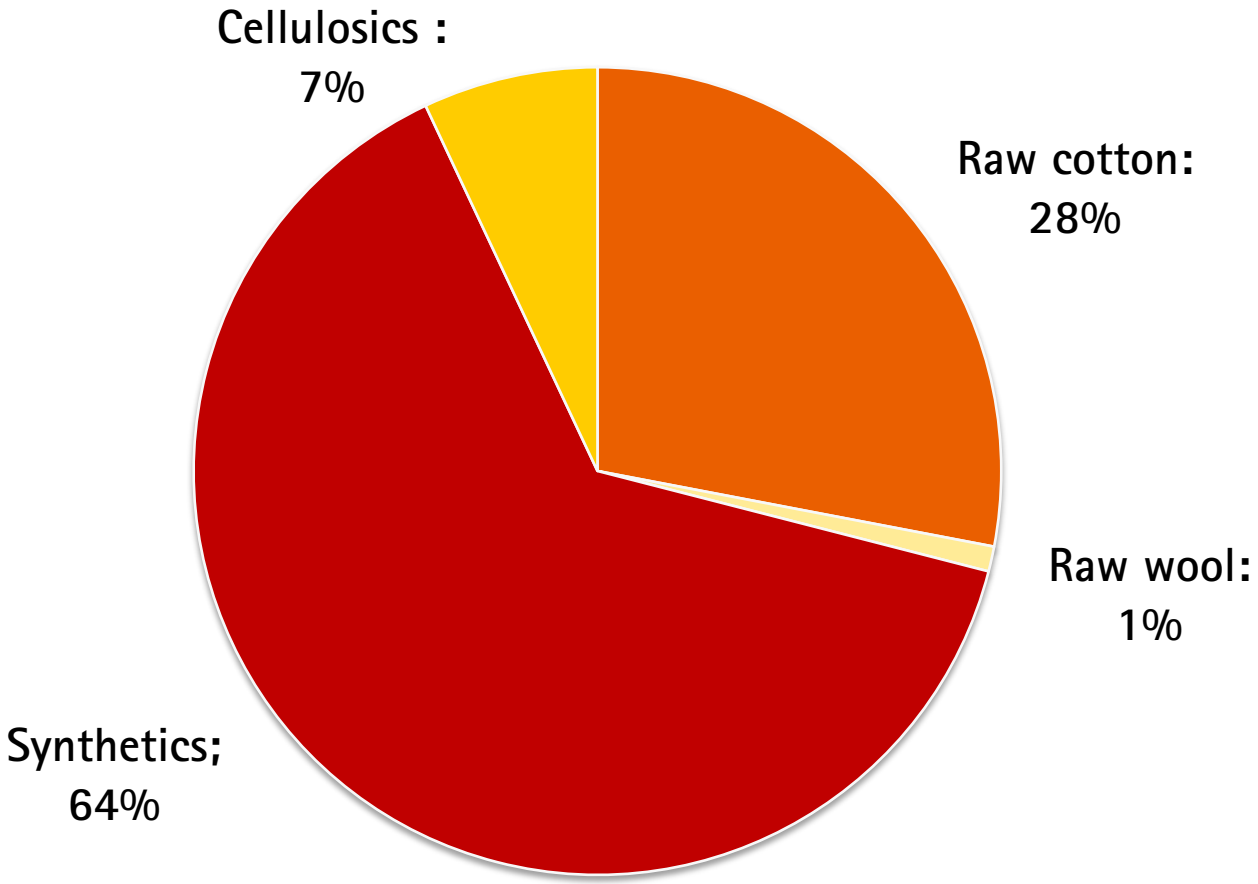
# Textile fibres –
## sustainability relevant aspects

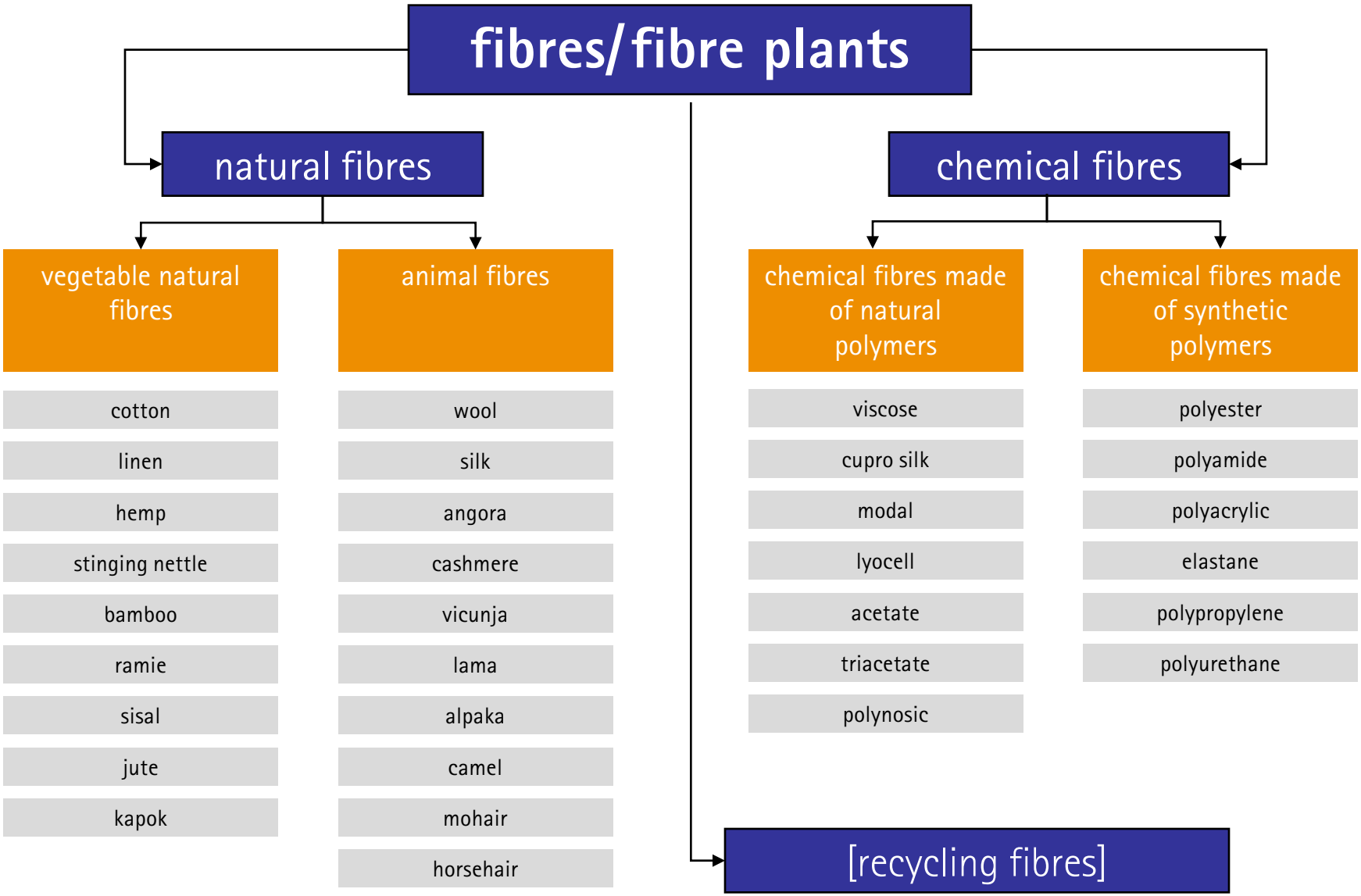
Heike Scheuer, International Association of Natural Textiles

# World production of textile fibres




Source: International Rayon and Synthetic Fibres Committee CIRF

# overview fibres



# White Gold –

## ecological + social challenges of cotton production

# overview

- history
- producing countries
- market figures and availability
- ecological challenges
- social challenges
- comparing labels
- properties and use

# history of cotton

**cotton (Gossypium)**

- cotton: arabic for „qutn“ [kutt:n]
- Textile Labelling Act:

  „fibre obtained from bolls of the cotton plant“
- international abbreviation: CO

**Organic cotton:** legally protected claim

EU-eco Regulation of the European Council

National Organic Program

Textile Exchange

# history of cotton

around 7000 B.C. > non verifiable reference in Egypt

around 1500 B.C. > proven source: Rigveda
the cultivation of cotton was mentioned for the first time in India

16th century > cotton was a luxury good
cultivation mainly in India
trade in Middle East

