Insights into
Future of Textile Materials

Photo:Eeva Suorlahti

14.9.2023

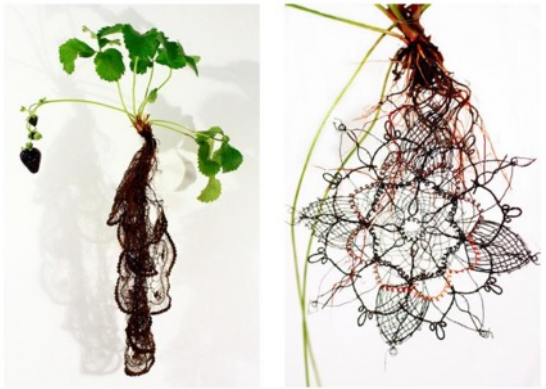
Pirjo Kääriäinen
Professor of Design and Materialities
School of Arts, Design and Architecture
Aalto University
pirjo.kaariainen@aalto.fi

Aalto University

Speculative design or material innovations?

Biocouture jackets made of cellulose material

Suzanne Lee
https://www.ted.com/speakers/suzanne_lee



Biolace by Carole Collet

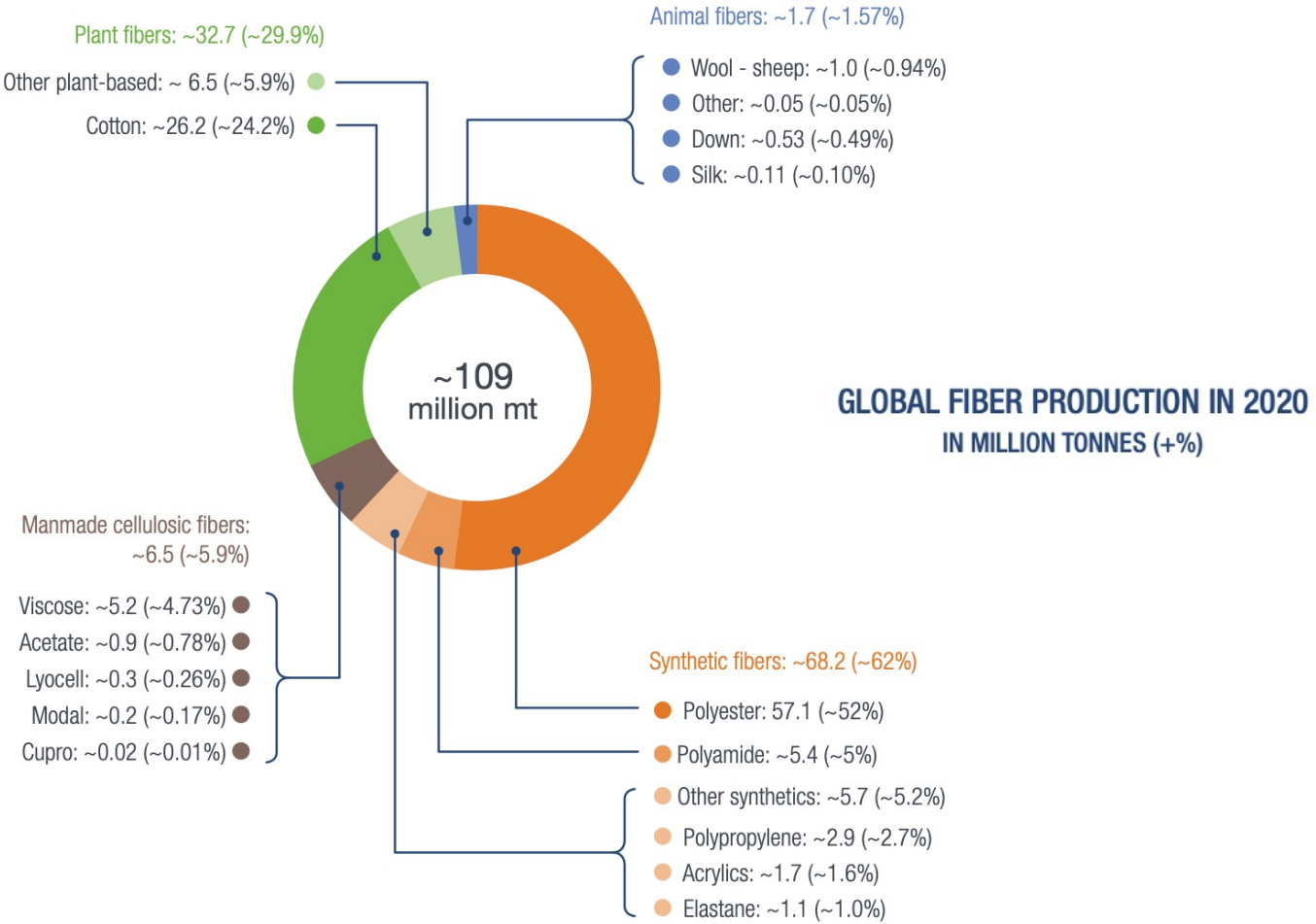
State of the Art

- Materials
- Production technologies
- Long value chains
- Collaboration

Photo: Eeva Suorlahti

Aalto University

Materials



https://textileexchange.org/wp-content/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

Three main production technologies

1) Weaving

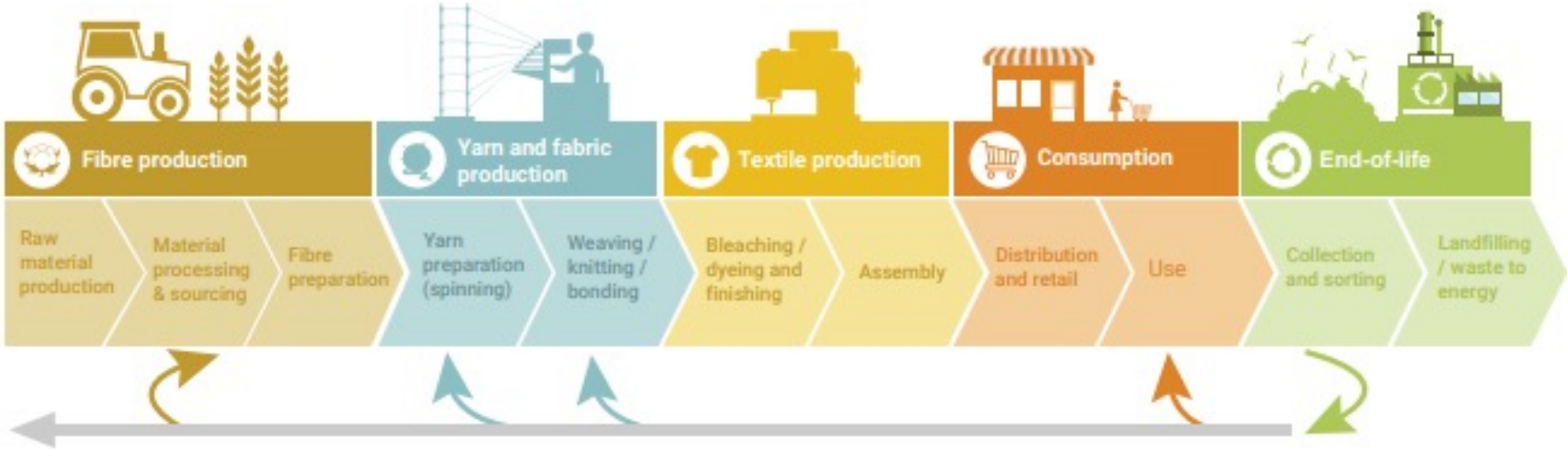
2) Knitting

3) Non-wovens and felting

(also others)

