Foreword

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Biosensors have become indispensable modern-days analytical tools which offer high performances (sensitivity and selectively) that are superior to any other diagnostic devices. Thus, researchers in this field are continually confronted with problems associated with the implementation and the design of new biosensors and their adaptation for eventual distribution to future users and customised applications.

First of all, it is important to define the word "biosensor". A biosensor is an analytical measuring tool comprised of a biological element of known molecular properties tightly coupled to a physical transducer responsible for converting the biological signal into quantifiable information (Fig. 1). Therefore, the biosensor selectivity is induced by the immobilisation, in the sensitive area of the detector, of the biological component (enzyme, DNA receptor, antibody, antigen, microorganism, cell, etc.) specific to the target analyte. The molecular recognition then corresponds to the association of the biological element and its target molecule (analyte) through an association such as: enzyme-substrate, antibody-antigen, receptor-hormone, complementary DNA sequencing, etc. These associations maximise the capacity of the biomolecules to recognise a unique substance among various substances.

The combinations of recognition-transducer systems are numerous and this explains the many definitions and nomenclatures of these types of sensors. The main methods of transduction that are the most current and well developed, from both a fundamental and experimental point of view, are: electrochemical, optical, acoustic and thermal. Figure 1 summarises examples of transduction methods for each of the categories cited above.

Besides this classification of biosensors, which is based on the energetic type of transduction method, it is also interesting to cite their classification based on the chemical nature of the alliance between the biological element and the target molecule. The resulting chemical transduction may be governed by:

– The transformation of the target analyte by one (or several) biocatalytic processes involving the biological component fixed on the sensor's sensitive area. This is the case with biosensors containing enzymes, cells or biological tissues.

– A specific interaction between biological components fixed in the sensor's sensitive area and the target analyte, resulting in a particular bioaffinity between them and then their binding. This is the case with antibody-antigen, complementary DNA sequences, etc.

The numerous varieties of biosensors, their analytical stakes and their medical, clinical biological, chemical, biotechnological and environmental repercussions explain the numerous publications and the abundance of international meetings and conventions that exist, regarding this subject. Among the existing writings, that of Alice Cunningham [1] is noticeable due to its broad view of basic knowledge for teaching the fundamental principles to aid young researchers. This writing presents, in a brief and a very clear manner, fundamental, practical and multidisciplinary aspects of the main types of biosensors currently developed. Among the international periodical scientific publications, it is necessary to mention the following journals: *Analytical Chemistry, Biosensors & Bioelectronics, Bioelectrochemistry & Bioenergetics, Sensors & Actuators, Electroanalysis*, etc... because their periodical follow-ups are very useful in compiling a quick bibliography. Among the international events, the biannual organisation of the "World Congress on Biosensors" [2] under the auspices of *Elsevier Science Ltd.* and the *Biosensors & Bioelectronics* journal offers an ideal meeting and exchanges opportunity for the scientific community in this field. The activity of the French scientists involved in this field is also well structured, especially via the "Club des Micro-Capteurs Chimiques CMC2" (Chemical Microsensors Club) [3].

The goal of the "BIOSENSORS" "Dossier" published this month in *Analusis* is to illustrate and specify the trends of the actual developments in this field. The aspects discussed in this "Dossier" are the mutifunctionality of biosensors science and the significant developments of their fundamental aspects. This is accomplished by illustrating with examples rather than by using heavy theoretical means. As the co-ordinator of this "Dossier", I have chosen to ask for contributions from several groups dealing with the different modes of transduction. Therefore, this document consolidates articles concerning electrochemical, acoustic, magnetic and piezoelectric biosensors, in which the different immobilisation concepts of the biological material in the sensitive portion of the transducer (the determinant stage in biosensor construction) and their improvements were analysed. The authors of these articles have also accorded particular attention to simple and commercial innovative devices and to the problems associated with biosensors stability. I would like to take the opportunity here to thank again all the authors for the high standard scientific level of their contributions and for their helpful efforts to constitute this "Dossier".

