



Fibre redesign for circularity

Sustainable Fibres Symposium 2025

Colleen MacMillan

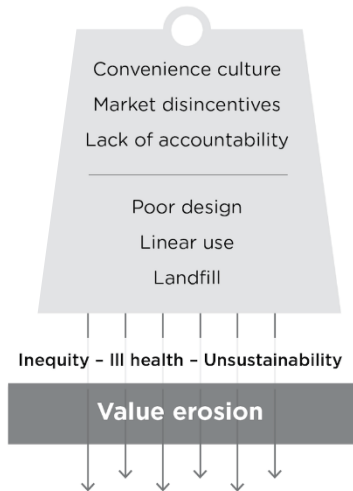


18 September 2025

Fibres and the circular economy transition

the whole is much more than it's (fragmented) parts

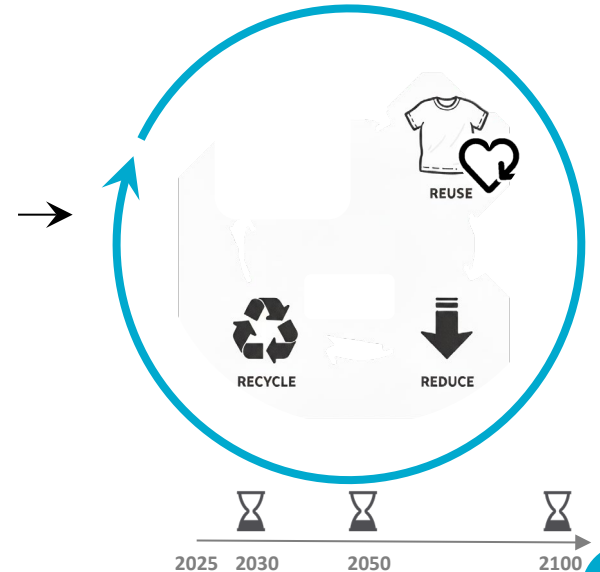
From linear deadweight



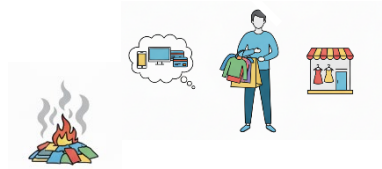
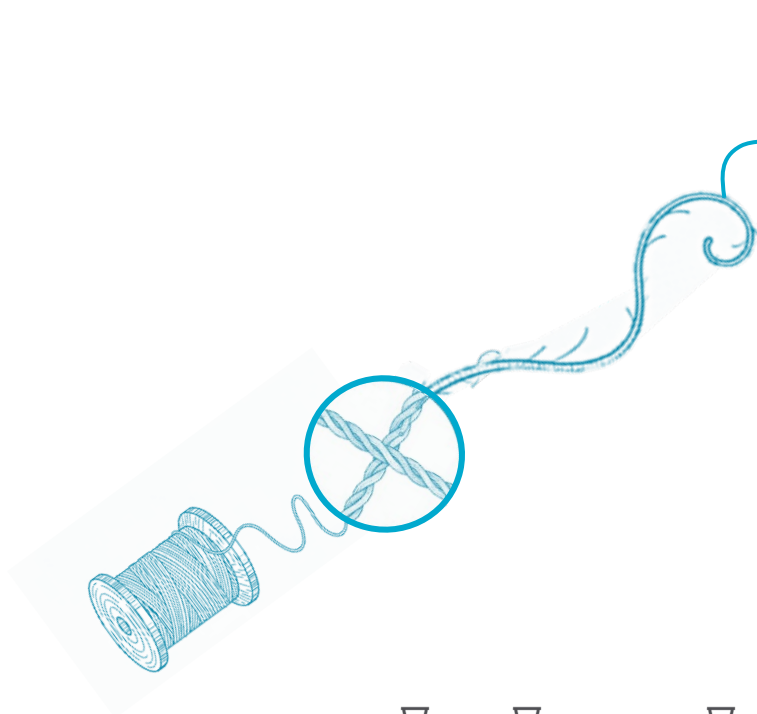
To a circular economy



What can **fibre redesign** do for circularity?



