You Are What You Eat (and Breathe): Exposure and Impacts of Nano- and Microplastics on Human Health

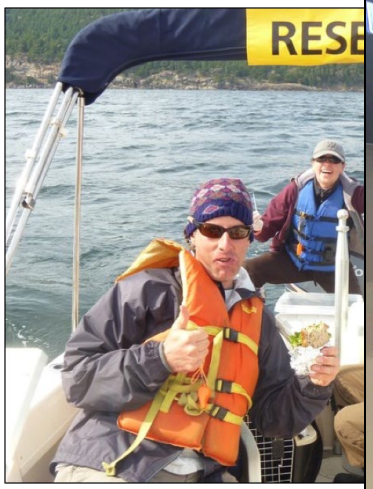
Dr. Charles Rolsky

Executive Director & Senior Research Scientist

The Shaw Institute

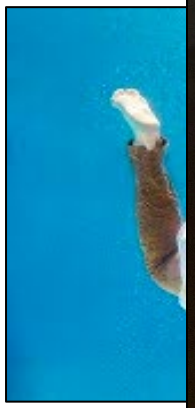
November 30, 2023

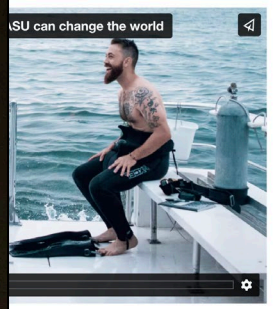
Shenan




EXIT
EXIT ROUTE


LEGISLATORS
LET'S TALK ABOUT
THE OCEAN




SU can change the world

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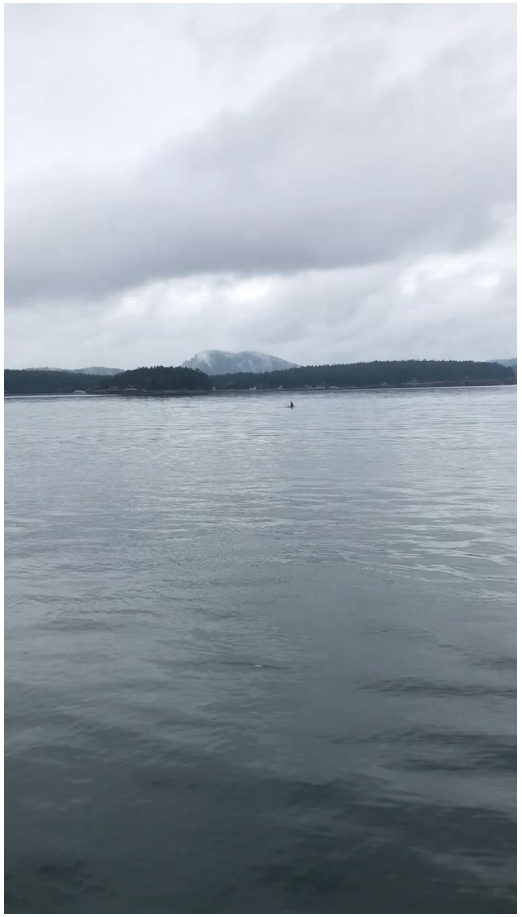
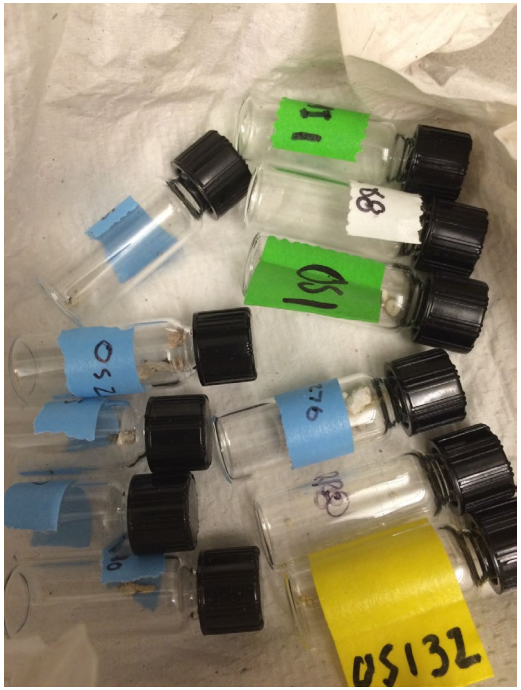
30 YEARS OF ENVIRONMENTAL IMPACT RESEARCH

