

Introduction

Welcome & Thank you!



Kenneth F. Ede, Ph.D., CHMM
Director, Professional Science Master's (PSM) Program
Environmental Science Graduate Program (ESGP)

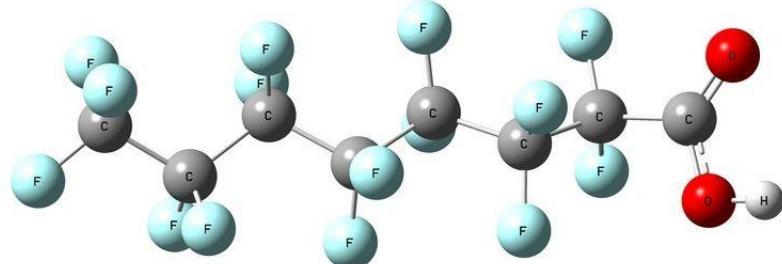
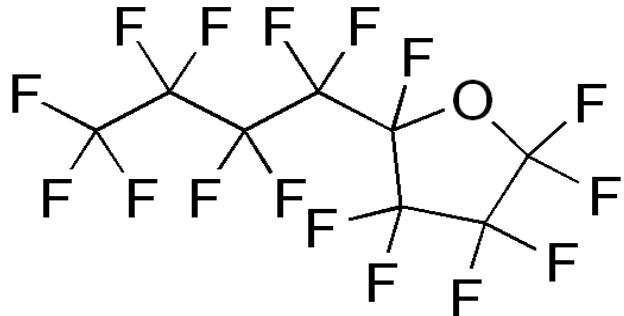
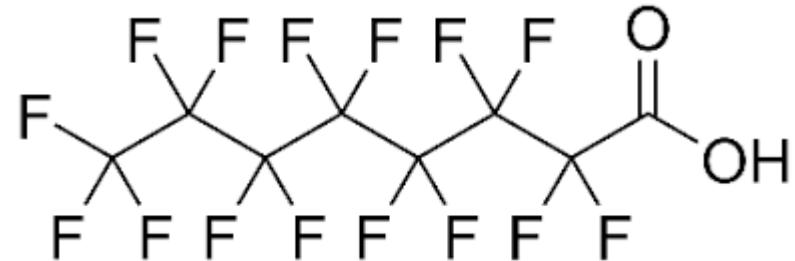
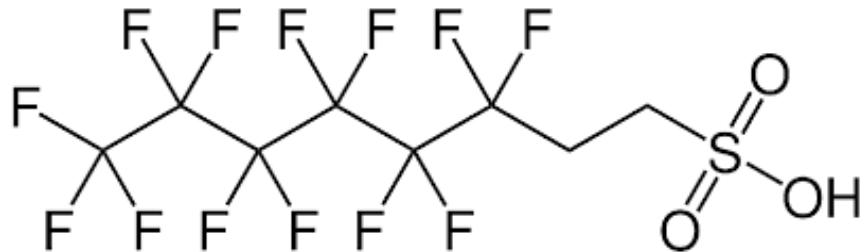
MY OSU PLUG

- If you have ever thought about your:
- Master of Science Degree in Environmental Science from Oklahoma State University,
- Please contact me!!
- Ken.Ede@okstate.edu



The Ubiquity and Uncertainty of PFAS (Per- & Polyfluoroalkyl substances)

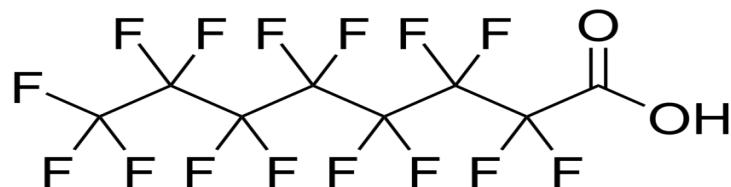
ONE CHEMIST'S PERSPECTIVE



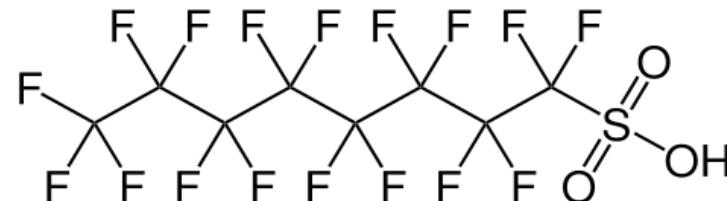
PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

- PFAS: Umbrella term
 - Aliphatic (straight carbon chains)
 - No aromatic rings
 - No chlorofluorocarbons (refrigerants)
 - PFAS are family of >6,000 manmade chemicals (PFOS, PFOA, etc....)

PFOS



PFOA



2017

2018

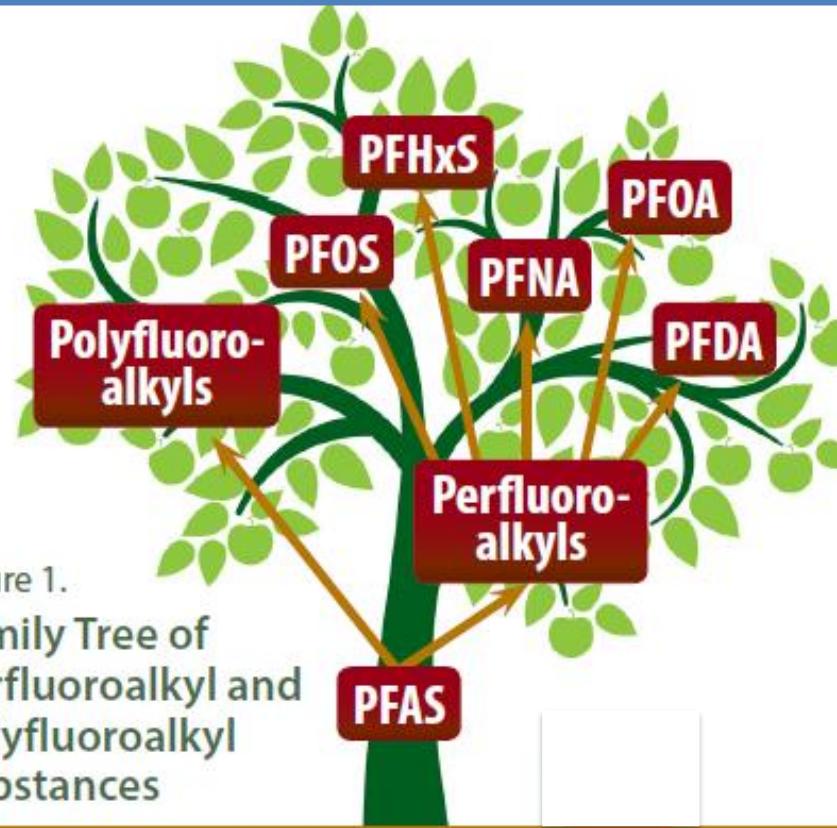
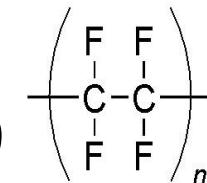


Figure 1.
Family Tree of
perfluoroalkyl and
polyfluoroalkyl
Substances

History of PFAS

- 1938: These type of compounds were discovered by Dr. Roy J. Plunkett with Dupont
- It was a result of a failed experiment involving refrigerator coolant (Freon)
- The waxy substance proved to be the most slippery material in existence
- Dr. Plunkett actually synthesized polytetrafluoroethylene (PTFE - Teflon)



American chemist **ROY J PLUNKETT**
died on May 12, 1994



MAN WHO INVENTED TEFLON

Most known for inventing **TEFLON**, a non-sticky substance with useful characteristics, in 1938

Cooking pans coated with Teflon, invented later, have **revolutionised** the way households cook

