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Infectious Diseases of the Eye: Loa Loa, Onchocerciasis, & Trachoma

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INFECTIOUS DISEASES OF THE EYE:

LOA LOA, ONCHOCERCIASIS, & TRACHOMA

A Thesis or Project

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Jessica Moon, Director, University Honors Program

Introduction

On December 16, 2006, I will graduate from the University of Northern Iowa with University Honors and a B.A. in both biology and psychology. I have always been interested in medicine and diseases, and this semester I wanted to explore some options for my future. At the start of the semester, I was considering applying to optometry schools after graduating from UNI. I am also highly interested in going on a mission trip, and perhaps a medical mission trip. In light of these interests, I decided to design my senior honors thesis around infectious diseases of the eye. With the help of my thesis advisor, Lisa Beltz, I narrowed my research focus to three diseases that significantly impact developing areas of the world: Loa loa, onchocerciasis, and trachoma. In addition to researching the specifics of the three diseases and their impact on endemic areas, I also wanted to investigate what is currently being done to treat and prevent these diseases.

Eye Anatomy

Of the five human senses, eyesight is perhaps used and valued the most. The human eye is a complex organ that, along with nerves and the brain, transforms light signals into visible images that can be seen. The orbit, or eye socket, is formed by the forehead, temple, and side of the nose. The eye globe sits on pads of fat in the socket, and through there run tendons, muscles, nerves, & blood vessels. The lacrimal gland is also found in the orbit, underneath the outer area of the upper eyelid. This gland produces and secretes lacrimae (tears) that lubricate and moisten the conjunctiva and cornea. Lacrimae also flush away foreign particles that enter the eye. After exiting the lacrimal ducts and passing across the globe, the tears drain away from the eye through the lacrimal puncta, which are small, single openings on the inner edge of the upper and lower eyelids. Tears then pass into the upper and lower nasolacrimal ducts, then into the lacrimal sacs, and through the bony canal to the nose's mucous membrane where they evaporate (Iliff 54).

The eye globe itself is approximately 24 millimeters in diameter and has several components. The "white of the eye" is called the sclera and extends around the eye globe, giving it shape and offering protection. The sclera is a tough, opaque coat made of connective tissue, elastic fibers, and blood vessels (Iliff 54). Attached to the sclera are six extraocular muscles that control the eye's movements. At the very back of the eye, the optic nerve attaches to the sclera.

At the most anterior part of the eye globe is the cornea, which is a transparent, dome-shaped layer at the center of the eye. The cornea acts to focus light entering the eye; it is a powerful refracting tool, providing two-thirds of the eye's focusing power (St. Luke's). The cornea is very sensitive due to the high number of nerve endings here—more than are found anywhere else in the body—and is composed of five layers. The epithelium covers the outer surface of the cornea and quickly regenerates if the cornea is injured. Just underneath the

epithelium is the tough Boman's membrane, which protects the cornea. The third and thickest layer, found just underneath Boman's membrane, is the stroma. The cornea's clarity comes from the special formation of the tiny collagen fibrils that make up the stroma. The fourth layer is Descemet's membrane, and the fifth and innermost layer is the endothelium. The endothelium has only one layer of cells that keep the cornea clear by pumping away water. These cells do not regenerate if damaged (St. Luke's). Oils and mucous that moisten and lubricate the eye are secreted by the conjunctiva, which is a thin, transparent tissue covering the visible part of the sclera. It begins at the outer edge of the cornea and lines the inside of the eyelids.

Just posterior to the cornea is the anterior chamber, filled with a clear, aqueous humor. The colored iris is situated between the anterior chamber and the posterior chamber, which is also filled with aqueous humor. Where the cornea and iris meet is the anterior chamber angle and the trabecular meshwork. Aqueous humor drains out of the eye at the trabecular meshwork, balancing pressure inside the eye (Graham).

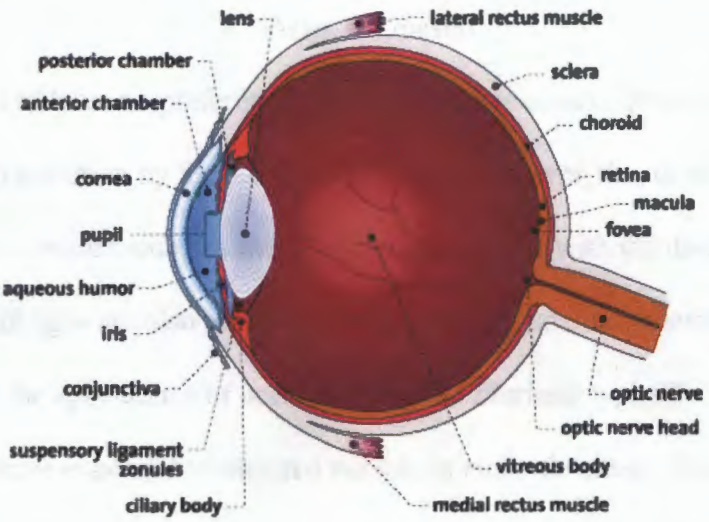
The iris itself is the colored part of the eye, consisting of pigmented fibrovascular tissue known as a stroma (St. Luke's). Connected to the stroma is a sphincter muscle that constricts the pupil and a set of dilator muscles that widen the pupil. The pupil is an opening in the iris, seen as the round, black area at the center of the eye. The constriction and dilation of the iris controls the amount of light entering the eye through the pupil.