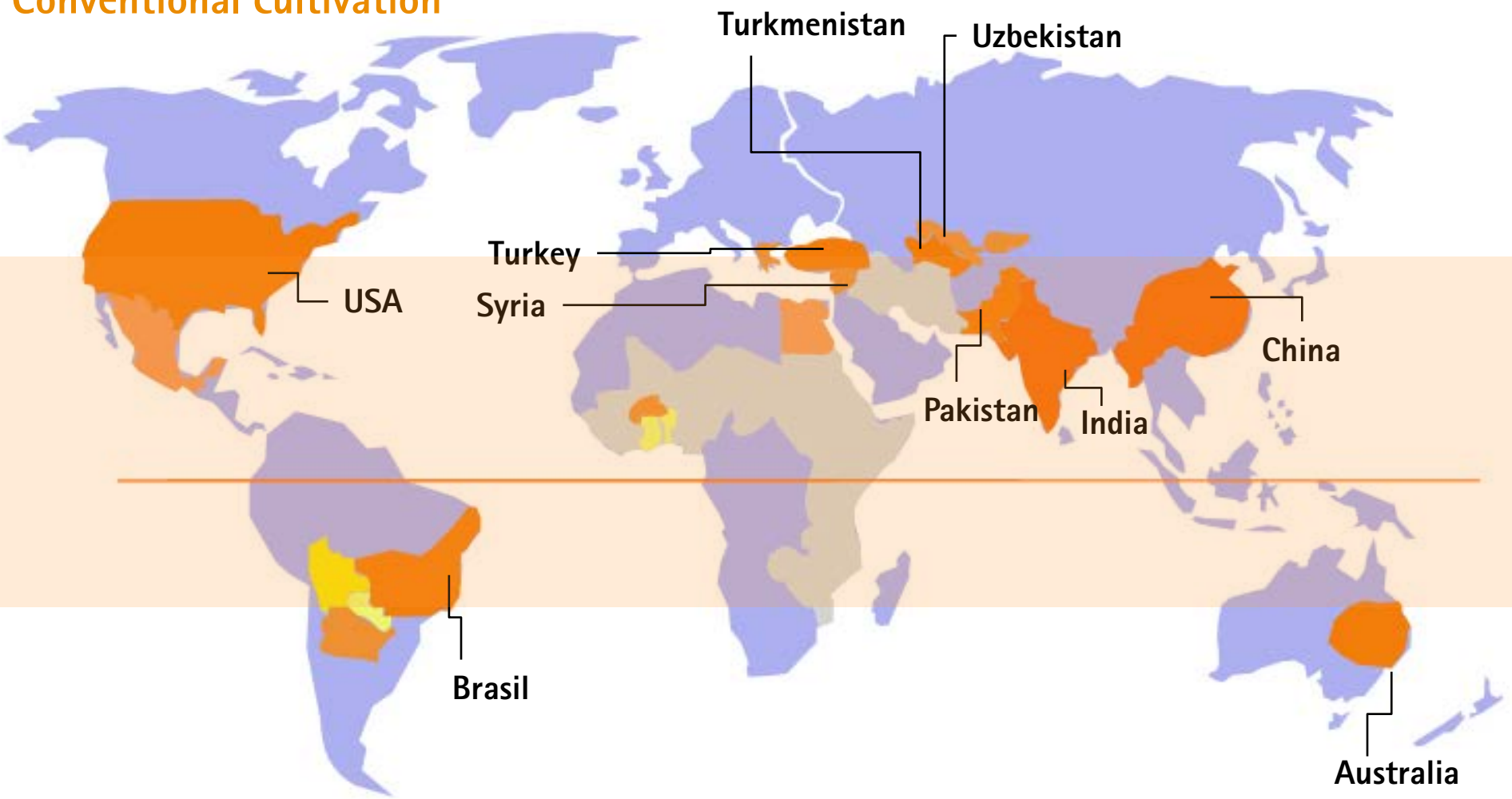
17th century > England imports cotton fabric
high period: during industrial revolution in England
hemp and linen get driven out

20th century > cotton gets driven out by man made fibres

2007 > EU-eco Regulation
defines organic cotton

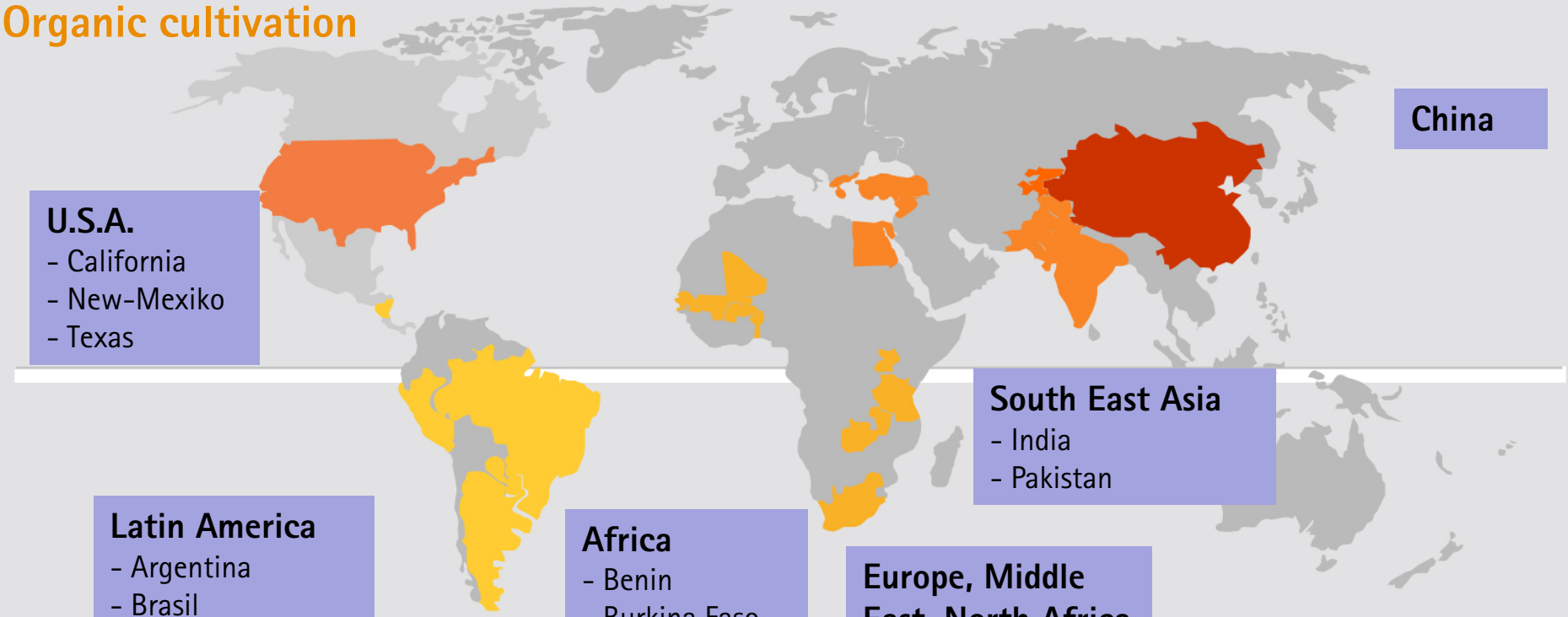
# conventional cotton versus...

## Conventional cultivation



# ... organic cotton

## Organic cultivation



**U.S.A.**
- California
- New-Mexiko
- Texas

**China**

**South East Asia**
- India
- Pakistan

**Latin America**
- Argentina
- Brasil
- Nicaragua
- Paraguay
- Peru

**Africa**
- Benin
- Burkina Faso
- Mali
- Senegal
- South Africa
- Tansania
- Uganda
- Sambia

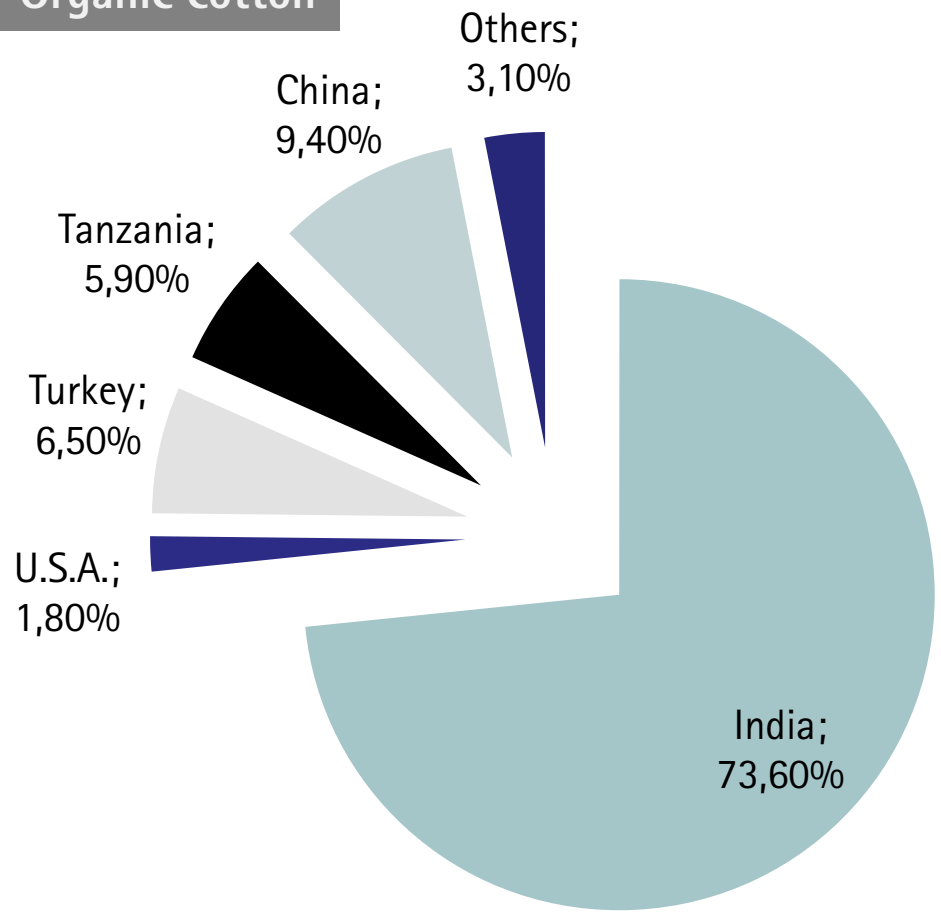
**Europe, Middle East, North Africa**
- Egypt
- Israel
- Greece
- Kyrgyzstan
- Syria
- Tadzhikistan
- Turkey

