ETH zürich

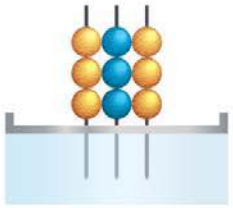
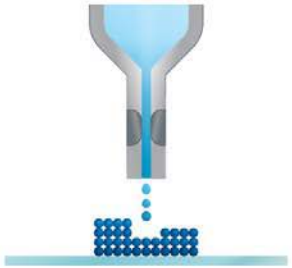
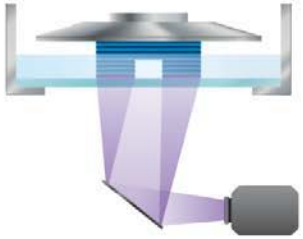
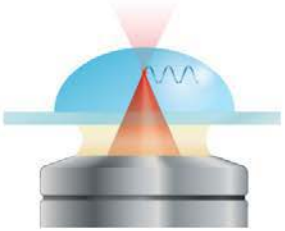
Mechanobiology

Materials and Mechanics in Medicine HS 2019

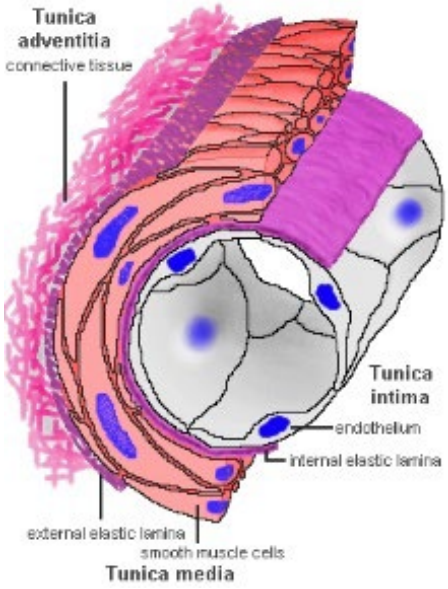
Jack Kendall

05.11.2019

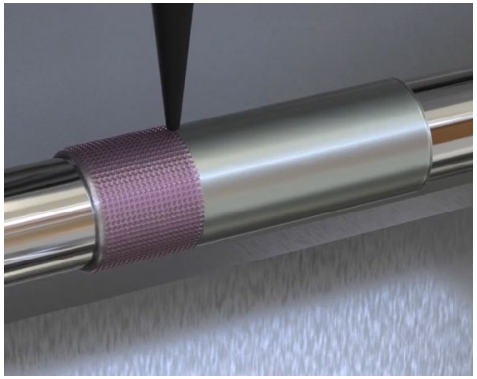
Quick Review: Methods of bioprinting

DEPOSITION BASED			STEREOLITHOGRAPHY BASED	
				
SCAFFOLD-FREE	EXTRUSION	DROPLET	PROJECTION	TWO-PHOTON

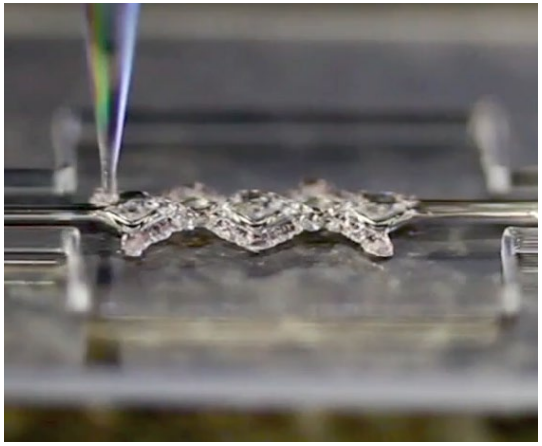
Quick Review: Application of blood vessel printing