The ciliary body is found posterior to the iris and is the site of aqueous humor production. Tiny fibers called zonules are attached to the ciliary body, and these zonular fibers suspend the crystalline lens within the eye. When the ciliary body contracts, the zonules relax and the lens is able to thicken. Thickening of the lens increases the eye's power to focus on near objects. Likewise, when the ciliary body relaxes, the zonules contract, thinning the lens to focus on

distant objects. The changing shape of the lens works to focus light onto the retina at the back of the eye.

Inside the cavity of the globe is transparent vitreous humor, which supports the structures of the eye. The structure found lining the posterior part of the globe, between the retina and sclera, is the choroid. The choroid has layers of blood vessels carrying the main vascular supply to the outer layers of the retina. The retina is the eye's sensory tissue, found at the back of the globe. It is multi-layered and highly differentiated, containing millions of photoreceptors called rods and cones.

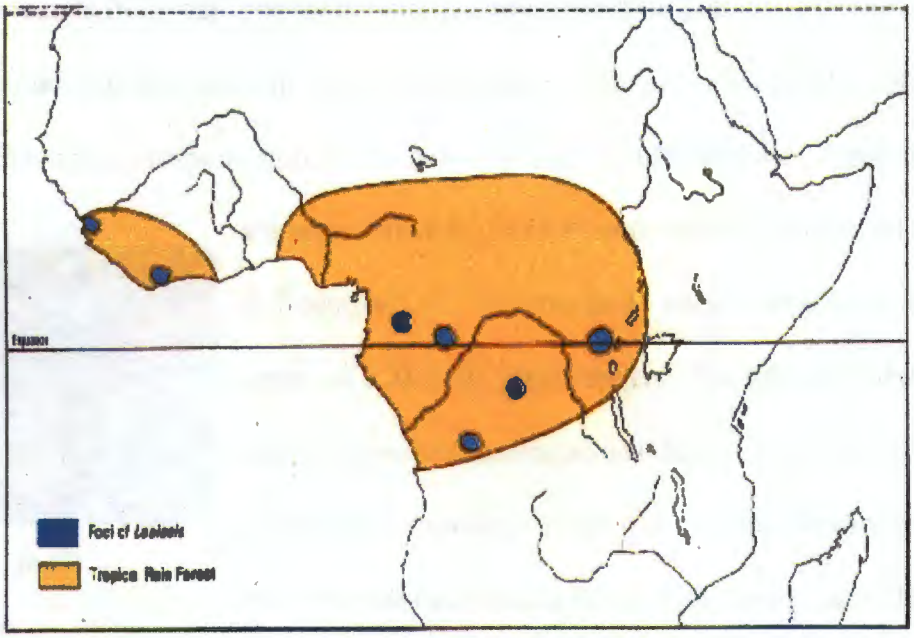
The approximately six million cones are found in the macula, the central region of the retina containing the pit-like fovea. The fovea is the area of most acute vision, due to the densely-packed cones. Cones function best in bright light and allow for the observation of color. The approximately 125 million rods function best in dim lighting and are therefore employed in peripheral and night vision. They are spread throughout the marginal areas of the retina. Once light signals are received by the photoreceptors, they are converted into electrical impulses that are transmitted along the optic nerve to the brain.



(Bagi)

Loa Loa

Loa loa, also known as loiasis or African eye worm, is found in the rainforest and swamp areas of tropical Africa. Endemic in Central and West Africa, from Sierra Leone to Cameroon, Loa loa is especially common on the Ogowe River. One estimate suggests that Loa loa larvae have infected between two and thirteen million people (Arcari). According to another estimate, Loa loa has infected approximately three million people in Central Africa alone (Nissen).



(Map of Loiasis)

Loa loa seems to have no preference for a certain race or sex. Men and women are equally susceptible to infection by the African eye worm; however, due to various work practices and exposure to insect vectors, one sex might come into contact with the disease more frequently (Nissen). People of all ages are also at risk for infection and potentially have microfilariae in their blood, although the appearance of acute and chronic filariasis typically occurs after several years of frequent, intense exposure to infected vectors in endemic areas. Therefore, clinical infection may not be evident even though microfilaremia rates increase with age, due to more

exposure to infected vectors (Nissen). Also, expatriates from any country who move to an area endemic with loiasis are more susceptible to symptoms of infection than local residents; people who are indigenous to endemic areas display higher tolerance to the presence of *Loa loa* worms (Rodger 163).

