THE COMPUTER-RELATED SCIENCES (SYNNOETICS) AT A UNIVERSITY IN THE YEAR 1975.

L O U I S F E I N

431 Ferne Avenue, Palo Alto, California.

FOREWORD.

One indicator of a changing culture is the set of new names and words for new ideas, things, modes of behavior, activities, vocations, avocations, intellectual disciplines, and so on. Consider the following set of names and words that have appeared in this generation: Information Theory, Communication Sciences, Automation, Cybernetics, Autonomics, Intellectronics, Computer Sciences, Bionics, Human Engineering, Operations Research, Theory of Games, Data Processing, Management Science, Artificial Intelligence, Adaptive, Cognitive and Self-Organizing systems. With these terms, we can describe roughly the ways in which we handle some of society's chores and how we solve some of society's problems. Much of the theory and practice in these fields are common and applicable in the treatment of a system (comprising people, computers and other such "mental" aids) whose distinctive attribute is that its (the system's) "mental" power is usually greater than the "mental" power of its components. The name Synnoetics has been coined as the science treating of the properties of such systems. Subjects such as Cybernetics, Computer Science, Bionics, are thus branches of Synnoetics.

I believe that developments in Synnoetics will be among the more important determinants of our cultural, social, and economic progress and of our security. I urge, therefore, that universities now deliberately plan and set up Departments or Schools of Synnoetics despite some in the universities now resisting such action or indifferent to it. Enough money, facilities, faculty and students could

be obtained. All that is needed in addition is a recognition of the need and the drive to do it.

The reader is asked to imagine that this is a reprint of an address to an alumni audience in the year 1975 by the president (a famous historian) of one of the major universities in the U.S. Following the text of the address is a verbatim transcript of the question-and-answer period that ensued. The title of the address is "Synnoetics at Our University."

Alumni and Friends:

Last year, we changed the name of our Computer-Related Science Department to the Department of Synnoetics. Since then, we've received many inquiries concerning this department from people who think it is newly formed rather than newly named. Today, I would like to talk to you about Synnoetics at our university.

This talk will consist of two parts. In the first part, I shall define Synnoetics and I will describe its present role and impact at our university: In passing, I shall mention the university climate and policies under which Synnoetics has been able to flourish. In the second part, I shall discuss its history. Afterward, I shall be glad to answer your questions.

WHAT SYNNOETICS IS ABOUT.

In coping with his environment, man uses his physical and mental powers more or less efficiently. His mental powers are used predominantly, when he invents machines and processes, conceives ideas, plans, paints, composes music and T.V. commercials, calculates, bargains, learns, teaches, administers, legislates, judges, forecasts, advises, "thinks," and so on.

During the Industrial Revolution, man together with the machines he built and controlled, provided himself with a tremendous supplement to his physical powers and skills. Sometimes, he designed and built mechanisms to control the machines. Some of the machines (such as hand calculators and bookkeeping machines) provided man with an important supplement to some of his routine mental powers as well. The enhancement of man's physical and mental prowess, by these means, was chiefly the product of his

basic resource--his innate ability to invent and to reason--his unenhanced mental power. In dealing with the world, man brought to bear on his problems an arsenal of both his basic unenhanced mental power and the enhanced physical and mental prowess that it produced. Up to about 1940 man, drawing on this arsenal, just about held his own. After that, the problems--some of which were generated by the very use of computers and other enhancers--were getting larger, more complex, more diverse, and more urgent! The penalties for mistakes were more severe. In the fifties and sixties and to this day, the penalty could be the extinction of the human race. Thus, the problem that became the largest, most complex, most diverse, and most urgent, was man's need to use his innate and his enhanced mental power more effectively than hitherto and to somehow further enhance his mental power. I suppose we could say simply that we had then and now to extend man's ability to solve problems and we had also to extend his ability to extend this ability to solve problems--to lift himself by his own bootstraps.

Among man's early feats in this pursuit were the development of digital and analog computers and operations research. And I am sure you all recall that these were used very successfully in their day. Society has gone a long way since then in providing us with aids for our mental processes and we have reaped the benefits of the consequent increase in our physical and intellectual powers. We've done this chiefly by enlisting the aid of (synnoetic) systems consisting of configurations of people, mechanisms, and automata--machines that exhibit some "mental" characteristics. University scholars have contributed their fair share to these practical advances. But their most important contribution has been the development of an orderly theory of Synnoetics and a coherent curriculum with core courses for it.

Synnoetics is the science treating of the properties of composite systems--consisting of configurations of people, mechanisms, plant or animal organisms, and automata--whose main attribute is that its ability to invent, to create, and to reason--its "mental" power--is usually greater than the "mental" power of its components. The word Synnoetics, which is derived from the Greek, means pooling together the resources of the mind. Syn is a latinized form of a Greek prefix meaning "together"; noetics is derived from the Greek, meaning "pertaining to the mind or intellect"; ics is a suffix that is an accepted form with names of sciences.

You are probably familiar with what the biologists call symbiosis, in which dissimilar plant or animal organisms live in advantageous association with each other. For example lichen is a composite plant formed out of a fungus and an alga growing together to produce an organism entirely unlike either component. The fungus gains nutrient from the alga: the alga gains an increased supply of water. So in synnoesis. We may have man-computer synnoesis or automaton-automaton synnoesis, or man-man synnoesis. If plant or animal organisms are included in a synnoetic system, we may have man-organism-automaton synnoesis.

The etymology of synnoetics in no way indicates that one is always talking about a man and an automaton as the components of the synnoetic system. However, since this is the most popular system studied now, usage may later confine its meaning to a man-machine synnoetic system.

By using this definition of Synnoetics as a criterion, we have been fairly successful in determining what subject matter is in its realm and what subject matter belongs to other disciplines. Since analog and digital computers are but one species of automata, one branch of Synnoetics is the theory and practice of the design, programming, and application of computers. This branch is called the Computer Sciences. Autonomics is the study of automata, in general, in synnoetic systems. Intellectronics, the implementation of synnoetic systems by electronics, is taught in the Engineering School.

