

M E M O R A N D U M
December 7, 1992

TO: Faculty Senate Council

FROM: Ad hoc Senate Committee to review the proposal for a Bachelor of Science In Biomedical Engineering from the School of Engineering.
Committee members: Professor Tom Herbert, Biology
Professor James Nearing, Physics
Professor Victor Pestien,
Mathematics
Professor Robert Warren, Cell
Biology (Chair) RW

SUBJECT: Final Committee Report

The proposal in question was originally submitted to the Faculty Senate for approval in the spring semester of 1992. An ad hoc committee was appointed to conduct a review of the proposal, but it was unable to complete its work and the committee was disbanded. The present committee was charged on November 10, 1992, with completing the review.

The new Bachelor of Science degree is designed to accommodate a growing interest in Biomedical Engineering as a separate discipline within the School of Engineering. At present, undergraduates can elect Biomedical Engineering as a major, but they receive an Engineering degree. The purpose of the present proposal is to formalize an integrated curriculum, with three orientations in Electrical, Mechanical, or Pre-Med specialization, and to meet the expressed desires of students to receive a Bachelor of Science in Biomedical Engineering. Two classes of undergraduates, admitted in 1991 and 1992, are now following this curriculum in the School of Engineering with the understanding that they will receive the new degree if it is approved by the Senate.

In conducting this review, the ad hoc committee or its chair have consulted with Professor Peter Tarjan (Chair, Biomedical Engineering), Dean Becker of the Engineering School, Dean Murfin of Arts and Sciences, The Chair and Vice Chair of the Faculty Senate, and the Faculty Council of the School of Medicine. It should be noted that, while faculty of Arts and Sciences and Medicine will be involved in teaching in the program, formal approval of the program by these Schools is not required for Senate approval of the degree. Dean Murfin's office has reviewed the curriculum of the program and noted its approval of the Arts and Sciences course listings in a memo to Dean Becker, and the Medical School Council was briefed on the program at its meeting of December 2, 1992. The School of Engineering has formally approved the proposal.

The deliberations of this Committee were concluded at a meeting held on December 4 that was attended by all members and Professor Tarjan. Professor Tarjan responded to questions about the proposal that had been had been addressed to him in a memo of November 18. The questions and comments from the Committee focussed on the following points:

- 1) The ability of the relatively small number of faculty in Biomedical Engineering (BME) to supervise all the senior projects and the adequacy of the laboratory facilities.
- 2) The identification of a "home base" for students in the program and the availability of faculty and administrative staff to assist and counsel students, an issue brought into sharper focus by the departure of Professor Eckstein.
- 3) The adequacy of the mathematics components of the curriculum and some inconsistencies in the listing of pre-requisites for some courses. Professor Tarjan was asked to provide a revised and updated curriculum for each orientation.
- 4) An up-dating of the budget.
- 5) Sources of funding to upgrade library holdings deemed necessary for a high quality program.
- 6) Up-dating of the CVs in the proposal to reflect the departure of Professor Eckstein and the addition of new faculty.
- 7) A general concern regarding quality of the students in the program in light of declining enrollments in engineering in the recent past.

Professor's Tarjan's responses are contained in the Addendum to the original proposal. In his meeting with the committee, he reported that the quality of the students that had entered the Honors Program in Biomedical Engineering or who were currently enrolled as Biomedical Engineering majors was high. Two classes of about 25-30 students have elected the new curriculum and their entering qualifications (grade point averages and SAT scores) are reported to be higher than those in the other engineering disciplines. Professor Tarjan noted that the inter-disciplinary curriculum is demanding and, at 129-133 credits, requires 10% more credits than the other engineering disciplines. Both Professor Tarjan and Dean Becker have indicated that they strongly support the maintenance of excellence in this program as a leader of quality in the Engineering School.

The committee has reviewed the issues that are dealt with in Professor Tarjan's addendum, and, on the strength of the additional information and the revisions to the curriculum that he has provided, recommend to the Faculty Senate that it approve the new degree. We believe that timely approval of the program can benefit the University through attracting some additional

number of well-qualified students that might otherwise choose a different institution were we not to offer this degree option. Some of these students may also elect to attend the School of Medicine after they complete their undergraduate work.

While the committee recommends that the Senate approve the degree proposal as it stands in its amended form, we also recommend that the Senate consider ways in which some additional suggestions to strengthen the program might be implemented in the near future.

- 1) The committee seconds Professor Tarjan's request that library holdings be improved in areas relevant to the program and urges that efforts be maintained to secure funding for this.
- 2) The Committee noted that the math credits required in the proposed degree are less than those required in the comparison programs listed at other institutions in the original proposal. Professor Tarjan was aware of this, but indicated that constraints imposed by the presently required courses in the Engineering School do not allow time for any additional mathematics courses in the curriculum. We suggest that the Senate urge the School of Engineering to review the relevancy of its required engineering courses for this curriculum with the goal of bringing the math curriculum in line with the accredited programs at other quality institutions.
- 3) The committee suggests that the Senate recommend to the School of Engineering that it grant the Faculty in the Department of Biomedical Engineering the right to review all applications to Biomedical Engineering in order to assure that students admitted to the program will have the necessary qualifications to maintain high standards. A similar right is presently granted to the faculty in the Marine Sciences faculty at RSMAS.



COLLEGE OF ARTS AND SCIENCES

Office of the Dean

MEMORANDUM

December 7, 1992

TO: Martin Becker
Dean, College of Engineering

FROM: Paul H. Blaney *P.H. Blaney*
Associate Dean, College of Arts and Sciences

RE: BS BME Proposal

The Faculty Senate forwarded the BS BME proposal to this office so that we could ascertain if we had any objections or suggestions regarding it that might affect whether it should be approved. We see no basis for objecting to it; it does not duplicate our offerings, and instituting this degree should not affect our staffing patterns adversely.

Given that the BS BME track which draws most heavily upon the resources of this College is the one labeled "Premed Orientation," I asked our Premedical Advisor, Suzette Rygiel-Abella, to review that part of the Proposal. Her comments are attached. I think you will find them helpful as you fine-tune this curriculum.

Although the Premedical Advisor is part of the College of Arts and Sciences Center for Student Academic Services, she serves premedical students throughout the University. All students with premedical aspirations and their departmental advisors--including those in the College of Engineering--should be made familiar with the role of the Premedical Advisor.

cc: Dr. William J. Whelan, Faculty Senate

phb:ek\bs.bme



MEMORANDUM



Committee on Premedical Studies
College of Arts and Sciences
P.O. Box 248004
Coral Gables, Florida 33124-4622
305-284-5176

To: Paul Blaney
From: Suzette Rygiel-Abella *SA*
Re: Proposal for BS in Biomedical Engineering
Date: December 1, 1992

After reviewing the proposal, there are just a couple of points I want to bring to your attention,

1. General Biology I is listed as a second semester course during the Freshman year. Biology 111 is not currently offered during the Spring semester. Students have, in the past, taken the first two biologies out of sequence (Bil 112 in Spring, Bil 111 the following Fall), but many students are reluctant to take these courses out of sequence. Therefore, the projected curriculum would need to be changed to reflect this, or the Biology department may need to start offering Biology 111 and 112 each semester.
2. Since University Physics is now a 3 semester sequence instead of 2, additional alterations in the projected curriculum should be made to reflect this.
3. Any students applying to medical school should take the MCAT in the spring of their junior year--this gives them time to retake the test in September of their senior year if their scores are low.

Overall, it looks like a very strong program. My only concern is the timing of courses.

FAXED
3/8/93



MEMORANDUM

TO: President Edward T. Foote II

FROM: Dr. William J. Whelan *WJW/wb*
Chair, Faculty Senate

DATE: March 3, 1993

SUBJECT: Faculty Senate Legislation #92017(B) -
Establishment of the Bachelor of Science Degree
in Biomedical Engineering

The Faculty Senate, at its meeting on February 22, 1993, voted to approve Faculty Senate Legislation #92017(B) - Establishment of the Bachelor of Science Degree in Biomedical Engineering. The proposal for the program and the Senate Review Committee's report are attached.

This legislation is now forwarded to you for your action.

WJW/b


Attachments

cc: Provost Luis Glaser
Dean Martin Becker
Dr. Peter Tarjan

CAPSULE: Faculty Senate Legislation #92017(B) -
Establishment of the Bachelor of Science Degree in
Biomedical Engineering

RESPONSE BY THE PRESIDENT:

DATE: 3/5/93

APPROVED: Yes 

OFFICE OR INDIVIDUAL TO IMPLEMENT OR PUBLISH: _____

EFFECTIVE DATE OF LEGISLATION: _____

NOT APPROVED AND REFERRED TO: _____

REMARKS (IF NOT APPROVED): _____



Executive

COMMITTEE

April 20, 1993

MEETING DATE

BOARD OF TRUSTEES

<p>SUBJECT:</p> <p>Establishment of B.S. Degree in Biomedical Engineering</p>
<p>PRESENTED BY: Luis Glaser</p>
<p>BACKGROUND/CURRENT STATUS/MATTERS REQUIRING ACTION/ FINANCIAL IMPLICATIONS:</p> <p>President Foote, Provost Glaser and the Faculty Senate have approved a B.S. Degree in Biomedical Engineering. The Academic Affairs Committee, at its meeting on April 13, 1993, reviewed the program and recommends its approval to the Executive Committee.</p> <p>Information on the program is attached.</p>
<p>BOARD RESOLUTION REQUESTED:</p> <p>Approval of the B.S. Degree in Biomedical Engineering.</p>



MEMORANDUM

TO: President Edward T. Foote II

FROM: Dr. William J. Whelan *WJW/b*
Chair, Faculty Senate

DATE: March 3, 1993

SUBJECT: Faculty Senate Legislation #92017(B) -
Establishment of the Bachelor of Science Degree
in Biomedical Engineering

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This legislation is now forwarded to you for your action.

WJW/b

Attachments

cc: Provost Luis Glaser
Dean Martin Becker
Dr. Peter Tarjan

Approval of Minutes

The minutes of January 25 were approved as submitted.

Matters Arising from the Minutes

Professor Green asked about discussions of the possibility of a merger of the Osteopathic School with the School of Medicine. The Provost responded that the University has postponed any further discussions until the fiscal problems at the Medical School can be resolved.

Recognition of Professor Clifford C. Alloway

Professor Eugene Clasby, former Senate Chair, spoke of Professor Alloway's many services to the Senate, including his great help to Professor Clasby as a new Senate Chairman and the numerous reasons why the Senate had decided to accord recognition to their colleague. Professor Alloway thanked the Senate and accepted a plaque commemorating the ceremony.

Membership of the Advisory Council

The Chair requested approval of the Advisory Council, comprised of Professors Awad, Green, Harrison and Knoblock, along with Vice Chairs Johnson and Yacoub. It was *moved* and seconded to approve the Council for the remainder of Professor Whelan's term of office. The *motion carried unanimously*.

B.S. in Biomedical Engineering (Second Reading)

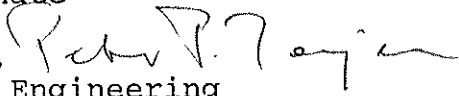
Professor Johnson introduced the proposal for discussion. Professor Tarjan addressed two issues raised at the first reading. The first was the establishment of a regional biomedical library funded by external funds. This venture has not yet been successful. The second issue, establishment of an adequate supply of books for the undergraduate program, has been resolved following a meeting with Mr. Rodgers and Mr. Mundy. They assured Professor Tarjan that \$10,000 would be set aside for the purchase of books. The required letter of financial support for the program from the Provost had been received by the Chair. It was *moved* and second to approve the proposal. The *motion carried unanimously*.



MEMORANDUM

DATE: February 20, 1993

TO: William Whelan, PhD
Chair, Faculty Senate

FROM: Peter Tarjan, PhD, 
Chair, Biomedical Engineering

SUBJECT: Library enhancement

Following discussions on February 15, 1993, with Frank Rodgers, Director, and Angus Mundy, Asst. Dir. Library Collections, of the Richter Library, we were requested to supply a list of books which would enhance the collection from the viewpoint of our undergraduate program. Such a list was delivered by me to Thomas Rogero of the Library's staff on Friday, February 19, 1993. The books were listed according their priority for inclusion in a BME collection with many volumes serving the interests of several disciplines. This is a natural phenomenon for a multidisciplinary field. A copy of the list is enclosed.

We were given verbal assurances by Mr. Mundy that funds would be allocated to purchase books for approximately \$10,000 during the current academic year.

Art Wasserman, Sr. Director for Corporate and Alumni Relations in the Development Office has been working with the College of Engineering on various development projects. Together we developed a proposal to Baxter International that included funds for a biomedical engineering collection to be housed at the Richter Library. Baxter turned us down but we intend to continue our work to establish a regional resource for the biomedical engineering field in South Florida. Art and I discussed the plans with Frank Rodgers who seemed to be in favor. We should have involved the staff of the library from the beginning, their involvement will be requested for future efforts.

I hope that these developments would settle the issue of the library's biomedical engineering holdings regarding the BS Biomedical Engineering program.

Thank you for your support!

enc.

cc. Messrs. Rodgers, Mundy, Rogero, Wasserman, Dean Becker

Dept. of Biomedical Engineering
College of Engineering
P.O. Box 248294
Coral Gables, Florida 33124-0621
(305) 284-2442

Recommendations to the Richter Library for books to be purchased
for the Biomedical Engineering undergraduate program
February 19, 1993¹

There are brochures and advertisements enclosed on on the majority
of the books except for those which are listed on a hand written
sheet in red ink by Dr. Ned Hwang. The prices were not available
for those. These were marked by "H" at the left margin.

* General interest to engineering students

Author	Title...	Subject	Publisher	Year	Cost
Category A+ Books of primary need for BME undergraduates for course work					
H	Caro	The Mech of Cihemodynam	Oxford		
H	Chandran	Cardiovasc	physiol	NYU Press	'92
H	Cobbold	Transducers	ininstrum	Wiley	
	Cohen	Biomedical I	sig proc	CRC	'86 150
	Cohen	Biomedical II	sig proc	CRC	'86 150
H*	Fung	Biodynamics C	physiol	Springer	'84
H	Fung	Biomechanics	biomechan	Springer	'81
H*	Gross	The rheology	appl biol	Sijthoff	'81
H*	Guyton	Human Physiol	physiol	Saunders	'87
H	Hwang	Forntiers in	rheology	Plenum	'93
	Kralj	Functional	rehabil	CRC	'89 98
H	Lih	Transport Phenmodels		Wiley	'75
H	Nichols	McDonald's (3)	rheology	Lea&Febiger	'90
H	Parmley	Heart as a pu	'physiol	AmPhysiolS	'81
H	Pedley	Fluid Mech	rheology	Cambridge	'80
H	Schimd-Sch'	Frontiers Biomechanics		Springer	'86
	Smith	Rehab...	rehab	CRC	'90 195
H	Vroman	The Behavior	appl biol	NYAC	'77
	Webb	The Physics	imaging	AmInstPhy	'88 154
	Webster	Medical	instr.	Houghton	'92 ?
H	Westerhof	Vasc Dynamics	appl biol	Plenum	'88
	Winter	Biomechanics	biomechan	Wiley	'90 ?
	Wise	Bioinstr	instrum	Butterwrh	'89 150
H	? Guidelines for	Blood-Material		NIH	'85

Category A Books of primary need for BME undergraduates for course work and books with general BME interest for senior projects

	Black	Biol Perform	materials	M Dekker	'92 100
*	Borgens	Electric fie	instrum	Liss	'89 70
	Cherny	Contempor	biomech	CRC	'90 70

¹ Compiled from the advertisements collected by O Ozdamar and P Tarjan over the past 2-3 years and from a list supplied by N Hwang, all faculty members in the Dept. of Biomedical Engineering.

*	Diderich	Artificial	neural nets	IEEE	'90	30	
H*	Gross	Animal models	physiol	Martin'-Nij	'85		
	Guha	Bioengin...	reprod	CRC	'90	170	
*	Hecht	Understand	lasers	IEEE	'92	25	
	Johnson	Biomechanics	biomechan	Wiley	'91	85	
*	Kamm	Real World	design	IEEE	'91	20	
*	Körner	Fourier Anal	mathematics	Cambridge	'88	38	
	Kuni	Intro Comp	imaging	CRC	'87	39	
H	Middleman	Transport Ph	model	Wiley			
H	Mirsky	Caridac Mech	physiol	Wiley			
*	Podbielska	Holography	imaging	SPIE	'91	60	
	Reilly	Elec Stim	instrum	Cambridge	'92	55	
H*	Rosen	Dynamic Sys	models	Wiley	'74		
	Rubin	The Prin of	instrument	CRC	'87	33	
	Sideman	Imaging, Meas	imag/model	Taylor&Fr	'91	95	
*	Stephenson	Advance Math	mathematics	Cambridge	'90	50	
	Udupa	3-D imaging	imaging	CRC	'89?	110	
*	Vemuri	Artif Neural	neural nets	IEEE	'88	20	
	Webster	Electrical	reference	Wiley	'90	70	
	Webster	ElecImpPleth	instrument	AmInstPhy	'90	70	
	Webster	Encyclopedia	reference	Wiley	'88	425	R?
	Wise	Appl Biosens	instrum	Butterwrh	'89	65	
	Wolfbeis	Chemical and	instrum	SPIE	'91	66	
*	Yeagers	Basic Biophy	biology	CRC	'92	40	
	? Biosensors, Theory		devices	Technomic	'92	85	
	? Blood Compatible Mat		materials	Technomic	'92	85	
	? Controlled release		devc/mat	Technomic	'92	150	
	? High Performance Bio		materials	Technomic	'92	165	

Category A- Books for undergraduates in less active areas of research and somewhat peripheral to main areas

	Berliss	Trace Source	rehab	TRACE	'91	50	
	Boggan	Three-Dimen	lasers	SPIE	'91	48	
*	Goldberg	Genetic Alg	biology	Addison		42	
*	Gomer	Future Dir	lasers	SPIE	'90	89	
	Hawkins	Auditory C	computing	Springer	'93?	?	
	Iyengar	Structuring	models	CRC	'92	70	
*	Jacques	Laser-Tissue	lasers	SPIE	'90	70	
	Kappenber'	Practical..	defib/devi	Futura	'92	35	
*	Kosko	Neural	neural nets	Prentice	'92	?	
	MacGregor	Neural and	models	Academic	'87	89	
	Miller	Cochlear	devices	Springer	'90	98	
	Muller	Microsensors	instrumen	IEEE	'91	60	
*	Muncheryan	Lasers & Opt	optics	Taylor&Fr	'91	110	
	Nabet	Sensory neur	models	IEEE/CRC	'91	70	
*	Parker	Image recon	imaging	CRC	'89	120	
	Polk	Biological	EM effects	CRC	'89	269	
*	Russ	The Image Pr	handbook	CRC	'92	90	
*	Sanchez-S'	Artificial	neural nets	IEEE	'92	32	
*	Schackelf'	The CRC Mat.	handbook	CRC	'92	108	

	Seireg	Biomechanica	models	Taylor&Fr	'89	100
	Sutton	The Found Pac	devices	Futura	'91	110
	Szycher	Szycher's Dic	materials	Technomic	'92	85
*	Wechsler	Computat	vision/comp	Academic	'90	65
*	Wiedersich	Sci of Adv	materials	ASM	'90	120
	? Adv in Biomaterials		materials	Technomic	'92	29
	? Biocompatible Polyur		materials	Technomic	'92	75
	? Biocompatible Surfac		materials	Technomic	'92	125
	? Biomaterials for '90s		materials	Technomic	'92	65
	? Computers in Cardiol		proceedings	IEEE	'91	100

Category B+ Books of general engineering for undergraduate program

	Agnew	Neural Pr	devices	Prentice	'89	55
	Carruth	Medical Laser	instrument	AmInstPhy	'86	60
*	Chelappa	Digital Image	imaging	IEEE	'91	75
	Shung	Ultrasonic	biology	CRC	'92	170

Category B Books of special research interest

	Barold	New Pers 1&2	instrum	Futura	'88	125
*	Bruce	Microcomput	mathematics	Cambridge	'90	90
	Chen	Biomed Mag	instrument	AmInstPhy	'89	90
*	Cracknell	Intro to rem	ergonomics	Taylor&Fr	'91	86
	Goldfinch	Radiation	industry	AmInstPhy	'89	121
*	Gupta	Validating	computers	IEEE	'91	80
*	Pheasant	Bodyspace	ergonomics	Taylor&Fr	'92	79
	Fahy	Sound Int	auditory	Elsevier	'89	102
*	French	Invention and	engineering	Cambridge	'87	70
*	Fukunaga	Introduction	pattern	Academic	'90	65
*	Ghosh Roy	Meth of Inve	physics	CRC	'91	180
*	Jones	Mechanics of	materials	Taylor&Fr	'75	60
*	Joy	Computer Gra	computers	IEEE	'88	60
*	Katzir	Optical Fibe	lasers	SPIE	'90	123
	Lau	Rate Adapti	devices	Futura	'92	80
	Matsuda	Cancer Res	therapy			
	Morgan	Neural Nets	neur/speech	Kluwer-A.	'91	70
*	Papalambros	Prin of Opti	design	Cambridge	'88	33
	Puliafito	Ophthalmic	instrum	SPIE	'91	60
*	Reghbati	Comp Graphics	computing	IEEE	'88	50
*	Rohatgi	Tribology	materials	ASM	'90	86
*	El Sherif	High-Res ECG	instrum	Futura	'92	98
*	Setian	Engineering	physics	Cambridge	'91	60
*	Vinogradov	Introduction	reliability	Taylor&Fr	'91	55
*	Weeton	Eng's Guide	materials	ASM	'85	63
*	Young	Roark's Form	design	ASM	'89	75
*	Yu	Principles	optics	WILEY	'90	
*	? Hydrogels: Specialty		materials	Technomic	'92	225
*	? Sterilization Methods		industry	Technomic	'92	45

	? Synthetic Biomedical	materials	Technomic	'92	NC#
	? Acoustical Imaging	acoustics	Plenum	'92	?
*	? Nonlinear Optics	instrum	SPIE	'91	?
*	Adv Composite Materials	proceed'ng	ASM	'91	97
	Critical Reviews of BME	13 back issues	CRC	'89+	520

Category B-

*	Saleh	Funda Photon	optics	Wiley	'91	
*	Close	Modeling	models	Houghton	'93	?
*	Fraser	Fitness for	ergonomics	Taylor&Fr	'92	72
*	Noro	PARTICIPATOR	ergonomics	Taylor&Fr	'91	85
*	Sienicki	Molecular	electronics	CRC	'92	80
	Wyndham	An Electroph	medicine	Futura	'91	15
	? Packaging of Hea	I&II	industry	Technomic	'92	195
	? Polymers in Medicine	materials	Technomic	'92	68	

Category C General engineering books of importance to BME undergraduates and books on medical specialties with significant engineering content

	Bayés de L	Clinical Ele	medicine	Futura	'92	80?
*	Becker	Dynamical Sy	computer	Cambridge	'89	655
	Birkui	Noninvasive	medicine	Futura	'92	48
*	Brogan	Visual Searc	devices	Taylor&Fr	'92	99
*	Brogan	Visual Searc	devices	Taylor&Fr	'90	110
*	Brundle	Encyclopedia	material	Butterwor	'92	95
*	Chung	Finite Eleme	fluids	Taylor&Fr	'92	200
*	Dasarathy	Nearest Neig	computers	IEEE	'91	62
*	France	The Living C	biology	AmInstPhy	'91	146
*	Kasturi	Comp Vision	computers	IEEE	'91	85
*	Konov	First Inter	lasers	SPIE	'90	70
*	Life	Simulation	computers	Taylor&Fr	'90	79
*	Mitchell	Electrochem	environm	Taylor&Fr	'92	79
*	Miszalok	MED TECH '89	imaging	SPIE	'90	70
*	Mothersill	New Development	medicine	Taylor&Fr	'91	99
*	Morgan	Artif Neural	neural nets	IEEE	'90	32
*	Müller	Second Germ	lasers	SPIE	'90	70
*	Poon	Prin	optics	Aksen	'91	58
*	Porter	Integral Equ	mathematics	Cambridge	'91	70
*	Rahimi	Human-Robot	ergonomics	Taylor&Fr	'92	88
*	Schwartzl'	Comp Arith I	algorithms	IEEE	'90	65
*	Schwartzl'	Comp Arith II	algorithms	IEEE	'90	70
*	Shriver	Artif Neural	video	IEEE	'88	129
*	Silvester	Finite Elem	computing	Cambridge	'90	48
	Van Bommel'	Quantitative	medicine	CRC	'92	89
*	Williams	Computers, W	ergonomics	Taylor&Fr	'89	79
*	Yang	Handbook of	flow	Taylor&Fr	'89	375
*	? Ion beam modification	materials	Technomic	'92	125	
*	? 1st Int Symp on Uncertain'	proc'	IEEE	'90	120	

Category C-

? Mould's Medical Anec	humor	AmInstPhys '84	25
? More of Molds's Medi'	humor	AmInstPhys '84	30

JOURNALS

Category A

Computerized Medical Imaging and Graphics	Pergamon	650/yr
Computers in Biology and Medicine	Pergamon	585/yr
Journal of Biomaterials Applications	Technomic	260/yr
Critical Rev of Biomedical Engineering	CRC	?

