

BME 10100 Introduction to Biomedical Engineering

Overview of the field of Biomedical Engineering (BME) & the CCNY BME program



What is Biomedical Engineering?

General definition:

Biomedical Engineering is the application of engineering principles and methods to solve problems related to the human body.

Why Do People Become Biomedical Engineers?

- To be of service to others by working on solutions to health-related problems
- For the excitement of working with living systems
- To apply advanced technology to the complex problems of medical care

What Does a Biomedical Engineer Do?

- Designs instruments, devices, and software
- Brings together knowledge from many technical sources to develop new procedures
- Conducts research to:
 - Understand the human body
 - Solve clinical problems

Where do Biomedical Engineers Work?

- **Hospitals and rehabilitation centers**
 - research, testing of medical equipment
- **Industry (medical instrumentation, prosthetics and implants, pharmaceutical, biotechnology)**
 - product design and testing
- **Government regulatory agencies**
 - establishing safety standards for devices
- **Educational and research institutions**
 - research, teaching, technical support

Specialty Areas in Biomedical Engineering

Summarized from www.bmes.org

- **Bioinstrumentation**

The application of electronics and measurements techniques to develop devices used in diagnosis and treatment of disease

- **Biomaterials**

Includes the development and testing of both artificial materials and living tissue for use as components of implantable devices

- **Biomechanics**

Applies both solid and fluid mechanics to solve biological or medical problems; has been used for many tissues in the body (heart, blood vessels, lungs, bone, cartilage, ligaments, tendons, intervertebral disks, etc.)

Specialty Areas in Biomedical Engineering

Summarized from www.bmes.org

- **Cellular, Tissue, and Genetic Engineering**

Utilizes the anatomy, biochemistry and mechanics of cellular and sub-cellular structures to understand disease processes and attempt to intervene at specific sites to combat diseases

- **Clinical Engineering**

The application of technology to health care in hospitals

- **Medical Imaging**

Uses different physical modalities (sound, radiation, magnetism, etc.) along with high speed data processing to display and analyze images

Specialty Areas in Biomedical Engineering

Summarized from www.bmes.org

- **Orthopaedic Bioengineering**

Methods of engineering are applied to understand the function of bones, joints, and muscles, and for the design of artificial joint replacements; also includes the development of biomaterials for the replacement of musculoskeletal tissues

- **Rehabilitation Engineering**

Includes the development of prosthetics as well as technology to aid people with physical and cognitive impairments

- **Systems Physiology**

Modeling and analysis of the feedback control systems found in living systems to gain an integrated understanding of the function of living organisms

Selected Areas of Work in Biomedical Engineering

Summarized from www.bmes.org

- **Artificial organs**

Hearing aids, cardiac pacemakers, artificial kidneys and hearts, synthetic blood vessels, joint replacements, prosthetic limbs

