TEACHING AND EDUCATION IN BIOPHYSICS

In the training of physicians biophysics is one of the fundamental sciences. It has a multifarious function. One of them is to provide basic knowledge, and to prepare for their application in practice. It has an important role in the formation of the scientific world concept of students. To provide – in cooperation with other fundamental disciplines – up-to-date theoretical and practical basis for the subsequent studies seems to be the most important function of this field of science.

Education in biophysics is taking place in Hungary at several universities. According to the number of students involved, we have to mention first the four university medical schools (in Budapest, at Debrecen, at Pécs and at Szeged). The bioengineers of the Technical University of Budapest and the biophysicists and biologists at different univesities of sciences are much fewer in number than the students of medical universities. The largest-scale training is at the Semmelweis University of Medicine (SOTE), located in the capital, Budapest. Therefore, somewhat arbitrarily, in the following paragraphs we would like to give a survey of the ongoing education at the Institute of Biophysics of SOTE, about the development, circumstances and problems of our educational schedule on biophysics.

1. Short history

The University of Nagyszombat (now Trnava in Slovakia), the predecessor of the Lorand Eötvös University of Sciences (ELTE), founded in 1635, became a complete – four faculty – university by establishing the Faculty of Medicine in 1769. From then on, for nearly a century, physics was learned by the students only in a two year preliminary philosophical course which was an obligatory requirement of becoming a medical student. According to the new code of examinations in 1875, however, physics was established as a pre-final examination for all future doctors. (The medical students visited the lectures together with the students of the faculty of philosophy.)

Despite the fact that the Faculty of Medicine had requested the establishment of a separate department of medical physics as soon as 1870, the situation remained unchanged, physics was taught by a department which was not part of the medical faculty, so the preferences of medical education were not accepted for a lenghty period of time.

The government decided in 1947 to set up the Institute of Medical Physics as a department of the Faculty of Medicine which has been functioning only

from 1949, from 1967 as Institute of Biophysics. In 1951 the Faculty of Medicine became an independent (self governing) university with three faculties, this is now the Semmelweis University of Medicine. Among the medical universities in the country, Debrecen and Pécs have their own Institute of Biophysics. (The latter was the first medical university in Hungary having the department of biophysics.) In Szeged, biophysics is taught by the Department of Biophysics of the University of Sciences. There is one condition which all four departments teaching biophysics for medical students must satisfy, namely that the program of the biophysics curriculum has to be constantly modernized. This is necessary due not only to the appearance of new trends, the widening of the scope of knowledge but to the change in the pre-university qualification of the students and to the coordination with the other sciences as well. Thus, our teaching program should be regarded as an intermediary station of a continuous progress. Today's students will become physicians, pharmacists and dentists of the upcoming decades.

2. Education in the near past and present

The Institute of Biophysics teaches on all three faculties of SOTE (Medicine, Dentistry and Pharmacy), thus oversees the biophysical (or pharmacophysical) education or all students in the first year. The number of students admitted to the faculties has varied throughout the years. There were years when this number exceeded 800 students.

At present, classes are the smallest ever (see Table 1). Their level of knowledge in physics can be regarded satisfactory, since they had to pass entrance examinations in physics (and in biology). Thus, we don't have to teach or to repeat the curriculum of secondary school physics. The previous statement does not apply to our foreign language students: teaching has been taking place in German since 1983 and in English since 1989. Our educational engagements in the academic year of 1992–93 are shown in Table 1. Besides the basic curriculum we give a tow hours seminar for our foreign language students weekly, in order to assure their satisfactory level of biophysical knowledge.

3. The scenes of education

Biophysics has a course of two semesters for all the faculties in the first year of the six year medical curriculum, and is finished by a final exam at the end of the second semester. Lectures and laboratory practices are held. The laboratory practices (and seminars) are held for separate groups of students of each faculty. The number of students in these groups vary from 10–24. Each member of the group has the opportunity to perform the same experiment simultaneously and individually, or maximum in groups of 2–3 students. In this aspect the Institute of Biophysics at SOTE provides a unique possibility in respect of practical work.