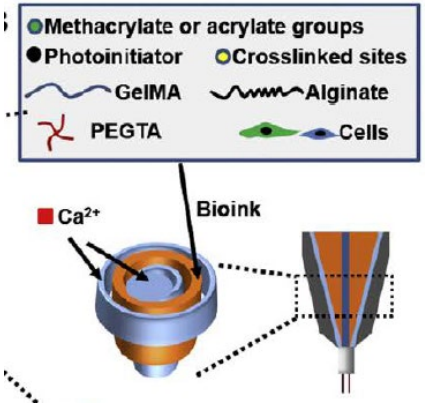
3) Rotating Cylinder



1) Thermosensitive Gel



2) Alginate

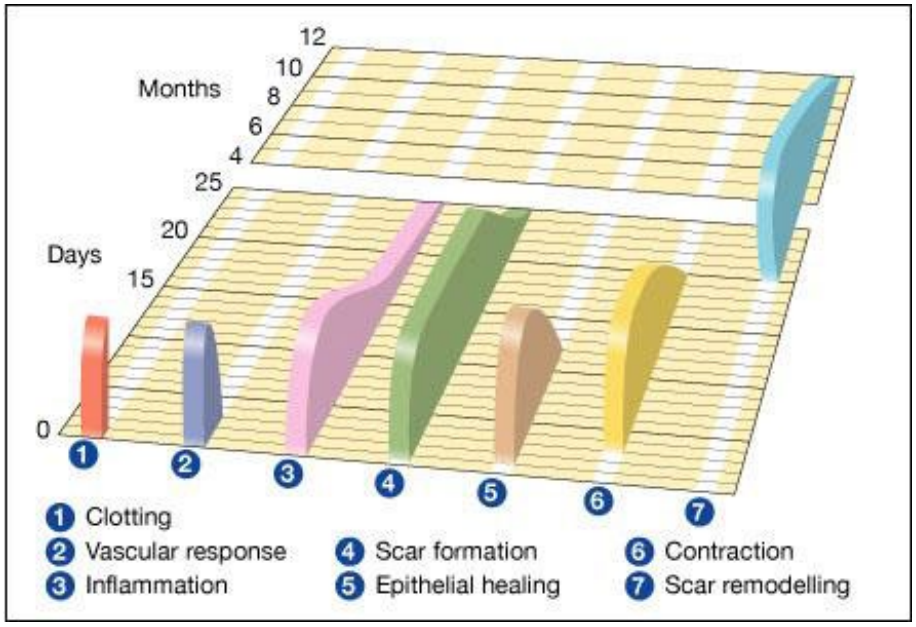


Learning Goals Mechanobiology

Why is biomaterial design is such a powerful tool in regenerative medicine?

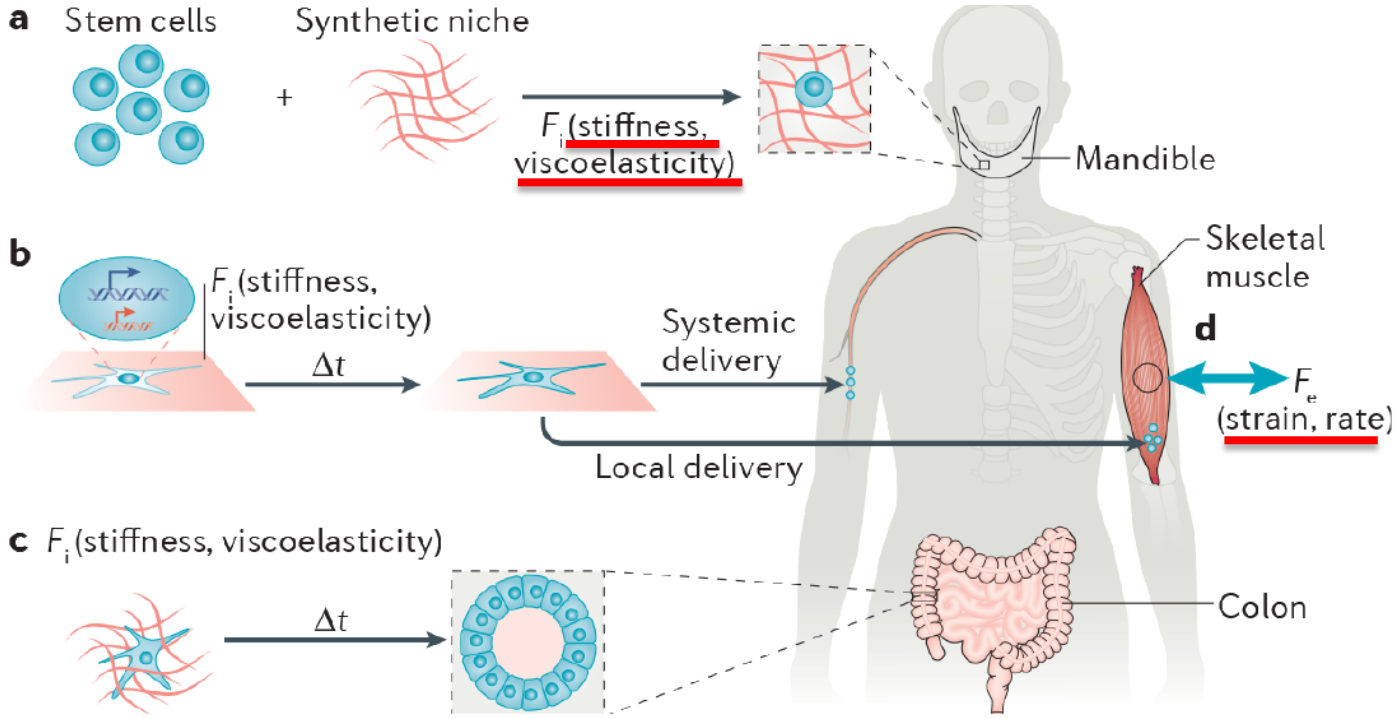
- ECM as a major physiological „driving cue“
- Mechanics as a key ingredient in physiology and biomaterial design
- How cells sense mechanical signals and convert them to “downstream signaling pathways” (molecular level)

