Biomedical Engineering Ethics

Biomedical engineering refers to the application of engineering principles in healthcare and biology. They integrate the aspects of electrical engineering, computer science, chemical engineering and mechanical engineering into their design process to come up with perfect solutions.

It is the convergence and application of engineering principles to human biology or medicine in order to develop technologies to improve health care and patient care. The discipline embraces applications from physiology, human biology, molecular imaging to the re-construction of tissues and organs. Technically, although biomedical engineers are not medical practitioners, they could be regarded as indirect practitioners, since the protocols, processes, and technologies they develop codetermine medical practice. Even though biomedical engineering is sometimes equivocated to biological engineering, the former is narrower in scope. Biological engineering generally deals with the engineering of biological functions and systems, and includes not only biomedical engineering but also tissue engineering, food engineering and biotechnology.

Ethical issues in biomedical engineering are currently studied in the fields of bioethics, medical ethics and engineering ethics. While biomedical engineers differ from other engineers, they are similar to medical practitioners, in that they aim to improve healthcare. Biomedical engineers, like other engineers, are involved in research and development of new medical technology, but not engage in the diagnosis and treatment of patients.

The ethical responsibilities of biomedical engineers thus combine those of engineers and medical professionals, by adhering to standards in medical and bioethics. Besides other inherent issues within their practice, biomedical engineers have an arduous responsibility of anticipating the consequences of their technological designs for medical practice, by ensuring that the designs support ethical principles for medical practice. Such principles include non-maleficence (doing not harm), beneficence (benefiting patients), informed consent (consent to treatment based on a proper understanding of the facts), patient autonomy (the right to choose or refuse treatment), confidentiality (of medical information), and dignity (dignified treatment of patients).

Genetic, Cellular and Tissue Engineering

These highly technical fields involve attempts at solving biomedical problems at the microscopic level. Genetic engineering specifically aims to alter the genetic material in cells. Most research goes into somatic cell therapy (and not the sperm or egg cells) in order to replace abnormal genes with functional ones. Quite a number of genetically engineered products are being clinically tested to treat diabetes, cancer, and other neuro-degenerative disorders. The narrative that somatic cell gene therapy to treat serious diseases is ethical is due to compelling evidence from empirical research.

Cellular engineering attempts to understand the cause and course of diseases at the cellular level in order to intervene by using devices that either inhibit or stimulate cellular processes. The objective is to prevent or treat disease. The field attempts to control cell function through mechanical, chemical, or genetic engineering of cells.

Tissue engineering aims to improve the functions of tissues or whole organs by means of biological replacements. One objective of tissue engineering is to create artificial organs for organ transplants. Major controversies involve the use of human embryonic tissue. The use of stem and germ cells from embryonic tissue is controversial because the harvested cells from the embryos, which are deemed potential humans, are destroyed in the process. The destruction of human embryos is seen by society as unethical, and therefore to have a medical practice that involves it renders it very controversial. Other ethical issues in tissue engineering concern the question of patenting the tissues, and whether human donors could profit from their use. The protection of the donor's privacy is another contentious issue. Tissues of donors are stored in bio banks or repositories of either public or private organizations but there are disagreements about the extent and manner to which such organizations are responsible for protecting the privacy and confidentiality of the donors. Another contentious ethical issue to be considered is the extent to which prolonging the life span of humans in tissue engineering should be, and how such a goal should be balanced against the quality of life.

Biomaterials, Prostheses, and Implants

One interesting area in biomedical engineering is the development of prosthetic devices and implants using biomaterials. In the field of biomaterials, non-biological materials in the form of prostheses or implants are used to interface with biological systems to replace, treat, or support functions of the body. The development and use of implants and prostheses in the form of artificial limbs and hips, pacemakers, and retinal implants have helped in restoring function in people with disabilities and function impairments.

The use of Prostheses and implants technology, which has enabled patients to receive artificial limbs and organs in the field of rehabilitation engineering, also poses ethical questions about human identity and dignity because it involves the replacement or addition of artificial structures to human biology. The use of prostheses and implants, particularly ones that have functioning parts, cyborgs (part human, part machine) raises the emotional question; can the resulting person still be called fully human? Can the artificial part cause a loss of identity? Should certain organs not be replaced by artificial systems?

Ethicist’s main concern has to do with the reality that people are becoming part human and part machine, forcing biologists and biomedical engineers to reconsider the definition of being human. Science disciplines like biomedical engineering, biomechanics, neuro-prosthetics, brain-computer interfaces, and rehabilitation engineering forces us to re-evaluate our impact on the world around us.

Neural Engineering

This new field combines engineering techniques and neuroscience in order to control the peripheral or central nervous systems through the direct interaction between the nervous system and artificial devices. The primary goal is to restore and augment human functions. In neuro-prosthetics, an impaired nervous function can be replaced or improved by neural prostheses. In brain-computer interfaces, computing devices are hooked to the brain to enable better signal exchanges. Neural engineering also involves the use of brain implants to enhance electrical stimulation of the nervous tissues. All these processes which involve device and human interfaces have raised troubling ethical questions regarding the dignity of humans, since artificial neural devices may affect personal identity by making the brain partially artificial, which could ultimately turn humans into cyborgs. There is also the tendency for individual autonomy to be undermined as neural devices could be used to control human behaviour. All these concerns then beg the question: can humans still be held morally responsible for their behaviour when their brains are no longer under their control? The possibility of neuro-alteration also raises a critical question which has been a subject of intense debate:

should neural engineering be employed to develop artificial human devices that have superior perception, cognition, and positive attitudes?