Loa loa

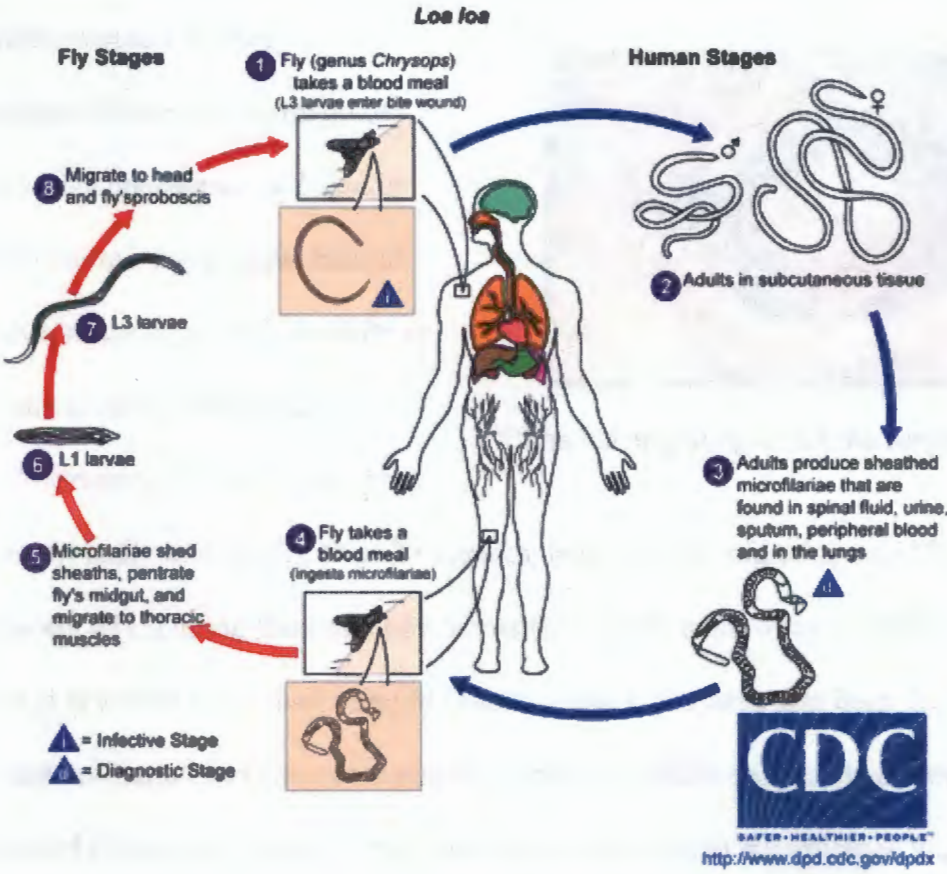
Loiasis results from infection by the microscopic nematode *Loa loa*. Humans are the sole reservoir for human *Loa loa*, and although monkeys can contract a simian *Loa loa* infection, it is very unlikely that natural transmission occurs between humans and monkeys. Adult male worms are approximately 2 to 3.5 centimeters in length and females, 5 to 7 centimeters. The sheathed microfilariae have an average length of 250 to 300 micrometers. The parasitic adults actively migrate in subcutaneous tissues throughout the human body, occasionally crossing beneath the conjunctiva of the eye. The microfilariae occur in the blood with diurnal periodicity. Therefore, the highest numbers of microfilariae can be detected in the blood between ten o'clock in the morning and two o'clock in the afternoon; during the night, microfilariae may be found in the lungs (CDC DPD).

("*Loa loa*")

Humans contract *L. loa* through the bite of infected, day-biting deerflies, horse flies, or mango flies of the genus *Chrysops*. When a fly bites an infected individual during the day, microfilariae from the host's blood are taken up via the fly's mouthparts. Once inside the vector, the microfilariae lose their

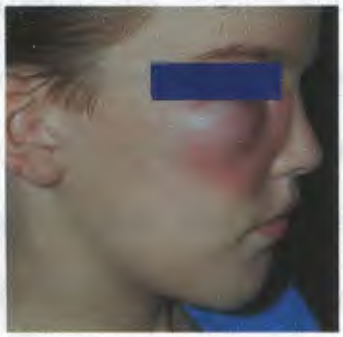
(Hutchinson)

sheaths and migrate to the fly's thoracic muscles. They then undergo various stages of growth, into first-stage larvae and eventually into third-stage larvae. Third-stage larvae are infective and migrate back to the fly's proboscis in order to infect a new human host during the fly's next blood meal. The development within the insect vector may take one or two weeks. Once inside a human host, the development of *L. loa* is very slow, taking four to six months to become adult worms. During this process the parasites live in the subcutaneous and deep connective tissues of the host (Arcari). After reaching maturity, adult male and female worms mate, producing thousands of sheathed microfilariae. The microfilariae may travel to various locations in their human host, as they have been extracted from spinal fluids, urine, and sputum.



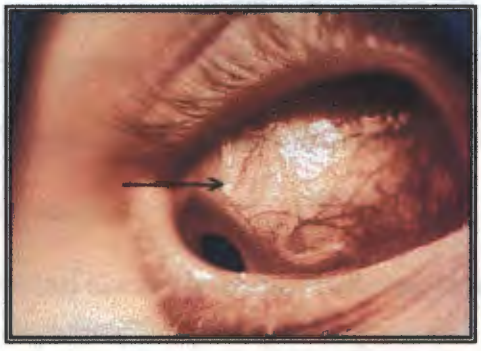
(CDC DPD)

Although many people infected by *L. loa* appear to be asymptomatic, the migration of the adult worms may be noticed by the host, especially if they cross beneath the conjunctiva of the eye (Arcari). The most common symptom of infection by the African eye worm is Calabar swellings. These red, itchy swellings can be five to ten centimeters or more in length and about the size of half a goose egg. They appear rapidly and generally subside after a few days, occurring in any part of the host's body. Calabar swellings are due to an allergic response of the host to filarial toxins released by the worms. Although the migration of *L. loa* may cause no serious trouble for the infected host, going unnoticed for a long period of time, much irritation and congestion may occur if a worm migrates to the eye.



("Calabar swelling")

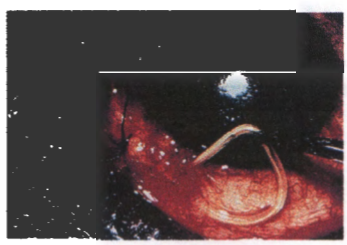
The name African eye worm comes from the disturbing appearance of *L. loa* in the eye. Adult worms may migrate beneath the conjunctiva, resulting in pain, inability to use the eye, and swelling of the eyelid (Rodger 163). Crossing the eye is a fairly quick process, typically taking only 15 to 20 minutes; however, the migration could last a few hours (Whitworth 63). During this migration across the eye, the adult worm is visible under the conjunctiva and is visible in the host's line of vision. Adult *L. loa* have also been identified in the eyelid, vitreous humor, and anterior chamber of the eye. Additionally, retinal hemorrhages due to aneurismal dilatation of retinal vessels have been attributed to microfilariae migrating to the retina and choroidal vessels (Klotz 677).



