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GUINEA worm no one should suffer

by Jimmy Carter

Once you've seen a small child with a two-foot-long live guinea worm protruding from her body, right through a large sore between her toes, you never forget it. I first saw the devastating effects of guinea worm disease in two villages near Accra, Ghana, in March 1988. In fact, Rosalynn and I saw more than 200 victims, including people with worms coming out of their ankles, knees, groins, legs, arms, breasts, and other parts of their bodies. When I revisited those villages in 1989, only four residents in one of the villages still had guinea worm. Health education, combined with the use of cloth filters, the chemical Abate, and the addition of three borehole wells, had nearly eliminated the disease.

Impact of an affliction

I first learned about guinea worm disease in 1986. I was shocked to find that this debilitating illness, which afflicts nearly five million people each year, could be easily prevented. In that same year the World Health Organization chose guinea worm as the next disease to be eradicated from the face of the Earth—by 1995. It is my hope that by then this horrible disease will be only a painful memory for the people of the villages in Ghana and others like them across Africa and in part of Asia.

A reporter in Africa once asked me, "Why in the world are you involved in a program to eliminate guinea worm?" The answer is easy. There is no reason people should suffer from an affliction that is so easy to prevent. The disease not only is physically debilitating but has great economic consequences as well. As a farmer, I understand the impact of having a third or more of the people in a community unable to work during planting

Jimmy Carter, the 39th president of the United States, is the founder of the Atlanta, Georgia-based Carter Center, a nonprofit organization that works to resolve conflict, promote democracy, preserve human rights, improve health, and fight hunger around the world.


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MR. JIMMY
CARTER
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Denchira, near Accra, Ghana, is one of two villages that Jimmy and Rosalynn Carter visited in March 1988 (previous page). At that time the Carters saw more than 200 cases of guinea worm disease in a total population of about 500. When they visited again a year and a half later (above), guinea worm had all but been eliminated (there were fewer than half a dozen cases). The former president sampled the safe drinking water that Denchira residents now have—thanks to the installation of borehole wells, the use of cloth filters and a larvicide, and intensive health education.

(Overleaf, above, and opposite page) Photographs, The Carter Center

or harvesting times. And guinea worm strikes at the heart of a society in other ways, by preventing children from going to school and keeping mothers from caring for their children.

Working with governments and their leaders

During a visit to Pakistan in 1986, I persuaded Gen. Mohammad Zia-ul-Haq, who was then president, to let the Carter Center work with his public health leaders to eradicate guinea worm. General Zia did not know about guinea worm, but his prime minister came from a village that had suffered from the disease. We quickly launched an eradication program that came to serve as a model for programs in other countries. Since that time, the Carter Center, in Atlanta, Georgia, through its Global 2000 project, has mounted guinea worm eradication campaigns in three African countries and has assisted with efforts in many more. Owing in large part to the dedication of Donald Hopkins, who has been directing the Global 2000 guinea worm eradication efforts since 1987, these projects are working; we are proving that it is possible to stop this disease.

The only other Asian country that still has the disease is India, and an eradication program has been under way there since 1980. Now we are increasing our efforts in Africa.

As chairman of the Global 2000 project, I feel a personal obligation to help carry out the fight against this cruel disease. In the summer of 1990, I accepted an invitation to speak about the importance of eradicating guinea worm to heads of state and government at the annual meeting of the Organization of African Unity in Addis Ababa, Ethiopia. While there, I also met with the foreign ministers of seven endemic francophone West African countries, where the incidence of guinea worm is very high, to urge them to support their ministers of health in eradicating the disease. When meeting with heads of government and other high-level leaders in countries where guinea worm is still prevalent, I try to enlist their support in eradication efforts; once they see that this is a popular and relatively easy thing they can do for their people, they are usually quite willing to help.

Combined efforts

In 1988 Flight Lieutenant Jerry Rawlings, the head of government in Ghana, visited 21 villages in the northern region of his country to personally show people how to filter their water to prevent the disease. And when a plane carrying an unusual fabric landed in Ghana in September 1990, millions of Africans took another major step toward freeing themselves from guinea worm. The fabric, which was woven into 1.4 million reusable nylon filters, was the first shipment from E.I. du Pont de Nemours & Co. and Precision Fabrics Group. Together, these two companies have agreed to donate more than eight million filters through the Carter Center over the next five years.

Help has also come from many other sources. In early 1990 the American Cyanamid Co. donated more than $2 million worth of Abate larvicide,

which destroys the guinea worm larvae in water supplies yet leaves water safe for drinking. Many international agencies are working hand in hand with the Carter Center and with each other to rid Africa of this disease. These combined efforts will be instrumental in ending the unnecessary suffering of millions of people.

Spreading the message

There is yet another vital link in the guinea worm eradication chain, and that is education. When villagers, often illiterate, are taught the causes and prevention of this disease, they learn the rudiments of more basic primary health care at the same time. Also, the nation's health specialists evolve better knowledge of their people's needs and are stimulated in their efforts by involvement in a successful project.

Because this is an obscure disease that afflicts people in poor rural areas, it has not received much attention in the national or international news media. I hope that in the future the media will pay more attention to the plight of those who are afflicted by this disease and to the exciting story of its eradication. The press is a very powerful weapon. My visits to endemic countries generate considerable local coverage and help inspire public support for eradication programs. Through our visits, Rosalynn and I hope to spread a message of hope and encouragement to the people of Africa and to those who suffer needlessly from hunger and disease all over the world.

A project for the world community

Because of the progress that has been made thus far, there is little doubt that, working together, we can rid the world of guinea worm by the end of 1995. But the world community must choose to do so, and the United States must do its part. We are a compassionate nation with a long history of helping others. Thomas Jefferson actively supported efforts to disseminate smallpox vaccine in the United States when he was president, and in 1965 Pres. Lyndon Baines Johnson committed our government, through the Agency for International Development and the Centers for Disease Control, to helping 20 countries of West and Central Africa eradicate smallpox. Pres. Franklin Delano Roosevelt contributed immeasurably to the battle against polio through personal example, his support for the National Foundation for Infantile Paralysis, and his establishment of the Georgia Warm Springs Foundation.

The world is full of difficult problems that we cannot yet solve. This is one we can solve, and we can do it quickly if we set our minds to it. Helping a village free itself of guinea worm has far-reaching consequences. Children can go back to school, and farmers can return to their fields. Most important, when people are healthy, they are more self-reliant and better able to improve their own lives. The eradication of guinea worm disease will be a gift whose full value is impossible to measure.

The Carters met a young guinea worm victim in July 1989 in the village of Idiori, in Ogun state, Nigeria. A guinea worm is emerging from the boy's right ankle. Children and adults suffer horribly as the worms emerge—a slow and excruciatingly painful process. Unfortunately, modern medicine has no treatment to offer those who are infected. It was seeing sufferers like this child that convinced the Carters of the importance of preventive measures. Through the Global 2000 project, the Carter Center has mounted guinea worm eradication programs in Nigeria, Ghana, and Uganda—efforts that have already yielded great benefits to the people.

