Collaborative Network
For a Cancer Free Economy

Hazards of PFAS

A FACT SHEET

Summary[1]

PFAS is an acronym (**P**er- and Poly**f**luoro**a**lkyl **S**ubstances) for a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom. The class includes more than 3,000 chemicals, although fewer are currently on the global market. PFAS vary in the number of carbon atoms forming the backbone of their molecule, from a chain of two carbons to large molecular weight polymers.[2]

PFAS are commonly used to manufacture non-stick, grease and stain-resistant coatings in a variety of industrial and consumer products, including food packaging, non-stick cookware, carpets and upholstery, ski wax, floor wax, outdoor gear, dental floss and firefighting foams.

The best-known PFAS chemicals are PFOA and PFOS, each with a chain of eight carbon atoms. These so-called *long-chain* PFASs have been voluntarily phased out in the United States, Europe and Japan. Many long-chain PFAS are now being replaced in multiple applications with chemicals with fewer fluorinated carbon atoms, often referred to as *short-chain* PFAS. The PFAS chemical family, and new generation PFAS being substituted for the phased out PFAS, however, include many other fluorinated compounds with different structures (see Figure 1).

Why are PFAS a Concern?

PFAS are found in the blood of more than 98% of Americans[3] and contaminate the drinking water sources for more than 16 million Americans.[4] PFAS released to the environment have been shown to travel around the globe[5] and bioaccumulate and biomagnify.[6] Their unique physicochemical properties lead to their extreme persistence and high mobility. They are therefore found virtually everywhere in water, air and terrestrial environments, even in remote locations far from points of release. In addition to drinking water, they are present in indoor dust, air, food and wildlife; they have also been found in the milk and serum of breastfeeding women.[7]

In their February 2018 *Product and Chemical Profile for PFASs in Carpets and Rugs**, California EPA's Department of Toxic Substances Control (Cal EPA DTSC) describes the potential for significant or widespread exposures and adverse impacts from PFAS (*note that Cal EPA DTSC has chosen to refer to this class of chemicals as "PFASs"):

Due to the strength of the carbon-fluorine bond, PFASs are characterized by high environmental persistence, which leads to continuous and poorly-reversible accumulation in the environment, and hence to likely increasing exposures. Most PFASs display significant mobility in environmental media, which makes them widespread in the environment and in living organisms. Many members of the PFAS class bioaccumulate significantly in animals or plants, including in foods consumed by humans, and undergo lactational or transplacental transfer from mothers to offspring. Certain PFASs also have high global warming potential, or may contribute to global warming by increasing cloud albedo.[8]

How are we exposed to PFAS?

We can be exposed to PFAS through direct contact or inhalation, food, consumer products, house dust, contaminated drinking water, eating fish and shellfish, or through workplace exposures.[9] Cal EPA DTSC further describes how humans can be exposed throughout our lives:

- PFAS are released from consumer products during use, contaminating indoor air and dust.
- Disposal of consumer products contaminates landfill leachates and subsequently surface and groundwater, as wastewater treatment plants are unable to remove PFAS.
- Sewage sludge contains PFAS, which can be taken up by plants, including agricultural crops.

What are the health impacts of PFAS?

The settlement from a large class action lawsuit against DuPont established the C8 Science Panel to investigate health effects from exposure to PFOA. Findings from the C8 Health Study have linked PFOA with kidney cancer and testicular cancers.[10] Exposure to PFOA has also been associated with liver and pancreatic tumors in animal studies.[11] A recent Danish study showed a link between blood levels of PFOS and PFOA during pregnancy and breast cancer later in life.[12] The International Agency for Research on Cancer (IARC) has classified PFOA as a Group 2B carcinogen, i.e., possibly carcinogenic to humans, primarily for kidney and testicular cancers.[13] Other health effects from PFAS exposure include hormone disruption,[14] immune system effects[15] (e.g., exposure to PFAS associated with decreased response to vaccines in children), high cholesterol, thyroid disease, hypertension,[16] lowered sex and growth hormones in children,[17] and altered mammary gland development.[18]

