

CSEN 1099 – Introduction to Biomedical Engineering

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CSEN1099 – Introduction to Biomedical Engineering

- Instructor
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- Office Hours
 - Tuesdays– 12:00pm to 1:00pm (Office: C7-210)
- Textbooks
 - “Introduction to Biomedical Engineering” by John Enderle and Joseph Bronzino. Elsevier, Academic Press, third edition, 2012
 - “Practical Biomedical Signal Analysis Using Matlab” by Katarzyna Blinowska and Jaroslaw Zygiereicz. CRC Press, Boca Raton, FL, USA, 2011
 - Other sources

CSEN1099 – Introduction to Biomedical Engineering

- Course Evaluation
 - 3 Assignments (Programming): 30%
 - Mid-term exam: 20%
 - 3 Quizzes: 10% (Best 2 out of 3)
 - Final exam: 40%

Biomedical Engineering

- Biomedical Engineering has emerged as an integrating medium for two dynamic professions: medicine and engineering
- Biomedical Engineers seek new solutions for the difficult problems confronting modern society
- This course aims to:
 - Introduce the field of biomedical engineering
 - Focus on biomedical signals analysis
 - Introduce different biomedical engineering applications
 - Describe physiological modeling of different systems

History of the Health Care System

- Starting from primitive humans, diseases were only cured by magic and herbs



Headaches

In prehistoric times people believed that a headache was caused if a person's spirit left their body or if a dark evil spirit entered the body.



If a person had a headache they would go to see the Medicine Man. The Medicine Man was a very important, powerful and respected person in the tribe because he could understand and deal with the spirits.



To treat illnesses in prehistoric times many people used plants and herbal remedies. For headaches people often used trepanning. This is where a hole is cut into the head and a piece of skull is removed, to relieve swelling of the brain.



Trepanning, although it sounds very dangerous, sometimes worked. Archaeologists have found skulls from prehistoric dig sites which have shown the use of trepanning and that the skulls have begun to heal.



History of the Health Care System

- Imhotep, the architect of the first pyramid (3000 BC), was honored through the centuries, not as a pyramid builder, but as a doctor
- He was deified in the Egyptian culture as the god of healing



Elbers Papyrus – 1500BC
(Remedies of pain)



Smith Papyrus – 1700BC
(Diagnosis and Treatment)

History of the Health Care System

- The symbol Rx that is used with any drug prescription comes from the Eye of Horus
- When Horus lost his vision, Thoth, the god of health restored his vision. The Eye of Horus became the symbol of recovery and protection ever since



- In 2000, German archeologists uncovered a 3,000-year-old mummy from Thebes with a wooden prosthetic tied to its foot to serve as a big toe

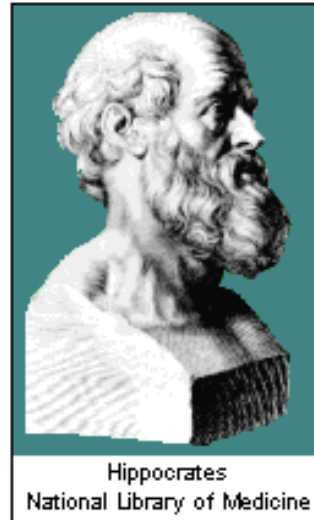
History of the Health Care System

- In Greece, the Aesculapia were temples of the healing cult and may be considered among the first hospitals
- Patients were received and psychologically prepared, through prayer and sacrifice
- If patients remained ill, it would be attributed to their lack of faith