My science lab

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RESEARCH
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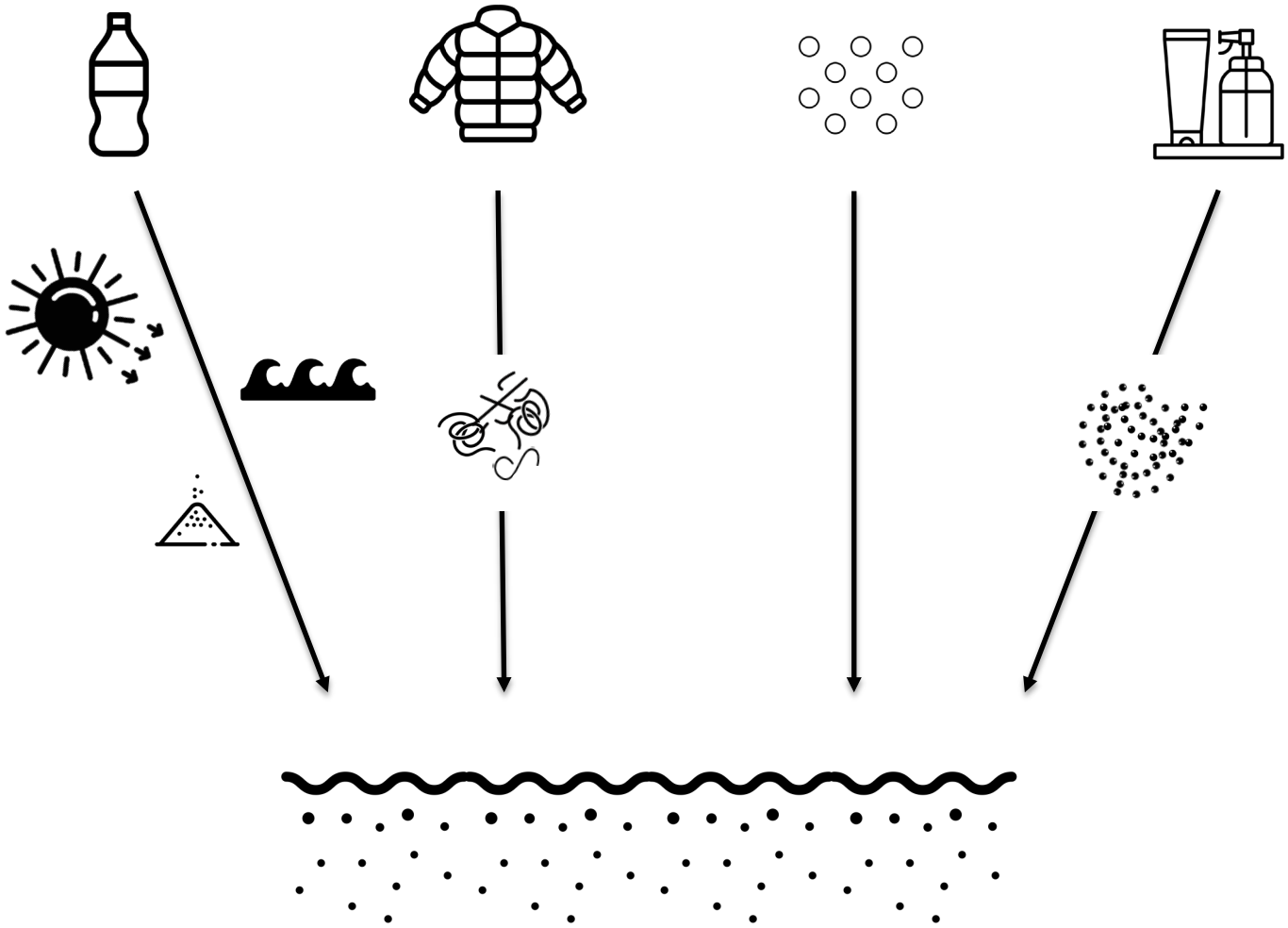
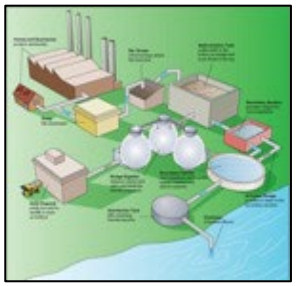
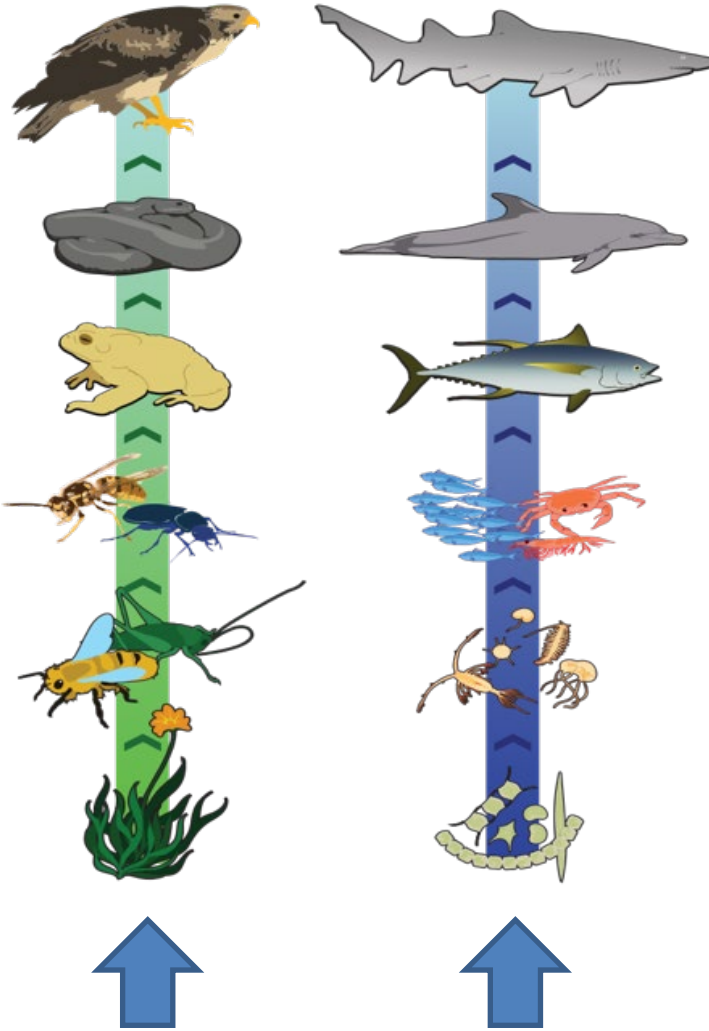


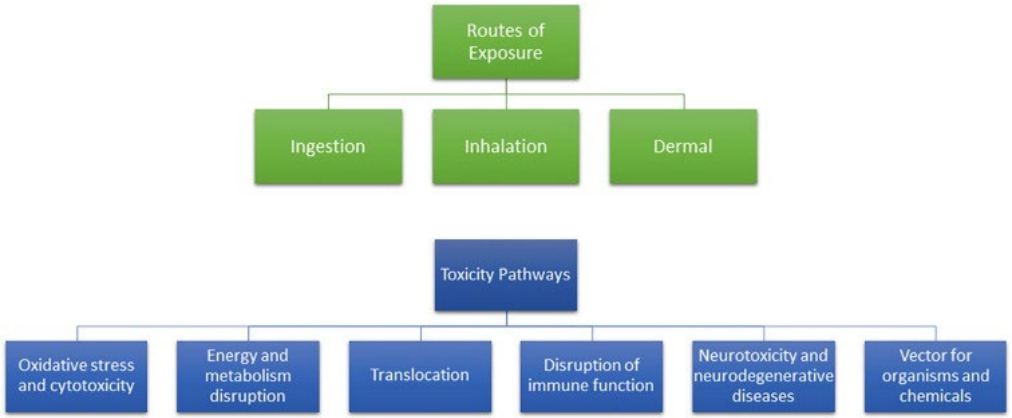
Primary microplastics



Secondary microplastics



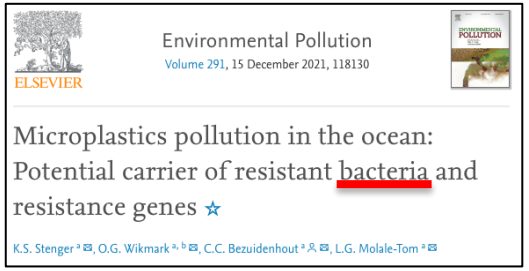
As a pollutant

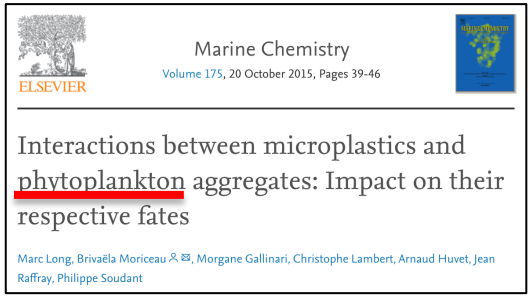


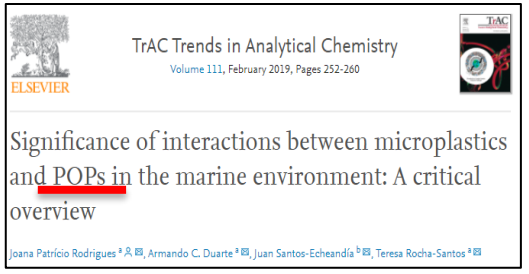
*Up to 1 million times relative to surrounding environmental concentrations

Prata, Joana Correia, et al. "Environmental exposure to microplastics: An overview on possible human health effects." *Science of the Total Environment* 702 (2020): 134455.

