Biomedical perspectives for spider silk fibres

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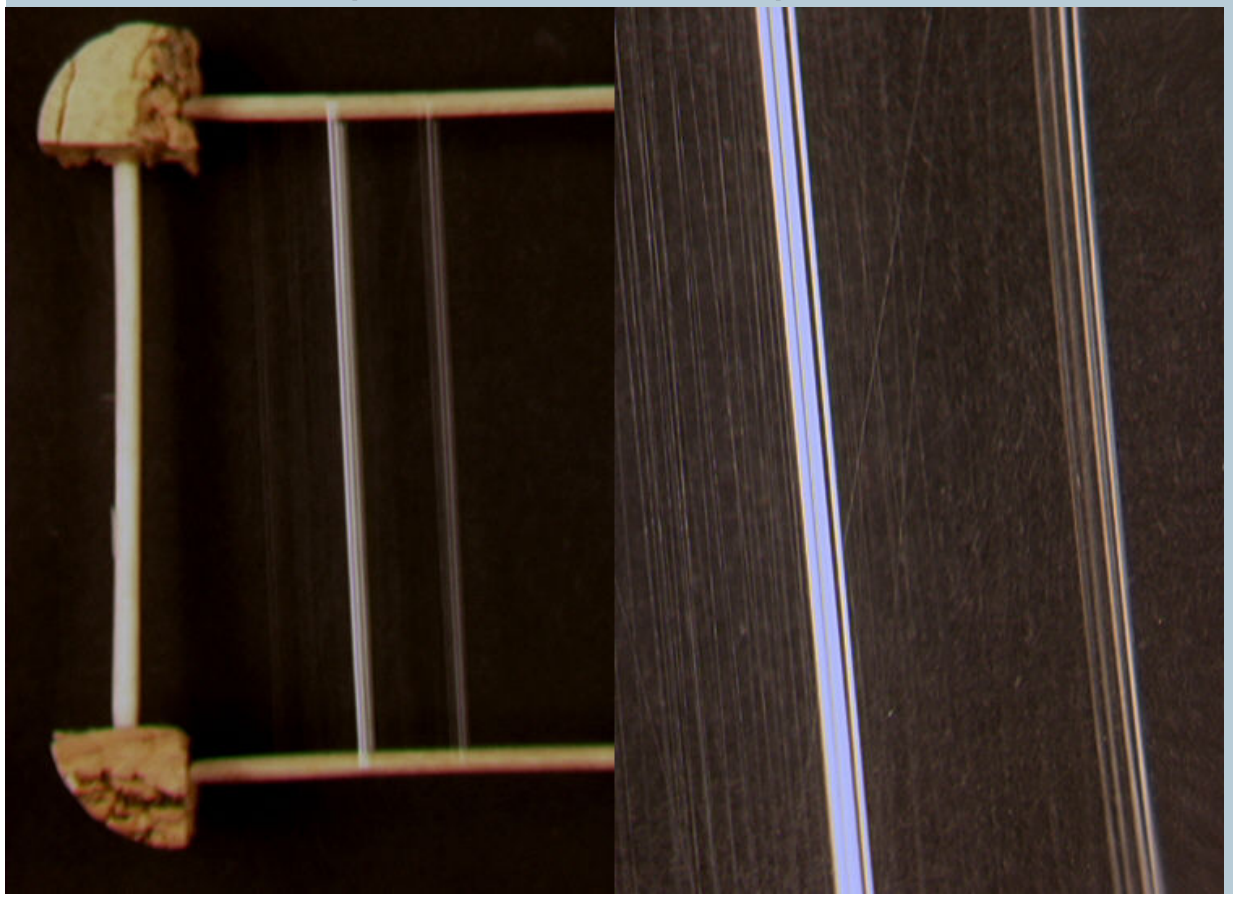
Why spider silk?

- Mechanical properties, proteinic nature
- Different silk threads => properties => applications
  - Spider drag line
  - Spider cocoon silk
  - Synthetic spider silk

