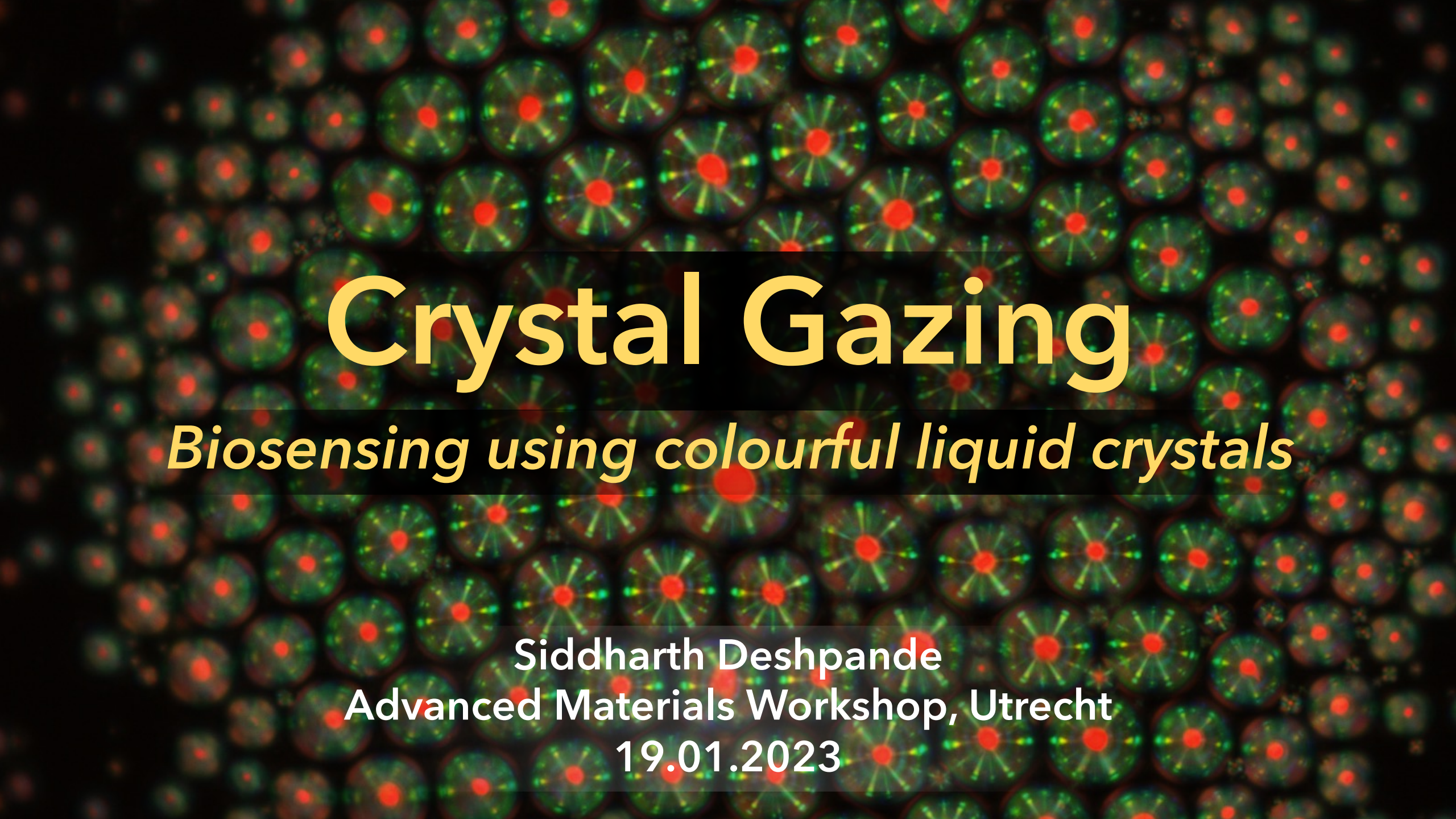


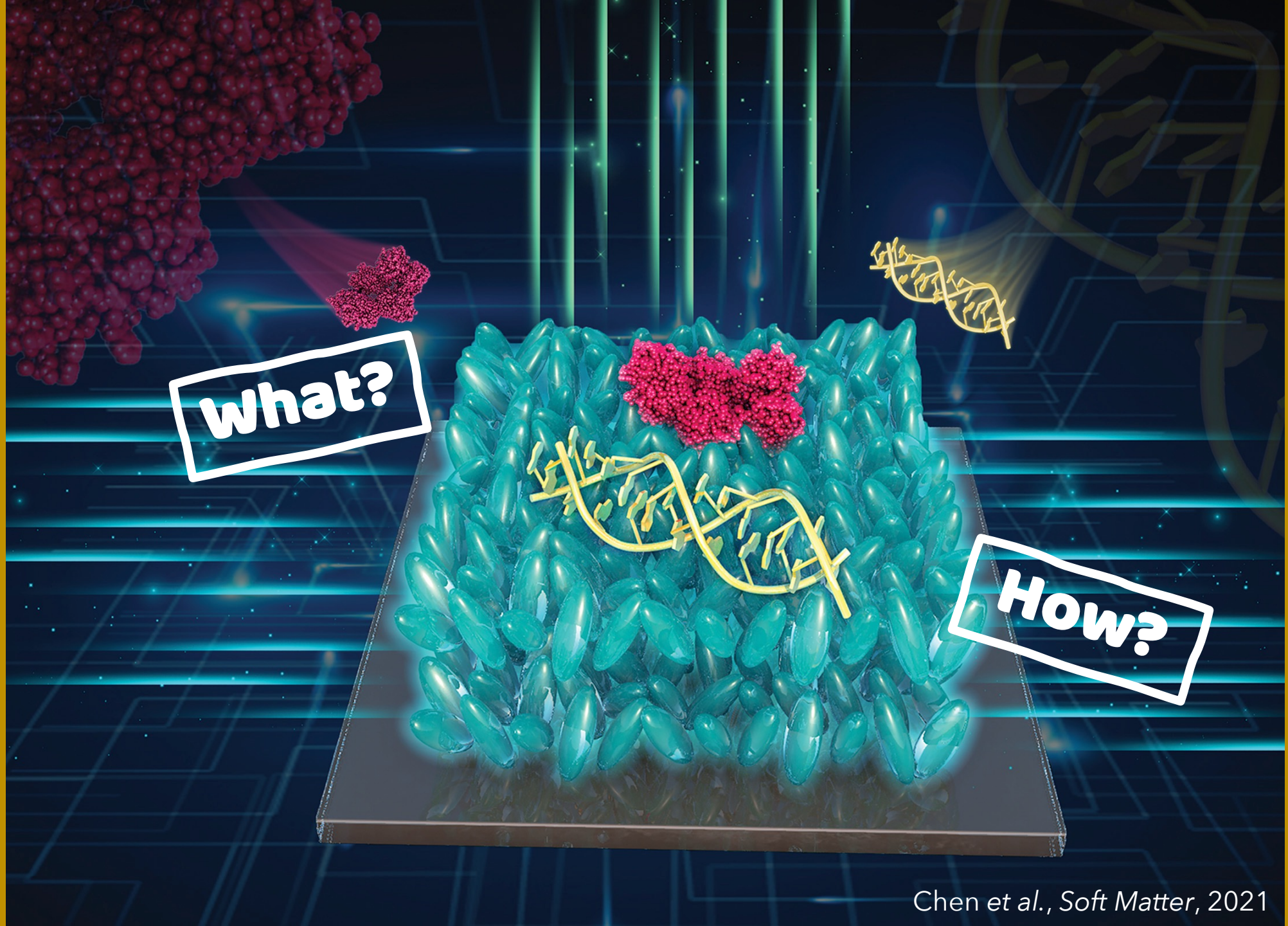
Crystal Gazing

Biosensing using colourful liquid crystals

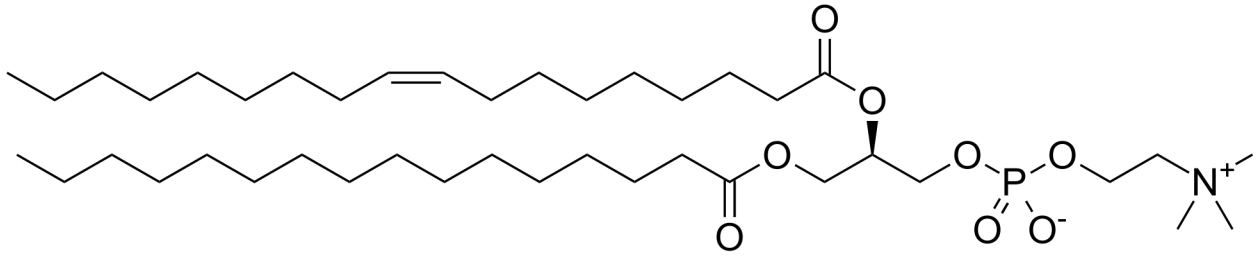
Siddharth Deshpande

Advanced Materials Workshop, Utrecht

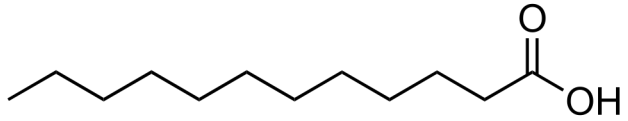
19.01.2023



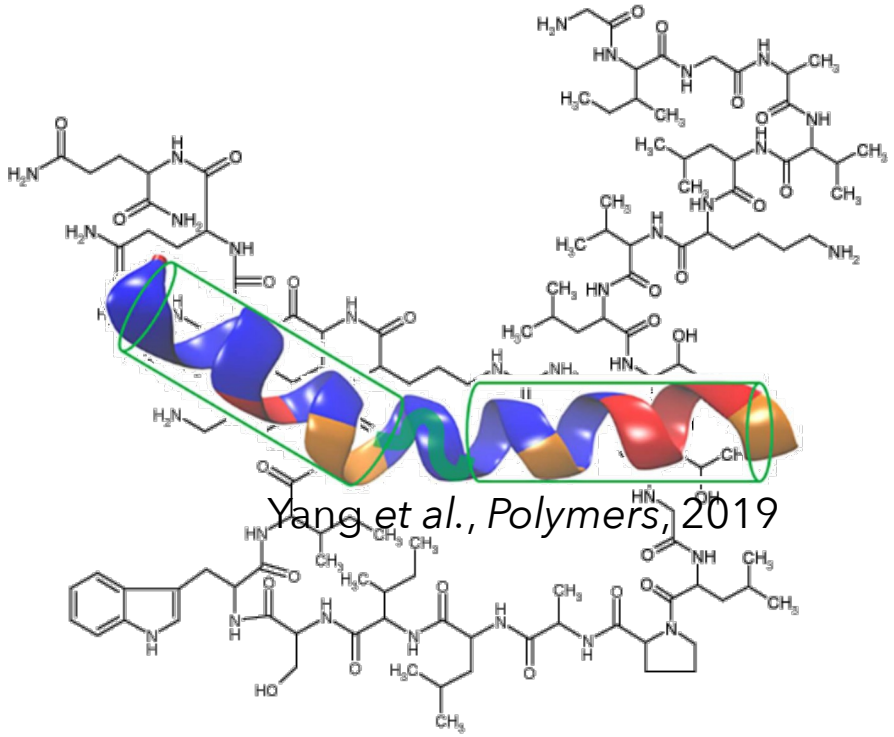
Chen *et al.*, *Soft Matter*, 2021



Phospholipids (POPC)



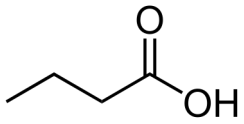
MCFAs (lauric acid)



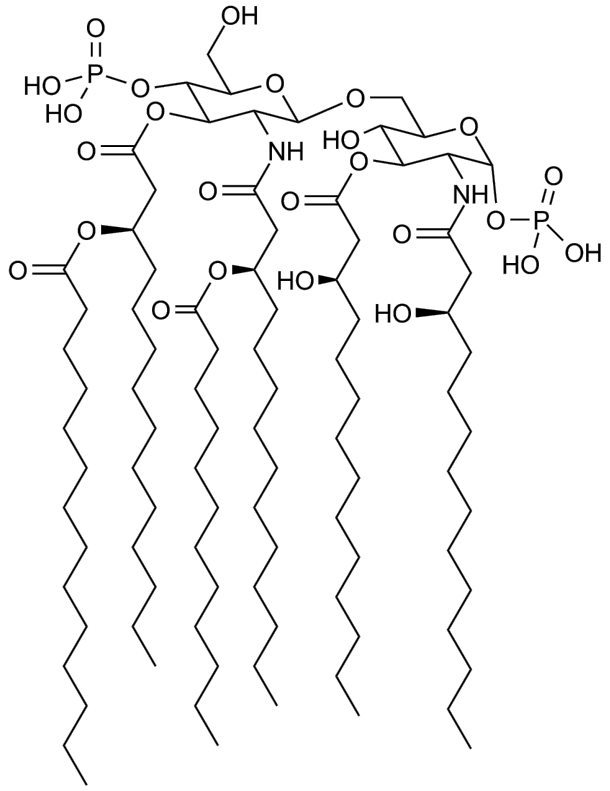
Yang *et al.*, *Polymers*, 2019

AMPs (melittin)

Amphiphiles!



