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GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

July 23, 1969

MEMORANDUM

TO: Dr. Walter L. Bloom

FROM: J. D. Walton, Jr.

SUBJECT: Final Report - Project E-300-900

A copy of the Final Report, "A Survey of Bioengineering Interests in Atlanta," under Project E-300-900 is enclosed. This report covers the work carried out jointly between Emory University and Georgia Tech for the period 1 November 1968 through 30 June 1969.

Due to the short time for this project and the limited time available from the principal investigators it was not possible to complete all phases of the program. Primarily the uncompleted work was concerned with developing means for establishing personal contacts among individuals who had been identified a being interested in participating in bioengineering programs. Such contacts would help to identify specific programs which should be most effectively pursued based on existing talents in the Atlanta area. Also, the interchange of ideas should stimulate potential investigators to contribute to the developmer of interdisciplinary activities related to their field of interest. Bioengineering Workshops were recommended as the best means for establishing such personal contacts and activities. Remaining funds would have been sufficient to organize these workshops, but unfortunately fiscal year restrictions terminated the current effort on 30 June 1969.

A summary of the financial status follows:

Budget	$12,500.00
Expended as of 6-30-69	8,728.56
Remaining Funds	$ 3,771.44

J. D. Walton, Jr.

JDW,Jr/js

cc: Dr. H. F. Robinson
Arthur P. Richardson, M.D.
Samuel B. Chyatte, M.D.
Dr. M. W. Long
Members, Georgia Tech
Bioengineering Committee

Enclosure

A SURVEY OF BIOENGINEERING INTERESTS IN ATLANTA

by

J. D. Walton, Jr.
Georgia Institute of Technology

and

Samuel B. Chyatte
Emory University

July 1, 1969

FINAL REPORT
Project E-300-900

for

Board of Regents
University System of Georgia
Atlanta, Georgia

Georgia Institute of Technology
Atlanta, Georgia 30332

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II. BACKGROUND

During the past several years there has been a growing interest in bioengineering at Georgia Tech. In 1967 Dr. Walter L. Bloom joined the Georgia Tech faculty to determine the extent of the interest, experience, and competence in bioengineering and to formulate future plans for bioengineering. The results of the effort to identify bioengineering related programs at Georgia Tech was published in summary form in July 1968. An expanded summary was published in August 1968. Copies of these documents are included in Appendix I. Concurrently, a series of Bioengineering Seminars were arranged to focus attention on this area of activity. As a result of the sudden growth of interest in this field a Bioengineering Committee was established in July 1968. It was the responsibility of this committee to coordinate existing activities, develop a suitable structure for future activities and implement bioengineering research and education programs for the 1968-69 academic year.

The first activity of the Bioengineering Committee was to examine the problems associated with organizing and conducting multidisiplinary programs. This was a particularly difficult problem in the case of bioengineering at Georgia Tech because existing interest covered the entire spectrum of this broad field. Also, there was concern over the fact that at many other institutions bioengineering had become identified with a relatively narrow field such as bio-instrumentation or bio-mechanics. Once such polarization had taken place it appeared that future growth of bioengineering at that institute was restricted to that specific area. Therefore, there was the problem of attempting to provide some sort of structure to Georgia Tech's Bioengineering Program without concentrating on any particular area. It was agreed that the success of such a broad scope program would depend upon maintaining the

continuing interest and participation of essentially all units of Georgia Tech.

Next, attention was turned to the other member of the bioengineering team, the medical doctor. Many of the existing Georgia Tech programs involved various physicians and medical researchers. However, these were usually two or three-man team efforts directed in relatively narrow areas of research and development. Again, the concern was how to involve a broad spectrum of interest and experience as possible without concentrating on any particular sub topic.

At this point it became clear that in the Atlanta community there existed a large number of potential researchers with a broad range of interest and competence related to essentially all areas of bioengineering. It was also clear that the scope of any future program in bioengineering would be influenced by the range of research and service programs that might evolve from the interaction of the Georgia Tech faculty, the medical community, and other academic institutions such as Georgia State College and Emory University. Therefore, it was decided that there would be no attempt made at this time to develop a structure for bioengineering or attempt to organize a bioengineering program for Georgia Tech until the other potential off-campus participants could be identified and their fields of interest and competence determined.

Throughout this period of growing enthusiasm in bioengineering at Georgia Tech the Board of Regents had been considering the role of the University System of Georgia in this field and how its various units might participate in such an effort. Also, the Regents were aware of the general interest in bioengineering that existed at the various educational institutions and in the medical community at large in the Atlanta area. However, up until this time only a few individuals and departments had actually been identified. Therefore,

it was determined that before any action should be taken to implement bioengineering programs within the University System, additional information was needed, such as names, affiliations, interests, and experience of the people who would be willing and able to participate in a bioengineering program. Also, the scope and general subject areas that would be covered by such a program should be determined. To provide this information the Board of Regents, in November 1968, funded a joint program with The Georgia Institute of Technology and Emory University to determine the interest of the Atlanta community in developing a coordinated program in bioengineering. Mr. J. D. Walton, Jr., of Georgia Tech and Dr. Samuel B. Chyatte of Emory were designated as the principal investigators to undertake the program.

III. RESULTS

On January 8, 1969 a Bioengineering Questionnaire was sent to the members of the Fulton and DeKalb Medical Societies and the Northern District Dental Society; faculty and staff of the Georgia Institute of Technology, Georgia State College, Emory University, Agnes Scott College, and Atlanta University Center; Lockheed-Georgia Company, and Scientific Atlanta. A copy of the cover letter and questionnaire are included in Appendix II. Approximately 3,800 questionnaires were distributed. Almost 400 replies were received of which over 300 were positive. The results of this first survey are summarized in Table I. This survey established the overall size of the interested community and identified potential participants. It also provided certain background information that was needed to develop a preliminary structure for bioengineeri The rationale that was used to develop this structure was based on a matrix which was designed to depict the interaction of the Physical Sciences with the Life Sciences.* A table was constructed with the sciences structured from the top to bottom from the basic to the applied. The interface between the science contain such interdisciplinary topics as instrumentation, modeling, and substitutes. From this matrix it was possible to arrive at seven subtopics for bioengineering. Collectively they covered the entire field, and yet each was sufficiently specific that it should allow easy identification with individual fields of interest. Figure 1 shows the completed matrix.

After this preliminary structure had been developed, attention was given to considering means for bringing together interested medical doctors, engineer and scientists in order to establish communications between the diverse disciplines represented by these professions. It was decided that seven workshops

*The concept for using such a matrix was first put forth by Dr. Huber V. Stevens of the National Institutes of Health during the November 1968 Bioengineering Seminar at Georgia Tech.

TABLE I

SUMMARY OF RESULTS FROM JANUARY 8 BIOENGINEERING QUESTIONNAIRE

	Willing to Participate in Bioengineering Program			Indicated Area(s) of Interest*												
	Yes	No	Maybe	1	2	3	4	5	6	7	8	9	10	11	12	13
MEDICAL DOCTORS (including Emory University Part Time)	118	10	5	43	14	16	31	38	40	2	6	34	9	14	12	1
DENTISTS	17	1	1	7	11	6	1	7	5	-	-	1	14	3	-	1
EMORY UNIVERSITY (Full Time Faculty)	49	7	4	23	6	8	20	9	10	2	15	9	2	8	6	6
GEORGIA INSTITUTE OF TECHNOLOGY	135	5	23	40	19	13	35	6	4	11	38	2	3	3	15	24
GEORGIA STATE COLLEGE	9	-	1	3	2	2	4	-	-	-	3	-	-	2	3	-
AGNES SCOTT COLLEGE	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
ATLANTA UNIVERSITY	NO RESPONSE															
LOCKHEED-GEORGIA COMPANY	10	1	-	4	1	3	2	-	1	1	2	1	-	4	1	2
SCIENTIFIC ATLANTA, INC.	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	340	24	34	121	53	48	93	60	60	16	64	47	28	34	38	34

*
1. Bioinstrumentation
2. Biomaterials
3. Biomechanics
4. Computer Applications
5. Diagnostics
6. Health Care Systems
7. Marine Bioengineering
8. Mathematical Modeling of Biological Systems
9. Patient Monitoring
10. Prosthetics
11. Psychophysiology
12. Social Systems
13. Other

