Editor's Page

In order to make THE PHYSIOLOGIST a true house organ type of publication it should provide space for exchange of ideas, individual member comments, suggestions, etc. Space is available in three of the four issues for this type of material and it is hoped the members will avail themselves of this privilege. Letters to the editor are always welcome.

The editor is also anxious to receive short provocative articles on timely subjects. This type of article stirs up interest and often leads to productive research.

SOCIETY ELECTIONS

On various occasions members have expressed some concern about the Society's method of electing officers now that the Society has become relatively large. In the following paragraphs I will try to summarize some of these opinions and suggestions for your consideration.

At present our Society still utilizes the so-called democratic method of electing officers. Nominations are made by ballot at the Spring business meeting. Those present who do this balloting and final voting represent only 1/10 to 1/5 of the membership. As the Society gets larger the number attending the business meetings seems to get smaller. Is it truly democratic to have such a small percentage of the membership determine who the officers shall be?

With nominations made by ballot during a hurried business meeting little time is given for consideration of who would be the best candidate. However, this type of nomination is certainly more democratic than one made by a small appointed nominating committee, but the voting by a small proportion of the membership that happens to be present at the meeting is certainly not truly democratic. Suggestions have been made as to how we can preserve the democratic way in both nominating and voting and at the same time permit a greater proportion of the membership to have a voice in who their officers shall be. It has been proposed that instead of having a nominating committee, nominations might be made at the preceding Fall meeting in the same manner they are now made at the Spring meeting. The members present at the Fall meeting would essentially be the nominating committee. A voting ballot could be made up of the three or four nominees having the largest number of nominating ballots at the Fall meeting. In the interim between the Fall and Spring meetings this ballot could be mailed to all members. The marked, sealed ballots would be returned by a certain deadline before the Spring meeting. At the meeting, appointed tellers would open and count the ballots. A plurality of votes would constitute election.

This would still leave the possibility of having to elect one Council member to complete the term of a Council member who might be elected to the position of President-Elect. Even though Section 5 of Article II of the By-laws states that "Council may fill any interim vacancies in its membership" it has always been the practice to permit the membership to elect a person to fill an unexpired term on Council. The election of a person to fill an unexpired term on Council, if a current Council member is elected to the position of President-Elect, could be handled by a decision to select from the Council member ballot the person receiving the second highest number of votes--the person receiving the highest number of votes being elected as the full-term Council member.

There are others who are strongly in favor of the present method of electing officers and would not want to see the system changed. Many feel that the selection of officers should remain in the hands of the hard core of professional physiologists who are most vitally interested in Society affairs and who make a point of attending the business meetings. It is true that members know elections take place at the Spring business meeting and it is possible for a person or a group to see that their candidate is placed in nomination. It is also true that if members cared about who was elected they would attend the business meeting. But since our Society is large and still growing it is doubtful if we will ever have a large proportion of the membership present at a business meeting as was the case when the Society was small.

Should we discard methods that are well adapted to a small Society but are not practically democratic for a large Society or should we continue our present method of selecting our leaders? Your comments to Council or letters to the editor of THE PHYSIOLOGIST are welcome. We hope you will take part in policy discussions of this sort through the medium of your journal, THE PHYSIOLOGIST.

CANADIAN FEDERATION OF BIOLOGICAL SOCIETIES

The Second Annual Meeting of the Canadian Federation of Biological Societies will be held at the University of Toronto, Toronto, Canada on June 9-11, 1959. The Federation is composed of the following four societies -- Canadian Physiological Society; Pharmacological Society of Canada; Canadian Association of Anatomists; Canadian Biochemical Society. Further information can be obtained by writing Dr. E. H. Bensley, Room 710, The Montreal General Hospital, Montreal 25, Quebec, Canada.

SILAS WEIR MITCHELL

In order to familiarize the present membership of the Society with one of its founding fathers who served as second President of the Society, it was thought advisable to reprint the section on Dr. Mitchell appearing in the "History of The American Physiological Society" published at the time of the Society's semicentennial in 1938. The following is taken verbatim from that publication.

"Weir Mitchell was born in Philadelphia, February 16, 1829, and died in the same city, January 4, 1914. He was the son of Dr. John K. Mitchell, himself a distinguished physician well known for his medical, scientific and literary attainments. Weir Mitchell graduated in medicine from the Jefferson Medical College, where his father was a professor, in 1850. After graduation he spent a year in Paris. His work there was somewhat interrupted by ill health, but he attended courses under Claude Bernard and Robin which made a deep impression upon him and influenced greatly his subsequent work. On his return to Philadelphia he entered at once upon that practice of medicine in which he was to be engaged for the rest of his long life. His career was brilliant and, indeed, remarkable, for he won a well-deserved distinction in medicine, in physiology and in literature. His literary work, begun late in life, he characterized as his play, in contrast to the more serious duties of his profession, but it brought to him fame and recognition throughout the country. All together he wrote some fifteen novels. The last one, 'Westways,' appeared when he was in his 84th year. He published also several volumes of poems and a number of addresses on both medical and non-medical topics.

"In medicine he became, perhaps, the leading practitioner, certainly the foremost neurologist of his time in this country. He was a prolific contributor to medical literature. Doctor Welch states in a memorial address (S. Weir Mitchell, Memorial Addresses and Resolutions, Philadelphia, 1914) that he was able to collect 246 references to his medical publications from the Index Medicus and the Surgeon General's Catalogue. He took an active part in many general movements of a medical scientific and civic character. It is greatly to his credit and honor that amid all these demands upon his time and energy he had the inclination, and made opportunities, to carry on scientific research, not only in clinical subjects but in pure physiology as well. It was evident to any one who came into contact with him that he had an active inquiring mind that was eager for new knowledge and happy in its pursuit.

"In 1894 he published, apparently for private circulation, what he called an analytical catalogue of his contributions. Examination of this list of researches makes clear his right to be considered the outstanding physiologist in the United States during the period preceding the establishment of the laboratories of physiology at Harvard and the Johns Hopkins in the seventies. Reference may be made to a few of these contributions to illustrate the importance and originality of his work. In 1860 he began his important researches on snake venom with a paper published in the Smithsonian Contributions to Knowledge. Further publications on the same subject appeared in 1868, 1870 and 1883, and finally in 1886 he and E. T. Reichert published in the Smithsonian Contributions their classical paper, 'Researches on the Venom of Poisonous Serpents,' which contained their discovery of the existence of toxic albumins. His well known work upon the physiology of the cerebellum appeared in 1869 (American Journal of the Medical Sciences, 57,320). The experiments and observations recounted in this paper convinced him that the motor disturbances following cerebellar injuries are mainly due to traumatic irritation, and led him to announce the general theory that the cerebellum functions as an augmenting organ to the cerebro-spinal motor system. In both these points he was confirmed later by Luciani's careful and extensive researches upon the same organ. In 1886 he published, with M. J. Lewis, their fundamental study of the knee-kick, its reinforcement and its diagnostic significance (Medical News, 48,168 and 198, and The American Journal of the Medical Sciences, 92,363). Mention might be made also of his book on 'Fat and Blood' in which he developed the principles of his famous 'Rest Cure' for functional nervous disorders. This book was translated into several foreign languages and the cure excited much discussion and interest in this country and abroad. It consisted mainly in rest, massage and overfeeding. More significant from a medical and scientific standpoint was his widely used book on 'Injuries of Nerves and Their Consequences,' 1872, which was based largely on his extensive hospital experiences during the Civil War. Students of the history of physiology in this country will be grateful to him for the 'Bibliography of American Papers on Physiology' which he published in 1858 in the North American Medico-Chirurgical Review. In this paper he gives a summary of American contributions to physiology which appeared in the (eighteen) forties and fifties. It is, to use his own words, 'a melancholy catalogue' compared with what was being done in Germany and France during the same period, but the paper is attractively written and contains material of considerable historical interest.

''While Mitchell's experimental researches took a wide range his interests were centered mainly upon the physiology and pathology of the nervous system. An indication of his keen appreciation of the problems in this field that needed investigation is given by the fact that on two occasions he offered prizes, through the Council of the American Physiological Society, for the best researches upon specified topics. The first of these prizes was announced by the Secretary of the Society, Newell Martin, in a printed circular dated February 20, 1889. The circular states that 'with the wish to promote research in certain departments of Physiology and to aid in defraying its cost a member of the American Physiological Society has offered two hundred dollars for the best research or researches bearing on one or more of the subjects stated below, viz: The rate of transmission of nerve impulses, afferent and efferent, and the duration of reflex and reaction time in the higher animals, especially man; also the conditions, normal and pathological, which alter such rates and times.' The competition was limited to residents of North America. A notation by the Secretary in the minutes of the Society states that 'no communications were sent to the Secretary in competition for the above prize and it, therefore, lapsed.'

"Shortly afterward Mitchell offered a second prize of two hundred and fifty dollars under the same general conditions. The circular making the announcement was issued on February 10, 1890. The problem to be investigated was stated very specifically, as follows: 'The regeneration of severed spinal nerves in mammals, including man, with specific reference (1) to the reunion and return of function in such severed nerves, without degeneration of the distal portion; (2) to the possibility of union with return of function between the central portion of any one spinal nerve and the distal portion of any other (e.g., the central portion of the ulnar with the distal portion of the median). Conclusions to be supported, so far as possible, by histological as well as physiological evidence.' In this case one and probably only one paper was submitted to the Secretary. The prize was awarded by the Council at its meeting Dec. 29, 1891 to W. H. Howell for an investigation by himself and G. C. Huber which was afterwards published in the Journal of Physiology under the title, 'A physiological, histological and clinical study of the degeneration and regeneration in peripheral nerve fibers after severance of their connections with the nerve centers.'

"Still later, at the Boston meeting, December 29, 1896, Mitchell suggested to the Council that a committee be appointed to undertake a study of the physiological properties of the poisonous fungi, and offered to contribute toward the expenses of the investigations. The Council approved the suggestion and appointed a committee consisting of Mitchell, Goodale, Chittenden, Abel and Pfaff. Both Mitchell and Goodale declined to serve on the committee and Bowditch was appointed in their place. The committee organized with Chittenden as Chairman and succeeded in obtaining an appropriation of $500 from the Bache Fund of the National Academy of Sciences in addition to the sum contributed by Mitchell, the amount of which is not stated in the minutes. As far as the records show no general report of the results obtained by this investigation was made to the Council, but researches under the fund were made in Chittenden's laboratory by Dr. W. S. Carter, and in Abel's laboratory by Dr. W. W. Ford. The results of these investigations were published in the current journals, and on the request of the chairman the committee was discharged at the sixth special meeting of the society, Washington, 1903.

"Weir Mitchell was probably the most distinguished and widely known member of the Society at the time of its foundation. He was a man of fine presence, distinctly patrician in his bearing and manners, making the impression of a cultured man of the world, but genial and courteous and deeply interested at all times in new discoveries in science. He took a very great interest in the founding of the Society. In addition to presiding at the organization meeting he served two terms as President, and he took an active part in the discussions at the early meetings. His participation in the work of the Society helped to give it prestige in the eyes of the medical profession. It is probable that he was chiefly instrumental in bringing about the close affiliation that existed for years between the Society and the Congress of American Physicians and Surgeons. The Society was fortunate, indeed, in having among its original members five men, Mitchell, Wood, Welch, Osler and Vaughan, who were or soon became the acknowledged leaders of scientific medicine in this country. They doubtless regarded the Society as an important agency to aid in the development of a scientific spirit in the medical profession, and for this reason the connections of the Society in the beginning were especially close with the leading medical organizations. All the special meetings were held in association with the Triennial Congress of American Physicians and Surgeons."

THIRD BOWDITCH LECTURE

New Concepts in Cardio-Pulmonary Physiology Developed by the Use of the Body Plethysmograph

By ARTHUR B. DuBOIS

Associate Professor of Physiology, Graduate School of Medicine, University of Pennsylvania, Philadelphia, and Established Investigator of the American Heart Association

Have you ever been overwhelmed by the amount of reading that you feel you ought to do? If you have, you may be interested to know that Dr. Henry Pickering Bowditch experienced precisely the same feeling. In 1887 (1) he wrote: "The accumulated literature in every department of science is already so enormous and is increasing at such a rapid rate that any association or individual undertaking to contribute thereto should do so only under a sense of grave moral responsibility." Apparently Dr. Bowditch struck a responsive chord in the heartstrings of some present-day editor, for serialized in the back pages of the "Journal of Applied Physiology" one may find four pages of information for authors in which the editor has expanded the term 'grave moral responsibility' into approximately 2,600 words. Although Dr. Bowditch did not have the benefit of these more explicit instructions he succeeded in writing about one or two papers a year and in them, you will recall, he managed to describe the 'all or none law of the heart', the 'Treppe' phenomenon, the indefatigability of the nerve trunk in its natural environment, and several factors affecting vasomotion, perception and growth. Dr. Bowditch did work of a timeless quality possibly as a result of an unconscious effort to have it outlast that of his grandfather, Nathaniel Bowditch, who in 1802 first published "The American Practical Navigator", a book which has been reprinted as recently as 1938. Nor did he set himself an easy task, for in the flyleaf of this book I found the following inscription to Dr. Nathaniel Bowditch: "...as long as ships shall sail, the needle point to the north, and the stars go through their wonted courses in the heavens, the name of Dr. Bowditch will be revered..."

But if Dr. Bowditch were here he would have us move on quickly to a history of the subject at hand. A single cell, such as a sea urchin egg, has no problem of respiration or circulation because oxygen simply diffuses in and carbon dioxide diffuses out. These processes can be measured by placing the tissue in a sealed chamber and measuring the rate of change of pressure in the chamber. A larger organism such as an earthworm has contractile blood vessels to pump the blood to and fro in the body. Molluscs, such as the clam, have a single ventricle which ejects the blood through the systemic circulation, and gills, and back into the auricles. The amphibia, such as salamanders and frogs, have a similar heart with single ventricle but, in addition, have primitive lungs which help to conserve water vapor when the animal breathes the ambient air back and forth over the vascular bed. Mammals have a four-chambered heart, the right ventricle having developed in order to pump the blood through the capillary bed of the complex lungs. If we think of the lungs as a box, we can picture the air going in and out through the dead space and ventilating the alveolar space of the lungs. At the same time, blood enters the lungs and after exchanging oxygen and carbon dioxide with the alveolar air it emerges and passes to the periphery of the body where the metabolic gas exchange occurs. At the turn of the century, Haldane began his studies on alveolar air, and August Krogh gave us quite an accurate description of gas exchange. However, it was not until the period between 1940-1950 that Dr. Wallace Fenn provided us with a quantitative description of the relationship between the ventilatory gas exchange, mean alveolar gas composition and metabolic gas exchange so precise that from the graphs of Rahn and Fenn, recently published in book form by the American Physiological Society, it is possible to predict the internal environment of the subject placed under bizarre conditions of stress such as deep under the water or orbiting in an earth satellite.

Meanwhile, Dr. Cournand and Dr. Richards had begun to explore the inside of the pulmonary circulation using their catheters, and Dr. Ward Fowler and Dr. Julius Comroe had become engaged in a death struggle with the 'Medusa' of uneven distribution of inspired gas. But it took Drs. Richard Riley, Hermann Rahn and, more recently, William Briscoe to sort out the uneven ventilation-bloodflow ratios and their effect on the net gas exchange of the lungs. Marie Krogh had made exploratory studies on the diffusion of carbon monoxide between the alveolar gas and the capillary blood and after some studies on reaction rates between carbon monoxide and hemoglobin by Dr. Roughton, Dr. Robert Forster was able to reconcile all of the problems and developed his method for measuring diffusing capacity of the pulmonary membrane and volume of the pulmonary capillary blood. Riley and Lilienthal carried out an analysis of the oxygen tension gradient resulting from a diffusing barrier which might occur in the presence of alveolo-capillary block. David Bates and Robert Marshall have further investigated the effects of uneven ventilation-diffusing ratios throughout the lungs.

The mechanics of the pulmonary circulation (fig. 1) were investigated by a number of prominent members of our Society starting with Dr. Bowditch and including Dr. Wiggers, Dr. Katz, Dr. Visscher, Dr. Burton and others, so well known to you that I need not mention their names. The mechanics of breathing on the other hand had a much slower start. The first complete studies were done in Europe by Fritz Rohrer, and von Neergaard and Wirz. But the subject was neglected on this continent until Otis, Rahn and Fenn published their article entitled 'Mechanics of Breathing in Man' in 1950. Since then, the studies on pulmonary mechanics by Mead, Whittenberger and

Radford; Fry, Ebert and Stead; Christie, McIlroy and Marshall; Comroe and associates have given us a clear picture of the alterations of pulmonary mechanics in a wide variety of physiological conditions. In this diagram, the lungs appear to be springs imbedded in molasses drawing air through a bundle of straws. Now, we know that the lungs are actually more like a paper bag containing a plastic bag containing a rubber bag filled with a froth of myriad bubbles. Correspondingly, the diagram of the pulmonary circulation reminds me of a string of sausages.

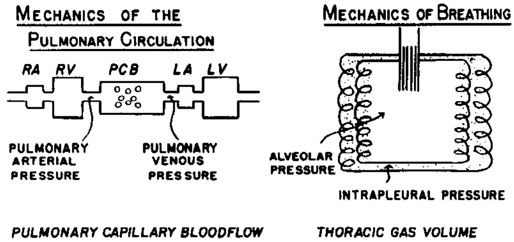

Fig. 1. Schemes of the circulatory system and lung-chest system. Factors interrelated in the study of cardiopulmonary physiology are listed on the illustration.