Fibres' purpose: tackling the start of the fibre cycle



Producers & Consumers

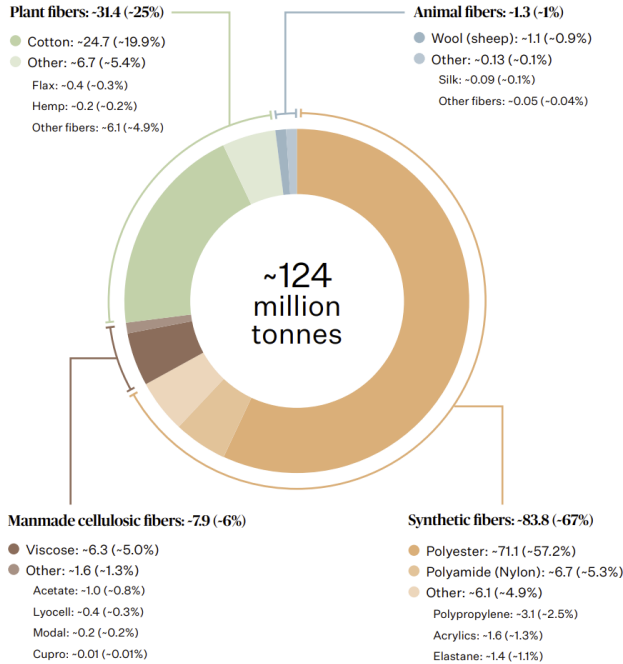
- **multiple fibres:** petrochemical, man-made, natural
 - **multiple functions:** clothing; bed and bath; medical; home, building and vehicle upholstery and furnishings; transport (e.g. tyres); hospitality; agriculture
- survive and thrive, protection, cultural, and more



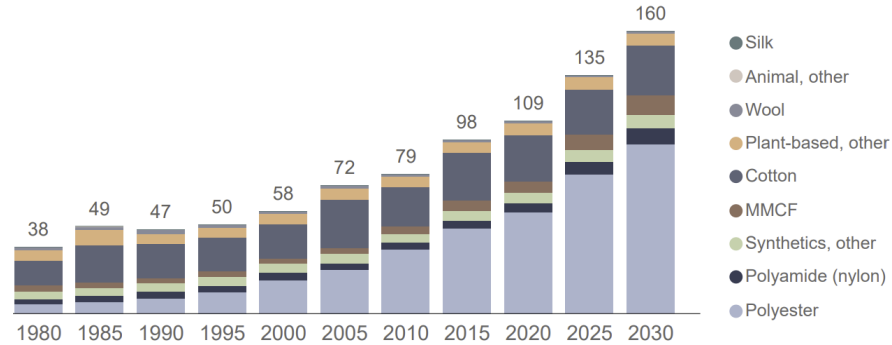
Fibre types & volumes



Global fibre production in 2023 (mT & %)



Global fibre production 1980 – 2025+ (mT)



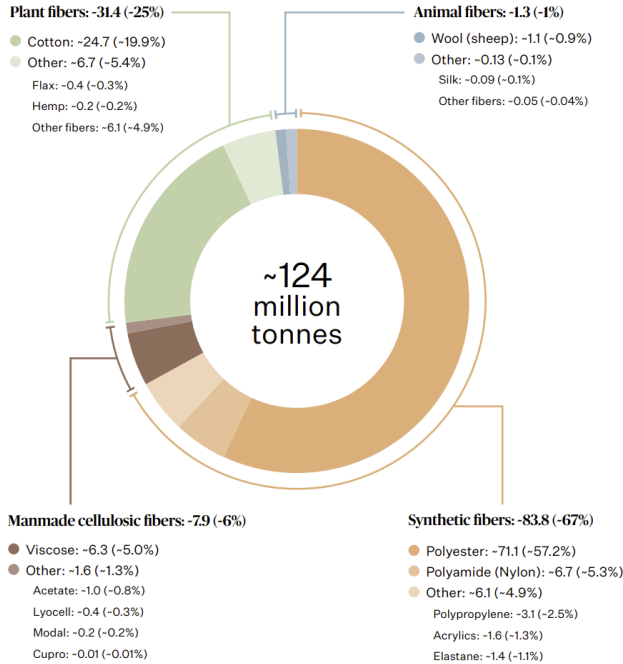
Source: Textile Exchange based on data from CIRFS, FAO, ICAC, IVC, IWTO, Maia Research, and its own modeling.

