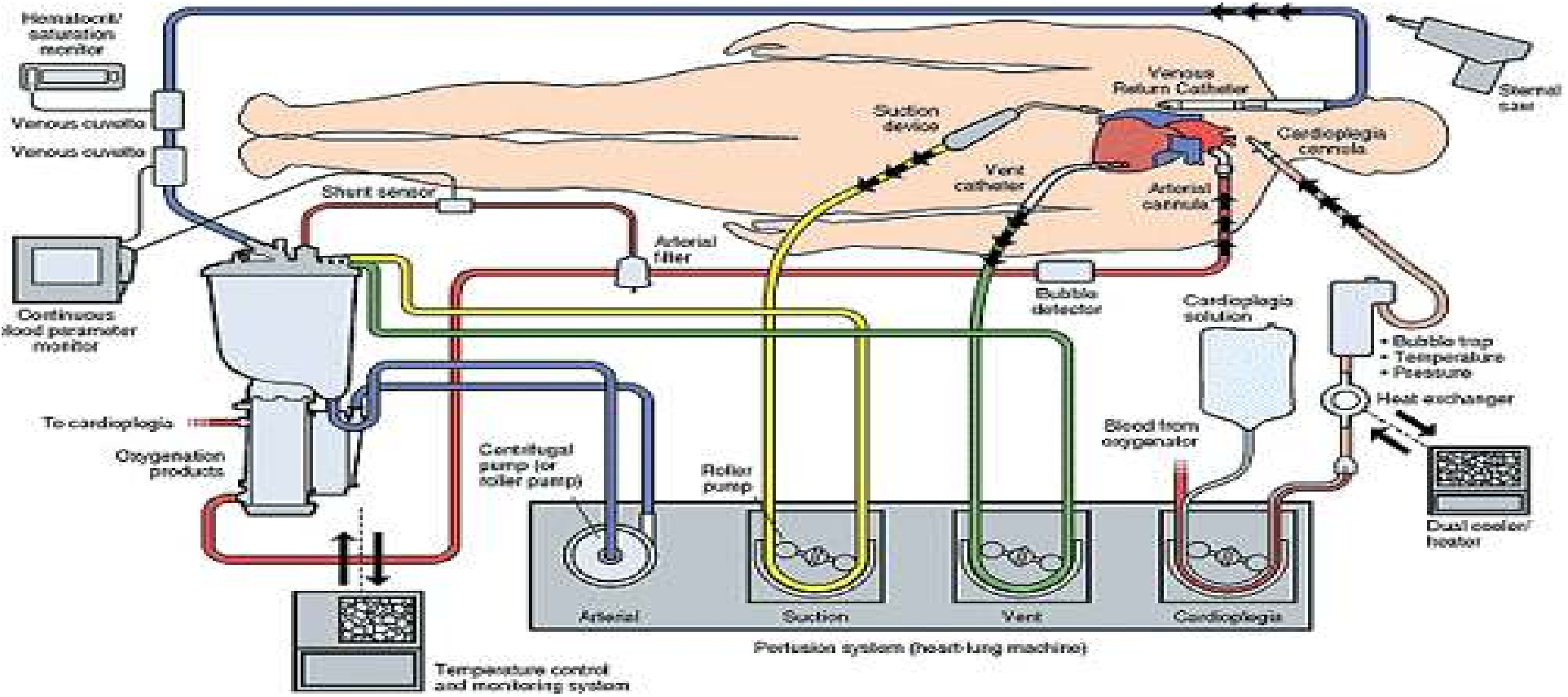
Fast and accurate measurements of the blood levels of the partial pressures of oxygen (pO_2), carbon dioxide (pCO_2) as well as the concentration of hydrogen ions (pH) are vital in diagnosis.



The effect of artifact on a pulsatile signal from an oximetry sensor



Mechanical Ventilation



Asthma - Breathing monitors

Electronic flow meters that store readings are very useful for Asthma diaries.