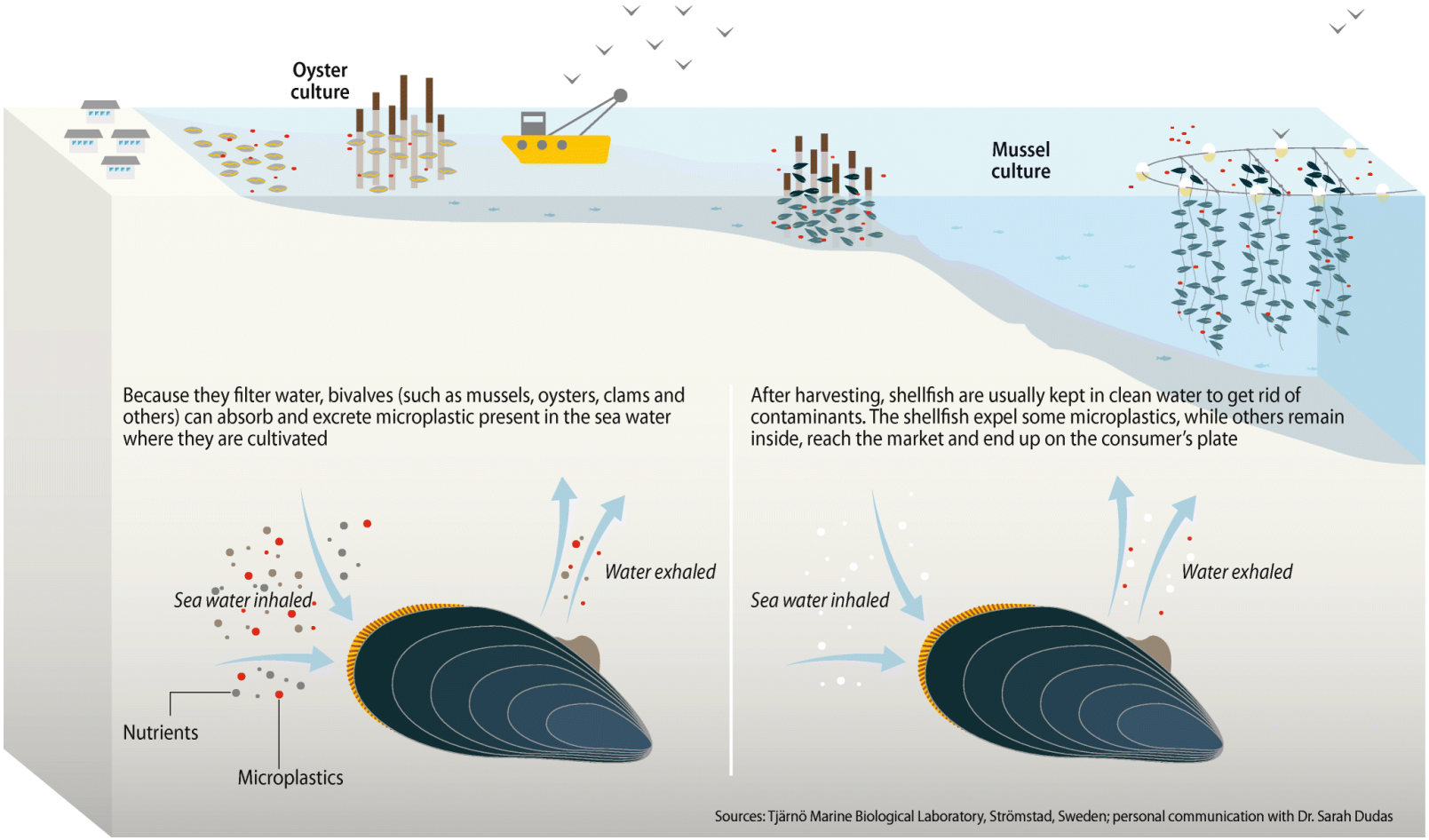
*Menéndez-Pedriza, Albert, and Joaquim Jaumot. "Interaction of Environmental Pollutants with Microplastics: A Critical Review of Sorption Factors, Bioaccumulation and Ecotoxicological Effects." *Toxics* 8.2 (2020): 40.







An example of how microplastics could end up on a consumer's plate

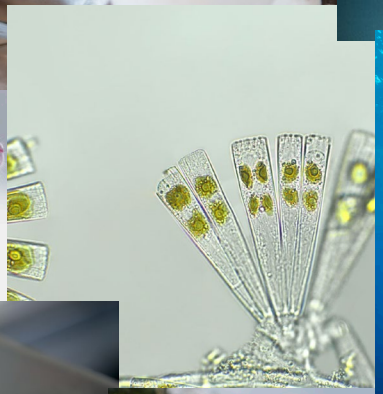
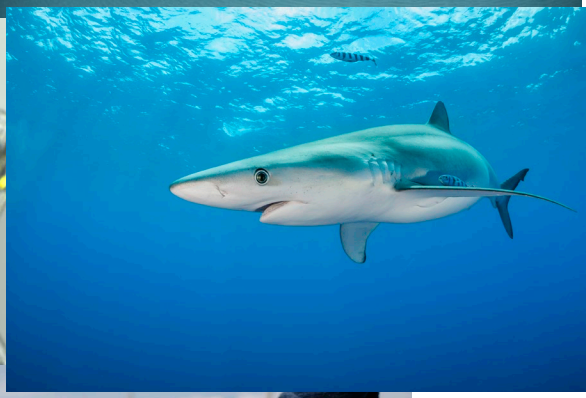


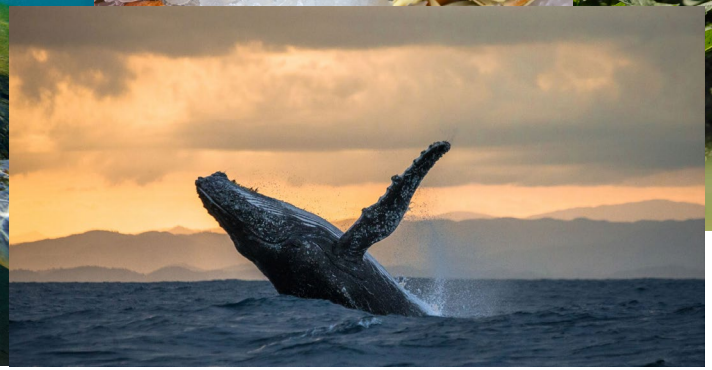
mith, Madeleine, et al. "Microplastics in seafood and the implications for human health." *Current environmental health reports* 5 (2018): 375-386.

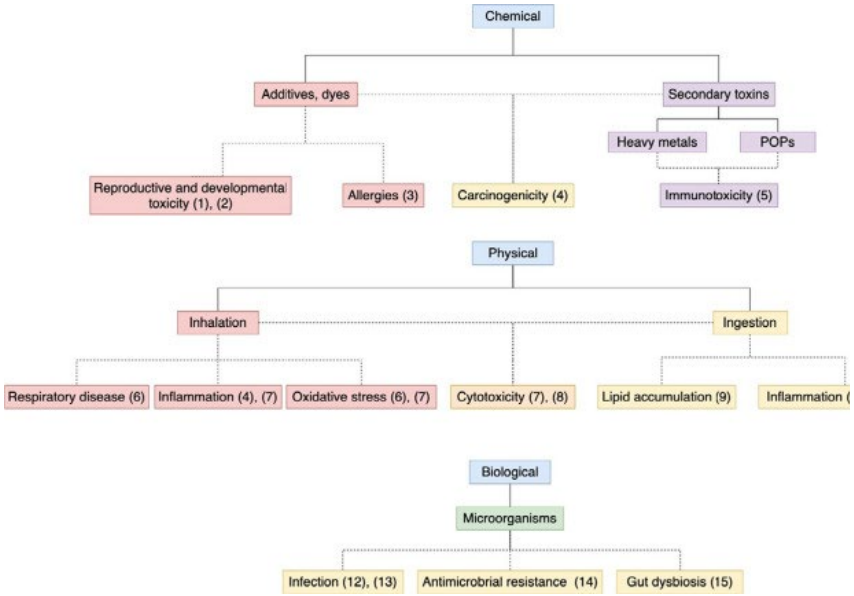
Do plastics harm humans?

