

INTRODUCTION TO BIOMEDICAL ENGINEERING PROFESSION

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History of Biomedical Engineering

► **Prior to the 1900's:**

- Medicine had little to offer the common individual
- At the turn of the 20th century, advances in almost all areas of sciences enabled medical researchers to make giant strides forward

► **Early 1900's:**

- First advances in medical diagnostics and imaging
 - *In 1896 Wilhelm Rontgen developed X-ray imaging*
 - » initially used for the diagnosis of bone fractures
 - » technology has evolved today to visual all organ systems (with the use of radio-opaque materials)
- Ex: in medical Radiography, Airport Security, etc...



Radiograph of the hand of Albert von Kolliker,

Röntgen went on to win the first Nobel Prize in 1901 for his invention



French physician Rene Laennec examining a **tuberculosis** patient by "immediate" auscultation with the unaided ear in the Necker Hospital, Paris. In his left hand is the **stethoscope** .

WHAT IS BIOMEDICAL ENGINEERING ?

- ▶ Biomedical engineering integrates physical, chemical, mathematical and computational sciences and engineering principles to study biology, medicine, behavior, and health
- ▶ Apply knowledge of engineering, biology, and biomechanical principles to the **design, development, and evaluation of biological and health systems and products**, such as artificial organs, prostheses, instrumentation, medical information systems, and health management and care delivery systems

Biomedical Engineering (BME)

BIOMEDICAL ENGINEERS

- ▶ *Design and manufacture products* that can
 - monitor physiologic functions or
 - display anatomic detail
- ▶ *Detection, measurement, and monitoring of physiologic signals*
 - biosensors
 - biomedical instrumentation
 - medical imaging
- ▶ *Assist in the diagnosis and treatment of patients*
 - computer analysis of patient-related data
 - clinical decision making
 - medical informatics
 - artificial intelligence/expert system
- ▶ *Supervise biomedical equipment maintenance technicians*
- ▶ *Investigate medical equipment failure*
- ▶ *Advise hospitals about purchasing and installing new equipment*

Achievements of Biomedical Engineering

- ▶ **Optical lens**
 - 1666, Newton
 - 1850–, ophthalmoscope, Helmholtz
- ▶ **Stethoscope**
 - 1819, hollow tube
 - 1851, binaural stethoscope
- ▶ **X-ray**
 - 1895, Rontgen
 - 1896, in diagnosis and therapy
- **Radioactivity**
 - 1896, Curie
 - 1903, in therapy
- **Electrocardiograph**
 - 1887, Waller, capillary meter
 - 1903, Einthoven,
 - galvanometer 1928, vacuum tube
- **Electroencephalograph**
 - 1924, Berger
- **Electrical surgical unit, 1928**

Achievements of Biomedical Engineering

▶ Assisting ventilator

- 1928, "iron lung"
- 1945, positive pressure

▶ Ultrasonic imaging

- pulse-echo, 1947
- Doppler, 1950s

▶ Magnetic Resonance Imaging (MRI)