Out of this tangle of springs and sausages let us pluck out the six variables generally thought to be important to the combined study of the pulmonary circulation and mechanics of breathing. These are the first six veils of Salome's dance. They are: the thoracic gas volume, alveolar pressure, pulmonary capillary bloodflow, pulmonary arterial pressure, pulmonary venous pressure and intrapleural pressure. Now it is possible to arrange six variables into six factorial permutations, totaling 720 different ways of presenting the data. 'Confusion' is Salome's impenetrable seventh veil. It is therefore not surprising that different investigators seldom study the same combinations and yet, as Dr. Burton has recently pointed out, the results of their investigations are generally compatible with each other. Dr. Bowditch himself explicitly stated (2) some of the characteristics of the pulmonary vascular bed as follows: "Though in general expansion of the lungs diminishes the size of pulmonary vessels, yet the maximum capacity of these vessels is not associated with a condition of absolute collapse but rather a slight expansion of the lungs." He drew a U-shaped graph of vascular volume against lung volume. Furthermore, he noted that "when lungs were inflated with a pressure about 29 cm of water the blood sank in the tubes on both the arterial and venous sides of the lung, seeming to indicate that at this high pressure on the internal surface of the lungs the pulmonary vessels had become more capacious." He thus recognized that the location of intrapulmonary vessels mattered a great deal. More recently, Dr. Burton has given us a clear picture of transmural pressure, or pressure difference between the inside and outside of the vessel wall, as well as an interesting description of the small branches of the pulmonary artery in a contracted state, which he termed 'gnarliness'.

Now, let us see what we can do to evaluate three of the six quantities in figure 1, that is, thoracic gas volume, alveolar pressure and pulmonary capillary blood flow, using a body plethysmograph to help us make these measurements in man. In 1882, Pflüger designed a wooden cabinet in which he could sit and voluntarily compress the gas in his lungs, the volume change being measured by a small spirometer attached to the chamber, and the pressure at the mouth being simultaneously measured by a mercury manometer. His attempt to measure residual volume by applying Boyle's Law to the data so obtained was interesting in concept but technically not satisfactory, and was subsequently abandoned in favor of gas dilution methods for measuring functional residual capacity. However, gas dilution methods are not entirely satisfactory either, because not all subjects properly ventilate all the gas in the different parts of the lungs. But a plethysmographic method of voluntary compression of the gas in the chest should measure the entire thoracic gas volume whether or not the alveolar air is in free communication with the trachea. Considering this possibility, Dr. Julius Comroe and Dr. Stella Botelho constructed a steel chamber (fig. 2) which has variously been called a telephone booth, isolation booth, respirometer or names not mentionable in present company. The subject enters with foreboding and is not reassured by the sign underneath the window saying 'in case of emergency, break glass'. When the subjects come out, they invariably say 'how do you know when there is an emergency?'

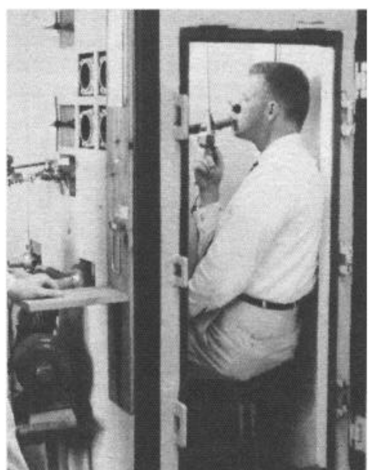

Fig. 2. Subject seated inside the body plethysmograph.

The object of our first experiment was to measure the thoracic gas volume of subjects breathing at resting level, or functional residual capacity. The principle used in this measurement is illustrated in the diagram (fig. 3). Voluntary compression of the gas in the lungs by breathing against a closed airway (shutter S) simultaneously raises the pressure of the gas measured by the manometer, P, and at the same time reduces the volume of gas in the lungs, L. This causes an expansion of gas around the body, measured by a pressure change in the plethysmograph, B, using a very sensitive capacitance manometer, C, to record box pressure against mouth pressure. The slope of the resulting line is displayed on the face of a cathode ray oscillograph, O. The slope of this line is dependent on the lung volume, which is calculated from an equation for functional residual capacity (F.R.C.) derived from Boyle's Law for compression of gases. The body plethysmograph is shown with the door closed (fig. 4) and the operator ready

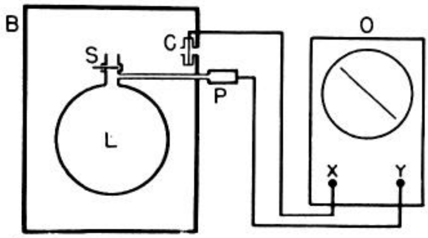

Fig. 3. Principle of the plethysmographic method for measuring thoracic gas volume.

to read the slope by means of a protractor attached to the face of the cathode ray oscillograph. The box is then opened and the subject taken into the next room where he is seated in a similar position for the determination of functional residual capacity by the 7-minute open circuit nitrogen washout method of Darling, Cournand and Richards. A comparison between the functional residual capacity determined by both methods in nine normal subjects (fig. 5) showed that the mean F.R.C. by the open circuit method was 3.07 liters and by the body plethysmograph method was 2.97 liters, with a standard deviation of the difference of 0.22 liters, which means that normal subjects have no evidence of unventilated gas breathing at resting level. But we postulated that nonventilated, or trapped gas should appear in plethysmographic measurements, whereas it might not appear during the washout procedure of 7-minutes' duration. To test this hypothesis, five subjects who had radiolucent areas, or cysts, visible in the lungs by x-ray were put through both procedures by Dr. George Bedell, and values so obtained are shown in the same figure. It is apparent that the body plethysmograph values were larger than those obtained by the washout method, the difference being significantly greater than that obtained in normal subjects. This confirmed the hypothesis that certain subjects had gas which was so poorly ventilated as not to be washed out during 7 minutes, or sampled by a forced expiration at the end of the 7-minute period.

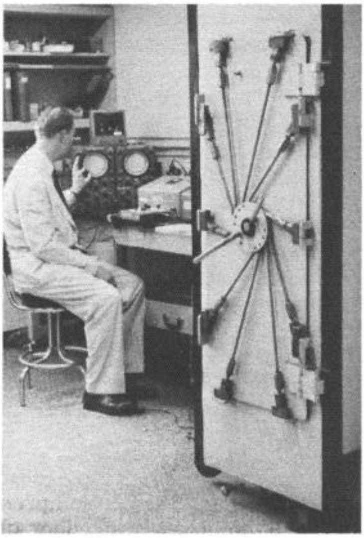

Fig. 4. Body plethysmograph apparatus, door closed and operator about to read lung volume from cathode ray oscillo graph scale.

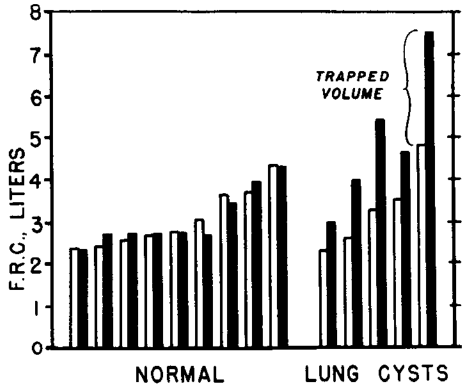

Fig. 5. Comparison between functional residual capacity determined by the 7-minute nitrogen washout method (open bars) vs. plethysmographic method (solid bars). Patients with lung cysts had a significant difference by the two methods.

To investigate the question whether gas in the abdominal cavity might be contributing an artifact to our measurements of functional residual capacity, we specifically compressed the gas in the abdomen by straining the abdominal muscles while keeping the glottis open. Intragastric pressure, measured by a small balloon, was plotted against change in plethysmographic pressure, measured as before on a cathode ray oscillograph. From Boyle's law for compression of gases, the volume of abdominal gas was calculated and found to average 115 cc, a quantity which is negligible by comparison with the functional residual capacity, which is approximately 3000 cc. To confirm this result, we took x-rays of the abdomen during the control period and then after adding 600 cc and 1200 cc to the colon through a tube. These x-rays show that the initial volume of the gas shadow appears to be small compared to the moderate and marked distention produced by the subsequent addition of air. We were thus able to rule out abdominal gas as a contributing factor to the lung volume method, and at the same time to provide data which were needed for studies of body specific gravity, and of rapid alterations of ambient pressure, as in ascent to high altitude.

To understand the very poor ventilation which is occasionally detected in abnormal lungs, the next step was to look at the concept of alveolar pressure and air flow and their ratio, which is airway resistance. This relationship is shown in figure 6, where a given rate of air flow through a slight constriction produces a pressure differential ΔP between the upstream and downstream ends of the U-tube manometer. When divided by the rate of airflow, $\dot{V}$, this gives the resistance. Maintaining the same rate of air flow, if the constriction is further narrowed to give a higher resistance the pressure drop, ΔP, will increase, following the general rule that the greater the airway resistance the higher will be the alveolar pressure for a given rate of air flow. The apparatus for measuring alveolar pressure and air flow in calculating airway resistance is shown in figure 7, which depicts the subject seated inside the closed chamber and breathing through a pneumotachygraph, which registers the rate of airflow at the mouth by causing a vertical deflection on the cathode ray oscillograph. Alveolar pressure is more difficult to measure than air flow; but to accomplish this end, we again count on the compressibility of gas in the lung to cause deflections in the plethysmographic

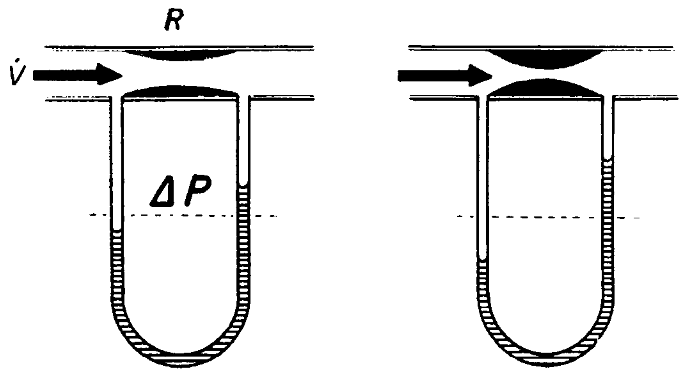

Fig. 6. Relationship between airflow, pressure difference and airway resistance in two tubes with different degrees of constriction. R = P/V (analogous to Ohm's law). (Reprinted from The Lung by Comroe, et al. Year Book Publishing Co.)

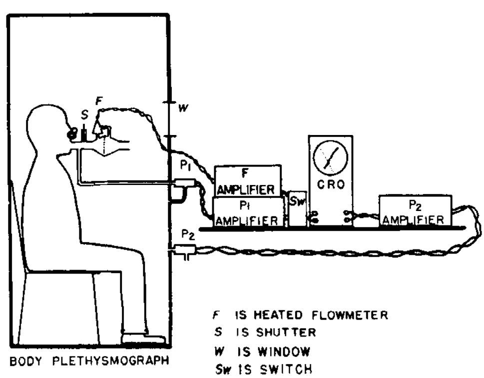

Fig. 7. Body plethysmograph apparatus for measuring airway resistance.

pressure gauge, P_2, which registers on the horizontal axis of the cathode ray oscillograph. During expiratory air flow the subject increased his alveolar pressure thus compressing the gas in his lung to a smaller volume and therefore expanding it around the body, causing a diminution in pressure registered by the gauge, P_2. On the other hand, during inspiratory air flow the subject expanded the gas in his lung, because of the negative pressure exerted on the gas, and therefore compressed the gas around the body, causing a positive deviation of pressure in the plethysmograph, registered by P_2. As the subject breathed back and forth with shallow breathing in a heated flowmeter, to prevent vaporization or condensation of the respired gases, he generated an S-shaped line of alveolar pressure against air flow, from which we calculated airway resistance, after making a correction for the measured volume of gas in the chest obtained by closing the switch, SW, and breathing tube, at point S, and having the subject perform the lung volume measurement as before. Values for air flow resistance so obtained in normal subjects scatter about 1 or 2 cm of water pressure/liter/second. In a variety of subjects with various forms of pulmonary conditions, including airway obstruction, the values ranged up to 10 or 12 times normal, depending on the degree of obstruction. Similarly, if the subject inhaled an aerosol of histamine, the values for airway resistance were found to be increased, as shown in figure 8.

But so far I have neglected to mention anything about gas trapping. However we now come to the beginning of some studies which are still being carried out in our laboratory. Dr. Briscoe made a series of airway resistance measurements with the subject voluntarily breathing at different respiratory levels or lung volumes. As you will recall, the body plethysmograph method gives values for resistance which are independent of other factors such as muscular force or tissue viscosity and values for volume which are independent of the degree of obstruction of the airways. Results of measuring airway resistance at different lung volumes in a single subject are shown in figure 9. Notice that in the inspiratory position the airway resistance is low, but in the expiratory position the airway resistance is considerably higher and that the intermediate points scatter about a curved line which Dr. Briscoe has been able almost to straighten out by replotting the data as the reciprocal of resistance against volume (fig. 10), the reciprocal being the conductance of the airways, in liters/second/cm H_2O. The straight line through these points now appears as if it would pass not far from the origin of axes, that is, at no lung volume there would be no airway conductance. Yet some subjects when plotted on a similar diagram showed a slightly different result, that is, the conductance appeared to be taking a nose dive toward zero as the lung volume was reduced to residual volume or extrapolated below. This led Dr. Briscoe to investigate the effects of old age, and he succeeded in enticing an 87-year-old lady, known as Great Aunt Bessie,

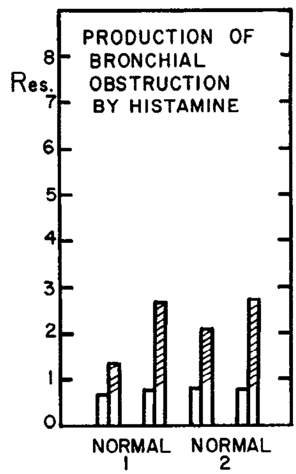

Fig. 8. Increase of airway resistance after breathing 3% histamine aerosol. Two subjects, each studied twice.

into the box for comparison with four other subjects in different age groups, ranging to as low as four years old. It was apparent that the older subject did not have increased airway resistance and that the subjects in all decades appeared to have approximately similar values for airway resistance when measured at similar lung volumes. Ten additional subjects between 75 and 90 have been studied and Dr. Alcala and I found a normal airway resistance in all of them. We are happy to be able to confirm Dr. Dickinson Richards' statement that older subjects do not appear to have airway obstruction.

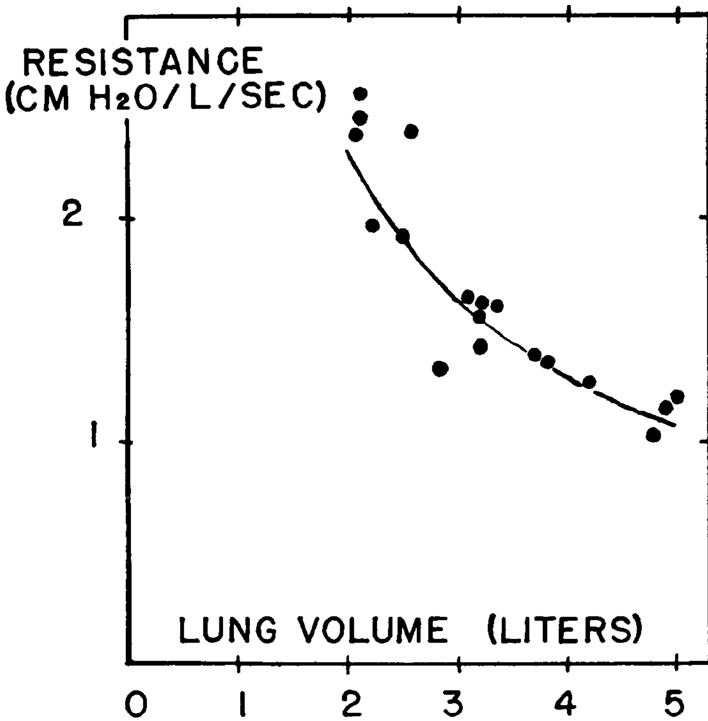

Fig. 9. Airway resistance at different respiratory volumes in one subject. (Reprinted from Brisco and DuBois, J. Clin. Invest. 37: 1279, 1958.)

However, this still doesn't answer the question concerning the failure of ventilation of certain regions of the lung in some subjects, but merely demonstrates a possible method for approaching the problem, by comparison of the airway resistance values at different lung volumes. We now know that many patients and even normal subjects may have an alteration of the slope of the conductivity line, or of its volume intercept, indicating that as a patient or normal subject breathes out into the expiratory position the airways become proportionately smaller, and could even conceivably close if he were able to go below residual volume. This behavior of the airways becomes exaggerated when subjects have narrowed airways. In addi-

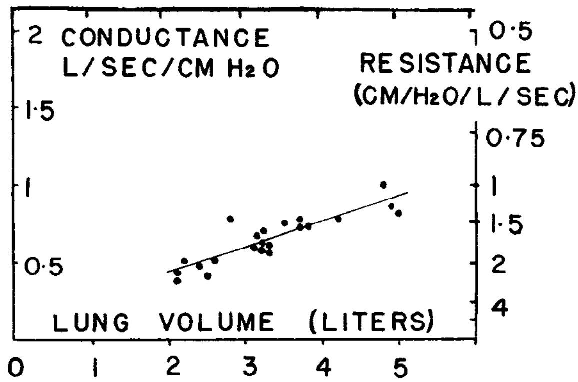

Fig. 10. Same data as fig. 9 replotted as airway conductance at different respiratory volumes. (Reprinted from Brisco and DuBois, J. Clin. Invest. 37: 1279, 1958.)

tion, we have found that some subjects with lung cysts failed to expire the gas from the cysts during a forced expiration. Putting these two items together, it is logical to suppose that failure of certain very poorly ventilated regions of the lungs to be washed out by breathing oxygen 7 minutes is probably due to the failure of these regions to empty properly during expiration owing to complete or almost complete closure of the air passages leading from those regions, a phenomenon termed 'air trapping'.

