

Session 2.

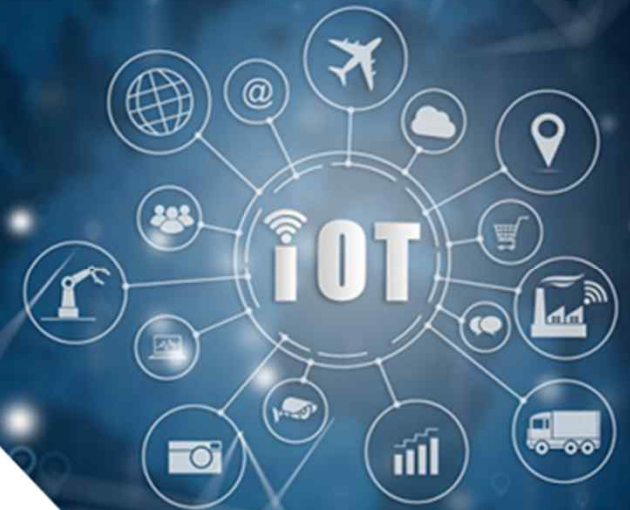
『Sensor related to Human Cognition』

Human Cognition with Receptonics by the nanobiotechnology

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Department of Nano Engineering

Sungkyunkwan University (SKKU)



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I Light cognition to Nerve response

II Challenges

Chapter I

Human Cognition for Sensors

DISEASE X



Discovering the receptors of human five senses



Richard Axel:
Howard Hughes Medical Institute,
Columbia University, Hammer Health Sciences
Center New York, NY, USA



Linda B. Buck:
Fred Hutchinson Cancer Research Center
Seattle, WA, USA

Dr. Richard Axel (USA)

Dr. Linda B. Buck (USA)

2004, The Nobel Prize in Physiology or Medicine

(Pioneering studies clarified how our olfactory system works)

Physical senses



Eyes for sight

Physical senses



HEARING

Physical senses



TOUCH

Chemical senses



Noses for smell

Chemical senses



Tongue for taste



Dr. George Wald (USA)

Dr. Ragner Granit (USA)

Dr. Haldan Keffer Hartline

1967, The Nobel Prize in Physiology or Medicine

(Discovering the eye's visual processes)

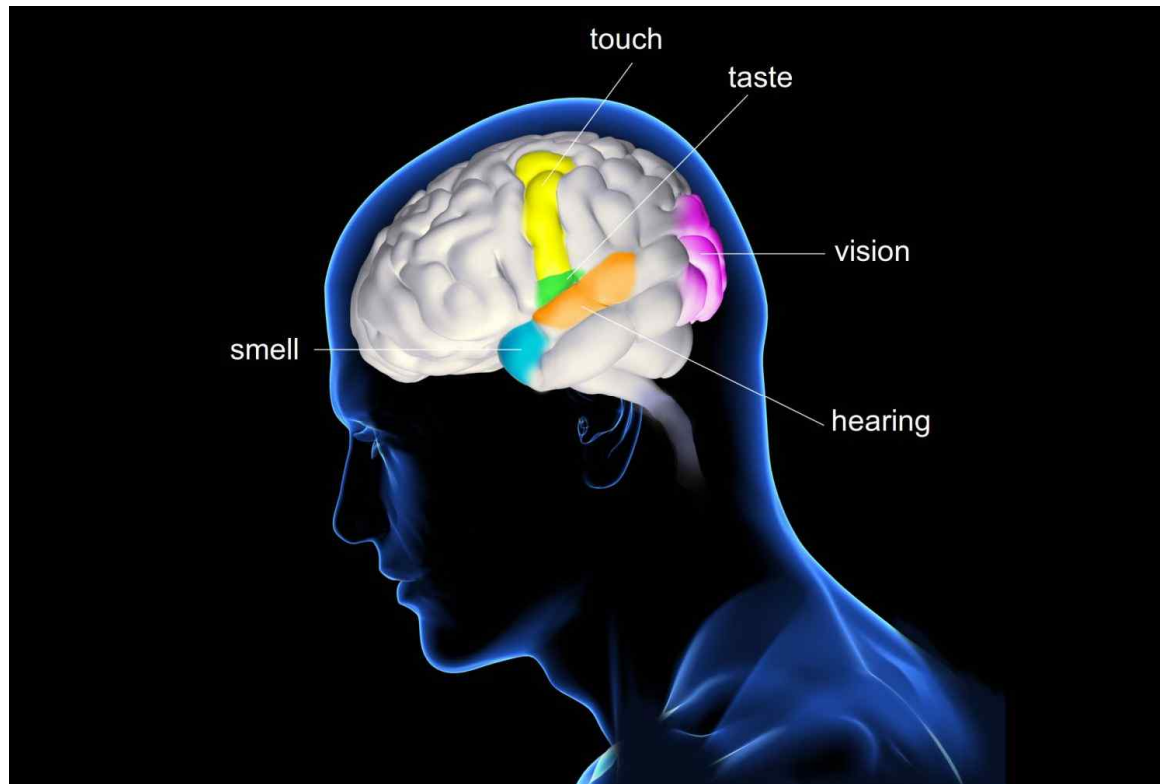


Prof. David Julius (USA)

Prof. Ardem Patapoutian (USA)

2021, The Nobel Prize in Physiology or Medicine

(Pioneering studies of receptors for pain and temperature)



