## Estimated Prevalence

<table>
<thead>
<tr>
<th>Organism</th>
<th>Estimated Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hookworms</strong></td>
<td>740,000,000</td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>1,472,000,000</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>1,049,000,000</td>
</tr>
<tr>
<td><em>Wuchereria bancrofti</em></td>
<td>107,000,000</td>
</tr>
<tr>
<td>Schistosomes (all)</td>
<td>200,000,000</td>
</tr>
</tbody>
</table>

Source: American Society For Parasitologists 2003
Morbidity and Mortality

The Burden of Chronic Disease
C. G. Nicholas Mascie-Taylor and Enamul Karim

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Prevalence of infection (cases, millions)</th>
<th>Mortality (deaths, thousands)</th>
<th>Morbidity (cases, millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>1450</td>
<td>60</td>
<td>350</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>1050</td>
<td>10</td>
<td>220</td>
</tr>
<tr>
<td>Hookworms</td>
<td>1300</td>
<td>65</td>
<td>150</td>
</tr>
<tr>
<td>Schistosomes</td>
<td>200</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
The Hookworms

Ancylostoma duodenale

Necator americanus
ARThUR LOoss, Ph.D.
1861 - 1923
GERMANY
DISCOVERED THE LIFE HISTORY OF THE HOOKWORM, EGYPT 1911
Antonie Dubini* and the Saint Gotthard Tunnel
Hookworm Epidemic of 1880

Length - 15 kilometers
Depth - 1,700 meters

“An effort….. to build a rail tunnel through the St. Gotthard massif was treacherous. That construction between 1872 and 1882 was plagued by bad rock and flooding. It killed 310 workers, incapacitated 877 others and bankrupted the contractor”.

Civil War -1861-1865

Gen. R. E. Lee

Pickett’s Charge

Gen. G. G. Meade
One theory suggests that hookworm disease may have influenced the outcome of the civil war. Southern troops grew up with the infection and had little in the way of sturdy clothing or shoes. Hookworms were brought to America from Africa in the early 1800s via the slave trade. They have been here ever since.

Economic recovery was slow following the Civil War, and J. D. Rockefeller wanted to know why!
John D. Rockefeller
Oil Baron *par excellent*

JDR established a sanitary commission (1909-1915) headed by Charles Wardell Stiles to look into the matter of “southern laziness”.

“southern laziness”
The Pit Privy

Distribution and installation began in the 1920’s following The Rockefeller Sanitary Commission Report to Congress.

Height to which hookworm larvae can crawl = 4 feet.
Colorado Out House*

* The camper’s best friend

Circa 2006
Adult female *Ancylostoma duodenale*
Adult male *Ancylostoma duodenale*
Adult *Ancylostoma duodenale*
Adult *Necator americanus*
Histological section of adult hookworm attached to villus of small intestine

- Head attached to villus
- Muscular esophageal bulb
- Villus
**Necator americanus**

- Filariform larvae "quest" on blades of grass
- Eggs pass out in feces
- Larvae hatch and develop in soil
- Larvae enter bloodstream, reach heart
- Larvae enter lung capillaries
- Larvae enter alveolar spaces
- Larvae migrate up trachea, are swallowed
- Adults mature in small intestine

**Pathology**

- Normal
- Anemia
Hookworm larvae in dog skin

- Hair shaft
- Capillary
Pathogenesis:
Adult worms suck blood and feed on villus tissue.

In order to do all this, the worm has evolved a set of powerful anti-coagulants* even more effective than those of the medical leech. The cDNAs for these HW peptides have been cloned and may offer some interesting practical applications for medical use.

Term: Para-pharmacology

Definition: The science of taking advantage of parasite-specific products to better humankind!

Rationale: The current pharmacopia of anti-parasitic drugs is running out of options. Let's turn their swords into our plowshares!
Hookworm adult as seen on endoscopy
Clinical Disease:

1. Iron-deficiency anemia

2. Failure-to-thrive syndrome (idiopathic endocrinopathy)
Diagnosis:
Microscopic examination of feces for eggs
Drug of choice:

Mebendazole

Mode of Action:
De-polymerizes invertebrate microtubules, only
Prevention and Control

“To prevent this (hookworm) it is only necessary to prevent soil pollution with the feces of infested individuals”

........Hookworm Disease

Asa Chandler, 1929

Greatest single invention of the 20th century!
Ancylostoma In India

Number Of People

Number Of Worms

Chart showing the distribution of Ancylostoma in India with a bar graph indicating the number of people affected by the number of worms.
Hookworm In Zimbabwe

Hookworm infections in Zimbabwe are categorized into two main groups: light and heavy. The diagram shows the frequency of infections across different infection groups. The map of Zimbabwe is also included to illustrate the geographical distribution of infections.
Dogs and *Ancylostoma caninum*

Paro, Bhutan
Infectious larva of *Ancylostoma* sp.
“Creeping eruption” on the foot of a patient who stepped on an infective larva of *A. braziliense*
Helminths
Nematoda:

*Strongyloides stercoralis*
Free-living female *Strongyloides stercoralis*
Parasitic female *Strongyloides stercoralis*
Epidemiologic features of Strongyloides stercoralis infection in an endemic area of the United States.

Walzer PD, Milder JE, Banwell JG, Kilgore G, Klein M, Parker R.

The epidemiologic features of Strongyloides stercoralis infection in Kentucky were studied by an analysis of clinical cases at the University of Kentucky Medical Center (UKMC); by an analysis of parasitologic records of the Kentucky Bureau for Health Services (KBHS); and by a prospective stool survey of school children in Clay County, located in southeastern Kentucky, an area of the state previously found to be highly endemic for intestinal parasites. S. stercoralis was the most common parasitic infection diagnosed at UKMC. The patients were predominantly white male adults who were over 50 years old, had an associated chronic or debilitating medical illness, were of low socioeconomic background, and resided in southeastern Kentucky. S. stercoralis was a common parasitic infection at KBHS and the patients showed a similar geographic distribution. Of 561 Clay County children surveyed, 23.7% harbored one or more intestinal parasite pathogens and 3.0% had S. stercoralis. Thus, S. stercoralis remains highly endemic in Kentucky and may cause disease even in geriatric patients.
Strongyloides stercoralis in situ
Larva of *Strongyloides stercoralis* in skin
Pathogenesis:

Worms invade epithelial cells, induce cell death
Clinical Disease:

1. Diarrhea

2. Malabsorption syndrome

3. Secondary bacteremia/septicemia as larvae migrate throughout body and defecate microbes that they ingested in large intestine.

4. Death due to overwhelming bacterial septicemia.
Diagnosis:

1. Microscopic examination of feces (x 6)

2. “String” test

Second stage larva
Drug of choice:
Ivermectin*

Mode of Action:
Blocks Cl\(^(-)\) ion channels, inhibits \(\gamma\)-aminobutyric acid receptor complex.

* Alternate drug for all geohelminths
Prevention and Control:
Sanitary disposal of human feces*

*Dog is a common reservoir host. Cannot control spread of dog feces which may contain infective larvae.