# Understanding and predicting the Properties and Behavior of PFAS in Food Packaging

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# Many factors influence the occurrence of PFAS in food

**PRODUCTION**

**PROCESSING**


**DISPOSAL**


**PACKAGING**

photo sources: [1-3].

# Today's focus: intentional use, particularly in FCM*


**PACKAGING**

*Food Contact Materials

# PFAS in food packaging

What do we need to know?

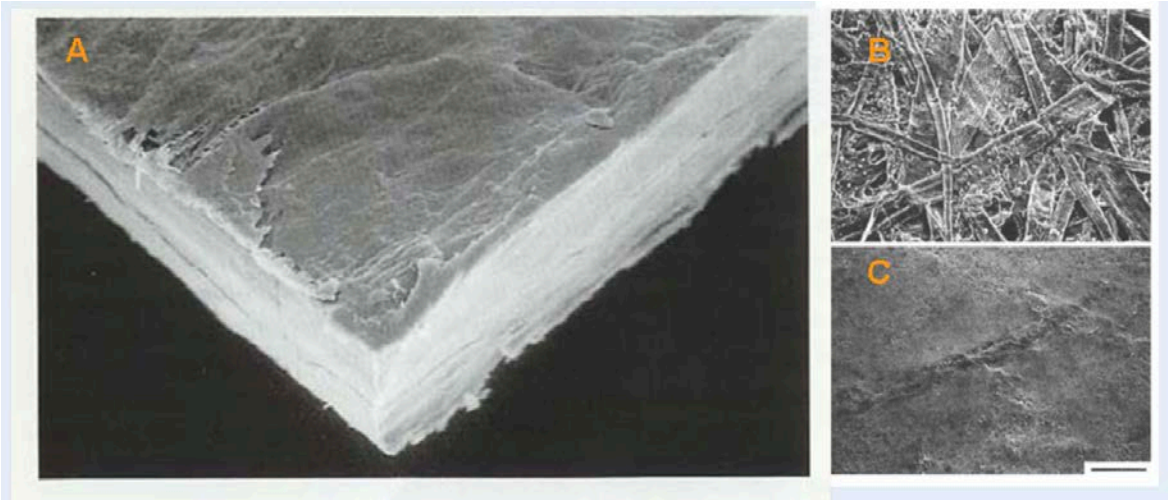
1. How PFAS transfer from packaging to food (migration).
2. How/whether PFAS transform within packaging and/or food.
3. Whether specific PFAS used in food packaging are bioavailable, bioaccumulative, and/or bioactive.

These will depend on the identity and properties of the PFAS present.

# Identity: Which PFAS are used in food packaging?

- Many of the PFAS used in FCM are classified as polymers.
- Some are film-type barriers.
- Many are “sizing” compounds for grease-proofing paper products.

- Difficult to find public information about structures and composition.
- FDA inventory of food contact substance notification (FCN) provides some data, but no structures or composition.




Scanning electron photomicrograph of the surfaces of B) surface sized and C) coated paper. Scale bar : 50 µm. The illustration is modified from The Chemistry of Paper, Roberts (1997).

Image source: Trier, X., et al. 2017 [4].

# Example of an FCN

## FCN No. 1676
## Asahi Glass Co., Ltd.
## AGC Chemicals Americas, Inc.

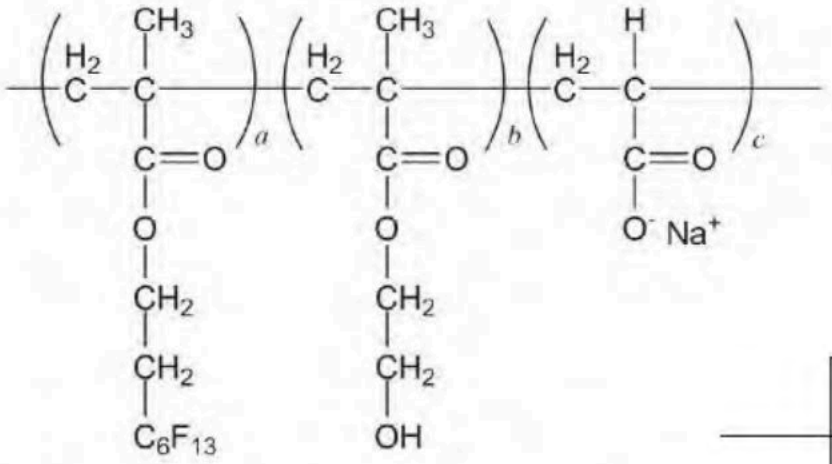
According to Section 409(h)(1)(C) of the Federal Food, Drug, and Cosmetic Act, food contact substance notifications (FCNs) are effective only for the listed manufacturer and its customers. Other manufacturers must submit their own FCN for the same food contact substance and intended use.

