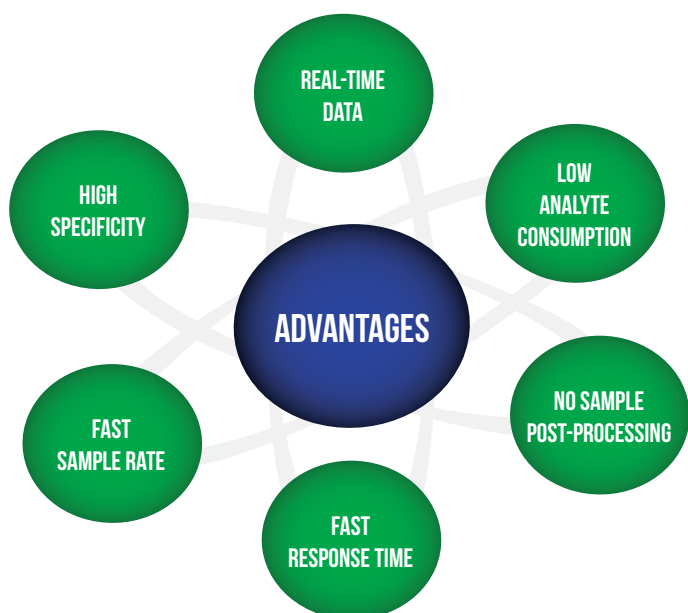




# BIOSENSORS



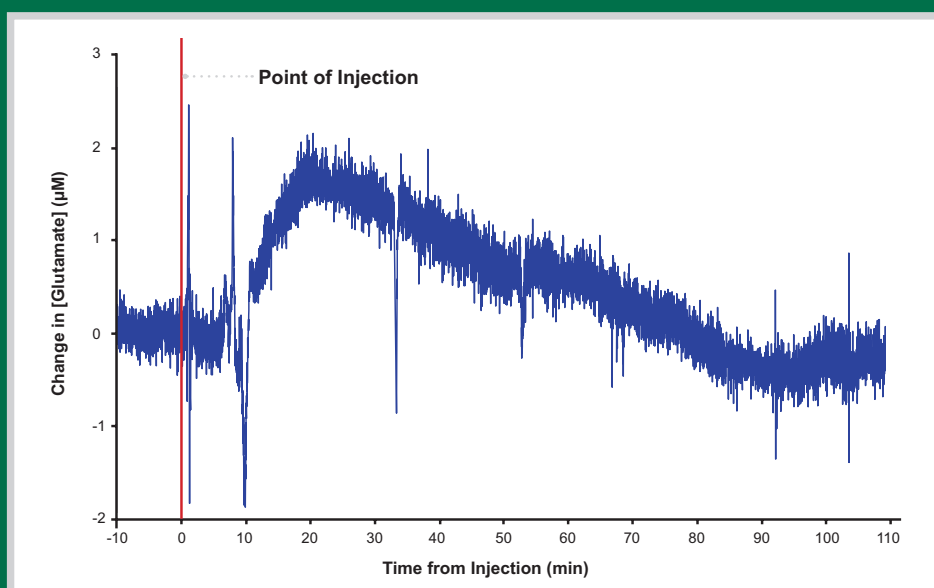
**BIOSENSORS** monitor real-time changes in neurochemical concentrations. They are fast, selective, and specific to the analyte of interest. Researchers can use biosensors with Pinnacle's electronics and software to routinely record and analyze second-by-second concentration changes in the brains of freely moving animals. Biosensors are an excellent choice for the unambiguous and accurate measurement of rapid neurochemical changes.



## AVAILABLE SENSORS

- GLUTAMATE
- ETHANOL
- GLUCOSE
- CHOLINE
- LACTATE

*Call about other analytes*



*In vivo* recording from a glutamate biosensor implanted in the mPFC of a C57 mouse. An intraperitoneal injection of MK-801 (0.18 mg/kg) was delivered at the zero-minute mark. Data were transformed to changes in glutamate concentration based on the sensor's post-calibration.