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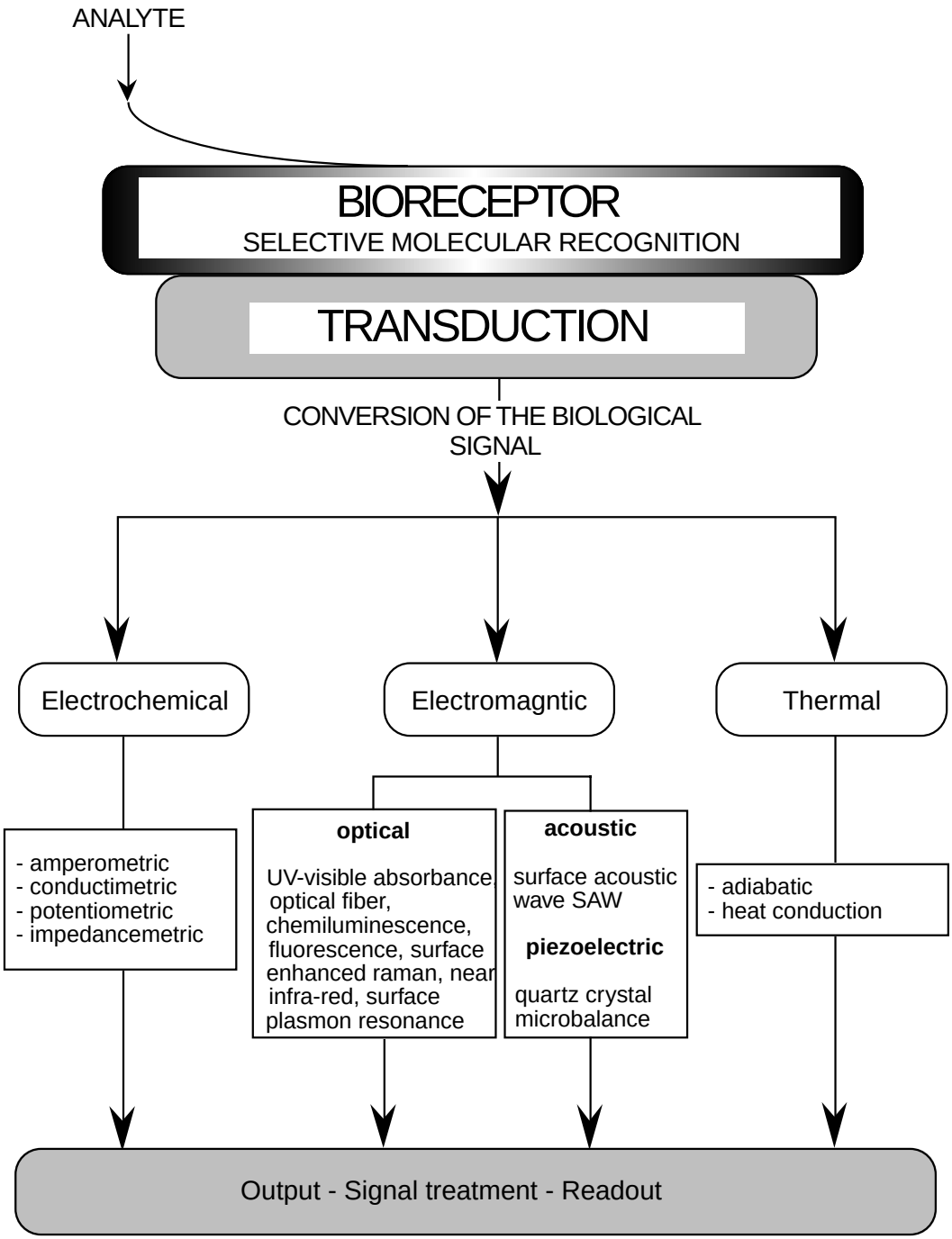

Figure 1. Sequences of processes for biosensing operations.

