

# The Science of PFAS:

Defining the Class of Chemicals, Health Effects, and Human Exposures

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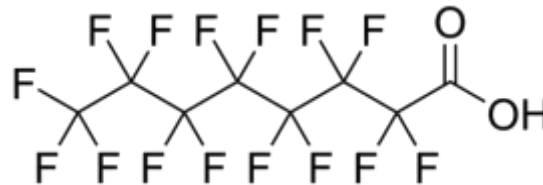
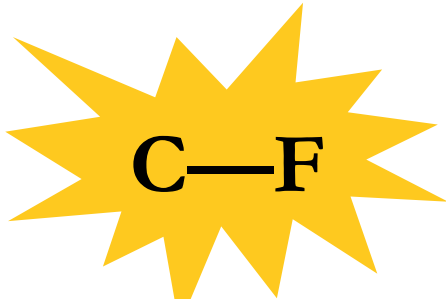
Rashmi Joglekar, PhD

ELI Webinar

June 13<sup>th</sup>, 2024

# PFAS: Per- and poly-fluoroalkyl substances

- Chemical class of over 15,000 substances
- Per- and poly-fluoroalkyl differ in structure
- Shared characteristics:
  - Carbon—Fluorine bond(s)
  - All chemicals are highly persistent
  - Studied PFAS are toxic
  - Highly mobile in air, water, & soil
  - Many bioaccumulate in living organisms



# PFAS: Per- and poly-fluoroalkyl substances are persistent

**Table 1-1. Summary of Estimated Elimination Half-lives for Select Perfluoroalkyls**

	Humans	Nonhuman primates	Rats	Mice
PFOA	<b>2.1–10.1 years</b>	20.1–32.6 days	Males: 44–322 hours Females: 1.9–16.2 hours	
PFOS	<b>3.3–27 years</b>	110–170 days	179–1,968 hours	731–1,027 hours
PFHxS	<b>4.7–35 years</b>	87–141 days	Males: 382–688 hours Females: 1.03–41.28 hours	597–643 hours
PFNA	<b>2.5–4.3 years</b>		Males: 710–1,128 hours Females: 33.6–58.6 hours	619.2–1,653 hours
PFBS	<b>665 hours</b>	8.0–95.2 hours	2.1–7.42 hours	
PFBA	<b>72–81 hours</b>	40.3–41.0 hours	1.03–9.22 hours	2.79–13.34 hours

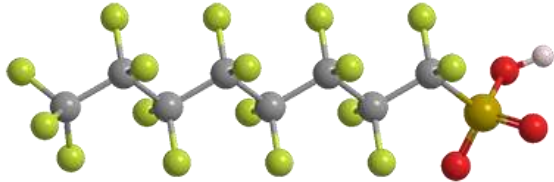
Source: ATSDR PFAS Toxicological Profile



# PFAS: Per- and poly-fluoroalkyl substances

## PFOS

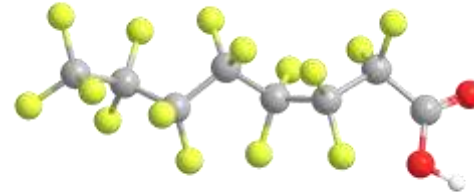
(perfluorosulfanoic acid)



- 17 C-F bonds
- Highly persistent (HHL=3-27yrs)
- Introduced in 1949 by 3M
- Highly toxic to humans and wildlife
- Found in >98% of people in US

## PFOA

(perfluorooctanoic acid)



- 15 C-F bonds
- Highly persistent (HHL=2-10yrs)
- Introduced in 1947 by 3M
- Highly toxic to humans and wildlife
- Found in >98% of people in US



