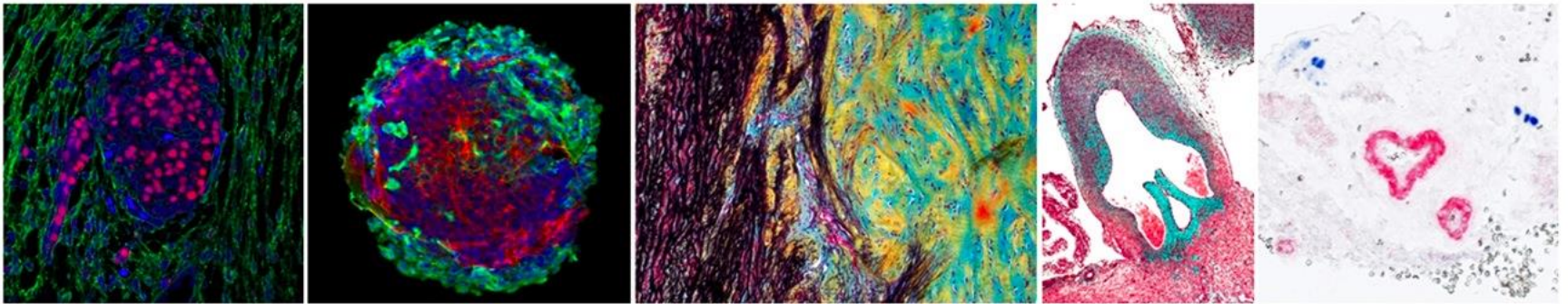


Electrospinning

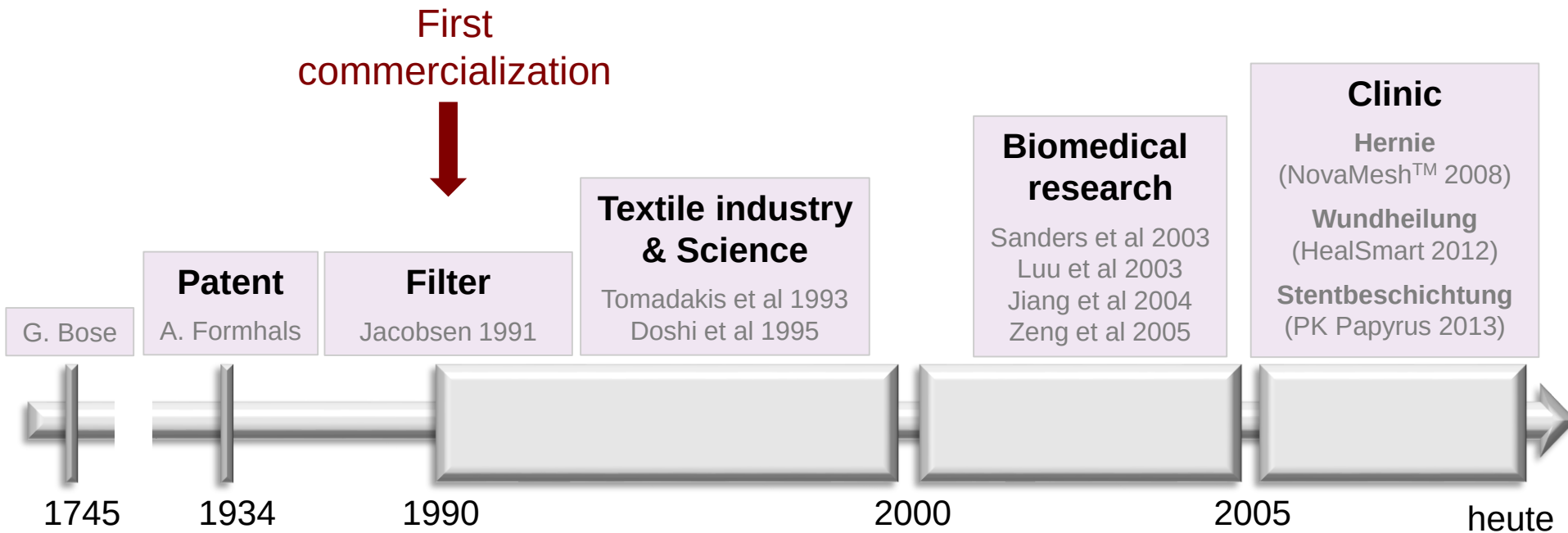
Dr Svenja Hinderer

NMI Reutlingen, Germany

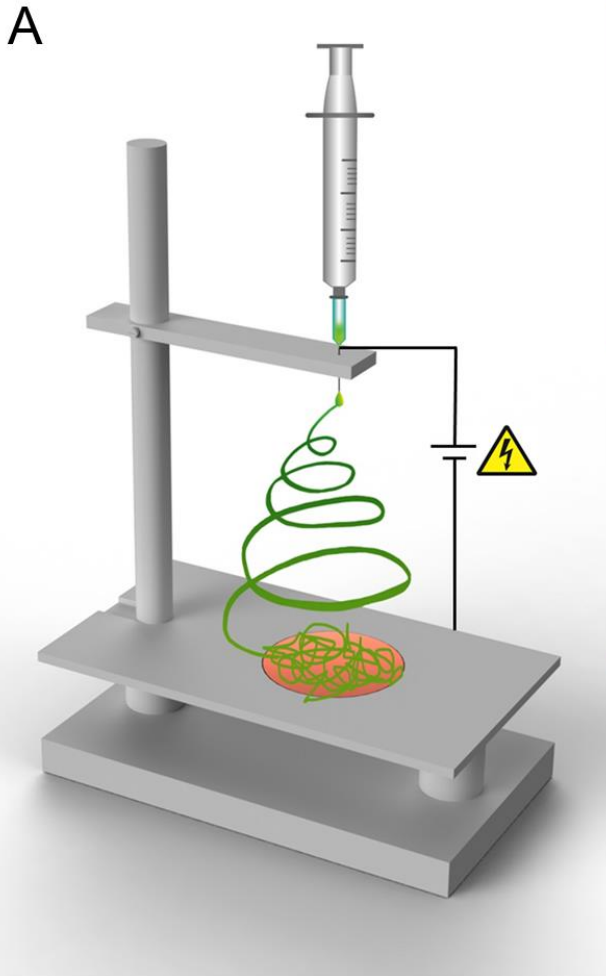
University Women's Hospital Tübingen, Germany