| | |
|---|---|
| **Food Contact Substance:** | 2-propenoic acid, 2-methyl-, 2-hydroxyethyl ester, polymer with 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt (CAS Reg. No. 1878204-24-0). |
| **Notifier:** | AGC Chemicals Americas, Inc. |
| **Manufacturer/Supplier:** | Asahi Glass Co., Ltd.<br>AGC Chemicals Americas, Inc. |
| **Intended Use:** | As an oil, water and grease proofing agent in paper and paperboard, except for use in contact with infant formula and breast milk (see Limitations/Specifications). |
| **Limitations/Specifications*:** | For use at a maximum level of 1.2 % by weight of the finished paper, in contact with all food types under Conditions of Use B through H, as described in Table 2. The FCS is not for use in contact with infant formula and breast milk. Such uses were not included as part of the intended use of the substance in the FCN. |
| **Effective Date:** | Sep 21, 2016 |
| **National Environmental Policy Act (NEPA)** Submission:** | Categorical Exclusion 25.32(i) |
| **FDA Decision:** | Categorical Exclusion Memo |

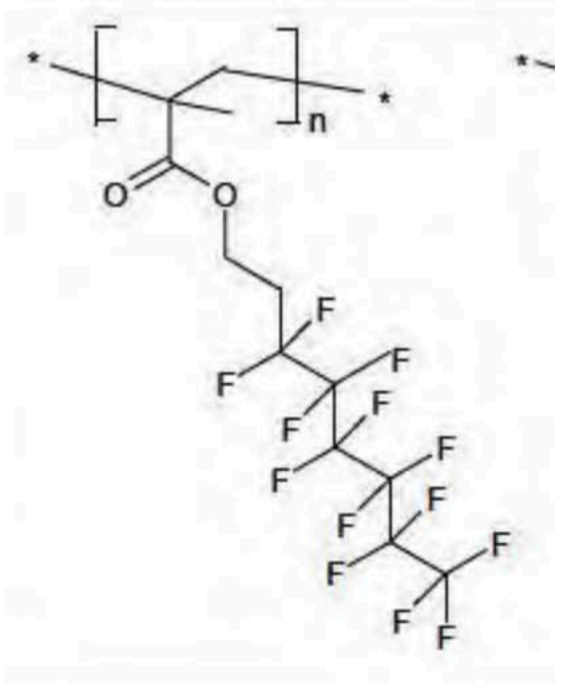
Source: FDA [5].