Aalto University

Long value chains



https://unemg.org/wp-content/uploads/2021/09/Panelist-Presentation_UNEP.pdf

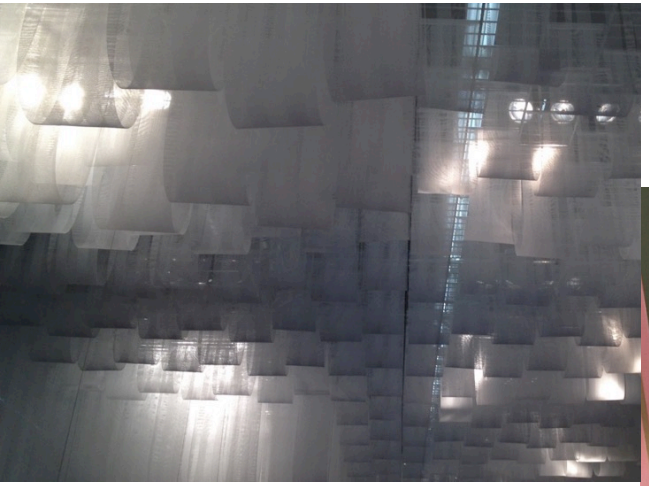
Textiles categorized by the use

1) Fashion and clothing

2) Interior textiles for home and public spaces

3) Technical textiles, e.g materials for construction, hygiene products, medical purposes, safety gear…

Ioncell by Anna Semi & Sofia Ilmonen 2019
Photo: Juho Huttunen



Aalto University

Forms of textile design decisions present in product design process

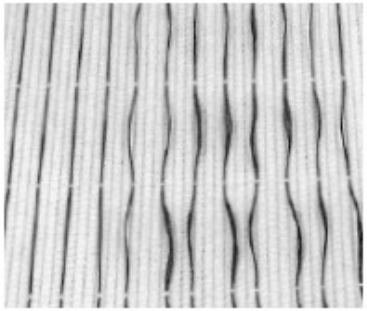
material
PRODUCTION

material
CONSTRUCTION

material
ALTERATION

material
SELECTION

material
SPECIFICATION



- Elastic
- Foldable
- Sustainable

Material scientists
Textile engineers
Textile designers

Textile designers
Textile engineers

Textile designers
Textile engineers

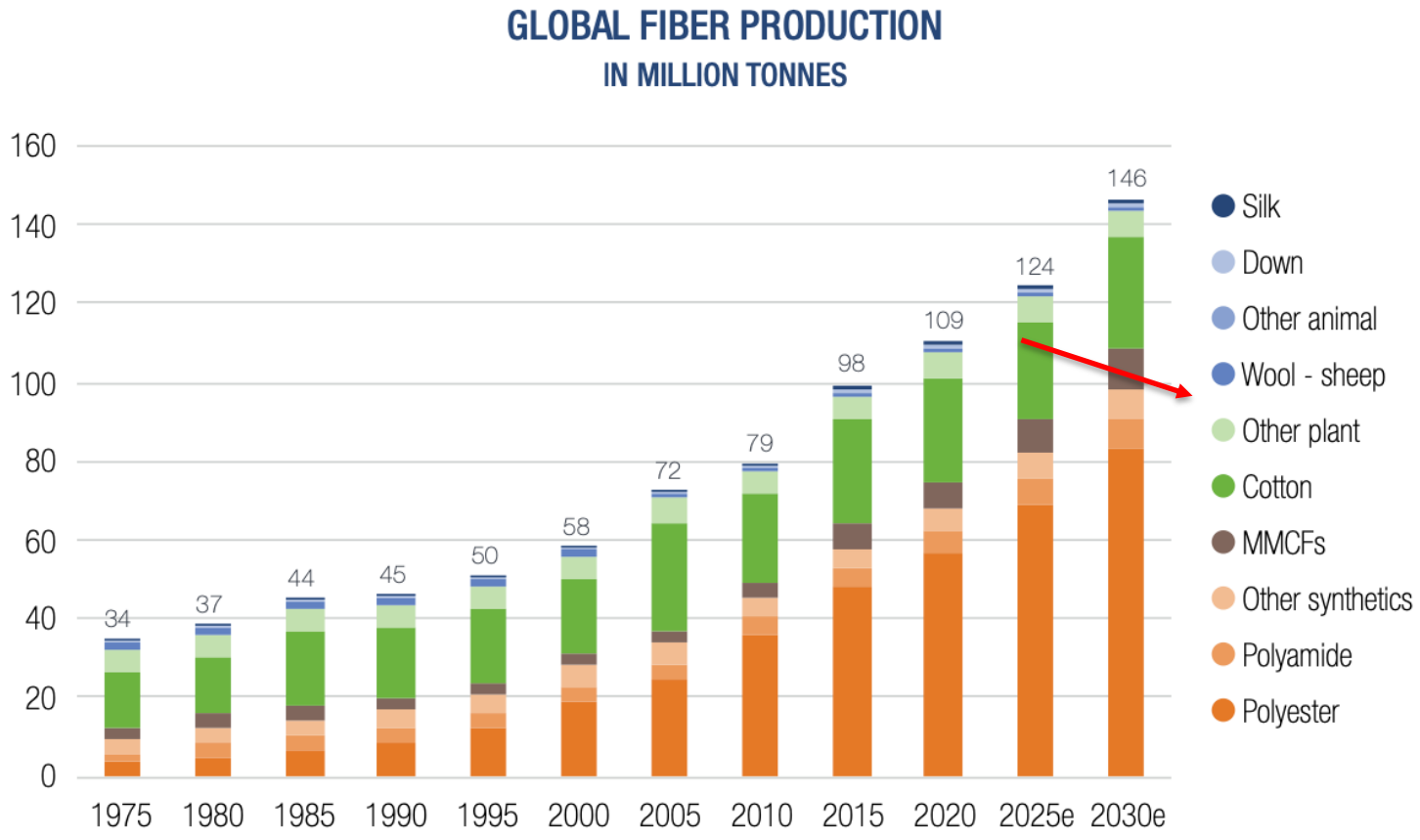
Interior architects
Fashion designers
Product designers
Buyers

Concept designers
Product designers
Users

Based on: Linnea Nilsson, licenciate project, Swedish School of Textiles, Borås
Completed by Pirjo Kääriäinen, Aalto University

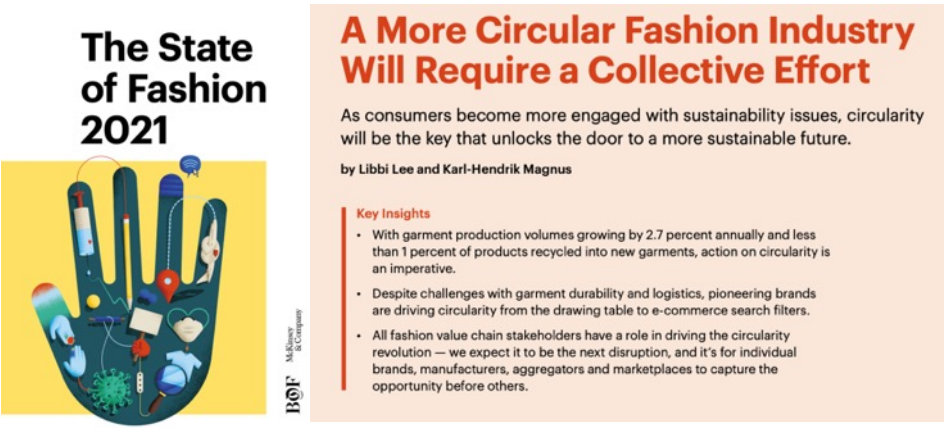
Aalto University


Future of Textile Materials
Kuva: Eeva Suorlahti
Aalto University



https://textileexchange.org/wp-content/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