Silk: Spider dragline silk

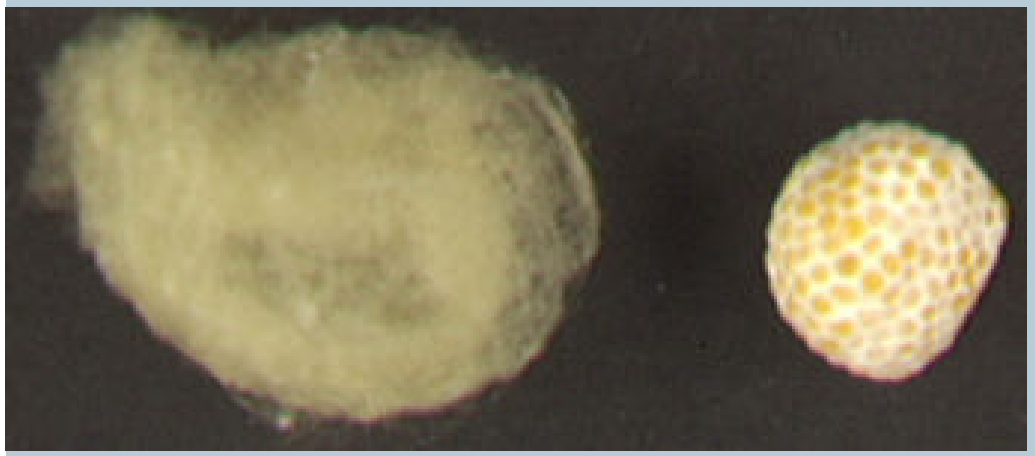
- *Araneus diadematus* grown in the lab:
- The spider is fixated and dragline can be reeled off (1 rps/10min.): 1 spider ~100m = ~1mg



- fine: D: 3-5 µm
- strong/ elastic

Silk: Spider cocoon silk

- *Araneus diadematus* grown in the lab:
- 1 spider => 1 cocoon => 10 mg of silk



- Easier to obtain than dragline

- Very elastic

- less strong than dragline

Synthetic spider silk

Genetic engineering of spider silk proteins

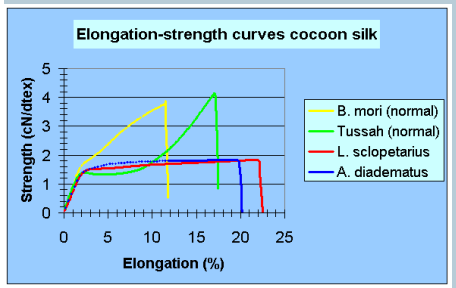
- Dupont: in Bacteria
- Hebrew University/Vollrath: Insect cells
- Nexia: in goats
- *Gatersleben*: in tobacco and in potato

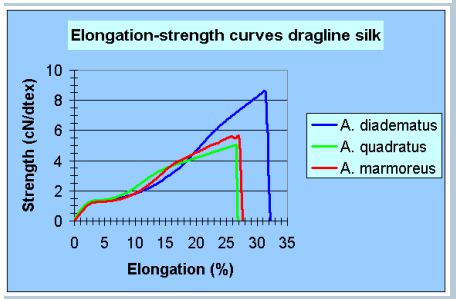
- Still facing the problem of spinning the spider silk proteins.

Biomedical applications: requirements

- Mechanical properties: strength/elasticity
- Sterilisable:
- Biocompatible:
- Biodegradable:
- Cell Support –not cytotoxic attachment/migration/expression/growth/differentiation/ ...
- ...

Mechanical properties





	Density [g cm^{-3}]	Tenacity [GPa]	Strain break [%]	Toughness [MJ m^{-3}]
nylon 6,6	1.1	0.95	18	80
kevlar 49	1.4	3.6	3	50
dragline of *A. diadematus*	1.3	1.1	27	160
cocoon of A. Diadematus	1,3	0,3	25-50	70
silk of the moth *B. mori*	1.3	0.6	18	70
wool	1.3	0.2	50	60
PLA	1.24	0.7	22	90
high-tensile steel	7.8	1.5	1	6

Sterilisation

- Ethyleenoxide: toxic residues are left
- UV-sterilisation: makes the silk fibre less elastic, less strong and stiffer
- Steam sterillisation: same but less effect than UV-sterillisation and more effective against bacteria.

