

# Tribology of orthopaedic devices: Multi-scale mechanical and physico-chemical analyses

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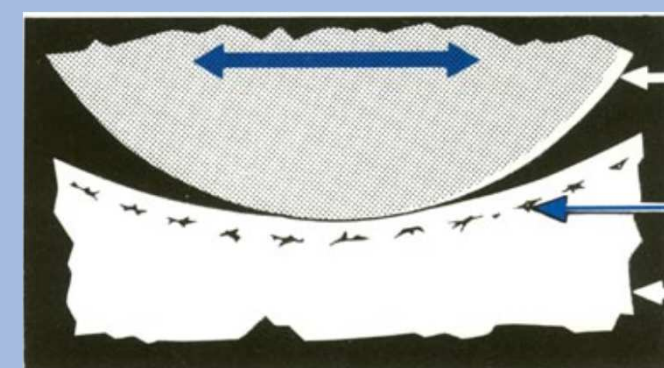
## Biomedical applications



Friction surfaces wear



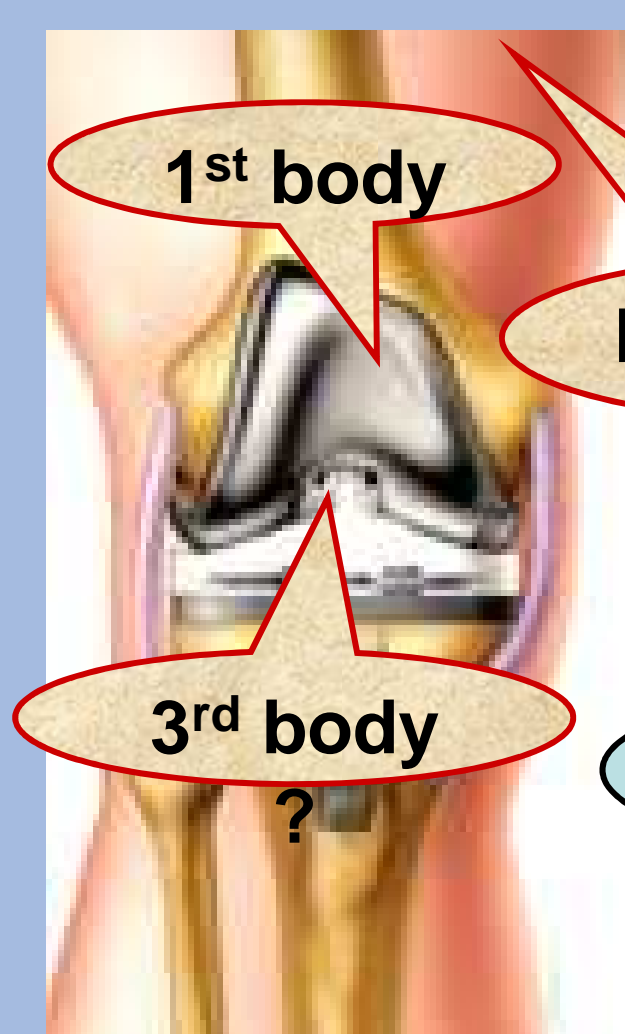
Loosening induced by small deflections at the bone / implant interface