- NRM, Bloch, Purcell, 1946
- MRI, 1982

• Computed tomography

- 1969, Cormack, Hounsfield

• Electrical heart defibrillator

- 1956, Zoll
- 1980, implanted

• Implanted electrical heart pacemaker

- 1960, Greatbatch

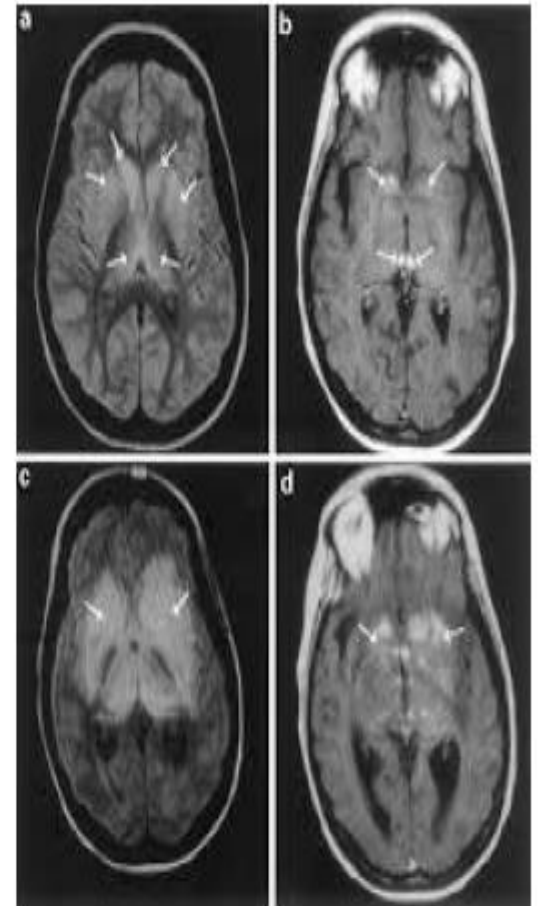
• Heart valves, 1975

• Cardiac catheter, 1975

• Artificial kidney (dialysis), 1960

• Artificial heart, 1984

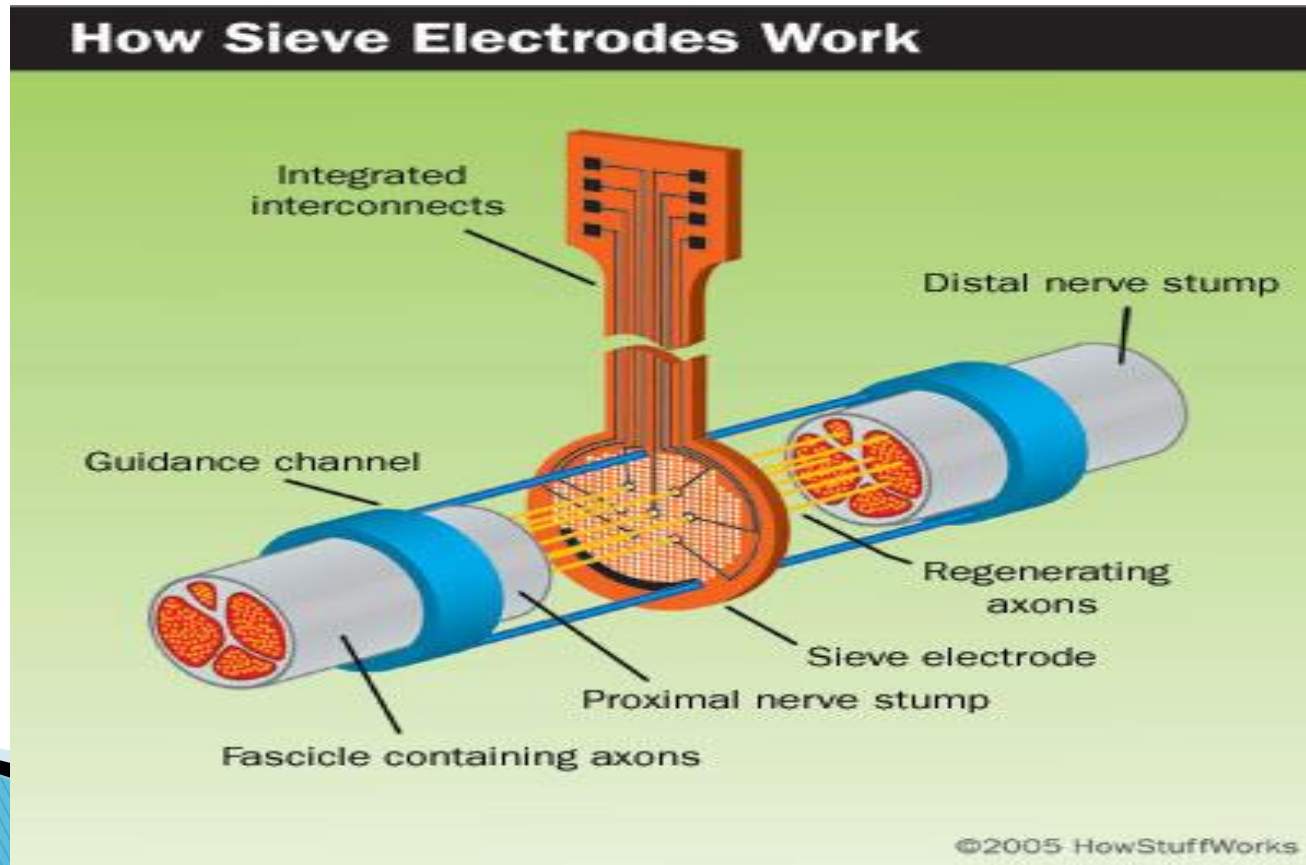
Magnetic Resonance Imaging (MRI)



