UNIVERSITEIT GENT

ELECTROSPUN NANOFIBRES
NEW POTENTIALS AND CHALLENGES FOR TEXTILE MATERIALS

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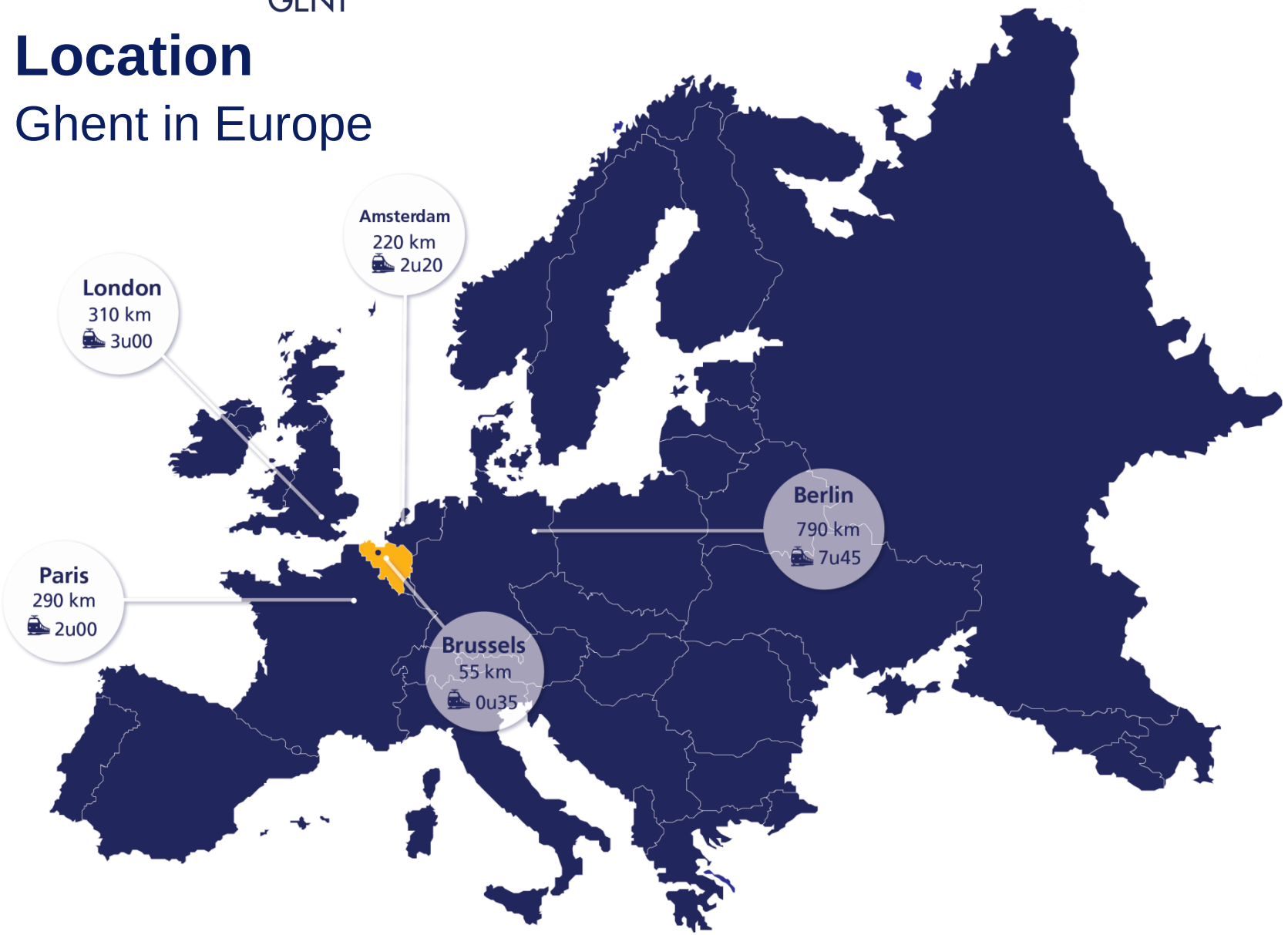
BRUSSELS, BELGIUM

UNIVERSITEIT GENT

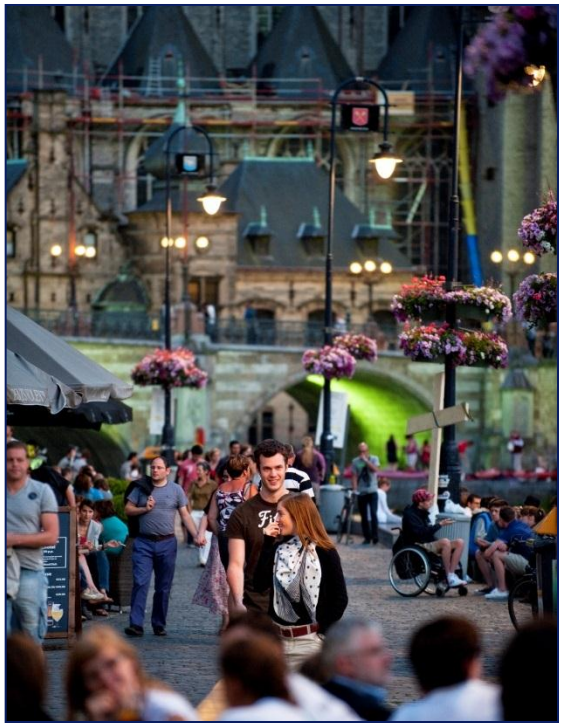
Location

Ghent in Europe



The city of Ghent

Students:
¼ of the city population



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Ghent University

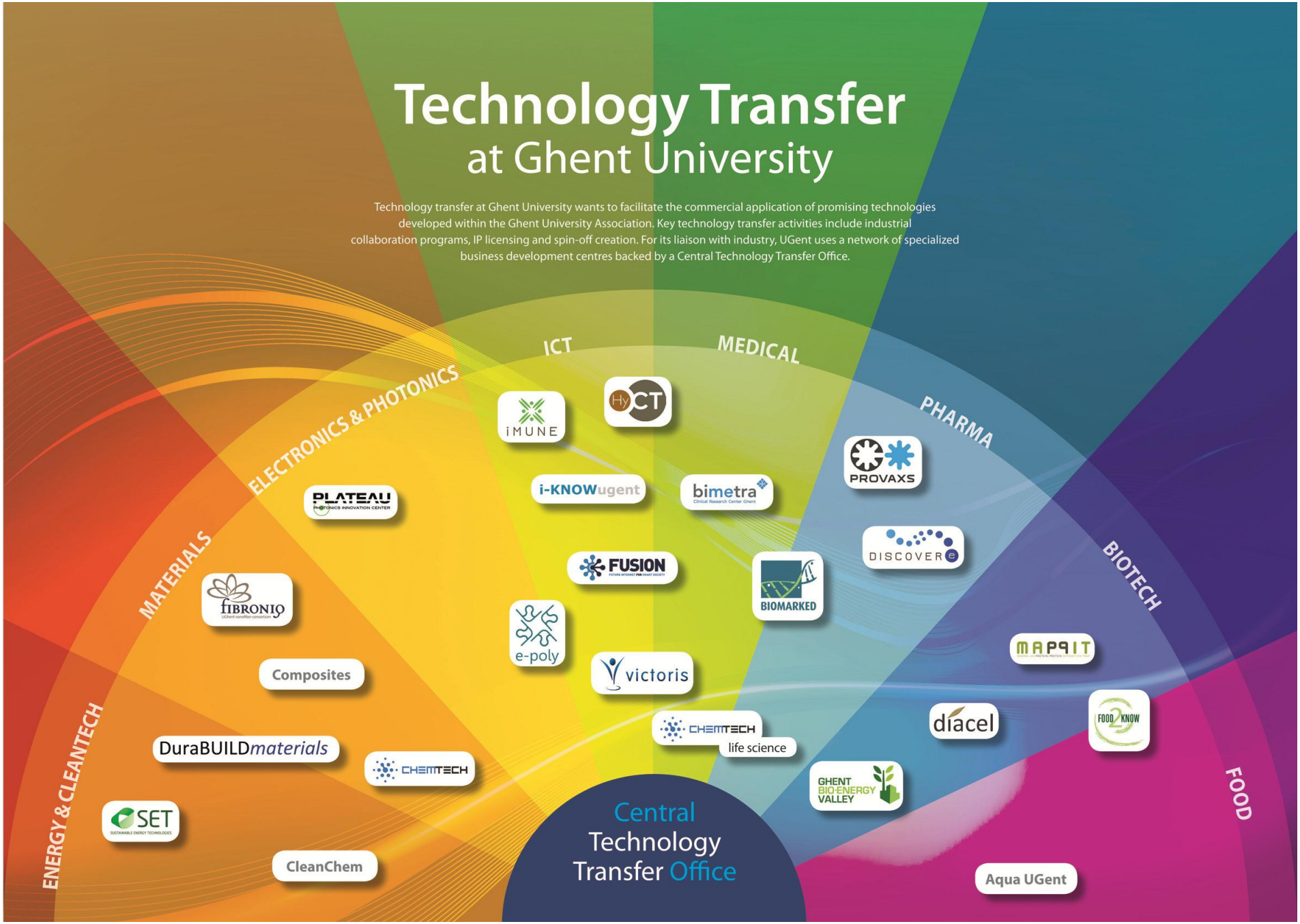
Faculty of Engineering and Architecture

Department of Textiles

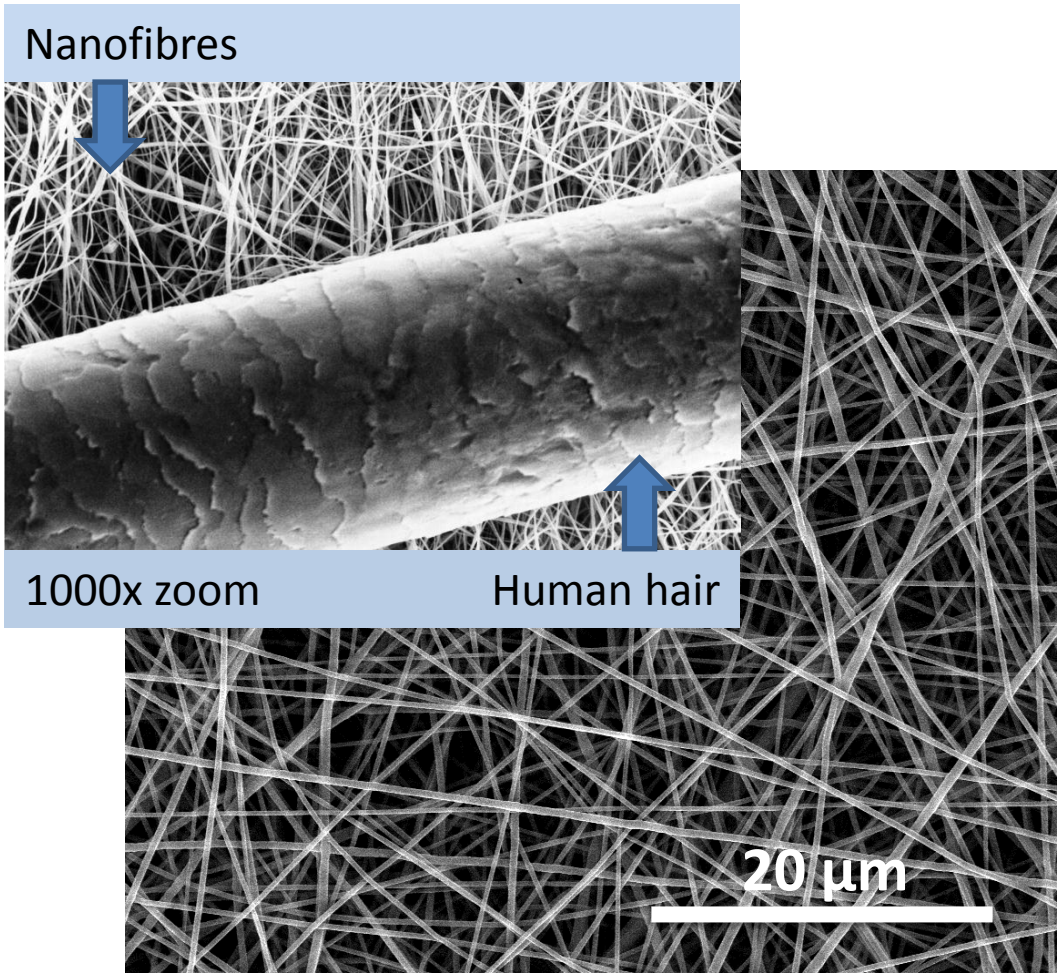
Chemical and Physical Textile Technology	**Polymer Technology**	**Fibrous Structures Smart textiles**	**Fibre and Colouration Technology**
Prof. Dr. Paul KIEKENS	Prof. Dr. ir. Dagmar D'HOOGE	Prof. Dr. ir. Lieva VAN LANGENHOVE	Prof. Dr. ir. Karen DE CLERCK

Technology Transfer
at Ghent University

Technology transfer at Ghent University wants to facilitate the commercial application of promising technologies developed within the Ghent University Association. Key technology transfer activities include industrial collaboration programs, IP licensing and spin-off creation. For its liaison with industry, UGent uses a network of specialized business development centres backed by a Central Technology Transfer Office.