Invented polytetrafluoroethylene (PTFE), i.e. Teflon, **accidentally** while conducting an experiment on a possible new refrigerant at a laboratory

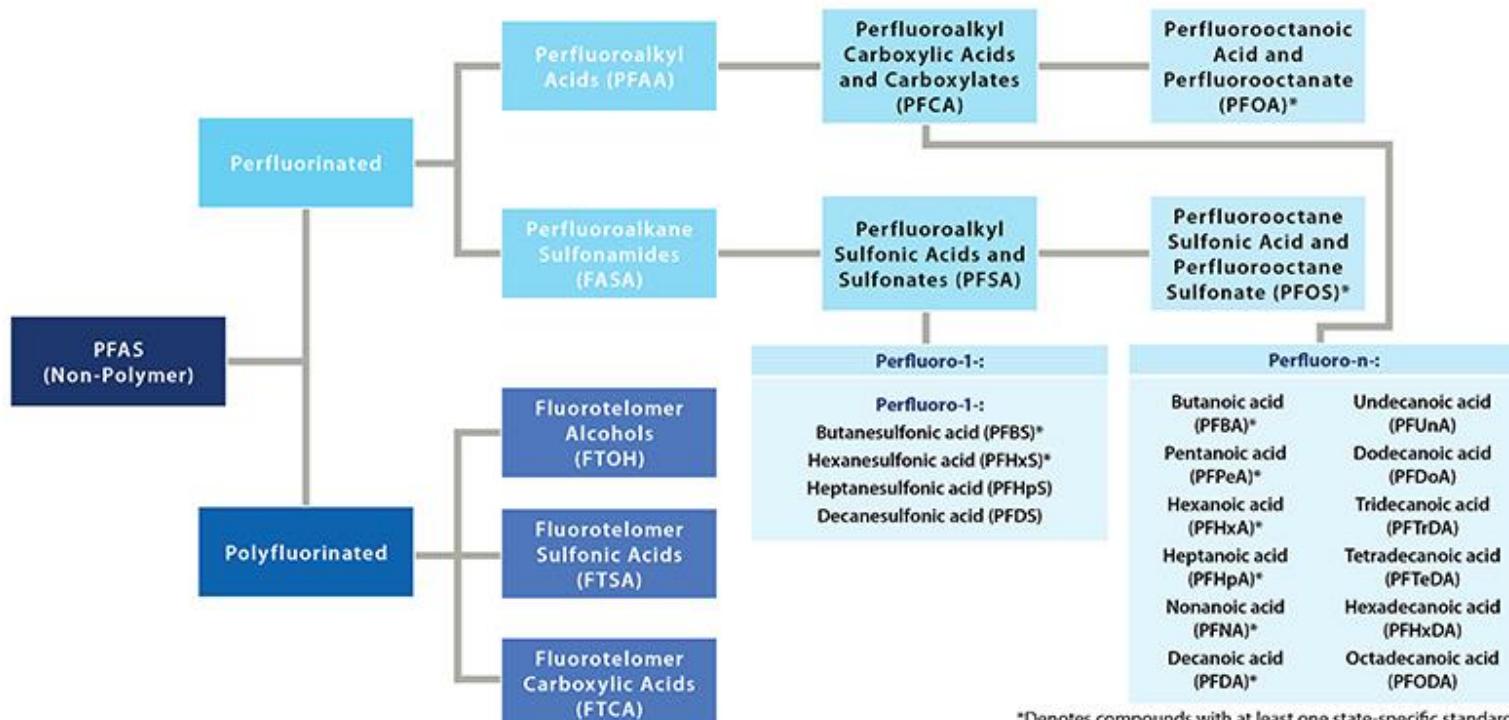
His invention was first used in **industrial & military applications** due to its high cost of production



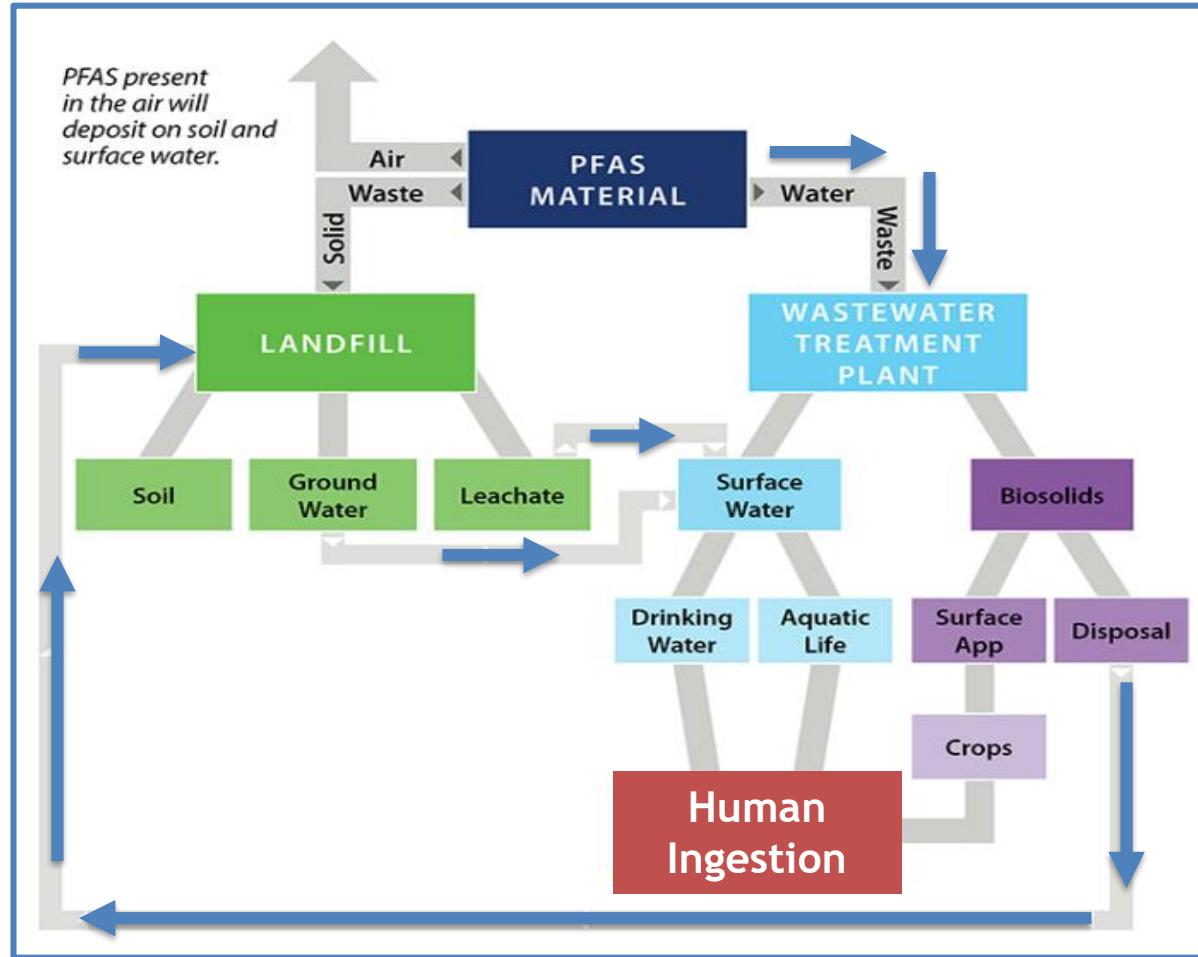
Was awarded a **PATENT** in 1941 for his invention

Plunkett was inducted to the **Plastics Hall of Fame** in 1973 & the **National Inventors Hall of Fame** in

