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ABSTRACT

Presented are the proceedings of a symposium on the implementation of contemporary biology in dental curriculum, sponsored by the University of Michigan School of Dentistry. Approximately 180 dental educators, including 69 official delegates from every dental school in the United States, Canada, and Puerto Rico attended. The program aimed primarily at presenting some selected views on basic science subjects with the hope that such presentations would serve the immediate future as a common matrix for reference and evaluation by all concerned. The current status of basic science courses in the dental curriculum was described, new and pertinent areas of information relative to contemporary biology and dentistry were delineated, and problem areas were identified. The symposium was made up of four sessions: Major Advances in Fundamental Biology During Post-War Period, Current Status of Basic Science Courses in Dental Curriculum I, Current Status of Basic Science Courses in Dental Curriculum II, and Future Needs and Directions. (PEB)

PROCEEDINGS OF SYMPOSIUM ON THE IMPLEMENTATION OF CONTEMPORARY BIOLOGY IN DENTAL CURRICULUM

June 16-17, 1971

The University of Michigan
School of Dentistry

Edited by S. S. Han

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TABLE OF CONTENTS

SESSION IV - Future Needs and Directions

INTRODUCTION TO SYMPOSIUM

S. S. Han:

On behalf of the Organizing Committee I take a special pleasure in introducing this symposium, as we have been most grateful to the enthusiastic response from all of you and your colleagues at home. Some of us characterize the post-war progress of biological sciences as revolutionary in its pace. Whether this should be called revolutionary or evolutionary in its character, most of us agree that the rate of progress has been extraordinarily rapid, and that several epoch making discoveries have been made in our understanding of the phenomena of life.

The bursting body of new information and knowledge resulting from such discoveries have created an entirely new challenge to biological scientists and teachers of biology alike. As these challenges created by the evolving biology provide a new basis for professional training of health science workers, each of the health science schools, including dentistry and para-dental areas, has been faced with the task of having to reassess the nature and extent of basic science courses that may be included in their undergraduate curriculum.

In fact, it is our common knowledge that curriculum committees in all dental schools have been struggling with this question for a long time. Consequently, several different formats of basic science instruction have been proposed and are being tried at different institutions. Common to all such efforts are: 1) the questions of how we can streamline the existing program so that enough new information can be added without disrupting the necessary continuity between the basic science content and substance of clinical training. 2) The question of how to reorganize the interrelationship between basic and clinical sciences so that meaningful interactions may be accomplished throughout the entire period of training ,and 3) Finally, the question of determining an ideal course of action which may lead to creation of a basic science program suitable for those schools that are starting from fresh ground.

The concept of vertical reorientation of basic sciences in association with parallel tracks of clinical areas, and methods of integrated instruction utilizing the resources of departments of oral biology have emerged as a common approach among dental schools.

When our planning committee first met, our idea was to develop a workshop-type conference in which the substance of various disciplinary areas might be discussed in detail, hoping to come up with definitive recommendations with regards to the content of each basic science discipline. Soon after the launching however, it became clear to all of us that such efforts would not be fruitful unless some general discussions and reassessment of the situation by all of the schools are made. Accordingly, we have developed the program for this symposium which primarily aims at presenting some selected views on basic science subjects with hope that such presentations will serve the immediate future as a common matrix for reference and evaluation by all concerned. Thus, this symposium may mark the beginning of a collective reassessment of basic science curriculum, and lead to generating thoughts among us so that in the near future a true workshop with respect to each disciplinary area may become a meaningful endeavor.

SESSION I

Major Advances in Fundamental Biology During Post-War Period

Dr. D.D. Dziewiatkowski, Chairman

INTRODUCTION TO SESSION #1

D. D. Dziewiatkowski:

It is a pleasure to serve as chairman of this session. In preparation, some thought was given to possible introductory remarks. In the course of these cogitations, my mind's eye reviewed some of the observations made during the past twenty-five years. These are years in which I have lived and during which there has been a personal participation at the scientific level. In retrospect, it has been a flight at supersonic speeds; the time has passed rapidly, incredibly so. This feeling is possibly due to the fact that things have changed so rapidly. Our relatively simplistic attitudes have become sophisticated attitudes. We have learned a great deal. I hope that some of our colleagues, the speakers in this morning's session, in addressing themselves to their topics, which are but a meager sampling of the pieces in the montage created within the past twenty-five years, will in part orient us as to where we stand as regards some developments in biology.

TECHNOLOGIC IMPACT UPON RESEARCH:

PROBLEM-ORIENTED AND MULTIDISCIPLINARY APPROACH

Samuel Pruzansky:

It was with considerable temerity that I accepted this invitation. In the first place, I have not been previously involved in curriculum design nor do I hold formal teaching responsibility in a college of dentistry. Secondly, the title assigned to me might have been more appropriate if the speaker were the President of the National Academy of Sciences. Indeed, I should like to recommend to you a recent book edited by Philip Handler entitled, Biology and the Future of Man.[1] This is a report on the "state of the art" compiled by a prestigious Survey Committee on the Life Sciences of the National Academy of Sciences. It includes chapters on molecular biology, cellular biology, evolution, development, biological structures, the nervous system, behavioral biology, ecology, heredity, digital computers, feeding mankind, and the national health, among other sections. For a while, I contemplated a review of this book as a way of fulfilling that part of my assignment which deals with the technologic impact on research.

In reflecting on the general title for this session which considers the advances in the period following the second world war, I began to feel my age for I realized how far we had come since I received my dental degree in 1945. Many of the tools that are now commonplace in our laboratories were unknown at the time. Molecular biology was about to be conceived as a result of the cross fertilization between biochemistry, microbiology and genetics. The combination of methodologies and information of these three disciplines forged powerful experimental and conceptual tools whose full impact on the biological sciences and future of man are yet to be felt.

The generation gap in understanding molecular biology between those of my vintage, who have not kept up, and recent graduates is best illustrated by an anecdote that Muriel Beadle relates.[2] It seemed that George Beadle has been invited to speak to a society of specialists in medicine about the spectacular advances in biology. Among those at the meeting was a college freshman, whose physician father had brought him along because of the boy's keen interest in science. After the meeting, several of the physicians ruefully confessed that they understood little of Dr. Beadle's lecture since the methodologies and concepts were unfamiliar to them. The college freshman, on the other hand, complained that the lecture had been so elementary that he hadn't learned anything new. "We had all that stuff in high school", he said.

Some years ago, I tried to make a case for including genetics into the curriculum by collecting articles from Time and Life, the New York Times Magazine, the Wall Street Journal, and other segments of the popular press to illustrate that advances in genetics were being discussed everywhere except in the college of dentistry. This continues to be one of several deficiencies that persist in the curricula of many schools and which I will touch upon further on.

Despite these deficiencies, the quality and quantity of scientifically trained manpower that has been recruited into dental education during the post-war period is impressive. This can be measured by the ever growing number of teachers holding advanced degrees. This program and the diversity of its participants is in itself testimony to how far we have come since 1945.

When I graduated, the University of Rochester was the primary source, if not the only one, for the training of dental graduates for a career in basic science. Today, the number of training programs of equivalent quality has increased substantially. Our present concern is dominated by the problems of placement and continued support of those who emerge from such programs.

I recall that for me dental school had been a let down. This was also true for others who graduated from a first rate liberal arts and sciences college and elected to study dentistry. The faculty, with some rare and notable exceptions, was often uninspiring, unscientific, provincial, authoritarian, lacking in the scholarly demeanor that characterized university faculties at large, and sometimes plainly maladjusted. Then, and now, dental schools were plagued by a dichotomy between technique and theory. If you did well in the basic sciences, then it followed that you had poor aptitude in clinical technique, and vice versa. This fiction was perpetuated by students and faculty alike and established an impenetrable barrier between the laboratory and the clinic.

There is a similar dichotomy between clinical and basic research; a more important distinction might be between good and bad research. Coinical research is sometimes downgraded by laboratory investigators without recognizing that opportunities exist in the clinic for making fundamental contributions that cannot be duplicated in the laboratory. Much of what is known about the vitamins and their deficiency diseases was first revealed in epidemiologic studies on man. This was also true for the origins of endocrinology. Although much of our present knowledge of immunology is dependent on sophisticated laboratory studies, it developed out of remarkable insights gained by the clinical study of experiments on the nature of man. For a more comprehensive treatment of this theme, I would refer you to the book edited by Beecher entitled, Disease and the Advancement of Basic Science.[3]

In most schools during my student days, research was something you did after five o'clock, week ends, and during summer vacations. A career in research was open only to a favored few. If it had not been for federally supported fellowships that became available in the early fifties and the generous research support that followed, very few of us who marched to the beat of a distant drummer whold have been al'.e to continue.

The generous financial support for research that flowed from Washington for almost two decades affected all of us and we continue to be dependent on it. In the current debate on the reapportionment of time between teaching and research, it should be emphasized that there is a dimension to research that is seldom stressed and which is particularly pertinent to our consideration here. That is, the contribution that research makes to the educational system. It is a medium for the training of potential teachers, it tests the validity of empirically derived knowledge, and adds new information that forms the core of our curricula.

The expansion of research support was not without complication. The largesse led to abuses by the academic community. The educational system began to mass produce Ph.D.'s; many were little more than highly trained technicians resulting in a plethora of investigators and a shortage of scholars. The intimate contact between trainee and preceptor that characterized the best aspects of graduate study was lost in the desire to expand training programs so as to justify new laboratories, institutes and building programs. In the process, professors found willing allies in administrators. If you ever served on a search committee for a new head of department, you learned that one of the major criteria listed by the dean in the review of the candidate's qualifications was his talent for grantsmanship.

Unwittingly, administrators created Frankenstein monsters more concerned with aggrandizement for their laboratories and perpetuation of their grants than with the instruction of students. This led President Eisenhower to caution NIH in the early 1960's that research was drawing teachers away from the classroom. Since so many of the newly coined professors were dependent on "soft" rather than "hard" monies, was it any wonder that their loyalties and obligations became confused?

About the same time, the Journal of the American Medical Association in noting a sharp increase in federal spending on medical research warned medical school administrators to be on the watch for unwise use of research grants, to guard against scientism, "...grant getting by wisdom of application, a combination of pseudo-scientific pecuniary pedantry and integrated cooperative research, based all to often on irrelevant or mininterpreted data, and compounded by mass computer techniques."

The cult of scientism depended on the worship of new and expensive tools. Research could be comandeered by a requisition order. Unfortunately, scholarships could not. The critical questions that flowed out of a repertoire of knowledge and carefully considered experience were missing from many of the protocols submitted for review. Some of those who were funded to purchase expensive gadgetry were later found traveling about the country looking for ideas to keep their laboratories busy.

The investigator who made a large capital outlay in equipment and space and accumulated a payroll of technicians became a slave to his investment. He was compelled to generate work to keep his factory in operation. He could not afford the luxury of taking a new tack in his research, however promising it might be, if that research were to leave his plant idle.

Since technology is essential, how can we avoid this trap for ourselves and our institutions and effect the economics that are so critical today? I tried to do something about this in the past but my timing was wrong. I wrote memoranda begging for pooling of departmental resources for central facilities that would serve many investigators and provide the economy, utility and freedom for each investigator to more conceptually and operationally from one tool to another. Was I successful? Have you ever tried to challenge the prerogatives and hegemony of departmental baronies?

Looking backward once more, I recall that the student body was also different. In my graduating class there was but one married student and he was substantially older than the rest. Nowadays, as much as fifty percent of the graduating class is married, many with children. Most of my classmates graduated feeling completely self-sufficient and looked forward to independent private practice, much like shopkeepers. The individualized entrepreneurial mode of private practice that prevailed then, and is still characteristic of current dental practice, is what attracted so many of then into dentistry in the first place. They cherished independence and the status of professionals.

I suspect that the social characteristics of our present student body is such as to make them more responsive to the anticipated shift from the cottage industry mode of private practice to the industrial revolution in delivery of health care. It is a future in which the individual entrepreneur becomes absorbed into health care systems that serve a new patient clientele and deal with third parties for payment of services. Although these changes may be more conspicuous in medicine, a similar change can be anticipated in dentistry.

What does all this have to do with our deliberations on the implementation of contemporary biology in dental curriculum planning? It is clear that political, social and economic events shape our academic destinies. Federal support for the expansion of research activity which occurred at such a rapid rate in the past has decelerated. If you consider the effects of continuing inflation, the increased number of scientists competing for research support, the identification of a greater number of problems worthy of support, coupled with the expensive armamentaria required to equip modern laboratories, then any plateauing in federal funding becomes in reality a severe cutback.

The effect on the scientific community has been uneven. The physical, chemical, and other theoretical sciences have been most severely affected. Although the health sciences have maintained a relative advantage, they have not been immune from critical questions by both politicians and the public whose faith in research has diminished. The way of the investigator has changed for he can no longer insulate himself from political, social and economic considerations and pressures. According to the director of NIH, we are in the process of an agonizing reexamination of the nature and level of support in the health sciences as this nation becomes increasingly, and quite appropriately, concerned with the major and even survival-threatning problems of population, environmental pollution, racial polarization, education, and the potential for instant self-destruction. The scientific community should welcome this examination and participate actively in its conduct.

To gain some perspective regarding the future, let us consider some of the highlights of the Carnegie Commission on Higher Education's report subtitled, "Policies for Medical and Dental Education"." It should be recognized at the outset that the substance of the report came as no surprise. It was a kind of consensus developed and refined over the past decade in a continuing dialog among deans and faculty, medical economists and sociologists, government administrators and foundation officers. The prestige of the commission, the comprehensive nature of the report and its timing when the issue of funding health care is before the Congress, make it an important guideline that will shape our institutions for the next generation.

The Carnegie Commission was concerned with the serious shortage of professional health manpower, the need for expanding and restructuring the educational systems, and the vital importance of adapting the education of health manpower to the changes needed for an effective system of delivery of health care.

To implement these changes, a 20 percent increase was recommended in the number of entrants into dental schools and a substantial shortening of the period of training. It was suggested that more rapid progress could be achieved through more extensive use of dentist's assistants and dental hygienists, and through greater emphasis on preventive programs. The New Zealand dental nurse program was singled out for impressive results achieved. Emphasis was placed on the development of a network of "health education centers" allied to medical schools as a means for improving health care through the country and to provide for continuing education of health manpower.

The report has been heralded as another Flexner report - the landmark report on medical education in 1910, which served to abolish proprietary medical schools and led to the ascendancy of modern, science-based medical education. You will recall that the Gies report, also sponsored by the Carnegie Foundation, had a similar effect on dental education. Dr. Gies also led the fight to liberate dental professional writing from its former proprietary control and founded the Journal of Dental Research.

The Flexner or research model for medical schools has been criticized for its self-contained approach which exposed two weaknesses in modern times: (1) it largely ignored health care delivary outside the medical school and its own hospital, and (2) it set science in the medical school apart from science on the general campus.

Our dental schools are susceptible to the same criticism. Students are trained to deliver quality dental care of a restorative nature that can be purchased only by a minority of American consumers. In the present tense when health care is considered a right, continued instruction in gold foil is an indefensible anachronism in our educational system that is fostered by aged dental pedagogues. Although the superiority of orthodontic treatment in the United States is widely recognized, the cost of such treatment precluded its availability except to an economically advantaged minority of the population.

As a result, we have two levels of dental care in the United States, excellent and none. What we need is an experimental program, making use of auxiliary manpower to expand the delivery of such care. Research should include measuring the costing and quality of such services. This is a proper task for the schools of dentistry to undertake in collaboration with community agencies of private groups such as welfare funds of labor unions.

In doing so, the dental schools would fulfill the objectives of one of the two new models for professional schools envisaged by the Carnegie Commission. This is, the health care delivery model, where the school, in addition to training, does research in health care delivery, advises local hospitals and health authorities, works with community colleges, carries on continuing education for allied health personnel, and generally orients itself to external service.

The second criticism levied against the Flexner model, that it set itself apart from science on the general campus, can also be levied against our dental schools. When dentistry obtained autonomy from medicine in this country and established the first school of dentistry in 1840, it provided a means and a motivation for the development of the profession. It was not until the turn of the century that most dental schools began to seek and obtain affiliation with universities. Still, they guard their autonomy zealously and fear with some reason, domination by the medical schools.

More recently, there has been increasing evidence that the colleges of dentistry are joining the family of scholars that constitute every university community. In establishing Dental Research Institutes, such as that at Michigan, the review committees looked for broad institutional support for dental research. Thus, we see evidence that at some universities the criticism directed at the Flexner model was anticipated and steps had been taken to integrate dental science with that of the general campus.

Concurrent with the grim predictions of shortages in dental manpower, the Surgeon General of the United States, in speaking at the dedication ceremonies for a new 12 million dollar dental school building predicted that science is close to conquering the problem of tooth decay. The direct quote was, "Perhaps of all the discrete entities which are being vigorously studied today...the one standing closest to the point of resolution is dental caries."[5]

If we are that close to elimination of dental caries what effect will that have on the practice of dentistry, which in the minds of many is a one disease oriented profession. Should we not in the highest councils of our profession, consider the impact this may have on recruitment, the undergraduate curriculum, as well as on continuing education. As of this date, I am not aware of a single conference designed to discuss this question.

Some feel that we have nothing to worry about on this score. Alvin Morris makes the prediction that our population will not be "caries free in 2003".[6] Morris assures us that his assessment does not reflect lack of appreciation for the potential of existing caries-preventive agents and procedures. While he anticipated important research breakthroughs in the next 30 years, he does not see the full benefit of existing and new approaches to the control of dental caries being realized by the population at large by the year 2000.

It may be that the administration is overly optimistic in its effort to buy political advantage. Or, it may be that Dr. Morris is overcautious and underrates the possibilities inherent in scientific discovery. The issue is not who is correct but what will be the effect of such discussion on the image of dentistry. Will Congress, your state legislature, and private philanthropy be disposed to vote large sums for dental education and research if the cure for dental caries is imminent?

This long preamble to the main thrust of my talk was intended to provide a backdrop which sensitizes us to the ferment in higher education and its interactions with the needs of society. This is as much a part of the technologic impact as the invention of new research tools for our laboratories. Against this backdrop we can examine the multidisciplinary approach to problem oriented research.

My own experience has been in an area largely removed from the mainstream of undergraduate education but which in practice is a microcosm of much that is current in our discussions. The mission in which I have been engaged is problem-oriented. The nature of the problem is such that it is refractory to solution by a single discipline and perforce multidisciplinary. It involves delivery of comprehensive health care over a state-wide basis, provides for continuing education of a variety of professional health manpower, and requires financing through third party agencies. We have been at this for almost a quarter of a century.

Our patients are children born with craniofacial birth defects that are referred to us as infants and stay with us through their development into young adults. For some of our older patients, we are providing genetic counseling as they contemplate marriage. We are also involved in the management of patients with developmental or acquired deformities, including the results of ablative surgery in the treatment of cancer.

In terms of therapeutic management, patients with craniofacial deformities present intertwined medical, dental, emotional, social, educational and vocational problems requiring prolonged supervision for optimal rehabilitation. The traditional pattern of hospital care that shuttles such patients through the maze of departmentalized clinics or by referral to an assembly line of isolated, specialized private practitioners, cannot provide the necessary integrated services. Needless to say, this system was demoralizing to the family who sensed that Dr. A was not communicating with Dr. B. The system was also unrewarding to the professional worker since he seldom acquired an overview of the patient's total needs and discovered that he might be unwittingly working at cross purpose to the efforts of others.

Keeping in mind the comprehensive needs of the patient with craniofacial anomalies, consider Dummett's recent forecast on the posture of community dentistry in the year 2000.[7] He wrote of his interest in the integration of human behavior and mental health prinicples in dental education which began twenty-three years ago. "It was recognized that the physical, mental, emotional, and social characteristics of an individual were indivisible constituents of a dynamic aggregate, and their complexities made it difficult to solve the problems of countless human adjustments." He goes on to decry the fact that the majority of American dental schools had not found a place for mental health, even at the bottom of the list of possible essential subjects in the dental school curriculums.

As you can see, I share Dr. Dummett's view on patient management. I would differ, however, on its introduction into the curriculum as an abstract subject. For the sake of economy of time and to avoid duplication, we need to agree on the teaching of essential principles and to reinforce such instruction by the selection of appropriate clinical models.

The handicapped child is just that kind of model. The lessons learned from the exposure to his multifaceted needs transcend in their application to include a wider range of more common problems. Most of all, they sensitize the student to the holistic concept of the patient.

Granted that there is a justification for the existence of mission-oriented interdisciplinary teams, do they belong within the framework of the university and if so, where?

To answer this question, consider the quality of such units. An interdisciplinary organization is more than the mere juxtaposition of representatives of two or more branches of science. Each requires an understanding of the conceptual frame of reference and units of measurement of the other. To achieve such understanding, it is first necessary to break down the semantic barriers of jargon, as well as the emotional impediments to communication that have their roots in professional traditions and bias.

The interdisciplinary unit is the educator's antidote to over-specialization. As the population of research scientists and clinical specialties proliferate, there is a tendency to split up into narrower fields of specialization. Recognizing that excesses in specialization decrease the range of science which will be interacting in the minds of creative individuals, the interdisciplinary organization provides the means for introducing the investigator to concepts developed in the other fields of science.

We discovered that certain personal attributes qualify an investigator for membership on a team. His interests should be pluralistic and he must be selfmotivating to move oeprationally and conceptually in a variety of directions.[8] The cohesive force that binds such individuals together was described by Norbert Wiener as being "...joined by the desire, indeed the spiritual necessity, to understand the region as a whole, and to lend one another the strength of that understanding."[10]

Wiener envisioned that such community would produce "... a range of thought that will really unite the different sciences, shared among a group of men who are thoroughly trained, each in his own field, but who also possess a competent knowledge of adjoining fields."[9]

Since our mission has to do with birth defects, a problem remote from everyday dental practice, what is the justification for involving our Center in the curriculum of the undergraduate? In a previous paper delivered on this campus, I offered an extended response to this question.[11] For our present purpose, let me highlight certain points.

Birth defects, including inborn errors of metabolism as well as structural malformations, are being studied with increasing interest by an ever widening array of disciplines whose interests range from molecular and cell biology to population genetics and epidemiology. This concentration of interests represents more than the current fashion in science. It stems from a universal recognition of the relatedness of such problems to the public health and the basic biologic import of the knowledge that can be gained from these studies.

As an example, let me cite what is transpiring in the field of teratology. Twelve years ago, the Teratology Society was organized as a small club of investigators drawn from developmental biology, genetics and clinical sciences who shared a common interest in the etiopathogenesis of congenital malformations. Along came the thalidomide tragedy and the ranks of the organization were suddenly swelled by investigators employed by pharmaceutical manufacturers. There was an urgent need for the expertise of its members in developing standards for determining the teratogenicity of drugs. As a consequence of this demand, workshops were organized which systematized existing knowledge, provided the specialized training, and sought to establish standards for experimental testing of drugs.

As you know, chemical mutagens have been employed for several decades by microbial geneticists and molecular biologists as tools for the elucidation of basic genetic structure and functions. More recently, practical and sensitive methods for detecting and measuring effects of chemical mutagens in vivo and in vitro mammalian systems and by microbial and other ancillary non-mammalian systems have been developed. Similar test systems have been developed for teratogenic agents although variable species response limits the extrapolation from laboratory animals to man.

The concern for the oncogenic, mutagenic and teratogenic effects of environmental pollutants, food additives and pesticides have thrust previously recondite branches of developmental biology into the limelight making them relevant to our daily lives. With increased funding from a variety of sources, we can anticipate that knowledge applicable to the public welfare will emerge. While much of the support will be for problem-oriented or applied research, if you will, we can expect a substantial yield of information fundamental to the biologic sciences.

Problem-oriented research serves to uncover the interfaces between disciplines and allows for mutual exploration of the wide unexplored areas that surround the islands of specialized interests. As an example, since 1966 the National Institute of Dental Research has supported the activities of the Joint Committee on Dental and Speech Pathology-Audiology for the purpose of promoting cooperation in the approach to problems of mutual interest. The committee has representation from the American Association of Dental Schools and the American Speech and Hearing Association. As a result of this collaborative activity a number of conferences have been held and several monographs based on the proceedings have been published.[12, 13] Such interactions augur well for the enrichment of instruction in the life sciences and help bridge the gap between the student's preclinical and clinical experience.

A word or two about the administration of centers such as my own. At some universities, multidisciplinary units are suspect simply because they do not fit into the conventional table of organizations based on the departmental unit.

In my view, mission-oriented centers should be scrutinized by outside reviewers at prescribed intervals. If the mission is completed or so well organized that it can be absorbed into the established table of organization, then this should be done. If the center becomes a model for duplication, this, too, should be made known. If the center is an effective unit that can expand its base of operations to include related problems, then this should be encouraged. For example, we were originally organized as a Cleft Palate Center. Since the professional resources mobilized were particularly suited to manage a wider range of problems and because we had the advantage of a wide basin of referral, it was natural for us to undergo a reorganization, as we did in 1967. Last year, New York University emulated our change and established its own Center for Craniofacial Anomalies. I understand that a third Center for Craniofacial Anomalies has also been established by the U.S. Air Force.

As administrative officer of the Center, I see my function as that of a broker. Except as it may affect our core research, we avoid making large capital investments in equipment. If the need arises for specific tools, we seek collaboration with existing facilities possessing the required technical capabilities. In doing so, we may contribute toward the purchase of ancillary equipment, hire technicians or purchase supplies, or contribute to any other arrangement that will provide access for our staff. The advantage for us is that it does not bind us to a given technology for an indefinite period. The arrangement is sufficiently flexible to permit us to move elsewhere as new problems requiring other technologies arise. It also protects us from changes in research programming that develop from the inevitable turnover in professional staff.

As an example of the resourcefulness that distinguishes some investigators, consider one of our recent collaborative studies on a family with a genetically transmitted disorder of hair. The investigation involved the utilization of conventional and scanning electron microscopy, x-ray diffraction, amino-acid analysis and other special studies on hair. In the process,we had to enlist the assistance of several departments and facilities within the university, as well as other institutions including the laboratory of a manufacturer of hair shampoo.

All of which brings me to several points I want to make.
1. To effect economy in research, we must avoid unnecessary duplication of resources within a given geographic area. Institutions should be encouraged to develop consortia in their application for grant funds. It is common experience that complicated equipment that is in full use and continually manned by a well trained technical staff functions more efficiently and increases the output for the investigators. Cooperatives in research not only reduce costs but can be more efficient.
2. To provide for diversity in the educational system the Committee on Institutional Collaborations should be expanded to include additional institutions so that students may be directed and permitted to sample diverse educational opportunities in accord with their special aptitudes and interest.
3. To take advantage of these opportunities, the undergraduate curriculum should provide for independent study programs. I am impressed by the success of our School of Medicine in uncovering latent talent that might otherwise have been submerged in an educational system geared to mass production where each student is an anonymous figure to the faculty.

Finally, on the basis of my personal experience and as a reflection of my own interests, I should like to see the undergraduate curriculum strengthened in the following areas:
a.) Course work in the neurosciences should emphasize pain, the physiology and pathology of the trigeminal system and motor and sensory function in the facial-oral-pharyngeal area. The physiology of taste and olfaction, its genetic mode of transmission, and its alteration by a variety of pathological conditions, including birth defects is of fundamental and practical interest to the dental scientist. Since the methodologies are available and there exists a growing body of literature, I find it deplorable that courses in oral physiology have not been organized to meet the special needs of the dental student. As an example of what can be done, I would draw your attention to the teaching of oral physiology at Osaka University as developed by Professor Kawamura.

b.) In the present scheme of teaching, the orthodontist's concept of occlusion differs from that of the periodontist and neither shares the perspectives of the prosthodontist. To develop some unifying concepts, I would suggest that occlusion be restudied in terms of masticatory efficiency. Some years ago Manly and his co-workers defined work output under variable conditions. To complete the equation we need to know something about energy input. Integrated electromyography is one of several approaches that can be employed to evaluate the relationships between structure an masticatory efficiency.

c.) The success achieved to date in training a cadre of dentists qualified to teach the basic sciences accentuates the lack of clinical teachers, well versed not only in their clinical specialty but also in the broader arena of human health and disease. Our schools need expert clinicians, soundly trained in the biology of disordered function, and endowed with enthusiasm for teaching to bridge the gap between laboratory and clinic. In my view, this is where the next major thrust in graduate education will need to take place.

In summary, I believe that the University should provide for diverse approaches to education and research. For those whose temprament and interests dictate an individual approach, suitable circumstances should be provided for the loner.

Multidisciplinary teams are but another mechanism in human enterprise and one that is particularly suited to problem-oriented missions. There is one distinction, however, that should be made between team research in industry or in the delivery of health services, such as open-heart surgery, as opposed to the academic purpose of furthering scholarship and inquiry. In the former, the chief is a sort of super-executive who fractionates the job to be done into its component parts and assigns them in accord with the talents of his subordinates. The chief is not primarily concerned with the intellectual needs of his subordinates. He has a job to do and this is the best way to get it done. In my view, this arrangement is not compatible with the purposes of the University.

This view can be clarified by expanding a previous citation from Norbert Wiener.[10] "We had dreamed for years of an institution of scientists, working together in one of the backwoods of science, not as subordinates of some great executive officer, but joined by the desire, indeed by the spiritual necessity, to understand the region as a whole and to lend one another the strength of that understanding."

Paul Weiss crystallized several thoughts that I have been struggling with when he wrote that in the mission of science, there is no place for the parochial view "...biological investigations are indispensible to the advancement of medicine, effects in the reverse direction are equally true and potent...Clinical investigation and biological research are integral parts of the same endeavor, as both contribute to the understanding of life."[14]

As a clinical investigator, I subscribe to the foregoing and it is a philosophy that I have tried to communicate to younger and future colleagues.

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MOLECULAR BIOLOGY AND NEW CONCEPTS IN GENETICS:

THEIR IMPACT IN BIOLOGICAL SCIENCES IN GENERAL

Rowland H. Davis:

The impact of molecular biology on biology in general has been so great that many biologists have seen their own areas become unrecognizable. Some have sensed defeat. The majority of biologists, however, recognize the growth of molecular biology as one of the great episodes in the history of their science, and have enjoyed--even if they did not participate--in the rare intellectual challenge it provided. I would like to summarize my impressions of the impact of molecular biology and the new genetics in biology. In particular, I would like to explore how the content of these new fields gave a language and conceptual framework to other areas, and how experimental approaches in biology have been affected by molecular biology. In doing so, I hope to demonstrate the simplicity of teaching biology nowadays, because of the skeleton that genetics and molecular biology have provided for many once unrelated fields.

I

Between 1900 and 1940, genetics was concerned with the transmission and mutation of genes. First, genes were found to be particulate entities carried by chromosomes. Because chromosome division and distribution in sexual and asexual reproduction are so reliable, the field of genetics was easy and precise. The rules of inheritance, moreover, were found to be universal among higher plants and animals. Second, the changes brought about by mutation were often found to be drastic, and the more obvious mutations were selected for use in experiments on heredity and gene function. A useful property of mutations was their discontinuous nature. A white-eyed variant of the normally red-eyed fruit fly, for instance, arose abruptly, it was an extreme change, and it was stable for many generations. It could therefore be used as a marker for its chromosome, and it is potentially useful for study of pigment formation. The particulate properties of genes imposed a peculiar formality on experimental work in genetics. The field became more logical than strictly quantitative, Mendelian ratios notwithstanding. Because genetic studies could give yes-no answers, hypotheses about gene structure, linkage and function could be formulated simply and tested powerfully. In this, we see the beginnings of the experimental tradition of molecular biology and what so sharply distinguished it from biochemistry at the time.

II

Biochemistry was a less unified field in 1940. Its major theme was to replace the vitalism still lingering even among biologists with utterly mechanistic principles. By 1940, biochemistry had demonstrated that cell-free extracts could perform long and complex biochemical transformation yielding chemical energy, macromolecular building blocks and other small molecules. It had gone on to define these transformations in terms of the action of many highly specific enzymes acting in sequence. The study of enzyme kinetics and energetics, however, made thinking in biochemistry quantitative and chemical; biochemistry became highly reductionist in its approach. The field turned, therefore, from studies of complex systems to individual elements of these systems, and the activities of whole cells were appreciated only theoretically as a set of highly interdependent rate processes. By 1940, the vitalistic impression of living biological systems was replaced less by chemical understanding than by faith in chemistry.

III

There was of course a great deal more biology than genetics and biochemistry in 1940. In fact, biology was usually thought of as the study of the phlogeny, anatomy, physiology and development of whole organisms. Genetics' impact was circumscribed, since it remained an inferential field, dealing with formal rules of inheritance. Biochemistry was related to medicine, agriculture or chemistry more than to the study of basic biology. How, then, did these fields come to play such a dominant role after the Second World War?

