

Bringing the Knowledge of Plastic Debris in the Oceans to Society

- Plastic: A Symptom of the Syndrome of Modern Global Change
- What we Know: Plastic is
 - produced a lot
 - used by everybody for everything
 - found everywhere
 - impacting the present as well as future of many billions of people
- Where are the Data and Knowledge?
- Linking Data and Knowledge to Society

Hans-Peter Plag
Old Dominion University
Norfolk, VA, USA



Our perception depends on the distance we have ...

Planetary Life-Support System for all life

Homo sapiens: one of (still) many species of mammals

Health Planetary Physiology: Homeostasis

Syndrome of modern global change



Planetary Physiology

Earth: Life-Support System for many species

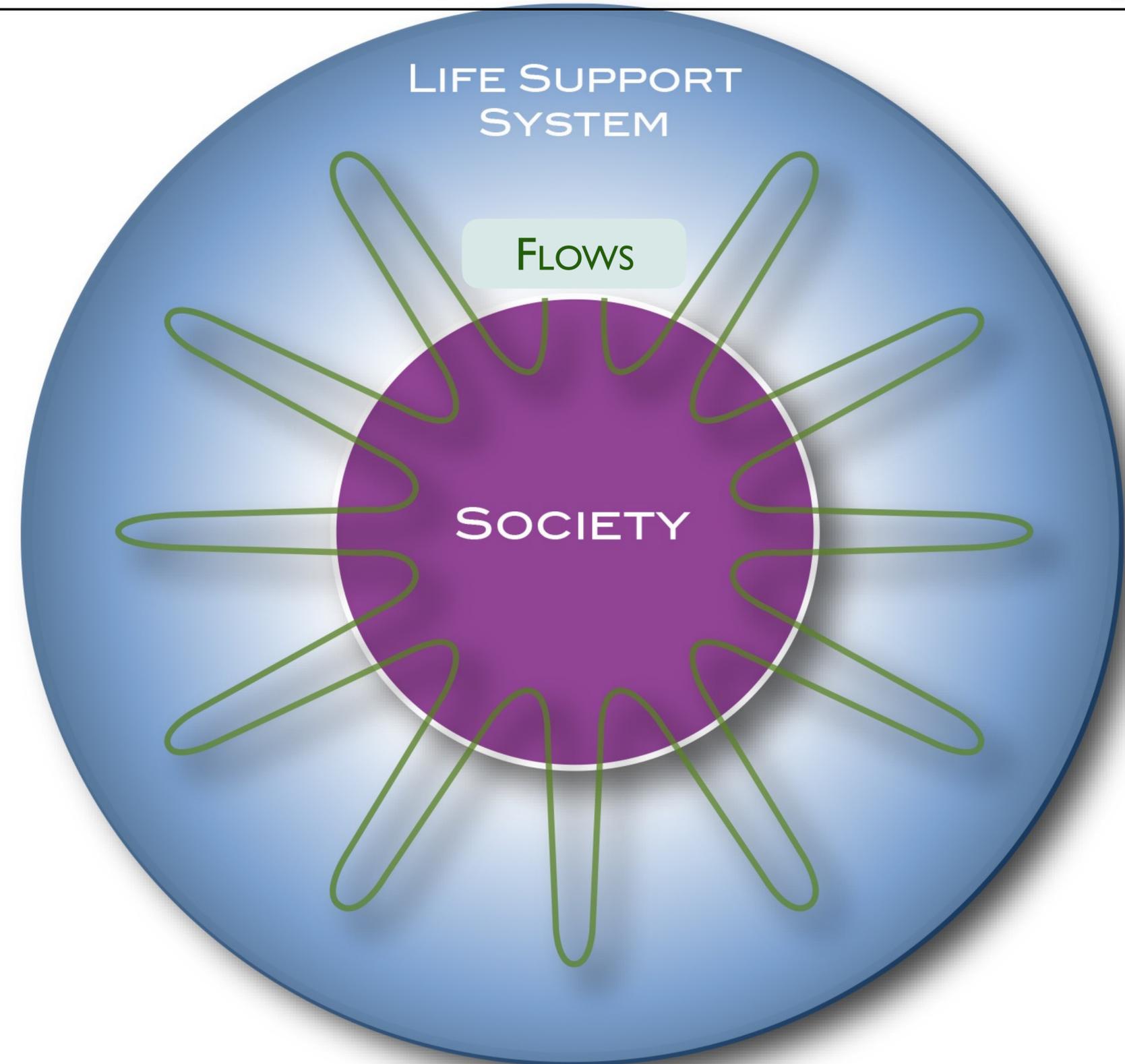


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Earth: Life-Support System for many species

Everything is about Flows



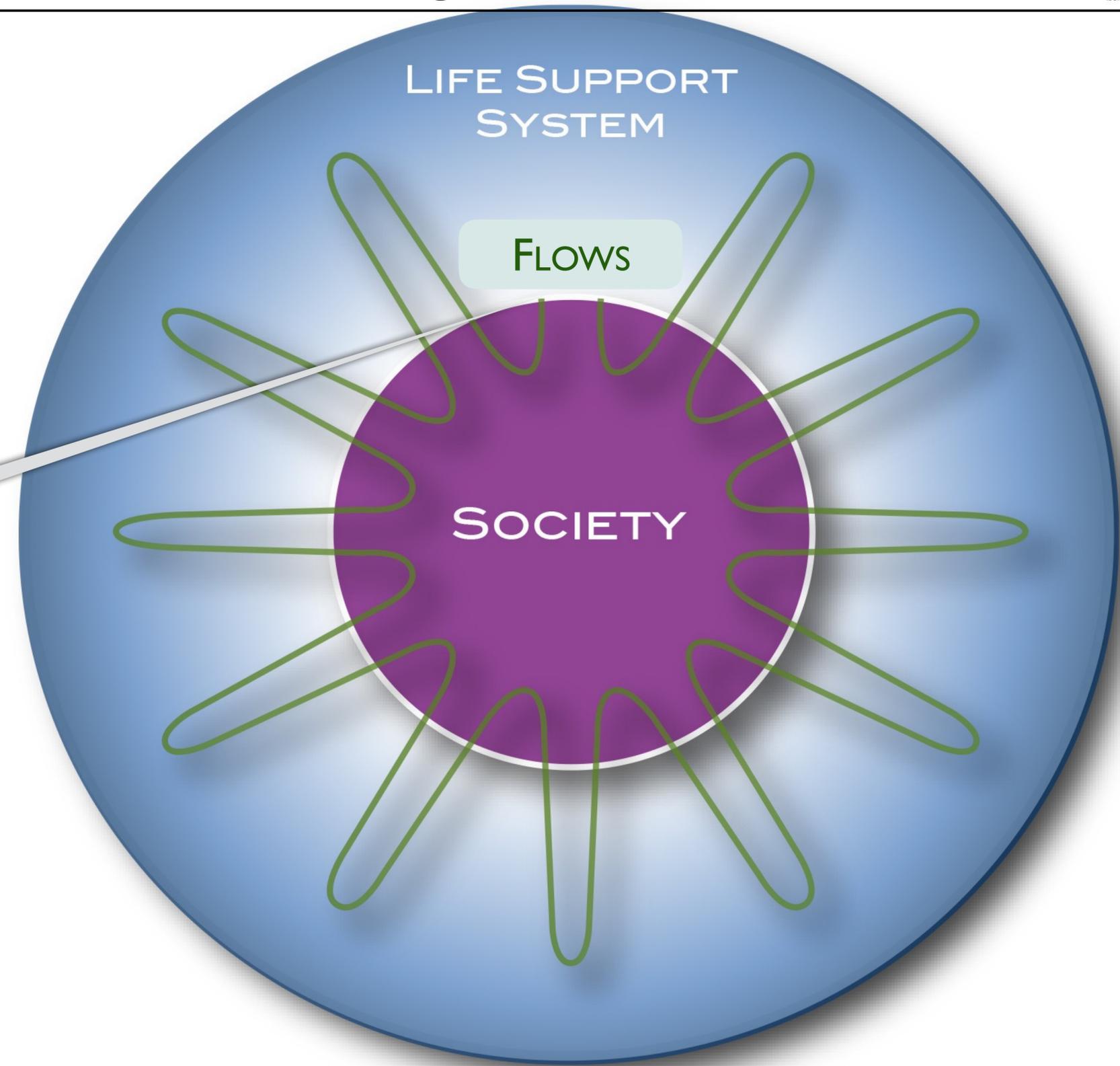
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Limitations in the flows
between a community and its life-
support system limit the growth of the
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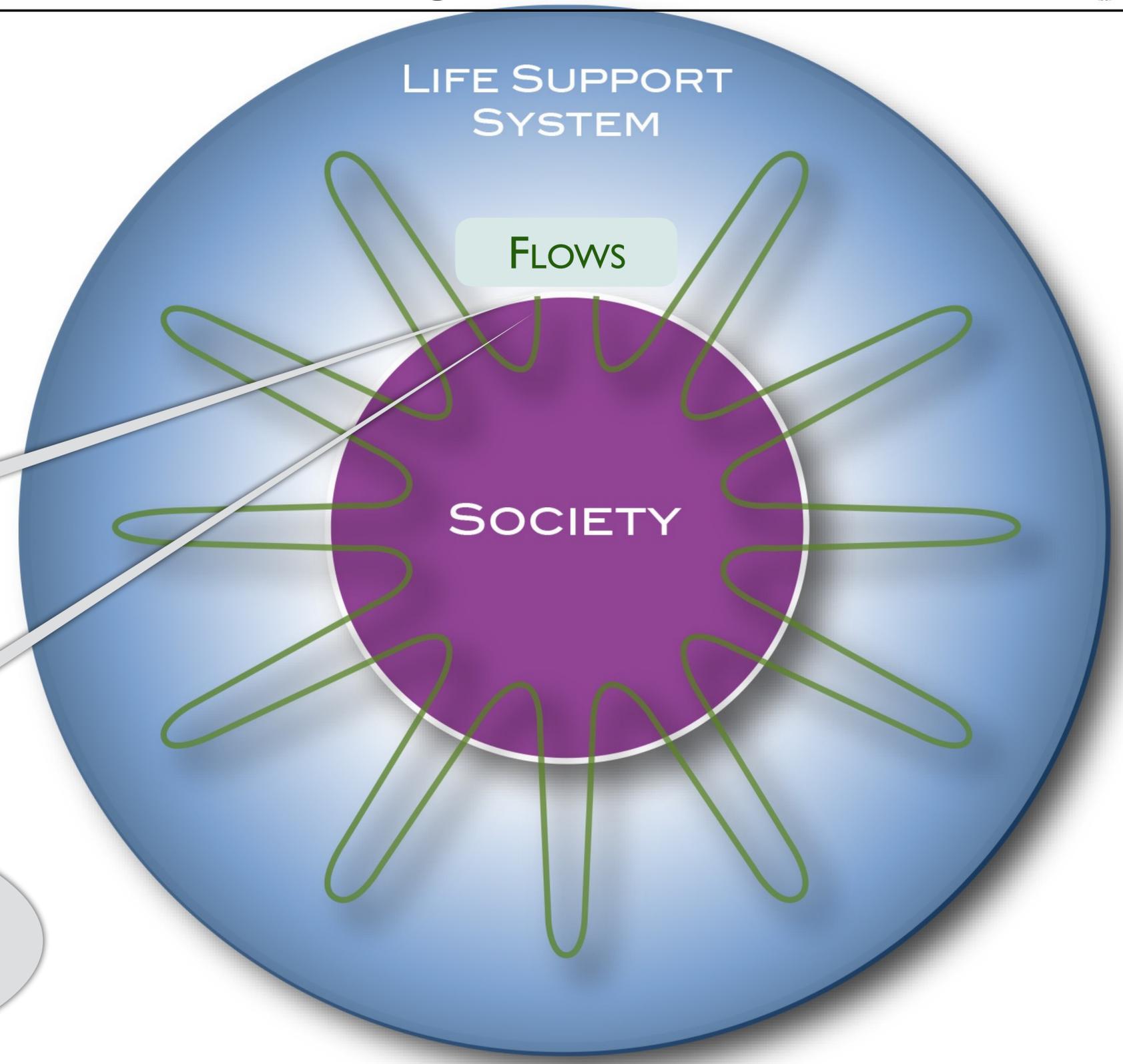


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Earth: Life-Support System for many species
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Limitations in the flows between a community and its life-support system limit the growth of the community

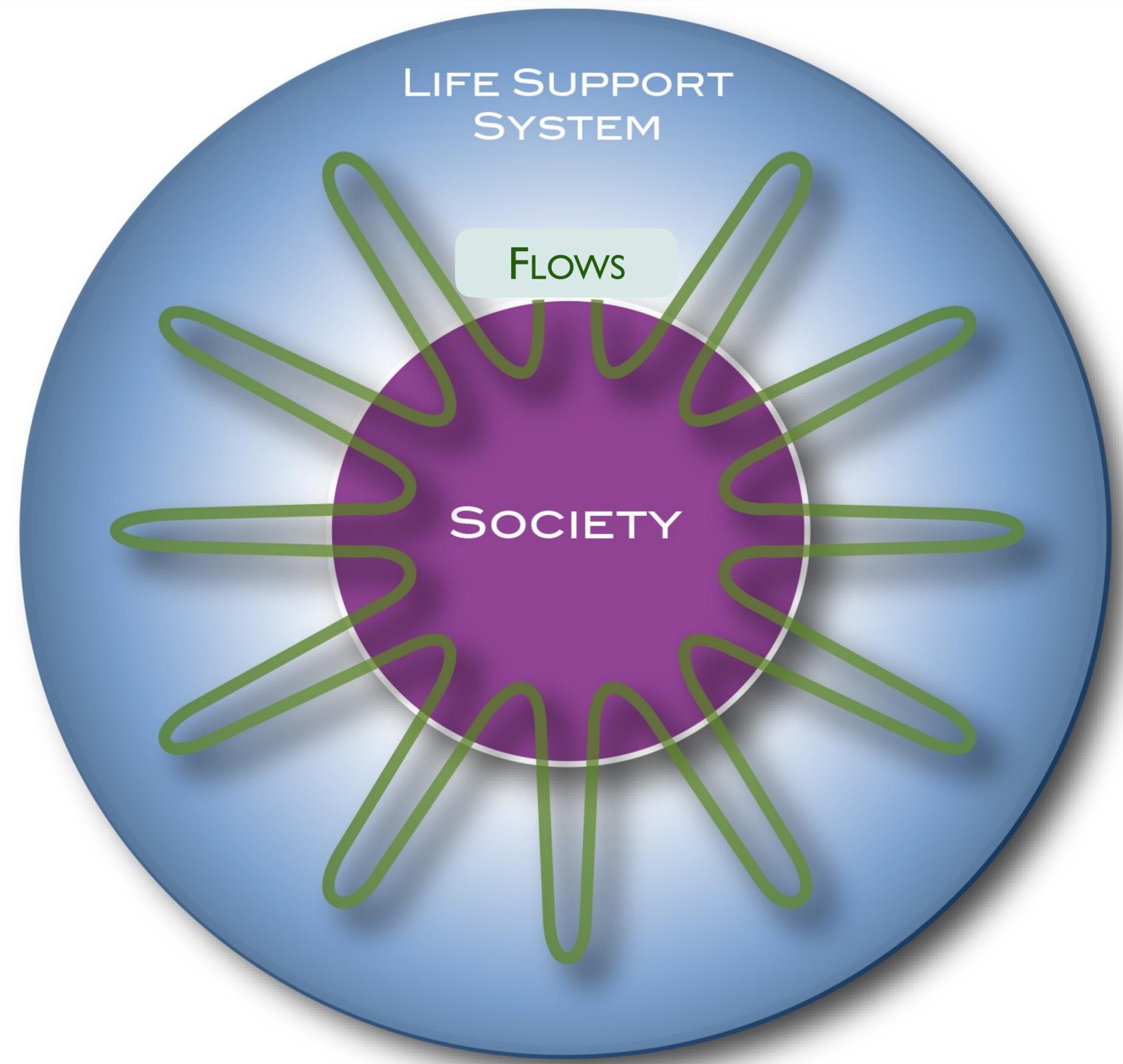
For Home sapiens, the flows are regulated by ethical, social, and - recently - economic rules



Planetary Physiology

Earth: Life-Support System for many species
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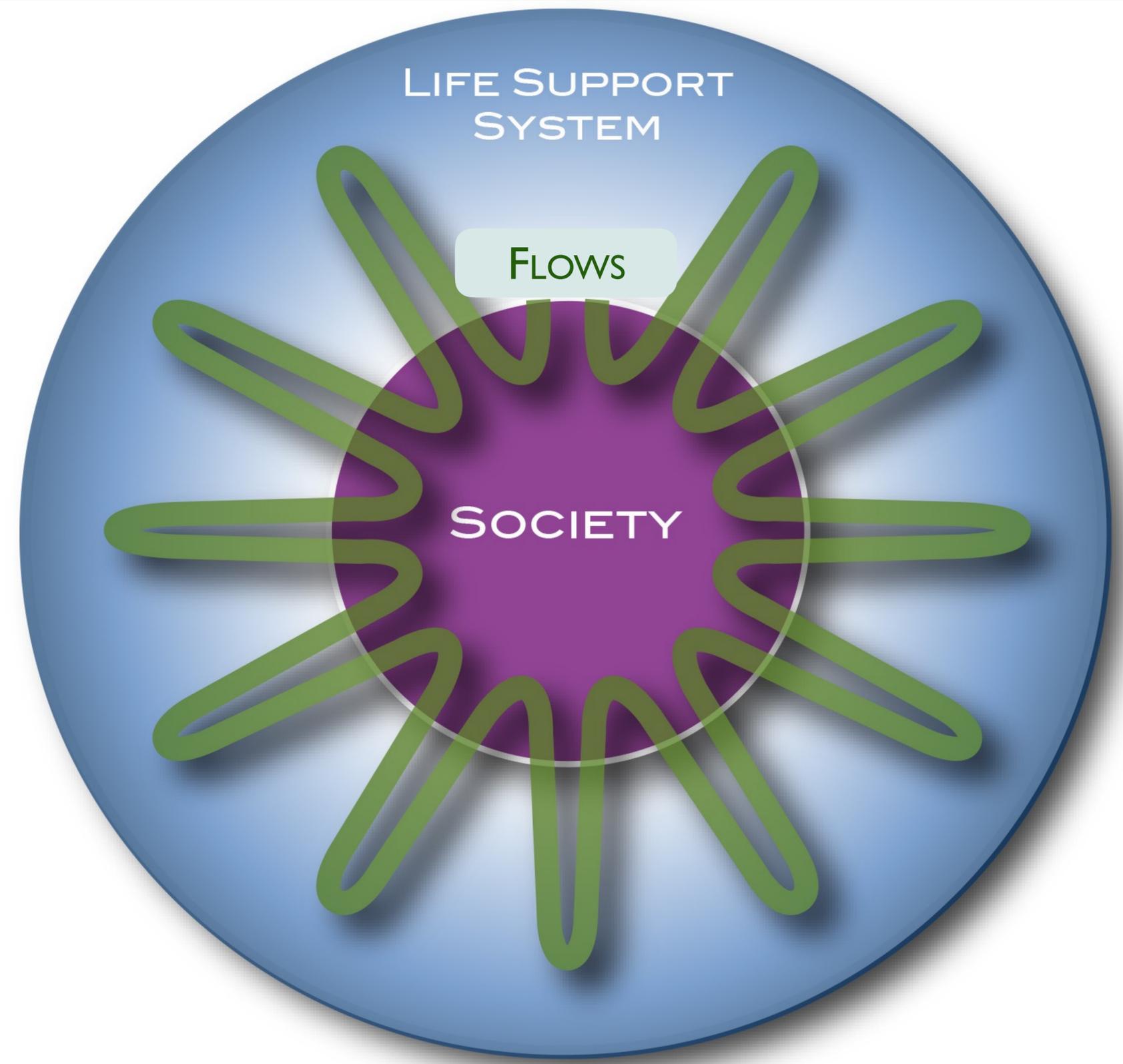
Flows have accelerated in the last 200 years; exploded in the last 70 years.



