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19. The medium for filling the capillary tubes contained $1 \times 10^{-2}M$ potassium phosphate at *p*H 7.0, $1 \times 10^{-3}M$ $MgSO_4$, $1 \times 10^{-3}M$ $(NH_4)_2SO_4$, $1 \times 10^{-4}M$ ethylene-diamine-tetraacetic acid, and $3 \times 10^{-5}M$ leucine, methionine, and threonine. Galactose (Sigma "essentially glucose-free" grade) or another energy source was added at concentrations specified in the text. One milliliter of the medium was shaken in a test tube at 37°C for one half hour just before use, in order to standardize the amount of dissolved oxygen. The addition of phosphate is necessary for buffering, since the motility is *p*H-dependent (*7*). Concentrations of phosphate greater than 1×10^{-2} mole per liter, however, lower the rate of travel of the bands. The $MgSO_4$ and $(NH_4)_2SO_4$ are not required, but they stimulate the rate of travel of the bands 25 to 50 percent. Since the motility is very sensitive to inhibition by heavy-metal ions (*7*), ethylene-diamine-tetraacetic acid was always included and only water distilled in glass was used. When leucine, methionine, and threonine (which are required for growth) are omitted, bands do not form readily, even though the bacteria are still highly motile. Actually, only methionine must be added to get the bands to form and travel; leucine and threonine stimulate the rate of travel of the bands about 50 perecnt. Prototrophic strains form the two bands on galactose or glucose very well without the addition of any amino acid.
The effect of the inoculum size was studied. When fewer bacteria were put into the capillary tube, it took longer for the bands to appear. For example, at 1/10 the usual inoculum size, the first band had a lag period of ¾ hour and the second band 1¾ hours. Apparently the migration does not begin until the bacterial population has grown to a certain density. Once the bands have formed, they move at about the same speed, no matter what the initial concentration of bacteria. Temperatures between 23° and 37°C were optimal for the migration of the bands. There were no bands at 0° or at 48°C, where motility is inhibited (*7*).
20. The *E. coli* used is a strain of K12 which is here called B275. It was prepared from A. Garen's F3-W1-6, a derivative of the Lederberg strain W1. For growth, it has an absolute requirement for leucine and methionine and a partial requirement for threonine. For experiments in which amino acids were the energy source, the bacteria were grown in a medium which contained minerals and each of the 20 amino acids (0.25 g/liter) commonly occurring in proteins. A full description of this medium and details of growing and washing the bacteria will be presented elsewhere (*8*). For experiments in which galactose or glucose was the energy source, the 20 amino acids in the growth medium were replaced by galactose (5 g/liter) plus the three essential amino acids (0.02 g of each per liter). Glucose was not used in the growth medium because in this strain of *E. coli* it inhibits formation of flagella (*7*).
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Ethics for an International Health Profession

World health problems give rise to questions that are not answered by the physician's traditional code.

Carl E. Taylor

Increasing numbers of physicians are being attracted to service in international health. Many international assignments are carried out by short-term experts on leave from regular positions in their own countries, but a career corps is needed to maintain the administrative framework of international agencies, to ensure continuity of activities, and to provide imaginative exploration of the many new dimensions of this expanding field.

Any professional group tends to develop an ethic or binding matrix of values, which is often more important than knowledge or skills in setting that group apart from other groups (*1*). The general medical profession has with considerable pride made its ethic explicit. No other group has such a long and consistent tradition of trying to maintain an idealistic view of its function and role; its ethical principles were long ago embodied in the Oath of Hippocrates, the Oath of Maimonides, and in India, the oath prescribed by Susruta from traditional rituals which originated well before the 1st century A.D. The total milieu of medical education specifically provides for the inculcation of these distinctive values.

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To a remarkable degree the professional subculture of medicine cuts across national and other cultural boundaries. But new problems in international health pose questions—most conspicuously, but by no means solely, the question of the effect of disease prevention on population growth—which are not encompassed by an ethic based on the relation of individual physician to individual patient. Thus the ethic of the specialty remains implicit and undefined. The basic values are vaguely perceived and, at best, are acquired by imitation in loosely organized preceptorship assignments with "old hands" who have made many of the obvious mistakes but have not necessarily learned the needed answers. Urgently needed is a clearer definition of the ethical values which will shape professional decisions in the troubled days ahead.

Ethic of the Physician

Respect for the sanctity of human life is the underlying value of the medical ethic. The seriousness of the "life and death" responsibility has led society to attach a special aura to the physician. The patient turns over to him his pains and his fears. Even when, in fact, he can do little to help organic disease, the physician brings assurance by "laying on hands" (*2*).

