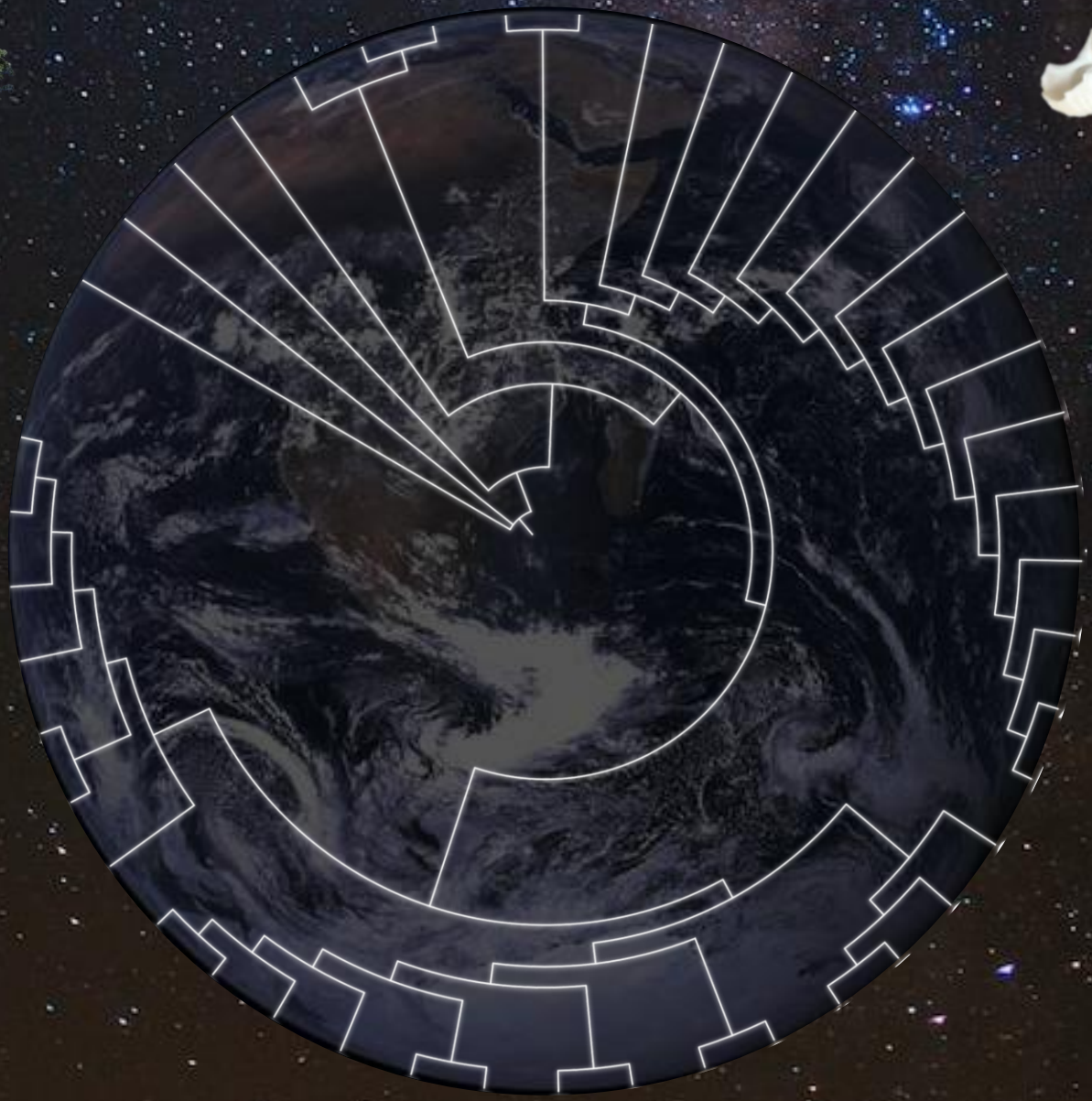
Seta di ragno: il materiale che ha affascinato l'umanità

Gabriele Greco



...

Ph. Ivana Cajina Ph: NASA

Molti ragni vivono in grotte, lontano dalla luce

Photo: Filippo Castellucci

I ragni colonizzano fino a 6700 msl

Eresus è un ragno che popola pendii erbosi

Photo credit: Alessandro Kulcyzicki

Le femmine di ragni lupo si portano gli ovisacchi in giro , ma anche i piccoli

Photo: Kerry Karloy, Jason Penney

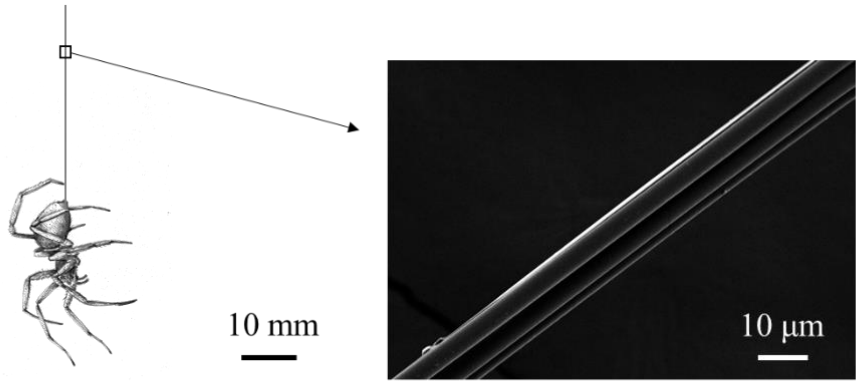
I ragni hanno conquistato quasi tutti gli ambienti naturali anche grazie alla loro capacità di produrre seta

Ph. Enrico Simeon

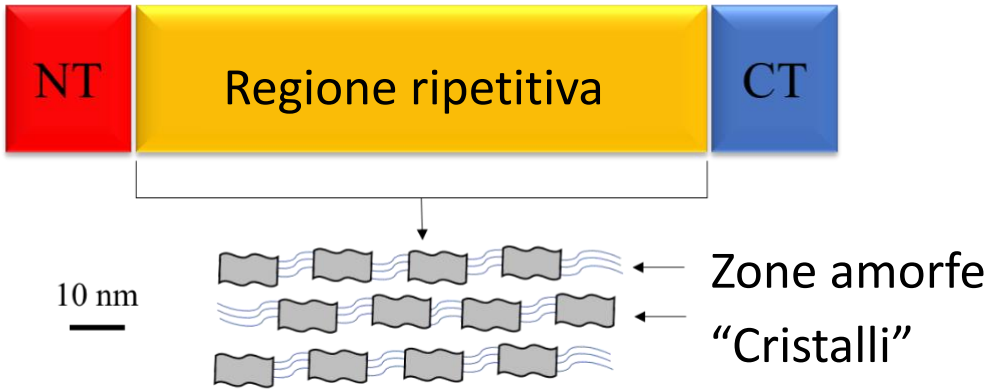
Outline:

- Sete di ragno
- Ragnatele
- Seta artificiale

La seta di ragno è un materiale proteico con proprietà uniche



Proteina della seta di ragno



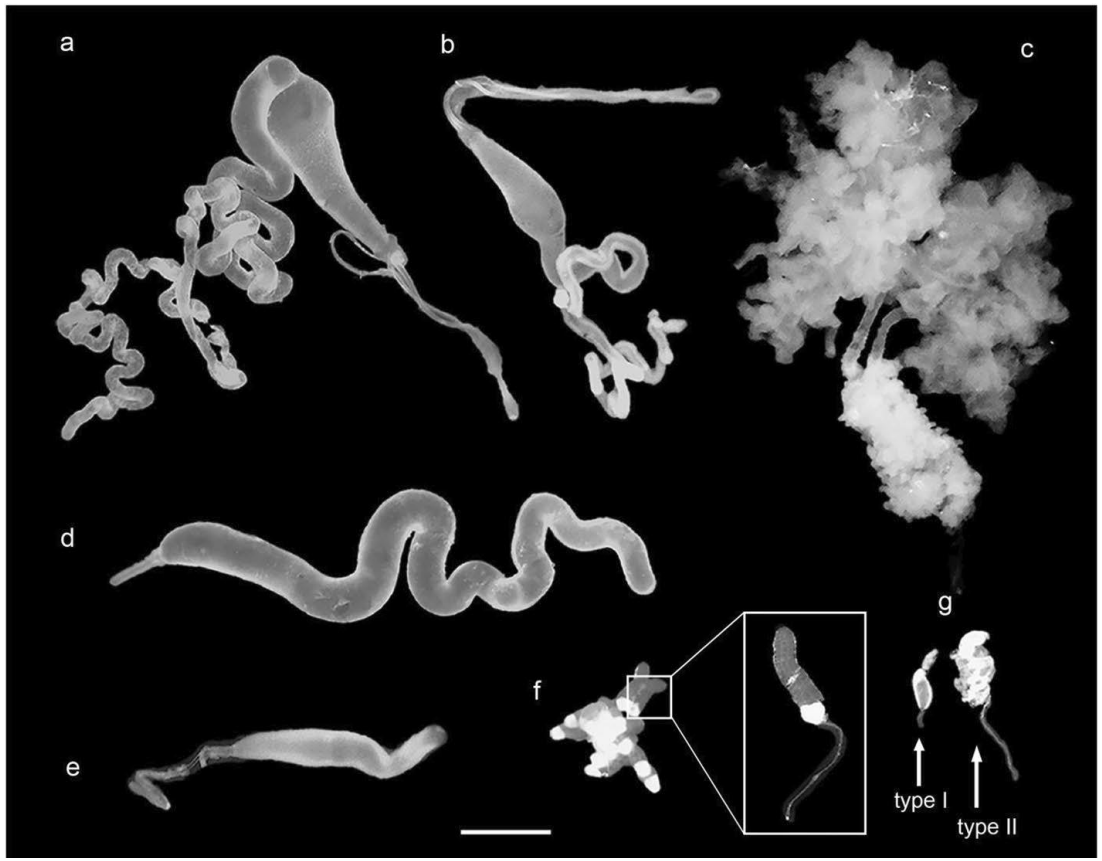
Resistente come l’acciaio

Molto più deformabile

7 volte più leggera

Prodotta usando acqua

Ogni ragno produce fino a 7 tipi diversi di seta.
>150000 tipi di sete di ragno.