Planetary Physiology

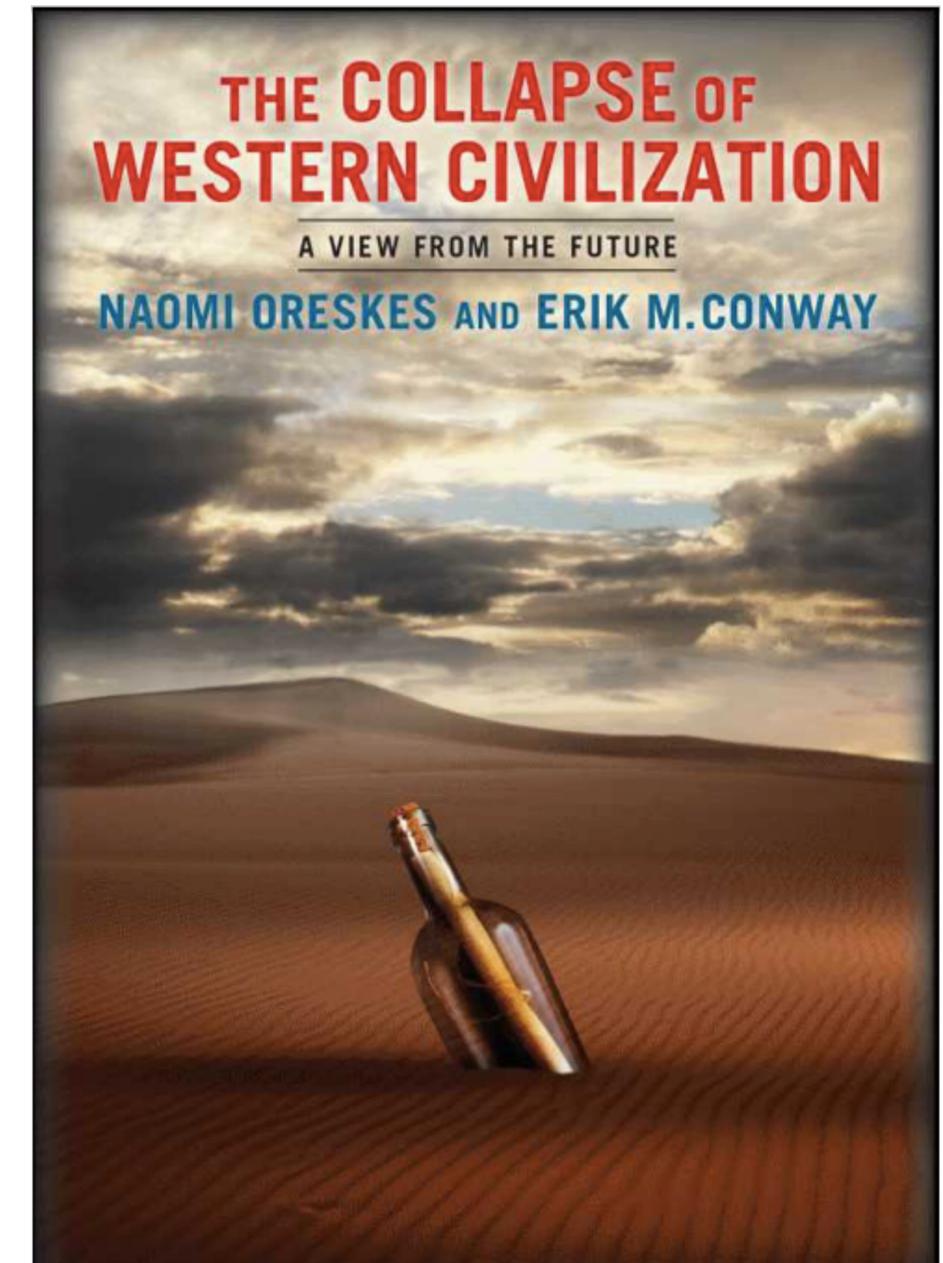
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Assessing the risk ...

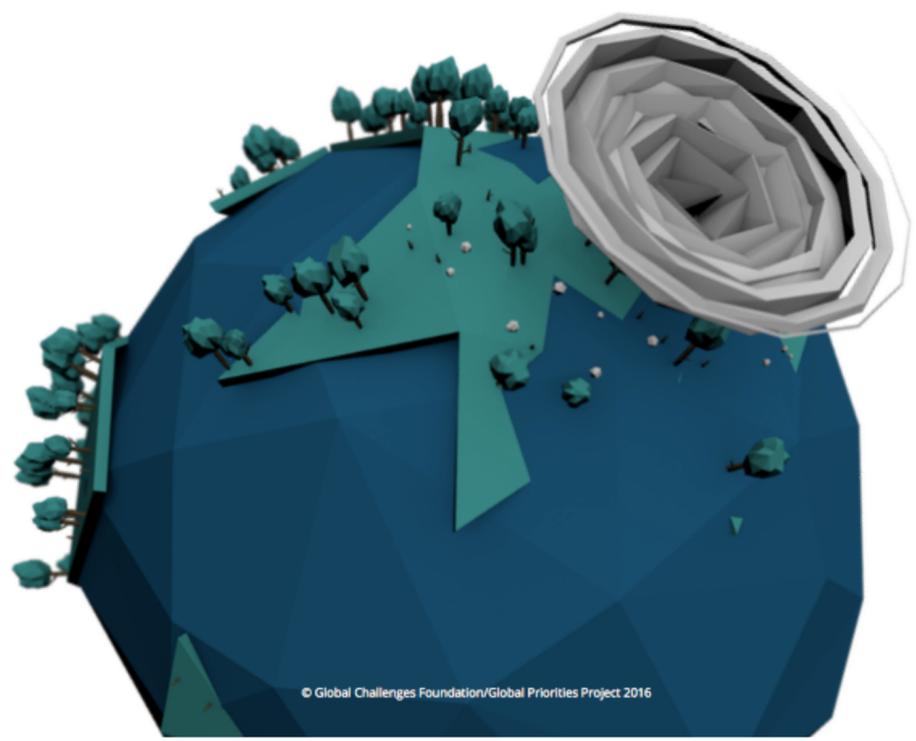


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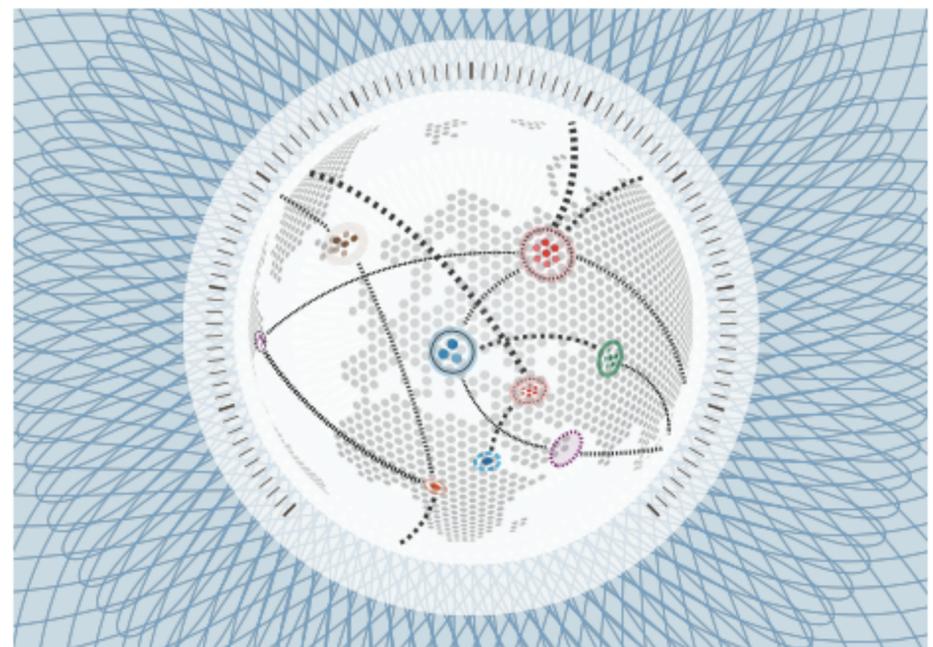
Global Challenges Foundation

Global Catastrophic Risks 2016

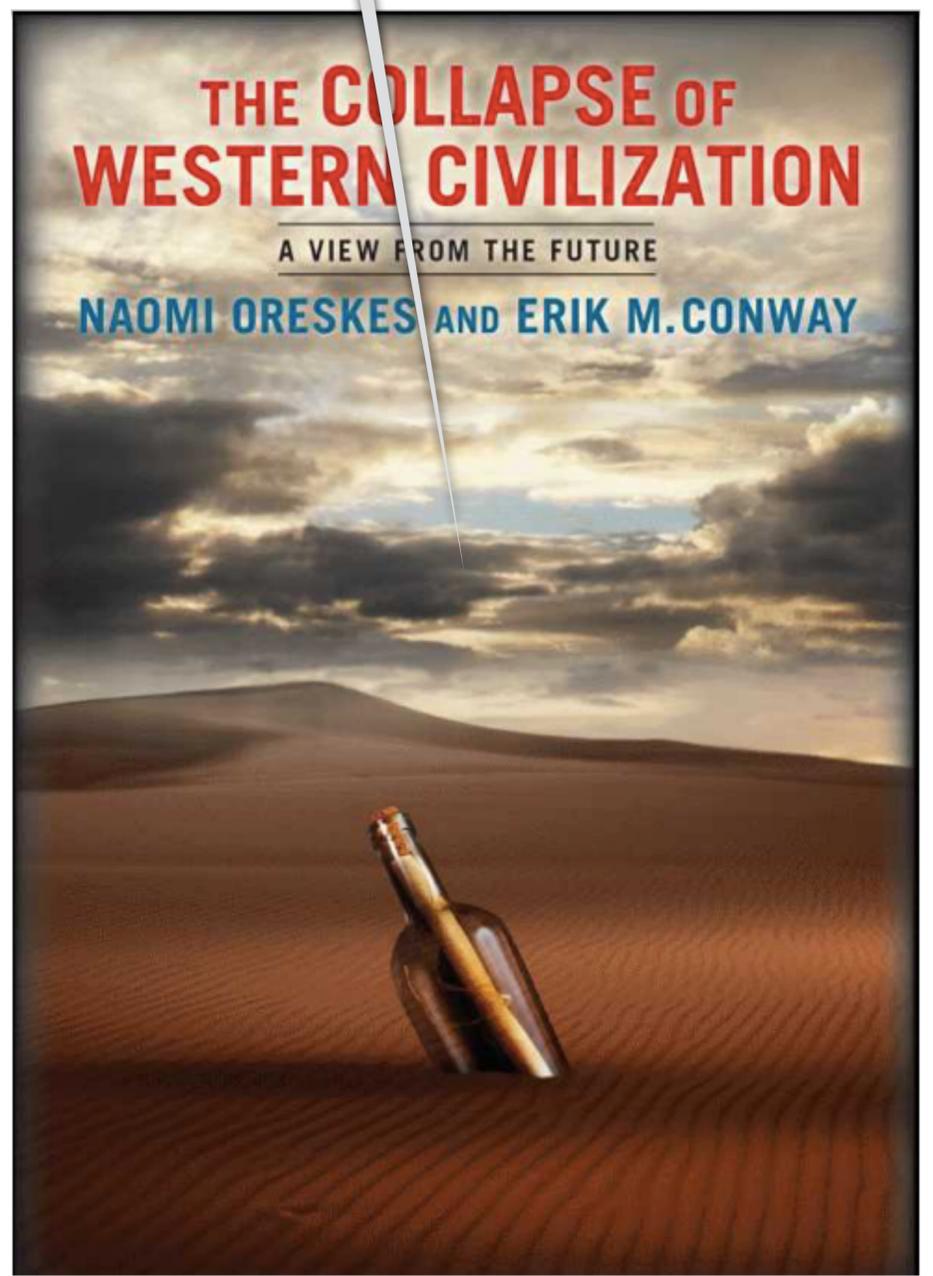


WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

Insight Report The Global Risks Report 2017 12th Edition



Plastics are missing



Plastic: A Symptom of the Syndrome of Modern Global Change

A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.

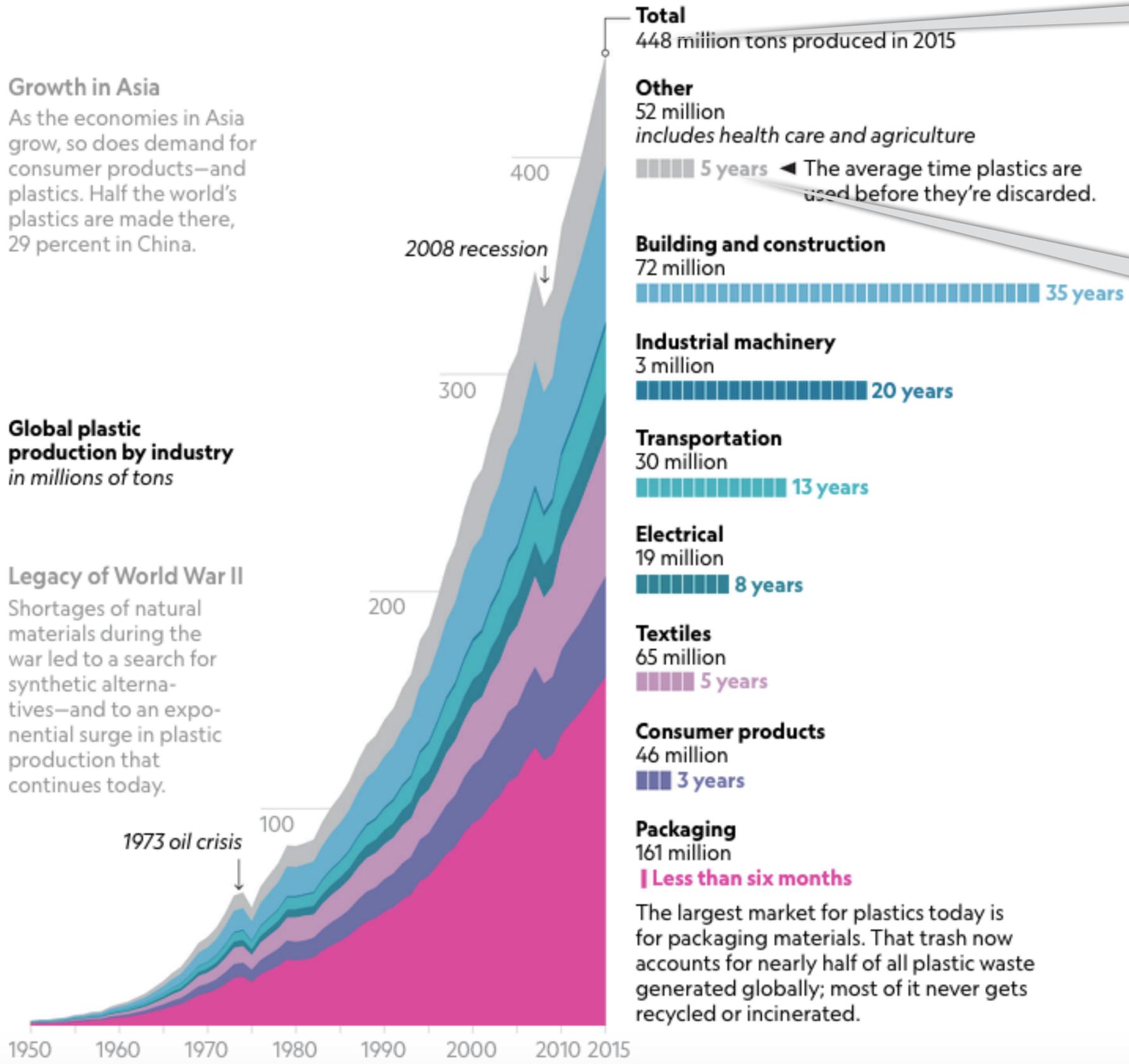
Growth in Asia

As the economies in Asia grow, so does demand for consumer products—and plastics. Half the world's plastics are made there, 29 percent in China.

Global plastic production by industry in millions of tons

Legacy of World War II

Shortages of natural materials during the war led to a search for synthetic alternatives—and to an exponential surge in plastic production that continues today.



448 Mt in 2015

Average usetime: 5 years

Average lifetime: 500 - 5,000 years

JASON TREAT AND RYAN WILLIAMS, NGM STAFF
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