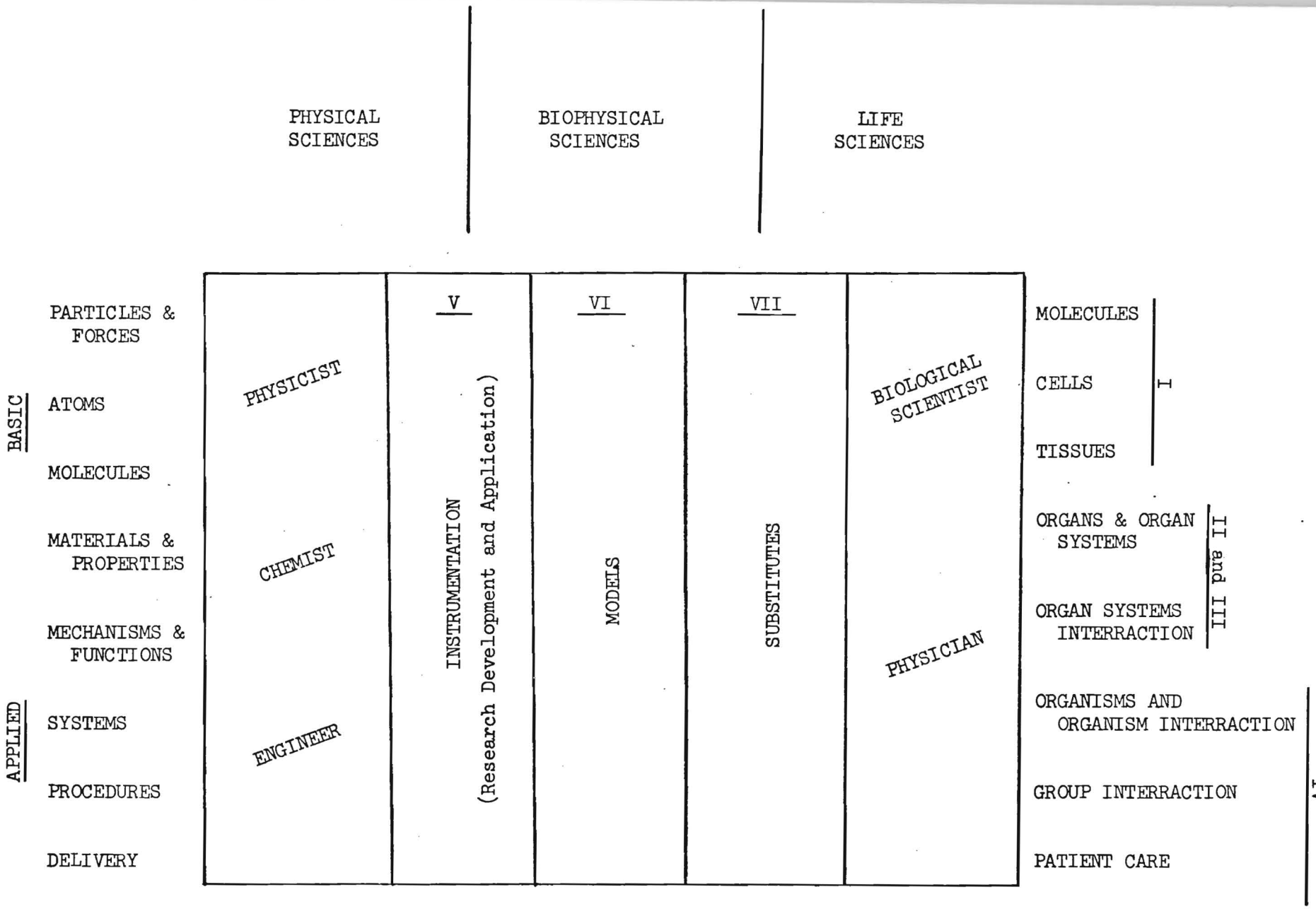


Figure 1. Areas for Bioengineering Activities.

based on the seven topics which made up the structure of bioengineering could serve as the instruments for establishing the desired lines of communication. The topics for the seven workshops are given in Table II. Proceeding on this basis, a second questionnaire was mailed on April 10, 1969 to those who had responded positively to the January 8th inquiry. A copy of the April 10th questionnaire, together with an expanded description of the subject matter which might be considered for each, is included in Appendix II. Table III summarizes the response to the April 10th questionnaires. Table IV and V provide a breakdown of the responses from Emory University and Georgia Tech respectively. Table VI shows the areas of interest in bioengineering which were indicated by the various Schools and Divisions of Georgia Tech.

TABLE II

AREAS OF INTEREST WHICH FORM STRUCTURE FOR BIOENGINEERING ALSO PRELIMINARY TOPICS FOR BIOENGINEERING WORKSHOPS

I. Cells & Tissue	V. Instrumentation
II. Fluid Systems	VI. Models
III. Motor Performance	VII. Substitutes
IV. Health Care Systems	

TABLE III

RESPONSE TO APRIL 10 BIOENGINEERING QUESTIONNAIRE

Affiliation of Respondent	Number of People Responding	Number of People Indicating Interest in Each Area*						
		I	II	III	IV	V	VI	VII
MEDICAL DOCTORS								
Private Practice	24	3	4	4	15	7	8	9
Southern Regional Education Board	1	0	0	0	1	0	1	0
State Health Department	1	0	0	0	1	0	1	0
Total - Medical Doctors	26	3	4	4	17	7	10	9
DENTISTS - Total	12	3	0	2	4	6	4	10
EMORY UNIVERSITY								
School of Medicine (Part Time)	46	10	14	19	28	24	16	20
School of Medicine (Full Time)	22	9	10	9	14	14	11	10
Basic Health Sciences	5	3	2	2	0	2	2	1
School of Dentistry	2	1	0	1	1	0	0	0
School of Arts and Sciences	12	4	1	0	5	5	6	3
Yerkes Primate Center	5	3	0	3	1	5	2	2
Total - Emory University	92	30	27	34	49	50	37	36
GEORGIA INSTITUTE OF TECHNOLOGY								
General College	14	4	0	3	6	8	3	1
Engineering College	34	6	12	8	7	16	16	11
Engineering Experiment Station	23	8	3	3	6	14	9	7
Administration	1	1	1	1	1	0	0	0
Total - Georgia Tech	72	19	16	15	20	38	28	19
GEORGIA STATE COLLEGE - Total	5	2	1	1	3	2	4	0
LOCKHEED-GEORGIA COMPANY - Total	3	1	0	1	0	2	2	0
SCIENTIFIC ATLANTA, INC. - Total	1	0	0	0	0	1	0	0
GRAND TOTAL . . .	211	58	48	57	93	106	85	74

*See Table II for key to Areas of Interest.

TABLE IV

SUMMARY OF RESPONSES FROM EMORY UNIVERSITY
TO APRIL 10 BIOENGINEERING QUESTIONNAIRE

Affiliation of Respondent	Number of People Responding	Number of People Indicating Interest in Each Area*						
		I	II	III	IV	V	VI	VII
SCHOOL OF MEDICINE								
(Part Time)								
Anesthesiology	1	1	0	1	0	1	1	1
Gynecology and Obstetrics	1	0	0	0	1	0	0	0
Internal Medicine	22	4	6	3	14	9	5	5
Opthalmology	3	1	1	2	1	3	2	1
Orthopedics	3	0	1	3	1	1	1	3
Pathology	1	0	1	0	1	0	0	0
Pediatrics	1	0	0	0	1	0	0	0
Physical Medicine	1	0	0	1	1	1	1	1
Radiology	1	0	0	0	1	0	0	0
Surgery	8	2	4	6	5	6	4	6
Total - Part Time	46	10	14	19	28	24	16	20
(Full Time)								
Anesthesiology	2	1	1	2	1	2	1	0
Gynecology and Obstetrics	1	0	0	1	1	1	0	0
Internal Medicine	9	6	7	3	6	6	5	5
Opthalmology	1	1	1	0	0	1	1	1
Pediatrics	2	1	0	0	2	1	1	0
Physical Medicine	1	0	0	1	1	1	0	0
Psychiatry	1	0	0	1	1	0	1	0
Radiology	2	0	0	0	2	1	1	1
Surgery	3	0	1	1	0	1	1	3
Total - Full Time	22	9	10	9	14	14	11	10
Total - School of Medicine	68	19	24	28	42	38	28	30
BASIC HEALTH SCIENCES								
Anatomy	3	2	1	2	0	1	0	0
Biochemistry	1	1	0	0	0	1	1	0
Pharmacology	1	0	1	0	0	0	1	1
Total - Basic Health Sciences	5	3	2	2	0	2	2	1

*See Table II for key to Areas of Interest.

(Continued)

TABLE IV (Continued)

SUMMARY OF RESPONSES FROM EMORY UNIVERSITY
TO APRIL 10 BIOENGINEERING QUESTIONNAIRE

Affiliation of Respondent	Number of People Responding	Number of People Indicating Interest in Each Area*						
		I	II	III	IV	V	VI	VII
SCHOOL OF DENTISTRY - Total	2	1	0	1	1	0	0	0
SCHOOL OF ARTS AND SCIENCES								
Biology	2	1	0	0	1	1	1	1
Chemistry	2	2	1	0	0	1	0	0
Physics	2	0	0	0	0	2	0	0
Psychology	2	1	0	0	1	1	1	1
Sociology	3	0	0	0	3	0	3	1
Statistics and Biometry	1	0	0	0	0	0	0	1
Total - Arts and Sciences	12	4	1	0	5	5	6	3
YERKES PRIMATE CENTER - Total	5	3	0	3	1	5	2	2
GRAND TOTAL . . .	92	30	27	34	49	50	37	36

*See Table II for key to Areas of Interest.

TABLE V

SUMMARY OF RESPONSES FROM GEORGIA INSTITUTE OF TECHNOLOGY
TO APRIL 10 BIOENGINEERING QUESTIONNAIRE

Affiliation of Respondent	Number of People Responding	Number of People Indicating Interest in Each Area*						
		I	II	III	IV	V	VI	VII
GENERAL COLLEGE								
School of Biology	2	2	0	0	0	2	1	0
School of Chemistry	1	1	0	0	0	0	0	0
School of Industrial Management	2	0	0	1	2	0	1	0
School of Information Science	1	0	0	0	1	0	0	0
School of Mathematics	1	0	0	0	0	1	1	0
School of Physics	4	1	0	0	0	4	0	0
School of Psychology	2	0	0	2	2	1	0	0
Department of Social Sciences	1	0	0	0	1	0	1	0
Total - General College	14	4	0	3	6	8	3	1
ENGINEERING COLLEGE								
School of Aerospace Engineering	6	1	3	4	1	3	4	3
School of Ceramic Engineering	1	0	0	0	0	0	0	1
School of Chemical Engineering	3	0	1	0	0	3	1	2
School of Civil Engineering	4	0	1	0	1	1	2	1
School of Electrical Engineering	5	1	1	2	1	3	3	1
School of Engrg. Science & Mechanics	3	0	1	0	0	1	2	0
School of Industrial Engineering	3	0	0	1	2	0	2	0
School of Mechanical Engineering	4	1	4	1	1	2	2	3
School of Nuclear Engineering	4	3	0	0	0	3	0	1
The A. French Textile School	1	0	1	0	0	0	0	0
Total - Engineering College	34	6	12	8	7	16	16	11
ENGINEERING EXPERIMENT STATION								
Chemical Science & Materials Division	1	0	0	0	0	1	0	1
Electronics Division	7	5	1	2	2	6	1	2
High Temperature Materials Division	2	0	0	0	0	0	1	2
Nuclear Sciences Division	7	3	2	1	3	4	4	1
Physical Sciences Division	4	0	0	0	0	3	1	1
Rich Electronic Computer Center	2	0	0	0	1	0	2	0
Total - EES	23	8	3	3	6	14	9	7
ADMINISTRATION - Total	1	1	1	1	1	0	0	0
GRAND TOTAL . . .	72	19	16	15	20	38	28	19

*See Table II for key to Areas of Interest.