Sonovane et al., Scientific Reports, 2023

Arakawa et al., *Science Advances*, 2022

I ragni usano la seta per

Cacciare

Nentwig, *Spider ecophysiology*, 2013

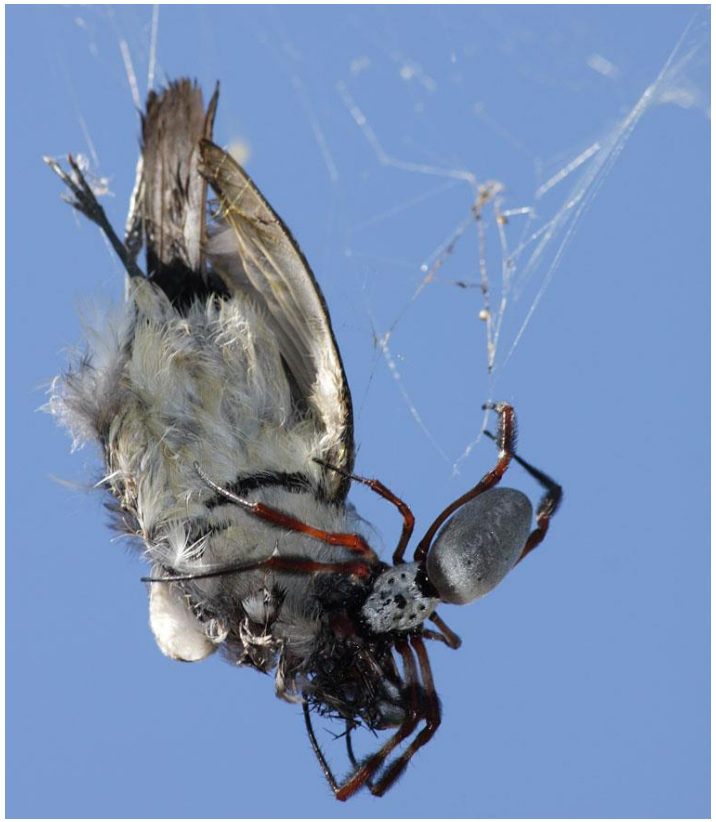


Photo credit: M. Bakker

I ragni usano la seta per

Volare

Recuperare nutrienti

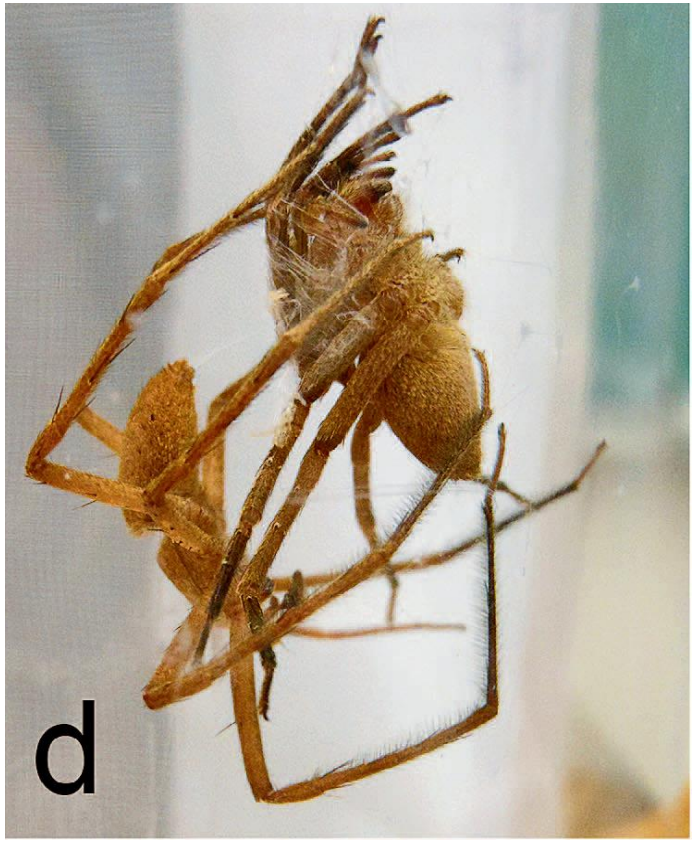
Reynolds, *Bio. Lett.*, 2006

I ragni usano la seta per

Protezione

I ragni usano la seta per

Accoppiarsi



Scott, *Journal of Arachnology*, 2018

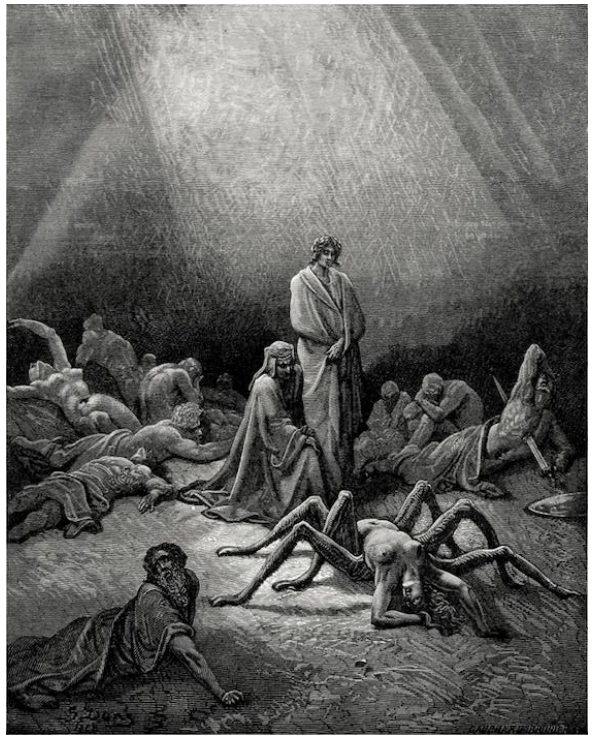
Archilochus colubris usa la seta di ragno per costruire i suoi nidi

Gary et al., *Northeastern Naturalist*, 2018

La seta di ragno è sempre stata presente nella nostra cultura

Il mito di Aracne

Ovid's *Metamorphoses (*Book VI)



Gustave Dorè XII canto purgatorio 1868

Greco & Mastellari et al., *Perspectives on Science*, 2021

La cappa di soffocamento

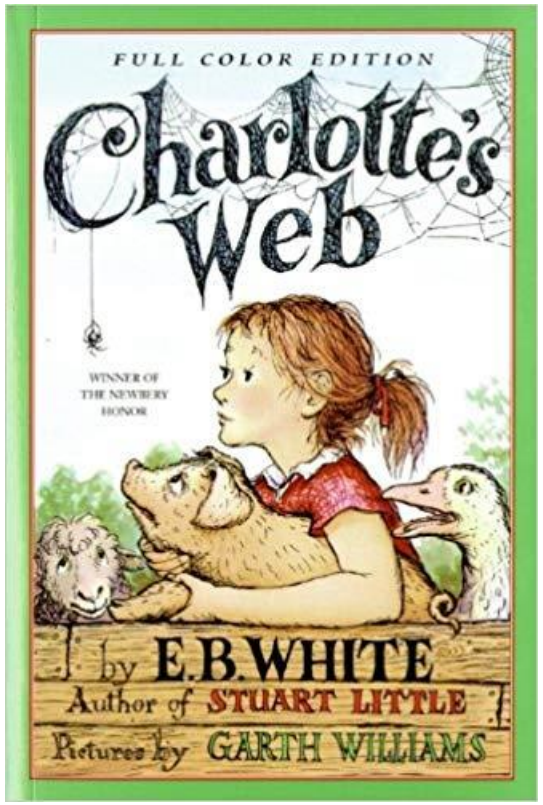
Science Museum, London

Morgan, *Gossamer Days*, 2017

Mastellari & Greco, *AKAN*, 2020

Letteratura moderna

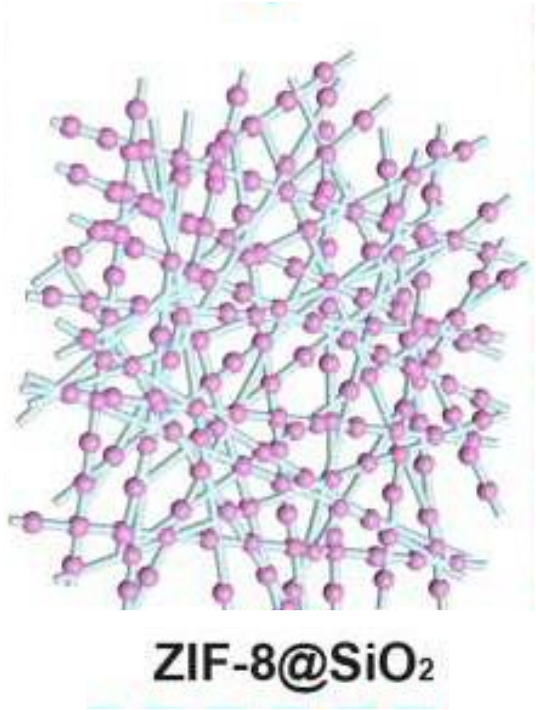
E.B. White, 1952



Seta di ragno: il materiale che ha affascinato l'umanità

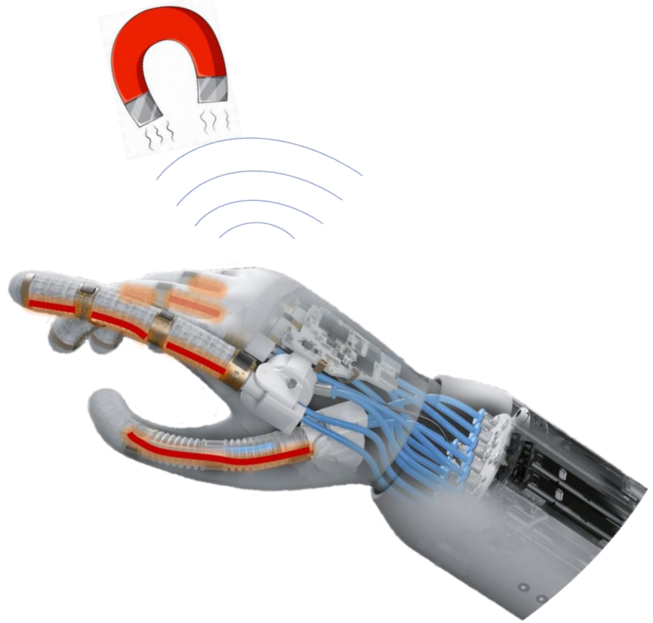
Le applicazioni bio-ispirate spaziano dalla chimica all'ingegneria areospaziale.

Membrane per catturare inquinanti



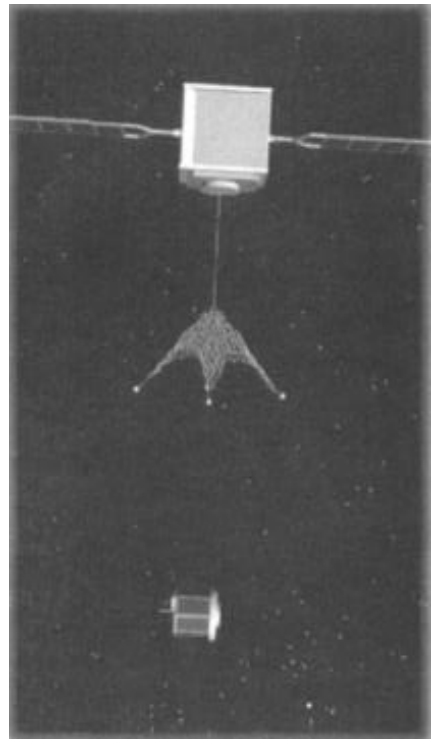
Zhu et al., 2019, *Journal of Membrane Science*

Sensori magnetici



Spizzo & Greco et al., 2022, *Adv. Funct. Mater.*

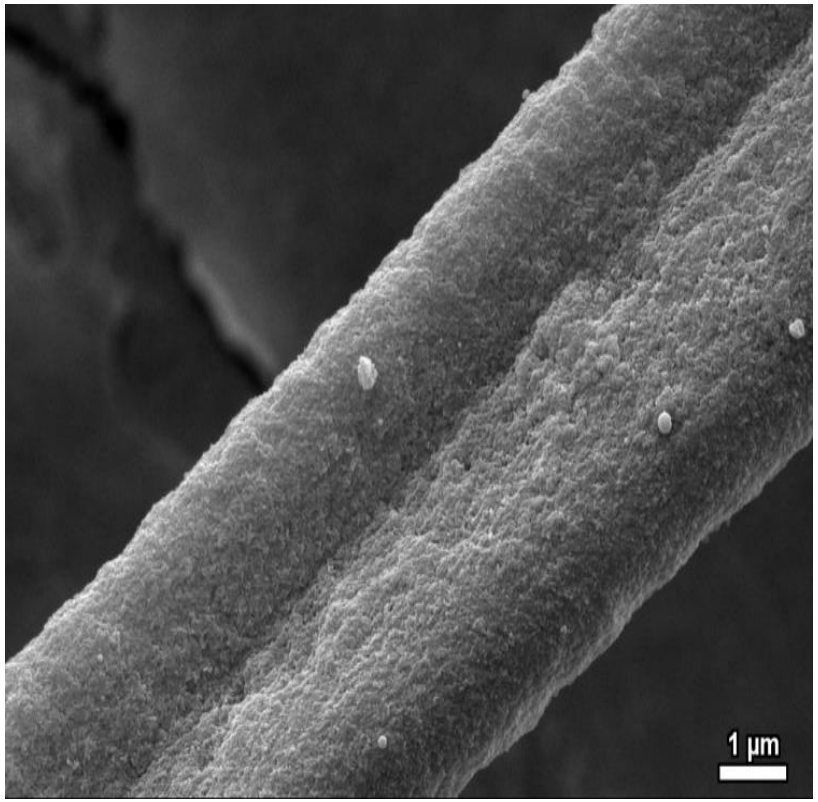
Dispositivi aerospaziali



Xu et al., 2019, *Acta Astronautica*

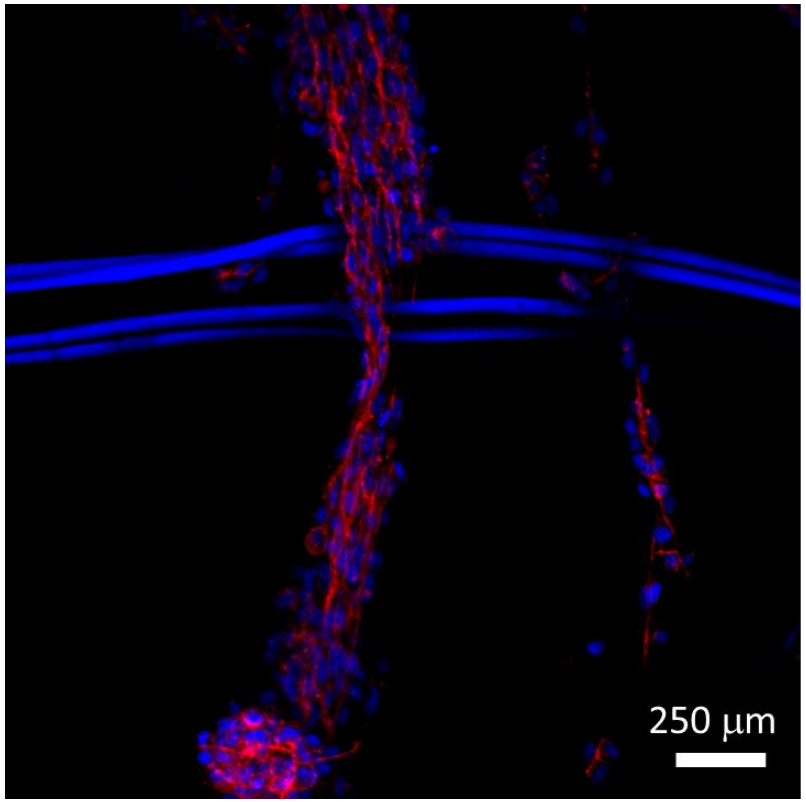
La seta di ragno in ingegneria tessutale, per rigenerare