# Health Effects of PFAS

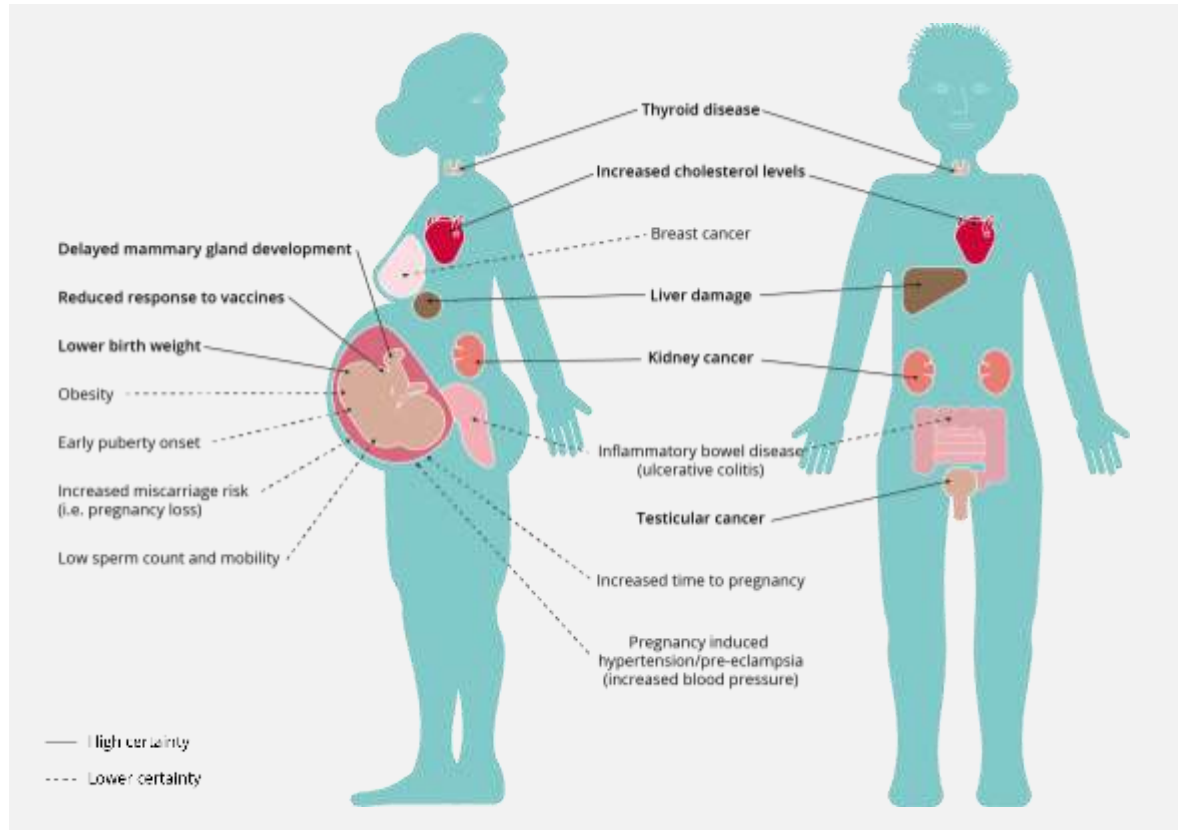


Image credit: European Environment Agency



# PFAS Exposure Routes & Pathways

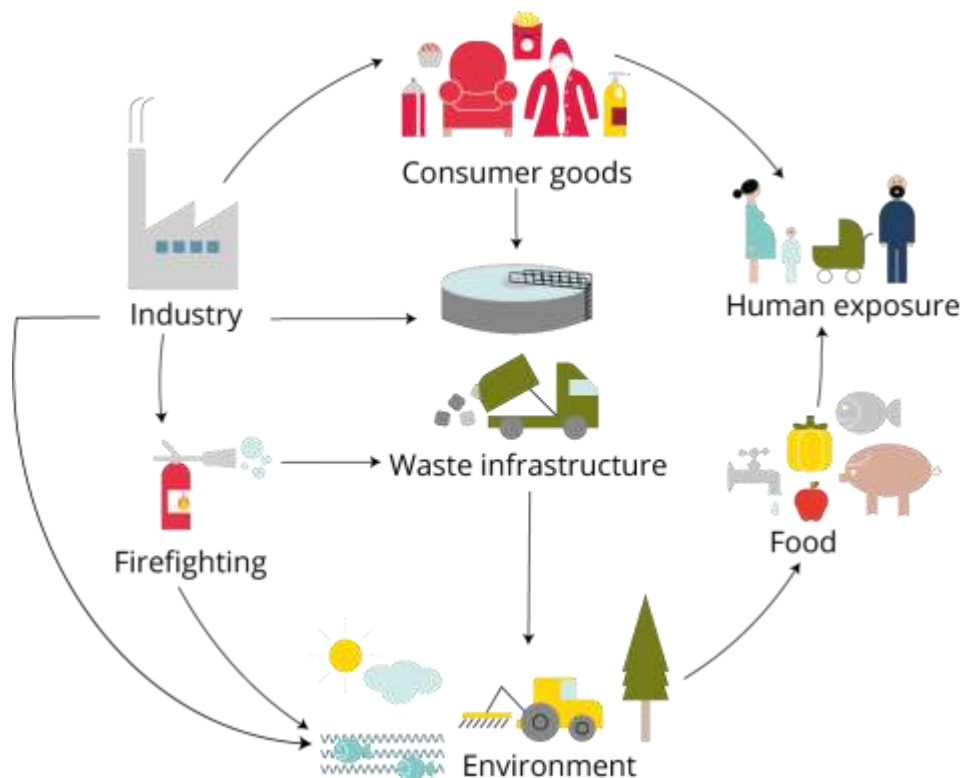
## Indoor Exposures

- Ingestion/dermal absorption of PFAS from using consumer products
- Ingestion/dermal absorption of PFAS-contaminated household dust
- Meta-analysis found 90% of US household dust samples contained PFAS

*Environ. Sci. Technol.* 2016, 50, 19, 10661–10672

## Environmental Exposures

- Land injection, water releases, air releases, landfill leachate
- Legacy exposures
- Ingestion/dermal absorption of contaminated water, soil, dust, fish
- Inhalation of PFAS released into the air via incineration, stack or fugitive emissions



