Introduction to PFASs
Highly Fluorinated Chemicals

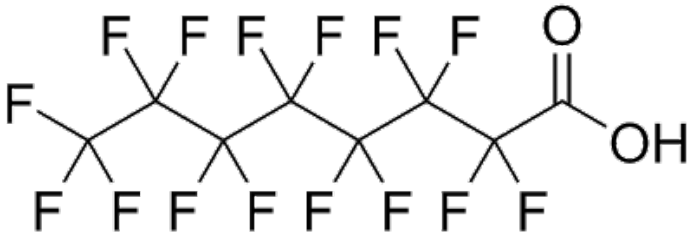
Kathryn Rodgers, MPH

SILENT SPRING INSTITUTE
Researching the Environment and Women's Health

Highly fluorinated chemicals or PFASs
Per- and polyfluoroalkyl substances

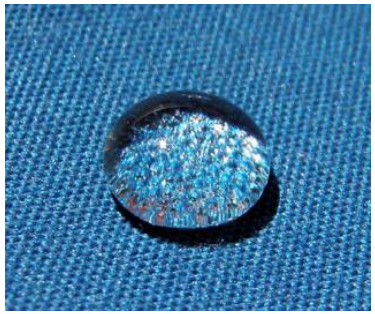
What makes this family of chemicals unique?

- **Persistence**
- **Complexity**
- **Versatility**



Widely used in household products

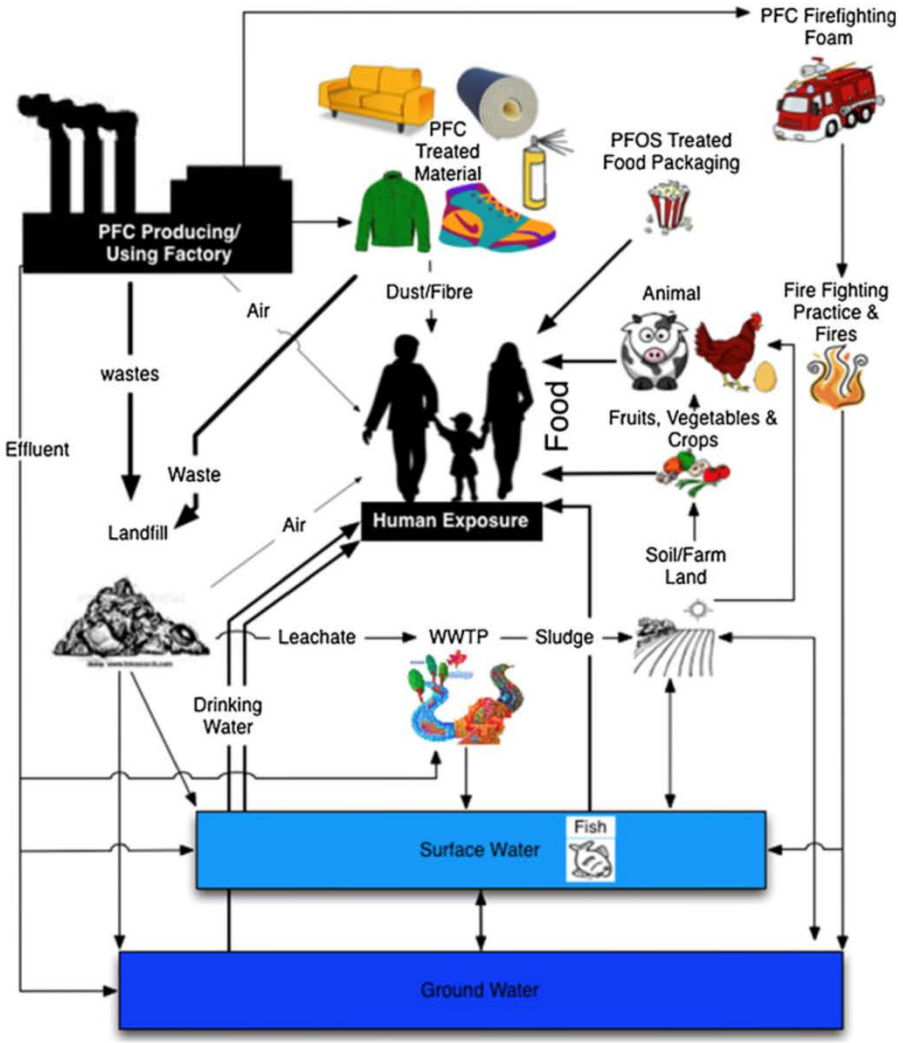
- Carpets & upholstery
- Waterproof apparel
- Waxes (floor, skis)
- Non-stick cookware
- Grease-proof food packaging
- Dental floss
- Paints