Wound Healing



Phase I Phase II Phase III

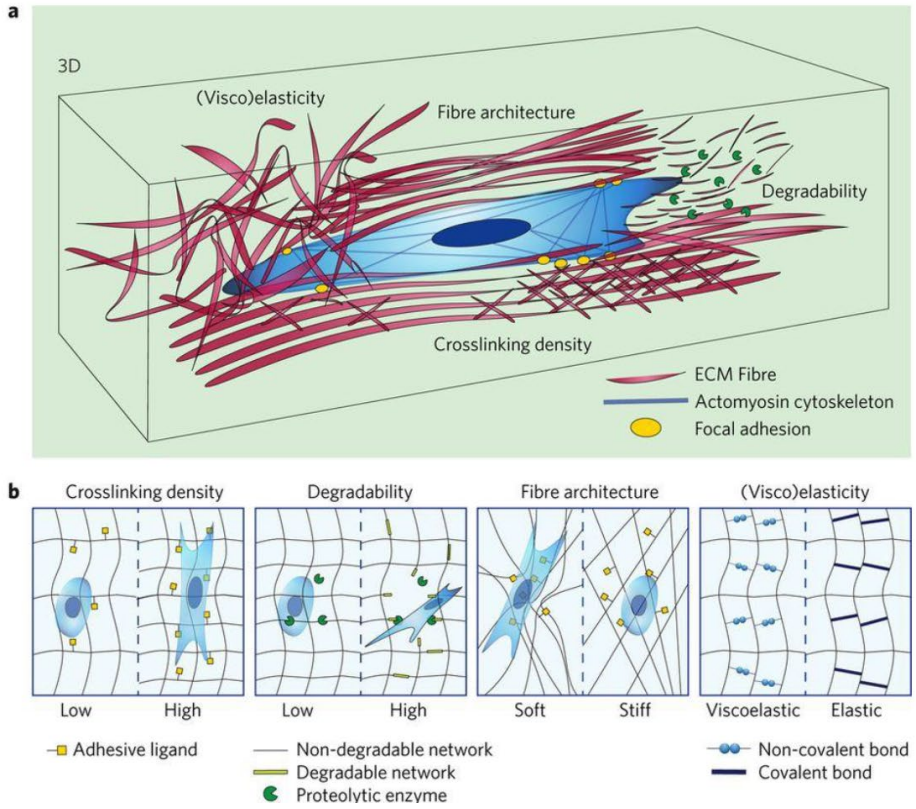
Forces as Key Ingredient of Tissue Engineering



