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FROM WHENCE THE NEXT GENERATION?*

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First I wish to thank Bob Shope for his kind introduction and all members of the Society for the privilege of serving as President and for the opportunity to address you.

In choosing a topic for this address, I, like my predecessors, was faced with two possibilities—one to discuss a specific scientific field related to my own research career and interests or instead, to consider a broader topic of interest to members of the Society.

In effect, the decision was made for me by the Charles Franklin Craig Lecture Committee and by the Craig lecturer of this year, Roy Chamberlain. First the Committee picked Roy and then Roy picked his topic—"Arboviruses—Then and Now." This sequence of events in effect selected my topic.

As you all know, there is a common saying that if one dose of medicine is good, two are better; but we know that that assumption is usually false. In fact, a double dose can produce toxicity and disease. This is especially true for arboviruses since many of them are dangerous to work with and must be contained in adequate laboratory facilities. Therefore, as a member of the Subcommittee on Arbovirus Laboratory Safety, I had to recommend to myself that topics on arbovirology be contained with respect to the formal addresses at this meeting, and be left in the able hands of Roy Chamberlain.

Thus I sought another facet of the Society's concern and of my experience that needs emphasis in today's world and that might interest you. This led me to the subject of this address—namely—"From Whence the Next Generation?"

Now I suspect that some of you are wondering "The next generation of what?" Is he planning to discuss encephalitis viruses, mosquitoes, or even God forbid, amplifying hosts—whatever they are? Have no fears! As I mentioned above, I discarded an arbovirus topic early since Roy has that ball in hand.

Another topic might have been the "Next Generation of Tropical Diseases." Indeed speculation about the kinds of tropical diseases both old—the ones we now recognize—and new—those that will appear, as have Lassa and Ebola fevers in recent years—would be an enjoyable excursion into the future. My problem, however, was where to find the equipment for the trip—namely a crystal ball.

Perhaps there are other "From whence the next generation of what" that some of you may be thinking of. If so remember it—you may need it for a presidential address in the future.

My choice for "From Whence the Next Generation?" concerns people—specifically biomedical scientists.

I shall not propose that the human brain will change qualitatively or quantitatively within the next generation. The minds of our generation are like those of our parents!

Rather, I am worried about the source of the next generation of people who will teach and investigate biomedical science and—in relation to our Society—tropical medicine.

Thus "From Whence the Next Generation of Biomedical Scientists" is the topic upon which I would like to focus your attention during the next few minutes. And I shall begin by considering as an example, one group of biomedical scientists—namely physician-scientists. Later I shall broaden considerations to all biomedical scientists.

Let's start with a proposal or theory and then examine the evidence to support it.

Together with many other persons, I contend that if the present situation in the United States of America continues—and I believe that other countries are in similar situations—there will be so few physicians in basic biomedical science teaching and research that one will have to use a high-powered lens—attached to a computer—to find them. As a long-time member of medical school faculties, I can personally attest to the acute shortage of physicians entering basic biomedical sciences—not only as career decisions,

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TABLE 1

*Numbers of NIH-supported physicians in training for medical research in the U.S.A. from 1968 to 1980**

Trainees	1968	1974	1980
Total	4,178	3,988 (≤1%)†	2,367 (43%)
New	2,059	1,797 (13%)	972 (53%)

* From Bickel et al.[1]
† Figures in parentheses = percent decrease from 1968.

TABLE 3

*Numbers and percent distribution of full-time medical school faculties in the U.S.A., 1978**

Academic departments	Physicians	Other doctorates
Basic	2,449 (24%)	6,610 (64%)
Clinical	21,433 (75%)	3,859 (14%)

* Personal communication by T. meikle from Association of American Medical Colleges data. Unaccounted percentages to make 100% represent combined degrees or nondoctoral degrees.

but even as temporary trials to taste life there. But my impressions are not the only evidence of a deficit in the supply of physician scientists.

