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The behaviour of *Homo sapiens*, the forgotten factor in the transmission of tropical disease

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Abstract

The behaviour of the pathogens responsible for tropical disease and the behaviour of the hosts other than man are both studied in great detail, but the behaviour of man, the third component in these cycles of transmission, is for the most part totally and inexplicably disregarded. Even when the pathogens are actively brought to us through the agency of an arthropod host, we too often ease the passage of the vectors either by unthinkingly providing facilities for their breeding or by neglecting the simple steps that can be taken to prevent their feeding on us.

The problem resolves itself into two parts, (i) the collection and collation of relevant data on human behaviour, and (ii) the taking of steps to change this behaviour. Part two has recently been greatly facilitated by the development of radio transmission *via* artificial satellite.

While WHO is now making a start on both these aspects it is doing so at a relatively low level. Instead, the two phases of this new approach should be given top priority even if it means large scale reorganization of relevant university departments and even of WHO itself. We have, after all, had almost 100 years to try out the old methods and, as far as the third world is concerned, they have for the most part failed.

Introduction

One could use the term man-made disease to cover all communicable diseases that affect man as a result of his own behaviour or in which the transference to man is made easier by his behaviour. It could be argued that concentrating people in an enclosed space, as in lecture theatres or in schools, places of entertainment and public transport, falls within this definition since the transference of pathogens from one person to another is certainly facilitated by such behaviour. We would also have to include Legionnaires' disease, since its spread appears to be associated with man-made apparatus; it would certainly include AIDS and also, of course, the fatal and debilitating diseases associated with smoking. The problems of man-made or man-assisted disease in industrialized countries are largely different from those in the developing countries, and this difference is not merely one of degree; it stems directly and indirectly from important climatic factors. This Society is dedicated to studying problems within the zone lying between Cancer and Capricorn, as our motto clearly states, and it is in this region that parasitic diseases, aided and abetted by high temperatures, dominate the scene (GILLETT, 1974, 1979a, 1981; KAMARCK, 1976). I propose, therefore, to restrict this inquiry to what is usually referred to as parasitic disease, that is those diseases resulting from invasion of our bodies by protozoa and helminths. This excludes bacteria and viruses although it is recognized that the distinction is purely arbitrary (GILLETT, 1974). I shall be inconsistent, however, and include bacterial and viral diseases that are transmitted from other vertebrates or from man to man by arthropods, for example plague and yellow fever.

I shall refer to two-component systems where transference to man by a pathogen occurs unassisted by a second host, even though the actual life-cycle of the pathogen may involve several hosts as in some flukes and tapeworms. I shall refer to three-component systems where transference to man by a pathogen results from active participation of another host, usually an arthropod, as in malaria, sleeping sickness and yellow fever. I shall avoid such loaded terms as secondary and primary hosts and refer merely to arthropod or invertebrate host and to human or vertebrate host. The sexual multiplication of *Plasmodium* occurs in the arthropod host; the sexual multiplication of *Wuchereria* occurs in the human host.

Two-component systems

Anisopteran dragonflies (Odonata) are the natural hosts of certain flukes (MACY, 1934; TIMON-DAVID,

1958), the aquatic stages rectally sucking up the cercariae released by water-snails both in North America and in south-east Asia and probably elsewhere. Why is it, then, that man does not become involved in the cycle of transmission in North America but does so in south-east Asia? The answer is simple in the extreme and may be taken as the keynote of what I am going to say this evening. In North America man does not eat dragonfly nymphs; in south-east Asia, or in Thailand to be precise, he does so (MANNING, 1971). Admittedly the genera of flukes involved is different in the two regions and it is, of course, possible that *Prosthogonimus* of North America is not transmissible to man. Nevertheless, two genera are involved in Thailand, *Prosthodendrium* being found in 58% of a sample of 24 people and *Phaneropsolus* in 63% of the same sample (MANNING, 1971) and man becomes involved because he is wont to eat dragonfly larvae either fresh out of the fishing nets or taken home and added to other food. In North America *Prosthogonimus* develop into the adult stage in falcons which eat the dragonfly adults (CORBET, 1962); in Thailand *Prosthodendrium* and *Phaneropsolus* develop into the adult stages in bats and rats and in monkeys respectively, in addition to man.

You will note that when I refer to man I denote the species, *Homo sapiens*; of course women become involved and children too but, at the risk of being accused of sexism and, I suppose, even agism, I shall continue to use the three letter word—man. In the same way I shall use the word horse to cover both mares and foals and dog to cover both bitches and pups. The important point is that we become involved almost entirely because of our own behaviour. This, as I say, will be the theme of this paper—our own part in the equation, the particular facet of our behaviour that is every bit as important in the cycle of transmission as, say, the man-biting and non-man-biting habits of a particular species of mosquito or indeed of a particular population of that species and of the behaviour of the parasite itself. It seems incomprehensible that we should spend so much time, money and effort studying the behaviour of the parasite and the invertebrate host and neglect almost entirely the third component that so often makes these many and varied cycles of transmission important, namely the behaviour of man.