Table 1. *Timetable of the Institute of Biophysics at SOTE*[1]

	number of groups	number of students	number of teaching hours				
			lecture			lab. practice	
			I–II. semester h/week		h/year	h/week	h/year
Med.[2]	24	265	2.5 2.5	2 2	67.5 67.5	60	1800
Dent.	6	66	2.5	2	67.5	15	450
Pharm.	6	124	2	2	60	18	540
German (Med.)	6	110	2.5	2	67.5	lab.: 5 sem.: 12	810
Med.+ Dent. English Pharm.	9	157	2.5 2	2 2	67.5 60	lab.: 23 sem.: 18	1230
Total	*51*	*722*	*16.5*	*14*	*457.5*	*161*	*4830*

4. The educational program

4.1. Course of lectures

The subject of the lectures – based on the knowledge of physics and mathematics acquired in secondary school – contains selected chapters. In selection the aspects of medical (dentist and pharmaceutical) education were emphasized. So the basic elements of the lectures at the different faculties generally coincide, but specific topics are also considered. Below we give a survey on the program of lectures of medical students and a summary of the laboratory practices.

4. 1. 1. Medical dataprocessing, computers (biomathematics, biometry)

The most frequently used functions for the mathematical description of the processes in nature and the of different physical laws describing the phenomena are duscussed with the help of simple differential equations. The specific relationship between the mathematical formalisms and their physical/ biophysical meaning is emphasized in order to reduce the aversion associated with the mathematics nowadays indispensable in medicine.

The majority of the basic concepts and methods of biometrics are discussed also in laboratories by solving problems with the aid of computers.

[1] Education is taking place in Debrecen, Pécs and Szeged at Faculties of Medicine and Dentistry, in Szeged at the Faculty of Pharmacy, too. The number of Hungarian students in these universities is about 1/3 each of that in Budapest. In all three of these universities there is English language education, too.

[2] The students of the Faculty of Medicine are divided into two parts, reading biophysics lectures separately.

4. 1. 2. The molecular structure of the living system

This chapter provides up-to-date structural and conceptional bases of the matter with special emphasis on the biological – partly ordered – systems.

4. 1. 3. Optical and ionizing radiations; biological effects and applications

This chapter deals with the physical basis of the interaction between radiation and the living matter with special emphasis on molecular interpretation. The bases of numerous modern measuring-technical, diagnostic and therapeutical methods are discussed. This knowledge serves as physical basis of presently used and future techniques in large diagnostic and therapeutic centers.

4. 1. 4. Methods of biological structure analysis

The principles of the most important methods and the information obtained by them is dealt with. This is a continuously developing chapter since almost all physical methods – even the newer ones, rapidly increasing in number – have a possible medical application.

4. 1. 5. Thermodynamic basis of life-processes; transport processes

Starting from general laws this chapter aims to give foundations for the study of macroscopic and microscopic transport phenomena playing an important role in physiologic and pathologic processes.

4. 1. 6. Medical signal processing, bioelectronics

Due to the development of microelectronics, an ever increasing number of electronic devices is used in medical practice for diagnostic and therapeutic purposes. The basis concepts of the medical techniques are presented.

