

# Bisphenol A Substitutes: Are They Safe?

Johanna R. Rochester

March 18<sup>th</sup> 2015

**TEDX**

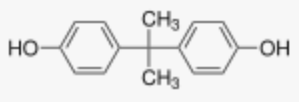
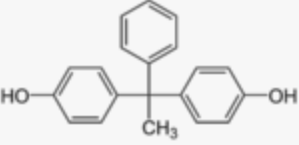
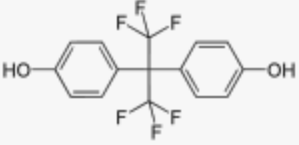
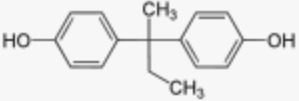
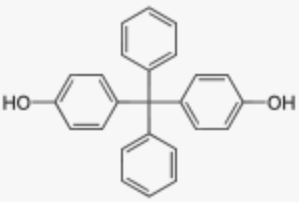
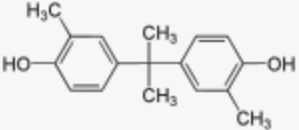
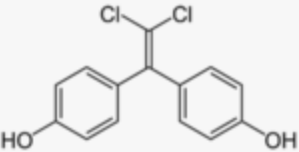
The Endocrine Disruption Exchange

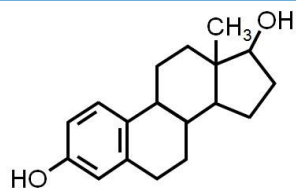


# BPA Substitutes

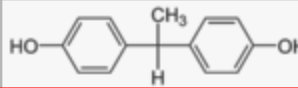
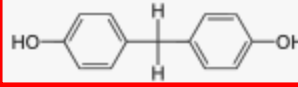
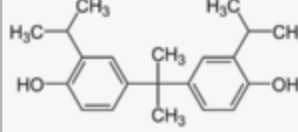
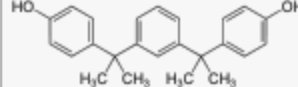
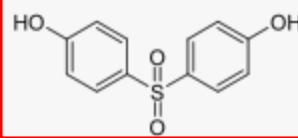
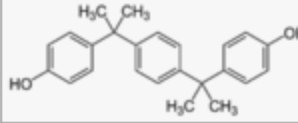
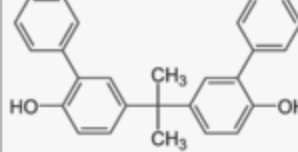
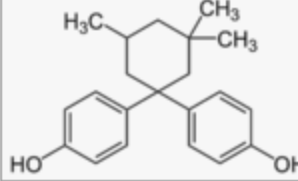
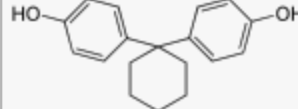


- BPA is an endocrine disrupting chemical (EDC)
- Growing consumer concern has prompted use of alternatives to BPA by manufacturers
- Many are bisphenol analogues
- Can be in products labeled “BPA free”

Structural formula	Name	CAS
	Bisphenol A	80-05-7
	Bisphenol AP	1571-75-1
	Bisphenol AF	1478-61-1
	Bisphenol B	77-40-7
	Bisphenol BP	1844-01-5
	Bisphenol C	79-97-0
	Bisphenol C	14868-03-2



17β-estradiol (E2)  
natural estrogen

	Bisphenol E	
	Bisphenol F	87139-40-0
	Bisphenol G	127-54-8
	Bisphenol M	13595-25-0
	Bisphenol S	80-09-1
	Bisphenol P	2167-51-3
	Bisphenol PH	24038-68-4
	Bisphenol TMC	129188-99-4
	Bisphenol Z	843-55-0

# Bisphenol S and F: A Systematic Review and Comparison of the Hormonal Activity of Bisphenol A Substitutes

Johanna R. Rochester and Ashley L. Bolden

*Environmental Health Perspectives*

Published online March 16<sup>th</sup> 2015

- Systematic Review
  - Focused on a research question
  - Comprehensive, structured, transparent
  - Study quality
  - Data synthesis



