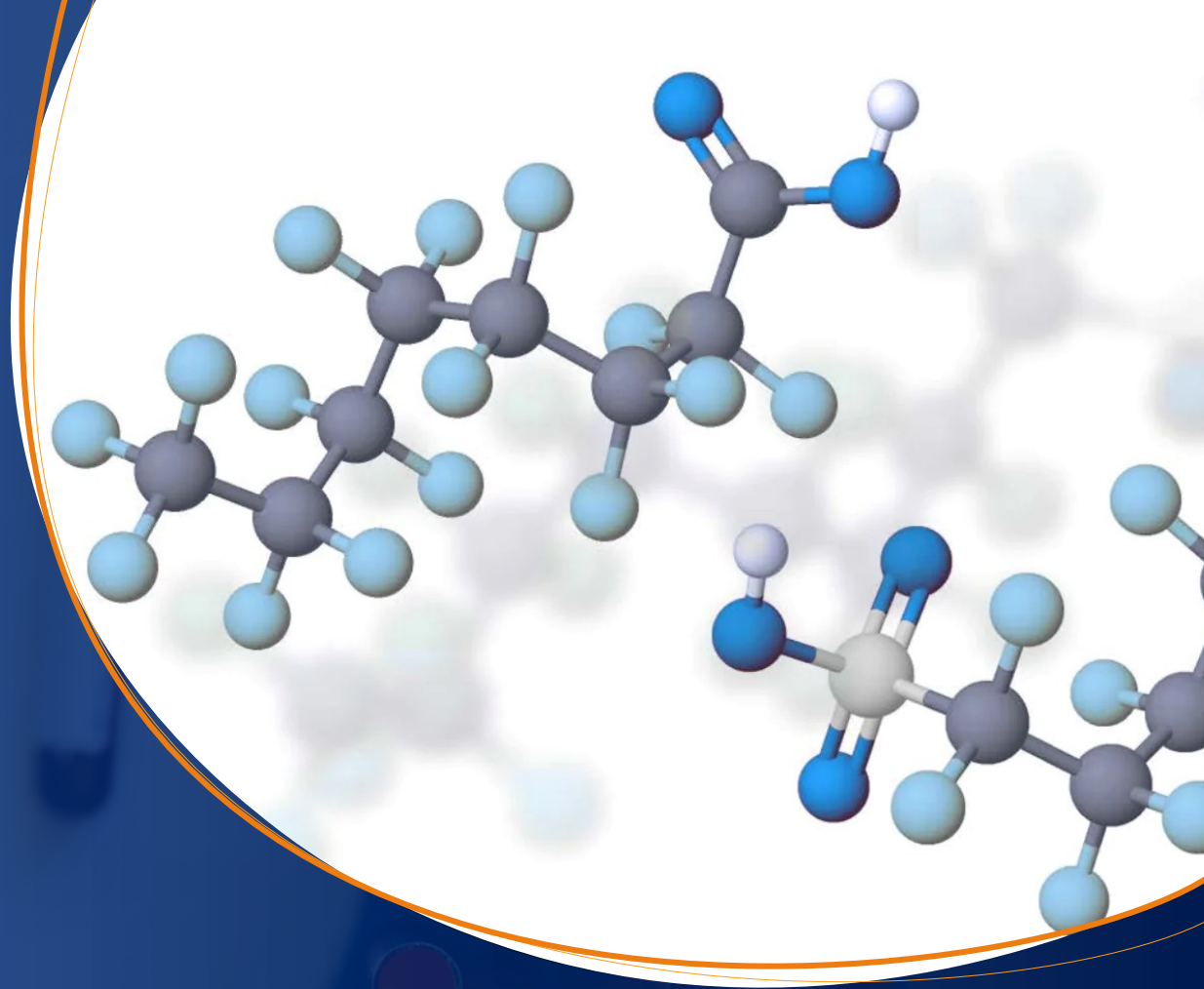