We study the theory and practice of control and communication in synnoetic systems--this branch is called Cybernetics.

As I already indicated, the fundamental motivation for the science of Synnoetics was the need to enhance man's ability to create, to invent, and to reason--to make him brighter--in order to solve his diverse problems and to attain his diverse goals. In the university community, results of investigations in synnoetics are used to invent processes and generate ideas for solving scholarly problems and attaining scholarly goals in whatever disciplines they are applicable. In this sense, synnoetics is supradisciplinary rather than interdisciplinary. (Subjects like physical chemistry are interdisciplinary in the sense that the subject matter of the field overlaps the subject matter of two other disciplines--physics and chemistry. Subjects like

logic and mathematics are supradisciplinary, i.e., there are a great number of disciplines in which one can apply their methods to the solution of problems.)

Models and simulators of various kinds are very popular for analyzing and synthesizing synnoetic systems, and for solving problems in various university disciplines. Thus, the study of the theory and practice of modeling, simulating, analyzing and synthesising is in the domain of Synnoetics. A popular model used in studying the functioning of automata is the human being, just as the study of automata has given insights into human functioning. Bionics is the branch of Synnoetics treating of such subjects. Systems theory is the name of the study of generic analytic and synthetic methods.

Teaching, learning, and the communication of ideas are certainly supradisciplinary scholarly activities. Thus, we study the theory and practice of teaching and teaching aids, of learning and learning aids, and of communication in synnoetic systems. Note that I said that we are concerned with teaching, learning, and communication in synnoetic systems. Thus, in the Department of Synnoetics, they do not study the problems of learning and teaching that have long been in the province of Educational Psychology. Nor do they study natural languages, like the structure, grammar, and syntax of French or German, which are in the province of the Linguistics Department. But, they do study the formal languages used in the communication between components of synnoetic systems. Similar comments may be made about studies in operations research, game theory, information storage, organization and retrieval and automatic programming.

One of the key issues in the design, construction, programming and use of synnoetic systems, is error. Specifically, we study the theory and practice of the control, prevention, masking, detection, diagnosis, and correction of errors in the design, construction, programming, and operation of synnoetic system.

Finally, we pay considerable attention to the "mental" characteristics of synnoetic systems--artificial intelligence--as well as to their cognitive, self-organizing, and adaptive properties.

The subjects of Synnoetics provide tools and aids which are being used with increasing degrees of success by prac-

titioners in engineering, law, music, chemistry, physics, medicine, psychology, and other disciplines, in ways which were quite unknown even ten years ago. These tools are also useful in the solution of management and control problems in business, industry, labor and government. I am sure you all recall how the famous strike of 1970 was settled when one of our faculty mediators used an automaton to aid both parties in agreeing to what was at once an optimum settlement for both sides.

The reason that we were not satisfied with the former name Computer-Related Sciences, was that the appearance of the word 'computer' was misleading; although we were acutely aware of the public relations value of this word. People ignored the qualifying word 'related' and associated the name exclusively with the computer-sciences--i.e., with the design, programming, and applications of computers, which is now only a small part of the number and variety of subjects we include in Synnoetics. The other names variously used, "Cybernetics," "Information Sciences," "Communication Sciences," etc., had similarly restricted connotations. We sought a more acceptable and appropriate name, and found one. We believe that Synnoetics connotes by its etymology something very close to what we intend.

The Organization of Our University.
Our university is rather old as universities go in this country. We have faculties in Law, Medicine, Agriculture, Engineering, Business, Education, Biological Sciences, Physical Sciences, Social Sciences, Political Sciences, Behavioral Sciences, Library Sciences, Mathematics--and the most recent, since 1969--Synnoetics (formerly called Computer-Related Sciences). The Schools of Law, Medicine, Agriculture, Engineering, Business, Education, and Library Sciences are separately endowed and supported; each school has its unique organization, policies, and practices which suit its needs. The other faculties are in Departments in the School of Arts and Sciences which is also, of course, separately endowed and supported. The Department of Synnoetics is in the School of Arts and Sciences.

Curriculum.
The Synnoetics Department offers an integrated and coordinated syllabus of about fifteen undergraduate courses and twice that number of graduate courses and seminars in both theoretical and applied subjects. (It may be interesting to you to know that there is growing pressure at our Uni-

versity to have two distinct and separate Departments of Synnoetics--one called the Department of Pure Synnoetics and the other called the Department of Applied Synnoetics. Those of you who are familiar with a similar situation in pure and applied Mathematics at the universities in the United States and in Europe in the nineteen-forties and fifties, will recognize and appreciate the kinds of arguments that are being put forward by those recommending such a split and by those resisting it.)

The names of some of the very interesting undergraduate and graduate courses which were given in the Department of Synnoetics last year in 1974 are:

Von Neumann Machines and Turing Machines
Elements of Automatic Programming
Theory, Design, and Construction of Compilers
Algorithms; Theory, Design, and Applications
Foundations of the Science of Models
The Theory, Design and Application of Non-Numeric Models
Heuristics
Self-programming Computers
Advice Giving--Man to Machine and Machine to Man
Simulation; Principles and Techniques
Pattern Recognition and Learning by Automata
The Grammar, Syntax, and Use of Formal Languages for Communication Between Machine and Machine and Between Man and Machine
Man-Automaton Systems; Their Organization, Use, and Control
Problem Solving; an Analysis of the Relationship Between the Problem Solver, the Problem, and the Means for Solution
Measurements of the Fundamental Characteristics of the Elements of Synnoetic Systems

Our integrated and coordinated curriculum is monitored and controlled by the Curriculum Committee of the Department. This committee is concerned with (a) the timeliness and quality of each course; (b) its relation to other courses given in the Department; (c) its relation to Synnoetics courses given in other departments and schools in the University; and (d) recommending Synnoetics high school curricula for students intending to meet the entrance requirements of the university. This working curriculum committee meets for four hours each month. Each committee member spends another eight hours per month outside the committee room considering these questions. Its chairman devotes full

time to this task.