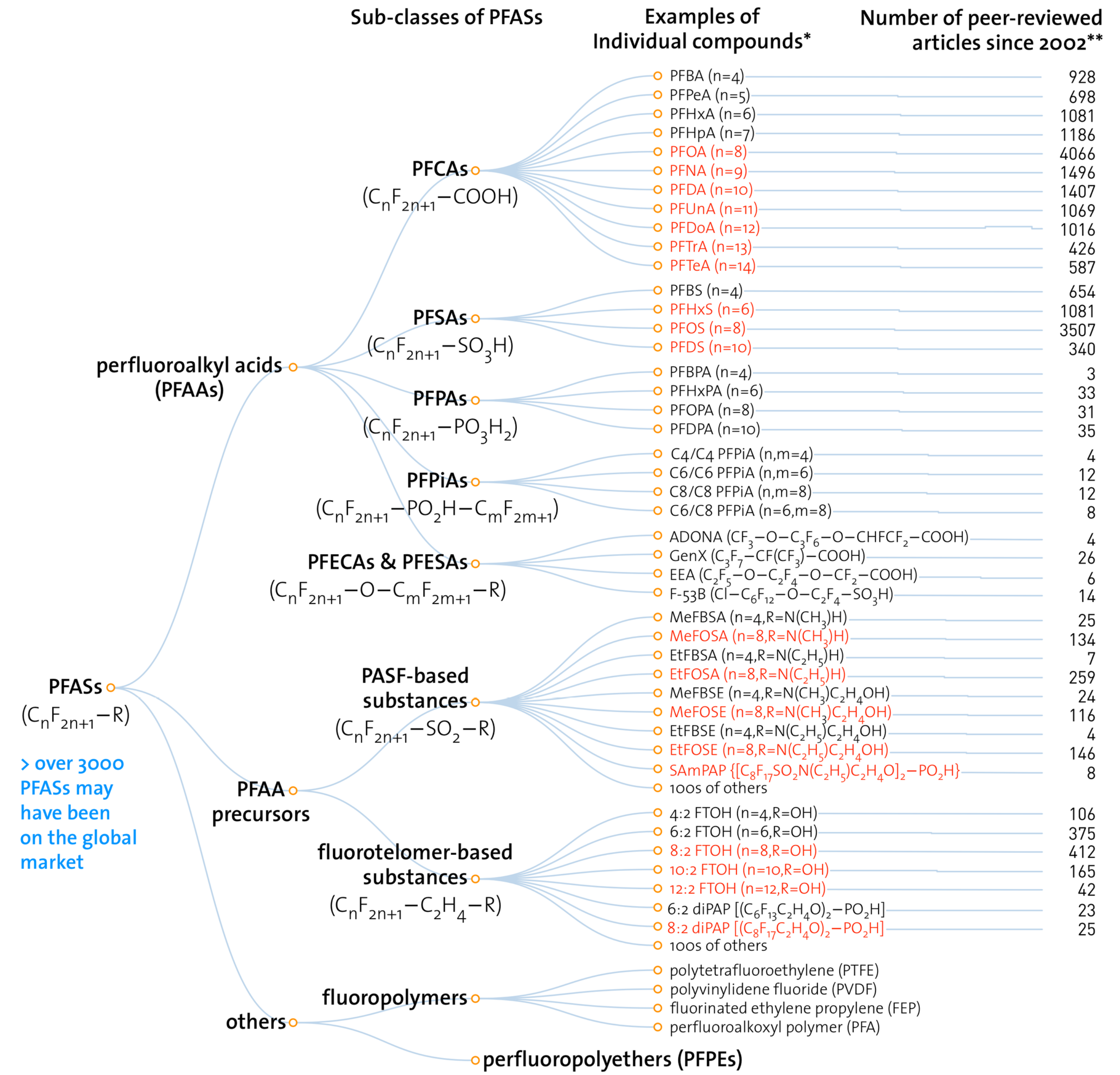
New Generation PFAS: A Regrettable Substitution

The phase out of long-chain PFAS has resulted in decreasing levels of certain long-chain PFAS substances in biomonitoring studies.[19] However, these long-chain PFAS have been replaced other PFAS compounds, including fluorinated ethers and shorter chain PFAS.