Conclusion: steam-sterillisation will be used

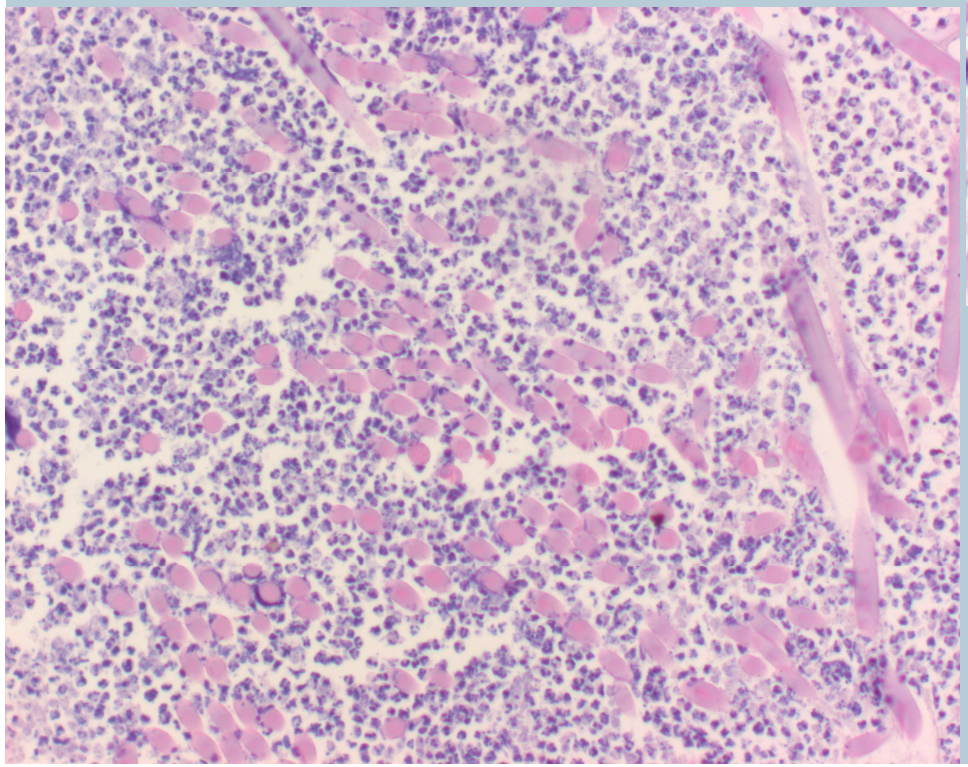
biocompatibility?

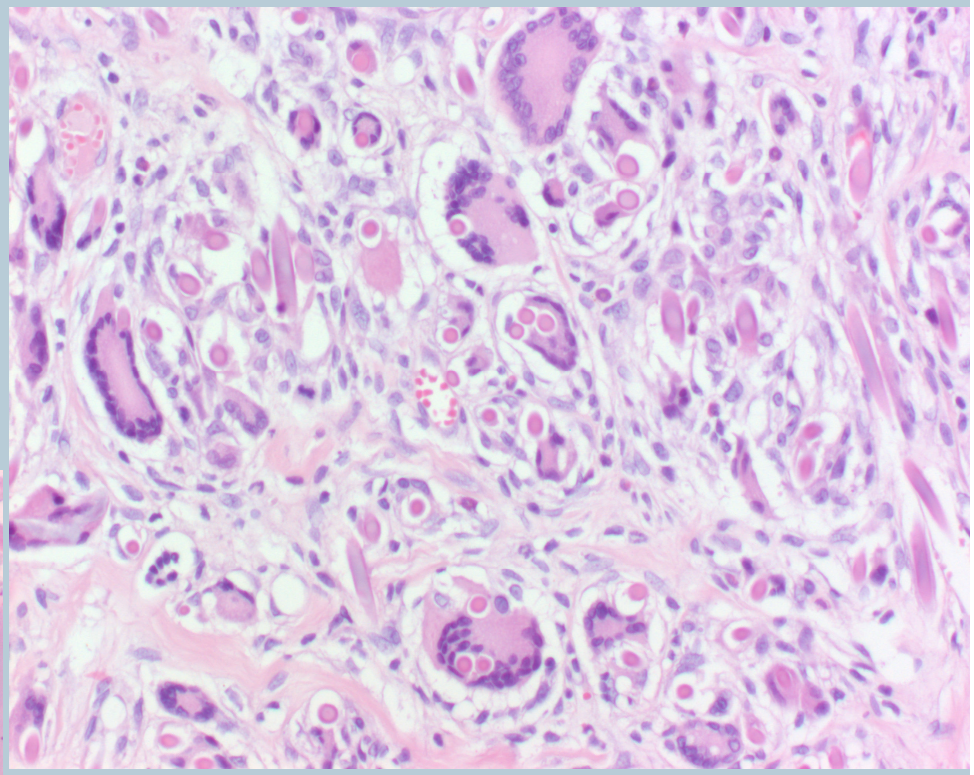
- Silkworm silk: fibroin with sericin-layer
  - problems: sericin shows biocompatibility problems
    - Can be removed by boiling in NaCO3-solution
    - Silk fibroin is biocompatible
- Spider silk: in vivo tests
  - Spider silk has no sericin
  - Macroscopically: pain? Redness? Swelling? Heat?

biocompatibility

No enzymatic treatment: just autoclavage:

- more immune-cells





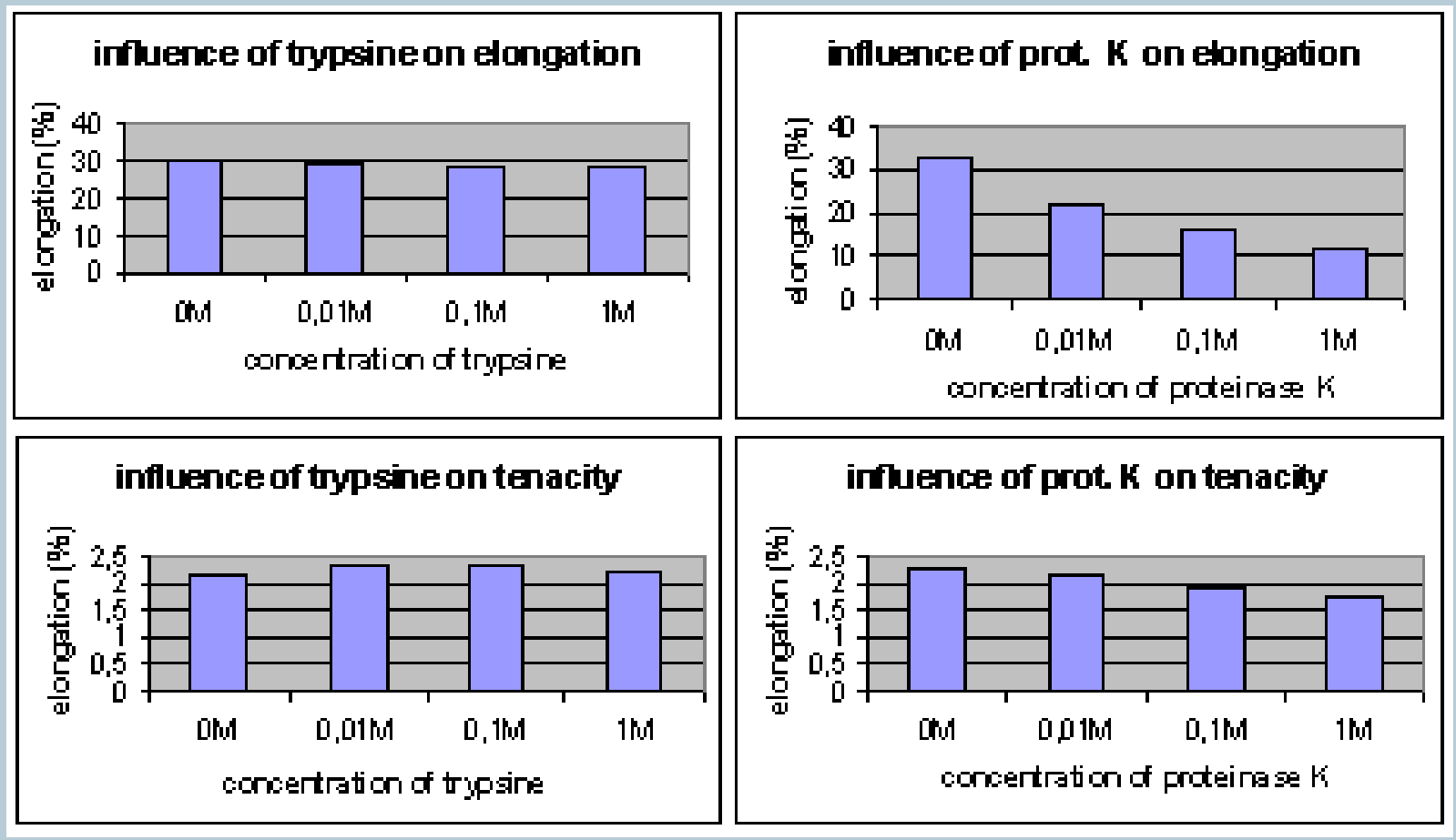
enzymatic treatment and autoclavage:

-less immune-cells

-Giant cells = typical towards inert material

-Fibrosis = recovery

Influence of enzymatic treatment



degradability

- In vivo: after 3 months silk is still there

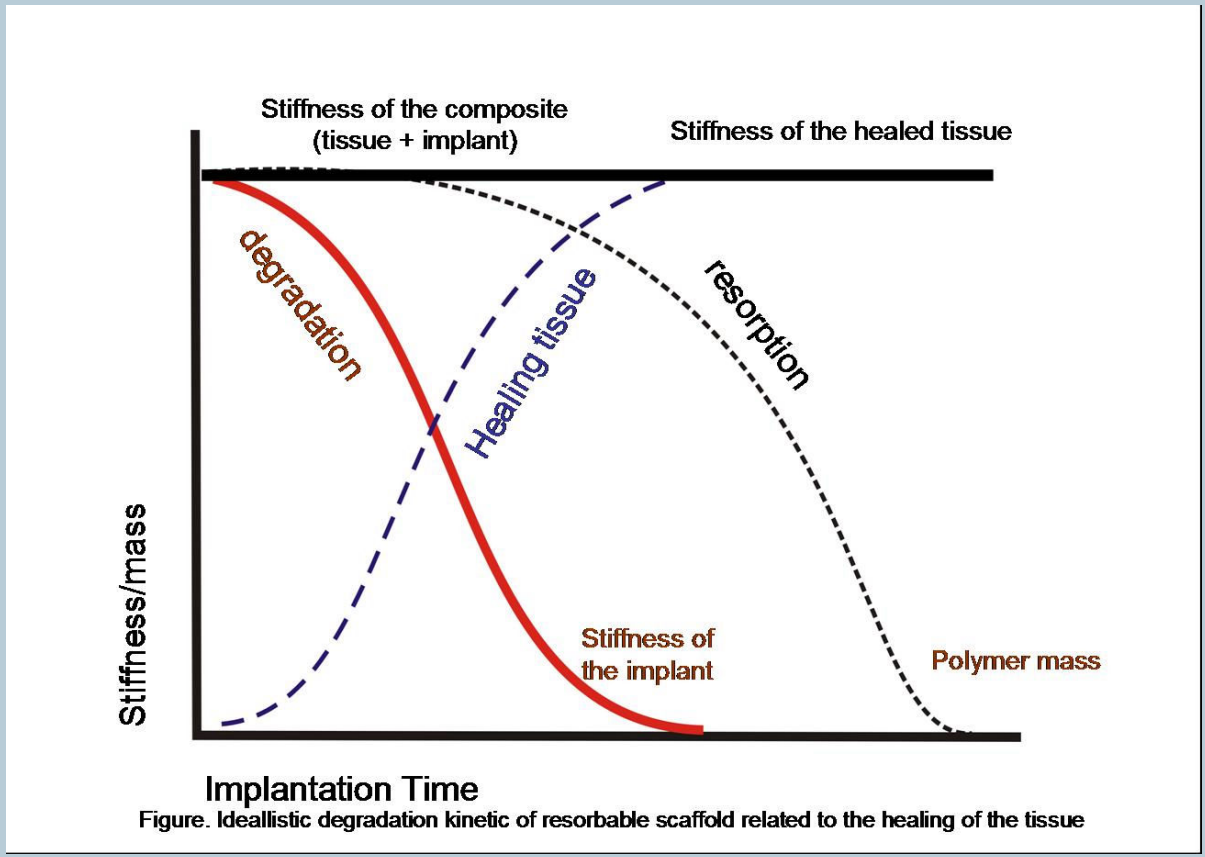


Figure. Ideallistic degradation kinetic of resorbable scaffold related to the healing of the tissue

Very slow degradability:

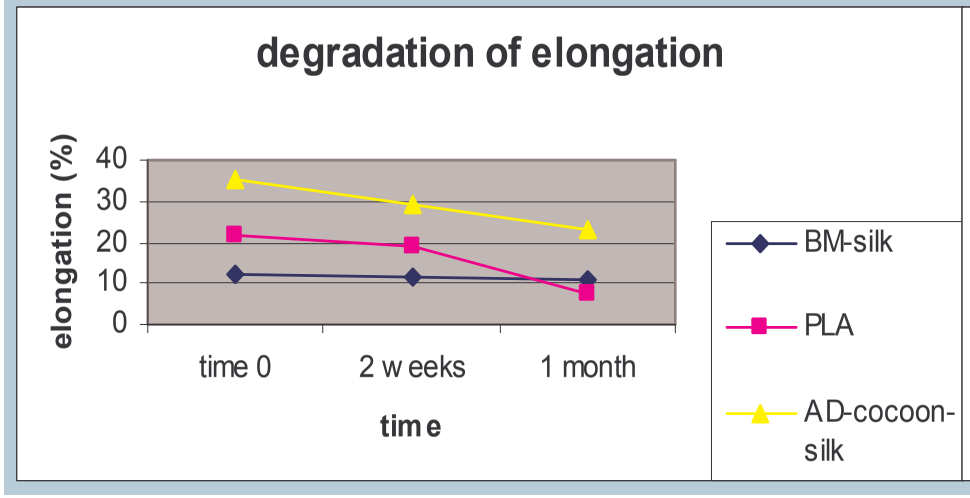
Negative for TE?