**Source: Textile Exchange**

# market share of cultivating countries

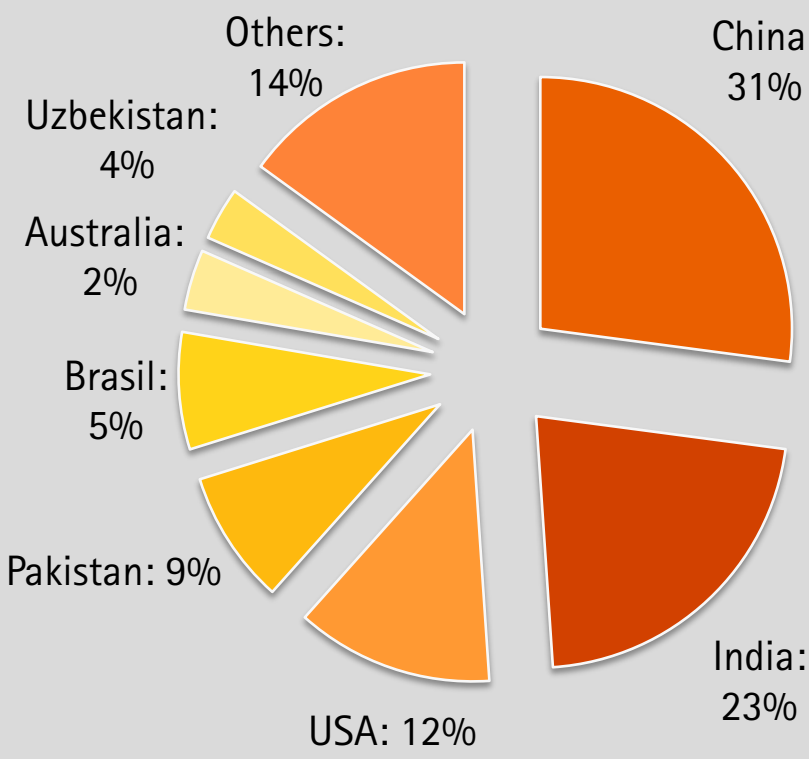
## Cotton production in 2012/13

### Organic cotton




Source: Textile Exchange -farm and fibre report 2012/13

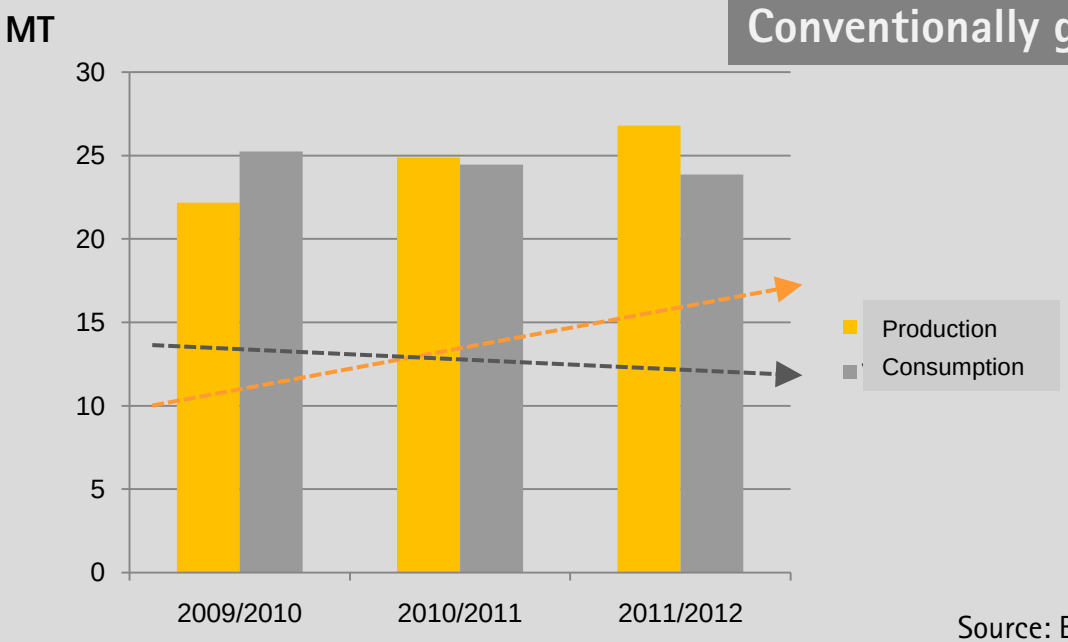
### Conventionally grown cotton




Source: USDA March 2012

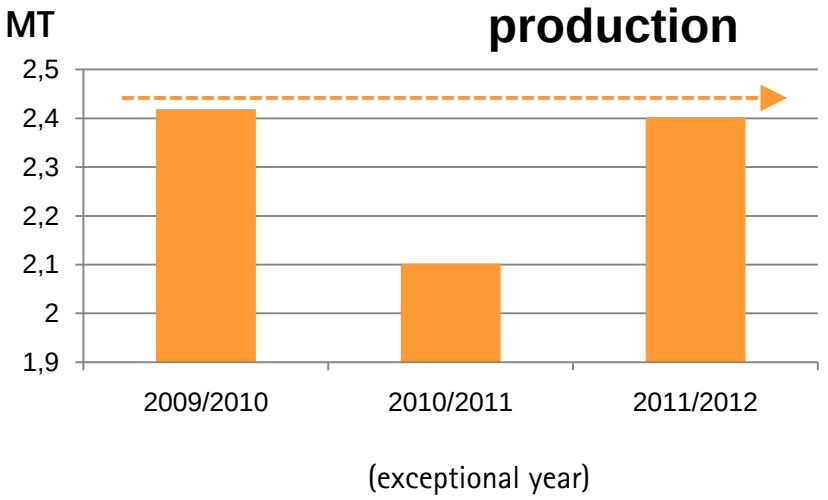
# global production & consumption

## Conventionally grown cotton

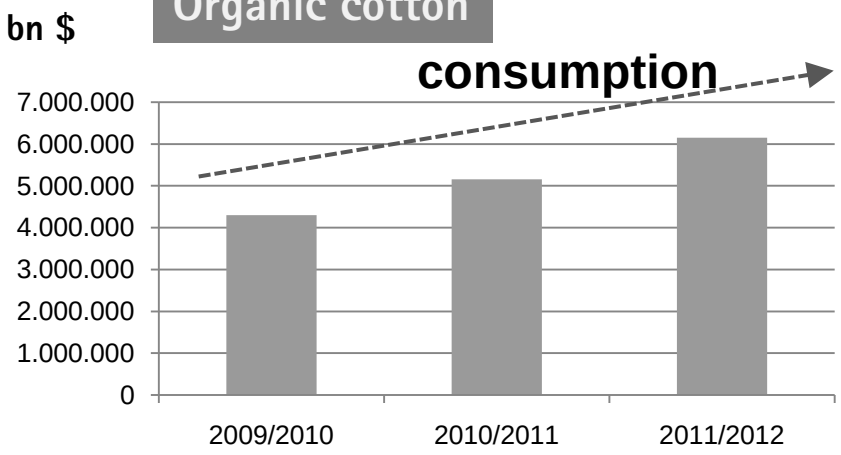



Source: Bremer Baumwollbörse

## Organic cotton




(exceptional year)




Source: Textile Exchange

# facts and numbers

## Conventionally grown cotton

| | |
|---|---|
| **25.635.000** | tons of CO produced |
| **1,5 %** | growth in comparison to previous year |
| **nearly100** | countries produce CO |
| **over 27 M.** | people make their living from cotton |
| **37 M. ha** | were used 2009 for cultivating CO |

0,09% market share

## Organic cotton

| | |
|---|---|
| **117.000** | tons of organic CO produced |
| **10 %** | growth in comparison to previous year |
| **23** | countries produce organic CO |
| **275.00** | people in Africa make their living |
| **460.000 ha** | used 2009 for cultivating organic CO |

Source: Textile Exchange, PAN, transgen

# ecological challenges

## Conventionally grown cotton

- CO grows on around 2,5 % of the global agrarian surfaces
- CO swallows up 11% of all pecticides (16% insecticides)
- soil contamination by synthetic fertilisers and herbicides
- increased pressure through monocultures
- biodiversity deteriorates through pesticides

## Organic cotton

bollworm

- no use of synthetic crop protection or fertiliser
- plant based measures, humus, collecting insects
- crop rotation
- accompanying cultivation for shaddow and shelter
- choice of location
- no monocultural cultivation

# ecological challenges

## Conventionally grown cotton

### water consumption

- over 50% of all CO grows on artificially watered fields
- between 10.000 to 30.000 l $H_2O$ to water 1kg of CO
- water from soil drilling, seas or river
- surface irrigation: evaporation up to 60%
- drinking water polluted through pesticides
- soil salination and erosion
- high water consumption for dyeing and finishing

Aral sea

## Organic cotton

### Alternatives in projects

- around 30% rainfed (no irrigation needed)
- drip or furrow irrigation saves up to 40% water
- 7000 l water used per kg CO
- healthy soil accumulates more water

# ecological challenges

## Defoliants for mechanical harvesting

- cotton harvested by strippers while the leafs still are green would be interspersed with green snippets and no longer white
- premature ripening guarentees simultaneous ripening bolls
- opened bolls absorb neurotoxin (nerve poison)
- medium-term devastation of the soil
- biodiversity is endangered
- groundwater pollution

**Conventionally grown cotton**

**Organic cotton**

## Organic cultivation

- prohibition of defoliants
- harvested by hand during a specific period of time

# ecological challenges

## facts:

**Genetically modified cotton**

- no satisfactory research
- 2014: 68% global market share on GM cultivation

## genetic engeneering – why?

- insect resistance, herbicide tolerance, fungicide resistence
- saving of pesticides and labour
- increased profits ??
- other possibilities: fibre quality, water consumption, climate etc.


