

Vitacrystallography: X-ray diffraction of biological tissues for cancer detection

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In the XX century, X-ray diffraction crystallography facilitated a breakthrough in materials science, allowing the determination of electron density and, hence, atomic positions from the angles and intensities of X-ray scattering. Later, in *biocrystallography*, this approach was extended to biological molecules. After crystallization, an electron density map can be constructed from X-ray diffraction data, and the molecular structure can be resolved.

We have further extended the X-ray diffraction to whole living tissues without crystallization. The extracellular matrix (ECM), which is not crystalline per se, contains many elements that exhibit structural periodicities that can contribute to X-ray diffraction patterns, such as collagen, keratin, adipose tissue, and water. These ECM components can be altered by cancerous cells, and the resulting cancer-induced modifications can serve as structural biomarkers.

In this presentation, three possible implementations will be addressed. First, this approach can be applied to small samples from the pathological lab for fast classification, serving as a triage procedure for histopathology. We achieved an excellent accuracy in distinguishing normal, benign, and malignant tissues. Second, it can be used for various animal models. I will report the revealing of cancer trajectories in mice with induced prostate or breast cancer. We have shown that cancer-induced alterations in the diffraction patterns can be observed not only in the affected organ but also in remote locations, such as the animal's skin. Another proxy organ for remote monitoring of the health status is the nails. We demonstrated that the nails of healthy and cancerous dogs can be distinguished with high accuracy. Recently, this approach has been extended to human samples. Finally, actual measurements of human patients to detect breast cancer are underway in our California lab.