# Overview

- Bisphenol A (BPA) as an endocrine disrupting chemical (EDC)
- BPA substitutes: BPS and BPF hormonal activity
- Potency of BPS and BPF compared to BPA
- Conclusions/Recommendations



# Bisphenol A

- Known estrogen since the 1930s
- Modern Uses
  - Hard plastic
    - Recycling codes #7, #3
  - Thermal receipt paper
  - Dental sealants/fillings
  - Can linings
- >3.5 million tonnes produced per year
- Humans exposed through diet, skin, dust



FRAME SLIDE FLOAT	400100972816	16.99	1 @	16.99
FRAME SLIDE FLOAT	400100972816	16.99	1 @	16.99
FLOAT FRAME WHITE	400100972885	14.99	1 @	14.99
FLOAT FRAME WHITE	400100972885	14.99	1 @	14.99
FLOAT FRAME WHITE	400100972885	14.99	1 @	14.99
FLOAT FRAME WHITE	400100972885	14.99	1 @	14.99
FLOAT FRAME WHITE	400100972885	14.99	1 @	14.99
SUBTOTAL				108.93
Sales Tax 7.65%				8.33
TOTAL				117.26
ACCOUNT NUMBER		*****2273		

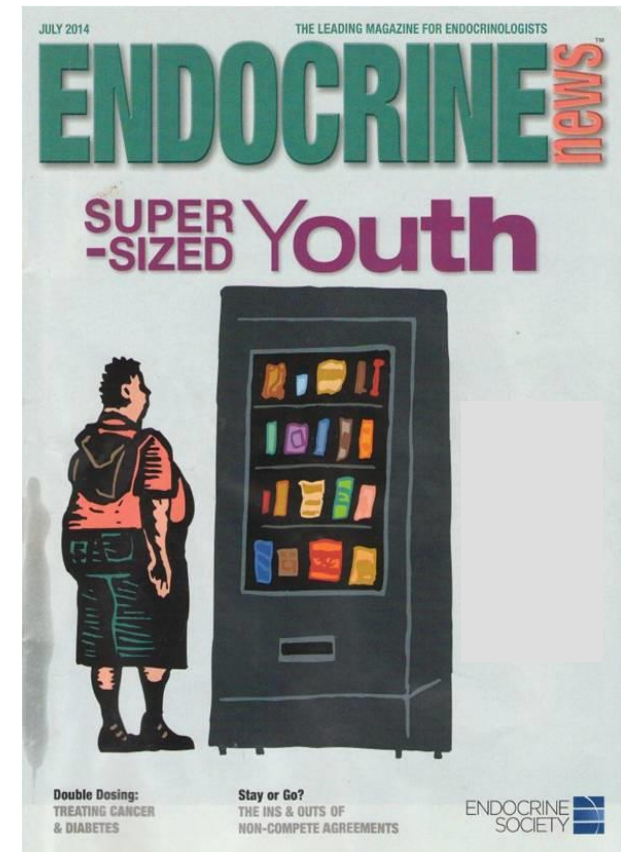
# BPA as an EDC

- Hundreds of studies
- *In vitro* and *in vivo*
  - Binds to estrogen, androgen, thyroid receptors
  - Disrupts reproduction, central nervous system, endocrine pancreas, immune system



# BPA and Human Health

- Over 75 epidemiological studies Rochester 2013. URL: <http://www.ncbi.nlm.nih.gov/pubmed/23994667>
- Disrupted reproduction, development, metabolic system, thyroid system, immune system, etc.
- Adulthood
- Development

