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## Plastic & microplastic pollution

2



# Plastic & Microplastic Pollution

# Measuring toxicity: Concepts & Principles

STUDENT ACTIVITY: A-B MONOLOGUE

# Plastic & Microplastic Pollution

## MARKERS OF ANTHROPOCENE

### **Skills you gain:**

- 1- The concept of plastic as a contaminant
- 2- Get familiar with the kinds of ecological impacts it may cause
- 3- Learn about its ecotoxicological impacts
- 4- Critically evaluate the procedures for laboratory toxicity test

# References:

PHILOSOPHICAL  
TRANSACTIONS  
OF  
THE ROYAL  
SOCIETY **B**

*Phil. Trans. R. Soc. B* (2009) **364**, 1985–1998  
doi:10.1098/rstb.2008.0205

## Accumulation and fragmentation of plastic debris in global environments

David K. A. Barnes<sup>1,\*</sup>, Francois Galgani<sup>2</sup>, Richard C. Thompson<sup>3</sup>  
and Morton Barlaz<sup>4</sup>

SCIENCE ADVANCES | RESEARCH ARTICLE

PLASTICS

## Production, use, and fate of all plastics ever made

Roland Geyer,<sup>1\*</sup> Jenna R. Jambeck,<sup>2</sup> Kara Lavender Law<sup>3</sup>

nature  
ecology & evolution

REVIEW ARTICLE

PUBLISHED: 20 APRIL 2017 | VOLUME: 1 | ARTICLE NUMBER: 0116

## Interactions of microplastic debris throughout the marine ecosystem

Tamara S. Galloway\*, Matthew Cole and Ceri Lewis



DOI: 10.1111/gcb.14020

OPINION

WILEY Global Change Biology

## Microplastics as an emerging threat to terrestrial ecosystems

Anderson Abel de Souza Machado<sup>1,2,3</sup> | Werner Kloas<sup>2,4</sup> | Christiane Zarfl<sup>5</sup> |  
Stefan Hempel<sup>1,3</sup> | Matthias C. Rillig<sup>1,3</sup>

# Plastics: The most common man-made materials

Polyester in clothing



<https://www.goalinn.com>

PET in Single use packaging



<http://cleanleap.com>

Epoxy resin in coating



<http://www.bestbartopepoxy.com>

Liquid gels for PCP



<http://www.buykorea.org>

**Activity:** What could be a definition for "plastics" in the context of pollution science?

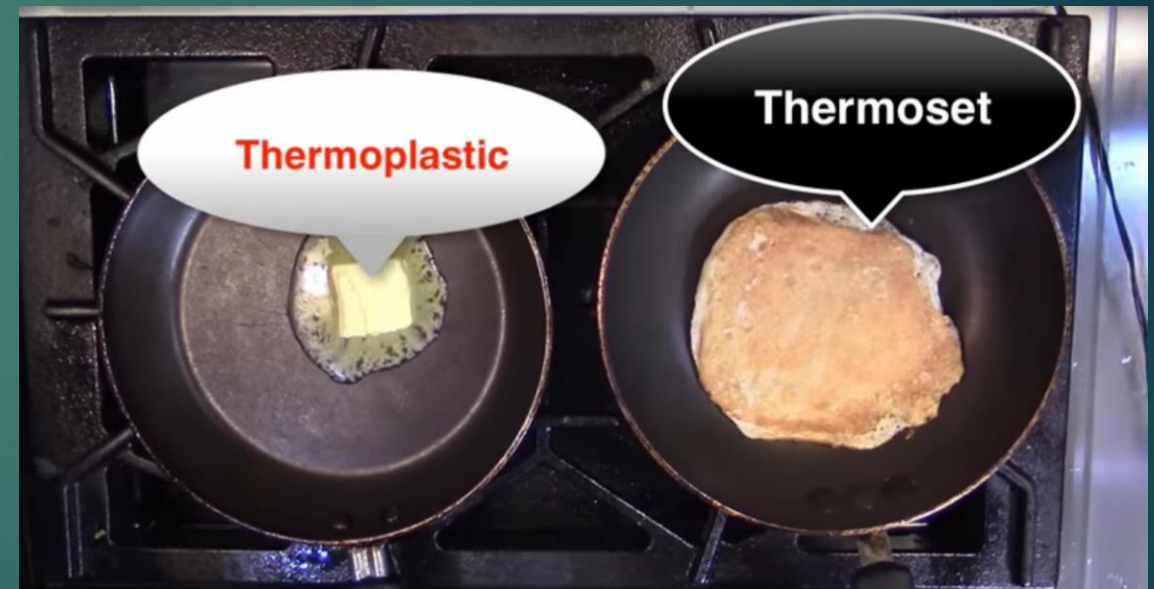
Plastics are classified in the group of polymer-based materials, a chemically, functionally, and structurally diverse group of environmental contaminants.

# What do we mean by plastic?

A chemically diverse group of synthetic or semi-synthetic polymer-based materials characterized by high plasticity (i.e. the capacity to change in shape in response to applied forces) at least at one point of their manufacture.

