[Date]

Dear [Diplomat],

We are a group of scientists and doctors who are writing you on account of your participation in the ongoing treaty negotiations of the United Nations Environment Program (UNEP) aimed at eliminating Persistent Organic Pollutants, or POPs.

You are no doubt aware that one of substances the POPs Treaty seeks to ban from future use is DDT, and that such a ban is supported by most wealthy Western countries and several environmental NGOs. However, you may not be aware that DDT is also a critical tool in the fight against malaria, which remains a terrible scourge of the developing world.

As people who have dedicated our careers to health in the developing world, we wish your country to carefully scrutinize any treaty proposal which could aggravate the burden of malaria upon your citizens. Although we entirely agree that DDT should one day be eliminated because of its known environmental effects, we also believe that human life must not be endangered in reaching that goal.

In our view, setting a deadline for the elimination of DDT -- whether that deadline is in 2007 or some other date -- unacceptably endangers health in countries with malaria. We simply cannot be sure when DDT will no longer be necessary for malaria control. Yet to act ethically, we must know, with the greatest of certainty, that DDT is unnecessary before we ban it.

Despite our oppostion to a deadline, we agree humanity must find and implement alternatives to DDT as quickly as possible. To be satisfactory, these alternatives must be: (1) equally effective, (2) equally inexpensive, and (3) able to replace DDT wherever it is now used or may be needed in the future for malaria control. This will require scientific and technical resources that developing countries lack, but which Western countries can offer.

We therefore advocate eliminating DDT in two phases. Phase one would immediately ban DDT use in agriculture, but would make an exception for the life-saving use of DDT in malaria control. Phase two would extend the ban to public health uses of DDT, but ONLY if Western countries research and successfully implement effective, affordable alternatives to replace DDT. This two-phase plan, we emphasize, does NOT rule out a DDT ban, but makes it contingent on Western countries funding global efforts to research, develop and deliver satisfactory alternatives to control malaria.

As a negotiator of the POPs Treaty, we believe it is helpful for you to understand the science and politics of DDT and malaria. In this letter, we explain why we believe DDT is a legitimate tool of malaria control, and why a two-phase ban is justified. It is our wish that you find this information useful in pressuring developed states to negotiate a POPs Treaty that respects both the environment and human health.

Why do we need to worry about malaria in eliminating DDT?

Malaria is responsible for about 500 million clinical cases of disease and about 2.7 million deaths a year, mostly those of children under five and pregnant women[1]. In Sub-Saharan Africa alone, malaria destroys 70% more years of life than do *all* cancers in *all* developed countries combined[2]. It therefore follows that even a tiny loss in the efficiency of a national malaria control program, occasioned by the loss of DDT or otherwise, would result in a tremendous number of additional deaths from the disease.

Malaria is a serious infection of *Plasmodium* parasites, which are spread by the bite of *Anopheles* mosquitoes. For this reason, nearly all malaria control strategies target either the parasite or the mosquito in some way. This is easier said than done. There are no fewer than four species of *Plasmodium* that infect people, each with thousands of genetic variants, and about thirty-five different species of malaria-transmitting mosquitoes. It is the complex diversity of the parasites, the mosquitoes, the local ecologies, socio-economic conditions, and human responses to disease that conspire to make malaria notoriously hard to control. As a result, there is no single prescription, not even DDT, which can successfully control malaria in all locales.

Yet DDT is still a very useful tool for malaria control in some places. Once or twice a year, DDT is applied to the interior walls only of a house. No spraying is done outdoors. Wall spraying is sufficient because mosquitoes tend to feed at night, when people are also indoors. If a mosquito is "DDT sensitive", the small amount of DDT it absorbs through its feet when it lands on a sprayed wall will kill it within a few minutes. If a mosquito is "DDT resistant", it will not die, but will be irritated by the DDT and fly outside. This irritant effect means that DDT continues to be moderately effective even in locales where DDT resistance is considered widespread[3]. In either case, whether DDT kills or irritates the mosquito, the opportunity for the mosquito to bite a person with malaria and carry the infection to another person is lost.

World Health Organization scientists have called indoor house spraying "the most easily applicable large-scale transmission control measure" for malaria[4]. DDT is often the insecticide of choice because it is both very cheap and effective. Data from the Pan-American Health Organization show that where South American countries stopped spraying houses with DDT, their rates of malaria increased, often dramatically[5]. Conversely, the single country to increase DDT house spraying (Ecuador) was also the only one to significantly reduce its rate of malaria (by 61% overall)[6].