Category B

Pattern Recognition	Pergamon	1060/y
Chaos, solitons and fractals	Pergamon	445/yr



February 3, 1993

Professor Peter Tarjan
Department of Biomedical Engineering
219 B McArthur, 0621

Dear Peter:

B. S. in Biomedical Engineering

At the Faculty Senate meeting on January 25, the Senate approved the first reading of the proposed program in Biomedical Engineering. We were, however, disappointed that neither you nor Bob Warren was present. Evidently there was a miscommunication, but it is important for the second reading of the proposal on February 22 that everyone involved be represented. Bob Warren has already called to indicate that he will be there.

At the meeting, Professor Gowing spoke to the question of library resources in terms that indicated that she did not find the proposal satisfactory.

It is important, if your program is to be approved at the second reading, that you and Professor Gowing and other interested parties should meet to discuss and try to resolve the concerns. It is not practical to try to do this on the floor of the Senate.

I urge you to take action in this respect and let me know ahead of the Senate meeting whether or not there remain any problems.

Thank you.

Yours sincerely,

A handwritten signature in cursive script that reads "W. J. Whelan".

William J. Whelan
Chair, Faculty Senate

cc: Professor Cheryl Gowing
Professor Robert Warren

Federal Law. The Senate authorized the Senate Chair to make appropriate changes in the *Faculty Manual* to make policies consistent with this general policy. It was *moved* and seconded to approve the proposed changes for recommendation to the President and Trustees. The *motion carried unanimously*.

Definition of Academic Counsel

It was *moved* and seconded to affirm that the meaning of 'academic counsel' in the *Faculty Manual* is that of full-time members of the University Faculty. The *motion carried* with 19 votes in favor, 3 against, and 1 abstention. Professor Bernard Oxman stated that, as a matter of record, in his opinion the resolution adopted exceeds the powers of the Senate and is not an interpretation but the adoption of an additional policy.

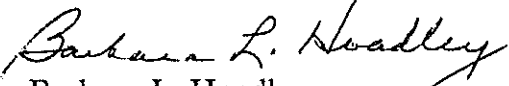
B.S. in Biomedical Engineering

Professor Whelan informed the Senate that the required letter of support for the proposed program from the Provost had been provided. Professor Gowing reiterated the Library's concern for the inadequate resources for the proposed program. She also expressed concern at the suggestion in the proposal to establish a regional library with the biomedical industry, funded by the latter, and serviced by the Richter Library that would entail hiring additional staff. It was *moved* and seconded to consider the proposal as a first reading, in the absence of the sponsors. The second reading would take place at the February Senate meeting. The *motion carried*.

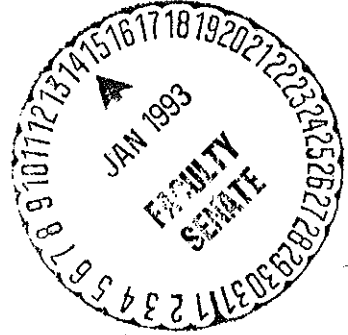
Future of the Graduate School

Professor Donald Olson, representing the members of the Graduate Council and Senate who were studying the future of the Graduate School, distributed and reviewed a combined information report. It was intended that the formal first reading of the legislation will take place at the February 22 Senate meeting. The issue of the relationship between the Graduate Dean, the Graduate Council and the Research Office of the University is being discussed with the administration. The definition of "graduate faculty" will be that the faculty member must come from a unit involved in graduate education, and must meet the Graduate School qualifications.

The meeting adjourned at 5:40 p.m.


Barbara L. Hoadley
Secretary to the Faculty Senate

FAXED
1-15-93



Executive Vice President and Provost

January 14, 1993

Dr. William Whelan
Chairman, Faculty Senate
325 Ashe

Dear Bill:

This letter is to indicate that the budget as listed on Page 28 of the proposal for Bachelor of Science in Biomedical Engineering dated February 27, 1992 has my approval.

I hope this program can be approved since it is one of the very exciting things at the University.

Sincerely yours,

A handwritten signature in cursive script that reads "Luis Glaser".

Luis Glaser
Executive Vice President
and Provost

LG:tmp



January 13, 1993

Provost Luis Glaser
Office of the Provost
240 Ashe, 4628

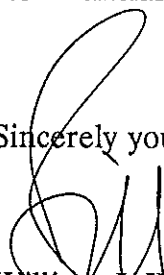
Dear Luis:

B. S. in Biomedical Engineering

Here is the proposal for the B. S. in Biomedical Engineering that will come before the Senate on January 25 where your letter of commitment to financial support is needed.

Thank you.

Sincerely yours,



William J. Whelan
Chair, Faculty Senate

WJW/ca

Enclosure

meeting. A nominating committee was appointed consisting of Professor Olson as chair, and Professors Alexandrakis, Awad, and Boardman. Professor Alexandrakis expressed his concern about the lack of text being attached to the legislation presented to the faculty. The Chair reminded him that a hard copy of the text was available from the Senate Office for anyone desiring to have a copy. He mentioned that the electronic bulletin board, intended to be used for viewing the text, had presented severe problems in loading the information to the computer system.

Surprise Visit

Professor Thomas Steinfatt, representative from the School of Communication, joined the Senate meeting for the first time since his accident, following Hurricane Andrew. He thanked the Senate for all the concern shown to him and his family.

Bachelor of Science Degree in Biomedical Engineering

Professor Robert Warren, Chair of the ad hoc committee to review the proposal for a Bachelor of Science degree in Biomedical Engineering, presented the committee's report and recommendations. The Provost assured the Senate of the administration's commitment to the proposed program and would communicate that information to the Senate Chair. Professor Peter Tarjan, Chair of the Department of Biomedical Engineering, addressed a query about the library resources for the program. The first reading of the proposed BS degree will take place at the January Faculty Senate meeting. The committee was thanked for its speedy deliberations and it was suggested that future program reviews should be modeled after this effort.

Future of the Graduate School

Professor Olson, representing the Graduate School in discussions regarding its future, explained the draft legislation prepared by an ad hoc committee of the Graduate Council and Senate representatives. The document will be presented for a formal vote at the January Graduate Council meeting and will be brought to the Senate on January 25.

Report of the Senate Budget Committee

Professor Green, Co-chair of the Senate Budget Review and Finance Committee, presented an interim report on the improvement in undergraduate student quality and the associated budget implications. He reported that the Provost will instruct the Enrollment Office to monitor the F6 students, and their acceptances. The number enrolled will be expected to

seconded that the amended paragraph, and the waiver paragraph, become a Council recommendation to the Senate for adoption. The *motion carried*.

Distinguished and University Professors and Fellows

The first issue to be decided was whether or not the schools should vote on whether to grant the appellation of Distinguished Professor in that school. It was *moved* that the Senate Council recommends against schools opting to grant the appellation. The *motion carried unanimously*.

The amount of the stipend will not be stated as part of the published description in the *Faculty Manual*. The second paragraph, second sentence will be changed to read: "Individuals holding ..., in addition to salary, a stipend to support professional activities." The amount of the stipend represents 10% of the average University's full professor's salary. There were some editorial changes made in the transmission of material through the Provost to the President. Paragraph 3, the second sentence, was amended to read: "...scholarly, or creative and artistic achievements...". Discussion took place on the issue of removing "superior teaching skills" as a criterion for the Distinguished Professor award in order to give it independent status elsewhere. The modified legislation is to be brought to the Senate following discussion with the administration.

B.S. in Biomedical Engineering

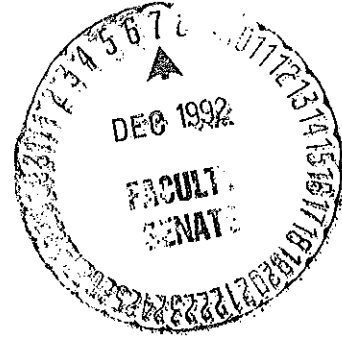
Dr. Robert Warren, Chair of the ad hoc Review Committee to review the proposal for a B. S. in Biomedical Engineering, presented the Committee's final report and Dr. Tarjan's responses to questions raised during the review. The Committee recommended approval of the program but did request additional funding for library resources. Consultation had taken place with the College of Arts and Sciences and the School of Medicine. The proposal had been approved by the College of Engineering. It was *moved* and seconded to approve the recommendation of the Committee and recommend the proposal to the Senate at the January meeting. The *motion carried*. A letter of financial support for the program will need to be secured from the Provost before consideration by the Senate. Dr. Warren, and his committee, were congratulated on the speedy review of the proposal and it was suggested that their activities be used as a model for future review committees.

Dr. Whelan asked about the status of the proposed Ph.D. in Physical Therapy. Dr. Gesse, a member of the review committee, said that the proposal had been sent back to the school for revision.

CDFHI



COLLEGE OF ARTS AND SCIENCES



Office of the Dean

MEMORANDUM

December 7, 1992

TO: Martin Becker
Dean, College of Engineering

FROM: Paul H. Blaney *PH Blaney*
Associate Dean, College of Arts and Sciences

RE: BS BME Proposal

The Faculty Senate forwarded the BS BME proposal to this office so that we could ascertain if we had any objections or suggestions regarding it that might affect whether it should be approved. We see no basis for objecting to it; it does not duplicate our offerings, and instituting this degree should not affect our staffing patterns adversely.

Given that the BS BME track which draws most heavily upon the resources of this College is the one labeled "Premed Orientation," I asked our Premedical Advisor, Suzette Rygiel-Abella, to review that part of the Proposal. Her comments are attached. I think you will find them helpful as you fine-tune this curriculum.

Although the Premedical Advisor is part of the College of Arts and Sciences Center for Student Academic Services, she serves premedical students throughout the University. All students with premedical aspirations and their departmental advisors--including those in the College of Engineering--should be made familiar with the role of the Premedical Advisor.

cc: Dr. William J. Whelan, Faculty Senate ✓

phb:ek\bs.bme



Committee on Premedical Studies
College of Arts and Sciences
P.O. Box 248004
Coral Gables, Florida 33124-4622
305-284-5176

MEMORANDUM



To: Paul Blaney
From: Suzette Rygiel-Abella *SLA*
Re: Proposal for BS in Biomedical Engineering
Date: December 1, 1992

After reviewing the proposal, there are just a couple of points I want to bring to your attention.

1. General Biology I is listed as a second semester course during the Freshman year. Biology 111 is not currently offered during the Spring semester. Students have, in the past, taken the first two biologies out of sequence (Bil 112 in Spring, Bil 111 the following Fall), but many students are reluctant to take these courses out of sequence. Therefore, the projected curriculum would need to be changed to reflect this, or the Biology department may need to start offering Biology 111 and 112 each semester.
2. Since University Physics is now a 3 semester sequence instead of 2, additional alterations in the projected curriculum should be made to reflect this.
3. Any students applying to medical school should take the MCAT in the spring of their junior year--this gives them time to retake the test in September of their senior year if their scores are low.

Overall, it looks like a very strong program. My only concern is the timing of courses.



MEMORANDUM

Committee on Premedical Studies
College of Arts and Sciences
P.O. Box 248004
Coral Gables, Florida 33124-4622
305-284-5176

To: Paul Blaney
From: Suzette Rygiel-Abella *SR*
Re: Proposal for BS in Biomedical Engineering
Date: December 1, 1992

After reviewing the proposal, there are just a couple of points I want to bring to your attention.

1. General Biology I is listed as a second semester course during the Freshman year. Biology 111 is not currently offered during the Spring semester. Students have, in the past, taken the first two biologies out of sequence (Bil 112 in Spring, Bil 111 the following Fall), but many students are reluctant to take these courses out of sequence. Therefore, the projected curriculum would need to be changed to reflect this, or the Biology department may need to start offering Biology 111 and 112 each semester.
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Overall, it looks like a very strong program. My only concern is the timing of courses.



MEMORANDUM

DATE: November 30, 1992

TO: Robert H. Warren, Ph.D.
Chair, Ad Hoc Faculty Senate Review Committee

FROM: Peter P. Tarjan, Ph.D. *Peter P. Tarjan*
Professor and Chair

SUBJECT: Addenda to "PROPOSAL FOR A BACHELOR OF SCIENCE IN BIOMEDICAL ENGINEERING...."

Our "Proposal for a Bachelor of Science in Biomedical Engineering Program in the College of Engineering of the University of Miami" was submitted to the Faculty Senate on February 27, 1992. Chaired by you, the second Ad Hoc Faculty Senate Committee requested certain clarifications and updates in your memo dated 11.18.92.

1. **Senior Projects:** There was some concern expressed about the faculty effort necessary for supervising 25-35 students. Indeed, the supervision of that many individual projects would be very great. However, the students in the College of Engineering (CoE) usually work in small groups. In our contemporary environment, engineering design is a team effort. Hence it is deemed appropriate to encourage the seniors to work in teams. In the traditionally accredited departments, such as Electrical and Mechanical Engineering, the students typically work in groups as large as 5 members, dividing the project into tasks, organizing themselves into a team, and periodically consulting with one or more faculty advisors. I have served as advisor to several Senior Project teams in both of those departments and found the experience interesting, rewarding and only a modest burden in time. The most time consuming part was the final review of the written report.

Dept. of Biomedical Engineering
College of Engineering
P.O. Box 248294
Coral Gables, Florida 33124-0621
(305) 284-2442

We proposed that our students begin their Senior Project during their first semester as seniors and use this time to find a problem, define it, review the literature and plan the work. During their final term, the work is expected to be completed and a report written. This should preempt the usual rush to complete the project when so many other things are happening in the lives of the seniors.

It has been recognized by the other departments in the CoE that supervision of the Senior Project requires serious faculty effort. Depending on the size of the senior class, usually one or two faculty members are assigned to deal with all the groups in an administrative way. Others serve as technical advisors. The teaching load of our faculty must and will reflect the task of supervising senior projects.

As far as the number of students in Senior Projects: presently we have four seniors HPEM students, working on the planning phase of their projects, all at Larkin Hospital. As their work contributes directly to the research interests of Dr. Adam Landsman, a resident in podiatric surgery who holds a Ph.D. in Biomedical Engineering, the collaboration is mutually beneficial to the students and the supervisor. -- The starting group of freshmen in 1991 has somewhat spread out in terms of progress. With transfer students and others moving faster than the model curriculum, the number of seniors in 1993-94 is expected to be about 5, in 1994-95 this should rise to 15-20 and then level off around 25-30. With the current trend in enrollment, our projected faculty should be able to carry out this as well as all the other tasks associated with an undergraduate program of 100 to 150 students.

In summary: proper supervision of the students involved in Senior Projects does not seem to pose a particularly difficult problem.

2. Specific information about the **laboratory equipment** purchased from the \$100,000 start-up fund was requested.

The original proposal stated: "There is a special fund of \$100,000 available for supplies and equipment. This is being carefully spent and the hardware is being evaluated on single instruments purchased for this task. We expect to duplicate the equipment to provide for at least 6 stations."

Using half-time Teaching Assistants, we have been developing multi-purpose work stations for our undergraduate laboratories. As single function electronic instruments (oscilloscopes, signal generators, spectrum analyzers) commonly used in biomedical engineering design, are expensive and present many problems in management and maintenance, we chose an emerging approach to instrumentation: a personal computer can be configured with commercially available hardware and software for the above tasks and for data logging, signal processing, report writing, etc. The first system was configured with a Gateway 486 personal computer, a special plug-in card for interfacing it with a variety of experimental set-ups, and with a software package purchased from Hyperception, Inc., Dallas, TX. Hyperception offers a variety of "bundled" functions and an academic discount. The software is suitable for block diagram generation to simulate analog and digital systems, it also serves as a two-channel oscilloscope, a spectrum analyzer and image processor. It also offers computer aided design for filters and, naturally, it serves as a data logger and recorder as well. The prototype functioned satisfactorily and five more computers and plug-in boards have been received, awaiting their installation over the break between semesters.

In addition, sensors and transducers are being purchased for the first of our laboratory courses to be offered during the

Spring '93 semester. An optical bench was also developed by Dr. Qiushi Ren for student experiments, with a variety of interchangeable items.

Experiments in biological fluid dynamics are under development. Various generic subsystems, such as a model pump, hydraulic models of portions of the vasculature are designed and constructed by a graduate student.

In groups of 3, with six stations, up to 18 students per laboratory session may be accommodated. With growth in enrollment, at the most, two sessions per week per laboratory course would be necessary to accommodate the students. This would still leave ample time for seniors to use the work stations for their Senior Projects. Naturally, this approach makes it impossible to use dedicated instruments for each senior project but it enables the program to teach laboratory skills affordably.

Finally, while the cost of dedicated instrumentation appears to be rising faster than inflation, due to more and more features being built into the instruments offered, the cost of personal computers has dropped significantly. We deliberately chose the most up-to-date PCs with many extra features for this laboratory to assure the longest possible delay in the equipment becoming obsolete.

3. Regarding **"Linkages:"** As stated on p. 16 of the proposal: "The graduate program in BME has enjoyed close research collaboration with many of the departments in the School of Medicine.... Involvement of the undergraduates in summer research projects is realistic and may be expanded to the academic year." Since our proposal was written, collaboration with two particular groups in the School of Medicine has flourished: i. Collaboration between the McKnight Vision

Research Center of the Bascom Palmer Eye Institute and the Dept. of BME has increased. Drs. R. Knighton, Q. Ren and J-M Parel are members of the McKnight Vision Center and hold primary or secondary appointments in the Dept. of BME. It is expected that Asst. Res. Prof. Gabriel Simon, M.D., Ph.D., a prolific innovator, will join this group of three and also be involved in our undergraduate activities. Dr. Ren and Mr. Parel have taught 500 level courses in optics and lasers in our program for the past year and a half. As a result of this effort, the interest among our students has increased greatly in this specialty and several BME graduate students are doing research in this area.¹ ii. Several BME graduate students have become involved in Dr. Dejan Popovic's rehabilitation engineering research in the Miami Project,² partially as a result of his seminars and a 500 level course taught by him.

Additional linkages with great potential began to evolve with the Sports Medicine group at Doctors' Hospital and with two physicians, who also hold advanced degrees in BME, at Larkin Hospital.³

Finally, Dr. Jay Yourist, Director of Vocational Rehabilitation (VR) for Florida, formed an advisory council and invited me to become a member. Under a federally funded program, VR is to develop the necessary infrastructure for the needs of the State of Florida, including post-secondary education of specialists in the field. Biomedical Engineering is one of the specialties. Our program has the potential for providing that function. Collaboration with the State in VR would be an attractive possibility for expanding the faculty

¹ Manns, Melgar, Ren and Wu.

² Nicolich, Reisbeck, Saksena and Wong.

³ Drs. Landsman and Lavernia.

and the physical resources of our program.

4. A question arose regarding the location or "home" for the program. The office of Dept. of BME is located in Room 219 in the MacArthur Engineering Annex with two staff members and a work-study. It has handled the registration of the Biomedical and Premed Option students in the BS ES program for the past two years. The offices of the faculty are on the same floor. The 73 undergraduate students and the 50 graduate students have been "homing in" on this location. Until August, 1992, Dr. Eugene Eckstein served as their primary advisor. Since his abrupt departure, I have acted in this role and continue to serve until our faculty expands and someone else can take on this task.

We now have two full-time staff employees,⁴ both are involved with registration and finding solutions to the problems of the students. One has the responsibility for dealing with applicants. Our work-study also assists in the correspondence with prospective students.

5. Curricular Changes:

- 5.1. The physics curriculum was revamped for 1992-93. The two semester University Physics, PHY 211, 231, 212 and 232 series, for 10 credits, was replaced by a three semester sequence of 11 credits: PHY 205 (3 cr.) PHY 206 and 208 (4 cr.) and PHY 207 and 209 (4 cr.) PHY 205 requires MTH 111 (or 131), Calculus I, as a prerequisite and MTH 112 (or 132), Calculus II, as a co-requisite. The students have been encouraged to start this sequence as early as possible, preferably during the second semester of the Freshman year. This is possible if either BIL 112 or the Soc. Sci./Humanities course is delayed.

⁴ Ms. N. Tangredi and P. Taylor.

- 5.2. BIL 112, General Biology II, is only offered in the Spring, hence, the original curriculum could not be implemented as stated. However, General Biology I and II, BIL 111 and 112, are considered sufficiently independent of each other that a number of students had started with BIL 112, followed by BIL 111. The interchange of these courses was permitted by the Biology Department. Several students reported that they experienced no problems with the reversed sequence.
- 5.3. BME 580, Biomedical Instrumentation, was taught with the participation of five undergraduate HPEM students, with Junior standing. It appears that this course may be more appropriate, as planned, for the senior year.
- 5.4. BME 624, Biomaterials, was taught during 1991-92 with the participation of four HPEM students registered for BME 524. Although the students had not yet taken MEN 301, Engineering Material Science, the review of basic concepts for the graduate students in the course was sufficient for the undergraduates to function well in the course. BME 624, Biomaterials, as taught in the past, required the graduate students to prepare three research papers based on current literature. Biomaterials, BME 524 may be taught with the same source material but with only one or two papers as well as a written examination that has not been a part of BME 624.
- 5.5. During the current semester, an experimental course, Transport Phenomena, BME 521, is offered as an elective. The material includes a number of important topics in biomedical engineering and may become a required course in the future.
- 5.6. Some apparent contradictions were found regarding the prerequisites for some advanced courses in engineering:
- a. MTH 211, Calculus III, was a prerequisite for CEN 210. As engineering students outside of Civil and

Architectural Engineering take a different mathematics sequence, Calculus III has been eliminated as a prerequisite.⁵

- b. MTH 210 Vectors and Matrices is listed as a prerequisite for EEN 308, a course scheduled only for the students in the Electrical Track. Based on conversations with members of the EEN faculty, MTH 210 is desirable but not essential for EEN 308. The instructor generally reviews the relevant aspects of matrix theory when the subject is needed. Another prerequisite, MTH 312, Vector Analysis, is essential and covers the skill required for dealing with vectorial quantities. -- It was also recommended that students in this track be allowed to substitute EEN 404, Communication Systems, for which the prerequisites are EEN 305 and EEN 307. This suggestion will be discussed at the next departmental meeting and, if approved, brought to the College Council and the College Faculty for approval.
- c. MEN 303, Thermodynamics, no longer requires MTH 210 as a prerequisite.⁶

Copies of the updated curricula are enclosed.

