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30. While considerations of space prevent us from discussing them, it should be noted that a number of other studies support our finding that the more eminent and highly achieving academics are politically to the left of the general memberships of their professions. See, for example, (*22*) and C. E. Noll and P. H. Rossi, *General Social and Economic Attitudes of College and University Faculty Members*, mimeographed (National Opinion Research Center, Chicago, 1968).
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32. We wish to acknowledge our debt to Clark Kerr, chairman of the Carnegie Commission, and Martin Trow of the University of California, Berkeley, who directed the administration of the surveys, and to their colleagues. We also wish to express our appreciation to the staff of the Social Science Data Center of the University of Connecticut for assistance in the preparation of this paper. Especially valuable was the work of Dennis Meltzer, Anne-Marie Mercure, Eleanore Wilcox, Margaret Russ, Ferdinand Engel, and Bartley Horwitz. Cynthia Ladd provided editorial assistance at a time when it was much needed. Preliminary presentations of these data were made by S.M.L. while he was in residence at The Salk Institute (San Diego) in the summer of 1970, and at the Weizmann Institute in October 1971. Comments from members of these institutes were quite helpful.

Scientists and Surgeons

The need for the surgical scientist and the Ph.D. in departments of surgery is discussed.

Francis D. Moore

Most of the great referral centers for surgical and medical care in the United States are university clinical units in the teaching hospitals. It is in these hospitals and their supporting academic departments that patients find final authoritative consultation and to which physicians throughout the country turn not only for complex surgery for their patients, but also for teaching, research, and updating by postgraduate education for themselves. Referral centers that were formerly outside of academia, in the private clinics, have developed increasingly strong university associations or teaching institutes in the past decade.

Such centers of excellence fill a national need that is both clinical and academic. Enactment of a national health insurance plan or any legislative expansion of health maintenance organizations will urgently require the expansion of our academic establishment in medicine—not only to provide manpower, but also to provide backup for patient referral and developmental research in all fields, especially in surgery.

In any assessment of manpower needs in surgery, one must look to the clinical responsibilities of surgeons in the university centers, as well as to their role in education. Manpower projections must also take into account the continuing need for a small, although key, group of highly trained scientists in university surgical departments. The development of the latter group has been the particular function of the research training grant programs in surgery.

What percentage of surgeons should be sophisticated about modern quantitative biology in relation to human illness? How many of them should understand the biosciences background of human illness and the pathophysiological responses to treatment? Obviously the answer to these elementary questions is "100 percent—all of them." All physicians who are privileged to carry out this most effective but dangerous modality of therapy should have a clear understanding of the biological processes with which they are concerned in the operative care of human illness. No shift in social focus will ever alter the need of the patient for perfection in surgery, nor alter this basic requirement for a strong biosciences orientation for all surgeons. The addition of less highly trained allied health personnel to the surgical team will only increase, rather than decrease, this quest for perfection in the surgeon, who is ultimately responsible for care.

It is quite another matter to define precisely that fraction of surgeons who should be productive scientists, devoting a decade or two to the development of new data by research—that is, the fraction who should be research training grant trainees. Although but a small fraction of surgeons needs this additional research capability, this small group will determine the quality of the total enterprise and the level of recruitment for the national surgical establishment, just as it will for pediatrics, internal medicine, psychiatry, and the other clinical fields.

Each of the 105 medical schools in this country needs several surgical laboratories, including some in general surgery and in the various special divisions of surgery. On this basis, I estimate that approximately 500 to 750 surgeons between the ages of 30 and 50 should be at a level of attainment that would enable them to make significant contributions to scientific journals

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and become members of the American Association for the Advancement of Science, the Society for Clinical Investigation, the Federated Biological Societies, or their equivalent.

There are approximately 50,000 surgeons in this country today who have passed the examinations of the various American boards of surgery. Of these surgeons, approximately 4000 are closely affiliated with academic units. Therefore about 12 to 15 percent of these university surgeons should achieve the sort of scientific career that is the mission of the research training grant programs. The current programs provide a number of surgical scientists in university laboratories of this type, but they are certainly inadequate to meet the growing demands of the rapidly expanding range of surgical techniques (*1*).

Why is this scientific work so important in surgery, and why is this level of scientific excellence among surgical investigators so difficult to achieve?

Although misapplications of surgery appear to be less frequent in university centers, the role of the surgical scientist should not be that of a policeman or watchdog (*2*). This function should be that of clinical teachers, clinical investigators, and professors of clinical surgery, who may occasionally be nudged, prodded, or discomfited a bit when their scientist colleagues poke holes in their dogmas or slay their sacred cows.