Research to date on the characteristics of members of the new generation of PFAS indicates that certain short-chain PFAS have shorter half-lives in blood than long-chain PFAS; however, these half-lives are still relatively long (on the order of weeks).[20] In addition, new generation PFAS have similar biological activity in vitro as their long-chain predecessors[21] and accumulate in the blood, stomach, liver and brain of animals.[22] Moreover, short-chain PFAS accumulate in plant shoots and fruits,[23] and are not as effectively removed by the treatment of drinking water.[24] Other research further indicates that the new generation of PFAS has health impacts similar to the older compounds, including reproductive and developmental toxicity, liver and kidney impacts, and systemic toxicity.[25]

In December 2017 the Endocrine Disruption Exchange (TEDX) summarized data from more than 50 peer reviewed studies showing potential endocrine disruption activity for several short chain PFAS chemicals.[26] Currently, 30 PFAS chemicals are listed by TEDX as potential endocrine disruptors. TEDX notes that the lack of evidence does not indicate a lack of effect, as not all chemicals have been tested for all effects.

Cal/EPA DTSC concludes that new generation "short-chain" PFAS are *"equally persistent and more mobile in the environment than the chemicals they are replacing, and also show potential for toxicity."* Moreover, "*[t]oxicological and epidemiological data clearly indicating the safety of aggregate, chronic and low-dose exposures to PFASs found in stain- and soil-repellents are lacking.*"[27]



* PFASs in **RED** are those that have been restricted under national/regional/global regulatory or voluntary frameworks, with or without specific exemptions (for details, see OECD (2015), Risk reduction approaches for PFASs. http://oe.cd/1AN).

** The numbers of articles (related to all aspects of research) were retrieved from SciFinder® on Nov. 1, 2016.

Figure 1. "Family tree" of PFAS, including examples of individual PFAS and the number of peer-reviewed articles on them since 2002 (most of the studies focused on long-chain PFCAs, PFSAs and their major precursors.).

Wang, et al. *A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFASs)?* Environ. Sci. Technol. 2017, 51, 2508–2518; DOI: 10.1021/acs.est.6b04806

[1]California Environmental Protection Agency, Department of Toxic Substances Control (Cal/EPA DTSC), Safer Consumer Products Program, *Product – Chemical Profile for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) in Carpets and Rugs*, February 2018

[2]For details of the chemistry of the PFAS class of chemicals, see Buck et al., *Perfluoroalkyl and Polyfluoroalkyl Substances in the Environment: Terminology, Classification and Origins*, Integr. Environ Assess Manag, 2011. Oct 7(4): 513-541. DOI: 10.1002/ieam.258; Wang, et al. *A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFASs)?* Environ. Sci. Technol. 2017, 51, 2508–2518; DOI: 10.1021/acs.est.6b04806

[3]Calafat et al. 2007. *Polyfluoroalkyl Chemicals in the U.S. Population: Data from the National Health and Nutrition Examination Survey (NHANES) 2003–2004 and Comparisons with NHANES 1999–2000.* Environ Health Perspect. Nov; 115(11): 1596–1602.

[4]Hu et al. *Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants*; Environ. Sci. Technol. Lett. 2016, 3, 344–350; DOI: 10.1021/acs.estlett.6b00260

[5]Giesy and Kannan, 2001, *Global Distribution of Perfluorooctane Sulfonate in Wildlife* Environ. Sci.Technol. 35(7):1339-1342

[6]Conder et al., *Are PFCAs bioaccumulative? A critical review and comparison with regulatory criteria and persistent lipophilic compounds*. 2008, Environ. Sci. Technol. 42 (4): 995-1003

[7]Cal/EPA DTSC 2018, Ibid.

[8]Cal/EPA DTSC 2018, Ibid.

[9]https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf

[10]Barry et al. 2013. *Perfluorooctanoic acid (PFOA) exposures and incident cancers among adults living near a chemical plant*. Environ Health Perspect. Nov-Dec; 121(11-12):1313-8; A full list of publications related to the C8 Study is available at www.c8sciencepanel.org.

[11]Biegel LB, et al. *Mechanisms of extrahepatic tumor induction by peroxisome proliferators in male CD rats*. Toxicol Sci 60(1):44–55 (2001); Filgo AJ, et al. 2015. *Perfluorooctanoic acid (PFOA)-induced liver lesions in two strains of mice following developmental exposures: PPARα is not required*. Toxicol Pathol. 2015 Jun; 43(4): 558–568; Wolf CJ et al. 2012. *Activation of mouse and human peroxisome proliferator-activated receptor-alpha (PPARα) by perfluoroalkyl acids (PFAAs): Further investigation of C4–C12 compounds*. Reprod. Toxicol., 33, pp. 546-551.