Note: This chart includes recycled fibers. Other animal fibers included here are alpaca, angora, camel, cashmere, guanaco, llama, mohair, vicuna, and yak. Other plant fibers included here are jute, coir, sisal, abaca, ramie, kenaf, kapok, and agave. Leather, down, and rubber are not included as they are considered non-fiber raw materials for the purpose of this report.

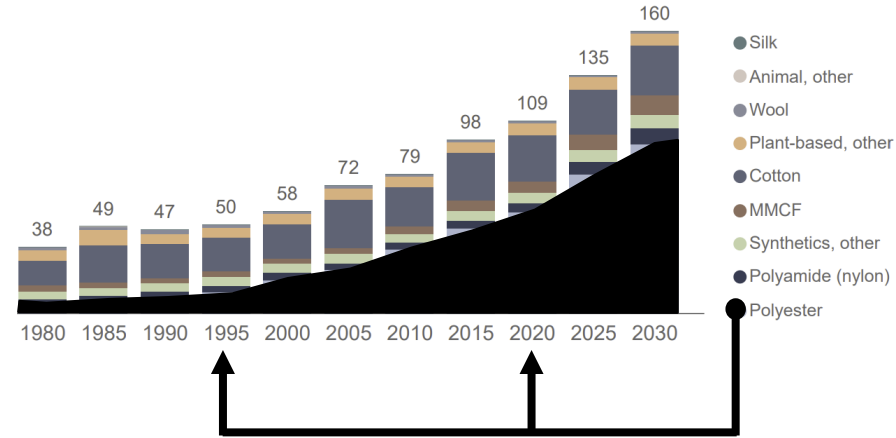
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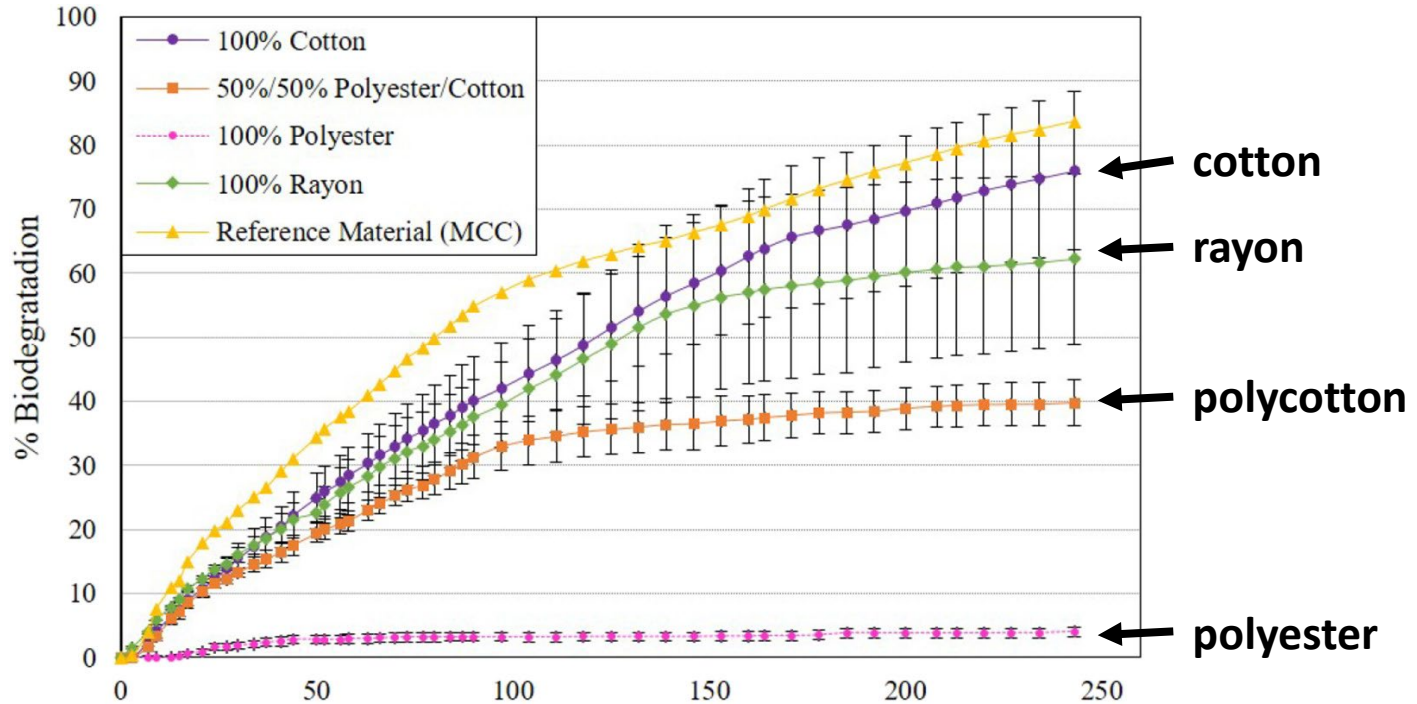


