COHERENT SYNCHROTRON X-RAYS TO ENLIGHTEN THE COMPLEXITY OF BIOLOGICAL ORGANS & ORGANISMS: A MULTI-SCALE AND MULTI-MODAL APPROACH

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Over the past decades, synchrotron X-rays have open new avenues in biomedical research. The high degree of coherence and brilliance of synchrotron beams have made possible to reach unprecedented level of detail in the investigation of biological tissues through the application of advanced experimental techniques in *in-vitro* and *in-vivo* models. *Ex-vivo* studies allow optimizing experimental parameters and following the progress of diseases in sacrificed animals and/or excised tissues. Sophisticated hard X-ray setups have been developed to examine the morphology and alterations due to pathology and treatments at smaller and smaller scales, from micro- down to nano-scale, on both human and animal specimens establishing what is now indicated in the literature as 3D 'virtual anatomical histology' by X-ray imaging. However, *ex-vivo* investigations cannot access functional parameters that are fundamental in the understanding of a pathology. Elucidating the 3D structure and real-time function of organs *in-vivo*, at small length scales, is one of the most challenging applications of synchrotron radiation biomedical imaging. Dynamic measurements using methods such as X-ray phase-contrast imaging or multi-energy imaging are crucial to study organ structure and function (brain, lung, cartilage etc.). Thus, while exploring at higher and higher spatial resolution is key to understand some of the basic features and bio-mechanisms, 3D *in-vivo* imaging may allow gaining insight on the full organism and its physiological interconnections. These are the two opposite and complementary main directions along which synchrotron radiation can play a key role in biomedical imaging research filling the gaps of standard laboratory analysis techniques.

I am convinced and I will prove that in order to extricate and understand the complexity of biological systems (organisms) the application of multi-scale and multi-techniques approaches is fundamental and is the way to go. Results from selected scientific cases ranging from pathology detection and analysis, to the follow-up of the effects of novel treatments (including radio- and pharmacologic-therapies) will be presented. The key requirements of biomedical imaging as well as the main challenges in the field will be discussed.