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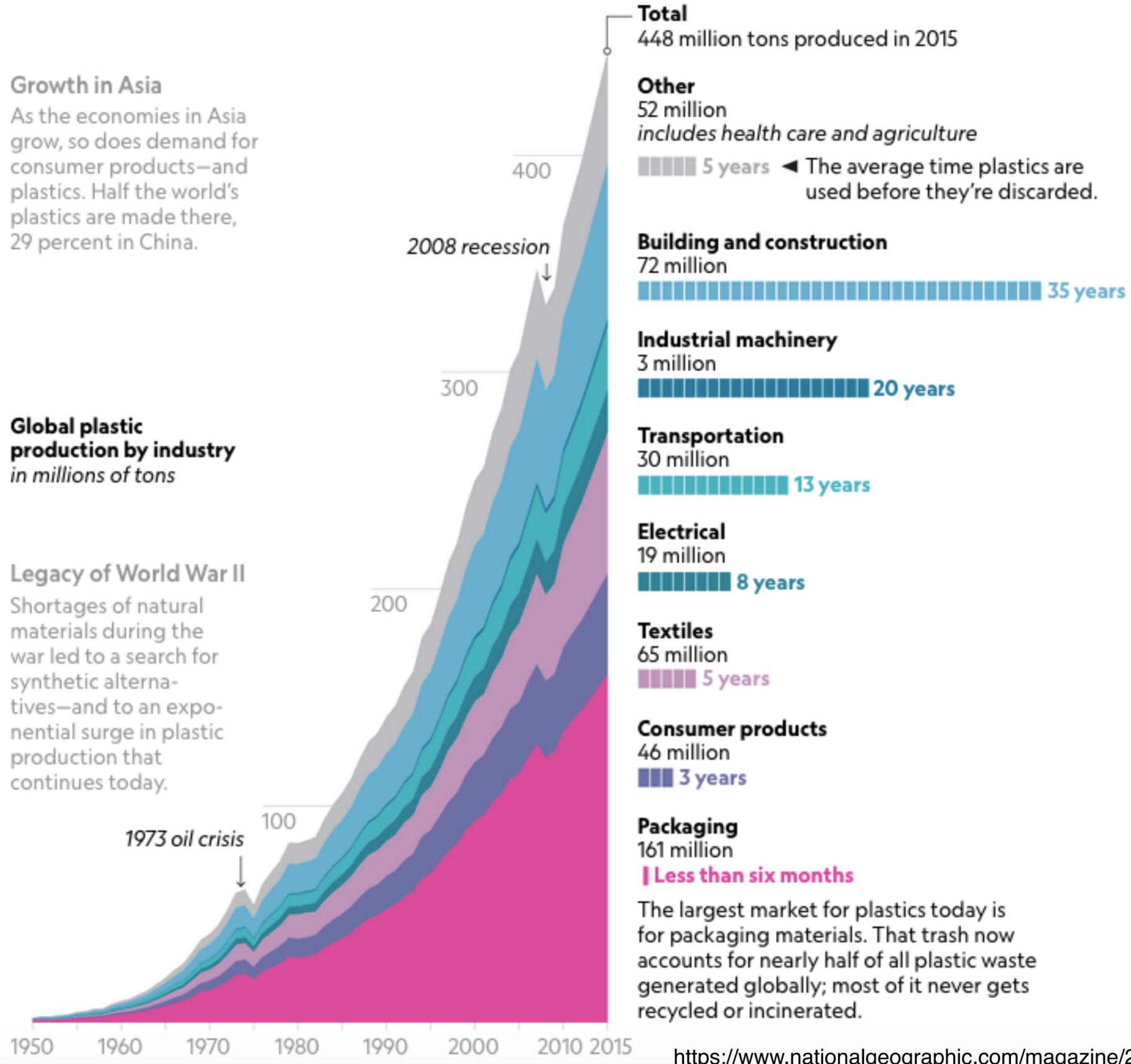
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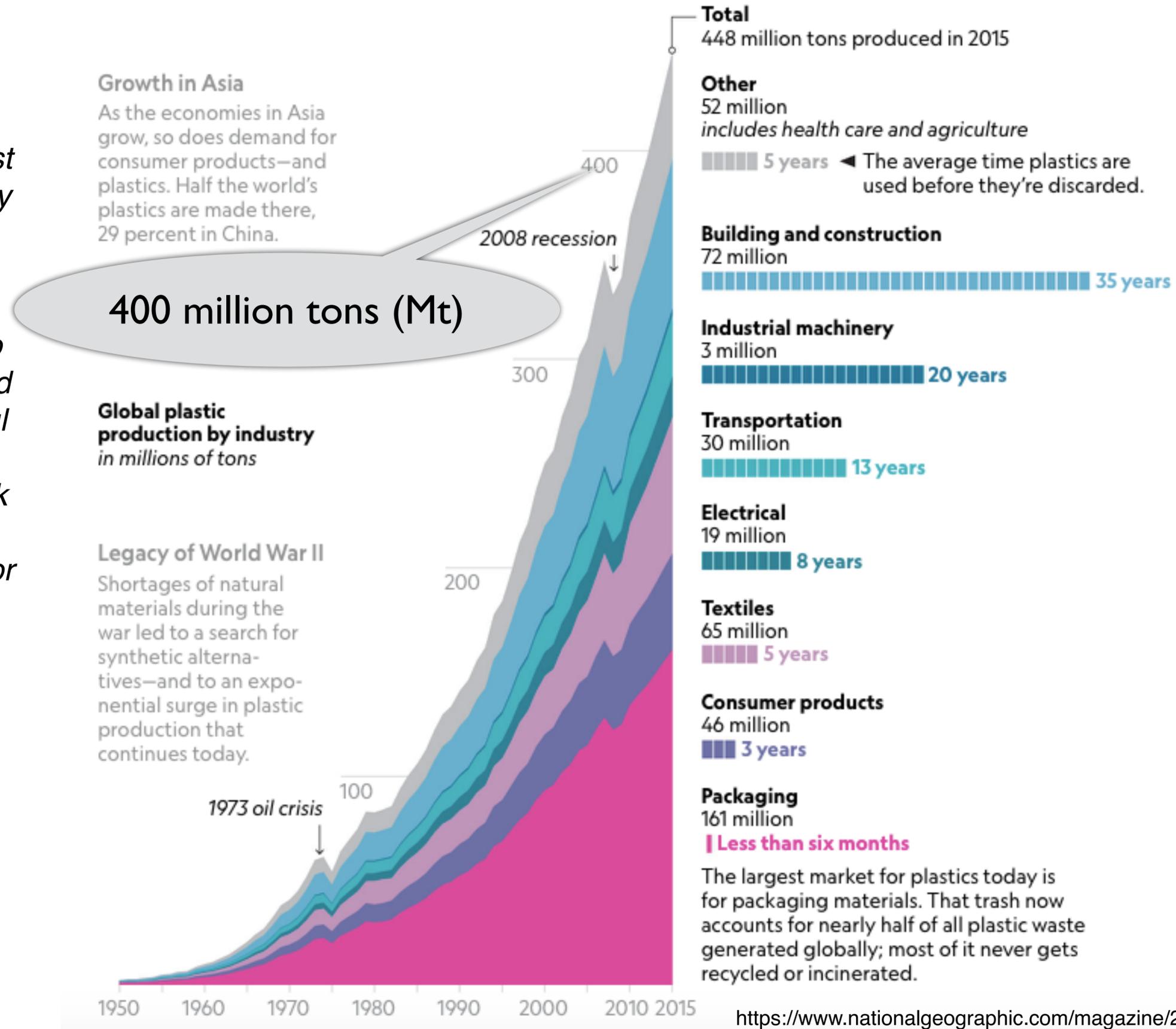
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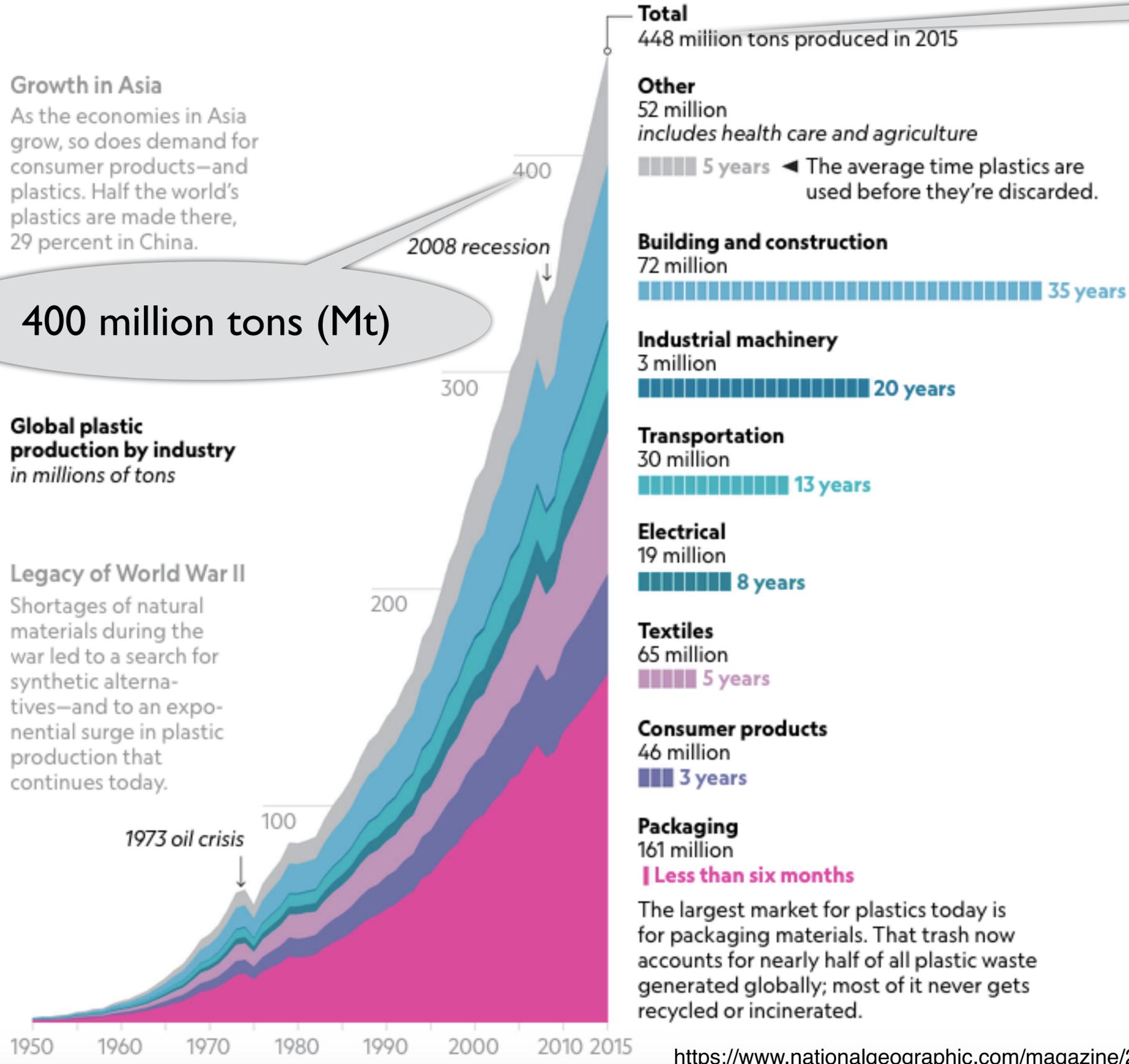
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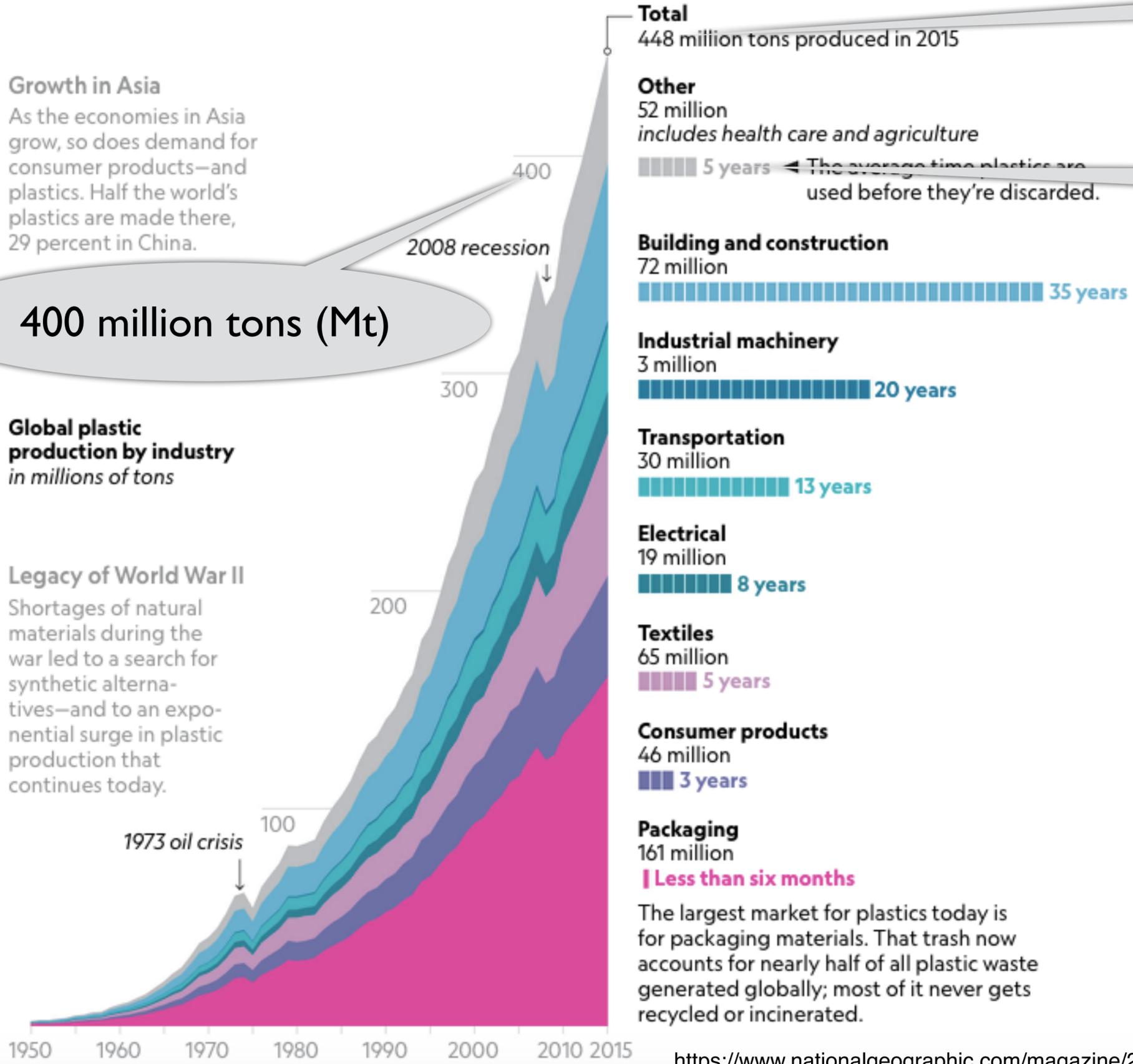
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The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

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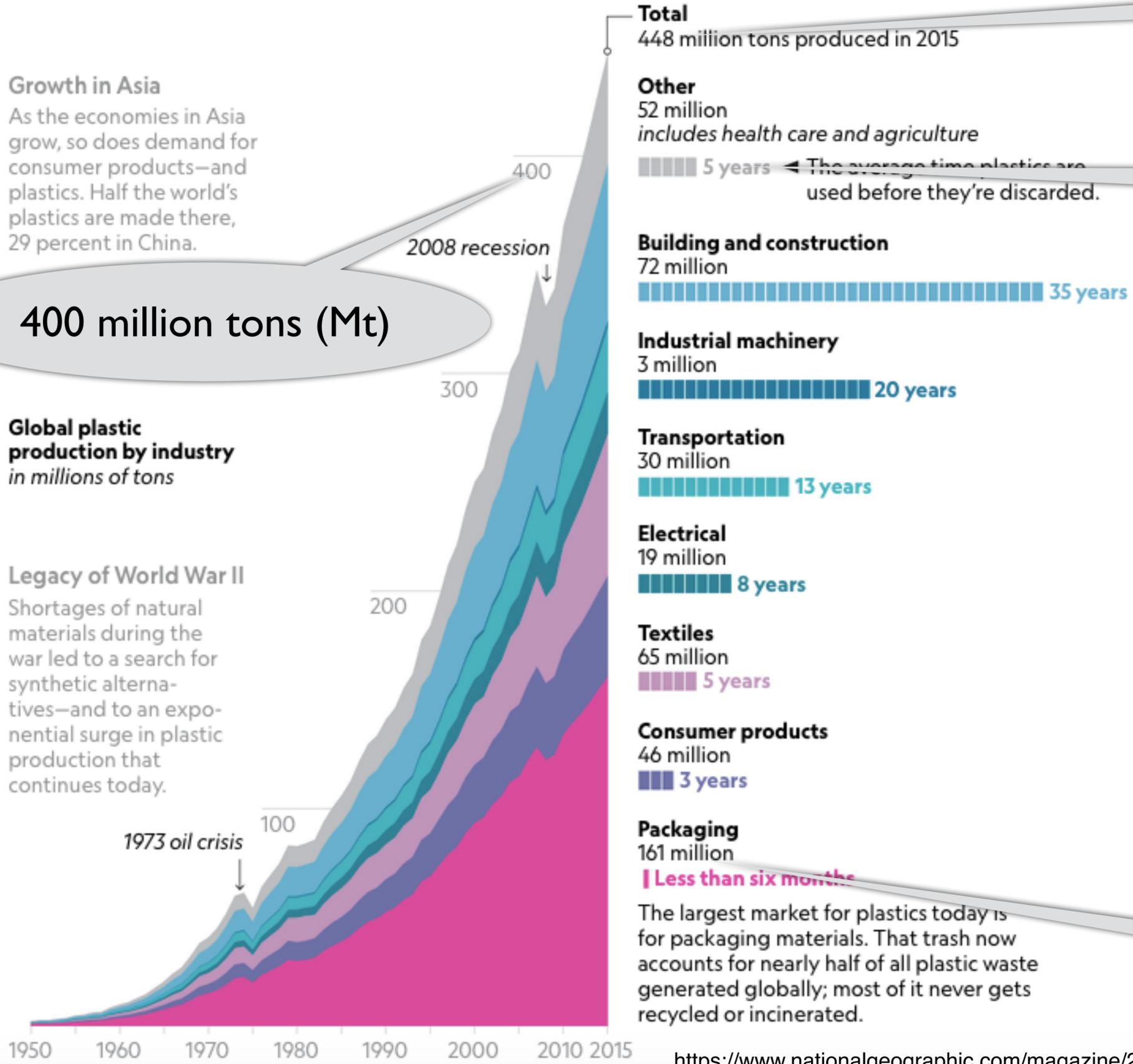
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Average lifetime: 5 years

161Mt < 6 months

What we Know: Plastic is produced a lot



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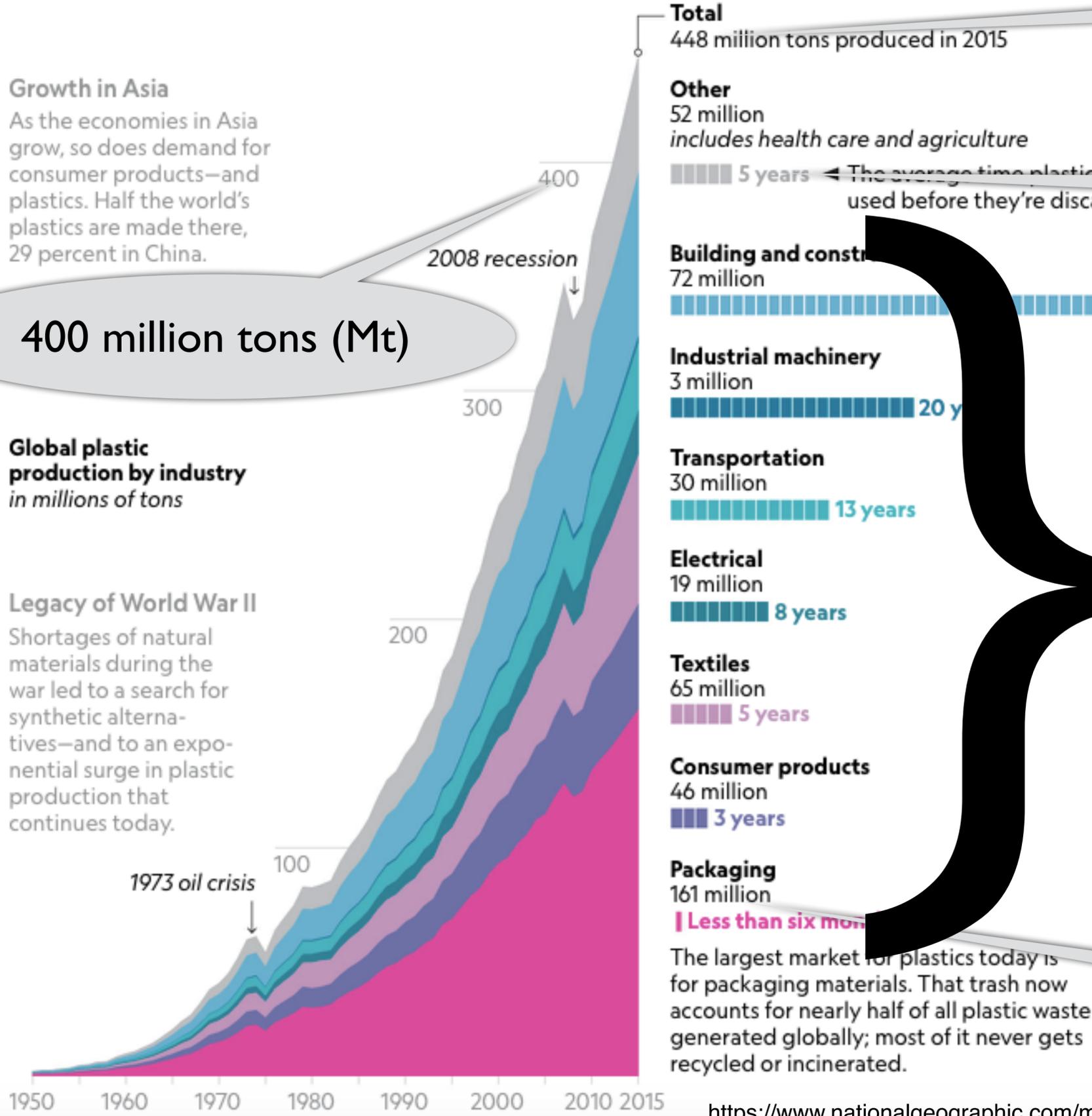
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448 Mt in 2015

Total
448 million tons produced in 2015

Other
52 million
includes health care and agriculture

5 years ← The average time plastics are used before they're discarded.