PFAS Family Tree

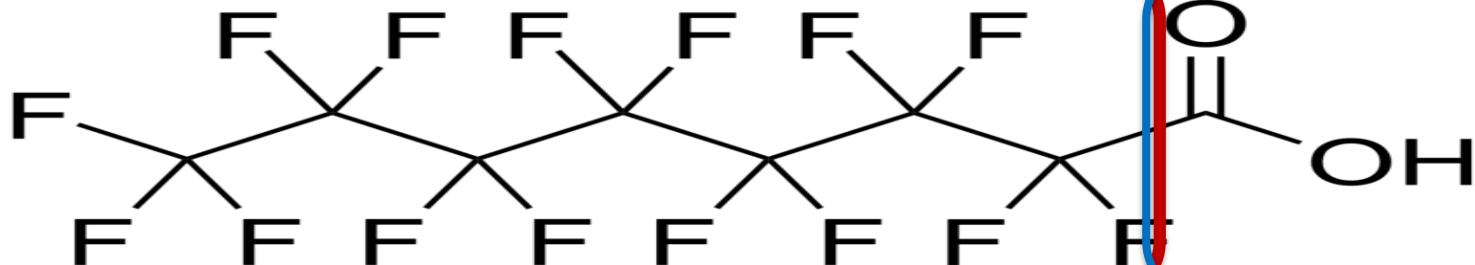


Typical Life Cycle of PFAS in the Environment



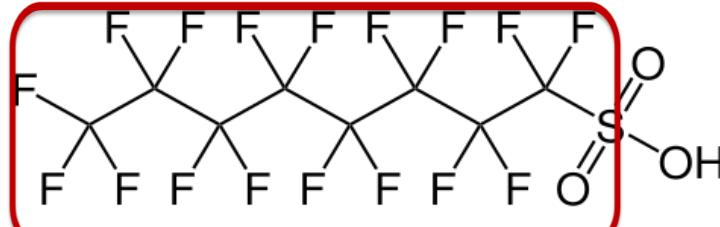
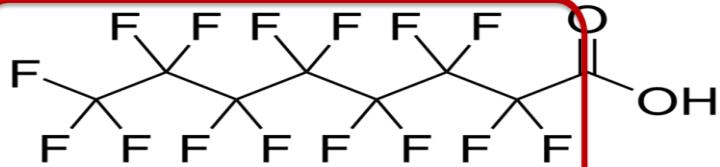
So, what is so special about PFAS?

- Why so chemically stable?
 - Low polarizability of Fluorine
 - Small size of Fluorine
 - Fluorine shields carbon but not the functional group



PFAS: Why so stable?

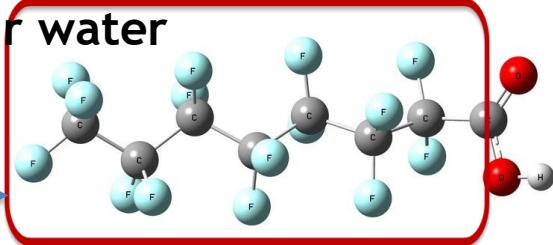
➤ Like an armored vehicle, no place to react



Do not boil your water

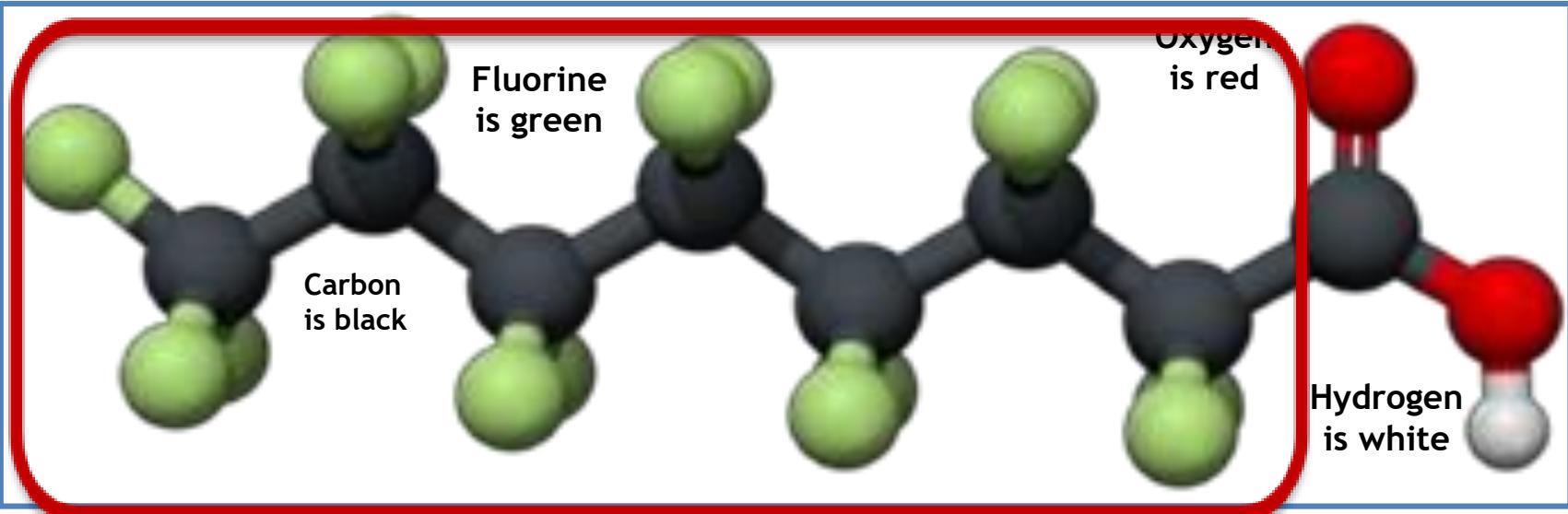
Melting Point of Carbon Steel: 1425°C

Destruction temperature: 1000°C



So, from a Chemistry perspective, what is so special about PFAS?

- Carbon - Fluorine bond is very **STRONG**
- Short bond length (due to very high electronegativity of Fluorine)
- Needs high energy to break bond between the carbon atom and fluorine
- Can be designed to repel water or
- Can be designed to repel oil!
- Thermally stable



Example of a fully-fluorinated six-carbon PFAS

The Evil Chemist

- My background is Chemistry
- This presentation is from a Chemist's perspective
- If I was an evil Chemist (which I am not) what substances and/or molecules would I synthesize to hurt mankind?

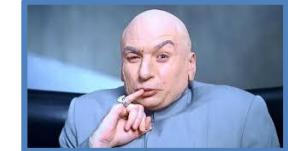


The Evil Chemist



- #1: I would synthesize a substance that would be used by everyone;
- Rich, poor, middle-class, infants, young children, middle-age, elderly, Blacks, Whites, Hispanics, non-Hispanics, Military, Civilians,everyone! But not just in the US..
- I would want contaminate everyone worldwide!

If I was an Evil Chemist



#2: I want design this substance to be extremely **slippery!**

- Therefore, you would use this in cooking
- Because every one wants non-stick, slippery cooking pots and utensils
- And then I would market this product to anyone who cooks (especially young couples)

Commercial and Consumer Products Containing PFAS

- In addition, I want this substance to be heat resistant!
- Therefore, every time you cooked I could ensure that I could contaminate you by allowing just a small amount (leach) each time



Then, I would market this substance as a “must-have”

Happy the young homemaker (and her husband, too!) who gets a full set of Everedy's TEFLON-Coated Aluminum Cookware. The cooking's better (no-stick)... the cleaning's easy (no-scor) ... the selection's complete. At fine stores everywhere.

THE EVEREDY COMPANY Frederick, Md. 21701
a division of Standard International Corp.

Wedding Gifts

AMAZING NEW CONCEPT IN *Cooking*

FREE SPATULA WITH EACH "HAPPY PAN"

NOTHING STICKS TO
"HAPPY PAN"

A cast iron skillet sealed with DuPont TEFLON®

Choose a pan like you choose a man.
It's what's on the inside that counts.