# Three PFAS FCS examples (from EDF FOIA request*)

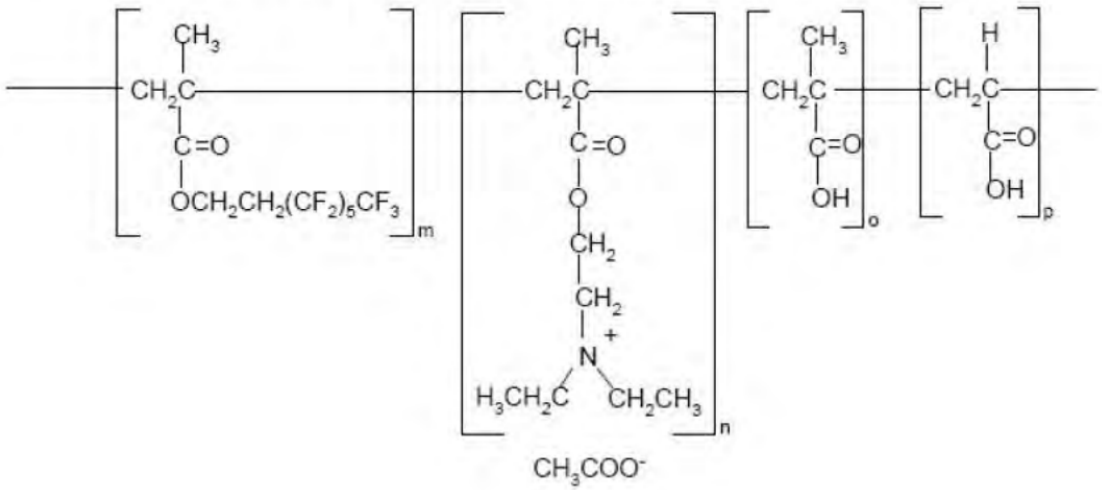
FCN 1676



FCN 1493



FCN 885

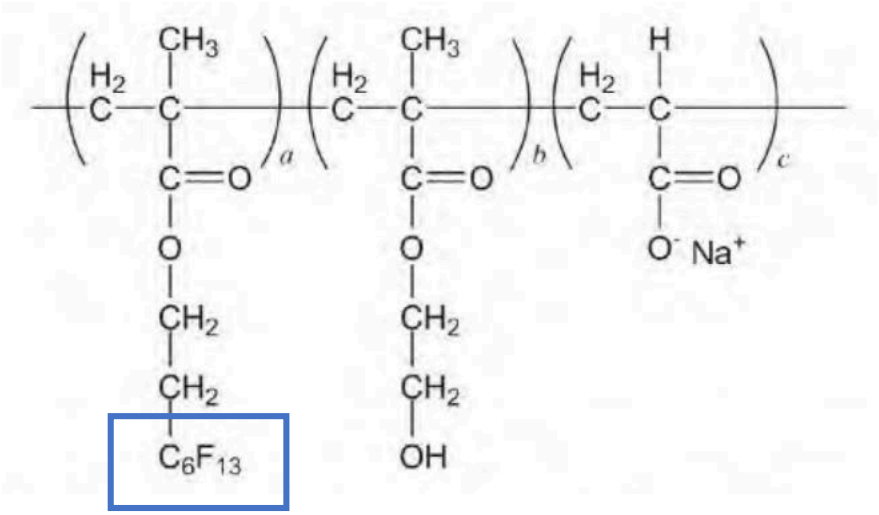


* https://www.edf.org/sites/default/files/EDF-PFAS-FOIA-FCN-Chemistry-Memos.pdf

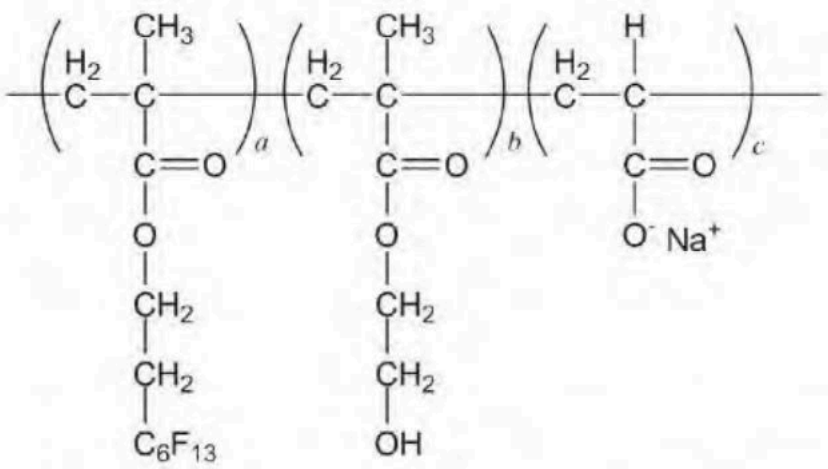
# What is known about their *properties*?

- Let's use as an example one of the polymers from the previous slide.
- Like the other two substances, it is a *side-chain fluorinated polymer*.

FCN 1676



# Fluoropolymer behavior in food packaging




- Industry argues that fluoropolymers are substances of low concern because they are not bioavailable.

Even if we accept this argument for the polymer itself, three potential routes remain for PFAS to enter food:

- Migration of residual monomer.
- Migration of PFAS impurities.
- Degradation of polymer and subsequent migration to food.