("Loa loa migrating under the conjunctiva")

Treatment and Prevention:

Loa loa may be treated with a synthetic, anthelmintic drug called diethylcarbamazine (DEC). This treatment kills both the microfilariae and adult worms, but may also induce allergic reactions as the body responds to the dead parasites (Plorde 707). Thus, a low dose (approximately two to three milligrams per kilogram body weight) is usually administered for the first three days, increasing to a higher dose (nine milligrams per kilogram) through day 21 (Nissen). DEC immobilizes the microfilariae, which are then destroyed in the liver. The adult worms are also unmasked by the drug, thereby being recognized as invaders by the human host's immune system (Rodger 164). Fever, malaise, joint swelling, joint pain, and intense itching may be experienced during treatment with DEC. Ivermectin, which is used in the treatment of onchocerciasis, is not as effective against loiasis. In fact, severe encephalitis is a risk if ivermectin is given to someone with a high *Loa loa* microfilarial count (Thomson). Adult worms may also be surgically removed from various sites.

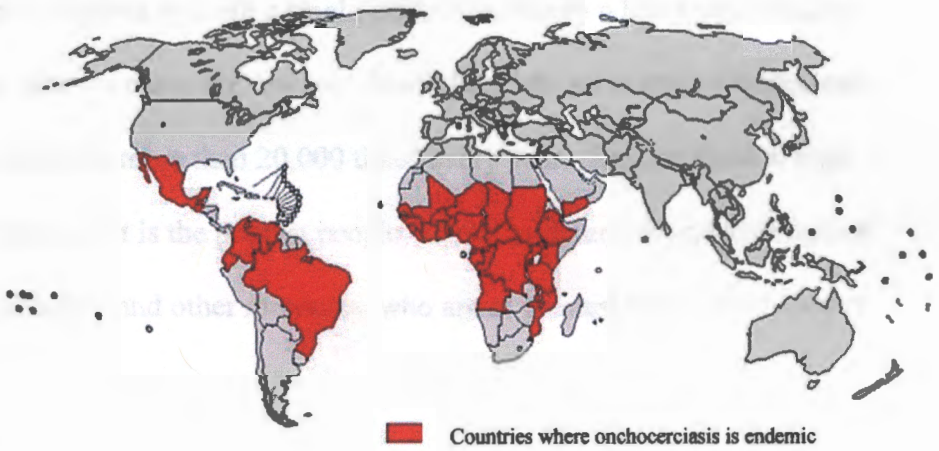


(Klotz 676)

Unfortunately, prevention of Loa loa through vector control has not been extremely successful. Therefore, people should wear light-colored clothing and stay away from fire smoke to avoid being bitten by infected *Chrysops* flies (Rodger 164).

Onchocerciasis

There is an African proverb that warns: *Nearness to rivers can eat the eyes* (Carter Center). The blinding disease onchocerciasis is found in Mexico, Guatemala, Ecuador, Colombia, Venezuela, Brazil, Yemen, and 30 African countries (CDC). Also known as onchocercosis, river blindness, Robles' disease, or blinding filariasis, this disease currently infects approximately 18 million humans (Brattig 113). The World Health Organization estimates that there are 500,000 humans visually impaired and another 270,000 blind due to onchocerciasis. In Africa, river blindness may infect 30 to 60 percent of the population in various regions (Marquardt 461). Onchocerciasis is endemic in 37 countries, and more than 99 percent of the people infected live in Africa, with Nigeria being the most endemic country in the world. In the Western Hemisphere, there are only approximately 800,000 infections (461).



(WHO)

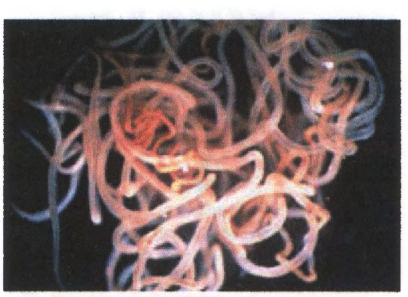
Onchocerciasis has had a huge economic impact globally, significantly reducing work productivity in infected areas. River blindness prevents people from completing everyday tasks, such as farming, going to school, and caring for children. It is most readily contracted and spread in remote, rural African agricultural villages that are located near rapidly flowing streams. As a result, people abandon rich, arable land near rivers and move to less fertile areas to protect

themselves from onchocerciasis. In some countries, this factors into food shortages in those communities (Carter Center).

Onchocerciasis is rare among casual travelers in endemic countries. People with more intense and prolonged contact to black fly bites, such as local residents, adventure travelers, missionaries, and Peace Corps volunteers, are at much higher risk for river blindness. This is because onchocerciasis is not acquired through a single infectious bite by a black fly; it usually takes hundreds of infectious bites to cause the disease. Black flies bite some men, women, and children living in infected countries more than 20,000 times every year. Among those at high risk for contracting onchocerciasis, it is the poorest people, unable to defend themselves against black flies by means of insecticides and other measures, who are at greatest risk (Carter Center; CDC).