I have spoken of the airways as if they were rather passive in their behavior, having an ordinary size at resting level, being stretched larger in the inspiratory position, and let down to small size in the expiratory position. However, the following experiment carried out with Dr. Dautrebande will show that the airways of even a normal man are capable of a marked reaction characterized by increased airway resistance, under certain circumstances. In this case a series of determinations was made on a normal subject sitting in the body plethysmograph, for the measurement of airway resistance, and at the same time total pulmonary resistance was measured by means of an esophageal balloon. During a control period, five determinations were made, all of them being within the normal range. The subject then inhaled 15 breaths of air containing a fine suspension of activated charcoal powder resulting in a marked increase in airway and total pulmonary resistance but no stridor audible at the throat. Twenty minutes later, the effect had partly worn off spontaneously, and after bronchodilator drugs had been given, the effect was completely gone, nor did it occur on re-exposure to the same type of charcoal subsequently administered. Similar experiments with other inert particles dispersed into the inspired air stream revealed that the chief effect was on the airway resistance, whereas the lung compliance, functional residual capacity, and vital capacity were practically unaffected. We are forced to reach the conclusion from these experiments that the airways of man are capable of a marked reactivity in response to the inhalation of various substances even though some of the substances are chemically inert or insoluble. Yet our knowledge of the intermediate mechanism of such responses is poorly advanced, as we do not know how much of the response is due to mucosal edema, congestion, or change in the tone of the bronchial smooth muscle. Nevertheless, we know that when we take a deep breath in, airways tend to become wide open, which is helpful in the prevention of atelectasis, which might otherwise occur if the closure of the smaller air passages persisted long enough so that there was complete absorption of gas behind the regions of temporary obstruction.

Now let us turn to some physiological observations on the passage of blood through the capillary bed of the lungs. These vessels are so minute that the red cells, according to microscopic observations, sometimes tumble through them side by side, and other times barely squeeze by, as Dr. Burton has put it, 'like oysters passing down an esophagus'. Although we would like to measure the rate at which these red cells enter the pulmonary capillary bed in the same way that the giant Cyclops counted sheep entering his cave, it is obviously impractical to put a red cell counter into the entrance of every capillary, and consequently we have to depend on a different method originally described in collaboration with Dr. Grant Lee. One application of this method is as follows. The lungs are enclosed in a sealed chamber which has on it a sensitive capacitance manometer for measuring very small changes in pressure. The manometer is calibrated by means of a known volume displacement, and therefore it can record very small changes in the quantity of gas in the chamber. If the lungs be filled with air, the blood flowing through them exchanges gases back and forth with the alveolar air so that the net volume change is negligible. However, if the lungs are filled with a very soluble gas, such as nitrous oxide, the gas dissolves in the blood as the latter enters the capillary bed, and since pressure changes in the lungs are transmitted throughout the box with the speed of sound, the plethysmographic pressure gauge gives an instantaneous measurement of the volume of gas which has passed into solution in the blood. The equation for this volume change is as follows: the quantity of gas being absorbed is equal to the rate of blood flow times the concentration of the gas in the alveoli, and divided by the solubility of nitrous oxide in blood, per atmosphere of nitrous oxide. From this equation, we solve for the quantity of blood per unit time, or instantaneous pulmonary capillary blood flow at any given moment of time. Using this method, Dr. Engelberg has studied isolated rabbit lungs, suspended in a closed chamber, and perfused with Krebs-Ringer's solution injected into the pulmonary artery or pulmonary vein by a motor-driven syringe placed within the same space. One of his records of venous perfusion is shown in figure 11. When the lungs were filled with air, the perfusion of them resulted in negligible changes in pressure in the plethysmograph, as the net gas exchange was very slight. However, when the lungs were inflated with nitrous oxide, and the syringe motor started so as to produce a steady motion of the barrel recorded on the bottom line of the diagram, the pulmonary venous pressure, measured by means of a strain gauge manometer (center line) increased, and then as fluid flow began to move into the capillary bed, nitrous oxide was instantaneously absorbed and plethysmograph pressure (top line) began to fall. The opposite events occurred when the pump was turned off.

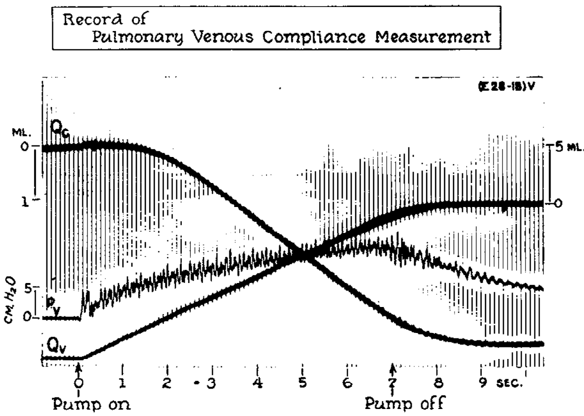

Fig. 11. Perfusion of isolated rabbit lung filled with N_2O, showing a fall in pressure in the plethysmograph in which the lung was suspended due to absorption of the gas by capillary fluid flow.

The quantity of fluid accumulating in the vascular tree under a given pressure, prior to onset of capillary flow, gave a measurement of the vascular compliance of the whole vascular tree right down to the point of the capillaries, that is, the volume change in the tree divided by the pressure change at the entrance of the vessels. The whole vascular bed was then closed off, and static measurements of pressure change resulting from small volume injections were recorded to obtain the compliance of the whole vascular bed. In other lungs the arterial tree or venous tree was blocked off by embolization with lycopodium spores, until fluid flow through the lungs ceased, after which the static pressure-volume characteristics of isolated segments of large artery or vein could be studied for comparison with the preceding measurements. The resulting conclusions have been that pulmonary venules had the greatest compliance, but that the arterial tree itself was capable of some distensibility. The capillaries did not constitute the greatest reservoir for distention. Indeed, their compliance is rather small.

Now let us turn to the examination of pulmonary capillary blood flow in human subjects. A normal subject was seated inside the body plethysmograph and told to take a breath of air, which he held at resting lung volume for approximately 10 seconds. The plethysmographic pressure and the electrocardiograph were recorded simultaneously. There was a very slight change in plethysmograph pressure which could be explained on the basis of respiratory quotient and thermal drift. However, the same subject was then asked to take a breath of 80% nitrous oxide, which he held in his lungs for a similar period of time. Pressure in the plethysmograph fell, going off scale so that the box had to be vented to allow the pen to come back onto the record. By comparison with the electrocardiograph underneath, it could be seen that the gas absorption did not occur in a steady line, but instead in bumps or pulses which were synchronized with the ejection from the right ventricle. The calibration of the plethysmograph allowed calculation of the volume of gas absorbed. At the beginning and end of breath holding, the subject delivered alveolar samples, which were analyzed for nitrous oxide. We therefore had all the information necessary to calculate the pulmonary capillary blood flow at each instant through the cardiac cycle using a modified Fick equation. The results of this calculation are plotted out in figure 12, showing the average of four single heart beats, first with the subject at rest, and then measured immediately following exercise.

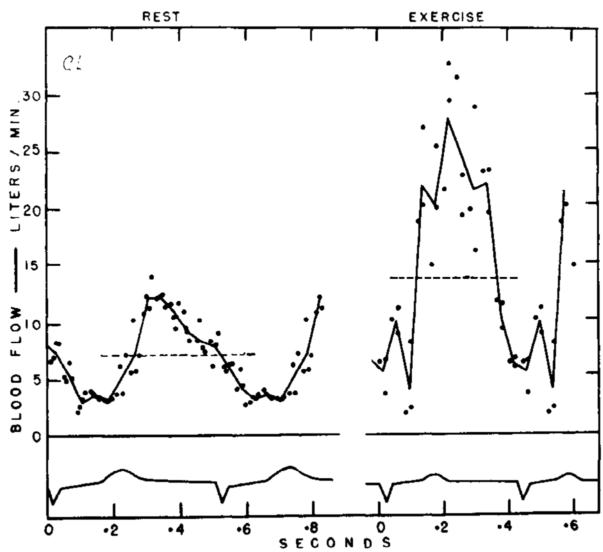

Fig. 12. Capillary pulse flow curve in a normal subject at rest and after exercise. ECG underneath. (Reprinted from Lee and DuBois, J. Clin. Invest. 34: 1380, 1955.)

It can be seen that the mean cardiac output determined by this method is slightly elevated because the subject was actively engaged, in these early experiments, operating the valves and sampling tubes. But the most notable feature is the markedly pulsatile nature of the capillary blood flow in the lung. After exercise this is still more exaggerated.

Also, from the individual pulses, we can calculate the beat-by-beat stroke output from the right ventricle. Now the question naturally arises as to how we can account for this pulsatile quality of the blood flow in the pulmonary capillary bed. The answer was anticipated by Dr. Cournand several years previously. He pointed out that the pressure gradient between the pulmonary artery and pulmonary veins is highly pulsatile, and that it was quite natural to expect that the capillary flow would be pulsatile owing to these conditions. The diagram on which he based his conclusions is shown in figure 13. Here, the pulmonary arterial pressure rises abruptly during systole, and declines during diastole, while the so-called 'PC' pressure follows along underneath, yielding a pressure gradient indicated by the shaded area between the two curves. The events were synchronized

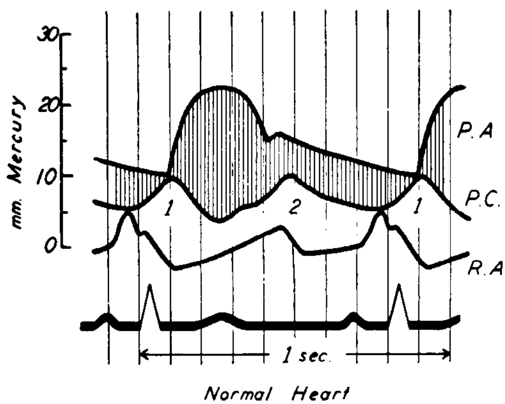

Fig. 13. Pulse pressure gradient drawn by Cournand to predict pulsatile capillary blood flow. (Reprinted by permission from Cournand, Circulation, 2: 641, 1950.)

with the electrocardiograph tracing at the bottom. We are happy to be able to confirm Dr. Cournand's opinion, and have already taken steps to compare the pulse pressure gradient with the pulse flow curves in individual subjects catheterized for clinical reasons. The first step in this comparison has been to study a few patients, sitting, in the body plethysmograph on a different day from their catheterization, which was done lying down. From this preliminary comparison, Dr. Kimbel and I have learned that patients were capable of performing the breathing procedure, yielding satisfactory reproduceable values for pulmonary capillary blood flow, provided they did not have grossly uneven distribution of inspired gas, or vascular shunts. But we have not yet compared the mean values of flow rate obtained by the plethysmographic method with blood flow obtained under similar circumstances by a standard method such as the direct Fick, because a simultaneous comparison with catheters in place requires the use of a special plethysmograph only recently pressed into service. However, with these restrictions in mind, comparisons between the pressure and flow waves in subjects having no pulmonary vascular disease showed that the flow waves corresponded closely in form to the pressure gradient waves, and that there was very little delay of one with respect to the other. I think we can conclude that it is at least theoretically possible to measure the instantaneous pulmonary capillary bloodflow in man, although the method is not recommended for routine use because of the various limitations mentioned above.

However, in the study of cardiopulmonary physiology we are desperately anxious to be able to measure all six variables (thoracic gas volume, alveolar pressure, pulmonary capillary bloodflow, pulmonary arterial pressure, pulmonary venous pressure and intrapleural pressure) at precisely the same time, and to be able to relate them to each other perhaps by the use of an electrical analogue. It begins to look as if this should finally be possible in human beings, because we now have a method for the rapid measurement of lung volume which includes all the gas in the lung, and a method for alveolar pressure during air flow independent of other factors such as pulmonary tissue resistance or muscular force, and thirdly a method for measuring pulmonary capillary blood flow which is instantaneous, and allows beat-by-beat determination of stroke output as well as moment-to-moment changes in the pulsatile flow curve. Therefore we are at the verge of being able to put all these things together for the solution of some problems in cardiopulmonary physiology. Let us, for instance, begin by examining the variations of pulmonary capillary blood flow throughout the respiratory cycle in man. A subject was seated within the body plethysmograph, rebreathing air in a bag controlled to body temperature and saturation, with a pneumotachygraph at the mouth to record the instantaneous rates of air flow, and an esophageal balloon to record the fluctuations of intrapleural pressure. As the subject inspired and expired from the bag, the pneumotachygraph deflection yielded a tracing during two complete respiratory cycles. Meanwhile the plethysmographic pressure fluctuated in proportion to the rate of air flow because of the alveolar pressure changes, owing to compression of gas in the lungs during expiration, and expansion of gas in the lungs during inspiration. Corrections were made to show what the plethysmograph pressure would do after allowing for the alveolar pressure changes, which were proportional to the rate of air flow. The net gas exchange during the respiratory cycle, breathing air, was essentially negligible. The gas exchange points were calculated immediately over the R-waves of the electrocardiograph. The nitrous oxide meter sampled automatically from the breathing tube and registered zero because the subject was rebreathing air. Now if the same bag was filled with 80% nitrous oxide, a similar set of recordings during two inspiratory-expiratory cycles revealed a rapid fall in plethysmograph pressure. The record was completed within 11 seconds, and therefore prior to the recirculation of blood. Again points were corrected for alveolar pressure changes, in proportion to the rate of air flow, in order to determine the beat-by-beat rate of gas absorption brought about by each ejection from the right ventricle. Despite the fluctuations in esophageal pressure throughout the respiratory cycle, and the fluctuations of alveolar pressure, it could be seen that the volume of nitrous oxide absorption progressed at a rate which was equal during inspiration and expiration, which was a fact rather remarkable in the face of the pressure fluctuations and volume changes which occurred in the lungs during the respiratory cycle.

One by one, the first six veils have slipped away. But because we did not at the same time measure pulmonary arterial and pulmonary venous pressures, we cannot give a solution to the old problem of vascular resistance changes which may occur throughout the respiratory cycle in man. 'Complexity', the seventh veil, remains. Consequently we are unable, as yet, to answer the question posed by Dr. Bowditch who, as the first cardiopulmonary physiologist of this Society, had himself studied the problem and arrived at the following conclusions (2): "Provided the cavities from which the blood is received and into which it is delivered are under the same pressure as the external surface of the lungs themselves...expansion of the lungs, by diminishing the size of the pulmonary vessels, presses out a certain amount of blood into the left auricle, and this causes a temporary increase in the flow of blood. But the vessels when reduced in size offer a greater obstacle to the flow of the blood, and this very soon results in a permanent diminution in the amount of blood transmitted. When the lungs are allowed to collapse, the opposite effects are produced.... It remains to be considered how far this condition prevails in the living animal." However, the epicyclic wheel of physiology has taken another turn in its course of revolutions, and brought us back to our point of departure; for the restless kymograph revolves and writes new records, using an old pen; and I feel that, though navigational procedures change according to the times, and though the American Practical Navigator of Nathaniel Bowditch is in jeopardy because of newer, shorter tables and the antiquity of the magnetic compass, nevertheless Dr. Henry Pickering Bowditch need not fear for the durability of his own work for:

> Though North becomes the North Star, ships be shoved
> By rockets toward the moon, and stars are dimmed
> By satellites, as long as hearts contract
> And physiologists assemble, teach and write
> The name of Dr. Bowditch will endure.

Acknowledgments

The author expresses his gratitude to Dr. Albert E. Navez for early guidance in biology, Dr. Wallace O. Fenn for valued supervision during a research fellowship, and Dr. Julius H. Comroe, Jr., who has been both teacher and collaborator during the investigations herein reported.

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REWARDS OF RESEARCH FROM THE VIEWPOINT OF THE SCIENCE WRITER*

MILTON SILVERMAN

Science Writer, San Francisco Chronicle

For the past 25 years, I have been a science writer--a reporter assigned to cover the world of scientific research. No matter what else anybody might say about this way to make a living, it has unquestionably been an active occupation. I have had ample exercise--primarily because my editors see no reason why I should get any sleep.

In addition, my employers have generously enabled me to visit a wide variety of interesting places. If nobody else has ever gone up to 40,000 feet to look at cosmic rays, or if nobody else has ever gone down in a deep-diving submarine to look at submerged canyons, or if nobody else has ever walked halfway across China to hunt for fossil redwood trees, this is where my editors send me. If nobody else has ever climbed through an aortic stenosis, or interviewed a perforated ventricular septum, this is for me.

In short, this has been the most annoying, upsetting and thoroughly exasperating job in the world. I've paid for it with a slight coronary occlusion of my own, and with a wife who thinks she married a portable typewriter. But I wouldn't trade places with anyone.

To me, serving as a kind of middleman or interpreter between the researcher and the public, this assignment has paid rich dividends far beyond my expectations. It has paid off handsomely in dollars -- I can afford my three meals a day, even if I don't usually have time to ingest them. But it has paid off more handsomely in a constant succession of surprises -- in unending excitement and warm emotional satisfactions.

Where my brother reporters in the city room must wait for the rare news break -- the absconding of a bank cashier, the election of a new politician, or an especially juicy love-nest slaying -- we science writers get our breaks almost every hour on the hour. Each day, it seems, there is the report of a new antibiotic to wipe out some old plague. Each day there is the discovery of a new gene, a new synthetic plastic, a new distant galaxy. Each day there is the unearthing of a long-forgotten remedy, the fitting of another link into a chain of scientific evidence, the unveiling of an exciting new scientific theory and the blasting of an outmoded old hypothesis.

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*Presented at a panel discussion of 'Rewards of Research' at the American Heart Association meetings, October 26, 1958, San Francisco.