Classifying plastic:

- Chemistry (e.g. polymer matrix, additives)
- Production (e.g. melting, extrusion, pelletization)
- Behaviour (e.g. thermal sensitivity)
- Size (e.g. nano, micro, meso, mega)
- Usage (e.g. single use, packaging, PCP)
- Shape & Structure (e.g. beads, films, fiber, foam)
- Degradability (e.g. biodegradable, bioplastic, oxydegradable)

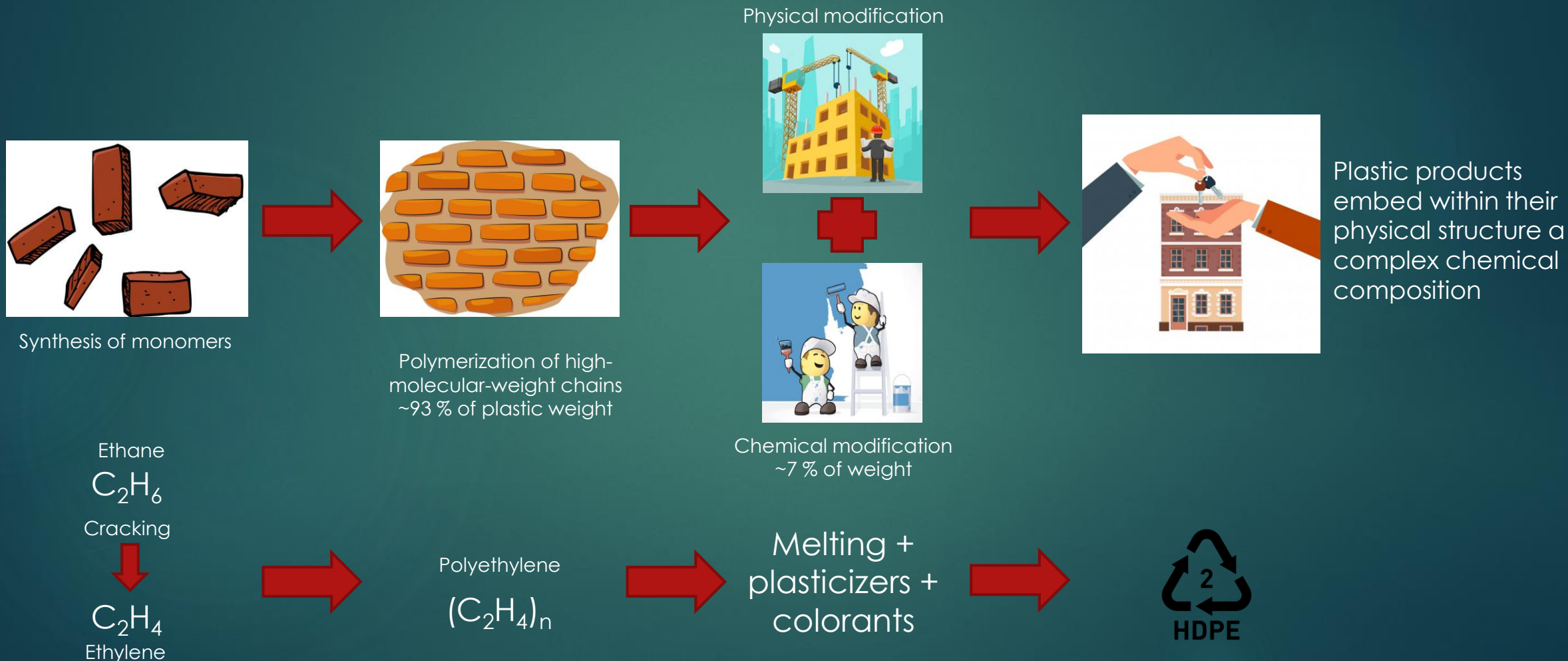


<https://www.youtube.com/watch?v=INS7TwWmlrg&t=29s>



# How are plastics made?

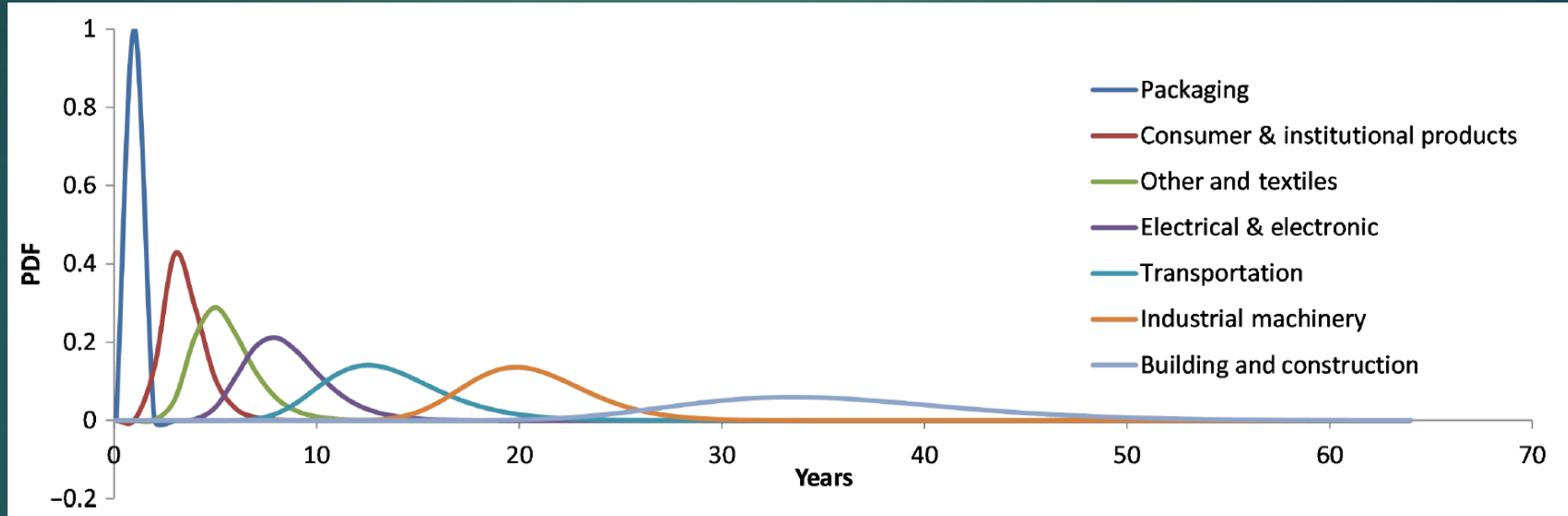
It varies a lot, but generally more than 80 % of non-fiber thermoplastics follow this procedure:



# How long do plastic products last?

Most of it becomes waste within few years:

## Product life time distributions

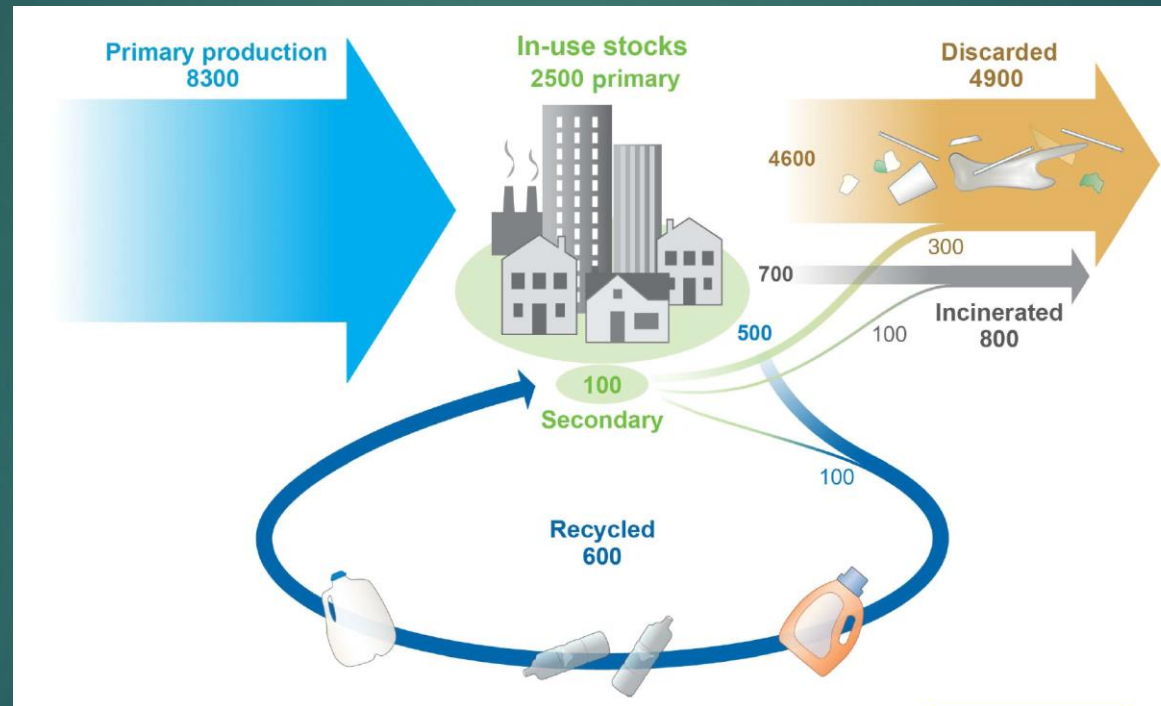


Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782

For waste management the intended use is more important than the polymer matrix

# How is plastic waste managed?

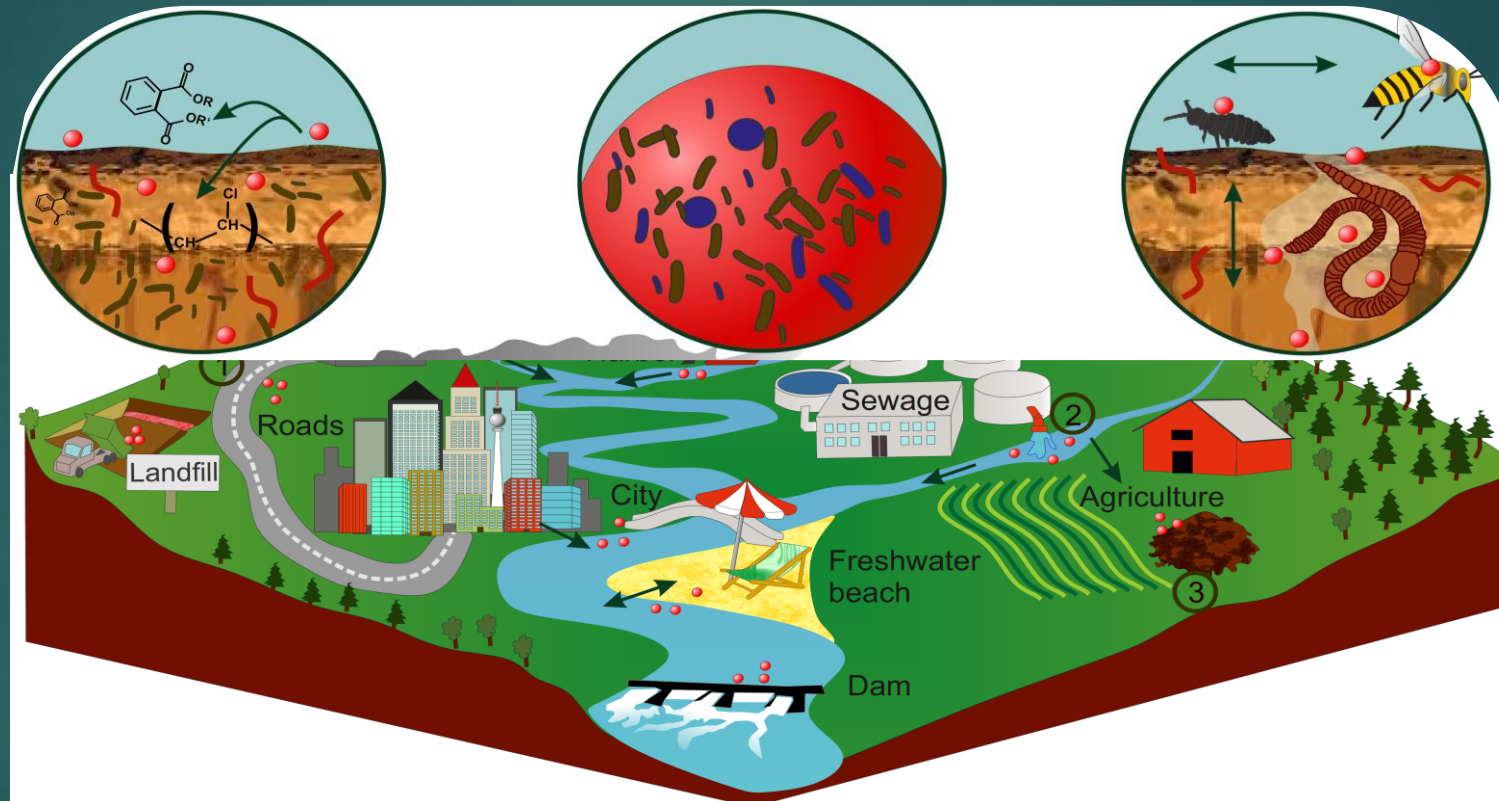
In 2014 the European demand of plastics was approximately 47.8 million tons, while only 25.8 million tons entered waste stream management



Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782

Global plastic recovery is even lower, and it is estimated that roughly 32% of plastic waste might find its first receptacle in soils or continental aquatic ecosystems

# Most of plastic litter starts its journey on land



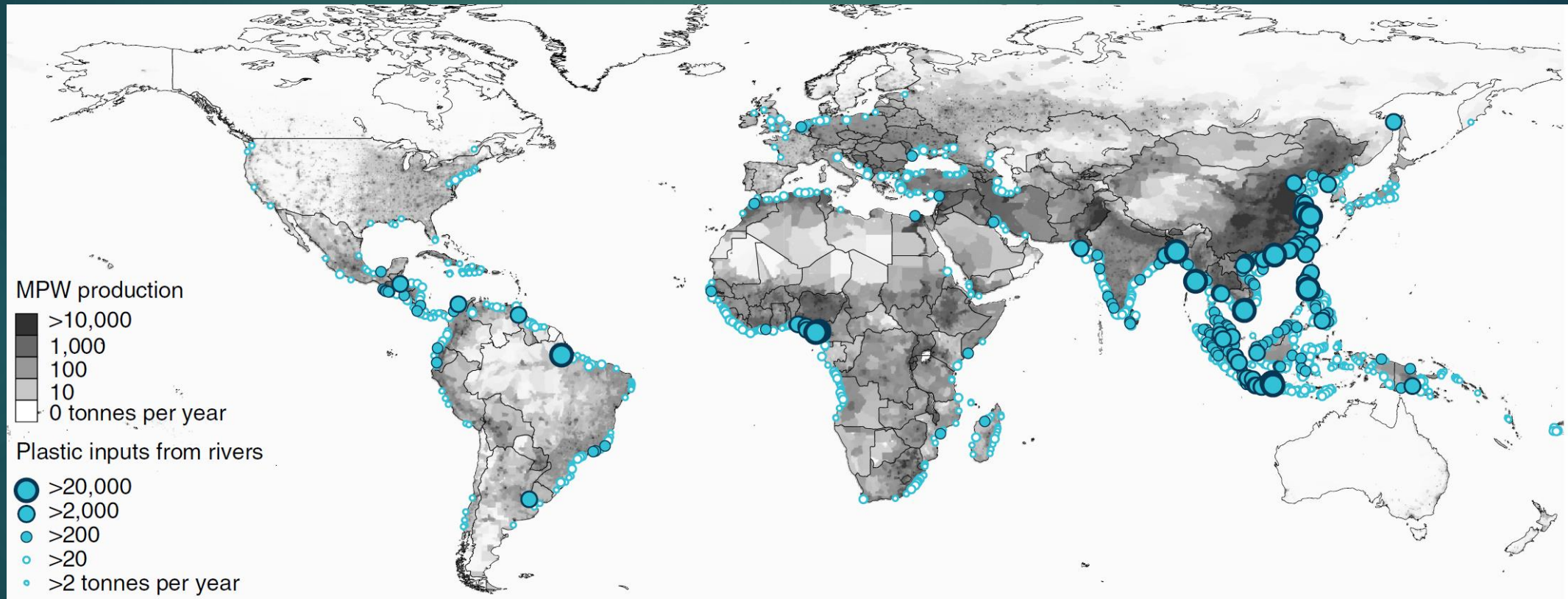
Microplastic contamination on land might be 4-23-fold larger than in the ocean, and, agricultural soils alone might store more microplastics than oceanic basins.