Nanofibrous nonwovens have unique characteristics



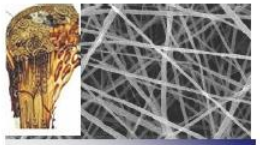
Very small fibre diameters (< 500 nm)

High specific surface area

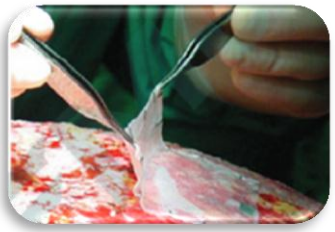
Small pore size

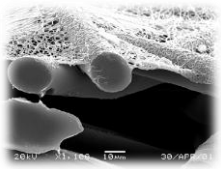
High porosity

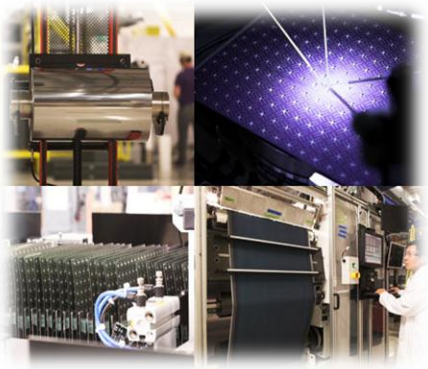
Nanofibres have various dedicated end-applications

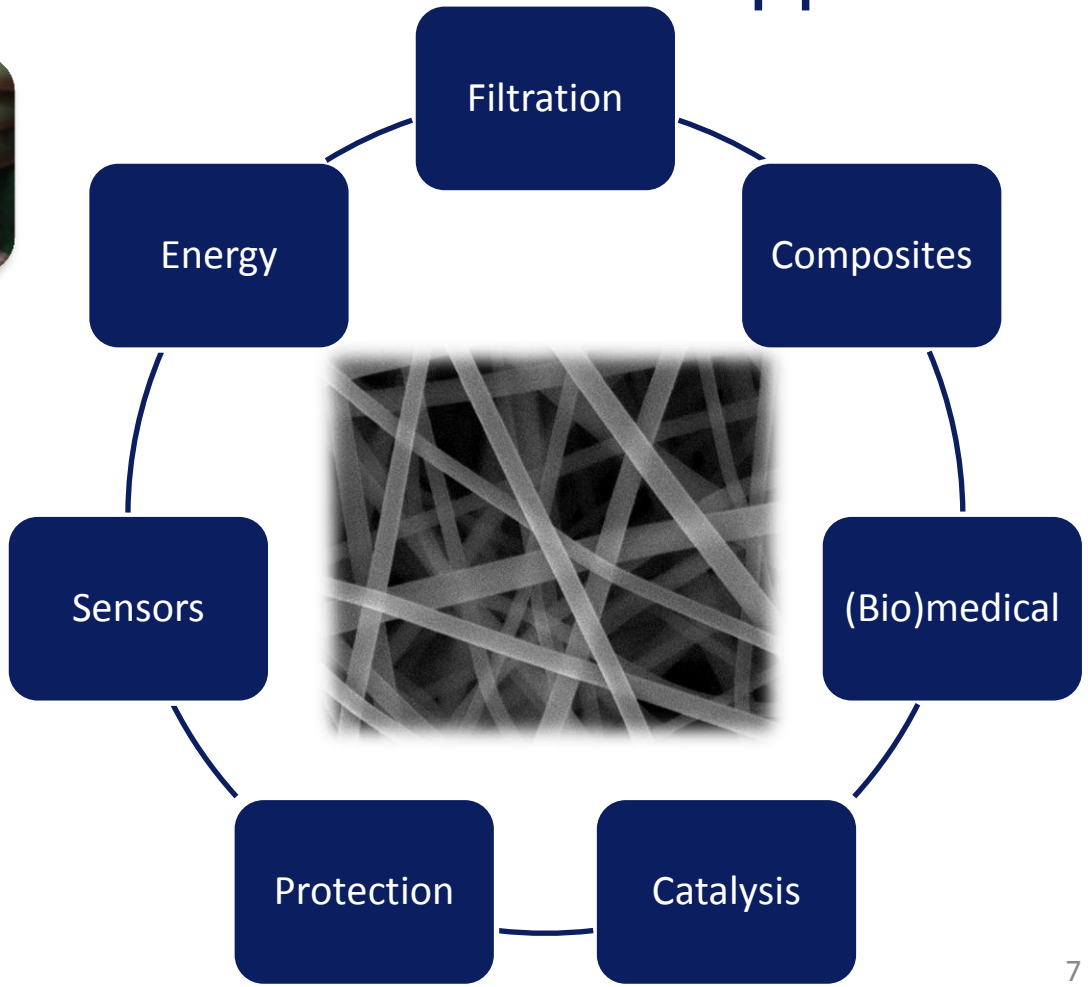


Bone Regeneration Implant

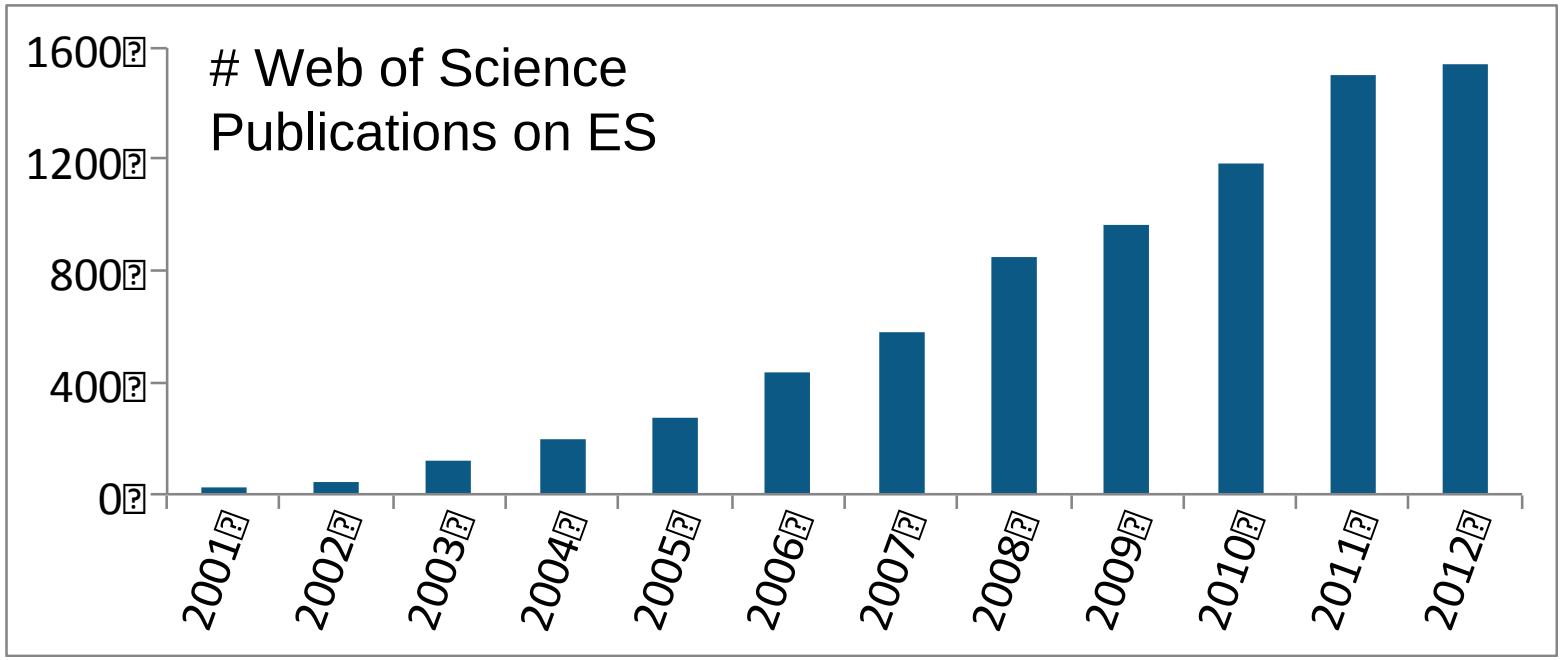






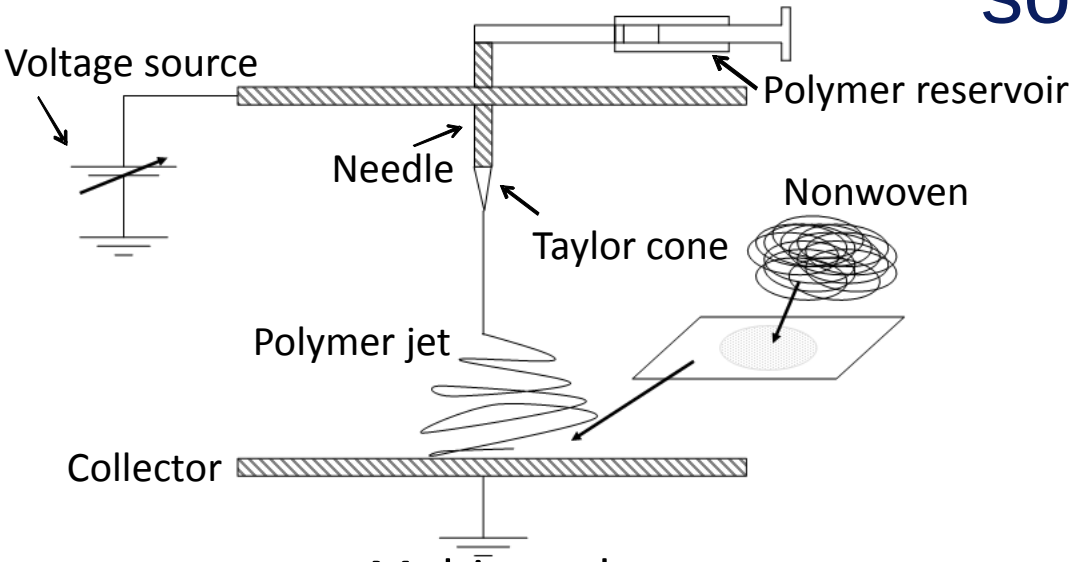


Electrospinning (ES) in literature



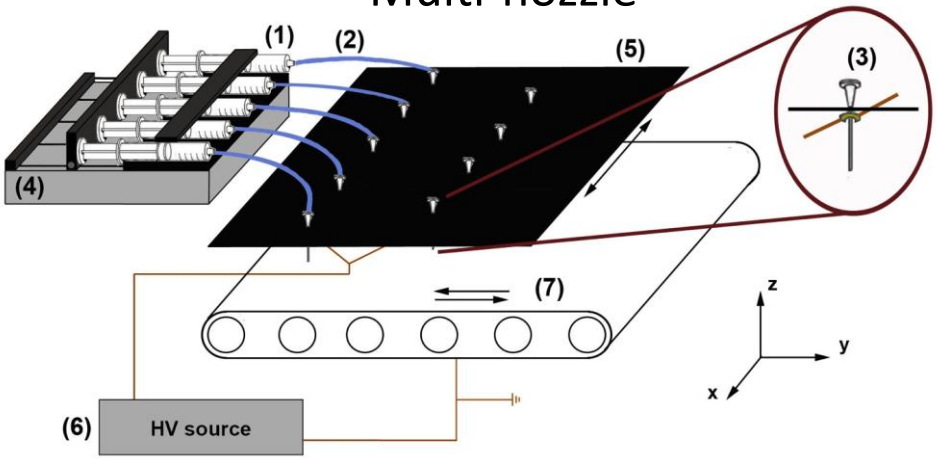
Highlights: Electrospinning technology and modelling
Novel polymer-solvent systems
Advanced applications for nanofibres

Electrospinning technology @ UGent: solvent electrospinning

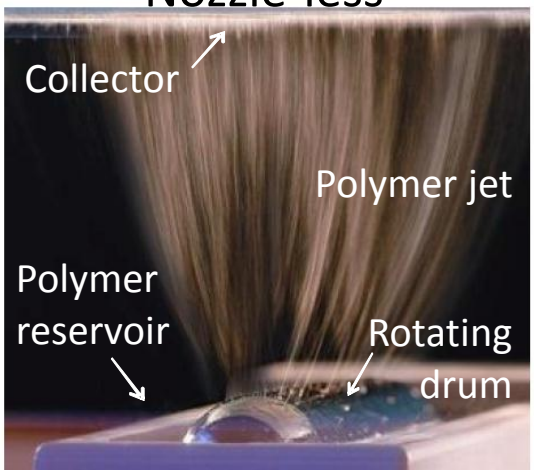


- ☑ High stability
- ☑ High reproducibility
- ☑ Fine fibres (nm-range)
- ☒ Use of solvents

Multi-nozzle

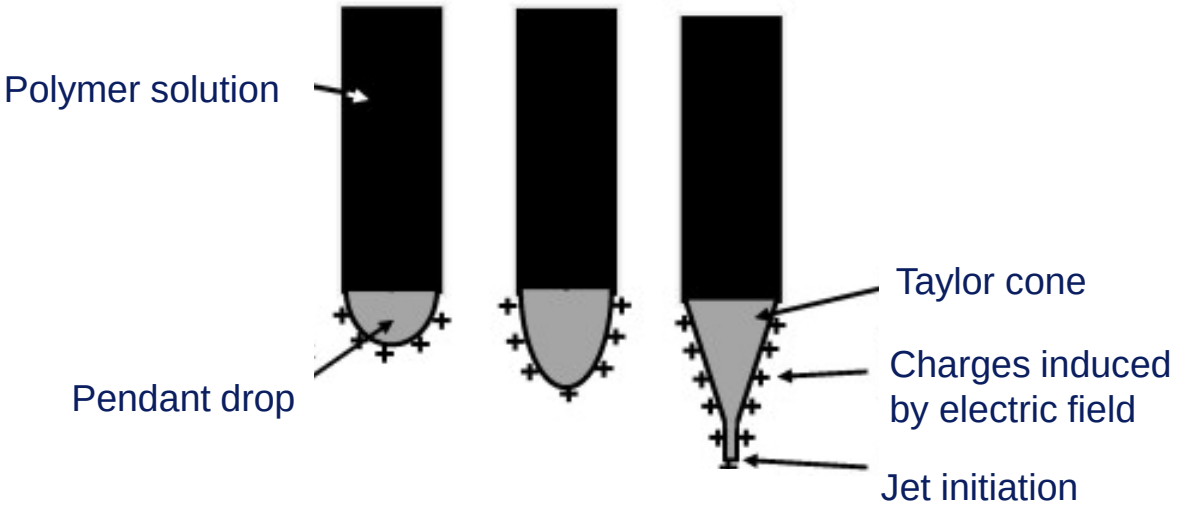


Nozzle-less

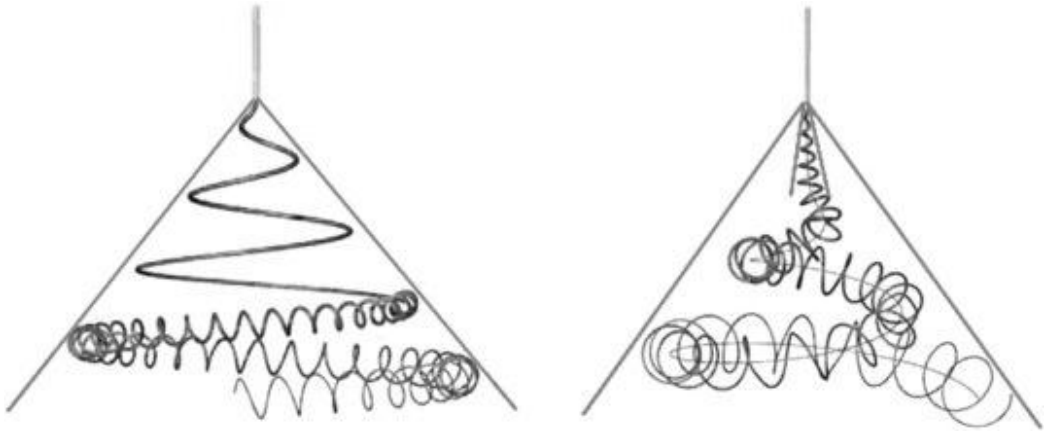


Principle of nozzle solvent electrospinning: a simple yet complex process

Initiation:
Formation of the Taylor cone



Bending instability:
Formation of the nanofibres by solvent evaporation, jet stretching and splitting



