A Cardiovascular Engineering Training Program

Edwin Lowenberg & Grant Myers
Dept. of Elec. Engr.
University of Nebraska
Lincoln, Nebraska
Robert Stratbucker and
William Angle
Dept. of Internal Medicine.
University of Nebraska
Omaha, Nebraska
Reprinted by special permission of the
Symposium on Biomedical Engineering.

ABSTRACT

To meet a need for bioengineering training programs designed for
life scientists The University of Ne­
braska has initiated a Cardiovascu­
ar Engineering Training Program.

I. INTRODUCTION

Bioengineering is a multidiscipli­
nary field which is in a process of
continuing evolution. The exist­
ten of bioengineering has been de­
finitely established as evidenced by
the number of journals published,
the number of societies formed, and
the number of conferences which are
held. There seems to be agree­
ment on what bioengineering, in
general, involves even though it is
difficult to formulate a concise de­
finition of bioengineering (regard­
less of whether it is called bio-med­
ic engineering, or one of the other
names used).

A bioengineer is not identified by
his college degrees or by his pro­nessional license, but by his partici­
pation in bioengineering activities.
Medical doctors have been identified
with medical electronics and bio­
engineering since the formation of the
I R E Professional Group on
Medical Electronics.

Bioengineering Conferences were
held as early as 1960. 2, 3. One
problem which continues to receive
considerable attention is the prob­
lem of bioengineering education.
Most bioengineering curricula are
graduate level and are designed for
engineers, physicists, or people who
have considerable background in
the physical sciences. 4. The prere­
quisites are such that the equivalent
of a bachelor degree in engineering
or the physical sciences is usually
required. Those who have a degree
in the life sciences must take many
prerequisite courses in mathematics,
engineering, and the physical sci­
ces. Since these courses must be
taken in sequence, those with life
science background find that the
time required makes many of the
bioengineering training programs
prohibitive.

It is no longer necessary for re­
search groups to design and con­
struct most of their own research
equipment. Commerically manufac­
tured units are available for use in
instrumentation systems. Hence,
more bioengineering effort has shift­
ed to research on the living systems
and to education.

The need for bioengineering train­
ing for life scientists is contin­
uing to increase in many specialties
within the life sciences. Life sci­
cients have traditionally studied liv­
ing systems. System engineering
concepts and models which are so
useful to engineers are equally use­
f ul to life scientists. In particular,
cardiovascular research involves in­
creasing quantification and higher
levels of sophistication in the ap­
lication of engineering system con­
cepts.

In a recent address, Perkins 5
pointed out that the medical scien­
tist will probably take over some of
the living system engineering prob­
lems. The engineers will then move on to new problems which
include education. Engineering ed­
curators have an opportunity for
performing a service by offering
courses especially designed for life
(and medical) scientists. One of the
educational problems involves the
fact that many present-day life
scientists do not receive the back­
ground required for graduate level
engineering system courses. A one­
year, intensive training program in
engineering system concepts and
analysis for life scientists was de­
gined to meet some of the needs.
A proposal was submitted to the
Heart Institute of the National In­
stitutes of Health by the Univer­
sity of Nebraska. This program
was funded and initiated on July 5,
1965.

II. CARDIOVASCULAR
ENGINEERING
TRAINING PROGRAM

The training program was de­
signed for pre and post-doctoral
researchers on the assumption that
the trainees would have no more
background in mathematics and the
physical sciences than the average
medical student. The first consider­
ation was to provide the additional
required prerequisites in the shortest
possible time. The goal of the
training program is not to make en­
gineers of the life scientists but ra­
ther to better train the life scientists
for research. This suggests that the
emphasis should be placed on funda­
mental concepts rather than on the
manipulative skills which are re­
quired in the solution of engineer­
ing design problems.

The one-year training program
begins in July with a nine-week
summer session which includes the
following courses:

1. Mathematics: This is an in­
tensive course beginning with a
brief review of trigonometry fol­
lowed by analytical geometry, dif­
ferential calculus, and integral cal­
culum. In addition, an introduc­
tion to Laplace Transform is taught
in parallel during the last four
weeks of the summer.