But leaving aside its effectiveness, what makes DDT attractive is its very low cost. Although exact data on cost per life saved are lacking, there is no doubt that indoor house spraying is among the most cost-effective malaria control strategies. For countries with small health budgets and worsening malaria problems, there may be

few, if any, practical alternatives, which may be a reason to immediately increase rather than eliminate DDT use. Thus, any treaty to ban DDT must be weighed very carefully, as against the uncertain cost of other strategies to control malaria, and the loss of human lives if these strategies are too expensive to be implemented.

Isn't DDT so dangerous to health that it outweighs any benefit in malaria control?

There is no doubt that there are health risks associated with DDT use. For this reason, some condemn DDT outright. This is inappropriate, because the relevant question is not whether DDT can pose health risks (it can), but whether these risks outweigh the tremendous public health benefits of DDT for malaria control (they do not).

Of all the criticisms one can make about DDT for which there is evidence, the worst is that it possibly causes cancer. This is the conclusion of the International Agency for Research on Cancer (a branch of the WHO), which classifies DDT in the lowest category of substances for which there is a definable cancer risk: DDT is "possibly carcinogenic to humans"[7]. The IARC rates DDT as being "possibly carcinogenic" because it found that there was sufficient evidence of risk in animals, but inadequate evidence in humans[8].

While it sounds worrisome that DDT is "possibly carcinogenic", we emphasize that this risk must be balanced against the public health benefits. It is only if the health risks of DDT outweigh the benefits of DDT for malaria control that we should consider not using it. Balancing health risks and benefits like this is not unusual. For instance, several prescription drugs are classified by the IARC as "possibly carcinogenic", "probably carcinogenic", and even "carcinogenic in humans" – but these drugs are still used to treat life-threatening diseases because the health benefits of a cure far outweigh the cancer risk[9]. The same is true of DDT.

Another possible risk of DDT is that it may shorten the duration of lactation in women. This is the view of one group of scientists who found that DDE (a product of DDT decay in the environment) reduced lactation time in Mexican women[10]. As of today, this conclusion has yet to be confirmed by a second or third group of scientists, as is necessary to have confidence in this result. This is especially so because experiments in rats contradict the human studies, and fail to show that DDE affects lactation time[11].

But even if DDT shortens lactation time, this too must balanced against the benefits of DDT for malaria control. The same scientists who found reduced lactation in Mexican women also noted an "absence of any apparent effect on the health of the children"[12]. That is, either DDT made no difference to childhood health, or made so little difference that the scientists overlooked it. Such a risk is insignificant alongside the 2 million childhood deaths caused by malaria yearly.

Finally, some critics, notably the World Wildlife Fund (WWF), suggest that DDT may disrupt hormones in the human body and adversely affect our immune and nervous systems. But the scientific evidence of such harm is scanty, if there is any harm at all. WWF itself admits that "the magnitude of immune suppression...is largely unknown", and that "direct effects to humans [nervous system] are difficult to assess"[13].

It would be ironic indeed if in running from the bogeyman of these speculative health risks, we banned DDT and ran directly into the familiar and deadly hands of malaria. Wisdom demands that one first *study* and *prove* that risks of hormonal disruption outweigh the benefits of malaria control. Until this is done, the only sensible conclusion is that all the health risks of DDT are outweighed by the concrete, demonstrable health benefits of DDT use in malaria control.

Why is DDT being attacked as a health risk?

The question of DDT's impact on human health is controversial because of the impact of DDT on wildlife. In their effort to bring about a total ban on DDT, it is unfortunate that some environmentalists have exaggerated the health risks of DDT.

A report distributed by World Wildlife Fund at the POPs Treaty negotiations shows how the science of DDT and health can be misrepresented in the endeavour to protect wildlife[14]. The report appears well researched and credible, in part because it cites a long list of scientific studies. But when one reads these studies, it becomes clear that WWF has inaccurately conveyed the conclusions of some studies to discredit DDT. This can be surprisingly blatant. Consider this quote from the WWF report:

> "Some studies have found correlations between higher concentrations of DDT and DDE and women who had developed breast cancer, while others have not."