Research Program.
The research program in the Department of Synnoetics is extensive. It is sometimes described as spectacular. I say spectacular because intuition is often misleading in this field, so that many of the results are surprising. One example of an enlightening (and to some people disturbing) result obtained by one of the graduate students in our Ph.D. program is a proof of the theorem that the maximum potential effectiveness of two people working together on certain kinds of abstract problems is at least as great as the maximum potential effectiveness of one of these people working together with an automaton on these problems.

There are between 50 and 100 research projects being pursued at any one time by approximately the same number of research people. Our graduate and undergraduate students, our faculty and visiting faculty members and visiting researchers from industry and from government all carry out research programs under the guidance and control of the Academic Research Standards Committee of the Department. The research program is balanced, covering a variety of subjects. Standards of excellence are high. We enjoy this status and can insist on such standards chiefly because we have enough moral and financial support from our own institution, from the industrial and business community, from the government, and from other interested individuals. We are thus in the pleasant position of not having to consider supporting a research program merely because it is a potential source of income. (But, of course, such moral and financial support has an important effect on our programs other-than-research--e.g., it also strongly affects our policies on the use of our computing equipment and service staff. Such policies will be mentioned later.)

A random selection of titles of current research projects are:

A Common Language for Automata and People
Aids for Extending the Intellect of Man, Automata, and Man-Automata Complexes
Functional Relationships Between Parameters of a Problem and the Parameters of a Computer Used in the Solution of This Problem
The Determination of Policies by Automata Playing Games Having Incomplete Theories.

The Dominant Component in Man-Machine Synnoetic Systems
The Nature of Musical Composition and the Structure of Music
The Design of Automata to be Used as an Efficient Aid in the Simulation of the Phenomena Studied in Psychiatry
A Theory of Models

For Synnoeticists not requiring a laboratory or special equipment, but requiring library services and office facilities, we have a building of well-equipped offices and a highly efficient library and document center with our own retrieval system for material in Synnoetics.

For the "applied" Synnoeticists, we have a four-story building (including a basement) with 10,000 square feet of usable research space on each floor. This laboratory is supplied with test equipment of various kinds and, of course, with a battery of miniaturized computers (in the basement).

About seven million dollars have by now been invested in the facilities for research in "pure" and "applied" Synnoetics.

The Degree Program.
The degree program in Synnoetics is orthodox. There is a prescribed set of required and elective courses for undergraduate "majors." Some undergraduates write theses.

There are two graduate degrees, the MA and the Ph.D. Course, language, theses, and residence requirements are also orthodox for this graduate program.

Annually, we graduate about 100 AB's; 50 MA's; and 15 Ph.D.s from the Department of Synnoetics in the School of Arts and Sciences. These graduates are sought by industry, business, the government, universities, and by the computer manufacturers. Except perhaps for the graduates of the Behavioral Sciences Department, these graduates command a higher starting pay than do graduates of any other of our departments or schools.

Faculty.
Altogether, we have 55 members of the staff for the instructional, research, and degree programs in the Synnoetics Department. This is the equivalent of a full time teaching

staff of 20. Aside from teaching undergraduate or graduate courses, sometimes with the aid of the teaching machines which they have programmed, characteristic activities of a faculty member are: writing textbooks and other instructional material incorporating research results, serving on the curriculum committee or research committee; doing research, writing papers for research journals, supervising student research, and serving his professional societies.

The salary range for our staff is between $9,000 and $29,000 per year; the averge is $22,000 per year. This generous and competitive salary scale is probably the main reason that one seldom finds our faculty engaged in consulting, even though they are in high demand and despite the fact that we have no administrative ruling whatever on faculty consulting. For another thing, my faculty tells me that most of their consulting opportunities are not professionally satisfying. This is so because--in many instances--consultants are called in to "put out fires" or merely to comment on opinions or decisions already made. Therefore, they leave most of the consulting opportunities to their colleagues at other universities who may need the extra income.

As is the case in every department of our university, the faculty in the Department of Synnoetics is recruited, selected and promoted chiefly on their qualifications as teachers and scholars. It might seem surprising to you that I make a point of this, since you might think that at most universities the faculty is recruited, selected, and promoted on the basis of excellence as teachers and scholars. However, such policies are possible only at schools that, like ours, have enough financial and moral support.

Some of our best teachers just teach and do not write. We are pleased to have them with us, as we are pleased to have those who do research and write and do not teach. Most of the faculty is engaged in some research and some teaching. I must admit that in the past, we insisted that our faculty publish--or else! But that was in the past. As I indicated, promotions are based on the excellence of a man as a teacher or scholar.

Of the 55 staff members, 25 have degrees in Synnoetics either from our university or from the seven other universities that have similar degree programs in Synnoetics; the remaining 30 were trained originally in a variety of other

disciplines. They have degrees in engineering, mathematics, linquistics, political science, psychology, physics, biology, neurophysiology, and economics. One of our most brilliant men is also a poet and philosopher.

Most of the 30 were recruited from industry, government, a university faculty or a research center or institute on a university campus where they were already working in a branch of Synnoetics. However, except for the three who came from research centers solely devoted to computing, in not a single one of these cases, were these people working in a group whose primary mission was the pursuit of knowledge in Synnoetics. For example, our former mathematicians, psychologists, and engineers who came from the universities, had appointments in the Mathematics Dept., Psychology Dept., and Engineering Dept. respectively. They were in "foster homes" where their tenure depended on the continued interest of the head of a department whose charter (and budget) was not primarily for Synnoetics; for after all, the charter of the Mathematics Dept. is to concern itself with Mathematics; of the Engineering Dept. with Engineering, etc. I think you can see how under such conditions, we could recruit an excellent faculty from the U.S. and indeed from the whole world, when we offered Synnoeticists a "natural academic home" in the form of a university department devoted exclusively to their field and where their colleagues would have a similar environment and kindred interests.

