FUTURE FIBRES

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Future Fibres Facility: A Unique Solution for Textiles Upcycling and Recycling

Dr. Md Abdullah Al Faruque

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Institute for Frontier Materials – Deakin University

DEAKIN UNIVERSITY

IFM INSTITUTE FOR FRONTIER MATERIALS

FUTURE FIBRES GROUP

ARC Research Hub for FUTURE FIBRES

Australian Government Australian Research Council

FUTURE FIBRES FACILITY

ANFF

NCRIS National Research Infrastructure for Australia An Australian Government Initiative

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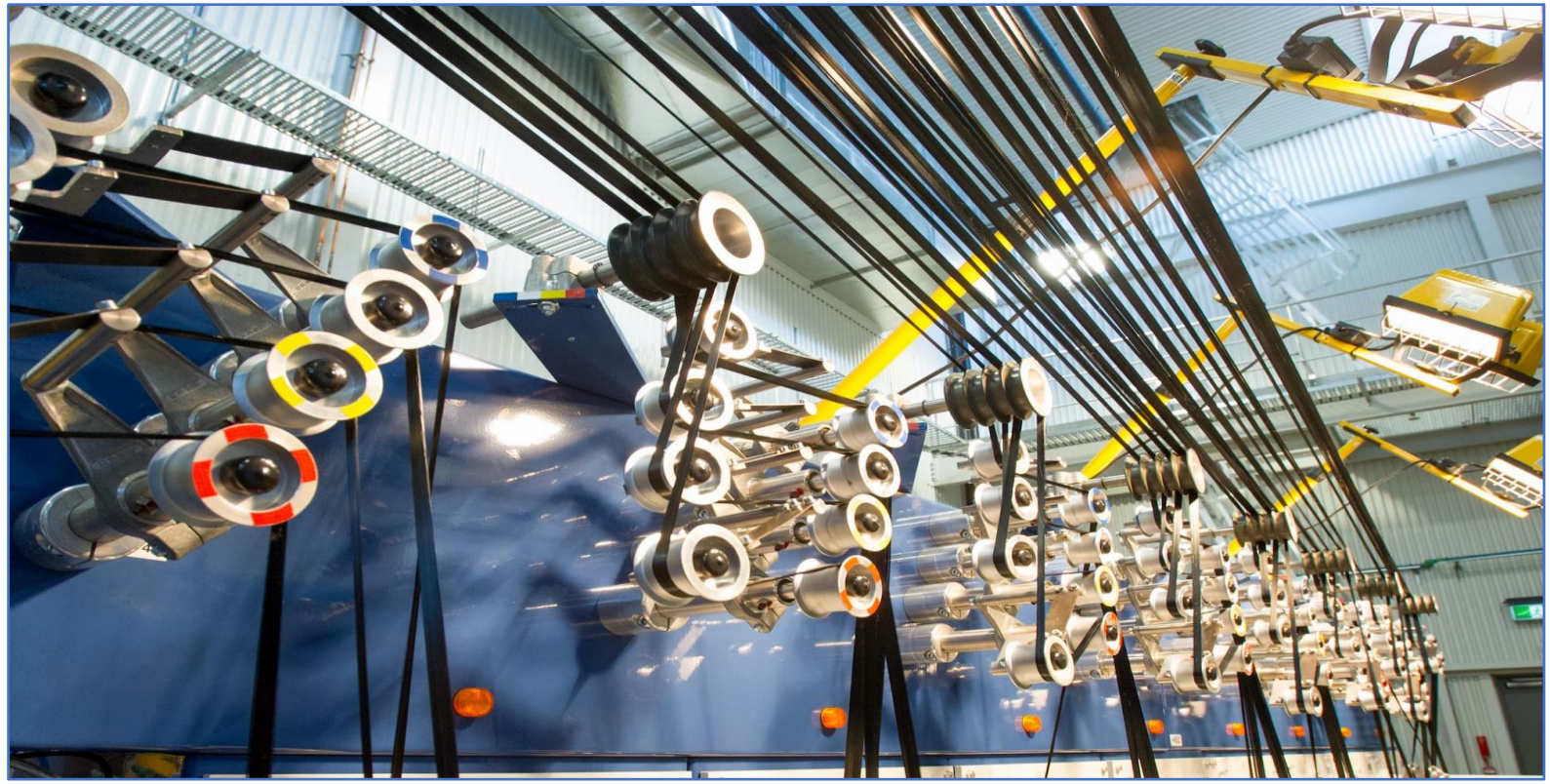

Institute for Frontier Materials (IFM)

- Engineering research
- Innovation in materials design
- Imparting materials with extraordinary functionality
- Redesigning materials for a circular economy

The Future Fibres Group

- Over 110 members
- Research-intensive Academics
  - 3 Professors
  - 5 A/Profs
  - 30+ Research Fellows
  - 65+ PhD Students
- Two Research Themes: Functionality and Sustainability
- A one-stop shop for research capability and scale: unique in the Southern Hemisphere

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Fibres, Textiles, and Composites

Multidisciplinary staff and students
Chemists, biochemists, physicists, materials scientists, fibre scientists, textile engineers, and engineers

Expertise across the fibre and textile value-chain, with a focus on improving the **sustainability of the industry** without compromising functionality, using a highly collaborative framework.

Peter
Advanced X-Ray
InSitX, Synchrotron

Luke
CF Surface Chemistry
High Value CF

Minoo
Solving Plastic Waste
CF Precursors

Claudia
CF Precursors
CF Composites

Chris
Textile Engineering
Protective Textiles

Rangam
Fibre. Powder, Silk
& Textile Engineering

Maryam
Natural Fibres
Sustainable Packaging

Ale
Textile Coatings
Microplastics

Jingliang
Textile Degradation
Biomimetic Scaffolds

Lingxue
Membranes
Clean Air &Water

The Future Fibres Facility

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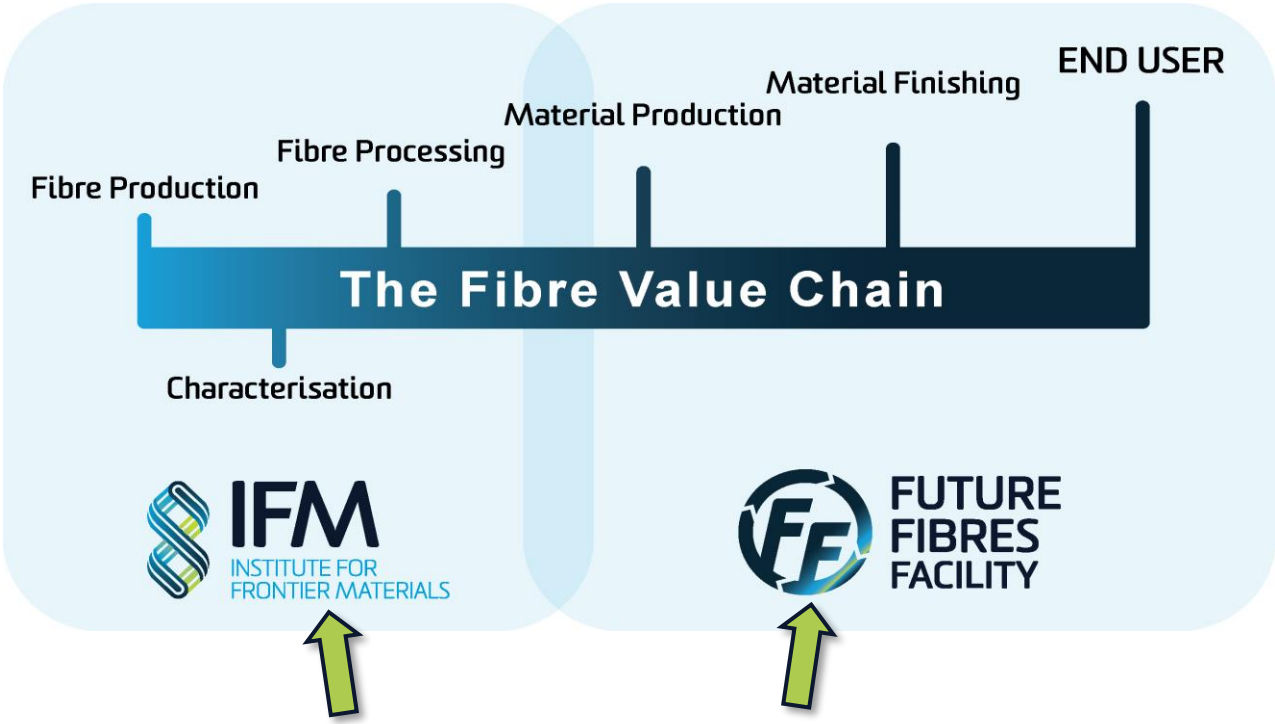

