

Meeting the Challenge of Microplastic Management to Protect Human Health and the Environment

Renewable Natural Resources Foundation

June 23, 2021

Scott Coffin, Ph.D.

California State Water Resources Control Board

 @DrSCoffin

Photo: Getty

1955

LIFE



Throwaway Living

DISPOSABLE ITEMS CUT DOWN HOUSEHOLD CHORES

1960: Plastic Particles Can be absorbed in Mice

Experimental Cell Research 22 137-145 (1961)

137

A STUDY OF PARTICULATE INTESTINAL ABSORPTION AND HEPATOCELLULAR UPTAKE

USE OF POLYSTYRENE LATEX PARTICLES

E. SANDERS and C. T. ASHWORTH

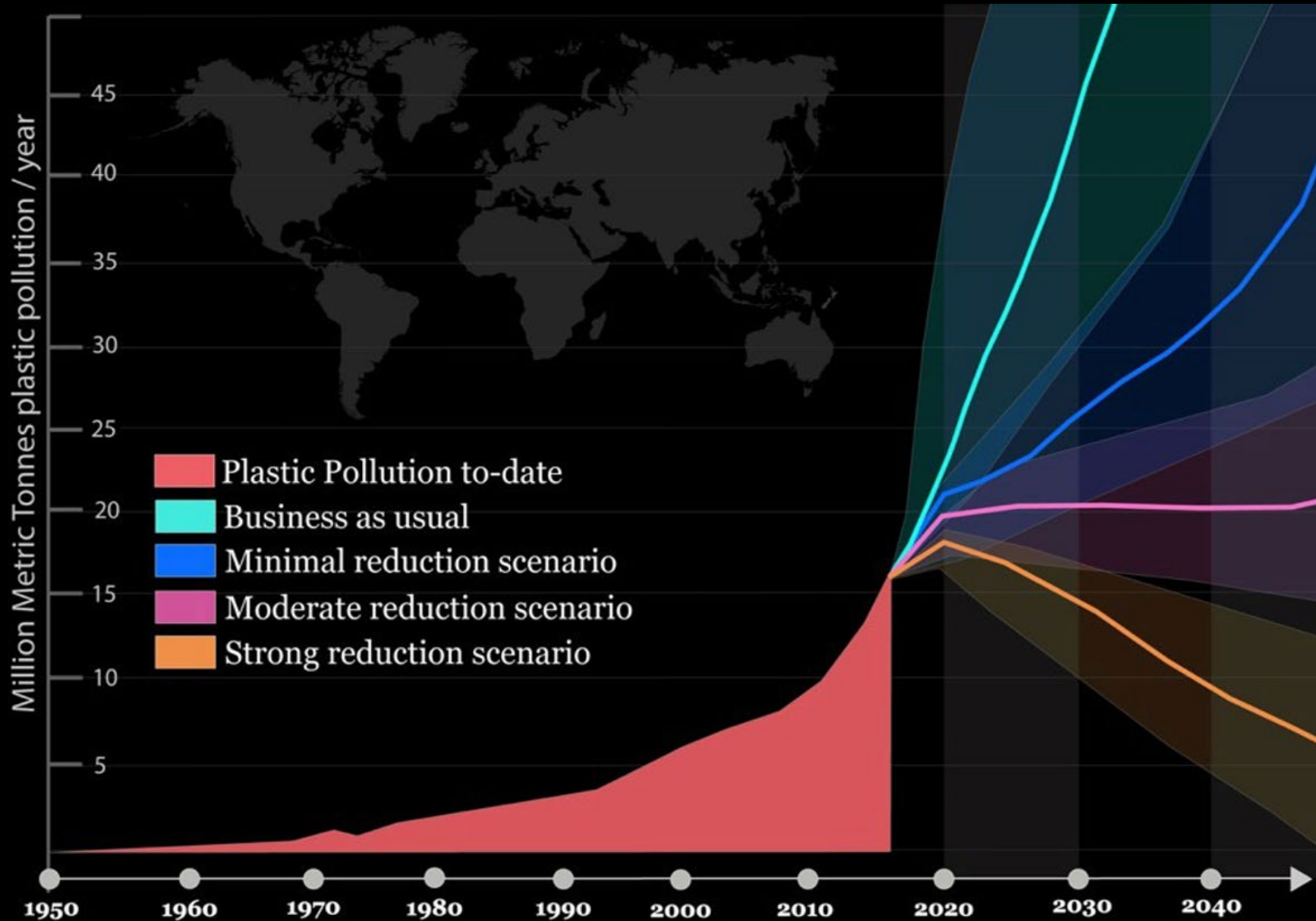
*Department of Pathology, University of Texas, and Southwestern Medical School,
Dallas, Texas, U.S.A.*

Received February 1, 1960

1969
Plastic found in
90/91 Laysan
Albatross in Hawaii



Plastic Pollution Increases Exponentially



Challenges to Assessing and Managing Risks of Microplastics

Ubiquity

Complexity

Secrecy

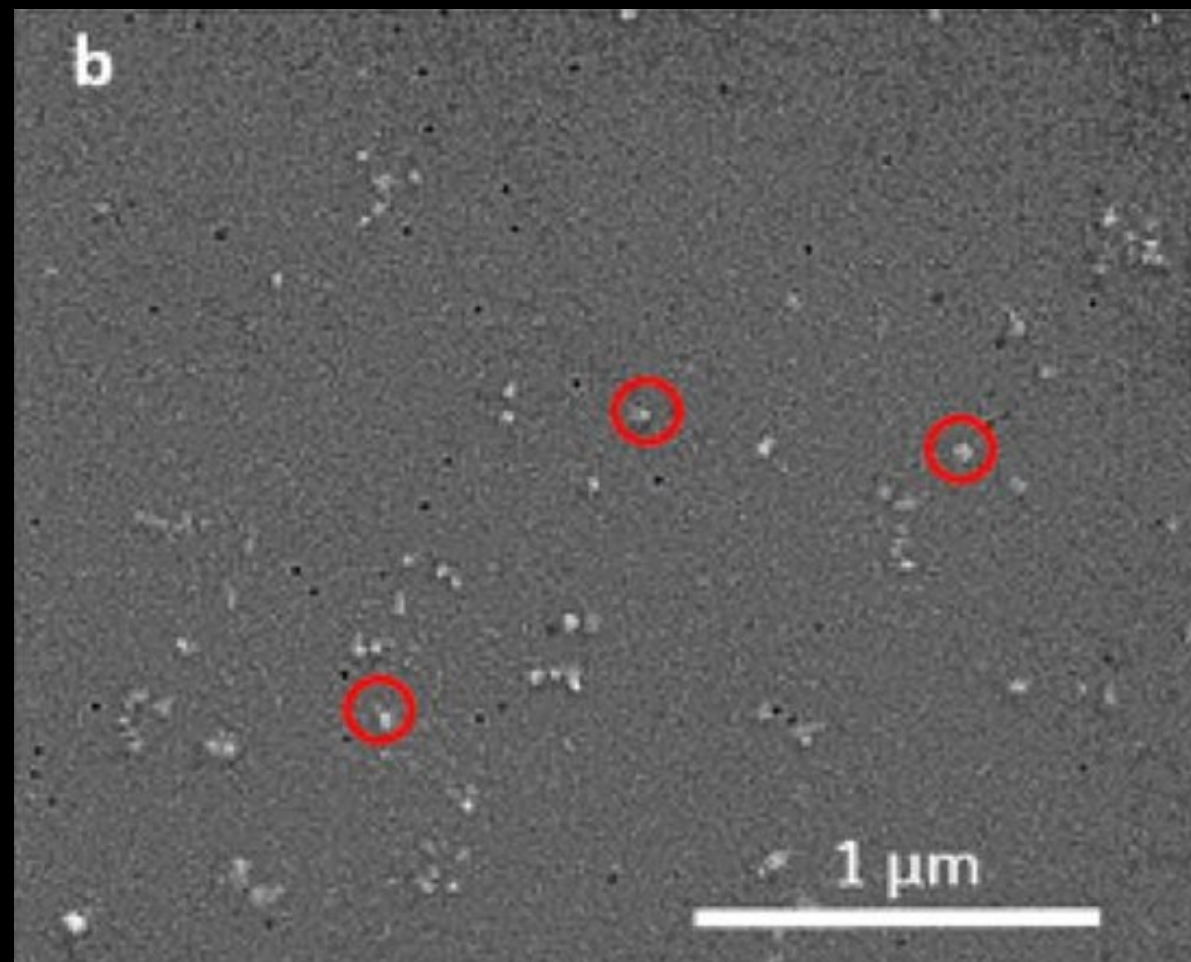
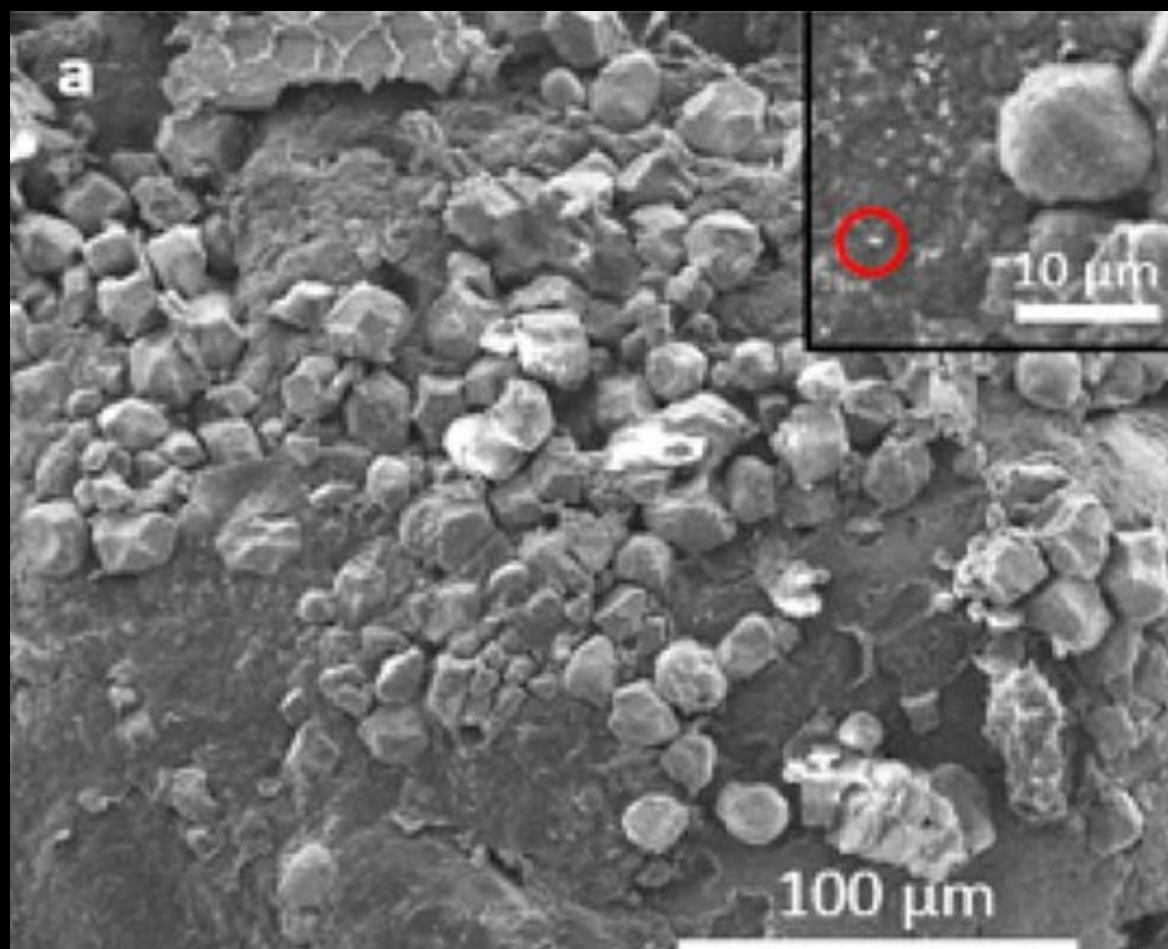
Persistence

Ubiquity



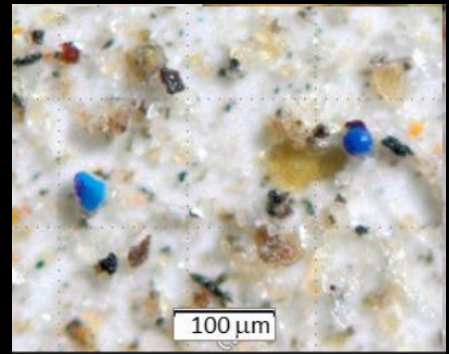
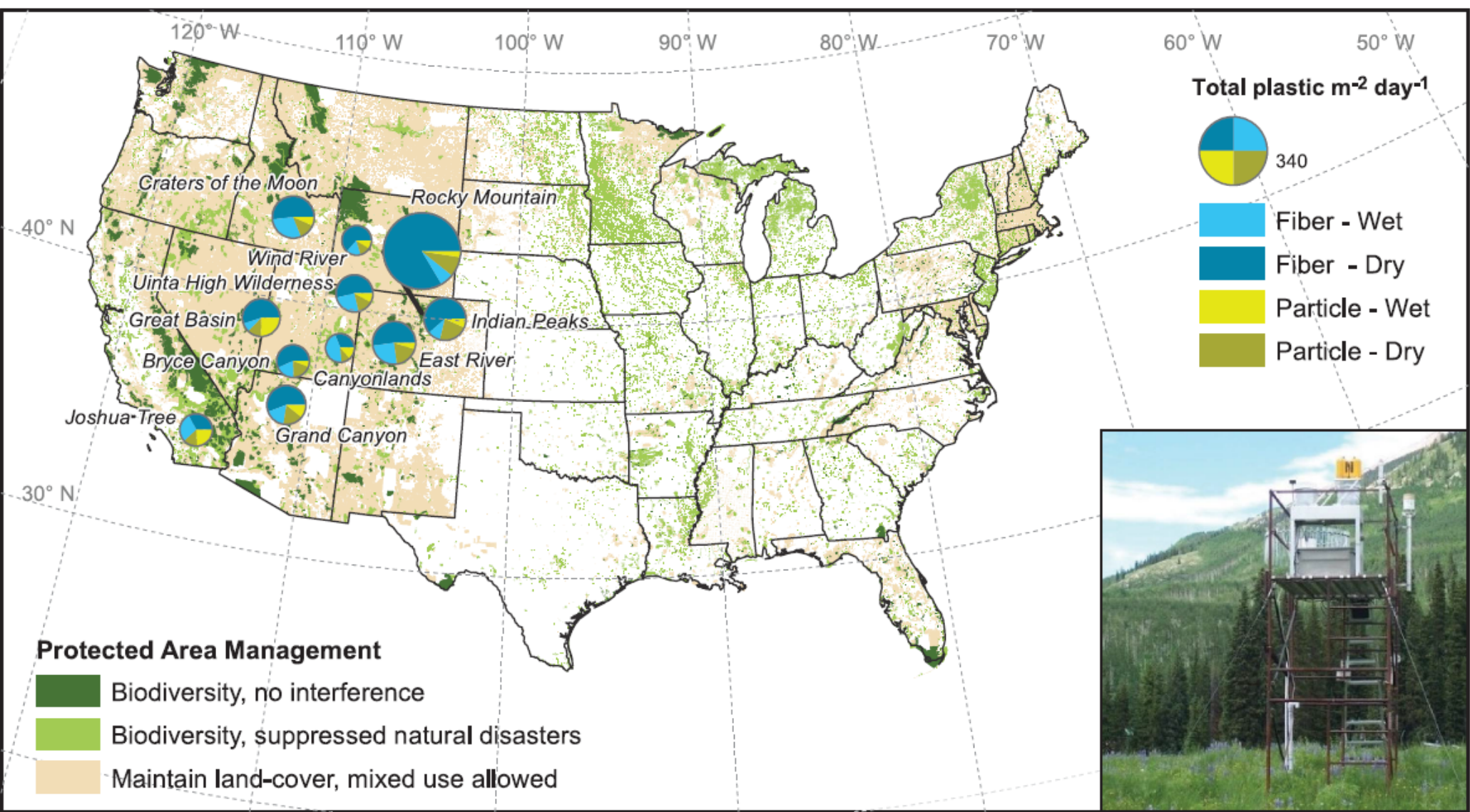
Plastic Degrades into Small Pieces