Onchocerca volvulus

River blindness is caused by the parasitic, filarial nematode *Onchocerca volvulus*, which has a five-stage life cycle (Brattig 114). *O. volvulus* is found almost exclusively in humans, and the adult worms reside in subcutaneous nodules called onchocercomas (WHO). Males average 3 to 8 centimeters in length and females 30 to 80 centimeters (Brattig 114). The microfilariae have two sizes, 285 to 368 micrometers or 150 to 287 micrometers in length. The males may migrate, although typically a male and female remain coiled together in a nodule where they mate, forming eggs inside the female that mature into microfilariae. Adult female worms can live up to 15 years, producing hundreds or even thousands of microfilariae each day, which leave the

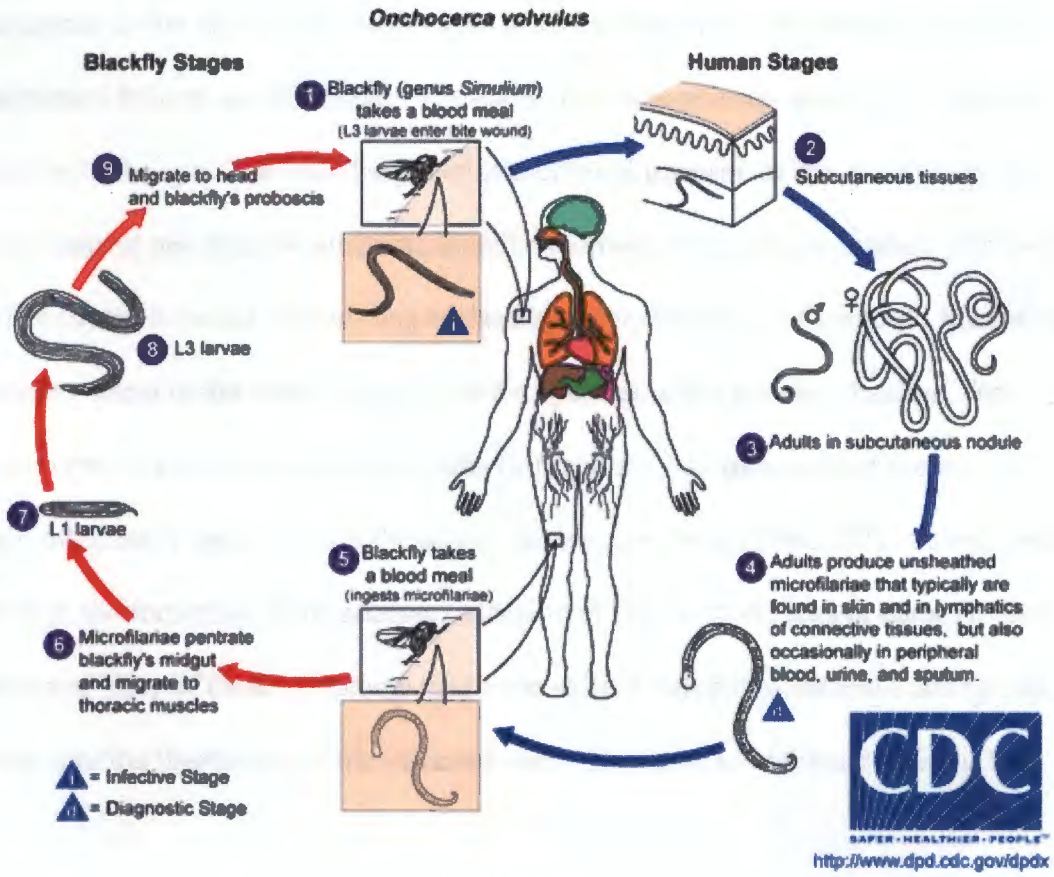


(WHO)

female one by one. The microfilariae can live for two to three years, with a common incubation period of one to two years (Enk 177).

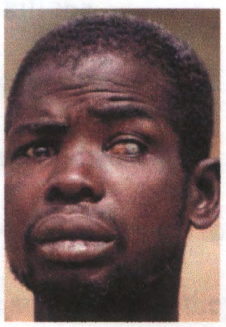
Humans contract *O. volvulus* when a *Simulium* black fly bites an infected individual, taking up microfilariae into its mouthparts during the blood meal. Over the course of approximately a week, microfilariae develop into L3 larvae in the thoracic flight muscles of the fly (Basáñez 431). At this stage the microfilariae can infect humans, escaping from the mouthparts the next time the fly take a blood meal, invading the host through wounds made by the vector. Once in the human host, microfilariae develop into adult worms, continuing the life cycle.

(WHO)



(CDC DPD)

Unlike other filarial diseases, onchocerciasis is caused by microfilariae and not by adult worms. The microfilariae migrate to near the surface of the skin and to the eye, irritating these areas. Some humans infected with this parasite are asymptomatic, but those showing signs of the disease generally display at least one of three symptoms: skin rash, eye lesions, and subcutaneous nodules (onchocercomas). With skin rashes may come intense itching and skin depigmentation, but the most serious symptom of onchocerciasis is blinding lesions in the eyes.



(Edwards)

Microfilariae may migrate to the eye, invading the conjunctiva, cornea, and other regions of the eye in patients with a high microfilarial load or in patients who have the rare occurrence of onchocercomas in the upper body, such as the head (Brattig 117). The human body's own immune system induces an inflammatory response due to increasing numbers of degenerating microfilariae in the eye. The initial signs of microfilarial invasion of the eye are seen as snowflake corneal opacities or punctuate keratitis (corneal inflammation marked with points or dots differentiated from the surrounding surface by color, elevation, or texture). Microfilariae may also be present in the anterior portion of the eye, and in the anterior chamber, dead microfilaria may cause severe anterior uveitis (inflammation of part or all of the uvea, middle tunic, and often other tunics such as the sclera, cornea, and retina) (Enk 178). Severe uveitis may result in the formation of synaechiae (adhesion of the iris to the lens or cornea), cataract, and glaucoma. Any of these symptoms may eventually develop into corneal scarring and a sclerosing keratitis (hardening of the inflamed cornea), leading to blindness (Brattig 117).