- **Advanced therapeutic and surgical devices**

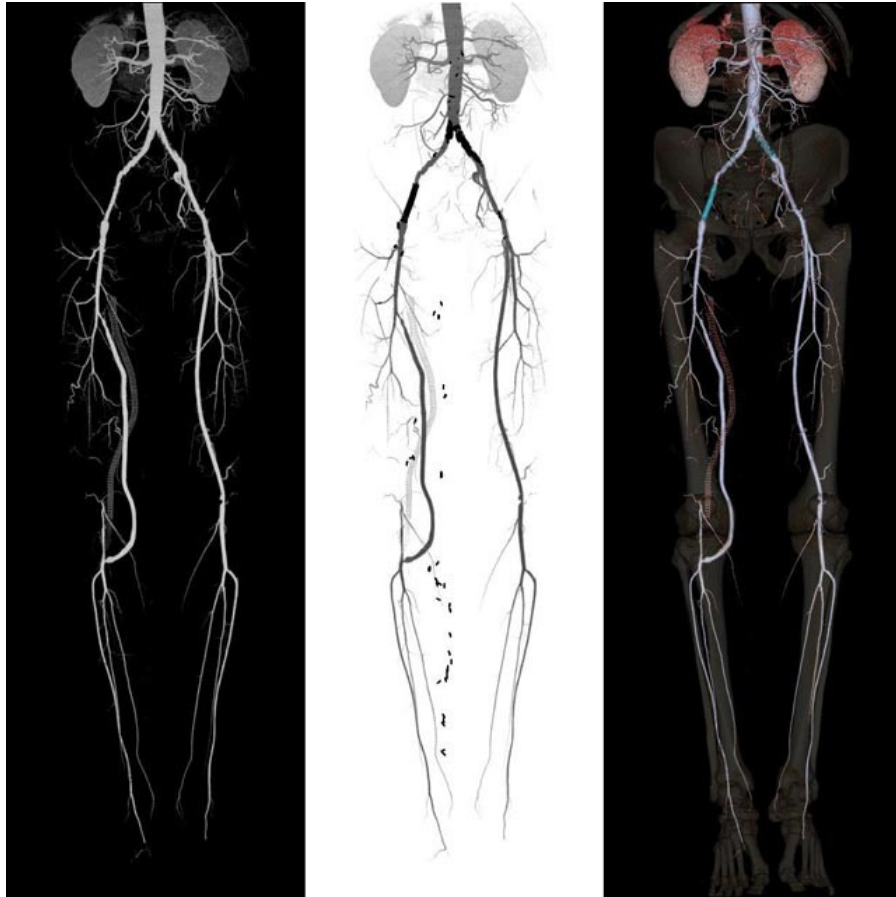
Laser systems for eye surgery, automated delivery of insulin



From pbs.org

Selected Areas of Work in Biomedical Engineering

Summarized from www.bmes.org



- **Medical imaging systems**
Ultrasound, computer-assisted tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), etc.
- **Application of expert systems and artificial intelligence to clinical decision making**
Computer-based systems for diagnosing diseases

From <http://gemedicalsystems.com>

Selected Areas of Work in Biomedical Engineering

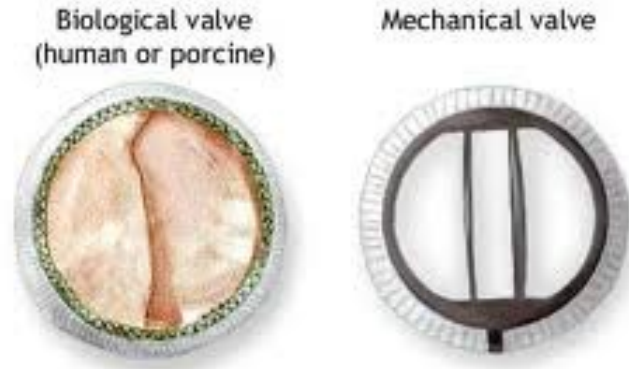
Summarized from www.bmes.org

- **Biomaterials design**

Mechanical, transport, and biocompatibility properties of implantable artificial materials; developing tissue-engineered materials