GUINEA WORM
THE END IN SIGHT

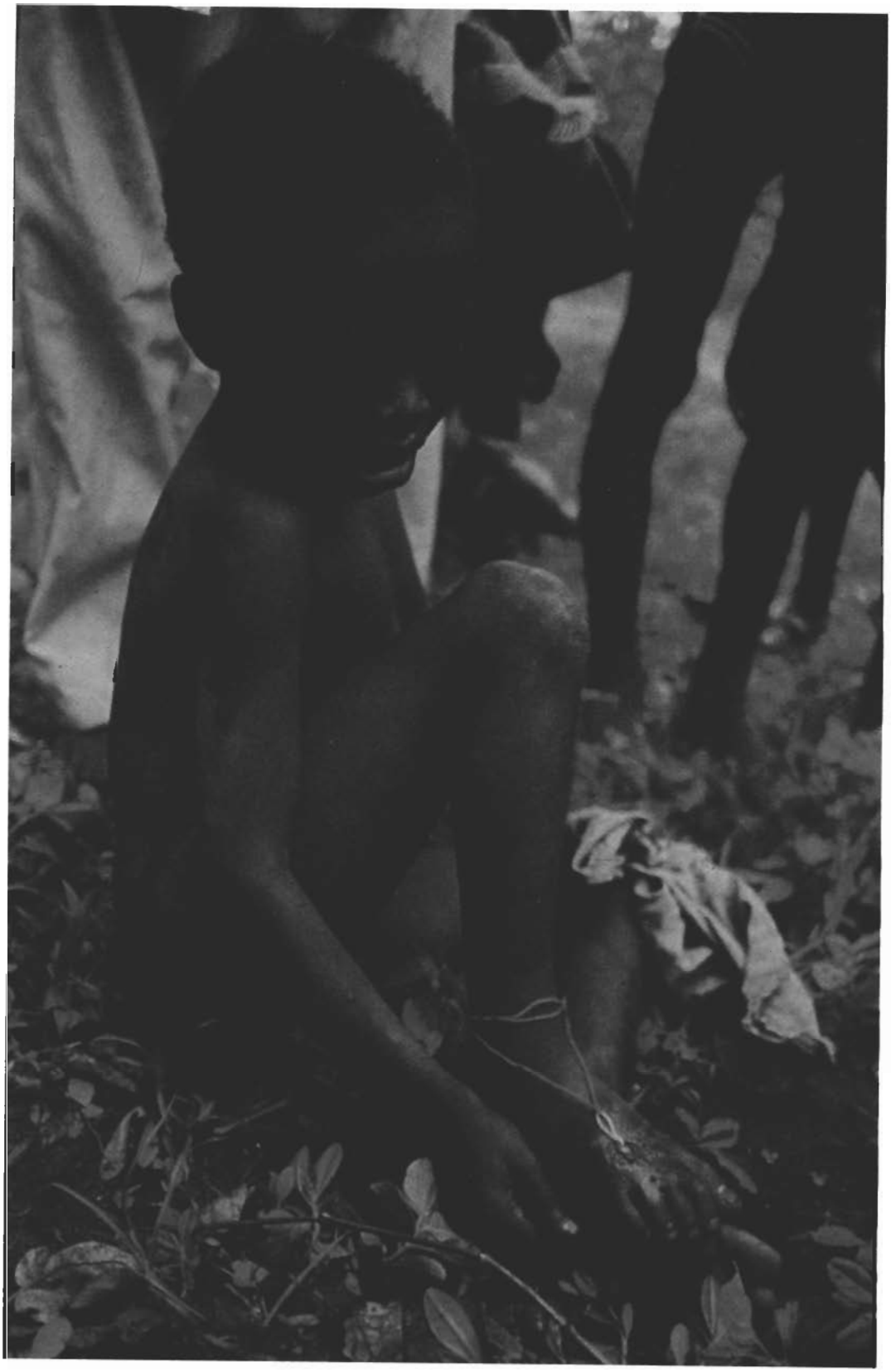
by Donald R. Hopkins, M.D., M.P.H., and
Ernestine M. Hopkins, M.A., M.P.H.

Along with smallpox and perhaps polio, guinea worm disease (dracunculiasis) is not expected to survive the 20th century. An eradication campaign that began in 1980 aims to end guinea worm's centuries-long affliction of humankind by 1995. The achievement will be an especially meaningful tribute to advances in international public health, as some scholars believe that the very symbol of medicine itself, the caduceus—the staff of Asclepius, entwined with a serpent—depicts the ancient practice of treating guinea worm disease by winding the parasite around a small stick as it emerges from the skin of its human victim.

Dracunculiasis is presently limited to fewer than five million victims in India, Pakistan, and 17 African countries; it was formerly much more widespread in Asia and Africa and in parts of the Americas. Over 100 million persons, however, are still at risk of contracting the disease in those remaining affected countries.

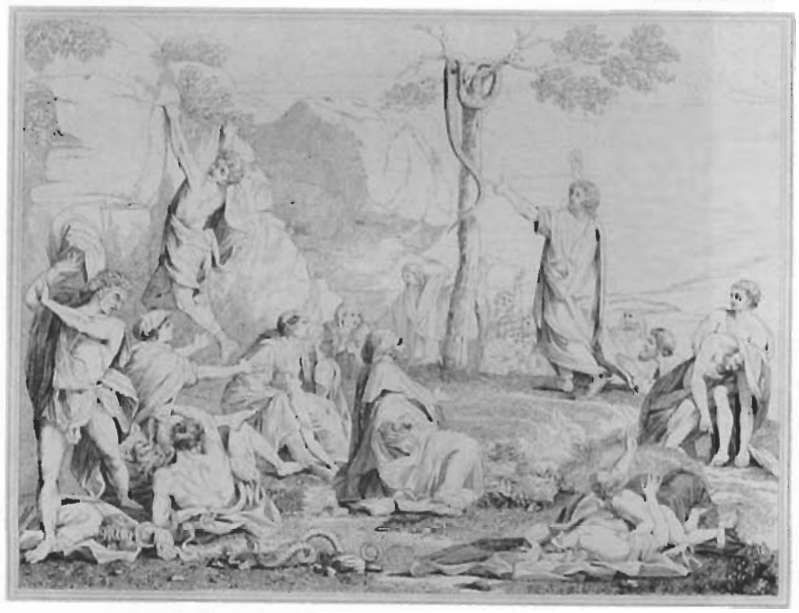
Ancient scourge

The earliest evidence of dracunculiasis is found in ancient Egypt, where an account of how to properly extract the worm is included in the Ebers Papyrus, one of the oldest known collections of medical texts, dating from about 1550 BC: "The process of winding the worm around a stick . . . is appropriately described by the same verb used for drawing out thread during a similar type of spinning." The Bible (Numbers 21:6) describes the "fiery serpents" that attacked Moses' followers in the 12th or 13th century BC, during their prolonged encampment on the shore of the Red Sea near modern-day Aqaba. Alfred J. Bollett, clinical professor of medicine at Yale University School of Medicine, has provided highly persuasive evidence that the biblical "fiery serpents" were indeed guinea worms. Physical confirmation that dracunculiasis existed in about 1000 BC in ancient Egypt came in the 1980s when a calcified guinea worm was found in the mummy of a 13-year-old girl. Significantly, both lower legs had been amputated from this New Kingdom girl shortly before her death, perhaps in an unsuccessful attempt to combat a gangrenous complication of her guinea worm infection. Guinea worm is apparently even mentioned in a myth about the Egyptian sun god, Ra, who was plagued by a worm that attacked his ankle.



Medical historians have speculated that the "fiery serpents" that afflicted Moses' followers in the 12th or 13th century BC may well have been guinea worms. Dracunculiasis, or guinea worm disease, was once endemic in the Middle East, particularly along the shore of the Red Sea—the site of Moses' prolonged encampment. Whether historically accurate or not, "fiery serpent" is indeed an appropriate description of the guinea worm. The female parasite grows within its victim's body to a length of up to 90 centimeters (3 feet), then migrates, usually to a lower limb, where it secretes a toxin that causes a painful, burning blister. The worm then begins to emerge at a rate of a few centimeters a day—a slow, excruciating process that can take several weeks or more.

The Mansell Collection



Several Greco-Roman writers, including Plutarch (AD 50–117) and Galen (AD 129–*c.* 199), mention the disease. Leonides, a Byzantine surgeon, is said to have referred to its occurrence in India and Ethiopia in the 2nd century AD. Galen, who admittedly saw no cases himself in his practice in Rome, first named the condition "dracontiasis," although he thought it was due to a protruding nerve. It was also during this period, when enlightened people realized the importance of not breaking the worm while extracting it, that the familiar extraction process may have served as a model for the symbolic healing staff of Asclepius, the son of Apollo and father of Hygieia, the goddess of health. Although the animal coiled about Asclepius' staff is often taken to be a snake, there appears to be no reason to wrap a snake around a stick—certainly no reason related to a treatment, as is the case with guinea worm. The confusion may be perpetuated by the modern scientific name of the genus of the worm, *Dracunculus,* which means "little snake." (Ironically, among the many species of *Dracunculus* are a few that infect snakes.)