Average lifetime: 5 years

Building and construction
72 million
35 years

Industrial machinery
3 million
20 years

Transportation
30 million
13 years

Electrical
19 million
8 years

Textiles
65 million
5 years

Consumer products
46 million
3 years

Packaging
161 million
Less than six months

The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

161Mt < 6 months

What we Know: Plastic is produced a lot



2% annual increase in production:

2025: 550 Mt

2035: 670 Mt

2045: 817 Mt

Total production:

2015: 7 Bt

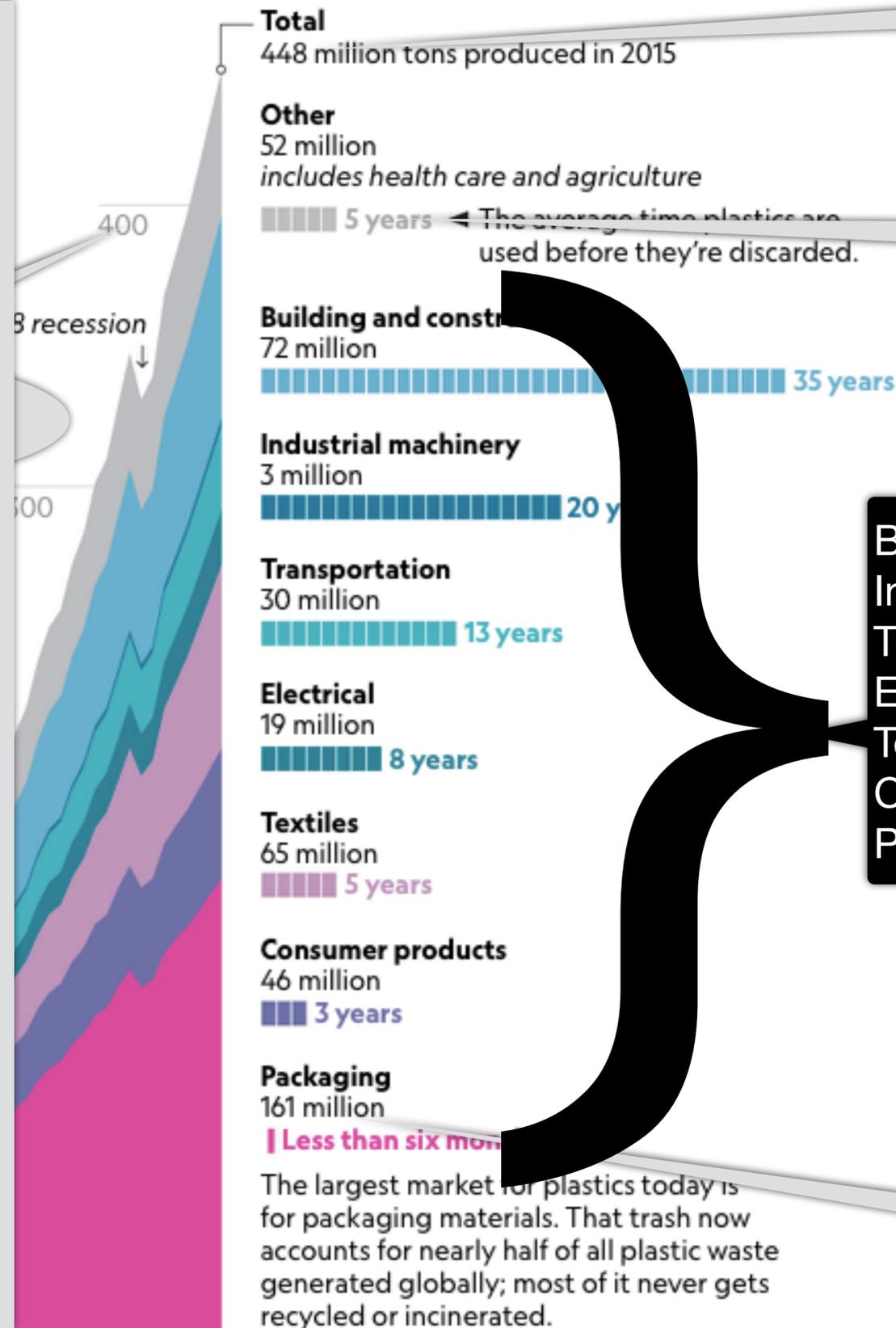
2045: 26 Bt

1% in the ocean: 260 Mt

In coastal built environment prone to

disasters:

1.7 Bt



448 Mt in 2015

Average lifetime:
5 years

Build.+Const.:	72 Mt, 35 yrs
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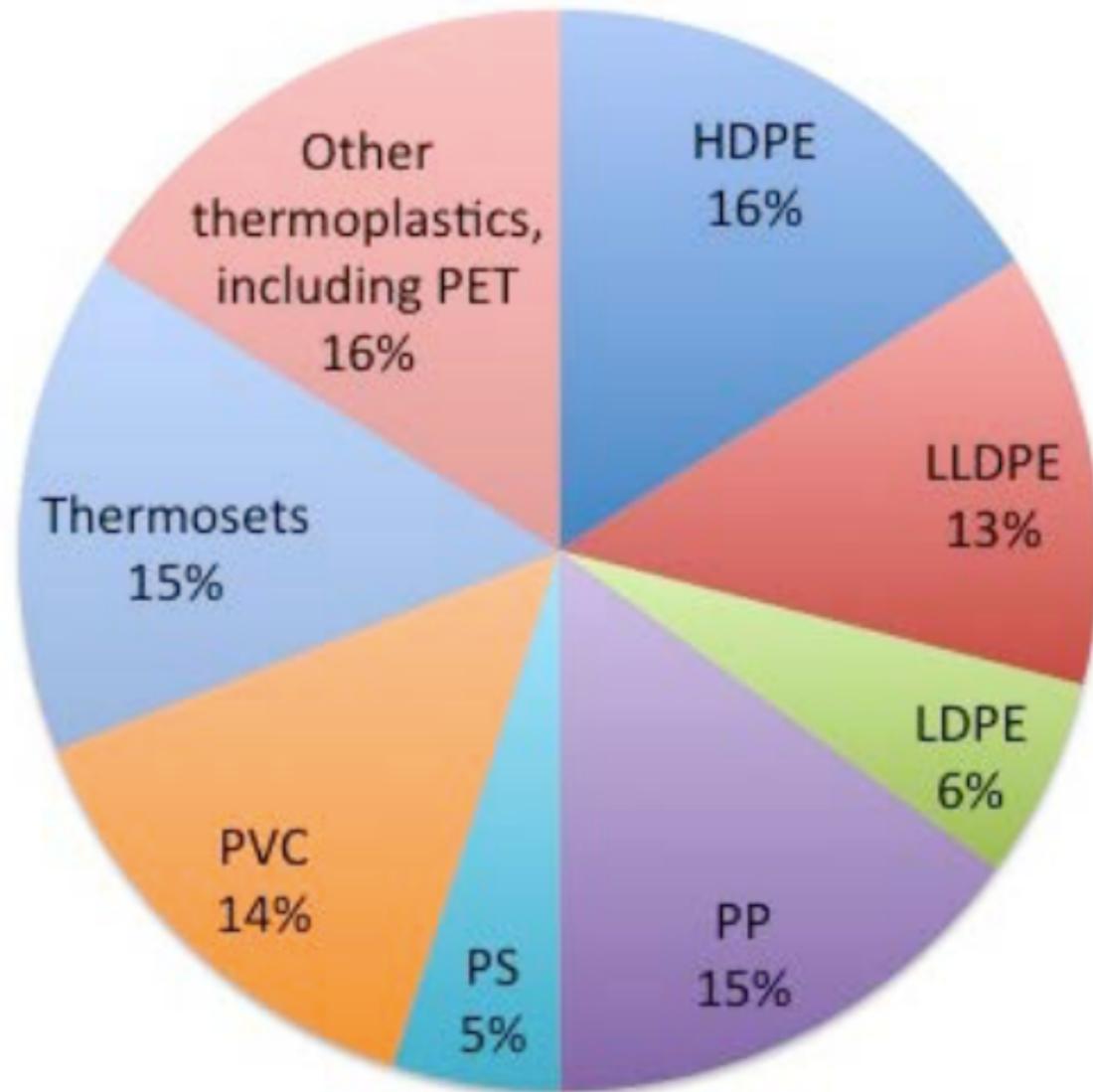
161Mt < 6 months

SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

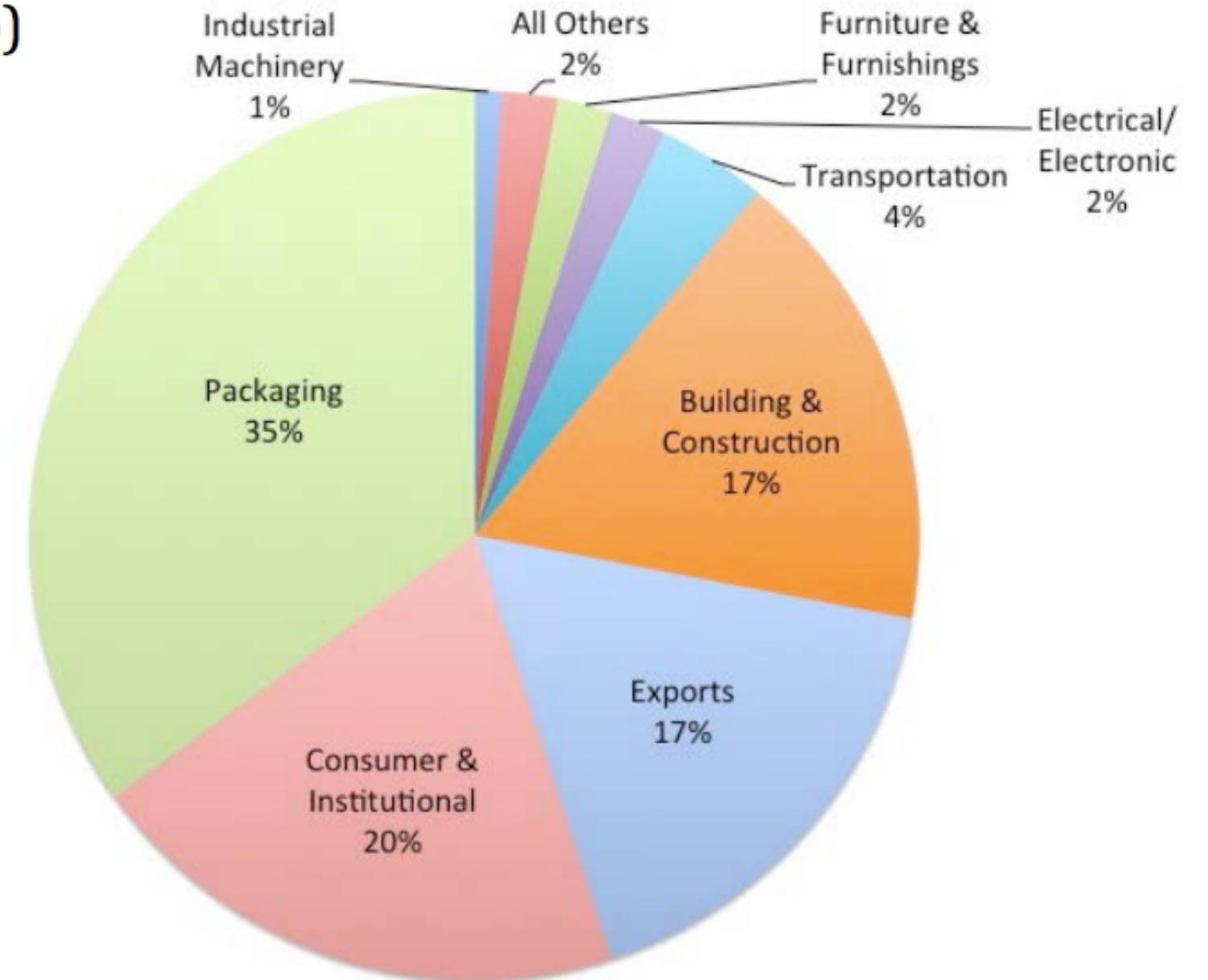
1950 1960 1970 1980 1990 2000 2010 2015

What we Know: Plastic is produced a lot

a)



b)



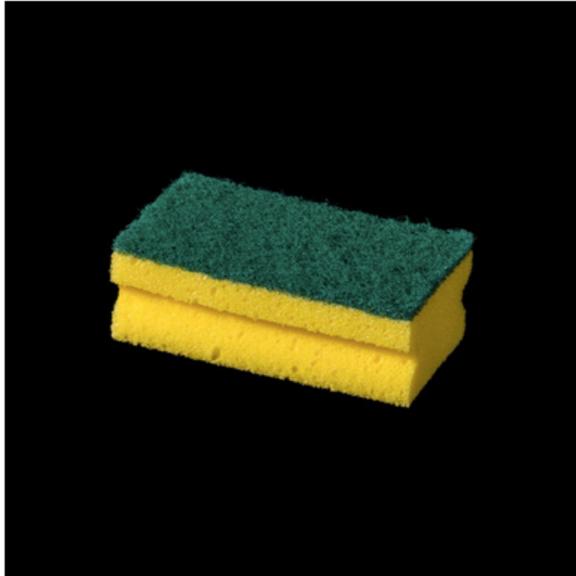
Supplemental Figure 1. (a) Percent distribution of U.S. production of plastic resins in 2014. HDPE = High Density Polyethylene; LLDPE = Linear Low Density Polyethylene; LDPE = Low Density Polyethylene; PP = Polypropylene; PS = Polystyrene; PVC = Polyvinyl Chloride; PET = Polyethylene Terephthalate. (b) Percent distribution of U.S. resin sales and captive use of thermoplastics (all materials shown in top panel except thermosets) according to major markets in 2014. Source: American Chemistry Council (2015). From

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What we Know: Plastic is used by everybody for everything



POLYURETHANE (PU)



POLYCARBONATE (PC)



POLYSTYRENE (PS)



POLYETHYLENE (PE)



POLYPROPYLENE (PP)



POLYVINYL CHLORIDE



POLYETHYLENE TEREPHTHALATE (PET)



BIODEGRADABLE PLASTICS

What we Know: Plastic is used by everybody for everything

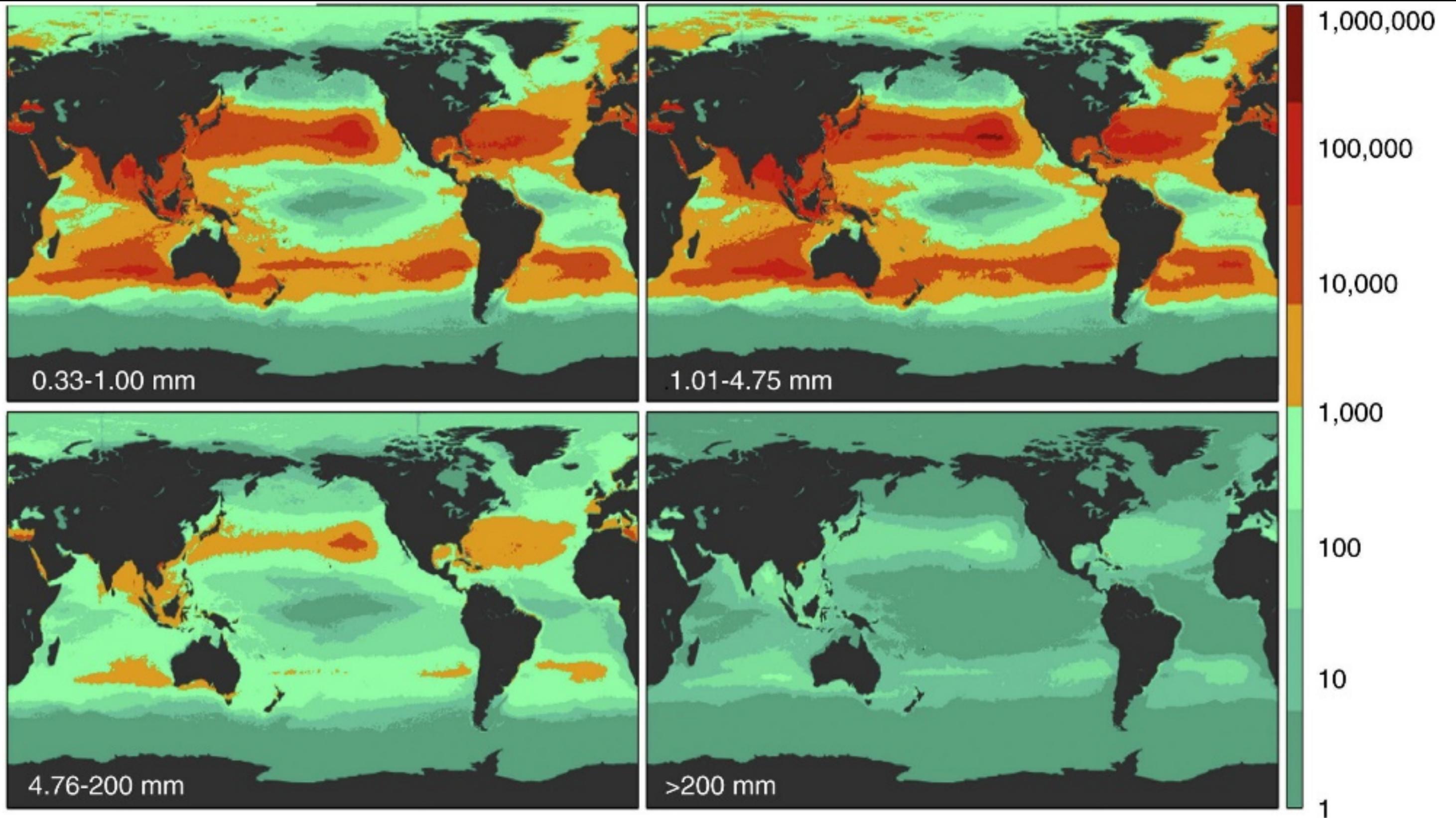


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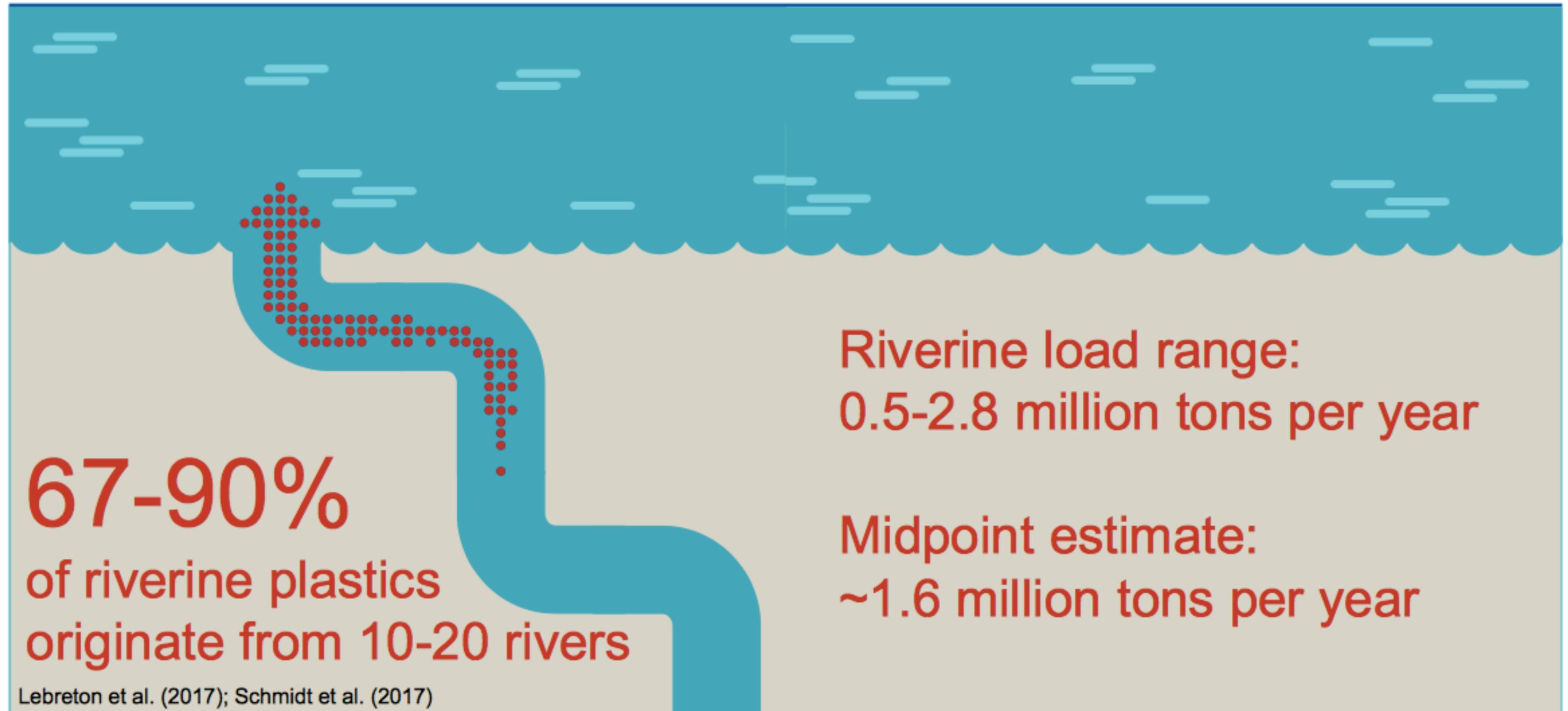
'Everywhere we looked': trillions of microplastics found in San Francisco bay

