Helminths = Parasitic Worms

Parasitic worms are common infections worldwide. Approximately 1.5 billion people are infected with soil-transmitted helminths worldwide.
Endemic worm infections. Many communities have 70-90% of population CURRENTLY infected.
Most worms do not cause great mortality but can result in morbidity (disease effects) for infected individuals.
Worm infections are often asymptomatic and difficult to diagnose.

Human-human transmission versus zoonoses

Some worm infections have high human-human transmission and are found primarily in humans.

- Humans can be definitive or intermediate hosts.
- Some of these infections can be transmitted human-animal-human-human-animal

Other helminths are zoonoses with distinct animal reservoirs and limited transmission to humans and between humans.

- For these zoonoses humans are usually infected by eating undercooked food, drinking "contaminated" water, and close interaction with domestic animals.

Parasitic Worms location

Size. Parasitic worms are large enough to be seen with naked eye. The large size makes the worms difficult to eliminate by normal immune function and thus worms are often "ignored" by the immune system rather than causing disease in attempts to eliminate the worms.

Location in host. Most are extracellular worms that live in the host intestine.

In some cases, worms have evolved to live outside the intestine:

- Schistosoma worms are blood flukes. Adults reside in blood vessels.
- Guinea worms that can live in peripheral tissues.
- Intestinal worms can traffic through lungs or other tissues as part of life cycle.
- Worms that can be found in an intracellular cyst form (especially muscle or nervous tissue). Cyst form enhances transmission.

Nematode- Pinworm Enterobiasis

•Pinworm infection is an urban pathogen caused by the worm *Enterobium vermicularis*.

Disease is enterobiasis

•Most common worm infection in the US.

•Rates of infected children (as egg carriers) vary by country, from 0.2-54%.

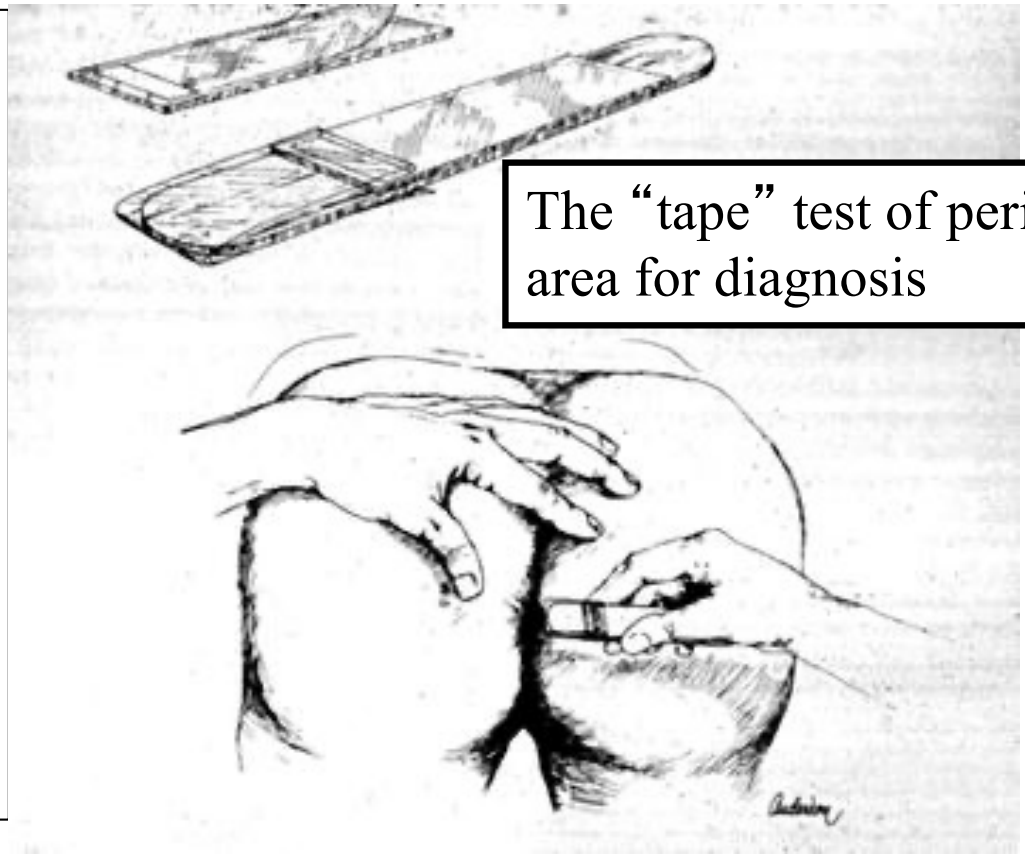
•No animal reservoir.

•Small segmented roundworms transmitted through fecal/oral route. Adults up to 1 cm long.

Pinworm

Fecal/oral transmission between humans. Not a zoonosis. People are infected by ingesting eggs on fingers, clothing, other surfaces.

Primarily a disease of small children
Child-care centers are most common sites of outbreaks.
Diagnosed by itching and examining for eggs by tape test.



The "tape" test of perianal area for diagnosis

Nematode
Ascaris lumbricoides

More than 1 billion people are thought to be infected at any given time.

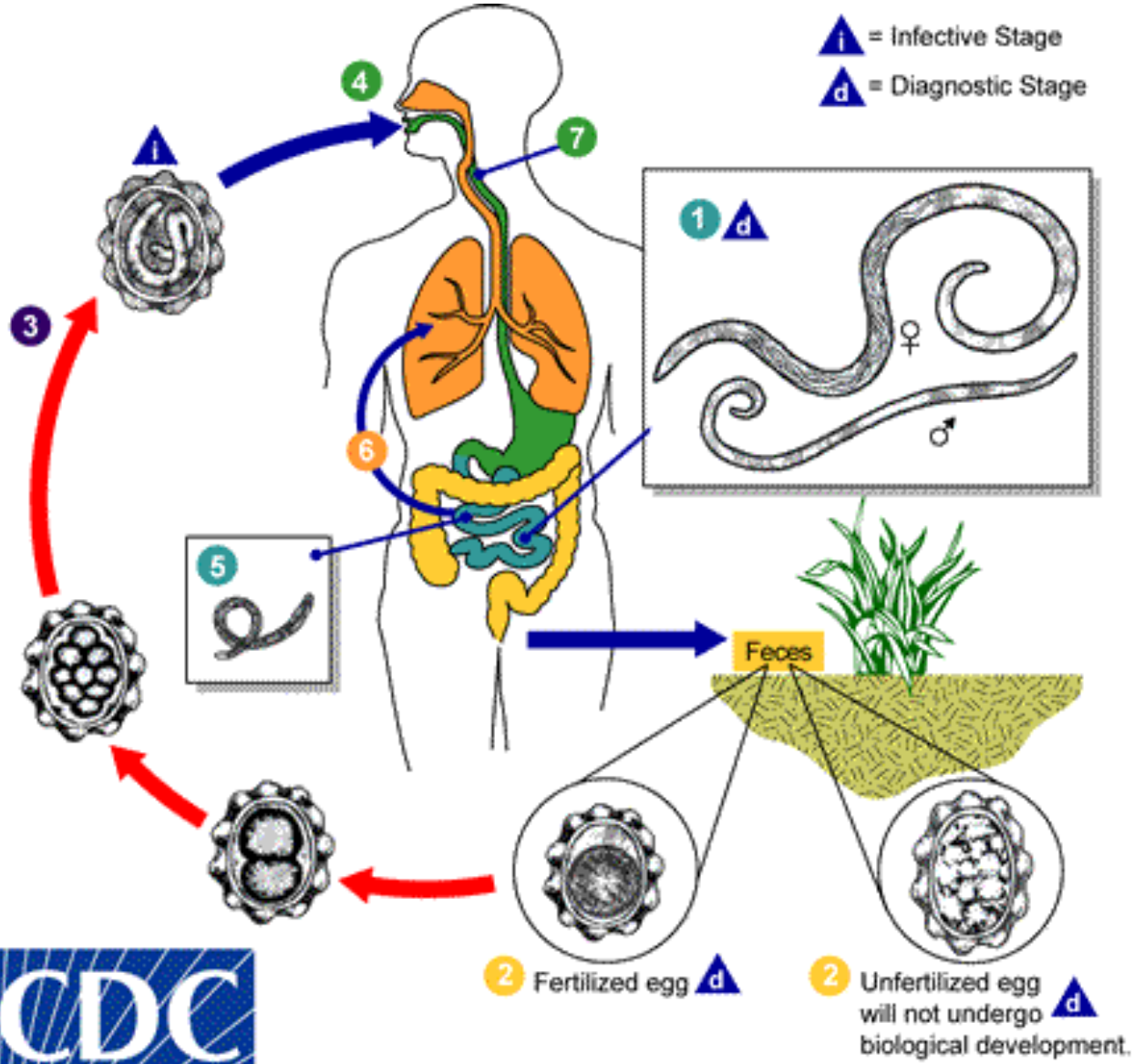
Adult females are up to 30 cm long whereas males are smaller.