In May 1981, a group at the Association of American Medical Colleges published the following sad facts. Between 1968 and 1980 the numbers of physicians in training for medical research in the U.S.A., either as post-doctoral research fellows or medical scientist trainees supported by the National Institutes of Health (NIH), fell from about 4,100 to 2,300 in training each year (Table 1).[1] During the same time period, the numbers of physicians *entering* post-doctoral research training supported by the NIH decreased from about 2,000 to 900 per year. These represent 43% and 53% decreases, respectively. Furthermore, the major portions of these decreases occurred during the last 6 years, between 1974 and 1980. Although some physicians receive training support from sources other than the NIH, these NIH numbers represent more than a majority of physician-trainees in the U.S.A. and clearly reflect universal trends.

The national need for physicians trained in research has been estimated by the National Research Council and the Association of American Medical Colleges. Although the estimates rest on several assumptions, both groups concluded that about 1,800 new physicians entering research training per year are needed to meet national requirements of the future.[2,3] Thus current production is below needs.

The percentage changes in full-time medical school faculties between 1968 and 1978 were negative for physician-faculty and positive for faculty with other doctorate backgrounds (Table 2). The negative trend for physician-faculty was greater in the basic academic departments (−4.9%) than in clinical departments (−0.7%). But please note that it was a negative trend even in clinical departments.

These trends resulted in the following distributions of physician-faculty and other doctorate-faculty in medical schools in 1978 (Table 3). Basic academic departments had about 2,400 physician-faculty and 6,600 other doctorate-faculty, or a 24–64% relationship. Clinical departments had about 21,000 and 3,800 or a 75–14% ratio.

Another dismaying trend that we must recognize and remedy is that in the eyes of medical students, and thus the physicians of the future—"research is losing its sex appeal." In 1963, 49% of Harvard medical students assigned a high priority to research, but only 2% did so in 1976 (Table 4).[4,5] Throughout the United States, 39% of medical students in 1960 stated that research would be a component of their careers but only one-half of that percentage (20%) so stated in 1979 (Table 5).[5,6] Between 1968 and 1975, the numbers of American physicians reporting research as their primary activity declined from about 15,000 to 8,000.[7]

In recent years, clinicians have vigorously fo-

TABLE 2

*Percent change in full-time medical school faculties in the U.S.A. between 1968 and 1978**

Academic departments	Physicians	Other doctorates
Basic	−4.9	+7.5
Clinical	−0.7	+2.0

* Personal communication by T. Meikle from Association of American Medical Colleges data.

TABLE 4

*Percentage of Harvard medical students assigning a high priority to research**

Year	%
1963	49
1976	2

* Funkenstein, D.H.[4] From Shires.[5]

cused on these trends in clinical departments. Perhaps this was best epitomized by the title of an article written by Dr. Wyngaarden in 1979. His title was "The Clinical Investigator as an Endangered Species."[7] His major concern was physician-investigators in clinical departments of medical schools. My concern here is not only with that group of biomedical scientists but with physician-biomedical scientists in basic science departments of medical schools.

The causes and consequences of the decline in numbers of physicians in training for research careers have been well presented by others.[1–3,7–9] Dr. Wyngaarden notes that the reasons for the decline in research interests among young physicians are complex, and he lists five contributing factors.[7]

1) Greater emphasis on medical care as a societal need and thus as a career goal of medical students.

2) Instability of Federal support of biomedical research and training which leads to prospects of insecurity for medical students and residents considering research careers.

3) The deletion of laboratory teaching in many of the basic science courses in medical schools, which results in the production of many physicians who have never had an opportunity to experience the excitement of a laboratory. Moreover, this educational void is no longer corrected by later experience in military research units or at the NIH since there is no obligatory military service for physicians.

4) Changes in requirements of specialty boards, such as the American Board of Internal Medicine have eliminated the possibility of a research fellowship as a qualifying year of postgraduate experience toward obtaining board certification.

5) The payback provision of the National Research Service Award Program. As Wyngaarden describes this, the neophyte physician-investigator needs "time to discover the pleasures of measurement, of designing and executing experiments, and of analyzing results, of pursuing an idea that does not fit into the conventional dogma, of testing ones creativity and experiencing the exhilaration of the experimental proof of the new hypothesis." I might also add experiencing the disappointment of ideas *disproved* experimentally! But that is another side of the coin.