TABLE VI

IDENTIFICATION OF AREAS OF INTEREST IN BIOENGINEERING IN THE SCHOOLS AND DIVISIONS OF GEORGIA INSTITUTE OF TECHNOLOGY

Engineering College	General College	Engineering Experiment Station
School	School	Division
Aerospace Engineering (ALL)	Applied Biology (I,V,VI)	Chemical Sciences & Materials (V,VII)
Architecture	Chemistry (I)	Electronics (ALL)
Ceramic Engineering (VII)	English	High Temperature Materials (VI,VII)
Chemical Engineering (II,V,VII)	Industrial Management (III,IV,VII)	Industrial Development
Civil Engineering (II,IV,V,VI,VII)	Information Science (IV)	Nuclear Sciences (ALL)
Electrical Engineering (ALL)	Mathematics (V,VI)	Physical Sciences (V,VI,VII)
Engineering Graphics	Modern Languages	Rich Electronic Computer Center (IV,VI)
Engineering Mechanics (II,V,VI)	Music	
Industrial Engineering (III,IV,VI)	Physical Training	
Mechanical Engineering (ALL)	Physics (I,V)	
Nuclear Engineering (I,V,VII)	Psychology (III,IV,V)	
Textile Engineering (II)	Social Sciences (IV,VI)	

NOTE:
I. Cells and Tissue
II. Fluid Systems
III. Motor Performance
IV. Health Care Systems
V. Instrumentation
VI. Models
VII. Substitutes

IV. DISCUSSION

The results from the January 8th questionnaire established the size of the community which would be available to contribute to a program in bioengineering. It also indicated the broad scope of the interest that was available in the area. The areas of interest that were used in this questionnaire were selected to illustrate the wide range of subjects which might be considered to fall within the field of bioengineering. It was not intended that all of the major subdivisions of bioengineering would be represented or that the topics would completely cover the field. Therefore it was not surprising that the tabulated results shown in Table I showed a wide dispersion in the number of respondants indicating an interest in the various areas of activity. Most interest was shown in Bioinstrumentation in which 35 per cent of the respondants indicated an interest. Less than 5 per cent checked Marine Bioengineering. Computer Applications, Diagnostics, Health Care Systems, Mathematical Modeling, and Biomaterials were all of more or less equal interest, having been indicated by 15 to 25 per cent of the respondants.

As a result of the information received from the January 8th questionnaire and the experience gained in studying the field of bioengineering, it was possible to develop a more concise and descriptive structure for the field of bioengineering as shown in Table II. This structure was used as the basis for proposing a series of workshops. Those people who responded in the affirmative to the first questionnaire were questioned concerning their interest in such workshops. Response to this questionnaire was encouraging, and from Tables III, IV, and V it can be seen that the interest was more equitably divided among the seven topics making up the new structure of bioengineering. These results suggested that these topics could serve as an

experimental structure and that seven workshops, one for each subject, should be scheduled as soon as possible. These workshops would serve the vital function of establishing communications between the various interested disciplines in the Atlanta area. Of equal importance, the workshops would also serve to sustain and develop the wide spectrum of interest revealed by the survey. A certain momentum has been gained through these contacts which might be lost if too much time lapses before some sort of implementation is provided.

In order to implement the workshops an additional questionnaire (Appendix III) should be sent to potential participants. This questionnaire is particularly important, not only because it will identify each person with his field of professional competence, but also because it will provide the information necessary to optimize the organization of the workshops. The next step would be to assemble an organizing committee for each workshop and have them arrange the details for their particular program.

This report represents a serious effort on the part of Georgia Tech and Emory University to establish a firm foundation for multidisciplinary programs in bioengineering. This work has identified a resource pool from which multidisciplinary teams can be assembled with the potential of solving the current and long-range bioengineering problems facing our City, State, and Nation. This work has been summarized in "Quo Vadis Bio-Engineering in Georgia?", which has been submitted for publication to the Medical Association of Georgia and is included in Appendix IV.

V. CONCLUSIONS

1. This program has determined that there exists in the Atlanta area a substantial and viable nucleus of individuals with expertise that span the field of bioengineering.

2. A structure consisting of seven topics has been developed to describe the field of bioengineering.

3. Interested professionsls have been identified with their affiliation and catagorized according to their areas of activity and interest within the bioengineering structure.

4. The availability, interest, and enthusiasm of potential participants, as revealed by this study, clearly show the need for immediate action to establish a coordinated bioengineering program in the Atlanta area.

APPENDIX I

A. Summary of Bioengineering Programs at Georgia Tech
July 1968.

B. Revised Summary of Bioengineering Programs at Georgia Tech
August 1, 1968.

July 1968

SUMMARY OF BIO-ENGINEERING PROGRAMS AT GEORGIA TECH

Dr. W. L. Bloom has prepared the following list of the bio-engineering oriented activities which are currently underway on the Georgia Tech Campus. Only those persons who are primarily involved in the programs are listed. The numerical order has no bearing on merit or priority of these programs.

1. An extensive program in aerobacteriology and aerodynamics of the operating room directed by Mr. Tom Kethley.

2. An extensive program in biomedical instrumentation, under the direction of Mr. Fred Dixon in the Physical Sciences Division of the Engineering Experiment Station and in the Department of Electrical Engineering.

3. A study of a mathematical model of respiratory function by Dr. John Jarrell, an anesthesiologist, and Dr. Ernst Tsivoglou in the Department of Civil Engineering.

4. The micro-cochlear-phonics laboratory in the Department of Electrical Engineering in which Drs. Webb and Schlag of the Department of Electrical Engineering are working with Dr. Bob Thompaon and Dr. Majoros, both ear-nose-throat surgeons.

5. A bio-electricity laboratory in the Department of Electrical Engineering under the Supervision of Dr. Demetrius Paris, and Dr. Bloom is an advisor or consultant in this area.

6. The Health Radiation Physics Group has a number of projects going on in biomedical engineering. This is under the direction of Mr. Robert Zimmerman.

7. A joint program between the Savannah River Project, the Medical College of Georgia, and Georgia Tech on the study and evaluation of neutron radiation. Dr. Lyle Roberts represents Georgia Tech's interest in this interdisciplinary and inter-institutional research project.

8. A proposed study of the evaluation of computer reading of electrocardiograms with the Regional Medical Program under the direction of Dr. Gordon Barrow, the computer center under the direction of Dr. I. E. Perlin, and the bio-instrumentation representation by Mr. Fred Dixon.

9. A program which has just been initiated in the study of the material sciences biological properties of materials by Mr. J. D. Walton of the High Temperature Materials Division and Dr. Gilbert of the Veterans administration.

10. A joint program between the School of Industrial Engineering and the Department of Physical Medicine at Emory University. This project is a time-and-motion study of the recovery capabilities of patients who have had nerve damage or strokes. The physician from the Physical Medicine group working on our program is Dr. Sam Chyatte, and Mr. Birdsong of the School of Industrial Engineering is doing the time-and-motion study.

11. The extensive program of the School of Industrial Engineering concerned with hospital management and management systems directed by Dr. Harold Smalley.

12. Extensive programs in the School of Applied Biology under the direction of Dr. Robert Fetner concerned with application of engineering knowledge and methodology to biological problems, as well as a study of biological models for their value in improving mechanical design.

13. This year in the School of Mechanical Engineering, four of the senior student groups worked on bio-engineering problems. One of these was oriented toward the study of a mechanical valve to be placed in the urinary tract, a second design project was oriented toward the design of a better exterior jaw splint, and a third program was directed toward a study of a drilling dome to be placed under the sea; a fourth project was designed to study a better mechanical means of collecting marine biological specimens.

14. A proposal from the Department of Continuing Education has been made to the Regional Medical Program to provide a course for doctors, nurses, hospital engineers, technicians in the connection with engineering and basic science content necessary for the medical and paramedical personnel who will work and maintain the coronary intensive unit.

15. The biophysical program of Dr. Don Harmer of Nuclear Engineering and Dr. Bloom is concerned with the surface interaction of foreign molecules and cell surfaces.

16. The program in Physics concerned with the physical characterization of the structure of dentine. The principal investigator on this program is Dr. Ray Young; however, a number of dentists in the community work in connection with this program as well as an inter-institutional interest between the Rochester Dental Research Clinic and Georgia Tech.

17. Dr. Ray Young in Physics is studying the interactions in the nucleo-protein molecule, this molecule being the basis of genetic information.

18. The programs in the School of Information Science concerned with information storage and retrieval, and possible techniques of history analysis by the use of computer technology, have been generated under the direction of Dr. Slameka. The major thrust is directed at the design of health information systems.

19. Marine bacteriological program under the direction of Dr. Nancy Walls, who has been working with the Department of Mechanical Engineering on the design of better equipment for making measurements and obtaining samples.

20. Design capability of radiation and preservation of food products under the direction of Dr. Nancy Walls.

21. The biochemical monitoring of a Georgia river, directed by Dr. Robert Ingols.

22. The development of sensors to control activated sludge treatment of waste water under the direction of Dr. Robert Ingols.

23. The study of the toxic response of digesting sludge to various salts under the direction of Dr. Robert Ingols.

24. The initiation of tracer studies of gas transfer kinetics of blood by Mr. George Mollison and Dr. Ernest Tsivoglou in Civil Engineering.

25. Dr. Stanford in Physics has been studying the ferro-electric properties of nucleo-proteins. This work will lead to studies of the physical forces of learning and behavior patterns.