<Human Sensory mechanism>

1. Receptor Cognition
(Physical and chemical reactions)

↓ Electrical signal
Or spikes

2. Nerve Stimulation/responses

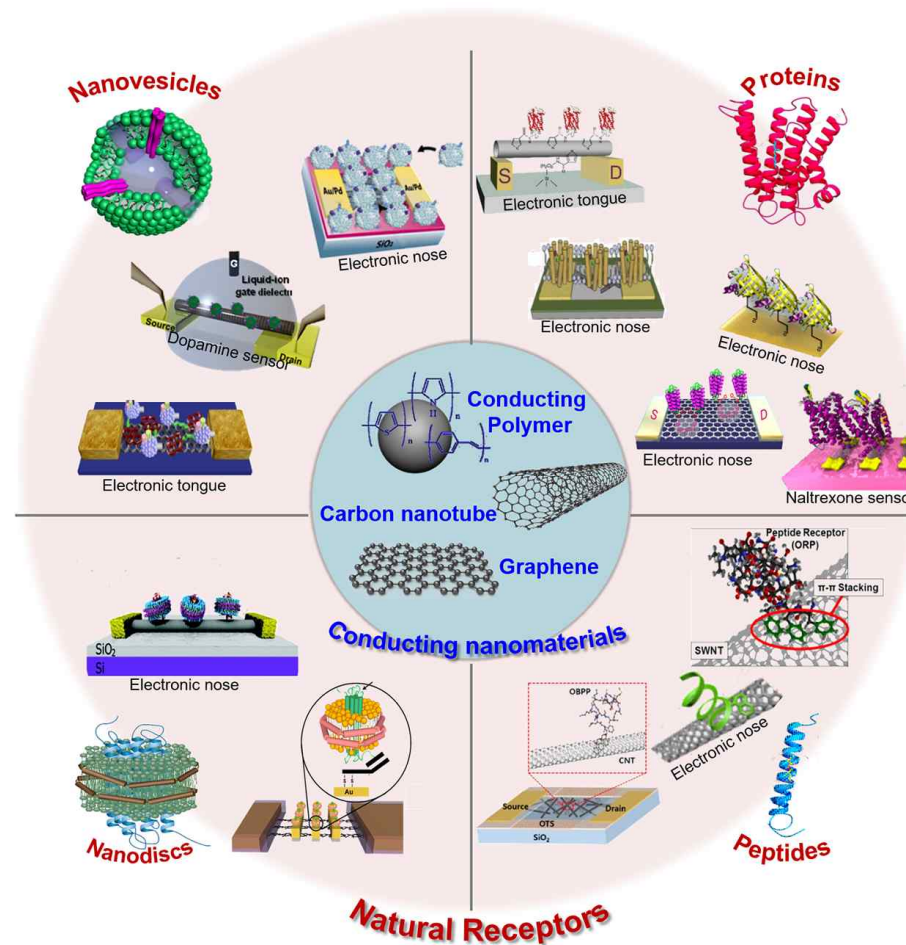
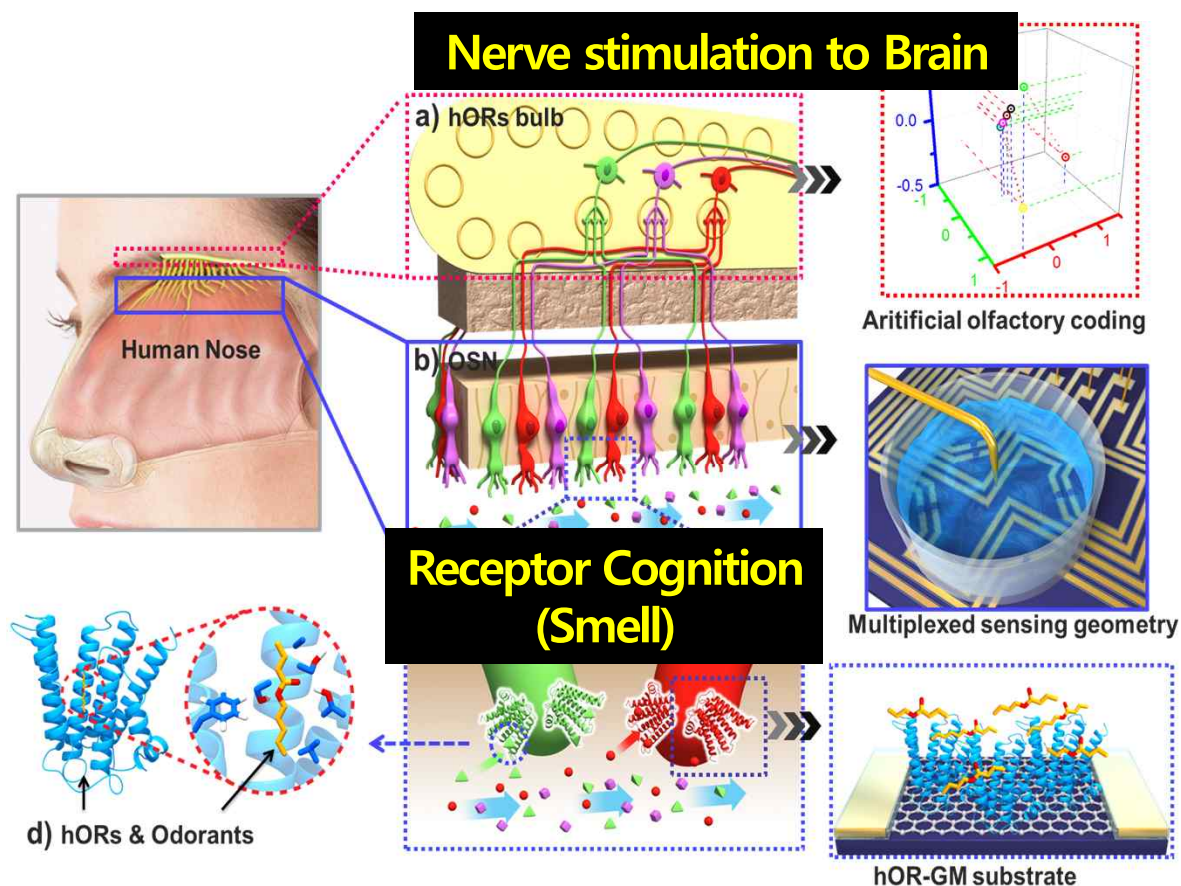