Of course, not all of these events wind up in print for our readers to assimilate along with their morning porridge. Many of these so-called new discoveries aren't really new at all. Many of them are based on a series of two patients, with a probable error of at least 100%. Many of them are of fantastic importance, but only to two or three people in the world -- such as a minor correction in the seventh decimal place of the specific gravity of 1-methyl-2-ethyl-3-propyl-iatrogenic acid.

But a remarkable number of all these reports meet our definition of news. In our view, news is anything that interests a newspaperman. They do seem significant -- even after we've checked them out -- and they do get printed and they do get read. They permit us to share our excitement and our delight with our readers.

Perhaps the most satisfying science stories for us are those which allow us to follow a research project from its start, as a piece of fundamental research, to its application as a practical device or procedure. Over the years, I've been fortunate enough to cover and report a few of those continuing stories myself -- largely because I happened to be in the right place at the right time.

I remember with deep pleasure, for example, reporting the first fumbling efforts of Ernest Lawrence more than 20 years ago, when he and his colleagues at Berkeley began to crack the atom with their original cyclotron, and then following their progress year by year as they helped create the structure of modern nuclear physics and the treatment of disease with radioactive isotopes. I remember following the basic studies of Wendell Stanley at Rockefeller on the nature of the filterable viruses, and reporting that story, year by year, to the development of the vaccines for influenza and for polio. And with great delight, I remember picking up the first whacky reports from India on a glamorous native remedy with an unpronounceable name, and then following the story, play by play, up to the work of your president, Robert Wilkins, on the use of Rauwolfia and reserpine in hypertension and anxiety states. This week we are seeing other preliminary reports on fundamental research: it is possible that, in the years to come, some of these may lead to the great science stories of the 1960's and the 1970's.

To a hopelessly incurable romantic like me, here is one of the richest rewards of modern research. Here I have a ringside seat for the unfolding of the great adventure stories that stand out as the Iliad or the Idylls of the King of our times.

Most rewarding of all are those stories which deal not only with research but also with researchers. More and more, we are able to interpret these researchers to the public, not as the long-haired, ivory-tower boys, but as they really are -- as human beings; as human beings who may possibly be geniuses or fanatics or crackpots, or simply calculators to the seventh decimal point; as human beings who may sometimes rise to the greatest heights of creative achievement and on other occasions can make the damndest mistakes; as human beings who can be inspired or unselfish or greedy and jealous; as human beings who, like us, also have wives and children and mortgages and stomach ulcers and even hangovers.

As an interpreter of science to the newspaper-reading public, however, I do not believe I should limit my interpretations to one direction. It is important, I believe, that we also attempt to interpret our readers to the scientists. This we are now doing, if only to destroy some dangerous stereotypes.

In the past, for instance, we were told that our readers had only a restricted appetite for science. We were told that reports on basic, fundamental research -- on the nature of our bodies, our world, our universe -- would not be read by our subscribers. We were told that the public would go for science only if it touched on sex, sensationalism, or superserums for sick sufferers. I don't remember which authoritative soothsayer told us all this. He must have had holes in his crystal ball. We have now found that depicting our public in such fashion is as inaccurate -- as dangerously inaccurate -- as portraying all scientists as ivory-tower dwellers.

Scores of newspaper and magazine surveys have clearly shown that if the public has a limited appetite for science, we have not yet approached that limit. In every major newspaper and magazine, readership studies have demonstrated that science and medicine together rank among the first three groups of stories for popularity. In a recent survey conducted for the National Association of Science Writers under a Rockefeller grant, the University of Michigan found that from coast to coast, in every section of the country, in every age group, in every educational group, in every economic stratum, the public wants more science news. It wants to know more about research.

Furthermore, our readers are interested in more than the practical aspects of science -- the wonder drugs, the life-saving surgical operations and the like. Of course, medicine ranks on top as the most widely-read branch of science. But in second place, you will find -- perhaps to your surprise -- astronomy and astrophysics. This may be true today for obvious reasons: the Sputniks are with us. But it was also true 10 years ago, and it was true 20 years ago, when the first space satellite wasn't even on the drawing borads.

It seems clear, therefore, that the public has more than a passing interest in the laboratories. Increasingly, it knows what scientists are doing and why they are doing it. The public is willing to support the research work of such organizations as the American Heart Association, not for charitable or philanthropic reasons, but because it appreciates the value of that research and wants it to continue. The public, in its own way and in its own time, has looked at research and found it good.

To those of you researchers who have helped carry this research story to the public by working with us, we who write science for the nation are truly grateful. We esteem the trust and confidence you have displayed in us. We ask only that you continue your friendship and cooperation -- keep sending us reprints.

And to those of you who are our readers, I can only say that the best is yet to come. We ask that you, too, continue your friendship and cooperation.

USE OF ENGLISH IN JAPANESE JOURNALS

In reply to an inquiry concerning the extent of the use of English summaries in Japanese Journals, Dr. Genichi Kato, of Keio University, Tokyo, supplied the following information.

Most Japanese medical journals written in the vernacular supply an English summary at the end of each paper. One of the journals of the Japanese Physiological Society does this.

The Japanese Physiological Society publishes a quarterly journal in English called the Japanese Journal of Physiology with Dr. Yas Kuno as editor. It is expected that this journal will soon be published bimonthly.

All of the 46 medical schools of Japan have their own journals printed in the vernacular and most of them carry English summaries. Several schools print an additional edition in English, the Tohoku Journal is an example.

The Proceedings of the Japan Academy is another journal printed in English. The Japanese Science Council and Ministry of Education publish annually a journal called Medical Sciences. This is a review type journal and contains abstracts of selected papers. It is printed in English by Gihodo Co., Ltd., Tokyo.

CONFERENCE ON MEDICAL EDUCATION

The Second World Conference on Medical Education under the auspices of the World Medical Association will be held at The Palmer House in Chicago, Ill. from August 30 to September 4, 1959. Various sections of the conference will deal with the following topics: Basic clinical training; Advanced education for general and specialty practice; Development of teachers and investigators; Continuing medical education. For further information write Dr. L. H. Bauer, The World Medical Association, 10 Columbus Circle, New York 19, N.Y.

EDUCATION COMMITTEE -- 1958 ACTIVITIES

Session on Teaching

At each Spring Meeting the Education Committee invites a person to chair and arrange a special session on a particular subject of interest to teachers. At the Philadelphia meetings in 1958, Dr. Roy O. Greep chaired a session on 'Some Basic Problems Pertaining to the Teaching of Physiology to Dental Students.' The participating speakers were Drs. John R. Brobeck, John Haldi, George Wakerlin, Wah Leung and George Sayers.

Refresher Course

Just preceding each Fall Meeting the Education Committee arranges a refresher course on some phase of physiology. At the Western Ontario meetings on September 2 and 3 Dr. H. W. Davenport conducted a refresher course on 'The Teaching of Physiology of the Digestive Tract'. The participating speakers were Drs. W. B. Youmans, C. F. Code, F. P. Brooks, C. A. M. Hogben, J. A. F. Stevenson, R. C. Herrin, M. I. Grossman, E. R. Woodward, M. H. F. Freidman and R. Buchholz.

Workshop

Each summer, starting in 1955, the Education Committee has sponsored workshops for college teachers of physiology. These workshops are 2-week sessions held on some appropriate college campus. An article by Dr. Ladd Prosser explaining the purpose and aims of these workshops appeared in the last issue of THE PHYSIOLOGIST. The workshops are supported by grants from the National Science Foundation. The 1958 workshop was held at Bucknell Univ., Lewisburg, Pa. for college teachers chosen from the surrounding states. Dr. Samuel Tipton was director. There were 28 college teacher participants and 8 discussion leaders in attendance.

The workshops have provided the Society with a number of resolutions that have led to a broadening of the activities of the Education Committee and the Society. Notable among these were: summer research traineeships for college teachers; associate membership in the Society; the collection and preparation of laboratory teaching material; and the traveling collection of recent monographs.

Those participating in the 1958 workshop were:

Discussion Leaders

Deyrup, Ingrith - Assoc. Prof. Zool., Barnard College, N.Y.C.
Frings, H. W. - Prof. Zool., Penn. State Univ., Univ. Park, Pa.
Green, J. W. - Assoc. Prof. Physiol., Rutgers Univ., New Brunswick, N.J.
Gross, P. R. - Assoc. Prof. Biol., New York Univ., N.Y.C.

Hitchcock, F. A. - Prof. Physiol., Ohio State Univ., Columbus, Ohio
Ramsey, R. W. - Prof. Physiol., Medical College of Virginia, Richmond, Va.
Stacy, R. W. - Assoc. Prof. Physiol., Ohio State Univ., Columbus, Ohio
Stephenson, W. K. - Asst. Prof. Biol., Earlham College, Richmond, Ind.

Participants

Bowman, R. - (Host) - Assoc. Prof. Physiol., Bucknell Univ., Lewisburg, Pa.
Alscher, Ruth - Prof. Biol., Manhattanville College, New Rochelle, N.Y.
Austin, L. G. - Prof. Biol., Maryland State College, Princess Anne, Md.
Chadwick, J. B. - Instr. in Physiol., Vassar College, Poughkeepsie, N.Y.
Curtis, W. E. - Assoc. Prof. Biol., Allegheny College, Meadville, Pa.
Elizabeth, Sister - Prof. Biol., Chestnut Hill College, Phila., Pa.
Francis, Sister - Asst. Prof. Biol., Nazareth College, Rochester, N.Y.
Heim, Louise - Asst. Prof. Biol., Adelphia College, New Hyde Park, L.I., N.Y.
Hintz, H. W. - Assoc. Prof. Biol., Heidelberg College, Tiffin, Ohio
Kiely, L. J. - Assoc. Prof. Biol., Niagara Univ., Niagara Falls, N.Y.
Lambert, F. L. - Asst. Prof. Biol., Union College, Schenectady, N.Y.
Lessler, M. L. - Assoc. Prof. Physiol., Ohio State Univ., Columbus, Ohio
Lieb, Rev. J. R. - Prof. Biol., St. Vincent's College, Latrobe, Pa.
Minsavage, E. J. - Instr. in Biol., King's College, Wilkes-Barre, Pa.
Murphy, Sister - Instr. in Biol., Mary Manse College, Toledo, Ohio
Naiman, Dorothy - Assoc. Prof. Physiol., Hunter College, N.Y.C.
Norman, C. - Assoc. Prof. Biol., West Virginia Univ., Morgantown, W. Va.
Peterjohn, G. W. - Assoc. Prof. Biol., Baldwin-Wallace College, Berea, Ohio
Peters, Rev. J. J. - Prof. Biol., Xavier Univ., Cincinnati, Ohio
Quintrell, Dorothy - Instr. in Biol., Fairmont State College, Fairmont, W. Va.
St. Agatha, Sister - Prof. Biol., Immaculata College, Immaculata, Pa.
Sandoz, Mildred - Assoc. Prof. Biol., Clarion State College, Clarion, Pa.
Schoenborn, H. W. - Prof. Zool., Univ. of Maryland, College Park, Md.
Shortess, G. S. - Prof. Biol., Lycoming College, Williamsport, Pa.
Trainer, J. - Prof. Biol., Muhlenburg College, Allentown, Pa.
Van Dam, L. - Prof. Biol., Ursinus College, Collegeville, Pa.
Whalen, T. A. - Assoc. Prof. Biol., Siena College, Loudonville, N.Y.
Wolf, L. N. - Prof. Biol., Univ. of Scranton, Scranton, Pa.

Summer Research Traineeships for College Teachers

This program was started in 1956 and has been operating each summer. The purpose of the program is to revitalize research interest in the dynamic biological sciences among college teachers.

The educational aspects of the program are most important -- training of teachers and in turn their training and interesting college students in research. The training period runs from 8 to 12 weeks during the summer months in a large university or institute research laboratory. This program is supported by grant funds from the National Heart Institute and the National Science Foundation. A great deal of credit for the success of the program goes to the many host laboratories who have offered their time and facilities and in many cases contributed some supporting funds.

In 1958 there were 38 college teachers chosen by the Committee to study in 30 host laboratories. Each laboratory accommodated from one to three teachers. The grant funds provide stipends, travel allowances, etc. for the teachers. The host laboratories supply facilities, general instruction and in most cases research supplies. Teachers are permitted to choose their host laboratory and the host laboratories have the right to accept or reject an applicant recommended by the Committee.

Those participating in the program for 1958 were:

Alexander, C. G. - San Francisco State College, San Francisco, Calif.
Host - G. A. Feigen, Stanford Univ.
Barrington, B.A., Jr. - King College, Bristol, Tenn.
Host - H. D. Green, Bowman Gray School of Medicine
Bond, R. R. - Salem College, Salem, W.Va.
Host - J. H. Fuller, Jackson Memorial Lab., Bar Harbor, Maine
Bowden, R. L. - Ohio Northern Univ., Ada, Ohio
Host - B. De Boer, Univ. of North Dakota
Brand, R. E. - Westmont College, Santa Barbara, Calif.
Host - P. R. Morrison, Univ. of Wisconsin
Buckholz, R. H. - Monmouth College, Monmouth, Ill.
Host - F. P. Brooks, Univ. of Pennsylvania
Chiasson, R. B. - Univ. of Arizona, Tucson, Ariz.
Host - W. F. Ganong, Univ. of California, Berkeley
Daniel, J. C., Jr. - Adams State College, Alamosa, Colo.
Host - R. K. Meyer, Univ. of Wisconsin
Derrick, Ethel - Central State College, Edmond, Okla.
Host - H. E. Hoff, Baylor Univ.
Duwe, A. E. - Wisconsin State College, Superior, Wis.
Host - G. W. Nace, Univ. of Michigan
Erickson, Mary - Santa Barbara College, Goleta, Calif.
Host - K. Killam, Univ. of California, Los Angeles
Folden, D. B., Jr. - Memphis State Univ., Memphis, Tenn.
Host - W. F. Hamilton, Medical College of Georgia
Garth, R. E. - East Tennessee State College, Johnson City, Tenn.
Host - H. E. Hoff, Baylor Univ.
Giere, F. A. - Luther College, Decorah, Iowa
Host - S. M. Horvath, State Univ. of Iowa
Gifford, C. A. - Univ. of Vermont, Burlington, Vt.
Host - C. E. Lane, Marine Lab., Univ. of Miami, Fla.
Girvin, E. C. - Southwestern Univ., Georgetown, Texas
Host - J. K. Hampton, Tulane School of Medicine

Hartley, R. T. - Wisconsin State College, La Crosse, Wis.
Host - R. K. Meyer, Univ. of Wisconsin
Howell, Barbara - Montana State Univ., Missoula, Mont.
Host - H. Rahn, Univ. of Buffalo
Hsu, Yin - Nebraska Wesleyan Univ., Lincoln, Nebr.
Host - H. I. Kohn, Univ. of California, San Francisco
Huber, Olive - Hunter College, New York City
Host - L. H. Peterson, Univ. of Pennsylvania
Johnson, M. A., Jr. - Grambling College, Grambling, La.
Host - S. M. Horvath, State Univ. of Iowa
Johnson, Sister - St. Joseph College, West Hartford, Conn.
Host - H.B. Steinbach, Marine Biol. Lab., Woods Hole, Mass.
Judd, Sister - The College of St. Catherine, St. Paul, Minn.
Host - J. L. Ambrus, Roswell Park Memorial Inst., Buffalo
Kadner, C. G. - Loyola Univ. of Los Angeles, Los Angeles, Calif.
Host - T. L. Jahn, Univ. of California, Los Angeles
Keller, R. F., Jr. - Univ. of Akron, Akron, Ohio
Host - G. Sayers, Western Reserve Univ.
Konheim, Beatrice - Hunter College, New York City
Host - J. T. King, Univ. of Minnesota
Levy, C. K. - Vassar College, Poughkeepsie, N.Y.
Host - B. R. Lutz, Boston Univ.
McArthur, P. T. - College of St. Teresa, Winona, Minn.
Host - H. Necheles, Michael Reese Hospital, Chicago
McElroy, W. T., Jr. - South Dakota State College, Brookings, S. Dak.
Host - B. M. Lewis, Wayne State Univ., Detroit
Orr, H. D. - St. Olaf College, Northfield, Minn.
Host - P. R. Morrison, Univ. of Wisconsin
Osborne, P. J. - Lynchburg College, Lynchburg, Va.
Host - K. M. Wilbur, Duke Univ.
Peary, J. Y. - Benedict College, Columbia, S.C.
Host - C. M. Ambrus, Roswell Park Memorial Inst., Buffalo
Schafer, Rita - Immaculate Heart College, Los Angeles, Calif.
Host - C. E. Lane, Marine Lab., Univ. of Miami, Fla.
Tamar, H. - Pembroke State College, Pembroke, N.C.
Host - H. Rahn, Univ. of Buffalo
Todd, R. E. - Colgate Univ., Hamilton, N.Y.
Host - E. Zwilling, Marine Biological Lab., Woods Hole, Mass.
Vallowe, H. H. - Ohio Univ., Athens, Ohio
Host - R. K. Meyer, Univ. of Wisconsin
Williams, Delores - Spelman College, Atlanta, Ga.
Host - C. L. Gemmill, Univ. of Virginia School of Medicine
Zorzoli, Anita - Vassar College, Poughkeepsie, N.Y.
Host - E. J. Boell, Yale Univ.

Teaching Tours

Each year the Education Committee has one or more of its members tour colleges in order to observe and report on various teaching methods, materials and conditions and to assist where they can in modernizing the presentation of physiology. From these tours much information is gained for the Committee and in many situations local problems and difficulties are discussed to the benefit of the teachers.

The first tour was conducted in 1956 by Dr. W. R. Amberson who visited 20 colleges mainly in Ohio and North Carolina. In 1957 Dr. Adolph visited three large universities and Dr. Martin visited several colleges in the Northwest, including state teachers colleges and church-affiliated liberal arts colleges. In 1958 and early 1959 Drs. Comroe and Prosser visited colleges near their own institutions.

