

Emerging Threats: Pharmaceuticals Wastes and Pollutants in the Aquatic Environment

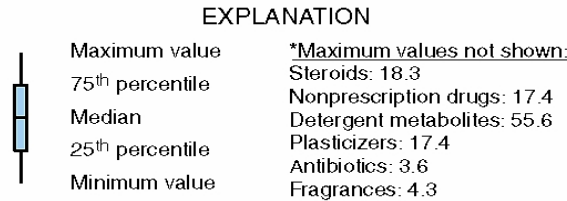
International Water Resources Association
World Water Day 2017 – Wastewater Webinar
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Gabriel Eckstein, Professor of Law



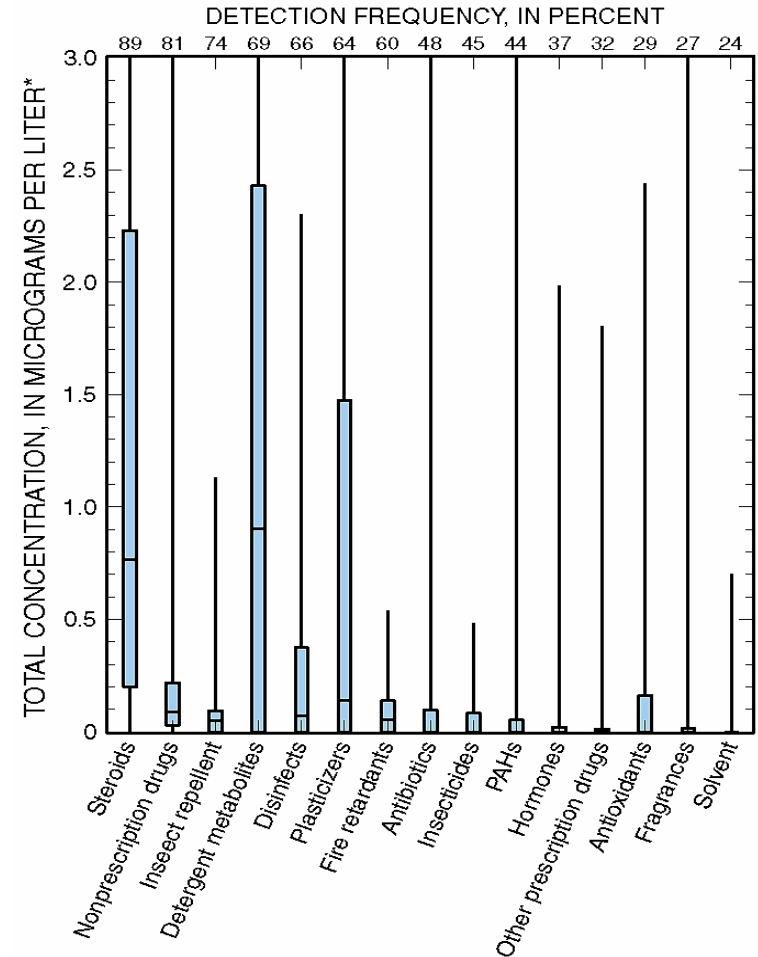
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Pharmaceuticals in the Environment