6. **Personnel** related developments:

- 6.1. Prof. Eugene Eckstein was offered an endowed chair at the University of Tennessee, accepted that position and resigned his post at the UM in August, 1992. Dr. Eckstein left at the end of August, although, on account of Hurricane Andrew, he returned for a week to assist with the registration of undergraduates for Fall '93. (This voluntary effort was very much appreciated.) His departure left a significant impact on

⁵ See "Undergraduate Studies, 1992-1993, A Bulletin of the University of Miami;" p. 235.

⁶ See "Undergraduate Studies, 1992-1993, A Bulletin of the University of Miami;" p. 259.

the department. First, because he was a strong and enthusiastic supporter of the undergraduate program and had served as advisor for all the undergraduates until that time. Second, because his research and service activities (joint projects with Dr. Norman Block, Dr. Sanjay Roy, etc.; Chairman Elect of the Faculty Senate for 1992-93, Member, Tenure and Promotion Committee, CoE, etc.) involved many individuals throughout the University. Despite his departure, following the chaos caused by Hurricane Andrew, the department has managed to take care of the needs of the undergraduates in the Biomedical Engineering Option of the BS ES program as well as all other activities. This is a considerable accomplishment in light of the fact that the homes of all three of us involved in the daily management and administration of the department, myself and the two administrators, suffered very severe damages.⁷

6.2. Ned H.C. Hwang, Ph.D. joined the department as Knight Professor of Biomedical Engineering in August, 1992. Prof. Hwang came from the Memphis State University where he had been Herff Professor of BME. His specialty is Biomedical Fluid Dynamics. His CV is enclosed. Prof. Hwang was accompanied by a Post-Doctoral Fellow and three graduate students. He was later joined by his long-standing collaborator, Prof. S.K. Wong, as a Visiting Scholar from China. In collaboration with the Dept. of Mechanical Engineering, Prof. Hwang has established the Fluid Mechanics Laboratory which is involved in research on artificial heart valves and blood handling devices, such as pumps. The laboratory is involved in six different industrially sponsored projects and other proposals to federal agencies are pending.

⁷ Ms. Taylor's home was completely destroyed and she is still living with her relatives in crowded conditions; Ms. Tangredi's home was severely damaged although her family was able to stay in it, and mine was damaged to the extent that it had to be evacuated and three months later it is nowhere near livable. The frustrations of rebuilding homes and lives have been amply presented in the media.

6.3. Dr. Sanjay Roy received his Ph.D. from the UM Dept. of MEN. He had been collaborating with Dr. Eckstein on fluid mechanically oriented biomedical research and has continued that work after Dr. Eckstein's departure. This semester Dr. Roy is teaching an experimental course in Transport Phenomena for BME students.

7. **Budget** related developments:

7.1. The issue of directing an appropriate portion of the **"incremental income"** to departments in the School of Arts and Sciences was raised by the Ad Hoc Committee. University budgetary practice automatically credits Arts and Sciences for 70 percent of the tuition paid by a student, while the rest is credited to the student's home school or college.

7.2. Update of "REVENUES" from p. 29:⁸

1991-2	Tuition fees of 36 undergraduates (excl. scholarships) \$380K+			\$ 380K+	
1992-3	Tuition fees of 73 (instead of 55) less scholarships	\$796K+			(\$600K+)
	release time for research for Knight Chair		\$ 20K		
	for 1 Asst. Professor		\$ 15K		
	Revenues			\$ 831K+	(\$635K+)
1993-4	Tuition fees of 80 to 90 undergraduates less scholarships	\$1,150K+			
	release time for research for Knight Chair		\$ 30K		
	for two Asst. Professors		\$ 30K+		
	Revenues			\$1,210K+	
1994-95	Tuition fees of 110-120 undergraduates less scholarships	\$1,552K+			
	release time for research for Knight Chair		\$ 35K		
	for two Asst. Professors		\$ 35K+		
	Revenues			\$1,622K+	
	INCREMENTAL INCOME			\$4,043K+	(\$3,847K+)
	YEAR INCREMENTAL INCOME - INVESTMENT =			NET	
1991-2	\$380K	\$115K+		\$ 265K+	
1992-3	\$831K	\$228K+		\$ 603K+	(407K+)
1993-4	\$1,210K	\$312K+		\$ 898K+	
1994-5	\$1,622K	\$328K+		\$1,294K+	
	TOTAL			\$3,060K+	(2,864K)

The incremental costs for the University to provide courses for these students in other departments is minimal as no special courses will be necessary outside of the BME Dept.

⁸ Updated figures in boldface.

8. Library resources:

Library resources should be increased for the undergraduate program. The present collection of books and journals in the Richter and the Calder Library are barely adequate. Improvements in the collection and subscriptions are highly desirable for a distinguished undergraduate program. The cost was estimated at about \$10K per year for the first three years. This budget may be subject to debate, however, an educational program that thrives for excellence must be supported by library resources. Recognizing the budgetary problems of the University in relation to the library, we have been working with the Development Office on identifying alternate sources of funds for a regional resource library to be shared with the local biomedical industry.⁹ The state of the local economy has not been helpful toward the achievement of this goal. Since the hurricane, financial support from most local firms has been directed toward the rebuilding of South Dade. This has been widely discussed in the local media.¹⁰ However, there has been significant progress toward normalization of life in Dade County. There is reason for optimism that the economy will improve and, along with that, the local biomedical industry would recognize the need for the shared library.

Encl.: Prof. Hwang's short CV

cc.: Dr. Thomas J. Herbert, Biology Dept., 29 Cox Sci. Bldg.
Dr. James C. Nearing, Physics Dept., 320 JL Knight Bldg.
Dr. Victor C. Pestien, Jr., Mathematics Dept., 531 Unger Bldg.

⁹ For some time, it has been an objective for the Dept. of BME to develop a strong Industrial Affiliates Program. This must be a give-and-take activity. Library services are extremely valuable to industrial firms. Maintaining their own collections and services is very costly compared to the cost of supporting a regional shared resource. The proposed collection would consist of books, journals, encyclopedias, technical dictionaries and other reference material, including hardware for patent and other database searches.

¹⁰ For example, see The Miami Herald, November 29, 1992, a front page article bemoaning the financial problems of the arts in the community. Also, a series of public announcements on radio by Ms. Judy Drucker, impressaria for classical musical events, has been making the same point. Also, personal discussions with Mr. C. McDowell and Dr. D. Larnard of Cordis Corp. confirmed the same statement.

BS Biomedical Engineering
Electrical Orientation
(Approved by College Council for BS Eng.Sci.)¹

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intr. to Software Engr.	3 ²
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 112	General Biology II	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ordinary Differential Equations. (MTH 112)	3
PHY 205	University Physics I	3
BIL 111	General Biology I	4
EEN 201	Electrical Circuit Theory I (MTH 112)	3
EEN 204	Electrical Circuits Lab.	1
	Soc. Sci./Humanities Elective	3

		17

EEN 307	Linear Circuits and Signals (EEN 201)	3
PHY 206	University Physics II	3
PHY 208	University Physics Lab I	1
CEN 210	Mechanics of Solids I (MTH 111, PHY 205)	3
MTH 312	Vector Analysis (MTH 112)	3
	Soc. Sci./Humanities Elective	3

		16

¹ With minor modifications due to changes in the physics program.

² Or an equivalent course in software design. It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
Electrical Orientation

JUNIOR YEAR

IEN 311	Applied Probab. and Statistics I (MTH 112)	3
PHY 207	University Physics III	3
PHY 209	University Physics Lab II	1
EEN 305	Electronics I (EEN 201)	3
MEN 301 ³	Engineering Material Sci (CHM 111, PHY 207)	3
	Soc. Sci./Humanities Elective	3

		16

EEN 306	Electronics II	3
EEN 311	Electronics Lab	1
EEN 304	Logic Design (EEN 117)	3
EEN 301	Electromag. Field Theory (MTH 312, PHY 207)	3
EEN 315	Digital Design Lab	1
PHY 360	Intro. to Modern Physics (PHY 208)	3
	Technical Elective	3

		17

SENIOR YEAR

EEN 308	Linear Control Systems (EEN 307, MTH 210 ⁴ and 311)	3
EEN 312	Microprocessors (EEN 304)	4
BME	Measurements (incl. lab.)	4
BME	Biomaterials (incl. lab.)	4
BME 400	Senior Design Project	2

		17

BME 580	Biomedical Instrumentation	3
BME 575	Biomechanics	3
BME 400	Senior Design Project	1
BME	Computer Applications in Medicine or	
	Technical Elective	3
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		16

TOTAL (131 or) 134 credits

³ MEN 301 is chosen instead of MEN 303 Thermodynamics.

⁴ Based on conversations with the EEN faculty, MTH 210 is desirable but not essential for EEN 308. The instructor generally reviews the relevant aspects of matrix theory when the subject is needed. It was also recommended that students in this track be allowed to substitute EEN 404, Communication Systems for which the prerequisites are EEN 305 and EEN 307.

BS Biomedical Engineering
 Mechanical Orientation
 (Approved by College Council for BS Eng.Sci.)¹

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intr. to Software Engr.	3 ²
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 112	General Biology II	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ordinary Differential Equ. (MTH 112)	3
PHY 205	University Physics I	3
BIL 111	General Biology I	4
EEN 201	Electrical Circuit Theory I (MTH 112)	3
EEN 204	Elec. Circuits Lab.	1
	Soc. Sci./Humanities Elective	3

		17

EEN 305	Electronics I (EEN 201) or	3
EEN 307	Linear Circuits and Signals	3
PHY 206	University Physics II	1
PHY 208	University Physics Lab I	3
CEN 210	Mech of Solids I (MTH 111, PHY 205)	3
CHM 201	Organic Chem. Lecture I (CHM 112)	3
	Soc. Sci./Humanities Elective	3

		16

¹ With minor modifications due to changes in the physics program.

² Or an equivalent course in computer usage (software design). It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
Mechanical Orientation

JUNIOR YEAR

IEN 311	Applied Prob. and Stat. I (MTH 112)	3
MEN 303	Thermodynamics I (MTH 112, PHY 206)	3
CHM 202	Organic Chem. Lecture II (CHM 201)	3
PHY 207	University Physics II	3
PHY 209	University Physics Lab I	1
	Technical Elective	3

16

MEN 207	Mechanics of Solids II (CEN 210)	3
MEN 301	Engr. Material Sci. (CHM 111, PHY 207)	3
PHY 360	Intro. to Modern Phys. (PHY 207)	3
BME	Measurements (incl. lab.)	4
	Technical Elective	3

16

SENIOR YEAR

MEN 202	Dynamics (CEN 210)	3
MEN 302	Mech. Behav. of Mat. (MEN 207, 301)	3
MTH	Elective	3
BME	Biomaterials (incl. lab)	4
BME 400	Senior Design Project	2
	Soc. Sci./Humanities Elective	3

18

MEN 309	Fluid Mechanics (CEN 210, PHY 206)	3
BME 580	Biomedical Instrumentation	3
BME 575	Biomechanics	3
BME 400	Senior Design Project	1
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

16

TOTAL (131 or) 134 credits

BS Biomedical Engineering
 Premed Orientation
 (Approved by College Council for BS Eng.Sci.)¹

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intro. to Software Engr.	3 ²
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 112	General Biology II	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ordinary Differential Equ. (MTH 112)	3
PHY 205	University Physics I	3
BIL 111	General Biology I	4
EEN 201	Electrical Circuit Theory I (MTH 112)	3
EEN 204	Elec. Circuits Lab.	1
	Soc. Sci./Humanities Elective	3

		17

EEN 305	Electronics I (EEN 201) or	3
EEN 307	Linear Circuits and Signals	3
PHY 206	University Physics II	3
PHY 208	University Physics Lab I	1
CEN 210	Mech. of Solids I (MTH 111, PHY 205)	3
CHM 201	Organic Chem. Lecture I (CHM 112)	3
	Soc. Sci./Humanities Elective	3

		16

¹ With minor modifications due to changes in the physics program.

² Or an equivalent course in computer usage (and software design). It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
Premed Orientation

JUNIOR YEAR

IEN 311	Applied Prob. and Stat. I (MTH 112)	3
MEN 303	Thermodynamics I (PHY 206)	3
CHM 202	Organic Chem. Lecture II (CHM 201)	3
CHM 203	Organic Chemistry Lab (CHM 201)	2
PHY 207	University Physics III	3
PHY 209	University Physics Lab II	1
	Soc. Sci./Humanities	3

		18

BMB 401	Intro. to Biochem. and Mol. Biol. ⁹	3
PHY 360	Intro. to Modern Phys. (PHY 207)	3
MEN 207	Mechanics of Solids II (CEN 210)	3
MEN 301	Engr. Material Sci. (CHM 111, PHY 207)	3
BME	Measurements (incl. lab.)	4

		16

SENIOR YEAR

MEN 202	Dynamics (CEN 210; co: PHY 205)	3
MEN 302	Mech. Behav. of Mat. (MEN 207, 301)	3
MTH	Elective	3
BME	Biomaterials (incl. lab)	4
BME 400	Senior Design Project	2

		15

MEN 309	Fluid Mechanics (CEN 210, PHY 206)	3
BME 580	Biomed. Instrum.	3
BME 575	Biomechanics	3
BME 400	Senior Design Project	1
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		16

TOTAL (130 or) 133 credits

⁹ Prerequisites: CHM 202 Org. Chem II (Lecture) and 2 semesters of biology

BIOGRAPHICAL SKETCH

Give the following information for the key personnel and consultants and collaborators. Begin with the principal investigator/program director. Photocopy this page for each person.

NAME	POSITION TITLE
Ned H.C. Hwang	James L. Knight Professor

EDUCATION (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)			
INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	FIELD OF STUDY
Cheng-Kung Univ., Tainan, Taiwan	B.S.	1957	Hydraulic Engineering
University of California, Berkeley	M.S.	1961	Fluid Mechanics
Colorado State Univ., Ft. Collins	Ph.D.	1966	Fluid Mechanics
Baylor College of Medicine, Houston, TX	Summer Institute	1969	Physiology

RESEARCH AND PROFESSIONAL EXPERIENCE: Concluding with present position, list, in chronological order, previous employment, experience, and honors. Key personnel include the principal investigator and any other individuals who participate in the scientific development or execution of the project. Key personnel typically will include all individuals with doctoral or other professional degrees, but in some projects will include individuals at the masters or baccalaureate level provided they contribute in a substantive way to the scientific development or execution of the project. Include present membership on any Federal Government public advisory committee. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years and to representative earlier publications pertinent to this application. DO NOT EXCEED TWO PAGES.

EMPLOYMENT/EXPERIENCE: (current appointments only)

James L. Knight Professor of Biomedical Engineering, University of Miami, 1992-present.
 Visiting Professor of Biomedical Engineering, Israel Institute of Tech., Haifa, Israel, 1989-present.
 Adjunct Prof. Biomedical Engineering, Tsing-Hua Univ., Beijing, China, 1986-present.

PUBLICATIONS:**BOOKS:**

Frontiers in Cardiovascular Engineering (eds. NHC Hwang, VT Turitto), The Plenum Publishing Corp., New York, NY, 1992.

Fundamentals of Hydraulic Engineering Systems (NHC Hwang) Prentice-Hall, Englewood NJ, 1981; 2nd Editions (NHC Hwang, CE Hita), 1987.

Rheology of Blood, Blood Vessels and Associated Tissues (eds. DR Gross, NHC Hwang) Sijthoff and Noordhoff, Alphen Ann den Rijn, The Netherlands, 1982.

Quantitative Cardiovascular Studies: Clinical and Laboratory Applications of Engineering Principles (eds. NHC Hwang, DR Gross, DJ Patel) University Park Press, Baltimore MD, 1979.

Cardiovascular Flow Dynamics and Measurements (eds. NHC Hwang, NA Normann) University Park Press, Baltimore MD, 1977.

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- Guo X, Zhou JS, Hwang NHC, "Mechanical valve closing velocity: Rigid vs flexible mountings," ASME Winter Annual Meeting, Atlanta, GA, Dec. 3-6, 1991.
- Hwang NHC, Liu CY, "Composite curvature - A new leaflet design concept," In, Surgery for Heart Valve Surgery (ed: E Bodnar), ICR Publishers, London, 1990.
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CONTINUATION PAGE: STAY WITHIN MARGINS INDICATED

BIOGRAPHICAL SKETCH

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NAME Ned H.C. Hwang	POSITION TITLE James L. Knight Professor		
EDUCATION (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)			
INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	FIELD OF STUDY
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University of California, Berkeley	M.S.	1961	Fluid Mechanics
Colorado State Univ., Ft. Collins	Ph.D.	1966	Fluid Mechanics
Baylor College of Medicine, Houston, TX	Summer Institute	1969	Physiology

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CONTINUATION PAGE: STAY WITHIN MARGINS INDICATED



November 20, 1992

Dr. Luis Glaser
Provost
University of Miami

Dear Luis:

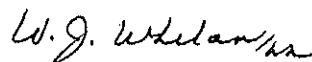
HPBM Program

Thank you for your message of November 13, regarding the Honors Program in Biomedical Engineering.

I am sharing your message with Bob Warren as the Chair of the ad hoc committee that is reviewing the B. S. in Biomedical Engineering proposal.

We will try to move expeditiously in examining the proposal. Bob has been asked to render an interim report to the Senate Council on December 7. How rapidly we can move depends on how well constituted is the proposal. Keith Wellman, the previous scrutineer, did turn up some significant problems.

Yours sincerely,

A handwritten signature in cursive script that reads "W. J. Whelan".

William J. Whelan
Chair, Faculty Senate

WJW/ca

FILED
11-19-92

CDFHI




Executive Vice President and Provost

MEMORANDUM

November 13, 1992

TO: Dr. William Whelan
Chairman, Faculty Senate

FROM: Luis Glaser
Executive Vice President
and Provost 

SUBJECT: HPBM Program

This is just to confirm our conversation regarding the five students who are currently seniors and who will graduate next summer, who were involved in the original Honors Program in Biomedical Engineering which carried their automatic admission to the School of Medicine. As you know, the program was born with some confusion, and unfortunately it continues.

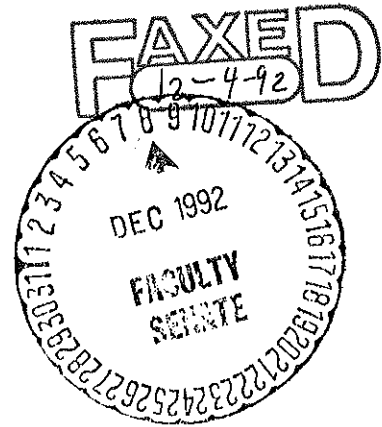
All of these students are making excellent progress and are following the curriculum which is currently being reviewed for the undergraduate program in Biomedical Engineering. For various reasons, that program has not yet been fully approved by the University, although it will almost certainly be approved this spring. In any case, we want to make sure that these students, through no fault of their own, do not get into trouble, and therefore we plan to award degrees to them in undergraduate Biomedical Engineering. These are fine students and we will be very proud of their performance.

Thank you for your assistance in this matter.

LG:tmp

cc: Dr. John Masterson

CDFHI



Executive Vice President and Provost

MEMORANDUM

December 3, 1992

TO: Dean Martin Becker
College of Engineering

Dr. Peter Tarjan, Chair
Biomedical Engineering

Mrs. Eileen Campbell, Assistant Director
Programs in Honors and Privileged Studies

FROM: John T. Masterson *JM*
Vice Provost for
Undergraduate Affairs

SUBJECT: Senior HPEM Students

This memorandum is a revision of and supersedes my memorandum dated November 18, 1992.

The Provost has met with the Senate Council and has presented the dilemma faced by the five HPEM students who are currently seniors following a biomedical engineering curriculum. This memorandum confirms that those seniors may graduate with undergraduate degrees in engineering contingent on their completing successfully the curriculum they've been advised to follow for the past four years.

I have asked Mrs. Campbell to notify these students as soon as possible as I know that they are quite concerned. Thank you.

JTM:sk

cc: Luis Glaser
William Whelan

P.O. Box 248033
Coral Gables, Florida 33124-4628
(305) 284-3356
Fax: (305) 284-6758



CDFHI

Executive Vice President and Provost

MEMORANDUM

November 18, 1992



TO: Dean Martin Becker
College of Engineering

Dr. Peter Tarjan, Chair
Biomedical Engineering

Mrs. Eileen Campbell, Assistant Director
Programs in Honors and Privileged Studies

FROM: John T. Masterson *JTM*
Vice Provost for
Undergraduate Affairs

SUBJECT: Senior HPEM Students

The Provost has met with the Senate Council and has presented the dilemma faced by the five HPEM students who are currently seniors following a biomedical engineering curriculum. This memorandum confirms that those seniors may graduate with undergraduate degrees in biomedical engineering contingent on their completing successfully the curriculum they've been advised to follow for the past four years.

I have asked Mrs. Campbell to notify these students as soon as possible as I know that they are quite concerned. Thank you.

JTM:sk

cc: Luis Glaser
William Whelan



November 10, 1992

Professor Robert Warren
Cell Biology and Anatomy
4095 RMSB, R-124

Dear Bob:

B. S. in Biomedical Engineering

I want to thank you, along with Doctors Tom Herbert, James Nearing, and Victor Pestien, for agreeing to study the proposal for a B. S. in Biomedical Engineering as member of an ad hoc Committee of which you have kindly agreed to be the Chair.

As you know, we began to look at this proposal in the late spring, and should have been further along now, but for the inability of the original ad hoc Committee Chair to continue. I hope that you and your colleagues will be able to make up for lost time.

Mrs. Hoadley will send each of you a copy of the proposal, and I leave it to you to organize the scrutiny. Most of all, we would like to have the proposal come to the Senate Council with all the necessary preliminary actions taken, including asking any other departments/schools, etc., which may be involved in the proposal to signify their acquiescence with its content.

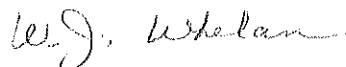
November 10, 1992

Page 2

The Council will hold its December meeting on Monday, December 7. If you could attend that meeting and give us a preliminary report, or even a final report, we will be able to learn whether there will be any problems in securing the necessary approval by the Senate during the current academic year.

Many thanks for your help.

Yours sincerely,



William J. Whelan
Chair, Faculty Senate

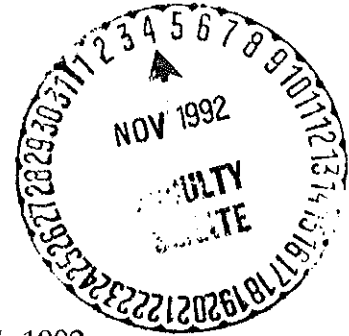
WJW/ca

cc: Provost Luis Glaser
Dean Martin Becker
Professor Peter Tarjan
Professor Thomas Herbert
Professor James Nearing
Professor Victor Pestien

FAXED
11-4-92

CDFHI

UNIVERSITY OF
Miami
FACULTY SENATE



October 27, 1992

RECEIVED
CHEMISTRY DEPARTMENT

Professor Keith M. Wellman
Chairman
Department of Chemistry
315 Cox Science Center, 0431

OCT 29 1992
AM 7 8 9 10 11 12 1 2 3 4 5 6 PM

Dear Keith:

B. S. in Biomedical Engineering

I wrote to you recently regarding the reactivation of the scrutiny of the above degree proposal. It is essential that we do not fall behind in the schedule for its consideration.

Please confirm that you can report to the Senate Council on November 16. If you are unable to act, please let us know at once, and we will appoint a successor.

Thank you.