Arabic-speaking medieval physicians were also very familiar with the infection. Rhazes (*c.* 865–923/32), the Persian-born physician in chief of the hospital at Baghdad, concluded that the swellings on the bodies of affected persons were due to a parasite. Avicenna (980–1037), who was a native of Bukhara, left the first detailed clinical description of the disease, which he called "Medina sickness" (*Vena Medina*) because it was so common in the holy Islamic city of Medina. In his influential *Canon of Medicine,* Avicenna also noted that the disease was found in Egypt. Furthermore, he wrote, "Should the worm be ruptured, much pain and trouble ensue, and even if rupture does not take place, the condition is tiresome enough."

European physicians and explorers began to take note of the infection in the 16th century, when the French surgeon Ambroise Paré thought, like Galen, that the worm was a damaged nerve. Amato (João Rodriguez de

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(Overleaf) Photograph, Daniel Heuclin

Castell Branco; 1511–68), a Portuguese physician, saw persons suffering from guinea worm infection at Salonika (now Thessaloniki, Greece) and reported that it was also known in India and Egypt. A Dutch navigator, Jan Linschoten, confirmed the disease's occurrence at Ormusz, on the Persian Gulf in present-day Iran, in 1584.

Supposedly, it was a European from Basel, Switzerland, who first called the disease "guinea worm," in 1611, after he saw it among Africans along the West African Guinea coast (modern Nigeria). It was reported from the area of the Elmina fortress on the coast of modern Ghana again in 1623 and 1625, and the Scottish explorer Mungo Park mentions it in his account of his travels in the inland area of modern Mali (1795–97).

Perhaps the most telling testimony to the disease's long existence in West Africa, however, is the fact that it is mentioned in the Dahomeyan legend explaining the kingdom's origin. A Dahomeyan prince named Homenuvo, son of king Tegbesu, could not flee when his village was attacked because he was crippled by guinea worm. He was captured by spirits. Through this captured prince, whom they cured of guinea worm and released, the spirits taught the Dahomeyans about the gods of the Sky, Earth, and Thunder and instructed them how to perform the ceremonies in worship of their ancestors and how to bury the dead.

Another Scottish explorer, James Bruce, contracted guinea worm himself during his travels in search of the source of the Nile (1768–73). A century later an expedition of Englishmen suffered from the same disease in the course of their invasion of Ethiopia. The Egyptian conquest of the Sudanese kingdom of Sennar (1820–21) is said to have led to a resurgence of dracunculiasis in Egypt, especially among Nubians enlisted subsequently into the Egyptian Army. It was also reported in Ceylon in 1805 and again in the years 1845–50.

Modern understanding of the infection, apart from the ancient admonition against breaking the worm while removing it, began with G.H. Velschius of Vienna, who published a thorough account of dracunculiasis, *Exercitatio de Vena Medinensis,* in 1674. Velschius' treatise included illustrations of Persian physicians removing the worm by wrapping it around any of several specially designed instruments. Around this time there is said to have been a consensus finally that the infection was caused by a parasite—*i.e.*, a worm—and not by a protruding nerve or vein. The famous Swedish botanist Carolus Linnaeus gave the worm its modern scientific name, *Dracunculus medinensis,* in 1758. In the 19th century the scientific designations *Filaria medinensis* and *Gordius medinensis* came into use. Colloquially, the parasite has also been called "Medina worm" or "dragon worm."

Ten years after Linnaeus first called the worm *Dracunculus medinensis,* the British naval surgeon James Lind, after traveling in Africa, published his suspicion that the disease was transmitted by drinking water. During his travels in the years 1795–97, Park had found that inland peoples of the savannah near the Niger River "allege that the people who drink from wells are more subject to it than those who drink from streams." Indeed, as early as 1650, when Msgr. de la Motte Lambert, the bishop of Beirut, came upon many infected persons in the Persian town of Lar, he reported

In 1674 G.H. Velschius of Vienna published a comprehensive treatise on the parasitic disease dracunculiasis. His text included the illustration below, which shows Persian physicians (in the foreground and background) wrapping a guinea worm around a small, slender instrument as it slowly emerges from its victim. This ancient practice of carefully winding the worm about a stick had been recognized for centuries as the proper method of extraction. If the emerging worm is broken—a dreaded circumstance—the remaining part of the worm retracts into the skin wound, where larvae and toxins are spilled into the victim's tissues, causing inflammation, pain, and often serious secondary infection.

National Library of Medicine, Bethesda, Maryland

the local wisdom that "the way to avoid this worm is to drink only wine, or if water is used, only such as has been carefully filtered through linen."

These rudiments of understanding about transmission of guinea worm disease were sporadic, however, and not generally accepted. Many observers mistakenly believed that the worm invaded people through the skin of their lower limbs, where the adult worms were usually seen when emerging. Scientific proof that the spectacular worm arose from drinking water contaminated by a type of water flea came only in 1871, when a young Russian scientist, Aleksey Fedchenko, published the results of his studies conducted two years earlier in Turkestan. He thus provided the first demonstration of an invertebrate host of a medically important disease of humans. His countrymen later used this knowledge to eliminate dracunculiasis from the southern reaches of the Soviet Union in the 1920s and '30s.

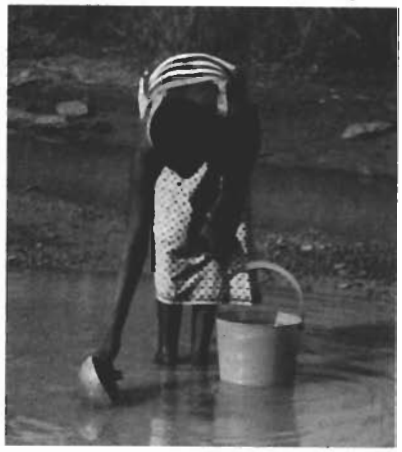
A dreadful disease

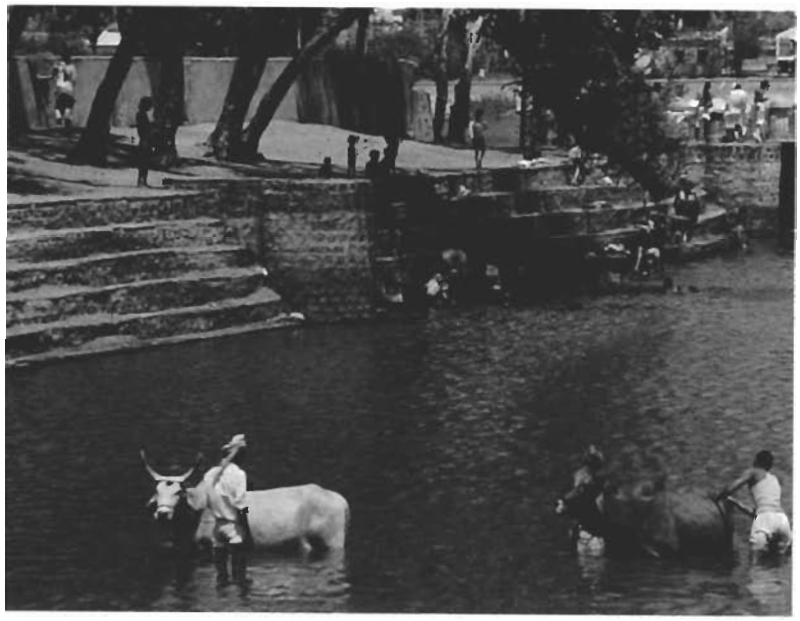
In January 1988 Peter Schantz, an epidemiologist from the Centers for Disease Control (CDC) in Atlanta, Georgia, visited the village of Budo Ayan Moro in Kwara state, Nigeria. His report following that visit described several of guinea worm's young victims.

We met Wahab Mahmoud, who is a twelve year old boy who had 21 worms emerging this year. The only way he could get around was by cane. He was a very bright boy and had been nominated as the "head boy" at [his] school, which means he is a special assistant to the teacher; this is a reflection of his academic achievement and good discipline. He has been unable to attend school, however, since the worms first started emerging in December.

We saw a pregnant fifteen year old girl with a worm emerging from her breast. In fact, three worms emerged from her breast. She had been treated by a local practitioner by a local custom of inserting a hot iron into the lesion caused by the emerging worm.