3. Brain

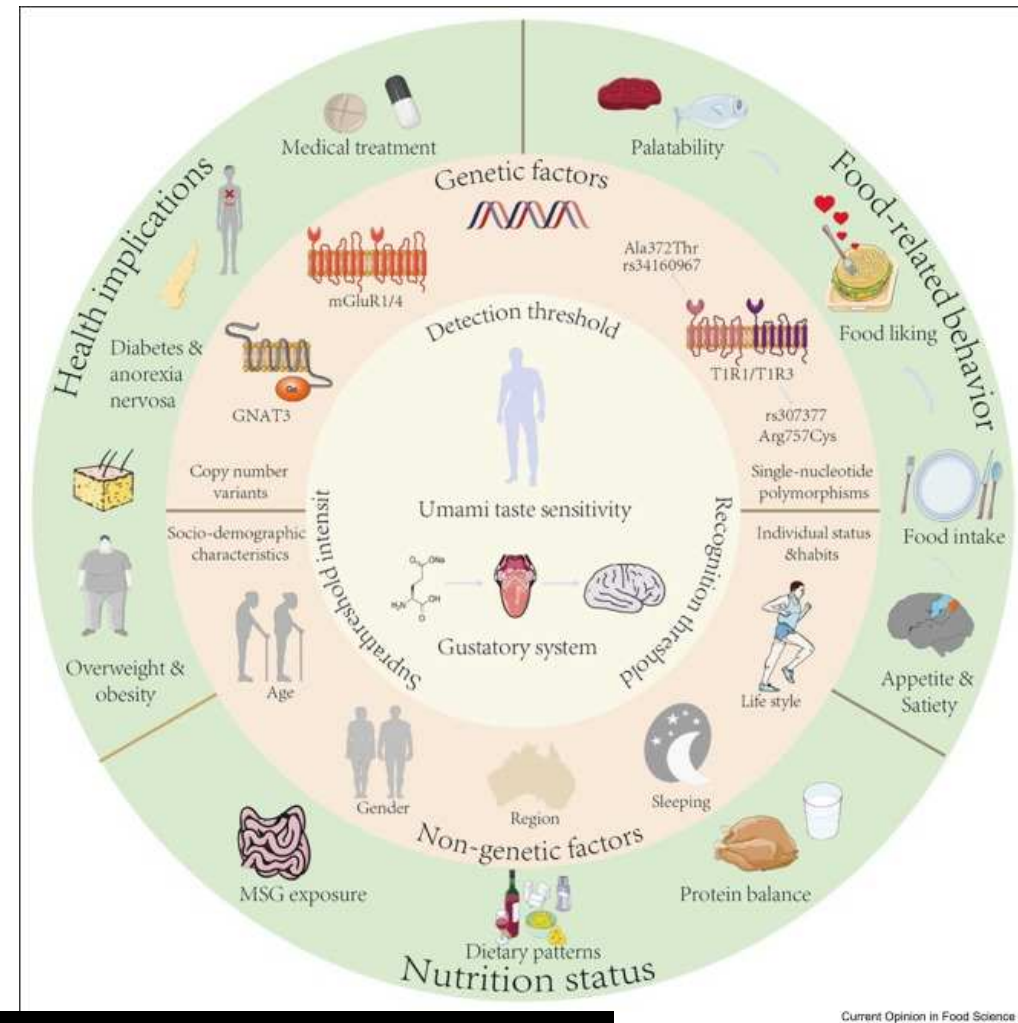
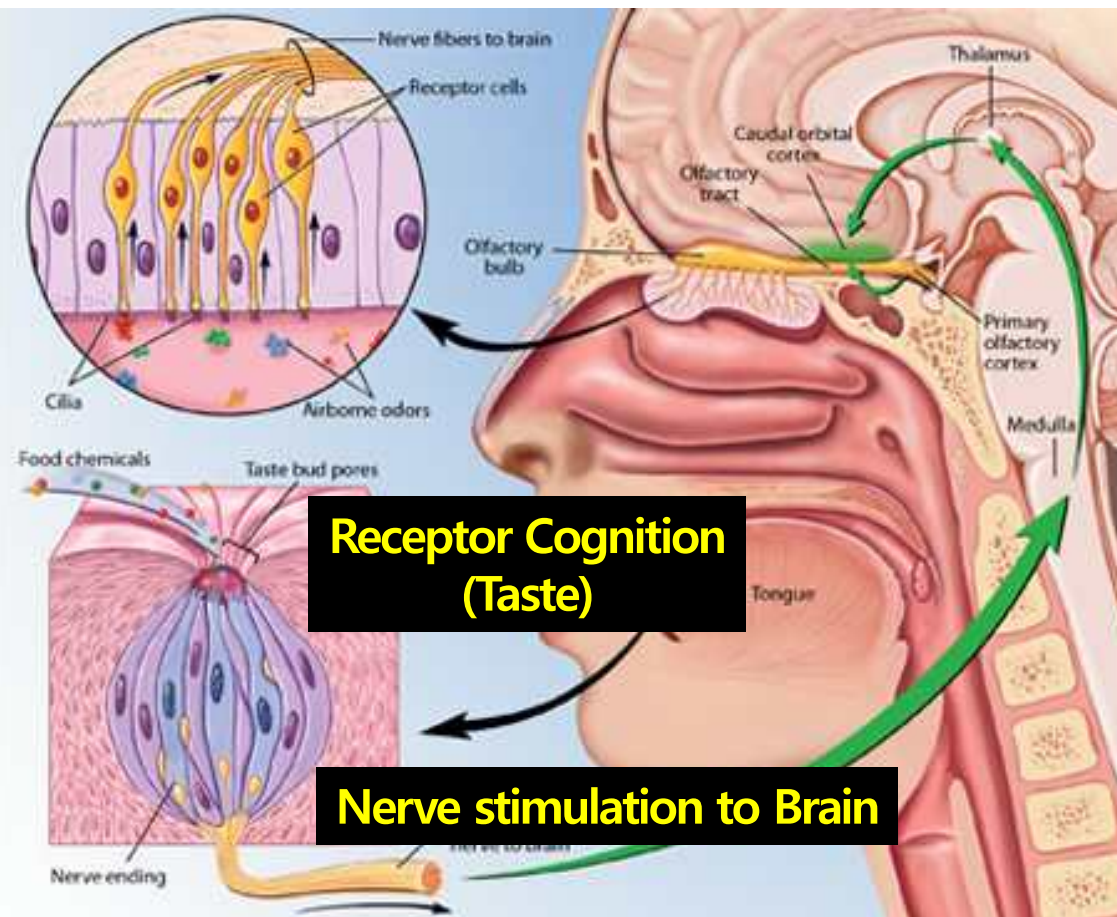