## COMMON USES

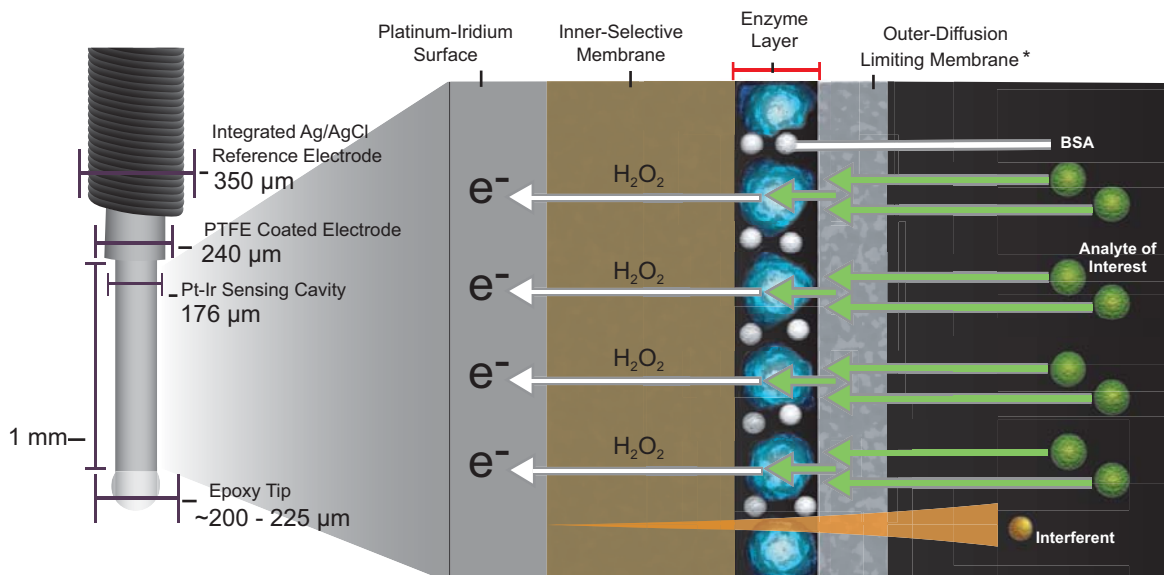
- In vivo* monitoring of brain chemical microenvironments
- Neurochemical monitoring during behavioral and physiological activities
- Drug screening, including neuropharmacologic effects
- Identification of biomarkers
- Investigating cognition, behavior, circadian cycles, stress, learning, memory, sleep, seizure, vigilance state, and new drug effects

# HOW BIOSENSORS WORK

**PINNACLE BIOSENSORS** function by the enzyme-mediated processing of the analyte of interest. This results in the production of hydrogen peroxide that is then detected by oxidation at a Pt-Ir electrode. Electroactive interferents present in the brain are excluded via a passive selective membrane and through active removal when necessary.

## EXPERIMENTAL BASICS

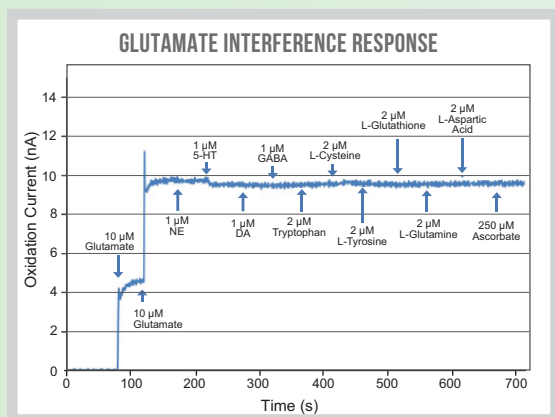
- ✓ Implant guide cannula(s) 5-7 days in advance.
- ✓ Receive biosensor(s) 2-3 days before experiment.
- ✓ Insert biosensor(s) to begin experiment.
- ✓ View real-time changes in analyte concentration and perform challenges.
- ✓ Explant biosensor(s) and post-calibrate.
- ✓ Analyze data.



