BIOMEDICAL ENGINEERING

A New, Promising Interdisciplinary Field

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ENGINEERING Versus SCIENCE

- Scientist strive to create new knowledge about how things work.
- Engineers understand well science and mathematics and utilize them to solve problems for public and economic gain.

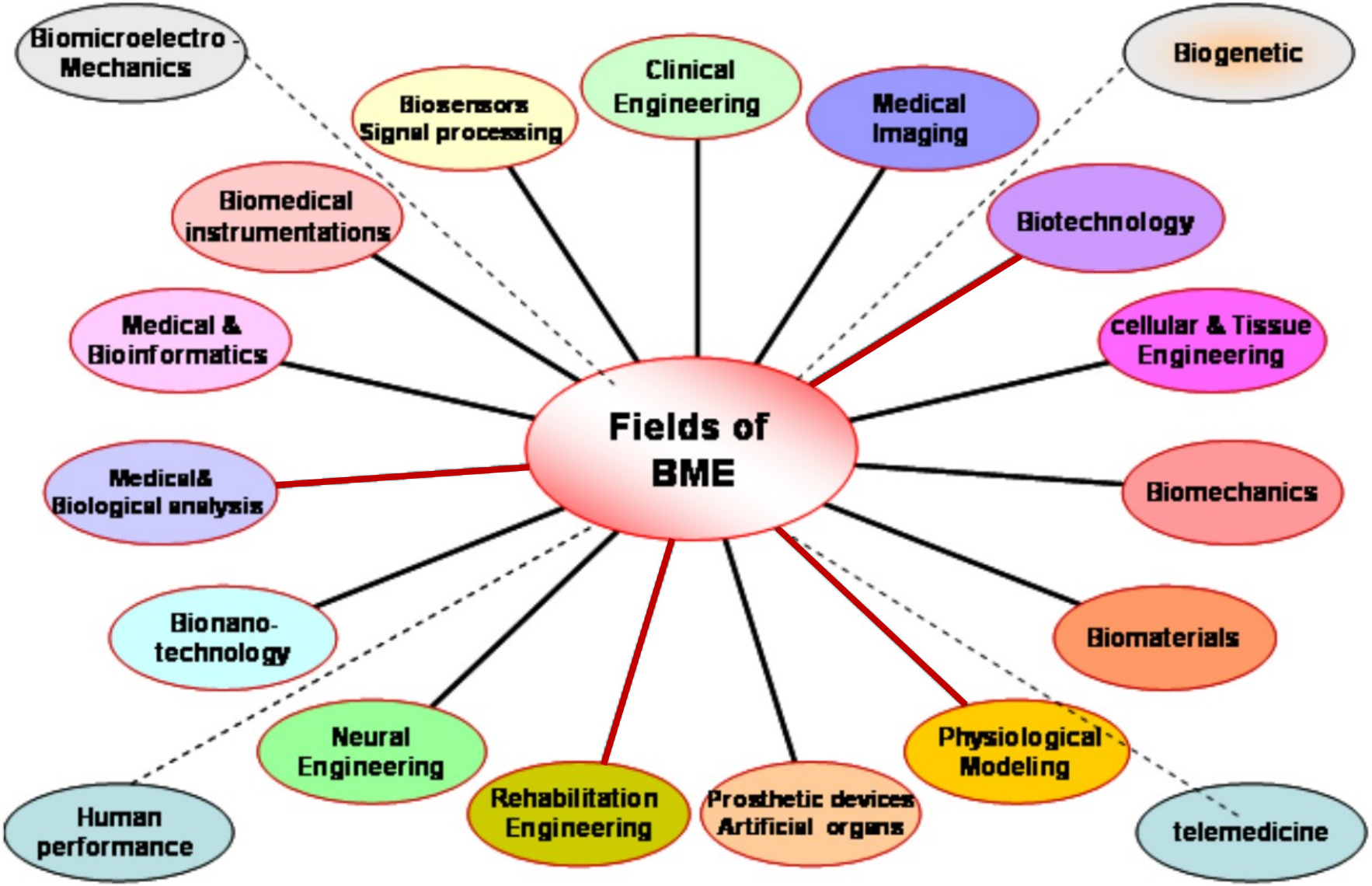
WHAT IS BIOMEDICAL ENGINEERING

According to the working definition of the National Institutes of Health (NIH), The application of concepts and methods of engineering, biology, medicine, physiology, physics, materials science, chemistry, mathematics and computer sciences to develop methods and technologies to solve health problems in humans.

WHAT IS BIOMEDICAL ENGINEERING

According to the United States Department of Labor, 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 heath management and care delivery systems.

Disciplines of Biomedical Engineering



Disciplines of Biomedical Engineering

- **Bioinstrumentation**
  - **Methods for obtaining invasive and noninvasive measurements from the human body, organs, cells, and molecules.**
  - **Electronic instrumentation, principles of analog and digital signal processing**
  - **Measurement concept such as accuracy, reproducibility, noise suppression, calibration methods, safety requirements.**

Disciplines of Biomedical Engineering

- **Biomaterials (Tissue Engineering)**
  - Design and development of materials derived from natural sources for medical devices and diagnostic products, tissue engineering, organ engineering, and drug delivery.
- **Biomechanics**
  - Cover both biofluid and biosolid mechanics at the molecular, cellular, tissue, and organ-system levels.