4. Decision
(Sight 87%, Listen 3%, Touch 7%,
Smell 2%, Taste 1%)

Cognition of smell with olfactory receptors

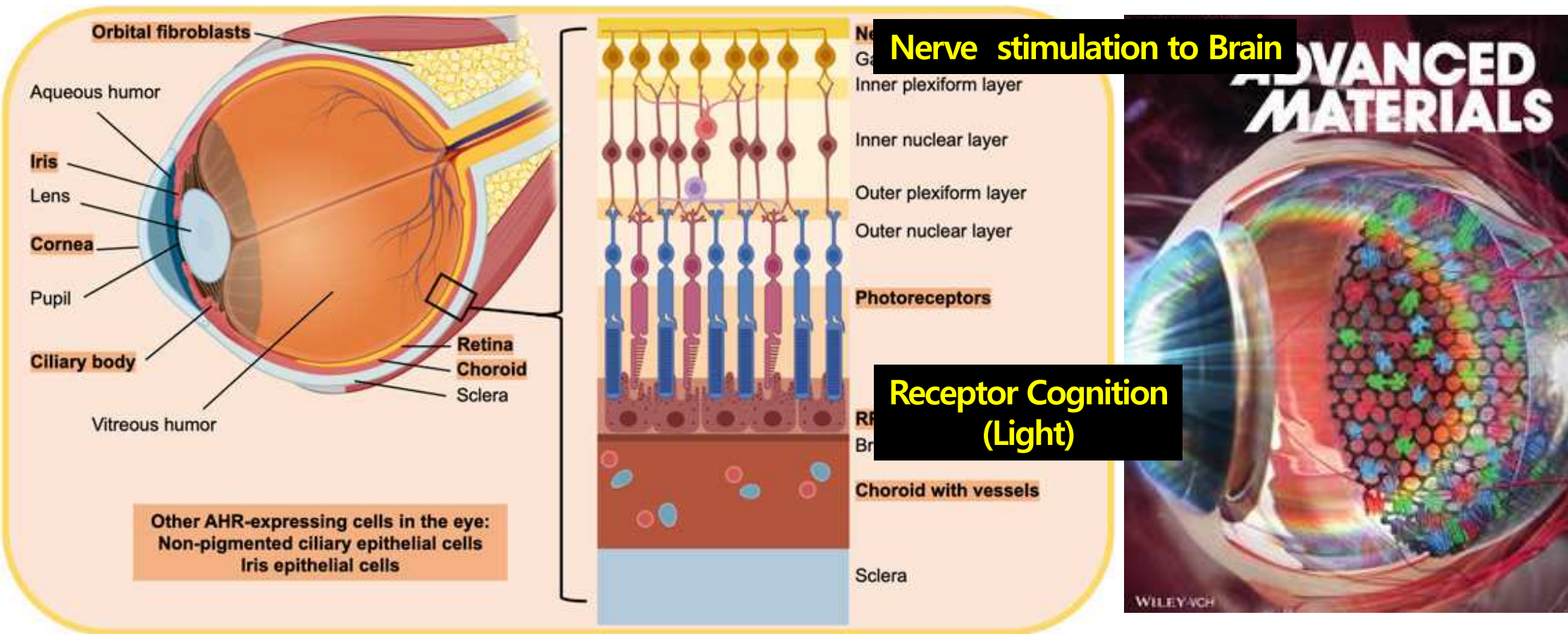


Cognition of taste with receptors in the tongue



Taste Cognition : Representative five receptors (Bitter, Umami, Sweet, Salty, Sour)

Cognition of light with receptors in the eyes



Light Cognition : Four receptors (Blue, Red, Green, Contrast (black and white))

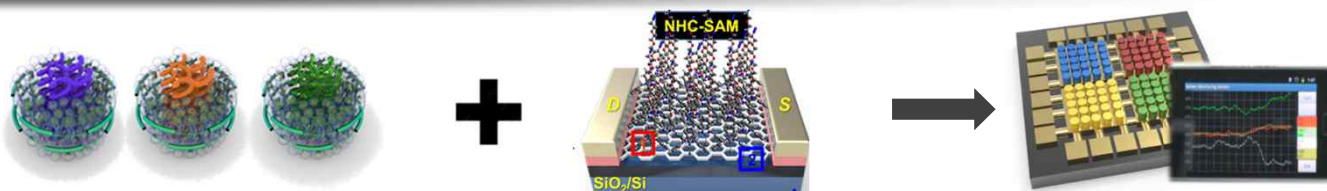
Chapter II

Human Cognition with Receptonics (Previous results)

DISEASE X



What is Receptonics?



Natural **Receptors** + Electronics with nanomaterials = **Receptonics**

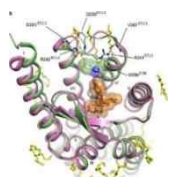
- Related Paper: Chem. Rev. (2019, IF 62) Advanced Materials (2023, IF 31), Advanced Functional Materials (2022, IF 19) PNAS (2022, IF 15) Angewandte Chemi (2022, IF 14)
- Domestic registration 16cases, application 35 cases, Abroad 3cases (U.S.A)
- Citations 6,066 (Google Scholar)



