

SUSTAINABLE MATERIALS

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FAB ACADEMY, RECITATION, MARCH 11, 2024

1. Why Care?

2. Commercially Available Options

3D printing

Molding & Casting

CNC Machining

3. DIY Ideas

4. The Materiom platform for regenerative materials

WHY WE CARE ABOUT SUSTAINABLE MATERIALS?



Humanity & Materials: An Inseparable Relationship



Adapted from "Materials That Changed History", Robert Friedel, 2010

21st Century: The Plastic Age

Revolutionary & fundamental material: **Versatile, durable & cheap**

Plastic production

- 1950s: 500,000 tons/yr.
- 2020: 500 million tons/yr.
- 2050: 1 billion tons/yr.



Sources:

- www.plasticseurope.org
- Fernandez & Dritsas, Matter, 2020

Plastic: A Blessing

Used in almost every sector

- Packaging
- Building & Construction
- Textiles
- Electronics
- Transportation
-





Apollo's heat shield made of epoxy phenolic novolac resin in a fiberglass honeycomb

... & A Curse



... & A Curse

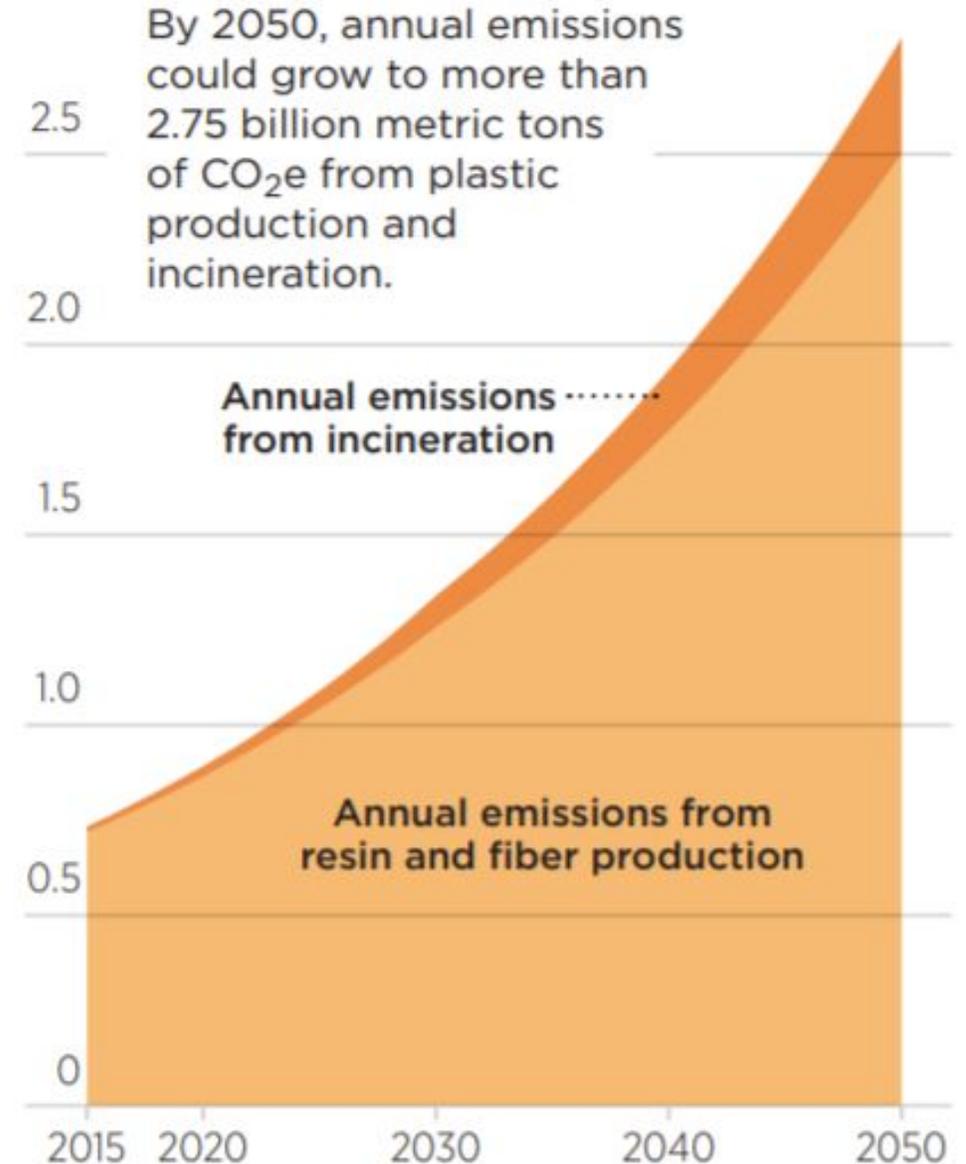


Environmental Impacts of **Plastic Production**

- GHG emissions from extraction, transportation & manufacturing
 - **~1 billion tons of CO₂-eq annually**