Computing Equipment.
The Department puts its computer-type equipment to a wide variety of uses in its instructional, research, and degree programs. The equipment is used as a routine mental aid in simple applications such as in calculation; it is also used as an abstract intellectual aid in very complex mathematical and logical applications such as in proving that solutions to certain problems exist; in proving that certain theoretical systems are consistent or complete and even in proving whether or not it can be decided that an assertion is true or false. A wide variety of equipment is available. Some special purpose equipment is used and controlled exclusively by a single group or individual of the Department. One set of general purpose equipment is shared by the University community. The equipment itself is used in allocating priorities automatically. The allocation and operation are monitored and controlled by a central administrative staff of the Computer Equipment Service Center. (This group is what remains of our former Computing Center

which once had the assignment and responsibility of planning and carrying out the academic programs we used to have in some branches of Synnoetics.)

Although we have no administrative policy on the matter, neither computer time nor programming time is sold to organizations outside the University in contrast to the practice of some other universities. The chief reason for this is that our faculty feels that there is no important new knowledge to be obtained by such practices.

Finances.
This year our faculty and research staff salaries will amount to 55 x $22,000 = $1,210,000. Our overhead expenses--including administration, insurance, maintenance of plant, and miscellaneous expenses will be about 75% of this amount or about $905,000 for a total of $2,115,000. Of this amount $450,000 will come from student fees and scholarship and fellowship funds; $200,000 from the support of research done by visitors from industry or government, $1,000,000 in grants and gifts from the government and private foundations, business and industry, and individuals; and $465,000 from endowment income.

Synnoetics and the University at Large.
I would now like to tell you how Synnoetics has affected, and indeed infected the instructional, research and degree programs in the other departments and in the other schools of our university.

Curriculum.
Some courses are exclusively devoted to a branch of Synnoetics as it bears upon a particular topic--for example, in the Engineering School, there is a course called "Automatic Programming for Engineers." In other courses, the use of a branch of Synnoetics as an aid in the solution of problems in the subject under study is occasionally illustrated and analyzed. Even in courses in modern philosophy, the role of quantitative numeric and non-numeric models (used in the solution of problems in fields ranging from engineering to business to politics) takes major attention. As a matter of fact, some such courses are required for all our undergraduates. We consider that an understanding of the principles of Synnoetics is indispensible to the modern liberally educated man.

Here are a few examples of the courses which were given in

the various Departments and Schools of the University last year in 1974:

Studies in Intuition and Intellect of Synnoetic Systems--Psychology Department
Patent and Precedence Searches with Computers--Law School
Computer-Aided Medical Diagnosis and Prescription for Treatment--Medical School
Synnoetic "Business Executives"--Business School
Theory of Creative Processes in the Fine Arts--Humanities Department
Theory of Error and Equipment Reliability--Engineering School
Design of Analog and Digital Computers--Engineering School
Simulation in the Behavioral Sciences--Psychology Department
Machine-Guided Taxonomy in Botany--Botany Department
The Theory of Graphs and the Organization of Automata--Mathematics Department
The Effect of Automata on the Legislative and Judicial Process--Law School
The Role of Synnoetics in Modern Society--Sociology Department
The Relationships between Models and the Phenomena that are Modelled--Philosophy Department

In general, a course in Synnoetics is given at the School or Department other than the Department of Synnoetics when students are interested in Synnoetics as a tool; but when Synnoetics is studied as a discipline in itself, and as a theory on which sound practice in other fields can be based, it is given in the Department of Synnoetics.

Research.
Unlike the situation with course work, where there are criteria for deciding whether or not a course is to be given in the Department of Synnoetics, a research project in Synnoetics may with equal justification be done in either the Department of Synnoetics or in the other relevant Departments or School. We do not make an issue of this. The research is done in that Department or School chosen by the faculty member, student, or visitor doing the work.

Degree Program.
In both the graduate and undergraduate degree programs, the student selects a major subject and a minor subject. At the

university, Synnoetics is the most popular minor subject for the undergraduate and graduate degrees. About twenty percent of all the theses done in Departments and Schools other than the Department of Synnoetics are on topics closely allied to Synnoetics.

History.

Of course, things weren't always this way for Synnoetics at our University. In the past, the university administration and faculty as well as the staff of the Computing Center blundered seriously in many ways. We underestimated the importance of the future role of Synnoetics both as a tool for practitioners in other disciplines and as a discipline in itself. We did not recognize the underlying unity of those subjects we now include in Synnoetics. We over-emphasized the importance of computer design and programming because we were blinded by the huge success of computers as practical tools. The administration was indifferent and some faculty members were hostile. Partially as a result of our attitude and our misjudgments, some of our department heads had to "bootleg" support for scientists working in a branch of Synnoetics.

Under these circumstances our policy on such matters was really not to have a policy at all. However, we were told that a modern university just had to have a computer on campus. So we drifted into accepting a computer from a manufacturer and paid him only 40% of the normal rental in exchange for our meeting his modest requirement of giving one course in numerical analysis and one course in business computer applications. We had one computer enthusiast in our Engineering Department. He was appointed Director of our Computing Center. Since we administrators knew little, and cared less, for this business, we appointed a governing committee for the "Computing Center." The members of the committee represented various interested departments; they met infrequently. Being inexperienced in such matters, they did not really help the Director except occasionally as in adjudicating matters of priority. Since we had no support to cover even the 40% of the normal rental of the computer, we instructed the Director to sell computer and programming time to anyone within or without the University. After we managed to transform our Director from a rather good scholar into a rather poor salesman, he succeeded in selling enough time to pay the rent--with a little to spare. We then saw that we had a good thing go-

ing and exploited it accordingly. Our benefactor, the computer manufacturer, objected weakly, but to little avail.