Forces as Key Ingredient of Tissue Engineering

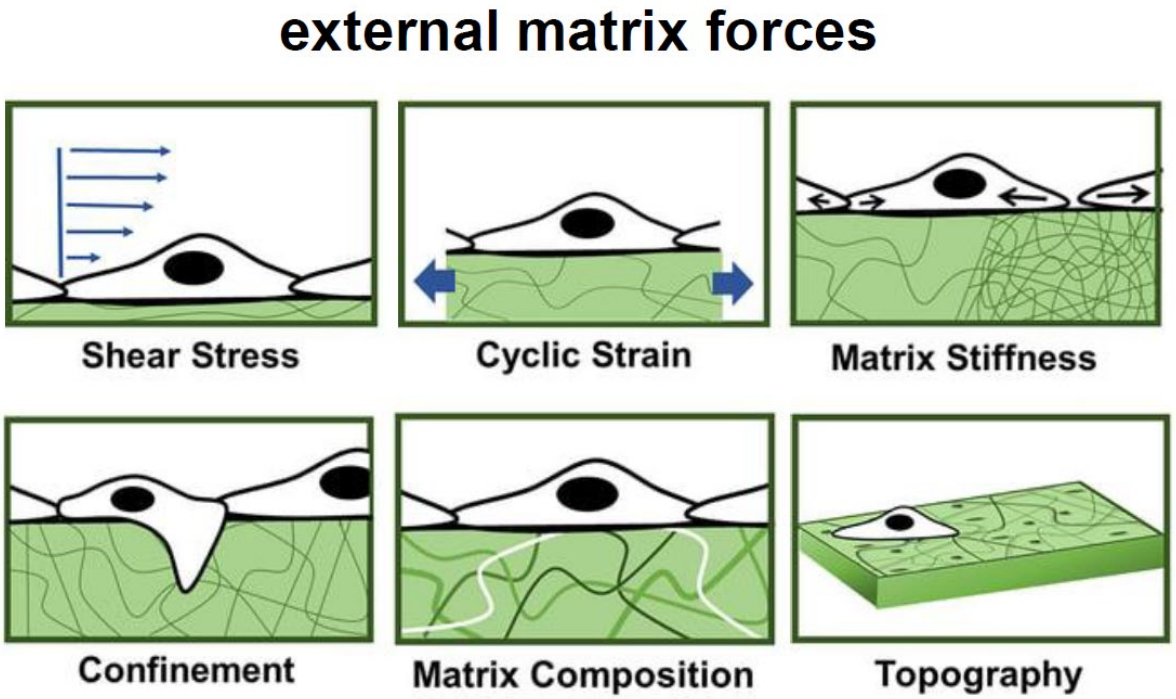
ECM

Biomaterial/
Mechanical
properties

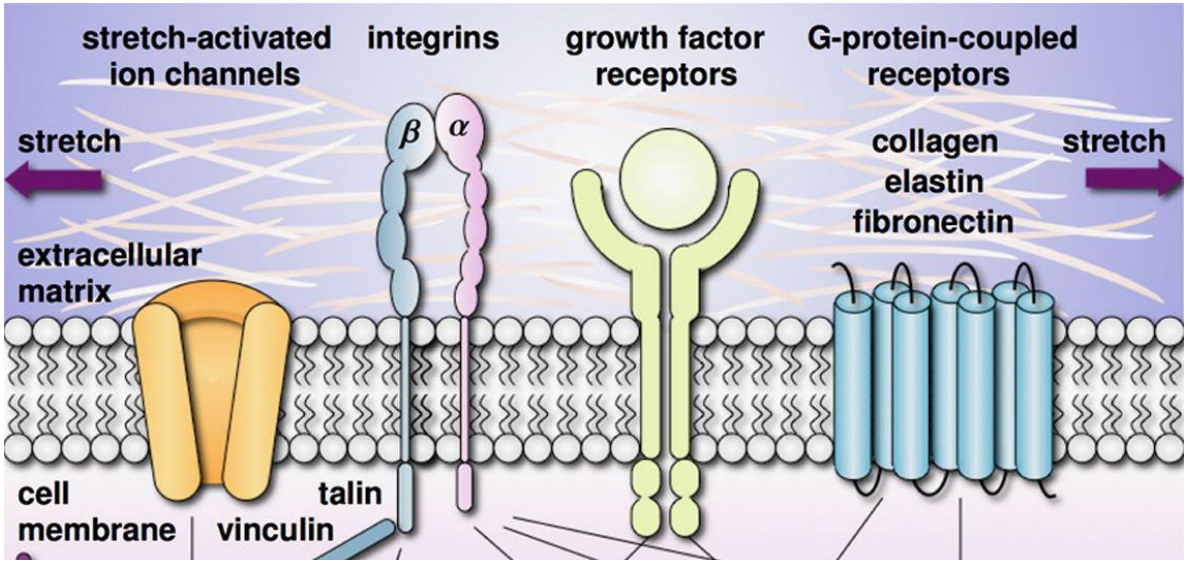


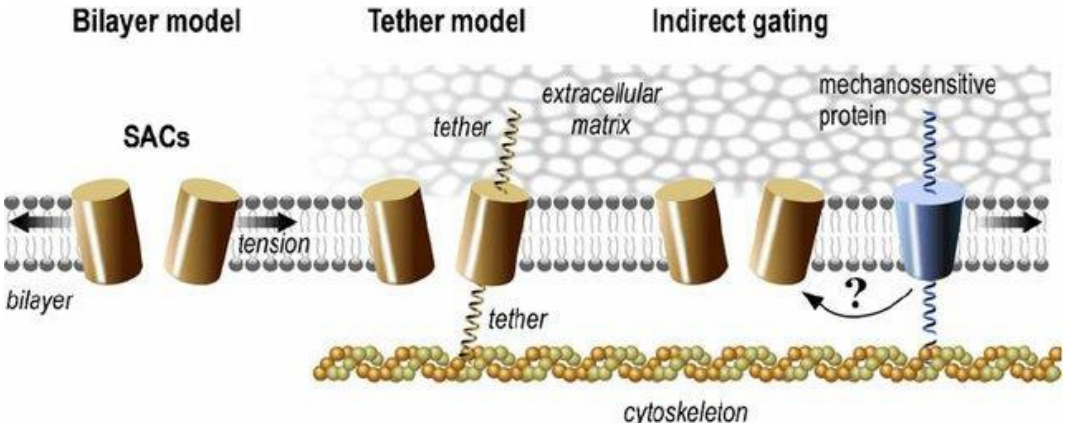
→ Cell behavior

Mechanobiology – Mechanical Signals



Mechanobiology - Sensation

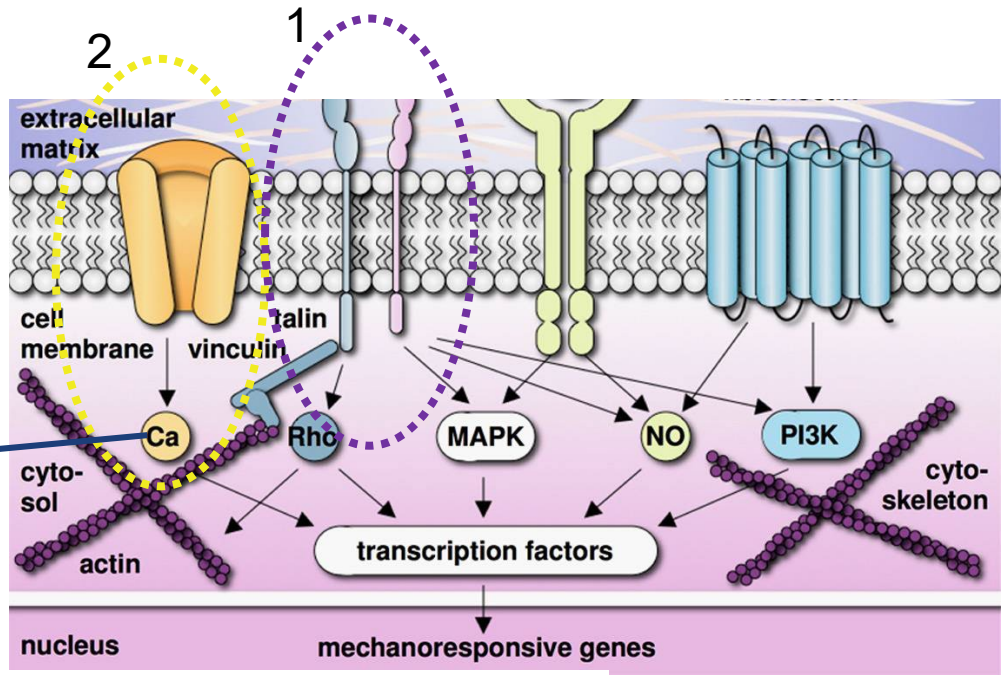


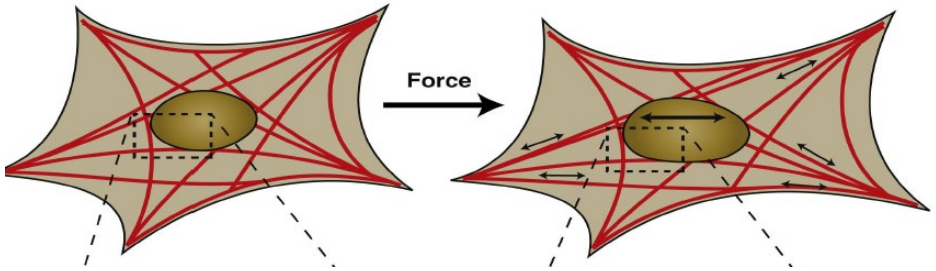


Mechanobiology – Conversion to biochem. signals

1. Integrin activation
2. Stretch-activated ion channels

many signalling kinases are calcium dependent





(i) Opening of chromatin structures
(ii) Freeing genes from repression
(iii) Conformational changes of the nucleus