It is estimated that all the people of Thailand harbour *Paragonimus* in the lungs, and that many also harbour gnathostomes elsewhere, from the habit of eating raw freshwater crabs and raw fish (and other uncooked flesh) respectively (MIYAZAKI, 1960; DAENGSVANG, 1980). All these parasites would disappear from ourselves if we could be persuaded to make one simple, inexpensive change in our habits; perhaps these delicacies would even be improved by cooking. Fuel, of course, does cost money. But the people concerned cook other food and so I do not see this as an insurmountable obstacle. What I do see as a very real obstacle is custom, habit and upbringing.

One step away from these simple systems in which the problem is quite clearly man himself are a host of other parasitic diseases. The unfortunate woman who died at childbirth at the age of 29 years and from whom Manning recovered post mortem more than 100 of the dragonfly flukes, also harboured the common liver-fluke *Opisthorchis viverrini*, the tapeworm *Taenia saginata*, hookworm and pinworms. Some of the people examined in Manning's survey had five species of trematode in addition to cestodes and nematodes. It could, of course, be argued that apart from the hookworms these visitors were doing her little harm and it is, I suppose, possible that some may even have been doing her good. I am certain, however, that not one of us present here would countenance their continued occupancy of ourselves or of our loved ones, whatever the basis of this abhorrence.

In the Philippines, small heterophyid flukes are also found in the intestine of man, living in intimate contact with the intestinal mucosa; these, too, apparently do little harm but both eggs and adult worms from time to time find their way into the general circulation and can cause cardiomyopathy or even cerebral haemorrhage; it has been estimated that 15% of all fatal heart cases in the endemic areas arise from myocarditis resulting from these infections (MANNING, 1971). Whether this is so or not, the point I wish to make is that a high proportion of trematode, cestode and nematode infections result from behavioural traits of man and may lead to unexpected complications, some of which are serious. It may be true that man when poorly nourished is more susceptible to the damage brought by these large parasites or is it, as ASH *et al.* (1984) ask, possibly the other way around—people are poorly nourished when carrying a huge load of parasites?

Hookworm infections could almost be regarded as one-component systems, for they do not involve any other host and depend entirely on our own behaviour; if we continue to foul the soil and walk barefooted we shall continue to keep *Ancylostoma* and its allies in business as nearly a billion of us continue to do. Even if safe disposal of faeces is not possible, as when mass movements of people are taking place, then a simple pair of sandals made from smooth-worn motorcar tyres will act as a perfectly satisfactory barrier. Such sandals are widely available and are cheap but people must be informed as to why they need to use them.

My colleague Professor Desmond Smyth told me some years ago of the curious story of the Turkana people in Northwest Kenya. These pastoral, cattle-owning people live in a region of desperate water shortage. Water is so scarce that they rely on their pet dogs for general cleaning purposes and have even trained them to clean the faces of their babies after meals. Not surprisingly a high proportion of these people suffer from hydatid cyst, many of them palpably so (GULLIVER & GULLIVER, 1953; NELSON & RAUSCH, 1963; O'LEARY, 1976; MATOSSIAN *et al.*, 1977).

Even when the life-history of the parasites is more complex as with *Schistosoma* spp. which, like the dragonfly flukes, require water snails if they are to complete their life-history, avoidance could be achieved by a fairly simple change in our own behaviour, primed by awareness. Why spend millions on trying to influence the ways of snails and flukes and leave our own ways untouched? Our own part in the cycle is as vital as any other part and often much more amenable to change. Awareness is the key—awareness of our own behaviour as well as that of the snails and parasites; awareness by the mothers who with their children perhaps make most contact with the danger-

ous watering places. Similarly with guinea-worm, we need only to teach people not to drink water containing water-fleas. A formidable task, admittedly, but so much simpler and safer than any other approach as I hope to show.

Thus far (with the exception of hookworm) we have been taking a brief look at systems that, although complex in themselves, resolve themselves into two component systems in terms of contact with and transfer to man. We eat uncooked flesh; we drink untreated water; we walk through or dip our arms into snail-ridden waters. There are other even simpler systems in which no host other than ourselves is involved. I have in mind that very important group of diseases leading to infantile gastro-enteritis and the fatal dehydration that accompanies it. Prevention of such infections often depends on simple behavioural changes. Equally or more important, however, avoidance of death resulting from these diseases also depends largely on ourselves; personal hygiene, water supply, breast feeding and the education of parents and older children (STEWART, 1984).

