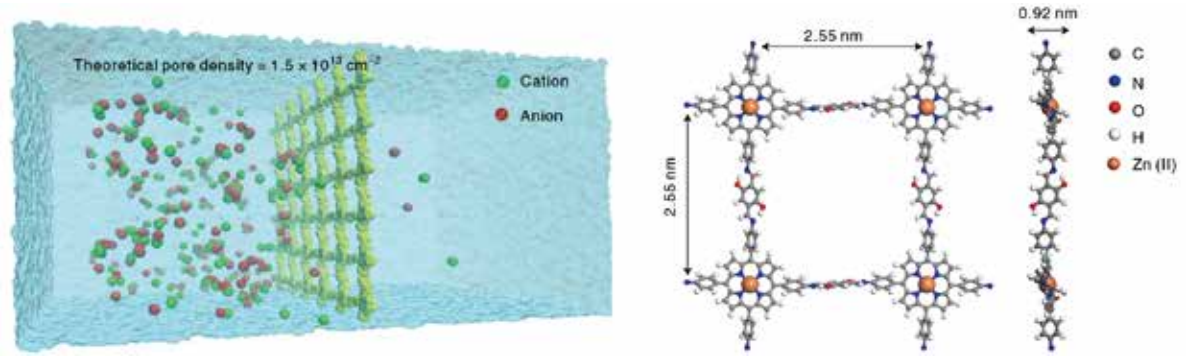
Harnessing Blue Energy with COF Membranes



Using anion-selective COF membranes to extract power from salt solutions of different concentrations. (Credit: YANG *et al.*/*Nature Biotechnology*)

Osmotic power, also known as 'blue energy', is a clean and sustainable energy source that is produced by mixing solutions of different salt concentrations. This process, known as osmosis, occurs naturally in many systems, including in the cells of plants and animals.

The efficiency of osmotic power generation depends on the ability of the membrane used to separate the salt solutions to allow ions to pass through while preventing the mixing of the solutions. This requires the membrane to have high ion conductivity and selectivity. In recent years, researchers have been exploring the use of two-dimensional thin membranes, which have a well-organized environment and high pore density, as a potential solution to this problem.

In a recent study published in *Nature Biotechnology* (doi: 10.1038/s41565-022-01110-7), YANG *et al.* from the National Center for Nanoscience and Technology of the Chinese Academy of Sciences have taken this research a step further by using covalent organic framework (COF) monolayer membranes to harness osmotic power. COF monolayers have the advantage of having a high innate pore density, as well as the ability to precisely adjust their pore structures using different building blocks. The researchers were able to demonstrate that these COF membranes had an extremely low membrane resistivity and ultrahigh ion conductivity.

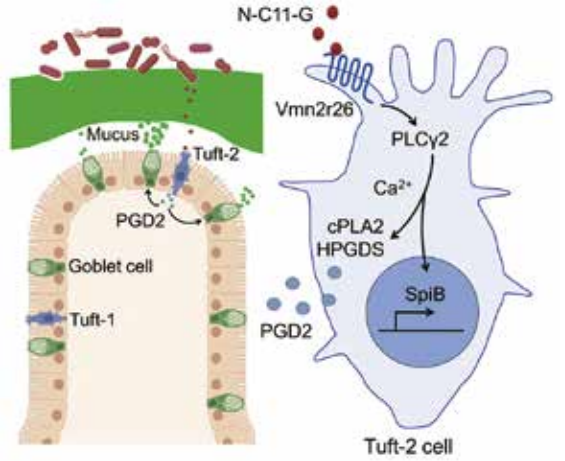
This new discovery could open up new possibilities for the use of porous monolayer membranes in osmotic power generation, as well as in other membrane-based technologies such as gas separation and water desalination. It also represents an important step forward in the development of renewable energy sources that can provide a sustainable alternative to fossil fuels.

The Hidden Role of Tuft cells in Combating Bacteria

Tuft cells are a type of intestinal epithelial cells that play a critical role in the immune system. These cells are found in epithelial barriers and are important for protecting the body against infection by parasites. However, until now it was not clear whether Tuft cells also play a role in combating bacterial infections.