These are large round worms that live in the small intestine of infected hosts.

Adult Ascaris worms in intestine

Ascaris lumbricoides Lifecycle

Ingested egg hatches in small intestine. The larvae penetrate the intestine, travel through lymph and blood to liver, heart and lungs. Larvae mature in liver and then travel out capillaries into lungs where larvae are coughed up and swallowed to enter intestine (9 days after initial infection). They mature over next 8-12 weeks into sexually mature adults.



Adult worms live up to year

Ascaris lumbricoides

Clinical Issues

- 807 million–1.2 billion people in the world are infected with *Ascaris lumbricoides* (sometimes called just Ascaris).
- Ascaris is highly endemic in many tropical and subtropical areas where as many as 85% of communities will be passing Ascaris eggs.
- Primary preventive issue is sanitary disposal of feces.
- Most people with Ascaris worm infections have a low worm burden and are usually asymptomatic.
- Even with heavy worm burden, most people are rarely diagnosed. Stomach problems or pneumonitis are not specific to Ascaris.
- Definitive diagnosis requires finding eggs in stool or worms expelled.

Ascaris lumbricoides
Clinical Issues

Most life-threatening complications of Ascaris infection involve blockage of intestine or bile ducts (with heavy worm burden). But these severe complications are rare. Only in cases with a heavy worm burden would adult worms exit nose, mouth or anus.

More Nematodes--Hookworms

Ancylostoma. These parasites are transmitted through contaminated feces or from contact with larval form in soil.

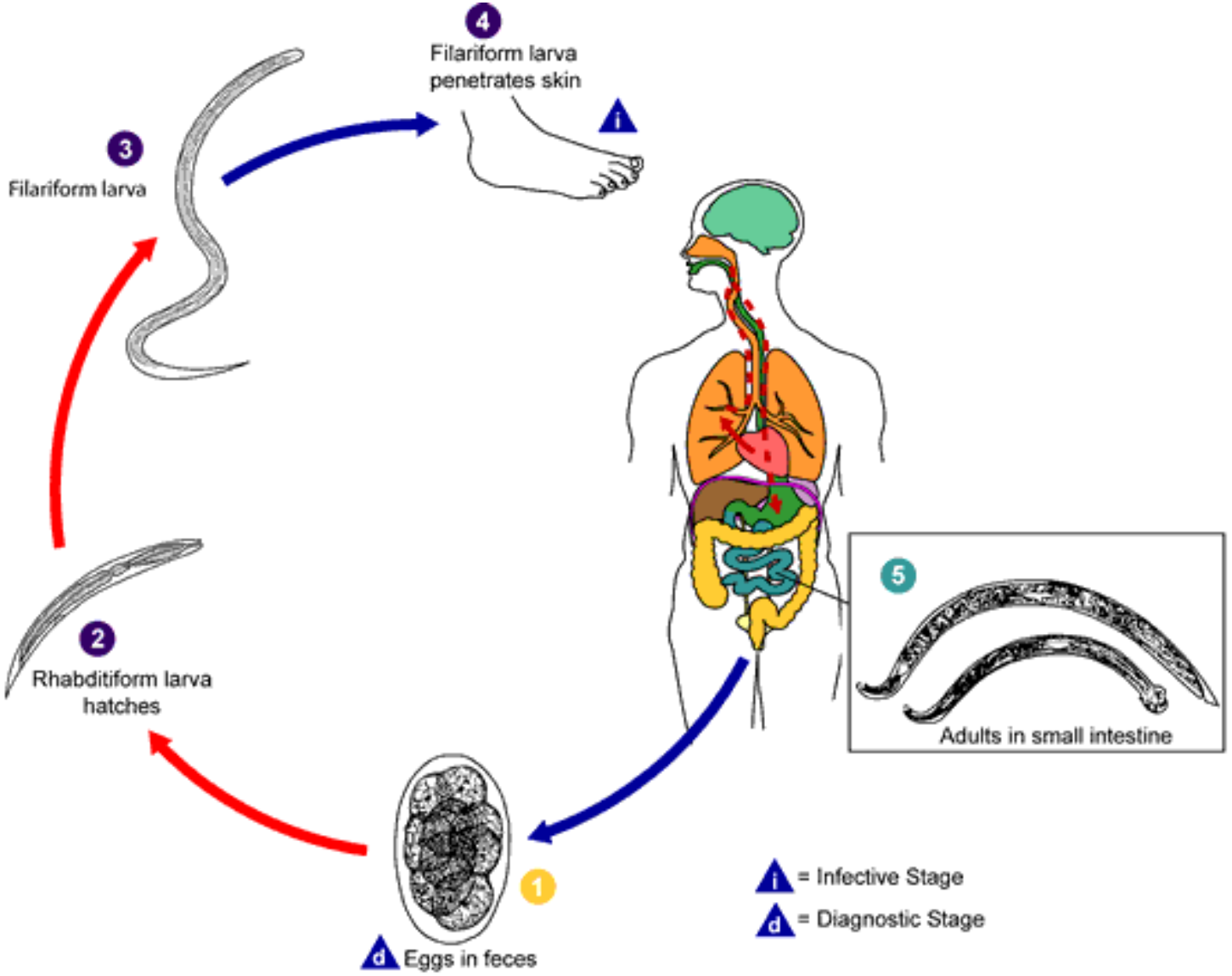
Actually “hook” on to intestinal wall with “teeth”.

Ingest red blood cells for nutrition.