Levels as high as 7 % of soil weight in Australian road sides or 60 % of soil weight in Chinese soils.

Plastic litter is mainly produced, used, and disposed on land, where it has its first chance to interact with biota eliciting impacts.

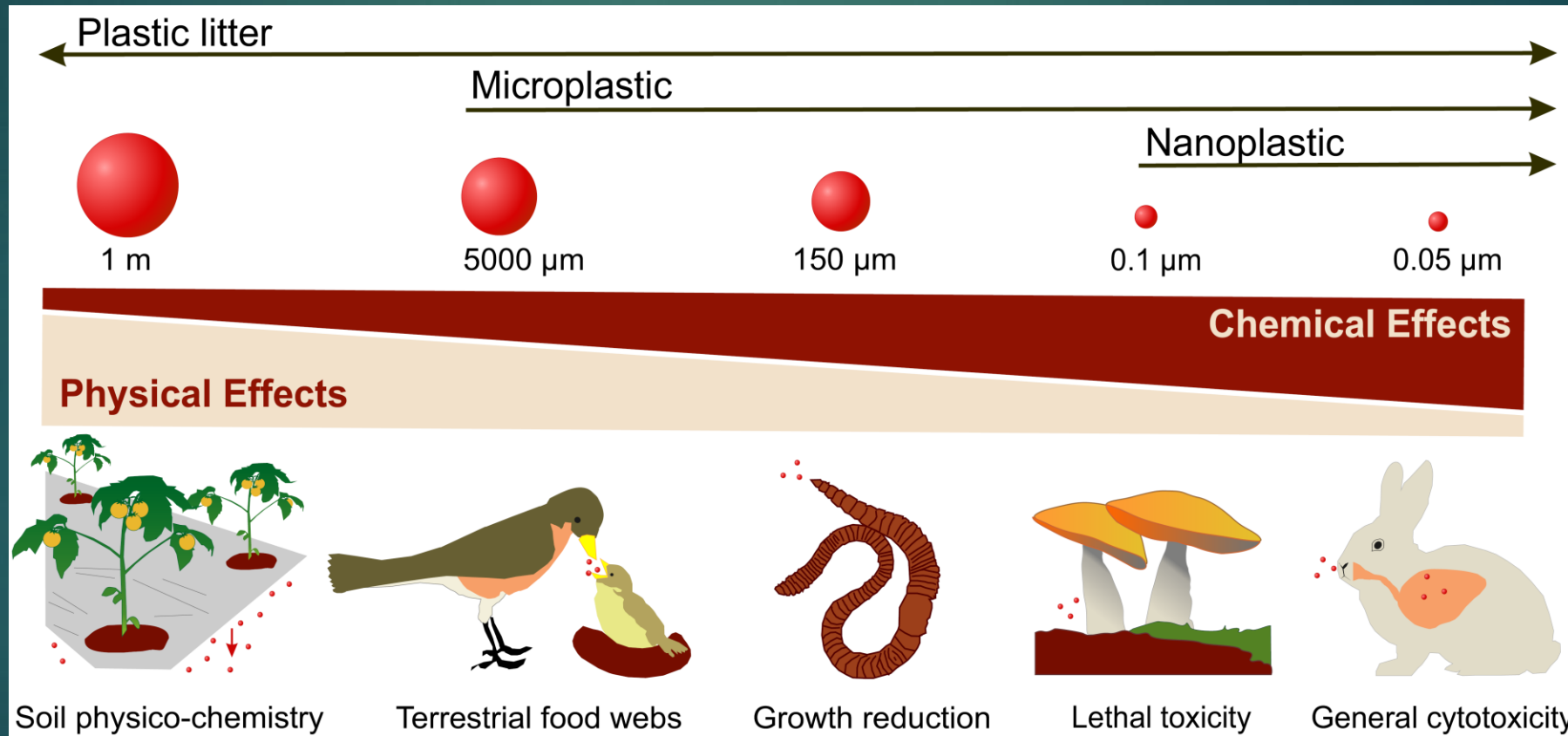
In Swiss montane natural reserves microplastic levels reach 0.002 %