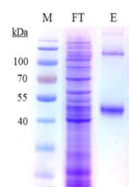
Kwon et al. Chemical Reviews 2017

Natural Receptors

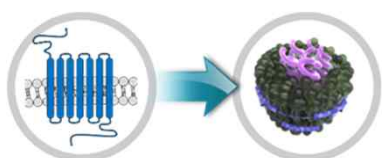
Lipid based Nanodisc



Protein



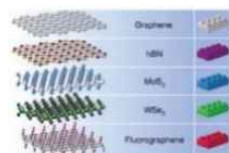
Western-blot



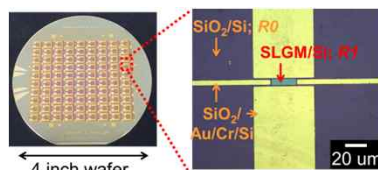
Nanodisc Mass-production

Bio-MEMS

Graphene based side-gating
Field-effect transistor



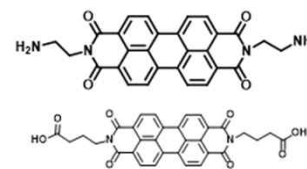
2D nanomaterials



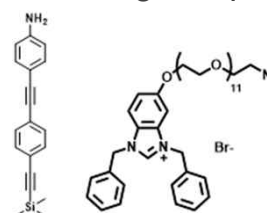
Bio-MEMS

Interfacing Chemistry

Carbene & OPE compounds



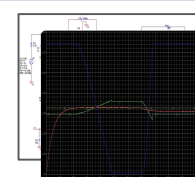
Pi-pi interfacing compounds



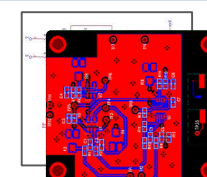
Chemical bonding compounds

H/W & S/W

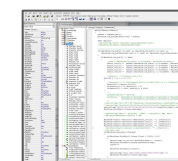
Firmware and Packaging



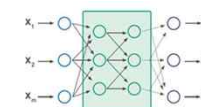
AFE simulation



H/W

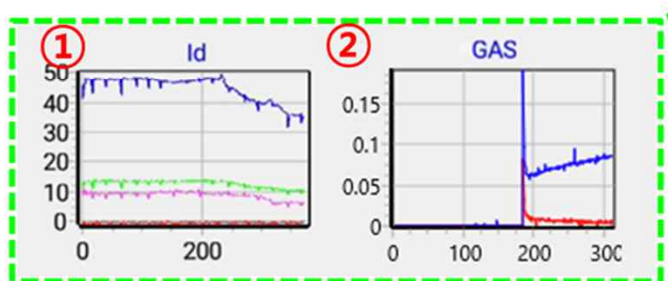
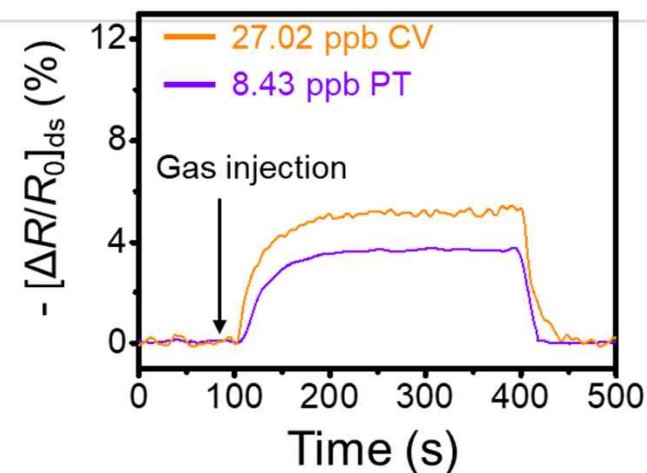
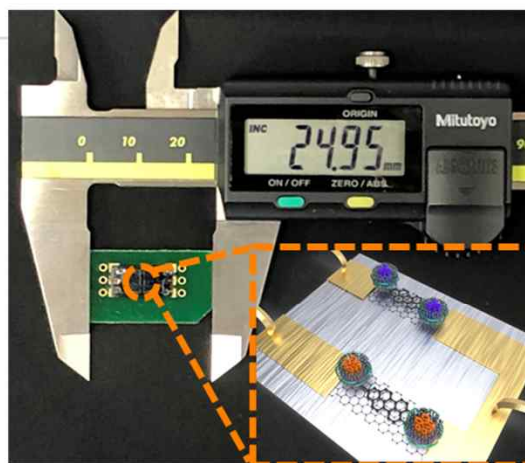
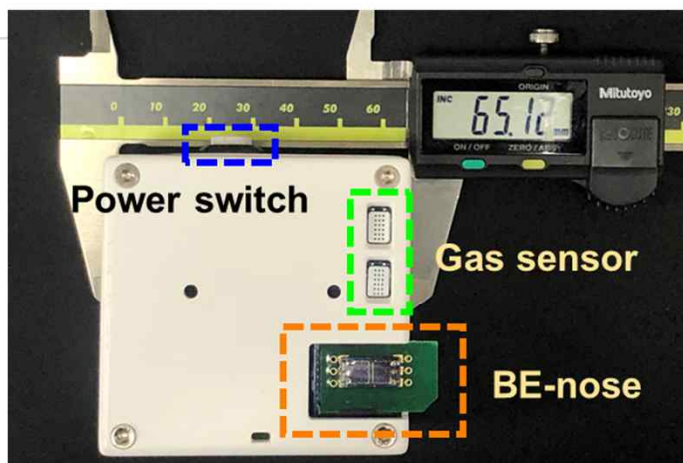


S/W



AI/ Big data

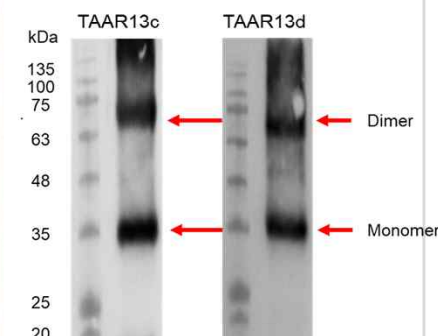
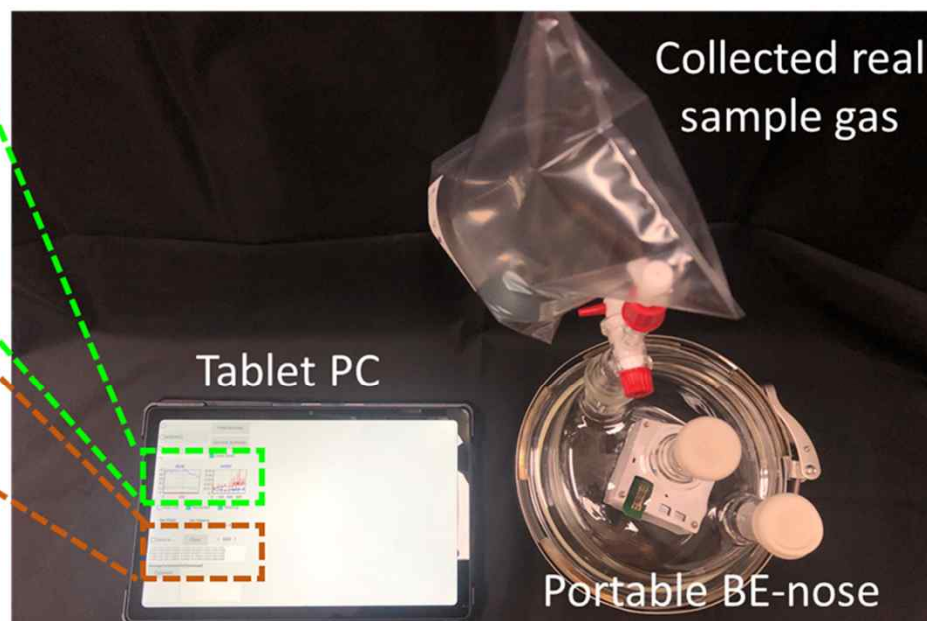
Real sample applications with Smell Receptonics



