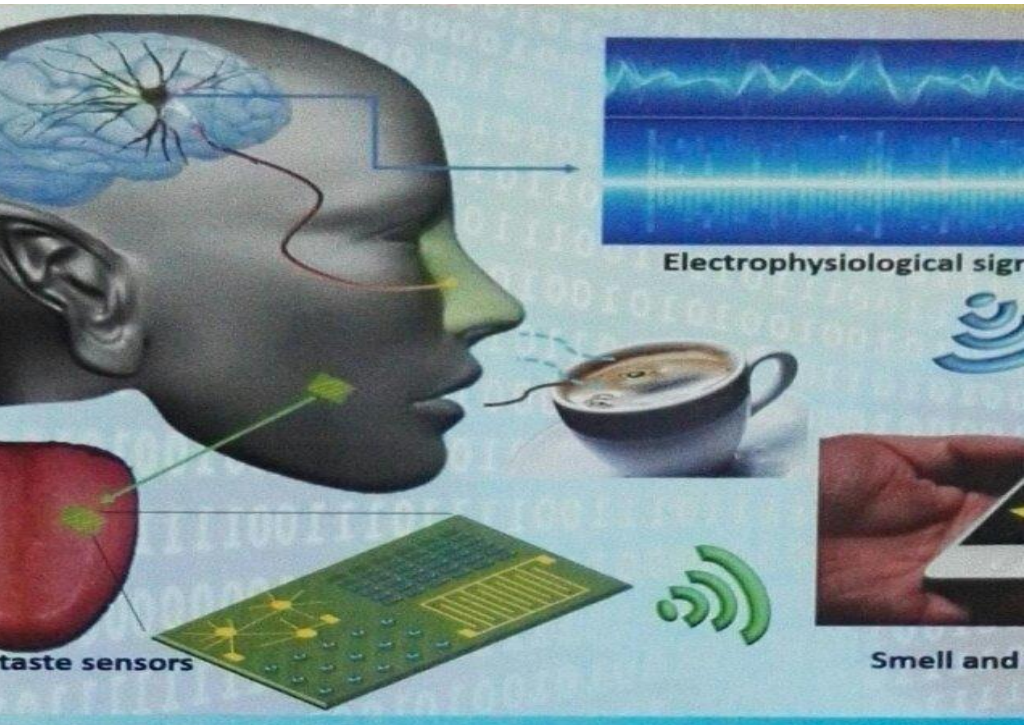
ISOEN

International Symposium on Olfaction and Electronic Nose

May 12-15 , 2024 | Grapevine, Texas

GRAPEVINE TEXAS CONVENTION & VISITORS BUREAU

Progress of Bioelectronic Nose and Bioelectronic Tongue *in vitro* and *in vivo* for Odor and Taste Perception



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Hangzhou city, Principle of Zhejiang Province of China

G20 Summit, Hangzhou, 2016
Asian Games, Hangzhou, 2022

Zhejiang University

Hangzhou, Zhejiang, China, Close to Shanghai, largest city

Zhejiang University is currently one of the largest and best universities in China with a history of 129 years. It ranks third in various rankings at home and abroad, after Tsinghua University and Peking University in China, and is also one of the universities with the most comprehensive disciplines in China

Our Yuquan Campus of ZJU and College of BME & Instrument Science

This is the Yuquan Campus which is one of seven campuses of Zhejiang University that focus in Engineering and Information

This is the building of our college of "Biomedical Engineering and Instrument Science" and our lab in there

The Contents of Talk

1. Electronic Nose and Electronic Tongue

2. Bioelectronic Nose & Bioelectronic Tongue *in vitro* and *in vivo*

3. Application of Bioe-Nose and Bioe-Tongue *in vitro* and *in vivo*

1st Part

Electronic Nose (e-Nose)

Electronic Tongue (e-Tongue)

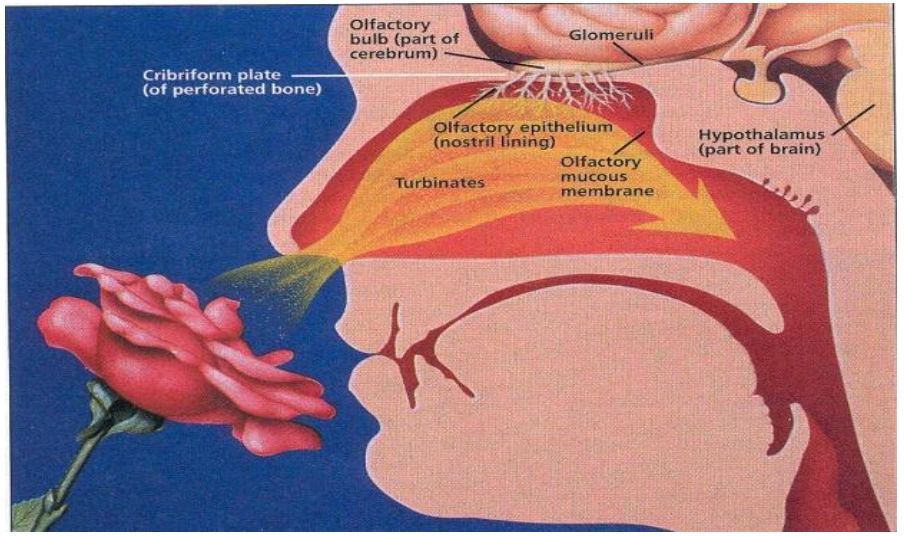
Electronic Nose (e-Nose)

The term " Electronic Nose " was presented in the 1980's.

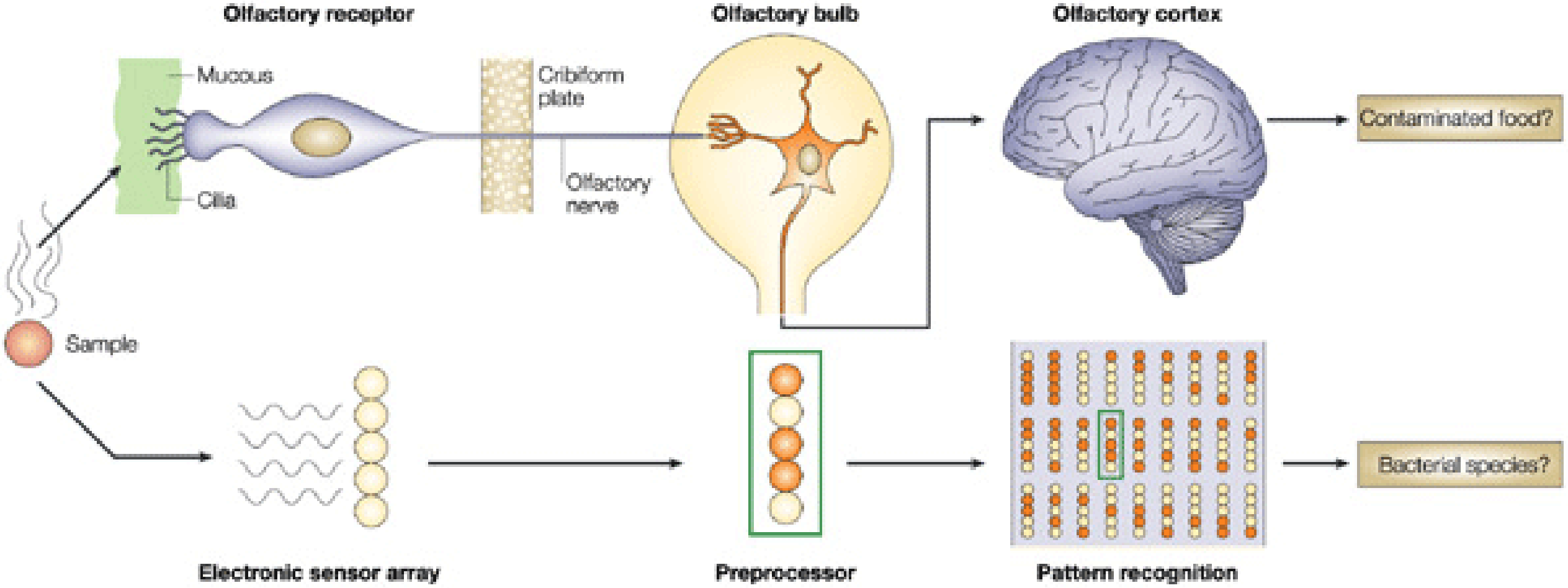
It became apparent that the animal and human olfactory systems operate on the same principle: A relatively small number of nonselective receptors can determine thousands of different odors.

“Electronic Nose" is a kind of electronic or optical analysis instrument and while it should be a kind of bionic instrument.

Prof. Gopel, Prof. Gardner, Prof. D’amico et al



e-Nose mimic human olfactory system



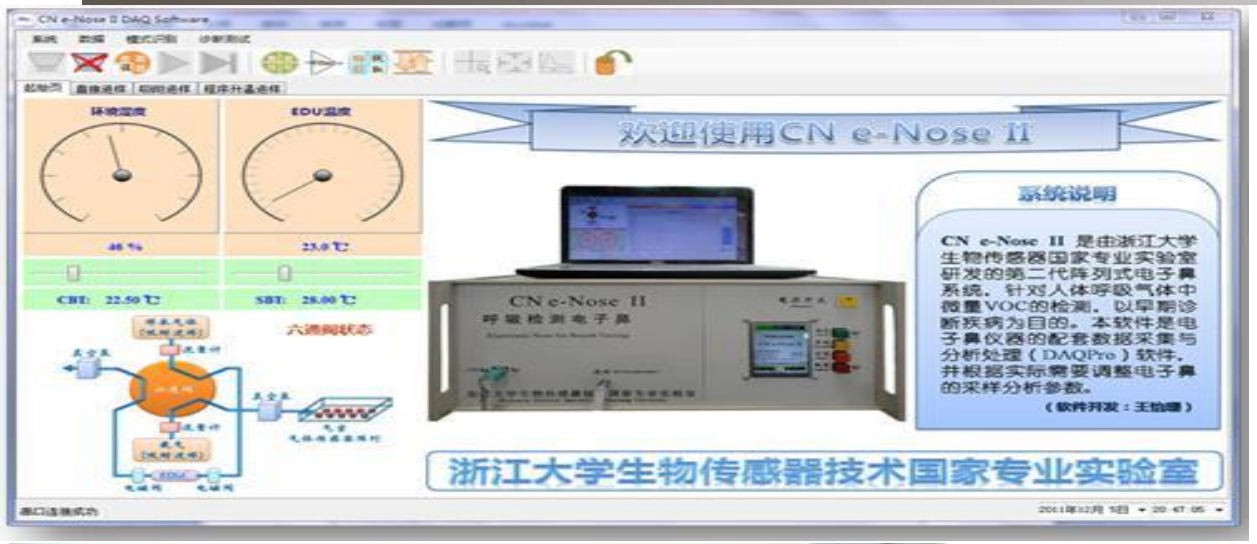
Nature Reviews | Microbiology

Comparing e-Nose with Human Nose

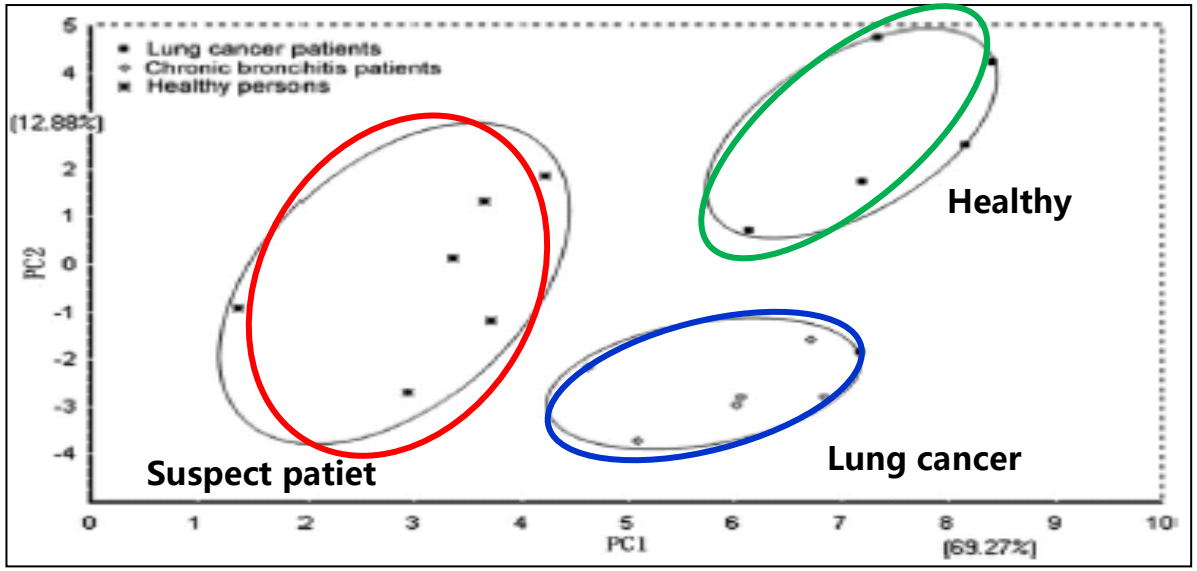
Table Comparing electronic nose with human nose

Bio-nose	Electronic nose
It uses the lungs to bring the odor to epithelium layer.	It employs a pump to smell the odor.
It has mucus, membrane and hair to act as filter.	It has an inlet sampling system that provides filtration.
The human nose contains the olfactory epithelium, which contains millions of sensing cells that interact with odorants in unique.	Electronic nose has a variety of sensors that interact differently with a group of odorous molecules.
The human receptors convert the chemical response to electronic nerve impulses whose unique patterns are propagated by neurons through a complex network before reaching the higher brain for interpretation.	Similarly, the chemical sensors in the electronic nose react with the sample and produce electrical signals. A computer reads the unique pattern of signals, and interprets them with some form of intelligent pattern classification algorithms.

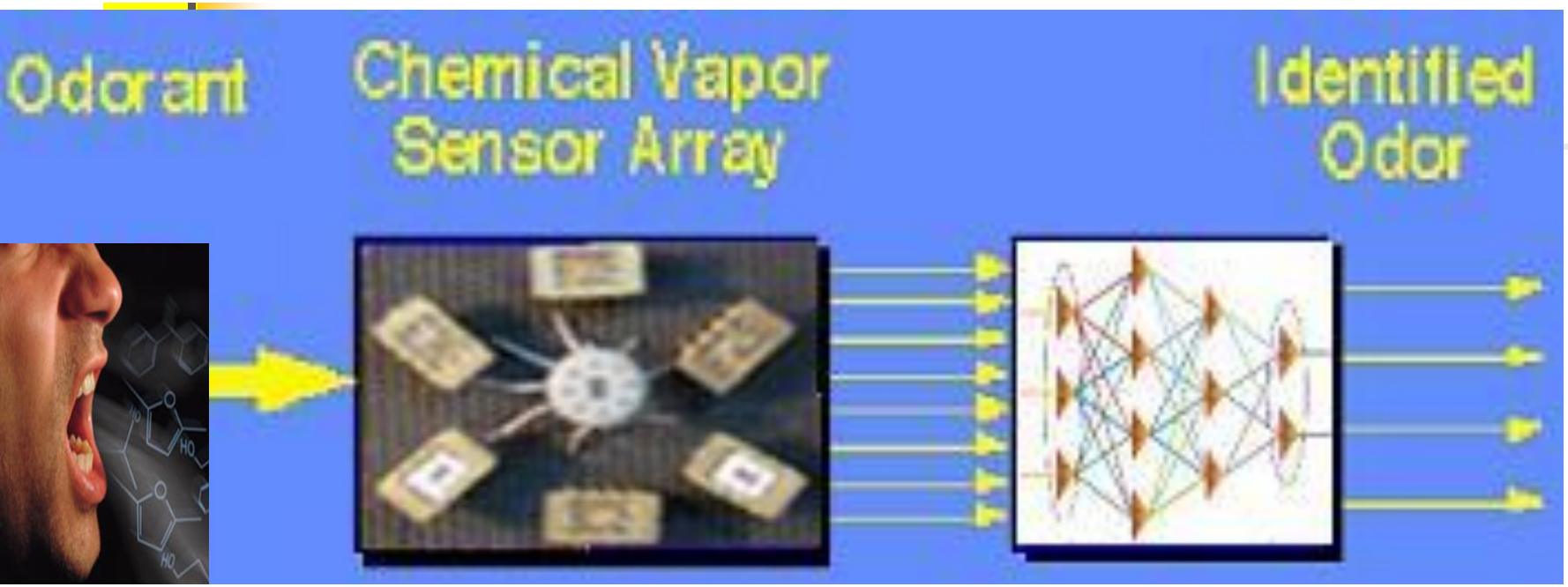
e-Nose for Health Monitoring



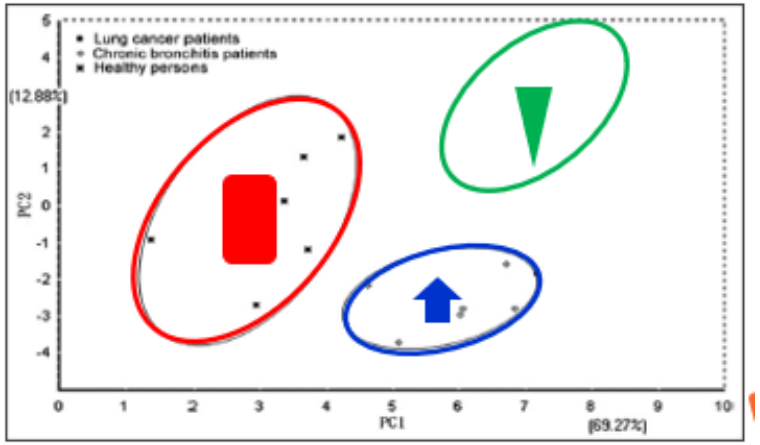
in home and communities service



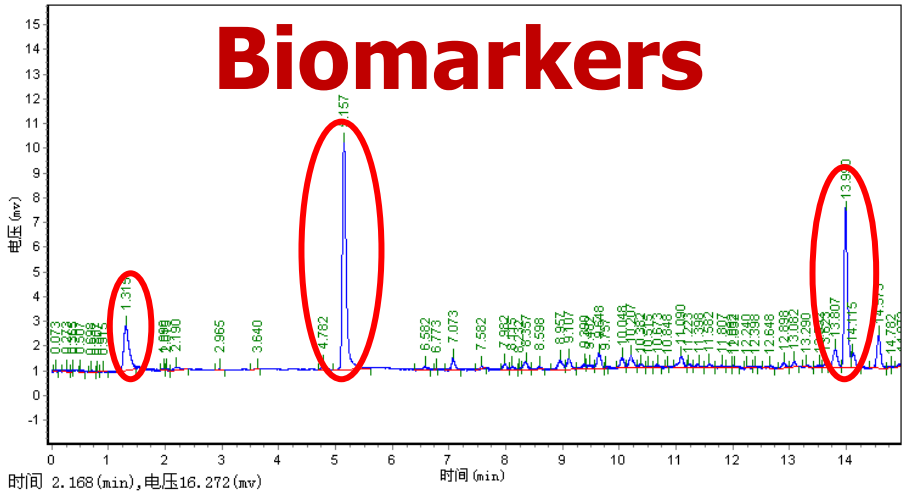
e-Nose for Health Monitoring



Health/Patient

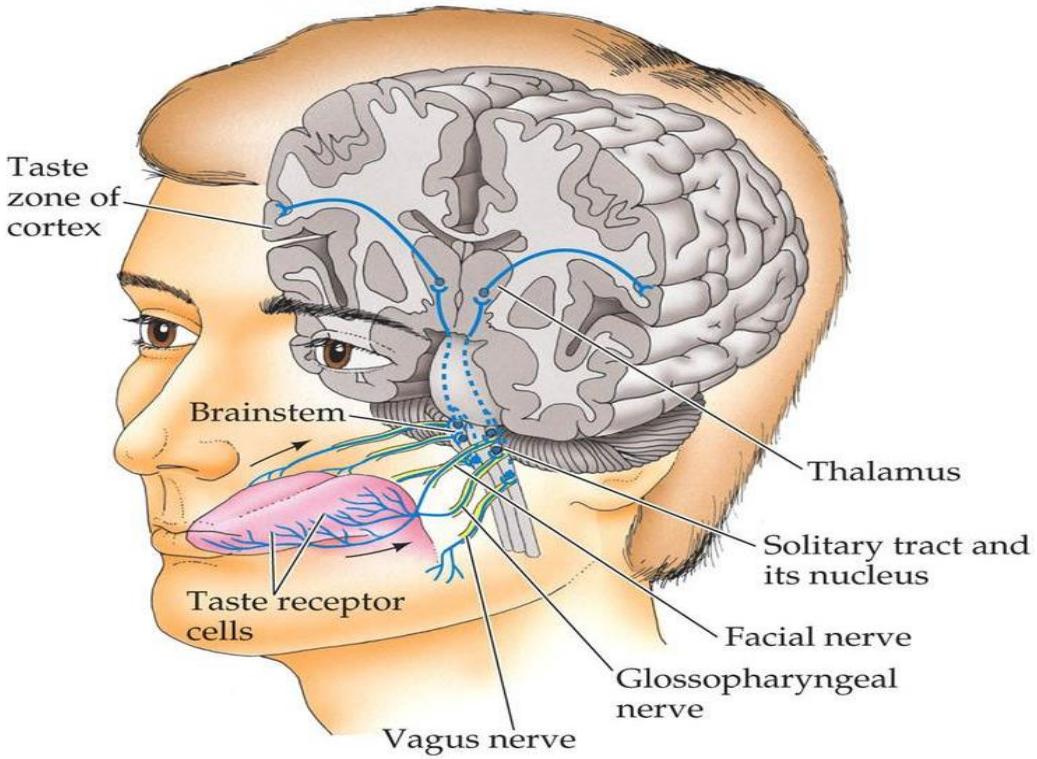


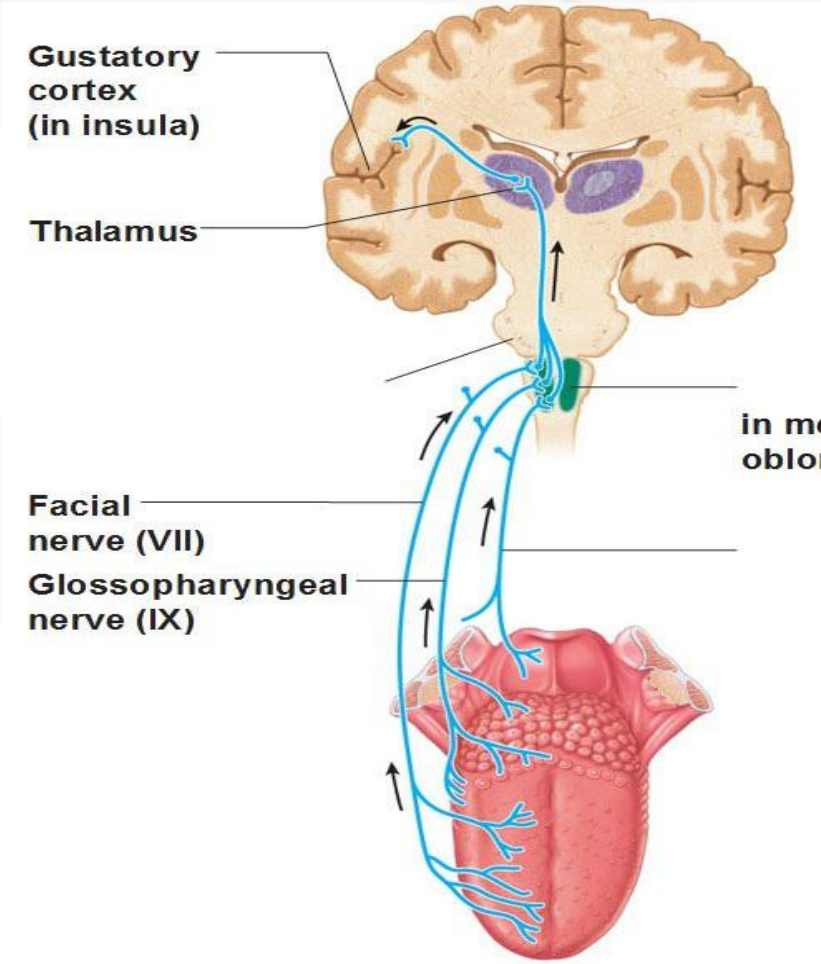
Biomarkers



Styrene (ethenylbenzene)	1,3-butadiene, 2-methyl- (isoprene)
Heptane, 2,2,4,6,6-pentamethyl	Octane, 3-methyl-
Heptane, 2-methyl	1-hexene
Decane	Nonane, 3-methyl-
Benzene, propyl-	1-heptene
Undecane	Benzene, 1,4-dimethyl
Cyclopentane, methyl-	Heptane, 2,4-dimethyl
Cyclopropane, 1-methyl-2-pentyl-	Hexanal
Methane, trichlorofluoro-	Cyclohexane
Benzene	Benzene, 1-methylethenyl-
Benzene, 1,2,4-trimethyl-	Hepatanal

Human Taste





gustatory cortex

thalamus

nucleus of solitary tract

Lingual epithelium

Electronic Tongue (e-Tongue)

The " Electronic Tongue " was presented in the 1990's.

It became apparent that the animal and human taste operating on the same principle.

“Electronic Tongue" is a kind of electronic(or optical) analysis instrument and while should be a kind of bionic instrument.