Career Brochure

For several years the Education Committee has had a brief leaflet describing careers in physiology that has been distributed to thousands of high schools. During 1958 the Committee felt that this leaflet should be enlarged and brought up to date. In addition it was felt that an illustrated brochure should be prepared for college students. The Committee is prepared to go ahead with both of these projects and is seeking financial support.

Monographs

The Education Committee has purchased and collected approximately 100 relatively recent monographs on various biological subjects. These are mainly for use at the workshops each summer but are also available to colleges on a loan basis. Each year a portion of the funds allotted by Council is used to add to and keep the set of monographs up to date. These monographs were displayed at the Fall Meeting at Western Ontario. Dr. H. W. Schoenborn of the University of Maryland is in charge of this collection of monographs.

Laboratory Experiments Project

Dr. Louise Wilson of Wellesley College is in charge of collecting college laboratory experiments in general physiology and Dr. Charlotte Haywood of Mount Holyoke College is in charge of collecting college laboratory experiments in human physiology. This material is being organized and the present plan is to have the various experiments tested at the college level. Those that prove acceptable for illustrating a physiological principle will be abstracted and distributed to colleges. The detailed experiments in loose leaf form will be made available through the APS office at a nominal cost. Efforts are being made to obtain further financial support for this project.

Other Activities

Among other activities the Education Committee is establishing a limited number of study groups to explore various aspects of the broad education problem. The Committee encourages local groups to become active in education problems and solicits suggestions of lines of action from the membership of the Society.

Finances

The Committee operates on grant funds from various sources. The funds received for the 1958 projects are as follows:

Workshops:

$8,155 from National Science Foundation

Summer Research Traineeships for College Teachers:

$50,000 from NSF
$20,000 from National Heart Institute
$ 2,300 in contributions from host laboratories
Approximately $8,000 of the NSF funds and $950 of the NHI funds are held over to start the 1959 program. The programs for 1959 and 1960 have been assured by continuing grants from the NSF and NHI.

Other Activities:

The Council of APS appropriated $1,000 to the Education Committee for other activities, not directly covered by specific grants, such as minor expenses for the refresher course, purchase of monographs, annual teaching tours, duplication of laboratory experiments, etc.

AMATEUR MUSICIANS

The musically-minded Federation-connected Amateur Chamber Music Players propose to congregate again at the Atlantic City meeting. Those interested in meeting with the group or having any ideas or desiring any information concerning the same are invited to communicate with W. E. Cohn, Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, who will attempt to coordinate activities. A growing number of individuals of all Societies of the Federation, both players and listeners, have expressed interest in this activity, which was enormously successful in Philadelphia.

SPRING MEETING

Atlantic City, N.J., April 13-17

The Society will hold its annual Spring Meeting as a part of the Federation Meetings as is the custom. Meetings will start at 1:30 P.M. Monday April 13 and run through Friday afternoon April 17.

The APS is arranging three symposia and one teaching session in addition to eight special sessions where selected chairmen give a 30-minute review of the particular subject. These are:

Symposium: Physiology and Drug Actions	April 14
Symposium: Biological Rhythms	April 16
Symposium: Life in Space	April 17
Teaching Session: Problems and Experiences in the Recruitment of Graduate Students for the Medical Sciences	April 15

Special sessions:

Renal Tubule - W.D. Lotspeich, Chr.	April 14
Peripheral Circulation - B.W. Zweifach, Chr.	April 14
O_2 and CO_2 Transport - C.J. Lambertsen, Chr.	April 15
Blood Volume Regulation - J.W. Remington, Chr.	April 15
Contractile Proteins - M.F. Morales, Chr.	April 16
Coronary - H.D. Green, Chr.	April 16
Adrenal Corticosteroids - G. Pincus, Chr.	April 17
Spinal Cord - K. Frank, Chr.	April 17

Business meetings of the Society will be held Tuesday and Thursday afternoons, April 14 and 16. Members please come.

R. A. GREGORY TO SPEAK AT G.I. SECTION

Dr. R. A. Gregory, Professor of Physiology, the Medical School, University of Liverpool, England, will be the guest lecturer of the Section on Gastrointestinal Physiology at the time of the Federation meetings in Atlantic City. The title of Dr. Gregory's address will be 'Problems of excitation and inhibition in the alimentary tract'. Dr. Gregory is internationally known for his many important contributions dealing with the mechanism of gastric secretion. Those interested are invited to attend this evening lecture. See the Federation Program for time and place.

FEDERATION PLACEMENT SERVICE

The Placement Service is designed to meet the needs of employers and of individuals desiring positions in the fields of the Federated Societies. Its activities are:

1) Listing positions, fellowships and exchanges available in academic, industrial and governmental institutions, foundations and societies

2) Listing applications for positions from qualified individuals, chiefly at the professional level (Ph.D. or equivalent)

3) Circulating
   a) Quarterly lists of applicants with brief summaries of their qualifications
   b) Semiannual lists of available positions, and
   c) Annual lists of available fellowships and assistantships

The Placement Service issues seven bulletins annually. Information to be included must reach the Washington office by the first day of the month of issue. Lists of candidates are prepared in February, May, August and November, lists of positions in March and September, and a list of fellowships in October. There is no charge for registering positions or fellowships. Registration cards for both will be supplied on request. Following are the established subscription charges:

Annual subscription to all lists of the Service (calendar year)	$20.00
Single copy of a list of Candidates	10.00
Single copy of a list of Positions	5.00
Single copy of a list of Fellowships	2.00

A copy of the fellowship list will be sent without cost to any member of a constituent Society upon written request.

As in former years, the Federation Placement Service will provide interview facilities at the Annual Meeting of the Federation in April at Atlantic City. These will be in Convention Hall and will be open only to registrants at the Annual Meeting.

Registration Procedures for Employers

The Placement Service will be open for employers:

Monday - Thursday	April 13-16	8:15 A.M. to 5:00 P.M.
Friday	April 17	8:15 A.M. to 12:00 M.

The facilities are open to all annual subscribers to the Placement Service or to subscribers for the single February list of candidates. Identification cards for admission to the interview service can be picked up at the Employers' Registration Desk in Atlantic City only by the subscriber or his authorized representative. Up to three identification cards can be issued for each subscription. If someone other than the subscriber, or additional persons from the same organization are to use the interview privileges of the subscription, the subscriber must send their names to the Washington office before April 1. Otherwise a $2.00 charge will be made for each identification card requested at Atlantic City.

To register IN ADVANCE for the PLACEMENT SERVICE in Atlantic City:

1) Subscribe for all the Placement Service lists for 1959 at $20.00 or to the single February list of candidates at $10.00 before April 1, 1959.

2) Obtain a registration card for each position you wish to fill and return the completed card to the Washington office before April 1, 1959.

Employers may register at Atlantic City by entering the required subscription there. Subscriptions taken there must be paid for at the time, for institutional orders are accepted only at the Washington office and before April 1. Advance registration will save considerable time.

Application forms of applicants present at the meetings will be available for examination and interviews will be arranged with applicants at the employer's request. New application forms will be continuously added to the file until Wednesday at 5:00 P.M. It is advisable to schedule appointments as early in the week as possible.

Registration Procedures for Applicants

The Placement Service will be open:

Sunday	April 12	1:00 P.M. to 5:00 P.M.
Monday - Thursday	April 13-16	8:15 A.M. to 5:00 P.M.
Friday	April 17	8:15 A.M. to 12:00 M.

Advance registration can be made by obtaining application forms from the Washington office and completing and returning them before April 1, 1959, with notification that attendance at the meetings is planned so that the forms can be processed and taken to Atlantic City. New registrations will be accepted at Atlantic City through Wednesday. Employers can examine application forms and request interviews only after applicants have completed their registration upon arrival at Atlantic City when a record is made of the hours they are available for interviews. Therefore, early registration there is a distinct advantage to applicants.

Interviews will be scheduled:

Tuesday - Thursday	8:30 A.M. to 5:00 P.M.
Friday	8:30 A.M. to 12:00 M.

There is an annual fee of $3.00 to applicants for maintaining registration. For further information address: Placement Service, Federation of American Societies for Experimental Biology, 9650 Wisconsin Avenue, Washington 14, D.C.

MOTION PICTURES RECOMMENDED AS AIDS IN TEACHING PHYSIOLOGY OF ALIMENTARY CANAL

C. F. CODE

Mayo Foundation, Rochester, Minn.

I. EMBRYOLOGY

'The Development of the Gastrointestinal Tract' (Silent)
- Author: Joseph J. McDonald, Dept. Surg., Columbia Presbyterian Med. Ctr., N.Y.C.
- Available from: Amer. Med. Assoc., 535 N. Dearborn St., Chicago 10, Ill.
- Charge: $4.00
- Duration: 35 minutes
- Comment: An embryological not a physiological film. It presents in motion sequence an excellent visualization of the embryological development of the alimentary canal of the human.

II. MOTOR ACTION

A. Deglutition

'The Mechanism of Swallowing' (Silent)
- Authorship: Dept. of Radiology, Univ. of Rochester Sch. of Med. and Dentistry Rochester, N.Y.
- Available from: Univ. of Rochester Sch. of Med. and Dentistry
- Charge: nil
- Duration: 15-20 minutes
- Comment: Superb teaching film illustrating by cineradiographic means the mechanisms involved in the movement of air and liquid from lips to esophagus.

'Intraoral and Pharyngeal Structures and Their Movements' (Talkie, color)
- Authorship: Dept. of Surgery, Veterans Administration
- Available from: Veterans Administration, Washington 25, D.C.
- Charge: nil
- Comment: Superb motion picture showing movements in mouth and pharynx during respiration, deglutition and speech in a patient with lower half of face mostly removed. A wonderful companion piece to 'The Mechanism of Swallowing'.

'Deglutition' (Silent)
Author: Lester W. Paul, Dept. of Radiology, Univ. of Wisconsin, Madison 6, Wis.
Available from: Dr. Lester W. Paul
Comment: Roentgen cinematography by means of image intensifier; passage of barium with swallowing through pharynx; pharyngoesophageal and gastroesophageal junctions are illustrated.

B. STOMACH

'Movements of the Stomach' (Silent)
Authors: Walter C. Alvarez and Arnold Zimmerman
Available from: Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
Charge: nil
Comment: A very interesting movie, made over 32 years ago, showing direct observation of movements of stomach in anesthetized dogs, rabbits and cats after removal of abdominal wall. Some excellent illustrations of type II contractions in the dog.

'Human Antral Gastric Motility' (Silent)
Authors: Alan W. M. Smith, Charles F. Code and Jerry F. Schlegel
Available from: Photographic Dept., Mayo Clinic, Rochester, Minn.
Charge: nil
Comment: Cineradiographic identification of type I and type II waves in the antrum of the human stomach with an indication of their function. Makes a fine combination with the Alvarez film on gastric contractions of the dog.

C. SMALL BOWEL

'Intestinal Peristalsis' (Silent)
Authors: Walter C. Alvarez and Arnold Zimmerman
Available from: Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
Charge: nil
Comment: Interesting historically but confusing physiologically. Direct observations of intestinal movements in anesthetized animals. Many of the motility patterns seem abnormal. Some of the spastic hyperactivity may be related to the morphine used in the anesthetic.

'Direct Observation of Human Intestinal Motility' (Silent, Color)
Authors: N. C. Hightower, R.K. Ghormley and C. F. Code

Available from: Photographic Dept., Mayo Clinic, Rochester, Minn.
Charge: nil
Comment: Observations on a healthy conscious patient with a large ventral hernia. Useful motion picture to show changes in amount of activity in small bowel with a meal, after morphine, prostigmine and banthine. Also illustrates rhythmic segmentation in small bowel, haustral contractions and mass movement in large bowel.

D. GALL BLADDER

'Contraction and Evacuation of the Gall Bladder in the Rabbit Following the Intravenous Injection of the Cholecystokinin' (Silent)
Authors: D.N. Danforth, H. Doubilet and A.C. Ivy
Available from: Audio Visual Medical Education Dept., 303 E. Chicago Ave., Northwestern Univ. Med. School, Chicago 11, Ill.
Charge: nil
Comment: Historically interesting. Illustrates early experiments with cholecystokinin--slow diminution in size of gall bladder of three rabbits following injections of cholecystokinin.

E. INTESTINAL VILLI

'Movement of Intestinal Villi' (Silent)
Author: F. Verzar
Available from: British Film Institute, Great Russell Street, London, England
Charge: 6 s
Duration: 4-5 minutes
Comment: Copy of film reviewed was badly scratched. Despite scratches film is of great interest since it is only motion picture reviewed which shows pumping action of villi and illustration of probable significance of this action in absorption. An ancient film of some historical significance.

III. SECRETION

A. GASTRIC

'Gastric Secretion' (Talkie)
Author: R.A. Gregory, Univ. of Liverpool, England
Available from: Imperial Chemical Industries, Ltd., 488 Madison Ave., New York 22, N.Y.
Duration: 45 minutes
Comment: Outstanding teaching motion picture illustrating construction of vagally innervated and

vagally denervated gastric pouches in dogs and their response to a meal of meat.

B. Pancreatic

'Pancreatic Secretion' (Talkie)
Author: R.A. Gregory, Univ. of Liverpool, England
Available from: Imperial Chemical Industries, Ltd., 488 Madison Ave., New York 22, N.Y.
Duration: 45 minutes
Comment: An outstanding undergraduate teaching movie demonstrating pancreatic ductal system; loss of granules from cells during stimulation; action of vagal stimulation as well as stimulation by secretin and pancreozymin.

IV. DIGESTION

'Digestion of Foods' (Talkie)
Authors: A.J. Carlson and H. G. Swann
Available from: Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
Duration: 16 minutes
Comment: Good demonstration of motor action of esophagus, stomach and intestinal villi.

SOME BASIC PROBLEMS PERTAINING TO THE TEACHING OF PHYSIOLOGY TO DENTAL STUDENTS*

Chairman: R. O. GREEP, Harvard School of Dental Medicine

Introduction

R. O. GREEP

This session will deal with some basic problems pertaining to the teaching of physiology to dental students. The thought behind this symposium was to provide those who teach dental students with an opportunity to get together to share experiences, and to exchange ideas relating to the teaching of physiology. The program is largely one of audience participation. Four speakers will outline briefly some of the pertinent problems. We hope to have a vigorous discussion of these matters.

Let me here pose some questions to warm your thinking. What should a course in physiology for dental students cover and how should it be taught? That's really the substance of our program this morning. We shall, of necessity, be concerned with the learner, the course, and the administration of the course. One of the issues is whether the course for dental students should be on a par with that for medical students; another, whether the course in physiology should be tailored to suit professional needs. Can physiology be looked upon as an area of knowledge basic unto itself, and yet be streamlined to meet the needs of special groups? Can we properly emphasize application in the teaching of physiology in either medicine or dentistry? What are the qualifications for effective teachers of physiology? Should they have a background in dental training? Does the physiology of the oral structure receive due consideration? It has been variously claimed that dental students have less motivation for learning physiology than medical students; is that true? It has been claimed that dental students regard physiology more as a hurdle to their clinical work; what is your experience? It has been said that the dental student is distracted by too heavy demands on his time by technic courses while he is taking physiology. Nearly all dental schools teach some dental technic early in professional training. Some believe that physiology courses in the dental curricula should be taught by dental faculties; others, that dental and medical classes are better taught separately by a common university department. Still others believe that medical and dental students should be taught jointly. What is the better arrangement? It has been claimed that

*A Symposium held on April 15, 1958 at the Society Meeting, Philadelphia, Pennsylvania

there is too little application of the basic sciences in clinical dental practice to justify giving the dental student a thorough background in physiology. In other quarters there is a growing conviction that modern dental practice requires the dental student to have the same grounding in human biology as the student of any other health science -- or that the dental student should receive a course equivalent in quality if different in content. These are some of the questions.

SCOPE, POINTS OF EMPHASIS AND OBJECTIVES IN PHYSIOLOGY FOR DENTAL CLASSES

J. R. BROBECK, University of Pennsylvania

First of all, I wish to begin by discussing the objectives of teaching as I see them. In my opinion, the objective of a course in physiology for dental students is not to please the students and it is not to please practicing dentists. One gets a very limited kind of information from these two groups as to the proper goals and the success of a physiology course. We all feel a desire to learn the opinions of our students, and I believe that they should have the chance to express their opinions. But the faculty must remember not to take their opinions too seriously. Otherwise, we shall find ourselves in a situation where the standards and the goals of our teaching in science are set in large measure by the wishes of our students. This idea, which may be called 'naturalism' in teaching, is a disservice to all students, but especially to the best ones. And it is unfair to the science that we represent. If we are inclined to believe that we should teach only what students want to learn, we should be reminded that this procedure tends to defeat the finest objectives of higher education. In one sense, our primary responsibility is not to the student at all; it is to the university community. Since we are selected by our associates in the faculty, and paid by the people who support the university, our primary responsibility is to represent, at an adequate level, scholarship in physiology. We do this mainly by the kind of scholars we are personally, rather than by the content of our courses. Every teacher should be inquisitive and every teacher must be the master of the tools of his profession; if he is inquisitive and is a master of these tools, he is certain to be an investigator. (This is different from the idea that everyone ought to do a little research and ought to publish one or two or three papers each year.) We have a similar responsibility to the other physiologists of the national and international scientific community. I believe it is possible to apply to our teaching this principle of responsibility to the scholars both within and outside the university, not in merely a nebulous and theoretical way, but in an effective manner that will determine the approach that we have and the way we go about our teaching of dental students.

