Clinical Surgery and Biological Science *

Francis D. Moore, M.D.

Surgeon-in-Chief, Peter Bent Brigham Hospital; Moseley Professor of Surgery, Harvard Medical School, Boston, Massachusetts

Difficulty in locating clinical surgery relative to biological science on the one hand and the nonoperative medical fields on the other, arises solely from the prominence of an effective technology in the practice and teaching of surgery. Despite the almost philosophical or theoretical nature of this difficulty some sort of resolution must be achieved in the practical matters of staff appointments, faculty promotions, curricular arrangements, and residency programs.

Worshiped by some, belittled by others, the manifold technics of surgery are without question its most important attribute in bringing relief to human suffering. Advances in surgery have resided largely in the growth of an effective technology. Applied without skill or conscience, these technics bring only hardship and expense in their wake. Applied with wisdom and mercy, they have been responsible for the growth of what has now become the largest single agency for definitive treatment in all of medicine.

The surgical technic of which we speak is not to be conceived in the narrow framework of how to lay in sutures or cinch up knots, how to wield a scalpel or join the bowel, or an endless discussion about suture materials to be used in wound closure. Rather, effective surgical technology lies both in the mind of the surgeon and in his hands. It consists in bringing to the operative event, and all the details surrounding it, an effective concept of what is to be done, how it is to be accomplished anatomically and physiologically, how to achieve this object with a minimal distortion of the patient's homeostasis, with primary clean healing, a short convalescence, and with lasting relief of his disease.**

It is the purpose of this article to express a view concerning the location of surgery relative to biological science, and to medicinal therapy, a view which claims its origin from years spent with Dr. Churchill at the Massachusetts General and its later growth from the privilege of conducting the service at the Peter Bent Brigham. This author would not wish to inflict any responsibility for these views either on his former chief, Dr. Churchill, or on his present Brigham colleagues.

* This account is based on the Second Annual John B. Rhoads Memorial Lecture given by Dr. Moore before the Benjamin Waterhouse Society of Boston University School of Medicine on November 27, 1961.

** Because of this remarkably clear quality-factor in operative surgery (applied to the trusting and anesthetized patient), and a greater identifiable responsibility of commitment than is seen in other therapeutic fields, there has been an attempt at quality control in surgery since the beginning of the Eighteenth Century. The growth of quality control has produced the structure of the American College, the Hospital Tissue Committee, and the American Board. Assaults on these conscientious attempts at quality control by splinter groups claiming surgical skill yet without paying the price of its achievement, have characterized surgical organizations since its beginning and are again pressing today.

Where is the Science in Surgery?

The fundamental act of clinical care is the assumption of responsibility for the welfare of the patient. To discharge this responsibility the physician or surgeon employs certain technics. Each field of medicine is then in turn underpinned by biological science, several large areas of which are so close to its clinical responsibility that they dominate the objectives of its research. In these fundamental relationships surgery is in no wise different from any other field of clinical activity.

Clinical responsibility defines the content of surgery. This content has grown steadily over the years as effective surgical technics could be extended and responsibility widened. These technics of the sterile anesthetized tissue dissection generally known as the surgical operation, have been generally applicable to diseases that were acute, focal, and traumatic. The entire range of tumors and cancers, congenital anomalies, local infections, wounds, injuries, and diseases localized to organs of the body (ranging all the way from mitral stenosis to gallstones) have been those most susceptible to its method. An understanding of these diseases, their diagnosis, management, and treatment, therefore defines the content of surgery. As the technic of surgical operation probes, tests, and proves itself in new areas so also the content of surgery is extended. In each instance, the responsibility of the surgeon is for the total welfare of the patient, not merely the performance of a dissection.

Modern biological science has become so effective in achieving practical answers to theoretical questions that the surgeon carrying out research cannot be differentiated in motive or method from the physician, the pediatrician, or any other holder of a doctorate in medicine, while in the laboratory. The research carried out by surgeons is usually directed at those areas of biology pertinent to the problems of surgical responsibility.

The concept that surgery has but a tenuous relation to science arises from individuals who have had no contact with the surgical operation or who have viewed it from a distance, or from surgeons who have had no contact with the laboratory. Viewing the surgeon surrounded by his team carrying out a sterile anesthetized tissue dissection, the view is one of tools, ties, and transfusions; the onlooker equates this with a repetitive craft far removed from biological science.

As one watches an internist making a visit in his patient's home, he is seen to talk with the patient, do an examination, listen to the heart and lungs with a stethoscope, write out a prescription, and finally give an injection or a pill. Viewing the physician thus engaged in the technic and arts of his profession, the onlooker might well conclude that there is no science in medicine.