# PFAS Exposure Routes & Pathways

## Indoor Exposures

- Ingestion/dermal absorption of PFAS from using consumer products
- Ingestion/dermal absorption of PFAS-contaminated household dust
- Meta-analysis of 1000 samples containing PFAS  
*Environ. Sci. Technol.*

**PFAS have been detected in all environmental media & most people living in the United States**

## Environmental Exposures

- Land injection, water releases, air releases, landfill leachate
- Legacy exposures
- Ingestion/dermal absorption of contaminated water, soil, dust, fish
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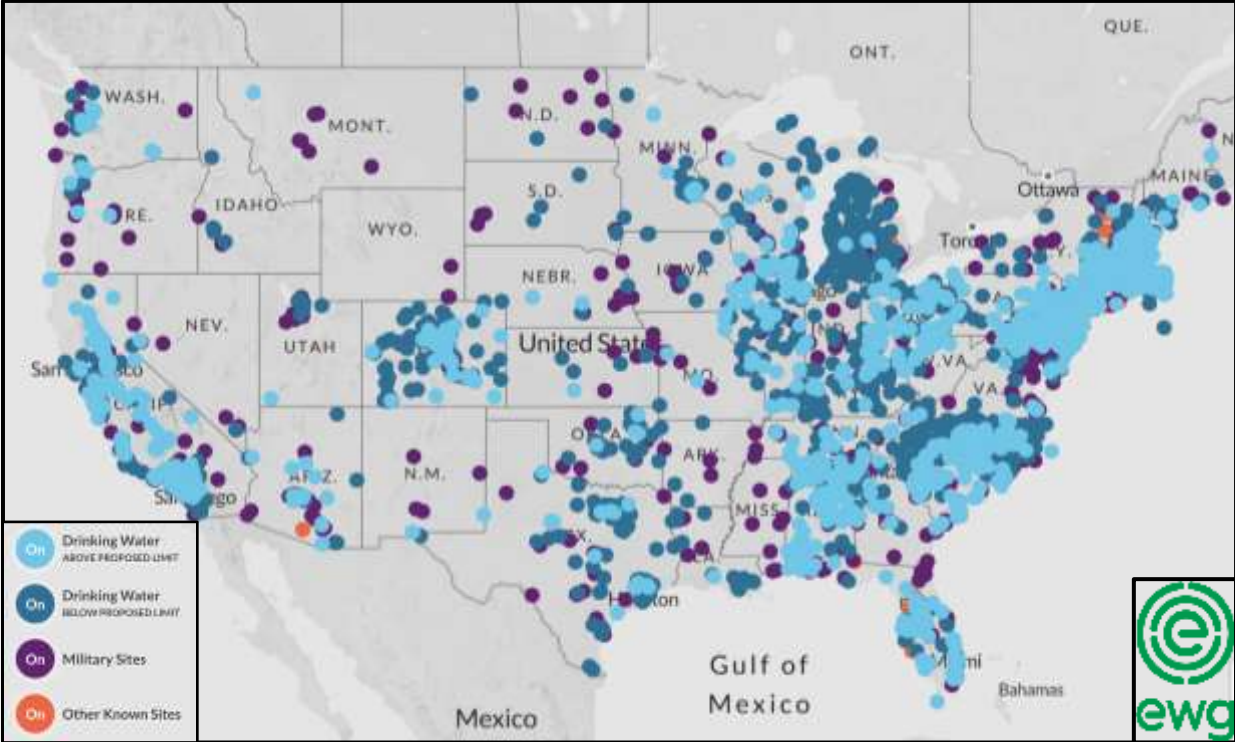
# A contamination crisis