In recent years, however, this psychological role has been diluted by the growing scientism of medicine. The doctor makes his quick rounds in the "sterile" atmosphere of the hospital ward and radiates confidence and authority, but patients complain of having lost personal contact with him. Psychologic and symptomatic support are no longer the only therapy provided while waiting for the crisis in lobar pneumonia—penicillin is infinitely more effective. While general medical practice continues to be concerned primarily with the individual, in specialty practice the focus has narrowed to an organ or physiologic system, and on the advancing frontiers of medical research the still narrower focus is on enzyme systems or the configuration of a nucleoprotein molecule. Even when recognized as essential, specialization is criticized because it fragments the doctor's view of the individual. This has led to the growing recognition in medical education of the need for a return to teaching about "the patient as a whole" (*3*).

These general comments about present trends in the professional image do not signify any real change in the basic values of physicians. Because research supplied more efficient methods dependent on expensive equipment, a shift occurred in the locus of medical care from the home to the office and hospital; but doctors know that they are doing a better job. There is an understandable lag in acceptance of this idea by the public. It is usually the older generation that reminisces about the family doctor who treated childhood illnesses with soda, encouragement, and faithful waiting at the bedside. Modern young mothers increasingly expect their children to be cared for in the shiny environment of preventive pediatrics.

The most encouraging development in the growing acceptance of preventive routines as an essential part of modern living is the willingness of a sophisticated public to pay for them. A preventive orientation in general medical practice requires better public understanding of disease causation. Scientific medicine traditionally has focused on the care of the sick, but as science has provided the understanding and methods, the goal has increasingly come to be fulfillment of the ancient aphorism, "The first responsibility of the physician is to prevent disease; if that be impossible, to treat illness; and if that be impossible, to relieve suffering."

Ethic of the Public Health Physician

The focus of public health is the community. The "patient" is a whole population unit. The shift in professional orientation and values which occurs as the unit of attention moves from the individual to the group must be clearly recognized and explicitly stated because it has led to many misunderstandings in the past. Practitioners of medicine have tended to regard public health officers as doctors who couldn't make good in the increasingly specialized atmosphere of modern medical practice, or who were not willing to work hard enough to meet the responsibilities of doctor-patient relationships. In contrast to the close and personal relationships developed with family physicians, the public has tended to be aware of health officers only when they were being blamed for an epidemic or a breakdown in health services. In fact, however, the values of public health workers tend to be particularly attuned to broad social problems and needs, and their work has growing relevance in modern society.

Recent psychological research supports the empiric observation that public health workers are basically different from medical practitioners or biomedical research specialists. In several studies of the process of professionalization, medical students and doctors, when asked their opinions of various career specialties, have described public health as attracting those who are altruistic rather than materialistic, interested in long-term goals rather than immediate rewards, and oriented toward security and social action rather than individualistic entrepreneurism (*4*). Nevertheless, most public health doctors feel some ambivalence as they give up the personal satisfactions to be experienced from concentrating on the needs of individuals in exchange for the intellectualized and less spontaneously satisfying feeling that they are contributing to the welfare of social groups.

Understanding community health needs requires the doctor to develop a new set of technical skills and tools (*5*). The pulse and temperature readings of a social group are a series of statistical measurements. Rates, such as those measuring births, deaths, infant mortality, and a variety of reportable conditions, become the routine operational indices of how the "patient" is progressing (*6*). The public health physician tries to find out how his "patient" feels by means of surveys and social feedback mechanisms. Such indices require a basic readjustment in thinking. A woman is either pregnant or not pregnant; a community is about 3 percent pregnant. A patient has or does not have heart disease within the limits of present methods of measurement; the community always has heart disease, though the rate may go up or down. The fact that these conditions are always present in the community facilitates ecological thinking about their causation. Their relation to several environmental and host factors may be studied. Disease is viewed not as being caused by a specific agent but as arising from shifting balances of multiple causes.

The setting of priorities becomes a primary obligation. Hard decisions must be made about whether to focus resources on expensive refinements of individual care or spread them out to benefit more people. The private practitioner is justified in squeezing the last drop of excellence out of scientific knowledge, technical skill, and complicated equipment to provide a small percentage of improvement in cure rates because individual patients are eager to pay for the best. When society is paying, there are so many different, urgent needs demanding attention that fine judgment is required to balance costs and benefits in social and economic terms (*7*).