**Organic cotton**

## facts:

- GMOs are forbidden in organic cultivation

GREENPEACE

## genetic engeneering – why not?

- infertility, cost expenditure / dept traps
- insects develop resistance
- uncontrolled experiment without any reversability
- contamination / coexistence

# ecological challenges

## Missuse of soil

**Conventionally grown cotton**

- GMO's and pollutants endanger biodiversity of soil life
- monoculturs lead to soil erosion
- fertilisation of soil by excessive use and overexploitation
- soil compaction through machines
- comparably low area output >> occupancy of agricultural areas
- water pollution through usage and erosion

## organic cultivation:

**Organic cotton**

- no use of pollutants
- avoidance of monocultures
- smaller harvest size
- hand harvesting and soil tillage
- crop rotation
- smart watering

# ecological challenges

## Within the production chain

**Conventionally grown cotton**

- bleaching with chlorides
- optical brightening
- mercerizing
- dyeing with polluting colours
- finishing (grip, pleasant feel, ioning free etc.)

## Eco production:

**Organic cotton**

- bleaching with oxygen environmentally compatible
- mechanical yarn treatment
- environmentally compatible colours
- no synthetic finishings allowed or environmentally compatible chemicals

# social challenges

## Intoxication by pesticides and chemicals

- poverty (no ressources for protective clothing)
- lack in education (reading instructions, no trainings)
- lack in awareness (no reuse of chemical canisters)
- sandblasting / potassium permanganate

**Conventionally grown cotton**

estimated 5m poisonings and
200.000 deaths in the last 10 years

**Source: PAN Germany**

HELVETAS
Handeln für eine bessere Welt

FAIRTRADE

## cultivation projects:

- protective clothing provided
- trainings, consultings, apprenticeships
- mutual support of farmers
- information given out in local languages
- higher income through bonus and organic cultivation

# social challenge

iVN

## Conventionally grown cotton

### child and slave labour

- school slaves in Uzbekhistan
- within families (leave school)
- sweatshops (10-12 hours without any breaks)
- Sumangali in India
- child labour in Indian cotton industry estimated on175.000

## Fairly traded cotton

FAIR WEAR FOUNDATION

FAIRTRADE

### projects and initiatives:

- campaigns and PR
- ban of child labour
- financial support
- schooling projects
- fair pay

BCI Better Cotton Initiative

COTTON MADE IN AFRICA

CIR

Kampagne für saubere Kleidung

Clean Clothes Campaign

# plant fibres

**cotton (gossypium)**

- botanic family of malvacae (cocoa, rose)
- seed fibre: Lint = extension of seed epidermis
- there are around 50 gossypium species
- only 4 of them comercially grown species
- normally persevering, still cultivated for one year
- 8 to 9 month from seed to crop
- grows 25 cm to 2m high
- on13 $m^2$ soil grows about1 Kilo CO

# fibre properties of cotton

## Cotton and ist properties

- skin-friendly and does not scratch
- breathable, unless it's not woven too dense
- high moisture absorbtion (65 % deadweight)
- dries slowely
- heat and alkali resistent, thus washable, longlasting
- tenacity and stability lower then bast fibres
- elasticity higher then bast fibres
- does not melt
- mothproof, but prone to mould
- warms not very well
- wrinkles easily and can shrink
- more tearproof than wool and silk

# quality of cotton

**Size matters.**

- Cotton is evaluated by ist staple length (fiber length).
- The longer the staple is, the higher ist quality
- three categories:
  - staple length of over 32 millimeters
    (about 10% fibers)
    Gossypium barbadense (Mako, Pima, Sea-Island)
  - staple length of 25 to 30 millimeters
    (about 90% fibers)
    Gossypium hirsutum (Upland)
  - staple length < 25 millimeters
    (about 2% fibers)
    Gossypium arboreum und
    Gossypium herbaceum

Source: The World Bank

# Bast fibres: hemp

# history

| | | |
|---|---|---|
| **10.000 B.C.** | >> | First archeological hints on hemp fabric in Asia |
| **1937** | >> | First prohibition law in the U.S.A. connecting it to marihuana |
| **After 1945** | >> | Hemp loses its importance due to technical evolvement of cotton and synthetic fibres |
| **1982** | >> | Restrictive drug policies lead to prohibition of cultivating hemp in some European countries |
| **1996** | >> | Ban on cultivation was lifted in Germany |

# properties of hemp

## Legal drug consumption

- one of the highest yielding renewable raw materials (in terms of tons per ha)
- no electrostatic charge
- low elasticity
- absorbs moisture and dries fast
- firm and strong fibre (gets stronger through moisture)
- wrinkles less then linnen and cotton
- rots very slowely

# ecological advantages and challenges

**Hemp farming: easy going**

- main ecological advantage:
  the whole plant can be used
- pioneer plant –
  robust and non demanding
- technical know how: lost

# ecological challenges

## Convetionally grown hemp

- **traditionally** not dependent on the use of pesticides however industrial agriculture brought about **ecological challenges**:
- growth hormones used for depilation
- fungizides used while water retting
- water or chemical retting: high water consumption and chemical input

## Organic hemp

- mechanical measures
- healthy topsoil
- enough space for plants

The cultivation of organic hemp lead to the destruction of **nature reserves** such as taiga and tundra

# Social impact

## Scarcity of certified organic hemp

- Because cultivating hemp does not require pesticides or fertilisers small farmers do not use it
- Large amount of hemp is cultivated by small farmers in a terrace system
- The financial challenge for certification is too high
- Traditional small farmers get excluded from this process
- Supply for certified hemp lower than demand

# social challenges

**ILO Conventions in China:**

- with 120.000-150.000 t hemp fibre production per year China ist the largest producer by far
- China hat ratified the ILO core norms but does dot really

# Bast fibres: linen

# history of linen

| | | |
|---|---|---|
| **36.000 B.C.** | >> | discovery of different dyed flax fibres in a cave in Georgia |
| **28.0000 B.C.** | >> | European flax processing is proved by a discovery in a tschec cave |
| **Ancient Meso-potamia/Egypt** | >> | linen: display of wealth |
| **Antique to Middleages** | >> | linen was besides wool THE material for clothing |
| **Today** | >> | Primarily grown in Western European countries and Ukraine |

# properties of flax/linen

- feels cool to the touch
- absorbs and loses water rapidly
- very durable, firm fabric
- poor elasticity and does not spring back readily
- wrinkles easily
- no electrostatic charge
- resists dirt and stains
- finished fabric lint-free
- gets softer the more it is washed
- usually expensive textile, small quantities

# ecological & social challenges

## Conventionally grown linen

- comparatively low chemical use
- growth restardants
- water retting: high water consumption
- fungicides while water retting

## Organic linen

- mechanical measures such as harrowing, chopping or currying instead of chemicals
- healthy topsoil nourishes modest flax
- enough space for plants instead of growth hormones
- crop rotation and attracting plants instead of insecticides
- natural dew retting

# Bast fibres: nettle

# properties

- simple weaving and spinning
- excellent dyeability
- silky gloss
- tear-resistant
- high durability
- wool-alike warming properties
- no electrostatic charge
- lint-free
- low maintenance

# Silk

# history

| | | |
|---|---|---|
| **3630 B.C.** | >> | used as wrapping for the body of a child in China |
| **2750 B.C.** | >> | fragments of silk fabric (radio carbon test) |
| **11th cnt.** | >> | the Crucades brought silk production to Western Europe |
| **19th cnt.** | >> | French silk worm killing epidemic |
| **19th cnt.** | >> | Industrial Revolution changed European silk industry |
| **20th cnt.** | >> | Japan and China regained their earlier role in silk production |
| **Today** | >> | luxury good |

# Silk production

**Bombyx mori**

- silk moth lays eggs on prepared paper
- after hatching they are fed with mulberry tree leafs
- after 35 days an 4 moltings carterpillars start spinning a cocoon
- two tryangle formed glands produce liquid silk
- killing of the carterpillars with hot steam or water
- soaking in hot water to soften sericin holding
- unwinding the continuous thread (1 mile)
- three to ten strands are spun together to one thread

**Mulberry silkworm**

- produces industrial silk

**Japanese Oak Silkmoth**

- and many others produce wild silk

*Filament silk:* continuous thread

*Schappé silk:* medium fibre length from broken cocoons or threads

*Coarse silk:* shortest fibres from broken cocoons with high amount of rest filament

# properties and use

- very thin and and light, however no warming property
- absorbs as much as moisture as cotton
- dries very fast
- fabric is able to regulate temperature
- high tear strenght and rub resistant
- mothproof but not insect proof
- resistant to dirt, no absorbtion of odors
- soothing and healing properties (eczemas, wounds)