Most comprehensive study to date finds plastic in sediment collected from bay and tributaries and digestive tracts of fish



▲ A plastic bottle floating in the ocean in the San Francisco bay. An estimated 7tn pieces of microplastics flow into the San Francisco bay via stormwater drains. Photograph: Sebastian Kennerknecht/Alamy

Rivers as a source for marine litter



What we Know: Plastic is found everywhere



U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2019-1048

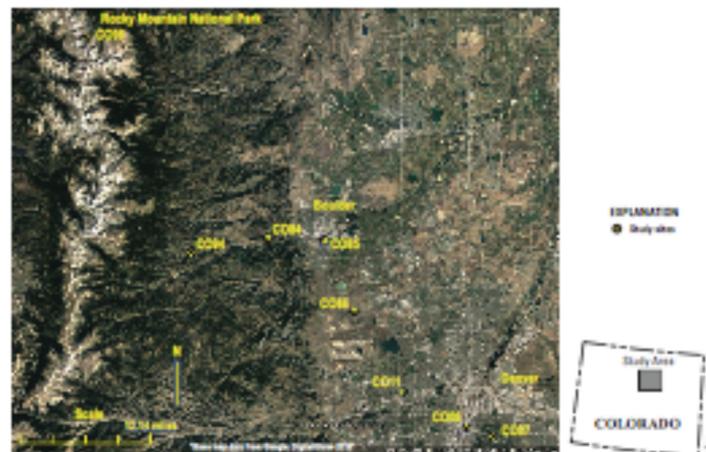
It is Raining Plastic.

By Gregory Wetherbee,¹ Austin Baldwin,² James Ranville³

¹USGS, Hydrologic Networks Branch, Denver, Colorado; ²USGS, Water Science Center, Boise, Idaho; ³Colorado School of Mines, Golden, Colorado

Overview

Atmospheric wet deposition samples were collected using the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at eight sites (see map) in the Colorado Front Range. Plastics were identified in more than 90 percent of the samples. The plastic materials were mostly fibers that were only visible with magnification, approximately 20–40 times (X). Fibers were present in a variety of colors; the most frequently observed color was blue followed by red>silver>purple>green>yellow>other colors. Plastic particles such as beads and shards were also observed with magnification. More plastic fibers were observed in samples from urban sites than from remote, mountainous sites. However, frequent observation of plastic fibers in washout samples from the remote site CO98 at Loch Vale in Rocky Mountain National Park (elevation 3,159 meters) suggests that wet deposition of plastic is ubiquitous and not just an urban condition.



Sampling Network

The Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is an NTN subnetwork of five sites in the Denver and Boulder, Colorado urban corridor. An additional urban site (CO84) is located outside Boulder, Colorado. Rural and remote montane NTN sites are nearby and form a southeast-trending transect of NTN sites with the NUANC.

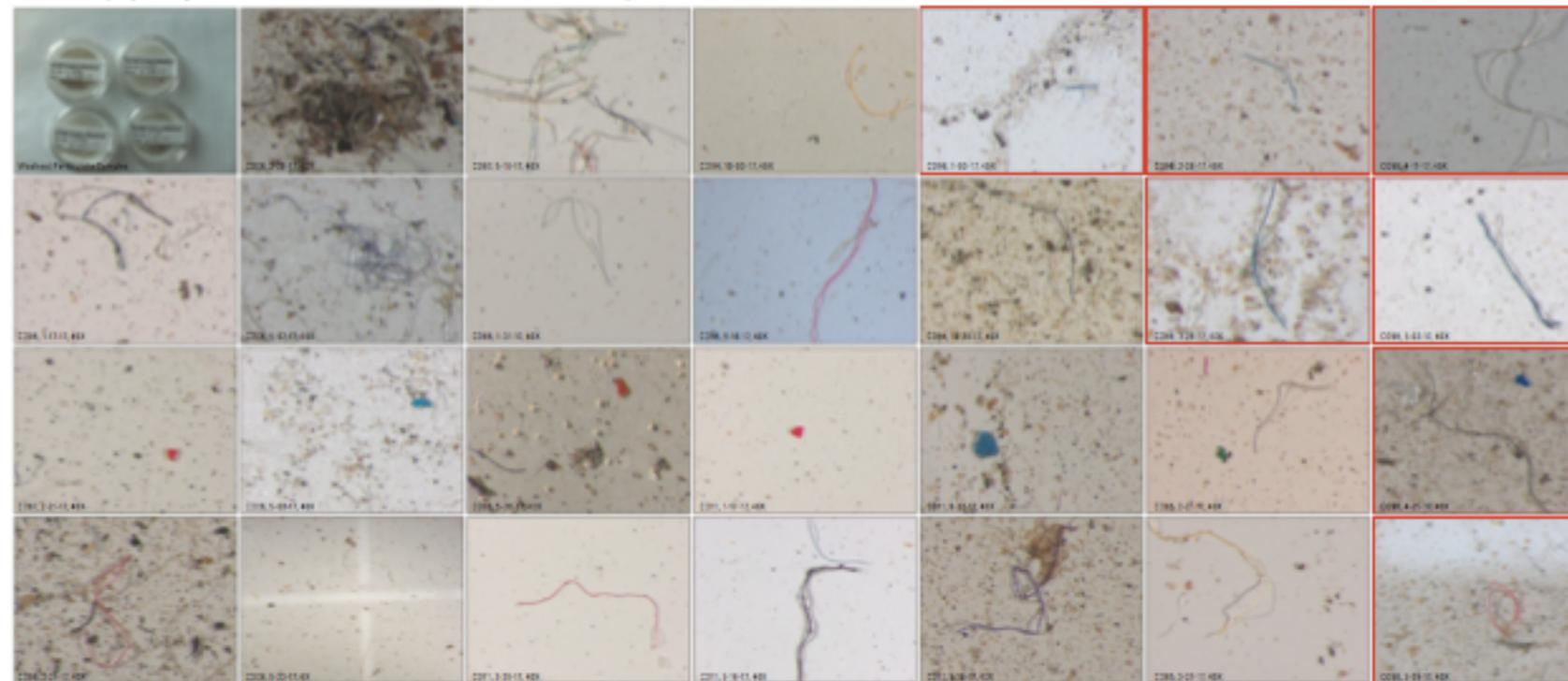
Methods

NUANC samples were collected in plastic bag-lined buckets. Sites CO84, CO94, and CO98 used standard, unlined NTN buckets. The entire volumes of each sample submitted to the NADP Central Analytical Laboratory were filtered (0.45 micrometer, polyethersulfone) to obtain particulates assumed to be washed from the atmosphere (washout). The filters were dried, weighed, and manually analyzed with a binocular microscope fitted with a digital camera (see photomicrographs). Four deionized water rinses of the sampling system were analyzed as blanks. This study was not designed for collecting and analyzing samples for plastic particles. The results are unanticipated and opportune.

Results

General types of particles were classified in the observations (see table). Air mass back-trajectory analysis for site CO98 samples was completed using the HYSPLIT model for 24 hours prior to each sample collection at 500-, 750-, and 1,000-meter altitudes. (National Oceanic and Atmospheric Administration,

Photomicrographs of plastics collected at the NUANC NTN subnetwork, Sugarloaf, and Loch Vale sites in Colorado



(Explanation of labels: CO06, site identification; 2-28-17, month-day-year; 40X, magnification; Red outline indicates Loch Vale samples.)

Data for washout particles collected at site CO98, Loch Vale, Rocky Mountain National Park.

(Bold values indicate easterly air mass back trajectories)

Site identifier	Weekly sample collection date (month/day/year)	Sample volume (mL/bucket)	Estimated solids concentration (µg/L)	Identified materials								Notes	Back trajectory (degrees from north)
				Mineral	Soil	Plant	Insects	Micro-plastic	Amorphous carbon				
No plastic positively identified													
CO98	1/24/17	337.0	11.4	Yes	Yes	Yes	Possibly	Possibly	Yes			227	
CO98	2/14/17	566.4	1.1	Yes	Yes	Yes	Possibly	Possibly	Yes	Egg-shaped particle might be plastic		235	
CO98	3/28/17	1,417.3	1.9	Yes	Yes	Yes	No	Possibly	Possibly	Possible blue fiber		159	
CO98	4/8/17	1,837.3	0.1	Yes	Yes	Yes	No	No	Possibly			169	
CO98	5/16/17	881.7	4.5	Yes	Yes	Yes	Possibly	Possibly	Yes	Possible black plastic fiber		62	
CO98	5/23/17	2,856.3	1.0	Yes	Yes	Yes	Yes	No	Yes			62	
CO98	7/18/17	320.9	3.8	Yes	Yes	Yes	Yes	No	Yes			251	
CO98	7/23/17	1,322.5	0.7	Yes	Yes	Yes	Yes	Possibly	Yes			252	
CO98	8/1/17	1,897.1	0.2	Yes	Yes	Yes	Yes	Possibly	Yes			213	
CO98	8/8/17	2,766.3	0.6	Yes	Yes	Yes	Yes	Possibly	Yes			156	
CO98	12/19/17	446.2	<2.2	Yes	No	Yes	No	No	Yes			260	
Plastic identified													
CO98	1/3/2017	530.3	7.5	Yes	Yes	Yes	Yes	Yes	Yes	Blue fiber		225	
CO98	2/28/2017	1,381.2	2.3	Yes	Yes	Yes	No	Yes	Yes	Blue fiber		216	
CO98	4/13/2017	918.7	6.1	Yes	Yes	Yes	Yes	Yes	Yes	Blue, green fibers, 2-3		240	
CO98	4/23/2017	1,352.8	3.1	Yes	Yes	Yes	No	Yes	Yes	Blue chunk		261	
CO98	5/2/2017	1,533.7	0.1	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fibers times 3		265	
CO98	5/9/2017	857.1	5.3	Yes	Yes	Yes	No	Yes	Yes	Red fiber		265	
CO98	5/20/2017	2,095.2	1.0	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fiber		265	
CO98	6/9/2017	357.9	1.7	Yes	Yes	Yes	No	Yes	Yes	White, blue plastic		254	
CO98	6/15/2017	2,981.0	0.1	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber		275	
CO98	8/29/2017	516.4	3.3	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber		266	

<https://ready.arl.noaa.gov/HYSPLIT.php>) Urban areas are southeast (approximately 140°) of site CO98, but plastic deposition was more positively identified for westerly storms than easterly storms. In the four blank samples, there was one small translucent fiber observed that might have been plastic. Translucent and white materials, which are the colors of the sampling apparatus, were disregarded in the analyses.

Discussion

The mass of plastic in even the most concentrated samples was not large enough to weigh or reliably estimate. Developing a routine capability to calculate plastic wet-deposition loads is not possible with current (2019) technology. Methods for more accurate estimation of plastic loads are needed.

Better quality control to limit cross contamination and methods for estimation of percent recovery of the plastic materials from NADP samples are needed. Retaining NADP filters for subsequent analysis would make a washout deposition network possible with very little added expense.

How these plastic materials are accumulating and being assimilated in the environment and biota is unclear. Moreover, the potential effects of these materials on biota is not understood.

Conclusions

It is raining plastic. Better methods for sampling, identification, and quantification of plastic deposition along with assessment of potential ecological effects are needed.

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This Open-File Report was prepared in accordance with the provisions of the National Archives and Records Administration (NARA) and the National Oceanic and Atmospheric Administration (NOAA) regarding the release of information from the U.S. Government.
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What we Know: Plastic is found everywhere



U.S. Department of the Interior
U.S. Geological Survey

It's raining plastic: microscopic fibers fall from the sky in Rocky Mountains

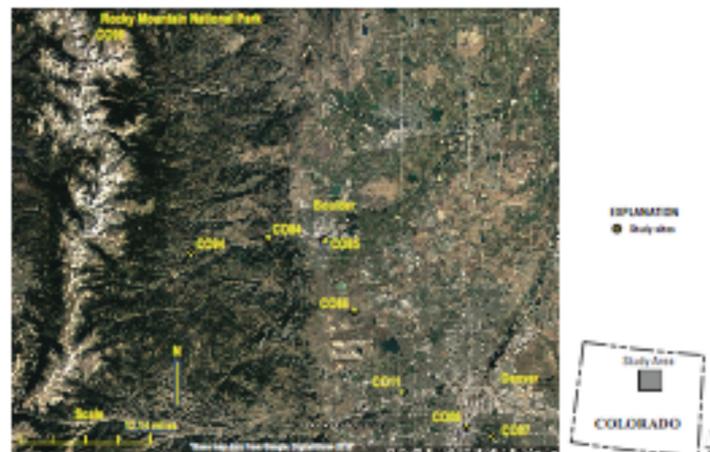
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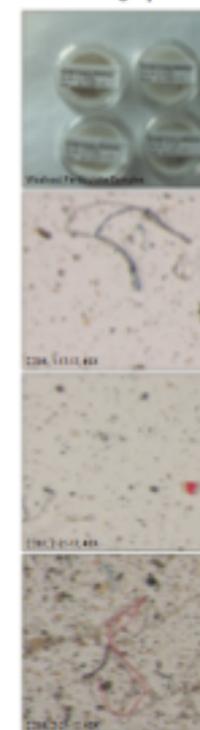
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Photomicrographs of



(Explanation of labels: CO)

Data for washout particles coll
(Bold values indicate exactly air coll)

Site Identification	Weekly sample collection date (month/day/year)	Number of particles	Color	Length (micrometers)	Width (micrometers)	Shape	Material	Number of fibers		
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CO98	3/28/17	1,533.7	0.1	Yes	Yes	Yes	Possibly	Yes	Blue fibers times 3	265
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CO98	7/25/17	516.4	3.3	Yes	Yes	Yes	Yes	Yes	Plastic fiber	266



▲ Trail markers on the trail near Colorado's highest peak, Mount Elbert, in the Rocky Mountains.

Photograph: Alamy

<https://www.theguardian.com/us-news/2019/aug/12/raining-plastic-colorado-usgs-microplastics>

Discovery raises new questions about the amount of plastic waste permeating the air, water, and soil virtually everywhere on Earth

READ THE ORIGINAL BY SCOTT MANNING/AMERICA'S

Conclusions

It is raining plastic. Better methods for sampling, identification, and quantification of plastic deposition along with assessment of potential ecological effects are needed.

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For sale by U.S. Geological Survey, Information Services, Box 2098, Federal Center, Denver, CO 80202, 1-800-485-6000.
Suggested citation: Wetherbee, G., Baldwin, A., Ranville, J., 2019. It is raining plastic: U.S. Geological Survey Open-File Report 2019-1048. 1 sheet, available at <https://pubs.usgs.gov/of/2019/1048/>.

Sampling Network

The Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is an NTN subnetwork of five sites in the Denver and Boulder, Colorado urban corridor. An additional urban site (CO84) is located outside Boulder, Colorado. Rural and remote montane NTN sites are nearby and form a southeast-trending transect of NTN sites with the NUANC.

Methods

NUANC samples were collected in plastic bag-lined buckets. Sites CO84, CO94, and CO98 used standard, unlined NTN buckets. The entire volumes of each sample submitted to the NADP Central Analytical Laboratory were filtered (0.45 micrometer, polyethersulfone) to obtain particulates assumed to be washed from the atmosphere (washout). The filters were dried, weighed, and manually analyzed with a binocular microscope fitted with a digital camera (see photomicrographs). Four deionized water rinses of the sampling system were analyzed as blanks. This study was not designed for collecting and analyzing samples for plastic particles. The results are unanticipated and opportune.

Results

General types of particles were classified in the observations (see table). Air mass back-trajectory analysis for site CO98 samples was completed using the HYSPLIT model for 24 hours prior to each sample collection at 500-, 750-, and 1,000-meter altitudes. (National Oceanic and Atmospheric Administration,

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- Linking Data and Knowledge to Society

Hans-Peter Plag
Old Dominion University
Norfolk, VA, USA

What we Know: Plastic is not handled well



'Plastic recycling is a myth': what really happens to your rubbish?

