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Careers

"Planning a Career in Biomedical Engineering"

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MORE INFORMATION

What is a Biomedical Engineer?

A Biomedical Engineer uses traditional engineering expertise to analyze and solve problems in biology and medicine, providing an overall enhancement of health care. Students choose the biomedical engineering field to be of service to people, to partake of the excitement of working with living systems, and to apply advanced technology to the complex problems of medical care The biomedical engineer works with other health care professionals including physicians, nurses therapists and technicians. Biomedical engineers may be called upon in a wide range of capacities: to design instruments, devices, and software, to bring together knowledge from mar technical sources to develop new procedures, or to conduct research needed to solve clinical problems.

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What are Some of the Specialty Areas?

In this field there is continual change and creation of new areas due to rapid advancement in technology; however, some of the well established specialty areas within the field of biomedical engineering are: bioinstrumentation; biomaterials; biomechanics; cellular, tissue and genetic engineering; clinical engineering; medical imaging; orthopaedic surgery; rehabilitation engineering; and systems physiology.

Bioinstrumentation is the application of electronics and measurement techniques to develop devices used in diagnosis and treatment of disease. Computers are an essential part of bioinstrumentation, from the microprocessor in a single-purpose instrument used to do a variet of small tasks to the microcomputer needed to process the large amount of information in a medical imaging system.

Biomaterials include both living tissue and artificial materials used for implantation. Understanding the properties and behavior of living material is vital in the design of implant materials. The selection of an appropriate material to place in the human body may be one of tl most difficult tasks faced by the biomedical engineer. Certain metal alloys, ceramics, polymers, and composites have been used as implantable materials. Biomaterials must be nontoxic, non-carcinogenic, chemically inert, stable, and mechanically strong enough to withstand the repeate forces of a lifetime. Newer biomaterials even incorporate living cells in order to provide a true biological and mechanical match for the living tissue.

Biomechanics applies classical mechanics (statics, dynamics, fluids, solids, thermodynamics, an continuum mechanics) to biological or medical problems. It includes the study of motion, material deformation, flow within the body and in devices, and transport of chemical constituen across biological and synthetic media and membranes. Progress in biomechanics has led to the development of the artificial heart and heart valves, artificial joint replacements, as well as a better understanding of the function of the heart and lung, blood vessels and capillaries, and bone, cartilage, intervertebral discs, ligaments and tendons of the musculoskeletal systems.

Cellular, Tissue and Genetic Engineering involve more recent attempts to attack biomedical problems at the microscopic level. These areas utilize the anatomy, biochemistry and mechanic:

of cellular and sub-cellular structures in order to understand disease processes and to be able t intervene at very specific sites. With these capabilities, miniature devices deliver compounds th can stimulate or inhibit cellular processes at precise target locations to promote healing or inhib disease formation and progression.

Clinical Engineering is the application of technology to health care in hospitals. The clinical engineer is a member of the health care team along with physicians, nurses and other hospital staff. Clinical engineers are responsible for developing and maintaining computer databases of medical instrumentation and equipment records and for the purchase and use of sophisticated medical instruments. They may also work with physicians to adapt instrumentation to the speci needs of the physician and the hospital. This often involves the interface of instruments with computer systems and customized software for instrument control and data acquisition and analysis. Clinical engineers are involved with the application of the latest technology to health care.

Medical Imaging combines knowledge of a unique physical phenomenon (sound, radiation, magnetism, etc.) with high speed electronic data processing, analysis and display to generate a image. Often, these images can be obtained with minimal or completely noninvasive procedure making them less painful and more readily repeatable than invasive techniques.

Orthopaedic Bioengineering is the specialty where methods of engineering and computational mechanics have been applied for the understanding of the function of bones, joints and muscle and for the design of artificial joint replacements. Orthopaedic bioengineers analyze the friction lubrication and wear characteristics of natural and artificial joints; they perform stress analysis the musculoskeletal system; and they develop artificial biomaterials (biologic and synthetic) for replacement of bones, cartilages, ligaments, tendons, meniscus and intervertebral discs. They often perform gait and motion analyses for sports performance and patient outcome following surgical procedures. Orthopaedic bioengineers also pursue fundamental studies on cellular function, and mechano-signal transduction.

Rehabilitation Engineering is a growing specialty area of biomedical engineering. Rehabilitation engineers enhance the capabilities and improve the quality of life for individuals with physical and cognitive impairments. They are involved in prosthetics, the development of home, workplace and transportation modifications and the design of assistive technology that enhance seating and positioning, mobility, and communication. Rehabilitation engineers are also developing hardware and software computer adaptations and cognitive aids to assist people wit cognitive difficulties.