Wyngaarden maintains that the young physician cannot know whether this will prove to be a gratifying and consuming experience unless research life can be sampled for a year or more without incurring what he considers to be unwarranted economic or professional penalties of the National Research Service Award Program. Obviously there are persons who disagree with this point of view, but it is certainly a factor in career decisions. However Dr. Wyngaarden presented convincing evidence that the decline in physician-investigators began in the late 1960s, *before* the redefinitions of NIH fellowships, training programs and payback provisions occurred in the 1970s.

TABLE 5

*Percentage of medical students stating that research would be a component of their career**

Year	%
1960	39
1979	20

* Association of American Medical Colleges 1978 Medical Student Graduation Questionnaire Survey.[6] From Shires.[5]

Lastly, the reasons that physician-scientists are important in biomedicine are relatively obvious. Bright physician-investigators and teachers are needed to insure continued development and transfer of scientific knowledge to clinical practice, to assess value and effectiveness of drugs, therapeutic devices and diagnostic procedures in humans, and to teach future medical students and residents.

Thus we cannot escape the conclusion that present educational trends are creating a physician-scientist vacuum that is already upon us and will certainly extend into the next generation unless effective remedies are applied.

By citing examples and evidence of the above trends concerning physician-scientists, I do not mean to minimize my concern for continued training of other biomedical scientists at levels appropriate to our national needs and predictions for the future. You are all aware of the story of training grants—their blossoming youth in the 1960s, nearly total demise in the early 1970s and current struggle to maintain a seed for the next generation.

Now, we come to therapy, prevention and control of disease. As you know, there are at least two aspects of therapy, prevention and control. The practicing physician's approach is usually a one-on-one attack, whereas health officers and epidemiologists view problems primarily at the herd level. The educational disease under consideration here needs remedial action at both levels.

The usual methods of therapy, prevention and control of a disease are the use of drugs, vaccines, insecticides, surgical intervention or other techniques. However, let me dispense with the technical approach as the cure-all of the biomedical scientist deficiency disease with the following story.

This concerns a novice golfer who began the first hole by asking for a putter and then proceeded to drive 395 yards to about 2 inches from the cup on the green. He then asked for a driver. He swung and missed the ball, but the wind created by his full swing blew the ball into the cup! Then he was stumped and had to ask for advice. He turned to the caddy and said "So far I have been sure of my tools and techniques, but now you will have to tell me. What club do I use to get the ball *out* of the hole?"

Thus I maintain, there is no inanimate single tool with which we can solve the problem of "From whence the next generation of biomedical scientists." The only tool available is animate—the human brain—and what we need are people to use tools rather than tools themselves.

To return to the basic approaches of therapy, prevention and control of diseases—one-on-one and herd tactics—we need more one-on-one interaction between students and educators. Medical school faculties need to stimulate and provide opportunities for medical students to sample and to evaluate for themselves the research and educational activities of the basic medical sciences as well as those related to clinical investigations.

Unfortunately, there are counter forces in these areas.

During the past 20 years many colleges began to provide research experiences for premedical students. As a result, many medical students with an inkling of interest in research have had a taste of it before entering medical school. In some instances, this taste has been pleasant and has led to a conviction on the part of the student to enter a research career. Indeed these students may find some of the basic science courses in medical schools too repetitious. However, in other instances the research was unrewarding and thus turned off the student from a future research career. Perhaps the topic or project was insufficiently exciting from the medical viewpoint to hold the premedical student's attention. The environment of a college or university in which undergraduate research is done is quite different from that of a medical center, where the various facets of medicine can more easily be related to research. Failures of experiments, such as we all experience, are sometimes not adequately explained to students in advance and thus can have crushing effects on the potential research interests of students.