# What is known about *exposure* to PFAS in packaging?

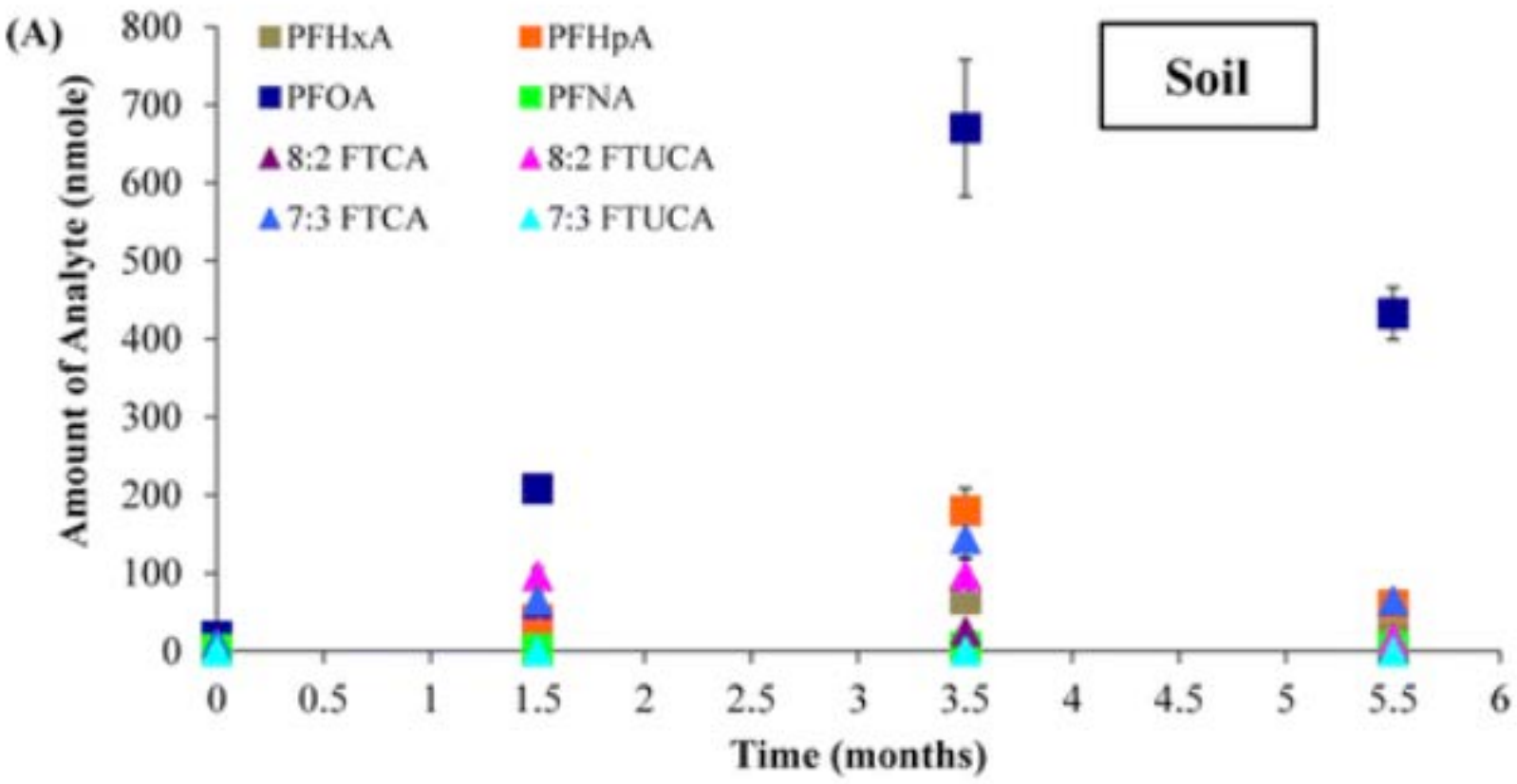
- Most industry-submitted FCNs exclude migration studies, opting instead to consider estimated daily intakes (EDI's) from the monomer residual as a "worst-case scenario."

**Exposure**

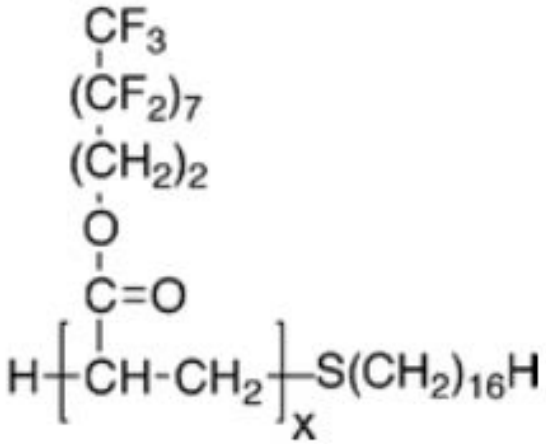
The notifier did not conduction migration experiments and instead relied on the 100 % migration calculation for the LMWOs and all impurities. The notifier's calculations are provided in Attachment 16. The dietary concentrations (DC) are reported in Attachment 7.