Yours sincerely,

W. J. Whelan, an

William J. Whelan
Chair, Faculty Senate

WJW/ca

cc: Professor Josephine Johnson

Bill - I am very sorry not to have done my job. Unfortunately, my current administrative duties prevent me from completing this task in a timely fashion. I am pointing a successor as best as I can. Best regards Keith

325 Ashe-Admin. Bldg.
Coral Gables, Florida 33124-4634
305 284-3721

Ad Hoc Committee on Teaching Awards

Professor Lorton, Chair of the ad hoc committee to review the proposal on Teaching Awards, submitted a recommendation to present three teaching awards a year. Discussion followed about the impact of the award on Faculty. Professor Lorton explained that since the Senate already offered an award for scholarship, the awards would bring balance. It was agreed to pass the recommendations of the committee to the new Senate.

B. S. in Biomedical Engineering

The Chair, Professor Whelan, introduced the proposal for a B.S. in Biomedical Engineering Degree. Professor Wellman, chair of the ad hoc committee to review the program, reported that the committee already had its first meeting, and they were generally favorably disposed toward the proposal. According to Professor Wellman the administration was also seen in support of the proposal. However, his committee found weak support systems. The College is not strong in electronic technology. There are three fields within the degree: Mechanical Engineering, Electrical and Computer Engineering, and Pre-Medical Engineering. The Committee feels that the Mechanical and Electrical and Computer Engineering are not sufficiently strong. The Faculty is small and will be raised to nine in a few years. Professor Eckstein, Senator for the College of Engineering, explained that new faculty lines were promised to Dean Becker by the administration. The funding for equipment is already available. Since the proposal was submitted well beyond the March 1 deadline, it was *moved* and seconded to table the program until the first meeting next fall. The *motion carried*.


**PROPOSAL FOR A BACHELOR OF SCIENCE
IN BIOMEDICAL ENGINEERING PROGRAM
IN THE COLLEGE OF ENGINEERING OF
THE UNIVERSITY OF MIAMI**

February 27, 1992





MEMORANDUM

DATE: March 19, 1992
TO: To Whom It May Concern
FROM: Martin Becker, Dean, College of Engineering 
RE: Proposal for a B.S. Degree in Biomedical Engineering

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The purpose of this memo is to state that the proposed B.S. degree in the Biomedical Engineering program does not require additional funds beyond what has already been committed in writing to this program by the University administration.

Funds have been committed to support one junior faculty member starting in the Fall of 1992, an additional faculty member starting in the Fall of 1993, and start-up research costs. The search for an occupant for the Knight Chair is reaching conclusion, and funds beyond the endowment for the salary and start-up cost have also been committed. An adequate amount has been budgeted and provided to establish undergraduate laboratories within the department. Finally, special scholarships have been established to attract outstanding students. These are to be phased out by Fall 1995.

MB:fc



PROPOSAL

FOR A BACHELOR OF SCIENCE IN BIOMEDICAL ENGINEERING PROGRAM IN THE COLLEGE OF ENGINEERING OF THE UNIVERSITY OF MIAMI

EXECUTIVE SUMMARY

The Department of Biomedical Engineering proposes the establishment of a Bachelor of Science degree program in Biomedical Engineering (BS BME) as an outgrowth of the Honors Program in Engineering and Medicine and the Biomedical Engineering Concentration in the BS in Engineering Science program.

The need for the BS BME program is presented and justified on the basis of rising interest in the field among high school students and existing industrial ties in the area. The basic goal of the program is to provide a well-balanced education both in engineering and in the life sciences thereby preparing the students either for employment in the biomedical engineering field, or for continued studies in graduate school or in medicine.

The proposal outlines the extensive history of the department's interactions with undergraduate students and its graduate programs. It also presents linkages with the UM School of Medicine.

The proposed academic program is compared with several existing ones in the USA from the points of view of curricula, objectives, geography, etc.

The size of the financial commitment from the University is outlined. More than half of the credits to be earned by the students in the proposed program are offered by the College of Arts and Sciences. At least a quarter of the credits are to be earned in the other four departments in the College of Engineering.

The resources within the community are also presented as the ground for future growth of the program and as employment opportunities for the graduates.

The program is expected to attract about 25 high quality entering students to the University each year. With that size and with expectations for a high quality program, the faculty of BME needs to be expanded from the present 5 primary appointments (with 2.35 faculty lines) to at least 9 primary appointments, including the Knight Chair in BME, over the next 2-3 years.

The BS BME program is intended for ABET accreditation as soon as it becomes eligible for that.

Support from the State's tuition equalization system, under PEPC, will also be sought for the benefit of Florida residents.

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INTRODUCTION

This document proposes the establishment of a Bachelor of Science in Biomedical Engineering degree program in the College of Engineering. It presents the rationale for this proposal, the objectives of the program, the proposed curriculum and comparisons with similar programs in the USA. It is followed by an economic justification of the program including a review of existing and additional personnel and resources needed for the success of the proposed program.

HISTORY OF WORK WITH UNDERGRADUATES

The Department of Biomedical Engineering has concentrated its efforts on the development of its graduate program for more than two decades. As a result of this focus, the department has been heavily involved in a variety of interdisciplinary research projects with researchers in the School of Medicine, in local medical institutions, in industrial firms and in other departments within the Coral Gables Campus. The Department's involvement with undergraduate students began with the Option in Biomedical Engineering offered by other engineering departments. These students would typically take twelve credits of 500 level work in the department. The basis of this activity was the BME 501/502 course series: Unified Biomedical Sciences, a 9 (originally 12) credit course taught by a group of physicians, life scientists and engineers.

Students in the Honors Program in Medical Education had studied in the Engineering Science program. Several of these students are now in the School of Medicine, working toward the M.D. degree. As two years of Engineering Science was deemed far too intensive for most of the students, a new program of eight years duration, the Honors Program in Engineering and Medicine (HPEM) commenced as a result of joint planning between the HPME Committee, the Engineering Science Program and the Dept. of Biomedical Engineering. (This resulted from the collaboration of Dr. Robert Hinkley, Director of the HPME Program, Dr. Jerome Catz, Director of the Engineering Science Program and Drs. Eugene Eckstein and Peter Tarjan of BME.) The students were offered the B.S. in Engineering Science Premed Option with preadmission to the School of Medicine. Presently 4 students are in their third year, two in their second year, and two more began in the Fall of 1991-92. Their performance has ranged from superb to very good.

Interest in the new HPEM program was very high (28 applicants during the first year without any promotion) and the candidates were extremely competitive. Despite the high level of interest, enrollment turned out to be small due to two main factors: The first year only five students were admitted and four of those enrolled. The second year only two students enrolled among the nine admitted. This was attributed to the alleged perception that Miami was a dangerous place to live because of the national exposure following the

public disturbances after the acquittal of certain police officers in the winter of 1989-90. The low yield of enrollment in 1991 appears to be the result of other programs throughout the country offering combined BS-MD programs with 6 to 7 years durations, compared to 8 years at the UM. Creation of a 7-year option for the HPEM is expected to stimulate additional interest and enrollment.

Despite the interest in accelerated programs, a number of excellent students recognized the advantages of getting a full and balanced sequence of undergraduate courses in the physical and life sciences as well as in various areas of engineering. It is widely recognized that many areas of medicine and engineering are in an interwoven partnership and those with training in both disciplines will be well prepared for the challenges of medicine in the coming century.

On account of the broad appeal of the biomedical engineering discipline to bright high school students, the Faculty of the College of Engineering agreed to expand the B.S. in Engineering Science program to a group of students whose ultimate goal is not necessarily to become physicians, but who may wish to practice biomedical engineering as a profession. The first group of 30 students, including 2 HPEM students, entered this program during the Fall of 1991-92. They came to the University of Miami with the anticipation that the Department of Biomedical Engineering would propose the establishment of the B.S. in Biomedical Engineering degree. While no commitment was made that the Faculty of the College of Engineering, the University Faculty Senate, the Administration or the Board of Trustees would approve such a proposal, the support of the President, the Provost and the Dean of the College for this program were quite explicit. This proposal is submitted partially in response to their enthusiastic support.

As of January, 1992, 28 of the entering undergraduates have completed the semester, about two third of them with GPAs above 3.0 and only 5 with academic difficulties. In addition, several undergraduates have requested to be transferred from other universities and other programs within the UM. The present number is 32.

For various social and economic reasons biomedical engineering appeals as a potential career to many bright high school students. This is partially due to the frequent and generally positive exposure of the achievements of biomedical engineers in the media and partly to the steady economic expansion of the health care field which receives strong technical support from biomedical engineering firms. The industry has grown steadily over the past four decades and has been relatively recession proof. The technical and social relevance of the results of biomedical engineering have a strong appeal. The industry has become international in every way. The nature of the field is such that an individual with a BS degree has a wide range of career choices which include further studies in medicine, law, business or in other graduate programs as well as entry level positions in industry and even a chance to excel as an entrepreneur.

The biomedical and biotechnology industries are already strong and growing steadily

within the entire State of Florida, in South Florida and in Dade County. Private and public corporations and institutions in South Florida have employed many of the graduates of the UM BME graduate program, including Coulter Electronics, Cordis Corp., Corvita Corp., Telectronics Pacemakers, Inc., NIMS, the Mt. Sinai Medical Center, Jackson Memorial Hospital, among others. Employment opportunities throughout the United States have been demonstrated by those with MS BME degrees from the Dept. of BME. They have found employment at such international firms as Medtronic, Inc. in Minneapolis, MN, Pfizer and Baxter Health Care Systems.

The strengths of the biomedical industry in South Florida are described in Appendix A. It presents the evolution of new firms from the initial few and provides information on local firms.

BASIC GOALS AND OBJECTIVES

The concepts, tools, skills and vocabulary of each professional field have become so specialized that most people find it difficult to absorb those from another field as well. For this reason ideas and technology move slowly from specialty to specialty. The barriers are high due to communication problems and cultural differences. It is difficult to learn the concepts and language of a second field after one has reached a certain degree of certification (and saturation) in one's original field. This potential difficulty should be preempted by the education of a biomedical engineer at the undergraduate level by learning basic and applied physical and life sciences in parallel while developing an understanding about the way those fields are or might be linked. Biomedical engineers need to know the basic sciences, understand engineering principles and relevant technologies, and appreciate problems in the health care field. The biomedical engineer is expected to develop complex knowledge and skills to be able to implement the transfer of various technologies to medicine and prove those for clinical use. Therefore, the education of the biomedical engineer must include mathematics, basic physical sciences, engineering principles, life sciences and the social, economic and political workings of both the health care field and the associated industries. In addition, the student must gain a thorough understanding of what biomedical engineers indeed do to contribute to the operations of industrial firms, research laboratories and medical centers.

A very important goal of our proposed undergraduate program is to become accredited by the Accreditation Board for Engineering and Technology (ABET) as soon as possible. Applications for ABET accreditation are not accepted before some students have graduated from the program. The ABET requirements are very difficult to meet in terms of its design related content. To meet that specific requirement the undergraduate curriculum is proposed to include design work in as many of the specialized courses as possible. The senior projects also need to be strongly design oriented and a solid test of a student's readiness for a career in engineering.

Another objective is to qualify for the State's tuition equalization system, under the Post-Secondary Education Planning Commission (PEPC) for eligible Florida residents. At this time there is no BS in Biomedical Engineering program within the State University System (SUS), hence approval is likely on the basis of need and cost effectiveness.

INDUSTRIAL EMPLOYMENT OPPORTUNITIES FOR GRADUATES

While there is a national market for the graduates of our MS and PhD programs, many of our graduates have found employment in the South Florida area. Most of the corporations in the biomedical devices and diagnostics industry operating in South Florida are described in Appendix A. Broad research and development activities exist outside the industrial firms but often with close cooperation them. The Biomedical Device Development Related Activities in South Florida are presented in Appendix B.

CURRICULUM

Biomedical Engineering is a very broad field and encompasses many engineering disciplines. It is proposed that three parallel tracks be offered, one with concentration in electrical technology, another in mechanical technology and the third one, premedical, for those who intend to enter medicine. The latter requires that the student be able to take the MCAT examination at the beginning of the fourth year of the program, hence the required preparation for entry to medical schools must be completed by then.

The curricula are presented on the next few pages. Three courses are included in the curricula which are yet to be fully developed:

Measurements (incl. lab.) 4 cr.

This course is intended for Juniors to further their experimental skills in the areas of mechanical and electrical measurement techniques and laboratory skills.

Biomaterials (incl. lab) 4 cr.

This course is an undergraduate version of a graduate level course that has been taught by our faculty for more than a decade. The subjects deal with the properties of living tissues, materials of biological origin and materials suited for contact with living tissues including metals, polymers and various fluids.

Senior Design Project 2 + 1 = 3 cr.

For the sake of making this a major experience, the "capstone" project is planned to span the entire senior year. The student is expected to select a project, review the relevant literature, develop plans and carry out the major part of the design and development work during the first semester. The second semester is intended for testing and preparation for the presentation of the project. A single grade is given at the completion and acceptance of the project.

It should be evident from the curricula and the summary table below that more than half of the credits in each of the three orientations for the BS BME are to be earned in the College of Arts and Sciences. More than a quarter of the remaining courses are to be earned in Engineering but not in the Dept. of BME:

Credits to be earned

	Electrical Orientation	Mechanical Orientation	Premed
Co of Arts and Sciences	67	67	78
General Engineering	40	40	34
Biomedical Engineering	26	26	20

BS Biomedical Engineering
Electrical Orientation
(Approved by College Council for BS Eng.Sci.)

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intr. to Software Engr.	3 ¹
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 111	General Biology I	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ord. Diff. Equ. (MTH 112)	3
PHY 211	University Physics I	4
PHY 222	University Physics Lab I	1
BIL 112	General Biology II	4
EEN 201	Elec. Circuit Theory I (MTH 112)	3
EEN 204	Elec. Circuits Lab.	1

		16

EEN 307	Lin. Circuits and Signals (EEN 201)	3
PHY 212	University Physics II	4
PHY 236	University Physics Lab II	1
CEN 210	Mech. of Solids I (MTH 211,PHY 211)	3
MTH 312	Vector Analysis (MTH 112)	3
	Soc. Sci./Humanities Elective	3

		17

¹ Or an equivalent course in software design. It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
Electrical Orientation
(Approved by College Council for BS Eng.Sci.)

JUNIOR YEAR

IEN 311	Applied Prob. and Stat. I (MTH 112)	3
EEN 301	Electromagnetic Field Theory (MTH 312,PHY 212)	3
EEN 305	Electronics I (EEN 201)	3
PHY 360	Intro. to Modern Phys. (PHY 212)	3
	Soc. Sci./Humanities Elective	3

15

EEN 306	Electronics II	3
EEN 311	Electronics Lab	1
MEN 301 ²	Engr. Material Sci (CHM 11,PHY 212)	3
EEN 304	Logic Design (EEN 117)	3
EEN 315	Digital Design Lab	1
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

17

SENIOR YEAR

EEN 308	Linear Control Systems (EEN 307, MTH 210 and 311)	3
EEN 312	Microprocessors (EEN 304)	4
BME	Measurements (incl. lab.)	4
BME	Biomaterials (incl. lab)	4
BME	Senior Design Project	2

17

BME 580	Biomedical Instrumentation	3
BME 575	Biomechanics	3
BME	Senior Design Project	1
BME	Computer Applications in Medicine	
	or	
	Technical Elective	3
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

16

TOTAL	(130 or)	133 credits
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² MEN 301 is chosen instead of MEN 303 Thermodynamics.

BS Biomedical Engineering
Mechanical Orientation
(Approved by College Council for BS Eng.Sci.)

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intr. to Software Engr.	3 ³
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 111	General Biology I	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ord. Diff. Equ. (MTH 112)	3
PHY 211	University Physics I	4
PHY 222	University Physics Lab I	1
BIL 112	General Biology II	4
EEN 201	Elec. Circuit Theory I (MTH 112)	3
EEN 204	Elec. Circuits Lab.	1

		16

EEN 305	Electronics I (EEN 201) or	
EEN 307	Linear Circuits and Signals	3
PHY 212	University Physics II	4
PHY 236	University Physics Lab II	1
CEN 210	Mech of Solids I (MTH 211,PHY 211)	3
CHM 201	Organic Chem. Lecture I (CHM 112)	3
	Soc. Sci./Humanities Elective	3

		17

³ Or an equivalent course in computer usage (software design). It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
 Mechanical Orientation
 (Approved by College Council for BS Eng.Sci.)

JUNIOR YEAR

IEN 311	Applied Prob. and Stat. I (MTH 112)	3
MEN 303	Thermodynamics I (MTH 211,PHY 211)	3
CHM 202	Organic Chem. Lecture II (CHM 201)	3
PHY 360	Intro. to Modern Phys. (PHY 212)	3
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		18

MEN 207	Mechanics of Solids II (CEN 120)	3
MEN 301	Engr. Material Sci. (CHM 111,PHY 212)	3
BME	Measurements (incl. lab.)	4
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		16

SENIOR YEAR

MEN 202	Dynamics (CEN 120; co: PHY 211)	3
MEN 302	Mech. Behav. of Mat. (MEN 207, 301)	3
MTH	Elective	3
BME	Biomaterials (incl. lab)	4
BME	Senior Design Project	2

		15

MEN 309	Fluid Mechanics (CEN 120, PHY 211)	3
BME 580	Biomed. Instrum.	3
BME 575	Biomechanics	3
BME	Senior Design Project	1
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		16

TOTAL (130 or) 133 credits

BS Biomedical Engineering
Premed Orientation
(Approved by College Council for BS Eng.Sci.)

FRESHMAN YEAR

ENG 105	Principles of Prose Expression	3
MTH 111	Calculus I	4
CHM 111	Prin. of Chemistry I	4
EEN 117	Pascal and Intro. to Software Engr.	3 ⁴
	Soc. Sci./Humanities Elective	3

		17 (or 14)

ENG 107	Sci. and Tech. Writing (ENG 105)	3
MTH 112	Calculus II (MTH 111)	4
CHM 112	Prin. of Chemistry II (CHM 111)	4
BIL 111	General Biology I	4
	Soc. Sci./Humanities Elective	3

		18

SOPHOMORE YEAR

MTH 311	Ord. Diff. Equ. (MTH 112)	3
PHY 211	University Physics I	4
PHY 222	University Physics Lab I	1
BIL 112	General Biology II	4
EEN 201	Elec. Circuit Theory I (MTH 112)	3
EEN 204	Elec. Circuits Lab.	1

		16

EEN 305	Electronics I (EEN 201)	or	
EEN 307	Linear Circuits and Signals		3
PHY 212	University Physics II		4
PHY 236	University Physics Lab II		1
CEN 210	Mech. of Solids I (MTH 211,PHY 211)		3
CHM 201	Organic Chem. Lecture I (CHM 112)		3
	Soc. Sci./Humanities Elective		3

			17

⁴ Or an equivalent course in computer usage (and software design). It may also be considered as a make-up course for deficient preparation.

BS Biomedical Engineering
 Premed Orientation
 (Approved by College Council for BS Eng.Sci.)

JUNIOR YEAR

IEN 311	Applied Prob. and Stat. I (MTH 112)	3
MEN 303	Thermodynamics I (MTH 211,PHY 211)	3
CHM 202	Organic Chem. Lecture II (CHM 201)	3
CHM 203	Organic Chemistry Lab (CHM 201)	2
PHY 360	Intro. to Modern Phys. (PHY 212)	3
	Soc. Sci./Humanities Elective	3

		17

BMB 401	Intro. to Biochem. and Mol. Biol. ⁵	3
MEN 207	Mechanics of Solids II (CEN 120)	3
MEN 301	Engr. Material Sci. (CHM 11,PHY 212)	3
BME	Measurements (incl. lab.)	4
	Soc. Sci./Humanities Elective	3

		16

SENIOR YEAR

MEN 202	Dynamics (CEN 120; co: PHY 211)	3
MEN 302	Mech. Behav. of Mat. (MEN 207, 301)	3
MTH	Elective	3
BME	Biomaterials (incl. lab)	4
BME	Senior Design Project	2

		15

MEN 309	Fluid Mechanics (CEN 120, PHY 211)	3
BME 580	Biomed. Instrum.	3
BME 575	Biomechanics	3
BME	Senior Design Project	1
	Technical Elective	3
	Soc. Sci./Humanities Elective	3

		16

TOTAL	(129 or)	132 credits
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⁵ Prerequisites: CHM 202 Org. Chem II (Lecture) and 2 semesters of biology

BIOMEDICAL ENGINEERING ELECTIVE COURSES

The following courses may be developed as future electives for seniors or graduate students depending on the specialties of the expanded faculty:

- Optics and Optical Engineering 3 cr.
This course was already taught by Dr. Ren to 7 graduate students in the Special Topics series during the Fall 1992 semester.
- Lasers and Optics Laboratory 1 cr.
Some equipment has already been accumulated for this, including a laser, an optical bench, lenses, etc.
- Signal Processing in BME 3 cr.
Based on experience gained by Dr. Ozdamar from having taught a graduate level course numerous times.
- Imaging Techniques 3 cr.
This course has been taught by Dr. Nagel at the 600 level to graduate students. It covers the physics of image production and some processing techniques.
- Electrophysiology 3 cr.
This course was conducted as a seminar/reading course by Dr. Tarjan in the Special Topics series to 3 graduate students in 1991. It covered membrane biophysics, cardiac electrophysiology, neurophysiology and devices for the treatment of related diseases.
- Sensors and Transducers 3 cr.
This course was taught by Dr. Nagel in the Special Topics series in the past.
- Hemodynamics 3 cr.
This course has been taught on numerous occasions by Dr. Eckstein to graduate students.
- Implantable Medical Devices 3 cr.
This course has also been three times in the past in the Special Topics series by Dr. Tarjan to graduate students. It covers the technologies of dental and orthopaedic implants, heart valves, vascular replacements, infusion and electrical stimulating devices and some legal and economic issues.
- Biomedical Computing 3 cr.
This course will be based on Dr. Ozdamar's past experience from teaching a graduate course on the applications of microcomputers in medicine.

Artificial Organs 3 cr.
This course has also been taught on numerous occasions by Dr. Eckstein to graduate students.

Clinical Engineering 3 cr.
At the present time no one on the faculty is involved in teaching this course and the interest among our graduate students has been modest, but in the past Mr. Routh, an experienced clinical engineer who is near the completion of his PhD in BME, taught this course in collaboration with Dr. Kline, Professor Emeritus and past Chair in the department.

Neural Communication - Neural Networks 3 cr.
Both Dr. Ozdamar and Dr. Nagel have taught these subjects in the Special Topics series to graduate students.

Engineering in Orthopaedics 3 cr.
This course would have to be developed either by Dr. Latta who holds a secondary appointment in BME or by one of the expected additions to the faculty.

Rehabilitation Engineering 3 cr.
This course may also be developed by a future member of the department.

Clinical, Legal, Economic and Ethical Aspects of BME 2 cr.
This course may be chosen by those students who intend to seek industrial employment upon graduation.

Man-Machine Systems 3 cr.
This course (IEN 557) is regularly offered by the Dept. of Industrial Engineering.

Depending on interest and other factors, advanced courses on these subjects may also be added to the above list.

LINKAGES TO OTHER PARTS OF THE UNIVERSITY

The proposed BME curricula are heavily dependent on basic science and engineering courses offered by the College of Arts and Sciences and by other departments in the College of Engineering. In addition to the introductory physics and chemistry courses, the BME students are expected to take Organic Chemistry, General Biology and electives of their choice. The program will also rely heavily on courses offered by the Electrical and Mechanical Engineering Departments. Students will be required to take the existing Engineering Core Curriculum.