Aalto University



Source: State of Fashion report by Business of Fashion & McKinsey, 2020

Source: State of Fashion report by Business of Fashion & McKinsey, 2021

Aalto University

Our material world is changing

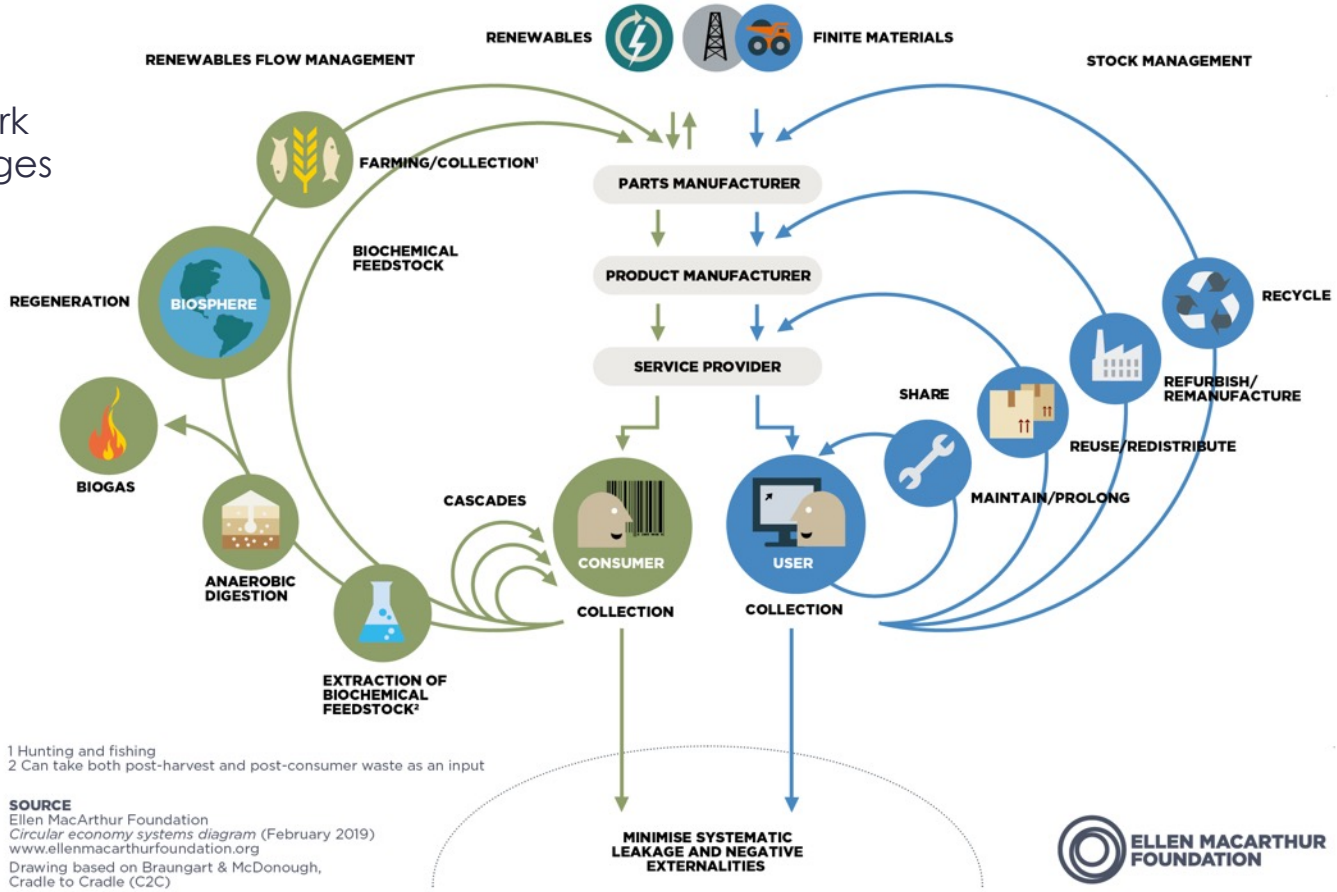
1. Circular economy
2. Material research for innovative use of raw materials
3. Digitalisation and automatisation continue
4. Biofabrication (use of biological processes)
5. Designing new materials, for example with synthetic biology

Photo: Eeva Suorlahti

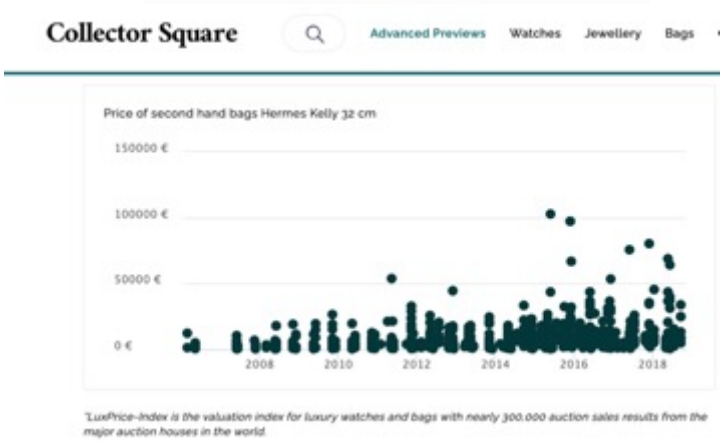
Aalto University

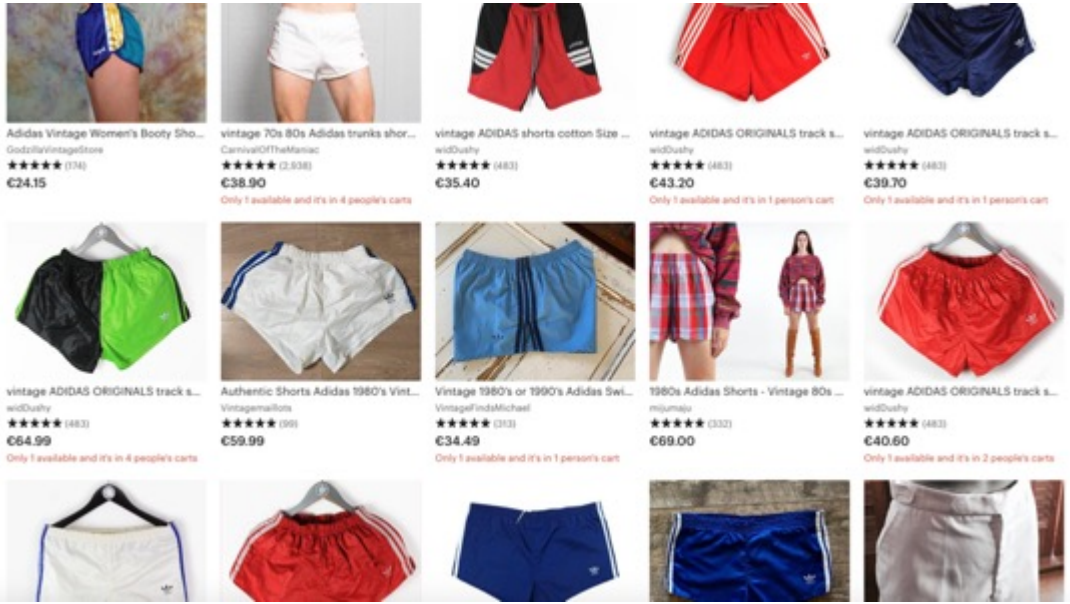
1. Circular economy

The circular economy is a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution.