The electrospinning process is governed by a multitude of parameters

Polymer solution parameters

- Solvent (type, mixture)
- Polymer (concentration, MW)
- Viscosity, surface tension, electrical properties

Processing conditions

- Voltage
- Distance
- Flow rate
- Needle, collector

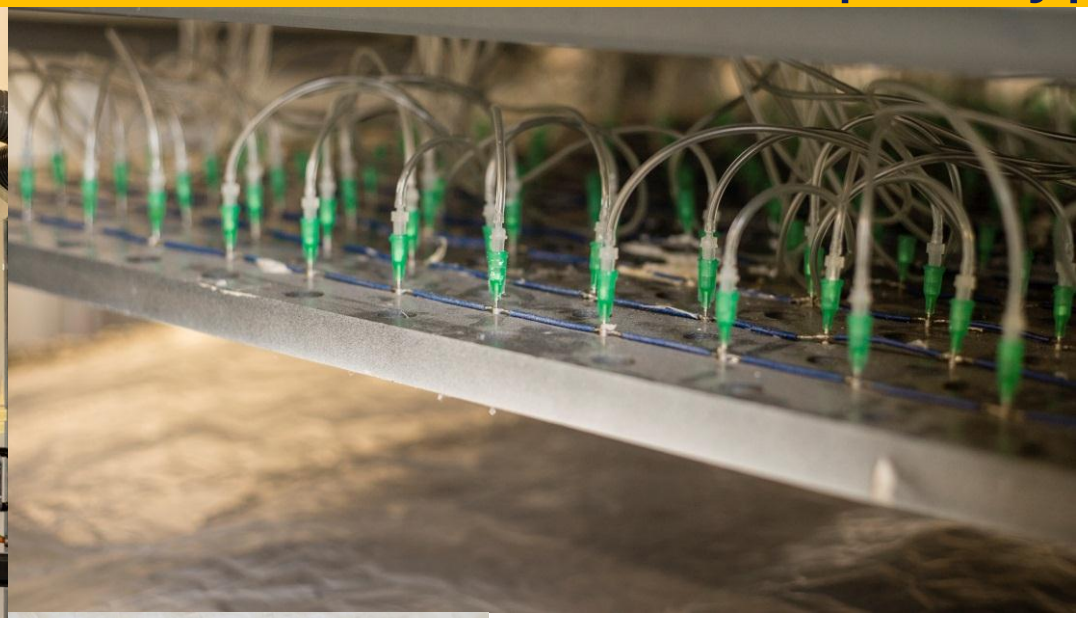
Ambient parameters

- Humidity
- Temperature
- Atmosphere

Stable process
Reproducible nanofibres
Upscaling

Upscaling

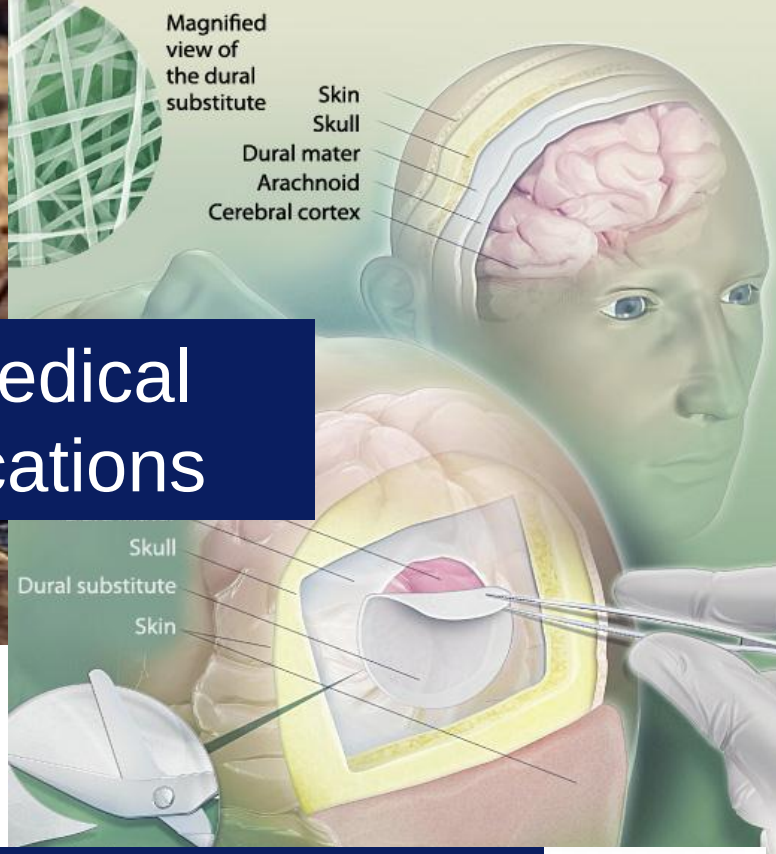
Semi-industrial multinozzle setup: +100 nozzles, modular based prototype



Production of nanofibre based media

- As rolled goods with or without substrate
- With grammage between 0.05 - 100 g m^{-2}

Waterfiltration

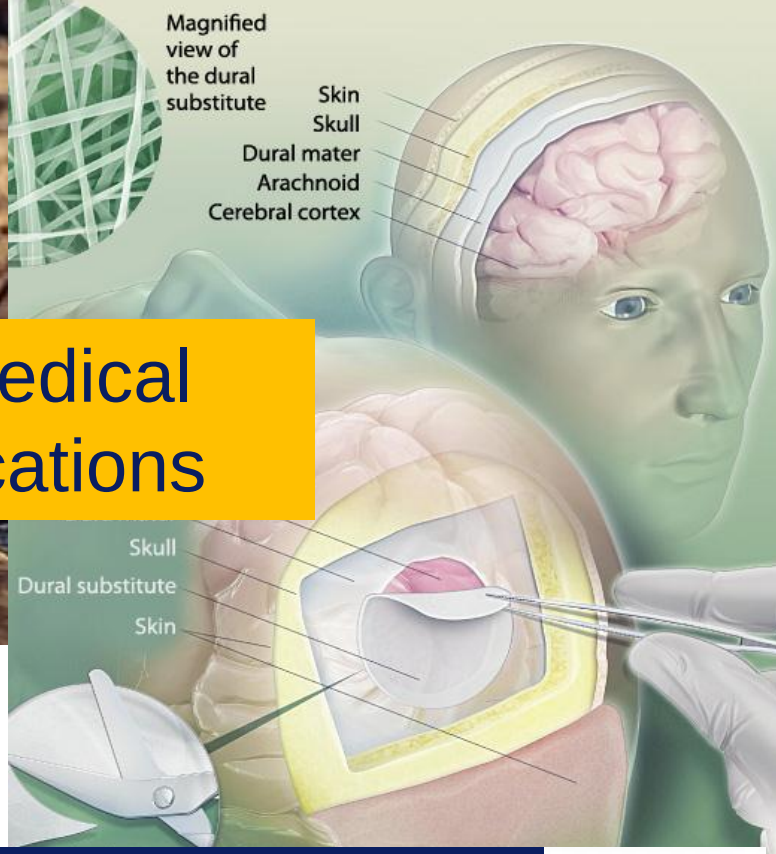


Biomedical applications

Composites

Optical monitoring: pH-sensors

Waterfiltration



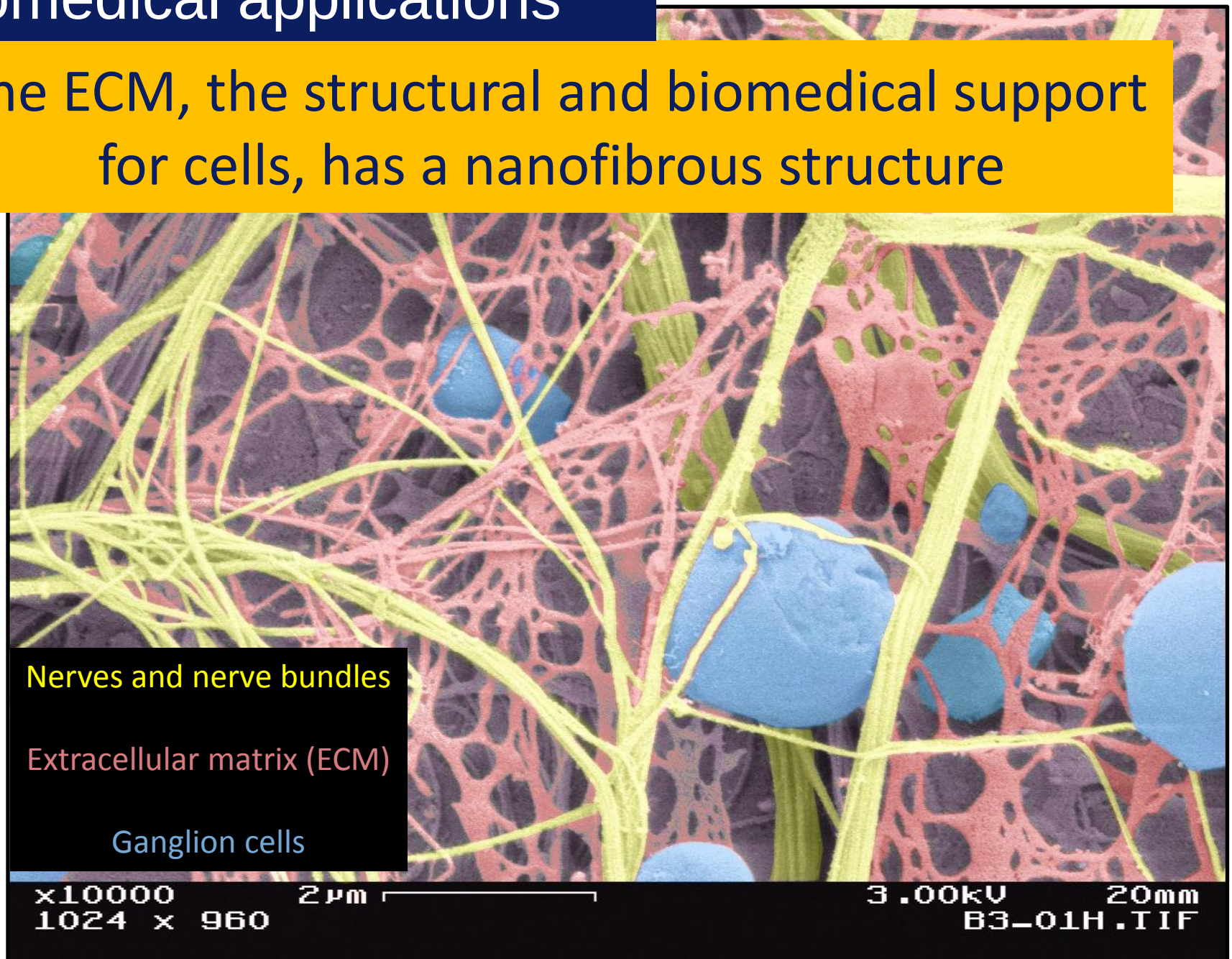
Biomedical applications

Composites

Optical monitoring: pH-sensors

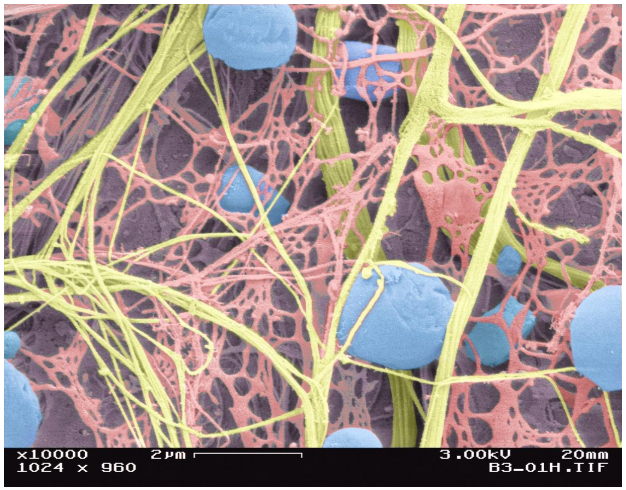
Biomedical applications

The ECM, the structural and biomedical support for cells, has a nanofibrous structure

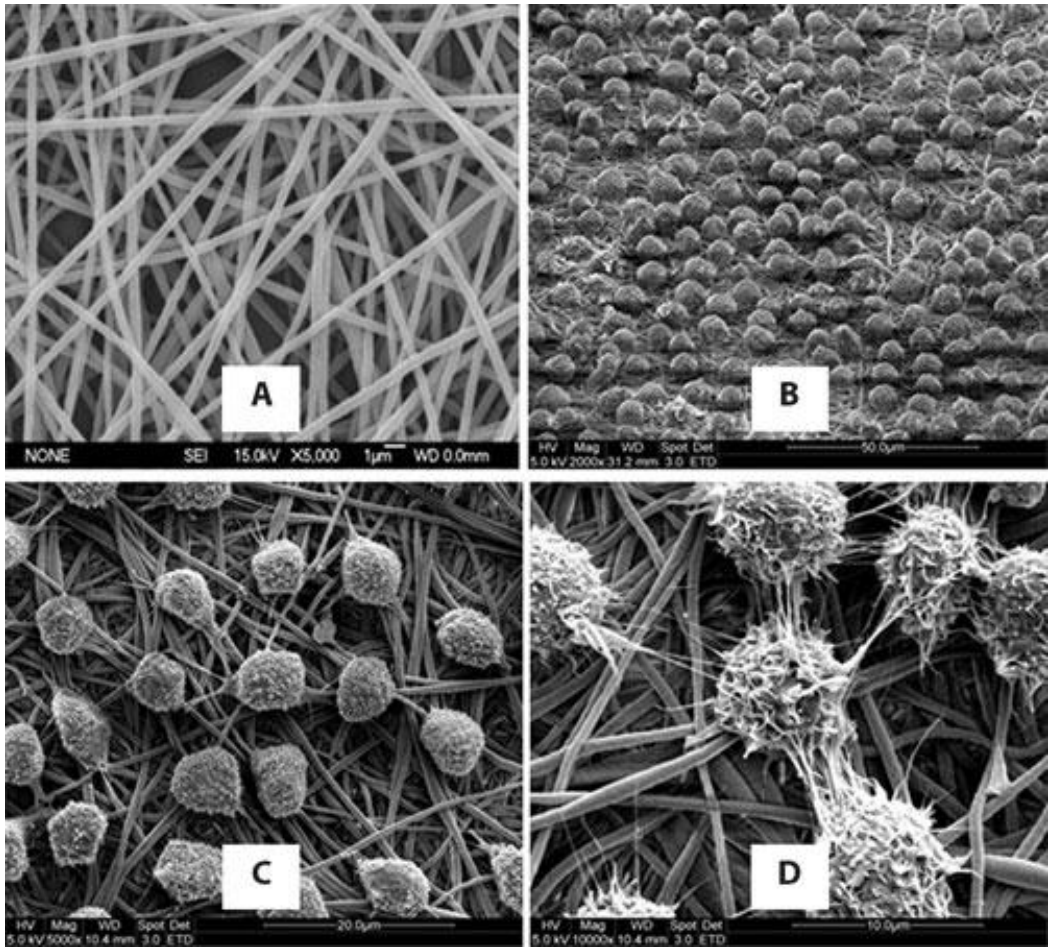


Electrospun nanofibres are the ideal candidate to mimic the ECM in biomedical applications