Ossa



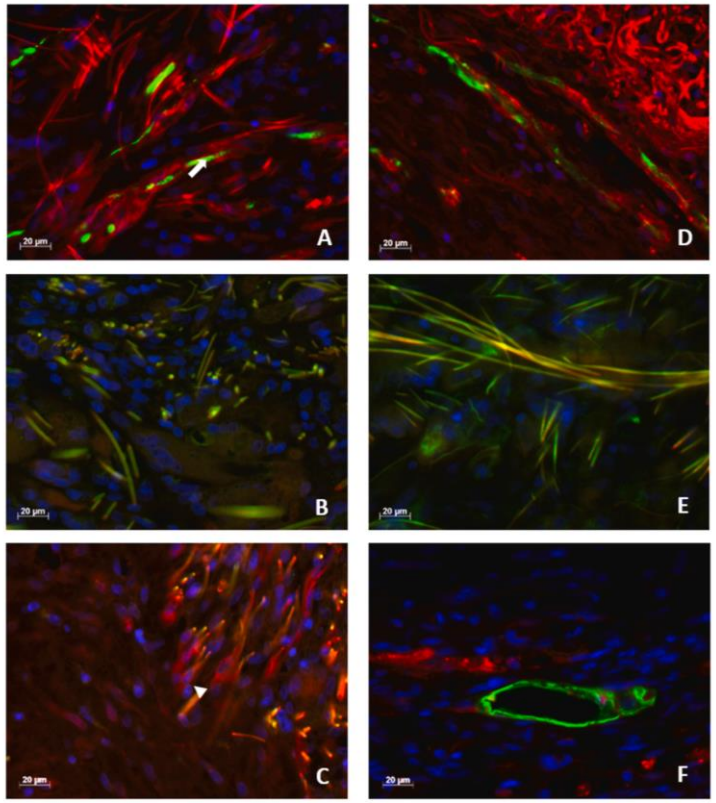
Dellaquila & Greco et al., *Journal of Applied Polymer Science*, 2019

Muscoli



Yang & Greco et al., *MSEC*, 2020

Nervi



Kornfeld et al., 2021, *Biomaterials*

Outline:

- ✓ Sete di ragno
- Ragnatele
- Seta artificiale

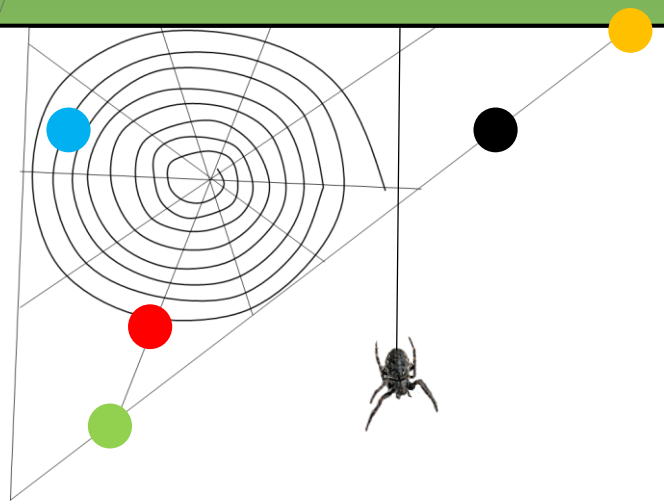
Le ragnatele orbicolari

Greco et al., *Sci Rep*, 2019

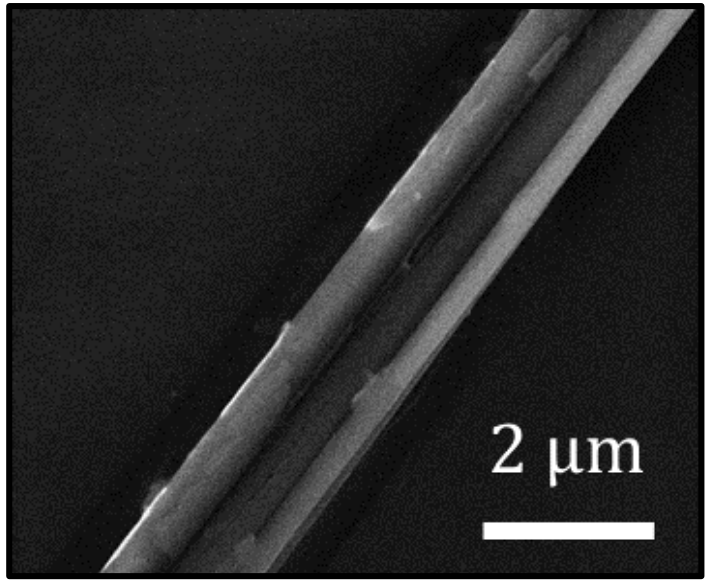
Photo credit: M. Bakker

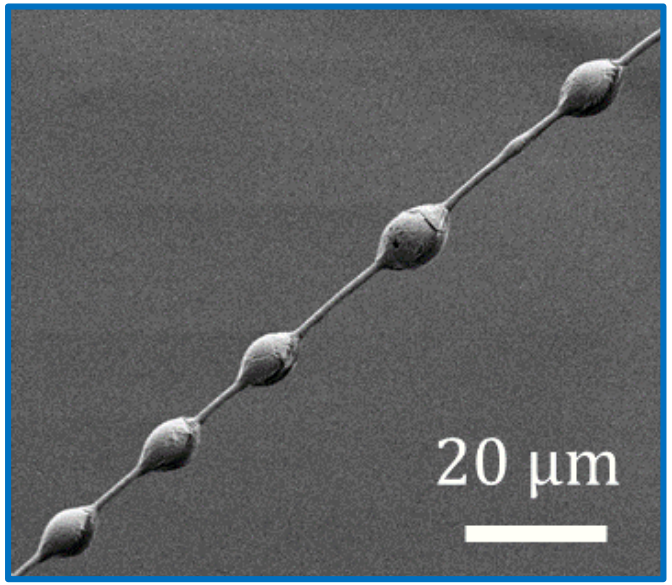
Nyffeler et al., 2013

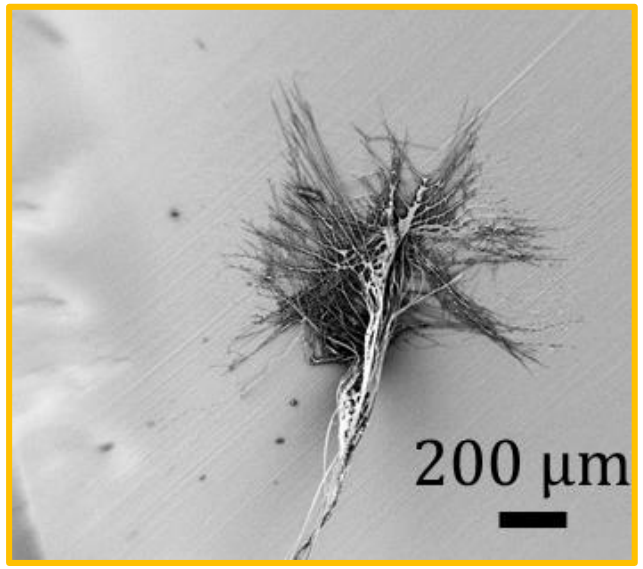
Seta di ragno: il materiale che ha affascinato l'umanità

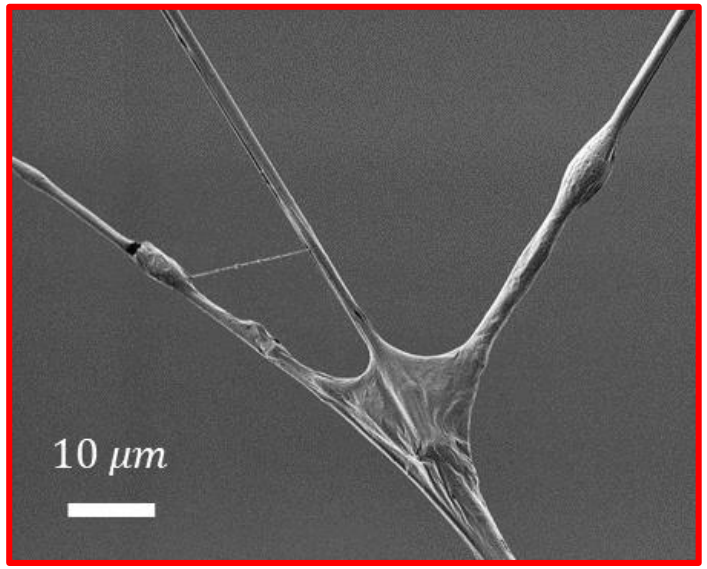


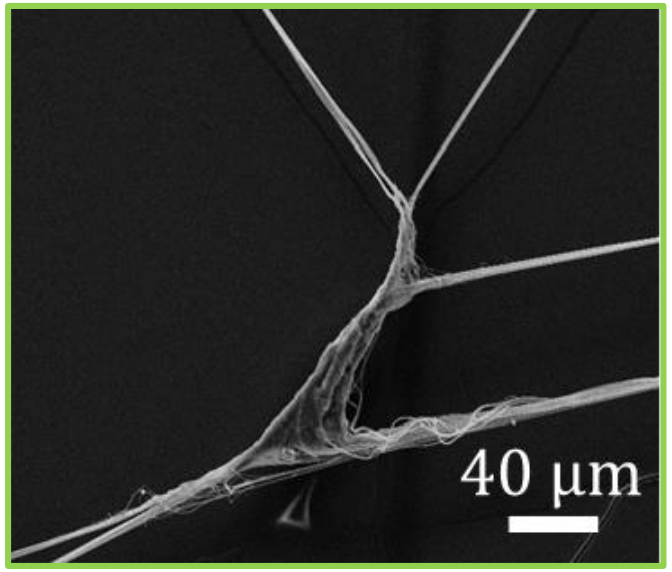
Greco et al., *Sci Rep*, 2019



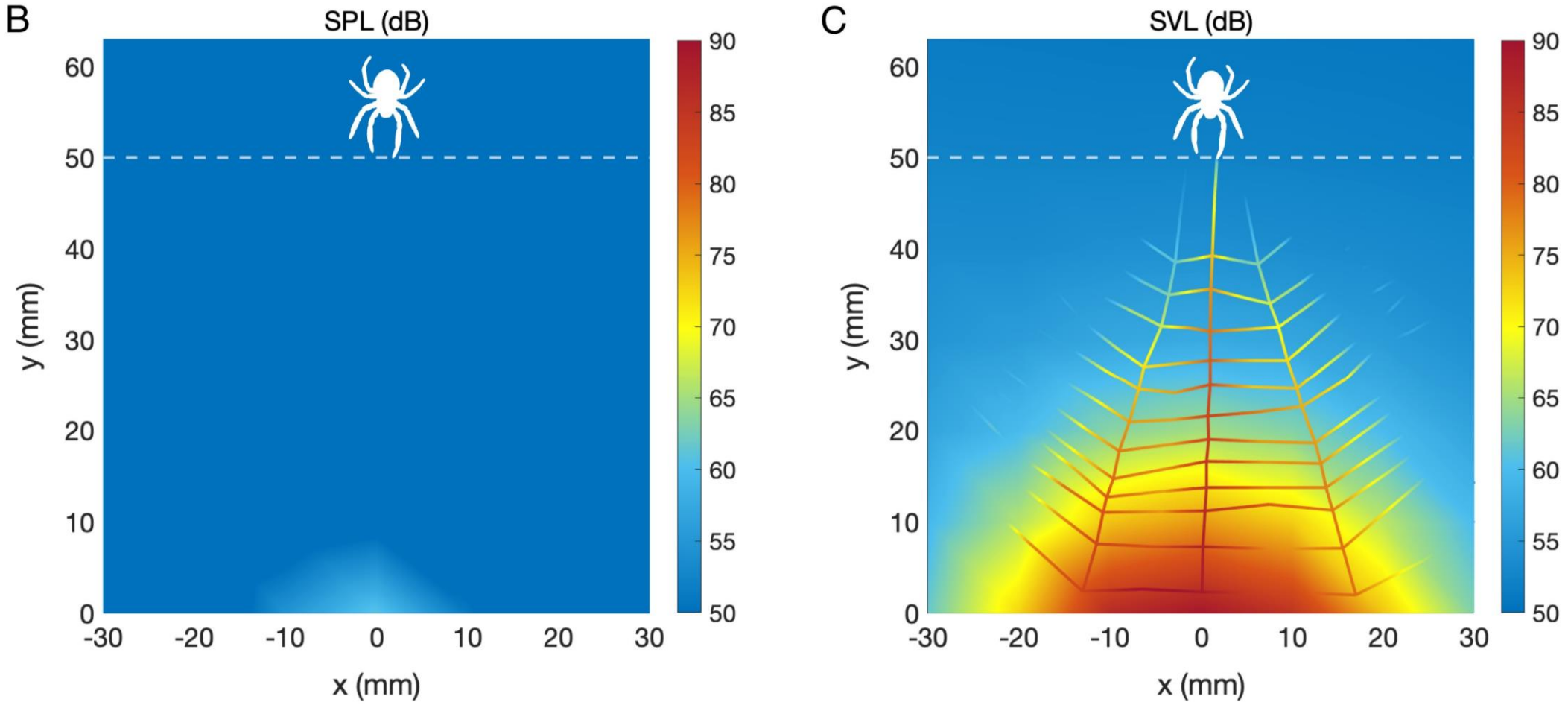








Espansione dell'area sensoriale di oltre 10000 volte



Zhou et al., *PNAS*, 2022

Picchi, falene e ragnatele… cosa hanno in commune?