Annual Plastic Emissions to 2050

3.0 billion metric tons



Source: CIEL, 2019

Environmental Impacts of Plastic Waste

- ~1 million tons/day
- **COVID-19: 1.6 million tons/day**
- **80% in landfills, dumps & natural environment**
 - Too long to biodegrade ~450 yrs
- **150 million tons polluting oceans**

“Plastics will outweigh fish by 2050”

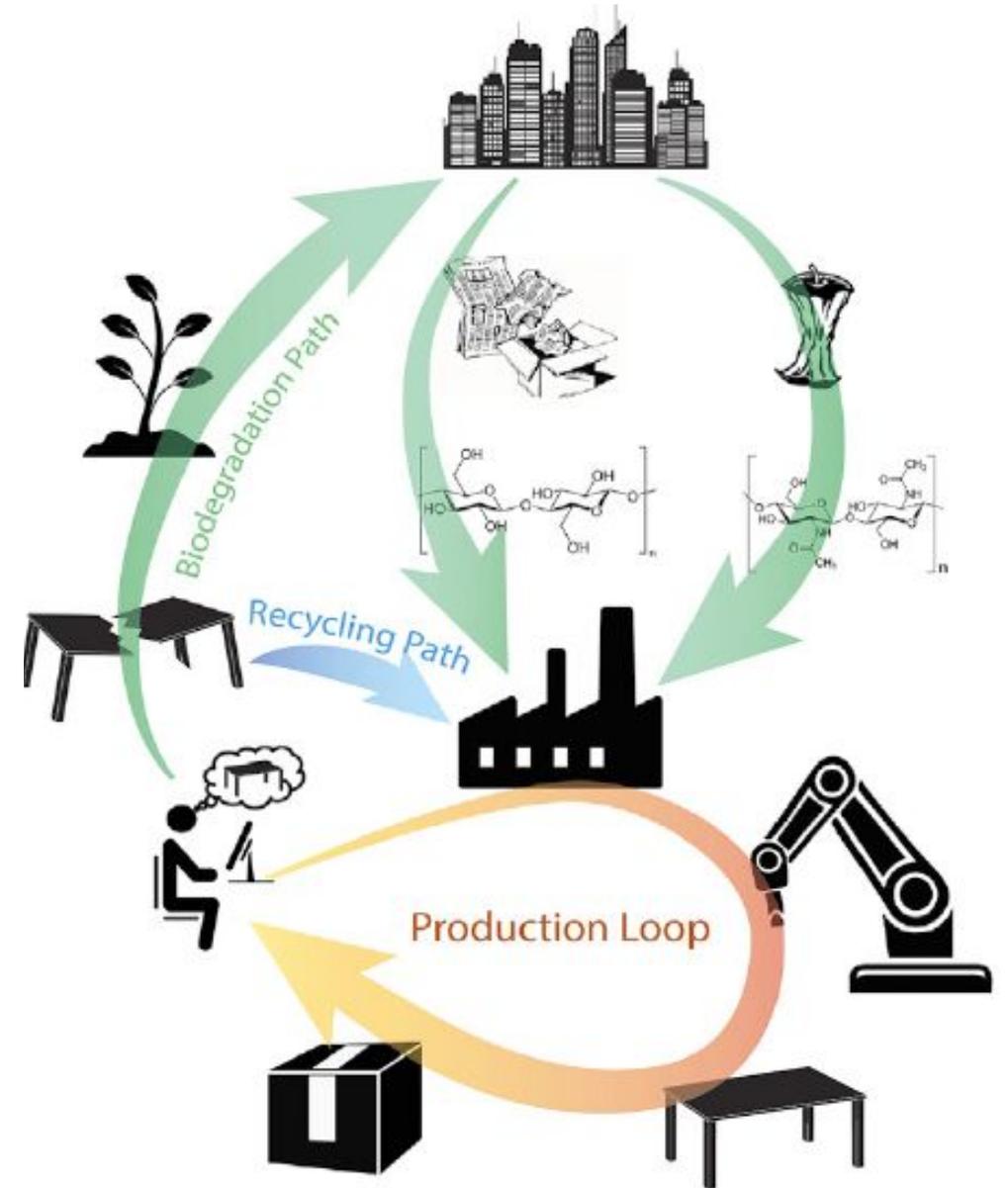
Jim Leape

Stanford Center for Ocean Solutions

Looking Beyond the Plastic Horizon

Renewable biomass sources

- Locally-sourced
- Abundant
 - Chitosan, starch, gelatin, agar
 - Lignocellulosic biomass