# ecological and social challenges

## Convetionally grown silk

- Use of peticides  on mulberry trees against predators
- Hormone therapy of silkworms for bigger cocoons
- Cocoons: worms killed by hot air fans
- Lack in social standards in Asian producing countries
- Weighing of silk fibre with heavy metals

## Organic silk

- Silkworm breeding on organically grown mulberry trees
- Social criteria for farmers
- Weighing with tea
- On violent = silkworms are protected and cocoons are collected and chipped after hatching
- Disadvantage: yarn tickens

# Sheep wool

## a wearable air condition system

# history of cotton

## Wool

- Hair from sheep, alpaca, merino, lama etc.
- Textile Labelling Act:
  „hair from the fur of mammals“
- Latin: vellere (to pinch or to burl),
- International abbreviation: WO

**Organic cotton:** legally protected claim

EU-eco Regulation of the European Council

National Organic Program

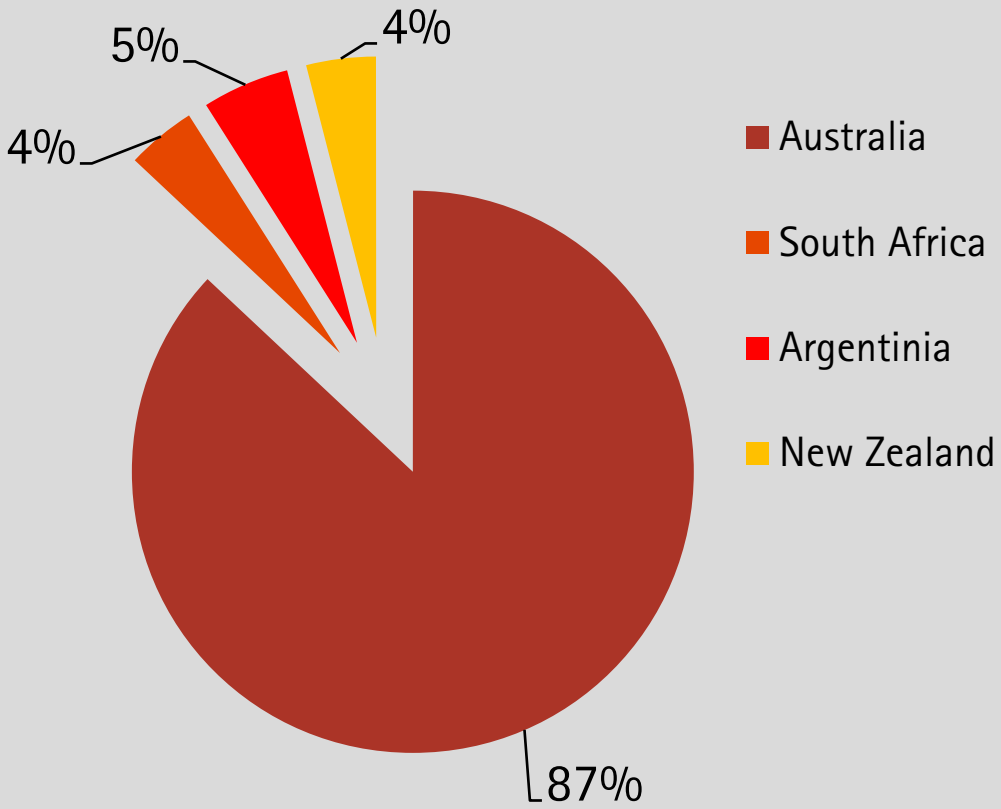
Textile Exchange

# history of cotton

| | | |
|---|---|---|
| **Stone Age** | > | Sheep skin was used for clothing |
| **Ar. 10.000 B.C.** | > | Man learned to use fallen out hairs<br>first yarns and fabrics were made |
| **Ar. 6.000 B.C.** | > | First evidence for domesticated sheep in Iran |
| **14th century** | > | breeding of merino in Spain pushed European wool industry |
| **19th century** | > | export of merinos to Australia, South America, New Zealand: wool becomes a global economic factor |
| **20th century** | > | Economic collapse of wool industry due to synthetic fibre |

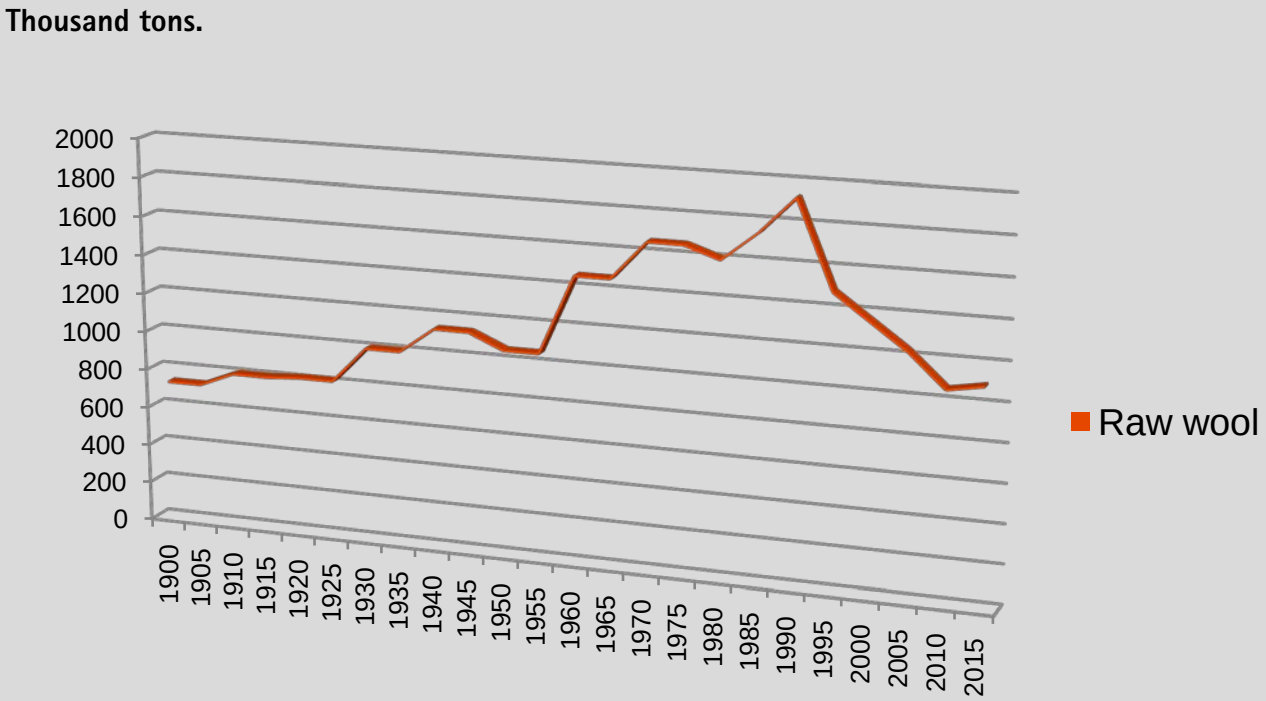
# market share of cultivating countries

## Wool production in 2013/14



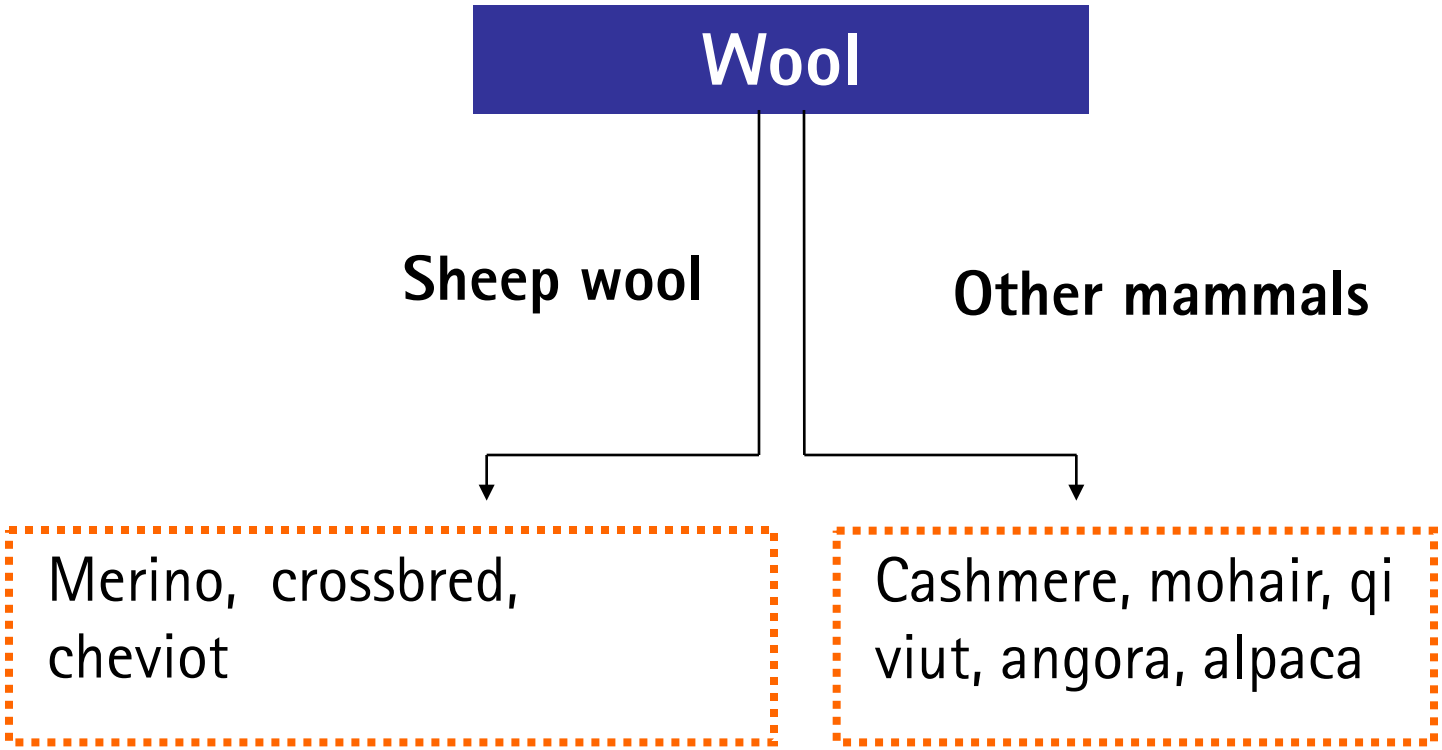

Source: New merino.com

# Global wool production




Source: C.I.R.F.

