Biological engineering

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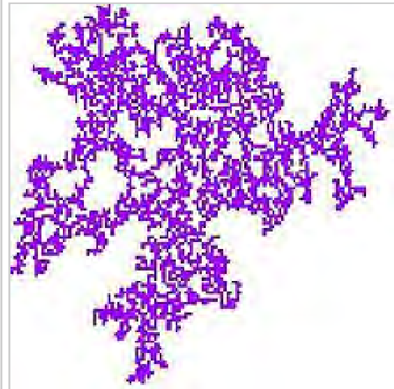

Modeling of the spread of disease using Cellular Automata and Nearest Neighbor Interactions

Biological engineering or **bio-engineering** (including biological systems engineering) is the application of concepts and methods of biology (and secondarily of physics, chemistry, mathematics, and computer science) to solve real-world problems related to life sciences or the application thereof, using engineering's own analytical and synthetic methodologies and also its traditional sensitivity to the cost and practicality of the solution(s) arrived at. In this context, while traditional engineering applies physical and mathematical sciences to analyze, design and manufacture inanimate tools, structures and processes, biological engineering uses primarily the rapidly developing body of knowledge known as molecular biology to study and advance applications of organisms and to create biotechnology.This may eventually include the possibility of biologically engineering machines and 3D printing that re-order matter at a molecular scale. Physicist Richard Feynman theorized about the idea of a *medical* use for these biological machines, introduced into the body, to repair or detect damages and infections. . Feynman and Albert Hibbs suggested that it might one day be possible to (as Feynman put it) "swallow the doctor". The idea was discussed in Feynman's 1959 essay *There's Plenty of Room at the Bottom.*[1]

Industrial bio-engineering extends from the creation of artificial organs by technical means or finds ways of growing organs and tissues through the methods of regenerative medicine to compensate reduced or lost physiological functions (Biomedical Engineering) and to develop genetically modified organisms, i.e., agricultural plants and animals as well as the molecular designs of compounds with desired properties (protein engineering, engineering enzymology). In the non-medical aspects of bio-engineering, it is closely related to biotechnology, nanotechnology and 3D printing.

An especially important application is the analysis and cost-effective solution of problems related to human health (human bioingeneering), but the field is much more general than that. For example, biomimetics is a branch of biological engineering which strives to find ways in which the structures and functions of living organisms can be used as models for the design and engineering of materials and machines. Systems biology, on the other hand, seeks to exploit the engineer's familiarity with complex artificial systems, and perhaps the concepts used in "reverse engineering", to facilitate the difficult process of recognition of the structure, function, and precise method of operation of complex biological systems.

The differentiation between biological engineering and biomedical engineering can be unclear, as many universities loosely use the terms "bioengineering" and "biomedical engineering" interchangeably.[2] Biomedical engineers are specifically focused on applying biological and other sciences toward medical innovations, whereas biological engineers are focused principally on applying engineering principles to biology - but not necessarily for medical uses. Hence neither "biological" engineering nor "biomedical" engineering is wholly contained within the other, as there can be "non-biological" products for *medical* needs as well as "biological" products for *non-medical* needs (the latter including notably biosystems engineering).

Contents

History

Biological engineering is a science-based discipline founded upon the biological sciences in the same way that chemical engineering, electrical engineering, and mechanical engineering[3] can be based upon chemistry, electricity and magnetism, and classical mechanics, respectively.[4]

Biological engineering can be differentiated from its roots of pure biology or other engineering fields. Biological studies often follow a reductionist approach in viewing a system on its smallest possible scale which naturally leads toward the development of tools like functional genomics. Engineering approaches, using classical design perspectives, are constructionist, building new devices, approaches, and technologies from component parts or concepts. Biological engineering uses both approaches in concert, relying on reductionist approaches to identify, understand, and organize the fundamental units, which are then integrated to generate something new.[5] In addition, because it is an engineering discipline, biological engineering is fundamentally concerned with not just the basic science, but its practical application of the scientific knowledge to solve real-world problems in a cost-effective way.

Although engineered biological systems have been used to manipulate information, construct materials, process chemicals, produce energy, provide food, and help maintain or enhance human health and our environment, our ability to quickly and reliably engineer biological systems that behave as expected is at present less well developed than our mastery over mechanical and electrical systems.[6]

ABET,[7] the U.S.-based accreditation board for engineering B.S. programs, makes a distinction between biomedical engineering and biological engineering, though there is much overlap (see above). Foundational courses are often the same and include thermodynamics, fluid and mechanical dynamics, kinetics, electronics, and materials properties.[8][9] According to Professor Doug Lauffenburger of MIT,[10][11] biological engineering (like biotechnology) has a broader base which applies engineering principles to an enormous range of size and complexities of systems ranging from the molecular level - molecular biology, biochemistry, microbiology, pharmacology, protein chemistry, cytology, immunology, neurobiology and neuroscience (often but not always using biological substances) - to cellular and tissue-based methods (including devices and sensors), whole macroscopic organisms (plants, animals), and up increasing length scales to whole ecosystems.