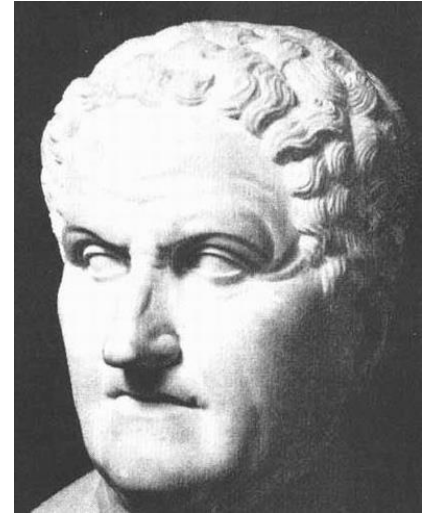
History of the Health Care System

- In 460 BC, Hippocrates, the most famous of all ancient physicians, was born. He and his students wrote over 70 books that tell much about ancient Greek healthcare and the beginning of professional medicine
- For Hippocrates, observation and clinical treatment began to replace superstition
- Hippocrates taught that disease was a natural process, one that developed in logical steps, and that symptoms were reactions of the body to disease
- Even today, physicians still swear to the Hippocratic Oath before beginning practice
- The Romans then made outstanding contribution to public health. The construction of sewer systems and aqueducts were truly remarkable⁹
Roman accomplishments



History of the Health Care System

- The most influential physician of the Roman era was Galen, who served the emperor Marcus Aurelius
- He wrote more than 300 books of anatomical observations, which included selected case histories and the drugs he prescribed
- He stressed that the best way to learn about health and disease was through the dissection of animals and the study of anatomy
- With the collapse of the Roman Empire, the Church became the repository of knowledge
- Members of the Church regarded curing patients by rational methods as sinful interference with the will of God



History of the Health Care System

- Although deficient in medical knowledge, the Dark Ages were not entirely lacking in charity. Christian physicians often treated the rich and poor alike, and the Church assumed responsibility for the sick
- From the fall of Rome until the European Renaissance of the 15th century, the Islamic world was the center of medical knowledge
- The Arabs improved many Greek and Roman medical techniques. They developed first-class civilian hospitals
- Ibn Sina (born 980AD) is the most famous and influential philosopher-scientist of the Islamic world
- His most famous works are The Book of Healing, a vast philosophical and scientific encyclopaedia, and The Canon of Medicine, which was a standard medical text at many medieval universities



History of the Health Care System

- During the Renaissance, fundamentals received closer examination and the age of measurement began
- Galileo encouraged the use of experimentation and exact measurement as scientific tools
- Body temperature and pulse rate became measures that could be related to other symptoms
- The development of the microscope amplified human vision
- Hospitals for long time remained a place to avoid. For example, in 1788 the death rate in the Hotel Dru, the oldest hospital in existence in Paris, was 25%. Death rate among workers was between 6 and 12%



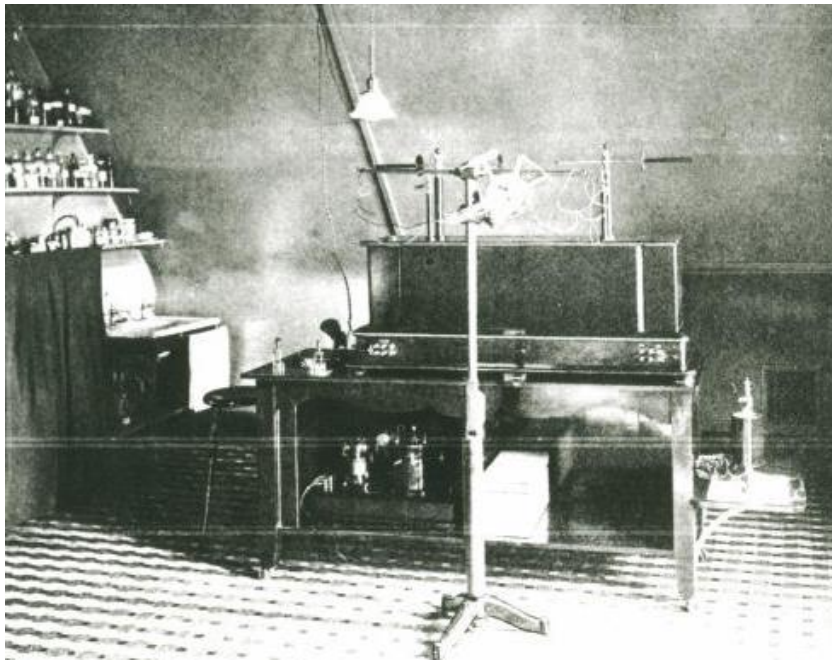
History of the Health Care System

- Not until the nineteenth century could hospitals claim to benefit any significant number of patients after Florence Nightingale practices
- She demonstrated that hospital deaths were caused more frequently by hospital conditions than by disease
- Modern medical practice began at the turn of the twentieth century
- Advances in the basic sciences (chemistry, physiology, pharmacology, and so on) began to occur much more rapidly



