Gijsje Koenderink
(AMOLF Amsterdam)

Fred MacKintosh
(VU Amsterdam)

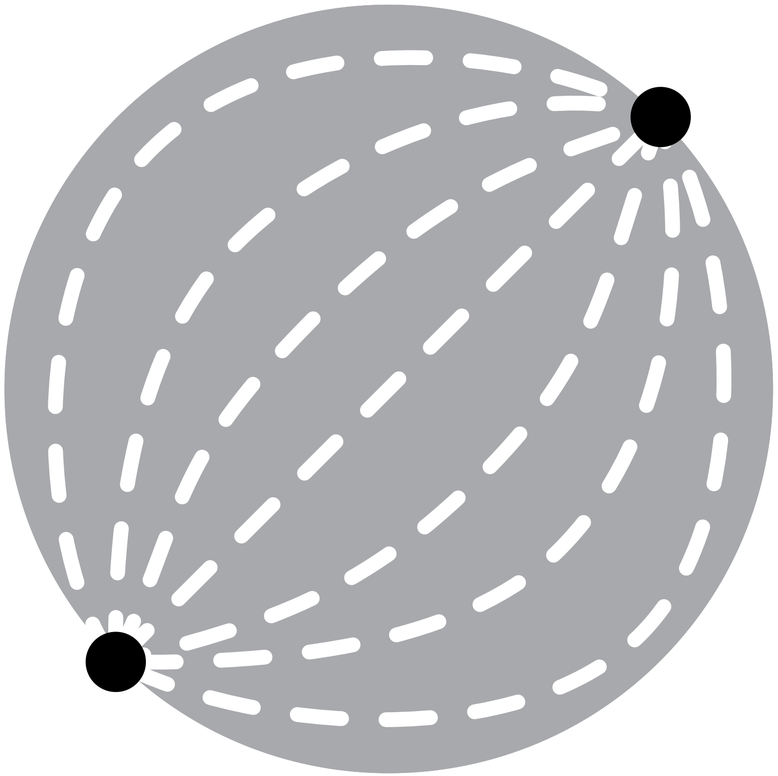
Michael Sheinman

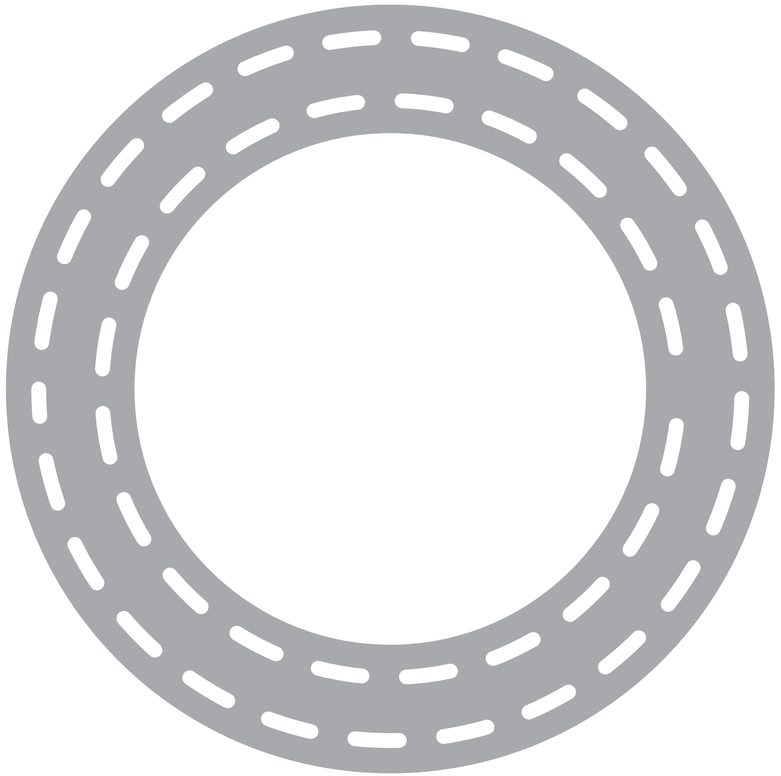
Abhinav Sharma

Critically connected state of active gels

José Alvarado

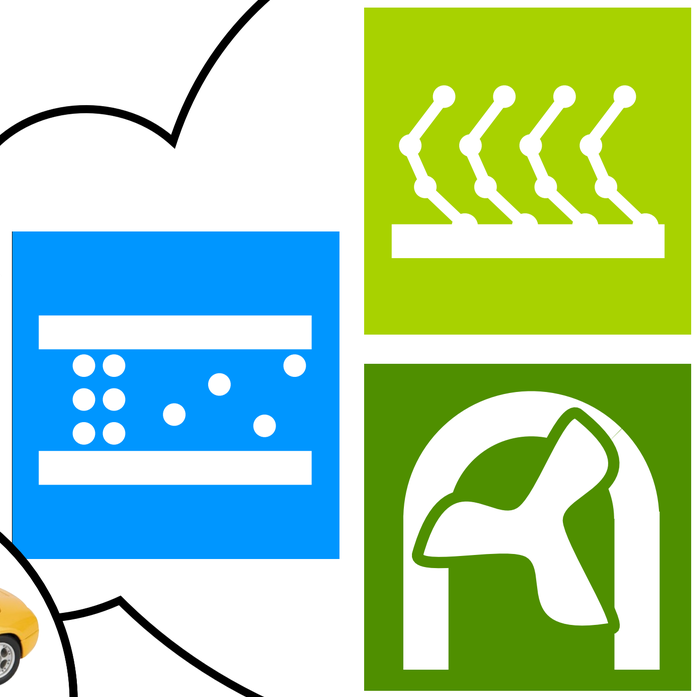
Ad #1



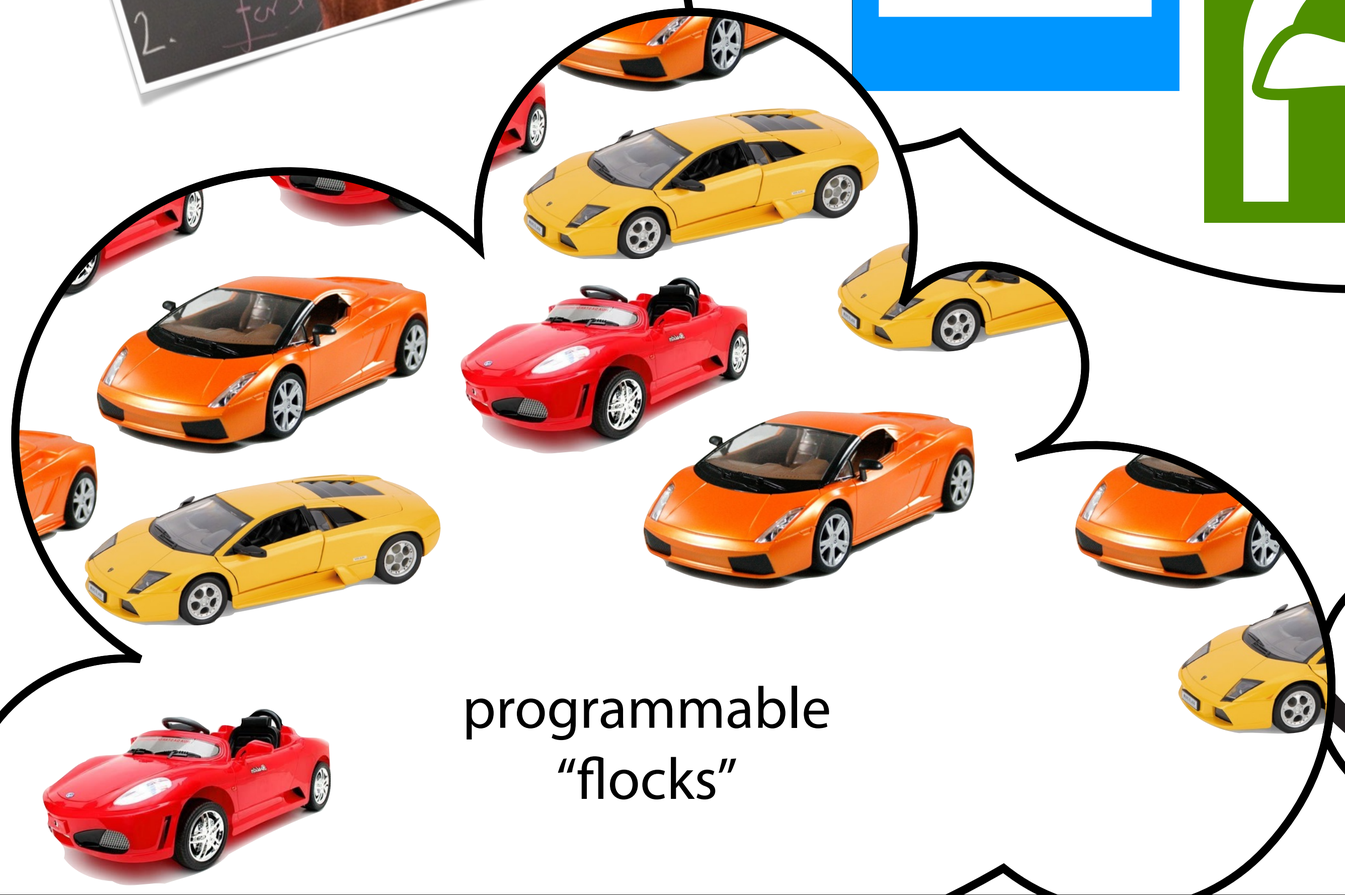


Ad #2

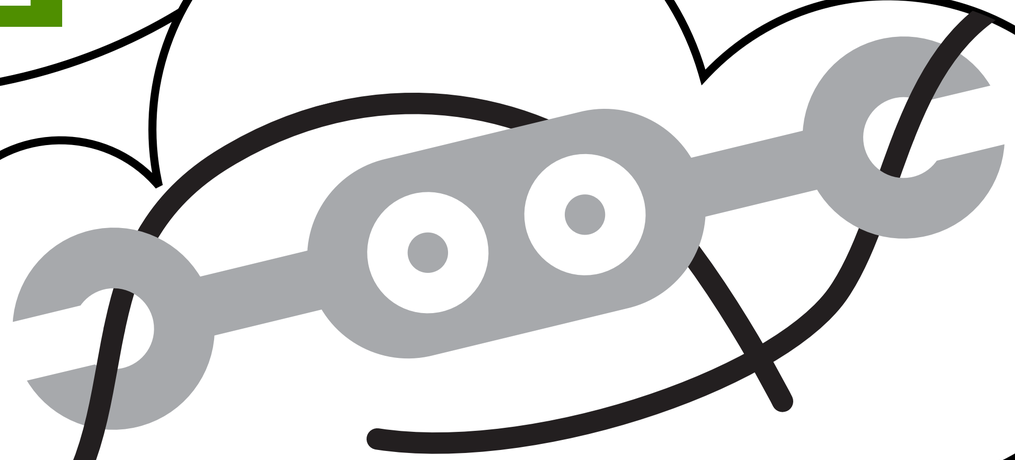
Peko Hosoi
(MIT)



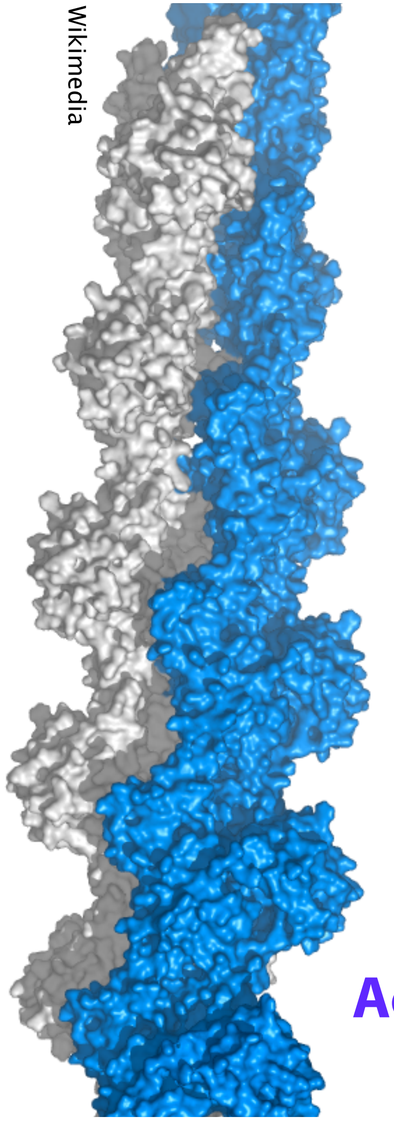
small
fluid
pumps



programmable
“flocks”



mechanical
“cytoskeleton”