The Director prevailed on some faculty members to use his facility in their instruction and research; also he and his staff were doing some respectable work in language translation and in programming research. Nevertheless, this program did not gain the kind of acceptance by the academic community that he sought. The Director had come to feel that the problems of exploiting a computer to the maximum advantage of scholars in any discipline--computer-oriented research he called it--was as intellectually challenging and stimulating as the problems dealt with by scholars in other disciplines. Thus while it was true that he was using his computing equipment and staff to provide a service as well as a laboratory, he felt that he was also a practitioner in a new discipline which was appropriately called the Computer Sciences. He wanted acknowledgment that Computer Scientists were engaged in legitimate academic scholarly pursuits. He felt that the Computing Center should be the prime mover in identifying and recommending both computer-oriented research topics and courses of instruction to the various Departments and Schools and to the Computing Center. The academic community did not acknowledge that the study of the design, programming and applications of computers constituted a discipline in the classical sense. They considered that the computing activity was little more than a convenient aid for routine calculation. But they did consider his recommendations for computer-oriented research topics and for computer-oriented courses of instruction. We ended up with a variety of courses taught in the Computing Center and in various university departments. The research program was similarly disposed. I suppose that this ad hoc program was typical and as good as any of the fifty or so others in the country. We even granted advanced degrees in the Computer Sciences to a few people. The conditions under which these degrees were granted were so informal, so ad hoc, that I have forgotten the details. No matter; the program was unsatisfactory. Unfortunately, I am ashamed to admit, we waited many years too long before correcting the situation.

I have never understood why our Director did not recommend a Computer Science Department. I have speculated that, his statements on the matter notwithstanding, perhaps he wasn't too strongly convinced that the Computer Sciences constituted a discipline in the classical sense. And he must have

felt intuitively that his Computer Center equipment and staff was destined to be a Service Center and Laboratory only and as such, could not possibly be, for very long the nucleus and spearhead of a curriculum, research and degree program. I also suspect that, feeling neglected, unappreciated, and not very well understood, he must have believed that any gains he could make for the Computing Center, the Computer Sciences, and himself would have to be plotted by roundabout means. He might have felt compelled to try to slip over his ideas on his uninterested administration and on hostile or indifferent colleagues. An informally run Computing Center governed by an ad hoc committee would be more suitable to this modus operandi than a formally organized Department.

But, in the end all bootleging operations must go out of business. Either they get caught or the laws and circumstances that fostered them are changed. In trying to operate legitimately under changed circumstances and new laws, the most successful bootleging operations are hardest hit. For the objectives, procedures, organization, and personnel of the successful bootlegger must be modified too drastically to convert to the new situation.

For a time, our Computing Center Director was a very successful bootlegger. He was hit very hard when circumstances in the university changed, i.e., when the administration and faculty realized the folly of its uninterestness and shortsightedness.

Now, with hindsight, our mistakes are easy to diagnose. We couldn't possibly have had an integrated and co-ordinated program when all of our academic activity in these fields was designed around the existence of computing equipment. The only problems which the Director of the Computing Center would consider were those amenable to solution by his computer. Actually, he was the administrator of a job shop and its chief salesman soliciting work from prospects inside and outside the university. Consequently, most topics whose study he urged were computer-oriented, i.e., they already had generated or they might generate problems soluble with his computer. Only occasionally did any program include Synnoetic subjects as we now define them and then only when the subject was also computer-oriented. Attention was then intensely concentrated on the exploitation of computing equipment; people did not admit that one could have an excellent university program in Synno-

etics--or any program at all--without having computing equipment, even though we had as an example before us an excellent high-energy-physics program and we did not have a cyclotron. And this was a reasonable attitude for people who considered that all the topics of what are now part of Synnoetics were computer-oriented. No wonder they could not imagine a program that was not equipment-centered and dominated.

We have by now largely solved these ideological problems. Both we in the University and the community at large now more clearly recognize the role of the University in modern society and the role of Synnoetics in the University and in Society.

As a former historian, I have been impressed with the role and impact of Synnoetics on our society; its impact, it seems to me, is fully as important to us in the latter half of the twentieth century as the Industrial Revolution was to Society of the eighteenth, nineteenth, and early twentieth century. It seems a pity and worse that we were so late in recognizing and acting on this impact. Had the universities and other segments of society oriented and adapted themselves appropriately in the forties or even the fifties, the fruits of the new revolution might have been harvested and enjoyed earlier. We might sooner have enhanced our creative mental powers, and consequently the ability and productivity of diplomats, judges, legislators, poets, teachers, artists, scientists, labor leaders, managers, psychologists, physicians, and others who contribute to the cultural, social, and economic progress and to the security of all of society.

Before closing, I would like to acknowledge the invaluable assistance given me in the preparation of this talk by our former Computing Center Director. He is now a Professor in the Engineering Department where he spends most of his time doing research on electronic components for Synnoetic Systems.

The following is a verbatim transcript of questions from the floor and the extemporaneous answers given by the President. Neither the questions nor answers were edited; thus, sometimes arguments and material in the address will be found repeated among the questions and the answers. It will also be found that some of the answers are more

thorough than others and indeed that, for a former historian, the President seems unexpectedly to be especially well qualified to speak on technical matters. When queried on these points, the President replied that on other previous occasions, he was asked similar questions, so that by now he was able to give extemporaneous answers that seemed to be well prepared.

Question: Who are considered to be the giants in Synnoetics?

Answer: Among the early ones in the field, the man who outstrips all others is of course John von Neumann. He pioneered in the design of stored program digital computers, in numerical analysis, in computational models, in automata and neural-net models, in the theory of error, in the theory of games, in probability, and in many other fields. He was an acknowledged genius.

A. M. Turing, an Englishman, made important contributions to the basic theory of computers and of artificial intelligence.

There are now five or six others who have made their mark.

Question: Do you think that Department of Synnoetics must have a giant or two in the field in order for its program to excel?

