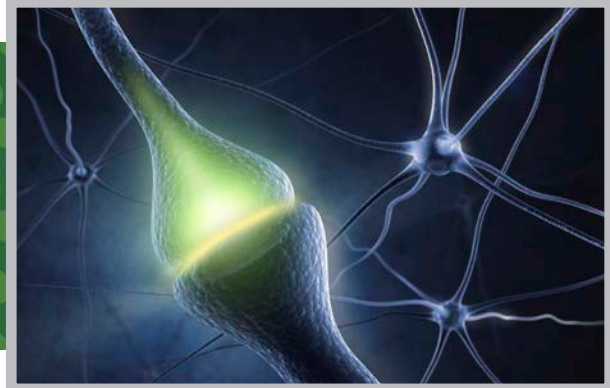
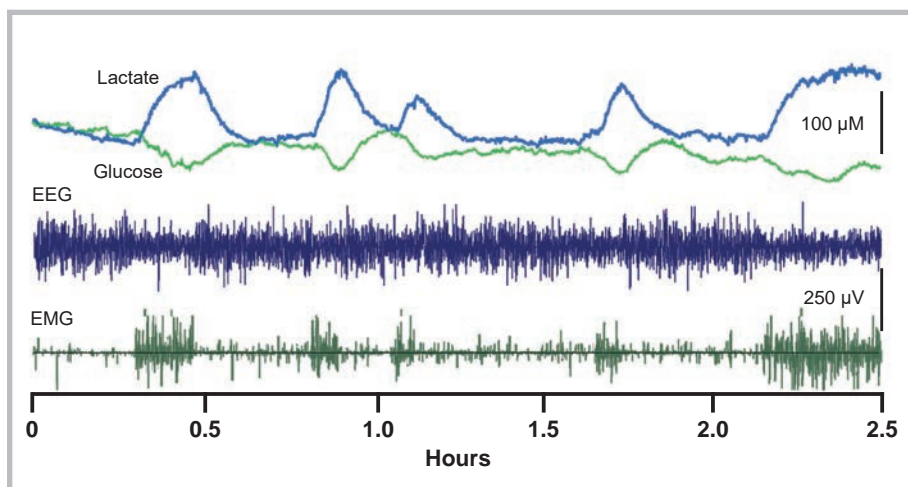




# SENSORS



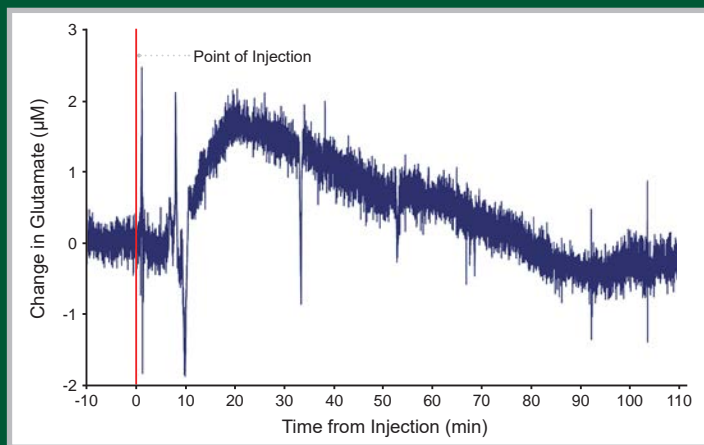
**BIOSENSORS** monitor real-time changes in neurochemical concentrations. They are fast, selective and specific to the analyte of interest. Researchers can use biosensors with Pinnacle's electronics and software to routinely record and analyze second-by-second concentration changes in the brains of freely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



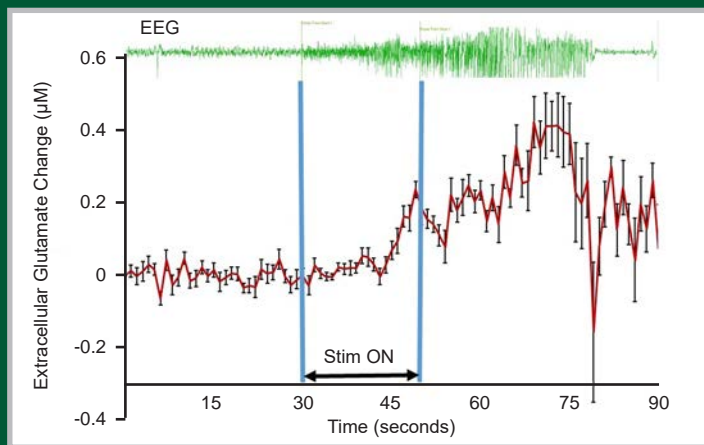
## COMMON USES

- ◇ **In vivo monitoring** of brain chemical microenvironments
- ◇ **Neurochemical tracking** during behavioral and physiological activity
- ◇ **Drug screening & neuropharmacology effects**
- ◇ **Biomarker Identification**
- ◇ **Investigating** cognition, behavior, sleep, seizures, stress, & drug effects