To back the first part of this statement, WWF cites two studies which it alleges demonstrate a correlation between these substances and breast cancer[15]. However, when one turns to the more recent of these studies, the scientists actually conclude just the opposite. In their own words:

> "[The] lack of association between exposure to organochlorines [*i.e.* DDE] and breast cancer was present regardless of length of follow-up, year of diagnosis, or the case patient's menopausal and estrogen-receptor status. CONCLUSION: The data do not support the hypothesis that exposure to DDE and PCBs increases risk of breast cancer."

In essence, WWF has cited a study that says "there is no association between DDE and breast cancer", as support for its position that DDE *creates* a risk for breast cancer. Needless to say, this is scientifically misleading, and dreadfully wrong.

WWF also misleads by concealing the fact that a much greater number of studies contradict its position than support it, and that study after study finds *no risk* of breast cancer associated with DDT or DDE exposure. WWF cites only a single negative study[16], but at least five studies reached this conclusion in 1997 alone[17]. This supposed breast cancer risk fails to be materialize even in areas where DDT is used for malaria control, as the authors of a recent study from Vietnam conclude:

> "[Our] results suggest that recent and past exposure to p,p'-DDT does not play an important role in the [cause] of breast cancer among women living in a country with a tropical climate where insecticide use for mosquito control is common."[18]

Thus, considering the many studies that have been done on the question, it is doubtful that there is any association between DDT exposure and the risk of breast cancer.

In summary, we would advise developing countries to be skeptical of claims that DDT is destroying the health of their people. Sweeping aside the unfortunate scientific misrepresentations, at worst there are small health risks, and very large health benefits to DDT house spraying. We therefore have no doubt that it would be a terrible error to eliminate DDT, which probably saves hundreds of thousands of lives a year from malaria.

What about the environmental dangers of DDT on wildlife?

It cannot be seriously disputed that DDT has devastated some wildlife populations, such as birds of prey. The effects of agricultural DDT overuse in the 1950s and 1960s on these populations are reversing only now. We agree this is a good reason to eventually eliminate DDT. However, the urgency with which DDT is eliminated in public health uses must not be an overreaction to the mistakes of agriculture, given the small amount of DDT that indoor house spraying requires.

The environmental impact of DDT use in agriculture and malaria control are not at all comparable. Indoor house spraying needs 2 g/m^2 of DDT once or twice a year, or about 470 g for a large house. Quite a lot of this DDT will remain indoors and never enter the environment. By contrast, a single 40 hectare field of cotton requires 795 kg of DDT per growing season – as much as 1700 times as much DDT, sprayed directly into the environment[19]. Spraying all the high-risk houses in a small country like Guyana is estimated to require only as much DDT as for a 4 km^2 cotton field[20].

Plainly, it is the agricultural uses of DDT which are a major environmental danger and which must be immediately banned. There is far less urgency in banning public health uses of DDT. Although this should eventually be done, we can safely postpone doing so until satisfactory alternatives to DDT are found and

implemented. To do otherwise, or to tie DDT elimination to an deadline that may pass without implementation of alternatives, is to endanger the health of the developing world for an environmental goal.

What are the alternatives to DDT and indoor spraying, and are they practical?

Suppose that DDT were banned today and it became necessary to adopt alternative strategies for malaria control. We would find, broadly speaking, that we had two choices:

(1) continue house spraying, but use insecticides other than DDT; or

(2) abandon house spraying of insecticides altogether in favor of non-chemical malaria control strategies.

Having said this, not all alternatives are equally attractive as DDT. We would therefore need to ask three questions:

(1) Is the alternative equally affordable as DDT house spraying?

(2) Is the alternative equally effective as DDT house spraying?

(3) Is the alternative equally safe as DDT for human health?

Of course, we would want to reject unsafe alternatives. We would also want alternatives to prevent the same number of deadly or disabling malaria cases per dollar spent. In short, we would want *safe* alternatives that are equally cost-effective as DDT. Cost-effectiveness is supremely critical to developing countries that have very little money to spend on malaria control.

With this to guide us, we can now consider some alternatives.

(1) Alternative insecticides

Leaving aside DDT, there are three families of insecticides used in malaria control: the carbamates, the organophosphates, and the pyrethroids. The first two are dangerous to handle and require special protective equipment that is not widely available in developing countries, so they are not practical alternatives. That leaves only the pyrethroids to substitute for DDT, although some worry that they are hazardous to health as well[21].

