

Spirurida Worms

- *Wuchereria bancrofti* Elephantiasis
- *Brugia malayi* Lymphatic filariasis
- *Onchocerca volvulus* River blindness
- *Loa loa* Eye worm
- *Dracunculus medinensis* Guinea worm

- Most are parasites of animals
- All species use arthropods as intermediate hosts
- Two important orders
 - Spirurina - includes filarial worms of humans
 - Camallanida - small number of worms - Guinea worm



Filarial worms

- Tissue-dwelling worms
- Adults release live larvae
 - No egg stage
 - Larvae are called microfilaria
- Important causative agents of disease and disfigurement in humans
- Arthropod vector which takes up L1 (microfilaria) and transmits L3

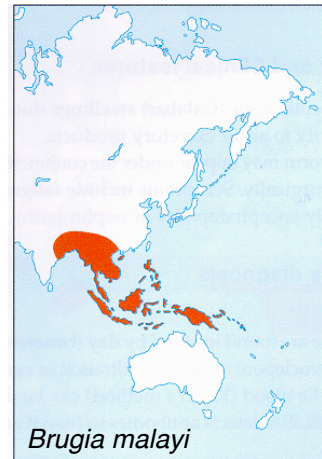
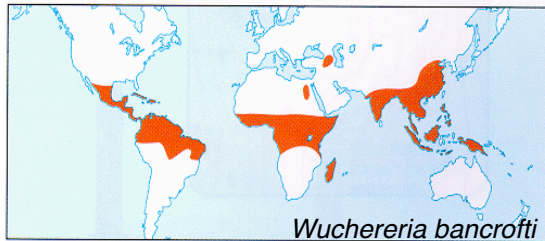


Lymphatic Filariasis

- Long known disease resulting in relatively rare cases in elephantiasis
- 120 million cases annually, but more than 1 billion people at risk
- Caused by three species of filaria: *Wuchereria bancrofti*, *Brugia malayi*, *B. timori*

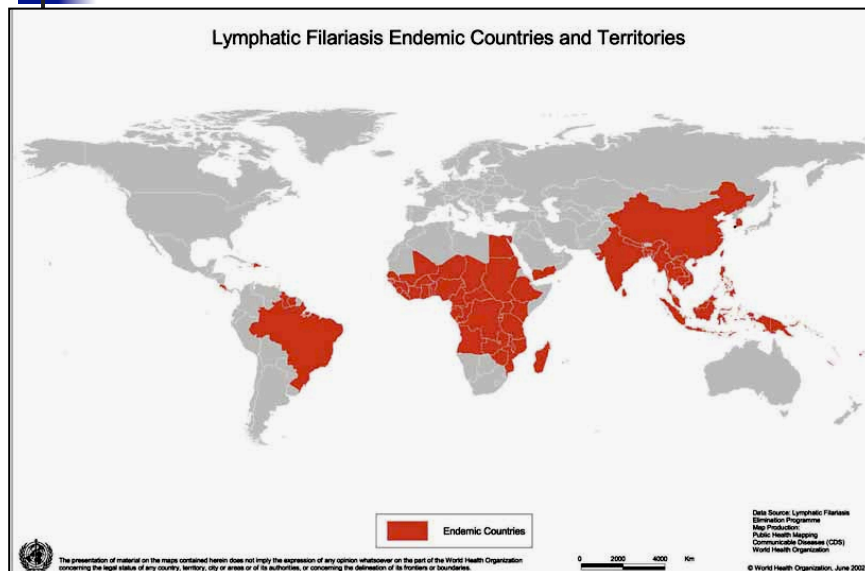


Distribution (1996)



- Both worms will cause similar disease pathology
- *B. malayi* will only cause pathology in distal portions of arms and legs

Distribution (2002)





Wuchereria bancrofti

- **Definitive Host:** Humans
 - No known reservoir host
 - This is not a zoonotic disease
- **Intermediate Host:** Night-feeding mosquitoes (wide variety of genera and species)
- **Geographic Range:** Around the equator, from central Africa, to Turkey, India, Southeast Asia, Philippines, Australia, and South America
 - Originally an Old World species spread to New World by slave trade

