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MALARIA[1]

MALARIA is a subject of multifarious scientific interest. Its study leads us into many biological considerations involving an undetermined number of species representing at least three phyla of the animal kingdom: protozoa, articulata, chordata.

Considering only human malaria, the subject has important biological, medical, economic and cultural aspects. The topic could have been profitably discussed under the general heading of "Contributions of Science to Medicine," and it is equally adapted to consideration under the caption "Contributions of Medicine to Science," since it is a toss-up whether the scientists taught the doctors more than the latter repaid them. It was convenient when Dr. Laveran discovered the parasite to find that the systematists had a pigeonhole ready for it. It was of immense help when Dr. Ross demonstrated mosquito transmission to find that entomology could furnish many ready-made criteria for discriminating between various kinds of these insects, and many pertinent facts regarding their anatomy and physiology. It has been a pleasure to observe the repayment of these large debts in kind, in the numerous contributions which medical men have made to protozoology and entomology incidental to the study of malaria.

I am not competent to discuss malaria from the standpoint of the protozoologist, the entomologist, even the malariologist, or any other variety of scientist having an academically recognized standing. My contribution must emanate from the modest outlook of the student of public health. The only advantage to be claimed for this outlook is that while too shallow to claim authority in any one scientific specialty, it may be broad enough to appreciate the significance of scientific research in many apparently remote fields and to appropriate to the cause of human welfare scientific knowledge wherever found. I would not have you put a purely pragmatic interpretation on this attitude. Let me say in illustration that I think it is doubtful from which source the child who receives malaria lessons in school derives the greater benefit, from the purely informational source which tells him to swat the mosquito or he will become sick, or from

[1] Presented as part of a symposium on "The Medical Problems of the South" at a joint meeting of the American Association for the Advancement of Science and the American Public Health Association, Nashville, December 28, 1927.

the inspirational source which opens up to his vision a world in which knowledge for its own sake is something worth living for—and worth avoiding malaria for. Culture and malaria are directly opposed, and if we admit that malaria conquered the culture of Greece and of Rome, it was at that time a decadent culture, and we can reassure ourselves that the insurgent culture of America will conquer malaria. At the same time that we visualize a vicious circle in which malaria leads through disease to poverty and ignorance and back to malaria, we must not lose sight of that concentric circle in which education, improved living standards and even a little initial financial help tend to eliminate malaria and produce a higher culture and a greater human prosperity.

Malaria has been stated upon the eminent authority of Dr. Henry Carter to be the only disease of man which is able to render an area of the earth's surface uninhabitable. Such diseases as bubonic plague, Asiatic cholera, yellow fever and hookworm may take a terrible toll of a human population, but even at their worst they do leave a battered and ragged remnant to carry on. Malaria at its worst prevents people from living in the area where it prevails. Fortunately, we in America do not suffer from such intensities of prevalence or malignancy, but we still have areas, not large and not continuous, where more than half of the population may show evidences of past or present malarial infection. The actual death-rate is not considerable, and it is known to health officials not to be accurately measurable. Our malaria in general is of too mild a nature to permit of its measurement by the death-rate. Of far greater significance is the morbidity rate, for this gives us an index of the social importance of the disease. It is not the relatively few individuals who are killed outright whose removal importantly hampers the march of progress. It is the infinitely larger numbers of the maimed and stunted whose impaired product constitutes a cultural and economic loss.

In the United States malaria was formerly much more widely distributed geographically than it is at the present time. Even during the past generation it has become remarkably restricted. During my own memory it was fairly prevalent in one of the boroughs of New York City. At the present time we find it of considerable public health significance only in the south Atlantic coast, the Gulf coast and the lower Mississippi valley regions, with the exception of isolated areas, notably one in a Pacific coast state. And even in this distribution careful field surveys have shown the reassuring fact that the affected areas are not confluent, but spotted here and there, so that the problem of eradication has become less formidable with increasing knowledge. There is perhaps no hotbed of malaria, in the tropical sense, within our boundaries at the present time, but areas of serious prevalence do remain, chiefly in the so-called delta region of the Mississippi River valley. Moreover, in at least one area in the southwest, the disease is on the increase. It is, therefore, no time to stop control work, but rather time for redoubled effort with the positive assurance of ultimate success.