SCFAs (butyrate)

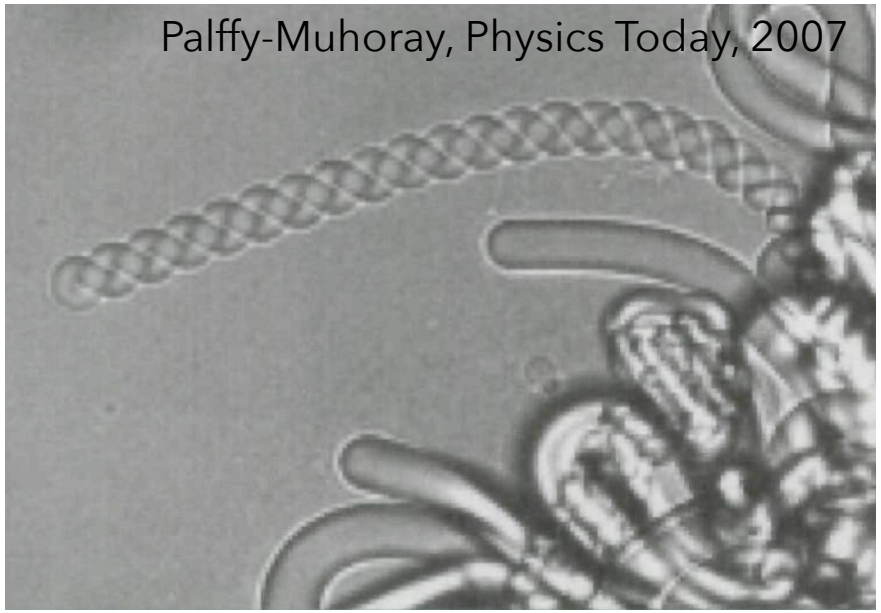


Endotoxins (lipid A)

We are going to use the omnipresent liquid crystals

liquid crystal displays
(LCDs)

very unscientific
mood rings

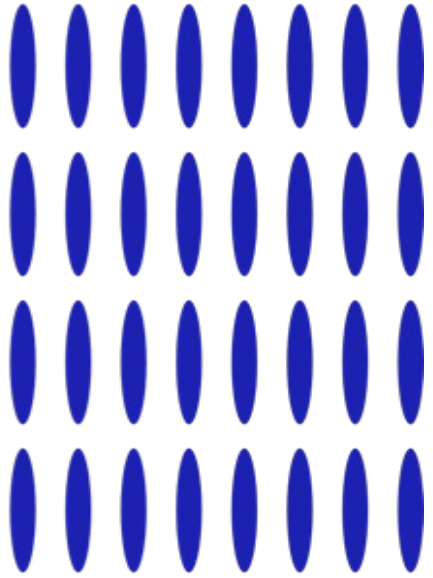


Biological systems
(lipids, cytoskeleton, viruses)

Liquid crystals – the in-between phase

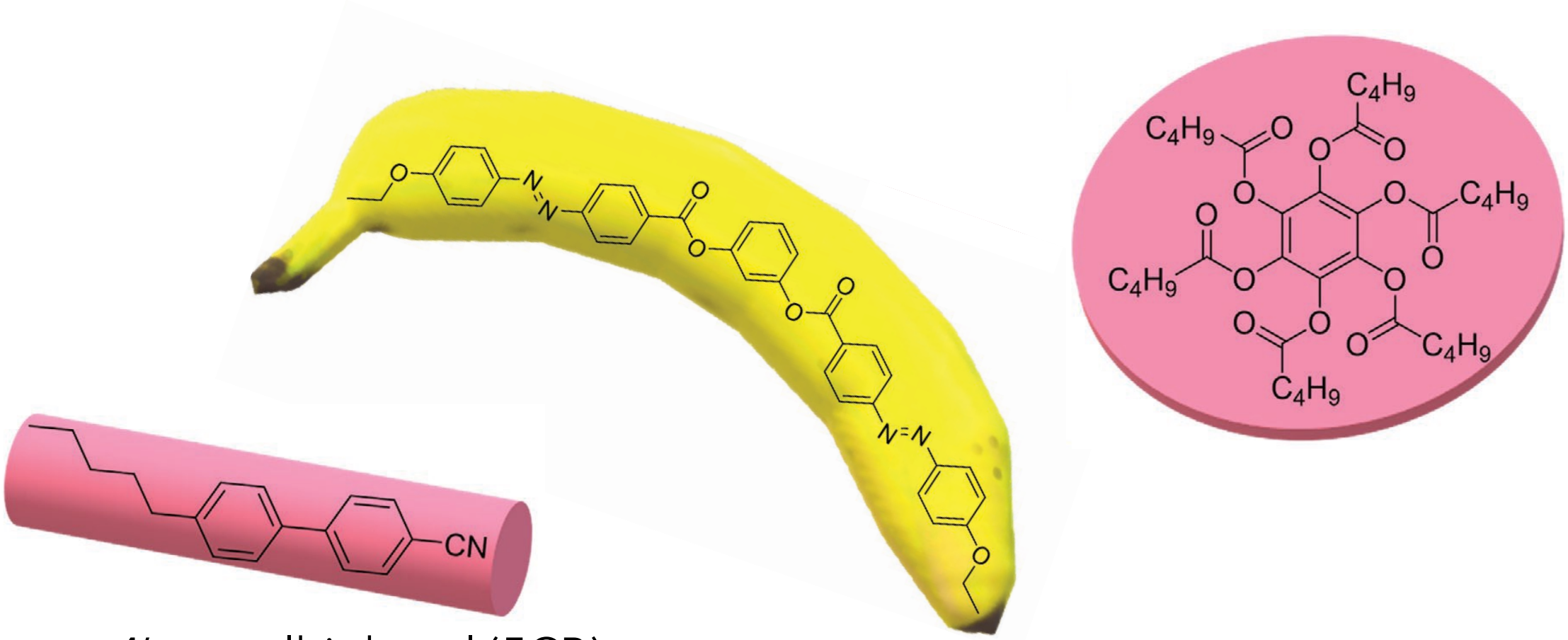
Liquid

Nematic
(long-range
orientational order)



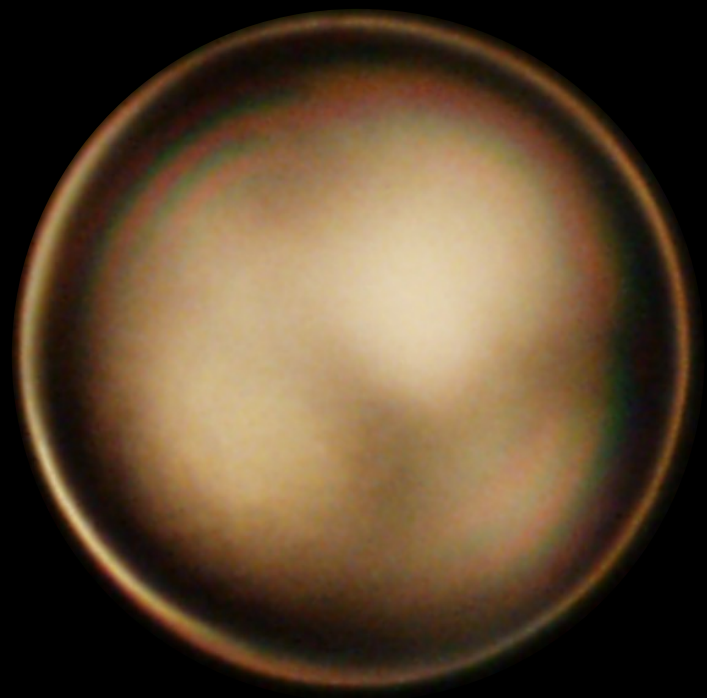
Crystal

LCs are anisotropic molecules

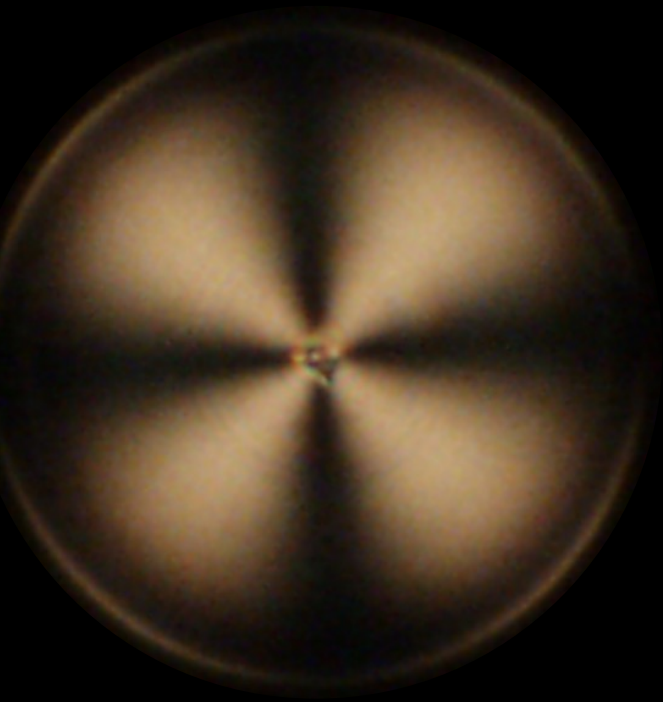


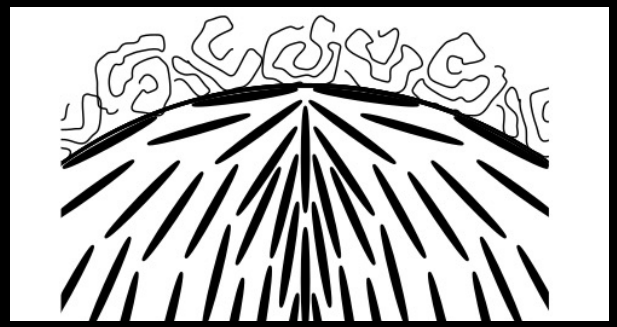
4-cyano-4′-pentylbiphenyl (5CB)

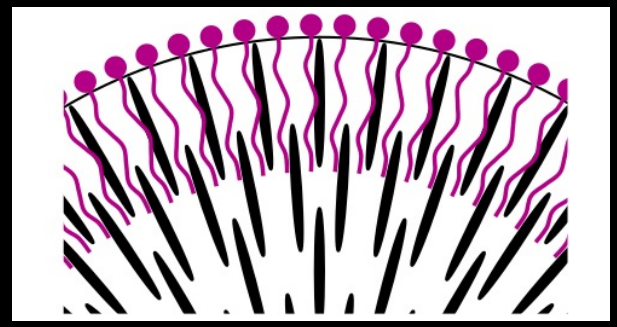
Roque *et al.*, *Adv. Optical Mater.*, 2020