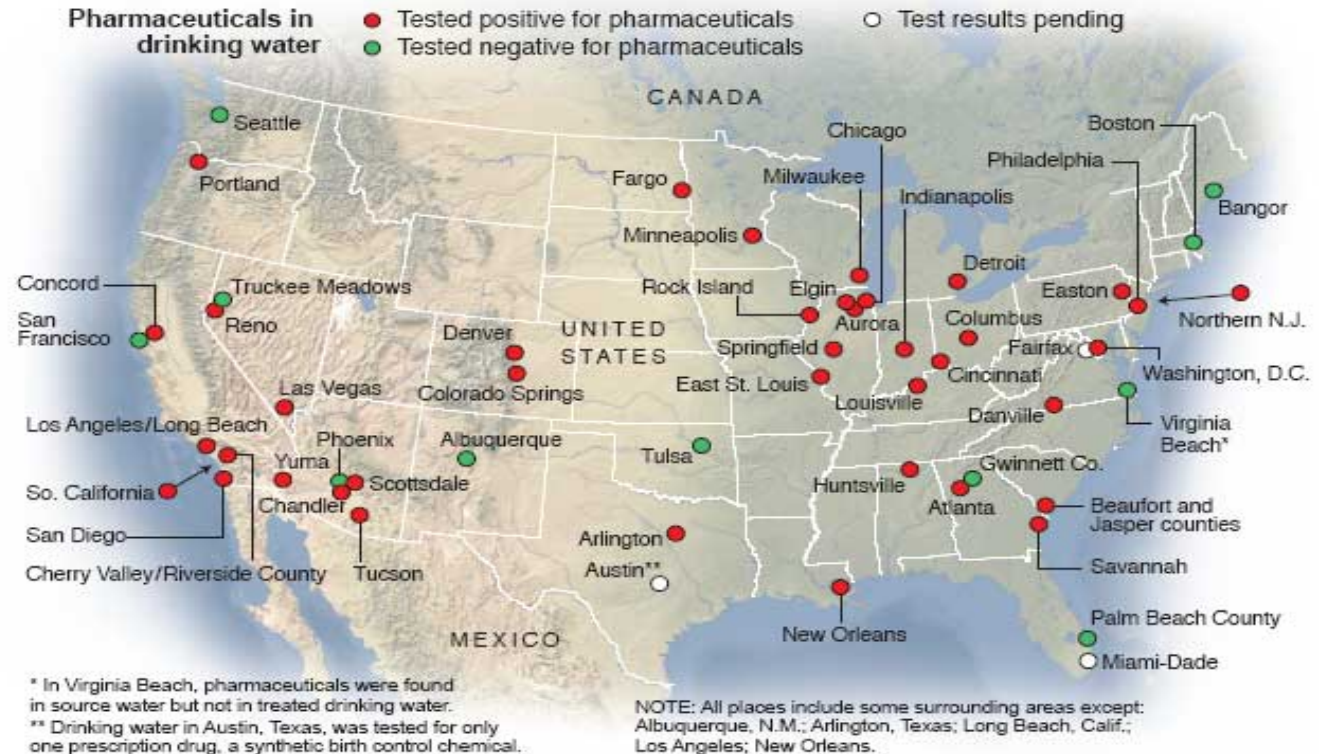
2002 study revealed that at least one of 95 organic wastewater contaminants studied was found in 80% of stream samples and in 93% of groundwater samples

Source: Kolpin, D.W., Furlong, E.T., Meyer, M.T., Thurman, E.M., Zaugg, S.D., L.B., B. and Buxton, H.T., "Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. Streams, 1999-2000: A national reconnaissance," 35 *Environmental Science & Technology* 1202 (2002)



Pharmaceuticals in the Environment

2008 Associated Press investigation found traces of pharmaceuticals in the drinking water of 41 million Americans in 24 major metropolitan communities. See http://hosted.ap.org/specials/interactives/pharmawater_site/



SOURCES: Drinking water providers' responses to Associated Press questions; AP review of scientific literature.

AP

Pharmaceuticals in the Environment

2013 EPA-funded study

- Sampled 50 large-size wastewater treatment plants nationwide
- Tested for 56 drugs including oxycodone, high-blood pressure medications, and over-the-counter drugs like Tylenol and ibuprofen
- **Results**
 - More than half of the samples tested positive for at least 25 of the drugs monitored
 - High blood pressure medications appeared in highest concentrations and most frequently

