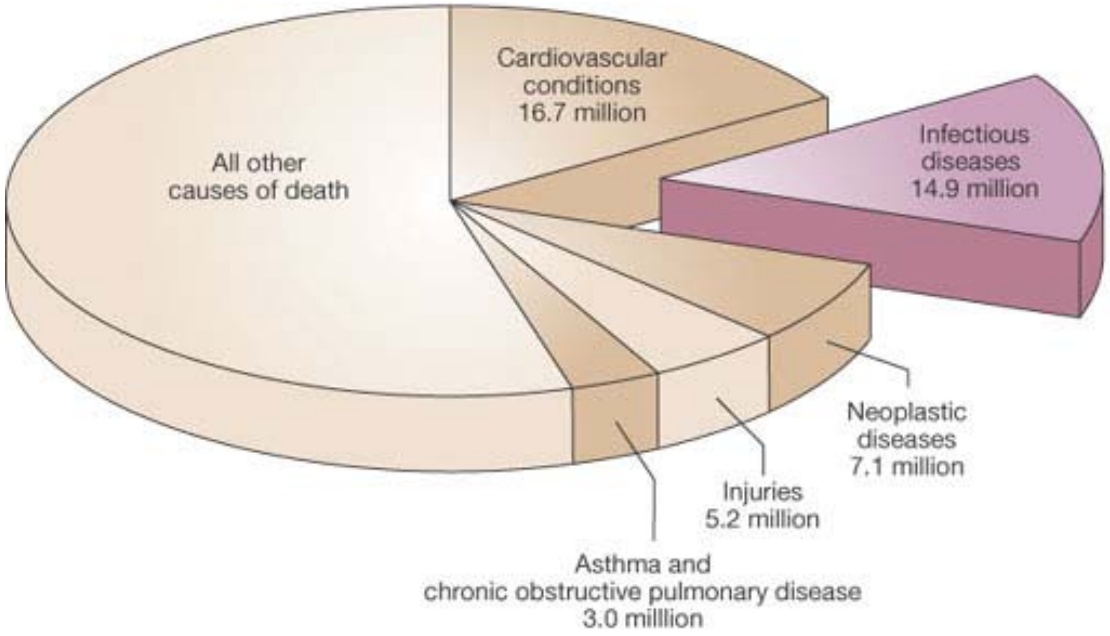
Biological characteristics of water II

Infectious diseases and pathogens



Infectious diseases	Annual deaths (million)
Respiratory infections	3.96
HIV/AIDS	2.77
Diarrhoeal diseases	1.80
Tuberculosis	1.56
Vaccine-preventable childhood diseases	1.12
Malaria	1.27
STDs (other than HIV)	0.18
Meningitis	0.17
Hepatitis B and C	0.16
Tropical parasitic diseases	0.13
Dengue	0.02
Other infectious diseases	1.76

Morens et al., Nature, 2004

- Types of disease-causing organisms (pathogens): (viruses), bacteria, protozoa, helminthes

Typhoid Mary

- Born in 1869. Carrier of *Salmonella typhi*
- 1900-1907: Worked as a cook in New York area
- 1900: After two weeks working as a cook in a house, residents came down with typhoid fever, and the laundress died. Spent months helping to care for the people she made sick, but her care further spread the disease through the household.
- Went to work for a lawyer, and 7 of 8 family members became ill.
- 1906: Took work as a cook on Long Island. Within two weeks, six out of eleven family members were hospitalized with typhoid. She changed employment again and three more households were infected.

http://history1900s.about.com

Typhoid Mary

- Typhoid researcher George Soper approached Mallon with the news she was possibly spreading typhoid, she rejected his request for urine and stool samples.
- Arrested, and found to carry typhoid bacteria, though asymptomatic.
- 1908 nicknamed “Typhoid Mary” in the J. American Medical Association
- Released after promising not to cook again.
- Changed her name and eluded capture for 5 years while spreading the disease.
- Held in custody for 23 years until she died in 1938.
- Positively linked to 10 outbreaks, 53 cases, 3 deaths.

http://history1900s.about.com

Water: more than just vehicle

- Water-borne: carried in water, transmitted by drinking of water (ex: cholera, typhoid fever)
- Water-washed disease: transmitted by washing and bathing. (ex: trachoma)
- Waste-based disease: pathogens spend all or part of their life in water or need aquatic organisms to complete their life cycle. (ex: Schistosomiasis, diseases by Legionella)
- Water-related disease: transmitted by insects that breed in the water or live near water. (ex: Yellow fever, Malaria)

Human viruses in water

Name	Disease caused
Enterovirus	Paralysis, meningitis, fever, Herpangina, hand-foot-and-mouth disease, myocarditis, heart anomalies, rush, pleurodynia, respiratory disease, gastroenteritis
Hepatitis A virus	Hepatitis A
Hepatitis E virus	Hepatitis E
Rotavirus	Gastroenteritis
Adenovirus	Gastroenteritis, respiratory disease, conjunctivitis
Astrovirus	Gastroenteritis
Coronavirus	Gastroenteritis, respiratory disease
Torovirus	Gastroenteritis