The analogy between medicine and surgery here is a close one, despite the different settings. In each case the doctor is giving his service to the patient through the application of skills, technics, and arts. These in turn find their justification in a bank of knowledge in which many deposits have been made by biological science. The same homily is true in all fields of medicine. The psychiatrist might be said to have an art in his interview, the neurologist in the neurological examination, the pediatrician in keeping the mother happy.

All of these technics or practical crafts are important. It just so happens that, despite their importance, they are neither as critical for survival nor as difficult to master as are the technics of the sterile anesthetized surgical dissection involving an extensive knowledge of gross and microscopic anatomy, physiology, biochemistry and bacteriology as well as an entire platoon of personnel, instruments, supporting anesthesia, and hospital equipment, plus the subtle property of tissue-handling skill in the surgeon's manual ability.

The attribute of science, meaning by that a systematic approach to the most probable truth, is found in the surgical operation itself as exemplified in its precise anatomy, bacteriology, biochemistry, and physiology. All of these are quite evident to the surgeon carrying out the procedure even if not to the untrained onlooker. But beyond these urgent daily acts of open anesthetized dissection, the relation of the surgeon to biological science can be arranged in three broad categories.

Three Roles of Surgery in Biological Science

The first role of surgery in science has been that of the surgeon himself, as a competent scientist, stepping aside from the pressure of his clinical responsibility to make contributions to biology.

The second role has been that of the surgeon employing scientific methods to seek practical answers to the question: how can I do my job better? This might be called applied research. Yet, even this differentiation is obsolete now. There is no longer any boundary between fundamental and applied research in biology; anything discovered that answers to *veritas* in biology may be applicable at the bedside tomorrow.

The third role of surgery has been that wherein science is using surgery as a means to a scientific objective wholly removed from surgical responsibility.

1. The Surgeon as a Scientist. As examples of the first role of surgery in science one may cite figures such as Andreas Vesalius, John Hunter, and Harvey Cushing. All of them were practicing surgeons. All of them made abundant contributions to science.

The importance of Vesalius as the Professor of Surgery at Padua lies in the fact that he approached Nature to achieve a synthesis of human anatomy free of ancient dogma. Although he did not carry out experiments in the sense of Claude Bernard, the intellectual approach was identical. A question was posed and then the answer sought from Nature. The question was not one of physiologic interaction but rather of anatomical arrangement. The method was not that of cleverly designed experiment with all variables controlled; it was instead the personal dissection of a cadaver. The literary history of Vesalius was unique. He had the prolificity of genius, but the entire outpouring occupied only a five-year period. In the words of Singer and Rabin, "The work of Vesalius is of high significance for the development of philosophy and of science, for it heralds the modern spirit of research. His importance extends far beyond the realm of medicine . . . the combined work is the first great achievement of modern observational science. It opens a new scene as with the quick rise of a curtain, for it is suddenly essentially and brilliantly modern."

One of the peculiarities of the surgeon as scientist is that surgery itself is very time-consuming and some sort of resolution must be made of this conflict of interest between the operating room and the laboratory. In the case of Vesalius this conflict was resolved by retiring completely from the operating room for about eight years; when the flash of insight had been thoroughly explored the Fabrica was published and Vesalius returned to his practice as a thoracic surgeon, draining empyema, stooping to the academic turmoil of the day, engaging in pseudo-religious scholastic controversy, and not conducting himself at all like a Nobel Prize winner. He is the prototype of the surgeon stepping aside from the patient to contribute to science.

John Hunter occupied the same role but occupied it continuously throughout his career, interrupting his practice each day or each week to pursue his other interests. He was a biologist in the most romantic sense of the term, interested not only in solutions for the most pressing detailed surgical problems of the day but likewise in such far-distant things as comparative zoology, the growth of deer antlers, and the mode of communication of venereal disease.