Streams in Biomedical Engineering

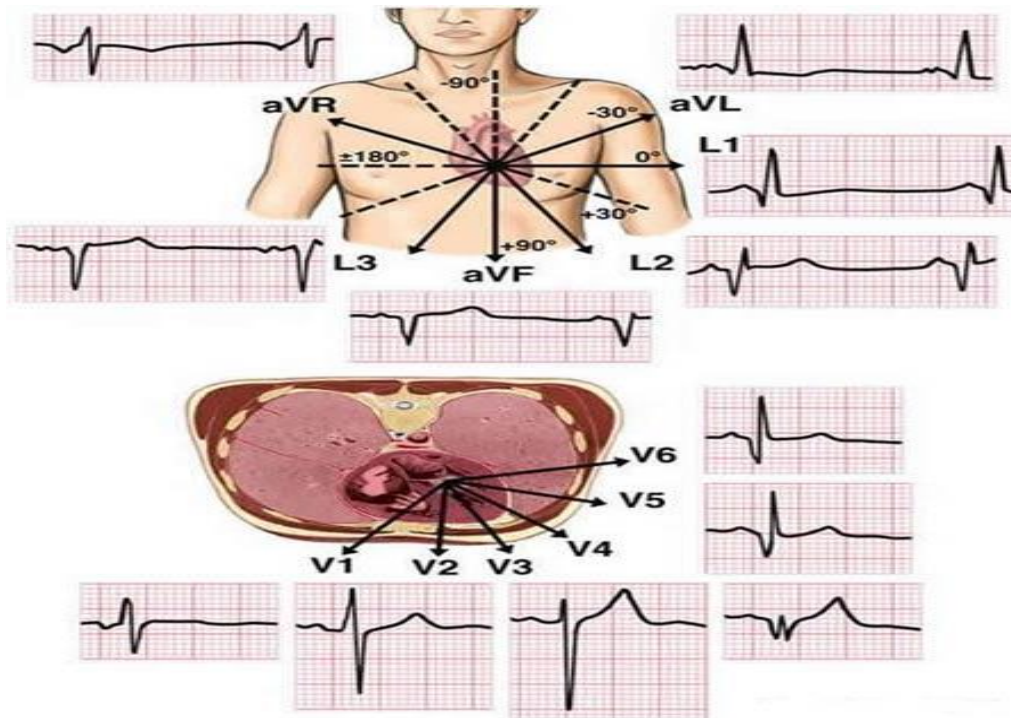
1. Biomechatronics

- Aims to integrate mechanical, electrical, and biological parts together. e.g. sieve electrodes, advanced mechanical prosthetics



2. Bioinstrumentation

- Construction of devices for measuring aspects of physiological status
e.g. Electrocardiography (ECG), Electroencephalography (EEG)

