Silk “quality” revealed
Using dynamic mechanical analysis

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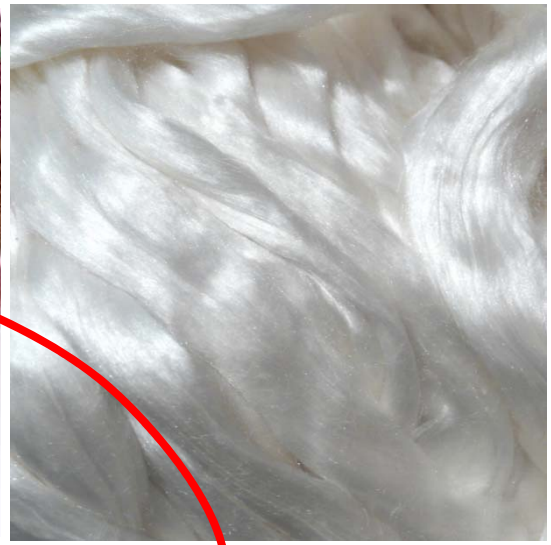
What silk am I interested in?

http://www.vam.ac.uk/__data/assets/image/0011/176879/golden_spider_silk.jpg



w.paulnoll.com/China/Suzhou/silk-11.jpg

://images-en.busytrade.com/23371800/raw-silk-

The tool: Dynamic Mechanical Thermal Analysis (DMTA)

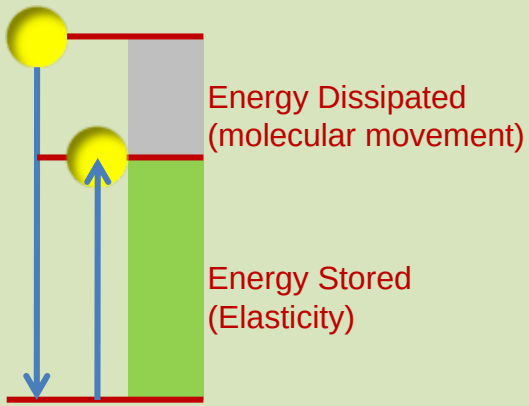
Silk: a bio-polymer

Question: why do some silks have better mechanical properties than others?

Dynamic Mechanical Thermal Analysis (DMTA)

Ball test (Mechanism)