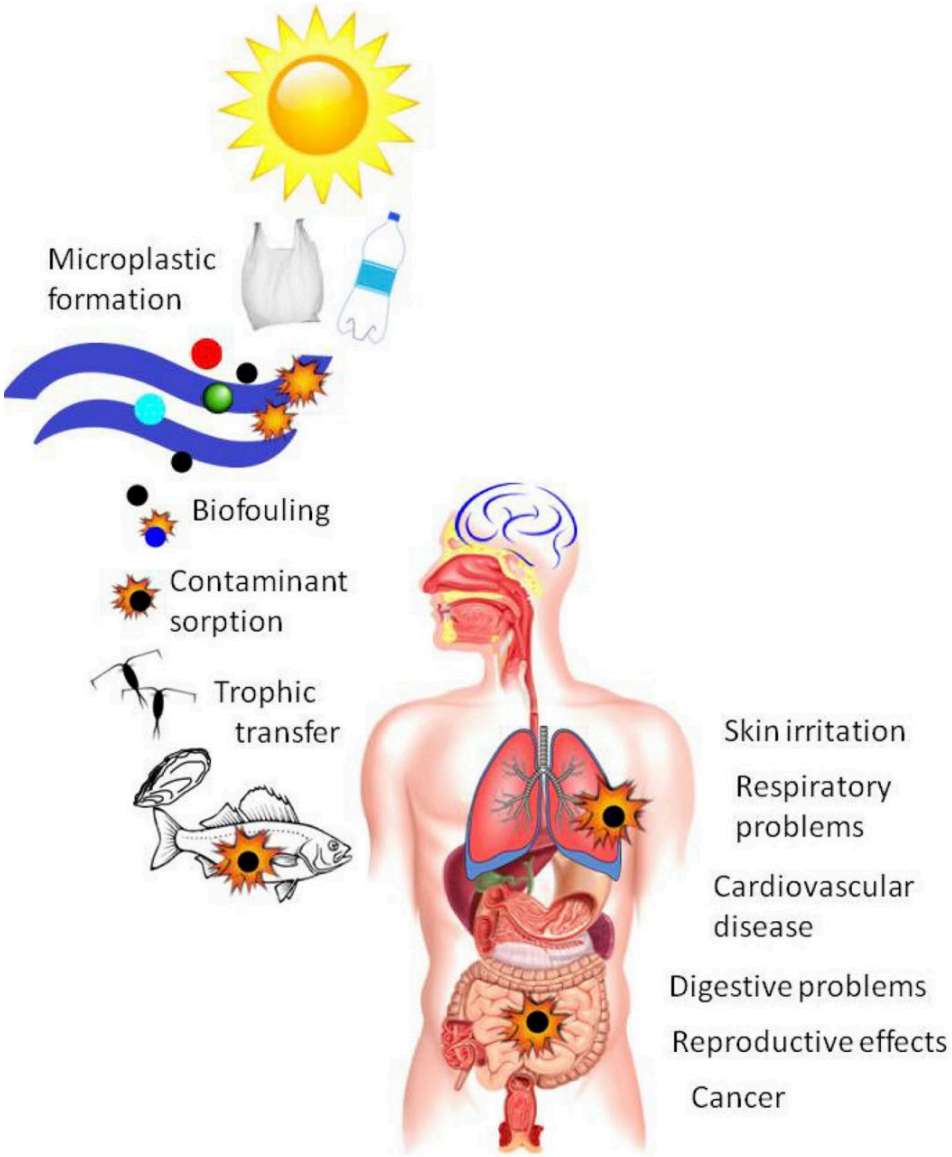




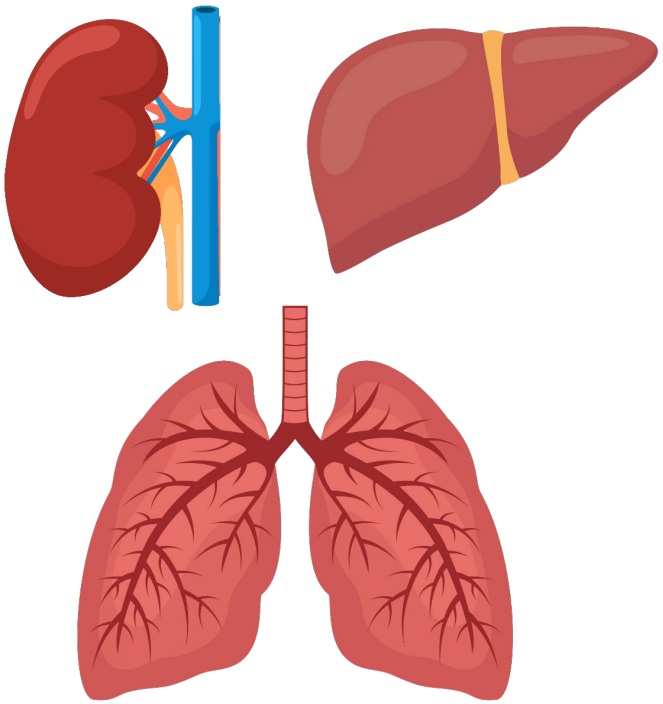



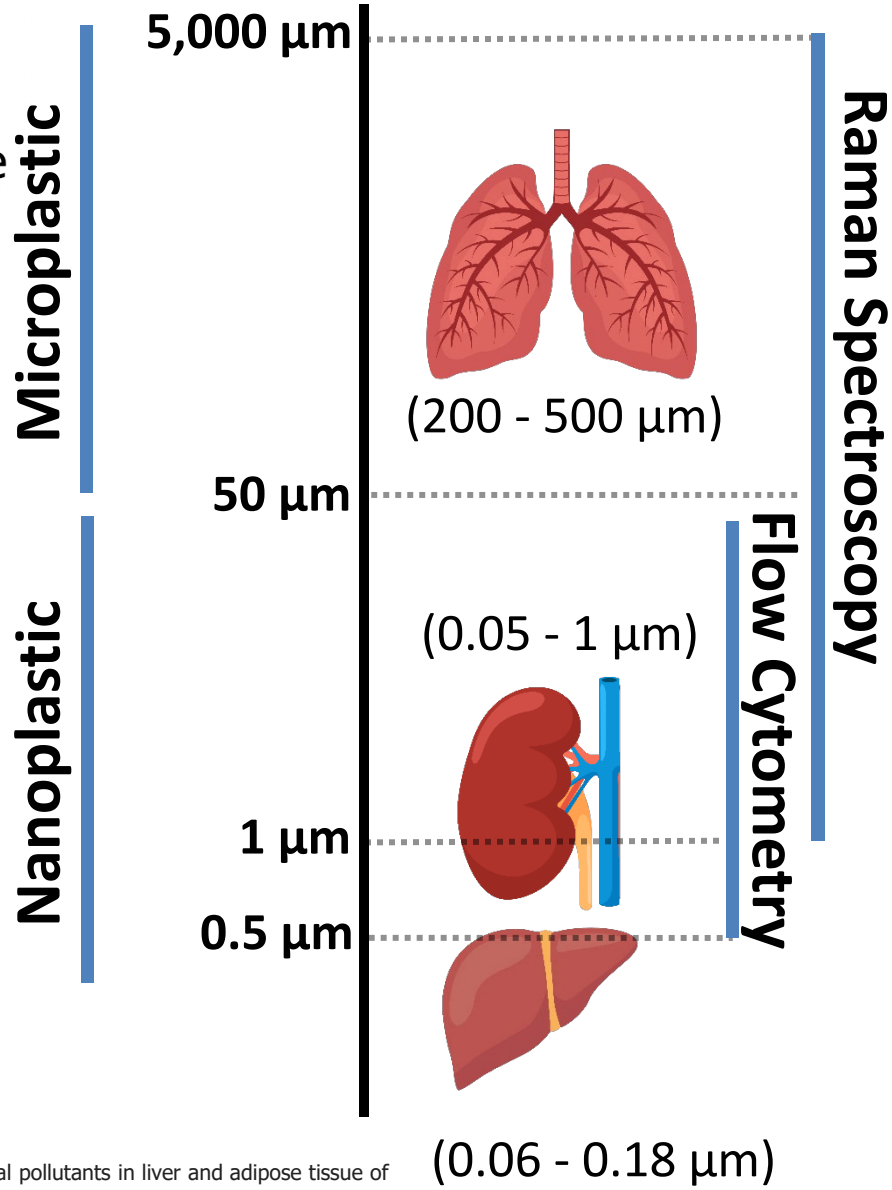





Carbery, Maddison, Wayne O'Connor, and Thavamani Palanisami. "Trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health." *Environment international* 115 (2018): 400-409.

Assessment of Persistent, Bioaccumulative and Toxic Organic Environmental Pollutants in Liver and Adipose Tissue of Alzheimer's Disease Patients and Age-matched Controls

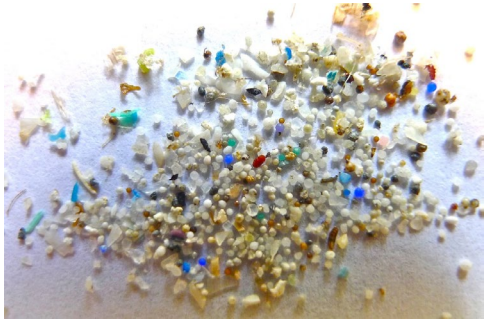


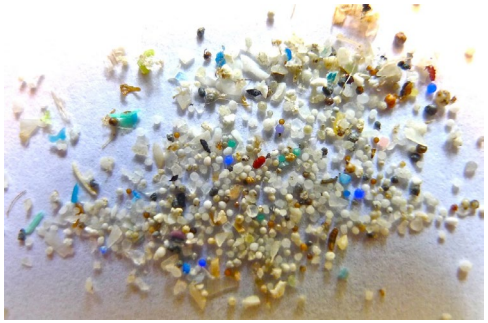


anivannan, Bhagyashree, et al. "Assessment of persistent, bioaccumulative and toxic organic environmental pollutants in liver and adipose tissue of lzheimer's disease patients and age-matched controls." *Current Alzheimer Research* 16.11 (2019): 1039-1049.

NYU Langone Health

HARVARD MEDICAL SCHOOL





Ulcerative Colitis
Crohn's Disease
Cancer

Microplastics and human health

- Rodent and placenta blood movement models:
  - Movemen… organs (<20 nm)
  - Transfer t… erine artery
  - Accumula… up 300 nm
- Human studies
  - Ragusa et… samples; Raman
  - Braun et a… al: n=17,

1.6µm-filtered deionised water. Since the experiments were conducted without the use of the laminar flow hood, the plastic fibres found in the samples were not considered in the results. Digestates were then filtered through 1.6µm-pore-size filter membrane

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Plasticenta: First evidence of microplastics in hu…

Antonio Ragusa [a], Alessandro Svelato [a,*], Criselda Santacroce [b], Valentina Notarstefano [c], Oliana Carnevali [c], Fabrizio Papa [b], M… Federico Baiocco [a], Simonetta Draghi [a], Elisabetta D'Amore [a], … Elisabetta Giorgini [c]

Article

Detection of Microplastic in Human Placent… a Clinical Setting

Thorsten Braun [1,2,*], Loreen Ehrlich [2], Wolfgang Henrich [1], Sebastian Koeppe… Philipp Schwabl [4,†] and Bettina Liebmann [3,†]

ELSEVIER Science of the Total Environment journal homepage: www.elsevier.com/locate/scitotenv

Identification of microplastics in human placenta using laser direct infrared spectroscopy

Long Zhu [a,b], Jingying Zhu [d], Rui Zuo [a], Qiujin Xu [b], Yanhua Qian [c,d,*], Lihui AN [b,**]

Microplastics and human health

NYU Langone Health

Aim 1