Many exposure pathways

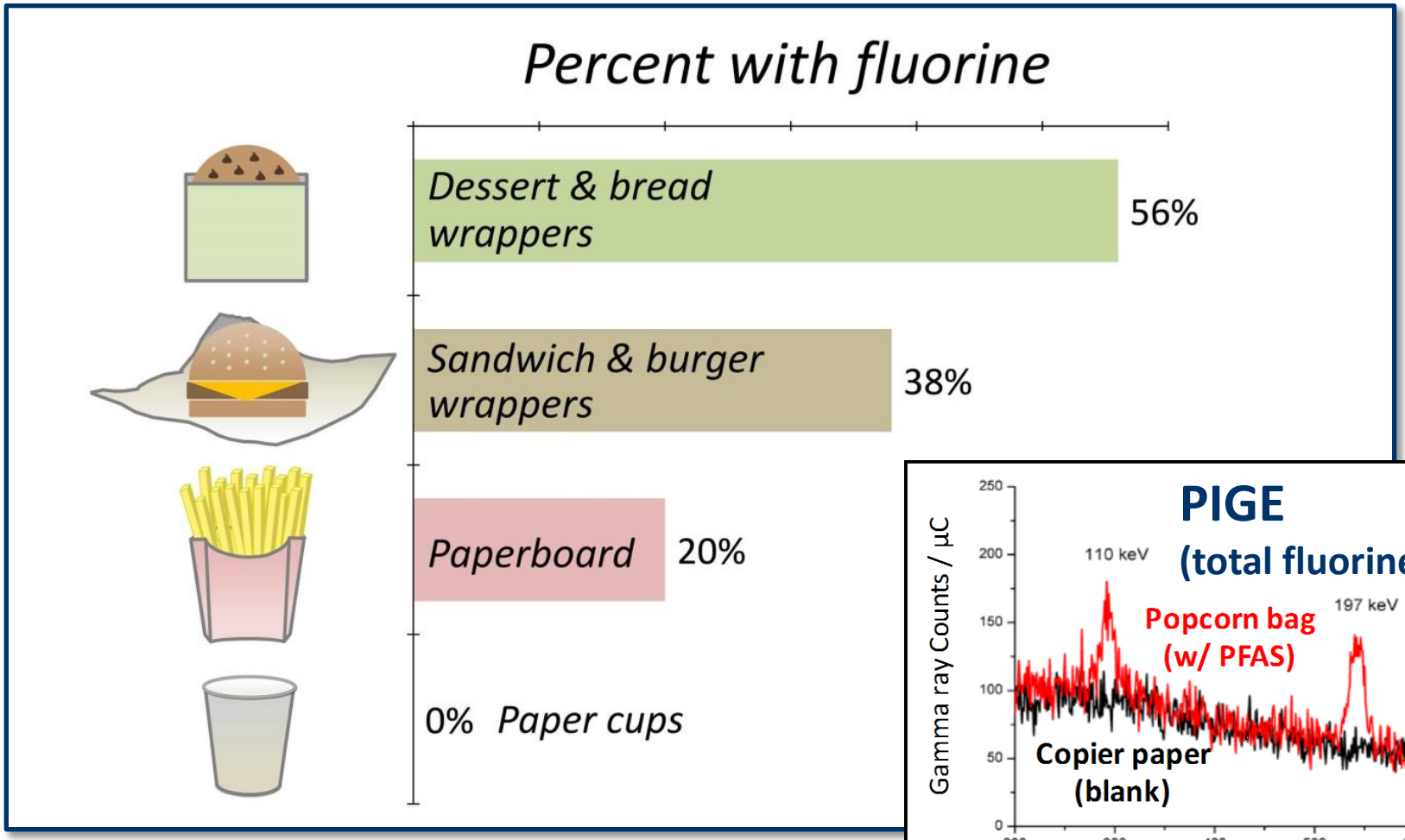
Environ Sci Pollut Res (2013) 20:1977–1992