Three-component systems

Much more complex than any of these are what we might call the three-component systems in which the invertebrate host of the pathogen does not passively wait for us to make contact but actively seeks us out and injects the pathogen directly into our blood, often at night when we are asleep. I am, of course, referring to arthropod-borne disease: malaria, plague, trypanosomiasis, leishmaniasis, typhus, relapsing fever, yellow fever, dengue and other virus diseases, and the filariases that normally come to mind when we think of tropical diseases. For centuries, indeed for millenia, these arthropods were for the most part dismissed as nothing but a nuisance. To be sure, the complex life-history of a few had fascinated the natural historian and the beauties of others had satisfied our seemingly innate need to collect and classify. That insects could be responsible for great epidemics of human disease and indeed be responsible for the outcome of wars and even the overthrow of nations and the shaping of history never or rarely seems to have occurred to us; never, that is, till the historic discoveries at the turn of the century that gave rise to the logo of this distinguished Society with which we are all familiar. We are now approaching the turn of the *next* century and it is, I suggest, time for us to take stock.

A new dimension

The great discoveries were commemorated recently at a Centenary Symposium on medical entomology convened by Dr. M. W. Service, at which due honour was paid to the principal players in this drama (WILLMOTT, 1978). I do not propose to go over this important and exciting period again, except to emphasize that the momentous discoveries of the parts played by the other players in the drama, the ticks, mites, mosquitoes, fleas, bugs, sandflies, tsetse flies, horseflies, midges and so on brought to medicine, and to tropical medicine especially, an entirely new dimension. Paradoxically, this new dimension was seen as the chink in the armour, the weak point, the defective link in the chain that with a little hammering would now easily be broken or bent. We all knew that arthropods were small and relatively short lived. Small suggested to our anthropocentrically tuned minds something necessarily simple, something easily dispatched. Hopes were raised and early limited successes lent credence to these hopes.

Early hopes

Mosquitoes seemed particularly vulnerable for everyone knew that they needed water in which to breed. Deprive them of that resource or make it inaccessible and the diseases would disappear. The transmission of yellow fever was soon brought to an end in Cuba and in the Caribbean generally. Yellow fever and malaria that had wrought such havoc to those building the Panama Canal were both brought under control. The operations directed against the breeding places were carried out with military precision and thoroughness and with military ruthlessness too that would be hard to repeat today unless in the exigencies of war (war against fellow man, that is, not war against the mosquito). Later these methods were extended down the east coast towns of South America with outstanding success. Then, one Sunday morning in Brazil in 1930 Shannon noted strange anopheline larvae and correctly identified them as the African species *Anopheles gambiae* sensu lato. This invasion was successfully brought under control by the energy and again quasi-military methods of Fred Soper; the newly established species in South America was successfully eradicated. Our president rightly drew attention to this triumph in his presidential address last year. But luck was on Soper's side; he and his team, even with his characteristic energy, would probably have failed had he tackled *An. gambiae* on its home ground, where it would be able to call on vast reserves of genetic versatility. Some of the celebrated successes of Sir Malcom Watson in Malaya also owed much to luck.

I have made this diversion because it helps us to see now the general climate of optimism that prevailed during the early part of the century following the implication of insects in tropical medicine. It may help us also to put some of the early hopes in better perspective. Halfway through the century in question the focus of attack changed from larvae to adult mosquitoes as the new residual insecticides became available. This brought hope and a renewed impetus for it looked as if prevention of malaria at last could be extended to the rural areas where the bulk of the infections occurred. Far be it from me to go into the history of this exciting period; its spectacular successes have been well publicized and they rightly brought hope of a final eradication of malaria throughout the world (BRUCE-CHWATT, 1971; 1979). Alas, the insect vectors of malaria and other diseases were still regarded as the weak links in the cycles of transmission, whereas, to be wise after the event, the insects of course are the strong and hardest links in the various chains. That smallpox seems in the interim to have been eliminated is *inter alia* precisely because there is no insect link to complicate and strengthen the cycle. Whatever the reasons, the concept of eradication had to be dropped. Some attributed this to difficulties of administration particularly in an enormous landmass such as the continent of Africa that makes up some 22% of the land surface of the world and with a 1000 or so languages. Others attributed the failure to the

complexities and unexpected powers of developing resistance on the part of the insect. As is usual in such cases, probably both were to blame, if that is the right word.

For the record, I must state clearly that the attempt at eradication had to be made; it would, in my opinion, have been utterly criminal not to have attempted to harness these new hopeful chemicals. But insects have survived at least two cataclysmic periods both of which brought extinction to most forms of life at the time, one at the end of the Permian, another at the end of the Cretaceous. Perhaps it is not altogether surprising that they, so to speak, blinked off our insecticidal onslaught; individuals succumbed in their thousands, to be sure, but new populations soon built up from the less susceptible individuals, populations now thoroughly adapted to the new environment imposed on them by man.

