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# THE WILLIAM ALLAN MEMORIAL AWARD LECTURE

## A Place for Genetics in Health Education, and Vice Versa

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It is always the hope of geneticists to put discoveries of the laboratory to use in the affairs of human beings. Some expressions of these hopes have appeared in the recent literature in the form of genetic engineering, reproductive manipulation, germinal selection, and the like. These papers reflect the view that while most of these methods will not have wide application in the near future, their implied threat to present mores requires some public debate to determine what is, or might become, acceptable, before eager investigators give them a life and impetus of their own. These ideas have been advanced mainly by laboratory workers who, moved by a strong social orientation, are prepared to consider the biological manipulation of individuals as a means of improvement of the whole society. Physicians, in contrast, have greeted the new eugenics with suspicion or indifference, no doubt for many reasons, but salient among them is the fact that clinicians are seldom attentive to anything beyond an individual patient's immediate problems, and although the patient's family may be acknowledged as being in their purview, the whole society is not.

These dissimilar views on the social benefits of genetic knowledge may soon be moving toward reconciliation, mainly, I think, as a result of changes in medical thinking which emphasize the prevention of disease and the preservation of human biological and social equilibrium by means of an approach which is being called "health maintenance." There is evidence, some of which I shall show, that genetics is not being included in the formulation of the content and the means for furnishing this special kind of medical care, and it is in the remedy of this deficiency that a common ground can be found embracing both broad social aims and attention to the individual patient.

What is the means whereby this deficiency may be made up? I believe it not to be the new eugenics, which, in the remoteness of its application, is in any case of low immediate priority. In addition, while proposing the uses of genetics to improve genotypes, whether for individuals or for the whole species, it neglects to

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say how genetics can be used to improve the lot of genotypes already in existence. Nor will it be through further refinement of environmental manipulation (euphenics) to ameliorate the effects of harmful genes in persons already ill. Rather, it will come as a result of the discovery of the means to apply genetic knowledge universally and unselectively in the prevention of disease and the promotion of physical and emotional health.

In the fulfillment of this effort, we must find ways to minimize the adverse effects of some genes, some of which have been in the gene pool for a long time and will continue to be represented there, and to maximize the virtues of others which contribute adaptively, all in a rapidly changing environment.

Let me express the point another way. The net effect of civilization is greatly to increase the number of environments for which some genotypes will be unsuitable Thus it might be said that the industrial revolution, while freeing human beings to enjoy the benefits of a technological society, has engendered a host of new genetical defects. Further, the increase in industrial, occupational, and cultural complexity is accompanied by a proliferation of physical and behavioral demands which should ultimately reveal the full range of innate variability. I suppose we have not yet achieved that ultimate, but we have come a long way. For example, the 1970 U.S. Census lists upwards of 23,000 occupations [1]. This is about 2½ times those listed in 1910, and although it is an impressive number, it still falls short of actuality, since many job headings include minor variations calling for differences in skills or allowing for greater or lesser exposure to health hazards. An editorial in a recent issue of the *Journal of Occupational Medicine*, commenting on a newly described occupational disease, revealed that there are already nearly 3,000 such disorders—a number, incidentally, which compares favorably with the number of genetic variations listed in McKusick's catalogue [2, 3]. It would be interesting to know how many undiscovered overlaps already exist in the two lists, and even more so to know how many of the occupational disorders will be added, in their turn, to the genetical list.

If this concept were to be accepted by the medical profession, then an important dimension of health maintenance should consist of a genotypic description of each individual which should lead to some definition of his own adaptive and nonadaptive environments. This is not a particularly new idea, except insofar as it suggests rather precise refinements in the biological characterization of the attributes of roundness or squareness of pegs to be fitted into appropriate holes.

It might be questioned whether such a concept could be accepted by workers in the field of health, and 5 or more years ago it could not be, and was not, but the climate for it is much more favorable today, since medicine is undergoing a profound transformation in which acute and episodic medical care is giving way to prevention of disease and preservation and enhancement of health.