History of the Health Care System

- The most significant discovery for clinical medicine was the development of x-rays by W.K. Roentgen in 1895
- The x-ray permitted to diagnose a wide variety of diseases and injuries accurately



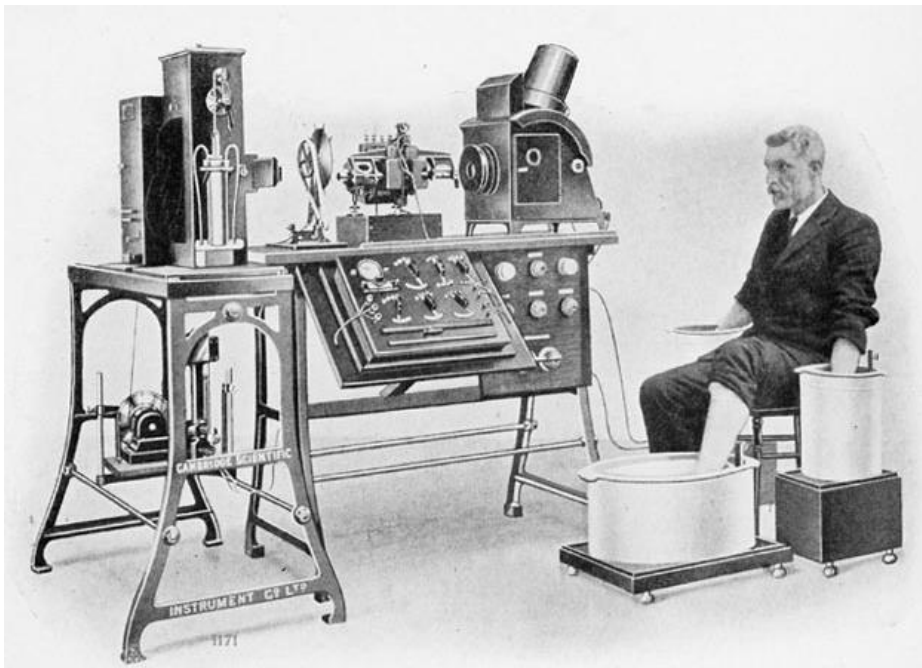
First X-rays Machine



Nowadays X-rays Machine

History of the Health Care System

- In 1903 William Einthoven devised the first electrocardiograph and measured the electrical changes that occurred during the beating of the heart



First Electrocardiogram



Nowadays Electrocardiogram

History of the Health Care System

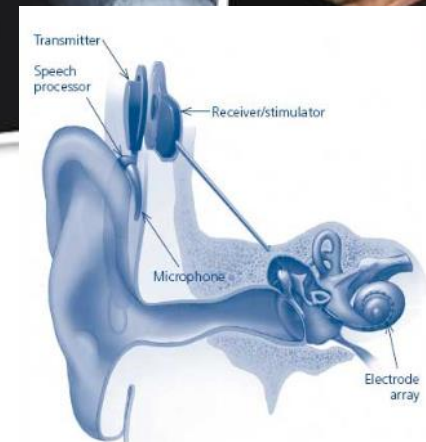
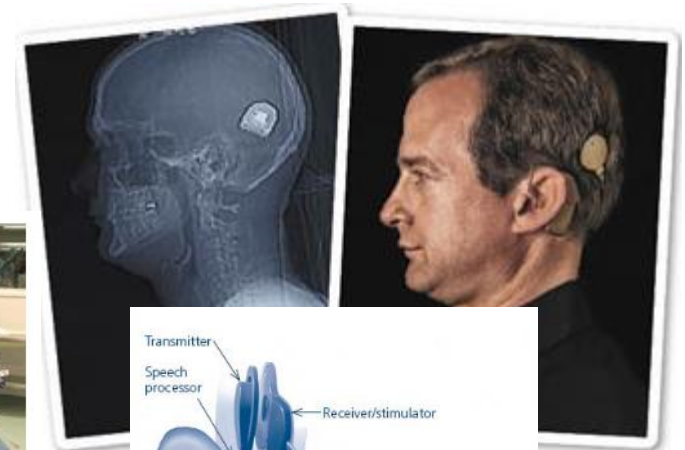
- The introduction of sulfanilamide in the mid-1930s and penicillin in the early 1940s significantly reduced the main danger of hospitalization: cross infection among patients
- The employment of the available technology assisted in advancing the development of complex surgical procedures



