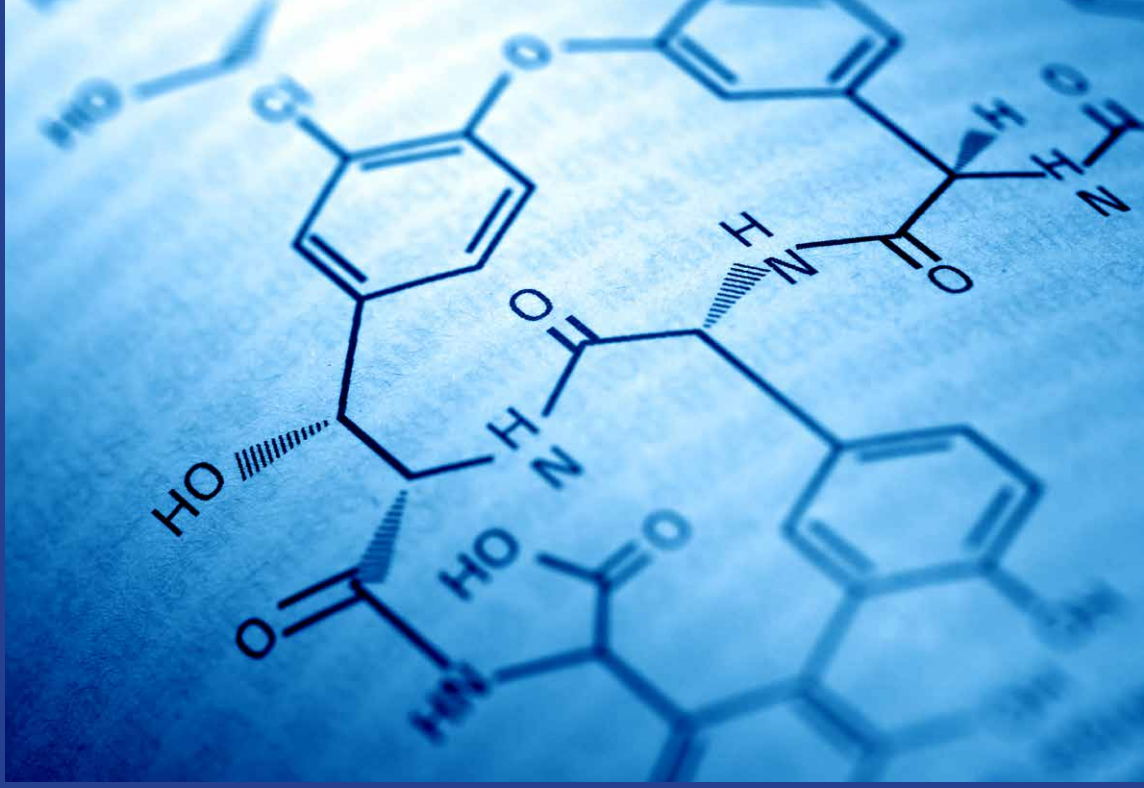

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The PET Method

Tracer Principle and Radiochemistry

Steinbeis-Transferzentrum
Institute for Radiopharmacy

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to
our families
and in particular
our youngsters
Alexander, Desiree, Lamar and Yousef

Preface

In medicine beside CT and MRT, Positron Emission Tomography (PET), combined as PET/CT or PET-MRT, is one of the *Molecular Imaging* modalities. Many colleagues and authors have continuously been involved in new developments within both research and clinical application as annually presented in the corresponding meetings in Europe and US. Yet, colleagues in many neighboring disciplines are still not aware of those developments. There are even large areas in which the PET Method has not really been recognized at all during the past three decades.

Among those imaging techniques, PET is more than just another procedure, it is a method exhibiting a unique role due to the fact of assessing metabolic processes. The PET radionuclides, which are typically applied, have short half-lives. That means, the compounds labeled with such radionuclides have a very low mass like 10^{-6} g and even less, as administered in a whole body dose. Thus, the metabolic processes to be studied are not altered while ongoing within the organism. Therefore, these compounds (tracers) allow to *"trace"* the biochemical processes of interest directly within the organism. In principal, the PET Method gives the possibility of a direct transfer from the *in-vitro* to the *in-vivo* level that means the translation from the static to the dynamic biological system. Therefore, *in-vivo* examinations are performed in animal models and can be transferred to humans directly in a subsequent study.

Among the PET radionuclides, carbon-11 is well suited for labeling any molecule without changing the biological properties. That has opened an outstanding possibility in drug research. Examinations in animal models show directly the kinetics of the metabolic turnover, provided that differences in circulations are considered. That approach, however, is practically not in use in drug development. Despite a few examples, it must clearly be stated that in pharmaceutical research and drug development, the PET Method is not used. In oncology, clinical trials are usually not controlled for multi-drug resistance (MDR). So the failure of such a trial may be due to the bad quality of the new drug, the presence of MDR or both. During the past twenty years even direct discussions with responsible CEOs never changed the route of drug development.

In general, follow-up studies in therapy and control of treatment strategies are immediately realized by applying the PET Method. In therapy of breast or prostate tumors, for example, response can be determined after two weeks and strategy of treatment may be changed in case of nonresponding patients. In neurology and psychiatry a typical example is the treatment of depression by SSRIs. That may directly be controlled by PET measurement of occupancy of serotonin transporter. In particular, the application of the PET Method in the field of brain receptors has opened a wide field in neurology and psychiatry.

The PET Method is slowly, but continuously developing and exhibits a driving force and its application remains a challenging and rewarding task in scientific and medical research. That gave the impact for this book to describe and explain applications and progress of the PET Method to students and colleagues in the neighboring disciplines within scientific and medical research.

May 2016
The Authors

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The Authors

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Aim

The PET Method plays a unique role because it makes it possible to monitor ongoing biochemical processes within the organism by a registration outside of the body. This ability is directly attributed to radioactively labeled compounds, which allow PET registration to provide a highly specific and selective assessment of the metabolic function of interest. The combination of PET measurements with CT or MRT localizes the registered metabolic alterations anatomically, which is necessary in clinical applications.

In general, PET is more than an imaging modality: it is a biochemical method based on the *Tracer Principle*, and most importantly, it is applied *in vivo*. A pre-requisite is the radio chemistry for radionuclide production, radiosynthesis and radioanalytics. Taken together, for applications in experimental, i. e., preclinical research areas and clinical diagnostics, the PET Method opens new dimensions of opportunities, for which impressive examples exist.

In the past, physical, technical and scientific methods and procedures had to be handled by highly specialized and experienced radiochemists and other experts, but meanwhile the tools, methods and procedures have become so well developed that the preparations for the PET Method are standard procedures in any radiochemical laboratory. This development is particularly well illustrated by the fact that, as self-shielded units, cyclotrons can be installed in any room or a building without special constructions.

It is the aim of this book to bring together

- the potential of the *Tracer Principle* applied in the PET Method,
- the basics of radiochemistry, offering a versatile array of radiosynthetic procedures and
- important examples illustrating the broad spectrum of experimental and clinical applications.