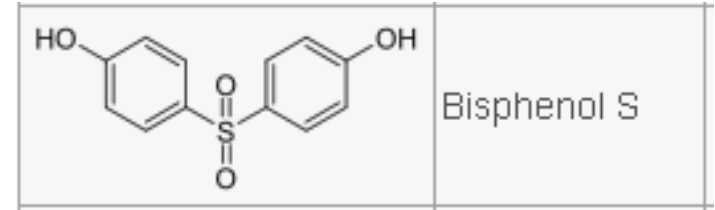




# BPA Substitutes

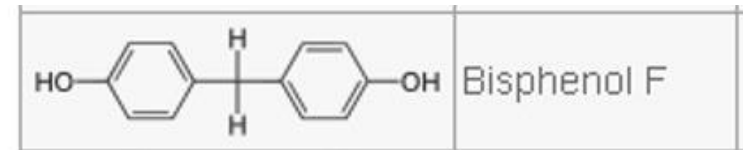
- **BPS**

- Industrial uses
- Thermal receipt paper (“BPA-free”)



- **BPF**

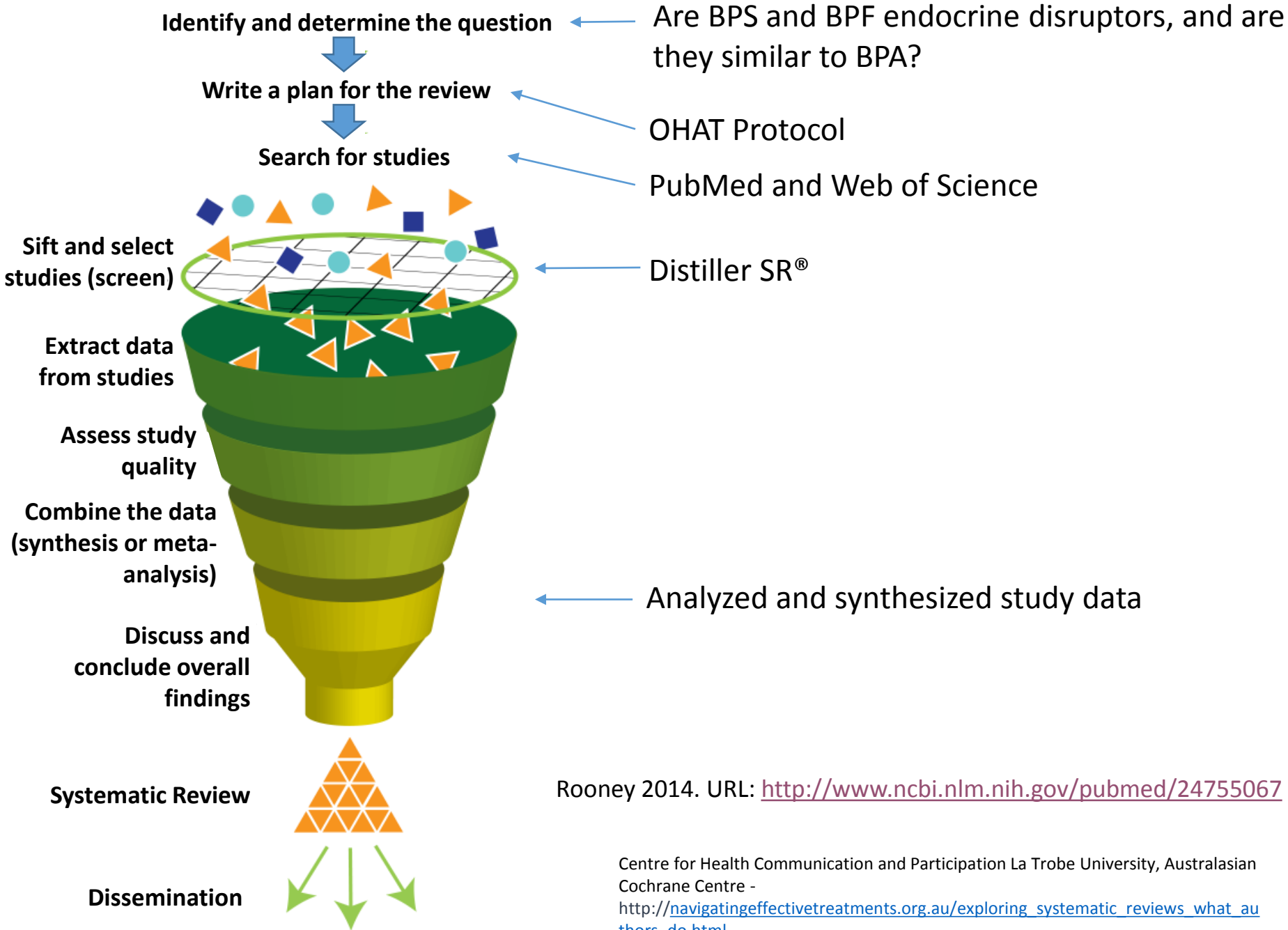
- Industrial uses
- Consumer uses



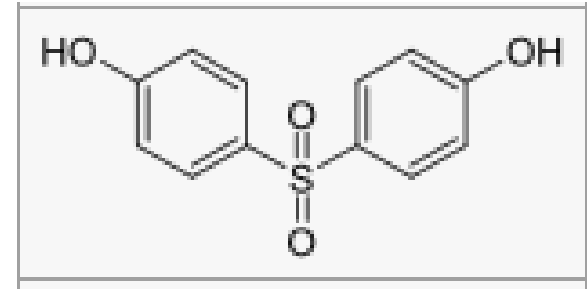
- Found in personal care products, paper products, food, dust, water, sewage effluent
- Both found in human urine at concentrations comparable to BPA

Liao 2012. URL: <http://www.ncbi.nlm.nih.gov/pubmed/22620267>

Zhou 2014. URL: <http://www.ncbi.nlm.nih.gov/pubmed/24316527>

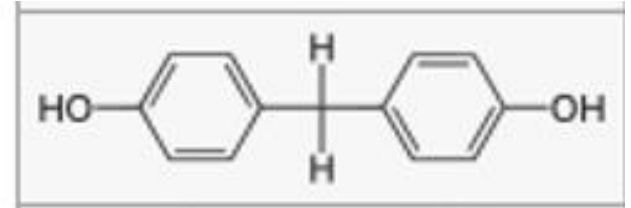


# Results: BPS activity



- *In vitro*:
  - Estrogenic
  - Androgenic
  - Anti-androgenic
  - Enzyme changes (caspase-8), liver cells, serum albumin binding, DNA damage
- *In vivo*:
  - Daphnia—acute toxicity
  - Zebra fish—reduced gonad weight, changes in serum hormones, disrupted reproduction
  - Rats—increased uterine growth