A combination of physicists, microbiologists, biochemists and geneticists gave rise to the field of molecular biology. Physicists tend to think in universal terms and to develop model systems for studying a basic problem. So it was with their first interest in problems of life. They asked: "What is the essence of replication in biological systems, and what is the nature of this stable molecule the geneticists call the gene?" To answer these questions, they used the simplest possible system with the properties of self-duplication and genetic stability, the bacterial viruses. Very quickly they demonstrated that DNA was the genetic portion of the virus, and confirmed the brilliant, laborious work of Avery and his predecessors, who demonstrated that DNA behaved like genetic material in Diplococcus, the pneumonia bacterium. Soon afterwards, Watson and Crick worked out the structure of DNA by refusing to confine themselves to empirical techniques as classical biochemists and biophysicists were doing. Instead, they allowed their intuitions to be guided by the important properties of genes as well as by the available chemical knowledge of DNA. Thus they were able to describe, as it turned out, not only the structure of the chemical DNA, but also of the abstraction known as the gene, having the properties of replication, specificity and mutation. At about the same time, geneticists and biochemists showed that mutations of genes, and therefore of DNA, could eliminate or alter enzymes and other proteins. DNA could then be appreciated as the source of information to make proteins, the vital catalysts in cell function. In a short time then, genetics and biochemistry fused, as the gene's structure and action were elucidated in chemical terms.

Many steps in the field were made, like those just mentioned, by selecting the most relevant phenomena for study, by conceiving formal models, and by testing them in simple ways. The biochemical details were pursued only when such refinement was necessary and worthwhile, and quantitative precision was thought less important than formulating experiments in which the possible outcomes were few and radically different. In this way, molecular biology got to the heart of important questions quickly and elegantly.

Why did DNA--and the molecular biology that grew up around it--create such a stir? I feel that DNA was a surprise in several ways. First, a gene's worth of DNA, as Crick pointed out, is the only type of molecule represented only once or twice in the cell. Second, the powers of amplification of DNA--both in its indirect template role in protein synthesis--is enough to dominate a cell's function and that of all of its descendents. Third, its intimate chemical structure was less important to most biologists than its information content, and this was a wholly new way of looking at a macromolecule. So, just as biologists became convinced that the chemistry of the whole cell was too complicated ever to understand, DNA--a master molecule, so to speak--put a simple physical foundation under the major problems of cell function and inheritance. In doing so, it gave continuity to the quite different levels of analysis in biochemistry, cell biology and genetics, and embraced them with a single means of discourse.

For some time, the highly deterministic behavior of DNA was not easily assimilated by biochemists and biologists, precisely because it was so simple. Often the disbelief of classical biologists reflected an ignorance of the power of genetic rationale. The attitudes of molecular biologists were abrasive and to physiologists, taxonomists, developmental biologists and anatomists, who were convinced that their fields--usually involving complex systems--were immune to "simplistic" approaches such as those seen in molecular biology. These gentlemen were sad to see attention on their fields displaced by the excitement of molecular biology. This regret remains--perhaps with more justification--today.

IV

How have genetics and molecular biology reshaped biology, particularly as a student sees it nowadays? I would like to remark on three related factors of change, and their influence in major areas of biology. The three factors are (1) the introduction of chemistry as the language of functional biology; (2) the enormous increase of information about biology; and (3) the increasingly universalistic attitudes of biologists. The development of these influences are clear in what I have already said. What then, have been their effects?

First, a biologist, even before he takes his first course in the field, must know some chemistry. Without it, he is forced to learn cell function and physiology in highly abstract terms; he cannot have an intuitive grasp of the Krebs cycle, nitrogen excretion, mutagenesis, gene-enzyme relations, active transport and a host of other subjects. Chemistry is the language in which biological function is now known and taught. Furthermore, it is the biochemistry of organisms which changes least in phylogeny, and chemistry therefore provides a possible skeleton on which students can build a knowledge of the enormous physiological diversity of the living world. Major current developments in functional biology now are really extensions of the molecular approach to more complex systems. We see this in current advances in the function of higher animal and plant cells, particularly in the structure and function of membranous organelles. We see it also in the study of regulation of gene action in cellular homeostatic mechanisms and development. These fields are now being absorbed by molecular biology, and it is hard to learn much about them from any other standpoint.

The second factor of change in the field is the burden of information. In the early part of this century, biology was mainly descriptive. The major emphasis on taxonomy, phylogeny, embryology and physiology tended to stress diversity and adaptation during evolution. Natural selection, of course, was a peculiarly biological phenomenon, and the best way of imparting a sense of the phenomenon was to be familiar with the types of organisms. The diversity of the living world made it hard to learn more than a small sample of organisms. With the explosive development of genetics and molecular biology, descriptive biology has given way. The study of biological diversity _per se_ is now more a scholastic than an original enterprise. Description of the biological world is now an adjunct to the study of principles, such as the genetic factors of evolution. In teaching, a pattern is already well-established in which one learns about insects in genetics labs, bacteria in molecular biology courses, phylogeny in evolution courses, frogs and trees in physiology or developmental biology courses. In my opinion, the integration of the themes of diversity and principle has been a great improvement; little has been lost.

Finally, biology now has a well-developed universalistic attitude. While this attitude has always been fairly strong among biologists, molecular biology challenged experimentalists to make their work as broadly relevant as possible. This challenge is met as the molecular biologists met it--by choosing systems which were models of principle, rather than by musing about intriguing, isolated phenomena. Work has begun, for example, on insects and round-worms as models of simple neurological systems, on yeast as the simplest of higher cell types, and on algae and protozoa as models for morphogenesis.

It has recently become clear that molecular biology and genetics are themselves getting a bit classical. They and their practitioners aged rapidly. But their influence will always be felt, even as biologists go on to study more complex systems such as evolutionary mechanisms, ecology or the mind. We can hope that molecular biology as it stands does not insist on its primacy as taxonomy once did. We can hope, in other words, that academic biology and medicine can adapt to students who learned about DNA in grade school, and who want to be equipped for something more--and perhaps something very different--in the future.

BIOMEDICAL DATA PROCESSING:

SYSTEMS ANALYSES IN BIOLOGY

Geoffrey Walker:

The classification of information into a series of systems is an arbitrary process, but is useful if it leads to a natural grouping which brings some degree of order to a subject which is otherwise massive and potentially vague. The groupings which will be used here are those of verbal, pictorial and numerical information systems. Essentially, these are systems which encode or store information, as for example words, pictures or numbers.

Verbal encoding may be spoken or written, the written or printed word being the conventional method of storage in western society. It should be kept in mind that preliterate societies were able to store information in verbal (spoken) form as tribal myths and legends and occasionally used symbolism or diagrams to depict totems and events, such as in rock and cave drawings.

Each of the three systems may be further divided into three operational levels, the levels being named

(1) Descriptive
(2) Deductive or analytic and,
(3) Inductive or synthetic.

The classification of the system is shown in Figure 1. Probably the most widely used information system, certainly since historical times, is the verbal system. At the descriptive level it provides much of our literature, such as historical and imaginative writings.

The early scientific literature was usually of a descriptive nature. Examples are the writings of the early alchemists who described physical events at great length, but only rarely were there evidences of deductive logic. Occasionally an investigator such as Joseph Priestley used an analytic approach and was able to isolate and observe specific elements, such as oxygen, from the generally complex compounds found in the physical world.

As the complex interrelationships of elements became more completely understood, one of the early pioneers in chemistry suggested that they could be grouped by divisions of their atomic number. Thus, in 1871 Mendeleeff's famous table of the elements provided a good example of inductive logic, or the inference of general principles from a mass of isolated facts. Another example of this inductive process was the discovery of the principle of organic evolution, described so vividly by Charles Darwin in his "Origin of Species" and published in 1859.

FIGURE 1

Types Of Information Systems

	VERBAL	PICTORIAL	NUMERICAL — METRICAL	NUMERICAL — STRUCTURAL
DESCRIPTIVE	VERBAL DESCRIPTIONS	PHOTOGRAPHS X-RAYS	MEASURE-MENTS DATA BANKS	DATA STRUCTURES DATA BANKS
DEDUCTIVE	DEDUCTIVE VERBAL INTERPRET.	DIAGRAMS MAPS	STATISTICAL ANALYSES	SHAPE ANALYSES
INDUCTIVE	SYNTHETIC VERBAL CONCEPTS	SYNTHETIC DIAGRAMMATIC PROJECTIONS	CONCEPTUAL MATHEMATIC. MODELS	SIMULATION + PROJECTIVE STRUCTURES

POWER (arrow pointing down, beside the rows)

INFORMATION CONTENT + UTILISATION (arrow pointing right, below the columns)

In this he synthesized a general theory which satisfactorily explained the changes and emergence of new species of animals and their adaptive relationships to a changing environment.

Information may also be stored in a visual or pictorial form. Examples of this medium are paintings, sketches, sculpture, and more recently, photographs and X-ray films. Once again, it is possible to divide this pictorial system into three operational levels. Examples of the deductive or analytic level are diagrams and flow charts which reduce the more general pictorial patterns to their essential elements. Synthetic or inductive levels are not as well expressed in pictorial forms. However, the creative moving pictures of Walt Disney may perhaps be used as an illustration of purely synthetic forms, even if the inductive content may not be particularly evident.

Figure 1 suggests that there is an intellectual barrier or chasm between the worlds of words and pictures, and those of numbers. The history of human thought provided evidence that mankind has rarely been at a loss for words, but seldom produced individuals who could create and manipulate symbolic languages such as the language of numbers.

The Romans used a very cumbersome method of recording numbers, which made calculation exceedingly difficult. In practice they used a counting board similar to the familiar abacus. The ancient Greeks such as Euclid, Pythagoras and Archimedes were keenly interested in numbers, and number theory but again, calculation was prohibitively difficult with the numerical system of their time. Calculations such as additions and substractions were not too difficult on a counting board, but the multiplication and division of numbers was a mental challenge. The "counting numbers" had been in use for many centuries, but a symbol to represent the null or empty set (zero, in our system) was not invented until the early part of the Christian era, when an unknown Hindu invented a dot he called 'sunya' to indicate the column of the counting board in which there were no beads. Thus came zero, in position the first of the digits; but the last to be invented. When finally the Indian notation made its way to Europe, it was thought the Arab world and became known as the 'Arabic' numerical system. It was not immediately accepted, and although many merchants recognized its usefulness, the more conservative Universities clung to the Roman numerals and the abacus; and it was not until about 1800 that Europe universally adopted the 'Arabic' notation system.

This reluctance to sail the numerical seas is present with us even today. The so-called exact sciences such as physics and chemistry early recognized the advantages of quantifying their experiments and most of these use metrical parameters to great advantage. The biological sciences have been in a more difficult position as much of their information is related to the shape or form of organisms. Simple metrical parameters such as lengths and ratios provide very austere and often incomplete estimates of size and shape, and it is only in recent times that structural mathematical models have been developed to quantify and analyze the more complex biological forms. Similarly, numerical taxonomy is of recent origin and currently in its very early experimental stages.

The numerical system has thus been divided into two sections, the first of which indicates the use of metrical parameters, (such as length, weight, volume etc.) and the second describes those which form structural models, such as triangles, squares, cubes, pyramids and more complex polygons.

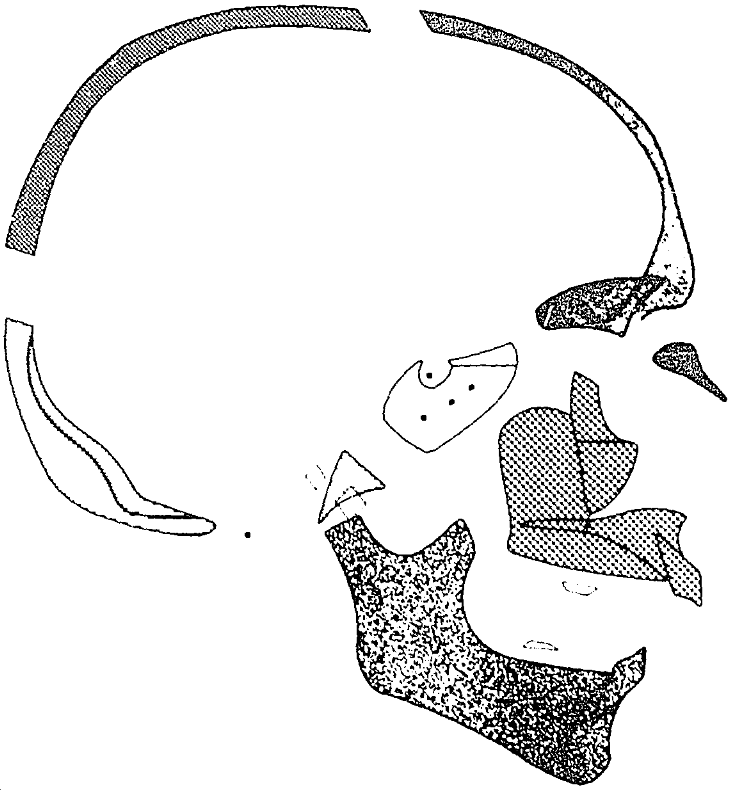
Metrical parameters may be accumulated to form DATA BANKS, and when analyzed, may produce statistical results such as means, variances etc. At a deeper level, these statistics may be tested dynamically and designed into statistical models of various systems. This technique is widely used in business operations and forecasting, and is often given the label of Operations Research.

In biology, the structural model has many possibilities, and examples from our current research will be given as follows. Our problem was to quantify the shape of the human head and face and to analyze the changes of shape which occur during growth. Many x-ray films of growing children were available and these were first translated to structural forms such as the outlines of various craniofacial bones shown in Figure 2. These were then digitized to a standardized model or map as in Figure 3. The co-ordinates of this model or map were converted to punch cards and stored in a computer. The computer was then programmed to reproduce the model as a computer plot, and is shown in Figure 4.

These maps or structures could be analyzed to produce means and variances, and Figure 5 shows the mean configuration or structure of some 1100 children ranging in age from 6 to 16 years of age. Many of our records were serial x-ray films of the same child and these were analyzed to show the vectors or directions of growth of the various points of the skull. These lines were plotted and called VECTORGRAMS, and an example is shown in Figure 6.

These vectorgrams could be grouped to form composites as in Figure 7, and further analysis of these composites provided us with the most probable rates and directions of growth of the various skull points or co-ordinates. From these composites we had sufficient information to synthesize or create a projection or forecast of facial growth for any particular child, and examples are shown in Figures 8 and 9.

Thus, we now have a powerful method of quantifying biological entities from a shape or structural point of view, and further, we may now analyze and manipulate these structures to echo the growth changes of the organism in its real world. The development and refinement of these simulations should lead to a deeper insight into the mechanisms of growth, a better understanding of factors which contribute to growth abnormalities, and eventually to better methods of diagnosis and treatment of craniofacial anomalies.



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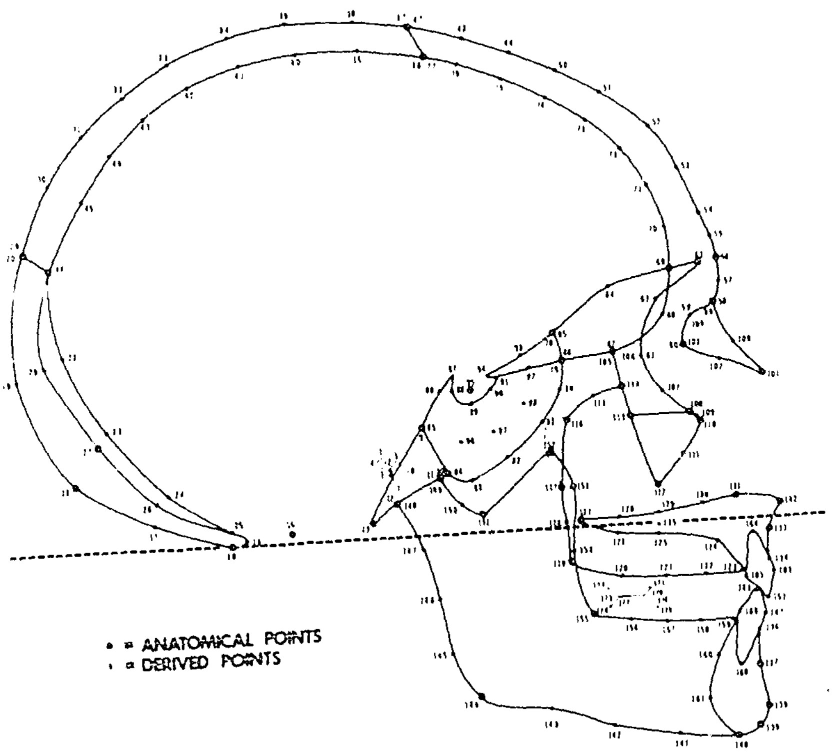

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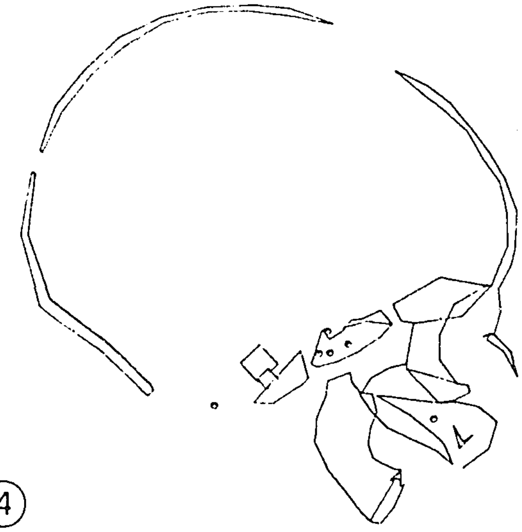

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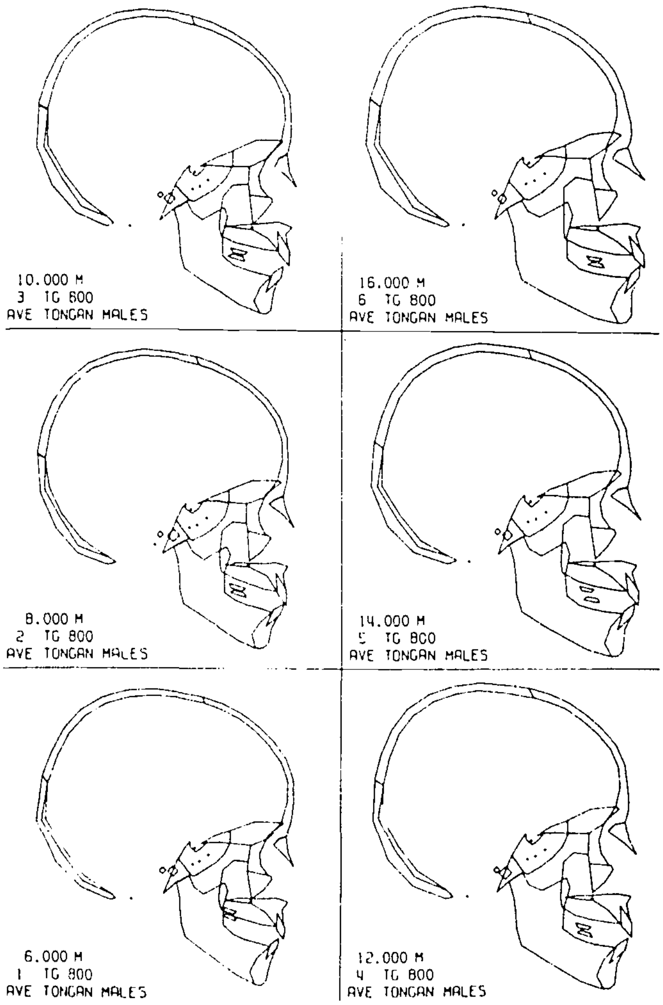
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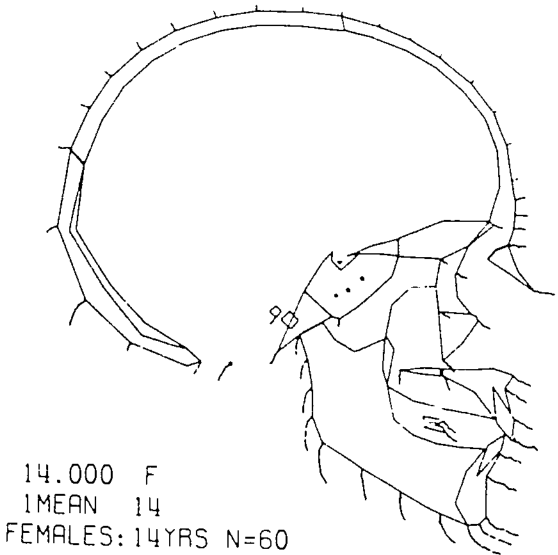

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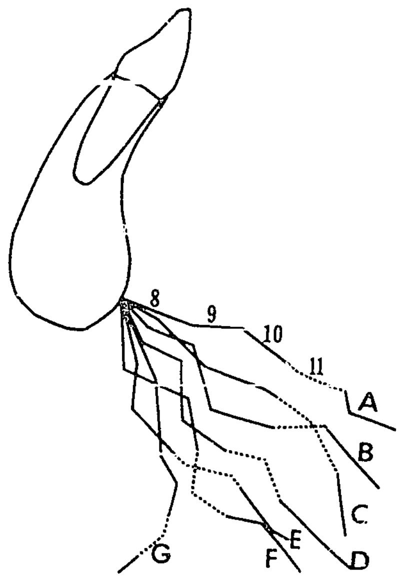

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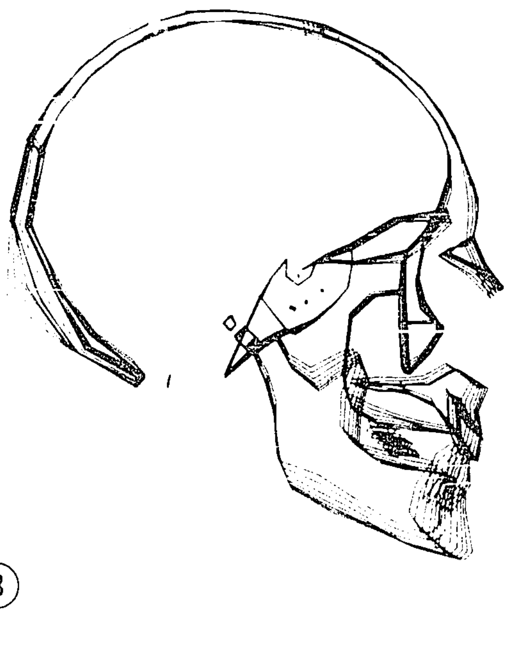

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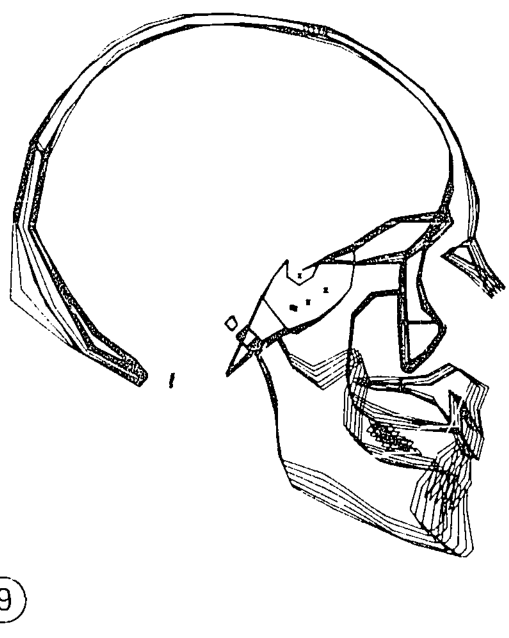

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DISCUSSIONS

Dr. Dziewiatkowski: We have heard three provocative essays this morning. I am sure you have questions.

Question: Why do botanists seem to ignore the great contributions of microbiology to molecular biology, molecular genetics and cell biology. Is not molecular biology a tool very useful in unifying biology?

Dr. Davis: I did not mean to slight any particular field. Microbiology is so much a part of molecular biology that I did not think it deserved separate mention. I hope that satisfies the questioner.

Question: How would you develop the activity you spoke of in view of the Carnegie Commission Report recommendation to: 1) upgrade class size in teaching loads, 2) shorten curriculum time, and 3) limit research to few insitiutions and make the others only training centers?

Dr. Pruzanksy: Part of the problem is establishing priorities, assessing the curriculum and modifying it to what we project are the needs of the students in the future. I do not think that the intent of the Carnegie Commission report was to restrict research to a few institutions. They favored the development of diverse institutions which would conform to different models. In some institutions there woule be a greater emphasis on research than in others. I did not read into this report an intent to develop institutions that would be completely devoid of research. I cannot envision it and I do not think they did. To do so, would rob the institution of an important ingredient vital to its existence. The question is one of emphasis. As you recall, they did urge that centers of excellence be established in large university centers. To that extent there may be a preference for regional institutions of a certain type. Such centers may provide the model or means for innovation and testing while other institutions evolve more slowly.

Question: What curricular activity would you propose for the student in terms of data processing?

Dr. Walker: The student should have some appreciation of an efficient approach to information gathering and how to record and analyse it. In other words he should condense the information down to some sort of data base and then it is important to know what should be done with this data base. For example, we have about 20 graduate students in our department, and they each have to produce a thesis, so we have some 20 theses to supervise every year. There is a great deal of data and data processing that goes along with this. In the last year we carried out the data processing for them. The information was brought to us, we coded it, converted it to punch cards, programmed the computer manipulations, and ran it through the machine. Although students could be trained to do this, it is probably more of a technical task than a professional requirement. Last year, computed information was fed back to the student in the processed form, and it was up to the student to evaluate and write it up.

Question: Is producing more dentists of a type we have been producing in a shorter time desirable? Will this be consistent with the technology of the future? Perhaps we need fewer dentists and more technicians?

Dr. Pruzansky: Let us examine the premise, "do we want to produce more dentists of the type we have been producing?" I would question that. I think the gist of what I am trying to say is that we need to produce a different breed of professionals. For example, we see at our clinic patients who have had ablative surgery and now require prosthetic devices. At the same time, we were faced with a manpower shortage since qualified maxillo-facial prosthodontists are few in number and command high salaries. At the same time, our University has a program in the School of Associated Medical Sciences where they train medical artists. It occurred to me that these medical artists could be turned into technicians. As a result, we developed a program of instruction for medical artists and we have trained a number of medical artists in the past five years who do much better work than most prosthodontists I know. Consequently, we employ one prosthodontist and 4 medical arts curriculum graduates as his assistants. His productivity is increased, the quality of the work is excellent, and the costs of such services have been reduced.

How can we plan instruction for a type of practice that may evolve 10 years from now? By that time the student may have forgotten what we taught him today. If he has not forgotten it, the material will be outdated. I am told that people who graduate from Schools of Aeronautical Engineering are outdated within 5 years. Well, that imposes a responsibility on the aeronautical engineer to continue his education. He has to be alert to changing times and he has to see which way the wind is blowing. I think our students, too have to be guided toward continuing education. For example, I have tried to encourage some dental graduates interested in academic life to enter a School of Business Administration. I think we are going to see an increasing number of dental graduates with MBA degrees.

If we are going to have competent administrators in dental schools; if we are going to have trained dental executives who can deal with third party systems, they need to know something about business procedures. I think this is an example of one of the directions in which we need to move. At one time, I thought that teaching students about practice management was a demeaning and unprofessional activity since it seemed to emphasize making more money. Unfortunately, this attitude was shared by others and our students have been denied training in sound business practice, which in my view is an essential ingredient in developing an ethical practice. Let me go back to another question: How do we foster creative and individual scholarly activity in the dental curriculum. We have a mass education system which tends to inhibit the talents of the special student. In our medical school, the independent study system has disclosed latent talent that might otherwise have been stiffled. We need similar programs in our dental schools. I am impressed by the innovative methods being developed to compensate for the shortage of good teachers. I was just told that one of the institutions has lectures by Harry Sicher on film. There may be only one Harry Sicher, but there are many other excellent teachers. An effort should be made to tape their lectures and to share their wisdom among many institutions. Why should busy people have to travel around from school to school as guest lecturers when you can put them on film or video tape and design teaching manuals to accompany these films? McGraw-Hill has a series of films and a manual on genetics. They have captured on film some of the leading scientists, including Nobel Laureates. These films bring into the hinterlands the cream of our national scientific talent. I think we need more of this and money will have to be invested in such teaching aids.

Dr. Dziewiatkowski: There are a series of questions here for Dr. Davis. I think perhaps you might want to answer all of them at the same time.

1) How do professional schools obtain integrated biologies from chemistry to biochemistry, with certain physical concepts, from undergraduate schools? Do professional schools have to accept this load to meet the Carnegie expectations?
2) If our students bring undergraduate molecular biology to dental school, how can the dental school respond to this type of preprofessional education?
3) This one is apparently addressed to any member who cares to take it up. What kind of biologist should the dentist be, and what should his training be? Perhaps Dr. Walker and Dr. Pruzansky might best handle the last question on the basis of their experience.

Dr. Davis: I think I will take the first one read here: how do the students get integrated training in undergraduate schools? This is a very difficult problem for undergraduate schools, just as similar problems arise in dental and medical schools. We have departments, and departments are the kingdoms of people that do not want to talk to people in other kingdoms. I happen to be in the plant kingdom, and I have difficulty talking with people in zoology. It is very hard to integrate, for instance, a course in genetics using the resources of both departments. We do this better than most fields can when it comes, for instance, to integrating organic chemistry with a study of biology. The choice is whether to become really equipped in organic chemistry as a chemist would be, or whether to have a course in organic chemistry relevant to biologists. Similarly, can you have the time to get organic chemistry, physical chemistry and biochemistry, with laboratory experience, while you are still an undergraduate? There is a tremendous amount of information in these fields as there is in biology as a whole. It is imperative to do something that academicians are very reluctant to do; that is, boil it down to the point where you get a feel of the scope of the field. We must admit that people are going to have to specialize their knowledge fairly early because of the burden of information. Most of the difficulties that you may have in dental education we have in undergraduate education. The willingness of departments to have courses put into the hands of curriculum committees with the power to devise an integration of subjects necessary for certain types of student is imperative. As long as the curriculum is in the hands of separate departments I do not think we are going to get very far.

At Michigan we have an honors program of physical sciences which very nicely integrates physics, chemistry, mathematics and biology, and this is a very good foundation for specialization in quite a number of subjects thereafter. At the most elementary level there also has to be cooperation among students and departments in single courses where you wrap up not *all* the details of the field as a professional might have to know them, but where you give the student a feel for the scope of the field just to enlist his interest.

I am not sure I can answer the question: Do professional schools have to accept this load to meet the Carnegie expectations? I think this is something that some of my colleagues might answer better. Regarding the other question: Where students bring undergraduate molecular biology to dental school how can the dental school respond to this type of preprofessional education? Well, I think you have to answer a prior question before you get to that; namely, what do you do about the diversity of the training of the students that come into a single dental school?

One cannot simply count on an adequate undergraduate education on the part of all students even if you require courses with certain names. I think that the response must be to expect to get a certain amount of sophistication among your entrants, know what that sophistication is, and then have a short review which will essentially homogenize your class with respect to a means of communication in certain areas, such as microbiology, molecular biology, biochemistry. In other words, have an orientation by which you establish a foundation on which to build your special curriculum. I think we all have an awareness of the sophistication of students now. To be blinded to that is foolish, but to count on it on the part of *every* student is equally foolish.

Question: If caries is cured in what direction do anticipate dentistry will go?

Dr. Pruzansky: I think anyone in this room can answer that as well as I can. My own view would be that certainly there are problems that affect the periodontium that have been neglected; and certainly there are problems of malocclusion. We shall need to expand manpower to deal with these problems. The whole approach of dentistry towards its clients requires redirection with emphasis on prevention rather than on restoration. It will require a reorientation in terms of training of students and in terms of our image with the public. Other professions, and the public, look upon us as a one disease-oriented profession. I have no hard data to substantiate that, but that is the view I have gotten from the sampling I have taken.

Dr. Walker: Perhaps I could comment on one question here, Dr. Dziewiatkowski. It is related to the question "what kind of biologist should the dentist be, and what should his training be?" For a specialist dealing with diseases of the face, jaw and teeth, much of the training is becoming more and more biologically oriented. It is rather difficult for a clinically trained individual to take in the whole scope of biology with the tremendous growth that is going on at the present time. However, there may be one approach which is worth investigating. I speak with some bias on this having spent so much time in physical anthropology. The study of human biology from a physical anthropological point of view gives the student an extremely broad and general approach to human biology. It does have one very great advantage; it gives you a framework of reference from a historical and evolutionary level as well as a biological level. Within this enormous framework everything tends to fall into place. The whole development of a subject even as apparently remote as mathematics, is part of the anthropological study of man. The new developments in biology once again all have a place of reference in it.

So if there is one form of general training which I think a dental student, or any biologist, could benefit from it is some exposure to physical anthropology in the broad sense. For anthropology includes the whole biology of mankind and provides a broad base to which the student could add all other disciplines as they come to the fore.

Dr. Pruzansky: About 3 years ago I published a short paper in the Journal of Dental Research entitled "What is Craniofacial Biology"? In that paper I took note of the iconogenesis that is occurring in which we are trying to change our image. You know that many departments of oral biology are being created. I think this is a reflection of a subconscious sensitivity to the inadequate image of dental research, because it is more than teeth. So we call ourselves oral biologists. I suggest that we might also label ourselves craniofacial biologists. This is an expansion of our image to tell it as it really is within the profession. We can cite many examples of the interphase between dental interests and those of other disciplines.