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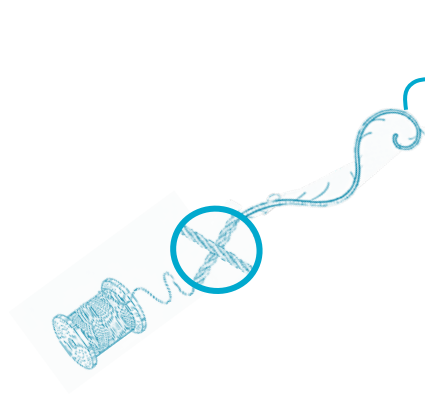
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Fibres types degrade differently

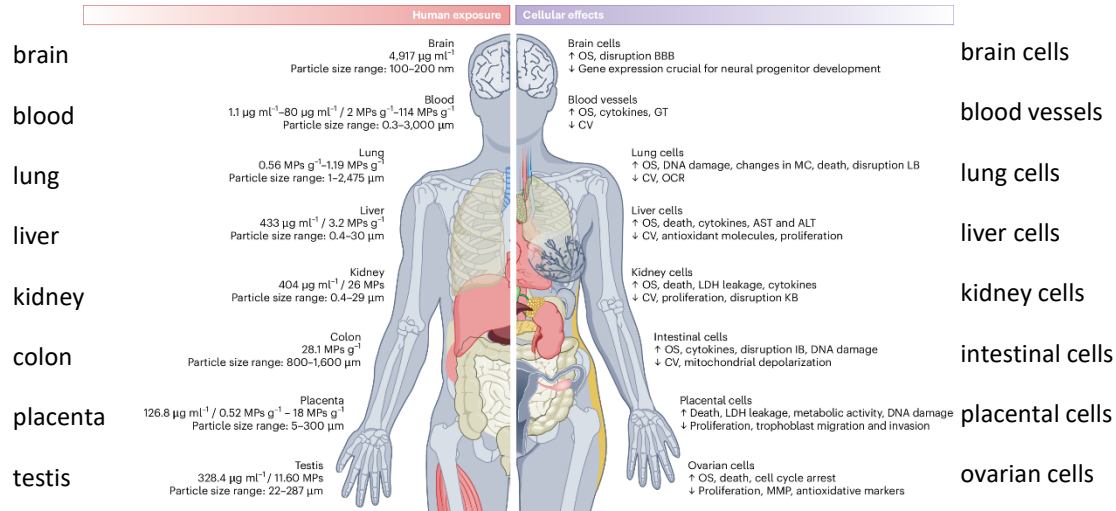
Microfibre % biodegradation over ~ 8 months (aquatic)