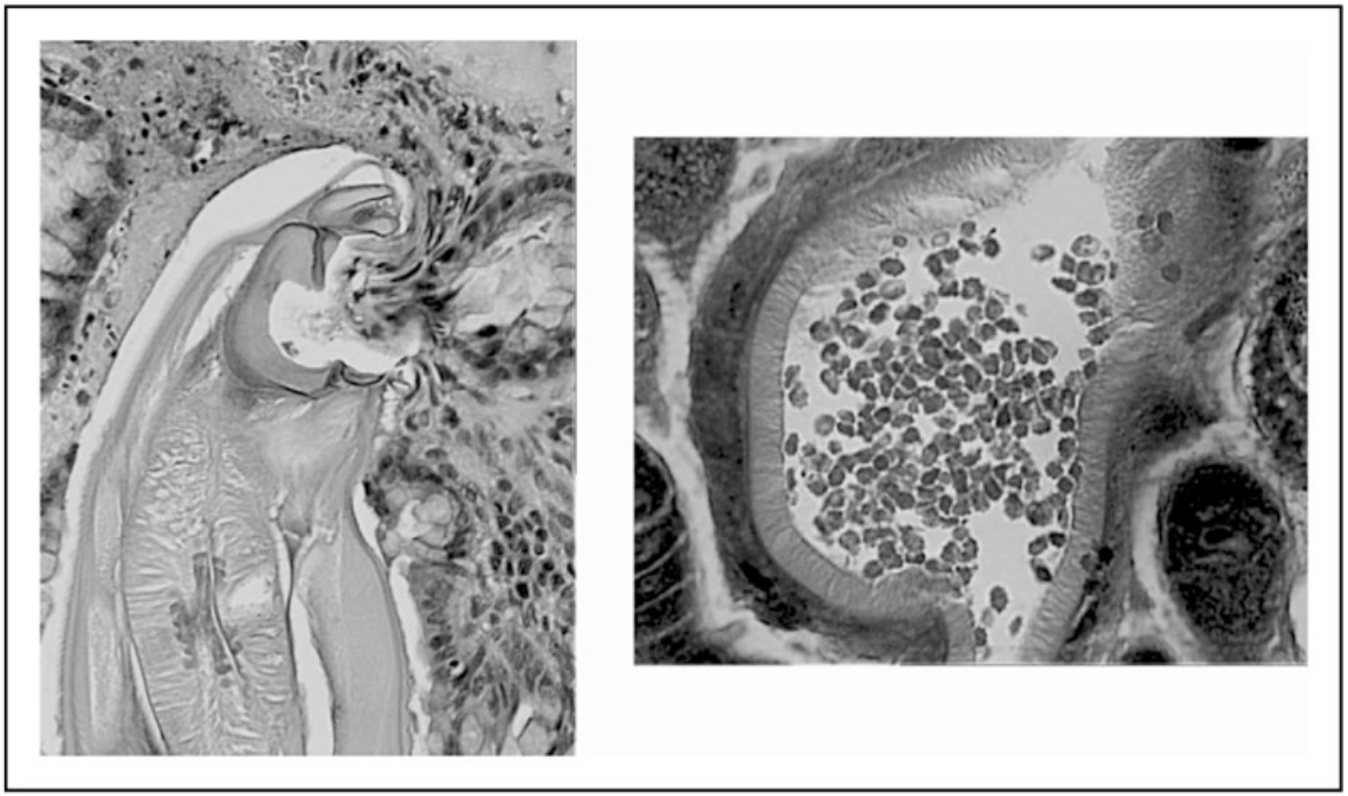
Ancylostoma Hookworms

Larval form in soil can actually enter through unbroken skin.

Travel to intestine mature into adult Find mate and produce eggs to pass in feces.

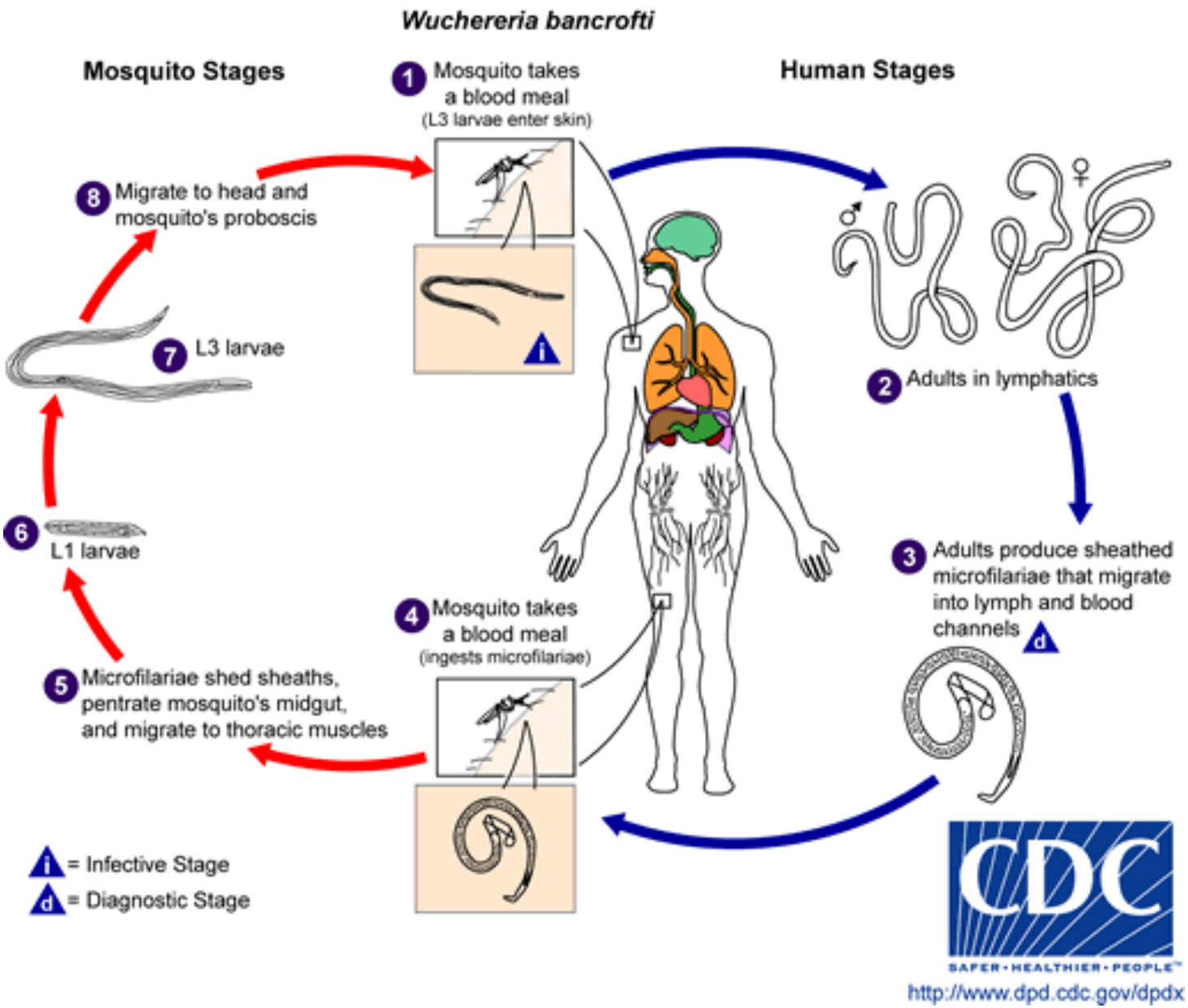


Hookworms Eating



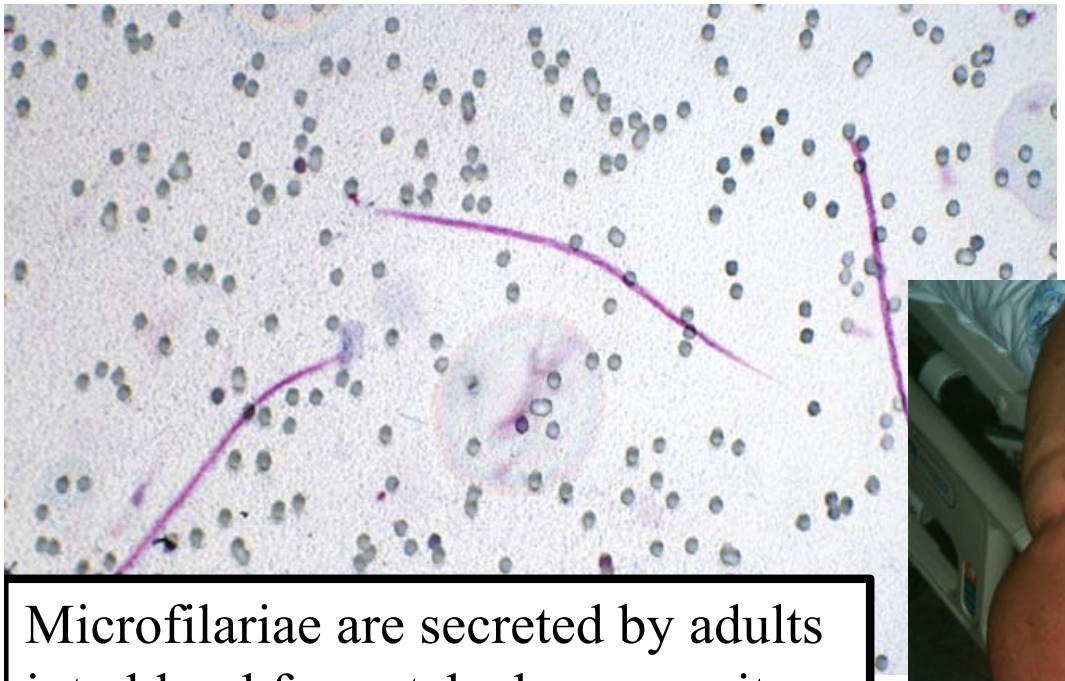
Electron micrograph cross-sections of head piercing intestinal wall and worm stomach with red blood cells.