③ Real-time data

```

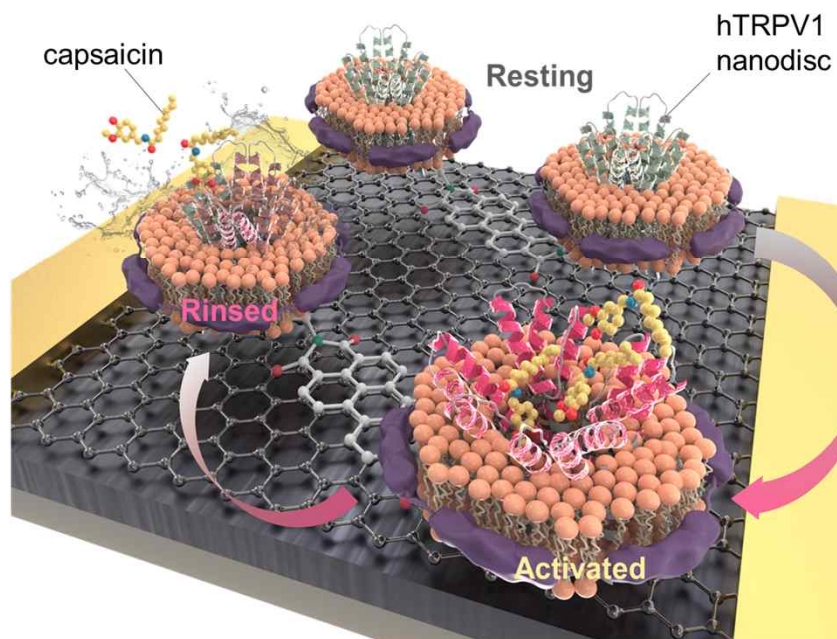
111430 -0.04 -0.04 0.00005 10.40304 33.37293 0.24229 0.021 0.007
111437 -0.05 -0.05 -0.16006 10.48384 35.29292 6.32231 0.020 0.008
111437 -0.04 -0.04 -0.08003 10.32378 34.89277 6.40234 0.019 0.007
111438 -0.04 -0.05 -0.08003 10.48384 35.13286 6.24229 0.021 0.008
111439 -0.05 -0.05 -0.08003 10.56387 35.37295 6.24229 0.020 0.008
    
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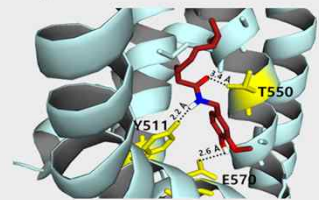
- ① BE-nose
- ② Gas sensor
- ③ Real-time data

Real sample applications with Spiciness Receptonics

Reusable electronic tongue for spiciness-related pain evaluation



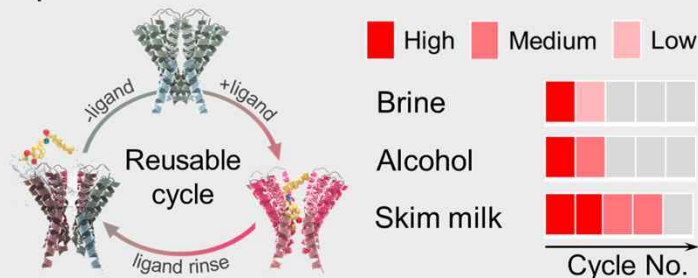
Spiciness evaluation