My own interest, as I cited in that paper, is in the growth of the mandible. By everytime I look at an x-ray of the mandible I also see the temporal bone. Whenever the mandible is deformed I also see that the temporal bone is deformed. Of necessity, I became an "unlicensed busy body", an amateur expert on the temporal bone. We see a lot of patients who have eye malformations. Well, if you have a defect that affects the growth of the eye, it may also affect growth of the maxilla. While my expertise is in the maxilla, I became interested in the eye as well. Conversely, if the maxilla is deformed, it will also affect the precise geometry that is involved in vision. Consequently, we are involved with ophthalmologists in the study of problems of mutual interest. The kind of biology that I do takes me into other areas. It compels me to learn the language of other disciplines. If you want to get somebody to work with you, you do not go and tell him about your problem. You study his problems, and recast your needs in terms that will interest the other fellow.

Question: Perhaps Dr. Pruzansky and Dr. Walker as well would like to respond to this one. Do you think that very much biology is needed for the successful training of a competent general practitioner of dentistry?

Dr. Walker: I suggest that the most useful type of biological training is the one where you glean enough general principles so that you can interpret what happens in the real world. The training should be very general, possibly even superficial, but should be wide in scope. It should give the student coverage in breadth rather than depth because we are not expected to be specialists in any particular branch of biology other than dentistry.

Dr. Pruzansky: Instead of making some broad sweeping generalizations let me tell you something I once read. If a man loses a leg, he loses three things, something to stand on, something to walk with, but also a third factor, something to feel with. Now, if we provide a prosthesis such as an artificial leg, we give him something to stand on, something to walk with, but we can never give him a sensory prosthesis; at least we do not have the means available right now. The analogy in dentistry is clear. When a patient loses his teeth we give him something to stand on, by restoring his vertical dimension. We facilitate locomotion, by giving him something to chew with. But, we do not give him anything to feel with. That is a concept. Let me show you how it is applied in clinical dentistry. I have seen many patients in consultation who have had full mouth reconstruction and who were unhappy. They did not know why they were unhappy and after spending several thousands of dollars, the end result was not as they thought it should have been. I examined them as best as I could and found nothing wrong. Then as I listened to the patient I realized what they were complaining about. They had sustained a loss of sensation. When you put full crown coverage on teeth, sensory input is diminished. I explained this phenomenon and they went away accepting the reality of their handicap, at least as far as I could tell. This has happened more than once. When I inform the dentist of what I told the patient, he reacts as if something new has been revealed to him for the first time. You see, our colleagues in restorative dentistry have a Benvenuto Cellini complex because this is what we have taught them, how to carve the finest cusps and marginal ridges and so on, but they know nothing about sensory physiology. We are not going to make them technically superior dentists by teaching them biology, but we are going to give them insights so that they can understand and handle their patients better. When a 45 year old woman entering menopause comes to you for full dentures, she brings far more problems than you will solve by finding centric occlusion. If you take a young man fresh out of dental school who knows very little about the change of life and the fears of advancing age and assign this lady patient to him, he will have very little insight into what is troubling her. We have to prepare our students toward a more holistic approach to their patients and this is the kind of thing I find missing in our curriculum.

Dr. Dziewiatkowski: Dr. Pruzansky, congratulations on being the most staunch advocate of biology. Are there any other comments or questions that the audience would like to raise. There are two others here which I think could possibly best be handled on a personal basis. Thank you very much gentlemen.

SESSION II

Current Status of Basic Science Courses in Dental Curriculum I.

Dr. James Avery, Chairman

ANATOMICAL SCIENCES: DEVELOPMENT OF AN ECLECTIC PROGRAM

Norman D. Mohl and William M. Feagans:

Today, many dental educators and some dentists are saying that dental schools need to change -- we need to innovate. The suggestions for change run the full spectrum from "I can train a man to be a dentist two years out of high school" to "There is no need for a dental school - dentistry should be taught strictly as a specialty within schools of medicine". As a consequence of this quest for change (or in the jargon of today - curriculum innovation), there is an effusion of articles, conferences and meetings related to the dental school educational structure. The extent of this activity probably surpasses that which followed the publication of the Bies report over forty years ago. We have read and discussed all of the variations and spin-off's of the horizontal, the vertical, the diagonal and, before long, the spiral curriculum.

Why all the fuss? What has led to all of this mass introspection? Two major factors deserve to be mentioned. The first is an extrinsic one which involves the present or impending crisis in health care delivery. Professional schools in the health field are being asked - no implored - to experiment with and develop delivery systems that can reach larger segments of the population. Such systems, with their cadre of health professionals and supporting personnel, require some modifications of the traditional outlook toward the training of these individuals. The identification and realization of this factor as a top priority problem has had a definite impact upon the educational structures of most health science institutions.

The second major factor influencing curriculum change is, as the purpose of this conference implies, an intrinsic one which involves the vast proliferation of information and knowledge in the biological sciences. Included in this is a significant body of knowledge which is specifically pertinent to dentistry. When the Gies report on dental education was published in 1926 the art and science of dentistry consisted mainly of the art and very little of the science. As we are well aware, this report had a profound effect on the educational programs of dental institutions in this country. Basic science and basic medical courses were added to the dental curriculum in an effort to expand the concept of dentistry in the profession, in the academic community and in the community at large.

This most certainly was a great improvement. However, these courses generally remained isolated from the mainstream of clinical dentistry and dental education because there were few dental educators who could utilize such material in a meaningful way. In addition, there was relatively little scientific knowledge pertaining specifically to the masticatory system and oral regions since research in this area was virtually non-existent. Much of this has changed. We now find ourselves with a significant pool of scientific information associated with dentistry and with more and more dental educators who are able and willing to impart this knowledge to dental students.

It also deserves to be noted that there has been a great impact resulting from the increasing sophistication of clinical dental procedures which are directed at preserving the natural dention and associated structures. The emergence of a wide variety of new dental disciplines, concepts and procedures has, along with the basic biological information now available, had a definite impact on the dental curriculum. It is no wonder then, that these and other factors have led to a proliferation of ideas, suggestions, demands and reports on the subject of dental education.

However, in fundamental terms, the success or failure of any educational program is not wholly dependent upon this myriad of evaluations, statements of objectives and committee meetings. Because, when you get down to the real substance of the problem, it ultimately depends upon the interaction between that faculty member at the lecture podium, in the laboratory, in the seminar or in the clinic - and his students. If he demonstrates a lack of enthusiasm and concern for his subject matter, for the rest of the educational program or for his students than your so-called vertical or diagonal curriculum has taken on a spiral approach - in other words, it is all fouled-up. The students will cry irrelevance, develop apathy and even alienation towards the school and, yes, even towards the profession. This reaction can be ameliorated or intensified during the clinical phases of the program depending upon the character of the clinical faculty. If they are unable or unwilling to relate basic science concepts to the realities of clinical situations then students who felt that there was a scientific foundation for the science of dentistry will be even further disenchanted. On the other hand those students who were turned off in the basic science courses will maintain that the material was indeed irrelevant and the concept of a biological basis for dentistry will cease to exist for those students.

One obligation of a good teacher, particularly in a basic science department, is not only to know what to teach but also what not to teach. It is not the purpose of basic science faculty to attempt to produce students in their own image, particularly when such students are entering a clinical profession. Thus, much of the depth - some say minutia - which one might expect of a graduate student need not be imposed upon a professional student, provided fundamental principles are mastered.

The only thing we can hope to do is to give each student the personal resources to enable him to pursue his own education, particularly after he leaves the University environment. This is why student motivation is so important because continued interest in a subject is dependent upon it. It is true that more dental students are coming to us with a broader background in the biological sciences than ever before. Cumulative grade point averages are higher and applications to dental schools are up. You would think from all this that the selection process alone would evolve classes that were superbly motivated in all respects. However, we all know that this is not the case.

As far as our educational product is concerned, it seems abundantly clear that we are all attempting to produce an oral health specialist who is primarily concerned with the preservation and maintenance of oral health, and failing that, with the restoration of function and health of those mouths in which disease was not prevented. This must be viewed within the context of a total health team and thus, the consequences of systemic disease upon the total management of dental patients must be consciously accounted for in the production of an oral health specialist.

It follows from this that the oral health specialist - that is, the dentist - even when viewed within the context of a total health team, is already "differentiated" when he enters professional school. He already knows what system of the body he will specialize in. If the current trend in medical education continues, the presently "undifferentiated" medical student will also be placed in a position where he too must make a similar choice early in his career.

Thus, it can be seen that there are many factors which come to bear upon our conception of what, how and when subjects like the anatomical sciences should be presented. One thing appears certain, basic science departments can no longer organize and present courses strictly as ends in themselves, especially in professional education where the training of clinicians is of primary concern.

Priorities must be developed after interaction with a wide variety of health science educators and competing priority systems. When it comes to professional education, institutional goals must be given as much, if not more, priority as departmental goals. In any event, some attempt must be made to assimilate the multiplicity of factors which come to bear upon the development of an educational program.

It is within this admittedly very broad frame of reference that we now turn to the question of developing a program in the anatomical sciences for oral health specialists. The use of the word program and not course is an important distinction. A program is a continuum of courses and experiences that lead in a certain general direction. An eclectic program is one in which there is some choice and diversity within the overall structure.

For the purpose of discussion permit us to divide this program into three phases. Phase I may be described as core information for all health professionals, be they "differentiated" or "undifferentiated". It would contain the minimum information necessary to understand the developmental, morphological and functional aspects of the human body and all of its component systems.

This would include many levels of biological organization from the microscopic to the gross. It would be presented so that, as Dr. James Avery suggested in 1965, "major principles and relations should be stressed and they should not be lost in an attempt to teach a voluminous amount of detail".

Central to this course would be a patient - for the student it would be like taking an elementary clerkship in human biology. The essence of gross anatomy would be learned by the students through cadaver prosection, fresh autopsy material and audio-visual techniques. In addition to the student anatomists usual armanentaria of forceps, scissors and scalpels will be the otoscope, laryngoscope, proctoscope, stethoscope, sphygmomanometer and percussion hammer to see, feel and hear living anatomy.

Whether this is taught as a systems approach with all levels of biological organization being demonstrated for each system one at a time or whether by a sequential biological organization approach which encompasses multiple systems at once is not really important. Whatever the approach, the traditionalism in us tends to prefer that the gross level precede, or at least coincide with, the histologic and cytologic levels of organization. However, even this is not all-important. What is important is a clear definition of the content and the manner of presentation.

Such a course, that is Phase I, could be presented and required during the first year of the appropriate professional school or in the terminal year of the baccalaureate program. It may form the core course for <u>all</u> health professionals including, besides physicians and dentists, nurses, nurse-clinicians, physician's assistants and other health care auxiliaries not yet identified. If incorporated into the baccalaureate structure, it could conceivably form the backbone of a specific degree program leading to a B.A. in the Health Sciences or in Human Biology.

Such a course in basic concepts of human form and function would create an educational baseline. From this, many students who, by temperament, lack of intellectual ability or initiative, may be advised, on the basis of their performance in human biology, to pursue a less rigorous professional program. In other words, it may be advisable for them to enter a paraprofessional field rather than the M.D. or D.D.S. program.

Students entering <u>Phase II</u> of the program would possess the working vocabulary and a knowledge and appreciation of basic biological concepts. The objective of Phase II would be to increase and intensify a student's understanding in specific areas of the anatomical sciences which form a portion of the foundation underlying the science of his particular field - in this case dentistry.

What subject areas should be given top priority for dental students may be somewhat debatable. However, the priority system suggested by Dr. Avery seems very reasonable to follow at the present time. His item analysis is fairly extensive but it is useful to demonstrate some portions of it here.

See attached tables.

The main thesis here is that phase II of this program would provide, according to Dr. Avery's classification, "comprehensive, functional knowledge with an adept ability to apply it". Most subject areas requiring only "general interpretive knowledge" or "superficial knowledge" would have been completed in Phase I of the program. The important feature is that Phase II is specifically designed for the students of dentistry, regardless of what sub-specialty of dentistry they ultimately tend towards. This would form much of the dental science core of the dental curriculum and would thus be required of all dental students.

Although it may be presumptuous to suggest changes in medical school education, it seems reasonable to observe that Phase II programs could also be developed individually for several of the large specialty areas of medicine. This would allow medical students to "differentiate" while still in medical school and permit earlier specialty identification - a phenomenon which ultimately comes about anyway but only after much time has elapsed.

LEVELS OF KNOWLEDGE (After Avery - 1965)

Table I

Level	Description of Level
I	Comprehensive, functional knowledge with an adept ability to apply it.
II	General interpretive knowledge with a potential but limited ability to apply it.
III	Superficial knowledge for the purpose of orientation and understanding general principles.

Table II
(Gross Anatomy)

Anatomical Subject	I	II	III
Tissues			
Epithelial	X		
Connective	X		
Nervous	X		
Genitourinary			
Kidney		X	
Bladder		X	
Ureter, Urethra			X
Male Reproductive			X
Female Reproductive			X

Table III

Anatomic Subject	I	II	III
Nervous System			
Central System			
Brain		X	
Spinal Cord		X	
Meninges			X
Peripheral System			
Cranial Nerves			
V and VII	X		
IX, X, XI, XII		X	
Others			X
Spinal Nerves			X

Table IV

Anatomic Subject	I	II	III
Musculoskeletal System			
Muscles			
Head and Neck			
Masticatory	X		
Facial	X		
Others		X	
Spinal			X
Thoracicoabdominal			X
Pelvic			X
Extremities			X

It still remains to be determined how Phase II of the dental student's program is to be presented. Much of this is governed by the clinical courses, the clinical faculty and the departmental organization within the dental school. The teaching effectiveness of the anatomical sciences is very often impaired when it is too far removed from the clinical atmosphere. If this association is not made then the result is that the information presented is premature and the student does not see the vital application of this knowledge to clinical problems. Block or discipline-oriented teaching may indeed be effective if the instructor is able to correlate the functional anatomical material with various clinical entities. However, he often cannot do this. Clinicians can assist this considerably, even then teaching on a traditional departmental basis, if they utilize the basic science information and reinforce the material. More often than not, they cannot do this either.

Because of these failures, many dental schools have developed so-called conjoint courses for the purpose of integrating the basic scientist and the clinician around a common pool of information. Dr. Howard Myers, in 1966, suggested that all dental teaching be organized around the four primary areas that dentists deal with; namely, cariology, periodontology, occlusion, and stomatology. As Dr. Myers advises, "the four areas are taught simultaneously in an integrated fashion, with both science and clinical courses contributing to a sequence of learning experiences of gradually increasing sophistication and complexity". We adhere to this concept but would add a fifth area called "Growth and Development."

It might even be desirable to go one major step further in order to permanently cement the scientific foundation of dentistry to its clinical application. The departmental structures of dental schools may well be reconstituted along lines similar to the five broadly based areas that have just been identified. Untraditional teaching performed through the vehicle of multiple traditional departments often brings chaos, maldirected identity problems for faculty and lack of permanent integration of science and clinical dental practice; not to mention the proliferation of committees, subcommittees, ad hoc committees, task forces, conferences and other activities which detract from and stifle faculty efficiency.

We are under no illusions that schools of dentistry will soon reorganize themselves along, what seems to us, more effective lines in the near future. However, even without this, the development of instructional packages similar to those suggested by Dr. Myers still has merit.

For example, an educational vehicle called "Growth and Development" would utilize the services of anatomists, anthropologists, geneticists, child psychologists, orthodontists, pedodontists, nutritionists, speech pathologists and pediatricians. Special attention would be given to the oral-facial complex of the embryo through adolescence at all levels of biological organization and including prevention and treatment of abnormalities. All subdivisions of anatomy would participate in this program and, in fact, form much of the foundation material.

Similar departments and/or educational packages could be developed for the other four areas mentioned. For example, cariology would need biochemists along with the operative dentists; periodontology would employ microbiologists along with the periodontist; occlusion would need neurophysiologists alongside the prosthodontist and stomatology would utilize radiation biologists along with oral pathologists. The potential in each area is enormous. The anatomical sciences would be represented in each and again would form the foundation upon which the other subject matter is built.

Phase III of this overall program would be strictly elective for the student and he would have several options to choose from. Once again, the anatomical sciences would provide many of these options. Although most elective programs are rightly concentrated at the end of the curriculum, such opportunities should be expanded to encompass the entire educational program. Elective courses should be in-depth experiences and have at least as much academic standing as the required or core courses. Elective courses may be sequentially ordered in such a way so as to provide a minor for each student. Thus, a student would graduate with a major in general dentistry and a minor in an area chosen from multiple options. He would have the breadth of a generalist and yet relative depth in something. It is perhaps unfortunate but nevertheless true that we cannot produce a graduate dentist who has a depth of knowledge in all areas of dentistry and its associated subjects. We can only hope to provide an educational framework that gives a broad view of fundamental principles, an in-depth study of some portion of this spectrum and, more importantly, the environment for student motivation and personal development to allow him to become self-educating throughout his professional career.

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PATHOLOGY: FROM MORBID ANATOMY TO MULTI-FACETED SCIENCE

Howard C. Hopps:

There was a long period during which we could afford to be inefficient in our teaching. There was not a great deal to teach, so the pressure of time was not upon us. That time is past, and this Symposium is evidence of that fact. Today we must think of teaching in the same way that time-motion experts think of certain physical activities. We must make every one of our motions count because, in our limited (contracting) time frame, false motions displace effective ones.

If I am to achieve the objectives that have been set for me, my presentation will have to be separated into three parts, considering first the nature of pathology, per se; second, how pathology fits in with other biomedical disciplines; and third, how pathology should be taught in the context of the total basic science curriculum.

To begin with, what is pathology? Actually, it is two things: [1] a professional/technical complex that functions as an administrative unit with respect to patient care -- performing laboratory analyses and evaluating the results of such analyses toward the goal of specific diagnosis and prognosis of the disease under study. With this approach, the clinical pathologist recognized that many different causes produce essentially similar effects, but he is also aware of and constantly alert to detect those unique characteristics which are the hallmark of a particular etiology.[1] And when we speak of laboratory analyses, we must include the biopsy as well as chemical, bacteriologic, and hematologic studies,etc. [2] Pathology is also that scientific discipline which concerns itself with the causes, the mechanisms of development, and the effects of disease. From this broader viewpoint, pathology differs from clinical medicine (in the conventional sense) in that the pathologist is disease-oriented whereas the clinician is patient-oriented.

One could argue that pathology is not a scientific entity in the true sense. But, even with that point of view, no one would deny that pathology is an enormously important area of correlation, and that it forms an essential bridge between the so-called basic and clinical sciences. Moreover, it is apparent that pathologists as scientists, teachers, and practitioners of medicine have reasonably well defined characteristics that mark them as pathologists. It is this second kind of pathology that I shall focus upon in this Symposium.

The first pathologists were those who looked at the organs and tissues of diseased individuals trying to SEE changes that they could correlate with the disease process. As instruments developed that improved the ability to see things--"extending" vision by magnifying the object under view--pathologists were the ones who used these devices most extensively and to greatest advantage. Such instruments, which used visible light, became more and more effective until they reached the theoretical limit of resolution (0.2μ). Then, as a logical extension in methodology, ultraviolet was substituted for visible light, but this approach was not fruitful. Then, as a somewhat <u>illogical</u> extension, beams of electrons were used, and electron microscopes were developed that increased the limits of resolution more than a hundred-fold, transforming molecular pathology from a dream to a reality.*

Consider our changing concept of the cell, for example. This is only one of many examples that I could use to support my assertion that the prinicple tools of the pathologist are related to <u>looking</u> at things. At the same time this example illustrates the enormous and rapid progress that has been made, even in contemporary biology - and the increasingly difficult task of teaching even the essentials of pathology in the limited time available. During the space of a few years, we have progressed from thinking of a typical mammalian cell as one with an outer membrane, a few miscellaneous bodies in the cytoplasm, such as "vacuoles", and a nucleus and a nucleolus, to our present day concept which recognizes: the cellular membrane as a multilayered, complex lipid-protein structure, many specific organelles within the cytoplasm (including their chemical structure and function), and the essential nature of the nuclear and nucleolar material, along with the role of this material in transmitting genetic information.

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*Comments by Alfred North Whitehead are highly pertinent:

"The reason why we are on a higher imaginative level is not because we have finer imagination, but because we have better instruments. In science, the most important thing that has happened during the last forty years is the advance in instrumental design. This advance is partly due to a few men of genius such as Michelson and the German opticians. It is also due to the progress of technological processes of manufacture, particularly in the region of mettalurgy. The designer has now at his disposal a variety of material of differing physical properties. He can thus depend upon obtaining the material he desires; and it can be ground to the shapes he desires, within very narrow limits of tolerance. These instruments have put thought onto a new level. A fresh instrument serves the same purpose as foreign travel; it shows things in unusual combinations. The gain is more than a mere addition; it is a transformation."

Figure 1 demonstrates this last point quite well. It is a good example of a specimen suitable for quantitative electron microscopy, a revolutionary concept and an enormously important method developed by Dr. Bahr and his colleagues. The figure also shows how much the three dimensional view can contribute, pointing up the great advantages of scanning electron microscopy in allowing us to see more clearly what things are really like. And a technical breakthrough in one area allows exploitation of others. Now that morphologic findings, such as the one shown in Figure 1 can be expressed as precise measurements of mass, through quantitative electron microscopy, it becomes possible to use the methods of information science and computer technology in studying relationships among the multiple components (multi-factorial analysis) that reflect disease at a subcellular level. This important approach is also being exploited by Dr. Bahr and his colleagues through TICAS, an acronym for Taxomonic Intracellular Analysis System, by which means it is possible to define cells critically on the basis of their size and shape, and the arrangement and density of their internal structures. With further development, it is expected that such a system will allow for automated exfoliative cytologic diagnosis of cancer, and provide also for many other important applications. If "to measure is to know", we are certainly coming to the point where the morphologic approach can contribute very much more precise information than it has in the past. Morphology is not the only concern of pathologists, however. If I may quote from my own work:[2]

> "In the approach to disease through pathology, there is emphasis on structure, but this is not meant to distract from the importance of chemical composition and function. If we look closely enough, and in the right way, we can see that, often, structure is an expression of altered chemical composition and that dysfunction is an inevitable consequence. The three things, structure, composition, and function, are inseparably related."

> "When form can be translated into terms of function,
> or states of being into terms of force,
> we are near the cutting edge of the
> scimitar of science."--Alan Gregg

But with all of our enthusiasm for electron microscopy and the many other wonderful new methods of scientific inquiry, we must remember that the new or advanced does not usually replace the old or elementary. Ordinarily the new supplements and/or complements the old. Methods of calculus have not replaced simple multiplication and division; symbolic logic has not replaced arithmetic; and molecular biology has not replaced that biology which is concerned -- in decreasing order of importance -- with the individual, the organ, the tissue, the cell, and the organelle. In fact, the undue emphasis on molecular biology, which is currently fashionable, has clearly demonstrated the importance of the total system approach in the biomedical sciences.

Turning now to: How pathology fits with other biomedical disciplines, each discipline has a dual responsibility: first, to present information in such a way that it can serve as a foundation upon which other subjects can build; second, to provide a framework so that the student who develops a specialized interest can readily go on to learn more about that particular discipline. Using an analogy drawn from agriculture, we can relate the foundation to a root structure and the framework to a trunk and its major limbs. As an aside, it is important not to equip each of the limbs with twigs and leaves -- and this is true for all basic sciences. These fine structures do not last; they are lost each year and each year replaced by a new crop. Such detailed information as is represented by the leaves of the tree the student must learn for himself -- not, however, until the time has come when he will actually use this detailed information in the course of his daily work. But more about this later, in connection with how pathology should be taught.

Certainly the more correlation among all the basic sciences (clinical ones, too) the better for the student. But it has to be a true, natural correlation -- a very difficult task. This approach to teaching is in high fashion today, and is widely used, but not very well. To be really effective, such a method requires an enormous expenditure of time and energy on the part of the (selected) teachers, who must work hard individually as well as together, if they are to understand each other's points of view, and to develop the perspective that comes only after learning a great deal about what specific information each of the other specialties can contribute. Only those individuals who have overcome the restrictions imposed by "loyalty" to their own discipline are likely to be successful. Unfortunately, there are very few places where teachers are sufficiently motivated (encouraged) and, at the same time, provided the necessary time and energy for this kind of teaching. Merely bringing together teachers from different departments periodically for a "correlation clinic" is not enough. As a matter of fact, such grossly inadequate efforts may cause correlative teaching to fall into disrepute on the basis of: "We tried it, but it did not work."

The problem of effectively teaching pathology in the context of the total system complex is, in principle, the same as for every other discipline/area, and this brings me to the third part of my presentation: How pathology should be taught. It is largely a question of ends and means: define the end and use appropriate means to achieve it. The rub comes because we have been unable to define the end, save in such general terms that there is no handle one can grasp. At the University of Missouri School of Medicine, just a month before this Symposium, we had a valuable day-long Spring Faculty Forum to consider what and how to teach our students--and when, in the context of the curriculum. Among other things, it was decided that our goals included the following: [1] The student should learn the principles of medical science and the scientific method; he should have a thorough understanding of the interrelationships between the basic and clinical sciences; and he should be able to apply this information and understanding to medical practice. [2] The student should master the fundamental medical skills and techniques upon which his subsequent professional education will depend. [3] The student should demonstrate that he has assumed the professional responsibility for acquiring information, skills, and attitudes independent of formal teaching programs. There were three additional goals, but the ones I have given will suffice. I do not see any rational basis for objecting to these goals. Similarly, I do not see how anyone could object to such goals as: we should all love one another; was is bad and should be abolished; etc., etc. But achieving goals such as these is something else.

How do we become more explicit in defining our goals? How can we measure our product with respect to the goals that we have set? Often we establish quite artificial standards, then test against these. If our students do well on the Snivleivitz Comprehensive National Proficiency Examination--fine. Is it? The examination questions are made up by a group of persons, none of whom has any better grasp on the real problem than many of us here--and a collection of ignorant persons does not make a wise group. It hardly seems necessary for me to tell you that I, too, am searching for answers to these vital questions. But I do not mean to be pessimistic. It is not required that we have the complete and final answers to make headway in our teaching, continually moving in the general direction (at least) of our ill-defined goals.

There are two principal ways to teach effectively:

(1) Consider first particular examples, and then determine how these can be collated and correlated to reflect the general case, i.e., the general principle;
(2) Consider first the general case, and then illustrate it with particular examples.

Both methods are useful, but neither the particular nor the general can stand alone. Both approaches tell it like it is, but with the second approach, an account of the particular comes after the student is prepared to recognize how it fits into the big picture, so to speak. I am a firm believer in emphasizing principles, but using highly specific examples to bridge the gap between basic and applied. In this way one can make it clearly evident that the principles are true, and significant, and pertinent. Each teacher of pathology has a somewhat different idea as to how this can best be done. Rather than spend the time to describe specifically the way I approach principles, I would refer you to the table of contents in Principles and Pathology.[2]

Many seminars and conferences have concentrated on particular methods of teaching, often trying to identify the best way. This is a fallacious concept. There is not a particular best way to teach students because both teachers and students are so variable. Some teachers are master lecturers and can capture the (collective) mind of their audience. The very same teacher may be poor in small group sessions--and vice versa. It is wrong to force round pegs into square holes. Good teachers should be allowed very considerable latitude in their approach to communicating with the student,[3] even if the course format has to be stretched a bit; the means should be made appropriate to the end. Full student access to a group of teachers, each of whom uses a different kind of approach, is probably the best overall mechanism, because this allows the individual student to match the wave length of his receiver, so to speak, with that of a suitable transmitter. Moreover, variation within the group of teachers will assure that a variety of teaching modes are used, one or the other of which will appeal to the student who learns best from visual OR auditory OR proprioceptive input--OR any combination of the three.

Turning from the general to the specific, in teaching pathology (anatomy, too) there is a particular problem that is both important and difficult. That is to help the student bridge the mental gap between what he sees by direct inspection of an organ or tissue (reflected light) and what he sees by looking at a plane section of the same organ or tissue through the microscope (transmitted light). Unfortunately, many teachers of pathology do not recognize this as a serious problem, and their neglect of it contributes to the fact that a majority (?) of dental and medical students never really connect these two ways of looking at things--to their serious detriment. This is one of the problems I have concentrated on in teaching, but rather than take the time for a detailed discussion, I refer you to two articles that describe a way of solving this problem.[4,5]

Since there are more important things to teach than there is time for, selection is critically important. And this requires that we discriminate among the many areas of knowledge, to say nothing of the individual facts. Some of the areas are at the stage where data are rapidly accumulating --but their significance is not quite clear. These areas do need to be presented, but not in detail. The objective is to identify them as rapidly expanding fields in which the important answers are not quite evident as yet, but soon will be--and to identify current hypotheses briefly, in this way alerting the student as to important advances that are soon to come. Other sci .tific areas are at the stage where the data are being correlated and integrated to yield solid information. These areas are the ones that require major teaching time. In pathology, areas in the latter category include inflammation, immunity/hypersensitivity, and genetics. The complex etiology and pathogenesis of many diseases that fall within these areas are much clearer to us now. Areas that are in category one--where data are rapidly accumulating, but not yet converted to solid information--include cancer (with respect to cause) and most of the so-called degenerative diseases.

How a student learns is as important as what he learns. He should be motivated to explore new areas independently, applying what he was taught (by others) to what he can learn (by himself). We should teach in such a way that the student develops a constructively critical point of view and the ability of effective inquiry. Since authority is no longer an acceptable basis of or motivation for learning, the student must be convinced of the truth of what his teacher is trying to put across--also its significance and its pertinence. The only good way to demonstrate pertinence (so far as I know) is to present information in the context of the kinds of problems that the student knows that he is certain to meet. Before the teacher presents material to the student, he (the teacher) should make certain that:

(1) its information content is large
(2) much of it is suitable for immediate utilization
(3) a considerable portion will (hopefully) become residual knowledge

Time is a fourth dimension in teaching as well as in physics. We know, intellectually, that education must be a continuing process if it is to be effective in the long run. But many who plan programs of continuing education (a euphemism for self-teaching) are schizophrenic in that they dissociate post-doctoral learning from pre-doctoral education. They ignore the fact that if we teach correctly in medical and dental and veterinary schools, instilling the motivation for continual learning, there will be no difficult transition; "continuing education" will follow naturally. As it is, we tempt the practicioner with closed system television, etc.,-- but the majority of those to whem we are speaking are not listening.

Let me conclude my remarks by presenting several statements that bear directly on the ends and means of effective teaching. As you will see, several of these are quotations from the works of others. They have been very helpful to me; perhaps they will also help you.

"The justification for a university is that it preserves the connection between knowledge and the zest of life, by uniting the young and the old in the imaginative consideration of learning. The university imparts information, but it imparts it imaginatively. At least, this is the function which it should perform for society. A university which fails in this respect has no reason for existence. This atmosphere of excitement, arising from imaginative consideration, transforms knowledge. A fact is no longer a bare fact: it is invested with all its possibilities. It is no longer a burden on the memory: it is energising as the poet of our dreams, and as the architect of our purposes."

--Alfred North Whitehead
(The Aims of Education)

"The purpose of elementary and higher education is not to make of the youth a truly wise man, but to equip his mind with an ordered knowledge which will enable him to advance toward wisdom in his manhood."

--Jacques Maritain
(Education at the Corssroads)

Is the Student a Vessel or a Lamp to Light? This question is aptly phrased because, pursuing the metaphor further, it is obvious that if the lamp hasn't been filled, it won't burn. We've been confused too long by the either/or point of view. Ideally, a student is taught principles and stimulated to build from these. Alfred North Whitehead put it beautifully saying: "The only avenue towards wisdom is by freedom in the presence of knowledge. But the only avenue towards knowledge is by discipline in the acquir .t of ordered fact. Freedom and discipline are the two essentials of education."--H.C.H.

"Probably the most impressive indictment that can be made of our educational system is that it provides the student with answers, but is poorly designed to provide him with skill in the asking of questions that are effectively directive of inquiry and evaluation. It teaches the student to 'make up his mind', ready or not, but it does not teach him how to change it effectively."

--Wendel. Johnson
(People in Quandries)

Bertrand Russell was thinking along similar lines when he said: "So long as men are not trained to withhold judgment in the absence of evidence, they will be led astray by cocksure prophets, and it is likely that their leaders will be either ignorant fanatics or dishonest charlatans. To endure uncertainty is difficult, but so are most of the other virtues."

(Unpopular Essays)

But withholding judgment must not be overdone. "...to raise clever doubts, to prefer searching to finding, and perpetually to pose problems without ever solving them are the great enemies of education."

--Jacques Maritain
(Education at the Crossroads)

To teach effectively is to do two things:

(1) to lead in the right direction (guide might be a better term)
(2) to inspire to learn--and to continue to learn

--H.C.H.

