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The Basic Medical Sciences in the Stanford Plan

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INTRODUCTION

The general features of the Stanford Plan of Medical Education have been described by Stowe (6). The purpose of this article is to discuss in greater detail how we teach the basic medical sciences during the first 3 years of the 5-year curriculum. Most of the material will be factual, but where expressions of opinion intrude they represent my own point of view and not necessarily that of my colleagues.

SALIENT FEATURES OF THE NEW CURRICULUM

For the medical student entering Year I the first striking difference from the traditional curriculum is his immediate exposure to an experimental laboratory course, "Cell Structure and Function," taught by a staff drawn from several disciplines (this year physiology, pharmacology, anatomy, genetics, microbiology, biophysics). Through lectures and conferences the student learns basic concepts of cell physiology, especially the interrelationships between structure, ultrastructure, and function. In the laboratory, mammalian cells grown *in vitro* provide material for experiments on growth, nutrition, metabolism, and morphology. The course serves to familiarize students with laboratory equipment and procedures and to inculcate sound methods of experimental design, data collection, and interpretation. Independent projects are undertaken by groups of students under close supervision, and

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selected ones report to the entire class at a symposium which closes the work of Quarter 1.¹ Also during the first quarter the student begins a lecture course in general biochemistry, a lecture-and-laboratory course in general microbiology, and a course in biostatistics. Except for the study of cell structure and ultrastructure the teaching of anatomy is conspicuously absent from the first part of the curriculum; we seek to provide an experimental rather than a descriptive introduction to the study of medicine.

Quarter 2 is largely devoted to further lectures in biochemistry and to very intensive laboratory work in this subject. The laboratory course is unusual, embodying our philosophy that "cookbookery" in the laboratory is pedagogically sterile and that complete "coverage" of material is unnecessary (1). Twenty 5-hour sessions of laboratory work are devoted to only two problems—the isolation and characterization of a single enzyme (hexokinase) and of DNA. During this quarter bioelectricity, nerve conduction, muscle function, and neuromuscular transmission are subjects of lectures by physiologists and pharmacologists. Cadaver dissection occupies two afternoons weekly, while microscopic anatomy is taught on a single afternoon; in both courses special stress is laid upon the extremities and peripheral structures, including nerves and muscles.

¹ Stanford uses the quarter rather than semester. The regular academic year consists of three quarters about 11 weeks long, the final week of each quarter serving as an examination period.

With a sound foundation laid in biochemistry and cell physiology the work of the third and subsequent quarters becomes largely system-oriented, but Quarter 3 includes a 10-hour course in basic genetics and the final portion of the 30-hour biostatistics course that extends throughout the first year. Quarter 3 concentrates on the peripheral autonomic nervous system, with the Departments of Physiology, Pharmacology, and Anatomy carrying major teaching responsibility. Other organ systems (cardiovascular, respiratory, renal, gastrointestinal, endocrine, reproductive) are taken up in sequence by the same departments during Year II (Quarters 4-5). We try to achieve a temporal coordination of all the lectures, conferences, and laboratory exercises dealing with a given system. The last part of Year II (Quarter 6) is devoted entirely to the subject of infection, with simultaneous teaching of specific vectors of infectious disease (Microbiology), tissue responses to infection (Pathology), medical parasitology (Preventive Medicine), chemotherapy (Pharmacology). This block of time is preceded by an introductory course in general pathology for 2 hours each week throughout Year II.

Year III is largely devoted to the central nervous system. Anatomy of the head and neck, neuroanatomy, neurophysiology, neuro- and psychopharmacology, and neuropathology occupy Quarters 7 and 8. Although we have no experience yet with this phase of the new curriculum we hope that the knowledge and sophistication gained in the 2 previous years will prepare the student well for this most complex area of study. Finally, in Quarter 9 there is intensive instruction in special pathology and in those integrative and therapeutic aspects of pharmacology not considered earlier. A second 10-hour lecture course in genetics (largely human) is presented. During

this year the Department of Preventive Medicine is responsible for 30 lecture hours on environmental hygiene, community health organization, and epidemiology.