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



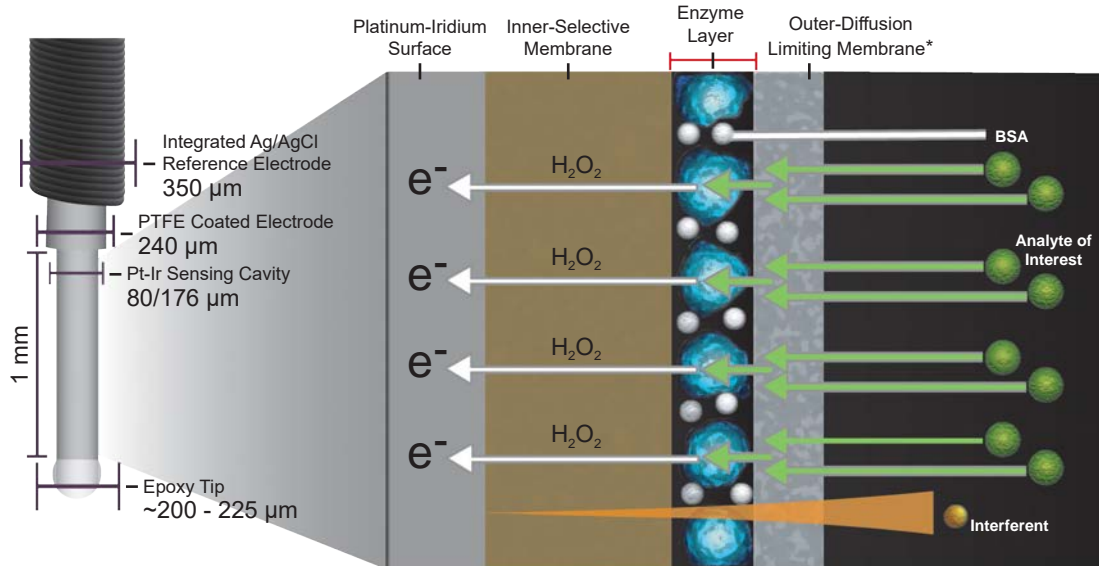
**DRUG RESPONSE.** *In vivo* recording from a glutamate biosensor implanted in the mPFC of a C57 mouse. An intraperitoneal injection of MK-801 (0.18 mg/kg) was delivered at the zero-minute mark. Data were transformed to changes in glutamate concentration based on the sensor's post-calibration.



**GLUTAMATE SENSOR & EEG ACTIVITY.** Glutamate concentration changes corresponding with seizure-like EEG activity. Stim ON indicates 20 second optogenetic seizure induction period (n=11 events, bars represent SEM).

# 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.



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

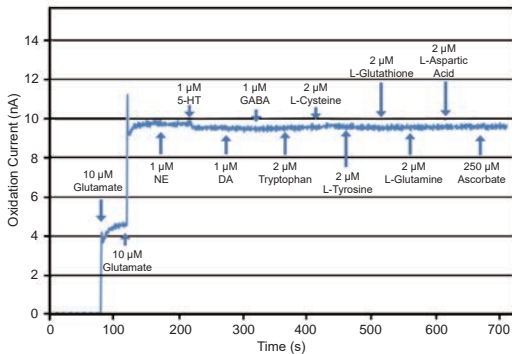
## EXPERIMENTAL BASICS

- ✓ 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.
- ✓ Explant biosensor(s) and post-calibrate.
- ✓ Analyze data.

## ORDERING BIOSENSORS

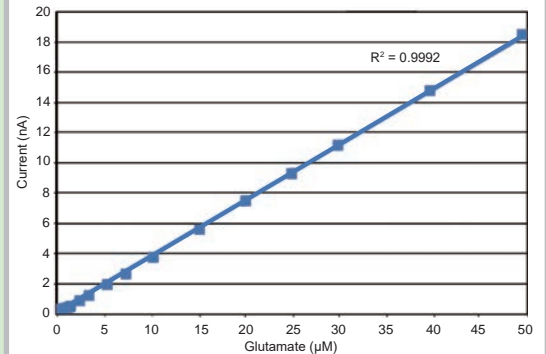
1	<b>Analyte of Interest</b>	Glutamate	Glucose	Lactate	Ethanol
2	<b>Cannula Type</b>	Mouse	Rat 1 sensor	Rat 2 sensors	
3	<b>Sensor Diameter</b>	80 μm	180 μm		

### GLUTAMATE INTERFERENCE RESPONSE



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

### GLUTAMATE BIOSENSOR LINEARITY



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

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

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

**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 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 2.4GHz Wireless USB dongle that interfaces with Pinnacle's Sirenia<sup>®</sup> Acquisition software for data recording.
- 4 The Rat Hat top protects the system, allowing for group housed and behavioral experiments.

## TETHERED SYSTEM FOR MICE & RATS



- 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.
- 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 Sirenia<sup>®</sup> Acquisition software for collection.

## ANESTHETIZED AND *IN VITRO* EXPERIMENTS



The four-channel fixed-potential potentiostat offers a cost-effective, user-friendly, and accurate solution for high-impedance amperometric biosensors and arrays. Designed for neuroscientists, it's ideal for anesthetized animal experiments, brain slices, and other *in vitro* studies. Compatible with Pinnacle and third-party biosensors.