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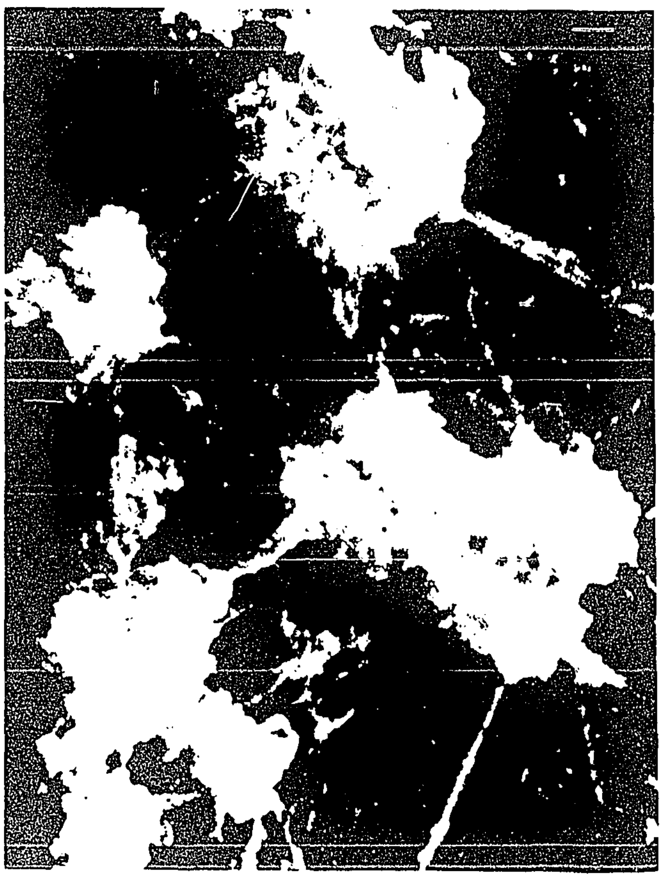
The following reference, though somewhat old, is by no means out of date. It is one of the most effectively critical considerations of medical education that I have seen. The majority of the comments are just as applicable to dental education.

7. The Training of a Doctor. Report of the Medical Curriculum Committee of the British Medical Association. London: Butterworth & Co. (Publishers), Ltd., 1948, 151 p.

LEGEND FOR FIGURE

Figure 1 This is a scanning electron micrograph of an intact metaphase plate derived from a human (cultured) lymphocyte. As can be seen, the human chromosomes are made up of tangled fibers, somewhat resembling a skein of yarn. Note the interconnections among them (which consist of approximately 15% DNA, and protein), the significance of which is not yet known. Such fibers have been suggested by classical cytologists, but were visualized for the first time by Drs. Golomb and Bahr[6] just a few months ago. I am indebted to Dr. Bahr for this scanning electron micrograph. (The chromosome in the middle of the field, to the left, is approximately three microns long.)



BIOCHEMISTRY; ON RECOGNIZING THE UNITY OF NATURAL SCIENCES

Howard M. Myers:

Anyone who has had the experience of teaching Biochemistry in a School of Dentistry has likely been confronted with the questions: What to teach? and why is it being taught? These same two questions, however, are really not distinct ones. They are so inter-related that they may be treated as parts of a single question; the answer to one being a part of the answer to the other. It should not be necessary with an audience such as this, to discuss the importance of Biochemistry in all aspects of current biological sciences. The answer to the question posed above is that biochemistry is taught both for itself and because it provides a background for virtually every other science in the biological arena. Thus far, agreement is easy for us. However, when students or practicing dentists are interviewed, a somewhat different reaction is obtained. This often takes the form of the question, "Why should I want to know about protein structure, enzyme kinetics or thermodynamics?" Traditionally, biochemists have answered such questions by saying that these were fundamental concepts necessary in the intellectual preparation of a health science worker because they provide building blocks for the understanding of biochemistry and the sciences based on it. However, we are dealing with an audience which often is unwilling to accept this answer as having any validity for itself. The demands for relevance, while at times excessive, do require some response on our part. We must answer them by showing the dental student and subsequent dentist, that biochemistry can have a meaningful bearing on what he sees, what he believes and what he can tell his patient in practice. Unfortunately, a lot of biochemistry has been taught without the effort to use relevancy in motivating dental students. It is my opinion that a great deal more pertinence can be introduced into the dental curriculum than is commonly done. The reason for this is the fact that biochemistry is taught by people who are primarily trained in the discipline of biochemistry. The motivation of these individuals to read dental literature or to try to relate articles in the biochemical literature to dental questions, is poor. There is no need to go into the reason for this or to assign guilt in this matter, but it should suffice to say that some of the student complaints about biochemistry have validity. The student often does not understand why he is studying biochemistry because he does not see its relationship to dentistry. I propose, in this paper, to present some of the fundamental ideas of biochemistry which can be related to topics that are of concern to dentists. Before doing so, It is necessary to point out that freshmen dental students not only do not know biochemistry, but also do not know much about dentistry. It becomes necessary therefore, in teaching biochemistry, to introduce certain ideas about dentistry at the same time. This is where the two parts of that question become one. This has been my experience in teaching biochemistry in a dental school for over a decade. The plan of this presentation will be to identify certain broad concepts in biochemistry and to show examples that have pertinence to dentistry which can be used while discussing these concepts.

Most courses in biochemistry begin with either physical chemistry, proteins or enzymes. I have chosen to begin my course by discussing energetics of metabolism. The course has three major areas: The first of which is the derivation of energy from fuels and foodstuffs; the second is the utilization of the special forms of energy, in biochemical events; and the third is the maintenance of control of the various reactions and pathways to maintain homeostasis in the whole organism. Very much the same type of organization is present in Lehningers new textbook which we have used successfully during the past year. My task was to introduce the dental considerations to these topics as they arose. Since everyone has his own particular organization of the subject of biochemistry, I will not attempt to discuss my particular outline or to fit things together in exactly the way they are sequenced in our course. Instead, I will attempt to identify some of the broad concepts which would be present in any biochemistry course and to give illustrations of how these broad concepts can oe related to dentistry.

II. MACROMOLECULES

The first idea in biochemistry which has much dental application is the concept of the macromolecule. Here we are dealing with proteins, carbohydrates and combinations, each with several levels of complexity. Enzymes can be described according to their general conformations with particular emphasis on their active sites. Other proteins can be considered from the point of view of their architectural arrangement and an excellent example of this is collagen. The subject of collagen structure and metabolism is an important one in dentistry; a slight digression to freshman dental students to explain the importance of collagen in the supporting apparatus of the tooth is a justifiable effort. This subject lends itself well to a discussion of the primary, second, tertiary and quaternary features of proteins. (1,2) The factors which govern collagen synthesis, its unique features and the factors which govern its breakdown, can be easily identified with periodontal disease. (3,4)

Other macromolecules include heteropolysaccharides such as the condroitin sulphates and hyaluronic acid. Here too, the importance of these substances in connective tissues should be emphasized, their structure given, their biosynthesis discussed, and even their breakdown related to the problems encountered in oral disease. (5,6)

Since carbohydrates and proteins are being discussed, it can be mentioned that glycoproteins are still another area of importance to dentists. The viscosity of saliva is due to certain glycoproteins, and much information has been obtained about the nature of these molecules. (7) A conceptual grasp of the proposed structure of glycoproteins can be of value even as new material is added to this field day.

In the area of homopolysaccharides, glycogen is of some importance. There is in dentistry, however, an excellent example in the form of dextrans and levans, for discussions of macromolecules made up of a single carbohydrate unit. Here too, the role of the dextrans and levans in plaque, their formation, their possible fate, can all be included in such a discussion. (8) Of considerable importance, in my view, is the unique role played by sucrose in serving as a precursor for dextran and levan synthesis. Here is an excellent example of the importance of the concept of free energy and its meaning in a specific biological situation. Comparisons of free energies of a variety of disaccharides can be made, and the unique role of sucrose in having sufficient enery to allow the glycosyl transferase activity to occur, can be illustrated entirely with concepts of interest to dentistry. (9)

Another important area of macromolecular structure has general validity extending to denstistry: The structure of the bacterial cell wall. Here, the role of antibiotics and their ability to prevent the growth and multiplication of bacteria, by blocking the synthesis of the complex structures of the cell wall can be shown.

In the area of protein structure, the fibrous nature of keratin and its possible molecular architecture, can be included along with keratinizing tissues and lesions found in the oral cavity. Relating to this as well, is a discussion of the protein matrix of enamel, both as the fetal and adult form. (10)

III. ENZYMES

In the field of enzymes, there are several worthwhile topics which can be mentioned which have dental application. The first of these, a fairly obvious one, is inhibition of enzymes by fluoride. (11,12,13,14) The possible importance of fluoride as an enzyme inhibitor and the particular ways in which fluoride is thought to inhibit enzymes may serve as an excellent example of the active site necessary for enzymatic activity. The action of fluoride in enolase and phosphoglucomutase are particularly helpful in understanding the type of complex formed between substrate, enzyme, activator and inhibitor. (15)

Not to be overlooked is the growing body of evidence demonstrating the isozyme patterns of various dental tissues. (16) The isozymes of lactic dehydrongenase in dental pulp has been recently elucidated, and implications concerning this and the pulp's ability to withstand anaerobic conditions for some period of time can be illustrated. Some indication of the sort of procedures that are performed on dental pulps could be included at this point, so that the freshman student had an understanding of why possible anaerobic conditions might be produced under certain circumstances.

The enzymatic potential of microorganisms is also a subject of dental interest; not only those organisms associated with the breakdown of soft tissues of the mouth can also be mentioned here. The obvious relationship of glycolysis to dental caries is usually not overlooked in most dental biochemistry courses, but it should be pointed out that a fairly significant body of information now exists concerning specific organisms and enzymes as they pertain to the overall process of glycolysis. (17,18) The same is true of plaque organisms and the biosynthesis of components of dental plaque. (19) There, too, the freshman dental student may have a poor understanding of microbiology, and a brief digression may be necessary in order to clarify for him the importance of enzymatic activity produced by oral bacteria. It would also be an excellent time to emphasize differences in pathways of bacterial metabolism from that of mammalian. Dextran synthesis from sucrose is an excellent example of this, along with the more conventional ones pertaining to folic acid and bacterial cell wall synthesis.

Since enzyme synthesis is intimately related to genetics, several examples of inherited molecular disease can be profitably exploited. The possible role of a deficiency of catalase can be cited. (20) In addition to that, the hereditary disaccharide intolerance conditions have a particularly pertinent application to dentistry. Individuals who have learned to avoid sucrose in their diets because of this hereditary condition, invariably have teeth which are completely free of deay. This fact can be cited in support of the contention that sucrose is specifically involved in the plaque development that leads to caries and destruction of the teeth. (9)

Recent findings of dental implications of phenylketonuria may also be used to illustrate genetic and enzyme relationships in dentistry. The high incidence of enamel defects found in PKU cases is one example (21); a second is the much higher degree of protection found after systemic fluoride in PKU cases compared to their normal siblings. (22)

Also to be included in hypophophatasia which has been shown to produce premature exfoliation of deciduous anterior teeth of individuals having this condition. (23)

IV. INORGANIC CHEMISTRY

Among the topics of inorganic chemistry that pertain to biochemistry, there should be mention of the importance of buffering especially in saliva. A classification of individuals with high and low buffering capacities, and high and low flow rates, has been used as an index of caries susceptibility. (24) Also, salivary secretion of the various components of saliva are excellent examples to be used in discussing the transport of ions and protein secretion across the cell membranes. Recent work in this general field of transport also includes the coupling of phosphate uptake by bacteria and protein secretion leading to acidification of the medium. (27) Here is an area of importance to dentistry which illustrates general biochemical principles in a particularly meaningful manner.

Some segment of the course should include the structure of hydroxyapatite, its chemistry and the role of fluoride in influencing its stability. The so-called "void theory" of Young can be used to explain the action of relatively small amounts of fluoride on the physical and chemical properties of apatite. (28)

Dentistry has an abiding interest in the mineralization process, a topic which offers discussion of phosphate and calcium transport and the enzymatic processes which may be involved. There is recent evidence to suggest that inhibitors of mineralization may play an important role in this phenomenon. (29) Much research in this area has been done in the field of dental enamel, which in turn, has a bearing on the general phenomenon of mineralization. (30) A highly relevant area in the general topic of mineralization is the formation of dental calculus and the mineralization of dental plaque. While this topic has less general validity than some of the others, it is of great enough importance to justify a digression to cover it. The nature of the mineral salts found in dental calculus differs to some extent from those found in skeletal tissue elsewhere in the body. The chemical nature of the mineral phases can be related to the age and process of formation of each of them. (31,32)

It is traditional for dental biochemistry courses to cover in some detail the fields of calcium in phosphorus metabolism. Vitamin D, parathyroid hormone, and calcitonin are usually added to the course for this purpose. Often overlooked is the fact that these topics offer at the present time a sufficient body of information to illustrate many general principles of biochemistry. The role of amino acid sequence in having biological activity and specificity can be derived from a consideration of calcitonin and parathyroid hormone. (33) The role of steroids as promoters of RNA and protein synthesis can be illustrated by using the example of Vitamin D. (34,35)

Mention should be made of the importance of lysosomal enzymes, both in the process of bone resorption and of soft tissue breakdown. (36) Some evidence exists that the proteins present in the fluid which emerges from the gingival sulcus may be of hematogenous origin. (37) This is an important biochemical concept for a dentist to retain.

Sufficient study has been made of the protein synthetic and secretory apparatus of salivary glands to justify using this material in the teaching of protein synthesis and selective transport. Much of the work dealing with pancreatic protein synthesis and secretion has been shown to apply to the salivary gland system. By utilizing examples from these oral tissues and relating their functions to the biochemical events, the topic can be given a greater relevancy than it will have if it is taught as a part of generalized biology.

The thrust of the above examples has been to show that there is a sufficient body of information which can be incorporated into a general biochemistry course to make it more dentally relevant. However, the mere mention of such things as connective tissue, plaque, dental calculus, etc., will not be sufficient to motivate freshman dental students to understand the implications of biochemistry in dentistry. Most first year dental students have too weak a concept of the nature of dental disease to be able to assimilate this material quickly and easily. An important educational concept is learning readiness, it refers to the fact that a <u>prepared</u> mind readily absorbs and digests information which is given to it. It is important to realize that a student who has never considered how dental calculus may be related to periodontal disease; how connective tissues are involved in periodontal disease; how plaque may be related to dental caries, will not be able immediately to understand why he is studying certain subjects. It is necessary for the teacher to allow the student to develop the learning readiness necessary to utilize the material he is giving. It would be a crime, indeed, if the examples from dentistry were not absorbed because of this failing. To accomplish this requires some effort on the part of the instructor to explain, clearly, the relative importance of keratin, collagen, etc., as the biochemistry of it is discussed. Many biochemists who are not dentists are somewhat reluctant to attempt this. If this is the case, invited guests should be brought in for portions of a lecture in order to explain the relative significance of this. One biochemist has led a panel discussion at the beginning of his course. The participants were dentists engaged in graduate work. Suffice it to say that the mere mention of names and words will not sufficiently prepare students to learn what is being given. More than a cursory presentation of this material is necessary. For too long, we have assumed that students are capable of absorbing factual information and that eventually they will learn to place it in a correct context. Educationally, this is very unsound, and it rarely works. It is far better to give the context, and then give the facts. It is hoped that this review of the topics and of how they can be incorporated into dental biochemistry will be of aid to those who have despaired of ever teaching the subject to a dental class. It is the experience of the speaker that biochemistry can be made into a meaningful and exciting class in a dental school if the above observations are kept always in mind.

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DISCUSSIONS - SESSION II

Dr. Avery: By no means in the short period of time available can we cover all of the thoughts and questions that each of you are concerned with in these particular basic science areas. I made a few brief notes which you will probably comment on concerning relevancy and making subjects exciting and on the various aspects that we might emphasize. So let us proceed to the first question.

Question: There is concern in the classical basic sciences about a possibility for loss of identity in a dental curriculum where basic sciences are taught as a core. I think the important part is that last aspect. Would you feel there is a loss of identity in a curriculum where basic sciences are taught as a core? This one is for Dr. Hopps.

Dr. Hopps: I think not, but it might be a good thing if there were. In my present post at the University of Missouri one of the things that I have been trying to do is to bring people together from rather widely different disciplines to focus their energies and use some of their data base in studies of health and disease. When I began with this I naively called it an interdisciplinary approach; now I speak of it as a multidisciplinary approach. Most scientists are so tied to thier disciplines, emotionally as well as scientifically, that it is virtually impossible for them not to protect the identity of that discipline. The core approach is a good way to avoid the things that so often happen with conventional methods - the pathologist works hard during the time he has a captive audience to make pathologists out of the group, as does the microbiologist to make microbiologists, the pharmacologist to make pharmacologists, and so forth. That is an opinion obviously.

Question: Would not the aspects and importance of biochemistry be better appreciated if these were taught in an integrated fashion with anatomy and physiology? If yes, why is this not done? If no, why not? Should biochemistry be covered by a predental course is another question which we will take up later.

Dr. Myers: The idea of an integrated biochemistry, physiology, pharmacology and perhaps anatomy too of course has been heard of again and again and I could argue either way on this. I have found that our problem is that in many schools the people who teach biochemistry, physiology or pharmacology are not dentists, but are primarily scholars in those disciplines. This may be changing around the country but in many cases still is that way and will undoubtedly remain that way for some period of time. Now if we dissolve the physiology and pharmacology courses in dental school and make them Oral Biology, we no longer identify physiology and pharmacology, and these people feel very insecure. This does not shock too much a person who is also a dentist because he still has an identity.

I think this can be gotten around however, simply by not dissolving but rearranging the schedule so that we teach these subjects concurrently. We plan what is going to be the integrated idea and the schedule each of these different sciences at the appropriate time. It can be done without dissolving departments. Under such conditions I would be very much in favor of it. I do not know why it is not done except that it is very difficult to get people together on things like this; they would rather just take last year's syllabus and use it again.

Dr. Avery: While we are formulating questions I see a hand over here, Dr. Jacobs, University of Iowa has a thought.

Dr. Jacobs: The theme of our symposium is Contemporary Biology in Dental Curriculum and I certainly don't think that anyone would question the role of contemporary biology in dental education and its importance in the primary prevention of dental disease. This morning, Dr. Pruzansky pointed to the fact that the eventual control of dental caries was going to change the very nature of dental practice; it is quite obvious that such developments will not have been possible, if the advances of contemporary biology had been ignored by Dentistry. However, despite the undisputable importance of contemporary biology, questions have been legitimately raised today as to how much biology should actually be offered in the dental curriculum.

If I understand Dr. Myers' earlier comments correctly, he feels that the fact that the contemporary biology is very exciting justifies by itself a generous offering of such subjects as biochemistry in the dental curriculum. Though no one would disagree with the fact that biology is indeed exciting—so is music; I, for myself, would love to see sensitivity for good music flourishing among our students. I also would like our students to understand the social, economic and political structure of our government and our society; this is also very exciting and our students don't seem to know very much about it. The fact is, however, that the taxpayers may not wish to subsidize the process of general intellectual and cultural maturation of the future "doctors", if it is not truly relevant to their basic professional competence. We seem to be talking these days about the cost effectiveness and the shortening of professional curricula and for that reason, I believe, we must apply rigorous criteria for developing our educational objectives and content, so that the knowledge and skills that our students acquire are truly relevant to their health care delivery capability.

I would like to refer very briefly to the slide shown to us by Dr. Walker earlier today; that slide dealt with "Information Content and Utilization". It seems to me that we do not pay sufficient attention to the "utilization" of the information acquired by the students in professional colleges. How do we measure the utilization of basic sciences after graduation from dental school? How effectively and how extensively do the practicing dentists utilize their knowledge of pathology, biochemistry and other biologic disciplines? Recently I picked up a copy of the Journal of the American Dental Association which contained data about the number of continuing education courses offered throughout the United States between February and May, 1971. During that period, 747 continuing education courses were attended by dental practitioners but only two of those could be classified as basic science courses; more specifically, these were head-and-neck dissection courses given at the University of Loyola and at the Medical college of Virginia. Quite obviously, there has been no great demand for continuing education in the field of biochemistry, pathology, neuroanatomy, pharmacology or microbiology among dental practitioners, and I don't think that we can afford to ignore that fact. Furthermore, we should not ignore the fact that at the time of graduation our students remember only a very small fraction of the basic science material acquired during the first two years of dental school. It seems to me that this suggests that the contemporary biology, as it is taught today, is not funcionally related to the tasks associated with the contemporary dental practice.

Dr. Hopps: Let me make one comment on this. If the content of the refresher courses that you were talking about was examined carefully, you would probably find that there was a significant amount of basic science, but directly related to clinical problems. Obviously, this is an excellent way to teach basic sciences—in the context of the real life problems that the people are involved with. The reason that we do not teach basic science in that context to a fuller extent in dental and medical schools is because of the chicken and the egg phenomenon. One has to start somewhere and we have chosen to start with the basic sciences. Perhaps we should consider teaching clinical aspects for the first two years, then do the basic sciences. This is possible.

Dr. Myers: I would like to comment on what Dr. Jacobs said. I do not think it is quite the same thing to compare the study of music with the study of biological science; you are extrapolating too far. It is certainly not only because it is exciting and interesting that we are teaching basic sciences. I have said that biochemistry is the most exciting part of biological science and by not teaching it well we are missing the opportunity to make such science exciting. I did not say that because it is exciting we have to teach it. The other point about the interest in basic sciences - continuing education is one measure, certainly of people's interest. However you do not find very many basic science courses offered in medicine or in any other areas either. They usually are present as Dr. Hopps indicated, as a content in other courses.

There are a few other things too that I think are important in terms of utilization. It is not just what a man does with his hands that counts. One has to give a lot of advice as a dentist, to talk and explain things to people. One has to think about things a little before giving advice and also to have some idea of what expectations there are when dealing with a case. All of these things are a part of the understanding of science.

One of the things that is lacking in dentistry and so much reflects the inadequacy of our basic science instruction is curiosity. How many interesting cases are passed by in a dental office that could have been worked up, and put into the literature. Such a case history might have led to something exciting as it often does in medicine, where many of the advances have been made because of clinicians' astute observations. My argument on utilization is that there is plenty of opportunity for it. If you say that dentistry as it exists right now is all that we are ever going to have, then I guess you would be right. I cannot quite accept that premise. I cannot live with it and I consider it is my job to try to disprove it. This lack of curiosity, this lack of interest in case histories and inability to see the ramifications of a single case in what I think is missing far too often in dentistry.

Question: Do you think that exposing the freshman dental students to clinical problems will help him to better understand the basic sciences and better relate them to the clinical dentistry and eventually to their functional practice. If yes, why don't we all implement this in the dental curriculum?

Dr. Unidentified: Let me comment that from the general point of view that if you do this, e.g. relating basic sciences to the problem, if the context becomes clearer to the student this is a great thing. If the relationship is such that the student decides he can hardly wait to get through this anatomy stuff before he can get to where the action is, then it is a bad thing. It is in the way it is approached. I believe very strongly that the goal is to present this thing in context than in this connection. Dr. Myers, I must say that the fact that biochemistry is exciting to you has got through to me and I was excited by your presentation. I would have liked to have had the course of biochemistry by you rather than the person who taught it who was not very exciting or excited about it. Thank you very much.

In fact one of the questions here is - aren't the talents of the teachers as important as a unique course. Should there not be more emphasis on the art of teaching? I think I tried to state before the method of teaching is very important. I think we saw an example in Dr. Myer's presentation. I would like to go back and take a biochemistry course now. I think the manner and presentation is very important. In that respect maybe we should think about the nature of Ph.D. graduate programs or maybe we should think of developing other types of degrees in which teaching ability is part of the overall training of people in higher education. I do not mean by that, that research ability is to be placed in a secondary place. It definitely should not be. I think teaching ability is important in the students' comprehension and motivation towards learning the material.

Dr. Avery: It seems we have talked a great deal about motivation this afternoon. We suggested making the subject relevant. We talked about making the subject exciting and many other ways. If we are not making the information relevant, then we may lose a valuable asset in retention. Dr. Myers, you have a question?

Dr. Myers: I have 4 questions that are all pertaining to content of biochemistry courses. One of them is "Are structural formulas adequate to communicate biochemical ideas-or whether you have a better method?" I do not have a better method, but I think how I handle structural formulas is important. I do not ask students to memorize structural formulas. I am interested primarily in their ability to recognize that a particular component part of the molecule is what reacts whether it be an aldehyde, a hydroxyl, amino group or some other portion of the molecule. What I do in my biochemistry course is to ask them to recognize the molecule, if I were to draw the formula. There is a difference between recognition and ability to reproduce the formula. If students recognize the molecule, and its active portion, I am satisfied that they have enough of an understanding of it. So far I have found that this works quite well. Students think this is reasonable and accept it. I have not had too much difficulty with this aspect of biochemistry.

Fortunately, the National Board, which is the next question, does not ask to reproduce structures. The questions require recognition once in a while, but that is all.

The next question was do I think my students would have difficulty with the current National Board if I taught Biochemistry as I stated. Well, I don't really teach it just exactly the way it was presented here. That was a pretty fast survey of biochemistry. Our students do pass the National Board, that is all I will say about it. We make some efforts to try to get our students through the National Board, but we are concerned about the subject matter of the boards. I personally have written a paper about the Boards, criticizing them for content. Newbrun and I feel that the present content does not really bring modern biochemistry into the examination. It is changing and it is improving.

Once we get across the concepts we still have to cover the detail. We haven't gone into the structure of membranes, we haven't gone into any of those details. This has to be done of course. It is necessary to have some of the details to strengthen the concept you are talking about. My point was to try to put the detail into context, the context of form and function which I think makes it more understandable and enjoyable.

The next question is, how much basic information must the student be provided with before he can be taught dental aspects of biochemistry. Well, that is a hard one and I am not sure what that is myself. I can only say that I started teaching biochemistry in a new sequence a couple of years ago. I began by talking about respiration and mitochondria, oxidation first and then phosphorylation. Some of the biochemists in my school said I could not do it. First I had to talk about enzymes, but before that I had to instruct them about proteins. Before I could talk about proteins, I had to talk about titrating proteins, and amino acids. Before that came buffers,. All I can say is what they told me sounded very good, but was not necessary. We can get across some of these things with a few phrases, get to the meat of it, and then come back to it later.

I think what your question implies is that we must provide a certain basic underpinning of essential information-like what is a buffer, what does a buffer curve look like, and what is a protein before you can talk about what a protein does. I am sorry, but I do not agree with that. I think you can discuss what a protein does, by talking about it as a catalyst without very much mention about its structure. We do indicate that it has a conformation or structure which we will come back to. In other words, we can work the main ideas in without having the piecemeal, lock-step kind of approach that biochemistry books generally follow. I find that dental students today are entering with far more knowledge of biochemistry, called by another name, than they ever had before. Approximately 30 out of our 75 incoming students have had a general course in biochemistry. This may not be quite the same as it is elsewhere but I think it is a general pattern. If you will pursue this in more detail you will find that they have covered the Kreb's cycle, protein synthesis, DNA (even in high school) and the nitrogen cycle. Many of them may have had the topics which are traditionally a part of metabolism in the overall subject of biochemistry. I can only plead that I cannot identify a single block of information that has to be produced first. You have to play it by ear. But there is much more knowledge of biochemistry there than we are led to realize. Students get it in cell biology, cell physiology, or even general biology.

There is one last question - no mention has been made of the essential aspects of nutrition in the dental curriculum. How do you see this fitting into teaching programs in biochemistry? Whose responsibility is it? I do not know, I do not have the responsibility for nutrition. I really do not quite know how to fit it in. I am not trying to say it is not important, but we have had trouble with it in our school. It has not been successfully taught now for quite a few years. We change instructors every year but it does not change things very much. We brought the nutrition department in from Berkeley and that did not do any good either. No, I cannot answer that question.

Question: How do you determine the priority for importance of subject matter in the teaching of pathology since it is impossible to give in depth coverage to all material?

Dr. Hopps: That is the $64 question. I do this by stressing general principles. Now let me go further, because that is one of those vague terms. I consider broad categories of disease. I talk about degenerative phenomena, inflammation, neoplasia, and the like. I try to make the basic principles "alive" and obviously significant and pertinent by using a variety of illustrations. I go into these illustrative disease entities and specific conditions in some depth, but by no means do I try to cover the whole range of disease entities.

It is very important in approaches of this sort to ask the right kind of examination questions not only because they will give you information about what the student has learned, but, even more significant, because what you ask the students on the examination is what they conclude you think is really important. So the examination becomes critically important as a learning mechanism. We have continued to use a minimal number of essay questions because they provide such a latitude of answers. One of our basic rules has been that immediately at the close of the examination, a variety of carefully formulated good answers are posted so that the students can understand what the problem was about. They are encouraged to come in and talk about the answers if they think they have a better one and a lot of them do. When the students can convince us that they have an answer just as good or better than ours, we post their answer too.

Question: In your opinion, what is the value of microscopic work in learning the fundamental processes of disease? Is this necessary and is the time commonly used justified?

Dr. Hopps: I think the time commonly used is not justified. I think that the presentation of microscopic structure is enormously valuable if it is well done. I think that in the majority of instances it is not well done.

Dr. Avery: I have got a question here that could be directed to any basic science area. It happens to be directed to anatomy, so I intercepted it here. It has been said that the anatomical sciences could be taught primarily in the premedical or predental level with only a superficial interdisciplinary approach given on a relevancy basis in medical or dental school. What is your opinion? Now, you might take any basic science area. Anyone want to speak to that?

Dr. Myers: The question is, "shouldn't biochemistry be covered as a predental course and could the objective of such a course be made in this way?" I believe it can be, and there is enough biochemistry around. I just finished talking about that. There are enough biochemistry courses available. The state colleges certainly have it and the university has it, even in the lower division. So biochemistry is pretty much available and can be obtained. We are going to require biochemistry at California as part of a 3 year requirement that is coming in. At the present time we are getting 30 out of 75 who have it, and we give them a special course. We do not make them take the general course. We teach them special topics in biochemistry while the rest of the class takes the special topics along with the regular course. I believe biochemistry can be done in the predental year, and I think that will allow the course in dental school to be more pertinent to dentistry. It has much more meaning to a student who is in dental school to study something about biochemistry of plaque and he is much better motivated to learn it.

Dr. Avery: Let me put you on the spot because I think we talked a lot about relevancy this afternoon and making things pertinent to the area of study, exciting and interesting. Do you think you would lose a lot of that if you were to turn this course over to someone who was not a physician, a dentist or someone interested in reaching the clinical levels along with the basic fundamental teaching? Do you think you might as you inditacted, in examples previously in biochemistry lose some of that if you were just to have a so-called relevant course in dental school and push the other course back onto the predental curriculum, Dr. Myers?

Dr. Myers: Just to start off by saying yes, I think would lose something. But it has been my experience having been around academic institutions for some years that you lose a lot in dental school too. It is the quality of teaching that counts the most and if you have a good teacher he makes a general biochemistry course come alive in other ways aside from dentistry. Biochemistry can be related to many different things and you can make it just as exciting as a general course to a student who has not had any experience in dentistry at all.

Leon Kraintz: At the University of British Columbia we now have some medical and dental students entering the first year with biochemistry or physiology previously completed on campus. The students have the option as undergraduates to take the physiology and, or biochemistry courses as part of their science program. This past year almost 50% of our students came in with biochemistry requirements and some came with physiology or both. In fact, the biochemistry offered at our school to dental and medical students is taught to the science students as well, in one large class. This biochemistry is not specifically medically oriented and essentially answers whether such an approach is possible. It is quite successful and the students who have had these courses before entering Dentistry have the option of taking electives in their first year. We have not altered our prerequisites, but hopefully would like to see all of our students have physiology and biochemistry before coming into medical school or dental school. I think the willingness of basic bio-medical science departments to participate in these programs depends on whether they consider themselves as being departments of medicine or dentistry or university departments. If they think of themselves as university departments, and in fact open the same courses to students throughout the university in addition to the medical and dental students, then there is no reason why students should not get credit for these courses before they are formally admitted to a dental or medical school.

Dr. Kroeger: I served this past year on an Ad Hoc Committee of The University of Texas, composed of representatives of both undergraduate and professional schools. The charge to the Committee was to examine areas where undergraduate colleges could present some of the basic science studies to the preprofessional students without increasing the time requirement; for example, can the professional schools have a one or two year integrated course in Biology and Biochemistry taught at the undergraduate level? The undergraduate colleges are not prepared to do this as yet; they find it difficult to relinquish their departmental lines to develop such a course. The professional schools would like to have this information taught at the undergraduate level provided we could have them taught in an integrated fashion and directed toward problems that exist in the health professions. This is difficult to achieve, if not almost impossible.

Dr. Weatherred: Just one further comment. If we do remove these disciplines to the undergraduate school I think there is a real danger we will lose a certain amount of research interest in dental problems. The majority of people in this room whether dentists or not, have gotten involved in dental research because they were in the dental school setting. We have a long way to go in dental research, and I think we would run the risk of losing these contributions.

Dr. Han: I would like to move back a couple of minutes and comment on the question of anatomical sciences. Some subject areas such as biochemistry and physiology can possibly be handled in the manner that has been tried at British Columbia. With respect to anatomy, I think it is rather important that we recognize the traditional fact that anatomy is composed of several sub-disciplinary areas, and that these areas require different methods of instruction. In the context of our discussion I can see that the transfer of teaching responsibility to undergraduate colleges could be realized in the area of cell biology, embryology and certain areas of microanatomy. With regard to gross anatomy, both in terms of faculty background and use of cadavers will present a unique problem for literary colleges. Under these circumstances it is more realistic to teach gross anatomy within medical or dental schools. There are also areas where amplification in teaching will be required in the future. For instance, neuroanatomy is taught to different extents among various dental schools. In general, I believe we have to expand and refine our teaching of neuroanatomy. In neuroanatomy, we not only have an opportunity to expose the students to important aspects of cranial nerves and traditional neuroanatomy, but we also have a chance wherein you can really do some integrated teaching in the form of a neuroscience program. You can bring in the molecular aspects of brain function as we understand it now, and bring in the biochemistry of adrenergic and cholinergic systems, tying with concepts in neurochemistry and peripheral nerve functions. There is a great potential in neuroanatomy for making the subject both exciting and meaningful to dental students. Thus, there are different factors in anatomy that have to be given separate considerations.