The second point that I wish to mention is this; having spoken of where our primary responsibility lies, we should consider also the nature of our responsibility to our students. First of all, we should remember that it is possible to teach physiology to a three-year-old youngster; it can be taught to children of any age. One can give a third grader a wonderful course in physiology, and this is true of a seventh grader or of a high school or a college student. In my opinion, it is a mistake for us to believe that a dental student, or a nursing student, or a student in physical therapy is different from all of these other populations of students, and for us to assume that when a student comes into dental school, he requires some unusual kind of motivation in order to learn physiology. The basic urge on which our teaching is built is the urge to learn. We should aim to take advantage of this natural inquisitiveness so as to develop our science in a liberal, broad way without depending upon, as inducement to the student, these so-called applications that can be made. It is my impression that one can make in about three lectures all of the known applications of physiology to dentistry. (In four lectures one can probably outline the known applications of physiology to medicine!) Perhaps I am underestimating this; but there are not very many practical things the dentist needs to know about physiology in order to be a good dentist. What he needs to learn in our courses, as I see it, is what is going on in the body and how one can find out about it. What are the methods which scientists have developed for studying a given organ system or particular kind of organism, and how does this provide the basis, philosophically and theoretically, for the practice of dentistry and the practice of medicine? In answering these questions we can take full advantage of the natural inquisitiveness of our students. Moreover, we have a responsibility not to waste their time and their energy. It is popular now to criticize the teaching of science and the scientific achievements of our young people. I have a feeling that we fail to recognize to what extent we, their teachers, are responsible for this present situation. Perhaps the present lack of interest in science and in science teaching is an outgrowth of the misuse of laboratory instruction in this country within the past thirty years. Sometimes I think that hundreds of students are wasting thousands of hours and millions of dollars in laboratory courses that are not intellectually stimulating, that are no more than a routine. We even have a tendency to give to our laboratory courses the nature of an initiation or a hazing process. We approach them with the idea that "I had to go through it in this way, and so do you." "It is impossible to get a high grade in this course. Science is not like English. You can get an 'A' in English, but you can get only a 'B' in science." "The highest grade in this course is 85." If this is the way we go at our teaching responsibilities, this is a mistake. We should recognize that our students spend many hours and much of their energy in a laboratory course, and that they deserve for this an introduction to physiology as it is--not simply a means of visual aid in the learning of the course nor a repetition of whatever experiments happen to be available in someone's laboratory manual!

In summary, our most important obligation to our students is to design a course that allows them to discover the fascination that we ourselves find in this science. We should make it impossible for our students to get through our courses without seeing a glimpse of the excitement there is in being a physiologist, in studying how the functions of the body are carried on. Whether it be a course for dental students, for medical students, or for professional physiologists, this is the objective that I believe to be most desirable--that our students get some idea of the attractions and the intellectual rewards that are offered by this science.

J. HALDI, Emory University

The thesis that I should like to develop in this symposium is two-fold: 1) that the course in physiology for dental students should be on a par academically with that given to the medical students; 2) that it should nevertheless be tailored insofar as possible to meet the future professional needs of the dental student.

Your acceptance or rejection of this thesis will depend on your acceptance or rejection of the concept of the dental profession and the attendant philosophy of dental education which serve as some of the guiding principles of the Emory University Dental School. Prior to 1944 this dental school was privately owned and was known as the Atlanta Southern Dental College. In that year it became integrated with Emory University. Four years later the school was reorganized under the supervision of the newly appointed dean, Dr. John Buhler. The old Atlanta Southern Dental College had provided excellent training in dental skills, but could not give much attention to the basic science courses. One of the first undertakings by Dr. Buhler was to organize basic science departments with the idea that these should be on a par with those in the medical school. To accomplish this purpose he enticed men who had taught in medical schools to join the dental school faculty and develop these departments. I use the word 'entice' advisedly because, for reasons you may all readily surmise, Dr. Buhler had to do a real selling job in persuading men to undertake this venture. Speaking for myself, I was sold on the proposition because I became intrigued with Dr. Buhler's philosophy of dental practice and dental education, which, I must confess, broadened my mental horizon and gave me an entirely new outlook on the dental profession.

This philosophy, which I accepted wholeheartedly and which I have since enlarged upon in my own thinking, can be briefly summarized as follows: dentistry is, or should be, a profession of the highest order -- an integral branch of the health services, no less than medicine. Like ophthalmology and otolaryngology which are restricted to certain areas in the medical services, dentistry is limited in its field of application to the oral cavity. The dentist, no less than the ophthalmologist and otolaryngologist, should be trained in the skills of his profession, but he should also have a solid background in the basic sciences comparable to that which we insist on giving to all our medical students even though the primary interests of some of these students later on will be more or less limited to some specific area in the field of medicine.

Will anyone gainsay the proposition that the teeth and the rest of the oral cavity constitute an integral part of the human organism? Let us not forget that when a dental student is graduated, the school confers upon him the degree of 'doctor.' When he passes his state board examination he is licensed by law to prescribe drugs and narcotics, to administer anesthetics, and to perform both minor and major surgery in the oral cavity.

Not infrequently a person in need of medical care does not consult a physician either through ignorance or for economic or other reasons, but he will come to the dentist's office because he has a toothache or pain which he may erroneously believe to be a toothache. Furthermore many people will visit their dentist once or twice a year whereas they will not go regularly to their physician for a physical check-up. Upon examination of the patient, the dentist may observe cheilosis, a magenta red tongue, spongy gums, or other pathognomic signs of a vitamin deficiency; a neoplastic growth in the oral cavity; physical signs suggestive of blood dyscrasias; pigmentation of the mucous membranes in the oral cavity characteristic of Addison's disease; edema of the eye lids; enlargement of the thyroid; adenoids or diseased tonsils; exophthalmus and tremor of the tongue; pallor of the skin and of the oral mucous membranes indicative of anemia; shortness of breath or a smell of acetone on the breath; signs of jaundice in the oral mucosa, or other manifestations of disease.

If the dentist has been trained only to prepare cavities and to make restorations in teeth, to design and fit dental prosthetic appliances and to perform the various other dental skills, these evidences of physiological disturbances would be passed by unnoticed, or, if noticed, would arouse no productive thought processes. On the other hand, the dentist with the kind of professional education that makes him an integral part of the health services recognizes the significance of what he observes, and tactfully explains to the patient his need of medical care. Without encroaching on the field of medicine, he may rightfully prescribe therapeutic measures in some instances, as, for example, when oral conditions are suggestive of vitamin deficiencies.

This is but one aspect of the way in which knowledge in physiology and in the other basic sciences prepares the dentist for participation in and contributions to the health services. Just as important and perhaps even more important is the mental development and mental discipline which enable him to observe for himself and to reason from his own observations both in the diagnosis and management of his patient. Take for example the problem confronting the dentist when a patient comes to him complaining of severe pain radiating over areas of the face. How can he determine intelligently whether he is dealing with a pulpitis, maxillary sinusitis, trigeminal neuralgia, temporo-mandibular joint disorder, otolaryngeal irritation or other causes of facial pain unless he knows something about the physiology of pain and in particular about referred pain.

Surgical procedures with attendant bleeding in the oral cavity may be called for in an hemophiliac or in a person suffering with severe anemia; a patient with severe cardiac disturbances or hepatic disorder may be in need of major oral surgery which might be contraindicated by his physical condition; in the dentist's chair the patient may suddenly go into an epileptic coma or suffer severe syncope or even a coronary occlusion; under anesthesia there may be evidences of severe anoxia. How can the dentist be expected to meet these situations unless he is well grounded in physiology and in the other basic sciences?

Numerous other situations calling for knowledge of the basic sciences might be cited, but I will take the time to tell briefly of only one more -- one which came to my attention and which shows how the qualified and well trained dentist may play a significant role in the health services. The upper lip and nose of the subject had been completely destroyed and an opening had been made in the palate by the unfortunate combination of disease and an automobile accident. He was such a repulsive sight that he felt impelled to wear a mask over his face while he stood in the street corner begging alms. In our clinic a plastic nose and lip of the same color of the face with an obturator was made and held on the face by an attached pair of spectacles. Not only did the patient then present an acceptable appearance but he was also able to speak fairly well when previously it was impossible to understand him.

This degree of rehabilitation was brought about by highly technical skill, but according to our philosophy the dentist's responsibility did not end here. He was dealing with a human being and like all human beings this person had to receive nourishment. Because of extensive scar tissue in the oral region it was found impractical to provide him with a set of dentures, and consequently he could not masticate his food. The dentist with a physiological background would know roughly the patient's daily caloric requirements, his need of essential nutrients including vitamins and minerals and thereby be in a position to cooperate with other segments of the health services in prescribing a soft or semi-liquid diet fulfilling these requirements.

Because of the limited time for this presentation I will have to be brief in discussing the second part of my thesis, namely, that the course in physiology should be tailored to the future needs of the dentist. I certainly do not mean to say that we should neglect in any way the teaching of physiological principles; nor do I believe that the course should be one in applied physiology. But I can see no reason why we should not seize every opportunity to descend from the ivory tower and point out to the students how these basic principles can be applied in clinical problems. It is my contention that by doing so we make the course much more interesting and much more meaningful to the student. I would hold out for this same procedure in teaching physiology to medical as well as to dental students. These students have not come to us with the idea of becoming professional physiologists but they are in school to prepare themselves for their chosen professional career. If any should decide to specialize in physiology, they will receive advance training in the graduate school.

While we recognize that there are definite limitations in applying physiological principles to dental practice, there are many times when this can be done. The same is true with regard to 'tailoring' laboratory experiments to the student's interest in dentistry. I believe that some of the old classic experiments can be replaced by others more pertinent to the dental student's training and that these can be no less instructive in physiological principles. Action potentials can be studied just as well on the muscles of mastication as on the frog's gastrocnemius or on human leg muscles. Induced bleeding in the mouth of the anesthetized dog and observations on the acceleration of blood coagulation by the action of saliva can serve by appropriate measures to supplement in vitro observations on the clotting mechanisms and the discussion on hemostasis. Mammalian experiments on salivary secretion can be made particularly interesting to dental students. The mechanical principles of respiration can be illustrated just as easily with mock resuscitation of a patient in a dental chair as with the prone method. Circulation in the venules, arterioles and capillaries can be shown in the pulp chamber more beautifully in a demonstration or movie than in the frog's mesentery. These are but a few examples of how the laboratory exercises can be tailored for the dental students. Interested and ingenious teachers genuinely dedicated toward meeting the needs of advancing dentistry have designed many more such experiments and have done so without sacrificing the ideal of teaching physiological principles. Others should be encouraged to explore the challenging opportunities in this area.

At the outset of this discussion I said I would try to develop the thesis that the course in physiology given to dental students should be on a par with that offered medical students and that insofar as possible it should be tailored to the interests and future needs of the dental students. I trust that within the limited time allotted me I may have met with some measure of success. In closing I would like to comment on a statement made in the course of discussion on the advisability of holding this symposium. Someone said that "the students whom I see going from college to dental school are usually those refused admission by several medical schools and are, therefore, third raters. Teaching such students is a necessary but disheartening job." I may add that some people have the idea that if a student fails in a medical school he can gain admission in a dental school without any difficulty. I do not know what the practice is in other places but I can say that a student who has flunked out of a medical school is wasting his time if he seeks admission to the Emory University Dental School. We would not consider his application. On the other hand, some of our students who were dropped from our dental school because of inadequacies in digital dexterity had no difficulty in gaining acceptance by a medical school. I have had years of experience in teaching both dental and medical students and I can say in all sincerity that the student body in our dental school is of the same high caliber as in our medical school. Teaching these students is not a disheartening but rather a pleasurable and rewarding job.

DISCUSSION

J. W. Johnston, Jr., Georgetown Schools of Medicine and Dentistry

I agree that having concrete examples of application of physiology to dental practice make the course more interesting, but one of the great drawbacks, as we have to operate, is to find time to do that and also to teach the students what's going on in the body and how one investigates these processes and, at the same time, try to keep up to date with current findings which refine the fundamental concepts. We also have a problem of salesmanship with dental and medical students because of their very pragmatic motivation. That's why they're pursuing a professional degree rather than a Ph.D. in science, and you have to know how to communicate with them. This is something that I won't generalize on, but at times I've found that in a formal lecture at least, a slightly 'V.I.P.' tone of voice seems to be more effective than a dispassionate, philosophical one.

George Sayers, Western Reserve Univ. School of Medicine

I would like to point out that practical problems arise in connection with the teaching of physiological principles in the clinic. Physiology departments in general do not have a sufficient number of staff members to provide physiologists for teaching in the clinic. Furthermore, I feel that the clinical staff should be sufficiently versed to bring the physiological principles into teaching at the clinic.

S. C. Harris, Northwestern Univ. Dental School

I'm inclined to ally more with Dr. Haldi than Dr. Brobeck. I'd like to say that our philosophy in teaching has been that the dentist, I suppose the physician too, is dedicated to maintaining or restoring the normal physiology of the body which requires first knowing what it is. There are, of course, many oral manifestations of organic problems, and there are organic problems which are manifest from oral problems, this being a two-way street. There are many things, I belive, that need to be evaluated about the mouth that are not yet known. We have many referrals to our dental school from the medical departments because they cannot resolve them. Although ideally, I agree with Dr. Haldi's comment, that these applied things should be taught by a clinical staff, rarely do we have a clinician of seniority who is sufficiently well rounded in basic sciences to point out these things. The few we have provide much encouragement to the students. It is encouraging to us in physiology that there are any number of graduate dentists who come back to do graduate work in physiology. At present, I have, I suppose, a dozen who are working for master's or doctor's degrees in physiology hoping to practice, teach, do research, or some combination thereof. They recognize the opportunity, now, to remove dentistry from a static concept to a dynamic concept which is, of course, the way the mouth functions.

Fred B. Benjamin, Univ. of Pennsylvania, School of Medicine

The physiology course for dental students should provide adequate physiological knowledge and understanding and it should be an integrated part of the total dental curriculum. Both aspects were brought out in today's discussion. Speakers representing schools where the dental teaching is assigned to the medical school underlined general physiological principles, and here emphasis on fields of dental importance and integration into the dental curriculum is obviously a major problem. On the other hand, speakers representing schools where there is a separate physiology department within the dental school emphasized dental application. Here the main problem is to provide the student with a well-rounded physiological education equal to that given to the medical students while integration into the dental curriculum is surely no problem. I wonder whether this does not indicate that in our approach to teaching we should not so much underline the advantage of our particular teaching system, as to correct its deficiencies.

N. A. DiSalvo, Columbia Univ. School of Dental and Oral Surgery

The problem of where the responsibility should lie for pointing out applications to the dental student is often buffeted about between the basic science teachers and the clinicians -- each feels that the other should be responsible for making the application. One of the things I would like to point out is that a person who is not trained in dentistry but who is trained in physiology and who has the responsibility of teaching physiology to dental students sometimes feels that he knows so little about dentistry that he cannot properly make applications. However, these same individuals who are physiologists but not necessarily trained as physicians nevertheless do point out applications of physiology to medicine. They have become sufficiently interested in the problems of medicine to find out what these applications are, and I think that it is the responsibility of these physiologists to find out what the applications may be to dentistry. Remember that the dental students take the physiology course at a very early stage in their careers, at a time when the instructors probably know as much about dentistry as they do. Therefore, the instructor is not at so much of a handicap to make these applications known to them, and I think that this, in some way, would increase the interest of the dental student to understand the basic principles of physiology. In cases where classes are taught side by side -- that is, medical and dental students -- it must appear to the dental student that physiology really is a medical science and not a dental science. When he attends various lectures and hears discussed physiological principles and then sees, pointed out to him, medical applications he begins to form in his mind the idea that physiology really is a medical science and not a dental science. I think these are just some of the points we should bear in mind.

Magnus I. Gregersen, Columbia Univ., College of Physicians and Surgeons

In regard to the stressing of application in the teaching of physiology to either medical or dental students -- and I'm going to say now something that may annoy all of you -- physiology doesn't belong either to medicine or to dentistry. Physiology is something which is used in medicine and dentistry. Physiology has application by chance to these two professions. The reason for the existence of physiology is not either medicine or dentistry. Physiology relates broadly to many disciplines in universities and I'll specify one. I've had something to do in years past with the physiology of man in relation to certain machines; engineers are constantly building machines and buildings and various things that human beings use without considering how they fit the human organism. There are many university disciplines which are actually dealing with the functions of man and they know not a thing about physiology. I'll quote a very extraordinary example. A few yeara ago an economist published a book called 'The Behavior of Money,' and it took him three years to discover that it wasn't money that behaved, it was human beings; and, subsequently, another fellow wrote a book on economics in which the first half was devoted to a review of human physiology. I introduce this because in medicine, the applications of this science are very broad. Medicine itself deals with many aspects of man besides the mere cure of disease -- it deals with the maintenance of man as a whole. It is important to keep this concept before us. I would say one last thing and that is that we are not necessarily training dental students and medical students to be professional physiologists, but I do think that men who enter these professions must feel the responsibility of adding to the intellectual capital of their own professions. In this day and age, they cannot simply expect to absorb the knowledge and then apply it for their own profit; they must make some contribution, not only as a responsibility to society, but actually for their own lives; if they do not do this, they become dead. They must keep learning and if they can keep up an interest in advancing some sector of the knowledge pertaining to their profession, they will be better men and live richer lives.

Edward L. Bennett, Univ. of California

In many schools of medicine, the problem of relating physiology and basic sciences in general to clinical problems is handled by the technic of the pre-clinical, clinical correlation course or conference. Since we are very soon going to have an increased teaching load with respect to dental students, I would like to ask whether anybody in this group has had experience with a similar technic in relating basic sciences generally to clinical problems in schools of dentistry.