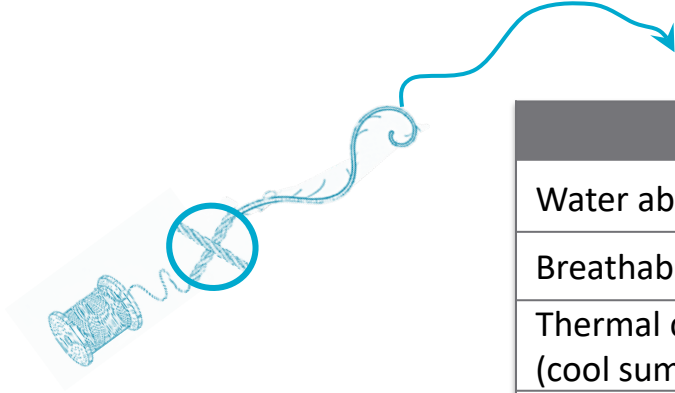
Fibres & plastic pollution: a big problem in tiny form



microplastic and nanoplastic exposure: health impacts

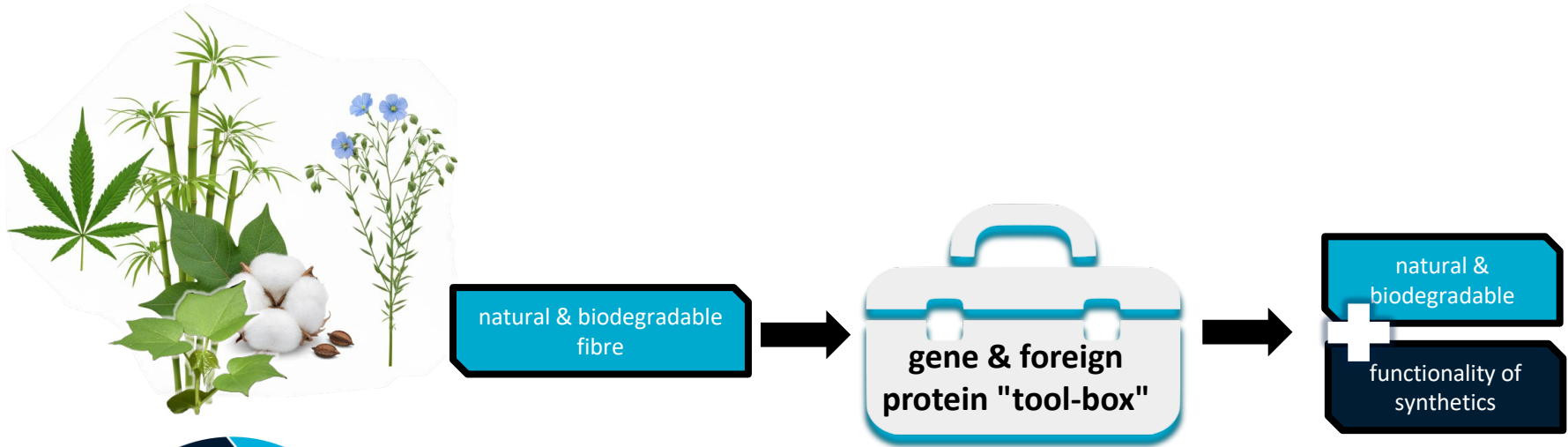


Fibres' purpose: tackling the start of the fibre cycle



Property	Cotton	Polyester
Water absorbing capacity	✓	✗
Breathability	✓	✗
Thermal conductivity (cool summer/warm winter)	✓	✗
Pilling	✓	✗
Elasticity	✗	✓
Weight/Density	✗	✓
Strength/Tenacity	✗	✓
Resilience (crease resistance)	✗	✓