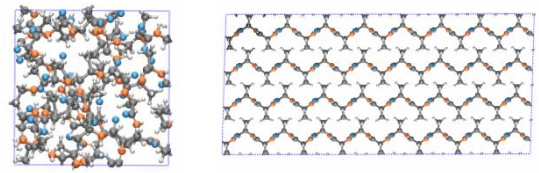
Energy management



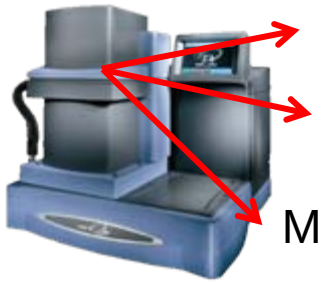
The information

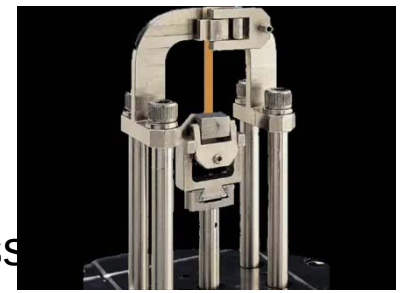
o Energy storage/dissipation

o What structure cause the engineering properties

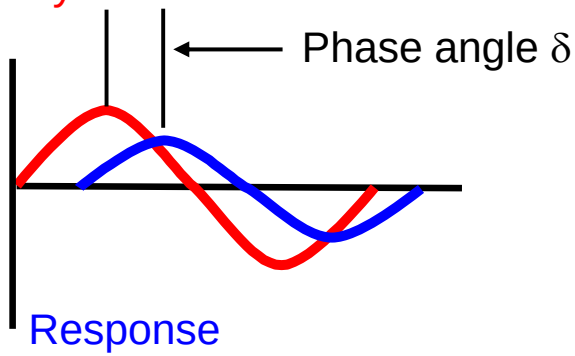


Actual test





Dynamic deformation



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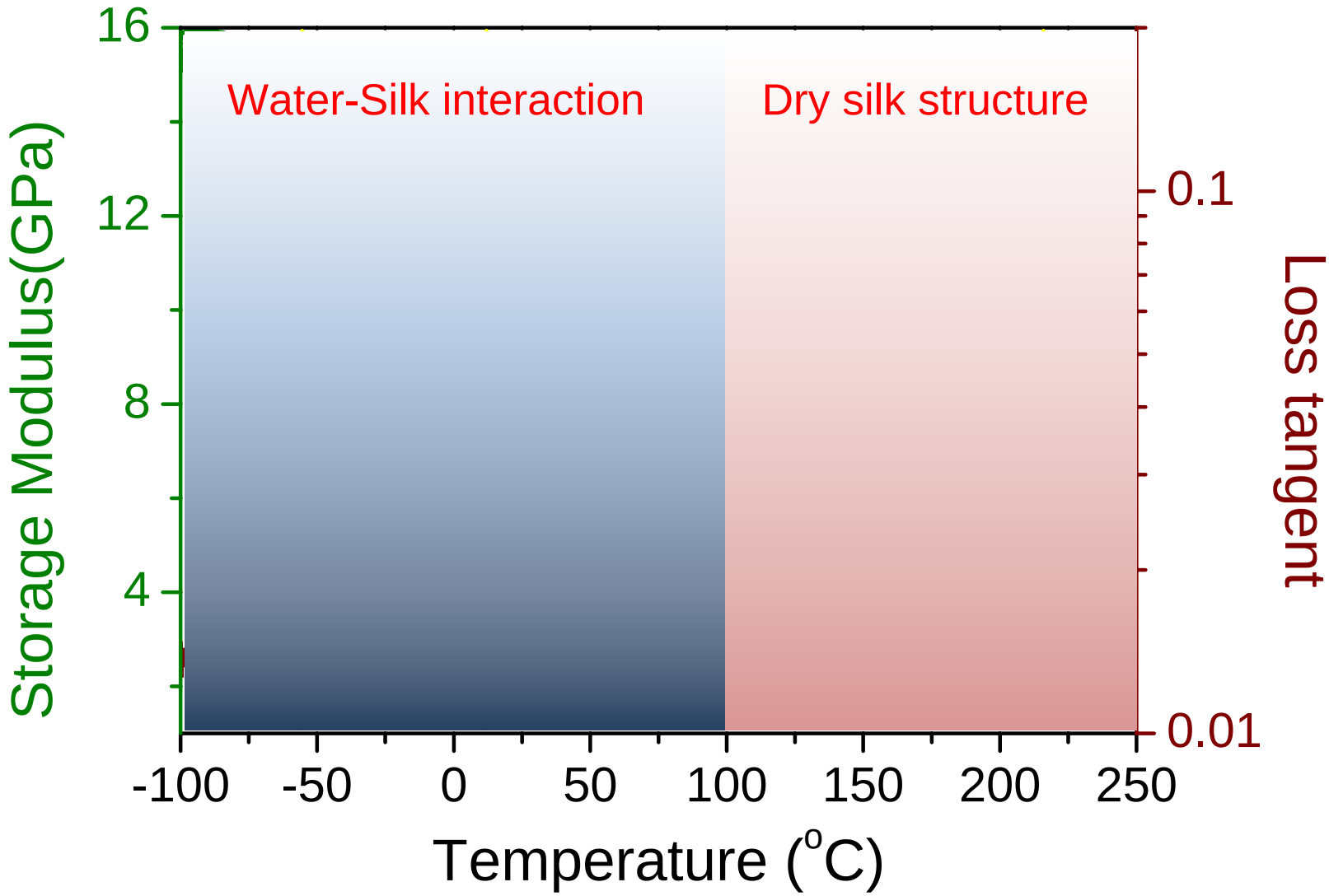
Typical DMA graph: Thermal analysis



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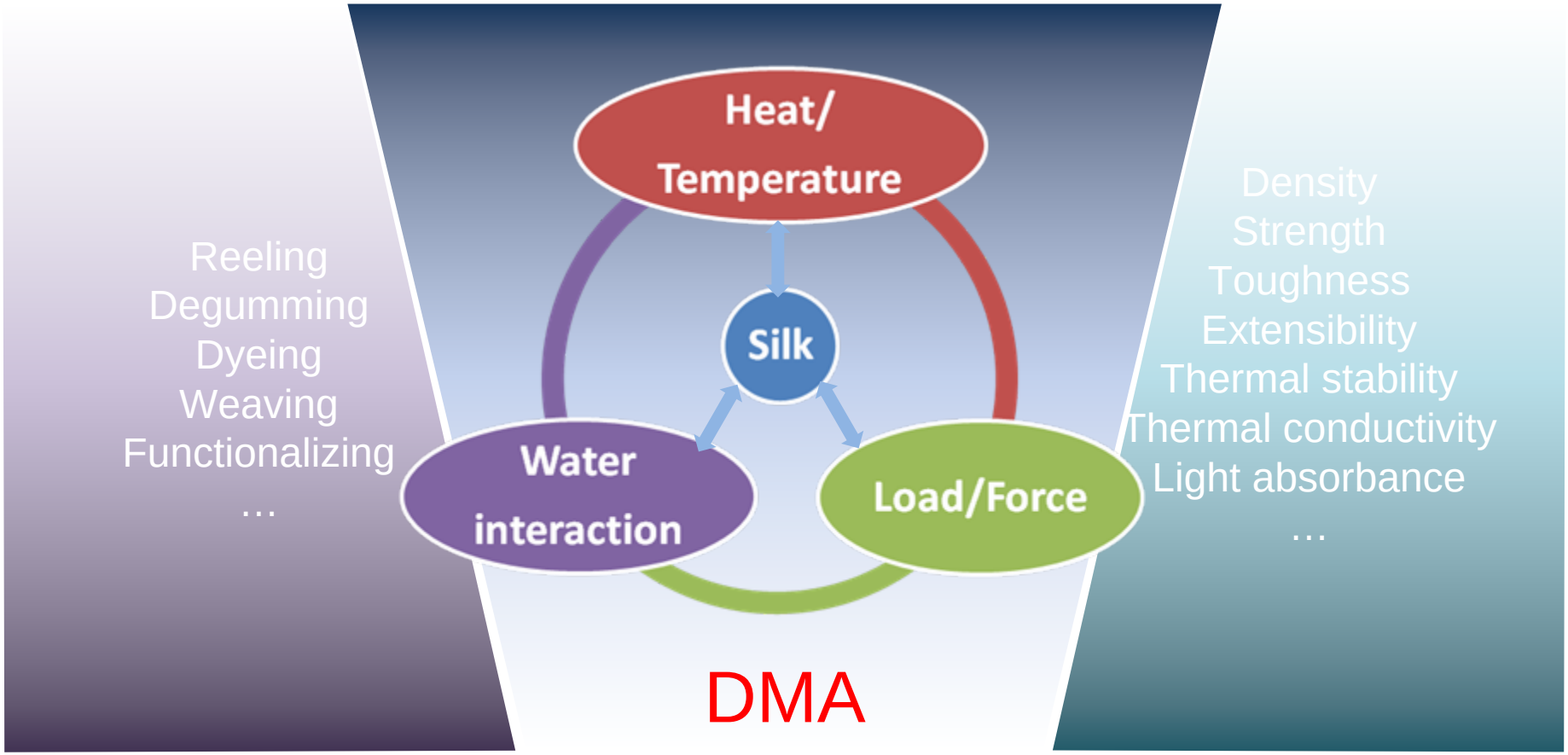