Pathogenic bacteria possibly in water

Genus	Species	Disease caused
Vibrio	*V. cholera*	cholera
	V. vulnificus, *V. parahaemolyticus*	gastroenteritis
Salmonella	*S. typhimurium*	salmonellosis, nausea, vomiting, diarrhea, fever, headache, chills
	S. enteritidis	gastroenteritis
	S. typhi	typhoid fever, fever, headache, anorexia, coughing, constipation, intestinal hemorrhage
	S. paratyphi	milder than typhoid fever
Shigella	*S. dysenteriae, S. flexneri,* *S. sonnei*	shigellosis
Campylobacter	*C. jejuni*	gastroenteritis, food poisoning
Helicobacter	*pyroli*	ulcers, gastritis, duodenitis
Legionella	*pneumonophila*	pneumonia

Pathogenic bacteria possibly in water

- Pathogenic types of *E. coli*

  Most types of *E. coli* are harmless, but there are several types that are pathogenic:

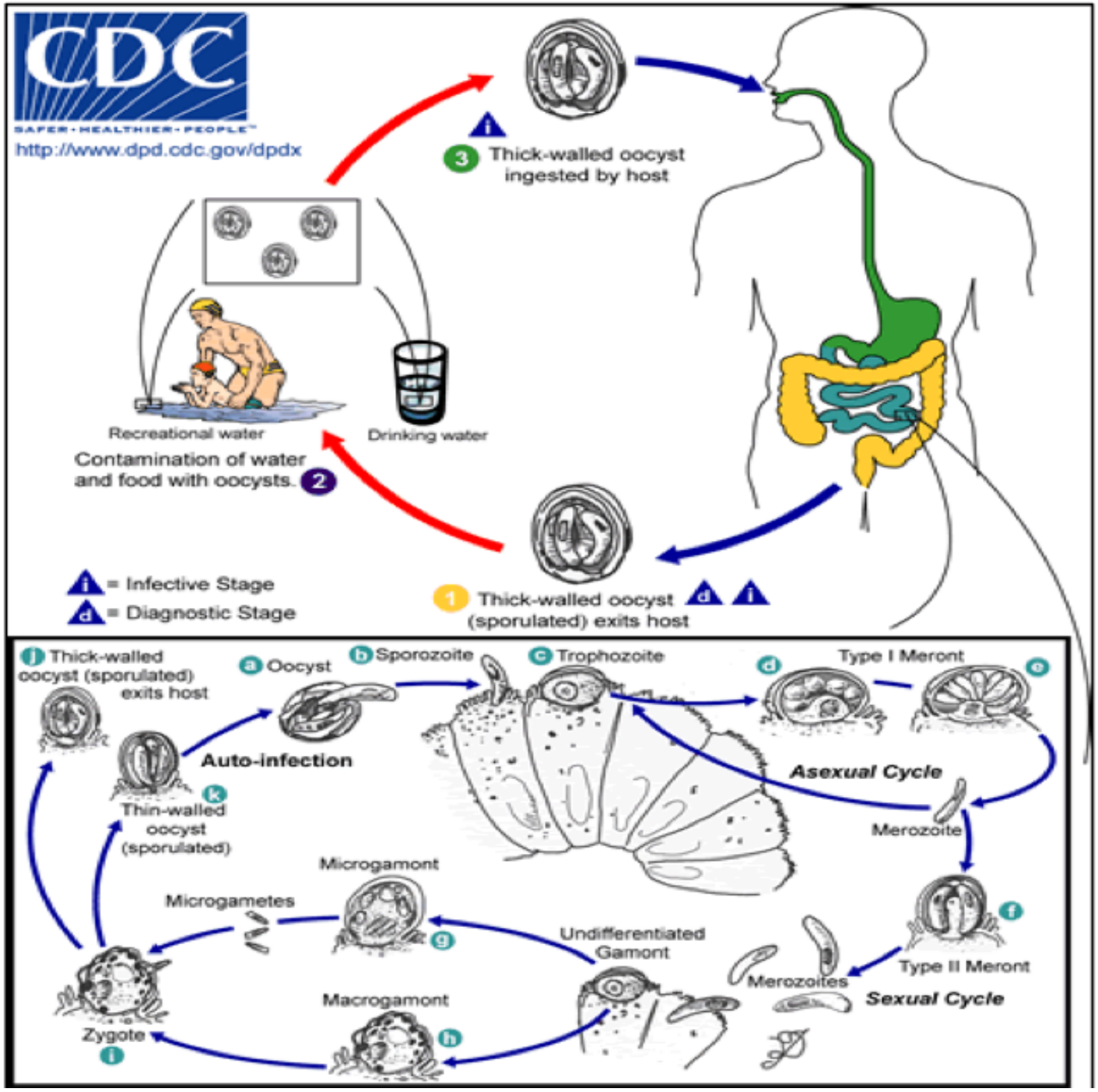
  – Enterotoxigenic: major cause of traveler's diarrhea
  – Enteropathogenic: major cause of infant diarrhea, can have high fatality
  – Enteroinvasive: severe intestinal cramps, watery stools, fever, mild dysentery
  – Enterohemorrhagic: one of this type, O157:H7, causes severe cramps, bloody diarrhea, renal failure. Mostly associated with undercooked meat, though waterborne outbreaks have occurred.