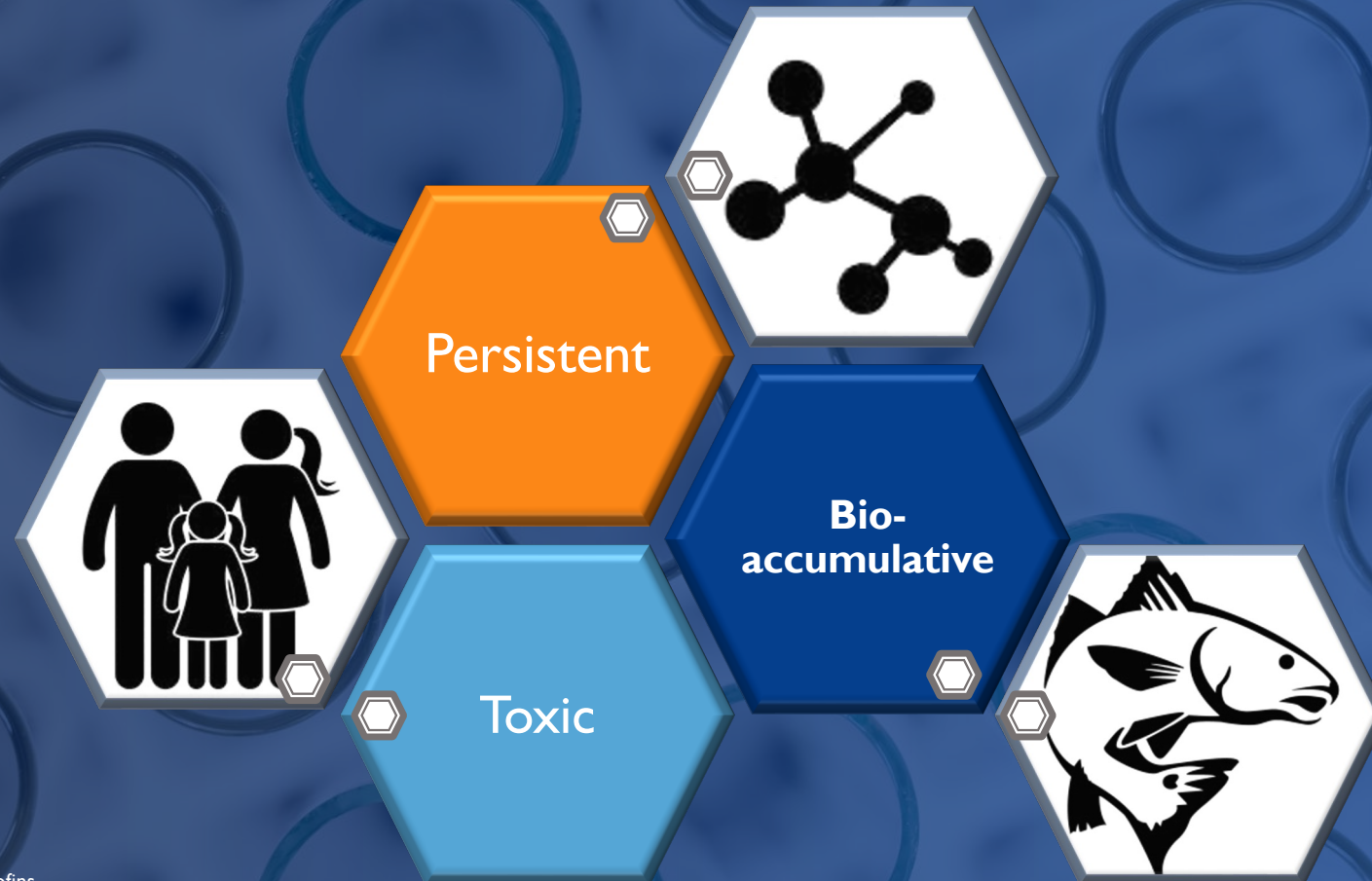