Treatment and Prevention:

Fortunately, there are ways to treat and prevent river blindness. In the past, diethylcarbamazine (DEC) was given to people infected with *O. volvulus* to kill the microfilariae. Allergic reactions often ensue when the parasite is killed too quickly. Specifically, the eyes can experience a brief period of watering, photophobia, and itching (Manson-Bahr 173). Therefore, diethylcarbamazine treatment must begin with small doses to prevent this negative side-effect. Since diethylcarbamazine does not kill the adult worms, they need to be surgically removed from obvious nodules or destroyed by a more toxic agent, suramin (173). In cases where the adult worms are not destroyed, the microfilariae reappear. People experience symptoms of infection after three to six months, and within one year the microfilariae multiply to half the original concentration (172).

Recently, the microfilaremic agent ivermectin has been used in treating onchocerciasis. This drug has been shown to be more effective than diethylcarbamazine, and people do not seem to have severe allergic reactions when treated with ivermectin. Like diethylcarbamazine, ivermectin fails to kill adult worms; therefore, people must be retreated over the duration of several years. An oral dose of 150 micrograms of ivermectin per kilogram body weight, with a maximum dose of 12 milligrams, is given every six to twelve months (CDC).

Prevention of river blindness mainly focuses on vector control. Unfortunately, it has been difficult to successfully reduce black fly populations because the larvae's habitats are remote. Also, *Simulium* species are strong fliers and may have long flight ranges (Marquardt 463). Insecticides and larvicides have been used to kill the vectors of *O. volvulus*, and since black flies bite during the day, wearing long sleeve shirts and long pants is a sensible preventative measure.

Organizations:

In 1974, the Onchocerciasis Control Program (OCP) was established to eradicate river blindness in eleven countries of West Africa (Benin, Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Senegal, Sierra Leone, and Togo). Approximately 40,000 new cases of blindness were reported each year at the height of the OCP movement. In 1987, the pharmaceutical company, Merck & Co., Inc., offered to donate Mectizan (ivermectin) to everyone who needed the drug. The partnership of the OCP with Merck and other sponsors has freed large areas of disease through aerial spraying and medication. Today, the West African OCP area is largely free of river blindness, but over 15 million people in East and Central Africa are still at risk.

Close to $560 million in donations has funded the OCP since its creation (OFID). This organization has prevented 600,000 cases of blindness, protected 18 million children from contracting the disease altogether, recovered 25 million hectares of land for resettlement and agriculture, and achieved an estimated economic rate of return of 20 percent (World Bank). The OCP was phased out in December of 2002, and at that time was redesigned to become a sub-regional, multi-disease surveillance center.

Due to the success of the OCP, the African Program for Onchocerciasis Control (APOC) was created in 1995. Its objective was to implement self-sustainable Community-Directed Treatment (ComDT) in the remaining 19 endemic African countries (Angola, Burundi, Cameroon, the Central African Republic, Chad, the Democratic Republic of Congo, the Republic of Congo, Equatorial Guinea, Ethiopia, Gabon, Kenya, Liberia, Malawi, Mozambique, Nigeria, Rwanda, the Sudan, Tanzania, and Uganda). Community-Directed Treatment empowers communities, enabling them to take full responsibility for controlling the disease. Ultimately,

APOC is striving to eradicate onchocerciasis as a public health threat from the entire continent of Africa (OFID). The organization hopes to be fully funded and treating 60 million people with Mectizan each year by its closing date in 2010.

In the eastern hemisphere is The Onchocerciasis Elimination Program of the Americas (OEPA). Led by the Carter Center, the OEPA is a coalition of partners striving to control river blindness (Carter Center). The Carter Center works closely with the Centers for Disease Control and Prevention and the Mectizan Donation Program to eliminate onchocerciasis from the Americas.

Trachoma

"I'm really worried about who will look after the children if I can't see" (Sight Savers). This is the fear of 75 year-old Ezereya, who lives in Uganda, where blinding trachoma is a real concern. Endemic in most countries at one time or another throughout history, trachoma is one of the oldest infectious diseases known to mankind, referenced on papyrus scrolls dating back to ancient Egypt (ITI). Also known as granular conjunctivitis and Egyptian ophthalmia, this disease is the leading cause of infectious ocular morbidity in the world, currently blinding approximately 3.6 million people worldwide (Subramanian). Trachoma is endemic in many areas of Africa, Asia, the Middle East, Central and South America, the Pacific Islands, and in aboriginal communities in Australia. Active trachoma is found in 55 endemic countries, 36 in Africa alone. Until the 1950s, trachoma still posed a significant health threat in industrialized countries; but with improved sanitation and living conditions, this is no longer true in the United States and Western Europe. Today, infection with trachoma impacts approximately 84 million people; eight million of those affected are visually impaired due to the disease (Solomon). Trachoma is responsible for more than three percent of the world's blindness, and threatens to blind nearly ten percent of the world's population (WHO; ITI).

(ITI)

Although trachoma is the world's leading cause of infectious blindness, many people have never heard of this disease. Trachoma receives little attention as an urgent public health issue because it does not kill its victims and is mostly confined to the poorest of the world's population. Unfortunately, this blinding disease often devastates the economic well-being of endemic communities. According to the International Trachoma Initiative, this disease causes a productivity loss estimated at US $2.9 billion each year (ITI). In endemic communities, blindness from any cause is associated with a higher risk of mortality, and trachoma makes it very difficult for adults to provide for their families. Trachoma is three times more likely to (blind women, the traditional homemakers. When this happens and women are prevented from caring for the home, a daughter is typically removed from school to take over for her blind mother. This results in the daughter and the community missing one more opportunity for a formal education and a chance to escape poverty (ITI).