26. Dr. Henry McGee has been investigating possible avenues to study chemical changes in cryobiology.

27. Dr. Clyde Orr has been exploring the possible applications of micromeritics to biological materials.

28. Dr. Al Sheppard and Dr. John Heise are developing improved cavities for use in biological studies of spin resonance.

29. Dr. Al Sheppard and Mr. Bob Shakelford are studying the behavioral response of moths to radiation from a far infrared laser.

30. Dr. Robert F. Hochman is currently directing Graduate Training Grants in dental metallurgy. He is also interested in corrosion problems associated with metallic surgical implants.

31. Dr. Willis Moody is carrying out thermal analysis of dental enamel in order to determine its structure and composition. The objective is to develop a synthetic dental enamel.

32. Mr. Doug Robertson is conducting a program on human and nonhuman speech intelligibility by studying the spectral content of the mimicked myna bird utterance.

August 1, 1968

REVISED SUMMARY OF BIOENGINEERING PROGRAMS AT GEORGIA TECH

2. Biomedical Instrumentation

Mr. Frederick Dixon
Physical Sciences Division
Engineering Experiment Station

Biomedical instrumentation activities in the Special Problems Branch (formerly the Defense Branch) were initiated during 1959 as an outgrowth of interest in physiological-simulation and related problems in the Branch's Analog Computer Laboratory. Fifteen projects have been undertaken in this general area over the past nine years. A variety of additional minor investigations and engineering services have been (and continue to be) performed in response to individual inquiries from medical personnel in Georgia and elsewhere.

The only biomedical-type projects currently active are B-315 (Emory/Pharmacology) and B-342 (NIH/Cardiovascular).

B-321/342: "P-N Junction Transducers in Cardiovascular Research." (National Institutes of Health, Grant HE-11317, 1967-70) Has as primary objective to develop catheter-tip transistor probes (No. 6F or smaller) for percutaneous recording of both pressure and sound signals from theheart or large blood vessels. (Under M. E. Sikorski, Head of Metal Physics Group, Physical Sciences Division.)

B-315: On-Line Analog Computing Devices for Kidney and Liver Clearance Studies. (Dr. J. L. McNay, Emory--Clinical Pharmacology, 1967-68)

It is hoped that major efforts will be started within the next year on (a) use of vectorgraphic displays for vowel and basic speech training of acoustically handicapped persons, and (b) development of a prototype central computing service for automatic preliminary analysis of clinical electrocardiograms from selected hospitals under the Georgia Regional Medical Program (see Bioengineering Item No. 8).

In addition to the two programs described above, 13 other programs have been carried out in the Physical Sciences Division. Key staff members involved in one or more of the projects are:

Frederick Dixon
Berry O. Pyron
Matthew E. Sikorski
Frank R. Williamson, Jr.

Note: Program number refers to original list of Bioengineering Programs at Georgia Tech which was distributed on July 12, 1968.

5. Bioelectricity Laboratory

Dr. Demetrius T. Paris
School of Electrical Engineering

In the latter part of 1967 a series of experiments were performed based on published results of investigations into the volt-ampere and impedance characteristics observed during controlled coagulation of blood. Though nothing conclusive came out as a result of these experiments, it was decided that much, potentially fruitfull research could, and should be performed in the future. As a result, in the Spring Quarter, 1968, a then graduating EE senior was hired to set up a laboratory (Room W 407 EE Building) where work of this kind could be performed on a more professional and scientific basis. The objective of this work is the study of electrical phenomena related to blood coagulation and, more specifically, the development of a practical method of presenting a complete histogram of this process for possible use by MD's, hospital technicians, etc.

Also on hand, in Room W 407 of the EE Building, is a combination EKG/EEG. Plans for the near future are to generate interest among undergraduates and graduates, alike, to do work in the vital area of macroscopic electrical pehnomena associated with living organisms, and principally man. Also, there are plans to arrange several seminar sessions in the fall, with the aid of a few local MD's, in order to summarize the presently known facts in the case.

6. Radiological Safety Program

Mr. Robert L. Zimmerman
Nuclear Sciences Division
Engineering Experiment Station

The Office of Radiological Safety has been established as a service group in order to facilitate research and teaching utilizing sources of ionizing radiation. The Radiological Safety Officer and his staff are available to consult with persons who are considering the use of radioisotopes for radiation producing machines in any type of research and development application. The staff will work with the investigators as the program is effected in order to ensure proper control of radiation hazards in compliance with applicable Government regulations. In addition, assistance is given in the training of personnel in safe methods of working with radioactivity. The office handles such matters as AEC licensing, disposal of radioactive waste, and provision of film badge service. Finally, the Office of Radiological Safety works on the development of new techniques and equipment to improve the radiation safety of on-going operations.

7. Biomedical Applications of Neutron Radiography

Dr. Don S. Harmer
School of Nuclear Engineering
School of Physics

A joint program between the Savannah River Laboratory, the Medical College of Georgia and Georgia Tech on the investigation of biomedical applications of neutron radiography. Dr. Don S. Harmer is adivsing two Ph.D. Student Programs in this area. Neutron Radiography is complimentary to conventional X-Radiography in that tissue differentiation is possible with neutrons and bone is transparent whereas the reverse is the case with x-rays. Neutron radiography presents the possibility of diagnosis of bone cancer at an early stage, has a far reaching potential in pathology, and presents the possibility of studies of the circulation in vivo, etc.

8. Proposal for Computer Analysis of Electrocardiograms

Mr. Frederick Dixon
Physical Sciences Division
Engineering Experiment Station

At the request of Dr. J. Gordon Barrow, Director of the Georgia Regional Medical Program, a proposal was submitted in January 1968 by Dr. I. E. Perlin (Chief, Rich Electronic Computer Center) and Fred Dixon (Head, Special Problems Branch, Physical Sciences Division) for a three-year cooperative project to establish a pilot computing service for routine daily screening of clinical ECG recordings from three Atlanta hospitals. The project would be expected to lead ultimately to the development of a state-wide operational system for automatic processing and interpretation of electrocardiographic data from a number of Area Heart Centers utilizing telephone-linked central computing equipment on a day-to-day basis.

Due to funding priorities, it is unlikely that this program can be implemented before mid-1969. However, some planning efforts may be authorized in the near future.

9. Biological Properties of Materials

Mr. J. D. Walton, Jr.
High Temperature Materials Division
Engineering Experiment Station

Dr. C. W. Gorton
School of Chemical Engineering

A cooperative program to study materials for use in prosthetic heart valves is being developed with Dr. Joseph Gilbert of the Veteran's Administration Hospital. Preliminary efforts will be concerned with the

design of in vivo and in vitro experiments to determine the thrombogenic property of inorganic nonmetallic materials. Such experiments will consider the geometry of the specimen (particularly with respect to influence on fluid flow) as well as the interface between the material and the environment. Special attention will be given to the problem of characterizing the material and the environment.

11. Program in Hospital and Medical Systems

Dr. Harold E. Smalley
School of Industrial Engineering

This program of education, research, and service is administered jointly by the Georgia Institute of Technology in Atlanta and the Medical College of Georgia in Augusta. Organized as a subdivision of the School of Industrial Engineering, this cooperative effort incorporates existing programs of Georgia Tech's Hospital Systems Research Group, as well as several pilot projects in which Georgia Tech and the Medical College have been cooperating. The new program is designed to meet educational needs within the interdisciplinary field concerned with improvements in the management of health services through industrial engineering, operations research, and management science.

The general purpose of this program is to promote the cause of better health services through education, research, and service. Of primary concern is professional education at the graduate level, but the inseparability of research and graduate education is recognized, and the value of scientific research as a means of developing new knowledge is appreciated. And, in an applied field of study, the generation and dissemination of knowledge is incomplete if theory is not related to practice. This given rise to the need for a real-world problem orientation which, in a publicity supported program, can best be promoted by channeling the results of educational and research activities into services which have value for the public.

14. A Proposed Program in Continuing Education for Medical and Paramedical Personnel in Bioinstrumentation of the Coronary Intensive Care Area

Dr. Richard Wiegand
Department of Continuing Education

This program of continuing education would be specifically designed to explain the many problems involved in coronary intensive care to three major groups: those involved in direct patient care, those responsible for the physical environment in the hospital, and those concerned with administration and fiscal matters.

Under the patient care heading, continuing education programs related to coronary intensive care would be designed for doctors, nurses, and technicians. Those concerned with the physical environment would include the hospital engineering staff and (possibly) those with respon-

sibility in housekeeping. The last group would be hospital administrators and assistant administrators and fiscal officers (such as controller, treasurers, business managers, etc.) who would have to implement and fund the establishment and continued use of coronary intensive care units.

The purpose of this preliminary statement is to establish a framework whereby the following objectives could be met through a comprenensive program of continuing education:

(1) To provide fundamental information and skills in the use and maintenance of the bio-electronic equipment utilized in coronary intensive care.

(2) To provide fundamental information and skills in the use and maintenance of equipment used in respiratory support for the patient in coronary intensive care.

(3) To provide continual analysis of instrumentation, the physical and architectural environment, and the systems problems emerging from widespread use of coronary intensive care units.

(4) Based upon analysis, to design improvements and to furnish consultation on physical matters related to coronary intensive care. (Such areas would include bio-instrumentation, design or renovation of physical facilities, systems engineering related to material and personnel flow problems, possible computer monitoring applications and implementations, etc).

(5) To develop continuing education programs in multi-media form which will eventually be provided to interested hospitals or personnel desiring to keep abreast of the field of coronary intensive care.

16. Physical Characterization of the Structure of Hard Tissue

Dr. R. A. Young
School of Physics, and
Engineering Experiment Station

An EES program being carried out in the EES, at the nuclear reactor, and in the Physics building is concerned with the physical characterization of the structure of hard tissue, particularly tooth enamal. Structural properties and substitution mechanisms are being studied with neutron and x-ray diffraction techniques. The principal investigator on this program is Dr. R. A. Young: however, dental students work in the program and a number of dentists in the community cooperate with it. In this program, considerable scientific inter-institutional cooperation exists between Georgia Tech and a number of dental research, minerological, and solid state physics groups in the U.S. and abroad.