## MODERN VIEWS OF MEDICINE AND HEALTH

Sanitation, improved nutrition, rising living standards and medical care have reduced the incidence of acute illness and have lengthened life, but these boons

have brought in their train an increasing incidence of the chronic illnesses of adult life which are presumed to represent the results of particular circumstances, habits, and modes of living, the kinds of disorders whose "risk factors" can be enumerated as age, sex, race, weight, and habits—dietary, smoking, and the like [4, 5]. Treatments are—and probably will always be—palliative, expensive, and profligate in use of medical care facilities and personnel, so that the obvious and most effective means of control should be preventive. This approach so far is more conceptual than overt, since the multifactorial origins of these diseases are not understood, but it is inescapable that they are strongly genetically influenced and represent the constitutional susceptibilities or diatheses which Archibald Garrod wrote about in his book *Inborn Factors in Disease* and which he suggested were no less the result of biochemical individuality than the inborn errors [6].

The emergence of the chronic diseases represents a change in the quality of medical problems to be faced, but might not of itself have forced the changes in medicine which we are witnessing today. Of all the causes of these changes, perhaps the most potent is the idea that health is a right, open equally to all [7]. This has produced a rising public expectation that scientific advances should be used, not only to treat disease, but to prevent it and to provide those social goods which, in addition to medical care, are necessary to promote and to achieve good health. So medicine is acquiring a pervasive social character in which the traditional physician in his one-to-one relationship with each patient is being augmented by instruments which preside over health, consisting of agencies and people with diverse skills who "deliver" a variety of elements of "medical care" and of "health maintenance." This means a greatly enhanced role for the practitioners of a wide range of special disciplines including: public health, occupational health, social health, health education, health behavior, and sociology and social work, as well as others whose activities are subsumed under such headings as medical care design, hospital administration, and the like, and whose business is the logistics of medicine.

It was pointed out in the Millis report that the need for physicians with these diverse skills strains the educational capacities of medical schools accustomed to graduating physicians all trained to do the same things; the system produces uniformity in the face of a need for variety [7]. Medical schools have moved to fill this deficiency in both educational and research functions by the creation of new departments variously titled: community health, community medicine, social medicine, family practice, family medicine, preventive medicine, and medical care [8–10]. In fact, of 104 medical schools in full operation and listed in the 1973 Association of American Medical Colleges directory, 78, or about three-fourths, have departments listed under one or other of these names [11].

Among the concerns of these new departments is research into new ways to organize and provide medical care. One, among other outcomes of these investigations, is the Health Maintenance Organization (HMO) [12], which is a new name for prepaid group practice plans. "It is a system designed to bring health manpower, facilities, and consumers together into more effective relationships for

meeting health care needs efficiently and in a manner convenient to provider and consumer. It places emphasis upon preventive services" [13]. The theme here is an efficient working relationship between the purveyor and the recipient of services intended to promote health. The emphasis on the recipient in something other than a passive role is both new and important.

Thus, there are major conceptual changes taking place in which programs for health are to be made available for all without identifying particular individuals and in which the practitioner is no longer simply to wait in his office for the sick patient to present himself. These trends make it likely that future physicians will be more concerned with the impact of civilization on the health of their patients, the hazards of commercial products, and the adverse effects of industry on the environment. In short, the time seems to be coming when doctors, traditionally the most conservative and parochial of people, may become advocates for health [14, 15].

## GENETICS AND THE NEW MEDICINE

The geneticist will immediately see breathtaking opportunities in the new medicine. The ideas of prevention of disease and promotion of good health are implicit in the predictive function of genetics and have been explicitly stated, at least since the 1930s [16]. Indeed, the point was clearly made by T. H. Morgan in his Nobel Prize address in 1935 [17]. In those early days, the predictions had to stand alone for lack of empirical data to attest to their accuracy. Now, however, we have some clues in the rapidly growing sum of evidences of the extent of human genetical variability in health and disease [18]. Harris has given us some idea of the extent of polymorphism, and the association with diseases of alleles of the HL-A and $\alpha_1$-antitrypsin systems suggests that mutants of the hemoglobin and G6PD loci may not be the only polymorphic genes associated with disease [19, 20]. Indeed, since the polymorphic alleles are the sources of the common human differences, they must contribute strongly to the susceptibilities which underlie the common chronic disorders now receiving so much medical attention.