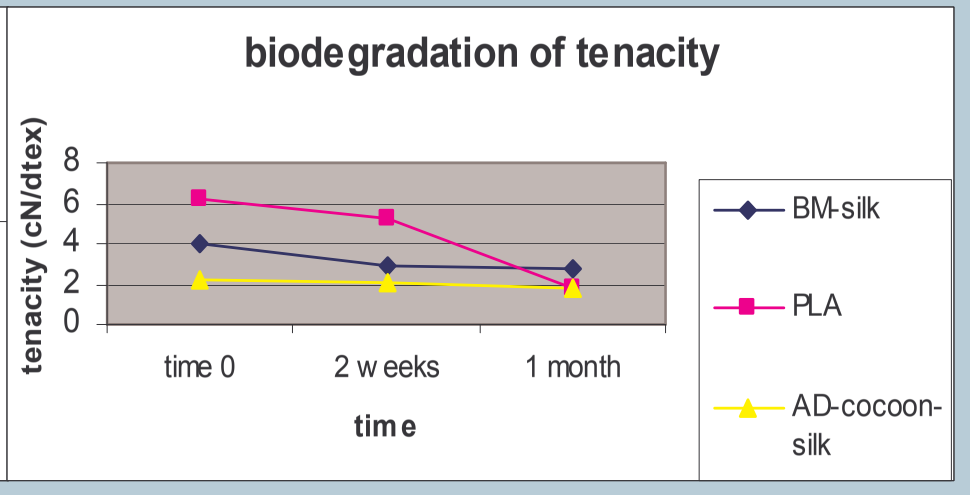
Speed of biodegradation < speed of healing of the tissue = good

degradability

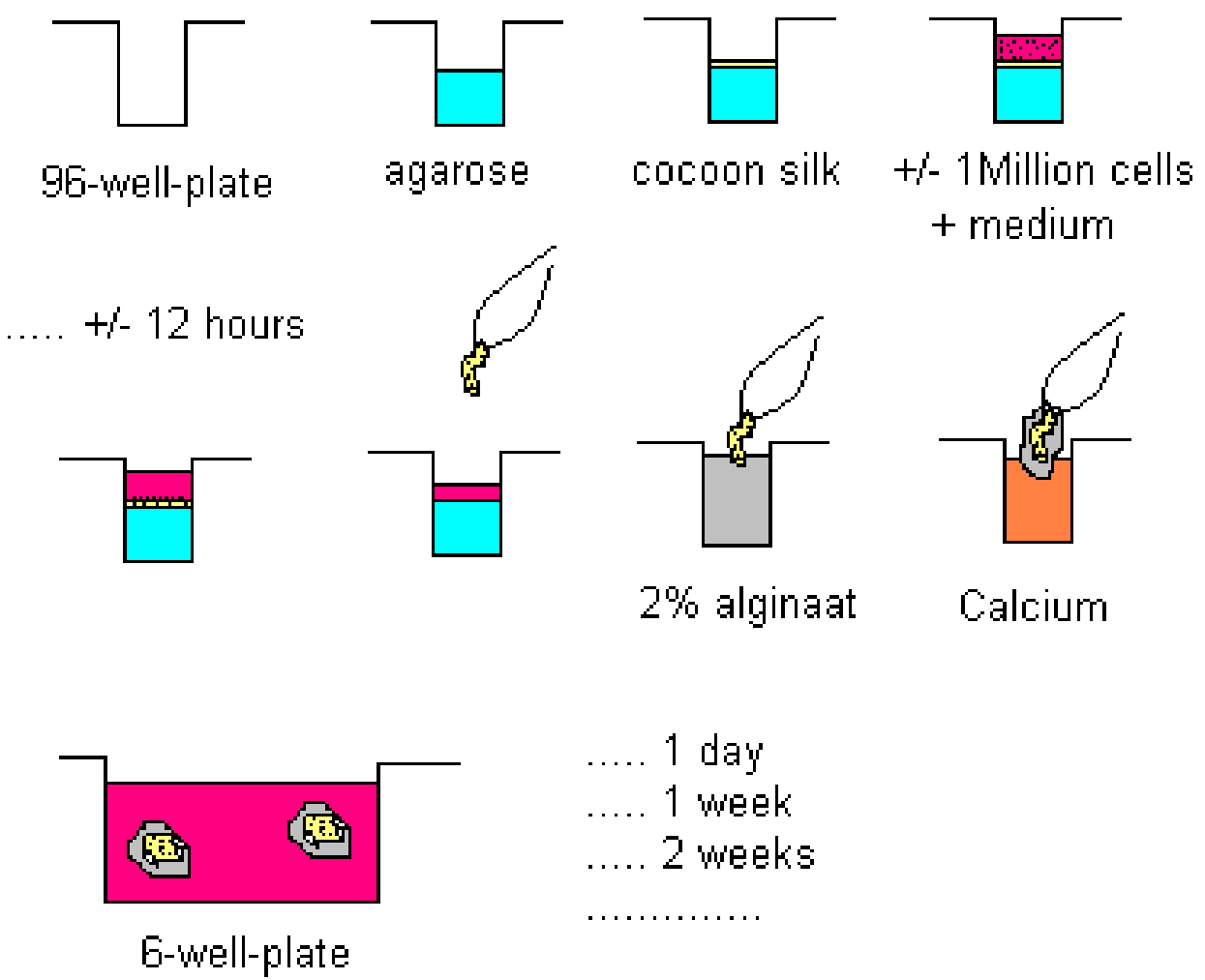
- In vitro: PBS, 37°C, ..., no stress, no enzymes

elongation(%)	BM-silk	PLA	AD-cocoon-silk
time 0	12,53	21,65	35,46
2 weeks	11,62	18,94	29,09
1 month	10,86	7,74	23,16
tenacity (cN/dtex)	**BM-silk**	**PLA**	**AD-cocoon-silk**
time 0	4,02	6,27	2,24
2 weeks	2,87	5,19	2,00
1 month	2,70	1,77	1,73