S. C. Harris

We have been doing this but, unfortunately, the burden of the responsibility has been on the basic science people rather than the clinicians. Clinicians who have attended these sessions have been grateful for what they've learned. I do not mean to deprecate the clinicians. They just did not have the training. The training we have in physiology enables us, as was said, to visualize the existing problems in dentistry. These correlation problems have been handled at Northwestern, I think, most effectively through the medium of faculty seminars in the presence of students, and most recently we have experimented with oral surgery clinics for senior students attended also by freshmen. These clinics are attended not only by the oral surgery staff but by representatives from the basic sciences. We seize each opportunity to illustrate, on the spot, a basic correlation of science with the clinical condition. The seniors enjoy this very much. It integrates the courses. We try as much as possible not to think of the basic science, the clinical science, the first two years, the last two years; we're trying to abolish this line between preclinical and clinical teaching because it's all part of the same thing.

F. B. Benjamin

I would like to tell you what we did at the University of Pennsylvania to bridge this gap between the basic science departments and the clinical teaching. During the physiology course we have weekly seminars where people from the clinical side of the dental school talk mainly about physiological application to their own field. In exchange, physiologists participate in faculty meetings, faculty committees, and seminars in the dental school. To interest the students further in physiology, every year one or two students take one year out of their regular dental studies and give their full time to physiological research and teaching. A number of other students work part-time on various physiological research problems. This program, while still far from perfect, has brought about a great improvement in the relation between the physiology department and the dental school and also in the attitude of the dental students toward the basic sciences.

Barnet M. Levy, Univ. of Texas Dental Branch

I'm not sure that I understand the so-called 'physiological approach'. One of the best ways to correlate the basic sciences with any clinical subject is through the C.P.C., or clinical pathological conference, where one tries to integrate all of the basic knowledge pertaining to a clinical problem. I think that there is no physiological or anatomical or pathological or histological approach to a clinical problem; there is only the biological approach, and sometime it might be well to discuss on a little more formal basis the possibilities of integrating the anatomy, physiology, biochemistry and other so-called basic sciences specialities in the field of medicine and dentistry.

Ernest Knobil, Harvard Medical School

Listening to the discussions this morning, it appears to me that two mutually exclusive lines of thought have been advanced. The difference between them are so profound that until they are resolved no lasting solution can be arrived at with reference to the teaching of physiology to dental students. These are, first, that dentistry is a medical specialty; if this is, indeed, the case, there is no problem at all. If dentistry is a medical specialty, it would follow that dental students should be trained in the basic clinical sciences just as the medical students are and should receive the same type of instruction along the lines that Dr. Brobeck talked about. Secondly, that dentistry is not or should not be considered a medical subject; if this is the contention, as has been voiced by some people here, then the instruction in the basic medical sciences to the dental students should properly differ from that offered in the medical curriculum as by perhaps greater use of illustrated material dealing with the oral cavity and so on. I do believe that one must come to an understanding in the basic philosophy involved before one can make any useful progress in the matter of curriculum.

R. F. Sognnaes, Harvard School of Dental Medicine

I would like to go a step further. First I should say that I am speaking as a dentist and not as a physiologist. A more basic point, it seems to me, is to recognize dentistry as a university discipline and not a vocation. That decision was made at Harvard nearly a hundred years ago, and we are still striving to live up to this recognition. Once the decision is made that we belong in a university family, we have obligations to scholarship and things basic whether immediately applicable or not, cognizant that what we are doing today, excellent as it may seem, is not the 'last word'. I'm afraid dentistry has been almost too good technically, for its own good, so as to make it seem that we already have all the answers. If that were true, then, of course, we have no business belonging to a university. We are still seeing extreme stands within this dual philosophy. In deciding for Haldi's concept vs. Brobeck's concept, it is, therefore, difficult if not undesirable to take one side at the exclusion of the other. At this moment, at least there are several practical difficulties. One problem is the lack of clinicians who have the adequate physiological and other basic science background to extend, apply and discuss the fundamental physiological, biochemical and other biological principles in reference to diagnosis, prevention and treatment. It would help a great deal if we in dentistry could provide more postdoctoral education in the sciences, research, etc., as, indeed, we are trying to do today. It is interesting to note what happened to the graduates of the Rochester Program (where I had the privilege to get further education): most of us made a career in basic science disciplines although we were dentists. Today, we are hopeful that we will draw into dentistry many more career scientists in the basic sciences, so that in the clinic we will conserve more scientifically educated dental practitioners as clinical teachers, who then will cross this gap between the two. I think there is a great future in this approach but, at the moment, there is a lack of clinicians who can transmit available basic knowledge as an integral part of clinical teaching. The other problem, for which the clinician cannot be criticized, is simply the fact that we don't have sufficient basic knowledge in the first place about the oral cavity to apply extensively in practice or to discuss intelligently in theory, either to satisfy the basic scientist, the clinician, or the student. Window dressing integration is only adding educational insult to injury when confronting intelligent students. There is a wealth of information that needs to be brought to light. To date, a great deal has been accomplished -- and this must be applied -- but there are very few people working intensively and fundamentally on the various structures and mechanisms pertaining to the oral cavity. If we had the help of physiologists and other basic science talent to explore these tissues and issues with us, I'm sure that knowledge would come about which would be very worth while to stimulate students and translate in the clinic. But at the moment, I'm afraid one can perform a great many clinical operations in dentistry without having reference made to the chemistry, the physiology and the biochemistry of the tissues involved. I could exemplify this many times over. Meanwhile, considerable progress in the technical field has been made; it was a lot harder to make the very inadequate dentures for George Washington, carved out of half a billiard ball of ivory, than it is to make a very good denture today. You don't have to be quite as expert with your hands to do a very good reconstruction of the teeth today, and I hope this is merely an historical example of what is continuously happening. The technically very demanding restorative aspect of dentistry is going to be with us for some time, but service no doubt is going to be better and, yet, technically probably simpler. If that came to pass, then I think all the biological aspects of dental medicine, including physiology, would advance faster and play a much greater role.

Joseph L. Johnson, Howard Univ. College of Medicine

I have no diffculty in taking sides in this matter and my lot would be cast entirely on the side expressed by Dr. Haldi. I firmly believe that the teaching of physiology to dental students should be on the same plane as physiology taught to medical students, and that insofar as possible we ought to tailor it to suit the needs of the dental students. As somebody has already expressed, one of the difficulties is the matter of time. I do find it difficult to agree with some of the concepts of Dr. Brobeck. I should like very much to be able to convince myself that the things that are necessary to be used in physiology in the practice of dentistry can be taught in three lectures or that the things that are necessary to be used in medicine can be taught in four lessons. I think that it's very important that we ground the student in all of the principles that we, as physiologists, know are essential to a complete understanding of the human body. As Dr. Gregersen said, physiology doesn't belong to medicine and it doesn't belong to dentistry. Another point I think that we as teachers are prone to overlook is that beyond our responsibilities for understanding our subject material is that of understanding the people that we have to teach. We work on the assumption that being well-prepared physiologists automatically qualifies us to teach. The question of whether the dental student is superior or inferior to the medical student becomes of very little importance when we take the position that our responsibility as teachers is to deal with the material as we find it, and in that respect it becomes important for us to try to understand the individual. Whether or not the responsibility of making the application belongs to the clinician or whether it belongs to the physiologist, I would say that as teachers, the responsibility belongs to us. I think those who are trained in physiology would have to acknowledge the fact that probably we haven't done all that we should do in trying to understand dentistry and the applications which physiology has for that field.

Leon Kraintz, Univ. of Texas School of Dentistry

I think the problem of teaching physiology to dental students is similar to the teaching of basic sciences in any area, and I do not know why we are discussing application. If we wish to produce nuclear physicists, we do not start with a course on the application of nuclear physics to reactors. We teach the nuclear physics first and hope that the student will eventually apply this knowledge toward newer application. The same attitude should prevail in relation to the teaching of physiology to the dental student. The dental profession needs people interested in basic sciences, and we are not going to stimulate this interest by teaching application of physiology to dentistry before the student is well-grounded in the basic fundamentals. Contemporary application is taught, or should be taught, in the clinical courses. The students need new concepts from basic sciences that may have nothing to do with dentistry, and possibly these concepts will be applied by them to the dentistry of the future.

Roger M. Reinecke, Univ. of Puerto Rico School of Medicine

The University of Puerto Rico organized a medical school starting in 1950. In this medical school we have had all the advantages and disadvantages of being a small department of physiology. One of the very real advantages has been that we have been able to adjust more rapidly to our situation. In doing so we find that in some ways we have been breaking away from the traditional approach to the teaching of physiology to medical students. One of the more important of these is that we have found it advantageous to devote the first part of the course, which we call descriptive physiology, to the development of a general conceptual framework of physiology. This is feasible because of the advances made in physiology in the last decades. Following this we delve more deeply into selected topics in physiology that we estimate will contribute more to the student's ability later on to understand and use the part of the clinical literature that is physiological in nature. In this regard we avoid topics like the physiology of heart failure, which the clinicians can teach better than we, and concentrate instead on topics such as the recent work on the membrane potential, which promises to form the basis for future research in a number of clinical fields. We intend to use the same approach in teaching physiology to dental students. Indeed we hope to be able to use the materials that we have developed for descriptive physiology for the medical students with little change for the dental students as well. Following this we expect to concentrate on topics of greater potential usefulness to the dental students. Last year at the opening of our dental school, a number of the deans of dental schools in the continental United States spoke on the future of dentistry. It emerged from these talks that the emphasis in dentistry is expected to shift from the tooth and its mechanical repair or replacement to the functional relationship between the tooth and its environment. From this it follows that physiological concepts and procedures will be much more important to the dentist in the future than they have been in the past.

R. O. Greep

It seems to me that this issue of application is an idea that has bothered the teaching of physiology for some time, i.e., whether one should teach classical mammalian physiology or human physiology. There have been distinct changes in emphasis in the teaching of physiology over the years. The shift is from classical mammalian toward more human physiology and toward more application. I suspect, regardless of what we wish, that the trend will continue toward the teaching of more application in both medical and dental physiology.

M. I. Gregersen

I have a certain pedagogical interest. Now, let me answer you, Dr. Greep. As an example, in our advanced medical departments today, clinicians are doing exacting quantitative work on the kidney. Where would they have been if, within the last twenty-five years, they hadn't worked with the boney fishes and other low organisms that have laid the foundations for the quantitative analysis of renal function in man? In almost every area of physiology, unless you turn your eyes to every opportunity in nature, you're not going to solve the fundamental functions. I have a strong feeling that there must be no canalization of one's attention to one particular organism. I cannot agree that if you look only at man you've made any great progress because you may get your most important clues from other sources. The thing which we are all striving for is to arouse the student's interest in fundamental ideas. As one of my much-admired teachers at Harvard kept emphasizing to me, as a student, if a thing is of fundamental importance -- if it's fundamental -- then one can be sure that it's going to be important. If you are working on something which is fundamental, don't worry about the application; it's going to be important.

W. V. Whitehorn, Univ. of Illinois College of Medicine

Dr. Gregersen's remarks induce me to introduce another point which may be a little premature in the discussion, and that is that we have not said anything so far about the motivation and attitude of the student in relation to the curriculum. I think many of the problems of whether to teach application and whether to teach a graduate or a professional type of program are intimately associated with this matter of the motivation of the student. I think that the students we get in the professional colleges have a considerably different basic motivation than the students who would be optimum for a non-professional graduate type of teaching. I think that the teaching of attitudes in physiology, as has been emphasized, is at least as important as the teaching of facts, and if we have students whose attitudes are already rather crystallized and solidified, then I feel that the margin we have to work with and the amount of change we can expect to make, regardless of what specific type of curriculum we use, is relatively small. I don't intend to pass the buck back through the educational system and to society in general, but I do think that we have to recognize the material which we work with and the degree to which fundamental changes may be made in this material.

COMPARATIVE STRENGTHS AND SHORTCOMINGS OF EXISTING DEPARTMENTAL ARRANGEMENTS FOR INSTRUCTING DENTAL STUDENTS

N. R. ALPERT, Univ. of Illinois College of Medicine

I am not posing as an expert on dental education but merely as a physiologist who has taught physiology to dental students both in courses separate from the medical physiology course and in a course given concurrently with the medical physiology course. The former was at the College of Physicians and Surgeons, Columbia University, and the latter is at the University of Illinois College of Medicine. The major questions which always come up are: 1) should the dental students be given exactly the same course as the medical students and at exactly the same time, and if not 2) what kind of a course should be designed for them? My comments will be restricted to the experiences we have had during the past five years at the University of Illinois.

At the University of Illinois the dental students and the medical students take the same physiology course and they take it at the same time. The course is given to 190 medical students and 77 dental students over three academic quarters, from early fall to late spring. The dental students, when they do come to us, are sophomores and have had biochemistry. The medical students are freshmen and are taking biochemistry concurrently. Our course consists of three or four lecture hours a week, one conference hour and one four-hour laboratory period a week. Thus, in an average quarter we have from 35 to 40 didactic hours, 10 conference hours, and 55 laboratory hours for a total of 100-110 hours and the gigantic grand total at the end of three quarters of 300 hours. The conference sections are 20 to 30 students in size and the laboratories have 4 staff members assigned to 77 students. This gives us a ratio of approximately 1 to 20.

If one should go, as I did, to every member of our staff, and ask them what they think about what we are doing in teaching the dental students, he would get the following response. To a man, they are unhappy with what we are doing and they don't like doing it. They comment that the students are immature, that the students are poorly motivated and that the students are not bright. The evidence used to substantiate these claims is examination performance. Here the dental students have, on the average, a ten point lower score than the medical students in examination performance. This is the evidence for a lack of motivation, lack of interest, and the fact that the students are not bright.

The students, on the other hand, are also somewhat paranoid. They feel the course is slanted for medical students despite the few special lectures given to the dental class. They feel the faculty is interested only in the medical students and as a result of this the instructors pay little or no attention to them. Finally, they feel that they have much too much work to do and that only through their own heroic efforts do they learn any physiology at all. The evidence cited for this position is National Board performance where the students do wonderfully well. This performance pleases the Dean and the Administrators and the people in power are very happy with what is going on. The only unhappy participants, it seems to me, are the dental students themselves and the faculty.

Can you blame the faculty of the Dept. of Physiology for this state of affairs? The answer, of course, is no. Can you blame the dental students for this situation? The answer again, of course, is no. Then who can you blame? And of course, you blame the administration. The evidence for this can be seen in the scheduling. The total clock hours for the first year of Medical School is 950; the second year of Dental School is 1200. These figures are from the Registrar's Office based on the official calendar schedule and indicate a statistically significant difference. The students of dentistry claim this official estimate is too low by 400 hours and that they must do scabbing at home in order to get their technic work finished.

What can be done about this situation? We've decided to completely redesign our course and to try to readminister the curriculum. The plan is essentially twofold. Our course will be arranged in such a manner as to have a minimum of conflict with the technic courses given during the second year. In addition the course will be specifically designed for the dental students; this does not mean a course in applied physiology, it means simply that there will be a group of people primarily responsible for and interested in educating the dental students. They will spend time with the students and the students will know there is a real interest in teaching them physiology. Finally, and this is extremely important, we are assuming that the students are mature, bright, motivated and dextrous. The course will be designed to develop this potential.

It is of interest that in all of the discussions which took place this morning, no controlled experiments are described. No one is really doing experiments in dental education; what we do is follow one prejudice or another. However, one thing is absolutely certain. If you are to have a successful course, and it doesn't matter whether the dental students are taught with the medical students or separately, the essential ingredient is an environment in which both the students and the faculty are enthusiastic and feel challenged. This can be done, but it requires time, effort and resources. At Illinois we feel that it can be best achieved by the design of a separate but better physiology course for the Dental School.

S. WAH LEUNG, Univ. of Pittsburgh School of Dentistry

In considering this problem of how and by whom physiology should be taught, it seems to me that the question is really secondary to the discussion which preceded these last two papers. Until we have a clear concept of what a course in physiology or, indeed, in any of the basic sciences, is trying to accomplish, it would be pointless to say how the job should be done and who is responsible for doing it. For that reason I should like to go over again some of the points raised earlier and try to express at least my own thoughts on this matter, before proceeding to consider the type of personnel and administrative set-up most desirable for accomplishing these purposes.

I believe that a course in physiology in a dental curriculum should have two main purposes: one, to provide the student with a thorough understanding of fundamental principles of human function and human biology and, too, to help him bridge the gap between these principles and their application to human patients. It is anticipated that this fundamental knowledge will serve the student as a base upon which he will build his professional career. These principles should enhance his appreciation that the patient is a biological entity, and not just an oral cavity containing a set of teeth. This basic foundation should serve not only as the starting point for his professional development, but also as a stimulant to his desire to contribute to the sum total of human knowledge. The stimulation and encouragement of research in the biological sciences should be as important a function of the course as the mere acquisition of facts.

This responsibility for the stimulation of research interest is one aspect of the problem about which very little has been said this morning, yet it is a matter of vital importance to the continued professional and scientific growth of dentistry. It has been pointed out earlier that there is a great area of ignorance when we talk about oral physiology. There are many questions in this field to which we have no answers; and the responsibility for providing the answers must lie in those who are primarily interested in this area, namely, dentists themselves. Unless members of the dental profession are able to contribute significant new knowledge in their own field, the profession, as Dr. Gregersen has pointed out, will be a dead one. You can have a living profession only if members of the profession, themselves, are adding fundamental knowledge to their particular science. The teaching of fundamental principles and the encouragement and performance of research are important functions and responsibilities of a physiology department serving dental students.