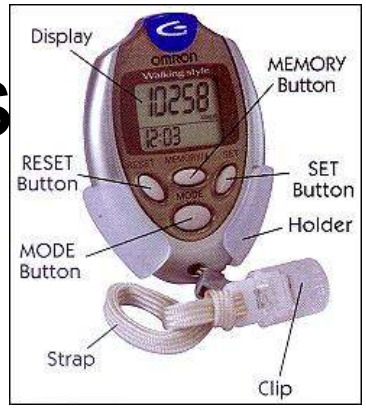
Ferraris Koko electronic, recording flow meter

Micromedical SpiroUSB Spirometer

Micromedical MicroDiaryCard recording Spirometer

Exercise pedometers

Omron

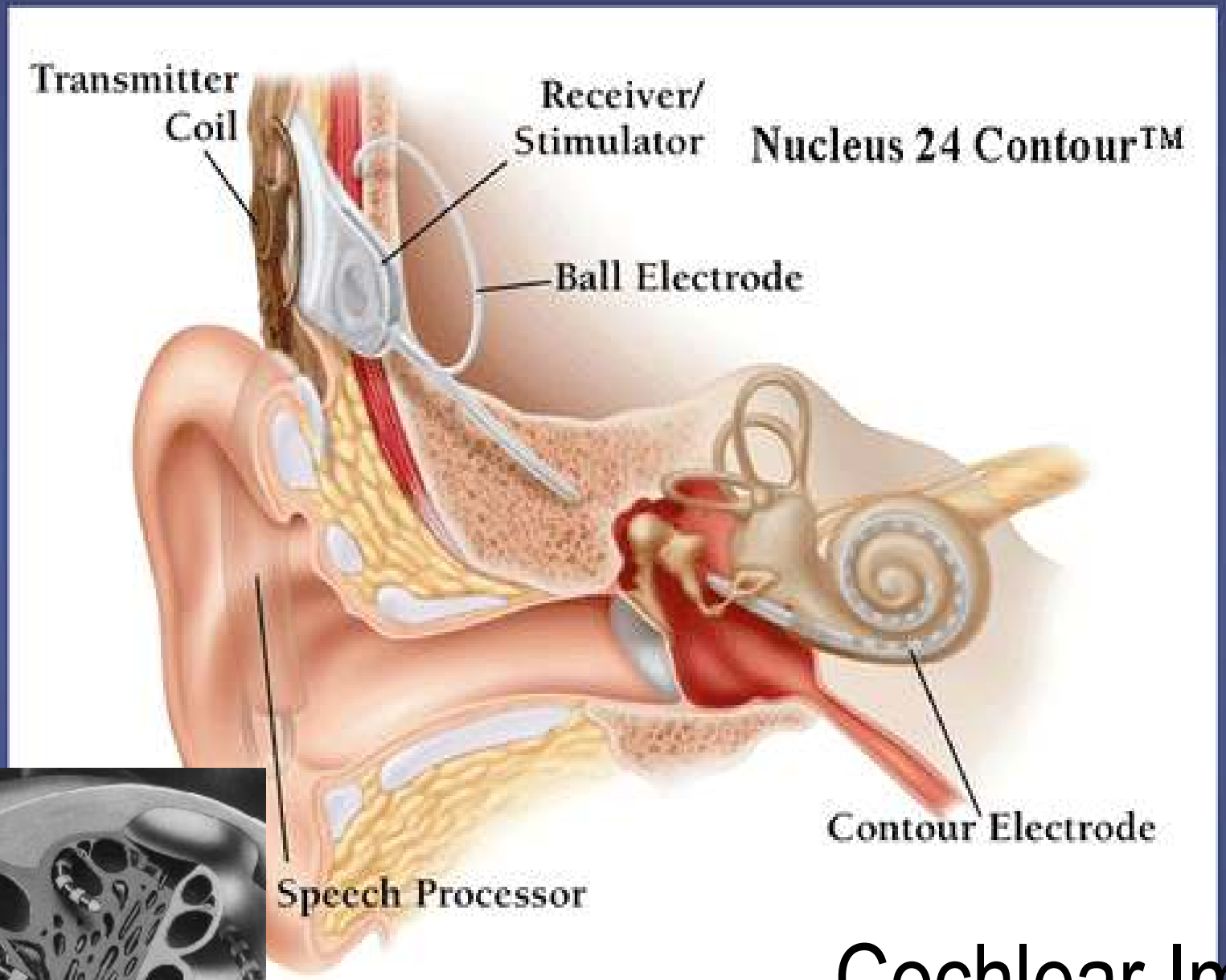


Accelerometer-based sensors detect leg motion. Sensor typically mounted in the shoe or at the waist.