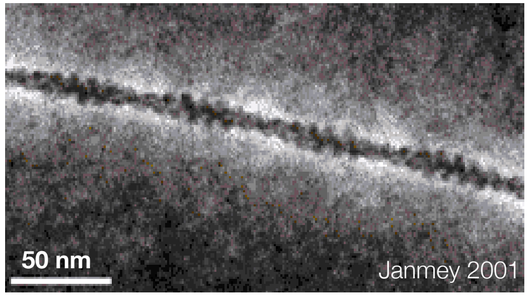


Wikimedia

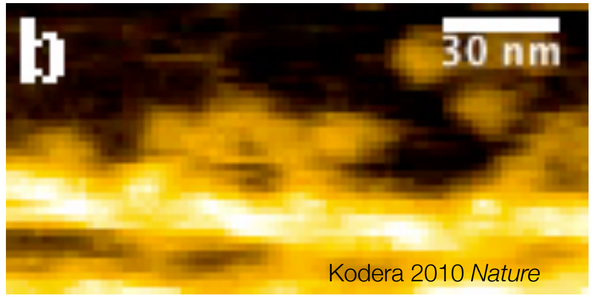
Actin

Myosin

Jessica Polka, Harvard Med

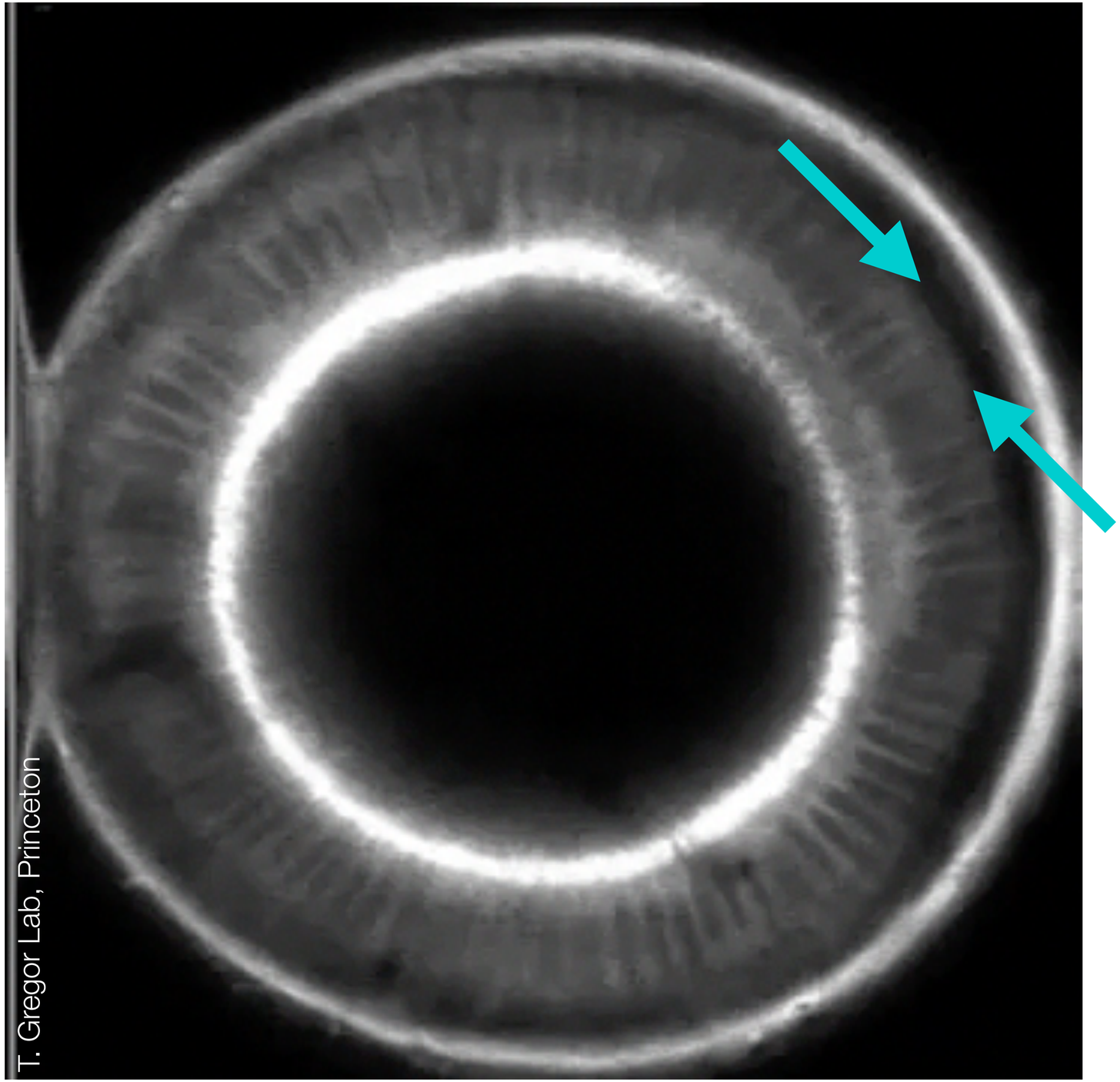


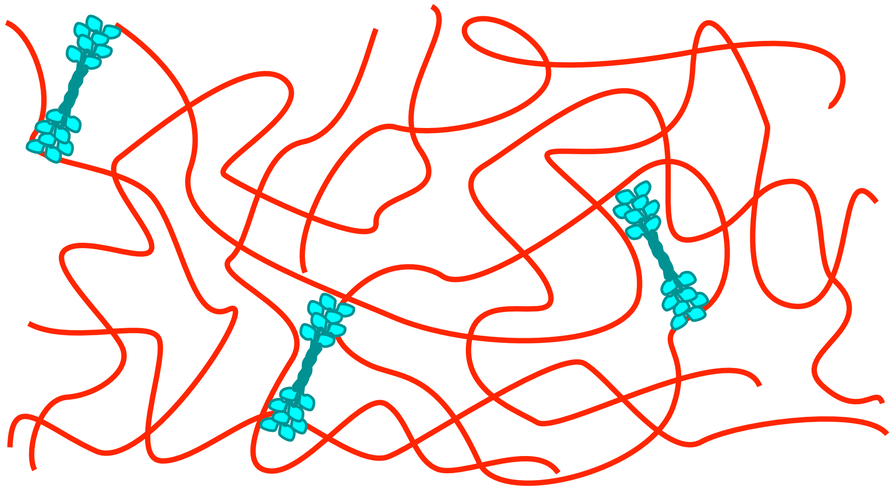
Janmey 2001



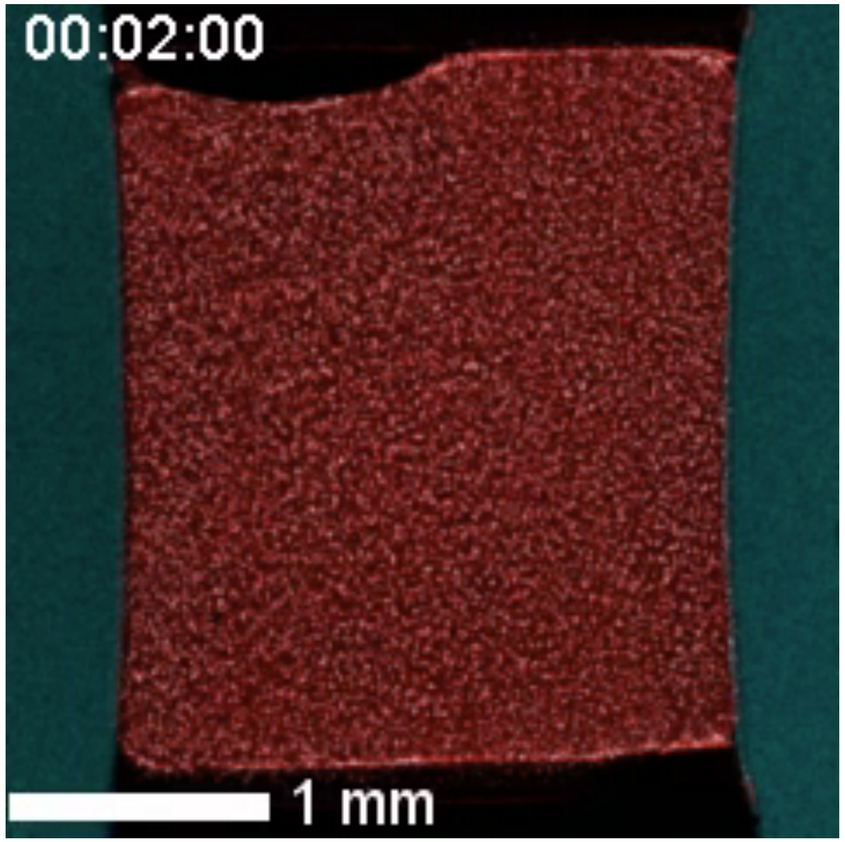
Kodera 2010 *Nature*

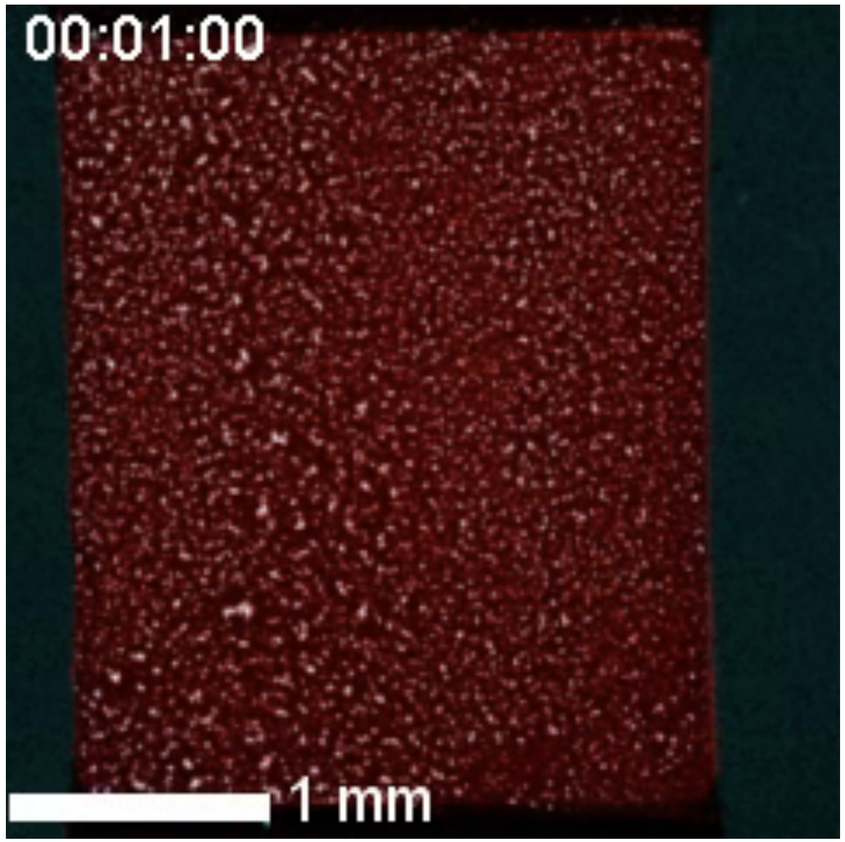
Wikimedia

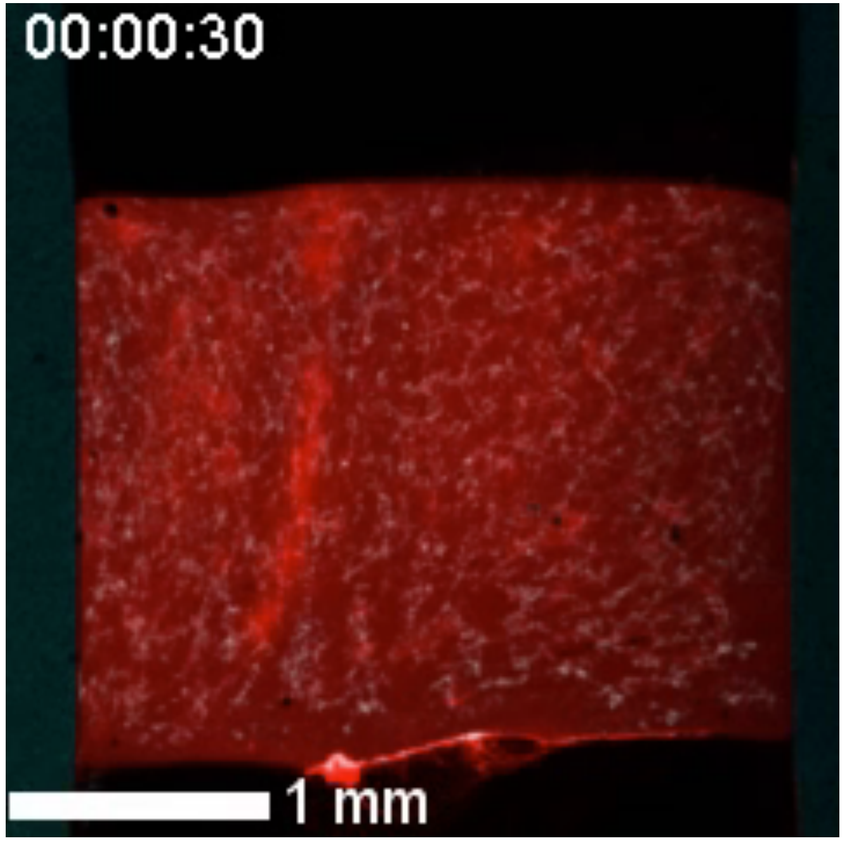


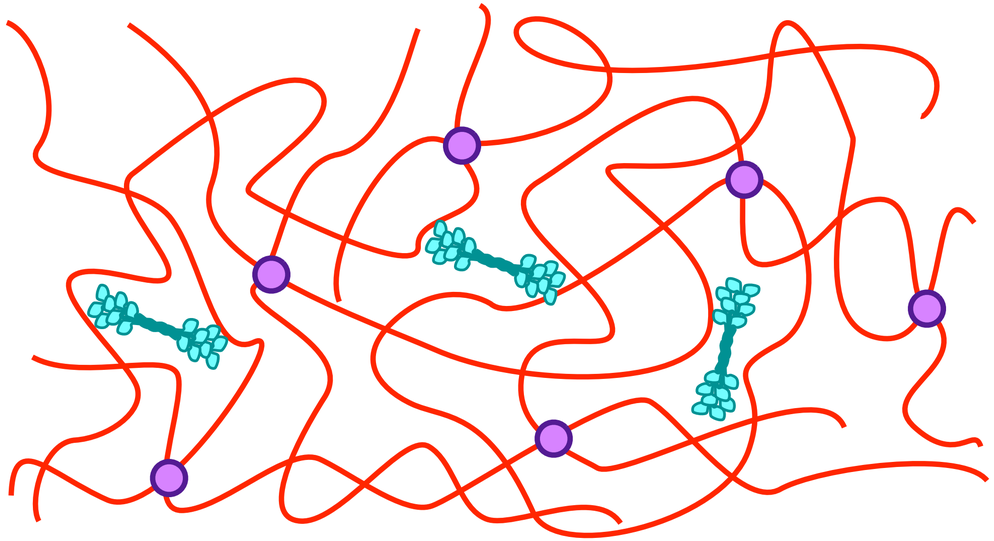


How do
myosin motors
exert contractile
stresses on
actin filaments
over long distances?