Rather than function as a watchdog, the surgical scientist should devote himself to the elucidation of pathophysiological problems peculiar to surgical patients, the development of more effective operative procedures, bioengineering for safer techniques in surgical care, and safe conduct of the patient through complex trauma and surgical illness. These scientists must be persons who are themselves involved in surgical care.

Examples of advances that have come about through such applications of science to surgery include the development of intracranial surgery in the 1920's, thoracic surgery in the 1930's, cardiac surgery in the 1940's, open-heart operations in the 1950's, and kidney transplantation in the 1960's. The application of these methods brings relief from suffering not to an elect few, but to thousands of patients from all walks of life each year. In addition, surgical scientists have made basic contributions in a number of areas of human biology, including the physiology of the gastrointestinal tract and the gastric antrum, coagulation, the immunology of histocompatibility and neoplasms, and the development of extracorporeal pump-oxygenator systems.

The difficulty of accomplishing this synthesis of science with surgery is traceable, in part, to the relative rarity of productive bioscientists in any population of students. It has been estimated that in the biological sciences less than 5 percent of Ph.D.'s publish, subsequent to their thesis, work that changes the concepts of their colleagues.

When one adds to this general rarity of scientific talent certain adverse factors in a clinical field such as surgery, the difficulty becomes more pronounced. The selection process for medical school places a premium on book learning rather than on inductive science. The selection process for surgeons from among other medical students places as much emphasis on clinical motivation, physical endurance, surgical crafts, and manual skills, as it does on creative thinking.

Most observers of creativity or productivity in the natural sciences suggest that these qualities pass away by the age of 45, at which time a man is either directing an institute as a research executive or has moved into clinical work or administration. This gives most biologists a 20-year run; for surgery it is only 12 or 15 years, since the training of a clinically competent surgeon who is likewise a productive scientist is rarely finished before the ages of 32 to 34. These 500 to 750 surgical scientists will therefore drop out of work in laboratories at the rate of about 50 percent every 7 years, with a total productive research time of only 10 to 15 years at most. Therefore, every 5 to 7 years we need approximately 250 to 375 more such men, or about 50 to 75 per year.

To produce this number of surgical scientists would require 60 to 70 research training programs that graduate two or three men a year, one or two of whom would probably answer this description. My estimate is based on current attrition rates among surgical research grant trainee graduates.

Just as the chemist or physicist may wind up in industry rather than in academia, the surgical scientist often goes into clinical work because of his skills and his inclination. In one group of 128 trainees who have recently completed the research training grant programs, 26 went into private practice. This loss of surgical scientific trainees to clinical practice is inevitable, but not unique, in medicine. It is seen also, though possibly to a lesser extent, in research training programs in medicine, pediatrics, and psychiatry. This attrition of surgical scientists becomes more marked with age because surgeons become increasingly involved with the care of difficult referral cases, serving a social function of unquestioned value.

Will these surgical scientists become professors and chairmen of departments—should this be the object of the research training grant programs? Some will become department chairmen because their scientific insights, verbal abilities, teaching talents, or large bibliographies will attract the attention of university search committees. If they also possess administrative skill and clinical talent, they make ideal department chairmen. Yet, surely this should not be the object of a national program for surgical scientists. A research training grant program should never exist for the petty object of providing a ladder to promotion, nor should it become a professor factory. Surgical excellence is the aim; professors are a by-product.

Why not utilize unemployed Ph.D.'s from the biological sciences for this surgical research function? In some cases, highly trained scientists from biology and engineering can find a secure place in departments of surgery. This has been especially notable in immunology and bioengineering. But even there these Ph.D.'s work essentially as collaborators, and their ability to understand problems in surgical biology rests on the existence of surgical scientists who understand the criteria of excellence in science and who can interpret some of the problems and difficulties of surgical care to their Ph.D. colleagues. In addition, some surgeons enrolled in the research training grant programs (or in similar, privately supported programs) will elect to take a Ph.D. as a feature of their postgraduate education (*3*).

The current research training programs of the National Institutes of Health have been the most important step taken by the government with relation to American surgery since World War II. They have provided a unique educational opportunity for many talented young men who will continue to strengthen American surgery. They are currently funded at an annual level of about $2.9 million, and from this budget approximately 31 departmental programs have been supported with approximately 169 trainees enrolled at any one time. It is my estimate that this program should be doubled and that, with this doubling, each department so supported will produce a small but continuing supply of scientists for this most demanding, widely applied, and, at times, most empirical of the medical professions.