Acetaminophen

Albuterol

Alprazolam

Amitriptyline

Amlodipine

Amphetamine

Atenolol

Atorvastatin

Benzotropine

Carbamazepine

Ciprofloxacin

Clonidine

Hydrocodone

Hydrocortisone

Ibuprofen

Lincomycin

Lisinopril

Melengestrol acetate

Methylprednisolone

Metoprolol

Norethindrone

Norfluoxetine

Norverapamil

Ofloxacin

Sulfamethazine

Sulfamethoxazole

Sulfamethoxazole

Testosterone

Testosterone

Theophylline

Triamterene

Trimethoprim

Trimethoprim

Valsartan

Verapamil

Warfarin

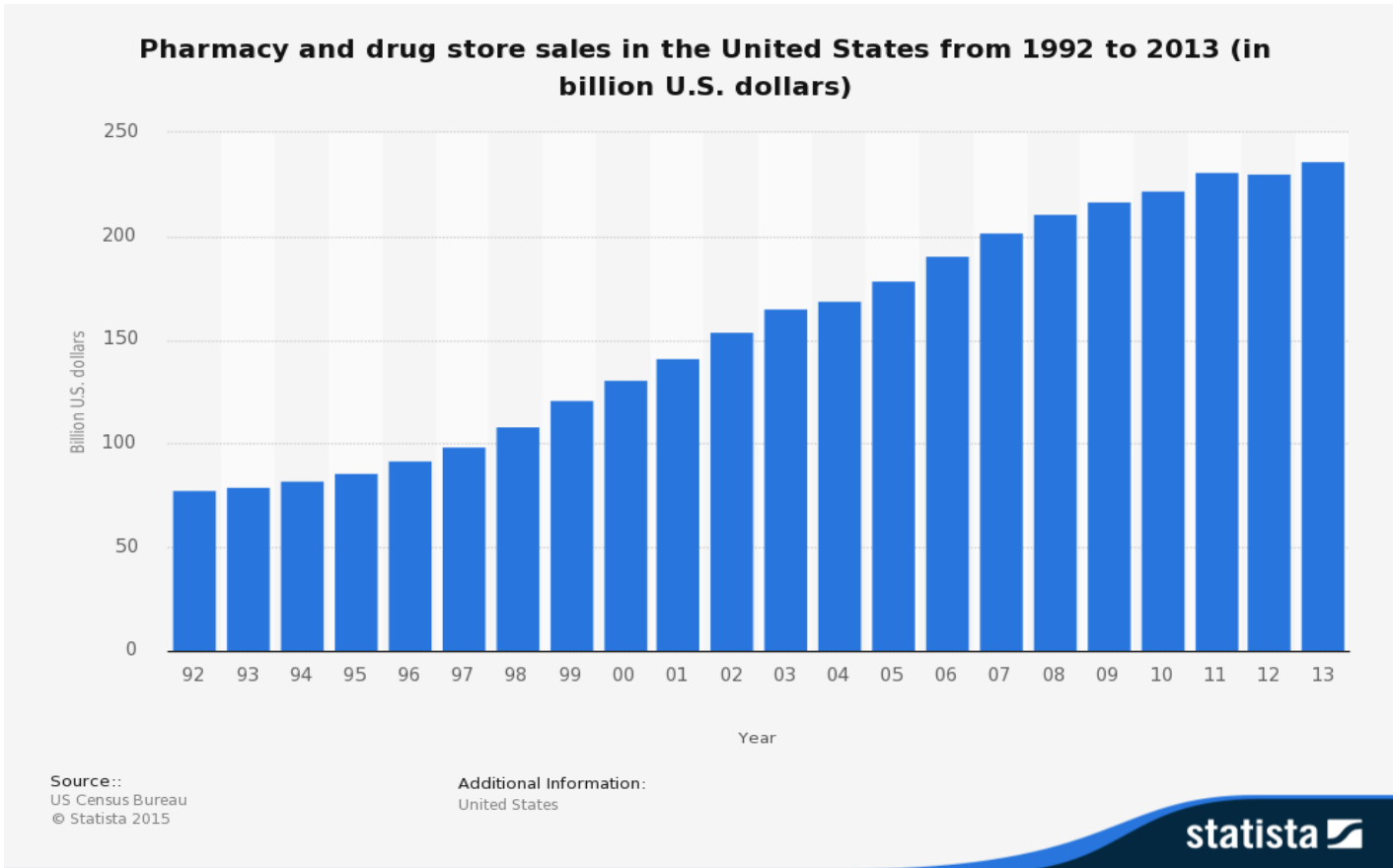
Source: M.S. Kostich, A.L. Batt, J.M. Lazorchak, "Concentrations of prioritized pharmaceuticals in effluents from 50 large wastewater treatment plants in the US and implications for risk estimation," 184 *Environmental Pollution* 354 (2014)