The history of our fight against malaria highlights one of the reasons for our failure after almost a 100 years for, regrettably, as far as the so-called Third World is concerned, our efforts have largely failed. Everywhere we hear not only of the increased spread of resistance to insecticides, but also of the increased spread of resistance to drugs on the part of the parasites, for they too have been under-estimated. But there is another reason for our failure—one that I have emphasized before: while we continued to study the behaviour of the parasites and the insects that transmit so many of them with all the ingenuity and sophistication that we can muster, studying each down to molecular level, we utterly neglect the third factor in the equation—namely, the behaviour of man himself (GILLETT, 1971a, 1973a, b; 1975; 1979a). The malariogenic and other mosquito-borne disease-generating behaviour of man falls into two kinds; the provision of facilities for mosquito breeding and the provision of facilities for mosquito feeding. Let us consider first mosquito breeding.

Man-assisted breeding

There are two main malaria vectors in Africa; *Anopheles gambiae* s.l. and *An. funestus* s.l. *An. gambiae* s.l. will be found in every muddy pool whether large or small as long as it is exposed to the sun for much of the day. They will also be found in depressions choked with algae. Hence *An. gambiae* abound in any footprint whether of man or animal, every depression in dirt roads and paths, in borrow pits, in irrigation channels and so on. It is not my intention to list the typical breeding places of this dangerous and widespread group of species or to include every unusual or atypical place. Rather it is my purpose to point out or to remind ourselves that for the most part these breeding places are man-made. The remaining unnamed species of this complex, species D (DAVIDSON, 1973; WHITE, 1974; 1975), is, as far as we know, restricted to the hot spring area of the Semliki forest; this is clearly not man-made, but since no people actually live at the hot springs and they are normally never visited at night, species D falls outside the scope of this paper, although it must be admitted that when we were working in the forest at night around the hot springs in 1944 we caught more than 30,000 adults of species D in the act of attempting to feed on us, an average of 750 per night (HADDOW *et al.*, 1947). Apart from species D most members of the *An. gambiae* complex are hard to find away from human habitation or activity. Hippo footprints on the shores of a lake or river curtained from the sun by vast stands of papyrus (*Cyperus papyrus*) are usually free of *An. gambiae*. But as soon as man opens up the area as a cattle watering place or as a tsetse-free landing place, then these same footprints become choked with larvae of *An. gambiae*. The same may happen, sometimes with disastrous results, when some armchair theorist decides on a policy of destroying the harmless papyrus to make room for cash crops (GILLETT, 1975).

There is, as I have pointed out before, a direct and causal relation between the activity of man and gambiae-transmitted malaria. Public works, brick fields and the like have long been recognized as prime producers of this species (s.l.) and until the advent of DDT these used to be taught as such in the schools of tropical medicine. The subject disappeared from the syllabus as assuredly as did the strict aseptic drill in the operating theatre with the advent of antibiotics (GILLETT, 1973b). Away from the towns the situation in Africa today is much the same as it was 40 or 50 years ago: footprints, puddles, wells and crop irrigation combine to produce ideal conditions for *An. gambiae*.

In the towns, as far as malaria is concerned, conditions have tended to change for the better in recent years, although the development of vast urban areas has led to some unexpected consequences: in India and Pakistan, for example, *An. stephensi* has become adapted to breeding in wells, cisterns and other urban domestic containers (SERVICE, 1984). With some culicine species increased urbanization has tended to produce problems of enormous magnitude as the production and availability of canned and plastic packaged goods outstrips the means for their disposal (GRATZ, 1973). MATTINGLY (1962), who came to a simular conclusion attributed the increase also to the disregard of conventional control measures that followed the greater use of the new insecticides. The deep drainage channels alongside city streets originally designed to take storm water as an anti-malaria measure are rapidly becoming the permanent breeding places of *Culex quinquefasciatus* as the channels become choked with human sewage from the expanding urban population (MATTINGLY, 1962; GRATZ, 1973). It has been estimated that in Tanga, Tanzania, each person is subject to about 10,000 bites from *Cx. quinquefasciatus* each year. The infection rate with *W. bancrofti* is only about 0·23% but this means that, on average, the chance of receiving an infected bite is once every 16 days. All this is man-made. In the 1930s, when human activity was taught as an important factor in many of the cycles of infection of parasitic disease in the tropics, an example used to be given of a whole family that had been interred following an urban epidemic of yellow fever. On the head-stone stood a vase of flowers with the larvae of *Ae. aegypti* breeding merrily inside. Below the vase were written the words "Thy will be done". 50 years later flower vases in cemeteries continue to provide facilities for the breeding of *Ae. aegypti* and on a vast scale. BARRERA-RODRIQUEZ *et al.* (1979) studied the cemetery in Caracas. The cemetery is 75 ha and is surrounded by commercial and residential buildings. They found 190,000 flower