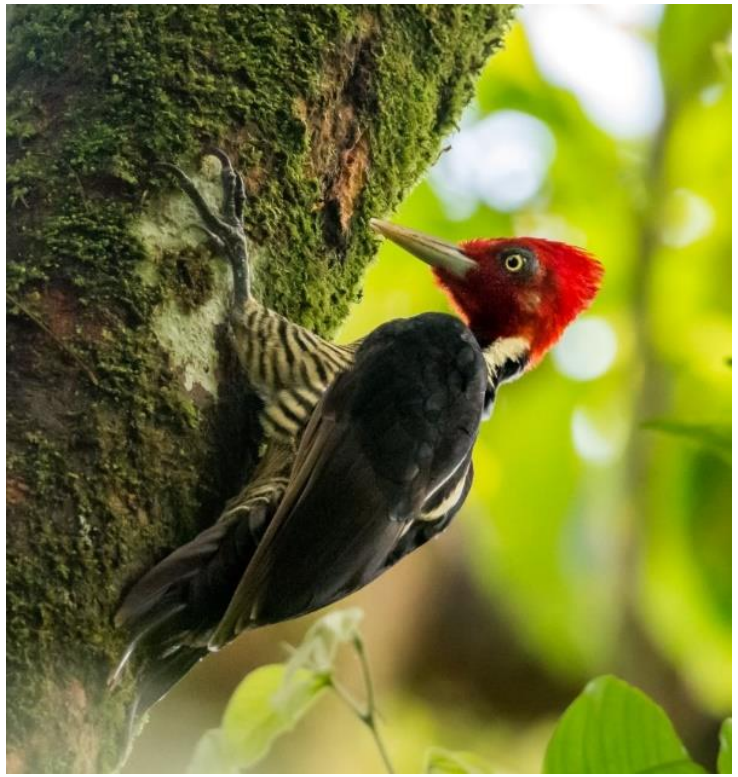


Foto di Filippo Castellucci

Bunaea alcinoe

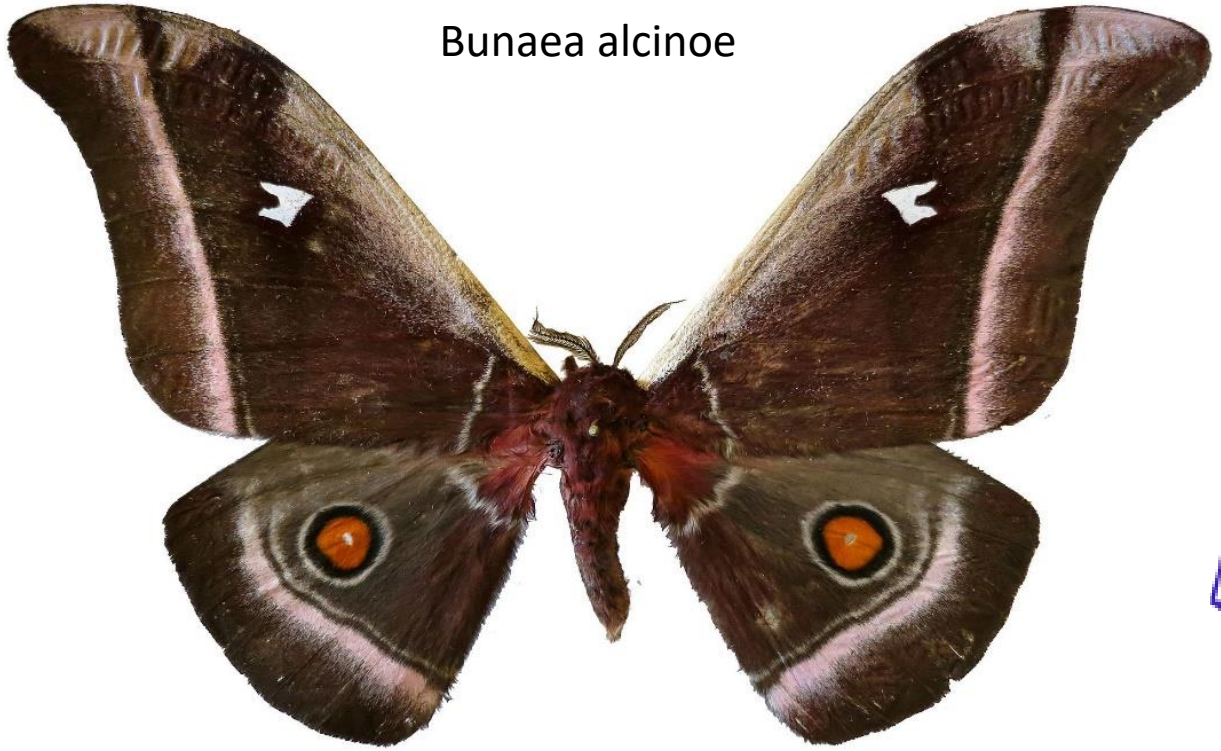
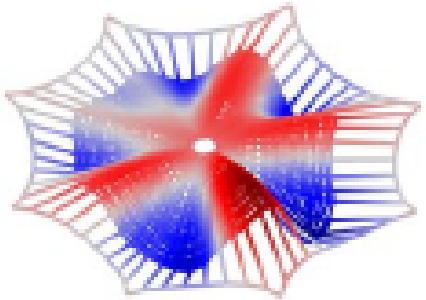
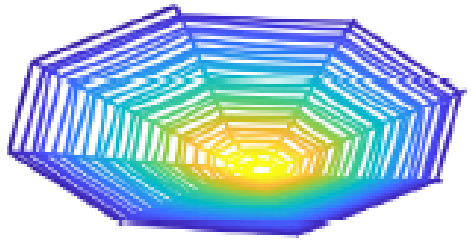


Foto di Lsadonkey - Own work, CC BY-SA 4.0





Bosia et al., Matter, 2022

Dal Poggetto et al., Adv. Theory Simul., 2022

Lott et al., Sci. Rep., 2022

Esistono tantissime tipologie diverse di ragnatele.

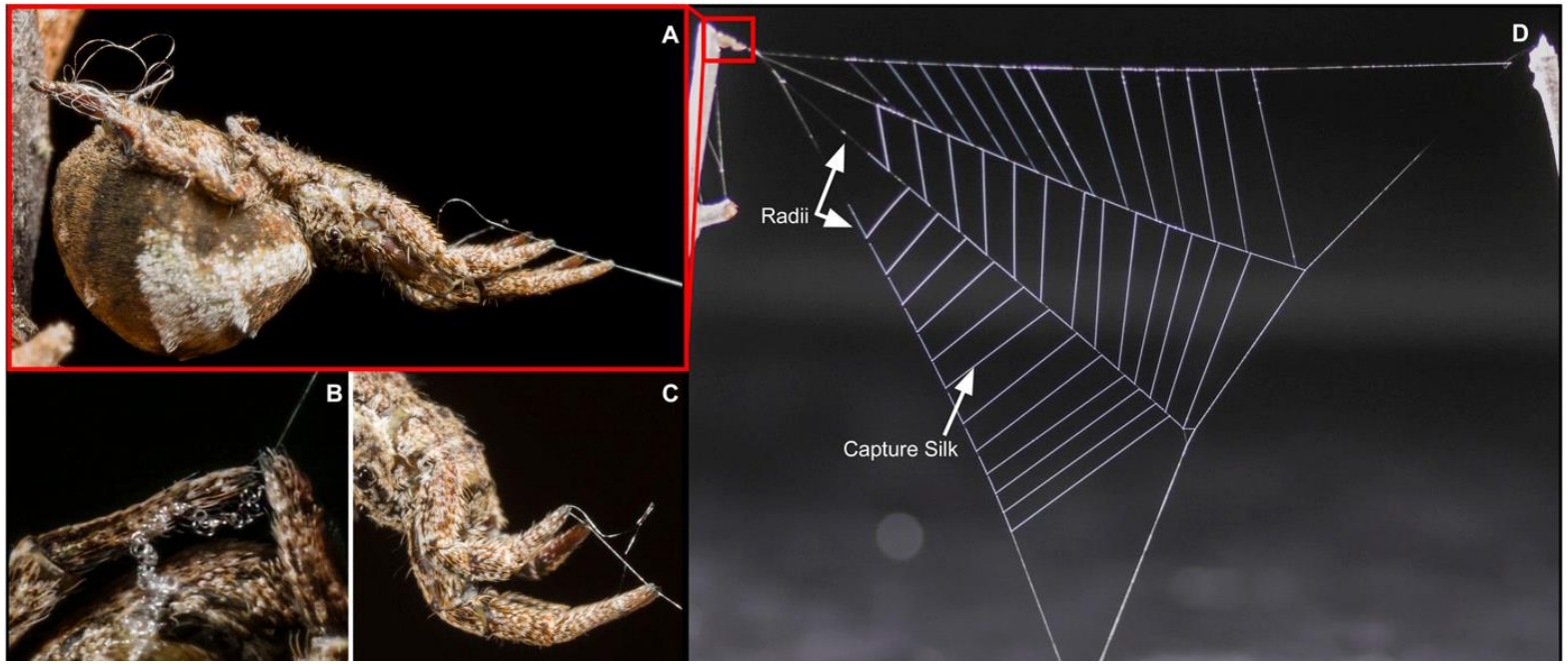
Foelix, *Journal of Arachnology*, 2017

Foelix, *Biology of Spiders*, 2011

www.aracnofilia.org

I ragni usano le ragnatele come strumenti.

Ragnatele come amplificatori di potenza.