PFAS CHEMISTRY & CHALLENGES

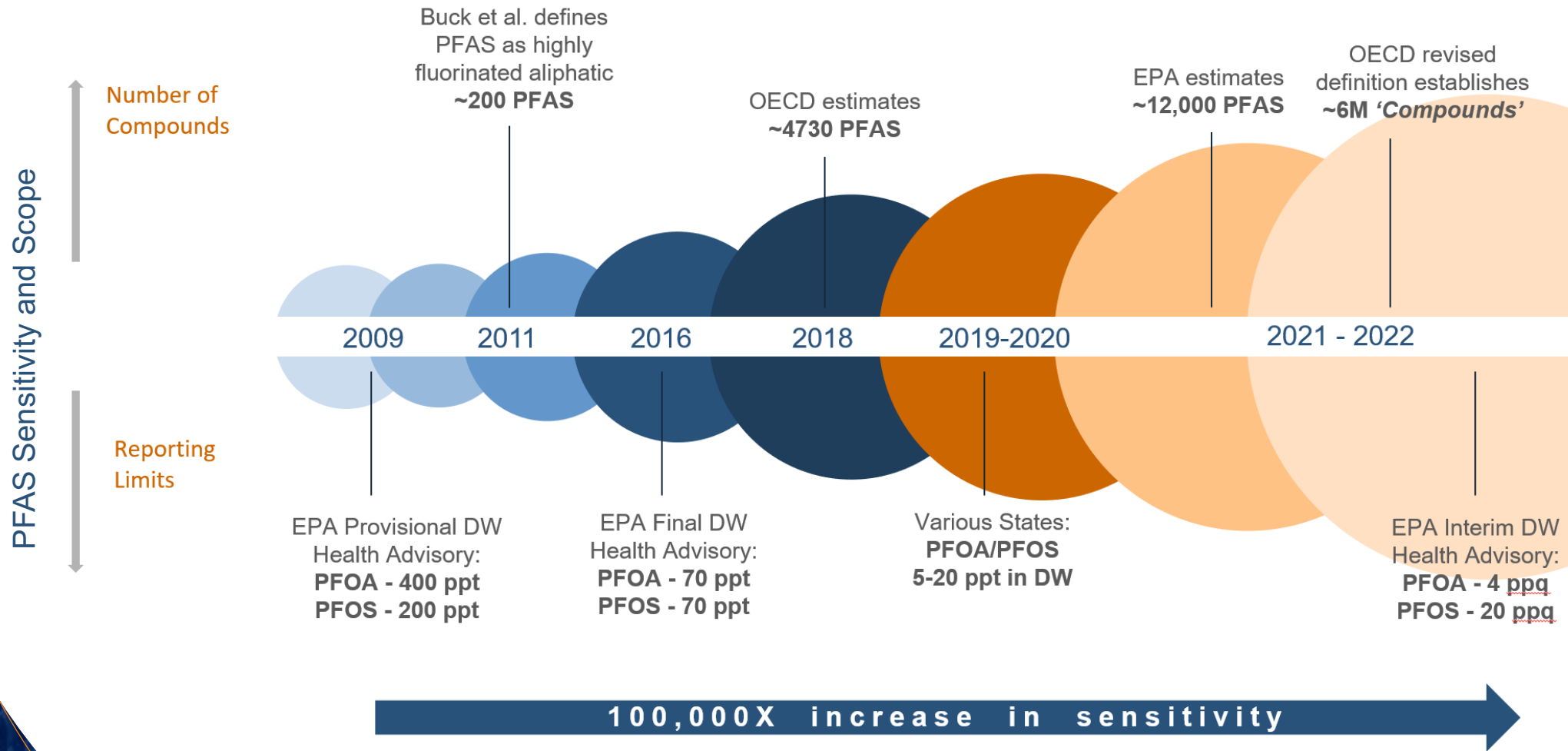


What are PFAS?

