

NEW TRENDS IN BIO-SYSTEMS ENGINEERING EDUCATION

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Abstract. The paper presents and discuss the objectives of engineering education in the fields of Biosystems Engineering (e.g. Agricultural Engineering). A hybrid system of Engineering and Biosystems is developed. Based on this hybrid system the interrelations between the components of engineering and biological systems are developed. Curricula for Agro-food Products Processing Engineering master study programs were developed.

THE BIO-SYSTEMS ENGINEERING CONCEPT

The Bio-systems Engineering concept represents a new approach to analyzing biological systems through an application and integration of engineering principles in biology. This concept is based on a hybrid system, consisting of a biological subsystem (B) and an engineering component (E) (Fig. 1). Systemic analysis implies the unitary evaluation of all the quantities which compose the system: the input parameters a_1, a_2, \dots, a_n ; the output parameters b_1, b_2, \dots, b_m ; the system states s_1, s_2, \dots, s_j , defined by the status parameters t_1, t_2, \dots, t_u . The perturbation factors p_1, p_2, \dots, p_i are represented by developments in collateral fields, concrete needs of the society, social and economical conditions etc. The interaction between the two components of the system (E and B) could be described through the abstract relations A and C.

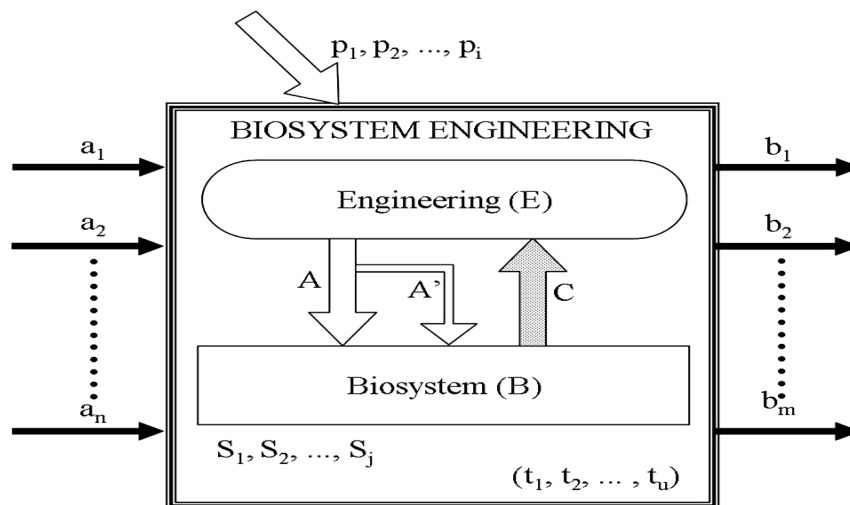


Figure 1: The hybrid system: Engineering and Bio-system

The relation A characterizes the application of Engineering principles in biology ($E \Rightarrow B$), which signifies “*Engineering for biology*” or an application of the concepts and methods of the physical and engineering sciences in biology. The connection A , as a functional relation between E and B , may be represented by different specific applications A' . The relation A' suggests the application of Engineering principles in medicine, meaning “*Engineering for health*” or in other field (e.g. environment, vegetal bio-systems etc.) The role of this relation consists in identification of the needs of a bio-systems, and of the means of meeting these needs using available technology. Design and development of materials, equipment and techniques for diagnosis and treatment of the patients comprise a new dynamic branch of engineering, called *Biomedical Engineering*. The action of E towards B ($E \Rightarrow B$) can be systematized as in Figure 2.

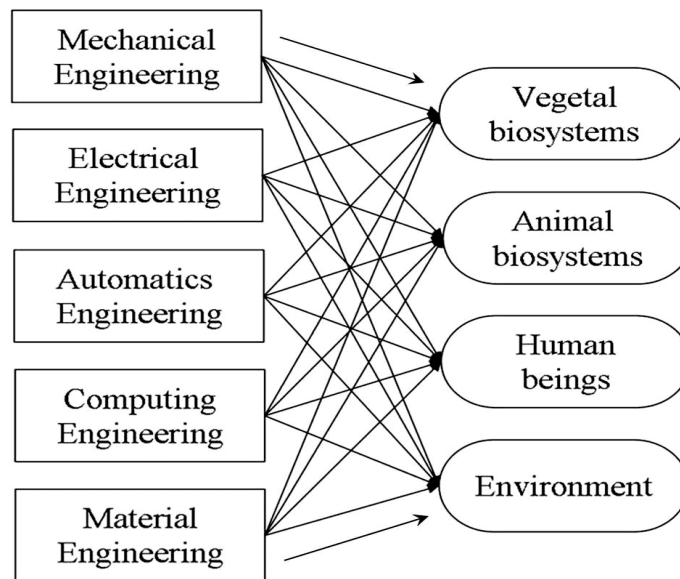


Figure 2: The concept “Engineering for biology”