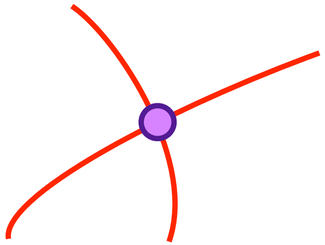


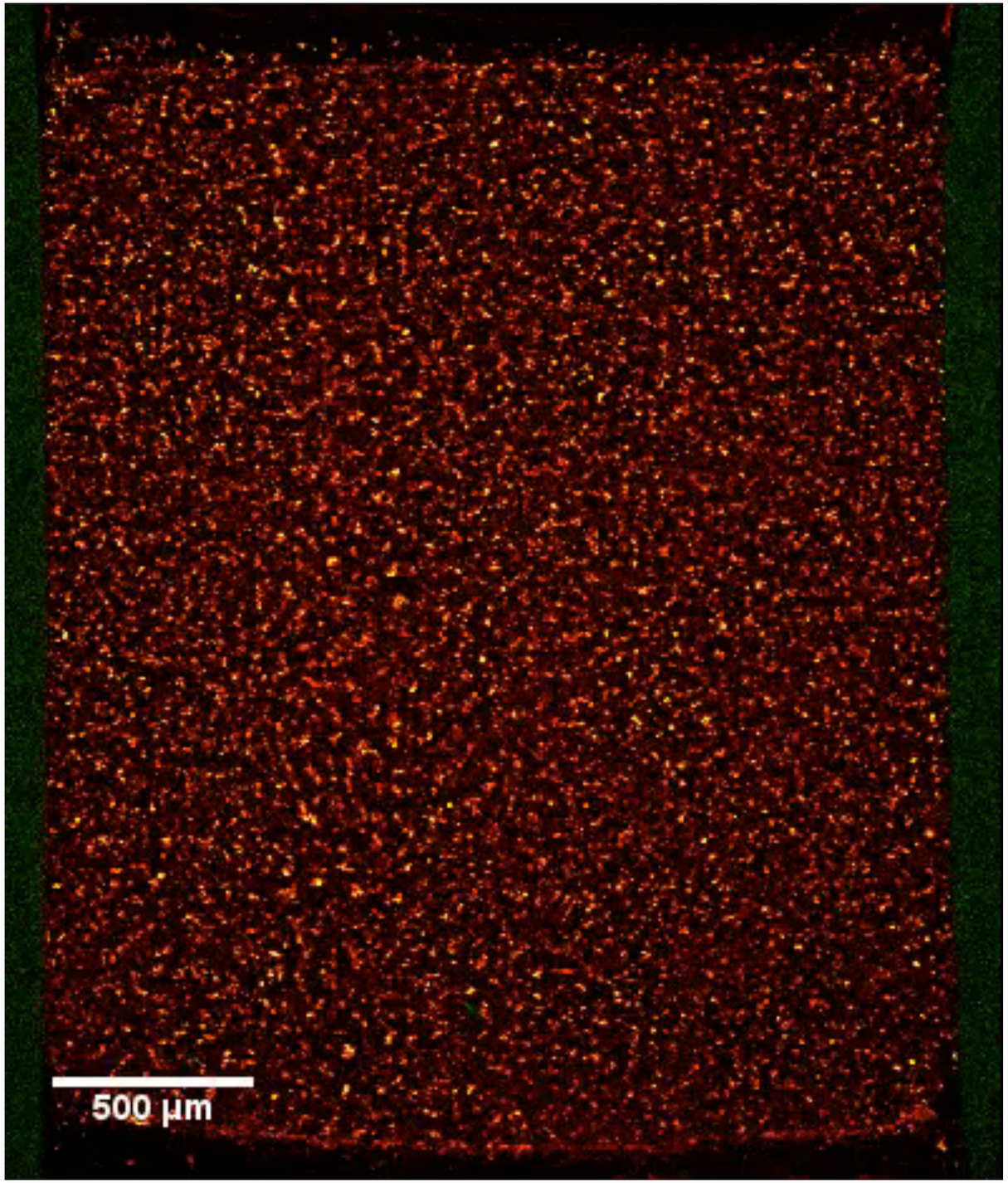


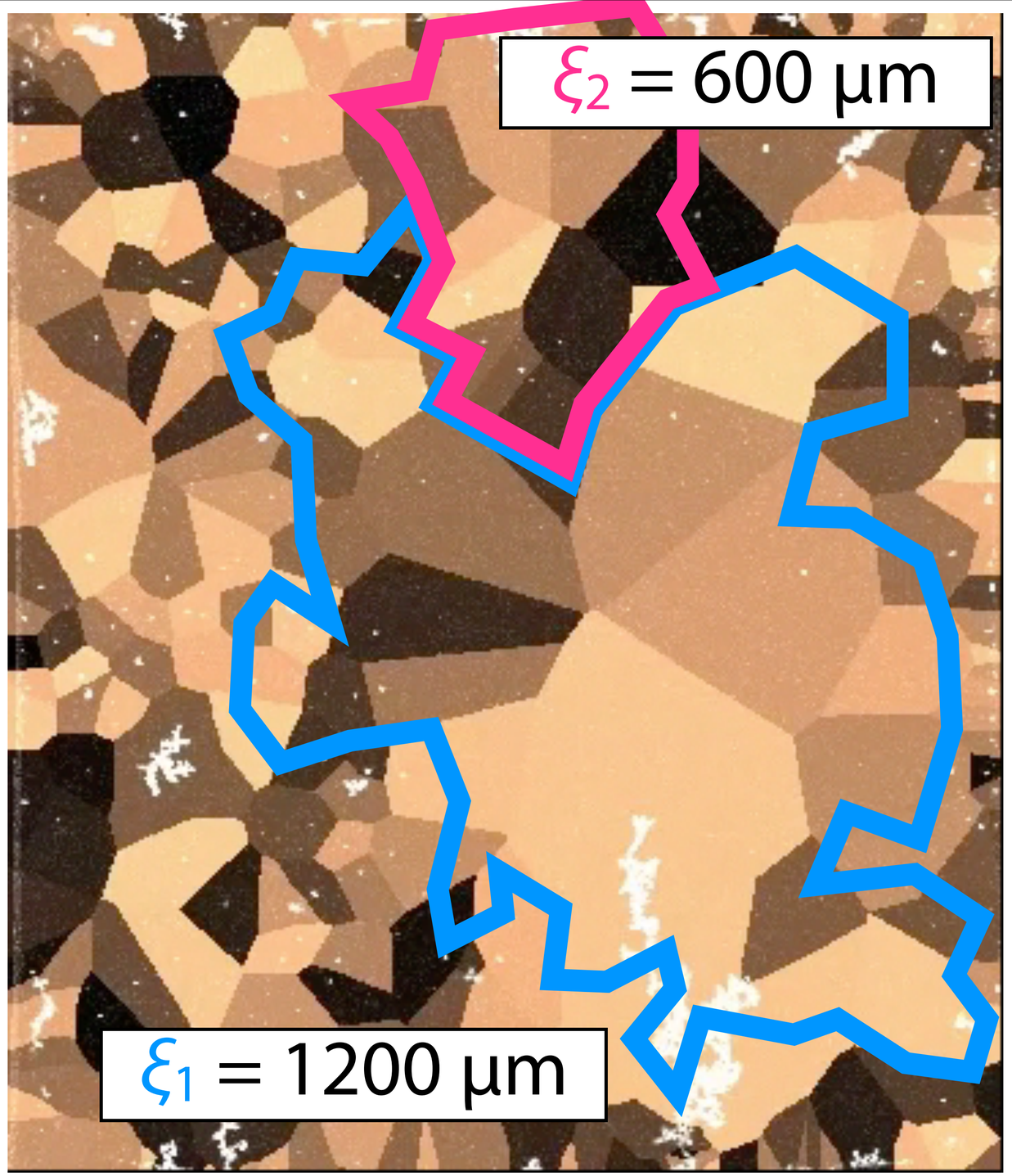


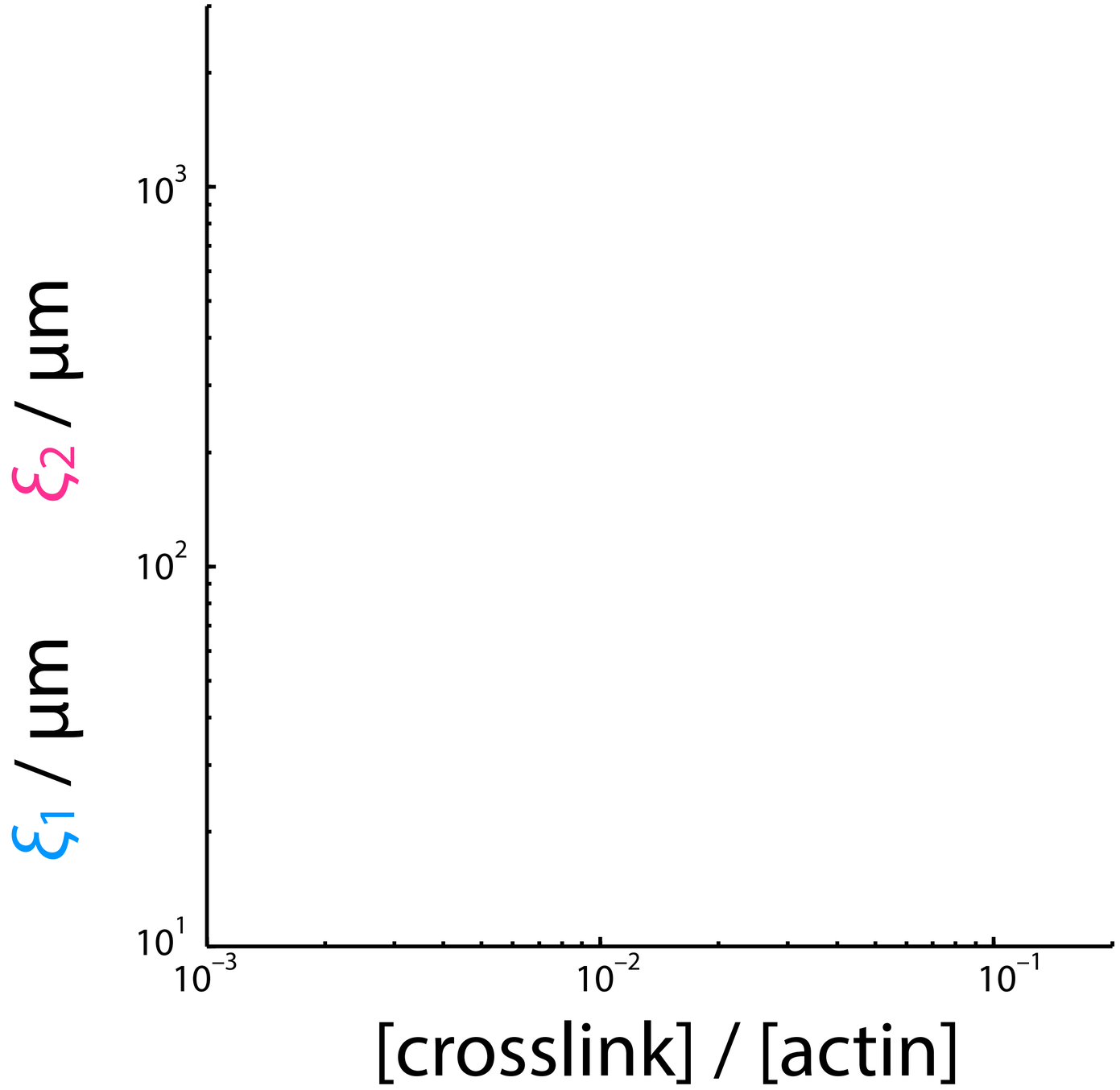


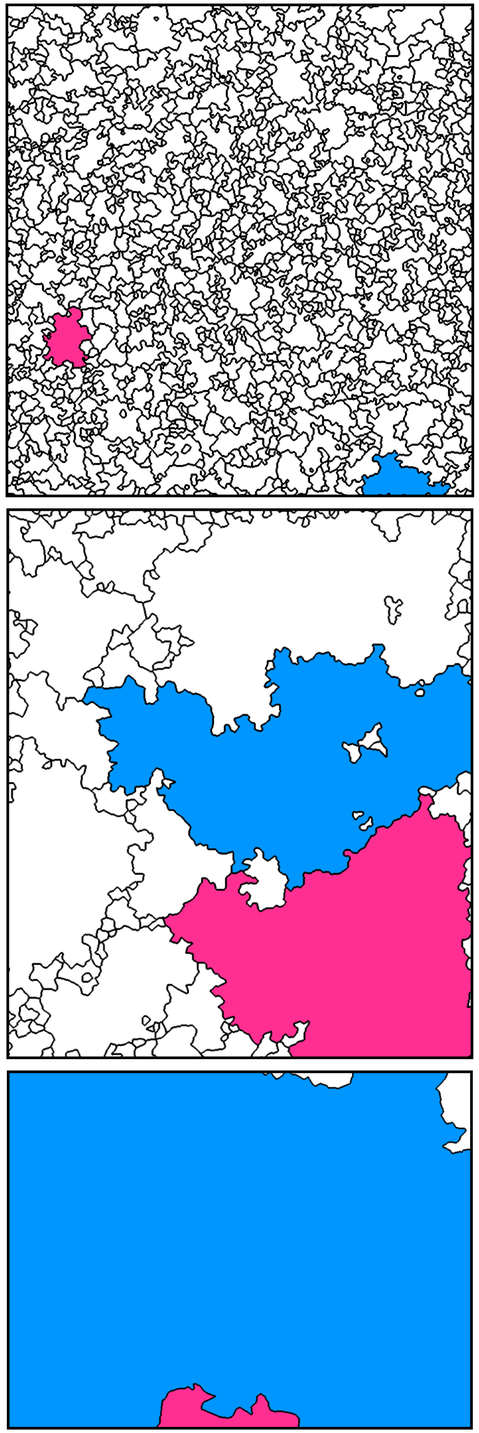
increasing **crosslink** concentration

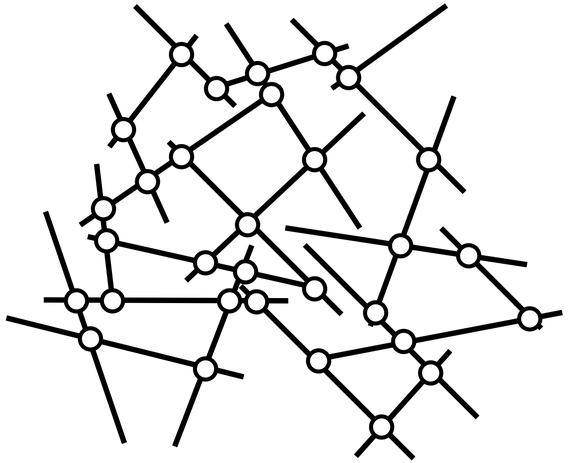



500 µm

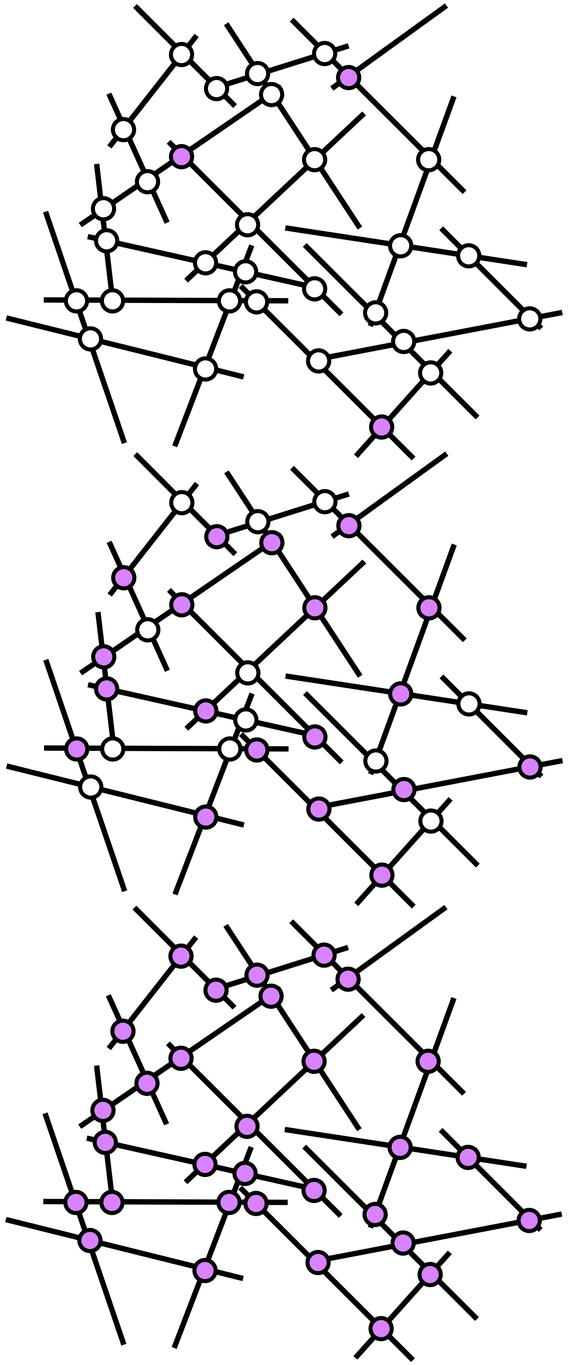

ξ_2 = 600 µm
ξ_1 = 1200 µm


ξ_1 / μm
ξ_2 / μm
10^3
10^2
10^1
10^{-3}
10^{-2}
10^{-1}
[crosslink] / [actin]