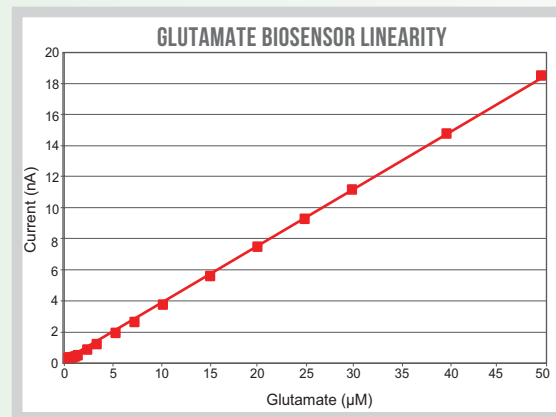
\* Outer-diffusion limiting membrane may not be present on all Pinnacle biosensors

## BIOSENSOR CHARACTERISTICS

	Glutamate	Glucose	Lactate	Ethanol	Choline
<i>In Vivo</i> Lifetime	36 hours	96+ hours	96+ hours	6 - 8 hours	8+ hours
Limit of Detection	0.05 - 0.1 µM	2 - 5 µM	5 - 10 µM	0.1 - 0.5 µM	0.05 - 0.1 µM



**LINEAR**  
**SELECTIVE**  
**FAST**



**Fast Response:** Capable of monitoring rapid physiological events

**High Specificity:** Excludes endogenous electroactive interferents present in the brain

**Linear Response:** Responds over a physiologically relevant concentration range at physiologic oxygen levels

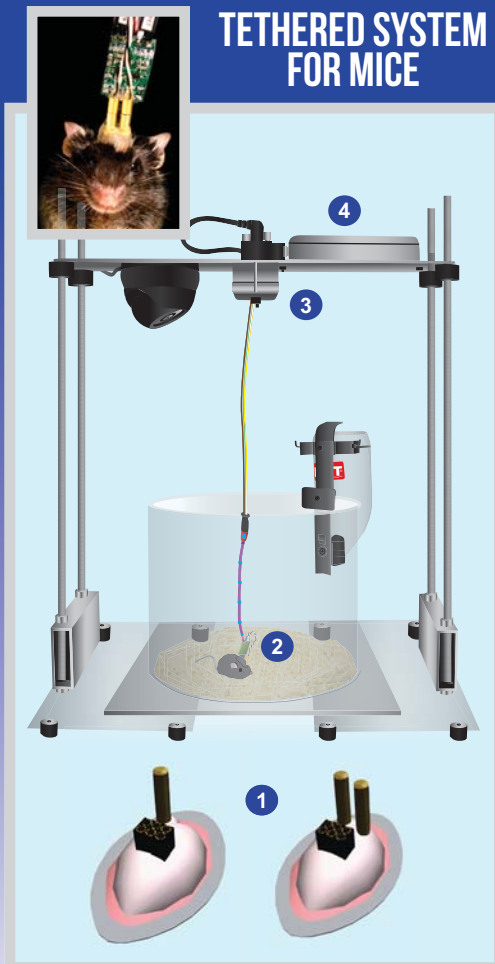
**PINNACLE OFFERS** a suite of biosensor recording systems suitable for a range of needs and experiment types. Turn-key electronics and software solutions are available for *in vivo* biosensor recordings in freely moving mice and rats. In addition, a desktop unit is available for recording in anesthetized animals and bench-top experiments. All systems are compatible with Pinnacle's line of biosensors.