Ubiquity



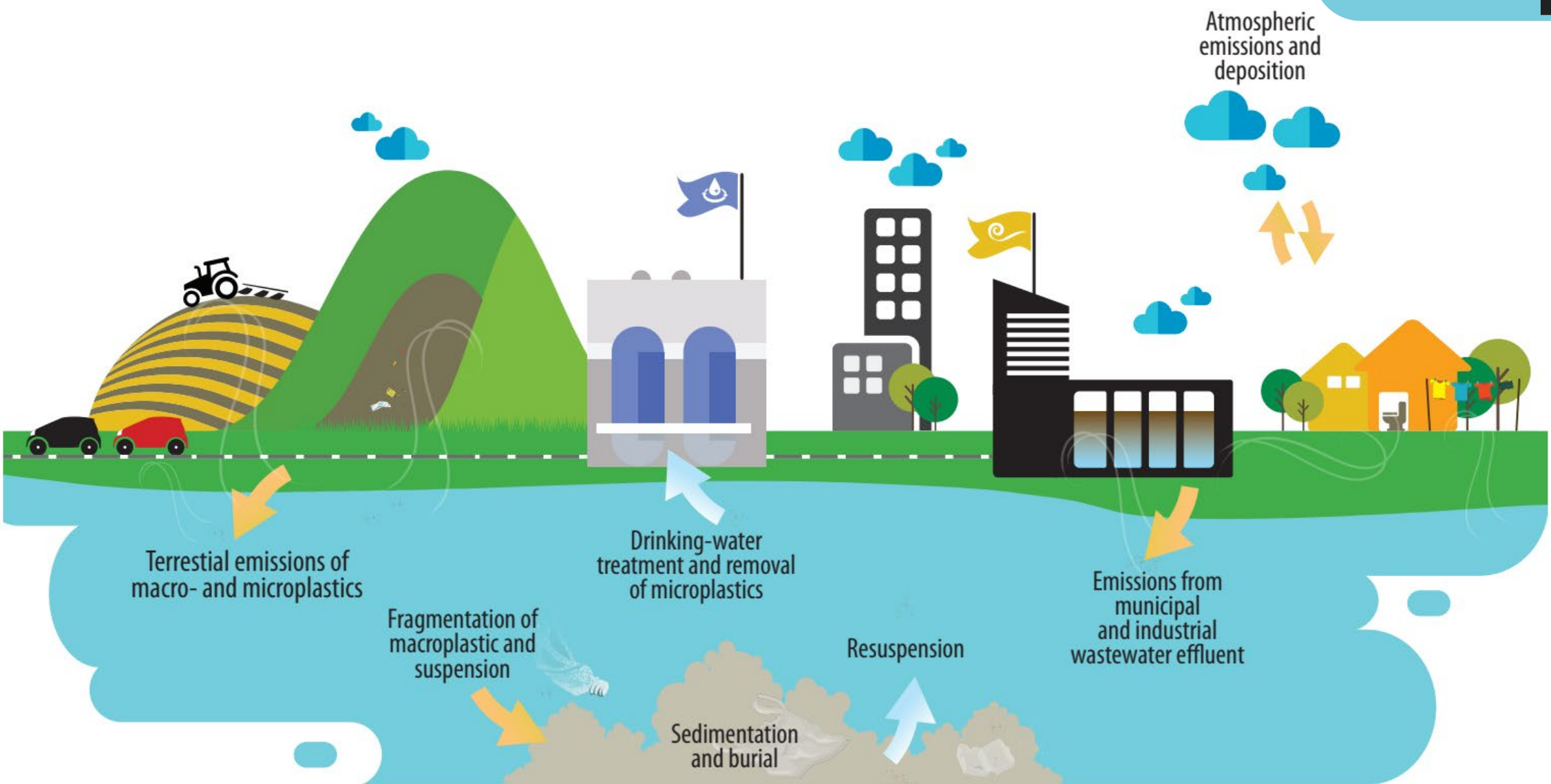
Wind and Rain transport Microplastics

Ubiquity

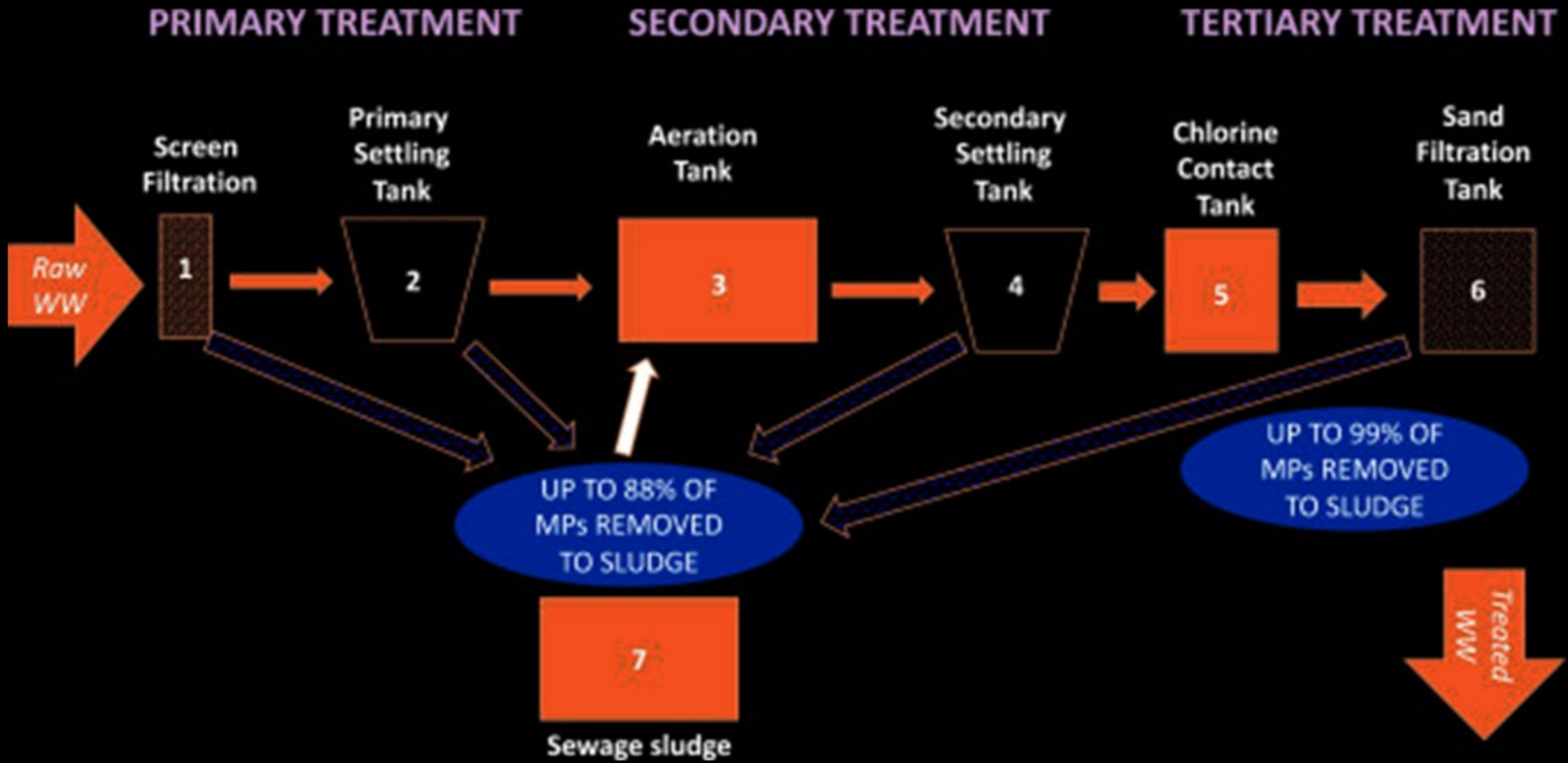


Plastic Enters Surface Waters

Ubiquity



Wastewater Removes 88-99% of Microplastics



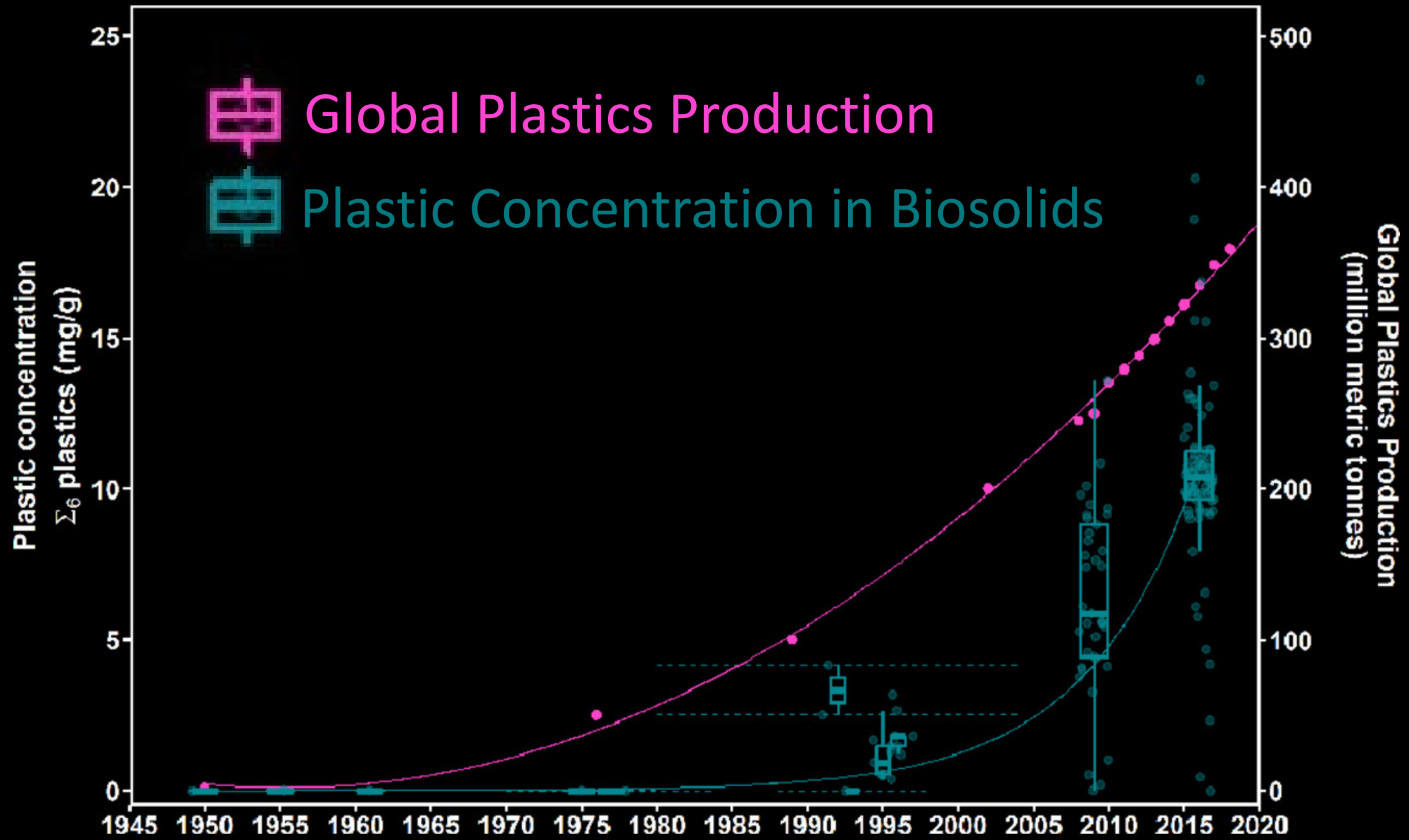
Biosolids Often Used as Fertilizer

Ubiquity



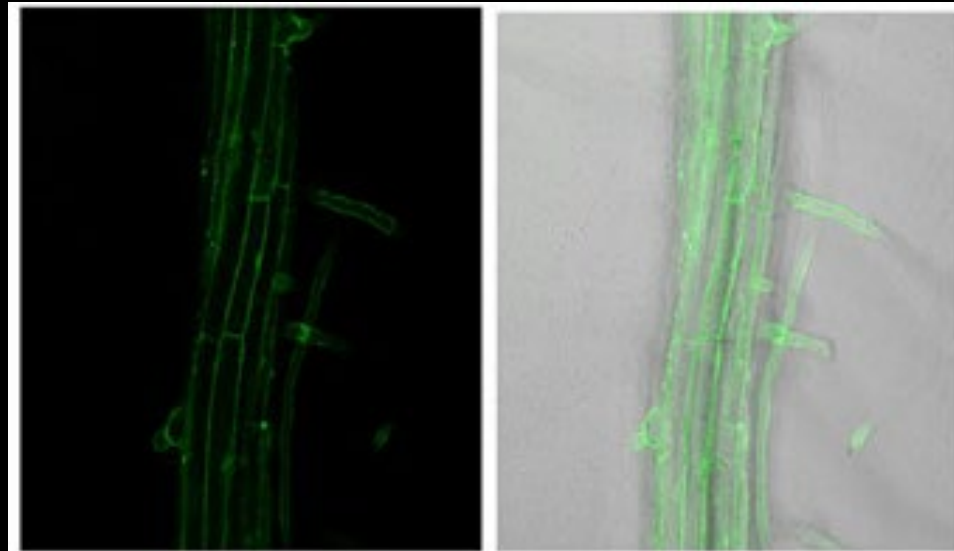
Biosolids applied to an agricultural field in the Central Valley, CA