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Translational research – Bench to Pilot Scale

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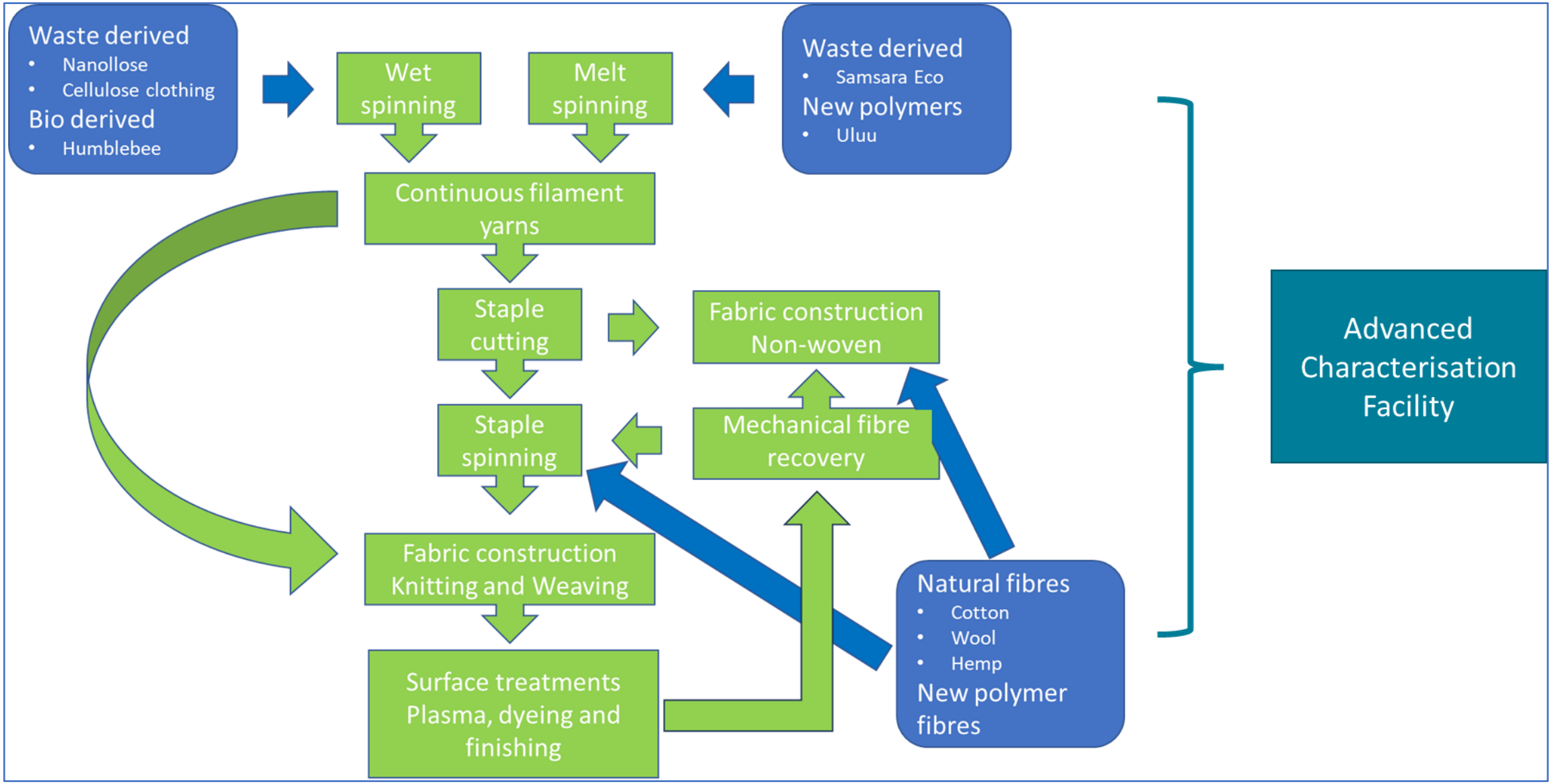
The Future Fibres Facility



Polymer Spinning Process

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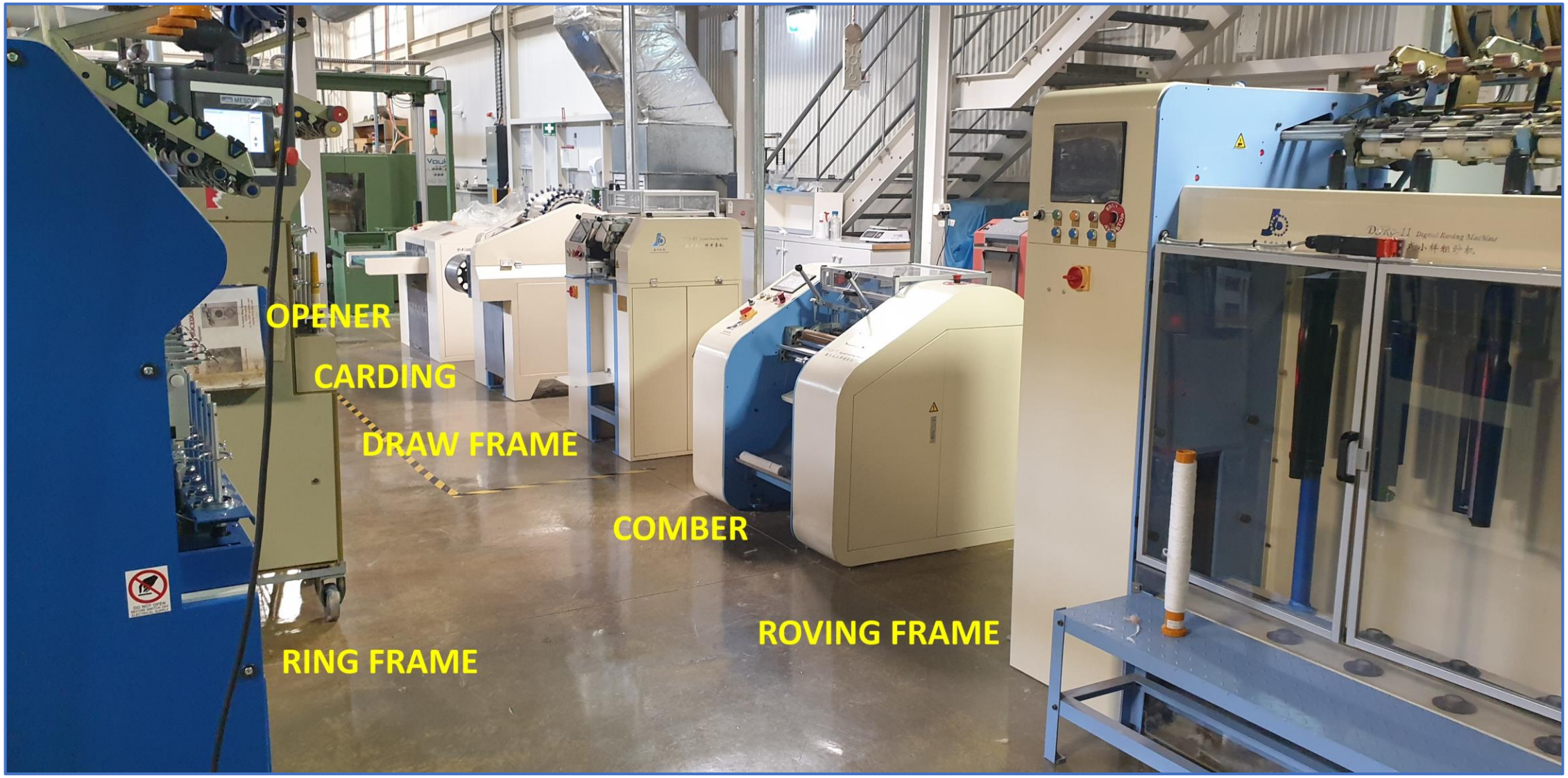
nanollose

Sample-scale Short Staple Spinning



Pilot-scale Short Staple Spinning

Mud to Marle Project

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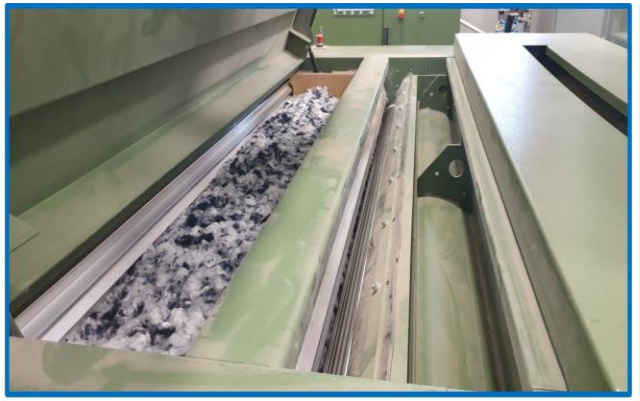