Medical Imaging Facility



Robotic Surgery



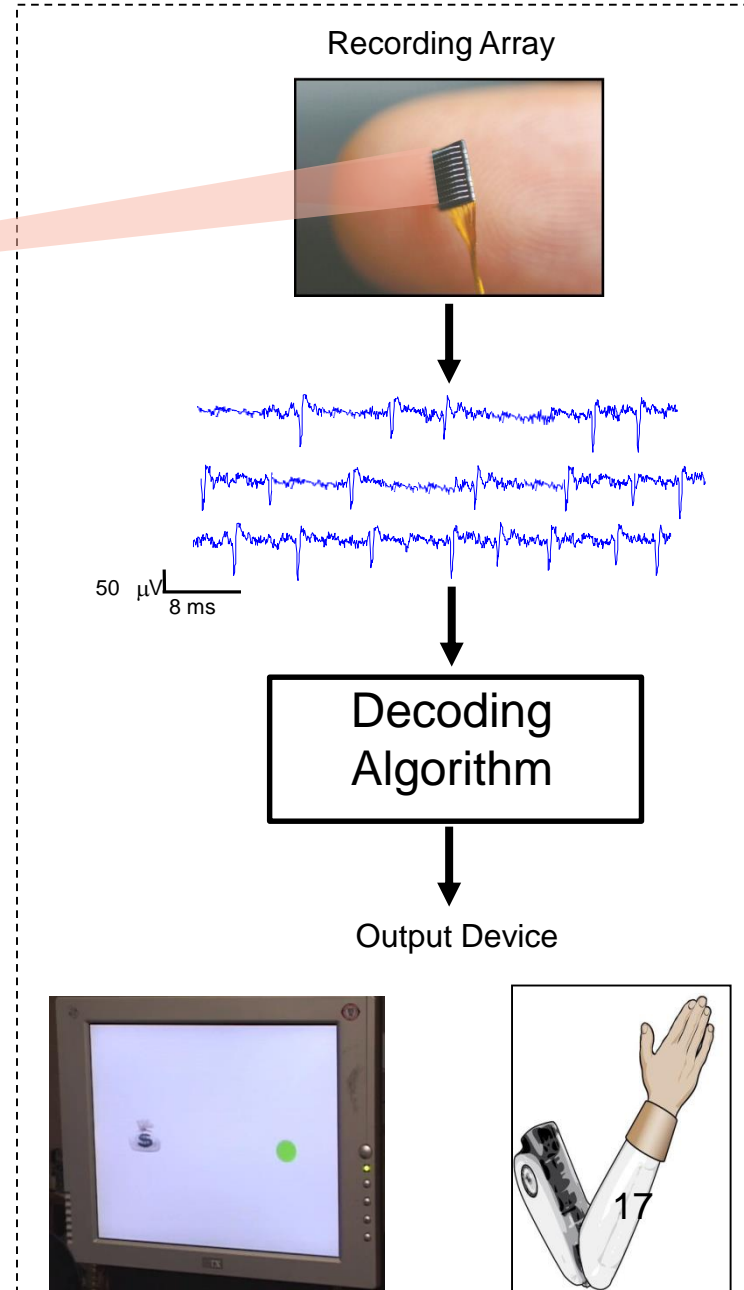
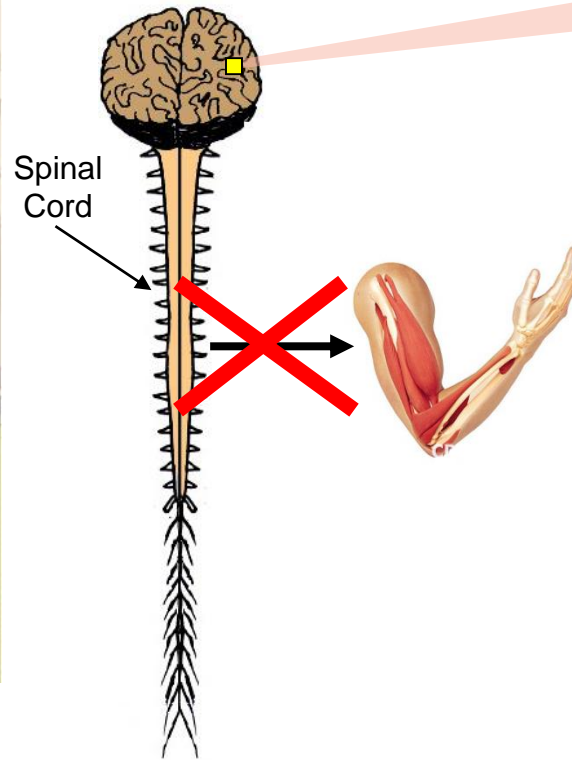
Cochlear Implant