vases in which they estimated that some seven million 4th-instar larvae of *Ae. aegypti*, *Cx. quinquefasciatus* and *Cx. corniger* were present at any one time in the dry season and some 51 million in the rainy season. All this in the capital of a country lying within the yellow fever and dengue belt. Again, all of it man-made and, most astonishing, almost 80 years after the epic discoveries that occurred at the turn of the century (REED *et al.*, 1900) and well nigh a hundred years after the pioneering work of FINLAY (1886). The wet season estimate of numbers, which averaged 350 larvae per water-filled pot, seems high but RIOS *et al.* (1978) have shown that denser populations of *Ae. aegypti* can be supported when *Cx. quinquefasciatus* is also present, a most interesting and perhaps important finding.

In 1962 about 175,000 cases of *Ae. aegypti* transmitted virus disease occurred among children in Bangkok. A survey showed that man-made containers were producing nearly two million adult mosquitoes per day (GRATZ, 1973). I could go on with example after example: *An. albimanus* in the western hemisphere, *An. balabacensis* in the eastern hemisphere, *Ae. simpsoni* in Africa, *Cx. tarsalis* in the USA where western equine encephalomyelitis affects both horse and man. The disease, misery and economic loss resulting from these are not merely man-assisted, they are, for the most part, man-generated (GILLETT, 1979a).

Man-assisted feeding

Sir Francis Galton, in his book "The Art of Travel", published in 1872, wrote "I have been informed of a sportsman in Ceylon, who took with him into the woods a cot with a mosquito curtain, as a protection not only against insects, *but against malaria*" (my italics) but it is not clear if he really saw the true connection (GILLETT, 1979b). This simple device has been in use or at any rate available for the prevention of malaria for well over a century. When properly used it can give reliable protection. Yet today its use by the peasant community that still makes up some 90% or more of the population of the areas of special interest to us, this example of low technology fails to give protection since it is more often than not used in such a manner as actually to invite mosquitoes in rather than keep them out. In Uganda, in the 1930s and 40s, if I wanted to know what species of nocturnal man-biting mosquitoes were present in any given region I would simply go and collect *inside* the nets of the local people and sure enough there I would find fully gorged females of *An. funestus*, *An. gambiae*, *An. moucheti* or *An. pharoensis*, together with the usual culicines, *Mansonia africanus*, *M. uniformis* and *Coquillettidia fuscopennata* by the score. Indeed when the search was on in 1959 for the vector of the newly identified virus responsible for the huge and crippling epidemic of o'nyong-nyong we applied this principle and actually issued the local population both inside and outside the epidemic zone with nets acquired specifically for the purpose in the sure knowledge that they would be used in the customary mosquito-trap fashion (CORBET *et al.*, 1961).

Unfortunately, the mosquito net, although simple in the extreme, does require a modicum of sophistication if it is to be used effectively. Also, because it is easily damaged, it has to be repaired or renewed fairly frequently and this pushes up the total cost. Unless the people see for themselves an obvious advantage they are hardly likely to invest in a consumable article merely to avoid insects they have always had: mosquitoes, midges, sandflies and bugs are as much a part of their surroundings as the poor soil, the heat, the squalor, the poverty, the hunger and the monotony of the diet, the poor health, the long walk to school and back again each day, early death and the loss of children and, as always, the incessant rain or the seemingly never ending lack of it.

When we move a little up the poverty scale we find a house, roofed perhaps with flattened cans or even corrugated iron or tiles. But like its country counterpart the infrastructure is as often as not in a tumbledown state owing to the marauding attacks of termites. The windows, what there are of them, may be covered with metal or plastic screening but this is rusted or otherwise holed and like the mosquito nets let many mosquitoes in but impede the departure of the repletes. To screen a house is expensive and once it is known that it does not last it will be left out of the list of requirements or allowed to remain in its defective state with no thought of repair or renewal. A few sheets of cardboard or flattened cans may cover the larger holes or partly so but the smaller holes will remain intact, if that is the right word, while increasing in number. Any opening $>1{\cdot}4$ mm across will allow mosquitoes to "break in" and deposit their deadly or crippling load (depending largely on the age of the recipient).

