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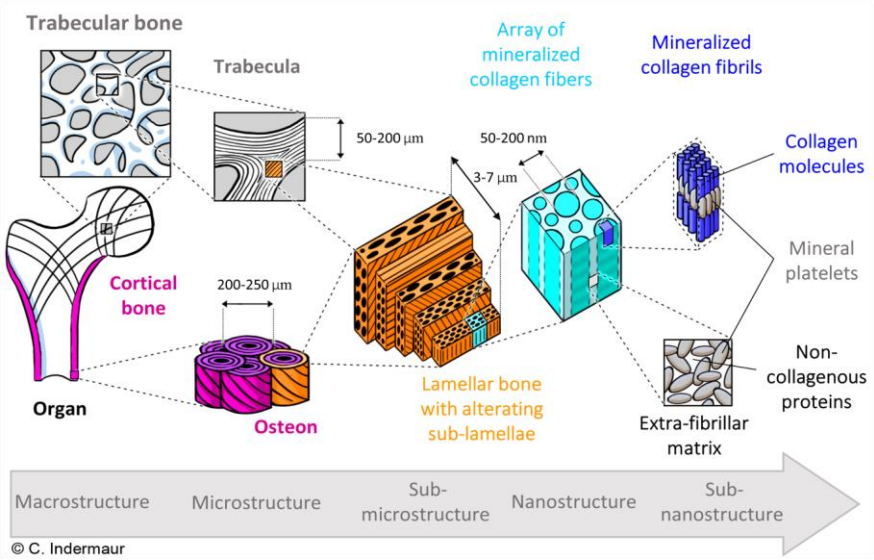
"Multiscale Bone Mechanics: From the Bench to the Bedside"

Osteoporosis is a metabolic bone disease characterized by a reduction of bone quantity and strength that results in low-energy fractures. Despite long-term research efforts, it remains unclear whether bone quality also contributes substantially to bone fragility. Bone is a multiscale composite made of mineral, collagen, and water that exhibits anisotropic viscoelasticity as well as diffuse cracking at the nanoscale and linear cracking at the micro scale along both shear and tensile overloading. Interestingly, opening of these cracks produce residual deformations at the microscale with coupled reduction in elastic modulus at the macroscale. This anisotropic, time-dependent, and non-linear behaviour of bone can be modelled in the frame of standard generalised materials to compute yield strength by finite element (FE) analysis from quantitative computed tomography (QCT) reconstructions. From a clinical perspective, the development of 2D-3D reconstructions of dual x-ray absorptiometry (DXA) images enables FE analyses of the proximal femur in a sideways fall and the establishment of a unified criterion with opportunistic QCT-based FE for fragile, low, and normal bone strength. Alternatively, high-resolution peripheral computed tomography (HR-pQCT) offers a distinct evaluation of trabecular and cortical bone structural integrity. Finally, the actual fracture risk of a bone is derived from conditional probabilities of falling, hitting the ground severely and presenting insufficient strength.



Philippe Zysset obtained a diploma in engineering physics and a PhD in biomechanics at the Swiss Federal Institute of Technology Lausanne (EPFL) in 1987 and 1994 respectively. After a postdoc in orthopedic research at the University of Michigan, he became an assistant professor in biomechanics at EPFL. In 2003, he was appointed professor of biomechanics at the Vienna University of Technology, where he founded a laboratory for nano- and micromechanics of biological tissues and promoted novel research activities in computational biomechanics. Since 2011, he is a professor of biomechanics at the University of Bern, continues his research in multiscale bone mechanics and heads a master program in biomedical engineering.