- A recent nationwide study found that over **200 million people living in the US** likely drink water polluted with dangerous levels of PFOA and PFOS





# A contamination crisis



**>200 million**

Americans drink PFAS-contaminated water



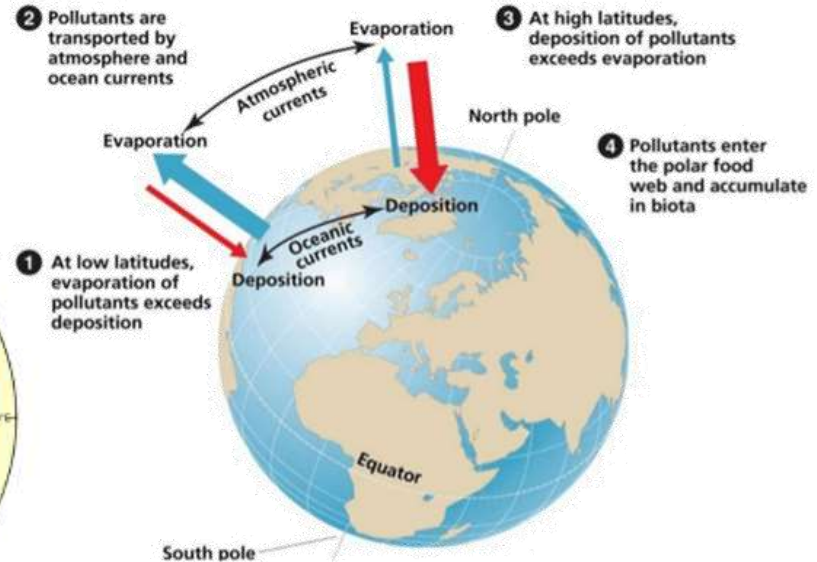
# Global Distillation of PFAS

- Persistent chemicals like PFAS travel thousands of miles and ultimately settle in the Arctic via global distillation, or the “grasshopper effect”
- Can concentrate, bioaccumulate, and biomagnify in traditional foods
- Can take thousands of years to degrade