Nematode-- Filarial worms



<u>Life Cycle</u>
Humans are definitive host with mosquito vector for transmission.
Not a zoonosis.

Filarial worms can cause lymphatic filariasis also known as elephantiasis

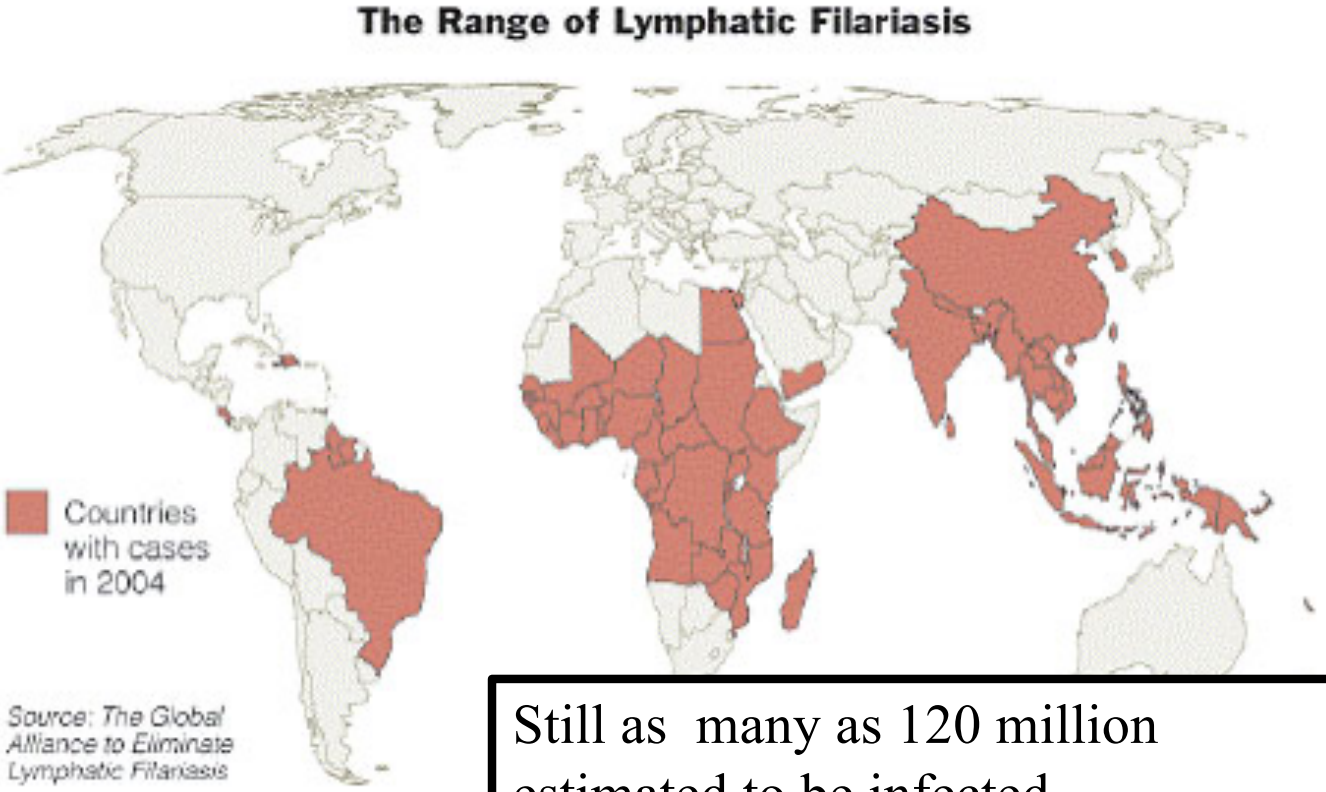


Microfilariae are secreted by adults into blood for uptake by mosquitoes

Microfilariae can also build up in lymphatic vessels and block fluid uptake along with other infections

Filarial worms are high on list of Neglected Tropical Diseases

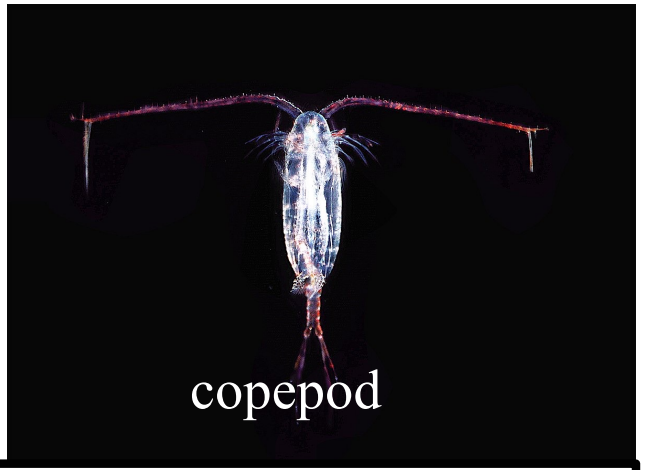
Carter Center
Has provided targeted elimination with drugs donated by Merck and GlaxoSmith Kline and insecticide-treated bed nets.



Still as many as 120 million estimated to be infected

Nematode--Guinea worm

Dracunculiasis or guinea worm is caused by ingestion of drinking water with infected small crustaceans (copepods).
Infects humans, dogs, baboons and cats.


copepod

Female Guinea worm extends anterior end through skin and forms a painful lesion up to 1 year after infection. **When exposed to water, the female releases larvae into water.**

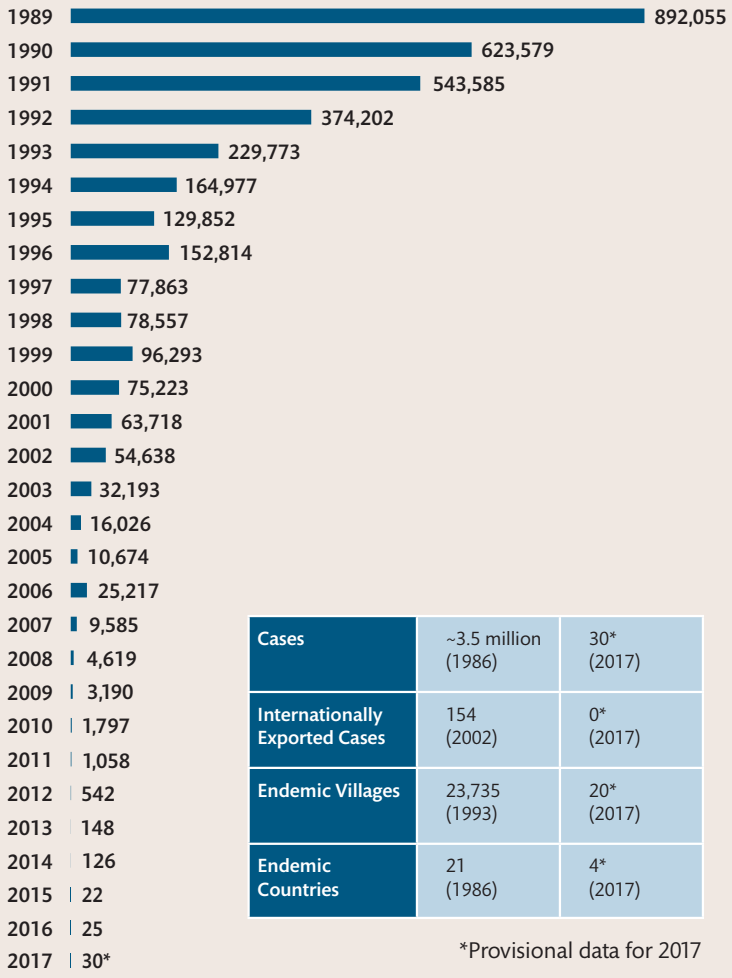
Guinea worm Removal by worm twisting

Adult female worms can
Be up to 1 meter long.
Female usually creates lesion
or blister on skin
of lower leg or ankle.