# Results: BPF activity

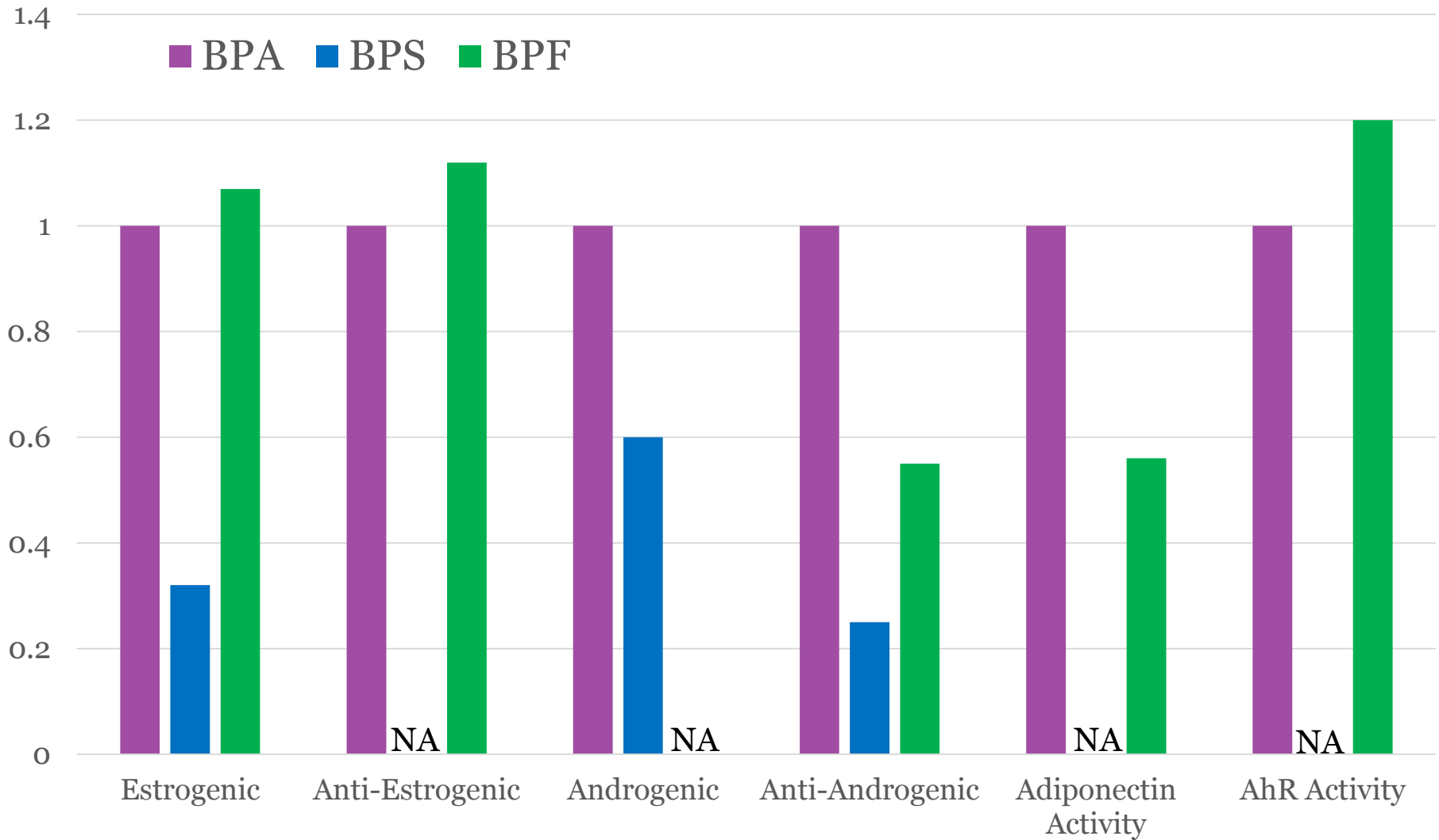


- *In vitro*:
  - Estrogenic
  - Anti-estrogenic
  - Anti-androgenic
  - Cytotoxicity, cellular dysfunction, DNA damage
- *In vivo*:
  - Daphnia—acute toxicity
  - Rats—increased uterine growth, increased male sex organ weight, thyroid disruption