The ECM, the structural and biomedical support for cells, has a nanofibrous structure

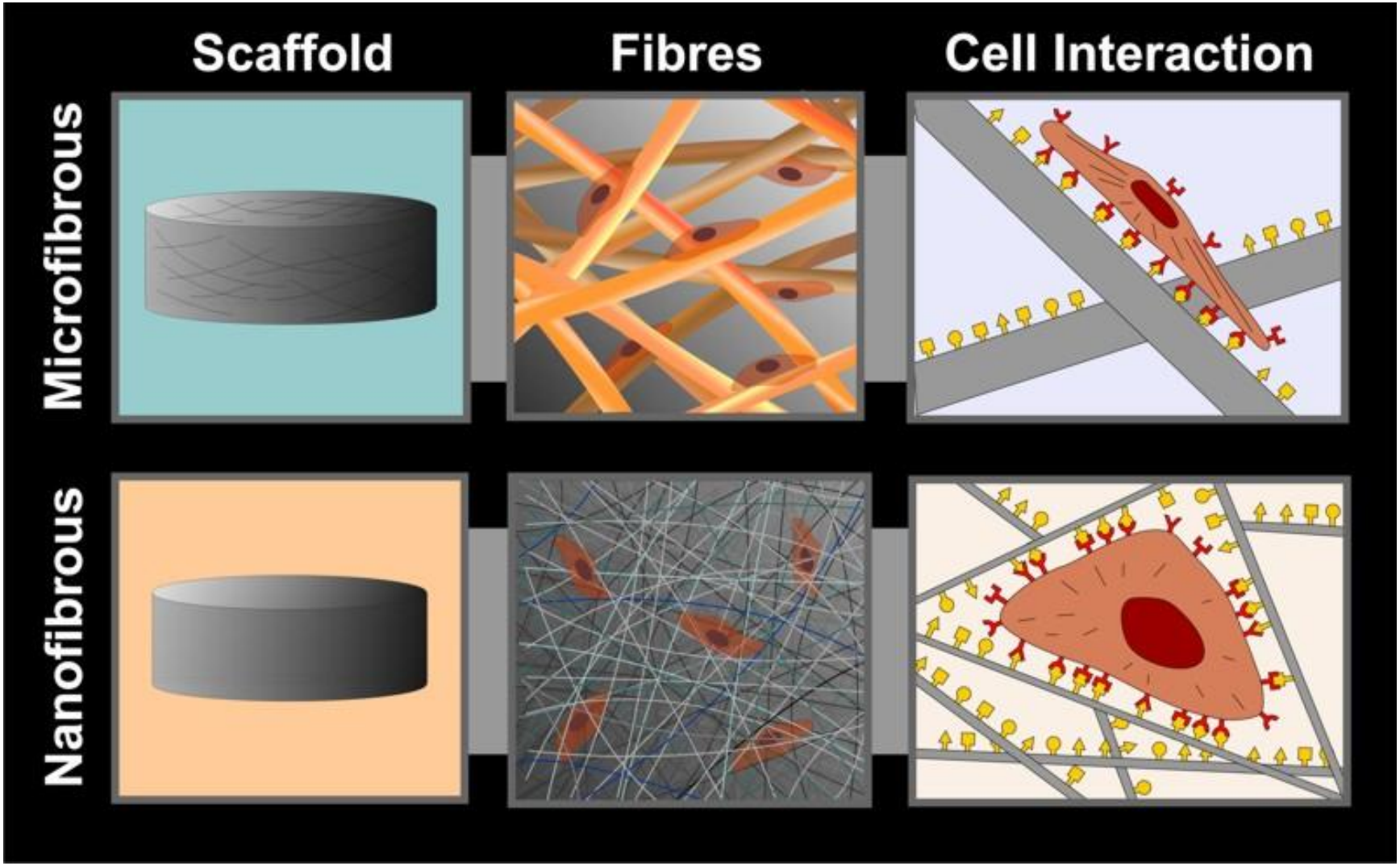


Stem cell cultures on man-made electrospun nanofibres

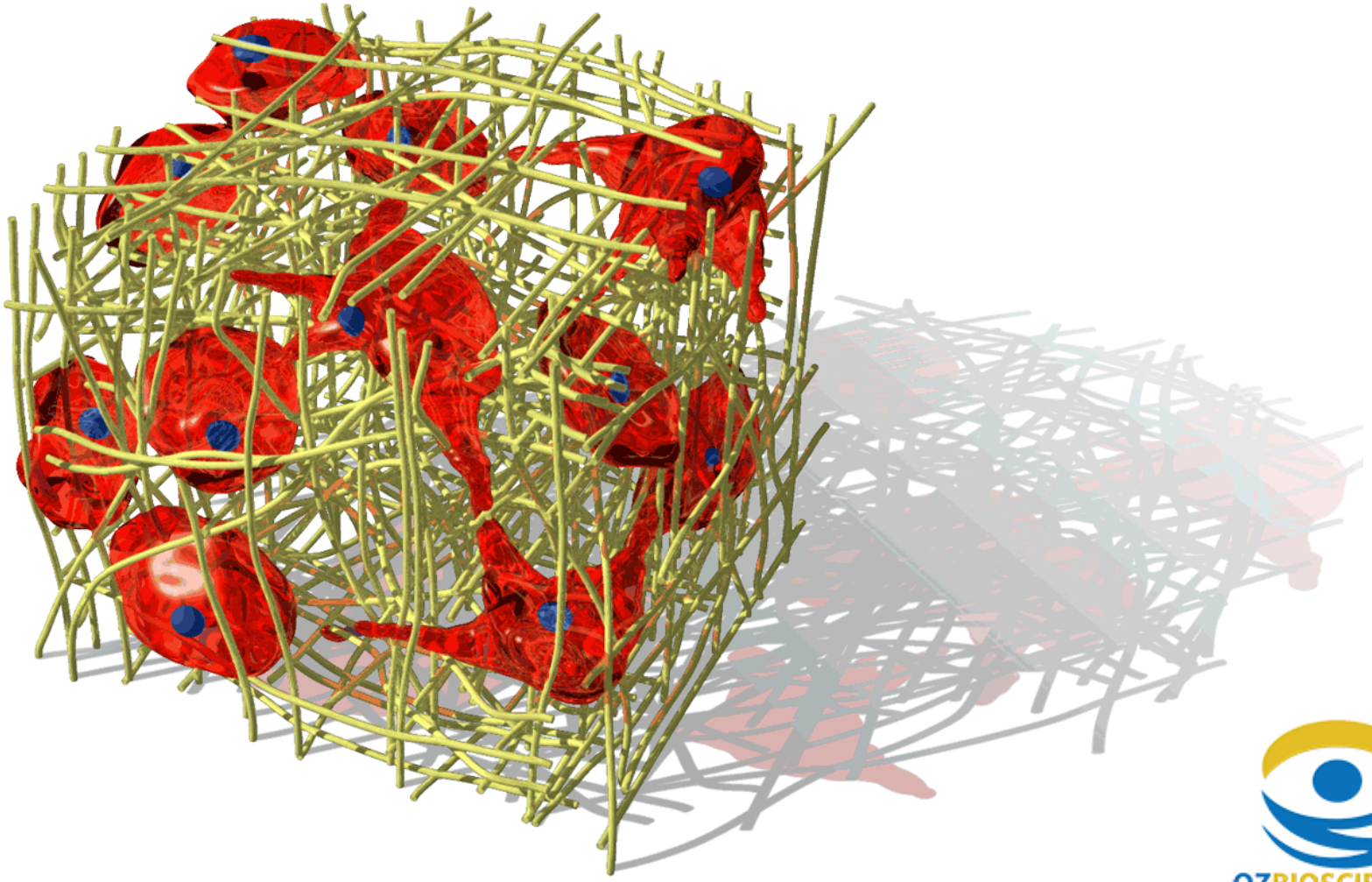


R. Sakthivel & Y. Zhao
Genetic Engineering & Biotech news (2010), 30 (16)

Cells are well-supported by nanofibrous scaffolds, making them suitable for cell cultures

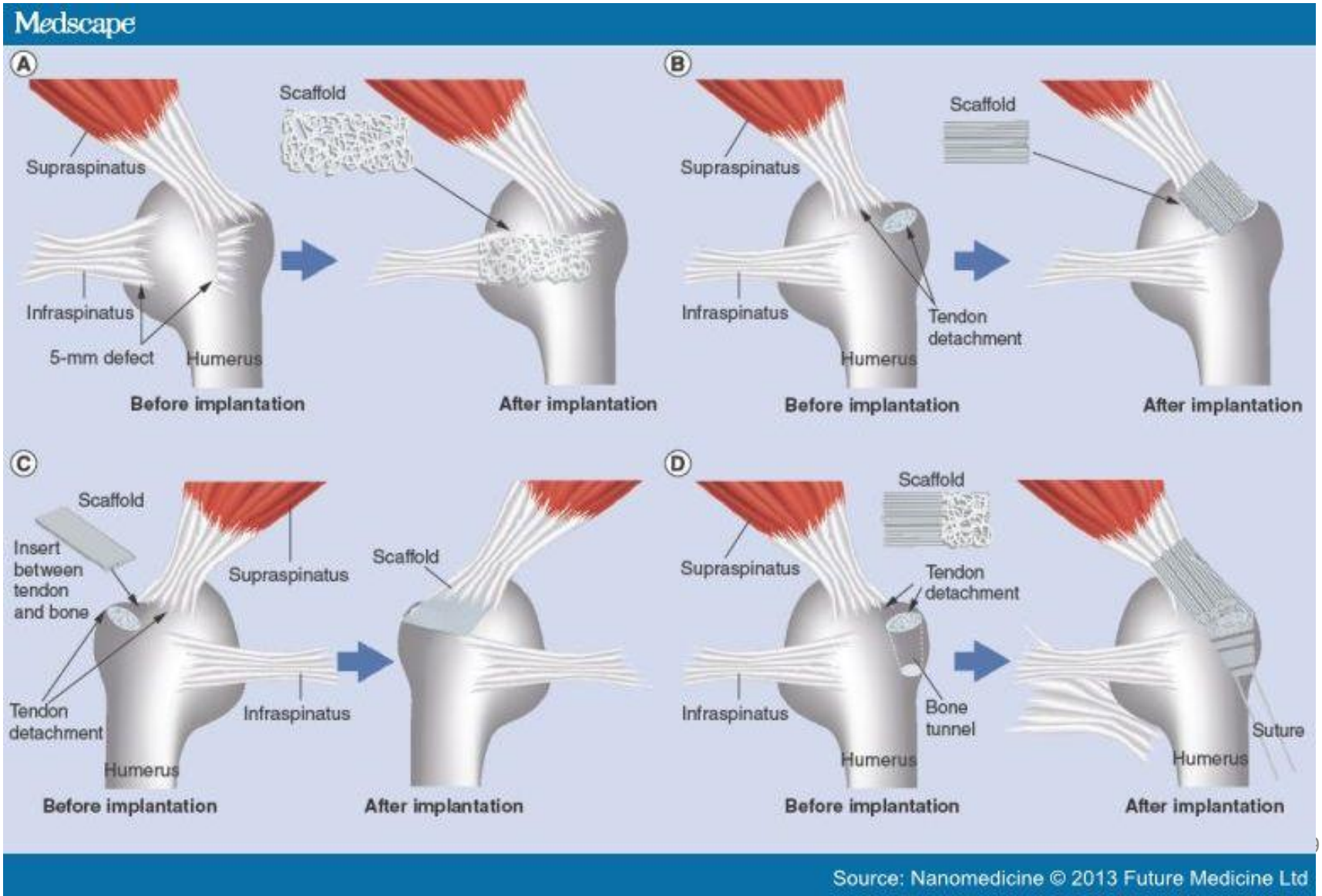


Infiltration of cells into the scaffold is important: scaffold design needs to be adapted

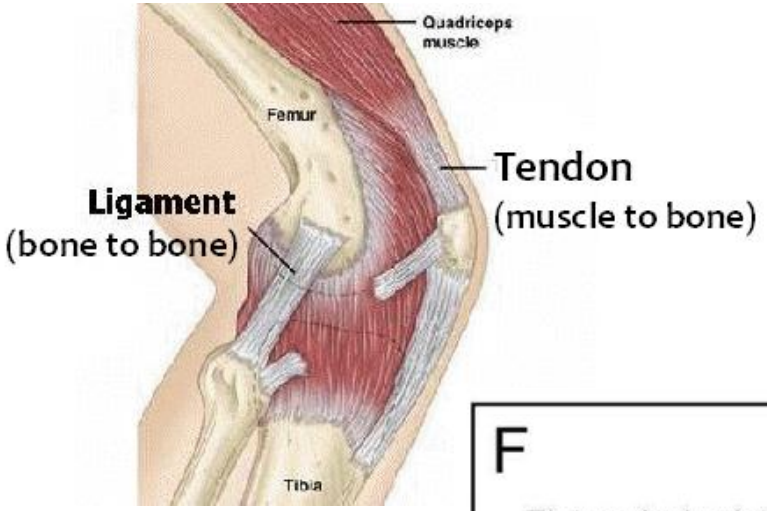


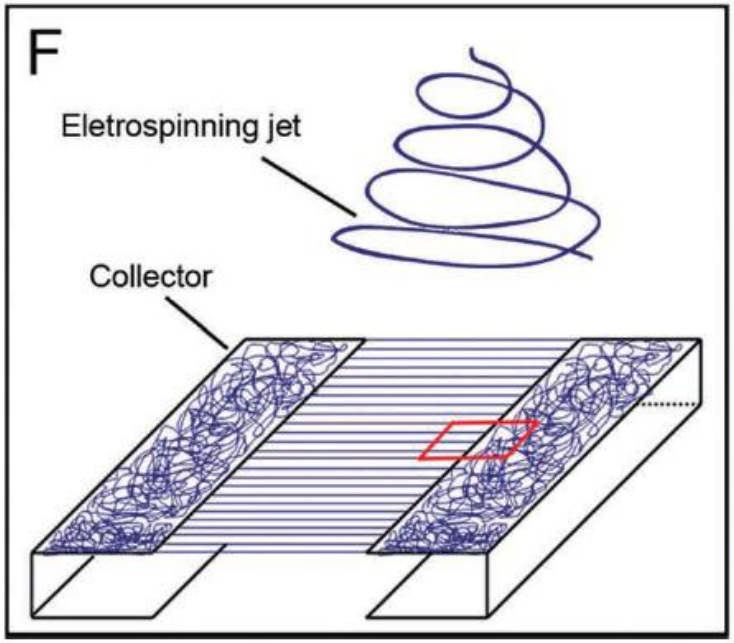
OZBIOSCIENCES
The art of delivery systems