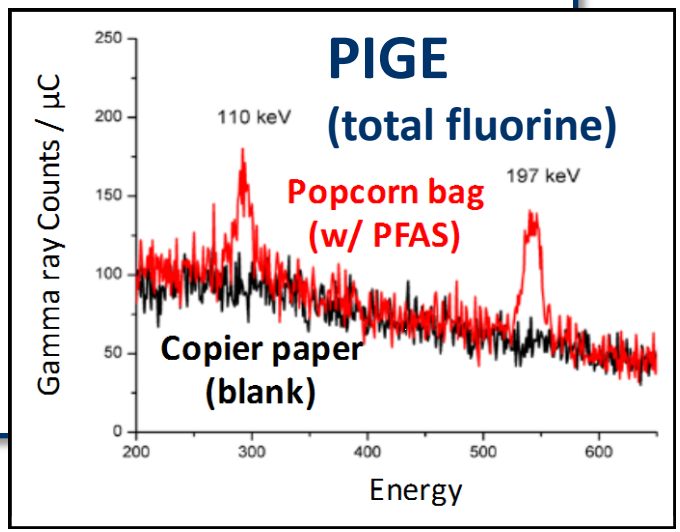
Fig. 1 PFC release from the technosphere and contamination pathways in the environment and exposure pathways to humans



Okiaei, et al. 2013

Prevalence of fluorinated chemicals in U.S. fast food packaging

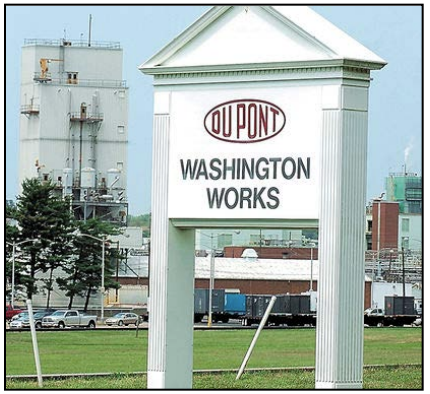




Schaider *et al*. 2017. *ES&T Letters.* 4(3):105–111.

Sources of drinking water contamination

- AFFF (aqueous film-forming foam) for fuel fires
- Production facilities
- Other industries
- Waste disposal sites
- Wastewater