It has been claimed by some observers that the diminution of malaria in the United States has been due solely to the advance of civilization and culture. In some areas of low prevalence and intensities this has undoubtedly been true. Malaria has literally been built out in certain places incidentally to the concentration of populations, without intentional effort having been directed toward eradicating the disease. On the other hand, it has repeatedly been demonstrated that intentional effort on the part of health agencies has resulted in the virtual eradication of the disease from areas where previously no tendency toward diminution was observable. It may also be claimed with reasonable supporting evidence that in certain places of high incidence and intensity the intentional control of malaria must come before civilization and culture can gain a foothold.

It is, therefore, a matter of congratulation that at the present time in all the states in which malaria offers any considerable public health menace there is a definite established machinery in the state health department for the study and control of this disease. This provision has come about within less than a score of years, since at the time when the Public Health Service first undertook the intensive study of malaria not a single state had made this provision.

I have stated that malaria is a many-sided subject. According to the approach to this subject which our experience and training determine, we may entertain different views both as to the cause of malaria and as to the best methods of combating it. One may regard it merely as an instance of protozoan parasitism in man and advise concentration upon a program of medical treatment of individuals. Another with entomological leanings may think of it as a typical insect-borne disease and seek to get rid of it solely by exterminating the insect. Another with a historical background may see in malaria only a manifestation of crude unconquered nature which will succumb to the general improvements incidental to the growth of civilization—the so-called "bonification" of European writers. But we must let the sociologists and economists have their say, and they will put their fingers on the sore spot of social and economic maladjustment, and tell us, "Here is where your trouble lies, and this is the place to begin your curative operation."

I do not know how many more different kinds of specialists might wish to contribute their wisdom to this problem, but I do know that it seems to be clearly up to the health official to do something about it—and after all he is the logical man to do it. It is he and his research workers who must go into the swamps where the pestilence breeds, must go into the rickety homes of tenant farmers and learn to call the children by their first names and in other ways live with and learn at first hand the many aspects of this disease. Then in the laboratory they must examine blood smears, dissect mosquitoes, try out larvicides, and in the study they must read the world literature, for no hint is to be neglected.

And what does the student of public health make of all the various view-points and advice which the literature brings to his study. Perhaps I do not arrogate too much authority in saying that he feels very much with regard to malaria as a disease upon a population, as a competent physician does toward malaria as a disease of an individual patient, and that is that both as to cause and remedy one must discriminate, that there is no such thing as a stock diagnosis and that the treatment must be selected to fit local conditions and the individual. This parallel may be carried further. If a doctor visits a patient, makes a diagnosis of malaria, prescribes his routine treatment and goes on his way without having noticed that the patient is also suffering from a broken leg, we call him a charlatan and sue him for malpractice. So also we should discountenance the action of a health official, who having determined the existence of malaria in a community would immediately divert all its health resources toward the eradication of that one disease without first considering the other health needs.

If these premises be true, first that antimalaria measures must be selected with reference to local conditions, second that the emphasis on antimalarial work should be proportionate to the relative local importance of the disease, it must follow that effective work must be administered by some competent agency completely familiar with the local situation. This is essential not only to the work which a community may wish to do of its own initiative and at its own cost, but furnishes the only effective means through which outside agencies, be they governmental, benevolent or developmental, can effect the desired improvements.

This reasoning, applied not only to the malaria problem but to health problems in general, has actuated the program of the U. S. Public Health Service, which attempts to encourage the establishment throughout the country of effective official local health organizations or units. Since the rural areas suffer the greatest need, emphasis has been chiefly upon county or district organizations consisting of a health officer and such inspectors, visiting nurses and other personnel as he may require. While there is no panacea for malaria, there is one essential requirement for its eradication and that is a competent health authority on the spot.