## HOW DO I CORRELATE CURRENT TO CONCENTRATION?

To relate the *in vivo* current changes to actual analyte concentrations, biosensors must be calibrated at the end of the experiment. Pinnacle offers systems for simultaneous calibration of up to four biosensors.



Calibration Kit

# AVAILABLE SENSORS



- GLUTAMATE
- GLUCOSE
- LACTATE
- ETHANOL

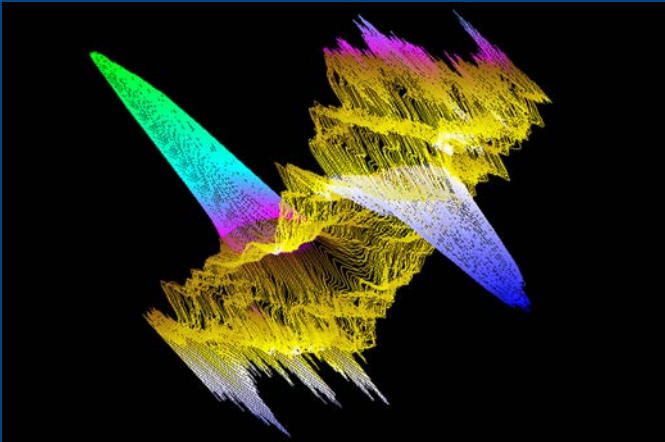
Call about other analytes

## BIOSENSOR CHARACTERISTICS

	In Vivo Lifetime	Limit of Detection 180 $\mu\text{m}$	Limit of Detection 80 $\mu\text{m}$
Glutamate	36 hours	0.02 - 0.08 $\mu\text{M}$	0.06 - 0.3 $\mu\text{M}$
Glucose	96+ hours	1.3 - 4 $\mu\text{M}$	1.9 - 15.2 $\mu\text{M}$
Lactate	96+ hours	0.2 - 0.6 $\mu\text{M}$	1.4 - 3.5 $\mu\text{M}$
Ethanol	6 - 8 hours	0.1 - 0.5 $\mu\text{M}$	N/A

## CARBON FIBER ELECTRODES

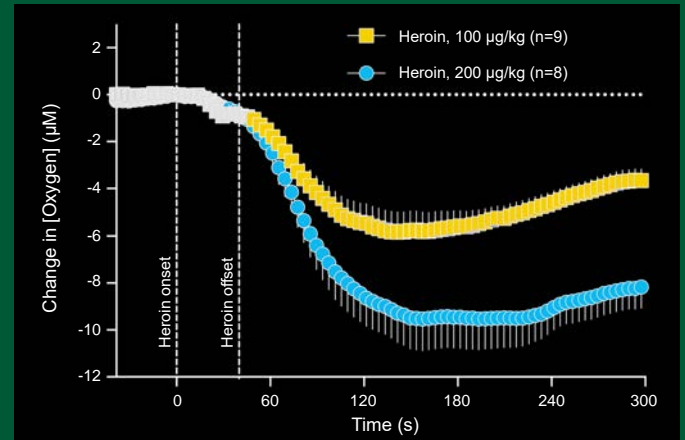
Pinnacle offers carbon fiber electrodes (CFEs) for use in fixed potential amperometry (FPA) and fast scan cyclic voltammetry (FSCV). Our CFE is a 7  $\mu\text{m}$  micro-CFE that is sheathed in a borosilicate glass and extends 30-80  $\mu\text{m}$  beyond the capillary. We also offer a 34  $\mu\text{m}$  diameter CFE housed in a silica sheath.



FSCV 3D color plot of dopamine oxidation and reduction. The green peak (left) is the current response to dopamine oxidation. The blue peak (right) is the response to the reduction of dopamine-o-quinone to dopamine.

## OXYGEN SENSORS

Pinnacle's oxygen sensors can be used with Pinnacle's electronics and software to routinely record and analyze second-by-second concentration changes in the brains of freely moving animals. Our oxygen sensor is a 180  $\mu\text{m}$  disc electrode with an integrated reference and operates under a -0.6 V bias.



Intravenous heroin induces rapid oxygen changes in the rat nucleus accumbens. Colored symbols (4-s mean,  $\pm$ SEM) are significantly different from the preinjection baseline. Solis et al. eNeuro (2017) Jun 7;4(3)

## MICRO-BIOSENSORS

Micro-biosensors use fixed potential amperometry to deliver accurate and sensitive detection and quantification of glucose and lactate in *in vitro*, *ex vivo*, and *in vivo* studies. Their small size and high spatial resolution allow for minimal tissue damage, making them ideal for probing intricate metabolic changes and neuronal activities.

25 $\mu\text{m}$ MICRO-BIOSENSOR SPECIFICATIONS	GLUCOSE	LACTATE
Active Site Diameter	25 $\mu\text{m}$	25 $\mu\text{m}$
Linear Range (minimum)	4 mM	400 $\mu\text{M}$
Electrode type	Pulled Capillary Electrode (includes connector wire)	
Applications	For use in brain slices or freely moving animals	