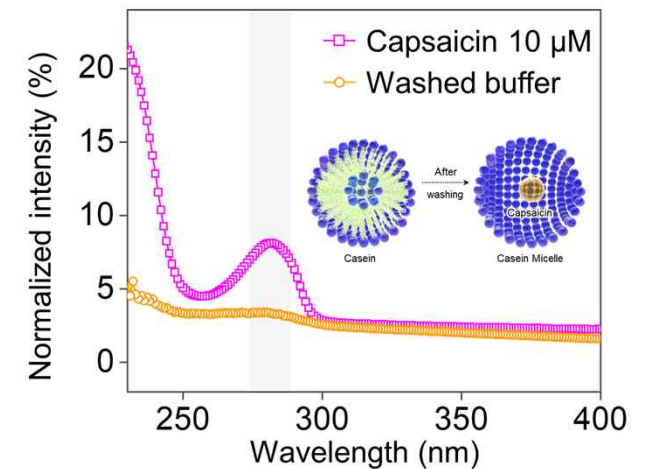
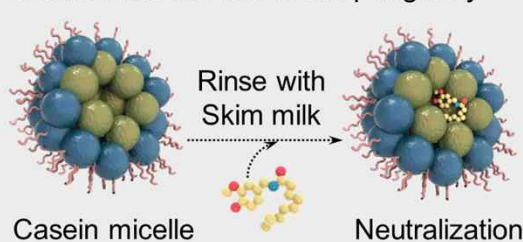
	Chili
	12000 SHU
	FET $1.92/10^{-5}$
	Pepper
	No Data
	FET $0.56/10^{-5}$
	Wasabi
	No Data
	FET $0.30/10^{-5}$
	Garlic
	No Data
	FET $0.032/10^{-4}$



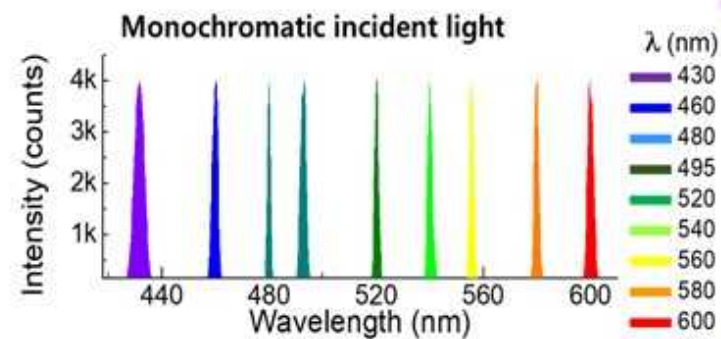
Spiciness neutralization



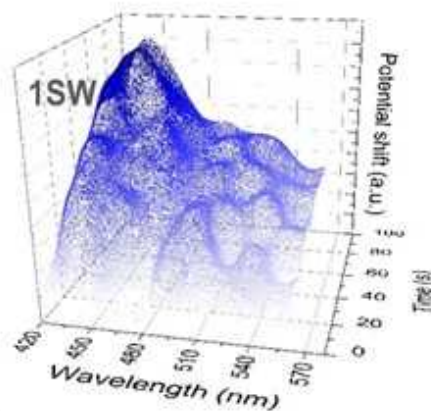
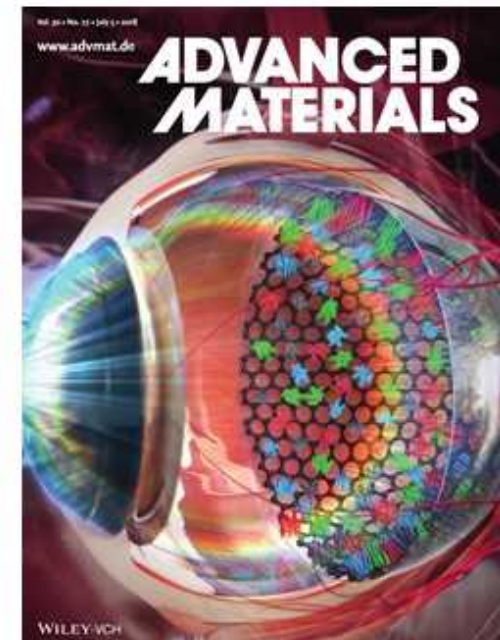
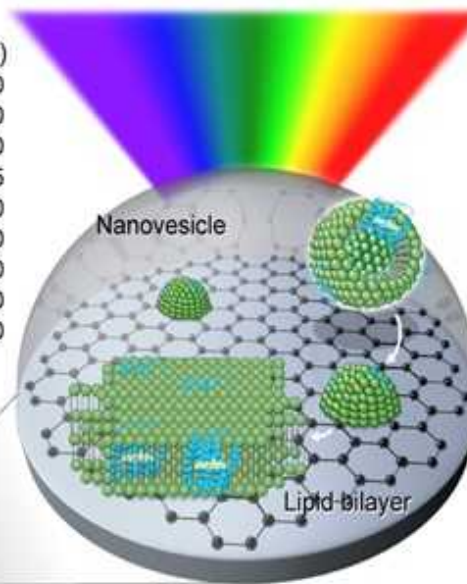
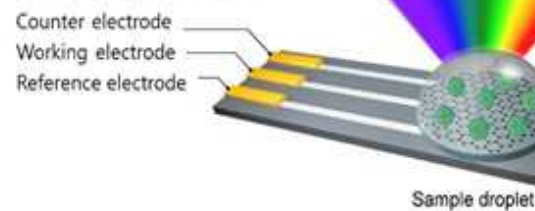
Mechanism to reduce the pungency



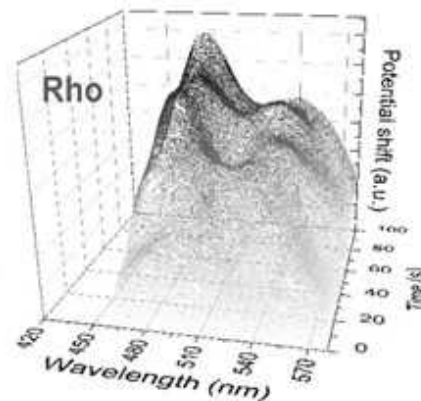
Optical absorption spectrum of human vision



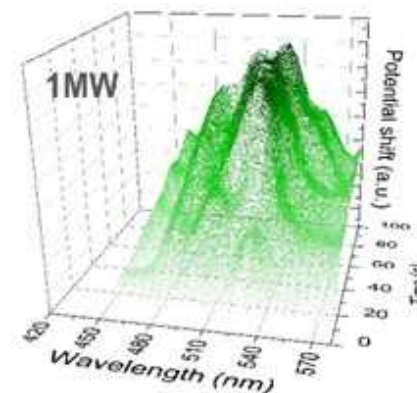
Screen printed 3 electrodes sensor



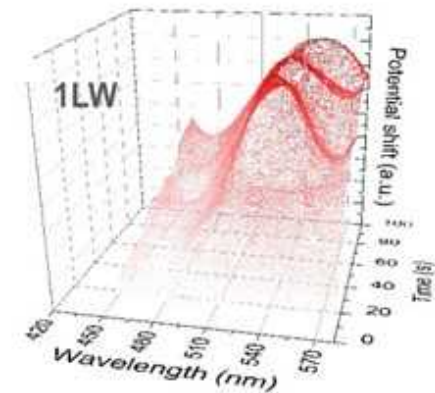