Dr. Sharawy (Med. College of Georgia, Sch. Dent.): I also disagree to move anatomy to predental years because I think we will be putting anatomy in the hand of some people who would teach it in a different way. They do not have the perspective. What we are after in a dental or a medical school is to develop a man who can diagnose and treat, that is all. We are not developing anatomists or we are not developing biochemists. If we are developing anatomists, then it is something else. We can just follow the old British system in education and keep the student in a dissecting lab with a cadaver for a year or two and ask him to follow Cunningham's manual of Anatomy. I think the emphasis for students of health professions, should be on applied anatomy and it should be clinical anatomy rather than descriptive anatomy. The student should know the relevance of anatomy to what he is going to do and this goal will not be accomplished if anatomy would be moved to predental years.

Question: Can we clarify the confusion in curricula without clearly defining the end product and desire?

Dr. Hopps: I do not think you mean crystal clear. I think not. But I believe that we can continually improve and work towards bettering this situation and a conference of this sort is a step towards this.

Question: What are the attributes of the end product in dentistry?

Dr. Hopps: I suggest that this be the subject of your next 2 day conference. I am quite serious about this. It would make an excellent conference. Maybe someone has the answer.

Dr. Avery: Since we will continue basic sciences tomorrow, we will hang onto that question. Dr.________do you have a burning question here?

Dr. unidentified: A couple of questions that pertain to the length of the curriculum. The question about the 3 year curriculum. I think that we have to look beyond the way dentistry is now practiced. I think we have to look perhaps at the way dentistry is going to be practiced in the future with 3rd party payment and the rest such as group practices. Whether it is in a private sector or in public sector is debatable. But even assuming it is in a private sector, I think we are going to see many more group practices coming in around the country. I think we are going to see group practices of general practitioners. General practitioners even now tend toward sub-specialty areas. They are not board qualified or certified in anything, but every general practitioner that I know has certain things that he likes to do, and certain other things he does not like to do. The things he does not like to do, he refers. Many of these are referred not because they are beyond his ability to do it, but because they are uneconomical, inefficient or he just does not have the interest and therefore a lot of upsurge in specialties now. Although I think specialties are important, a lot of the upsurge in specialties are really specialties by default. They develop by default because of the general practitioner's failure to do those things. When we are talking about a sub-specialty in dental school, we are not talking about a specialist the way we define it now. We are talking of an area of interest for a general practitioner.

As far as the 3 year dental school is concerned, I am not prepared in my own mind to say I am in favor of the 3 year curriculum. I think at the present time I probably am not in favor of this across the board. However, I think what we need is flexibility at both ends. We need flexibility for the educationally advantageous student. The one who has had many of these subjects need a program where perhaps they could go through dental school in 3 years by such things as advanced placement opportunities. We also need flexibility at the other end of the spectrum for students who may need 4, 5, 6 or perhaps 7 years to go through dental school. We cannot say that we need just to make dental school 3 years for everybody.

Question: *When should you teach biochemistry and why limit these basic sciences to freshman year? Should they better be given when students have had some dentistry?*

Dr. Myers: When you do this in a junior or senior year, the students have become resistant to such presentations. It is more difficult to try to teach a science course certainly with any kind of a content in the last 2 years. I can only tell you that it is done to some extent. Pharmacology is taken I believe in the last 2 years and our students have gotten interested and really want it. A couple of years ago they even asked for extra night time classes in Pharmacology because they could not get any time in the curriculum during the day. The Pharmacology Department willingly and happily provided evening instruction for the students. It seems it was not a question of whether you could turn them on—but how to.

Dr. unidentified: It is very difficult to identify a basic science course as a separate entity late in the curriculum. I think at least from my experience, students are not motivated to take such courses, but I think they do accept the material if it is given within the context of a clinical discipline. This is again why I think perhaps the departments should think about how they are created in order to bring this into the formula of their education.

Dr. Myers: Might I add one little thing here? Ernie Newbrun made a survey of what was being taught about dental caries and found that caries was mentioned in pathology a little, in histology and biochemistry a little. Of course it was eventually talked about in Operative Dentistry in a somewhat different context. He decided that a course in cariology was appropriate and it is now offered in the junior year. He throws in a lot of biochemistry because he is a biochemist; he brings in plaque and fluoride in greater detail. So far it has only been offered for a few years but I think it has been rather successful.

SESSION III

Current Status of Basic Science Courses in Dental Curriculum II.

Dr. Nathaniel Rowe, Chairman

INTRODUCTION TO SESSION #3

N. H. Rowe:

In order to assess the current status of the basic sciences in the dental curriculum one needs the perspective of the past as well as insight into the future needs. Primitive man had his dentist who rose to the occasion of toothache with various procedures. Dentistry in remote villages among isolated primitive people is still practiced today along similar lines. The methods of treatment are limited and the rare complications seem to be accepted as "the will of the Gods". Interestingly, one of our observations while studying the Choco indian of the remote interior jungles of Panama was the cultivation of an unclassified plant whose leaves possessed anesthetic properties. The "toothache" plant was one of the few plants purposefully cultivated by the Chocos and taken with them when the family moved from one location to another. Had we here witnessed the primeval stirrings of basic science being introduced into the dental curriculum? It is difficult to date the introduction of the basic science precisely since by definition much of the earlier information pertaining to the art and science of dentistry must be classified as art. Within the last century certainly, scientific investigation and application to the practice of dentistry has come of age. Who among us today would consider seeking dental care from one who knew nothing of antisepsis, analgesia, or the natural history or oral disease?

One goal of contemporary dental education is to familiarize each student with the normal structure and function of the oral tissues and masticatorysystem so that he may readily recognize deviations from normal when they occur. Additionally he must be familiar with the cause (etiology) and natural history (pathogenesis) of each entity he will encounter so that he will be prepared to manage the disease process effectively. In some instances this will require him to know when to do nothing! Certain developmental aberrations, such as hemifacial hypertrophy are best only identified and the temptation to treat resisted. The early literature contains numerous examples where the nature of this deformity was misunderstood and several of these unfortunate children became mortality statistics because of misdirected therapy. The first goal of the therapist should be to do no harm!

Historically the practice of both medicine and dentistry has been crisis-oriented. In the case of dentistry, toothache is still the most compelling reason for seeking treatment. Treatment options at this stage of disease development are costly, time consuming and discomforting; in short, undesirable. Disease prevention is a more attractive but rigorous approach to oral health. The challenge presently facing basic scientists who are dental educators is to teach students how to identify impending disease before disaster strikes and then how to utilize available expertise to abort the process by bolstering the patient's own defense in order that he may heal himself. One example of this type of treatment might be the incipient smooth surface carious lesion which appears as only a chalky etched spot beneath gingival dental plaque. Plaque control, fluoride application, and salivary remineralization of the etched are able to reverse and arrest the caries process. The problems attendant to operative restorations such as material failure, marginal leakage and recurrent caries are thereby prevented. Insight into the microscopic and chemical events which characterize the natural history during development of this disease makes possible interruption of the usual sequence of events.

Currently the dental curricula at institutions the country over are in a state of transition. Pressure from many sources is reshaping the classic curriculum. Calendar time of dental education is being shortened to expedite outflow of graduates, new courses are being introduced to prepare the dentist to meet changing needs in a new social climate, class size is increasing to accommodate the growing population, and clinical application is part of the new vocabulary. The question must be raised, "Can too much basic science instruction be programmed into the dental curriculum?" The present undergraduate dental student is certain that this is the case. It must be recognized that no one person can be all knowing about all topics. The question of relative utility of various topics creeps in here. It should be apparent that certain pieces of information and operative techniques are basic to clinical practice and must be mastered before any dental care delivery can take place. Basic science instruction under no circumstances can be at the expense of this information, no matter how zealous the curriculum committee is that the student be well grounded in basic science subjects. How will history decide that we at this time have balanced educational opportunities between the basic and clinical sciences? Of course here prediction approaches guesswork. It would appear however from recent changes in the traditional health care delivery system that repetitive technical procedures will be increasingly placed in the hands of individuals possessing more limited knowledge of the totality of dental science. As Research Laboratories and Institutes translate theoretic principles into therapeutic procedures the need for many repetitive activities will be eliminated. Correspondingly a shift away from crisis-oriented practice toward planned health management will occur. The dentist will increasingly be expected to evaluate oral health status, prescribe treatment regimens and manage the oral health delivery team. These activities will require that the dentist consider the patient as a biologic entity, certainly more than just 32 teeth. Knowledge of fundamental homeostatic processes and biologic principles would seem to constitute the corner stone of such a practice.

Applied to the present day curriculum, what one characteristic above all other should we seek to develop in our dental graduates as a result of basic sciences? Optimal judgment would be my reply. Judgment to defer treatment when none is necessary. Judgment to recognize and alter unfavorable conditions when by so doing impending disease can be reversed. Judgment to recognize when conventional therapy is still the most practical solution. A man's judgment is only as good as his knowledge. The responsibility of dental educators in the basic sciences is to assist the student in the time allotted to acquire that requisite knowledge.

MICROBIOLOGY, IMMUNOLOGY AND VIROLOGY

Solon A. Ellison:

By virtue of not having been the initial speaker at this Symposium, there are several problems created. First of these is the high probability of being redundant to some degree. Second is the temptation, hard to resist, to revise my presentation in reaction to the preceding discussions. Third is the fact that the more I am made to think about curriculum - that is about content, about methods, and about timing of courses - the less sure I become that my concepts are more than ad hoc hypotheses to justify my prejudices. As Dr. Hopps pointed out to us last night, cause-effect relationships are often less direct and more complex than we see them as being from our vantage point, and I suspect that the relation between teaching and learning is at least as involved a study as is parasitic disease in African tribesmen.

For teaching in a specific biological subject area to be considered successful, it must achieve at least one objective. The student should be able to understand in reasonably precise terms the manner in which prevention and treatment, by accident or design, depend upon application of the information which comprises the discipline. If we were to confine our consideration to prevention of the two plaque-associated conditions, caries and periodontal disease, we could justify the position that what is required is not knowledge but propaganda. Clean teeth don't decay; gingival inflammation requires plaque. Don't teach microbiology and immunology. Teach tooth cleaning and teach it well. One risk taken, however, would be that if less than 100% success in prevention were achieved, there would be neither direction nor logic available as a guide to intelligent and specific therapy. A second risk, somewhat more speculative, would be that more effective and simpler means of prevention, whose definition and development stem from an understanding of the biological characteristics of disease, would not be sought, nor discovered save by accident. The third point which is to me most important is that knowledge of the disciplines involved is transferable to biology broadly and forms an inseparable part of it. Defining curriculum by the sole criterion of its place in a specific clinical function is not desirable nor really possible.

The necessity of including the subject matter in the curriculum is thus clear. The issue immediately becomes the far more complex one of determining how extensive the curriculum must be, how detailed, how divided, correlated and integrated, and how and when it should be taught. In presenting my thoughts on these subjects, as they relate to Microbiology and its related disciplines, I shall start by making two broad statements. Unless the student understands how concepts are derived from experimental findings, he is not equipped to learn from the literature, and thus to grow in knowledge and understanding once he is in practice. Presentation of subject matter must be based upon description and analysis of relevant data. Second, the subject matter comprising my discipline is huge. It is complex. It is difficult. It is relevant. It is also fascinating. It provides the basic systems for studying the molecular basis of life and the biology of disease. It is too important to leave to the microbiologists. It cannot be learned by attending a single course, nor does its relation to treatment become apparent and functional without reinforcement in the clinic. It is pointless to teach it at all, unless opportunity is made to use it, and thus to master it.

In considering content, it is worthwhile first to display our goals in two contrasting fashions. The first is a simple topic outline. It looks logical and straightforward. Information is presented and developed in a stepwise fashion. Thus, in the area of Bacteriology we start by examining bacteria as living things and go on successively to learn about their distinguishing characteristics, about the diseases they produce, about therapy, and so on. It does not seems to be a confusing story requiring skipping around. This may be so, but I rather doubt it. Consider a different way of looking at the subjects we propose to cover. Here I have taken some of the topics and arranged them according to the conceptual level at which they are customarily presented. You may wish to differ with me concerning my classification, and I admit immediately that it is arbitrary and may not stand up under close analysis. But it serves to illustrate that the logic of the topic outline is not completely supportable. Each topic requires that we cover an entire span of biological and biochemical activities. The task we face is therefore neither simple for us as teachers nor for the student. There is no reason to act surprised if there is difficulty in getting the message across. There is, unfortunately perhaps, no way to avoid the problem. There is plainly the necessity of striving continually to achieve a degree of conceptual unification in this diverse field.

There is no simple guide which can help us in the process of selection from this material. I prefer as one criterion, to use the probability that clinical training during dental school can offer an opportunity to reexamine the subject area. On this basis, the areas of immunology and oral bacteriology deserve most detailed study. All dentistry is practiced in a single environment--an environment whose health is a function of the interaction between a complex indigenous flora and our normal immune and defense mechanisms.

Another criterion is the degree to which knowledge relating to the subject area helps provide a unified concept of biology. Analysis of data relating for example to bacterial genetics and to virus-cell relationships would merit inclusion from this point of view even if they did not directly have anything to do with human disease. The only criterion which I feel impelled to resist is that is has been customary to include the subject.

The function of the laboratory is to familiarize the student with the manner in which data are obtained. If it also provides an opportunity to learn basic facts, that is lagniappe. The laboratory serves also as the place where a language is learned. It is important that this be learned as a living tongue in which a student can express himself, not a series of words which have repeatedly to be looked up in the dictionary. If we expect, for example, that he will understand a term such as "growth requirement", we must somehow be sure that this evokes an operational as well as a semantic response. If at some later time a report from a clinical laboratory is to be meaningful to him in treating a patient, he must be able to appreciate the problem he is posing when he collects and send in a sample. Practitioners often believe that the question is, "What disease does my patient have?", when in fact, laboratories can't answer such questions.

I should like to see substantial revision in our approach to discussing bacterial diseases. A convincing argument can be made for greatly decreasing the time devoted to describing in detail the bacteria which cause diseases of the respiratory, and g-i tracts, venereal diseases and the like. These could be recast as patterns of infection. The emphasis would be placed on examining and contrasting epidemiological patterns, pathogenetic mechanisms, diagnostic procedures, and immunity. This could be done by systems, the object being to delete much of the specific material on characteristics of organisms. In discussing enteric infections, for example, the practical problem of identifying the causative organism is not unimportant. But the opportunity that exists to compare the function of the secretory immune system in diseases such as cholera, typhoid fever, and dysentery is far more relevant. If we are to devote laboratory exercises to these infections, it is more profitable to devise experiments which stress physiology rather than the use of selective media. The former provide subjects for later discussions in pathology, and in such clinical subjects as surgery. There will be opportunity elsewhere to consider diagnostic procedures, the selection and evaluation of therapeutice measures, and the like.

If we are to present detailed material on any group of bacteria, surely it is the oral bacteria and the indigenous flora in general which deserve our attention. Our aim here must be to develop a comprehensive and clinically useful picture. Although this can be done by means of a second-level course, I believe it preferable to make this material the major substance of the basic course. The information required to do this is available, and is certainly worth examining in depth.

Although immunology developed in close association with microbiology, it now clearly has substance on its own. In Table 3, I have shown in a diagrammatic form a manner in which it could be presented in two phases. A portion of the subject matter is comprehensible as soon as the student has a background knowledge of cell structure, the structure of proteins and polysaccharides, and the mechanisms of protein synthesis. This part would be given as a unit. It would start with the characterization of antigens, and go on by analyzing the steps in the immune response, ending with the appearance either of immunoglobulin antibodies or immune cells. Included as well, would be the structural basis for immunological specificity.

The second phase consists of characterizing the immune individual. It includes immune mechanisms in infections as well as hypersensitivity as disease. This would be joined with pathology and have as a prerequisite knowledge of the histopathology of inflammation. If such a division of subject matter were employed, this might best be preceded by that portion of the curriculum which dealt with bacteriology. Since it would include consideration of the biological mediators which are involved in hypersensitivity, some physiology and pharmacology might also be introduced. An opportunity would be created for participation of faculty with diverse backgrounds. One could also, for example, include here recent data relating immune mechanisms, biological activities of complement, and periodontal disease. In this way, natural links to the clinic can be made.

The dynamic character of virus infections makes this an area of particular interest. Formerly, it was the acute infections, not amenable to treatment, and epidemic in character which were the subjects seeming to require most emphasis. As the nature of viruses has been clarified, and particularly as information has become available regarding the relation between an infecting particle and a host cell, it is clear that it is the effects of viruses upon the molecular biology and genetic structure of cells which are of greatest importance in animal biology. Acute disease is far less common than infection. Viruses are an agency for genetic exchange among cells and among individuals. The consequence of infection is the presence in our cells of bits and pieces of information waiting the opportunity to be transcribed or otherwise to redirect our activities. This hybrid vigor is, unfortunately, best recognized in certain malignant disease, but doubtless has its biological advantages as well.

Unless a curriculum committee has been particularly generous in its assignment of time, this is an area in which we have some particularly harsh decisions forced upon us. There are two separate fashions in which we should like to approach the subject. One, of course, deals with virus infections by systems. Here, disease is described in terms of the manner in which infection is acquired, the site in which an agent propagates, its spread throughout the body, the damage it produces, and so forth. Since recovery, resistance to reinfection, and the basis for immunization all derive from such considerations, it is clearly necessary that we include them. The other approach considers viruses in terms of their structure, composition, reaction with antibodies, relation to an infected cell, and mode of replication. This second set of information is particularly relevant in describing viruses and tumors, for example, and trying to explain latent infections. Perhaps the best way we can approach this is to insure that there will be opportunity later in the curriculum to reconsider these aspects in clinical contexts.

I stated earlier that I considered clinical reinforcement to be important in learning. There is presently little opportunity made available for this to occur. If we want this to happen, we shall have to develop a series of criteria for the evolution of therapeutic procedures which use the information contained in the basic science curriculum. In most clinical practice, a limited range of diagnostic tools is employed - x-ray, mirror, explorer and periodontal probe. Perhaps, rather than think in terms of revising basic science curricula, we should concentrate on developing methods for diagnosis and treatment evaluation which can apply the information in routine practice.

By way of conclusion, I can only say that I hope I have not dissapointed you. The curriculum in professional schools, unlike that in other branches of the University, remains a prescribed and rigid one. If we were really courageous, we might do as our associates in graduate education do, and place the burden onto the students. We could simply set requirements, offer our individual courses, and require the student to show appropriate proficiencies. Perhaps we shall someday do that. Until then, we are forced into compromise.

TABLE 1. TOPIC LIST FOR A MICROBIOLOGY COURSE.

Bacteriology	Virology	Immunology
1. Bacterial morphology and structure.	1. Virus composition and structure.	1. Response to an antigen.
2. Classification nomenclature. Growth, metabolism, nutrition, ecology.	2. Cell-virus relationships. Virus growth.	2. Characterization of antibody and of immune cells.
3. Pathogenicity.	3. Bacteriophage	3. Detection of the immune state *in vivo* and *in vitro*
4. Specific organisms. Principles and practice of laboratory diagnostic tests.	4. Specific diseases.	4. Specificity.
5. Antibodies and infections.	5. Immunity	5. Antibodies and infections.
6. Indigenous flora	6. Latency.	6. Hypersensitivity. Complement.
	7. Viruses and tumors	7. Natural antibody, tissue antigens. Transfusion.

TABLE 2. SOME TOPICS FOR A MICROBIOLOGY COURSE ARRANGED ACCORDING TO CONCEPTUAL LEVEL

	Subject Area		
Conceptual level	Bacteriology	Virology	Immunology
Functional Molecular structure and Biology	Adaptive enzymes Transformation	Virus multiplication Radiation effects Helper viruses Latency	Ig Synthesis Ig Differentiation
	Endotoxins	Neutralization	Antigen-Antibody reactions
	Antigenic Classification	Attachment	Antigen recognition Complement
Cell and Tissue	Bacterial Metabolism Claffisication Ecology Structure	Infection Structure	Distribution of Immunoglobulins Phagocytosis Inflammation Hypersensitivity mechanisms Complement
Whole animal	Diagnosis of Disease Assay of Pathogenicity Ecology Indigenous flora	Disease Immunization	Clinical Aspects of Allergy Immunization

TABLE 3. COURSES IN IMMUNOLOGY

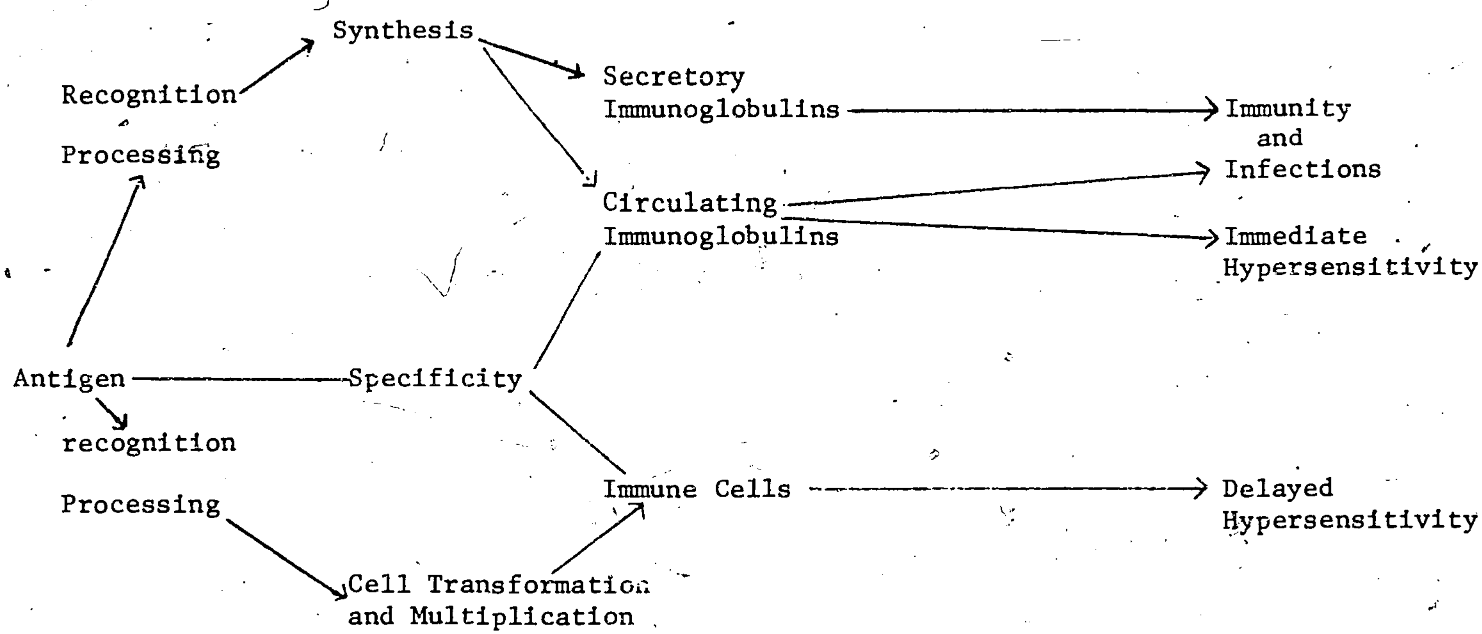
<u>Prerequisite</u>

Cell Structure
Protein and Polysaccharide Structure
Protein Synthesis

<u>Prerequisite</u>

Histopathology of Inflammation

Complement



<u>Addenda</u>

Genetic Diseases
Immunologic Identity
Immunology as a Tool

PHYSIOLOGY AND NEUROSCIENCES:

A PRAGMATIC APPROACH

Arthur Storey:

What and how one teaches any basic science will be dependent on the objectives of the programme and the background and motivation of the students in that programme. In physiology courses for dental students there has always been two lines of thinking regarding objectives - the "Brobeck" versus the "Haldi" concepts of the American Physiological Society Symposium of 1968. One objective is that physiology is taught for its own sake. "What is going on in the body and how one can find out about it!" The "how one can find out about it" exemplifies the scientific method and serves as a model for analytical thinking. Physiology like other health sciences and liberal arts courses such as history and philosophy have as their purpose, to quote J. J. Schwab in College Curriculum and Student Protest "to develop the arts of recovery, inquiry, and criticism appropriate to each discipline".[2] The other objective has been to teach the relevant and applied physiology pertinent to dentistry. As Haldi stated it "the course in physiology for dental students should be on a par academically with that given to the medical students" but "should nevertheless be tailored insofar as possible to meet the future professional needs of the dental student."[3] Dean Robert H. Ebert of the Harvard School of Dental Medicine echoes Haldi's sentiments: "Too long dental education has been a pale copy of medical education. It is time for dental education to take the initiative and exploit the very real advantage of educating for one special area of medicine, rather than all of medicine".[4] The goals of the dental student being more precisely defined than the medical student means "that the entire education of the dentist can be planned so that it is relevant.....the quality of scientific instruction for the dental student should be equal to that of the medical student but it does not follow that the content should be identical".[4]

Over the past few years very noticeable changes have occurred in the backgrounds and motivation of students entering dentistry. Their college biology and zoology courses now offer a much higher content of physiology than in the past. William S. Beck in his preface to Human Design, Molecular, Cellular and Systematic Physiology recognizes "the growing trend towards the transfer of medical school science courses into the undergraduate years in order to avoid redundancy and shorten the time needed to obtain a medical education".[5] Several illustrations from college texts will make the point. This figure from Weisz's Science of Zoology demonstrates the sophistication of presentation on energetics. This figure from the same text on the muscle twitch is standard fare in university physiology courses. This figure from Speed's General Biology illustrates the technique of measureing blood pressure in the human and the following figure the ionic basis for generation and transmission of the action potential in a nerve fibre. In Keeton's Biological Science the relationship of arteriolar blood pressure to cross sectional diameter of the vascular tree is illustrated along with the mechanism of concentration of urine and the pattern of discharge of a muscle receptor with varying degrees of stretch.

Many of our students enter dentistry with degrees; an increasing number have had courses in physiology. Last year at the University of Toronto 75 out of 125 students in first year dentistry possessed bachelors or higher degrees - 12 requested exemptions in physiology indicating some extensive experience in physiology. The degree students felt that they have acquired an adequate general background for dentistry - the students with previous training in physiology resent the repetition of general topics in physiology. The Brobeck concept has decreasing relevancy for today's dental student.

With a demand for more and better dentists coupled with a public concern for the costs of training health professionals there is a current trend toward making the health care education more pragmatic and shortening the period of medical and dental education (see Carnegie Commission Report). Dental curriculum committees tend to be cutting time from basic science courses in order to provide extra hours for new programmes and more clinical experience. These changes in the student background, and reduced time for the basic sciences in the dental curriculum give impetus to a more pragmatic approach to the teaching of physiology to dental students. It is increasingly difficult to offer a general physiology course in depth in the dental course. Indeed the objectives for doing so need to be reexamined. John B. Macdonald has "about faced" on this in a period of approximately ten years. In his 1957 paper "The Role of Basic Sciences and Dental Education" he stated "One of the purposes of professional education is to provide a basis for growth of professional knowledge. This by itself without any consideration of applied basic science is enough reason to teach basic science...the real reason for teaching basic science is permit understanding, and not merely to provide material for correlation with clinical practice".[6] In a recent report commissioned by the User Committee of the Faculty of Dentistry, University of Toronto, Dr. Macdonald advises as follows, "The teaching of basic biological sciences on which an understanding of dental disease depends should be tailored to meet the requirements of practicing dentists and specialists. It should not be designed to qualify students for admission to graduate programmes in basic science subjects without the likelihood of having to take additional preparatory courses. The evidence of the last decades suggests that dental practice in fact is not going to depend more heavily on biological sciences. If this conclusion is correct, it would be wasteful practice to design the undergraduate dental programme to prepare all students for graduate school when only a very few will proceed in this direction".[7] Macdonald goes on to suggest "that the objectives and content of the undergraduate science courses be reviewed carefully. The courses should instill a good understanding of basic principles of the pertinent sciences, should provide a broad survey aimed at acquainting the student in general terms with the state of the subject (without undue detail), and should give solid training in those aspects of each science which have application to the practice of any aspect of dentistry".[7] In light of present trends for a longer and more physiologically oriented college background I believe general physiology is more appropriately a prerequisite for entry into dentistry. Kraintz[8] has suggested that dental students should begin dental school with subjects such as fundamental anatomy, physiology, biochemistry, microbiology and pharmacology behind them. Until such time as physiology becomes a prerequisite to dentistry I suggest that the objectives of the dental physiology course should be as follows. a) to teach the physiology which the dental student must know so that other basic sciences, e.g. biochemistry, pharmacology, pathology, etc. and clinical sciences, e.g. surgery, preventive dentistry, etc. can build on this information. It is obvious that continuous dialogue is necessary between physiology and these disciplines. b) to participate in meaningful coordinated teaching efforts with other basic and clinical sciences, e.g. neurosciences, occlusion, etc. c) to teach the logical framework to support the physiological concepts defined in a) above. d) with the remaining time available to teach the physiology that can be done with a flair.

These objectives obviously tailor the physiology course to the particular institution where it evolves. This is the way I think it should be. I realize that in this country the National Board examinations in physiology would put restraints on this approach. I think it would make good sense to accredit physiology programmes (as is currently being done in the specialty areas) rather than certifying individual students.

Perhaps I can best illustrate the implementation of these objectives by reference to our own physiology programme at Toronto. The course is under the direction of Dr. J. Campbell of the Physiology Department which is a department of the Faculty of Medicine. Dr. B. J. Sessle and I are dually trained and have honorary appointments in the Department (Dr. Sessle joined our Faculty at the beginning of this year). Approximately 50 hours are allocated in the second dental year to lectures and approximately 36 hours for laboratories. The lecture hours have remained constant over the past ten years but the laboratory time has been cut in half. The course has been tailored somewhat to the needs of the dental student (Table I) for example lectures are given on connective and calcified tissues: the lectures in gastrointestinal and neuromuscular physiology are very much slanted towards the dental student. A series of lectures on the physiology of mandibular position and movement are given in the undergraduate orthodontic programme.

Over the past several months Dr. Sessle and I have attempted to redefine the physiological background material expected of the dental student by the people offering subsequent basic and clinical science courses. Although a number of our Faculty are acquainted with the systems approach to curricular planning, i.e. task analysis, task detailing and formulating of objectives we have not as yet defined the objectives in this "awesome detail" (to use the term of one of our educational consultants). As a result of these discussions we discovered that general pathology found the students inadquately versed in the characterization of the blood, particularly the non-cellular elements. In light of the current relative analgesia fad, anaesthesiology felt greater emphasis should be placed on cardiovascular and respiratory control mechanisms. Restorative dentistry urged a more intensive treatment of heamodynamics of the pulp and supporting structures of the tooth, the reflex basis of mandibular position and movement and pain referral in the oral-facial region. Pathology wished to see a change in emphasis so that the effects or radiation on function and the endocrine control of calcium and phosphorus was more intensively treated. Pharmacology was anxious to see a better job done in the area of general mechanisms of excretion. Suggested changes in emphasis in the lecture programme are being relayed to the five persons involved in the lecture programme. Time may have to be found in the lab schedule to accommodate topics to receive increased emphasis.

With respect to the laboratory we are proposing to make it increasingly relevant to the dentist. The present laboratory exercises, as is often the case, have been borrowed from the medical laboratory programme (Table II). Dr. Sessle has reviewed the laboratories suggesting that some be retained others retired, some revised, others added. We propose to revise the laboratories on Capillary Circulation and Nerve Conduction and Reflexes and establish three new laboratories on Salivary Secretion, Oral Sensation and Taste and Emergency Measures. In order to provide time for the new laboratories we are contemplating consolidation of four student participation laboratories into two sessions with a demonstration format. The revised laboratory on Capillary Circulation will use the hamster cheek pouch to study inflammation and the effects of the drugs (Table III). Next year we hope to use a heart tooth

TABLE II

University of Toronto Second Dental Year Physiology Labs (With Proposed Changes)

1.	BLOOD, CELL CONSTITUENTS, CLOTTING	(retain)
2.	CARDIAC FUNCTION (TURTLE HEART)	→ new lab, demonstration of 3 muscle types.
3.	CAPILLARY CIRCULATION	(revised)
4.	RENAL FUNCTION	(retain)
5.	SKELETAL AND SMOOTH MUSCLE	→ new lab, demonstration of 3 muscle types.
6.	VISION, HEARING, TOUCH	(retire)
7.	VENOUS PRESSURE AND FLOW	→ new lab, demonstration
8.	CHO METABOLISM	(retain?)
9.	NERVE CONDUCTION, REFLEXES	(demonstration & revised)
10.	BLOOD PRESSURE AND FLOW	→ new lab, demonstration
11.	RESPIRATION	(retain)
12.	RESPIRATION	(retain?)
	TOTAL 36 HOURS	TOTAL 27 HOURS

TABLE III

5	BODY FLUIDS	
2	BLOOD CLOTTING, HAEMOSTASIS	(† blood characterisation)
6	CARDIOVASCULAR SYSTEM	(† relative analgesia, haemodynamics of pulp, supporting structures; EKG-cardiac function lab)
5	RESPIRATION	(† relative analgesia)
5	CONNECTIVE, CALCIFIED TISSUES	(⊂ effects of radiation)
7	ENDOCRINE GLANDS	(⊂ endocrine control of calcium and phosphorus: clinic cases to illustrate)
3	ALIMENTARY TRACT	
9	NEUROMUSCULAR SYSTEM	(† reflex basis of mandibular position and movement; pain referral in orofacial region)
6	RENAL FUNCTION, ELECTROLYTE - ACID BASE BALANCE	(† general mechanisms of excretion)
2	INTEGRATIVE ACTIVITIES	
	TOTAL 50 HOURS	Additional time may have to be found in lab schedule.