Throughout the 3-year span of basic medical science teaching about $\frac{1}{2}$ -day weekly is devoted to a course entitled "Introduction to Clinical Medicine," which is described in Stowe's (6) article. Also provided are substantial amounts of elective time within the medical curriculum (in addition to other free time discussed below), in which all departments, clinical as well as preclinical, offer a variety of optional courses dealing with specific topics in a more thorough way than the "core" curriculum permits.

Difficult to describe in words is a certain atmosphere that pervades our teaching in the new curriculum, an outward expression of the faculty's resolve to treat our medical students as the mature graduate students they are. That such a policy would evoke appropriate student attitudes in response was obvious to all but the most cynical among us. I have found it both satisfying and stimulating to teach in this unusual academic environment.

In some measure the more favorable student attitudes may be attributed to our abolishing the most pernicious aspects of rank grading (2), and substituting a simple A, +, E system. "Grade-point averages" and rank standings are not computed, for we reject the meaningless arithmetic that makes A in one course plus D in another equal to C+ (in what?). On the other hand, a student's several instructors are expected to submit thoughtful descriptive evaluations of his year's work, so that his manifold capabilities and weaknesses in every segment of the medical course can be assessed qualitatively.

A large part of the improved student morale must be attributed to the slower

(and steadier) pace permitted by a stretched-out basic medical sciences curriculum. There is simply more time for reflection, for unhurried contemplative reading, for assimilating the best of the original literature in each field. Most welcome of all, our students seem to be learning early that real study is more rewarding than "cramming"; that, since textbooks oversimplify, accessory sources must be consulted; that the controversies are usually more interesting than the "facts"; and that all our present knowledge serves mainly as a springboard into the fascinating unknown.

THE TEACHING LABORATORIES

All laboratory teaching in the basic medical sciences (except for gross anatomy) is conducted in multidiscipline laboratories. The essential feature of the

teaching laboratory is that it belongs wholly to the sixteen students assigned to it. They have access to it 24 hours a day, and no other students ever work in it. The 22 × 36-ft. laboratory (Chart 1) contains a long central table with desk space for eight students on each side, with drawers, microscope cabinets, book rack, gas, and electric outlets.² When the students are sitting at their own places, an instructor has only to stand at the blackboard or projection screen, and a conference group is in session. Behind the students, along both walls of the room, are "stand-up" workbenches,

²The original plan was based on a 24-ft. width. The need for economy forced a general reduction of the bay size to 22 ft., and this has proved to be just barely adequate. However, we strongly prefer the original 24 × 36-ft. design.

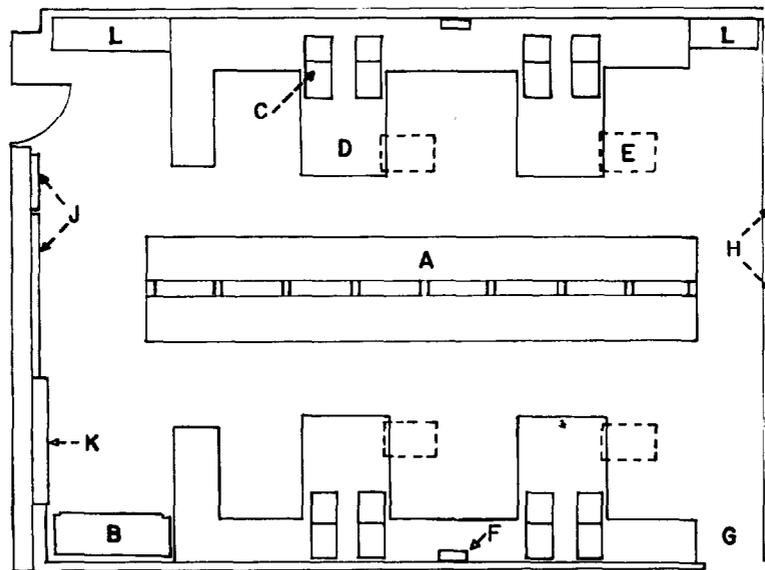


CHART 1.—Basic medical sciences teaching laboratory.