At this time, there is reason to be enthusiastic about the pyrethroids. Like DDT, pyrethroids require little protective equipment and are safe in ordinary use. There is, however, controversy as to their cost-effectiveness. Although pyrethroids cost

very much more per kilo than DDT, one uses less of them to spray a house[22]. Taking this into account, a recent World Health Organization study estimated pyrethroids cost over three times as much as DDT in actual use[23]. On the other hand, one study from Brazil suggests that pyrethroids can equal or surpass DDT for cost-effectiveness in house spraying[24]. All in all, the evidence is unclear.

However, even if pyrethroid house spraying were comparably cost-effective as DDT in one or a few cases, this does not mean that it will be in all cases, or that DDT is no longer needed. The problem, as always, is the tremendous diversity of malaria – four *Plasmodium* species; thirty-five species of malaria-transmitting mosquitoes; and different local conditions everywhere – a diversity so great that it is dangerous to say, after only a few studies, that pyrethroids can always substitute for DDT's remarkable cost-effectiveness. For instance, if we ban DDT, what would we use in locales where mosquitoes are resistant to pyrethroids? Alternating between DDT and pyrethroids can avoid this resistance in the first place. In short, it would be absolutely imprudent to have only the single arrow of pyrethroids in our quiver to fight malaria.

The diversity of malaria also requires that we be cautious with pyrethroid-based metho other than indoor house spraying. Scientists have tried hanging pyrethroid-dipped cloths over doors and windows, or soaking mosquito bednets in pyrethroids. Sometimes these strategies are comparably cost-effective as DDT house spraying[25]. But again, success depends on the local ecology, mosquitoes, and socio-economic factors. Take pyrethroid-dipped bednets: these can dramatically reduce childhood deaths from malaria. But how can nets ever work in areas where people are too poor to buy nets (at $5-10 each); how can a net help where the local climate makes it unbearably hot to sleep under a net[26]?

While we believe the pyrethroids could one day largely substitute for DDT, we are not prepared to gamble with human lives by abandoning DDT outright. The diversity of malaria demands that we maintain an equal diversity of control strategies to fight the disease. If the world banned DDT today and later found that pyrethroids were sometimes, but not always, equally cost-effective or useful, the cost of this "mistake" in human lives would be too awful to contemplate.

(2) Alternatives other than insecticides

Insecticides are not the only way to control malaria. Drugs, vaccines and environmental modifications can work to varying degrees. As always, which strategies work best depends on the local features of the disease.

The difficulty with these options again is cost-effectiveness. Decades ago, a very inexpensive drug known as chloroquine was used, often together with DDT, in national campaigns against malaria. Today, chloroquine is increasingly ineffective throughout the world, and the replacement drugs are too expensive for many

people in developing countries[27]. Improving this situation will require a major, new committment from technologically developed countries. *Not one* major western pharmaceutical company is researching drugs for malaria[28], and the world's most productive malaria drug laboratory (belonging to the US Army) is having its budget cut[29]. In short, the future of malaria drugs remains questionable so long as developed countries do little to support drug research.

Vaccines are even less promising in the foreseeable future. Despite what the press sometimes reports, there is no commercial malaria vaccine. A few vaccines have been tried in humans, but they all have severe limitations: they only work against malaria strains of a particular region (a global vaccine doesn't exist); and they protect only about 30% of those vaccinated from disease, for a year or two at most. Technology has a very long way to go before vaccines are practical tools of malaria control[30], and at the current, poor level of research funding, developed countries are barely advancing vaccine technology[31]. Even if scientists tomorrow discovered a cheap, effective vaccine that gave lifelong protection (a huge "if") on past experience it would take a decade, or decades, to vaccinate people worldwide[32].

Finally, there is environmental control for malaria. World Wildlife Fund advocates planting trees to dry out wet areas, and introducing fish that eat mosquitoes, among other ideas[33]. Environmental controls are probably best suited to areas where malaria transmission is moderate -- but much of Africa, Asia and South America is not like this. Where people receive hundreds of infected mosquito bites yearly, or the wet season brings great monsoons, environmental controls are likely to be overwhelmed. And even where they work, environmental controls can be very expensive[34]. Thus, while environmental controls deserve more research, they cannot presently substitute for DDT.

CONCLUSIONS AND RECOMMENDATIONS

Today, there are no alternatives that can substitute for DDT in all cases. This is because of the diversity of the disease. There is no doubt that *some* alternatives can substitute in *some* areas, or even improve on DDT in other areas, but we cannot be sure that if we ban DDT there will always be an effective and affordable alternative. Yet there are good environmental reasons to eliminate DDT as soon as possible. The essential matter, therefore, is to test and implement alternatives *before* a DDT ban comes into force. Otherwise, we are gambling with human lives.