Pathogenic protozoa possibly in water

Genus/species	Disease caused	Notes
Entamoeba histolytica	Amebic dysentery	500 million infections per year, 100,000 deaths. Transmitted by ingestion of contaminated food and water; flies and cockroaches can serve as vectors.
Giardia lamblia	giardiasis (diarrhea, weakness, loss of appetite, cramps, …)	**Resistant to disinfection.** Several outbreaks in developed countries in late 1990s & 2000s.
Cryptosporidium parvum	cryptosporidiosis (diarrhea, anorexia, nausea, vomiting, abdominal pain)	**Resistant to disinfection.** Quite prevalent: estimated to cause 8-19% of diarrheal diseases in developing countries, several outbreaks in developed countries (e.g., 1993 Milwaukee outbreak* in U.S.)

* Milwaukee cryptosporidiosis outbreak: ~403,000 of 1.61 million residents became ill; >100 deaths

C. parvum life cycle



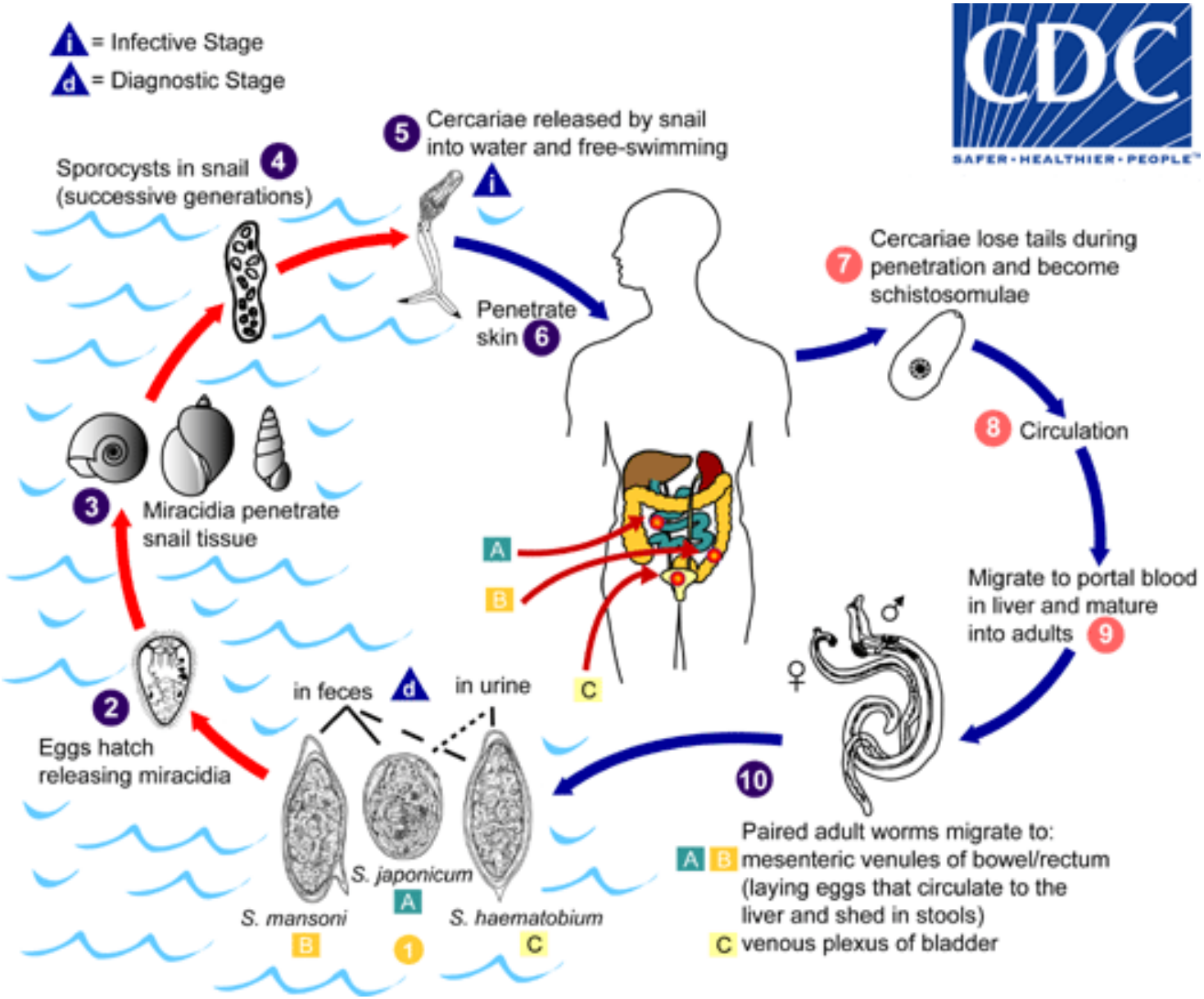
Parasitic worms (helminthes)