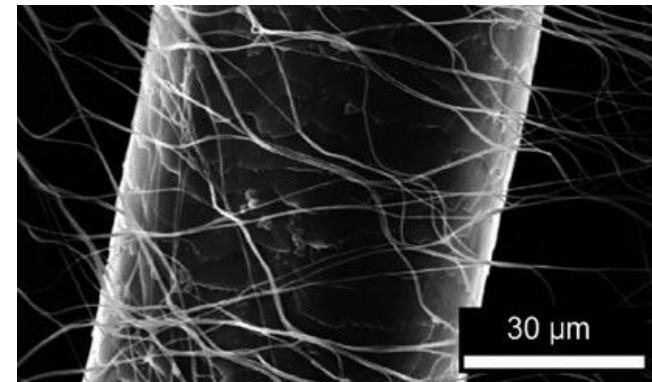
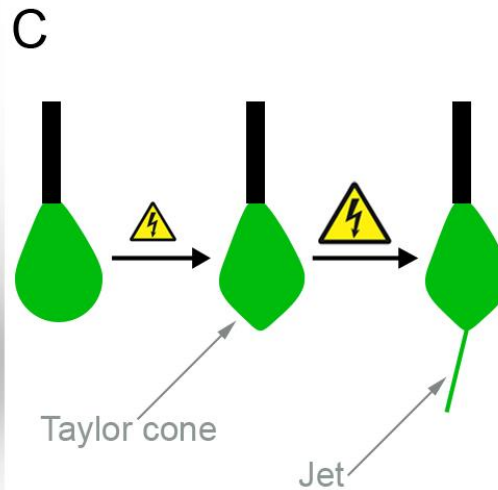
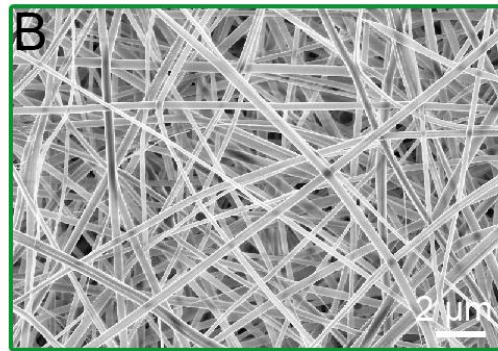
History and clinical application



The electrospinning process



Hinderer et al. Adv Healthcare Mater (2015)



Greiner et al. Angew Chemie (2007)