The University of Miami (UM) has one of the strongest and largest medical schools in the

Southeastern United States. The research budget for the School of Medicine (SM) is over \$130 million for the current year. Cooperative programs have been worked out between various departments on the Medical Campus and in the affiliated hospitals of the SM, and the Department of Biomedical Engineering (BME) in the CoE. This cooperation has resulted in numerous joint research proposals, some of which have been funded by federal, state and private sources. Other avenues of cooperation were found through the assignment of graduate students to various projects funded through the SM. In addition, substantial collaboration has been achieved between the Department of Industrial Engineering (IEN) and the Comprehensive Pain Rehabilitation Center at South Shore Hospital. Finally, there are a number of faculty members within the CoE who have found some opportunities for joint projects either with individual researchers in the medical faculty or with biomedical firms.

The graduate program in BME has enjoyed close research collaboration with many of the departments in the School of Medicine and medical faculty members regularly provide lectures to the BME 501/502 Unified Medical Sciences classes. Involvement of the undergraduates in summer research projects is realistic and may be expanded to the academic year.

The many Shared Facilities of the UM School of Medicine which are expected to enhance the research and teaching of the BME Department; these are listed in Appendix C.

It is also expected that collaboration on Senior Design Projects with seniors in other departments might evolve. In the past several EEN and MEN students had found projects in the BME Department.⁶

ENROLLMENT TRENDS

The population segment of 18 year olds is expected to decline until about 1995 and then it will begin to rise slowly. This has created a serious problem for most private universities. Some are rumored to downsize themselves considerably (e.g. Syracuse). In addition, the general decline in the nation's economy makes it harder for more and more people to study at private or even at public universities. The current recession is expected to be followed by slow recovery as the nation's business is being reorganized. Furthermore, at the national level enrollment in engineering and the sciences has been declining for several years. Biomedical Engineering undergraduate programs, as it will be evident from the upcoming section on comparing curricula at various institutions, exist primarily at private universities. Most of the programs are expanding and represent significant portions of the engineering enrollment. These considerations all indicate that

⁶ Howard Preissman, MEN, 1990, Lisbeth Olsen, EEN 1990, Marc Camacho, EEN, 1990, Charles Herbert, EEN 1990, David Beutel, MEN, 1991.

the establishment of a BS BME program is a constructive step toward improving enrollment both within the College of Engineering and within the University. This is borne out by the Engineering Science enrollment of Fall 1991, and applications to date for the Fall 1992 Freshmen class.

Another consideration that contributes to the background of this proposal is the trend toward reductions in the federal defense budget. This trend will manifest itself in the reduction of funds for projects sponsored by the Department of Defense. NASA funding is difficult to obtain and the computer industry is having a difficult time with decreasing hardware prices and intense international competition. Funding for research in Biomedical Engineering should be less vulnerable than in many other areas.

All these factors point to the importance of our joint efforts to increase and strengthen the activities in medical and life science related areas within the CoE.

COMPARABLE PROGRAMS

A recent publication⁷ provided historical information on undergraduate BME programs with ABET accreditation. The following list shows the designation of each program and its year of accreditation:

Duke University	Biomedical Engineering	1972
Rensselaer Polytechnic Inst.	Biomedical Engineering	1972
Brown U.	Biomedical Engineering	1973
U. of Illinois at Chicago	Bioengineering	1976
Case Western Reserve U.	Biomedical Engineering	1977
Texas A&M U.	Bioengineering	1977
Northwestern U.	Biomedical Engineering	1982
U. of Pennsylvania	Bioengineering	1982
Boston U.	Biomedical Engineering	1984
Johns Hopkins U.	Biomedical Engineering	1983
Marquette U.	Biomedical Engineering	1983
Arizona State U.	Bioengineering	1985
U. of Iowa	Biomedical Engineering	1985
U. of Pennsylvania	Biomedical Engineering	1982
U. of California at San Diego	Biomedical Engineering	1987
Wright State U.	Biomedical Engineering	1988

⁷ "Biomedical Engineering" by JD Bronzino, in Encyclopaedia of Applied Physics, VCH Publ, Inc, 1991, Vol. 2, p. 513; Bronzino cited Pilkington et al. IEEE EMBS Mag.;8(3) 9-17 (1989)

MISSION STATEMENTS

University of Miami:

The undergraduate BME degree is worthwhile as engineering in medicine and biology does require that the life sciences be intensively and jointly studied and integrated with subjects in the technical and physical science areas during the first few years of university studies. The student may learn the necessary special skills later in graduate school or on the job. Many graduates with BME degrees pursue somewhat unconventional careers for engineers. Many go to medical school, some work as clinical engineers, others find jobs as clinical researchers, or work in medical product sales and marketing. The ones who wish to do research, typically go on to graduate school.

There are special opportunities for the especially highly motivated and ambitious student to achieve both sets of skills in parallel. The existing B.S. Eng. Sci. BME Option program has two objectives:

1. Prepare the students for a career in the industrial/commercial world, starting right after graduation;
2. Prepare the students for advanced studies, including medicine, law or business.

For the sake of understanding the missions of the existing programs, we studied the bulletins of many of these institutions and found that the objectives of most of the programs are to prepare their undergraduates either for graduate study or further professional studies in medicine, law or business. Some examples of the objectives of the programs are cited here from the bulletins of the institutions:

Boston University:

"...integrated training in science, engineering, and mathematics as preparation for a variety of careers in engineering and the health care professions. All standard premedical requirements can be met within the program."

"Graduates...are strongly encouraged to pursue further training in engineering, science, medicine, business, law, or other health-related programs."

Brown University:

"The Brown University Engineering Curriculum emphasizes an in-depth understanding of the fundamentals of physical and chemical science, mathematics and engineering science which underlie technical work in all fields of engineering."

"The concentration is completed by passing a coherent set of nine courses in one of the specialized areas of Engineering."

Case Western Reserve University:

".... the biomedical engineering program is suitable for students seeking employment in industry and hospitals immediately after graduation, students planning to pursue graduate studies in biomedical engineering or some other field of engineering, or students seeking advanced degrees in medicine or other health professions."

University of Iowa:

"Students who complete this program may pursue career opportunities in industry, in government, or they may elect or continue their formal education in the engineering, medical, or legal professions."

Johns Hopkins University:

"The program emphasizes preparation for advanced study in an area related to biomedical engineering and is broad enough to accommodate students who plan graduate work in biology, medicine, engineering, biophysics, physiology or biomedical engineering."

Louisiana Technical University

"...at the end of the first three years of study the student will have completed the basic requirements necessary for admission to medical school."

Marquette University:

"Since the curriculum satisfies the entrance requirement of many professional schools, the student can, usually without additional preparation, pursue studies in medical school, dental school, schools of veterinary medicine, graduate biomedical engineering, or traditional areas of engineering."

Northwestern University:

"...prepares students for careers in dentistry, medicine, and/or research or with corporations in the health care industry."

The following citations are from institutions which do not offer BS BME or BS Bioengineering degrees:

Mercer University (BS EE):

"The professional preparation of biomedical engineering normally requires educational preparation beyond the bachelor level."

Thayer School of Engineering (B.Eng.):

Dartmouth College

"....biomedical engineering students construct their own programs in consultation with their advisers, and, since the students in biomedical engineering may have very different interests, they may follow very different routes."

Vanderbilt University (HONORS PROGRAM):

" The undergraduate curriculum serves as a premedical program, preparation for advanced study in biomedical engineering and biomedical sciences, or preparation for a career in the practice of biomedical engineering."

In summary, the objectives may be summarized:

Boston University	G	M	
Brown University			
Case Western Reserve University	G	M	I
Duke University			
University of Iowa	G	M	I
Johns Hopkins University	G	M	
Louisiana Technical University	M		
Marquette University	G	M	
Northwestern University	G	M	I
Rensselaer Polytechnic Institute			
Tulane University			
Wright State University			
Mercer University	G		
Thayer - Dartmouth College	individually tailored		
Vanderbilt University	G	M	I

G - emphasis on graduate school, M - premed, I - industrial jobs

Based on the brief quotations from the mission statements of the universities offering BME programs, it is fairly clear that they all emphasize the interdisciplinary nature of biomedical engineering. Most of the program statements either urge that the entering student have the aim to continue beyond the bachelor's degree in biomedical engineering or simply state that the program will prepare the student for medical, veterinary or other graduate studies.

ENROLLMENT

The BS BME and BS in Engineering enrollments were also presented in the reference⁸ and the data is shown in Fig. 1. The scale is both for the number of engineering undergraduates divided by 100 and the number of BME students. While both numbers were rising steadily, the percentage of all engineering students studying BME increased from 0.70 % in 1975 to 0.98 % in 1986 as shown in Fig. 2.

⁸ ibid. p. 543

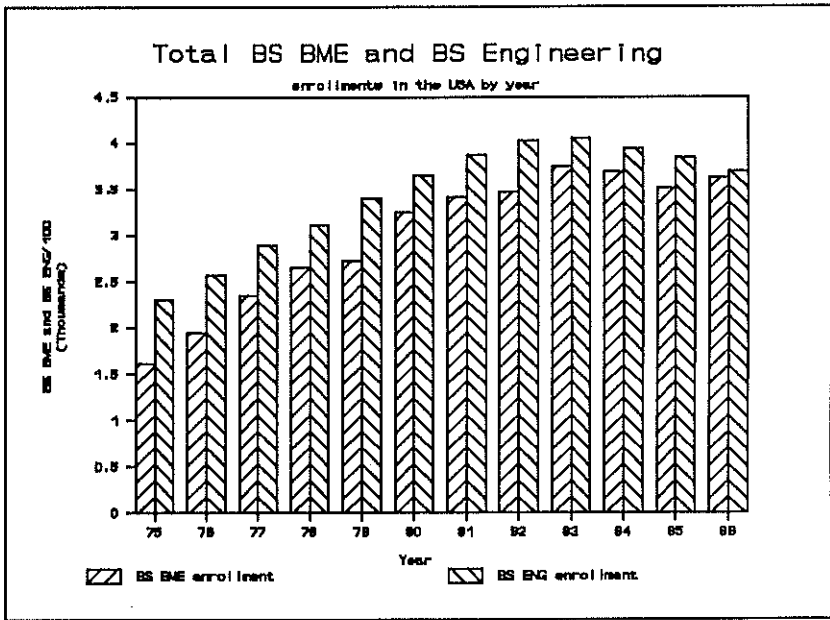


Figure 1 Enrollment trend in undergraduate Engineering and Biomedical Engineering programs in the USA by year. (Pilkington et al. '89)

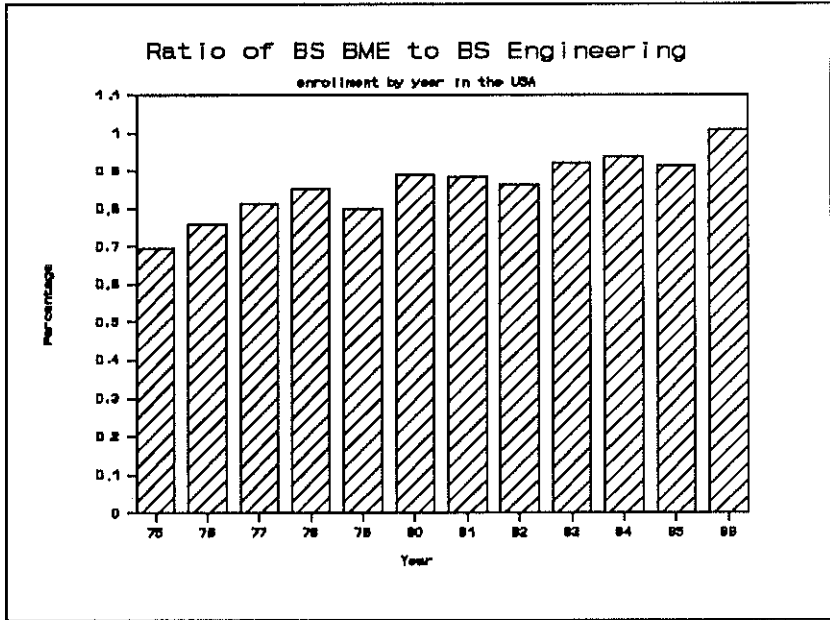


Figure 2 Trend in ratio of BS BME to BS Engineering enrollment in the USA

The Annual Survey of Biomedical Engineering programs in the USA is assembled by Louisiana Technical University. The tabular data in the report for 1990 is summarized for comparison with Pilkington's survey and it is presented on the next page. The total enrollment of 2668 in that survey does not include all the programs, for example, Boston University and Brown University are both absent. The data was obtained from those who voluntarily participated in the survey.

GEOGRAPHIC DISTRIBUTION OF BS BME PROGRAMS IN THE USA

The geographic distribution of the ABET accredited BS BME and Bioengineering programs is along a diagonal strip from Southern California to New England, with none in the Northwest or in the Southeast. Geographically the closest programs to Miami are offered at Tulane, Louisiana Tech U. and Duke.

**SUMMARY OF SURVEY OF BIOMEDICAL ENGINEERING PROGRAMS
ISSUED BY LOUISIANA TECHNICAL UNIVERSITY**

BME UNDERGRADUATE AND GRADUATE PROGRAMS

INSTITUTION	BS CREDITS	ABET	ENROLLMENT		
			BS	MS	PhD
AR State U	133+6	yes	133	23	7
Carnegie Mellon U	opt	yes	121	25	inc.
Case Western Reserve U	?	yes	174	110	inc.
The Cathol. U of Amer	137	yes	59	6	3
Duke U	?	yes	240	3	58
U of IL, Chicago	192q	yes	100	15	18
U of Iowa	128	yes	145	29	29
Johns Hopkins	124	yes	284	44	27
Louisiana Tech U	139	yes	139	9	11
Marquette U	Eng 133	yes	245	50	inc.
Mercer U, Macon GA	opt 204q		52		
premed	opt 207q				
U of Miami	option		inc.		
BSES-MD	126/132		6	46	19
North Dakota State U	opt 204q		44	55	2
Northwestern U	46 courses	yes	188	12	58
U of Penn	37 courses	yes	135	8	85
U of Southern CA	128/136	yes	180	14	20
Syracuse U	136	EAC			
Texas A&M U	136	yes	240	24	16
Trinity College	option		N/A		
Vanderbilt U	129		183	11	14
Wright State U Dayton OH	203q	yes	N/A	N/A	N/A
premed	207q				
SUM			2668	484	367

Detailed comparisons of the curricula of Boston University (138)⁹, Brown University (128), Case Western Reserve University (132), Thayer - Dartmouth College (N/A), University of Iowa (128), Johns Hopkins University (124), Louisiana Technical University (139), Marquette University (133), Mercer University (204 qu.), the three proposed options of the University of Miami (133, 132, 133), Northwestern University (48 courses), and Rensselaer Polytechnic Institute (134) is provided in Appendix D.

⁹ Semester credits, quarter credits (qu.) or courses required for graduation are given in parentheses.

SPECIFIC MANPOWER AND OTHER NEEDS

Personnel:

We are already committed to the HPME and B.S. Eng. Sci. BME Options with 8 HPME and about 30 other undergraduates enrolled. The present BME consists of five faculty members with primary appointments in the Dept. of Biomedical Engineering. These are shown in Table 1:

TABLE 1

Name	Year of Appt.	Present Rank	Terminal Degree	Inst.	Yr
Eugene C. Eckstein	1975	Professor	PhD	MIT	'75
Joachim H. Nagel	1986	Professor	PhD	Erlangen (Germany)	'79
Özcan Özdamar	1983	Professor	PhD	Northwestern U.	'76
Qiushi Ren	1991	Asst. Prof.	PhD	Ohio State U.	'90
Peter P. Tarjan	1987	Professor	PhD	Syracuse U.	'68

Brief Curricula Vitae of these five faculty members are provided in Appendix E.

The total "hard" faculty lines for the department in the university budget amount to 2.35 FTE. The rest of the compensation for the faculty is from a variety of research grants. With the arrival of the undergraduates, the faculty has been overtaxed. Resources have been committed to the Department to alleviate these difficulties beginning in FY 1993.

The Department is currently conducting interviews for a suitable candidate to fill the Knight Chair in Biomedical Engineering. The search is directed at a researcher with national and preferably international reputation.

By the Fall Semester of 1992 it would be essential to be able to recruit at least one junior faculty member for course and laboratory development. One additional colleague is expected to join the department during the Fall of 1993. This would bring the faculty to 8 with primary appointments. These faculty additions have been committed by the Administration.

Starting in the Fall of 1992, three half-time Teaching Assistants would be needed to help in developing laboratory exercises and to teach and supervise undergraduate laboratories. It is expected that a small group of students, perhaps 10 individuals, a mixture of HPEM and transfer students, would be enrolled in laboratory courses during the Fall Semester of 1992.

The development of laboratory exercises and the selection of equipment for the undergraduate teaching laboratories did begin with graduate students being temporarily assigned to these tasks while searching for more permanent support for their thesis research. Presently one half-time TA is employed.

There is a special fund of \$100,000 available for supplies and equipment. This is being carefully spent and the hardware is being evaluated on single instruments purchased for this task. We expect to duplicate the equipment to provide for at least 6 stations.

Library resources must be increased significantly for the undergraduate program. The cost is estimated at about \$10K per year for the first three years. However, this cost may be offset by a proposal under development that would establish a regional resource library for the local biomedical industry at the University with external support, initially from a single benefactor.¹⁰

FUTURE POSSIBILITIES

Dual Majors

We may offer a true dual major to qualified BS BME candidates where the student is required to complete a wider set of courses than in any of the three aforementioned tracks. This may take an additional one or two semesters.

With a similar level of extra effort a student with good grades could enroll in graduate school and opt for an MS.

If the dual major program at the BS level is not too restrictive in terms of academic performance then it may offer an attractive alternative to the student whose grades are not spectacular, but still quite respectable (CGPA > 2.8 ?)

Honors Program in BME

Another possibility is an Honors Program in BME, after the model of the HPEM program, for exceptional students with high SAT scores or excellent CGPAs at the end of the freshman year. These students would possibly earn both the BS BME and MS BME degrees within four years. (Possible requirements: SAT > 1200 and 3.2+ GPA at the end of the freshman year.)

¹⁰ For some time, it has been an objective for the Dept. of BME to develop a strong Industrial Affiliates Program. This must be a give-and-take activity. Library services are extremely valuable to industrial firms. Maintaining their own collections and services is very costly compared to the cost of supporting a regional shared resource. The proposed collection would consist of books, journals, encyclopedias, technical dictionaries and other reference materials including hardware for patent and other database searches.

Courses for Premed Students, not in Engineering

The introductory BME courses may be modified by eliminating their design orientation for science electives to students with their eyes toward medicine and without interest in an undergraduate engineering degree. The BME Program would thus enhance the elective opportunities of Premed students in the College of Arts and Sciences.

Potential Dual Majors with Business Administration

Dual Major Options or Dual Degrees (BS BME with Business Education) may be developed for students with an interest in the entrepreneurial aspects of the biomedical education.

Unique Honors Programs (HP)

Unique programs may be tailored in several departments. For example, one might combine the BS BME with an MBA in five years. An MS in Health Care Administration may be combined with a BS in BME. Engineers tend to view MBA training as a tool for advancement in industrial organizations, rather than a way to switch their careers to non-engineering employment, such as financial management or marketing. Saving a year in graduate school would partially offset the higher tuition. A potentially higher starting salary is another attraction.

State Tuition Subsidy

The Dept. of BME intends to establish **State support** for its BS BME program to attract a larger number of interested residents from Florida. Such a program seems to be a feasible goal. A target date for this may be set for 1995-96. Note that state support for Biomedical Engineering already exists for the MS program and funding for Ph. D. students has been recommended by the Post-Secondary Education Planning Commission, starting in the Fall of 1992.

Industrial Cooperative Programs

Such programs are extremely popular throughout the country both for finding part-time employment and a source of support, and for on-the-job training for undergraduates. The strengths of the local industry and the variety of opportunities for such programs are outlined in Appendix A.

RETURN ON INVESTMENT ANALYSIS FOR THE PROPOSED PROGRAM

INVESTMENT:

1991-2	UG Laboratories	\$100K	
	Additional Sr. Stf. Asst. ¹¹	\$ 12K	
	CFB for Sr. Stf. Asst.	\$ 3K	
	TOTAL		\$115K
1992-3	Supplement for Knight Chair ¹²	\$ 40K	
	CFB for Knight Chair (30%)	\$ 27K	
	1 Assistant Professor	\$ 45K	
	CFB for Asst. Prof.	\$ 14K	
	Start up research cost	\$ 30K	
	UG Laboratories	\$ 20K	
	Additional administrative person ¹³	\$ 25K	
	CFB for Sr. Stf. Asst.	\$ 7K	
	2 additional TAs	\$ 20K	
	TOTAL		\$228K
1993-4	Supplement for Knight Chair ¹²	\$ 45K	
	CFB for Knight Chair (30%)	\$ 29K	
	2 Assistant Professors ¹⁴	\$ 95K	
	CFB for 2 Asst. Prof.	\$ 29K	
	Start up research cost	\$ 30K	
	UG Laboratories	\$ 20K	
	Additional administrative person ¹³	\$ 26K	
	CFB for adm. pers.	\$ 8K	
	3 TAs ¹⁵	\$ 30K	
	TOTAL		\$312K
1994-95	Same as for 1993-94 + 5%		\$328K
	INCREMENTAL COST IN FOUR YEARS		\$983K

¹¹ This person was hired in late January, 1992.

¹² The endowment yields approximately \$50K per year, depending on the prevailing interest rate.

¹³ Not a new hire but the same position that was opened in January, 1992.

¹⁴ One of these is a new hire.

¹⁵ Only one is a new TA position.

REVENUES:

1991-2	Tuition fees of 36 undergraduates (excl. sch'ships) Revenues	\$380K+	\$ 380K+
1992-3	Tuition fees of 55 undergraduates less scholarships release time for research for Knight Chair for 1 Asst. Professor Revenues	\$600K+ \$ 20K \$ 15K	\$ 635K+
1993-4	Tuition fees of 80 to 90 undergraduates less scholarships release time for research for Knight Chair for two Asst. Professors Revenues	\$1,150K+ \$ 30K \$ 30K+	\$1,210K+
1994-95	Tuition fees of 110-120 undergraduates less scholarships release time for research for Knight Chair for two Asst. Professors Revenues	\$1,552K+ \$ 35K \$ 35K+	\$1,622K+
	INCREMENTAL INCOME		\$3,847K+

YEAR INCREMENTAL INCOME - INVESTMENT = NET

1991-2	\$380K	\$115K+	\$ 265K+
1992-3	\$635K	\$228K+	\$ 407K+
1993-4	\$1,210K	\$312K+	\$ 898K+
1994-5	\$1,622K	\$328K+	\$1,294K+

TOTAL **\$2,864K**

This net amount, obviously, is not intended to be projected as profit. However, the incremental costs for the University to provide courses for these students in other departments is minimal, no special courses will be necessary outside of the BME Dept.

After 1992 it is expected that the added faculty members would devote about one third to one half of their time to research.

The rate of expenses and revenues should reach a steady state by 1995-96 when undergraduate enrollment is expected to reach about 120 students. This assumes about 30 to 40 freshmen and about 5 transfer students per year. In engineering programs a fairly large percentage of the entering students transfer to other fields with less demanding requirements. We estimate that our attrition rate would be approximately 25-30 percent over four years.

We expect to extend the State PEPC subsidy for the BME program, now covering the MS BME degree (and the PhD BME program in 1992-93). This could dramatically increase the undergraduate enrollment and the associated revenues.

It is possible that as the program expands, it will prove desirable to increase support for faculty and for infrastructure. Should such additional commitments be deemed necessary, the University will be in a position to do what is appropriate, given the large net revenue benefit of this program, without compromising other programs. In essence, the University has a built-in reserve for contingency should it turn out that needs exceed current projections and requests.

The net advantage of establishing the BS BME program is clear.

