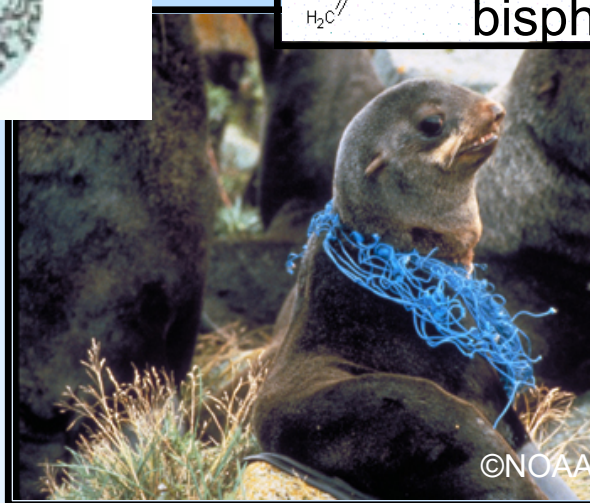
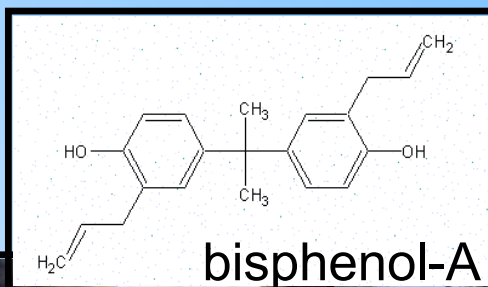


# The Ecology, Biology & Chemistry of MARINE DEBRIS



**UC DAVIS**  
**BODEGA MARINE**  
**LABORATORY**



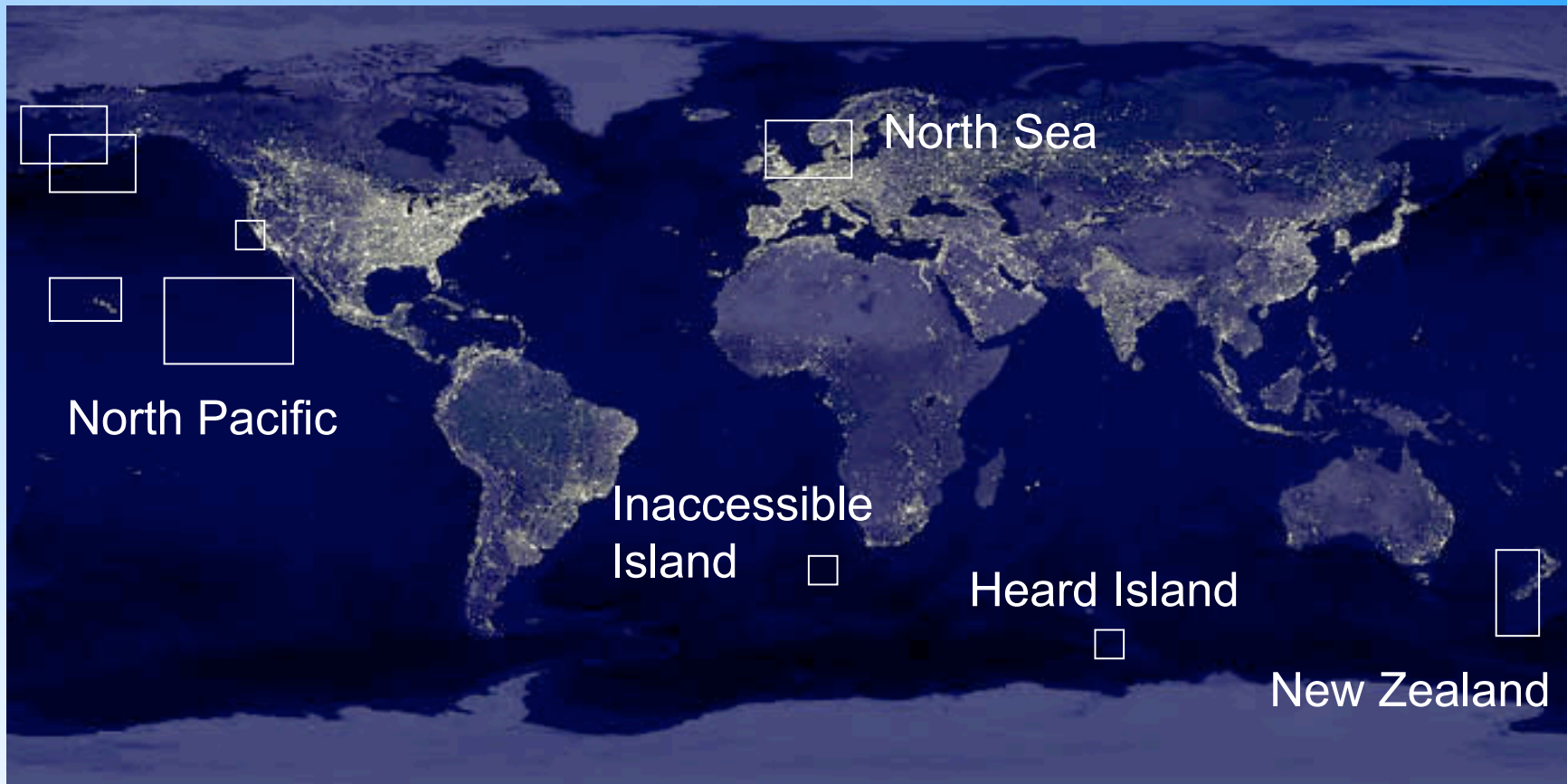


# Marine debris is found:

- on beaches
- floating on the water surface
- mixed in the water column
- on the bottom of the sea