Answer: Some administrators, in and out of universities, do not pay much attention to organization. They insist that if they have good people they do not need formal organization to make a program go well. They claim that no organization will work well without competent people. It is common practice for such administrators to appoint ad hoc committees to solve miscellaneous problems as they arise. Obviously, there is no necessary relationship between the work and objectives of these committees. Each such committee dissolves when the crisis, it was created to handle, is over.

Others incline to paying more attention to organization, arguing that as long as one has good people, a good organization can't hurt: but when one doesn't have the good fortune to have good people always, a program is more likely to go well if such people work in a well-organized way.

I ultimately saw the futility of having scattered, unrelated, ad hoc courses. So, as for the Department of Synnoetics, I didn't feel that I should postpone its organiza-

tion, waiting for the giant to arrive on my campus, and I did not wait. We do have a giant or two now.

Question: Your description of the role of Synnoetics at the university seems to me to be very sensible and appropriate. Did you use a model for solving this problem?

Answer: Yes, we did. As a matter of fact, I hinted at it (the model) in the address, when I referred to the pressure to split the Department of Synnoetics at our university into a pure part and an applied part as had been done in some Mathematics Departments. Actually, we modelled the incorporation of the Synnoetics curriculum and research program on our Mathematics program because there are so many correspondences between the two disciplines. They both include a variety of subjects that can be studied as disciplines in themselves in Departments devoted to these disciplines, and furthermore the subjects in the domain of each provide tools for almost all the other disciplines studied in the University. Incidentally, we used the University Library as a model for the ways in which we provide computer equipment and service. Finally, the difficulties that Statisticians had in gaining acceptance by academicians and in incorporating a Statistics curriculum and research program into the Universities was a model for our difficulties in attaining similar objectives.

While we are talking about Mathematics and Synnoetics, let me make this additional point: BECAUSE OF THE CORRESPONDENCES BETWEEN THE TWO DISCIPLINES, IF THERE IS NO JUSTIFICATION FOR THE ESTABLISHMENT OF A DEPARTMENT OF SYNNOETICS AT A UNIVERSITY, THEN THERE WAS NEVER A JUSTIFICATION FOR THE ESTABLISHMENT OF A DEPARTMENT OF MATHEMATICS!

Question: Would you elaborate on exactly how your faculty mediator used a computer in settling the 1970 strike?

Answer: He simply got both sides first to agree that each would benefit by concentrating attention--not on arguing and finally settling the issues one at a time--but on arguing and finally settling on a program for an automaton. This program would evaluate the thousands of alternative settlements and would recommend a small class of settlements each of which was nearly optimum for both sides. The automaton took only 30 minutes to produce the new contract last year. It would have taken one year to do this manually and even then it would have been done less exhaustively.

Agreeing on the program took one week. Of course, you have already heard that in many areas where people are bargaining or trying to make optimum decisions such as in the World Nations Organization, in the World Court, and in local, federal and world legislative bodies, there is now serious consideration being given to convincing opposing factions to try to agree on a program and having once agreed on it, the contract or legislation or judgment or decision produced with the program would be accepted as optimum for opposing sides. Automata may also be provided to judges and juries to advise them of the effects of such factors as "weight" of evidence on verdicts in civil cases.

Question: Are all faculty members in the University paid as generously as those in the Department of Synnoetics?

Answer: The faculty members in the Departments in the School of Arts and Sciences are paid roughly on a uniform scale. The faculty members in other Schools of the University have different scales. As I indicated in my address, each School is separately endowed and supported and each has its own policies.

Question: Please elaborate on the details of the automatic priority scheduling for the shared computer(s).

Answer: The shared general-purpose equipment is in the basement. Input, display and output devices are in two dozen or so different locations at the University, each of which may be used as a communication station with the shared equipment which has a large enough capacity to run as many as 20 medium-sized jobs simultaneously. Usually there is no waiting line. If there is a queue, then the automatic priority allocation program indicates to the user when he can expect to get on the equipment. The program makes this allocation on the basis of its priority list, the estimated time to run the program and other data and criteria. Only rarely does a user go to the machine room. When he does, it is to discuss mutual problems with the hardware and programming maintenance crews.

Programming is of course not the problem it used to be. People state their problems in a language designed especially for the classes of problems generated in the various disciplines. We have languages oriented to political sciences, social sciences, mathematical sciences and seven or eight others. As with natural languages, these discipline-oriented

languages seem to be changing continually. Thus, the languages which are used now are named respectively POLOL '72, SOCOL '71, MATHOL '69, etc. POLOL '72 is the 1972 version of the Political Science Oriented language, etc. Users feed the computers a statement of their problem in appropriate language. From then on, a compiler automatically takes over, a program is written in a language that the computer can understand and then this program is run.

Question: Why did you wait until 1969 to start the Synnoetics program? Why didn't our university or any other university start on such a curriculum, research, and degree program way back in 1960 as you indicated in the address would have been advantageous to both society and the universities? Surely then as now, the studentdemand was large: financing certainly was available from government agencies, private foundations and individuals, from business and industry, and especially from the manufacturers and users of computing equipment. Furthermore, faculty should have been easily available for the same reason that you say you now find it easy to recruit: you provide a natural "academic" home for Synnoetics teachers and scholars now in "foster homes". How do you explain that despite having had the necessary ingredients of a successful undertaking in 1960--demand (students), ability to supply the demand (faculty) and the ability to obtain financing,--you didn't get around to this undertaking until 1969?

Answer: I agree that in 1960, a few universities had the requisites for being able to plan and carry out such a program. In the United States, we did have sufficient student demand, and we could have (with difficulty) recruited faculty and (without difficulty) obtained adequate financing. But I must point out that it does not necessarily follow that if one is merely able to do a job, that this job will be done soon after this ability is acquired. As you know, one must be <u>ready</u> and <u>willing</u> as well as <u>able</u>. In 1960, there was not the readiness and willingness to plan and carry out a coordinated and integrated program in Synnoetics such as the program we and seven other universities now have. Let me elaborate on these points, some of which were already made in the address.