Accelerazione = 772.85 m/s^2 ~ 80 g

Han et al., *PNAS*, 2019

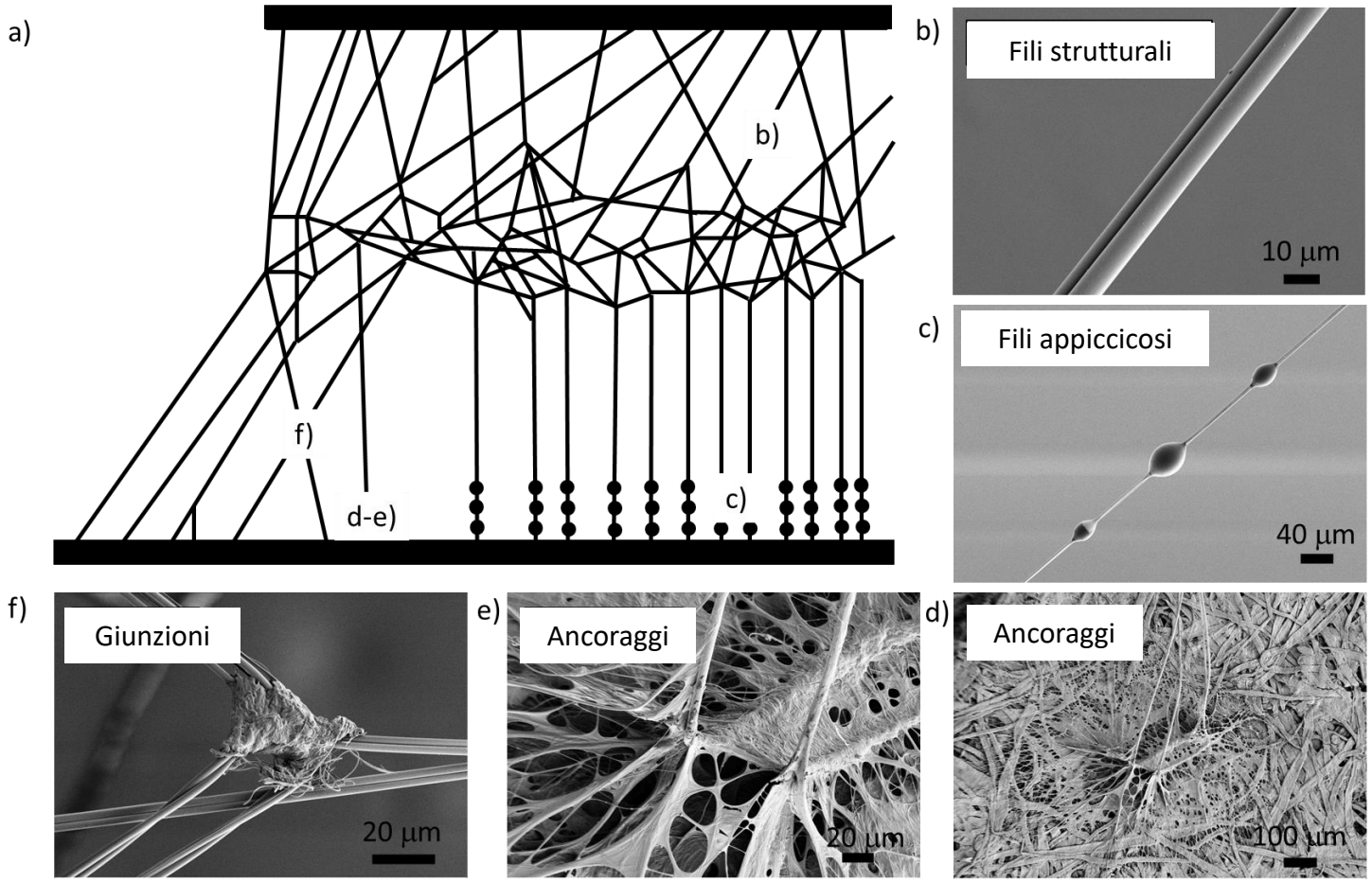
Quante volte vi è capitato?

Evento non raro: i ragni possono sollevare oggetti pesanti

Nyffeler et al., *Journal of Arachnology*, 2018

Greco & Pugno, *J. R. Soc. Interface*, 2021

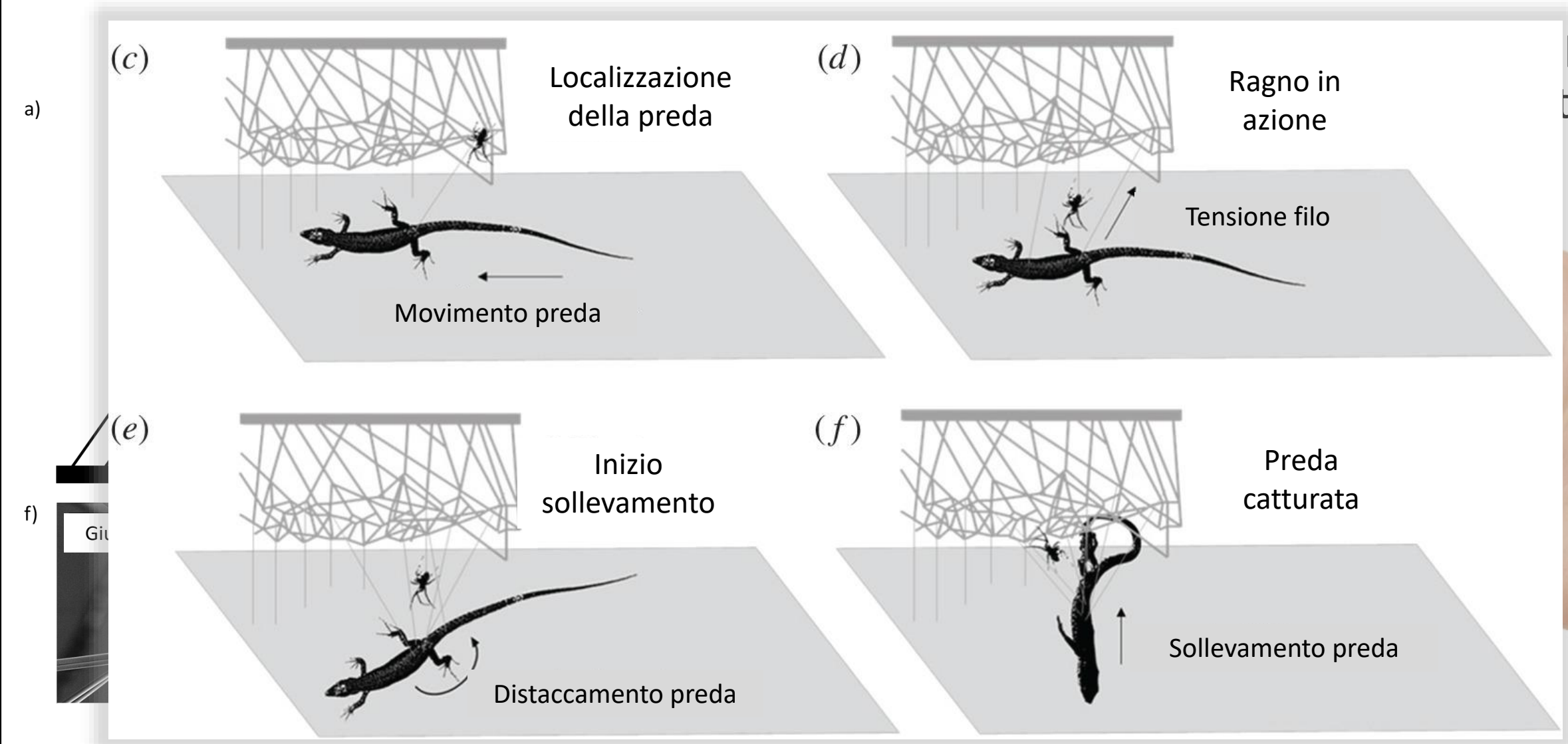
Ragnatela di *Steatoda* sp.



La seta è tirata ed usata per applicare una forza elastica

Greco & Pugno, *J. R. Soc. Interface*, 2021

Seta di ragno: il materiale che ha affascinato l'umanità

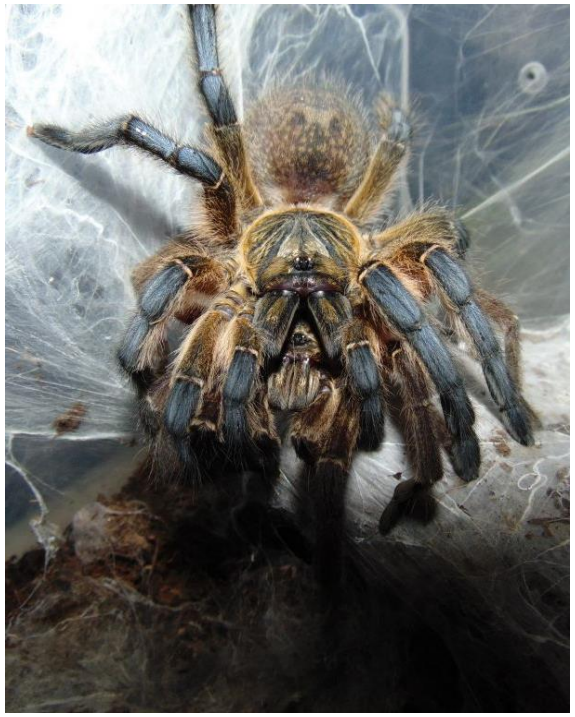


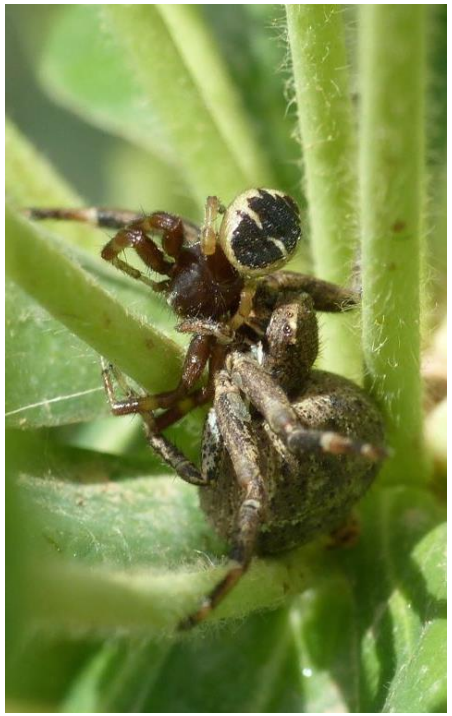
Greco & Pugno, *J. R. Soc. Interface*, 2021

Outline:

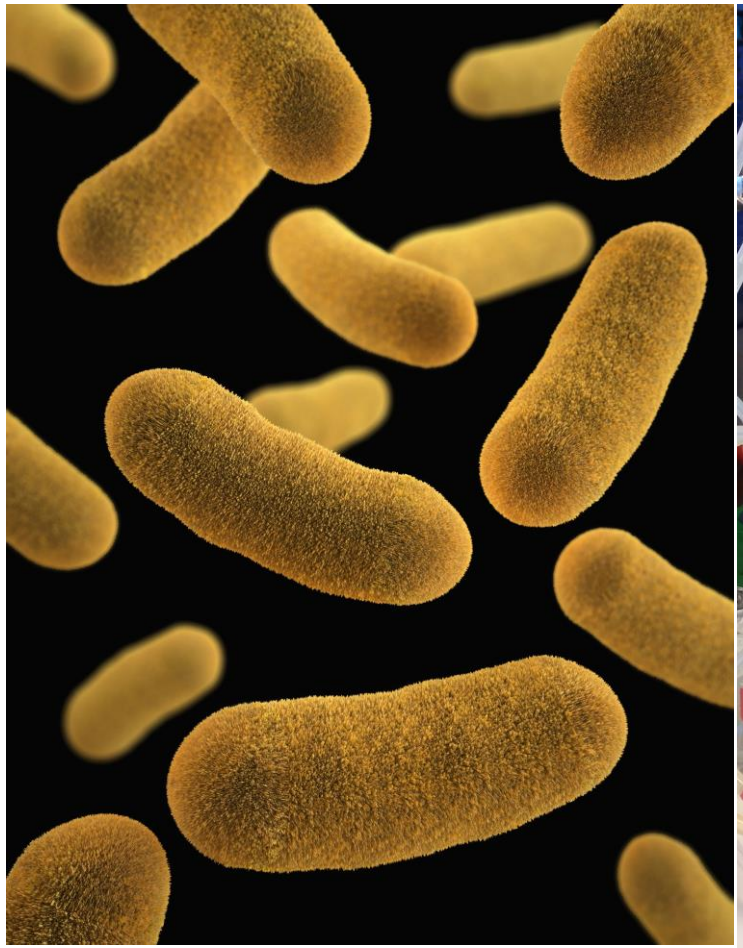
- ✓ Sete di ragno
- ✓ Ragnatele
- Seta artificiale

Perché abbiamo bisogno della seta artificiale?