Developing countries should consider that Western countries have an ethical duty to research and implement these alternatives. A 1996 study put total global spending on malaria research at only $84 million[35]. For the price of only a single Stealth Bomber (the United States has twenty), the global malaria research budget could be sustained for two decades -- an interval in which over 50 million people will die from the disease. Other Western countries are equally guilty of neglecting malaria research.

If Western countries do not commit the resources to test pyrethroids, develop malaria vaccines, distribute drugs, or provide the tropical world with bednets, why should they dictate the terms of a DDT ban? Western countries want a DDT ban because DDT is transported by atmospheric phenomena to northern latitudes, and it is there that the environmental problems are most serious. They should, accordingly, pay for it. We recommend that African countries reject any firm timeline to ban DDT, whether in 2007 or at a later date, unless given guaranteed funding to develop and implement alternatives to DDT for public health. Funding under the POPs Treaty should support research and control efforts in developed and developing countries alike, and should include:

1. Biomedical research to develop drugs and vaccines.

2. Development aid to make future drugs or vaccines affordable in the developing world.

3. Development aid to finance alternatives such as pyrethroids or bednets.

4. Technical aid to train health workers in the safe handling and use of alternatives such as pyrethroids.

5. Clinical research and disease surveillance to prove that whatever alternatives a country adopts in place of DDT are equally effective.

It will take all these steps to conquer malaria and ban DDT safely. Please demand this in the POPs Treaty negotiations.

We wish you the best of luck in defending your country's interests in the POPs Treaty negotiations, and hope our information has been helpful. We would also be very glad to hear from you, and to work with you on developing your country's negotiating position on DDT. Please do not hesitate to write us if we may be of assistance.

Sincerely,

[Names of Signatories]

REFERENCES

[i] World Health Organization, The World Health Report 1996 (WHO, Geneva, 1996), p. 47.

[i] World Bank data, as tabulated in World Development Report 1993: Investing in Health (Oxford University Press, Oxford, 1993), p. 216-9.

[i] Roberts, D. and Andre R.G. (1994), "Insecticide resistance issues in vector-borne disease control", *American Journal of Tropical Medicine and Hygiene* 50:21-34.

[i] J.A. Nájera, R.L. Kouznetov and C. Delacollette, Malaria Epidemics: Detection and Control, Forecasting and Prevention (World Health Organization, Division of Control of Tropical Diseases, WHO/MAL/98.1084/English), p. 39. The authors are referring to indoor house spraying generally.

[i] J. Mouchet *et al.* (1998), "Evolution of malaria in Africa for the past 40 years: impact of climatic and human factors", *Journal of the American Mosquito Control Association* 14(2):121-30; D. Roberts *et al.* (1997), "DDT, global strategies and a malaria control crisis in South America", *Emerging Infectious Diseases* 3(3):295-302, available at http://www.cdc.gov/ncidod/EID/vol3no3/roberts.htm (no period).

[i] Ibid.

[i] International Agency for Research on Cancer, World Health Organization, DDT and Associated Compounds, IARC Monographs volume 53 (1991). Updated conclusions (1997) appear on the internet at http://193.51.164.11/htdocs/Monographs/Vol53/04-DDT.HTM (no period).

[i] DDT is therefore less of a cancer risk than other POPs such as dioxin, which is "carcinogenic to humans", or PCB, which is "probably carcinogenic to humans".

[i] The following are examples of "possibly carcinogenic" drugs: Bleomycin (an anti-cancer drug), Metronidazole (an anti-parasitic drug), Phenytoin (an anti-convulsant); and Progestogen (a contraceptive). There are also "probably carcinogenic" drugs: Chloramphenicol (an antibiotic); Cisplatin (an anti-cancer drug). Finally, there drugs that are definitely "carcinogenic in humans": Chlorambucil (an anti-cancer drug); Ciclosporin (a drug for organ transplants); Methoxsalen (a skin drug).

[i] Gladen, B.C. and Rogan W.J. (1995), "DDE and shortened duration of lactation in a northern Mexican town", *American Journal of Public Health* 85(4):504-8.

[i] Kornbrust, D. *et al.* (1986), "Effects of 1,1-dichloro-2,2-bis[p-chlorophenyl]ethylene (DDE) on lactation in rats", *Journal of Toxicology and Environmental Health* 17(1):23-36.