As for more direct and obvious genic and chromosomal causes of human disease, the literature abounds in testimony to the proliferation of that knowledge, testimony derived largely from representatives of this society and familiar to all its members. The application of this knowledge to the traditional care of sick patients need not concern us here. The question I would like to examine is, To what extent does genetics permeate the thinking and behavior of the participants of the transactions of health maintenance? If genetics is to play much of a part, it will be because its pertinence is recognized by professionals and public alike.

## MEDICAL PRACTICE

No one would argue that genetics has not become integrated into medical education and standard medical practice. No less than 19 American medical schools have departments of genetics or committees which fulfill that function [11]. Twenty-eight more have officially designated divisions of genetics and 80%

list required or elective courses in their catalogues. Respectable treatment is accorded genetics in text books, at least of medicine and pediatrics, and genetics clinics are to be found in most, if not all, teaching hospitals. In addition, the research and clinical journals give ample space to papers on genetical subjects (table 1).

TABLE 1

MEDICAL AND PEDIATRIC JOURNALS OFFER AMPLE SPACE FOR PAPERS ON GENETICS

| Journal | No. Papers Published 1968–1972 | | |
|---|---|---|---|
| | Total | Genetic | % Genetic |
| *J Clin Invest* | 1,422 | 179 | 12.59 |
| *Am J Med* | 959 | 119 | 12.41 |
| *Pediatrics* | 1,145 | 189 | 16.51 |
| *J Pediatr* | 1,499 | 372 | 25.67 |
| Total | 5,025 | 859 | 17.09 |

While this is gratifying evidence that genetics is not neglected, scrutiny of the titles and content of these papers produces the realization that only a minority of them deal with the distribution and frequencies of the genes in populations or with the characteristics of the gene pool of which the qualities of populations are a reflection. That is, a majority of the articles in the clinical literature deal with genes and abnormal chromosomes as a cause of disease in specific persons and with their treatment and care. These publications are in the traditional medical vein of description and management of disease and generally ignore population genetics. And yet the appositeness of population genetics to the new social-community-preventive medicine is obvious.

Obvious, but ignored. I have found only the most glancing references to genetics in the literature of these new disciplines [8, 9]. For example, *Scientific American* devoted a whole number to "Life and Death and Medicine" with little mention of genetics, while a symposium on community medicine and heart disease, listing 12 papers which appeared in the *Bulletin of the New York Academy of Medicine*, essentially ignored genetics, despite the obvious relationship of the hereditary disorders of lipids with some cases of myocardial infarction and the hereditary factors in the genesis of hypertension [22, 23]. A series of 19 articles on Health Maintenance Organizations published in the *Journal of Medical Education* was altogether innocent of any recognition of the connection of population genetics and preventive medicine [24].

Turning now to the literature of other medical and health-related fields, one finds almost no attention to genetics. This is substantiated by looking at the titles of the papers which filled a number of journals during the period 1968–1972. If the title was ambiguous or unrevealing, the paper was scanned until I was

satisfied it did or did not contain some genetical content. I am aware that journals cannot reflect precisely the most current ideas, but they must contain the prevailing opinions and views of their constituents (table 2).