World Neighbors

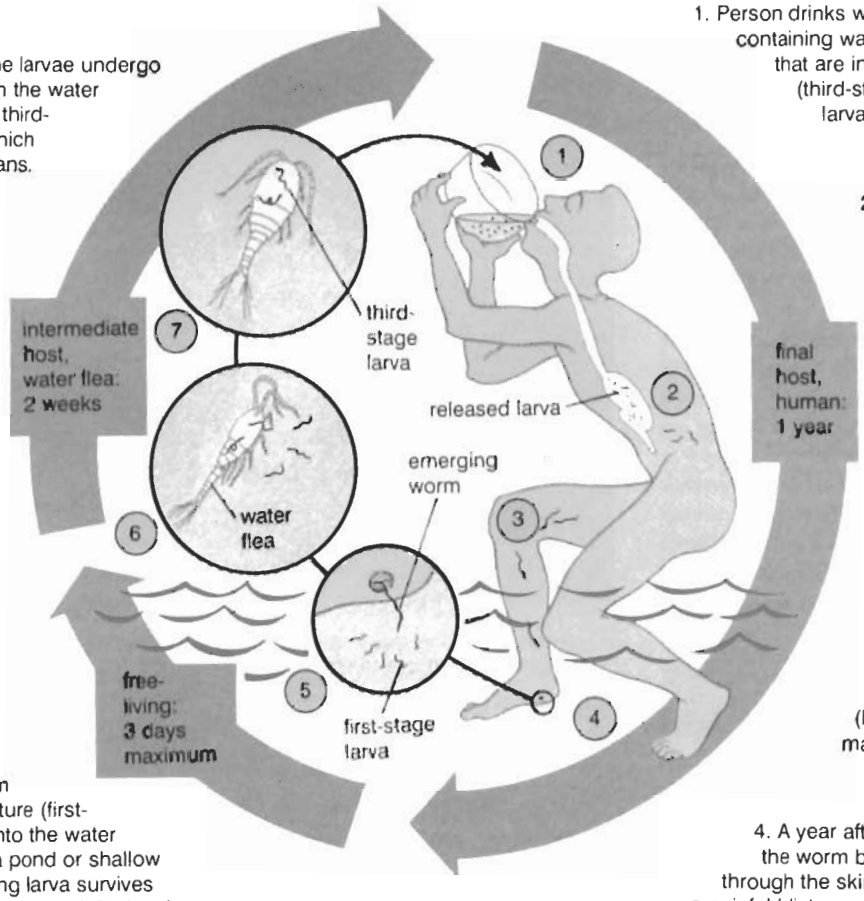




Michael M. Kliks, Ph.D., CTS Foundation, Honolulu, Hawaii

Unsafe drinking water is a major cause of sickness in the less developed world. Of the many waterborne diseases, none is as painful—or as preventable—as guinea worm disease. (Above) A West African woman draws water from a pond that harbors the Cyclops, *a tiny water flea that contains embryonic guinea worm parasites. Guinea worm infection starts when people drink the water from such infested stagnant water. In India (right) step wells that provide drinking water for entire communities are the most common sites of transmission of guinea worm. When people with emerging worms step into the water—often the only way to quell the pain of a burning blister—larvae from their wounds are released into the water. The pernicious cycle is perpetuated as others then consume the contaminated well water.*

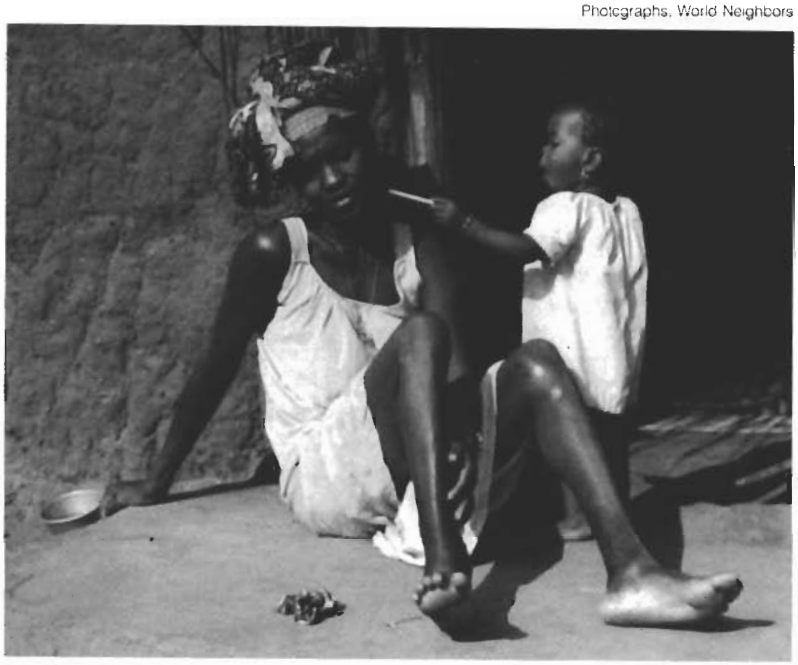
Life cycle of the guinea worm



How did these youngsters come to be infected? The life cycle of the guinea worm is relatively simple: people are infected when they drink from a stagnant water source (pond or step well) that harbors the *Cyclops,* a tiny crustacean, or water flea (copepod), containing the embryonic parasite. The copepods are killed by digestive juices in the person's stomach, thus releasing the larvae of the worm, which penetrate the stomach or intestine and migrate into the tissues of the abdomen. In a few months the worms mate; then the male worms die. The female migrates, usually to the victim's lower leg, where it emerges as a slender 60–90-centimeter (2–3-foot)-long adult worm about 12 months after the infected water fleas were swallowed. (The worms sometimes migrate to and emerge from other body parts, such as the breast, scalp, tongue, scrotum, or uterus.) When a person with an emerging worm enters a body of water, the female worm releases hundreds of thousands of larvae into the water, where they may be eaten by copepods to begin the cycle again.

The water fleas may be barely seen as tiny moving flecks if a glass of water containing them is held up to the light. The immature larval form of the parasite itself is invisible to the naked eye. People who are infected experience no symptoms until the adult female worm is ready to emerge.

Photographs, World Neighbors



Typically, those who are infected by guinea worm are incapacitated for a month or more. The more unlucky victims develop secondary infections that can lead to abscesses, arthritis, and other complications and in some cases may cause permanent disability. In the village of Kati, Togo, a mother, who is very sick from guinea worm infection (right), suffers from extreme lethargy and is unable to care for her playful child. The man below is not only in great pain from his infection but severely crippled as well. Dracunculiasis rarely causes death, but the toll on communities can be staggering; adults cannot work, and children cannot go to school.

The worm secretes a toxin that causes a painful, burning blister to appear on the skin (hence, "fiery serpent"). When the victim attempts to quell the "fire" by immersing the affected body part in cool water, a common practice of villagers in areas where the infection is endemic, the blister ruptures, relieving the pain and releasing the larvae, after which the long worm slowly begins to emerge. An ulcer often forms around the emerging worm at the base of the blister. The thin, cream-colored worm usually takes weeks to emerge completely; only a few centimeters are freed from the tissues each day as the worm releases declining numbers of larvae each time it is immersed in water. All the female worms emerge from the body within a year; those that do not are either absorbed by the body or become calcified in body tissues—usually a benign situation.

The pain associated with the blister at the site of the worm's emergence is often only the beginning of the victim's troubles. Over half of the sites of the worms' emergence become infected secondarily with various bacteria, causing abscesses, sepsis, arthritis, and other common complications. If the emerging worm is broken, the remainder of the worm retracts into the wound, where larvae and other substances that are spilled into the tissues from the ruptured worm cause a severe inflammation—a dreaded phenomenon that has been recognized for centuries. Especially unlucky patients may contract tetanus from contaminated wounds, which can then become fatal. Most victims experience only one worm, but some may suffer up to a dozen or more worms emerging simultaneously.

Because of the associated pain, half or more of the victims may be temporarily incapacitated for periods averaging as much as one to three months. A small number of victims are permanently crippled by scarring from the secondary infections. No matter how often they are infected, people do not become immune, so many suffer year after year.