Aalto University





Aalto University

Reuse – fashion and luxury

The circular economy is based on main three principles, driven by design

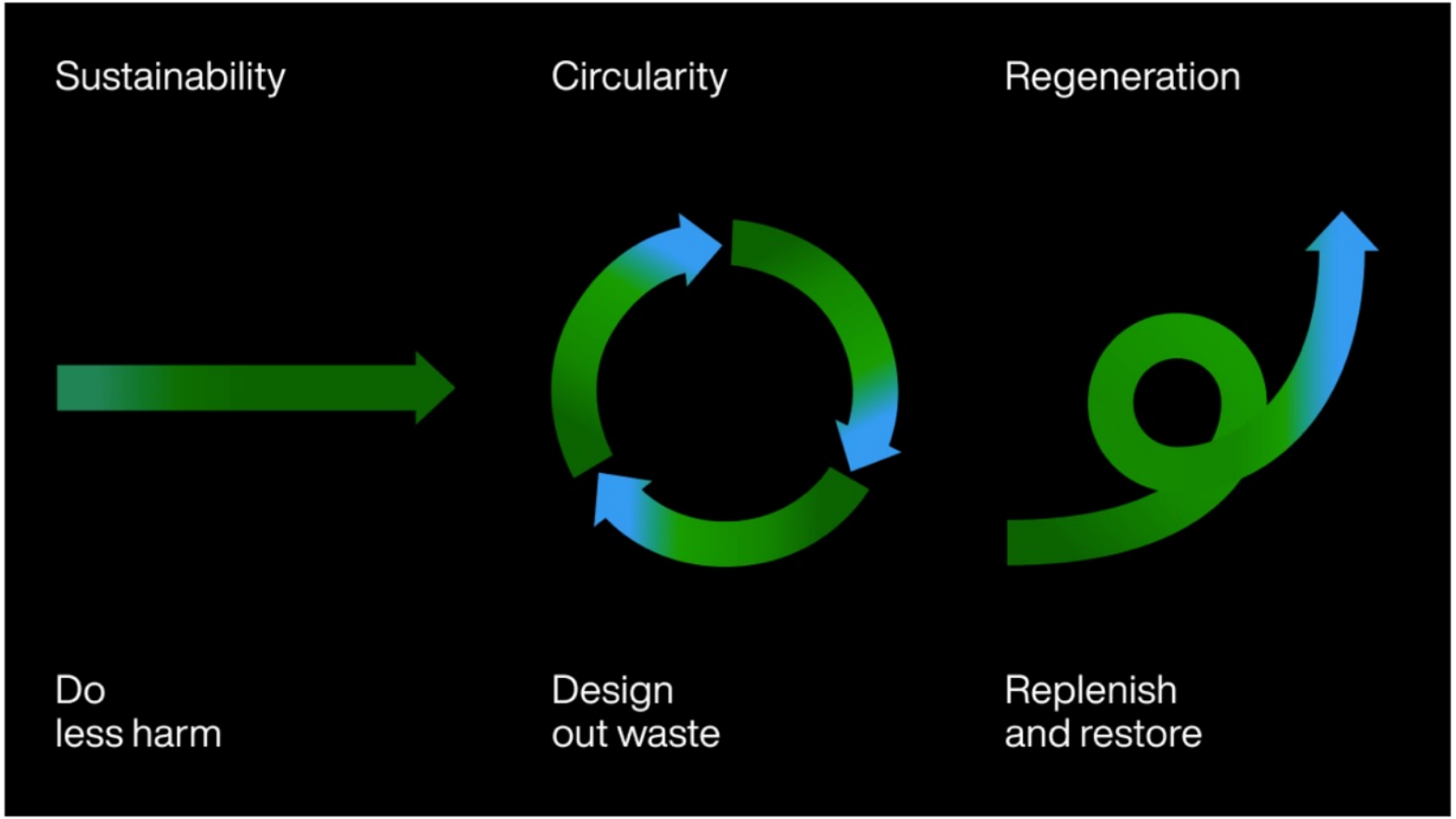
- Eliminate waste and pollution
- Circulate products and materials (at their highest values)
- Regenerate nature

'In circular economy materials are not only reused or recycled; they are merely stored in products, and used again and again'

Prof. Mark Hughes Aalto CHEM

Adidas Futurecraft shoes made of monomaterial to enable recycling

Aalto University



https://space10.com/regenerative-by-design/

Do less harm

Example: Several new man-made textile fibre production technologies in Finland

Photo Mikko Raskinen

More information:

ioncell.fi
spinnova.com
infinitedfibre.com
metsagroup.com
nordicbioproducts.fi

Aalto University

Ioncell

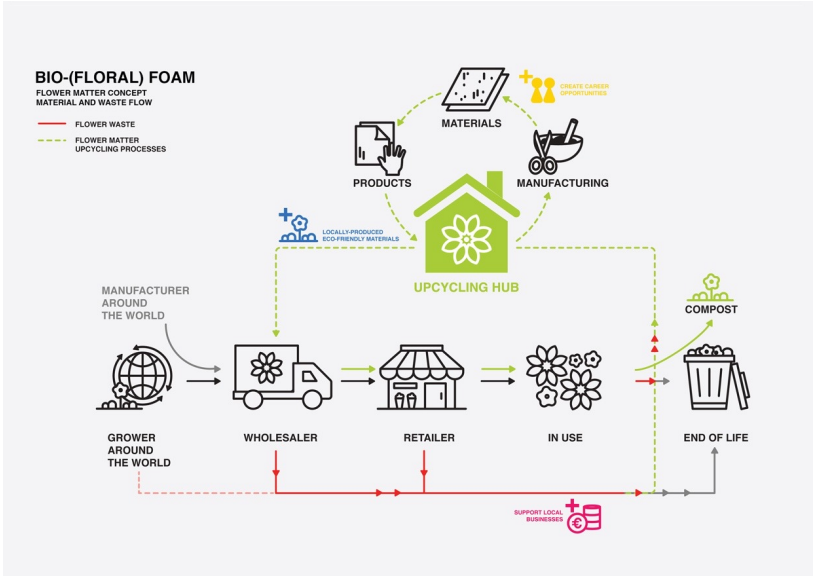
- **Company**: Ioncell
- **Origin**: Aalto University
- **Technological innovation:** High-quality textile fibres by dissolving cellulose with non toxic ionic liquids
- **Feedstock**: Cellulose-rich virgin or waste materials
- **Business status**: Small scale pilot at Otaniemi, Espoo.

https://ioncell.fi

Ioncell dress project 2018
Photo Vesa Moilanen/Lehtikuva

Aalto University

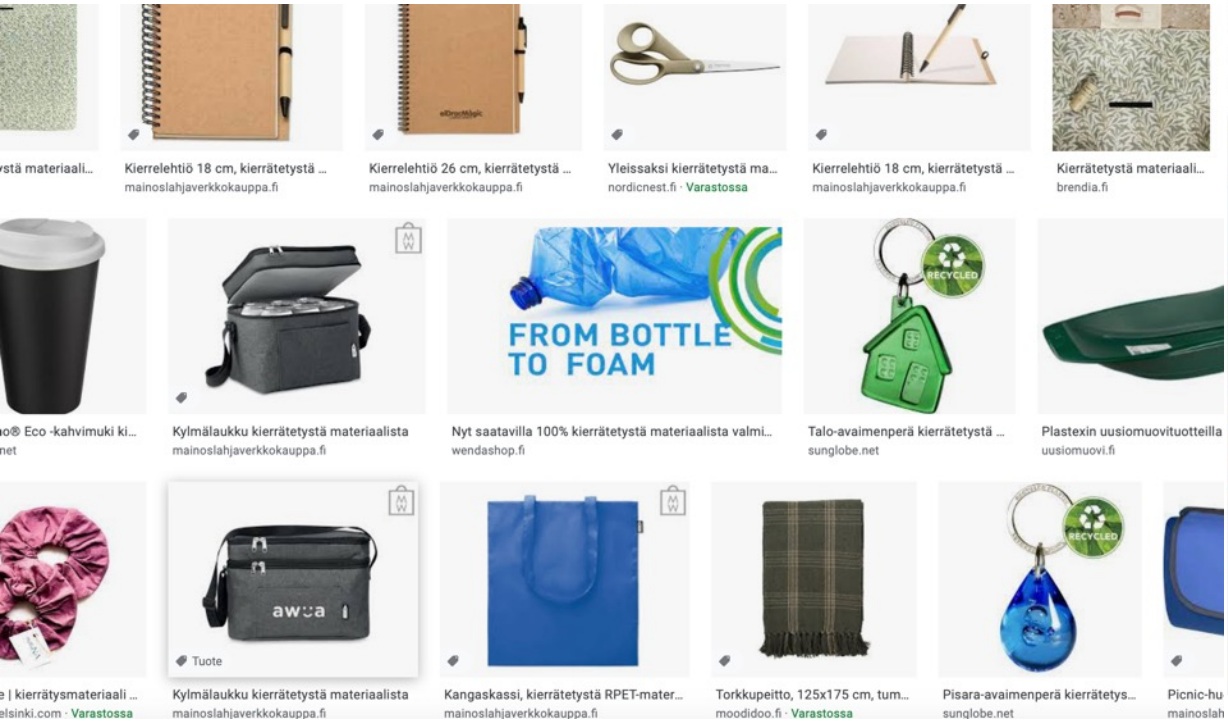
Design out of waste
Example: From flower waste to products – transforming materials and systems



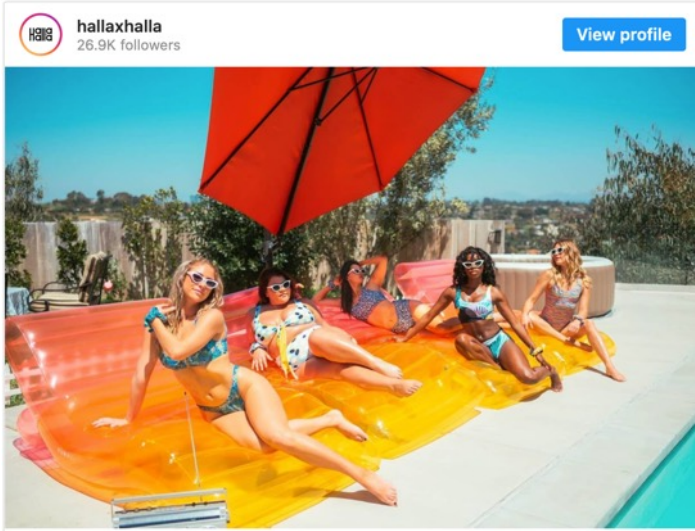
irenepurasachit.com

Aalto University

Upcycling plastic waste is great



Halla Hallan pirteät bikinit ja uikkarit ovat olleet pinnalla jo muutaman vuoden ajan. Perustajat Salla Valkonen ja Hanna Chalvet saivat idean uikkarimerkkiin huomatessaan matkoillaan, miten paljon meressä kelluu muovijätettä. Halla Hallan uima-asut tehdäänkin merten jätteistä valmistetusta Econyl-kankaasta, ja myös nämä uikkarit ommellaan Balilla.