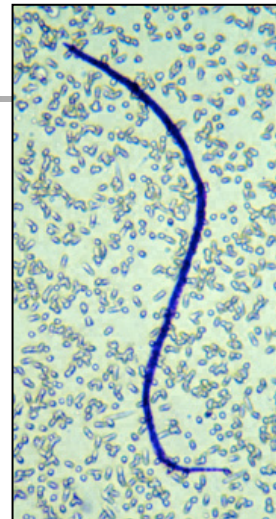


**Causes 90% of
Lymphatic Filariasis**



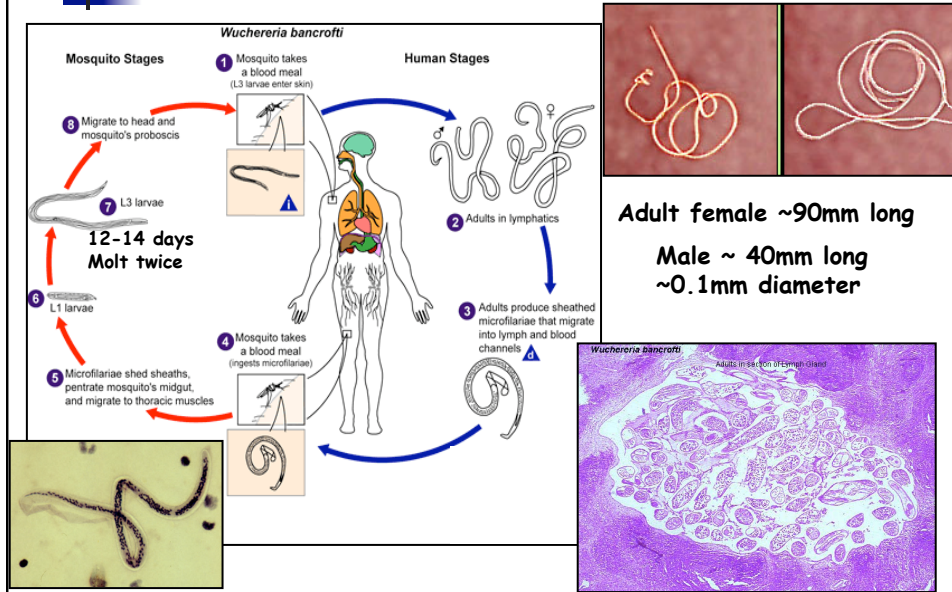
Wuchereria bancrofti

- **Location:** Lymph channels near major lymph glands
- **Pathology:** Depends on immune and inflammatory response of host.
- 50% are clinically asymptomatic, but are important carriers of microfilaria
- People with first exposure in adulthood quickly kill the worm and do not develop disease
 - Of 10,431 U.S. naval personnel that contracted *W. bancrofti* during WWII, none developed elephantiasis - 20, hydrocoele
- Where the parasite is endemic, fetus is exposed to adult parasite's antigens
 - Body's immune system "learns" that microfilaria are "normal" and doesn't kill them (tolerance).



Microfilaria <0.3mm long

Wuchereria bancrofti Life cycle



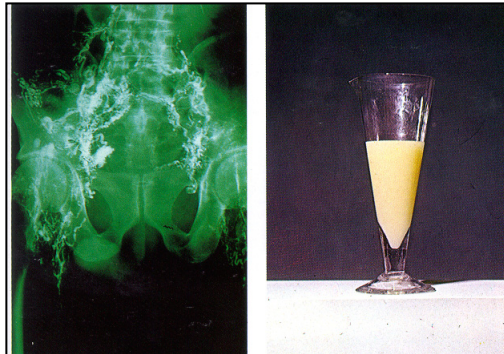
Lymphatic Filariasis

- Adult worms (macrofilariae) live in the lymphatic vessels and lymph nodes of the lower body half
- Females are ovoviparous producing L1 larvae still in the egg membrane (the sheath)



Lymphatic Filariasis

- Progressive chronic disease can lead to wide spread fibrosis and damage of lymphatic vessels, which can result in rupture and discharge of lymph into the urinary system (chyluria) or the scrotum



Lymphatic Filariasis

- **Symptoms:** Filariasis
- **Three phases**
- **Asymptomatic Phase**
 - Large number of microfilaria in blood
 - Some have swelling of lymph nodes
 - May lead to other two phases
 - But not always
- **Inflammatory (Acute) Phase**
 - Due to antigens of adult worms
 - No disease caused by microfilaria
 - Dilate lymph channels
 - Interferes with lymph flow
 - Attacks are marked by sudden onset of fever, chills, rigors, sweating, swollen, warm skin over lymph nodes, painful lymph node
 - Fever may reach 104F for several days,
 - May also show orchitis (swelling of testes).