Scale diagram of the 16-man unit laboratory, 22 × 36 ft. A central desk for sixteen students with central book trough and gas and electric outlets. B—hood with all utilities. C—sink and drainboard serving two students. D—37-inch high bench serving four students and extending also along wall. E—detachable animal board. F—cup sink. G—passage to "interlab" serving 2-unit laboratories. H—windows with blackout shades. J—chalkboard, tackboard, and intercom unit. K—bookshelves. L—cabinets for general storage; all high benches contain standard drawer-and-cabinet storage space.

animal boards, sinks, reagent shelves, cabinets, and alcoves for polygraphs and other specialized equipment. It is easy to move from experimental procedures to conference discussions and back again, as circumstances dictate. We have been pleased with the way students have made the laboratory their "home"; late evening or weekend visits never fail to discover groups of students studying, arguing, drinking coffee, and even exercising their traditional right to complain about the curriculum.

There are twelve laboratory units, as described above, enough to accommodate three whole classes of 64. Between each pair of sixteen-man laboratories is a 13 × 36-ft. "interlab" containing equipment such as refrigerators, refrigerated centrifuges, and incubators, too large to fit into the regular laboratories. The "interlabs" also provide unassigned space for students carrying out special experiments, and for demonstration material. Numerous additional rooms are available for special purposes—for example, a human experiment laboratory, a calculating and drafting room, balance rooms, regulated-temperature rooms, readily accessible animal quarters, a large stockroom, glass-washing and medium-preparation areas, repair shops, and secretarial and administrative offices.

All equipment is up-to-date and of research caliber. Our philosophy has differed sharply with the view that students should learn to work with the simple tools of yesteryear. We believe medical students are quite capable of using modern research instruments to good effect, and we are impressed by the way these young people, who have grown up in a mechanized, automated, electronic civilization accept as commonplace the complex armamentarium of modern medical science. A complete equipment list would not be appropriate here, but a few examples are in order. For biochemical

experiments there is in each laboratory a refrigerated centrifuge, spectrophotometers (visible-range), ultraviolet spectrophotometer, torsion balance, water baths, fraction collector, refrigerator, freezer, radio-isotope detectors, and scalars. Centrally located are a few high-sensitivity automatic balances, a preparative ultracentrifuge, a scintillation detector for gamma counting. For physiological experiments each group of four students has a four-channel polygraph with a variety of transducers and other input devices, a research-type stimulator, an oscilloscope, an electric kymograph. Again the class as a whole shares a smaller number of specialized items such as treadmills, instruments for gas analysis, stereotaxic apparatus, automatic calculators. All the equipment belongs to the teaching laboratories, for the exclusive use of medical students. The cost of equipping these laboratories partially to date has been close to \$300,000; we estimate a total expenditure of a half million dollars before the job is completed. This may seem a shocking sum by the old standards, but we believe any appraisal of the cost of a first-rate medical education today must take account of such equipment needs in a realistic way.

The teaching laboratories operate as an autonomous administrative unit under a Director (Dr. Frederick A. Fuhrman, Professor of Physiology), who also acts as coordinator of the entire basic medical sciences curriculum. An independent budget covers the total cost of operation, including personnel, equipment, supplies, and animals, for the teaching needs of all the preclinical departments. The staff includes an assistant director (post-doctoral), four technicians, secretary, stockroom supervisor, and equipment maintenance personnel. The Director's research space is provided in a contiguous area rather than in any department of the medical school.

A major advantage to the departments is that most of the preparation for laboratory teaching exercises is undertaken by the staff of the teaching laboratories. The usual procedure is for department faculty members to try out the laboratory experiments and furnish lists of supplies, equipment, solutions, and animals. A prototype set-up is assembled, which the teaching laboratory staff can then reproduce for each group of students. Thus, although teaching functions are physically removed from departmental areas, any inconvenience is offset by the lesser burden of preparation upon the department faculty and by the greater efficiency of a full-time staff trained for this type of work.

Since space in the teaching laboratories is fully occupied throughout the academic year, the initial construction is obviously more economical than if each department were provided with its own teaching area, which would then lie idle for much of the time. On the other hand, the yearly expense of laboratory teaching is greater than it would be under departmental auspices, although it is difficult to calculate precisely how much greater. We believe that the benefits justify considerable additional cost, especially when measured in terms of greater teaching effectiveness and better utilization of faculty time.