PROCESSIN G ← SYNERGY → PROPERTY

FUNCTION

STRUCTUR

Mechanical, electronic, bio-compatibility, degradability, antibacterial…

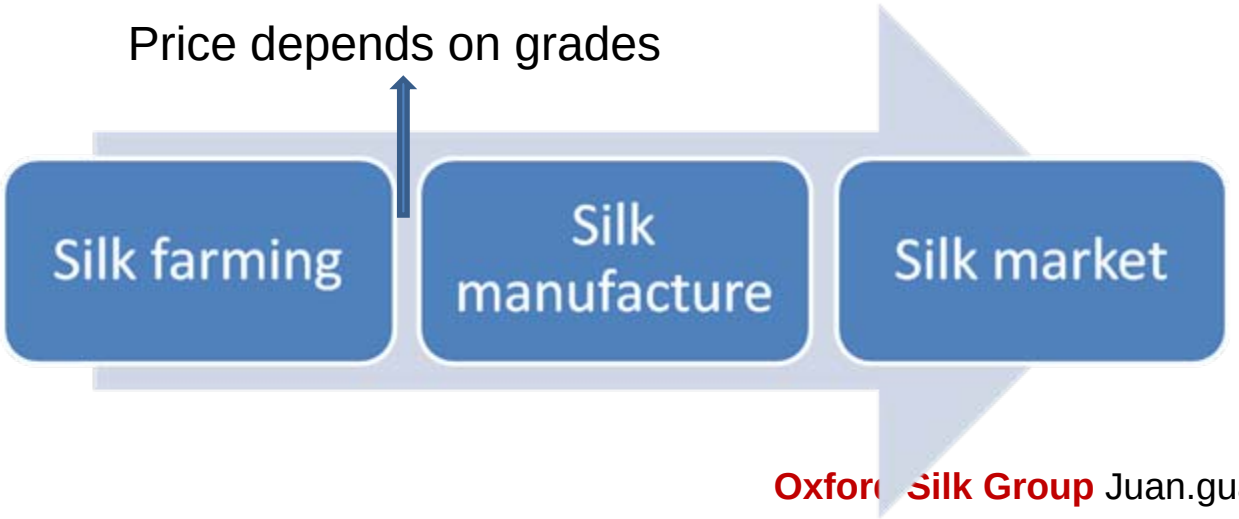
Sequence, Composition, Helical structure, Random coil, β-sheet crystals, Hierarchical structure…

…

Case study: Silks of 3 grades

Mulberry field in Jiangsu Prov. China.

Silk farmers working happily in yard.