From Prof. Legin’s Lab

Prof. Vlasov, Prof. Toko, Prof. Legin et al

Human Taste and e-Tongue

生物味觉系统

Human Taste

口腔

大脑

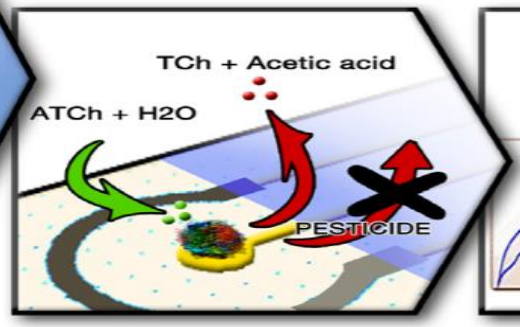
感官评价

数据采集 → 数据处理 → 结果输出

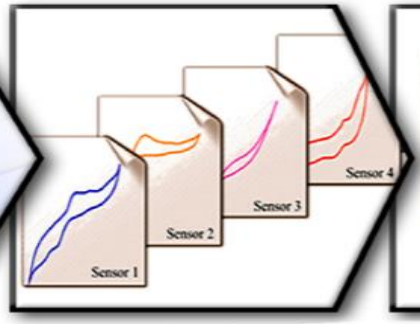
仿生味觉系统

e-Tongue

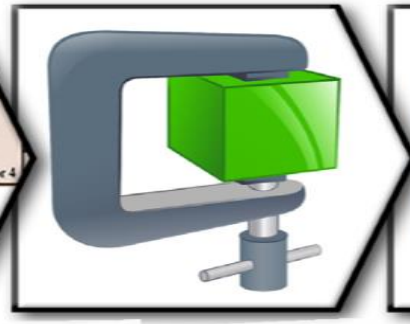
样品



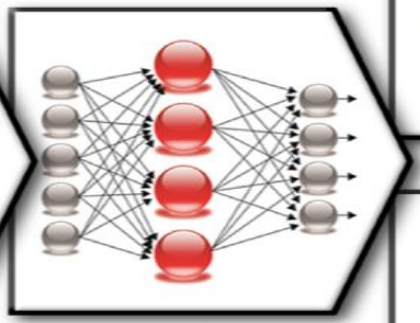
传感器阵列



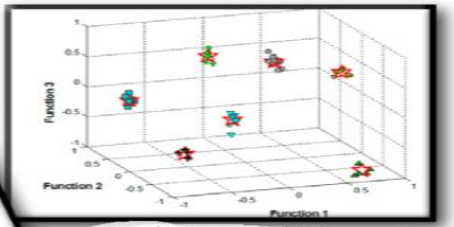
数据采集



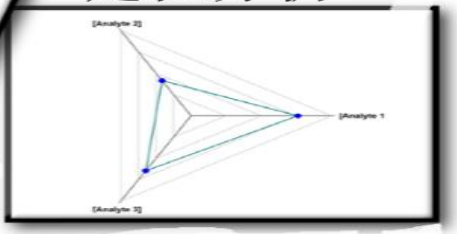
信号处理



化学计量模型

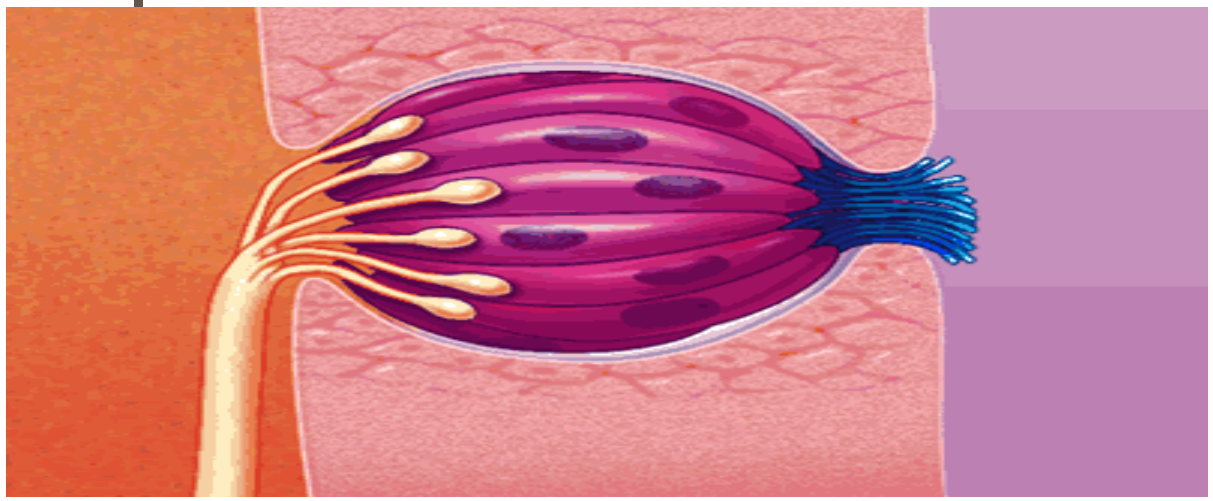


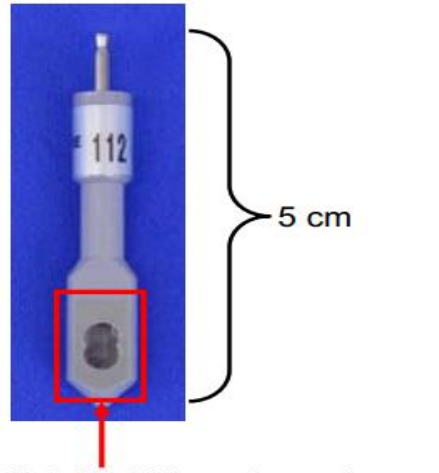
定性分析

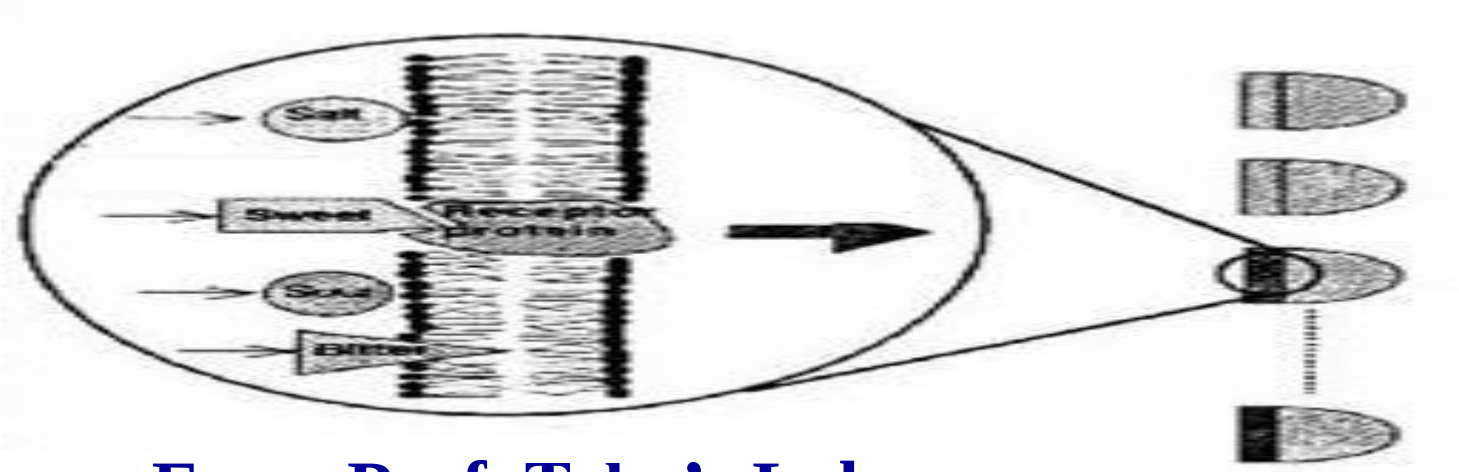


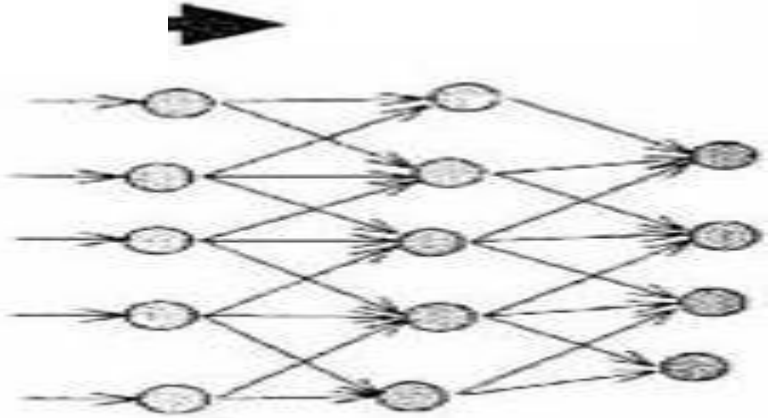
定量分析

Biomimetic Electronic Tongue



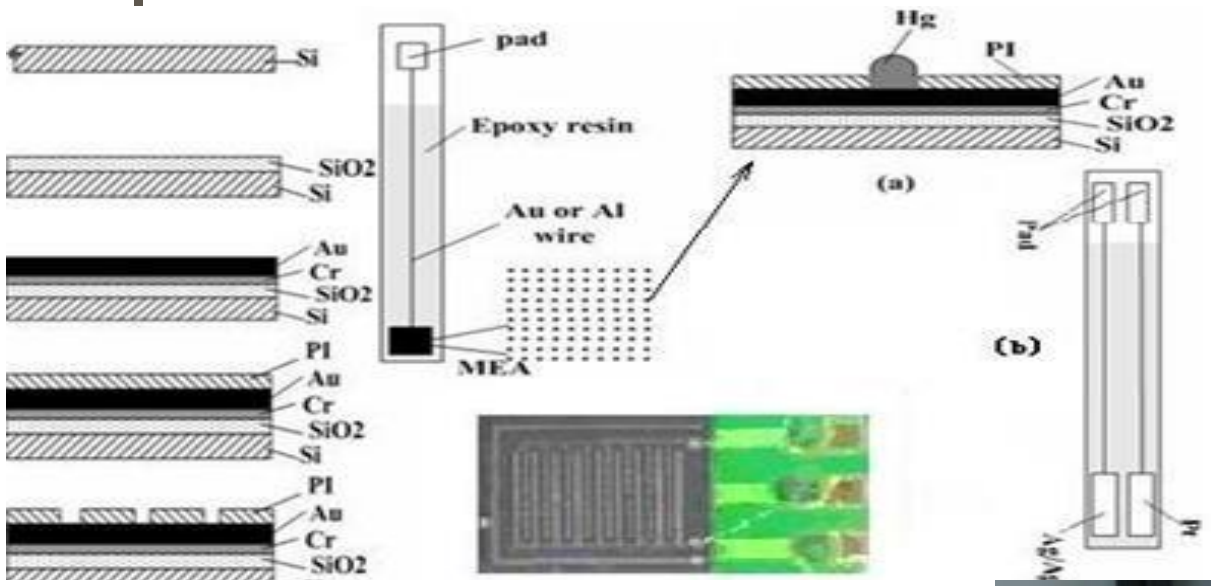


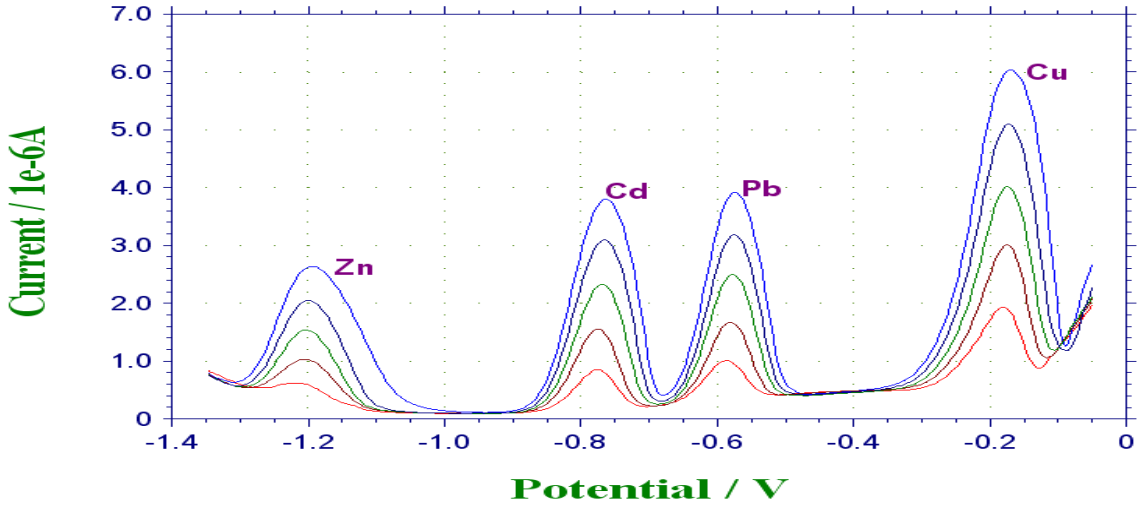


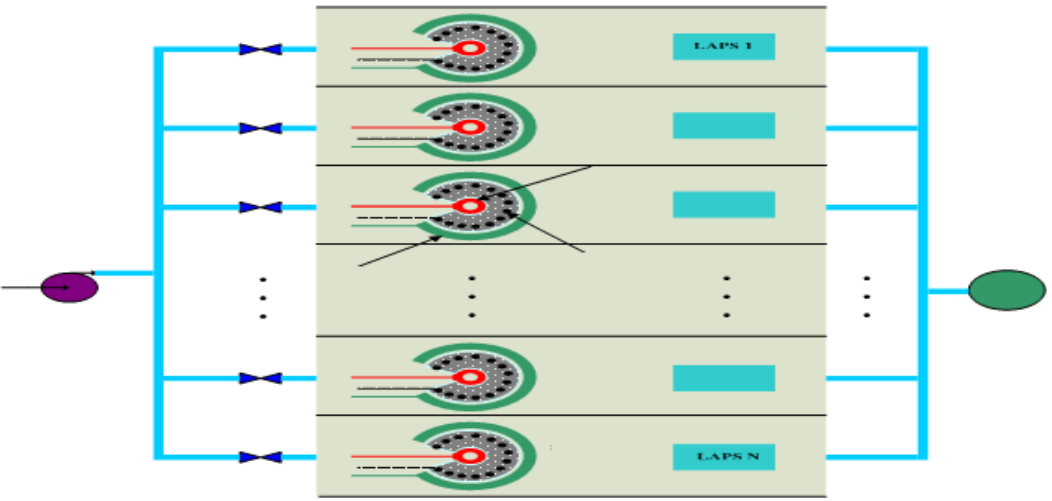


From Prof. Toko's Lab

Developed electrochemical e-Tongue





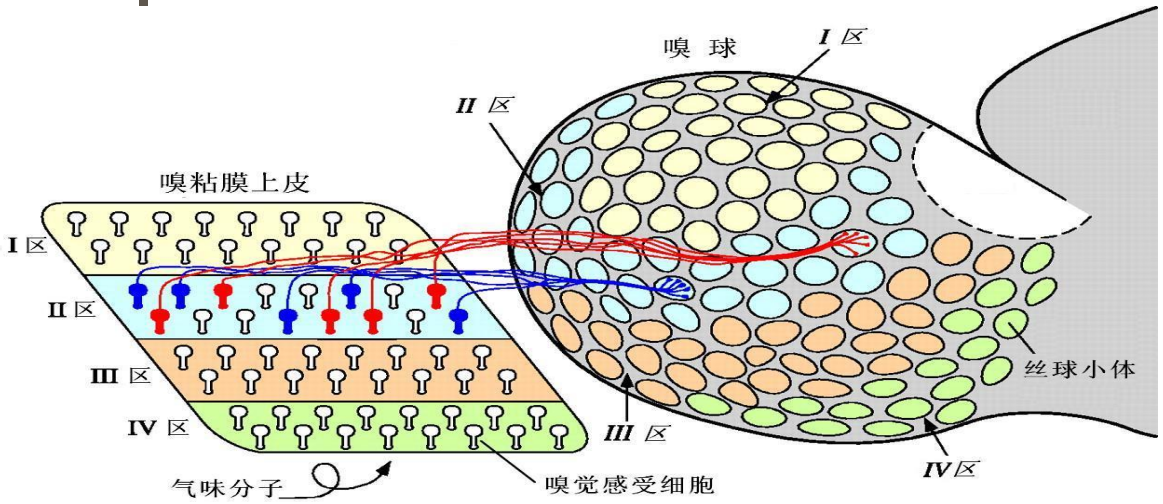


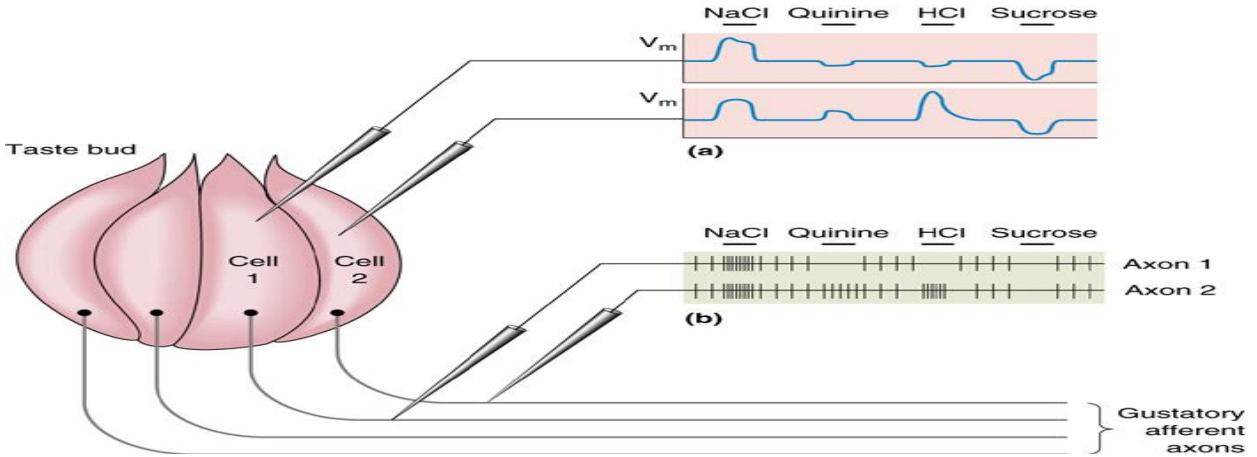
2nd Part

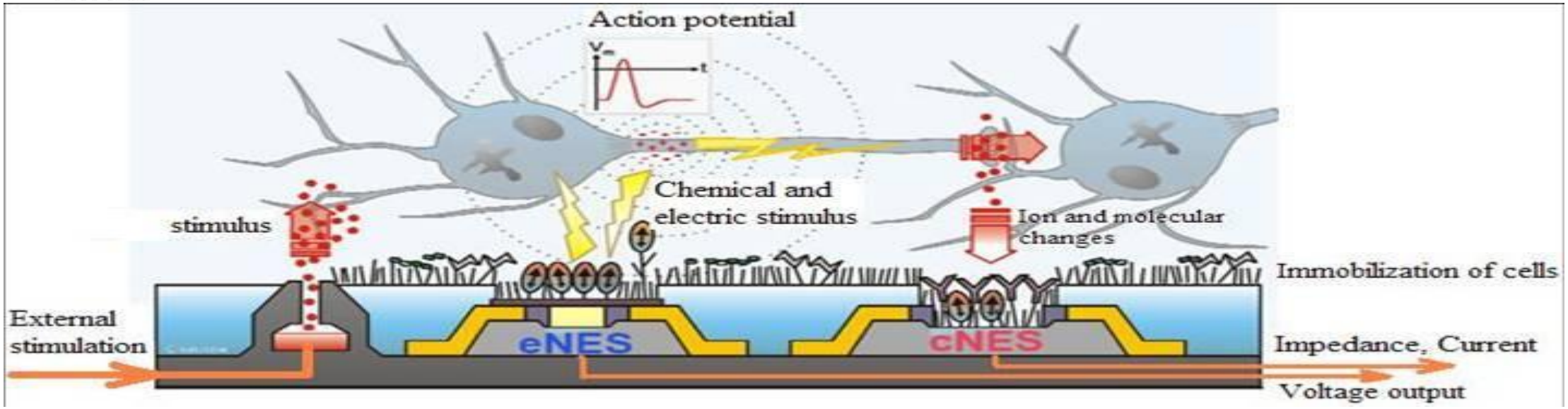
Bioe-Nose and Bioe-Tongue

In vitro and *in vivo*

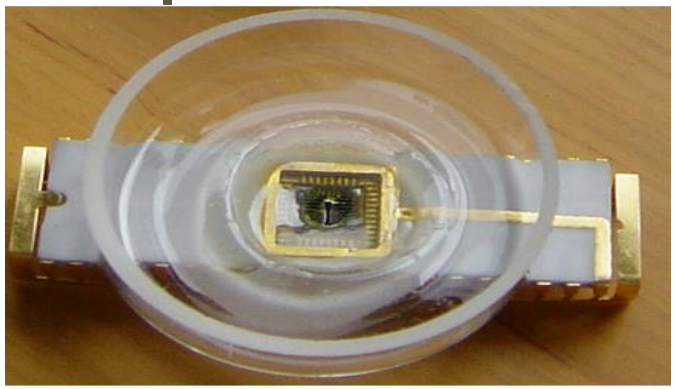
Bioe-Nose and Bioe-Tongue *in vitro/vivo* uses Bioactive Elements and Biotechnologies

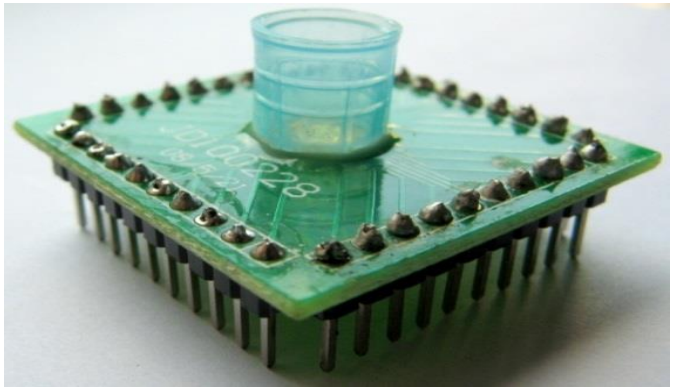


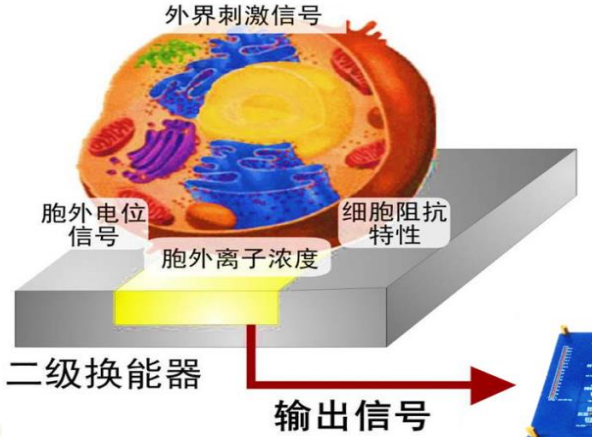


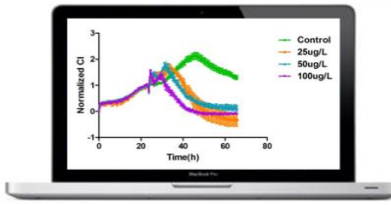


Biomimetic nose and tongue chips



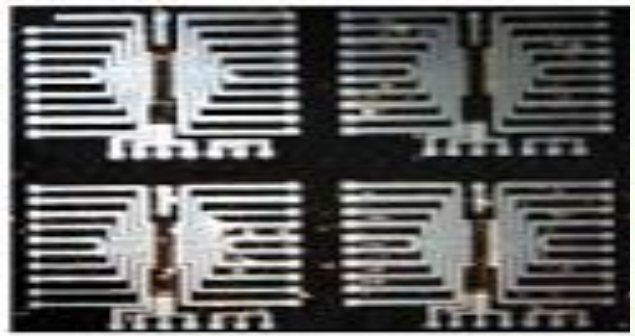


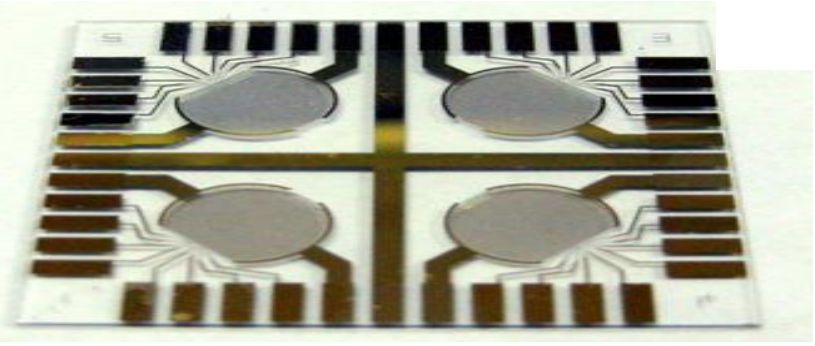


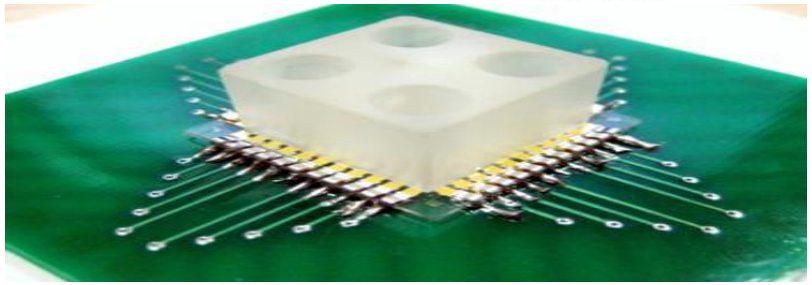


计算机

电路系统

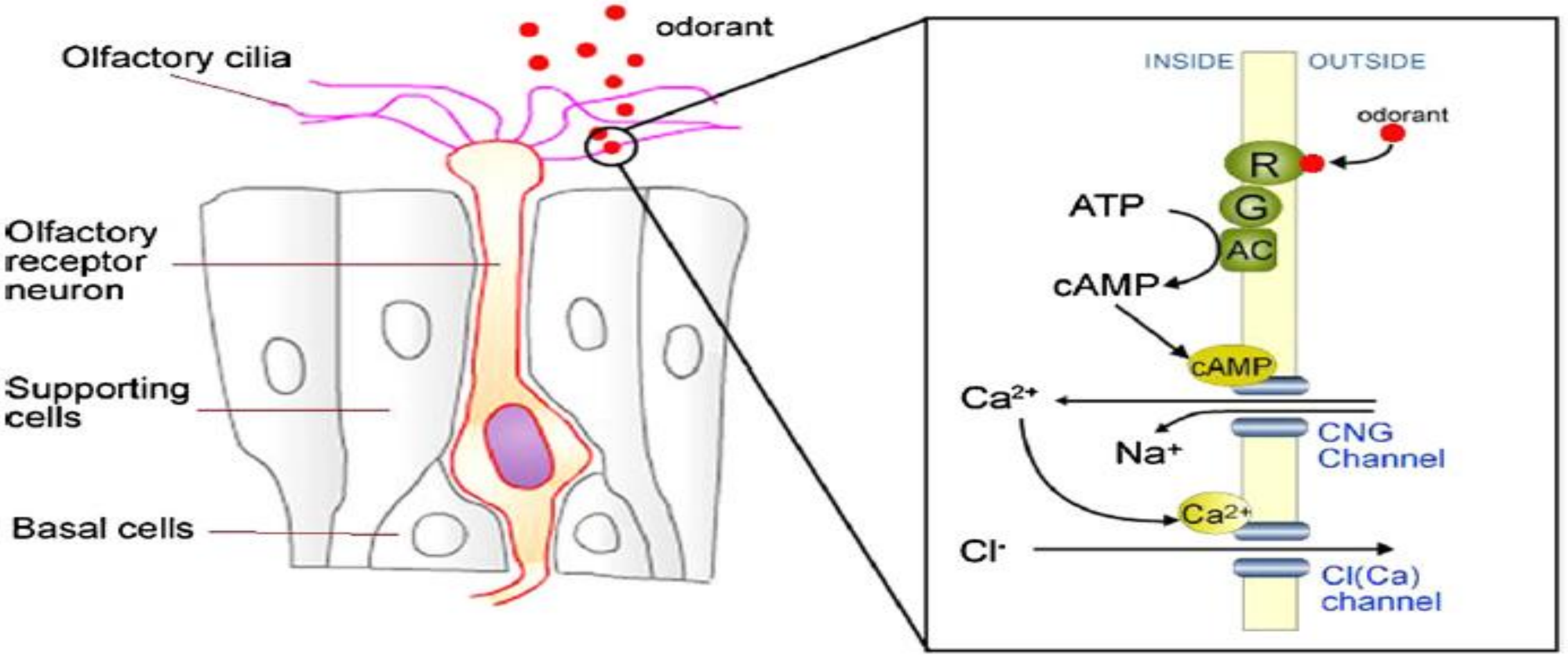




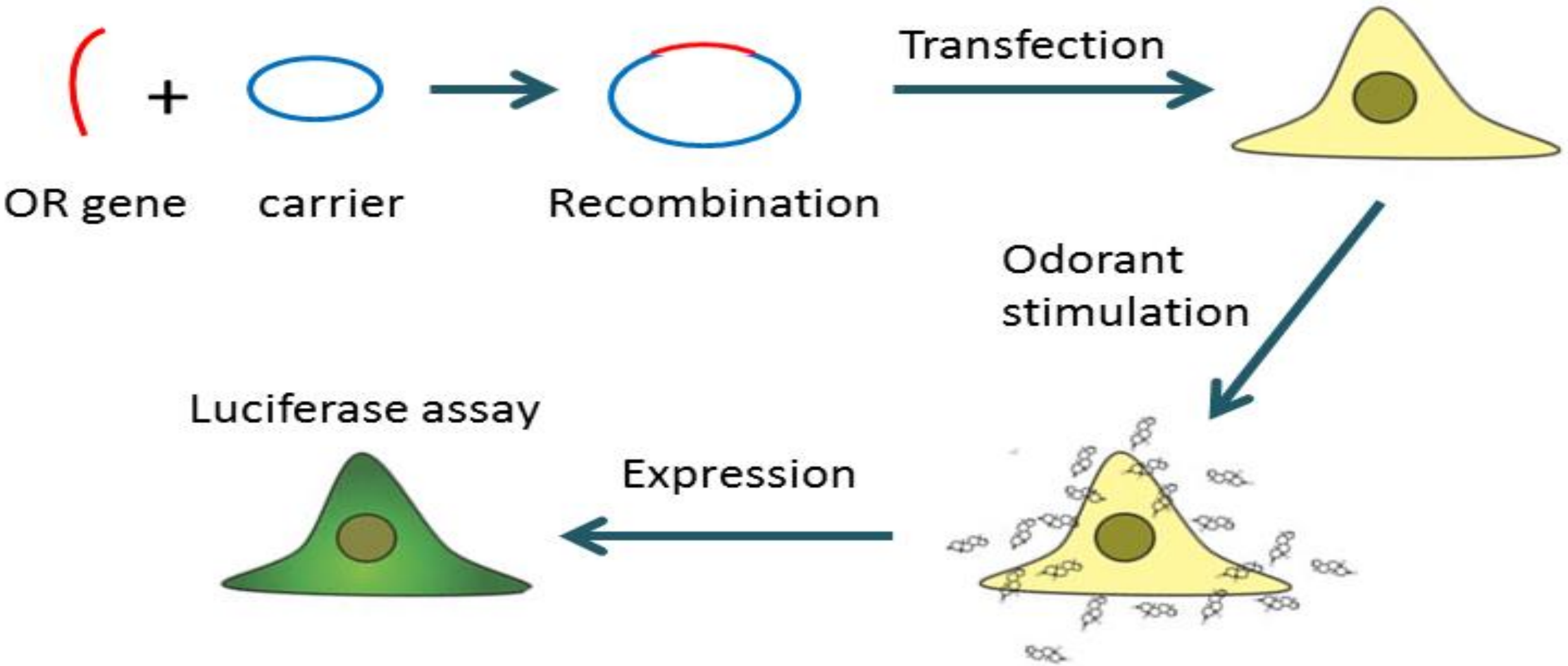


The development the device integrating FET array and culture olfactory and taste bud cell on the device and detect the response under stimulants of odor and taste.

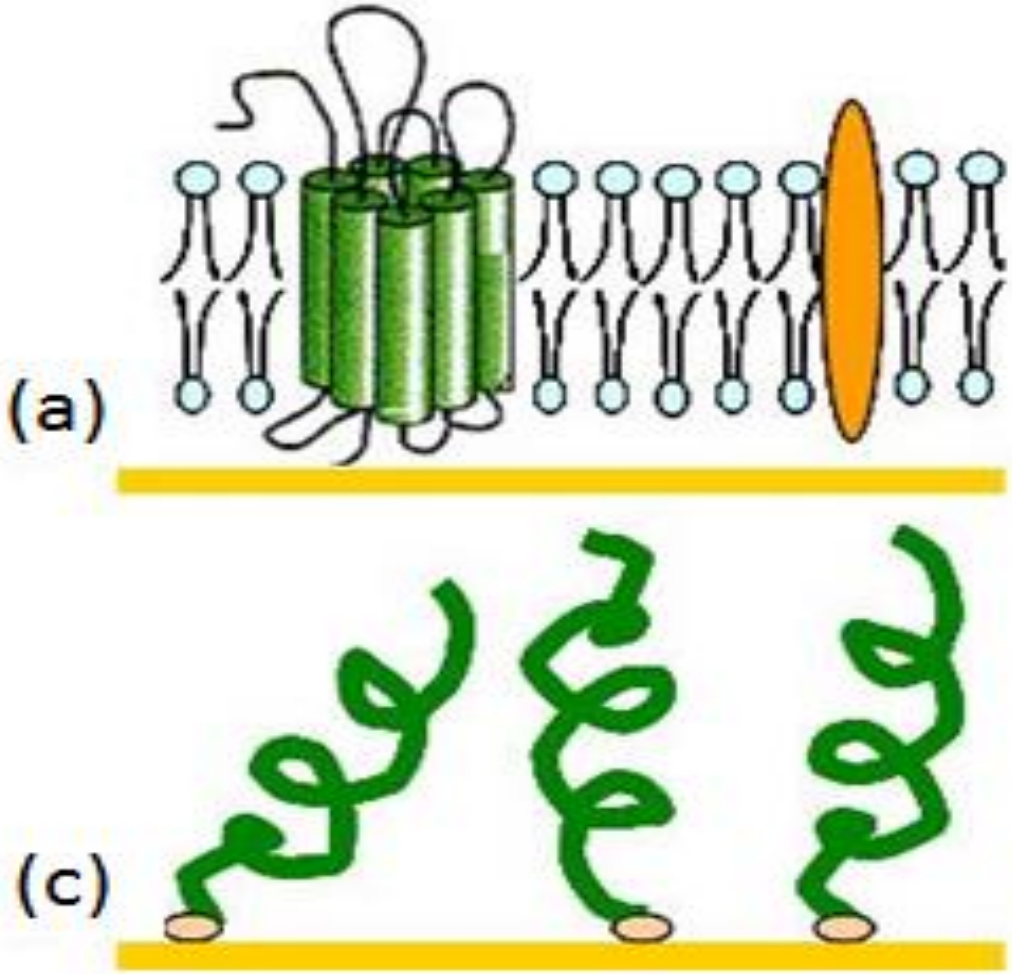
Olfactory receptor neuron and the ion channels in the cilia

