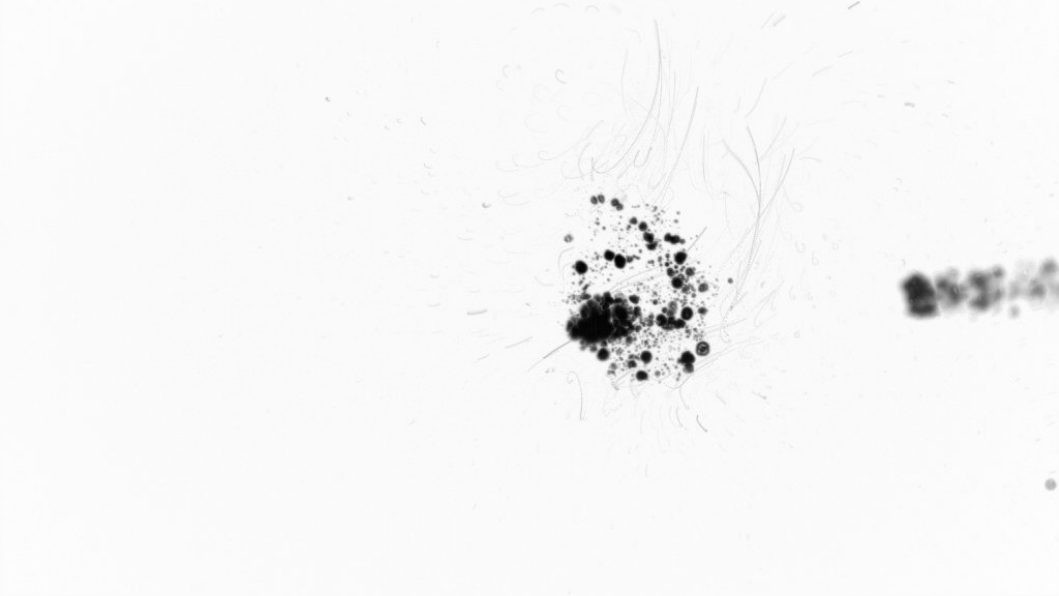
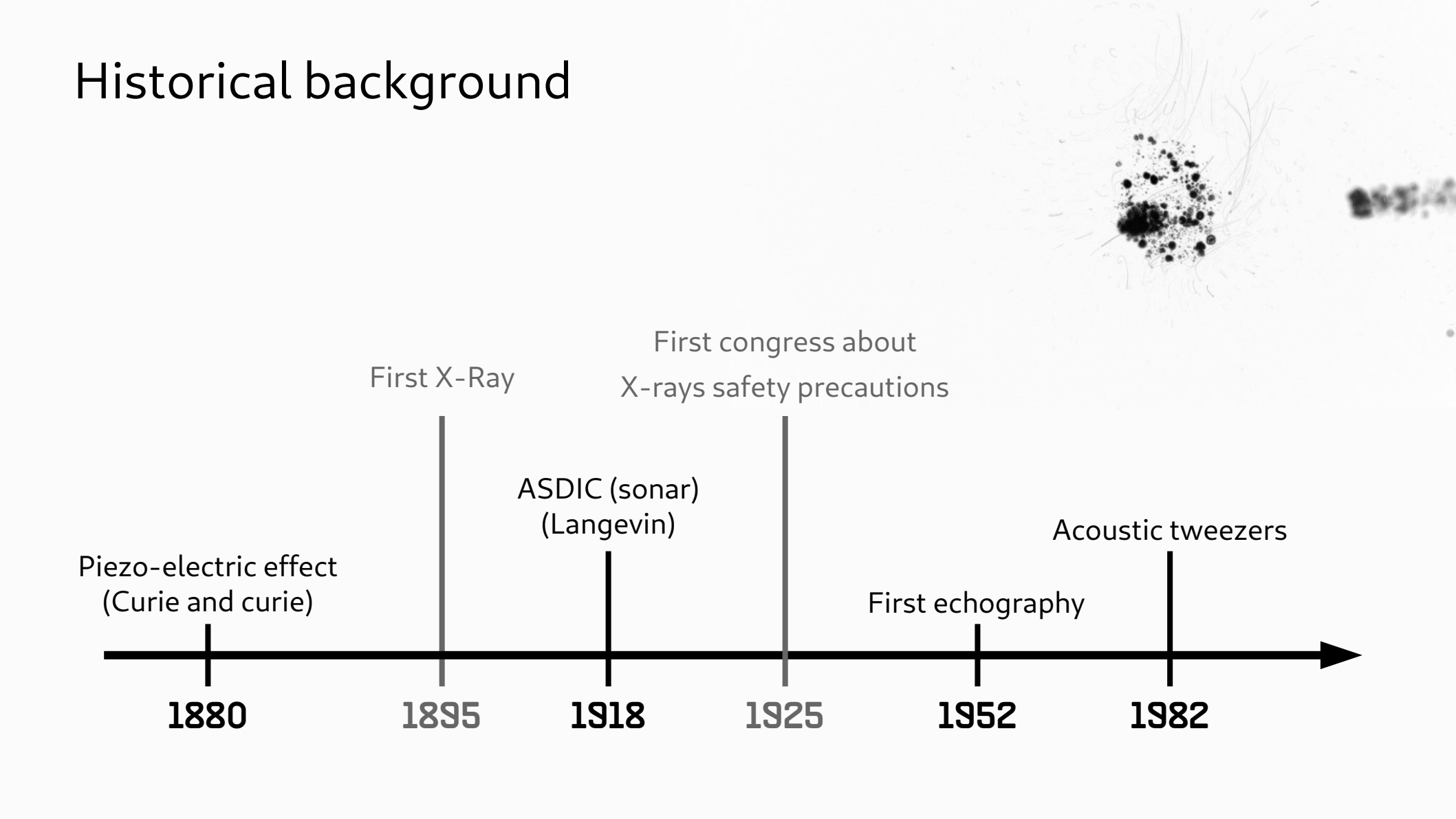
Ultrasound & Biology