- **Computer modeling of physiologic systems**

Blood pressure control, kidney function, visual and auditory systems



ADAM

From health.allrefer.com

Selected Areas of Work in Biomedical Engineering

Summarized from www.bmes.org

- **Biomechanics of injury and wound healing**

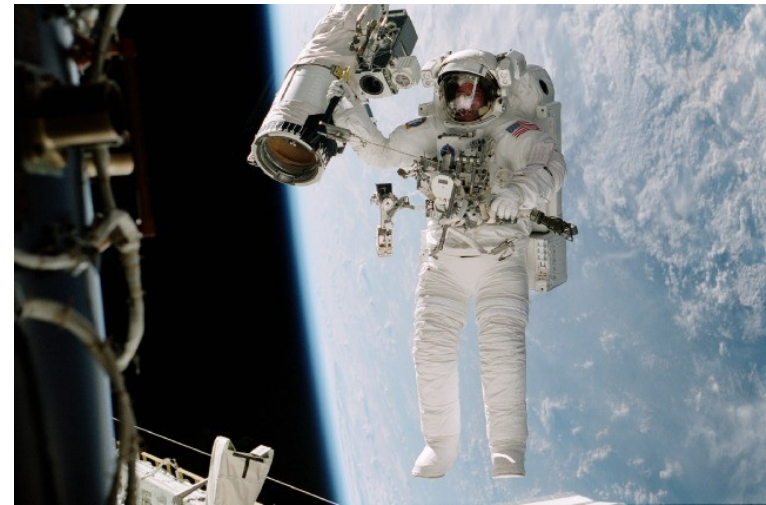
Gait analysis, application of growth factors, etc.

- **Sports medicine**

Rehabilitation, external support devices, etc.

- **Automated patient monitoring**

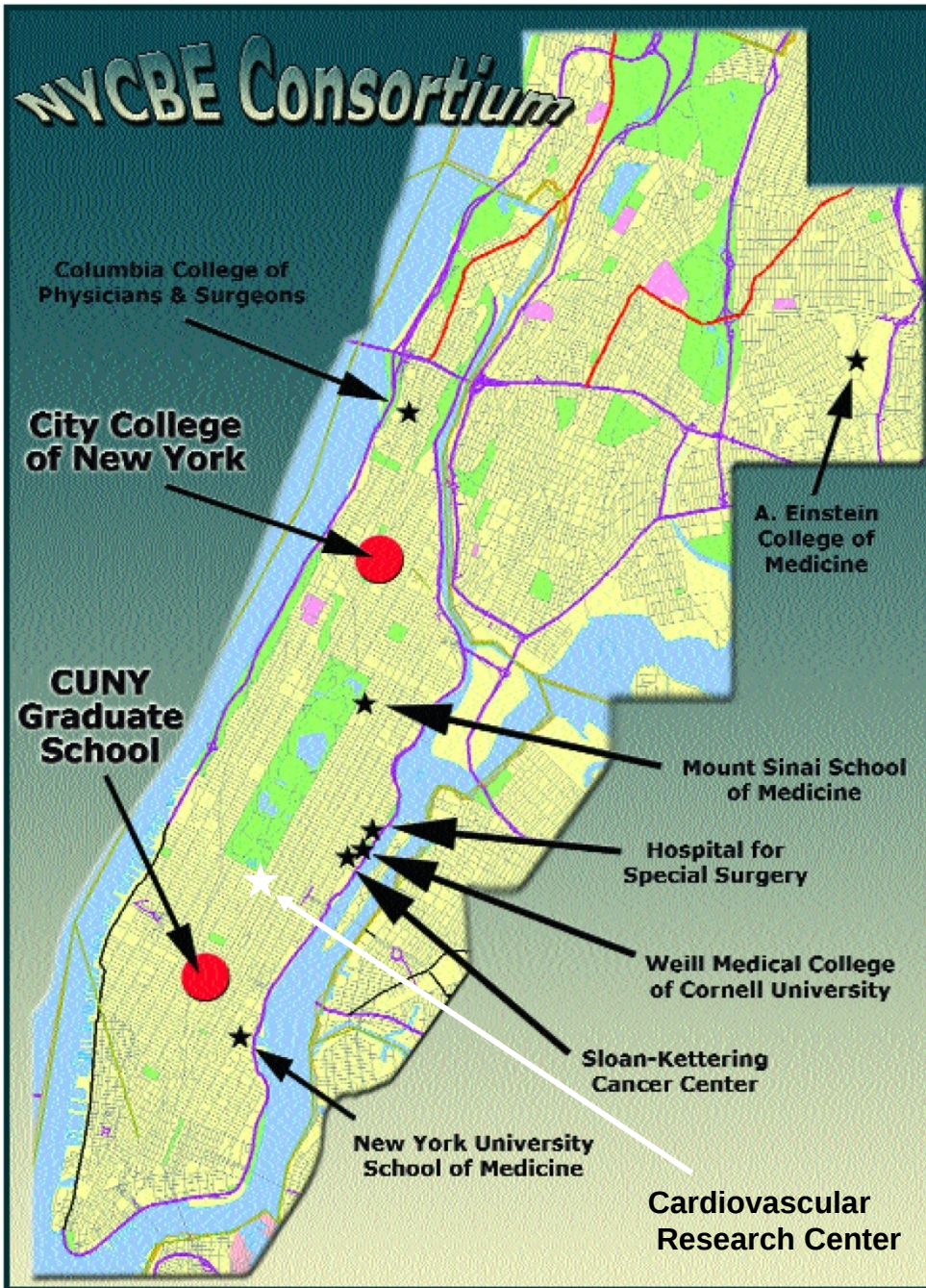
During surgery or intensive care, or for people in unusual environments such as astronauts in space