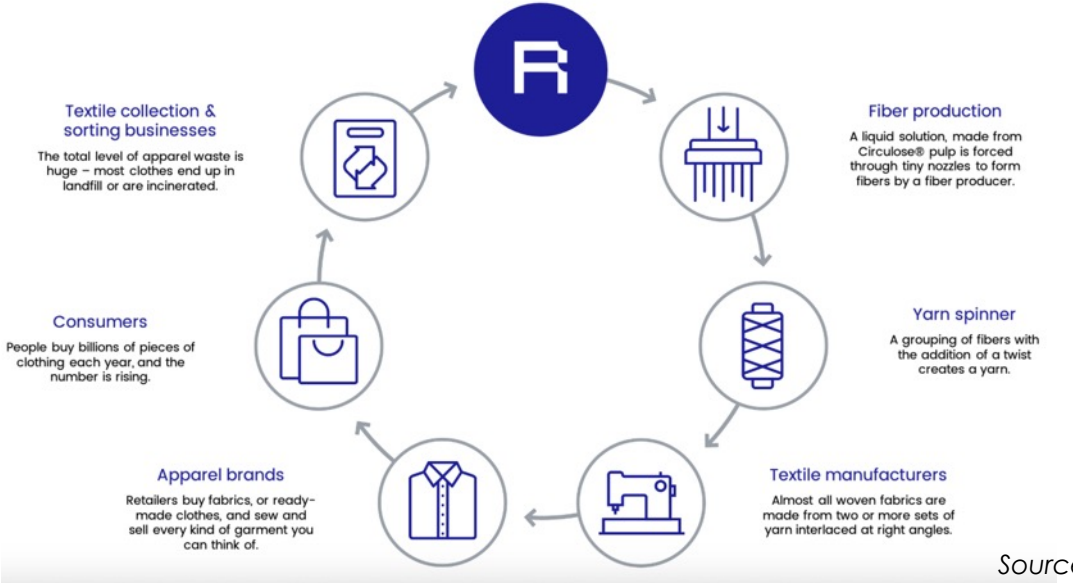


Aalto University

... but we also need to solve the original problem.

RENEWCELL

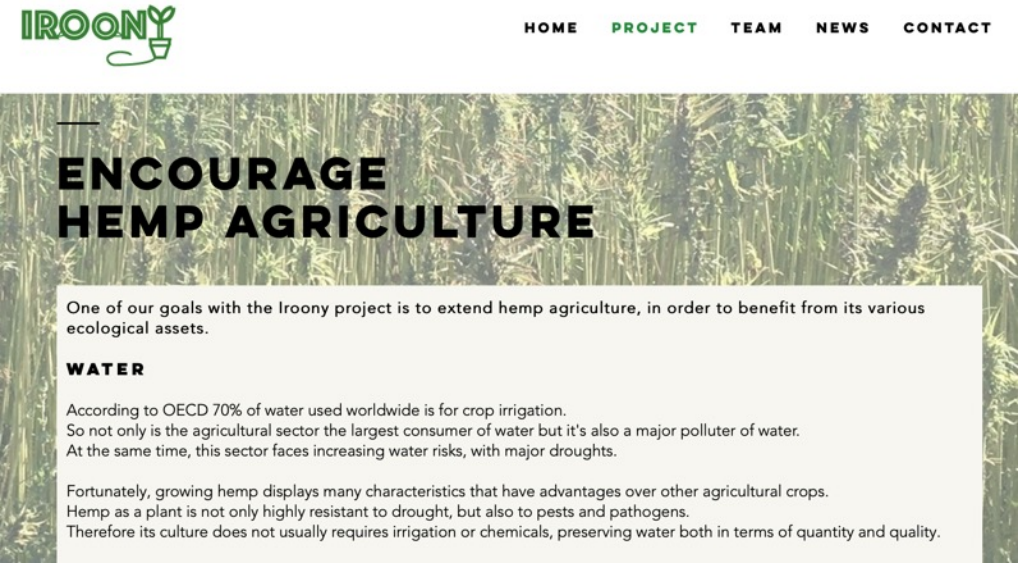
Our recycling technology dissolves used cotton and other natural fibers into a new, biodegradable raw material, Circulose® pulp. Our customers use it to make biodegradable virgin quality viscose or lyocell textile fibers. This is the link that has been missing from the cycle. We have closed the loop. The way fashion is produced and consumed can finally be transformed into a never-ending loop.



Source: renewcell.com

Aalto University

Replenish and restore
Example: Transforming systems towards positive ‘handprint’



Source: fluffstuff.fi

2. Material research for innovative use of raw materials

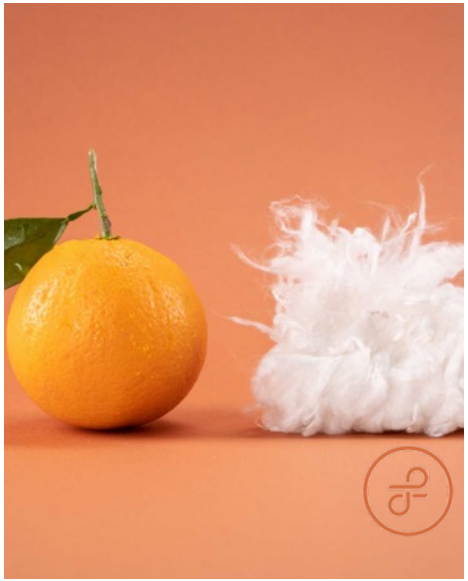
Cellulose is the most abundant organic polymer in the earth
- it is in wood, plants, algae.

Trees and plants contain also lignin, hemicellulose, bark, long bast fibres, extractives for colours and natural ‘chemicals’…

Aalto University

Wheat straw -based textile fibres

Soy fibres I Soysilk



https://orangefiber.it

Corn fibre I DuPont Sorona

Man-made textile fibres are produced mainly with chemical processes.

NOTE: Raw materials and textile fibre production technology are different things.

Lignin + textiles

By Pia Johansson in collaboration
with Biocolour research project 2021-22

Helena Sederholm in collaboration
with Prof Hummel's team 2023

Hemp, linen, nettle…

Ecologically Efficient Agri-Food Systems for Development of Advanced Textiles Supply Chain - Production of nettle (Urtica dioica) for regenerative fashion

Samica Sadik Summer 2021

PhD. Student (University of Helsinki Dept. Craft studies, Milano Politecnico)

MSc Agricultural Economics & Business Administration (University of Helsinki)

Samica Sadik

Natural dyes
Aleksandra Hellberg & Jenny Hytönen
Aalto Chemarts 2019. Kuva Eeva Suorlahti

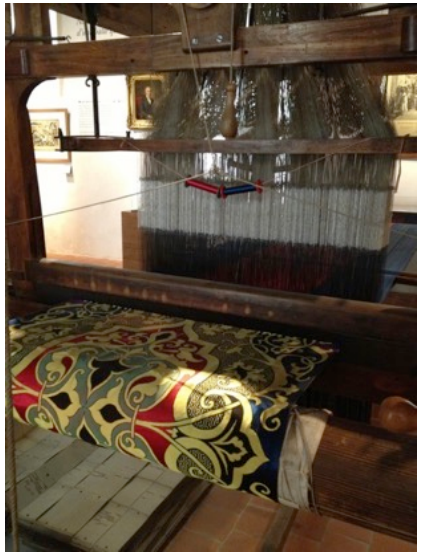
Dyeing with coffee waste Natural Indigo Finland + Paulig 2023

Natural Indigo Finland & Marimekko 2021
Kuva Mikko Raskinen.