History of the Health Care System

- Brain-Machine Interfaces (BMIs)



(Hochberg et al., 2006)



History of the Health Care System

- Brain-Machine Interfaces (BMIs)

In 2012, scientists at Brown University, USA, reported a BMI that a paralyzed subject can use to control a robotic arm to grab a bottle and drink from it

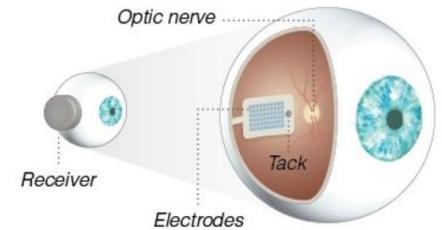
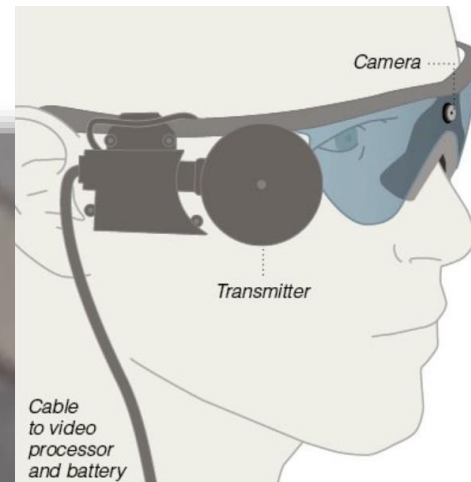


<http://www.youtube.com/watch?v=cg5RO8Qv6mc>

History of the Health Care System

- Visual Prosthesis for the Blind

A device to restore vision in the blind by electrically stimulating the retina. Got approved for humans in the US in 2013