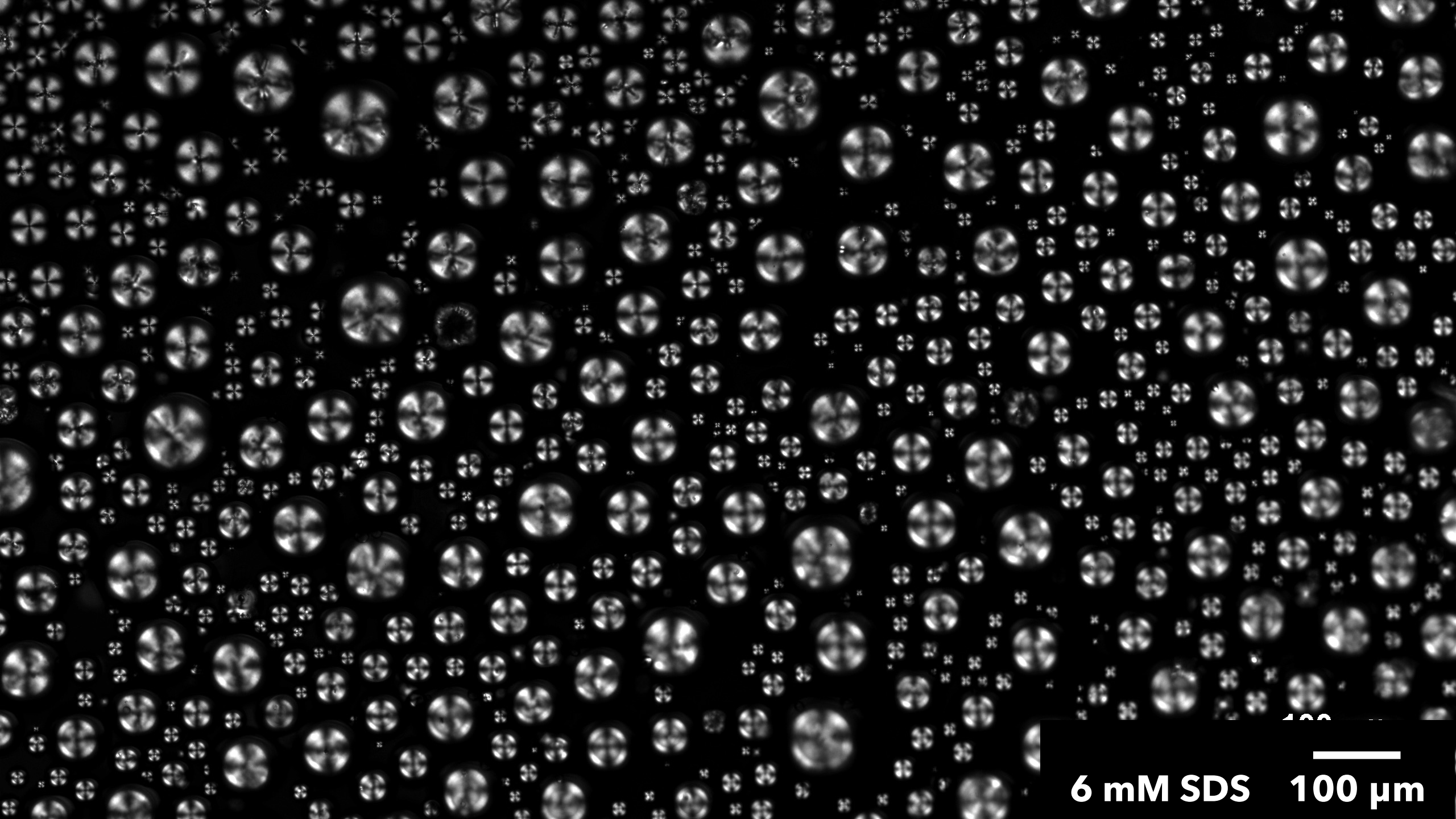
amphiphile
(SDS)



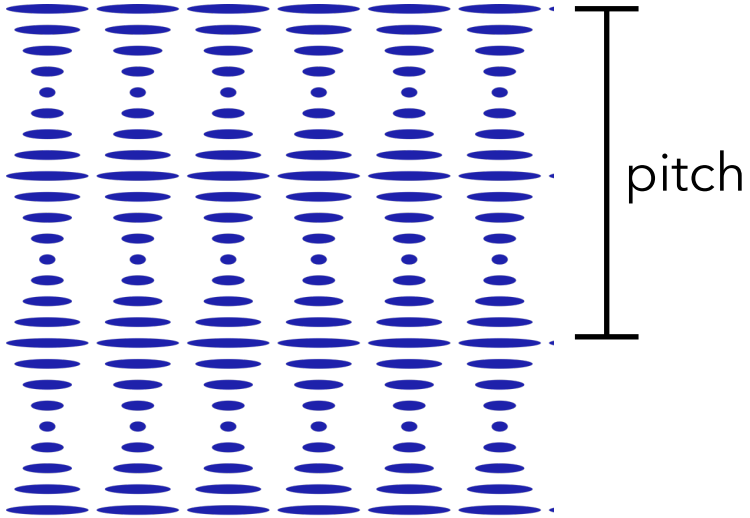




~50 µm

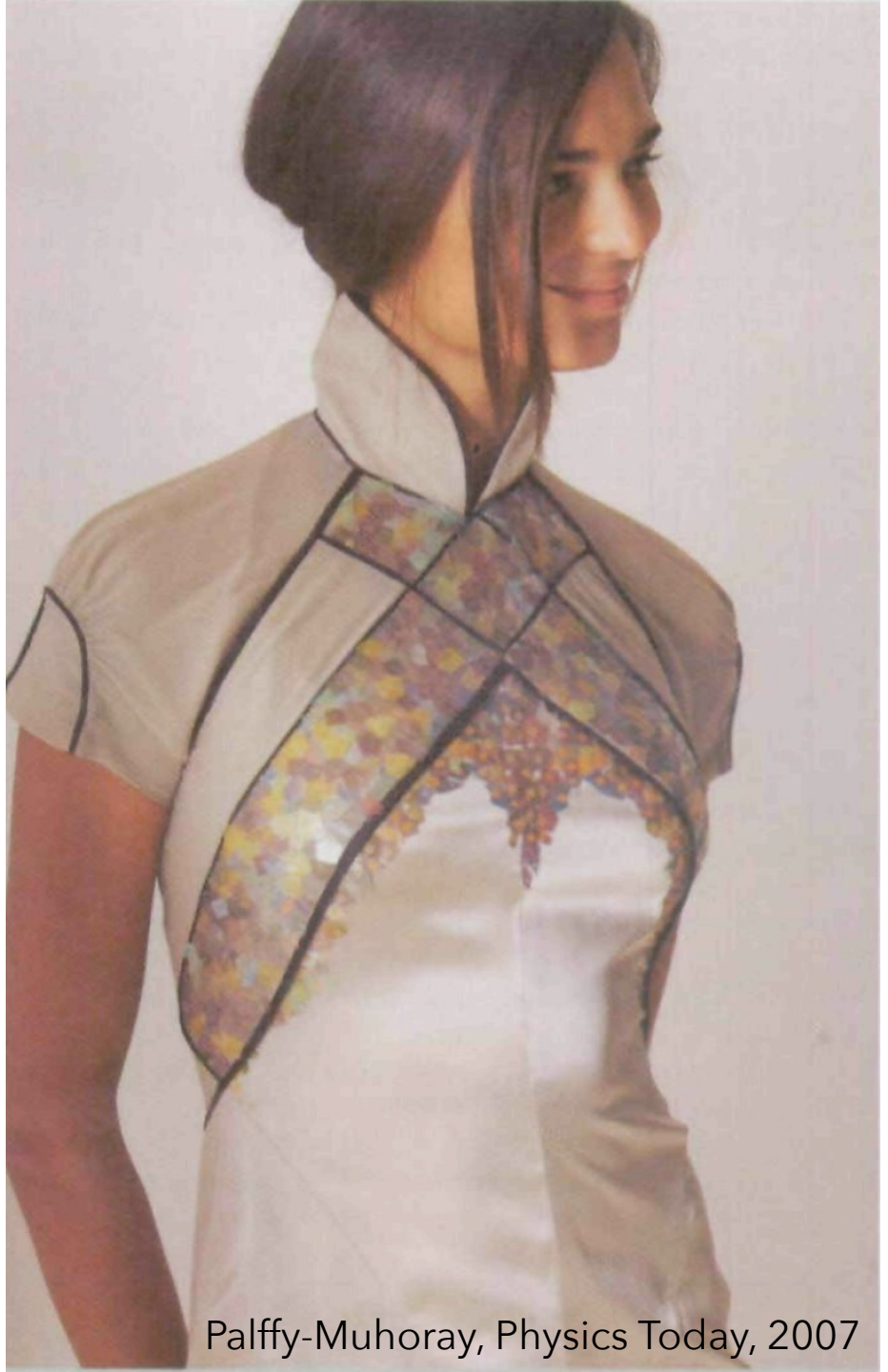

6 mM SDS
100 µm

Cholesteric liquid crystals (CLCs)