Lymphatic Filariasis

■ Obstructive Phase

- Lymph channels become blocked by dead worms
- Lymph backs up and causes swelling of the area
- Area is then filled in with scar tissue
- Results in elephantiasis
 - Extreme enlargement of body parts
 - Particularly common in arm, legs, and scrotum
- May be due to repeated re-infections of the worm.
- Not fatal
- High morbidity



Lymphatic Filariasis

- Some develop lymphoedema & elephantiasis
requires hyperinfection – 1000's of bites

- Complex immune response to worms blocking lymph glands and tissues
- Worms die → fibrous granuloma obstructs lymph channels
- Stretched skin susceptible to injury – bacterial & fungal 2° infections
- Microfilaria may cause eosinophilia & splenomegaly



Lymphatic Filariasis

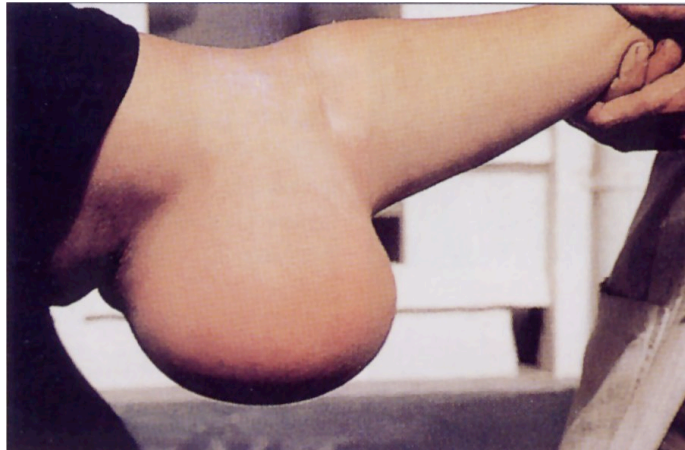


Wucheria bancrofti
Orchitis - inflammation of
testes



Brugia malayi
Hydrocele - inflammation of leg

Lymphatic Filariasis



Elephantiasis - epitrochlear gland
Common in South Pacific

Lymphatic Filariasis

■ Social and Psychological Impact

- Elephantiasis can result in chronic disfigurement
- May lead to sexual dysfunction
 - 27 million men have elephantiasis of scrotum
 - 13 million people, mostly women, have elephantiasis of breast
 - Can result in marriages devoid of physical and sexual intimacy
- Elephantiasis of the scrotum can also cause leaking of lymph through scrotal skin
 - Makes it look like person wet his pants
 - Can cause thoughts of suicide



Lymphatic Filariasis

- In men, chronic infection often results in hydrocele, the painful swelling of the scrotum
- Up to 15-20% of all grown men in certain communities in Haiti suffer from hydrocele
- No effects on fertility, but wide spread sexual disability
- Devastating effects on patient's self esteem and quality of life

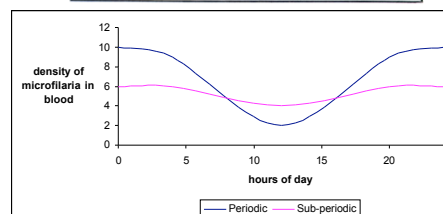
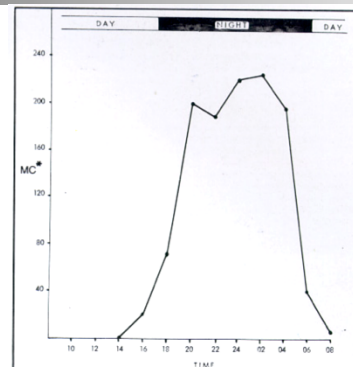


Disfiguring Disease



Lymphatic Filariasis

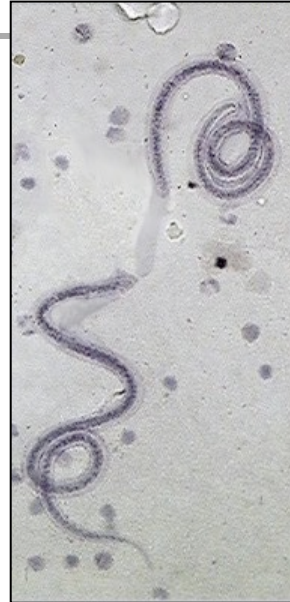
- Microfilaria show diurnal rhythm
- *Wucheria* and *Brugia* microfilaria are found in the peripheral blood during night time whereas *Loa* is found during the day hours
- Sub-periodic – Pacific islands
- Periodic – rest of the world
- Microfilaria in blood at peak biting times for the most suitable mosquito vector





