Agenda

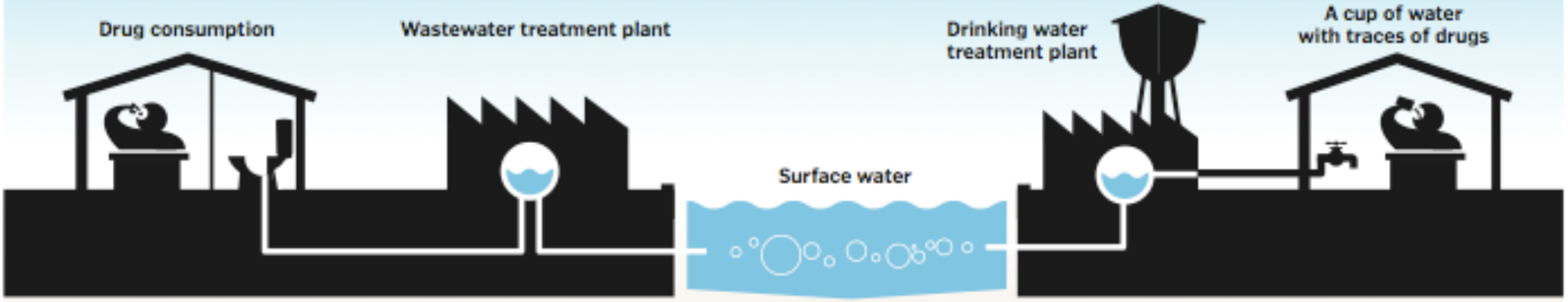
- Field Trip – February ??
  - Water Treatment Plant (Drinking or Waste)
- Water in the News

- **WATER SUPPLY AND WATER QUALITY**
- **Part 2**

Pharmaceuticals and Personal Care Products in the Water

Pharmaceuticals in drinking water

An investigation by The Associated Press found that drinking water supplied to at least 41 million Americans carried residues of antibiotics, anti-convulsants, mood stabilizers, sex hormones and other pharmaceuticals.



An estimated 90 percent of pharmaceuticals in the environment come from consumers. Many drugs end up in toilets, unmetabolized by the body or thrown away.

Sewage treatment plants were designed to remove disease-causing microbes and pathogens from water – not pharmaceuticals.

Testing has confirmed more than 100 different pharmaceuticals in surface waters. Fish, mollusks and algae are adversely affected by contamination.

Standard treatments used to clean drinking water are not good at removing pharmaceuticals.

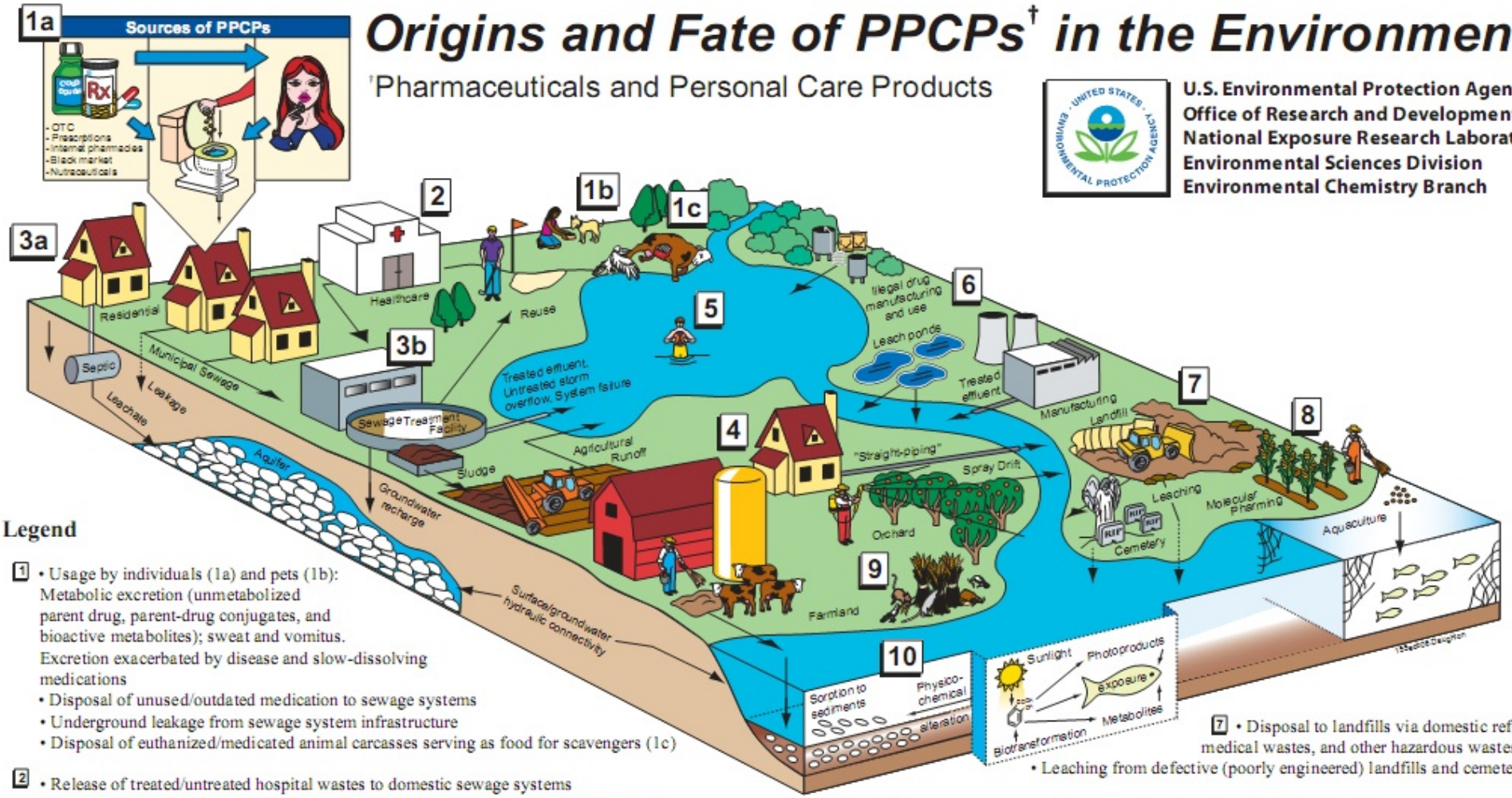
Humans may be affected by the consumption of water that contains pharmaceuticals.