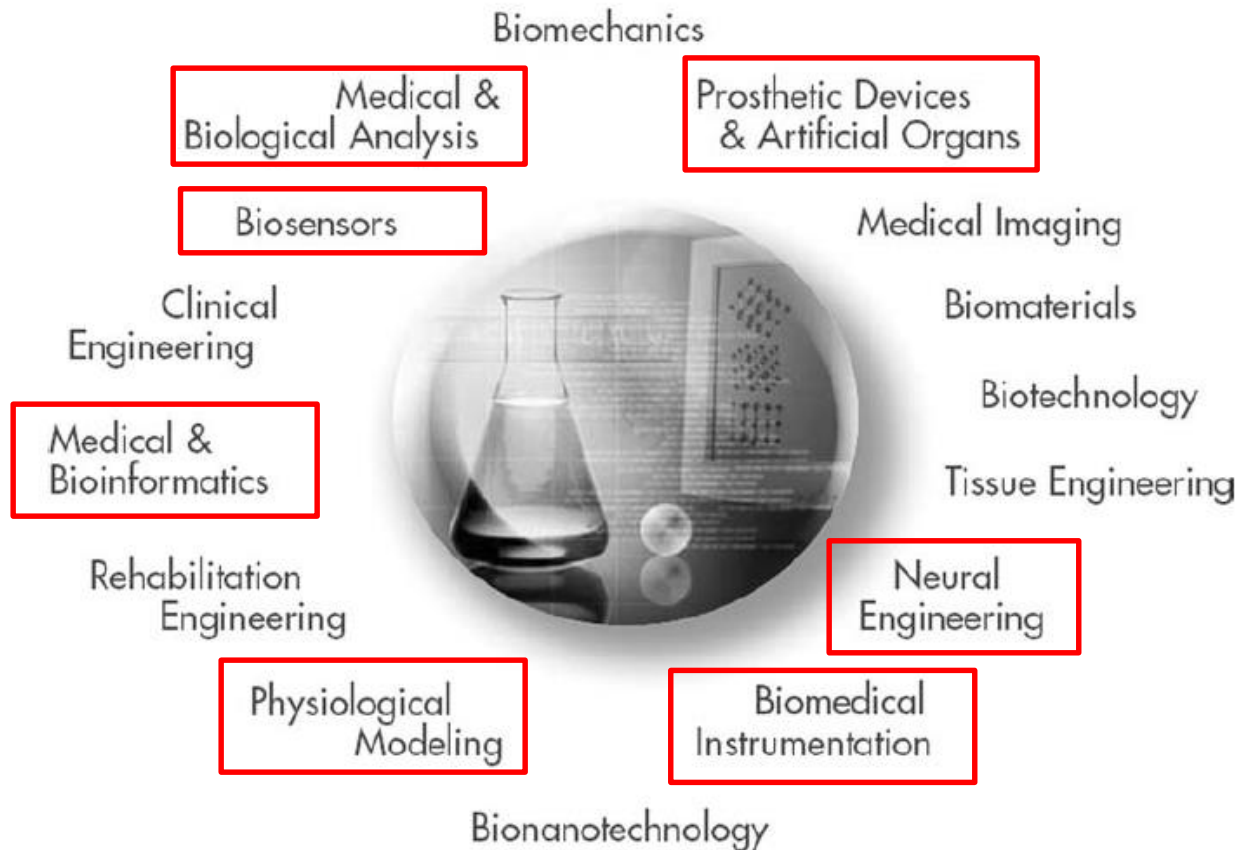
An Artificial Retina

Currently in use to treat people with damaged photoreceptor cells, the device consists of a small camera, a belt-worn video processor and an implanted array of 60 electrodes. Images are converted into patterns of light and dark and transmitted to the electrodes, which send signals through the optic nerve to the brain and form a crude image of light and dark patches.

Biomedical Engineering

- Biomedical engineers apply electrical, chemical, optical, mechanical, and other engineering principles to understand, modify, or control biological (i.e., human and animal) systems