Weaving (CCI Looms)

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Knitting (Circular and Flatbed knitting)

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Pierret Cutting Machine (Guillotine)

Textile Deconstruction (Closing the Loop)

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Industry partners involved with the Future Fibres Facility

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COUNTRY ROAD

made with ulUU

nanollose

Warner Research Institute

LoomTex

lululemon

Seamless

fullcirclefibres

MICHELL 1870

WE ARE WOOL

RMIT UNIVERSITY

samsara eco

KNOVUS

CSIRO

HEIQ

xefco

ANFF

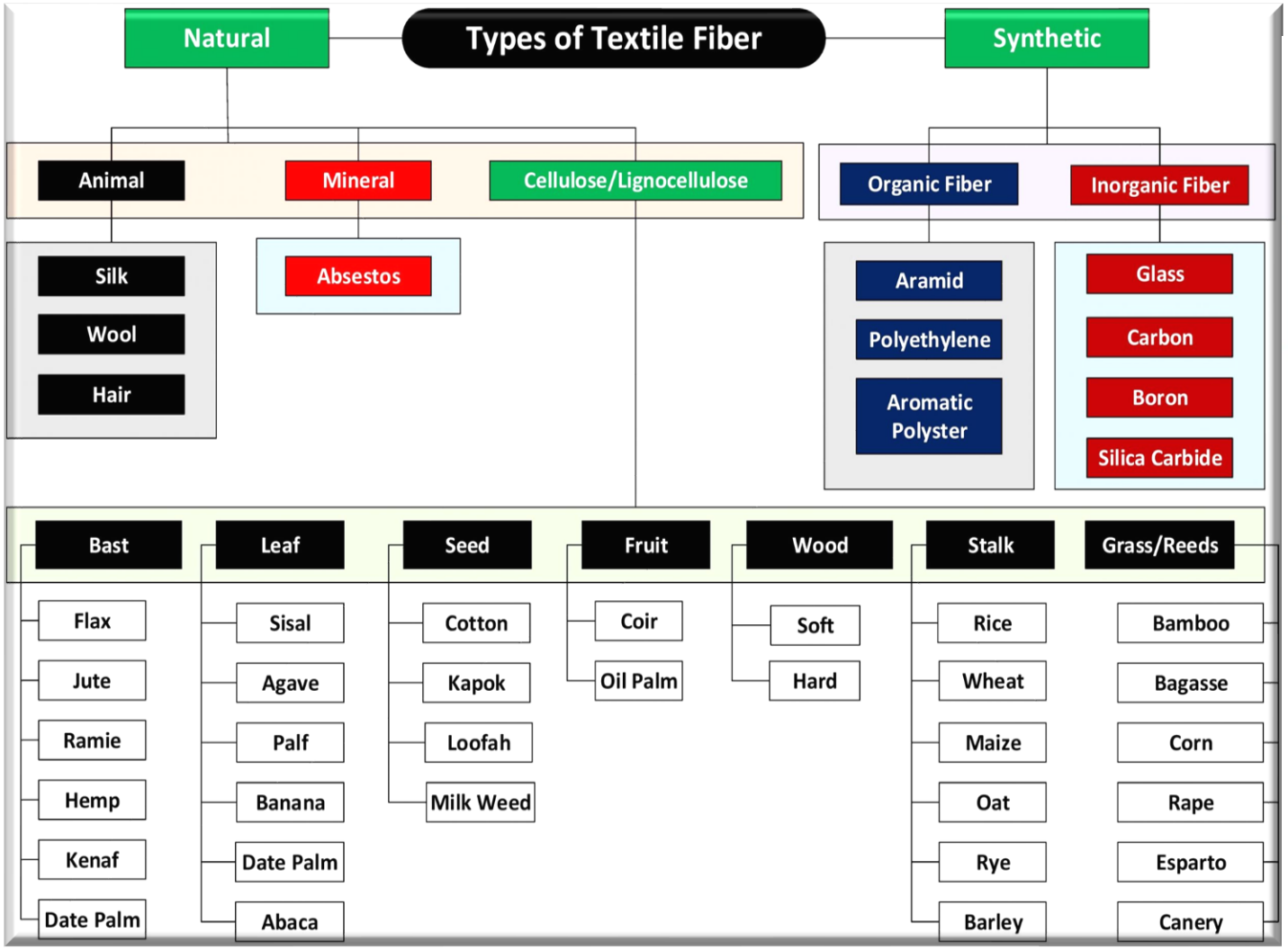
Simba Global

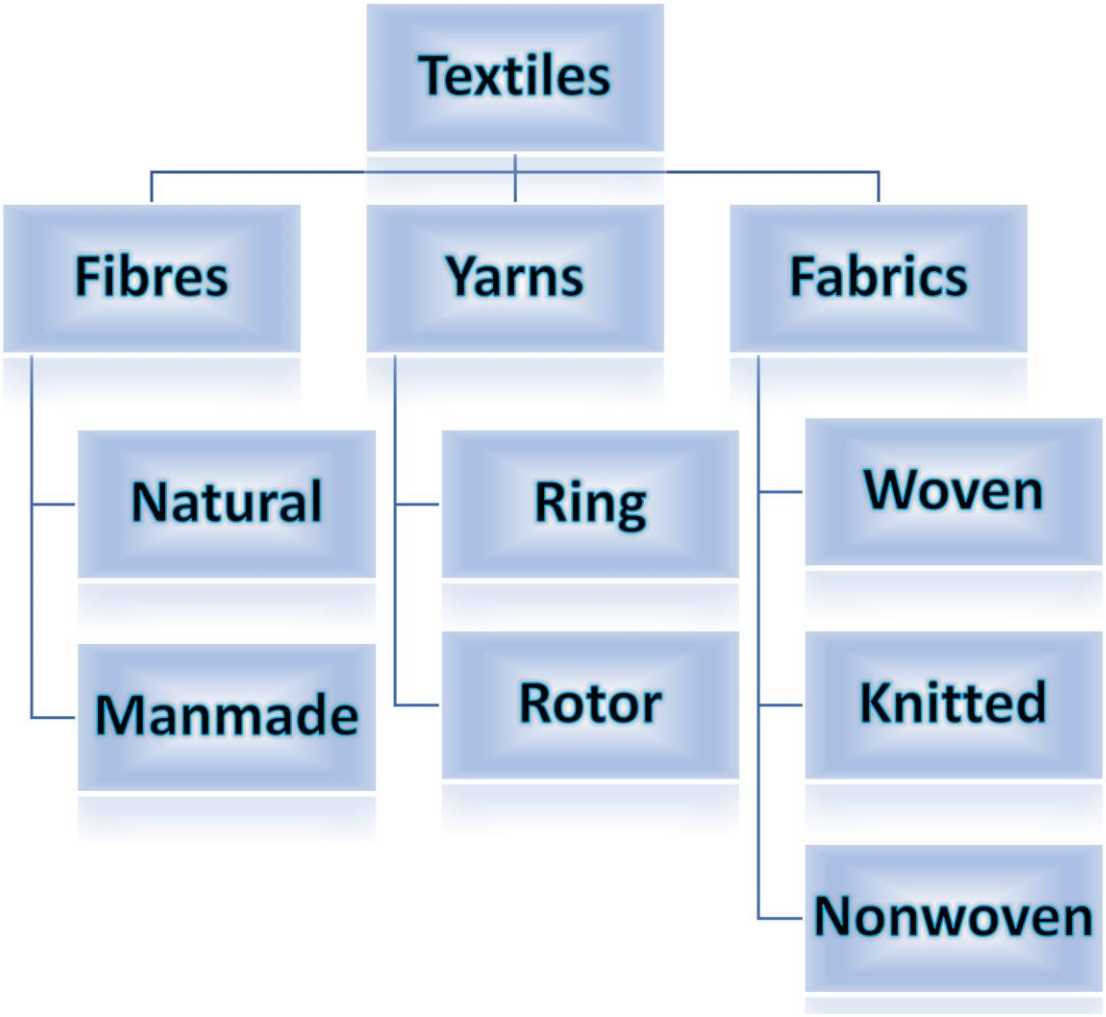
Spinning Process of Cotton-Eqwools Blended Yarns

Dr. Md Abdullah Al Faruque
Associate Research Fellow
Institute for Frontier Materials – Deakin University

The Spinning Process

The spinning process is the **industrial method** used to convert **fibres (natural or synthetic)** into **yarn**, which is then converted into **fabrics** using weaving, knitting, or nonwoven processes.