Other senior people directly associated with this project are:

Dr. R. J. Gerdes; EES
Dr. C. O. Pollard; EES/Geophysical Sciences
Dr. S. Spooner; EES/ChE (metallurgy)
Dr. K. Sudarsanan; EES
Dr. R. A. Young; EES/Physics

21. A Study of Georgia Lakes and Rivers

Dr. Robert S. Ingols
Chemical Sciences and Materials Division
Engineering Experiment Station

A Study of Georgia Rivers and Lakes is a project supported by Georgia Tech. Observations have been made in many areas of the State particularly with graduate students. Many instruments for water quality testing have been obtained by this project. These instruments have then been available for work with industrial sponsors as well as for obtaining fundamental scientific information. At present several instruments are recording water quality data on the Etowah River near Cartersville. These observations are involved in evaluating a new procedure for lessening the damage effect of powder impoundments upon downstream river water quality.

The correlations between the chemical and physical characteristics of a river or lake and the biota present is done for industry and general information.

22. Sensors for Controlling the Activated Sludge Process

Dr. Robert S. Ingols
Chemical Sciences and Materials Division
Engineering Experiment Station

The project for developing sensors to control the activated sludge process of treating waste water is funded by a contract with the City of Atlanta. The city needs a new water pollution control facility using the Activated Sludge Process for the waste water from the Peachtree Creek drainage basin which will treat 3 cubic meters per second on the average.

The activated sludge process depends on microorganisms for its effectiveness in reducing the polution load (effect) on the Chattahoochee River. The process which has several operating variables treats a waste water with variable characteristics. At times the effluent will have to be more highly treated than at other times. Because of (1) the large number of variables and (2) the time required to obtain laboratory data to assay the variables and (3) the added cost of operating the process at its maximum effectiveness and (4) the non-professional training of the available personnel and (5) the possible economy of using computers, the decision was made to provide computer control for the Peachtree Creek Plant. All the necessary sensors were not available for computer input

and the electronic circuits are necessary to convert all the sensor circuits to digital form.

This project has developed two new sensors and the electronic conversion circuits for a digital printout device. The two new sensors include an oxygen uptake rate apparatus and a sludge concentration reader.

23. Waste Water Treatment and Analysis for the City of Macon

Dr. Robert S. Ingols
Chemical Sciences and Materials Division
Engineering Experiment Station

The City of Macon has a major outfall sewer discharging into the Ocmulgee River without treatment. Directly adjacent to the outfall are two major industries also discharging untreated process waste water. While the city's waste water can be treated readily the chemical character and strength of the waste water from theGeorgia Kraft Company and Armstrong Incorporated are not readily treated separately. Laboratory scale experiments have indicated that the three waste waters can be successfully treated after mixing.

This project will involve a pilot plant for studying the size of plant required and for choosing the best technique of disposing of the byproduct sludges. The pilot plant will use the activated sludge process. The need for added mineral nutrients will be studied as well as possible sensor use for possible computer control.

The plant because of the industrial waste water characteristics will treat only 1/6th the volume of the plant under design for Atlanta but will be 1/2 the size of the Atlanta Plant in order to obtain a satisfactory effluent.

Part of the study will involve information necessary to develop an equitable base for charging the industries for the cost of treating their waste water.

25. Bio-Physics

Dr. A. L. Stanford
School of Physics

Dr. A. L. Stanford in Physics, Drs. E. Jo Baker and Jack Marr in Psychology and Dr. John Dyer in Chemistry are studying nucleic acids and their relationships to nolecular memory mechanisms.

26. Cryobiology

Dr. Henry A. McGee, Jr.
School of Chemical Engineering

The Cryochemistry Group is interested in the use of very low temperatures to (1) study basic problems in biology (cryobiology), (2) develop very low temperature storage techniques for living cells or tissue or organs, (3) develop cryogenic techniques useful in surgery, and (4) study the possible relation or utility of cryogenic techniques to the field of gerintology. In the biological area one might typically be concerned with the mechanism of cell destruction upon severe cooling and techniques for its alleviation. Cryogenic storage of semen and bone marrow are successful, but skin, kidney, heart, etc. storage has not been successful. We are interested in such problems. Cryosurgical techniques have been developed for the treatment of Parkinson's disease and several others. They are interested in working with surgeons in the further development of such cryogenic applications. By virtue of the effect of temperature on chemical reaction rates it may be possible to study the mechanism and nature of ageing. The cessation of metabolic processes in living systems by extreme cooling represents a sort of suspended animation that could be useful.

Although the Cryochemistry Group has no work in these areas underway, they are well qualified in any sort of a cryogenic problem. At the present time they have no relationship with life-science types who would be absolutely necessary for the success of any program of the sort mentioned here. They seek this relationship, and with success would be eager to expand their present activities into the biomedical area.

27. Applications of Micromeritics to Biological Materials

Dr. Clyde Orr
School of Chemical Engineering

Synergistic effects come into play when airborne particulates and pollutant gases are inhaled in combination. Some research has been conducted in this area but much more is needed. Inhalation therapy utilizing atomized (droplet) detergent solutions has been employed in treating bronchial conditions. The efficacy of air ions (really very small, charged particulates) is debated with regularity, but no real proof has been submitted. The Micromeritics Laboratory has equipment for producing all types of particulates that might be required if such studies were initiated. Knowledge of the solubility of materials in body fluids is also largely unexplored. The Laboratory has at least some of the equipment required for this type of endeavor. All of the suggested subjects readily lend themselves to graduate-student research. Appropriate disciplines at Tech would be Sanitary Engineering, Applied Biology, and Chemical Engineering.

28. Improved Microwave Cavities for Biological Applications of Electron Spin Resonance

Mr. R. G. Shackelford and Dr. A. P. Sheppard
Electronics Division
Engineering Experiment Station

Dr. J. J. Heise
School of Applied Biology

The purpose of this project is to study more effective ways of illuminating biological samples with visible and ultraviolet light while investigating their electron spin resonance properties. Advantages of such a system can offer the opportunity of generating substantially more free radicals through the use of the ultraviolet radiation than is now possible, thereby getting better ESR data. The cavities that appear to have the most promise for realizing this are the Fabry-Perot resonator, which has been used extensively in the implementation of the optical laser, and in a dielectric cavity. Plans are under way to implement the dielectric cavity using sapphire, which has very good transmission properties through the ultraviolet and visible spectrum and into the near infrared. The cavities will be designed to fit within a six-inch magnet gap. Upon their completion appropriate biological samples will be inserted to determine both the size and the extent of illumination possible with the new design.

29. Electromagnetic Effects on Arthropods

Mr. R. G. Shackelford and Dr. A. P. Sheppard
Electronics Division
Engineering Experiment Station

The purpose of this program has been to support scientists at the U. S. Department of Agriculture by materials measurements and by furnishing of electromagnetic sources for insect stimulation. Work to date has included measurement of dielectric constant of insect exoskelton in the millimeter wave region and examining the correlation of electrical properties of ground insect exoskelton with the whole exoskelton sample. The design and construction of a far infrared laser has been used to furnish a variety of far infrared wavelengths that offer potential stimulation of insects. The rationale for interest of this nature from the Department of Agriculture stems from the dangers to nature and to man himself from the chemical poisons used for economic insect control. It would be highly desirable to find some electromagnetic frequency which would optimally cause a behavioral change in insect response either sexually or from the life cycle standpoint so that economic insect eradication could be effectively precipitated without recourse to deadly chemicals.

32. Human and Non-human Speech

Mr. D. W. Robertson
Electronics Division
Engineering Experiment Station

During the past two decades, numerous investigations have been conducted in an attempt to define and extract the basic information carrying or "invariant parameters" of speech. The primary objectives have been (1) to reduce the channel bandwidth requirements for transmission of speech signals and, (2) to provide for electromagnetic recognition and generation of speech. Included were some excellent studies concerned with internal processing, nerve stimulation, and brain pattern storage. To date, these techniques have permitted bandwidth reductions of only two or three to one for acceptable quality speech and have not led to identification of the invariant parameters.

The current investigation is directed to the study of a non-human system, which is capable of receiving (hearing) and re-transmitting (speaking) speech of considerable fidelity, i.e., the mimicked human speech sounds as uttered by a trained Mynah bird. Previous studies of vocal equipments of birds (including Mynahs) have failed to produce evidence of vocal cords or of vocal cavities of a size normally considered necessary for the production of human speech sounds. Consequently there seems to be considerable merit in the comparative study of the human and Mynah bird speech mechanisms as an approach to defining and extracting the invariant parameters.

Two Indian Hill Mynahs have been housed in individually acoustically isolated chambers and are being exposed, through use of repetitive tape recordings, to selected test words and phrases several times during the day. The initial goal is to spectrographically compare the learned Mynah sounds with those of the trainer. Project efforts to date have been concerned with procurement of the birds, construction of the acoustical chambers, establishment of the housekeeping details and initial training. Future efforts will be concerned with study and analysis of the spectrograms and the approach to a more extensive physiological study of the vocal and hearing mechanisms of the Mynah bird.

33. Acoustic/Radio Interaction

Mr. C. H. Bonham III and Mr. W. K. Rivers
Electronics Division
Engineering Experiment Station

This project has been concerned with the changes in conductivity of a saline type solution that can be caused by an acoustic source immersed within the solution and interacting at the solution's surface with an electromagnetic radiation. Frequencies of the acoustic source are typically 17 KHz and the radio frequency source 144 MHz. The investigation to this point and in the near future will continue to be oriented toward the Navy's interest in perturbations of the properties of sea

water. However, it is believed that there is sufficient analogy between the properties of blood and saline solutions for this area and capability, which includes detection of very very low level signals, to offer some vast opportunities for better understanding coagulation and clotting through a knowledge of the electrical properties of the blood.