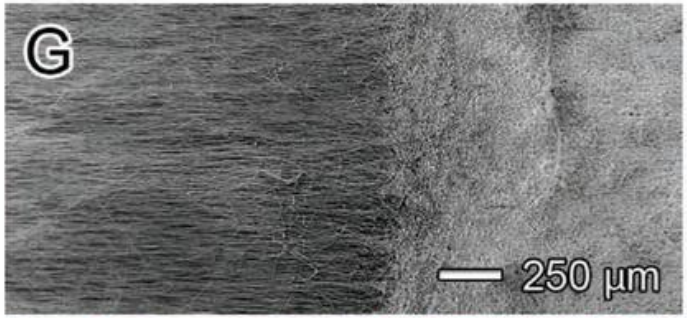
Repair of tissues, including bone, cartilage, tendon, muscle, ligament, meniscus

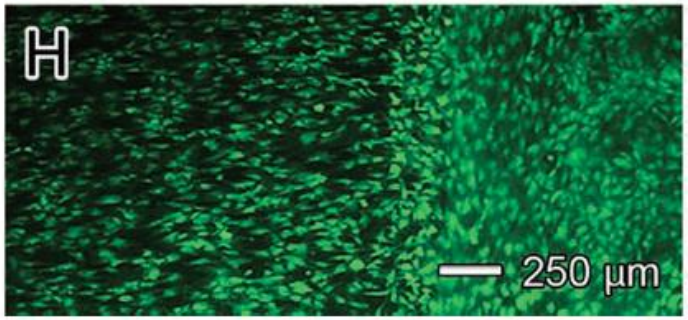


The importance of fibre alignment in tendon/ligament-to-bone repairs

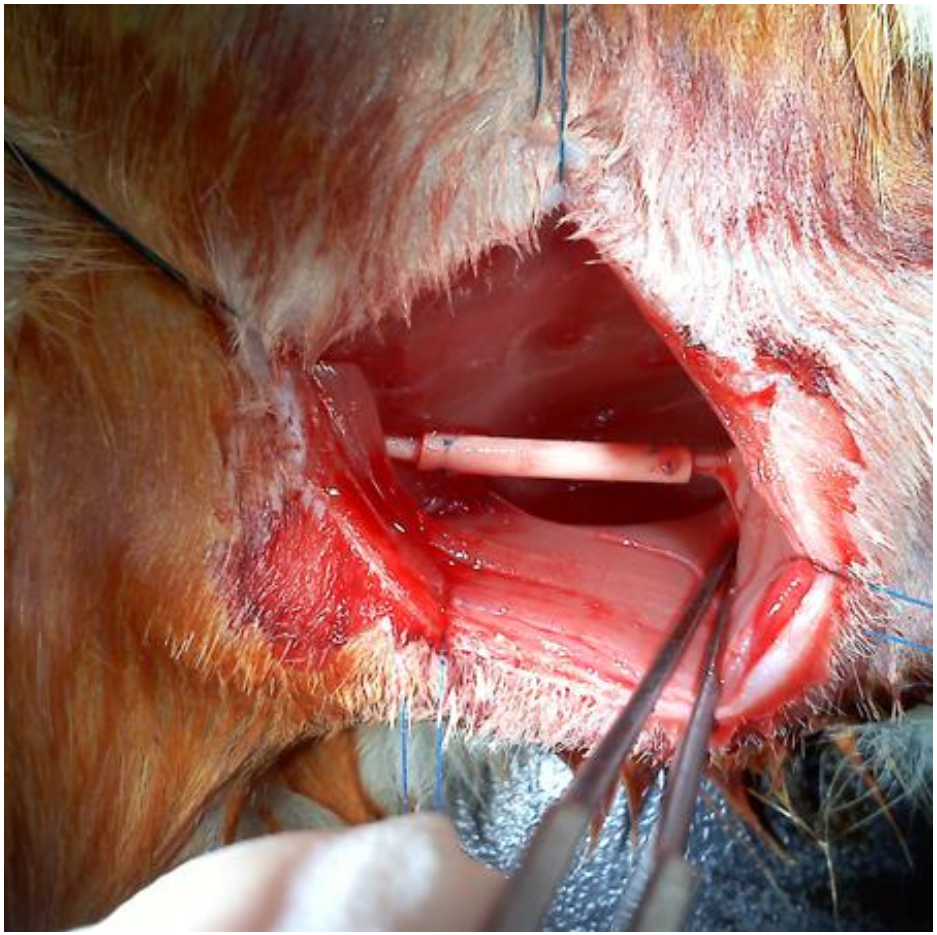


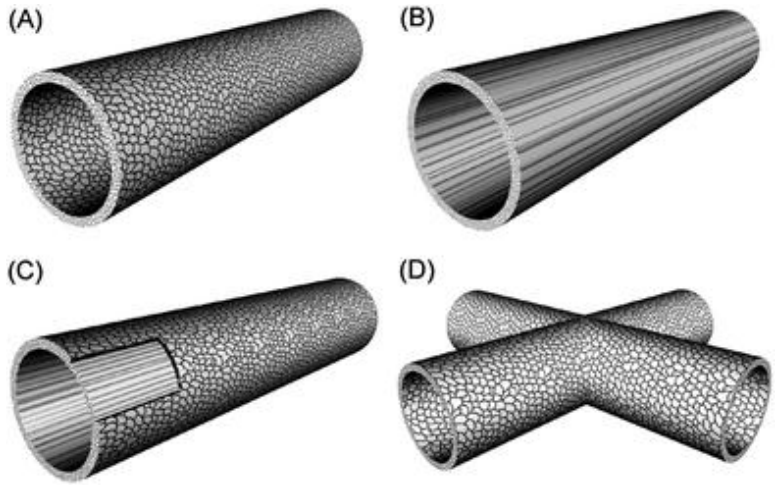






Tubular grafts make repairing of nerves and arteries possible





J. Xie et al. Nanoscale (2010) 2, 35-44

Materials for wound dressings: a wide variety and an important choice

Natural polymers

Better interaction with cells
Low immunogenicity

Collagen / gelatin
Chitosan
Silk

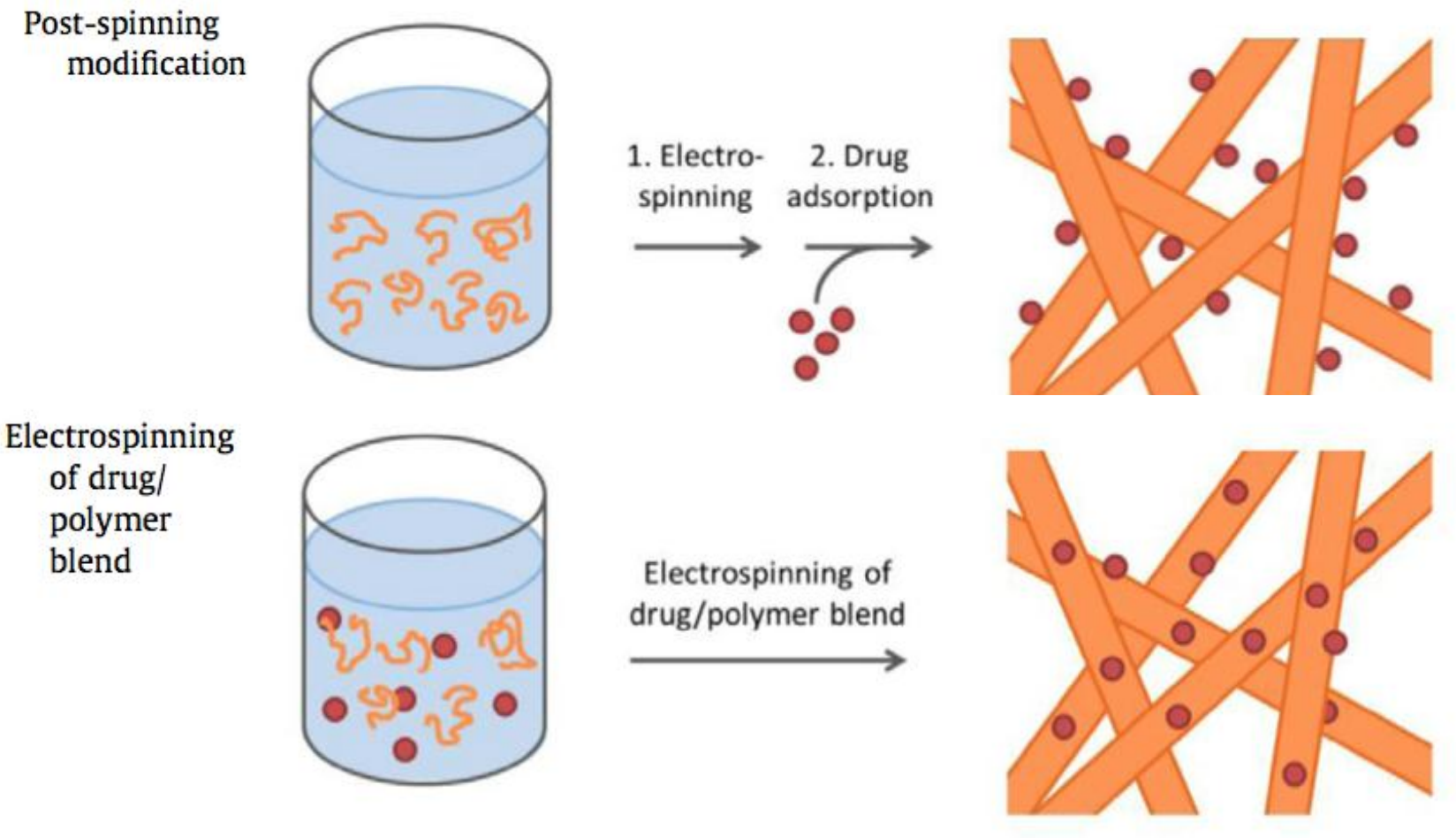
Synthetic polymers

Mechanical properties
Tailorable biodegradation
Easy processing

Synthetic polyesters (PGA, PLA, PCL)
Polyurethane
Polyvinyl alcohol

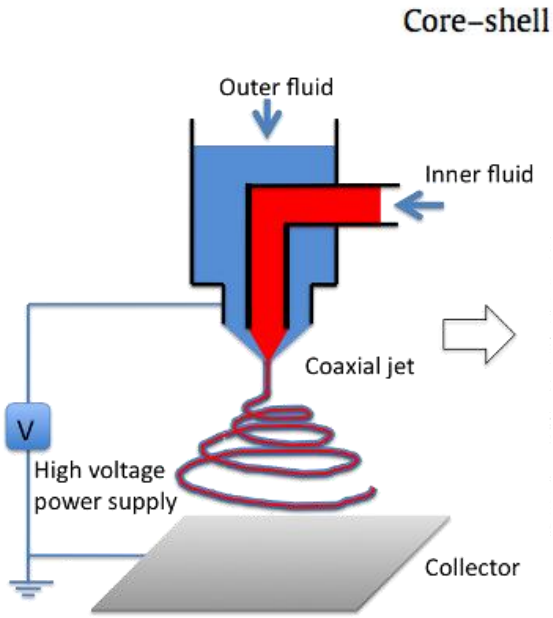
Combining them takes advantage of the best of both worlds

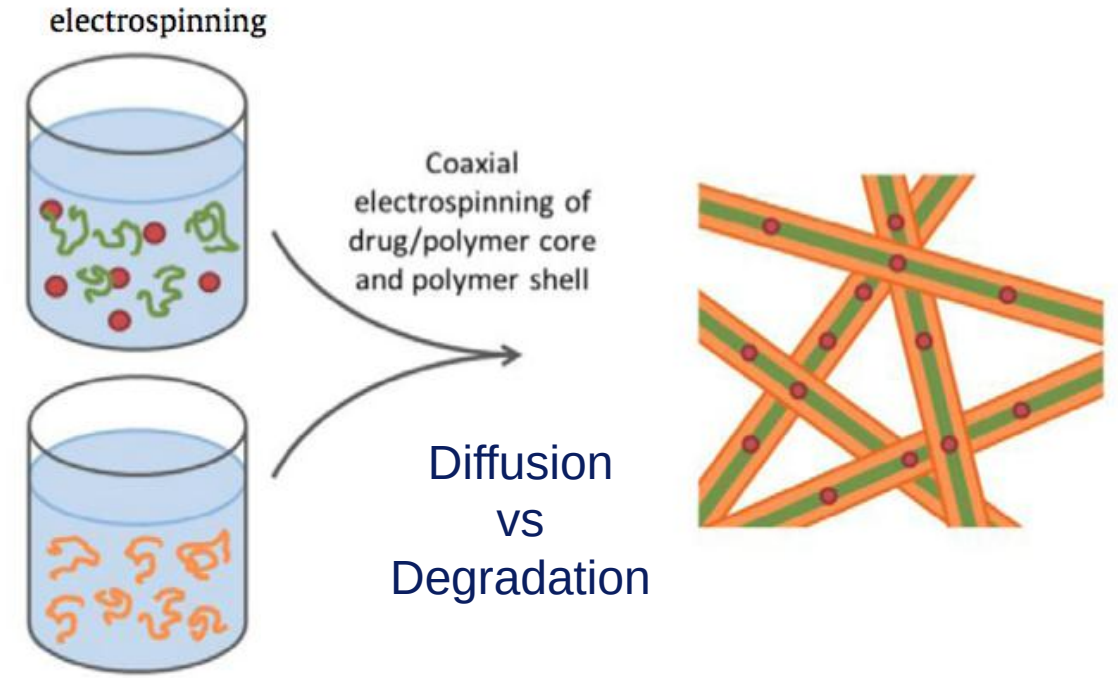
Drug delivery using nanofibres: several production methods and materials available, making tailored release possible

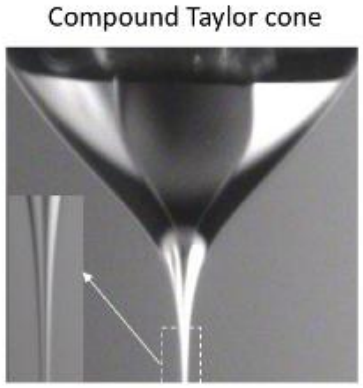


A.J. Meinel et al. European Journal of Pharmaceutics and Biopharmaceutics 81 (2012) 1–13