Notes

1. An additional estimate of the number of surgeons devoting their postresidency years to scientific training and research is provided by the Society of University Surgeons, which currently has 250 active members (with 300 senior or inactive members) and 160 candidates for membership. The sum of these numbers (about 400 men under age 40) is particularly significant because active membership ceases at the age of 45, and this society, plus its candidates, would represent a reasonable majority of those in the country who consider themselves surgical scientists.
2. Fields of surgery that become separated from a biosciences mission have shown a pernicious tendency to revert to a service-oriented craft—inflexible and misapplied. After 50 years of criticism, routine tonsillectomy in children bewilders the onlooker.
3. The concept that no funding support need be given during postgraduate education because such trainees will all earn large clinical incomes at a later time is particularly self-defeating in this area. Most medical students enter their internship and residency period with a considerable debt. The temptation to leave the laboratory and earn enough money to repay these debts is already strong enough (and sufficiently destructive of academic careers) without adding to it an additional debt incurred during scientific training.

Technology in Ulster: Rubber Bullets Hit Home, Brainwashing Backfires

Belfast. The disorders in Northern Ireland, now in their fourth year, may not amount to a civil war but are making the country a dangerous place to live. In 1971, 173 people on all sides were killed, somewhat more than half the number of homicides that occurred in Washington, D.C., during the same period. Modern science has not contributed importantly to this tally. Unlike the Vietnam war, which has spawned major technological gadgetry such as the electronic battlefield, Ulster's principal gift to mankind's arsenal has been the rubber bullet. Like much of recent British policy in Northern Ireland, the bullet is an ad hoc development—blunt, soft-headed, and pacific in intent but liable to cause severe damage when discharged not according to rules.

A less successful application of science to war has been the psychological interrogation techniques used in the early days of internment last year. As devised by the British army, the techniques are probably unmessy. Unfortunately, in the hands of the Royal Ulster Constabulary, they were applied with sufficient brutality to ensure wide attention. British citizens who had believed that brainwashing was the exclusive prerogative of totalitarian nations learned otherwise. Those who objected to such techniques argued that they were in the first place immoral, in the second illegal, by British, Northern Irish, and international law, and in the third place inefficient, compared with other, incidentally humane, methods of interrogation. The British government, while denying that any brainwashing had occurred in Ulster, promised last March that no more would be countenanced in that or any future war. In its own way, this decision is as notable a fallout of the Ulster war as the rubber bullet.

The organization which has followed most closely the use of technology in Northern Ireland is the British Society for Social Responsibility in Science (BSSRS). In a recent statement, the society warned that the efficacy of new weapons resided in their novelty and that the British army was introducing one new weapon after another in order to maintain the deterrent element of surprise. In fact, the army has been if anything conservative in its choice of weapons. In policing the 270-mile border between Northern Ireland and the Irish Republic, the army has apparently eschewed the sensing devices developed for use in Vietnam and presumably available through exchange agreements with the United States; the most advanced piece of equipment applied to this chore is a backpack ground surveillance radar made by a British manufacturer. In the cities, the principal nonlethal weapons used for crowd control have been water cannon, CS gas, and rubber bullets. No use has been made of the many fancy gadgets developed for crowd control in the United States.

This conservatism is presumably a deliberate policy; an infatuation with technology is notably absent from the theoretical tract on urban warfare published recently by one of Britain's leading counterinsurgency experts, Brigadier Frank Kitson. With experience in the successful campaigns in Kenya and Malaya, Kitson stresses development of information as the key to counterinsurgency. New weapons should only be introduced after full consideration of their impact on public and world opinion. An officer who understands the importance of information gathering "is more use to his government and to his men then one who has spent years learning how to use the latest devices produced by modern technology."* The Irish Republican Army (IRA) is said to be among the closer students of Kitson's book; until last month, Kitson was commander of the brigade covering Belfast.

Kitson's advice was not heeded with CS gas. Although developed for antiriot use by British chemists in the late 1950's, the first use of CS gas† in the United Kingdom was in the Bogside at Londonderry in August 1969. Used indiscriminately in the narrow city streets by the Royal Ulster Constabulary and later by the British army, the gas can have done little harm to the IRA recruiting campaign, and in any event aroused such protest after its first appearance in the Bogside that the government set up an inquiry, the Himsworth committee, to study its use and safety. Spokesmen at Porton Down, where the gas was developed, continued to insist on its harmlessness for use against crowds—"no more toxic than bonfire smoke" was the homely line given out at one time. In fact, CS is somewhat more poisonous than chlorine, according to the only British scientist outside Porton to have studied

* F. Kitson, *Low Intensity Operations* (Faber and Faber, London, 1971).
† The chemical formula of CS gas is 2-chlorobenzylidene-malononitrile.