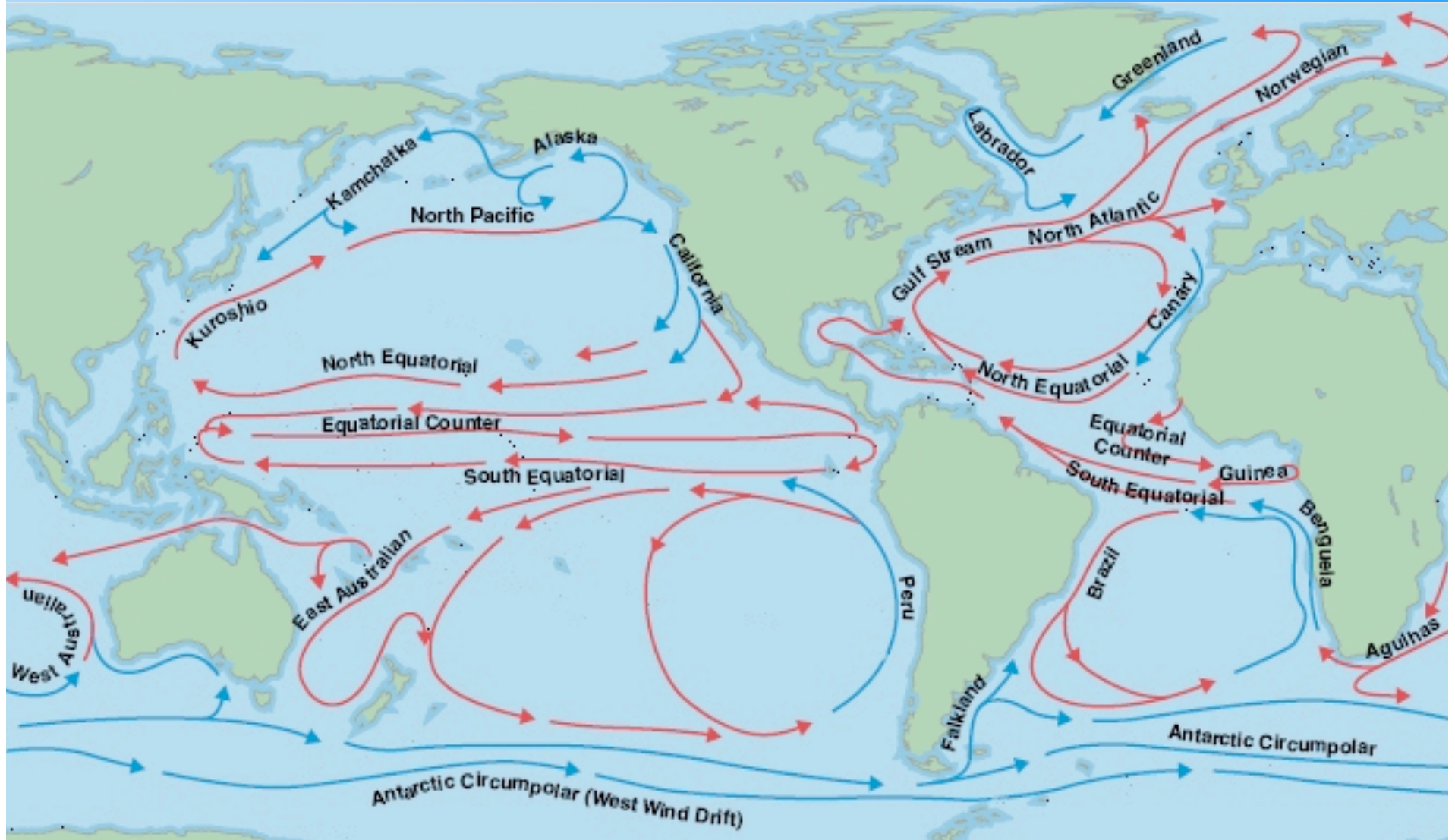


# Plastics are a global problem





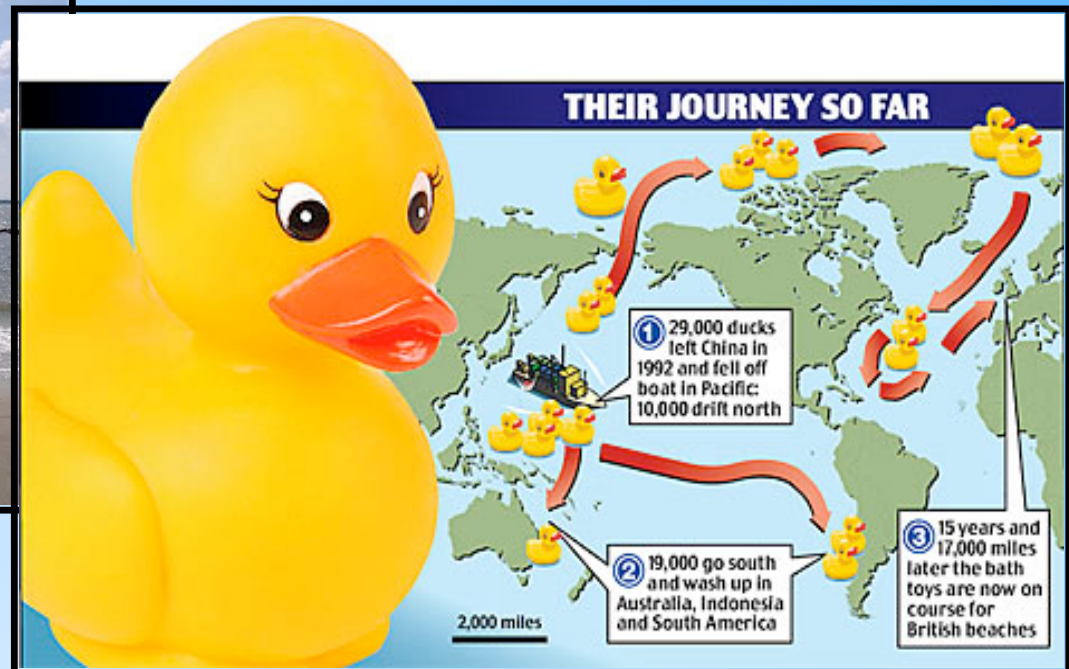
# How does marine debris move around in the ocean?



# Rubber Ducky Transport

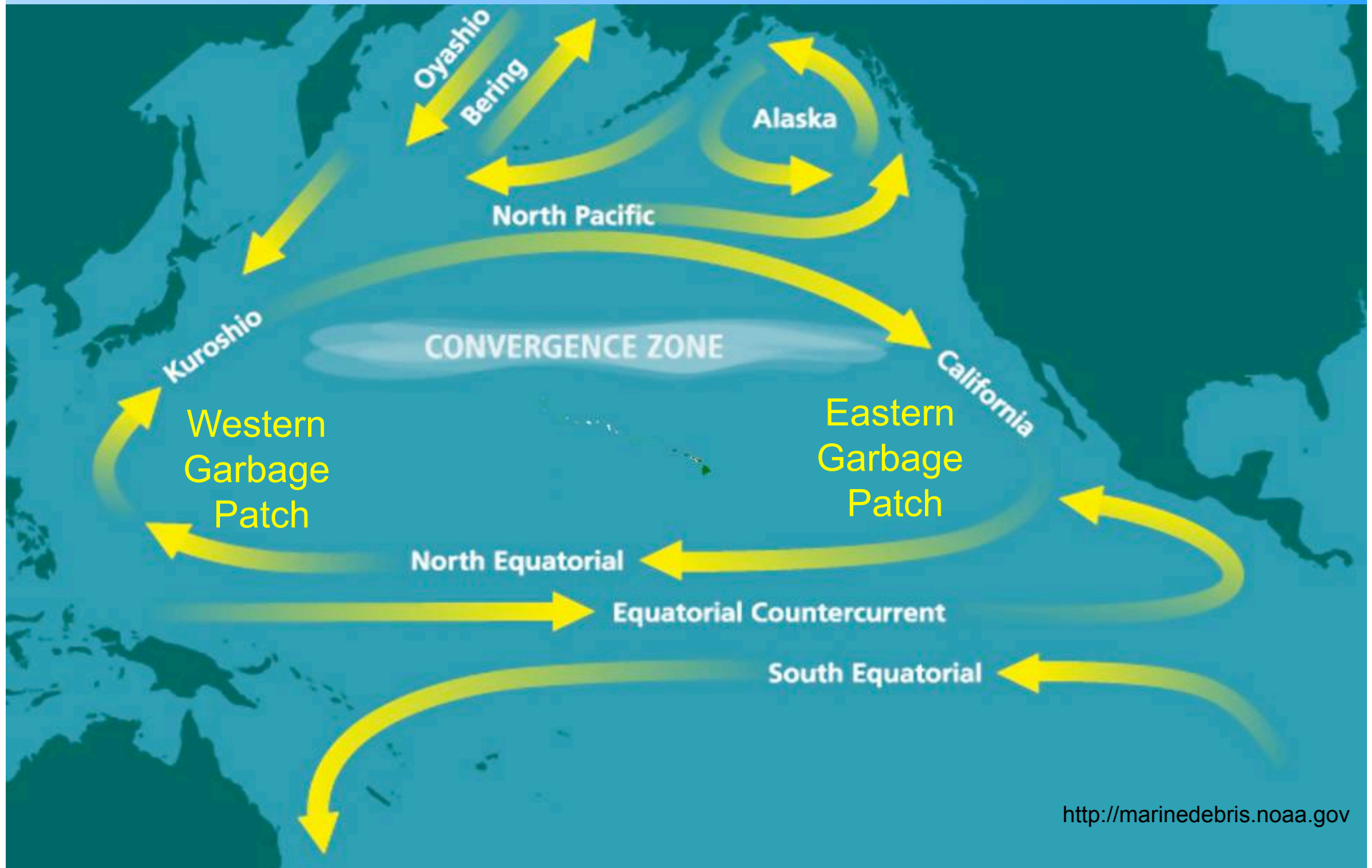


- 1992: 29,000 plastic toys spilled
- 1993: Washed up in Alaska
- 1995: Washed up in Hawaii, Japan and the USA
- 2000: Some are observed near Maine, USA
- 2007: Found on the shores of the United Kingdom





# Ocean surface currents collect debris into “garbage patches”



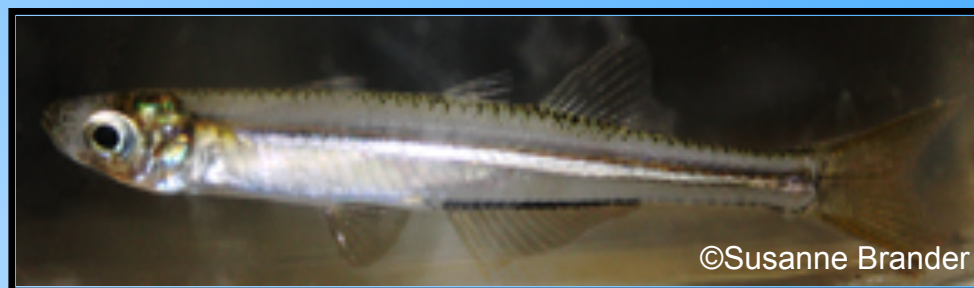
# Biological Indicator Species



*A species whose health status and abundance can be used to monitor the condition of an ecosystem or the environment.*

These species can be monitored for:

- biochemical changes
- physiological changes
- behavioral changes



## Example

- Tubifex (sludge) worms  
presence indicates water with  
low oxygen, a common feature  
of polluted water!