# Some of plastic litter ends its journey in the oceans



DOI: 10.1038/ncomms15611

# Environmental impacts of plastics vary with particle type & properties



As particles decrease in size they increase in biological reactivity

Microplastics: plastic particles with less than 5 mm in largest dimension

## STUDENT ACTIVITY: A-B DIALOGUE



<https://plasticchange.org/our-documentation/microplastic/>

THE VERY NATURE OF PLASTIC AS ANTHROPOGENIC SYNTHETIC XENOBIOTIC-RICH AND BIOPERSISTENT PARTICLES COMBINES POTENTIAL EFFECTS ON BIOTA THAT ARE BASICALLY PHYSICAL, CHEMICAL, OR A COMBINATION OF BOTH.

DISCUSS WITH YOUR COLLEAGUE WHICH POTENTIAL EFFECTS ARE LIKELY TO ALL PLASTIC PARTICLES?

WHICH WOULD VARY WITH POLYMER TYPE?

#WHICH WOULD DEPEND ON PARTICLE SIZE?

# Impacts of plastics in marine systems

Habitat change

Biota entanglement



<https://www.pinterest.com>

Pseu



<https://www.theverge.com/>

Plastisphere ecosystems



<https://www.theguardian.com/science/2014/jun/11/plastisphere>

long-known impacts on the biota



# Impacts of plastics in marine systems

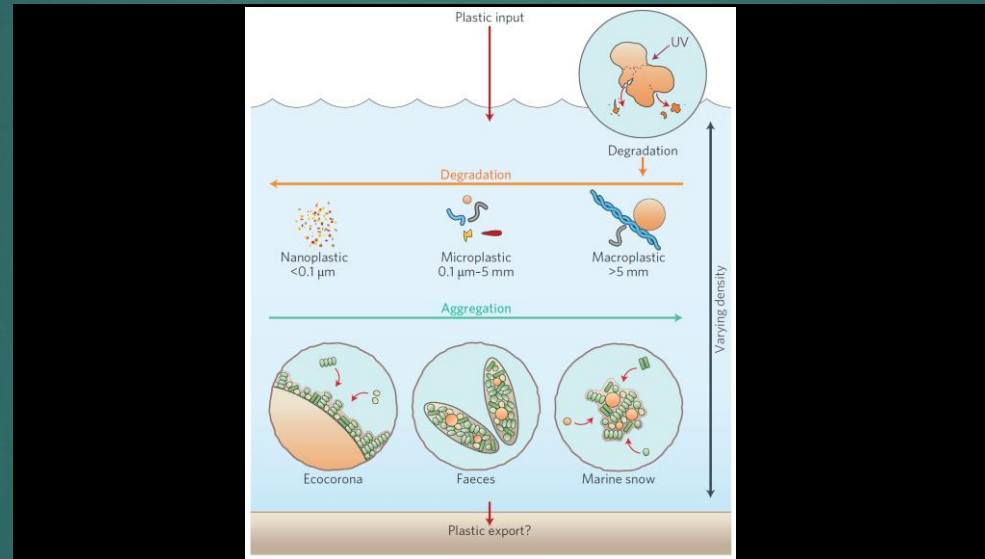


Sky news, June, 2018

# Microplastics & the marine environment

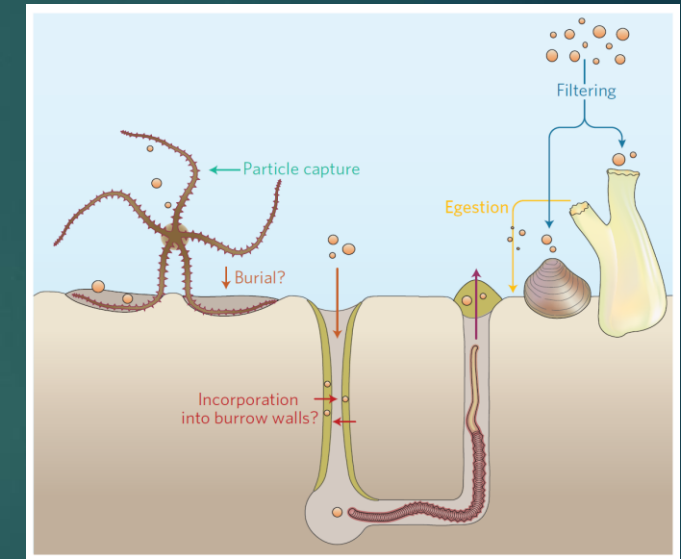
Small plastic particles also interact with biota in multiple ways