- Flatworms (flukes, tapeworms), roundworms

"The parasitic helminthes infecting the people of certain semitropical countries metabolize more of the produce of those countries than do the inhabitants; and half the work of the sick peasant population is thus put into the cultivation of food for the very worms that make them sick"

Anonymous (1970)

Schistosoma life cycle



Toxoplasma gondii

Parasite Makes Rats More Vulnerable to Cats

Updated 9:59 AM ET July 26, 2000

By Patricia Reaney

LONDON (Reuters) - A parasite found in mammals causes behavioral changes in rats that makes them more vulnerable to cats, scientists said Wednesday.

Rats normally have an innate aversion to their feline foes but British researchers at the University of Oxford have discovered that a parasite called Toxoplasma gondii makes rats less fearful and an easier prey for cats.

The parasite lives in the intestines of cats and is excreted with feces. In infected rats, it alters their behavior toward cats, which eat them, completing the parasite's lifecycle.

"Parasites are amazing things, if they can manipulate behavior to increase their chance of completing their life cycle they will," Professor Joanne Webster, a parasitologist at the University of Oxford, said in a telephone interview.

"Toxoplasma gondii is an ideal parasite to do this. It has a two-stage life cycle, with rats as the intermediate host.

Toxoplasma gondii

"There is a whole suite of behaviors it seems to change, all of which makes them more likely to be preyed on by the cats, the definitive host," said Webster.

The findings, reported in the latest issue of the science journal Proceedings of the Royal Society, are particularly interesting because many humans, including 22 percent of Britons, are infected with the parasite.

"It goes up to something like 87 percent of the French because they are more likely to eat raw and undercooked meat," Webster said.

In most humans the parasite is dormant. But in people with suppressed immune systems, such as AIDS patients or cancer sufferers undergoing chemotherapy treatment, the parasite can become active.

It can reside in any organ but is most common in the brain.

"We shouldn't be ignoring such a prevalent parasite in our brains. Indeed there is evidence that we can expect subtle behavioral differences in humans too," Webster warned.

Toxoplasma gondii

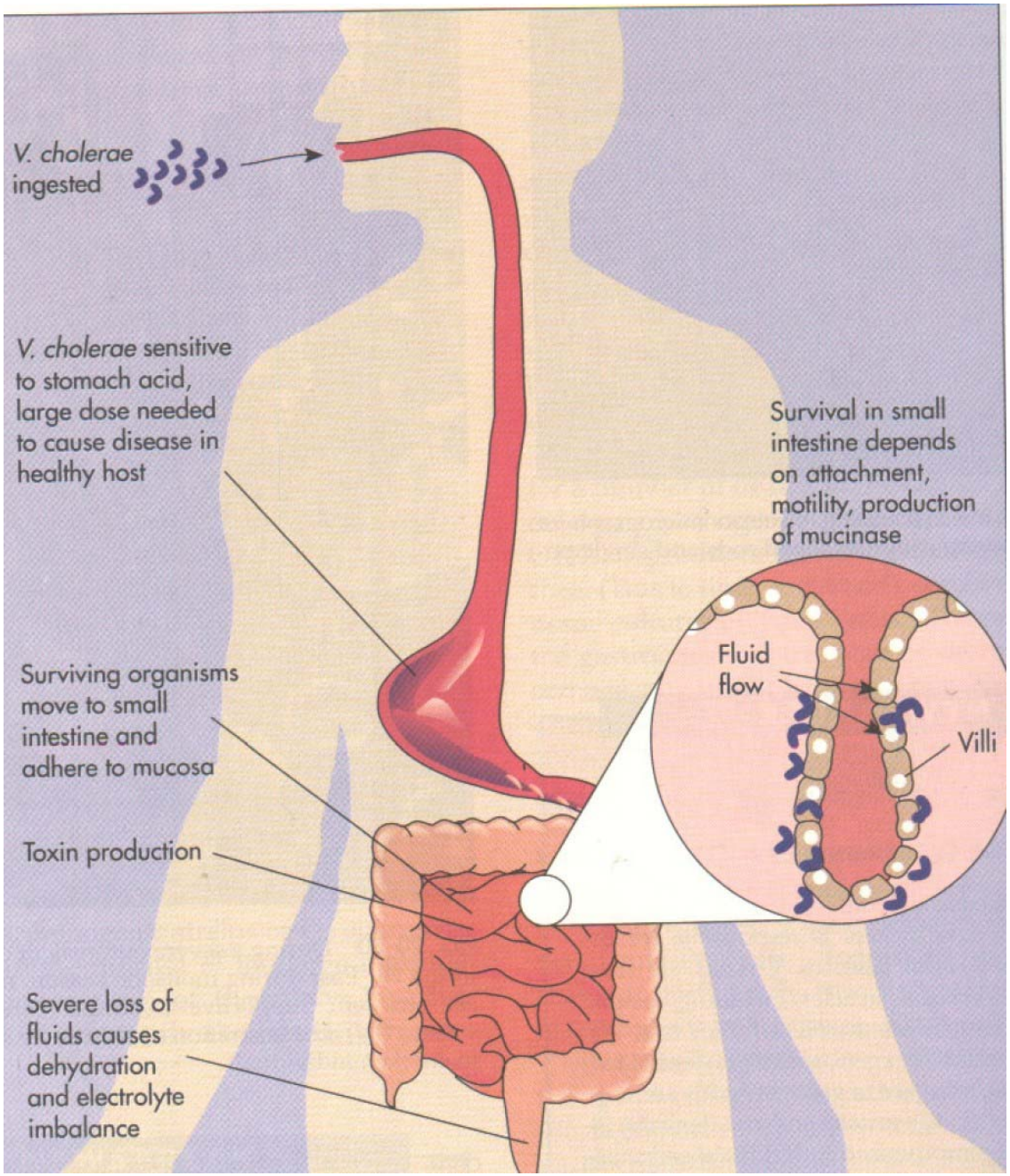
CALLS FOR RESEARCH IN BEHAVIORAL CHANGES