Pharmaceuticals in Our Drinking Water

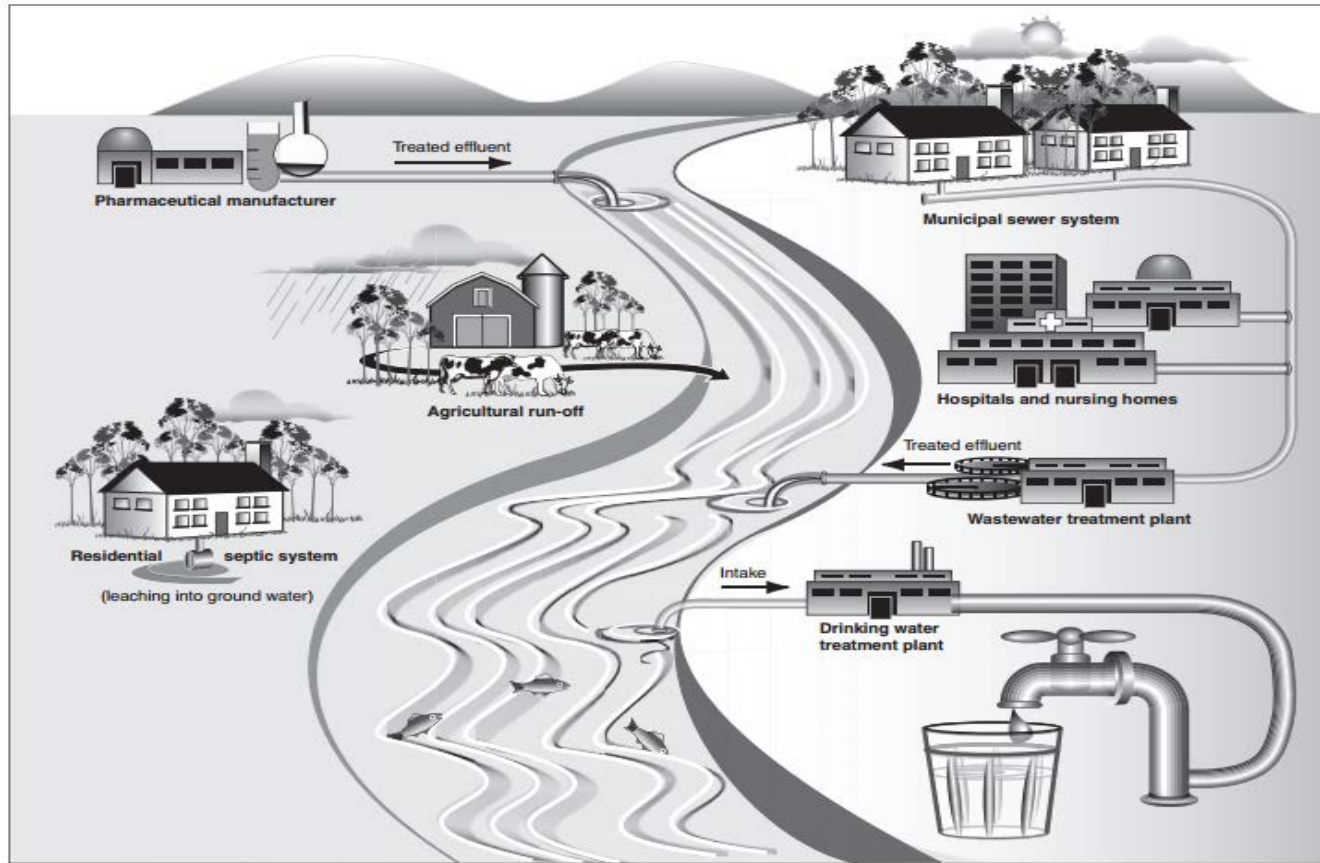
- 2008 Associated Press study identified pharmaceutical chemicals and hormones, including some that are known endocrine disruptors, in the drinking water of at least 14% of Americans.
- 2010 EPA-funded meta-analysis of 48 publications found 54 active pharmaceutical ingredients and 10 metabolites in treated drinking water.