In a recent study published in *Immunity* (doi: 10.1016/j.immuni.2022.03.001), a team of researchers led by Dr. FAN Zusen from the CAS Institute of Biophysics set out to answer this queation. Using

experimental data, the team showed that Tuft-2 cells can quickly expand in response to bacterial infection by sensing a specific molecule secreted by gut bacteria. This molecule, called N-C11-G, is picked up by a receptor called Vmn2r26, which then activates a cascade pathway that promotes the production of prostaglandin D2 (PGD2). PGD2 in turn enhances mucus secretion by goblet cells, which provides an anti-bacterial immune response. This new discovery sheds light on the mechanisms of antimicrobial immunity and could potentially lead to new approaches to treating bacterial infections.

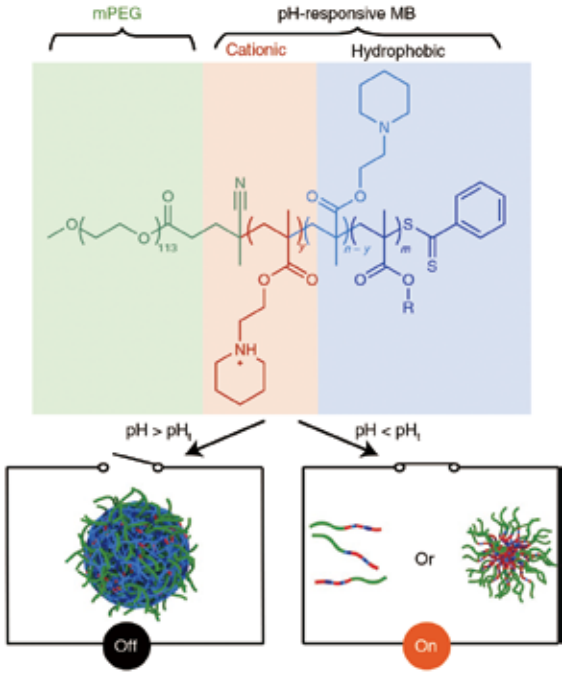


Intestinal Tuft-2 cells exert antimicrobial immunity via sensing a certain bacterial metabolite. (Image by FAN's lab)

New Nanodetergent Shows Promise for Treating Cancers

One of the major challenges in cancer treatment is the development of drug resistance, which can render traditional therapies ineffective. A potential solution to this problem is to target cancer cells by rupturing their plasma membranes. Plasma membrane rupture is a process in which the outer membrane of a cell is disrupted, leading to the death of the cell. However, the low tumor selectivity of existing membranolytic molecules has limited their application in cancer treatment.

In a recent study published in *Nature Biotechnology* (doi: 10.1038/s41565-022-01085-5), LIU *et al*. have designed a new type of nanodetergent called a "proton transistor" that can selectively target cancer cells and cause their plasma membranes to rupture. The nanodetergent, called P(C6-Bn_{20}), is able to sense subtle changes in pH and convert them into sharp signals of membranolytic activity. At physiological pH, P(C6-Bn_{20}) self-assembles into neutral nanoparticles with inactive membranolytic blocks shielded by poly(ethylene glycol) shells, making the nanodetergent low in toxicity. However, when the nanodetergent arrives at tumor sites, it senses a decrease in pH and undergoes a conformational change. This exposes the hydrophobic parts of the nanodetergent, which can then be inserted



Schematic of 'proton transistor' nanodetergents that undergo drastic structural changes across a transition pH. The molecules can effectively rupture plasma membranes at the 'On' state. (Image by LIU *et al*./*Nature Biotechnology*)

into the cell membranes, causing them to rupture.

In mice, P(C6-Bn_{20}) was well tolerated and showed high cancer-killing efficacy in various tumor models. Using nanodetergents to selectively kill cancer cells could potentially be a promising approach for treating drug-resistant cancers.

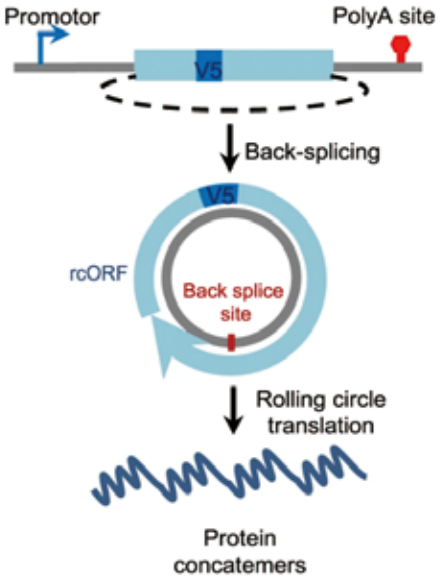
Exploring the Epigenetic-Metabolism Axis and Aging