34. Potential Relationships of Swimming Water Quality to Outer Ear Infections Among Swimmer

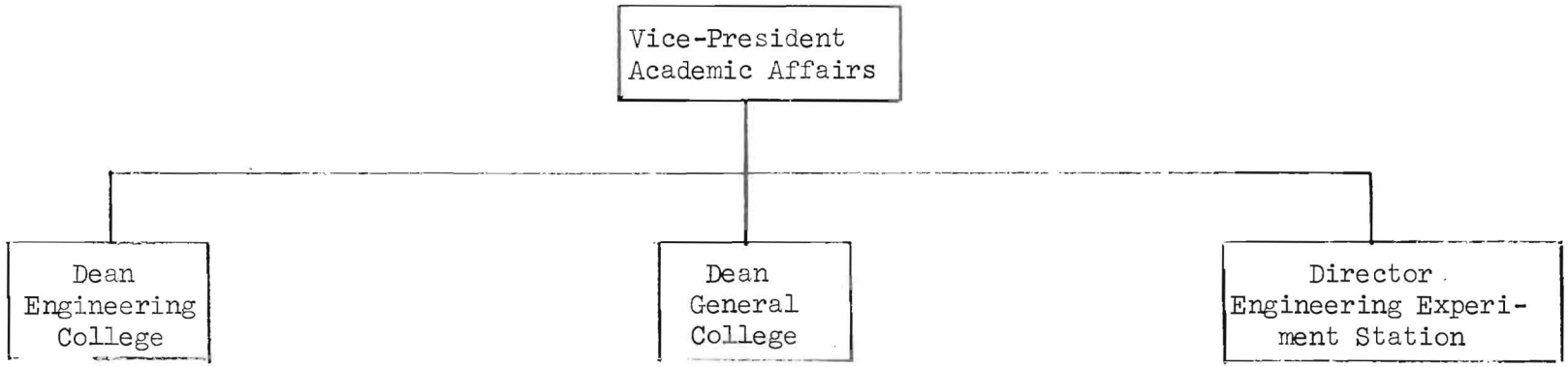
Dr, A. W. Hoadley
School of Civil Engineering

Enumeration and isolation of potential pathogenic bacteria from bathing waters and typing of strains from water and infected ears.

35. Application of Continuous Culture Techniques to the Study of the Effects of Environmental Variables of Bacterial Growth

Dr. A. W. Hoadley
School of Civil Engineering

In planning stage. Design and construction of continuous culture device. Title descriptive of ultimate objectives.



School

Aerospace Engineering
Architecture Engineering
Ceramic Engineering (31)
Chemical Engineering (26,30)
Civil Engineering (3,24,34,35)
Electrical Engineering (4,5)
Engineering Graphics
Engineering Mechanics
Industrial Engineering (10,11)
Mechanical Engineering (13,19)
Nuclear Engineering (7,15)
Textile Engineering

School

Applied Biology (12)
Chemistry
English
Industrial Management
Information Science (18)
Mathematics
Modern Languages
Music
Physical Training
Physics (17,25)
Psychology
Social Sciences

Division

Chemical Sciences & Materials (21,22, 23,27)
Electronics (28,29,32,33)
High Temperature Materials (9)
Industrial Development
Nuclear Sciences (1,6,20)
Physical Sciences (2,8,16)
Rich Electronic Computer Center

(14) - The Department of Continuing Education is a unit of the Engineering Extension Division which reports to the Vice President for Academic Affairs.

*The numbers in parentheses refer to the corresponding numbers on the attached list of Bioengineering Programs.

APPENDIX II

A. January 8, 1969 Bioengineering Questionnaire, Cover Letter, and Selected Areas of Activity.

B. April 10, 1969 Bioengineering Questionnaire, Cover Letter, and Preliminary Topics for Bioengineering Seminars and Workshops.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

January 8, 1969

Dear Colleague:

A survey is now in progress to determine the interest of the Atlanta community in developing a coordinated program in "bioengineering". Sponsored by the Georgia University System, the survey seeks to assess current activities and capabilities in bioengineering and to determine whether a set of problem areas exists which could profitably be attacked through an interdisciplinary bioengineering program.

Bioengineering may be broadly considered as the interaction of biological and engineering systems so that the theories, techniques, instrumentation, materials and/or information found in one system aids in the advancement of the other system. To illustrate the potential scope of the field, various observers have placed the complex of human transportation, the issues of marine resources for man, and the fluid dynamics in the human circulatory system all within bioengineering. While a great deal of activity has centered around the development of instrumentation, more diffuse benefit is likely to be derived by such efforts as the consideration of the engineering approach to biological problems (e.g., not how does one obtain more precise blood pressure readings, but why do we bother in the first place?). Conversely, the brain may represent the most fantastic computer system and energy conservation system the physical-engineering disciplines could ever hope to develop. Man's endocrine system may represent the ultimate in closed loop systems, one which the industrial engineer, systems and management analyst could profitably consider.

The enclosed questionnaire is designed to help you indicate areas of current or recent activity related to bioengineering. In addition, your comments about areas within your own discipline or within other disciplines which might profit through a bioengineering program are invited. An attempt to categorize replies is made, but, if it hampers your response, please feel free to comment in any form you desire.

For your information we have enclosed a list of six of the general areas of activities which are included on the questionnaire. These have been subdivided to illustrate the types of subjects which might be considered related to the major topic.

Thank you for your assistance in this survey.

Sincerely,

J. D. Walton, Jr., Chairman
Bioengineering Committee
Georgia Institute of Technology

Samuel B. Chyatte, M.D.
Bioengineering Representative
Emory University

JDW-SBC/js

BIOENGINEERING QUESTIONNAIRE

I. Current or Recent Activities

A. Concerned with (check one or more)

- ☐ Bioinstrumentation
- ☐ Biomaterials
- ☐ Biomechanics
- ☐ Computer Applications
- ☐ Diagnostics
- ☐ Health Care Systems
- ☐ Marine Bioengineering
- ☐ Mathematical Modeling of Biological Systems
- ☐ Patient Monitoring
- ☐ Prosthetics
- ☐ Psychophysiology
- ☐ Social Systems
- ☐ Other _____

B. Title and brief description of activity: _____

II. Areas in your field which would benefit from or contribute to bioengineering:

III. Areas in other fields which would benefit from or contribute to bioengineering:

IV. Of your colleagues, who would you recommend to discuss the interface between your field and bioengineering? _____

V. Assuming one develops, would you be interested in participating in an interdisciplinary bioengineering program?

☐ YES ☐ NO

VI. Comments: _____

Name: _____

Address: _____

PLEASE RETURN TO:

J. D. Walton, Jr., Chairman
Bioengineering Committee
Georgia Institute of Technology
225 North Avenue, N.W.
Atlanta, Georgia 30332

NOTE: If more space is needed to complete your answers, use back of questionnaire.

- BIOENGINEERING -

Selected Areas of Activity

BIOINSTRUMENTATION

1. Research and Development
   a. Biotelemetry
   b. Electronic Systems
   c. Lasers
   d. Optics
   e. Transducers and Other Sensing Devices
   f. Ultrasonics
2. Physiological Phenomena
   a. Blood Flow
   b. Blood Pressure
   c. Ventricular Dynamics
3. Applications
   a. Criminology
   b. Diagnostics
   c. ECG
   d. EEG
   f. Neurophysiology
   g. Pacemakers
   h. Patient Monitoring
   i. Regulation of Vascular Resistance

BIOMATERIALS

1. Applications
2. Characteristics
3. Compatibility with Body Fluids, Bone and Tissue
4. Development
   a. Ceramics
   b. Metals
   c. Plastics
   d. Textiles

COMPUTER APPLICATIONS

1. Analysis
2. Hospital Operations
3. Image Recognition
4. Processing and Display

HEALTH CARE SYSTEMS

1. Accident Prevention
2. Economic Analysis
3. Facilities Design and Management
4. Hospital Automation
5. Hospital Information Flow
6. Intensive Care Unit
7. Medical Data Processing
8. Mobile Health Delivery System

MATHEMATICAL MODELING OF BIOLOGICAL SYSTEMS

1. Biochemical
2. Biophysical
3. Cardiovascular
4. Circulatory
5. Flow
6. Muscle
7. Nerve and Synapse
8. Respiration

MARINE BIOENGINEERING

1. Aquaculture
2. Ecology
3. Material Resources from Living Organisms

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

April 10, 1969

Thank you for contributing to the overwhelming response to the recent survey on "Bioengineering". Three hundred and thirty persons indicated that they were now active in or would be interested in the field.

While there will be a time lag prior to any definitive action being taken, please be assured that the material is being analyzed and an appropriate plan of action will be developed.

In all probability, the first stage will revolve around a series of conferences, seminars, or workshops to allow the diverse disciplines represented among the respondants to begin to communicate. A preliminary series of discussion topics are listed on the attached sheet for your information. Please note that a card is included for you to indicate your interest in participating in such meetings. Also, please indicate the topic or topics that are most closely related to your field of activity or interest. If all goes well, the seminars or workshops could commence during the summer. Breaking the language barrier is likely to be a delightful but frustrating experience and will be given priority in any plan of action.

You will receive further memos periodically and news flashes of momentous breakthroughs immediately!