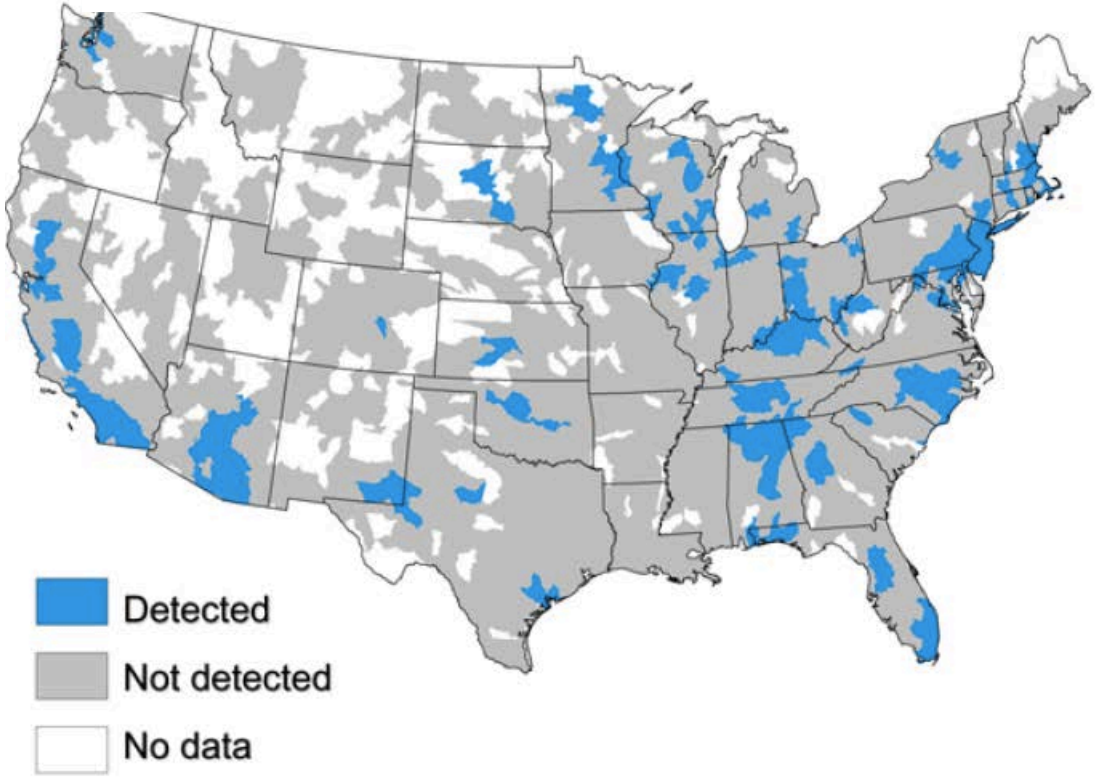


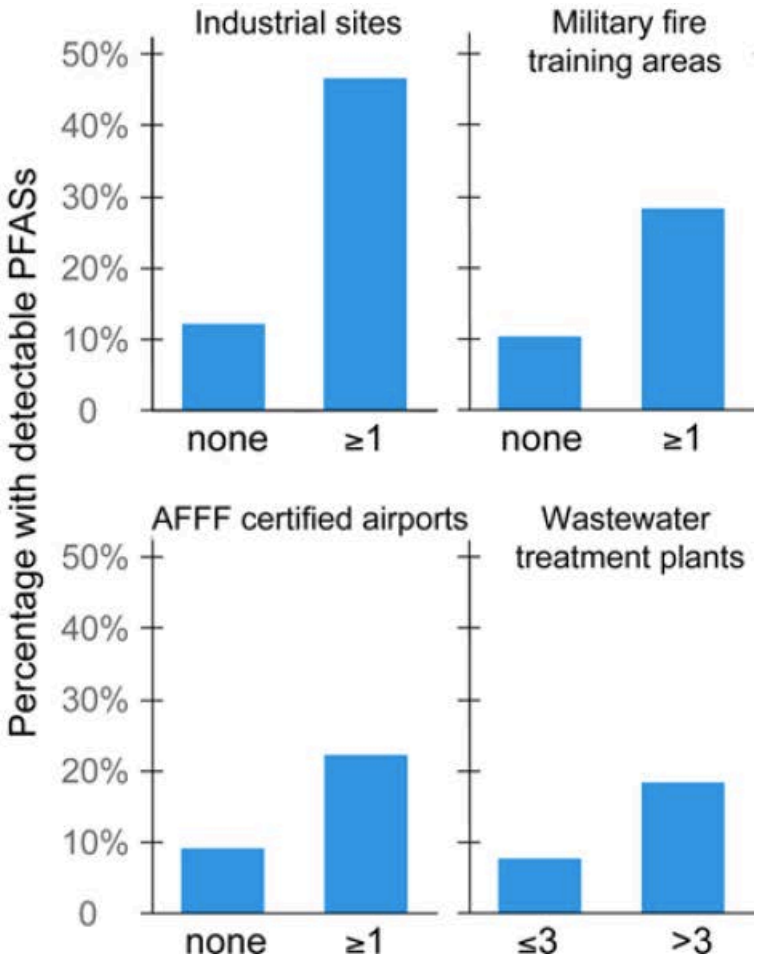
SAINT-GOBAIN
PERFORMANCE PLASTICS
Advanced Film Products

Sources of PFASs to public water supplies

U.S. EPA's UCMR3 data (2013–2015)