Plant-generated fibres, with designer-functionality



Precedent? Yes. 30+ years

Plant GM traits tackling chemical use



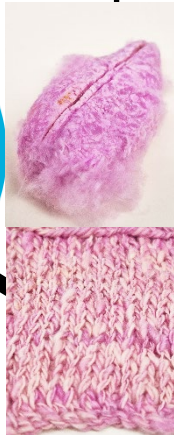
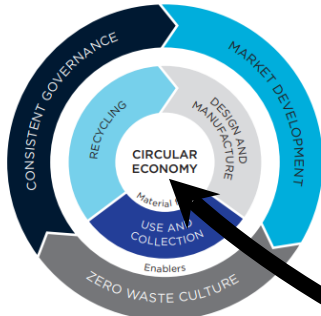
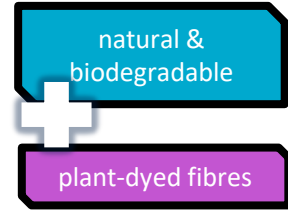
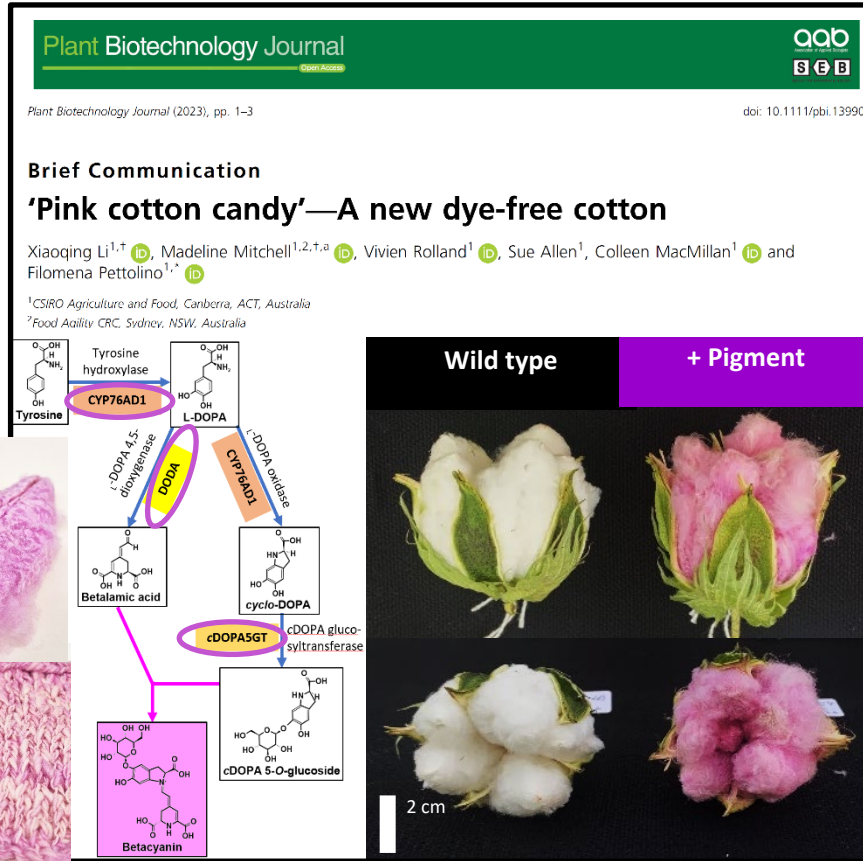
- Bt: natural bacterial proteins (*Bacillus thuringiensis*); toxic to some specific insect pests
- cotton plants genetically-modified to make Bt protein (+ BG II[®], BG III[®] ...)
- since introduction, 85% reduction in insecticide use on Australian cotton farms
- significant positive impacts ... reduction chemical use on-farm + in soil, yield/hectare