Removal must be gradual
to prevent breaking off of
worm under skin.

Guinea worm is close to eradication

Annual Number of Cases of Guinea Worm Disease Worldwide Since 1989



Cases	~3.5 million (1986)	30* (2017)
Internationally Exported Cases	154 (2002)	0* (2017)
Endemic Villages	23,735 (1993)	20* (2017)
Endemic Countries	21 (1986)	4* (2017)

*Provisional data for 2017

Credit: The Carter Center

Next WHO disease for eradication.

3.5 million human infections in 1986

27 human cases in 2020

15 human cases in 2021

13 human cases in 2022

2022 = 490 infections in animals-21% reduction.

https://www.cartercenter.org/health/Guinea worm/case-totals. Html

- Education has been key to limit transmission.
- There is no drug treatment or vaccine to prevent disease. Carter Center has been key in reducing numbers.

Cestodes are flat segmented worms
Primarily intestinal dwelling **tapeworms**

Cestodes are true parasites in that they lack a mouth, alimentary tract, circulatory system, body cavity, and major metabolic pathways. These worms absorb nutrient molecules through their body surface.

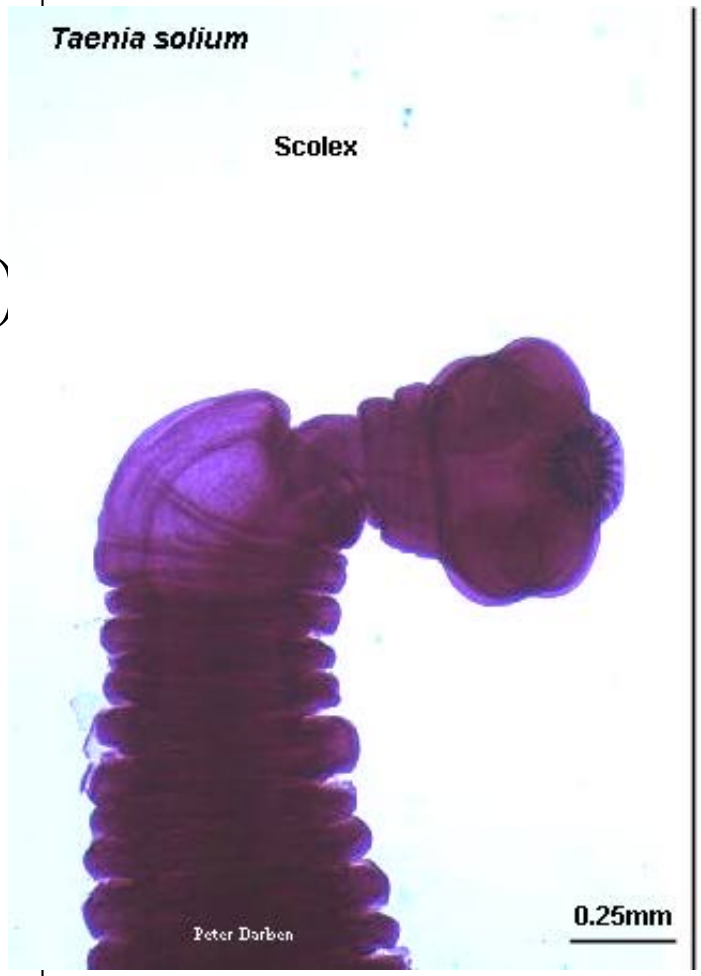
Adult tapeworm
4-10 meters in length

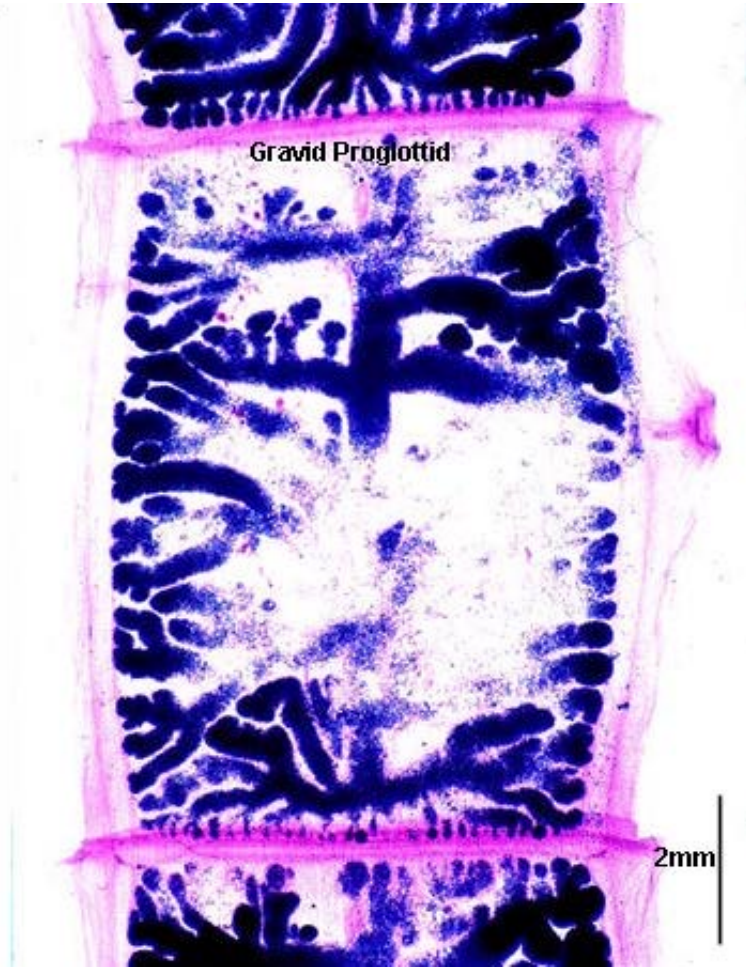
Pasta for lunch?