Subbasins (large watersheds) with detectable PFASs

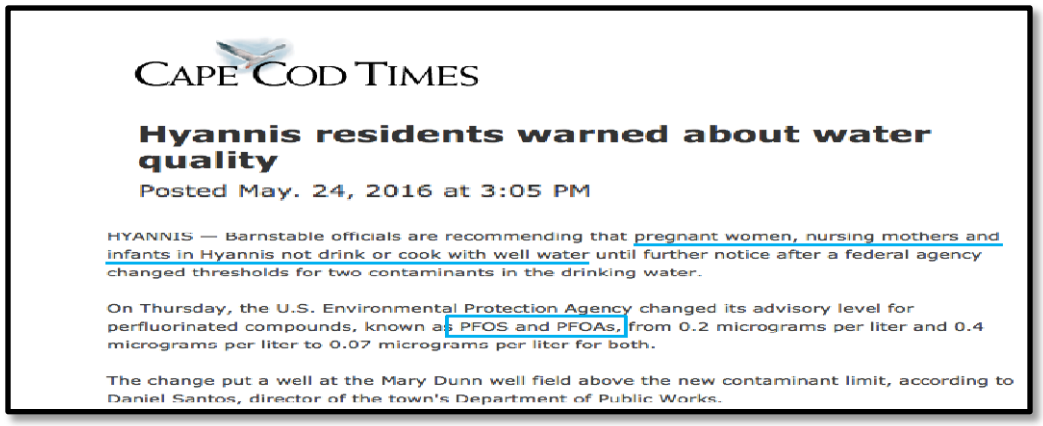




Hu *et al*. 2016. *ES&T Letters.* 3:344-350.

PFASs in private wells

- PFASs in public and private wells on Cape Cod, MA:
  - County fire training area
  - Municipal airport
  - Military base
  - Household wastewater



CAPE COD TIMES

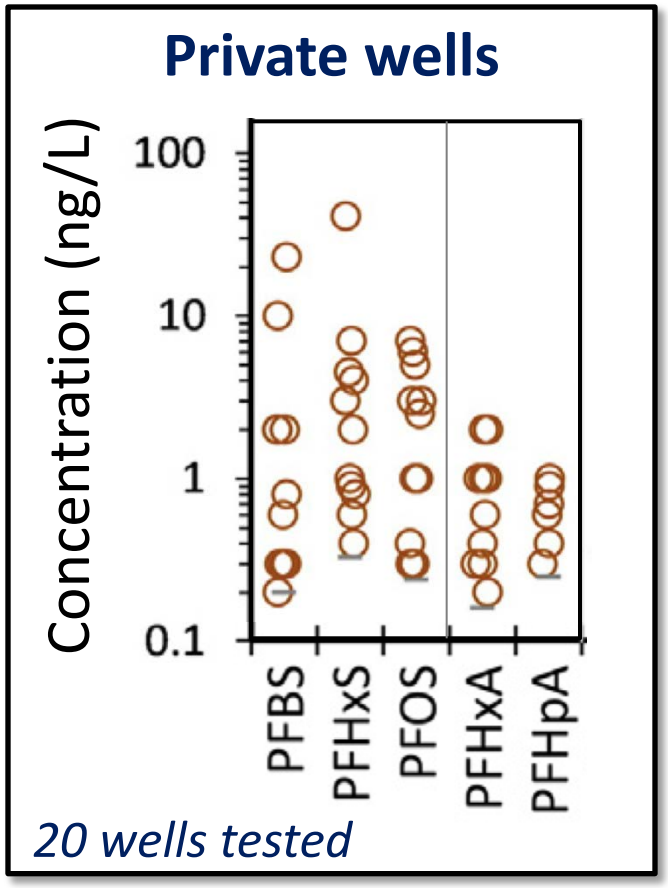
Hyannis residents warned about water quality

Posted May. 24, 2016 at 3:05 PM

HYANNIS — Barnstable officials are recommending that pregnant women, nursing mothers and infants in Hyannis not drink or cook with well water until further notice after a federal agency changed thresholds for two contaminants in the drinking water.