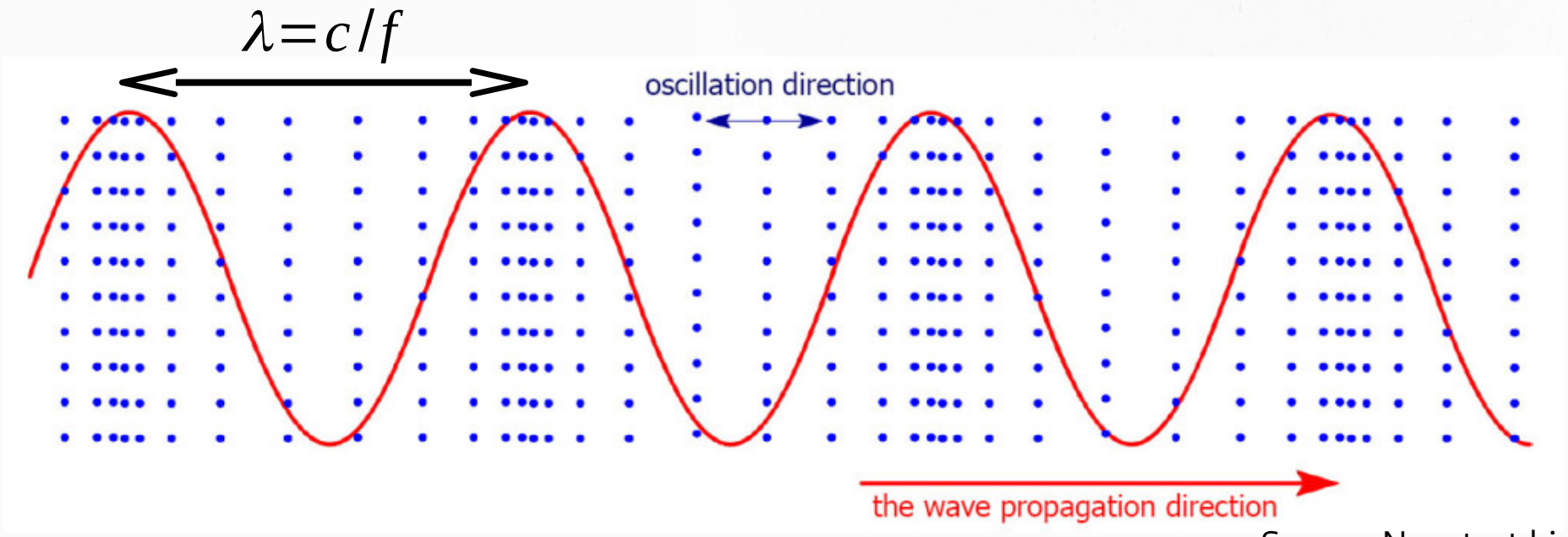


Historical background



What is an acoustic wave?

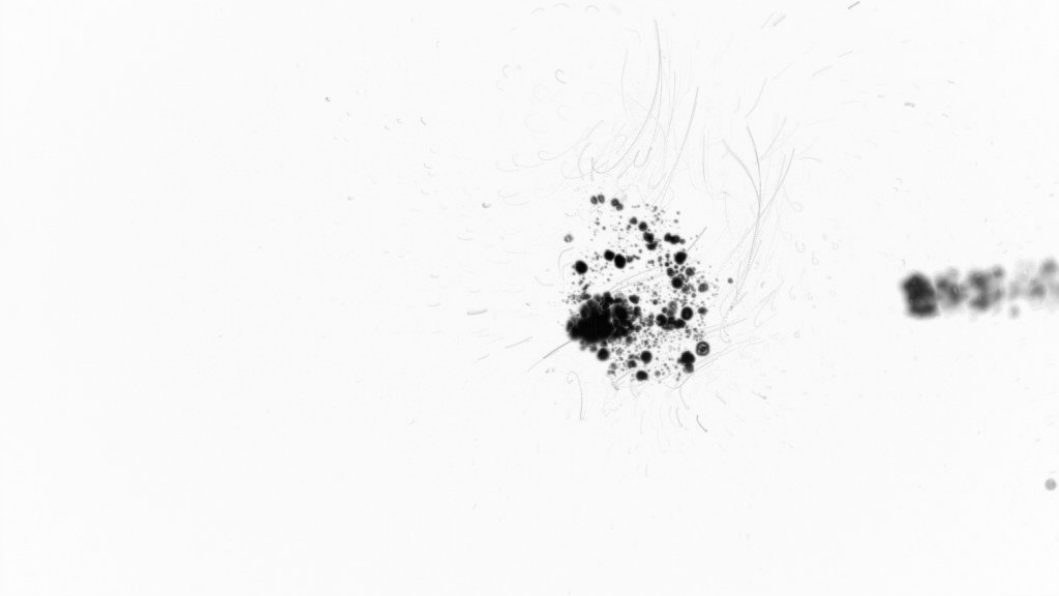
→ propagation of energy by compression/decompression of a medium