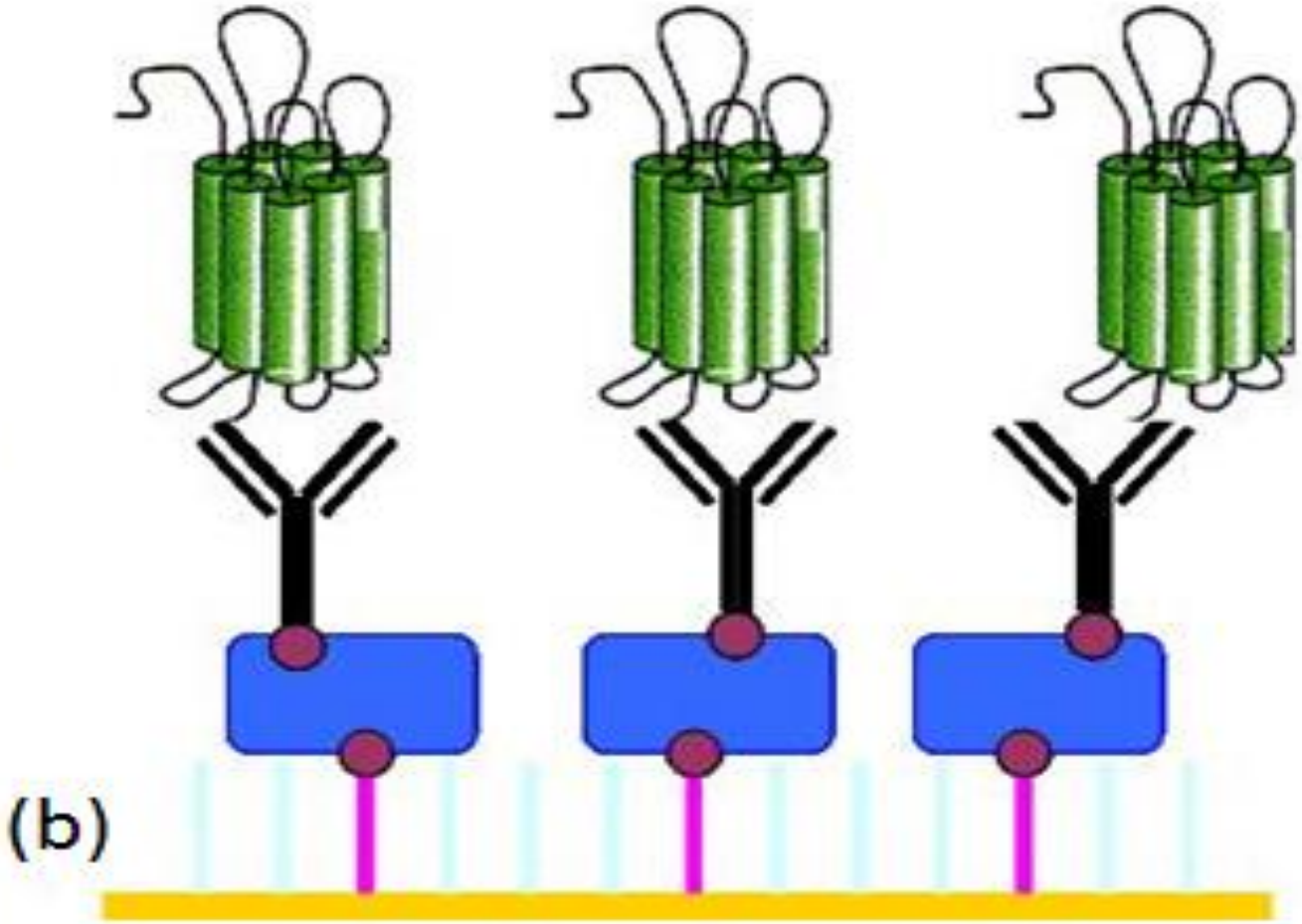


Cell-based Olfactory Receptor Synthesis and Expression



immobilization methods for ORs coupling with transducers

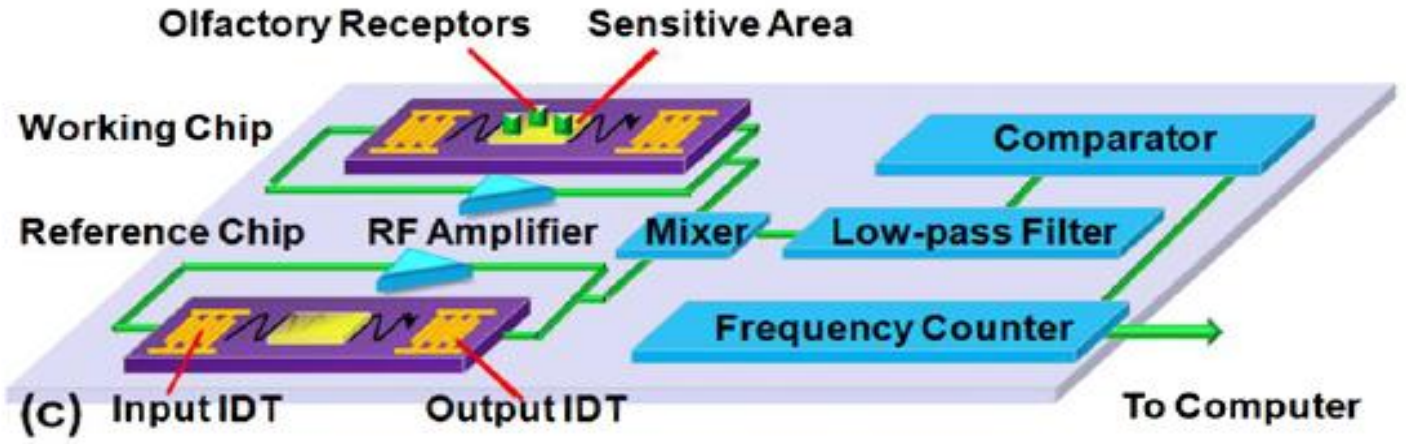


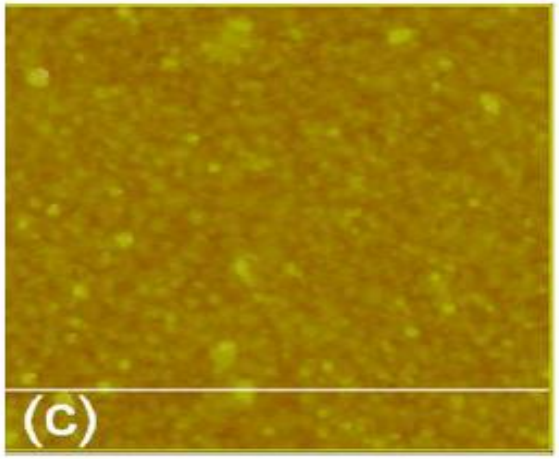


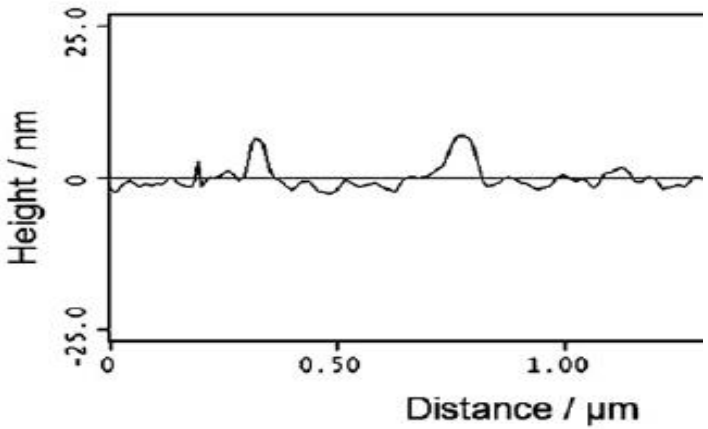
Receptor-based Bioe-Nose

surface acoustic wave (SAW)

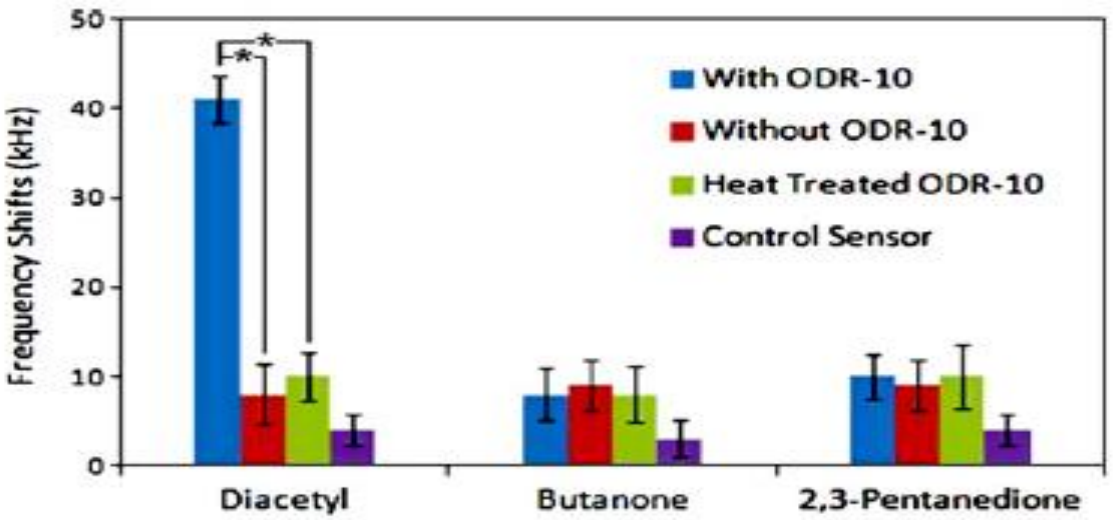
- ✓ Mass change
- ✓ Cell and receptor







AFM scans of the SAW chips with a sensitive surface immobilized with ODR-10 by SAMs.



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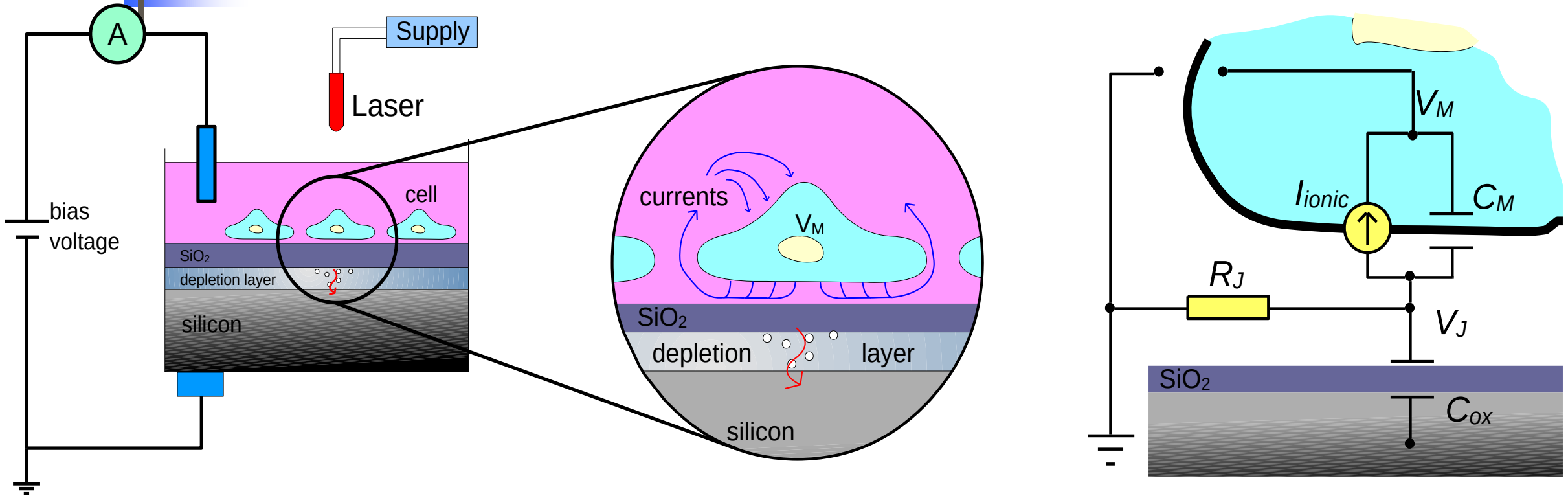
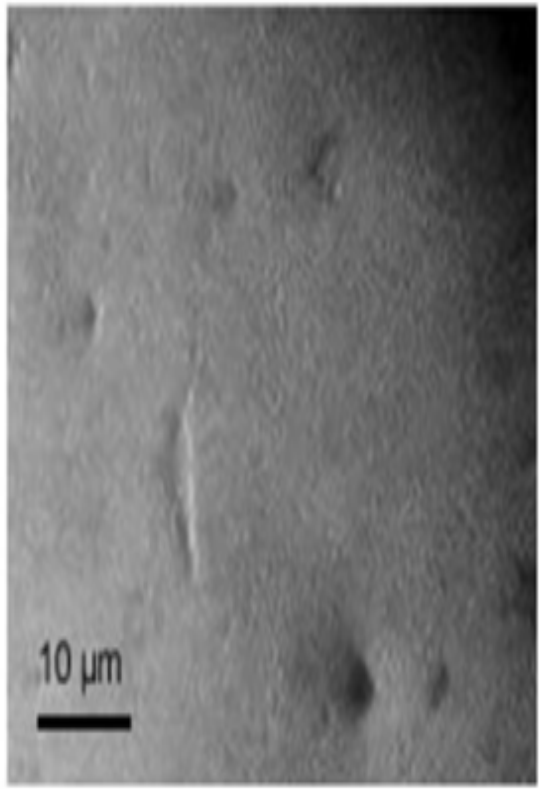
LAPS for electrophysiological sensing of olfactory cells



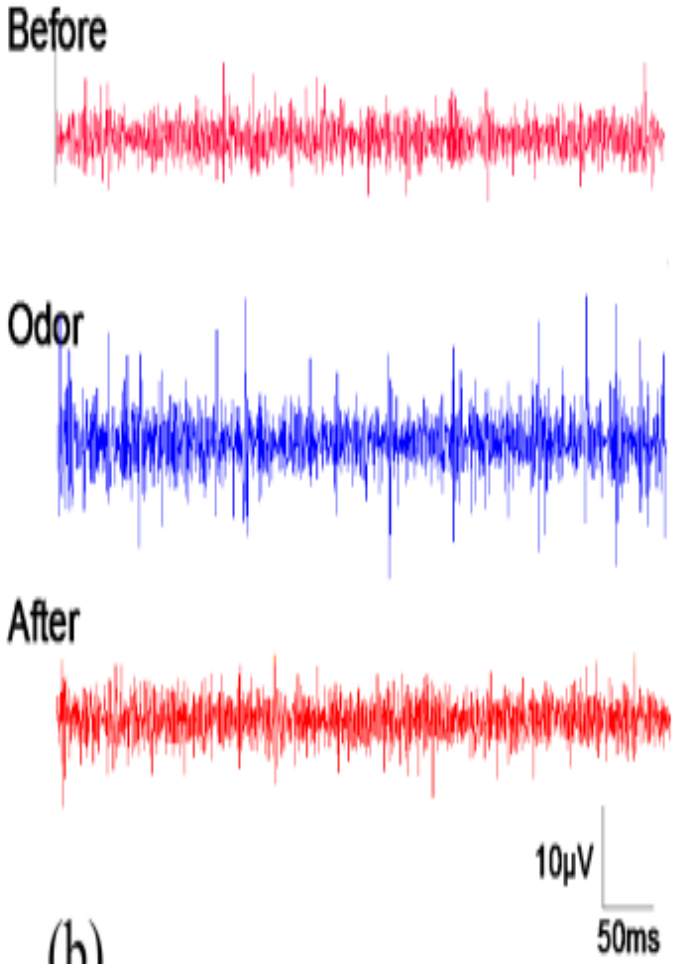
(a) (b) $\frac{V_J}{R_J} = C_M \frac{d(V_M - V_J)}{dt} + I_{ionic}$ (c)

Fig. 3.2. Principle of the olfactory-LAPS system. (a) The schematic of cell-based biosensor using LAPS. (b) Simplified cell-semiconductor interface. (c) Schematic circuit of the cell-

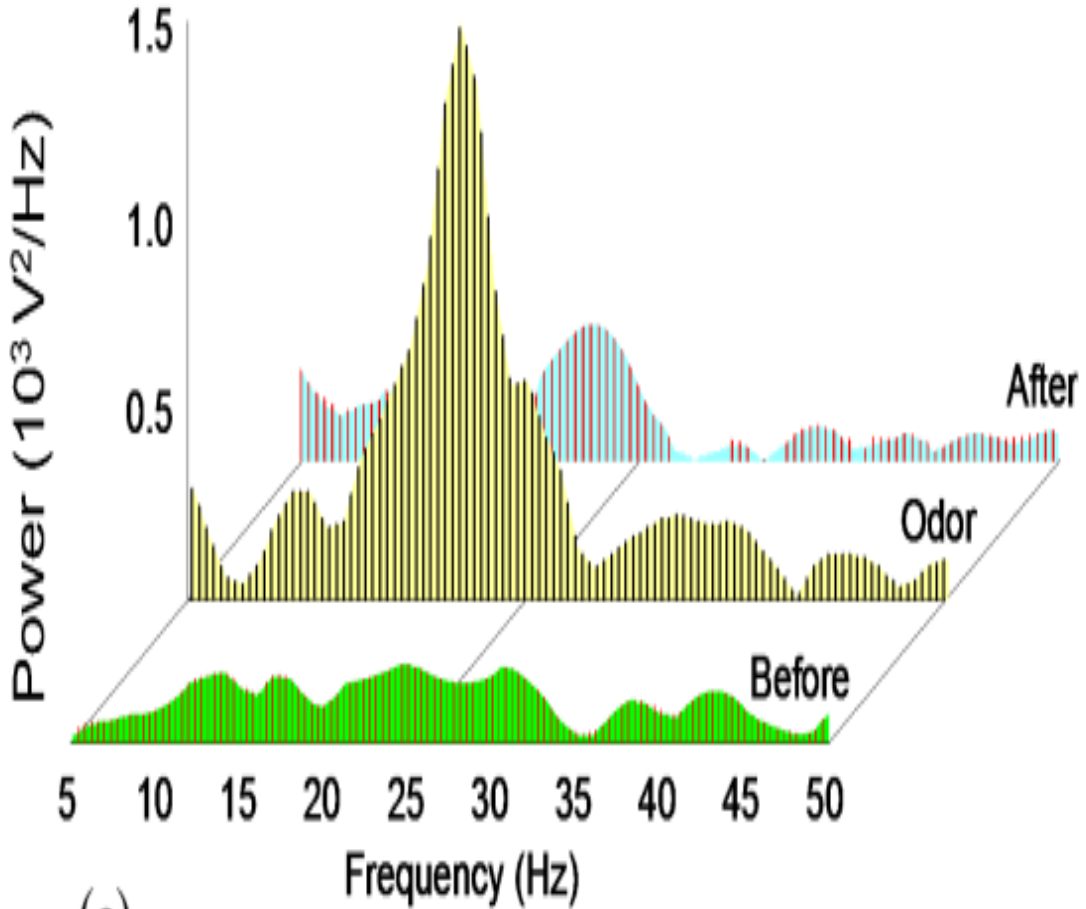
Odorant-elicited Extracellular Potential of the Olfactory Receptor Cells



(a)

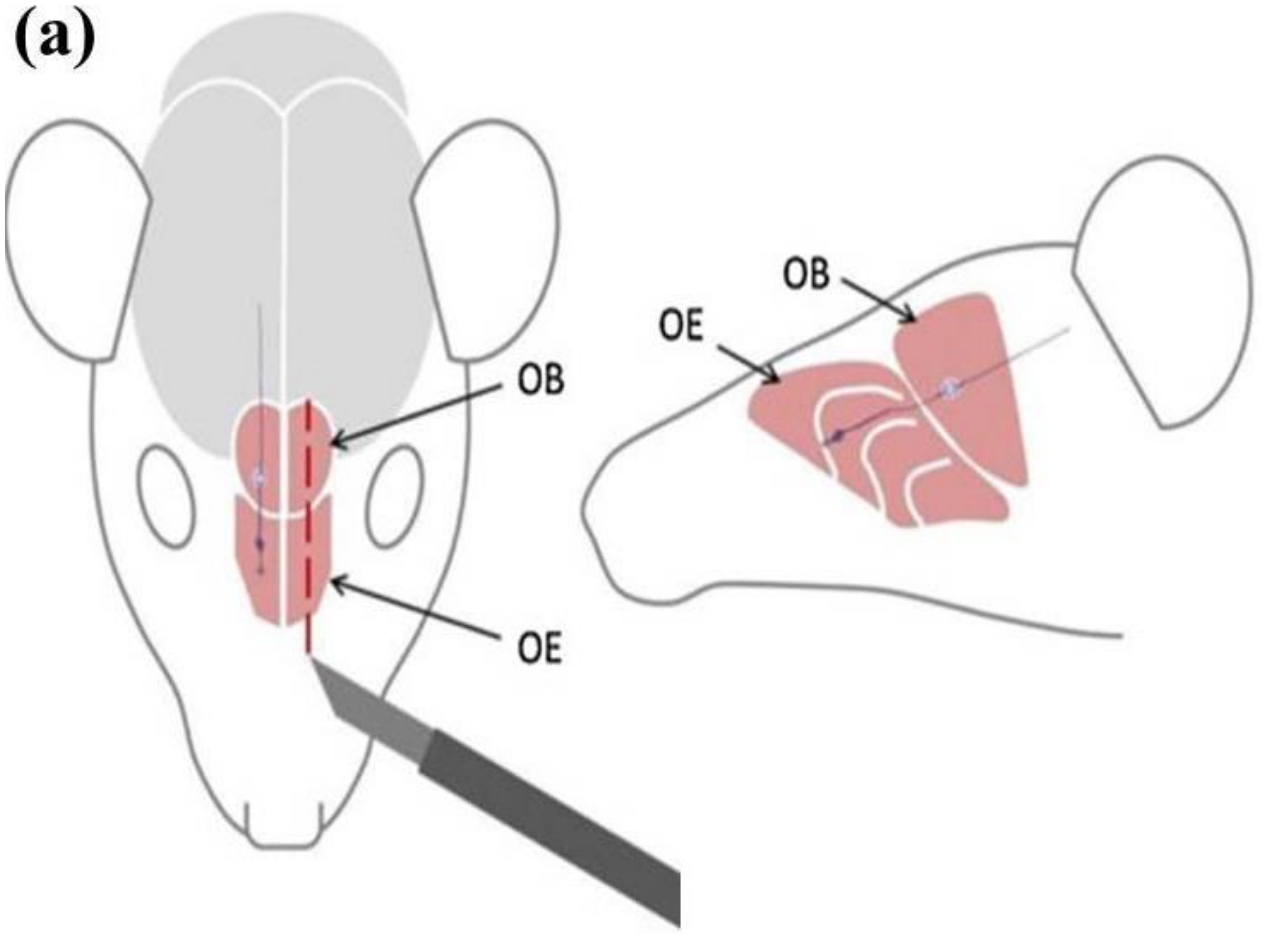


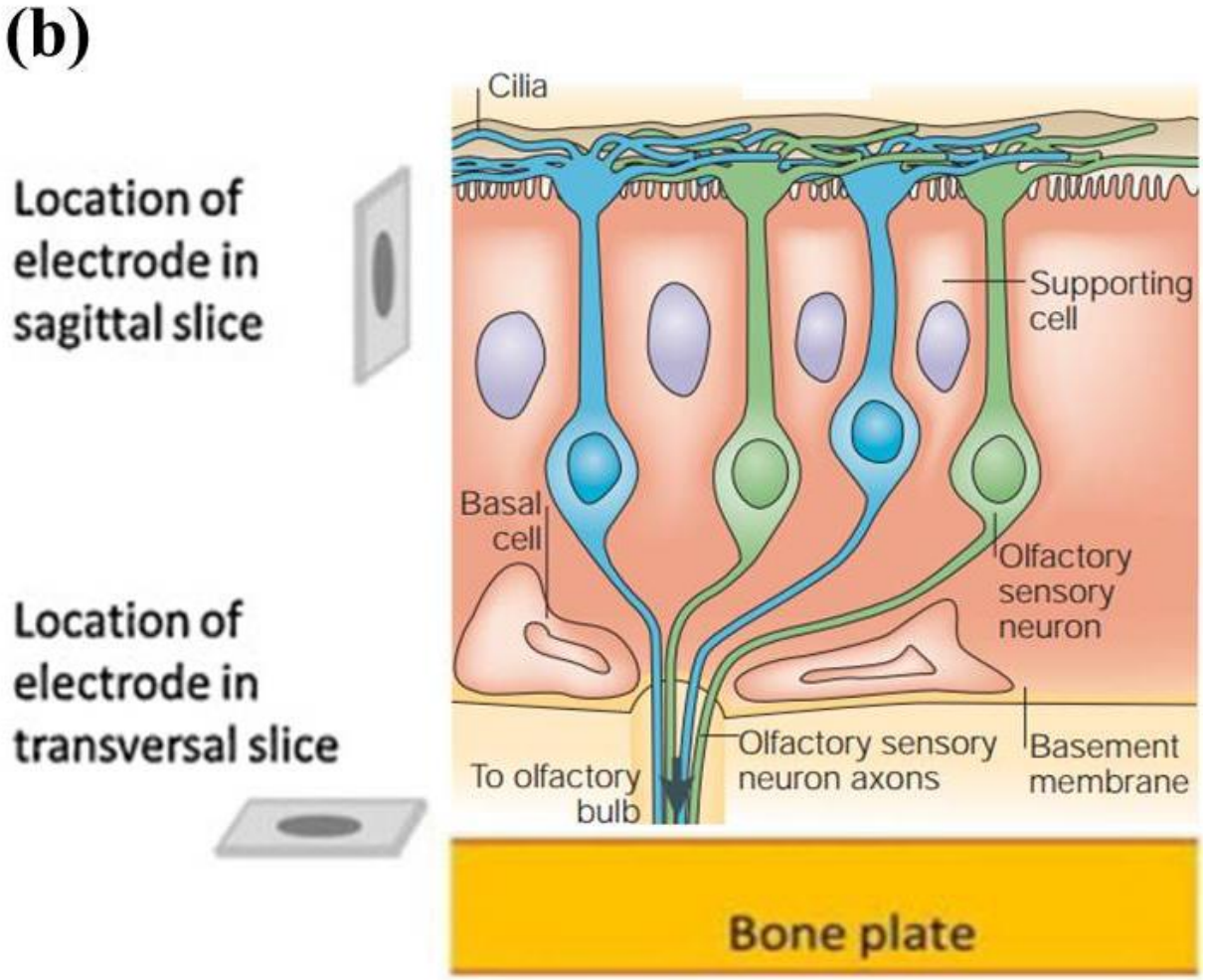
(b)



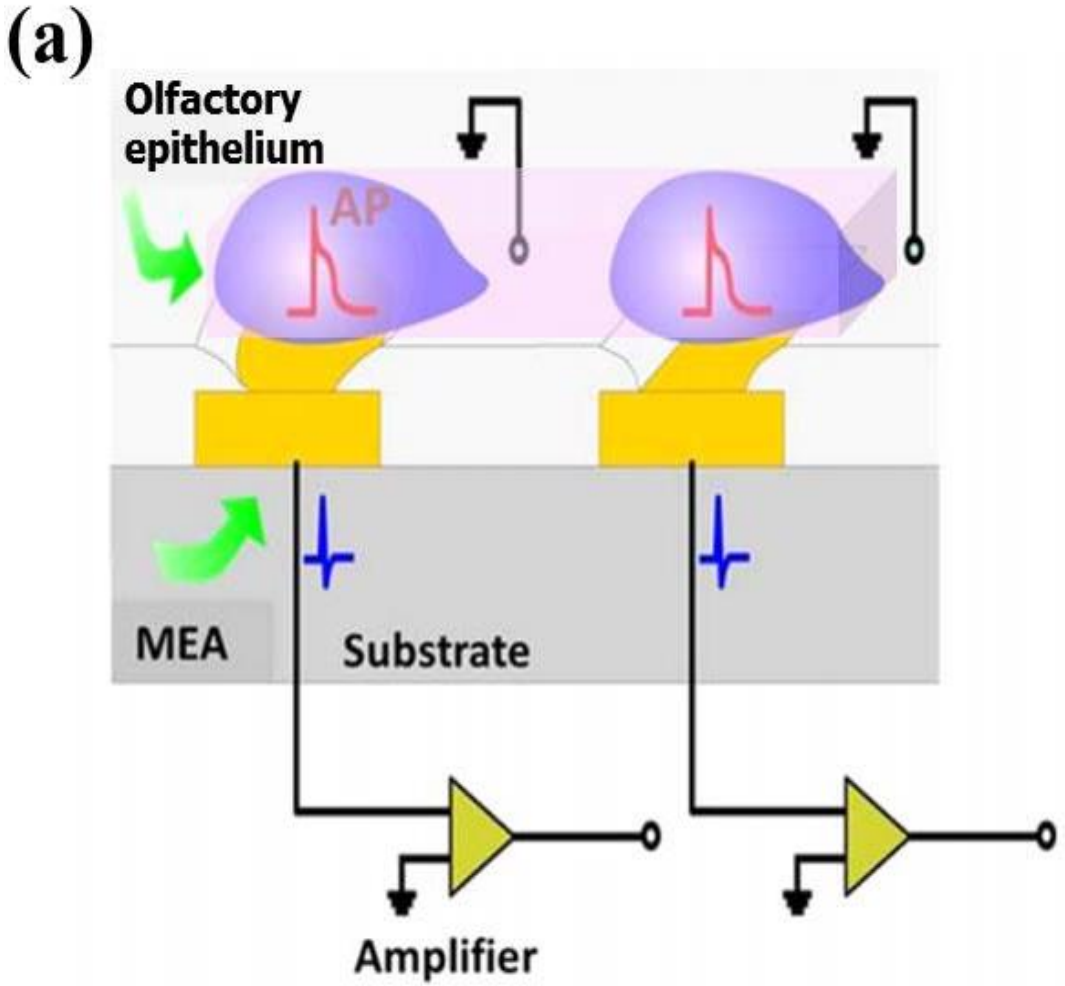
(c)

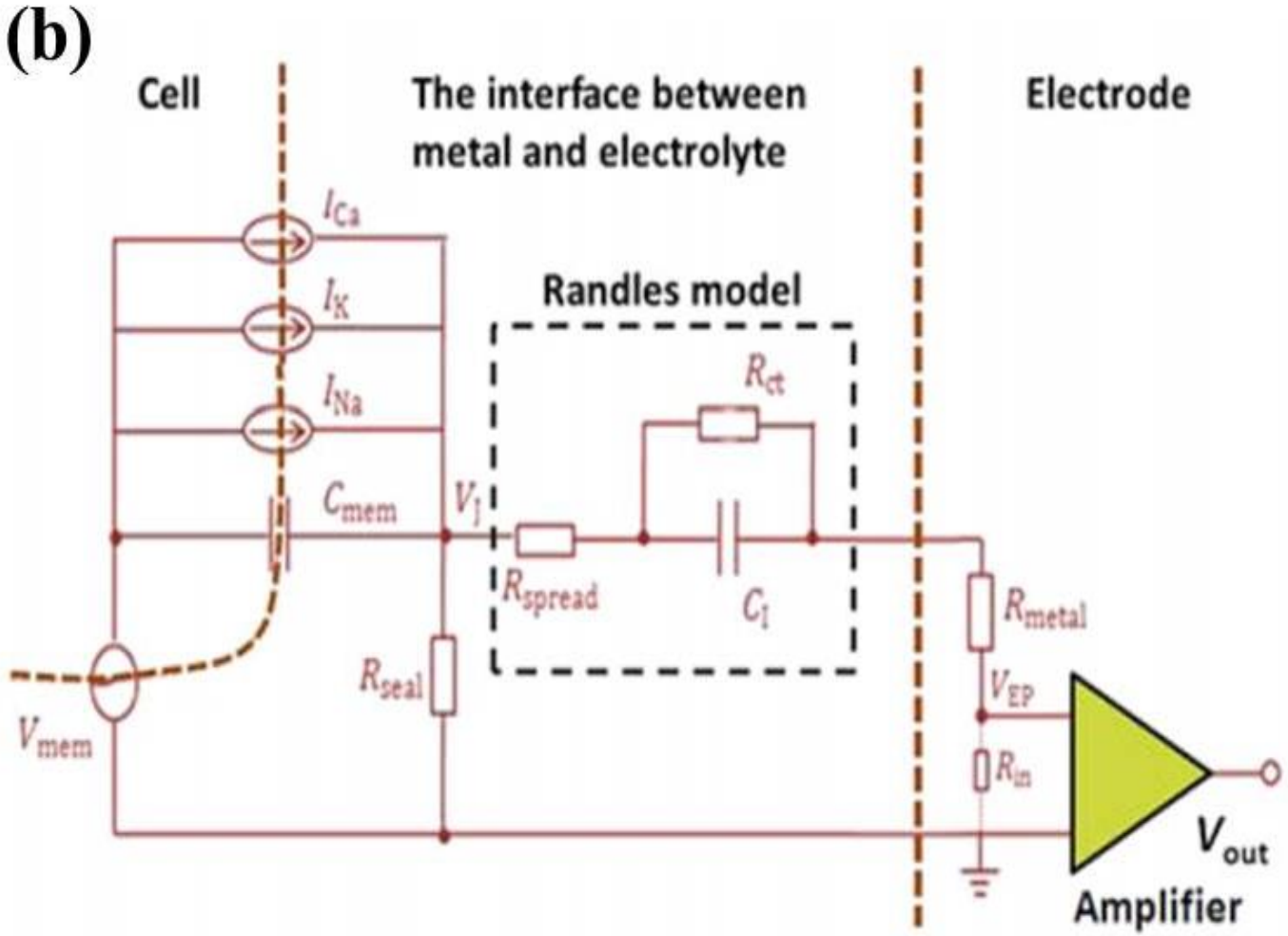
Smell Sensors Based on Olfactory Epithelium