TABLE IV

UNIVERSITY OF TORONTO
SECOND DENTAL YEAR
REVISED AND NEW LABORATORIES

REVISED:		
A)	CAPILLARY CIRCULATION	(hamster cheek pouch; heart- tooth model; inflammation; effects of drugs - collaboration with endodontics, pharmacology, pathology)
B)	ORAL REFLEXES	(nerve conduction demonstration; ulnar nerve conduction velocity; EMG of levator muscles-response to occlusal interferences)
NEW:		
C)	SALIVARY SECRETION	(relationship of flow to pH, phosphate, amylase; effect of atropine - collaboration with biochemistry, pharmacology, preventive dentistry)
D)	ORAL SENSATION AND TASTE	(two point discrim, stereognosis; tooth thresholds; size discrimination between teeth; taste thresholds-Henkin)
E)	EMERGENCY MEASURES	(office emergency laboratory (after Knapp) or simulation technique ? (after Jarabak) - collaboration with pharmacology, oral surgery, anaesthesiology)

model to study pulpal haemodynamics. We propose that this laboratory be a collaborative one with endodontics, pharmacology and pathology participating. The salivary secretion laboratory is being prepared with the guidance of Dr. Colin Dawes. It is designed to demonstrate the relationship of flow to H+, phosphate and amylase concentrations and the effects of drugs on salivary flow. This laboratory will involve the departments of biochemistry, pharmacology and preventive dentistry as well as physiology. The laboratory on Oral Sensation and Taste will utilize techniques being used in a clinical study at the Sick Children's Hospital in Toronto. The new laboratory on Oral Reflexes will include an EMB study of levator muscle response to artificial occulusal interferences if the techniques currently being tested can be transferred to the student laboratory. The Emergency Measures Laboratory we hope to pattern after the Office of Emergency Laboratory designed by Don Knapp. We wish to time this so that it comes in close proximity to the lectures and laboratories on resuscitation techniques given by the Department of Anaesthesiology. Pharmacology would also be involved.

You will note from the programme that I was assigned the topic Physiology and the Neurosciences. The neurosciences encompass one system which lends itself well to the interdisciplinary approach. We are all aware of the advantages and disadvantages of the systems approach. I participate in both the gastrointestinal and neural systems teaching to the medical students at the Unversity of Toronto. This can be a very satisfying type of programme for both the students and teachers if the prerequisite interdisciplinary ground work has been properly done. For example the topic of pain was handled around the Melzack and Wall and Casey and Wall model for pain transmission. A neuranatomist presented the specific and non-specific conduction systems, I dealt with the physiological mechanisms and two neurosurgeons dealt with the clinical implications. I believe some topics are eminently suited for this type of interdisciplinary approach - in dentistry, I think occlusion is one of the best examples. Any time invested in an interdisciplinary approach in the area of occlusion would be time well spent. I have reservations about a heavy investment of time in an interdisciplinary approach to the neurosciences if as has been suggested physiology, anatomy and perhaps pharmacology become prerequisites to dentistry. Those aspect of neurosciences which are highly relevant to dental practice could be organized along interdisciplinary lines and moved into the oral biology programme when and if physiology and other basic sciences become part of the predental experience.

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PHARMACOLOGY;

EXTENT OF TEACHING THERAPEUTICS AND NEW DRUGS

Raymond Ruddon:

The title of this discussion could be paraphrased to read "The Role of Pharmacology and Therapeutics in the Dental Curriculum" since the proper teaching of therapeutics should assume that students have a strong background in the principles of pharmacology. The objective of this talk will be to discuss some of the factors necessary for the adequate preparation of students of dentistry to use drugs clinically. The placement and content of a course in pharmacology and therapeutics in the dental curriculum will be considered. I should point out at the outset that, in my opinion, teaching separate courses labeled "Pharmacology" and "Dental Therapeutics" is not the ideal way to present this material. There are advantages to teaching pharmacology and therapeutics as a "continuum" and not tempting the student to place them into separate niches in his learning experience. If these topics are presented as a single body of knowledge, the student is more likely to see the "relevance" of basic concepts about drugs to their clinical use. The following topics bear on these points:

I. When should a course in pharmacology and therapeutics appear in the curriculum?

A. Pre-clinical years:

There are several advantages to presenting this material in the pre-clinical years. One is that the student is exposed to basic knowledge about drugs before he is in the clinics seeing patients who are taking drugs for dental and/or medical reasons. It is also at a time when other basic sciences are fresh in his mind, and pharmacology has to build on these other sciences in order to be meaningful. The disadvantages are that the student, in his opinion, is already overburdened with basic science courses and may consider pharmacology just another course to get through on his way to the clinics. Thus, he may miss the relevancy to clinical dentistry.

B. Clinical years:

At this time the student has all the necessary "building blocks" in place. He will have had anatomy, biochemistry, physiology, microbiology, and pathology, and theoretically his mind should be fertile (and eager) for knowledge about drugs. In addition, he is now beginning to see patients and is aware that he must know what drugs to prescribe. He begins to realize that his patients are taking a variety of medicaments which may affect the proper practice of dentistry. A disadvantage is that he is so engrossed in clinical practice and techniques that he doesn't care about "more basic science courses."

C. Concurrent curricula:

There are, of course, a number of reasons why the teaching of an integrated basic science curriculum is desirable. The presentation of various organ systems can be accomplished in an organized, unified way. The student is made to realize that a given organ has an anatomical structure, a functional physiology, is subject to various maladies, and can be altered by chemical agents and drugs. This type of presentation may be quite efficient and tends to minimize repetition.

I believe that pharmacology can be taught in this sort of curriculum, and in some instances it may be beneficial to do so, e.g. the discussion of agents affecting the central nervous system and the autonomic nervous system at a time when the anatomy and physiology are being taught. However, an argument may be made that pharmacology is best taught to a student who has prior exposure to the other basic sciences and a modicum of appreciation of clinical problems as well. There is a distinct body of information regarding "principles of drug action" which requires a knowledge of anatomy, biochemistry (e.g. kinetics, enzyme reactions, transport mechanisms), physiology (function of organ systems), pathology (role of disease states in altering physiology and drug actions), microbiology (basis for chemotherapy); and, the point of view could be supported that pharmacology needs to build from a prior exposure to these areas.

The answer to the question posed is probably that pharmacology and therapeutics can be taught in a number of different ways and at a number of different times in the dental curriculum and that as long as it is done well, the students will learn what is required.

II. How much time should be devoted to teaching pharmacology and therapeutics?

This is a very difficult question to answer, and one which a number of dental schools have been wrestling with for some time. As a generalization it could be stated that the course should be designed 1.) to present basic concepts of drug action and the pharmacology of the most important classes of drugs used in dentistry and medicine, 2.) to provide exposure to the clinical use of drugs used in dentistry and medicine, 3.) to provide a series of laboratories, demonstrations, discussion and quiz sections to insure that the student has adequate feedback to achieve proficiency in the area, and 4.) to provide some "on the job training" in the clinical use of drugs.

Obviously, the time that it takes to do this will vary with the quality of the teaching, the availability of personnel to teach, and the availability of clinical facilities for the training of dental students in both the dental area and in affiliated hospitals. I think that it is a mistake to go at it the other way, i.e., to say that dental students need such and such a number of hours (often based on what has been done in the past and what other schools are doing,etc.) and then to decide how to fill these hours. In the latter case, I am sure Parkinson's law will prevail.

III. Who should teach pharmacology and therapeutics to dental students?

The answer to this also depends to some extent on "who is available." Ideally, the basic information in pharmacology should be presented by a well-rounded pharmacology department which can bring to bear the expertise of several different people with first hand knowledge of various drug classes. In most universities this is best accomplished by one department of pharmacology, based usually in the medical school (though not necessarily so) which is responsible for teaching pharmacology to trainees in the various health professions on the campus. To have separate departments in each school of the university merely dilutes the available manpower. Given the current demands for high quality pharmacology courses in many areas of the health professions, e.g. medicine, dentistry, nursing, pharmacy, veterinary medicine, graduate programs in health sciences, and even in some literary college undergraduate programs, the practical solution to this problem may well involve the organization of courses in pharmacology into various "minicourses", or concentrated 2-8 week sessions in various areas of pharmacology and therapeutics. The basic principles of drug action and the pharmacology of certain areas of drugs related to all fields would be contained in one "core" or basic minicourse which all health professionals would take. Superimposed on this basic core course, then, would be a number of minicourses designed to add information on other areas of drug action or on the therapeutic use of drugs as needed and desired by the student. Obviously, the dental student should have additional training in areas which include general and local anesthetics and antibiotics, etc. but would not need as much information on cardiac glycosides, anthelmintics, or cancer chemotherapy as a medical student. The minicourses should also be designed to allow the student some selection of areas in which he might wish to take extra training. Dental clinicians should be very much involved in the planning and teaching of the areas of pharmacology and therapeutics which relate to their clinical specialty.

IV. What should a dental student learn in pharmacology and therapeutics?

The dental student should gain some expertise and experience in the following areas:

A. Concepts of drug action.

1.) Principles involved in absorption, distribution, metabolism, excretion, adverse effects, toxicity, mechanism of action, and clinical use of drugs. 2.) Factors which influence the above, e.g. age, sex, prandial state, presence of disease, "pharmacogenetic" make-up of the patient. 3.) Drug interactions.

B. Pharmacology of the major classes of drugs used in dentistry and medicine (e.g. general and local anesthetics, neuromuscular blocking agents, sedative-hypnotics, ataractics, narcotic and non-narcotic analgesics, antidepressants, adrenergic and cholinergic agents, vasodilators, anticoagulants, cardiac glycosides, antiarrhythmic agents, diuretics, hormones, antibiotics).

C. Use of agents in clinical dentistry.

This should include some "on the Job" training. Ideally, the dental student should participate in the writing of prescriptions and orders for patients and should have an opportunity for a significant rotation on a hospital service where he can participate in ward rounds and in the therapeutic management of patients.

D. Ability to evaluate new drugs.

This requires some awareness of the meaning of dose-response relationships, "potency", "efficacy", and the therapeutic index of drugs. An insight into the relationships between potency vs. efficacy, and efficacy vs. toxicity should be provided. The student should be made aware of the properties of an "ideal" agent for each class of drugs. He should also be made aware of the cost to the patient of various agents he prescribes.

DISCUSSIONS - SESSION III

Dr. Rowe: I see an audience of this size composed of many old friends this early in the morning is testimony to the type of program we had the first day. This morning we also have some outstanding speakers with topics of interest to us all and so without further delay we will begin.

Dr. Pruzansky: Thank you Dr. Rowe. I think this morning's session came closest to fulfilling the objectives of this conference and all three papers had certain common ingredients which I would like to distill. I would also add that I wish I could enroll in the courses taught by the preceding speakers. The leitmotif that ran through all the papers were fundamental concepts in education, the ingredients for successful instruction of students, how a student learns, and how concepts are derived. Dr. Storey told us that professional education should include the arts of recovery, enquiry and criticism and I could not agree more.

Each speaker dealt with basic principles within their particular field, the concepts and the tools that characterize their discipline. Yet, each was capable of demonstrating the relevance of his field to a particular dental problem.

It seems to me that there are two essential ingredients for teaching biology to dental students. First, deciding on the basic principals to be taught. Secondly, developing a body of knowledge that make these principles relevant to the clinical mission.

To illustrate, what I am driving at, let me share a personal experience. In 1953 I was sitting for my examination in physiology. Like any other anxious student, I tried to second guess what the examiners were going to ask me. Since I was concentrating on neurophysiology, I felt I could speak rather well on the neurophysiologic control of a variety of bodily functions. The only area in which I felt deficient was the neurophysiologic control of mastication or mandibular movements. This realization began to disturb me because nowhere in the curriculum had I learned anything about this and indeed, I could not remember finding anything in the textbooks I had surveyed. This was in 1953. About 11 years later I was invited to address a conference on the trigeminal system. In preparation, I revived this project that I first undertook in 1953. I reviewed all the textbooks that I could find in physiology with respect to two topics, which I felt were relevant, mastication and deglutition. I found that there was precious little on mastication, except for saliva. Why is this? Mastication is usually discussed at the beginning of the chapter on the alimentary tract. The classic textbook in physiology says something about mastication, something about saliva, a little bit more about deglutition and then it concentrates on the gut. Physiology textbooks are not being written for dentists. Now then, do we really know anything about the neurophysiologic control of mastication? My lead was an illustration on the monosynaptic reflex are in the trigeminal system in Fulton's textbook of physiology. I discovered that indeed there was a body of knowledge which was very relevant to dental education but nobody had ever put it together. That is why I admire what the previous speakers are doing. I think they have made a real effort in trying to put together a body of knowledge which cannot be found in textbooks but which does exist in the literature. They are assimilating it and making it relevant and applicable to dental needs.

The sum of what I am saying is this. When the Department of Health, Education and Welfare begins to give grants to develop teaching manuals, for revision of curriculum, for the development of teaching materials applicable to specific needs, then I think the status of the teacher will have been elevated to that of the researcher. Thank you.

Dr. Rowe: The way we will handle questions, which include a great many and interesting ones, will be to divide them between the panelists and let them select the priority for answering. Dr. Storey, let me ask you to begin.

Question: Would you agree that too frequently our educational objectives are fatal for vagueness? Should not they be expressed in precise behavioral terms? What should the end product of our educational system suppose to be able to do that relates or could not be done by him without the background in physiology? Otherwise, should not we in fact attempt to spell out the needs of dentists in the fields of physiology?

Dr. Storey: I know what you are after, and I am sympathetic to it. We recently had a session in Toronto where we were defining and detailing tasks and I agree that it ought to be done detail. I guess we are lazy or we have other things to do. Yes, I think this is a desirable goal and I am sympathetic to it and I think eventually in time I would like to go in that direction myself. There are many other people who would too.

Question: In the clinic years how is the information taught in your course reinforced? Does your laboratory carry out routine diagnostic procedures? If not, why not, who does?

Dr. Ellison: There is in fact in our clinic a bacteriologic diagnostic laboratory which carries out whatever procedures are required for patient handling. One of the problems I think in running such a laboratory is that we really have very few diagnostic procedures to offer in the care of a patient which have any particular value and we really have not gone very far in developing such procedures.

Question: In order to meet the needs of the dentist in immunology particularly in the areas of the immunological defenses of the body, *immunization, and immunological disease, is it not more logical to teach immunology in the pathology course in the absence of integrated or interdigitated courses?*

Dr. Ellison: I think the place to teach immunology is in an immunology course.

Question: Does the average M.D. really understand the pharmacological action of all the drugs his patient may be taking or is he relying heavily on the literature supplied by the drug companies?

Dr. Ruddon: I guess my answer to that is that if he does not understand all the pharmacological actions, he should. Obviously, I think it is true that the dental practitioner as well as the physician should certainly know very very well the drugs that he uses and relies on all the time. The cardiologist very well better understand backwards and forwards the pharmacology of digitalis, of anti hypertensive drugs, of vasodilators, anticoagulants and so on. He may know less about steroids, antifertility drugs, and so on. I think this is probably true of the dentist as well. Certainly he should know more about the drugs that he uses all the time. When you are talking about newer drugs coming out, busy physicians and busy dentists do not always have time to go back to the basic literature. This is a real problem and I think that they do rely on information from the drug companies and this is not really all bad. As a matter of fact, the Physician's Desk Reference, and the package inserts that come out now with drugs are very detailed, and they may even be overly cautious in their description of toxicity. If any adverse reactions have been reported they should be mentioned on that package insert. So the information that comes from the drug companies is very useful information and quite detailed. So I would not attempt to downgrade that. What I do object to is acceptance of the sales pitch by the drug company salesman without carefully evaluating what he says.

Question: Some people have abandoned laboratory in physiology. What is your feeling about it?

Dr Storey: I think one has to look at the means to your end. Getting back to the question I had previously. Is the laboratory the most appropriate way of doing it, or is discussion, or is programmed learning, or is just reading the way to handle it? I think you have to decide why you give a laboratory and then you can decide I think whether a suitable topic is to be dealt with that way. I see the laboratory in a number of ways. One of them being that it is an opportunity to get close to the student, and also it can be a highly motivating kind of experience.

Question: Would you comment on the inclusion of only 3 hours of alimentary tract in your outline? In my view this seems to be somewhat inadequate.

Dr. Storey: At our school, there was concern about the 3 hours devoted to the alimentary tract in the lecture program. The question is to whether it is covered elsewhere in the program. Yes, it is. Preventive dentistry covers a great deal of it. The alimentary tract which I deal with is very much tailored to the dental student. I give them a sizeable packet of questions dealing with some of the general areas here, ask them to use their textbooks, to indeed do much of the work themselves. I will answer questions on it afterwards, but I deal with what is happening in the upper end of the tract.

Question: Do you think it worth the effort to design laboratory sessions, illustrate general principles, but utilize dental models to stimulate interest?

Dr. Ellison: I have sort of a yes and no feeling about that. If the model can illustrate the principle as well as it could be done using any other model, I think yes, of course, this is preferable. I can think of my own experience. One of the things the student used to do was immunize rabbits. They immunized them with serum, and with serum fractions so they could get some antiserums to work with. We had dental students also immunize with saliva and the results were really quite interesting. As a matter of fact, they started me working on the immunology of saliva so that there was a double benefit. I think, provided that the using of dental models does not make the general principle harder to discern, it is fine. These models are not always available and may not always be the easiest ones for the students to manipulate.

Question: To your knowledge do continuing education courses offer therapeutics in the use of new drugs and so on? If not, why not?

Dr. Ruddon: I am not really sure I am the right person to answer that. I would guess that Dr. Myers might have more information on that as well as some of the other people involved more in what has gone on in the past. I simply know that the way we work it here is that at least several times a year I am approached by one of the clinical departments, the endodontics department particularly, to come to one of their postgraduate courses and talk about drugs. I guess if you were looking at titles you might not catch that. In other words it might be listed under something in endodontics and not under pharmacology. Maybe this means we should advertise better. I do certainly think that there should be continuing education courses in dental therapeutics, but I guess I do not really know to what extent it goes on.

Dr. Rowe: Ray, I'd emphasize as you have done that reading through the catalogue of the ADA looking at the nomenclature under which courses are offered is very misleading. For example, there are a multitude of graduate and postgraduate education experiences here at this university each year and I think the Departments of Pathology and Oral Pathology participate in perhaps 90% of them, yet there is no course listed under the direct heading of Oral Pathology, but it certainly is part of the continuing education experience here. Now, I wonder Dr. Myers if you would comment.

Dr. Myers: Well, I am not directly involved in these continuing education classes, but I know that at California periodically at least once a year and several times a year on some occasions, courses are offered by the Pharmacology Department together with people from the School of Dentistry in continuing education. Dr. Frederick Meyers is very active in this and Dr. Silverman, and a few other people have contributed to it. In general, there are several courses offered. This is a fairly active program and there is a lot of activity of all types in continuing education.

Question: If one does move physiology and other basic sciences into the predental program, are not you substituting preprofessional education for professional education? Should not you dissuade predental students from taking these courses? Instead they should take such courses as psychology, mathematics, physical chemistry, that is you are narrowing them in and destroying the function of a basic program, a liberal arts kind of program.

Dr. Storey: Yes., I think that is true if you are talking about the student who comes in maybe with one of two years predental training. The trend as I pointed out is towards people coming in with degrees which means that they have spent more time in the predental program. If that is the case, then it may be possible to have the best of both worlds.

Question: Are not you talking out of both sides of your mouth at the same time? On one hand we want to make our basic science presentations relevant to the clinical phenomena. But how can we accomplish this if we move our basic science courses into the undergraduate curriculum? Are we not abdicating responsibility?

Dr. Storey: Not as I see it, because I see the basic core with the applied superimposed on it. The basic core I think can be taught in the undergraduate program and I was comforted to find that other people think that way. In the dental program I think the basic science has to be related to the clinical setting. I think the way to teach my discipline, physiology, is in close proximity in order to deal with say the basic aspects of physiology of mastication and deglutition, to cite two important areas that Dr. Pruzansky raised. But, I think it ought to be as a member of a team, actually the presence of the patient, so I do not see that one necessarily excludes the other.

Question: *The enthusiasm for intermultidisciplinary teaching so prominent three and four years ago seems to be markedly tempered. Dr. Myers commented yesterday on the identity problem. Are separate basic science courses with limited and controlled input by different disciplines more desirable than integrated courses such as cellular biology?*

Dr. Ellison: Well, I do not really have an answer to that. We expect that the student is going to be able to put all of this knowledge together in a package and apply it to a clinical situation. I am myself convinced that integration is best done with the patient in view.

Until there is something to focus attention on when giving the integrated or interdisciplinary course, it does not really accomplish anything that is uniquely accomplishable at that moment. When I first came to Buffalo there was a course given in the first year on the cell. This comprised histology, ultrastructure, biophysics, biochemistry and so forth. It was given in a sequence of lectures. It has now been essentially discarded and we are back to the disintegrated curriculum. I do not think that one is more successful necessarily than the other. The amount of integration is going to depend on the amount of effort which the students put into trying to see this as a package. We do not have the student's eyes. We can only give him something to look at. He is the one who is going to have to see it.

I am sure that I do not know all the reasons by any means why the course I referred to was discarded. I think one of the reasons was that student acceptance of the course proved insignificant. I think another reason was faculty acceptance of the course. I think still another was the essential realization that it really was not integrated. In order to integrate something you have to start out with a certain number of facts. No matter how you present this material until the facts are stretched out before you, you really cannot put the jigsaw puzzle together. There is a place for integration but I do not think one can do this the first time you show someone something.

Dr. Rowe: It is a shame to see the hour run on because we are just beginning to approach the most productive areas. In terms of summary, I think we have not yet packaged the issue. There is nothing then to summarize except to say that this has been a very challenging morning. My job this morning has been made particularly easy by the excellence of these three panelists. The questions this morning that came forth were not the kind that you can answer with a yes or no. The willingness by the audience to participate has made this session a very valuable one, and you are to be commended upon sitting so long and so patiently and participating right to the final gun. Thank you.

SESSION IV

FUTURE NEEDS AND DIRECTIONS

Dr. Warren Seibert, Chairman

INTRODUCTION TO SESSION #4

W. F. Seibert:

Let me suggest at the outset that the principal needs and the most likely directions for the future of dental education are - or they appear to be - highly consistent with the themes of the three papers we are about to hear. If the choice were mine, though, I would probably arrange the themes in a different order than the papers indicate. In the first position - certainly in terms of its future importance and the need which it represents - I would put the theme of individualization - of individualized teaching. This theme is Don Strachan's and in the agenda today, Don appears to be last. I know Don's interest in teaching to the individual needs and interests of students and his experience in implementing these ideas and he is an able spokesman for this important topic.

In second position on my modified agenda, I would suggest the theme of "vertical core concepts" and I would suggest also that these vertical concepts include any of the many areas of skill and comprehension which include several progressive and intermediate levels toward subject mastery. These vertical concepts are Bob Doerr's to discuss and in today's agenda, he appears first. An additional word should be said about vertical concepts and about progressive steps in learning, since we seem toooften to teach as if students will somehow master large domains or complex skills all-at-once and on first introduction. Yet students don't - or at least not often do they have those great moments of insight which transport them from a condition of chaos and mental poverty to a condition of rich comprehension. However, if our educational planning is good, we can teach in a way which will recognize and use each student's present skills, which will extend these skills gradually toward mastery, which rewards all goal-oriented progress that is made, which is both sincere and unrelenting in the requirement to progress, and which "weans" the student in the end and launches him as a person possessing both the requisite skils and the inclination to improve them.

And finally, on the modified agenda, I would place "Depts. of Oral Biology - Their Role and Position in Core Curriculum". It seems to me that the theme which centers on departments should come last for two reasons. First, something has to be last. And secondly, in my view, departments of all kinds are primarily matters of administrative convenience and necessity, rather than directly valuable from the standpoint of students and their learning. If we could somehow eliminate departments and the lines between them, the chances for coordinated teaching and efficient learning would surely improve. ---But more positively, I think we might agree that departments of oral biology are among the few places where dental students may expect to learn the good and useful concepts and the principles which will continue to be helpful throughout most of their practitioner lifetime.

If we have learned anything from observing recent progress in the sciences, it is surely that specific information and particular skills or technologies have very short lives. To the extent that we teach skills and information that have been separated from their validating principles, we are assuring that current students will very soon be practicing under a handicap of obsolescence. Much of the information they possess will be out-of-date, in a great many cases it will already be forgotten, their skills will be old-fashioned, and much of their career will still be before them. But, to the extent that we select and teach the strong principles and most powerful concepts of each discipline, students will acquire skills that have greater value both initially and in the long run.

This all is reminiscent of a statement attributed to Kurt Lewin, one of the great psychologists of the last generation. In a discussion of pure vs. applied science or practical vs. theoretical science, he said: "There is nothing more practical than good theory." A more disturbing but related notion is the one expressed by Alfred North Whitehead, who indicated that by the middle or latter part of his own scientific career, most of the science he had learned in school was wrong. To me, then, as a psychologist somewhat familiar with the purposes and procedures of dental education, it would seem that the most important function of the sciences within the dental curriculum is as a preventive of early obsolescence and as efficient principles which can be remembered well and applied frequently.

Besides suggesting three themes which somehow represent the three presentations we will hear - the themes of individualized teaching and individualized rates of student accomplishment, of vertical concepts in the curriculum and of graduated and rewarded student progress towards mastery, and the protective-preventive role of selected principles from oral biology in enlarging and extending the adequacy of an aging practitioner - I might also try to relate these needs and trends to those present elsewhere in the educational world.

Not surprisingly, I would suggest that what we face and must face in dental education shows more parallels than differences, when compared with the rest of contemporary education. Educators elsewhere are also trying to resolve much the same set of problems we face.---They realize that they, too, must finally do more to recognize and use the large intellectual and motivational differences among students---and that finally there are effective means and alternatives which can allow this. Other educators also see that it is educationally wise to plan for and to teach toward steadily increasing levels of student skill and the refinement of student's understanding. Although our individual sins in the past may differ, we have nevertheless generally tended to expect instant or at least very rapid mastery from students. Now, more realistically, many educators operate on a basis which could be attributed either to B. F. Skinner or Jerome Bruner, both of whom are psychologists deeply interested in education and the learning process. In Skinner's terms, complex learning is "shaped".---It develops in easy steps that begin with the simplest components of a student's final performance and that then move gradually through successive approximations to the full, skilled execution. To Bruner, a similar problem is treated in a statement which says that any subject can be taught to any student at a level that is appropriate to the student's present ability and is intellectually honest. It is unimportant whether Skinner, Bruner or someone else receives credit for this conception of learning and achievement, but it is important throughout education that we secure the benefits of student skill and student motivation which can ensue.

And, finally, educators generally have deep concern with questions about the "role and position of..." this subject or that one in the curriculum, just as we are concerned here with the same question as it relates to oral biology. In part, the question is one of selecting for inclusion the most promising principles and most promising concepts from each discipline---then teaching them well. There is a better and a broader term to cover this same question, though, and it is one every educator now recognizes.---It is "relevance". And if we should be inclined to grow lax about relevance students now are inclined to remind us---sometimes in colorful language, that there are serious questions of relevance and importance to be asked and answered.

On the basis of limited evidence, I have tried to detect a structure and even some priorities to go with the themes of our three speakers this afternoon. At this point, I am by no means positive that I have sensed the themes accurately, much less provided the right structure or the right priorities. But the best way for us all to find out is to ask the speakers themselves.---

We will follow a sound psychological principle in the introductions---namely, I will conceal from you most of the sins and virtues of each speaker. You must discover these for yourself---and when you do, you will remember them better.

Our first presentation is by Dr. Robert Doerr, Associate Dean, here at Michigan. Bob has many credentials, but perhaps the most significant one, in this context, is that he is the primary architect of Michigan's new curriculum. Bob will present a paper entitled "Vertical Core Concepts: Principles and Applicabilities."

Our second speaker is Dr. Arnold Tamarin, who will present his paper entitled "Departments of Oral Biology: Their Role and Position in Core Curriculum."

Last, Don Strachan will present a paper entitled "Elective Programs and Individualized Instruction." Don is Assistant Dean of the School here at Michigan and Associate Professor of Anatomy.

VERTICAL CORE CONCEPTS:

PRINCIPLES AND APPLICABILITIES

Robert E. Doerr:

Instead of confining this paper to a strict discussion of the principles and application of vertical core concepts, I should like to include consideration of the topic in the broader context of curriculum organization. Although time does not permit an exhaustive examination of curriculum design and organization, there are concepts and problems other than those associated with vertical core programs that deserve mention.

The principles of learning related to the design and organization of a curriculum are knowledge of goals, motivation, reinforcement, transfer, and evaluation. I believe that all of us would agree that definition of objectives must precede the development of any organizational plan. Whereas graduation of a general practitioner of dentistry may be adequate as a broad objective, we must be much more precise if we are to develop a plan that can be evaluated. Among many other considerations, we must look at the needs of society and provide learning experiences that will prepare graduates for a new role in the community.

Presently, a dentist is not considered a successful practitioner unless he possesses a high degree of manual skill - unless he has 'a good pair of hands'. Many of us hope that in the future the purely technical, mechanical aspects of dental treatment will be delegated to auxiliaries who have been trained in the performance of expanded duties. The dentist can then devote his time to the more biologically-oriented needs of his patients, and can function as a medical specialist concerned with the prevention and treatment of diseases of the oral tissues and related structures. He should be an expert pathologist and diagnostician, highly knowledgeable in the field of occlusion, and in the latest methods of prevention of disease and the psychology of patient management. In the future, the dentist will incorporate within his general practice much of what is reserved for dental specialists today. Consequently, we will have to rethink our present concept of specialization which too frequently results in discontinuous rather than continuous care; in partial rather than comprehensive care.

If students are to be motivated, learning must impress them as being relevant and related to ultimate goals - to what they, the learners, are preparing themselves to do. In order for students to understand and enjoy the curriculum, they must be familiar with its objectives. Students should be apprised of the details of the educational venture upon which they are embarking early in the curriculum. They must be given an overview that includes an introduction to dental education and to the practice of dentistry.

We must also develop a more complete understanding of our students. Although we tend to think of our students as a homogeneous group because of the various selection factors, there is actually great heterogeneity and it will probably increase in the years ahead. Some students come to us from systems of education in which the DNA molecule and nuclear physics were discussed in the second or third grade. Significant changes have occurred in the teaching of biological and physical sciences in secondary schools, and in colleges and universities. One has only to examine textbooks of 15 to 20 years ago to appreciate the tremendous differences. There is a new approach to the study of biological systems. Core curricula in biology are being offered that place an increasing emphasis on the molecular and cellular levels of organization at the relative expense of courses in morphology and systematics. Such emphasis necessitates increased preparation in chemistry, mathematics, and physics. Other students come from more traditional backgrounds. Proper curricular organization can provide basic learning experiences for all students, and then allow for diversification and individualization. If we accept the basic tenet that students cannot learn everything while in dental school, we are confronted immediately by the question of how much knowledge is required in order to provide minimum competency. This question has particular significance in the consideration of shortened curricula.

One of the primary reasons we are interested in curriculum design and organization is because we are striving constantly to improve the integration and correlation of subject matter; in particular, the basic and clinical sciences. This problem has plagued dental education since the mid-1920's when, as a result of the Carnegie survey, the basic sciences took their rightful place in the dental curriculum. Today there are still conflicting opinions about the basic sciences. Some educators believe the content should be reduced and the courses made more applied and pragmatic. They are of the opinion that only the oral sciences should be taught and that the remainder of the curriculum should be devoted to subjects that actually relate to dental practice. Other persons feel strongly that if the courses are too pragmatic they lose their educational value and become vocational training programs. This school of thought contends that we need not apologize for asking students to learn more of the basic sciences than can be applied directly to the practice of dentistry. Students have a lifetime ahead of them and it is difficult to predict what the future will demand. Consequently, they need a broad, diverse base upon which to build.

The importance of the basic sciences to dentistry is no longer questioned, yet dentistry has difficulty in defining the role of the basic sciences with the preciseness required to structure meaningful learning experiences for students. One of the bitterest complaints of students is that the methods of evaluation preclude learning concepts and principles, and require them to memorize - as they refer to them - rat facts. We frequently fail to remember that dental education is specialty education; therefore, the basic sciences should be more than just courses taught by scientists. As one important input, dentists in practice should be asked to evaluate the significance of subject matter content. Objectives for courses must be developed in precise behavioral terms and a content analysis should be done in order to assign levels of learning to each area of subject matter. That is, whether the learning required is to be in depth, a familiarity with, or merely superficial.