A good pan isn't hard to find. Providing you examine it from our side first. The inside. If it's a "Teflon" coated pan you've made the right decision. Because "Teflon" coated cookware honours its promise of being non-stick. It makes cooking easier. It makes washing up effortless. It's scratch resistant. So you can use ordinary kitchen tools. Now you can concentrate on the other side. There are dozens of lovely

outdoors, all different colours and patterns. But get your priorities right. Examine the inside before you look at the outside. And always remember to look for the "Teflon" label. Happy pan hunting.

DU PONT HARD BASE QUALITY
TEFLON SCRATCH-RESISTANT FINISH

DuPont Teflon
PTFE non-stick finishes

© The Advertising Archives *DuPont's registered trademark. DuPont Company (UK) Limited.

Marketing Teflon

TEFLON II* certified bakeware does the trick for our Tic Tac Toe cake.

A cake that's baked in TEFLON-coated bakeware滑出 of the pan so easily you'll almost never have to repair a broken corner or a split end. And because clean-up is such a snap with TEFLON-coated cookware, you'll have more time to enjoy all the masterpiece you create.

When you shop, just be sure to look for the TEFLON II Quality Seal so you know you've got the original recipe for no-stick baking and easy cleaning.

TIC TAC TOE CAKE

3 ounces semisweet chocolate

1 cup butter

2 1/2 cups sifted cake flour

1 1/2 cups granulated sugar

3/4 cup milk

1 1/2 cups sugar

1/2 cup oil

1 1/2 cups sugar

1 egg white

3 eggs, 1 egg white

Preheat oven to 350°. Melt chocolate in a saucepan coated with TEFLON over very low heat, and let cool. Cream butter in mixing bowl to soften. Sift flour and other dry ingredients onto butter. Mix with milk and nuts to play tic toe too.



The TEFLON II Quality Seal is DuPont's registered mark for TEFLON-coated bakeware which meets DuPont's exacting standards for no-stick bakeware.

Scallop-molded. Beat two minutes. Add eggs and chocolate and beat one minute longer, scraping bowl often. Pour into 9" x 8" greased and floured TEFLON-coated loaf pan. Bake 1 1/4 hours, or until cake tests done. Cool for 10 minutes before removing from pan.

FROSTING

1/2 cup soft butter

3/4 tsp. salt

1 tsp. vanilla

1 lb. sifted confectioners' sugar

1 egg white, unbeaten

1 or 2 lbs. milk

Cream butter, salt and vanilla until light and fluffy. Add sugar alternately with egg white, beating well after each addition. Add milk gradually, beating until smooth and to the desired consistency.

TO ASSEMBLE
Trim loaf into rectangle. Cut into thirds horizontally. Frost between layers and reassemble. Wrap loaf in plastic wrap and refrigerate. When ready to serve, remove from plastic wrap and frost again. Frost between layers and reassemble. Frost sides and top of cake. Chill until serving. Cut into 1" slices and use tiny marshmallows and nuts to play tic toe too.



Now...
a MIRRO-MATIC PRESSURE PAN
finished inside with 2-layer
TEFLON

MILLIONS HAVE
AND THEY'RE DELIGHTED!

OUT OF THE FRYING PAN AND ONTO THE IRONING BOARD COVER!

NO-STICK SPEED-COOKING — Our MIRRO-MATIC Pressure Pan has been saving time and money for millions of women, for years and years.

No more labor-saver, too!

With its new, 2-layer Teflon finish, you get no-stick speed-cooking and no-scorch cleanup, with the same, long-lasting satisfaction that every other Teflon-finished MIRRO utensil gives you. That's because the MIRRO way is to bake on one layer of no-stick, no-scorch Teflon, then add a second layer of Teflon on the Teflon. And that's the only way you get Teflon at its best.

You really shouldn't go another meal without a MIRRO-MATIC. Especially now that there's one with a 2-layer Teflon finish.

The BIG Difference

MIRRO revolutionized home cooking with Teflon, the first major advance in ironing board covers in more than a decade. And now, with this amazing discovery that brings you graceful, no-scorch cleaning — now you can have the same great results with your free-frying pans — now you can have the super-professional results in far less time. And for \$5 less than ordinary covers, you'll enjoy super-economy, too. But most of all, you'll enjoy

Dramatic test proves the MIRRO-MATIC Pressure Pan with 2-layer Teflon—NO SCORCH after 10 minutes of continuous use. Ordinary aluminum pressure pans scorch after 10 minutes.

Another **Maple** first!
NEWARK, NEW JERSEY

4 qt. Teflon lined \$18.95
Others unlined, \$14.95 to \$22.95

NO-STICK SPEED-COOKING — Our MIRRO-MATIC Pressure Pan has been saving time and money for millions of women, for years and years.

No more labor-saver, too!

With its new, 2-layer Teflon finish, you get no-stick speed-cooking and no-scorch cleanup, with the same, long-lasting satisfaction that every other Teflon-finished MIRRO utensil gives you. That's because the MIRRO way is to bake on one layer of no-stick, no-scorch Teflon, then add a second layer of Teflon on the Teflon. And that's the only way you get Teflon at its best.

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Dramatic test proves the MIRRO-MATIC Pressure Pan with 2-layer Teflon—NO SCORCH after 10 minutes of continuous use. Ordinary aluminum pressure pans scorch after 10 minutes.

Another **Maple** first!
NEWARK, NEW JERSEY

ENJOY A TOTALLY NEW EXPERIENCE IN IRONING!
MAGLA IRONING BOARD COVER coated with **TEFLON***

With Teflon, revolutionizing home cooking is just the beginning. Now, revolutionizing ironing board covers in more than a decade, too! And now, with this amazing discovery that brings you graceful, no-scorch cleaning — now you can have the same great results with your ironing board covers — now you can have the super-professional results in far less time. And for \$5 less than ordinary covers, you'll enjoy super-economy, too. But most of all, you'll enjoy

Dramatic test proves the Magla Ironing Board Cover coated with Teflon—NO SCORCH after 10 minutes of continuous use. Ordinary ironing board covers scorch after 10 minutes.

Another **Maple** first!
NEWARK, NEW JERSEY

From frying
pans to
ironing board
covers



The Evil Chemist: I would also market this to your children

(2) 48 T 32005 MD—Sink with running water, shelves. Wt. 4 lbs. 8 oz. 7.79 separately. Ship. wt. 21 lbs. 4-pc. set 28.16

100 pieces **5.99**

52 pieces **5.49**

“Teflon” tea set . . . just like Mom’s

An old-fashioned pattern for today’s little girl. Service for 6 includes: 6 plates (4-in. diam.), dessert plates, cups, saucers, goblets covered soup servers, flatware and napkins. Plus teapot with cover, sugar bowl, creamer, 2 covered saucepans with handles, 2 covered casseroles, 6-piece utensil set with rack, salad bowl, pot warmer, napkin holder, fruit bowl and 9 pieces of “fruit.” All made of easy-clean nontoxic plastic.

48 T 32389—Ship. wt. 2 lbs. 7 oz. set 5.99

48 T 32390—Ship. wt. 1 lb. 10 oz. set 5.49

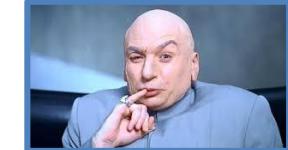
I2⁹⁹

Sturdy all-in-one kitchen

He’ll enjoy hours of playtime fun “cooking” on the 4-burner oven; “baking” in see-thru oven; washing dishes in sink with running water; keeping her kitchen neat by storing foods! in refrigerator, dishes and pots on overhead shelves, sturdy corrugated fiberboard unit; easy-clean plastic countertop and trim. Easy to assemble—shipped flat to save you money. Accessories not included—why not add a Wande tea set? 46 in. high. Mailable.