Aalto University

Natural / non toxic dyeing, printing, finishing…

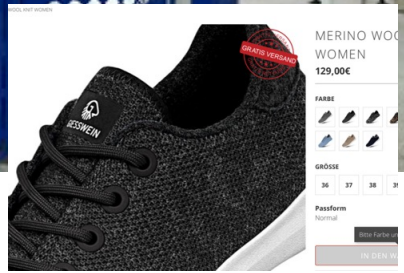
3. Digitalisation and automatization continue



"There is so much within fashion that is unexplored." — Iris Van Herpen

Iris Van Herpen via Paper Magazine

Aalto University

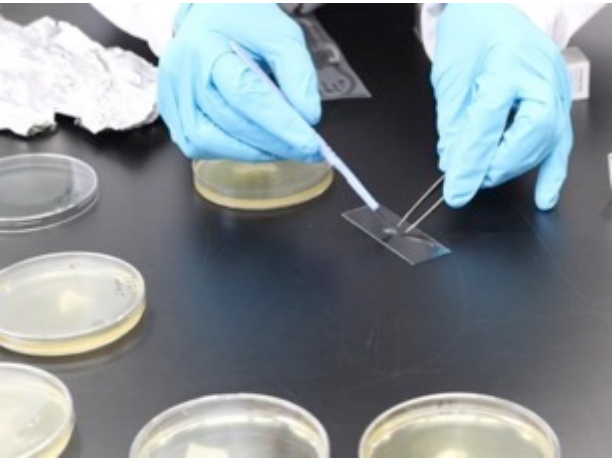


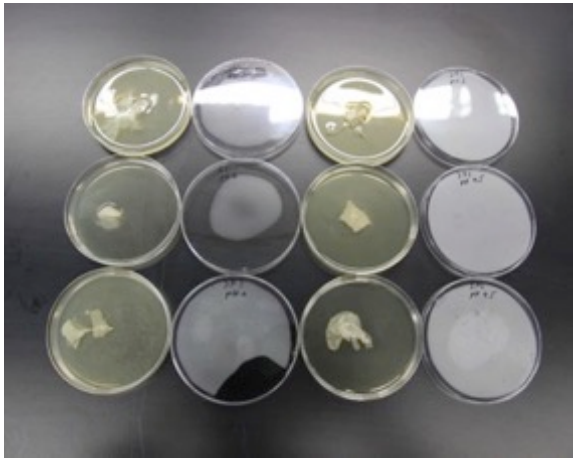
3D Additive manufacturing?
Traditional crafts / Super efficient, digitalized industrial processes

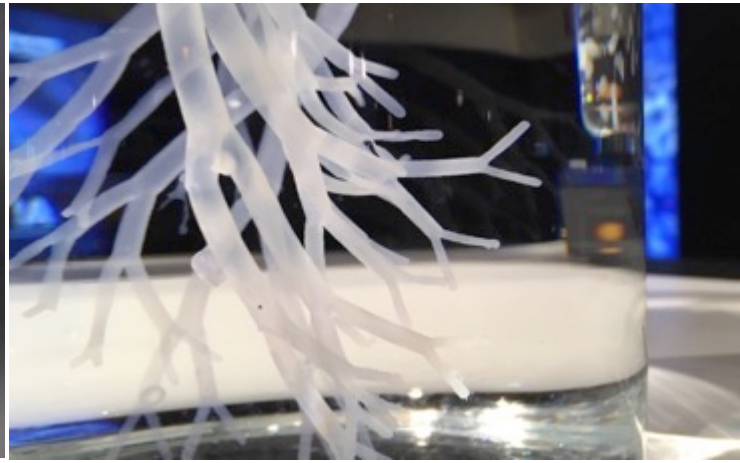
Aalto University

4. Biofabrication - use of biological processes

(with microbi, yeast and fungi)



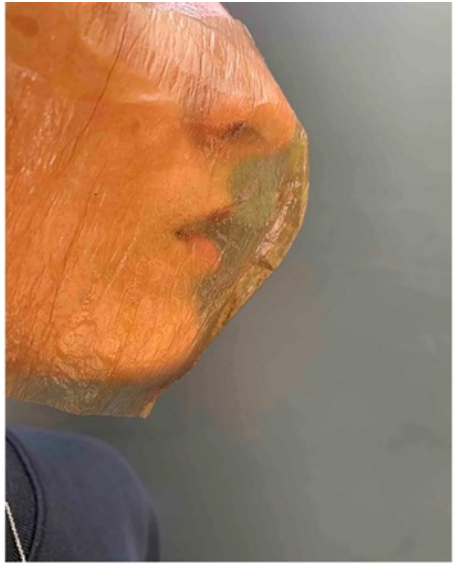




Complex structures of microbial cellulose grown by Prof. Orlando Rojas's team 2018, Aalto University

Aalto University

’Have you seen this recipe to grow your jacket?’



A bio-design studio has grown the material in their home kitchen for a protective mask made of xylinum. Photo: Elizabeth Bridges and Garrett Benisch, Sum Studio.

Textile-like materials from microbial cellulose and other bio-based materials. Julia Strandman, Aalto University CHEMARTS 2018. Photo Esa Eeva Suorlahti

Experimental mycelium jacket By Aniela Hoitnik https://neffa.nl/portfolio/

Aalto University

Materials with fungi (mycelium)

arup.com

Home > News and ideas > An alternative for leather and synthetic leather: VTT succeeded in demonstrating continuous production of mycelium leather

An alternative for leather and synthetic leather: VTT succeeded in demonstrating continuous production of mycelium leather

https://www.youtube.com/watch?v=vj0-94b-2S0&t=2s

Biologically produced Biology vs. synthetic biology

zenaholloway.com

dianascherer.nl

biofabricate.co

Aalto University

5. Designing new materials, for example with synthetic biology

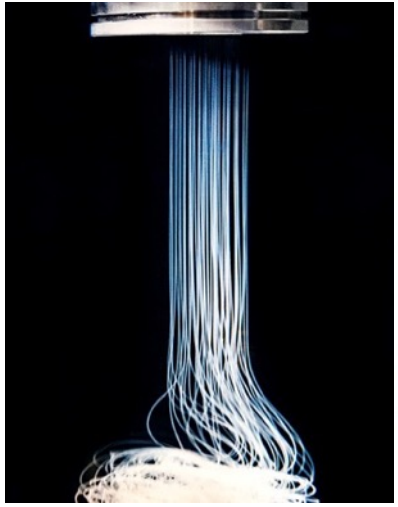
Combining artificial silk-like proteins with cellulose, NewSilk project, Aalto University

Transgenic glowing silk. Fantasma by Another Farm et al. Japan.

Pigments of Micro organisms Master's thesis on microbial colour by Eveliina Juuri, Aalto University 2020 photo Eveliina Juuri

Aalto University

’Let’s brew for a pullover!’