Secondly, role models for medical students in basic sciences and even clinical sciences are decreasing in numbers. In fact, physicians on basic science medical faculties are becoming not only an endangered but truly an extinct species! This results in a vicious cycle. Without enthusiastic, exciting physicians in basic medical science departments, medical students cannot find role models to help them in their decisions toward basic medical science careers. The remaining few physicians in basic medical science need to work especially hard as role models for medical students and residents. We should try to identify the young students and physicians who will become the next generation, give them perspective and guidance in their research and clinical development, and help them develop intellectually into independent investigators and academicians. Somehow we must break this destructive cycle and change the slope from downward to upward.

Fortunately there does not seem to be a current shortage of excellent role models for students interested in entering biomedical research careers by way of graduate schools. Otherwise we would have a serious overall shortage of biomedical scientists in basic science departments of medical schools. However, there are other problems for all research-destined biomedical students that presently act as deterrents in career decisions.

Young people considering a career in basic biomedical science today are faced with the very real problem of personal financial rewards. This country has short-changed research and research development during the past 10 years, and if this practice continues we shall fall well behind other nations. Entering the profession of a basic biomedical scientist is not financially attractive—not that it ever was very attractive, but it is less so now than in the past several decades. For physician-trained scientists, this presents even more of a dilemma because of the lucrative attractions of private practice.

Visionary funding of long-term research that may involve even more than one generation of investigators has been glowingly absent from our scientific community. There are undoubtedly many scientific questions that cannot be answered, nor chronic diseases understood, without experiments that may extend for decades. Mankind will continue to suffer from many chronic diseases until this type of research is underway at a significant level of activity.

The numbers of physicians on tenure tracks in universities and biomedical institutions are disproportionately low. If a newly trained biomedical scientist is lucky enough to find an assistant professorship in a university, it is likely to be after 4 years of college, 4 or 5 years of graduate or medical school, and about 4 years as a post-doctoral trainee. In other words, 8 or 9 years after graduation from college, or age 30–31 years. Despite this in-depth, extensive, specialized education, the salary is often in the $20,000–$40,000 range.

Then if he or she does receive a position at an academic institution, the next hurdle is competition for a relatively small number of research grants and the understandable demand by university administrations that a significant proportion of salary be derived from such grants. If the grant is funded and research begins, the new faculty member is soon faced with the need to publish results since without publication, he or she certainly cannot count on receiving tenure *if* tenure is available. There are often limited tenure tracks and the tenure system itself is periodically under attack at many universities. Will this person find it attractive to begin an academic career with a nontenure-track position and relatively little hope of transfer to a tenure-track? The answer is probably no. Without receiving tenure the new scientist will be released according to many of today's ground rules in about 5 to 7 years, and a new assistant professor 5 years younger will be employed. Thus individuals perish and the system aborts, and though it survives temporarily the system eventually will self-destruct since it is producing no next generation of biomedical scientists.

By now I am sure you are no longer wondering why the number and quality of scientists entering biomedical research and education are steadily decreasing, and I suspect that you are happy and thankful to have whatever you have. These considerations bring me to possible remedies at the herd level.

At this level, we often employ statistics for planning experiments and analyzing results. That the problems we are considering are not quite yet amenable simply to a statistical solution is my current opinion. And I shall quickly terminate an attempt statistically to analyze the problem by citing the story of the statistician who refused to fly on airplanes because there was a 1 in 10^4 chance of a bomb being on the plane. He spent years traveling on trains because of this. Suddenly one day he asked his secretary to arrange an air trip. She asked him why and he said "I just realized that if there is a 1 in 10^4 chance of one bomb being on a plane, there is a 1 in 10^8 chance of there being two bombs on the plane. Since obviously a 1 in 10^8 chance is very unlikely to occur, all I have to do to be safe on a plane is to carry one bomb in my suitcase."

Another aspect of possible remedies at the herd level is involvement with bigness—big organizations, such as governments, foundations, medical and graduate schools. If one ranks these three with respect to bigness, governments of course are first (big money and big staffs), foundations second (big money and often small staffs), and medical and graduate schools third (big staffs but no money). I shall leave to each of you the challenge of ranking governments, foundations and medical and graduate schools with respect to ideas, creativity and effectiveness.