Morphology: cocoons and silks

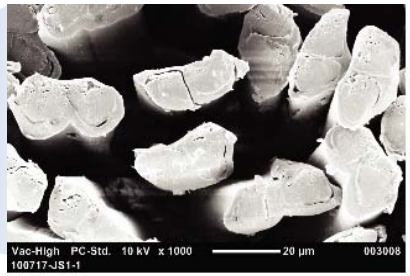
Cocoons

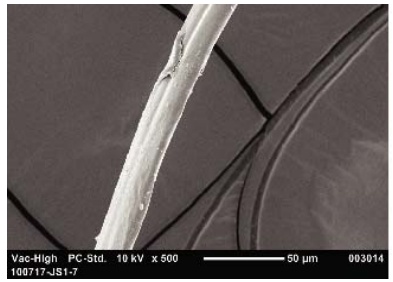
Raw silks

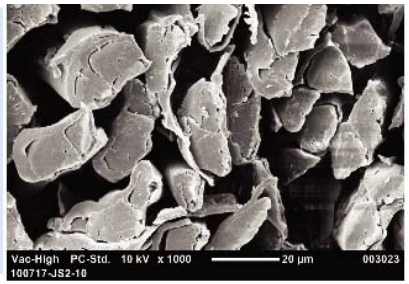
G1

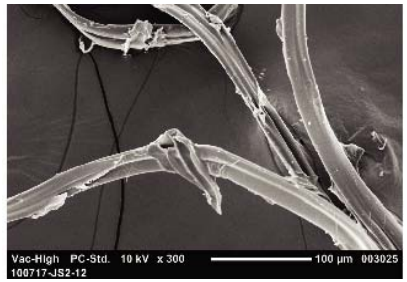
G2

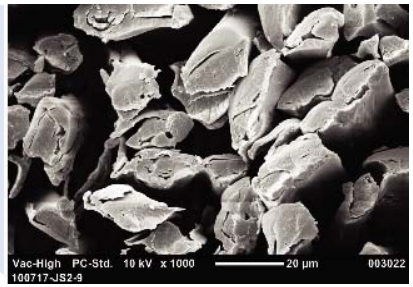
G3

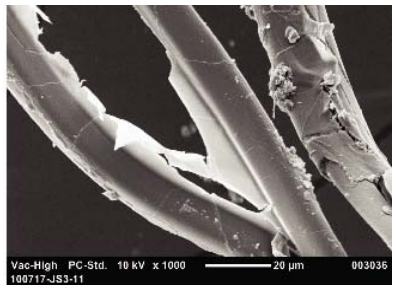












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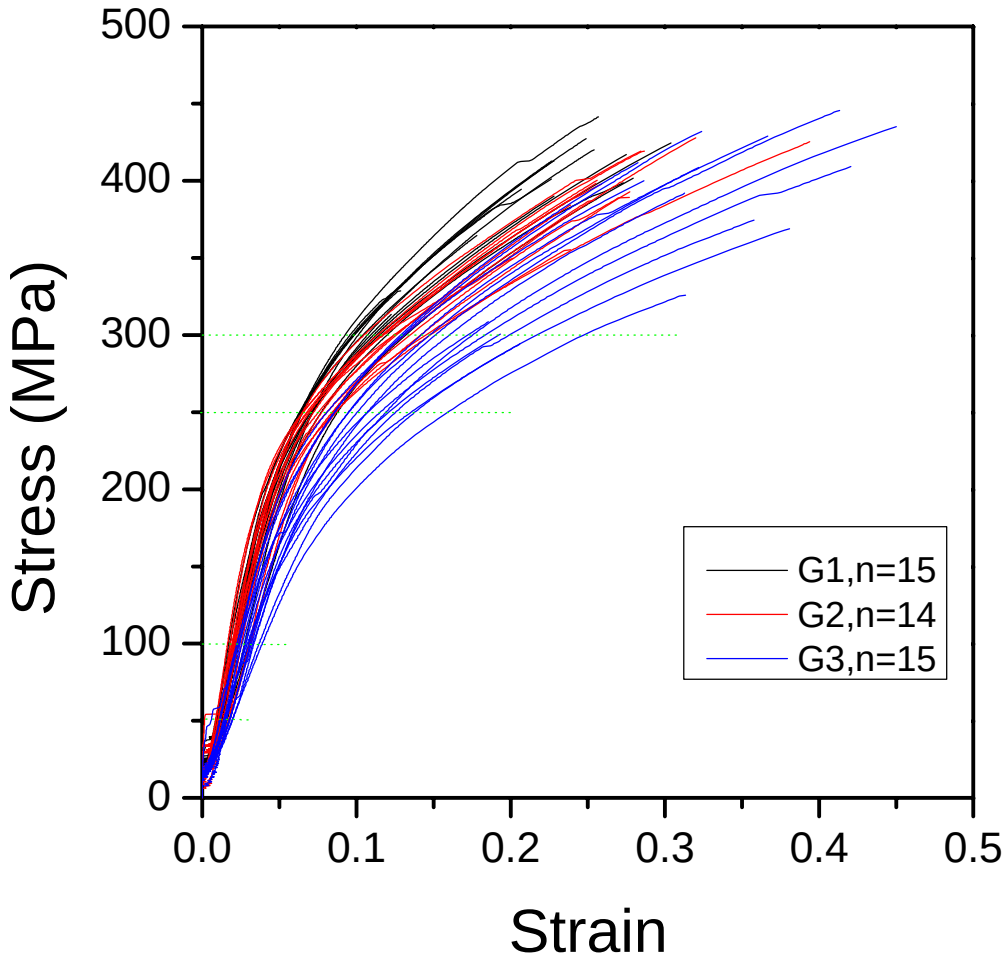
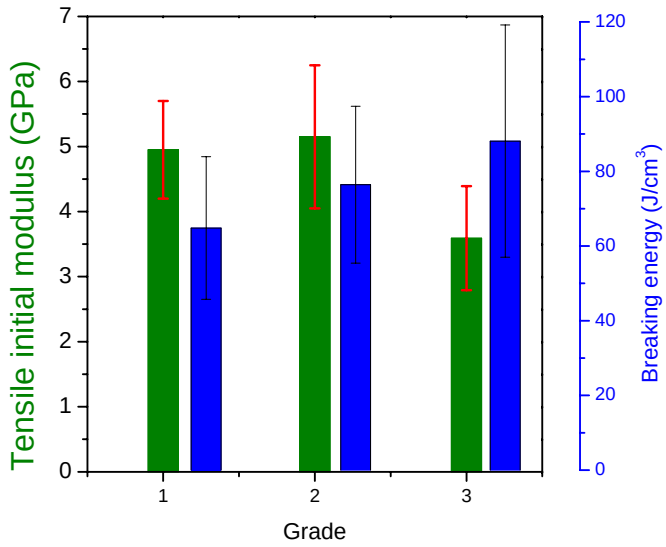
Tensile properties