TABLE 2

JOURNALS IN SEVERAL MEDICAL AND ALLIED FIELDS PUBLISH ONLY OCCASIONAL ARTICLES WITH GENETIC CONTENT, OR NONE AT ALL

| JOURNAL | NO. PAPERS PUBLISHED 1968–1972 | | |
|---|---|---|---|
| | Total | Genetic | % Genetic |
| *Am J Public Health* | 981 | 12 | 1.22 |
| *Health Serv Rep* | 649 | 8 | 1.23 |
| *Br J Prev Soc Med* | 198 | 6 | 3.03 |
| *Am J Epidemiol* | 616 | 11 | 1.79 |
| *Med Care* | 235 | 0 | 0.00 |
| *Arch Environ Health* | 957 | 23 | 2.40 |
| *J Occup Med* | 452 | 4 | 0.88 |
| *Ann Occup Hyg* | 173 | 1 | 0.58 |
| *Br J Ind Med* | 255 | 2 | 0.78 |
| *Ind Med Surg* | 342 | 3 | 0.87 |
| *Am Ind Hyg Assoc J* | 499 | 1 | 0.20 |
| *Soc Sci Med* | 275 | 1 | 0.36 |
| *J Health Soc Behav* | 175 | 0 | 0.00 |
| *Soc Casework* | 273 | 1 | 0.37 |
| *Br J Sociol* | 158 | 0 | 0.00 |
| *Am J Sociol* | 225 | 1 | 0.44 |
| *Am Sociol Rev* | 231 | 0 | 0.00 |
| *J Sch Health* | 481 | 6 | 1.25 |

In the public health journals there were a number of papers on the adverse effects of radiation, but little about screening, antenatal diagnosis, or counseling. The journals of environmental and occupational medicine contained even fewer genetical works, despite many reports of exposure to almost numberless agents of just the sort the geneticist might expect to be hazardous to some and not to others. The sociological journals, whether medical or not, contained almost no genetical papers, despite the social problems raised by screening, antenatal diagnosis, and counseling. Finally, although the *Journal of School Health* seemed preoccupied mainly with drugs and smoking and with programs of education for health, there were two enlightening papers outlining the value of some knowledge of genetics in preventive medicine and in promoting good health. So it is apparent that little attention to genetics is paid by proponents of community-family-preventive medicine or by investigators in public health, occupational and industrial medicine, school health, and medical sociology, and yet these fields must be the portals through which population genetics would most naturally be introduced and the natural ways in which the social aims of genetics would be realized.

What this seems to mean is that people concerned with the effects of the

environment on health, with the prevention of overt disease and the maintenance and enhancement of health, do their work with only occasional reference to possible genetical origins of the differences between the people they serve, or to the chance that these genetical differences might be critical for the appropriate disposition of specific individuals. Preventive measures are of little use to nonsusceptible persons, while to discover those who are liable to the injury to be prevented is to make sure that they are not exposed at all. To omit to take innate propensities into account in preventive medicine is to make rules which in presuming to suit all may suit none, or which at the least impose unnecessary constraints upon nonsusceptible persons.

## EDUCATION IN GENETICS FOR PHYSICIANS AND THE PUBLIC

The lack of reference to genetics in the journals reviewed is surely a reflection of a deficiency of convincing empirical evidence and a lack of practical experience with genetical characteristics and diseases. But these journals carry reports of the research done in these fields and the lack of articles of a theoretical or pioneering nature suggests that physicians in preventive medicine, public health, and environmental medicine do not think genetically. If so, we may ask whether population genetics, as it is currently being taught in medical schools, will fill this gap. Further, if one believes that genetics is essential for the successful outcome of the new medicine, then one must ask whether its beneficiaries, the patients, will have the foundation of knowledge required to allow them that participation so often proclaimed as one of its pillars.

### *Medical Teaching*

Population genetics is always accorded a place in the course on human genetics given in medical schools and it is usually given, as indeed it must be, a strongly mathematical treatment. On the other hand, insufficient attention is often paid to its meaning to patients and medical practice. This is partly due to a lack of those empirical data which illuminate a mathematical argument for the nonmathematician, and partly because genetics in medical schools is grouped among the preclinical sciences. The course is usually given in the first year, and those schools whose emphasis on genetics is attested by required courses, departments, and divisions turn out to be the same ones whose faculties engage in and stress research, while those whose emphasis is on patient care and whose avowed purpose is to produce practitioners tend to accord genetics a lukewarm reception or to ignore it [25]. Further, there is a strong negative correlation in medical schools between the possession of departments and divisions of genetics and departments of community and preventive medicine [25]. All this means that population genetics is given little or no attention in some schools, and in those places where its value is acknowledged, its concepts are given little reinforcement in the clinical years.