World's Textile Fibres production and Consumption

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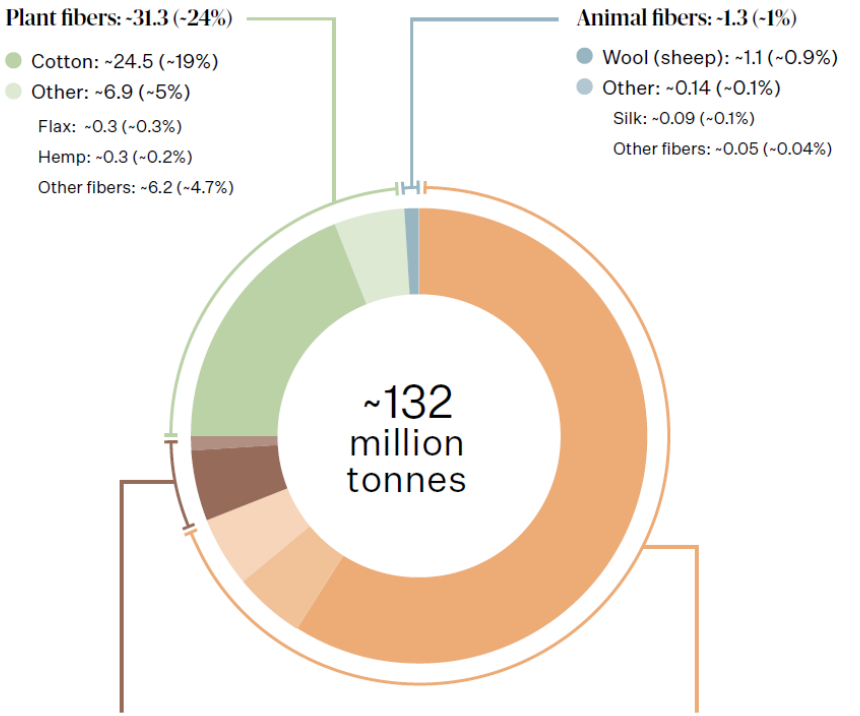
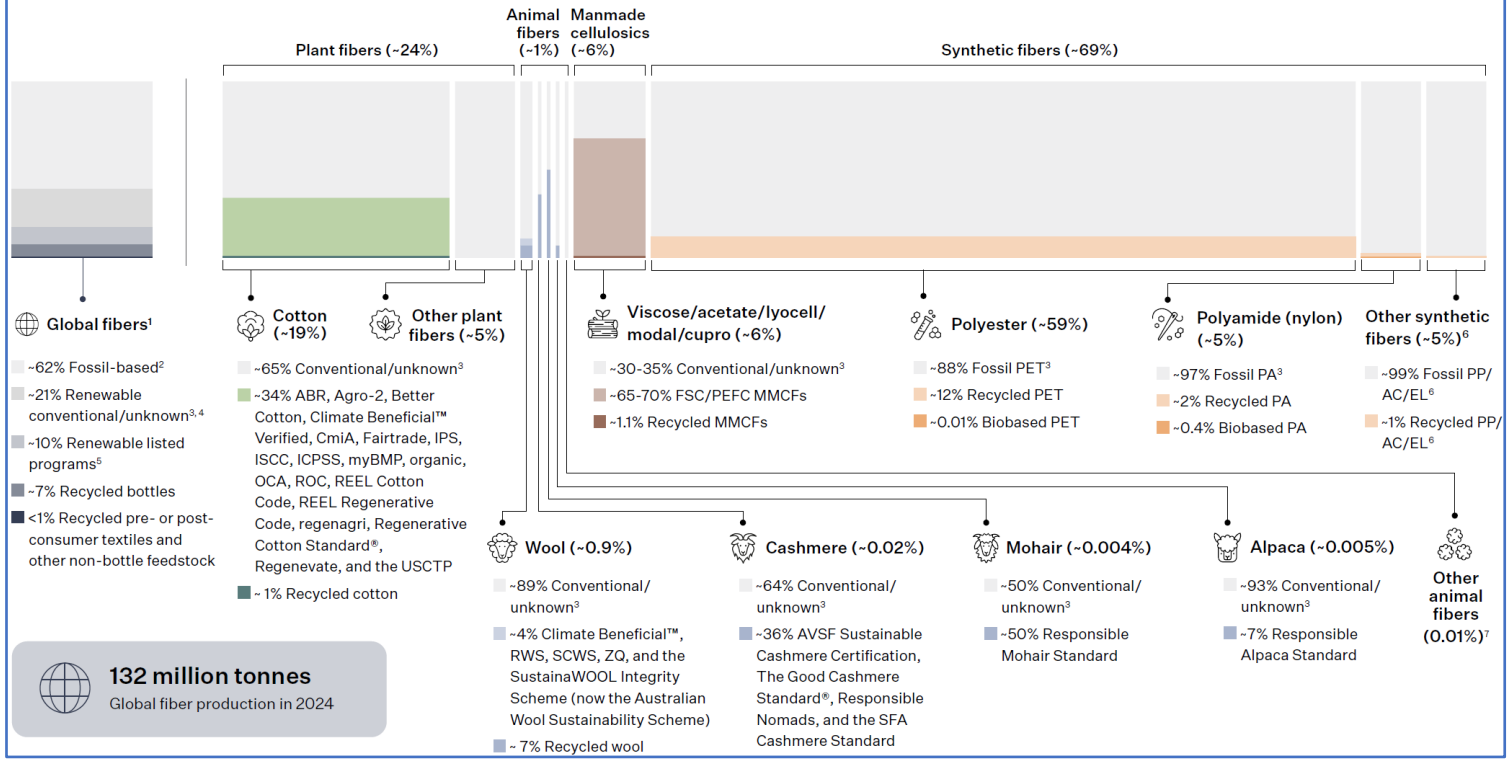
Global fiber production in 2024
(in million tonnes and % of global fiber production)

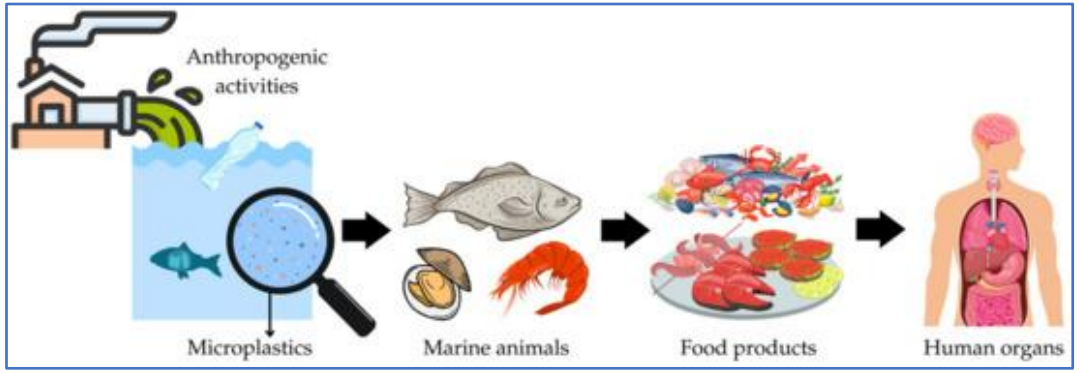


Source: Textile Exchange based on data from CIRFS, FAO, ICAC, IVC, IWTO, Maia Research, Mohair South Africa, and its own modeling.