The social and economic havoc wrought by dracunculiasis is compounded by the high prevalence rates in some communities (up to 50% or more in some African villages); by the disease's seasonal occurrence, often coinciding with the harvest or planting, periods of high demand for agricultural labor; and by the fact that productive adults—especially laborers such as farmers, who need to drink large volumes of water—are affected more often than others. School absenteeism may exceed 60% during the "guinea worm season," either because children themselves are afflicted or because they must replace another stricken family member on the family's farm. In recent years, in a fertile rice-growing area in southeastern Nigeria, the rice farmers alone in a heavily affected population of 1.6 million persons were losing an estimated $20 million per year in potential profits because so many of them were affected by guinea worm during the harvest season. In this way, dracunculiasis effectively crushes the key building blocks of poor rural societies—health, education, and agriculture—as year after year the disease cripples communities attempting to emerge from their status of underdevelopment.

Modern medicine offers no cure or vaccine for dracunculiasis. Palliative drugs (such as aspirin for pain and antiseptic ointments and liquid dressings for inflamed blisters) can help relieve the pain and minimize secondary infections, but once persons are infected, they can scarcely do better than await the worm's emergence and begin winding it carefully around a small stick. If the adult worm is detected beneath the skin before it raises the blister to begin emerging, a physician or other medical practitioner can slip it out readily via a small surgical incision. Most worms remain deep in the tissues, however, and once the body's response is manifest in a blister, inflammation around the body of the worm creates resistance to pulling the worm out easily.

Fortunately, dracunculiasis can be completely prevented in three different ways: (1) by providing safe sources of water such as borehole wells, where the underground water cannot be contaminated by copepods or guinea worm larvae; (2) by teaching villagers to filter their drinking water through a fine cloth or to boil it (less common because most cannot afford the cost of sufficient fuel)—and not to contaminate the source of drinking water in the first place by entering it when they have emerging guinea worms; and (3) by treating contaminated pond water with a chemical, temephos (Abate), which kills *Cyclops* and infective larvae but leaves the water safe for human and animal consumption. These three interventions are similar to those employed over 60 years ago by the Soviets to eliminate dracunculiasis from southern areas of the U.S.S.R.

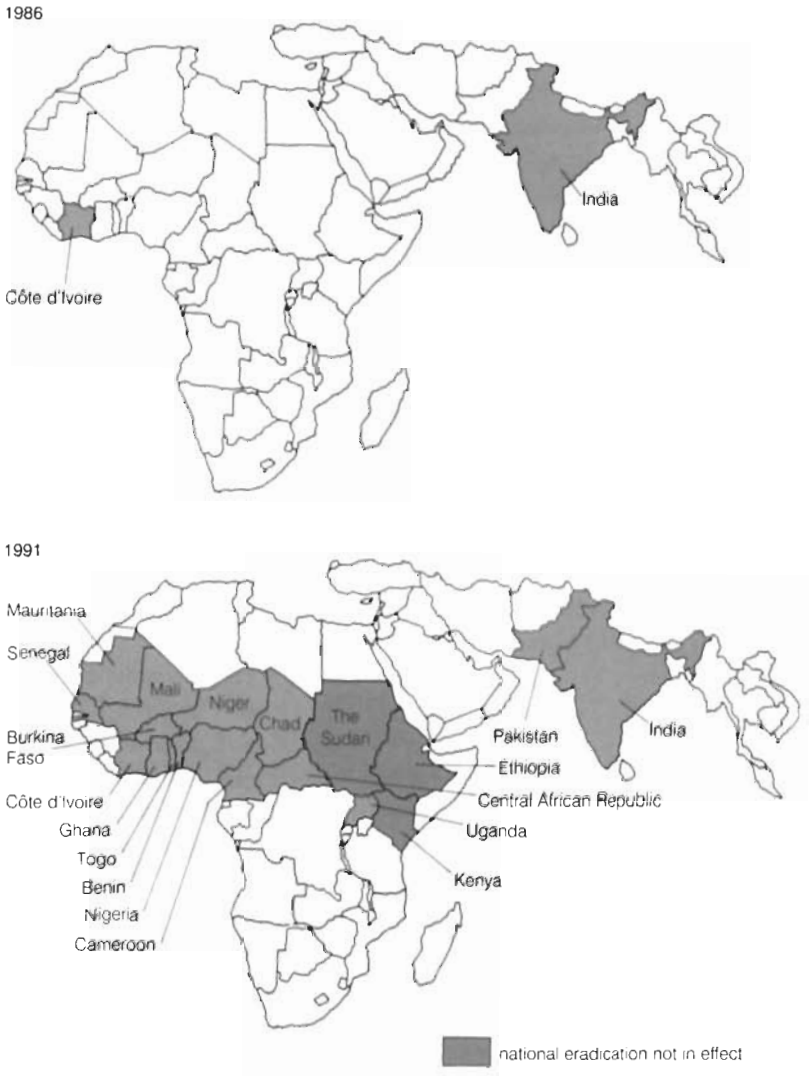
Early eradication efforts

In the early 20th century, dracunculiasis was prevalent in the Indian subcontinent, southern parts of the Soviet Union (Turkestan), Iran, coastal Saudi Arabia and Yemen, several North African and other Middle Eastern countries, and sub-Saharan Africa as far south as present-day Tanzania and Botswana. Some cases still occurred in northeastern Brazil, Guiana, and islands of the West Indies as a result of infections imported during the

A Pakistani man is treated for a secondary infection of guinea worm disease. Modern medicine offers no cure or vaccine for guinea worm, and people who are infected do not become immune.

The Carter Center

Actively combating guinea worm



Several characteristics of dracunculiasis make it an ideal target for eradication. India and Pakistan launched highly successful guinea worm eradication efforts in the early and mid-1980s, respectively; by the early 1990s both countries had nearly eliminated the disease. By 1991 all but three endemic countries in Africa (Ethiopia, The Sudan, and Kenya) were actively combating guinea worm and were formally committed to achieving eradication by 1995.

slave trade. In 1947 the parasitologist Norman R. Stoll estimated that there were about 47 million cases of dracunculiasis worldwide.

The Soviet Union began its campaign to eradicate dracunculiasis in 1926, when guinea worm still affected an estimated 10,000 persons in Bukhara and surrounding areas. Using health education, installation of safe water supplies, controlled expulsion of larvae, topical treatment of victims' wounds, and disinfection or destruction of contaminated water sources, by 1933 officials had eliminated the disease from the U.S.S.R.

A similar eradication effort led to the reported demise of the disease in Iran in the 1970s. Elsewhere, notably in the Americas, North Africa, and other parts of the Middle East, dracunculiasis quietly disappeared, apparently as an indirect consequence of improvements in drinking water supplies. In the early 1970s, however, there existed at least one small area in Saudi Arabia and adjacent Yemen where the disease was still prevalent.

An ideally eradicable disease

By 1980 guinea worm disease was limited to India, Pakistan, and about 19 African countries, although at that time it was thought that the disease still existed in a few others as well. In the late 1970s and early 1980s, the World Health Organization (WHO) estimated that guinea worm disease affected about 10 million persons each year. Just before WHO inaugurated the International Drinking Water Supply and Sanitation Decade in December 1980, one of these authors, Donald R. Hopkins, then assistant director for international health at the CDC, pointed out that the aim to provide safe drinking water for all peoples of the world by December 1990 afforded an unprecedented opportunity to eradicate dracunculiasis—the only infectious disease that is transmitted by drinking water alone. Consequently, in April 1981 the steering committee for the Water and Sanitation Decade issued a statement supporting dracunculiasis eradication as a subgoal. In 1986 the World Health Assembly adopted its first resolution formally targeting dracunculiasis as the second major infectious disease to be eradicated—after smallpox—but set no target date. By 1988 African ministers of health, meeting under the auspices of WHO, resolved to eradicate guinea worm from Africa by 1995. Finally, in May 1991 the 44th World Assembly adopted a resolution that calls for the global eradication of dracunculiasis by the end of 1995.