A modern example of the surgeon in this role is to be found in the career of Harvey Cushing. Cushing, like Hunter, was into everything. During an early period of his life he was interested in what he called *comparative surgery.*[13] He wrote a number of articles dealing with veterinary surgery and therapeutic operations done on dogs, cats, horses, cows, and monkeys. If he found a horse with a hernia, he repaired it; he did bowel resections and took out tumors on various animals. At one time in the laboratory in Baltimore a dog was brought in with massive ascites. Cushing and his cohorts tapped the ascites, spun the fluid down and made a smear of it. It was a bloody ascites with cells in it so they thought the dog had a disseminated tumor. They watched the dog along from day to day, making very careful notes with sketches in the typical Cushing fashion. The dog finally succumbed. So they did a complete postmortem examination and found that the dog had mitral stenosis and tricuspid insufficiency. They set out the next day to produce mitral stenosis and tricuspid insufficiency in the dog. They worked through this problem quite successfully prior to the advent of positive pressure anesthesia. Their operations were done by placing a tracheotomy tube and giving the anesthesia by this route. They puzzled as to whether they were going to carry out their cardiac operation via the auricle or the ventricle.[11]

In 1908, Cushing published an article entitled, "Experimental and Clinical Notes on Chronic Valvular Disease in Dogs and their Possible Relationship to Future Surgery of the Cardiac Valves." In this article he forecast two things: first, that it was going to be better to operate on the cardiac valves through the auricle than through the ventricle. And secondly that one would have to give a lot of thought as to what he was going to say to the very first patient who was operated upon. The risk would be great and the surgeon would have to balance off the problem of the high risk of nonoperative treatment in a nonmalignant condition: late congestive heart failure. This little episode in Cushing's early work shows the rather Hunterian character of his probings and searchings stance of Cushing's work on the pituitary, around among a whole variety of fields, without any regard to standard disciplinary boundaries.

However, the best example of Cushing stepping aside from clinical pressures to contribute to science is his book on the pituitary.[10] This book is a fine product of an individual with an inquiring mind, who also has the unusual knack of being able to collect, codify, and remember clinical details so that later they can be recalled in reproducible combinations. In the instance of Cushing's work on the pituitary these retrospective combinations constituted the first important American contribution to endocrinology and quite transcended any immediate problems of operative management.

The book was an extension of a Harvey lecture given in 1910. It was published in 1912. It is interesting that at the time of its publication Cushing had just been made Moseley Professor of Surgery but had not yet taken up the job. He was evidently very anxious to get this on his publications so he followed the title with the word *Elect*. Furthermore, the publishers had never heard of the hospital involved (which was not yet built) and the proofreading was evidently a little hurried, so that this Moseley Professor-Elect is indicated as about to take up his position at the "Peter Bent Bingham Hospital."

The presence of pituitary pathology in states of excessive growth such as acromegaly led Cushing to interest himself in the presence of a pituitary growth hormone. The finding of a combination of abdominal striae, hypertension, diabetes, polycythemia, muscular weakness, and excessive adipose tissue led him to postulate this as an endocrine disorder, the one still carrying his name. Froehlich's syndrome, the relationship of the brain to duodenal ulcer, the effect of hypophysectomy on the growth of puppies, all of these were an outgrowth of this fertile period in Cushing's life.

In this book is found not only the first description of Cushing's syndrome but also a large variety of data about hypo- and hyperpituitary states in which pictures of dogs and pictures of people run about in equal quantity. It would bring pleasure to Cushing were he to hear about the cases currently arising in which total adrenalectomy for Cushing's syndrome has been followed ten years later by a progressive visual field defect and the belated recognition of a pituitary tumor!

All of this was a contribution to endocrinology by a surgeon who at the time was much more concerned with science than with operative management of these conditions though the latter followed immediately and in rich measure.

There are several other features of Cushing that are of interest here. He was prolific throughout his life. In the later years of his life Cushing resolved the scientific enigma of surgery by putting his laboratory and operating room in the same place. He was in the fortunate position of cultivating both of his vocations simultaneously, a point of maximum efficiency which could result in great productivity. Every time he operated on a patient with a brain tumor he was working in his laboratory. Each case was one more brick in the edifice of knowledge concerning neoplasia in the central nervous system, this being the scientific field of endeavor that occupied him from aproximately 1925 until the time of his retirement. No other surgeon of the modern era comes to mind, for whom the laboratory and the operating room were quite so directly superimposed thus making it possible to maintain activity in his chosen field of scientific research at the same time that he was operating on sick patients.

2. Surgery Enjoying the Scientific Method. In the second category of surgical roles in science is the surgeon using the methods of science to find out a solution to a pressing clinical problem. This is the familiar scientific role of surgery and surely the most important. It is only the most exceptional surgeon—or physician, pediatrician, or neurologist—who can make primary original scientific contributions to the general field of biology. But every surgeon who attempts to do anything new, or who tries to achieve the best answer to a challenging clinical question, should use the scientific method in its most effective form. And from this work emerges much of scientific worth as well as practical advance. As Iselin stated in his Newcomen Lecture, "The Pathfinder of the Seas": ". . . no matter how pure the idealists among us try to keep science, there is little doubt that important advances frequently are achieved because someone realizes the practical applications that can be made of a particular course of study. . . ." Recent attempts to downgrade applied research in clinical medicine and surgery only because it may not involve the technics of biophysics or molecular biology, are to be deplored.

