# Soft Matter Physics in 2025

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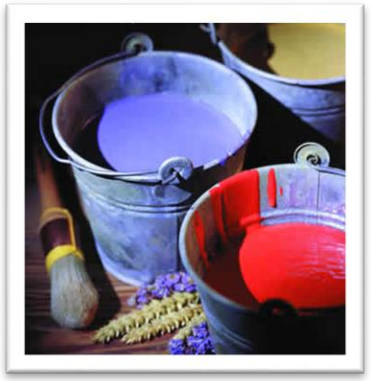
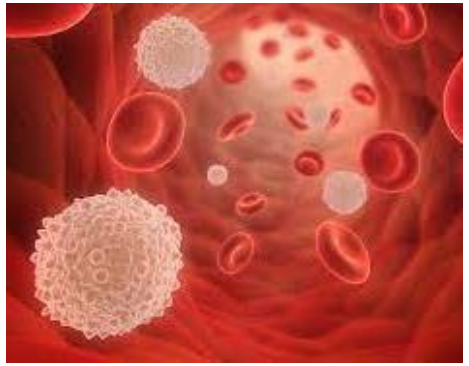
# Soft Matter in daily life

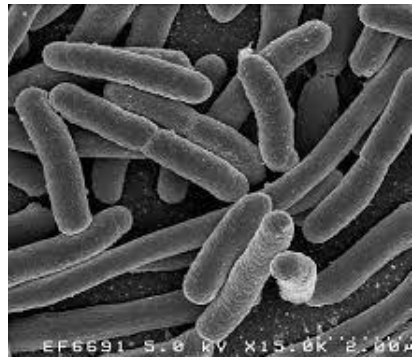
## Passive Materials



## Living systems



Blood



Gut Bacteria

# What defines Soft Matter?

## Soft matter

From Wikipedia, the free encyclopedia

*For the journal, see Soft Matter (journal).*

**Soft matter** or **soft condensed matter** is a subfield of condensed matter comprising a variety of physical systems that are deformed or structurally altered by thermal or mechanical stress of the magnitude of thermal fluctuations. They include liquids, colloids, polymers, foams, gels, granular materials, liquid crystals, pillows, flesh, and a number of biological materials. These materials share an important common feature in that predominant physical behaviors occur at an energy scale comparable with room temperature thermal energy. At these temperatures, quantum aspects are generally unimportant.

**Macroscopically:**

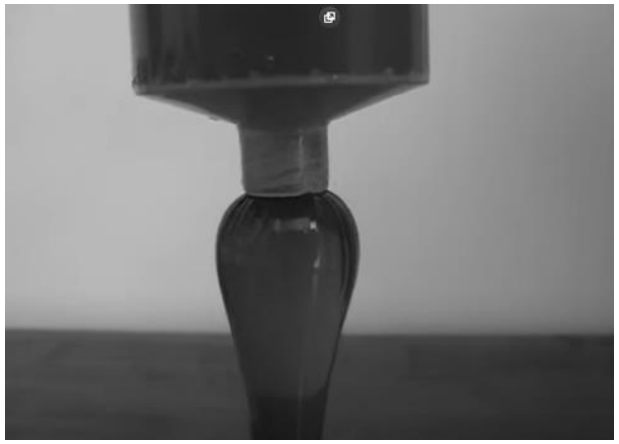
- Easy to deform
- Relaxation time(s)
- (Quasi) equilibrium