## WIRELESS SYSTEM FOR RATS



- 1 Stereotaxically placed guide cannula(s) allow for the insertion of biosensors post-surgery.
- 2 The wireless system uses a Rat Hat to house the electronics, battery, guide cannula, and biosensor. The Rat Hat bottom is affixed to the skull with bone screws and dental acrylic. The fully assembled system weighs 11.8 grams.
- 3 A low-powered, wireless, two-channel potentiostat applies a bias and transmits up to two digitized signals to a paired Bluetooth® USB dongle that interfaces with Pinnacle's Sirenica® Acquisition software for data recording.
- 4 The Rat Hat top protects the system, allowing for group housed and behavioral experiments.

## TETHERED SYSTEM FOR MICE



- 1 Stereotaxically placed guide cannulas allow for the insertion of biosensors post-surgery. Prefabricated headmounts are affixed to the skull with dental acrylic and act as a connection port for the two-channel biosensor preamplifier.
- 2 Headmounted preamplifiers house two connectors for biosensors and are key to quality, artifact-free data. The fully assembled system weighs 2.2 grams.
- 3 A low-torque commutator allows for unencumbered freedom of movement.
- 4 The data conditioning and acquisition system performs secondary amplification and filtering before sending data to Pinnacle's Sirenica® Acquisition software for collection.

## ANESTHETIZED AND *IN VITRO* EXPERIMENTS



The four-channel fixed potential potentiostat provides a cost-effective, easy-to-use, and highly accurate system for the development and use of high impedance, amperometric biosensors and biosensor arrays. Designed with the neuroscientist in mind, it is well suited for anesthetized animal experiments, brain slices, and other *in vitro* studies. The system is compatible with Pinnacle's biosensors and third-party sensors.

## HOW DO I CORRELATE CURRENT TO CONCENTRATION?

To relate the *in vivo* current changes measured by a biosensor to actual changes in analyte concentration, it is necessary to calibrate biosensors at the conclusion of the experiment. Pinnacle offers a number of calibration systems for the simultaneous calibration of up to four biosensors.

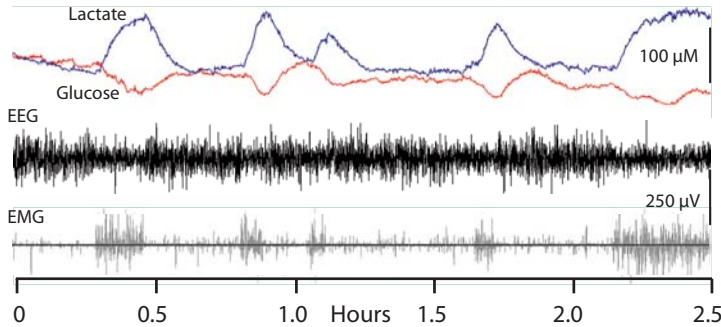


Calibration Kit

## ADD EEG/EMG OR VIDEO

## COMBINED EEG/EMG/BIOSENSOR SYSTEMS

Easily add synchronized EEG/EMG recordings to biosensor measurements! Pinnacle's four-channel biopotential system provides tethered solutions for the simultaneous measurement of EEG/EMG waveforms and neurochemical activity in freely moving mice and rats. This powerful combination is perfect for unlocking new findings during sleep, seizure, and behavioral studies.



EEG and EMG waveforms are plotted simultaneously with calibrated biosensor traces for lactate and glucose recorded from a single animal.

## INTEGRATED VIDEO

Synchronized video recording can be added to any new or existing biosensor hardware system, providing a platform for correlating changes in brain chemistry with behavioral states. Captured video is displayed live on screen as it is streamed from the animal, and, in playback mode, video is synchronized with other recorded data.



Biosensor traces for lactate and glucose are recorded simultaneously with full-color video.

Need a smaller sensing cavity?

Working with larger animals?

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## CARBON FIBER SENSORS

Pinnacle offers carbon fiber sensors (CFS) for use in fixed potential amperometry (FPA) and fast scan cyclic voltammetry (FSCV). Our CFS is a 34  $\mu\text{m}$  diameter carbon fiber housed in a silica sheath that extends 0.5 mm beyond the end of the silica.

**PINNACLE**  
TECHNOLOGY INC