Source of Pharmaceuticals Pollutants/Wastes



Source of Pharmaceuticals Pollutants/Wastes



Examples of Pathways through which Pharmaceuticals May Enter Drinking Water Supplies

Source: "Environmental Health: Action Needed to Sustain Agencies' Collaboration on Pharmaceuticals in Drinking Water," US Government Accountability Office, GAO-11-346 (2011)

Source of Pharmaceuticals Pollutants/Wastes



Source of Pharmaceuticals Pollutants/Wastes

Compound	Pharmaceutical Product Group	Parent Compound Excreted (%)	Reference
Amoxycillin	Antibiotic	60	Bound & Voulvoulis, 2005
Atenolol	Beta-blocker	90	Bound & Voulvoulis, 2005
Bezafibrate	Lipid regulator	50	Bound & Voulvoulis, 2005
Carbamazepine	Antiepileptic	3	Bound & Voulvoulis, 2005
Cetirizine	Antihistamine	50	Bound & Voulvoulis, 2005
Clofibric acid	Active metabolite ³	6	Alder et al., 2006
Diclofenac	Anti-inflammatory	15	Alder et al., 2006
Erythromycin	Antibiotic	25	Bound & Voulvoulis, 2005
Felbamate	Antiepileptic	40-50	Bound & Voulvoulis, 2005
Ibuprofen	Analgesic	10	Bound & Voulvoulis, 2005
Indometacin	Anti-inflammatory	10-20	Alder et al., 2006
Metoprolol	Beta-blocker	10	Bound & Voulvoulis, 2005
Paracetamol	Painkiller	4	Bound & Voulvoulis, 2005
Propranolol	Beta-blocker	<1	Alder et al., 2006
Sulfamethoxazole	Antibiotic	15	Bound & Voulvoulis, 2005

Excretion rates of unmetabolized active ingredients for selected pharmaceuticals

Source: DWI (2007) Desk based review of current knowledge on pharmaceuticals in drinking water and estimation of potential levels. Final report prepared by Watts and Crane Associates for Drinking Water Inspectorate, Department for Environment, Food and Rural Affairs (Defra Project Code: CSA 7184/WT02046/DWI70/2/213; <http://dwi.defra.gov.uk/research/completed->

Environmental Impact !

Diclofenac = non-steroidal anti-inflammatory drug given to working animals in India/ Pakistan between 2000-2007 to reduce joint pain and increase productivity



Diclofenac causes kidney failure in several species of vultures, including the Gyps Vulture native to India/Pakistan

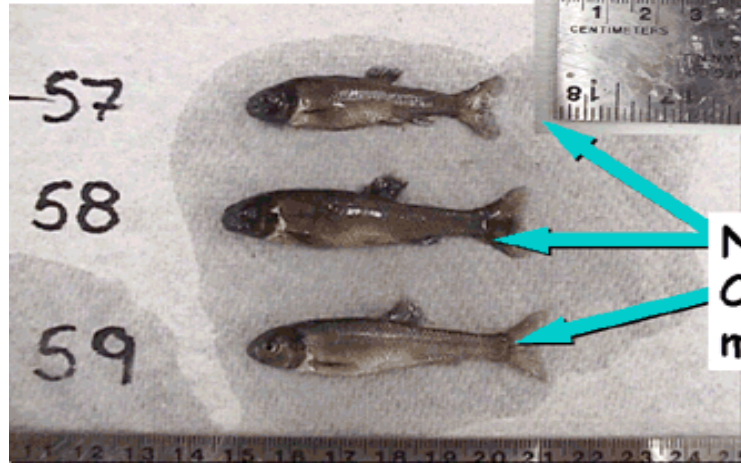
Killed ~95% of India's and 90% of Pakistan's Gyps vultures

Environmental Impact !