Microsilk by Bolt Threads, U.S

Stella Mc Cartney x Bolt Threads

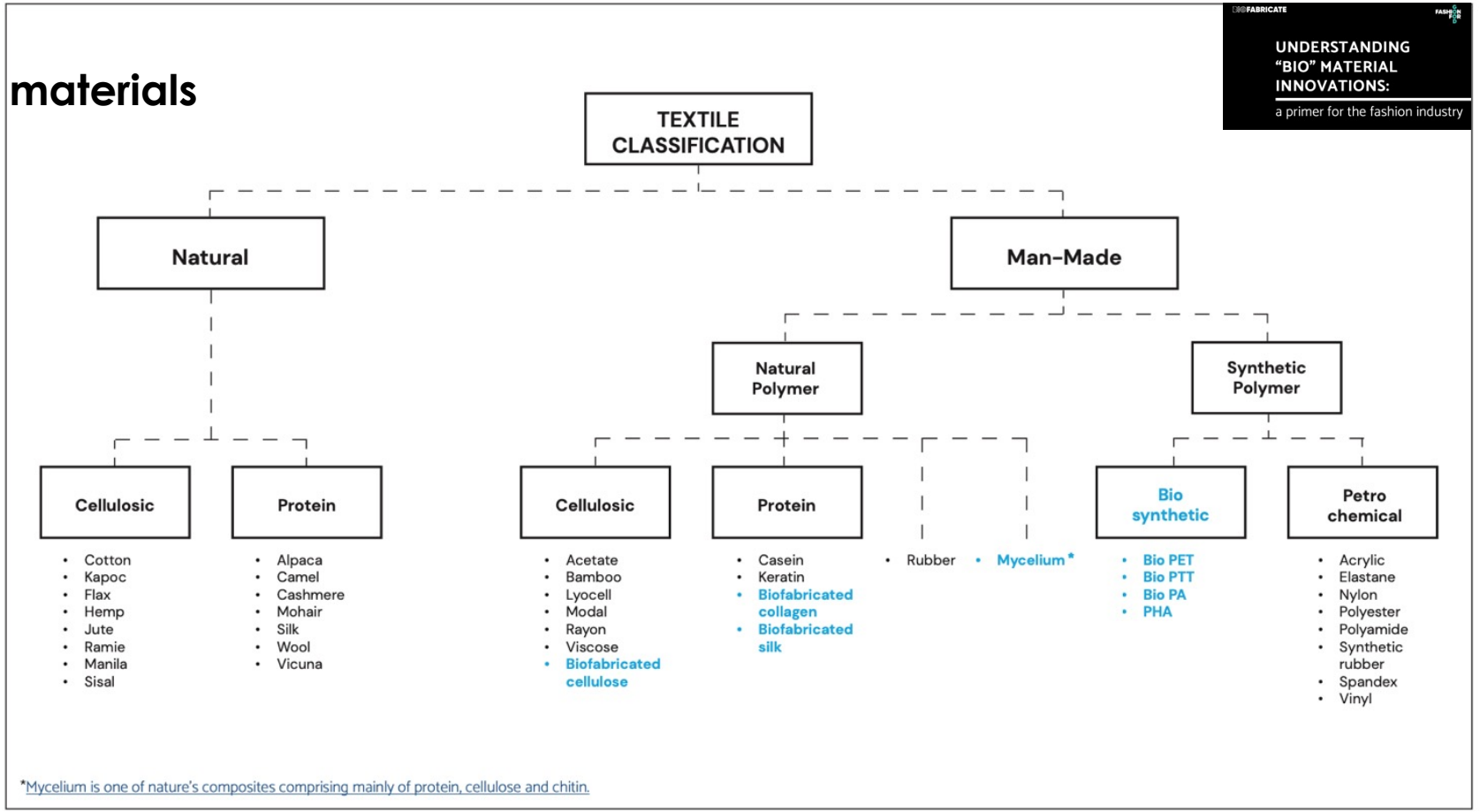
Brewed Protein by Spiber

New kind of textile factory: Brewed Protein by Spiber

Source: ‘Understanding ‘Bio’material Innovations’ report 2020. biofabricate.co

Aalto University

New materials



HOW?

How to be a designer in this fuzzy world of emerging materials?

Photo: Eeva Suorlahti

Aalto University

Keywords

Curiosity
Creativity
Collaboration
Communication
Critical thinking
Complexity > Persistance

Photo: Eeva Suorlahti

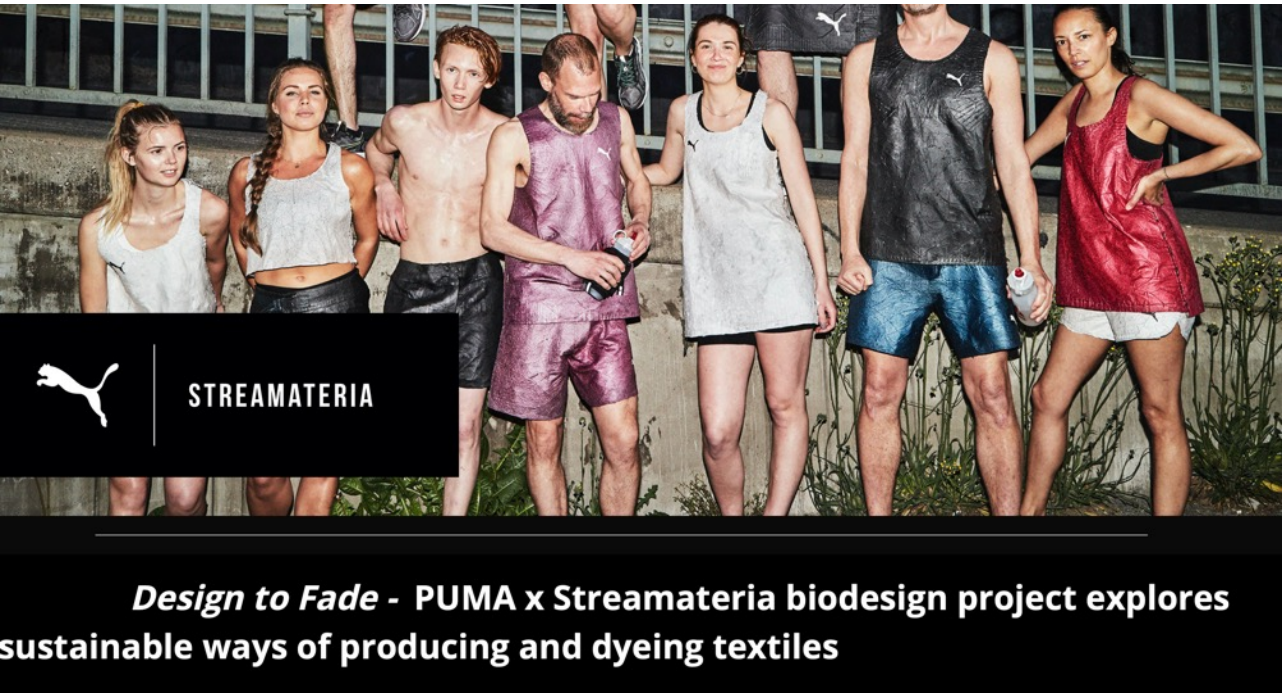
Aalto University

CURIOSITY

Follow material development and new technologies

Aalto University

Pigments of Micro organisms - Master's thesis on microbial colour by Eveliina Juuri, Aalto University 2020, photo Eveliina Juuri



Source: streamateria.com

CREATIVITY

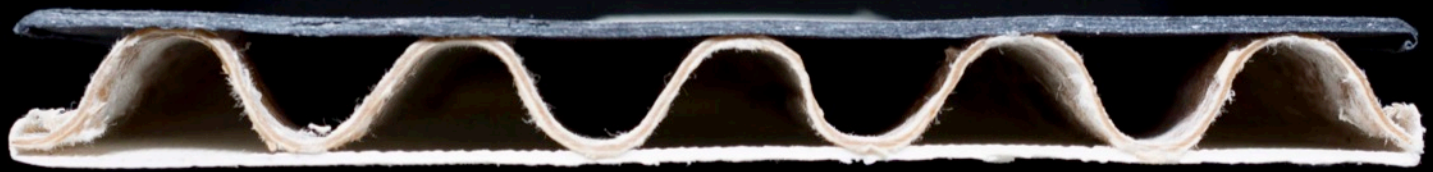
Changing perspective: problems might be possibilities

Aalto University

COLLABORATION

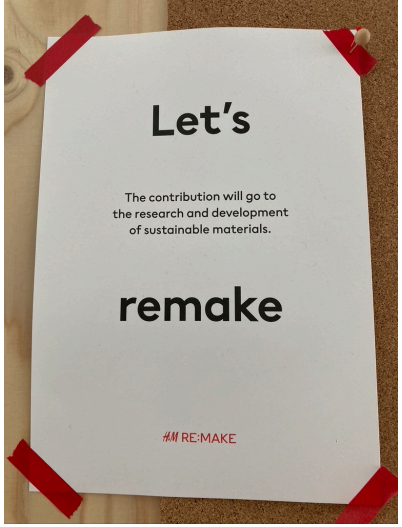
‘The challenges to our planet are so complex that they cannot be solved by one discipline. Design is a bridge. It translates scientific ideas and discoveries into real-world applications.’