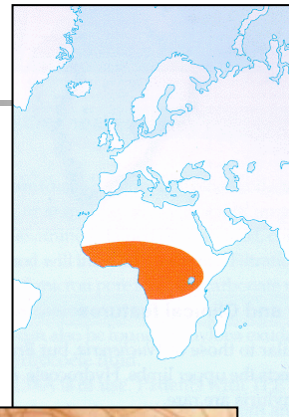
Filarial worms

- **Diagnosis:** Microfilaria in peripheral blood sample at night
 - Blood should be taken between 10 p.m. and 2 a.m.
 - Microfilaria spend day in deep tissues
 - Move to peripheral blood during night to get picked up mosquitoes
- **Treatment:** Hetrazan or DEC (Diethylcarbamazine) used to kill microfilaria.
 - Nasty side effects
 - Repeated treatment needed
- Ivermectin can prevent infection.
 - Cheaper and fewer side effects
- Best is combination of the two.
- DEC impregnated table salt is available as well.
- Surgery for elephantiasis

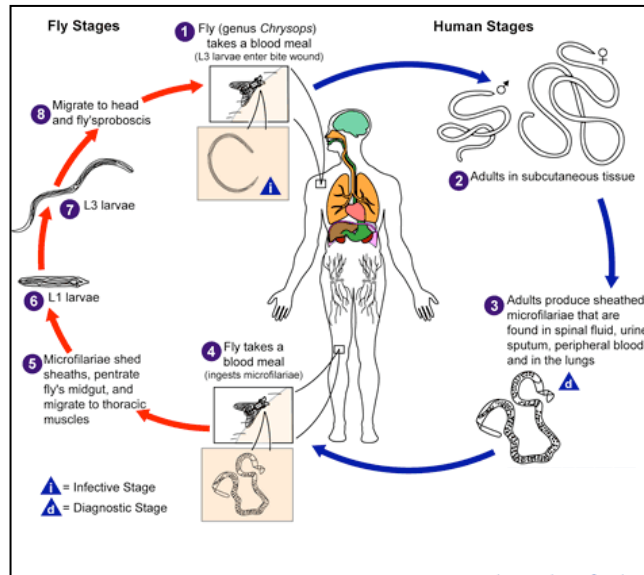


Loa loa - Eye worm

- **Definitive Host:** Humans
- **Intermediate Host:** Deer fly (*Chrysops* sp.)
- **Distribution:** Rain forests of west Africa and equatorial Sudan.
 - Existed for short time in West Indies but disappeared
- **Transmission:** Enters wound from fly bite
Daytime transmission
- **Location:** Just under skin and in eye.

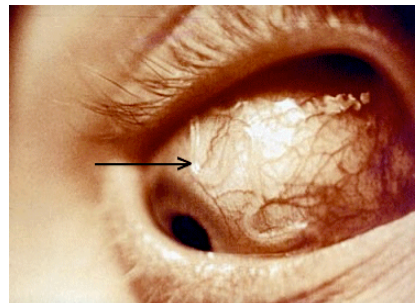
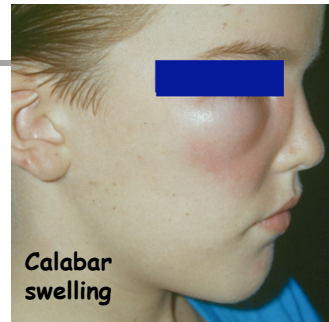


Loa loa Life Cycle



Loiasis

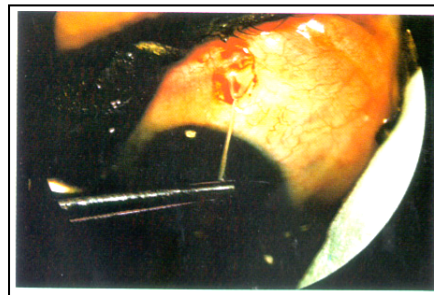
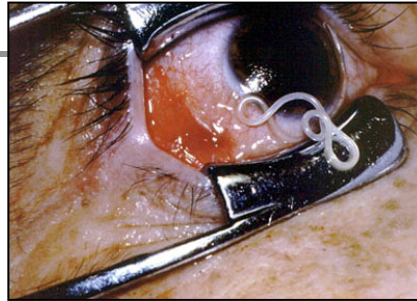
- **Pathology and Symptoms:** Infection called Loiasis.
- Causes very little pathology.
- Wander just under skin, causing allergic reactions
 - Called Calabar swelling or fugitive swelling
- Frequently wanders through eye
 - Can cause emotional distress!
- Most frequent symptoms are itching, joint pain and fatigue.
- Rarely, wanders deeper and can cause fatal encephalitis