*The Public*

I know of no comprehensive study of the extent of the public's knowledge, or even awareness, of genetics; it would be a study of much interest and use. A few papers have appeared, however, mainly during the past 2 years, which suggest that many people are ignorant of genetics and that there are problems of grasp, even when the lesson appropriate for their particular disorder is given them [26–33]. The results presented in these papers, embracing phenylketonuria, cystic fibrosis, mongolism, congenital heart disease, hemophilia, sickle cell disease, Werdnig-Hoffman's disease, and others, may be telling us that a significant part of the difficulty these parents had in receiving and remembering what they were told consists of an inadequate foundation on which to impose a coherent account of the disease and its pattern of inheritance. Favoring this view is the significant relationship between intelligence and previous educational attainment and the ability to grasp and to remember genetic knowledge, including probabilities [33, 34]. On the other hand, the papers also suggest that the facts may not be received at all, may be misinterpreted, or may be ignored, depending upon a person's perception of the relationship of those facts to himself and to his life. Thus, there appear to be two levels of knowledge which a human being requires to deal rationally with genetics. Both are necessary, but neither alone is sufficient for rational judgment and decision. This is borne out in the large literature on patients' compliance with doctors' directions [35, 36]. These studies, mainly testing conformity with instructions to take drugs by patients with all degrees of illness, showed that on the average about one-third of the patients paid little heed to the doctor's orders, and this figure rose in some reports to as much as 85%. Again, these studies give evidence that while nothing can be done unless the facts are clearly grasped, beyond this some insight and psychological engagement on the part of both doctor and patient are also required.

Education in genetics for the general public appears to be scanty. Several foundations, the American Medical Association, and other medical organizations furnish pamphlets, articles, films, and other material including television spots, often in conjunction with fund raising. Disease-related foundations also supply educational help to the victims or families of patients with genetic diseases.

The mass media, taking their educational responsibilities lightly, publish articles on genetic disease or counseling, some of which are good, while some, for example "The Obsolescent Mother" which appeared in the *Atlantic*, are only sensational [37]. To see what the affluent middle-brow who reads *Time* magazine would learn, I looked at the articles which appeared under the headings "Medicine" and "Science" during the 4 years, 1969–1972 [38], table 3. Under "Medicine" there were 303 articles, of which 12 were genetical in content, while of 272 articles labeled "Science," there were six. With the possible exception of an article entitled "The New Genetics, Man into Superman," and one which engenders the illusion of an effective treatment of sickle cell anemia, none of the articles is of itself un-

TABLE 3

SUBJECTS OF ARTICLES WHICH APPEARED IN *Time* MAGAZINE UNDER THE HEADINGS MEDICINE AND SCIENCE, 1969–1972

| Medicine | Science |
|---|---|
| Thymic Transplantation | Cattle Breeding |
| Mental Retardation | Transformation of Gal− Cells by Virus |
| Spinal Cerebellar Degeneration | Khorana's Synthetic Gene |
| "The New Genetics: Man into Superman" | Reverse Transcriptase |
| Tay-Sachs Screening | Electron Microscopy of DNA |
| Treatment of Sickle Cell Anemia | Isolation of Lac Operon |
| Dermatoglyphics | |
| Porphyria in the British Royal Family | |
| Transplantation Rejection | |
| Hexosaminidase A Deficiency | |
| Amniocentesis and Antenatal Diagnosis | |
| Nobel Prize Winners for 1969 | |

worthy, but the rarity of the diseases and the recondite nature of the molecular biology which supply their content cause me to wonder in what context the reader is able to view them and to comprehend them.

*Genetics in Primary and Secondary Schools*

Subsequent generations will be much more knowledgeable in genetics than present ones, due to the transformation of the teaching of science in primary and secondary schools, said to be a consequence of the space rivalry with the Soviet Union. Even a superficial review of science teaching in schools reveals a very encouraging acceptance of science as the equal of more traditional subjects and the availability of thoughtful and well constructed courses which begin in the kindergarten and are sustained through twelfth grade. Genetics is given a place of prominence here and the universal application of its principles is given appropriate emphasis [39–44]. Furthermore, scientific principles are seen to be within the grasp of all but a few school children.

There seems to me to be only one failing in this and that is one of omission. That is, the anatomy, physiology, and development of man is given relatively little space, especially in the elementary school texts, and when it does appear it is often out of context and rather diffidently or awkwardly treated, or sometimes it is offered in the form of health-related homilies about washing hands, or having immunizations, the kinds of things the teacher may regard as hygiene (table 4).