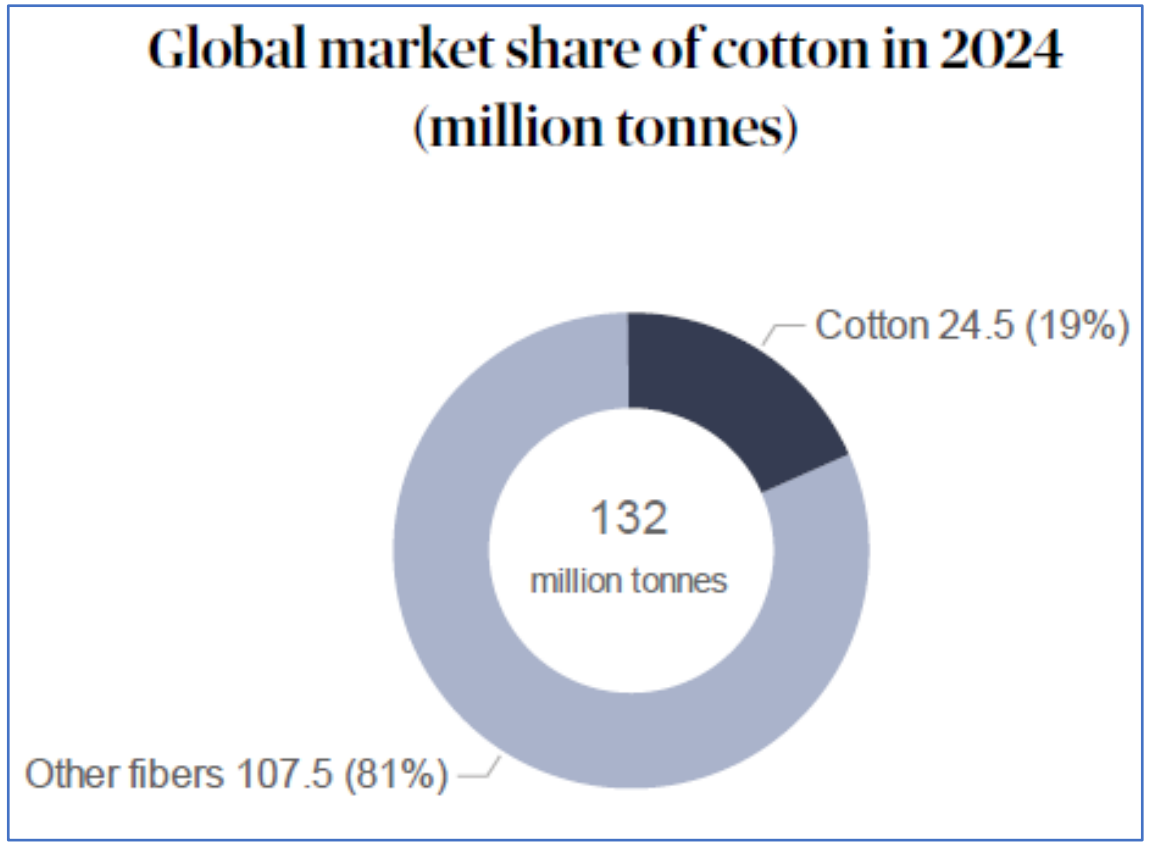
NOTE: This chart includes recycled fibers. Other animal fibers included here are alpaca, angora, camel, cashmere, guanaco, llama, mohair, vicuna, and yak. Other plant fibers included here are jute, coir, sisal, abaca, ramie, kenaf, kapok, and agave. Leather, down, and rubber are not included as they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

The global fiber market 2024: Program overview





World’s Textile Fibres production and Consumption



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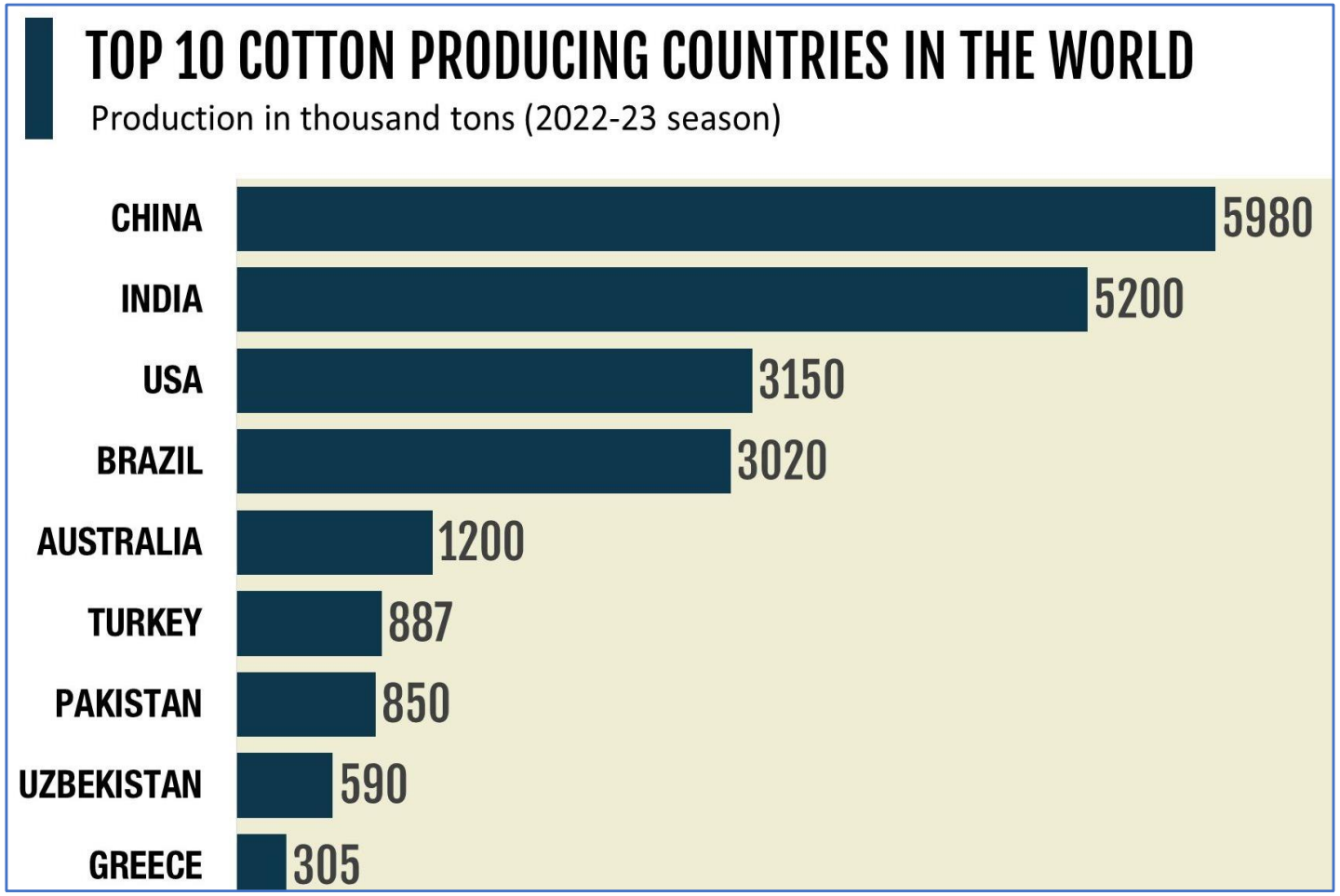
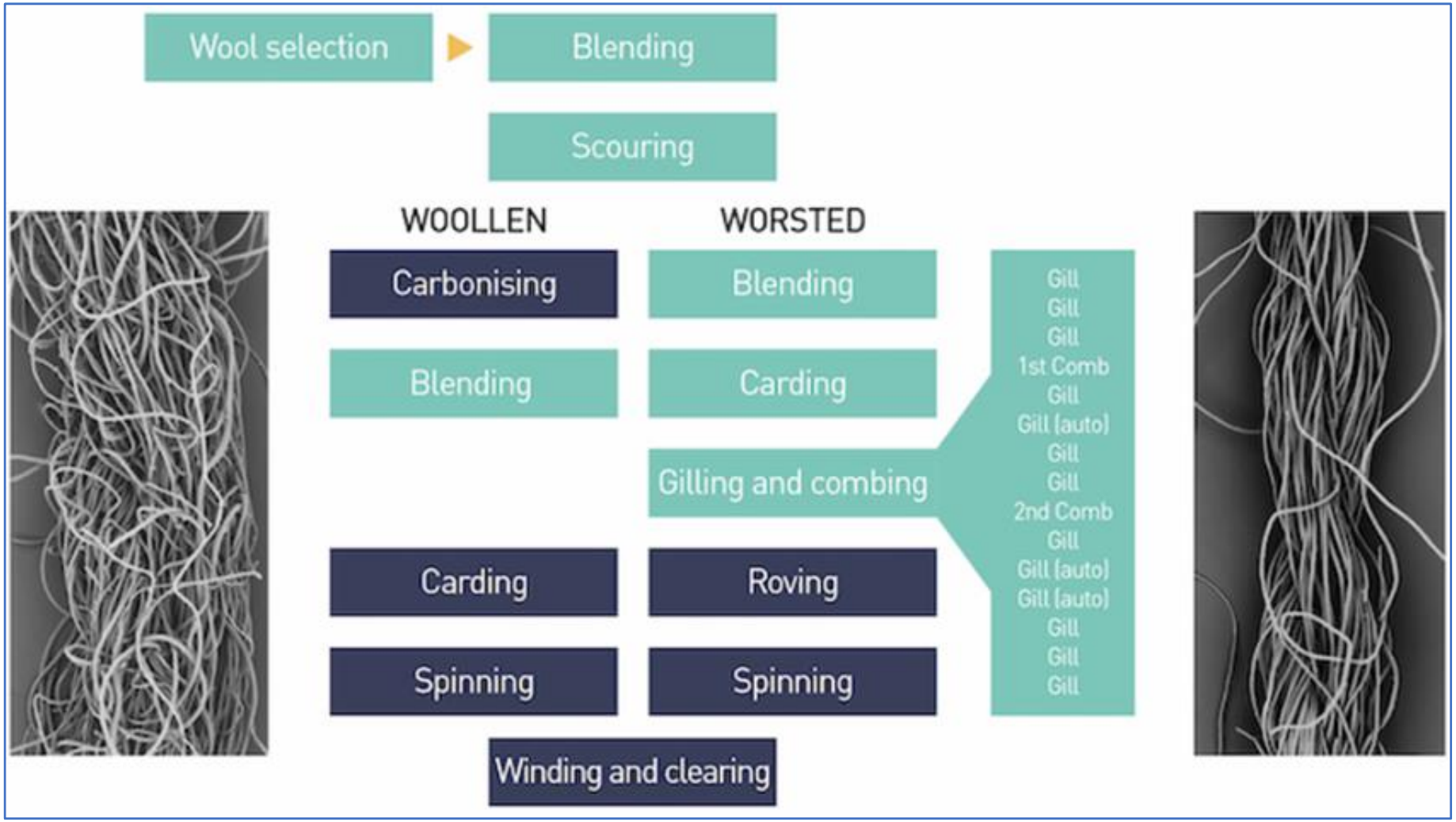
World's Textile Fibres production and Consumption