long-range orientational
+ *helical* order

Roque *et al.*, *Adv. Optical Mater.*, 2020

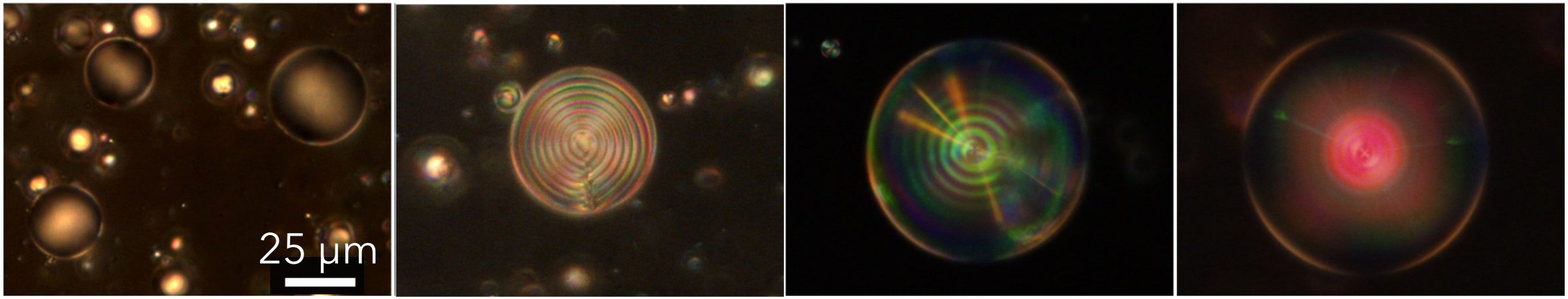


Palffy-Muhoray, Physics Today, 2007

CLCs show reflected colors in the visible range

nematic

cholesteric

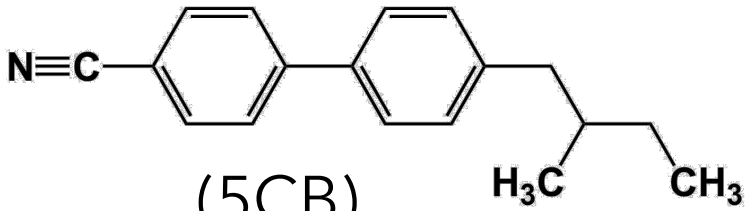


no chiral dopant

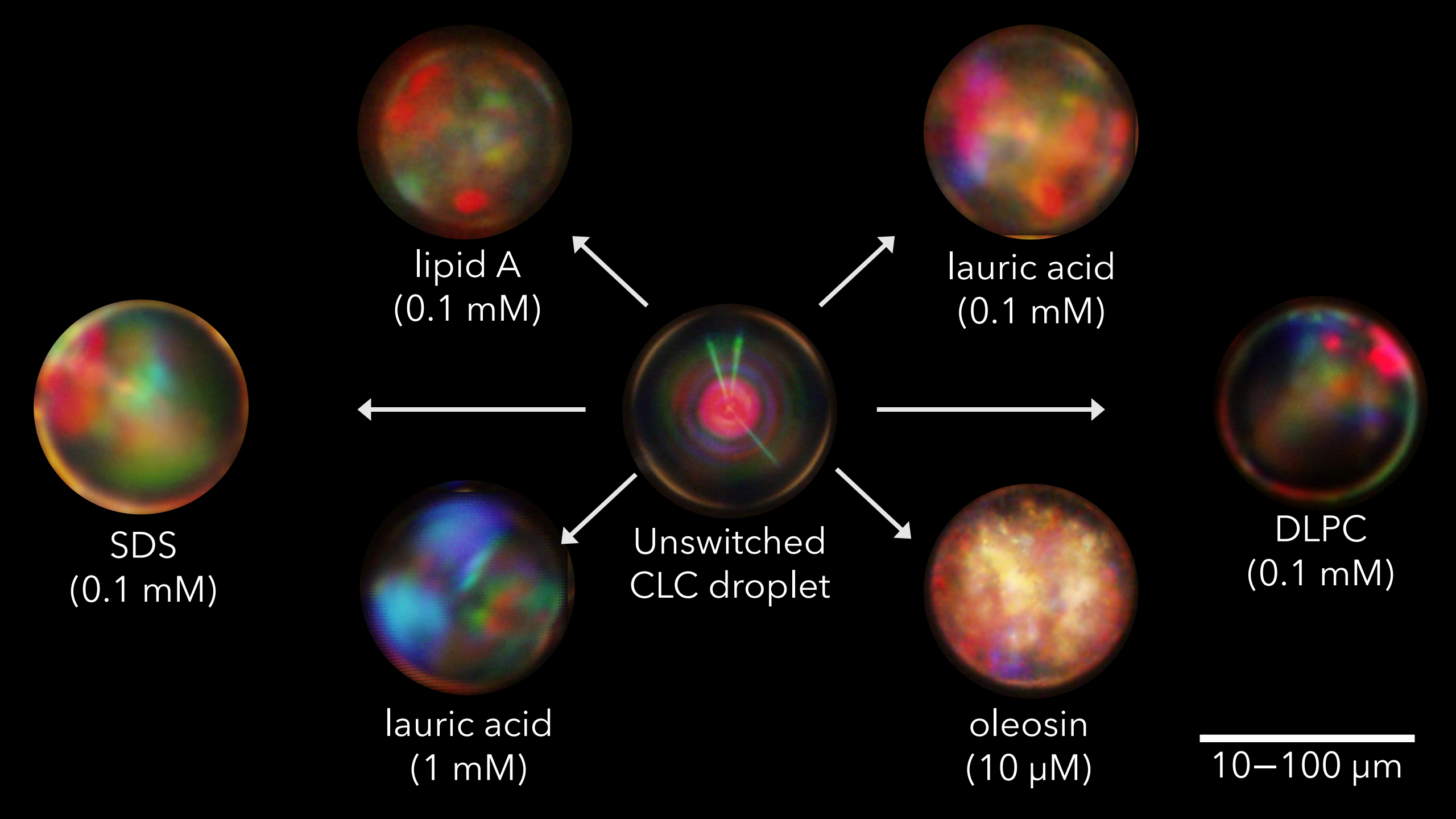
3% (long-pitch)

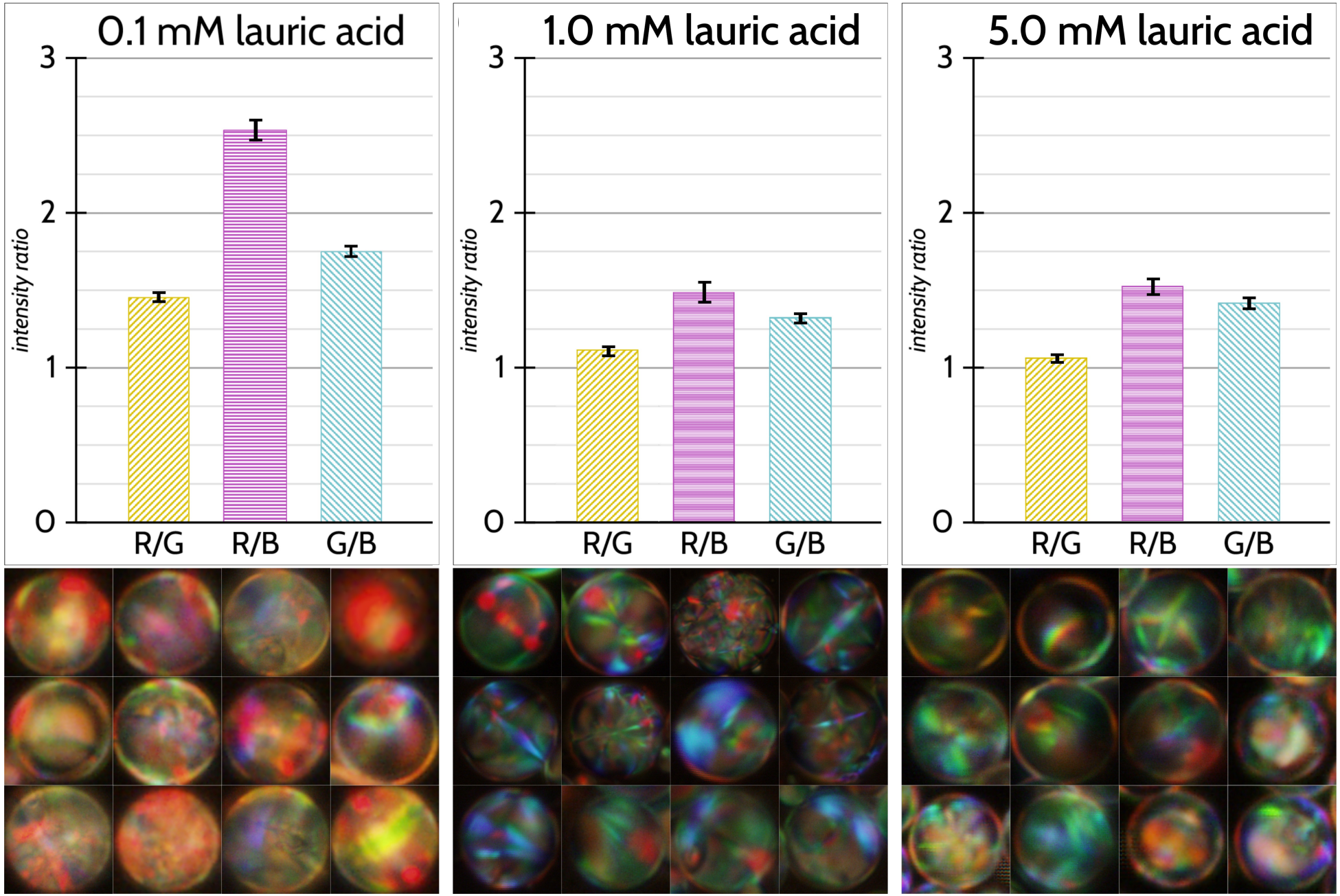
30% (short-pitch)

35% (short-pitch)

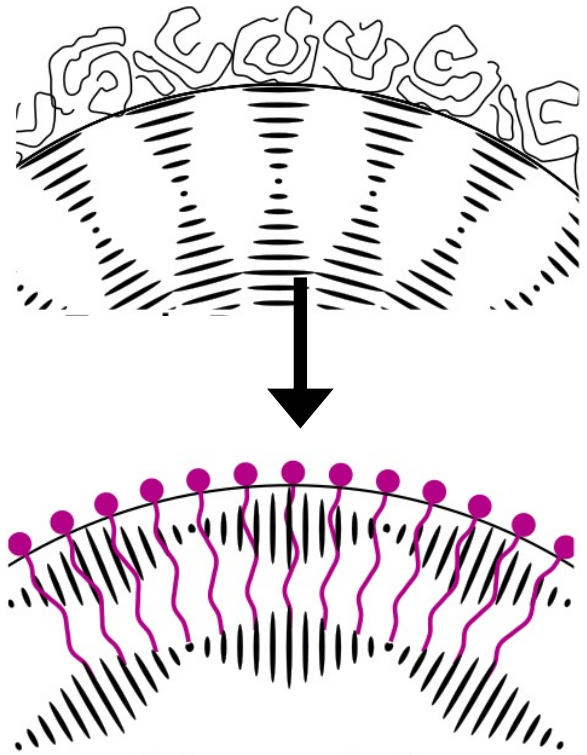


(5CB)


lipid A
(0.1 mM)
lauric acid
(0.1 mM)
SDS
(0.1 mM)
Unswitched
CLC droplet
DLPC
(0.1 mM)
lauric acid
(1 mM)
oleosin
(10 μM)
10–100 μm

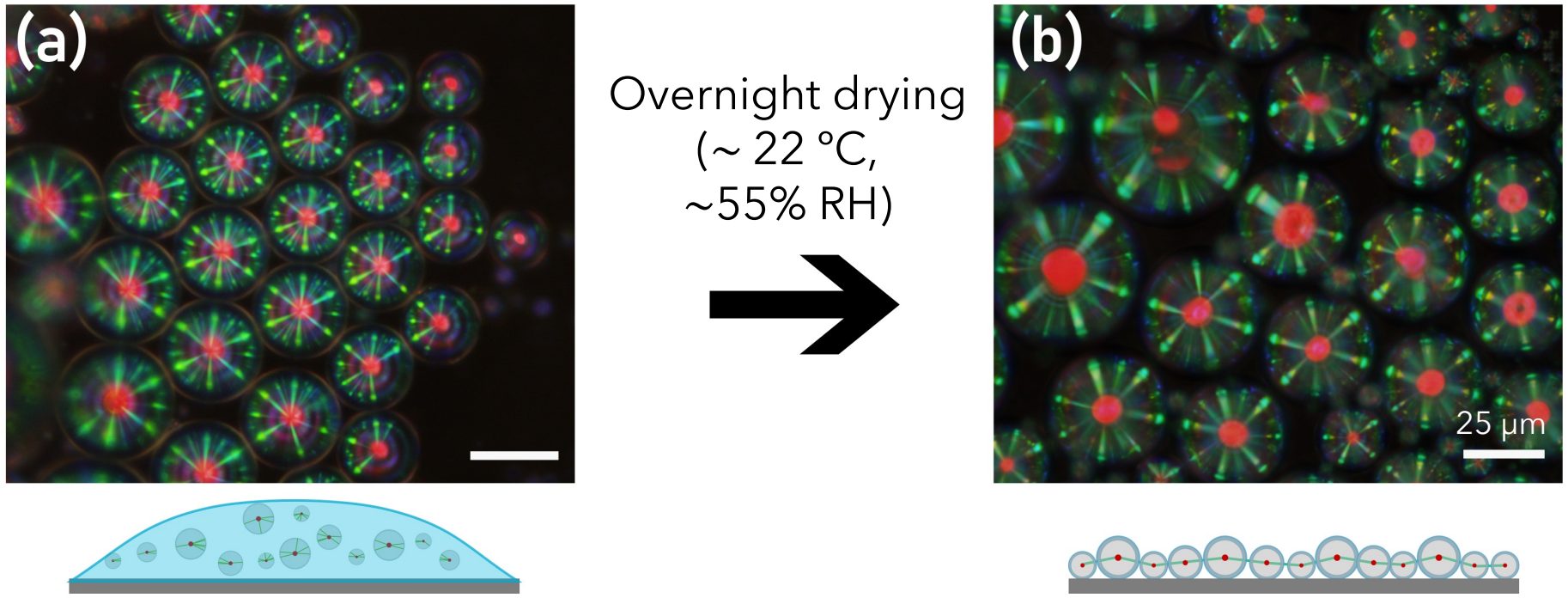

0.1 mM lauric acid
1.0 mM lauric acid
5.0 mM lauric acid
intensity ratio
3
2
1
0
R/G
R/B
G/B