Malaria, as it arises from what may for the time be called purely natural causes, presents problems enough, and it has only been after years of patient work that we are beginning to solve them, when to add to our troubles along comes man himself with a number of modern activities and artificially multiplies our difficulties. Curiously enough these activities are all intended to be beneficent, and would be so if their directors were properly concerned with health matters. High roads and railroads have been built through backward areas with the intent of developing them, of bringing in enlightenment and progress and taking out an increased product, but constructed in such a way as to bring this deadening disease malaria to the very populations which it was intended to benefit. This occurs, of course, through such bits of carelessness as blocking off loops of running streams and leaving undrained borrow pits which then become the breeding places of innumerable anopheline mosquitoes. Agricultural drainage, surely a beneficial undertaking in the abstract, has actually had the effect in some places of establishing permanent breeding places within a half mile of every inhabitant of the area treated. This is because the ditches become partly filled up at places and converted into a succession of small pools. Again, projects for the impounding of streams, intended to harness the force of gravity for the use of man, may succeed, so far as the health officer can see, only in greatly increasing the gravity of the local malaria problem. However, the correction of these errors is by fairly obvious means and probably offers no difficulties which may not be overcome within a few years.

Since we all have some personal bias, I may as well confess to mine with relation to malaria. To me it seems in final analysis, under our American conditions, to be chiefly an economic problem. Dr. Weir Mitchell once said that the majority of his patients could be cured merely by receiving a legacy of $25,000. Undoubtedly health and happiness came cheaper in those days. Although malaria belongs to a far different category of diseases from that with which Dr. Mitchell dealt, it is nevertheless one of the diseases the immunity to which is purchasable. The proper approach, however, is not to solicit outside funds of charitable origin with which to bless the suffering for a brief period, afterwards forgetting about them, but to devise cheap enough methods of eradication so that those who really wish to get rid of ma-

laria can afford to do so at their own expense and on a permanent basis. As regards thickly settled communities—cities, towns, villages—where the wealth, even though scanty, is relatively high per square foot of ground surface, this has already been fairly satisfactorily accomplished. It would indeed be a rather decrepit specimen of the American community which could not afford to rid itself of malaria by applying intelligently methods already at hand—or else one peculiarly unfortunately situated. But in rural areas where the population is sparsely scattered and money even scantier, and the surrounding breeding areas are vast, the problem is far more difficult. And here again we come upon those economic causes which are associated with faulty or questionable business methods. Tenant farming and single crops for example require for their successful management an intelligence and a humanity not always encountered, and one result of their failure is malaria. The program of education to correct these conditions must be a slow one. Perhaps it is too much to hope that far-sighted statesmen will arise who will contribute to the solution of a part of the problem, or that inspired business organizations, alive to all the economies which arise from health protection, will see the gold mines which lie waiting to reward the application of higher intelligence.

Meanwhile, much has been done to help diminish malaria even under existing unfavorable economic conditions. We can now cheaply screen and otherwise mosquito proof almost the most disreputable tenant home which a negligent landlord will tolerate, and if the tenant will swat the few mosquitoes which succeed in getting in, and stay indoors at night during the breeding season he is much more likely to stay on his feet during the year than he is without these precautions, and his wife and children likewise. This means that the crops under his charge are much more likely to be planted, cultivated and gathered. In the aggregate this means much, but not the complete eradication of malaria.

Airplane dusting with Paris green will control the breeding of anopheles mosquitoes in almost any kind of tree or weed-grown swamp. The cost data are not completely worked out, but I will hazard the personal statement that it is within the means of, and would repay, any sufficiently large combination of owners of contiguous or nearby plantations where malaria is a serious matter. I can not at present see why this measure combined with medical treatment of those already infected should not completely control malaria during the seasons of its employment. This would liberate a considerable man power not only for the cultivation of existing farm land but for the reclamation to agriculture of swamp lands now worse than useless. This is one of the opportunities which big business may see.

We are accustomed to big things in America, and one big thing which I think many of us here present will live to see is the practical eradication of malaria. Such a hopeful prophecy, however, must be predicated upon the continued progressive acceptance of scientific findings and their intelligent application to this problem of human welfare.

I am quite aware of the fact that the Malaria Committee of the League of Nations, after able and prolonged study of conditions obtaining chiefly in Europe, advises a general policy of amelioration or palliation rather than one of thorough-going eradication, but this is apparently only because, as they state, their mandate confines them to measures which require little expenditure of money. They are thus led to ignore relatively such measures as the broad scale attack upon the breeding of mosquitoes, and to concentrate upon so-called direct methods which deal with the patient and his house, though advocating the general raising of the cultural and economic level. This is doubtless wise advice adapted to the areas concerned, and in some instances to conditions which may be found in America. However, places in the United States where conditions obtain which render such a restricted policy necessary do not represent the culture of America, which, as is well known, demands that every citizen may claim as a birthright a bathtub, a flivver, and a radio set, and if these, why not freedom from malaria which costs much less? Incidentally, we must ask the psychologists why it is possible for the knowledge of a popular subject like radio to become diffused throughout the land in a few months so that the majority of inhabitants over the age of fifteen are able to discuss ohms, wave-lengths, filaments and grids, interference, audio-frequency and a hundred other hitherto unfamiliar subjects, and to apply knowledge of them to getting results, when it takes years of teaching to spread the simple truth that malaria is conveyed by mosquitoes and that if you separate mosquitoes from man by whatever means, you prevent the spread of the disease.