BodyMedia
BodyBugg

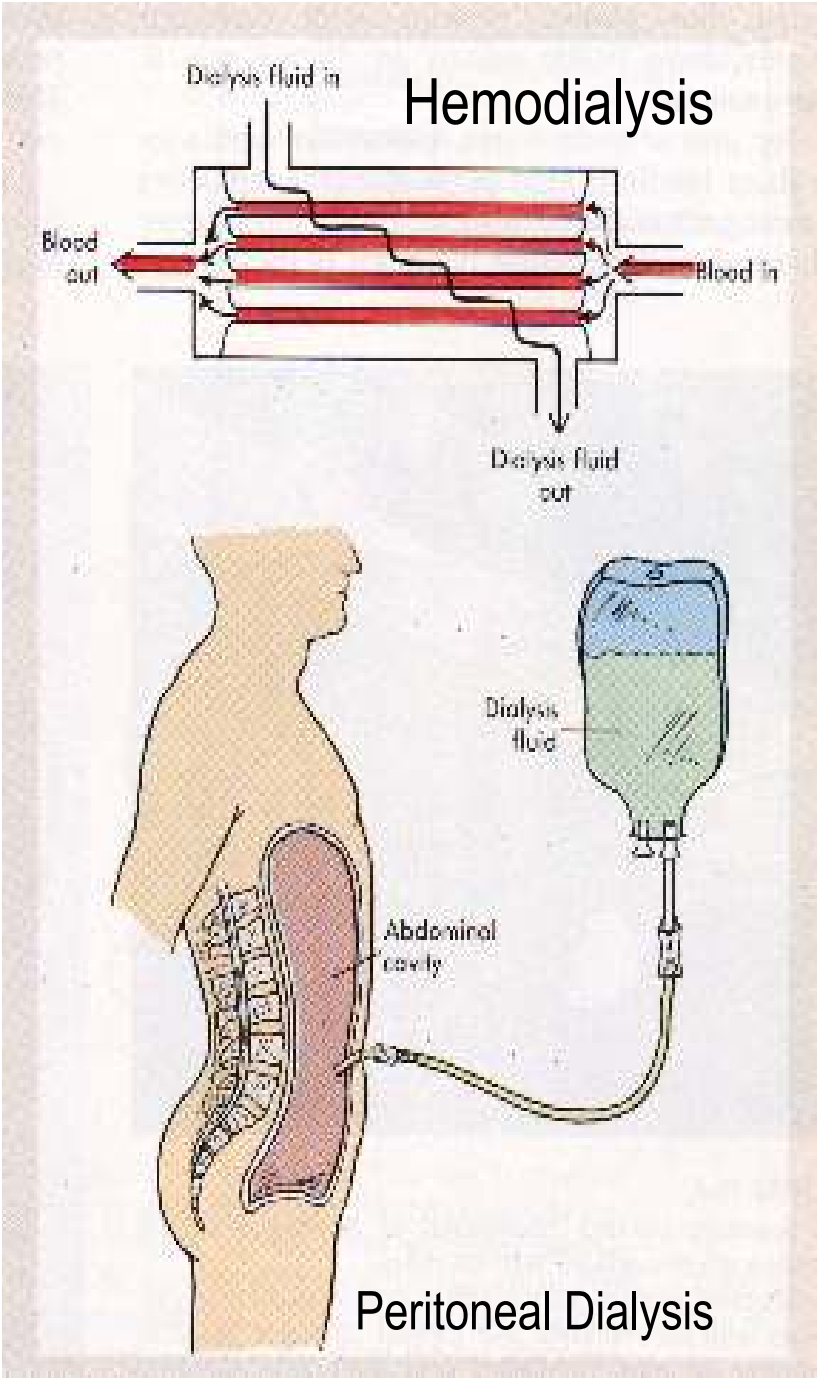
Suunto's T6, Footpod and X9i

Fitsense pacer and bodylan



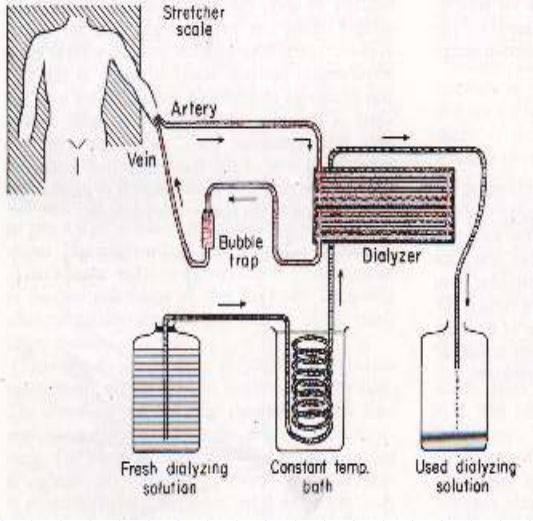
Cochlear Implar