Feminized male



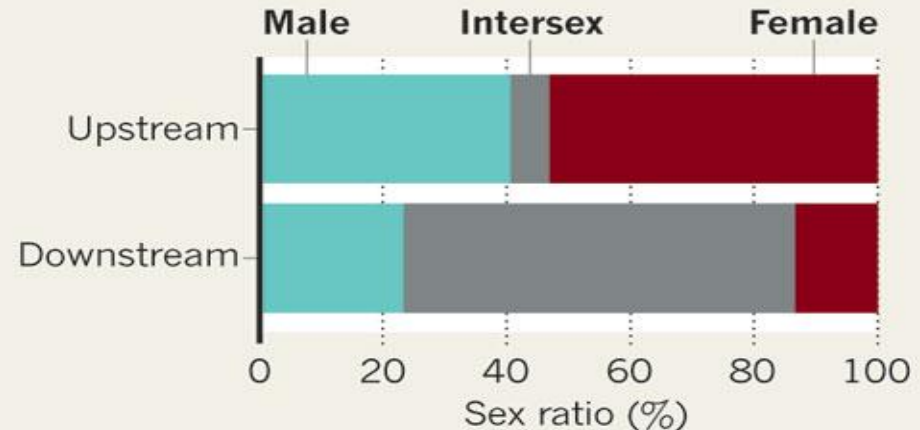
Normal / Control males



Source: K.A. Kidd, et.al., Collapse of a fish population after exposure to a synthetic estrogen, 104(21) *Proceedings of the National Academy of Sciences* (2007) (doi: 10.1073/pnas.0609568104)

FISHY FIND

Fish downstream of a French pharmaceutical factory were much more likely to show characteristics of both sexes (intersex) than those upstream.



Source: Natasha Gilbert, Drug waste harms fish, 476 *Nature* 265 (15 August 2011), (referring to Sanchez, W. et al. Adverse effects in wild fish living downstream from pharmaceutical manufacture discharges, 37(8) *Environment International* 1342 (2011))

Human Impact ???



“Although current risk assessments indicate that very low concentrations of pharmaceuticals in drinking-water are very unlikely to pose any risks to human health, there are knowledge gaps in terms of assessing the risks associated with long-term, low-level exposures to pharmaceuticals and possible combined effects of chemical mixtures, including pharmaceuticals.”

World Health Organization, Pharmaceuticals in Drinking-Water (2012)

Human Impact ???