CONCLUSION

The proposed BS BME program has been shown to be competitive with similar programs in the USA. Certain local circumstances make the program especially promising, including the high quality and large size of the UM School of Medicine, the existence of our rapidly growing graduate program in BME, the strength of the local biomedical industry, the absence of competing programs in Florida and the Southeastern USA with the exception of Tulane's program.

The investment in both new faculty and equipment appear modest in light of our success in attracting high quality students to the field of Biomedical Engineering before the proposed BS BME program was formally established. External funds may be obtained for the program to lessen the financial burden on the University.

While the program should help maintain or even increase enrollment in the College of Engineering, it is expected to provide benefits to the Premed students with an interest in technology.

APPENDIX A

INDUSTRY STRENGTHS

The industries based on medical technologies have been in existence in South Florida for about four decades, the history is interesting and deserves a review to understand the successes and some of the problems.

EXISTING RESOURCES

Southeast Florida is already established as the leading medical center in the State. It is also a center of the international medical device industry. Biomedical firms in the Southeast area include Coulter Electronics, Cordis Corp., Baxter Health Care Systems, Althin Corp., Telectronics Pacemakers, IVAX Corp., Symbiosis Corp., and many smaller but rapidly growing firms such as Corvita Corp., Hyperion, Inc., NIMS, Intelligent Hearing Systems, Mekanika, and so on.

An extensive and strongly research oriented health care system has developed around the medical school of the UM. It is complemented by the health sciences and engineering resources of the UM and FIU.

THE BIOMEDICAL INDUSTRY IN SOUTHEASTERN FLORIDA

The biomedical industry in Southeastern Florida produces a broad range of products including diagnostic reagents, angiographic and radiologic catheters, hollow fiber hemodialyzers, diagnostic instrumentation, implantable pacemakers and neural stimulators, pharmaceutical products, orthopaedic devices, ophthalmic products. The list of companies is incomplete for several reasons: some firms are only engaged in a secondary way in these industries, their primary business activities are classified elsewhere; distributors were generally not included, several relatively new firms have been included thanks to a personal network, others may have been omitted for lack of visibility.

Mario Gonzalez and other members of The Dade Manufacturers' Council studied the history of this industry in South Florida. Those firms which have been internal or external spin-offs of other firms are shown below with an indentation. The purpose of this is to illustrate entrepreneurial and technical linkages in this area which are essential for the creation of new jobs for our graduates.

John Elliott was identified as the first significant entrepreneurial innovator in the biomedical industry in this area. He founded the **John Elliott Blood Bank** in 1946, and developed a number of blood typing sera as well.

Dade Reagents was founded on Elliott's original work producing diagnostic and clinical chemistry products. Dade Reagents was acquired by the American Hospital Supply Corp. and it is now **Baxter Dade Reagents**, a division of **Baxter Health Systems**. The main location of the firm is located in the western part of the city. It develops and manufactures reagents for diagnostic use and automated laboratory instruments in its Dade County facilities. It recently acquired the original Cordis Administrative and Technical Center on West Flagler Street and NW 107 Avenue, a modern building complex with about 250,000 ft² of space.

William P. Murphy, Jr., M.D. arrived from Boston to become Director of Research at Dade Reagents in 1955. Dr. Murphy, an inventor, was also trained as a mechanical engineer. He started the Medical Development Corporation in 1957. This firm was renamed **Cordis Corporation** in 1959. The company developed some innovative instruments and devices in its first few years of operation, including the first disposable procedure kits and trays. In 1962 Cordis entered the field of implantable pacemakers and it soon became the second largest supplier of those in the world. In the mid-1960s the company developed two additional major product lines, implantable valves for hydrocephalus, and torque controlled angiographic catheters. In each of these markets it became the largest global supplier. In 1970, in a joint venture with the Dow Corp., Cordis introduced the first disposable hollow fiber artificial kidney, a major advance. The artificial kidney and pacemaker businesses had been sold, but each one remained in Dade County. Cordis Laboratories specialized in enzyme tagged immuno- essay test systems. Most of its R&D, manufacturing and commercial activities are in Dade County. Cordis operates manufacturing facilities in Miami Lakes, the Netherlands and France.

Theratek, Miami Lakes, was a joint venture between Cordis and an out-of-state firm, conducting a program to develop and commercialize a novel rotating hydrodynamic angioplasty device for reopening occluded arteries. Theratek was acquired by the Dow, Corning Wright Corp. in 1990. Roberta Goode, an engineer, holds the MS BME from the UM.

Althin, CD Medical, Inc., Miami Lakes, was established to develop and commercialize hollow fiber artificial kidneys, as a joint venture between Dow and Cordis, but it is now wholly owned by Mr. Althin, a Swedish entrepreneur. Its engineering and manufacturing facilities are located in Miami Lakes.

Telectronics Pacing Systems, Inc., Miami Lakes, a manufacturer of implantable cardiac pacemakers and leads, as well as a supplier of associated instruments, is a subsidiary of Telectronics Pty. Ltd., a firm with headquarters in Sidney, Australia. Telectronics is a member of the Nucleus group in Australia which in turn was acquired by Pacific Dunlop in 1988. Telectronics is located in Miami Lakes where R&D and manufacturing are its dominant activities. This Dade company was acquired from Cordis Corporation in 1987. Several technical employees, including Rosemary

Serbent and Peter Accorti hold MS BME degrees from the UM.

Diamedix, Corp., Miami, is the successor of Cordis Laboratories. Dr. Joseph Giegel is now the president of the corporation. He had served as the Director of Research of the Dade Division of the American Hospital Supply Corp. Diamedix is one of the branches of the IVAX Corp. Dr. Giegel was trained at the UM School of Medicine as a biochemist.

Corvita Corp., Miami, was founded by Norman R. Weldon, Ph.D. in 1987. Dr. Weldon served as president of Cordis for seven years before acquiring the rights from Cordis to develop a line of unique arterial grafts. The majority of Corvita's employees were formerly employed by Cordis. Leonard Pinchuk, Ph.D. Vice President, received his doctorate from the UM in "Interdepartmental Biomedical Engineering."

Hyperion, Corp. was formed by combining two companies with closely related medical products and markets. Drucker was formerly owned by Coulter Electronics and Hyperion by Cordis. The firm develops and manufactures various types of laboratory instruments and infusers in its South Dade facility.

Exonix, Inc., Miami, is a designer and manufacturer of cardiac pacemakers for export. The company was started by Frank Barreras and Oscar Jimenez, two engineers who had worked for Cordis Corp. for more than a decade. The firm sells kits for final assembly in Uruguay and other countries and is beginning to manufacture a line of special diagnostic angiography catheters in a partnership with St. Jude Medical Corp. of St. Paul, MN.

Novoste, a radiological catheter manufacturer began its operation in Miami. It was founded by Thomas Weldon and Charles Larsen who had both worked for Key Pharmaceuticals and for Cordis. Tom Weldon is the son of Dr. Norman Weldon of Corvita. The manufacturing plant is in Puerto Rico.

Symbiosis, Miami, is a new and rapidly growing engineering and manufacturing firm started by Kevin Smith and Thomas Bales, two engineers who also had spent many years in the angiographic activities at Cordis. They manufacture disposable surgical instruments for various procedures. The company has grown at a phenomenal rate based on the acceptance of its products by the medical community.

Coulter Electronics was founded by Wallace Coulter, the inventor of the Coulter Counter for cell counting. This invention became the cornerstone for a series of highly successful laboratory instruments developed, manufactured and marketed by Coulter Electronics in Hialeah. The company has diversified from the instrument field and it is involved in diagnostic and therapeutic biological products. Wallace and Joseph Coulter are the sole owners of the company. Coulter's commercial network is global.

Key Pharmaceutical Products, Inc. was founded as a distributor of pharmaceutical products on Miami Beach in 1947. The company later became well-known for its controlled release patches for therapeutic agents, particularly for hypertension. The company is now owned by Scherring Plough.

Guidelines, Inc., a consulting firm specializing in regulatory affairs and the conduct of clinical research, was founded by Allyn Golub, Ph.D. with David Cohen who had been employed by Keys Pharmaceutical.

IVAX Corp., Miami, was founded by Philip Frost, M.D. The firm manufactures and markets specialty chemicals, soaps and detergents, diagnostic test kits, reagents and instruments. It is also engaged in research and development. The company has four subsidiaries in the area: **IVAX Industries, IMED, DIAMEDIX and Pharmedics.**

Artificial Hearing Systems, Miami, is engaged in the development of evoked potential recording equipment for diagnostic purposes, and tactile vocoders for the deaf. Its principals are mostly UM faculty members.

Biosearch, Inc., Ft. Lauderdale, specializes in regulatory services for the biomedical industry.

Brain Power, Inc., Miami, specializes in instruments and in the application of specialized coatings to optical lenses. The president, Dr. Herbert Wertheim is a UM Trustee.

Data Link Systems, Inc., Ft. Lauderdale, is engaged in the assembly and marketing of medical data processing and information retrieval systems for medical practices.

HEICO, Corp., Hollywood, manufactures medical lab equipment.

Hemodynamics, Inc., Boca Raton, markets a non-invasive diagnostic device for venous and arterial disorders.

Merimed, a Hialeah is engaged in the development and manufacturing of orthopaedic appliances.

Neuromed, Inc., Ft. Lauderdale, develops, manufactures and markets implantable neural stimulators and associated products.

NIMS, Inc., Miami Beach, is involved in the development, manufacturing and distribution of noninvasive systems for respiration and cardiac monitoring in the intensive care setting. Herman Watson, vice president, holds the MS BME from the UM.

Verimed, Inc., Ft. Lauderdale, produces electronic instrument systems for biofeedback based therapeutic purposes. William Mee, vice president, is an MS graduate of the

APPENDIX B

BIOMEDICAL DEVICE DEVELOPMENT RELATED ACTIVITIES

Some of the activities in South Florida which may play important roles in the practical training of the BME undergraduates, including cooperative training programs. The list may be incomplete, and every element does not have to participate in it to be successful. Its intent is to show the breadth of activity in the region and how industrial links may develop.

The elements are not in any order of priority, no one should try to rate their importance, size, recognition, etc.

1. Eye surgical instrumentation - mechanical, lasers, optics

Bascom Palmer Eye Institute

Jean-Marie Parel, Dipl. Eng., Qiushi Ren, PhD, David Denham, MS and Richard Parish, MD.

They have developed a number of instruments and techniques which have been commercialized. They have expertise in ophthalmology, optics, lasers, micromechanical design and micromachining.

2. Radiation oncology related products for mechanical fixation of the patient, selective irradiation, image processing, etc.

Radiation Oncology Dept.

J. Schwade, MD, Pavel Houdek, PhD, C. Gottlieb, PhD.

A variety of instruments have evolved to improve stereotactic reproducibility or precision in radiation therapy. Patents have been issued, some pending.

3. Orthopaedic prostheses, orthotic devices, instruments for surgery and rehabilitation

Rehabilitation Center and the Dept. of Orthopaedics

Mark Brown, MD, PhD, Loren Latta, PhD, David Holmes, MS and graduate students in BME.

Also, Dr. Sunderesan at the UM ME Dept. is interested in composites and the development of an improved artificial hip.

Instrumentation for the intraoperative measurement of spinal stability is approaching commercialization. A chemo-nucleolysis technique was tested in primates with promising results and no side effects. A tissue bank is operating which can supply materials for fixation and joint replacements. Laser techniques have been developed for anastomosis and microsurgical reconstructions. Biofeedback devices are

developed and evaluated to treat stroke and head trauma patients and those with spinal cord injury.

The Orthopaedics Biomechanics Laboratory at Mt. Sinai Medical Center is active in rehabilitation research for arthritis and other orthopaedic problems. The activities of the lab also include biomechanical testing of orthopaedic devices.

Merimed, a Hialeah firm produces orthotic devices. Dr. Latta is an active consultant of the firm.

4. Auditory sensory aids or substitutes, hearing tests

Mailman Center and an NIH SBIR supported firm.

Ozcan Ozdamar, PhD, Kim Oller, PhD, and Rebecca Eilers, PhD, Ed Miskiel, MS, and BME graduate students.

Developed a tactile auditory sensory substitute that is being used extensively to rehabilitate deaf children. Also, test instruments have been developed to determine the level of hearing in infants, using auditory evoked potentials.

Neural network type processing is being applied to classify auditory evoked potentials and EEGs in patients with epileptic seizures.

5. Neuroprostheses

Miami Project

Large staff of scientists and some engineers. The project is lead by Drs. Bunge and Green.

Also, two companies are involved in the development of implantable neurosurgical instrumentation:

Cordis Corporation (Marvin Sussman, PhD and staff),
Neuromed (William Borkan, President)

The Miami Project's ultimate objective is to cure, or rehabilitate spinal cord injured patients, but it also carries on research in neural tissue transplantation, which is intended to be applied to the treatment of Parkinson's disease and other neurological problems. These will probably require the development of special surgical instruments and evaluation techniques using new test instruments.

Extensive facilities exist for the rehabilitation of spinal cord injured patients. Functional neural stimulation is being employed by Dejan Popovic, PhD, who is a Visiting Professor at the Miami Project along with two of his graduate students from the University of Belgrade.

6. Diagnostic, therapeutic and measuring instruments for the rehabilitation of patients with low back pain

Pain Research Center at South Shore Hospital, MB.

H. Rosomoff, MD, T. Khalil, PhD, S. Asfour, PhD, M. Goldberg, PhD, Dr. Abdel-Moty and several UM IE graduate students.

Ergometric instruments, functional electrical stimulation, monitors for muscle reeducation and possibly new forms of transcutaneous nerve stimulation for analgesia during functional manipulation have been or will be developed.

7. Urological prostheses

BME Dept. and Urology Dept. of UM. Eugene Eckstein, PhD and Norman Block, MD have cooperated on the development of an artificial urinary prosthesis. A US patent was issued for a coating material for the bladder that undergoes volumetric changes with pH in the urine to prevent the formation of calculi.

8. Nephrology

Althin, CD Medical, is a major supplier of hollow fiber hemodialysis units for patients in renal failure, and is developing new devices for hemodialysis and blood oxygenation.

9. Neonatal monitoring

The UM Dept. of Pediatrics is a major regional center for neonatal care. Research is conducted toward the development of improved techniques for the evaluation of patients at risk for SIDS and for neonatal vital signs monitoring.

10. Instruments for physical and emotional stress assessment

The Behavioral Medicine Research Center has two facilities in operation: the Coral Gables laboratory performs a variety of research projects in vitro and in vivo. The Jackson Towers Center is dedicated to study the causes of hypertension, particularly among blacks. A large staff is directed by Neil Schneiderman, PhD. (Joachim Nagel, PhD and several BME graduate students are developing instrumentation.)

Noninvasive instruments for blood flow, blood pressure, and other physiologic parameters have been developed or modified. Also, various devices have been integrated into the hypertension test program, and the data collection and analysis portions have been automated to a great extent.

11. Medical image processing

Up-to-date MRI (Magnetic Resonance Imaging) and CT (Computer-aided Tomography) centers are operating at JMH, Mt. Sinai MC and at other local hospitals. The integration of different types of diagnostic data and the control of treatment is a central theme of research. (Jonathan S. Kippenhan, Ph.D., a 1991 graduate of the UM BME program is a research staff member at Mt. Sinai MC.)

12. Pulmonary function testing and diagnosis

Mt. Sinai Medical Center, Marvin Sackner, MD, Adam Wanner, MD, Horst Baier, MD, and others have been involved in the development of such instrumentation.

Dr. Sackner is the founder and CEO of NIMS, Inc., a company involved in a novel non-invasive respiratory and cardiac monitoring system.

13. Cardiovascular devices and electronic implants

John Lister, MD, has been pioneering the use of dual channel interactive stimulators for cardiac electrophysiologic diagnosis. He has worked in close cooperation with E.D. Smith and others.

J. Walter Keller, MS, has been developing a complex model for the electrical activity of the heart under contract with Wallace Laboratories. The model is not only a teaching tool for medical professionals, but it has the potential to become a useful tool of research in cardiology. The project offers opportunities for numerous educational products.

Cordis Corporation, Miami, is a major manufacturer of disposable diagnostic and therapeutic devices for the cardiovascular system.

Dow Corning Wright's Theratek, Inc. is commercializing a novel rotating hydrodynamic angioplasty device for reopening occluded arteries, in parallel with intensive development that involves Eugene Eckstein, PhD, Sanjay Roy, PhD and graduate students of the UM BME and MEN Departments.

Telectronics Pacemakers, Inc., a subsidiary of the Australian Telectronics Pty. Ltd., is a significant participant in the pacemaker field. Important research has been performed by the company toward the development of implantable automatic antiarrhythmic pacemakers and defibrillators.

Claude Lindquist, PhD, in the EE Dept of the UM has been working with some graduate students in EE on body surface ECG processing problems.

Exonix, Inc. is a Miami firm that manufactures pacemaker electronic kits and diagnostic catheters.

14. Biomedical Expert Systems

The EE Dept. has several faculty members interested in applications of E.S. Biomedical applications are natural extensions of the work.

15. Computer applications in medicine

The activity in this area is very diverse and it ranges from hospital and office management to smart, automated measurement systems and mathematical modelling of biological systems.

For example, Mr. Keller's teaching and research model of the heart is a major effort

by one person.

Robert Leif, PhD, Coulter Fellow, and his staff are applying software engineering precepts to cancer and other diagnostic problems.

Ozcan Ozdamar, PhD and several graduate students in the BME Dept. of the UM have been active in the analysis of speech, as well as in the development of a signal averaging system for the analysis of auditory evoked potentials from the brain stem.

These are just a few examples of computer applications in the South Florida area.

16. Biomaterials

Leonard Pinchuk, PhD, developed a unique polyhema coating for artificial bladders as his doctoral research project under the supervision of Eugene Eckstein, PhD of the BME Dept. and others at the UM. Dr. Pinchuk is now leading the development of a non-woven small arterial graft in Corvita Corp. in Miami. Clinical trials have been conducted with this graft in Europe. His specific expertise is in biocompatible polymers which are also considered for breast implants and other tissue replacements.

Considerable materials technology has been amassed in the field of membranes for blood oxygenation and hemodialysis at Althin, C-D Medical Corp. in Miami Lakes.

Cordis Corp. has laboratories for the development and quality control of polymers used in its own product lines with up-to-date instrumentation to support this work.

Biocompatibility of polymers has been actively studied in rabbit eyes by a team headed by Richard Parrish, MD at the Bascom Palmer Institute.

17. Cytometric and clinical laboratory instrumentation

The Papanicolaou Institute had been a pioneer in cytology. One of its researchers, Robert Leif, PhD is now Coulter Fellow at Coulter Electronics, Inc. in Hialeah and an active member of the UM BME Dept. The company was founded by Mr. Wallace Coulter, the inventor of the Coulter counter. His firm has grown not only to be financially important, but to become internationally recognized for innovations in cell processing and diagnostic instrumentation. The development of diagnostic and therapeutic agents for cancer is a more recent business interest of Coulter.

Baxter is another locally active firm in clinical laboratory instrumentation and in the preparation of biochemical reagents.

18. Noninvasive vascular diagnostic instrumentation

Jeffrey Raines, PhD of the UM SM is the inventor of a diagnostic instrument for lower extremity vascular diseases. Dr. Raines has been involved in developing products in the field with Life Sciences, Inc., a Connecticut firm.

19. Miscellaneous areas of technological development

Prof. Patricia Mertz of the Dept. of Dermatology has led a group in the development and evaluation of an "electrical band-aid." Wound healing has been an area of active research for her group.

Hyperion is a Miami firm engaged in the development of infusion pumps for the lymph system and other biomedical instruments.

Symbiosis, Inc. began operations less than four years ago. Since then it has become a major force in the disposable surgical instrument field through its unique systems for minimally invasive surgical procedures, such as the removal of the gall bladder via three small abdominal incisions, on patients who enter and leave the hospital the same day.

A South Broward firm manufactures and supplies dental implants for permanent reconstructions.

Motorola's Fort Lauderdale facility is a leading supplier of medical, and other paging equipment.

In summary, the combined resources of the School of Medicine, the local hospitals, and the existing local industry provide a strong base for the development of cooperative opportunities for undergraduates in Biomedical Engineering.

APPENDIX C

SOME EXISTING SHARED FACILITIES AT THE SCHOOL OF MEDICINE

1. ELECTRON MICROSCOPY:

Trained technicians and a PhD electron microscopist will fix, section and photograph any biological or non-biological samples using high resolution transmission and scanning electron microscopes.

2. GRAPHICS WORKSTATION - MOLECULAR MODELING:

Minicomputer based 3-dimensional color graphics workstation is available for use by molecular biologists and structural chemists for studies on site directed mutagenesis, protein structure and enzyme active site analysis. PhD protein chemist is director of the facility.

3. FLOW CYTOMETRY:

Dual laser automated flow cytometer facility operated by the South Florida Papanicolaou Comprehensive Cancer Center of the University of Miami School of Medicine. Cell cycle, cell size analysis, cell typing, surface and total cell antigen and protein quantitation and other analyses available.

4. MEDIA MAKING CENTER:

Tissue culture media made to order and tested for mycoplasma and other contaminants.

5. PROTEIN ANALYSIS LAB:

One, two and three dimensional polyacrylamide gel electrophoresis performed and samples prepared to order.

6. CLINICAL RESEARCH DATABASE - AT&T:

A clustered system of 50 computers was established as a model for data acquisition and analysis in a high volume clinical setting. Linked to a local area network at the

Medical Center, this facility includes systems technologists, biostatisticians and programmers, all available on a fee for service basis. The system links clinics involved in research at the South Florida VA Medical Center, at Jackson Memorial Hospital, and at the various hospitals and clinics affiliated with the UM School of Medicine.

7. IMAGE PROCESSING FACILITY:

Five clustered Micro-VAX 3 computers in the National Parkinson Research Foundation Building are linked to the 25 other buildings of the medical campus. Software for image analysis and biostatistics with programming and systems support are available.

8. ANALYTICAL PHARMACOLOGY:

HPLC of biological samples are performed by the Cancer Center.

9. MEDICAL LIBRARY:

The Calder Medical Library houses more than 150 thousand volumes, over 2100 periodicals and comprehensive database services. Over 200,000 people per year use the library. About 3000 computer searches and 20,000 interlibrary loans were performed last year.

10. BIOMEDICAL COMMUNICATIONS:

A modern computer aided facility for slide and video tape production including medical art and film studios.

11. MEDLINE DATABASE ON LASER DISC:

Free Medline searches are provided for all faculty and staff.

