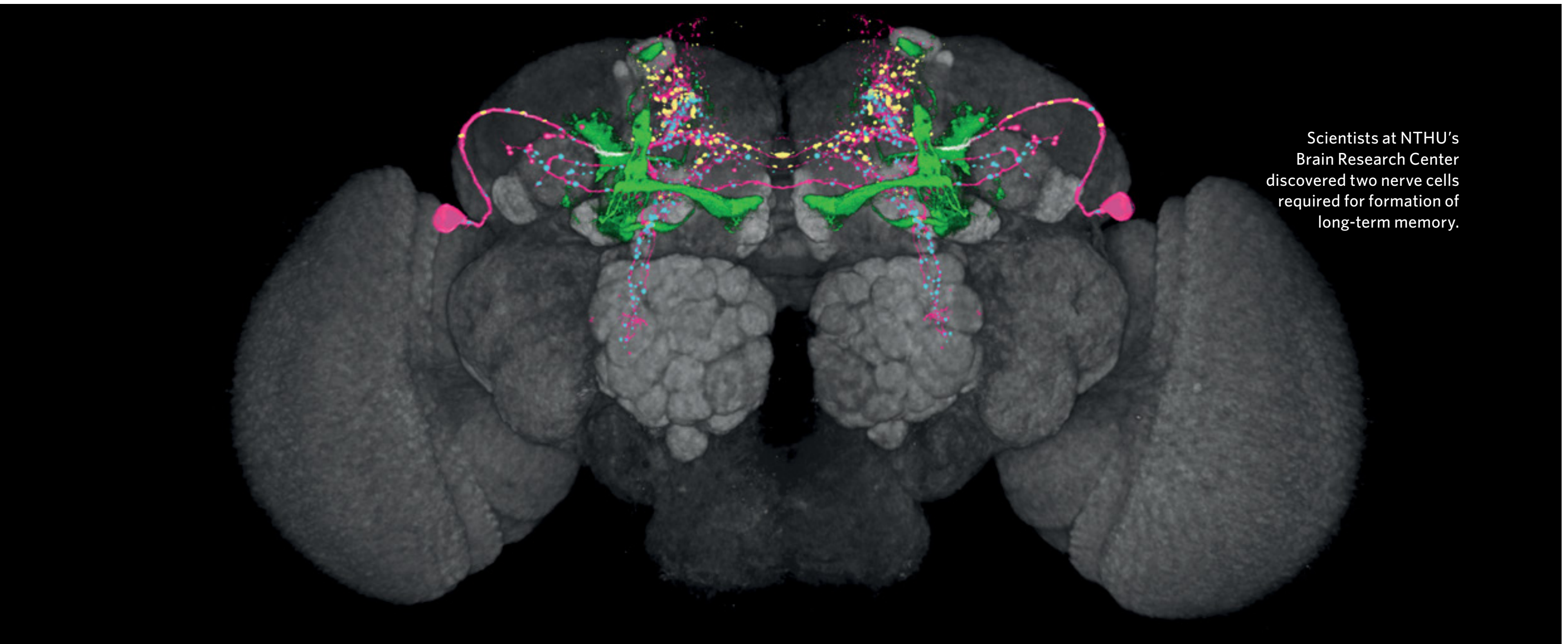


Scientists at NTHU's Brain Research Center discovered two nerve cells required for formation of long-term memory.

WORLD-CLASS RESEARCH FUELS BRILLIANT BREAKTHROUGHS

At a PREMIER UNIVERSITY IN TAIWAN, researchers have made enormous achievements, enhancing multidisciplinary discovery.

From an institute focusing on nuclear science and technology, National Tsing Hua University (NTHU) has developed into a comprehensive university consistently ranked as one of the best on the island. NTHU has contributed across a range of science and technology fields, ranging from neuroscience, to chemical and materials science, and translated results into tangible benefits.

Deciphering memory formation

The way a new experience is remembered, and where it is stored in the brain has long puzzled neuroscientists. In a seven-year study, a team at NTHU's Brain Research Center, led by Ann-Shyn Chiang, located two nerve cells essential for the formation of long-term memory.

In collaboration with Tim Tully, now an NTHU professor, who has identified numerous long-term memory (LTM) genes in fruit flies, NTHU's Chun-Chao Chen further revealed where these LTM genes were expressed, and compared their expression patterns. The team further found that after inhibiting protein synthesis required for LTM formation in just two dorsal anterior lateral (DAL) neurons, LTM was impaired. The DAL neurons were also necessary for memory retrieval after the completion of LTM formation, but were not required for learning.

Chen believes that the DAL neurons are not the only memory cells. "The identification of additional memory neurons will enable discoveries of additional 'memory proteins', thereby inspiring better understanding of the molecular mechanisms of learning, memory and associated diseases," he said.

The team has launched a new project mapping out the full memory circuit in the fly brain to identify all the neurons and proteins involved in LTM formation. Given the similarities of memory storage among animals, researchers are confident that insights from the flies will help inform knowledge about human memory.