## Interaction with zooplankton



<https://www.youtube.com/watch?v=2b1GexhURTY>

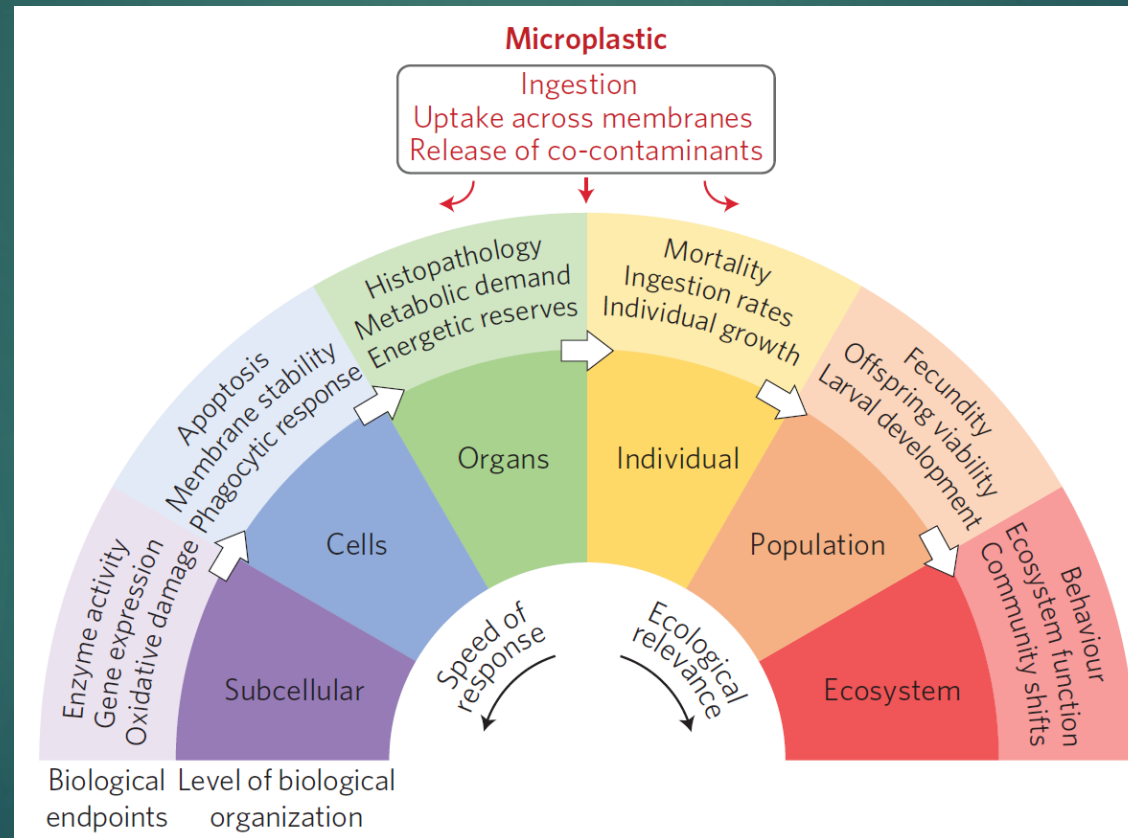
## Interaction with macrobiota



DOI: 10.1038/s41559-017-0116

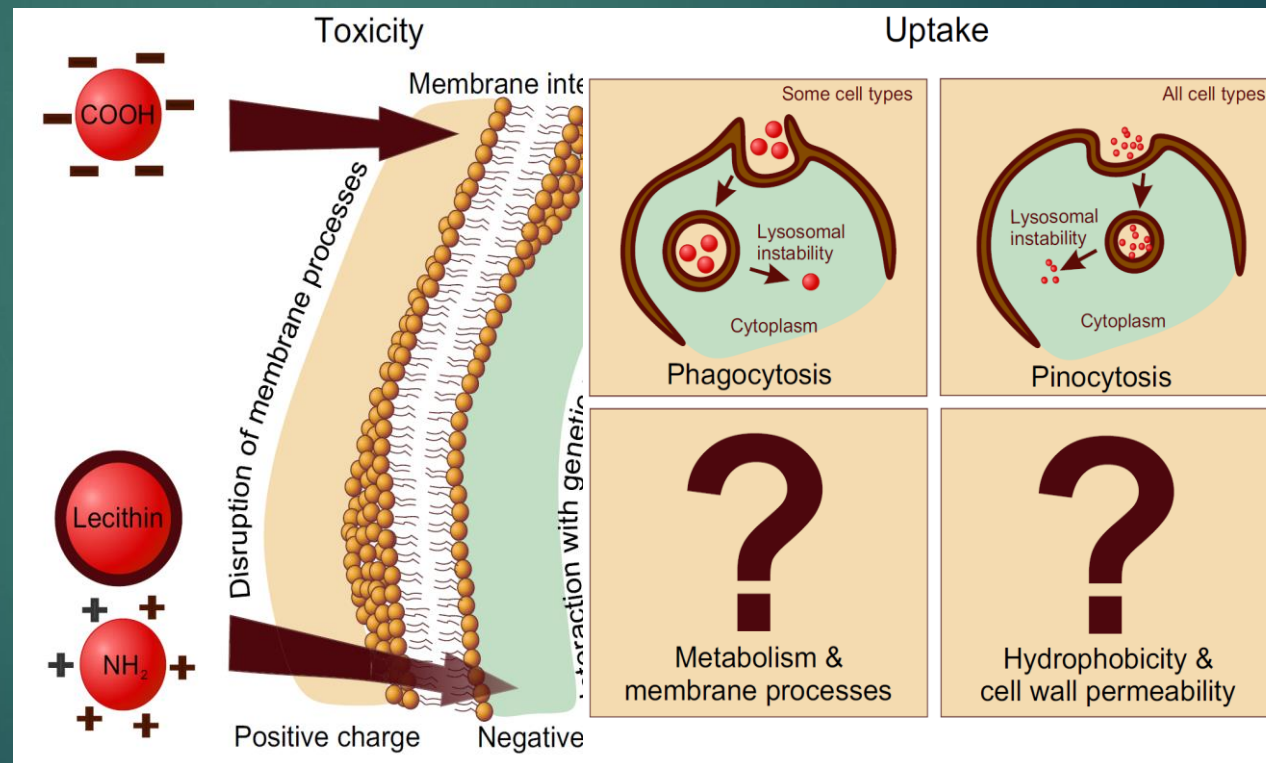
# Microplastics & the marine environment