Systems Physiology is the term used to describe that aspect of biomedical engineering in which engineering strategies, techniques and tools are used to gain a comprehensive and integrated understanding of the function of living organisms ranging from bacteria to humans. Computer modeling is used in the analysis of experimental data and in formulating mathematical descriptions of physiological events. In research, predictor models are used in designing new experiments to refine our knowledge. Living systems have highly regulated feedback control systems that can be examined with state-of-the-art techniques. Examples are the biochemistry of metabolism and the control of limb movements.

These specialty areas frequently depend on each other. Often, the biomedical engineer who works in an applied field will use knowledge gathered by biomedical engineers working in other areas. For example, the design of an artificial hip is greatly aided by studies on anatomy, bone biomechanics, gait analysis, and biomaterial compatibility. The forces that are applied to the hip can be considered in the design and material selection for the prosthesis. Similarly, the design o systems to electrically stimulate paralyzed muscle to move in a controlled way uses knowledge the behavior of the human musculoskeletal system. The selection of appropriate materials used in these devices falls within the realm of the biomaterials engineer.

Examples of Specific Activities

Work done by biomedical engineers may include a wide range of activities such as:

- * Artificial organs (hearing aids, cardiac pacemakers, artificial kidneys and hearts, blood oxygenators, synthetic blood vessels, joints, arms, and legs).
  * Automated patient monitoring (during surgery or in intensive care, healthy persons in unusual environments, such as astronauts in space or underwater divers at great depth).
  * Blood chemistry sensors (potassium, sodium, O2, CO2, and pH).
  * Advanced therapeutic and surgical devices (laser system for eye surgery, automated delivery of insulin, etc.).
  * Application of expert systems and artificial intelligence to clinical decision making (computer-based systems for diagnosing diseases).

* Design of optimal clinical laboratories (computerized analyzer for blood samples, cardia catheterization laboratory, etc.).
* Medical imaging systems (ultrasound, computer assisted tomography, magnetic resonance imaging, positron emission tomography, etc.).
* Computer modeling of physiologic systems (blood pressure control, renal function, visu and auditory nervous circuits, etc.).
* Biomaterials design (mechanical, transport and biocompatibility properties of implantable artificial materials).
* Biomechanics of injury and wound healing (gait analysis, application of growth factors, etc.).
* Sports medicine (rehabilitation, external support devices, etc.).

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Where do Biomedical Engineers Work?

Biomedical engineers are employed in universities, in industry, in hospitals, in research facilities of educational and medical institutions, in teaching, and in government regulatory agencies. Th often serve a coordinating or interfacing function, using their background in both the engineerin and medical fields. In industry, they may create designs where an in-depth understanding of living systems and of technology is essential. They may be involved in performance testing of new or proposed products. Government positions often involve product testing and safety, as well as establishing safety standards for devices. In the hospital, the biomedical engineer may provide advice on the selection and use of medical equipment, as well as supervising its performance testing and maintenance. They may also build customized devices for special healt care or research needs. In research institutions, biomedical engineers supervise laboratories an equipment, and participate in or direct research activities in collaboration with other researcher with such backgrounds as medicine, physiology, and nursing. Some biomedical engineers are technical advisors for marketing departments of companies and some are in management positions.

Some biomedical engineers also have advanced training in other fields. For example, many biomedical engineers also have an M.D. degree, thereby combining an understanding of advanced technology with direct patient care or clinical research.

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How Should I Prepare for a Career in Biomedical Engineering?

The biomedical engineering student should first plan to become a good engineer who then acquires a working understanding of the life sciences and terminology. Good communication skills are also important, because the biomedical engineer provides a vital link with professional having medical, technical, and other backgrounds.

High school preparation for biomedical engineering is the same as that for any other engineerin discipline, except that life science course work should also be included. If possible, Advanced Placement courses in these areas would be helpful. At the college level, the student usually selects engineering as a field of study, then chooses a discipline concentration within engineering. Some students will major in biomedical engineering, while others may major in chemical, electrical, or mechanical engineering with a specialty in biomedical engineering. As career plans develop, the student should seek advice on the degree of specialization and the educational levels appropriate to his or her goals and interests. Information on sources of financial aid for education and training should also be sought. Many students continue their education in graduate school where they obtain valuable biomedical research experience at the Masters or Doctoral level. When entering the job market, the graduate should be able to point t well defined engineering skills for application to the biomedical field, with some project or in-the field experience in biomedical engineering.

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For More Information

Accredited Programs: Accreditation Board for Engineering & Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, 410-347-7700 or **www.abet.org/accredited_prgs.html**

Graduate Programs: Available on the Internet at www.bmenet.org and Peterson's Guide to Graduate Programs at **http://iiswinprd01.petersons.com/gradchannel/**

Academic Programs in Biomedical Engineering: Available on the Internet at **www.whitaker.org/academic/**

Biomedical Engineering Academic Program Annual Report. Available on the Internet at **www.bmenet.org**

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