Of course the breeding of many species of mosquito is often right outside our influence. *An. funestus* s.l. and *An. moucheti* breed among the emergent and floating vegetation at the edges of waterways, even along the shady edges of comparatively large rivers with considerable movement of the water, provided there is sufficient vegetation of the right type along or near the banks. But these too are mostly endophilic feeders and so, although we do nothing to encourage their breeding we can and do, by improper use of nets and screening, invite them to feed on us once the adult stage has been reached. But feeding of mosquitoes, too, can be outside our capacity to prevent, particularly the feeding of diurnally active species: *Ae. simpsoni* may feed on us as we work in bright sunshine in a maize field or in fleckered sunshine in a banana grove, feeding mostly on our scalps and remaining out of sight to ourselves and even to our companions as the black and silver mosquitoes burrow down to reach the skin through a thick thatch of hair (GILLETT, 1971a). *Eretmapodites chrysogaster* will attack us in forest during the daytime but they too remain largely out of sight because they feed almost entirely below knee-level (HADDOW, 1946). The former species can infect us with the virus of yellow fever, the latter with the virus of Rift Valley fever (MAHAFFY *et al.*, 1942; SMITHBURN *et al.*, 1948, 1949).

It is unnecessary for me to point out that many other insect vectors of disease are largely outside our influence either in breeding or feeding or both. One has only to think of species of *Simulium*, *Culicoides*, *Phlebotomus*, *Lutzomyia*, *Psychodopygus*, *Glossina* and *Chrysops*. But I am concerned with those that are or can come under the influence of ourselves. If I have

tended to paint a simplistic picture of a very complex subject it is because this aspect of infection by bloodsucking arthropods is these days usually disregarded or played down as of secondary importance. It is true that it is sometimes difficult to draw the line between aetiologies in which human behaviour is an important factor and those in which it is relatively or entirely unimportant. Also there is considerable difference between disease produced by the behaviour of the individual person and that resulting from community practice or government policy, although both are clearly examples of man-made disease. In Afghanistan irrigation in the Kunduz Valley has led to a huge increase in the numbers of man-biting *An. hyrcanus* and *An. pulcherimus* (SERVICE, 1984).

A well known and much honoured scientist once remarked how fortunate it was that bubonic plague had never occurred in Uganda. But this person arrived in Uganda just as plague, that formerly gripped the eastern parts of the country, mysteriously disappeared in the early 1940s. Uganda, in those days flourished financially mainly because of two introduced cash crops: coffee and cotton, both of which brought great wealth to the country, but the latter also increased the populations of rats. Almost every peasant householder had his patch of coffee or cotton or even both, according to his location in respect to rainfall and to edaphic and indeed to general pedogenic factors.

The disappearance of plague from Uganda coincided with the introduction of antibiotics and DDT but probably had nothing to do with either, just as the virtual disappearance of malaria from the USA in the 1950s (which stood at 4 million cases per year in the 1930s) had little, if anything to do with the new anti-malarials and DDT. I well remember L. W. Hackett emphasizing this point when I was studying epidemiology at Berkeley in 1955. In the USA, as in Western Europe, changes in the ways of man were probably involved. Perhaps some of us should be making a special study of the factors involved in bringing about these great recessions with as much energy as we bring to the study of the factors responsible for the establishment of endemic and epidemic conditions (BRUCE-CHWATT & DE ZULUETA, 1980).

I have had to be selective and space allows me merely to touch on what is a vast subject. I have concentrated mostly on Africa because I know parts of that continent well and because the problems there are especially complex. If we accept that a part of human disease, particularly what is usually known as parasitic disease, results from our own behaviour we have also to accept that the approach to this problem has to be social rather than medical, entomological or parasitological. This is understandably difficult to accept by many. When I earlier put forward some of these ideas one distinguished worker for whom I had and still have the highest regard, but *qui sine nomine manere licet*, complained that the policy I was advocating would lead to unemployment of entomologists. But what I was suggesting was not something to replace entomology, parasitology, immunology, biochemistry, cytogenetics and molecular biology but something to be added to these important studies. The scheme that I put forward (GILLETT, 1971a, b; 1973a, b; 1975; 1979a) has to be seen against the backdrop of the 1 to 1·5 million people who die of malaria each year, young people for the most part, mostly under 15 years of age who die without ever having the chance to fulfil themselves, while 343 million soldier on under the malarial yoke. The scheme has to be seen against the 1000 million people infected with *Ascaris* worms, sometimes packing the gut so tightly as to cause serious obstruction; I have seen adults and children stop by the roadside while they pass 20 cm roundworms through the mouth and nose; ASH *et al.* (1984) record a boy of 10 years vomiting and otherwise passing 175 such worms. It is estimated that 3000 million people (a very significant proportion of the human species) suffer from nematode, cestode and trematode infections; these are in addition to the 200 million suffering from filarial and the 126 million suffering from schistosomal infections respectively. Over the past 13 years I have been suggesting that the time is now ripe for an entirely new approach to be made in the prevention of tropical disease and that this would have to fall into two phases: (i) in-depth studies of human behavioural traits that predispose to human disease and (ii) the spread of information (based on the data gained by (i)) using the mass media to get into peoples homes. I published these views in a book (GILLETT, 1971) and first gave them in public the same year at a SEATO meeting in Bangkok. I enlarged on these views at a workshop meeting in Singapore the following year, at which was present a senior member of WHO (GILLETT, 1971b, 1973a). I enlarged on them still further in subsequent publications (GILLETT, 1973b, 1975, 1979a).