Quantify and characterize microplastic particles and fragments in placenta tissue collected from clinical samples and create a database of potential contaminants present during sample collection and processing.

Aim 1

SETAC EUROPE 33RD ANNUAL MEETING

30 APRIL - 4 MAY 2023 | DUBLIN, IRELAND + ONLINE

Characterizing Human Exposure to Microplastics During Pregnancy

Shaw Institute
Colby
HARVARD MEDICAL SCHOOL
NYU CHES
NYU Langone Health | CTSI

Charles Rolsky[1,5], Whitney Cowell[2], Michelle Berger[1], Greg Drozd[3], Eleanor Medley[4], Kurunthachalam Kannan[2,6], Varun Kelkar[5], and Leonardo Trasande[2]

1 Shaw Institute, Blue Hill, ME, USA; 2 Department of Pediatrics, New York University Grossman School of Medicine, New York, NY, USA; 3 Department of Chemistry, Colby College, Waterville, ME, USA; 4 Department of Population Health, New York University Grossman School of Medicine, New York, NY, USA; 5 Plastic Oceans International, Malibu, CA, USA; 6 Wadsworth Center, New York State Department of Health, and Department of Environmental Toxicology and Health, State University of New York, Albany, NY, USA

- A novel method has been developed to locate and identify nano- and microplastics (NMP) extracted from human placentas and other tissue samples, with a 75% recovery rate.
- Contamination controls can facilitate more accurate assessment of NMPs in tissue samples.
- These methods will be used to understand the impacts of NMPs on human health and disease.

AIMS

Short Term

- To develop and test two novel methods to reduce and document sources of contamination from the delivery room and the analytical laboratory.
  - Create a database of all medical plastics involved in labor and delivery at one hospital.
  - Create an innovative housing for extracted samples to reduce opportunity for airborne contamination during plastic analysis.

Long Term

- To understand fetal and infant risks from nano- and microplastics (NMP) exposure by quantifying and characterizing NMPs extracted from the chorion side of 300 placenta samples.
- To identify sociodemographic, dietary, behavioral and other lifestyle factors that predict exposure to microplastic particles and fragments during pregnancy correlated with bisphenol and phthalate additives measured in maternal urine during pregnancy.