Source: Novotest.biz

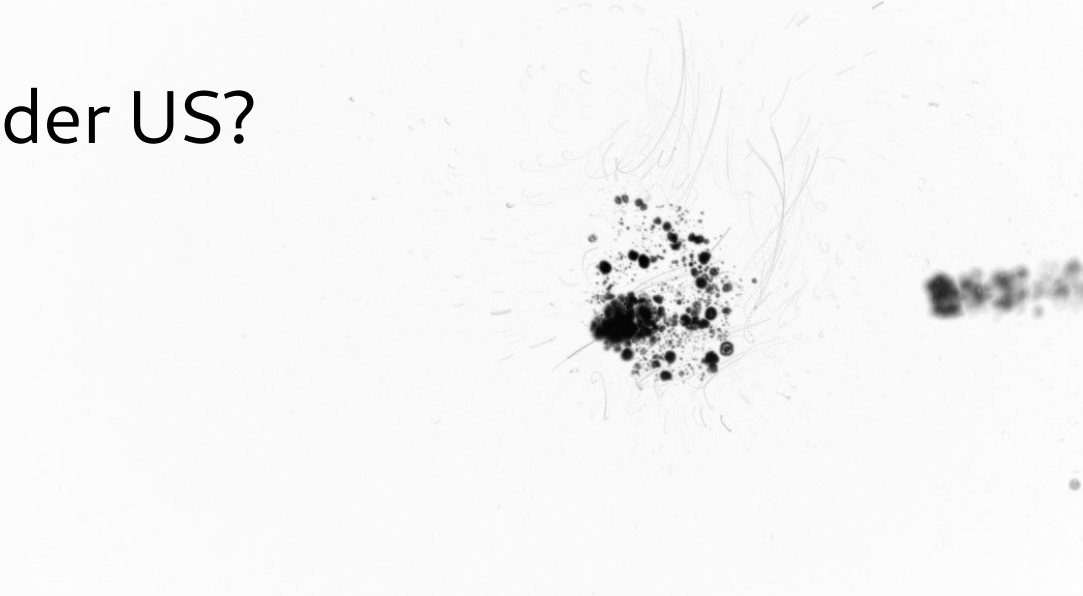
The physicist problem

- Wavelength



- Acoustic impedance

What can happen to cells under US?



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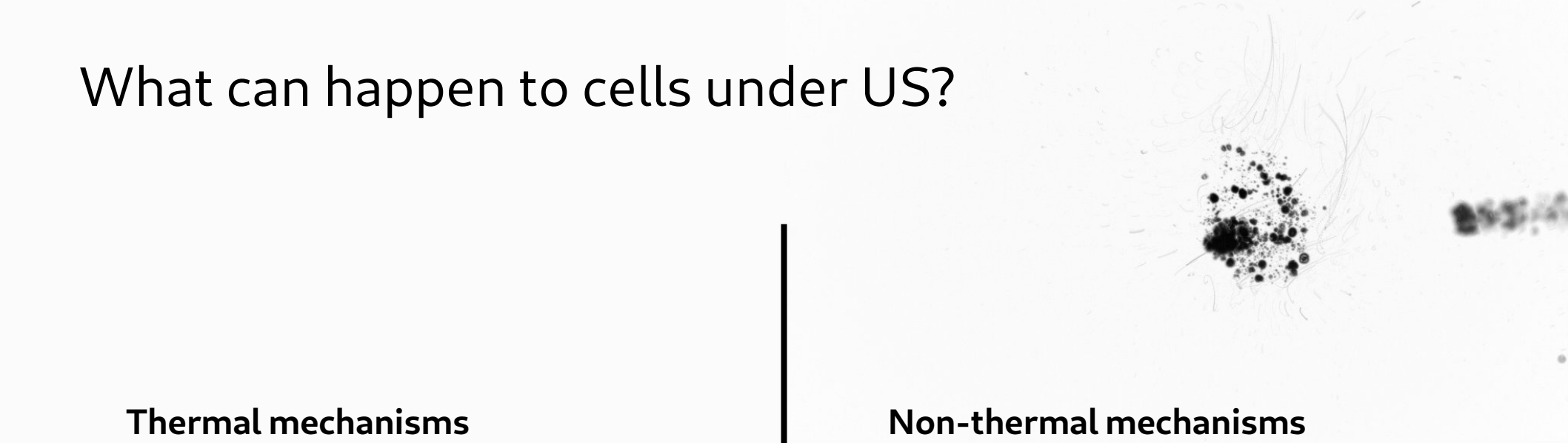


