The world’s water supply

If all earth’s water fit in a gallon jug, available fresh water would equal just over a tablespoon—less than half of one percent of the total. About 97 percent of the planet’s water is seawater; another 2 percent is locked in icecaps and glaciers. Vast reserves of fresh water underlie earth’s surface, but much of it is too deep to economically tap.
20% of the Earth’s liquid fresh water is in just one place.
Lake Baikal, Siberia

Maximum depth: 1,632 m
“Dehydration from diarrhea is still a constant threat to the survival of the world’s children, accounting for almost 3 million deaths each year.”

USAID Save The Children Program
LEADING INFECTIOUS KILLERS
Six high-burden diseases cause 90% of total disease deaths

Source: World Health Organization/CDS 1999
DEATHS IN DEVELOPING COUNTRIES

Two out of three deaths among children and young adults in Africa and Southeast Asia are due to seven causes (ages 0-44)

- AIDS: 13%
- Other Causes: 43%
- Malaria: 6%
- TB: 4%
- Diarrhoeal diseases: 9%
- Measles: 5%
- Maternal & perinatal conditions: 11%

Source: World Health Organization/CDS
Access to safe drinking water is everyone’s right.
Water Borne Infectious Diseases
Clinical Syndromes

Type I
a. Noninflammatory (enterotoxin, etc.)
b. Proximal small bowel
c. Watery diarrhea
d. Examples:
   - Rotavirus
   - Vibrio cholerae
   - Giardia lamblia
   - Cryptosporidium parvum
   - Cyclopsora cayetanensis

Type II
a. Inflammatory (invasive, cytotoxin)
b. Colon
c. Dysentery (bloody diarrhea)
d. Examples:
   - Salmonella enteriditis
   - Clostridium difficile
   - Campylobacter pylori
   - Entameba histolytica

Type III
a. Penetrating
b. Distal small bowel
c. Examples:
   - Salmonella typhi
   - Yersinia enterococolithica

Cholera toxin

Giardia lamblia

Entameba histolytica
Discoverer Of The First Water Borne Infectious Disease: *Giardia lamblia*

Anton Von Leeuwenhoek
Water Borne Infectious Diseases: Viruses

Rotavirus
Polio
Hepatitis A
Hepatitis E

Rotavirus
Polio virus
Hepatitis virus
Water Borne Infectious Diseases:

**Bacteria**

- *Vibrio cholerae*
- *Escherichia coli 0157*
- *Salmonella typhi*
- *Shigella flexneri*
- *Campylobacter pylori*
- *Chlamydia trachomatis*
Water Borne Infectious Diseases:

**Protozoa**

- *Giardia lamblia*
- *Entameba histolytica*
- *Cryptosporidium parvum*
- *Cyclospora cayetanensis*
- *Balantidium coli*
Water Borne Infectious Diseases:

**Helminths**
- Strongyloides stercoralis
- Dracunculus medinensis
- Schistosoma mansoni
- Schistosoma japonicum
- Schistosoma haematobium

Strongyloides stercoralis

Schistosome adult
Water Borne Infectious Diseases:

**Bacteria**

*Vibrio cholerae*
*Escherichia coli 0157*
*Salmonella typhi*
*Shigella flexneri*
*Campylobacter pylori*
*Chlamydia trachomatis*
Cholera
Distribution Of Estuaries

- Major river deltas
- Freshwater lakes of more than 5,500 sq miles
Trophic Relationships Of The Mangrove Estuary

From: E. Odum Fundamentals Of Ecology
New Cholera Outbreaks Frequently Occur In Communities Adjacent To Estuaries. Why?
Because *Vibrio cholerae* and its relatives are marine microbes, fully integrated into their respective food webs.