Mechanobiology – Conversion to biochem. signals

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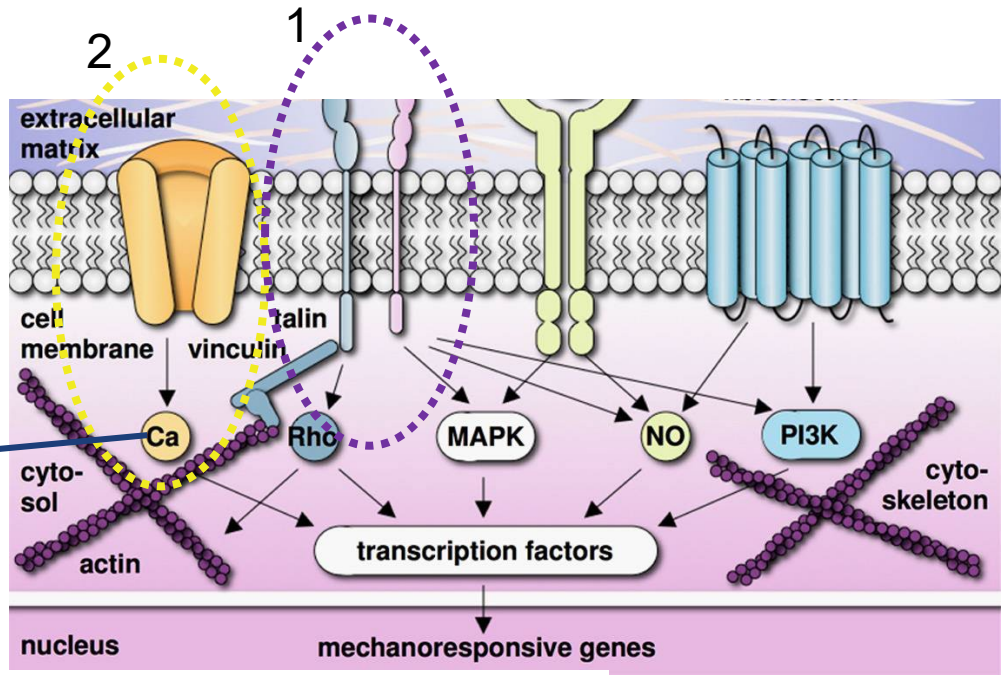