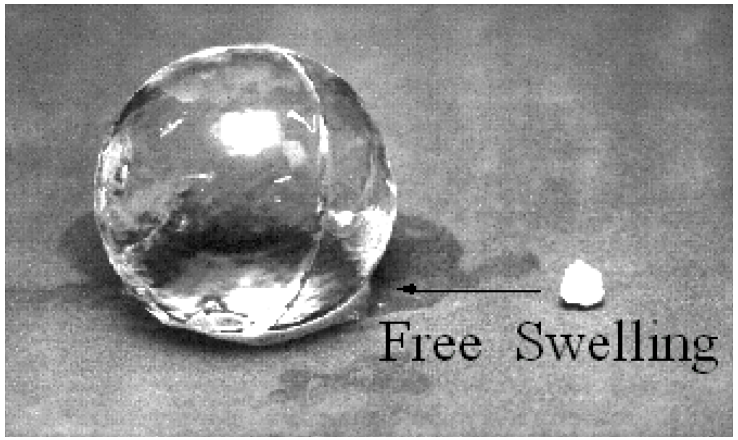
↑ **physics**

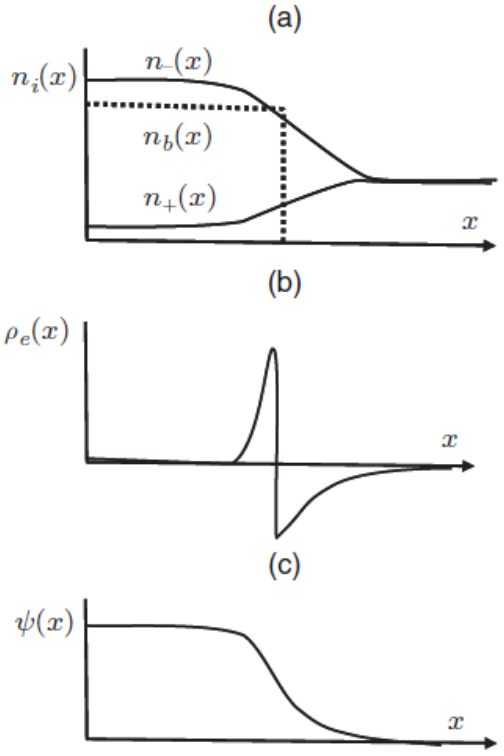
**Microscopic Origins**

- Length scales: small + ‘large’
- Thermal collisions, energy ~ $k_BT$
- Reversible self-assembly

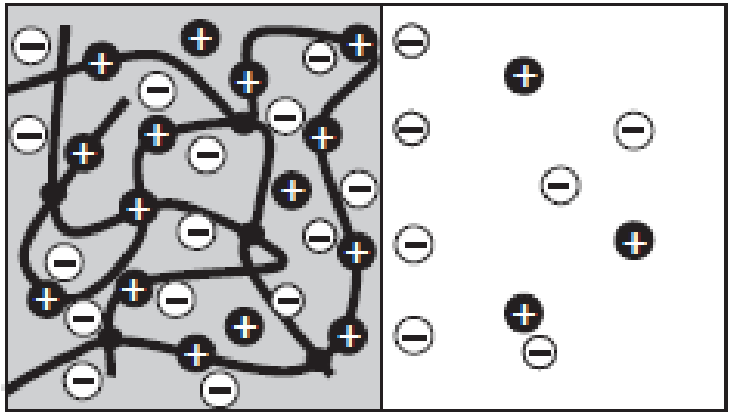
# Polymers in solution + charge and salt