Percolation theory

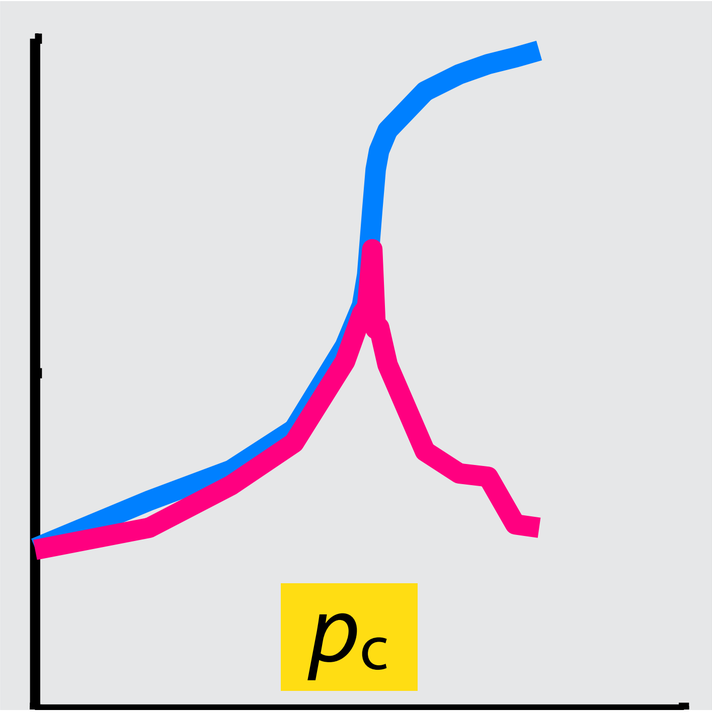


$p \rightarrow 0$

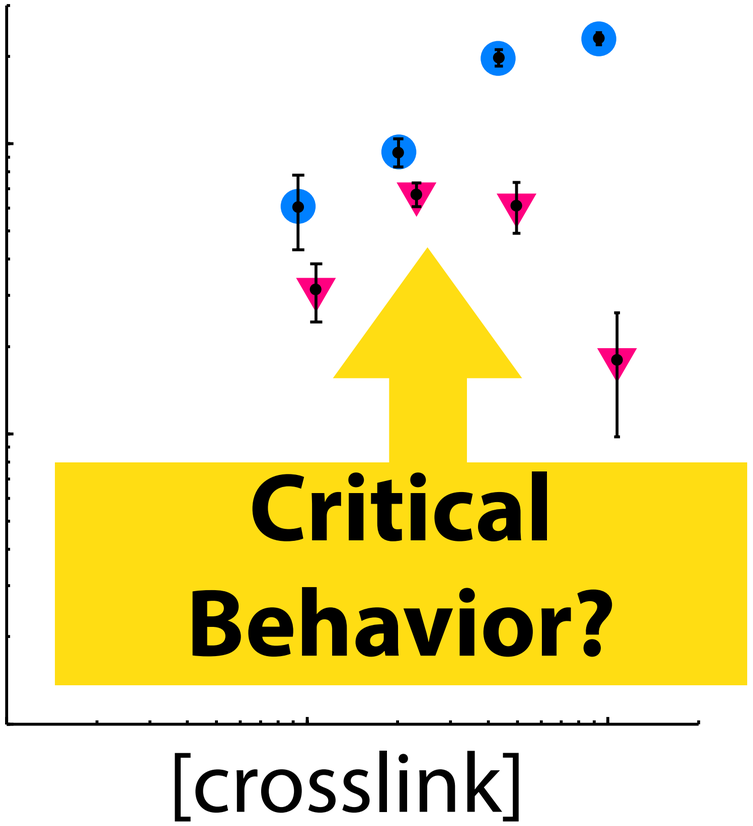
$p \rightarrow p_c$

$p \rightarrow 1$

Percolation theory



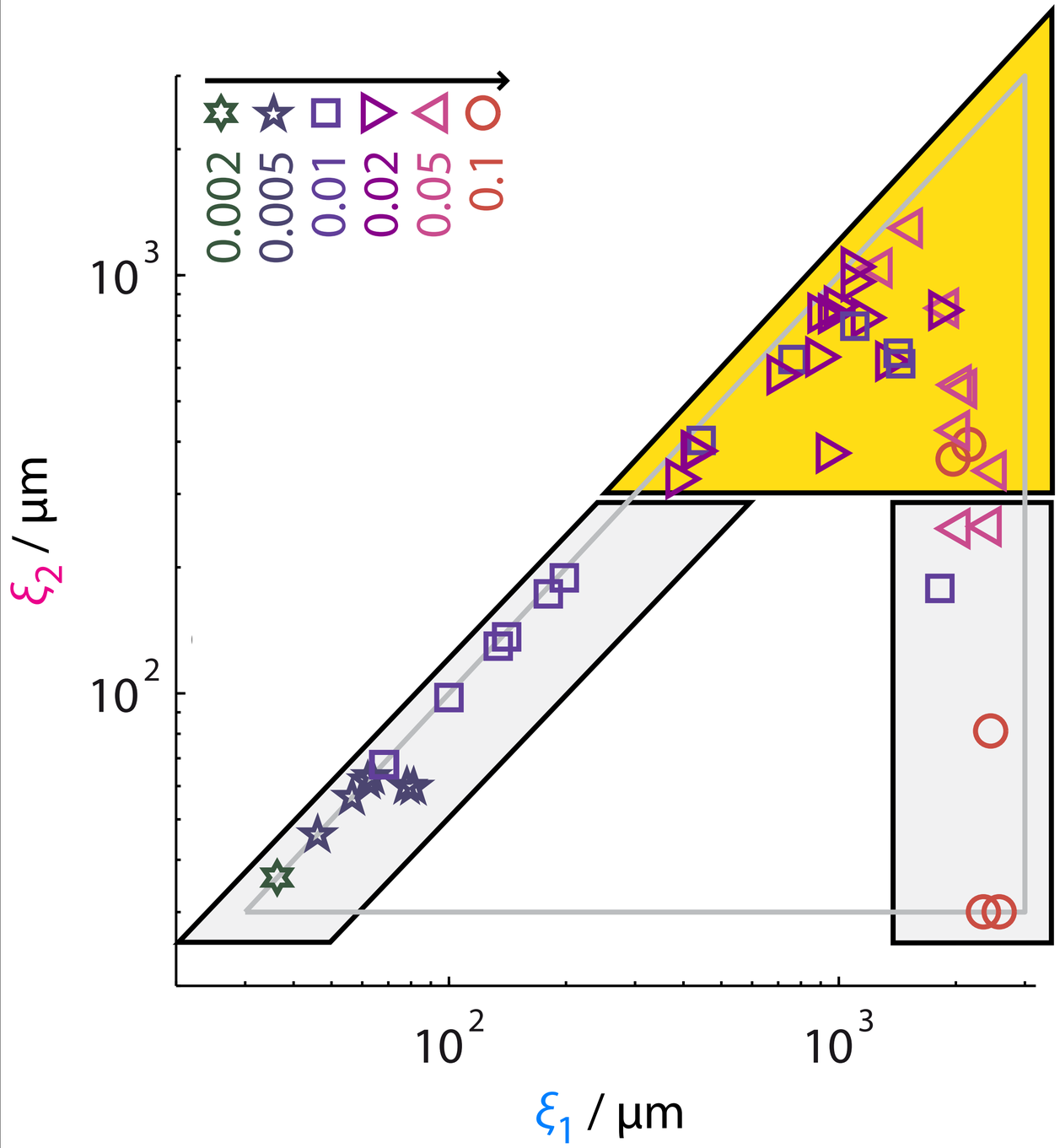
Experiment

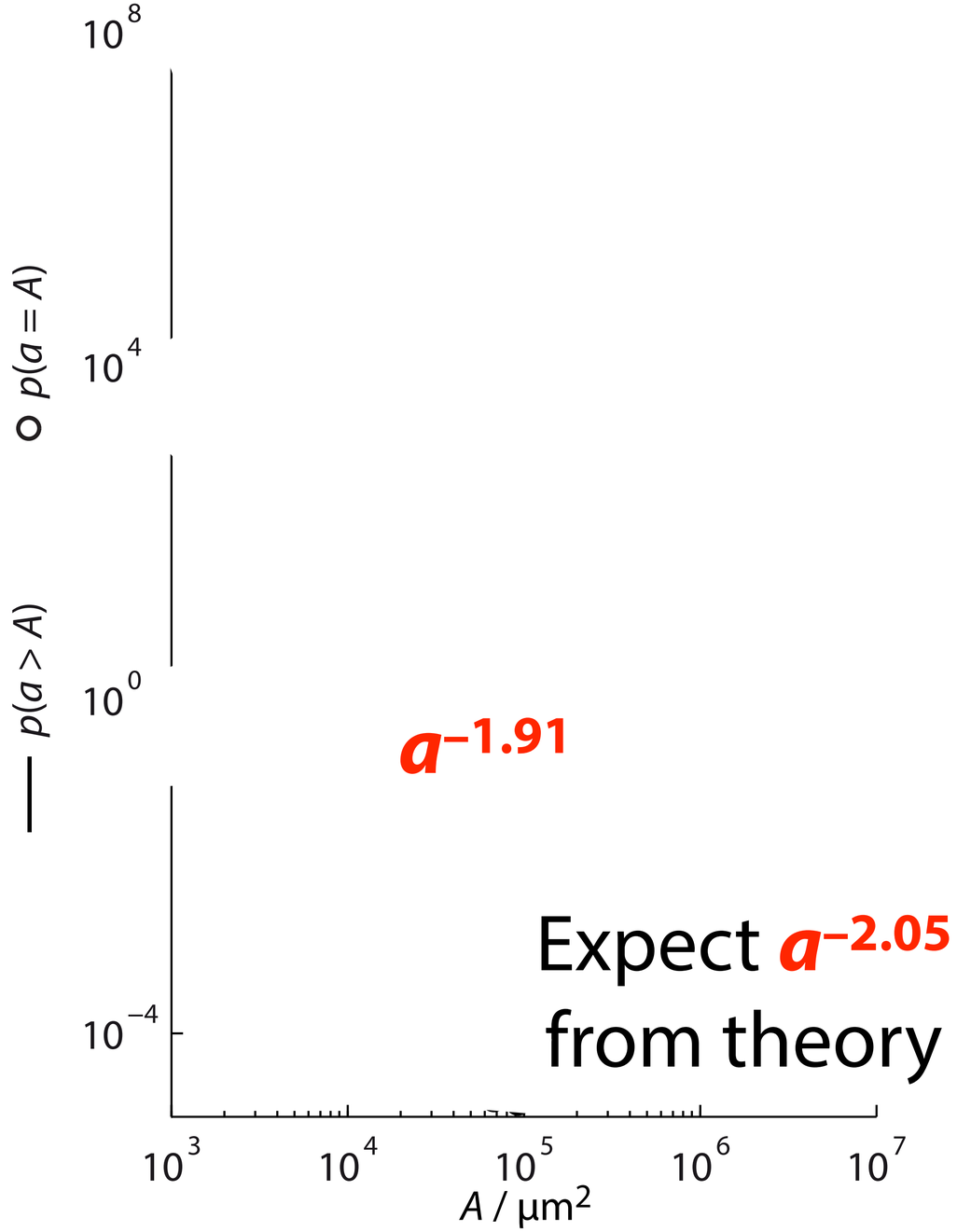


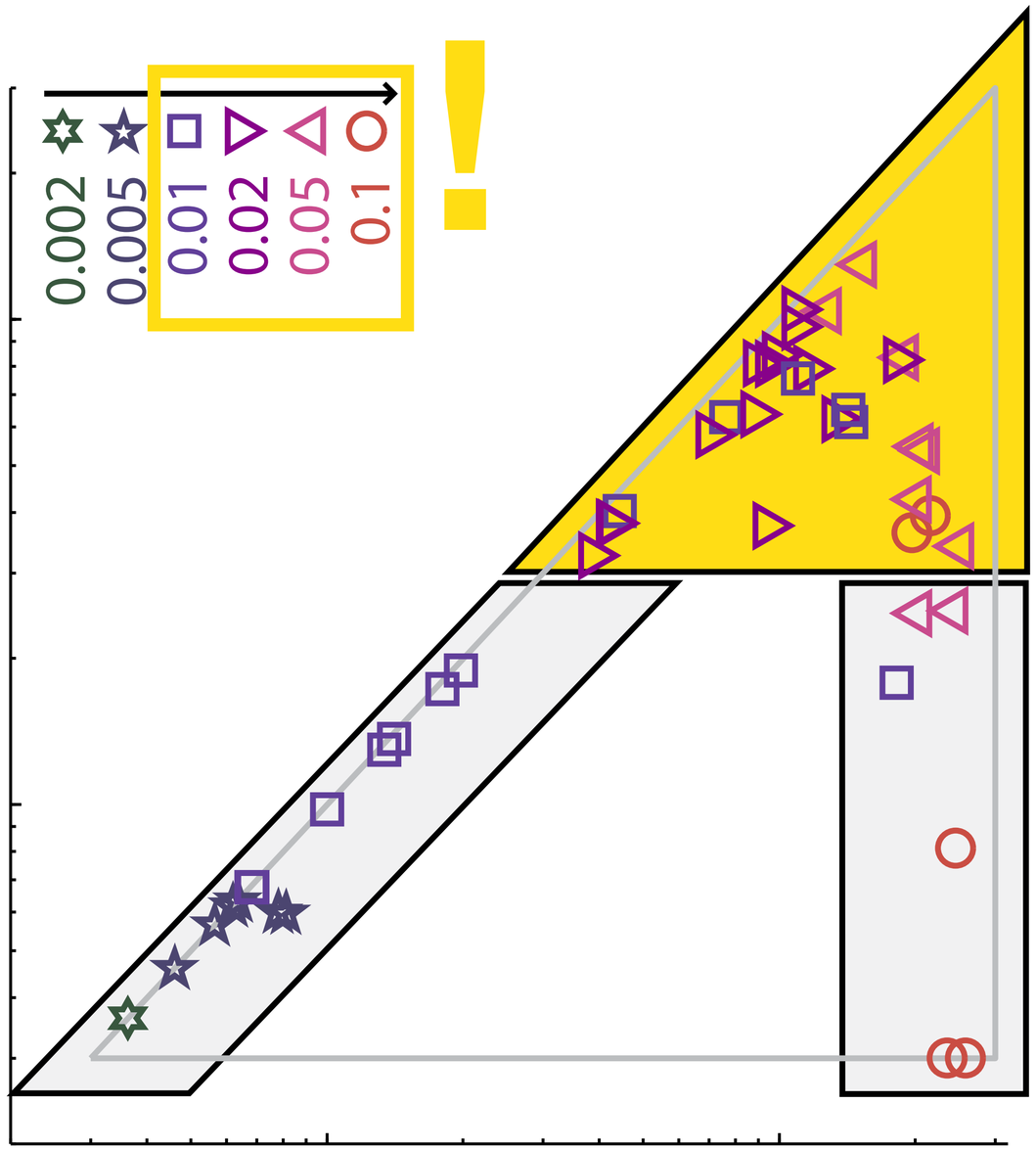
fully correlated