Suspected Direct Impact

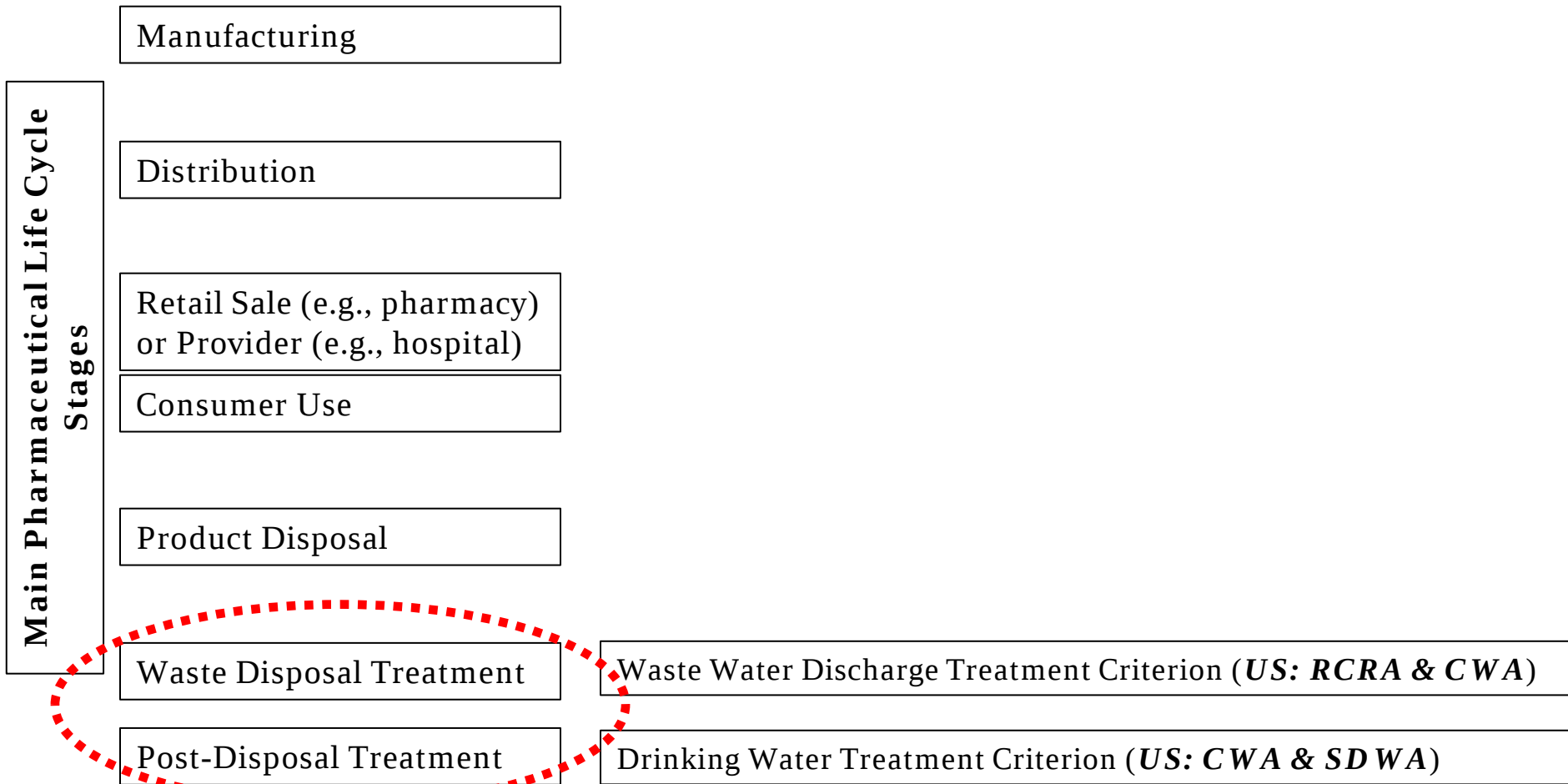
- *Low sperm count and infertility*
- *Hormonally triggered human cancers*
- *Neurological disorders in children*
- *Hyperactivity and attention deficit disorder*
- *Genital deformities*
- *Lowered IQ*

Suspected Indirect Impact: Antibiotic resistant bacteria

Challenges of Regulations – Where?



Responses: Existing Approach



Responses: New Approach

Main Pharmaceutical Life Cycle Stages

Manufacturing

Product Design (e.g., improve physiological sorption of drugs, better or “smarter” drugs that achieve desired therapeutic objectives at lower dosages), Impact Assessments, and Burden of Safety

Distribution

Product Distribution (e.g., more targeted distribution), Promotion and Marketing (e.g., enhanced doctor and patient education on proper use)

Retail Sale (e.g., pharmacy) or Provider (e.g., hospital)

Product Dispensing Criterion and Monitoring (e.g., nationwide system monitoring dispensing of certain drugs)

Consumer Use

Product Use Criterion (e.g., use education) and Alternative Products (e.g., preventative health care to reduce need for products, use of similarly effective products without drugs)

Product Disposal

Product Disposal, Recycling & Pollution Prevention Criterion (e.g., take-back programs, proper disposal criterion)

Waste Disposal Treatment

Waste Water Discharge Treatment Criterion (**US: RCRA & CWA**)

Post-Disposal Treatment

Drinking Water Treatment Criterion (**US: CWA & SDWA**)

Thank you!

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