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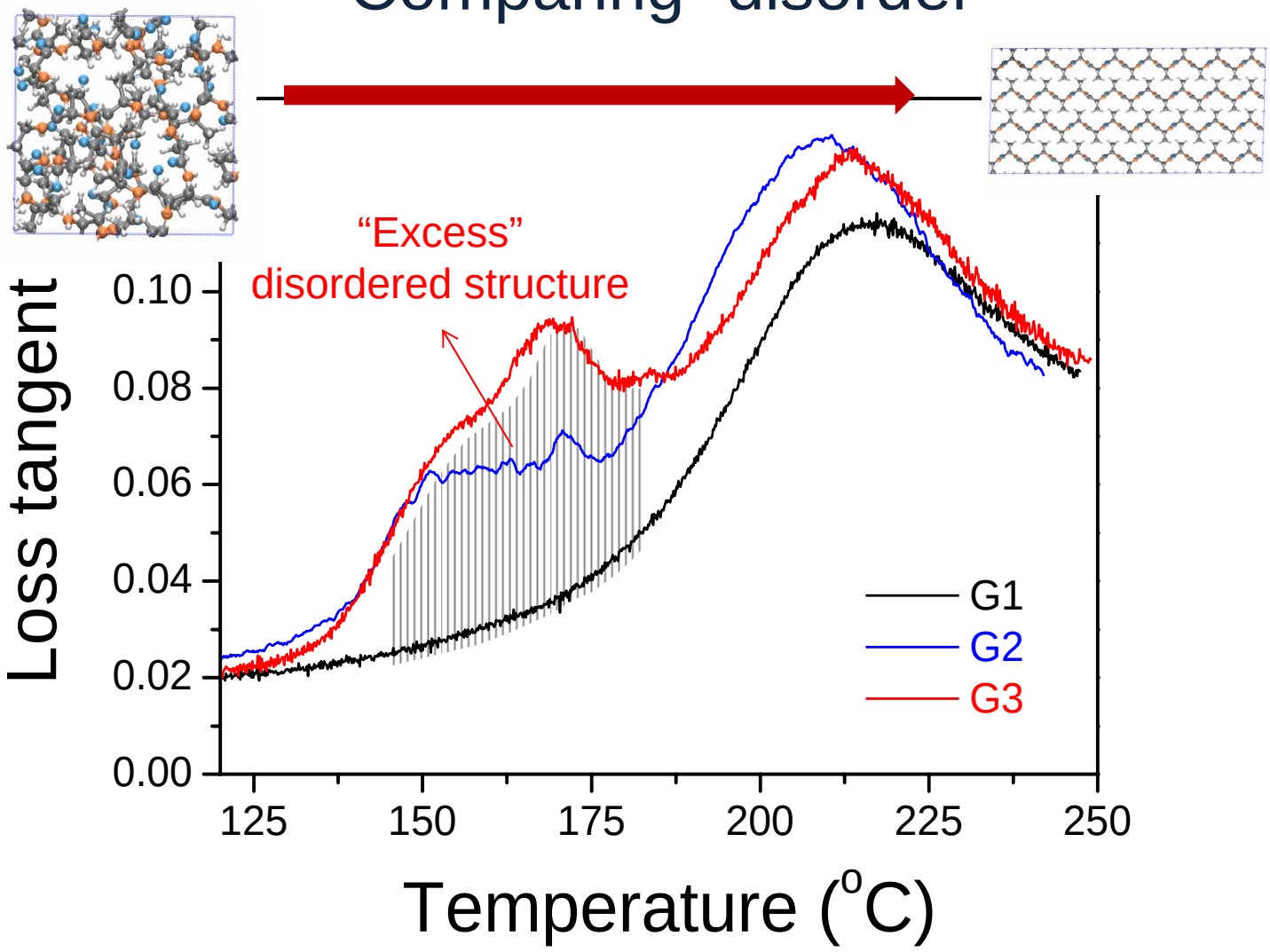
What's more?