Tapeworm anatomy

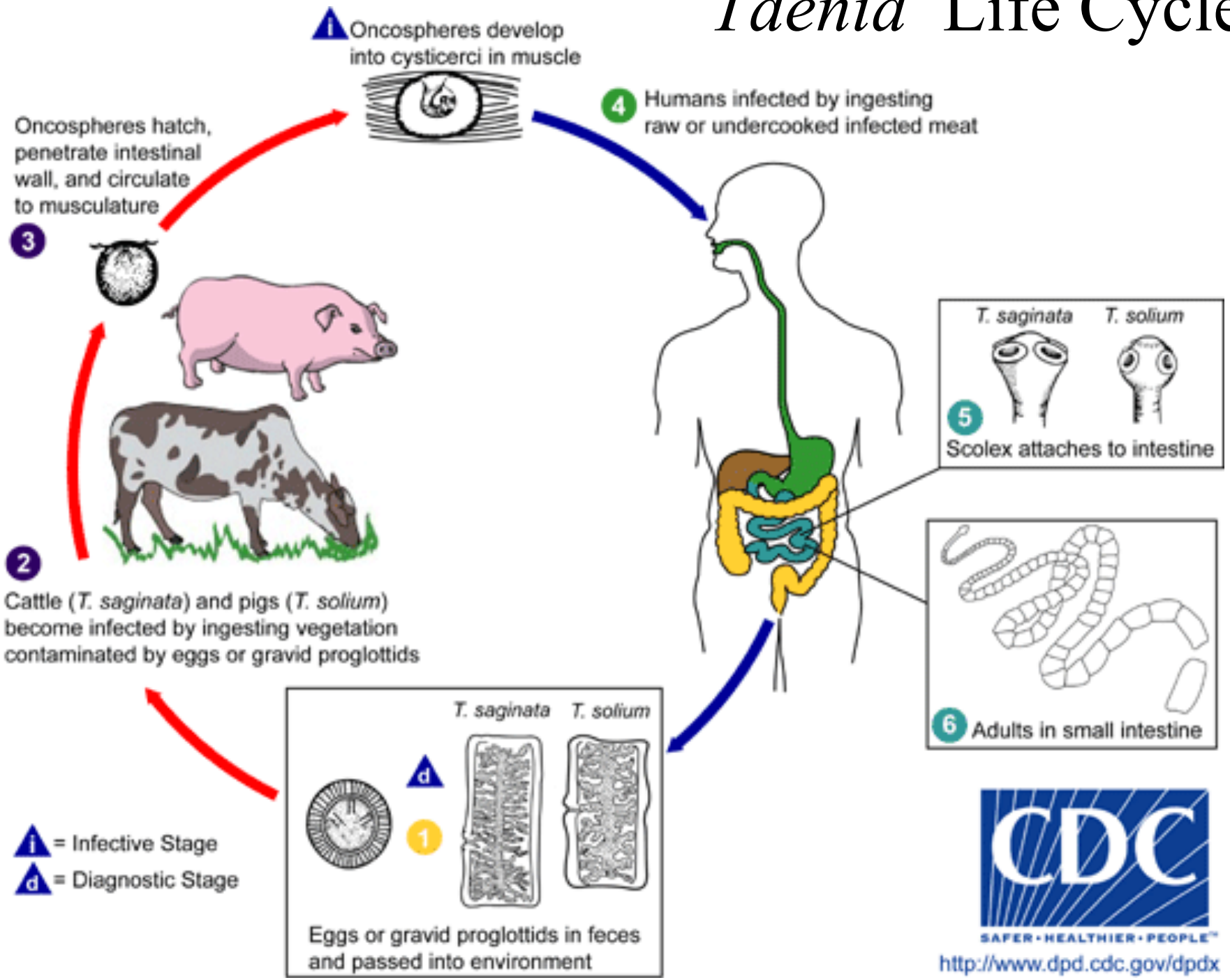
The neck is followed by a chain of flat, **ribbon-like segments** referred to as the **proglottids**.

The **scolex** is the anterior-most portion of the adult worm (head) and is armed with **large hooks** that alternate with small ones.





Taenia Life Cycle



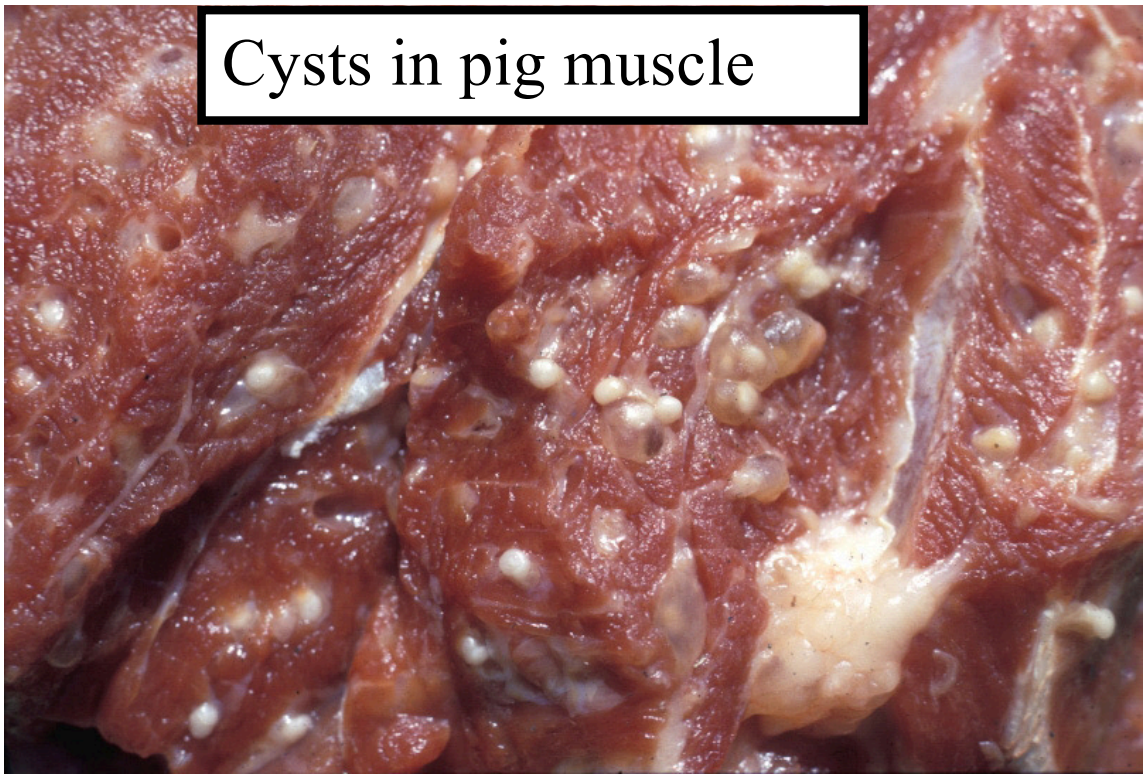
CDC
SAFER·HEALTHIER·PEOPLE™
http://www.dpd.cdc.gov/dpdx

Tapeworm infections cause Taeniasis and the worms are found world-wide

Taeniasis occurs when raw or undercooked beef (*Taenia saginata*) **or** pork (T. *solium*) are eaten.

T. saginata is prevalent in cattle regions of: Africa, Middle-East, Central and South America and Asia.

T. solium is prevalent in Central and South America, Africa, South-East Asia, Eastern Europe, Micronesia.



Humans carry the adult forms of *T. saginata* and *T. solium* meaning they are definitive hosts. However, humans can also be infected with cysts of *T. solium* and therefore can also be **intermediate** hosts.

Estimated in 2010 by WHO that the global burden is 514,000 infections but cysts can cause the serious disease of **cysticercosis.**

Taenia solium and cysticercosis

Cysts (cysticerci) can be found in any organ of the body and can range in size from 5 mm to 20 cm in diameter.

Cysts in the muscle or liver might just lead to muscle aches or inflammation but cysts or a cysticercus in the eye might lead to blindness, or a cysticercus in the brain (**neurocysticercosis**) could lead to neurologic damage.