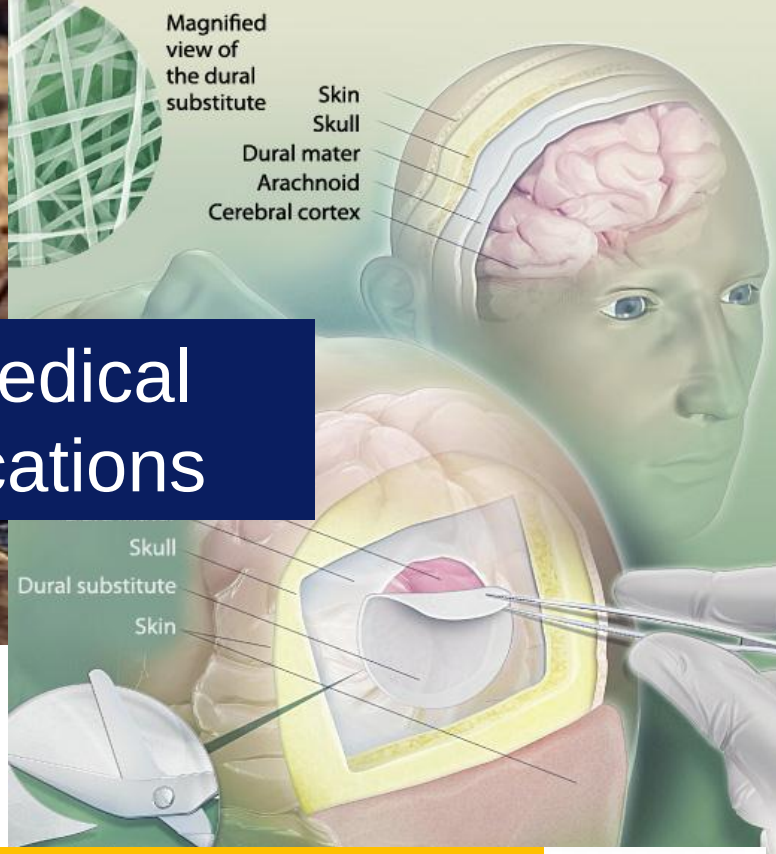
There are several possible production methods and materials available, making tailored release possible







Waterfiltration



Biomedical applications

Composites

Optical monitoring: pH-sensors

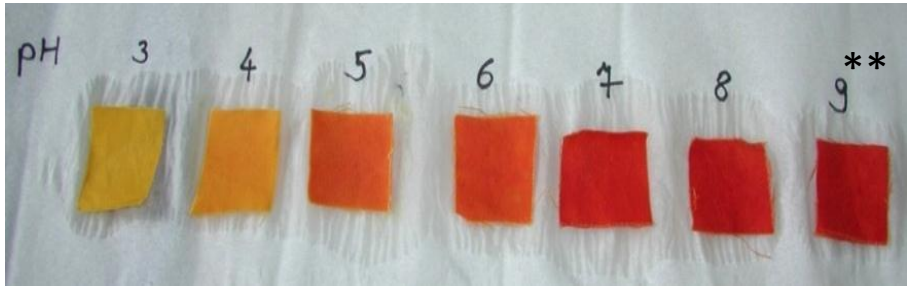
pH sensors

First signal or warning

Application in wound dressings, protective clothing, ….

Various combinations of pH-indicators and textile fibres are promising

Dyes applied through conventional dyeing technique



√ acceptable dyeing performance

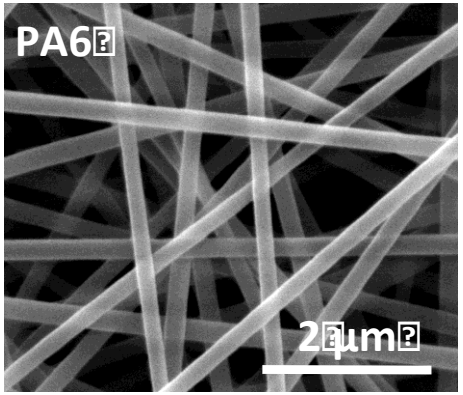
clear halochromic sensitivity

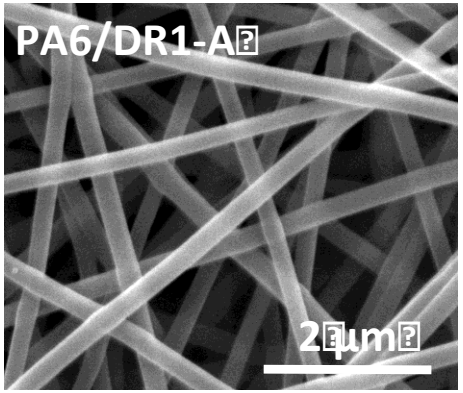
pH-indicator	cotton	polyamide
Xylenol Blue		√
Cresol Red		√
Methyl Orange	√	√
Ethyl Orange	√	√
Congo Red	√	√
Alizarin Red	√	√
Methyl Red		√
P-Rosolic Acid		√
Bromocresol Purple		√
Alizarin	√	√
Nitrazine Yellow		√
Bromothymol Blue		√
Brilliant Yellow	√ **	√
Neutral Red	√	√
Phenol Red		√

Van der Schueren et al.
Text Res J 80 (2010) 590

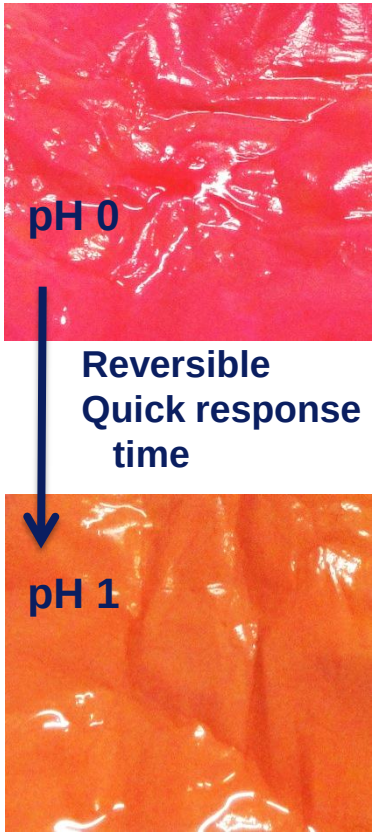
Production and analysis of nanofibres functionalised with a pH-sensitive dye

Influence on the electrospinning process



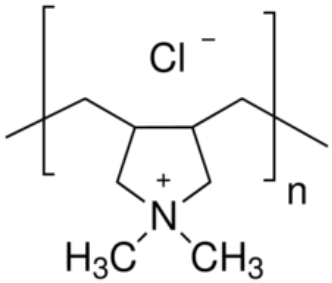


Colour change with pH



Minimising dye migration

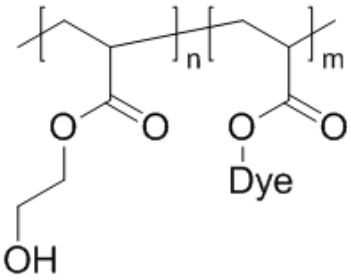
Use of a complexing agent



Faster response time

Minimal dye leaching

Use of functionalised polymers



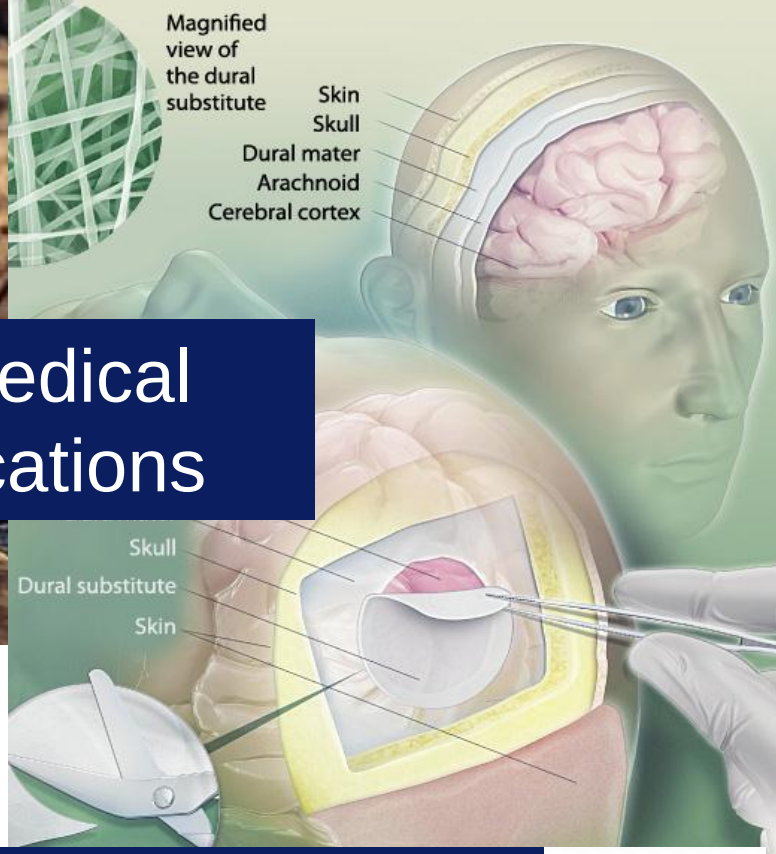
Halochromic PCL/chitosan nanofibres show potential for wound dressing applications

Dagarville et al.
Biosens Bioelectron 41 (2013) 30

- ☑ Biocompatible
  Antibacterial
- ☑ Stimulation of wound healing
- ☑ Monitoring of pH: indication on
  - healing stage
  - infections

Van der Schueren et al.
Carbohydr. Polym. 91(1) (2013) 284-293

Waterfiltration



Biomedical applications

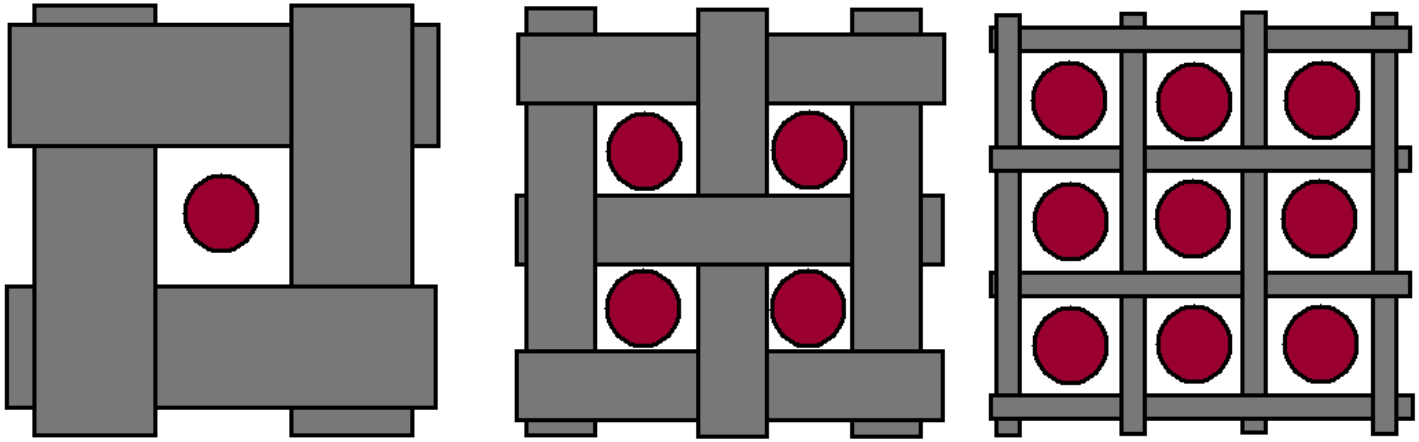
Composites

Optical monitoring: pH-sensors

High potential for water filtration

Same filter surface, high porosity, higher flux

High potential for water filtration

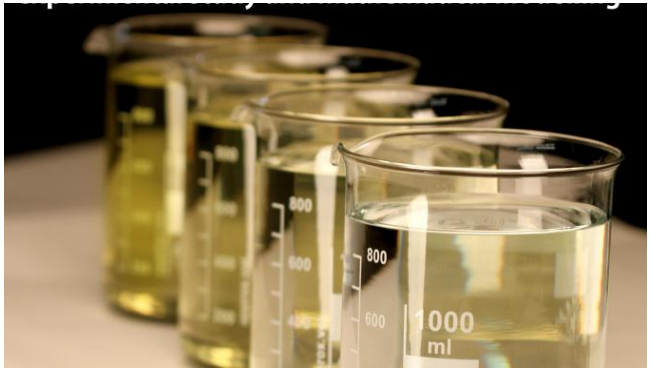


Conventional membrane | Microfibre membrane | Nanofibre membrane

2 000 l/m³.h.bar ↔ 20 000 l/m³.h.bar

Effluent microfiltration

Secondary effluent is often discharged into surface waters, while there is an increased interest in water reuse.



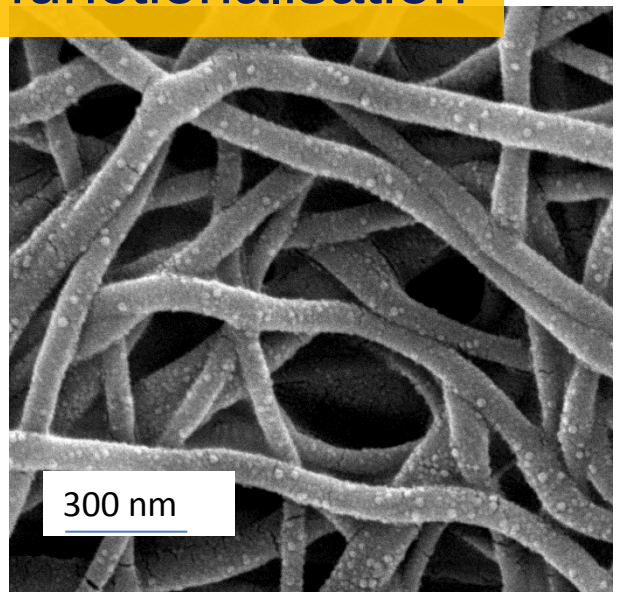
Removal after filtration with nanofibres:

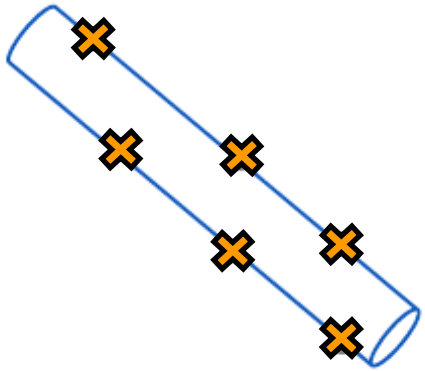
- 69% turbidity
- 76% biological activity
- 44% humic acids

High-flux filtration technique for effluent recuperation.