Influencing the electrospinning process

- Polymer
 - Viscosity
 - Concentration
 - Molecular weight and molecular weight distribution
 - Type of polymer
- Solvent
 - Conductivity
 - Volatility
- Device
 - Flow rate
 - Applied voltage
 - Electrode distance
 - Nozzle size
- Humidity, temperature, air pressure

Impact on fiber size, porosity, quality and morphology

Correlations – a few examples

- Acceleration impacts fiber size (the faster, the thinner)
voltage
collector distance
- Thinner fiber when ...
conductivity↑
volatility↓
nozzle diameter↓
- Morphology
humidity (high = pores on fiber surface)
polymer concentration (low = beads)
volatility and collector distance (low = flat fibers)

Complex interaction: changing only one parameter is in most cases not possible. This is just to get an idea, the list is not complete!

Polymers utilized for electrospinning

Synthetic polymers

- Polyurethane Bergmeister et al 2013
- Poly- ϵ -Caprolaktone Kriebel et al 2013
- Polylactic acid Hinderer et al 2014
- Poly(ethyleneglykol) Schultz et al 2013

Natural polymers

- Collagen Matthews et al 2002
- Elastin Rnjak- Kovacina et al 2011
- Hyaluronan Ji et al 2009
- Chitosan Matsuda et al 2007

Advantages:

Stability
Controlable
Reproducibility

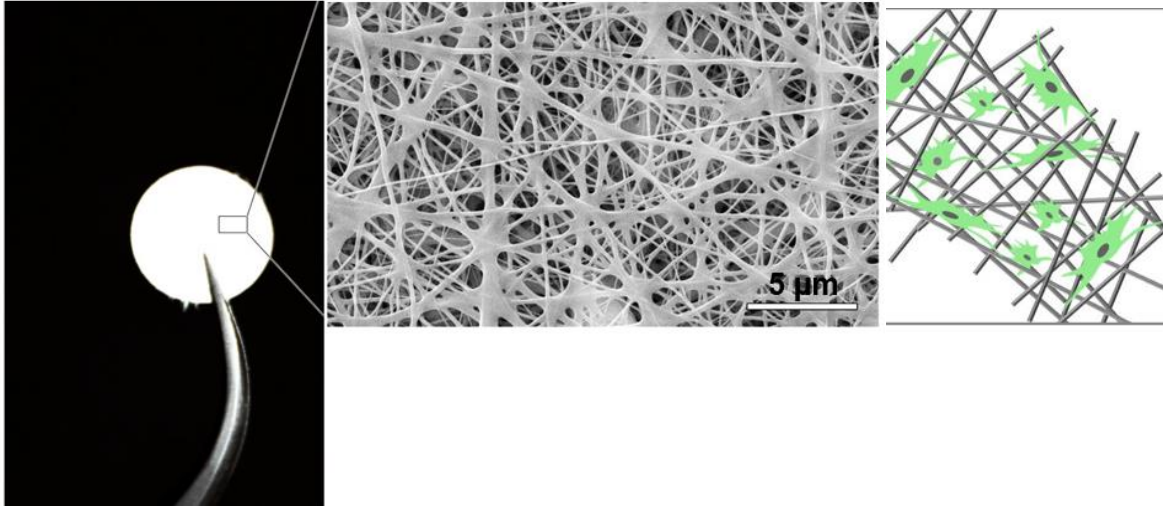
Advantages:

Biochemistry
Biocompatibility
Patient-specific

Hybrids

- Polyurethane/Cellulose Unnithan et al 2014
- Poly- ϵ -Caprolaktone/Decorin Hinderer et al 2012
- Polylactic acid/Collagen Wang et al 2013

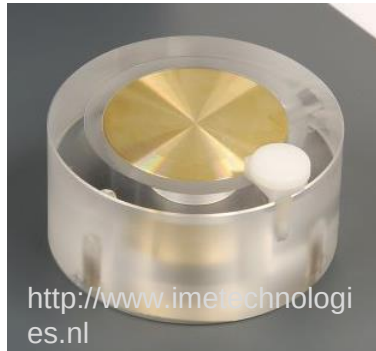
Interesting scaffold for Reg Med



- 3D fibrous and porous structure
 - similar to the extracellular matrix (ECM)
 - improved implant integration
 - impact on cell behavior (proliferation, migration and differentiation)
- Application in regenerative medicine:
 - “advanced” cell culture
 - implant / drug delivery system
 - test system