It must be acknowledged that separate courses in human biology are given in some schools, and that many imaginative teachers augment and enliven the standard texts, but it must be a rare child in our schools who is given a coherent idea of his own origins, or of how his body works, what he may expect of it, and how he differs from other people.

Some attempt is made to fill the need by efforts to teach the meaning of good health and how to attain and keep it; but although the School Health Education

TABLE 4

SCIENCE TEXTS FOR ELEMENTARY SCHOOL STUDENTS DO NOT EXPOSE CHILDREN TO MUCH HUMAN BIOLOGY

| TITLE AND PUBLISHER | No. VOLUMES EXAMINED | No. PAGES | | |
|---|---|---|---|---|
| | | Total | Human Biology | % Human Biology |
| *Concepts in Science,* Harcourt Brace | 6 | 1,723 | 78 | 4.5 |
| *Science,* Silver, Burdett | 6 | 1,315 | 120 | 9.1 |
| *World of Science,* Bobbs-Merrill | 6 | 1,488 | 93 | 6.3 |
| *Science for Tomorrow's World,* Macmillan* | 5 | 1,246 | 253 | 20.3 |
| *Science for You,* Ginn | 5 | 1,081 | 30 | 2.8 |
| *Basic Science Program,* Scott-Foresman | 6 | 1,183 | 43 | 3.6 |
| Total | 34 | 8,036 | 617 | 7.7 |

* Dr. Benjamin Spock was a member of the editorial board.

Study group is making a strong and positive effort to update and otherwise improve this field by designing courses to be given from kindergarten through twelfth grade, and other educators agitate for time and teachers, school health education still too often remains in the reluctant hands of departments of physical education who give instruction in hygiene, nutrition, posture, and reproduction, as well as the evils of smoking, drugs, and venereal infections [45–47].

To summarize, while public education in biology and genetics is incomparably better than only a few years ago, the enlightened participation of the mass of people in preventive programs for health seems still to require that the teaching in school be more specifically oriented to providing that basis upon which specific details of knowledge of disease and health may be later imposed.

## WHAT IS TO BE DONE?

If these deficiencies really matter, they will be made up in time, motivated by the exigencies of preventive medical care, but such a result could only come piecemeal and without coherence. An alternative might be an attack on several fronts at once, with the aim of weaving genetics into the conceptual fabric of health maintenance for physicians and patients alike.

### *Teaching Population Genetics*

The first question is where in medical schools to teach "practical" population genetics and in what context.

The obvious setting is those very departments of preventive medicine, community health, and family practice which, as we have seen, lack knowledge or even much awareness of genetics. The preoccupation with the effects of environmental influences on human health, their concern with prevention of disease and the preservation of health, their interest in developing affinities with the objects of

medical care, namely, people, families, and other community elements, their knowledge of the economics and logistics of medicine and their use of epidemiological methods in research all conspire to suit them for this responsibility.

A convincing medical context appears to be emerging in the discovery of the extent of human polymorphism, and the relationship of polymorphic alleles to disease, as well as in the growth of programs for screening for genetical disorders with the intention to institute treatment or to give advice about preventive options. As these practices increase, the connection between the distributions and frequencies of genes and diseases will become the focus of much more medical interest.