<http://www.nilesbio.com>



# Seabirds are **Biological Indicators** of plastic pollution



- Adult birds ingest plastic when foraging and capturing food
- Adults then feed plastic to young
- An increasing number of species affected by plastic debris and incidence of plastic



ingestion



# What is this?





# What is this?



©Ocean Conservancy



©Clare Flacker

©Kinnan



# An Albatross Bolus!



## Should contain:

- 50% fish
- 32% squid
- 5% crustaceans
- 10% stomach oil

(Harrison et al. 1983; Fry 1987; Kinnan 2000)



# BUT.....



©Kinnan



©Dr. Dwayne Meadows



©Rachel Fontana



# Short Term Effects of Plastic Ingestion

- Infection of cuts caused by plastic
- Obstruction of esophagus by plastic pieces
- Reduced food intake
- Dehydration



# Long Term Effects of Plastic Ingestion

- Plastic slowly breaks down in stomach
- Plastic can leach toxic chemicals (i.e. plasticizers)
- Seabirds absorb toxic chemicals into their bodies





# Other species at risk from plastics



©Alejandro Fallabrino



©John Sieben



<http://www.mindfully.org>



©Bill Macdonald

# Types of Plastics



Plastic type	Full name	Recycling code	Examples	Recyclable
PETE	polyethylene terephthalate	1	soda bottles	yes
HDPE	high density polyethylene	2	milk jugs, shampoo bottles, yogurt containers	yes
PVC	polyvinyl chloride	3	clear food packaging, candy wrappers, some bottles	sometimes
LDPE	low density polyethylene	4	squeezable bottles, shopping bags	yes
PP	polypropylene	5	caps, straws, some bottles	yes
PS	polystyrene	6	disposable plates & cups, CD cases	not usually
PC, other	polycarbonate	7	water jugs, sunglasses, DVDs	not usually

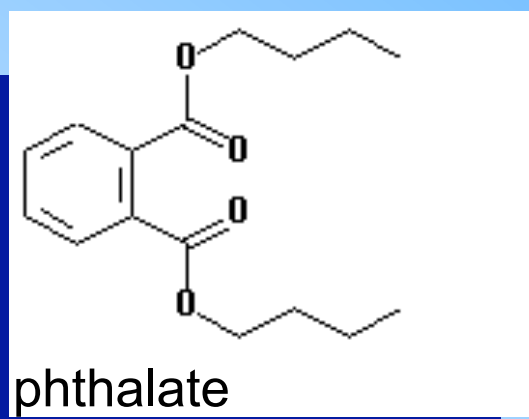
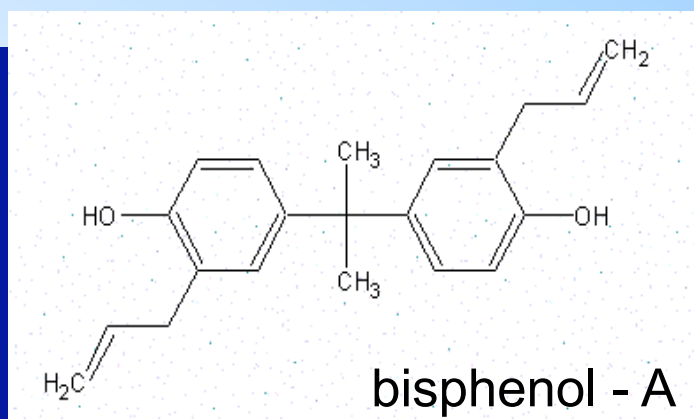
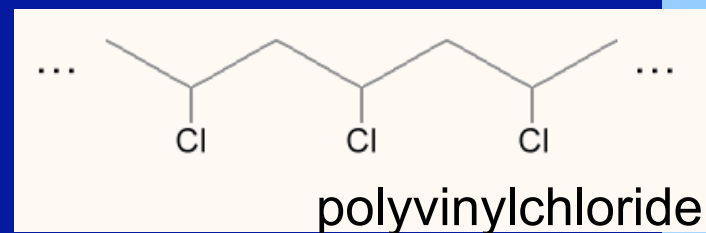
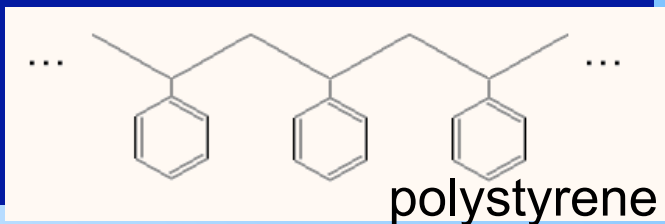


# Summary of Toxic Effects



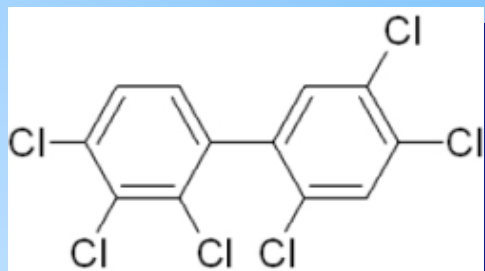
Toxic compound	Use	Effect(s)	Plastic type(s)
bisphenol A	plasticizer, can liner	mimics estrogen	PVC, PC
phthalates	plasticizer, artificial fragrances	Interferes with testosterone, sperm motility	PS, PVC
persistant organic pollutants (POPs)	pesticides, flame retardants, etc.	possible neurological and reproductive damage	all plastics
dioxins	produced in manufacture of PVC, during waste incineration	carcinogen, interferes with testosterone	all plastics
nonylphenol	anti-static, anti-fog, surfactant (in detergents)	mimics estrogen	PVC
polyaromatic hydrocarbon (PAHs)	produced when fossil fuels are burned	developmental and reproductive toxicity	all plastics
polychlorinated biphenyls (PCBs)	electronics manufacture	interferes with thyroid hormone	all plastics
styrene monomer	breakdown product	carcinogen, can form DNA adducts	polystyrene