Loiasis

- Adult worms wander through connective tissue causing inflammation and irritation
- Typical Calabar swellings can develop in reaction to the worms which disappear when the worm moves on
- Extreme itching, pain, fatigue
- Worms can occasionally be seen in the conjunctiva
- Diagnosis by demonstration of microfilaria in blood or observation of adults
- Responds to DEC treatment but therapy can be risky due to strong allergic reactions
- Surgical removal of worms



Onchocerciasis

- River blindness
- 18 million people infected of which 770,000 already have impaired vision with 250,000 blind
- Caused by infection with the filarial worm *Onchocerca volvulus*



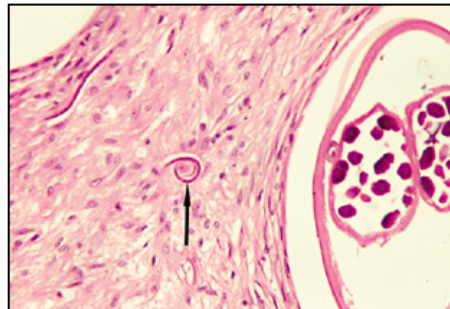
Onchocerca volvulus

- **Definitive Host:** Humans
 - Up to 90% of people are infected in some areas
- **Intermediate Host:** Black Flies (*Simulium sp.*)
- **Distribution:** Africa, Arabia, Guatemala, Mexico, Venezuela, and Columbia
 - Reached the New World with slave trade
 - Most common along rivers
 - Preferred habitat of I.H.
 - Fast flowing rivers for black fly development

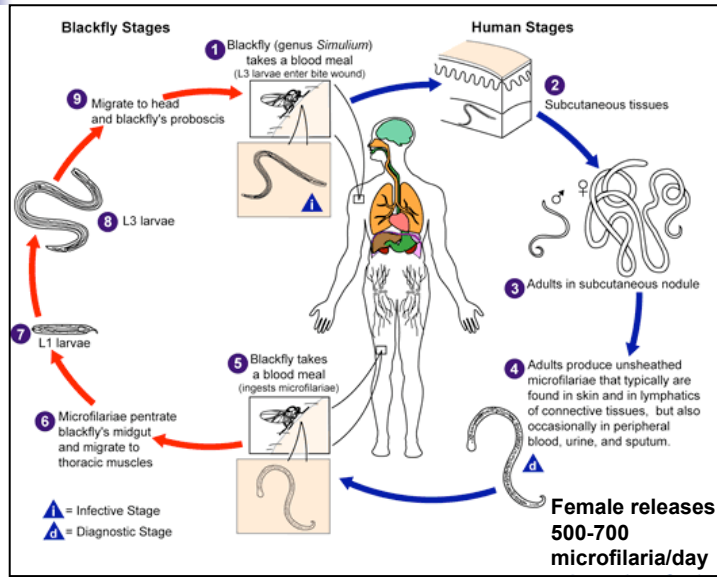


Onchocerca volvulus

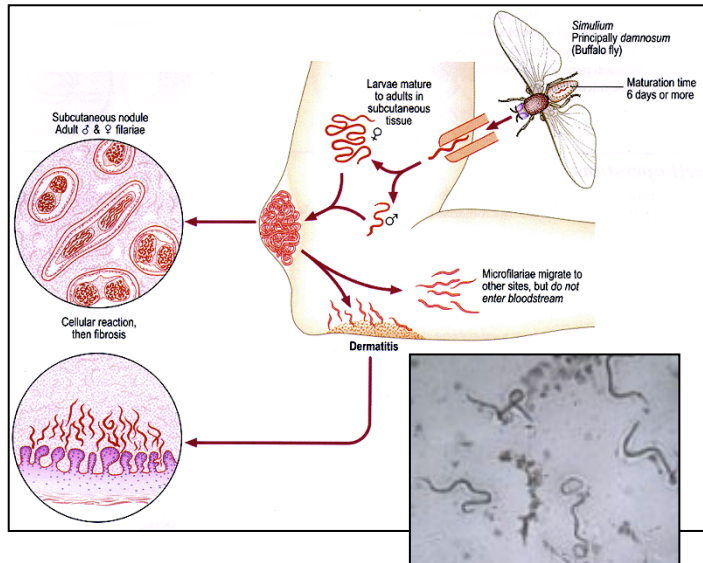
- **Transmission:** L3 Larvae move into tissues through wound made by bite
- **Location in D.H.:** Just under the skin in nodules
 - Most below the waist in Africa
 - Most above the waist, particularly the head, in New World
 - Biting preferences of the flies in these geographic regions