▲ Everything you own will one day become property of the £250bn global waste industry. Composite: Guardian Design Team

You sort your recycling, leave it to be collected - and then what? From councils burning the lot to foreign landfill sites overflowing with British rubbish, [Oliver Franklin-Wallis](#) reports on a global waste crisis



United States of Plastic

Americans' plastic recycling is dumped in landfills, investigation shows

Pearl Pai holds a bag of sorted recyclables that she was unable to posit at her local recycling center. Photograph: Hardy Wilson/The Guardian

Consumers' efforts to be eco-friendly go to waste as many communities find themselves with nowhere to send their refuse

<https://www.theguardian.com/environment/2019/aug/17/plastic-recycling-myth-what-really-happens-your-rubbish>

<https://www.theguardian.com/us-news/2019/jun/21/us-plastic-recycling-landfills>

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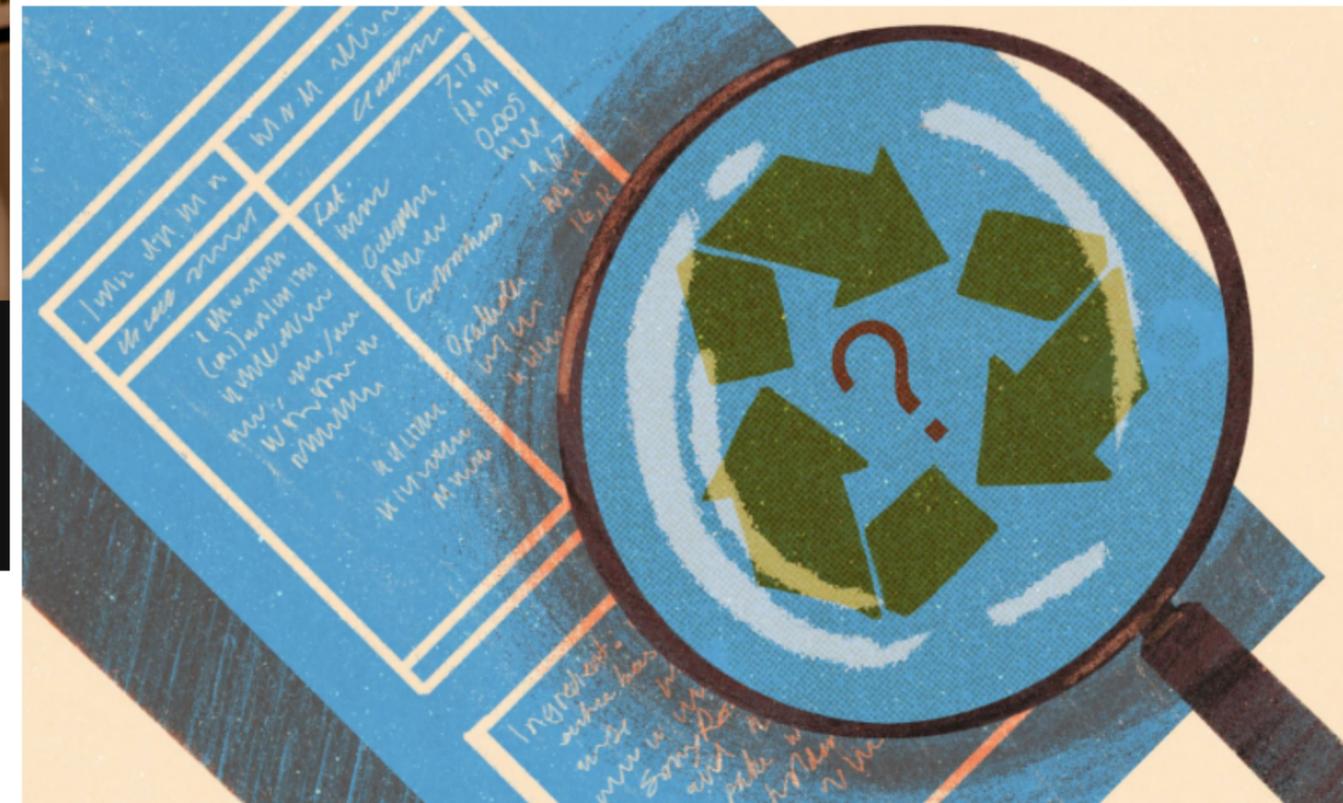
United States of Plastic

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Pearl Pai holds a bag of sorted recyclables that she was unable to posit at her local recycling center. Photograph: Hardy Wilson/The Guardian

Consumers' efforts to be eco-friendly go to waste as many communities find themselves with nowhere to send their refuse

How you're recycling plastic wrong, from coffee cups to toothpaste



▲ Illustration: Sonny Ross/The Guardian

If you don't clean your recycling, it can harm more than it helps. And that icon with the arrows is virtually meaningless

Advertisement

<https://www.theguardian.com/environment/2019/aug/17/plastic-recycling-myth-what-really-happens-your-rubbish>

<https://www.theguardian.com/us-news/2019/jun/21/us-plastic-recycling-landfills>

<https://www.theguardian.com/environment/2019/jun/17/recycling-plastic-wrong-guide>

“Solutions” that create new problems:



- In 1993, Patagonia became the first outdoor gear company to use recycled PET bottles to make some of its fleece garments.
- This environmentally conscious firm proudly states that this was “a positive step towards a more sustainable system—one that uses fewer resources, discards less and better protects people’s health.”
- Since then, some 92 million PET bottles have been transformed into articles of clothing.
- However, for many firms that produce fleece pullovers and jackets, recent discoveries about microfibers in wastewater present a challenge to take a further innovative step to protect the environment.

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What we Know: impacting the present as well as future of many billions of people



Dead whale found with 115 plastic cups, 2 flip-flops in its stomach

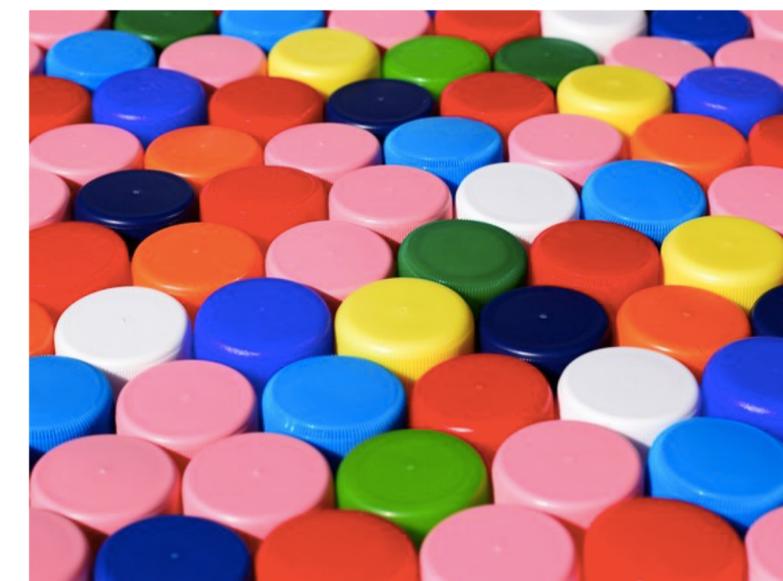


Detritus also included more than 1,000 other plastic pieces, including plastic bags, bottles

The Associated Press · Posted: Nov 20, 2018 9:03 AM ET | Last Updated: November 20



ROBBIE GONZALEZ SCIENCE 10.22.18 06:00 PM
YOUR POOP IS PROBABLY FULL OF PLASTIC





SEA TURTLES

Green Turtles Are Mistaking Plastic for the Sea Grass They Normally Eat

By  Jordan Davidson | Aug. 09, 2019 01:18PM EST

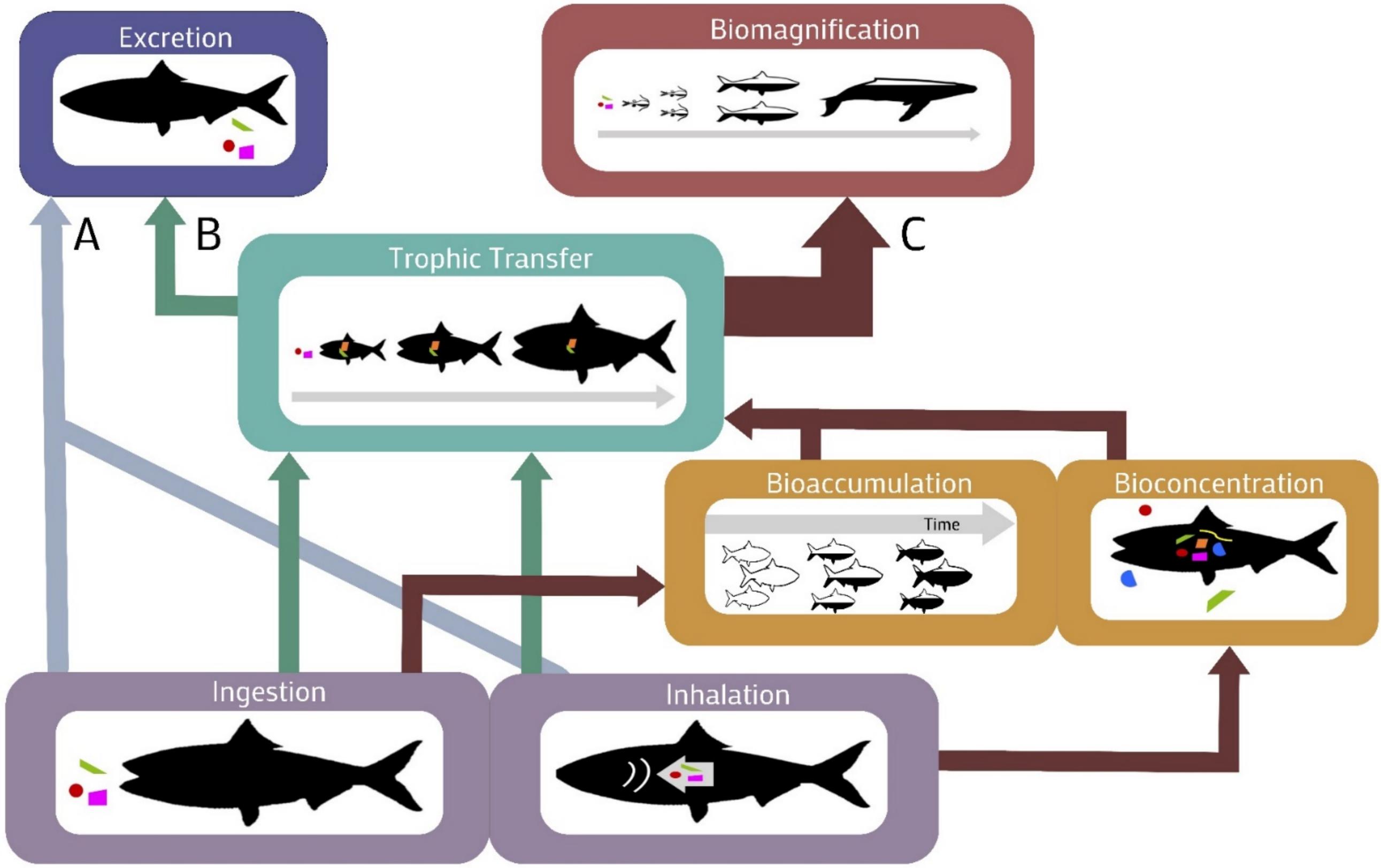
ANIMALS

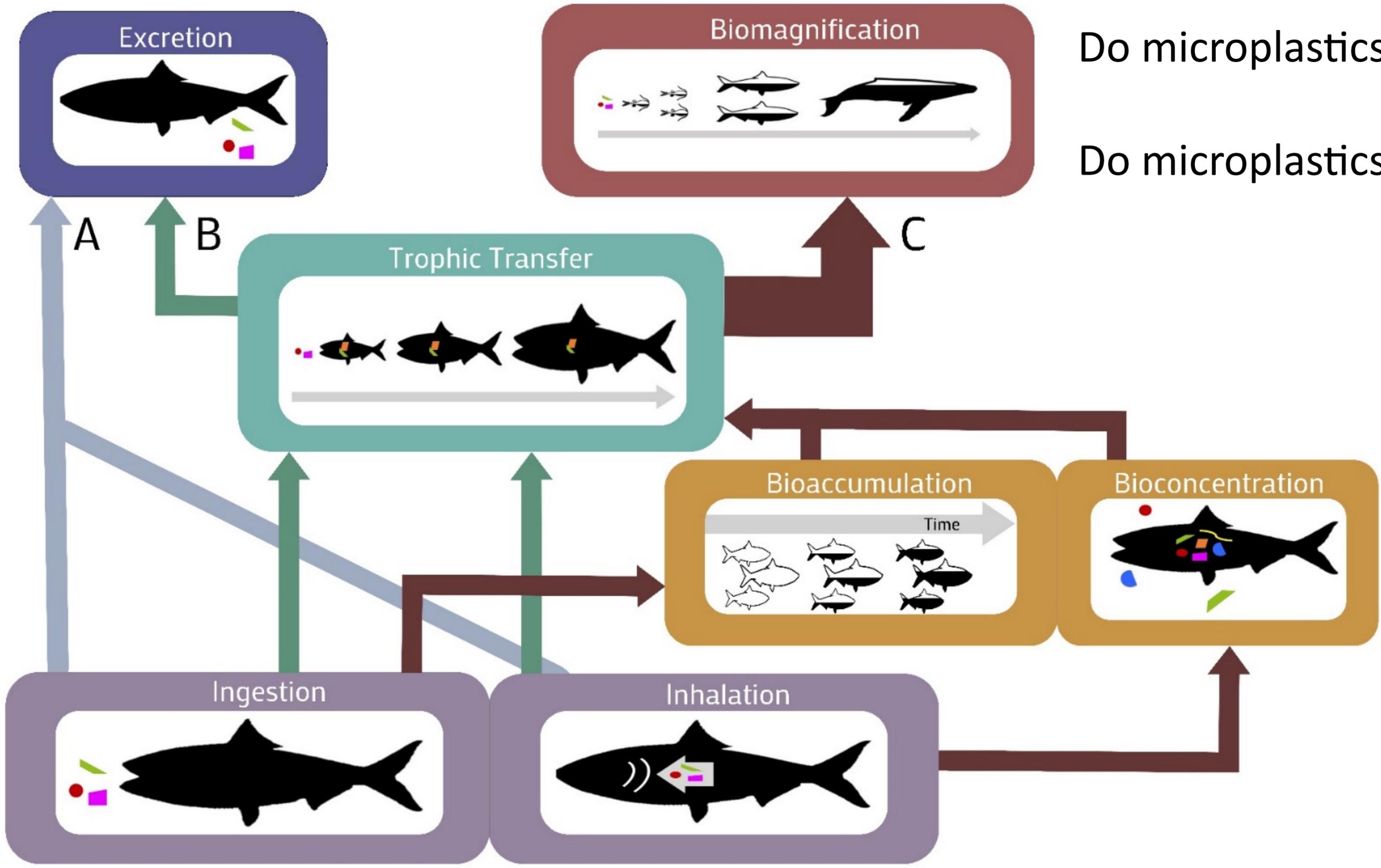


The green sea turtle (Chelonia mydas) on Hikkaduwa coral reef, Sri Lanka. danilovi / E+ / Getty Images

Endangered green turtles are having a problem. They're mistaking plastic pollution for the seaweed they survive on, according to [new research](#) from the University of Exeter in the UK and the Society for the Protection of Turtles in Cyprus, as [Newsweek](#) reported.

What we Know: impacting the present as well as future of many billions of people





Do microplastics bioaccumulate?

Do microplastics biomagnify?

Provenger (2018)

🕒 SEPTEMBER 25, 2017

Brain damage in fish affected by plastic nanoparticles

by Lund University



A school of sardines in Italy. Credit: Wikimedia / Alessandro Duci

Calculations have shown that 10 per cent of all plastic produced around the world ultimately ends up in the oceans. As a result, a large majority of global marine debris is in fact plastic waste. Human production of plastics is a well-known environmental concern, but few studies have studied the effects of tiny plastic particles, known as nanoplastic particles.

SCIENTIFIC REPORTS

Article | [Open Access](#) | Published: 13 September 2017

Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain

Karin Mattsson, Elyse V. Johnson, Anders Malmendal, Sara Linse, Lars-Anders Hansson & Tommy Cedervall

Scientific Reports **7**, Article number: 11452 (2017) | [Cite this article](#)

8360 Accesses | **58** Citations | **484** Altmetric | [Metrics](#)

Abstract

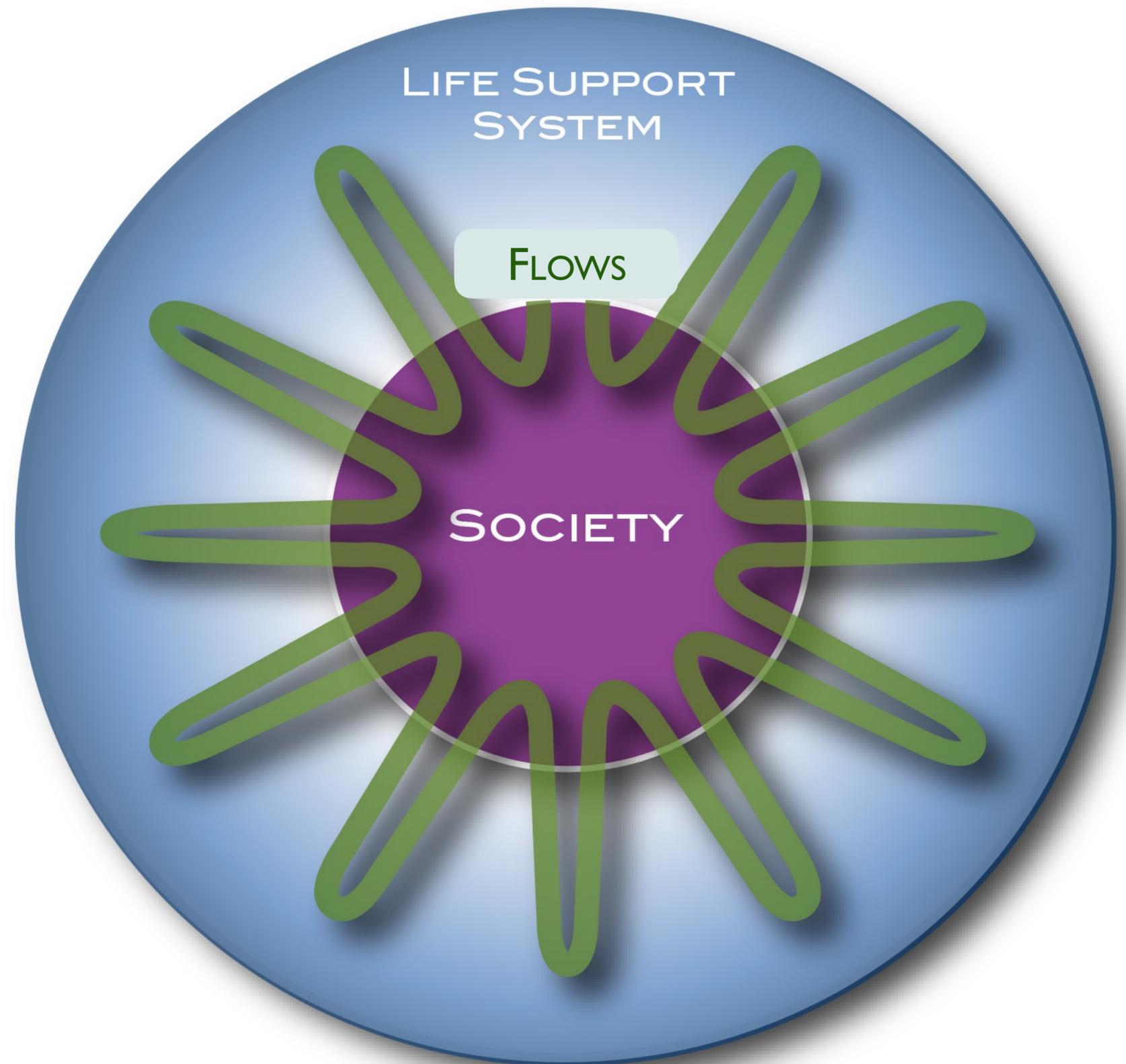
The tremendous increases in production of plastic materials has led to an accumulation of plastic pollution worldwide. Many studies have addressed the physical effects of large-sized plastics on organisms, whereas few have focused on plastic nanoparticles, despite their distinct chemical, physical and mechanical properties. Hence our

Planetary Physiology

Earth: Life-Support System for many species

Everything is about Flows

Flows have accelerated in the last 200 years; exploded in the last 70 years.