Sincerely,

J. D. Walton, Jr.
Chairman, Bioengineering Committee
Georgia Institute of Technology

Samuel B. Chyatte
Bioengineering Representative
Emory University

JDW-SBC/js

Enclosures

PRELIMINARY TOPICS
Bioengineering Seminars or Workshops

I. CELLS AND TISSUE

A. Function and Structure
B. Submolecular and Molecular Properties
C. Substitutes or Modification
D. Instrumentation

II. FLUID SYSTEMS (Biological)

A. Fluids
B. Conduits
C. Pumps
D. Filtration Systems
E. Substitute Parts and Systems
F. Instrumentation

III. MOTOR PERFORMANCE (Biological)

A. Neuro-Muscular-Skeletal Basis
B. Substitutes
C. Monitoring and Instrumentation
D. Motor Performance of Individuals and Group Interaction Based on Motor Performance

IV. HEALTH CARE SYSTEMS

A. Health Related Procedures and Their Delivery
   1. patient or health professions transport
   2. patient flow and/or care flow
   3. automation and mechanization
B. Physical Plant and Equipment
   1. plant design
   2. equipment design and utilization
C. Economics
   1. management (systems analysis, cost decision, information storage and retrieval, manpower)
   2. insurance
D. Social Factors
   1. community planning
   2. individual and group health factors

V. INSTRUMENTATION

A. For Biological Studies of:
   1. cell, tissue and organ structure, function and performance
   2. organ system function, performance and interaction
   3. organism function and performance and interaction of organisms and groups
B. Instrument Research and Development
   1. properties and behavior of instrument materials in contact with biological systems
   2. properties and behavior of instrument components in contact with biological systems
   3. mechanism and function of instrument components and systems
   4. procedure for instrument operation
   5. manufacture and delivery of instruments and instrument systems

VI. MODELS

A. Cells and Tissue
B. Fluid Systems
C. Health Care Systems
D. Motor Performance
E. Computer Applications

VII. SUBSTITUTES

A. Artificial Organs or Parts
   1. functional
      a. kidney, heart, etc.
      b. limbs
      c. eyes, ears, palate
   2. cosmetics
      a. facial, ocular, aural, oral
      b. breast
      c. other
B. Artificial Cells, Tissue, Fluids including replacements for:
   1. blood
   2. skin
   3. bone
   4. teeth
   5. hair
   6. other
C. Materials
   1. preparation
   2. properties and behavior
D. Psycho-social Reactions to Artificial Parts

NAME (please print) _____

			A	B	C	D	E	F
☐	I.	CELLS AND TISSUE	☐	☐	☐	☐		
☐	II.	FLUID SYSTEMS (Biological)	☐	☐	☐	☐	☐	☐
☐	III.	MOTOR PERFORMANCE (Biological)	☐	☐	☐	☐		
☐	IV.	HEALTH CARE SYSTEMS	☐	☐	☐	☐		
☐	V.	INSTRUMENTATION	☐	☐				
☐	VI.	MODELS	☐	☐	☐	☐	☐	
☐	VII.	SUBSTITUTES	☐	☐	☐	☐		
☐	VIII.	OTHER _____						

APPENDIX III

Undated Letter on Bioengineering Workshops

-FLASH- -FLASH- -FLASH-

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

TO:

FROM: J. D. Walton, Jr. JDW and Samuel B. Chyatte, M.D. SBC
Chairman, Bioengineering Committee — **Bioengineering Representative**
Georgia Institute of Technology — **Emory University**

Start making plans now for the Bioengineering Workshops. Figures from the latest questionnaire showed that there was general interest in all seven topics, so seven workshops are planned and are scheduled as follows:

1969	Workshop	1970	Workshop
October	Instrumentation	January	Substitutes
November	Health Care Systems	February	Cells and Tissue
December	Models	March	Motor Performance
		April	Fluid Systems

However, additional information is needed before the organizational details can be completed. Many respondants indicated interest in two, three, or more topics. But in order to insure the most effective use of existing talents in establishing communications between disciplines and formulating future courses of action, it is important that each participant be identified with the one area which is most closely related to his expertise. Please indicate below the appropriate workshop together with the other information requested and return as soon as possible to J. D. Walton, Jr. Your identification with this workshop does not preclude your participation in any other workshop(s).

Workshop Closest to Your Expertise

- ☐ Instrumentation
- ☐ Health Care Systems
- ☐ Models
- ☐ Substitutes
- ☐ Cells and Tissue
- ☐ Motor Performance
- ☐ Fluid Systems

Your Participation

- ☐ Formal Presentation
- ☐ Discussion Group
- ☐ Other _____

Preference for Day(s) of Week

- ☐ Monday
- ☐ Tuesday
- ☐ Wednesday
- ☐ Thursday
- ☐ Friday
- ☐ No Preference

Type of Meetings

- ☐ Full Day(s)
- ☐ Half Day(s)
- ☐ Evening(s)
- ☐ No Preference

Your Telephone Number _____

APPENDIX IV

QUO VADIS BIO-ENGINEERING IN GEORGIA?

QUO VADIS BIO-ENGINEERING IN GEORGIA?

By

Samuel B. Chyatte, M. D.
Emory Representative
Bio-Engineering Committee,
Director of Training
Emory University Regional Rehabilitation
Research and Training Center

J. D. Walton, Jr.
Chairman,
Bio-Engineering Committee
Chief,
High Temperature Materials Division
Georgia Institute of Technology

Nearly every major medical and engineering center in the nation has felt the surge of interest in "bio-engineering" or "bio-medical-engineering". While terminology varies from center to center, basically the process being identified is the interaction of biological concepts, techniques, systems and materials with engineering or physical science concepts, techniques, systems and materials.

As in any natural process of evolution, the development of the field has had variable success and variable pathways of expression, dependent in large measure on local conditions. Often, individual projects progress unnoticed even among an investigator's colleagues. Yet, it is the individual investigator in collaboration with other individual investigators who must form the nucleus of a meaningful organized "program" in bio-engineering.

In order to better identify individual workers and to determine the extent of both current activities and interest in bio-engineering in Georgia, the Board of Regents of the University System of Georgia authorized the selection of a survey team to delve into these questions.

For convenience, the survey team elected to sample the potential bio-engineering community in the geographic area of Atlanta. A questionnaire was designed to determine persons currently active in or interested in bio-engineering and to identify problems which might productively be considered by the bio-engineering approach.

Because the academic community forms only a part of the scientific community in any geographic area, an attempt was made to reach private practitioners of medicine and dentistry as well as non-university based engineers. The survey team felt that any broadly-based bio-engineering cooperative venture would have to include the viewpoints of personnel who deal daily with the practical problems of their professions.

Three hundred and forty (340) responses indicating current activity or interest were received from the first questionnaire. From the types of activities, interests and problems listed a panorama of bio-engineering could be discerned. The panorama is illustrated in Table I.

Table I represents, in its horizontal components, the increasing complexity of organization common to both the physical and life sciences. Particles, forces, atoms and molecules are organized into materials with special properties, mechanisms and functions. These more basic components are applied as systems and procedures to deliver the product in usable form to the "consumer". On the life science side, molecules, cells and tissues are the units which are organized into organs and organ systems. Organ systems interact producing the functional organism. Organisms interact on a one to one basis or in groups. Two end results of the interaction are patient care or the delivery of health services.

Vertically, the physical sciences represented by the physicist, chemist and engineer blend with the life sciences represented by the biological scientist, physician and behavioral scientist to develop the biophysical sciences. Instrumentation, mathematical or other models of life systems and substitutes for structure or function also vertically cross the organizational layers.

Activities at all vertical and horizontal levels are currently in progress in Atlanta. Some projects already involve inter-disciplinary effort; others evidence a desire to obtain inter-disciplinary assistance. When professional disciplines intermingle, communications are usually the major initial problem. Even members of the same discipline in the same institution or in the same community seldom have adequate communications. Technical jargon, the deluge of printed material (alias logorrhea), and the lack of awareness of the presence of a project related to one's own all contribute heavily to the problem.

In order to enhance the process of interchange of ideas and to alert potential colleagues to each other's existence, it was decided that a series of seminars (privately dubbed the "Tower of Babel Seminar Series") would be a logical first step. Using the panorama chart as a basis, the following seminars were outlined:

I. CELLS AND TISSUE

A. Function and Structure

B. Submolecular and Molecular Properties

C. Substitutes or Modification

D. Instrumentation

II. FLUID SYSTEMS (Biological)

A. Fluids

B. Conduits

C. Pumps

D. Filtration Systems

E. Substitute Parts and Systems

F. Instrumentation

III. MOTOR PERFORMANCE (Biological)

A. Neuro-Muscular-Skeletal Basis

B. Substitutes

C. Monitoring and Instrumentation

D. Motor Performance of Individuals and Group Interaction Based on Motor Performance

IV. HEALTH CARE SYSTEMS

A. Health Related Procedures and Their Delivery

1. patient or health professions transport
2. patient flow and/or care flow
3. automation and mechanization

B. Physical Plant and Equipment

1. plant design
2. equipment design and utilization

C. Economics

1. management (systems analysis, cost decision, information storage and retrieval, manpower)
2. insurance

D. Social Factors

1. community planning
2. individual and group health factors

V. INSTRUMENTATION

A. For Biological Studies of:

1. cell, tissue and organ structure, function and performance
2. organ system function, performance and interaction
3. organism function and performance and interaction of organisms and groups

B. Instrument Research and Development

1. properties and behavior of instrument materials in contact with biological systems

2. properties and behavior of instrument components in contact with biological systems

3. mechanism and function of instrument components and systems

4. procedure for instrument operation

5. manufacture and delivery of instruments and instrument systems

VI. MODELS

A. Cells and Tissue

B. Fluid Systems

C. Health Care Systems

D. Motor Performance

E. Computer Applications

VII. SUBSTITUTES

A. Artificial Organs or Parts

1. functional

a. kidney, heart, etc.

b. limbs

c. eyes, ears, palate

2. cosmetics

a. facial, ocular, aural, oral

b. breast

c. other

B. Artificial Cells, Tissue, Fluids, including replacements for:

1. blood

2. skin

3. bone

4. teeth

5. hair

6. other

C. Materials

1. preparation

2. properties and behavior

D. Psycho-social Reactions to Artificial Parts

The seminars are projected to begin in September 1969.

The respondents who had indicated current activities or interest were surveyed again. They were asked to indicate which seminar(s) would be of interest and most closely related to their own current efforts. Two hundred and eleven (211) responses were received from the following sources:

1.	Emory University		92
	a) Physicians (part-time faculty)	- 46	
	b) Physicians (full-time faculty)	- 22	
	c) Dentists	- 2	
	d) Arts and Sciences	- 12	
	e) Basic Sciences	- 5	
	f) Yerkes	- 5	
2.	Georgia Institute of Technology		72
	a) General College	- 14	
	b) Engineering College	- 34	
	c) Engineering Experiment Station	- 23	
	d) Administration	- 1	
3.	Georgia State		5
4.	Lockheed		3
5.	Scientific Atlanta		1
6.	Non-Emory Physicians		26
7.	Non-Emory Dentists		12

Interest in each seminar was generalized. Many respondents indicated more than one area of interest.