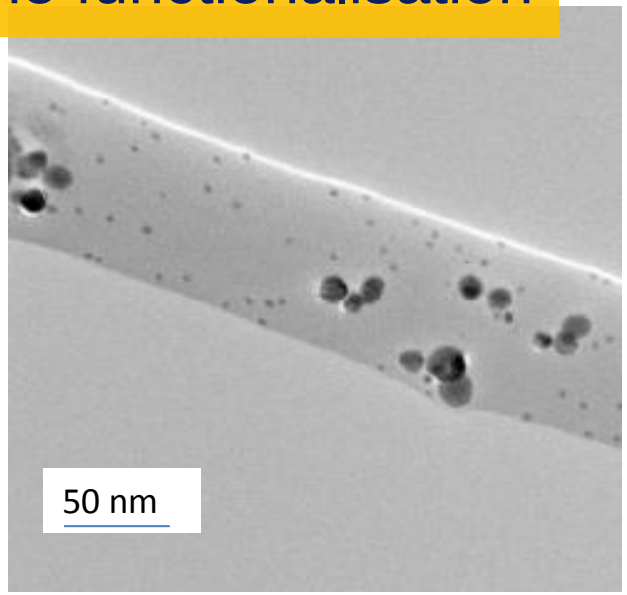
Functionalisation of nanofibres

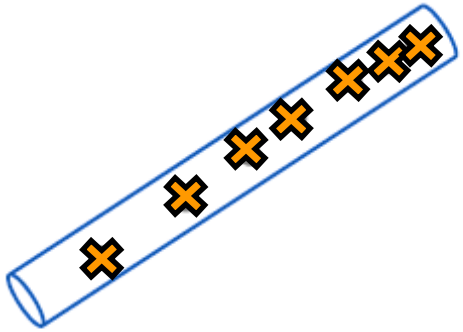
Post-functionalisation





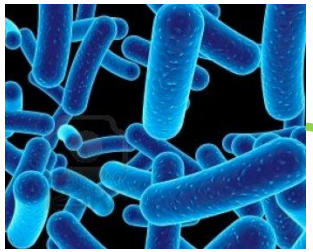
Inline functionalisation





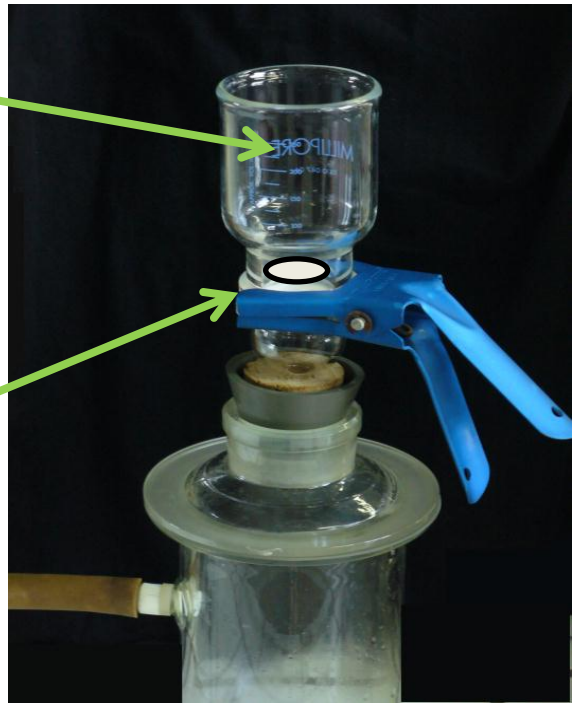
Daels N. et al
Sep. Purif.
Technol. (2014)
133, 282-290

Functionalisation with biocides/active nanoparticles

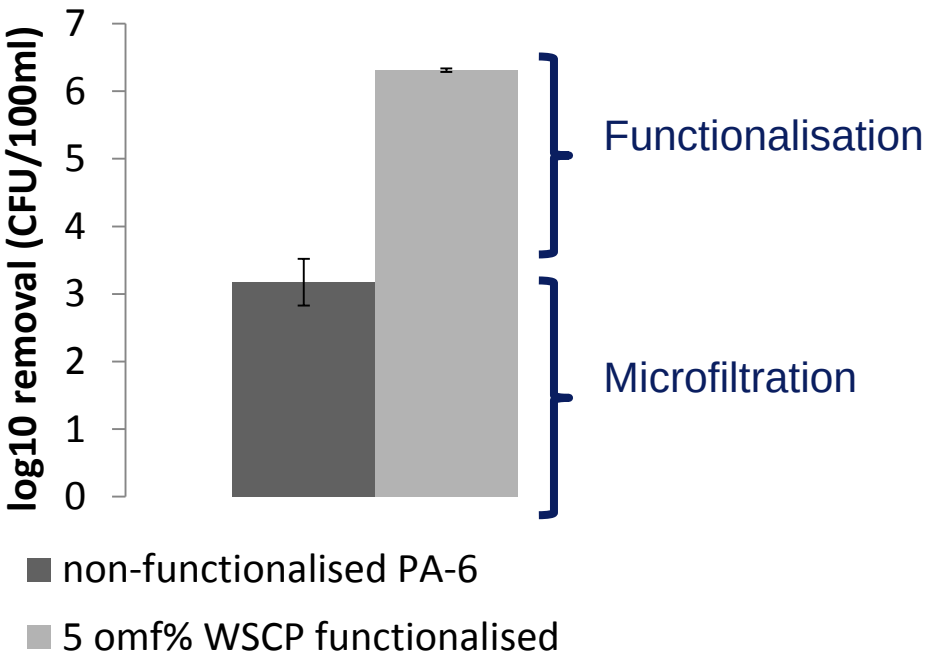


Bacteria

Nanofibre membrane

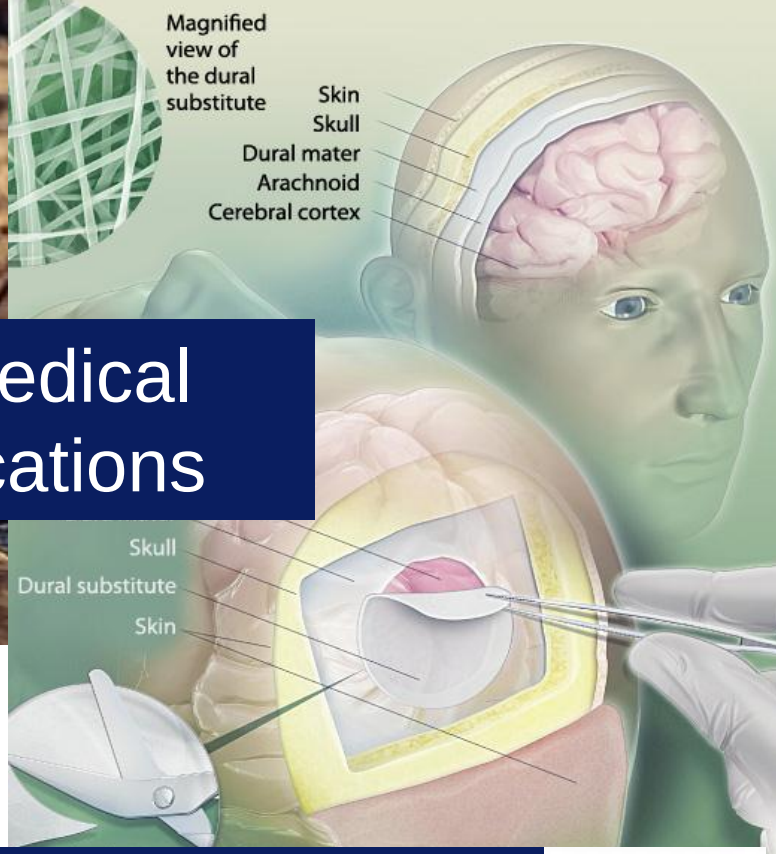


Lab scale filtration set-up



De Vrieze S. et al Text. Res. J. (2012) 82(1), 37-44

Waterfiltration



Biomedical applications

Composites

Optical monitoring: pH-sensors

Composites

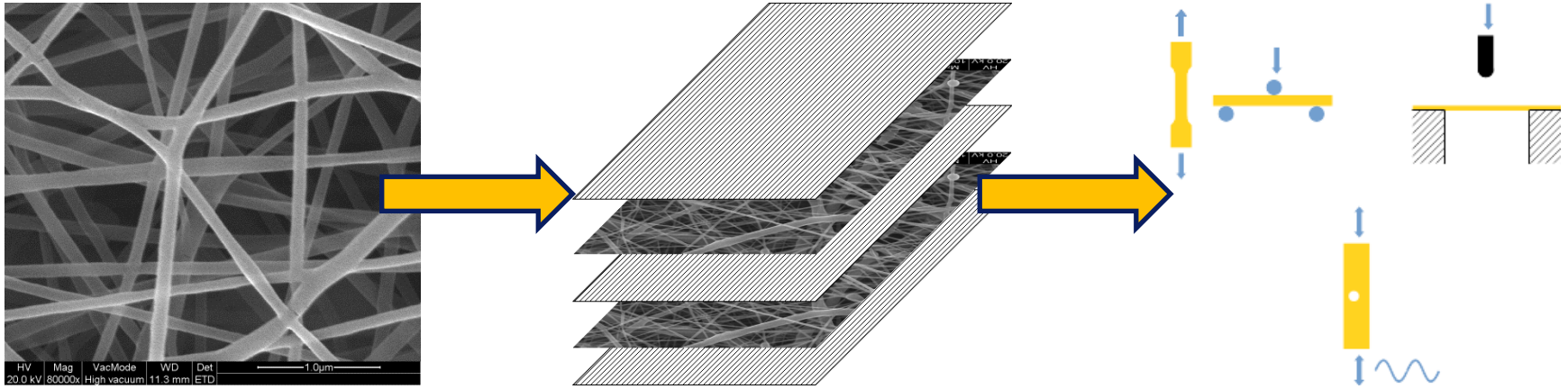
"Delamination is the most frequently encountered type of damage occurring in composites during service."