- But **are** these worst-case?
  - Stability testing often only takes into account heating of the FCN.
  - Exposure estimation only takes into account low-molecular-weight oligomers (LMWOs) and impurities, not degradation products.

# Recent data on fluoropolymer degradation (1)

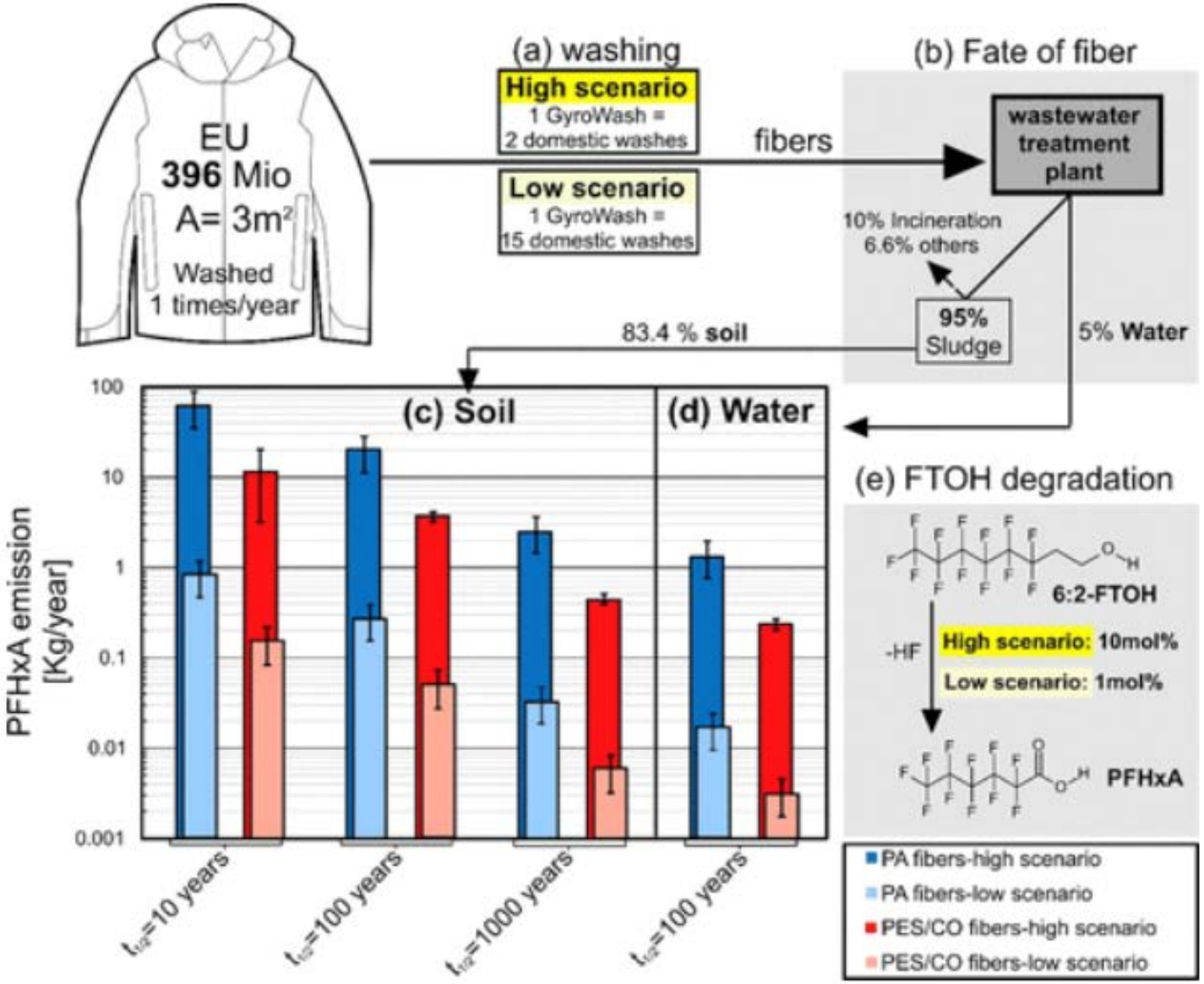



Studies clearly show that fluoropolymers can (slowly) release low molecular weight (bioavailable) PFAS into the environment.




Rankin et al. 2014 [6].

# Recent data on fluoropolymer degradation (2)




Studies clearly show that fluoropolymers can (slowly) release low molecular weight (bioavailable) PFAS into the environment.

What about food contact material?

Schellenberger et al. 2019 [7].