It is my opinion that the dental curriculum can ill-afford the time, nor is it feasible or practical, to give dental students the same basic science courses required for medical students. Basic science courses for dental students should be tailored especially for their needs. This necessity is accentuated by examples of imbalance between the basic and clinical sciences. Some foreign programs in which dental and medical students participate in the same basic science courses do not devote sufficient time to the development of clinical skills. Conversely, some of our products approach technical perfection, but are inadequately prepared in the biologic foundations of sound dental practice.

Yet another consideration in the organization of the basic sciences is the possibility of moving some of the basic sciences into the preprofessional curriculum. Much of the success of this approach would depend upon the local situation. It is difficult for junior and community colleges to offer high quality, diverse science programs, and the quality of science courses offered by four-year liberal arts colleges contrasted with major universities may also differ greatly. Furthermore, incorporation of the basic sciences in the preprofessional curriculum reduces the breadth of liberal arts education, and makes preparation for admission very difficult for two-year college students and for those students who decide upon dentistry in their third or fourth year of college. The potential for developing an exciting program should not be ignored, however.

There is one final point that I would like to make before leaving the discussion of organization of the basic sciences. Dental education should stop emulating medical education. We have been engaged in specialty education since 1840 while medical education is only now recognizing that it must change in order to accommodate the majority of its graduates who go on to specialty training. Perhaps the most significant reason for dental education to exert its independence is that we know we have a group of students who want to become dentists, not physicians. The quality of basic science education for dental and medical students would be the same; however, the content should be different. There are those who argue that common basic sciences encourage medical and dental students to work together. It is the contention of others, however, that dental and medical students should share experiences at the clinical level where both the dentist and physician must function as a team if they are to provide comprehensive health care for patients. To this end, hospital dental programs should be expanded.

Dental educators have had the opportunity to innovate and lead in developing curricula that are completely relevant to the established goals of graduating a general practitioner of dentistry. Again, for the most part, we have waited for medical education to change; to streamline its curriculum and make it more meaningful to the students it educates. The manner in which medical schools developed within universities is responsible for some of the serious problems existing in both medical and dental education. The Flexner report of 1911 recommended that medical education be within the framework of the university with the objective that the quality of medical education would be improved if it were based upon the scientific and other disciplines of the university. As pointed out by Dr. Millis,[1] former chancellor of Case Western Reserve University in an address to the American College of Dentists in the fall of 1967, the medical schools were ready for and needed the university in 1911, but the universities were not ready for the medical schools. There were only a handful of universities where the disciplinary departments were developed to the level to participate in a graduate-professional educational program. To quote Dr. Millis[1] again: "The continuing dichotomy between the sciences and the arts, that is, between knowledge, pure and unadulterated and its purposeful use in the arts was unresolved. The medical school was mistakenly located in or near the hospital rather than in the university itself. There have been some consequent developments. We have seen duplication of departments of biology, physiology, microbiology; duplicated departments of chemistry and biochemistry. Each department and each discipline has become surrounded by an impervious membrane through which neither man nor ideas may flow."

The same dichotomy between the sciences and the arts referred to by Millis plagues dental schools, particularly those that depend upon medical basic science departments for instruction of dental students. The solution is not for the dental schools to establish their own basic science departments and further duplicate existing facilities and faculty. This process is impractical both philosophically and economically. The ideal solution is for the health sciences to truly become part of the university. "The responsibility for the translation of the science of knowing into the art of doing has been placed upon the institutions of higher education and particularly upon those institutions engaged in the education of the learned profession...The central problem of the university is the interface between science and art, between knowing and doing. It is only in the learned professions that this interface is clear and viable..."[1]

If we substitute dentistry for the term learned profession, it becomes evident that dental education must establish within the student and, hence, the practitioner, a symbiotic relationship between knowledge and skill, between knowing and doing. This challenge has led to the reorganization of curricula by verticalizing or diagonalizing the scientific and artistic components of dentistry. In this approach the clinical sciences are introduced during the first year and the basic sciences are spread into the third and fourth years in an attempt to correlate and integrate more effectively. Some curricula identify tracts for important subject areas such as diagnosis, pathology, occlusion and community dentistry. These tracts, under the direction of multidisciplinary committees, coordinate related subject matter from all departments. Whereas didactic learning and acquisition of manipulative skills have been the core of professional education, educationally we are now proceeding towards multiple tracking and individualization of instruction. Philosophically, we are moving from the concept of the independent-professional to the social-manpower concept.

Although the vertically or diagonally oriented curriculum assists with the integration and correlation of the basic and clinical sciences, it is not the ultimate solution. Some students become even more frustrated than with the traditional horizontal organization because the experience clinical courses in which there is high motivation - courses in which they feel they are learning dentistry - and concommitantly they study courses in the basic sciences in which they perceive no relevance and which, therefore, become even greater hurdles. Dentistry has done an inadequate job of demonstrating the importance or the basic sciences to the actual treatment of patients. In some instances the behavioral sciences assist with the integration of basic and clinical sciences. Behavioral courses bridge the gap between the biology of behavior and the management of the patient. For example, pain is not only biologically based, but has also both learned and social components.

Interest in core programs or core curricula is evidence of the continuing quest to solve the problems of integration and correlation and is in partial response to the explosion of knowledge in the sciences. Core programs are an attempt to substitute for individual courses broad categories of vertically oriented instruction. The effect of the knowledge has multiplied eight times since 1750,[2] that 80 percent of everything known to man has been learned in the past 15 years, that 7 to 10 prescriptions for drugs today are for drugs unknown 10 years ago, that health literature doubles every 5 years, and that textbooks are out of date in 5 years. The task of just keeping up in one's subject area is tremendous without assuming the additional challenge of continually reorganizing programs to benefit the learner.

Although the concept of core programming or core curriculum is not new (experimentation with something actually called core curriculum began in the years immediately following World War I, but the concept can be traced back much further), its transition from primary concern with reorganization and grouping of existing courses of study to the elimination of subject matter as entities and the substitution of activities is noteworthy. Since the late 1940's the more sophisticated approach to core curriculum has been to organize experiences and activities of students and relate subject material to these activities. Students play an important part in identifying experiences for which they feel a need.

"Alberty[3] describes six different program designs as core programs, in the order of their deviation from conventional curriculum organization, as follows: 1) The core consists of a number of logically-oriented subjects or fields of knowledge each of which is taught independently. 2) The core consists of a number of logically-organized subjects or fields of knowledge, some or all of which are correlated. 3) The core consists of broad problems, units of work, or unifying themes which are chosen because they afford the means of teaching effectively the basic content of certain subjects or fields of knowledge. These subjects or fields retain their identity, but the content is selected and taught with special reference to the unit, theme, or problem. 4) The core consists of a number of subjects or fields of knowledge which are unified or fused. Usually one subject or field serves as the unifying center. 5) The core consists of broad, preplanned problem areas, from which are selected learning experiences in terms of psychological and societal needs, problems, and interests of student. 6) The core consists of broad units of work, or activities, planned by the teacher and students in terms of needs as perceived by the group. No basic curriculum is set up."

Obviously, there is significant latitude regarding the definition of core programs or core curricula. The first three program designs described by Alberty represent slightly different approaches to subject matter organization. Only programs 4, 5, and 6 differ to any obvious extent from a basic subject matter orientation.

Educators agree that core programs should have several important characteristics and advantages. First, they should attempt to promote a greater integration of learning by unifying subject matter. Secondly, they should attempt to focus on problems that are real and that have meaning. This form of organization provides an opportunity to use problem solving techniques. Thirdly, they should attempt to unify subjects, thus providing greater flexibility in terms of time and instructional methods.

Combining subjects is not the only method of integrating learning. Much in the way of integration can be accomplished by developing within students more consistent patterns of thinking, stressing broad concepts that are shared by more specialized subjects, and assisting students in developing a consistent approach to understanding the ways in which these concepts are used in these more specialized disciplines.

In general education, and I think the same is true in professional education, core programs present some real difficulties that may account for the relatively slow spread of this type of curriculum organization. I am not speaking of the current vogue in dental education to refer to any conglomerate of courses as a core, but about difficulties in the use of more complex core programs as we have described them. Integrated thinking by a team of subject matter specialists poses a real challenge. Departmental lines and barriers must be crossed and this necessity requires a reorientation in the focus of teaching that some content specialists are either unwilling or find it impossible to accomplish.

Planning procedures commonly employed in curriculum development are not usually designed to overcome this difficulty. Because of these difficulties, attempts at integrating learning around broad, unified areas represent at best a patchwork of existing content. "Combining subjects instead of integrating ideas is the rule rather than the exception."[3] In the process of combining, one subject may dominate. "New relationships between fields are thus developed at the price of overlooking the essential principles or thought forms essential in a discipline.

It is no wonder, then, that a great many core programs can be more accurately described by their time arrangements in scheduling than by the substance of the content or type of content organization."[3] Too frequently, core programs consist of the replacement of poorly organized subjects with something that has no organization at all.

Core curricula or programs that represent more than mere subject matter organization require teachers with special skills that are compatible with the plan. Most subject matter specialists, and that would include the majority of dental educators, should have the assistance of professionals from the field of general education in order to organize meaningful core programs. A number of dental schools are developing departments of educational resources staffed by educational psychologists, social scientists, method specialists, systems analysts, programmers, production technicians, and other support personnel. This team of specialists work with other members of the faculty in developing the best organizational pattern and mode of instruction for various subject matter areas.

An example of a core program which represents basically subject matter organization is offered by Dean Harry Blechman[4] of New York University's School of Dentistry, in describing speciality education for endodontists. He refers to three groups of courses in the curriculum: The core group, the required group, and the elective group. The core group of courses are common to the education of all specialty candidates. Included are gross anatomy, histology, biochemistry, physiology, pharmacology, pathology, microbiology, biometrics, epidemiology, and research methods, and clinical pathology and medicine. The terms core is used in this instance merely to designate a group of individual courses appropriate to all students engaged in specialty education.

The proposed organization of the curriculum for the new School of Dentistry at the State University of New York at Stony Brook offers an example of a more integrated or unified approach to the organization of core programs. "In this course of study each student will receive a core of pertinent education in the fundamental natural, social, and behavioral sciences with special emphasis on the mastery of concepts, but without undue stress on the memorization of rapidly-forgotten detail. In this core each student will also gain familiarity in those clinical disciplines common to all aspects of patient care. Extensive experience will be provided in the detection, treatment and prevention of disease in the oral cavity. These portions of the curriculum will constitute a common core required of all students. It will extend over a period of twenty-four months and will be most heavily concentrated in the early parts of the program. Eighteen months of elective study with distributional requirements will be designed to round out each student's basic predoctoral professional education in a way that will be congruent with his individual needs and with the emergence of his future career goals. The distribution by area and approximate period of study will be as follows:

Core studies	24 months,	3360 hours
Non-clinical core	11 months,	1540 hours
Clinical core	13 months,	1540 hours
Elective studies	18 months,	2520 hours
Non-clinical core	6 months,	840 hours
Clinical core	6 months,	840 hours
Unspecified	6 months,	840 hours
Total predoctoral curriculum	24 months,	5880 hours."[5]

In this curriculum the first 24 months will be comprised of a non-clinical core of 11 months and a clinical core of 13 months while 12 of the last 18 months will be equally divided between non-clinical and clinical core programs.

The development of effective core programs cannot always be accomplished easily or, if accomplished, adequately controlled. Basic science departments develop attitudes towards teaching and research that are sometimes incompatible with learning. Also, basic science departments, particularly those within schools of medicine, develop commitments to medical education that relegate the teaching of dental students to a secondary position. It is for these reasons and others, that some dental schools have organized core programs that provide basic science instruction at the introductory level. Students interested in pursuing one or more of the sciences in greater depth have access to the medical departments. In a number of schools, departments of oral biology assume the responsibility for the organization and presentation of a significant portion of the basic program. The organization and control of the basic science departments in an important consideration in the development of core programs.

In summary, I have attempted to give some perspective to the matter of curriculum organization that will be helpful in the implementation of contemporary biology in the dental curriculum. I know of no perfect solution, but I am encouraged by the amount of experimentation that is currently taking place in an attempt to provide more relevant learning experiences for our students.

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DEPARTMENTS OF ORAL BIOLOGY;

THEIR ROLE AND POSITION IN CORE CURRICULUM

Arnold Tamarin:

Leo Sreebny:

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The convocation of this symposium is witness to the fact that biology has an important place in dental education. Yet, if we were to present our concept of "oral" biology as a specialized field, there would be no unified definition upon which we would all agree. In fact, many of us would admit that there is a certain amount of vagueness in our concept and that we are not completely sure whether the term "ORAL BIOLOGY" can have any definitive meaning such as the terms "anatomy" "pathology", or "physiology". Because of this uncertainty we may hesitate to justify a definition of oral biology as a proper noun or as a formal discipline. In spite of this, the term oral biology has become an accepted phrase: It is a topic of major concern in dental education and has achieved status as the formal title for autonomous departments in many dental schools. We hope to clarify this seeming paradox by demonstrating the origins of oral biology and its role in the core curriculum within schools of dentistry.

Biology is the study of living things through the application of the methods and facts of basic science. Health science is that part of biology directly devoted to the enhancement of human life by preventing or treating disease, injury and pain. Dentistry is a specialization within the health sciences which functions through its specialized knowledge of the masticatory apparatus and its related problems. Oral Biology is that aspect of dental education which synthesizes, integrates and communicates the pertinent aspects of basic biology as a rational foundation for the exercise of dental diagnosis and treatment. In this sense, oral biology is the exclusive domain of no single department or individual, but rather is an attitude concerning the methods and goals of dental education as a whole.

The development of oral biology as an identifiable area in dental education is the result of the exponential growth of all biologic science since the late 1940's. It represents a defacto recognition that fundamental areas in biology have become so diverse and specialized that "keeping up" and integrating the new knowledge into the dental curriculum is a full-time job. Its role in research and graduate training is inseparable from its obligations to the undergraduate program and to the practice of dentistry because it actively participates in the creation of new knowledge that is taught to dental students and is used by dental practitioners.

All the foregoing would be mere platitude if we were unable to demonstrate substantive examples wherein departments of oral biology (by whatever title) affect dental education. For this purpose we will relate some experiences at the University of Washington, which, despite some unique problems, are probably representative of experiences encouraged at many dental schools. Initially, as the Department of Oral Pathology, our primary responsibility entailed the presentation of etiology pathogenesis, morbid morphology, and differential diagnosis based on clinical signs and symptoms. It soon became apparent that we were taking for granted a certain amount of integrative sophistication on the part of our students which was, in fact, unwarranted. Although they already had formal exposure to basic sciences such as anatomy, general histology, oral histology and embryology, physiology and biochemistry, many of these subjects had not been presented in terms of their applicability to the specialized problems of dentistry. As a result, the relevance of the subject to the dental curriculum had eluded many students. It became apparent that because of our background as dentists actively involved in basic research, we had the opportunity to act as the link between basic science and clinical subjects. It also became apparent that courses such as oral histology and embryology were courses ideally suited for the integration of concepts in basic and clinical science and, as such, could serve a mechanism to help students make the intellectual transition from basic biology to the biology of the mouth and related phenomena. By including oral histology and embryology, the scope of our department was widened, not only in terms of our student contact hours and the related teaching responsibilities, but it provided the opportunity to expand upon the actual material covered by these courses. For example, it was now possible to delve into the ultrastructural organization of mineralized tissues and to show the implications in respect to the pathogenesis of caries, it was easier to relate submicroscopic form to growth and function, and to demonstrate the implication of such factors in respect to chemical and physical parameters in the clinical treatment of teeth.

Our expanded course responsibilities made it convenient to shift certain kinds of subject material into more logical sequences which effectively fortify the student's understanding of basic principles and the relevance to clinical problems. Anomalous tooth form and calcification are presented as part of the discussion of tooth development, and congenital malformations are analyzed in terms of the embryogenesis of the head and neck. The examples just given are obvious relationships between histology, embryology and pathology. This is no radical departure from traditional presentations of this material, but it does demonstrate how topics in basic biology can be integrated with topics of direct clinical significance. In our experience this integration also takes place on another level; that is, by the greater personal contact made with the basic science faculty. Members of our own department as well as some members of clinical departments who have a special background in biology participate in the teaching of courses such as physiology, anatomy, general pathology and pharmacology. Here, the interchange of attitudes and ideas concerning the goals of curriculum result in a greater use of pertinent clinical examples by the basic science faculty, and a greater sensitivity on the part of the dental school faculty concerning the biologic basis for clinical procedures. One evolutionary result of our expanded responsibility and interaction with other departments was the recognition of the need for special courses on specific subjects such as caries and biomineralization.

As indicated previously, research and graduate training have a profound effect on the role of a department in respect to undergraduate teaching. It would be no overstatement to suggest that in the absence of a graduate and research program, a really strong program in undergraduate oral biology is impossible. Direct involvement with graduate teaching and research enables the teacher of undergraduate students to maintain currency in the material presented and to make better estimates of the areas in research which are most likely to have an effect on clinical science in the future. This suggests another role for oral biology which is not immediately apparent, but which is not trivial; to prepare today's dental student for the advances which will affect the execution of his responsibilities tomorrow. From a clinical standpoint this probably has its greatest impact in the area of preventive measures which results from the understanding of the etiology of dental diseases and of how dental tissues interact with the intraoral environment. The presentation of such subjects in a complete and accurate manner entails a sound background in the basic sciences as applied to the particular conditions of the mounth, i.e., Oral Biology.

As our departmental horizon widened in respect to undergraduate, graduate and research responsibilities it became clear that we were, in fact, representing much more than the term "oral pathology" would indicate. In this light it seemed appropriate to change the name of the department to "Oral Biology."

In some dental programs, it may be appropriate to develop courses in oral biology over and above the specific obligatory courses. We are in the process of developing such a course with the intention of making it an elective to advanced undergraduate and graduate students. The overall objective of this course is to imbue the student with an appreciation for the relationship of Stomatology to biologic science in general. The course will be designed to present a general background of relevant biologic principles; to develop particular subjects in depth; and to synthesize these in terms of special problems related to dentistry. The following sequence of topics presents one possible approach to such a course.

1. The evolution of hard tissues; bone, cementum, dentin, enamel.
2. The role of teeth in vertebrate evolution; emphasis on human tooth form.
3. The comparative anatomy of the jaws; emphasis on T.M.J. and occlusion.
4. The comparative anatomy of the suspensory apparatus.
5. The biophysics and biochemistry of calcium-hydroxyapatite.
6. The biophysics and biochemistry of collagen.
7. Biomineralization; various systems in the animal kingdom with emphasis on vertebrates.
8. Endocrine interactions with dental-oral tissues; with emphasis on mineral metabolism and soft tissue tone.
9. The biophysics and biochemistry of keratin.
10. Tissue permeability and transfer phenomena; hard and soft tissues.
11. Bioadhesives; general considerations in the animal kingdom (e.g. barnacles and mussels) with special emphasis on vertebrate tissues (e.g. epitheliodental junction, the acquired dental cuticle, cell to cell adhesion, etc.)
12. The biophysics and biochemistry of olfaction and gustation.
13. The oral cavity as an eco-system

    a. the biophysics and biochemistry of saliva
    b. the microbiota and their products
    c. tissue response, inflammation and immunity
    d. interaction of teeth and paramasticatory structures

14. Nutrition; effects on oral health, dependency on oral health.
15. The oral cavity in respect to mastication, deglutition and digestion.
16. The oral cavity in respect to speech.
17. Biomechanics of oral tissues.

It becomes apparent that oral biology develops as a multidisciplinary program. It would be presumptuous to suggest that one department would include experts in all the pertinent areas, but the inclusion of specialists from any given area has an effect on the thought processes of an entire organization and significantly expands its teaching potential. It is not too difficult to prevail on experts from other parts of a university to present special topics as seminars or single lectures, but acquiring bonafide additions to a department is a different matter. The question arises as to whether only people with a dental background are properly prepared to expound oral biology. From the standpoint of first organizing a department with direct commitments to the dental curriculum: The answer would be a qualified "yes". But as a department develops and as its place in the dental program becomes clarified, personnel will be included strictly on the basis of how well their special talents compliment the needs of the department. In an ongoing oral biology program, the non-dental colleague will become integrated and will make valuable contributions on an academic level as well as to research projects. We would venture that as an oral biology department matures, it needs non-dental people as insurance against parochialism.

Ideally, it would be most logical to follow a premeditated plan as to which areas need expansion and to enlist or develop people to serve this need. However, it could happen by serendipity. Here is a case in point: One of us attended a meeting in New England and in casual conversation discovered that a major institution with a graduate program in Nutritional Biochemistry was about to graduate a new Ph.D. who also had a dental degree. He was interviewed, and he accepted recruitment into our department because of his desire to continue research in nutrition. Through him we became more sensitive to the importance of nutrition as a special subject deserving attention in the Dental School. A course outline was formulated and submitted to the Curriculum Committee as an official proposal for the undergraduate program. The initial outline was rejected as being too esoteric, but the proposal itself was received with enthusiasm. A broad committee was appointed to formulate an outline which would represent the concerns of all departments in respect to nutritition and by consensus a new course was added to the curriculum. This story provides a number of lessons: An alert staff will recognize opportunities for recruiting good new people; the presence of research facilities attracts potentially important new members to the teaching staff; the addition of new members can sensitize the residence staff to important omissions in the existing program; an aware nucleus of people can prevail upon the decision-making body to recognize the need for alterations in curriculum; a progressive faculty will act to effectuate valid new ideas in education. This story also suggests some pitfalls: We tend to become stale in our attitudes unless we are exposed to outside ideas; we may over-emphasize the basic science of a subject at the expense of concordance with the overall program. We don't imply that it is possible or even desirable to continually provide clinical correlations to basic science subjects, but as the part of the dental program which stands between the clinical and basic sciences, Oral Biology has the obligation to make scientific knowledge relevant to the dental curriculum as a whole.

As with other phenomena, it appears that after Oral Biology reaches a certain critical mass, its attraction for new talent and its reaction with dental curriculum becomes rather profound. This occurs directly, as indicated previously, and indirectly by providing an example which encourages other departments to think along scientific lines and to develop research programs which reflect their own interests. This has an effect on the approach to teaching because it tends to place more emphasis on causal relationships in clinical methodology. This, after all, is the basis for rational therapy.

In professional schools, the difference between training and education is often lost sight of. These two processes are not mutually exclusive but the latter is often inadvertently down-graded in the promotion of the former. Dental Schools are particulary prone to this because of the necessarily great emphasis placed on manual skills. As greater emphasis is placed on preventive and curative aspects of Dentistry, the neglect of education becomes increasingly untenable. Leonardo DaVinci is credited with the simile that "He who loves practice without theory is like a seafarer boarding the ship without wheel or compass and knows not whither he travels." An adequate foundation in biologic science is the wheel and compass of dental education.

ELECTIVE TIME AND INDIVIDUALIZED INSTRUCTION IN THE DENTAL CURRICULUM

Donald S. Strachan:

Elective time and individualized education concern us today. At the most recent American Association of Dental Schools meeting, a resolution was passed stating that "dental schools continue to study and revise their curriculums to accommodate the different needs and abilities of students and the needs of society." The acceptability of advanced placement was acknowledged. The Academic Affairs Committee of this group recommended that "a program of elective courses be developed within each dental school curriculum." These electives should cover a wide range of subjects and not be limited to basic and clinical sciences. Where feasible dental students should be offered courses in literature, arts, behavioral sciences and the humanities. These courses would be taken in undergraduate schools rather than the dental school.[1]

Of more importance are the results of a detailed questionnaire covering the special report and recommendations of The Carnegie Commission on Higher Education (CCR) concerning policies for Medical and Dental Education. This questionnaire was sent to deans of developing and operating dental schools and directors of associate member educational institutions of the American Association of Dental Schools. In response to CCR recommendations 75% agreed that a larger portion of the dental curriculum should be elective while 95% agreed that there should be more opportunity for independent study and instruction.[2]

Therefore we have clear documentation endorsing the concepts of individualized instruction and elective time from our fellow educators and from a national commission.

For those who might ask "What is individualized instruction?" the answer is simply that it means working, learning, and progressing toward properly defined educational objectives and goals on an individual basis. Everyone would be able to accomplish the stated objectives but on an individual basis. (Note that this does not define the method or technique of instruction.)

Elective time is the time in the curriculum spent working and learning toward different goals and expertise. This definition does not rule out increased experience in areas that already are components of the dental curriculum, nor does this term define the method or technic of instruction. Elective time could be on an individualized basis.

We can identify these groups of candidates for elective experiences:

1) The preempted student

2) Exceptional students

3) Everyone

We might ask of the preempted student, "Does he have credit or sufficient background in biochemistry or physiology? Does he have competency by being a former dental lab technician, army dental assistant, dental hygienist?" By pretesting we will be able to identify these students.

It is a known fact that exceptional students require added challenge and stimulation to develop their intellectual potential to the fullest degree. In fact some exceptional students may wish to work on an advanced degree.

By including everyone in the elective program we would encourage the dental student to maintain, develop, or acquire interests in disciplines not necessarily directly related to his professional education in dentistry. These experiences would provide for satisfaction of the individual students intellectual needs.

Another reason to include elective time would be to encourage every student to develop further his sense of responsibility and obligation to the profession, the community, and society at large. We want to provide each student with the mechanism which will permit him to test his ideas, interests, and perceptions to the potential of his ability; to exercise his intellect in a more resilient academic environment; to pursue and evaluate his professional and personal aspirations in a larger context with greater insight.

Actually elective time is not a new phenomena to many medical and dental curricula. Today, however, there is an increased emphasis and an additional commitment of time in new dental curricula for these experiences. What kinds of experiences would be considered to be elective time?

Many of our students have had research experience in dental school, and certainly we would consider this as an elective time experience. Advanced clinical work and graduate level courses in specialty areas could be included. Many other courses, seminars and conferences could be offered to the student on an elective basis. To give you a general view, some of the elective time courses for the new dental curriculum offered by the dental faculty at The University of Michigan include: Field Studies in Dental Anthropology; Orientation to Research Techniques;

Psychology of Learning; Introduction to Computers and Computer Programming Techniques; Health Education in the Community; Introduction to Medical Sociology; Psychosocial Basis of Health Programs; Rehabilitation of Children with Oral Clefts; Special Laboratory Project in Dental Materials. These and many other kinds of elective experiences would fulfill our philosophical goals for elective time in the dental curriculum. The concept of elective time is not a new one, but it is one of increased emphasis and commitment for increased time for these elective experiences. As mentioned before the description of elective time does not define the method of presentation. Elective time could be given on an individual instructional basis.

Individualized instruction has been used for years in preclinical and clinical instruction and basic science laboratory instruction. As you know, individualized instruction through personal contact is a most demanding, routine and many times an ineffective method of instruction. Individualized instruction should not be a laissez-faire type of instruction, but, in fact, should require regular routine evaluation and well-defined goals. Self instruction by automated means is definitely one of the more promising methods of individualized instruction. Self-instructional media can relieve the faculty from regular and routine evaluating and checking and does allow for more time for positive interplay between faculty and student on interpretation, implications, critical evaluation and clinical significance.

Many examples of the effectiveness of self-instructional materials for individualized instruction are documented in the educational literature. Recent examples of this are:

> Dr. James L. Conklin of The University of Michigan Anatomy Department showed that students using self-instructional material in an embryology course for medical students performed better than in the conventional teaching program. Of significance was the fact that these students used less than one-half the laboratory time in attaining these proficiencies compared to the other students on the conventional teaching program. (He now has developed self-instructional units in histology and organology which he is now evaluating).[3]
>
> In June 1971, the University of Kentucky conference on the "Exchange of Instructional Materials" was held in which there were 46 different table clinics demonstrating self-instruction, computer assisted instruction and evaluation. All of these were dentally oriented and practically all were available in an individualized instruction format.[4]
>
> In a high cost area of instruction (as in dentistry), Frank Giunti, associated with the Army Signal Corps at Fort Monmouth, New Jersey, showed the distinct advantages for using computer assisted

> instruction for individualized instruction. The trainee is taught to repair and use electronic equipment. These are actual performance and manual skill experiences. Students in the conventional teaching program suffered a high failure rate and all required approximately 42 hours to finish the course. With CAI (individualized instruction with the computer) the failure rate was less than half and the average time to completion was 12 hours less. Everyone completed the practical exercises and the attitudes were very positive with CAI. Of additional interest is the fact that with this form of individualized instruction, the failure rate was less than predicted for the low aptitude student.[5]

To gain the fullest advantage of individualized instruction we should have a curriculum based on performance, not time. The term ability can be defined as, "the amount of time to learn a skill to the desired level of competency." The higher ability students learn the material in the fastest amount of time. We do have differing levels of abilities in our students, in fact, we have a wide range of abilities. We have a broader range with the acceptance of the educationally disadvantaged students in the dental school, individualized instruction offers us the opportunity to deal with this broader spectrum of students and abilities.

In the development of individualized instruction, one is almost forced into an analysis of educational strategies. First and foremost we must know when the student has reached the goal and when he has met the educational objectives of the course. The student must know what these goals are. If the student meets these objectives quickly, we should not increase the goals arbitrarily. We must know when to apply incentive and when to cease pushing.

We should not expect perfect accomplishment of all our goals at the first experience. The student needs practice; he needs to evaluate his progress if he is to accomplish the objectives. He should be allowed the priviledge to fail and to recover and evaluate his mistakes.

One hears from conscientious faculty statements such as: "I want the student to learn as much as possible in my course." "A student cannot fail to gain from all the scheduled time in my discipline." These statements sound very desirable, but they present nebulous goals to the student with no finality and with a lack of sense of accomplishment. We should be able to set a realistic goal for the student, and it should be a goal to challenge him.

Once reaching the goal he may or may not elect to proceed to further study in this discipline. The faculty should be aware that their ego is involved and should take care that the goals and objectives meet the criteria set for the over-all dental curriculum and not only for their own discipline.

We should pre-test the student. Does he have the prerequisites? If not, we should design remedial work for him. Does he know part of the material? If so, we should excuse him or offer him other alternatives as electives. In some cases he may know all of the material and have already met the goals. In this case he should be excused from the course.

It would be appropriate, but is not always possible, to have different kinds of learning activities. Some students learn better with different approaches.

Individualized instruction benefits from self-tests. These tests should be non-puntitive and enable the student to self-evaluate his progress. If he is deficient, immediate feedback helps him so that he can restudy or recycle his information. Then on an individual basis he could repeat the self-evaluative tests.

We should have a post-test or a final test to determine if the student is proficient. This test would give not only a grade but also would establish the minimum performance level for the student. Again, remedial work or recycling is possible with an individualized program. If the student desires additional experiences in an area of study a prescription for future work should be available. Or, as Mager would say, does he still have approach tendencies? Can we offer him additional experiences if he desires? Is he turned off or on? Does he ever approach or study the subject again?[6]

There should be long term evaluation of the overall effectiveness of the program extending to performance after graduation.

Using educational strategies discussed above, individualized instruction becomes efficient and meaningful. Individualized instruction is best suited on a curriculum based on performance, not time. We should set measureable objectives, pre-test and, if possible, offer different learning activities. The student should be able to self-evaluate himself with immediate feedback. A post-test should be available not just to establish a grade but to establish a minimum performance level. We should have approach tendencies and an evaluation of the overall effectiveness of the program.

What are some of the approaches or techniques for successfully achieving individualized instruction? We need a comprehensive analysis of content. Besides knowing what we teach, we should make decisions on the worthiness and usefulness of what we teach. The term relevancy is used many times. Building instructional modules or minicourses is one appropriate pathway to success. Drs. Postlethwaite and Russell at Purdue University analyzed the content and established several minicourses in botany and zoology. They found that there was over-lap in certain subjects such as mitosis, oxidative phosphorylation, membrane transport. Students arriving at these courses with knowledge of these areas would not be required to take them.[7] In the dental curriculum are there analogous situations? We found that fusion of the palate was covered in four separate courses: Cranial facial growth, histology, oral histology and pathology.

If our courses were organized in a modular manner, it would allow for individualized instruction, eliminate unplanned repetition, allow for planned repetition and enable us to discover areas not covered in the curriculum.

We could excuse students from parts of the course in which they had previous competency. This would allow the slow learner to proceed at his own pace and allow the student who fails only parts of the course to go back and repeat only those deficiencies.

There are two other real advantages that come to mind when looking at the modular approach. Our experience in a course in oral histology on the development of twenty-five slide tapes, each on a single modular concept, has allowed us to reduce the actual time in presentation of materials. For example, a lecture previously requiring over thirty minutes on the tonsils has now been reduced to twelve minutes. The information now is presented on a slide tape in a self-instructional form.[8] In the development of individualized instruction, going through the educational strategies of defining objectives, et cetera, we find a distinct savings in time and better organization of the material.

Another advantage, one that will enable us to implement these modular systems, is that an analysis of the commonality of curriculi for students in all the health sciences will result in a cost benefit that can occur with the use of modular systems. There are increasing demands on basic science departments to teach additional allied health personnel. Basic science departments are now teaching dental students, medical students, nurses, dental hygienists, medical technologists, physical therapists and graduate students are feeling the strain. Several of our content modules would be applicable to all these health trainees.