Disciplines of Biomedical Engineering

- **Biosignals (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.**

Disciplines of Biomedical Engineering

- **Biosystems**
  - **Molecules and cells are the building blocks of organ systems.**
  - **Integrate properties of biological systems with engineering tools of system analysis to understand physiological relationships.**

Disciplines of Biomedical Engineering

- **Biotransport**
  - Cover transport processes from the organ to the subcellular level.
  - Transport of mass, momentum, and energy.
  - Transport of ions, proteins, viruses, and drug.

Disciplines of Biomedical Engineering

- **Cellular Engineering**
  - **Develops and communicates quantitative biochemical and biophysical design principles that govern cell function.**
  - **Control metabolism, signaling, regulation, proliferation, migration, and differentiation.**

Disciplines of Biomedical Engineering

- **Clinical Engineering**
  - **Managing diagnostic and laboratory equipment in the hospital.**
- **Rehabilitation Engineering**
  - **Works directly with patients such as disabled individuals to modifies or designs new equipment to achieve a better standard of life.**

Homework 1

Pick any of the listed tracks for biomedical engineering (instrumentation, clinical, material, imaging) and write a two-page paper about an invention, current research, or instrument used in diagnosis, treatment, or improving a health problem.

Due: Thursday 1/26/2017

WHAT DO BME STUDENTS LEARN

- Basic biology and human physiology
- Basic chemistry knowledge and laboratory techniques.
- Physics and Engineering principles
- Knowledge of biomaterials, biomechanics and related fields

WHAT DO BME STUDENTS LEARN

- Latest instrumentation and methodologies in biomedical engineering
- Use computers in a biomedical setting
- Research experience in biomedical settings
- Practical biomedical engineering experience through industrial internships and biomedical design projects

CAREER OPPORTUNITIES

- Pharmaceutical Company as a process engineer: Equipment design, producing new drug.
- Clinical engineering in hospital
- Graduate School: Research
- Medical School: M.D./Ph.D. (Funded by NIH)

JOBS FOR BME GRADUATES

- Design, construct, and test 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

- Design and Build sensors to measure blood pressure and blood chemistry, such as potassium, sodium, 0_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

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

JOBS FOR BME GRADUATES

- 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.

U.S. Department of Labor Projections Jobs

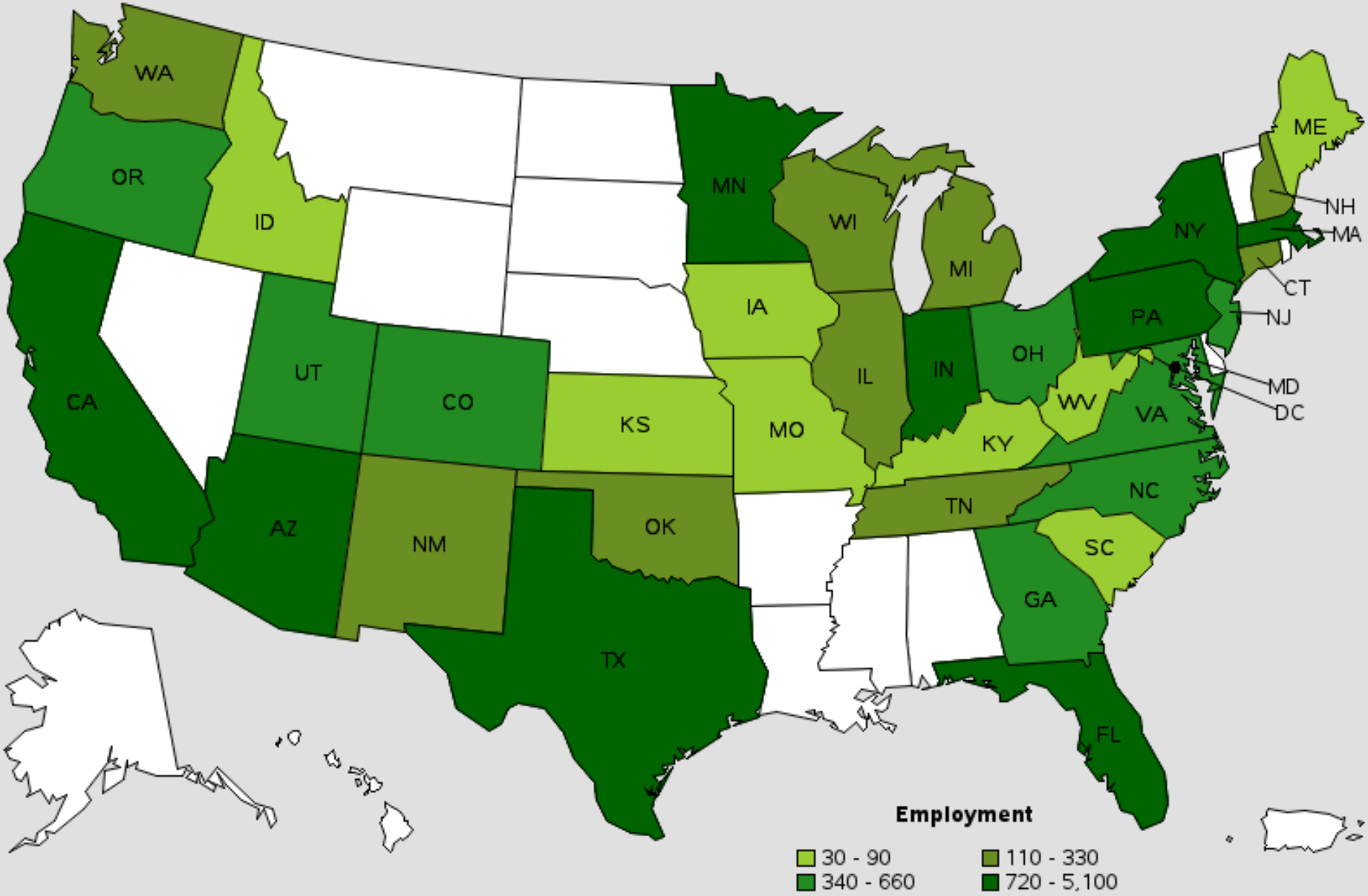
Discipline	2014	2024	%
Biomedical	22,100	27,200	23
Computer	79,000	82,000	5
Electrical	315,000	315,000	0
Mechanical	277,500	291,500	5
Biologist	87,000	95,000	9
Chemist	98,400	101,000	3