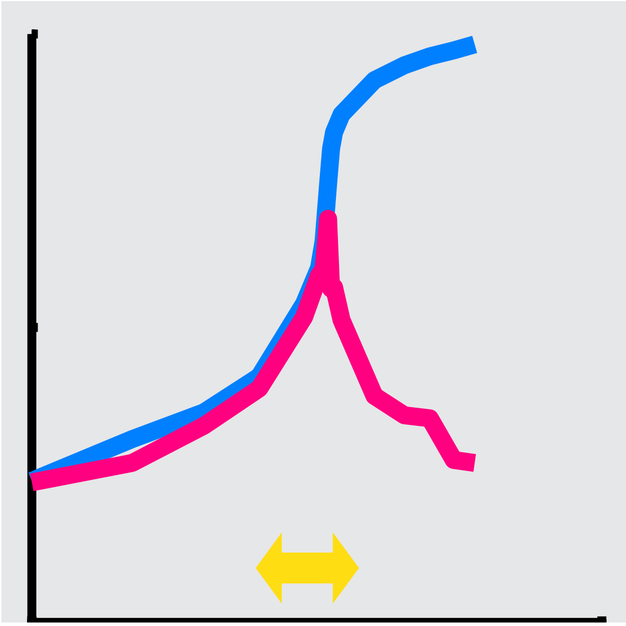
critically correlated

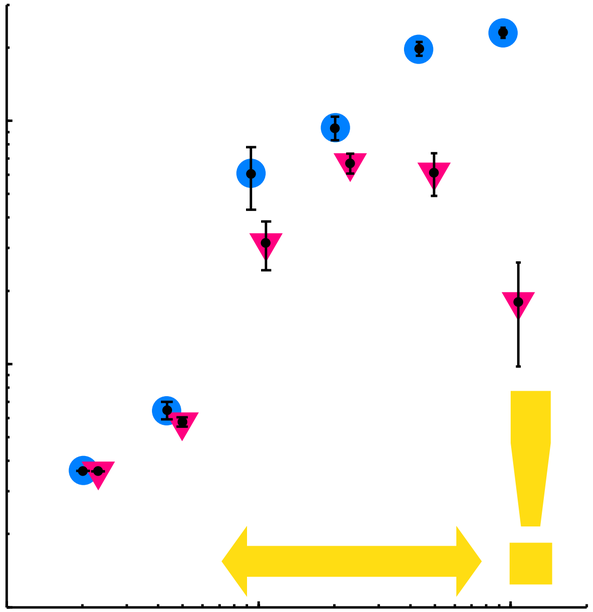
locally correlated


0.002
0.005
0.01
0.02
0.05
0.1
10^3
10^2
ξ_2 / μm
10^2
10^3
ξ_1 / μm


10^8
10^4
10^0
10^{-4}
o $p(a = A)$
— $p(a > A)$
$a^{-1.91}$
Expect $a^{-2.05}$
from theory
10^3
10^4
10^5
10^6
10^7
A / μm^2