# Plastics at the Molecular Level

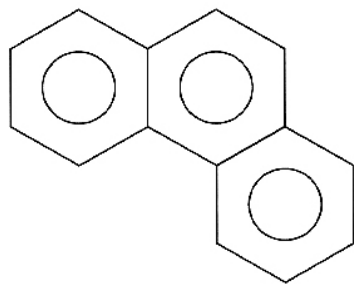




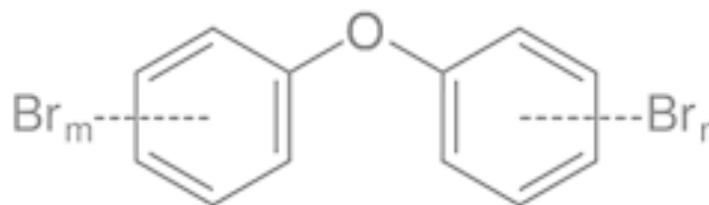
# Chemicals “adsorb” to plastics



PCB

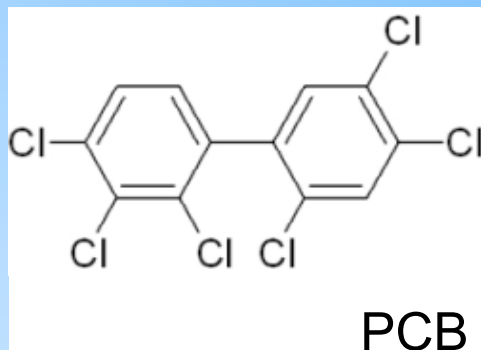


PAH



PBDE

# Chemicals associated with plastics

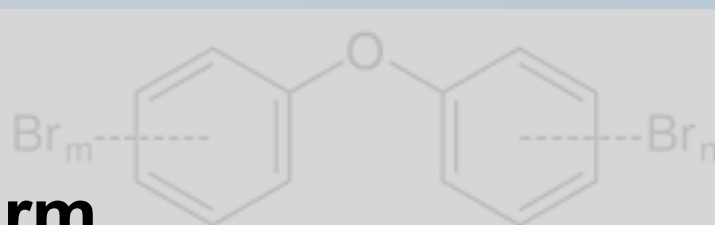
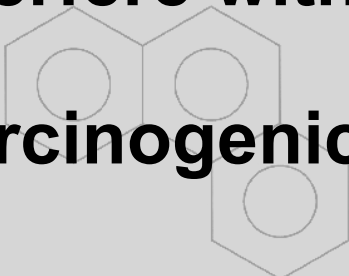


**Why are these chemicals harmful to organisms?**

- **Interfere with hormones**

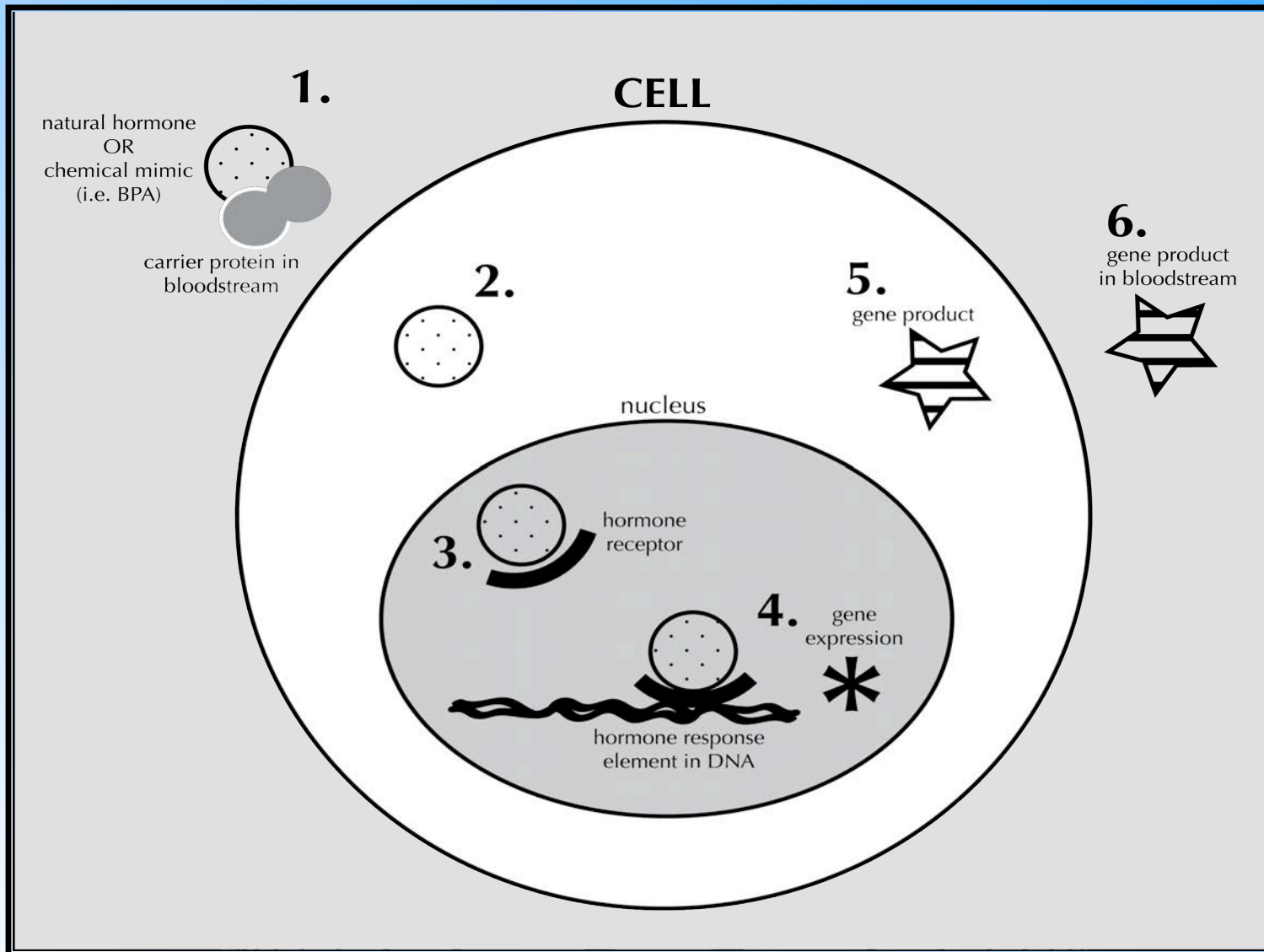
- **Carcinogenic**

- **Cause reproductive harm**

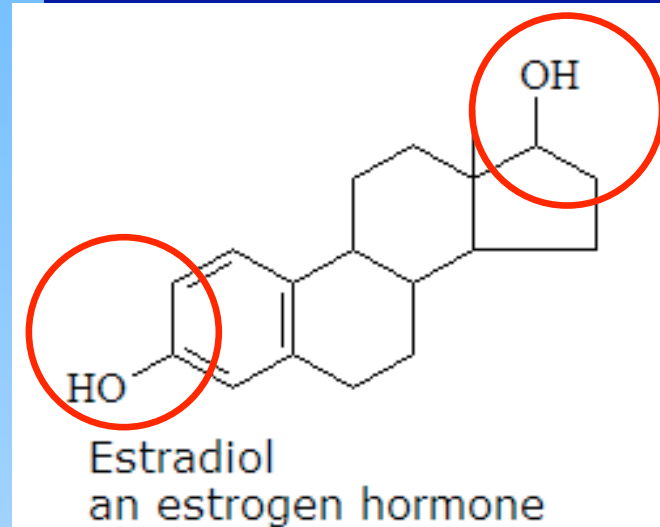
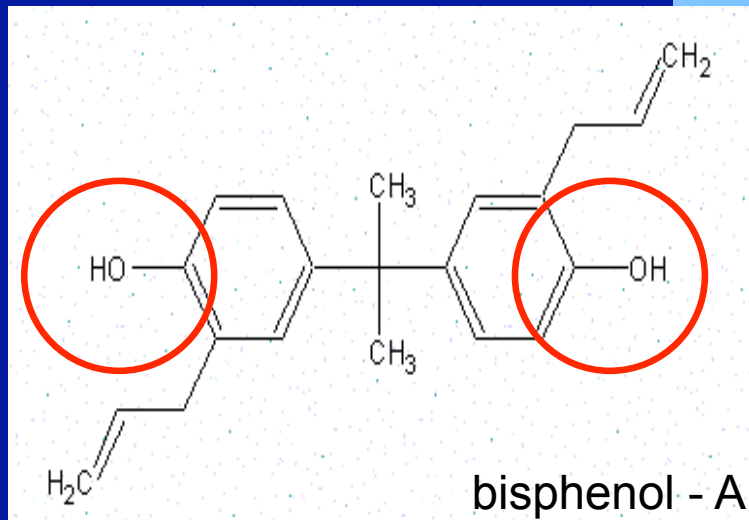