SYNTHETIC COMPOUNDS FORMED FROM CARBON CHAINS WITH FLUORINE ATOMS ATTACHED



Evolution of the Science



Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)

Non-Polymers

Perfluoroalkyl Substances

Table 2

Compounds for which all hydrogens on all carbons (except for carbons associated with functional groups) have been replaced by fluorines

- (Aliphatic) perfluorocarbons (PFCs)
- Perfluoroalkyl acids
- Perfluoroalkane sulfonyl fluorides
- Perfluoroalkane sulfonamides
- Perfluoroalkyl iodides
- Perfluoroalkyl aldehydes

Polyfluoroalkyl Substances

Table 3

Compounds for which all hydrogens on at least one (but not all) carbon have been replaced by fluorines

- Perfluoroalkane sulfonamido derivatives
- Fluorotelomer-based compounds
- Semifluorinated *n*-alkanes and alkenes

Polymers

Table 4

Fluoropolymers

Carbon-only polymer backbone with fluorines directly attached

Perfluoropolyethers

Carbon and oxygen polymer backbone with fluorines directly attached to carbon

Side-chain Fluorinated Polymers

Variable composition non-fluorinated polymer backbone with fluorinated side chains

- Fluorinated acrylate and methacrylate polymers
- Fluorinated urethane polymers
- Fluorinated oxetane polymers

<http://dx.doi.org/10.1002/ieam.258>

Polymer

Inert, Non-soluble, Non-toxic, Non-bioavailable

Non-Polymer

Water-soluble, Mobile, Bioavailable, Toxic

Perfluoro

Completely fluorinated, stable

Polyfluoro

Incompletely fluorinated, biotransform

will

Used in the production of

Polymer vs. Non-Polymer

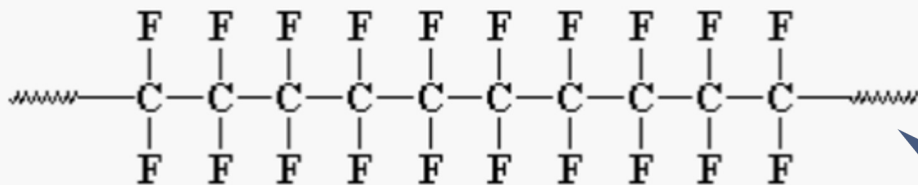
polymer

chemistry

By The Editors of Encyclopaedia Britannica • Edit History

polymer, any of a class of natural or synthetic substances composed of very large molecules, called macromolecules, that are multiples of simpler chemical units called **monomers**.

Polytetrafluoroethylene (PTFE)



10s to 100s of thousands of repeating monomers

Polymers are large, stable, inert polymeric molecules that are too large to cross biological membranes and are therefore non-bioavailable and non-bioaccumulative