Cracking

Metallic side  
Intern cracks  
Polyethylene

## Innovation key-points



Tribological triplet

Mechanism

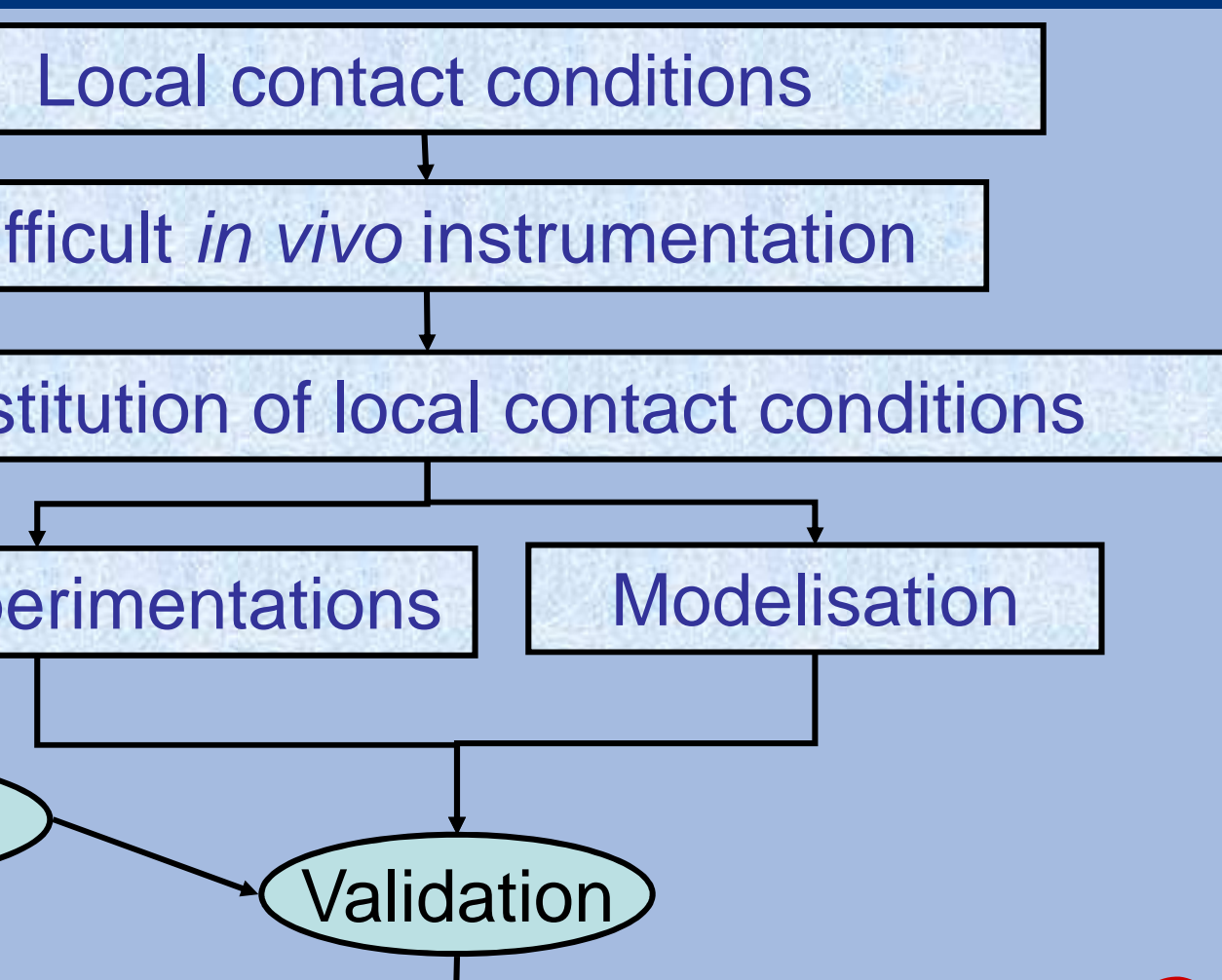