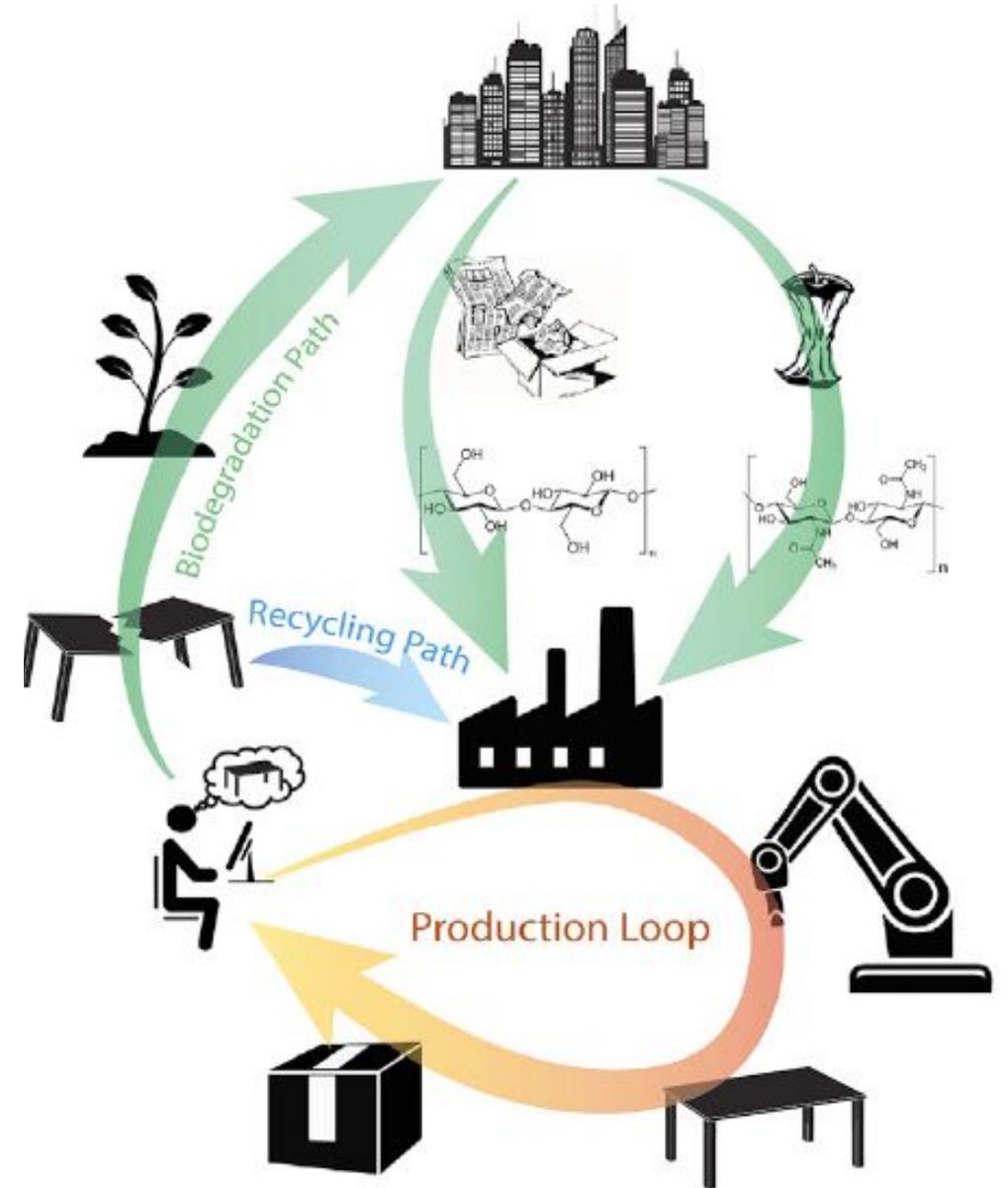
Looking Beyond the Plastic Horizon

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Circular systems

- Inspired by nature
- Recycling
- Biodegradability