The second major responsibility of a physiology course in a dental school is to develop in the student an appreciation of the relationship between the principles and facts he is taught and the patients whom he will be treating in later years. The extent to which a basic science department should be responsible for this correlation between the theoretical and the practical is, admittedly, a controversial issue. Nevertheless, it is an issue which must be faced squarely and objectively by all holding responsibility to dental students. It is very well for the purists to say that the extent of their responsibility is only in the teaching of the basic science, but we must remember that when these students enter dental school they are not motivated to become physiologists; they are not motivated to become scientists; they are not motivated to become research workers. These students are in dental school to acquire knowledge and professional skills which they hope to apply for the benefit of their patients. The introduction of physiology as a formal course into the dental curriculum may be attributed to the realization of the important contribution which physiology can make in enabling the dentist to provide better service to his patients. This is one of the important points which I think a teacher of physiology should bear constantly in mind. A teacher who remains in the ivory tower of pure science will soon lose the interest of his students and find that his teaching has been ineffectual and a waste of time.

Recognizing that some degree of correlation between the fundamental sciences and their clinical application is important, the point of issue is the extent of the responsibility of the basic science department in making such applications. Thus, Dr. Haldi proposed that the physiology course in the dental school should be especially tailored to dental students by bringing specific dental examples to illustrate physiological principles. He mentioned, for instance, that the study of circulation could be illustrated by using the pulp of the tooth just as well as by using other organs of the body. With this I can find no disagreement. It seems to be quite proper and commendable if, whenever possible, the course content is brought closer to the special area of the student's interest, without sacrificing the student's need for a knowledge of basic principles. This should be clearly differentiated, however, from the concept that the making of actual practical applications to clinical problems should be the responsibility and function of the basic science departments. With this I could not disagree more. The responsibility for actually applying the basic principles for the treatment and care of patients belongs to the clinical teacher and not to the basic science department.

With these two primary purposes of a course in physiology in mind the question arises as to who is in the best position to accomplish these purposes and what type of administrative set up is the most desirable. What type of background should a teacher of physiology to dental students have? Should he be a physiologist whose interest is only in fundamental knowledge and pure research; should he be someone who is medically trained or medically oriented, whose interest is mainly in terms of internal of general medicine; or should he be a dentist or dentally oriented individual? What about having a combination of such talents within a single department? Should we have a department in which persons of various interests and disciplines are jointly responsible for the teaching? Should we have a physiology department which contains not only physiologists, as such, but also dentists or dentally oriented persons?

What about the department itself? Under what type of departmental arrangement should the teaching be done? Should we have a department which is in the medical school giving the course to dental students; should the department be a department of the university, merely providing a service to the dental school; or should we have a department as an integral part of the dental school itself?

In our own particular arrangement at the University of Pittsburgh we happen to be in a position where all of the basic sciences are within the dental school. We have our own departments and our own faculties of basic sciences. In some cases this faculty consists of persons who have a dental degree with some further non-degree training in the science in which they are teaching. In other instances we have persons who hold doctorate degrees in the particular science they are teaching, and in certain other instances we have combinations of both, that is, persons who have a dental degree in addition to a degree in the basic science. Thus, throughout our departments we have a spectrum of abilities or, at least, a spectrum of training. Naturally, coming from such a school, I am whole-heartedly in favor of such a system. This is particularly true since I, myself, went through dental school under the arrangement where the basic sciences were taught in the medical school. The dental students were taught in the same class as the medical students. I can honestly say that, under such a system, we dental students were more often than not made to feel like outcasts, or second-rate citizens, or even third-class citizens. We were not up to par, in the view of the department, and were permitted to attend these classes only by the grace of the department head. This attitude is probably due mainly to the lack of sympathy on the part of the department with problems unique to the dental students. There is a lack of understanding that the needs of dental students in the area of basic sciences are not necessarily identical to the needs of the medical students.

The important factor, then, is in the attitude of the teacher. It makes little difference, really, whether he is a dentist, an M.D., or a pure physiologist. Rather, it is his attitude toward the students which is important. We should remember that we are teaching students, and not merely teaching a subject. We must, therefore, bring the students' problems and needs into focus if we are to accomplish our purpose. We need to motivate the students to the end that they will try to get the most out of what we are trying to teach. Thus, the question of who is to do the teaching becomes secondary to the attitude of the teacher towards the student and the subject matter. Whether the teacher is an M.D., or a D.D.S., or a Ph.D., or combination of these is of lesser importance than that he should have the proper attitude.

Along the same line, whether the physiology department is in the dental school, in the medical school, or in the science school is also not of major importance, provided the department is able to fulfill its obligations to the dental students conscientiously and effectively. Nevertheless, I believe there are certain definite advantages in having the department under the aegis of the dental school. I think that the students feel a greater degree of identification with the subject matter if the course is taught in the dental school. They accept this as being an integral part of their curriculum and not merely an appendage attached to their main course of study.

Now I have heard it said at other meetings that these basic science courses should be presented as intellectual hurdles, a sort of obstacle course which the students must overcome in order to attain their professional goal. This, I believe, to be fundamentally wrong. These courses should never be placed in a position of being merely intellectual hurdles. They should be presented in such fashion that the students realize they constitute important foundations on which their eventual professional development will be based. It should be made clear to them that these basic science courses are at least as much a part of the main dental curriculum as, say, operative dentistry or prosthetic dentistry, and that they are not put in the curriculum just to make it more difficult for the student to be graduated. This, I believe, could be more easily achieved if the departments were made integral parts of the dental school and staffed by members of the dental faculty.

Under such an arrangement as I have described not only would the students benefit but, I think, the school and the faculty would also benefit. Thus, the members of the department would consider their first loyalty to be to the dental school, rather than the medical school or the college. The problems of the dental school and of dental education become their problems. There would develop also, a better rapport between the department members and the school administration, as well as between the departments of basic sciences and the clinical departments. This feeling would be reciprocated by the clinical teachers and would instill in them a greater appreciation for the efforts of the basic science departments in preparing the students for clinical work. Since the primary responsibility of the basic science instructor is now to the dental school the clinical departments would feel freer to call upon these persons for consultation and participation in clinical conferences and seminars. The end result is more effective and more stimulating teaching.

There is another reason why it would be desirable to have the basic science departments within the framework of the dental school. This is in the area of the department's research activities. Here, we would find that most of the research would be at least dentally oriented. This does not mean, of course, that all the research projects will necesarily be in the field of dentistry, but a good percentage of them would have important dental implications. This would not only increase our contributions to dental science, but would also serve as stimulation to our students who come into daily contact with active research in the basic science departments. If the research is being conducted only in the basic science departments in the medical school or in the college, much of this important contact would be lost to our students.

Although it is desirable to have such a departmental arrangement there are, nevertheless, certain disadvantages or difficulties in putting such a system in operation. One of the first problems one encounters is the matter of financial support for independent science departments in a dental school. This is admittedly a costly venture for most universities to adopt. And yet I believe it to be a matter of sufficient importance to dental education and dental practice that, if the universities and the dental schools are to fulfill their obligations they must eventually put it into practice. The scientific development of dentistry is advancing at an ever-increasing pace. This makes it imperative that the dental schools, themselves, begin to shoulder a greater share of responsibility by developing within the schools a stronger respect for fundamental investigations in the basic sciences of importance to dentistry. We can no longer look to the medical schools or to the science departments of the college to relieve us of our responsibility.

There is another problem connected with establishing separate basic science departments within the dental school, and that is the matter of getting adequate staff. I would venture to guess that at present there is an acute shortage of the type of persons needed to staff such science departments if all the dental schools were to suddenly start setting up their own departments. The type of personnel required would be persons who are either dentists with specialized training and interest in the biological sciences, or persons primarily interested in the biological sciences but have developed an appreciation for dental problems. This difficulty is by no means insurmountable but time will be required to overcome it. A start, at least, has already been made in many institutions. Dr. Sognnaes mentioned, for instance, the program at Rochester, which was developed to fill such a need for dentists with specialized training in the basic sciences. Other schools have developed similar programs, not only to provide opportunities for dental graduates to receive such additional education, but also to encourage the dental student to enter careers of teaching and research in the basic sciences.

There is a third and final disadvantage which I see to such a departmental arrangement. That is the possible physical isolation of these basic science departments from similar departments throughout the university. We all recognize, of course, that the exchange of ideas through daily formal and informal contacts with fellow scientists is an important part of the individual's scientific development. The lack of such contacts, through either voluntary or enforced isolation, can be a serious handicap. Here again, the problem is not insuperable. It could be readily overcome through personal initiative on the part of the members concerned.

In summary, one might say that the responsibility for the professional development of the dental student lies within the dental school; within the administration of the dental school; within the faculty of the dental school. This responsibility extends all the way from clinical teaching to pre-clinical teaching. We cannot say that the teaching of clinical dentistry is the responsibility of the dental school, but that the teaching of the basic sciences -- anatomy, physiology, biochemistry, etc. -- is the responsibility of someone else! The day must come when the dental schools will have to shoulder their full share of responsibility to develop departments and courses in the basic sciences fitted to the needs and interests of the dental students and the dental profession.

DISCUSSION

Edwin L. Smith, Univ. of Texas Dental Branch

It appears to me that there is a very close connection between the question of whether the dental students should be combined in a physiology course with other students, and the question as to whether the course should contain only basic physiology, or basic and applied physiology. For instance, the course we gave to the dental students at the University of Nebraska was one in which the dental students were combined with pharmacy students, physical education students and other arts and science students. Such a course was, of necessity, a basic course of the kind Dr. Gregersen was advocating. The application of physiology to dentistry was left entirely up to the dental faculty. At the University of Illinois, when I was there, we gave the dental students a separate course in physiology which was again almost exclusively a basic course. I think it is interesting to note that in the years since I left Illinois they have shifted over to combining the dental students with the medical students in the basic physiology course, and are now, as has just been pointed out by Dr. Alpert, considering separating them again. Since these changes have all come about under the same department head, one has to assume that this last change is based on lessons learned from the experiment. At the Medical College of Virginia, the dental students, although taught by the service department which handled the medical and pharmacy students as well, were given a separate course, which not only included basic physiology, but aspired to the teaching of some applied physiology. The University of Texas Dental School is geographically isolated from all of the other teaching branches of the University, so, of course, the dental students have their own physiology course in which we stress both basic and applied aspects. I am sure we all agree that basic knowledge must be taught and I do not believe that there are many who would question the teaching of the applied aspects of the subject. In all of my experiences, and I think as a general rule, the physiology department is willing to take the responsibility for the basic material. The question then becomes, 'Who will teach the applied material'? I think the answer is obvious, 'the man who is qualified'. It does not matter whether he is in the physiology department or in one of the dental departments. If someone, by his own interests, his own abilities and his own knowledge, is qualified, he is the man, I think you will all agree. The trouble is that in many physiology departments, there is no one who knows sufficient dentistry to teach the application of physiology to dentistry, nor is there any senior clinical man who has enough background in physiology to do this. Dental physiology at the Universities of Nebraska and Illinois, as I knew it, along with many other schools, suffered because the physiology departments in these schools had no one with either a particular interest in or knowledge of dentistry. In addition, dental physiology suffered at Illinois because the attitude was that it was of lesser importance than medical physiology and the teaching was relegated to the less experienced members of the department. The Illinois shift to a combined class eliminated this last mistake. At the Medical College of Virginia, the physiology department did have a more active interest in dental problems and hence was able to teach some of the application of physiology to dentistry, but again the dental course was definitely playing second fiddle. In Houston, where the dental school of necessity maintains its own basic science staff with no other responsibilities, the teaching of both basic and applied physiology is welcomed. I wonder if most of your problems would not be solved if your dental school administrations were to be convinced that it should so support the department of physiology, that it would be possible for the department to maintain personnel who were interested in and whose only responsibility was the dental course. In addition to their interest in dental physiology, their qualifications in general should be as high as those of the usual medical school faculty.

D. J. Anderson, Univ. of Oregon, Dental School

I teach now at a school in which we are entirely responsible for our own basic sciences. I would like to add one more responsibility to the list that Dr. Brobeck gave, and this is our responsibility to the community in training dentists. I do not suppose any of you would go to a dentist who was a good physiologist unless he was a good clinical dentist at the same time. Whether we like it or not, dentistry is still a highly technical subject and, therefore, it seems to me it is extremely difficult to justify a course of physiology which, as we've been saying this morning, is on a par with the medical course. This, as I understand it, means that it has the same factual content and, in my opinion, will not adequately motivate the students. Speaking as a dentist, I think that our duty is to change the dental student; rather, change the future dentist, so that he will constantly criticize the approaches made by the clinicians and so that, by reason of our training, he will gradually lift dentistry out of being a simple technical subject into something which has more academic content. Dentistry will improve itself by virtue of our training and I think physiology stands in a particularly important position in this regard. There is one other point which I would like to mention, and so far no one has mentioned it. Sooner or later, the students will be taking the National Board examination and this, it seems to me, is a test not of his understanding of the subject but merely of his capacity for factual recall. It seems that we are wasting our time almost, from the student's point of view, in trying to motivate him toward an understanding of physiology when he can get through his National Board without a great understanding of physiology but merely by having the capacity for recalling a large number of facts.

F. B. Benjamin

The fact that the Physiological Society decided to hold this symposium is ample evidence that we have here some problems and that we cannot take any qualified physiologist and expect him to make a good job out of dental teaching. If you have to give a single guest lecture you try to find out as much as possible about your audience. If you want to teach a whole course to a group of dental students, you should be familiar with the dental literature and the dental curriculum. If you still decide to limit your teaching to basic physiological principles, all right, but the decision should not be one of ignorance.

Leonard H. Elwell, Univ. of Michigan

I'd like to say a few words about motivation. It seems to me that dental and medical students are not fundamentally different. But we must recognize that dental students are conditioned to their training in a way that medical students are not. Even before entering dental school the student knows he is entering a very specialized field. On the other hand, the medical student enters his professional training with the understanding and acceptance that he is to undergo a general training regardless of any intention he may have of specializing later. This difference between the dental and medical students makes necessary a different approach in teaching. I see no reason why dental students shouldn't be taught the same kind of physiology as medical students. However, we must take into consideration the different initial conditions of motivation of the student and adjust our teaching methods accordingly. Motivation of the student is a function of the instructor. It is his duty to make physiology vital, important and fascinating to his students whether they are medical, dental or general science majors.

R. F. Sognnaes

May I be permitted to say a word to echo this point; it is a very significant fact that the prospective dentist is signing on the dotted line, committing himself to dentistry, the day he is graduated from a dental college. He is entering his special area immediately, whereas other students in the 'external' medical specialties, from ophthalmology to proctology, can postpone this decision. On the positive side, we in dentistry should capitalize on this advantage of focusing the education towards a special area. At the same time, this does present the danger which Dr. Brobeck talked about, that we may prematurely limit the basic science coverage. An example is sometimes more convincing than a general statement, so let us merely remind ourselves of what happened some fifty years ago when the physiologist and the pharmacologist looked over the curriculum for the dental students; 'What would a dentist want to know about the metabolic action of fluorine?' Nothing, it seemed at that time. Today, the dentist is supposed to be the authority. We ought not to let this happen again. I think it's going to be very important to follow the philosophy of Dr. Brobeck and seek a broad background for the sake of science and not merely to please the student or satisfy the clinician. At the same time, I do think we are in a favorable situation to capitalize on this early decision for dentistry and its unique combination of art and science.

Charles F. Morgan, Georgetown Univ. School of Medicine and Dentistry

There are certainly a lot of problems involved here, and I think not the least of all, probably the most important, is one of teaching and the interests that a man has as a good teacher. I think he must do his utmost to try to motivate the students, to interest them in the subject matter, and to bring out all the applications necessary to put the subject matter across. Some of the problems involved, for example, are problems of administration. I think the men at Illinois said that there were too many hours devoted to such courses as dental material in the first few years; we recognize that this is possibly true at Georgetown too, and our dean has been whittling away at these hours so the students will have more time to devote to the basic courses in physiology and pharmacology. As a result, the dental student is approaching the medical student in his scholastic average.

RESUME

GEORGE SAYERS, Western Reserve University

This session leaves no doubt in my mind that all of us here are very much interested in the education of the dental student. There are obvious differences of opinion as to how it should be done. However, regardless of these differences I think that most of you would agree that if we are to improve dental teaching we must have available more adequate facilities and a larger staff. The ideal situation for the teaching of physiology to 60 dental students requires 4 full-time staff members. Administrators and government supporting agencies should be made aware of such needs.

The problem of the treatment of the dental student as a second-rate citizen in a medical school physiology department is in large measure a result of limitations of time on the part of the staff of such a department to devote its effort to teaching of medical, dental and graduate students. Dr. Alpert of the University of Illinois suggests that it would be best to have a separate staff for the teaching of physiology to dental students. Under these circumstances there can be no doubt as to the loyalties of the staff. Dr. Leung of the University of Pittsburgh presents a situation in which two separate physiology departments exist. Dr. Leung has described the close liaison which exists between the members of the dental school physiology department and the departments involved in the clinical aspects of dentistry. He has also pointed out the fact that the members of the staff of the physiology department have constantly in mind the subject dentistry while they teach this basic discipline to the dental students. The disadvantage as has been noted by Dr. Leung is the matter of budget. Two separate departments require a relatively high financial outlay.

At Western Reserve the Medical School Department of Physiology has the responsibility of teaching physiology to the dental students. I have been impressed with the interest, motivation and practical 'know-how' of the dental student. They are proficient in the laboratory and have the ability to fit experimental data into conceptual thought.

The problem as to whether dental students should be presented a course in 'pure' physiology or applied physiology has been discussed with some vigor. My own point of view is that the dental student should be presented physiology as a subject in itself. It should not be given as a gimmick to explain practical problems in dentistry. Physiology is part of a liberal education, it is thought provoking when presented in the right way to any student. The practical application to dentistry should in my opinion be left to competent clinicians.

Finally a word about self-education for the dental student. Is it possible to make time available in the dental student curriculum for the students to read over and beyond the regular lecture material? With rapid advances taking place in medical and dental research it behooves us as educators to prepare a student for the day when he leaves the environment of the university and embarks on a career as a practitioner. He must be prepared to keep up with important advances in dentistry and a good way to prepare him is by making time available in the dental school curriculum for self-education.