Collection and collation of data

It is gratifying to see WHO now concerning itself with both these phases. The first phase is being taken up as a part of the Special Programme for Research and Training in Tropical Diseases and a beginning of the second phase or a suggestion of it at least, is included in a WHO Technical Report (1983). I had supposed that the first phase would be studied by the universities and schools of tropical medicine but if it can be planned under a single conceptual framework by WHO then obviously this is clearly to the good. The UNDP/World Bank/WHO programme rightly concentrates, in the first instance, on malaria, schistosomiasis, filariasis, guinea-worm, African and Tropical American trypanosomiasis, leishmaniasis and leprosy. The anti-leprosy campaign using dapsone failed, incidentally, largely owing to human behavioural traits. As so often, patients would cease their treatment as soon as they themselves recognized a remission of the overt symptoms; this, as pointed out by MACKENZIE (1984), has now led to wholesale drug resistance and ruined what at first seemed so hopeful. In the same way programmes of chloroquine protection against malaria have been sabotaged by the behaviour of the very people the programmes were designed to protect (MACCORMACK & LWIHULA, 1983).

The UNDP/World Bank/WHO programme sees hope in control through modification of man's behaviour in all the above except, apparently, for leishmaniasis. Perhaps there would be some hope for the control of this disease too in certain regions if we knew what aspects of the interaction between man,

dog and other domestic animals (including rats) encouraged breeding and feeding of sandflies. In India and Bangladesh, where man appears to be the only vertebrate host and in other parts where the main vertebrate reservoirs are in non-domestic mammals, the methods of study would have to be quite different. The least hopeful of the WHO list would appear to me to be onchocerciasis, for man's part is much less obvious, if indeed it exists at all.

I am sorry to see the much simpler systems excluded from the preliminary study now being undertaken: hookworm, roundworm and flukes other than schistosomes. If WHO wishes to back another winner to add to its triumphant smallpox score then, surely, hookworm is the candidate. At any rate a start is now being made on the first phase of the scheme, namely the collection and collation of data on the disease-producing-habits of man and I will pass on to the much more difficult task of phase two: how these habits may be changed.

Changing the behaviour of man

When we have completed the main studies on the disease producing or pathopoeic behaviour of our own species and duly categorized and classified this behaviour not only for each disease but in each locality (for even when sociological and religious customs are the same, local ecological conditions may be entirely different, and conversely, when ecological conditions are the same, sociological and/or religious customs may be entirely different), the next step must surely be to explore the possibility of introducing simple measures that will change this behaviour. It is, of course, one thing to write this and quite another to carry any meaningful programme through. Anyone with personal experience of conditions in tropical countries where the bulk of the population is made up of subsistence peasant farmers, most of whom are just above or below the 'breadline', will know at once what a preposterous suggestion I am making. Even when the connection between man's ways and disease is straighforward and the change simple, as with hookworm, resistance to change, in other than totalitarian states, would be enormous. I am aware of this and also how much more difficult to bring about meaningful changes in the more complex host-parasite systems. The enormous size of the continent of Africa and the vast human population in south-east Asia would appear to waft any hope of change into pipedream fantasy.

This seemingly overwhelming difficulty amounting to what looks like impossibility would have to be accepted but for one new dimension: the development of communication through mass media. This allows simultaneous entry into the very homes of the people. I drew attention to the possibilities that this new development offered and the revolution it could bring to our approach to these problems in the series of publications referred to above. In most of these I advocated an indirect approach rather than direct preaching; an indirect approach using stories about realistic ordinary people, people with whom the local population could identify. This, of course, sounds far removed from immunology, genetic engineering and other high level topics customarily discussed in this Society. Why stories instead of simply telling them the facts of life and of death? Simply because people will not respond to hearing about facts which to them seem to have no bearing on everyday life. But stories of people they can admire, love and hate, people who succeed in matters of making money and sex because they are free from the parasitic burden that weighs down their rivals—these will get across quickly. People tend to copy those they admire.