Looking Beyond the Plastic Horizon

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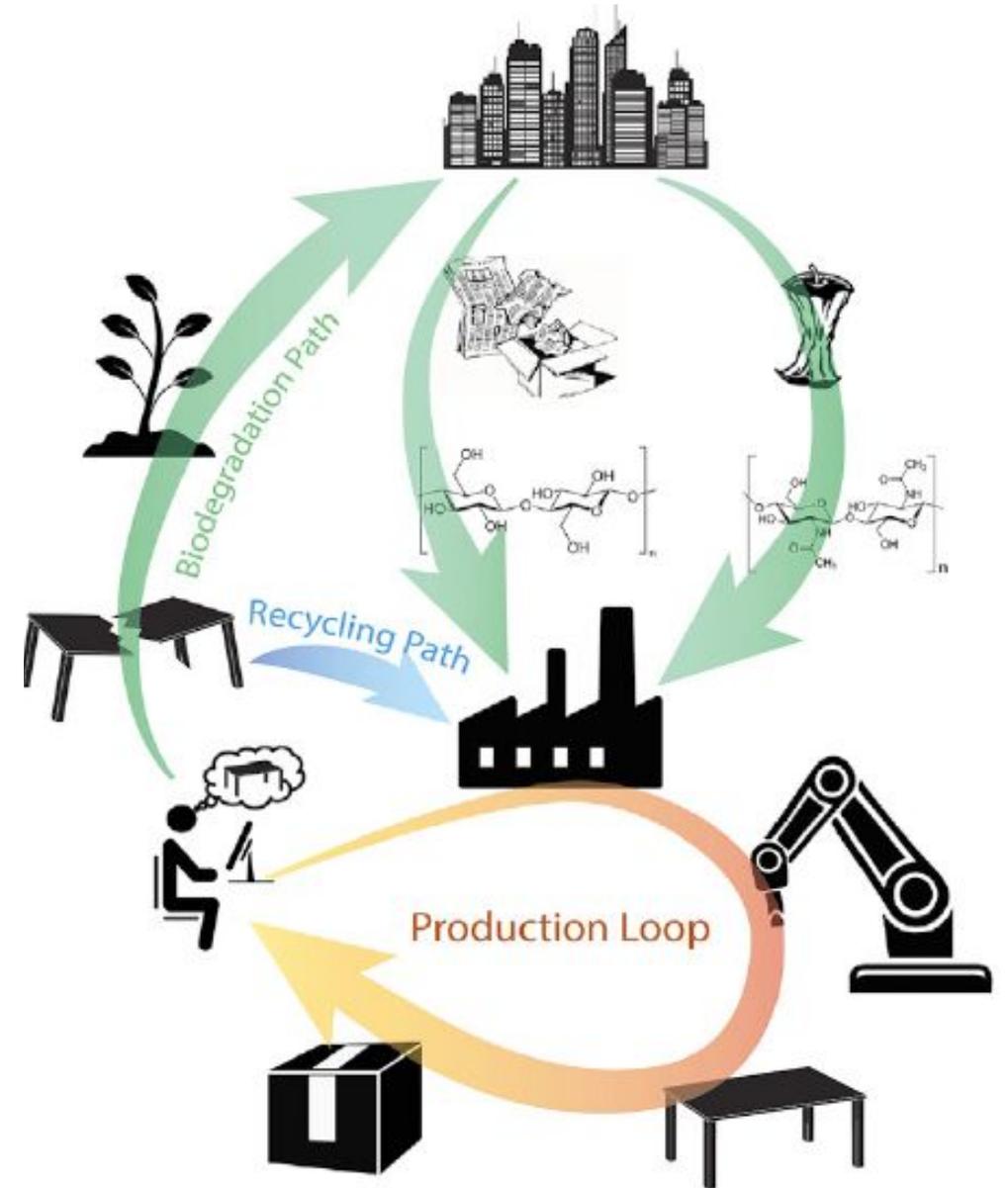
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Digital fabrication