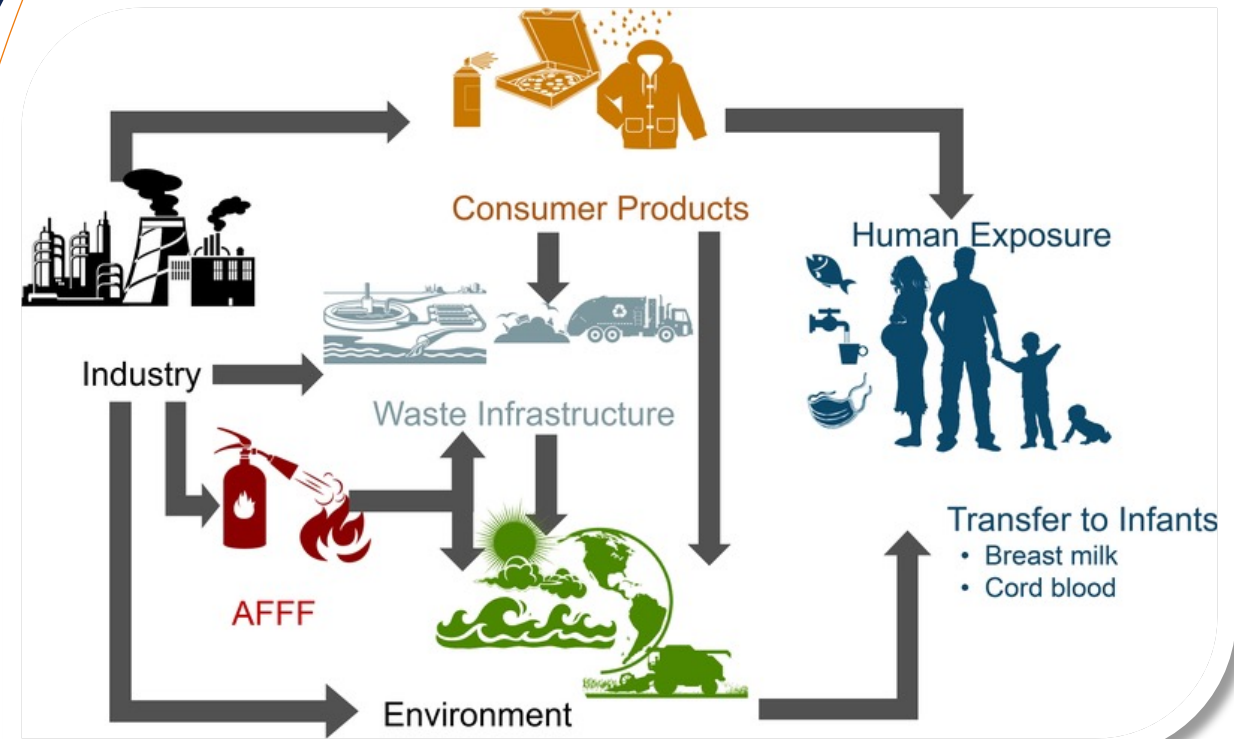
Examples of Polymers vs Non-Polymers

- Side-Chain Fluorinated Polymers
- Perfluoropolyether (PFPE)
- Fluoroplastics (PTFE, PVDE)
- Fluoroelastomers
- Specialty Fluoroplastics

- PFOA
- PFOS
- PFBA
- HFPO-DA (GenX)
- PFNA
- 6:2FTS
- 6:2diPAP

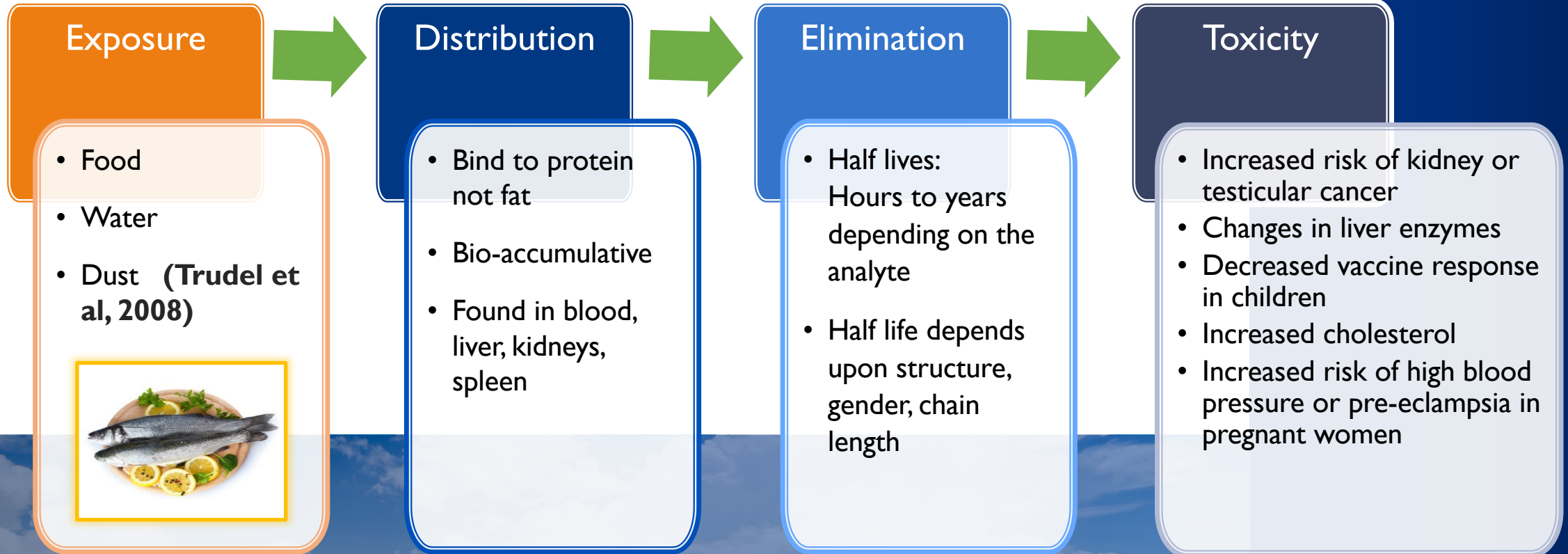
How are we exposed to them?

