Mosquitoes, Malaria, and Man

By Zachary DeWald

In 1906, Henry Dewald was called to the mission field to serve in Christianborg, Gold Coast, British West Africa (now called Ghana). He knew there were a variety of risks that he was taking by going to Africa, including the possibility that he would contract malaria. The risk became a reality in 1916, and his malaria was treated with doses of quinine sulfate. In 1928, he was forced to return to the United States for health reasons. By this time Henry had lost vision in one eye caused by the quinine given to him to treat the malaria. He had also developed a cataract condition in the other eye that doctors said was a result of the quinine, which eventually led to complete loss of sight.

Henry is just one example of how man is affected by mosquitoes and malaria. Malaria's health and economic cost to a single person in this case included loss of eyesight which resulted in loss of employment, having to relearn typing and the use of woodworking tools, and learning to read by braille. He was fortunate to have survived. Even today, many do not.

Man and malaria exist in a parasitic relationship. However, it is the existence of another parasitic relationship, the one between man and mosquito, which has allowed malaria to flourish and spread so easily. Four species of organisms in the genus *plasmodium* can produce malaria: *Plasmodium vivax, P. ovale, P. malariae*, and *P. falciparum*. These four species of *plasmodium* reproduce inside certain species of the female *Anopheles* mosquito, the most common species being *Anopheles* gambiae. *Anopheles* female mosquitoes, like all female mosquitoes, need blood to nurture their eggs. Humans are an abundant source of blood for the female mosquito, and just the bite, or more correctly the saliva, of an infected *Anopheles* female can transmit *plasmodium* into the human. The parasite then works its way into the liver and starts multiplying inside the

hepatic liver cells, turning into merozoites, which then enter into red blood cells. The cycle repeats itself when an uninfected *Anopheles* female bites an infected human. Eliminating either the *plasmodium* or the female *Anopheles* mosquito would seem like a simple solution to this disease producing cycle. (4,8,9,18)

Malaria has been causing problems for mankind for a very long time. The Egyptians knew of it, though they thought it was “miasma” or bad air or gas from swamps. The Chinese have been using the herb *Artemesia Annua* for the past 2000 years as a prevention and treatment for malaria. In 1907, a French army doctor named Charles Louis Alphonse Laveran was awarded the Nobel Prize for Physiology for being the first person to describe the life cycle of malaria.(6,8) During all of this time man has been trying to find an effective way to combat this disease. It’s just not as easy as it sounds.

In most cases malaria won’t actually kill its host (humans) because the *plasmodium*, like many other infectious diseases, relies upon its host for survival. If malaria did cause death in all humans that contracted the disease, the *plasmodium* would quickly run out of people to infect and would itself die out. The Centers for Disease Control and Prevention (CDC) and the Bill and Melinda Gates Foundation both estimate that malaria kills approximately 1.3 million humans and infects another 300-500 million.(1,4,5,11,16) Two factors that increase an individual’s survival rate are 1) a healthy immune system, and 2) if the disease is caught early and treatment given. In general, an individual that is in good health will suffer mild symptoms from malaria. The most common symptoms of malaria are flu-like and include fever, shivering, aches in joints, sweating, headache, nausea, and general malaise.(4,6,8,18) Reoccurring exposure to the parasite seems to lessen the symptoms to the point that if contracted repeatedly, the patient might feel as if they are

having a bad day instead of experiencing the more severe symptoms associated with malaria. Symptoms usually occur between 9 to 40 days (depending upon which *plasmodium* the person is infected with) but have been known in some cases to take months to develop. The most serious problems occur when the parasite infects a person that has a weaker immune system such as the elderly, young children, and pregnant women. In these cases infected red blood cells can block the blood vessels leading to the brain or other major organs resulting in death if not treated immediately. Delays in seeking treatment also increase the risk of serious complications or death.[9,18]

Research has demonstrated that malaria is both a very curable and preventable disease.[8] In the 1960s some countries, such as the United States, were able to completely eradicate malaria.[1] However, all or parts of Africa, China, India, Southeast Asia, and South and Central America and south Asia still have major problems with the disease.[9,12,19] What is lacking in the ill-fated regions that allows the disease to continue to spread? Researchers have identified several major problems that countries face in making progress toward prevention of the disease. A lack of money, education, health systems, and the general inability to be able to take measures toward stopping this disease are the leading causes. [1,9,16] Organizations such as the World Health Organization (WHO) and the Bill and Melinda Gates Foundation are funding millions of dollars for malaria research and to provide existing medicines, pesticides, and personal protection devices to areas most heavily affected by malaria.[1,2,14,17,19] We will probably never know the number of hours in human aid that are being spent in hopes of finding a cure or helping those that currently suffer from the disease.