In a recent study published in *Signal Transduction and Targeted Therapy* (doi: 10.1038/s41392-022-00964-6), LI *et al*. used artificial intelligence (AI) to uncover the mechanism behind the interaction between epigenetic alterations and metabolic dysfunction in aging. The team found that the epigenetic alterations of gene ELOVL fatty acid elongase 2 (Elovl2) play a crucial role in regulating lipid metabolism, and that impaired Elovl2 function leads to increased endoplasmic reticulum stress and mitochondrial dysfunction, resulting in feature aging phenotypes at both the cellular and physiological levels. The researchers also found that restoring mitochondrial activity could rescue age-related macular degeneration (AMD) phenotypes induced by Elovl2 deficiency in human retinal pigmental epithelial (RPE) cells. Overall, this study reveals an epigenetic-metabolism axis contributing to aging and highlights the potential of AI-based approaches in structure-function studies.

Pervasive Translation of Circular RNAs

Circular RNAs (circRNAs) are prevalent in animals and plants and are created through the back-splicing of pre-mRNAs. Previously thought to be by-products, the discovery of circRNA's hidden roles in gene regulation has led to a greater understanding of their importance. These molecules may act as molecular sponges by sequestering miRNAs or RNA binding proteins, or may promote the transcription of nearby genes. Recent research has shown that circRNAs require the internal ribosomal entry site (IRES) for translation in a cap-independent mechanism due to the lack of a 5' end. However, the research community does not share a common opinion on the existence of IRESs in eukaryotic transcriptomes, casting doubts on the scope of circRNA translation.

To solve the debate, a team led by Dr. WANG Zefeng from the Shanghai Institute of Nutrition and, the Chinese Academy of Sciences developed a cell-based system to screen random sequences and identified 97 overrepresented hexamers that



Proteins can be synthesized via rolling circle translation from circular RNAs, which is found to be a pervasive process in cells. (Image by WANG Zefeng's lab)

drive cap-independent circRNA translation (*Nature Communications*, doi: 10.1038/s41467-022-31327-y). In the study, they found these IRES-like short elements to be significantly enriched in endogenous circRNAs and sufficient to drive circRNA translation in a rolling-circle way. Additionally, they found that circRNAs containing only coding sequences can be translated through internal IRES-like elements in the coding region, and identified hundreds of circRNA-coded proteins through mass spectrometry. This study reveals the pervasive translation of circRNAs, which may be a general function of these molecules in living organisms.