# How can plastics interfere with cell functioning?



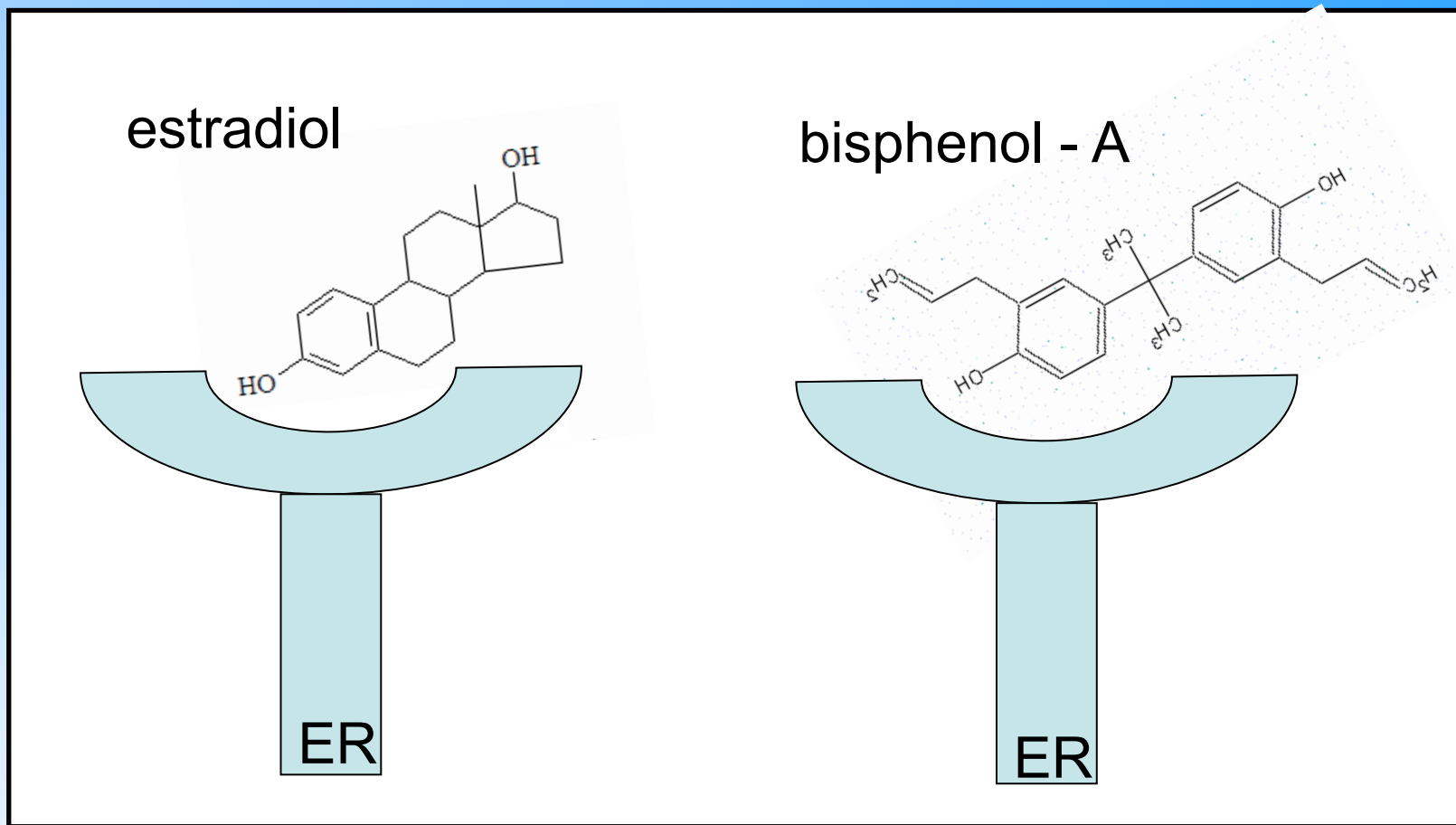
# Receptor Binding (“lock & key”)



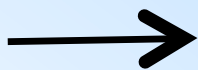
*Artificially synthesized molecules can interfere with processes in the cells of organisms cells by mimicking natural molecules (i.e. hormones)*



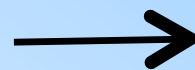
# Estrogen Receptor (in cell nucleus)



Molecule  
binds ER



ER binds  
to DNA



Gene is turned  
on or off

# Possible Impacts of Plasticizers



- Problems with reproduction
- Population reduction
- Altered male:female ratio
- Behavioral changes



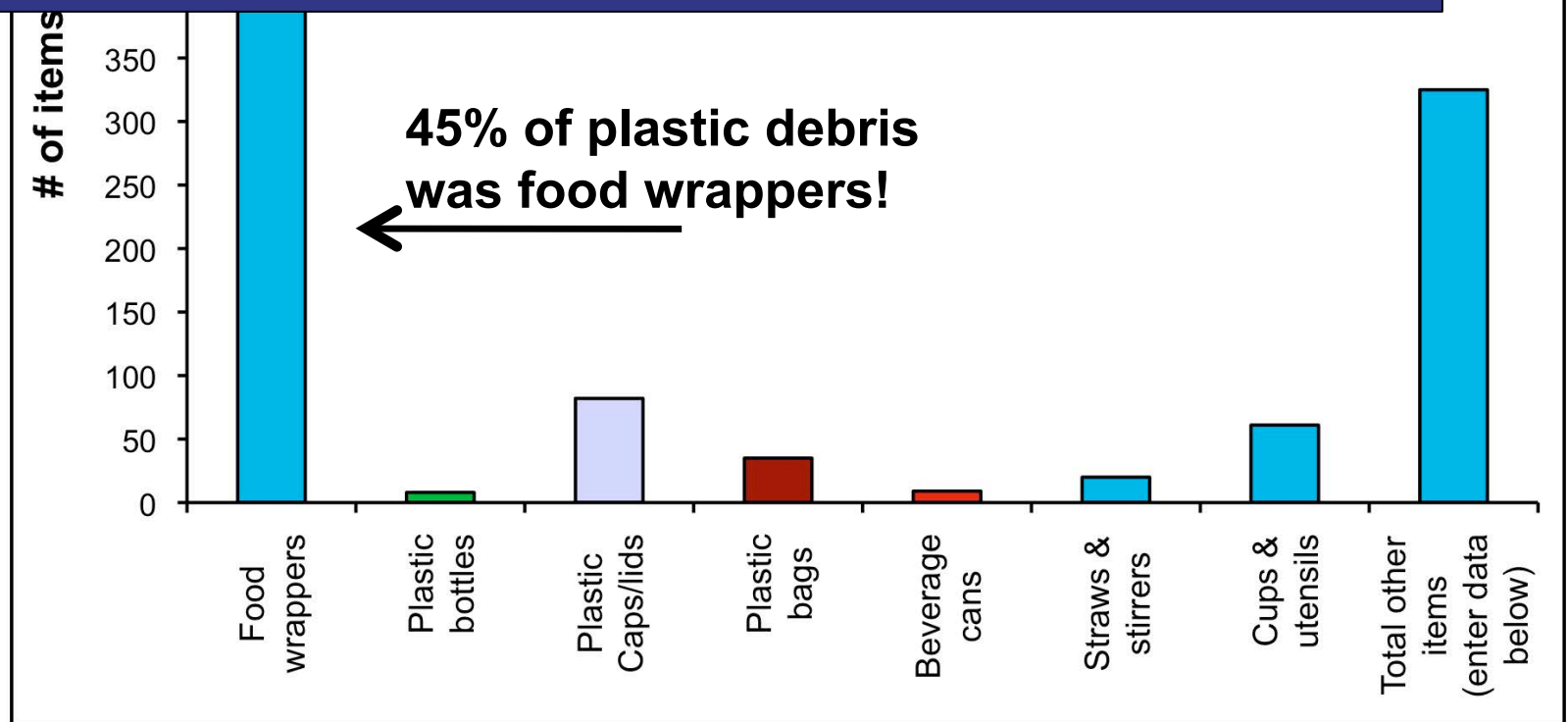


# Plastics on a High School Campus



Items that contain plasticizers or other harmful plastic-associated pollutants are common in litter found on high school campuses.

This graph shows amounts and types of litter collected during one afternoon at a California high school.



