Chapter 19
Utilization of Bio-Imaging in Cancer Studies

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ABSTRACT

Biological studies have always relied on visual data and its precise interpretation. Bio-imaging is an integral part of cancer research as well as the diagnosis and treatment of various cancers. Cancer research employs the various bio-imaging techniques of fluorescence microscopy like confocal microscopy, FRET, FRAP, TPEF, SGH, etc. to study the complexity and characteristics of different cancer cells. The development of live-cell imaging has also helped in understanding the important biological processes which differentiate cancer cells from their environment. Advancement in the field of cancer diagnosis has taken place with the development of sophisticated radiology techniques like MRI, CT scans, and FDG-PET. Also, the development of novel nanotechnology-based probes has improved the quality of both cancer research and diagnosis. In this chapter, the authors summarize some of the bio-imaging techniques which are being used in the field of cancer studies.

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INTRODUCTION

"Seeing is believing" is an old saying used to justify the necessity of visual evidence for a hypothesis. Science itself would not have evolved without the inventions of microscopes and telescopes. Today's science is highly dependent upon visual shreds of evidence. Biology and its branches employ most of the technology for visualization of not only the problems but also in unsheathing the solutions to those problems and this had lead to the emergence of a whole new science called bio-imaging. Biomedical Imaging or bio-imaging can be defined as a process of acquiring the biological information in the form of images or visual effects while least affecting the concerned biological process (Vadivambal R., & Jayas D. S. et al., 2016).

Initially, only light microscopy was prevalent but it was after the 1960s that the real advancement started with the emergence of wide-field fluorescence microscopy till the early 1990s. During the decade of the 1990s further dye-based fluorescent techniques were developed such as monodensylcadaverine for autophagy detection. However, with the dawn of the new century, new horizons were explored in the field of live cell imaging (Vadivambal R., & Jayas D. S. et al., 2016; Ghamsari M. S. 2018). Many new techniques were then developed to generate high-resolution images some of which will be discussed in this chapter. Today the conventional techniques are empowered with tools such as machine learning and pattern recognition to better interpret the data and draw conclusions from radiology scans, histopathology slides, etc. (Bizzego A. et al., 2019). The field of bio-imaging is vast, thus we will limit our focus to the techniques which are extensively employed in cancer research and diagnosis.

BIO-IMAGING IN CANCER RESEARCH

The development of immuno-fluorescence techniques boosted cancer research by helping the scientists to understand the histo-chemistry and complexity of tumor organization. Confocal fluorescence imaging is very often used to study the nature of cancer cell cultures (Jogalekar M. P. et al., 2018; Le Roux L. et al., 2008). The concept of confocal microscopy is to scan a section of the specimen point by point in a given plane of focus and assembling the image after scanning the entire field. Thus, it allows the optical sectioning of the specimen by scanning the specimen in X,Y and Z axis just by changing the focal plane (Reynaud K. et al., 2001). The technique and nuances of confocal microscopy have been discussed in depth by (Semwogerere D. et al., 2005; Rai V. et al., 2011). The new technological advancements in confocal imaging include live-cell imaging (Dailey M. E. et al., 2006) and endo-microscopy (Belykh E. et al., 2019). These fluorescence techniques require a source of illumination which could be a laser or any monochromatic incandescent lamp which could bleach the specimen if overexposed. Sometimes photo-bleaching causes hindrance in studying the interaction between two molecules. To overcome this problem Forster resonance energy transfer or fluorescence resonance energy transfer (FRET) was invented. FRET implies the transfer of energy from one molecule (donor) to another molecule (acceptor) which happens to be a fluorescent molecule and within proximity of the donor (Hussain S. A., 2009). It is used to study the protein-ligand interactions, the intracellular distribution of molecules, etc.. Another modification of fluorescence microscopy is the fluorescence recovery after photobleaching (FRAP). This technique took a boost after the development of fluorescent tags which could be genetically attached to the cloned proteins. FRAP implies to the permanent or irreversible photo-bleaching of a pool of fluorophore and recovery of fluorescence by the diffusion/movement of intact probes from the surroundings