Onchocerca volvulus Life Cycle



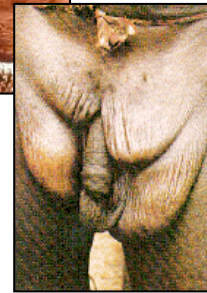
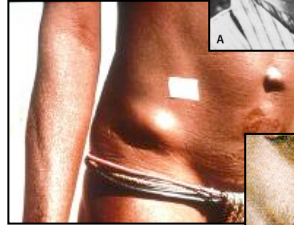
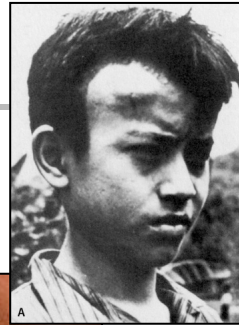
Pathology





Onchocerciasis

- Most pathology due to immune and inflammatory response of body.
- Adults form skin nodules
 - Called onchocercomas
- Little pathology from live larvae and adults
- Dead worms cause inflammatory response
 - Causes severe dermatitis over the area
 - May result in thickening, depigmentation of skin
 - Often mistaken for leprosy
 - Causes “hanging groin” in Africa and Venezuela
 - Elephantiasis is rare



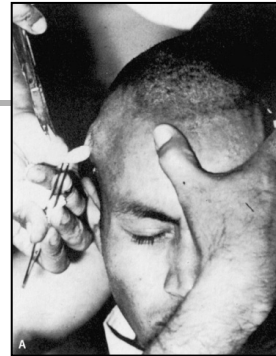
Onchocerciasis

- Inflammatory reaction causes progressive changes of the skin
- These are in part due to the reaction to microfilaria and in part to secondary bacterial infection
- Bacterial infections are often the result of scratching due to the unbearable itch produced by allergic reaction to microfilaria



Onchocerciasis

- Why River Blindness?
- Microfilaria migrate through the eyes
 - Some times they die there
- Inflammatory response causes the cornea to harden and become opaque
 - Causes blindness
- In many areas of Africa and Central America, everyone over the age of 40 is blind
 - Little children guide blind adults to work
 - Blindness is more common in Central America than Africa
 - Flies prefer to bite on the head



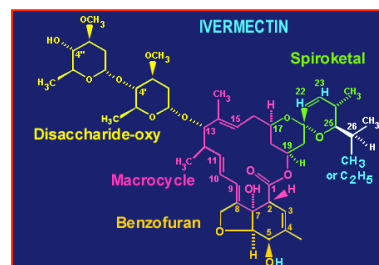
Onchocerca volvulus

- **Diagnosis:** Microfilaria in *bloodless* skin snip. Microfilaria detected during an eye exam.
- **Treatment:**
Ivermectin kills microfilaria and eventually kills adults
 - Also a preventative
 - Nodulectomy: adult worms can be removed surgically to reduce microfilarial load to alleviate symptoms
- **Prevention:**
reduce Black Fly populations



Onchocerciasis

- **Treatment:**
- Ivermectin kills microfilaria and may eventually kill adults (paralysis of worms by interfering with neural ionchannels)
 - Also a preventative
- Diethylcarbamazine DEC (kills microfilaria and in some species macrofilaria slowly with unknown mechanism - not *O. volvulus*)
- Albendazole (blocks glucose uptake)
- Killing of parasites can provoke strong allergic reactions



The Carter Center



- Guinea Worm Eradication Program (1986)
- River Blindness (1987)
- Lymphatic Filariasis Elimination Program (15 year goal)
- Schistosomiasis Control Program
- Ethiopia Public Health Training Initiative





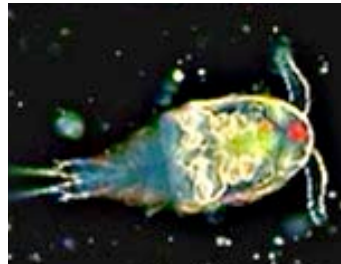
Onchocerciasis Control Program

- Before OCP: River blindness was 2nd leading cause of infection-based blindness
- Annual community mass treatment is used to alleviate pathology due to microfilaria and to reduce prevalence
- Pharmaceutical companies have donated free drugs for this purpose
- One of the few success stories in recent tropical medicine
- Adult *O. volvulus* worms live for 10-15 years or longer and there is no drug that can kill them.
- **Therefore, control measures must be continued for 15 or more years to interrupt transmission.**
- In addition to the obvious financial burden, it may promote the development of insecticide resistance in the flies!