At any rate in today's world, without the participation and help of the man-made entities of governments, foundations and educational institutions—as well as others like industries—we could not make much progress towards remedying herd problems.

And so it is with the next generation of biomedical scientists. Herd therapies for the biomedical scientist deficiency disease have been the subject of recent publications and include the following possibilities and impossibilities.

One impossibility is to turn back the time clock to the good old days when the United States population was expanding, more students were entering educational tracks, more faculties were needed, and financial support for biomedical education and research was plentiful. This period of time was aptly described by Erwin Chargaff, Professor Emeritus of Biochemistry at Columbia University as "the time of the Sputnik, roughly 1957–1967, which signaled the onset of scientific megolamania."[10] He further commented "The force-feeding of research became fashionable, to which purpose the universities were encouraged by all sorts of head and overhead money to take in more students, expand their facility, build more laboratories, etc. Secretaries of study sections of NIH traveled throughout the country soliciting new and more grant applications that required more bureaucracy on the part of the universities, and pyramids of uselessness were erected everywhere. A great deal was spent to control the flow of funds, in order to prevent the investigator from buying a hotdog on his grant. On the other hand, the weirdest types of symposia and congresses were financed, and travel money could be had easily." And I might add training grant money also. In discarding this possibility, let us take solace in the recollection that not all the good old days were so good, in fact some of them were pretty bad. And thus we are probably fortunate in not being able to turn back the timeclock.

Among the possibilities for herd remedies for the deficiency of biomedical scientists are the following:

1) M.D.-Ph.D. programs. Those that are currently underway are showing early indications of success and there is a strong move to expand them. Actually some of these programs should be termed Ph.D.-M.D. since for example in the one at Cornell University Medical College, the student first obtains a Ph.D. and then an M.D. This is done by taking the first 2 years of medical school, followed by 3 years of research and preparation of a thesis that results in a Ph.D. degree, and then lastly a 6th year of clinical experience analogous to the 3rd year of the ordinary medical curriculum. This is followed by the M.D. degree.

I'd like to emphasize that I am not convinced that the M.D.-Ph.D. or Ph.D.-M.D. programs are the only herd solution to the present and future shortage of biomedical scientists, but I believe that they may be one of the better currently available means to enable budding medical students to become "hooked" on the excitement of research and teaching in biomedical science.

2) Admissions committees of medical schools with active research programs could select a percentage of each entering class on the basis of parameters for a career in research. Certainly this is being done in many schools, but could probably be increased quantitatively throughout the country.[8]

3) Stabilize Federal Government funding for research training of medical students who desire to enter basic science research and teaching careers. I wish I knew how that could be done!

4) Consider reducing the sizes of certain medical school classes if the school wishes to encourage and increase the role model activities of faculties as stimulants for medical students to enter biomedical science careers. The gap between medical students and medical faculty has widened in the last 15 years. Reasons for this are many, but one of the major ones is the increase in class sizes so that an individual faculty member can no longer even recognize the faces of all students in a class.

5) Open tenure tracks in medical schools for more young scientists. Richard Atkinson, former director of the National Science Foundation, has proposed that government assistance programs might facilitate mid-career shifts for tenured faculty interested in striking out in new directions and in such a way might open positions for younger scientists. Or that a program of Senior Research Scientist Grants for outstanding scientists be developed so that they could devote more time to research and in turn free their university salary support for tenure appointments for young faculty members.[11]

Since the biomedical science deficiency disease has multiple etiologic factors, multiple therapies are probably needed. Let's hope that none is antagonistic to another, that in fact some are synergistic and that if any aspects are "shotgun," the gun does not backfire.

In 1974, on the occasion of the 50th anniversary of the American Society of Parasitology, this memento was generously given to all attendants. On the back, it states that "A parasitologist is like an orchid." How appropriate for biomedical scientists interested in tropical medicine!

I will therefore close merely by readdressing the question of the title "From Whence the Next Generation?" in the context of our Society. Obviously, the answer is that the next generation of parasitologists and tropical medicine scientists and educators will come from the orchid growers of today. May orchids blossom vigorously during the next generations!

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