A number of characteristics of dracunculiasis enable it to be singled out for eradication. First, the disease is easy to diagnose. Second, there is no animal reservoir from which the infection could reenter the human population once it has been eliminated. (Many species of *Dracunculus* infect wild animals, including animals in North America, but those parasites do not infect humans, and *D. medinensis* does not naturally infect animals.) Third, the infection has a self-limited duration of one year in humans if they are not reinfected. Fourth, naturally occurring seasonal declines in incidence and the one-year-long incubation period can be exploited to increase the efficiency of control measures. Fifth, though it does not usually kill its human victims, guinea worm is nonetheless a common, important cause of misery in affected areas; thus, political support for a cost-effective eradication effort is feasible. Finally, there are the three previously mentioned effective and practical ways to completely prevent the infection, even though it cannot be treated or cured.

Slaying the fiery serpent

The strategy of guinea worm eradication programs is simple: identify the affected villages and then help the inhabitants prevent the infection. The first step is for each affected country to conduct a nationwide, village-by-village search to identify all endemic areas and the numbers of cases occurring annually. Such a baseline survey is needed for planning, monitoring, and evaluating the eradication program. It is also useful for increasing awareness of the disease and creating political support for efforts to eliminate it. In the national search for cases, health workers and other volunteers are sent to each village in the country. If the residents say that there has been no guinea worm infection in their village in the past year, the workers pro-

Education is among the most important strategies in the conquest of guinea worm. People must be made aware of the disease and taught to change their daily habits. Many endemic villages suffer year after year largely because the people do not know how the infection is transmitted. On March 20, 1991, Nigeria held its second annual National Guineaworm Eradication Day. On the same day, the Nigerian Postal Service Department issued three guinea worm commemorative postage stamps. The postmaster general expressed his "sincere hope" that the stamps would "carry the message [of eradication] to all nooks and corners of Nigeria." The stamp below was designed by Nigerian artist G.N. Osuji.

Nigerian Philatelic Service

ceed to the next village. Where villagers say that there have been persons infected in the past year, the workers conduct a house-to-house search to count the number of guinea worm victims during a given period.

The value of thorough national searches to discover the true extent of dracunculiasis was graphically demonstrated in Ghana and Nigeria, each of which conducted such searches within a few months during 1988–89 (Nigeria) and 1989–90 (Ghana). Previously Ghana and Nigeria had relied on passive reporting from rural health centers, and both countries reported only about 4,000 cases of guinea worm annually to WHO in the early 1980s. Underreporting of cases was common because incapacitated guinea worm sufferers in remote areas have no incentive to travel for treatment to distant health centers, where cases could be recorded, since most of them know that modern medicine offers no cure for the disease. Thus, when they conducted their first national searches, Ghana found nearly 180,000 cases and Nigeria discovered more than 650,000. These shockingly high figures helped increase the national concern and, indeed, the governmental willingness to cooperate in eradication programs in both countries.

Once the geographic extent and magnitude of the problem are known and most of the affected villages have been identified, the next step is to begin interventions in those villages as quickly as possible. The fastest method will usually be education of villagers—promoting the use of cloth strainers to filter out water fleas and infective larvae from drinking water. At the same time, wherever possible, priority should be given to introducing new sources of safe drinking water, such as borehole wells. In selected villages, chemical control of the larvae-containing copepods with Abate is utilized as an additional intervention. Although theoretically it is possible to stop transmission of the disease in only one year, generally two to four years of active intervention are needed to eliminate the disease totally in affected communities.

In the early 1980s one of the first examples of a successful approach to community education and participation in construction of safe drinking water sources occurred in Kati, a village of about 3,000 persons in Togo. Nearly a third of Kati's population (928 persons) had guinea worm disease in 1981. With the assistance of two nongovernmental organizations that trained volunteers from the village itself, residents were educated in 1982 and 1983 about the cause and prevention of guinea worm. The villagers then raised funds for several borehole wells, which were constructed and fitted with hand pumps in 1984 and 1985. These efforts resulted in dramatic declines in the incidence of guinea worm disease: 263 cases in 1983, 7 cases in 1985, and 5 cases in 1987. There have been no reported cases since 1987.

The successful Kati eradication effort has been repeated in many other African villages. One that occurred well before a global eradication plan was inaugurated was in a town of 30,000 persons in Nigeria in the 1960s. Before piped water was introduced, 60% of the population were afflicted by guinea worm annually; with the new water source, the incidence plummeted to zero within two years.

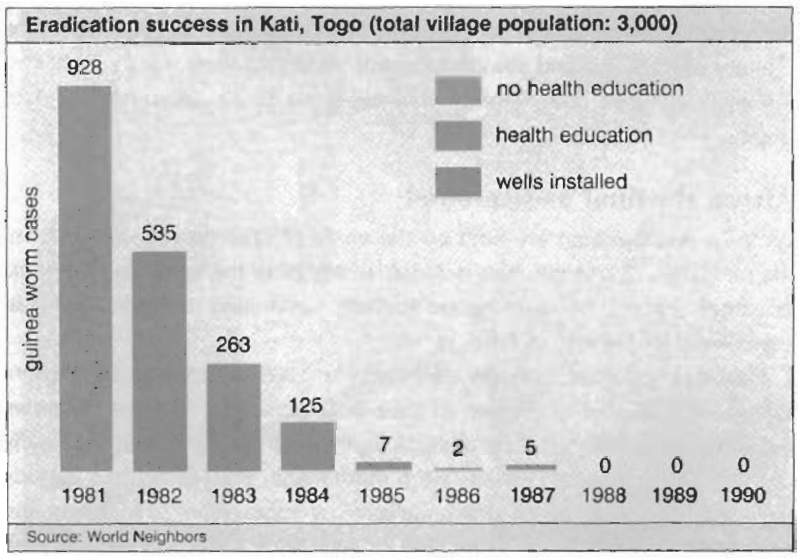
The early 1980s saw the incidence of guinea worm reduced to zero in

three villages in Burkina Faso, from previous rates of 54, 37, and 24%. This was achieved within only two transmission seasons simply by educating villagers to filter their drinking water. A United Nations Children's Fund (UNICEF)-assisted rural water supply project in Nigeria reduced the average prevalence of dracunculiasis in 20 villages from 59.6% in the 1983–84 transmission season to 11.3% three years later, with rates in three of the villages falling to zero (from 62, 52.7, and 44.8%). The apparent disappearance of guinea worm disease in the 1980s from the country that shares its name—the Republic of Guinea—is attributed to an extensive rural water supply program begun in the 1960s.

