Use of X-ray fluorescence microscopy for archival tissue sample investigation

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Excitation and subsequent detection of element characteristic X-ray fluorescence is a simple and accurate method to determine elemental concentrations and distribution in cells and tissue sections. There are several approaches to induce elemental X-ray fluorescence—exposing the samples to electrons, to protons, or to X-rays. The last, X-ray fluorescence microscopy (XFM) has a very high sensitivity for most elements of biomedical interest. Additionally, due to the large penetration depth of hard X-rays, specimens do not need to be thinly sectioned which improves the accuracy of elemental quantification. A high throughput XFM is done at the sector 8 bending magnet (8BM) beamline at the Advanced Photon Source (APS) at Argonne National Laboratory (ANL).

We have access to a large collection of archival dog tissue samples from external beam gamma-ray and internal radionuclide exposures. A recent data analysis has shown that there was an increased probability for prostate cancer development in dogs exposed to radiation at an early age. However, random H&E analysis of these samples has shown a high fraction of possibly benign prostate disease. In order to investigate this matter further, we would like to evaluate the prostate samples by XFM as well: these dog prostate tissues were never precisely evaluated for presence of cancer vs. benign prostate hypertrophy. Scanning of archival paraffin embedded samples by XFM allows simultaneous elemental quantification of dozens of elements in tissues. Most importantly, beam spot size used for raster scanning of samples at 8BM is in most cases large enough to provide rapid scanning of paraffin embedded tissue samples. Recently, concentrations of a set of chemical elements (easily quantifiable by XFM) were evaluated in human samples of normal prostate, benign prostate hypertrophy, and prostate cancer using the particle induced X-ray emission (PIXE) technique (Guntupalli et al., 2007); this technique allowed an accurate estimate of the elemental content, but not a 2D map of the prostate tissues. Using 8BM we began to evaluate the dog prostate samples in our archival tissue repository. Preliminary data show a correlation between quantity of zinc and prostatic disease in these samples; suggesting elemental distribution similarities among comparable types of prostate disease in dogs and man.

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