- On-demand production
- Reduced waste & emissions



COMMERCIALLY AVAILABLE OPTIONS



3D PRINTING



Polylactic acid - PLA

TODAY



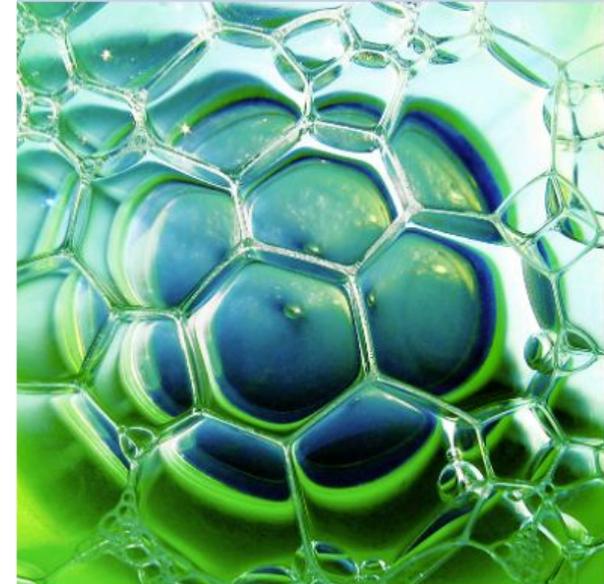
Dextrose and sucrose from cassava, corn starch, sugar cane, or beets.

INDUSTRY DEVELOPING



Lignocellulosics: Sugars from bagasse, wood chips, switch grass or straw.

NOW ASSESSING



CO₂ to lactic acid technology
CH₄ to lactic acid technology

PLA Filaments

- Biobased
- Industrially compostable
 - Few months
 - In nature needs 80+ yr. to biodegrade
- Recyclable



- Virgin
 - [NatureWorks - Ingeo PLA](#)
 - [PolyTerra PLA](#)
 - Plants a tree for every spool near the region of purchase
- Recycled
 - [Prusament PLA Recycled](#)
 - [3D Jake](#)
 - [Reflow](#)

Polyhydroxyalkanoates - PHAs

- Biobased
 - Fermentation of glucose, sugar or lipids by bacteria
- Microbial polymerization - Biodegradable
 - 1 yr. in nature
 - < 10 yr. in seawater
- 100% PHA filaments
 - [colorFabb](#)
- PLA/PHA blends
 - [colorFabb](#)



Recycled Filaments

- Re-PETG - chemical resistance, durability
 - [Prusament](#)
 - [Reflow](#)
 - [GreenGate 3D](#)
 - Made in the US

- Re-TPU
 - [Kimya](#)



Sustainable Composite Filaments

- [Filamentive – Wood PLA](#)
 - 40% re wood fibers
 - 60% re PLA
- [Filamentive – Carbon Fiber PETg](#)
 - 15% re carbon fibers
 - 85% re PLA
- [3D Jake options](#)
- [Filament2print options](#)



MOLDING & CASTING



Sustainable Mold Making

- [Glycerol / Gelatin Mold](#)



- [Natural Latex Mold](#)



- [Alginate Mold](#)



Sustainable Epoxy Options

- 20-50% biobased content
 - vegetable oils, lignin from wood products, tannins
- [Entropy resins](#)
- [GreenPoxy](#)
- [Ecopoxy](#)