THE WORLD OF BIOMEDICAL ENGINEERING

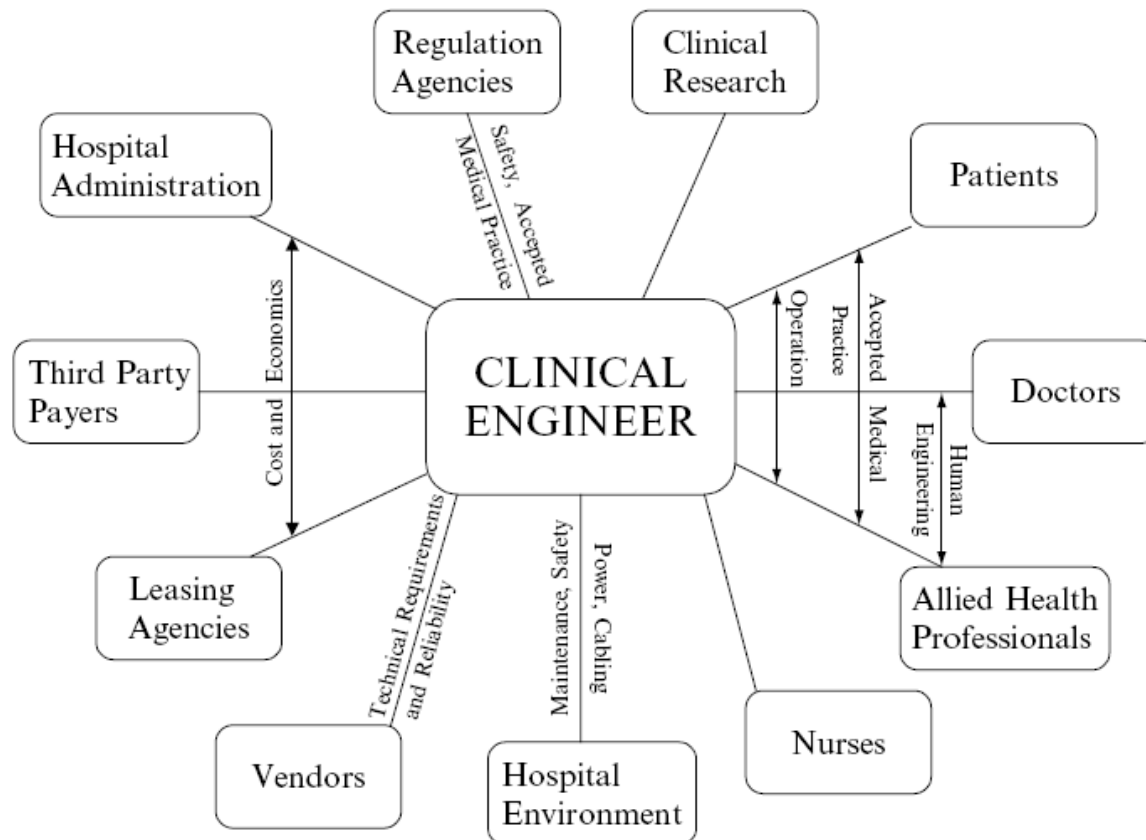


Biomedical Engineering

- Biomedical engineering includes the following areas:
 - Application of engineering system analysis (physiologic modeling, simulation, and control) to biological problems
 - Detection, measurement, and monitoring of physiologic signals (i.e., biosensors and biomedical instrumentation)
 - Diagnostic interpretation via signal-processing techniques of bioelectric data
 - Therapeutic and rehabilitation procedures and devices (rehabilitation engineering)
 - Devices for replacement or augmentation of bodily functions (artificial organs)
 - Computer analysis of patient-related data and clinical decision making (i.e., medical informatics and artificial intelligence)
 - Medical imaging; that is, the graphical display of anatomic detail or physiologic function

Biomedical Engineering

- Some hospitals hire **clinical engineers** (biomedical engineers employed in hospitals or clinical settings) to meet their engineering requirements
- It started by most large hospitals relying on in-house departments to provide the technological support necessary to address electrical safety concerns