48 T 32009 M—Ship. wt. 9 lbs. 12 oz. 12.99 BACKS 351

If I was an Evil Chemist



- Next, I would design this same substance to be repel both oils & greases
- I would market this substance as a “coating” on all food packaging
- This would prevent “soggy” containers
- This way I could contaminate you just a small amount each time you ate!

The Evil Chemist



- No one wants a soggy pizza box
- No one wants a soggy popcorn bag
- No one wants a soggy food containers



Evil Chemist: Use this material to repel oil in food packaging

- Therefore, every time you used a:
- pizza box,
- microwave popcorn bag,
- Chinese take-away container, would be coated internally so I could contaminate you!



Evil Chemist: Use this material to repel oil in food packaging

- And any other food container
- Just a small amount would leach each time



Microwave Popcorn PFAS

BRAND	TYPE	LIKELY PFAS-TREATED*
Act II	Butter Lovers	X
Act II	Kettle Corn	X
Act II	Buttery Kettle Corn	X
Act II	Movie Theater Butter	X
Act II	Light Butter	X
Act II	Mini Bags Butter	X
Pop Weaver	Kettle Corn	X
Pop Weaver	Extra Butter	X
Pop Weaver	Butter	X
Pop Weaver	Light Butter	X
Orville Redenbacher's	Movie Theater Butter	X
Orville Redenbacher's	Ultimate Butter Pop Up Bowl	X
Clover Valley	Extra Butter Flavor	X
Clover Valley	Kettle Corn	X
Lowrey's	Bacon Curls Microwave Pork Rinds	X
Lowrey's	Bacon Curls Microwave Pork Rinds - Hot & Spicy	X
Pop Secret	Homestyle	X
Pop Secret	Movie Theater Butter	X
Regal Cinemas	Movie Theater Butter Flavor	X

PFAS CHEMICALS FOUND IN FAST FOOD CONTAINERS

DESSERT AND
BREAD WRAPPERS



BURGER AND
SANDWICH WRAPPERS



PAPERBOARD



PAPER CUPS



56%

38%

20%

0%

The Evil Chemist

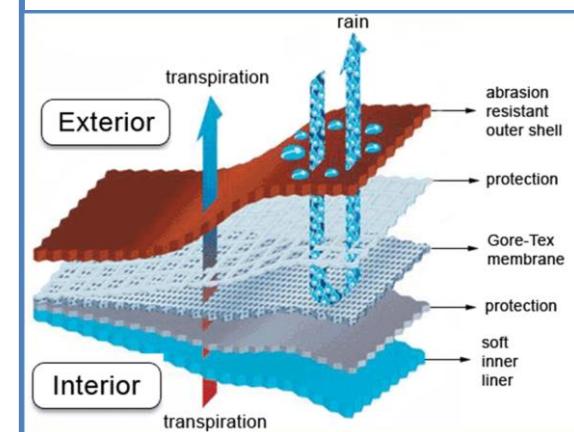


- Next, I would synthesize a substance everyone would use to waterproof your
- backpack,
- tent,
- shoes,
- And your clothing
- A little contamination every day

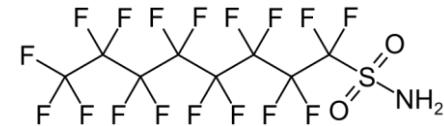


Real World: Gore-Tex

- 1969: Gore-Tex invented
- Waterproof, breathable fabric membrane
- It is composed of polytetrafluoroethylene (PTFE), AKA Teflon
- PTFE is made using an emulsion polymerization using PFOA
- In 2013, (after 44 years) Gore-Tex eliminated the use of PFOAs in the manufacture of its weatherproof functional fabrics



The Evil Chemist



- Next, I would synthesize a substance everyone would use to for stain resistance & water resistance
- I would place this substance on:
- Carpets
- Fabrics
- Furniture



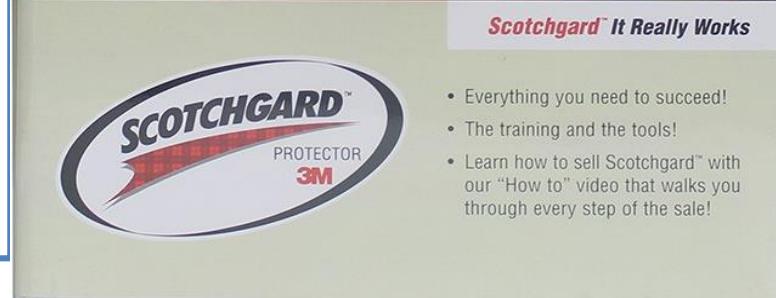
Real World: History of Scotchgard

- 1956: 3M begins selling Scotchgard Protector
- 1999: EPA began an investigation into the class of chemicals used in Scotchgard
- May 2000: 3M announced the phase-out of the production of PFOA, PFOS, and PFOS-related products
- 44 years later!



History of Scotchgard

➤ 2018, 3M agreed to pay the state of Minnesota \$850 million to settle a \$5 billion lawsuit over drinking water contaminated by PFOA



In a First, California Moves to Protect People from Toxic PFAS Chemicals in Carpets

By **Tasha Stoiber, Senior Scientist**



TUESDAY, MARCH 13, 2018

In a groundbreaking move, California has proposed that carpets and rugs containing the stain-resistant fluorinated chemicals known as PFAS^[1] should be considered a priority product under the state's Safer Consumer Products program. This could lead to the development of safer alternatives to the use of these potentially harmful chemicals in carpets and rugs.

Carpets and rugs cover nearly half of all U.S. homes and workplaces. The California Department of Toxic Substances Control has identified carpets and rugs as the largest potential sources of significant and widespread PFAS exposures, especially for children.

The Evil Chemist

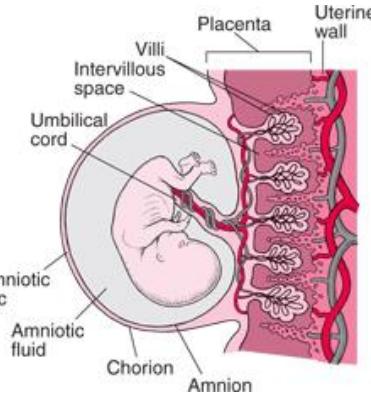


- As stated earlier, as an evil Chemist I want to contaminate:
- Unborn babies
- Nursing Infants
- Young Children/Toddlers



Real World: Unborn babies

- PFAS found in the umbilical cord blood from their mothers can cross the placenta barrier during pregnancy to the baby
- Therefore, every time the Mother is exposed to PFAS, I could also contaminate the child!



EHP Environmental Health Perspectives

HOME CURRENT ISSUE ARCHIVES COLLECTIONS AUTHORS ABOUT

Research

Maternal Concentrations of Polyfluoroalkyl Compounds during Pregnancy and Fetal and Postnatal Growth in British Girls

Mildred Maisonet, Metreica L. Terrell, Michael A. McGeehan, Krista Yorita Christensen, Adrienne Holmes, Antonia M. Calafat, and Michele Marcus

First Published: 30 August 2012 | Cited by: 78

Rappazzo, K. M., Coffman, E., & Hines, E. P. (2017). Exposure to Perfluorinated Alkyl Substances and Health Outcomes in Children: A Systematic Review of the Epidemiologic Literature. International Journal of Environmental Research and Public Health, 14(7), 691.

Real World: Nursing Babies

- Newborns can be exposed to PFAS through breast milk or
- Through Formula made with water that contains PFAS



Do not boil your water

Rappazzo, K. M., Coffman, E., & Hines, E. P. (2017). Exposure to Perfluorinated Alkyl Substances and Health Outcomes in Children: A Systematic Review of the Epidemiologic Literature. *International Journal of Environmental Research and Public Health*, 14(7), 691.