Medicine

Mecanic

Biology

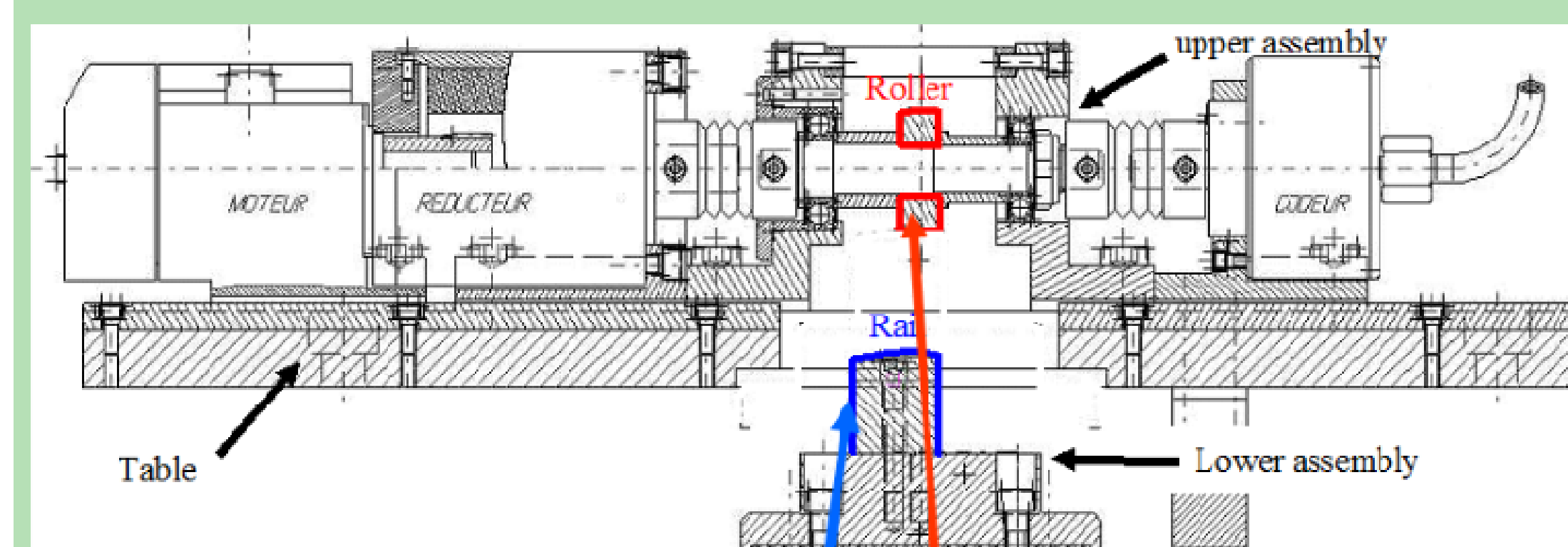
Chemistry

Materials



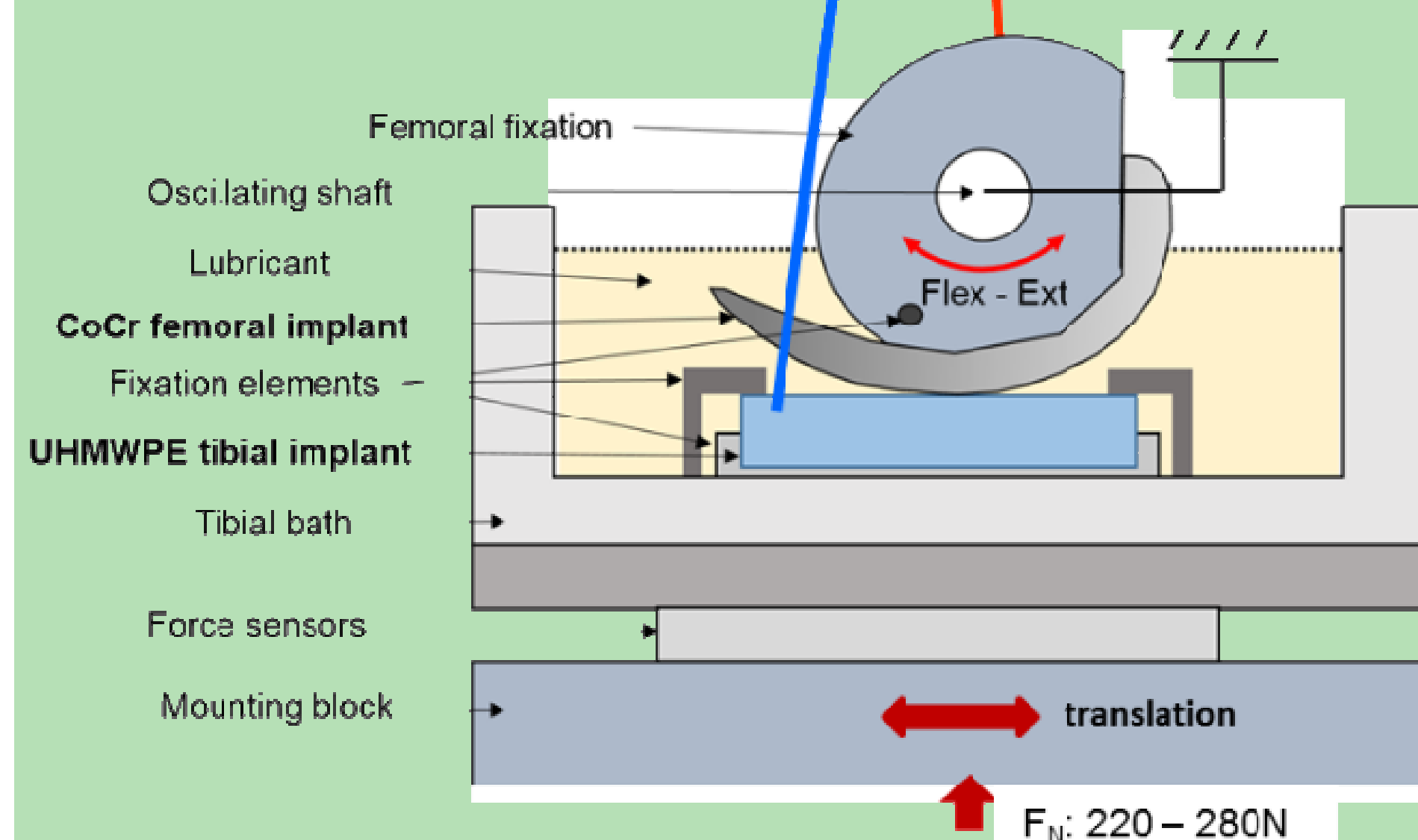
Realist tribological analyse!