A most spectacular recent example of this scientific role of surgery has been the development of the surgical care of diseases of the heart and lungs, and of extracorporeal circulation for its accomplishment. Here is an example where the entire range of surgical therapy has been enriched through the extension of its technology—the sterile anesthetized tissue dissection—to an organ system previously closed to it.

Dr. Churchill's own work illuminates much of this history.

Dr. Churchill graduated from Northwestern University in Evanston, Illinois in 1916 following which he took a Master's Degree in Biology also at Northwestern.

Following his graduation from Harvard Medical School in 1920, Dr. Churchill entered his House Officer years at the Massachusetts General Hospital, taking an increasing load of clinical responsibility as each year passed. During his final year of residency he established a small experimental laboratory at the Massachusetts General Hospital, working on the production of lung abscess, and on lobectomy.

Completing his four years as House Pupil and Resident in June, 1924, Dr. Churchill supported himself by assisting some of the Senior Surgeons and by Out-Patient teaching. In the fall he began working part-time with Dr. Cecil Drinker at the Harvard School of Public Health.

On September 15, 1926, he left for Europe for a year as a Moseley Travelling Fellow, studying pathology with Max Borst in Munich, and as an observer, attended the happenings in the Sauerbruch Clinic across the street. He then joined Krogh's laboratory where he found himself working again with Dr. Cecil Drinker and with Dr. A. N. Richards on subjects of cardiovascular physiology.[12]

After a year at the Massachusetts General Hospital Dr. Churchill moved to the Boston City Hospital as Surgeon and Director of the Surgical Research Laboratory, and in September, 1928, began his work there. Dr. John H. Gibbon joined him in January, 1930, as a research collaborator.

Much of Dr. Churchill's work prior to and during his tenure at the Boston City Hospital, and following his studies with Drinker, Sauerbruch, and Krogh must be regarded as playing an important germinative role in the subsequent development of pulmonary surgery, and cardiovascular surgery.

In 1929, Dr. Churchill published the article describing his operation for constrictive pericarditis.[17] This article described the decortication of the heart carried out by Dr. Churchill for constrictive pericarditis on July 18, 1928. This was the first successful case in the United States and one of the few successful cases then on record in the world literature. It is of historical interest that the physicians concerned were under the impression that the procedure available was *thoracectomy* of the Kocher-Brauer type, and had not envisioned the *constrictive* pericarditis syndrome as described by Volhard and Schmieden. In 1930, Dr. Churchill and Dr. Gibbon published their article on "Changes in the Pulmonary Circulation Induced by Experimentally Produced Arteriovenous Fistula."[14] In this study, a peripheral arteriovenous fisula was created in the leg of an experimental animal. An increased pulmonary blood flow was recorded in the lung, yet with only a minor increase in pulmonary artery pressure. This led the authors to the conclusion that a peripheral arteriovenous fistula had, through mechanisms then unknown, produced a decrease in the pulmonary vascular resistance. Following this line of investigation, these same two authors, now with Mary Hopkinson (soon to become Mrs. Gibbon), published their work entitled "Changes in the Circulation Produced by Gradual Occlusion of the Pulmonary Artery."[16] In this study, as in the previous one, the investigators were using what they called "the Drinker heart preparation"; cardiac output was measured by the Fick principle and it was clearly shown that gradual occlusion of the pulmonary artery was well tolerated by the organism until a late stage when, quite abruptly, the circulation deteriorated.

In June, 1930, Dr. Churchill resigned his post at the Boston City Hospital and returned to the Massachusetts General Hospital as Associate Professor of Surgery under Dr. Edward P. Richardson. Dr.

Gibbon returned also to the Massachusetts General Hospital, and a few months later to Philadelphia, only to come back again to work with Dr. Churchill in the period 1932–1934. Dr. Churchill's publications during his first six or seven years after returning to the Massachusetts General represented both a scientific and a clinical fruition of the groundwork laid by his previous studies both in this country and abroad.