[i] Rogan, W.J. *et al.* (1987), "Polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethene (DDE) in human milk: effects on growth, morbidity, and duration of lactation", *American Journal of Public Health* 77(10):1294-1297.

[i] World Wildlife Fund, Resolving the DDT Dilemma: Protecting Biodiversity and Human Health (Toronto and Washington DC, 1998), pp. 12-15.

[i] Ibid.

[i] Wolff, M.S. *et al.* (1993), "Blood levels of organochlorine residues and risk of breast cancer", *Journal of the National Cancer Institute (USA)*, 85(8):648-52; Krieger, N, Wolff, M.S. *et al.* (1994), "Breast cancer and serum organochlorines: A prospective study among white, black and Asian women", *Journal of the National Cancer Institute (USA)*, 86(8):589-99.

[i] Hunter, D.J. *et al.* (1997), "Plasma organochlorine levels and the risk of breast cancer", *The New England Journal of Medicine*, 337(18): 1253-1258.

[i] Longnecker, M.P. *et al.* (1997), "The human health effects of DDT and PCBs and an overview of organochlorines in public health", *Annual Review of Public Health*, 18:211-44; Lopez-Carrillo *et al.* (1997), "Dichlorodiphenyltrichloroethane serum levels and breast cancer risk: a case-control study from Mexico", *Cancer Research*, 57(17):3728-32; Van't Veer P. *et al.* (1997), "DDT and postmenopausal breast cancer in Europe: case-control study", *British Medical Journal*, 315(7100):81-5; Schecter A. *et al.* [including M.S. Wolff] (1997), "Blood levels of DDT and breast cancer risk among women living in the north of Vietnam", *Archives of Environmental Contamination and Toxicology*, 33(4):453-6; Hunter D.J. *et al.* [including M.S. Wolff] (1997), "Plasma organochlorine levels and the risk of breast cancer", *New England Journal of Medicine*, 337(18):1253-8.

[i] See the study by Schechter *et al*, ibid.

[i] See Roberts, footnote 5 above. The comparison remains extreme even if one assumes a population density typical of a nation like Tanzania (33 persons per square kilometer). In that case, 13.2 persons would occupy the same 40 hectares of this cotton field, making up perhaps three families in three

homes. Spraying those homes would require about 1.4 kilos of DDT; the cotton field still requires 560 times as much.

[i] Ibid.

[i] World Wildlife Fund report, footnote number 13 above, recommendation number 4, page 43.

[i] While DDT is manufactured in developing countries, pyrethroids are made only by multinational chemical companies. Pyrethroids therefore sell at higher prices, which could readily explain why Western chemical companies -- and their governments -- favour a DDT ban.

[i] J.A. Rosendaal (1997), "Vector control, methods for use by individuals and communities" (World Health Organization, Geneva).

[i] Charlwood, J.D. *et al.* (1995), "A field trial with Lambda-cyhalothrin for the intradomiciliary control of malaria transmitted by Anopheles darlingi root in Rondonia, Brazil", *Acta Trop* 60(1):3-13.

[i] J. Voorham (1997), "The use of wide-mesh gauze impregnated with lambda-cyhalothrin covering wall openings in huts as a vector control method in Suriname", *Rev Saude Publica* 31(1):9-14; Wu, N. *et al.* (1993), "Field evaluation of bednets impregnated with deltamethrin for malaria control", *Southeast Asian Journal of Tropical Medicine and Public Health* 24(4);664-71.

[i] Wirth, D.F. and J. Cattani, "Winning the war against malaria", *Technology Review* (Massachusetts Institute of Technology, August 1997).

[i] The preferred drug is now mefloquine (Lariam), which sells for about US$5 a treatment. Newer drugs, such as artemether, can cost about $15: M. Day (1997), "Is the African launch of a new malaria drug premature?", *New Scientist* (November 22, 1997), p. 18.

[i] National Academy of Sciences (USA), America's Vital Interest in Global Health (1997), p. 36.

[i] The Walter Reed Army Institute of Research, which invented 3 of the 4 leading malaria drugs since World War Two, now receives only $5 million a year from the US Government for malaria drug work.