Case study I : plant-dyed cotton fibres



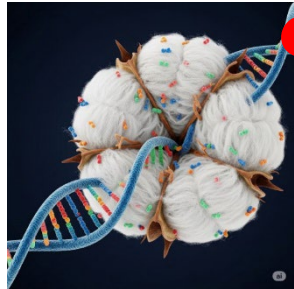
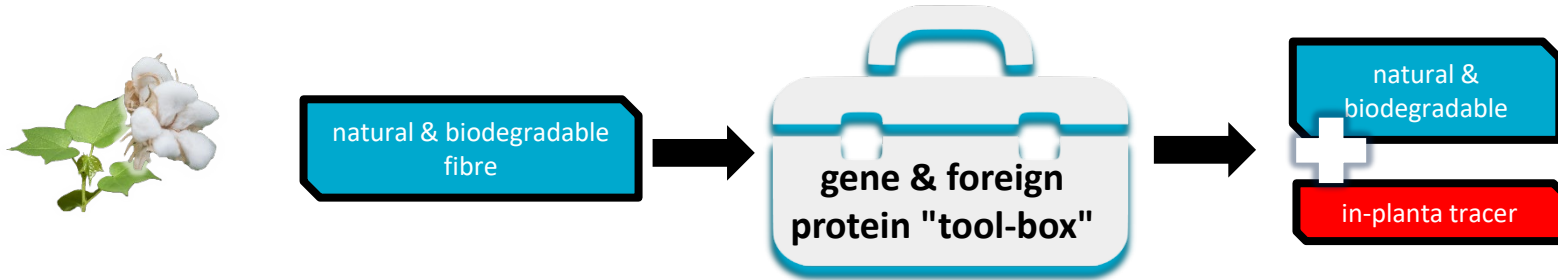
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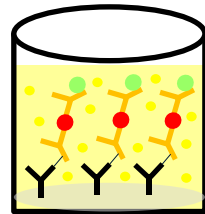
CSIRO Synthetic Biology Future Science Platform Novel Fibres
 L-R: Filomena Pettolino, Maddie Mitchell, Colleen MacMillan, Xiaoqing Li, Viv Rolland + team



Case Study II: in-planta traceability



Antibody-based detection



Y Y

antibodies

●

target protein

Detectable in:
< 0.2 mg mature
dry fibres



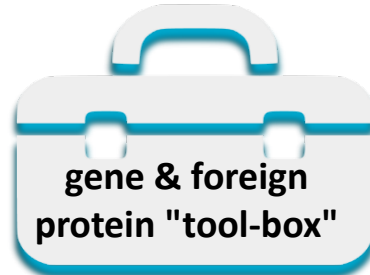
Dr Xiaoqing Li
+ CSIRO team



Plant-generated fibres, with designer-functionality

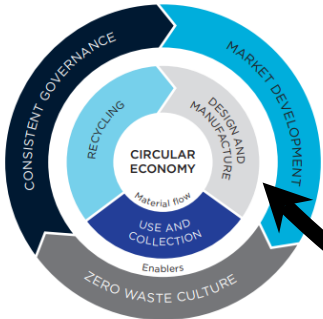
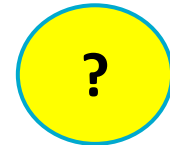


natural & biodegradable fibre

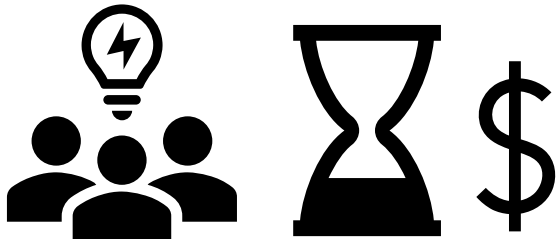
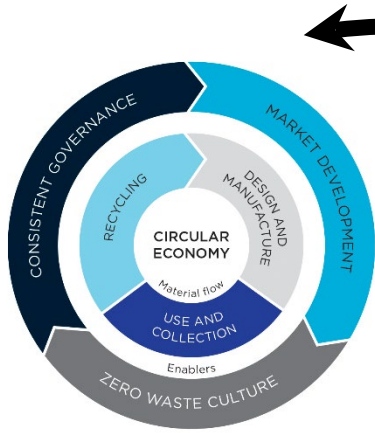


natural & biodegradable
+
functionality of synthetics

Property	Cotton	Polyester
• Water absorbing capacity	✓	✗
• Breathability	✓	✗
• Thermal conductivity (cool summer/warm winter)	✓	✗
• Pilling	✓	✗
• Elasticity	?	✓
• Weight/Density	?	✓
• Strength/Tenacity	?	✓
• Resilience (crease resistance)	?	✓