Plastics in Biosolids Strongly Correlates to Plastic Production

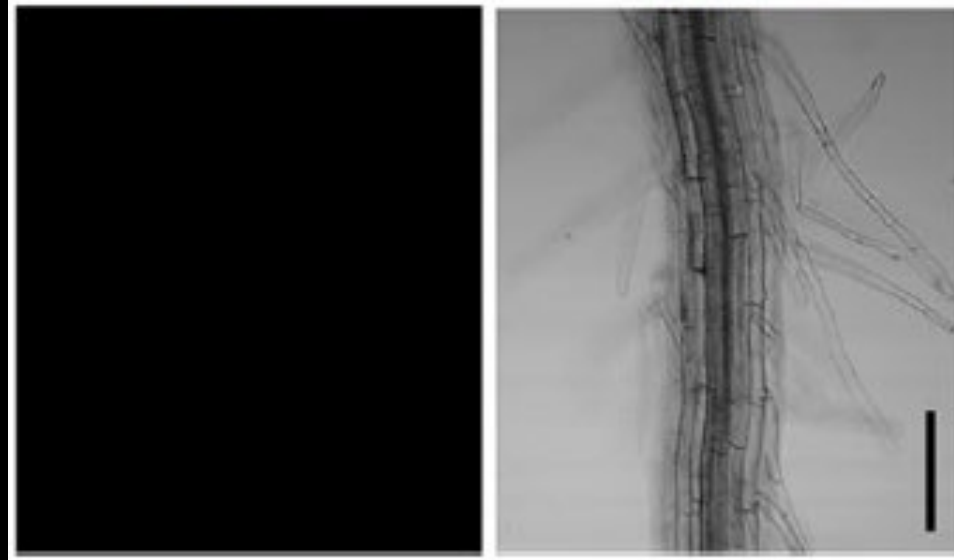


Plants Uptake and Accumulate Microplastics

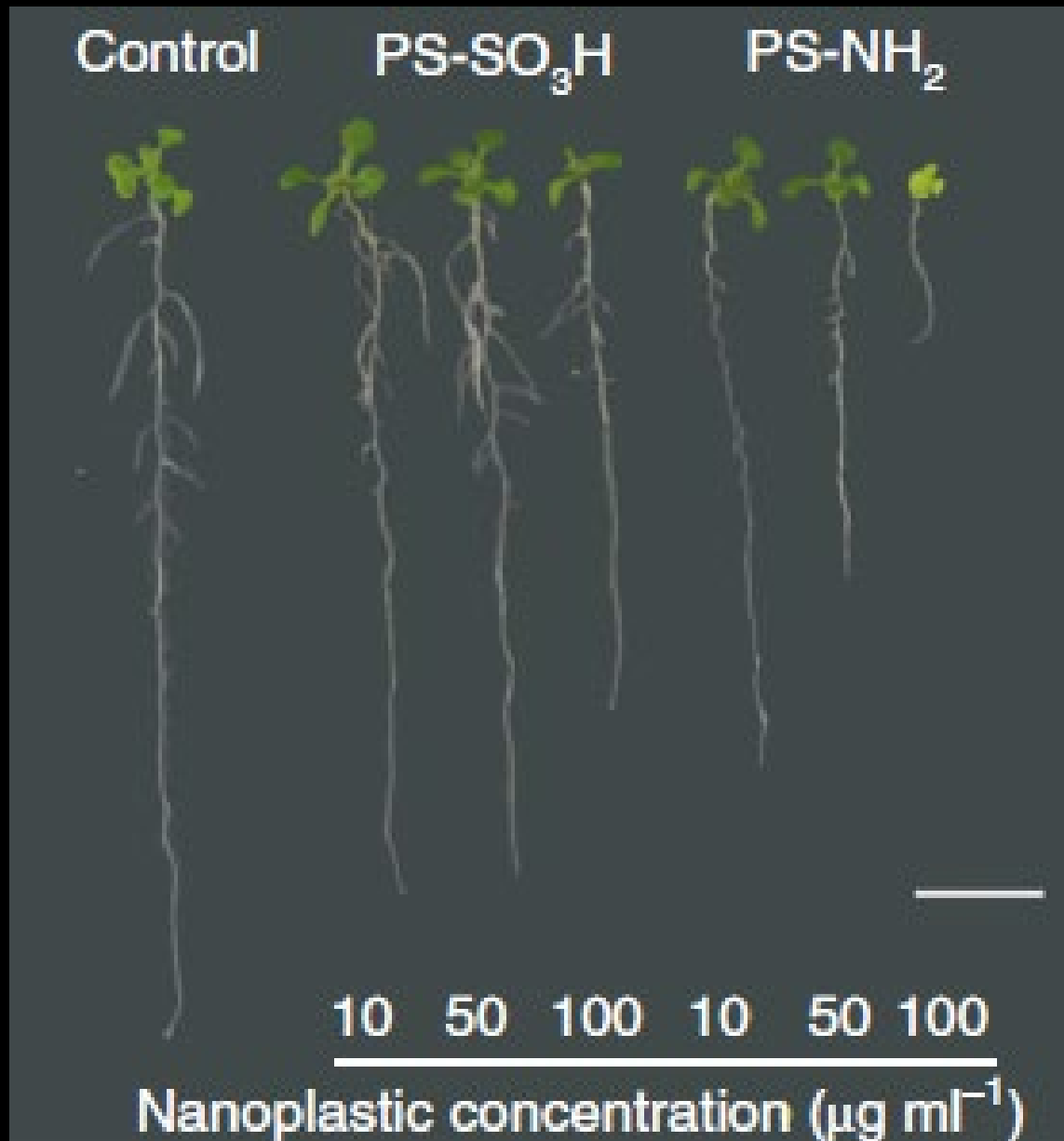
Microplastics



Control

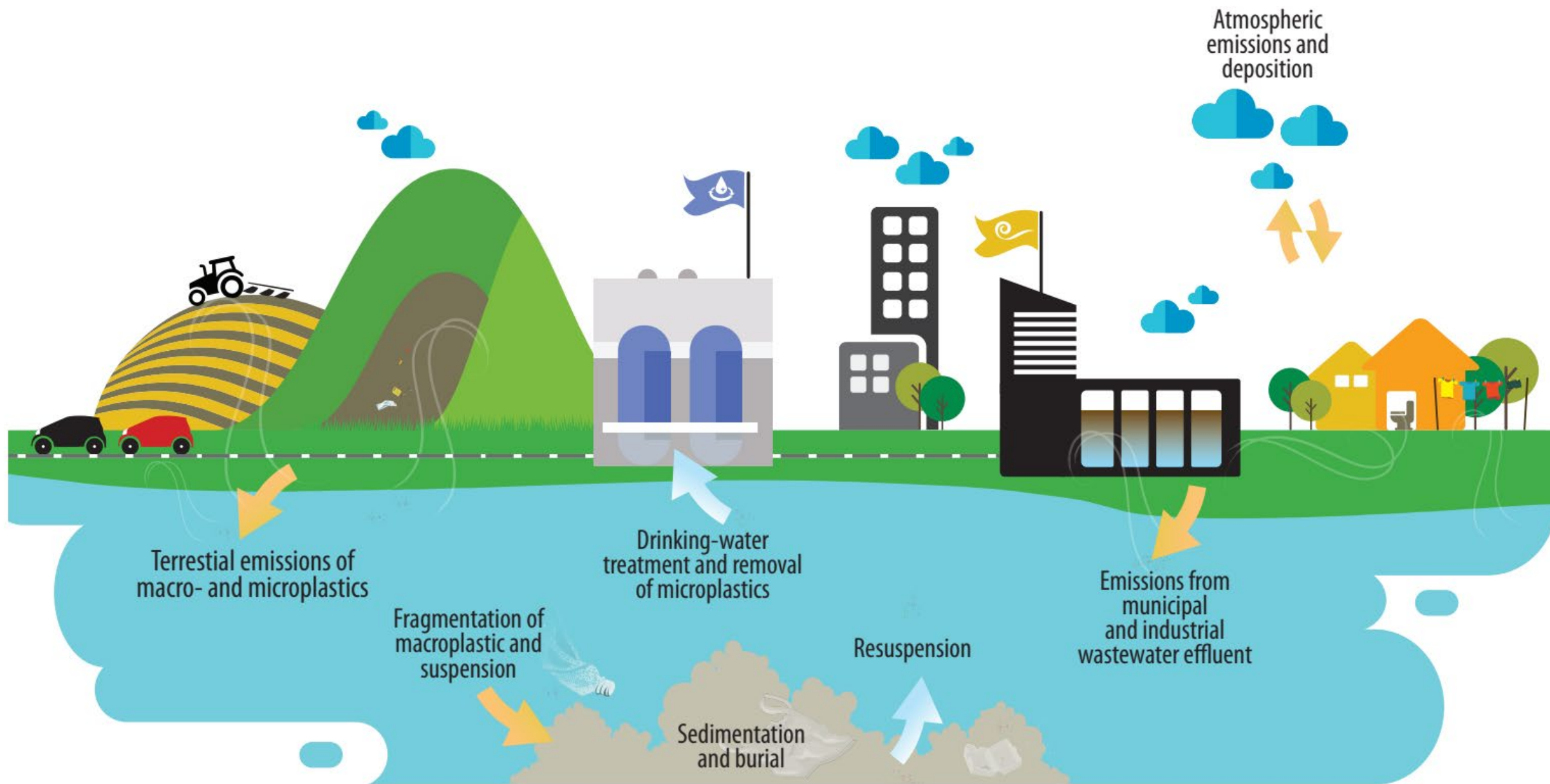


Microplastics Reduce Plant Growth



Microplastics Decrease Tomato Production





California Senate Bill 1263 (2018): Statewide Microplastics Strategy

2022

- Initiate Statewide Microplastics Strategy



2026

- Develop **risk assessment** framework
- Develop standardized **methods**
- Establish baseline **occurrence** data
- Investigate **sources** and **pathways**
- Recommend **source reduction** strategies

Deadlines

PLASTIC FIBERS IN TAP WATER, 2017



orb. one world. one story.



PREVALENCE OF MICROSCOPIC PLASTIC FIBERS BY SAMPLE SOURCE LOCATION.



WORLDWIDE
83%



USA
94%



EUROPE
72%



INDONESIA,
JAKARTA
76%



INDIA,
NEW DELHI
82%



LEBANON,
BEIRUT
94%



UGANDA,
KAMPALA
81%



ECUADOR,
QUITO
75%



CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

July 1, 2020

California Senate Bill 1422 (2018)

- Define 'microplastics'



July 1, 2021

- Standard method
- Four years of testing
- Health-based guidance level
- Accredited laboratories

Deadlines

Complexity



Official Definition: 'Microplastics in Drinking Water'

'solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers.















Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.'



CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Polymers included in Regulatory Definition

All “Traditional” Plastics...

						
						
PET	HDPE	PVC	LDPE	PP	PS	OTHER
Polyethylene Terephthalate	High-Density Polyethylene	Polyvinyl Chloride	Low-Density Polyethylene	Polypropylene	Polystyrene	Other

Polymers included in Regulatory Definition

...and “Non-Traditional” Plastics



Synthetic rubber



Synthetic fibers



Silicones



Bio-based and
biodegradable polymers



Cellulose acetate

European Microplastics Definition Excludes Biodegradables

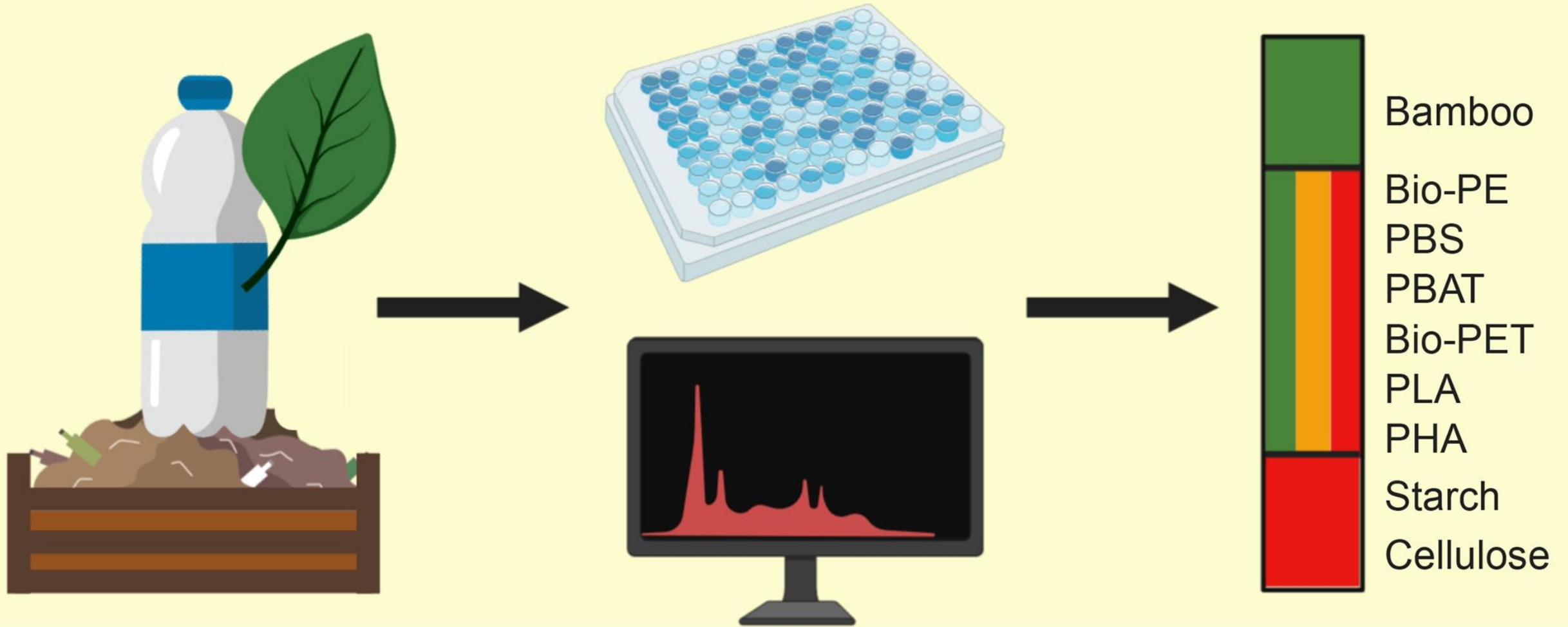


‘solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers.

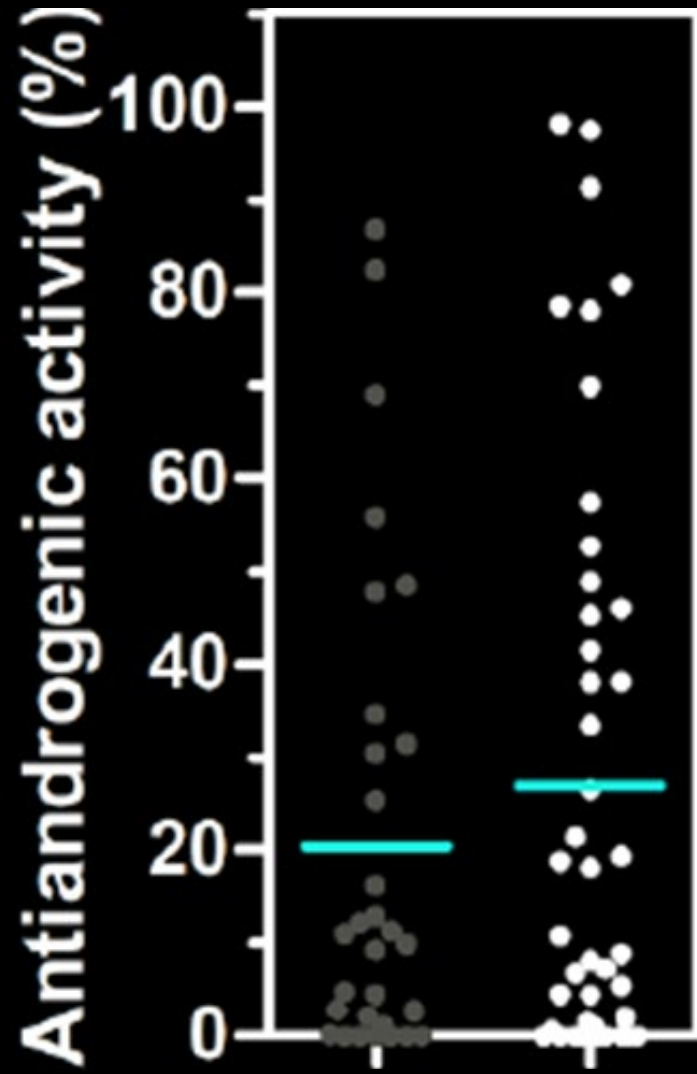
*Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded, **as are polymers that are (bio)degradable.**”¹*



Are Bioplastics Safer than Conventional Plastics?