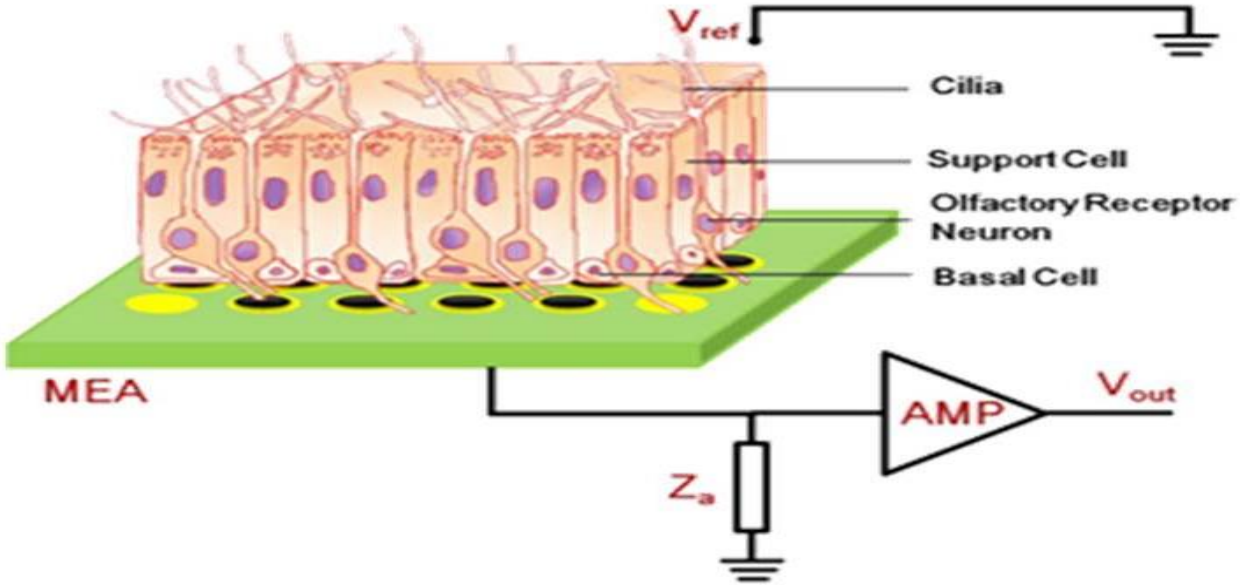
The olfactory epithelium and MEA bio-hybrid Bioe-Nose



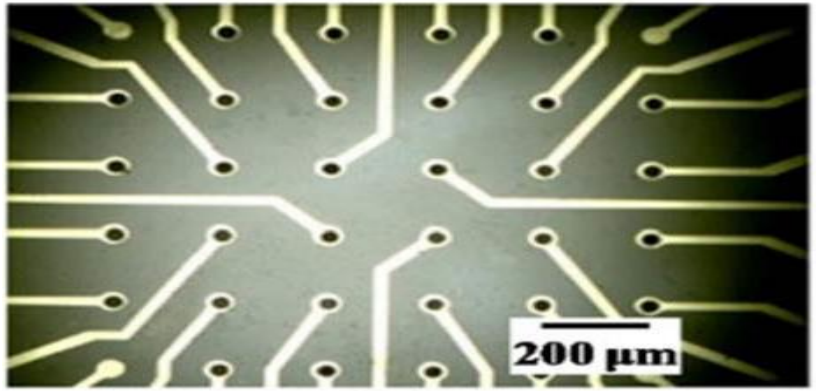


Design of the olfactory epithelium-based Bioe-Nose

(a)



(b)



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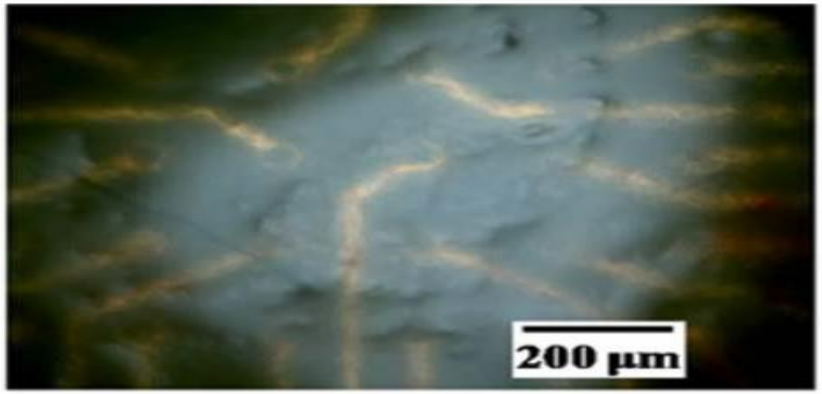
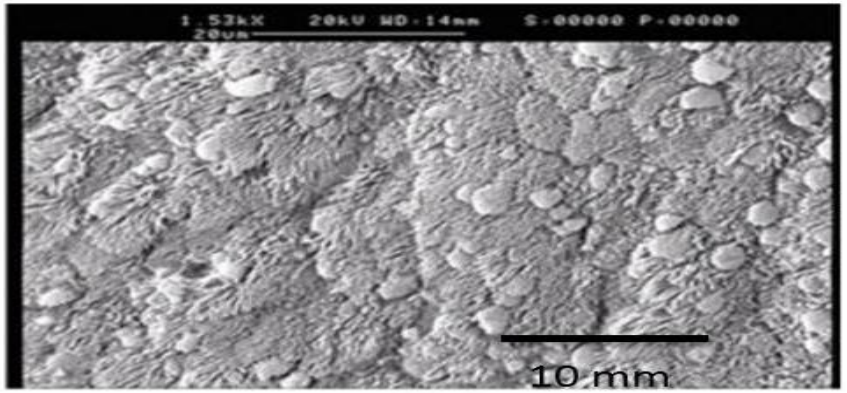
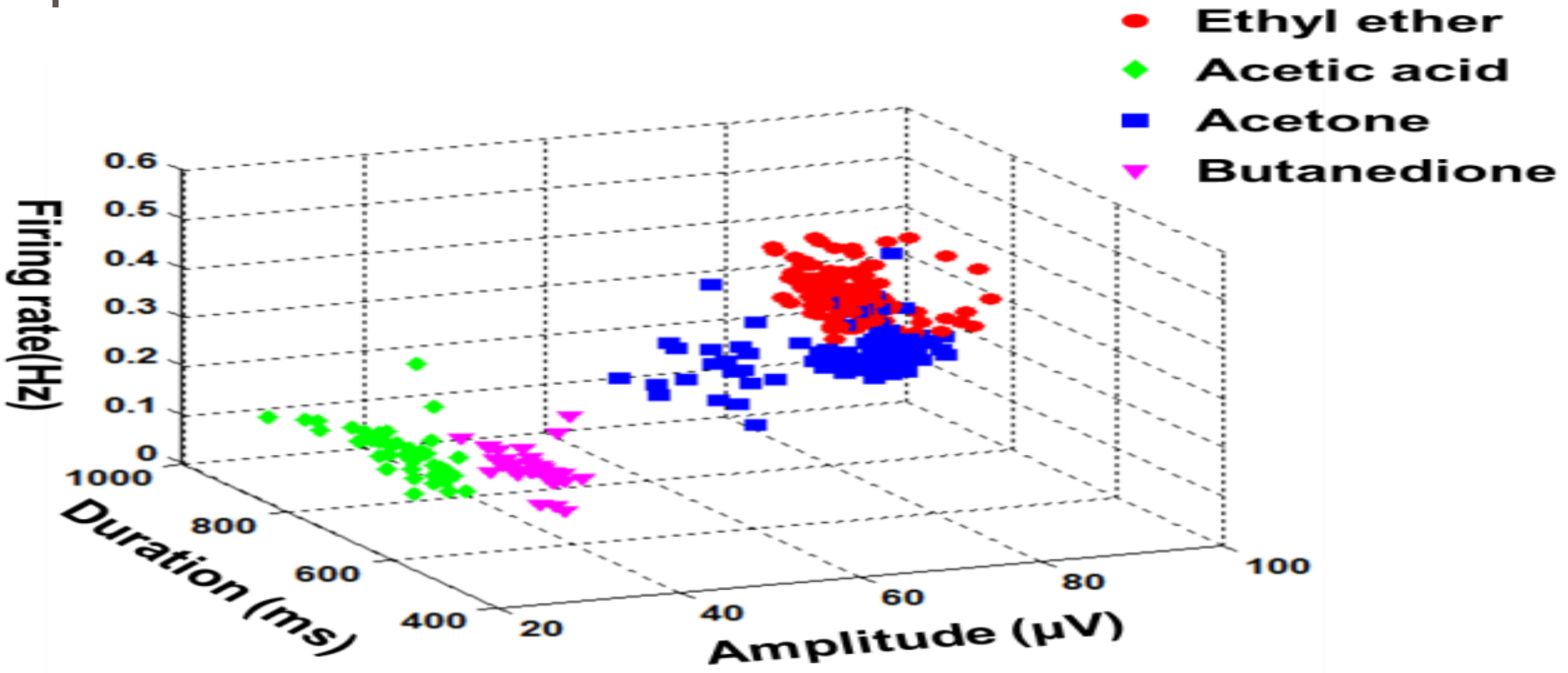


(d)

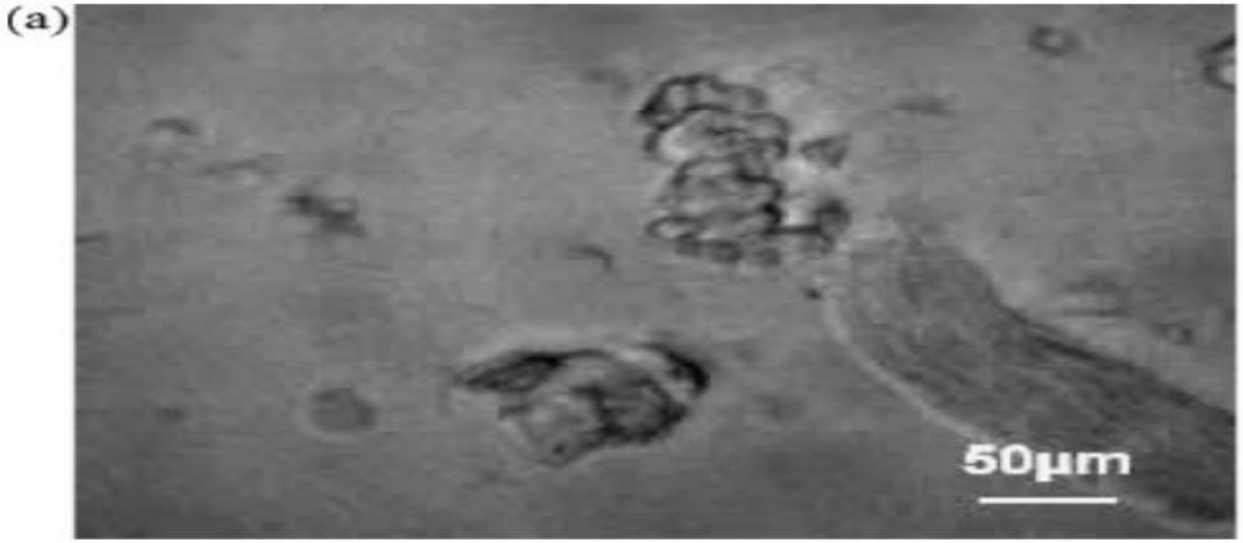


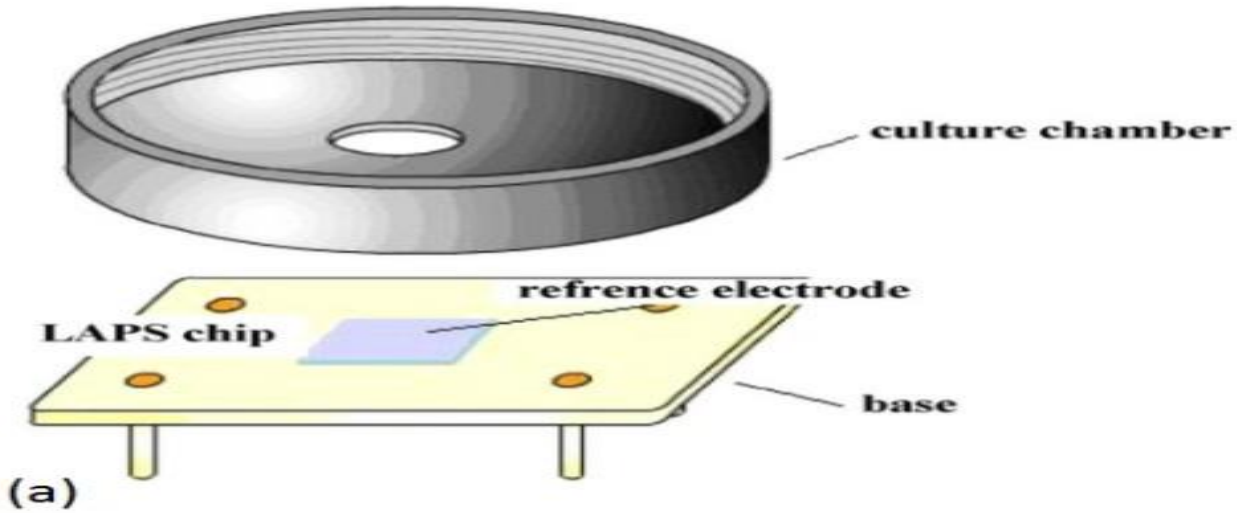
(e)

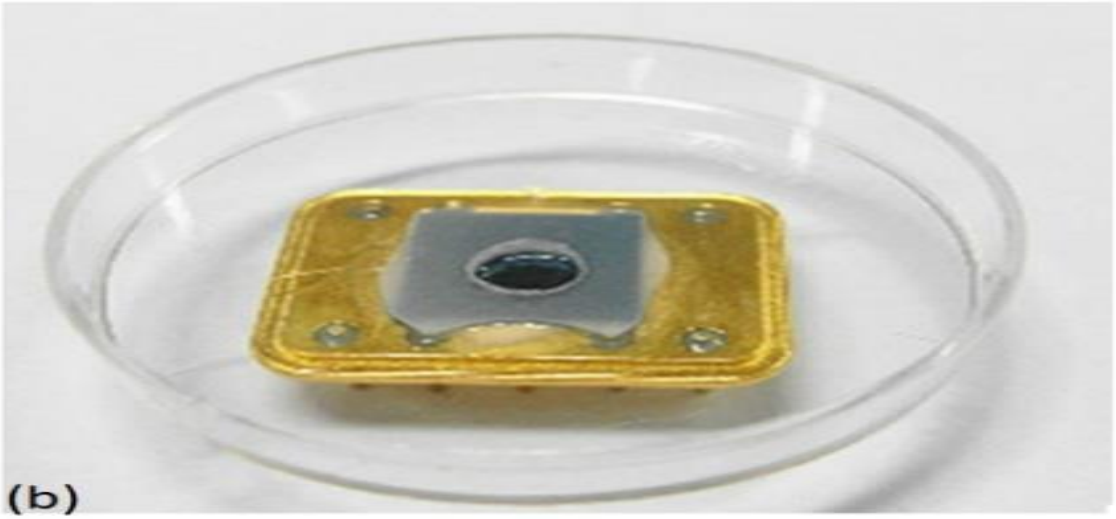
The Recognition Pattern Sensed by Olfactory Epithelium-based Bioe-Nose



Primary Taste Bud and Receptor Cells Isolated from Rats Cultured on LAPS chip

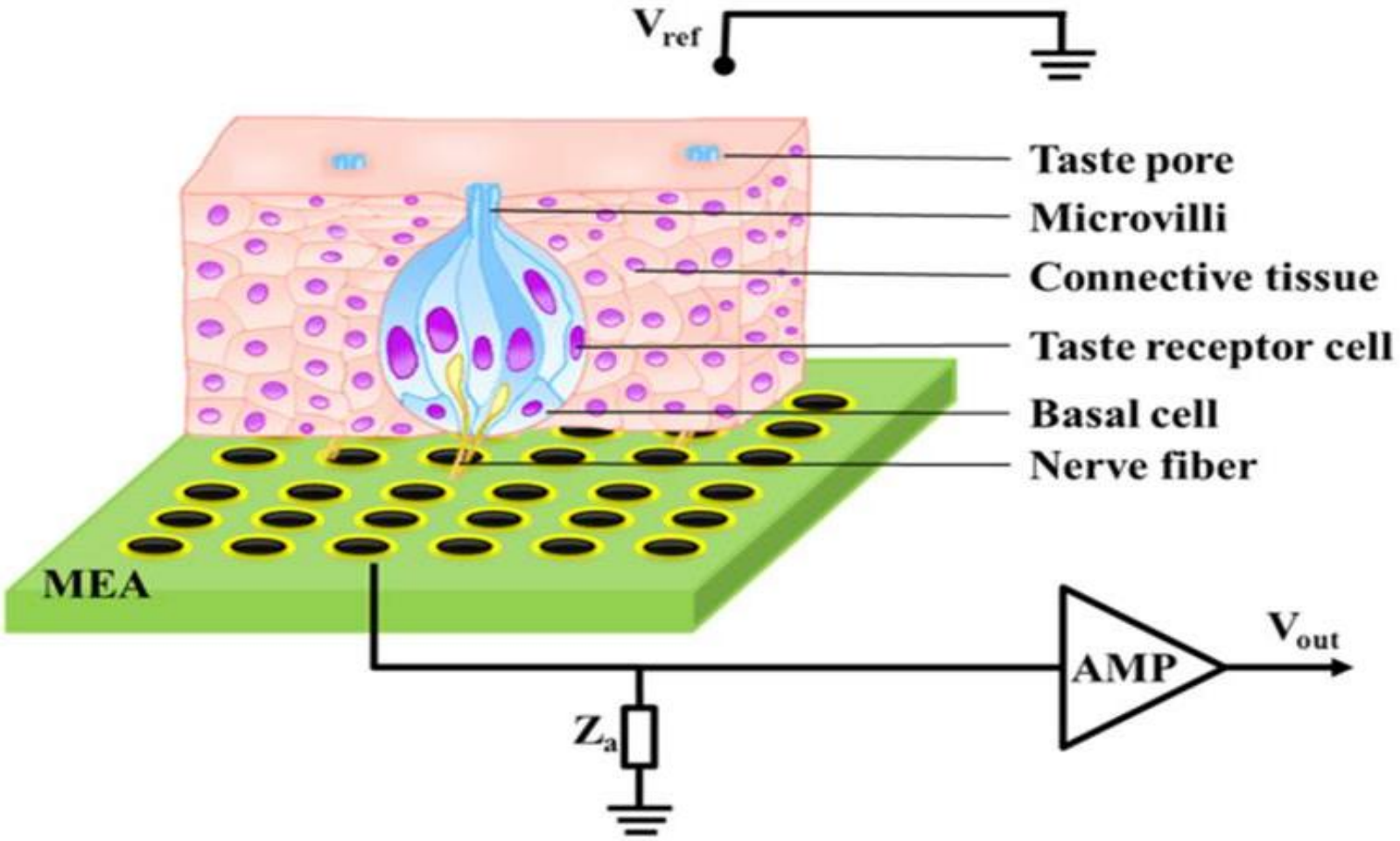






Record Extracellular Potentials of Taste Receptor Cells in Taste Buds by MEAs

(a)



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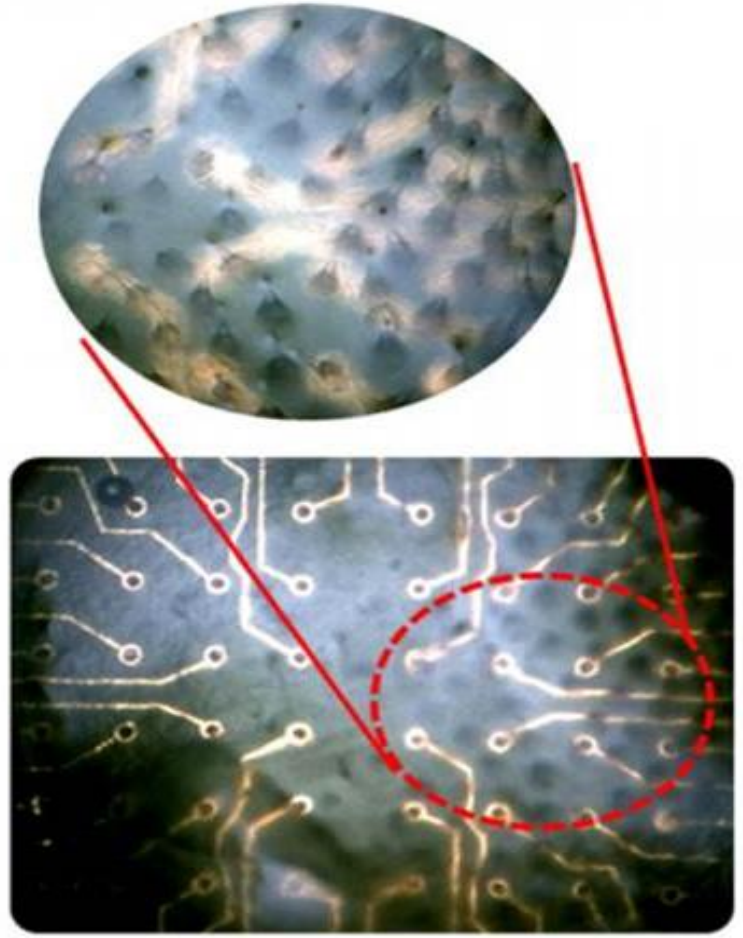
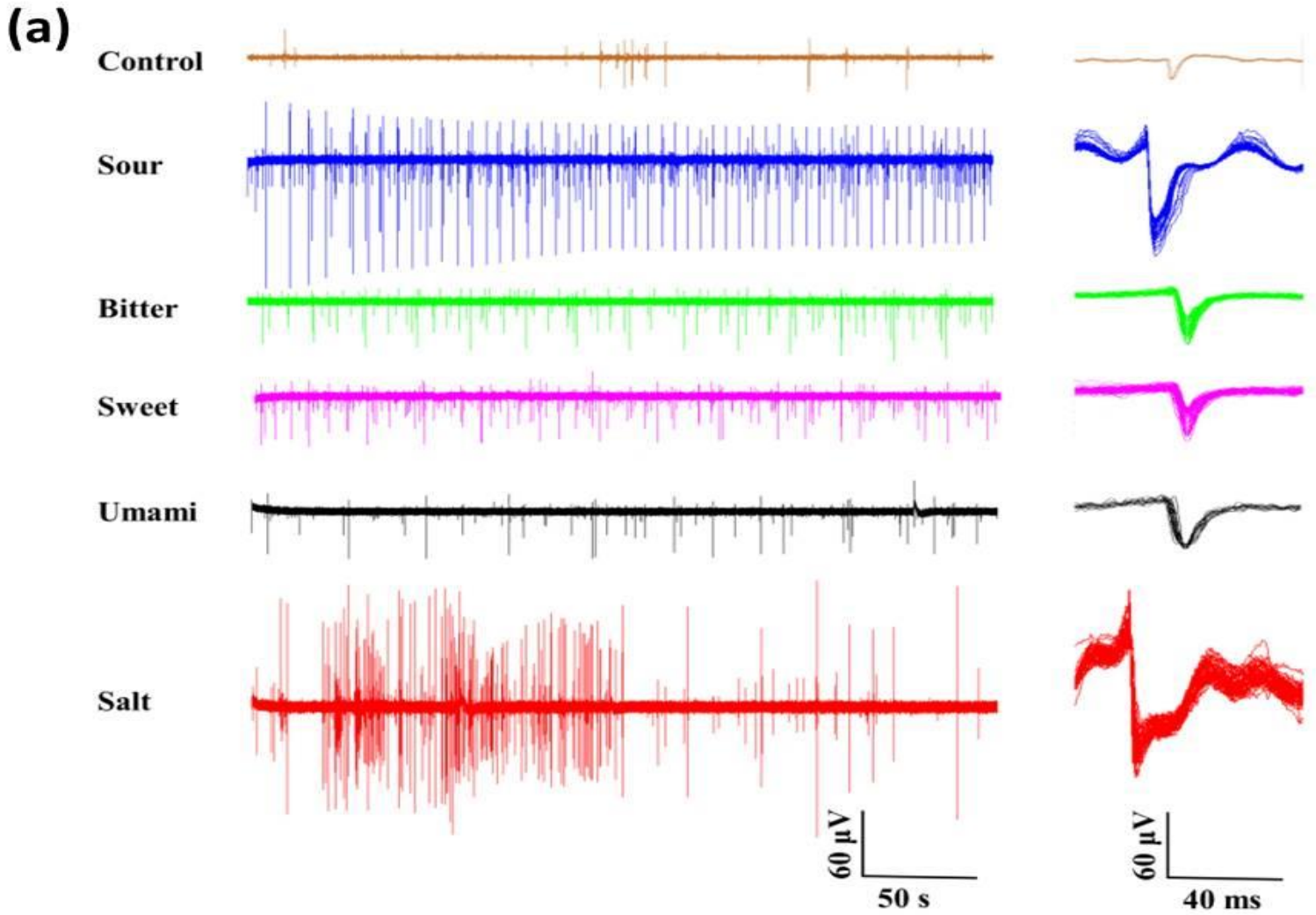
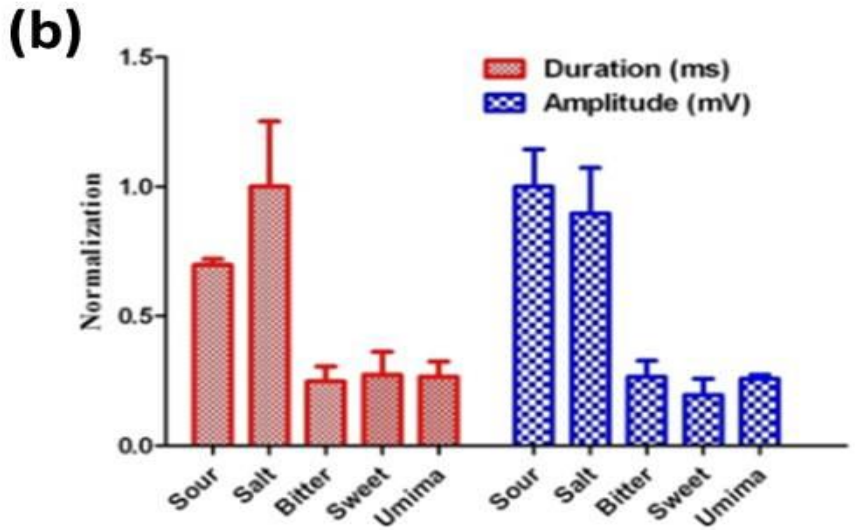
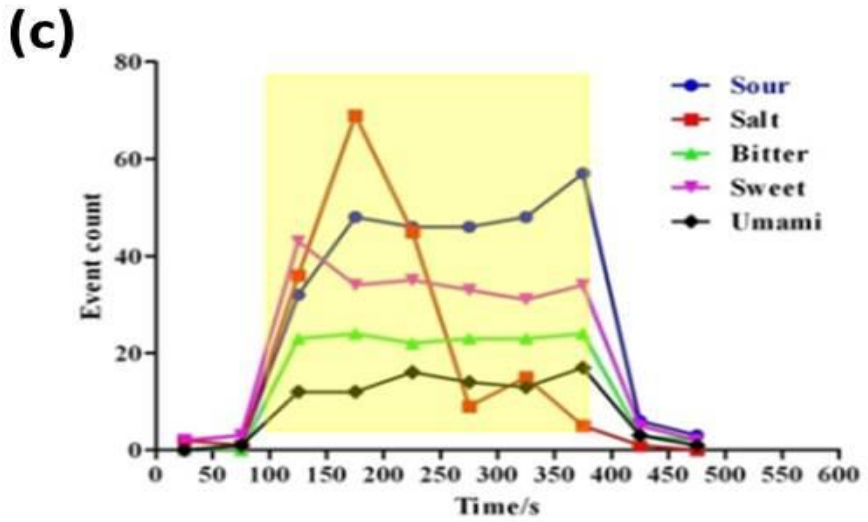


Record Extracellular Potentials of Taste Receptor Cells in Long Time by MEAs

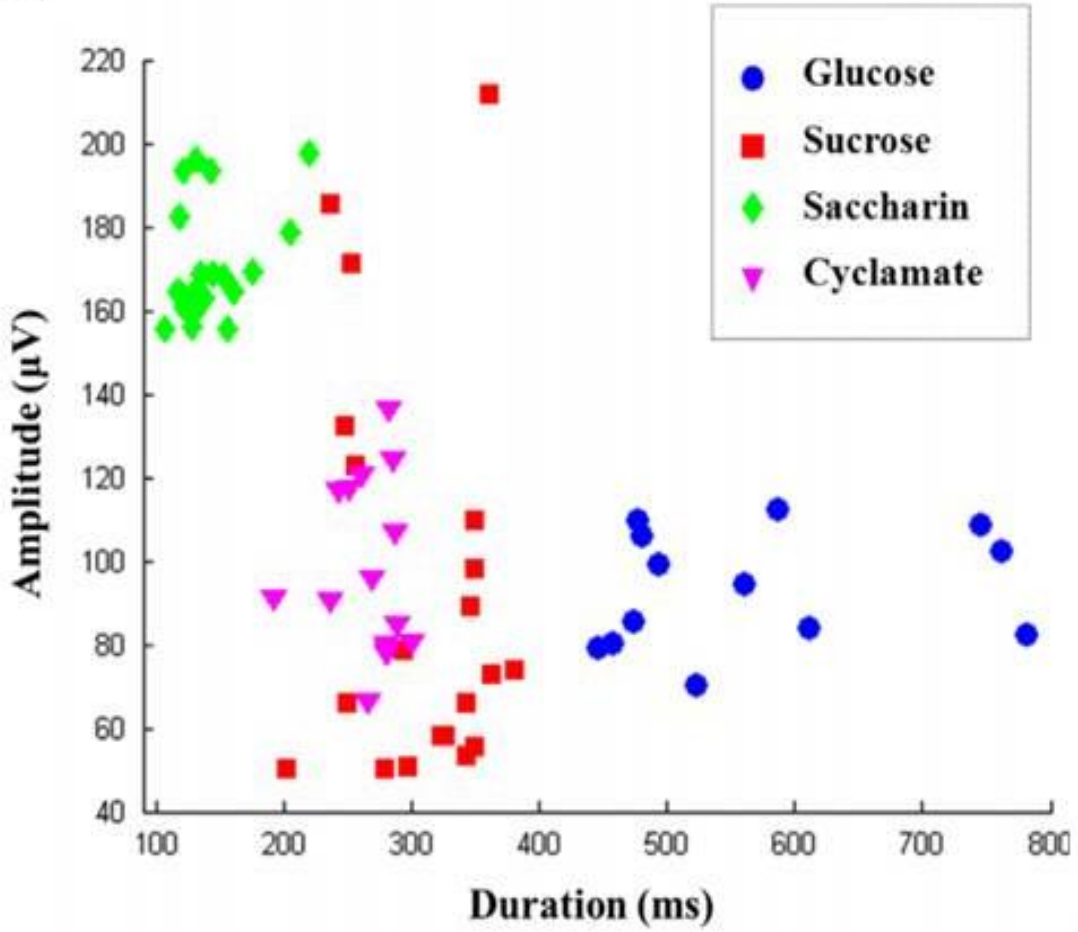




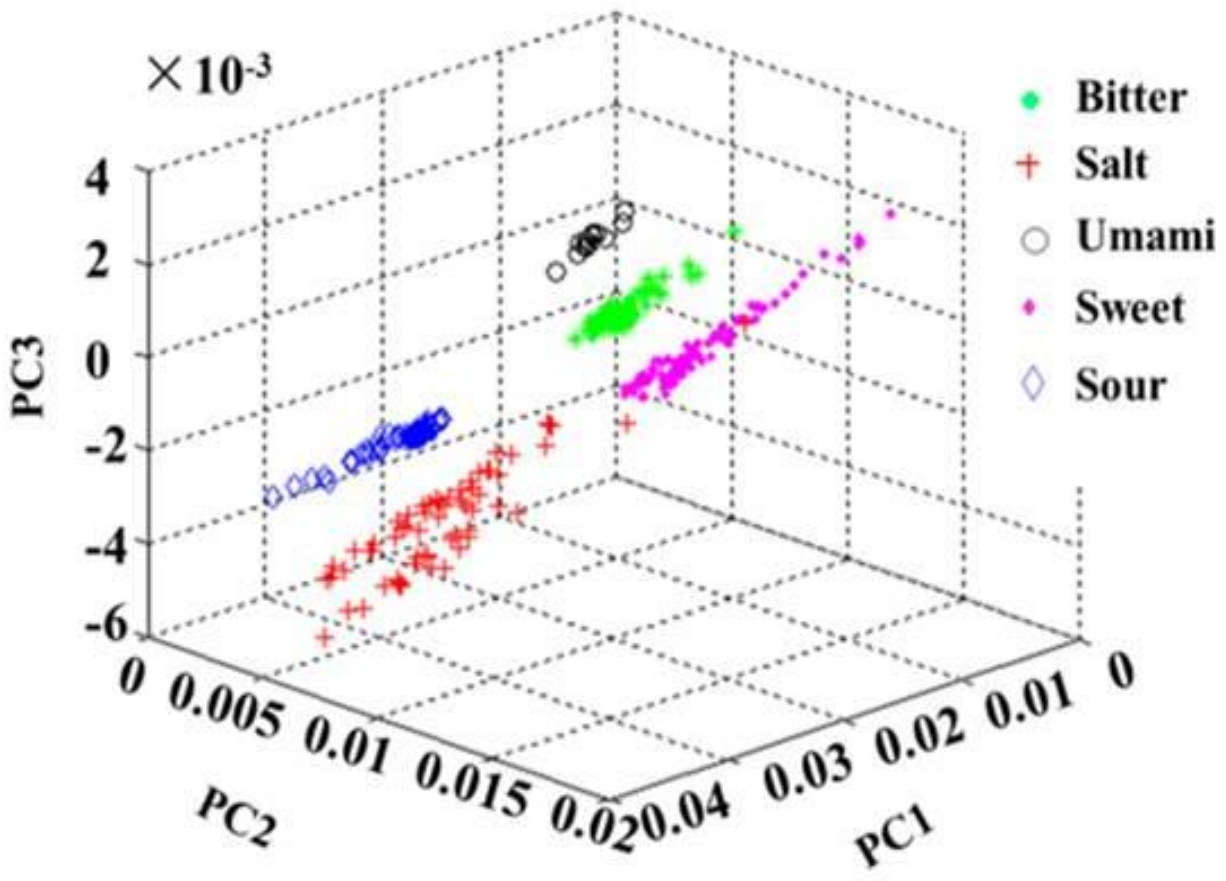


The PCA analysis of action potentials of Taste Receptor Cells in Taste Buds by MEAs