On Thursday, the U.S. Environmental Protection Agency changed its advisory level for perfluorinated compounds, known as PFOS and PFOAs, from 0.2 micrograms per liter and 0.4 micrograms per liter to 0.07 micrograms per liter for both.

The change put a well at the Mary Dunn well field above the new contaminant limit, according to Daniel Santos, director of the town's Department of Public Works.



Schaider *et al.* 2016. *Sci Tot Env.* 547:470-81.

In our bodies and the environment

- Global transport recognized in early 2000s

  (Giesy and Kannan, 2001, *ES&T.* 35:1339-1342)

- Some can bioaccumulate and biomagnify

  (Conder et al., 2008, *ES&T*. 42:995-1003)

- >98% of Americans have PFASs in their blood (NHANES)

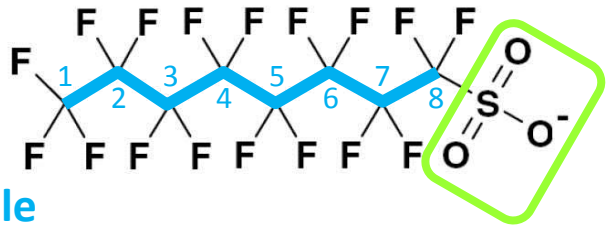
  (Calafat et al., 2007, *EHP*. 115: 1596-1602)

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

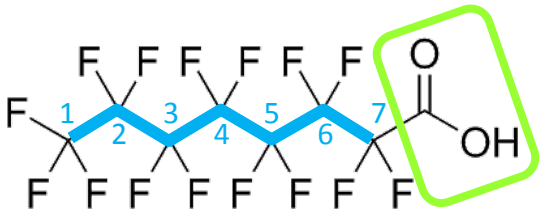
PFOS *(sulfonate)*

Tail: Water and oil insoluble



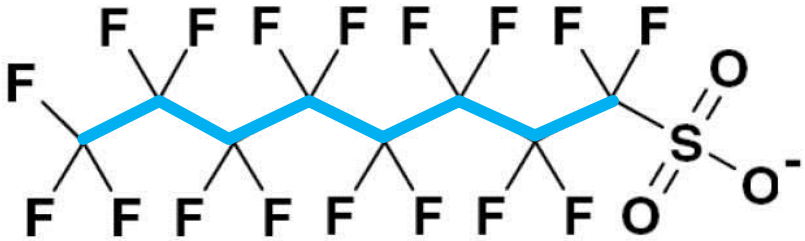
Head: Water soluble

PFOA or C8 *(carboxylate)*



Per- versus poly- fluorinated

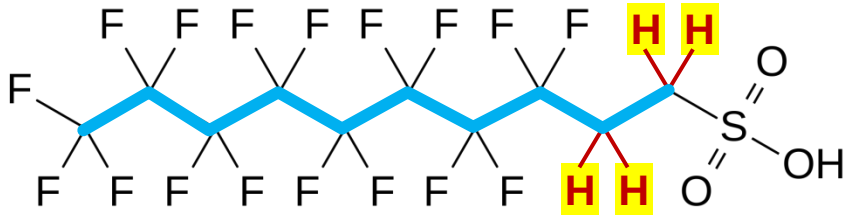
Per = fully fluorinated



PFOS

Perfluorooctane sulfonic acid

Poly = partly fluorinated



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

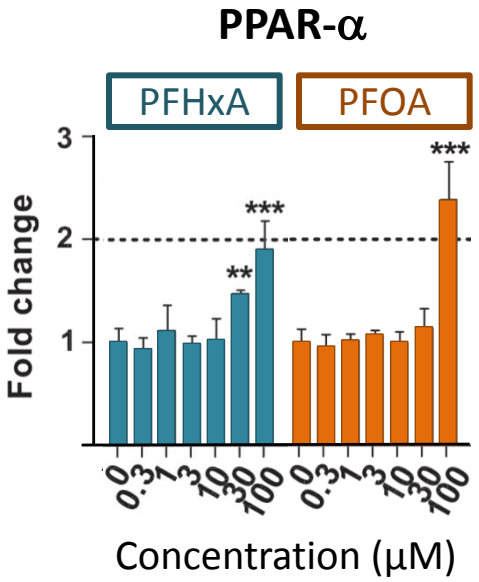
- Mainly shorter versions of PFOA, PFOS, and related compounds
- Retained in body for days to weeks
  - Shorter than long-chains
  - Longer than some other chemicals of concern