FREE TIME IN THE FIVE-YEAR CURRICULUM

Of particular significance for the basic medical science departments is the fact that the customary 2-year span of pre-clinical teaching is extended over 3 full academic years. If the number of hours of required course work remained unchanged, this extension would leave about one-third of the total time unscheduled. However, we have reduced the hours devoted to required course work in the preclinical curriculum by about 15 per cent, to create even more unscheduled

time. The free hours are quite evenly distributed over the 3 years, so that nearly half of every day is free, mornings in Years I and III, afternoons in Year II. How may this large amount of free time be used? If the student has yet to earn his baccalaureate degree, that obligation takes priority. However, the majority of our students have completed a college course, so that they are at liberty to use the free time however they wish. Opportunities for graduate study in nonmedical fields have been mentioned by Stowe (6). I wish to point out here the remarkable opportunity for our medical students to undertake a research program in one of the departments. A student may work in the laboratory half of every day during the academic year, for 3 years, and full-time for two or three summers. This is no mere dabbling in research, but a chance to participate fully in department activities and to receive continuous research training on a long-term basis. After 3 years the student may decide to concentrate upon clinical studies exclusively. Alternatively, he may, while going on with his clinical courses, return to the laboratory during blocks of 6 weeks and 12 weeks free time in Years IV and V, respectively, and full-time in the summers. On the other hand, if he decides, after so thorough a taste of basic research, that his career lies in that direction, he may change to a Ph.D. program and earn his degree at about the same time his classmates receive their M.D. degrees. Yet another choice would be to spend an additional year or more beyond the 5-year curriculum and earn both M.D. and Ph.D. degrees.

Because this program offers substantial research training to medical students and promises to recruit some very able people into careers in the basic medical sciences, it can be supported to a significant extent by training grants. If a student spends all his free time during the aca-

demical year in a research program, and works in the laboratory all summer, he may receive more than \$2,000 in trainee stipends. We hope that by thus easing the financial burden of the extra medical school year, we may further succeed in attracting promising students into medical research careers. We aim frankly at producing more graduates who are competent investigators and will bring their research training and outlook to bear upon whatever field of medicine they enter.

THE ROLE OF DEPARTMENTS

Teaching of the basic medical sciences, as described above, is programmed as a planned sequence of subjects extending over 3 years, rather than as a series of time-blocks assigned to departments for intensive exposition of their own disciplines. What are the effects upon the teaching role and autonomy of the departments?

One problem arises from the much longer total span over which most departments must spread their teaching. The Department of Pharmacology, for example, teaches in every quarter except the 7th, so that three classes are simultaneously receiving instruction in our subject. Our total teaching time varies from 1 to 9 hours weekly. Under the traditional block-teaching pattern, the year is generally divided into teaching and nonteaching segments; the former is discounted by the department faculty as all but useless for research, which is then expected to flourish without distraction during the latter period. We have obviously sacrificed whatever advantages may inhere in this dichotomy. However, I believe (but it is still too early to verify this) that the spread-out teaching responsibility, coupled with the relief from set-up chores in the teaching laboratory will actually increase the fraction of the year which is effectively avail-

able for research, since even the heaviest teaching schedule preempts but a small part of each week. Moreover, as in any curriculum, increased staffing can free faculty members in rotation for periods free of all teaching obligations.

A legitimate concern is whether dilution of a department's teaching effort may weaken its pedagogic impact and make it difficult to communicate the "feel" of the discipline to the students. Our limited experience so far makes us believe that just the opposite is true. First of all, the simultaneous teaching by appropriate departments at each stage of the subject sequence produces an interplay of the various disciplines which appears to stimulate broader student thinking about the topics under study. Secondly, we feel that the influence of a particular discipline upon a student's education is determined by a variety of factors, including not only the number of teaching hours, but also the total duration of exposure. We suspect that our 154 hours of pharmacology instruction will have far greater effect over a 3-year period than would the same number of hours condensed into a few months. The minimum benefit of which we are certainly assured is that the student will no longer be able to put a whole discipline behind him after a single intensive period of study. And each successive topic in the subject sequence builds so systematically upon earlier ones that the operation of such a learning-forgetting cycle becomes much less probable.

