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BOOK REVIEW

Essentials of *in vivo* Biomedical Imaging

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Essentials of *in vivo* Biomedical Imaging edited by Simon R. Cherry, Ramsey D. Badawi and Jinyi Qi, CRC Press, London, 2015, pp. xvi + 272. Scope: edited book, £63.99, ISBN 978-1-4398-9874-1 (Hardcover). Level: postgraduates, research scientists.

In an earlier era the only way to look deep inside the human body was by exploratory surgery or postmortem dissection, but all changed with Roentgen's discovery of x-rays in 1895. Very quickly, descriptions of symptoms and analyses of body fluids could be supplemented by images of the internal structures, providing a far more rounded and complete picture to assist the clinician in arriving at a diagnosis. Other major innovations in imaging followed after a delay, mostly after the Second World War when advances in computing and electronics could be brought into play. The 1970s was the decade of tomography when methods were devised to create 2-D slices through 3-D objects, both for x-ray images and MRI (magnetic resonance imaging), based on what had long been familiar in physics as NMR (nuclear magnetic resonance). Similar mathematical methods were applied to positron emission tomography. Ultrasound imaging grew from techniques adapted from military sonar and radar. We have now reached the stage where almost any property for which spatial information is available can be used as the basis of a new kind of imaging.

Developments in imaging all share common problems in terms of the need to optimise spatial resolution and image contrast, while minimising noise and maximising acquisition/processing speed. The need for the latter is not just to save time for patients and medical staff. All living systems evolve with time, from birth to death, and exist in dynamically quasi-steady nonequilibrium states where many processes are oscillatory in character and involve movement, for example respiration or heartbeat. So an image that takes too long to collect will inevitably become smeared or distorted. Ideally, the acquisition and processing should be fast enough to follow the movement with only tiny changes between successive "frames", as in a ciné film. Currently, only ultrasound and x-ray fluoroscopy truly meet this real-time criterion, but progress is being made on speeding up other methods too. In addition, for all imaging methods, the process should be as nonintrusive as possible, should not produce significant heating and any unavoidable changes made to the body, e.g. due to the effect of ionizing radiation, should be minimal. Cost and accessibility are of course crucially important criteria in determining whether a given imaging method is going to be useful in a clinical setting.

Cherry *et al.* have edited a book with the intention of conveying the essential features of the more important imaging methods to biomedical imaging researchers. They envisage the latter as scientists having expertise in at least two of physics, chemistry, mathematics, computer science, and engineering – in other words fit to be members of the kind of multidisciplinary team that brings new imaging methods into play and enhances and improves existing methods. They hope that the book will also be of interest to clinicians, although it is not primarily aimed at them. It is wider in coverage than most books on clinical imaging because many of the techniques and principles described are still some distance from clinical application. Also, the approach adopted tends to be more quantitative.

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Perhaps surprisingly, at first sight, the book includes nothing whatever on the light microscope, despite its images having played a pivotal role in the history of medicine since the 1600s. However the omission is fully justified because the microscope does not normally provide *in vivo* imaging of the body, but more usually the analysis of tissue samples. Following an introductory overview by the editors, there are chapters on imaging by x-rays (including tomography), MRI, ultrasound (including Doppler applications), optics and photoacoustics, and radio-nuclides. Each of these chapters focuses on the fundamentals of how the signals are generated and on the characteristics of the corresponding images of which a huge number of interesting examples is presented, mostly in colour, for both humans and laboratory animals. The final chapter discusses image analysis techniques and problems that most of the different imaging methods share in common. There is an extensive and very necessary glossary listing the meanings of the abbreviations and acronyms that are scattered throughout the text.

Have Cherry *et al.* and the chapter authors succeeded in their aim? My feeling is that yes, they have, to a very large extent. Obviously the choice of imaging techniques has had to be restricted. Some recently-introduced and highly promising methods are not included, e.g. NIRS (near infra-red spectroscopy), and the coverage within chapters has needed to be fairly succinct, e.g. covering all of MRI within 40 pages. However, the scientific principles are clearly presented in each case and discussed in reasonable detail, the advantages and drawbacks are considered, and the examples of images give an excellent idea of what can be achieved. Lists of references and/or suggestions for further reading are provided at chapter ends. The book is well written and attractively produced and I believe it will prove genuinely useful to the target audience and also to a wider range of scientists who make use of imaging for their work or find the topic interesting.

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