

## NEWS

The plastic eaters p. 36

When plastics are precious p. 40

## POLICY FORUM

A binding global agreement to address the life cycle of plastics p. 43

## PERSPECTIVES

The myth of historical bio-based plastics p. 47

Achieving a circular bioeconomy for plastics p. 49

## REVIEWS

Plastics in the Earth system p. 51

Plastic ingestion as an evolutionary trap: Toward a holistic understanding p. 56

The global threat from plastic pollution p. 61

Toward polymer upcycling—adding value and tackling circularity p. 66

## RELATED ITEMS

REPORT p. 107 PODCAST VIDEO



# A DEVIL'S BARGAIN

By Jesse Smith and Sacha Vignieri

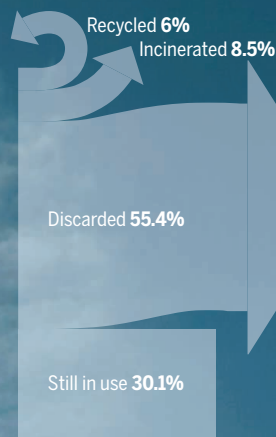
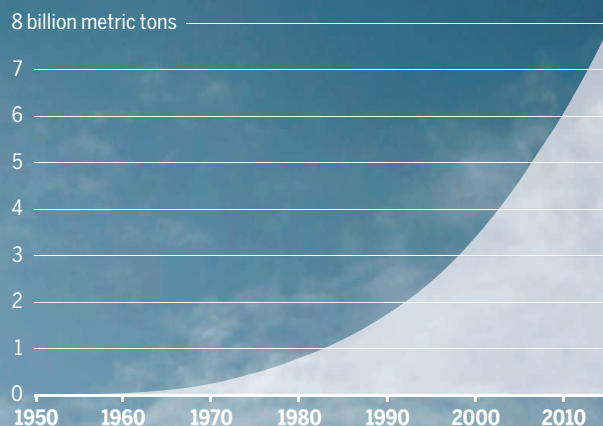
**P**lastics have become an essential material of the modern global consumer economy, yet many of the properties that make them useful in so many applications also make them a serious environmental threat. As for much new technology, their development and proliferation occurred with little consideration for their impacts, but now it is impossible to deny their dark side as we confront a rapidly growing plastic pollution problem. In this special issue, we examine a range of topics related to plastics, from their distribution in the environment to their development into an evolutionary trap for animals to ways we can rethink them to create a better future. A series of Reviews discusses how plastics are best understood as novel geomaterials, the evolutionary and ecological dimensions of plastic ingestion by wildlife, the accumulation and effects of plastic pollution in the

environment, and how innovations in upcycling and recycling may affect the fate of plastics and drive advances in next-generation materials design. Complementing these Reviews, a Policy Forum and a pair of Perspectives discuss efforts to develop a global agreement to combat plastic pollution, provide an overview of the history of environmental bioplastics and their implications, and offer suggestions for designing plastics for a circular bioeconomy. Finally, a brace of News Features explores how enzymes are being used to aid in plastic recycling efforts and how museums are trying to stop plastics in their exhibits from breaking down. The time for preventing plastic pollution is long past—the time for changing the future of plastics in our world, however, is now.

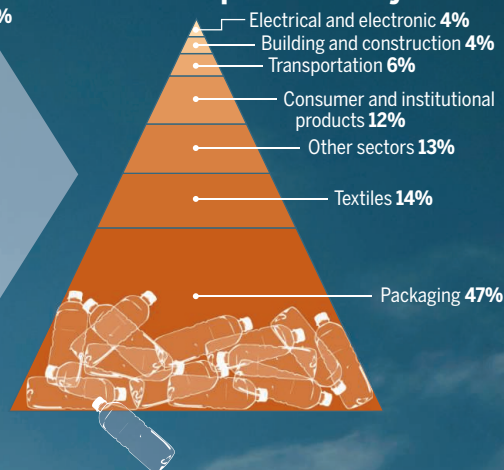
*Michael Funk, Brent Grocholski, Lila Guterman, Marc Lavine, and Brad Wible also contributed to this special issue.*



## Cumulative global plastics production



## Plastic waste production by sector



## Impacts of plastic waste on marine species

(Species not shown to scale)

By Sacha Vignieri  
and Kelly Franklin



### Seabirds

Plastics have been found in the stomachs of a wide array of species, from the largest albatrosses to the smallest phalaropes, and in birds that feed throughout the water column, from the surface to the depths.



**3%**

of the global plastic waste is estimated to enter the oceans each year. In 2010, that was around **8 million metric tons**.

### Sea turtles

Sea turtles often become entangled as hatchlings when they crawl through beach debris on their way to the sea and again as females return to lay eggs. They ingest plastic in many forms, notably as plastic bags, which they may be fooled into thinking are jellyfish.



### Seals and sea lions

A variety of, mostly, single-use plastics have been found in the guts of pinnipeds (seals and sea lions). Curious and playful, they often put their heads through loops of plastic, from discarded fishing lines and boat rigging to plastic packing strips.



### Amphipods

Microplastics have been found in the guts of amphipods across six of the deepest ocean trenches. A new species of amphipod was recently named after the plastics that it had ingested, nearly 7 kilometers deep in the Mariana Trench.



### Whales and dolphins

Entanglement threatens all types of whales and dolphins, primarily from discarded or active fishing nets. Large plastic items such as bags and flip-flops have been found in toothed whales. Baleen, or filter-feeding, whales are especially threatened by microplastics.



### Corals

Discarded fishing gear and plastic waste physically damage coral reefs, prevent filter feeding, and carry pathogens. Corals also ingest microplastics, and these have been found in corals living across ocean depths, from shallow waters to the deep sea.



## A devil's bargain

Jesse Smith and Sacha Vignieri

*Science* **373** (6550), 34-35.

DOI: 10.1126/science.abj9099

### ARTICLE TOOLS

<http://science.sciencemag.org/content/373/6550/34>

### RELATED CONTENT

<http://science.sciencemag.org/content/sci/373/6550/36.full>  
<http://science.sciencemag.org/content/sci/373/6550/40.full>  
<http://science.sciencemag.org/content/sci/373/6550/43.full>  
<http://science.sciencemag.org/content/sci/373/6550/47.full>  
<http://science.sciencemag.org/content/sci/373/6550/49.full>  
<http://science.sciencemag.org/content/sci/373/6550/51.full>  
<http://science.sciencemag.org/content/sci/373/6550/56.full>  
<http://science.sciencemag.org/content/sci/373/6550/61.full>  
<http://science.sciencemag.org/content/sci/373/6550/66.full>  
<http://science.sciencemag.org/content/sci/373/6550/107.full>  
<file:/content>

### PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

---

*Science* (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

Copyright © 2021 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works