In the development of modular units for dental education, we must have media sharing. The cost for each school to develop all its own self-instructional units is prohibitive. Protectionist and provincial attitudes in sharing should be examined and, if possible, eliminated. By sharing these educational resources we should find that a commonality of course content will occur. Federal funds have been used in the development of much of the media and the testing and sharing of this material should be implemented immediately. Regional centers for the development, funding, review and dissemination of self-instructional materials may be the logical solution for the future.

If we had courses on a self-instructional modular basis, a student could proceed at his own pace and complete the program when he has completed all the modules. The practicality of this in the next few years is questionable. We need time to develop the individualized modular packages. An Ohio State Medical School in the Pilot Medical School, an attempt is being made to approach Medical Education in that manner. They are using a computer to manage the system and to document the progress for each student. Any of the 32 students enrolled in this program may have completed a different number of the instructional modules at any one time.[9] It is a program that deserves careful observation for future program development in individualized education in dentistry.

Individualized instruction is compatible with the educational strategies of the basic scientist. We have in many cases working with basic scientists defined our objectives more clearly and have improved our teaching methodology in both philosophy and practice.

A serious dilemma is created when reductions in clock hours have been made in basic science and these hours are arbitrarily assigned to clinical areas which have no defined or poorly defined educational objectives.

Basic scientists have done an excellent job in teaching and will continue to do so in the future. In conclusion the overall problem is as follows:

1. There has been a reduction in time allocated to basic sciences in the dental curriculum.

2. There has been an increase in basic science information. (Information explosion)

3. There is the obligation to produce a graduate in less time (with equal competency).

A possible solution is proposed as follows:

1. An analysis of content and evaluation of the worthiness of the content in relationship to the overall dental curriculum and objectives.

2. The setting of operational objectives and goals.

3. The use of individualized instruction based on educational

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DISCUSSION - SESSION IV

Question: To what extent have current changes in curriculum influenced the criteria for admission to the dental school? Have the social characteristics of the present generation of dental students had an affect on curriculum?

Dr. Doerr: In answer to the first question, I do not think that they probably have influenced them as much as I believe they should. I do believe that as you talk with Admissions people across the country and Donald will probably want to comment on this also, there is a greater realization of the heterogeneity of students. As we develop individualized instruction to a more significant point I think we will be able to accommodate students who come to us with these individual differences. I am sure the position taken by the Council on Dental Education has influenced most Admissions Committees so that they are not as rigid and inflexible in the actual enforcement of preprofessional requirements.

With respect to the second question, there have not been any characteristic studies recently that I know of. I would suspect that we again are getting a greater difference within the students we admit than before. In other words, I think we are getting a greater heterogeneity and I expect this to appreciably increase. We seem to have greater polarity in our dental classes than we have had before. I think the impact on the dental curriculum is the rather vocal demand on the part of a significantly increasing body of students for community kinds of experience, for community practice schemes of one type or another. I think we have a group of students that on the whole is much more idealistic than the group of students we have dealt with in the past. To further complicate the picture, we also have some students who are perhaps more irresponsible than students have been in the past and this causes, or perhaps represents, the polarity that I mentioned. Perhaps the other two panelists would like to comment on these questions.

Dr. Strachan: Today students expect more from us as to changes in education and methodology. They are being exposed to these changes continuously in high schools and colleges and are going to pressure us into change. They are speaking it out. They have had these feelings before; but now they are actually saying it.

Dr. Doerr: I think students come to us without the hang ups that many of us had when we approached our formal education. They have been taught to question, they have exercised that prerogative throughout their elementary, secondary and collegiate schooling. It is only natural that they bring that experience to the professional school.

Dr. Strachan: Let me clarify that point also. The presentation of the instructional material can be done in a self-instructional manner and one method we use is the synchronized slide-tape. But what has it done for us? It has expanded the time that we get to talk with the students about their individual learning problems, to do the motivational things one wants to do, to expose the student to some current research. The routine day to day one-way transmission of information of the identification of histology can be done in a self-instructional manner. It is not the presentation of the material as we did before. We tell the student what we are going to tell him, we tell it to him and quiz him on it and it makes, I think, an effective package. But do not get away from the student by using a canned production. We all know how to give a 40 minute lecture and then spend maybe 10 minutes with questions from the students, finding out you are wrong in some place or left something out or something was confusing. Would not it be better if that lecture was 20 minutes and one had half an hour to do the kind of interplay that is necessary to clarify the content? So, it is a different approach. It does not relieve any faculty member of any kind of responsibility, nor does it depersonalize education.

Dr. Doerr: I just want to make two observations. I think it is obvious that it does cast the teacher in a different role. I also believe that the teacher perhaps is quite uncomfortable in this role and there needs to be some retraining and inservice opportunities for this teacher to adapt to the different kind of role that he or she will play. I think it is much analogous to the general practitioner who all of a sudden encounters expanded duties or expanded auxiliary function concept. He does not really know what to do. You hear so many practitioners say, 'what do you expect me to do?, stand around and twiddle my thumbs if I delegate all these duties?' I think the teacher who has traditionally been lecture and classroom oriented frequently experiences this same kind of panic.

The other observation is really a word of caution. The development of programmed material, regardless of the format, is a disturbingly slow process. It takes a lot of time and I think it may have one of the disadvantages that the development of motion pictures has; when you have invested time and dollars in the development of a film you are reluctant to rework it and keep it current. I think there must be an awareness that as we go more and more into the development of various kinds of programmed learning, the knowledge explosion requires a constant effort on our part in order to keep materials up to date.

Dr. Seibert: I have a request here also. Dr. Jacobs would like to make a comment and the floor is his.

Dr. Jacobs: Thank you. I would like to expand on some of the very exciting comments made by our three speakers. As we all know, implementation of a new curriculum or even changing curriculum organization is, as a rule, very difficult; let me share with you some observations on this subject. As Bob Doerr told us today, a vertical reorganization or our curricula would be quite desirable but it appears to me that before a vertical curriculum can be implemented, faculty has to face up to the problem of prerequisites which, traditionally, are greatly responsible for imposing curricular rigidity. For example, when you talk to the faculty in the department of physiology they will probably tell you that students need biochemistry before taking physiology, and similarly, the clinical faculty, as a rule, will identify a whole battery of prerequisites which, supposedly, students must have satisfied before entering the clinics. This, of course destroys the concept of vertical curriculum. I would like to suggest that our approach to prerequisites be radically revamped. It seems to me that we must (1) depart from our system of vague and broad prerequisites which are routinely described in terms of departmental subject matter, and (2) replace these broad prerequisites with a description of specific knowledge, skills and attitudes--stated in behavioral terms--that students must possess before entering a given course. Such specific task-oriented "mini-requirements", which, by the way, could be satisfied either through "mini-courses" or by means of various self-instructional materials, not only would enhance a vertical organization of our curricula but would add to their overall flexibility and pedagogical soundness. Of course, one might expect that some college administrators would oppose such curricular changes on the basis that they would undermine the "regular" semester-oriented scheduling of courses and staff.

Dr. Seibert: I think there is another advantage to the mini-course idea too. It related to what Don was saying about the exchange of good instructional materials. Some effort has been underway for 10 or 15 years in a variety of fields to achieve a fairly liberal exchange of teaching materials and yet not much really has resulted. However, the bits of success that there are can be at least partly attributed to the fact that what people are exchanging is primarily on the mini-course level. For example, I would not take your full or intact course in whatever-it-is. That would be an awful commitment and it would be quite an admission for me to make to adopt such a large package. But I am willing to make the kind of minimal adoption that is required when you present me a good brief segment of something which I am already trying to teach. It won't hurt me much to acknowledge that you have done it better than I, and perhaps better than I ever can. I think educators have begun now to program in these smaller segments and to sequence or cycle students through many segments, monitoring the students progress closely on each specific proficiency and skill area. Also, I think the mini-course or small segment idea has the practical advantage of hastening the day when we can freely exchange good materials and share the wealth they represent.

Dr. Strachan: When we talk about sharing materials we are going to have to have some common objectives. Let me tell you of one interesting experience that relates to the communality of objectives. In a request to the anatomy departments of the country asking for multiple choice, true and false and fill in questions in histology, answers were received from about 30 or 40 schools. The object was to build a data bank of questions and access the questions from a computer terminal so the student could self-evaluate his performance. But everybody says they teach differently or that the course content differs between schools. There may be some individual differences, e.g., one school teaches the history of anatomy in some detail, however this information cannot be justified as to the objectives of the dental curriculum. But, overall, the content of these examinations is the same. Also, they are all of a high level. What we want to do is to present the content in a compact package and get it to the students. Then with the time saved, we will use this time to impress upon the student other goals such as motivation, philosophy, and just contact with them personally. We must have time to do that. If you are teaching histology the courses are practically identical. They are only different in the reflection of the personality of that person or in what his research interests may be.

Question: In reference to the work relevance, I have the feeling that it is used synonomously with reduction in teaching of basic sciences. Would you like to comment whether to make basic sciences more relevant, we need more or less basic sciences instruction?

Dr. Strachan: In many new dental curricula, reductions in time have been made in the basic sciences. There are other areas in the dental curriculum that deserve as much consideration. If the other areas will do the same kind of critical evaluation of content, analysis of teaching methodology and improvement in delivery of information, then reductions can be made in these areas also.

Dr. Tamarin: I think I would discuss that question in a different context. In fact the other night Seong and I were talking somewhat to this point. In my opinion the question of relevance is not a question of reducing and reducing to an absurd level. I would like to ask whether we are able to analyse objectively the ingredients of intuition and clinical ability in terms of the really good doctor. I mean this in the sense of developing insights into his response to his patients where consciously or subconsciously he reaches back into a wealth of information, that he either remembers objectively or otherwise, to make the kinds of judgments or evaluations that make him a better doctor than the next guy. My own feeling about this is, and I will probably get clobbered for this, that this is not only related to a rather full schedule of a professional school curriculum, but probably goes back to the predental curriculum and the attitude towards knowledge in general. I probably did not answer the question but I feel that it is the method of delivery that has to be improved. If it can be done in a shorter period of time so that we can expand in other areas, fine. But the reduction of time to my mind should not imply a reduction of the material that people are responsible for.

Dr. Doerr: I do not know that I have too much to add. I certainly do not agree that relevance is related in any way to reduction of time. The relevance we are talking about is meaningfulness, or making the subject area more meaningful to the student. This might actually mean an increase in the amount of time that is devoted to a basic science. I think, along the lines that Arnold was talking, I feel very strongly that we have not asked the skilled practitioner to participate sufficiently in the development of objectives for teaching the basic sciences. We have not allowed them to interpret this need, really. In our own curricular experience where we reduced the amount of time in the basic sciences, we more than compensated by adding oral sciences in an attempt to make the sciences more meaningful. We are teaching more basic science than the medical school has in its curriculum. I think this means that we have to look more closely and have to redo the content analysis that we did originally and try to involve the practitioner of dentistry, the clinician.

Question: I would like to hear the arguments against placing electives in the senior year.

Dr. Strachan: If only electives were taken the last three or four months, there is no reason why that instead we should graduate that student at that time. Electives should be throughout the curriculum. If, during the senior year a student has competencies in all levels and he wants to do graduate work, we should allow him to do that. Once the student has come to a point in time where he has perceived and accomplished all the goals of the usual dental curriculum we should let him go.

Dr. Tamarin: I would like to suggest that the exceptional advanced student who has fulfilled his obligations, perhaps in some ways, is one of the best teachers. He could be used in terms of helping students that are not as advanced; in his own class or with under classmen. The cause of "hang ups" that inhibit breaking through and achieving, are probably better understood by the student than by us.

Dr. Strachan: We are coming up now to a point in time that I think we can start measuring clinic competency in the clinic, we happen to be using a computer to do it. On a broader administrative basis having a director of clinics, having people who have responsibility to monitoring the overall progress of the student, we can find that some nice strategies that can be employed. If the student needs more time in one area than another, this can be done. But we have to have some way of deciding earlier not just at graduation whether that student has achieved all the proficiencies in all departments. I think we can do that now with the computer we are using and the establishment of more directors of clinics. Those same kind of techniques can be used in the computer management instruction systems throughout all didactic courses. We have our students in different areas like ward rounds, pedodontics, etc. We have 17 different schedules at different times and doing different things. We can monitor and keep track of that activity. It might be possible to do the same thing in all of the dental curriculum, if we had it broken down in the same kind of modules that the clinical areas are broken down into. The student does not have to do class I amalgam at a certain particular time. He can do it anytime, he gets credit for it and we know he has got it. So it might be possible to do something like that. We have the techniques in computer technology to do it. We do not have to worry about the measurement and monitoring of the progress of the student. Our problem is to develop the educational modules.

Question (read by Dr. Doerr): This is a statement and several questions interjected which have to do with the argument that continues to rage regarding the basic sciences. Whether or not they should be applied or whether they should be taught in the true sense of the basic science. I would deduce from the statement that the person submitting the question is of the opinion that I believe we should teach only the applied portion of the basic sciences in dentistry.

Dr. Doerr: That does not happen to be my personal belief. I believe in the educational value of the basic sciences. However, as I attempted to point out, I believe that they should be tailored especially for the needs of dental students. I do not believe that we have the luxury of sufficient time in the dental curriculum to produce both a basic scientist and a dentist. The basic science experiences that we do provide our students, or provide for their learning, should be ones that have been defined by practitioners of dentistry as being important. Certainly within this context I believe we have to consider the requirements of health professionals engaged in the comprehensive care of patients. I believe rather firmly that the half-life of information and the retention of information is such that we waste time in the dental curriculum if we give full gamut of basic sciences. The same is true in the medical curriculum as far as that is concerned. I suppose someone can take this argument and turn it by saying that I am talking only about relevance and reduction of time. I am not talking about just that. I am talking about content analysis and about the determination of the levels of learning that you wish to assign to each area of subject matter within the basic sciences. We found this to be an extremely time consuming process, but one which did have a lot of merit. Each bit of subject matter was categorized after talking with clinicians and with basic scientists, i.e., what areas should be learned in depth, what areas students should have familiarity with and what areas they should merely be exposed to. Superficial knowledge of an area could well be gained in an introductory or survey kind of experience, whereas those areas to be learned in depth, or those area in which the student should be familiar with the subject matter, would require a different type of exposure.

I do not know whether this clarifies or confuses, but we would not confine basic science instruction to just those areas of obvious relevance to dentistry. This practice would deprive students of the general knowledge needed in order to understand each discipline, in addition to the requirement of understanding the health problems related to the other areas of the body. In addition, because we may not see readily the relationship of dentistry to some areas of the general basic science does not mean that they do not exist. If those areas are not taught, their dental relevance may never be recognized or be delayed.

Dr. Strachan: Do not deceive yourselves. We are making decisions about the content to teach the dental students all the time. One can teach histochemistry to anatomy graduate students, in fact it can be a whole semester course 3 days a week including laboratory experience. Histochemistry is certainly histology. But we do not teach that much detail or information to the dental students. We are making judgments about what to teach. The question is, could we have some additional input into those decisions of what you are going to teach. Now we are talking about how and who will decide the content. We are being very naive in assuming that we are not making decisions about content. It is just a question of how those decisions are going to be made and it would be appropriate if there was some dental input. Professor Doerr mentioned that it might even be better if we got some practitioner's input into it.

Dr. Tamarin: I would essentially agree with my two friends here. But there is one point of caution that should be made. That is, we tend to take upon ourselves the entire burden of making basic science relevant to clinical practice. I would like to suggest that an equal amount of burden, if not more, is on the shoulders of the clinical faculty to make these relevancies, in fact, even to make clinical science relevant to basic science. I tend to be a little disturbed about the idea of asking the practitioner what should be taught in a basic science course. Now mind you, there should be input, but I sometimes wonder if some of our faculty should not be re-exposed to some basic science concepts. We should evaluate whether the clinical things we are doing violate any principles on a theoretical or on a scientifically practical level. If so, the clinical practice should be altered to conform to a scientifically sound rationale.

Dr. Seibert: There are several of you in the audience who are eager to get an oar in here, so let us take a few minutes at least and pick up some of these comments that people are anxious to make. Dr. Pruzansky, I think, has one.

Dr. Pruzansky: Thank you. As you know there is a considerable effort these days to reduce clinical examination forms to a format suitable for electronic data processing. We are attempting to do something with the hospital record so it is more intelligible and manageable. We find, as others have stated very well, this is not only a technical problem as much as it is a sociological problem. One has to teach clinicians to be explicit. One has to teach them to validate the information, to test it for reliability and so forth. While I know very little about programmed teaching, it seems to me, it has certain commendable attributes. It teaches people to be explicit. Does anyone know what effect this is having on the student who is now entering the clinic? Is there a carry-over of these attributes in terms of his clinical learning?

Dr. Seibert: I will make a stab at that question. I feel sure that no experience anywhere is sufficiently large for a person to answer the question fully. I would say however, that if the philosophy and methods of instructional technology are well applied you will not observe serious side effects from students. Then whether you will observe the side benefits of a more rational approach on the part of students, I would be doubtful. But still, I doubt that anyone has implemented a program with a duration long enough and sufficiently broad to provide a documented answer.

Dr. Strachan: I know of some experience at the University of Illinois Medical Center. William Harless has done some of this work. He has developed a computer program that simulates a patient. In this situation the physicians had to go through a series of steps to reach a diagnosis. They have tested the program with competent physicians from several hospitals and have had them try the program. Now they are plotting out the diagnostic strategies of these "competent" physicians to get information on the logics of the decision making process to be able to teach this student, or to be able to judge a student as he approaches those goals. Although preliminary, these techniques have much promise.

Dr. Jacobs: I don't share Dr. Tamarin's apparent uneasiness about asking the practitioners what they think should be taught in basic science courses. In fact, I believe that we should make a sincere effort to adapt all aspects of our professional curricula to the realities of the actual process of health care delivery.

The need for a drastic reassessment of our academic standards has been brought to focus by a recent study in which 80 parameters of physicians' performance were analyzed on a sample of several hundred Utah physicians. These data revealed that the employed "real-life" yardsticks of professional productivity" were virtually unrelated to medical and pre-medical grade point averages or to Medical College Admission Test Scores. This may very well suggest that professional curricula have very little relevance to professional competence and "success" after graduation.

Dr. Tamarin: I think it only goes to prove that truth is not arrived at by consensus. I do not say we should not get the opinions of people in practice, but I think we should be selective in what we choose to give credence to. One of the discussions that went on yesterday in the hallway, concerned the fact that dental schools (or dental education) seem to follow the profession, in contrast to the trend in medicine where the profession has followed the medical schools; where the innovations were being made, where the direction for the future was being created. I do not know if this is really true or not. But, I think this is one of the problems dentistry has to face to get over the feeling that we are obligated to "organized dentistry." What the practitioner envisions to be the best methods of practice, is not always adequate to meet the needs of our country.

Dr. Strachan: May I just comment to substantiate what you are saying? There is a study by John Lewis at the University of Iowa concerning liberal arts undergraduates to determine what they are doing after they have been out of school for several years. This study was especially oriented towards community activities. The results showed that the low achieving liberal arts graduates were the ones that were the most active in community affairs. Maybe there is an inverse relation between acceptable performance or some of these criteria measures that we want to use to compare dental practice and the grade point average in dental school. These ideas bother us a little bit in the admission of dental students.

____________: Maybe I am out of order in speaking today. I am not a basic scientist. I am chairman of an Operative Department. I would like to say that I have thoroughly enjoyed the last two days. I am very pleased that the oral biologists are studying the problem. I was also pleased in the comment that possibly the clinical teacher and the general practitioner should be consulted somewhat. I also agree that the general practitioner or the clinical teacher should not be asked what should be in or be taught by the oral biologist, but I do think that we must get together. Oral biologists cannot decide what should be taught without consulting with the clinical teacher and probably the general practitioner in practice. I have had the feeling, as I have listened to some of the speakers, that if some of the basic material were cut out of the dental curriculum that possibly there would be a loss of identity of the oral biologist in the faculty. My feeling is that it would be the other way around. I would like to see the oral biologists more involved in what we have been talking of the last few minutes; the relevant things, the things that we see in the clinic, the things that will happen if the student does not treat the patient correctly, and so on. I think that the only way this can be done is that we forget about the twitching of the frog muscle for instance, in the basic sciences and get right into the applied oral biology even if it means having prescribed predental programs. Thank you.

Dr. Tamarin: I agree with you 100%. I would like to say in my own situation we do get up into the clinic, although not as often as we should. But I would even like to go further and say that I would like to see more clinical people come down to the basic science departments to see what is going on since 10-20 years ago.

Dr. Jacobs: Pursuing the subject of mini-courses, do you envisage the possibility of teaching a given subject matter such as, for example, physiology, not as a semester-long course, offered, let's say, during the sophmore year, but as short mini-courses designed to have task orientation and given at various points of a vertical curriculum?

Dr. Strachan: If I understand the question, the answer is no. I do not envisage that. If it is implemented in the way they are typically intended to be, it is simply an instructional experience with some well stated instructional goals. When the student has satisfied the competency goals, there is no need for the repetition that is referred to here. Now, it may be and in good instruction I think, that there be some provision made for well what some people call a periodic review. Occasionally, at least with respect to critical competencies you will arrange to recycle quickly through them to restrengthen.

Dr. Doerr: I was just going to comment on the point that Dick Jacobs made. I think it would be possible to organize in that fashion. Actually, that type of organization is more in the concept of the spiral curriculum that was developed in general education and is now in some disrepute, primarily because it brings into focus at succeeding levels too many bits of subject matter. A student has to be concerned with too much diversity. In the vertical organization of subject matter, the objective is to have exposure throughout the curriculum.

Question: If a student is allowed to repeat just the modules which he has failed and not the rest of the course, is there no danger that he will never see the forest for the trees? That is, he will not see the overall relationships of the numberous modules.

Dr. Strachan: Well, we should have a post-test over all the materials. There should come a time when he has a comprehensive examination over all the materials. A hybrid system might work, i.e., using exams over modular units and also comprehensive exams.

Question: You have implied that some students respond better to individualized instruction. McKeachie's recent contribution from the Center of Research on Learning and Teaching documents this. How do you take this into consideration?

Dr. Strachan: Well, one of the points I did make was couched in other terms. I called it different approach strategies, whether you use TV or slide tapes or the conventional lecture material. There is some documentation from the Ohio State Medical School which includes psychological data which allows them to be able to identify the kinds of students that would select a structured course or a completely non-structured course in gross anatomy. Historically, that is how they came to use self-evaluation, a tutorial self-evaluation system, in the non-structured course. Now they are using this technic for an experimental medical school, the Pilot Medical School.

Dr. Seibert: There is a literature building up in educational psychology which concerns itself with something called aptitude-treatment interactions (or ATI). I think it really is what is being referred to here, that is it is concerned with the extent to which individuals, because of their particular configuration of aptitudes, may adapt better to one kind of teaching treatment than to another. The research is of interest to people like myself, but I do not think it is yet at a place where there is much to be said to most practicing educators. This is true, first, because it is a new field and perhaps also because the effects that we are dealing with - at least the ones that have been seen so far - are generally weak effects. An example of this kind of result which appeared in the literature some years back involved programmed instruction. As I recall, it used programmed instructional material which in one case had been preserved intact in a nicely sequenced form so that there was order and progression to it. The sequence helped and prompted the learner. Then, for a second condition the study used the same programmed materials, but it scrambled the individual frames and sentences into a random order. The results were that, generally, the high ability learners did not need the sequencing. They apparently could sequence for themselves, but the lower ability or marginal learners apparently derived a benefit from the prompting that came from sequencing. Again, it is a weak effect as I recall the results, and I am not sure who did it, but I believe it was Lawrence Stolurow, at Illinois. In any event, it shows a form of interaction between abilities of the learner (aptitudes) and characteristics of the instruction (treatments) and parallels to this have shown up elsewhere in the ATI literature.

___________: One very brief comment. At the Medical College of Virginia Medical School, they have had self-instructional carry-out for 7 or 8 years using a variety of media, including slide tape, TV and so forth. They found that 80% of the students used this material in groups, 20% individually. They are redesigning their entire unit.

Dr. Seibert: I think there may be a danger of over-generalizing from that though. At Purdue and at other places where audio-tutorial instruction is employed, students function essentially individually, and I think there is no question about the student's inclination, at least in that setting, to continue individually. It is a very good scheme, highly individualized, and well accepted.

___________: I would like to comment. This may present a lesson to us in terms of maybe the ways not only of learning that is more efficient, but maybe in ways in which practice might be more efficient if group activity has this result that is on the side.

Dr. Strachan: One of the advantages of self-instructional materials is that it is always available to the student. At Michigan the dental library has just been completed and we will have the individualized instructional material available there. Our students also work in groups. Last semester in one class, we presented the slide tapes to half the class at a time. The labs were open on Monday and Tuesday night and a sophmore dental student who was good in anatomy served as a tutor-proctor. Students, if they wanted would come back and use the materials on a self-instructional basis. About 30-40 per night availing themselves of this. The student is starting to decide how much he needs to utilize the self-instructional materials. Currently we are working towards self-testing devices to let the student know whether he knows the materials or not. So we have tried to include students of all abilities, the bright students who will learn with only one exposure, others--the slower learner or the more compulsive learners will have the opportunity to reuse the self-instructional packages. I have not studied the frequency of repetition. Maybe the average student might need two exposures. The material is really quite condensed, and it would require some review.

Question: Is not this depersonalization?

Dr. Strachan: We do not think the use of these individual strategies for teaching courses are depersonalized instruction. The evidence that we have from a comprehensive evaluation of the course using these materials is quite the opposite. It is a lot more fun for the instructors and the students tell us that they have established a more positive kind of rapport with the faculty in this course. There certainly are a lot of other factors that we are not always measuring when you go about looking at the learning processes.

Dr. Seibert: Let me thank Dr. Doerr, Dr. Tamarin, and Dr. Strachan and turn these proceedings back to Dr. Han, but before I do, it seems more than dangerous to attempt a broad and final chairman's summary here, even though that is the chairman's prerogative, and there are two main reasons why I will decline the honor. First, each of our speakers has drawn upon his own large and special experience for his remarks, so any effort on my part to improve on those contributions will serve more to distort than to enhance what they have said. And secondly, most of the future directions for education remain hidden in clouds, even though many of its needs do not. But at least, one must be careful in exercising the chairman's prerogative to the prescient.

Education needs change and it especially needs people with the imagination to invent alternatives and with the determination to see them implemented. It is moving, still too slowly, but nevertheless sufficiently to give hope that the determined inventors will increase in numbers and in the acceptance they receive. We need also to take stock of the resources which we have or could have to help with the work of education. The variety of resources has expanded greatly in the last several years and this expansion continues. To improve our effectiveness and our efficiency, as well as to enjoy the fun of new and beneficial work, we need to become informed about these new resources and their educational uses. And we need to extend further the trends now developing with respect to evaluation in education. We can evaluate and, especially, we can diagnose students' skills and status better than we typically have, we can use this evaluative information not only to motivate and order students, as we traditionally have, but to locate flaws in our instruction so that these can be mended quickly and appropriately. In the process, we can - and we need to - dissolve the partition which has separated teaching and learning from the evaluation of the results, so that teaching, learning and evaluation of results become parts of a continual and closely coupled operational cycle.

EPILOG

In completing the editing of this proceedings, I cannot but help recall the enthusiasm and interest expressed by the participants without whose efforts the substance of our discussion would have not been recorded here. Despite this, I also feel somewhat frustrated as I realize the ambiguity and lack of agreement with respect to each area we have discussed. Perhaps this is a natural result as we must realize the particular situations and problems that each and every dental school has to contend with, which may be somewhat different from "average problems of an average dental school". Indeed, as we recognize the individual nature of the educational process, unanimity from such a symposium as this should be suspect. The following two points which have become self-evident throughout our discussions may serve as a matrix for our future thoughts regarding dental education in the immediate future.

The first one is that in approaching dental education, or any professional education for that matter, we cannot ignore the newer methods provided by educational psychologists based with professional schools who call for total re-evaluation of subject areas of instruction with respect to the overall goal of dental education. By defining an educational goal of dentistry as a profession, the goal of a school in a particular locale, and the goal of a disciplinary area within a given school, we may be able to consolidate the area of coverage within each curriculum. Continued experimentation with methods of presentation may also be of importance. Thus, utilization of audio-visual materials including video-tapes and formation of a completely catalogued set of instructional materials which can be made available on a national basis would be of importance. In relation to the presentation of biological information to dental students, we should be able to capitalize on pertinent information derived from more multidiscipline-oriented research efforts which would, in turn, call for an integrated manner of presentation to the students. To say the least, our past efforts indicate that integrated training of dental students takes more, not less, faculty hours, and that it takes an extremely well coordinated effort on the part of the curriculum committee or core programmer, a point which cannot be overemphasized.

The second point is related to the first; that is the question of how we can consolidate our four-year program into a three year program. On the basis of national pressure, and the incentive provided by the capitation grants, etc., it would be fair to say that in the foreseeable future most of the dental and medical schools will be operating on a three year basis. Again, consolidation without the loss of quality calls for not minor modifications of course contents here or there, or trimming of contact hours here or there, but rather a totally new conceptual approach without which an elimination of existing contact hours would be impossible. It is clear that the dental community does not wish to degrade the quality of our education, and that it does not wish to lower the professional standards of future dentists. It is our hope that, by continued improvement and innovation of educational methods and philosophy, we may be able to teach our students to have greater adaptability to rapidly changing social conditions, and at the same time to become most biologically oriented so that they may make dental health care more pertinent to contemporary concepts and knowledge of biological sciences.

As I mentioned at the beginning, it is our hope that these proceedings could serve as a basis upon which we may develop future collective efforts towards achieving these immediate goals of dental education.

My thanks are due to Dr. D. Dziewiatkowski, J.K. Avery, N. Rowe and W. Seibert who have spent many hours in going over the transcriptions of discussions. I would also like to extend my apology to these whose comments could not be identified.

Spring, 1972
S.S. Han

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SUMMARY RELEASED FOR PRESS

The Symposium on the Implementation of Contemporary Biology in Dental Curriculum held on the 16th and 17th of June, 1971, at the University of Michigan in Ann Arbor, was attended by approximately 180 dental educators, including 69 official delegates from every dental school in the United States, Canada, and Puerto Rico.

The Symposium was aimed at assessing the current status of basic science courses in the dental curriculum, delineating new and pertinent areas of information relative to contemporary biology and dentistry, and identifying areas of problems. It was hoped that the Symposium would make a beginning toward collective reassessment of the basic science curriculum in dental schools on a national basis.

Following the first morning session, which dealt with recent advances in biology and allied sciences, each of the basic science areas was reviewed by ranking teachers in those various disciplines. Through discussion and presentations, the following salient points emerged:

1. Educators are far apart in their concepts and approaches to the teaching of basic science subjects, and therefore no representative views can be extracted at this time with respect to individual disciplines.

2. Rapid changes in students' background, particularly during the past ten years or so, require constant revision and reorientation of the philosophy and instructional goals of individual courses. For example, by the time a student enters a dental school today, he is likely to have been adequately exposed to the fundamentals of modern genetics and molecular biology - a state of preparation which was only a noble idea for the most pioneering students of biology a mere 15 years ago.

3. The nature of changes and problems in each discipline is unique and different from that of the others. In this regard a number of educators felt that certain subject areas, such as portions of biochemistry and physiology, could be dealt with in an undergraduate program. This was thought to be reasonable in view of the amplified basic science preparation of predental programs.

4. Dynamic changes are evident at interdisciplinary "interfaces", since the various disciplinary areas are undergoing constant change. This would mean that any integrated core program in basic sciences will have to undergo constant revision and detailed scrutiny by an active multidisciplinary basic science committee.

5. There are many regional differences in the sociological aspects of dental education; consequently a uniform basic science curriculum applicable to the entire nation, let alone the rest of the world, may not be feasible at this particular point in history.

As indicated in the opening remarks by the chairman, the Symposium was not designed to arrive at conclusions and answers to every existing problem, but rather to identify broad problem areas and develop questions. The last half day of the Symposium was particularly meaningful in this respect, as presentations and discussions became very intense in dealing with the future needs and changing directions which should influence the development of core concepts and individualized dental education of the future.

The organizing committee notes that the Symposium may have imprinted the participants with certain common questions. These questions include:

1. How extensive a common body of information can or should the courses taught at different schools offer to dental students?

2. How much common structural organization can dental schools develop in meeting their particular educational needs?

3. What are the most timely and effective modes of instruction in each subject area?

4. How feasible is the multiscience core course in basic biology?

5. How much of what is being taught in the dental school now could be transferred to the pre-professional curriculum?

6. What would be the effects of such a transfer of responsibilities on the structure and functioning of dental school departments?

7. How can one evaluate the student's performance?

It is hoped that these questions, posed to the minds of dental educators, may serve to crystallize viewpoints appropriate to the particular conditions of different schools, and that consequently a true workshop on specific areas may become a meaningful experience in the near future. The planning committee, recognizing that such an effort should be a continuous affair, hopes further that the next such conference might permit answers of a more concrete nature to some of the questions identified by this Symposium.

S.S.H.

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