Optical signature matrix

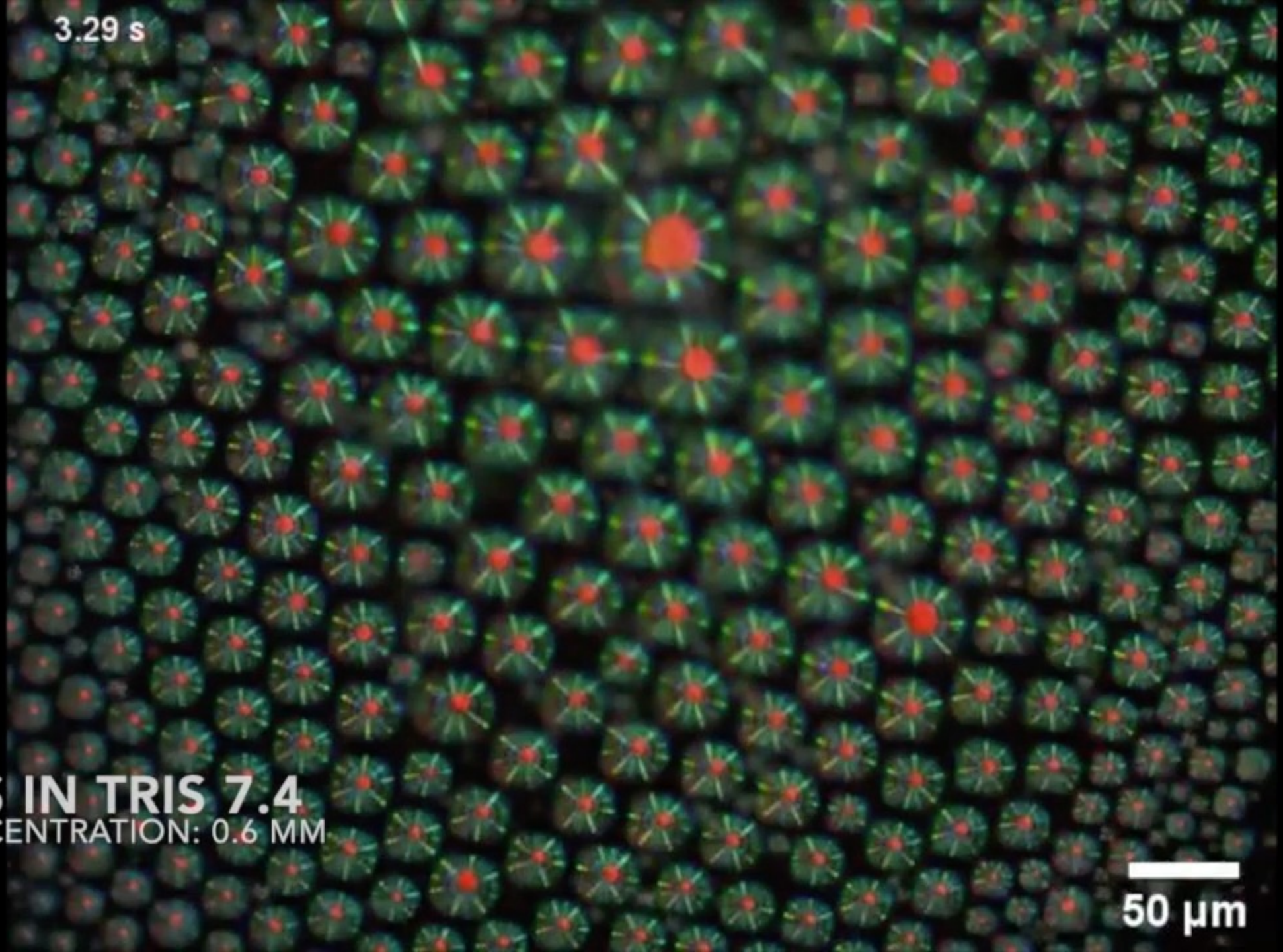


	PVA 0.2% w/w	SDS 0.1 mM	SDS 0.6 mM	SDS 6.0 mM	lauric acid 0.1 mM	lauric acid 1.0 mM	lauric acid 3.0 mM	lauric acid 5.0 mM	Kdo2-Lipid A 0.1 mM	Kdo2-Lipid A 1.0 mM
PVA 0.2% w/w		all	all	all	all	R/G R/B	R/G R/B	all	all	all
SDS 0.1 mM			all	R/B G/B	R/B	all	all	all	R/G R/B	R/G R/B
SDS 0.6 mM				G/B	all	G/B	all	R/G G/B	all	R/G R/B
SDS 6.0 mM					all	G/B	R/G G/B	all	all	all
lauric acid 0.1 mM						all	all	all	R/G R/B	R/G G/B
lauric acid 1.0 mM							none	none	all	R/G R/B
lauric acid 3.0 mM								none	all	R/G R/B
lauric acid 5.0 mM									all	all
Kdo2-Lipid A 0.1 mM										R/B G/B
Kdo2-Lipid A 1.0 mM										

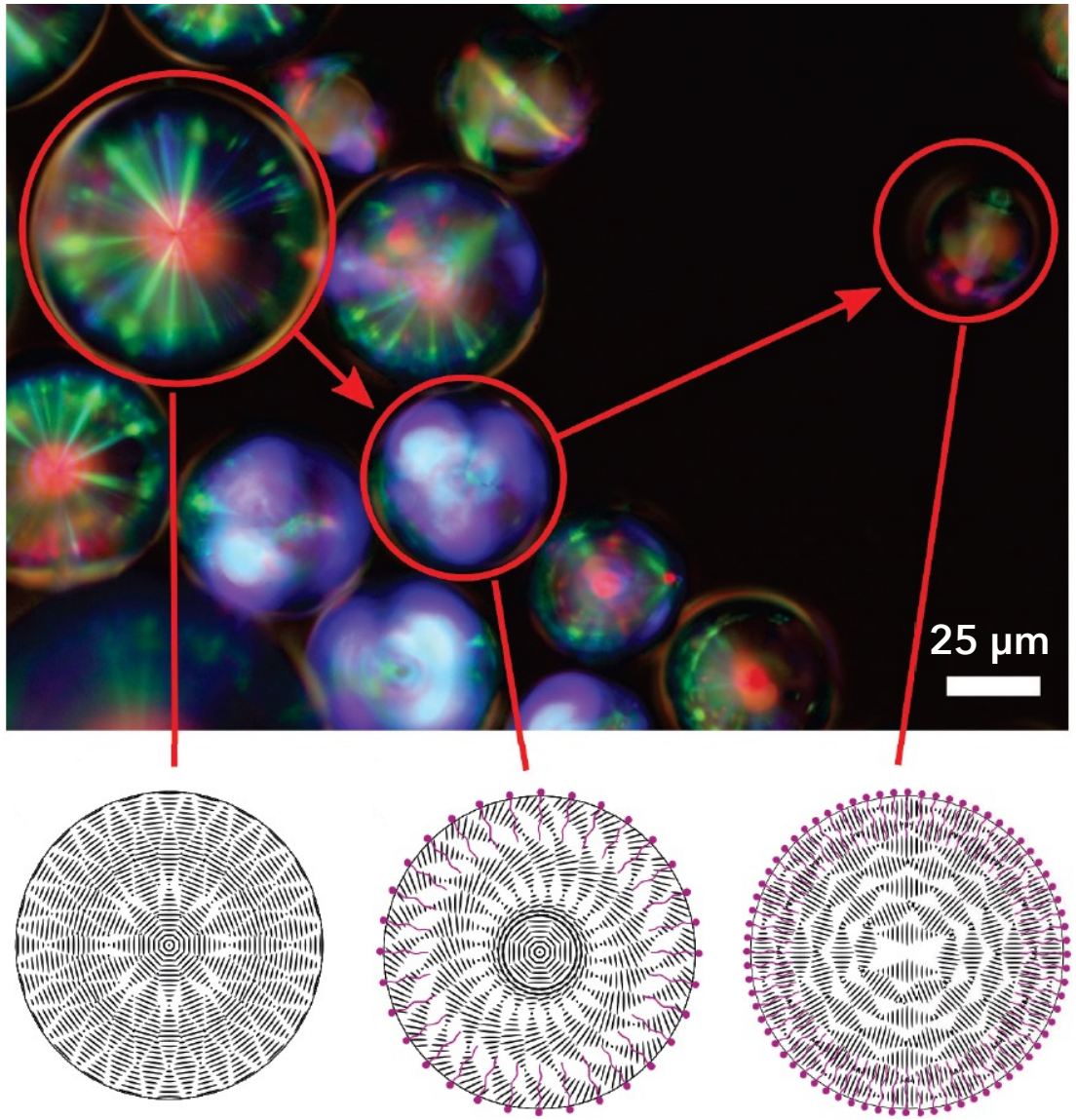
Towards portable lab-on-a-chip platform

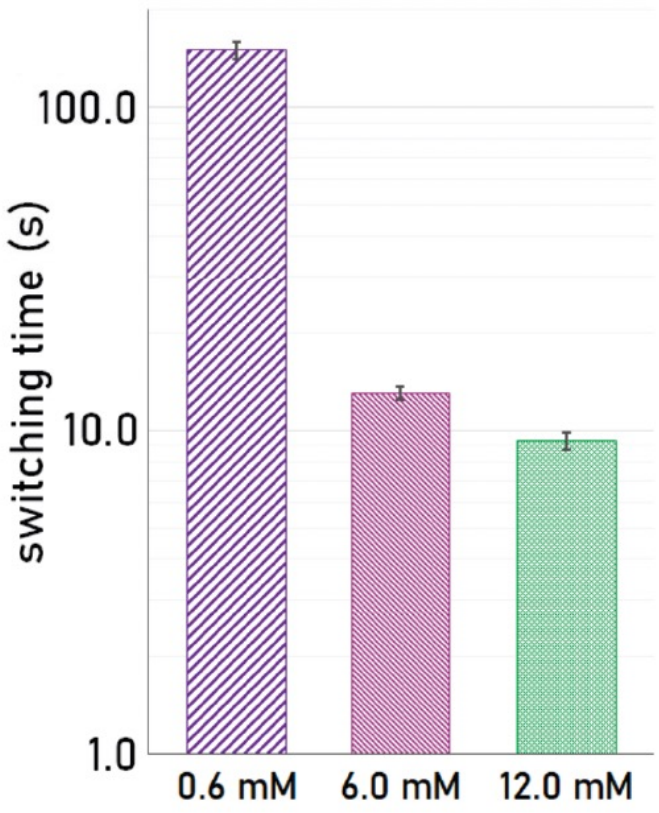


A compact 2D array of sensing droplets, with the same optical response


3.29 s
SDS IN TRIS 7.4
CONCENTRATION: 0.6 MM
50 µm

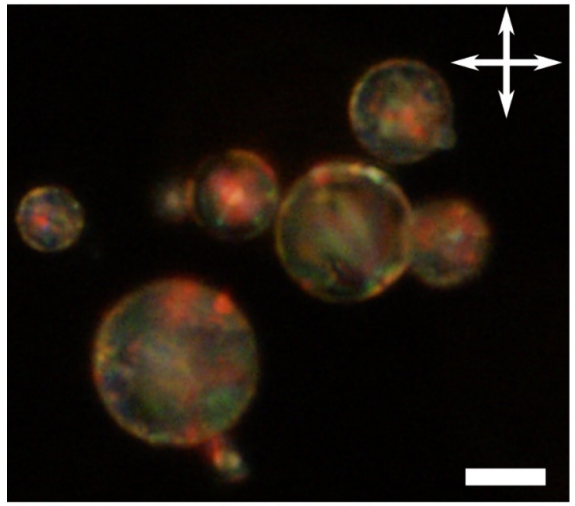
Quick and dynamic response



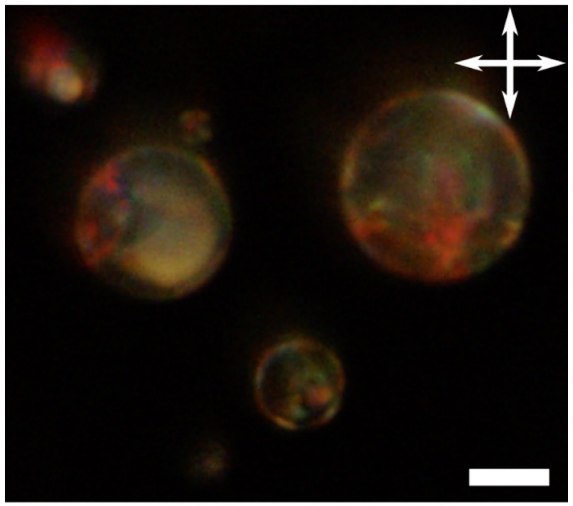


How sensitive are our LC biosensors?