Real World: Young Children

- Young children have a higher risk of exposure to PFAS from carpet cleaners and similar products, largely due to time spent lying and crawling on floors in their early years



Toddler



Real World: Young Children

- In addition, children of all ages are exposed to PFAS in stain resistant car seats covers



FIRE FIGHTING FOAM & FIRE FIGHTERS

- Next, if I was an evil Chemist, I would synthesize molecules would be essential for extinguishing large fires
- Therefore, I would develop an innocent looking firefighting foam so I can both contaminate the ground, groundwater and the firefighters



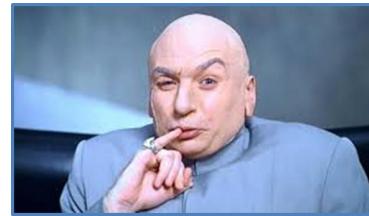
FIRE FIGHTING FOAM

- As the evil Chemist, I would ensure that this foam would be used by both our military
- And civilians
- Therefore, I could contaminate all military bases & military personnel worldwide
- In addition, I could contaminate civilian airports and personnel

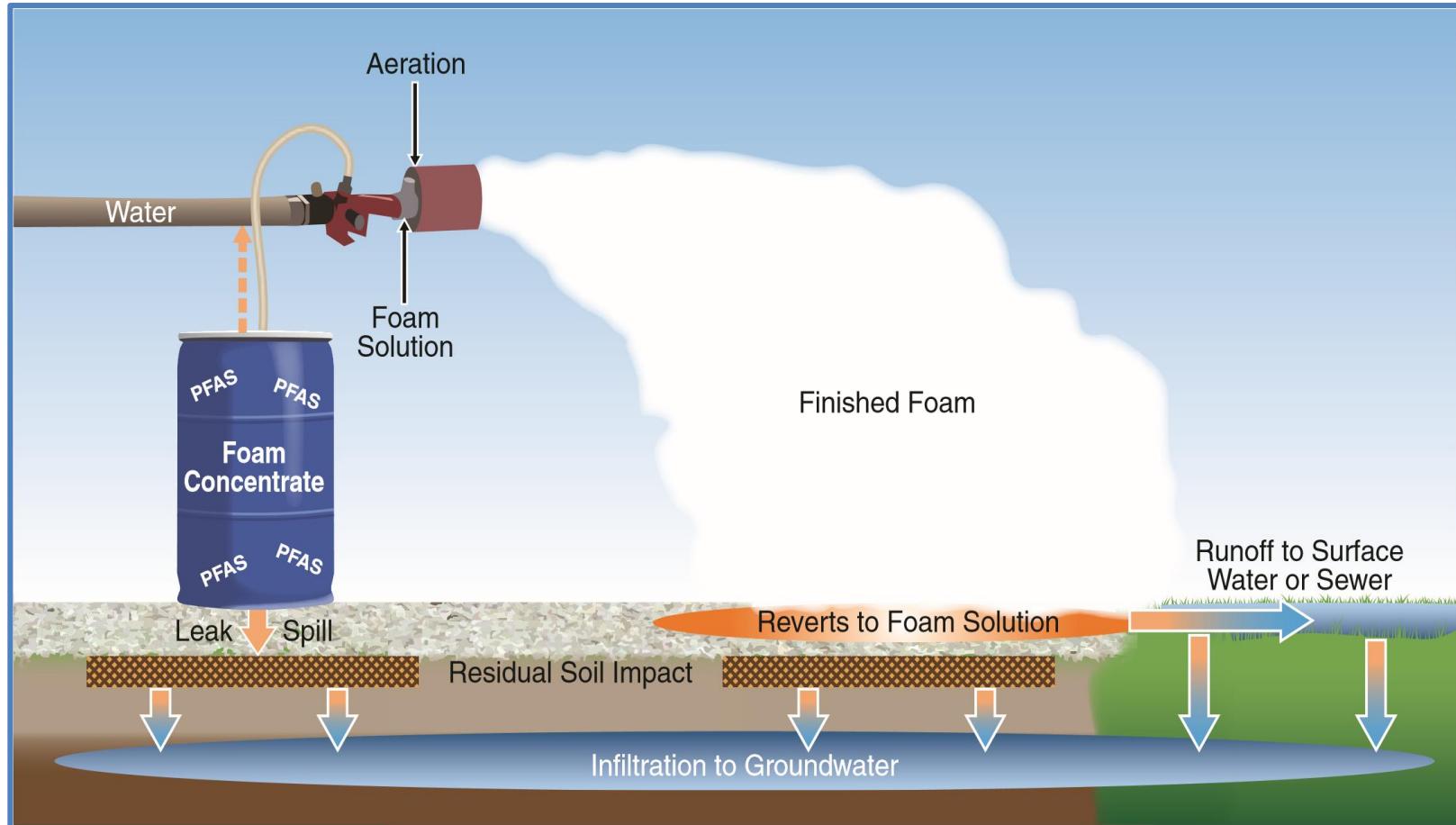


FIRE FIGHTING FOAM

- If I was an evil Chemist, I would develop a “**deluge system**” that would be required in all aircraft hangars (both military and civilian)
- All insurance companies would require this deluge system to insure the hangars



Fire Fighting Foam with Deluge System







Test Ellsworth AFB POL



AFFF









FIRE FIGHTING FOAM



- Next, if I was an evil Chemist, I would ensure that the volume of foam generated by this **“deluge system”** would be so great, that the only disposal option would be to open the hangar doors and release it to the environment
- Therefore, I could contaminate the stormwater outfalls (rivers, creeks, lakes & oceans), the soil and groundwater







This is not snow!





818







Real World: History of AFFF

- AFFF (Aqueous Film Forming Foam) contains per- and polyfluoroalkyl substances
- Both the Defense Department and Civilian organizations have used AFFF since the 1970s to suppress liquid fuel fires
- AFFF acts quickly by smothering fuel when a thin film of foam forms on the fuel, stopping contact with oxygen
- Repeated historical applications of AFFFs at sites were a result of fire-fighter training exercises and equipment testing

Real World: Cancer Rates in firefighters are on the rise!

LOCAL

Battle After the Blaze: Current firefighters grapple with the 'age of cancer'

One Jeffersontown firefighter said cancer is the "unfortunate risk of our jobs."

Author: Rob Harris

Published: 1:05 PM EDT October 8, 2018

Updated: 7:00 AM EDT October 9, 2018

LOUISVILLE (WHAS11) -- For firefighters, the line of duty dangers doesn't end when the flames are out.

"It's an unfortunate risk of our jobs, just as the black lung is an unfortunate risk of being a coal miner. You know, this is ours," Sgt. Joshua Johnson with the Jeffersontown Fire Department said.

Cancer rates in firefighters



41 year old non-smoker



The Evil Chemist

- As an Evil Chemist, I would introduce products that the populace would use everyday without even thinking about it
- For example, I would synthesize a substance that is used in the following:



Commercial and Consumer Products Containing PFAS

- Paper and packaging
- Clothing and carpets
- Outdoor textiles and sporting equipment
- Ski and snowboard waxes
- Cookware
- Cleaning agents and fabric softeners
- Polishes and waxes
- Latex paints
- Pesticides and herbicides
- Hydraulic fluids
- Windshield wipers
- Paints, varnishes, dyes & inks
- Adhesives
- Medical products
- Shampoo
- Hair conditioners
- Sunscreen
- Cosmetics
- Toothpaste
- Dental floss



Cosmetics with PFAS

- Eye Shadow
- Lipstick
- Foundation
- Facial Powder
- Bronzer
- Blush



Commercial and Consumer Products Containing PFAS

➤ Cosmetics

Cosmetics giant L'Oréal to eliminate PFASs in products

Sixth company commits to phase-out following Swedish NGO campaign

19 July 2018 / Personal care, PFCs, Retail

French brand L'Oréal has become the latest of six large cosmetics companies to commit to eliminating per- and polyfluoroalkyl substances (PFASs) in its products, since December last year.