COMPUTER-CONTROLLED MACHINING



- Sustainable Plywood



- Recycled Acrylic Sheets

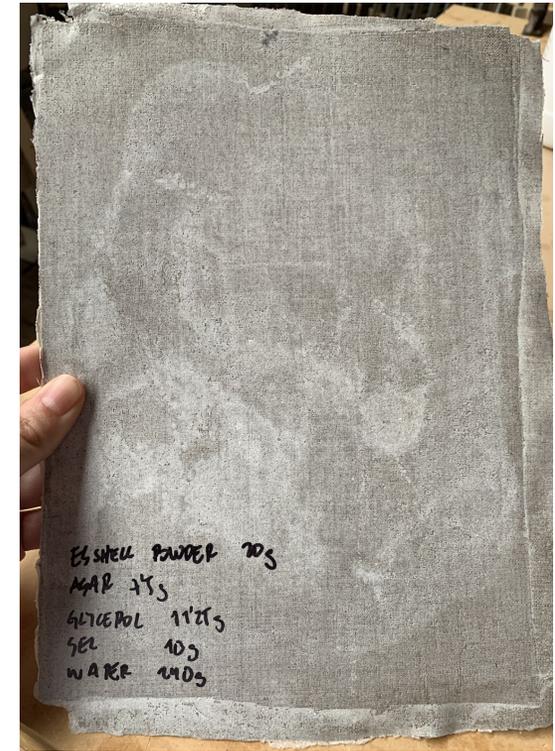


DIY IDEAS



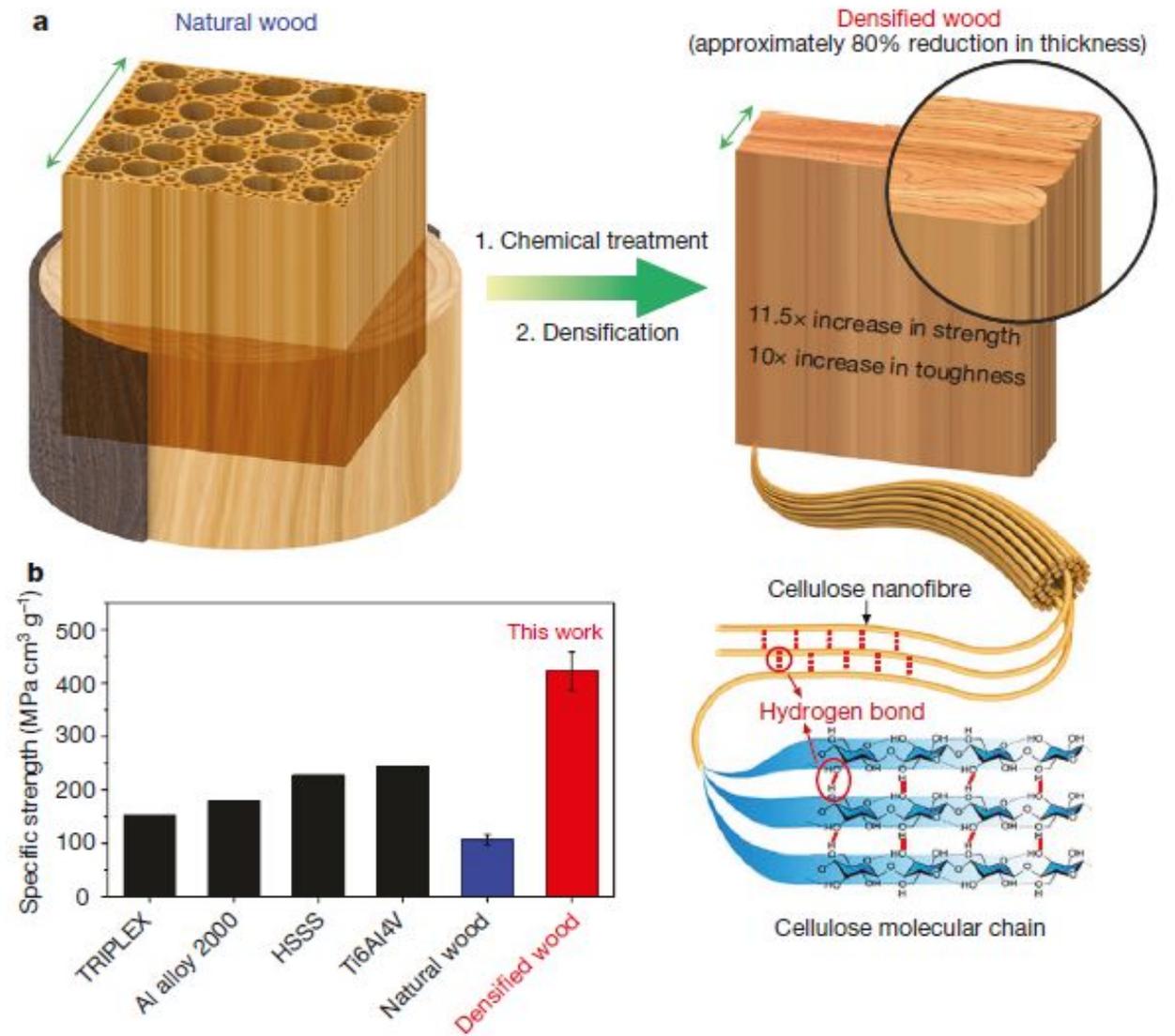
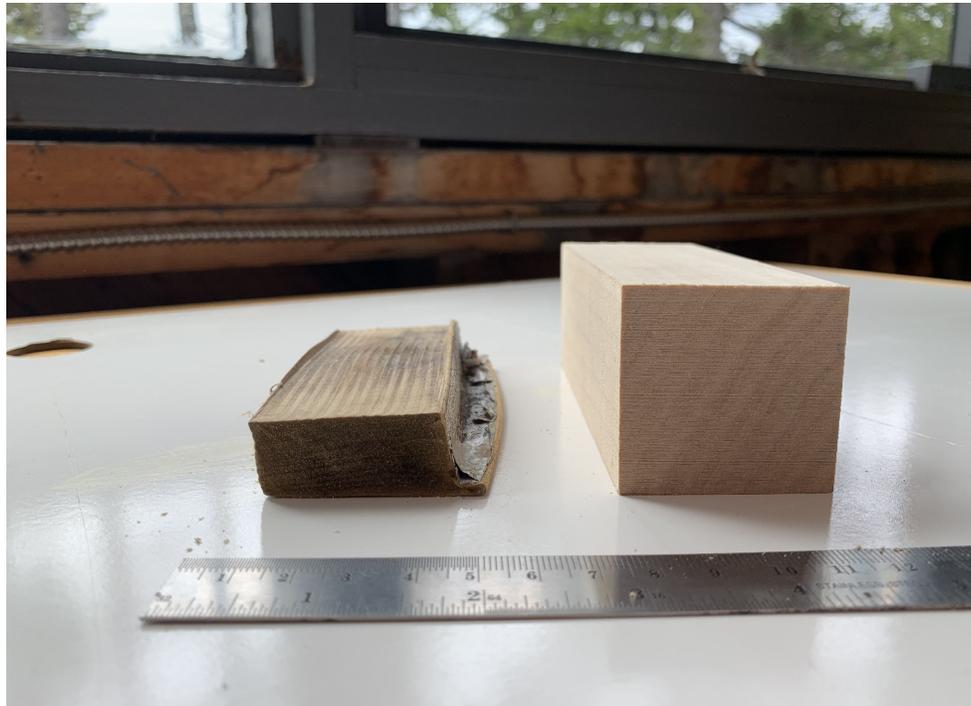
Wet lay-up biocomposites