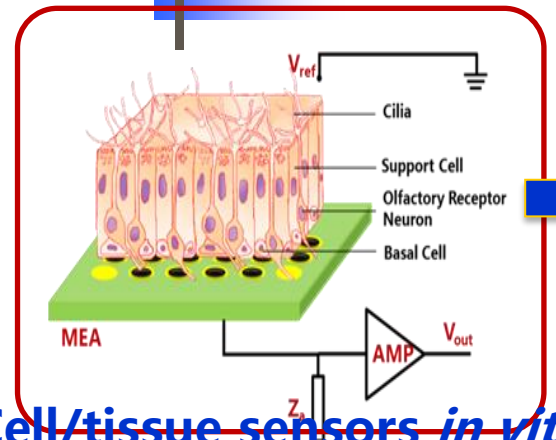
(a)



(b)

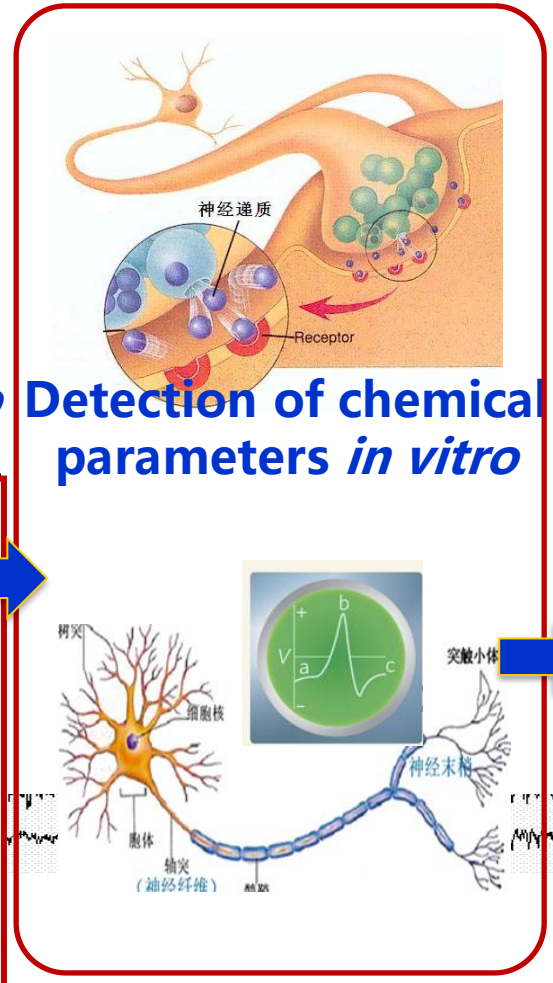


The Further Study on Bioe-Nose/Tougue Combined *in vitro* with *in vivo*

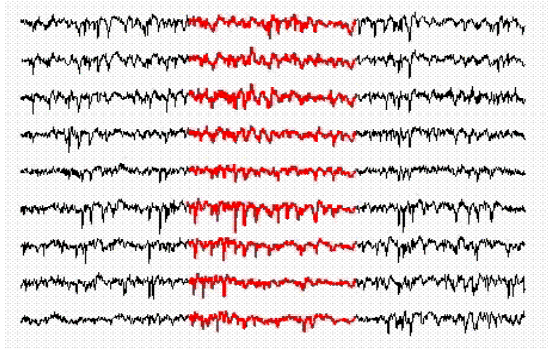


Cell/tissue sensors *in vitro*

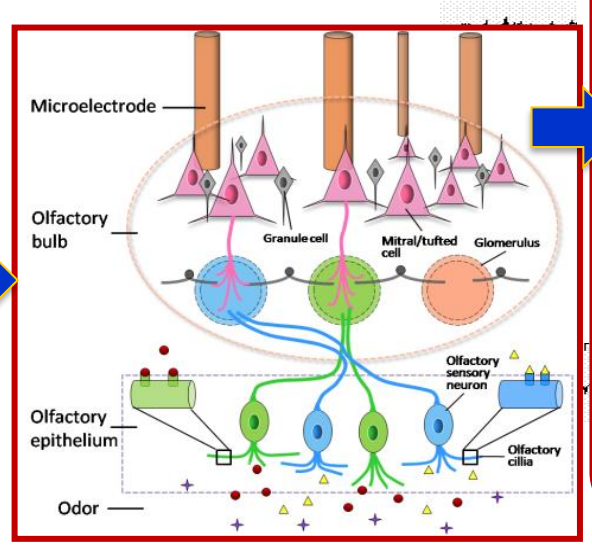
Neuron network *in vitro*



Detection of chemical parameters *in vitro*

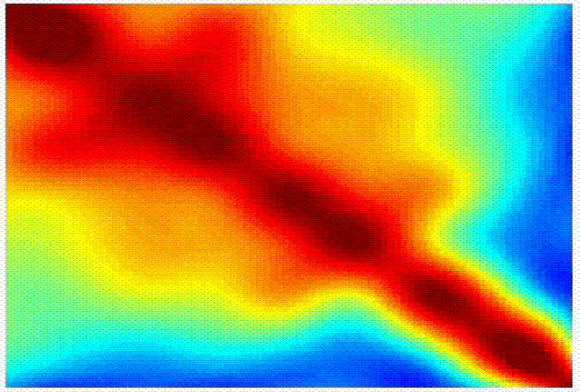


Cell/tissue sensors *in vivo*



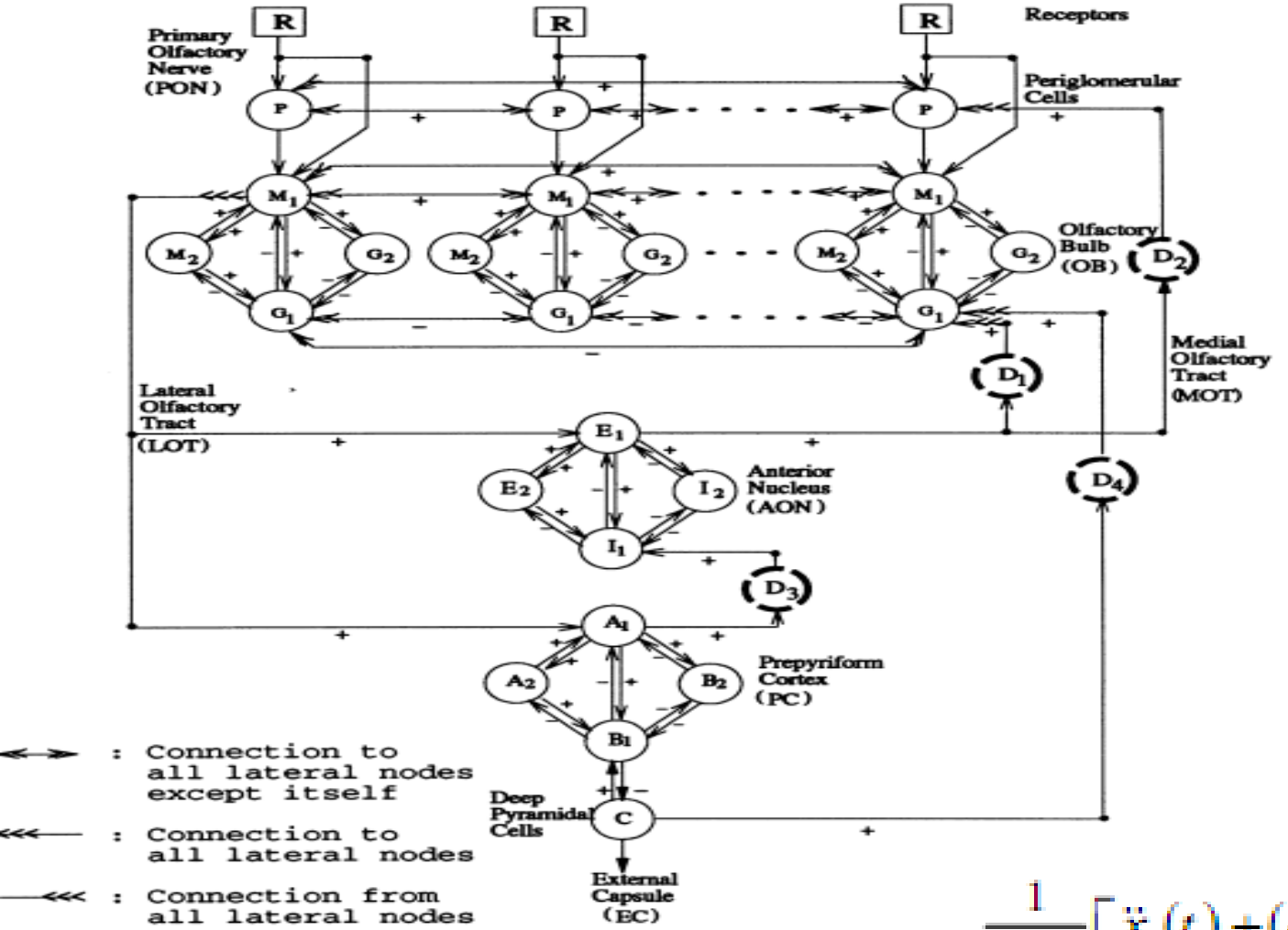
Neuron network *in vivo*

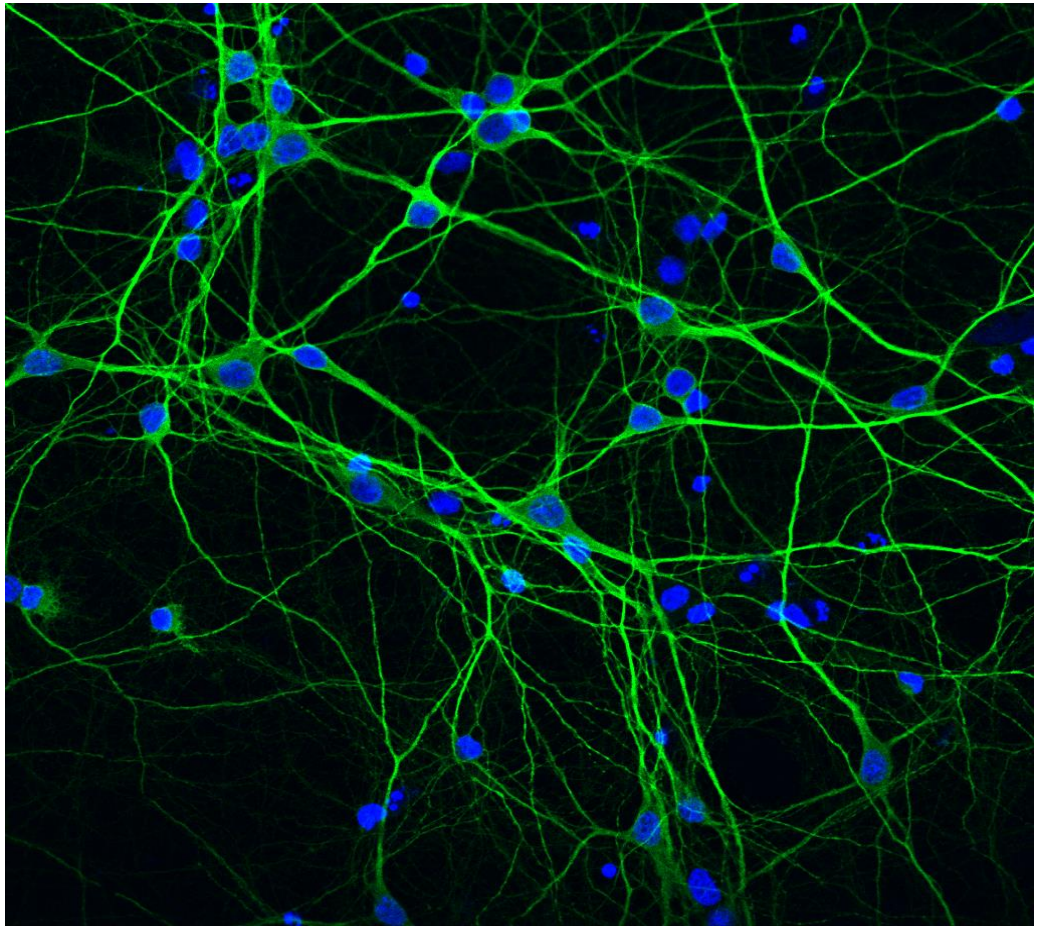
Detection of chemical parameters *in vivo*



Synthesis and integrated analysis combined in vitro with in vivo

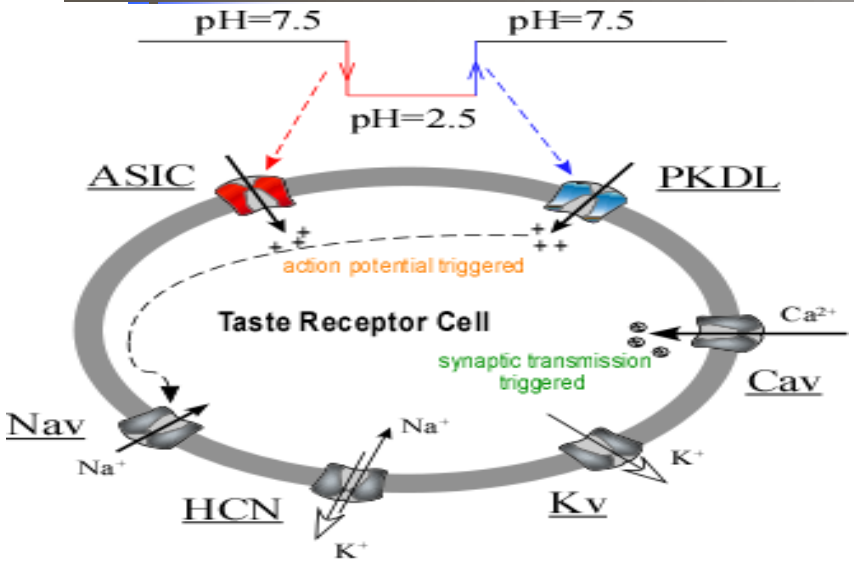
The Research on Olfactory Neural Network OE and OB *in vitro and Vitro*

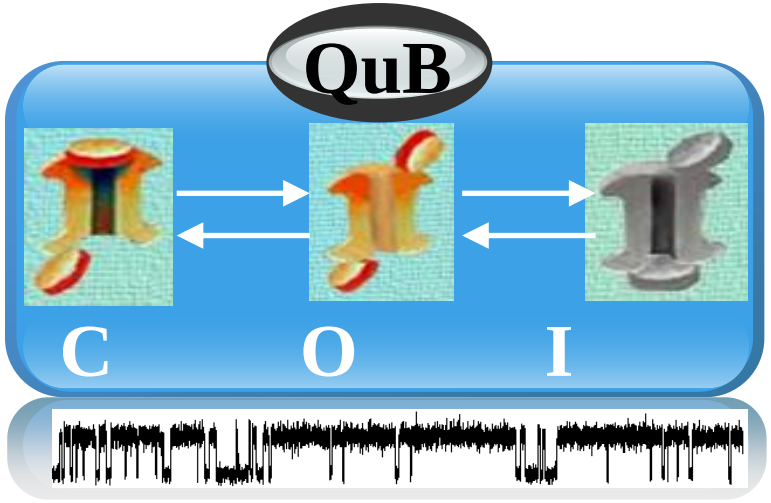


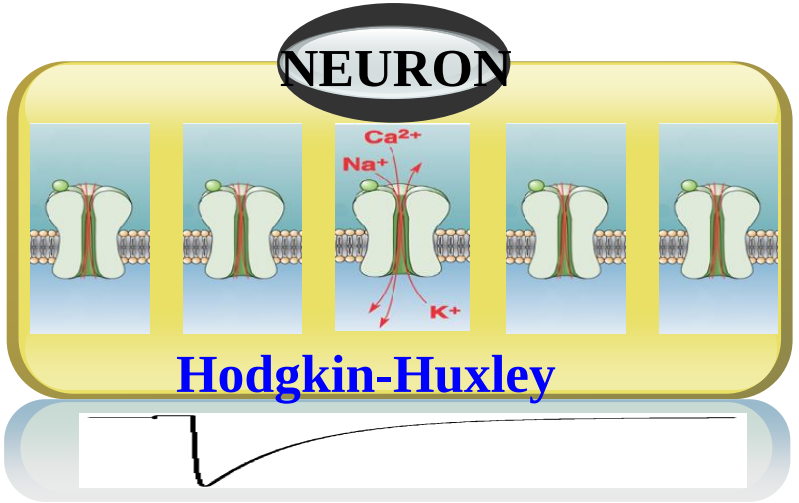


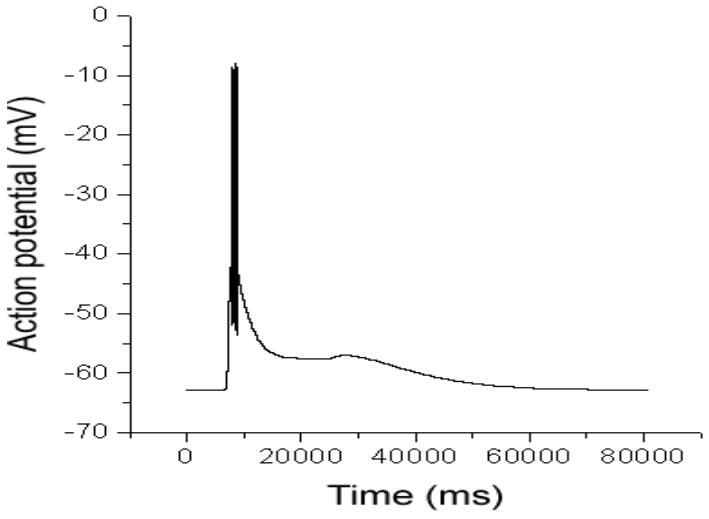
$$\frac{1}{a \bullet b}\left[\ddot{x}_i(t)+(a+b)\dot{x}_i(t)+a \bullet b \bullet x_i(t)\right]=\sum_{j=1}^{N}\left[W_{ij} \bullet y\right]+I_i(t)$$

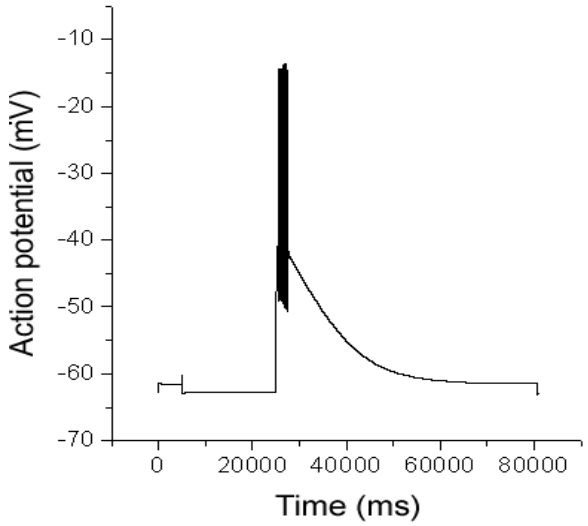
Modeling for taste receptor cells

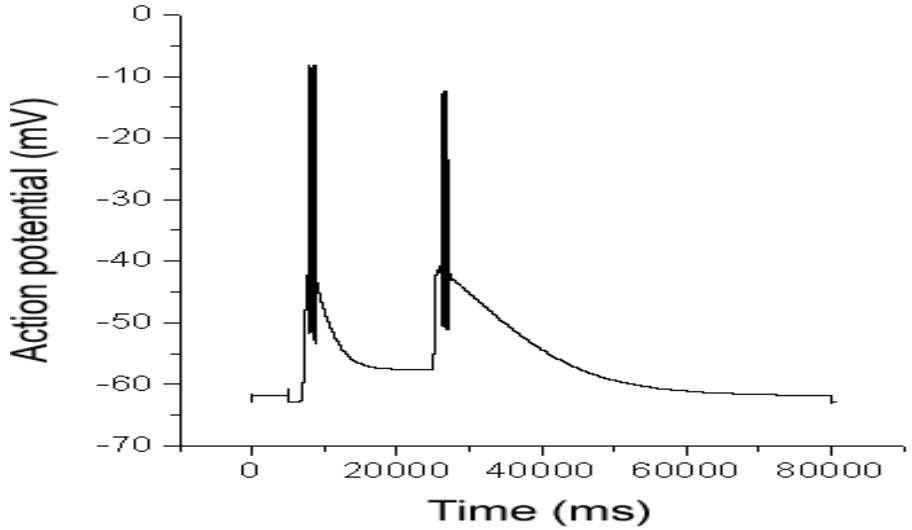




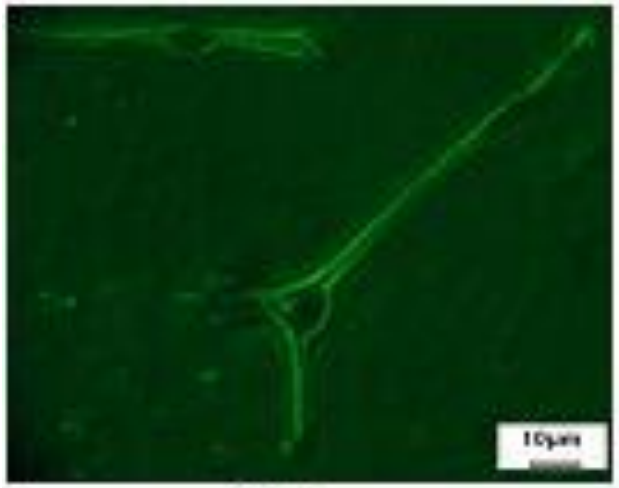


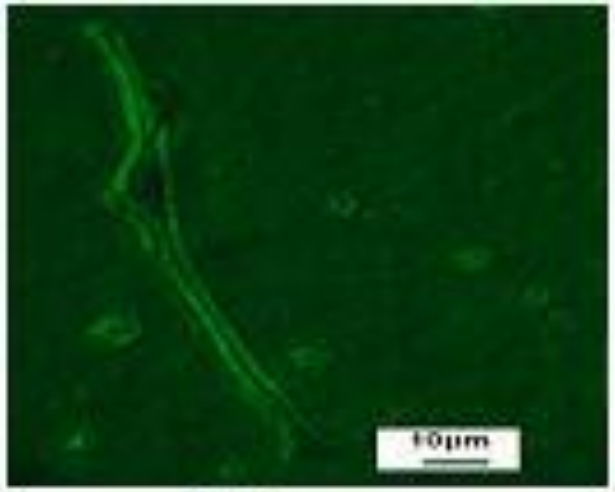






Bioe-Nose and Bioe-Tongue Chips Using Olfactory and Taste Cells Network *in Vitro*


(a)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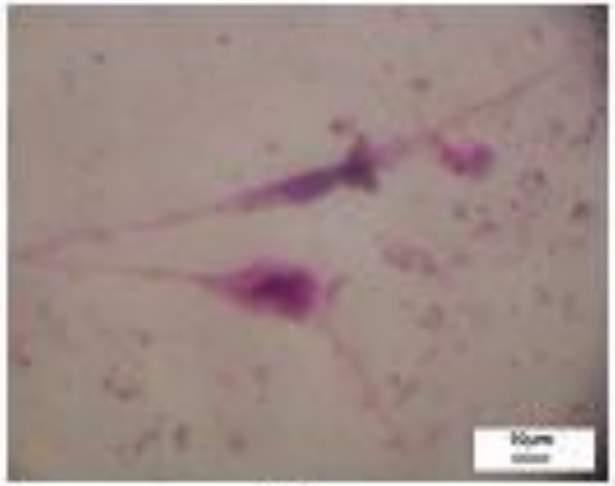
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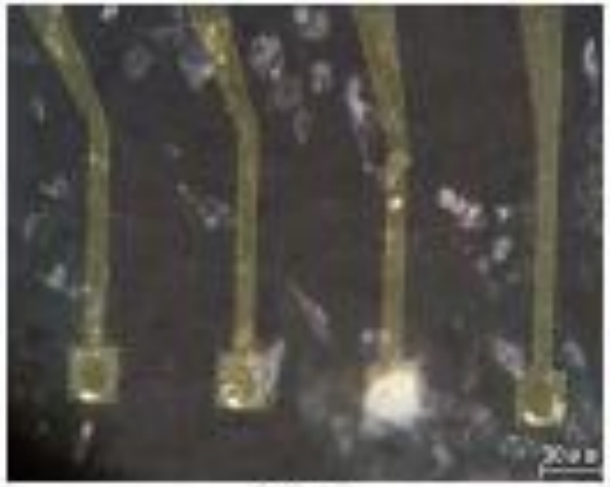
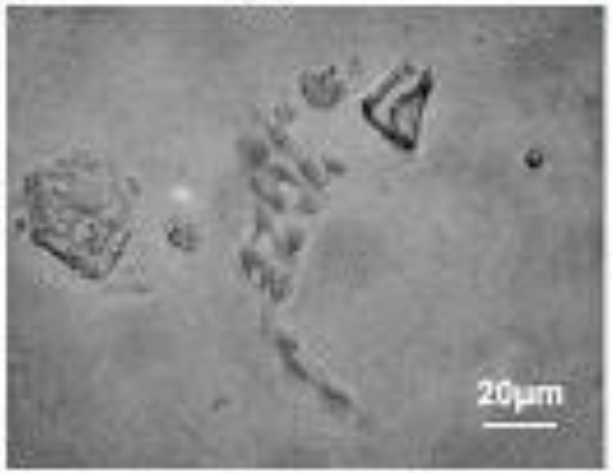
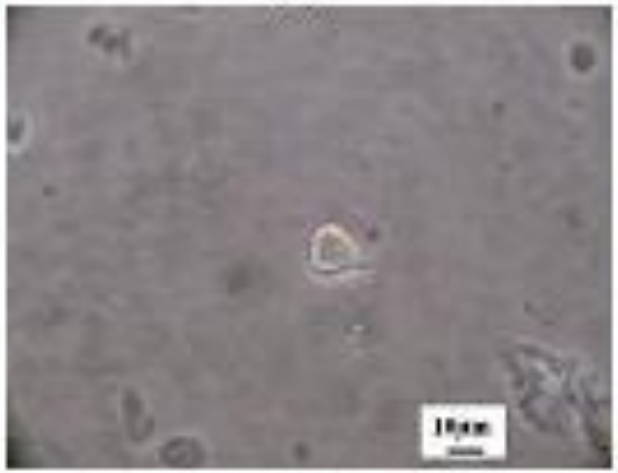

(d)



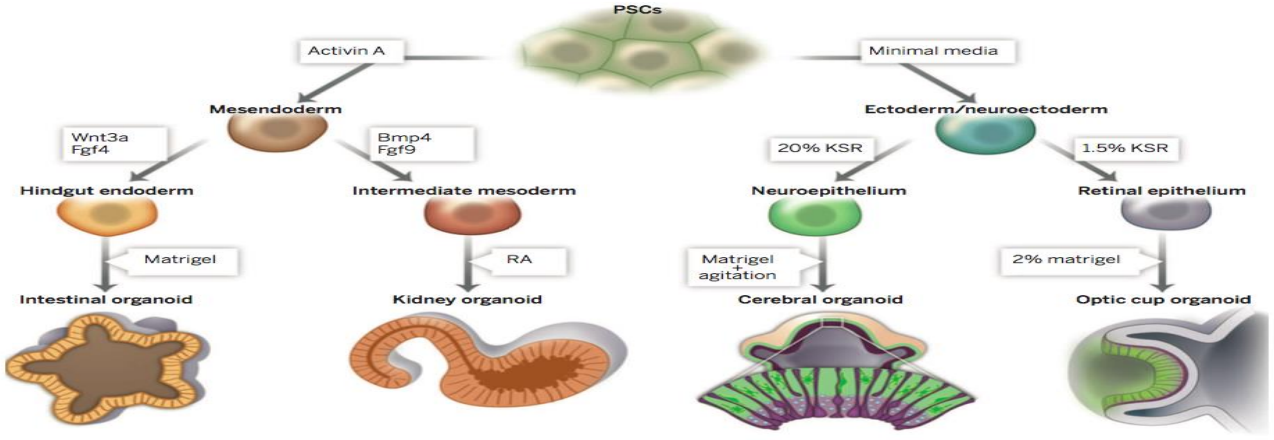
(e)

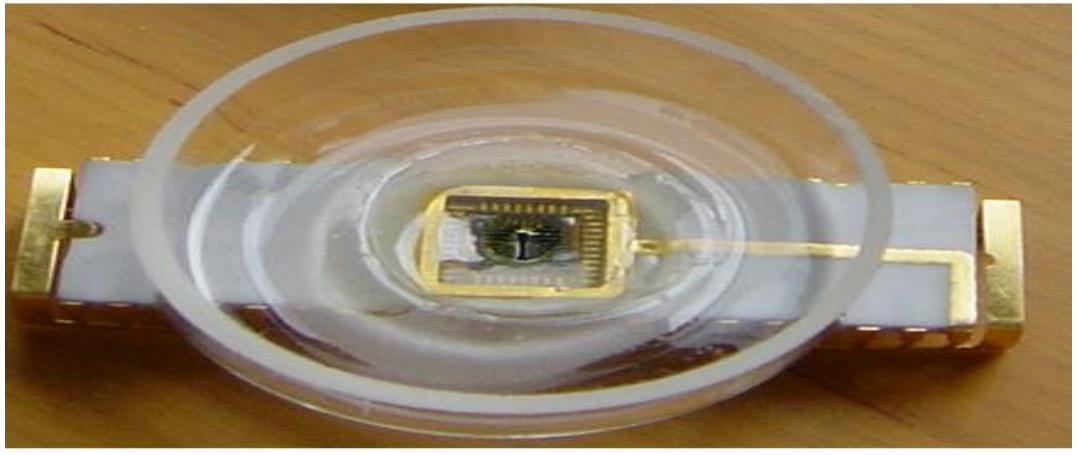

(f)