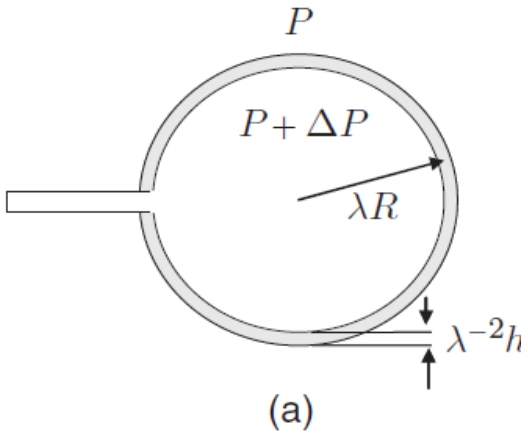





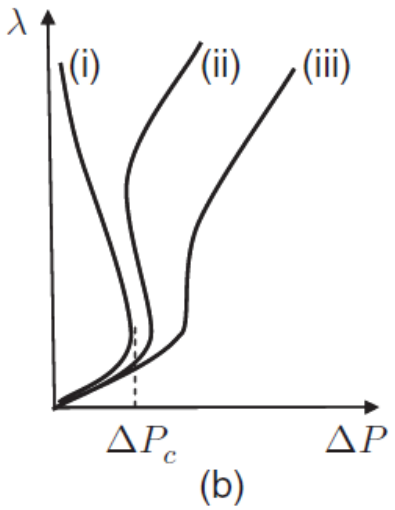


$$\epsilon \frac{d^2\psi}{dx^2} = -e_b n_b(x) - \sum_i e_i n_{is} e^{-\beta e_i \psi}$$

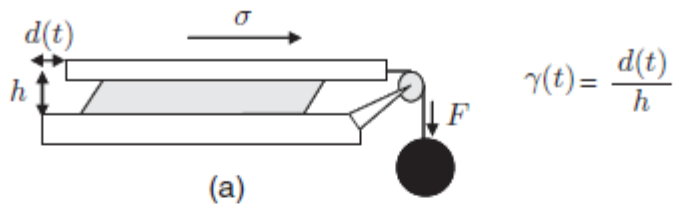
# Elastic and visco-elastic behavior



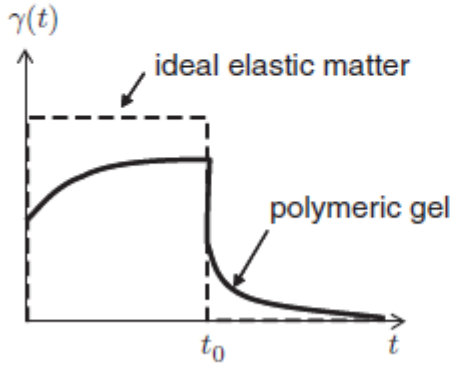
(a)



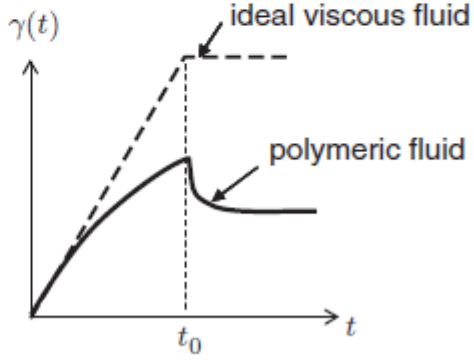
(b)



(a)



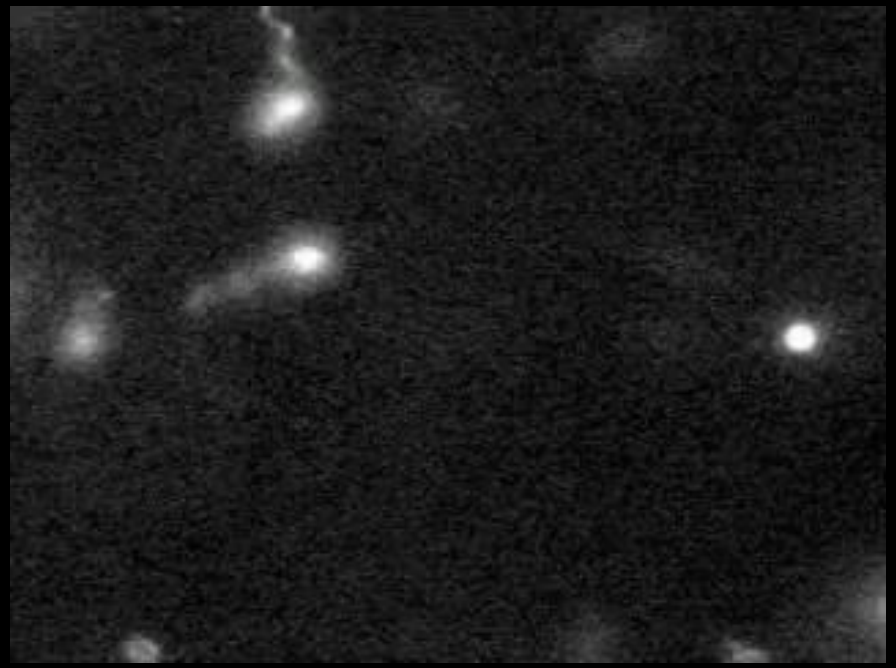
(b)