# About those food wrappers ...

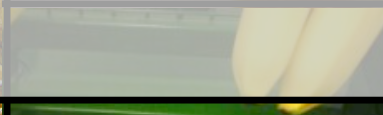


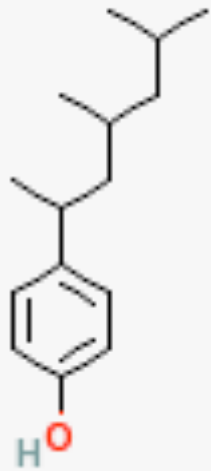


# About those food wrappers ...



**NONYLPHENOL**



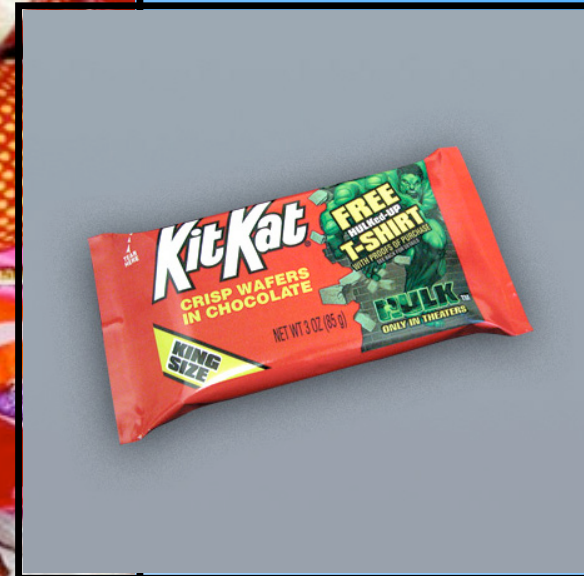


## **NONYLPHENOL**

- Can bind to the estrogen receptor
- Can mimic or interfere with estrogen
- Can accumulate in fish livers and cause tumors
- Bioaccumulates in prey items and effects predators

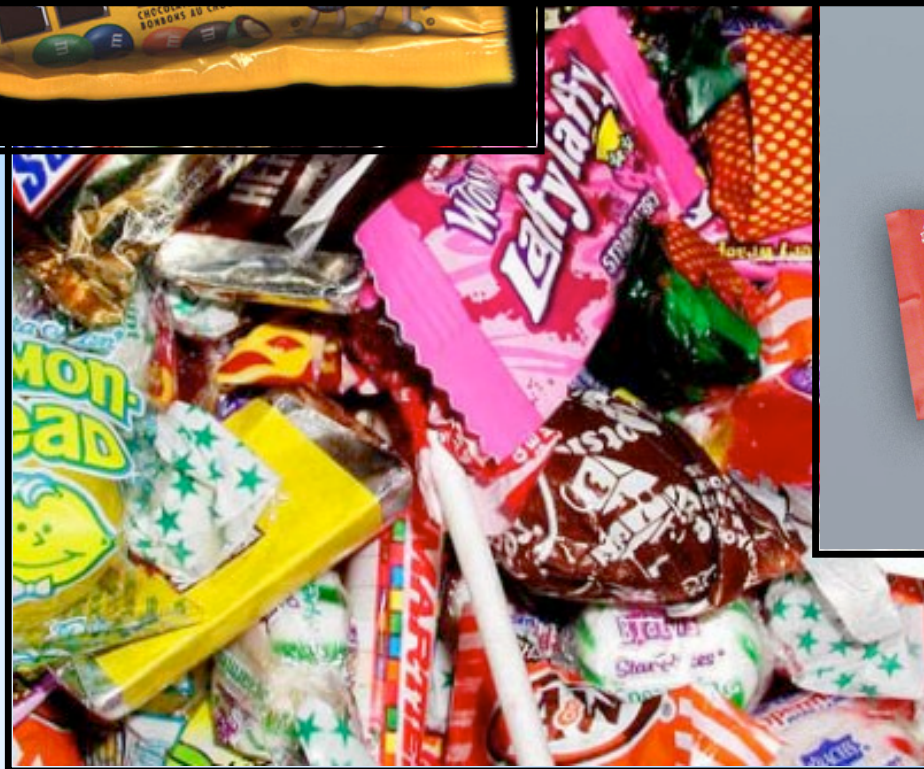


and these candy wrappers ...

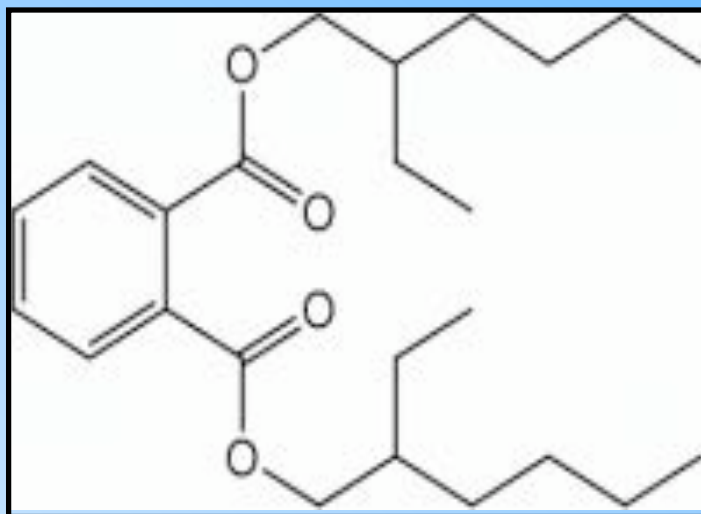




# DIETHYLHEXYLPHTHALATES







## **PHTHALATES**

- Can interfere with estrogen receptor or block the receptor for testosterone
- May interfere with thyroid hormone function
- Possible interference with sperm motility

