Introduction to PFASs
Highly Fluorinated Chemicals

Laurel Schaider, Ph.D.
What makes this family of chemicals unique?

- Persistence
- Complexity
- Versatility

Highly fluorinated chemicals
or PFASs
Per- and polyfluoroalkyl substances
Widely used in household products

- Carpets & upholstery
- Waterproof apparel
- Waxes (floor, skis)
- Non-stick cookware
- Grease-proof food packaging
- Dental floss
- Paints
Prevalence of fluorinated chemicals in U.S. fast food packaging

Sources of drinking water contamination

- AFFF (aqueous film-forming foam) for fuel fires
- Production facilities
- Other industries
- Waste disposal sites
- Wastewater
Sources of PFASs to public water supplies

Subbasins (large watersheds) with detectable PFASs

Cape Cod, Massachusetts

- PFASs in public and private wells:
  - County fire training area
  - Municipal airport
  - Military base
  - Household wastewater

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_Schaider et al. 2016. Sci Tot Env. 547:470-81._
In our bodies and the environment

• Global transport recognized in early 2000s

• Some can bioaccumulate and biomagnify
  (Conder et al., 2008, *ES&T*. 42:995-1003)

• >98% of Americans have PFASs in their blood (NHANES)
  (Calafat et al., 2007, *EHP*. 115: 1596-1602)
Long-chain PFASs

- Long chain of fluorinated carbon atoms
  - At least 6 for sulfonates, at least 7 for carboxylates
- Some PFASs can be converted to PFOS or PFOA
**Per- versus poly- fluorinated**

**Per** = fully fluorinated

**Poly** = partly fluorinated

**PFOS**
Perfluorooctane sulfonic acid

**8:2 FtS**
Fluorotelomer sulfonate
Phasing out long-chain PFASs

• Concerns about toxicity and persistence led to phase out of U.S. production of PFOS and PFOA
  ‒ 2000: 3M phase-out of PFOS
  ‒ 2006: EPA’s 2010/2015 PFOA Stewardship Program

• Stockholm Convention for Persistent Organic Pollutants
  ‒ PFOS: 2009, Annex B (Restriction)
  ‒ PFOA: 2015, Nominated for listing
In May 2016, EPA issued stricter drinking water guidelines for PFOS and PFOA

- **2009 guidelines:**
  - 200 ng/L PFOS, 400 ng/L PFOA

- **2016 guideline:**
  - PFOS + PFOA: 70 ng/L

- Guidelines lacking for other PFASs
- Some states have lower guidelines
  - NJ noted effects on mammary gland development
Replacements: Short-chain PFASs

- Mainly shorter versions of PFOA, PFOS, and related compounds
- Retained in body for days to weeks
  - Shorter than long-chains
  - Longer than some other chemicals of concern

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<thead>
<tr>
<th></th>
<th>Half-lives in the human body (geometric means)</th>
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<tbody>
<tr>
<td></td>
<td>Long chain</td>
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<tr>
<td>PFHxS</td>
<td>7.3 years</td>
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<tr>
<td>PFOS</td>
<td>4.8 years</td>
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<tr>
<td>PFOA</td>
<td>3.5 years</td>
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<tr>
<td>PFHxA</td>
<td></td>
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<tr>
<td>PFBS</td>
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<td>BPA</td>
<td>3-6 hours</td>
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Concerns about short-chain PFASs

**Similar biological activity in *in vitro* lab testing**


**Poorer removal during GAC drinking water treatment**


**Varying patterns of accumulation in animal organs**


**More accumulation in plant shoots and fruits**

Tomato
Peas

Other replacements

Over 3,000 PFASs on the global market
(Wang et al., 2017, *ES&T*, 51:2508.)

**GenX**


**ADONA**


**Firefighting foams and misc.**
PFAS terminology is tricky

- Shift from PFCs to PFASs
- Long vs. short chain
- Definitions of “PFAS”
- How to interpret shifts in retailer and manufacturer actions?

Target’s Chemical Goals
CHEMICAL MANAGEMENT

» Improve textile products by removing added Perfluorinated Chemicals (PFC’s) from products by 2022.

RESPONSIBLE USAGE OF FLUOROMATERIALS
Gore Fabrics’ Goal and Roadmap for Eliminating PFCs of Environmental Concern
Class-based approach

Madrid Statement (2015)

“We call on the international community to cooperate in limiting the production and use of PFASs and in developing safer non-fluorinated alternatives.”

Signed by 230 scientists from 40 countries
Next steps for scientists

• For scientists and regulators, chemical-by-chemical approach is too slow
• How much evidence is enough?
• How can we be strategic in filling gaps?
Highly Fluorinated Chemicals (PFASs)

Highly fluorinated chemicals called PFASs (also known as PFCs) are added to many consumer products to make them non-stick, waterproof, and stain-resistant. They are also used in firefighting foams and industrial processes. Their strong bonds make them very effective at repelling water and oil even at high temperatures, but these characteristics also make them persistent. They are ubiquitous in the environment – even in Arctic wildlife – and most Americans have PFASs (per- and polyfluoroalkyl substances) in their bodies due to their widespread use. Silent Spring Institute is studying PFASs because some have been linked to cancer, including breast tumors in animal studies, hormone disruption, reproductive problems, and other health effects.