Produzione di proteine della seta artificiali



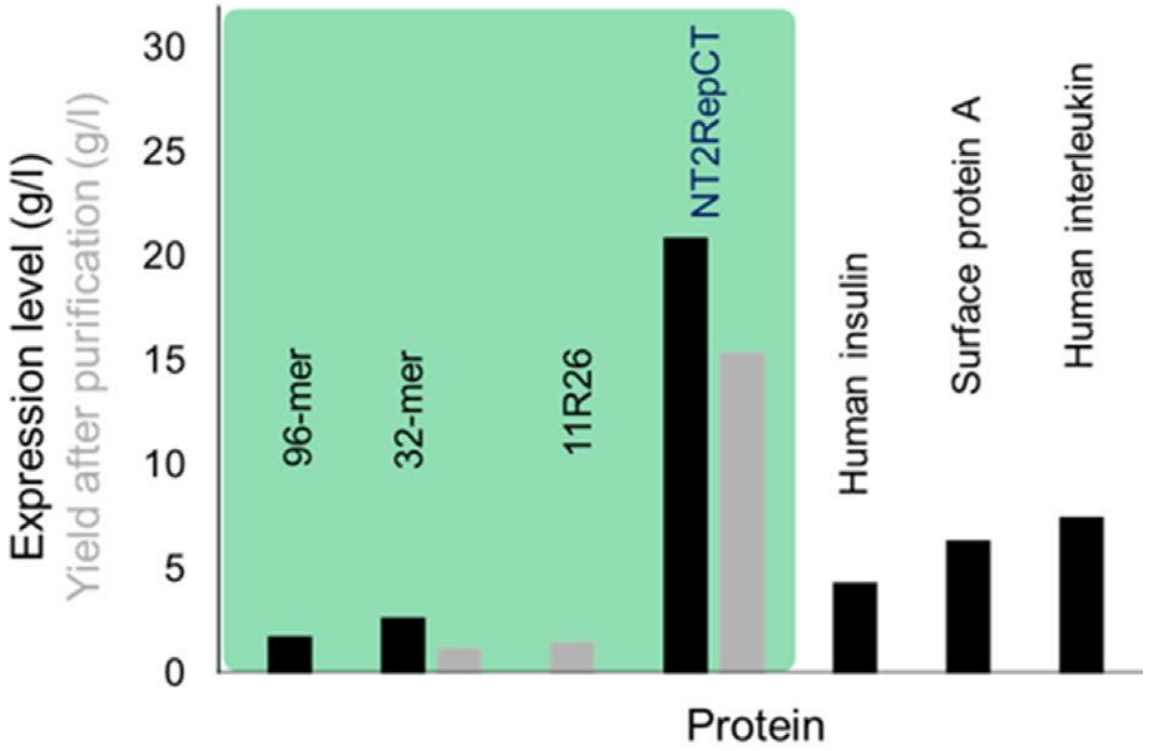
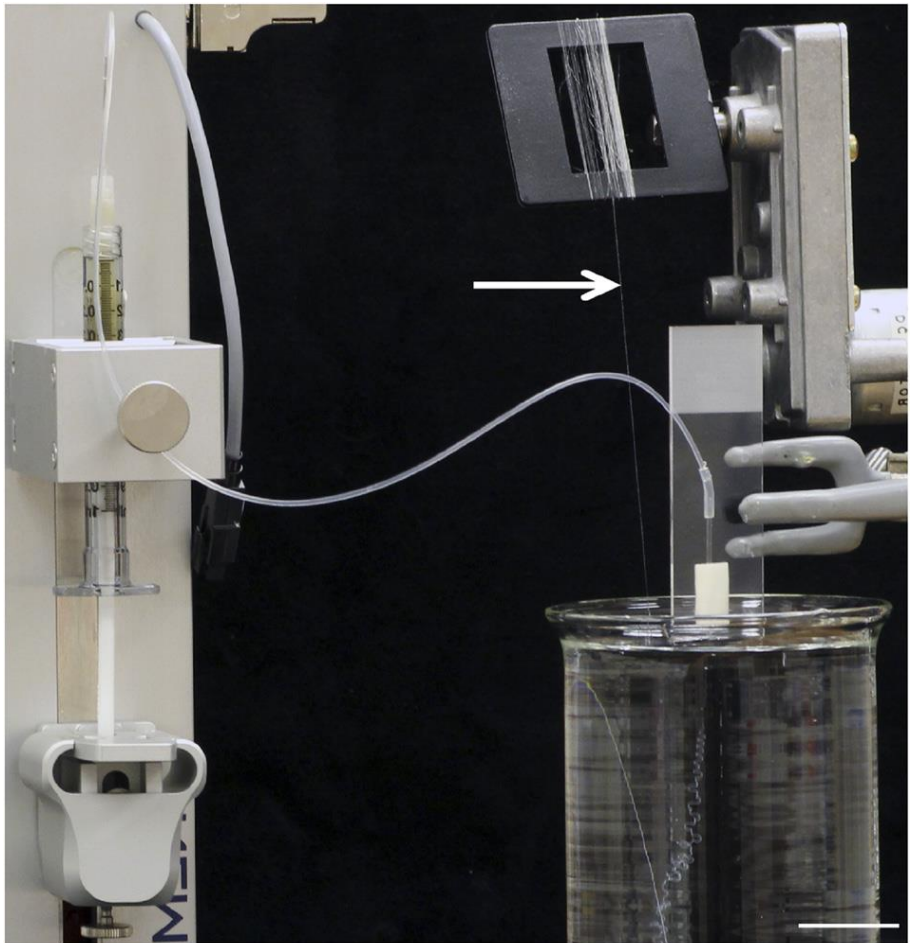