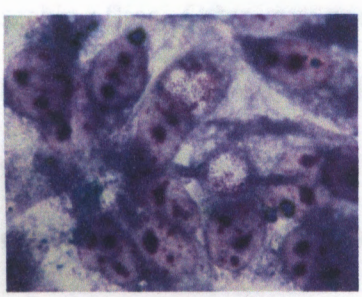
Endemic trachoma is found primarily in developing countries in overcrowded, rural communities with inadequate access to clean water and health care, especially in dry, dusty areas. It is transmitted almost exclusively from human to human through close personal contact, such as through sharing bath towels. If flies come into contact with infected eye or nose discharge, they may also transmit trachoma to an uninfected person. Children under the age of five are the main reservoir of trachoma infection, and women rather than men are traditionally in closer contact with children in endemic areas. The hyperendemic prevalence in pre-school children may be as high as 60 to 90 percent (WHO). This explains women's higher risk of developing the blinding complication of trachoma. Although social behaviors and customs put

(ITI)

women and small children at greater risk for infection in endemic communities, trachoma does not discriminate against any race, age, or sex. In hyperendemic communities, active trachoma may infect nearly every member of most families (Solomon).

Chlamydia trachomatis

Trachoma is caused by the bacterium *Chlamydia trachomatis*, an obligate, intracellular parasite. Serovars A, B, Ba, and C are responsible for trachoma, whereas serovars D through K cause genital Chlamydia infections and serovars L1 through L3 cause lymphogranuloma venereum (Solomon). *Chlamydia* species are generally round and approximately 200 to 400 nanometers in diameter (Tarizzo 1165). They have one of the smallest DNA genomes among prokaryotes, possessing only one-fourth the size of the genome of *E. coli*. Their cells contain DNA and RNA, as well as nucleoids, ribosomes to synthesize protein, and discrete cell envelopes. *Chlamydia* species cannot, however, produce their own ATP and must rely on the host cell's metabolism for precursors to nucleic acids and for energy production (Tarizzo 1165). Similar to Gram negative bacteria, their cell envelopes have inner and outer membranes; however, there is no peptidoglycan layer between the membranes in *Chlamydia* cells.



(Petersen)

C. trachomatis exists in two forms. The first is the elementary body, a tough, infectious form with a small size of approximately 0.3 micrometers. The second is the reticulate body, which is the larger (at least one micrometer in diameter), fragile intracellular replicative form (Drew 423). The plasma membranes of susceptible target cells have glycoprotein or glycolipid receptors to which the elementary body can attach. The bacterium then enters the host cell by

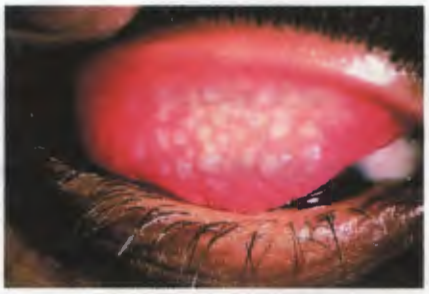
endocytosis, and within 8 to 12 hours, the elementary body experiences metabolic changes, reorganizing into the much larger reticulate body (10 to 100 times larger). The reticulate bodies continue to grow and divide by binary fission, using the host cell's ATP. Eventually, the *Chlamydia* organisms fill much of the infected host cell, forming a large cytoplasmic inclusion body. Within 24 to 72 hours, the large reticulate bodies once again reorganize to create multiple smaller elementary bodies. These elementary bodies are capable of infecting other susceptible cells when the infected cell lyses (424).

C. trachomatis is easily spread by an infected person's hands or clothes, or by eye-seeking flies. Often, eye or nose discharge from an infected person is left on a towel, handkerchief, piece of clothing, or finger. The bacteria are able to spread to the next person who comes in direct contact with the eye, nose, or throat secretions from an infected person or by contacting a contaminated item. Therefore, the most crucial environmental risk factors are lack of clean water, poor personal hygiene, crowded communities, and sometimes eye-seeking flies.

After the initial infection, *C. trachomatis* has an incubation period of 5 to 12 days (Subramanian). Also, there is almost no risk of blindness from a single incidence of acute Chlamydial conjunctivitis. Instead, the blinding complications experienced later in life seem to result from prolonged exposure to trachoma infection throughout childhood and young adulthood. People who are infected with trachoma do not instantly suffer complications or go blind; the disease progresses gradually. Trachoma begins as conjunctivitis and can be described in four stages (Manson-Bahr 588).

In Stage I, the infected person may experience lacrimation (shedding of tears) and slight edema (swelling from excessive accumulation of serous fluid in tissue) of the eyelid. Tufts of dilated capillaries, follicles, and formation of epithelial papillae appear in the conjunctiva of the

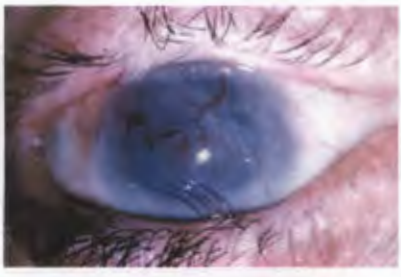
upper eyelid. The conjunctiva develops a granular appearance due to the follicles, which may be two to three millimeters in size. This first stage may continue for several months, and the upper lid is consistently worse than the lower lid.