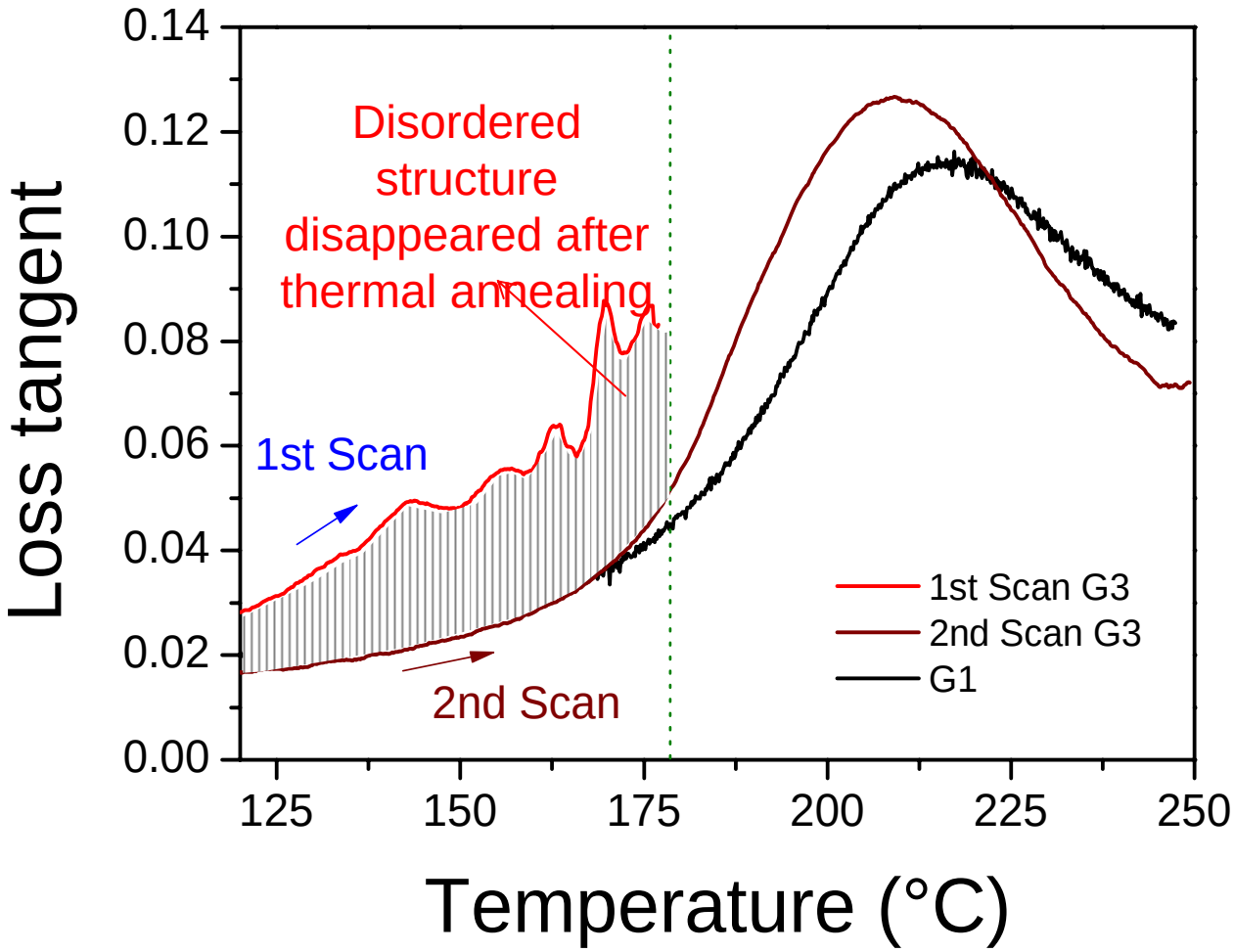
J. Guan, D. Porter*, F. Vollrath. Thermally induced changes in dynamic mechanical properties of native silks. *Biomacromolecules*.

Dynamic mechanical thermal analysis
Comparing "disorder"