# Evidence of exposure from food packaging

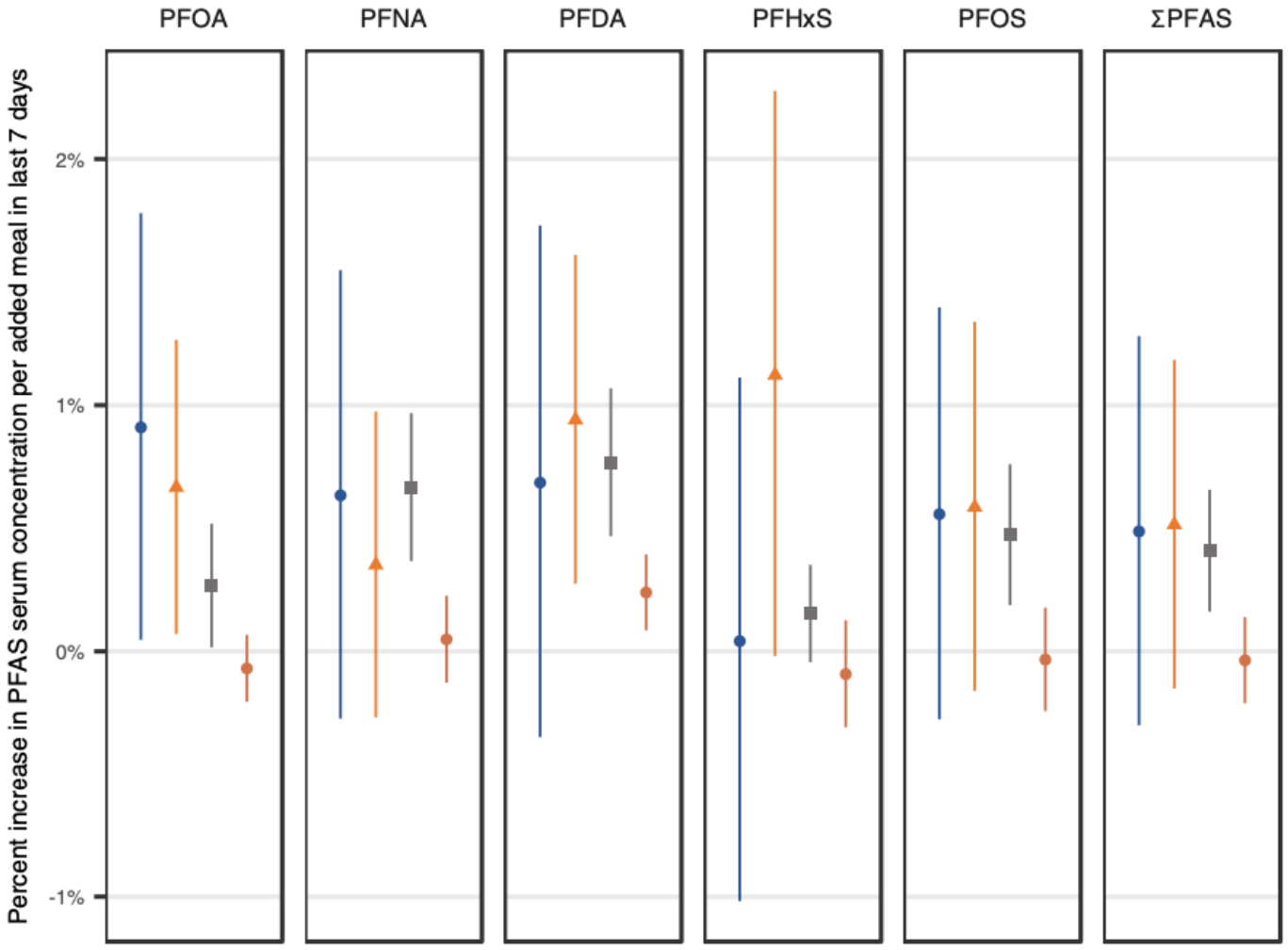
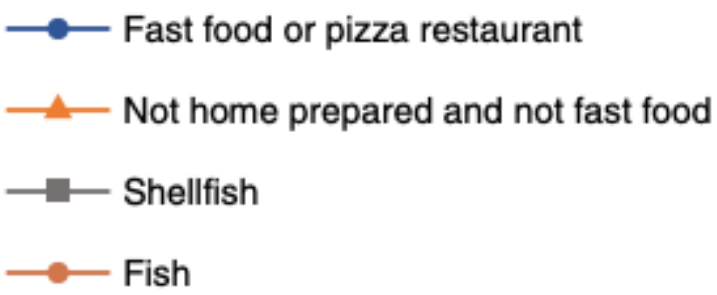



**Figure 2.** Comparison of regression coefficients from the 7-d/30-d recall model, based on 2007–2014 data.

- Consumption of fast food/pizza associated with increases in serum PFAS.
- Consumption of popcorn (not shown) associated with increases in serum PFAS.
- More associated with *where* food is being consumed than *which* food is being consumed.