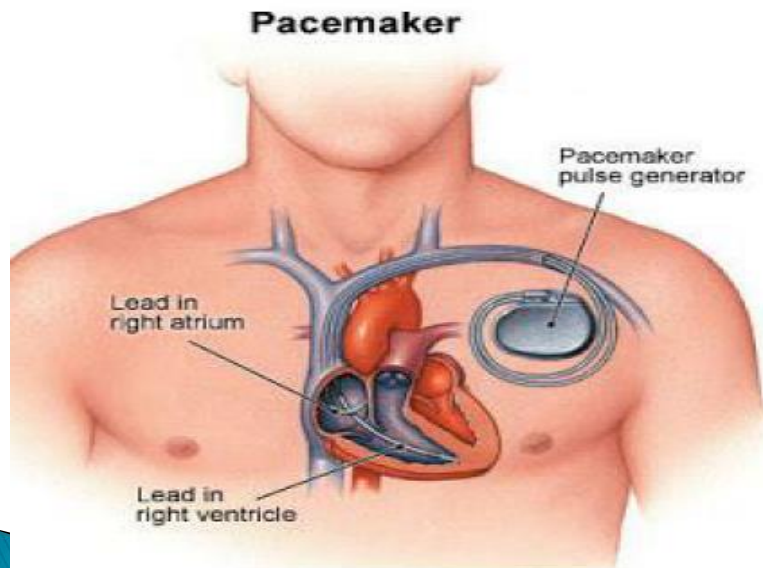


12 lead EKG configurations

3. Biomaterials

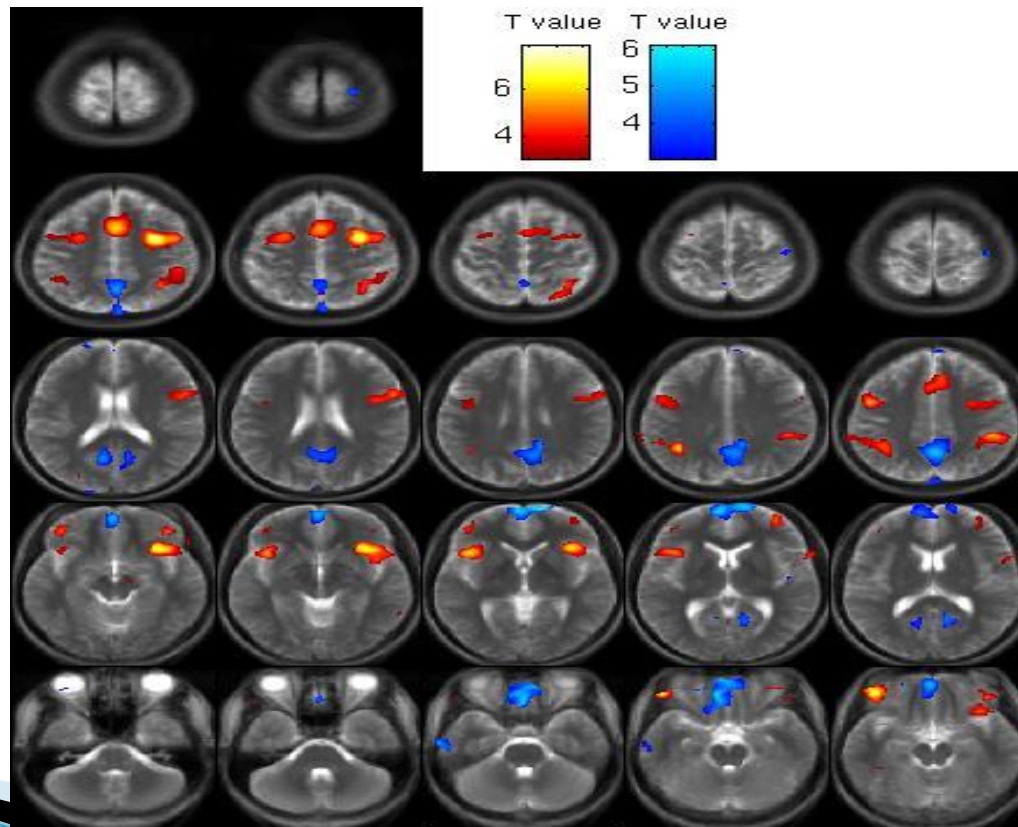
- Development of materials either derived from biological sources or synthetic, generally used for medical applications

EX. Biopolymers, Scaffold material for tissue engineering, Coating for transplants, Artificial ligaments and tendons, Heart valves, Skin repair devices (artificial tissue), etc, ...