[i] D. Kwiatkowski and K. Marsh (1997), "Development of a malaria vaccine", *Lancet* 350(9092):1696-701; Graves, P.M. (1998), "Comparison of the cost-effectiveness of vaccines and insecticide impregnation of mosquito nets for the prevention of malaria", *Annals of Tropical Medicine and Parasitology* 92(4):399-410.

[i] The United States Army and Navy, which have the leading malaria vaccine laboratories in the world, together spend only about $5 million a year on malaria vaccine research.

[i] The polio vaccine was discovered in the 1950s, yet global vaccination to eradicate polio only began in 1988 – three decades later. The disease will not be eradicated before the year 2000.

[i] World Wildlife Fund report, footnote 13 above, pp. 27-28.

[i] There is little data on the cost of environmental control of malaria. The World Bank estimates environmental control of dengue fever, a mosquito-borne disease which is *less* virulent than malaria, costs several thousand dollars per year of life saved: World Development Report 1993 (Oxford University Press, 1993), page 62.

[i] The Wellcome Trust (1996), Malaria Research: An Audit of International Activity (Wellcome Trust, London).

---

[1] World Health Organization, The World Health Report 1996 (WHO, Geneva, 1996), p. 47.

[2] World Bank data, as tabulated in World Development Report 1993: Investing in Health (Oxford University Press, Oxford, 1993), p. 216-9.

[3] Roberts, D. and Andre R.G. (1994), "Insecticide resistance issues in vector-borne disease control", *American Journal of Tropical Medicine and Hygiene* 50:21-34.

[4] J.A. Nájera, R.L. Kouznetov and C. Delacollette, Malaria Epidemics: Detection and Control, Forecasting and Prevention (World Health Organization, Division of Control of Tropical Diseases, WHO/MAL/98.1084/English), p. 39. The authors are referring to indoor house spraying generally.

[5] J. Mouchet *et al.* (1998), "Evolution of malaria in Africa for the past 40 years: impact of climatic and human factors", *Journal of the American Mosquito Control Association* 14(2):121-30; D. Roberts *et al.* (1997), "DDT, global strategies and a malaria control crisis in South America", *Emerging Infectious Diseases* 3(3):295-302, available at http://www.cdc.gov/ncidod/EID/vol3no3/roberts.htm (no period).

[6] Ibid.

[7] International Agency for Research on Cancer, World Health Organization, DDT and Associated Compounds, IARC Monographs volume 53 (1991). Updated conclusions (1997) appear on the internet at http://193.51.164.11/htdocs/Monographs/Vol53/04-DDT.HTM (no period).

[8] DDT is therefore less of a cancer risk than other POPs such as dioxin, which is "carcinogenic to humans", or PCB, which is "probably carcinogenic to humans".

[9] The following are examples of "possibly carcinogenic" drugs: Bleomycin (an anti-cancer drug), Metronidazole (an anti-parasitic drug), Phenytoin (an anti-convulsant); and Progestogen (a contraceptive). There are also "probably carcinogenic" drugs: Chloramphenicol (an antibiotic); Cisplatin (an anti-cancer drug). Finally, there drugs that are definitely "carcinogenic in humans": Chlorambucil (an anti-cancer drug); Ciclosporin (a drug for organ transplants); Methoxsalen (a skin drug).

[10] Gladen, B.C. and Rogan W.J. (1995), "DDE and shortened duration of lactation in a northern Mexican town", *American Journal of Public Health* 85(4):504-8.

[11] Kornbrust, D. *et al.* (1986), "Effects of 1,1-dichloro-2,2-bis[p-chlorophenyl]ethylene (DDE) on lactation in rats", *Journal of Toxicology and Environmental Health* 17(1):23-36.

[12] Rogan, W.J. *et al.* (1987), "Polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethene (DDE) in human milk: effects on growth, morbidity, and duration of lactation", *American Journal of Public Health* 77(10):1294-1297.

[13] World Wildlife Fund, Resolving the DDT Dilemma: Protecting Biodiversity and Human Health (Toronto and Washington DC, 1998), pp. 12-15.

[14] Ibid.

[15] Wolff, M.S. *et al.* (1993), "Blood levels of organochlorine residues and risk of breast cancer", *Journal of the National Cancer Institute (USA)*, 85(8):648-52; Krieger, N, Wolff, M.S. *et al.* (1994), "Breast cancer and serum organochlorines: A prospective study among white, black and Asian women", *Journal of the National Cancer Institute (USA)*, 86(8):589-99.