Many Bioplastics Contain Hazardous Chemicals



Conventional Bioplastics





CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

July 1, 2020

California Senate Bill 1422 (2018)

- Define 'microplastics'



July 1, 2021

- Standard method
- Accredit laboratories
- Health-based guidance level
- Four years of testing

Deadlines

Method Development and Standardization

4 Matrices



Drinking Water



Ocean Water



Fish Tissue



Sediment

Method Development and Standardization

40 Participating Organizations



UNIVERSITY OF
TORONTO

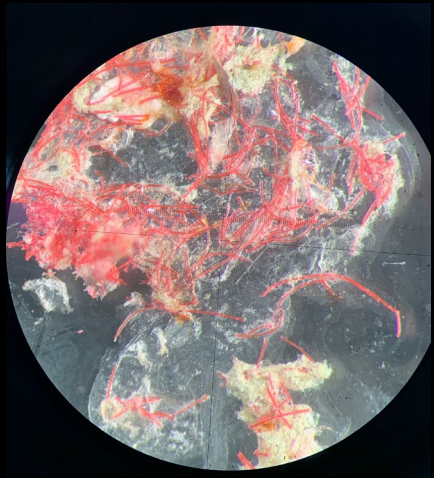


UNIVERSITY
OF
CALIFORNIA

ThermoFisher
SCIENTIFIC



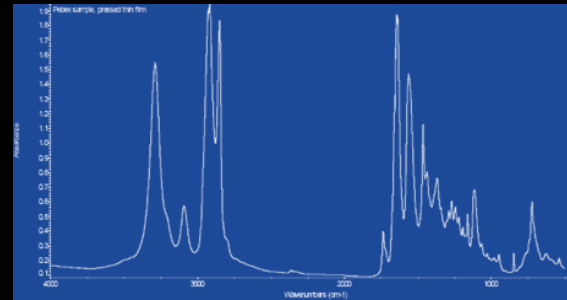
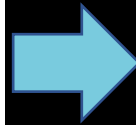
Polymer Identification



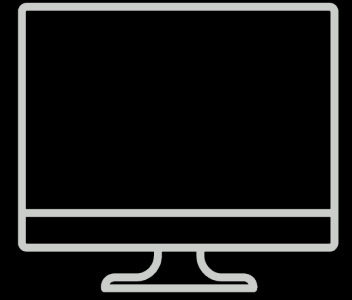
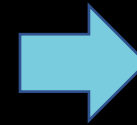
Sample



FTIR



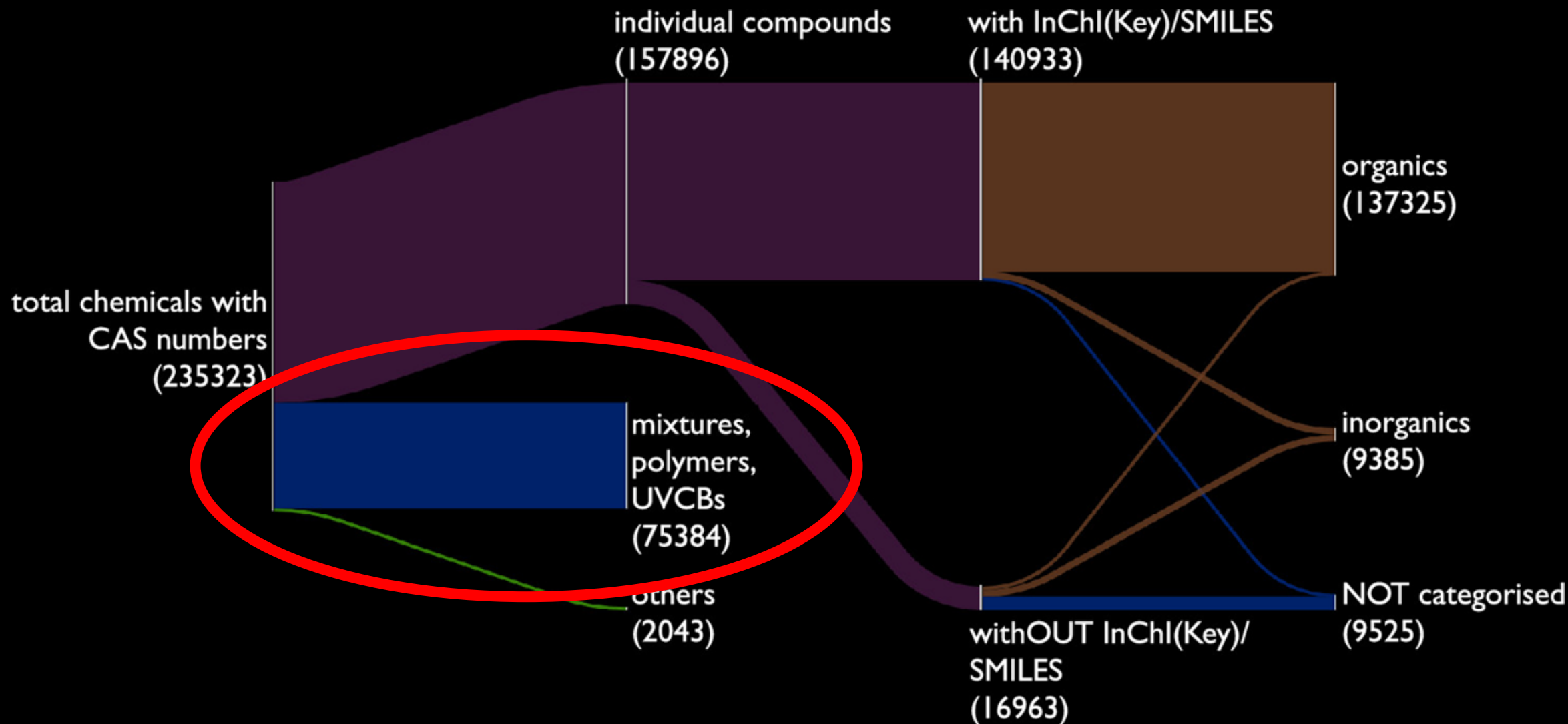
Spectra



Library Match

>37,000 Unique Polymers in Commerce

Complexity



Solution: Open Data Libraries

Secrecy

Open Specy

View Clean Identify Share





CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

July 1, 2020

California Senate Bill 1422 (2018)

- Define 'microplastics'



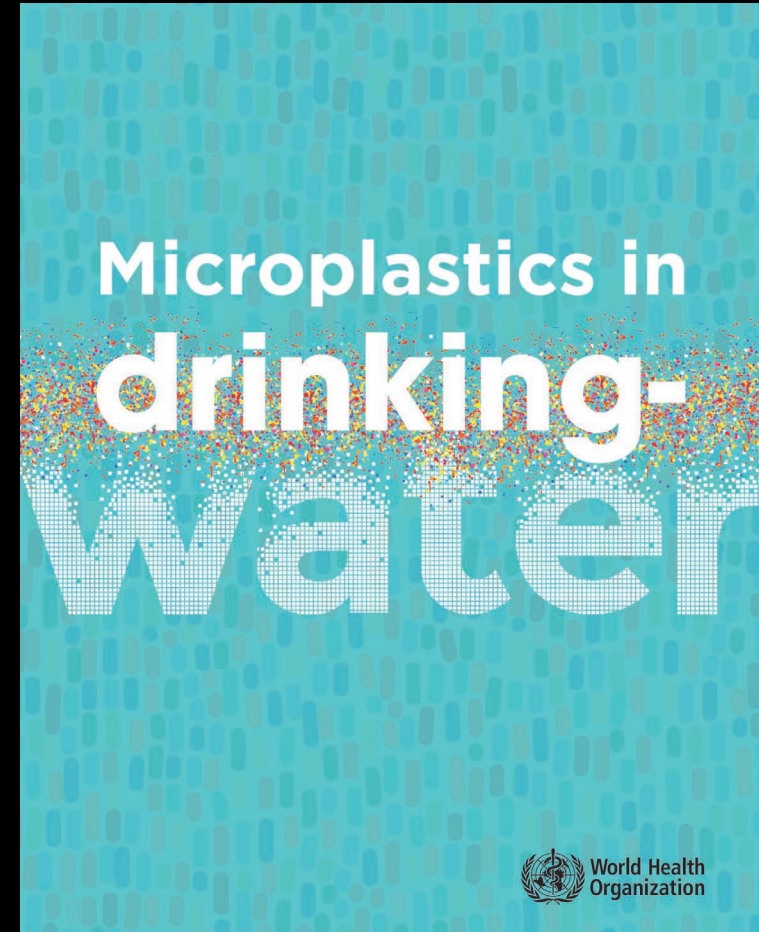
July 1, 2021

- Standard method
- Accredited laboratories
- **Health-based guidance level**
- Four years of testing

Deadlines

“Humans have ingested **microplastics** and other **particles** in the environment for decades with no related indication of adverse health effects... [there is] ...no **evidence** to indicate a human health concern.”

– World Health Organization (2019)



“There is no evidence against x.
Therefore x is true.”

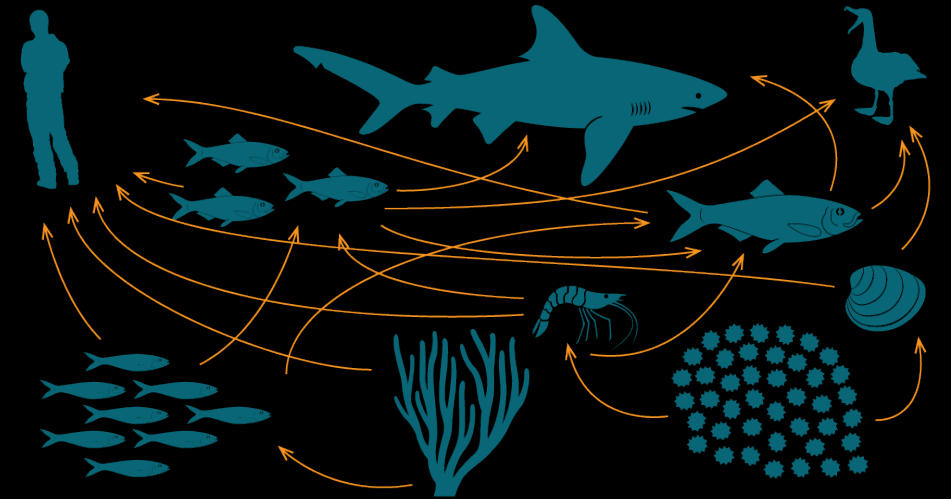
- *‘appeal to ignorance’ fallacy*
(Locke 1690)