	Seminar Title	Number Indicating Interest
I.	Cells and Tissue	58
II.	Fluid Systems	48
III.	Motor Performance	57
IV.	Health Care Systems	93
V.	Instrumentation	106
VI.	Models	85
VII.	Substitutes	74

And now, "Quo Vadia?" In the 1969 session of the General Assembly of the State of Georgia, "An Act to Create the Institute for Research in Bio-Technology (S.B. 263)" was passed. The bill authorized the State of Georgia to financially support in part a Bio-Technology Institute during its first three years of existence with the following objectives:

"The institute shall conduct research and generally explore and promote the combination of medical and engineering sciences and related fields of science. It shall be the objective of the institute to find new ways in which physical and engineering disciplines may contribute to improved health and longer life through such developments as artificial and substitute organs; the application of engineering experiences in physics and chemistry to body processes; the accommodation of the human body to new and varied environments; and to other biological-technological interfaces. The institute may undertake basic research to add to the store of human knowledge; but it is specifically encouraged to work in areas of applied research which may lead to the establishment of new industries and the creation of new jobs in Georgia."

Certainly, then, the political, academic and community climate is favorable for "bio-engineering" growth and development. But what kind of growth, and development in which directions?

One pathway to the future might be to simply let things go as they now are. Individual investigators working in blissful ignorance of fellow investigators' related undertakings, sometimes duplicating each other's failures and successes, incompletely capitalizing on the advancements of others to promote one's own project, and each investigator seeking inter-disciplinary collaboration only when desire and opportunity coincide. Despite these drawbacks, such a system has proven "productive", if not "efficient".

An alternate pathway might seek ultimate "efficiency". All investigators gathered together in a glittering institute crammed full with sophisticated equipment, expertise and instant consultation. Information transfer systems, toilet facilities, and hardware all in orderly stacked units. The investigator no longer owing allegiance to a home university or corporation is freed from financial and administrative tentacles. Yet, in time, the individual drifts from his original discipline and instead of the chemical engineer becomes the bio-engineer. The unique viewpoint and background which made him different from the other engineers who came to the institute tends to blur. The institute develops the administrative or financial complications of the university or corporation. Communication with those outside of the institute becomes more difficult. Perhaps most critical, such an institute does not grow out of the demands of the investigators; it usually is superimposed upon them. It is rarely designed by the workers, but the workers function within its limitations. Perhaps, then, it would not be prudent to seize upon the opportunity for a Bio-Technology Institute of this type at this moment.

An organized cooperative bio-engineering venture is in its infancy in Georgia. It is beginning to express natural directions of growth. Given a forum for the interchange of ideas and communications in general, the

individual may profit from the efforts of others but retain his identity and unique qualities. In time, individuals will gradually coalesce into functioning cooperative units. When such units become complex enough so that they seek a combined base of operation, it will be appropriate to seek sophisticated institute-like organizations.

But, the moment for action must not slip by unnoticed and without response. The explosive impact of bio-engineering upon the nation's scientific and economic frontiers demands prudent but tangible action from the Georgia community if it is to be a pioneering participant rather than a spectator.

Now is the time to capitalize upon the excellent but embryonic syncytium which has been identified. Now is the time to accelerate the rate of growth, while maintaining the natural developmental options.

As a vehicle for action, the following is proposed:

1. That there be established a Georgia Congress for Bio-engineering composed of representatives from
   a. The Georgia Institute of Technology
   b. The Emory University School of Medicine
   c. The Medical College of Georgia
   d. The Georgia University System
   e. The Emory University

) those units not included in A, B, or C

   f. The industrial community
   g. The medical and dental community
   h. Physical and Life Science disciplines
   i. State and local legislative bodies

2. The Congress would be charged with the following responsibilities:

   a. To assist individuals in the processes of grant writing and the identification of sources of research funds.

   b. On an inter-institutional level, it will act as a body for the evaluation of projects seeking federal and state funding.

   c. As a monitor of national and state trends in bio-engineering, it will focus the attention of individuals or groups within the state upon any opportunities which may be thus identified. It will then be the instrument through which talents and facilities from various sources are utilized optimally in responding to the identified opportunities.

3. In order to discharge the above responsibilities, the Congress will

   a. Develop and maintain a registry of all bio-engineering projects in the state, including title, synopsis, investigators and key word index.

   b. Develop and maintain a list of persons in the state willing to act as consultants to bio-engineering projects with data as to areas of expertise and previous investigative or other efforts.

   c. Develop and maintain a state-wide newsletter which reports current bio-engineering activities, pertinent current legislation, grant sources, etc.

   d. Maintain the bio-engineering seminar program already initiated.

In addition, it is suggested that the members of the Medical Association of Georgia request the formation of a bio-engineering subcommittee which then would act to represent and protect the interests of the physician within the Congress of Bio-engineering.

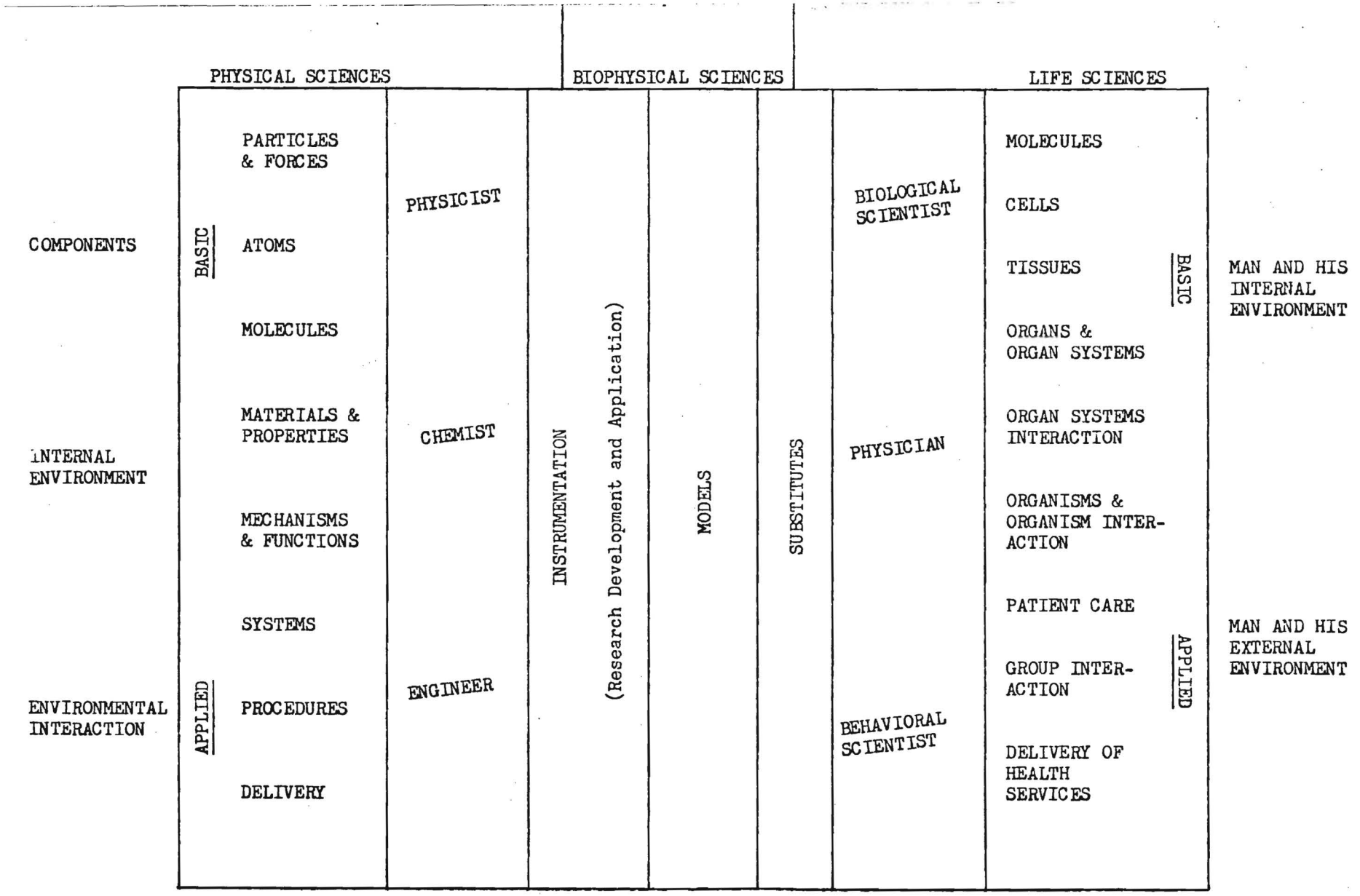

PHYSICAL SCIENCES
BIOPHYSICAL SCIENCES
LIFE SCIENCES
COMPONENTS
INTERNAL ENVIRONMENT
ENVIRONMENTAL INTERACTION
BASIC
APPLIED
PARTICLES & FORCES
ATOMS
MOLECULES
MATERIALS & PROPERTIES
MECHANISMS & FUNCTIONS
SYSTEMS
PROCEDURES
DELIVERY
PHYSICIST
CHEMIST
ENGINEER
INSTRUMENTATION
(Research Development and Application)
MODELS
SUBSTITUTES
BIOLOGICAL SCIENTIST
PHYSICIAN
BEHAVIORAL SCIENTIST
MOLECULES
CELLS
TISSUES
ORGANS & ORGAN SYSTEMS
ORGAN SYSTEMS INTERACTION
ORGANISMS & ORGANISM INTER-ACTION
PATIENT CARE
GROUP INTER-ACTION
DELIVERY OF HEALTH SERVICES
BASIC
APPLIED
MAN AND HIS INTERNAL ENVIRONMENT
MAN AND HIS EXTERNAL ENVIRONMENT

Table 1