She called for further neurological research to determine how the parasite can manipulate behavior, which part of the brain is involved and whether the parasite is interacting with neurotransmitters.

Dr. Manuel Berdoy, a zoologist who also worked on the study, said the results could explain reports of altered personalities and IQs in some people.

"Although we clearly represent a dead-end host for the parasite, these symptoms represent the outcome of a parasite evolved to manipulate the behavior of another mammal," he said in a statement.

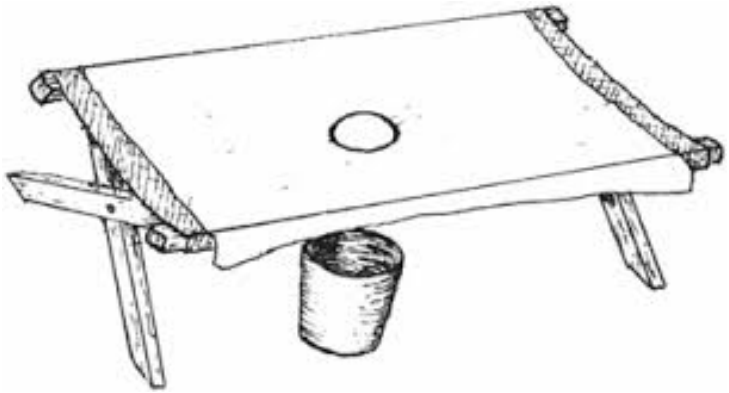
Pathogenesis of cholera



http://www.hubpages.com

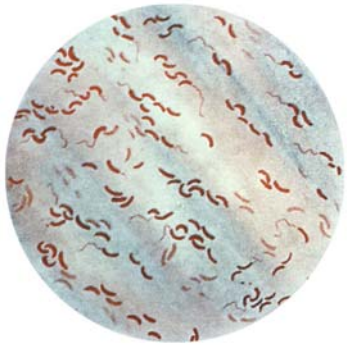
Cholera - effect of human infection

- The cholera cot



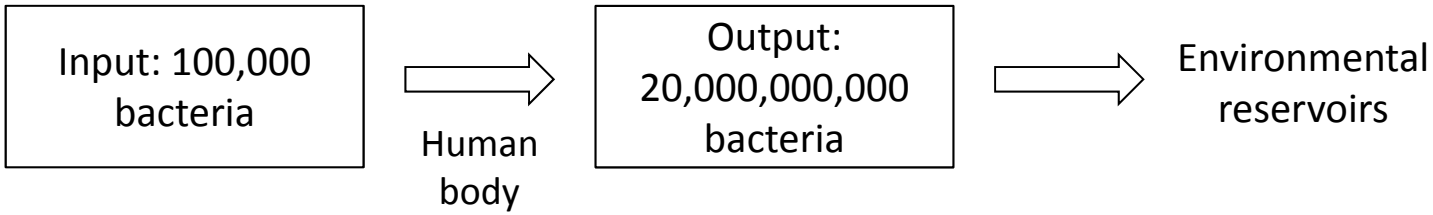
http://en.hesperian.org

- *V. cholerae* in "rice water stool"



