Investigation of the Capabilities of Enzyme- and Hydrogel-Based Biosensors (Dr. Kirk Bundy, Biomedical Engineering Dept. and Dr. Jean Jacob, LSU Eye Center)

Project Concept:

Though it is not at first obvious, detection of chemical and biological weapon (CBW) agents, detection of substances in the body that cause implant biocompatibility or toxicity problems, detection of proteins and other molecules whose presence or levels are biomarkers of serious diseases such as ovarian cancer or diabetes, separation of valuable molecules, and detection of certain environmental pollutants all share a common attribute. All of these applications can benefit from improvements in biosensor technology.

Practical sensor systems for the purposes listed above often face some formidable engineering requirements, however. One of these is that the concentration of the agent to be measured usually is extremely small. With conventional sensors, the presence of the agent might be masked by many other extraneous substances (found at much higher concentrations). Also, molecules that actually are not too harmful might affect the sensor, creating false positive readings.

Here biology may come to the rescue. *In vivo*, there are many instances where biomolecular recognition phenomena are used to overcome just this sort of problem. Enzyme/substrate, antigen/antibody, and receptor/ligand interactions are examples. These interactions, in effect, involve the detection of a very specific target molecule even in the presence of similar (but discrete) substances found at concentrations thousands of times higher than that of the target. A sensor based on the principles described above is known as a catalytic or affinity biosensor.

Despite their potential attractiveness, though, there still often are major research difficulties to be surmounted before biosensors become practical means for detection. For example, for atmospheric CBW agents, the delicate sensor biomolecules involved may easily dry out (becoming denatured and unusable) or else can only be used one time. Under *in vivo* conditions, fouling due to an adsorbed coating of protein can inhibit the efficiency of the biosensor.

To solve such problems, biomaterials and nanotechnology research may be of assistance. In this project we are examining polymers known as hydrogels for their suitability as the basis for an advanced type of biosensor useful for many different applications. A hydrogel is an open polymer network containing a very large amount of water. It should be able to preserve the biomolecules in a non-denatured form. When the correct biomolecules are attached to the hydrogel structure in an appropriate way and interact with the target agent to be detected, a signal is produced (such as a pH shift) that is proportional to the concentration of the agent.

This project is co-directed by Drs. Bundy and Jacob. It is a continuation of work performed on various research grants in which undergraduate, graduate, and postdoctoral students have participated. Development of practical hydrogel-based biosensors is the ultimate aim of this research, and this junior/senior project will be a part of this effort. Since our interests in the biosensor area are quite wide ranging, as described in the next section, up to three students can work on this project.

Description of Biosensor Research in the Coming Year:

In the next project year we may be investigating the use of biosensors for dental, metal poisoning treatment monitoring, and ovarian cancer treatment applications. Through further studies of the biofouling problem, we hope to gain more insight into the *in vivo* potential for the hydrogel-based biosensor. We also plan to make our approach more versatile by investigating additional sensing agents, carrier matrices, and analytes besides those we have explored in the past. To gain insight into the potential of our biosensors for studying biocompatibility, we will continue our attempts to correlate measurements made with biosensors to those made with a well accepted bioluminescent bacteria-based biosensor. Further efforts to optimize the performance of our biosensors, as well as to understand the underlying mechanisms by which they work, will also be a focus of our activities in 2004.

Attributes of Students Working on This Project:

Students taking on this project need to have a strong interest in chemistry, biology, nanotechnology, and biomaterials. For most aspects of this project an aptitude for experimental work is required. However, for those students who are mathematically inclined, there are aspects of this work (related to understanding of how mass transport and enzyme kinetics influence biosensor performance) where your talents could be of service. A willingness to learn about many diverse topics from a range of individuals with expertise pertinent to various aspects of hydrogel-based biosensors is also essential. Since there is a lively market potential for new biosensors, this project could appeal to someone with an entrepreneurial bent. Qualified students interested in ultimately becoming graduate students working on biosensor research projects will definitely be given preference here. Another important attribute, for a student working on this research, is that he or she has the ability to work with a minimum of supervision toward the end of this project, since Dr. Bundy may be on sabbatical leave in the Fall 2004 semester.

To learn more about this project, please send a letter of application and a resume to Dr. Kirk Bundy (kbundy@tulane.edu) and Dr. Jean Jacob (jjacob@LSUHSC.edu).