Dialysis and Blood Manipulation techniques



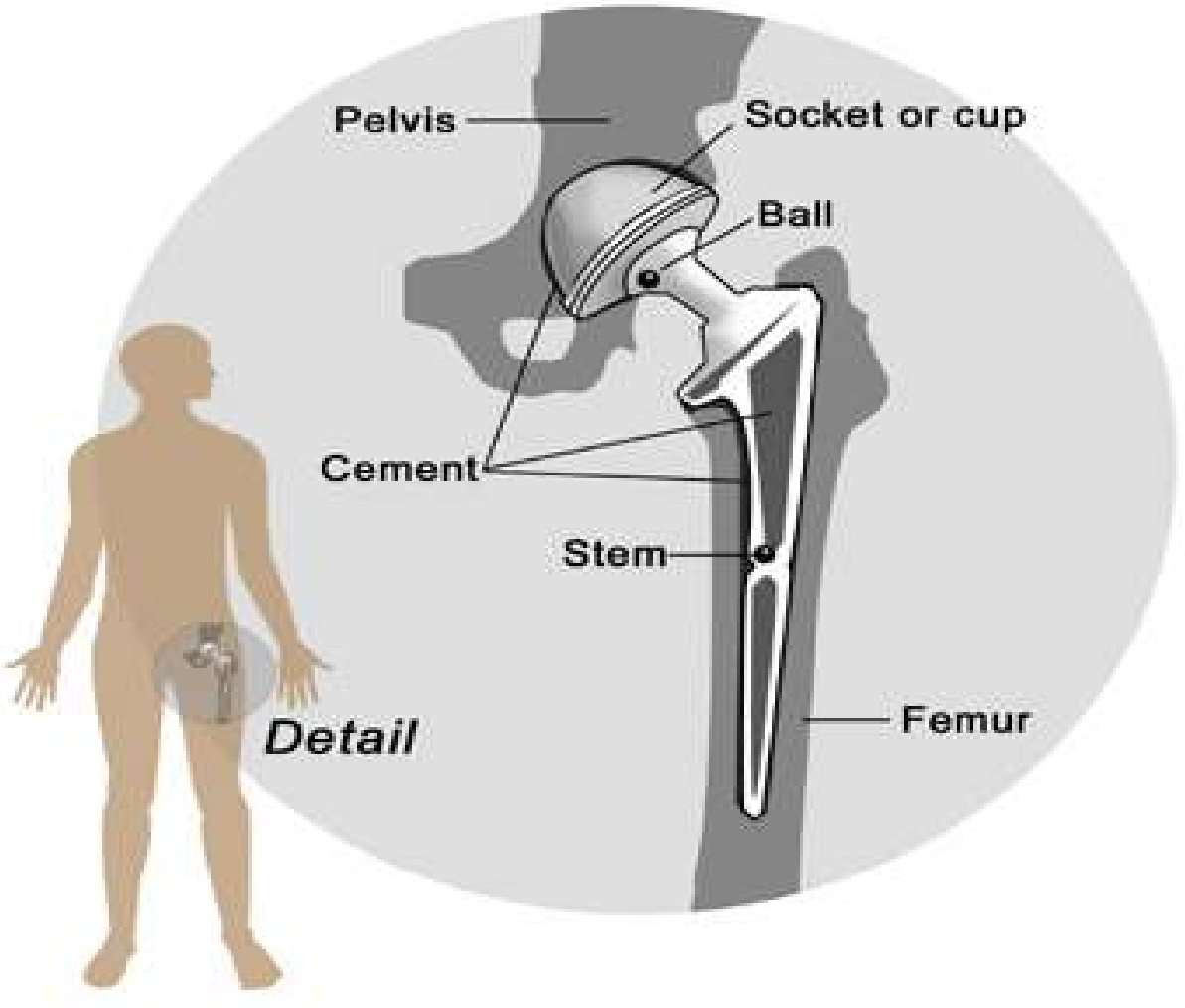
Hemodialysis

Peritoneal Dialysis



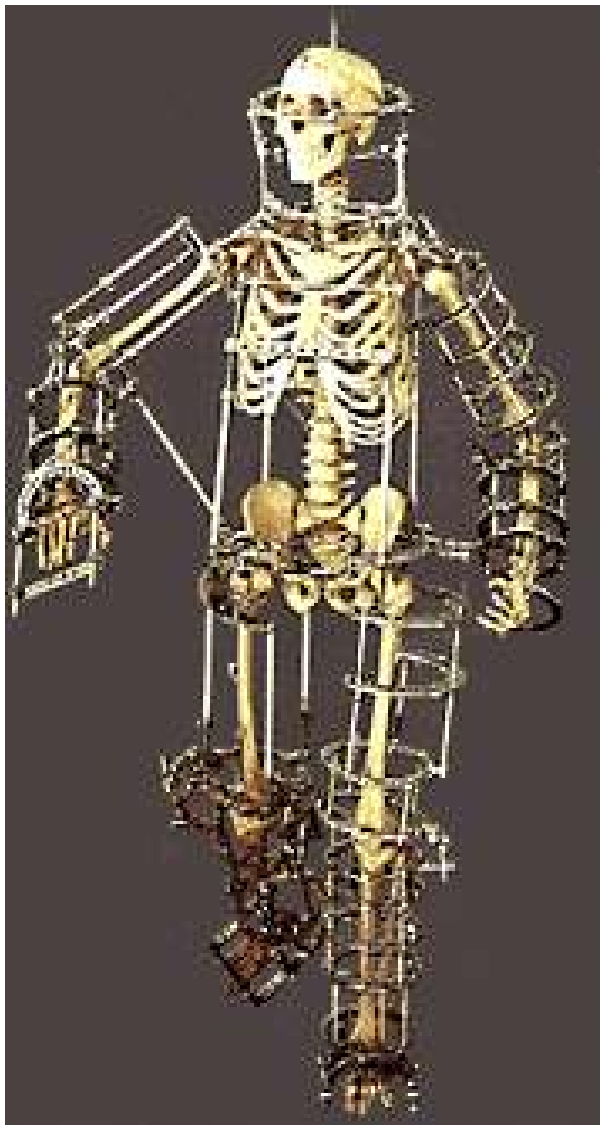
Hollow Fibre Module