Microplastics: Antidote or Trojan Horse for Aquatic Plants

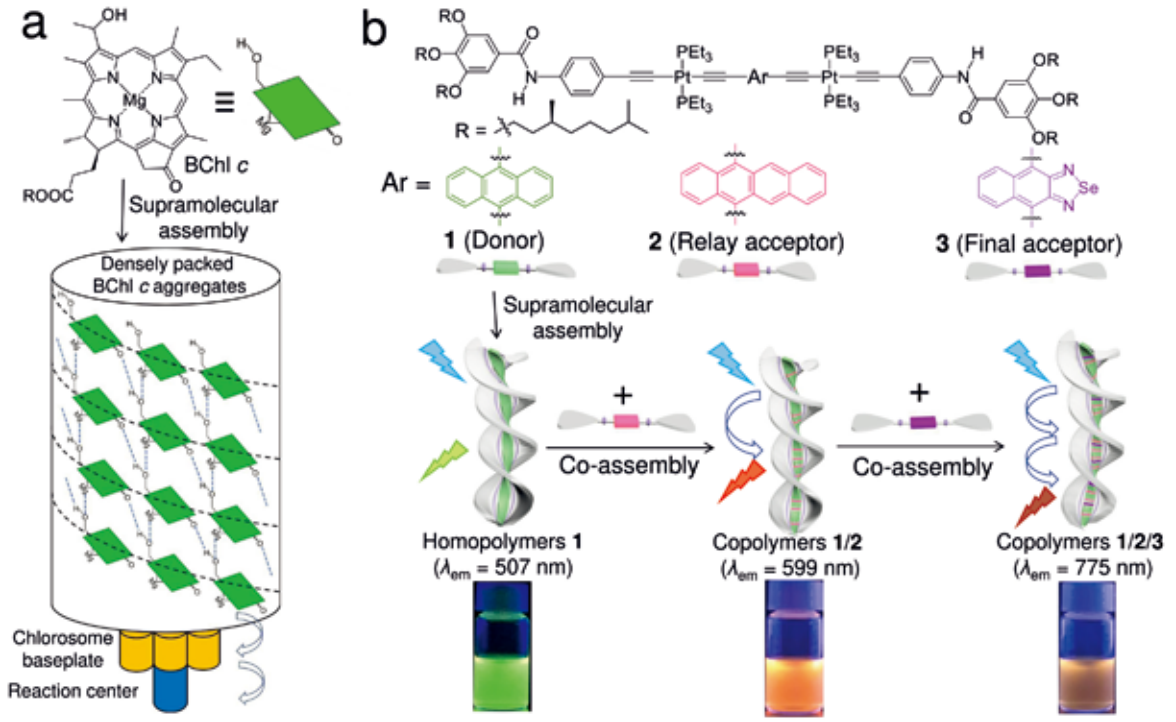
Microplastics are tiny bits of plastic that are smaller than 5 millimeters in size. Their surface can attract and hold onto other contaminants. When this happens, it can change how toxic of these contaminants and where they end up in water systems. In a recent study published in *Water Research* (doi: 10.1016/j.watres.2022.118354), researchers fromWuhan Botanical Garden of the Chinese Academy of Sciences looked at how copper ions stick to and travel with two sizes of microplastics made of a material called polyethylene, and studied how these combinations affected four different types of aquatic plants. The study found that adding the microplastics made the water contain less copper ions and more copper ions stuck to the microplastics as the amount of copper ions in the water increased. The microplastics alone did not harm the water plants, but the copper ions were harmful. However, the combination of microplastics and copper ions caused less harm to the plants, with the amount of harm differing among the plant types. The researchers also found that the microplastics might carry the copper ions from one place to another and that the copper ions could then harm water plants in the new location. This research helps us better understand microplastics and other contaminants' risks to water systems and aquatic organisms.

An illustration of microplastics attached to an aquatic plant. (Image created by DALL-E 2)

Bioinspired Approach Improves Artificial Light Harvest

Scientists at the University of Science and Technology of China (USTC) have developed a new method for improving the efficiency of energy transfer in artificial light-harvesting systems (LHSs), according to a study published in *Nature Communications* (doi: 10.1038/s41467-022-31094-w).

Traditionally, artificial LHSs use donor and acceptor (D/A) chromophores anchored to scaffolds such as



Natural (a) and artificial (b) sequential energy transfer systems. (Credit: *Nature Communications*)

vesicles, micelles, and biomacromolecules. However, the disordered organization of these chromophores often leads to low overall energy transfer efficiencies of less than 70%.

To address this issue, scientists developed supramolecular copolymers made up of long chains of molecules held together by non-covalent interactions, mimicking densely and orderly packed pigments found in purple photosynthetic bacteria. By incorporating different D/A chromophores into these copolymers, they achieved a high degree of sequential energy transfer.