This sort of cost-benefit analysis is repugnant to the values and ethic now inculcated into most medical graduates. One cannot function in public health without it. Increasingly, modern society will require all doctors to be aware of the implications. Any busy practitioner is, in fact, making such judgments all the time in daily decisions on how to invest his time. He is aware, as he stands at the bedside of an elderly patient unconscious in the terminal stages of malignancy, that in the next bed is an acutely ill young mother separated from a large family. His decision about where to spend a few extra minutes of concentrated attention is necessarily influenced by this cost-benefit judgment. He needs to learn to accommodate the troublesome guilt feelings that arise from inability to do everything for each patient. One of the reasons specialty practice is so attractive is that it permits concentration on high-quality care for a few, and thus evades some of this priority pressure. Some progressive medical schools (*8*) are giving

more attention to community medicine, partly in order to provide young doctors with a responsible framework for making decisions on the basis of the good of the community, rather than on the basis which has finally tended to control such decisions in the past—who can pay the most for the doctor's time?

Finally, public health physicians must view therapy in terms of social action. Many health problems grow out of poverty, ignorance, bad nutrition, poor housing, and other social ills. Action must be channeled toward cooperation with other forces in society which are trying to abolish the underlying causes of social pathology (*9*). This requires close collaboration with lawmakers and law-enforcers. As civil servants, most public health workers learn to use political action to produce changes in society. Cooperation with other disciplines involved in economic and educational improvement makes it necessary to learn their language and values.

Ethic of the International Health Physician

The trend in values that can be traced from clinical medicine to public health moves one step further in international health. Medicine has always been one of the most international of the professions. We have coined the word *ecumedicine* from Greek roots referring to the forces holding the world together. Mankind's universal concern with physical suffering has prompted widespread and rapid communication about the healing arts. Throughout history, physicians have freely crossed national boundaries, and, as they moved in response to remuneration from the wealthy, they shared knowledge and skills with local practitioners. One of the greatest strengths of scientific medicine, as contrasted with the relatively stagnant systems of indigenous medicine, has been this continuing exchange and sharing of information.

The first characteristic of the international health ethic, then, is the need to share information and skills with foreign colleagues in spite of the many cross-cultural problems of working with doctors from different national and educational backgrounds.

The origin of international health activities can be traced directly to the fact that disease crosses national boundaries even more readily than efforts to control it. The first organized effort in international health was the systematization of quarantine procedures (*10*). By the end of the 19th century a series of international congresses had developed uniform laws and regularized practices to provide barriers to the spread of epidemics without interfering excessively with the flow of trade. In the present century the reliance on quarantine barriers has shifted progressively to a realization that the spread of disease is best limited by attacking problems where they originate. The long research tradition of tropical medicine has contributed much to practical solutions. Control measures are directed first to isolating endemic sources and then to reducing these foci. In this effort major responsibility has been appropriately assumed by the World Health Organization as it was by its predecessor, the Health Division of the League of Nations.

Behind the long tradition of epidemic control is a somewhat selfish motive—that of protecting oneself by preventing illness in others. The more altruistic motive which the international health profession hopes to encourage is the realization that humanity's suffering is a world-wide responsibility. This attitude is typified by the philanthropic foundations, which made some of the most important early advances in international health. The statement in the deed founding the Rockefeller Foundation in 1913 is an idealized motto for international health workers (*11*): "To promote the well-being of mankind throughout the world." Religious missions have also been strongly influenced by this altruistic motivation.

The countries of the world vary greatly not only in the degree of health they have achieved but in their systems of achieving it, which range along a spectrum from highly individualistic to highly socialized patterns of medical care. Any program of assistance from the outside has a limiting factor which should be realistically recognized by both donor and recipient. However altruistic the intent, there is an uncontrollable tendency for the helping country or organization to draw the recipient country toward its own approach, organizational pattern, and values. Sometimes such a goal is an explicit and frankly stated reason for providing help. Even when protesting that he intends only to help the recipients along their chosen course of development, an international worker brings with him norms and deeply internalized patterns of behavior that necessarily influence the direction of his recommendations and work. Even in multinational agencies, individuals tend to continue to think and behave according to their distinctive cultural orientations. This should not lead to guilt feelings. Changes in national behavior depend on a general progressive milieu and often on major alterations in basic morality. Development cannot come without painful changes, especially in a traditional society. The tendency to influence, as well as to help, is dangerous only when ruthlessly or thoughtlessly imposed.