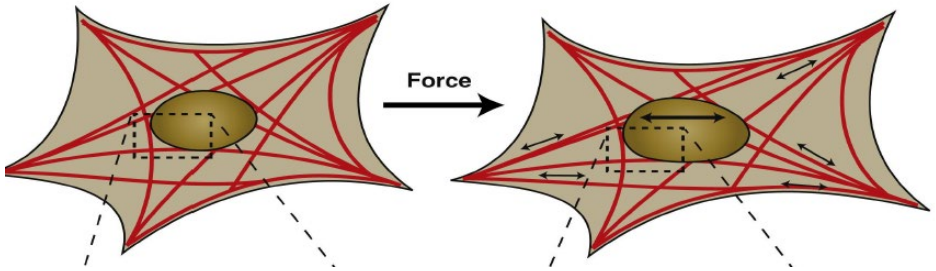

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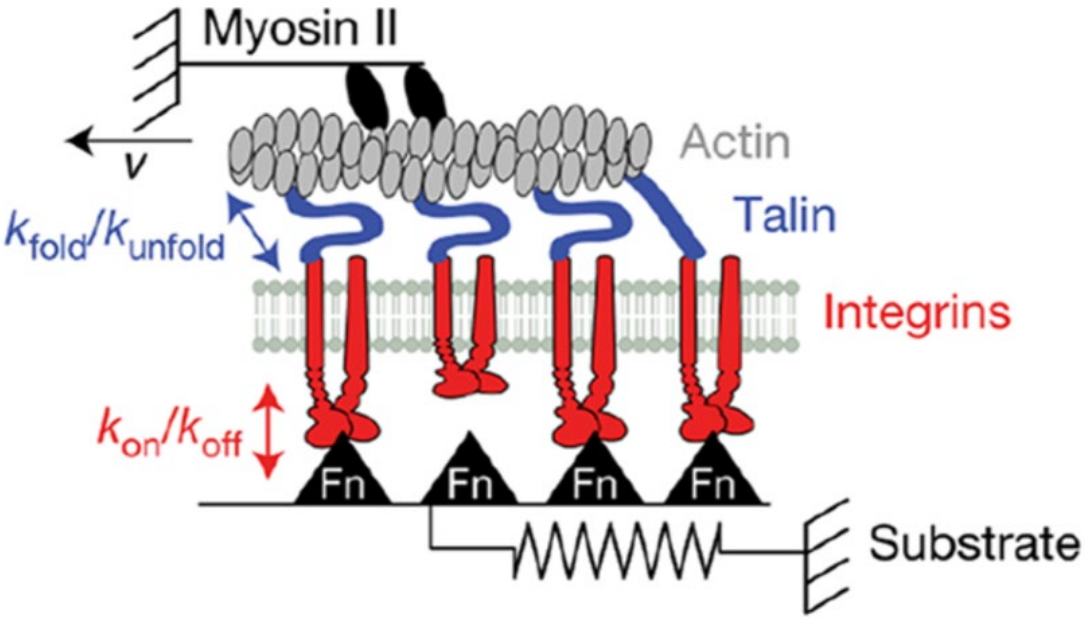
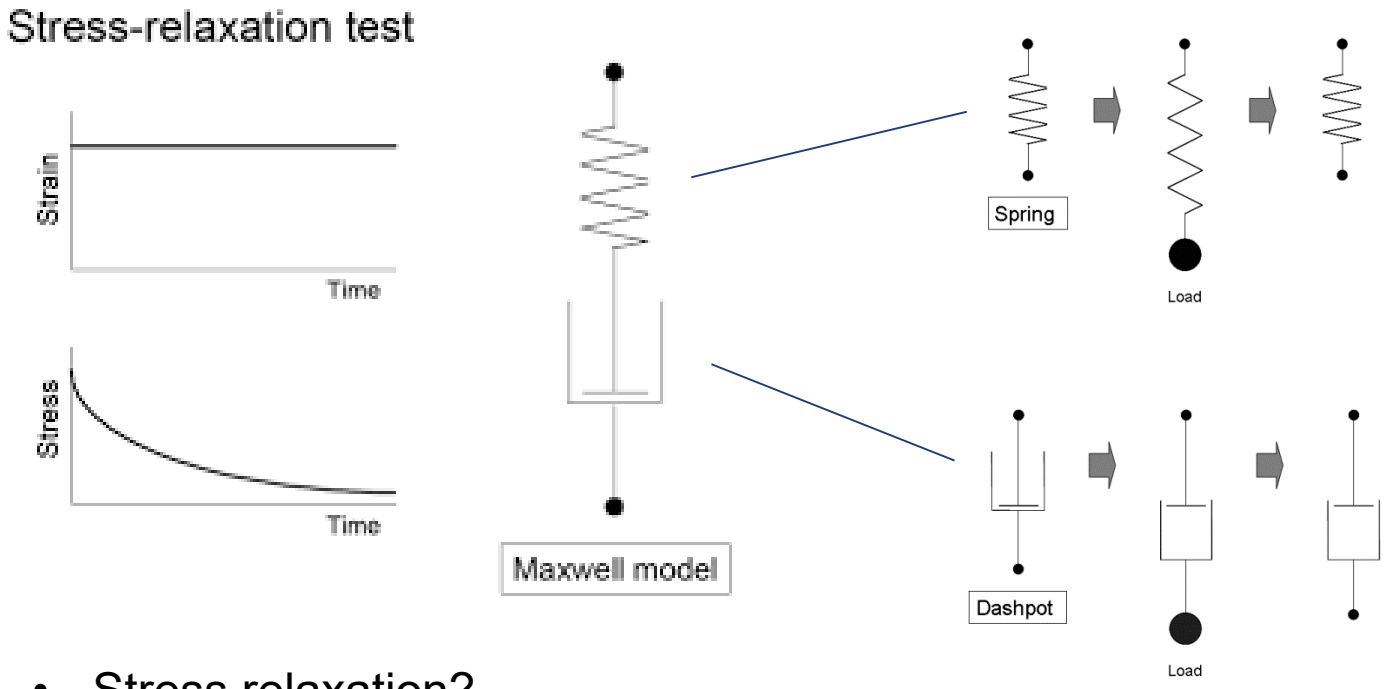
Question 1