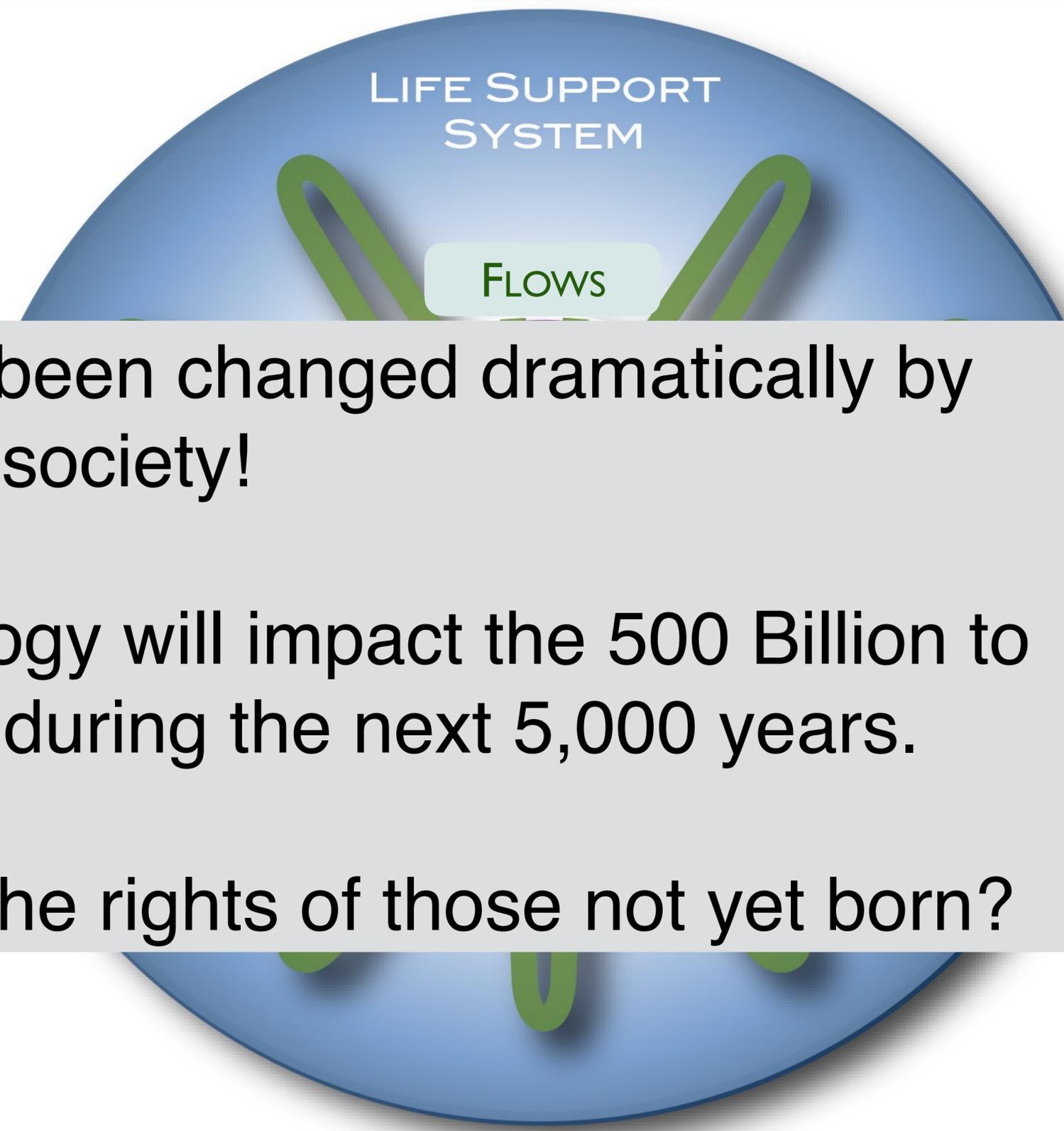
What we Know: impacting the present as well as future of many billions of people



Planetary Physiology

Earth: Life-Support System for many species

Everything is about Flows



The planetary physiology has been changed dramatically by modern society!

Plastics in the planetary physiology will impact the 500 Billion to 1 trillions of people to come during the next 5,000 years.

Does the plastics crisis violate the rights of those not yet born?

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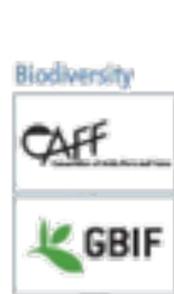
Where are the Data and Knowledge?

International Data Providers*

Environment



Biodiversity



Disasters



Energy



Food & Security



Satellites



Water



Regional and National Providers*

Chile



China



France



Germany



India



Italy



Japan



New Zealand



Norway



Russia



South Africa



United Kingdom



USA

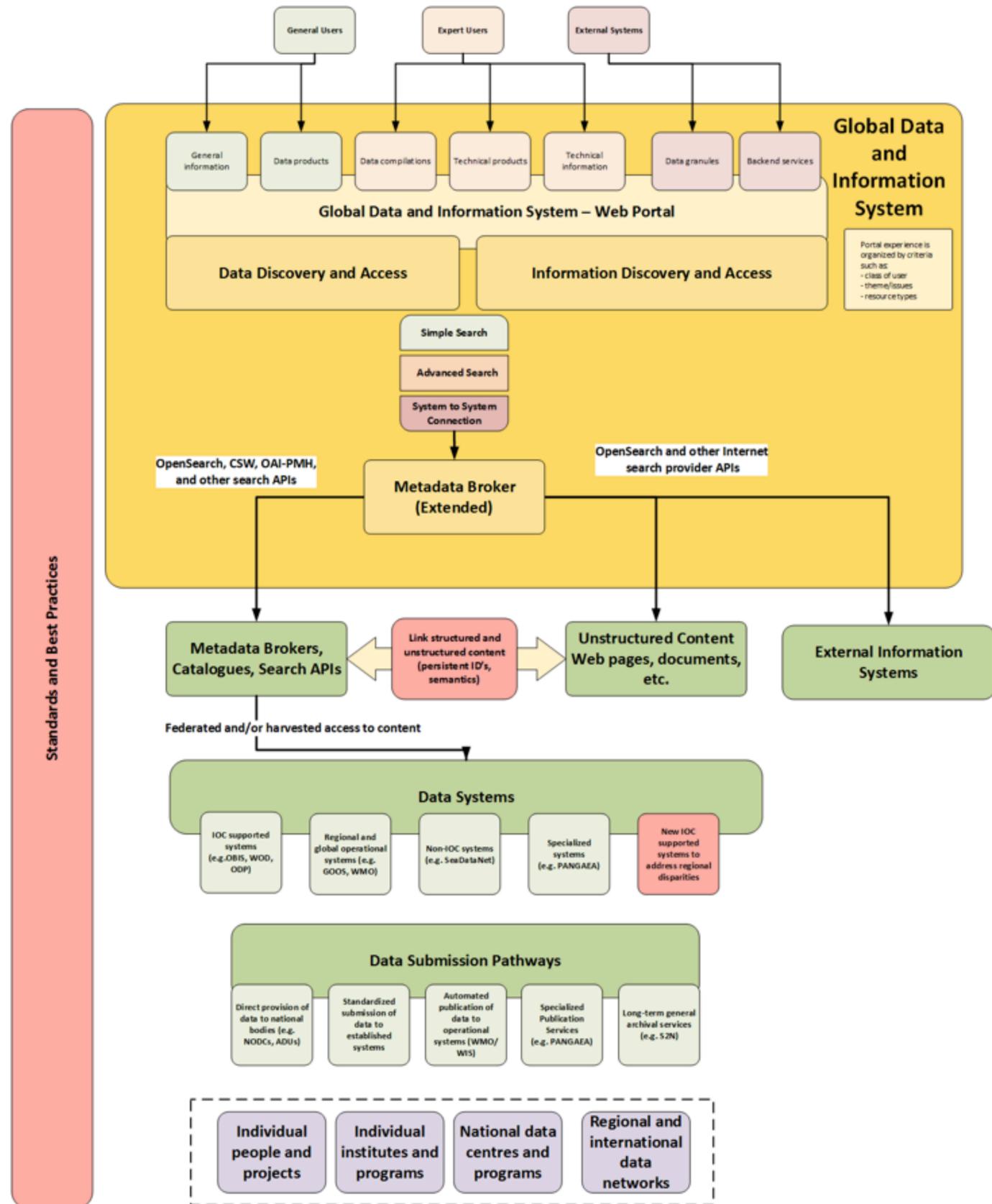


Private Sector Providers



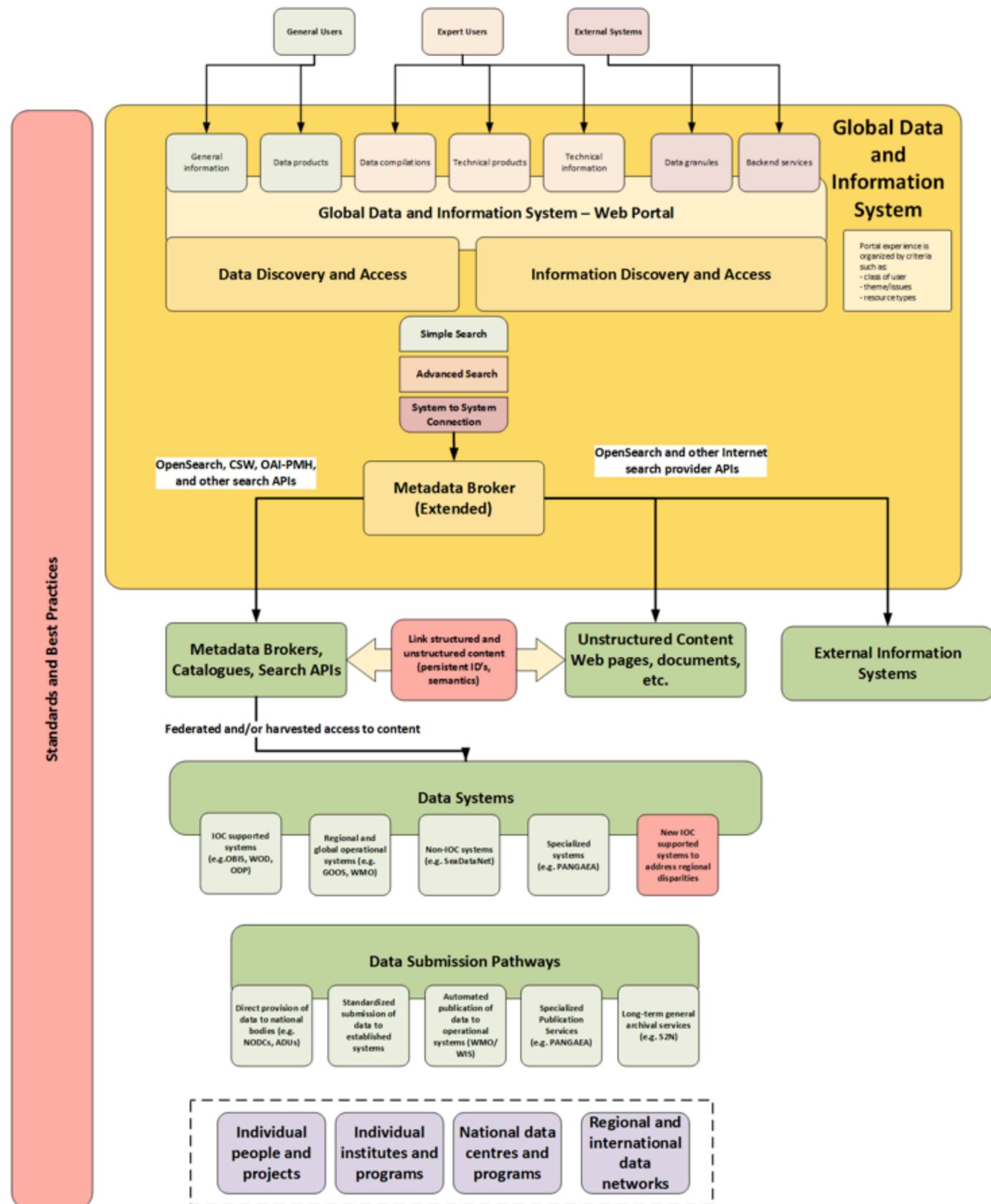
* a selection of more than 150 providers

Where are the Data and Knowledge?



The Conceptual Architecture of ODIS (Spears et al., 2017)

Where are the Data and Knowledge?



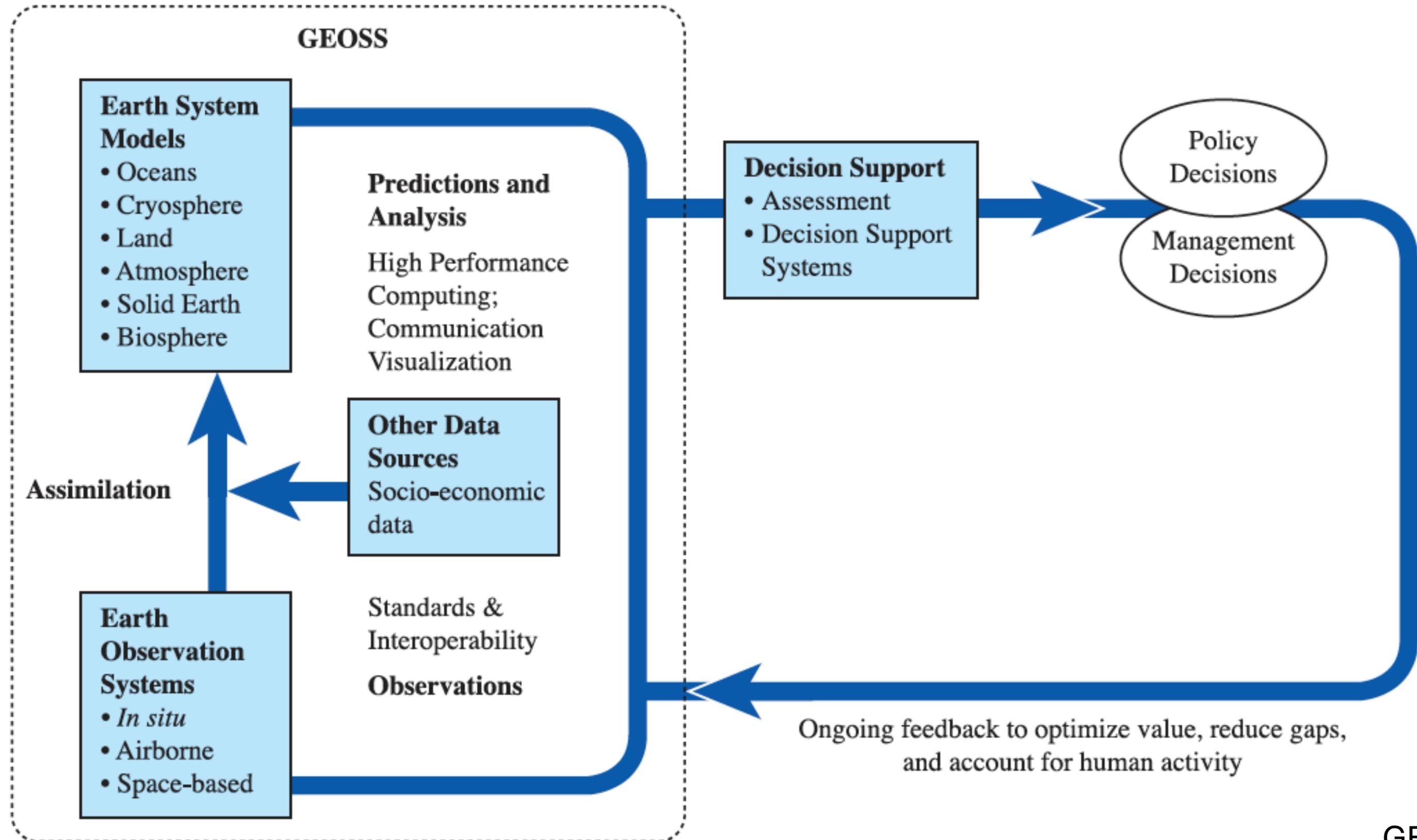
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... see Smail et al. (2019)

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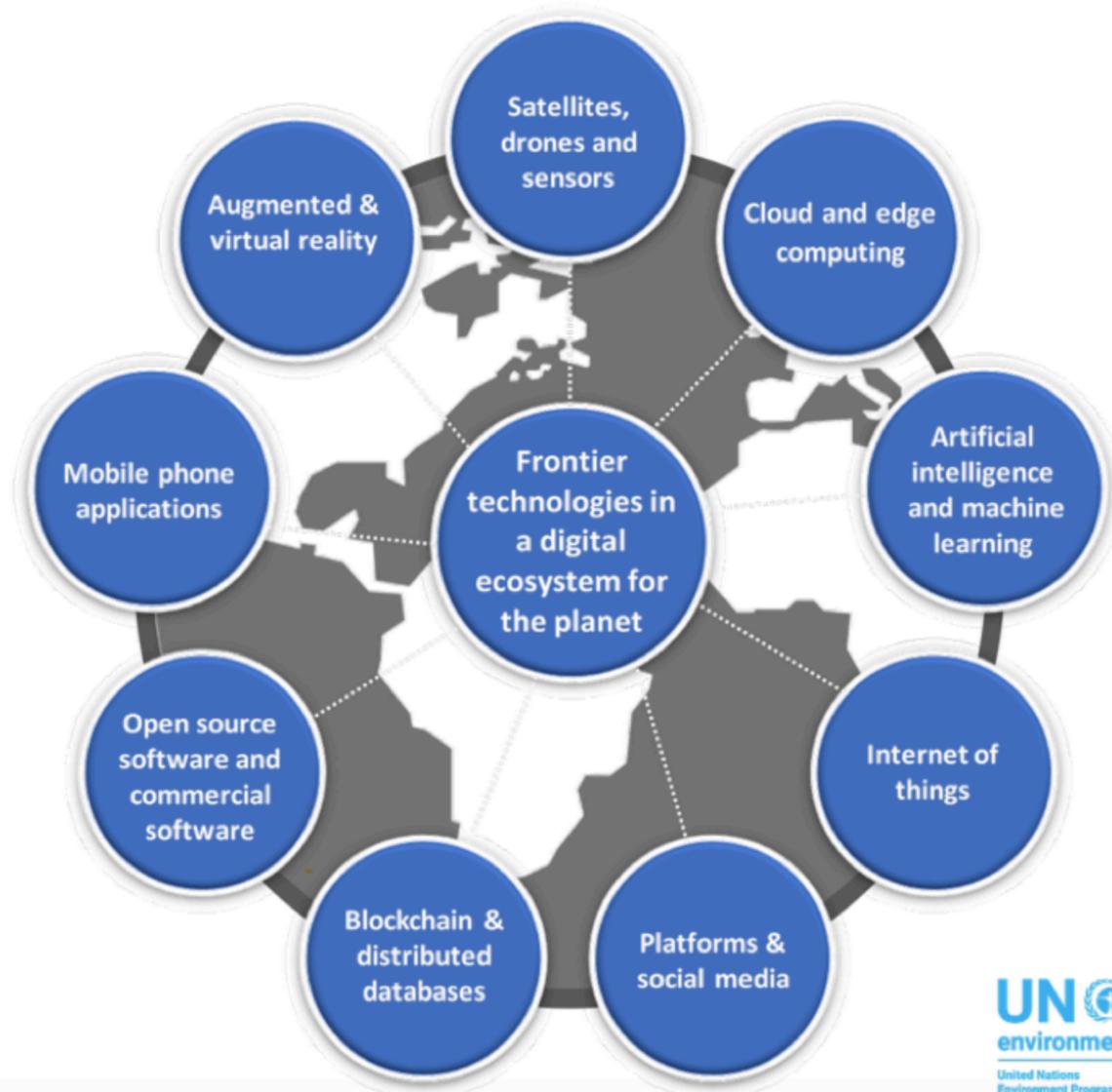


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Could a Digital Ecosystem for the Environment Have the Potential to Save the Planet?