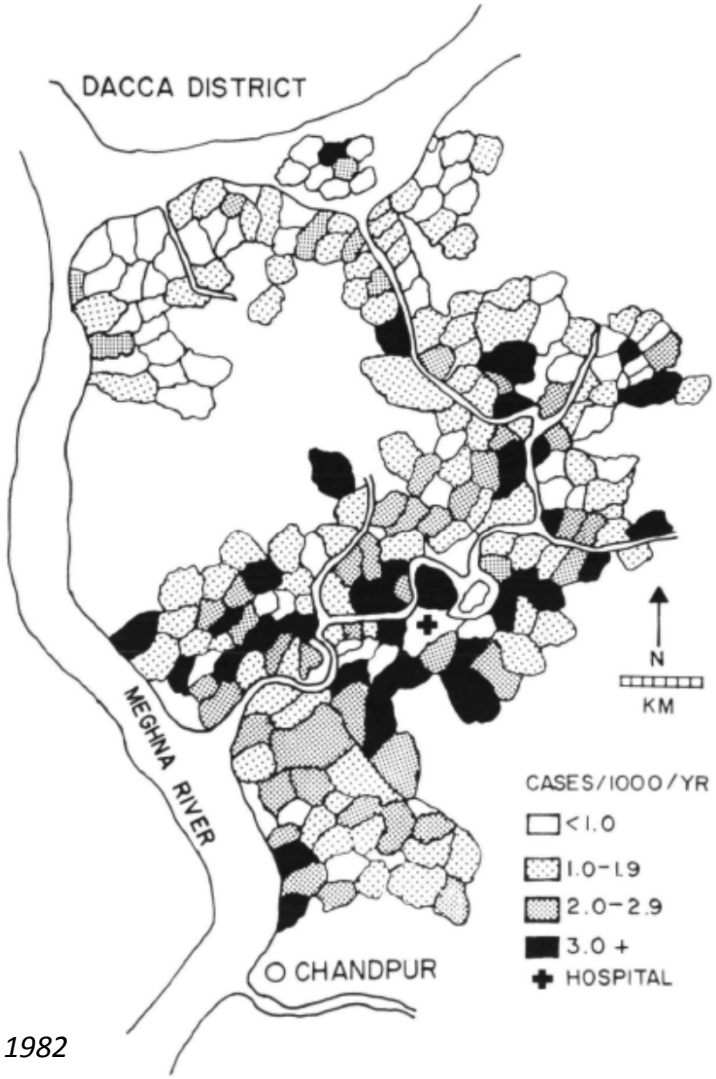
http://medicull.com/vibrio-cholera/

- Benefit that *V. cholerae* gets from humans



Endemic cholera in Bangladesh

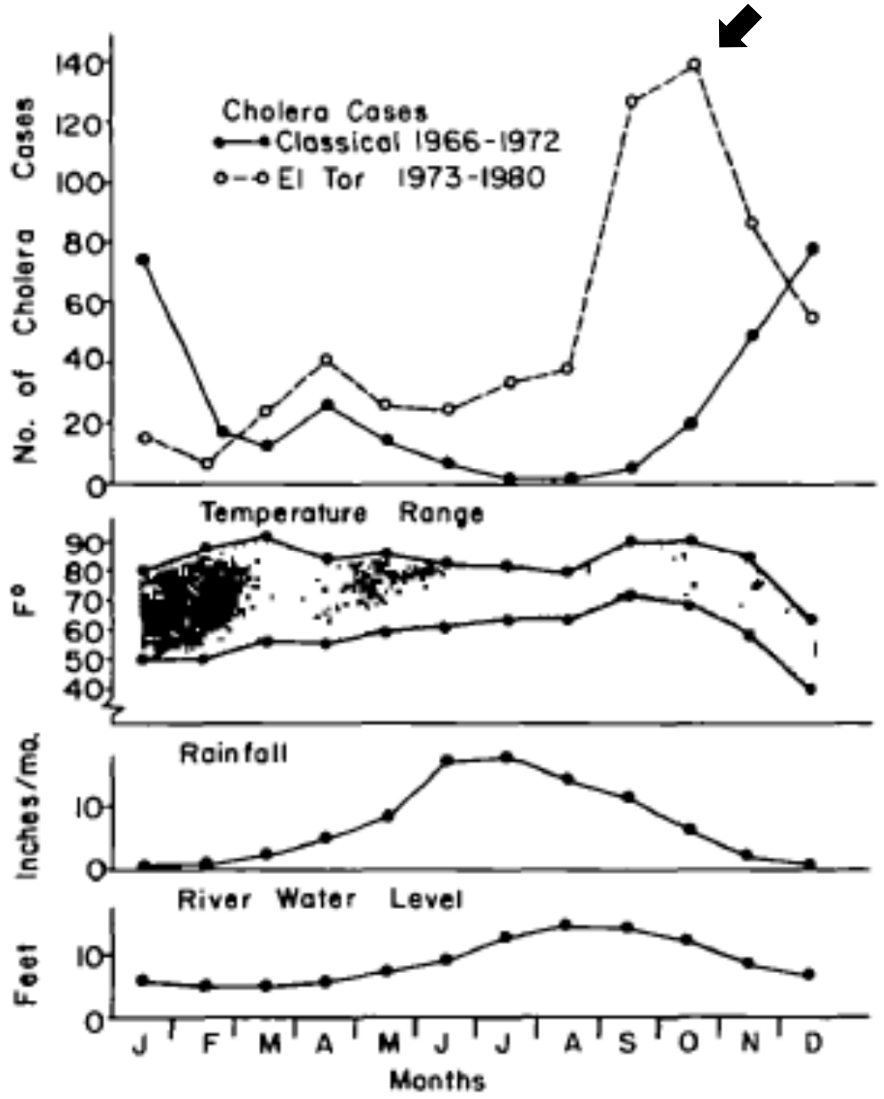
Hospitalization rate for cholera, Matlab, Bangladesh, 1968-1977