## Technological processes

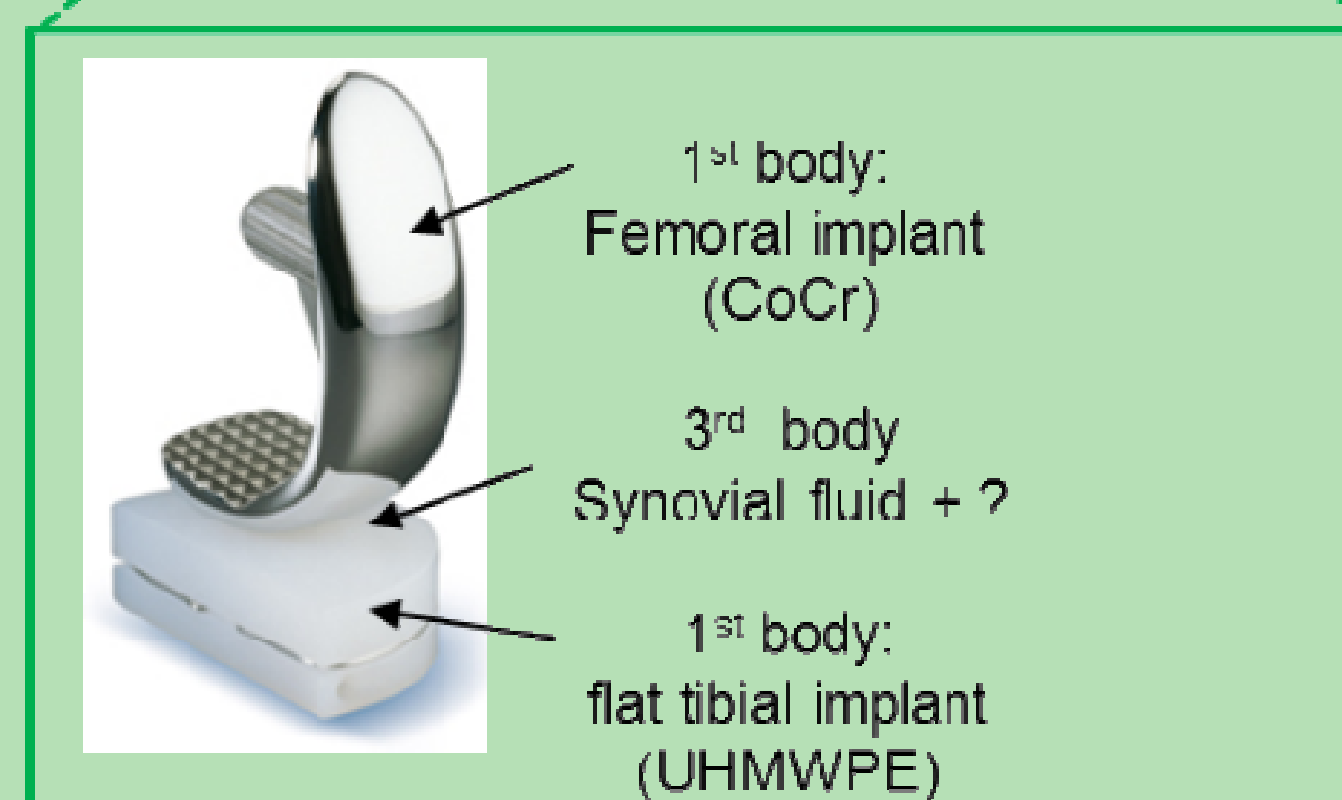
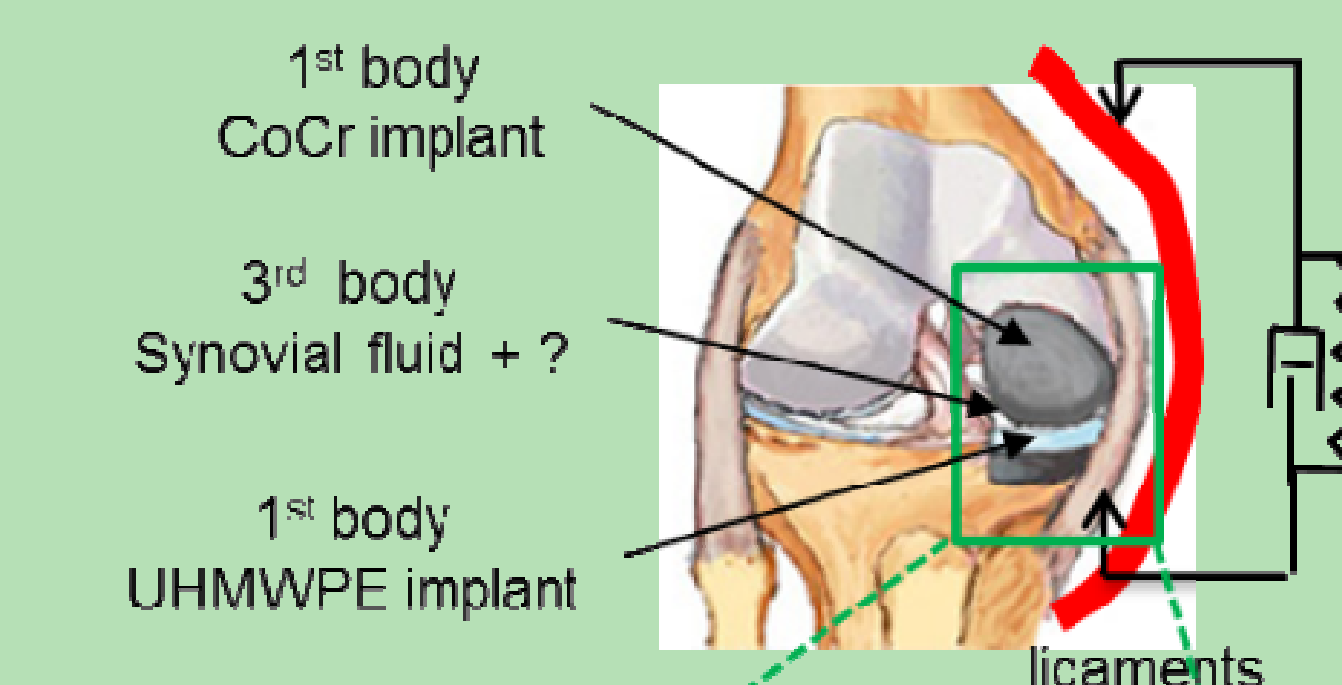


Rlt. Glt.