On August 10, 1931, Dr. Churchill resected the lower and middle lobes of the right lung for adenocarcinoma of the bronchus, the bilobectomy being performed with individual ligation of the hilar vessels. This was the first case in which primary healing of a major bronchus was obtained by direct bronchial suture. This tumor was later classified as a bronchial adenoma, but demonstrated the basic principles of a single-stage resection by separate ligature of the vessels and primary suture of a major bronchus, followed by temporary catheter drainage of the pleural space and healing without suppuration. It is quite evident that interests being pursued involved at least three areas simultaneously, all of them subjected to scientific and clinical appraisal: occlusion of the pulmonary artery *per se,* occlusion of the pulmonary artery by embolus, and ligature of the pulmonary artery to accomplish the removal of the lung.

In 1934 and 1936, two further publications, dealing with massive pulmonary embolism, emerged from Dr. Churchill's laboratory. These were "The Mechanism of Death in Massive Pulmonary Embolism, with Comments on the Trendelenburg Operation"[7] and "The Physiology of Massive Pulmonary Embolism; an Experimental Study of the Changes Produced by Obstruction to the Flow of Blood through the Pulmonary Artery and its Lobar Branches."[15] The first of these two articles was primarily a clinical review. The case history of a patient was presented, in which the Trendelenburg operation had been carried out, but too late. In this article Dr. Churchill makes it quite clear that his operative series had not been uniformly successful, and he states, "It is not our privilege to discuss the technical features of this operation on the basis of unsuccessful cases. . . ."

In the second of these two articles it appears that Dr. Churchill and Dr. Gibbon were setting forth their views on the differential physiologic effects of massive as versus minor pulmonary emboli. The authors imply that this work had been carried about as far as they had planned to carry it in the laboratory. By precise physiologic methods they showed the difference between the asphyxial changes due to occlusion of the small vessels to pulmonary lobes, and the contrasting picture of acute circulatory collapse with syncope produced by sudden occlusion of the main pulmonary artery. The differentiation was shown both clinically and chemically.

Incidental to this study, Dr. Churchill was the first to use spirometry to measure the crippling of pulmonary ventilation caused by abdominal operations,[8, 9] and he, with Dr. Cope, described the reflex mechanism producing rapid shallow breathing in pulmonary congestion and edema. This background in pulmonary physiology was important also in the study of collapse therapy and later in the adoption of extirpative therapy in the treatment of pulmonary tuberculosis. This interest, running through 20 years of Dr. Churchill's career, was likewise one of his very first. The report of a lung abscess in a child, cured following artificial pneumothorax, was the subject of one of Dr. Churchill's earliest publications.[1]

These articles all show to the reader 30 years later, the effectiveness and elegance of applied research, bringing physiologic and biochemical disciplines to the problems of surgery. These areas of surgical research were obviously applicable to the immediate problems; as it turned out they had far-reaching effect and were applicable to a whole variety of problems in cardiac and pulmonary surgery then dimly seen save by a few. Dr. Churchill's interest in the pulmonary aspect of these problems might be said to have flowered in its most spectacular clinical form with the publication of his initial series of lobectomies for bronchiectasis carried out with the lowest mortality then achieved anywhere in the world, in 1937.[3]

This brief summary neither intends to, nor can possibly do justice to Dr. Churchill's contributions in pulmonary surgery, cardiac surgery, the surgery of the parathyroid glands, or the surgical treatment of war wounds. It is quoted rather as an example of the second major relationship of surgery to science, and in many ways the most important: the application of scientific discipline in observation, deduction, and experimental design, to specific clinical problems.

Subsequent to this work, in the further development of valvular surgery and intracardiac surgery, many other investigators brought to bear a wide area of biochemistry. The surgeon doing an open-heart operation at the present time is using on a minute-to-minute basis the entire area of biochemistry initially outlined in the period 1915–1930 by Henderson, Hastings, Van Slyke, Peters, and Gamble. These were the data which provided a sound method and interpretive framework for quantitative clinical chemistry in such familiar fundaments as oxygen saturation, blood pH, lacticacidemia, erythrocyte fragility, tissue perfusion, oxygenation versus carbon dioxide removal, and myocardial irritability. Those surgical workers who followed in Dr. Churchill's footsteps and most closely applied biochemical disciplines to expert operative surgery, were the ones who first successfully brought the new method of extracorporeal circulation to safe practical realization. Those others who saw in the area only a challenge to mechanical perfection without physiologic control achieved neither safety for their patients nor validity for their data. To quote Dr. A. B. Hastings: ". . . The most practical thing in the world is sound fundamental research."