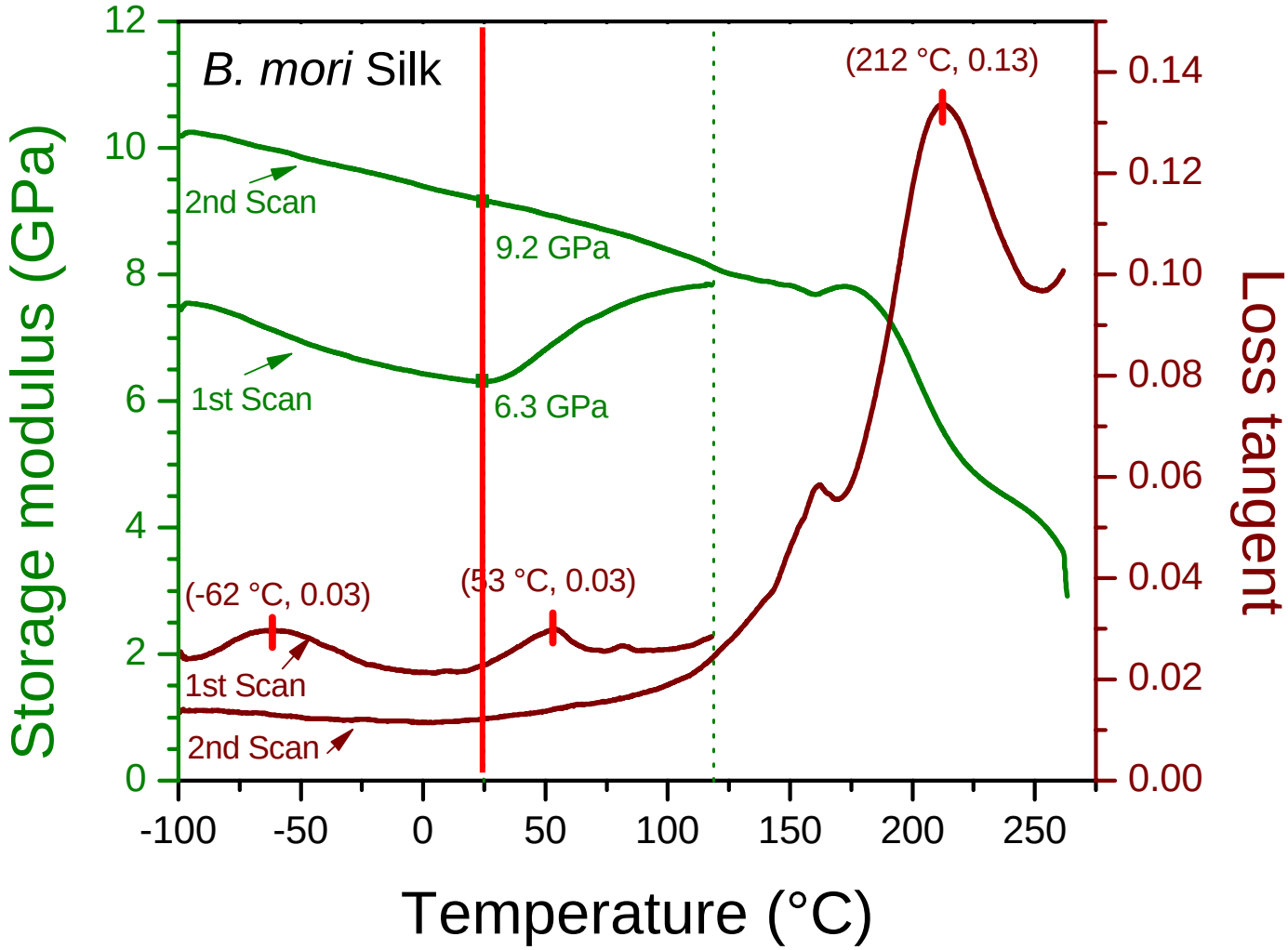
J. Guan, D. Porter*, F. Vollrath. Thermally induced changes in dynamic mechanical properties of native silks. *Biomacromolecules.*

Dynamic mechanical thermal analysis
Annealing “disorder”: Thermo-mechanical Treatment



J. Guan, D. Porter*, F. Vollrath. Thermally induced changes in dynamic mechanical properties of native silks. *Biomacromolecules.*

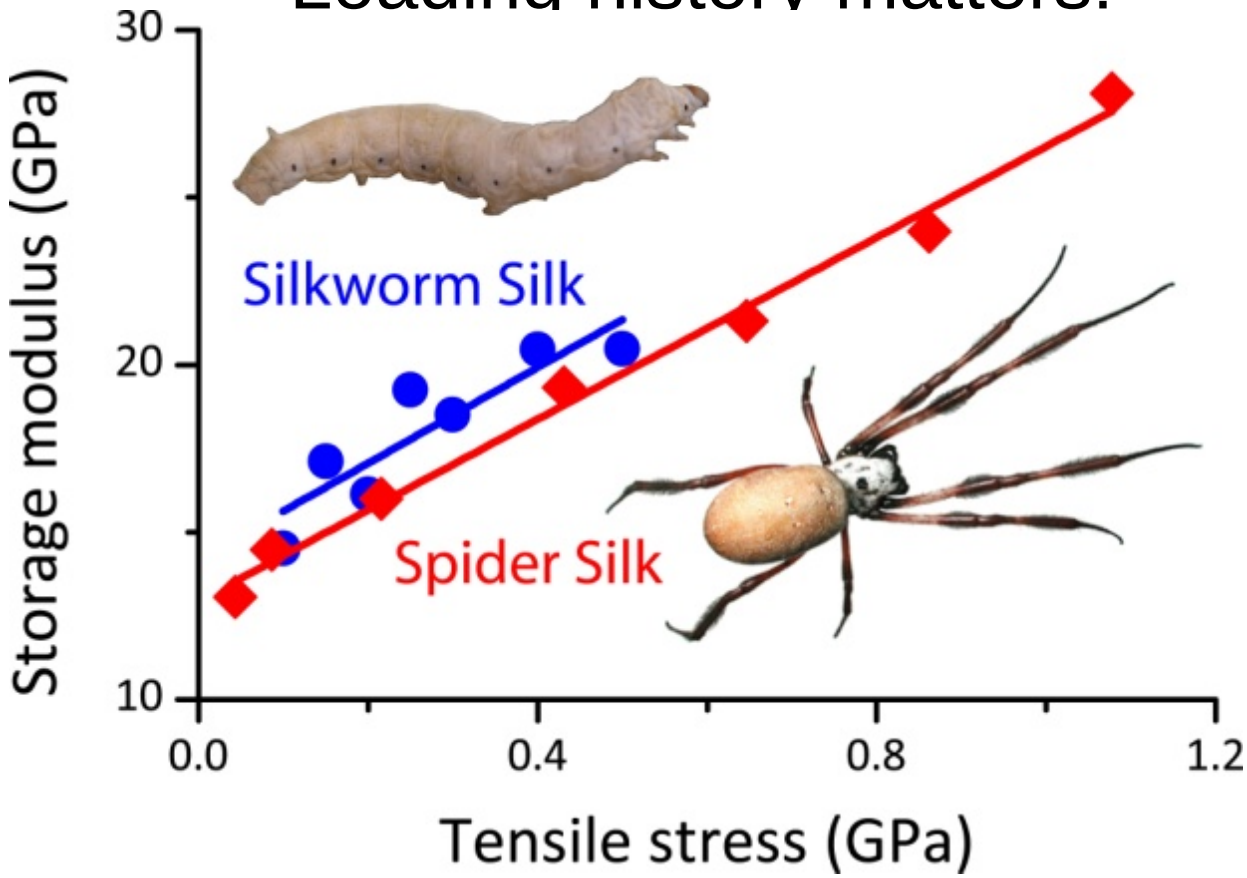
Dynamic mechanical thermal analysis
Hydrated or not?