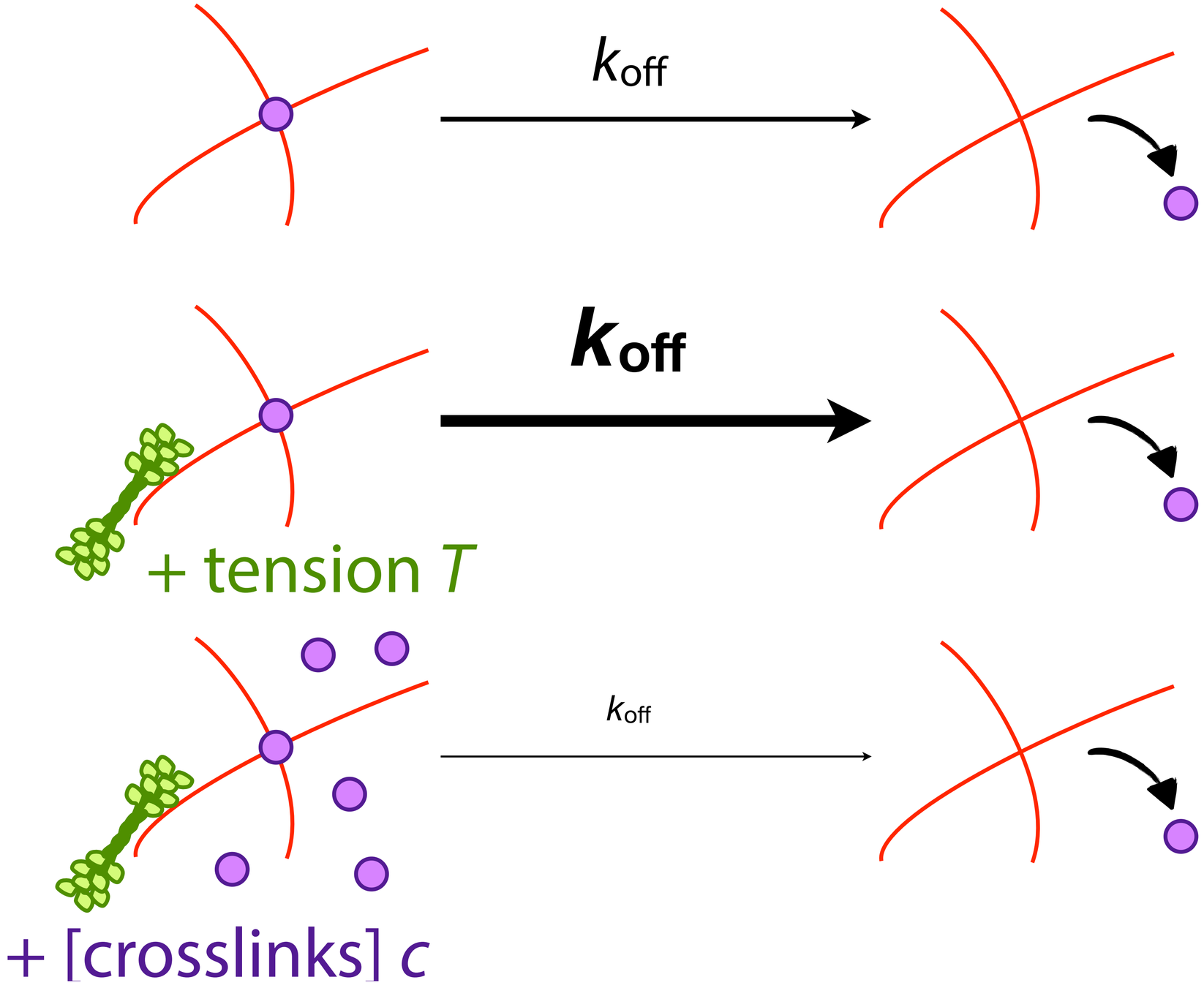
Broad

ξ_2

peak

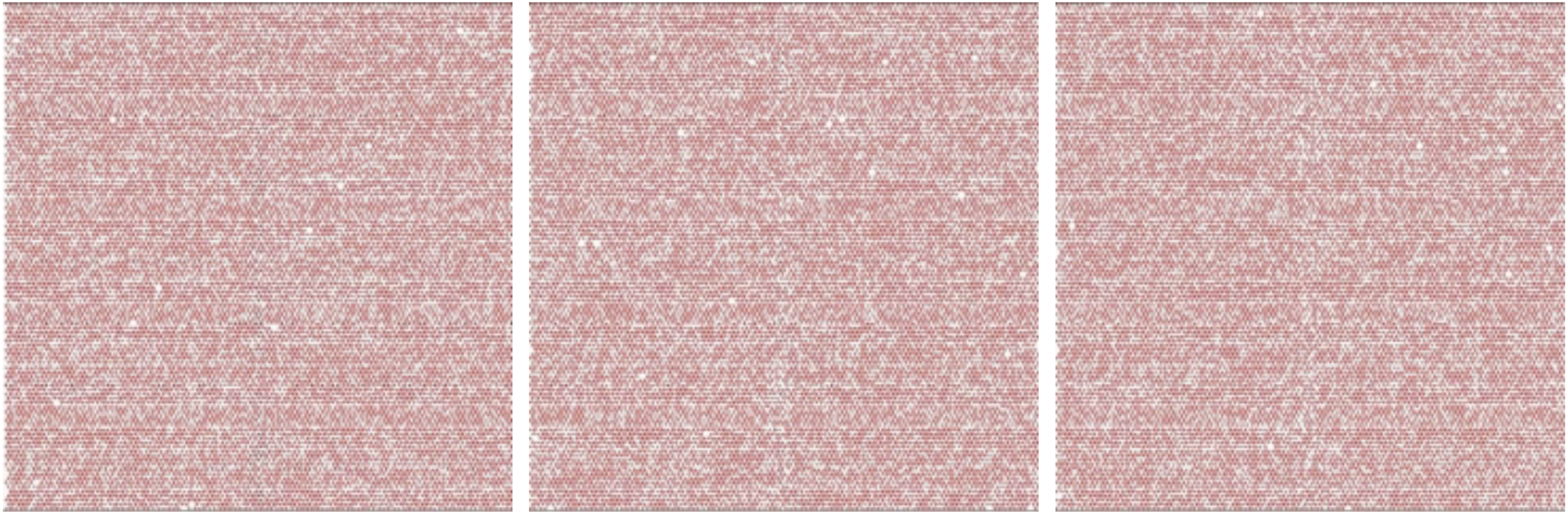
"Robust" critical behavior

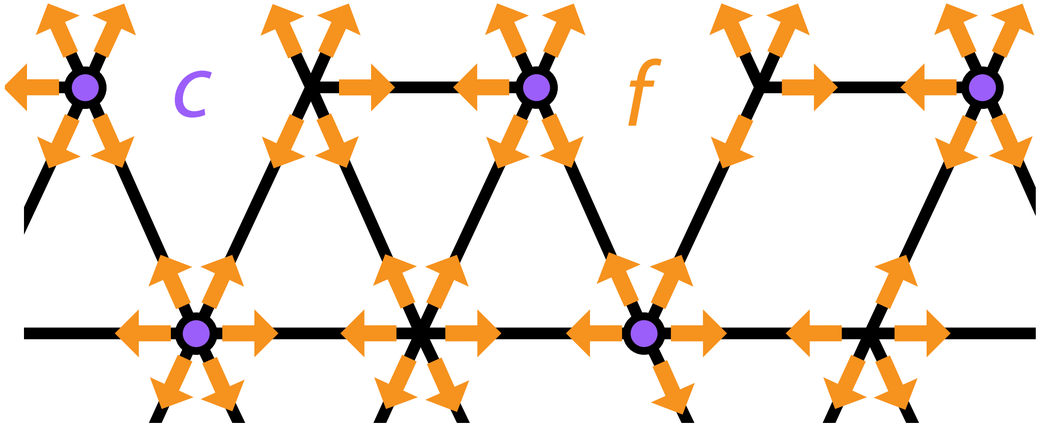
Not predicted by percolation theory



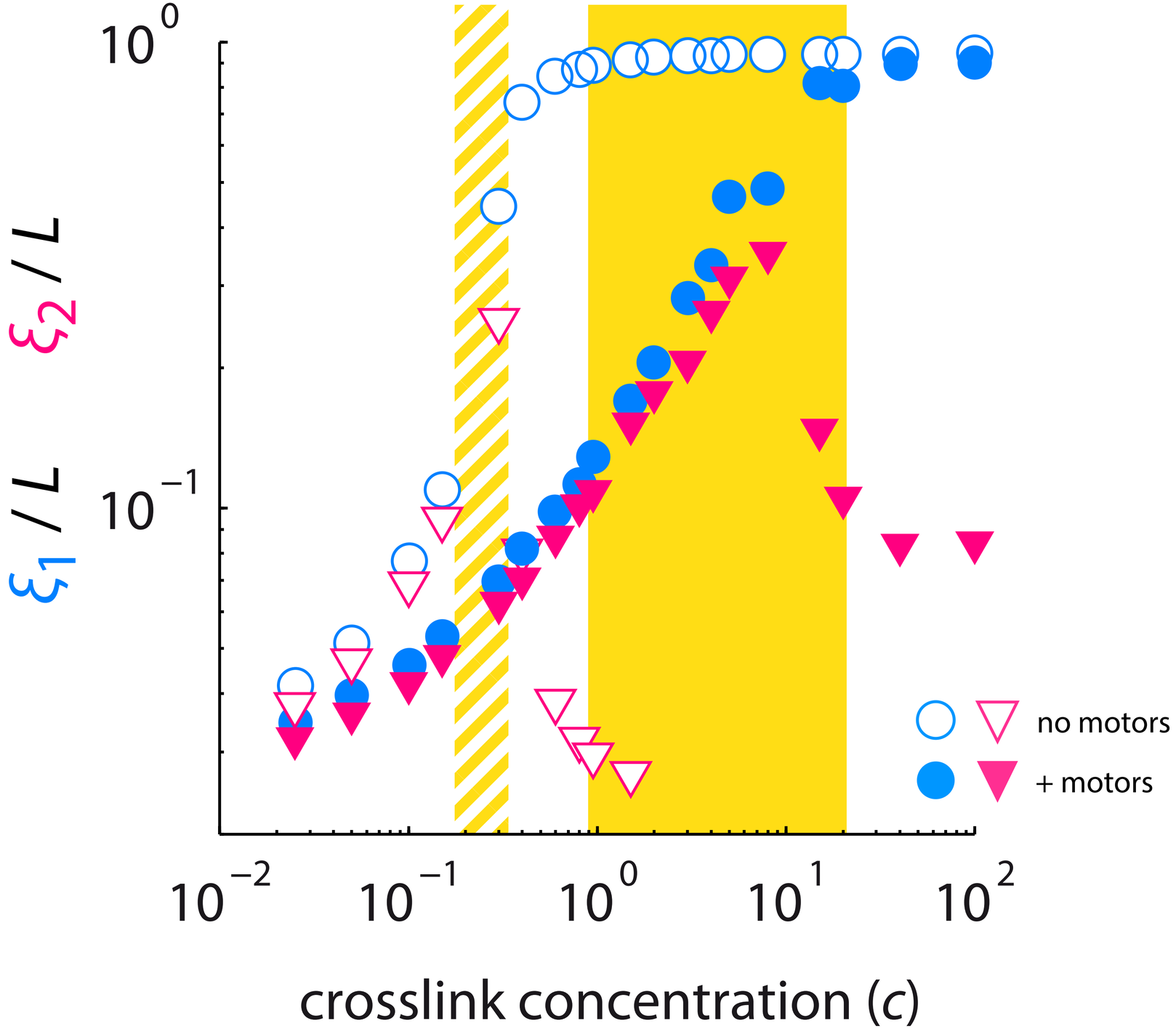
Modify percolation theory

$$k_{\text{off}} \sim \exp\left(\frac{T}{T_0}\right) \exp\left(-\frac{c}{c_0}\right)$$