- Organic fabrics + Biopolymers



SuperWood

- [Song et al., 2018](#)
- [SuperWood making](#)



Lignocellulosic bioplastic

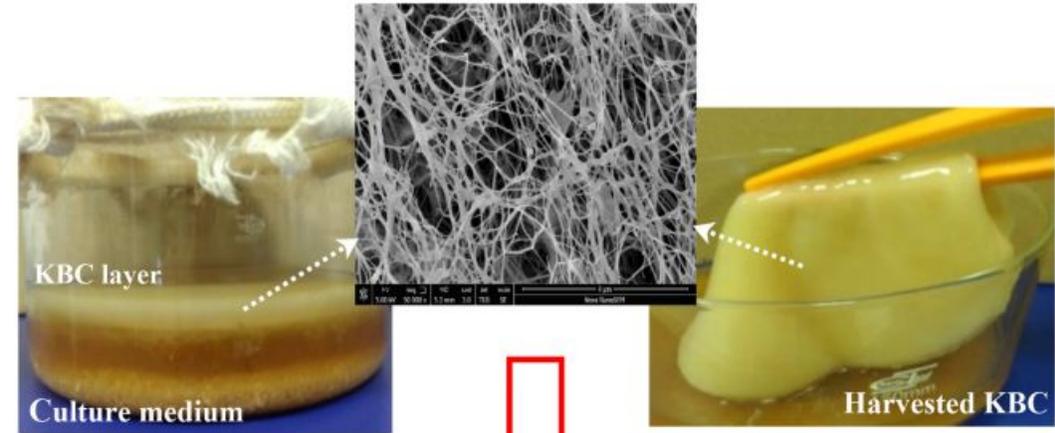
- [Xia et al., 2021](#)



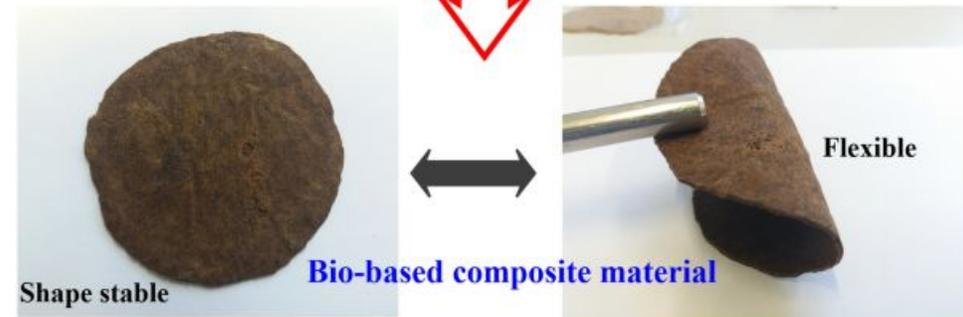
Bacterial Cellulose Fibers

- [Kombucha Scoby Recipes](#)