There are three groups whose opinions and judgements are decisive in determining the readiness and willingness of a university to adopt and carry out such a major program. These groups are: a) the public: including the government,

industry, labor, consumers, students, and alumni b) the university trustees and administrators, and c) the university faculties. The unreadiness or unwillingness of any one of these three groups to endorse a program can kill the program.

People are usually willing to consider a proposed program, if they are convinced that 1) it will help them in performing one of their assigned roles or that 2) it is a "better" program than any alternative. Even if they are willing, they will not pursue a program until they are ready. People are usually ready to pursue a proposed program, if they are convinced that 3) they have or can get the sympathetic understanding and backing of the people in their own organization and of their sponsors, and that 4) the proposed program is high enough on the list of priorities of other tasks that the organization must also perform and that it will be worth more than its cost, and that 5) they have or can easily obtain the resources to plan for and carry out the proposed program.

Against these five criteria, may I elaborate on the statement above "In 1960, there was not the readiness and willingness to plan and carry out a coordinated and integrated program in Synnoetics ..."

(1) University administrators and faculty were not convinced that any one of the assigned roles of the university would be served by such a program. Few administrators or faculty foresaw the developement of the subjects now included in Synnoetics into disciplines. They did not consider that the study of such subjects was the legitimate activity of a university scholar. The arguments pro and con were probably similar to those that raged in university communities prior to incorporation of Medical Schools, of Business Schools, and of Statistics Departments into the academic structure of the university. Some of the most vehement objections came from the so-called purists among the mathematicians who incidently were also the strongest objectors to incorporating Statistics into university structures. (On the other hand, there were one or two empire builders among Chairmen of Departments of Applied Mathematics who were willing, nay, eager to take on all computer-oriented activity including circuit design.)

(2) The university administrators and faculties thought that alternative programs were "better." Being convinced that computers and Synnoetics (these were confused then as now) would soon lose their glitter and that what was left of their substance would be taken over by technical colleges, vocational schools, etc., administrators and faculty members tolerated the temporary support of Synnoeticists scattered around the departments and schools of the university. They also countenanced computing centers and staff as well as specialized research institutes so long as they made a profit and so long as the university was not committed to their staff, if not to their directors, with tenure contracts.

(3) Even if the university administrators were convinced, they could not count on the sympathetic understanding, agreement, and support of their faculty for a Department of Synnoetics. The faculty members who thought that the computing center should be the main stimulus for scholarship would confine their studies to computer-oriented topics. Not foreseeing the underlying unity and fundamental character of Synnoetics, these computing center people favored an organization and program designed to be a supplement to computing equipment and resisted an organization and program that would have the computing equipment (if it was there at all!) as a supplement to it. Other faculty members in the various departments of the university who were introducing computer-oriented topics into their courses sometimes shared their colleague's shortsightedness and their vested interests as well. Being uncertain about how the introduction of a new integrated program would affect their position in a university that already had some kind of program, they would resist, be indifferent to, or at best counsel caution on such a new program. No wonder the university administrators weren't exactly eager to pursue such a program! Besides this, the "great" universities were not leading the way. They too had computing centers,

research institutes, and unconnected, uncoordinated, albeit excellent courses and research projects. If the "great" universities were not farsighted, why should others have been expected to be pioneers? Evidently, the university sponsors (the public et al.) wanted it that way. Perhaps some administrators were farsighted. But on the record, none was determined enough to overcome the obstacles and pursue such a program. Rather, they and we, strung along with computing center-oriented programs of one kind or another.

(4) The public had given low priority to the traditional role of the university for foreseeing, developing and establishing new disciplines and incorporating them into the university structure. The university trustees and administrators acceeded without significant dissent. With the worth of such new programs thus downgraded, universities were discouraged from investing their resources in them.

During the decade of the fifties, the United States was engaged in a running luke-cold war with the U.S.S.R. as now with China. The pressure was on to beat the Russians in military power, and in the exploitation of space. This was a deadly earnest quest for devices to be developed as soon as possible. Government, industry, research establishments, and the universities were enlisted in this expensive quest. To perform this high-priority role, the universities set up institutes, development laboratories (but called research centers, of course) and administered, staffed and housed expensive special projects. Many faculty members acted as consultants to industry engaged in such work. Simultaneously, the universities were engaged in a race with the Soviets to turn out engineers and technicians while the student demand in the United States for an orthodox college education was already straining the limited resources of the universities. And these were indeed limited resources both in plant capacity and in quality of faculty. Many of the best faculty members had been

lured to more remunerative employment. For similar reasons, new faculty members were hard to recruit. On the average, the teaching staff in U.S. universities was inadequate. And as already indicated, many of the staff were consulting or working on special projects thereby reducing the time they could devote to teaching and scholarship.

(5) It was difficult to obtain the resources for incorporating a first-class program into the university structure.

Few university administrators had ever planned and incorporated a new curriculum, research, and degree program into their university. Many of them didn't know how to do it, and were naturally reluctant to try.

While a faculty for a Department of Synnoetics could be recruited for reasons already given, an excellent faculty would probably require higher salaries than the prevailing rate in the university at large. This would be impractical--especially since there was no one of the acknowledged caliber and status of John von Neumann who could be used as a center of attraction.

Synnoetics was relatively new. Few textbooks and little instructional material for an integrated curriculum was available. Writing an integrated and coordinated syllabus would be a formidable task. Some administrators might have been reluctant to pursue such a program while they doubted that they could gather a faculty that could do this kind of preparation well and in a reasonably short time.

While <u>all</u> I have just said is not descriptive of the new colleges and universities that were started in the late fifties and early sixties, apparently, they too were not ready and willing.