[16] Hunter, D.J. *et al.* (1997), "Plasma organochlorine levels and the risk of breast cancer", *The New England Journal of Medicine*, 337(18): 1253-1258.

[17] Longnecker, M.P. *et al.* (1997), "The human health effects of DDT and PCBs and an overview of organochlorines in public health", *Annual Review of Public Health*, 18:211-44; Lopez-Carrillo *et al.* (1997), "Dichlorodiphenyltrichloroethane serum levels and breast cancer risk: a case-control study from Mexico", *Cancer Research*, 57(17):3728-32; Van't Veer P. *et al.* (1997), "DDT and postmenopausal breast cancer in Europe: case-control study", *British Medical Journal*, 315(7100):81-5; Schecter A. *et al.* [including M.S. Wolff] (1997), "Blood levels of DDT and breast cancer risk among women living in the north of Vietnam", *Archives of Environmental Contamination and Toxicology*, 33(4):453-6; Hunter D.J. *et al.* [including M.S. Wolff] (1997), "Plasma organochlorine levels and the risk of breast cancer", *New England Journal of Medicine*, 337(18):1253-8.

[18] See the study by Schechter *et al*, ibid.

[19] See Roberts, footnote 5 above. The comparison remains extreme even if one assumes a population density typical of a nation like Tanzania (33 persons per square kilometer). In that case, 13.2 persons would occupy the same 40 hectares of this cotton field, making up perhaps three families in three

homes. Spraying those homes would require about 1.4 kilos of DDT; the cotton field still requires 560 times as much.

[20] Ibid.

[21] World Wildlife Fund report, footnote number 13 above, recommendation number 4, page 43.

[22] While DDT is manufactured in developing countries, pyrethroids are made only by multinational chemical companies. Pyrethroids therefore sell at higher prices, which could readily explain why Western chemical companies -- and their governments -- favour a DDT ban.

[23] J.A. Rosendaal (1997), "Vector control, methods for use by individuals and communities" (World Health Organization, Geneva).

[24] Charlwood, J.D. *et al.* (1995), "A field trial with Lambda-cyhalothrin for the intradomiciliary control of malaria transmitted by Anopheles darlingi root in Rondonia, Brazil", *Acta Trop* 60(1):3-13.

[25] J. Voorham (1997), "The use of wide-mesh gauze impregnated with lambda-cyhalothrin covering wall openings in huts as a vector control method in Suriname", *Rev Saude Publica* 31(1):9-14; Wu, N. *et al.* (1993), "Field evaluation of bednets impregnated with deltamethrin for malaria control", *Southeast Asian Journal of Tropical Medicine and Public Health* 24(4);664-71.

[26] Wirth, D.F. and J. Cattani, "Winning the war against malaria", *Technology Review* (Massachusetts Institute of Technology, August 1997).

[27] The preferred drug is now mefloquine (Lariam), which sells for about US$5 a treatment. Newer drugs, such as artemether, can cost about $15: M. Day (1997), "Is the African launch of a new malaria drug premature?", *New Scientist* (November 22, 1997), p. 18.

[28] National Academy of Sciences (USA), America's Vital Interest in Global Health (1997), p. 36.

[29] The Walter Reed Army Institute of Research, which invented 3 of the 4 leading malaria drugs since World War Two, now receives only $5 million a year from the US Government for malaria drug work.

[30] D. Kwiatkowski and K. Marsh (1997), "Development of a malaria vaccine", *Lancet* 350(9092):1696-701; Graves, P.M. (1998), "Comparison of the cost-effectiveness of vaccines and insecticide impregnation of mosquito nets for the prevention of malaria", *Annals of Tropical Medicine and Parasitology* 92(4):399-410.

[31] The United States Army and Navy, which have the leading malaria vaccine laboratories in the world, together spend only about $5 million a year on malaria vaccine research.

[32] The polio vaccine was discovered in the 1950s, yet global vaccination to eradicate polio only began in 1988 – three decades later. The disease will not be eradicated before the year 2000.

[33] World Wildlife Fund report, footnote 13 above, pp. 27-28.

[34] There is little data on the cost of environmental control of malaria. The World Bank estimates environmental control of dengue fever, a mosquito-borne disease which is *less* virulent than malaria, costs several thousand dollars per year of life saved: World Development Report 1993 (Oxford University Press, 1993), page 62.

[35] The Wellcome Trust (1996), Malaria Research: An Audit of International Activity (Wellcome Trust, London).