The next question is how to put the cause of population genetics before its potential teachers, as well as other physicians engaged in public health, occupational and industrial medicine, and the like. We may be sure that it cannot be done by talks such as this one, by preaching to the converted, or by publications which appear in the genetics literature. We shall have to find ways to carry the message to those places where it will have the most effect. The sociologists tell us that an innovation is most rapidly disseminated if it can be brought to the attention of, and is taken up by, the opinion leaders of the field in question [48–50]. Opinion leaders are those weighty members of the Establishment whose views are heeded by lesser folk. They are generally conservative, opinionated, and slow to change, but they represent and mold prevailing opinion, and if they accept a new idea, it is likely soon to become the standard view. Who are the relevant opinion leaders and how can they be influenced? They are the professors and chairmen of departments of community health, family medicine, and so on; directors of the large prepaid medical groups, such as Kaiser-Permanente; deans of medical schools and schools of public health; state and city public health officials; and the money men at the National Institutes of Health and private foundations, including the disease-oriented foundations. How can they be approached? Directly, by members of this society in their roles as faculty or as members of national societies and advisory bodies, whether to the National Institutes of Health or other organizations; by appropriately placed reviews, articles, or editorials, especially in the journals read by those to be influenced; by offering fellowships in genetics to people with degrees in epidemiology or public health; and possibly in the meetings of this society. For example, the American Society of Human Genetics might sponsor a meeting on some aspects of the applications of population genetics to, say, preventive medicine, possibly in conjunction with its annual gathering, with participants to be invited from among the "opinion leaders" to be influenced, as well as from the society. The proponents of preventive medicine and health maintenance would give us their thoughts and we would give them ours. Whatever ways are tried, they will be successful in the degree to which members of the human genetics establishment see the continuing education of our colleagues as part of our work.

As a second priority among medical educators to influence, I suggest the movers and shakers of the new schools of allied health sciences. These schools

will have strong effects on the personnel who will man the Health Maintenance Organizations and comprehensive care clinics, people who will occupy a primary position as educators and counselors to the public in preventive medicine and health behavior. I have no data on the place of genetics in the minds and programs of the developers and functionaries of these schools; it bears looking into, but experience suggests it will be neglected.

*The Public*

As for the adult public, the job is a difficult one and expectations should be trimmed to fit possibilities. Education designed to change lifelong habits is notoriously difficult and depressingly often unsuccessful. Because of this, and in response to the increasing complexity of the medical scene, new kinds of efforts are being made to help people learn the significance to them of medical care.

Health education is relatively new. One it consisted merely of handing out pamphlets in outpatient departments and in exhibiting posters and charts. Then someone noticed that these measures fell short of desirable achievement and began to investigate what might be required to persuade people voluntarily to do things which maintain and enhance their own health. To this end it has been necessary to use the methods of the behavioral and social sciences, and investigators of health education and behavior tend to have those viewpoints.

One result is the recognition of differences in behavior of patients in sickness and in health [51–53]. A patient who perceives himself to be sick may be willing to surrender himself to the care of his doctor, but a healthy person requires to be convinced of the usefulness of preventive measures and usually must himself take active steps to obtain them. He is likely to do so if he perceives the seriousness of the condition to be prevented, and recognizes his own susceptibility. He will not do so if these perceptions are beclouded by lack of knowledge or other barriers to action. Further, it is a well-known human failing to neglect to act, even on rational grounds, without some sharply focused, sometimes painful, impulse.

All this sounds so self-evident. In the instance of genetical diseases, one has only to tell the potential screenee or counselee that the condition they face is a bad one, that they have a specific susceptibility, and that particular steps will lead to prevention, or that they now have the wherewithal to make a sensible reproductive decision. But we all know it is not so simple, and I suggest that it is in the discovery of the many reasons why it is not simple that the viewpoint and methods of health educators may be of help to the geneticist. As it happens, the papers of workers in health education and behavior reveal no recognition of genetical problems, but the record of research by geneticists into the successes and failures of counseling, screening, and antenatal diagnosis is also poor in references to the experts in health education. Some collaboration, on the other hand, could not fail to help in studies of the impact of educational efforts to apprise the public of the use and availability of preventive services, of the barriers which inhibit some people from accepting them, and of the cues which trigger the actions of those who do. Such investigations are essential, since the success of a preventive

effort is measured directly by the proportion of the population at risk who avail themselves of it. Probably no preventive program should be undertaken without such validating studies as an integral part of the service.

As the results of this research accumulate, they may suggest the factual content and the context in which to present it which will lead to successful education for adults in genetics.

For children, we have seen that science teaching has entered a period of fruitful and diverse proliferation. It remains to capitalize on that impetus, and in doing so, some organized medical and genetics institutions ought to play a leading part.