Health Effects Workshop



October 2020
—
Summer 2021

Drinking Water
Thresholds



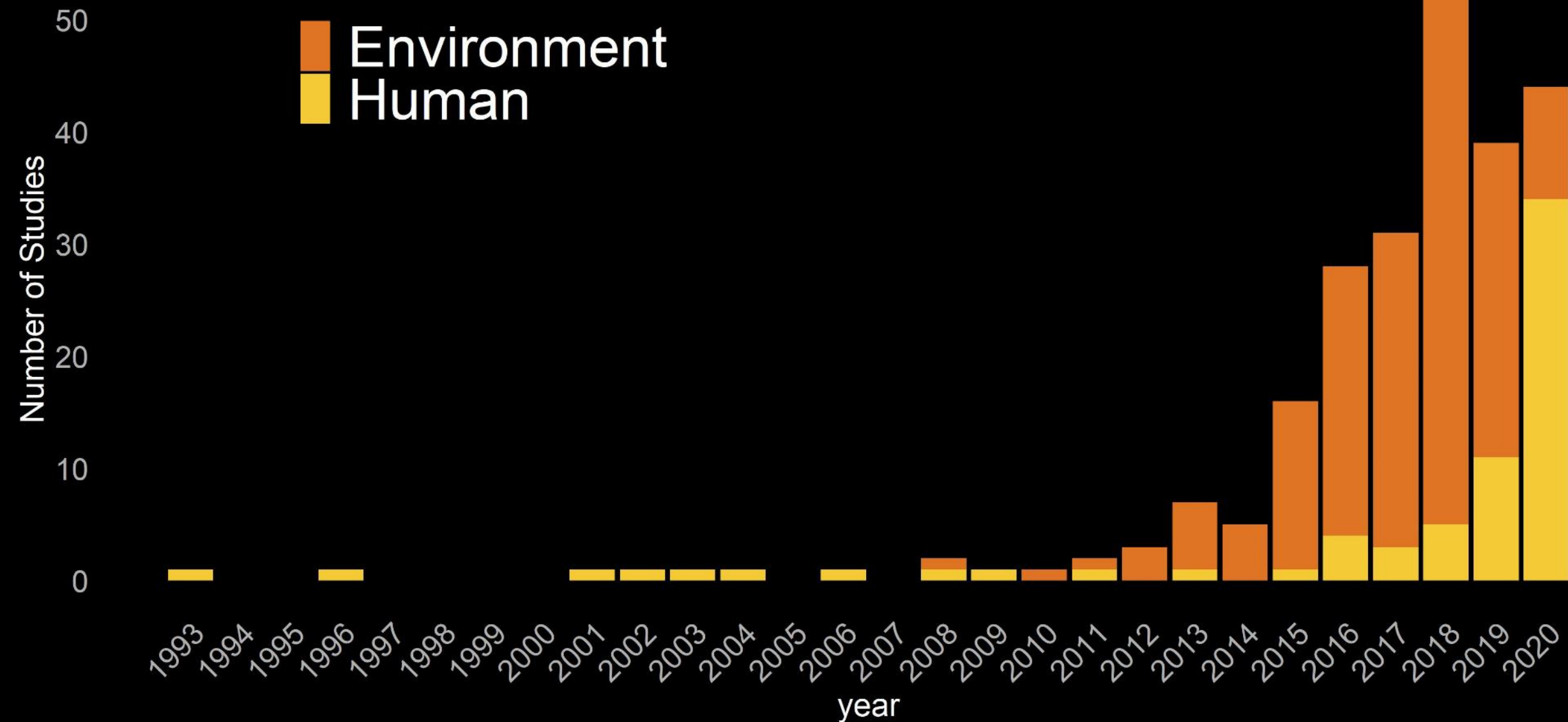
Ecosystem Thresholds



UNIVERSITY OF
TORONTO



Rapidly Developing Science



Hazard

Potential to cause harm



Exposure



Risk

Probability to cause harm



Hazard

Potential to cause harm



Exposure

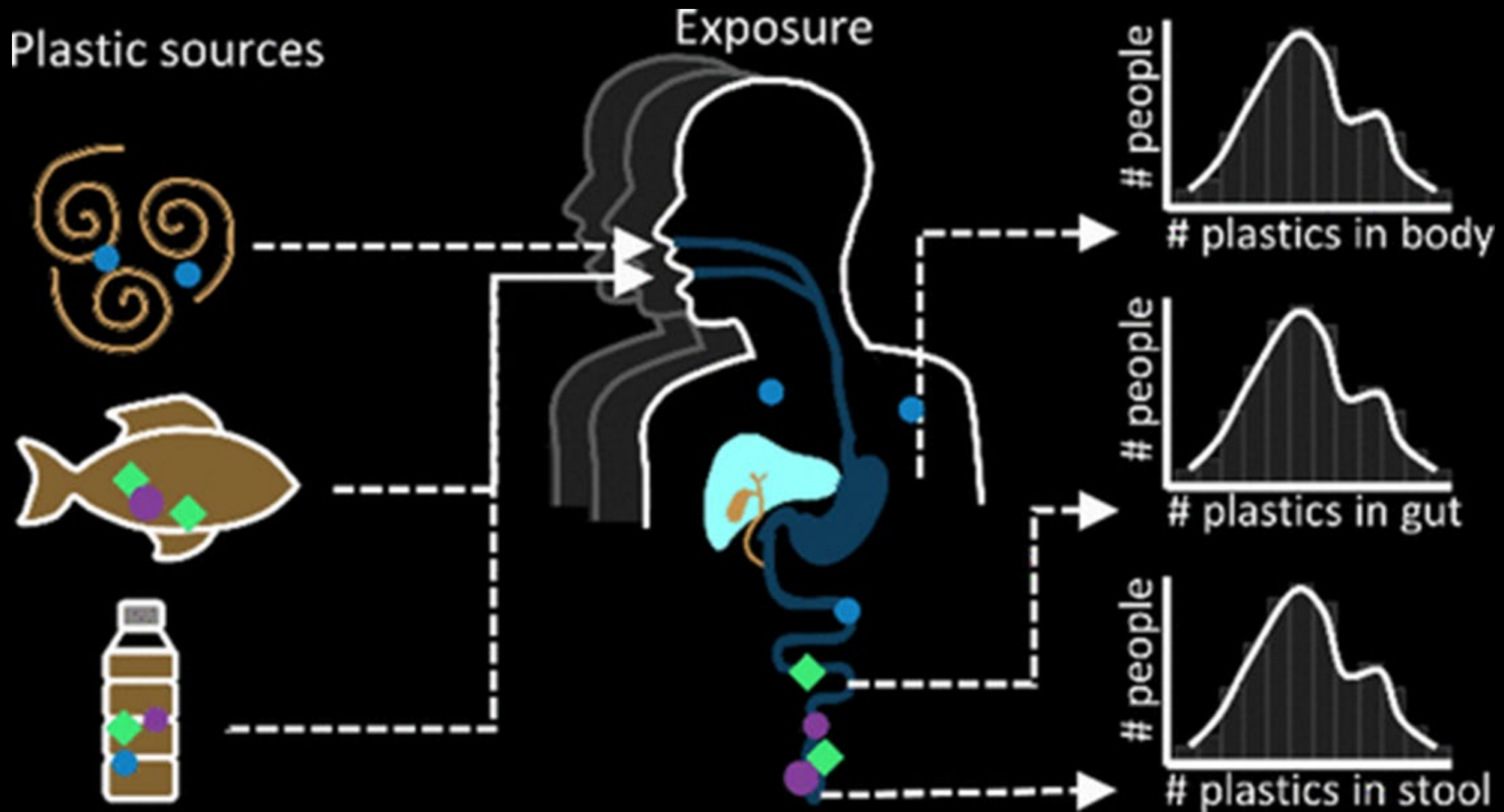


Risk

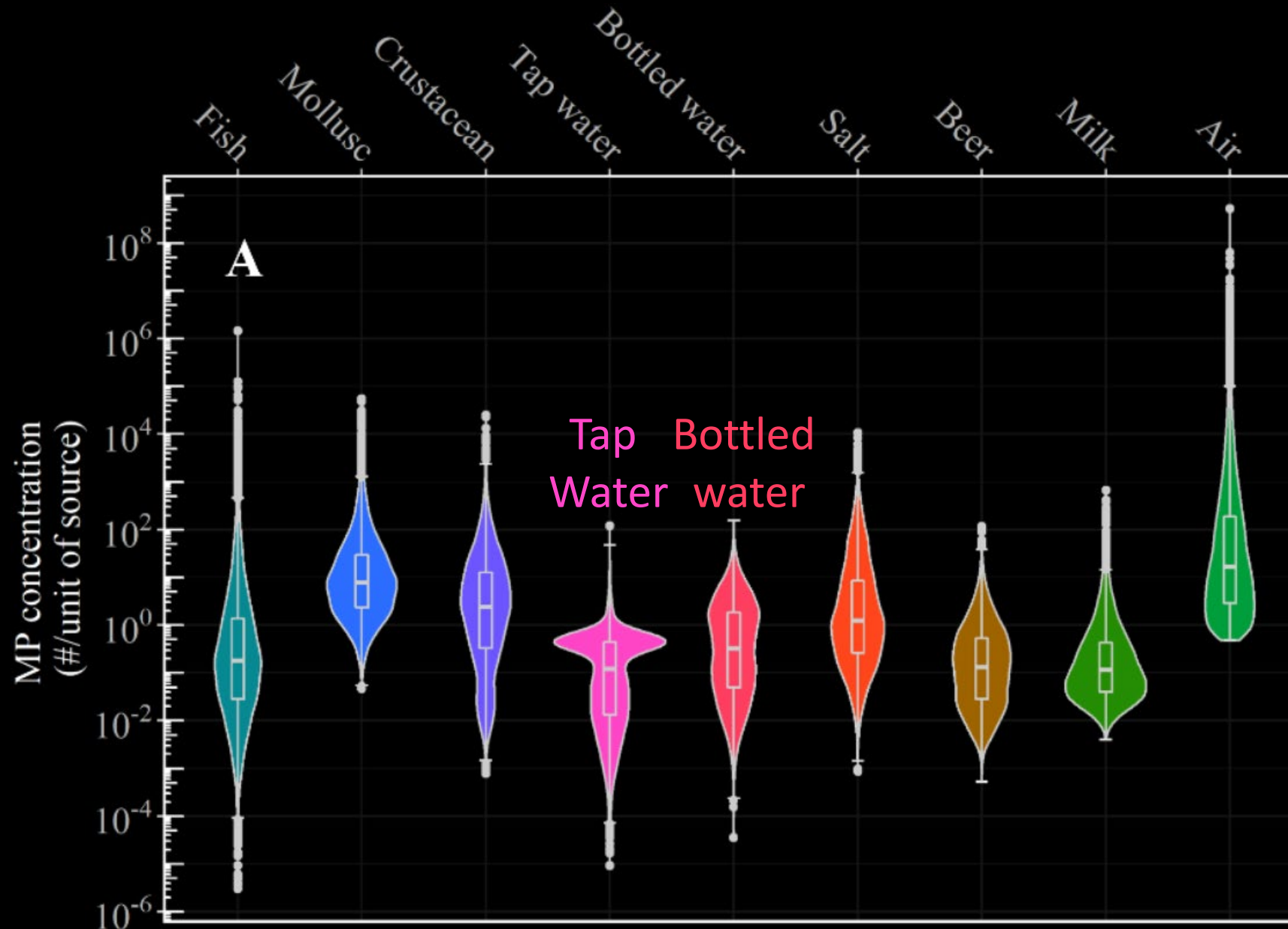
Probability to cause harm



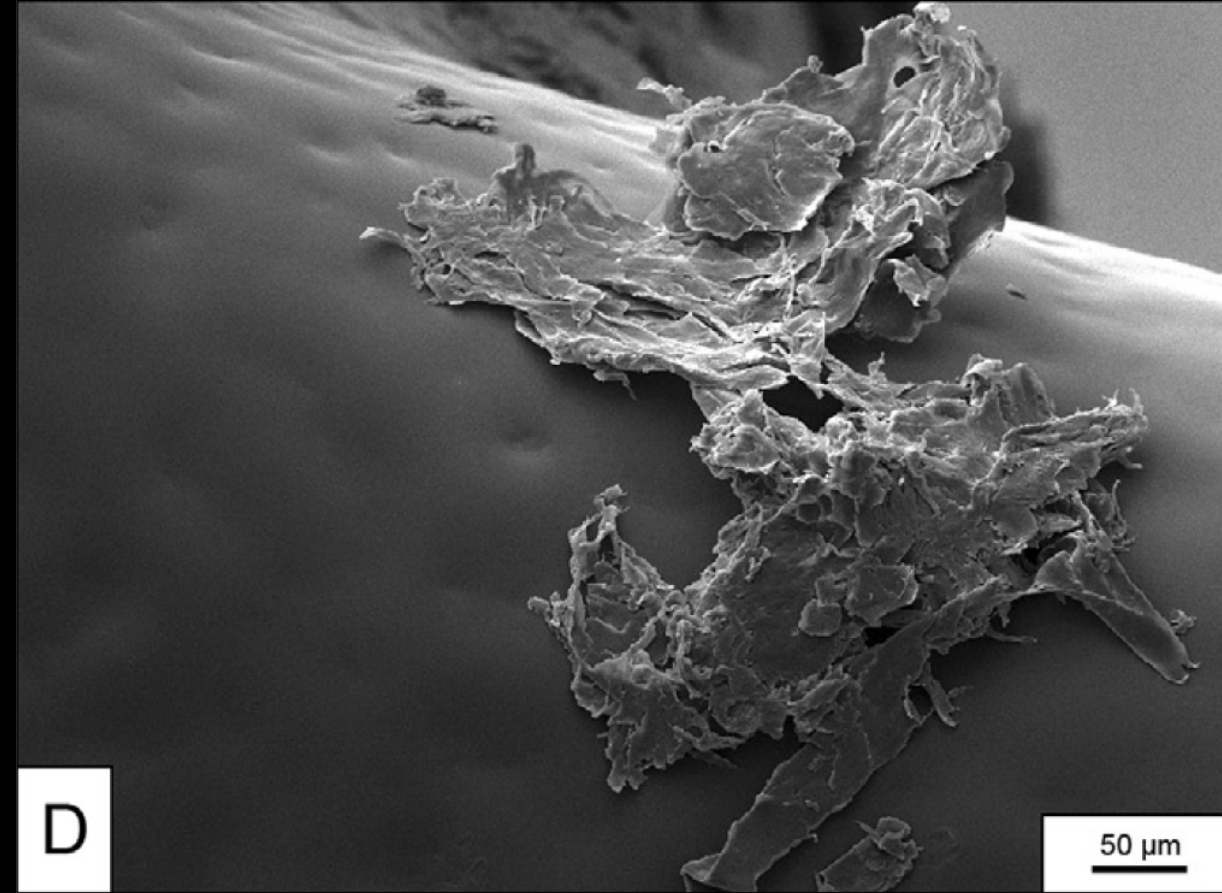
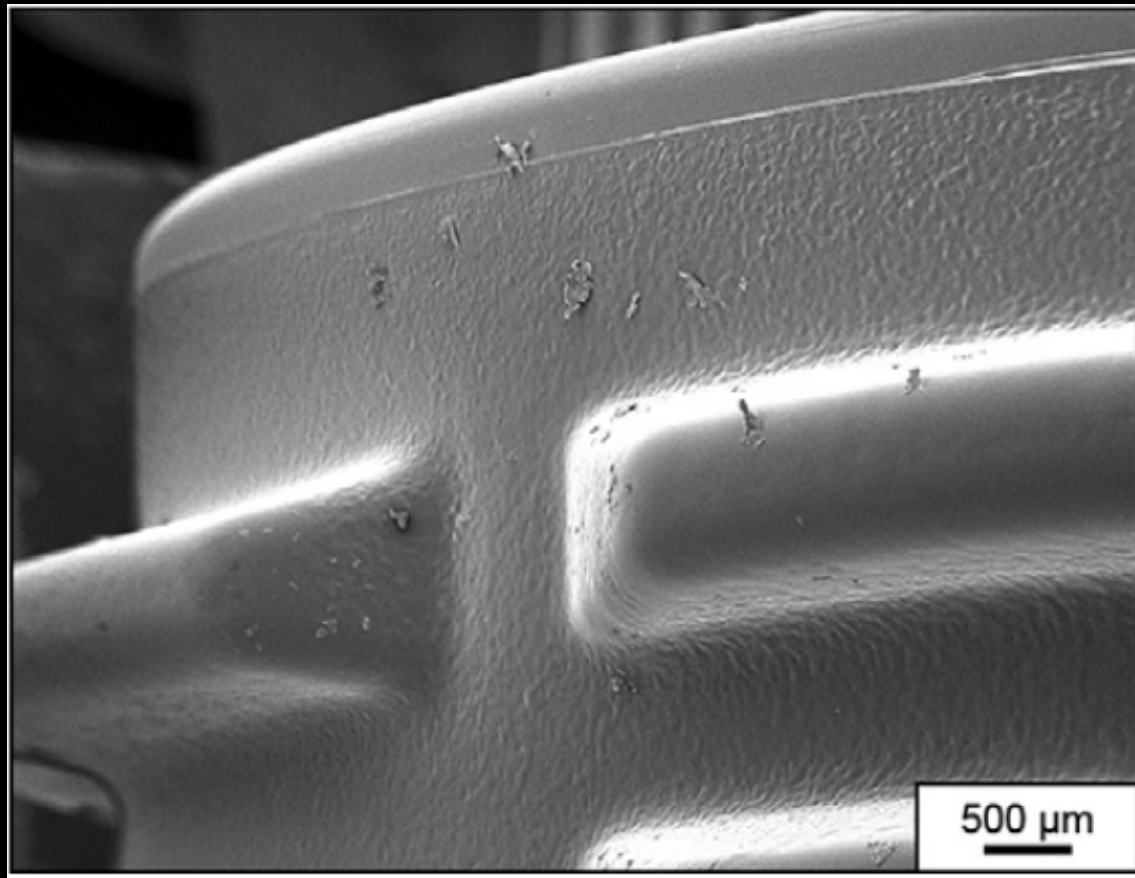
Assessing Human Exposure



More Microplastics in Bottled Water than Tap Water



Plastic Packaging Releases Microplastics



Opening a plastic water bottle releases **14-2,400** microplastic particles

Sobhani, *et al. Sci Rep* (2020)

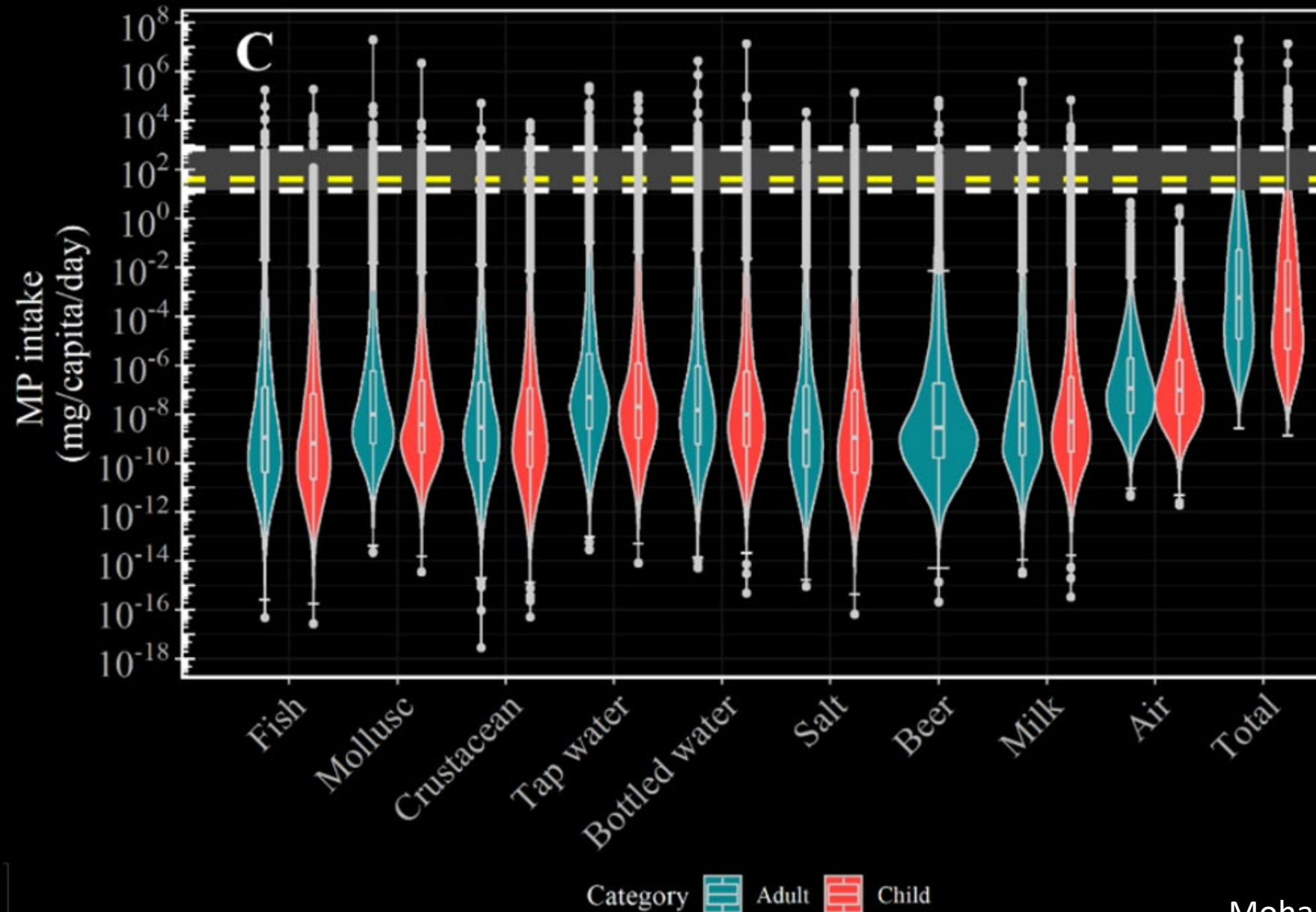
Winkler, *et al. Water Research* (2020)

Infant Bottles Release Millions of Microplastics



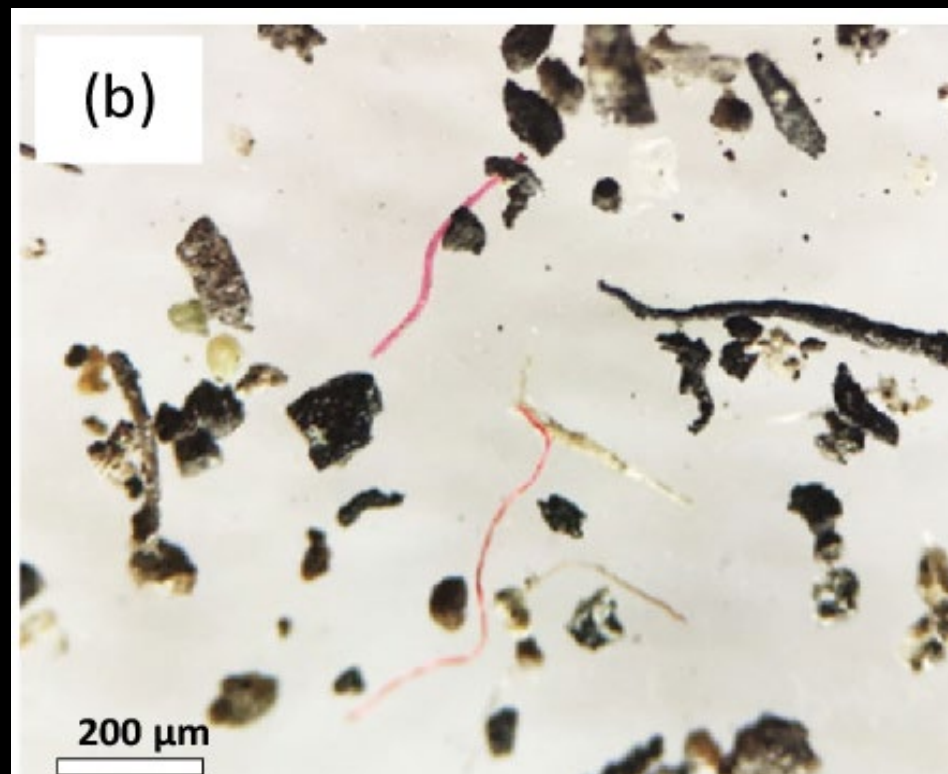
- Polypropylene feeding bottle releases **~16 million particles/L**
- Daily Exposure to Infants: **14,000 – 4,550,000 particles**