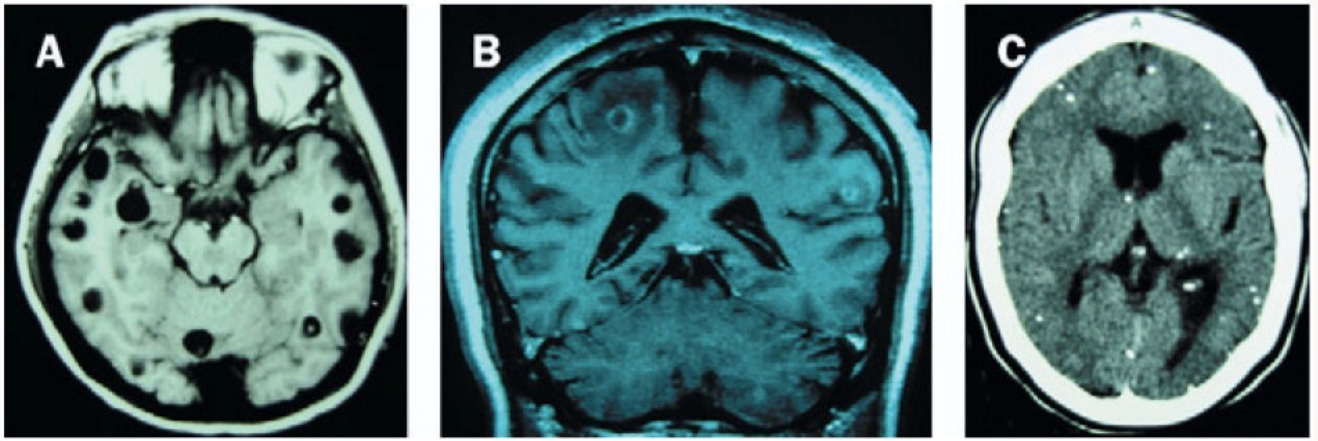
Cysticercosis image from stained muscle

A. Cysts in pork tissue
B. Cysts excised into Petri dish

Neurocysticercosis and Epilepsy

Cysts in the brain cause **neurocysticercosis**. Neurocysticercosis is common throughout Latin America, most of Asia, sub-Saharan Africa, and parts of Oceania, and is the **greatest cause of acquired epilepsy** worldwide.

Countries with higher endemic helminth infections have higher rates of epilepsy.



MRI of viable (A) and degenerating (B) cysts, and CT of calcified cysticerci (C).

"*The total number of people suffering from neurocysticercosis, including symptomatic and asymptomatic cases,* ***is estimated to be between 2.56–8.30 million****, based on the range of epilepsy prevalence data available.*"
https://www.who.int/news-room/fact-sheets/detail/taeniasis-cysticercosis

Trematodes (Schistosomes)

Trematodes are commonly known as flukes. Life cycle for trematodes includes a replication stage in **water snails**.

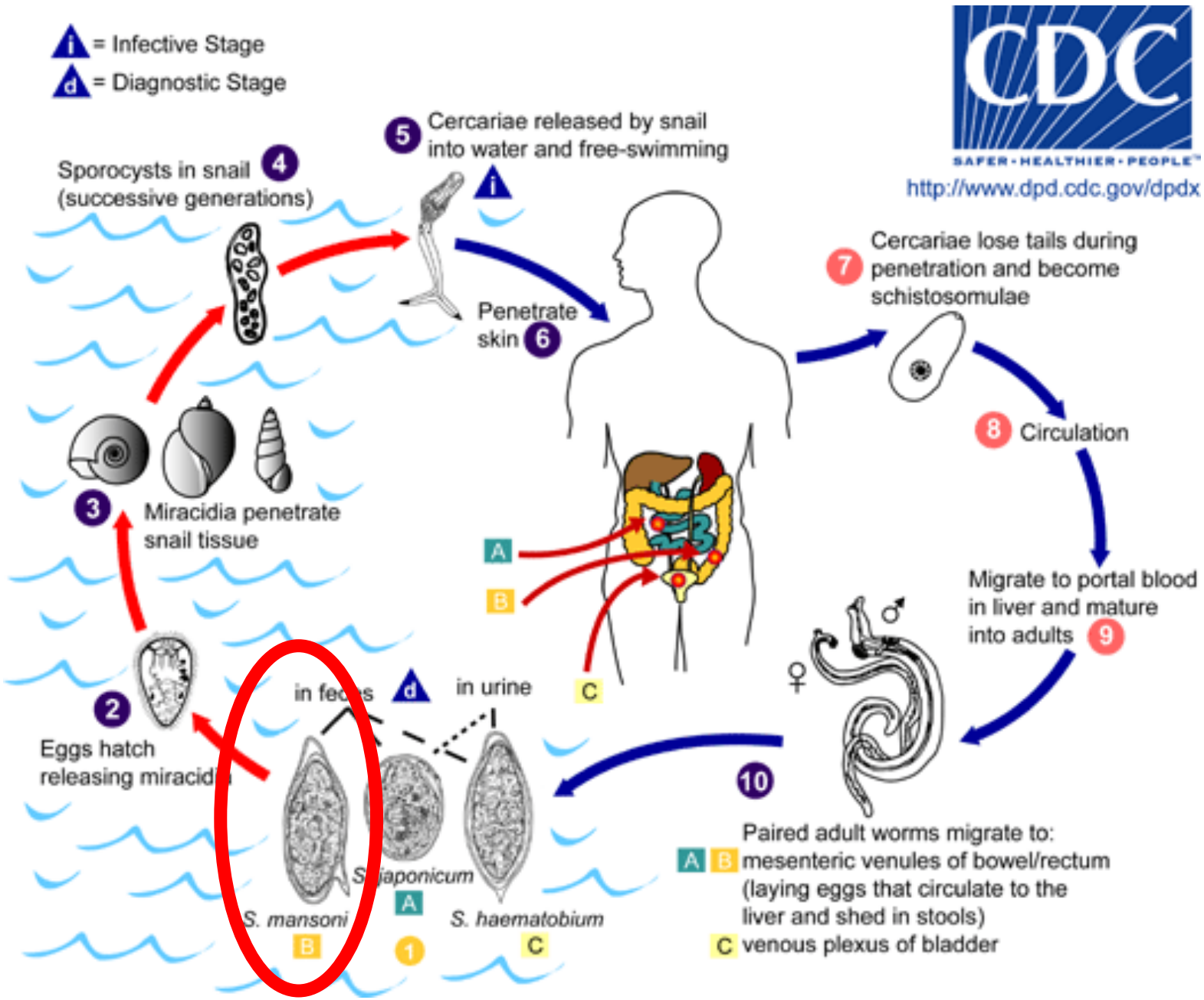
Snails are intermediate hosts or animal vector.

Schistosomiasis, also known as Bilharzia or Snail fever, is a parasitic disease caused by helminths from the genus Schistosoma.

Schistosome mansoni **Blood fluke.** Adult worms live in mesenteric (intestinal) veins. These worms can be extremely long-lived in hosts, usually 4 years but can live for up to 20 years.

Schistosomiasis may be found in up to 200 million people worldwide and is endemic to 76 countries throughout the tropics.

Schistosome life cycle



Eggs are released in urine or stool of infected individuals into fresh water where they hatch and infect the intermediate host, a freshwater snail. After infection, asexual proliferation occurs in the snail and thousands of new larval parasites (cercariae) emerge to swim and ultimately penetrate skin.

Schistosoma disease

Adult worms do not cause disease. People get bloated abdomen from excess fluid released into peritoneum from inflammation triggered by **egg induced granulomas in tissues surrounding adult worms**.