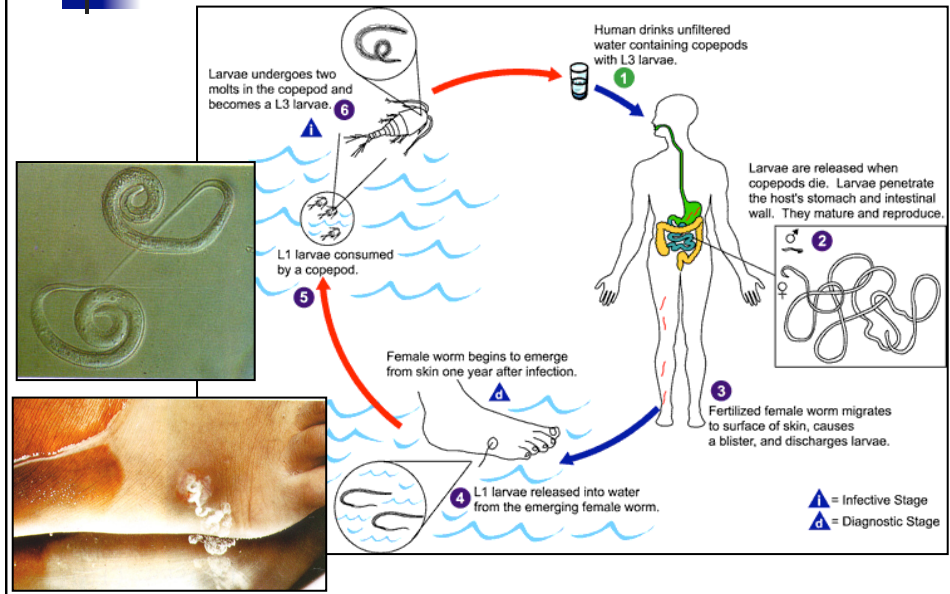


Dracunculus medinensis

- **Definitive Host:** Humans
 - Rhesus monkeys have been infected in the lab
- **Intermediate host:**
Cyclopoid copepods
- **Distribution:** Africa, India, Middle East
 - Reports from North America are probably different species, *D. insignis*
- **Transmission:** Ingestion of copepods in drinking water.
- **Location:** just under the skin



Dracunculus medinensis Life Cycle



Dracunculus medinensis

- Female becomes swollen with larvae and body wall breaks
 - Releasing larvae just under skin.
 - Causes inflammation which results in a blister
 - Blister breaks and part of worm sticks out
 - Common secondary bacterial infections
 - Area of blister is very hot
 - Relief comes from putting area in cold water
 - Stimulate uterine contractions
 - Female releases up to half a million larvae in water



History

- Long history with humans
 - “Fiery serpent” of Bible
 - Found in the writings of ancient Greeks and Romans
 - Caduceus carried by God of Medicine probably depicts worm on stick
 - Treatment officially described in 1674
 - But I.H wasn’t discovered until 1869



From *Exercitationes de Vena Mediensis et de Vermiculis Capillaribus Infantium* by G.H. Velschius, published in Augsburg, Germany 1674



Dracunculiasis



- Caused by three factors
 - Emerging worms cause severe allergic reaction to worm waste
 - Rash, nausea, diarrhea, dizziness, localized swelling
 - Symptoms stop after female emerges
 - Bacterial infections are common at site of emergence.
 - Nonemergent “dead” worms can cause inflammatory response.
 - Symptoms can include arthritis and paralysis

Control Measures

- **Dracunculiasis is preventable**
- No reservoir
- Prevent contact of infected people with water sources
- Filter water to remove intermediate host
- Relatively low cost educational campaign
- Incidence increases during droughts
 - Larvae and I.H. host concentrated and more likely to be ingested.

Eradication: WHO predicted it would be eradicated by 1995. Missed the deadline but incidence continues to decline.