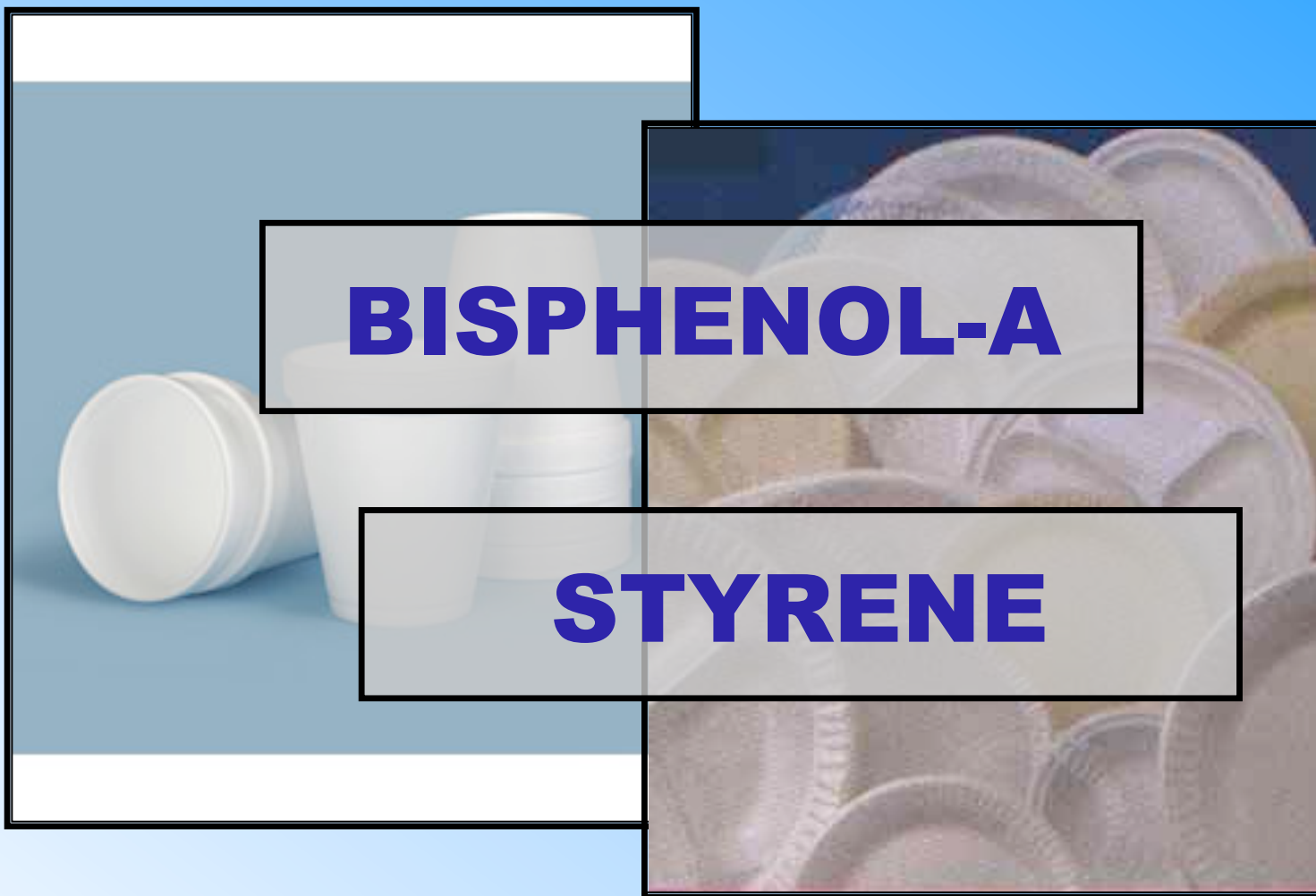


# Styrofoam ...



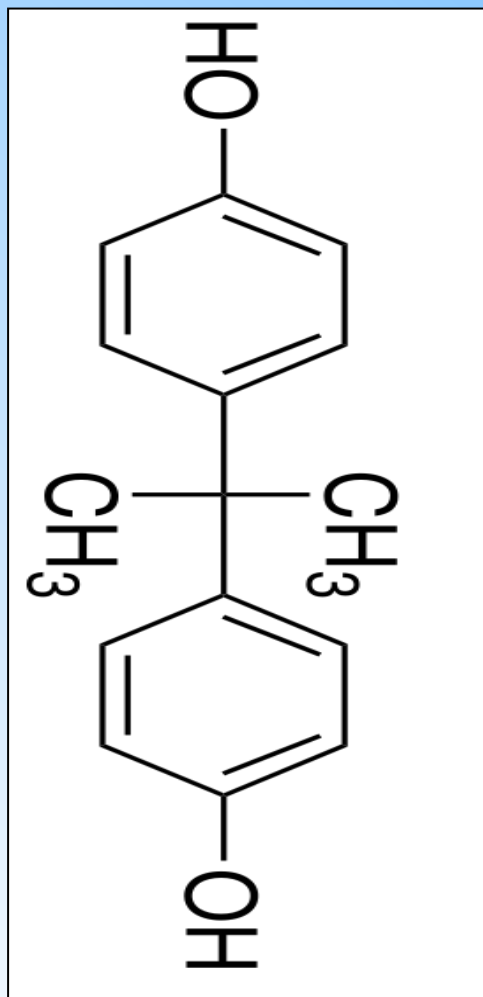


# Styrofoam ...

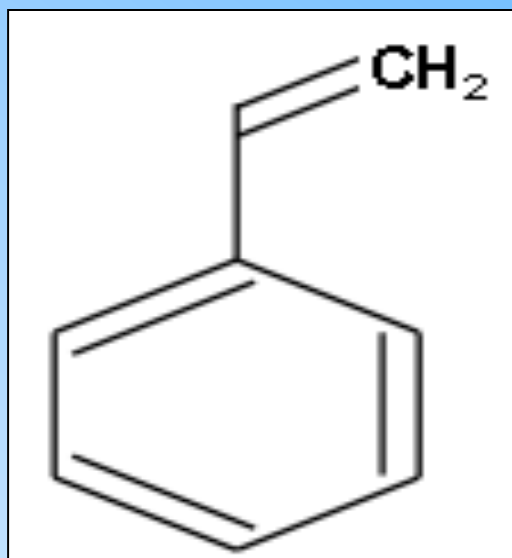




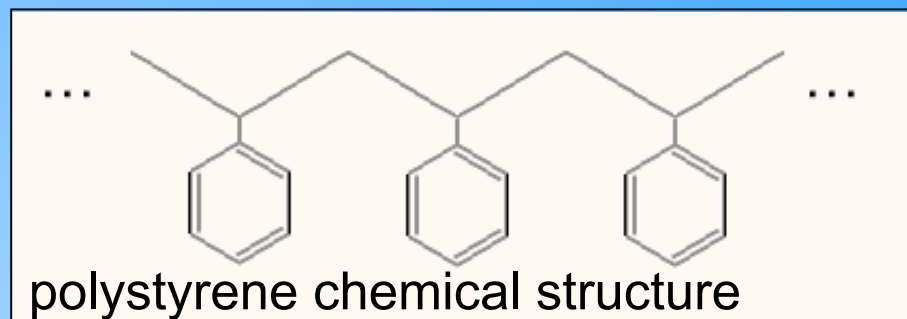
# BISPHENOL A



- Can bind to the estrogen receptor
- Can mimic or interfere with estrogen
- Possibly increases the risk of breast cancer



# STYRENE

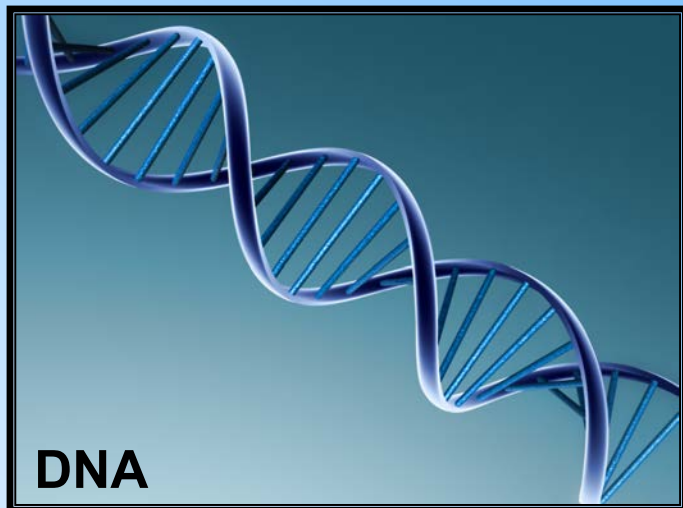


- Makes up the structure of polystyrene (Styrofoam)
- Is a confirmed mutagen
- Mutates DNA via **“adduct formation”**