Collectors/ Electrodes

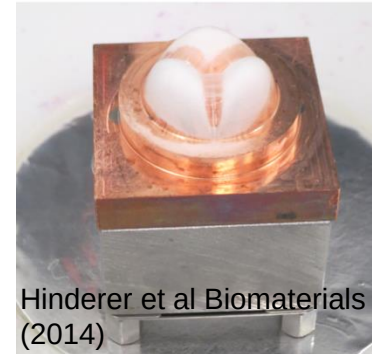
Flat collector



Rotating collector



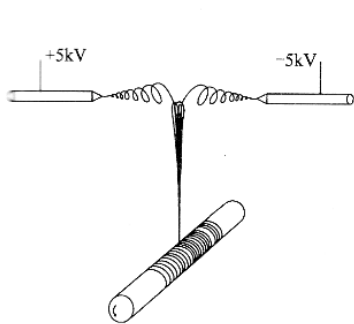
Customized shapes



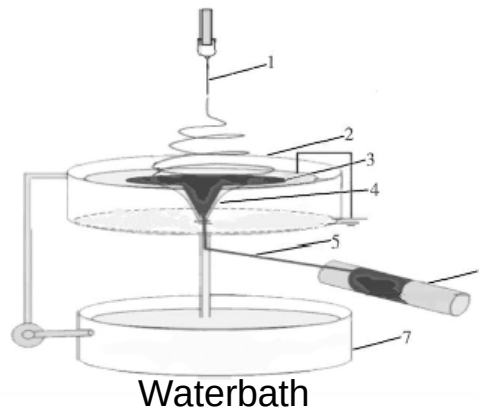
Frame collector



Yarn production collectors



Conjugated



Waterbath

<http://www.electro-spinning.com>

Need to be **conductive!**

E.g.: Al, Cu, Au,...

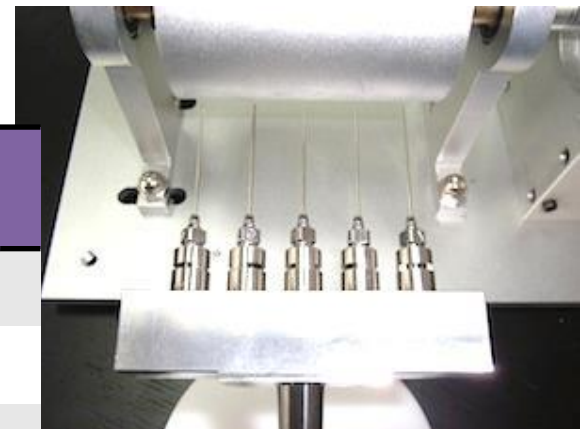
Nozzle/ Electrode

Single nozzle



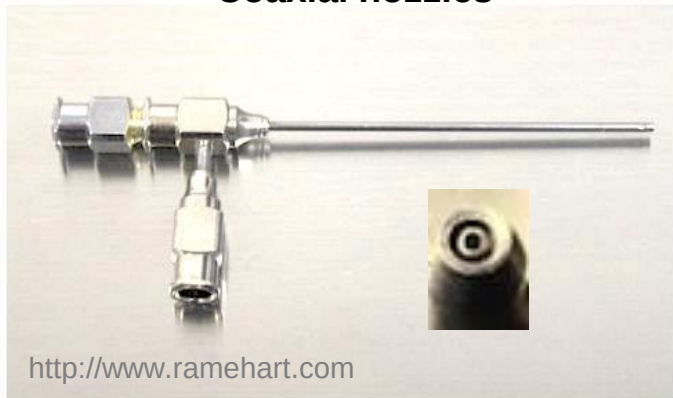
Hinderer et al Adv Drug Deliver Mater *in press*