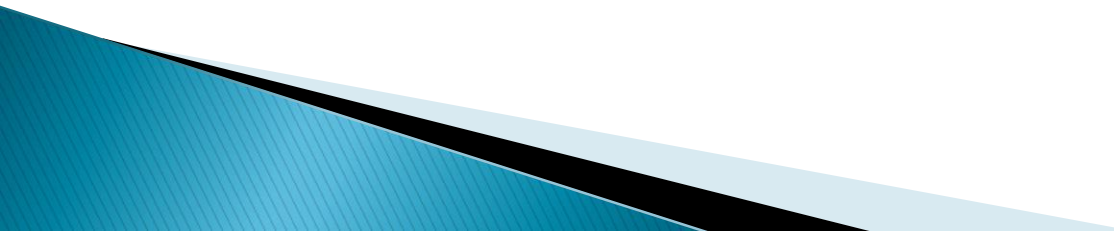


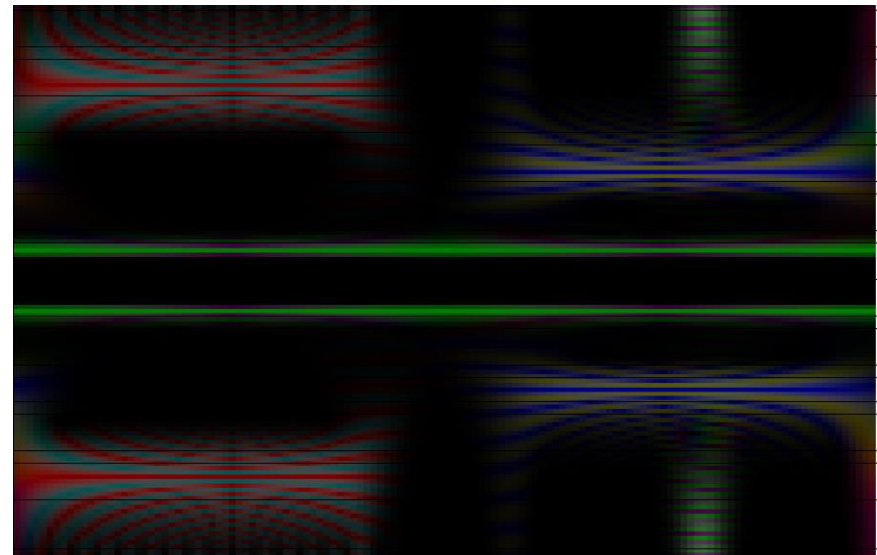
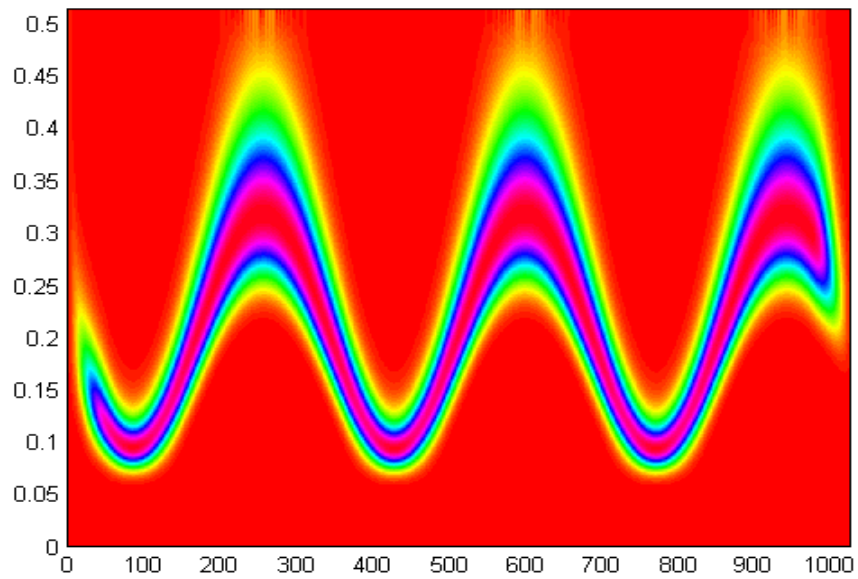
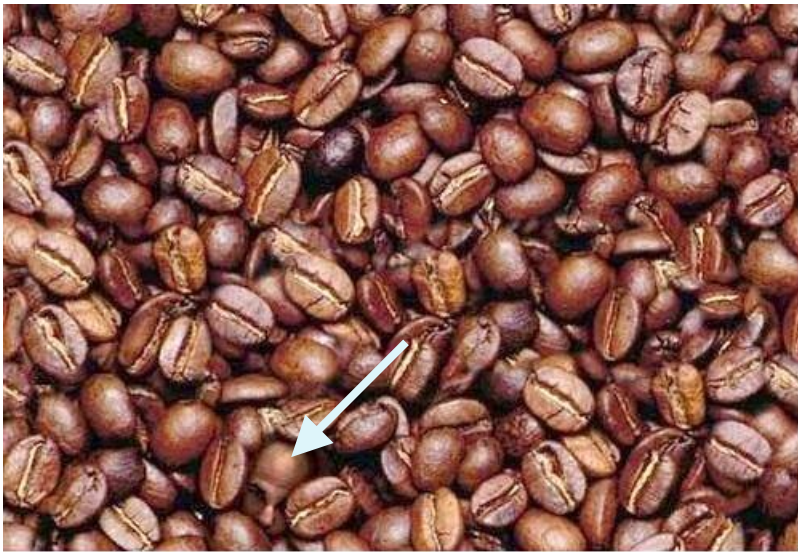
4. *Medical imaging*