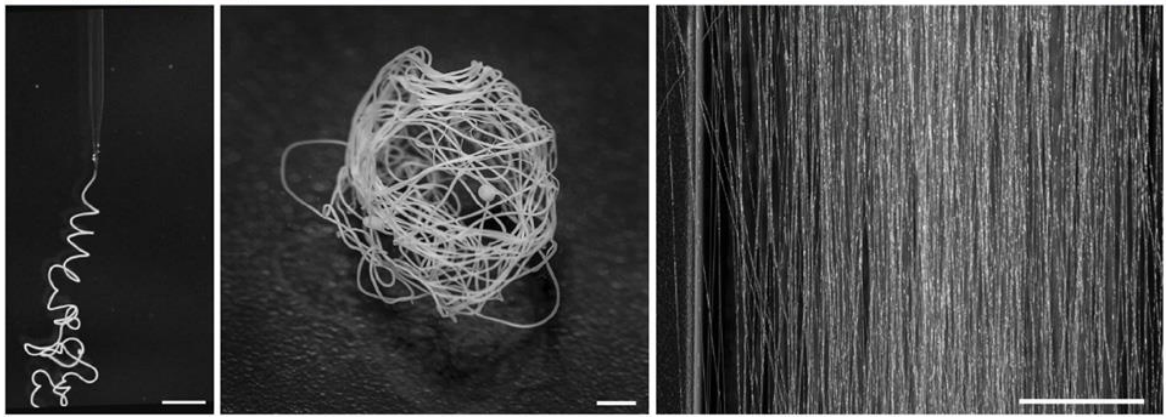
Photo: CDC su Unsplash

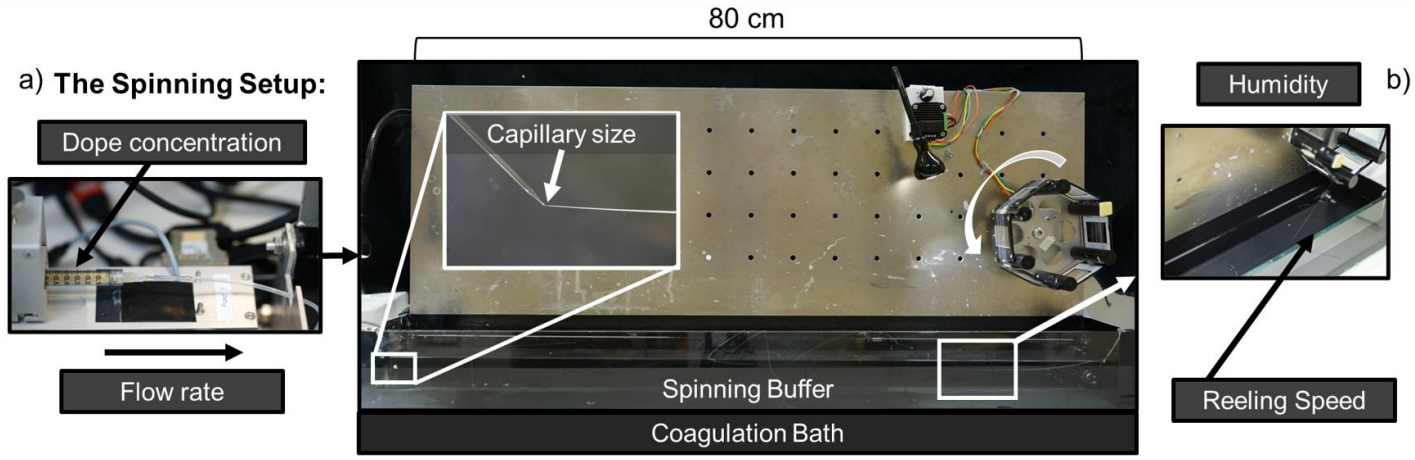
Schmuck et al., *Materials Today*, 2021

Processo di filatura bio-ispirato

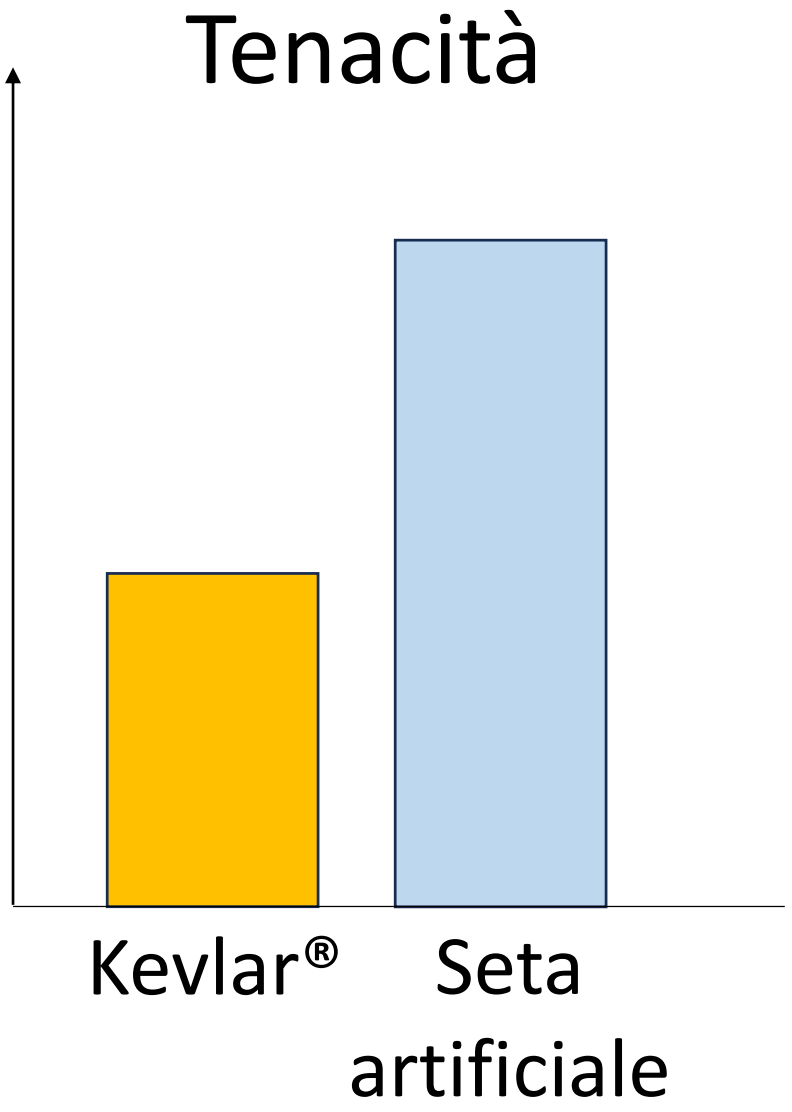


Andersson & Jia et al., *NATURE CHEMICAL BIOLOGY*, 2017





Schmuck et al., *Communications Materials*, 2022

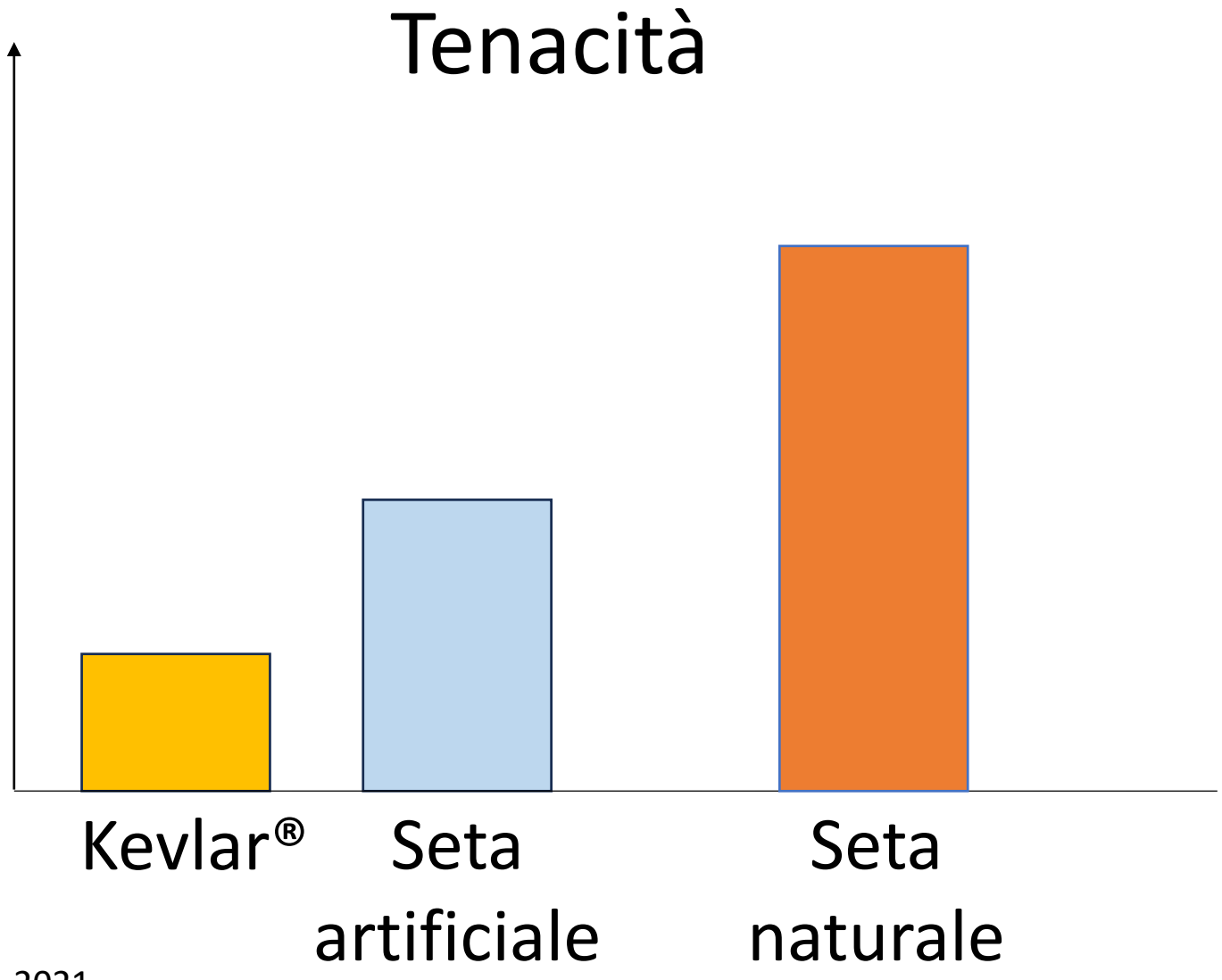


Kevlar®:
Acido solforico
Alte temperature

Seta artificiale:
Acqua
Temperatura ambiente

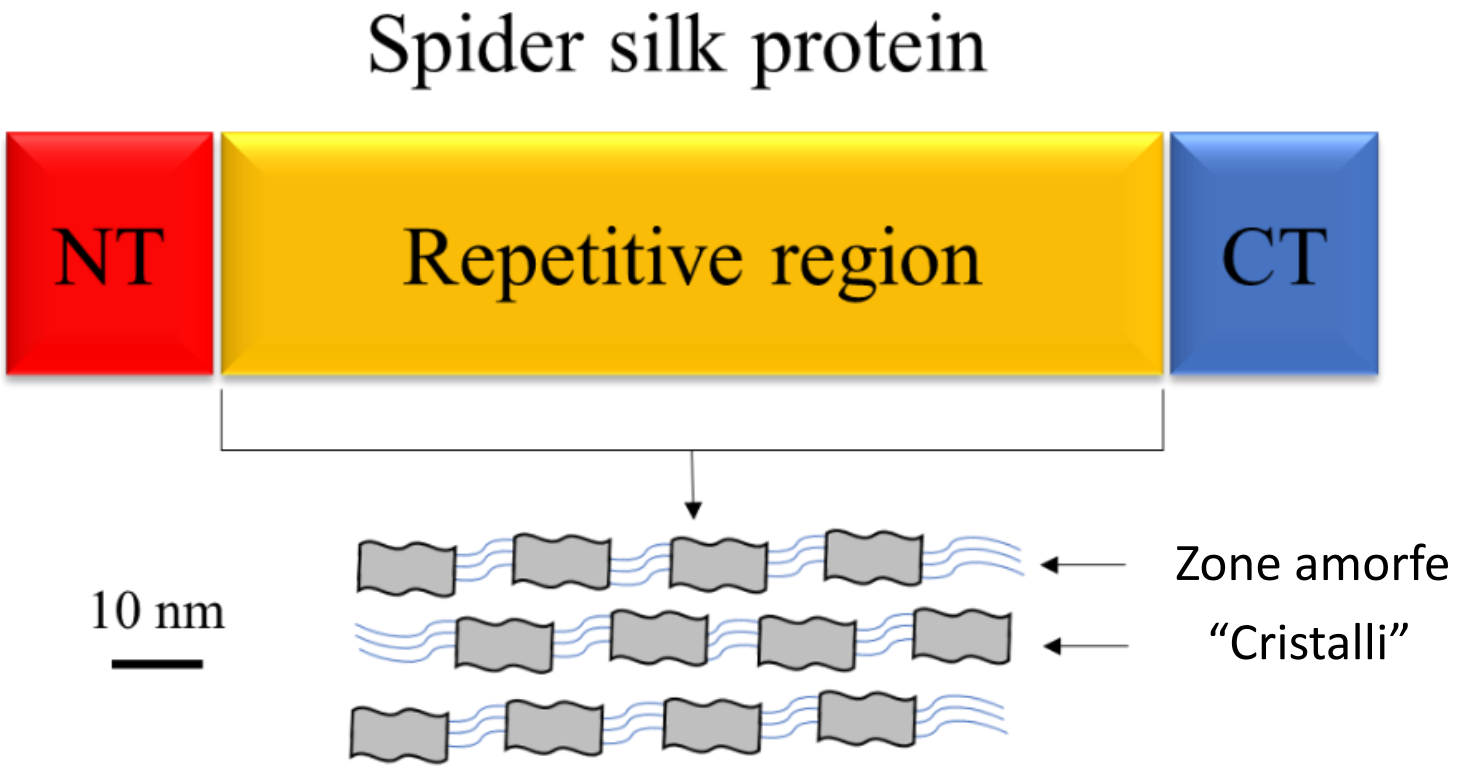
L’industria della moda è responsabile del 10% dell’inquinamento globale

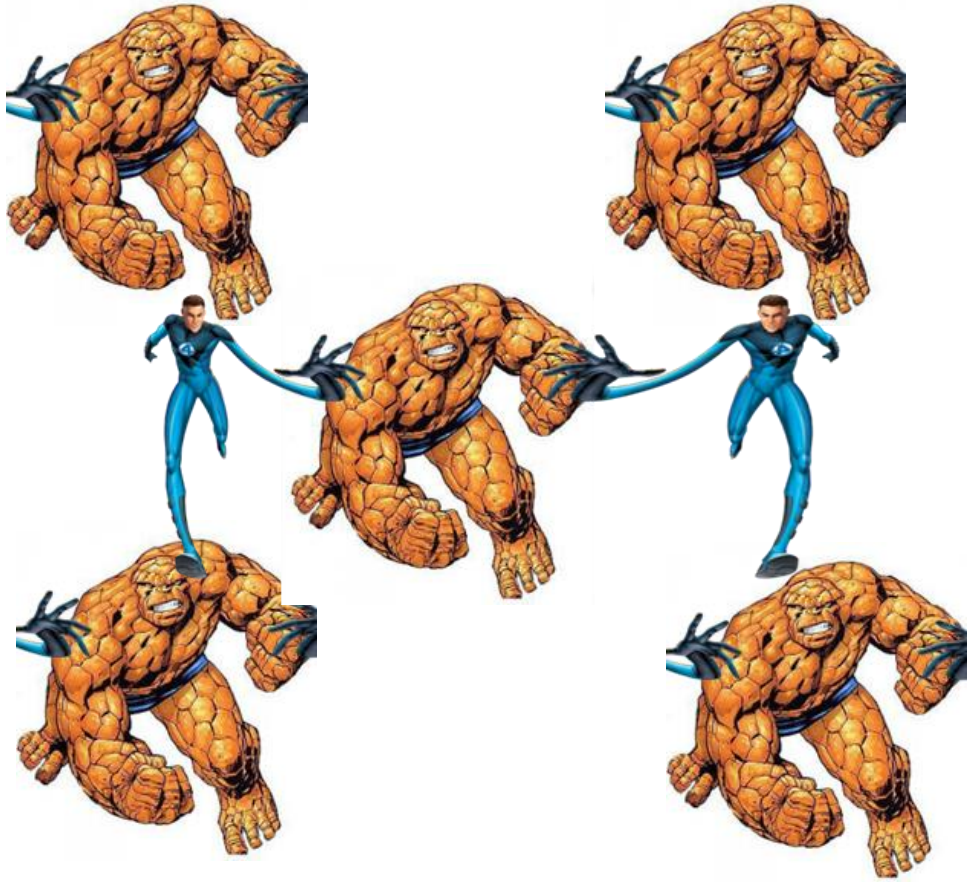
(ref: World Bank, Commissione Europea)



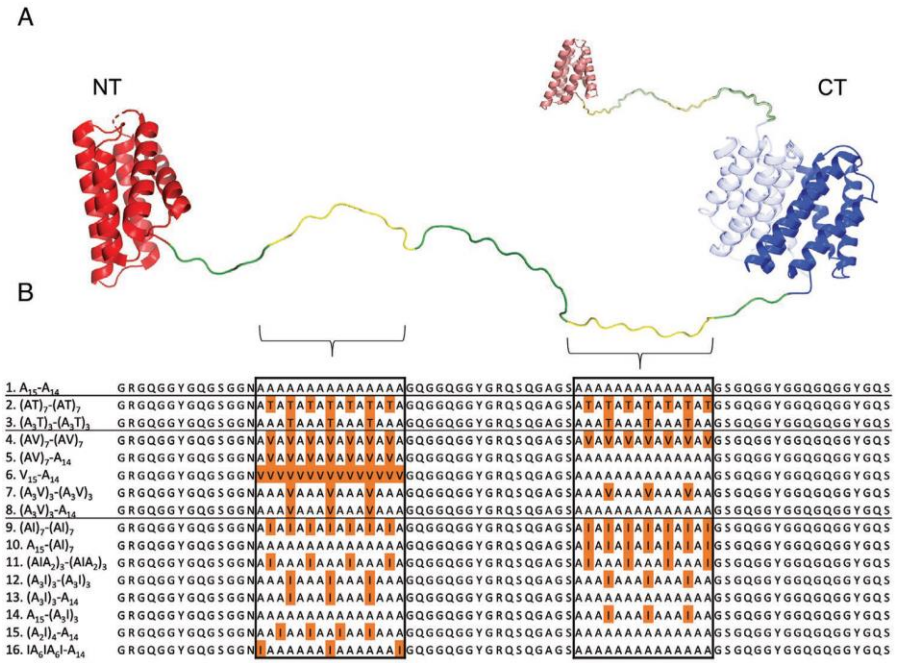
Schmuck et al., *Materials Today*, 2021

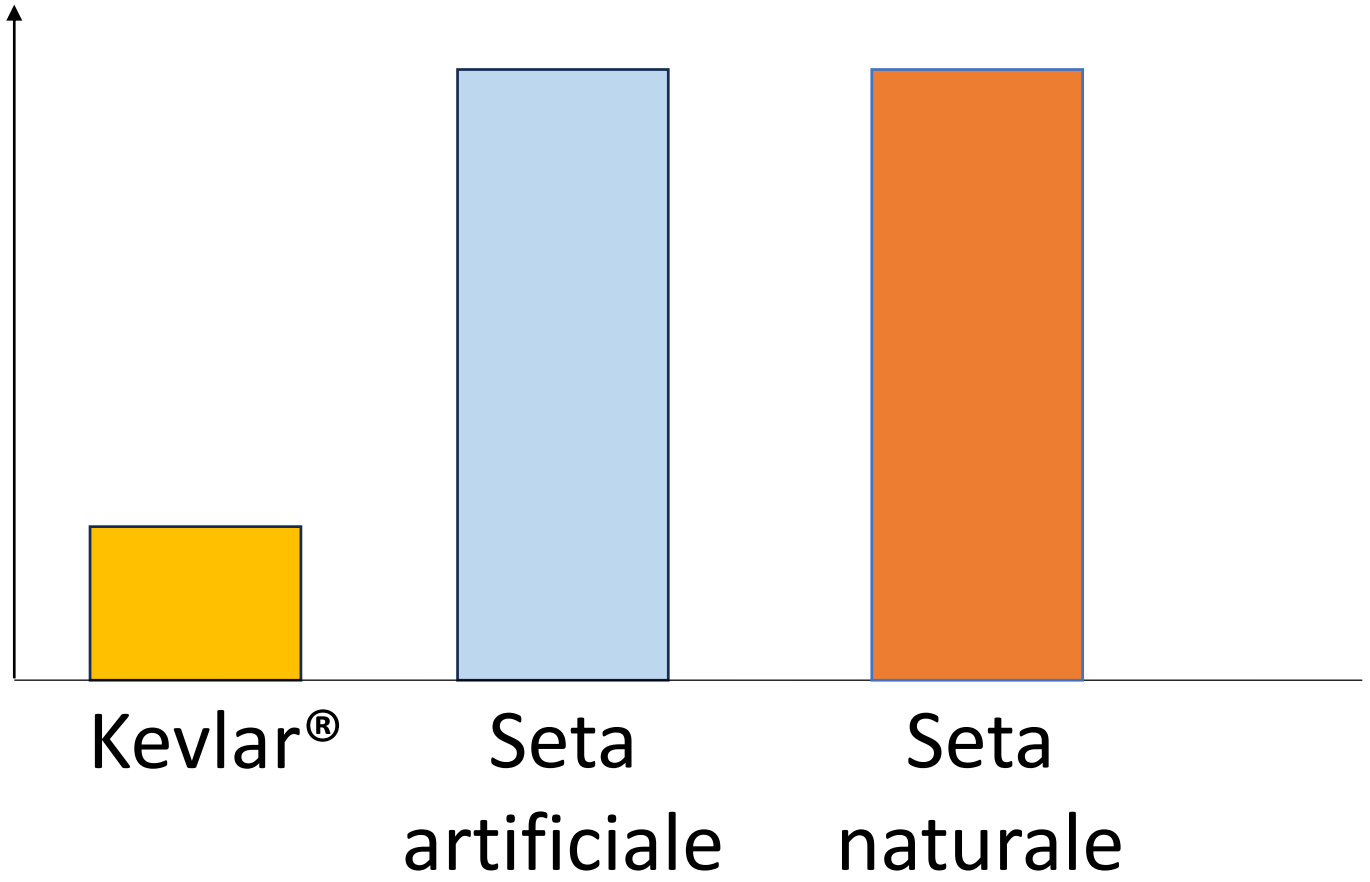
Le proprietà meccaniche dipendono dalla zona centrale delle proteine