APPENDIX D

COMPARISON OF BME PROGRAMS

UNDERGRADUATE BME REQUIREMENTS

Boston University

BME major for premeds

Curriculum: 136 credits

	credits	
Mathematics	20	14.7%
Calculus 1, 2, 3		
Diff. Equ.		
Elective		
Basic Science	32	23.5%
Biology 2		
Gen. Chem. 1, 2		
Gen. Physics 1, 2		
Organic 1, 2		
Syst. Physiology		
Basic Engineering	36	26.5%
Engr. Computation 1, 2		
Engr. Mechanics 1		
Elec. Circuit Theory		
Electronics 1, 2		
Fluid Mechanics		
Mech. of Materials		
Engr. Thermodynamics		
Elective		
BME	24	17.6%
Signals & Systems in BME		
Engr. Physiology Lab		
Control Sys. in BME		
Senior Project 1, 2		
Elective		
Soc. Sci./Humanities	24	17.6%
Intermediate Comp.		
<hr/>		
Total	136	99.9%

Boston University

BME major for non-premeds

Curriculum: 138 credits

	credits	
Mathematics	20	14.5%
Calculus 1, 2, 3		
Diff. Equ.		
Elective		
Basic Science	26	18.8%
Biology 2		
Gen. Chem. 1, 2		
Gen. Physics 1, 2		
Syst. Physiology		
Basic Engineering	36	26.0%
Engr. Computation 1, 2		
Engr. Mechanics 1		
Elec. Circuit Theory		
Electronics 1, 2		
Fluid Mechanics		
Mech. of Materials		
Eng. & Thermodynamics		
Elective		
BME	24	17.4%
Signals & Systems In BME		
Engr. Physiology Lab		
Control Syst. in BME		
Senior Project 1, 2		
Elective		
Soc. Sci./Humanities	24	17.4%
Intermediate Comp.		
Professional Elective	8	5.8%
Total	138	99.9%

Brown University

Curriculum: 128 credits

	credits	
Engineering Core		
Mathematics	16	12.5%
Calculus 1 and 2		
Applied Math 1 and 2		
Basic Sciences & Engineering	32	25.0%
Intro. to Mech. & Engr. Computation		
Dynamics & Vibrations		
Materials		
Electricity & Magnetism		
Thermodynamics		
Fluid or Solids Mechanics		
Intro. Chem.		
Electives	44	34.4%
At least 4 electives (12.5%) must be Soc. Sci./Humanities courses		
Additional Science Course (2)	8	6.3%
BME Core	16	12.5%
Biomechanics		
Neuroengineering		
Bio-Instrumentation Design		
Medical System & Device Design		
Recommended		
Biomedical Ethics		
"Specialized suboptions" within BME	12	9.3%
1. Biomechanics		
2. Materials		
3. Bioelectrical		
TOTAL	128	100%
General core course for all engineers	56	43.8%
Courses for concentration	28	21.9%
Electives	44	34.4%

"The course work must include at least:

1. One year of an appropriate combination of mathematics and basic sciences,
2. One year of engineering sciences,
3. One-half year of engineering design, and
4. One-half year of humanities and other social sciences."

Case Western Reserve University

Curriculum: 131 hours

	credit hours	
Mathematics	17	13.0%
Calculus 1, 2, 3		
Diff. Equ.		
Statistical Methods		
Basic Science	25	19.0%
Gen. Chem. 1, 2		
Chem. Lab		
Gen. Physics 1, 2, 3		
Basic Engineering	15	11.4%
Computer Programming		
Engineering Core		
Signals & Systems 1		
Numerical Methods		
BME	21	16.0%
Physiology-Biophysics 1, 2		
BME Lab 1, 2		
Biomed. Instrumentation		
Senior Project		
Intro.to Biomed. Materials		
Modeling of Biomed. Systems		
Technical Electives	24	18.3%
Soc. Sci./Humanities	27	20.6%
Physical Education	2	1.5%
	<hr/>	
Total	131	99.8%

Dartmouth College: Thayer School of Engineering

"...biomedical engineering students construct their own programs in consultation with their advisers, and since the students in biomedical engineering may have very different interests, they may follow very different routes."

Some BME courses or related courses include:

Introduction to Biotechnology

Biological Kinetics and Reactors

Bioseparations

Physiological Control System Modeling

Physiology for Bioengineers

Biomaterials

Medical Signal Processing

Medical Imaging

Physical Principles of Microscopes in Biology

Biotechnology Engineering Seminar

Engineering Aspects of Diabetes Treatment

University of Iowa

Curriculum: 128 credits

	credits	
Mathematics	21	16.4%
Calculus 1, 2		
Matrix Alg. for Engr.		
Diff. Equ. for Engr.		
Vector Calculus for Engr.		
Probability & Statistics		
Basic Science	10	7.8%
Chemistry		
Animal Biology		
Basic Engineering	51	39.8%
Intro Engr.		
Engr. Graphics		
Engr. Computations		
Statics		
Dynamics		
Intro. to Electronic Sci.		
Linear Systems Analysis		
Materials Sci.		
Computation in EE		
Thermodynamics		
Electronic Instrumentation		
Mechanics of Deformable Bodies		
Mech. of Fluids and Transfer Proc.		
Design 1, 2		
Engr. Physics 1, 2		
BME	25	19.5%
BME Physiology		
Biol. Systems Analysis		
Blomaterials		
Blomed. Measurements		
BME Design 1, 2		
BME Electives		
Soc. Sci./Humanities	21	16.4%
Total	128	99.9%

Johns Hopkins University

"...emphasizes preparation for advanced study in an area related to biomedical engineering and is broad enough to accommodate students who plan graduate work in biology, medicine, engineering, biophysics, physiology, or biomedical engineering."

Curriculum: 124 credits

	credits	
Mathematics	24	19.4%
Calculus 1, 2, 3		
Lin. Alg./Dif. Equations		
+ 1 more math course		
Basic Sciences	25	20.2%
Gen. Physics		
Intro. Chemistry		
Physical Chem.		
OR		
Statistical Physics		
Humanities/Soc. Sciences	18	14.5%
Ethics and Technology		
BME program	24	19.4%
Circuits		
Signals & Systems OR		
Continuum & Fluid Mech. OR		
Materials & Continuum Mechanics		
BME Physiology		
BME Seminar		
Additional Engineering Courses	33	26.6%
Total	128	100.1%

The university also offers a B.A. in BME.

Curriculum: "120 hours"

Basic Sciences	25	20.7%
Mathematics	20	16.5%
Humanities/Soc. Sciences	24	19.8%
BME, engineering & physiology	22	18.2%
Engineering	30	24.8%
Total	121	100.0%

Louisiana Technical University

Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology

Curriculum: 138 credits

	Credits	
Mathematics	18	13.0%
Calculus 1, 2, 3, 4		
Ordinary Diff. Equ.		
Statistics		
Basic Sciences	25	18.1%
Gen. Physics 1, 2		
Gen. Chemistry 1, 2, 3, 4, 5		
Botany & Zoology		
Basic Engineering	22	15.9%
Electrical		
circuits		
linear systems		
Statics and Dynamics		
Computers		
programming		
graphics and modeling		
Ethics		
Soc. Sci./Humanities & Economics	27	19.6%
Communications	3	2.1%
Technical Electives	12	8.6%
Courses given by BME department	31	22.5%
Basic BME Principles		
BME Microcomp. Applications		
Biomed. Fluid Mechanics & Energy Transport		
Bioenergetics		
BM Instrumentation 1, 2		
Biomaterials & Biomechanics		
BME Seminar		
Biomed. Mass Transport		
BME Design 1, 2		
Analysis and Design of Physiol. Control Systems		
 TOTAL	 138	 99.8%

Marquette University 1986/87

Curriculum: 133 hours

	credits	
Mathematics	19	14.3%
Calculus 1, 2, 3		
Linear Alg. & Diff. Equ.		
Elective		
Basic Science	29	21.8%
Gen. Chemistry 1, 2		
Biology		
Organic Chem		
Gen. Physics 1, 2		
Biol. Investigation		
Basic Engineering	36	27.1%
Digital Computers		
El. Circuits 1, 2		
El. Devices & Applic.		
Digital Elec.		
Analog Elec.		
Exp Problem Solving 1, 2		
Linear Systems		
Statics & Dynamics		
Energy Engr.		
BME	25	18.8%
Intro to BME		
Electives		
Computer Applic. in BME		
BME Design Lab		
Physiological Transport		
BME Instrumentation Design		
Soc. Sci./Humanities	24	18.0%
Total	133	100.0%

Mercer University

Curriculum: 204 quarter hours

	credits	
Mathematics	32	15.7%
Calculus 1, 2, 3, 4		
Eng. Matrix Theory		
Diff. Equ.		
Probl. Analysis		
Probl. & Statistics		
Basic Science	50	24.5%
Gen. Chemistry 1, 2		
Gen. Physics 1, 2, 3		
Organic Chem. 1, 2		
Biol.: Org. & Cells		
Vertebrate Physiology		
Basic Engineering	48	23.5%
Methods of Engr.		
Statics & Strength of Materials		
Dynamics		
Seminar		
El. Networks and Lab		
Digital Systems		
Thermodynamics		
Digital Systems Lab		
Engr. Economy		
Engr. Mech. Lab		
Technical Communication		
El. Devices & Systems		
EE Lab II		
Engr. Design Project 1, 2		
Feedback Control/Instrum. of Dynamic Systems		
Systems & Instrum. Lab		
BME	34	16.7%
BM Materials		
Bio-Electric Phenomena		
Biomech. Thermodynamics		
Dynamics of Biol. Fluids		
Biomedical Instrumentation		
Biomechanics I		
Electives		
Soc. Sci./Humanities	40	19.6%
Public Speaking		
(Economics)		
TOTAL	204	100.0%

University of Miami

BME with Electrical Technology Orientation

Curriculum: 133 credits

	credits	
Mathematics	17	12.8%
Calculus 1, 2		
Ord. Diff. Equ.		
Vector Analysis		
Applied Probability & Statistics 1		
Basic Sciences	29	21.8%
Gen. Chem. 1, 2		
Gen. Physics 1, 2		
Modern Physics		
Gen. Biology 1, 2		
Basic Engineering	37	27.8%
Pascal / Intro Software engineering		
Elec. Circuit Theory 1		
Lin. Circuits and Signals		
Electromagnetic Field Theory		
Electronics 1,2		
Logic Design		
Digital Design Lab		
Linear Control Systems		
Microprocessors		
Mech of Solids		
Engineering Materials Science		
Soc. Sci/Humanities	24	18.0%
Electives		
Prin. of Prose Expression		
Sci. and Tech Writing		
BME departmental courses	20	15.0%
Measurements		
Biomaterials		
Senior Design Project		
Biomed. Instrumentation		
Biomechanics		
Senior Design Project		
Comput. Applic. in Med.		
Technical Elective (BME)	6	4.5%
Total	133	99.9%

University of Miami

BME with Mechanical Technology Orientation

Curriculum: 133 credits

	credits	
Mathematics	17	12.9%
Calculus 1, 2		
Ord. Diff. Equ.		
Applied Probability and Statistics		
Elective		
Basic Science	35	26.3%
General Chem 1, 2		
Organic Chem. 1, 2		
General Physics 1, 2		
Modern Physics		
General Biology 1, 2		
Basic Engineering	31	23.3%
Pascal / Intro Software engineering		
Elec. Circuit Theory 1 + lab		
Lin. Circuits and Signals OR		
Electronics 1		
Mech. of Solids 1, 2		
Engineering Materials Science		
Thermodynamics 1		
Dynamics		
Mech. Behav. of Mat.		
Fluid Mechanics		
Soc. Sci/Humanities Elective	24	18.0%
Prin. of Prose Expression		
Sci. and Tech. Writing		
BME	17	12.8%
Measurements		
Blomaterials		
Senior Design Project		
Blomed Instrumentation		
Biomechanics		
Senior Design Project		
Technical Elective (BME)	6	4.5%
<hr/>		
TOTAL	133	99.9%

University of Miami

BME for Premedical Students

Curriculum: 132 credits

	credits	
Mathematics	17	12.8%
Calculus 1, 2		
Ord. Diff. Equ.		
Applied Probability and Statistics		
Elective		
Basic Science	40	30.3%
General Chem 1, 2		
Organic Chem. 1, 2		
Intro. Biochem. & Mol. Biol.		
General Physics 1, 2		
Modern Physics		
General Biology 1, 2		
Basic Engineering	31	23.5%
Pascal / Intro Software engineering		
Elec. Circuit Theory 1 + lab		
Lin. Circuits and Signals OR		
Electronics 1		
Mech. of Solids 1, 2		
Engineering Materials Science		
Thermodynamics 1		
Dynamics		
Mech. Behav. of Mat.		
Fluid Mechanics		
Soc. Sci/Humanities Elective	24	18.2%
Prin. of Prose expression		
Sci. and Tech. Writing		
BME	17	12.9%
Measurements		
Blomaterials		
Senior Design Project		
Blomed Instrumentation		
Biomechanics		
Senior Design Project		
Technical Elective (BME)	3	2.3%
TOTAL	132	100.0%

Northwestern University

"...prepares students for careers in dentistry, medicine, and/or research or with corporations in the health care industry."

Curriculum: "48 courses"

	Courses	
Mathematics	6	13.0%
Calculus 1, 2, 3		
Multiple Integration and Vector Calculus		
Sequences and Series, Linear Algebra		
Elem. Diff. Equ.		
Basic Sciences	5	10.9%
Gen. Physics 1, 2		
Gen. Chemistry 1, 2, 3		
Basic Engineering	6	13.0%
Mechanics		
Thermodynamics		
Fluids and Solids		
Materials Science		
Electrical Science		
Computer Sciences		
Computer Programming	1	2.2%
Soc. Sci./Humanities	7	15.2%
Communications		
Unrestricted Electives	5	10.9%
BME Core	7 courses	15.2%
Org. Chem.		
Biology/Biochemistry		
Sys. Phys. 1, 2, 3		
BME Lab.		
BME Design		
Specialization	9 courses	19.6%
Electronic Instr.		
Optical Instr.		
Mechanics		
Transport Processes		
Biotechnology		
Bioenergetics		
BME Departmental Program Total	16	34.8%
<hr/>		
TOTAL	46	100.0%

Rensselaer

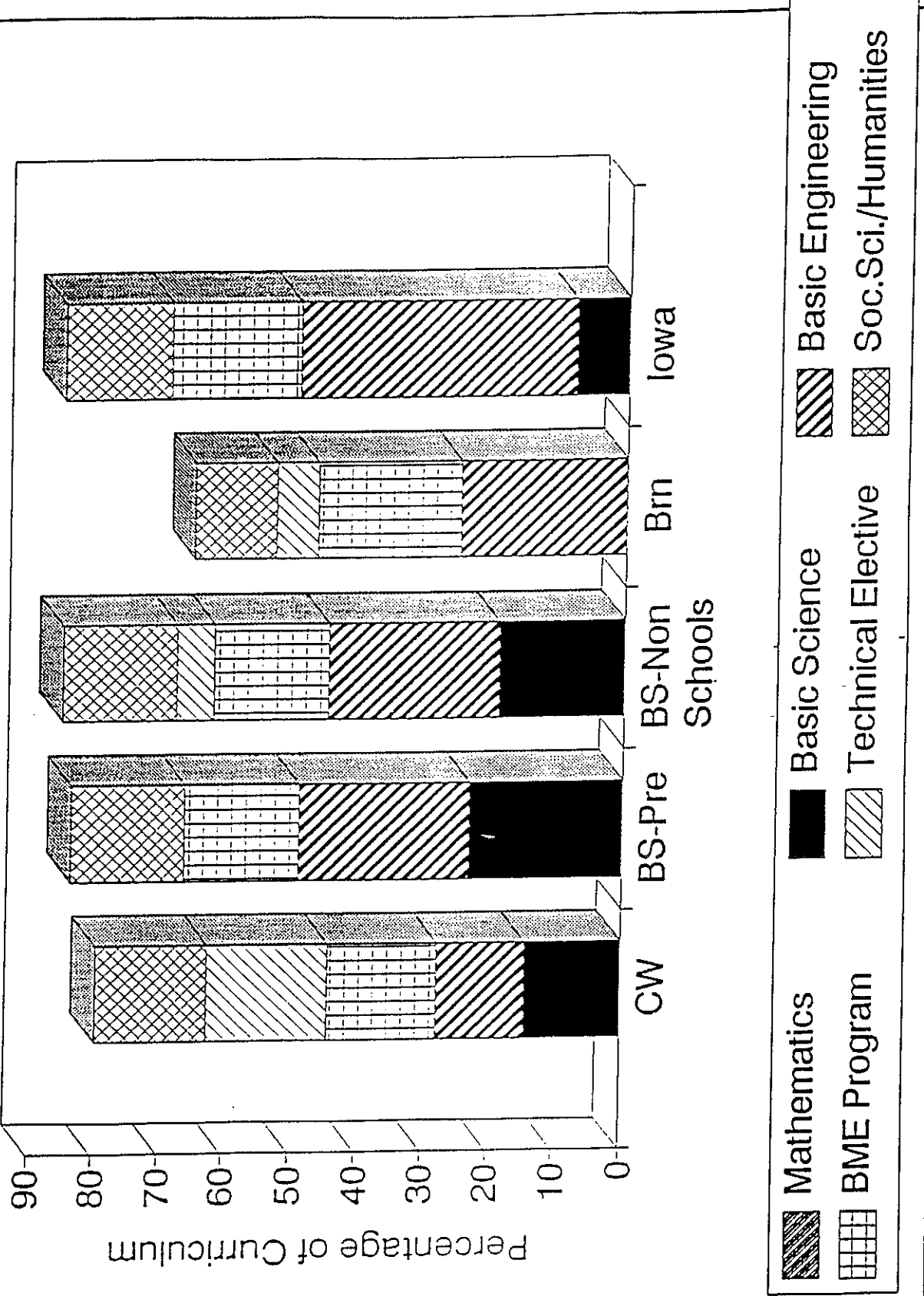
Curriculum: 134 credit hours

	Credits	
Mathematics	17	12.7%
Calculus 1, 2		
Linear Algebra		
Intro. Diff. Equations		
Basic Sciences	20	14.9%
Physics 1, 2, 3		
Chemistry 1, 2		
Basic Engineering	23	17.2%
Computer Science		
Engr. Graphics & CAD		
Engr. Modeling & Design		
Mechanics 1		
Engr. Thermodynamics		
Materials 1		
Engr. Lab 1, 2		
Statistical Methods		
Soc. Sci./Humanities	24	17.9%
BME	16	11.9%
Human Physiol. Systems		
Advanced Systems Physiology		
BME Lab 1, 2		
BME Design		
Concentrations	34	25.4%
Electrical		
OR		
Mechanical		
OR		
Materials		
<hr/>		
TOTAL	134	100.0%

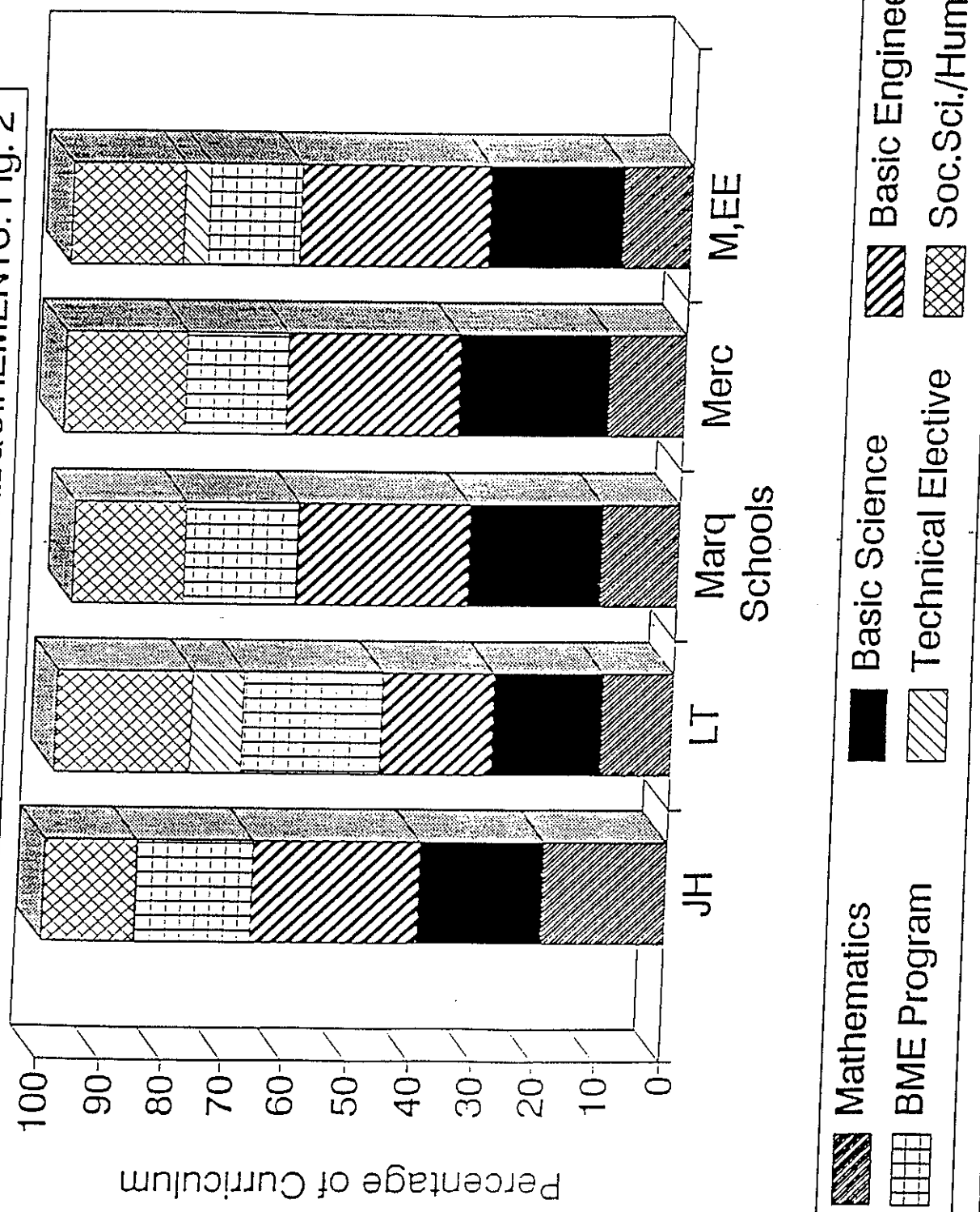
October 1991 Ed.: Dr. Paul N. Hale, Jr., Sponsored by ASEE
 BIOMEDICAL ENGINEERING ACADEMIC PROGRAM - ANNUAL REPORT

	DEGREE	HOURS	STUDEN	STU/FAC	FACULTY TOTAL
Arizona State U.	BSE Bioeng.	139	174	7.9	22
Boston University	BS	138	234	13.0	18
U. of Calif., San Dieg	BS Bioeng.	192 q	291	16.2	18
Case Western	BS: BME & Clinical		>150	>3.3	45
Catholic U. of Americ	BBE BME	137	59	8.4	7
Duke University	BS		251	9.7	26
U. of Illinois, Chicago	BS Bioeng.	128	100	7.1	14
U. of Iowa	BS	128	148	8.2	18
Johns Hopkins U.	BS	124	350	7.3	48
Louisian Tech U.	BS	139	158	9.9	16
Marquette U.	BS	133	231	38.5	6
Mercer U.	BSE w/ BME special.	204 q			4
U. of Miami	BSES	126	36	7.2	5
Milwaukee (MSOE)	BS	207 q	90	11.3	8
North Dakota State	BS w/ Bioeng. option	204	42		
Northwestern U.	BS	46 cou	200	8.7	23
U. of Pennsylvania	BSE Bioeng.	39 cou	149	12.4	BME: 12
	BAS Bioeng.	33 cou	32		
Rensselaer (RPI)	BS	134	72	9.0	8
U. of Southern Calif.	BSBME	128	180		
	BSBM.ME	133			
	BSBM.EE	136			
Syracuse U.	BS Bioeng.	137	63	6.3	10
Texas A&M U.	BS Bioeng.	136	240		4 ?
Trinity College	BSE w/ BME option				3 +
Tulane U.	BS	136	170	18.9	9
Vanderbilt U.	BE BME	129	201	25.1	8
U. of Washington	BS Bioeng.	192 q	10: jnrs+s	0.5	20
Wright State U.	BS: BME	203 q	15 grads/	3.0	5
	BS: Human Factors	203 q			3
U. of Wyoming	BSEE: Bioeng. optio	134	22	11.0	2
TOTAL			>3668	7.7	
RANGE				0.5 to 38.5	