BACKGROUND

- Increasing global plastic production has led to increasing pollution from macro- (>5 mm), micro- (1 µm – 5 mm) and nanoplastics (<1 µm).
- Humans are exposed to NMPs through air, food, bottled water, and many other sources.
- NMP exposure has been linked with both physical and chemical toxicity in many organisms.
- NMP contamination of human lung, placenta, liver, colon, breast milk and feces has been demonstrated.
- Studies on plastic contamination effects on human health have increased since 2017 (Fig. 1), but the effects of this contamination on vulnerable individuals such as infants or individuals battling disease are still unclear.
- The placenta is a unique, non-invasively available tissue from healthy adults that provides insight into the health of both mother and infant.
- Previous studies have analyzed NMP in placentas, but sample sizes were very small (<20) and there were challenges with contamination from plastic in labor/delivery rooms and the laboratory.

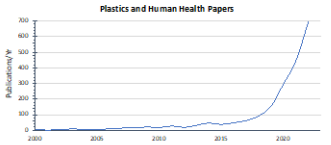


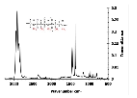
Figure 1. Number of papers published with "plastics" and "human health" in the title, abstract, or keywords from 2000 – 2022 in the Scopus database.

Acknowledgements

This work is supported by New York University's Children's Health & Environment Study via funding source UG3UH3OD023305. It is also supported in part by New York University's Clinical & Translational Science Institute via funding source NIHNCATS ULITR001445. We thank our collaborators for their assistance and all participants enrolled in the NYU Children's Health & Environment Study birth cohort.

METHODS and RESULTS

Contamination Database



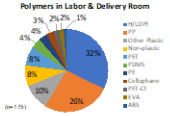
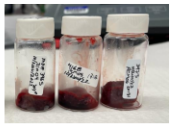
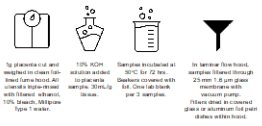


Figure 2. FTIR spectra were collected from 175 objects and parts used in a labor and delivery room at a NYU hospital to be able to identify potential sources of contamination stemming from a birth. Analysis was conducted using a Nicolet IS5 FTIR, KBr Windows, Diamond ATR.

Figure 3. The most common plastics were high/low density polyethylene (HI/LDPE), polypropylene (PP), and polyethylene terephthalate (PET). Non-plastic materials included cotton, paper, and cellulose.

Tissue Digestion



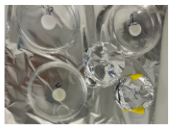


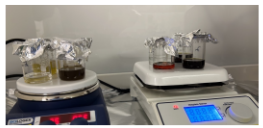
1g placenta cut and weighed to clean lab-lined fume hood. All utensils triple-rinsed with filtered ethanol, 10% bleach, Millipore Type 1 water.

10% KOH solution added to placenta sample. 30mL/g tissue.

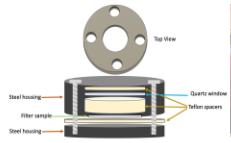
Samples incubated at 30°C for 72 hrs. Beakers covered with foil. One lab blank per 3 samples.

In laminar flow hood, samples filtered through 25 mm 1.6 µm glass membrane with vacuum pump. Filters dried in covered glass or aluminum foil petri dishes within hood.





Sample Housing



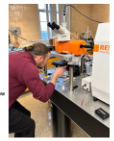
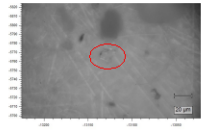


Image 1 (left). The novel steel and Teflon housing minimizes sample contamination post-filtration and allows for in-situ confocal Raman spectroscopy without opening the sample housing.

Image 2 (right). Renishaw inVia Qontour microscope at 532 nm with an 1,800/mm grating, and an Olympus 50X ultra long working distance objective identified Sigma Aldrich Monodisperse polystyrene latex particles (10 µm) that were first diluted and then spiked.

Tissue Samples



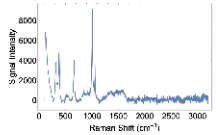


Figure 4. Preliminary testing of Raman spectroscopy analysis of particles of interest. One particle (left) was located and analyzed via a Raman spectrometer and was subsequently identified as a plastic polymer based on peak intensities and wavelengths.

Microplastics and human health

NYU Langone Health

NYU Children's Health & Environment Study (CHES)

- Prospective birth cohort
- Ongoing enrollment beginning in 2016
- N ~ 3000 enrolled
- NYU affiliate hospitals in Manhattan & Brooklyn
- Eligibility: 18 or older, <18 weeks gestation, pregnancy not medically threatened, planning to deliver study hospital

ECHO

NYU Langone Health
NYU CHES
Children's Health and Environment Study

Microplastics and human health

NYU Langone Health

Aim 2

Identify sociodemographic, dietary, behavioral and other lifestyle factors that predict exposure to microplastic particles and fragments during pregnancy.

- Age
- Race/ethnicity (culturally-driven variation in diet, personal care product use and other lifestyle factors)
- Socioeconomic position (income, education, insurance)
- Diet: drinking water type & source, honey, sugar, fish & seafood, dairy products, hot tea, packaged foods.
- Frequency of take-out food
- BMI
- Smoking & vaping
- Vitamin, supplement, medication use

- Plastic dental devices (braces, invisible braces, retainers, mouthguards, recent fillings/crowns)
- Masks due to Covid-19
- Implantable medical devices (artificial joints, breast implants)
- Drug delivery systems (insulin pumps)
- Leave on cosmetics (BB creams, sunscreens)
- Salt and spices
- ***Air concentrations!***

Microplastics and human health

NYU Langone Health

Aim 3

Characterize patterns of joint exposure to microplastics measured in placenta tissue and bisphenol and phthalate additives measured in maternal urine during pregnancy (n=100)

- **Plastic additives** used to enhance properties of products (strength/flexibility)
- Polycarbonate plastics, thermal papers, epoxy resins, food packaging, **PVC flooring**, medical devices, pharmaceuticals, perfumes, lotions, cosmetics, etc.
- **Leach** from products
- **Endocrine disrupting properties**
- Ubiquitous **human exposure**
- MPs may be vector for **bisphenol/phthalate exposure** or could have cumulative/synergistic toxicity
- In CHES: **maternal urinary bisphenol and phthalates** measured during pregnancy by HPLC-MS/MS

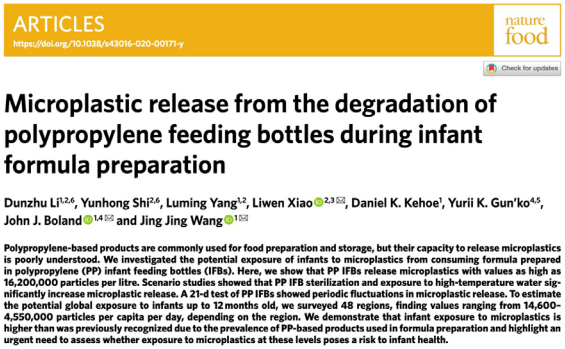
Microplastics and human health

NYU Langone Health

Future directions

Other environmental media relevant to human exposure:

- Baby formula heated in plastic bottles
- Breast milk pumped through plastic tubing
- Pacifiers
- Recent reports suggest plastic baby bottles can release over 16 million plastic particles per liter of formula with unknown consequences for the infant →



ARTICLES

https://doi.org/10.1038/s43016-020-00171-y

nature food

Check for updates

Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation

Dunzhu Li[1,2,6], Yunhong Shi[2,6], Luming Yang[1,2], Liwen Xiao[2,3]✉, Daniel K. Kehoe[1], Yurii K. Gun'ko[4,5], John J. Boland[1,4]✉ and Jing Jing Wang[1]✉

Polypropylene-based products are commonly used for food preparation and storage, but their capacity to release microplastics is poorly understood. We investigated the potential exposure of infants to microplastics from consuming formula prepared in polypropylene (PP) infant feeding bottles (IFBs). Here, we show that PP IFBs release microplastics with values as high as 16,200,000 particles per litre. Scenario studies showed that PP IFB sterilization and exposure to high-temperature water significantly increase microplastic release. A 21-d test of PP IFBs showed periodic fluctuations in microplastic release. To estimate the potential global exposure to infants up to 12 months old, we surveyed 48 regions, finding values ranging from 14,600–4,550,000 particles per capita per day, depending on the region. We demonstrate that infant exposure to microplastics is higher than was previously recognized due to the prevalence of PP-based products used in formula preparation and highlight an urgent need to assess whether exposure to microplastics at these levels poses a risk to infant health.