Ingegneria delle proteine per migliorare le fibre

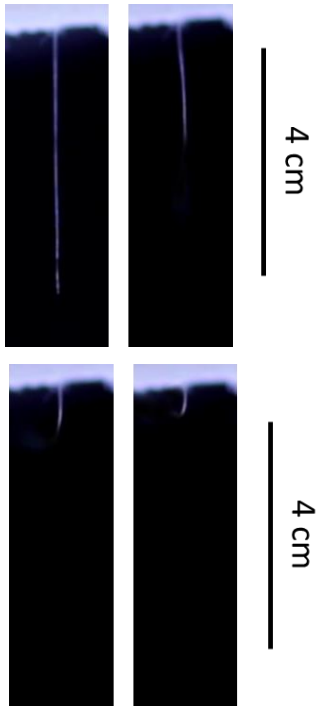




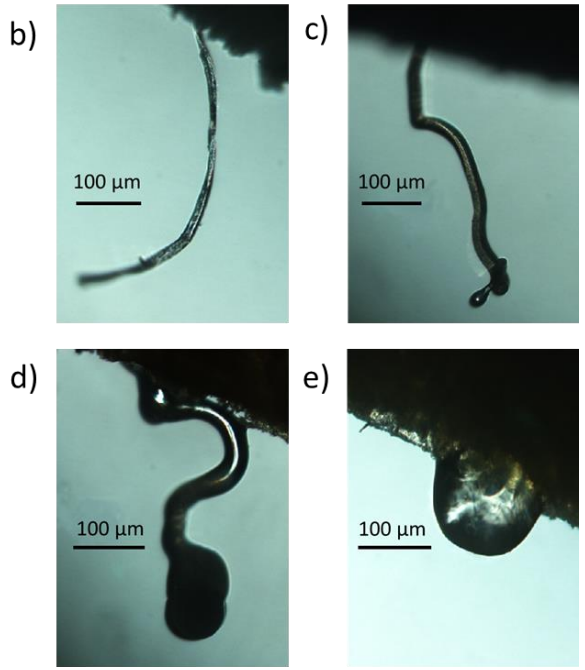
Arndt et al., *Adv. Funct. Mater.*, 2022

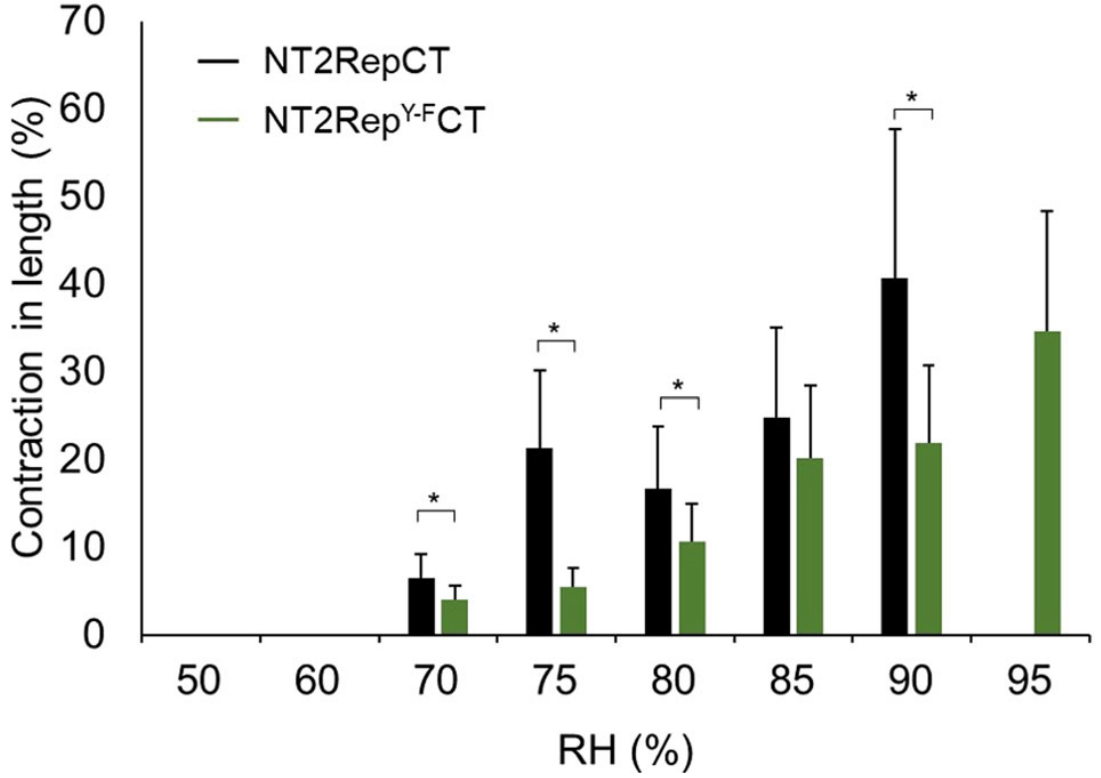
Ingegneria delle proteine per rendere le fibre resistenti all'acqua

Fibre si contraggono ad umidità >70%



Fibre si dissolvono ad umidità >88%





Greco et al., *Comm. Mater.*, 2021

Qualche idea pazza?

FERRARI

Misticanza di seta, Ghezzi e **Greco**

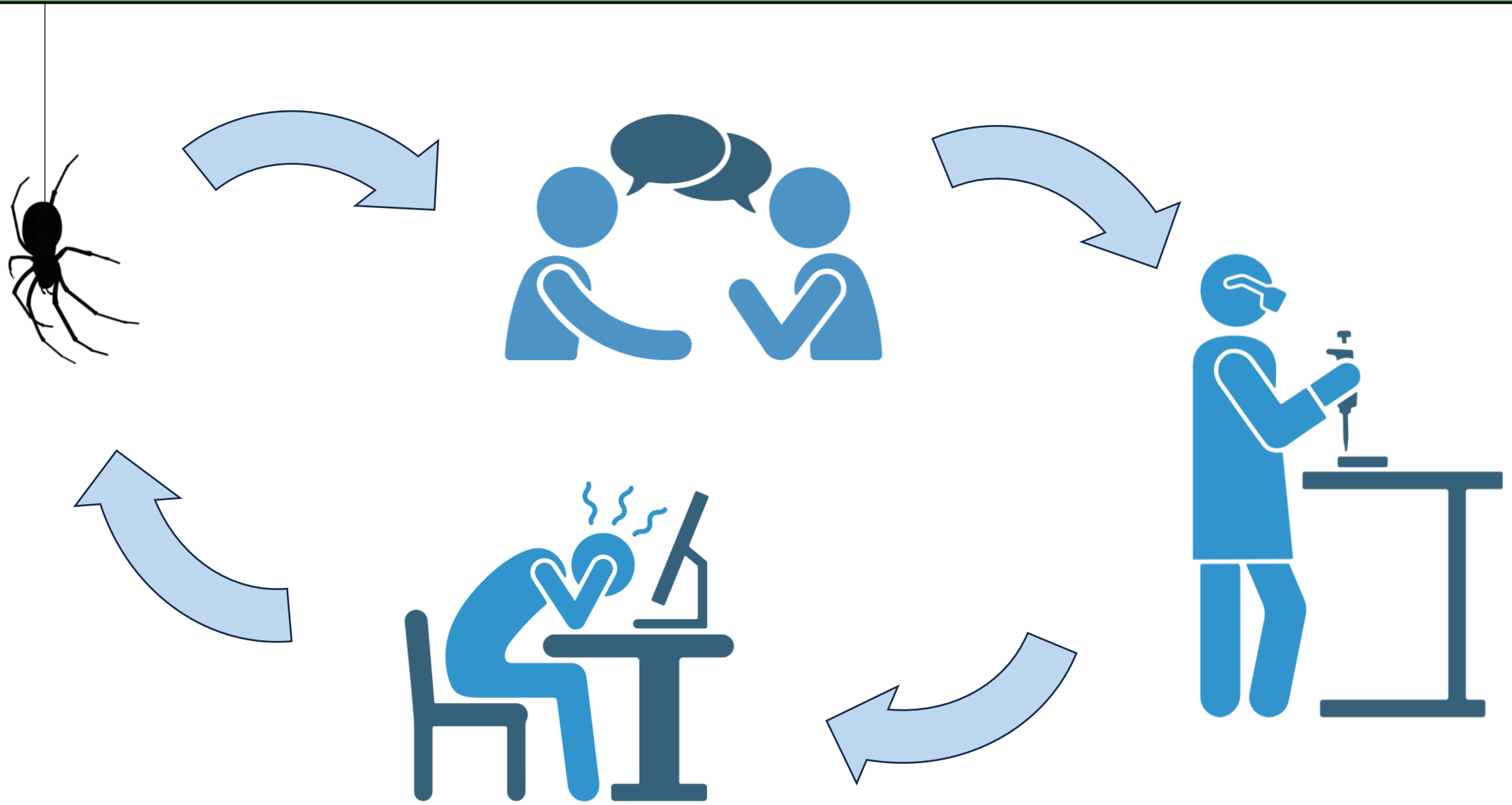
BIOtech Biomedical Technologies

LOCANDA MARGON

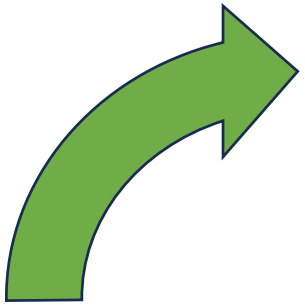
Outline:

- ✓ Sete di ragno
- ✓ Ragnatele
- ✓ Seta artificiale

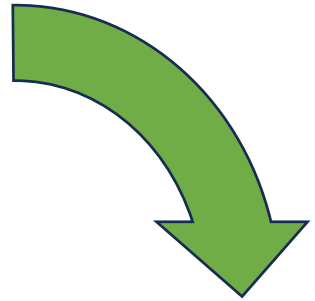
Seta di ragno: il materiale che ha affascinato l'umanità



Realized with Biorender



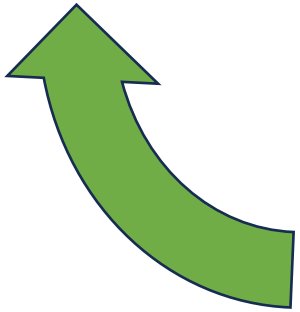
Natura



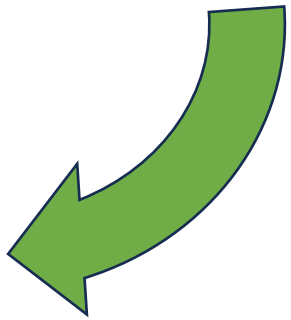
Problema
Sociale/tecnologico

Approccio
Bio-ispirato

Problema
biologico



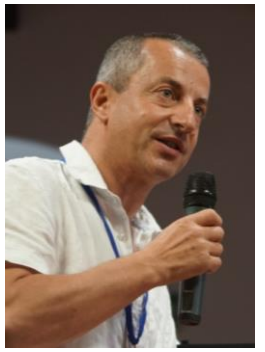
Soluzioni
Efficienti e sostenibili



Antonio Raimondo

Prof. Rising

Prof. Pugno



FONDAZIONE CARITRO
CASSA DI RISPARMIO DI TRENTO E ROVERETO

OLLE ENGKVISTS STIFTELSE

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Domande?

Thank you