I do not wish to dwell on this aspect since I have said it all before. It is, however, encouraging to note that WHO is now suggesting a widening of the use of the mass media and even go so far as to suggest the telling of stories to get the message across (WHO, 1983). Indeed, impromptu drama is already being used to convey important ideas of health and prevention of disease in Zambia by RAU (1978); drama, he says, provides entertainment for the village and commonality of emotional experience, while containing a message about desirable change. But how much more effective if we make use of developments *we already have* and convey the message to dozens of villages simulanteously. But, say the sceptics, this is all very well but the cost would be prohibitive.

For those of us who must think of everything in terms of cost effectiveness I would ask how much is the cost of a human life? I am quite sure that what I am suggesting would cost, in terms of money, more than a million dollars per day i.e., one thousandth part of defence spending seven years ago (GILLETT, 1979a). Such spending, and it could cost several times this amount, is quite impossible on a national scale. But if we *really mean* health for all mankind by the year 2000 (or, say, even 2050) then this kind of spending will have to be undertaken at the supranational level.

WHO was set up to deal with conditions as they existed 40 years ago. But a revolution in communication has since taken place and this new technology should now be embraced by WHO to replace the other methods which time has shown to be inadequate to deal with the problem. Indeed recent developments in communication technology greatly increase the scope and feasibility of this appraoch. Broadcast via artificial satellite removes the need for multiple transmitters (GILLETT, 1979a) and the new Dolby memory-chip technology would (according to a recent technical report, *New Scientist*, 1984) allow millions of receivers to be sold at low cost.

Can I really picture a television set or even a radio receiver in every Karamajong or Turkana household and being maintained in working order? No, I cannot; but I can imagine one in the local beer-house and in the local school. I can imagine their spread from these gathering grounds to the home in the fullness of time. In Thailand television masts sprout from the roofs of houses in the most unlikely places; even the barges that ply up and down the great rivers sport a much branched mast from the covered permanent quarters in the stern of each craft. A huge, probably colour, set dominates the neat and spotless houses and a tiny set resides on the counter of the shops to keep the vendors contented between customers. Thailand is, of course, a comparatively rich country compared with all but those of the far north or southern tip of Africa. Thailand, too, by comparison with the huge bulk of Africa is already well developed. Nevertheless it shows what can be done even in a largely peasant farming community. In Africa there are more than 50

separate countries and, as I say, more than 1000 languages. All this puts the problem on a vastly different scale or, as I prefer to think of it, presents an enormous challenge. It is recognized that, like the attempt at eradication through the use of insecticides, it would be no good reducing disease in one area only to have it reintroduced on all its frontiers. The challenge is immense and the odds positively frightening. I do not think it can be tackled merely as a sideline or adjunct to other approaches. It must be planned, tackled and carried through as a main, entirely separate and new approach manned by a huge, devoted and energetic team under the aegis of a supranational world authority, which could either be a new and separate branch of WHO or indeed a re-constituted WHO itself. Or, dare I say it, even a re-constituted WHO and FAO combined, for the problems of soil, food production and creeping famine are probably even greater and could also be tackled through the mass media. It has to be done on the grand scale after a period of wholesale collection of data (much of which already exists). It has to be done by an enlightened world that sees human life on the planet as a single problem. It has to be utterly free from creed and petty political prejudice except for the creed of "Let us help rid ourselves of the terrible burdens of parasitic and other man-made disease".

It is now more than 10 years since I wrote that this new phase is for 50 years time. That may have seemed pessimistic then but one fifth of that time has already passed. I see this as a completely new phase not, as I have stressed earlier, instead of other approaches but in addition to them. Immunology and the hope of vaccination against malaria (clearly the greatest problem) may have delayed the implementation of this new approach. Personally, much as I admire the exciting immunological work now being done, I do not myself see vaccination as being a practical solution unless the programme is also harnessed to communication through the mass media as I am suggesting. Otherwise it might protect visitors to malarious regions and, heaven forbid, be helpful in the event of war. Nor can I see the breeding or releasing of predators or genetic variants as anything but a local answer over a short period of time.

We have had nearly 100 years to try the old ways. Are we going to continue to put off the new phase, i.e., man's active but unthinking part in the maintenance of cycles of transmission, while we forever hope for some miracle cure or preventive? I suggest that we must start now (not as a sideline but as a major new activity supported by new departments in universities) first to collect the data and then to plan the programmes of whatever sort that are best calculated to rid us of these pestilences. During the 100 years we *had* to try these short cuts. But now, not only do we have the new tools, they are actually improving and becoming more suitable for our purposes as each year passes. Let us use these tools to contact the people who so often are the forgotten component in the cycles of infection we strive to prevent. We seem willing to pump tonnes of chemicals into human populations with little but local and temporary results to show for it but reluctant to pump knowledge and understanding to the people. If profit is the driving force then perhaps it is time for a change in emphasis from chemical industry to that of the mass media. We should plan to start now even if it means wholesale reorganization on a huge scale, or be judged on why we failed to act.

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