Thermal mechanisms

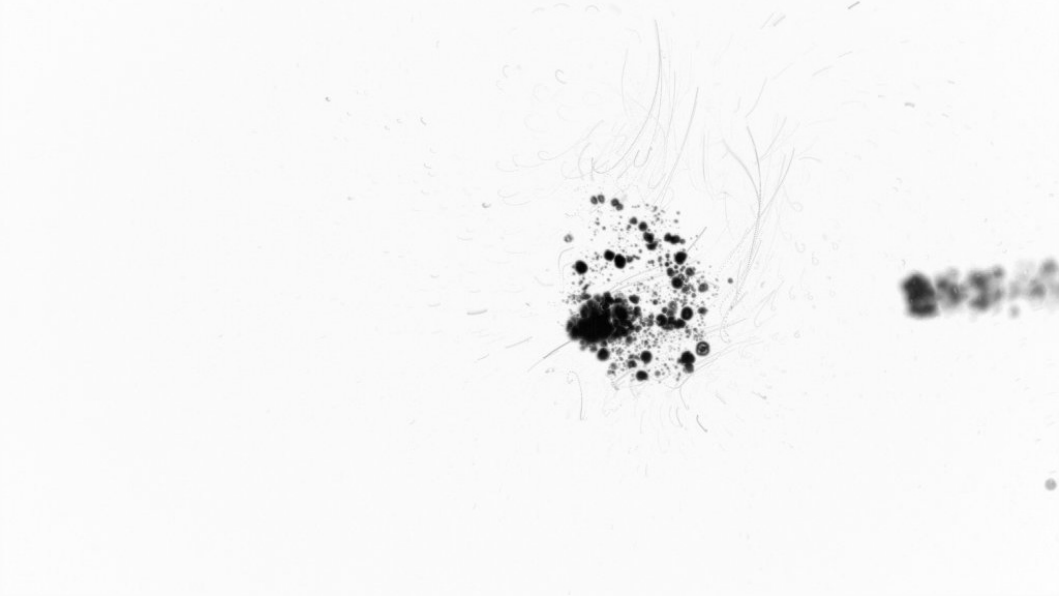
- wave absorption

Non-thermal mechanisms

- radiation forces
- bubbles nucleation
- bubbles oscillation

Thermal mechanisms:

Energy deposition



Non-thermal mechanisms:

Radiation force: 1D example

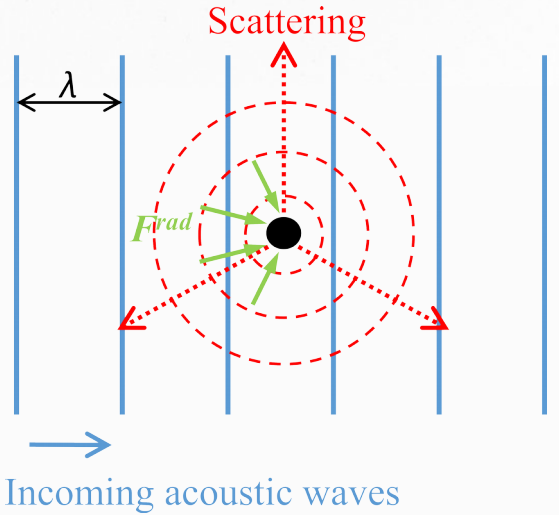
$$p_{ac} = p_0 \cos(kx) \sin(\omega t)$$ steady acoustic field

$$\boxed{F^{rad} = V_0 k E_{ac} \sin(2kx) \Phi}$$

$$E_{ac} = \frac{p_0^2}{4} \rho_f c_f^2$$ acoustic energy density

$$\Phi = \frac{5\rho_p - 2\rho_f}{2\rho_p + \rho_f} - \frac{\rho_f c_f^2}{\rho_p c_p^2}$$ **acoustophoretic** contrast factor

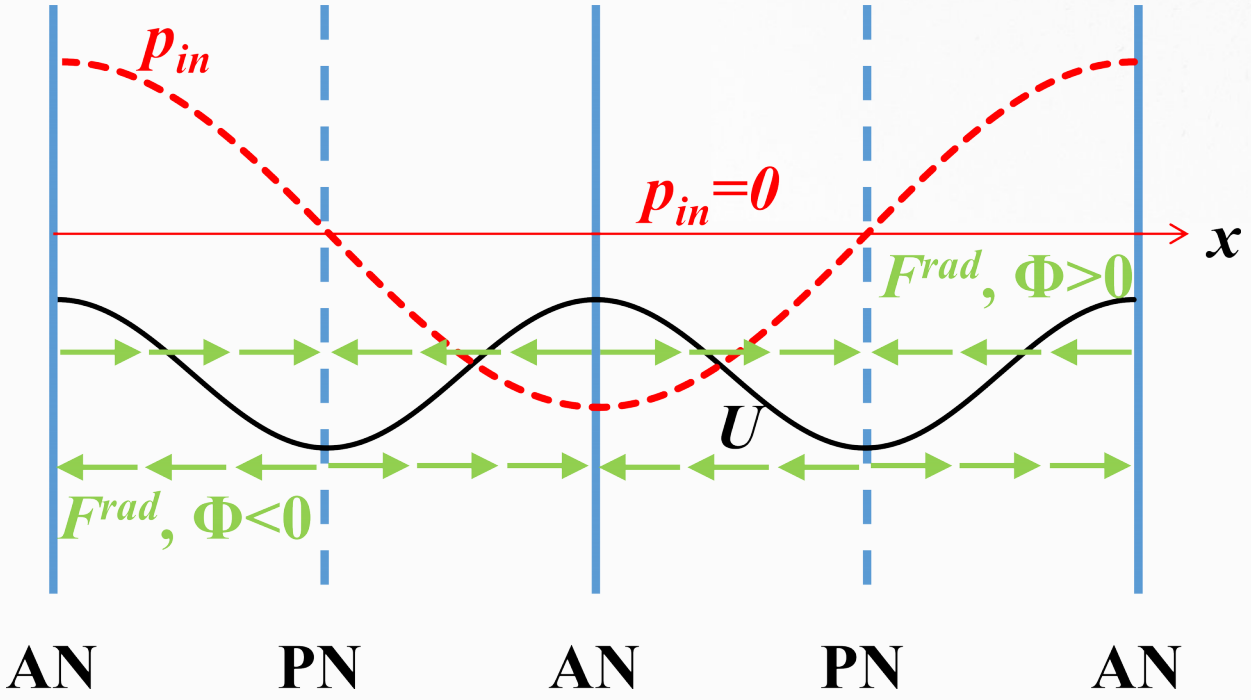
(More info: Bruus, Henrik (2012) 10.1039/c2lc21068a)