	1 Litre	2 Litres	3 Litres	4 Litres
Boiled Water	250ml	500ml	750ml	1 litre
De-chlorinated water	750ml	1.5 litre	2.25 litre	3 litre
Sugar	50 - 100g	100 - 200g	200 - 300g	300 - 400g
Tea (either teabags or teaspoons of loose tea. All black, or a mixture with green, white or other)	1	2	3	4
Scoby	1 small	1 medium	1 large	1 large
Starter Liquid	100ml	200ml	300ml	400ml



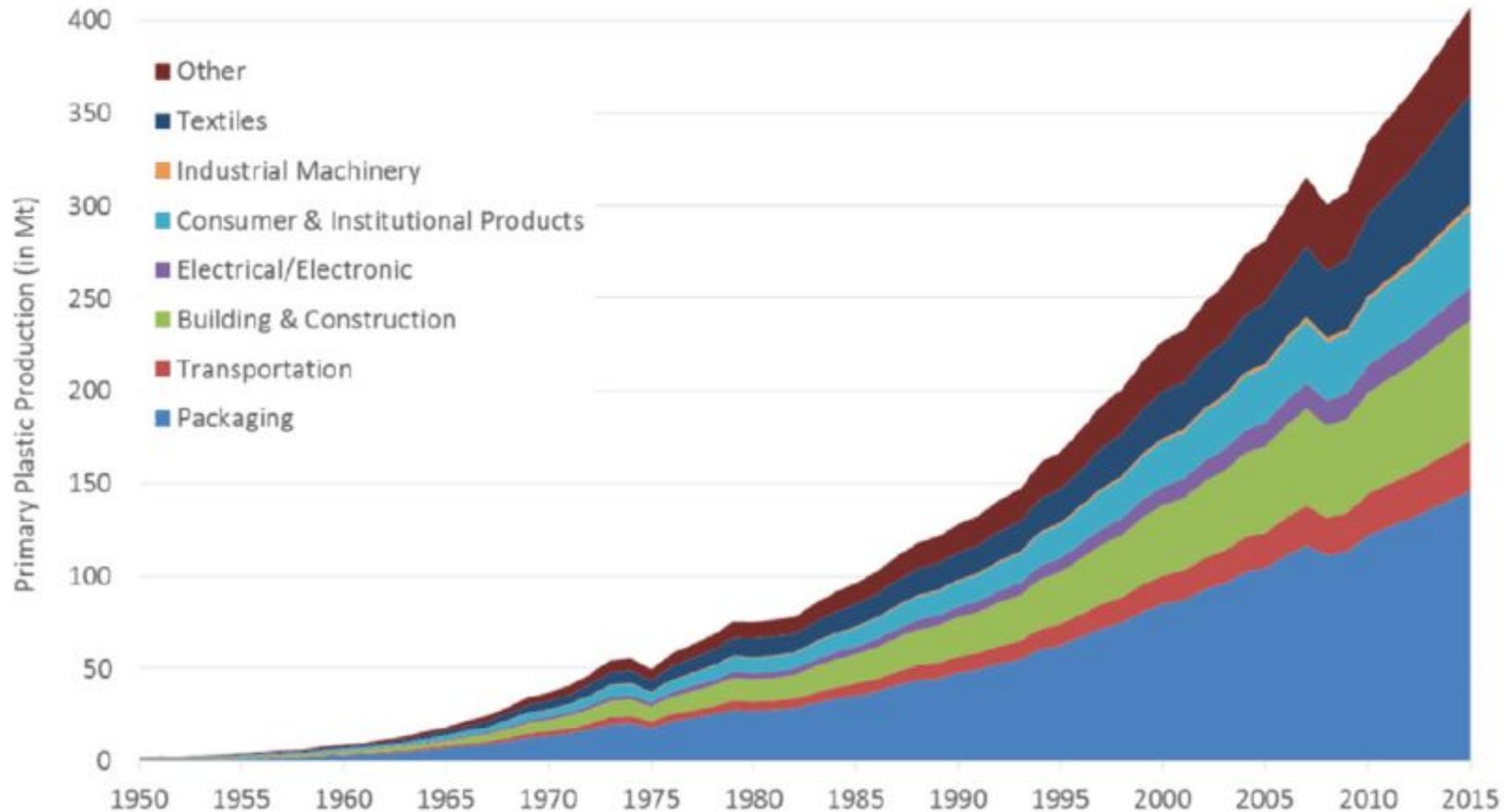
Biosynthesis to application



Backup Slides

Global primary plastics production according to industrial use sector from 1950 to 2015 (million metric tons)

Source: US Department of Agriculture, <https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx>



Materiom recipes

- [Eggshell biocomposite](#)
- [Oyster Alginate Composite](#)