Macdonald et al, 2005

## Transport to the Arctic: “Global Distillation”



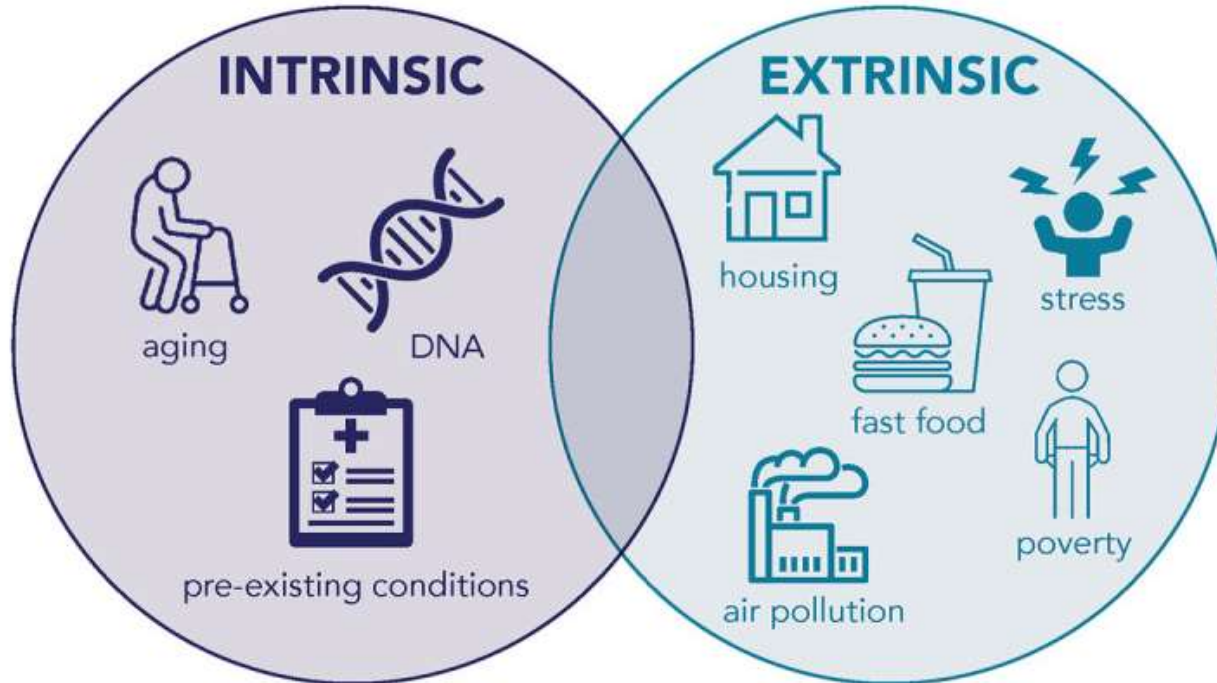
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# Disproportionate Exposures: Arctic Indigenous Peoples

- Because of global distillation, persistent organic pollutants (POPs) like PFAS are pervasive in Alaska and the Arctic
- POPs often originate from thousands of miles away, and disproportionately accumulate in people and ecosystems
- Arctic Indigenous Peoples have among highest chemical contamination on Earth, including PFAS



# Intrinsic and extrinsic risk factors of disease



No adverse outcome

Adverse outcome

Baseline risk



Baseline risk + Intrinsic Factors (e.g. age, genetics)



Baseline risk + Intrinsic Factors (e.g. age, genetics) + Extrinsic Factors (e.g., stress, racism, poverty)



Physiological parameters (e.g., blood glucose levels, blood pressure)





# Cumulative impacts

*“...the totality of exposures to combinations of chemical and non-chemical stressors, and their effects on health, well-being, and quality of life outcomes.” –US EPA*



# PFAS as a Class of Chemicals are Highly Persistent, Toxic, and Mobile



**PFAS-TOX DATABASE** Database Chemicals Health

[How to Use](#)

Search

The numbers in the heat map indicate the number of studies, not the number of significant effects. Click to select studies, click again to deselect.

Colors correspond to the study type: human in green, animal in blue, [in vitro/cell culture](#) in orange.

PFAS	Total	Metabolic & Digestive System	Body Weight, Blood Levels	Endocrine System	Systemic Toxicity/Organ Specific/Others	Reproductive System	Cell Toxicity/Mortality	Circulatory System	Nervous System & Behavior	Immune System	Urinary System	Respiratory System	Musculoskeletal System	Genotoxicity	Sensory System	Cancers
PFNA	633	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFHxS	578	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFDA	506	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFUnDA	297	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFAS mix	204	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFDODA	203	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFBS	150	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFHpA	143	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFHxA	120	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFBA	99	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFTyDA	90	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFTeDA	67	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MeFOSAA	66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFAS + other	59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFHpS	58	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFPeA	57	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EtFOSAA	49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:2 Cl-PFESA	44	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
GenX	29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFDS	24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8:2 Cl-PFESA	13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:2 FTSA	11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HFPO-TA	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ADONA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFOADA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFOSDoDA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFPeS	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nafion BP2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PFNS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1





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