Susmann et al. 2019 [8].

# Life Cycle Concerns: Single-use packaging enters a “forever loop”

**PRODUCTION**

**PROCESSING**

**PACKAGING**

**DISPOSAL**

# America's Dairyland May Have a PFAS Problem

Stone had spread PFAS-contaminated sludge and paper mill ash on his fields for 20 years, but he stopped that practice in 2004. After 15 years, the substances were still there in amounts that could severely taint the milk of Stoneridge Farm, which is now out of business.

Many currently listed FCSs are fluoropolymers that degrade into perfluorinated acids of varying chain lengths.

Slow polymer degradation and high persistence of the degradation product may represent a *near-constant source* from legacy contamination.

Susan Cosier, NRDC, October 11, 2019 [9].

# What can be done?

- Consider potential impact from a life cycle perspective.
- What constituents will be released when the material is:
  - Manufactured
  - Integrated into products
  - Used for food packaging
  - Disposed of

- If risk is to be quantified, it is essential to obtain information about the *quantity* and *identity* of chemicals in the material!

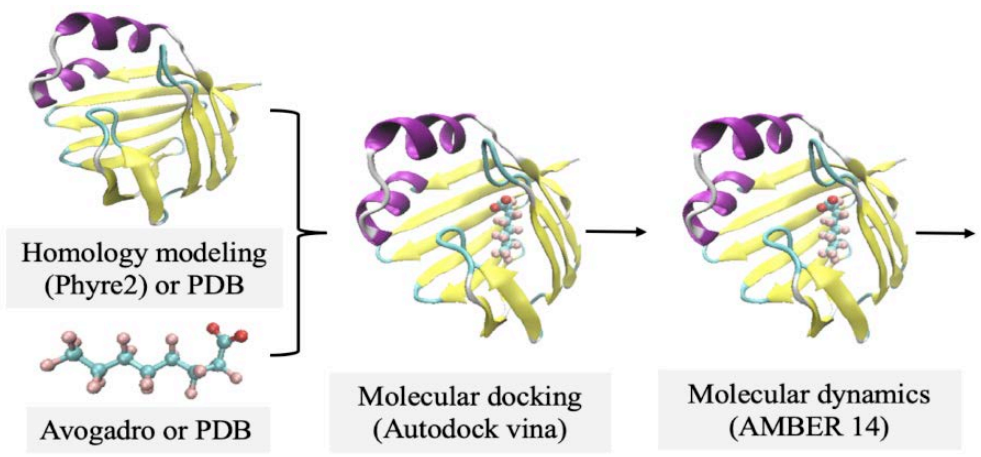
- With this information, we can begin to test/predict/evaluate and, if necessary, find safer alternatives.

# A few words about models for PFAS

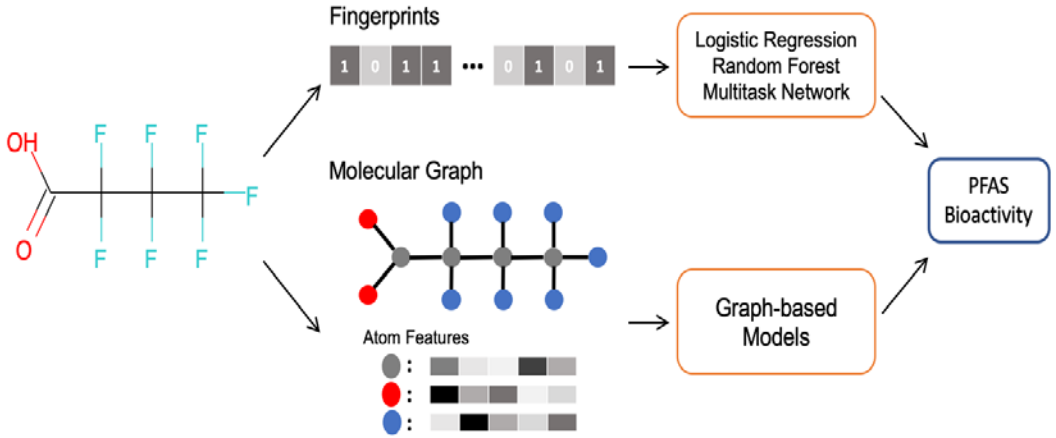
In my group we develop models to predict:

- whether and why PFAS bioaccumulate.
- PFAS-protein binding and subsequent tissue distribution in different organisms.
- potential PFAS bioactivity.