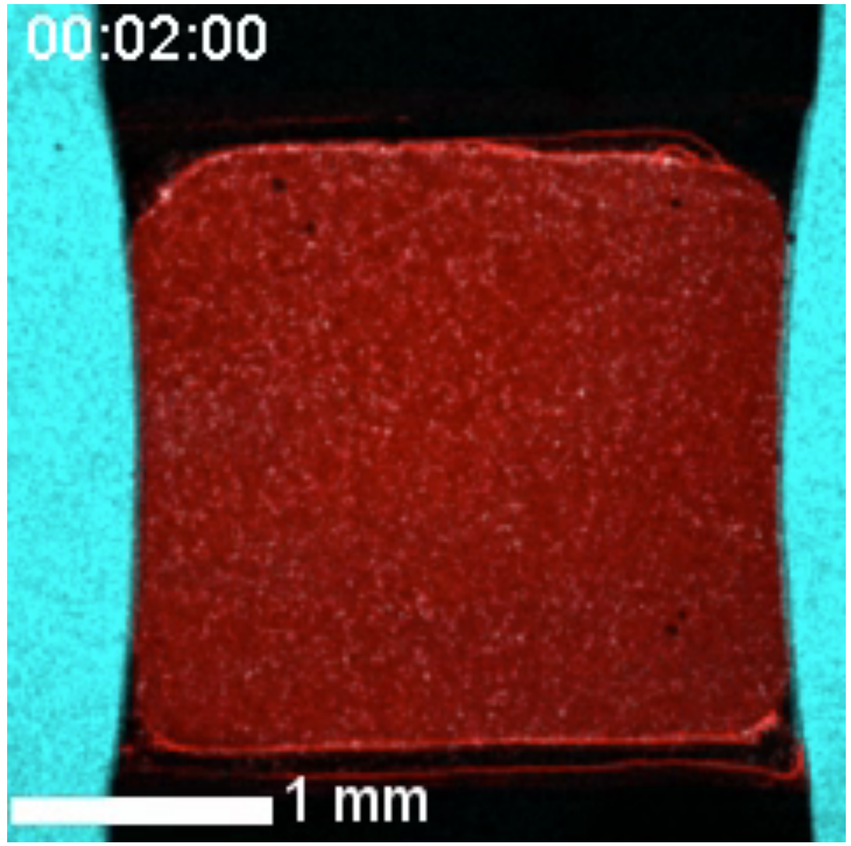


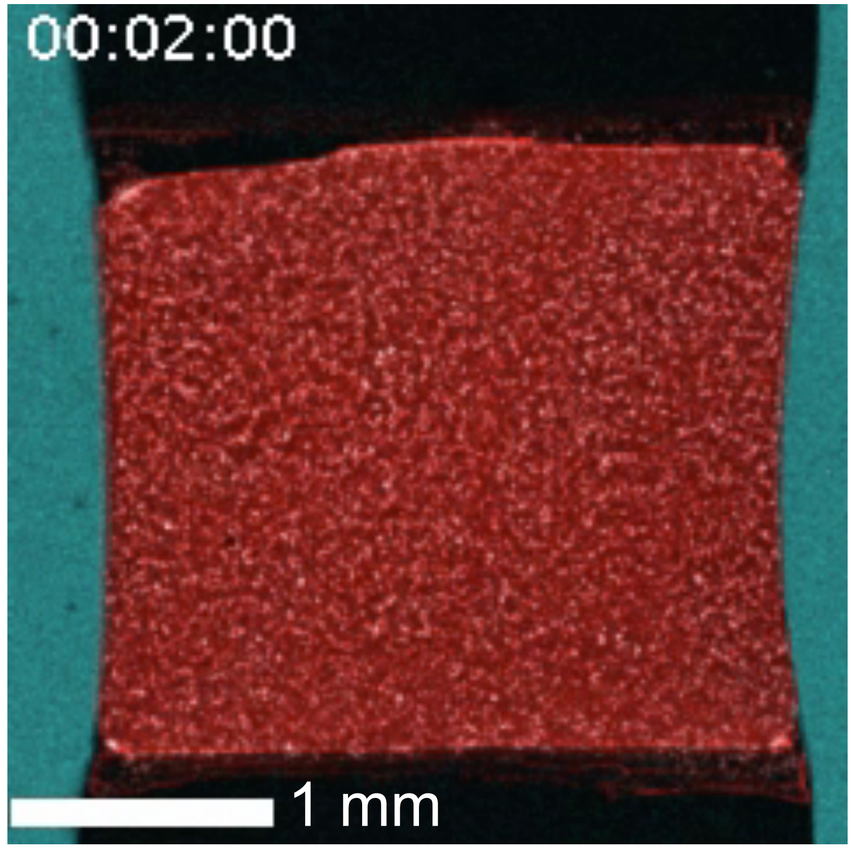


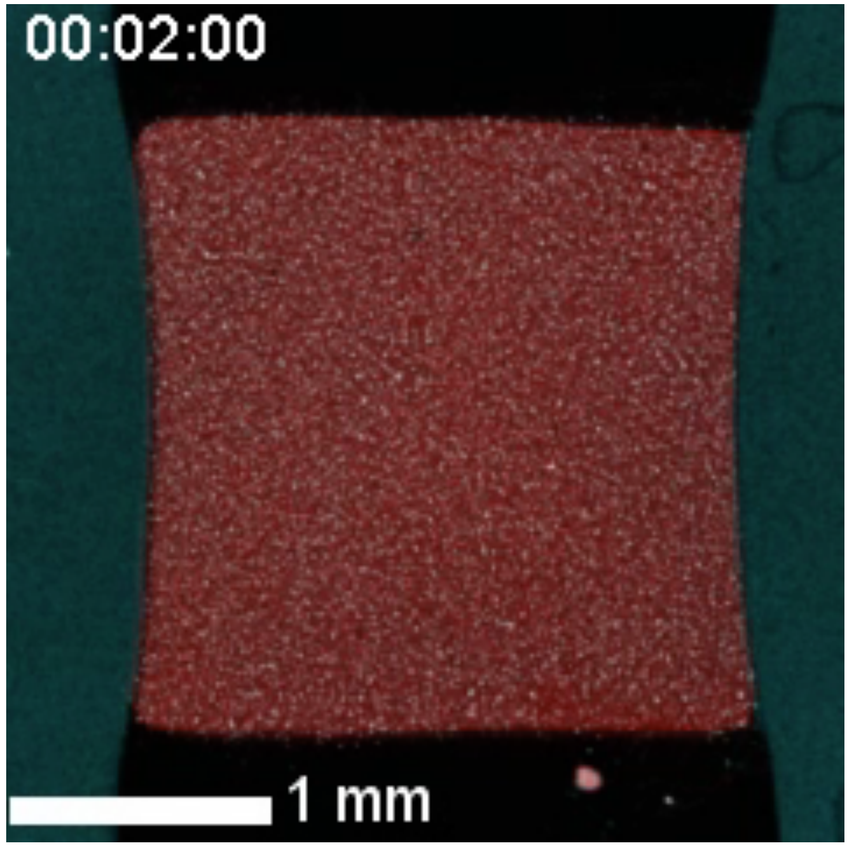
increasing *c*



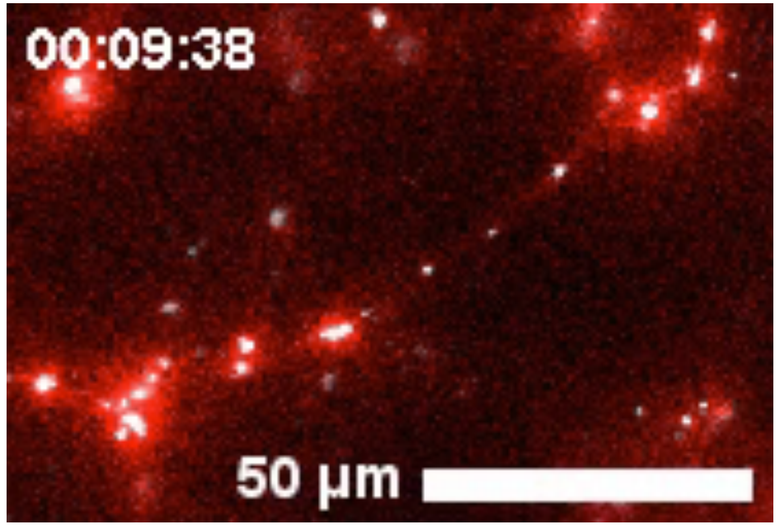
Motor activity broadens critical zone





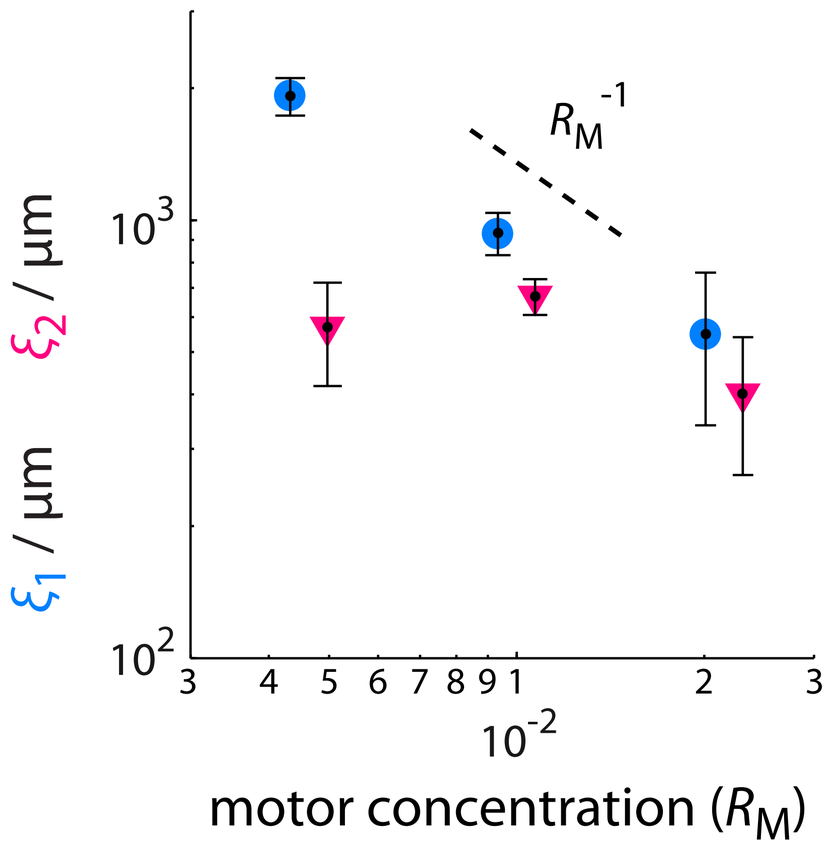


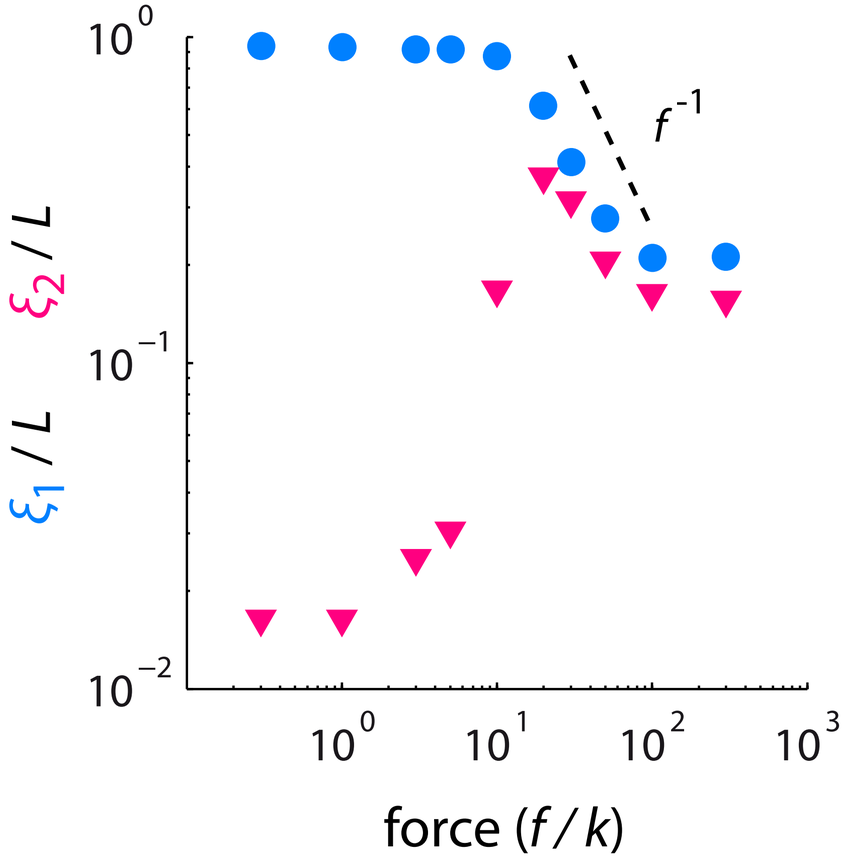
increasing **myosin** concentration



More force: more ruptures

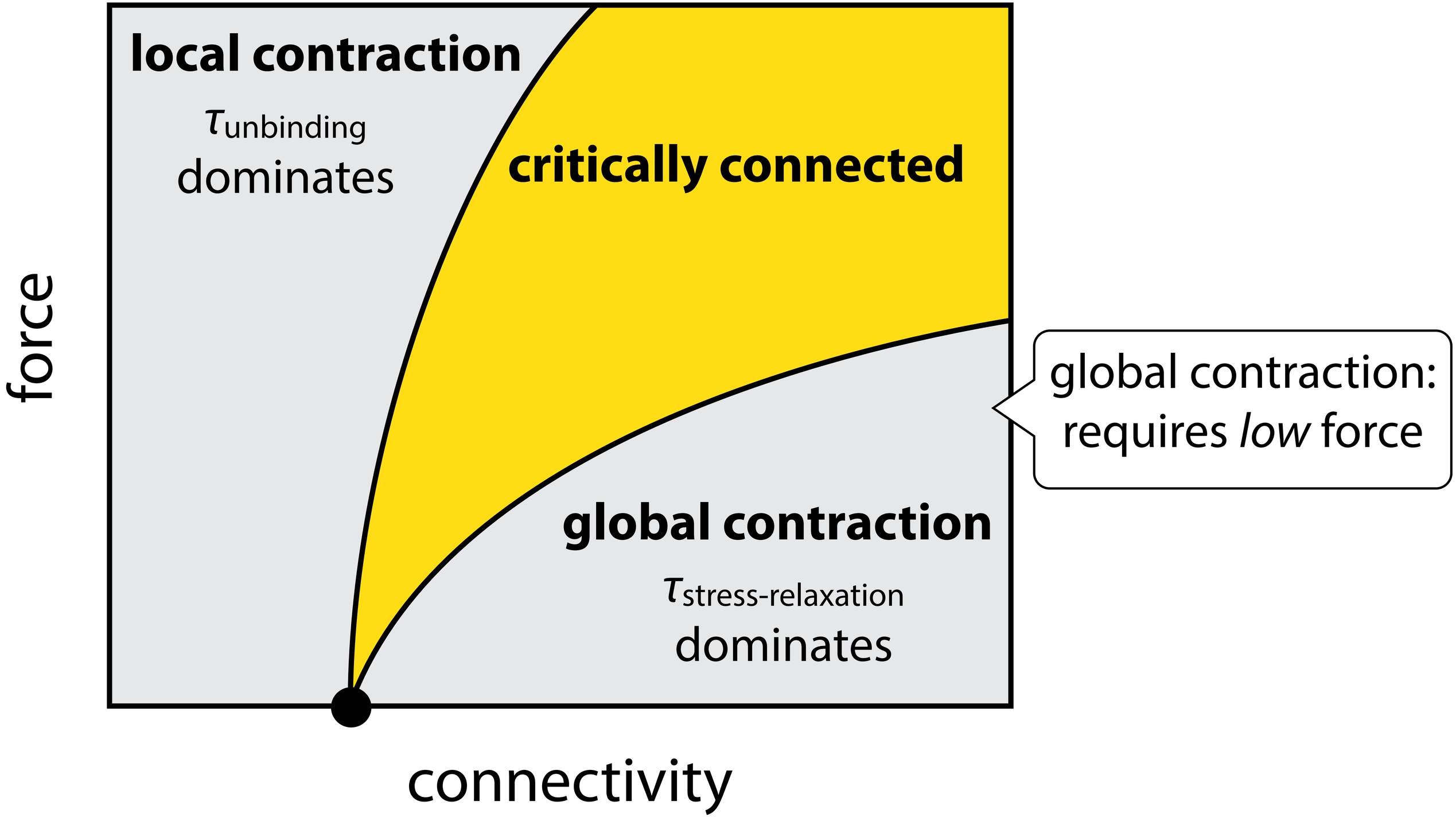
More force: smaller clusters