In the second relation category the information transfer is oriented from B to E ($B \Rightarrow E$), which means that the bio-systems provide the inspiration and the models used to develop high-performance engineering systems. The principle of the *optimum project* which determines the optimal operation of the bio-systems, justifies the transfer of some information from biology to engineering. According to the above-mentioned principle, natural selection develops and promotes those individuals that are best adapted to the environment. The study of this interaction between engineering (E) and biological (B) systems has developed very much, under the name of *Bionics*. This fundamental and practical science deals with the tendency to copy and reproduce some qualities of the biological processes, using different materials than the ones specific to living beings, using means provided by physics, chemistry and engineering sciences.

In the last decades, the complexity of the problems which appear in nature and the necessity of understanding biological systems has been leading to a reanalysis of the education and research systems in order to ensure their normal development in line with the requirements of the long-term development of living systems. This fact implies a multidisciplinary approach in education and research. The integration of engineering principles with biological systems (vegetal, animal, environmental and human-related) represents one of the goals of present-day education and research.

Education in Bio-systems Engineering

Generally, engineering is the application of science to the needs of humanity. Engineers have to gather knowledge of science (mathematics, physics, chemistry, biology etc.) and to use their experience to find suitable solutions to the problems. They use, among other things: prototypes, scale models, simulation, destructive and nondestructive testing. In order to put knowledge to work for society, engineers must be able to work across many different disciplines and fields and make the *connection* that will lead to deeper insights and more creative solutions. Since engineering itself is an integrative process, engineering education must likewise be integrative. The crucial question is: what and how much does an engineer has to learn in order to be able to build something? Bio-systems are related to vegetal, animal, human and environmental fields. What should be the difference between Engineering Education and Bio-systems Engineering Education?

The work in Bio-systems Engineering requires profound understanding of the features of bio-systems, including human beings. The specialists need a relatively complete biophysical and medical knowledge to identify and solve integrated problems and imagine and design innovative products, devices and procedures. Any curriculum in this field, have to be based on the following general competences: an ability to apply knowledge of mathematics, science and engineering; an ability to design and conduct experiments, as well as to analyze and interpret data; an ability to design a system, component, or process to meet desired needs; an ability to function on multi-disciplinary teams; an ability to identify, formulate and solve engineering problems; an understanding of professional and ethical responsibility; an ability to communicate effectively; the broad education necessary to understand the impact of engineering solutions in a global and societal context; a recognition of need for, and an ability to engage in life-long learning; a knowledge of contemporary issues; an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice; an understanding of biology and physiology, and the capability to apply advanced mathematics, science and engineering to solve the problems at the interface of engineering and biology; the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction living / non-living materials and systems.

As is already known, a new educational path was adopted, consisting of a first level degree (Bachelor) eventually followed by a second level, specialist degree or Master and finally by the PhD. For a better correlation between the needs of education and the requirements of job competence, a scheme illustrating the relationship between engineering / biological knowledge and bio-systems components was developed (Fig. 3). This scheme is developed in a systemic concept so each element may be developed in other subsystems and may be quantified in terms of credits or percentage related to the whole program of study. Based on this scheme we can more easily develop a study program for undergraduate (BS), graduate (MS and PhD) and lifelong learning in the agricultural and biomedical fields.

Curricula development

First, a curriculum for a master program in agro-bio-system engineering dedicated to our country is proposed. The development of the study program is based on the following considerations:

- the agricultural process is still in a transformation stage;

- the education systems are in the period of restructuring - most of the Higher Education Institutions strongly support the ideas of the Bologna Declaration, as well as the creation of a