Swedish NGO, the Nature Conservation Association, announced the move online, after receiving an email from the company in response to its social media campaign.

The campaign which launched in the summer of 2017, placed pressure on eight major cosmetics companies to phase out PFASs.

In its email to the NCA, L'Oréal says it has "decided not to use PFASs any more" as part of its global sustainability programme.

"The reformulation process is being completed and we are doing our utmost to remove PFAS topics. Please note that this applies to all L'Oréal-owned trademarks," the email continues.

Karin Lexén, general secretary of the NCA, called the company's announcement an "amazing result".

NEWS

EWG cosmetics database indicates PFAS in 66 different products from 15 brands



FOOD & DRINKING WATER

➤ If I was an evil Chemist, I would ensure that these molecules would be introduced into a food and drinking water

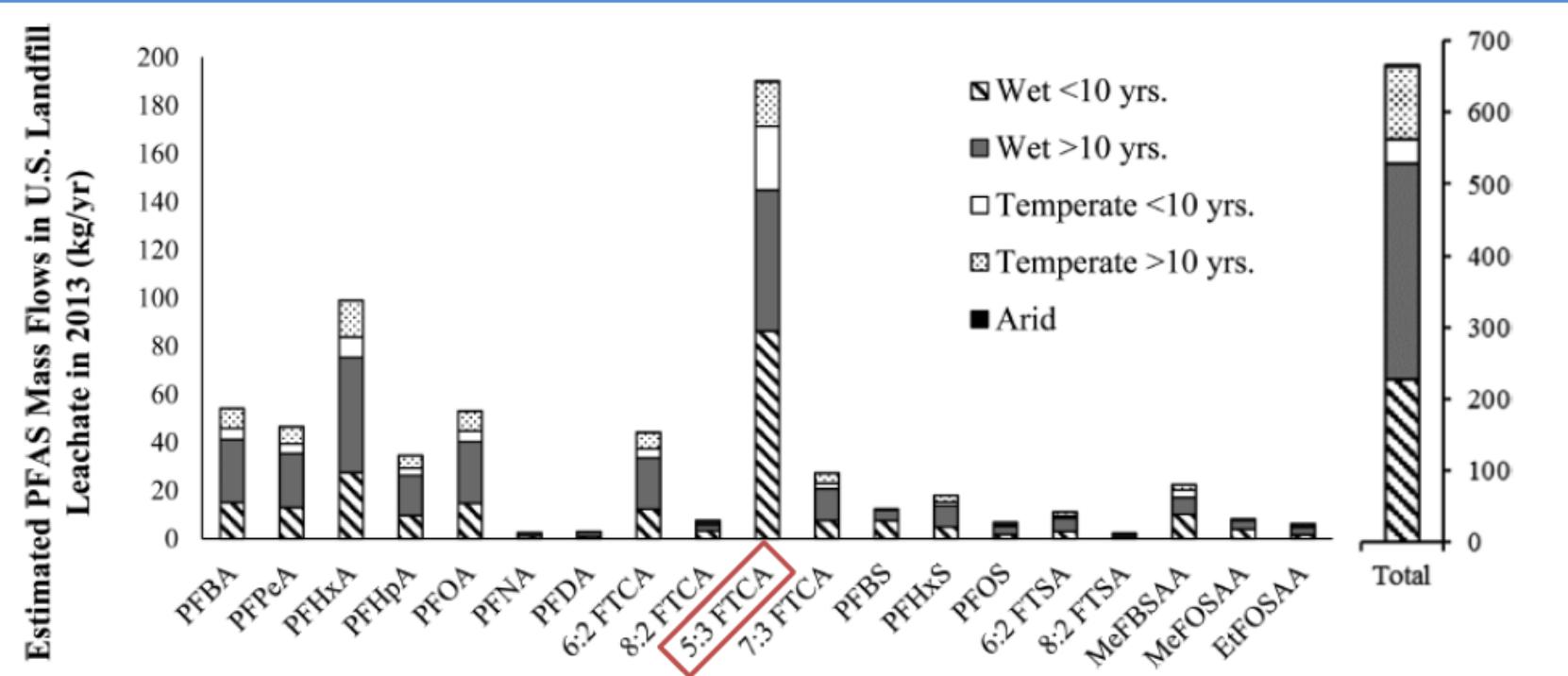


PFAS: Waste Disposal

- Waste in landfills from consumer products containing Scotchgard, Teflon, Gore-Tex, etc., create landfill leachate containing PFAS¹
- 89% of post-consumer carpets ends up in landfills across the country
- 4,000,000,000 pounds per year!² (4 billion pounds/year)
- This leachate can contaminate groundwater with PFAS that is used for drinking water

1. Busch et al. 2010; Eggen, Moeder, and Arukwe 2010
2. Greenwaste, 2015

PFAS Release from U.S. Landfills to WWTPs for waste landfilled in 2013



How long do PFAS remain in the body?

According to CDC, PFAS with long carbon chains have estimated **half-lives** ranging from 0.1 to 9 years such as:

- PFBS: 0.1 years
- PFOA: 2 to 4 years
- PFOS: 5 to 6 years
- PFHxS: 8 to 9 years
- What are the medical problems with PFAS?

Human Health Effects associated with PFAS

➤ Probable link between C8 (PFAS) the following diseases:

- Kidney Cancer
- Testicular Cancer
- Other Cancers
- Ulcerative Colitis (long-lasting inflammation and ulcers in the digestive tract)
- Thyroid Disease
- Pregnancy Induced Hypertension
- Low birth weight