3. **Science Enjoying Surgery.** The third type of relationship between surgery and science is one not shared by any other of the medical therapeutic technics. It is that of the scientist, not a practicing surgeon, using the effective technical edifice of surgery—the sterile anesthetized tissue dissection—in order to obtain data applicable to his own field of work. The best example of this, and one in Dr. Churchill's earlier days, was that of Walter B. Cannon using the technics of surgery to accomplish survival experiments involving sympathectomy, cardiac denervation, and a whole range of similar procedures on the autonomic nervous system. Cannon had to do a sympathectomy on a kitten and then have the kitten grow up to be a cat. This cat was then his own bioassay for catechol amines.[2]

Many scientists in the fields of pharmacology, physiology, and biochemistry use the open sterile anesthetized tissue dissection to find information on a variety of topics. It is of interest, historically, that extracorporeal circulation itself, a device perfected by surgeons for a clinical surgical purpose, now finds usefulness in the study by biochemists and physiologists of the isolated function of such organs as the liver, the kidney, and isolated limb or muscle preparations.

There is every reason to believe that in the years to come the relationships of science and surgery will still fall into these same three groups. The advent of the new biology raises questions about these relationships and the education needed to meet them.

Molecular Biology and Clinical Medicine

The young doctor, recently the recipient of an M.D. degree, was formerly well-qualified to undertake research on whole organ systems, the whole organism, or the analysis of fluids and tissues. Such research bore a close family relationship to the concepts and technics learned in medical school and applied daily to the clinical problems of patients. In sharp contrast, an effective approach to biology at the molecular level involves the technics of biophysics, the daily application of higher mathematics beyond the educational realm of most doctors, and a whole series of complicated laboratory technics which currently bear little relationship to those applied to the sick. Their ultimate application to illness is unquestioned, but the educational content for their mastery is not a part of medical education as we know it today.

The picture of the physician with his little black bag knocking on the door of his patient's home and giving out a pill or prescription was used as an example of the craftsmanship or nonscientific art of internal medicine. This example has a converse counterpart which also should be cited in analyzing the relationship of science to clinical activity.

This is the example of the physician in the enzyme laboratory spending full time in quantitative molecular biology. In so doing he is pursuing the only pathway he knows to faculty promotion and national recognition. He is scarcely able to take an hour a week off to see patients, and then he finds it burdensome and unprofitable. In this relation, the surgeon superficially appears to be far better off because, while he is active as such, the surgeon can never slip quite so far away from the urgent commitment of his patients, as can his brethren in the nonoperative medicinal fields. Surgery, through its responsibility, is brought very close to the urgent care of the critically ill, and deals with such patients at a level of intimate personal commitment. This makes it harder for the surgeon to contribute to science, but easier for him to keep a clinical balance in his work.

The advance of science has brought the surgical practitioner and the university surgeon closer together, whereas in internal medicine it has split the practitioner and the professor farther apart. The competent surgeon in his community hospital, far removed from medical students or laboratories, deals with diagnoses and operations in a way scarcely to be differentiated from his university counterpart. One of the delights of modern surgery is to see the uniformity imposed by excellence. By contrast, in medicine and pediatrics the world of the university has become so heavily concerned with scientific research wholly removed from the patient that the daily work of a practitioner seems almost to be a different profession and certainly requires an entirely different set of talents.

The problem, a bogey 50 years ago, of "How will we get the surgeon into the laboratory?" now finds an equally baffling counterpart, "How will we get the physician back to the patient?" This matter is beyond the scope of this article save to call attention to its existence. This problem is found on university services both in this country and abroad. It is traceable not to any fault on the part of the physician, but rather to his very concern with scientific contribution and advances in an era when molecular biology is the most productive pathway to truth, and is very demanding of its devotees.

The easy-going marriage between biological science and clinical medicine has had a nice honeymoon which appears to be over. Now the hard part comes. During the honeymoon era—epitomized by the work of such men as Dr. Fuller Albright—

it was possible for a brilliant clinician with an inductive scientific mind, to take his observations from the bedside and quickly translate them into the laboratory and vice versa. There, using standard technics of quantitative chemical analysis, clinical observation could be transformed into high-grade scientific research.

The events in biology since World War II have changed all that. As expressed by a member of our faculty at a recent meeting, the time has passed when the young physician can "take a year off in the laboratory to build his bibliography." The technics are too exacting. The mathematics are too advanced. It is a simple matter to achieve a nodding acquaintance and write a few papers. But this does not constitute depth of penetration in an era of molecular biology. A small advance on some narrow front can still be made, but a broader scientific validation will require a much longer time of study and it will take the physician assuredly far and sometimes permanently away from his patient.