J. Guan, D. Porter*, F. Vollrath. Thermally induced changes in dynamic mechanical properties of native silks. *Biomacromolecules.*

Dynamic mechanical properties of silks under load

Loading history matters!



Silks increase their modulus at higher stress at the cost of losing extensibility.

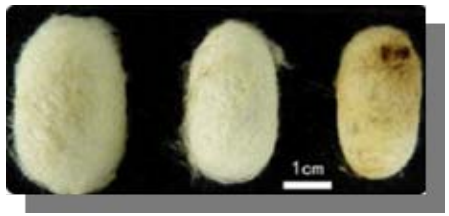
J. Guan, D. Porter*, F. Vollrath. *Polymer* 2012 (57) 13: 2717-2726.

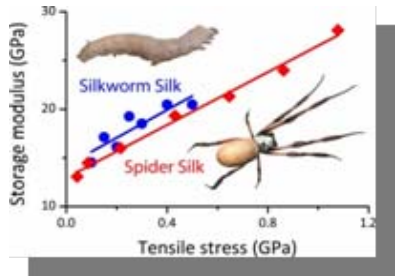
Summary

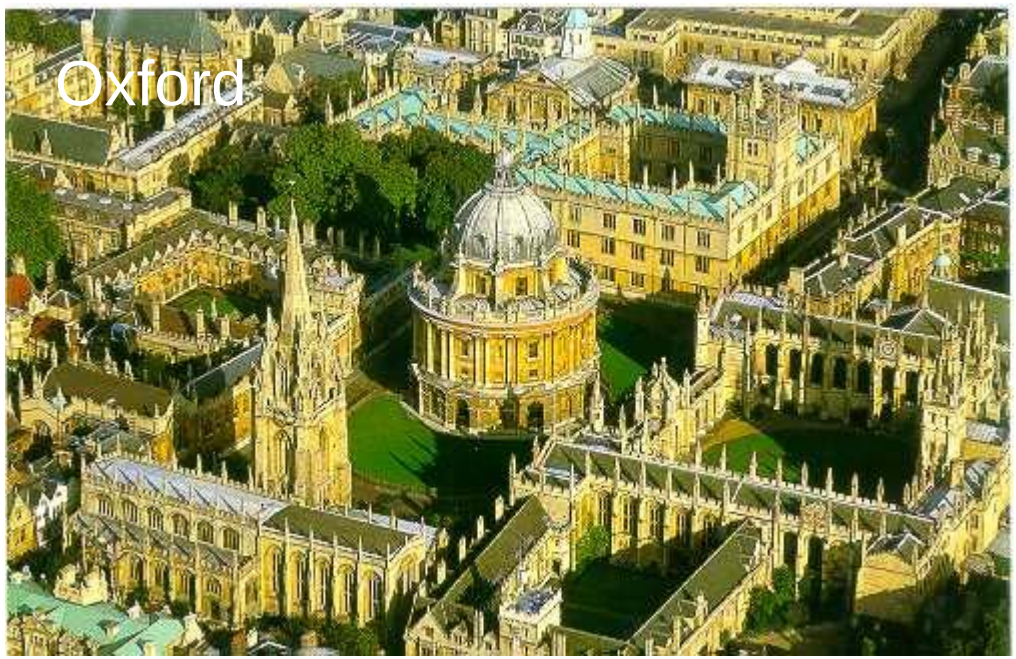
•Dynamic Mechanical Thermal Analysis (DMTA) is sensitive to the structural differences between silk grade;

•Thermal-mechanical treatment could improve the dynamic mechanical properties of poor-grade silks;

•Hydration and loading history affect the mechanical properties of silks.



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Zoology
Thank you very much!