Human Health Effects associated with PFAS

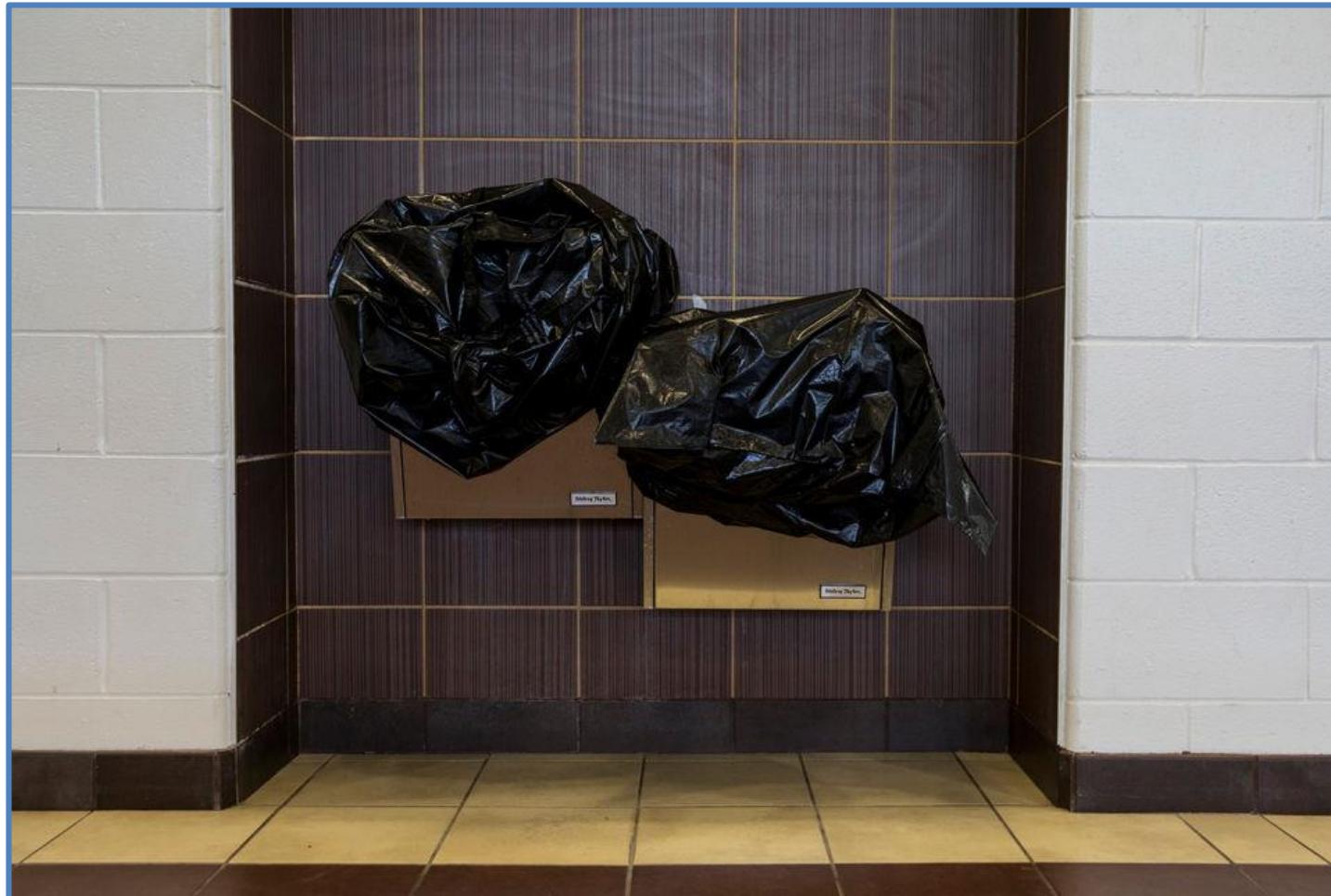
- Probable link between C8 (PFAS) the following diseases:
- Preeclampsia
(pregnancy complication characterized by high blood pressure and signs of damage to another organ system, most often the liver and kidneys)
- Hypercholesterolemia
(high cholesterol)
- Decreased vaccination response

PFAS in Drinking Water

- The Swedish National Food Agency has determined that the drinking water of over one third of the country's municipal consumers is at risk or already affected by PFAS contamination

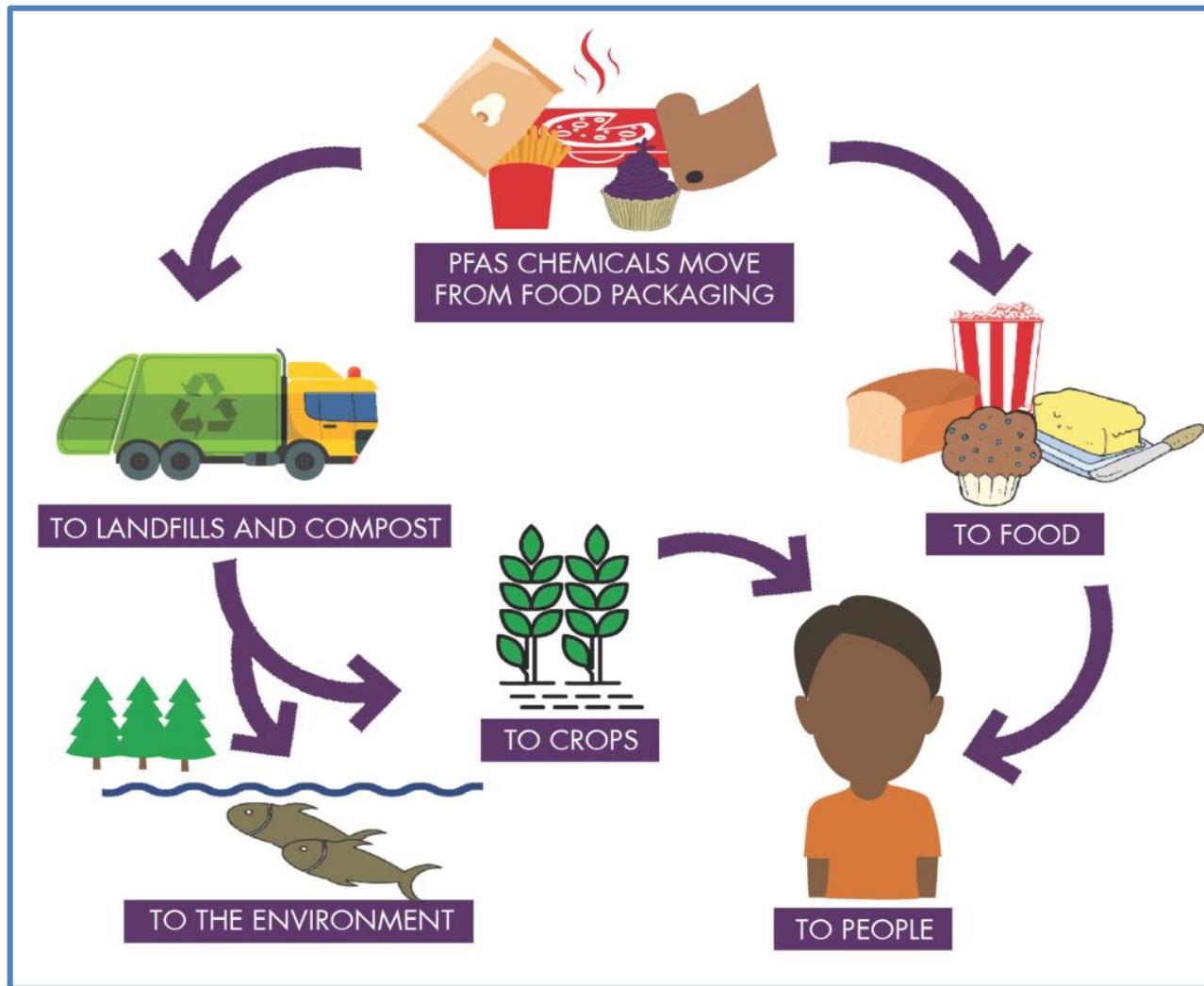


PFAS contaminated water



The result of PFAS





Biosolids

- PFAS have been found in domestic sewage sludge
- Problem: According to USEPA states that more than half of the sludge produced in the United States is applied to agricultural land as biosolids, therefore biosolids application can be a source of PFAS to the environment

Phase-out of Long-Chain PFAS

- In May 2000, 3M, the principal worldwide manufacturer and sole U.S. manufacturer of PFOS, announced a voluntary phase-out of PFOS, PFHxS, PFOA, and related precursors

Phase-out of Long-Chain PFAS

- This may be of little help
- The problem is that PFAS are manufactured globally
- Recently increased production of PFAS in China, India, and Russia have potentially offset the global reduction anticipated with the U.S. phase-out

The Future of PFOAs

- Early 2000, manufactures have shorten the length of these compounds from ≥ 8 carbons to ≤ 6 carbons
- And have added new names:
 - ❖ GenX (consent order with EPA)
 - ❖ ADONA
- Less toxic???
- We shall see.....

Analytical Techniques for PFAS

- Potable Water: USEPA 537, Version 1.1
- Just 14 compounds out of 5000 to 10,000 compounds
- Non-potable water or soil: None
- But EPA developing analytical techniques
- Draft SW-846 Method 8327 Direct Injection
- Draft SW-846 Method 8328, Solid Phase Extraction

The Evil Chemist



In summary, here are our challenges with PFAS:

1. Persistent (does not breakdown) = bioaccumulate
2. Mobile (water and/or fat soluble) so it can Bioaccumulate
3. Toxic to human health & the environment
4. Placed on items we use every day
5. Poor analytical techniques

QUESTIONS?



A man testing a prototype football helmet. [1912]