One of the first and most difficult lessons an international health worker must learn is to minimize his own feelings of alienation and to identify himsef with local goals and hopes. He must intellectually and emotionally accept the people he works with in order to be accepted by them. But he need not thereby sacrifice the opportunity to encourage a better way of life by his own daily example. He should consider and decide what can and should be changed by deliberate efforts to demonstrate better patterns of everyday living and working. When a development worker in an Indian village tried to settle too completely into the village way of life, the villagers commented to me that this was proof that improvement was hopeless for them. "If he can't do any better, what chance is there for us?" (*12*).

Even more than an ordinary public health specialist, the international health worker must be constantly aware of social factors. In some ways he has an advantage in coming from a different culture. Anthropologists long ago demonstrated that the most fundamental values are so deeply internalized that it is difficult for a member of a culture to identify those of his own values which control his willingness to innovate. Cross-cultural observation permits perspective and objectivity. Once cultural blocks to change have been identified, it usually takes the insight of someone brought up in the local culture to work out ways in which needed innovations can be introduced.

Health needs in developing countries are so massive and so acute that they quickly overwhelm the carefully nurtured doctrine that the doctor owes each individual patient his maximum attention. To this professional shock is added the cultural shock experienced by anyone exposed to extreme need for the first time. The most sensitive doc-

tors tend to be the most frustrated. A doctor who stays in international work turns in one of two directions in making peace with his conscience. He may choose to continue as a traditional medical practitioner, serving the needs of one town or village. A good doctor is soon swamped as emergency follows emergency. Thousands of medical missionaries have made contributions in their chosen localities as great as those of such international heroes as Schweitzer, Seagraves, and Dooley. Over years of such struggle with recurring problems, the perceptive practitioner often develops an acute sense of responsibility for community-wide preventive measures.

At the other pole is the job of the typical adviser in public health for an international agency. The early pioneers of the Rockefeller Foundation concentrated on mass needs and public health methods and had a profound effect on the health of much larger numbers of people than could be reached by individual practitioners. Members of colonial medical services tended to develop similar wide interests. It is this breadth of interest that characterizes the doctors who serve with the World Health Organization, the U.S. Agency for International Development, the Peace Corps, and other U.S. governmental agencies with international responsibilities.

The health adviser finds his time occupied with long-range planning committees and conferences, with memoranda and speeches, with working with local government officials to establish priorities, and all too often with the red tape entailed in getting supplies and personnel to the periphery of such activities as a malaria eradication program.

To function effectively as an international health adviser a research point of view is helpful, because many of the answers are not known. Needs are so obvious that the temptation is great to rush in with programs that seem reasonable; but international work is full of surprises. Each new activity needs to be carefully tested. Tropical disease research has typically developed scientists of the widest ecological orientation.

Perhaps the most difficult ethical adjustment for a doctor going into international health is to learn to think like an economist in coordinating health work with the total national effort in economic development. Serious misunderstandings and antagonisms have developed between health professionals and development economists. These are directly related to basic differences in their value systems. To a doctor, economists seem cold, impersonal, and ruthless as they calculatingly decide not to build hospitals or to postpone maternal and child health programs. To economists, doctors seem to be totally unrealistic in their eagerness to do everything possible for the present generation without concern for long-term trends and sequelae. Since development economists increasingly control the funds, international health workers must learn to communicate in terms they understand. Research is needed to demonstrate associations between health and development; but clearly, causal effects go both ways. The fall in death rates in England during the Industrial Revolution was more directly related to general economic development than to specific health programs (*13*). Any international health worker has been in situations where the construction of a bridge or a road would have improved the health of a community more than the building of a hospital. Cleanliness of homes, especially kitchens, tend to improve markedly after electricity lights up dark corners. On the other hand, some development projects have had notoriously bad effects on health. Irrigation projects, particularly, have caused epidemics of malaria and schistosomiasis which virtually neutralized economic benefits (*14*). Rapid urbanization and industrialization typically predispose to high rates of tuberculosis, affecting the most productive age groups in the population. Such consequences can be prevented only by close cooperation between all technical specialists and health workers.

Certainly "development" should encompass much more than per capita income. The ultimate objective is the well-being of people. Better health can bring clearly discernible qualitative differences in productivity, attitude to work, and willingness to change.

The main objection that development economists have to health programs grows out of the opinion that better health produces population growth and population growth neutralizes development achievements. There is much fuzzy thinking about this complicated subject, and considerable ethical malaise as health workers try to justify their work when it is blamed for the population problem.