Glass et al., J. Epidemiology, 1982

Endemic cholera in Bangladesh

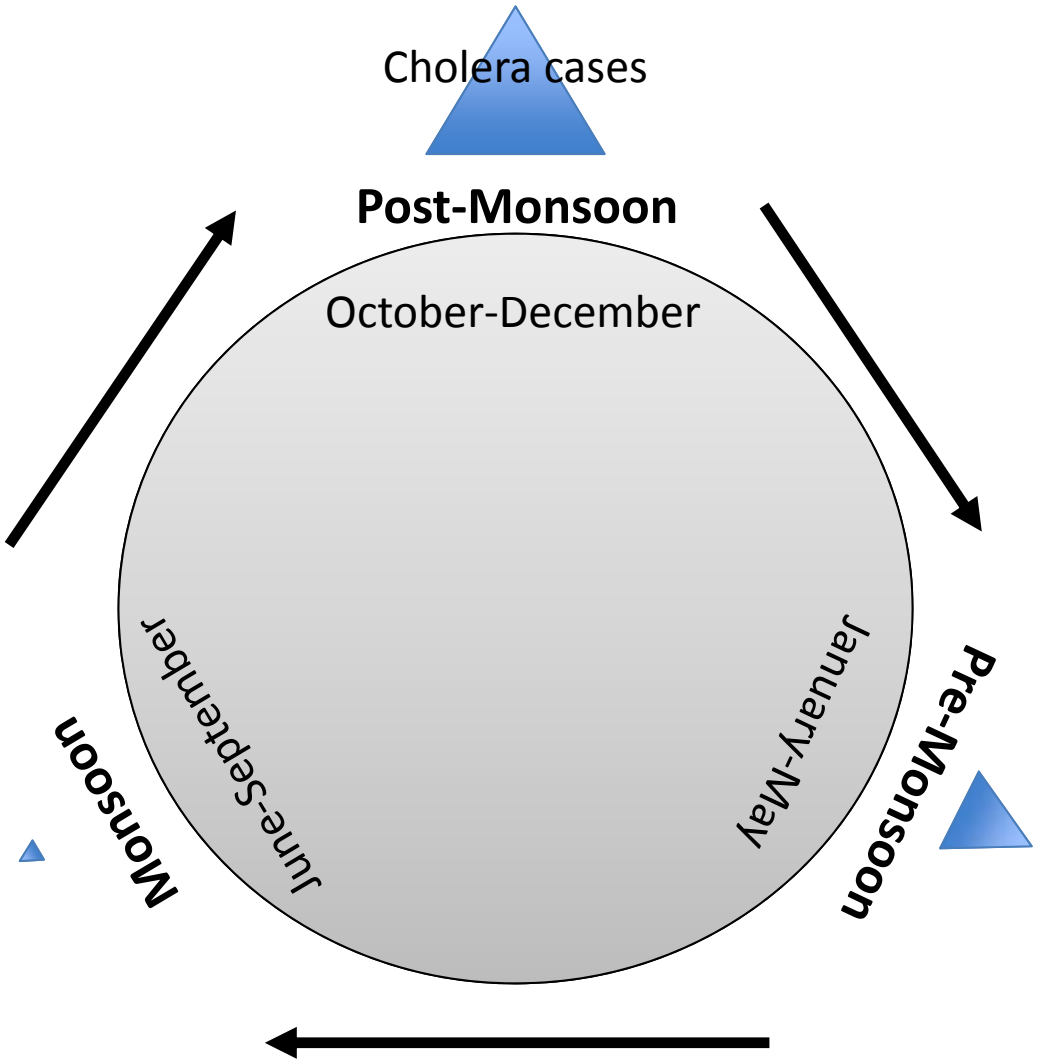
Relationship of season to cholera outbreaks (Matlab, Bangladesh)