ASSOCIATED PRESS

Origins and Fate of PPCPs† in the Environment

†Pharmaceuticals and Personal Care Products

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch



Legend

1 • Usage by individuals (1a) and pets (1b): Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus. Excretion exacerbated by disease and slow-dissolving medications
• Disposal of unused/outdated medication to sewage systems
• Underground leakage from sewage system infrastructure
• Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)

2 • Release of treated/untreated hospital wastes to domestic sewage systems (weighted toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus

3 • Release to private septic/leach fields (3a)
• Treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
• Overflow of untreated sewage from storm events and system failures directly to surface waters (3b)

4 • Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
• "Straight-piping" from homes (untreated sewage discharged directly to surface waters)
• Release from agriculture: spray drift from tree crops (e.g., antibiotics)
• Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)

5 • Direct release to open waters via washing/bathing/swimming

6 • Discharge of regulated/controlled industrial manufacturing waste streams
• Disposal/release from clandestine drug labs and illicit drug usage

7 • Disposal to landfills via domestic refuse, medical wastes, and other hazardous wastes
• Leaching from defective (poorly engineered) landfills and cemeteries

8 • Release to open waters from aquaculture (medicated feed and resulting excreta)
• Future potential for release from molecular pharming (production of therapeutics in crops)

9 • Release of drugs that serve double duty as pest control agents: examples: 4-aminopyridine, experimental multiple sclerosis drug → used as avicide; warfarin, anticoagulant → rat poison; azacholesterol, antilipidemics → avian/rodent reproductive inhibitors; certain antibiotics → used for orchard pathogens; acetaminophen, analgesic → brown tree snake control; caffeine, stimulant → *coqui* frog control

10 Ultimate environmental transport/fate:
• most PPCPs eventually transported from terrestrial domain to aqueous domain
• phototransformation (both direct and indirect reactions via UV light)
• physicochemical alteration, degradation, and ultimate mineralization
• volatilization (mainly certain anesthetics, fragrances)
• some uptake by plants
• respirable particulates containing sorbed drugs (e.g., medicated-feed dusts)

Christian G. Daughton, U.S. EPA-Las Vegas

March 2006
(original February 2001)

http://epa.gov/nerlesd1/chemistry/pharma/images/drawing.pdf
from: http://epa.gov/nerlesd1/chemistry/pharma/

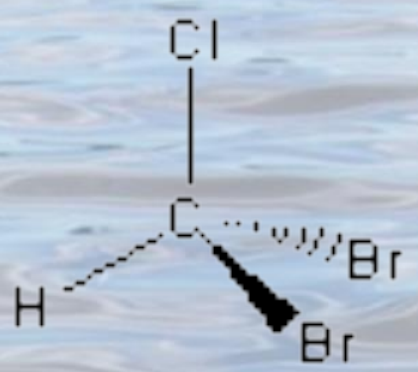
17α-Estradiol

Estra-1,3,5(10)-triene-3,17β-diol

Thousands of different active molecules belonging to various therapeutic classes, with different physiochemical properties, chemical structures, environmental behavior and persistence have lead to the complex issue involving environmental pollution from PPCPs.