**Environmental Conditions Favoring Growth Of Vibrio:**

1. **Low salt**
2. **High Nutrient Load**
3. **20°C**
4. **Triggers phytoplankton bloom**
5. **Followed by zooplankton bloom**
6. **Followed by a cholera outbreak**

Marine copepod with *Vibrio cholerae* attached to egg cases.
The ToxR Regulon

Environmental signal (pH, osmolarity, temperature, bile, amino acids, CO₂)

TCP island

TCP

AphAB

CTXΦ

Cholera toxin

TCP
Mechanisms of Pathogenicity

1. Colonization of intestinal epithelium
2. Growth and multiplication
3. High cell density; protease-on virulence-off
4. Low cell density; virulence genes expressed
5. Cells pass through the gastric acid barrier
6. Oral ingestion
7. Biofilm
8. Persistence in aquatic reservoirs
9. Diarrhea

- vps genes repressed; cells escape from biofilm
Monsoons

1. lower the salinity of the estuary
2. bring nutrients to the estuary
3. raise the ambient water temperature of the estuary
Water Borne Infectious Diseases: 
Protozoa

Giardia lamblia
Entameba histolytica
Cryptosporidium parvum
Cyclospora cayetanensis
Balantidium coli
Giardia lamblia
SEM of *Giardia lamblia* in situ
**Giardia lamblia**

Cysts are ingested along with fecally contaminated water or food

Reservoir host

Cysts pass with feces

Quadranucleate cysts

Trophozoites emerge in small intestine

Trophozoites encyst in small intestine

Trophozoites live on surface of villi

PATHOLOGY

Normal villi

Flattened villi
Clinical Disease:

1. Diarrhea (steatorrhea)
2. Weight loss
3. Constipation
4. Fatigue
Pathogenesis:

Trophozoites induce malabsorption of fats. Mechanism(s) unknown.

Histopathological correlate: Flattened villi
Diagnosis:

1. Identify trophozoites and cysts by microscopic examination of stool
Diagnosis:

2. Antigen Capture ELISA using stool sample

3. PCR

4. IHA serology:
   Intestinal - 95% predictive of active infection
   Extra-intestinal - 100% predictive of active infection
Drug Of Choice: Metronidazole

Mode Of Action:
Inhibits Oxidoreductase.
Effective Against All Anaerobic Organisms
Entameba histolytica
Morphology

Trophozoite

Cyst

RBCs

Nucleus

Chromatoidal bar

Nuclei

15 µm
Entamoeba histolytica

Cysts are ingested along with fecally contaminated food or water

Cysts pass with feces

Quadrnucleate cysts

Trophozoites encyst in colon

Trophozoites invade tissues of colon

PATHOLOGY

Liver abscess

Flask-shaped ulcer

Brain abscess
Gross pathology of large intestine due to *Entameba histolytica*
Flask-shaped ulcer due to infection with *Entameba histolytica*
Trophozoites of *Entameba histolytica* in situ in flask-shaped ulcer
Entameba histolytica in culture with Chinese hamster ovary cells
Pathogenesis:

1. Attachment of amebae to target cells mediated by galactose, then pore-forming protein disrupts target cell membrane:


Clinical Disease:

A. Intestinal:
   1. Diarrhea
   2. Dysentery (bloody diarrhea)

B. Extra-intestinal:
   1. Liver abscess (most common site)
   2. Lung abscess
   3. Brain abscess (usually fatal)
Diagnosis:

1. Identify trophozoites and/or cysts in feces. Cannot distinguish *E. histolytica* from *E. dispar* by morphology unless cytoplasm contains RBCs.
Drugs of Choice:

1. Intestinal:
   Metronidazole and Iodoquinol

2. Extra-intestinal
   High doses of Metronidazole
Cryptosporidium parvum
Histologic section of small intestine of patient suffering from HIV/AIDS, infected with Cryptosporidium parvum.