- Many studies of aquatic and murine species have linked plastic particles with reduced prenatal growth and placental vascular lesions
- No large human studies of microplastics and these endpoints
- NYU collects data on:
  - **Fetal biometry**: head circumference, abdominal circumference, femur length, biparietal diameter, EFW
  - **Birth anthropometrics**: head circumference, length, weight
  - **Birthweight/placental weight ratio** (BWPW): indicator of placenta ability to maintain adequate nutrient supply to the fetus. Relatively small placentas associated with fetal growth restriction
  - **Chorionic vascular "fit"**: measure of the chorionic plate and vessels that indicates functionally compromised placentas. "Fit" defined as the ratio of the area of the vascular to the full chorionic surface area.

Microplastics and human health

HARVARD UNIVERSITY

A pilot study to investigate a potential role of microplastic in ulcerative colitis and Crohn's disease

Joshua Korzenik, MD
Brigham & Women's Hospital
Harvard Medical School

Charles Rolsky, PhD

- UC and CD are chronic inflammatory diseases of the intestine which are considered autoimmune, but the etiology remains uncertain.
- **May not be that MPs are the primary causative agent of these diseases but may have a role modifying influence on severity and persistence of disease.**
- MPs may exert a proinflammatory effect in both diseases.
- Will investigate if there might be an association to explore the nature of how MPs influence the CD and UC.
- Inflammation in these diseases, which cell types might be involved and potential pathways of how microplastics may be involved in the pathophysiology of these diseases will be studied.

Microplastics and human health

HARVARD UNIVERSITY

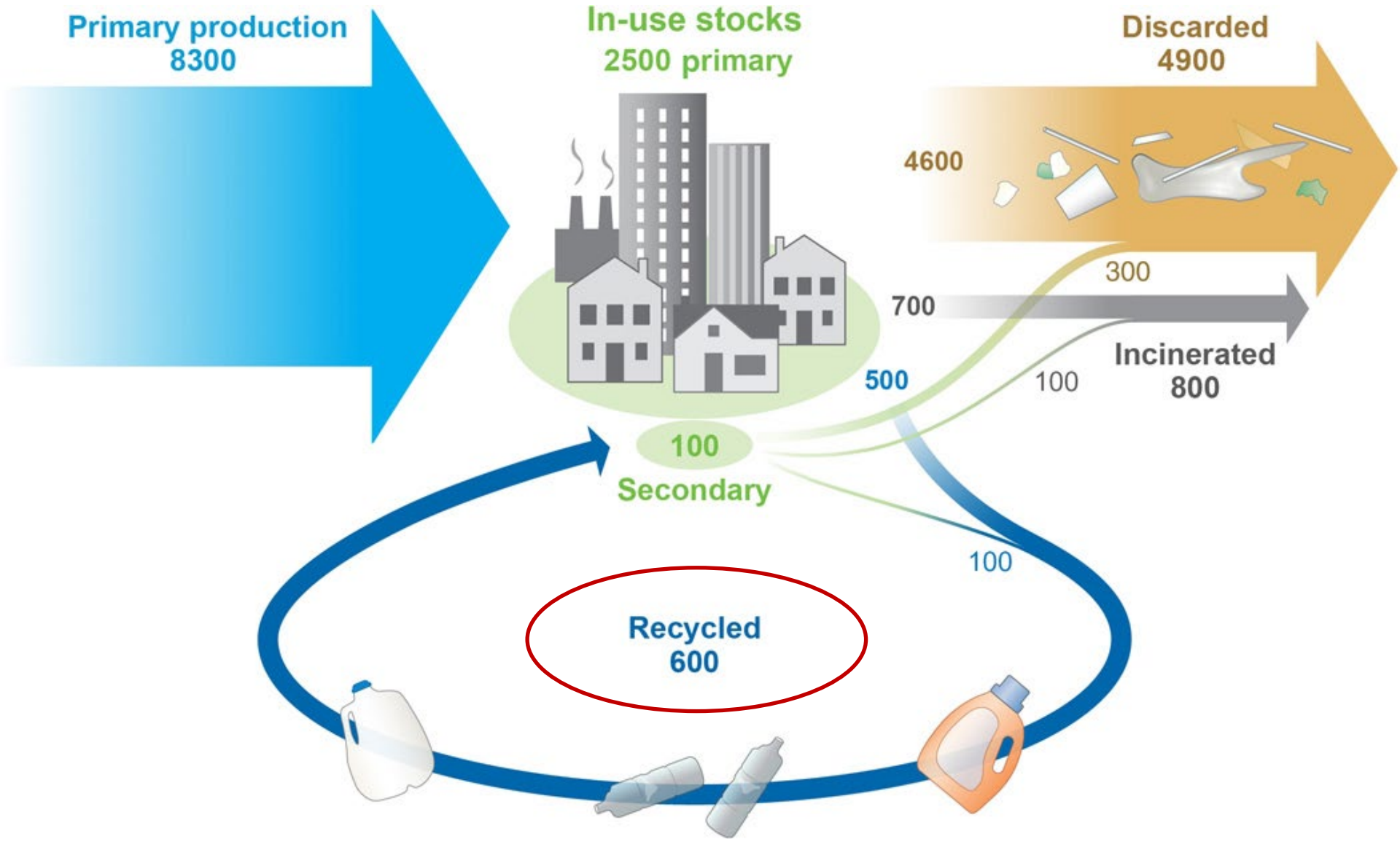
A pilot study to investigate a potential role of microplastic in ulcerative colitis and Crohn's disease

Joshua Korzenik, MD
Brigham & Women's Hospital
Harvard Medical School

Charles Rolsky, PhD

- Will obtain intestinal samples from 3 different subgroups of patients: ulcerative colitis (UC), Crohn's disease (CD), and diverticular disease (DD) (n=60 total since exploratory)
- Includes patients with cancer as well

How did we get here?



Geyer, Roland, Jenna R. Jambeck, and Kara Lavender Law. "Production, use, and fate of all plastics ever made." *Science advances* 3.7 (2017): e1700782.


cholesterol, dietary fiber, vitamin D, calcium and iron.
*%DV = % Daily Value
GLUTEN FREE
NO CAFFEINE
MANUFACTURED FOR:
BA Sports Nutrition, LLC
New York, NY 11357
BPA FREE
PLEASE RECYCLE
210415.006
REFRIGERATE
AFTER OPENING
CA CRV, CTRV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greenwashing

[grəən-wash-ing] */verb*

1. Is a term used to describe the marketing tactics used by big-name, fast-fashion companies to advertise their new supposed sustainable lines of clothing.