By Rsla1 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=33333920

Non-thermal mechanisms:

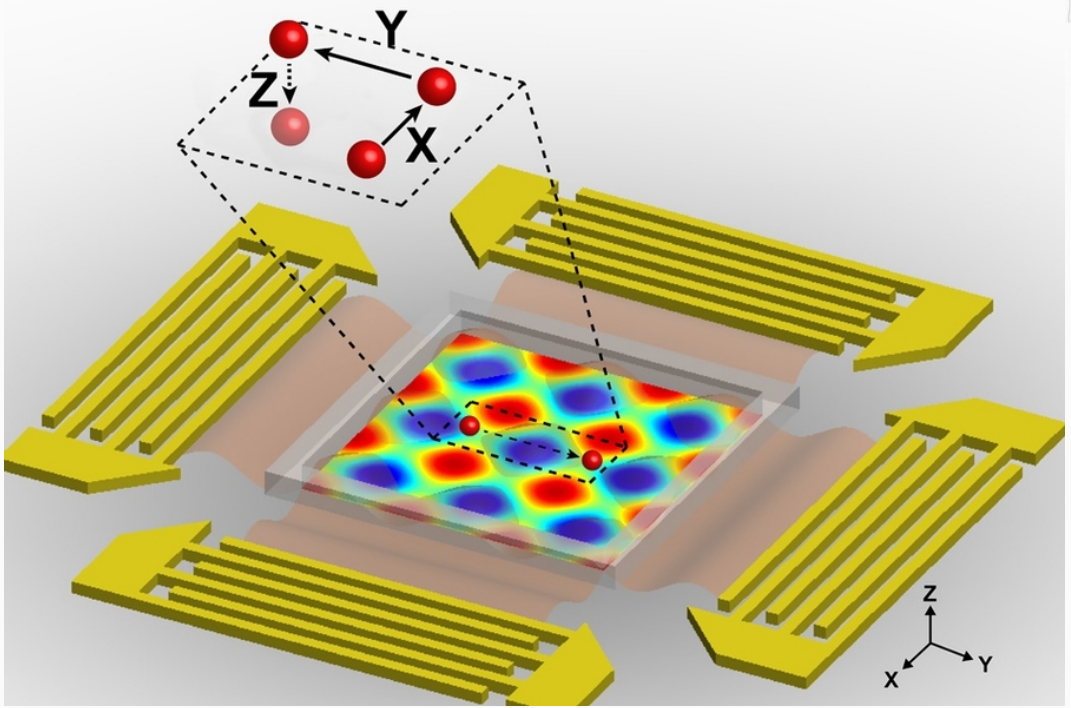
Radiation force



Non-thermal mechanisms:

Radiation force: acoustic tweezers

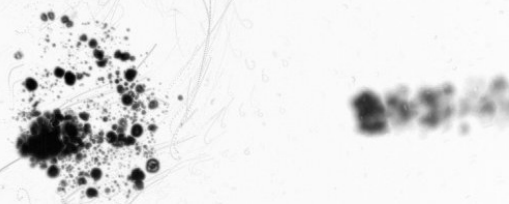
(video courtesy of Marmottant, P. and Thibault, P.)



Feng Guo *et al.*

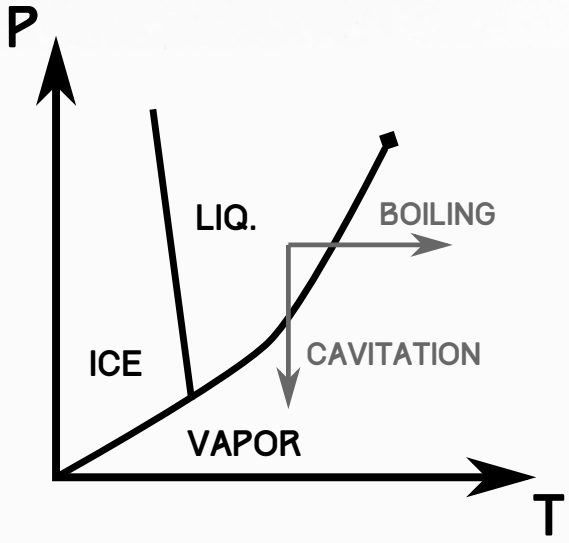
Non-thermal mechanisms:

Cavitation



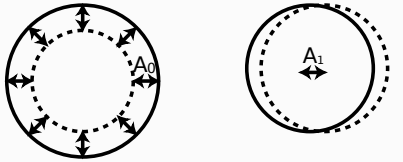
<u>Cavitation:</u> gaz bubbles that can nucleate in a liquid under low pressure.

Happens during decompression illness, in US cleaners...