I say medical institutions here, not for any parochial reason. Indeed, medical professionalism may be one of the factors which has inhibited the teaching of human biology in the past. But medical schools are the only schools of human biology, and short of sweeping structural changes in institutions of higher learning, they will continue to be, and as such must accept some responsibility for the design and organization of teaching in human biology. Since in the past clinicians have shown neither awareness of duty nor aptitude for this work, they are unlikely to do so now. Perhaps this is another job for the schools of allied health sciences, who might organize medical school resources, as well as their own, to design new courses in human biology for primary and secondary school students, and undertake to teach the teachers as well. Other possibilities are those universities which have brought together faculty from medicine and biology to form programs and give degrees in human biology. A possible career for a doctoral product of such programs might be in research in human biology education for school children. Others who might become engaged, especially in teaching genetics, perhaps in the schools of allied health sciences, are the graduates of the schools of genetic counseling, for example those at Sarah Lawrence and Rutgers.

There is precedent for involvement of university faculty in lower school teaching. The International Clearinghouse on Science and Mathematics Curricular Developments lists experiments in curriculum design for elementary and secondary schools from all over the world [54]. There are 111 science projects listed in the United States, of which about two-thirds are entirely or mainly biological, and a further 33 in mathematics. These courses are the work of thoughtful and inventive educators, mainly members of university departments of biology, chemistry, physics, and mathematics, who were given financial support by the American Association for the Advancement of Science, the National Science Foundation, the U.S. Office of Education, and others. These scientists were motivated by their recognition of the inadequacy of science teaching, first in secondary school, then all the way down to the kindergarten. Why should medical faculty do any less?

Whatever is done, whether in conformity with these suggestions or with others, there must be some degree of reorientation in the approach to science teaching in schools. As it is, except in those instances in which the teachers are unusually perceptive and original, the teaching of science, including biology—and possibly above all genetics with its emphasis on probability—cultivates too little aware-

ness of its social significance. The teaching is disciplinary and can be quickly learned and as quickly forgotten. This discrepancy between the discipline-oriented teaching received in school and the mission-oriented activities of contemporary and later life creates that sense of dissonance in the minds of some students which leads to cries for "relevance" or engenders apathy [55]. It is this mission-oriented ingredient which the medical school can and should inject into teaching of human biology and genetics in schools. If the people are truly to participate with physicians in the preservation and enhancement of their health, rather than supinely to accept the doctor's orders or irrationally to reject them, a sense of this responsibility and the knowledge to execute it must be cultivated from early childhood. This cannot be accomplished if school is perceived by children to be unconnected with living, or if courses in education about health are perceived to be unrelated to those in biology.

## CONCLUSION

Francis Galton is known as the inventor of the idea that selective breeding would bring worthwhile social benefits. It is little known, however, that he was not in favor of beginning on such a course until its wisdom could be shown. He said: "When the desired fullness of information shall have been acquired, then, and not till then, will be the fit moment to proclaim a holy war against customs and prejudices that impair the physical and moral qualities of our race" [56]. Most of us would agree that we have not the "desired fullness of information," and I doubt we ever will, but the path of evolution medicine has taken offers genetics a favorable context in which to develop an approach to a different galtonian end; to wit, the means to help people to make capital of genetical advantages and to skirt the genetical traps which lurk in their own chromosomes. This requires no less public collaboration than other preventive medical measures, and no less knowledge, together with the understanding to use it wisely. To this end, medical geneticists must help to educate both their medical colleagues and the public, hoping to build in the latter some structural skeleton of information to which the details of particular medical and genetical circumstances could be applied in easy comprehension. One wonders why we are so late in doing so, why the biology of man has not been a primary object of education. The causes of this omission would make an absorbing study which has apparently not been done, but whatever they are, the lack has not gone unnoticed, having been remarked, for example, by Thomas Huxley, who in many papers returned again and again to the point. I will give only one example. It is taken from an essay entitled "On Elementary Instruction in Physiology" published in 1877, 96 years ago [57]. It reads: "It is, I think, eminently desirable that the hygienist and the physician should find something in the public mind to which they can appeal; some little stock of universally acknowledged truths, which may serve as a foundation for their warnings, and predispose towards an intelligent obedience to their recommendations."

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