Simulateur Pedeba

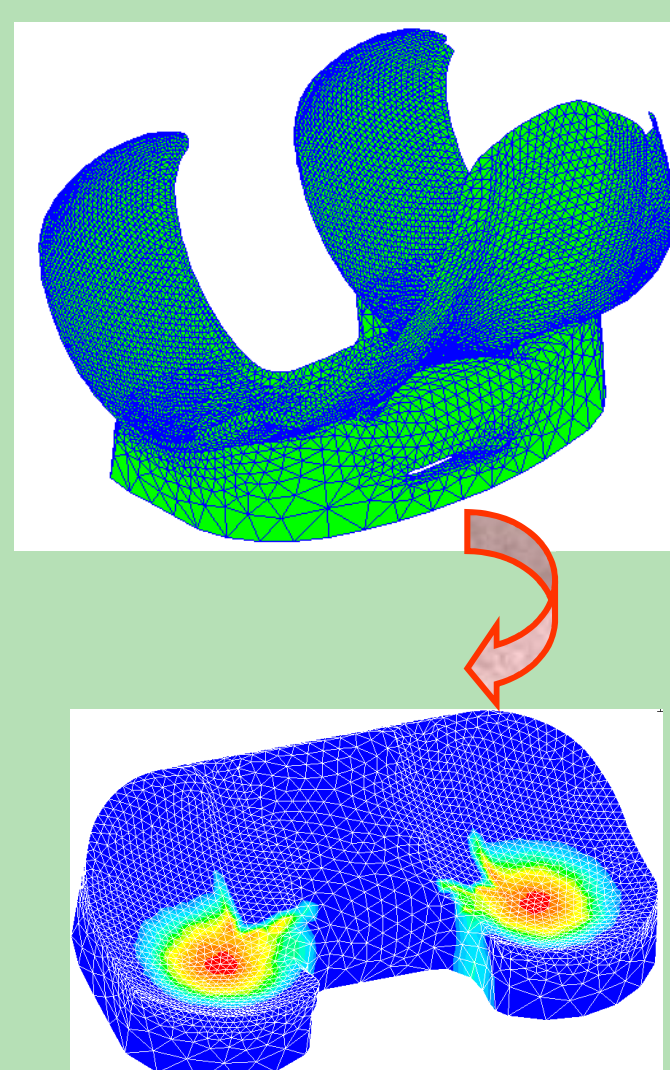


local condition replenishment utilities

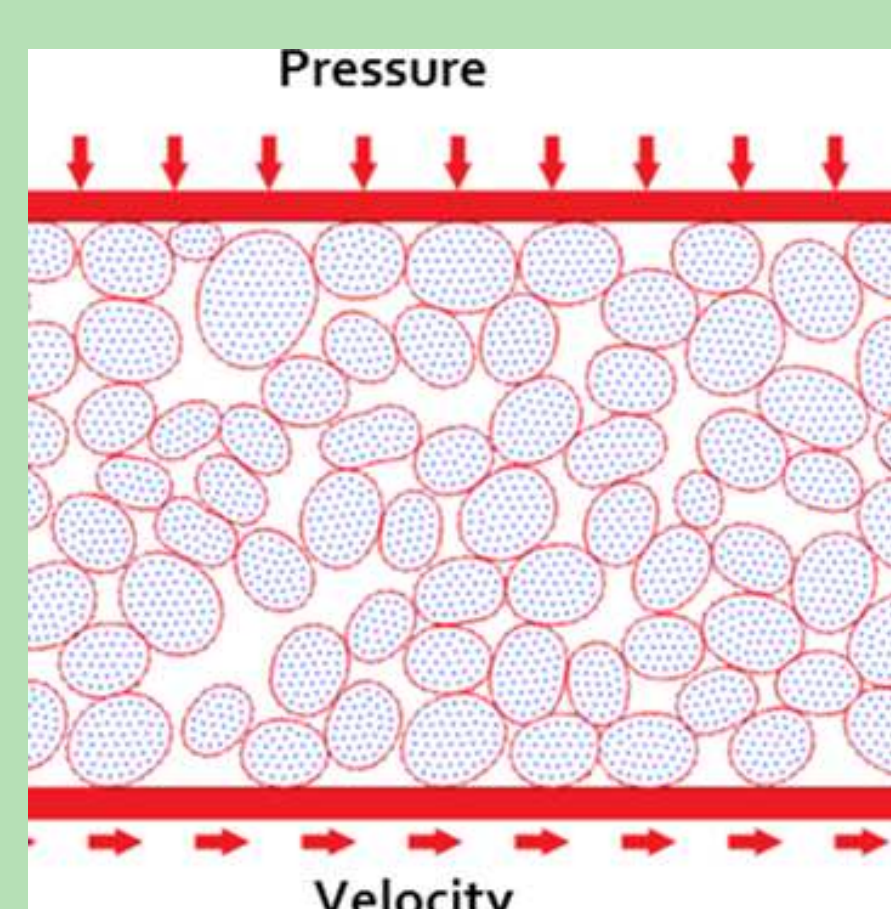


## Theoretical models

Finite element model of a knee prosthesis



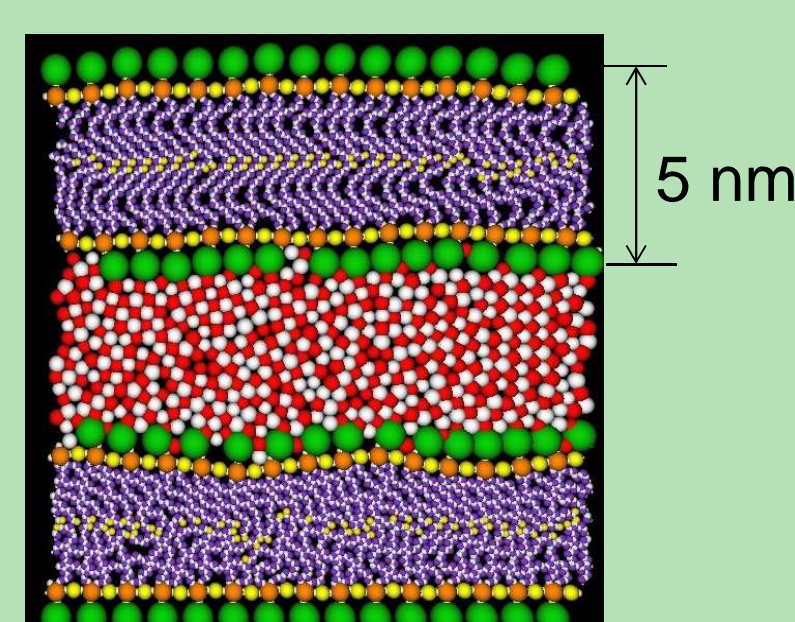