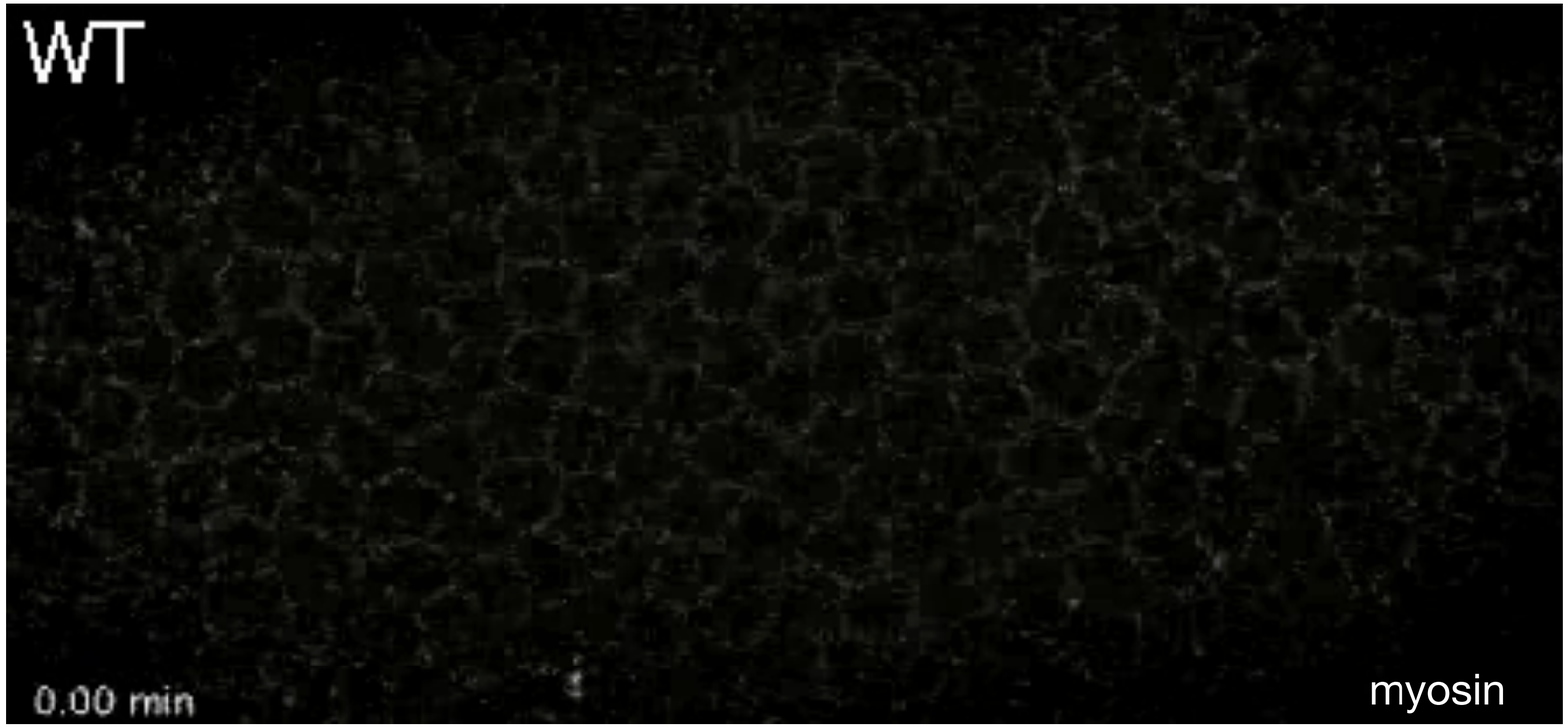




Experiment

Simulation

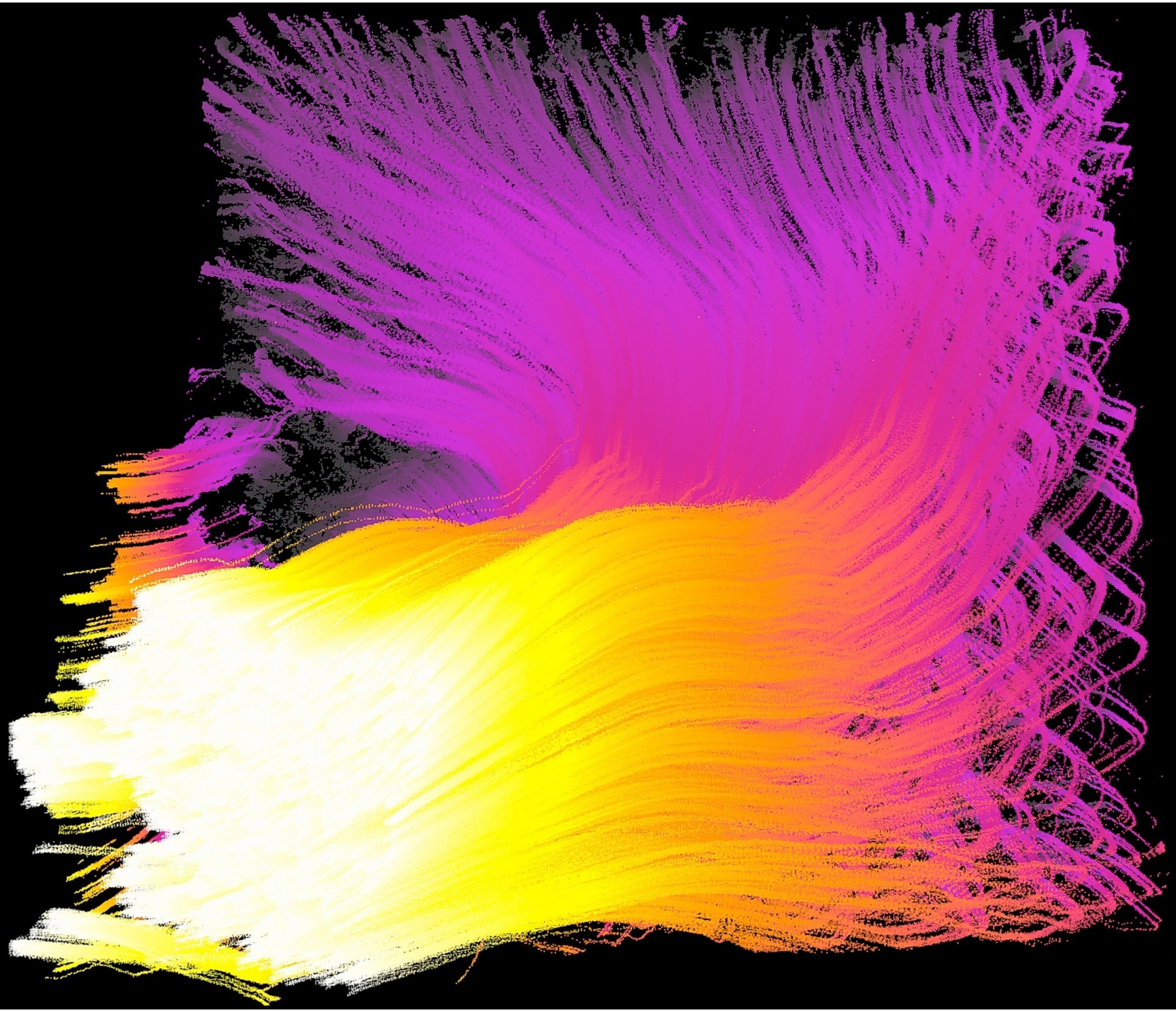

local contraction
$\tau_{\text{unbinding}}$
dominates
critically connected
global contraction
$\tau_{\text{stress-relaxation}}$
dominates
force
connectivity
global contraction:
requires *low* force



Does our framework apply to tissues?

healthy embryo

mutant with **reduced connectivity** between cells



Thanks