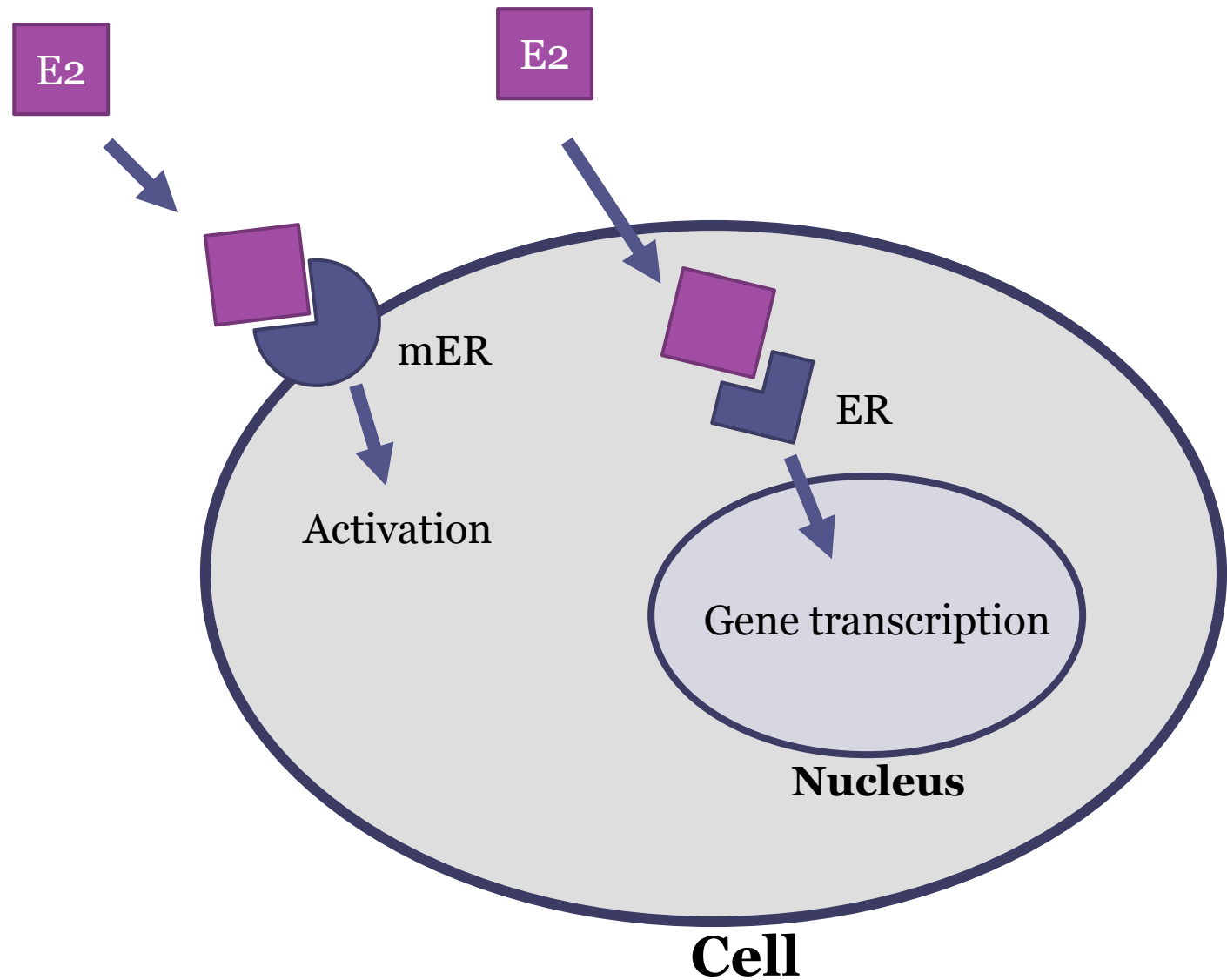
# How do BPS/BPF compare to BPA?

- Analyzed studies that tested BPF and/or BPS and BPA in the **same assay**
- *In vitro*
- Relative Potencies were calculated by dividing the BPS or BPF potency by the BPA potency in the same study