Synovial fluid multibody modelling without mesh



Lubrication model (EHD, HD, squeeze...)



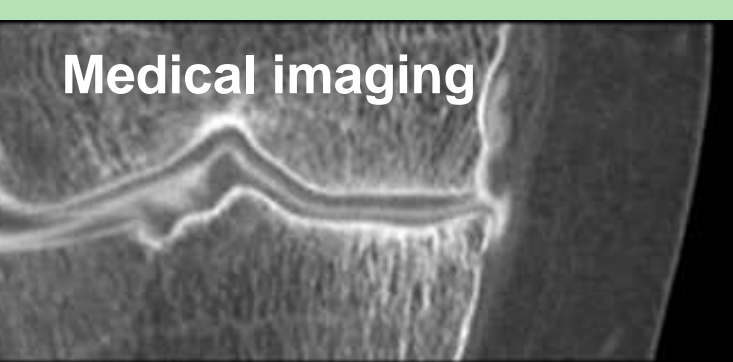
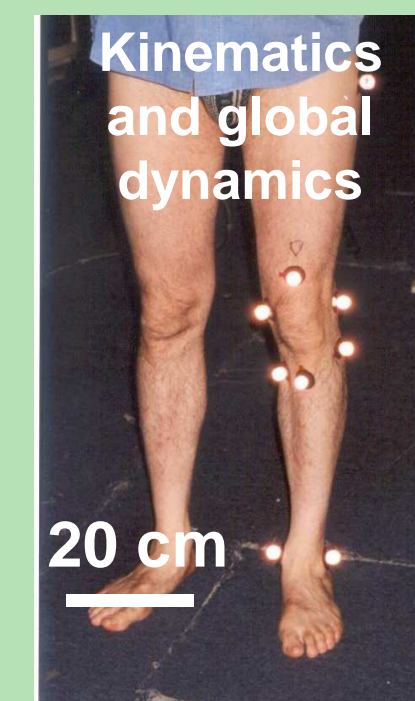
Molecular model of biomolecular interface