Another question concerns the degree to which teaching is "integrated" in our program. Our approach is based primarily upon temporally coordinating the teaching contributions of several departments. We have sought to create favorable conditions for departments to reinforce each other's efforts, to collaborate to the extent they wish, and actually to merge their teaching efforts only if the

mutual desire and good will are present. In the basic medical sciences we have not vested direct teaching responsibilities in "subject committees" but have left these in the hands of autonomous departments. We believe that excellent teaching is a product of inspired and dedicated individuals, competent in their fields and free to exercise their individuality as they choose. The departmental structure already provides a conclave of colleagues who, in an atmosphere of mutual respect, can work constructively to improve their own teaching. The pride a department feels in being known for excellent teaching as well as for excellent research acts as a further beneficial stimulus.

To what extent, then, has departmental freedom of action been curtailed? There is a single committee, comprising a representative of each preclinical department, under the chairmanship of the director of the teaching laboratories, which oversees the basic medical sciences curriculum as a whole and makes such changes as seem desirable. Departments are bound by the decisions of this committee with respect to the subject sequence and the detailed teaching schedule. During the weeks when the kidney is under discussion, for example, the Department of Pharmacology is quite naturally expected to deal with pertinent topics, such as the diuretic agents. However, within the framework of the subject sequence the actual content of lectures and laboratory exercises and the manner of presentation (although they may be subjected to critical discussion in the committee) remain matters for decision by the department. Each department's teaching time is so designated in the schedules distributed to the students, and (thus far at least) we have devised our own departmental examinations and submitted our own evaluations of student achievement. There have been pro-

posals for expanding the scope of conjoint, nondepartmental teaching, and for adopting integrated examination and grading procedures, but these seem unlikely to be acted upon in the near future.

CONCLUSION

Anyone who has followed the history of medical school curriculum revision during the past decade cannot be unaware of the major contribution made by the faculty at Western Reserve in breaking radically with the past and thereby forcing us all to think more flexibly about curriculum patterns (5). We owe a debt of gratitude to these pioneers, for even though we have followed a different path and even vigorously reject some of their principles, the Stanford Plan nevertheless shows more than a few traces of the Western Reserve influence. It is also proper to acknowledge the contribution of the Harvard Medical Sciences Program (4) to our thinking, and of the Baylor physiology program (3) to the design and equipment of our teaching laboratories.

As Stowe (6) has pointed out, our approach is (and will continue to be) subject to revision. I do not like to call it experimental, because, in the scientific sense, where proper controls are impossible there can be no true experiment. Already the nature of our program has caused obvious changes in the caliber of our applicants. I think we should keep a sense of balance about what can and cannot be accomplished through "objective" assessments of a new curriculum's achievements. Certainly we should learn what we can about testing and other evaluative procedures that may be useful in measuring what our students gain from the new curriculum. In addition to such evidence, I would depend quite heavily upon the consensus of the faculty after a trial period of 5 or 10 years. The program might be considered successful

if at that time our students have performed well academically³ and in clinical or other postgraduate training, if an increasing number are entering careers in research or at least maintaining close ties with academic medicine, and if the faculty still feels that the curriculum favors effective teaching. Meanwhile, the very existence of a new curriculum, by compelling all of us to examine the impact of our separate efforts upon the medical student's total educational experience, generates enthusiasms and controversies that enliven the whole academic environment. We do not necessarily urge the wider adoption of our curriculum, and it may even be quite unsuited to the aims of other medical schools. In this period of curriculum reexamination, variety rather than uniformity will probably add the most strength in the long run to medical education everywhere. However, each unique program deserves to be understood thoroughly if we are to benefit by one another's experiences, and it is to promote such understanding that this account has been presented.

³ National Board examinations are now mandatory.

In conclusion, I should like to point out that a new curriculum is necessarily the product of many minds and enthusiasms, and to acknowledge with gratitude the devoted and effective efforts of my colleagues on the Planning Committee for the Basic Medical Sciences during the years of my chairmanship.

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