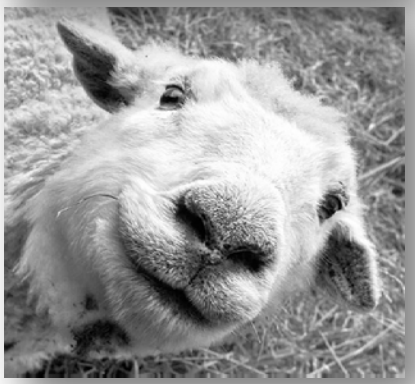
# Classification of man-made fibres



# ecological challenges

## Sheep breeding

- routine forcing throuh pesticide baths
- intensive mass animal farming
- pesticide residues remain in wool products
- phosphate and Pyrethroide are neurotoxic
- no adequate animal housing
- animal welfare: Mulesing, transport, slaughter



## Organic sheep breeding

- small, robust flock
- no preventive use of pesticides
- individual shearing
- mulesing no longer allowed

# welfare challenges

## Mulesing of merinos

- Deep wrinkles around buttocks retaining feces and urine attracting flystrike fromthe blow fly
- This skin part is cut off (seize of a plate) without anesthezation
- The practice is cruel and painful
- Only in Australia and New Zealand

## Alternatives

- re-breading merinos into sheep with less wrinkles
- skin clips
- crutching

NASAA CERTIFIED ORGANIC

# ecological challenges

## Production

- detergents used for washing raw wool
- pretreatments with chlorine substances
- anti-pilling treatments
- superwash treatments

## Alternatives

- use of non hazardous substances – GOTS conformity
- mechanic or physical treatments

# fibre properties of wool

## Cotton and its properties

- high moisture absorption
- high heat insulation
- high breathability
- natural odor control
- very high elasticity
- flame resistent
- can felt
- can pick
- bacterium and fungus resistent
- warms not very well
- wrinkles easily and can shrink
- more tearproof than wool and silk
- easy to dye

# Man made fibers

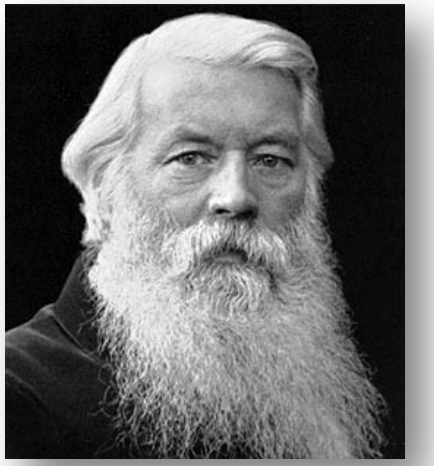
## saving soil but non degradable

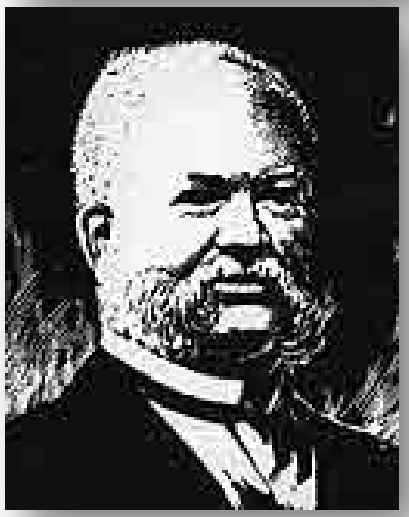
# overview

- history
- producing countries
- market figures and availability
- ecological challenges
- social challenges
- properties and use

# history

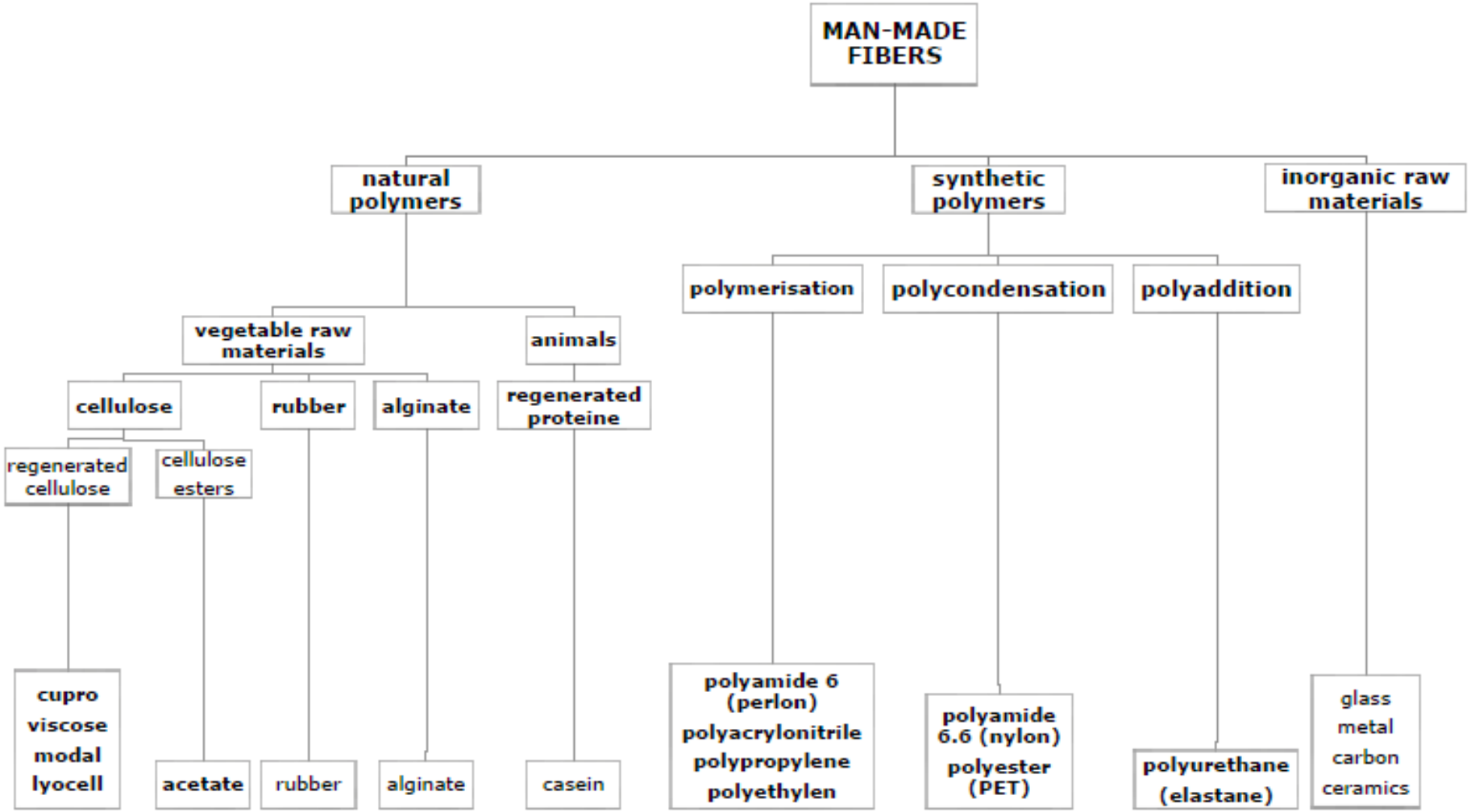
| | | |
|---|---|---|
| 17th c. | > | documentations on first considerations to produce articicial fibers – silk |
| 1664 | > | Microscopical attempts to analyse cell structure of silk (Robert Hooke) |
| 1882 | > | **Joseph Swan** invents first carbon filament while developing light bulp with **Edison** |
| 1898 | > | **Hilaire de Chardonne** invents first artificial silk (nitrocellulose) as answer to the french silk worm killing epidemic |
| 1894 | > | development of „viscose", a reaction product of carbon disulfide and cellulose |
| 1935 | > | **Wallace Hume Carothers** invents Nylon, the first real synthetic fiber (DuPont) of coal |
| 1941 | > | Polyester (Dacron) by **John Rex Whinfield** |