2. The process of conveying a false impression or providing misleading information about how a company's products are more environmentally sound.

Laundry and dish detergent pods

- **Green circle** - The chemical has been verified to be of low concern based on experimental and modeled data.
- **Green half-circle** - The chemical is expected to be of low concern based on experimental and modeled data. Additional data would strengthen our confidence in the chemical's safer status.

Code	Common Name	CAS Registry Number	Functional Use
	Polyvinyl alcohol	9002-89-5	Polymers

among the safest available for a particular function, the function fulfilled by the chemical should be considered an area for safer chemistry innovation.

- **Grey square** - This chemical may not be acceptable for use in products that are candidates for the Safer Choice label and any currently certified products that contain it may need to reformulate per Safer Choice Compliance Schedules. Manufacturers are invited to provide information to justify continued listing of this chemical on SCIL and use in Safer Choice-certified products. Unless information provided to EPA adequately justifies continued listing, this chemical will be removed 12 months after grey square designation.

PVA work continues

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Degradation of Polyvinyl Alcohol in US Wastewater Treatment Plants and Subsequent Nationwide Emission Estimate

by Charles Rolsky [1,2,*,†] and Varun Kelkar [1,3,†]

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Figure 2. Mass balance of PVA in a conventional activated sludge treatment plant, considering clarifier efficiencies and biodegradation efficiencies. Numbers in red indicate the percentage of PVA in respective treatment streams, and numbers in green represent the amount (% absolute) of degraded PVA in respective sections. RAS and WAS represent return activated sludge and waste activated sludge, respectively. Numbers in parentheses represent the degradation efficiencies of respective sections.

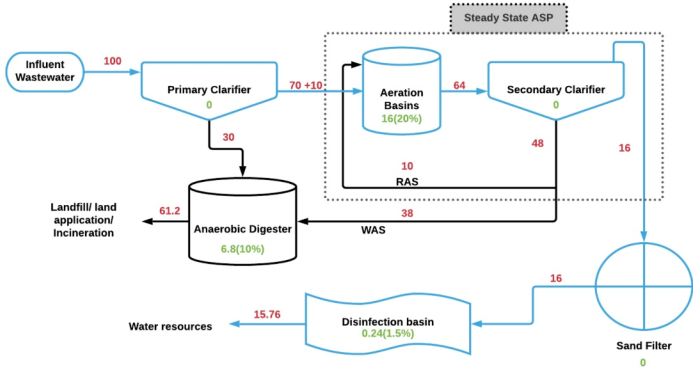
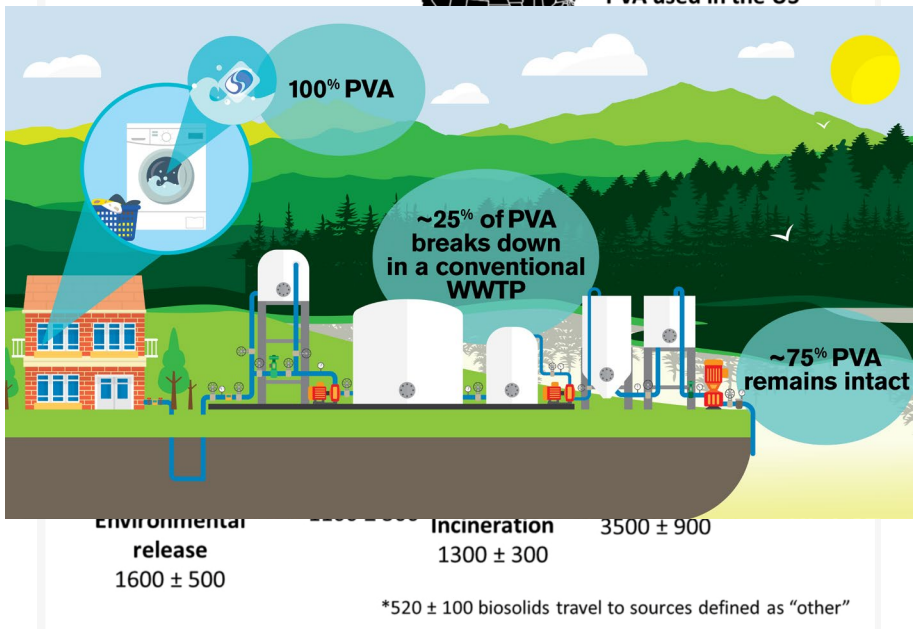


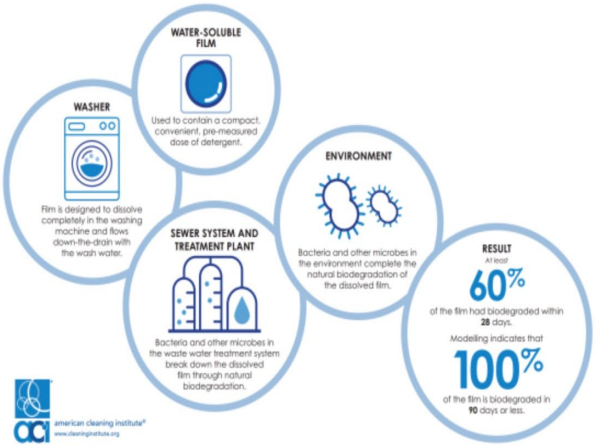
Figure 4. Modeled PVA usage and emissions in metric tons per year (mtu/yr) in the US.



Shaw Institute

Attack on Detergent Packets Ignores Decades of Evidence on Film Biodegradability

07/27/2021



American Cleaning Institute Statement: Misinformation Campaign on Valuable Chemistry Used in Detergent Products

11/15/2022

PVA work continues

ADWEEK

Sustainability https://www.adweek.com/category/sustainability/)

Laundry Pods and Sheets Are Exploding in Popularity. But Are They Safe?

More than 75% of 'dissolvable' plastics end up in the environment

By Kathryn Lundstrom | 4 hours ago

The plastic in pods and sheets dissolves in a lab. Will it dissolve in nature?

Credit: Kacy Burdette

Maybe you've seen the ads on Instagram: Little sheets of concentrated laundry detergent avoid the need for a big plastic jug of liquid soap.

Instead, these perforated sheets come nestled in plastic-free cardboard packaging. Their ads https://www.youtube.com/watch?v=c9m0Uh130eI) describe them as the most "environmentally responsible way to do your laundry."

The Washington Post

The Washington Post
Democracy Dies in Darkness

Does the film around detergent pods really biodegrade? A debate is raging.

A cleaning-products company and anti-plastics groups are asking the EPA to assess the safety of polyvinyl alcohol, which encases detergent pods

By Allyson Chiu

November 15, 2022 at 9:00 a.m. EST

Ban, recycle, or replace.

What's the solution?

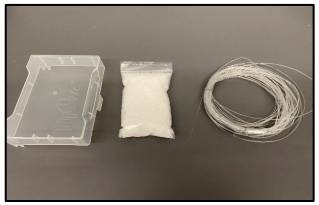
“We need plastics, we don‘t need toxins or waste”

It’s complicated!

…and that’s okay

Three things that I’m excited about

1. Above ground mining



2. Materials science

3. Proper recycling

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Questions?