From <http://spaceflight.nasa.gov/gallery>

History of BME @ CCNY

- **1994** First Whitaker Special Opportunity award to create New York Center for Biomedical Engineering Undergraduate BME concentration (15 credit)
- **1995** NSF Graduate Curriculum Development Grant
- **1997** Second Whitaker Special Opportunity Award
- **1999** PhD program in BME started
- **2000** MS program in BME started
- **2001** First NIH grant in UG minority education
Third Whitaker Special Opportunity award
First U.S. Dept. of Education Fellowship Grant
- **2002** New BME Department and UG degree program (120 credits)
- **2003** First Wallace H. Coulter Grant
- **2004** New home for BME
- **2006** First Graduating Class
- **2006** Second Wallace H. Coulter Grant
- **2011** ABET ACCREDITATION
- **2013** Third Wallace Coulter Grant

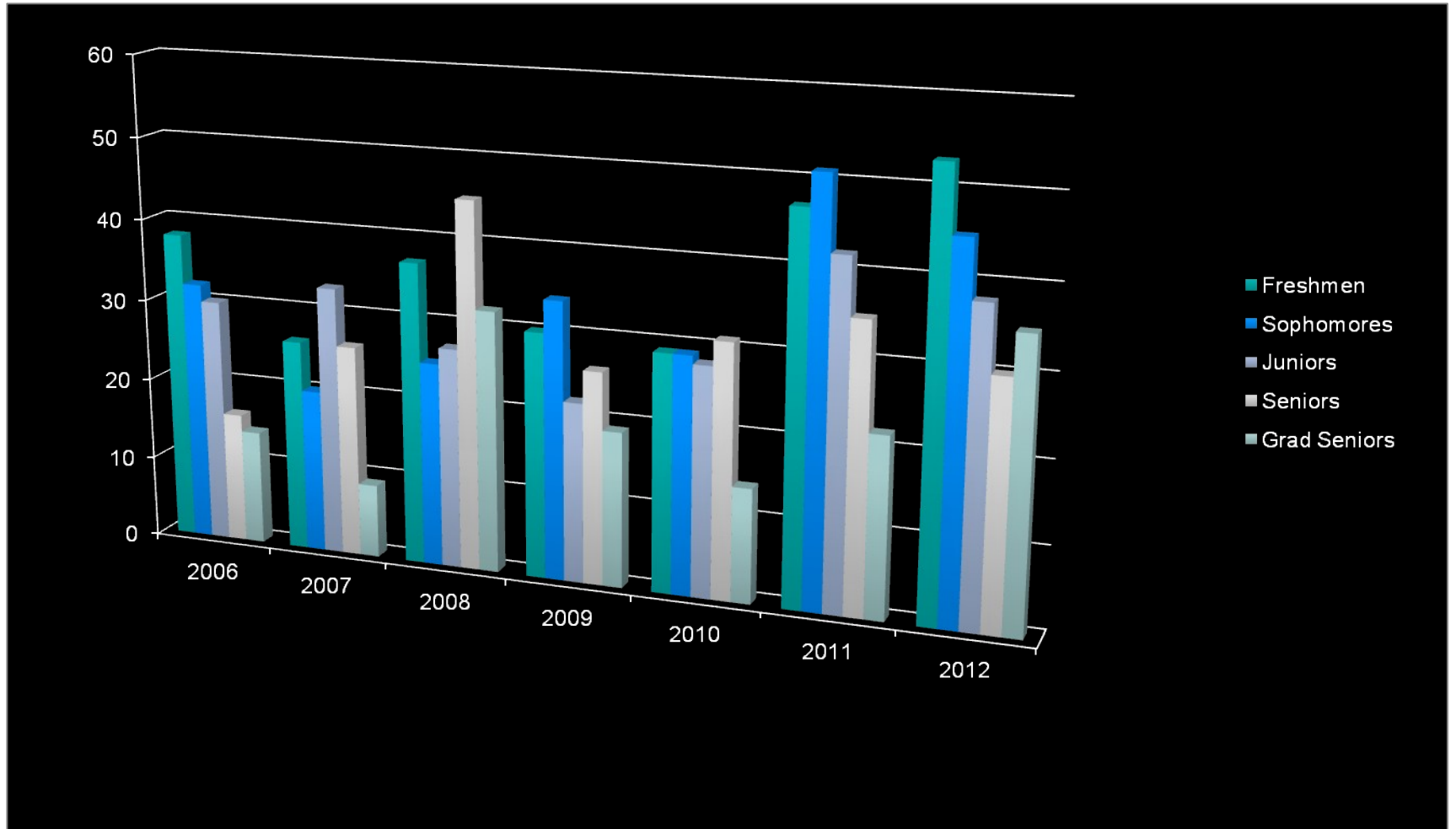


Location of Consortium Members

Undergraduate Program

- Freshmen 51
 Class GPA 3.00
- Sophomores 45
 Class GPA 3.08
- Juniors 38
 Class GPA 3.11
- Seniors 65
 Class GPA 3.19

Undergraduate Enrollment 06-12



Senior Class (2013)

- Graduating Seniors (35)
GPA 3.22
- #Graduates who received scholarships
NIH Scholars : 4 GPA: 3.29
NSF Graduate Fellowship: 1



BME Undergraduate Program Educational Objectives

updated Fall 2010

Our objectives are to prepare graduates:

- 1. For productive employment in biomedical and health related industry.**