- Nearly 5% of global cotton production.
- Australia is the 3rd – largest cotton exporter.
- Asia is the main consumer.
- High-quality, traceability, sustainability.
- Premium quantity, longer fibre length and can be spun into finer yarn count.
- Almost zero contamination.
- Produced with the highest environmental and social standards.
  - → 97% less pesticides
  - → 48% less water
  - → 34% less land

Cotton and Wool Spinning Process

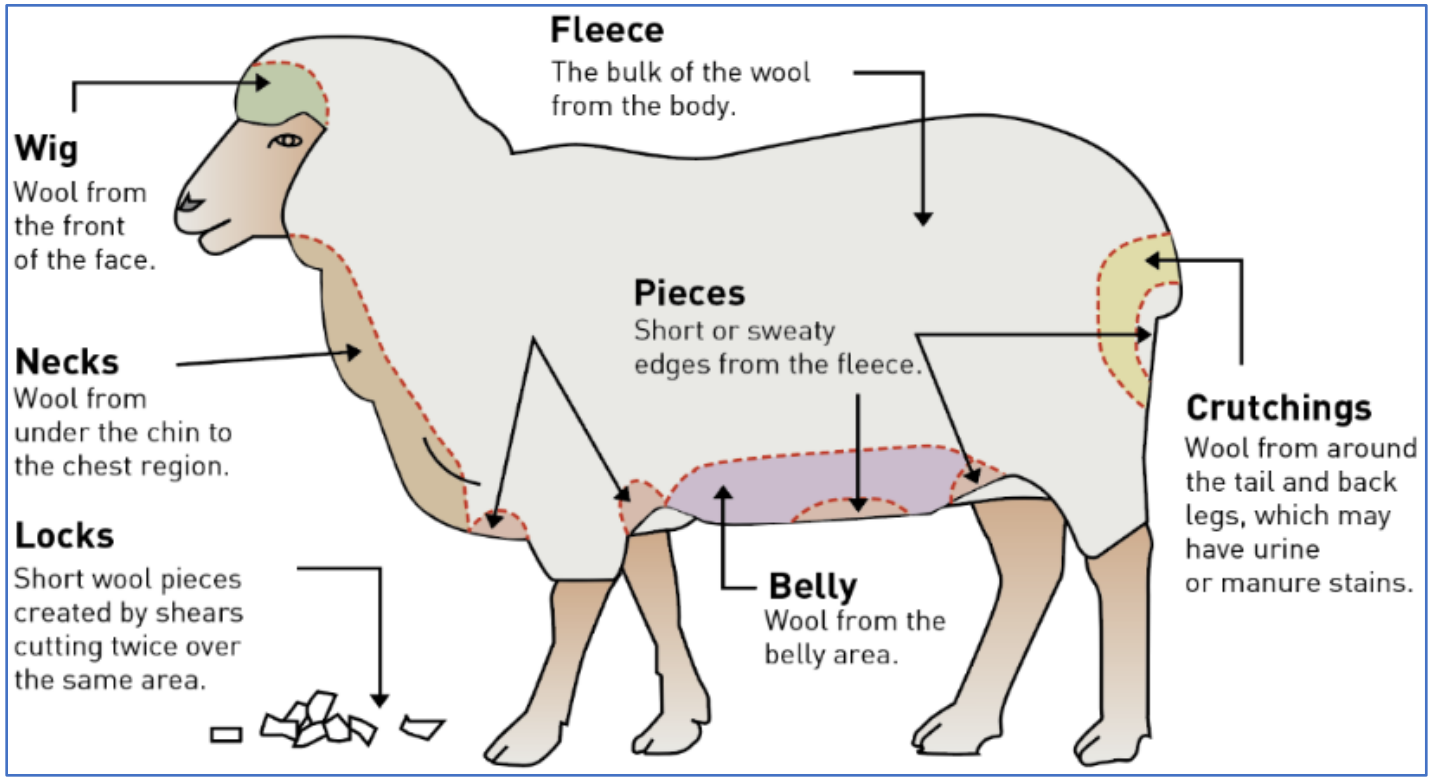


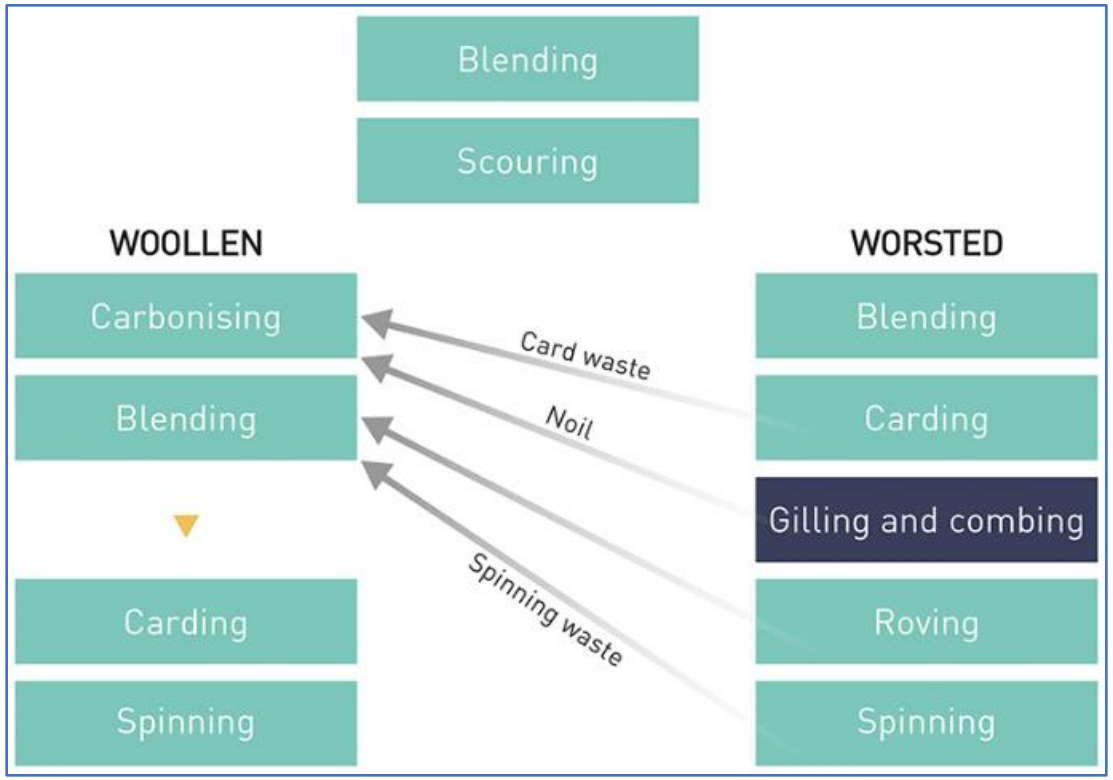
Woollen is the **short-staple wool** fibres (<50 mm).
Worsted is the **long-staple wool** fibres (>60 mm).

Scouring: Removal of grease, suint, and dirt from the fleece.
Carbonising: Removal of the remaining grease, VM, e.g., seeds, burs, and grass.

Carding: Disentangling and aligning fibres, removing VM.
Gilling: Better alignment of fibres, mix & blend fibres.
Combing: Straightening & aligning the fibres, removal of short fibres & neps, and further removal of any VM.