- Industrial Discharges
- Application of AFFF
- Waste Infrastructure
- Land Application of Biosolids
- Ambient and Indoor Air
- Indoor Dust
- Consumer Good Usage



Source: Sunderland et al. (2019)
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6380916/>

The Risk of Non-Polymers



TOXICITY ASSESSMENTS



Date	Status	Analyte	RfD (mg/kg/day)	Lifetime Health Advisory Limit (ng/L)
2016	Final	PFOA/PFOS	0.00002	70
2022	Interim	PFOA	0.00000000015	0.004
2022	Interim	PFOS	0.00000000079	0.02
2022	Final	HFPO-DA (GenX)	0.000003	10
2022	Final	PFBS	0.00003	2,000

https://iris.epa.gov/AtoZ/?list_type=alpha

https://sab.epa.gov/ords/sab/f?p=100:19:14408101720086:::RP,19:P19_ID:963

PFOA
&
PFOS
 Revisited
 &
 Revised

SCOPE OF STATE LEGISLATIVE ACTIONS

“PFAS means any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom”

This includes polymers

AFFF	Textiles	Juvenile Products	Food Packaging	Misc
<ul style="list-style-type: none"> • Prohibits use for training • Restricts use, capture and disposal after incident • Prohibits the manufacture or sale of PFAS containing foams 	<ul style="list-style-type: none"> • Carpeting, rugs, upholstered furniture, textile furnishings, fabric treatments • Requires disclosure about protective equipment 	<ul style="list-style-type: none"> • Booster seats, changing pads, crib mattress, nursing pillow, infant carrier, mouthable products 	<ul style="list-style-type: none"> • Bans manufacture, sale or distribution of wraps, liners, plates, boxes, plant-based food packaging 	<ul style="list-style-type: none"> • Cosmetics • Cleaning products • Requires disclosure about cookware

Product Certification Drivers



**BIODEGRADABLE
PRODUCTS
INSTITUTE**

- 1) The product formula must not contain fluorinated chemicals — as evidenced by safety data sheets for all ingredients.
- 2) Test results from a BPI-Approved lab showing a maximum of 100ppm total organic fluorine.
- 3) A statement of no intentionally added fluorinated chemicals, signed by the manufacturer.

[https://www.bpiworld.org/Fluorinated-Chemicals-\(PFAS\)](https://www.bpiworld.org/Fluorinated-Chemicals-(PFAS))

*Is
paper/board
coated in
PFAS really
compostable?*



Public Perception Drivers

Toxics Group Spurs Nationwide Efforts to Ban PFAS in Packaging

The Home Depot bans PFAS-treated carpets [Share](#)