Dracunculiasis

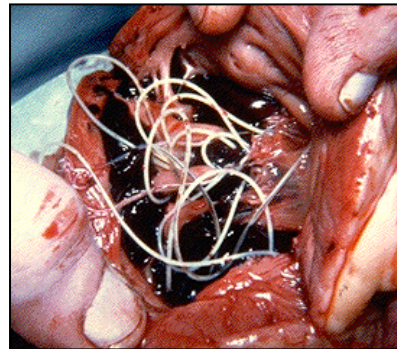
- **Diagnosis:** Larvae can be found in fluid of blister. Large white worm protruding from wound also diagnostic.
- **Treatment:** Adult female is removed by slowly by winding it on a stick.
 - Cold water is washed over the worm
 - She expels larvae and can be pulled out about 5 cm
 - Takes about 3 weeks to remove entire worm
- Breaking the worm can result in massive allergic reaction
- Surgery can be used to remove calcified worms





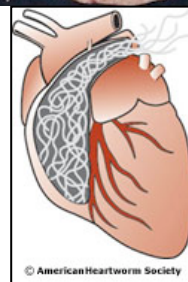
Dirofilaria immitis

- Heartworm
- **Definitive Host:** Dogs, cats, ferrets, sea lions, and other mammals including humans.
- **Intermediate Host:** Mosquitoes
- **Distribution:** Cosmopolitan
 - In U.S., most common along Mississippi River, Atlantic and Gulf Coast states
 - Incidence 45% in dogs
 - Rare in the western U.S.
 - Incidence can be as high as 5% in California and Oregon dogs



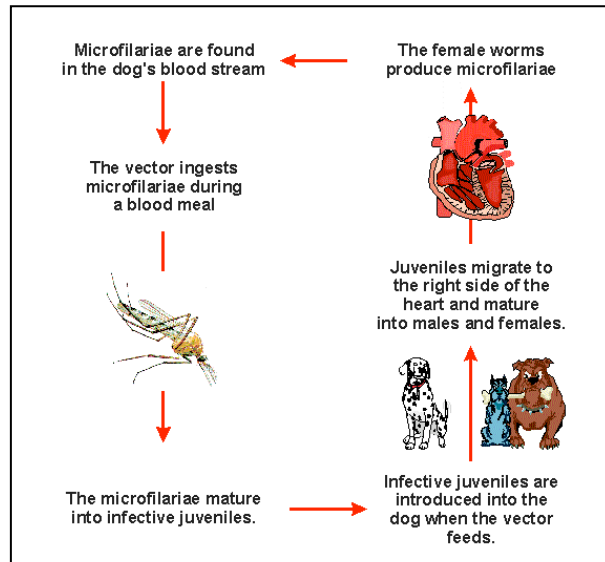
Dirofilaria immitis

- **Location:** Right side of heart and pulmonary artery
- **Transmission:** Injected during blood meal.
- **Pathology:** Large number of worms block the valves of heart
 - Results in inefficient pumping of blood
- Respiratory complications can occur

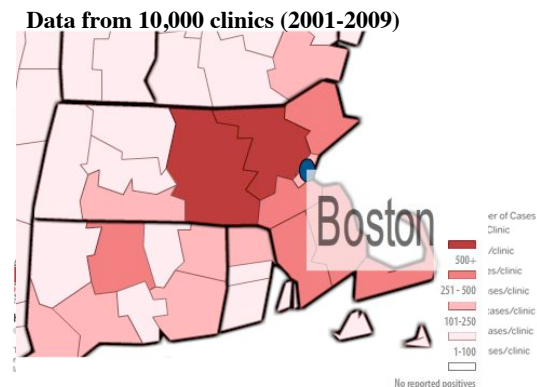


© American Heartworm Society

Dirofilaria immitis Life Cycle



- Human cases: only ~200
 - Appears to be independent of dog ownership
- Follows epidemiology of canine disease
- Prevalence has increased in last 3 decades
 - All states - extends up into Canada
 - Coyotes



- Symptoms:** Vomiting, Respiratory insufficiency, chronic cough, exercise intolerance. Death usually comes from cardiopulmonary failure
 - Human cases are rare but can result in chest pain, cough, coughing up blood, fever, malaise
- Diagnosis:** ELISA test. Microfilaria are not diagnostic
- Treatment:** Difficult. Early cases can be cured. Dead adult worms may cause more damage than live ones. Can be prevented by giving Ivermectin (Heartguard) during mosquito season.



Heartworm preventatives

	Heartworm Prevention	Prevents Intestinal Worms	Flea Prevention	Tick Prevention	Applied Topically	6 Month Continuous Protection	For Use In Cats
Heartgard®	YES	YES ¹	NO	NO	NO	NO	YES
Interceptor®	YES	YES ²	NO	NO	NO	NO	NO
Sentinel®	YES	YES ²	YES ³	NO	NO	NO	NO
Revolution®	YES	NO ⁴	YES	YES	YES	NO	YES
Proheart® 6	YES	NO	NO	NO	NO ⁵	YES ⁶	NO



Huge Industry!