- 2. To perform successfully in graduate school, medical school or professional programs.**
- 3. Who will ethically and responsibly apply their engineering talents for the benefit of society, demonstrating an integrated, multidisciplinary approach to problem solving.**
- 4. Who will continue to develop technical knowledge, awareness and leadership skills that will allow them to address domestic or global problems in human health.**



Empoyment & Graduate School Trends

for CCNY BME Bachelor's degrees awarded 2006-10

data compiled June 2010

85 BME graduates from 2006-10

38% employed in industry, hospitals or government agencies

49% pursuing post-graduate degrees

primarily master's degrees in BME

13% seeking a job, stay-at-home parent, or current status is unknown



Employment Trends

for CCNY BME Bachelor's degrees awarded 2006-10

data compiled June 2010

Name of Employer	# of CCNY BME Alumni Employed
Merck & Co., Inc.	5
Covidien	3
Cardiovascular Research Foundation	3
Medtronic, Inc.	2
JPMorgan Chase	2
Massachusetts General Hospital	1
Bristol-Myers Squibb	1
Kendle International, Inc.	1
Deep Breeze Ltd.	1
Acolyte and Company Inc.	1
South City Hospital	1
US Patent and Trade	1
U S Genomics Inc.	1
Baystate Medical Center	1
N-tech Solutions Group Inc.	1
Kimberly Clark Inc.	1
Genentech, Inc.	1
Goldman Sachs	1
Rockefeller University	1