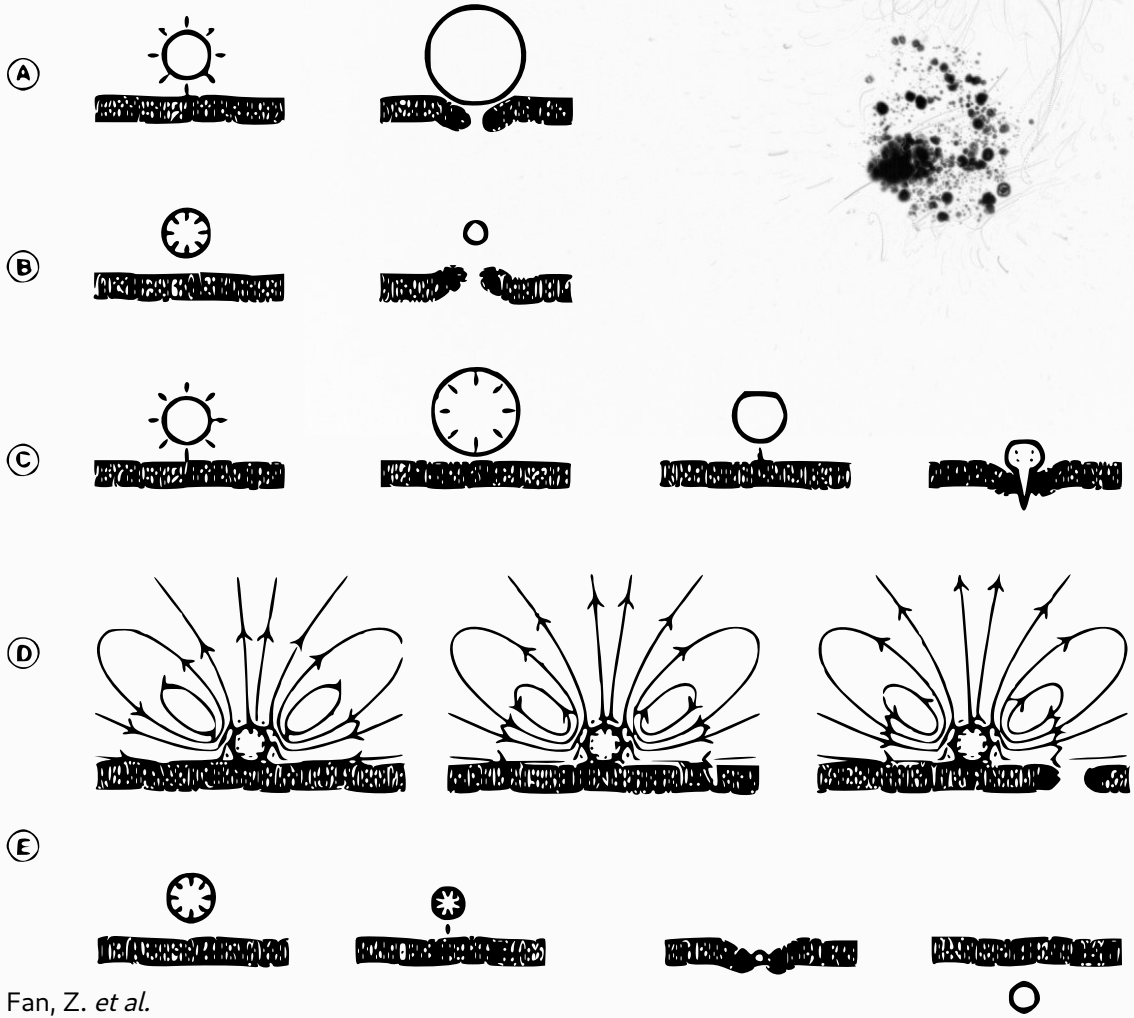
Non-thermal mechanisms

Examples of potential cavitation effects on a membrane



Mode 0 (pulsation)