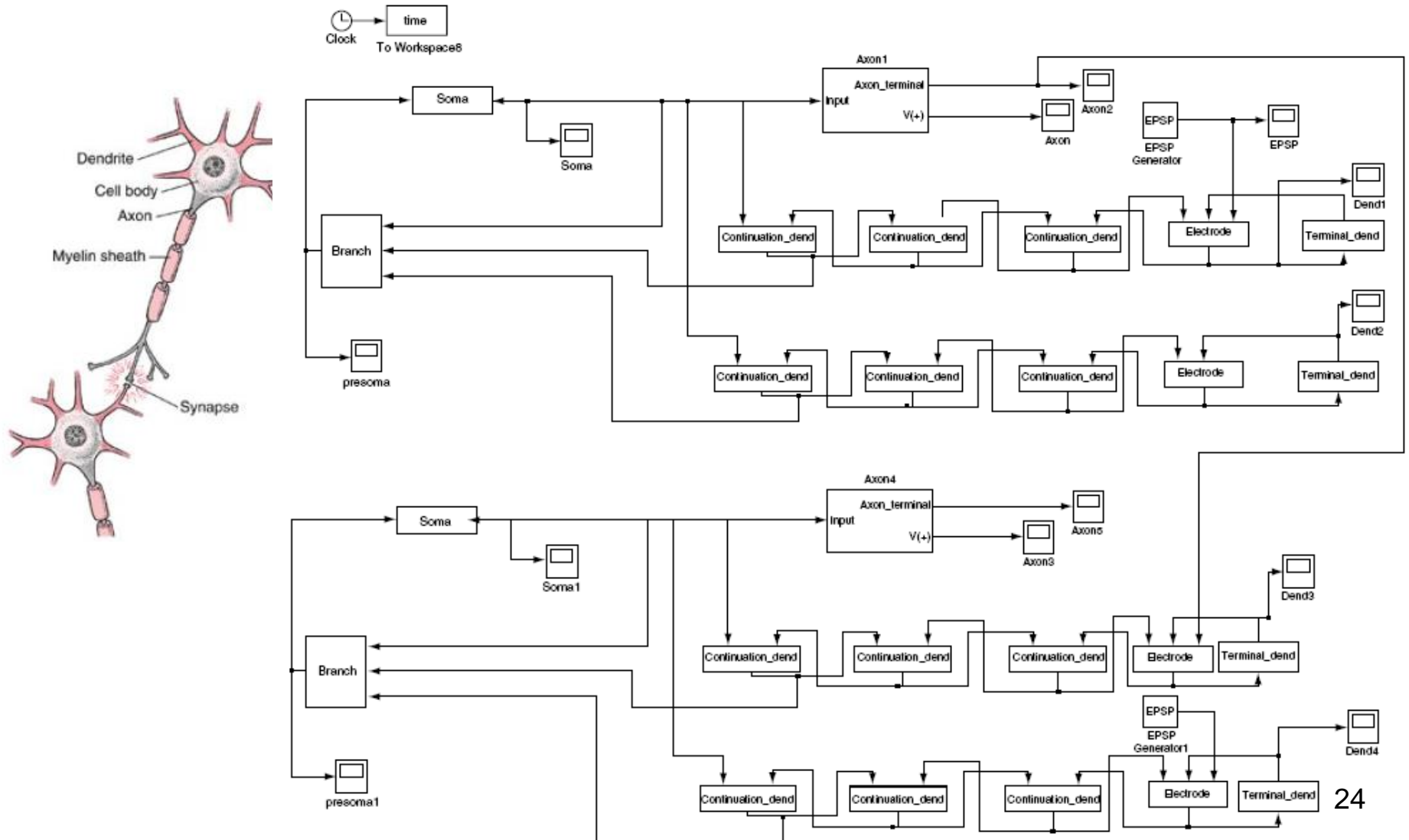


Biomedical Engineering

- Biomedical engineering involves training essentially three types of individuals:
 - (1) the clinical engineer in health care
 - (2) the biomedical design engineer for industry
 - (3) the research scientist
- Biomedical engineering scientists aim at applying engineering concepts and techniques to the investigation and exploration of biological processes

Biomedical Engineering

- SIMULINK Model of Two Connected Neurons



Course Outline

- Biomedical Engineering History and Overview
- Anatomy and Physiology Background
- Biomedical Sensors
- ECG and Heart Signals
- Cardiac Pacemakers
- EMG and Muscle Activity
- Brain Electrophysiology
- Brain-Machine Interfaces
- Physiological Modeling