Health programs bring with them the best prospects of lowering birth rates. Many developing countries are now placing high priority on national family planning programs under the direction of the health services. The experience of Ceylon is instructive (*15*). The postwar population surge resulted from a drop in the island's death rate from 20.3 in 1946 to 14.3 in 1947. This was at first attributed to malaria eradication. The facts show, however, that the death rate fell in both the nonmalarious and the malarious portions of the island. General postwar prosperity, with improved nutrition and general living conditions, appears to have been responsible for a large part of the reduction in mortality. The net effect of malaria eradication was to reduce population pressure by opening the underpopulated but potentially productive malarious two-thirds of the island to settlement. Now, as intensive family planning is being introduced in health centers, the birth rates are beginning to fall.

It is important to recognize that people will not practice birth control until they are convinced that death control will save their children (*16*). Families used to have six to eight children in order to raise three or four; half of all children died before reaching adulthood. It takes about a generation for parents to be convinced that their children will survive. In the meantime, parents will be most ready to learn family planning from the health workers who have gained their confidence by contributing to the survival of their children. As research demonstrates ways in which birth rates can be made as responsive to control as death rates, health programs which include family planning will become an increasingly important component of international aid.

Conclusion

These thoughts about an ethic of international health can be summarized in a very free revision of the Hippocratic Oath:

> I will share the science and art by precept, by demonstration, and by every mode of teaching with other physicians regardless of their national origin. I will try to help secure for the physicians in each country the esteem of their own people, and in collaborative work see that they get full credit.
>
> I will strive to eliminate sources of disease everywhere in the world and not merely set up barriers to the spread of disease to my own people.

I will work for understanding of the diverse causes of disease, including the social, economic, and environmental. I will promote the well-being of mankind in all its aspects, not merely the bodily, with sympathy and consideration for a people's culture and beliefs.

I will strive to prevent painful and untimely death, and also to help parents to achieve a family size conforming to their desires and to their ability to care for their children. In my concern with whole communities I will never forget the needs of its individual members.

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NEWS AND COMMENT

Bell Labs: Computers Loom Large In Both Research and Operations

In the nonage of the computer, the people with worthwhile problems didn't know how to use the machines, and the programmers didn't have worthwhile problems.

This intentional overstatement of the predicament of researchers in the recent past was made recently by a member of the Bell Telephone Laboratories technical staff and implies that a new phase has begun in computer usage.

Transition to the new phase has not been abrupt, but its effects are conspicuous in an enterprise like the Bell system because not only is the computer being used more and more extensively as a research tool, but telecommunications equipment is becoming more and more computer-like.

At Bell Labs in recent years, there has been a strong, general effort to increase the interaction of man and computer. The labs have also been a stronghold of information and communications theory, which is particularly relevant to telecommunications, data processing and control, and is also being regarded with increasing interest as an instrument useful in exploring human behavior.

The new era is marked principally by the sharp reduction in the amount of expertise, vis-a-vis the computer, required of the person who wants to use the machine and also by progress in ameliorating the so-called time-sharing problem.

Digital computers, which were first used as high-speed calculators, proved adaptable for handling research data. In business, they were widely used for such routine work as billing and payroll operations and for more complex tasks like handling airline reservations. In industry the computer has proved a versatile and highly reliable control instrument which makes feasible the "automated" factory.

Computers, therefore, tended to be used for three fairly distinct purposes—research, business, and control. Scientists used computers to perform complex operations on relatively small quantities of data. In business, the computers generally performed relatively simple operations on large quantities of data. The control computer operated in "real time" determined by the steps in the process it was controlling.

The next step was the fairly obvious one of designing computers which were sufficiently fast and flexible to handle different types of functions simultaneously.

Necessity prodded invention here, as military systems—particularly those concerned with air and missile defense—were required to handle a great variety and volume of data very fast. The performance of parallel tasks on one computer or more is called a time-shared system (TSS).

In a lucid article on time-shared computer systems in the technically middleweight house organ *Bell Laboratories Record* for February, N. K. Poole defines such a system as a "'hardware-software' package allowing many different users with different goals simultaneous access to the computing system. The TSS is not a military control system, nor is it a computer. It is actually a method, a means through which the computer may be shared, for implementing control of the military system and serving support needs. If the TSS is effective, every user will feel that he is in complete control of the computing system when he is using it."

A smoothly functioning time-shared system permits simultaneous access by a number of users and insures that their problems will not conflict. When a priority program—for example, an urgent tactical problem in a military system—demands increased time, less important programs must be curtailed or delayed according to a preestablished order.

The new generation of time-sharing computers serve their patrons better in two main ways—they are easier to use and afford quicker "turn-around time," which is the period between the