The destruction of the actual parasite seems like a simple and logical way to eliminate malaria since it is the transmission of the *plasmodium* through the saliva of the mosquito that causes malaria. Destroying the *plasmodium* before it enters into a commensalism relationship with the mosquito could eliminate malaria and possibly spare the mosquito from extinction. Currently, the only way to kill *plasmodium* before it enters the bloodstream of a human is to kill the *plasmodium*-carrying mosquito. Research is being done on the DNA of the mosquito and the parasite in hopes of discovering a way to interrupt the parasite's life cycle before it leaves the mosquito and infects man. (17) Once man is infected, anti-malarial drugs that kill the parasite are available for use, and projects funded by foundations such as the Bill and Melinda Gates Foundation hope to develop new drugs. Anti-malarial drugs used today cause other physical problems in humans or don 't provide complete protection from malaria. One of the oldest anti-malarial drugs used to disrupt the cycle of malaria, quinine sulfate, has numerous side effects, some very serious such as the blindness that Henry experienced. Drugs such as melfoquine (Larium) can cause psychiatric symptoms such as depression and hallucinations while other anti-malarial drugs can cause damage to the liver if taken on a long-term basis. Malarone, a drug with relatively few side effects, has been developed in recent years, but even this drug is not 100% effective in preventing the initial infection of malaria.(3,7) Part of the challenge in developing new drugs to eliminate the parasite in man is that the parasite itself has had the ability to become resistant to some anti-malarial drugs in the past.(13) Resistance to some of the more common drugs such as chloroquine (Aralen) has limited the ability to treat the disease when it occurs and may even make it harder to control malaria. Because of this, anti-malarial drugs are most effective when

used by travelers who will be exposed to infected mosquitoes on a short term basis rather than distributed community-wide for long periods of time.[1,15,19] Funding for anti-malarial drug research is increasing, and a new drug or drugs may be one way to control malaria in the future. If more effective drugs are discovered, health organizations would most certainly distribute them to areas where malaria is a problem. New anti-malarial drugs would definitely be one way to significantly decrease infection rates.

Since eliminating the parasite has failed so far, most countries have tried to eliminate the actual mosquito that carries the paramecium. To that extent, research has been very effective. Chemicals have been developed that are very effective at killing mosquitoes and have been an inexpensive way to help fight the spread of malaria. Some of these chemicals have also caused problems. The use of chemicals in the past has had a variety of negative effects on the environment. Dichlorodiphenyltrichloroethane (DDT) is a good example of one such chemical. DDT's insecticidal properties were discovered around 1939. DDT became a popular insecticide as a vector control due to its low cost and quickly became the insecticide of choice in the fight against mosquitoes. DDT was used to rid the United States of malaria and it worked well. However, man's early attempt at the eradication of malaria-carrying mosquitoes by using DDT on such a large scale had undesired consequences in other areas of the environment that had not been known prior to its use. In 1962, biologists associated the widespread and often careless use of DDT to the disappearance of songbirds. They soon discovered DDT in fish, livestock, and house pets. There is even the possibility that DDT caused cancer in humans who had not used caution when applying the chemical. With further research and time, previously unknown effects of DDT were realized, and by the early 1980s most developed countries had

stopped using it. DDT is still considered to be effective in the control of malaria-carrying mosquitoes, and the World Health Organization (WHO) has begun suggesting the use of DDT again despite its misuse in the past. The reason for this is that there are still many people dying of malaria and no other insecticide has been found that is as effective or as cheap as DDT. WHO, along with other United Nations agencies and health organizations, has recently recommended the use of DDT and proposes that DDT be used as a spray inside a house to prevent mosquito entry. WHO has concluded that a very limited and controlled used of DDT will have minimal effects on the environment but will have an impact in the control of malaria.[13,19] It is the negative effects that chemicals such as DDT have had on the environment that has slowed research and development in this area. A chemical discovered today with the potential of eliminating mosquitoes would most likely be met with resistance because of the potential for catastrophic effects on the environment. It could take years before the necessary research is completed to determine if new insecticides would really eliminate the malaria-carrying mosquito and to fully understand how surrounding environments may be altered. As responsible scientists we need to question and consider all possible outcomes, including those that we may not agree with, and then make a decision. In the case of malaria, what risks are we willing to take? Will man discover an insecticide that is safe, more effective, and still affordable?