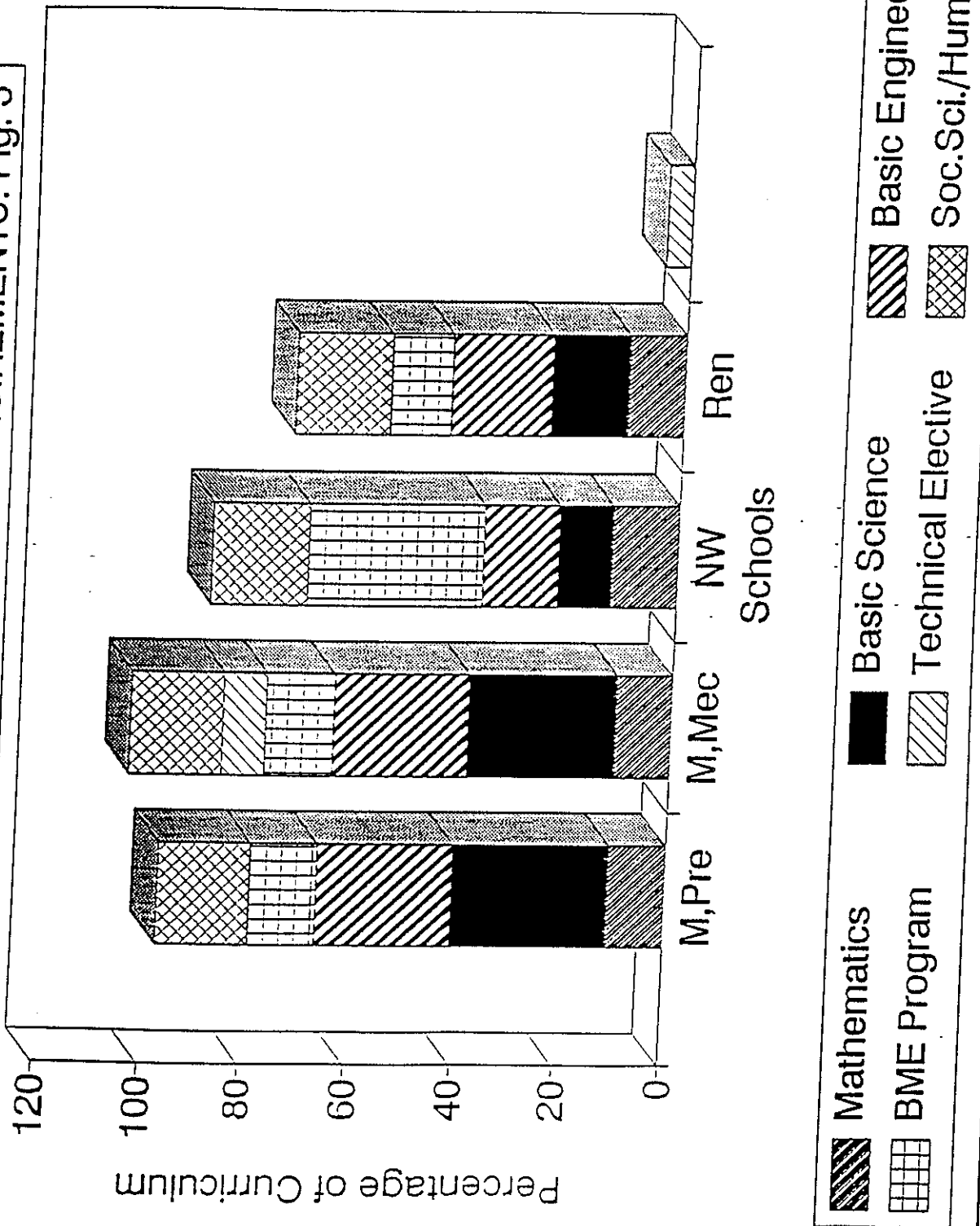
UNDERGRADUATE BME REQUIREMENTS: Fig. 1



UNDERGRADUATE BME REQUIREMENTS: Fig. 2



UNDERGRADUATE BME REQUIREMENTS: Fig. 3



APPENDIX E

CURRICULA VITAE OF FULL-TIME FACULTY MEMBERS
WITH PRIMARY APPOINTMENTS IN BIOMEDICAL ENGINEERING

CURRICULUM VITAE

PERSONAL

1. Date: 20 February 1992
2. Name: Eugene C. Eckstein
- 3a. Home Phone: (305) 232-5737 3b. Office Phone: 284-2442
4. Home Address: 10881 S.W. 124th St., Miami, FL 33176
5. Employment Status: Full-time, tenured.
6. Current Academic Rank: Professor
7. Primary Department: Biomedical Engineering
8. Citizenship: U.S.A. 9. Visa Type: N/A

HIGHER EDUCATION

10. Massachusetts Institute of Technology, Ph.D., 1975 (Thesis: Particle Migration in a Linear Shear Flow, Advisor: Ascher H. Shapiro of the Dept. of Mech. Eng.)

Massachusetts Institute of Technology, S.M. in M.E. & S.B. in M.E. 1970 (Thesis: The Effect of Reynolds Number on Peristaltic Pumping, Advisor: A. H. Shapiro)
11. Non-Institutional Training: No entry
12. Certification, Licensure: None

EXPERIENCE

13. Instructional: University of Miami: Professor, 6/1/88 to present. Associate Professor, 6/1/79 to 5/31/88. Assistant Professor, 8/15/75 to 6/1/79.
14. Professional: Harvard University, School of Medicine, and Peter Bent Brigham Hospital, Associate in Medicine (Bioengineering), 9/1/74 to 8/15/75

Massachusetts Institute of Technology,
Research Assistant, 1968 - 1974
15. Military: None.

Curriculum Vitae

Date: January 1992

PERSONAL

Name	Joachim H. Nagel, Ph.D. (Dr. rer. nat. habil., Dipl.-Phys.) University of Miami Dept. of Biomedical Engineering P.O. Box 248294 Coral Gables, Florida 33124
Phone	(305) 284-2442 office (305) 663-0283 home
Home Address	5111 SW 77th Street Miami, Florida 33143
Employment Status	Regular, tenure
Academic Rank	Professor
Primary Department	Biomedical Engineering
Secondary Departments	Psychology, Radiology
Citizenship	German
Visa Type	Permanent Resident
Languages	English, German, French

HIGHER EDUCATION

University of Saarbrücken, W-Germany, Diploma in Physics (M.Sc.), 1973, "with distinction".
Combined degree in Applied Physics and Electrical & Electronics Engineering.

University of Erlangen-Nürnberg, W-Germany, Dr. rer. nat. (Ph.D.), 1979, "summa cum laude".
Combined degree in Biomedical Engineering and Physics.

EXPERIENCE

- 1991 - present Professor of Biomedical Engineering, Radiology, and Psychology; Departments of Biomedical Engineering, College of Engineering, Radiology, School of Medicine, and Psychology, School of Arts and Sciences, University of Miami
- 1991 - present Project Leader and Director of Engineering Core, NHLBI Program Project "Psychophysiology of Cardiovascular Reactivity", Behavioral Medicine Research Program, University of Miami
- 1991 - present Member of the Executive and Scientific Committees, NHLBI Program Project "Psychophysiology of Cardiovascular Reactivity", Behavioral Medicine Research Program, University of Miami
- 1986 - present Preceptor, Behavioral Medicine Research in Cardiovascular Disease, NHLBI Training Program, University of Miami
- 1989 - present Editor, Annals of Biomedical Engineering, Section Instrumentation
- 1990 - present Liaison Representative of the IEEE/Engineering in Medicine and Biology Society to the IEEE Engineering Research and Development Committee
- 1992 - present Representative of Region 3 (Southeast USA) to the Administrative Committee of the IEEE Engineering in Medicine and Biology Society

- 1991 Chairman of the 13th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Orlando
- 1986 - 1991 Associate Professor of Biomedical Engineering, Department of Biomedical Engineering, College of Engineering, University of Miami
- 1988 - 1991 Associate Professor of Psychology, Department of Psychology, School of Arts and Sciences, University of Miami
- 1990 - 1991 Associate Professor of Radiology, Department of Radiology, Medical School, University of Miami
- 1986 - 1991 Director of Engineering Core, NHLBI Program Project "Psychophysiology of Cardiovascular Reactivity", Behavioral Medicine Research Program, University of Miami
- 1986 - 1987 First BME Representative of Region 8 (all European countries, USSR, Near East, and Africa) to the IEEE/EMBS ADCOM (elected 1985).
- 1988 - 1990 Advisor, Ph.D. Program Biomedical Engineering, Dept. of Electrical Engineering, Tsinghua University, Beijing, China
- 1980 - 1986 Academic Councillor, Tenure, (equivalent rank: Associate Professor), Department of Biomedical Engineering, University of Erlangen-Nürnberg, W-Germany
- 1976 - 1985 Director of Medical Electronics and Computer Division, Dept. of Biomedical Engineering, University of Erlangen-Nürnberg
- 1976 - 1986 Self-employed development of biomedical instrumentation and software
- 1983 Visiting Professorship, Tsinghua University, Beijing, China
- 1976 - 1984 Consultant, Biotronik Diagnostic and Therapeutic Instruments Comp., Berlin
- 1975 - 1979 Assistant Professor, Tenure, Dept. of Biomedical Engineering, University of Erlangen-Nürnberg
- 1974 - 1975 Research Associate and Lecturer/Instructor, Tenure, Dept. of Biomedical Engineering, University of Erlangen-Nürnberg
- 1973 - 1974 Research Associate and Lecturer/Instructor, Dept. of Instrumentational & Analytical Chemistry, University of Saarbrücken

Current Research:

Cardiovascular Monitoring, Medical Imaging, Signal Processing, Artificial Intelligence and Expert Systems, Transducers and Instrumentation, Cardiology, Behavioral Medicine

Most Important Achievements:

- Invention and development of procedure for "Sub-Nyquist Sampling" of signals for statistic signal processing, 1971-1973.
- Invention of "Macros", 1974.
- Invention and development of technique for removal of recurrent signal interferences, 1974-1979.
- Detection of functional relationship between abdominal EMG and intrauterine pressure, 1978.
- Detection of correlation between maternal and fetal heart rates, and its physiological modeling, 1978-1985.
- Detection of relationship between gestational age and PCG spectrum, 1980.
- Invention and development of NMR imaging of electric currents, 1980-1985.
- Invention and development of Individual Flow Profile Controlled portable drug infusion system, 1979-1981.
- Invention and development of passive telemetry for analogue signals, 1980-1982.
- Invention and development of dynamic plunger-pumps, 1981-1985.
- Development of correlational multi-modal image matching, 1986-1989.
- Development of event detection techniques for impedance cardiograms, 1987-1989.

CURRICULUM VITAE

Özcan Özdamar, Ph.D. Professor February 1992

Primary Appointment: Department of Biomedical Engineering
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Secondary Appointment: Pediatrics and Otolaryngology
School of Medicine, University of Miami
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Education

Middle East Technical University Electrical Engineering B.S. 1971
Ankara, Turkey

Northwestern University Biomedical Engineering M.S. 1973
Evanston, Illinois

Northwestern University Biomedical engineering Ph.D. 1976
Evanston, Illinois

PROFESSIONAL AND RESEARCH EXPERIENCE

Institution

University of Miami Professor 1991-present
College of Engineering Department of Biomedical Engineering
School of Medicine Department of Pediatrics (secondary)
School of Medicine Department of Otolaryngology (secondary)

University of Miami Associate Professor 1986-1991
College of Engineering Department of Biomedical Engineering

University of Miami Associate Professor 1986-1991
School of Medicine Department of Pediatrics (secondary)

University of Miami Assistant Professor 1983-1986
College of Engineering Department of Biomedical Engineering

University of Miami Assistant Professor 1984-1986
School of Medicine Department of Pediatrics (secondary)

University of Miami Monitoring Systems Manager 1983-1984
School of Medicine Medical Information Systems

Michael Reese Hosp. Med. Cen. Head, Electrophysiology 1978-1983
Chicago, Illinois Laboratory

University of Chicago Assistant Professor 1982-1983
School of Medicine, Chicago Department of Otolaryngology (secondary)

Middle East Technical Instructor, Department 1976-1978
University, Ankara Life Sciences

SELECTED PUBLICATIONS

- Ozdamar, O., Dallos, P., "Input-output functions of cochlear whole-nerve action potentials: Interpretations in terms of one population of neurons", J. Acoust. Soc. Amer., 59: 143-147, 1976.
- Ozdamar, O., Dallos, P., "Synchronous responses of the primary auditory fibers to the onset of tone bursts and their relation to compound action potential", Brain Res., 155: 169-175, 1978.
- Ozdamar, O., Stein, L., "Auditory brainstem responses (ABR) in unilateral hearing loss", Laryngoscope, 91:565-574, 1981.
- Ozdamar, O., Kraus, N., "Auditory middle latency responses in humans", Audiology, 22: 34-49, 1982.
- Kraus, N., Ozdamar, O., Hier, D., Stein, L., "Auditory middle latency responses (MLRs) in patients with cortical lesions", Electroenceph. clin. Neurophysiol., 54: 275-287, 1982.
- Ozdamar, O., Kraus, N., Stein, L., "Auditory brainstem responses in infants recovering from bacterial meningitis: Audiological evaluation", Arch. Otolaryngol., 109: 12-18, 1982.
- McGee, T.J., Ozdamar, O., Kraus, N., "Auditory middle latency responses in the guinea pig", Amer. J. Otolaryngol., 4: 116-122, 1983.
- Ozdamar, O., Kraus, N., "Auditory brainstem responses in infants recovering from bacterial meningitis: Neurological assessment", Arch. Neurol., 40: 499-502, 1983.
- Kraus, N., Ozdamar, O., Stein, L., Reed, N., "Absent auditory brain stem response: Peripheral hearing loss or brain stem dysfunction?", Laryngoscope, 94: 400-406, 1984.
- Kraus, N., Ozdamar, O., Heydemann, P.T., Stein, L., Reed, N., "Auditory brainstem responses in hydrocephalic patients", Electroenceph. clin. Neurophysiol., 59:310-317, 1984.
- Ozdamar, O., Kraus, N., Grossman, J., "Binaural interaction in the auditory middle latency responses of guinea pigs", Electroenceph. clin. Neurophysiol., 63: 476-483, 1986.
- Miskiel, E., Ozdamar, O., "Computer monitoring of auditory brainstem responses", Comp. Med. Biol., 17: 185-192, 1987.
- Ozdamar, O., Kaplan, R., Miskiel, E., Delgado, R., "Human-machine interface for an interactive evoked potential electrodiagnostic system", in Trends in Ergonomic/Human Factors IV, S. Asfour (ed.), North Holland, Amsterdam, 1121-1129, 1987.
- Kaplan, R., Ozdamar, O., "Microprocessor-based auditory brainstem response (ABR) simulator", Med. Biol. Eng. Comp., 25: 560-566, 1987.
- Ozdamar, O., Eilers, R.E., Oller, D.K., "Tactile vocoders for the deaf", IEEE Engineering in Medicine and Biology Mag., 6(3): 37-42, 1987.
- Ozdamar, O., "Signal transmission and processing in the nervous system", in Handbook of Biomedical Engineering, J. Kline (ed.), Academic Press, New York, 655-683, 1988.
- Delgado, R.E., Ozdamar, O., Miskiel, E., "On-line system for automated auditory evoked response threshold determination", In IEEE Frontiers in Engineering and Computing in Health Care, Tenth Ann. Conf. Proc., 1472-1473, 1988.
- Simler, D., Ozdamar, O., "Experimental expert system for audiometric testing", In IEEE Frontiers in Engineering and Computing in Health Care, Tenth Ann. Conf. Proc., 1436-1437, 1988.
- Ozdamar, O., Lopez, C.N., Delgado, R.E., "A digital speech processor with lateral inhibition for artificial hearing", In IEEE Frontiers in Engineering and Computing in Health Care, Tenth Ann. Conf. Proc., 1545-1546, 1988.
- Eilers, R.E., Ozdamar, O., Oller, D.K., Miskiel, E., Urbano, R., "Similarities between tactual and auditory speech perception", J. Speech Hearing Res., 31: 124-131, 1988.
- Ozdamar, O., Oller, D.K., Miskiel, E., Eilers, R., "Computer system for quantitative evaluation of an electrotactile vocoder for artificial hearing", Comp. Biomed. Res., 21: 85-100, 1988.
- Eilers, R.E., Ozdamar, O., Oller, D.K., Miskiel, E., Urbano, D., "The effects of vocoder filter configuration on tactual perception of speech", J. Rehab. Res. Dev., 26(4):51-67, 1989.
- Ozdamar, O., Alpsan, D., "Classification of evoked potentials using multilayer feedforward neural networks", In Florida Artificial Intelligence Research Symposium, Second Proc., 172-176, 1989.
- Ozdamar, O., Eilers, R.E., Miskiel, E., Widen, J., "Classification of audiograms by sequential testing using a dynamic Bayesian procedure", J. Acoust. Soc. Am., 88(5): 2171-2179, 1990.
- Ozdamar, O., Delgado, R.E., "Fiber tract model of auditory brainstem response generation using travelling dipoles", in Auditory Evoked Magnetic Fields and Electric Potentials, F. Grandori, M. Hoke, and G.L. Romani (eds.), Karger Publ., Basel, 194-206, 1990.
- Ozdamar, O., Alpsan, D., "A neural network based automated device for evoked response audiometry", In IEEE Proc. SouthCon'90, 384-389, 1990.
- Delgado, R.E., Ozdamar, O., "Automated ABR peak labelling using matched filters", IEEE Frontiers of Engineering and Computing in Health Care, Twelfth Ann. Conf. Proc., 870-871, 1990.
- Ozdamar, O., Delgado, R., Eilers, R.E., Widen, J.E., "Computer methods for automated hearing determination with auditory brainstem responses", Ear and Hearing, 11(6): 417-429, 1990.
- Ozdamar, O., Yaylali, I., Jayakar, P., Lopez, C.N., "Multilevel neural network system for EEG spike detection", Fourth Ann. IEEE Symp. Computer Based Medical Systems, 272-279, IEEE Computer Society Press, 1991.
- Tansel, I., Mekdeci, C., Ozdamar, O., Lopez, C.N., "Classification of phonocardiograms with unsupervised neural networks", in Intelligent Hearing Systems Through Artificial Neural Networks, Dagli, C.H., Kumara, S.R.T., Shin, Y.C. (eds.), 345-350, ASME Press, 1991.
- Alpsan, D., Ozdamar, O., "Brainstem auditory evoked potential classification by backpropagation networks", Int. Joint Conf. Neural Networks, Singapore '91, 1266-1271, 1991.
- Ozdamar, O., Delgado, R., "Two dimensional filtering of auditory evoked potentials for signal enhancement", IEEE EMBS Ann. Conf., 13(4):1881-1882, 1991.
- Wen, H., Ozdamar, O., "Auditory brainstem response classification using modular neural networks", IEEE EMBS Ann. Conf., 13(4): 1879-1880, 1991.
- Eilers, R.E., Miskiel, E., Ozdamar, O., Urbano, R., Widen, J.E., "Optimization of automated hearing test algorithms: Simulations using an infant response model", Ear and Hearing, 12:191-198, 1991.
- Ozdamar, O., Lopez, C.N., Oller, D.K., Eilers, R.E., Miskiel, E., Lynch, M.P., "An FFT-based digital tactile vocoder system for real-time use", Med. Biol. Eng. Comp., in press, 1992.

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CURRICULUM VITAE

1. DATE: 08/27/91

PERSONAL

2. Name: Qiushi Ren
3. Home Phone: (305)573-8213
4. Office Phone: (305)326-6044
5. Home Address: 601 N.E. 39th Street Apt. 316, Miami, FL 33137
6. Current Academic Rank: Research Assistant Professor
7. Primary Department: Ophthalmology
8. Citizenship: P.R. China
9. Visa Type: Working authorization under President Bush's executive order for the Chinese

HIGHER EDUCATION

10. Institutional:

- 1984 Huazhong University of Science and Technology, Wuhan, China B.S.
Optical Engineering
- 1987 Ohio State University, Columbus, OH M.S.
Electrical Engineering
- 1990 Ohio State University, Columbus, OH Ph.D
Electrical Engineering

11. Non-Institutional: None

12. Certification, licensure: None

EXPERIENCE:

13. Academic:

- 1991 - present Research Assistant Professor, Department of Ophthalmology,
University of Miami School of Medicine, Miami, FL

- | | |
|-------------------|--|
| 1990 - 1991 | Research Associate, Department of Ophthalmology, Emory University |
| 1989 - 1989 | Research Assistant, Wellman Laboratory of Photomedicine, Harvard Medical School |
| 1988 - 1989 | Graduate Research Associate, Department of Electrical Engineering, Ohio State University |
| 1986 - 1988 | Graduate Research Associate, Department of Ophthalmology, Ohio State University |
| 1985 - 1986 | Fellowship student, Department of Electrical Engineering, Ohio State University |
| 14. Non-Academic: | None |
| 15. Military: | None |

PUBLICATIONS

16. Books and monographs published: None

17. Juried or refereed journal articles and exhibitions:

"Corneal Refractive Surgery Using UV (213 nm) Solid State Laser"
Ren, Q.S., Gailitis, R., Thompson, K.T. and Lin, J.T. SPIE Proceedings vol. 1423, 1991 (in press)

"Axicon, A New Beam Delivery System for Biomedical Applications"
Ren, Q.S. and Birngruber, R. IEEE. J. Quant. Electron. Special Issue on Lasers in Medicine and Surgery vol.26, 2305-2308, 1990.

"Ablation of the Cornea and Synthetic Collagen Using a W (213 nm) Solid State Laser"
Ren, Q.S., Gailitis, R.P., Thompson, K.P., and Lin, J.T. IEEE. J. Quant. Electron. Special Issue on Lasers in Medicine and Surgery vol.26, 2284-2288, 1990.

"Laser Welding of Synthetic Epikeratoplasty Lenticules to the Cornea"
Gailitis, R.P., Thompson, K.P., Ren, Q.S., Morris, J. and Waring, G.O. Refractive & Corneal Surgery. 6:430-436, 1990.

BIOGRAPHICAL SKETCH

NAME	TITLE	BIRTHDATE
Peter P. Tarjan	Professor and Chairman, Dept. of Biomedical Engineering, University of Miami, Coral Gables, FL Vice-President, SciBuTec, Inc., Miami, FL	05/28/36

EDUCATION: Technical University of Budapest, Hungary
Electrical Engineering, 1954-56.
Purdue University, West Lafayette, IN
BS in EE "With Distinction", 1959.
Mass. Inst. of Technology, Cambridge, MA
SM in EE, 1960
Syracuse University, Syracuse, NY
PhD in EE, Major: Biomedical Engineering, 1968

EMPLOYMENT:

June 1987 - Professor and Chairman, Dept. of Biomedical Engineering, University of Miami, Coral Gables, FL
Responsibilities include administration of the department, teaching at the graduate level, supervision of research.

Aug. 1988 - Vice-President, SciBuTec, Inc., Miami, FL
Responsibilities: Planning and the preparation of proposals.

1980 - 1987 Chief Scientist, Cordis Research Corp., Miami, FL
Responsibilities: planning and supervision of research and development activities of 50 to 80 people in the field of medical devices and diagnostics; various corporate functions.

1972 - 1980 Manager, Biomedical Engineering, Cordis Corp., Miami, FL. Supervised between 10 and 20 engineers and scientists working on cardiovascular and neurosurgical instrumentation.

1968 - 1972 Staff Engineer, Cordis Corp., Miami, FL. Responsible for the coordination of research activities related to cardiac pacing and other areas, including phrenic nerve stimulation for respiratory support.

1960 - 1963 Engineer, Semiconductor Products Dept. and the Electronics Laboratories of the General Electric Co., Syracuse, NY. Development of novel semiconductor devices.

PUBLICATIONS: 19 articles in peer-reviewed journals,
9 book chapters,
2 invited lectures,
32 abstracts and poster presentations,
17 US patents,
mostly in the field of medical instrumentation.