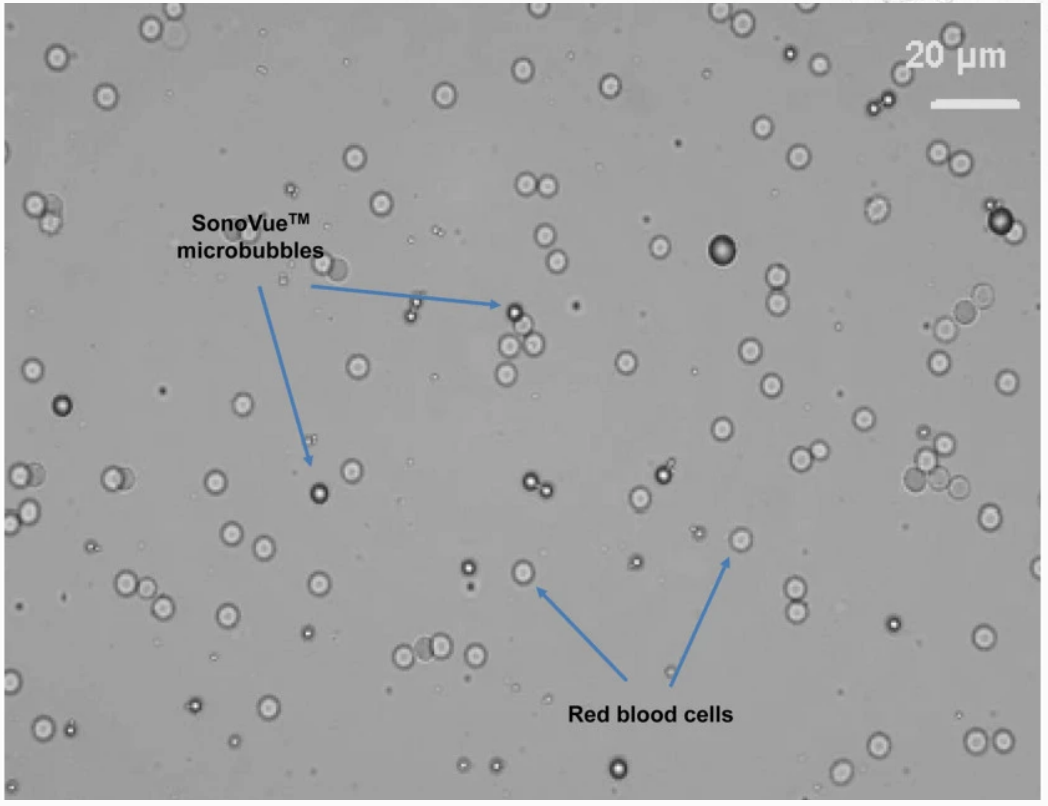
Mode 1 (translation



Adapted from Fan, Z. *et al.*

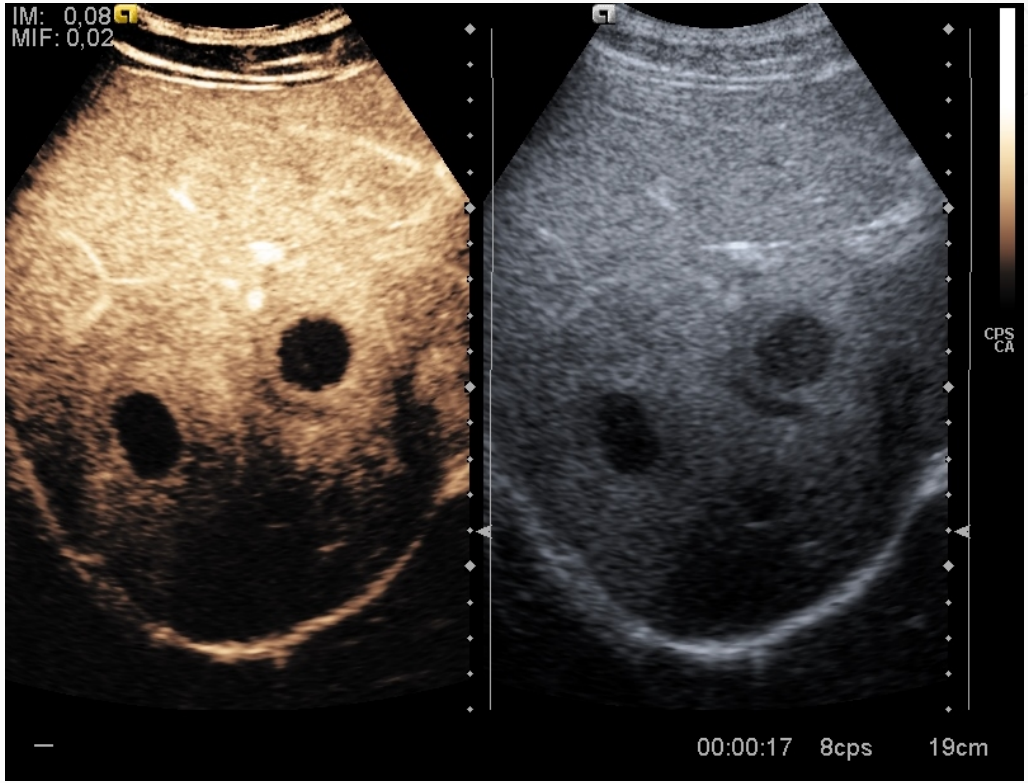
Non-thermal mechanisms

Ultrasonic Contrast Agents (UCA)



Non-thermal mechanisms

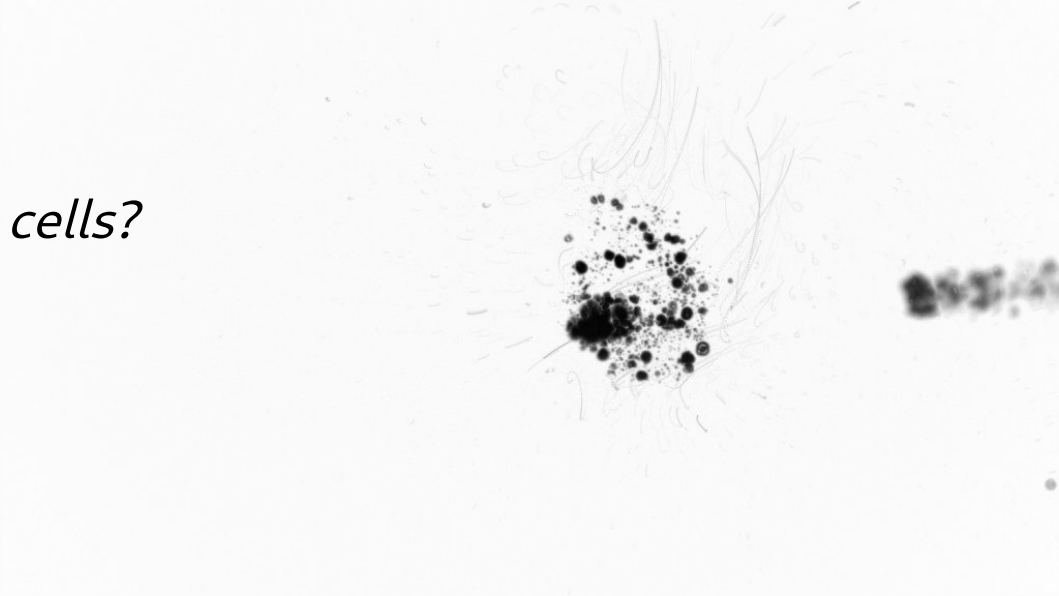
Ultrasonic Contrast Agents (UCA)