(Custom Medical Stock Photo Inc.)

In Stage II, blood vessels invade the cornea at the upper limbus. Eventually, a combination of new vessels and infiltrate known as pannus covers the cornea, impairing the host's sight. Also, ulcers may form and become epithelialized, further distorting vision. The infiltration can soften the cornea, causing ectasia (the protrusion of a thinned, scarred cornea) and even rupture. This second stage may last from 6 to 12 months or longer in untreated persons.

During Stage III, linear cicatrisation (scarring) starts in the tarsal conjunctiva and in the subtarsal groove. White cicatrices replace ruptured follicles, creating a smooth, white, avascular covering over the conjunctiva. This matrix gives trachoma-afflicted eyes their bluish, milky appearance. Follicles in the cornea may also rupture or cicatrize, creating Herbert's Pits (a series of lacunae at the limbus). At this time, economic sight may return as long as ectasia or rupture has not involved the cornea. This third stage may persist for several years.



("Blinding Trachoma")

In Stage IV, the active disease cannot be found; death of the cornea has come to an end. Scar tissue has replaced the follicles, and the main activity during this stage is the progressive cicatrisation of the scar tissue. The margin of the eyelid experiences entropion, the turning in of the eyelid toward the cornea due to the contraction of scar tissue in the tarsal plate.

Consequently, the eyelashes are turned in on the cornea and secondary lines of eyelashes appear, growing in all directions. This condition of trichiasis results in constant irritation of the eyeball due to the motion of the distorted lash-bearing lids. The cornea becomes vascularized and ulcerated again, due to the irritation. Lacrimal secretion may be cut off by the cicatrisation of fornices, causing xerophthalmia (abnormal dryness of the conjunctiva and cornea). The conjunctiva then becomes coated by a skin-like membrane, leading to blindness (Manson-Bahr 588).

Treatment and Prevention

If treated early, the prognosis for trachoma is very good. Currently, an oral antibiotic called azithromycin is used to combat infection. Previously, oral tetracycline was used, but azithromycin is more effective against *C. trachomatis*, although it is also more expensive (Solomon). Tetracycline eye ointment may also be used topically in conjunction with an oral antibiotic. Azithromycin is easier to administer than the topical tetracycline, and its administration can be monitored directly, so compliance is higher with the oral medicine. This drug also has few negative side-effects, the most common being fairly mild (upset stomach or rash). The World Health Organization (WHO) recommends that in communities where the prevalence of follicular trachoma in children aged one to nine years is 10 percent or higher, antibiotics should be given to everyone throughout the district (Solomon). Children are generally given 20 milligrams of azithromycin per kilogram body weight in a single dose; adults are given a single dose of one gram. Tetracycline eye ointment should be applied to both eyes twice daily for six weeks.

In addition to oral and topical treatments, surgery may be required to repair eyes in advanced stages of trachoma (Drew 426). Trichiasis can be corrected by surgery that rotates the eyelid. This remedy prevents further corneal scarring and sometimes results in improved vision (Solomon). Long-term follow-up care is important after surgery because people living in endemic areas are at risk for re-infection by *C. trachomatis*.

Prevention of trachoma is largely behaviorally based. Improving sanitation and not sharing personal items like towels significantly reduces the spread of trachoma. Educating communities about the importance of facial cleanliness is also crucial in preventing the spread and severity of this blinding disease. In the past, a reduced occurrence and even the disappearance of trachoma has been closely associated with improved personal and community hygiene. This has been true of Europe, the Americas, and Australia, as well as Africa and Asia (Solomon).

Organizations

The International Trachoma Initiative (ITI) was founded in 1998 by the Edna McConnell Clark Foundation and Pfizer Inc., with the goal of eradicating blinding trachoma. The ITI collaborates with WHO, government agencies, national ministries of health, and other partners to determine where trachoma control will be targeted. The ITI then works to implement the SAFE strategy and mobilize people and resources in country-led programs. The SAFE strategy has four components: eyelid surgery, antibiotic treatment (Zithromax, or azithromycin, donated by Pfizer), facial cleanliness, and environmental changes (WHO). Progress in the eradication of trachoma is demonstrated in communities that apply this four-part strategy.

Currently, the ITI works in 12 countries: Ethiopia, Ghana, Kenya, Mali, Mauritania, Morocco, Nepal, Niger, Senegal, Sudan, Tanzania, and Vietnam. Just last month, Morocco celebrated its success as the first country to complete the campaign for trachoma control due to the implementation of the SAFE strategy. Morocco was able to end its mass administration of antibiotics in the endemic areas. Next, Morocco will conduct a disease surveillance plan to ensure that the infection levels remain within the World Health Organization's guidelines. The global initiative to rid the world of blinding trachoma, GET 2020 (Global Elimination of Trachoma), hopes to eradicate the disease by year 2020 (WHO).

Personal Reaction

I find it encouraging that groups such as the OCP, APOC, OEPA, and ITI dedicate so much time, money, and effort to treating and preventing infectious diseases like onchocerciasis and trachoma. Interesting, I did not find any specific information on a group that focuses solely on loiasis; however, since loiasis and onchocerciasis often occur in the same areas, groups such as the OCP often encounter *L. loa* as well. At the end of this project, I feel that I have learned a lot about three diseases that I had never heard of before this year. This research has also opened my eyes to the fact that I know very little about the health of people worldwide. I still have a strong desire to participate in a mission trip in the next few years, and I still feel that a medical mission trip would be very interesting. Although I do not know that I will be involved with any groups that work with these three diseases, I will keep it a consideration in the future.

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