Potential cascade of events in the biological hierarchy



DOI: 10.1038/s41559-017-0116

# When particles get smaller they increase biological reactivity

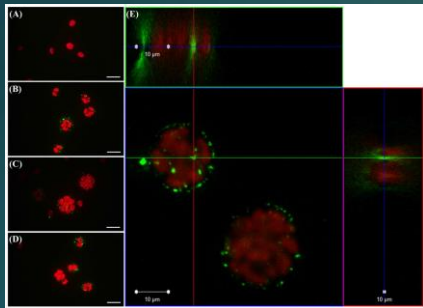


DOI: 10.1111/gcb.14020

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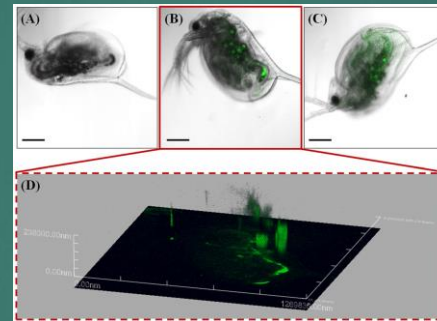
# When particles get smaller: An example from freshwater

*Chlamydomonas reinhardtii*



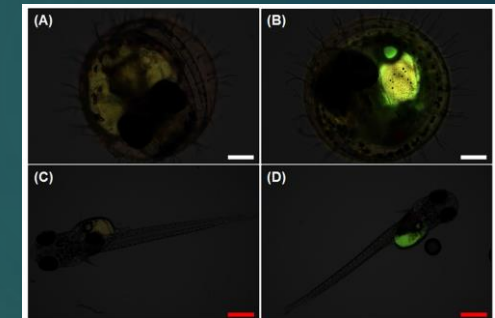
The primary producer accumulated nanoplastics on its external cell walls

*Daphnia magna*



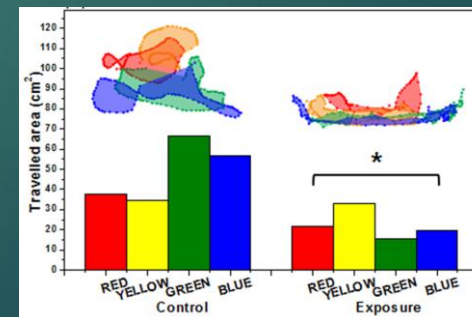
The primary consumer internalized the nanoplastics

*Oryzias sinensis*



The secondary consumer could internalize the nanoplastics already as embryos

*Oryzias sinensis*



For all figures: DOI:10.1038/s41598-017-18849-y

# Microplastics as priority contaminant

Comparing microplastic against the criteria proposed for classification of pollutants as persistent organic pollutants under the Stockholm Convention and against the criteria for recognition as a planetary boundary threat

Classifications and criteria	Criterion met?
<b>Persistent organic pollution*</b>	
Environmentally persistent	Yes
Transported over large distances	Yes
Bioaccumulate through the food web	Yes
Cause adverse health effects	Yes
<b>Planetary boundary threat<sup>†</sup></b>	
Disruptive effect on vital Earth system processes of which we are ignorant	Uncertain
Disruptive effect is not discovered until the associated impacts manifest at a global scale	Uncertain
Impacts are poorly reversible as the pollutant cannot be readily reduced in the environment	Yes

DOI: 10.1038/s41559-017-0116

# Summary: Plastics & Microplastics

- ▶ Plastics are diverse materials that present “plasticity” at some point of manufacture.
- ▶ They outgrow most man-made materials.
- ▶ Most of plastics are thermoplastics under suboptimal waste management.
- ▶ Decreasing particle size generally increases biological reactivity.
- ▶ Multiples impacts with biotic and abiotic aspects of ecosystem functions & processes.
- ▶ Microplastic and nanoplastic pollution might have impacts on biodiversity of both continental and marine systems.



Plastic on Blue Planet II BBC

Plastics & microplastics might not be the most toxic (lethal or sublethal) contaminant. However, there are consistent past, present, and future trends of increasing a near-permanent plastic contamination of natural environments at global scale.



My name is Miranda Wang,

# Thanks

NOW LET'S THINK ABOUT OPTIMIZING OUR TOXICITY TESTS