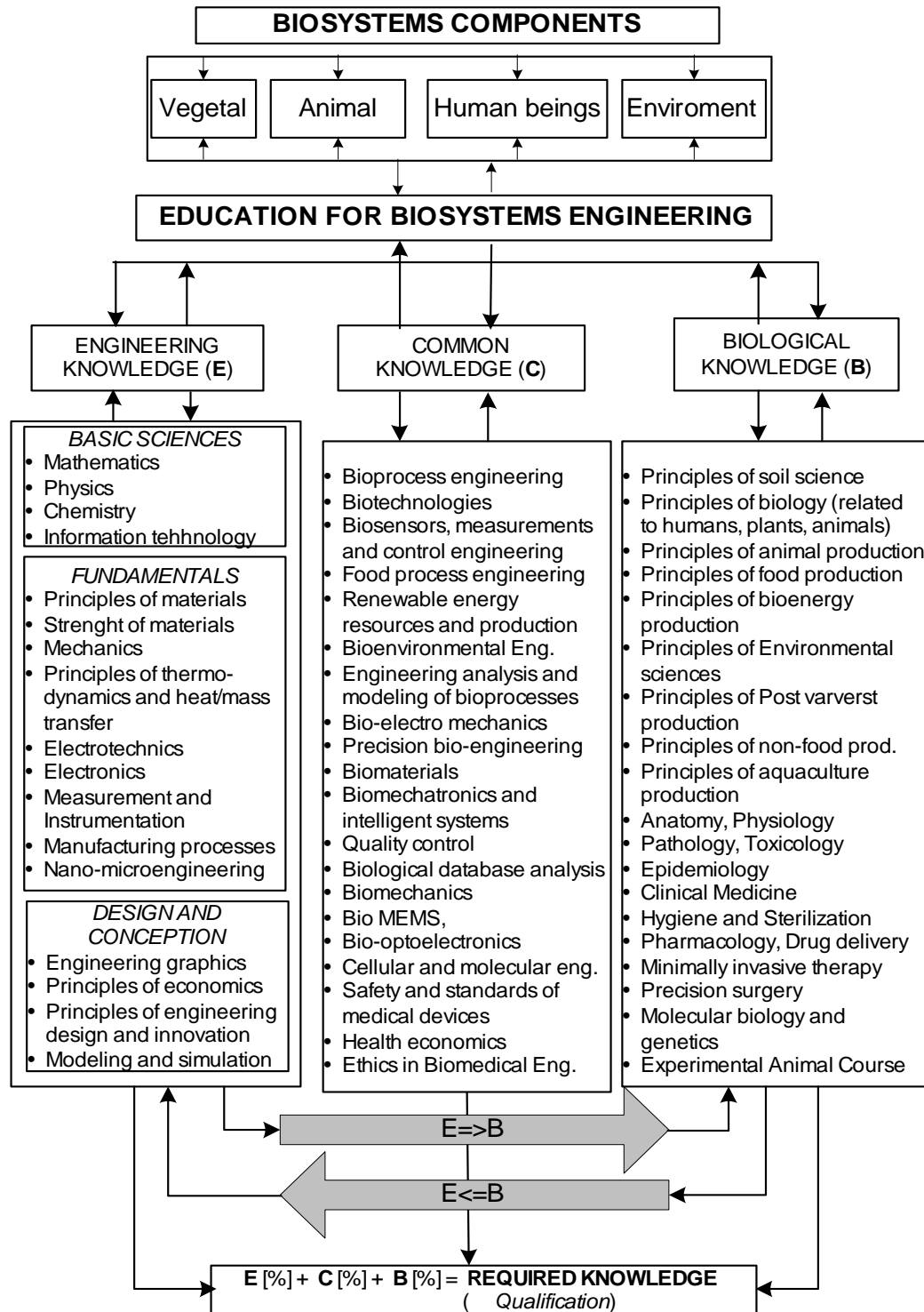


Figure 3: The scheme illustrating the relationship between engineering / biology knowledge and biological components

European Area of Higher Education;

- the proposed curricula is based on FEANI criteria and is in line with current trends in European agricultural/bio-systems Engineering education. The courses cover new application areas for bio-systems engineering (processing and transformation of agro-products, quality control of agro-food products, new orientation of industry toward agricultural products like biomaterials, waste treatment in agricultural sector etc.);

- the package of courses proposed for the master program of study integrates higher knowledge for a specific practice-oriented purpose, developing a capacity for creation and technological innovation, opening tremendous possibilities in the agro-bio sectors.

Figure 4 presents the structure of the master program courses in agro-bio-systems engineering. The program is named *Master Program in Agro-food Products Processing*. This program integrates courses related to vegetal, animal, food and non-food production, enabling graduates to get jobs in different sectors of the agriculture, food industry, as well as, in bio-sensors manufacturing, quality control of agro / food products etc.

The program of study is extended over a period of two years and a total of 120 credit points [CP] is needed. Each course (lectures + exercises) has a number of hours equal with 6 x number of CP. For Projects / essays 18 CP are allocated (480 hours in total). For Master Thesis 30 CP are allocated (800 hours in total).