Inhalation Likely Greatest Exposure Pathway



Indoor Air Has More Microplastics

- **Household dust:** 1.5-13% microplastic¹
- **Indoor air** ~15x more microplastics > outdoor air¹
- **Mostly Fibers** (~88%)¹



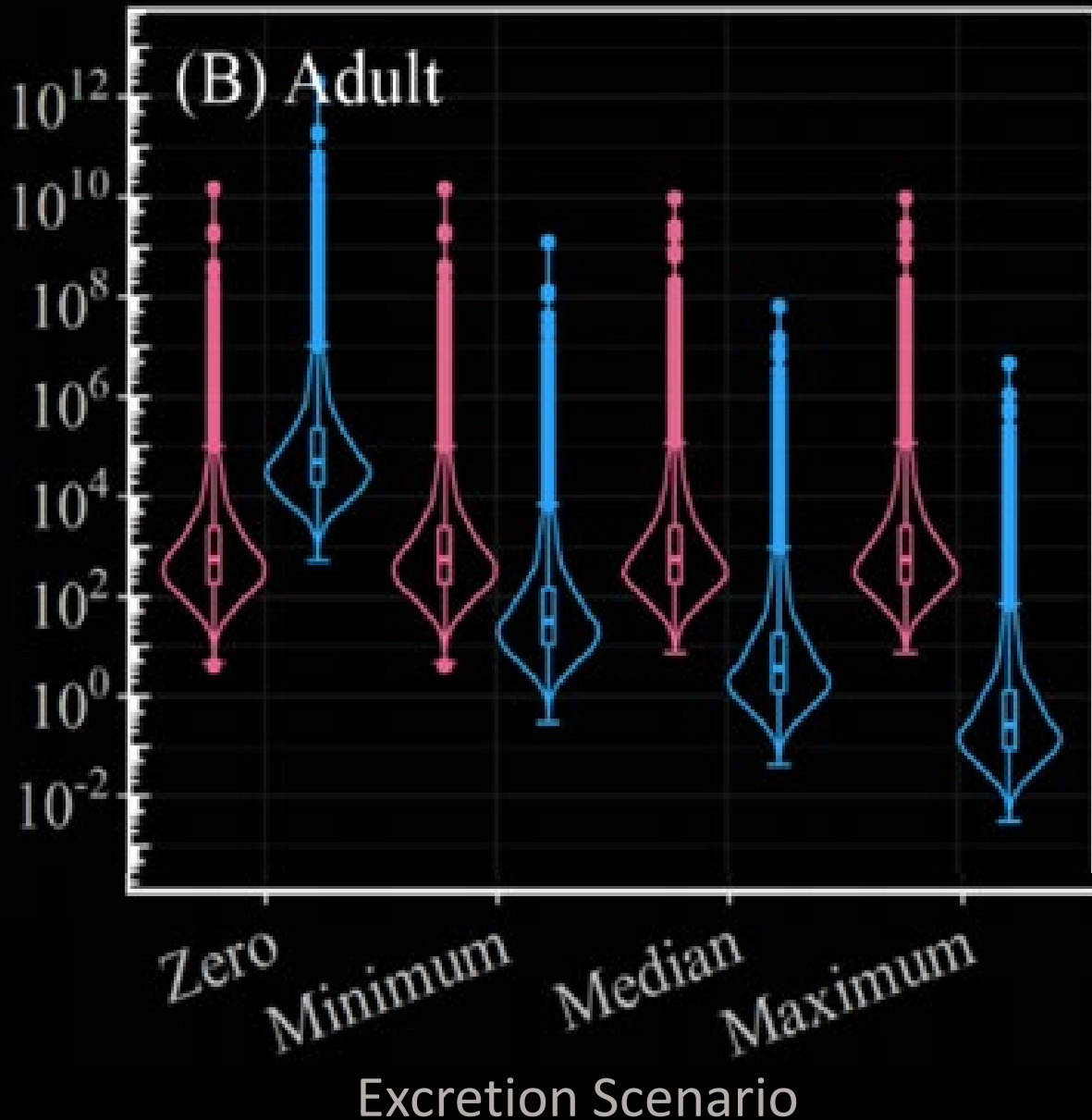
¹C. Liu et al, *Environment International* 2019

Microfiber in dust²

²Dehgani et al., *Environmental Science and Pollution Research* 2017

Microplastics Accumulate in Humans

Persistence



525 – 9,330,000
microplastics/person
(0.8 – 9,850 ng/person)

Microplastics Found in Human Placenta

Ubiquity

Persistence



4/6 placentas contained
microplastics

 @MicheleDoesArt

California Senate Bill 1263 (2018): Statewide Microplastics Strategy

2022

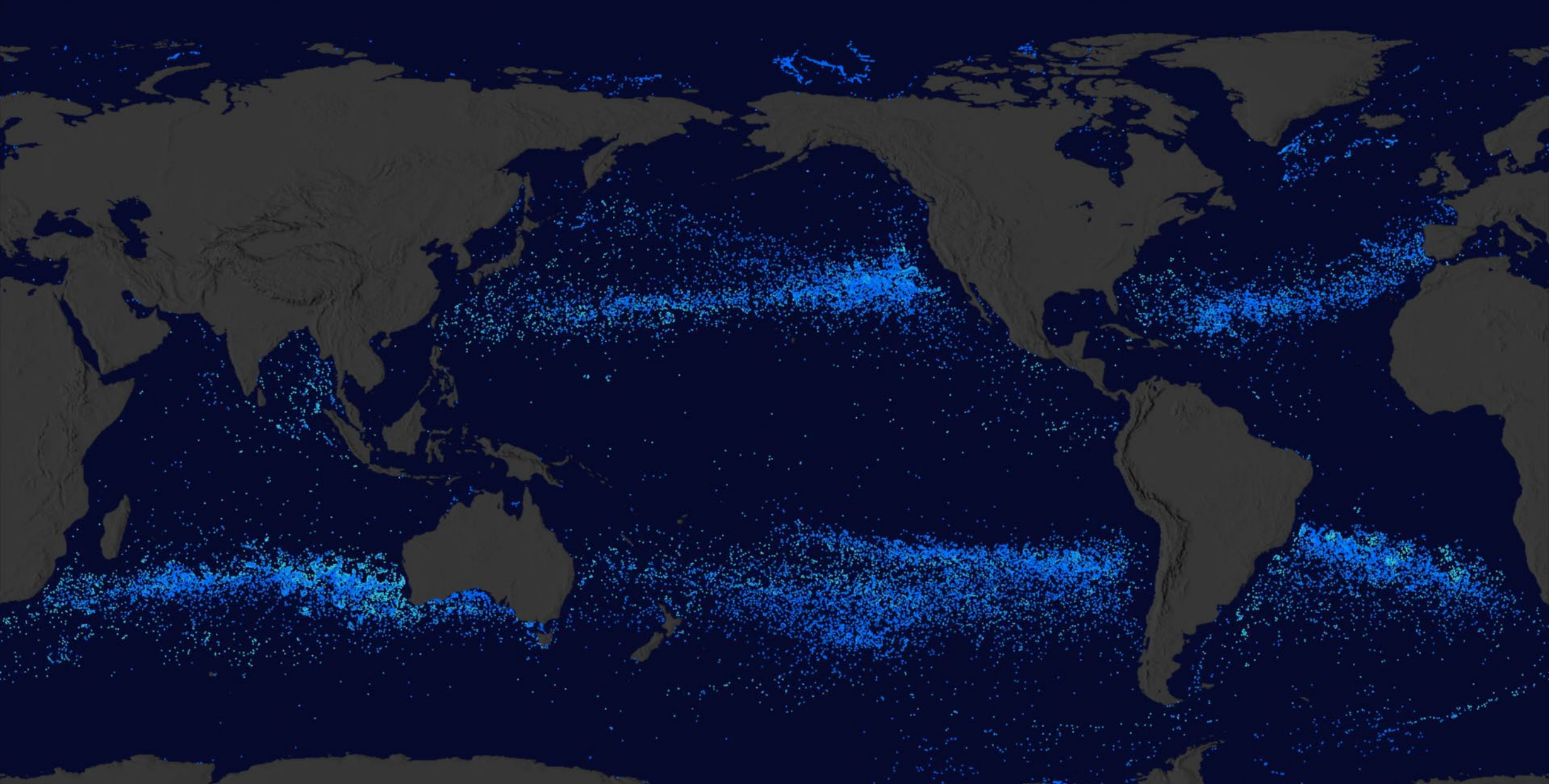
- Initiate Statewide Microplastics Strategy



2026

- **Develop risk assessment framework**
- Develop standardized methods
- Establish baseline occurrence data
- Investigate sources and pathways
- Recommend source reduction strategies

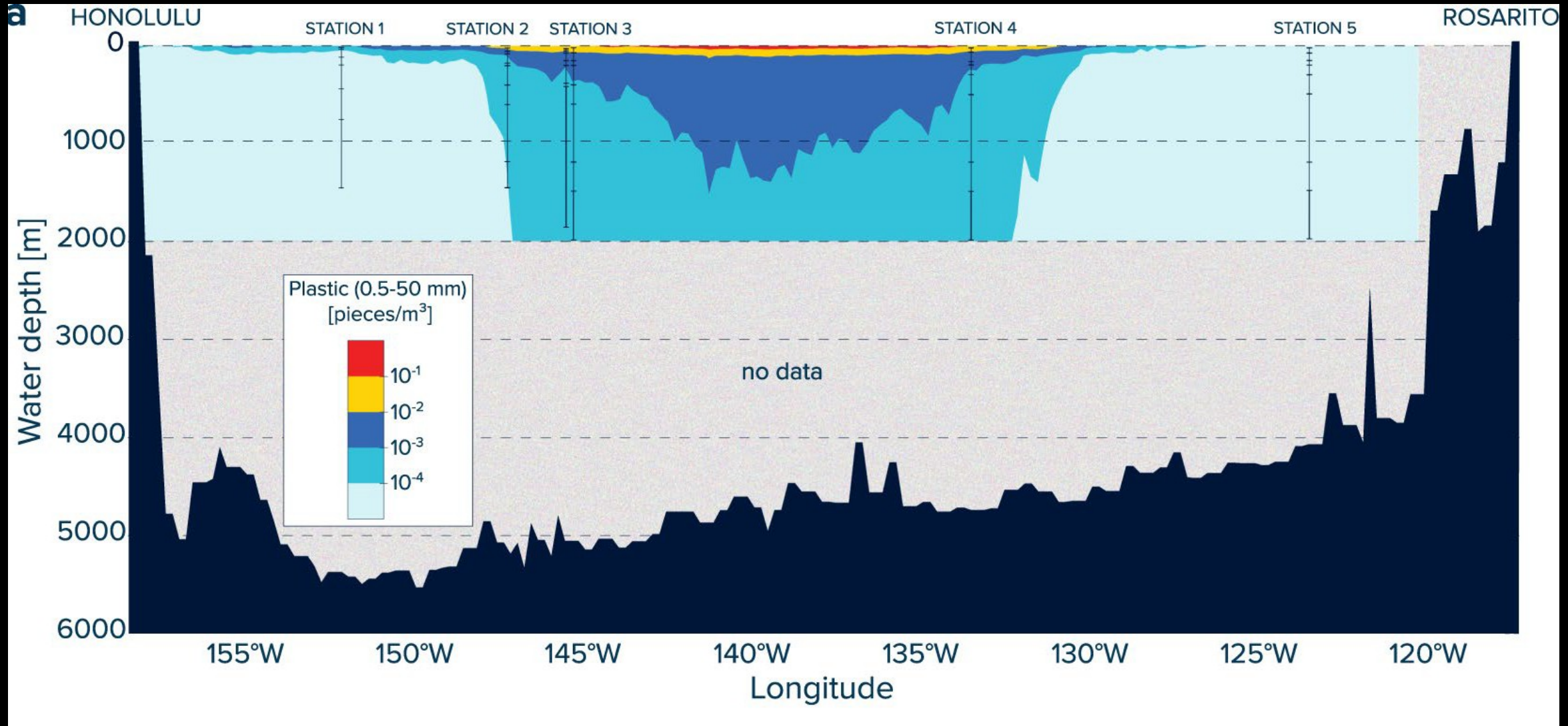
Deadlines



Days since release: 1430

Models Account for ~1% of Ocean Plastic

Ubiquity



Hazard

Potential to cause harm



Exposure

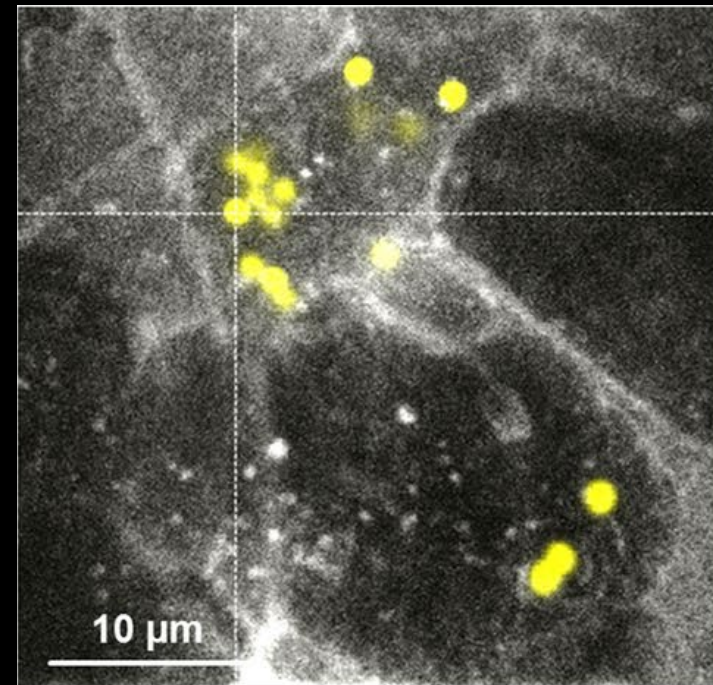
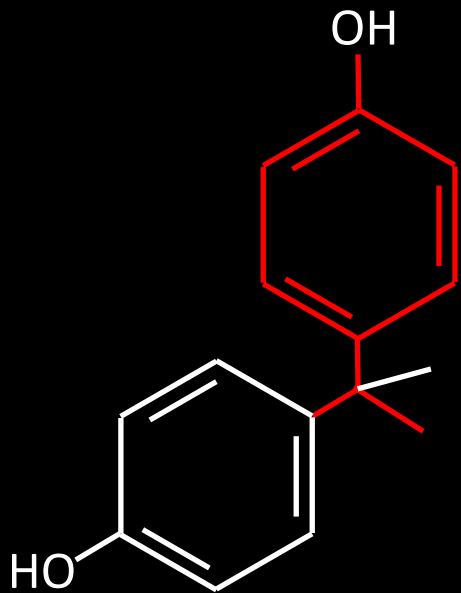


Risk

Probability to cause harm



Chemical and Particle Hazards



Stock et al. (2019). *Archives of Toxicology*

Plastic Often Contains Hazardous Chemicals

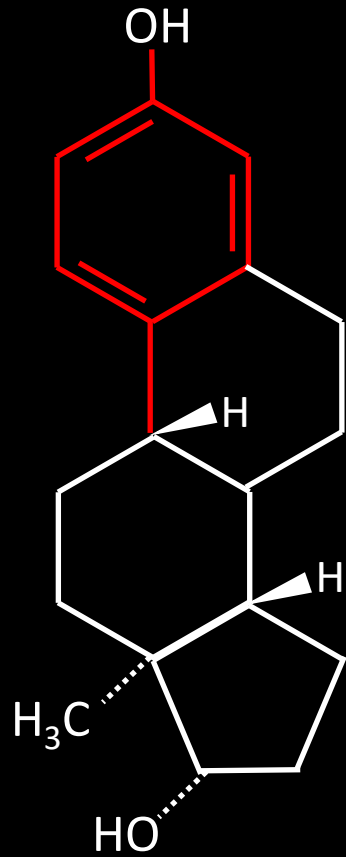
- >3,300 known additives
- 98 hazardous
- 7 persistent, bioaccumulative, toxic
- 15 **endocrine disrupting**