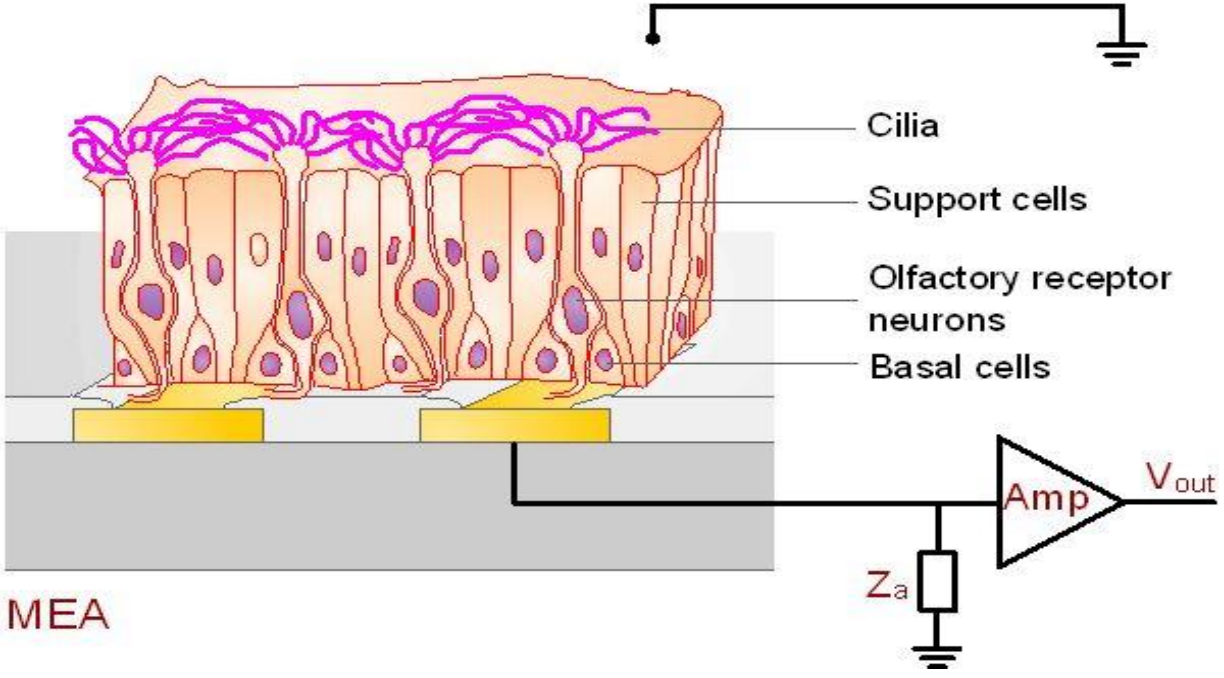

(g)


(h)

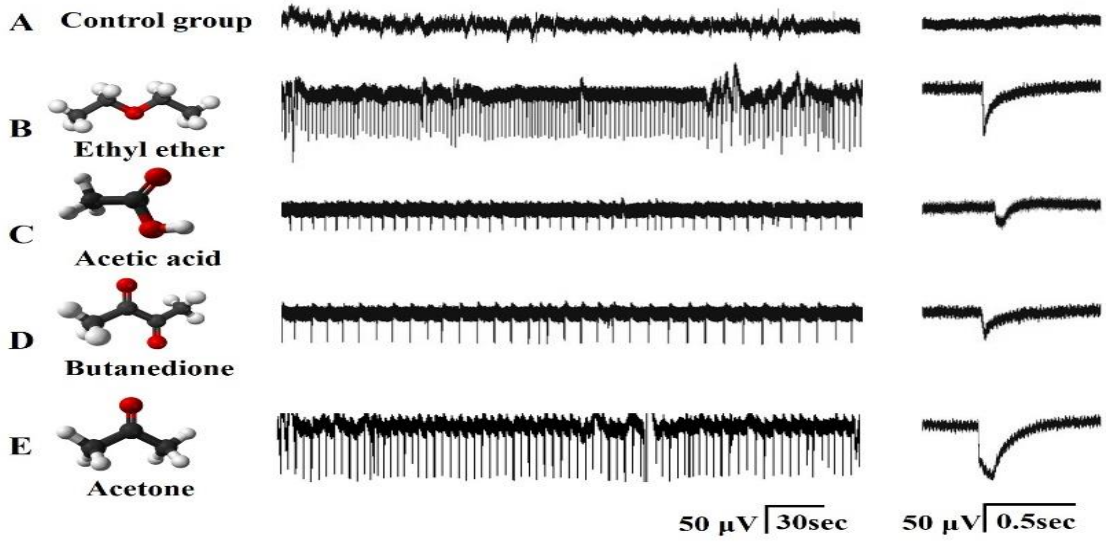
Bioe-Nose and Bioe-Tongue with living 3D cells and Organoids *in Vitro*



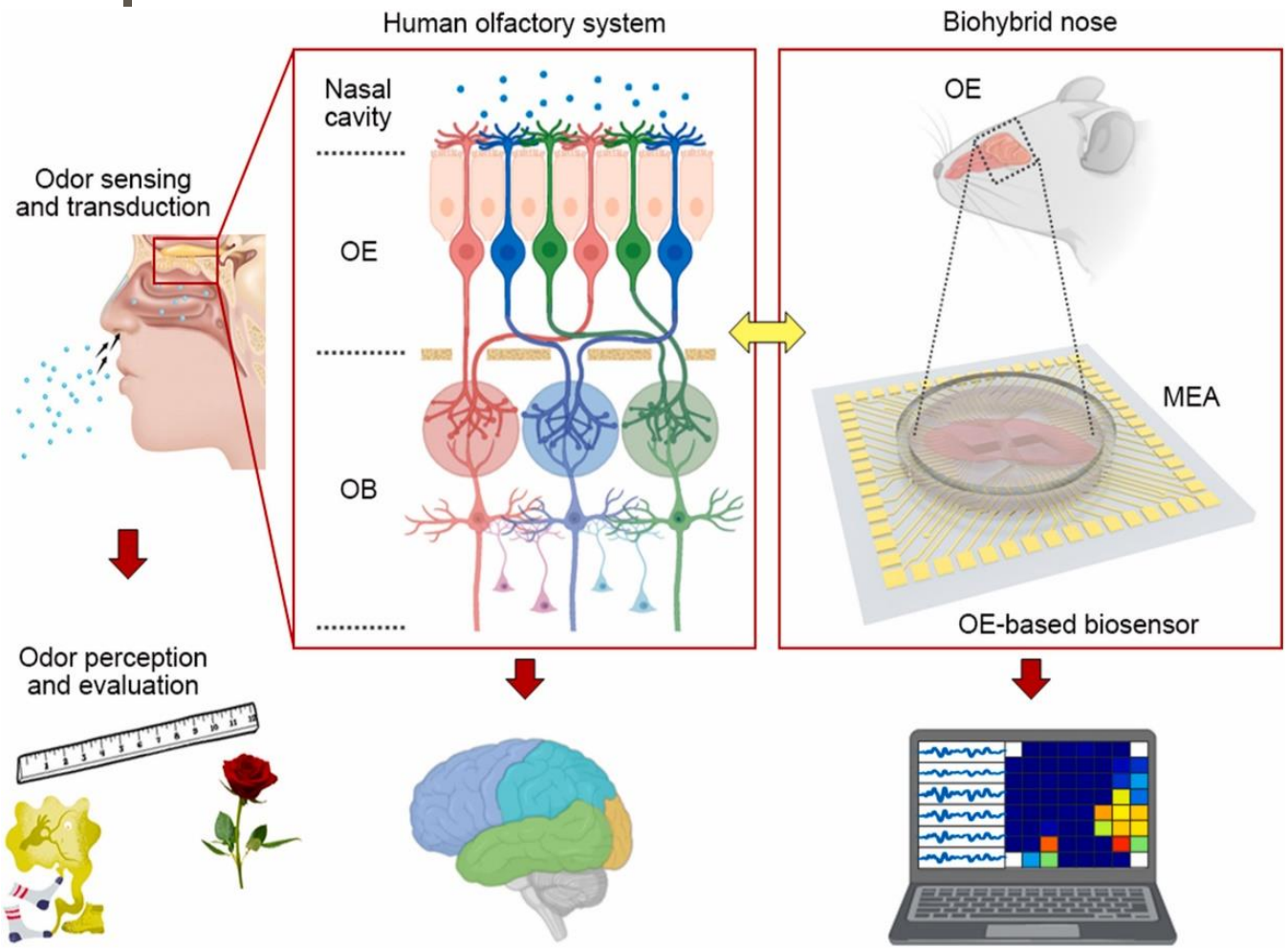


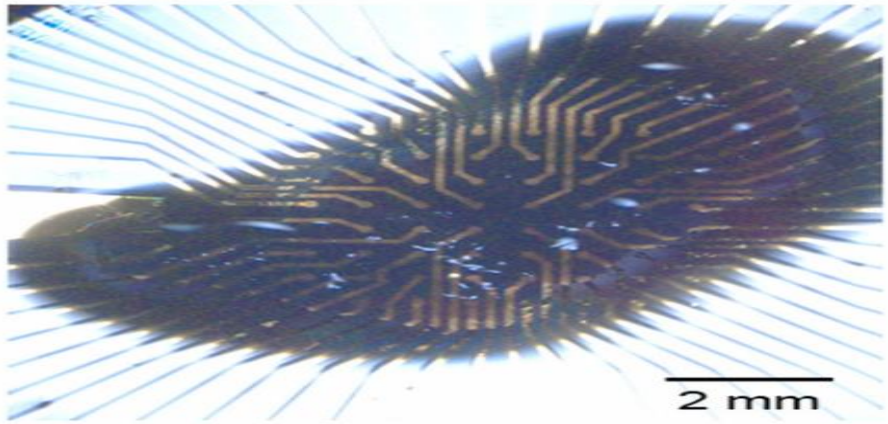


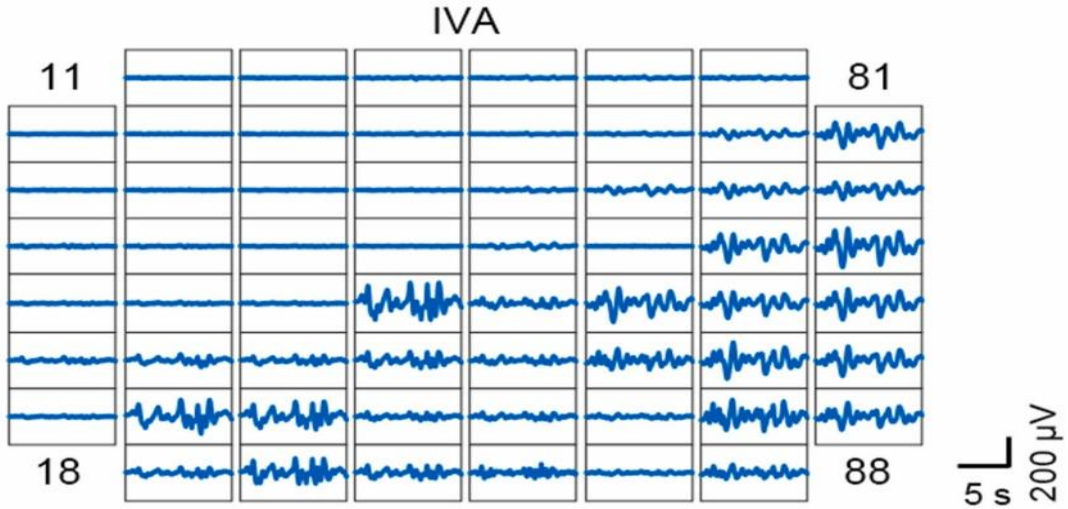
气味响应



Oganoid-based Bioe-Nose *in Vitro*







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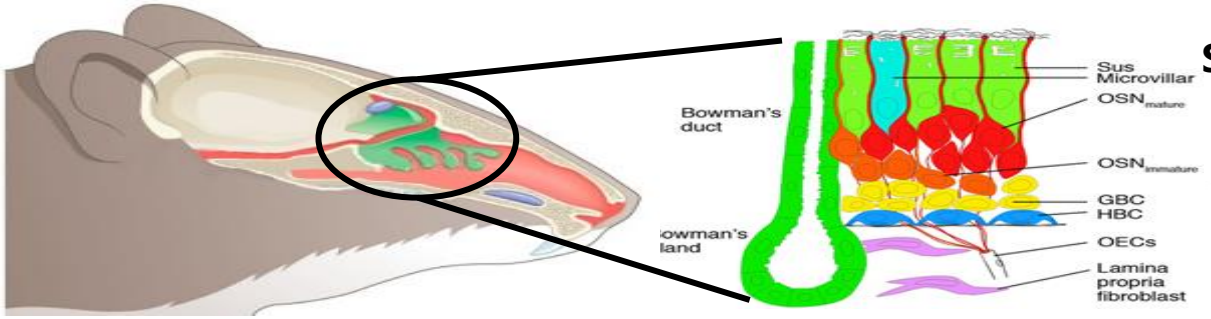
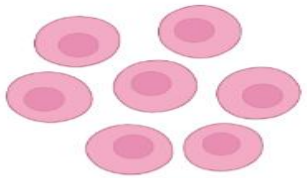
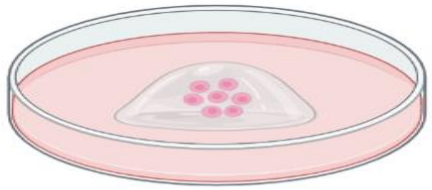
Oganoid-based Bioe-Nose *in Vitro*

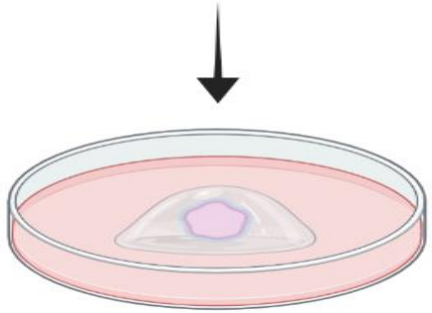


Stem/progenitor cells

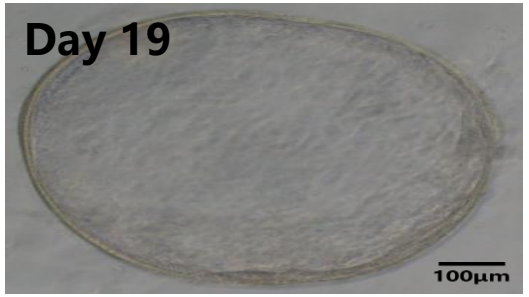


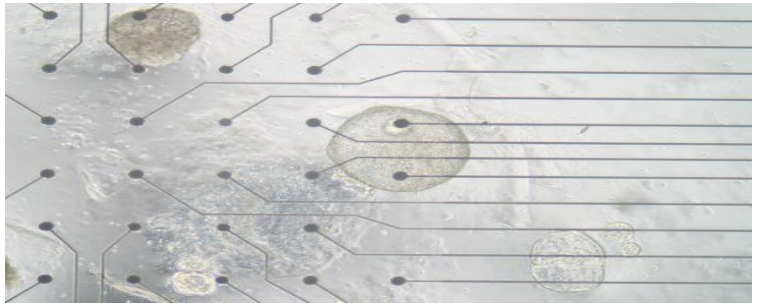
Growth factor





Olfactory organoid





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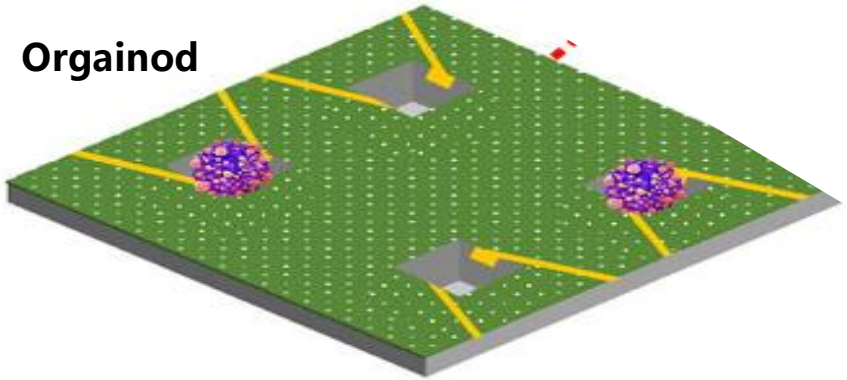
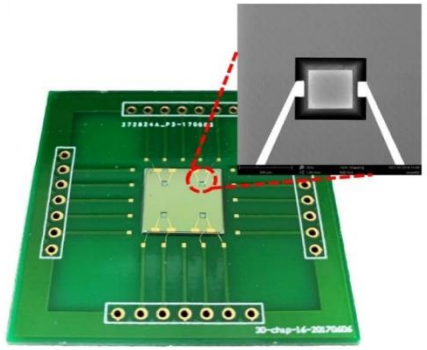
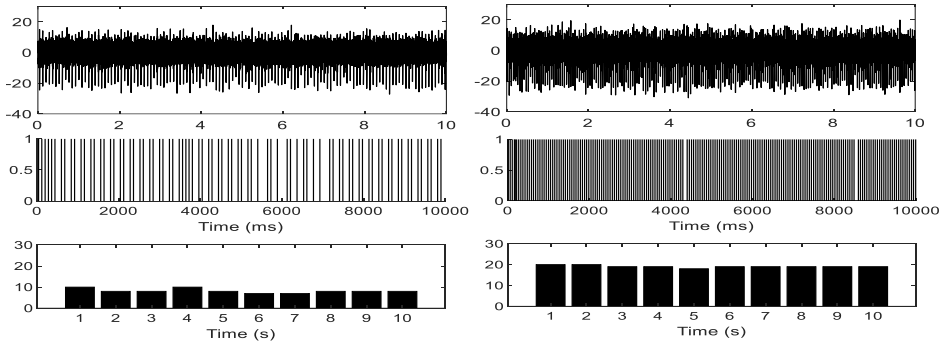
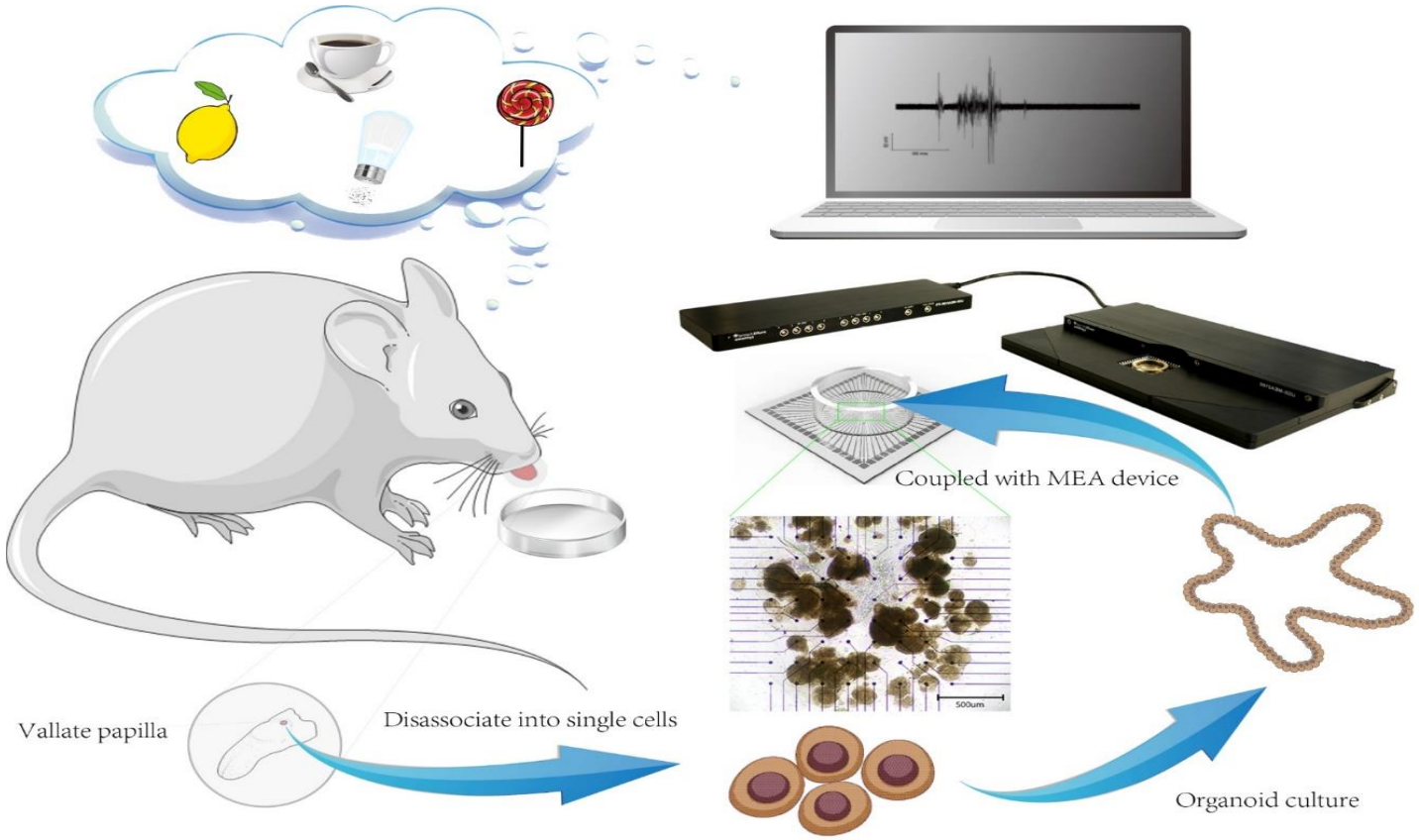


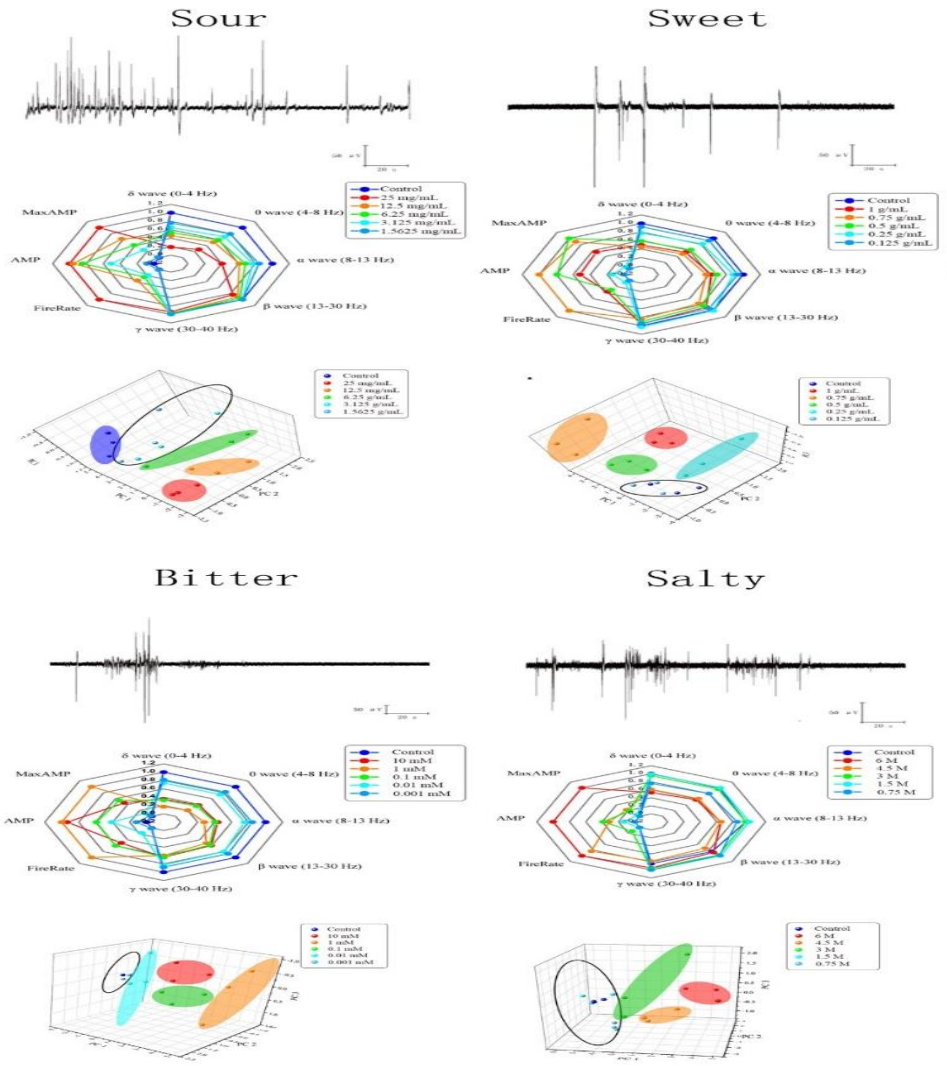




in the manuscript and see talk of Hao Wan

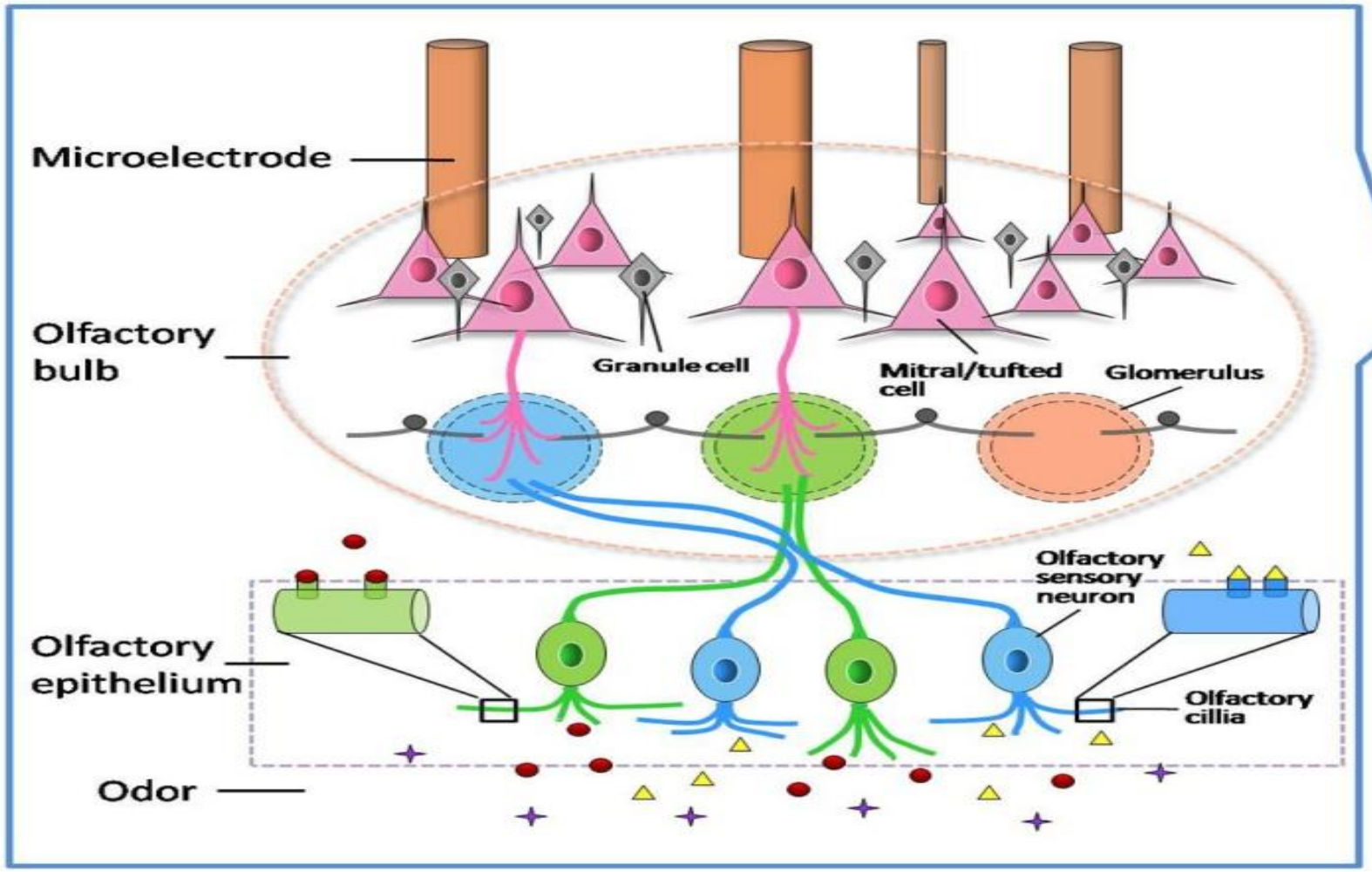
Oganoid-based Bioe-Tongue *in Vitro*



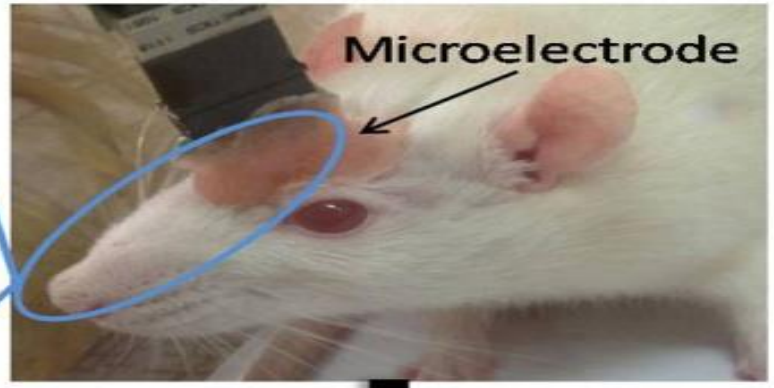


Unpublished

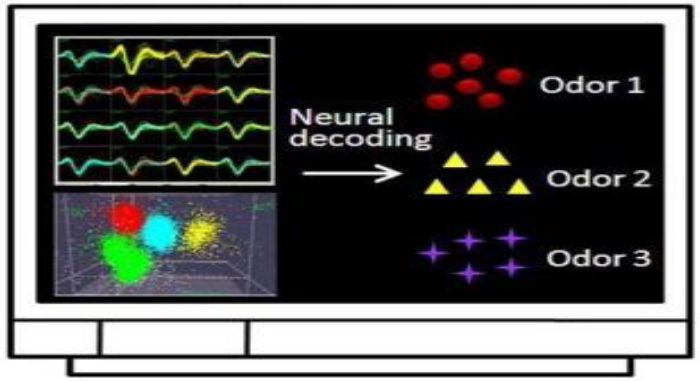
Bioe-Nose *in Vivo Using BCI Techniques*