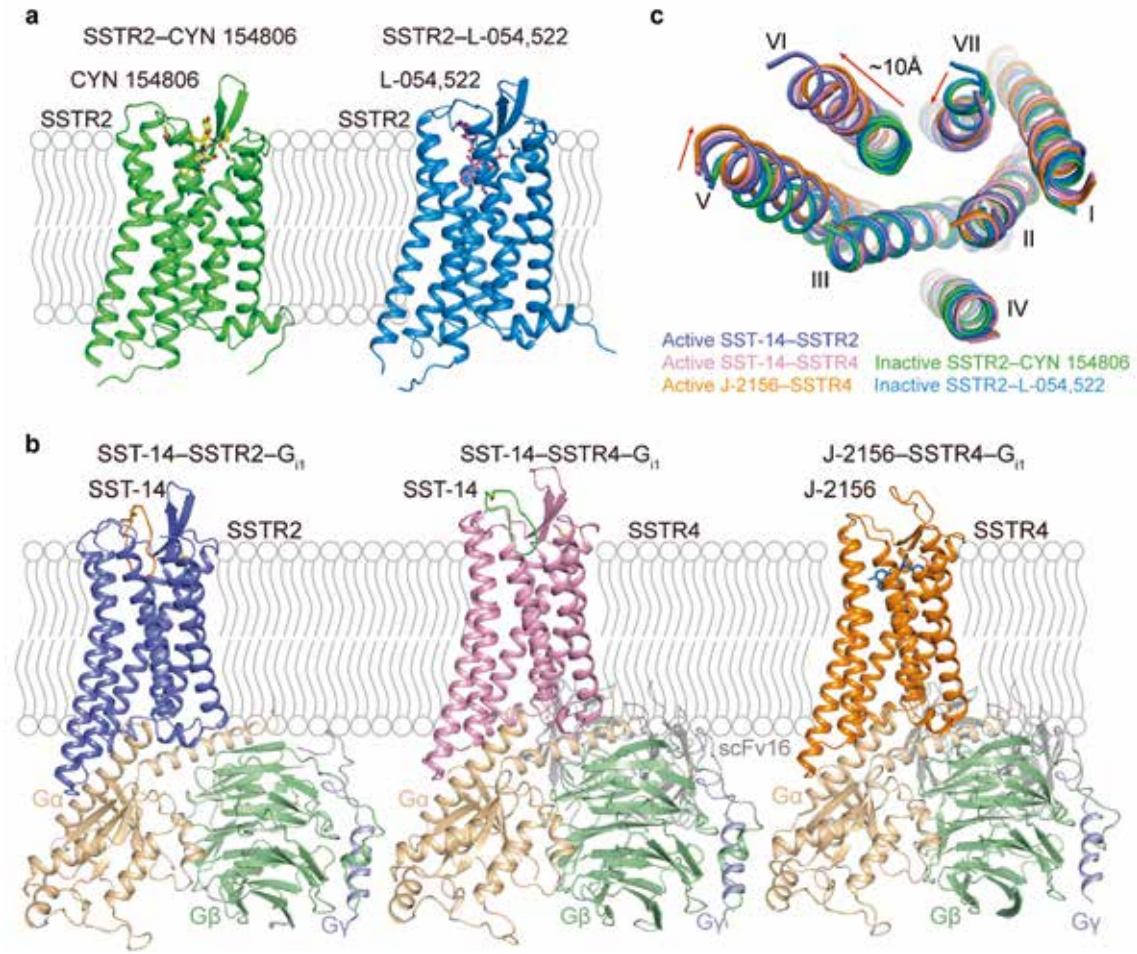
They used σ-platinated (hetero)acenes as the chromophores and introduced amide groups to the monomers to increase the non-covalent packing strength of the copolymers and facilitate supramolecular copolymerization.

In the resultant supramolecular copolymers, the green-emitting chromophores served as a donor matrix, transferring energy to the near-infrared (NIR) emitting chromophores through sequential D/A energy transfer with an overall efficiency of 87.4%, a great leap compared to the formerly reported 70%.

This bioinspired approach represents a promising way to improve energy transfer efficiency in artificial LHSs.

Structural Insights into Ligand Recognition and Selectivity of Somatostatin Receptors

Somatostatin is a hormone that regulates multiple hormone releases and cell proliferation in the human body. It does this through a group of somatostatin receptors (SSTRs), of which there are five types: SSTR1-SSTR5. SSTR2 is the most well-known and is often targeted in treating neuroendocrine tumors and acromegaly. SSTR4, highly expressed in the central nervous system, has been shown to have the potential



Overall structures of SSTR2 and SSTR4 complexes with different bounding ligands. (Image by SIMM/*Cell Research*)

for use in non-opioid pain control.

In recent years, research has focused on developing SST analogs and non-peptide ligands to target these receptors for various medical applications, including cancer treatment and pain management. However, there are concerns about these therapies' effectiveness and potential side effects.

Reported in *Cell Research*, scientists from the Shanghai Institute of Materia Medica (SIMM) of the Chinese Academy of Sciences illustrated the crystal structures of SSTR-ligand complexes (doi: 10.1038/s41422-022-00679-x), shedding light on drug design against these receptors.

By solving the crystal structures of SSTR2 and SSTR4 bound to various ligands and combining these with mutagenesis, molecular docking, and molecular dynamics simulations, the authors identified key signature features necessary for ligand binding to these receptors. This new knowledge could be helpful in the rational design of new drugs that are more selective and effective in targeting specific SSTR subtypes for the treatment of particular diseases.