The word bioengineering was coined by British scientist and broadcaster Heinz Wolff in 1954.[12] The term bioengineering is also used to describe the use of vegetation in civil engineering construction. The term bioengineering may also be applied to environmental modifications such as surface soil protection, slope stabilization, watercourse and shoreline protection, windbreaks, vegetation barriers including noise barriers and visual screens, and the ecological enhancement of an area. The first biological engineering program was created at Mississippi State University in 1967, making it the first biological engineering curriculum in the United States.[13] More recent programs have been launched at MIT [10] and Utah State University.[14]

Description

Biological engineers or *bio-engineers* are engineers who use the principles of biology and the tools of engineering to create usable, tangible, economically viable products.[15] Biological engineering employs knowledge and expertise from a number of pure and applied sciences,[16] such as mass and heat transfer, kinetics, biocatalysts, biomechanics, bioinformatics, separation and purification processes, bioreactor design, surface science, fluid mechanics, thermodynamics, and polymer science. It is used in the design of medical devices, diagnostic equipment, biocompatible materials, renewable bioenergy, ecological engineering, agricultural engineering, and other areas that improve the living standards of societies.

In general, biological engineers attempt to either mimic biological systems to create products or modify and control biological systems so that they can replace, augment, sustain, or predict chemical and mechanical processes.[17] Bioengineers can apply their expertise to other applications of engineering and biotechnology, including genetic modification of plants and microorganisms, bioprocess engineering, and biocatalysis.

Because other engineering disciplines also address living organisms (e.g., prosthetics in bio-mechanical engineering), the term biological engineering can be applied more broadly to include agricultural engineering and biotechnology, which notably can address non-healthcare objectives as well (unlike biomedical engineering). In fact, many old agricultural engineering departments in universities over the world have rebranded themselves as *agricultural and biological engineering* or *agricultural and biosystems engineering*. Biological engineering is also called *bioengineering* by some colleges, and biomedical engineering is called *bioengineering* by others, and is a rapidly developing field with fluid categorization. Depending on the institution and particular definitional boundaries employed, some major fields of bioengineering may be categorized as (note these may overlap):

- biological systems engineering
- biomedical engineering: biomedical technology, biomedical diagnostics, biomedical therapy, biomechanics, biomaterials;
- genetic engineering (involving both of the above, although in different applications): synthetic biology, horizontal gene transfer;
- bioprocess engineering: bioprocess design, biocatalysis, bioseparation, bioinformatics, bioenergy;
- cellular engineering: cell engineering, tissue engineering, metabolic engineering;
- biomimetics: the use of knowledge gained from reverse engineering evolved living systems to solve difficult design problems in artificial systems.

References

1. Richard P. Feynman (December 1959). "There's Plenty of Room at the Bottom". Retrieved March 2010. Check date values in: `|access-date=` (help)
2. NIH working definition of bioengineering accessed (http://www.becon.nih.gov/bioengineering_definition.htm) Archived (https://web.archive.org/web/20080512145814/http://www.becon.nih.gov/bioengineering_definition.htm) May 12, 2008, at the Wayback Machine., 1/1/2007
3. *Biological Engineering*. Gale Virtual Reference Library. 2015. p. 18. ISBN 978-1-62968-526-7.
4. Cuello JC, Engineering to biology and biology to engineering, The bi-directional connection between engineering and biology in biological engineering design, Int J Engng Ed 2005, 21, 1-7
5. Riley MR, Introducing Journal of Biological Engineering (http://www.jbioleng.org). *Journal of Biological Engineering*, vol 1, article 1, 2007.
6. Endy D (2005). "Foundations for engineering biology". *Nature*. **438**: 449–4.
7. ABET Accreditation (http://www.abet.org/accreditation/), accessed 9/8/2010.
8. Linsenmeier RA, Defining the Undergraduate Biomedical Engineering Curriculum (http://www.vanth.org/curriculum/def_bme_curr.pdf)
9. Johnson AT, Phillips WM. "Philosophical foundations of biological engineering". *Journal of Engineering Education*. **1995** (84): 311–318.
10. "MIT, Department of Biological Engineering". Retrieved 16 April 2015.
11. "MIT Directory, Doug Lauffenburger". Retrieved 15 April 2015.
12. "Professor Heinz Wolff". Heinzwolff.co.uk. Archived from the original on 2012-10-20. Retrieved 2011-11-13.
13. "Mississippi State University, Agricultural & Biological Engineering Department". Abe.msstate.edu. Retrieved 15 April 2015.
14. "Utah State University, Department of Biological Engineering". be.usu.edu. Retrieved 2011-11-13.
15. *Biological engineering*. Gale Virtual Reference Library. 2015. p. 10. ISBN 978-1-62968-526-7.
16. *The Basics of Bioengineering Education*. 26Th Southern Biomedical Engineering Conference, College Park, Maryland. 2010. p. 65. ISBN 9783642149979.
17. Pasotti, Lorenzo; Zucca, Susanna (2014-08-03). "Advances and Computational Tools towards Predictable Design in Biological Engineering". *Computational and Mathematical Methods in Medicine*. **2014**: 1–16. doi:10.1155/2014/369681. PMC 4137594. PMID 25161694.

External links

- Benchling (https://www.benchling.com/)
- Genome Compiler (http://www.genomecompiler.com/)
- Bioengineering Society (http://www.bioengineer.org/)
- Biomedical Engineering Society (http://bmes.org/)
- Institute of Biological Engineering (http://www.ibe.org/)
- Benjoe Institute of Systems Biological Engineering (https://web.archive.org/web/20110710043251/http://www.sysbioeng.com:80/stes/sysbiology01.html)
- American Institute of Medical and Biological Engineering (http://www.aimbe.org/)
- American Society of Agricultural and Biological Engineers (http://www.asabe.org/)
- Society for Biological Engineering (http://www.aiche.org/sbe/index.aspx) part of AIChE
- Journal of Biological Engineering, JBE (http://www.jbioleng.org)
- Biological Engineering Transactions (https://web.archive.org/web/20130503153540/http://www.asabe.org/publications/publications/periodicals.aspx)

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