Glass et al., J. Epidemiology, 1982

Endemic cholera in Bangladesh

Relationship of season to cholera outbreaks



Endemic cholera in Bangladesh

N fertilizers in runoff + sunlight in post-monsoon

→ Algal bloom

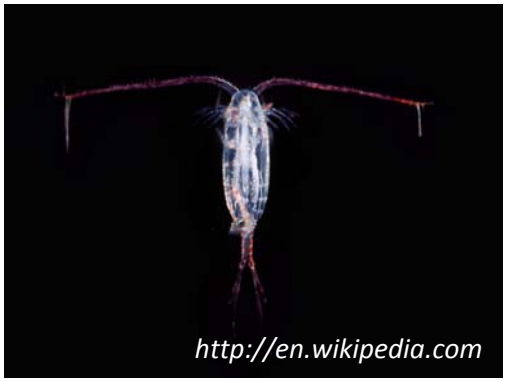
Affan et al., Science Alert, 2015

Endemic cholera in Bangladesh

Algal heterocyst

N_2 fixation – attracts microbes, provides nitrogen

Blue-green algae,
Anabaena variabilis



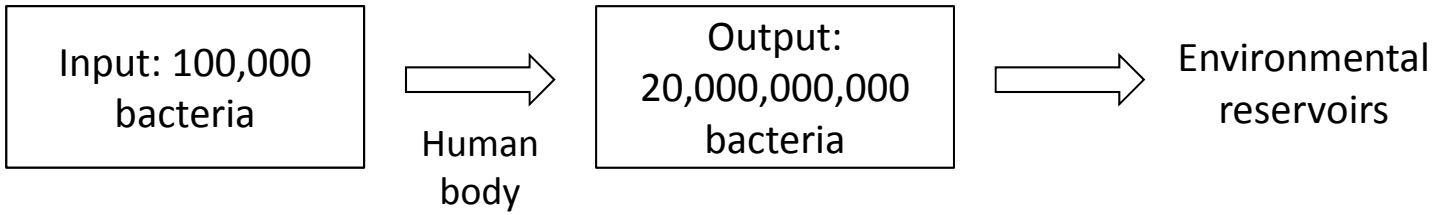
Copepod
(small crustacean)

V. cholerae attaches to chitin surface and feeds on it

<Algal bloom> → <Copepod bloom>

Endemic cholera in Bangladesh

- Once humans are infected…

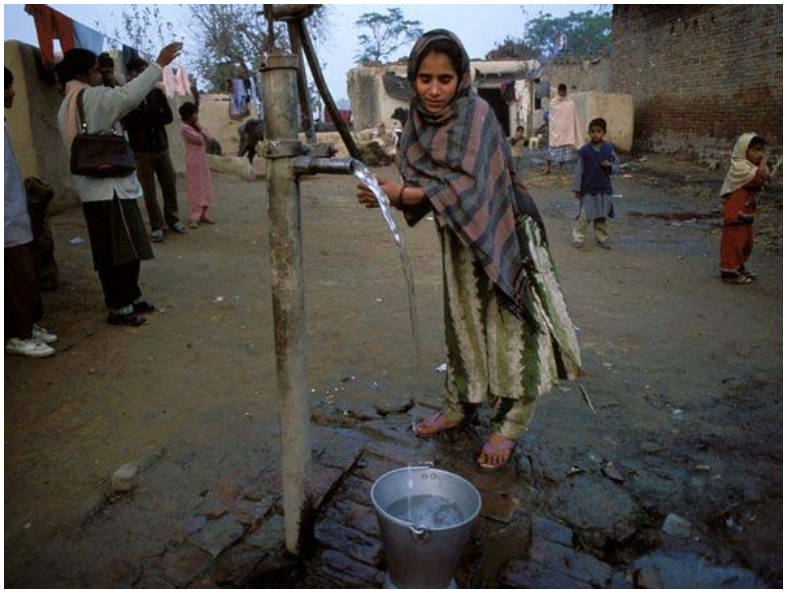


The “hanging latrine” of Bangladesh

http://vietnamarchitecture-nguyentienquang.blogspot.kr/2014/08/cau-tom-hanging-toilet.html

Cholera solutions?

- Removal of hanging latrine
- Drill wells
  - 1985-2000, millions of tube-wells drilled in Bangladesh
  - By 2000, tube-wells supplied water to 97% population



http://environment.nationalgeographic.com

Cholera solutions?

- 50% of groundwater wells: >10 µg/L (46 million persons)
- 28% of groundwater wells: >50 µg/L (28 million persons)
- Arsenic poisoning:
  - Hyperpigmentation (1,200,000 cases/yr)
  - Keratosis (600,000 cases/yr)
  - Skin cancer (125,000 cases/yr)
  - Fatalities (3,000 cases/yr)

http://www.rsc.org

"Largest mass poisoning of a population in history"

Real cholera solutions?

- Filtration of surface water using cloth?
- Rainwater harvesting?
- Other “appropriate technologies” you can think of??