Graduate School Trends

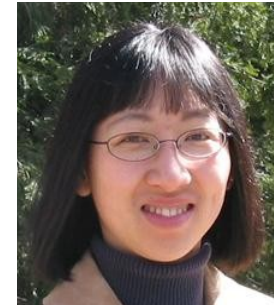
for CCNY BME Bachelor's degrees awarded 2006-10

data compiled June 2010

Academic Institution	# of CCNY BME Alumni Attending	Degree Program
CCNY	27	MS, BME (23); PhD, BME (3); 2nd BS (1)
Columbia University	3	MS, BME (2); PhD, BME (1)
University of Toronto	1	MS, BME
Cornell University	1	MS, BME
SUNY Buffalo Medical School	1	MD
Duke University	1	PhD, BME
Johns Hopkins University	1	PhD, BME
University of Connecticut	1	MS, Clinical Engineering
Albert Einstein Medical School	1	MD/PhD
University of Florida	1	MS
Universidad de Palermo (Buenos Aires)	1	MBA
Bethel Seminary	1	MDiv
Brooklyn College Law School	1	JD
Rutgers University	1	PhD, BME
Total	42	1 2nd BS, 29 MS, 1 MBA, 1 MDiv, 1 MD, 1 MD/PhD, 7 PhD



Nanotechnology , Biomaterials & Tissue Engineering



Prof. Gilchrist

Prof. Auguste

Prof. Nicoll

Prof. Vazquez

Prof. Wang

These faculty use micro- and nanotechnology along with cell and molecular biology to address issues related to disease progression and development of replacement tissues.

Auguste's lab: Biomaterials, Drug Delivery and Tissue Engineering

Gilchrist's lab: Development of membrane protein-based biomolecular materials

Nicoll's lab: Development of living tissue surrogates for connective tissue restoration

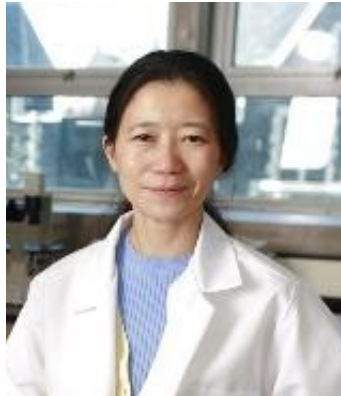
Vazquez's lab: Microfluidics applications to neuronal cell migration

Wang's lab: Genomics and microfluidics for cancer research/drug screening

Cardiovascular Engineering



Prof. Tarbell



Prof. Fu



Prof. Weinbaum

Our research in Cardiovascular Engineering is motivated by the desire to understand the mechanisms of cardiovascular disease, particularly atherosclerosis, which underlies heart attacks and strokes, the leading cause of death in Western societies.

Tarbell's lab: Effect of mechanical forces on vascular cells, mechanotransduction

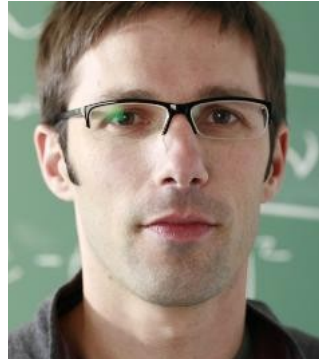
Fu's lab: Micro-vessel permeability, transport across the blood-brain barrier

Weinbaum's lab: Vulnerable plaque rupture in coronary arteries

Neural Engineering & Imaging



Prof. Bikson



Prof. Parra



Prof. Kelly

Our Neuronal Engineering group analyzes nervous system function at multiple levels including single channel, single cell, tissue, whole animal, and human cognitive levels. We integrate experimental insights with computational modeling and pursue translational research through the NYCBE.