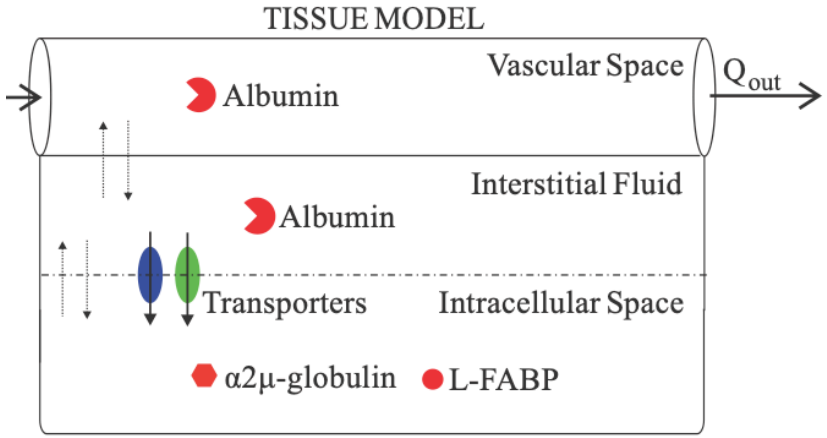
Models help *screen and prioritize* the wide variety of PFAS structures for which *no experimental data exist*.




PFAS Molecular dynamics [10].




Machine Learning Models for PFAS Bioactivity [11].




PFAS Toxicokinetics [12,13].

# What can be done *now*? The Essential Use concept.

**Table 1** Three essentiality categories to aid the phase out of non-essential uses of chemicals of concern, exemplified with PFAS uses

| Category | Definition | PFAS examples |
|---|---|---|
| (1) "Non-essential" | Uses that are not essential for health and safety, and the functioning of society. The use of substances is driven primarily by market opportunity | Dental floss, water-repellent surfer shorts, ski waxes |
| (2) "Substitutable" | Uses that have come to be regarded as essential because they perform important functions, but where alternatives to the substances have now been developed that have equivalent functionality and adequate performance, which makes those uses of the substances no longer essential | Most uses of AFFFs, certain water-resistant textiles |
| (3) "Essential" | Uses considered essential because they are necessary for health or safety or other highly important purposes and for which alternatives are not yet established[a] | Certain medical devices, occupational protective clothing |

[a] This essentiality should not be considered permanent; rather, a constant pressure is needed to search for alternatives in order to move these uses into category 2 above.

Cousins et al. 2019, Environmental Science: Processes and Impacts [14].

# Applying Essential Use to FCM:

| Use | Category[a] |
|---|---|
| Personal care products including cosmetics | 1 |
| Ski waxes | 1 |
| Fire-fighting foams (commercial airports) | 2 |
| Fire-fighting foams (military) | 2 or 3 |
| Apparel (medical: long operations) | 3 |
| Apparel (protective clothing oil and gas industry) | 3 |
| Apparel (medical: short operations, everyday) | 2 |
| Apparel (military: occupational protection) | 2 or 3 |
| Waterproof jacket (general use) | 2 |
| Easy care clothing | 1 |
| Food contact materials | 1, 2 or 3 |
| Non-stick kitchenware (fluoropolymers) | 1 or 2 |
| Medical devices (fluoropolymers) | 1, 2 or 3 |
| Pharmaceuticals | 2 or 3 |
| Laboratory supplies, equipment and instrumentation | 1, 2 or 3 |
| Perfluorosulfonic membranes in fuel cells | 2 |
| Perfluorosulfonic membranes in chlor-alkali process | 3 |

[a] Note that the categories in the above table represent the current evaluation and may change in the future.

In FCN data, the results of the "Kit test" (TAPPI T559) is often given as a means to demonstrate the efficacy of a fluorochemical treatment to paper or paperboard.

But "efficacy" is not equivalent to "essentiality".

***How do we determine the level of function needed for food packaging?***

# References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