The surgeon who seeks to apply the technics of biophysics to current problems in surgery, such as immunogenetics for transplantation, organic chemistry for tumor chemotherapy, or gas chromatography in prostatic endocrinology, as examples, must face and solve this same problem. Those concerned with staff appointments and faculty promotions as well as membership in national societies must recognize the fact that there are going to be important contributors to surgery who cannot carry out a major operation daily while concerned with such studies most of which are done in the years after the residency.

To raise a generation of surgeons who can employ modern biology to solve their *ad hoc* problems as Dr. Churchill used physiology and biochemistry to solve his, is going to require some heady application to matters of curriculum and postgraduate support. There is every reason to believe that success will be achieved but only when we realize that research productivity is not essential for everyone, and those that wish to make the fullest use of molecular biology in surgery cannot be expected to do this on the basis of "a year in the dog lab."

Pressures from the Surgical Patient for a Clinical Curriculum

It was mentioned above that the advance of science tends to bring the world of the practitioner and the world of the teacher closer together in surgery, whereas in medicine they seem to be drifting farther apart. By the same token, advance in knowledge has brought more and more surgical patients into the hospital, whereas advance in medicinal knowledge (particularly public health and the antibiotics) has made unnecessary the admission of large numbers of patients who would formerly have been on medical services.

It has thus come about that in the modern urban general medical and surgical hospital, somewhat over 70 per cent of all patients admitted come to the care of the surgeon. Modern hospital practice—clearly that associated most prominently with the universities—has become more and more dominated by the availability of operative technics and surgical practice. The sterile anesthetized tissue dissection is best carried out in hospitals. The extension of surgical technology to new areas has a curious institutional overlay. This is not exhibited, for example, by such a spectacular advance as the development of a poliomyelitis vaccine that has rendered unnecessary the hospitalization of a large group of patients—a most welcome relief both for the pediatrician and the orthopedic surgeon.

This distortion of American urban hospitals in the direction of surgery is of importance in the curriculum of medical schools. In several medical schools where the surgical curriculum has been downgraded, it has become evident that the curricular authorities conceive of surgery only in terms of the operative act itself (and then only in the narrowest imaginable framework of *craftsmanship*) and have regarded this teaching as a postgraduate function. They have quite overlooked the fact that it is the very ***responsibility of surgery for a large number of patients,*** rather than its technics, that should determine its curricular position. Its deceptive removal from molecular biology has not modified its clinical urgency. If the student is going to see patients with tumors he must have a good surgical course. What is the medicinal treatment of cancer of the rectum? If the student is going to see the psychiatric results of sterility he must take a surgical course: the patient comes to the gynecologist, not the psychiatrist. What is the medicinal treatment of harelip, of a crushed chest, of carcinoma of the esophagus? Is not speech-training part of human biology? Is not stabilization of the rib cage an important way to spare the intracellular buffer mechanisms an excessive load of carbon dioxide?

To see all the patients suffering from diseases for which surgeons have responsibility the student must have an extensive surgical course as an undergraduate. Patients with vascular insufficiency of the periphery, with valvular heart disease, degenerative disease of the aorta or carotids (to cite merely one group of patients with diseases of the circulatory system) are now concentrated on the surgical services.

The clinical pressures, then, which affect the relationship of the surgeon to science are the same pressures that make it absolutely essential for surgery to loom so large in the undergraduate curriculum. If surgery is reduced to but a few weeks in the clinical years, the medical school will graduate a generation of students who have never had a first-hand contact with some of the most pressing and common diseases of our population and who have a pseudo-academic scorn for anything that is simple, anatomical, reparable, clinically useful, or therapeutically effective.

To teach this surgical curriculum best one of the three scientific roles of surgery appears to be essential in a teacher's career. This constitutes the final and in some ways the most baffling aspect of the relationship between biological science and clinical surgery.

The Scientist as a Surgical Teacher

With these clinical pressures and this scope of responsibility of surgery, it might seem probable that the most effective teachers of surgery would be those who were wholly concerned with clinical activity. Generally this is not the case. By the same logic, there should be no reason to anticipate that ability to apply quantitative biology to surgical problems in the laboratory should have anything to do with the teaching of surgery. The fact of the matter is that, in substantive content, it does not.

The notable association between effective teachers of surgery and scientific research in the laboratory does not trace itself to any ability these teachers may have to inform their students about their own personal activities in the laboratory. This is only a mine of boredom for the younger generation. Passing out reprints is not a substitute for surgical education.

The association between teachers of surgery and scientific research is traceable, instead, to the fact that the ability to conduct well-organized research is often associated with the qualities of imagination, verbalization, inspiration, and a sense of forward progress, that is found challenging and refreshing by students and residents alike.