[12]Bonefeld-Jorgensen et al. 2014. *Breast cancer risk after exposure to perfluorinated compounds in Danish women: a case-control study nested in the Danish National Birth Cohort*. Cancer Causes Control, 25, pp. 1439-1448.

[13]Benbrahim-Tallaa et al. 2014. *Carcinogenicity of perfluorooctanoic acid, tetrafluoroethylene, dichloromethane, 1,2 dichloropropance, and 1,3-propane sultone,* The Lancet Oncology, Vol 15 (9) pp 924-925.

[14]Henry ND et al. 2013. *Comparison of in vitro cytotoxicity, estrogenicity and anti-estrogenicity of triclosan, perfluorooctane sulfonate and perfluorooctanoic acid.* J Appl Toxicol. Apr;33(4):265-72.

[15]Grandjean et al. 2017. *Serum Vaccine Antibody Concentrations in Adolescents Exposed to Perfluorinated Compounds*. Environ Health Perspect. Jul 26;125(7):077018.

[16]www.c8sciencepanel.org

[17]Lopez-Espinosa MJ, Mondal D, Armstrong BG, Eskenazi B, Fletcher T. 2016. *Perfluoroalkyl Substances, Sex Hormones, and Insulin-like Growth Factor-1 at 6-9 Years of Age: A Cross-Sectional Analysis within the C8 Health Project.* Environ Health Perspect. 124(8): 1269-1275.

[18]White SS, et al. *Gestational and Chronic Low-dose PFOA Exposures and Mammary Gland Growth and Differentiation in Three Generations of CD-1 Mice*. Environ Health Perspect. 2011 Aug;119(8):1070-6. DOI: 10.1289/ehp.1002741

[19]Cal/EPA DTSC, 2018, Ibid.

[20]Olson et al. *Perfluorinated Chemicals and Fetal Growth: A Study within the Danish National Birth Cohort*. 2007 Environ Health Perspect, 115(11): 1677-1682 DOI: 10.1289/ehp.10506; Olsen et al. *A comparison of the pharmacokinetics of perfluorobutanesulfonate (PFBS) in rats, monkeys, and humans*. 2009 Toxicol. 256 (1-2), pp 65-74 https://doi.org/10.1016/j.tox.2008.11.008 ; Russell et al. *Elimination Kinetics of perfluorohexanoic acid in humans and comparison with mouse, rat and monkey.* 2013, Chemosphere 93 (10) pp 2419-2425 https://doi.org/10.1016/j.chemosphere.2013.08.060

[21]Rosenmai et al. *Fluorinated alkyl substances and technical mixtures used in food paper-packaging exhibit endocrine-related activity in vitro*. 2016, Andrology 4(4):662-672 https://doi.org/10.1111/andr.12190

[22]Burkemper et al., *Radiosynthesis and Biological Distribution of ^{18}F-Labeled Perfluorinated Alkyl Substances* Environ. Sci. Technol. Lett., 2017, *4* (6), pp 211–215 DOI: 10.1021/acs.estlett.7b00042

[23]Blaine et al., *Perfluoroalkyl Acid Distribution in Various Plant Compartments of Edible Crops Grown in Biosolids-Amended soils.* Environ. Sci. Technol., 2014, *48* (14), pp 7858–7865 DOI: 10.1021/es500016s

[24]Sun et al., *Legacy and Emerging Perfluoroalkyl Substances Are Important Drinking Water Contaminants in the Cape Fear River Watershed of North Carolina.* Environ. Sci. Technol. Lett., 2016, *3* (12), pp 415–419. DOI: 10.1021/acs.estlett.6b00398
a. 2016 ES&T Letters 3:415-419

[25]Toxic-Free Future, *The Toxicity of New Generation PFASs*, January 2018; www.toxicfreefuture.org

[26]TEDX Factsheet: Select PFAS Listed on TEDX List of Potential Endocrine Disruptors

[27]Cal/EPA DTSC, 2018, Ibid.

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