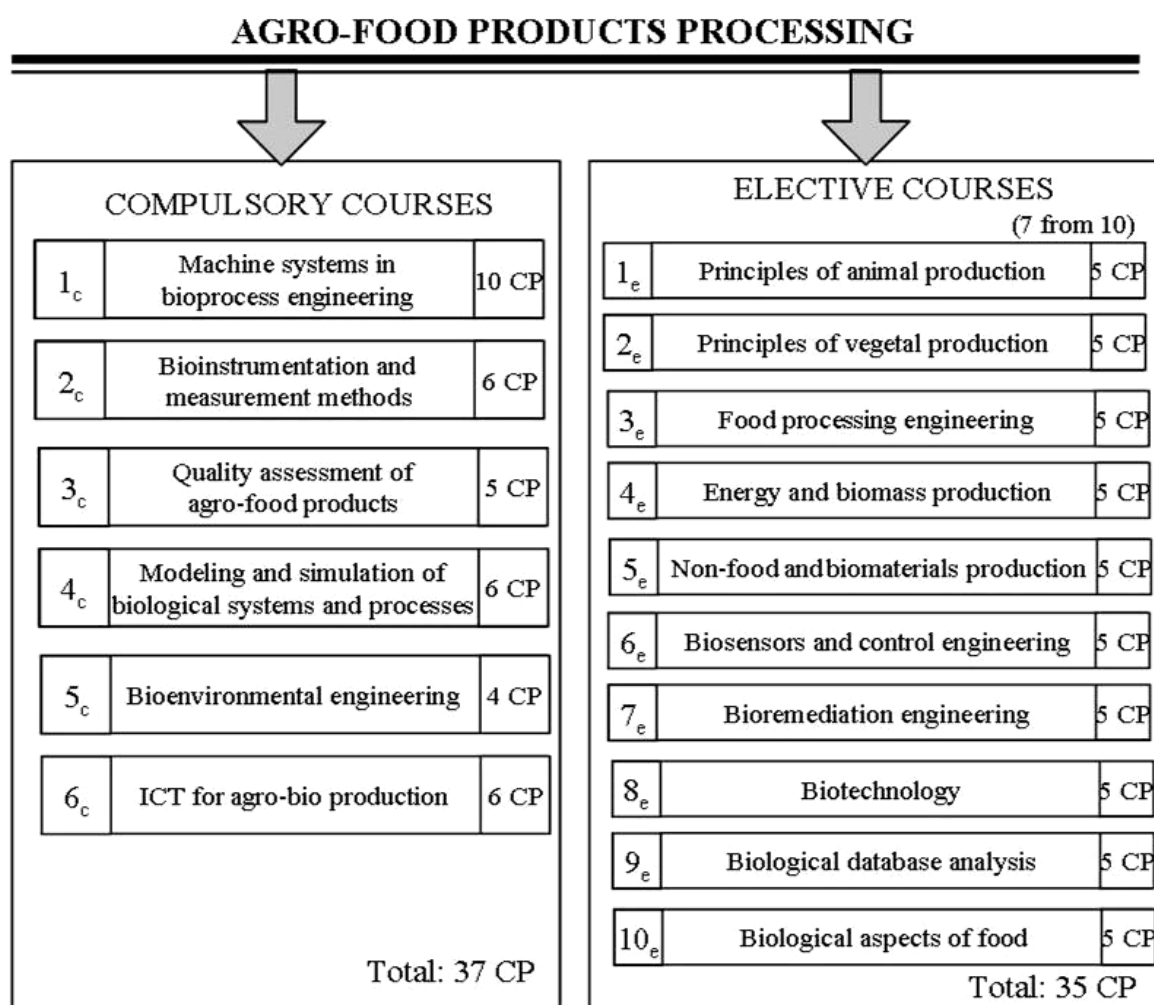


Figure 4. The structure of the Master study program Agro-Food Products Processing.

CONCLUSIONS

Today, engineering is increasingly oriented toward living beings, to nature and human beings. The strong link between engineering and biology is required by the current developments in both areas and by the needs of society, determining the progress in the field of Bio-systems Engineering. The Bio-systems Engineering education has to respond to multi-disciplinary requirements. The challenge for the educators is to develop the courses that are relevant to the needs of health care, agriculture and the food industry.

The basic principles and objectives of Biomedical Engineering are emphasized. The most important peculiarities of Bio-system Engineering Education are presented. The relationship between engineering/biological knowledge and medical/agro-biological components was established in a systemic manner and curricula for *Agro-food Products Processing* master study programs, was developed.

Bio-systems Engineering offers hope and means in the battle to ensure a high quality of life, to overcome poverty and dearth. Perhaps the next generation will name the 21-th century the century of the “*Bio-engineering revolution*”.

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