Bikson's lab: Effects of electric fields on brain function, electrical stimulation

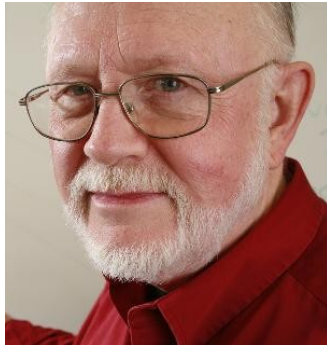
Parra's lab: EEG studies of auditory and visual perception and attention, tinnitus

Kelly's lab: Brain-computer interfacing

Musculoskeletal Biomechanics



Prof. Cardoso



Prof. Cowin



Prof. Fritton



Prof. Schaffler



Prof. Weinbaum

These faculty aim to understand the mechanism of musculoskeletal maintenance and adaptation, with focus on bone and its adaptive response to mechanical loading.

Cardoso's lab: Development of ultrasound technology for bone quality assessment

Cowin's lab: Analysis of bone microstructure and its effects on mechanotransduction

Fritton's lab: Effect of osteoporosis on bone structure and mechanotransduction

Schaffler's lab: Bone and tendon mechanics, skeletal fragility, osteocyte function

Weinbaum's lab: Bone mechanotransduction via interstitial fluid flow

Funding and Scholarship

- Coulter Challenge:\$2.5M/Match (complete)
- NIH Minority Educ. Grant: \$5.0M (complete)
- New Coulter Challenge: \$500K/Match
- Proctor and Gamble: \$123K Match
- Sy Moskowitz Award: \$500K/5yrs
- Arthur Gelb Award: \$250K/5yrs
- Active Research Grants
 - 17 NIH
 - 8 NSF
 - 9 Other (includes \$100K P&G)

Funding and Scholarship

- Refereed Journal Articles 2011-2012: 99
- Book Chapters: 11
- Books: 1
- Presentations: 129 (6 keynote/ 20 invited)
- Citations (ISI): 2011 – 3000 Total: > 28,800
- Patents (Granted/Pending): 10
- Review Panels / Editorial Boards: 23

Faculty/Department Recognition

- Weinbaum – Amer. Acad. of Arts and Sciences
- Auguste – NIH Director's New Innovator Award
– President's Obama Innovator Award
- Schaffler – CUNY Distinguished Professor
- Cardoso – CCNY Outstanding Teaching Award
- Bikson – Dir.of Kaylie Prize for Entrepreneurship
- Nicoll – Chair of CCNY IACUC Committee
- Parra – CCNY Cluster Hire Award
- Vazquez – CUNY TV – Women in STEM

Graduate Program

- **Total Graduate Students: 72**
- **Masters: 33**
 - 3 in NYCBE Labs, 21 in Dept. labs
 - 13 graduate spring 2013;
 - 12 accepted for Fall 2013 (10 from PhD applicants)_
 - Recent graduates (examples): Johns Hopkins, Brown Medical School, Morehouse School of Medicine, NY Methodist Hospital, MSSM, HSS, Covidien, Boston Scientific, Nike, Merck, Hi Tech Pharma, Novamed, Regeneron Pharma, CUNY startups (Neuromatters, Soterix), Nobel Biocare, Zimmer Ortho., Roche Diag. Oscor Inc., Capital One Finance, GDC Medical Electronics, EPA, Hahusha Systems, Hearst, MediGuide, Software Research Group America, St. Jude Medical

Graduate Program Continued

➤ Ph.D. 39

9 in NYCBE Labs, 30 in Dept. labs

5 graduates in 2012 -2013

7 entering Fall 2013: mean GPA 3.6,

GRE Quant. (85th %)

From: Illinois, UCal, NJIT, Univ Rome,

Pusan Univ., 3 CCNY MS

Recent graduates: post docs at Harvard,

Michigan, Delaware, MSKCC, MSSM,

Columbia, Illinois, industry, start ups

NRC Rankings (2011)

City College BME

- Overall Quality (S) Ranking: 12-14
- Research Productivity: 7
- Diversity: 1