Question: You stated that a Department of Synnoetics might have been introduced into Universities 15 years ago in 1960. If this were the year 1960, rather than 1975, and if you

knew then what you know now, how would you have gone about introducing such a program into our university?

Answer: Before answering the question directly, let me first summarize (a) the things I know now that I did not know then, (b) the obstacles and difficulties in 1960, and (c) the favorable circumstances in 1960.

I know now that by directly supplementing our creative mental powers and by indirectly supplementing both our routine mental powers and our physical skills, Synnoetics have been the most important single factor in our cultural, social, and economic progress--and indeed of our security. It is therefore one of society's highest priority obligations to cultivate Synnoetics in all of its institutions--including the universities.

I know now that there is an underlying unity among the subjects in the domain of Synnoetics which is a discipline worthy of study by university scholars, and that this discipline is not confined to studies of the theory, design, programming, and application of computing equipment. By extending the mental prowess and ability of teachers and scholars in almost all intellectual disciplines, (by augmenting their brains and thereby making them brighter, if you please) Synnoetics is itself the most representative of supradisciplines. A Department or a School is the habitat most conducive to scholarship and to the instruction of students in Synnoetics.

I know now that Computing Centers become service centers just as libraries (are) and that they become laboratories just as chemistry or physics laboratories (are). Since Computing Centers are destined for such roles only, the staff and equipment of the Computing Center just should not be the nucleus of an organization and program for scholarship and instruction. All efforts at the Computing Center should be devoted exclusively to making it a better Service Center and Library. The curriculum and research program must be left to a curriculum committee and a research committee in a duly recognized Department.

I know now that in planning for and operating a Department of Synnoetics (or any other university department for that matter) planning, administering, monitoring and evaluating must be done by scholars or teachers who are also competent in these things and who will in many instances spend full

time doing them because that is what a respectable job requires.

The obstacles and difficulties in 1960 were: 1) the tasks to which the universities were already committed were straining their limited resources; they could not take on anything more. 2) Many faculty members and administrators did not consider Synnoetics to be a legitimate academic discipline. They were opposed ideologically. 3) The developing vested interests of computing-center staff and other faculty opposed, or were indifferent to, setting up a Department or 4) Very few people prefer the sufferings of being a pioneer to the glories. One stated objection to being the only university with a Synnoetics Department or School is that its graduates who would prefer to remain in university work have nowhere else to go. 5) The Synnoetics faculty would probably be more expensive than the average university faculty because they were doing well financially where they were.

The favorable conditions in 1960 were 1) Finances were available for a university that was ready, willing and able to plan for and set up a Synnoetics Department or School. 2) There would be prestige and glory for the pioneer. It was certain that other universities would follow suit. 3) A faculty was available. 4) There was a large student demand.

This is what I wish we had done 15 years ago in the light of what we know now.

1. I would use all the public relations talent at my command to convince my trustees and sponsors (government, industry, alumni, etc.) of the importance to society of Synnoetics and would urge them to place such a program very high on its priority list for the university.

2. By the sheer force of my personal conviction and my administrative position, I would try to convince the trustees and the faculty that Synnoetics would develop into a discipline and that the university should design around that fact now.

3. As a discipline and as a supradiscipline with such ramifications, I would insist that Synnoetics be treated as we treat other disciplines, such as

Mathematics, for example. We organize a Department or School.

Having thus laid the groundwork and having decided in principle what I was going to do, I would then plan and carry out the details of a Synnoetics program in the following order:

4. In the first year, I would select academic, administrative, and service heads of the department (or school) who would spend the year making a "five-year plan" of faculty, financing, curriculum, research program, computing equipment, rate of growth, etc. Policies and degree requirements would be established. In fact, they would produce tentative Synnoetics Department catalogs for each of the next five years in as much detail as they could. Research faculty and teaching faculty would be hired for purposes of writing a curriculum and preparing for a research program. I would raise money to finance those items on which agreement had already been reached. (If the vested interests and the shortsighted people were powerful enough to block the introduction of a Department and if also it were difficult to obtain faculty at the going faculty salaries, then I might first set up a separately endowed and supported Graduate School and Research Center in Synnoetics and I would continue to battle from that base.)

5. In the second year, probably only graduate courses and seminars would be given and the research program would start. The undergraduate curriculum and the rest of the graduate curriculum would be in preparation. The financing, faculty, equipment, and facilities plan would continue to be carried out. The Computing Center would be equipped and staffed sufficiently to make it the kind of Service Center and Laboratory planned for during the first year.

6. In the third year, some undergraduate courses would be given, the graduate course and seminar offerings would be enlarged as would the research program.

7. In the fourth and fifth years, the curriculum and research program would be modified and enlarged in accordance with recommendations of curriculum and research committees assigned to monitor and control curriculum and research policies and practices.

By the fourth year, I would expect to have been deluged with exhortations from other university presidents asking for advice on how to set up a Department of Synnoetics.

BIBLIOGRAPHY

Louis Fein - "The Role of the University in Computers, Data Processing and Related Fields"

This title was used for three different papers: An unpublished report prepared for Stanford University in October 1957; a paper delivered at the 1958 Western Joint Computer Conference; (see Transactions of 1958 WJCC); a paper published in the September 1959 issue of the Communications of the Association for Computing Machinery.

J. B. Wiesner - Communication Sciences in a University Environment IBM Journal of Research and Development, Vol. 2/No. 4/ October 1958.

Report on a Conference of University Computing Center Directors June 2-4, 1960.

Communications of the ACM Vol. 3/No. 10/October 1960.

Conference Report on the Use of Computers in Engineering Classroom Instruction.

Communications of the ACM Vol. 3/No. 10/October 1960.

M. L. Minsky - Some Methods of Artificial Intelligence and Heuristic Programming Proceedings of Symposium No. 10--Mechanization of Thought Processes--National Physical Laboratory; November 1958. Her Majesty's Stationery Office 1959.

C. P. Snow - The Two Cultures and the Scientific Revolution. Cambridge University Press, 1960.