More efficient fuel cells

Environmentally friendly and high-performance fuel cells for electric vehicles, a central pursuit of energy scientists, are a strong focus for NTHU. Tsan-Yao Chen, a professor at NTHU, and his collaborators recently designed a way to significantly improve efficiency of alkaline fuel cells (AFCs) by using ultrasonic waves to confine a platinum catalyst.

Many factors affect the efficiency of a catalyst, a key component in electrochemical and energy industries, said Chen. Size is an important factor; at the same volume, smaller catalyst particles and larger surface areas enable greater performance. When particles are too small, they become unstable.

Chen therefore proposed a unique nanostructure with various atomic clusters on the surface of nanoparticles to confine the catalytic reaction to an atomic scale. This resulted in tiny grooves on the surface of various materials, which would facilitate the reaction kinetics, and increase stability. The design would double the AFC efficiency, reduce cost by more than 95%, and extend the lifespan in oxygen reduction reactions.

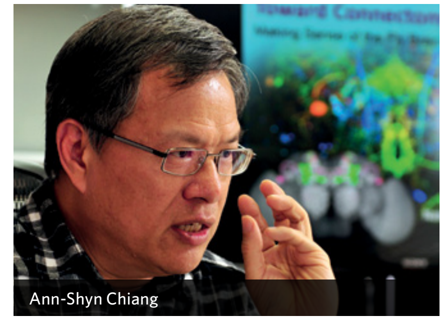
To make cells even cheaper and more efficient, Chen's team is now turning to

Tsan-Yao Chen

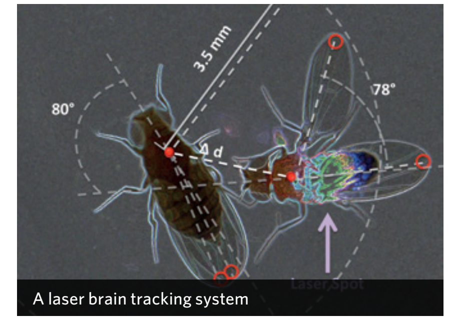
Kuo Chu Hwang

Pawel Urban

Shangjr Gwo



Ann-Shyn Chiang



A laser brain tracking system

quantum-size correlation and synergetic effects in catalysts. Their development is already showing promising results, with considerable improvement on the CO_2 and oxygen reduction performances compared to catalysts with conventional nanostructures.

Green alternatives for chemical manufacturing

Another notable green technology developed at NTHU addresses environmental threats posed by the production of adipic acid, a key precursor for the synthesis of nylon.

Current industrial nitric acid oxidation processes produce almost 1.2 million tonnes of nitrous oxide annually, an ozone-depleting greenhouse gas, along with huge amounts of waste water. Kuo Chu Hwang and his team at NTHU has developed a sustainable process for direct oxidative conversion at room temperature. Using ozone exposure, combined with UVC radiation, the process requires no metal catalysts and produces no nitrous oxide. And as adipic acid is formed as a solid precipitate, no waste water is produced. The team also used the ozone-UV process to convert p-xylene to terephthalic acid, a notable precursor for the synthesis of polyethylene terephthalate (PET). Their technology offers a possible solution to pollution problems associated with chemical industries.

Boosting experimental accuracy

Developing tools to detect chemicals, from small molecules to large biopolymers, in various sample components, including biological specimens and foodstuffs, is integral to research at NTHU's analytical chemistry laboratory, led by Pawel Urban. In particular, they have developed low-cost prototyping instruments for sample preparation, enabling chemical experiments which are unfeasible with high-end or standard equipment.

Researchers build low-cost experimental systems when they cannot address a problem with standard chemistry toolkits, says Urban, who praises the easy access to research infrastructure available to researchers at NTHU. For example, his laboratory has built a system for real-time monitoring of volatile organic compounds emitted by fungi.

At Urban's leading analytical chemistry lab, prototyping sample preparation systems created using 3D-printing technology and open-source electronics allow the meticulous preparation required by trace chemical analysis using mass spectrometry. For example, to avoid samples being contaminated by the plastics used in 3D-printing, the team designed instrument parts that would only put the samples in contact with chemically inert materials. Their innovations have found diverse applications, including for clinical settings.

New phase for semiconductors

Transformative technologies, including high-speed transistors and lasers, are made possible with semiconductor heterostructures. A recent example is the development of an atomically thin lateral heterostructure (LHS) based on the monolayer transition metal dichalcogenides (TMDs), a new two-dimensional (2D) semiconductor by the team of Shangjr Gwo, from NTHU's physics department.

In 2D-TMD semiconductors, excitons, or bound electron and hole pairs, may be created locally via electrical or optical excitation, while those having very large binding energies are responsible for most of optical processes.

While the activation of the entire LHS by excitons requires efficient and long-distance exciton transport, its diffusion length is less than or close to one micron in monolayer TMDs, due to ultrafast exciton recombination lifetime and moderate exciton mobility.

Despite the challenges, NTHU researchers came up with a solution by forming a planar metal–oxide–semiconductor (MOS) structure to extend the exciton transport range to tens of microns with minimal interfacial losses. The structure provides a hybrid platform that combines 2D light-emitting materials with plasmonic properties, offering great potential for developing integrated photonic/plasmonic functionalities. ■

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