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Commentary

Analysis of Proteins and Small-Molecule Drugs by a Biosensor

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DESCRIPTION

Biosensors are powerful tools for analysing proteins and small-molecule drugs, offering advantages in sensitivity, specificity, and real-time monitoring. These devices have transformed drug development, personalized medicine, diagnostics, and therapeutic monitoring by providing fast, accurate, and cost-effective analysis without complex lab techniques. A biosensor integrates biological molecules e.g., enzymes, antibodies, nucleic acids with a transducer, which converts the biological interaction into a measurable signal. The main types of biosensors used in drug analysis are electrochemical measuring changes in electrical properties and optical detecting changes in light sensors. These biosensors are essential for analysing both proteins and small molecules in pharmaceutical research and clinical practice, offering valuable insights into drug interactions, efficacy, and safety.

Biosensor-based protein analysis

Proteins, as the fundamental building blocks of cells, plays an important role in drug discovery, biomarker identification, and disease monitoring. The ability to analyse proteins quickly and accurately is essential for drug development, clinical diagnostics, and therapeutic applications.

Protein-Protein Interactions (PPIs): The study of Protein-Protein Interactions (PPIs) is vital for understanding cellular functions and designing new drugs that target specific molecular pathways. Biosensors enable the analysis of PPIs by measuring changes in the optical or electrochemical properties of the sensor when two proteins interact. For example, the use of Fluorescence Resonance Energy Transfer (FRET) biosensors allows researchers to monitor PPIs in real time, offering valuable insights into cellular processes like signalling, transcription, and cell communication.

Biomarker detection: Biosensors are also employed in the detection of protein biomarkers for diseases such as cancer, diabetes, and cardiovascular disorders. By using antibodies or aptamers specific to disease-related proteins, biosensors can offer highly sensitive and specific detection, often in the range of nanomolar concentrations. The ability to perform rapid, on-site detection of biomarkers could enable earlier diagnosis and personalized treatment plans for patients.

Biosensor-based analysis of small-molecule drugs

Small-molecule drugs, including both traditional pharmaceuticals and newer compounds, require precise and sensitive analysis to ensure their safety, efficacy, and proper dosage. Biosensors offer an effective, real-time approach to monitoring drug interactions, pharmacokinetics, and efficacy in a cost-effective manner compared to traditional methods.

Drug detection and quantification: Electrochemical biosensors are commonly used to detect and quantify small-molecule drugs. These sensors measure changes in electrical properties when a drug interacts with biological receptors, such as enzymes or antibodies. For example, enzyme-based biosensors can detect anti-inflammatory drugs like aspirin by measuring the electrochemical response to drug-receptor binding.

Drug-receptor interaction: Biosensors like Surface Plasmon Resonance (SPR) and Quartz Crystal Microbalance (QCM) are effective for studying how drugs bind to their molecular targets. They provide real-time data on binding kinetics, affinity, and specificity, aiding in the optimization of drug efficacy and understanding the mechanism of action.

Drug metabolism and toxicity testing: Biosensors are increasingly used in drug metabolism and toxicity testing, offering a more cost-effective alternative to animal studies. Enzyme-based biosensors can track drug metabolism *in vitro*, while cell-based biosensors assess potential toxicity by measuring cell viability, enzyme activity, or apoptosis in response to drug exposure.

High-throughput screening for drug discovery: Biosensors play a key role in High-Throughput Screening (HTS), allowing rapid detection of drug interactions. This accelerates the identification of potential lead compounds by screening large libraries of small-molecule drugs for activity against specific disease targets, speeding up drug discovery.

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CONCLUSION

Biosensors have emerged as versatile and effective tools for the analysis of proteins and small-molecule drugs, offering unique advantages in terms of sensitivity, real-time monitoring, and cost-efficiency. Their applications in protein analysis, drug development, disease diagnostics, and personalized medicine are driving innovations in the pharmaceutical industry. As biosensor technology continues to evolve, overcoming challenges such as selectivity, sensitivity, and interference, the role of biosensors in drug discovery and clinical applications is expected to expand, providing a transformative impact on healthcare.