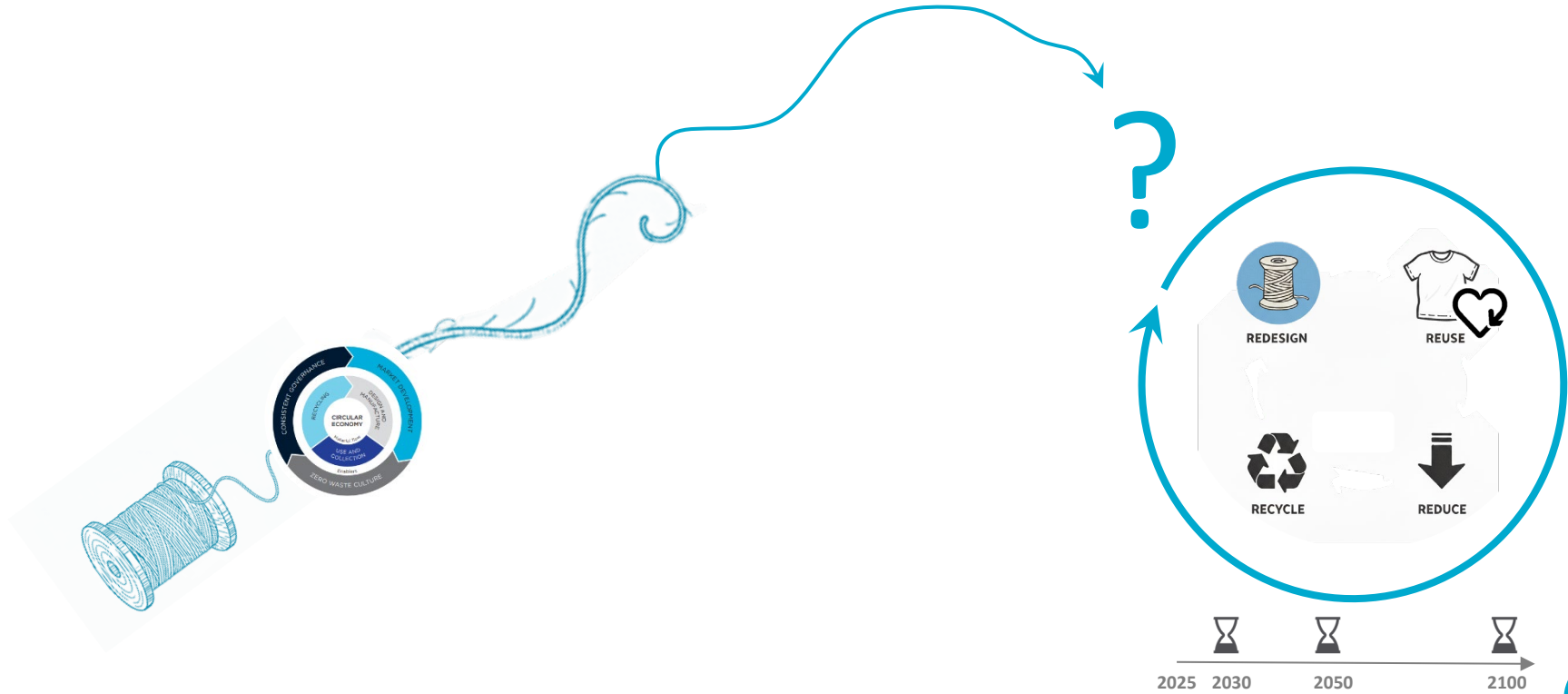


Opportunities & challenges for plant fibre redesign



fibres for circularity

the whole is much more than it's (fragmented) parts



Thank you

Agriculture and Food Research Unit

Colleen MacMillan | Principal Research Scientist | Cotton Fibre Quality; Circular Economy

colleen.macmillan@csiro.au