It is true that a surgeon cannot organize a university service including a research laboratory if he does not himself know something about research. Yet, the more important factor in his own research (relative to leadership) has to do with his ability to plan it, express it, analyze it, and synthesize it in a meaningful way, rather than with actual substantive content. A young surgeon investigating a small area in depth and with sophistication often will exhibit these qualities associated with leadership to a greater extent than some individual whose research sprawls into all areas of surgery but without sophistication in any. What is needed here is scholarship in its broadest sense, not science in its narrowest.

Science versus Scholarship

A scholarly approach to surgery is not limited to laboratory science. The relation of biological science to clinical surgery has drifted out of focus when scientific investigation is regarded as the only pathway to scholarship in surgery; this differentiation is of greater importance in the residency years than it is either before or after. The emphasis during a residency should be on scholarship and a scholarly approach to the problems of surgery, and not on laboratory research and bibliographic output alone. The resident who grinds out a couple of papers each year while his operations are sloppy, asepsis careless, whose families are unhappy and patients lost to follow up, represents the loss of focus in the relationship of science to surgery. Such a resident might be accomplishing something in science, though this is highly doubtful, but he has lost sight of the fact that the American tradition in the surgical residency is one of a scholarly approach to all aspects, and with a large dose of humanism.

In a university teaching hospital in the United States today scholarship should be regarded as the prime quality of the resident. If he does not have it or does not wish to seek it, he should acquire his training at some other type of an institution. Leadership in surgery will not come from scientific research alone but from scholarship in all phases of surgical responsibility. Such scholarship may take the form of scientific research, or a critical look at methods, results, and clinical problems. Even though it is but one criterion of scholarship, bibliographic output is important for two reasons. First, that publication constitutes the only permanent public record of work brought to completion, a record that can be used by others who wish to build further. Second, is the fact that it is only the rare scholar who wishes to hide his data in the drawer. Such do indeed occur and there are notable historic examples. But they are rare and, in general, a total lack of publication usually signifies a lack of scholarship.

Summary and Conclusions

Surgery has trafficked with science in three ways: the surgeon has left the clinic to contribute in the laboratory, surgery has employed the laboratory to solve practical and important problems, and finally, laboratory science has used the technology of surgery to achieve its own ends.

The content of surgery is defined by its clinical responsibility for the care of patients usually treated by sterile anesthetized tissue dissection. The areas of biology of interest in surgery are largely determined by this very broad clinical responsibility. The specific areas of responsibility of the surgeon change from year to year as its methods become more broadly applicable.

As science and medical knowledge have advanced, the hospitalization of many diseases treated by medicinal means has become less and less essential. Many have been prevented. By contrast, as surgery advances, it requires the hospitalization of many patients who formerly would be left to succumb under palliative or expectant treatment. For this reason the modern urban or university hospital has become increasingly a surgical institution.

The increasingly surgical nature of large urban university teaching hospitals makes it mandatory that medical school curricula include a very large section of time for surgery. This surgical teaching is not to be concerned only with the technical matters of sterile anesthetized tissue dissection, but instead with allowing the students a free opportunity to observe, diagnose, treat, and understand the wide range of diseases which are on the surgical service and nowhere else. The problem is epitomized by the question, "What is the medicinal treatment of cancer of the rectum?"

These clinical pressures have kept the surgeon close to the patient both in his clinical work and in his biological science; a physician by contrast is much more easily pulled away from the patient because he is not held by the urgent personal commitment of open tissue dissection. The time-honored question: "How are we going to get the surgeon into the laboratory?" has been replaced by a new question asked in many universities: "How are we going to get the physician back to the patient?"

Teachers of surgery appear to be most effective when they have been associated with biological science. This is an illusory phenomenon because it is scholarship in its broadest sense rather than laboratory investigation which should be required not only of the teacher of surgery, but of any person concerned with the residency or attending staff appointment at a university hospital. Scholarship in surgery has many pathways other than laboratory science; laboratory science has provided a stimulus and a podium for many scholars of surgery in the past and will probably continue to do so in the future.

A most imposing problem of the future lies in the increasingly complicated and challenging nature of biological science. A young person entering biophysics has an education fully as rigorous as a young surgeon. The most outstanding differences are the emphasis on higher mathematics in biophysics, and clinical judgment in surgery. It is going to be the rare surgeon who can take the time or the talent to speak with the molecular biologist on equal terms even though, in decades past, many surgeons could speak on equal terms with physiologists or biochemists. For surgery to continue to exhibit its first two relationships with science, universities and national societies must take note of the fact that the surgeon so doing must devote several extra years to his education.

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