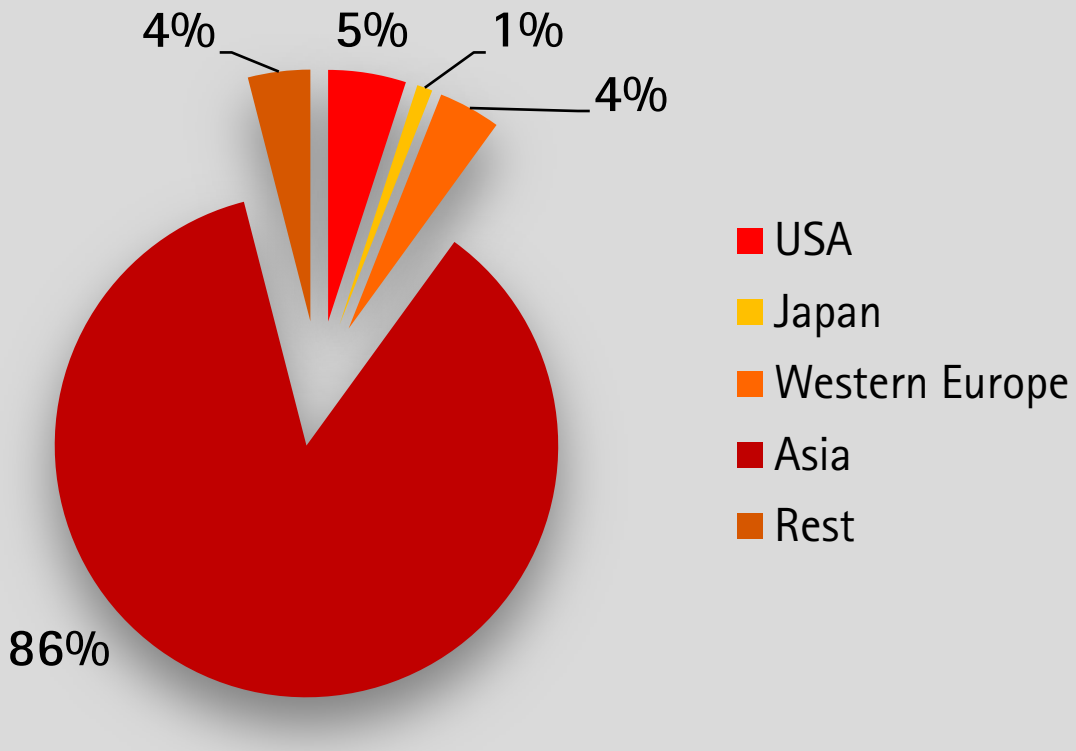
# Categorization of man-made fibers

Source: BMZ (German Government)



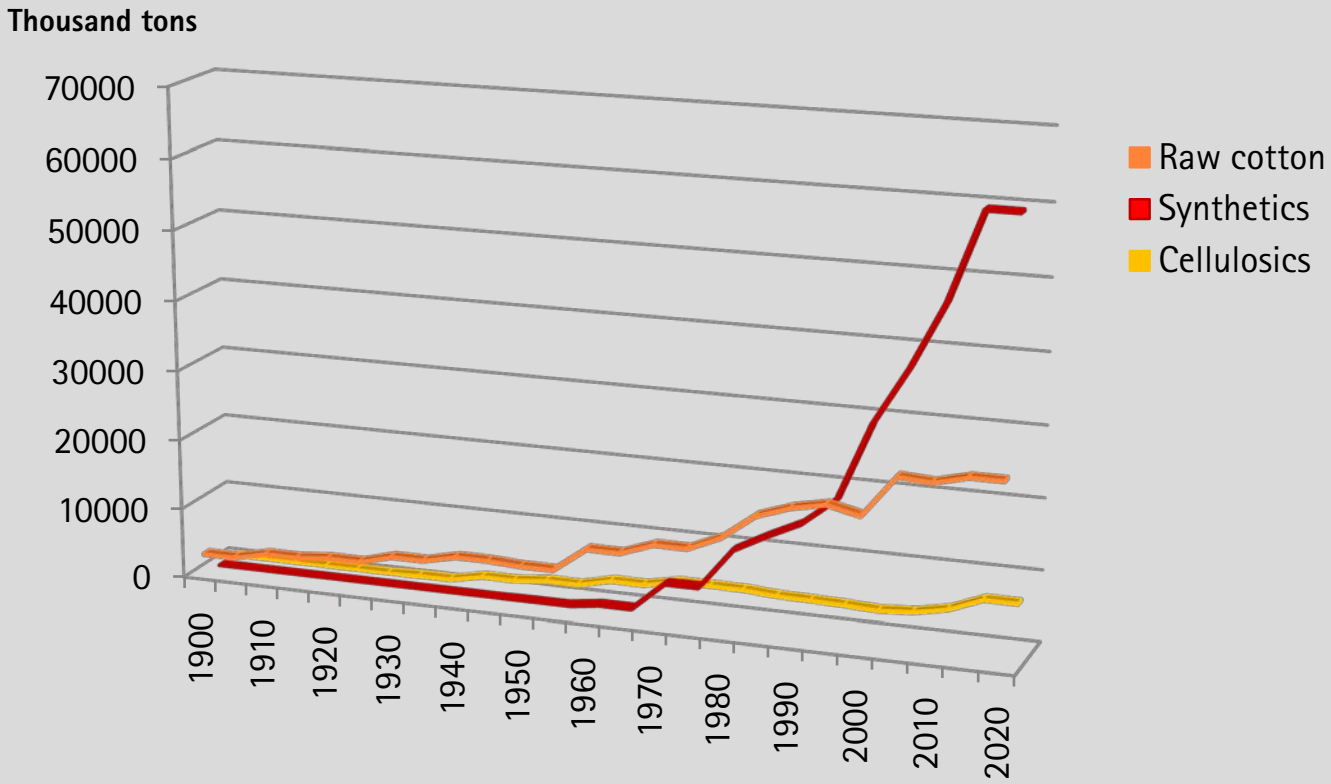
# market share of cultivating countries

## Fibre production in 2014




Source: ivc-ev.de

# Global man-made fiber production

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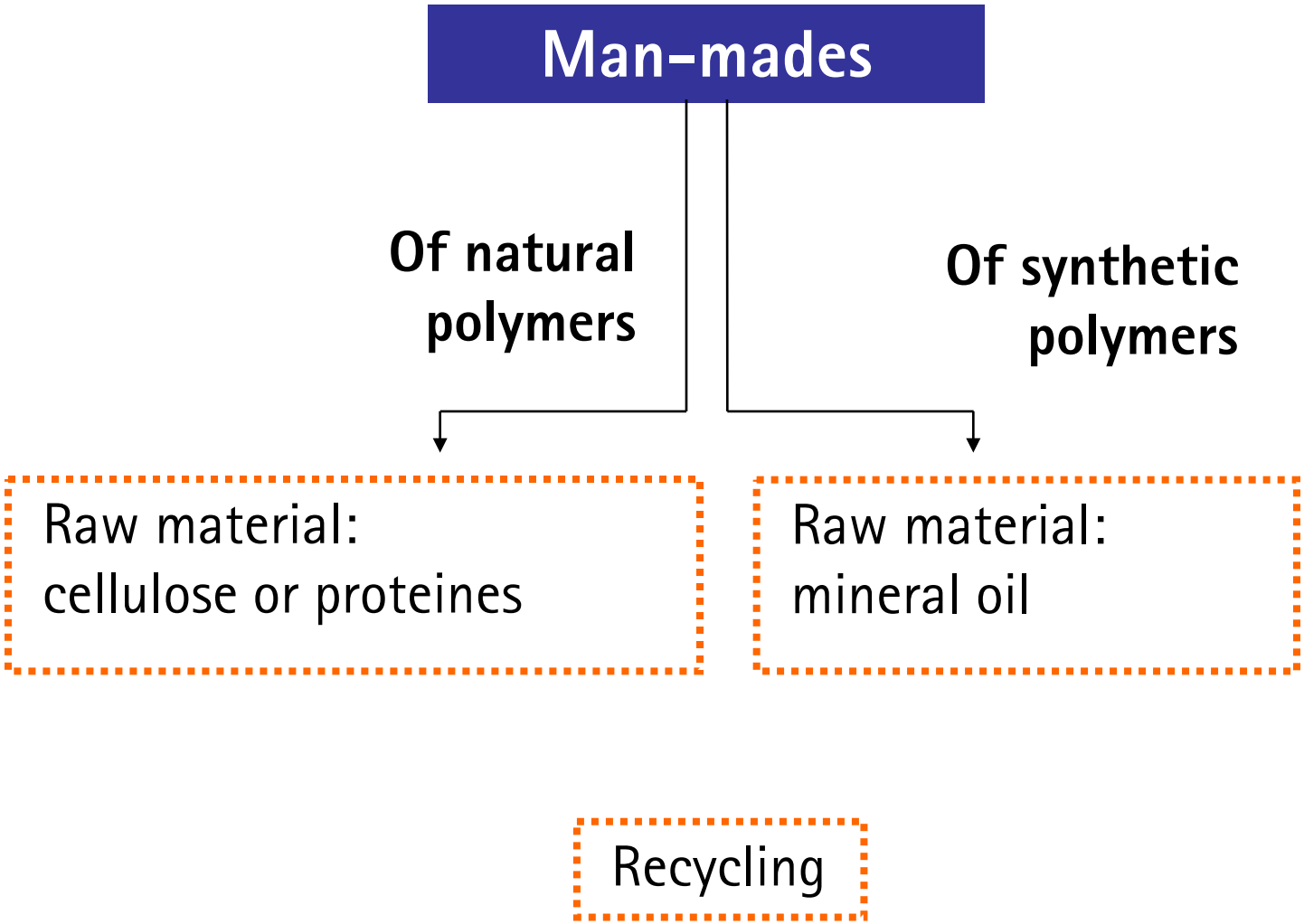