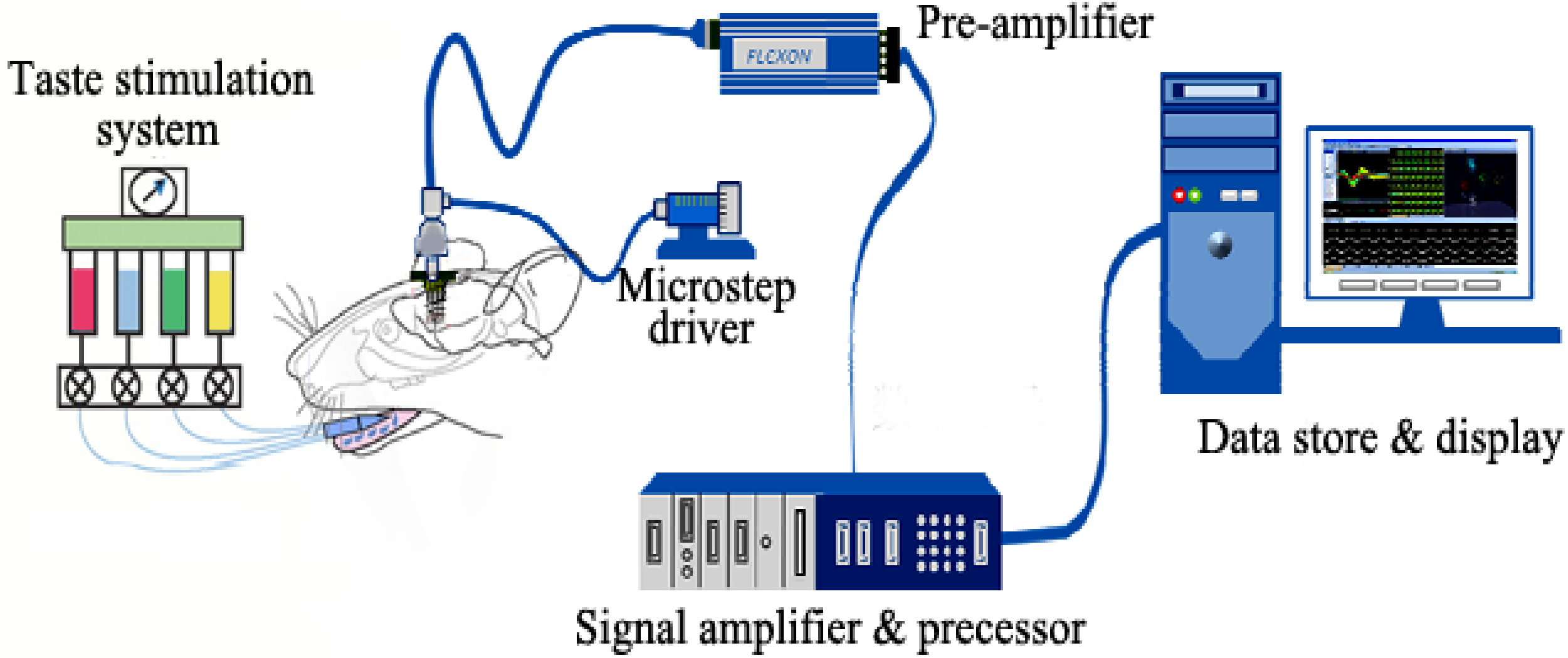
Sensor-odor interaction and Signal generation



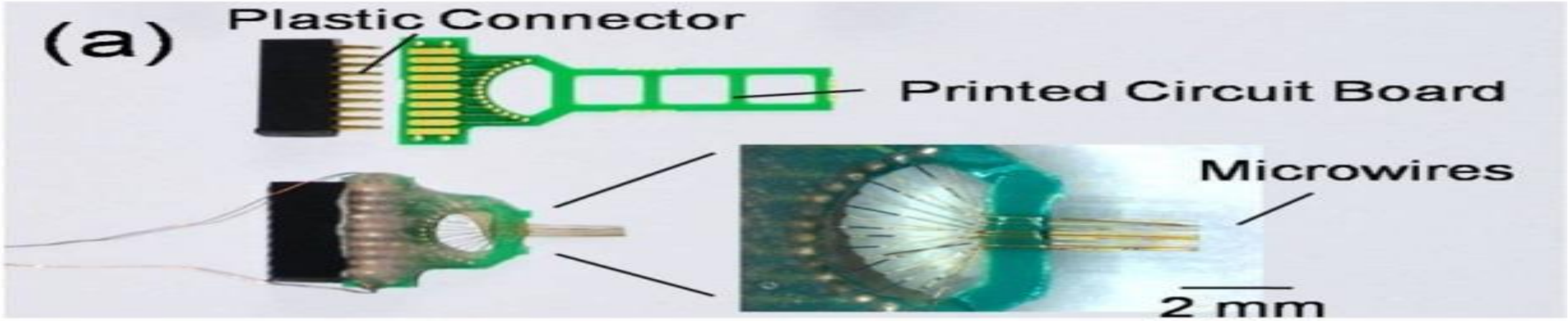
Pattern recognition and Odor discrimination

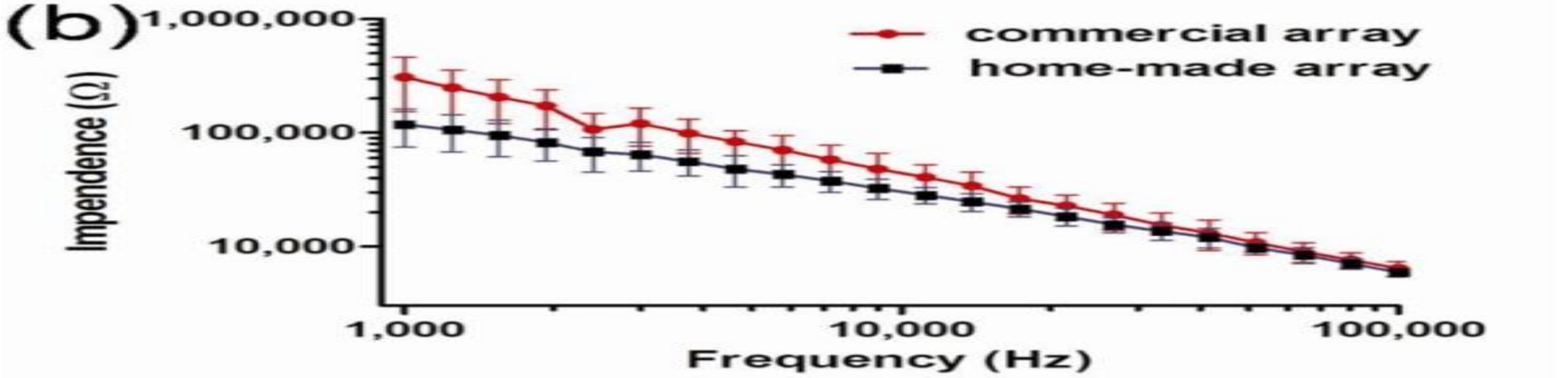


Bioe-Nose and Bioe-Tongue *in Vivo* *Using BCI Techniques*

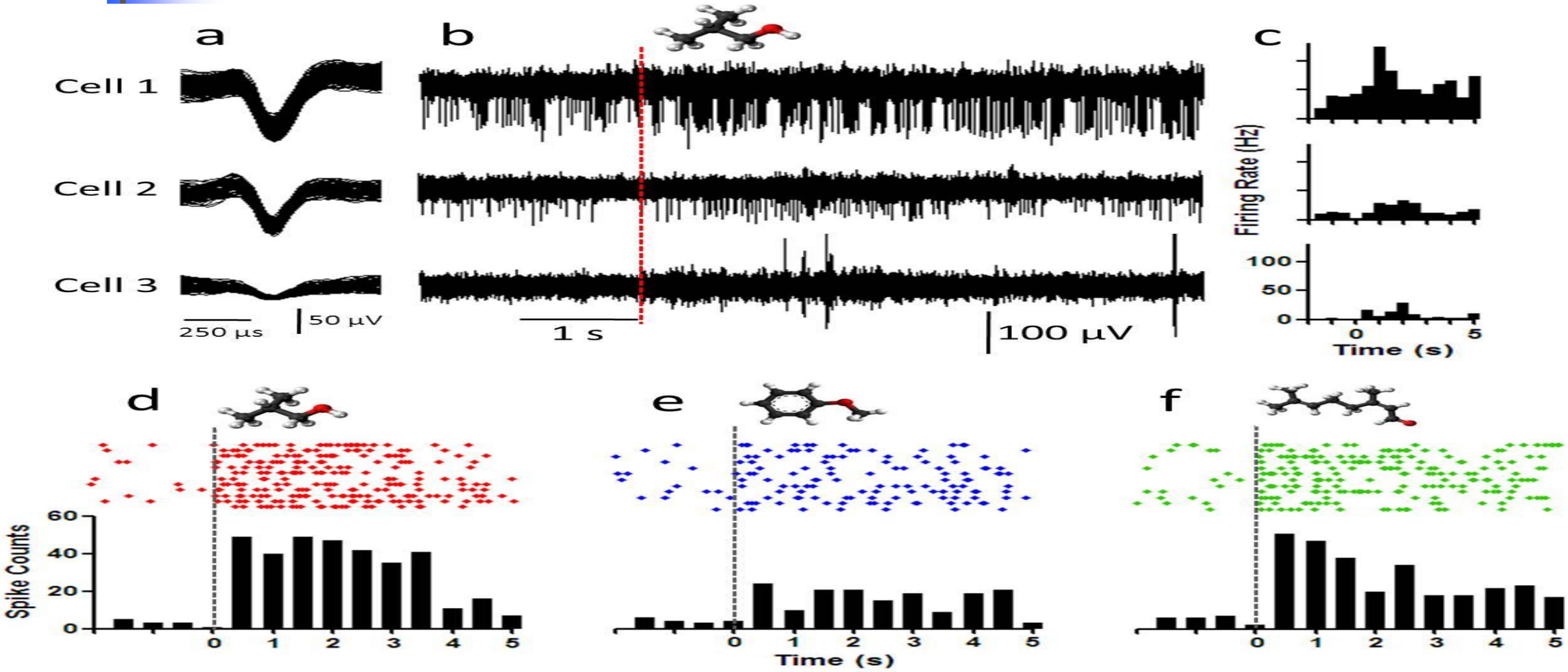


Mico/Nano Electrodes Arrays of Bioe-Nose *in Vivo*

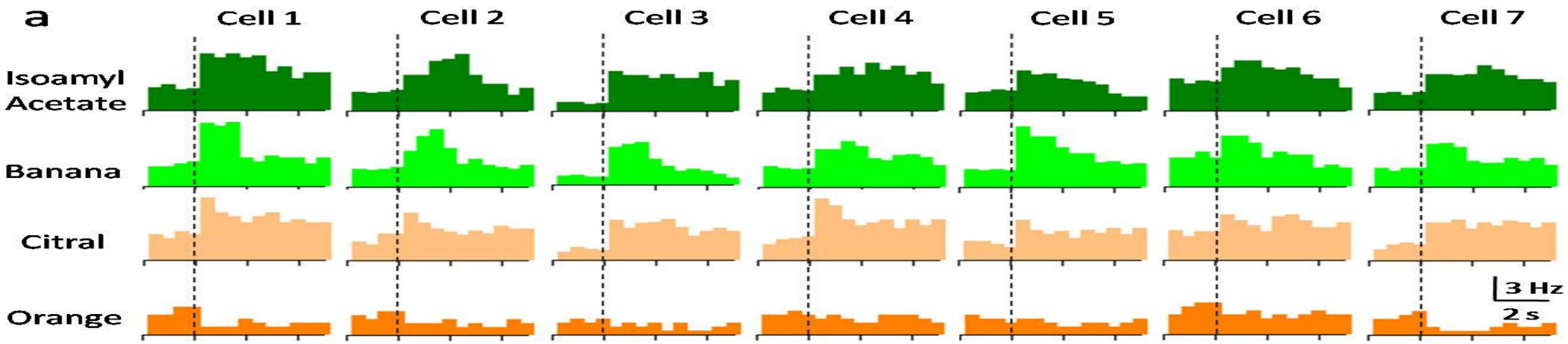


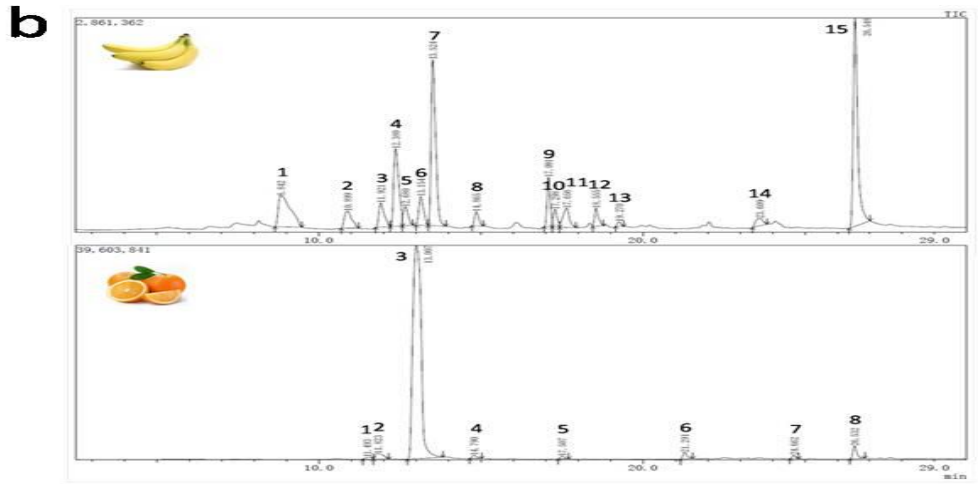


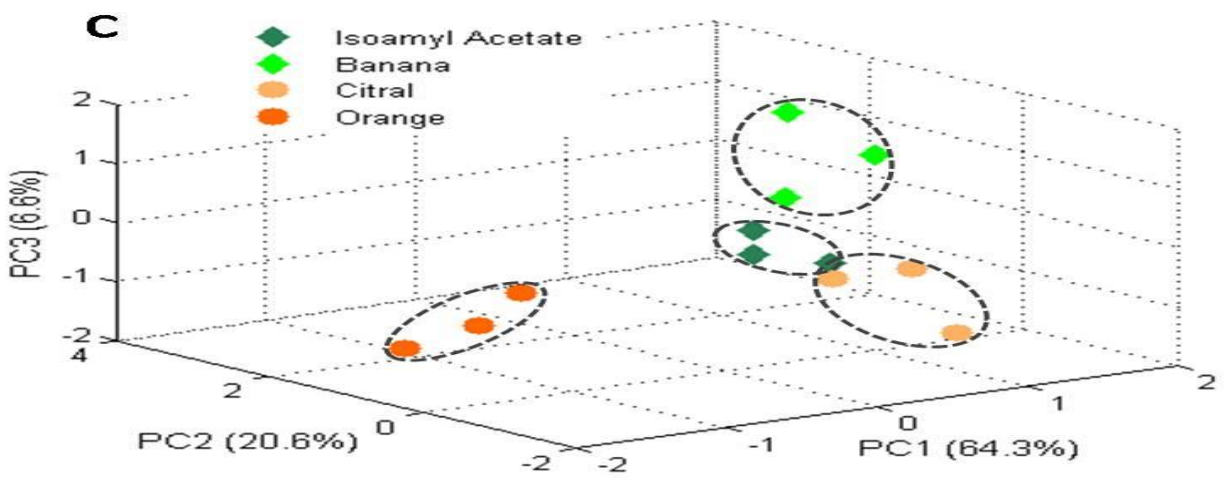
Odor detection and Signal Analysis of Bioe-Nose *in Vivo*



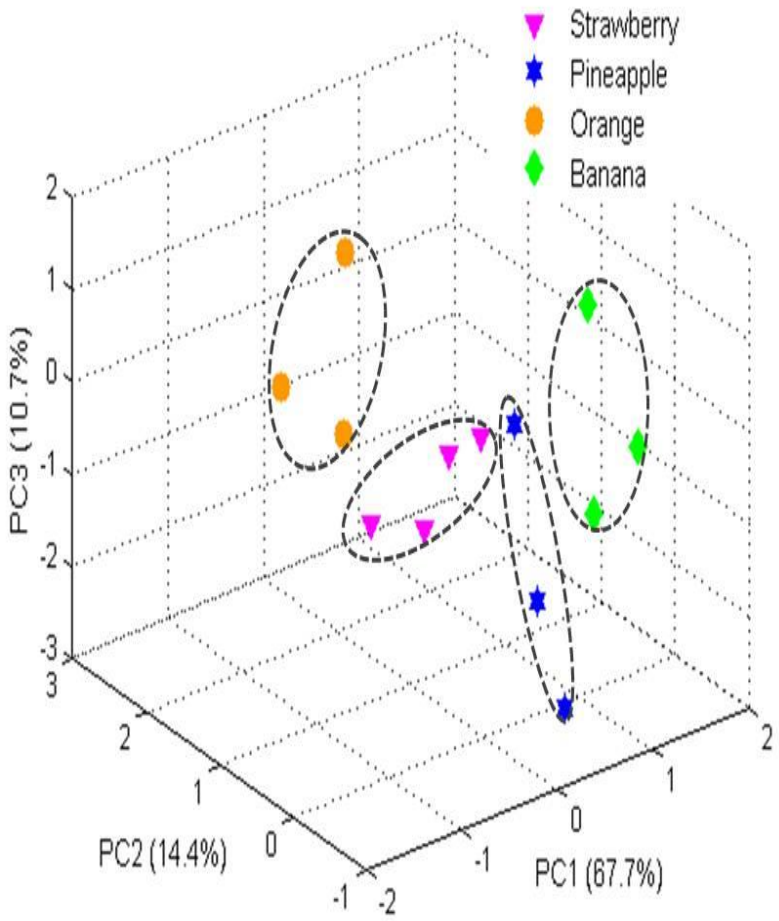
Odor detection and Signal Analysis of Bioe-Nose *in Vivo*

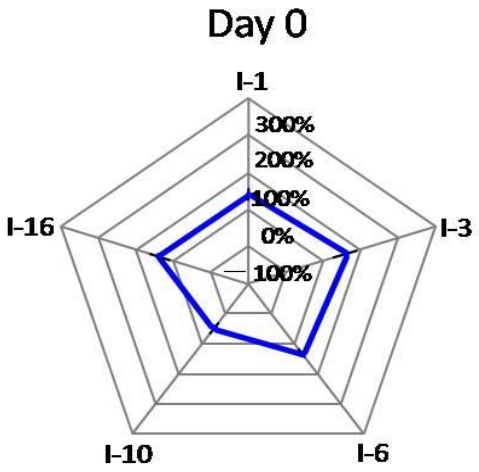


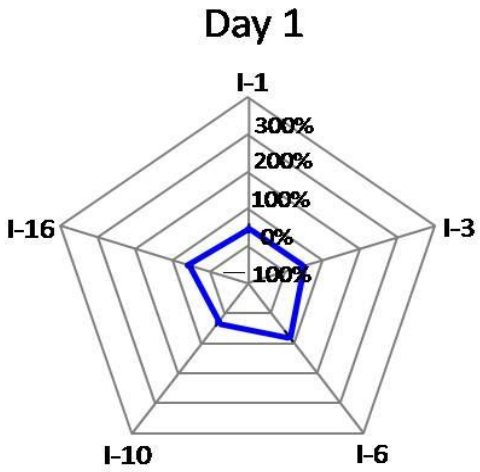


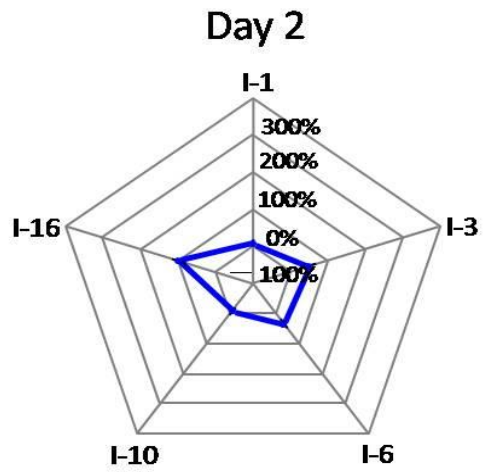


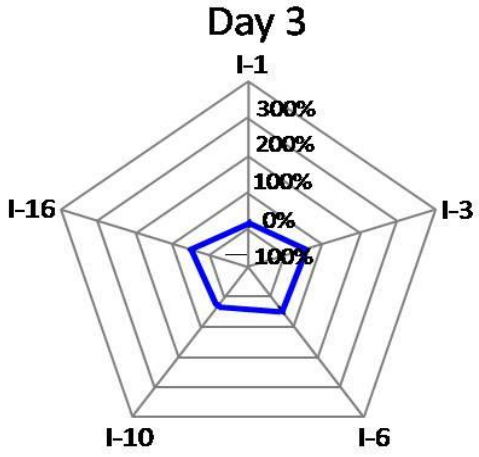
Odor detection and Signal Analysis of Bioe-Nose *in Vivo*

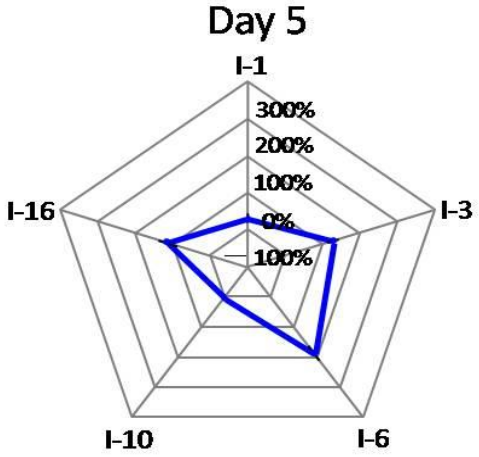


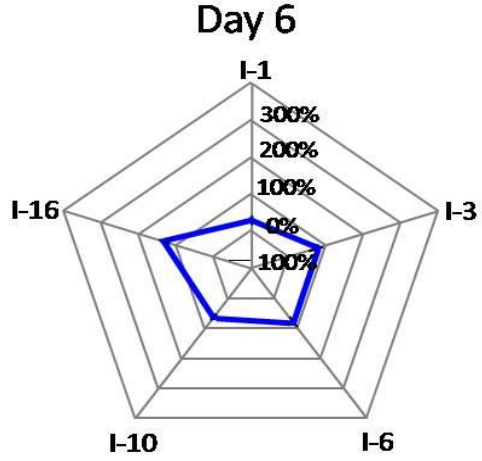




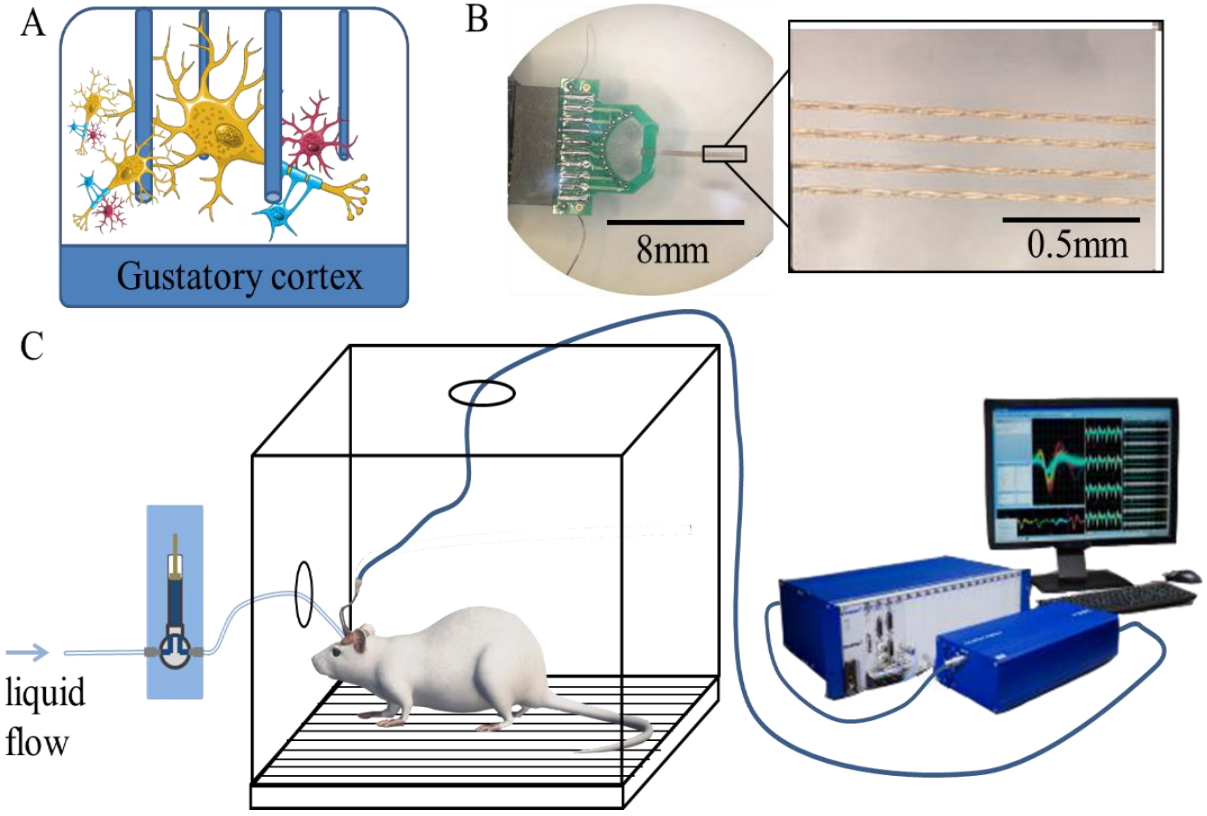


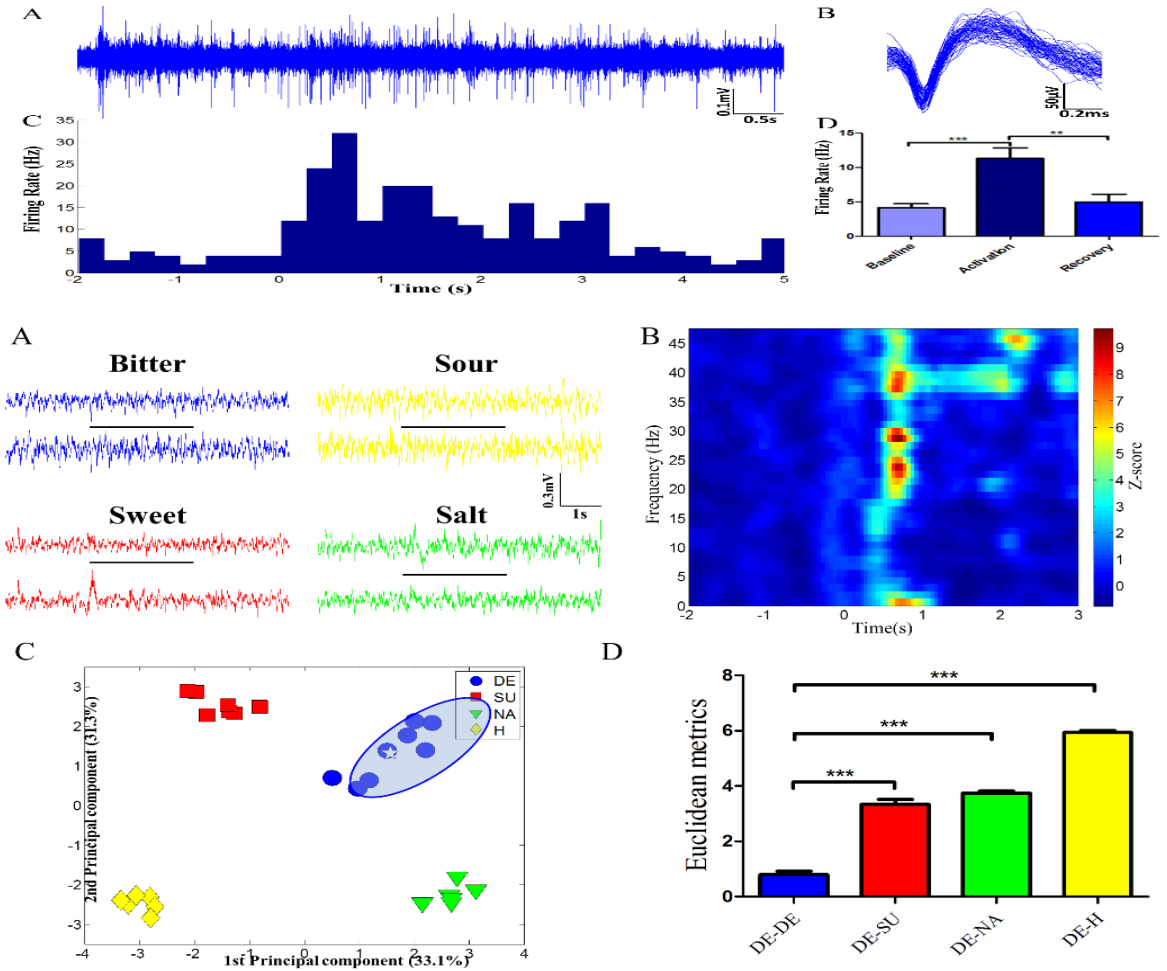






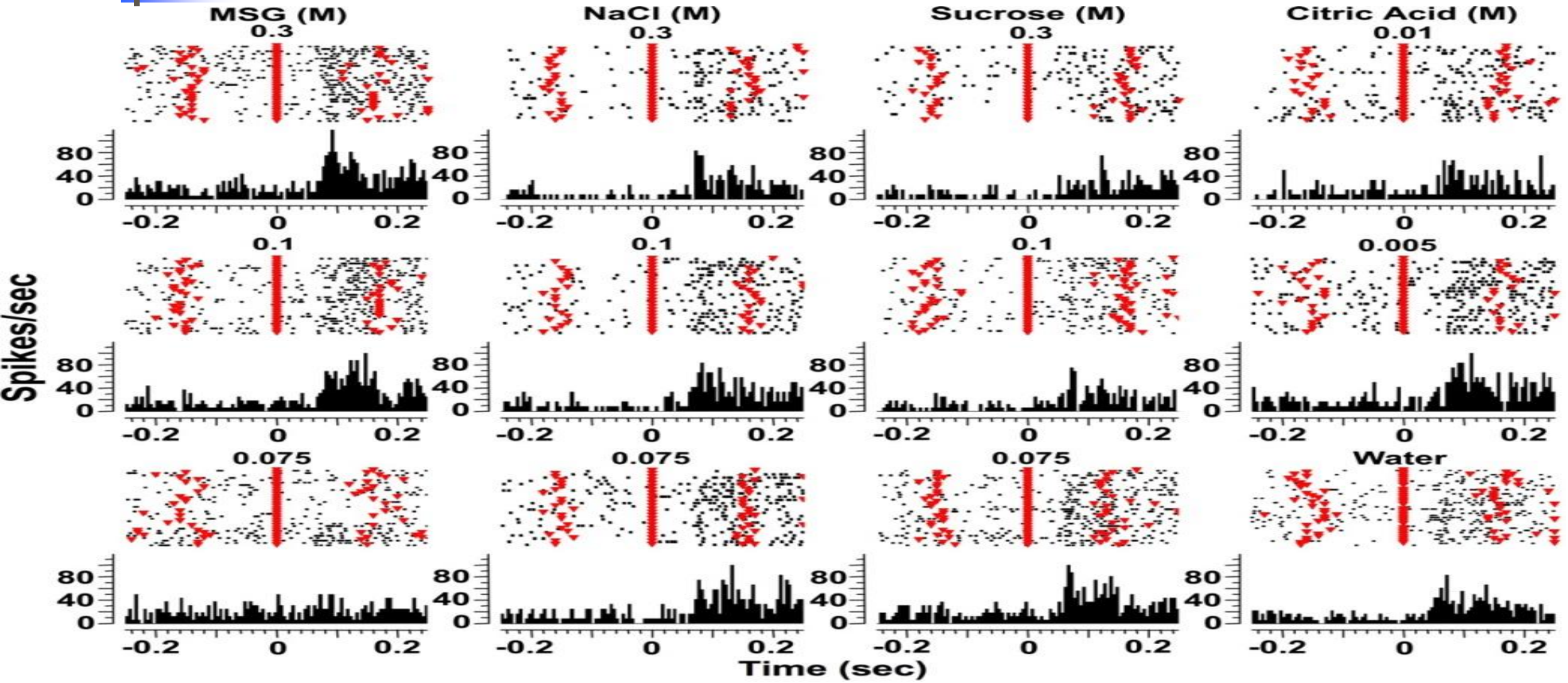
Bioe-Tongue *in Vivo Using BCI Techniques*





Biosensors and Bioelectronics, 2016, 78: 374-380
Sensors and Actuators B: Chemical, 2017, 239: 746-753
37th Annual International Conference of the IEEE. IEEE, 2015: 7550-7553