(c)

$$\sigma(t) = \sum_i G(t - t_i)\Delta\gamma_i = \sum_i G(t - t_i)\dot{\gamma}(t_i)\Delta t$$

# Colloids driven by '$k_BT$' + active motion



$$m\frac{dv}{dt} = -\zeta v + F_r(t)$$

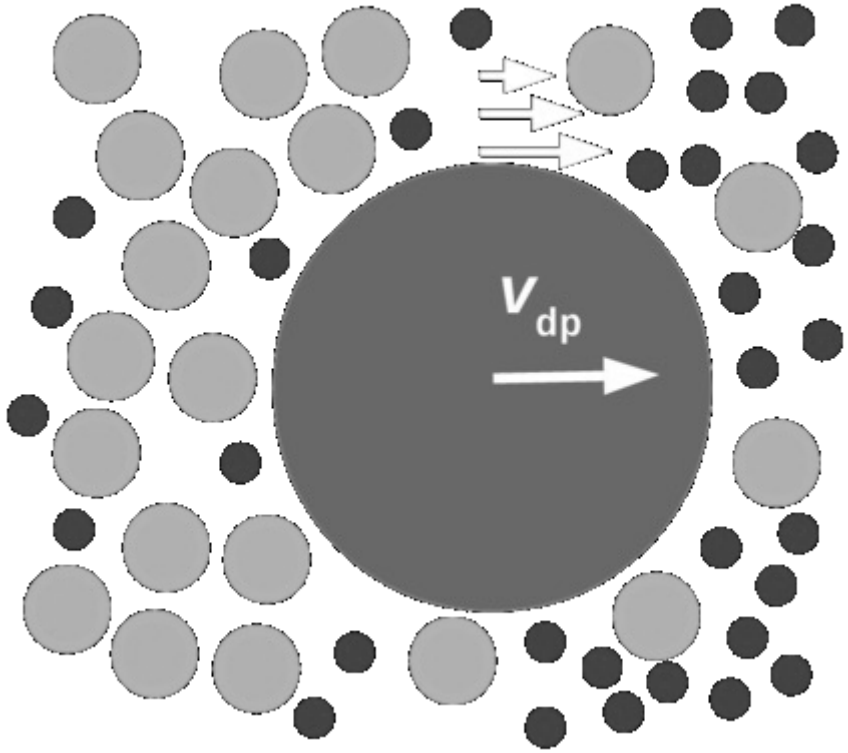
$$v(t) = \frac{1}{m}\int_{-\infty}^{t} dt_1 e^{-(t-t_1)/\tau_v} F_r(t_1)$$

$$\tau_v = m/\zeta$$

$$\langle \Delta r^2 \rangle = \langle [r(t+\Delta t) - r(t)]^2 \rangle = v^2 t^2 + 4D_t t$$

$$\langle \Delta \theta^2 \rangle = \langle [\theta(t) - \theta(0)]^2 \rangle = \omega^2 t^2 + 2\, D_r t$$