Malaria is controllable in America at the present time if the public would be as lavish with money for that purpose as it is for radio. Since the public gives no indication of becoming lavish in this direction, it must be the work of science to cheapen the price until it becomes sufficiently attractive to make all classes willing to purchase freedom from this disease. At the same time we must work away at overcoming those psychological and social impediments which always stand in the way of innovations for the public good unless the latter have the happy

appeal of radio—or chewing gum. These impediments are well known to consist of such factors as the inertia of habit, the conservatism of the self-interested, ignorance and the fear of loss in untried investments.

It would not be proper to complete this address without some reference to recent scientific research in the subject. The observations of what may be called experimental clinical malaria have been fruitful in correcting and making more precise our conception of the course of this disease. It is seldom that the physician is able to study a disease by direct inoculation of the human subject with the causative organism, and then by observing by all the means of measurement at his command the natural course of events. This was made possible in the case of malaria by the fact that inoculation with malaria organisms exerted a favorable and sometimes curative effect upon sufferers from general paresis and other forms of chronic and hitherto incurable diseases of the central nervous system. It became therefore not only legitimate but a duty to explore further this means of benefitting the suffering.

The cure of malaria itself by medication has been shown by investigations within the past few years not to be the simple matter which it was assumed to be only a generation ago. At that time quinine was considered a specific and when administered in time and properly an almost infallible remedy. We still find it invaluable for preventing the explosive manifestations of malaria and keeping our patients on their feet, but we have learned to our sorrow that there are grave limitations to its potency in completing the destruction of the parasite or "sterilizing" the patient with regard to it. The practical application of this fact to malaria control is obvious, since some other means is needed in order to render our patients incapable of infecting other persons through the mediation of the mosquito. New therapeutic preparations have been introduced which appear to be vastly superior to quinine in this respect, but which will require the test of large scale field application in order to determine their real and permanent value.

From the entomological standpoint much of interest is developing in this country. The extensive prevalence of an anopheles species hitherto regarded as a scientific curiosity has been determined for certain areas—I refer to *Anopheles atropos*. Its significance, real or potential, as regards malaria remains to be determined. That merely because it is an anopheles it is necessarily important to malaria of course does not follow, since it has been found, for example, that both *crucians* and *punctipennis* have very limited practical significance, although known to be capable of developing the parasite. Another species, *maculipennis*, distinguishable only with difficulty from the prevalent and destructive *quadrimaculatus*, but having different habits which would affect its control, is known to exist locally in this country and further study of its potentialities are demanded.

Despite the attitude of the Malaria Commission previously referred to, larvicides will continue to be useful in America, and their study is urgently demanded, not only from the standpoint of malaria control but from that of exterminating the salt marsh mosquito pests. Paris green has demonstrated its value, and we have Dr. Barber to thank for introducing its use as a larvicide, after painstaking tests. At first designed for the control of relatively small pools, by the simple process of dusting by hand, it has now been found absolutely effective in controlling anopheles breeding in large areas, even if they be overgrown with trees and other vegetation, when distributed by airplanes. An interesting feature of this latter mode of distribution is the almost incredible ability of the dust to penetrate the foliage of vegetation and become deposited on the underlying water which would seem to be protected by the trees and shrubs. This property appears to be associated with an electrical charge imparted to the dust by friction during its release. Studies of these electrical phenomena and the influence of materials and states of aggregation upon them are in progress. Paris green is cheap and efficient and may be the best larvicide which can be devised, but further studies are desirable to determine the exact limitations of this method and to devise refinements in the direction of economy.

RECAPITULATION

To recapitulate the factors concerning malaria which appear to me most important from the standpoint of the health official:

(1) Malaria in this country is in general a diminishing menace.