Kinase activity if…

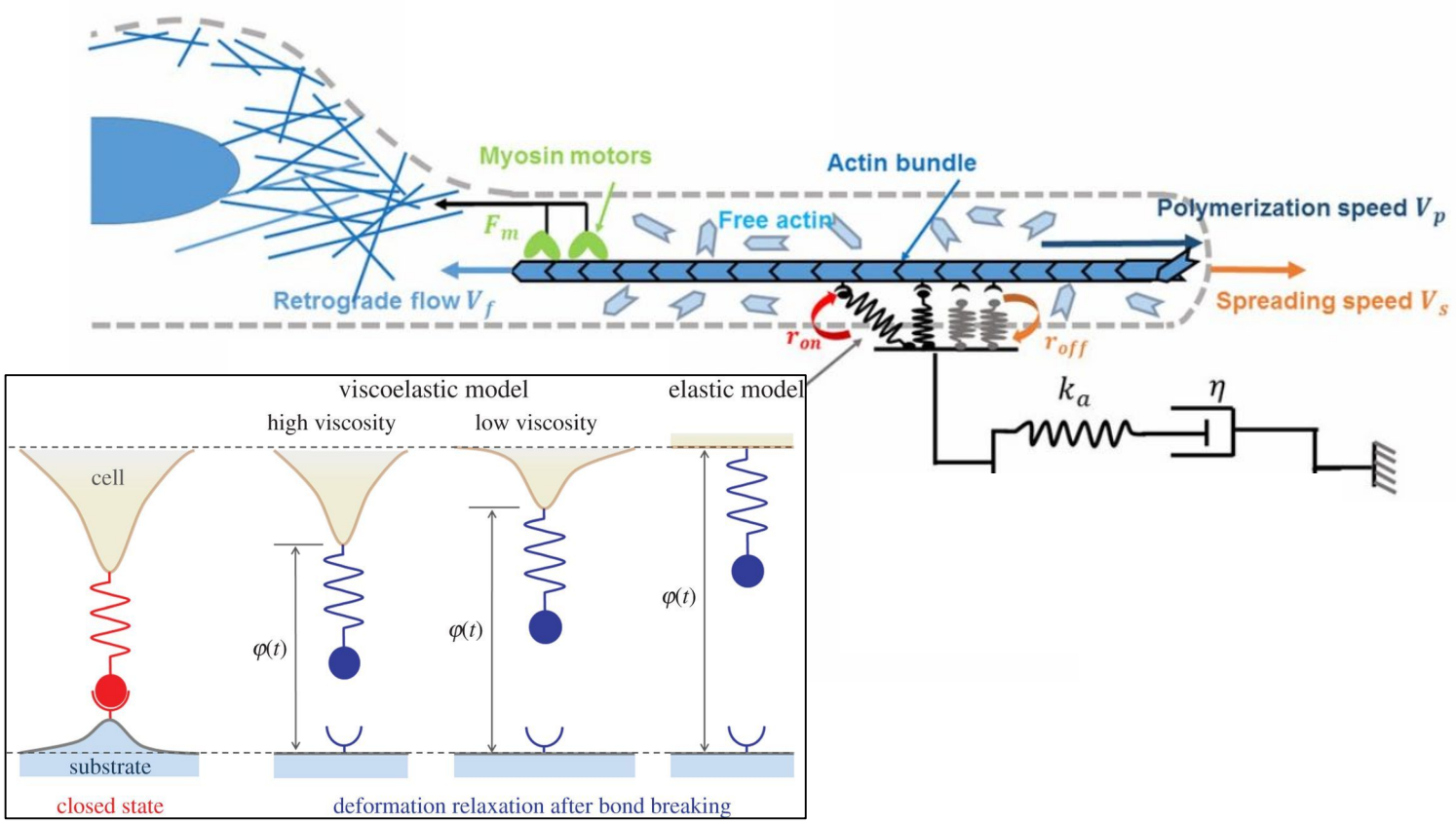
- Talin density *increases?* → ${}^{K_{fold}}/_{K_{unfold}}$?
- Matrix density *increases?* → $K_{on} \uparrow$, K_{unfold} ?
- Integrin density *decreases?* → $K_{off} \uparrow$, K_{unfold} ?
- Substrate stiffness *decreases?* → $E_{cell} > E_{ECM}$

Question 2



- Stress relaxation?
- High vs Low Viscosity?
- High vs Low Stiffness?

Question 3


Myosin motors
Actin bundle
Free actin
Polymerization speed V_p
F_m
Retrograde flow V_f
Spreading speed V_s
r_{on}
r_{off}
k_a
η
viscoelastic model
elastic model
high viscosity
low viscosity
cell
substrate
$\varphi(t)$
$\varphi(t)$
$\varphi(t)$
closed state
deformation relaxation after bond breaking