Multiple nozzles



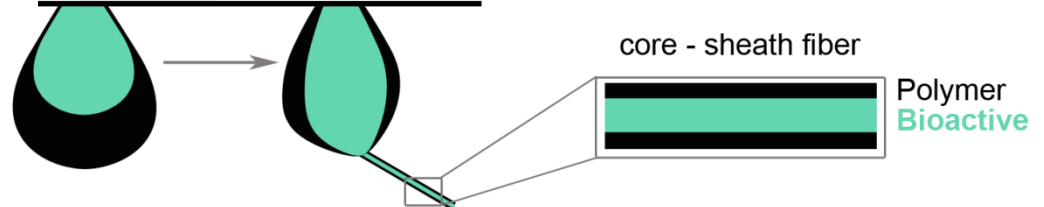
<http://www.electro-spinning.com>

Coaxial nozzles



<http://www.ramehart.com>

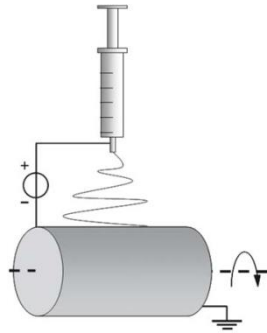
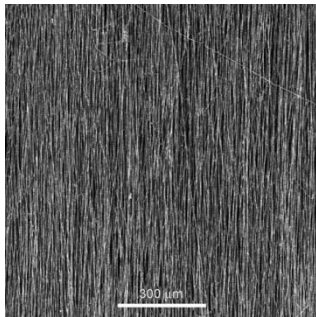
Gauge (G)	mm
10	2.588
13	1.828
15	1.449
18	1.024
20	0.812
22	0.644
24	0.511



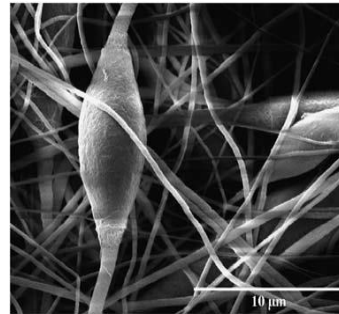
Hinderer et al Adv Drug Deliver Mater *in press*