S.W. Tsai

1.
Producing nanofibrous webs

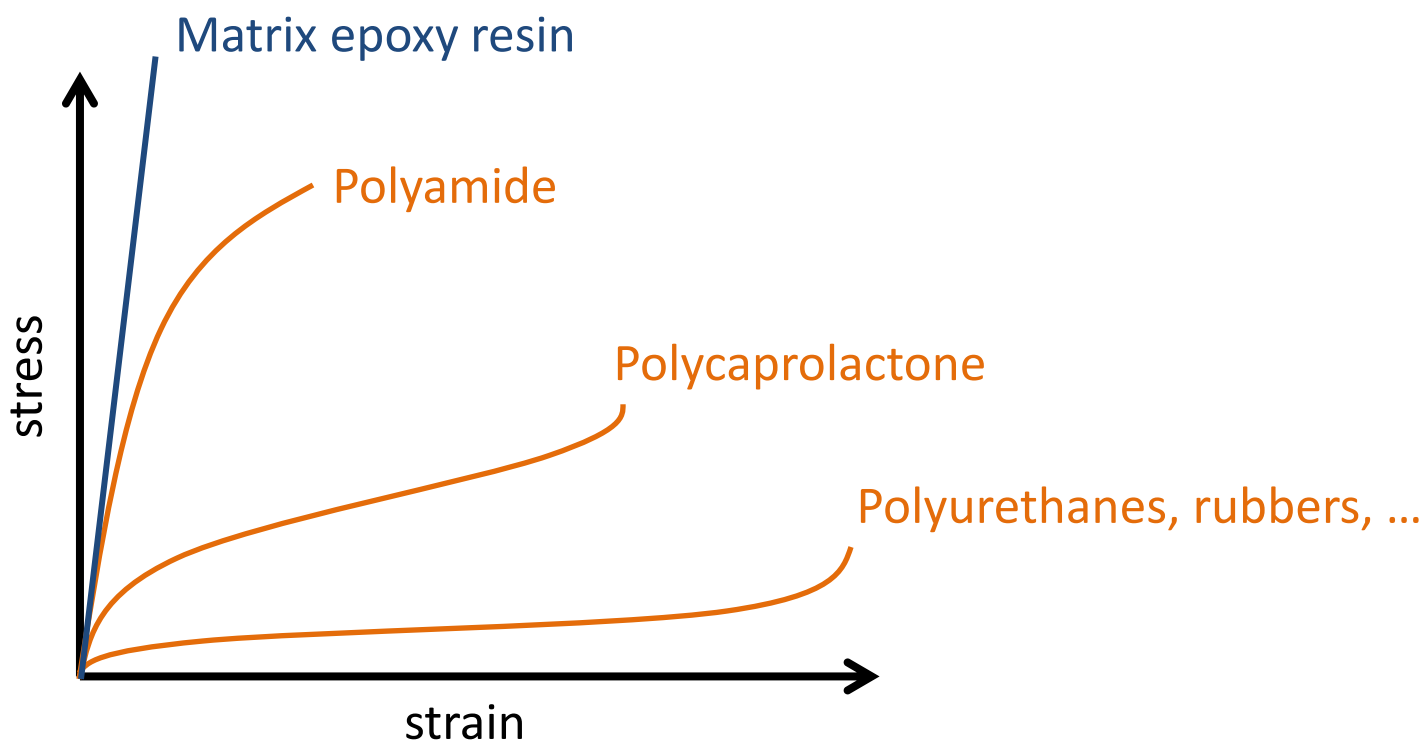
2.
Interleaving composite laminates

3.
Testing for mechanical properties

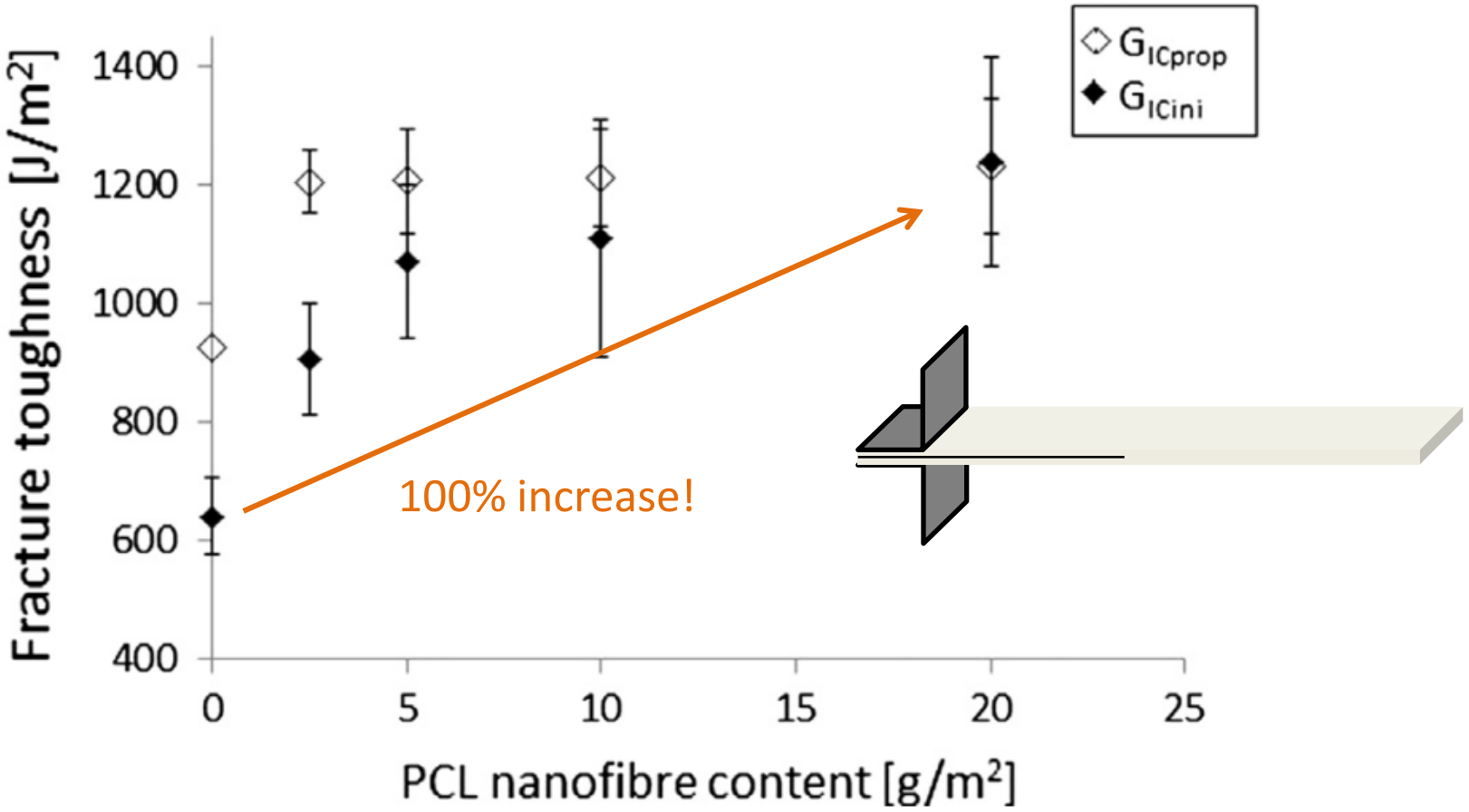


A whole range of polymers can be electrospun into nanofibrous webs

Freedom to choose whatever properties you like, e.g. Young's modulus



PCL nanofibres double the Mode I interlaminar fracture toughness

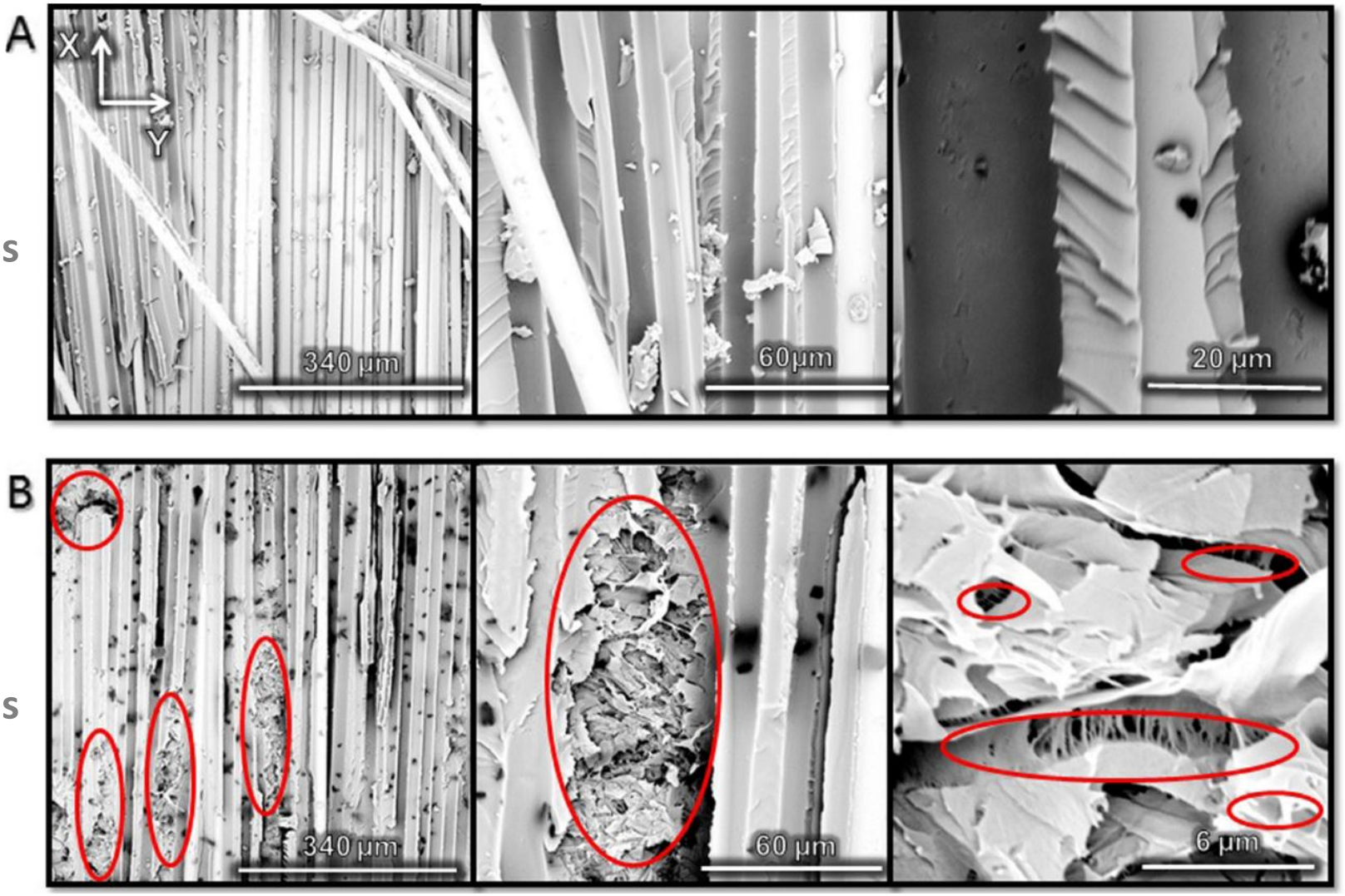


Van der Heijden et al. Compos. Sci. Technol. (2014) 104, 66-73
De Schoenmaker et al. Polymer Testing (2013), 32(8), 1495-1501

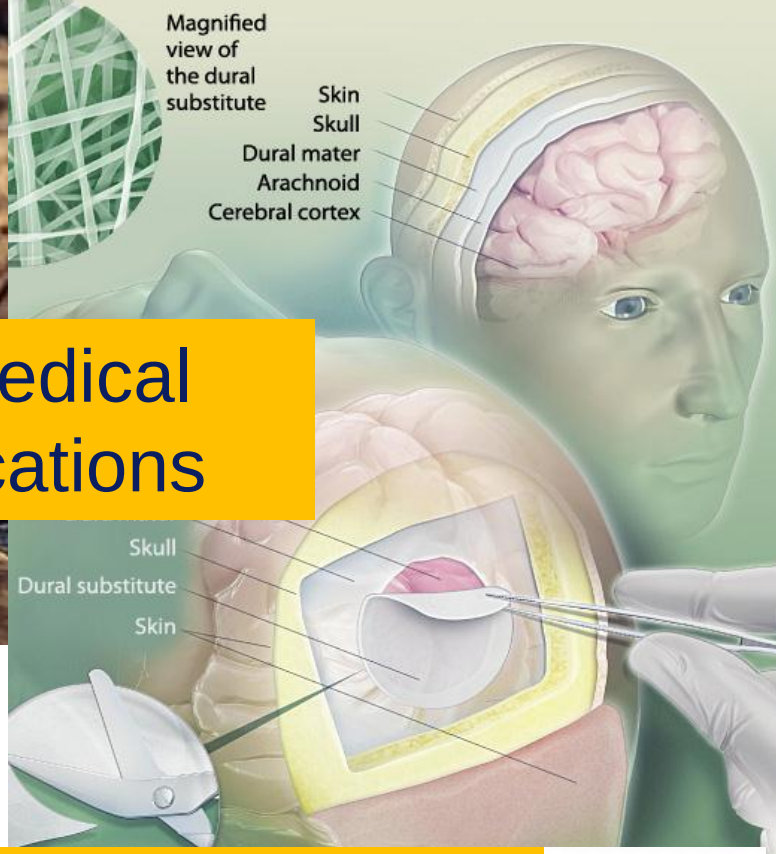
Nanofibres can bridge cracks and absorb energy

without nanofibres

with nanofibres



Waterfiltration



Biomedical applications

Composites

Optical monitoring: pH-sensors

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

COST Action MP1206

Electrospun nanofibres for bio-inspired composite materials and innovative industrial applications

Participating Countries : 33

Country of proposer/chair : red

Participating countries: blue

UNIVERSITEIT GENT

THANK YOU

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European Technology Platform *for the future of* textiles *and* clothing

10 years

of European Textile Innovation

Textile Research & Innovation in Europe from 2005 to 2025

10th Annual Textile ETP Conference,
25-26 March 2015, Brussels

www.textile-platform.eu

Conference supporters

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10 years of European Textile Innovation

Conference Programme

Day 1 – 25 March 2015

10.30 -11.00 Registration and welcome coffee

11.00 – 12.30 Opening session: Textile Research & Innovation for a Better Europe

Session chair: Jacques Tankéré, Textile ETP Vice-President

- Opening keynote by Clara de la Torre, European Commission, DG Research and Innovation
- European Textile Research and Innovation - from 2005 to 2025, Paolo Canonico, Textile ETP President
- Research on Emerging Textile Technologies – the role and strategies of Europe's Universities for Textiles, Dominique Adolphe, President of AUTEX
- Applied Textile Research – the role and strategies of Europe's Textile Research and Technology Organisations, Braz Costa, President of TEXTRANET

12.30 – 13.45 Networking lunch

13.45 – 15.30 Textile Materials of the Future – sustainability & functionality

Session chair: Emanuele Pivotto, Sinterama, Textile ETP Board Member

- Sustainable fibre innovation, Robert van de Kerkhof, Lenzing AG, Austria
- Bio-polymer based fibres & biofunctional coatings, Luc Ruys, Centexbel, Belgium
- Nanofibres and electrospinning – a new frontier for textile materials, Karen De Clerck, Ghent University, Belgium
- Electroactive textiles with fibers for sensing, energy harvesting and heating, Bengt Hagstrom, Swerea, Sweden
- From wired clothing to real printed electronics on textiles, João Gomes, CeNTI, Portugal

15.30-16.00 Coffee break

16.00 – 17.45 Textile Materials of the Future – high-performance and new applications

Session chair: Mustafa Denizer, Diktas, Textile ETP Board Member

- Market trends in carbon and other high-performance fibre based materials, Hendrik van Delden, Gherzi, Switzerland
- Textile reinforced buildings and infrastructures – the future of construction, Matthias Tietze, TU Dresden, Germany
- Textile-based medical materials and devices , Erhard Mueller, ITV Denkendorf Produktservice GmbH & Michael Doser, ITV Denkendorf, Germany
- Innovative technical textiles for off-shore bio-mass production, Joost Wille, Sioen Industries, Belgium
- Potential of warp-knitted technical textiles for wound dressings, composites and agricultural applications, Nadège Boucard, MDB Texinov, France

17.45-18.30 Formal General Assembly – for full and associated (premium & standard level) **ETP members only**

19.00 – 21.00 Networking dinner

European Technology Platform for the future of textiles and clothing

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Day 2 – 26 March 2015

9.00 – 10.45 **Textile Manufacturing Technologies of the Future**

Session chair: Michael Kamm, Sympatex, Textile ETP Board Member

- A new world of textile functionalisation, Marc Van Parys, Unitex, Belgium
- Textile biotechnology, Jan Marek, Inotex, Czech Republic
- Manufacturing of technical textiles in 3D, Dominique Maes, Van de Wiele, Belgium
- New technology developments in non-woven production and advanced non-wovens from recycled carbon fibres, Petra Franitza, Saxon Textile Research Centre STFI, Germany
- Will 3D Printing also revolutionise the textile industry?, Ger Brinks, Saxion University of Applied Sciences, The Netherlands

10.45 – 11.15 Coffee break

11.15 – 13.00 **The Textile and Fashion Industry of the Future and its New Business Models**

Session chair: Pierre Van Trimpont, TIC, Textile ETP Board Member

- ManuTex 4.0 - the future of textile manufacturing, Yves Gloy, ITA RWTH Aachen, Germany
- The SpeedFactory, Gerd Manz, Adidas AG, Germany
- Digitalising the Fashion Industry, Philippe Ribera, Lectra, France
- Collaborating creative value chains for textiles and fashion, Meike Tilebein, DITF-MR, Germany
- New business models for personalised fashion products, Michel Byvoet, Bivolino.com, Belgium

13.00 - 14.00 **Networking Lunch**

14.00-15.30 **Closing session: The Textile & Clothing Industry in an European Industrial Renaissance – European and national strategies**

Session chair: Francesco Marchi, EURATEX, Textile ETP Board Member

- European policies for an Industrial Renaissance, Jean-François Aguinaga, European Commission - DG Internal Market, Industry, Entrepreneurship and SMEs
- Euratex strategies for a competitive and innovative EU Textile and Clothing industry, Serge Piolat, Euratex
- A strategic plan for the future of the French Textile and Clothing industry, Yves Dubief, Union des Industries Textiles, France
- A new joint Technology Platform for the Italian Textile and Clothing industry, Aldo Tempesti, TexClubTec, Italy
- The European Technology Platform – the next 10 years, Lutz Walter, Textile ETP

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10 years of European Textile Innovation

Practical Information

Venue

HUSA President Park Hotel, Blvd. du Roi Albert II, 44, B-1000 Brussels,
www.husapresidentpark.com

Conference organiser

The European Technology Platform for the Future of Textiles and Clothing a.i.s.b.l., Brussels

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Conference Materials

All validly registered conference participants will receive hand-out documentation containing programme, participants list, speech abstracts and various other information materials.

Conference presentations will be made available electronically, subject to clearance by the speaker, within 2 weeks after the conference.

www.textile-platform.eu

The conference facilitates dissemination of results of collaborative research projects and is for this purpose supported by the following projects and organisations:

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