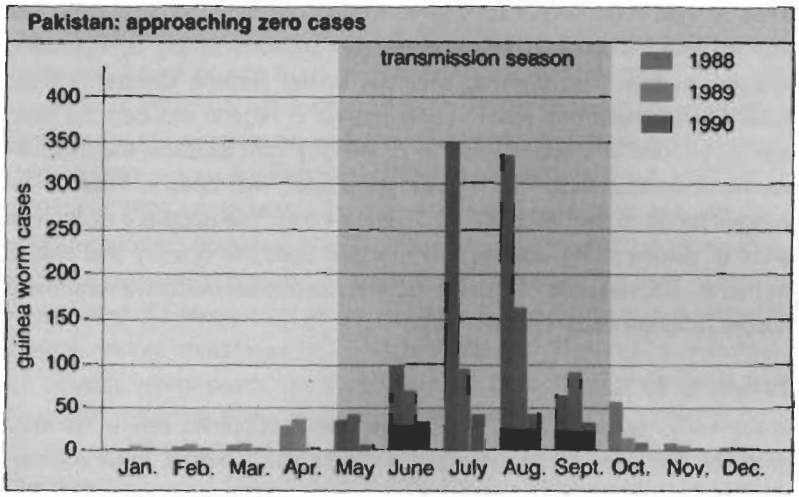
Progress in Asia

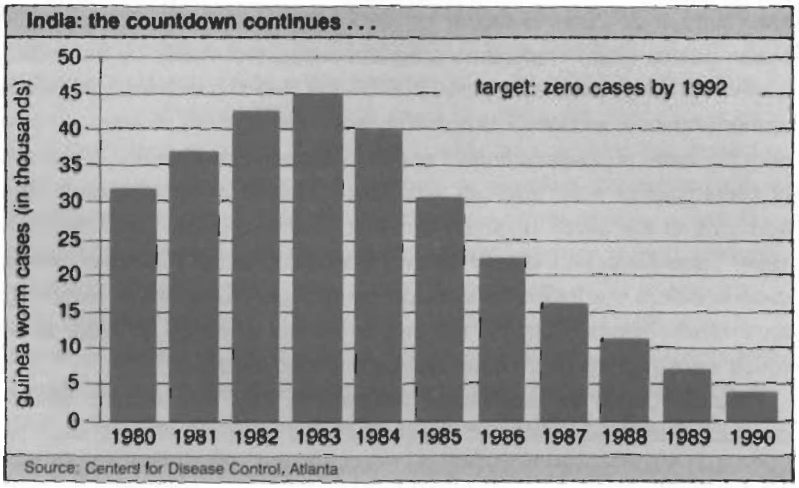
In the early 1990s the two remaining endemic countries where the most progress has been made nationally are India and Pakistan. India enumerated over 44,000 cases in its first national search for cases in 1983. The total number of cases detected in 1990 was about 5,000. The rigorous Indian guinea worm eradication program, supported mainly by the Indian government with assistance from UNICEF, the Swedish International Development Agency, and WHO, is presently emphasizing both provision of safe drinking water supplies to known endemic villages and chemical treatment of contaminated water sources with Abate. Guinea worm was eliminated from one of the seven originally endemic states of India, Tamil Nadu, in 1984. Tamil Nadu had started its own statewide control measures over a decade before the Indian national program began. One of the remaining six endemic states, Gujarat, had only a handful of cases in 1989, all of which were imported from other nearby endemic states.

Pakistan began its eradication program in 1987. A national search conducted that year detected fewer than 500 affected villages, with an estimated 2,400 cases. The program then selected and trained at least one person from each of the affected villages to initiate control measures. Interventions emphasized prompt detection and topical treatment of victims'



The West African village of Kati, Togo, demonstrated in a matter of a few years how health education and the provision of a safe water supply can effectively break the cycle of guinea worm infection and end the misery it causes.





By the early 1990s complete elimination of guinea worm was in sight in both Pakistan and India, the two remaining endemic countries in Asia.

wounds, the use of cloth filters for water in all households, treatment of local drinking water sources with Abate, and monthly reporting of cases from each endemic village. In 1990 only 160 cases were found in the entire country of Pakistan, and stringent control measures were rapidly instituted for each of those. The country was expected to be completely free of guinea worm in 1991.

Africa: the final battleground

As India and Pakistan are both on the verge of eliminating guinea worm, the main area of concern now is Africa, where all of the remaining endemic countries (except The Sudan) are formally committed to eradicating dracunculiasis by the end of 1995.

Having conducted national searches in 1989 or before, Cameroon, Ghana, and Nigeria are ahead of their neighbors, and all three countries were mounting intensive interventions against the disease nationwide early in 1991. Preliminary indications were that Ghana and Nigeria had already reduced the incidence of dracunculiasis by more than 30% during the previous two years. At the same time, at least 12 of the 17 endemic African

countries had begun guinea worm eradication programs, and over half of them had conducted or begun nationwide searches. Burkina Faso found over 40,000 cases of guinea worm in its first national search late in 1990—a time when powerful allies were engaged in supporting the struggle against dracunculiasis in Africa. (Early in the campaign, resources were far less available.)

Despite the endorsement of dracunculiasis eradication as an official subgoal at the beginning of the Water and Sanitation Decade, actual support for eradication activities, especially in Africa, was very slow in coming (apart from continued leadership by CDC epidemiologists). In June 1982 in Washington, D.C., the U.S. National Research Council convened a workshop focusing on opportunities for the control of dracunculiasis, with funding provided by the U.S. Agency for International Development (USAID). This was the first international meeting devoted to the disease, and it provided a firm scientific basis for further action. Still, the various international assistance agencies stuck to their own priorities, which did not include dracunculiasis eradication. An early exception was the UNICEF mission in Nigeria: in 1983, largely because of the presence of guinea worm disease, UNICEF began installing borehole wells in selected areas of the country; two years later UNICEF provided vital support for Nigeria's first national conference on dracunculiasis. Also in 1983, both WHO and UNICEF, along with epidemiologists from the CDC, helped initiate guinea worm eradication investigations in Benin, Côte d'Ivoire, Togo, and Uganda.

After the 1986 World Health Assembly adopted the first resolution calling for guinea worm eradication, the first African regional dracunculiasis conference was convened in July of that year in Niamey, Niger, with considerable support from the Carnegie Corporation of New York. In November 1986 Global 2000, a charitable project of the Carter Center, based in Atlanta, Georgia, agreed to provide major assistance to Pakistan in eradicating

Photographs, The Carter Center

A watershed in support for guinea worm eradication came at an international donors conference, held in Lagos, Nigeria, in July 1989. Approximately $10 million was pledged in cash and gifts-in-kind from sources as diverse as the Peace Corps, the Japanese government, UNICEF, and the American Cyanamid Co. The conference's key sponsor was Global 2000, whose chairman, former U.S. president Jimmy Carter, and senior consultant, Donald R. Hopkins, are pictured above. At left, in August 1989, Jimmy and Rosalynn Carter inspect a borehole well in the Ghanaian village of Elevanyo; the well and pump, a pipe-borne source of safe drinking water, were installed as a result of the former president's earlier visit to the village in March 1988.

Toshiro Mado

Filtering drinking water is one of three basic ways of preventing guinea worm disease. (Right) In June 1988 Ghana's head of state, Flight Lieutenant Jerry Rawlings (second from left), visited 21 villages in the northern region of his country to show people how to filter their water properly. (Below) A Nigerian woman pours water through a nylon filter to catch the guinea worm larvae that cause the disease. The filters were developed and donated by E.I. du Pont de Nemours & Co. in partnership with Precision Fabrics Group; the companies pledged to provide over eight million filters to meet the needs of the entire guinea worm eradication campaign through its target date of 1995.

E.I. du Pont de Nemours & Co.

guinea worm disease from all endemic parts of that country. Prior to that pledge of support, former U.S. president Jimmy Carter had gone to Pakistan to meet with and enlist the support of the country's president, Gen. Mohammad Zia-ul-Haq. Over the next several years, Global 2000 made formal commitments to work with the Ministries of Health of Ghana (in December 1987), Nigeria (in June 1988), and Uganda (in March 1991) in initiating national guinea worm eradication programs. In all three of the African countries, the assistance pledged by the Carter Center included the assignment of one experienced public health adviser and the provision of a small operating budget so that local public health personnel could conduct national searches for cases, plan the national eradication programs, and mobilize necessary resources. Nigeria's Anambra state had already secured over $5 million in support from the Japanese government for water supply projects in the state's endemic villages, and Japan soon began a similarly targeted rural water supply project in Ghana.

Carter helped draw more attention to the problem in Africa when he and his wife, Rosalynn, attended Africa's second regional conference on dracunculiasis in Accra, Ghana, in March 1988. The Carters also visited Ghanaian villages where guinea worm disease was still rampant, and they witnessed firsthand the terrible suffering of afflicted children and adults. Their appearance among Ghanaian guinea worm victims and their stopover in Lagos, Nigeria, for the official signing of Global 2000's agreement with Nigerian authorities gained wide local and national press coverage.

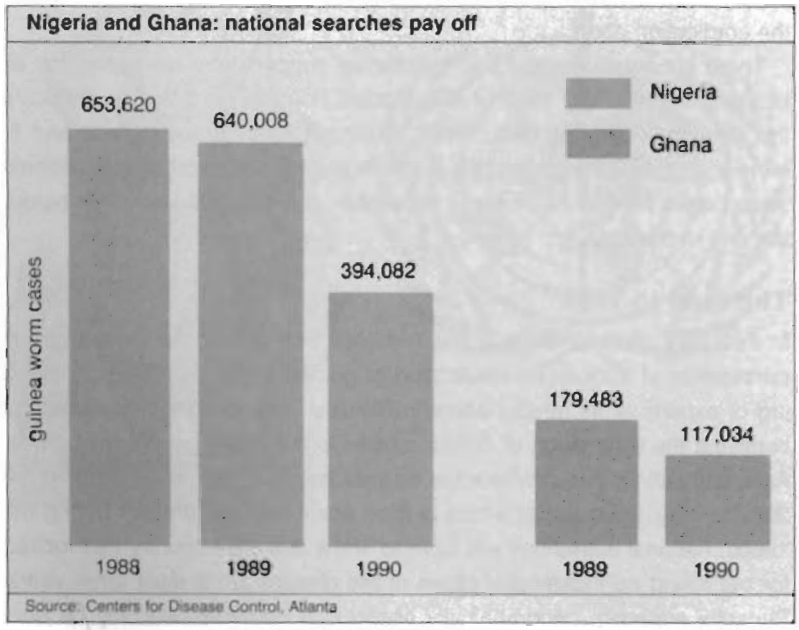
Dollars against disease

A year later, on the last day of July 1989, the real watershed in international support for the initiative to eradicate dracunculiasis came when approximately $10 million in new support was announced at an international

donors conference in Lagos called "Target 1995: Eradication of Guinea Worm." The conference was organized by Global 2000, and Carter, the project's chairman, gave the keynote address. Official cosponsors were the United Nations Development Program (UNDP)—whose regional director for Africa, Pierre-Claver Damiba, chaired the meeting—and UNICEF.