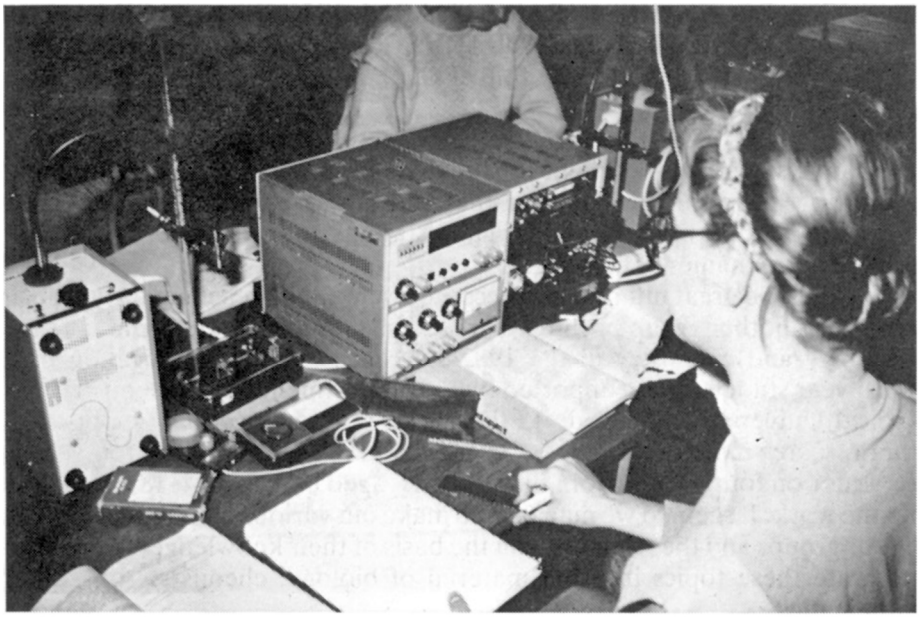
4. 1. 7. The biophysical basis of excitation processes

A few simple bioelectric phenomena are discussed based on non-equilibrium thermodynamics and bioelectronics, in accordance with the special characteristics of the partially organized systems; at the same time this gives a good example for the exact discussion of biological phenomena.

This knowledge helps to understand physiologic and pathophysiologic excitatory processes, as weel as their relationships with informatics.

4. 2. Laboratory practices

In the majority of the practices the students carry out the experiments and the evaluation of the measured data in protocols individually. There are a few measurements where, – having only one special device (e.g. X-ray apparatus, EKG, dosimeters, . . .) –, the whole group works together led by the tutor. Some medically interesting, unique student experiments were developed by the staff on the Institute of Biophysics, e.g. the model of CT scan or the electric model of the vascular system. Only thematic groups of the practical experiments are listed below:



Medical students experimenting on the model of sensory function in the Institute of Biophysics (SOTE), Budapest

- Medical dataprocessing
- Optical methods of structure analysis
- Ionizing radiation, dosimetry
- Physical basis of the biological effect of the electric current; medical signal processing
- Biological processes, sensations

We have a textbook and a laboratory manual in three languages to give help to the students in their studies. Textbook: „An Introduction to Biophysics", edited by G. Rontó and I. Tarján (7th revised and enlarged edition, 1991) „Laboratory Manual of Biophysics" compiled by the staff of the Institute of Biophysics (director: prof. G. Rontó).

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TEACHING BIOPHYSICS IN RADNÓTI MIKLÓS KÍSÉRLETI GIMNÁZIUM (THE EXPERIMENTAL SECONDARY SCHOOL „RADNÓTI MIKLÓS") IN SZEGED

Biophysics was first taught in study circles in our grammar school in the autumn of 1981. In the first year the course was launched for third grade students. The topics were stimulus manifestations, the biophysics of perception and the biomechanics of muscles.

Taking the great interest into account, we went on teaching the group and organized another group of third year students, taught by Béla Gál, a teacher of biology and chemistry in the 1982/83 school-year. The education of the fourth year students was supported by the Department of Biochemistry of the Medical University of Szeged. At that time this group was also supported by other research institutions of the Academy and other universities too.

Later on four groups from the students, aged between 14–18, were drawn into the work. It seemed we managed to make out various biophysical topics for all four groups and the students – on the basis of their knowledge – were also to intergrate these topics into the material of biology, chemistry, physics and mathematics.

In the 1985/86 school-year an experimental special biophysics class was launched for 18 students. Teaching of this subject has been going on ever since. After taking a successful entrance exam, 10–16 students can get into this section from all over the country every year. The textbook for students was written by Béla Gál and Dr. Gábor Németh. Expert opinions on the book were given by Dr. József Tigyi, Dr. Lajos Keszthelyi, members of the Hungarian Academy of Sciences and by Dr. Attila Török assistant professor. Biofizika (Biophysics) by Szalai-Ringler is also used as supplementary material.