U.S. Department of Labor EARNING

Discipline	2015
Biomedical Engineering	$ 86,220
Mechanical Engineering	$ 83,590
Electrical Engineering	$ 95,200
Biologist	$ 59,680
Chemists	$ 72,610

http://www.bls.gov/oes/current/oes_nat.htm#19-0000

Employment of biomedical engineers, by state, May 2015



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BME CURRICULUM PROGRAM AT UCO

- Biology: 11 hours
- Chemistry: 10 hours
- Engineering: 51 hours
- Math and Computer Science: 18 hours
- Physics: 14 hours
- BME Technical Electives: 15 hours
- Total: 126 hours

BME COURSES AT UCO

- **Principle of Biomedical Engineering (3)**
  - **Applications of physics and engineering principles to biomedical systems**
  - **Study of biomedical functions of the human body using mechanics, electricity and magnetism, optics, and thermodynamics**
  - **Responses of human biomedical functions to different bioengineering applications**

BME COURSES AT UCO

- **Biomedical Instrumentation (3)**
  - **Sensors and Principle**
  - **Amplifier and Signal Processing**
  - **Origin of Biopotential**
  - **Biopotential Electrode and Amplifier**
  - **Clinical Laboratory Instrument**
  - **Therapeutic And Prosthetic Devices**

BME COURSES AT UCO

- **Medical Imaging (3)**
  - **Signals and Systems**
  - **Image Quality**
  - **Physics of Radiography**
  - **Projection Radiography**
  - **Physics of Magnetic Resonance**
  - **Magnetic Resonance Imaging**

BME COURSES AT UCO

- **Medical Engineering Laboratory (2)**

  -Electromyogram Measurement and Analysis (EMG):

  – **Electrocardiogram and Pulses (ECG)**

  – **Ultrasound to Evaluate Pulmonary Function**

  – **Extracellular Stimulation and Recording of Action Potential from Frog Sciatic Nerve**

BME COURSES AT UCO

- **BioMechanic (3)**
  - **Application of mechanics to describe the cardiovascular and musculoskeletal systems.**
  - **Biological Transport Processes**
  - **Interrelationship between biomechanics and physiology in medicine, surgery**
  - **Design of prosthetic devices.**

BME RESEARCH AND FACULTY AT UCO

- Cancer Treatment Using Selective Photothermal Interactions (Dr. Wei Chen)
- Cochlear Implant and Image Transmission (Dr. Mohamed Bingabr)
- Image Quality and MRI Image Construction (Dr. Yuhao Jiang)
- Biofluid Mechanics (Dr. Evan Lemley)
- Microfluidics, Instrumentation, & Diagnosis (Dr. Robi Hossan)
- Musculoskeletal Mechanics & Biomaterials (Dr. Morshed Khandaker)
- Cellular and Tissue Biomechanics (Dr. Gang Xu)

FURTHER INFORMATION ON BIOMEDICAL ENGINEERING

- Biomedical Engineering Handbook
- Related Web Sites:
  - Biomedical Engineering Society
    - http://mecca.org/BME/BMES/society/
  - The Whitaker Foundation for BME
    - http://www.whitaker.org/
  - US Department of Labor
    - https://www.bls.gov/oes/current/oes172031.htm

THE END