not stabilized



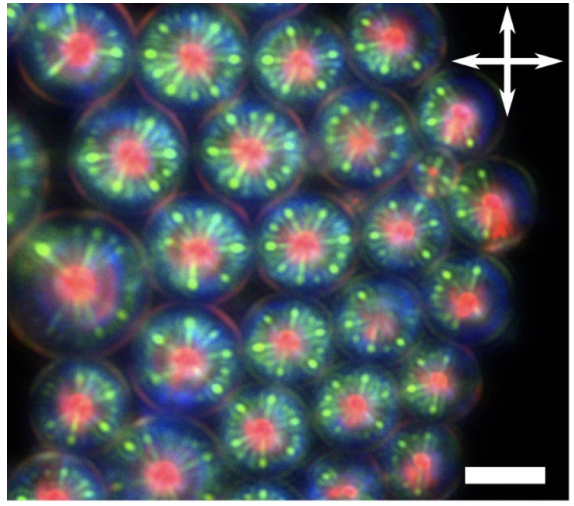
50 nM SDS



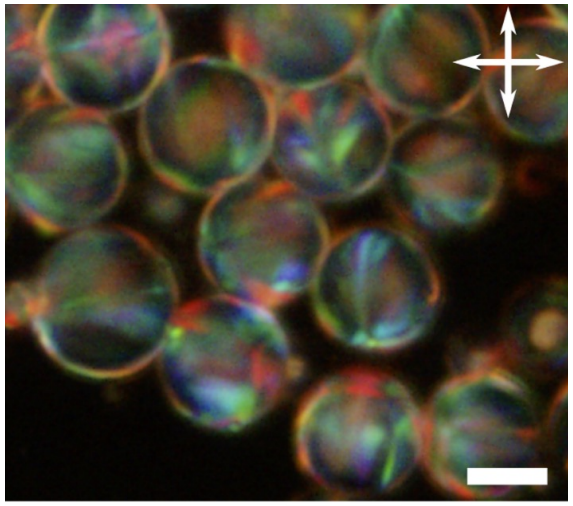
10 nM lauric acid

~nM

stabilized



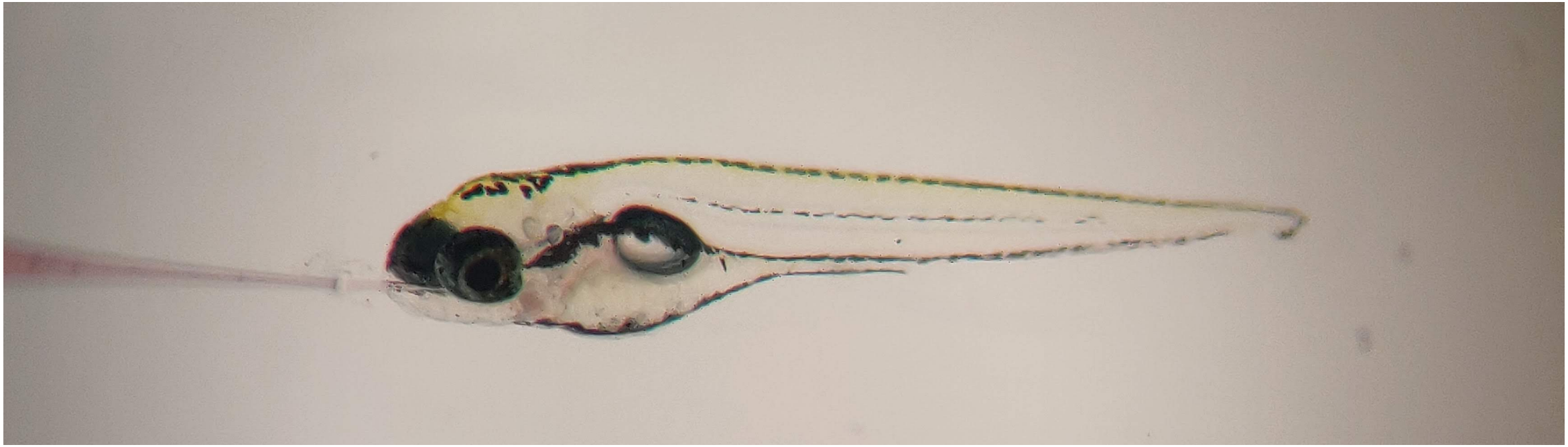
PVA + 60 µM SDS



PVA + 100 µM SDS

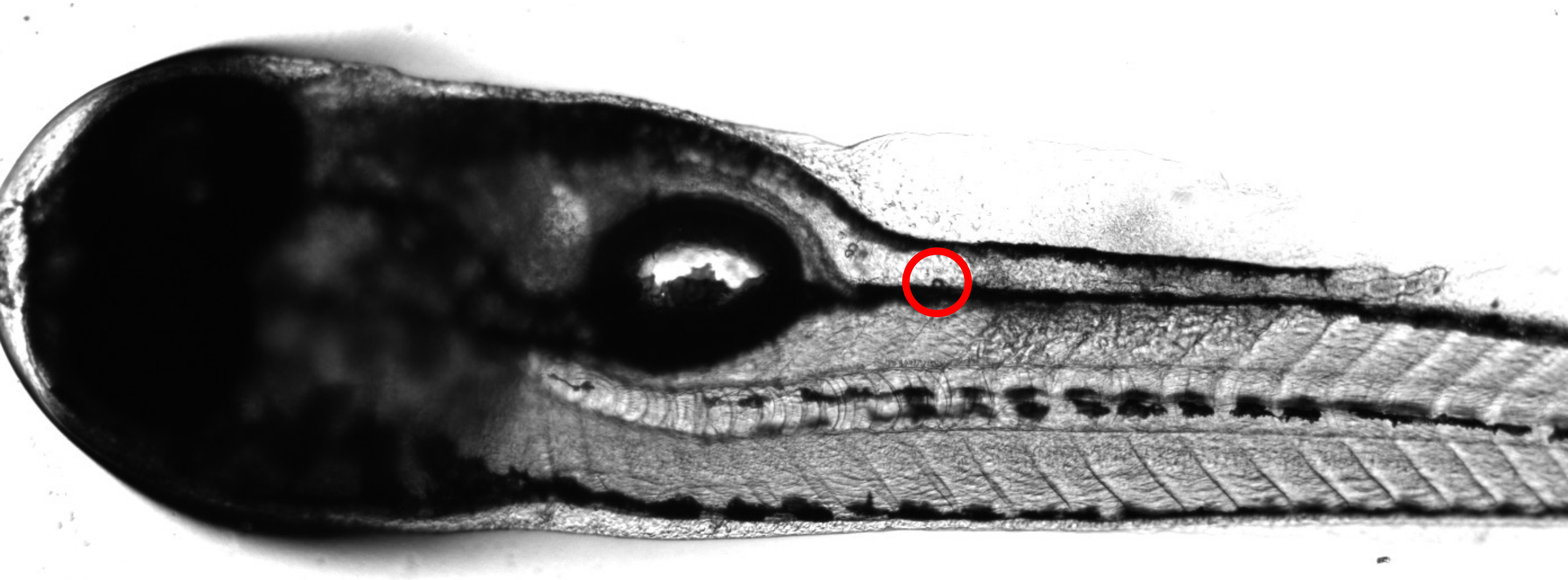
~µM

In vivo biosensing: the zebrafish sacrifice!

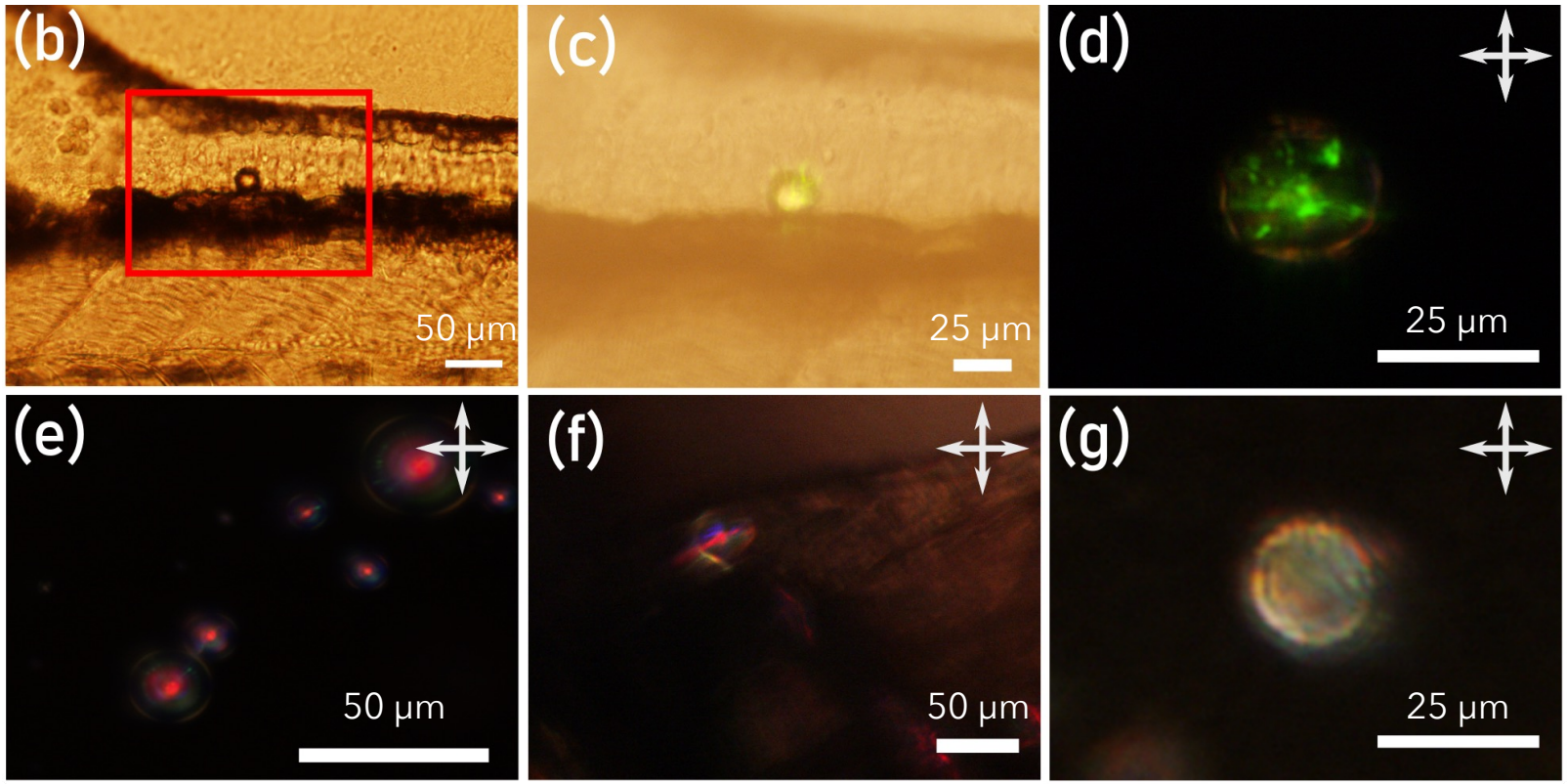


zebrafish larvae
(transparent, amphiphile-rich intestinal tract)

Feeding CLC sensors to *live* zebrafish



We get environment-specific signals!