## Relative Potency of BPS/BPF (Compared to BPA)



# Different Pathways of Estrogen Action



# Estrogenic Activity

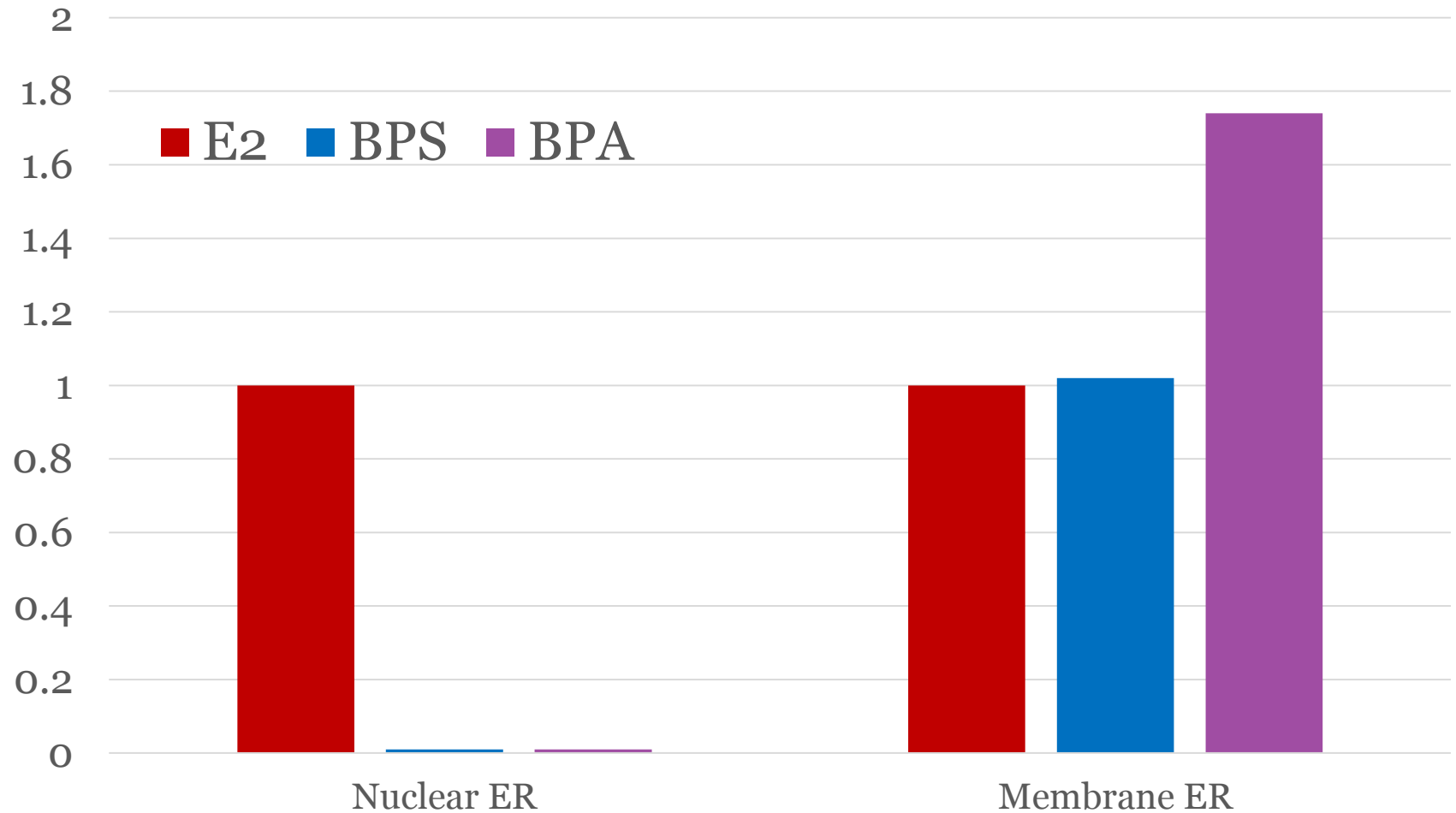
- BPA, BPS, and BPF are considered “weak” estrogens in *nuclear* receptor models
  - $10^{-6}$  to  $10^{-4}$  times less potent than E2
- However in *membrane* receptor models, BPA and BPS are of similar and greater potency to E2

Vinas 2013a. URL: <http://www.ncbi.nlm.nih.gov/pubmed/23458715>

Vinas 2013b. URL: <http://www.ncbi.nlm.nih.gov/pubmed/23530988>



## Relative Potency of BPA/BPS (Compared to Estradiol (E2))



# Conclusions

- BPS and BPF are EDCs
- Similarly potent to BPA via many hormonal activities and actions
- BPS and BPF are not good substitutes for BPA



# Recommendations

- Chemicals should be tested before being released
  - “Regrettable Substitutes”
- Classes of chemicals should be regulated
- Research should be directed towards developing biologically inert substitutes for harmful chemicals



# Acknowledgements

- Co-Author: Ashley L. Bolden
- TEDX Team: Carol Kwiatkowski, Lynn Carroll, Chris Ribbens, Kim Schultz
- This manuscript was dedicated to Dr. Theo Colborn (1927-2014), founder of TEDX