This "Dossier" devotes a large part to electrochemical biosensors as do the majority of annually published articles. The majority of the articles regarding electrochemical biosensors are dedicated to the recent development of the various designs. *Cosnier* and *Gondran*'s article describes the various innovative methods of enzyme immobilisation at the surface of an electrode by fixation in electrogenerated organic polymers through the use of several strategies: (1) covalent binding of the biomolecule on an eletropolymerizable monomer (such as pyrrole, for example), (2) incorporation of the biomolecule during the organic polymer electrogeneration, (3) non-denaturing fixation of the biomolecule on a biotinylated polymer by the way of the avidin-biotin affinity system. *Pontié* and *Bedioui*'s article is

related to some of the recently reported various electrochemical detection strategies of the superoxide anion in biological systems. These strategies ally, in certain cases, the advantages of electrochemical transduction with those of immobilisation of the biological element within an electrogenerated organic matrix.

The article by *Hart* and coworkers describes recent developments towards the fabrication of disposable carbon ink-based "screen-printed" biosensors incorporating the redox mediator "Meldola's blue". The authors report recent results obtained with this type of biosensor configuration in order to illustrate the advantages brought by the redox mediator incorporated into the sensitive part of the device. *Jaffrezic-Renault* and coworkers article describes the performance of a new type of biosensor based on the field-effect transistor technology for measuring pesticides. The elaboration of this biosensor is based on the concept of urease binding in a film of polyvinyl alcohol carrying styrylpyridinium groups. The authors also clearly show that this type of biosensor configuration allows the preservation of the enzymatic activity of the bound biomolecule.

The article by *El Murr* and coworkers describes another type of electrochemical biosensor configuration based on the concept of the carbon paste electrode. The authors illustrate this concept by reporting the preparation method and the performances of a new glucose bi-enzymatic biosensor made up of mutarotase and glucose oxidase. In regards to the carbon paste electrodes, the article by *Pingaron* and coworkers describes an electrochemical biosensor composed of graphite, Teflon, and tyrosinase for the monitoring of phenolic compounds in an aqueous-organic media. The authors demonstrate in their study the advantages of the use of such a biosensor configuration for detection in a predominantly organic media.

In respect to the application of biosensors in a non-aqueous media, the article by *Turner* and coworkers focuses on the recent developments of organic-phase immunosensors, including all types of transduction. Indeed, the recent double discovery of the necessity to detect a large number of analytes in a non-aqueous solution (due to their weak solubility in aqueous solution) and of the preservation of enzymatic activity of a certain number of enzymes in an organic media has contributed to the development of biodetection in a non-aqueous media.

Perrot, *Kriz* and *Rapp* and their coworkers also examine the piezoelectric, magnetic and acoustic transduction methods in this "Dossier", thanks to their articles. The three articles constitute brief and very complete reviews on electromagnetic biosensors and depict a large scope of applications. Nevertheless, it is necessary to give mention to the article by *Rapp* and coworkers who describe the development of immunobiosensors exclusively based on the utilisation of commercial acoustic transduction devices.

Gibson's article summarises the problems associated with biosensor stability. He discusses and illustrates, using several examples, all the aspects and parameters defining this problem in which expertise is necessary for the development of all biosensor devices.

Finally, the article by *Souteyrand* covers an extremely important aspect in the biosensor domain: DNA micro ships. Indeed, the detection of nucleic-acid sequences corresponds to the enormous potential needs for the clinical diagnostic of diverse pathologies. This article summarises the intense research activity, which has been developed over the course of last five years in this field. It describes the principle functions of these biosensors and the different stages of their evolution, to note several examples of their various and significant applications.

[1] Cunningham, A. J. *Introduction to Bioanalytical Sensors*, John Wiley & Sons, Inc., 1998, 418 p.

[2] "The sixth World Congress on Biosensors", 24-26 mai 2000, San Diego (USA). E-mail: e.reed@elsevier.co.uk; Web page: http://www.elsevier.nl/locate/biosconf.

[3] Club des Microcapteurs Chimiques (Chairman: Nicole Jaffrezic-Renault), Laboratoire d'Ingénierie et Fonctionalisation des Surfaces (UMR 5621), Ecole Centrale de Lyon, BP 163, 69131 Ecully Cédex, France.