Courtesy J. Lefkowitch
Pathogenesis:

Secretory diarrhea. May produce up to 10 liters of watery stool per day! Mechanism unknown.
Diagnosis:
Find oocysts in stool

Oocysts of Cryptosporidium parvum
Water Borne Infectious Diseases:

**Helminths**

- *Dracunculus medinensis*
- *Strongyloides stercoralis*
- *Schistosoma mansoni*
- *Schistosoma japonicum*
- *Schistosoma haematobium*

**Strongyloides stercoralis**

**Schistosome adult**
Strongyloides stercoralis
Parasitic female *Strongyloides stercoralis*
*Strongyloides stercoralis* in situ
Strongyloides stercoralis

Reservoir hosts

Larvae penetrate unbroken skin

Free-living soil cycle

L4

soil

L1

L2

L3

Larvae enter bloodstream reach lung capillaries

Larvae enter alveolar spaces

Larvae develop to L3 in colon, enter bloodstream

Larvae pass out in feces

Larvae are swallowed

Adult worms live in small intestine

Autoinfection
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. Microscopical examination of feces (X6)

2. “String” test

Larva of *Strongyloides stercoralis*
Drug of choice:
Ivermectin

Mode of Action:
Blocks Cl\(^{-}\) ion channels, inhibits \(\gamma\)-aminobutyric acid receptor complex.
Dracunculus medinensis
Dracunculus Lesion On Leg

Origins Of The Cadeusus?

Adult Worm
Dracunculus medinensis

1. Larvae inside copepods are swallowed.
2. Copepods ingest larvae.
4. Larvae migrate to lower extremities.
5. Larvae enter subcutaneous tissues.
6. Larvae penetrate small intestinal wall.
7. Larvae are freed from copepods in small intestine.
8. Larvae mature and live in subcutaneous tissues.
9. Larvae enter abdominal wall.
Dracunculus and Step Well Ecology

Dracunculus infective larvae

Cyclops

Extraction of dracunculus adult

Step Well
Drug Of Choice: Metronidazole

Mode Of Action: Inhibits Oxidoreductase Enzyme
Medical Ecology

www.medicalecology.org
Medical Ecology

Statement of purpose:

*Medical Ecology* is an emerging science that defines those aspects of the environment that have a direct bearing on human health. The concept of ecosystem functions and services helps to describe global processes that contribute to our well-being, helping to cleanse the air we breathe, the water we drink, and the food we eat. Environmental degradation often leads to alterations in these aspects, leading to various states of ill health. The term Medical Ecology was first coined by the eminent microbiologist, Rene Dubos, who intended it to embrace the concept that natural systems, if explored fully, would provide for many of our needs, as for example, quinine did regarding the treatment of malaria. Dubos discovered gramicidin in 1939, a powerful topical anti-microbial agent. Together with Alexander Fleming’s discovery of penicillin in 1928, these findings led the way into the modern era of anti-microbial therapy, in which soil organisms played a dominant role.

*Medical Ecology* as described here is re-defined to a much broader level. We believe that ecological principles, when applied to the human condition will offer a resolution to the dichotomy of the "man versus nature" paradigm. In fact, humans are an integral part of nature, but most of the time we are unaware of our connectedness to the rest of the world. *Medical Ecology* links natural processes with living on earth, from the point of view of being human. The environment in which we live is characterized by countless physical, chemical, and biological systems, and it is in this complex setting that we carry out our lives, whether we are aware of them or not. The more aware of them we are, the more likely it is that we can avoid those situations that take away from our sense of well-being.
Basic Sciences:

- Geology
- Ecology
- Oceanography
- Hydrology
- Biochemistry and Molecular Biology
- Physics
- Atmospheric Sciences
- Chemistry
- Remote Sensing
Applied Sciences:

Biostatistics  Medical Sciences
Epidemiology  Anthropology  Agronomy
Environmental Health Sciences
Socio-Medical Sciences  Toxicology
Medical Geography
February 3, 2000

El Niño Increases Diarrheal Disease Incidence by 200 Percent

The El Niño phenomenon--the warming of the equatorial Pacific ocean that occurs every two to seven years--has been linked to outbreaks of dengue, malaria, and cholera. Now, researchers from the Johns Hopkins School of Public Health, A.B. Prisma, and the Instituto Nacional de Salud in Lima, Peru, have found that the 1997-1998 El Niño season increased hospitalizations for diarrheal disease by 200 percent, according to a study published in the February 5th issue of *The Lancet*. The results are cause for concern, said the researchers, since diarrhea already causes one billion episodes and three million deaths annually in children under five worldwide.
It Is Everyone’s Right To Have Access To Safe Drinking Water
Everyone’s!!!