Jillian Campbell, Ur
David Jensen, Unite

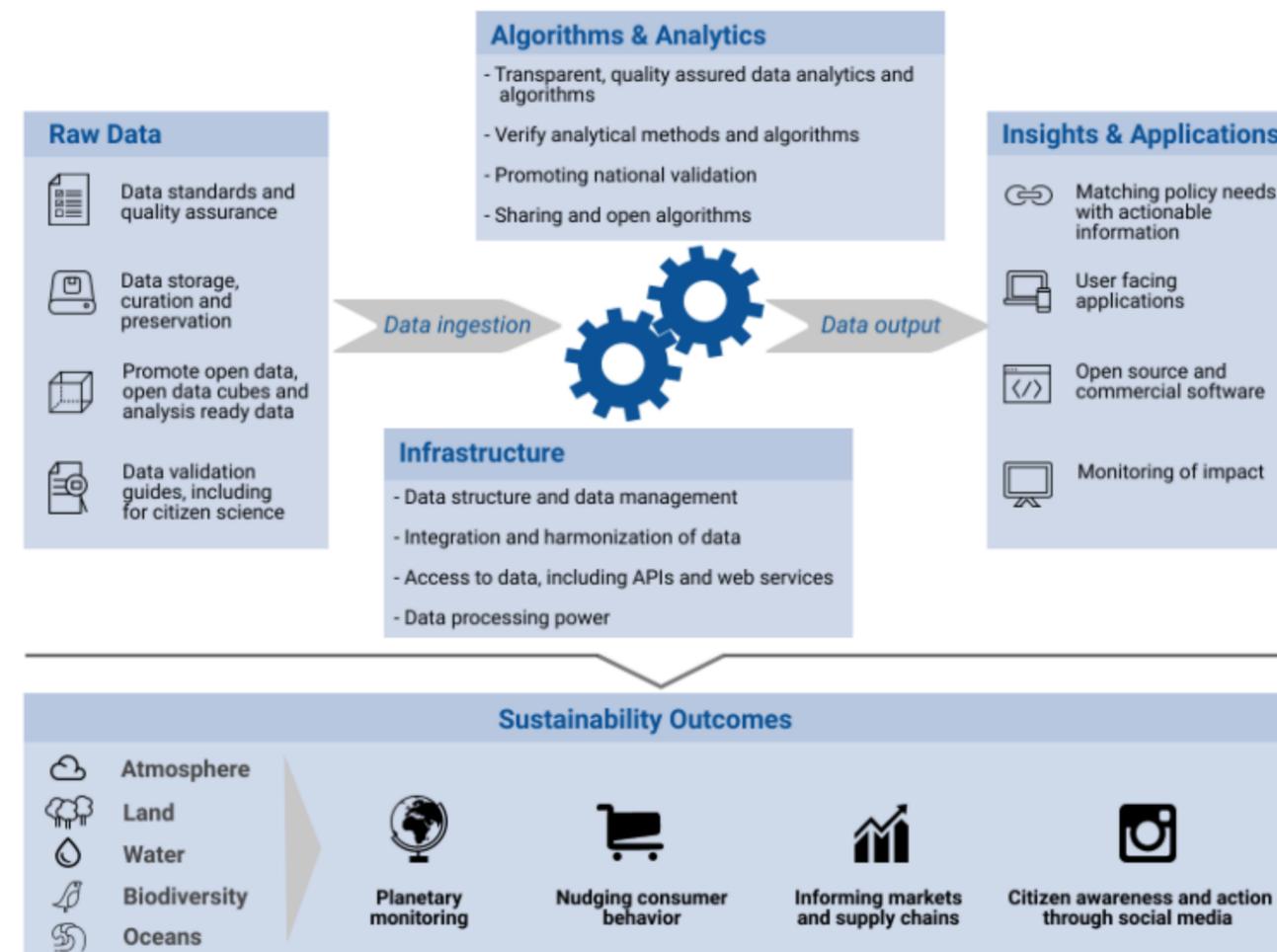


The promise ecosystem for

Key decisions are neede
robust architecture and

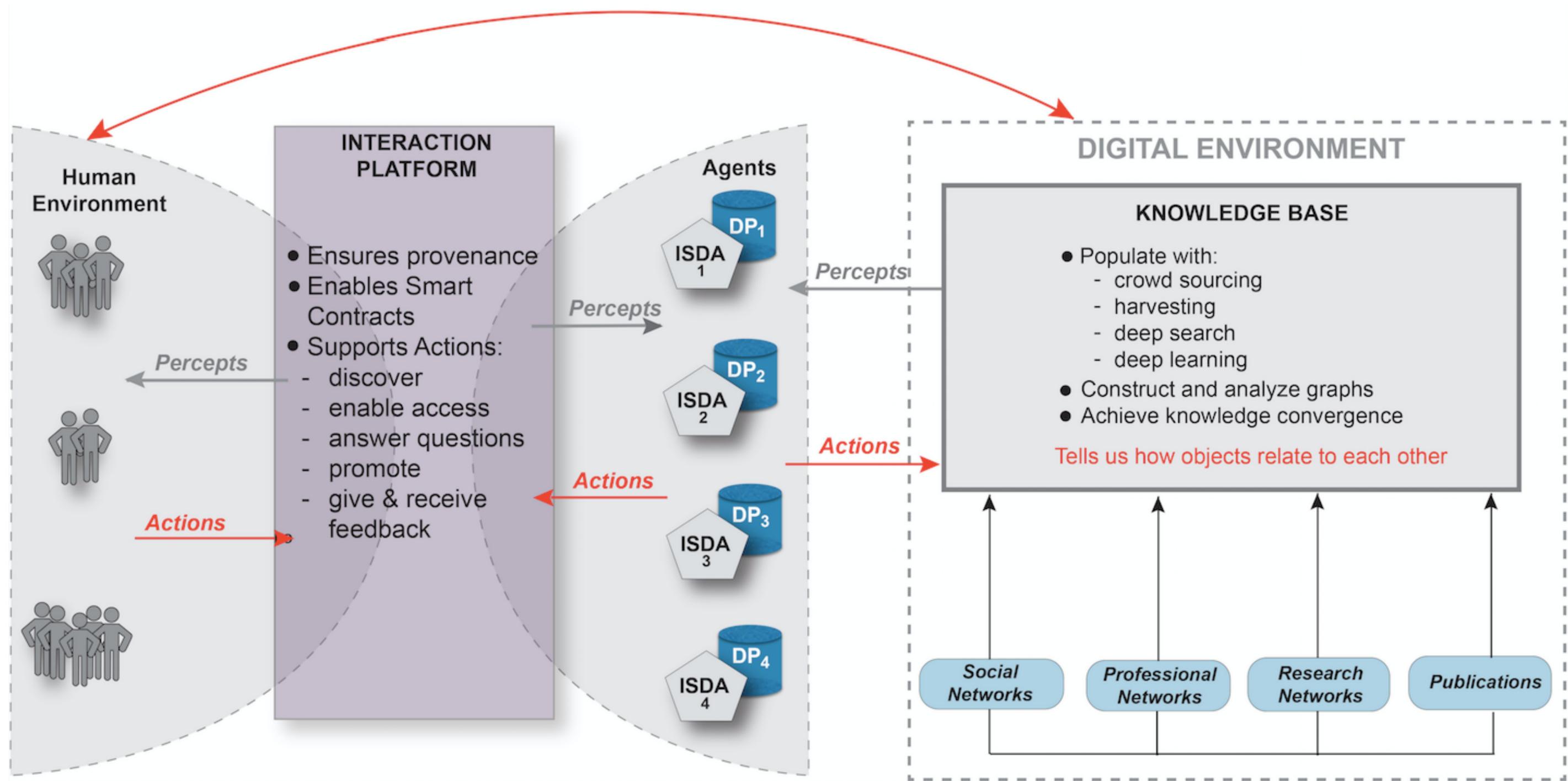


A Digital Ecosystem for the Planet



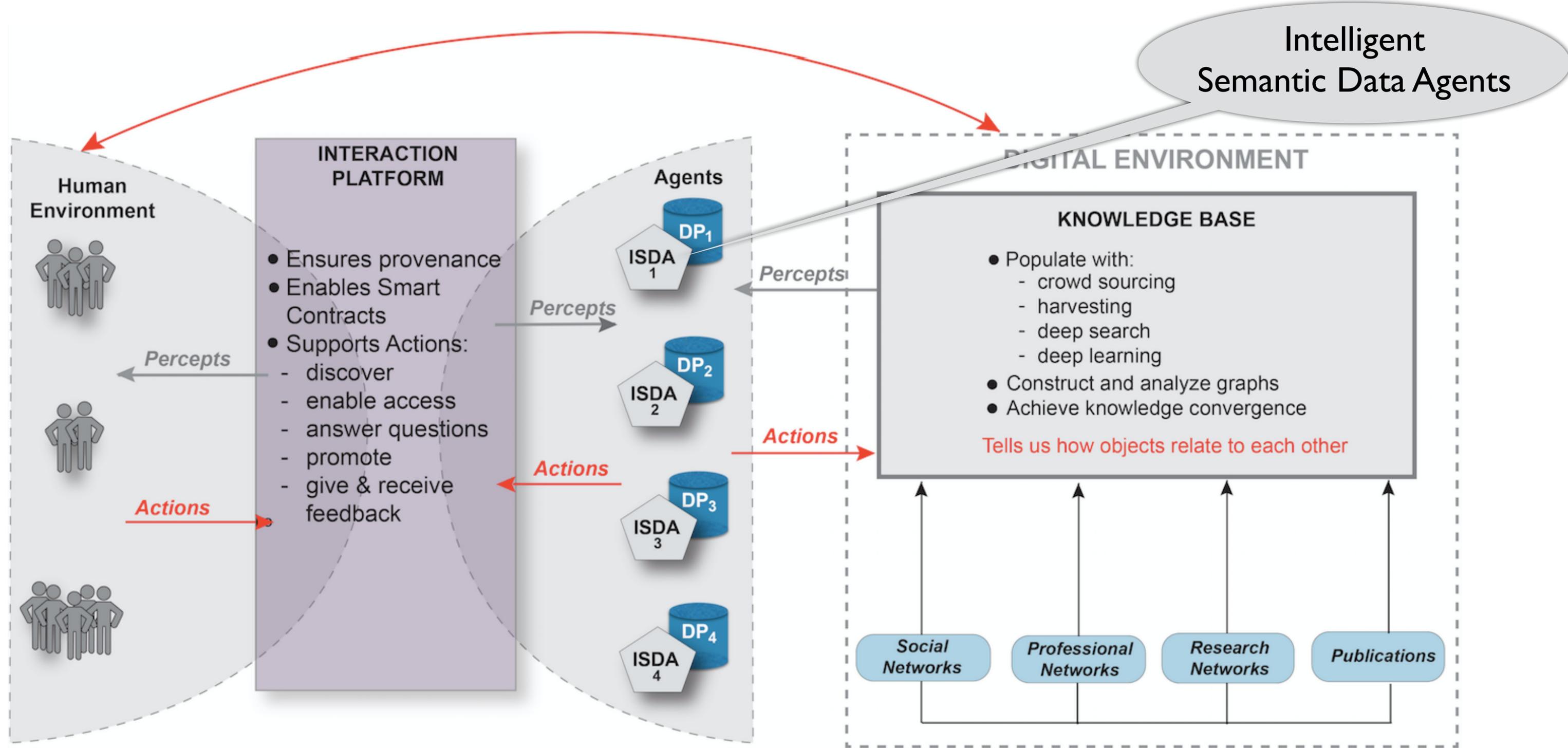
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A Transformative Concept: From Data Being Passive Objects, to Data Being Active Subjects



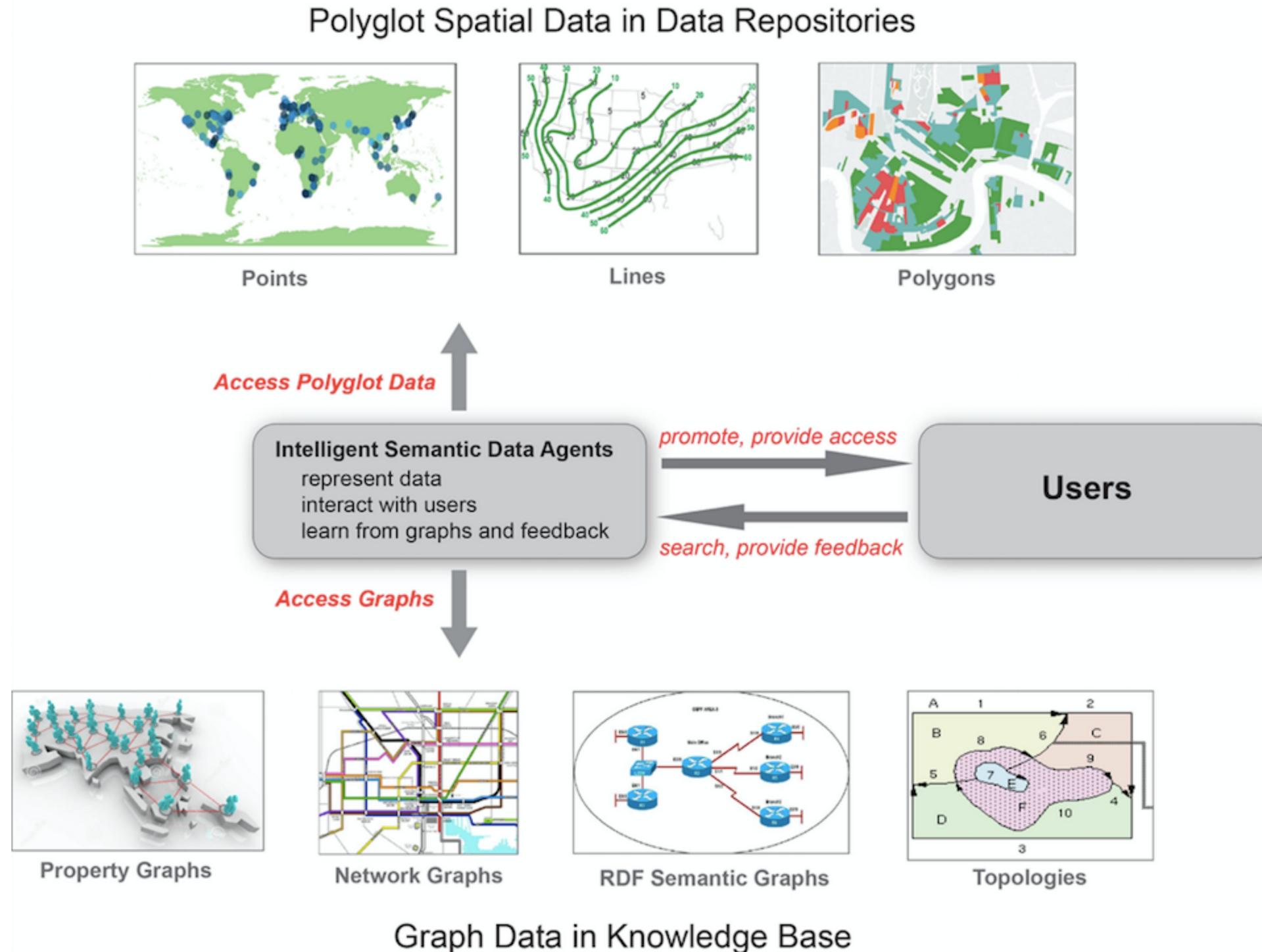
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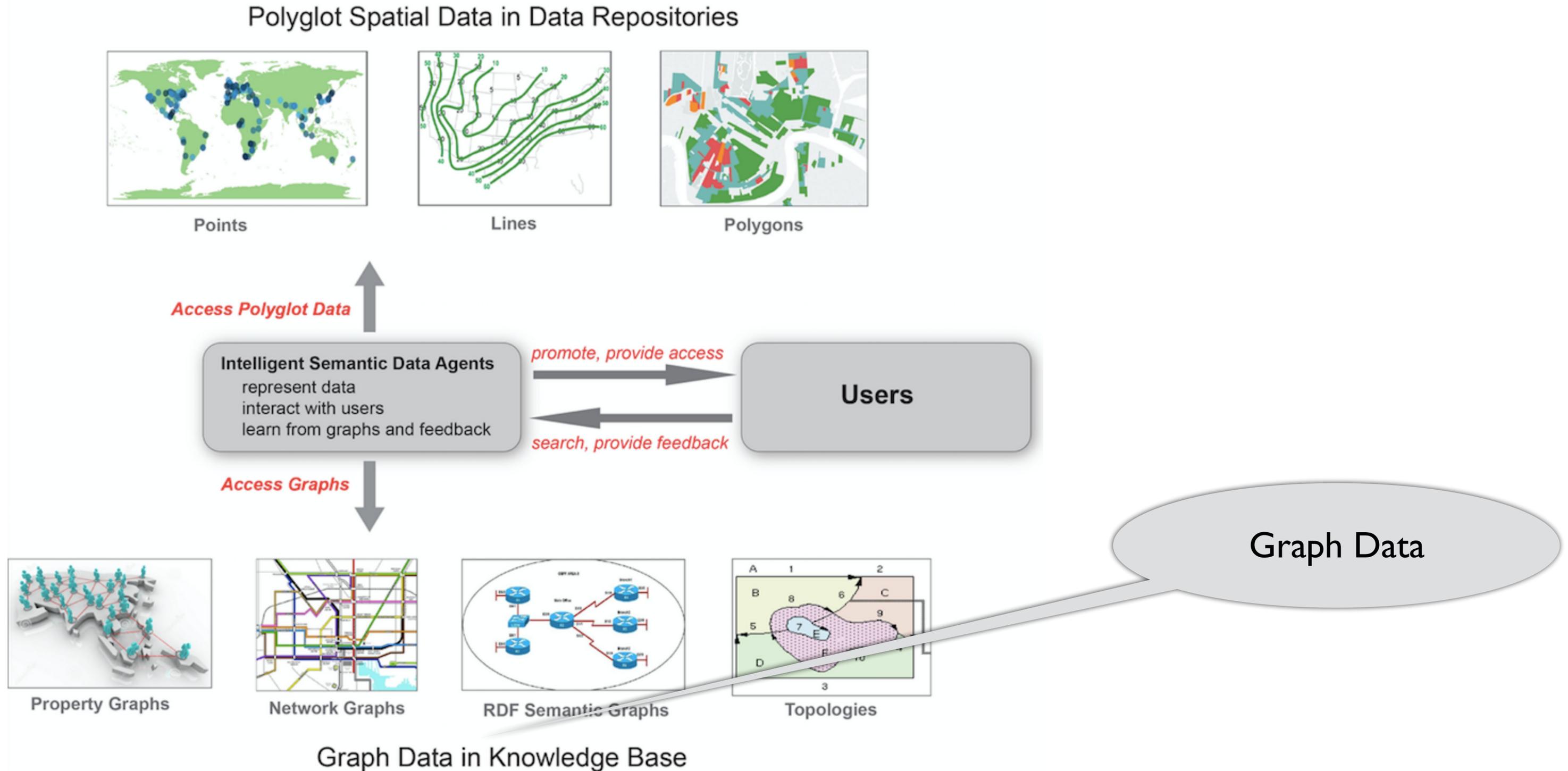
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From Data being passive objects, to data being active subjects



Linking Data and Knowledge to Society

From Data being passive objects, to data being active subjects



Bringing the Knowledge of Plastic Debris in the Oceans to Society

- Plastics have many many advantages - can replace many other materials
- Current mainstream economic model allows for production-costs only, without considering impact-costs
- Production is rapidly increasing
- Single/one-time use is a major fraction
- There is no recycling, only down-cycling
- Plastics are everywhere
- Plastics are in everything
- Plastics impact ecosystems and accelerate extinction
- Microplastics are in all food chains
- There are many time-lagged impacts: land fills, built environment, coastal infrastructure
- Sea-level rise, climate change impacts (including storms, wildfires) can disperse plastics
-
- The threat is increasingly better understood ...

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