Fiber morphology

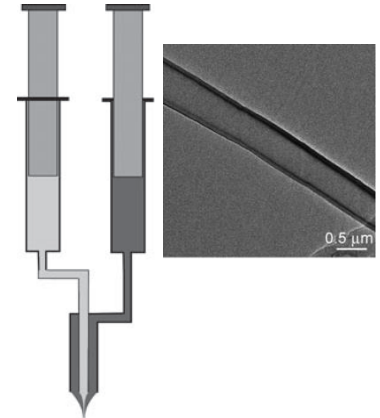
random vs. aligned



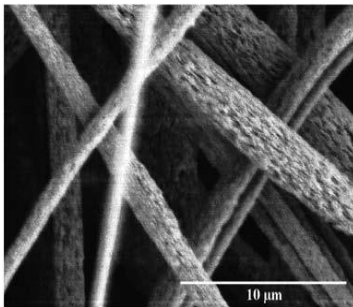
beads



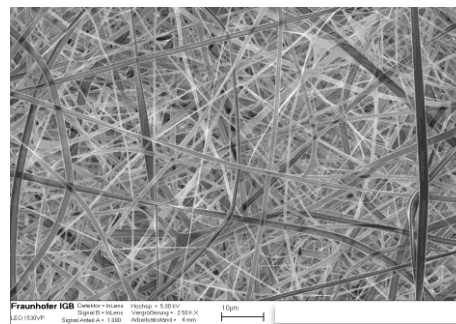
core-shell



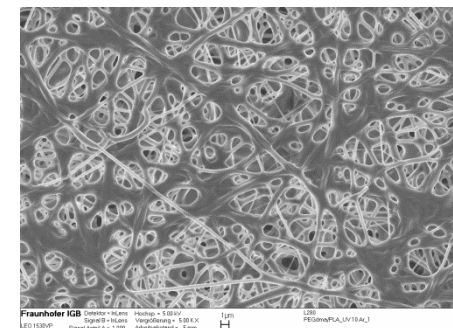
porous fibers



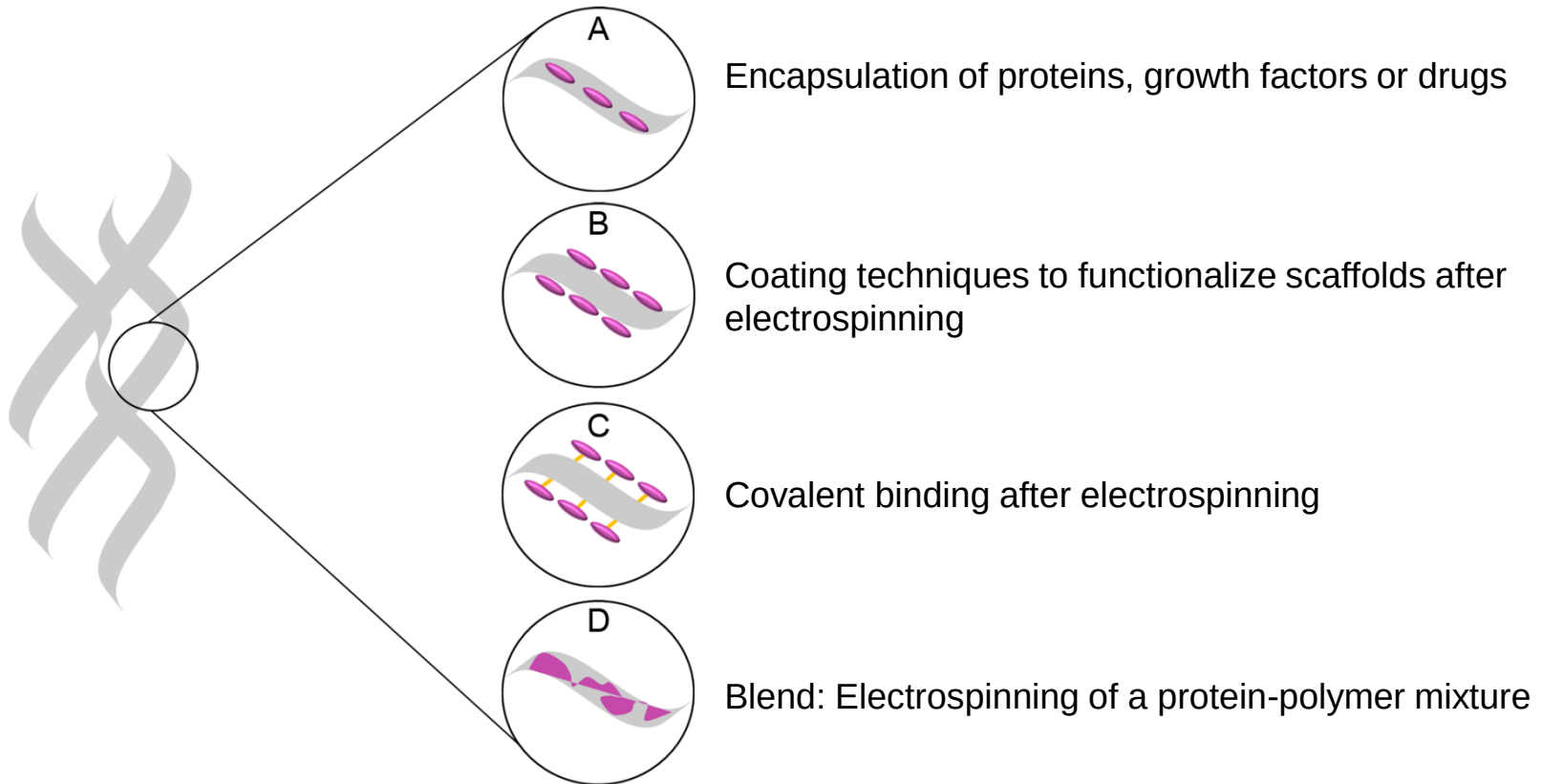
tape-like



crosslinked



Functionalization



3 groups – 3 variations of electrospinning

Near field electrospinning

 Technology Briefs

A Computer-Controlled Near-Field Electrospinning Setup and Its Graphic User Interface for Precision Patterning of Functional Nanofibers on 2D and 3D Substrates

Gobind Bisht^{1*}, Sergiy Nesterenko^{2*}, Lawrence Kulinsky³, and Marc Madou^{1,3,4}

Near-Field Electrospinning

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DOI: 10.1089/ten.teb.2014.0347

Melt electrospinning

Melt Electrospinning and Its Technologization in Tissue Engineering

M. Lourdes Muerza-Cascante, MEng,¹ David Haylock, PhD,^{2,3}
Dietmar W. Hutmacher, MBA, PhD,^{1,4,5} and Paul D. Dalton, PhD^{1,6}

Electrospraying

Electrospraying: A Facile Technique for Synthesis of Chitosan-Based Micro/Nanospheres for Drug Delivery Applications

Neha Arya,* Syandan Chakraborty,* Nikhil Dube, Dharendra S. Katti

Department of Biological Sciences and Bioengineering, Indian Institute of Technology, Kanpur – 208016, India

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Published online 3 April 2008 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/jbm.b.31085

- describe the principle
- difference to electrospinning
- advantages/ disadvantages
- potential applications

→ Each group presents

Literature and References