The Potentials of Bioe-Tongue *in Vivo*



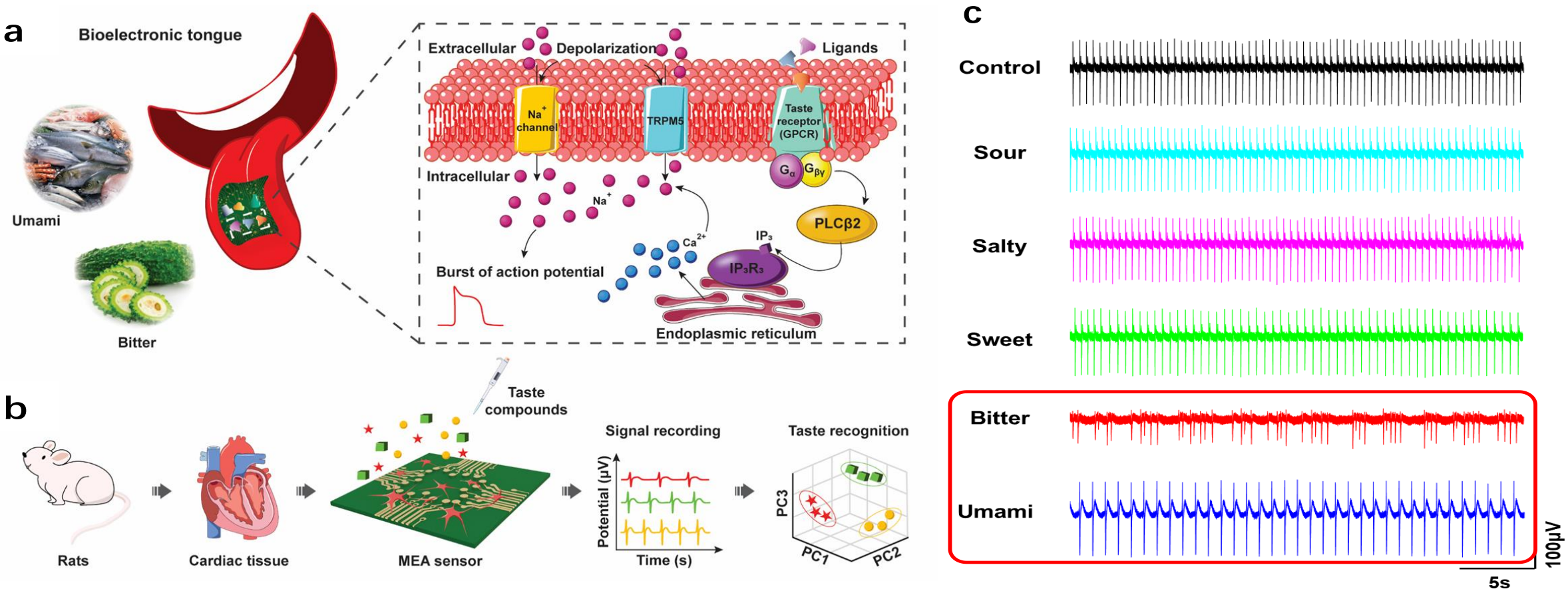
3nd Part

Application Bioe-Nose and Bioe-Tongue

in vitro and i*n vivo*

Bioe-Tongue' Perception Results are Similar with Human Taste

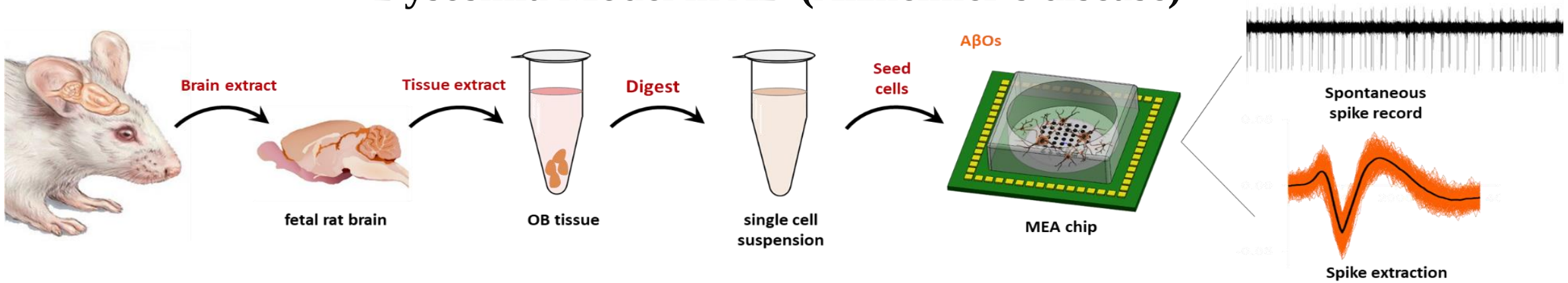
The *in vitro* bioelectronic tongue for bitter and umami detection



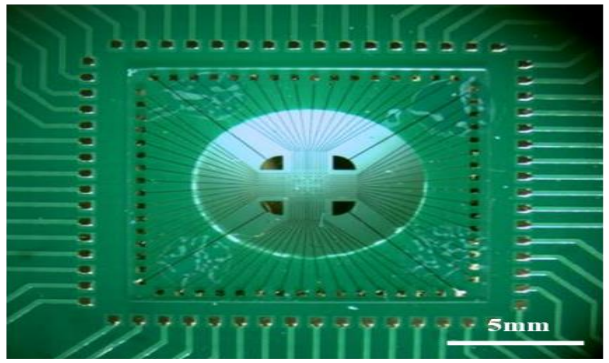
Biosensors and Bioelectronics, 2019, 145: 111673.

Bioe-Nose for AD Detection and Drug Screening in Therapy

Olfactory Bulb Neuronal Network Chip-based Biosensor of Dysosmia Model in AD (Alzheimer's disease)



A

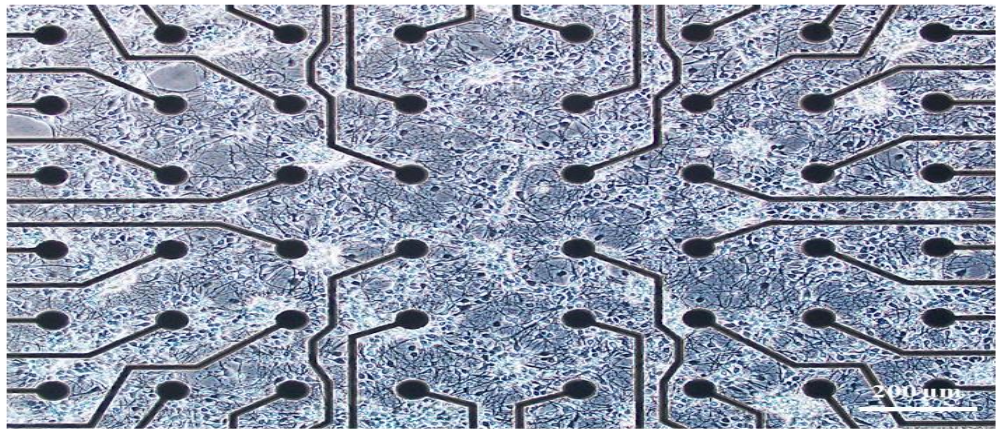


MEA Chip

B

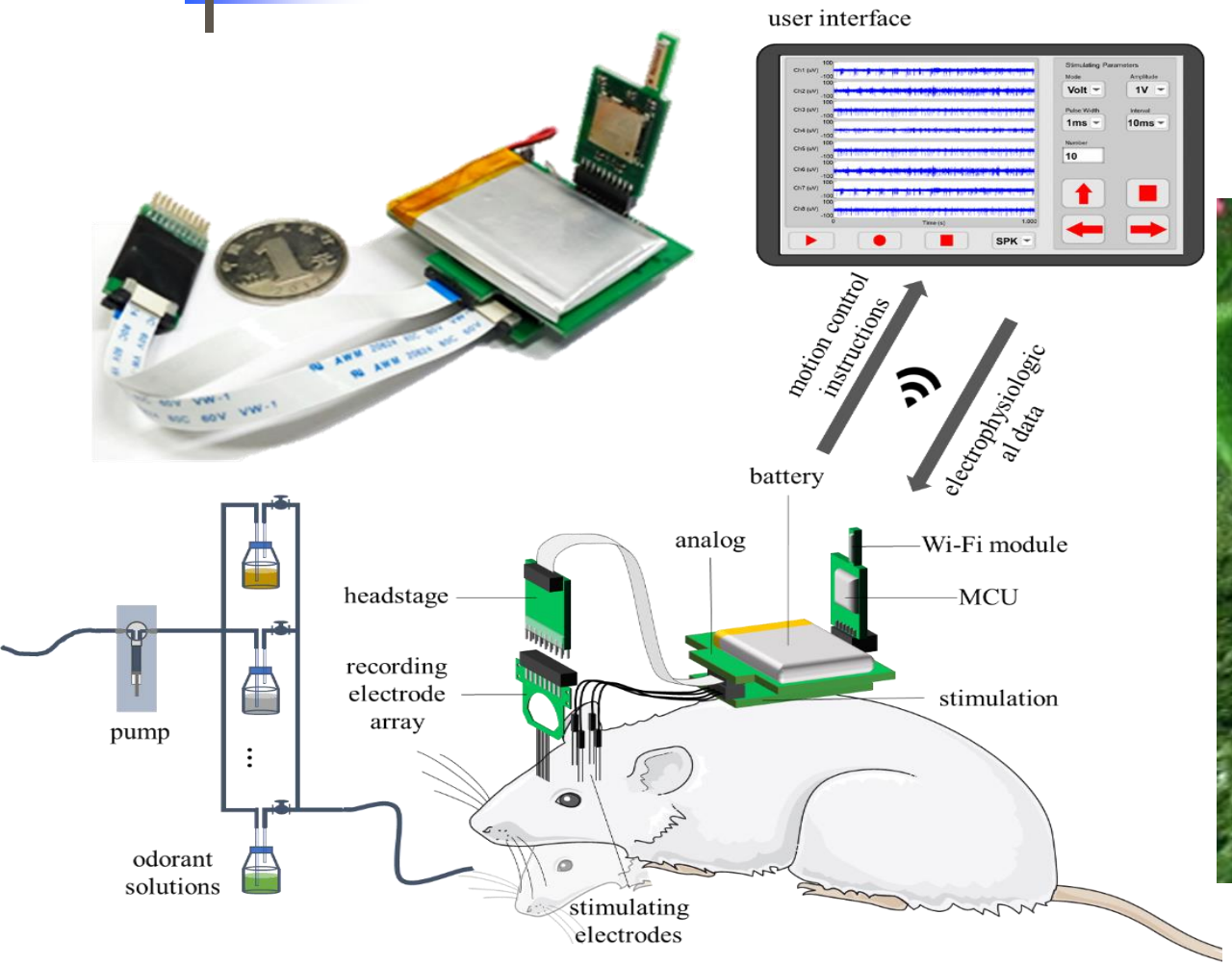
MEA System

C



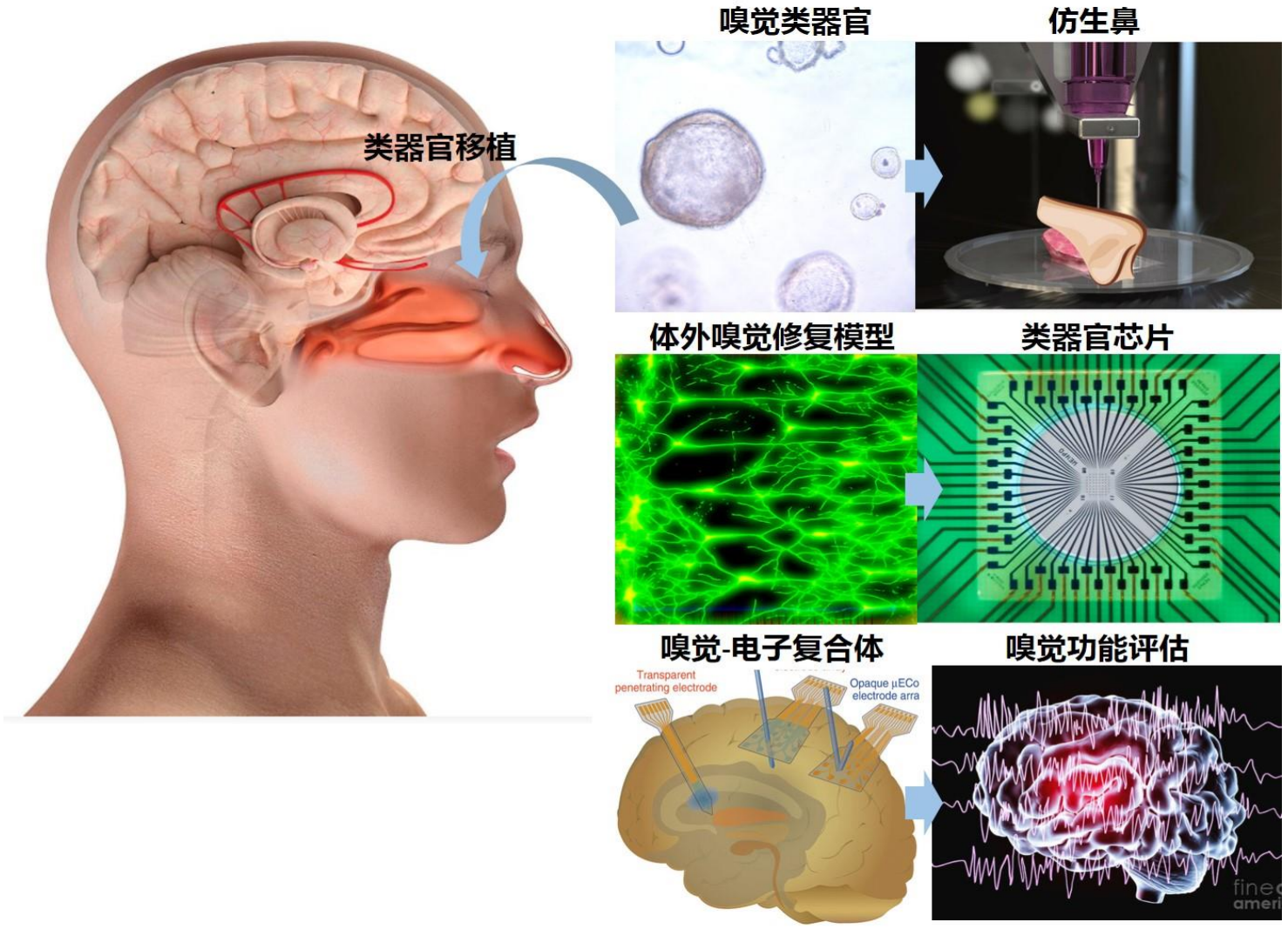
OB neuronal network on MEA

Animal Robot with Bioe-Nose *in vivo* for Hazardous Detection



Robots with Bioe-Nose *in vivo* for Food Quality Monitering

Rehabilitation of Human Olfaction with Flexible Micro/Nano Bioe-Nose *in vivo*



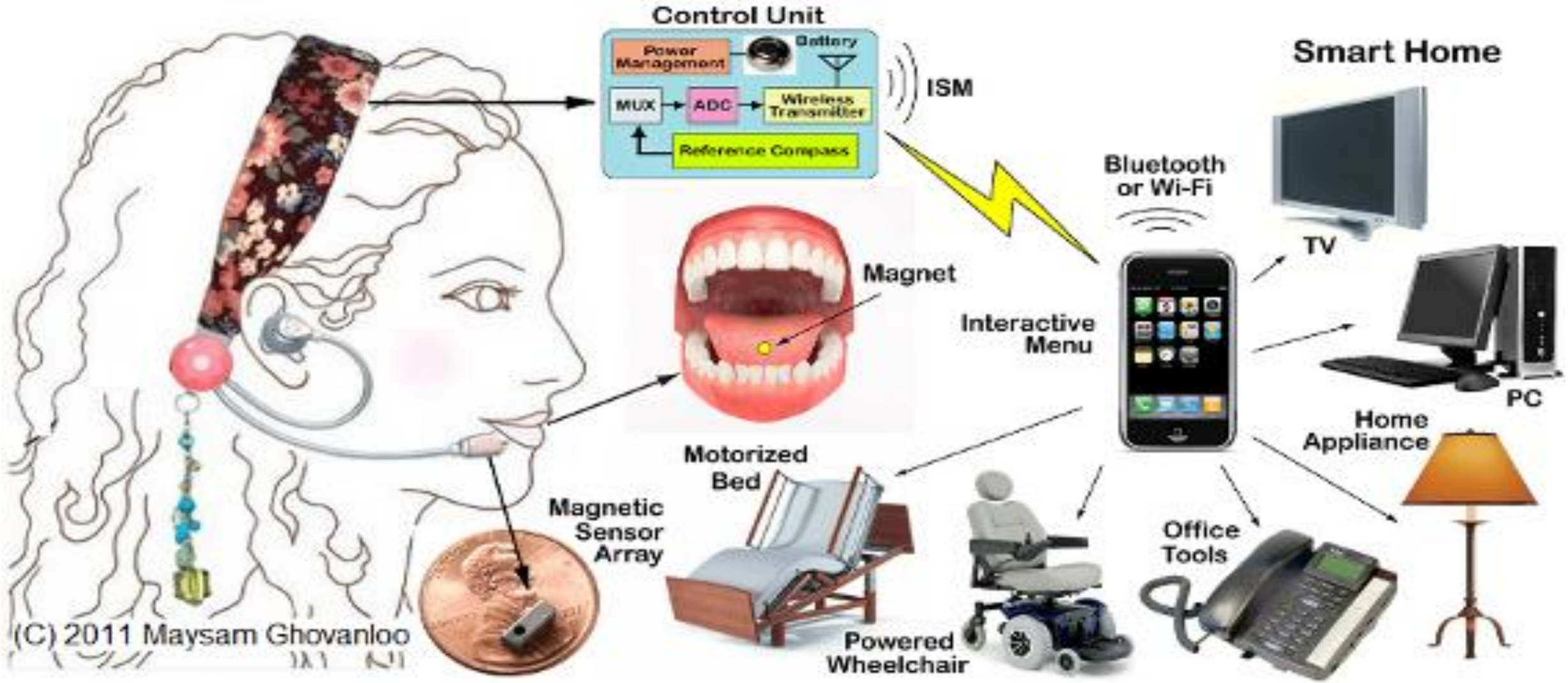
Olfactory regeneration and intelligent regulation

The complex is implanted in the nasal cavity

Flexible electrode and cell/organiod complex

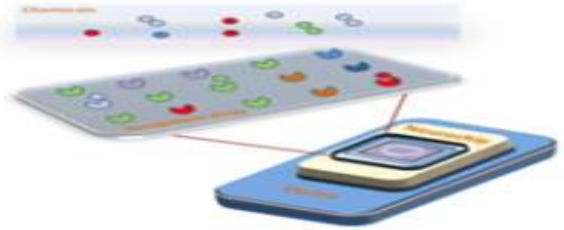
Preparation of olfactory epithelial organoids

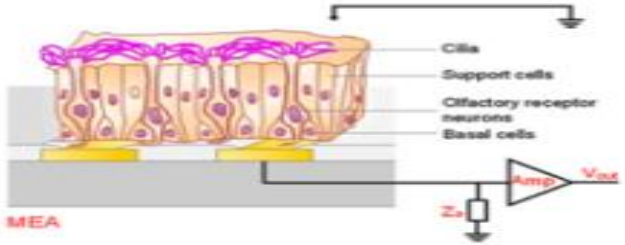
Robot with Bioe-Nose/Tongue *in vivo* for Hazardous Detection



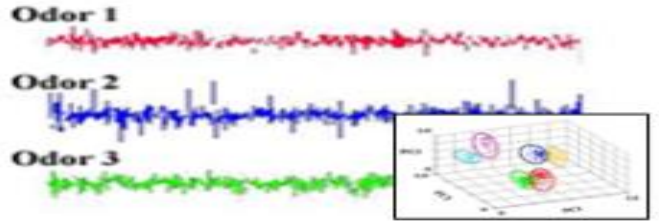
Robot with Bioe-Nose/Tongue hybrid Sensing-Actuation System

1 Cell-based olfactory sensor array to detect chemicals

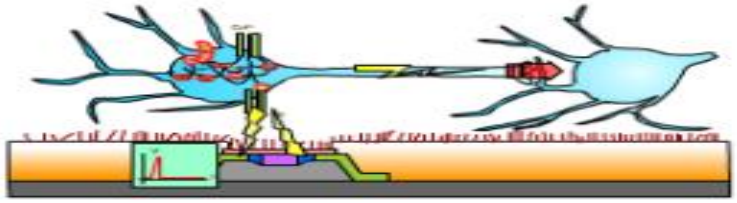




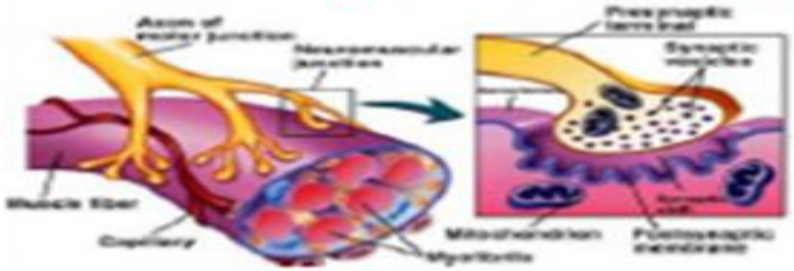
2 Signals are analyzed to identify patterns of chemical moleculars



3 Send action potentials to electrodes controlling the muscle cells

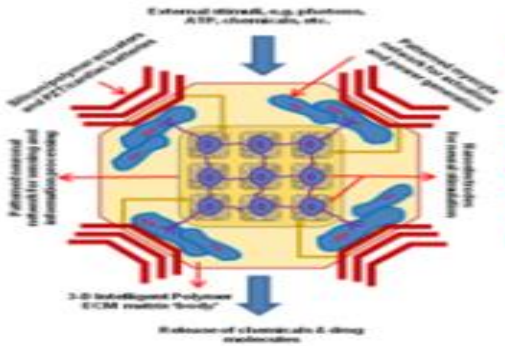


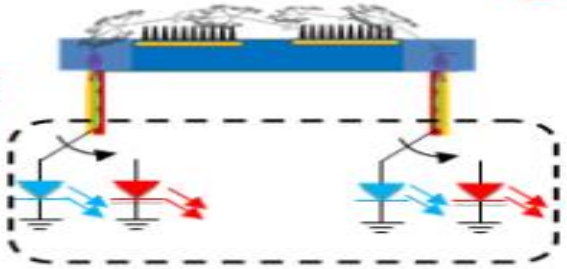
4 Neuromuscular junction to excite myocytes



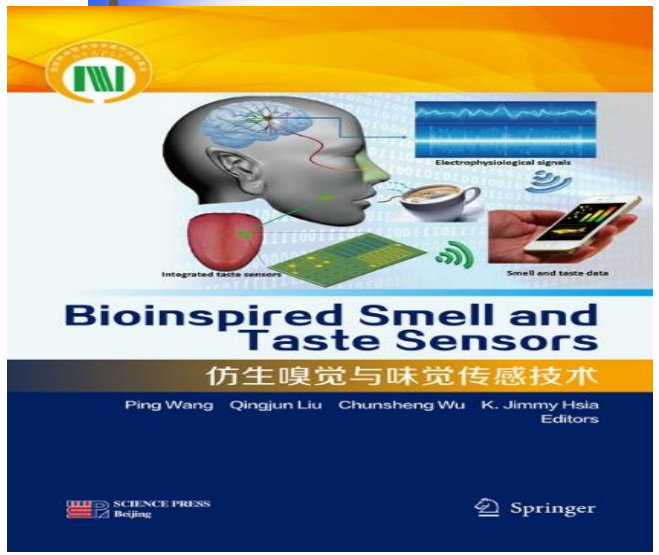
5 Myocyte contraction or relaxation

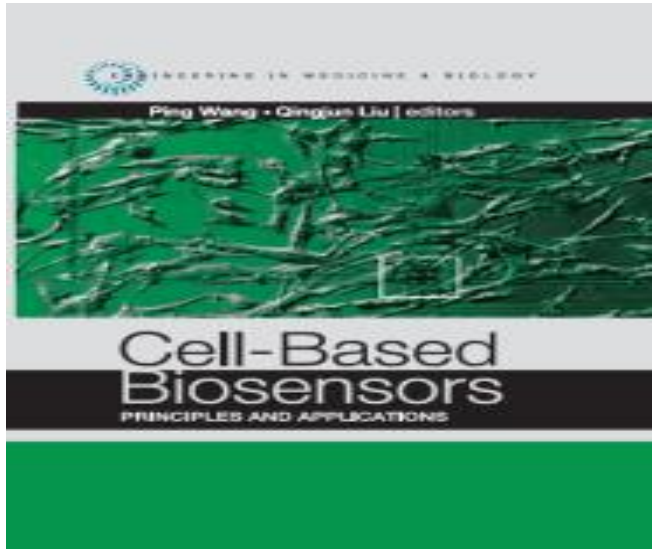
6 Controlled release of mitigating chemicals or directed locomotion

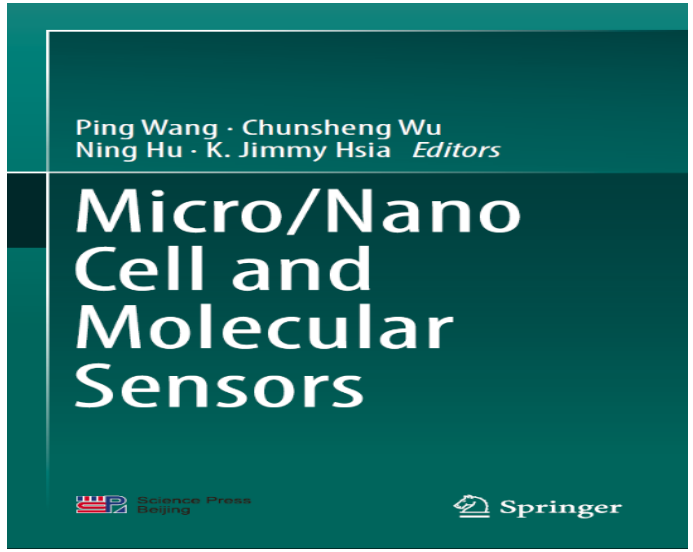


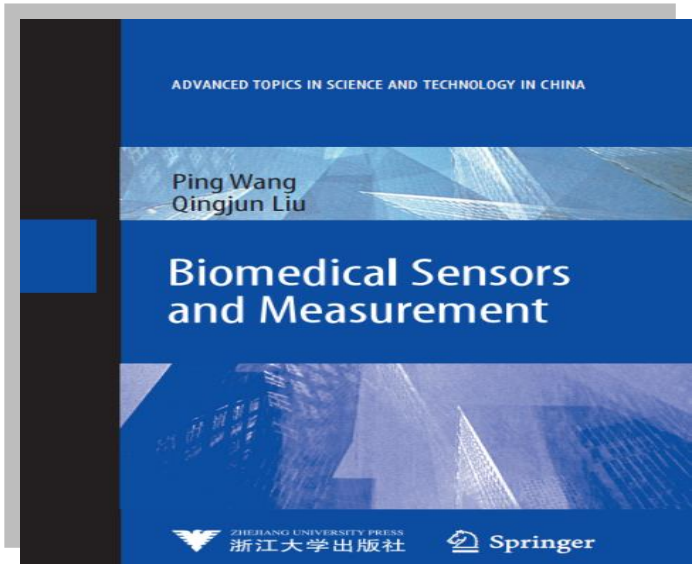


Our Some Published Books









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International Symposium on
Olfaction and Electronic Nose

2009
Brescia/Italy

Prof. Ping Wang, Department of Biomedical Engineering, Zhejiang University, China:

"Progress in Biomimetic Artificial Nose and Tongue"

Prof. Peter Mombaerts, Department of Molecular Neurogenetics, Max Planck Institute of Biophysics, Germany :

"How a Mouse Smells"

Prof. Alan Gelperin, Monell Chemical Senses Center & University of Pennsylvania, USA:

"Olfaction with DNA-Coated Nanotubes"

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International Symposium on Olfaction and Electronic Nose

May 12-15 , 2024 | Grapevine, Texas

GRAPEVINE TEXAS CONVENTION & VISITORS BUREAU

Keynote Speakers

Prof. Andreas Schütze

High performance gas measurement systems – bridging the gap between sensors and analytics

Photo Credit – Oliver Dietze

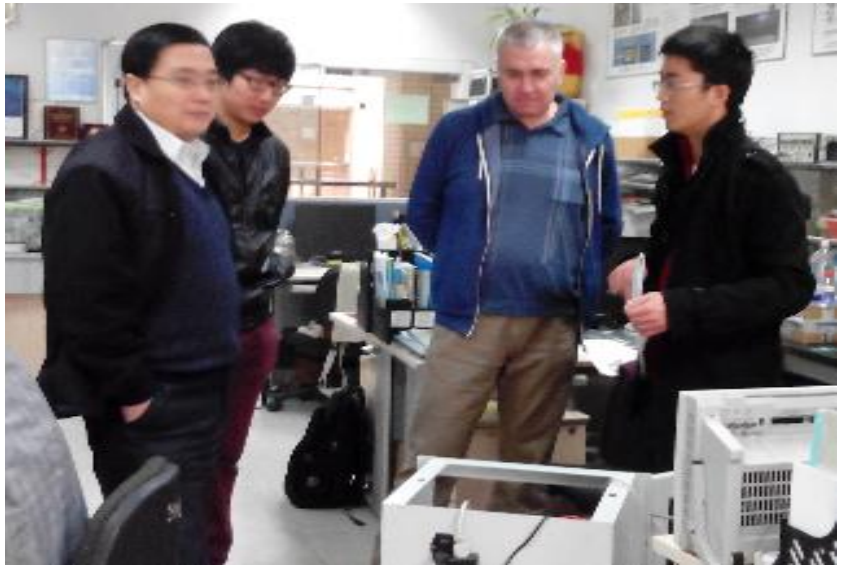
Dr. Yogesh Gianchandani

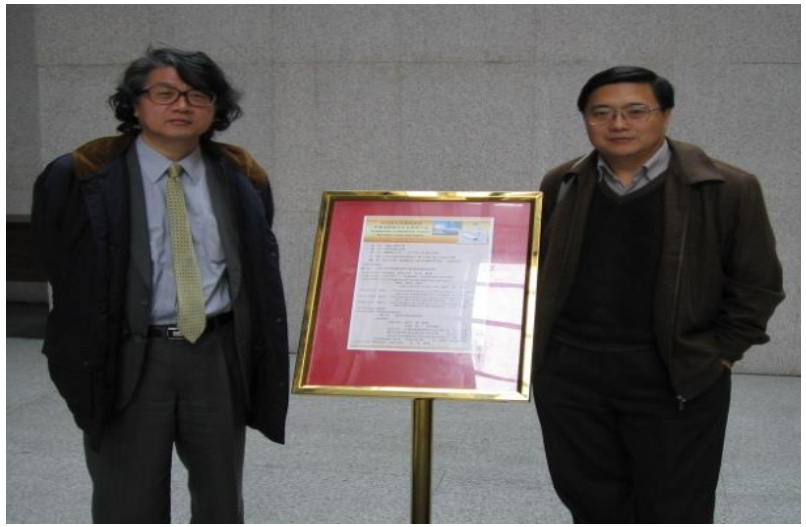
On-chip sampling and analysis — a selective view

Dr. Ping Wang

Biosensor National Special Lab, Department of Biomedical Engineering, Zhejiang University, Hangzhou, China

International Exchanges and Cooperation





International Exehanges and Cooperation

学院、系或实验室等机构都可以

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International Symposium on Olfaction and Electronic Nose

May 12-15 , 2024 | Grapevine, Texas

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Thank you For your listening !

Ping Wang

Biosensor National Special Laboratory

Department of Biomedical Engineering

Zhejiang University, Hangzhou ,China

cnpwang@zju.edu.cn