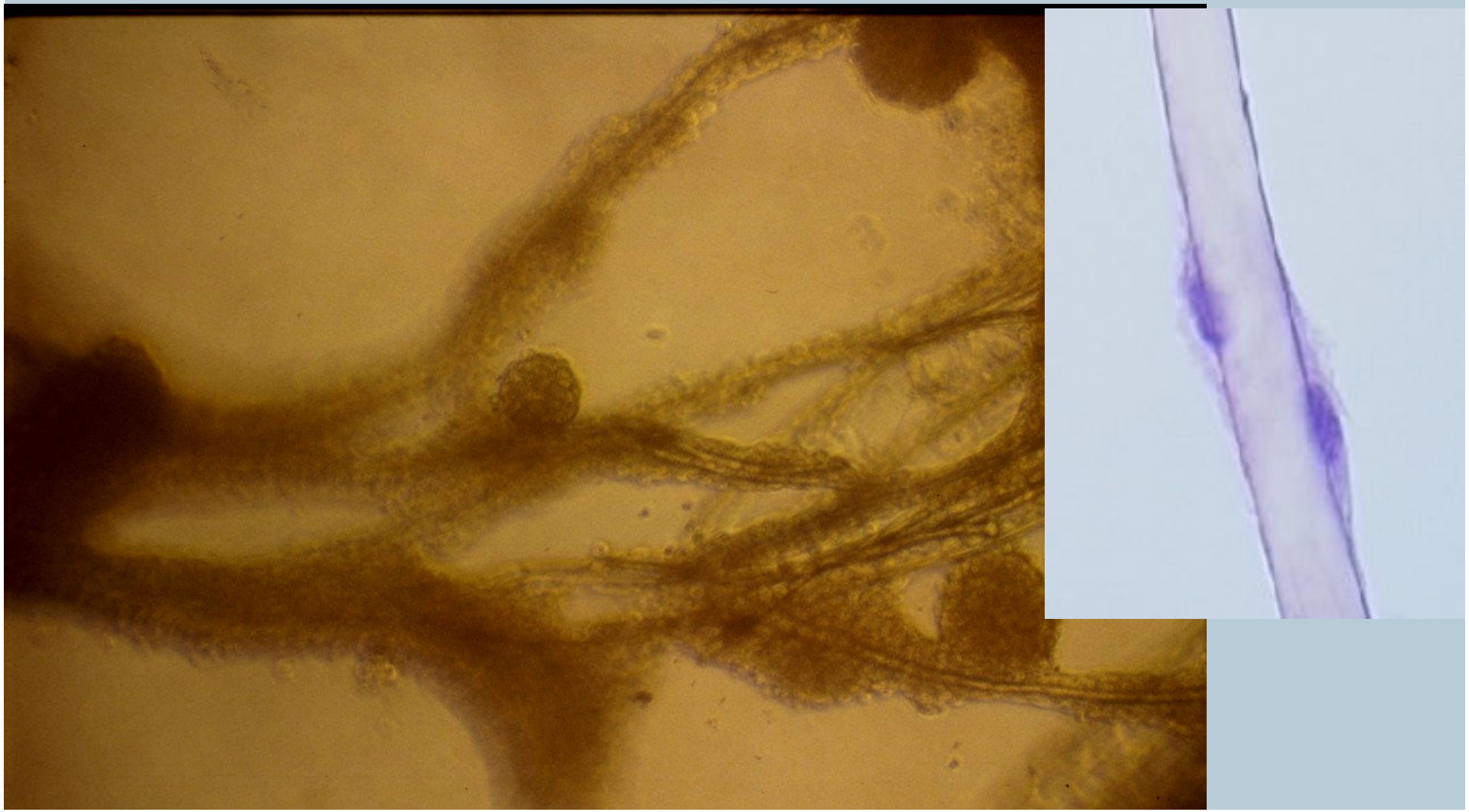




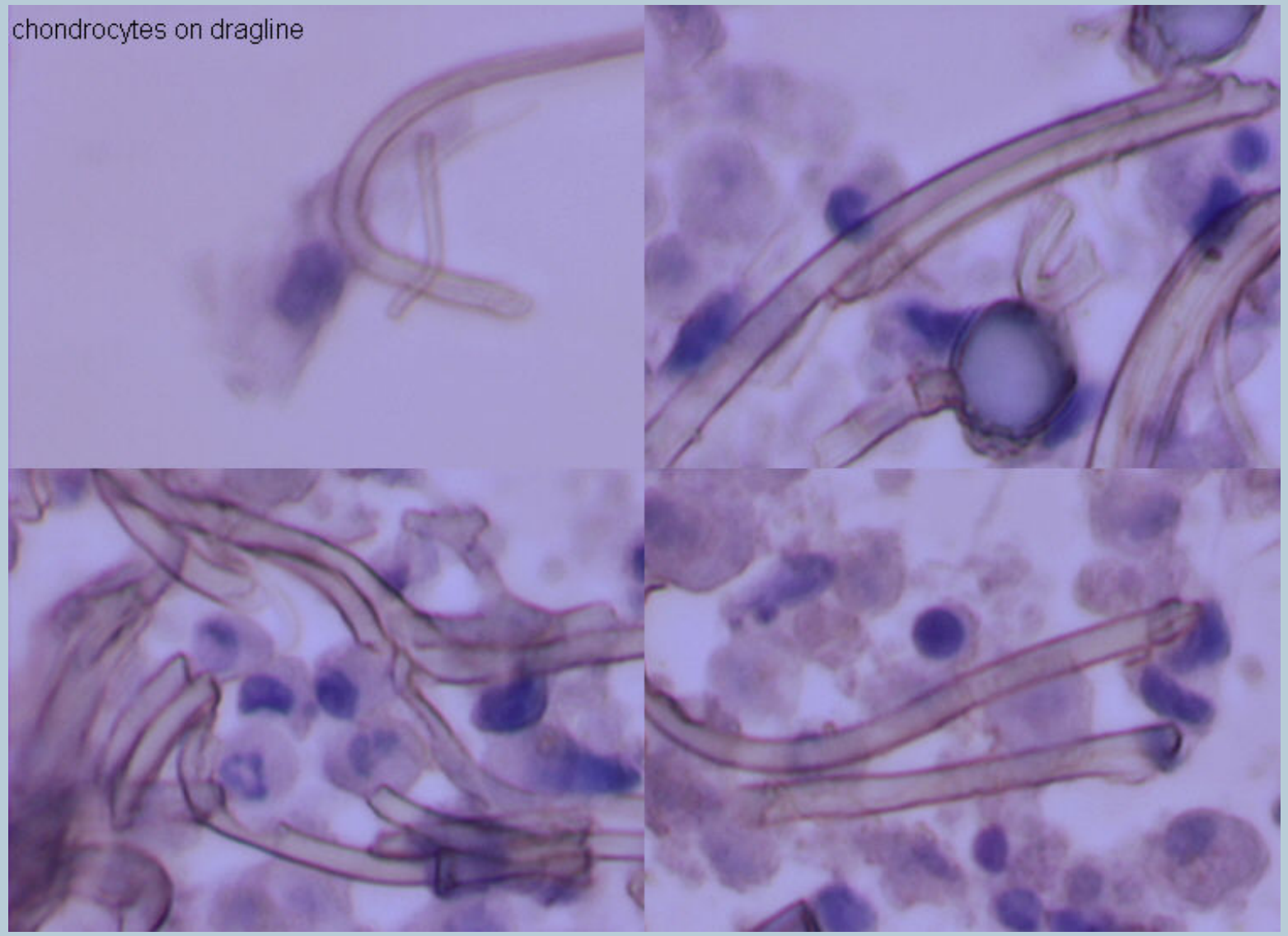
Cyto-intoxity and cell-attachment



Cell-growth on spider cocoon silk fibres

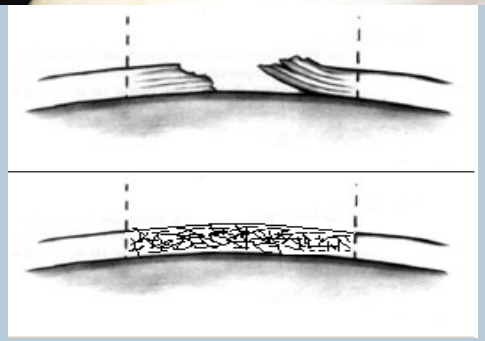


Cell-growth on spider dragline fibres



Possible biomedical applications?

- Suture material.
- Wound dressing?
- Guiding of nerve cell or vascular tissue
- Scaffolds for
  - cartilage regeneration?
  - tendon repair?



Conclusion

- Biocompatible, slowly biodegradable, non-cytotoxic, sterillisable
- Natural and synthetical spider silk
- Usable in many applications

Acknowledgement

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