The Ecology, Biology & Chemistry of MARINE DEBRIS

UC DAVIS
BODEGA MARINE LABORATORY

oikonos

bisphenol-A

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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!
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
What is this?
What is this?
An Albatross Bolus!

Should contain:
• 50% fish
• 32% squid
• 5% crustaceans
• 10% stomach oil

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

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http://www.mindfully.org

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# Types of Plastics

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

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

- Polystyrene
- Polyvinylchloride
- Bisphenol - A
- Phthalate
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?

1. natural hormone OR chemical mimic (i.e. BPA)
2. carrier protein in bloodstream
3. hormone receptor
4. gene expression
5. gene product
6. gene product in bloodstream
Artificially synthesized molecules can interfere with processes in the cells of organisms 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

estradiol

bisphenol - A
Possible Impacts of Plasticizers

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

45% of plastic debris was food wrappers!
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
PHTHHALATES

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

BISPHENOL-A

STYRENE
BISPHENOL A

- Can bind to the estrogen receptor
- Can mimic or interfere with estrogen
- Possibly increases the risk of breast cancer
• Makes up the structure of polystyrene (Styrofoam)

• Is a confirmed mutagen

• Mutates DNA via “adduct formation”
Chemical covalently binds to DNA backbone (i.e. styrene monomer)
Other Plastic Items
Other Plastic Items

polypropylene & polyethylene
plasticizers *not* used
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 and PBDEs are hydrophobic, meaning they do not mix well with water.
- 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
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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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3 - Director of Curriculum at U.S. Satellite Laboratory, Inc. and President of the New York State Marine Education Association

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