- Visualization of anatomy and physiology, essential for modern diagnosis and treatment
e.g. X-ray, CT, MRI, fMRI, PET, SPECT, ultrasound



5. Bio signals (Medical Informatics)

- ❑ Signal analysis (statistics and transform) of biological signals
 - ❑ Use data to uncover the mechanisms of signal production, and the fundamental origins of the variability in the signal
 - ❑ Data collection and analysis to assist in decision making
- 

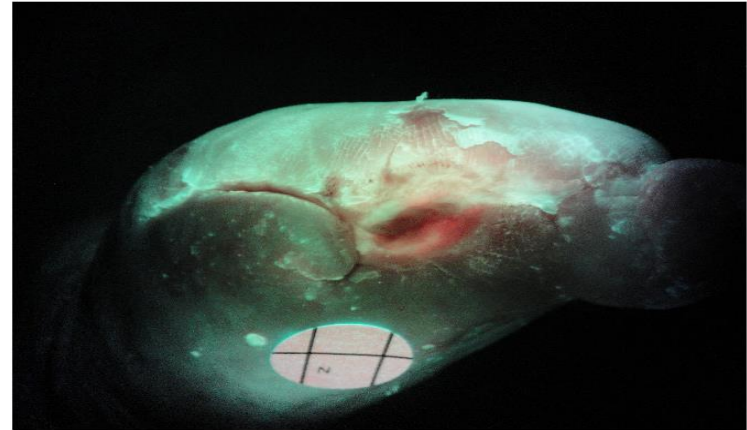


Diabetics

White light



Florescence



Dermatology

Malignant Melanoma



© 1996 Jeffrey L. Melton

Tinea Corporis
(of the arm)



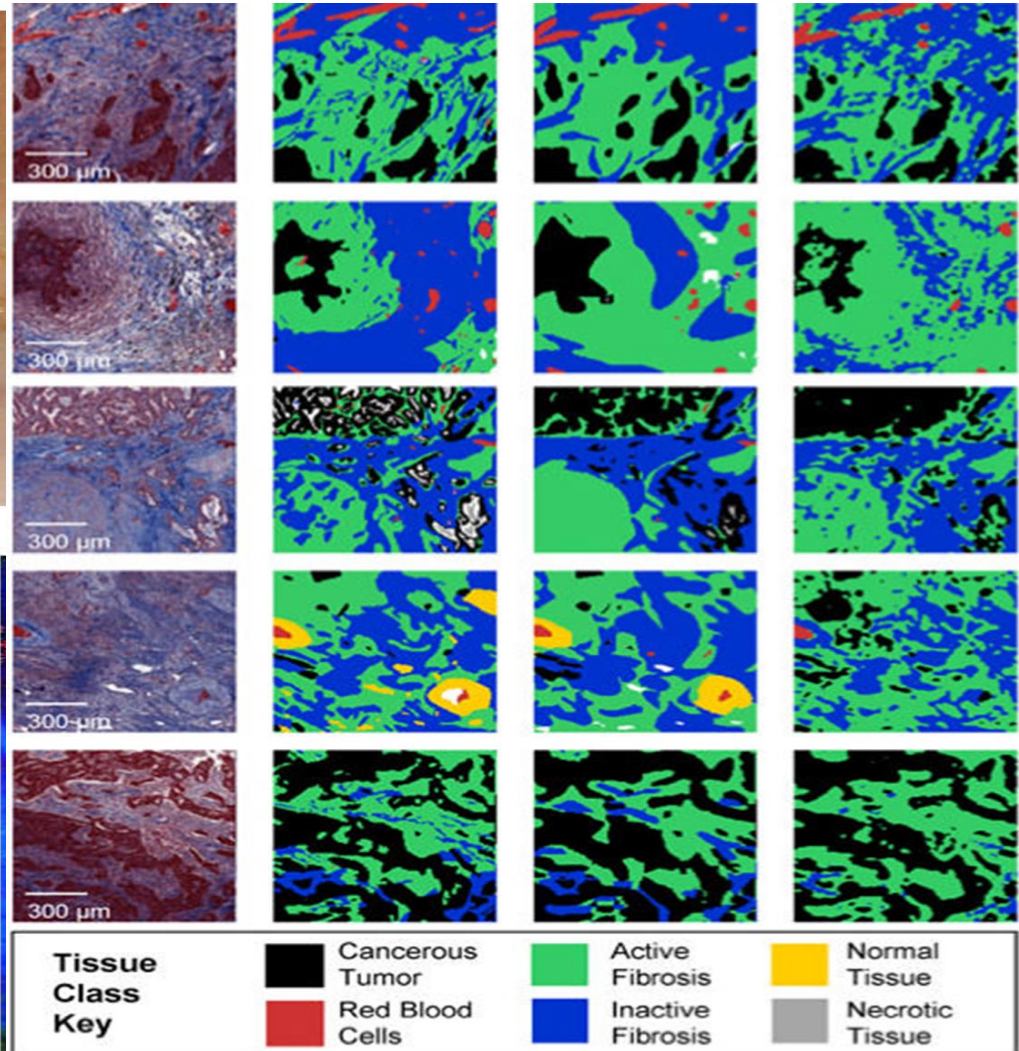
© 1989 Jeffrey L. Melton, M.D.