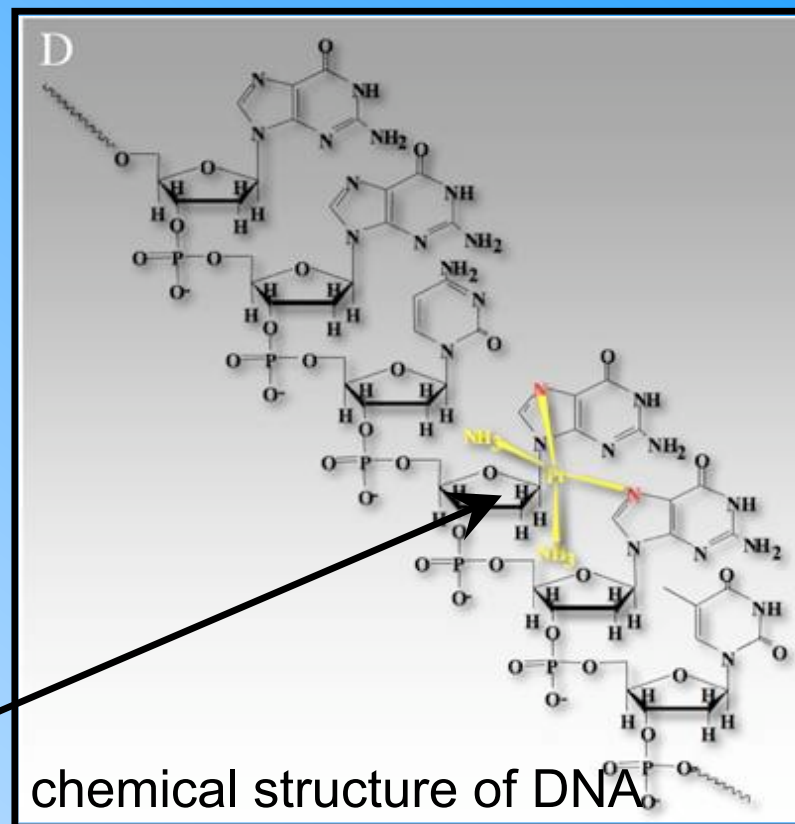




# DNA adduct

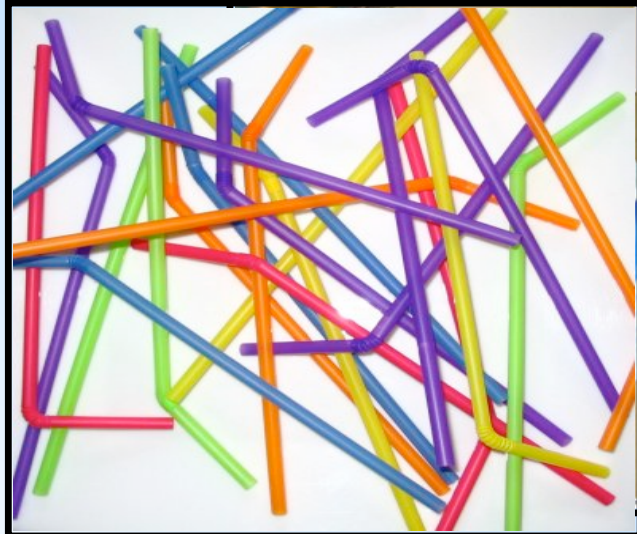


Chemical covalently binds to DNA backbone (i.e. styrene monomer)





# Other Plastic Items

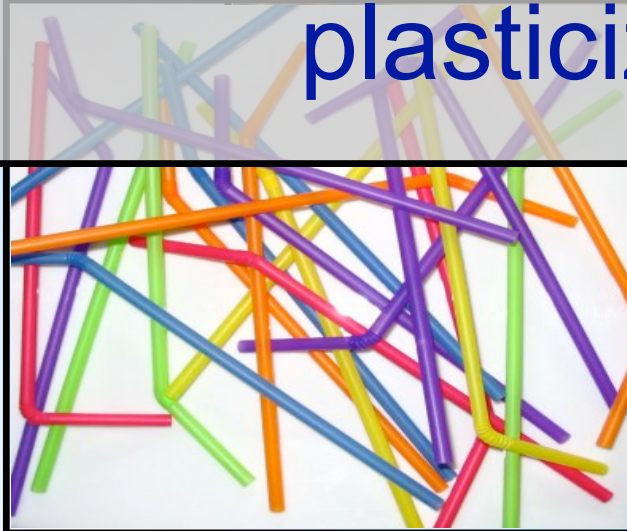




# Other Plastic Items



polypropylene & polyethylene  
plasticizers *not* used

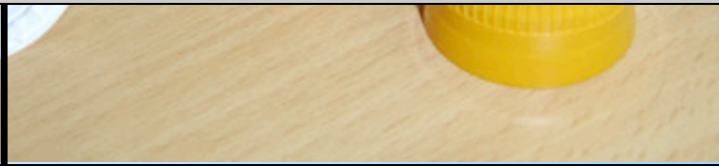




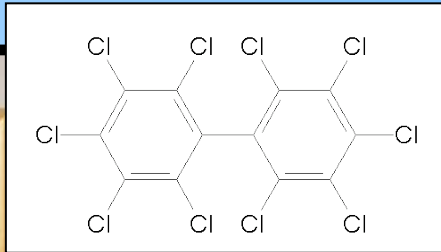
# Other Items



But other dangerous chemicals like pesticides, flame retardants (used in sofas), and PCBs (used in older electronics) can adsorb to and become concentrated on plastics in water.

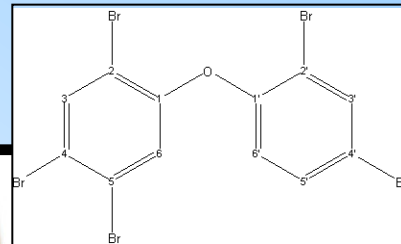


# Other Chemicals associated with Plastics



**PCBs**

- PCBs and PBDEs are hydrophobic, meaning they do not mix well with water.



**PBDEs**

- These types of chemicals bind and concentrate on plastics in water.

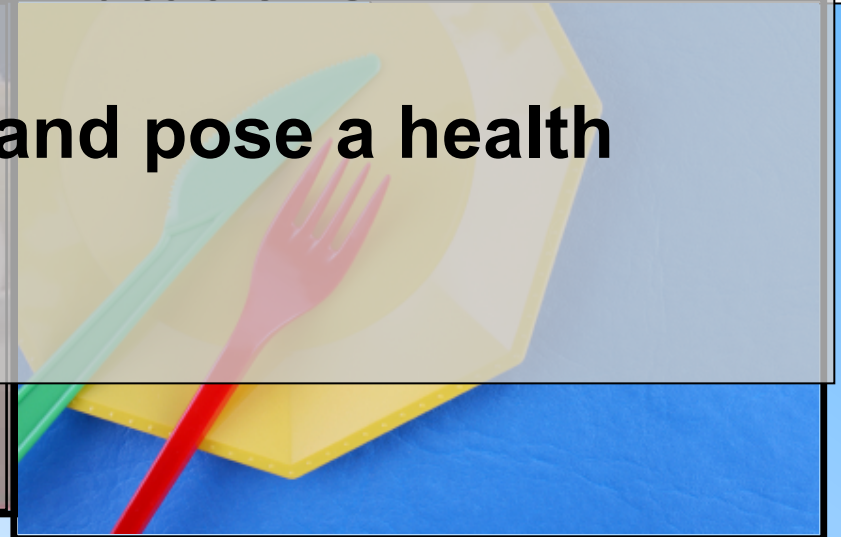
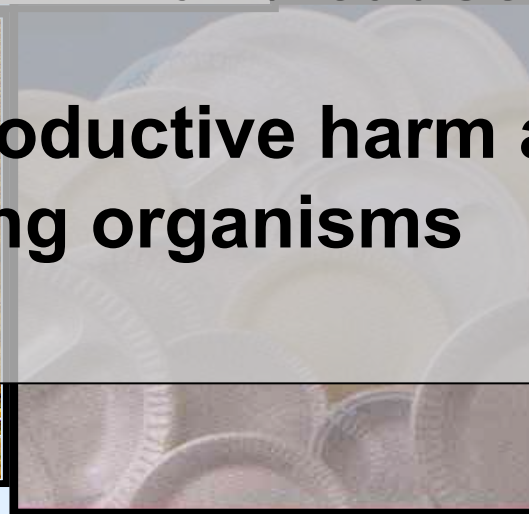


# In summary



## Plastic-associated chemicals can:

- Bind to receptors and interfere with hormones
- Cross-link DNA and cause mutations
- Cause reproductive harm and pose a health threat to living organisms



# Summary of Toxic Effects



Toxic compound	Use	Effect(s)	Plastic type(s)
bisphenol A	plasticizer, can liner	mimics estrogen	PVC, PC
phthalates	plasticizer, artificial fragrances	Interferes with testosterone, sperm motility	PS, PVC
persistant organic pollutants (POPs)	pesticides, flame retardants, etc.	possible neurological and reproductive damage	all plastics
dioxins	produced in manufacture of PVC, during waste incineration	carcinogen, interferes with testosterone	all plastics
nonylphenol	anti-static, anti-fog, surfactant (in detergents)	mimics estrogen	PVC
polyaromatic hydrocarbon (PAHs)	produced when fossil fuels are burned	developmental and reproductive toxicity	all plastics
polychlorinated biphenyls (PCBs)	electronics manufacture	interferes with thyroid hormone	all plastics
styrene monomer	breakdown product	carcinogen, can form DNA adducts	polystyrene



# What can we do about the plastic pollution problem?





# Make a difference!



- **Limit your use of plastics**
  - reusable containers
  - avoid types of plastic with BPA, phthalates, etc.
- **Dispose of trash properly**
  - pick up litter, recycle!
- **Write to your legislators about the plastic issue**
- **Report illegal littering**





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**LABORATORY**



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*2 – Founding Board Member and researcher with Oikonos Ecosystem Knowledge*

*3 - Director of Curriculum at U.S. Satellite Laboratory, Inc. and President of the New York State Marine Education Association*

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