(2) Its continued diminution is dependent upon the persistence of those forces which have led to this diminution, the march of culture and active health work against the disease.

(3) In this country it is possible to look forward at no very distant date to the practical eradication of the disease, and the policy of mere amelioration should be only temporarily adopted in some local instances.

(4) Improved and more economical methods of eradication must be based upon rigid experimentation in many fields of inquiry.

(5) The means to be used in any given locality must be expertly selected after thorough knowledge of local conditions has been secured. There is no panacea.

(6) The first indispensable step toward undertak-

ing antimalaria measures is the establishment in the area concerned of an effective official health unit.

(7) Programs of malaria control should definitely aim at the eventual and even early taking over of activities by the local agencies and their support by local funds.

(8) Antimalaria programs should neither be allowed to take precedence over nor to be subordinated to other health activities in the area. After a careful study of local health needs they should be allotted their proportionate share in health activities.

(9) Malaria is as much due to social and economic causes as to the plasmodium or the mosquito. The problem as to just where to interrupt the vicious circle varies with locality and must be decided after local survey.

(10) Malaria in the United States could be not only controlled but virtually exterminated by methods already known and at not unreasonable cost.

(11) Impediments to malaria control and eradication arise from the well recognized psychological and social phenomena which always delay the adoption of useful innovations, unless the latter happen to come in peculiarly attractive form or are laden with considerable emotional appeal.

(12) It is essential that researches in malaria be continued. Not only are economic refinements of methods desirable, but from the standpoint of science a very productive field awaits further cultivation.

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U. S. PUBLIC HEALTH SERVICE

PARASITOLOGY IN RELATION TO MEDICAL PROBLEMS OF THE SOUTH[1]

THE medical problems of the south include several diseases that are endemic in the region in addition to those that occur over the country as a whole. Some of the more important ones of these diseases are caused by large parasites like, for instance, the helminths, and intelligent dealing with them requires that advantage be taken of information to be derived from that division of parasitology which deals with this class of parasites—helminthology.

Other diseases endemic chiefly in the south are caused by microscopic parasites, the protozoa, and intelligent dealing with them requires practical application of information to be derived from the division of parasitology which deals with this class of parasites—protozoology.

[1] Presented as part of a symposium on "The Medical Problems of the South" at a joint meeting of the American Association for the Advancement of Science and the American Public Health Association, Nashville, December 28, 1927.

The specific organism of some of the diseases of the south that are due to protozoa and some of those that are due to bacteria are transmitted from man to man, or in some instances from animal to man by insects, and these can be dealt with intelligently only by taking advantage of information to be gained from entomology, which we may include as another division of the general subject of parasitology. It often occurs that such a disease may be most successfully combatted by measures directed against the insect host of the specific organism or against the animal host of the insect host of the organism, as in bubonic plague.

The medical problems presented by a disease, parasitic or otherwise, are chiefly those of diagnosis, cure and prevention. Any and all of these are dependent more or less upon a knowledge of the life history of the specific organism or parasite, as in the case, for instance, of hookworm disease, or of both the specific organism and of the insect host as in malaria. Diagnosis is necessary for intelligent treatment of a parasitic disease, but both diagnosis and treatment may be applied only to the individual or either or both of them may be utilized in combatting or preventing the disease in the community. In other instances the cure of patients, as in the case of yellow fever or of plague, has little or no significance in dealing with the disease as a community problem.

Parasitology discovers the life history of the parasite and its environmental requirements for propagation and mischief. Unless we remind ourselves, we are likely not to fully realize how much the success we have had in dealing with several of the diseases that have been dealt with successfully during recent years was made possible by studies of the parasite or its insect host. During comparatively recent years yellow fever has been banished, never to return, thanks to the practical application of knowledge of the life history of the insect carrier; bubonic plague is under control and will never be a serious disease again, thanks to the practical application of knowledge of the life history of the rat-flea and its host; hookworm disease is no longer a serious disease in the south except in limited areas and in small numbers of people compared with twenty years ago, thanks to the practical application of knowledge of the life history of the parasite; malaria has been placed under control and practically eliminated from numerous demonstration communities, thanks to the practical application of knowledge of the life history of both the parasite and the insect host. Numerous other instances could be given in which the problem of endemic diseases has been solved to considerable extent at least through knowledge of the life history