Half-lives in human blood *(geometric means)*		
PFHxS	7.3 years	**Long chain**
PFOS	4.8 years	
PFOA	3.5 years	
PFHxA	32 days	**Short chain**
PFBS	26 days	
BPA	3-6 hours	

Olsen *et al*. 2007. *EHP.* 115:1298.
Olsen *et al.* 2009. *Toxicol.* 256:65.
Russell *et al.* 2013. *Chemosphere*. 93:2419.
Taylor et al. 2011. *EHP*. 119:422.

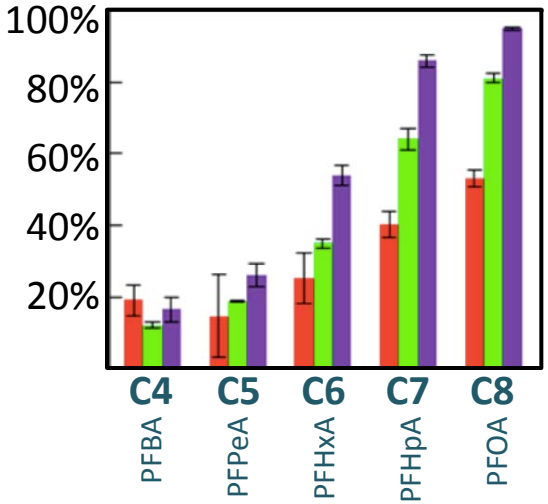
Concerns about short-chain PFASs

Similar biological activity in *in vitro* lab testing



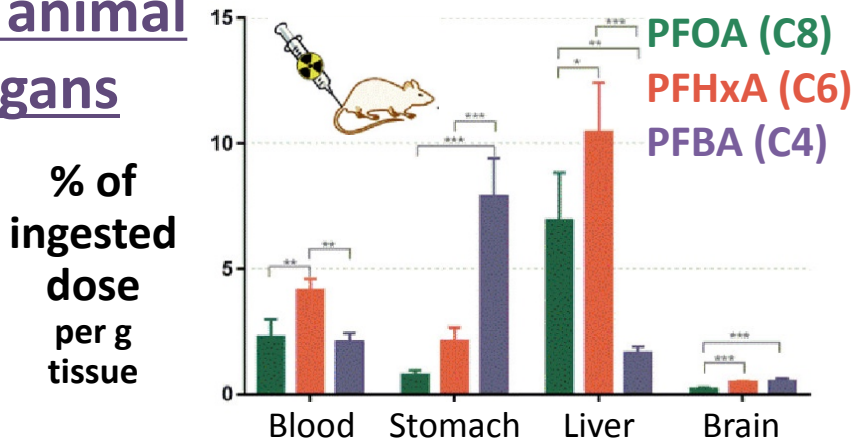
Rosenmai *et al*. 2016. *Andrology.* 4:662-672.

Poorer removal during GAC drinking water treatment



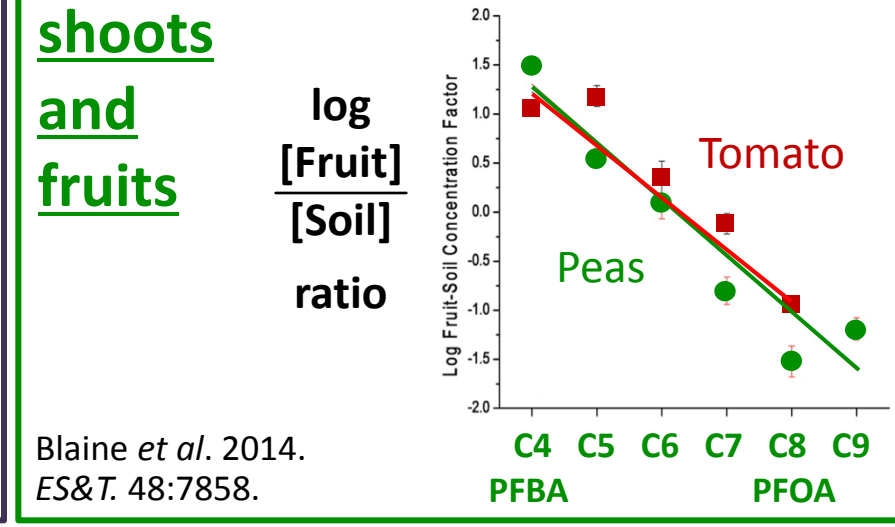
Sun et al. 2016. *ES&T Letters*. 3:415-419.