Collection point of wool fibres from a Sheep for spinning





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Difference between Woollen & Worsted Spinning

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Feature	Woollen Spinning System	Worsted Spinning System
Fibre Type	Short-staple wool (<50 mm) – "Carding wool".	Long-staple wool (>60 mm) – "Combing wool".
Fibre Alignment	Fibres are randomly arranged and crisscrossed.	Fibres are highly parallel and aligned.
Yarn Structure	Soft, bulky, fuzzy, less compact.	Smooth, compact, and firm.
Yarn Strength	Weaker due to less fibre alignment.	Stronger and more uniform.
Appearance	Dull and hairy surface.	Lustrous and clean surface.
Process Steps	Fewer steps (no combing or gilling).	More steps (includes gilling, combing, and drawing).
Machinery Used	Woollen card, condenser, and ring frame.	Worsted card, gill box, comb, drawing and ring frame.
Yarn Count	Coarser yarns (low count, thick).	Finer yarns (high count, thin).
Production Speed	Higher — simpler and faster process.	Slower — more precise and controlled.
Typical Uses	Sweaters, Knitwear, blankets, rugs & carpets.	Suits, gabardine, crepe, fine dress fabrics.

Why Cotton-Eqwools blended textiles?

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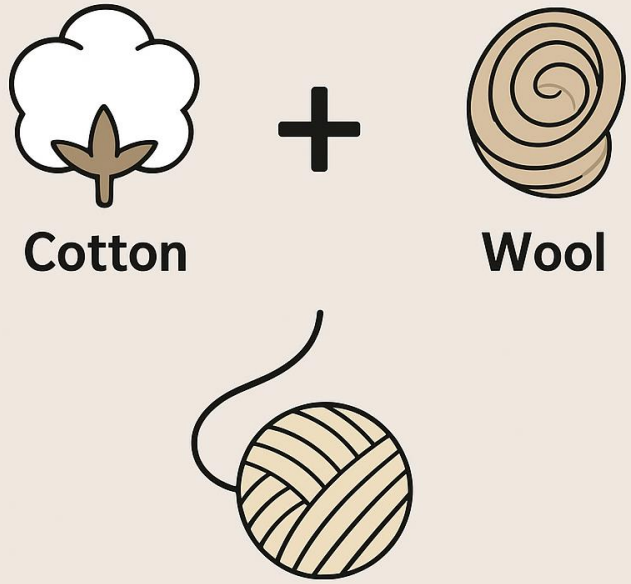
Property	Cotton Contribution	Wool Contribution	Combined Benefit
Comfort	Soft, cool	Warm, resilient	Balanced comfort
Strength	High tensile strength	Elastic recovery	Durable yarn
Warmth	Moderate	High	Thermally balanced
Moisture Control	Absorbs liquid	Absorbs vapour	Dry & breathable
Shrinkage	Stable	Shrinks	Improved stability
Cost	Low	High	Cost-effective blend



- Combines strength of cotton and warmth of wool
- Improved comfort and handle
- Better moisture management
- Cost-effective

Cost-effective value addition: **Blending cotton with short, low-value wool fibres offers the same comfort and functional benefits as fine Merino wool, while significantly reducing material costs.**

Preparation for the cotton-Eqwools spinning

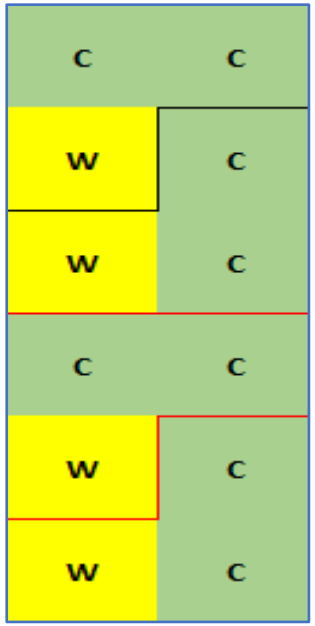
Cotton bale

Wool bale

Bale conditioning

Lubrication

Hand mixing & blending



Bale management

Why lubrication?

1. **Reduce Fibre-to-Fibre Friction:** Lower fibre breakage & improve yarn evenness.
2. **Control Static Electricity:** Stable operation on carding and spinning frames.
3. **Help in Drafting and Twisting:** Better yarn evenness and appearance.
4. **Control Fly and Dust:** Healthier workspace and reduced waste.
5. **Improve Cohesion Between Fibres:** Produces a stronger, more uniform yarn.
6. **Reduce Wear and Tear on Machinery:** Smooth operation and lower machine care.

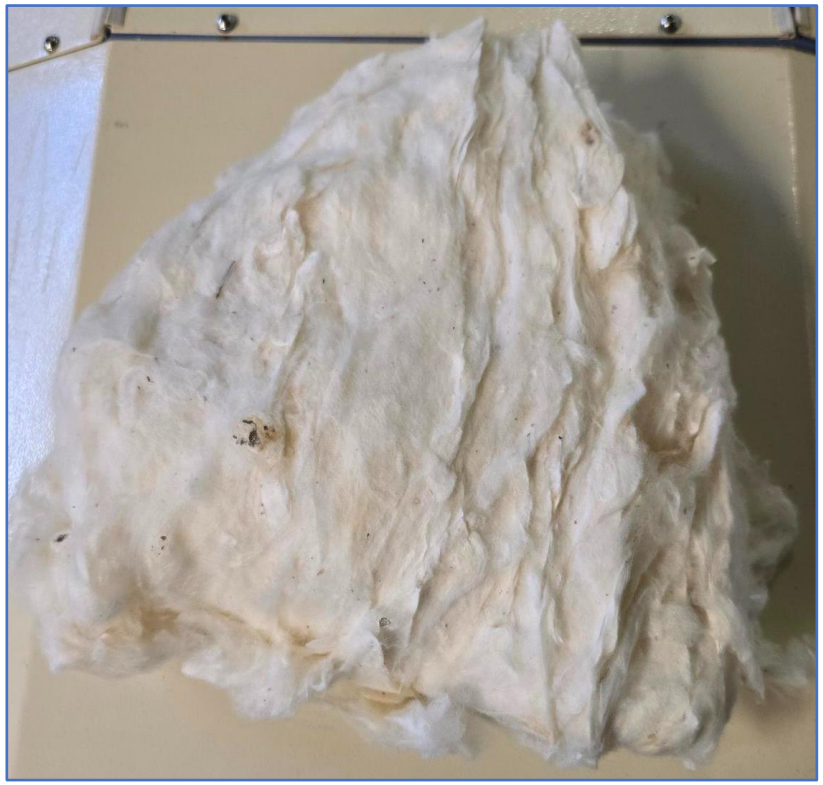
Need synthetic oil-based Lubricant

Apply 0.5-1.0% on the wt. of Wool

Apply anti-static during carding

Experiments...

Cotton spinning using unopened and opened cotton fibres.



Unopened cotton fibres

Sample opener

Opened cotton fibres

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Comparison of Opened and Unopened 100% Cotton Spg.

Sample	Wt after carding (gm)	Yarn count (Ne)	Yarn count (Tex)	Twist (TPM)
Opened - 2-pass	16.03	28	21.08	800
Unopened - 2-pass	16.48	30.43	19.42	837

Sample	U%	CV%	Thin-50%	Thick+50%	Neps +200%	IPI	Strength (cN/tex)
Opened - 2-pass	11.49	14.77	0	280	290	570	14.65
Unopened - 2-pass	12.61	16.08	25	290	185	500	11.33

- Opened 2-pass samples showed better strength (≈23%), but lower evenness (≈12%) compared to the unopened 2-pass samples.
- The cotton-eqwools blends will be spun following these:
    1. Cotton fibres will be opened before blending with eqwools.
    2. Two carding passes will be performed in the same direction.

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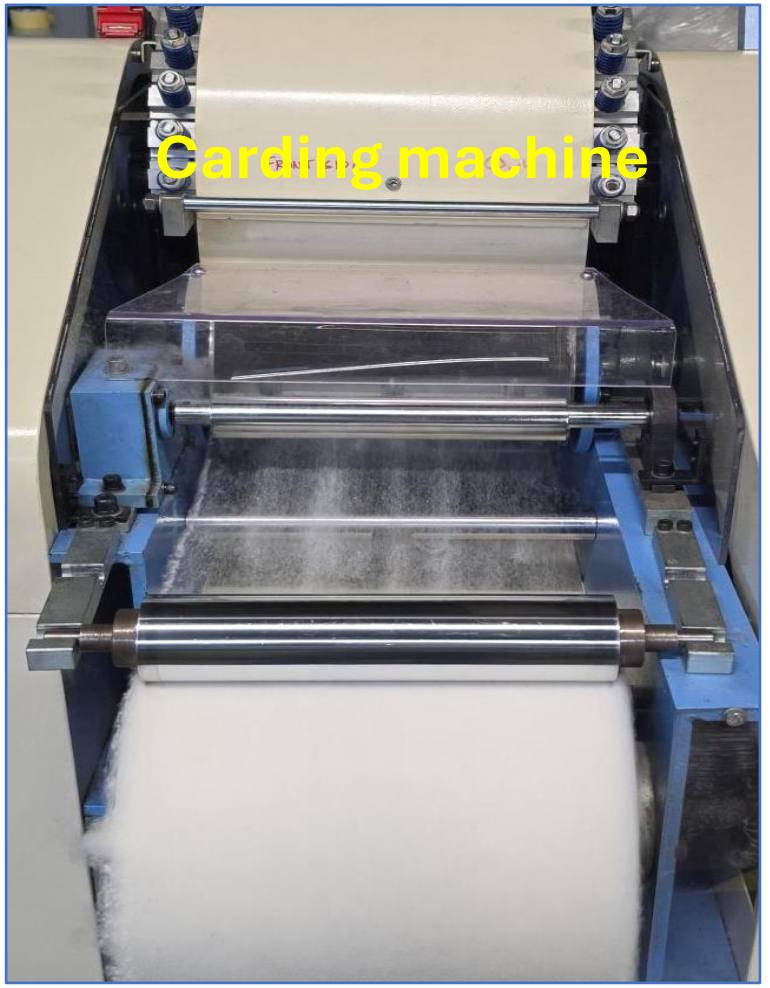
Neat Lubricant and
Antistatic agent


Opened cotton fibres


Carding machine


Lubricated Wool fibres


Blended fibres


Carded web

Cotton-Eqwools Spinning Process

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Cotton-Eqwools Spinning with different blending ratios

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- The Eqwool fibres were lubricated, and an anti-static agent was used before the carding process.