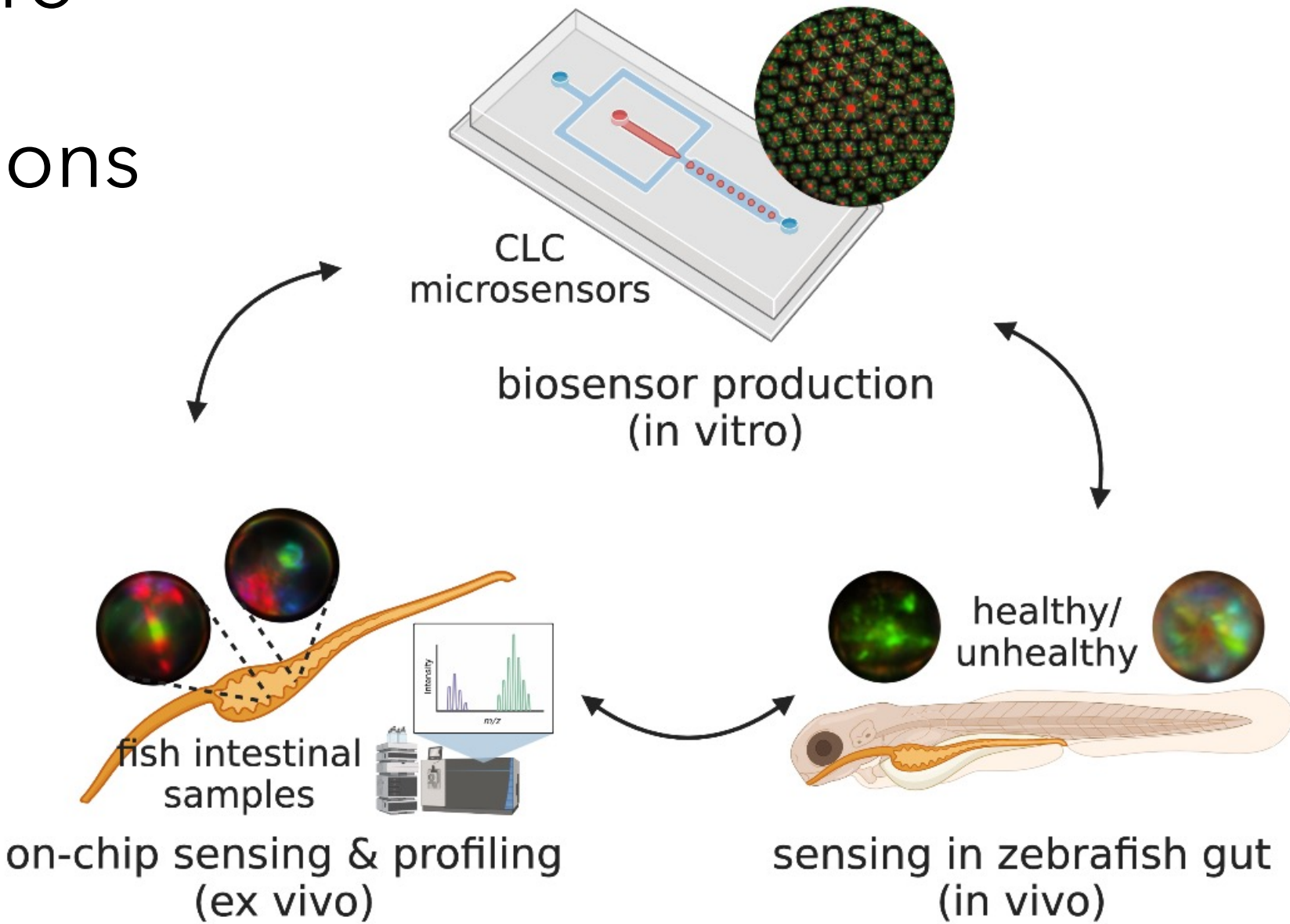
Healthy gut

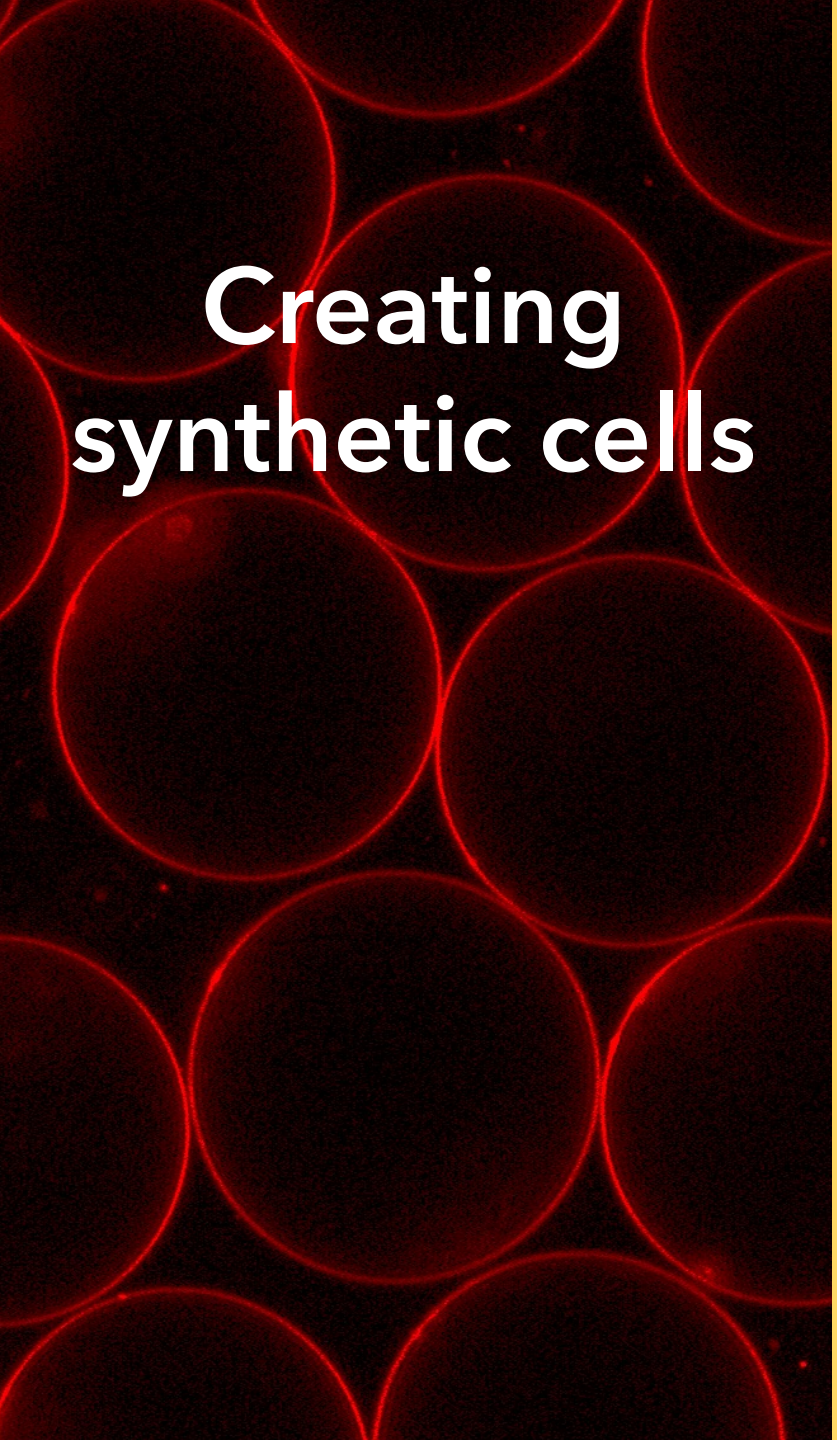
In vitro negative control

In vivo negative control (mouth)