Some Plastic Ingredients are **Endocrine Disruptors**

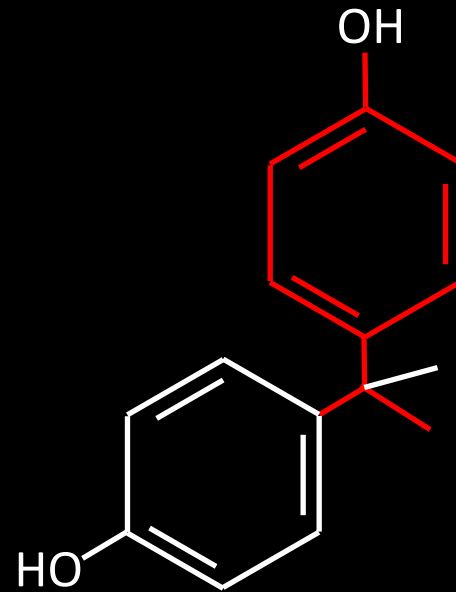
Estrogen

Endogenous Hormone

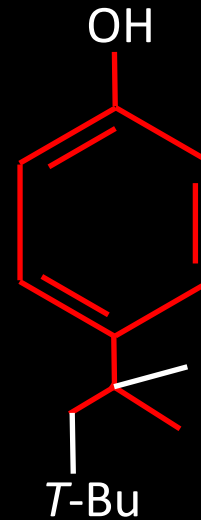


17-β-estradiol

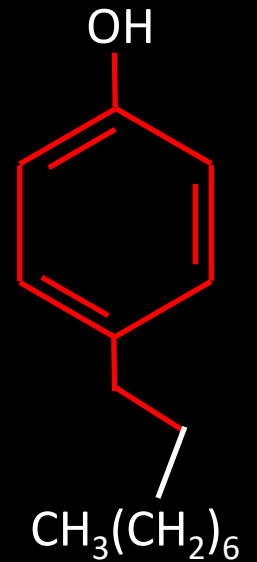
Common Plastic Additives



Bisphenol A



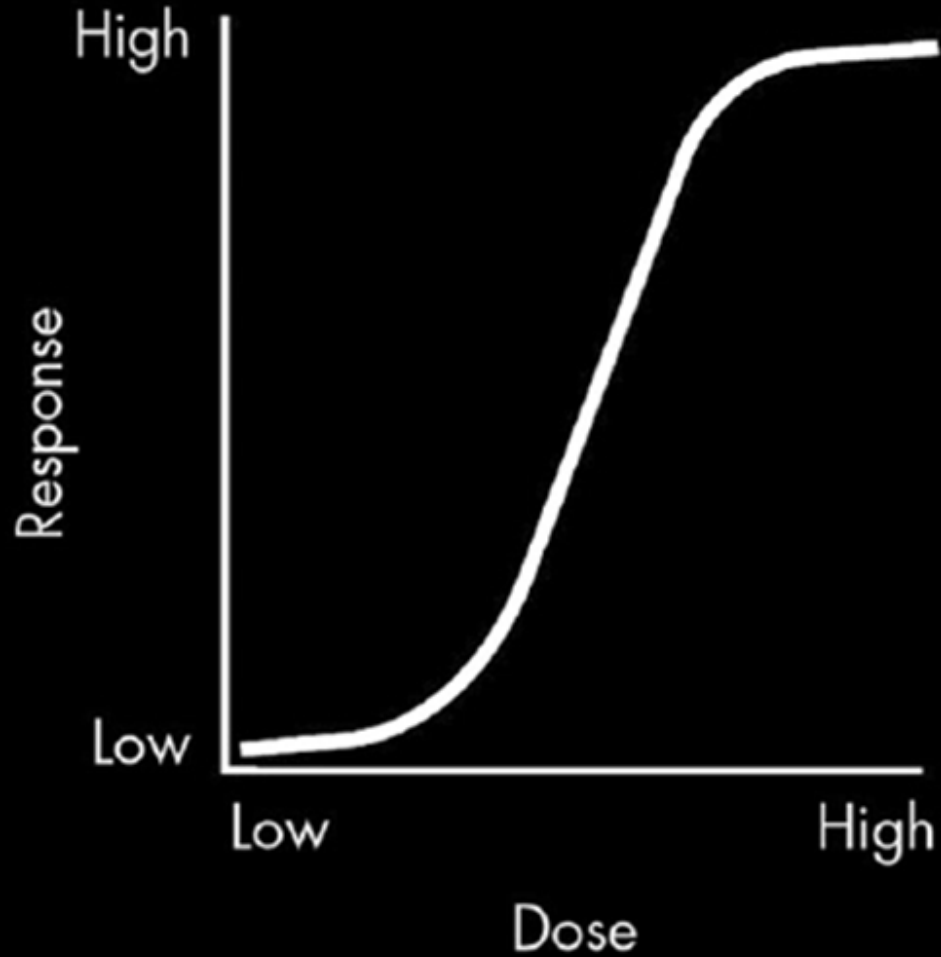
4-*tert*-octylphenol



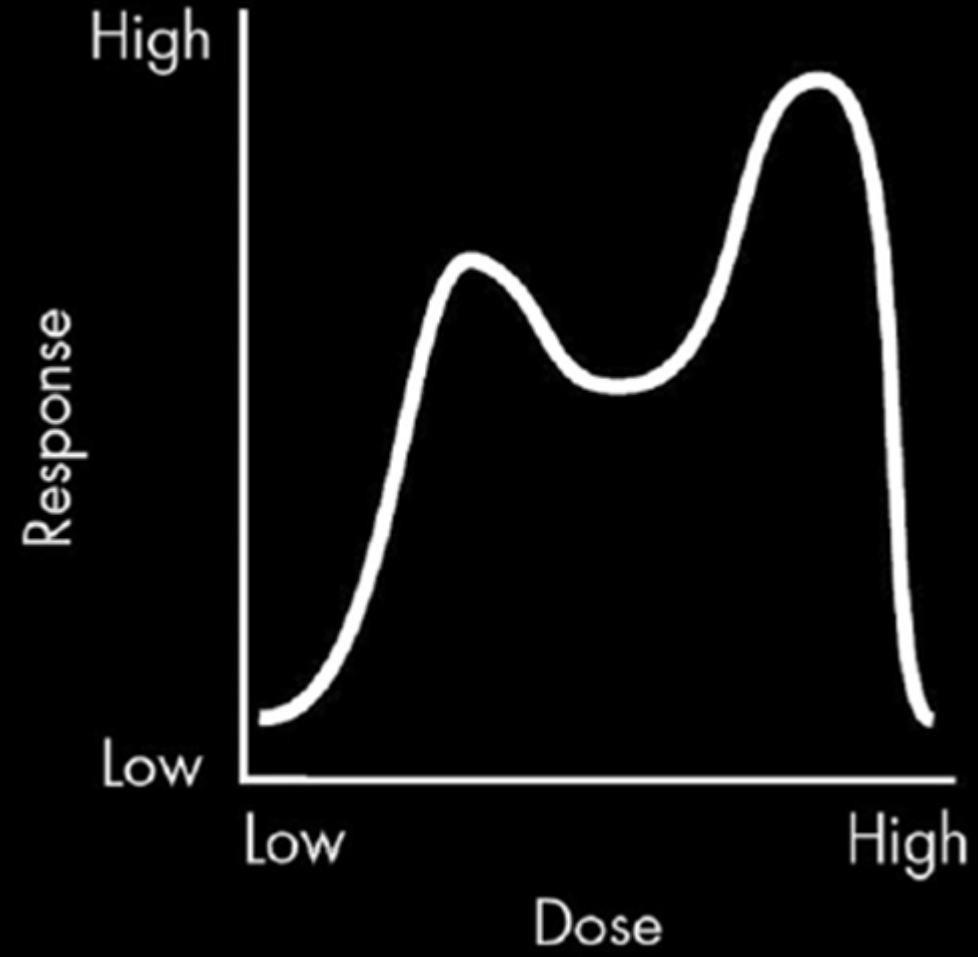
4-n-nonylphenol

Endocrine Disruptors Behave Strangely

Complexity

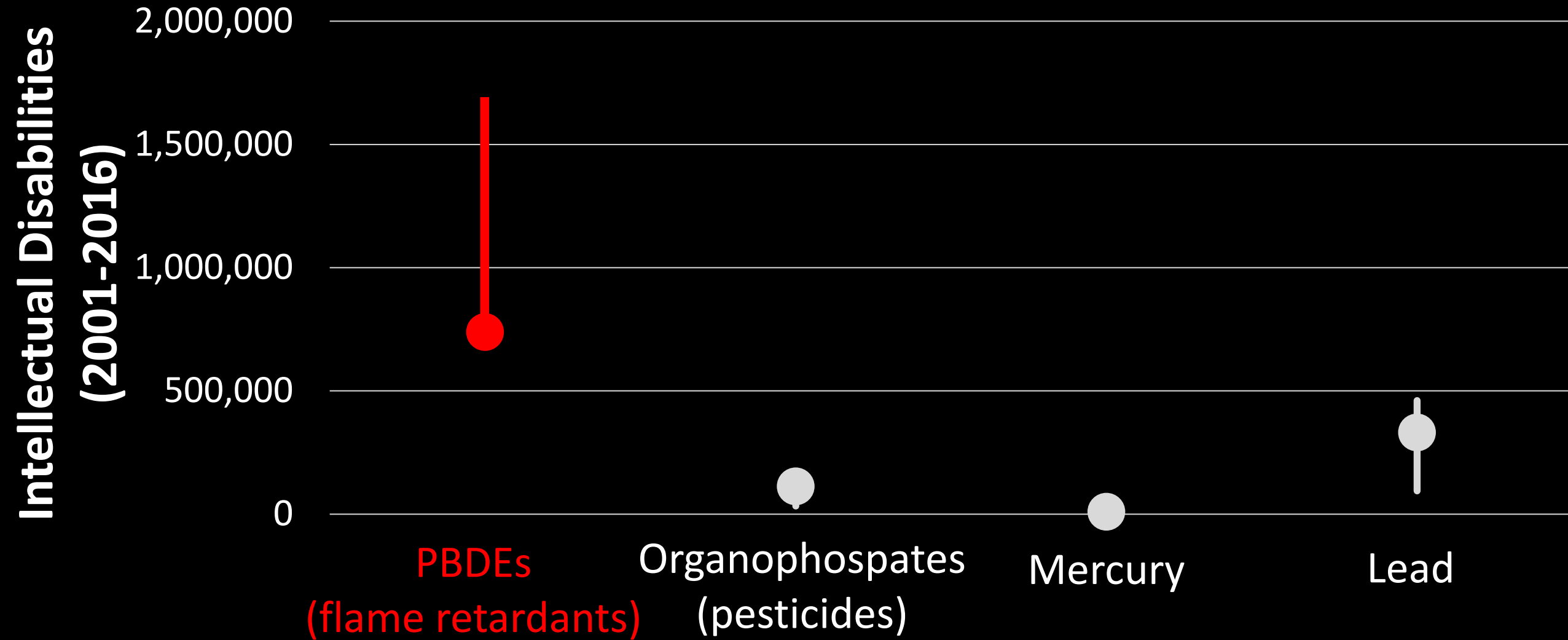


'Typical' Toxicant



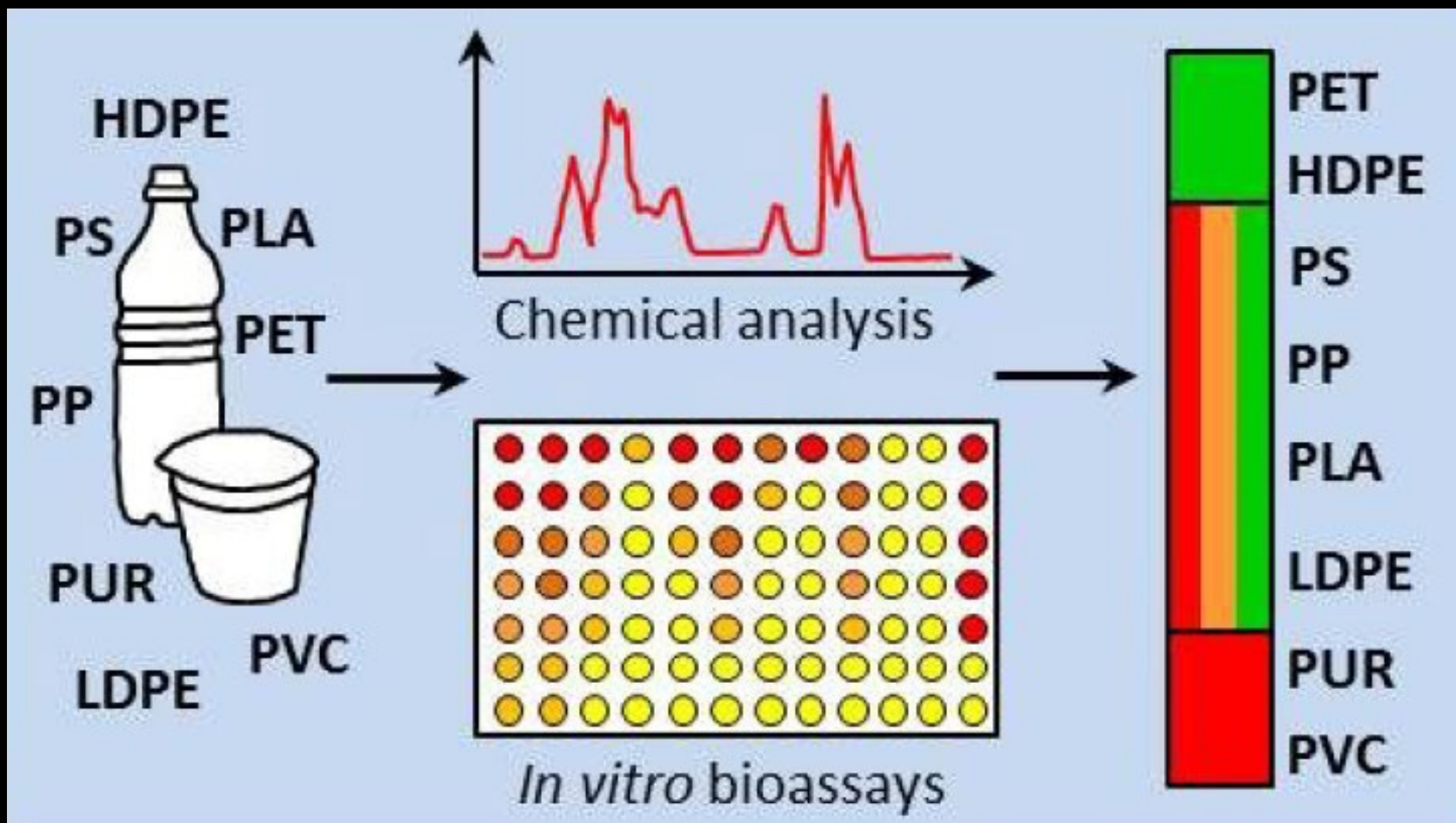
Endocrine Disruptor

Some Endocrine Disruptors Cause IQ Loss

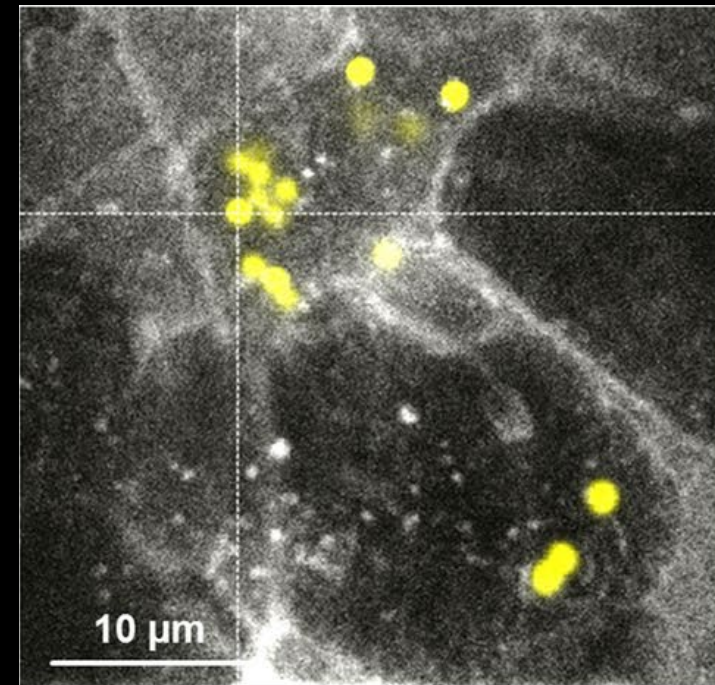
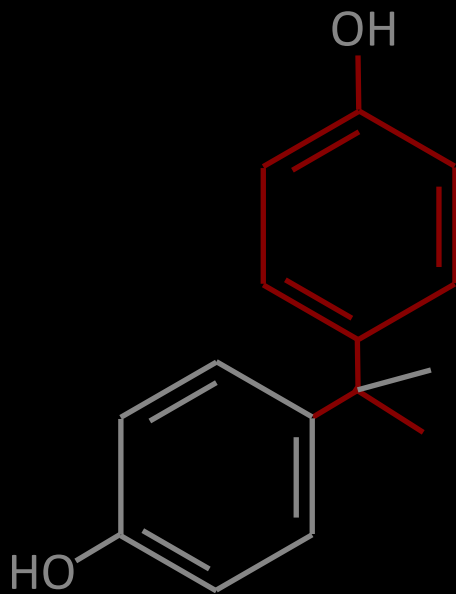