Chlorination Disinfectant Byproducts

TRIHALOMETHANES (THMs)



- Chlorine is a disinfectant added to drinking water
- Reduces and eliminates microorganisms such as viruses and bacteria
- CDBPs are chemical compounds that form when water, containing natural organic matter, reacts with chlorine
- THMs are a major subgroup of chlorination by-products

PROBLEM?

Evidence of close relationships between bladder cancer and exposure to THMs

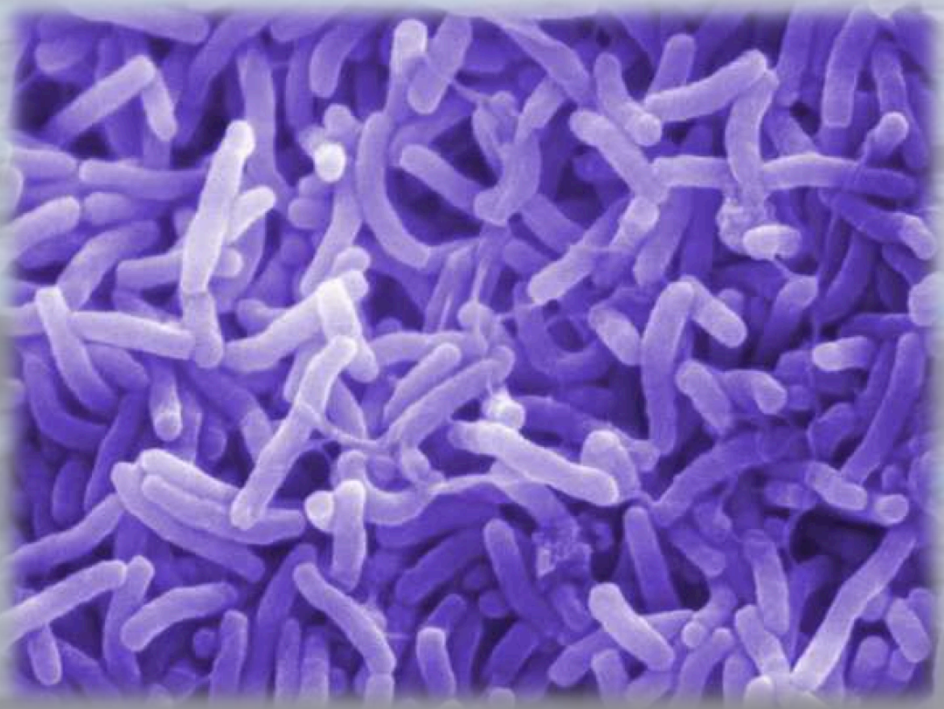
Case Studies

- One study in Ontario, Canada examined the relationship between bladder cancer and exposure to chlorination byproducts in public water supplies (King and Marrett, 1996).
- Thunder Bay has also done studies on the rate of bladder cancer in Loch Lomond water supply

Solutions:

- A carbon filter can remove chlorine and its byproducts
- Alternatives to chlorine disinfectants
  - Ozonation
  - Chloramines
  - Chlorine dioxide
- Better knowledge and application of more precise methods
- Ontario drinking water quality standard (ODWQS)

Waterborne Diseases



Waterborne Diseases

- Types of diseases linked to water
  - Water-based diseases
  - Water-washed diseases
  - Water-related diseases
  - Water-borne diseases
    - typhoid
    - cholera

Solutions

- Vaccinations
- Oral Rehydration Therapy
- Need to be Proactive!
  - Education
  - Water Treatment Facilities (urban)
  - Safe Water System (rural)
  - Wells vs Surface Water

Water Terrorism

- Biological, chemical, cyber and physical threats
- Risks to infrastructure, human health, economy
- Biological
  - potential to do the most harm
  - Anthrax, salmonella, Q fever, pneumonic plague, human waste
  - Contaminate reservoirs, bottling plants
- Chemical
  - Pesticides, chlorine, prussic acid (large quantities)
  - Some available in stores, others on the black market