2. Physical Principles: This
course begins with units and de­
finitions and proceeds through
topics covering models of the atom,
condensation phenomena, electron
emission, semi-conductors, P - N
junctions, and diodes.

3. Electrical Circuit Analysis:
This is an introductory course
which includes the major topics
from the first two regular electrical
engineering courses. Includes lab­
atory.

The summer session may appear
to be rather formidable, but con­
siderable effort is made to have the
courses complement each other. In­
structors work very closely together
so that, for example, the concepts
introduced in the mathematics
courses are applied in the engineer­
ing courses. This is one of the
significant features of the program.
The post-doctoral researcher will usually be unable to spend more than one calendar year in a training program, so the time limit and the desired levels of attainment were the major considerations in the design of the program.

The fall semester involves the following courses. The first three are undergraduate engineering level and do not count toward a graduate engineering degree.

1. Instrumentation: Electronic instrumentation systems for biological research. Includes laboratory.

2. Electronic Circuits: The emphasis is on circuit representations for electronic control devices and circuit applications such as amplifiers. Includes laboratory.

3. Electromagnetic Fields and Waves: This is an introduction to electromagnetic fields using vector representations and in introduction to traveling wave phenomena.

The following fall semester courses are the level of senior elective courses and may be applied toward a graduate degree in electrical engineering:


5. Probability and Statistics: This is an introduction to probability and statistical methods applied to engineering problems.

6. Bioengineering Seminar: This meets weekly with lectures given by outside experts, staff, and participating graduate students.

The spring semester courses are all senior level or graduate level. The course on Information and Signals does not apply toward a graduate electrical engineering degree because it is required for the B.S. degree. The spring courses are as follows:

1. Advanced Control Systems: A graduate level course covering the analysis and synthesis of control systems.

2. Information and Signals: This is a senior level course best described by listing the text: Information Transmission, Modulation, and Noise by Schwartz.

3. Analog Computer Circuits: Basic design and operation on analog computers and analog simulation. This is a senior level course carrying graduate credit.

4. Digital Computers: This is a senior level course which includes programming but the main emphasis is on numerical analysis using digital computers.

5. Communication Theory: This is a graduate level course on stochastic processes.

6. Bioengineering Seminar: Continuation of the fall seminar.

The trainees “live” in a medical college environment so that they are in contact with other researchers who share their professional interests. The courses included in the one-year training program are all given on the medical college campus in Omaha. These are special courses so that the orientation is especially for the life scientists. At the present time, there are six instructors teaching these special courses. All have had prior experience in bioengineering.

The trainees may apply for admission to the Graduate College and, if admitted, register for the courses included in the training program. Degree programs are incidental to the training program. If a trainee elects to work toward a graduate electrical engineering degree, he will need to complete the remaining degree course requirements by taking regular electrical engineering courses. The one-year training program is special for the trainees, but any additional work will be done as a regular electrical engineering graduate student meeting the same requirements.

Since the training program is supported by the Heart Institute of NIH, fellowship stipends are available only to those interested in the cardiovascular system. However, the courses are not limited to those receiving fellowship stipends. A post-doctoral trainee this year is an obstetrician and gynecologist who has completed his residency.

The performance of the trainees in the program has been most gratifying. A full evaluation of the success of the program will not be possible until the trainees have had an opportunity to apply their training to their research problems. However, the present indications are that the select group of research-oriented life scientists will benefit considerably. The trainees seem to comprehend the fundamental concepts.

III. CONCLUSIONS

There is a need for bioengineering training programs which are especially designed for the life scientists. The most challenging problem it to provide the prerequisite background in a minimum of time. Until the life scientists receive more background in mathematics and the physical sciences, special courses which emphasize the fundamental concepts are needed. A training program which is designed for a select group has been initiated at the University of Nebraska. The present indications are that it is quite successful.

IV. ACKNOWLEDGEMENT

The authors are grateful to the Heart Institute of The National Institutes of Health and The University of Nebraska for financial support of the program.

V. REFERENCES

"Reprinted by special permission of the author and the Symposium on Biomedical Engineering."


5. "The Ever Changing State of Biological Engineering" by Perkins, W. J., Special lecture given at The Sixth International Conference on Medical Electronics and Biological Engineering, August, 1965, Tokyo, Japan. Published in the Conference Digest.