Basal Cell Carcinoma
(of the Cheek)



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Wound/Tissue/Object Classification





Administration



Central



Emergency



Engine



Housekeeping



Healthcare



Laboratory



Laundry



Physical Therapy

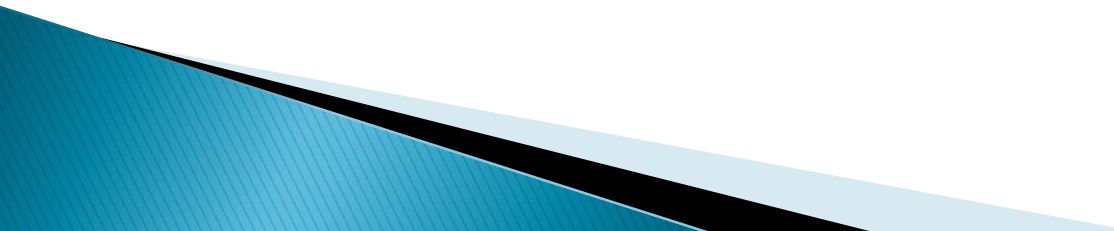


Radiology

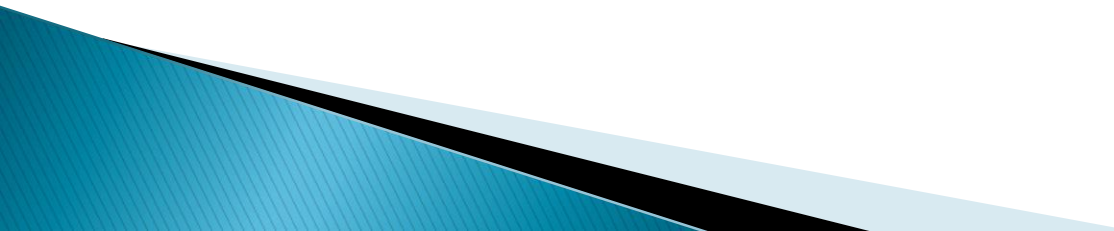


Surgical

6. Rehabilitation Engineering

- ❑ Works directly with patients such as disabled individuals to modify or design new equipment to improve patients quality of life
 - **Orthopedic devices:** appliances that aid an existing function
 - **Prosthetic devices:** provide a substitute
- 

Biomedical Engineering in Ethiopia

- ▶ A lot of emphasis given to it by the Government (GTP/HSDP/HSTP).
 - ▶ Setting up Biomedical Engineering team at the existing and future hospitals.
 - ▶ Emphasis for biomedical engineers at the three actors (FMOH, ~~PFSA~~/EPSA, ~~EFMHACA~~/EFDA).
 - ▶ Huge research opportunities.
 - ▶ The market needs MANY Biomedical Engineers.
 - ▶ Biomedical manufacturers are coming.
 - ▶ Academia: BSc (JiT, AAiT, HU, GU), MSc (AAiT, JIT,BIT), PhD (AAiT), TVETs
- 

WHAT DO BME STUDENTS LEARN AT AAiT

- ☐ Basic biology and human physiology
- ☐ Basic chemistry and laboratory techniques
- ☐ Human biological systems in terms of fundamental physics and engineering principles
- ☐ Biomaterials, biomechanics and related fields

WHAT DO BME STUDENTS LEARN AT AAiT (Cont...)