UNICEF headquarters in New York began to take an active role after the organization's executive director, James Grant, witnessed the ravages of guinea worm during a visit to a village in Ghana in March 1989. In his poignant opening address, Damiba described to a rapt audience the suffering he endured as a young boy growing up in Upper Volta (now Burkina Faso), when he was infected by guinea worm. Another emotional highlight of the meeting was the showing of a film made during a June 1988 tour of 21 endemic villages in Ghana, when the nation's head of state, Flight Lieutenant Jerry Rawlings, provided personal instruction to villagers on the proper technique for filtering their drinking water.

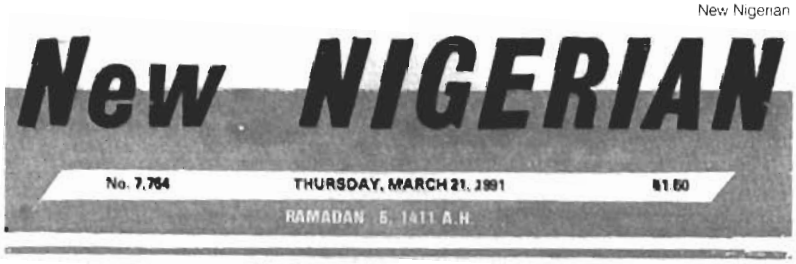
The true commitment to eradication was marked by pledges. The two UN agencies and Global 2000 each pledged over $1 million in cash support, while the CDC pledged $1 million (in kind). Gen. Ibrahim B. Babangida, Nigeria's head of state, announced on behalf of the government $1 million in new support for his country's eradication program. The Peace Corps, in association with USAID, announced that volunteers would be trained to help villagers in local guinea worm eradication efforts in all endemic African countries where the Corps was active. Less than a week after the donors conference, the USAID mission to Ghana announced a grant of over $2 million to that country's Ministry of Health for its eradication program. Later that year Japan worked out an $8 million agreement to help Nigeria's Niger state place borehole wells in villages affected by guinea worm, and in 1990 the Japanese government further agreed to provide $1 million in motor vehicles for Nigerians to implement their eradication strategy. The



Nigeria and Ghana discovered shockingly high rates of guinea worm infection when they conducted their first national searches, beginning in 1988 and 1989, respectively. Thanks to the rapid introduction of intervention programs in affected villages, by early 1991 both countries were able to announce dramatic reductions in the number of guinea worm cases.

In March 1991 the Nigerian government stepped up its "war on guinea-worm," directing local governments throughout the country to allocate 10% of their health budgets for eradication. Vice Pres. Augustus Aikhomu emphasized that if the disease was phased out completely at the grassroots level, the whole nation would be free from the menace that for such a long time has stricken so many of its citizens and prevented socioeconomic gains. Just one of the dividends of eradication will be that the Nigerian people finally will be able to lead lives that are more socially and economically productive.

New Nigerian


New NIGERIAN

No. 7,764 THURSDAY, MARCH 21, 1991 $1.50

RAMADAN 5, 1411 A.H.

TOTAL WAR ON GUINEA-WORM

A villager in Aga Laav, Benue state, Nigeria, helps spread the word: "Stop guinea worm disease!"

Rubina Imtiaz, M.D., Centers for Disease Control, Atlanta

latter donation was especially welcome and timely; during the first national search for cases in Nigeria in 1988–89, Nigerian health workers and volunteers had depended on haphazard means of transportation—borrowed or rented trucks and cars, motorbikes, bicycles, taxis, and personal vehicles—and some had walked long distances in order to reach villages all over the country.

In 1990 major pledges to the dracunculiasis eradication campaign came from U.S. businesses. In March the American Cyanamid Co., the world's only manufacturer of Abate, announced that it would donate through the Carter Center enough larvicide to eradicate guinea worm in all the affected African countries up to 1995—the target date for full conquest of the disease. UNICEF subsequently agreed to ship the donated Abate to Africa. Then in October, E.I. du Pont de Nemours & Co., in partnership with Precision Fabrics Group, donated over a million nylon filters and promised to supply another several million filters for water-filtration purposes throughout the eradication effort.

There is now committed and substantial support from many sources as efforts are under way in all of the affected countries in Africa to eradicate the "fiery serpent" by 1995. While additional strategic assistance and financial support are needed, the encouraging response on an international scale bodes well for Africa—and the world—to be guinea worm free before the end of the century.

The road to 1995

In February 1990 WHO took the first step in the process toward official certification of successful eradication of guinea worm disease. At a meeting of experts at its headquarters in Geneva, criteria were established for certifying the elimination of dracunculiasis in the many countries of Africa, Asia, and Latin America where the disease has been known to occur in the 20th century. In countries where guinea worm was still present during the 1980s, national authorities will have to show that their country has looked for but found no indigenous cases of the disease for at least three years. Recently endemic, geographically contiguous countries will only be considered for certification together, when the full requirements have been met

in each of the countries. Pakistan has already requested WHO's assistance in preparations for certifying its eradication of guinea worm.

Civil wars in northeastern Africa are the most serious remaining obstacle to eradication of dracunculiasis, but at worst even they can only delay, not prevent, its achievement. The Smallpox Eradication Program succeeded only 10 months after its target date despite civil wars in Nigeria, Pakistan, and The Sudan. The apathy of some national and international officials and misunderstanding of guinea worm disease by villagers still must be overcome in some areas, but that, too, is only a matter of a little more time.

In October 1989 Global 2000 campaign leaders visited the village of Nkwanta in Wenchi district of Ghana's Brong Ahafo region, which was experiencing for the first time a notable decline from previous years in the number of cases of guinea worm disease because the Roman Catholic Church had recently built a well there. Among the victims in Nkwanta was a young man, 19 years old, whose story was particularly poignant. He had been afflicted with guinea worm several times before and had recovered completely; that year he was recovering from what would likely be his last episode of guinea worm ever, for the disease was close to being eliminated in his village. Unfortunately, however, this time the parasite had emerged from a blister near his right knee, causing severe scarring at the site. The result was that his right leg was permanently flexed at the knee, and he would be crippled for life. For this victim, tragically, eradication came too late.

By December 1995 there should be no more such tragedies. Future generations in Africa and Asia will not know what they are missing. Medicine's very symbol, the staff of Asclepius, will have a new significance.

The eradication of guinea worm disease will give new significance to the very symbol of medicine. Some scholars believe that the "serpent" entwined about the symbolic healing staff of Asclepius, the Greco-Roman god of medicine, in fact depicts the mode of treating guinea worm. The caduceus is also the logo chosen by the World Health Organization (WHO) to stand for its global commitment to the highest level of health care for all people. In the late 1980s WHO selected guinea worm disease as the second major infectious disease—after smallpox—for eradication from the face of the Earth. WHO believes that all people deserve health services that will enable them to lead socially and economically productive lives. With that dedication, the organization has played a leading role in the conquest of guinea worm thus far. In early 1990, confident that the target date of 1995 for the disease's complete elimination could be met, WHO took the first step in the official eradication certification process. Pakistan was expected to be the first country declared guinea worm free.

Photographs, (left) National Library of Medicine, Bethesda, Maryland; (right) World Health Organization