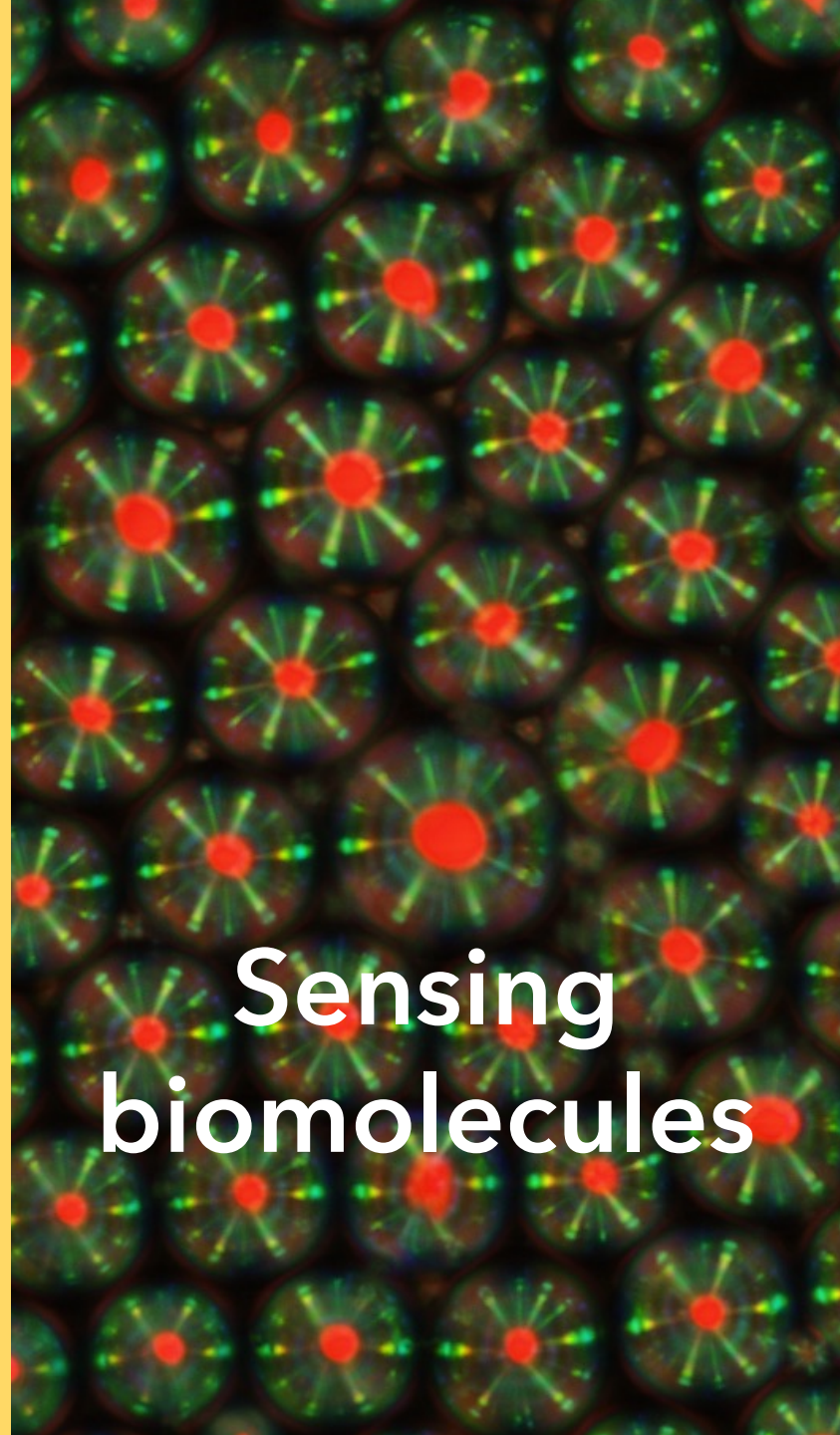
Inflamed gut

Future directions



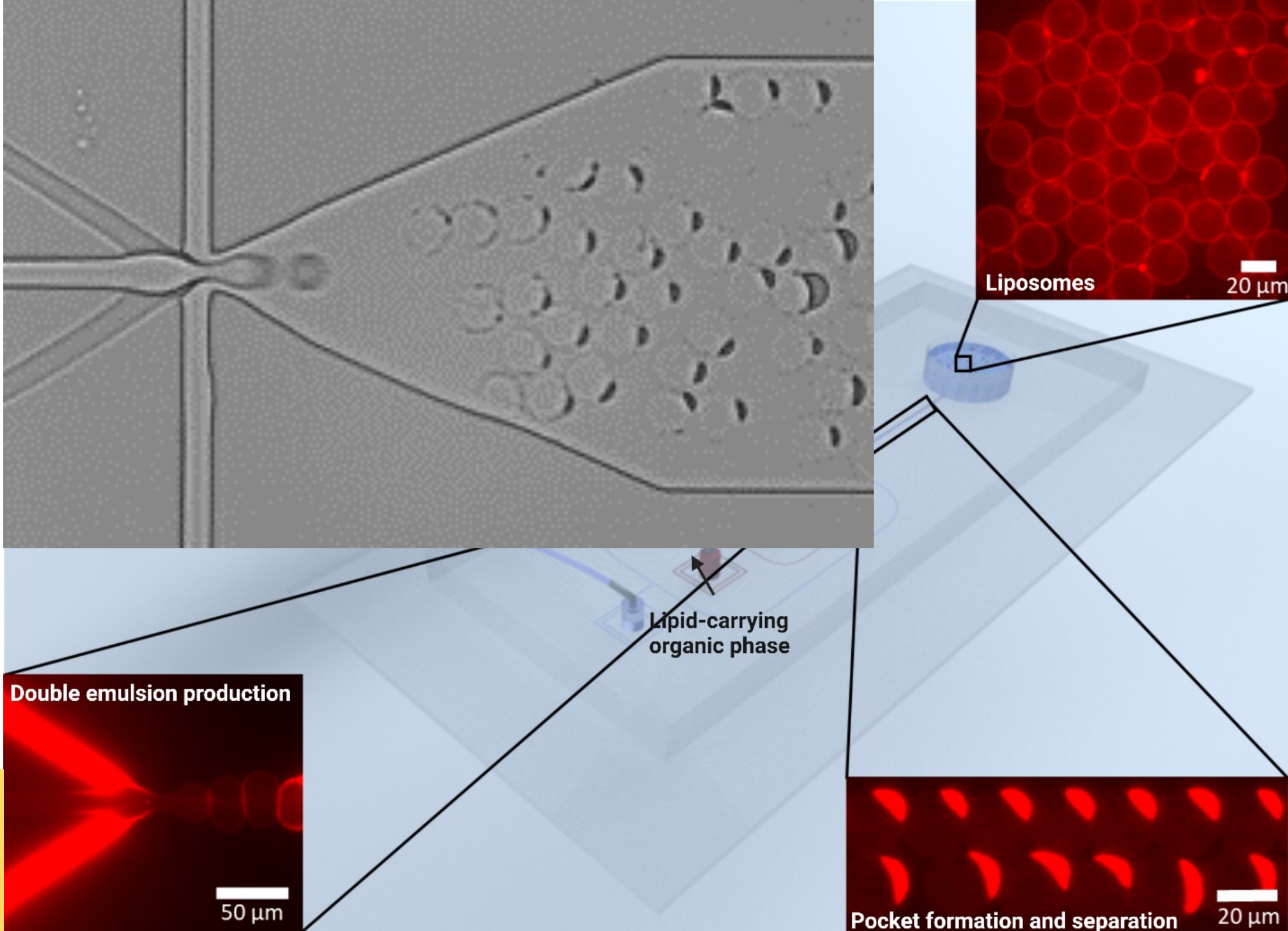

Creating
synthetic cells


Understanding
self-
organization

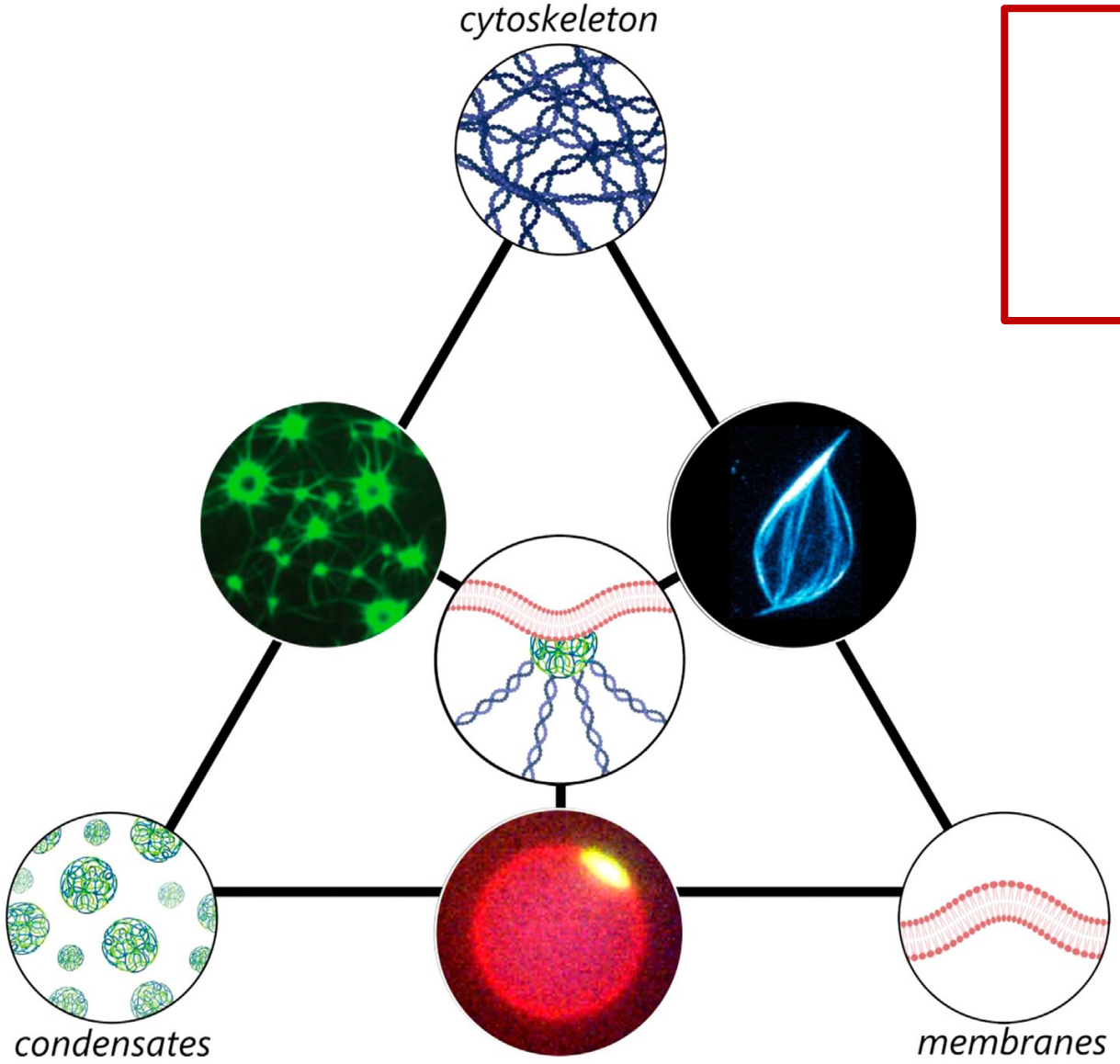

Sensing
biomolecules

OLA

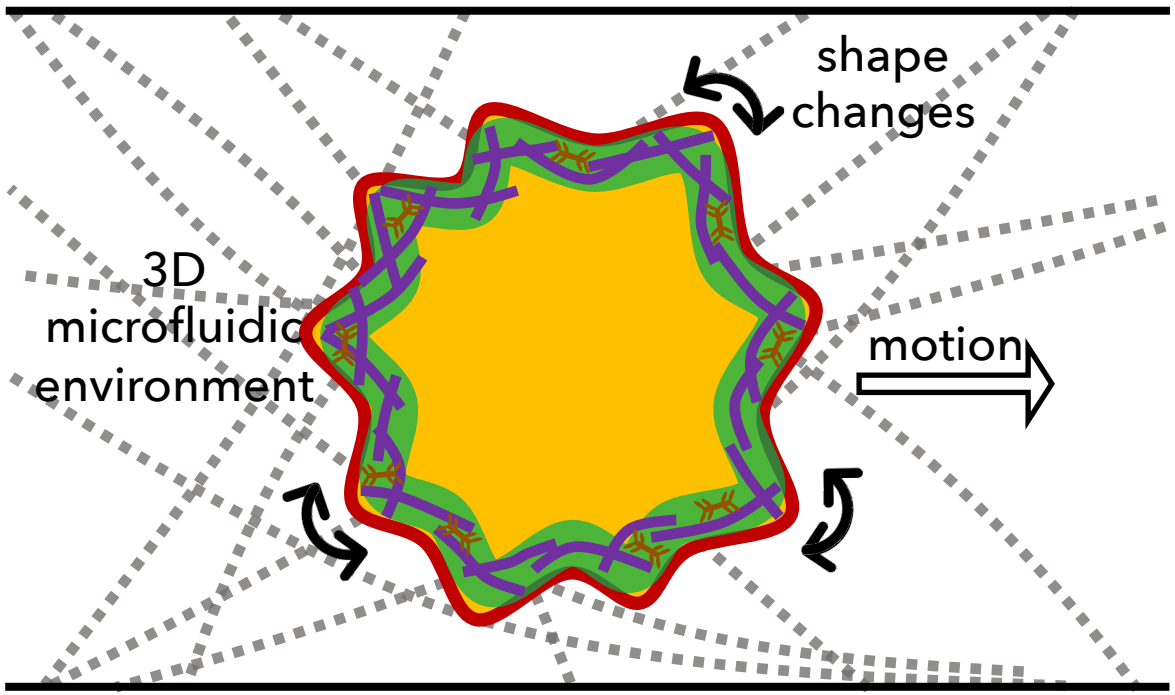
Octanol-assisted Liposome Assembly



Chang *et al.*, under revision at JoVE

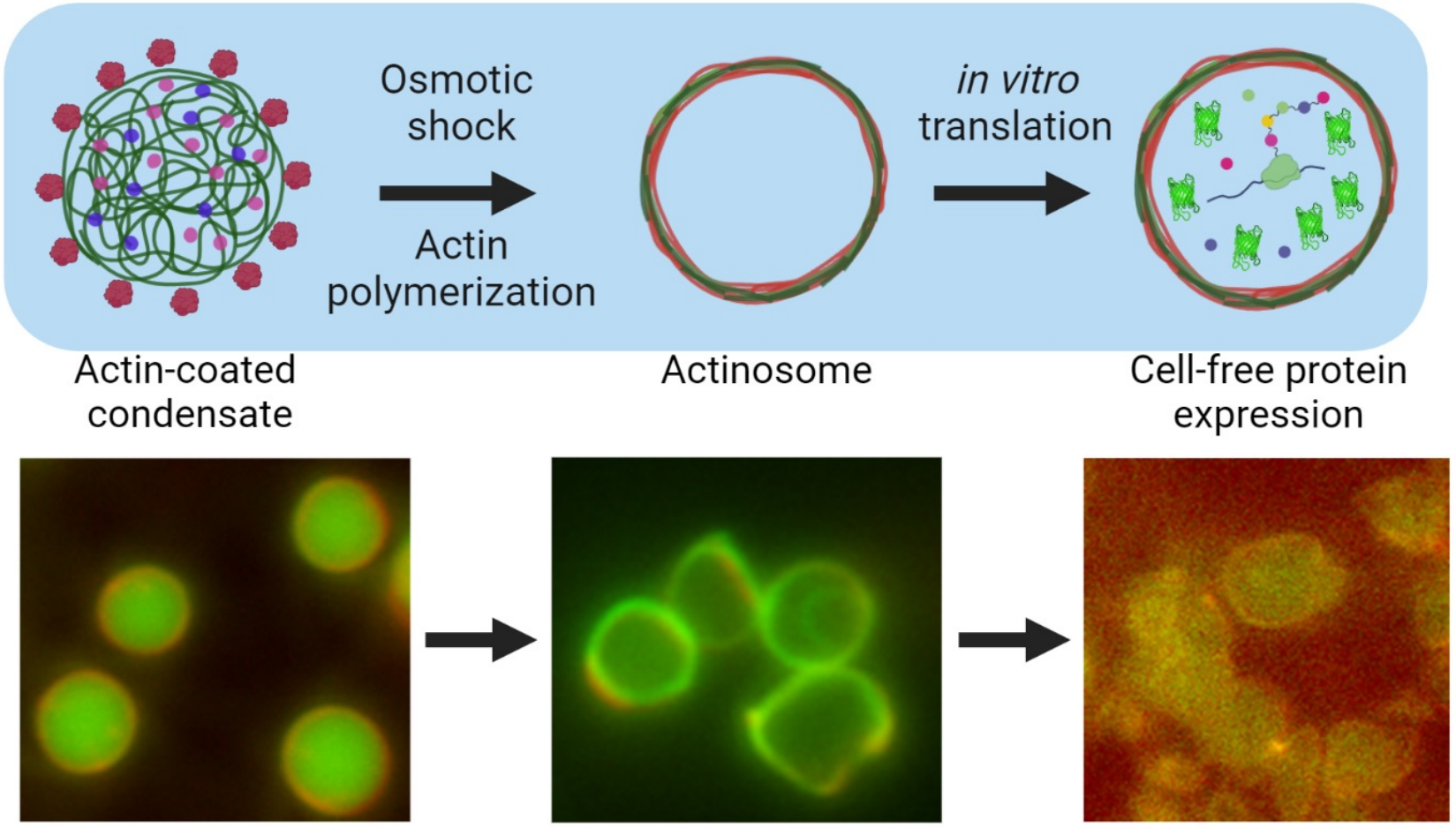


Shaping & moving synthetic cells



Ganar *et al.*, *Current Opin. Colloid Interface Sci.*, 2021

Actinosomes: new synthetic cell containers



Ganar *et al.*, *ACS Synth. Biol.*, 2022

Larry

Sylvia Brugman
(HMI)

WAGENINGEN
UNIVERSITY & RESEARCH

PCC

Thank You!

Honaker *et al.*, *ACS Appl. Mater. Interfaces*, 2022

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https://siddharthdeshpandelab.com