Blue



Contrast



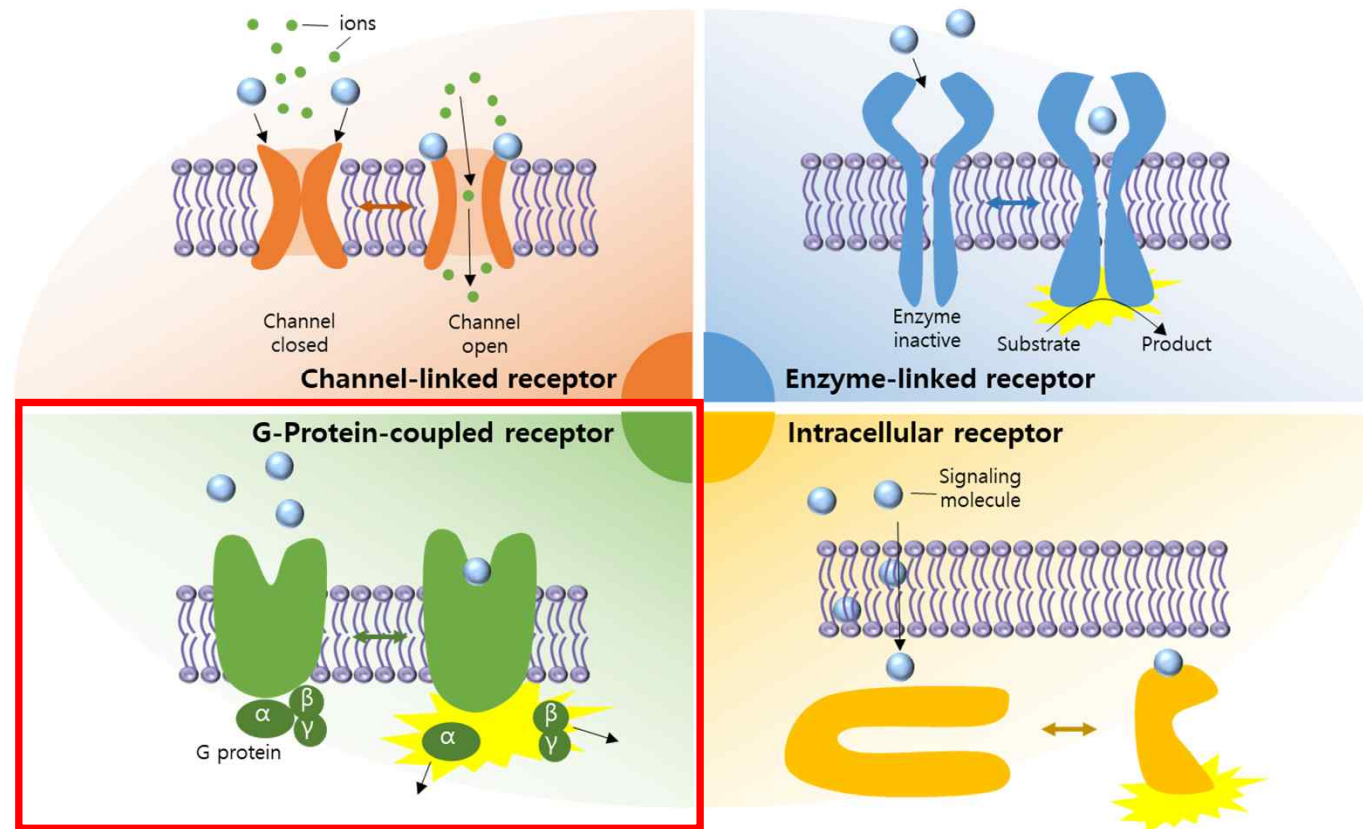
Green



Red

Limitations of seeking the nanodisc candidates

Types of Receptors

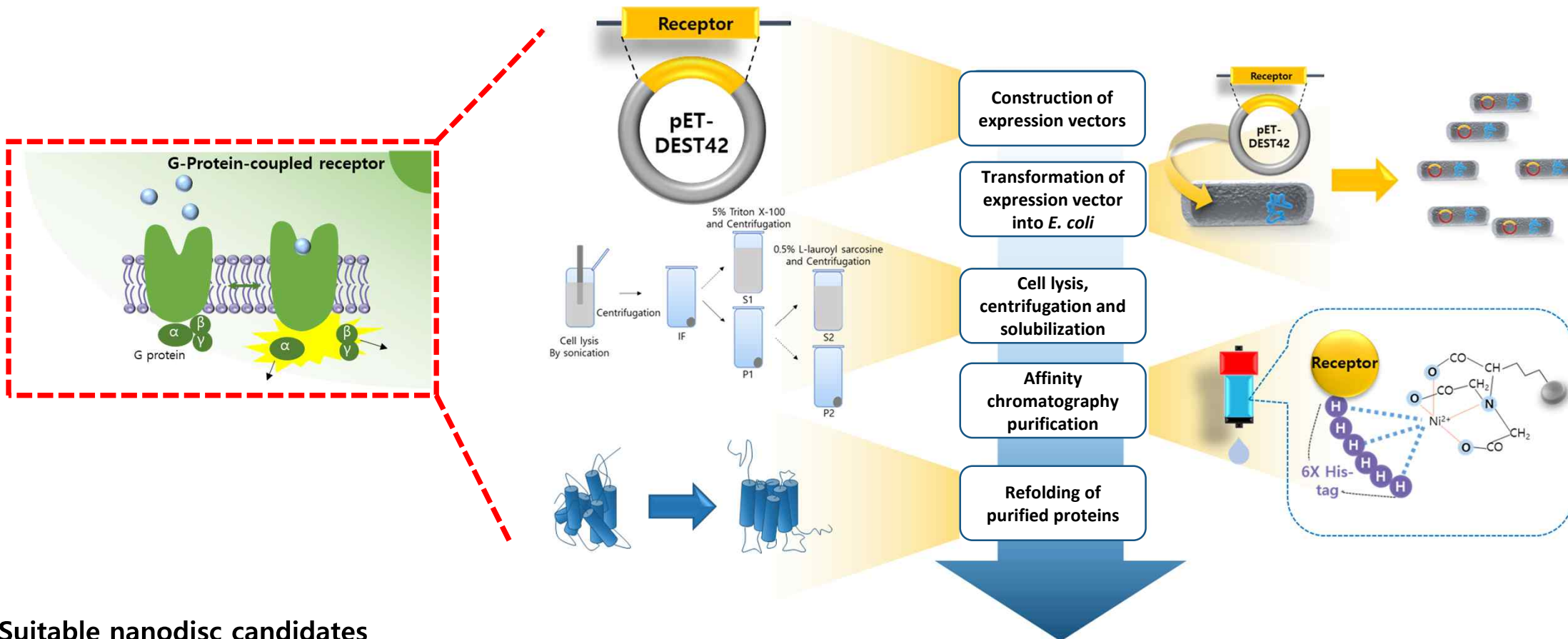


Only GPCR candidates

- However, there are a few GPCR in the human. So, I need to advanced technology which can make an ultra-stable natural receptors such as nanodisc with other receptors.

Fabrication of Nanodisc with GPCR

Receptors



Suitable nanodisc candidates

- These gene size of the candidates should be under 100 kilodaltones (kDa) because the *E. coli* (BL21, HEK293) can't express such GPCR.

Challenges

- Biological synthesis with only interaction part of GPCR.



Thank you for listening

NanoBio Electronics @ 2023