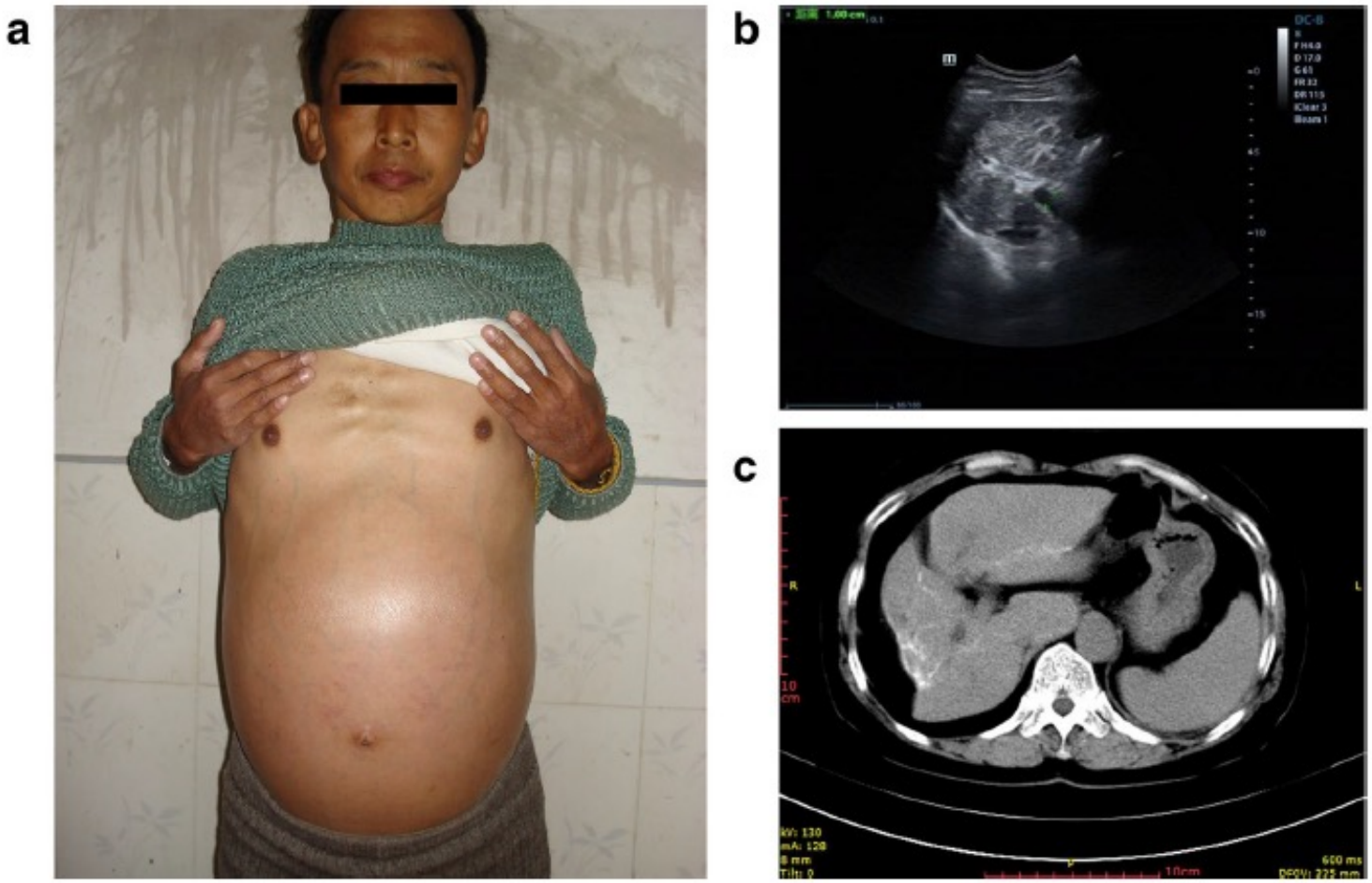
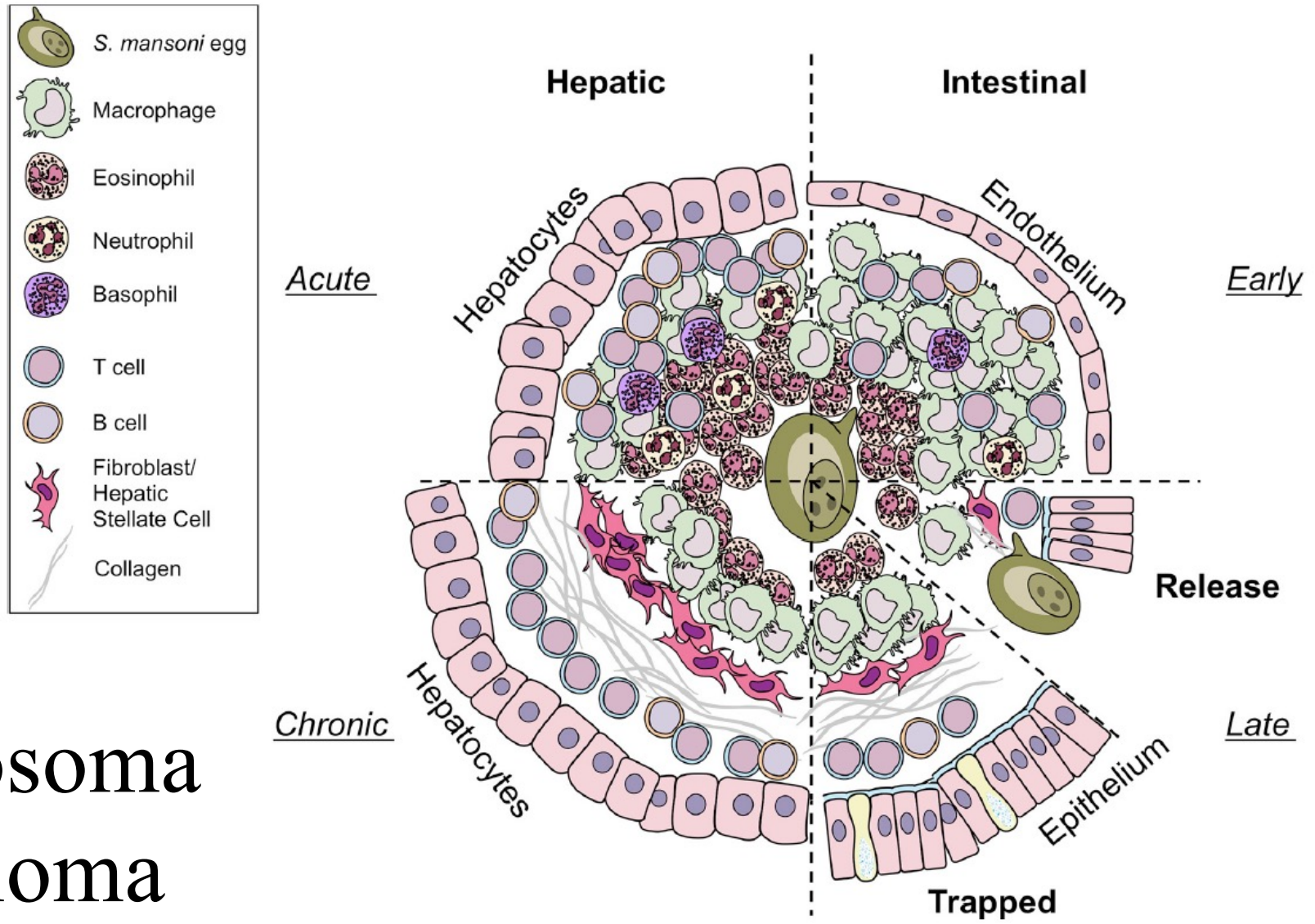


Fig. 4 Clinical features of advanced schistosomiasis. **a** Abdominal sign: subcutaneous varicose vein of the abdominal wall and abdominal distension (ascites/splenomegaly). **b** Ultrasonography of the liver: fibrosis and increased diameter of the portal vein (portal hypertension). **c** CT image of the liver: fibrosis. Photographs were from Jingzhou City No. 3 People Hospital, with permission of the patients

Schistosoma granuloma



Hepatic vs intestinal granuloma. Granuloma composition in the liver (left) and the intestine (right). Intestinal granulomas have less eosinophils, T cells, and B cells than hepatic granulomas, but more macrophages are present. During later stages (lower half) eggs in the liver become trapped and eggs in the gut seek to be released. Schwarz/Fallon Frontier in Immunology October 2018 | Volume 9 | Article 2492

Schistosome couple

Each adult worm pair can deposit millions of eggs into the urine or feces of infected individuals.