Physical barriers to the bite of a mosquito have proven to reduce malarial transmission. Window screens and bednets are two examples of barriers that limit human-mosquito contact. Repellents and protective clothing are additional ways to control contact. [1,2,9,19] All seem practical, but have had limited success. The major challenge with the physical barriers is getting people to use and maintain the barriers properly. For

instance, bednets have been found to be more effective if they are treated with chemicals that either repel the mosquitoes from biting or shorten the mosquito's life span so that the malaria infection cannot be transmitted. Re-treatment of the bednets is necessary for them to continue to be effective, but it has been estimated that only 5% are re-treated.[14,16,19] The use of physical barriers seems so simple, but why aren't they used more extensively? One of the main deterrents is their cost. Humans most at risk for catching malaria are among the poorest in the world. The limited finances that are available are spent on basic survival needs, and bednets and window screens are not considered to be a necessity by most of these people. Not understanding the benefit of using and maintaining physical barriers also contributes to their lack of use. People not familiar with physical barriers are not in the habit of using them. They need to be convinced of their usefulness and taught how to use them.[14,16, 19] Funding is being made available to provide personal protection barriers and to educate those most in need of protection, but barriers themselves will not prevent the spread of malaria and are not a cure.

Health problems created by malaria may contribute to the economic decline in many of the countries where malaria is widespread. Countries that have the highest rates of malaria have developing economies and high rates of poverty. The economic gap widens between countries that have malaria and those who don't every time a person contracts the disease and experiences a decline in health. In Africa, malaria is said to be both a disease of poverty and a cause of poverty.[14] When an individual becomes ill with the disease and has to stay home from work, money is lost. Education is interrupted each time a child cannot go to school. Social development of children is often delayed because

of permanent neurological and other damage due to severe episodes of the disease. Each death from malaria is a loss in potential earning power. Without money, individuals cannot afford a visit to the doctor, anti-malarial drugs, transportation to a medical clinic, or personal protection barriers that may reduce the risk of getting malaria. Governments in the poorest parts of the world spend large amounts of money on medical clinics, mosquito control, education, and research. In some countries malaria consumes 40% of the public health money. In heavily infected areas it is not unusual for people to give up hope despite the efforts of their governments and health organizations to prevent the disease. As a result of this, social conditions in these countries have deteriorated. Tourism in these regions also suffers because most people do not have a desire to travel to countries with high rates of malaria and poverty. Without a tourist industry, government and local economies already struggling to meet the economic burdens of malaria are lacking a source of income that could help finance the fight against malaria. [8,14,19] The loss of man-hours and potential earnings, the cost of treatment and prevention, and the decline of the tourist industry results in millions of dollars lost each year to malaria. In these underdeveloped countries a microscopic creature contributes to a cycle of declining health and economic conditions that won't be stopped until a safe and economical way is discovered to prevent the disease.

In July 2006, I had the opportunity to travel to Tanzania, Africa, exactly 100 years after Henry, who was my great-grandfather, first entered the continent. I also knew that malaria was a health risk, but with the advances of science and medicine within the past century I didn't worry much. I was taking Malarone, had packed mosquito repellent with me, and slept in a bed surrounded by a treated mosquito net. I traveled to many parts of

the country, all of which had some form of mosquito eradication program in place. I felt protected. Unfortunately, I met natives of all ages who are infected with the malaria virus and many who have lost a family member or a friend to the disease. I personally witnessed the fact that the medicines, insecticides, and the personal protection devices that currently exist either do not provide adequate protection or are too expensive for people in many parts of the world. This allows mosquitoes and malaria to continue to be a very real threat to the health and welfare of man. From my own observations during the very limited time I spent in Tanzania I know that it's going to take tremendous efforts by scientists and large amounts of financial support if we hope to destroy the unhealthy relationship that exists between man, malaria, and mosquitoes.

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