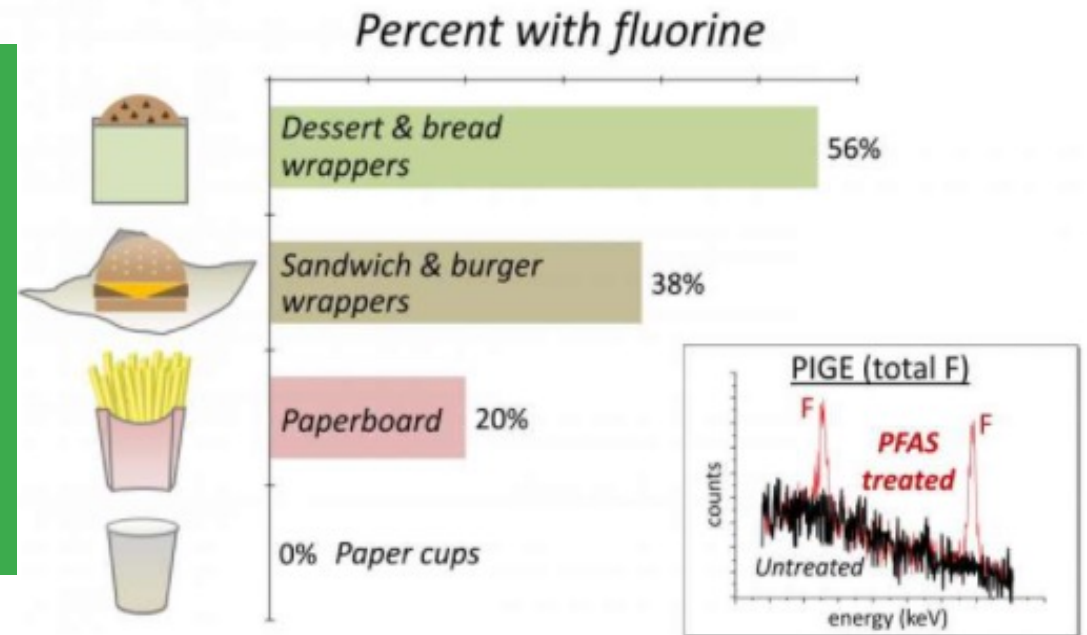
Home improvement retailer says policy will minimize the environmental impact of the products it sells

The bowls at Chipotle and Sweetgreen are supposed to be compostable. They contain cancer-linked “forever chemicals.”




Fast food packaging contains potentially harmful chemicals that can leach into food

by Silent Spring Institute



Legislative Language in PFAS Bans

intentionally adverb

 Save Word


in·ten·tion·al·ly | \ in-'tench-nə-lē , -'ten(t)-shə-nəl-ē \

Definition of *intentionally*

: in an [intentional](#) manner : with awareness of what one is doing : [PURPOSELY](#)

unintentional adjective

 Save Word

un·in·ten·tion·al | \ ,ən-in-'tench-nəl, -'ten(t)-shə-nəl  \

Definition of *unintentional*

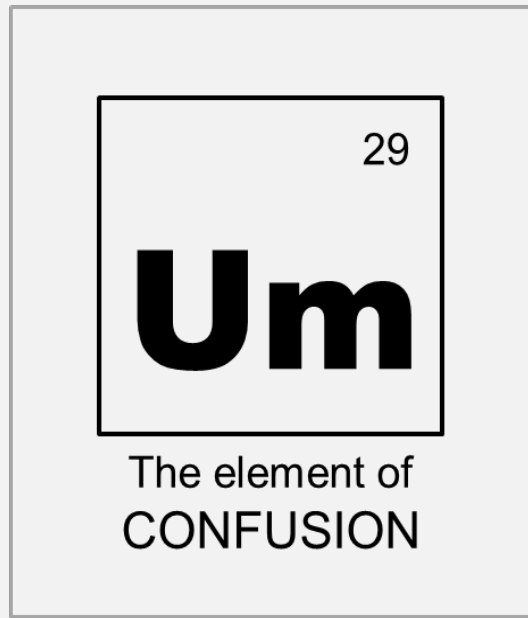
: not done by [intention](#) or design : not [intentional](#)

Intentionally
Added
vs.
Unintentionally

What Will Compliance Look Like?

Batch testing?

Will we measure for Fluorine?



PFAS not listed on SDS

At what limit?

“no party shall manufacture, sell or distribute food packaging materials containing intentionally added PFAS”