Sample	Wt after carding (gm)		Yarn count (Ne)	Yarn count (Tex)	Twist (TPM)
9010 Ctn-Eqwools - Instant	17.34	13%	28	21	797
8020 Ctn-Eqwools - Instant	16.82	16%	29	20	830
7030 Ctn-Eqwools - Instant	16.38	18%	31	19	815

Sample	Wt after carding (gm)		Yarn count (Ne)	Yarn count (Tex)	Twist (TPM)
7030 Ctn-Eqwools - Overnight	16.95	15%	31	19	830

Sample	Strength (cN/tex)	CSP	U%	CV%	Thin-50%	Thick+50%	Neps +200%	IPI
9010 Ctn-Eqwools - Instant	11.82	1938.5	14.4	18.2	295	292	232	819
8020 Ctn-Eqwools - Instant	9.55	1566.2	13.8	17.4	118	285	200	603
7030 Ctn-Eqwools - Instant	7.48	1226.7	14	18.3	115	505	390	1010

Sample	Strength (cN/tex)		CSP	U%	CV%	Thin-50%	Thick+50%	Neps +200%	IPI
7030 Ctn-Eqwools - Overnight	9.71	30%	1592.4	14.7	18.8	175	635	525	1335

Overnight lubrication showed lower fibre loss during the carding process

Higher strength

Benefits of Overnight Lubrication

1. **Better Oil Penetration and Fibre Conditioning:** Uniform lubrication that enhanced blending and drafting.

2. **Equalization of Moisture and Static:** More stable fibre behaviour ensures smoother processing and mixing.

3. **Improved Fibre Cohesion and Interlocking:** Fibres hold together, ensuring a more uniform yarn structure**.**

4. **Enhanced Fibre Migration and Distribution in the Blend:** Lower fibre clumps, more homogeneous blending.

5. **Reduced Fibre Damage:** Wool is softened and pliable, resulting in fewer neps and uniform yarn evenness.

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Drawbacks of Instant Lubrication

1. **Uneven Oil Distribution:** Oil remains uneven; some fibres remain dry, causing uneven drafting and unevenness.

2. **Inadequate Moisture Balance:** Fibres may have surface oil, but internal dryness increases fibres' brittleness.

3. **Increased Static and Fibre Fly:** Generation of higher electrostatic charges during carding & spinning.

4. **Harder Fibre Handle:** Harsh and springy wool, poor parallelization, and produces less uniform sliver and yarn.

5. **Higher Friction with Machinery:** Wet patchy wool causes slippage, drafting tension shifting & mechanical strain.

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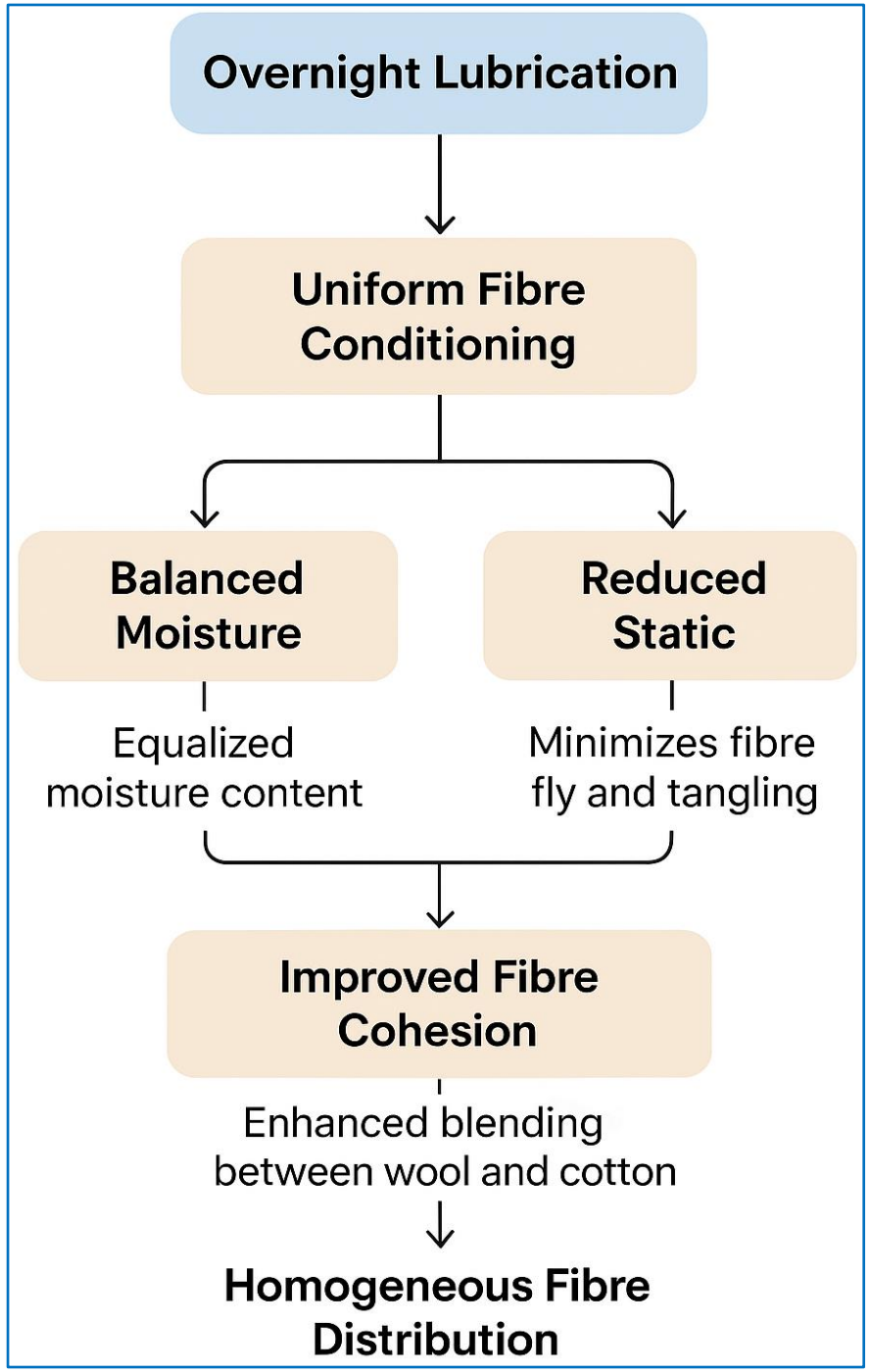

SPINNING BENEFITS

- Smoother drafting
- Uniform blending
- Stronger, even yarn
- Fewer defects

How’s the Cotton–Eqwools blending coming along?

100% Cotton

100% Wool

70:30 Cotton-wool

Conclusion and suggestions for Cotton-Eqwools Spinning

1. Cotton fibres need to be **opened properly** before mixing & blending with wool.
2. **Selection of Cotton fibre** will play an important role in the blended yarn properties.
3. Application of **0.5-1.0% lubricant on the weight of wool fibres** and keep **overnight/8-10 hrs.**
4. Cotton-Eqwools blended materials can be run at the **same speed** as cotton fibre.
5. However, some slight speed adjustments may be needed.
6. **Still, the production speed of the cotton-eqwools blend will be higher on the cotton system.**
7. **Further research is underway, exciting developments ahead — stay tuned!**

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Activities in the ARC Research Hub for Future Fibres, Future Fibres Group and Future Fibres Facility are supported in whole or in part by the Australian Research Council (ARC IH21000023) and the Australian National Fabrication Facility (ANFF – Victoria)

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