Orthopedics – Artificial Hip

- 

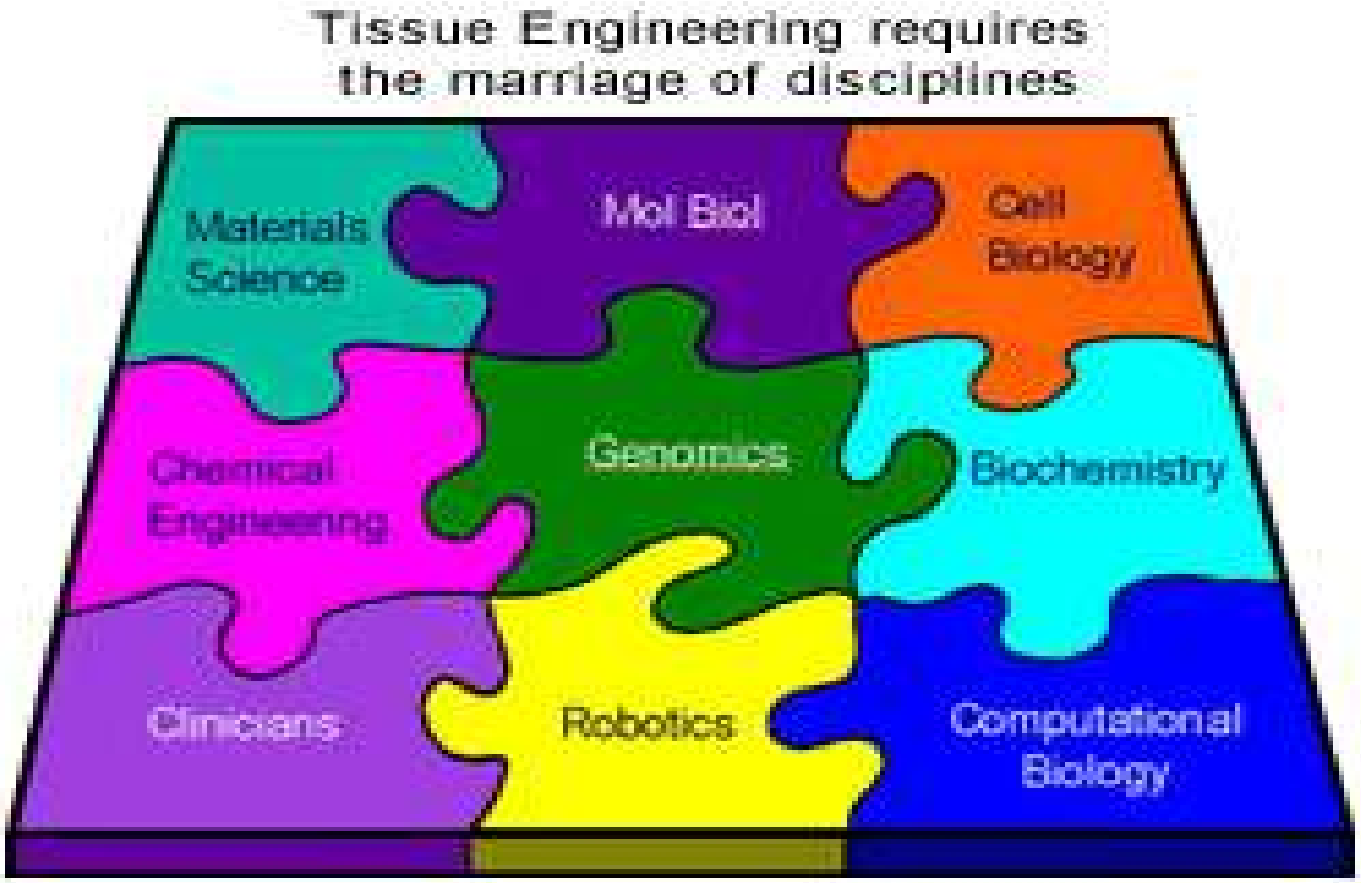
http://www.depuyorthopaedics.com/

Ilizarov – Limb Lengthening



- 

Tissue Engineering is Multidisciplinary



Source: *http://www.utoronto.ca/IBBME/research/tissue.htm*

Telemedicine & Health Robots

Telemedicine + Robotic Surgery

Intouch Health

www.intouch-health.com