- Matilda McQuaid, Curator at Cooper-Hewitt Smithsonian Design Museum, NYC
in the exhibition catalogue: 'Nature: Collaborations in Design', 2019



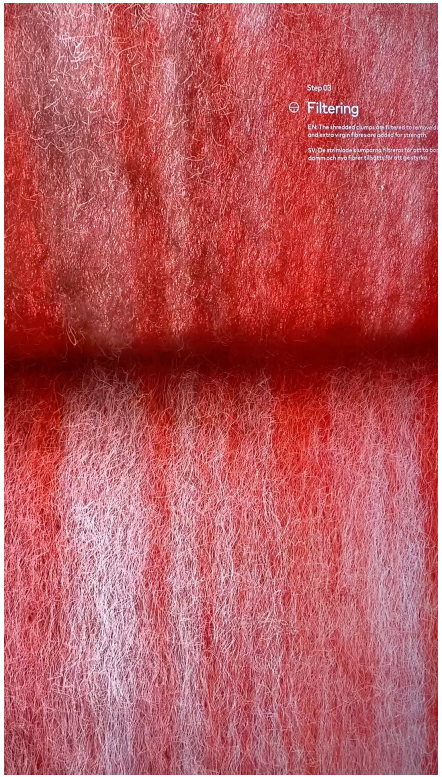
Aalto University

Multilayered nanocellulose sheet / Maker Tiina Härkäsalmi, DWoC project 2017, photo Eeva Suorlahti

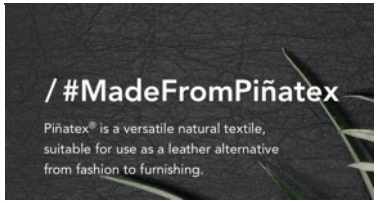


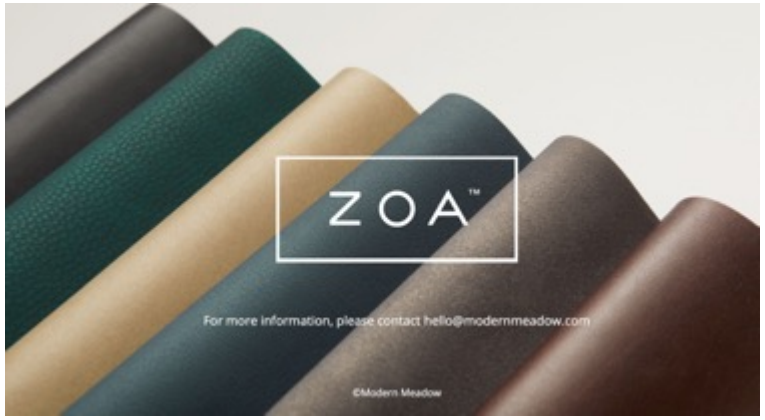
Aalto University

COMMUNICATION

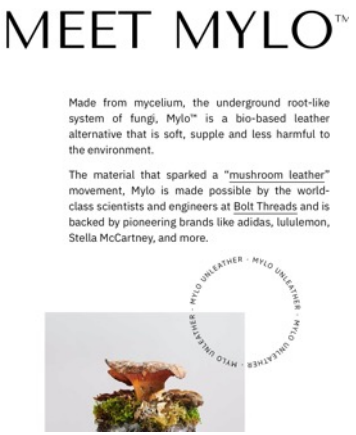


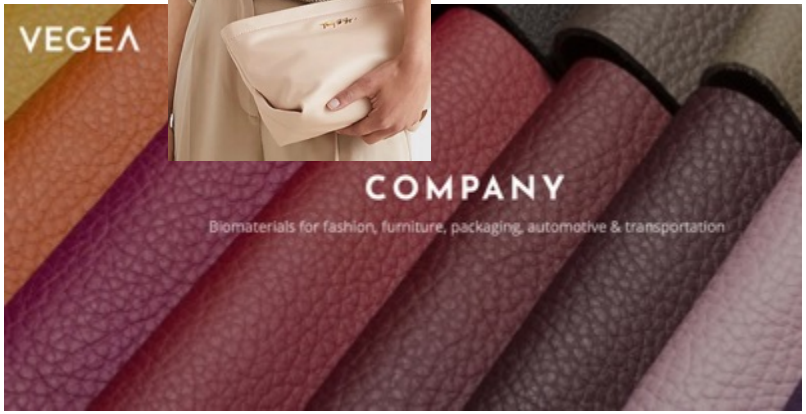
Aalto University

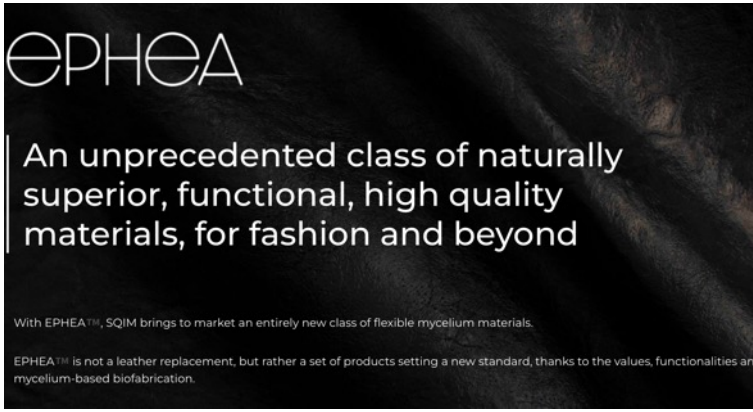




Replacing leather – but what about material sustainability?







Aalto University

CRITICAL THINKING

By **SARAH KENT**

31 October 2022

BoF PROFESSIONAL

KEY INSIGHTS

- Brands are using buzzy but vague marketing terms like “vegan leather” and “plant-based” to describe materials with vastly different properties and compositions.
- Most leather alternatives are made of plastic, but more options are becoming available that reduce and even eliminate fossil-based content.
- These materials are facing mounting scrutiny as fashion faces a greenwashing reckoning, pushing brands to be more transparent about their benefits and shortcomings.

The sneakers are made from Vegea, an emerging leather alternative that has been used by brands including Ganni and H&M. It’s just under 30 percent plastic, according to the small print on the product’s material composition. It can only be recycled with difficulty, according to information published elsewhere on Pangaia’s website.

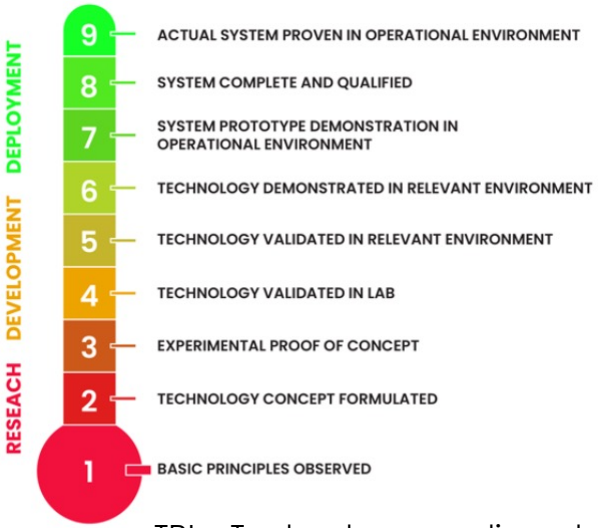
The landscape has become so confusing that nonprofit Textile Exchange has recommended brands stop describing any materials that aren’t derived from animal skins as “leather” to avoid conflating fossil-based synthetics and newer plant-based alternatives.

Even within the category there are variations between the materials and their properties. For instance, Mylo is a mix of mycelium and plant-based fibre with a water-based polyurethane finish. Ephea is pure mycelium stabilised using green chemistry.

Even more **futuristic materials** grown or fermented in labs have yet to make it to market in a meaningful way. And adding to the complexity, leather itself is often coated in plastic.

COMPLEXITY > PERSISTENCE

Long journey
from idea to innovation
and products:
material development
takes 5-15 years



TRL - Technology readiness levels

Methods mapped against the spiral showing the seven stages of innovation

Innovation cycle by Nesta

Aalto University

To conclude:

- No bad or good materials as such; right materials in right place
- Traditional and new materials utilized in new ways
- Efficient product and material recycling
- Non-toxic chemicals and alternative dyeing and finishing methods
- Emerging biotechnologies vs learning from past
- Local vs global
- Digitalized value chains
- Transparency of production chains
- New business opportunities and models
- Collaboration enables innovation and development

Photo: Eeva Suorlahti

Aalto University

Thank you!

Photo:Eeva Suorlahti

Pirjo Kääriäinen
Aalto University
pirjo.kaariainen@aalto.fi

Aalto University