Case courtesy of Dr Teresa Fontanilla, Radiopaedia.org, rID: 30925

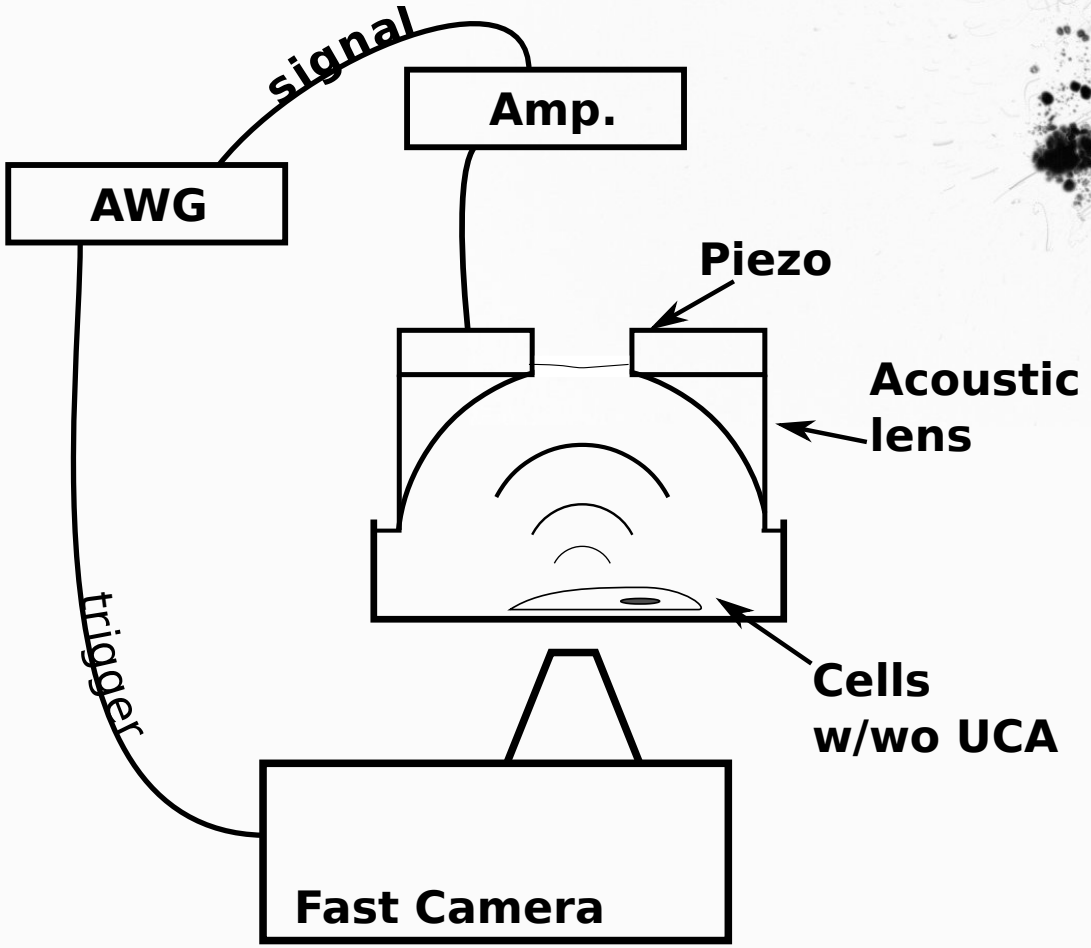
Today's experiment

Are UCAs increasing the effects of US on cells?



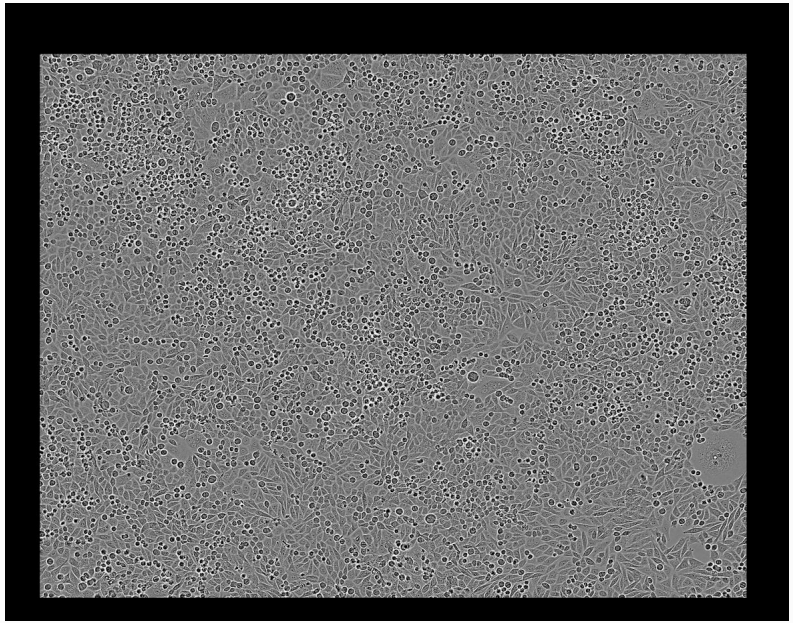
Today's experiment

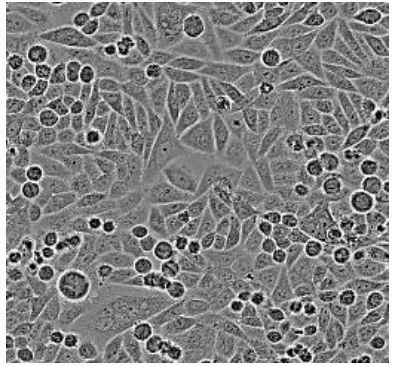
Setup for today



Today's experiment

Long run monitoring (@HTH lab)





Today's experiment

Long run monitoring (@HTH lab)