- ☐ Latest instrumentation and methodologies in biomedical engineering
- ☐ Use computers in a biomedical setting
- ☐ Research experience in biomedical settings
- ☐ Practical biomedical engineering experience through job-related training, industrial internships, and biomedical design projects
- ☐ Hands on: Biomedical Instruments, **Brand new Design Studio/Maker Space**, etc

CAREER OPPORTUNITIES IN ETHIOPIA AND ABROAD

- ☐ Pharmaceutical companies as a process engineer: equipment design, producing new drug...
- ✓ Multi-Billion Dollar Business!
- ☐ Clinical engineering in hospitals
- ☐ Graduate School: Researcher

JOBS FOR BME GRADUATES IN ETHIOPIA AND ABROAD

- ☐ **Design and construct medical devices** such as cardiac pacemakers, defibrillators, artificial kidneys, blood oxygenators, hearts, blood vessels, joints, arms, and legs
- ☐ **Design computer systems** to monitor patients during surgery or in intensive care

JOBS FOR BME GRADUATES IN ETHIOPIA AND ABROAD (Cont ...)

- ☐ **Design and Build sensors** to measure blood pressure and blood chemistry, such as potassium, sodium, O_2 , CO_2 , and pH
- ☐ **Design instruments and devices** for therapeutic uses, such as a laser system for eye surgery or a device for automated delivery of insulin
- ☐ **Construct and implement** mathematical/computer models of physiological systems

JOBS FOR BME GRADUATES IN ETHIOPIA AND ABROAD (Cont ...)

- ❑ Establish and maintain clinical laboratories and other units within the hospital and health care delivery system that utilize advanced technology
- ❑ Design, build and investigate medical imaging systems based on X-rays (computer assisted tomography = CAT), isotopes (positron emission tomography = PET), magnetic fields (magnetic resonance imaging = MRI), ultrasound, or newer modalities

JOBS FOR BME GRADUATES IN ETHIOPIA AND ABROAD (Cont ...)

- ❑ **Design and construct biomaterials** and determine the mechanical, transport, and biocompatibility properties of implantable artificial materials
- ❑ **Implement new diagnostic procedures**, especially those requiring engineering analyses to determine parameters that are not directly accessible to measurements, such as in the lungs or heart



- Although biomedical engineers are not medical practitioners, one could say that they are indirect practitioners, since the technologies and techniques they develop co-determine medical practice
- The ethical responsibilities of biomedical engineers thus combine those of engineers and medical professionals
- The Code of Ethics of Biomedical Engineers involved in the healthcare activities, R&D and training is indicated as follows:



Biomedical Engineering Professional Obligations

Biomedical engineers in the fulfillment of their professional engineering duties shall:

1. Use their knowledge, skills, and abilities to enhance the safety, health, and welfare of the public.
2. Strive by action, example, and influence to increase the competence, prestige, and honor of the biomedical engineering profession.



Biomedical Engineering Healthcare Obligations

Biomedical engineers involved in health care activities shall:

1. Regard responsibility toward and rights of patients, including those of confidentiality and privacy, as their primary concern.
2. Consider the larger consequences of their work in regard to cost, availability, and delivery of health care.



Biomedical Engineering Research Obligations

Biomedical engineers involved in research and development shall:

1. Comply fully with legal, ethical, institutional, governmental, and other applicable research guidelines, respecting the rights of and exercising the responsibilities to colleagues, human and animal subjects, and the scientific and general public.
2. Publish and/or present properly credited results of research accurately and clearly.



Biomedical Engineering Training Obligations

Biomedical engineers entrusted with the responsibilities of training others shall:

1. Honor the responsibility not only to train biomedical engineering students in proper professional conduct in performing research and publishing results, but also to model such conduct before them.
2. Keep training methods and content free from inappropriate influence from special interests.

WELCOM TO THE
DEPARTMENT OF BME

where

“Hybridization” of skills
and knowledge has
become a reality!

END OF PRESENTATION