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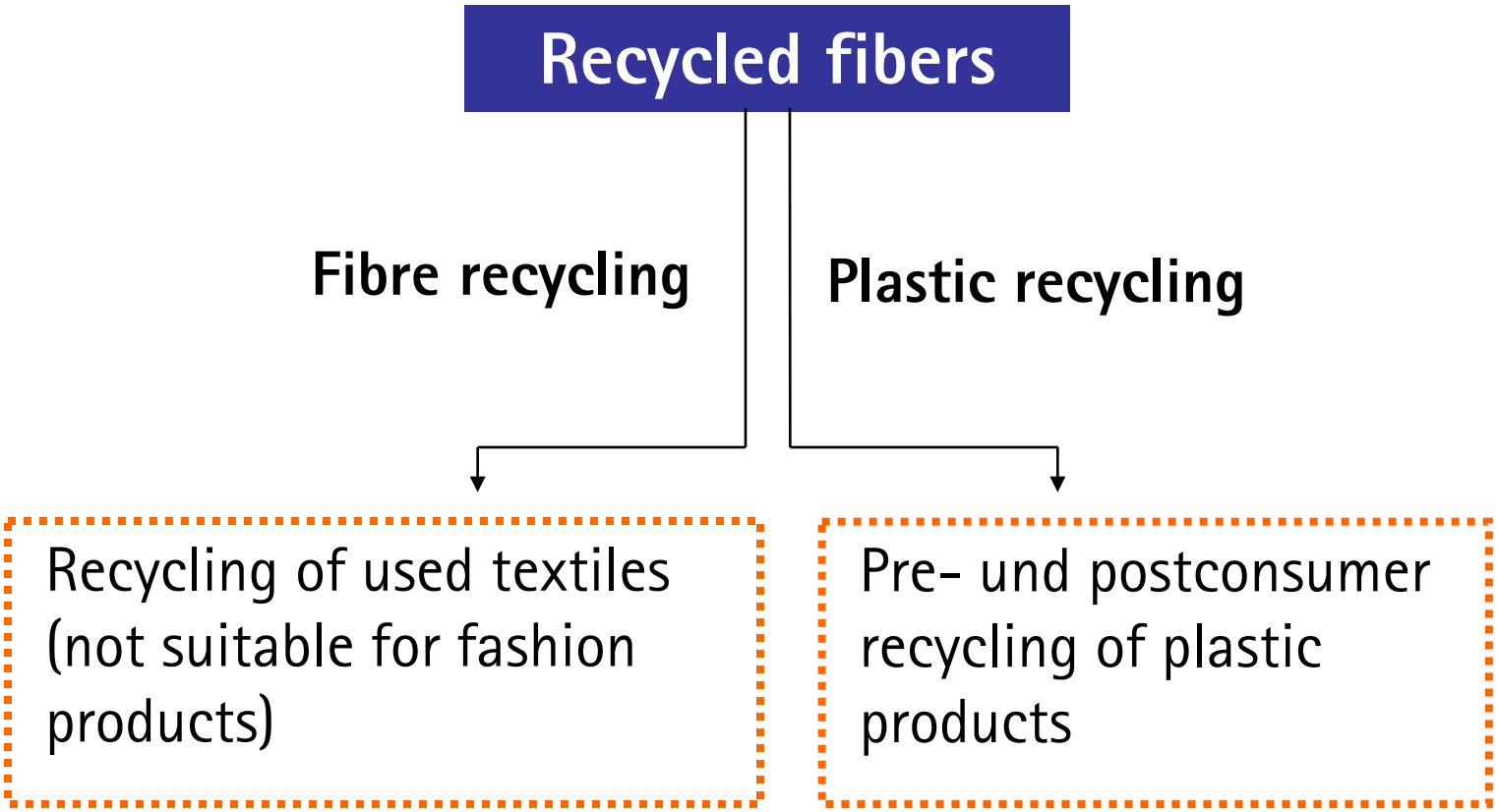
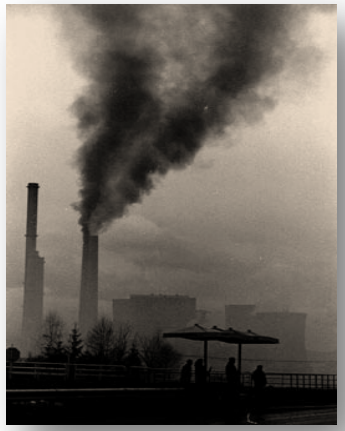


# ecological challenges

## Synthetic fibres

- fibre production: high water + energy demand
- fibre production: hazardous preparation agents
- raw oil: non renewable ressource
- yarn production: hazardous inputs
- disposal of waste, low degree of biodegradability
- advantage: modifiability, low price



## Alternatives:

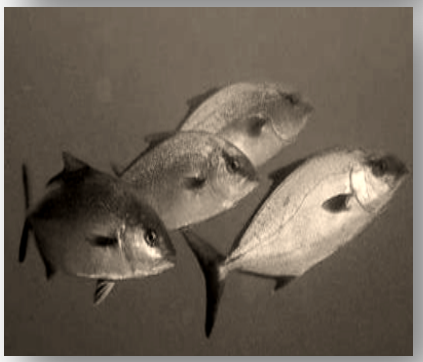
- biopolymeres
- recycling

# ecological challenges

**Hazardous preparation agents**

- mineral oil (water polluting)
- ethylene-propylene oxide adducts (persistent)
- fatty esters (water pollution)

>> Significant part of COD load



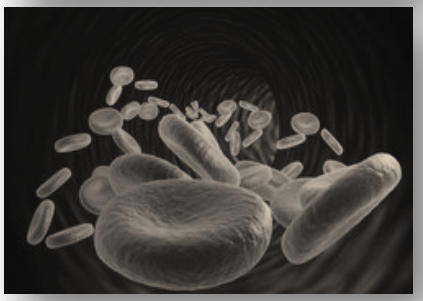
**Alternatives:**

- closed-loop production

# ecological challenges

**Hazardouse substances in pre-treatment process**

- polyamide: Caprolactam
- polyester:  Antimony
- polyacrylics: Dimethylformamide
- elastane: Dimethylformamide



**Alternatives:**

- substitution

# ecological challenges

## Non renewable source mineral oil

- needs  300-400 years to develop
- global consumption per day: over 50 million barrel
- global production per day: nearly 55 million barrel
- world deposit: 620 billion barrel
- we have raw oil for only 33 more years
- 1% of the production floats into textile fibres

Source: German Federal statistic office and ivc

# ecological challenges

## Disposal and biodegradability

- non compostable
- fibre mixes
- plastic litter in environment
- incineration: air polution
- microplastic by abrasion in washing processes

# ecological challenges

## Recycling fibers

- fibre production: high water + energy demand
- fiber production: hazardous preparation agents
- yarn production: hazardous inputs
- disposal of waste, low degree of biodegradability
- fibre purity within post-consumer recycling
- advantage: modifiability


## Alternatives:

- intelligent collection systems
- closed loop production

RECYCLED 100 claim standard

Global Recycle Standard

bluesign®

## Production process of viscose

- raw material: pulp of wood or bamboo
- swelling in caustic soda and adding carbon disulphide to start the viscose process.
- dissolving by adding sodium hydroxide
- riping, degassing
- pressed through spinnerets into a highly acidic spinning bath

# ecological challenges

**Regenerated cellulose fibers**

- agriculture plus processing
- forest clearing
- pulp production: elemental chlorine, AOX and carbon disulfide
- great amount of solid waste

**Alternatives:**

- sustainable raw material (recycling, organic, FSC, )
- use of less problematic acids and bases
- closed loop production (Lenzing Modal Edelweiß)

# Social challenges

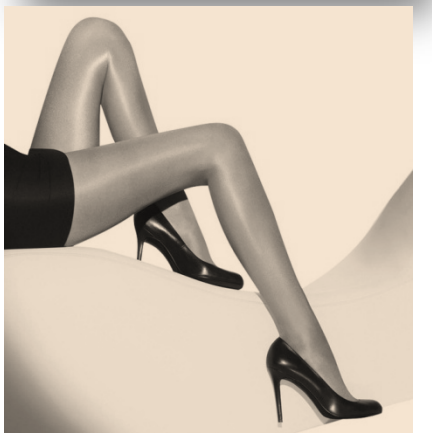
**Blackbox: man-made fibre production**

- fibre dust
- dangerous vapours
- no information on social responsibility
- 90% of production in low-wage countries

# fibre properties of synthetic fibers

## Do what you want

- production process of synthetic fibers can be influenced
- fibre properties can be adjusted
- ideal for functional requirements:
  thinner than silk or voluminous likewool,
  warming or cooling, perspiration wicking,
  glossy or matte, elastic, fast drying, waterproof ...
- require (or allow) no ironing
- do not absorb odours
- electrostatic



# fibre properties of cellulose fibers

## Natural feeling with synthetic fibres

- excellent dying behaviour
- brillant coulours
- glossy fabric
- smooth and soft
- breathable and temperature compensating
- skin-friendly
- high moisture agbsorption
- non electrostatic