# Diffusiophoresis




$$V_{dp} = \mu_m \nabla C$$

$$\mu_m = \varepsilon \psi_{zeta} / \eta$$

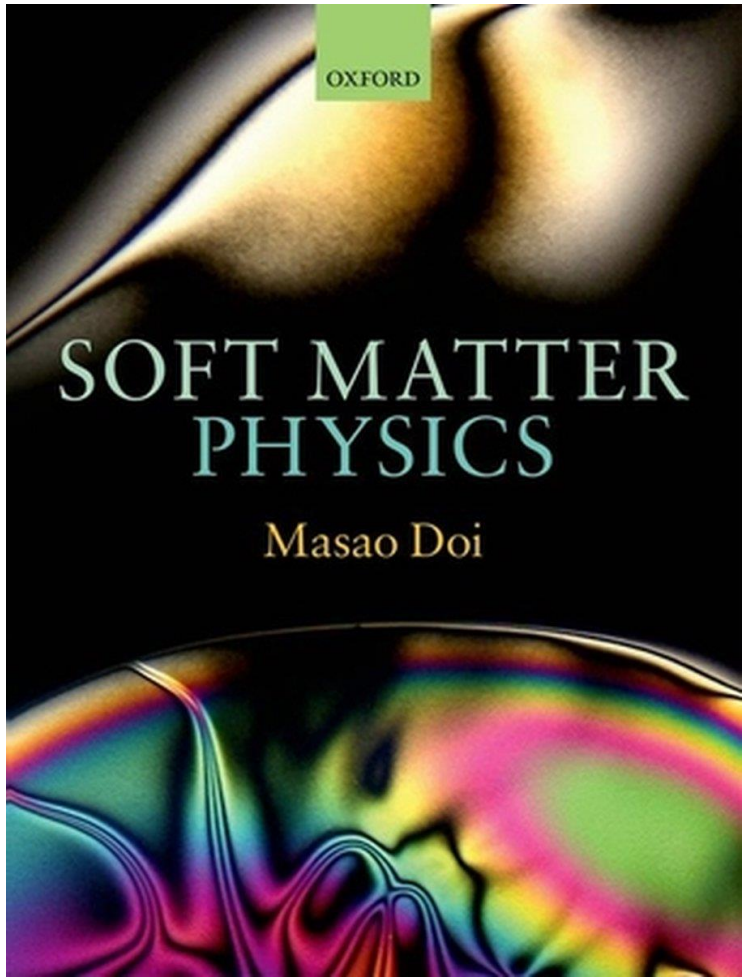
Spontaneous motion of colloidal particles or molecules in a fluid, induced by a concentration gradient of a different substance

# Learning Objectives

After passing this course you will be able to:

- Explain the link between *micro*scopic descriptions of Brownian motion and *macro*scopic diffusion laws
- Describe and solve common physical models of soft matter systems such as (viscoelastic) polymers, surfactants and ionic solutions
- Describe the key physical characteristics of active soft matter
- Interpret basic experimental data for techniques such as rheology

# Topics, Material and Organization




| Session | Date | Instructor | Topic | Material |
|---|---|---|---|---|
| 1 | Thu 6 Febr | Michel | Soft Matter solutions | Doi Ch 2 |
| 2 | Fri 7 Febr | Michel | Elastic Soft Matter | Doi Ch 3 |
| 3 | Tue 11 Febr | Michel | Tutorial Ch 2+3 | Excercises |
| 4 | Fri 14 Febr | Rao | Brownian Motion | Doi Ch 6 + slides |
| 5 | Tue 25 Febr | Rao | Brownian Motion | Doi Ch 6 + slides |
| 6 | Fri 28 Febr | Rao | Brownian Motion | Doi Ch 6 + slides |
| 7 | Mon 3 March | Rao | Tutorial Ch6 | Exercises |
| 8 | Fri 7 March | Rao | Soft Matter Dynamics | Doi Ch 7* |
| 9 | Tue 11 March | Rao | Life at Low *Re* | Slides+ Exercises |
| 10 | Fri 14 March | Rao | Active Soft Matter | Slides+ Exercises |
| 11 | Tue 18 March | Michel | Rheology | Doi Ch 9* + slides |
| 12 | Fri 21 March | Michel | Tutorial Ch 9 | Excercises |
| 13 | Tue 25 March | Michel | Ionic Soft Matter | Doi Ch 10* |
| 14 | Fri 28 March | Michel | Tutorial Ch 10 | Excercises |
| 15 | Tue 1 April | none | Literature study | Assigned paper |
| 16 | Fri 4 April | Both | Lit. presentation | |
| | Tue 15 April | Both | Exam (morning) | |