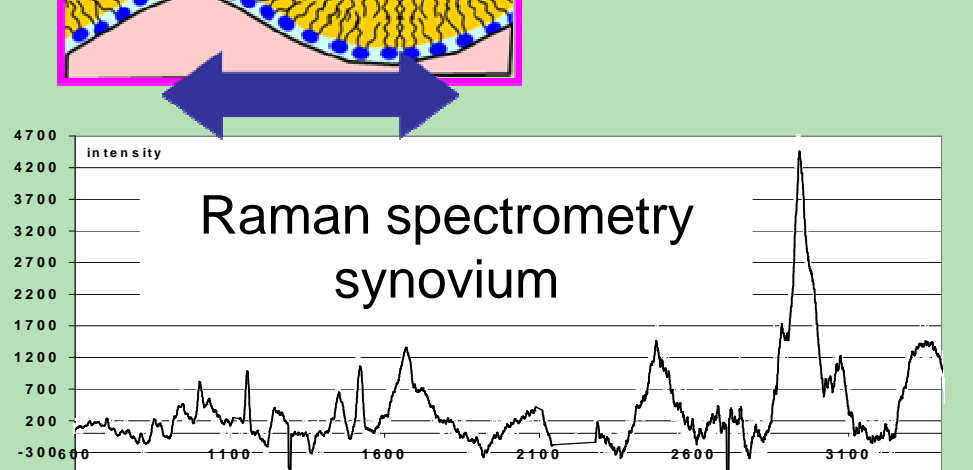
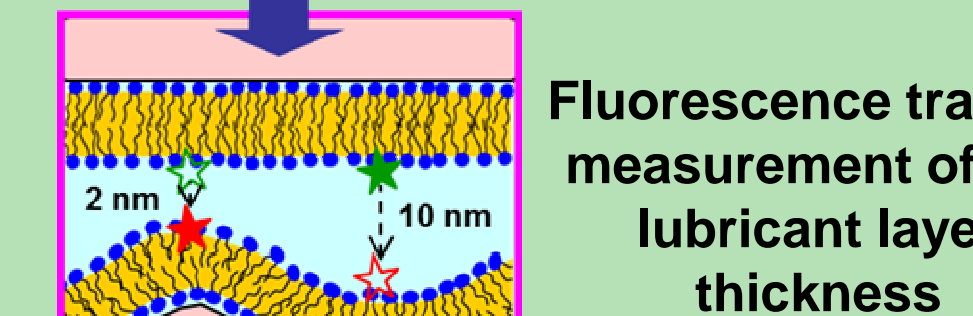
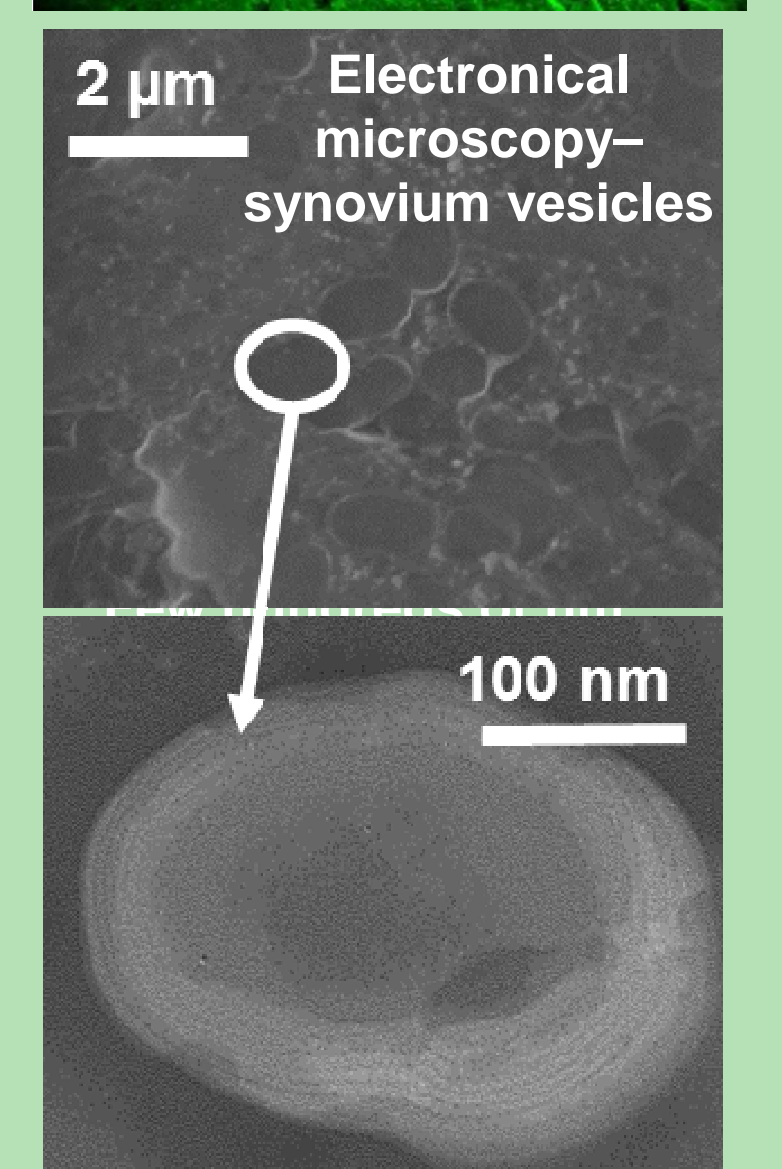
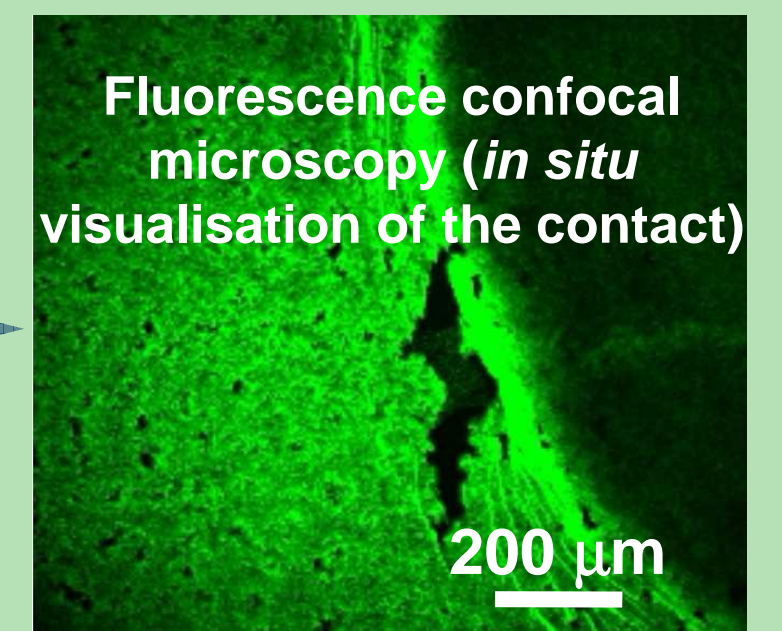
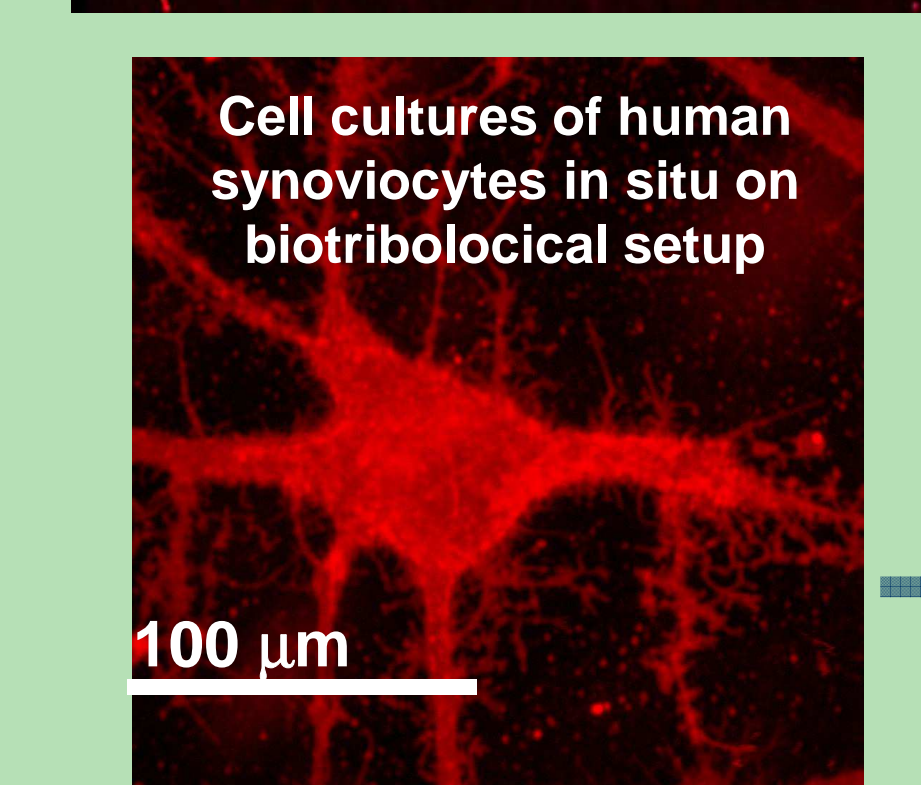
## Basic principles

### Multi-scale and multi-physics expertise

In vivo and in situ experimentations



Medical imaging



Biomimetic simulations

## State of the art

### Tribological studies of an articular implant

#### Medical problem

Many diseases that require joint implants  $\Rightarrow$  *In vivo* functioning of implants not correlated with *ex vivo* predicted functioning  $\Rightarrow$  Often inflammations and rejections of implants

#### Scientific difficulties of actual studies

*ex vivo* on implant materials in the presence of different lubricants  $\Rightarrow$  Difficulties of simulating the biological environment (synovial fluid, musculo-ligamentous system ...)  $\Rightarrow$  *In vivo* on the prosthetic articular assembly  $\Rightarrow$  Insufficient resolution to go back to local operation

**Need to know and reproduce *ex vivo* biological components having a tribological role in the operation of an implant**

## Knowledge of the laboratory

- Characterization and *ex vivo* reproduction of the biological medium
  - biomolecular structures: lipid layers, synovial gel pockets with hyaluronic acid and albumins
  - real kinematics and dynamics
- Realistic experimental models - tribometers reproducing mechanics and physico-chemistry of *in vivo* functioning
- Theoretical models at different scales (materials, lubricating film, biomolecular interfaces)