Béla Gál, the teacher of Radnóti Miklós Kísérleti Gimnázium, has taught biophysics since the very beginning. He did research in the subject in question with an academic scholarship. Dr. Gábor Németh, who took up the work later, had done research for about two decades in the Medical Biology Institute of the Medical University of Szeged.

In the first year mainly methodology is taught as weel as how to use biophysical equipment, such as microscopes and electronmicroscopes. Students learn about the light- and electronmicroscopic structures of the cell, isolation of the ingredients of the cell, centrifugation, gel filtration with special regard to macro-molecules.

The material in the second year contains the mechanism of respiration, the biophysical problems of heart and circulation and the biophysical interpretation of muscular functions. Students also get acquainted with the terminology of biometrics this year.

The material of the third year deals with the biophysics of senses. Starting out from the phenomena of membrane stimulus, the students learn about the biophysical aspects of eyesight, hearing, skin and chemical perception. The subject matter is brought to completion by a lot of practice. The material in the

fourth form is about the problems of energy conversion of living beings. It also deals with ATP production in general connection with the effectivness of the thermodynamic laws in living organs. The material also in volves ATP production of Halobacterium, the photosysthetic pigments and the mitocondria according to the Mitschell chemiozmic conception.

For two years the first and second year materials have been taught together in the second form. Our results have proved that on the basis of the country-wide selection and entrance exams, the most talented and diligent students could get into the special biophysics class. Three classes have taken school-leaving exams since biophysics was introduced and there were only three students who couldn't get into the university right after finishing their secondary education. But they all continued their studies at the university a year leter.

It is also worth mentioning that there are 2–3 third or fourth graders – specialized in biophysics – among the first ten of the National Biology Competition for Secondary School Students.

When introducing biophysics, our aim was to give modern, dynamic, scientific knowledge and conception to our students. It's getting more and more important to prepare our students suitable for higher education. Although it is possible to get into universities from any other secondary school, the way we prepare our students is not indifferent.

With bulding biophysics into the curriculum, we would like to give our students basic biophysical knowledge already in secondary education, so that we could make it easier for them to continue their studies in higher education. We also do our best to poularize teaching biophysics in Hungary on the basis of experiences abroad.

GÁBOR NÉMETH

TEXTBOOKS BY HUNGARIAN BIOPHYSICISTS FOR UNDERGRADUATED COURSES

The books listed below cover a wide range of topics of interest to students and research workers in biological and medical sciences studying biophysics. They provide basic concepts of mathematics and physics, current techniques and applications.

Ernst, E.:	Biophysics of the Striated Muscle Akadémiai Kiadó Budapest, 1963 (first impression in German: 1958)
Ernst, E.:	Inroduction to Biophysics Akadémiai Kiadó Budapest, 1968 (in Hungarian)
Ernst, E.:	Biophysics (second, extended edition) Akadémiai Kiadó Budapest, 1977 (in Hungarian) (first impression: 1974)
Tarján, I.:	Physics for physicians and biologists Medicina Kiadó Budapest, 1964 (in Hungarian)
Tarján, I. (editor):	Introduction to Biophysics Medicina Kiadó Budapest, 1977 (in Hungarian)

Szalay, L., Damjanovich, S. (editors): Luminescence in Biology and Medicine
Akadémiai Kiadó
Budapest, 1983
(in Hungarian)

Szalay, L., Ringler, A.: Biophysics
Tankönyvkiadó
Budapest, 1985
(in Hungarian)

Tarján, I., Rontó, G. (editors): An Introduction to Biophysics
Medicina Kiadó
Budapest, 1987
(in Hungarian)

Rontó, G., Tarján, I.: An Introduction to Biophysics with Medical Orientation
(second, revised and enlarged edition)
Akadémiai Kiadó
Budapest, 1991
(firs impression: 1987)

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