Varying patterns of accumulation in animal organs



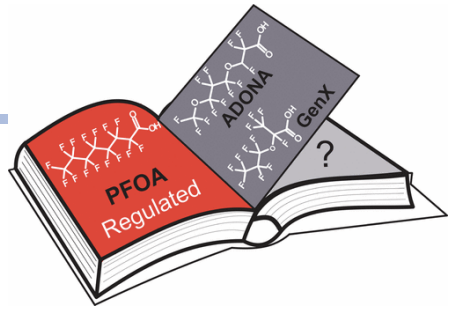
Burkemper *et al*. 2017. *ES&T Lett.* 3/9/17

More accumulation in plant shoots and fruits



Blaine *et al*. 2014. *ES&T.* 48:7858.

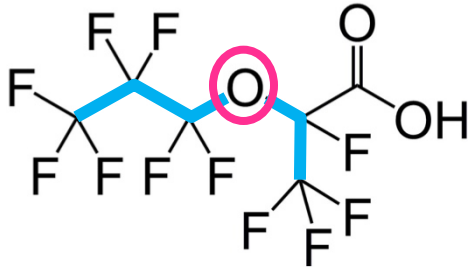
Other replacements



Over 3,000 PFASs on the global market

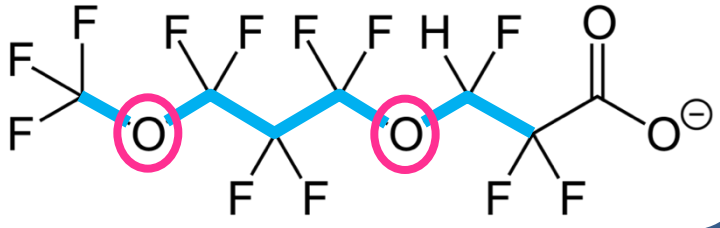
(Wang et al., 2017, *ES&T*, 51:2508.)

GenX



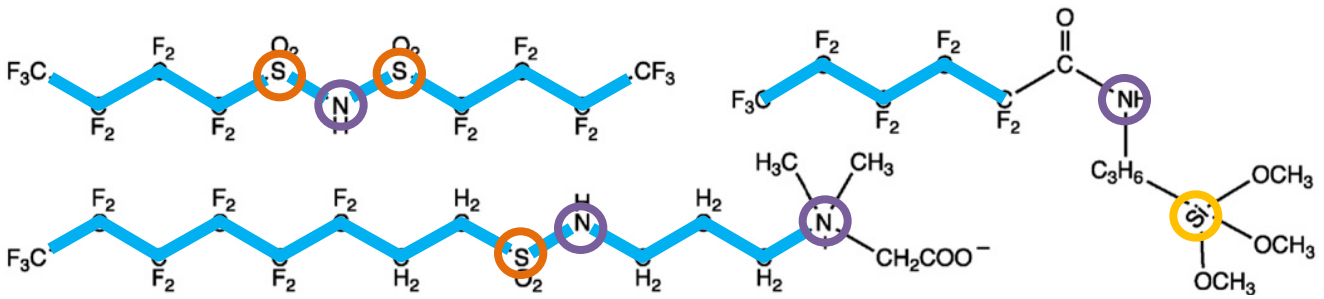
Sun et al. 2016. *ES&T Lett.* 3:415.

ADONA



Wang et al. 2013. *Environ. Int.* 60:242.

Firefighting foams and misc.



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?