>85% of Plastic Ingredients are Confidential

Secrecy



Chemical and Particle Hazards



Stock et al. (2019). *Archives of Toxicology*

Particle Effect Mechanisms in Aquatic Organisms

Oxidative Stress

“Food Dilution”

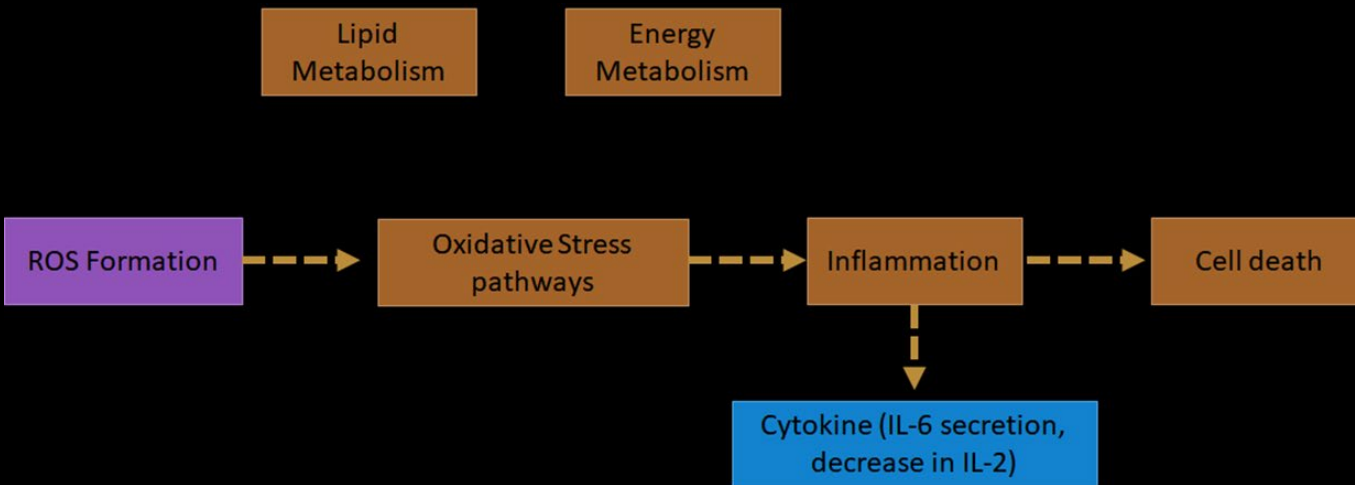


Photo: Marcus Eriksen

“Food Dilution”



Chris Jordan



Chris Jordan

Chris Jordan

Environmental Microplastics

polydisperse

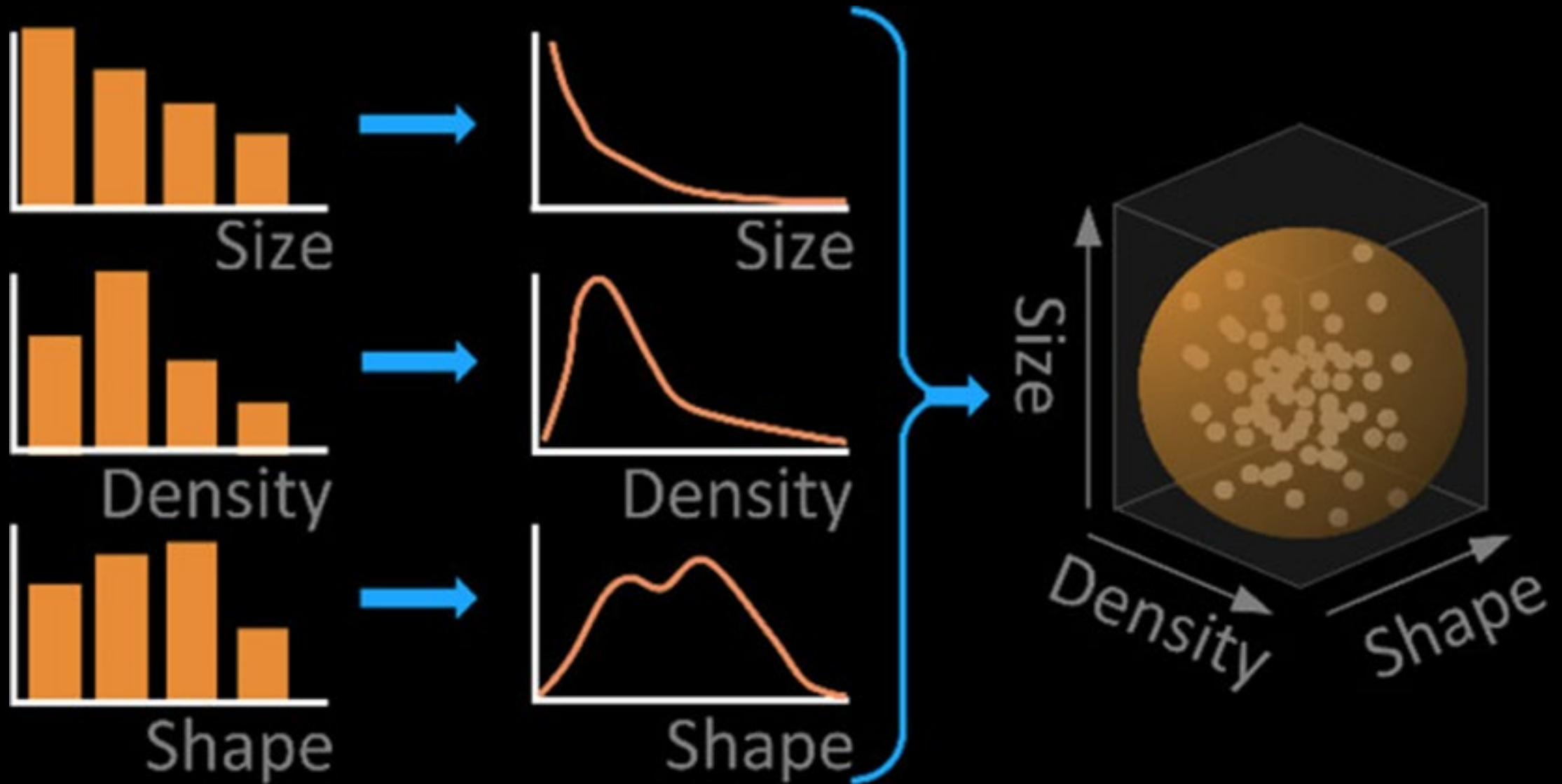


Lab Studies

monodisperse

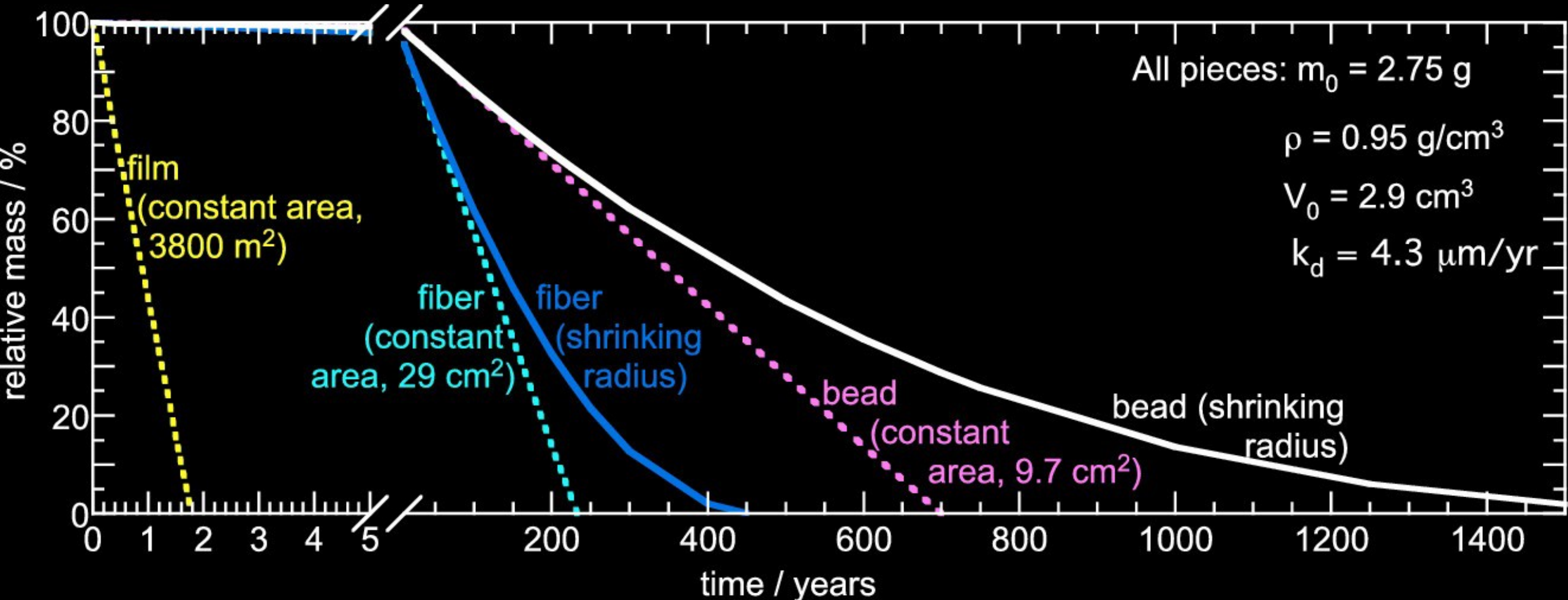


Solution: Probability Distribution Functions



Plastic Degrades *Very Slowly* In Ocean

Persistence



Widespread Risks (May Be) Inevitable

A black-to-yellow color scale is used to indicate plastic concentration:

- black = low concentrations

- yellow = high concentrations

(all concentrations are in microplastics per m²)

A year can be selected using the slider below.

Pushing the green play button will allow you to progress automatically through the years from 1960 to 2100.

You can also click on the map to see the number of microplastics per m².

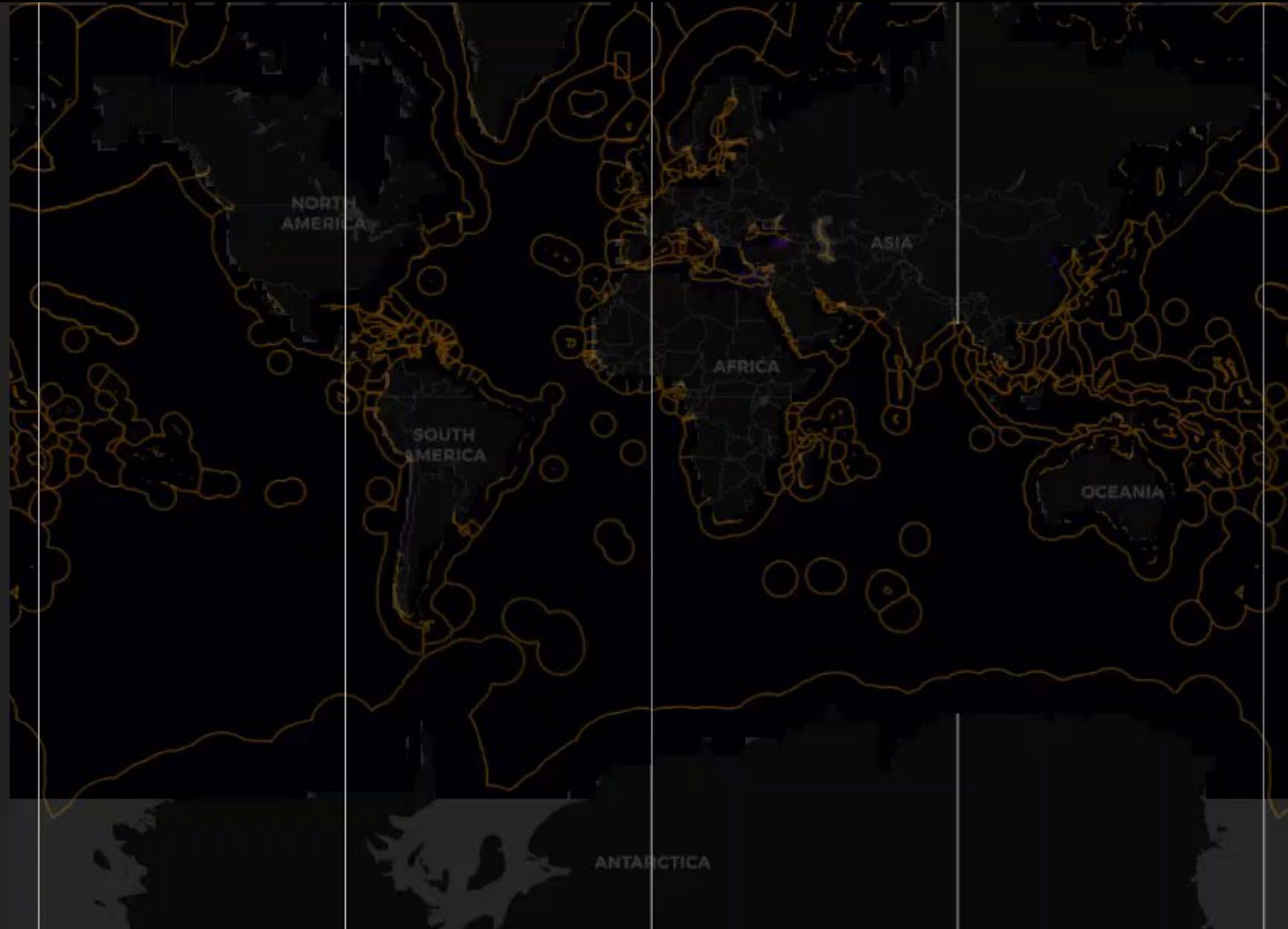
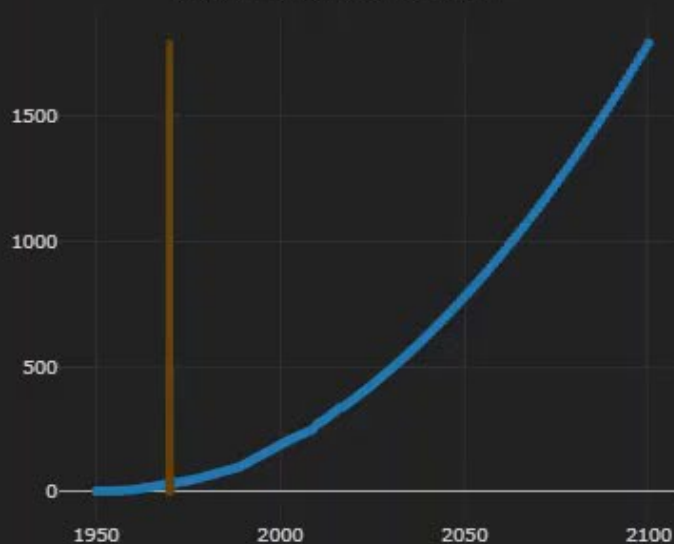
Year selection

1973



1961 → **2100**

Global Plastics Production





Managing Uncertain & Persistent Contaminants

Microplastics are a
“Non-threshold contaminant”
for which
no safe discharge exists

- European Chemical Agency (2019)

Conclusions

- Microplastics are everywhere, complex, persistent, and contain secret chemicals
- Inter-sector collaboration necessary
- Rethinking risk assessment paradigms necessary

