Protein Assembly: A New Platform to Develop Biomimetic System

Junqiu Liu College of Material Chemistry and Chemical Engineering Hangzhou Normal University, Hangzhou 311121, China

Abstract

Sophisticated protein self-assemblies have attracted great scientific interests in recent few decades due to their various potential applications. The design and control of proteins into hierarchical nanostructures *via* self-assembly strategies offers unique advantages in understanding the mechanism of naturally occurring protein assemblies and in creating various functional biomaterials with advanced properties. Protein self-assembly into exquisite, complicated yet high-ordered architectures represents the supreme wisdom of nature. However, precisely manipulating protein self-assembling behaviors *in vitro* is a great challenge. By taking advantage of supramolecular strategies such as the metal ion chelating interactions, host-guest interaction and non-specific protein-protein interactions, accuracy control of the orientation of protein self-assembly has been achieved. The designed nanostructures have been used as biomimetic scaffolds for developing biomimetic enzymes, light harvesting system and muscle mimics.

Junqiu Liu received his Ph.D in macromolecular chemistry from the State Key Laboratory of Supramolecular Structure and Materials, College of Chemistry, Jilin University in 1999 under the supervision of Professor Jiacong Shen. Following his doctoral studies, he was a Humboldt Fellow and a Postdoctoral Fellow with Professor Günter Wulff at the Institute of Organic and Macromolecular Chemistry, Heinrich-Heine University, Germany. In 2003 he joined the faculty of the State Key Laboratory of Supramolecular Structure and Materials in Jilin University as a



full professor of chemistry. In 2020 he joined Hangzhou Normal University. His main research interests include supramolecular chemistry, biomimetic chemistry, and bionanomaterials.

Harnessing Unnatural Nucleic Acids for the Expansion of Central Dogma

Tingjian Chen

Designer membraneless organelles in living bacteria

Xiao-Xia Xia

State Key Laboratory of Microbial Metabolism (SKLMM)

Department of Bioengineering, Shanghai Jiao Tong University, Shanghai, China Abstract

Membraneless organelles, a new type of cellular compartments, are formed by liquid-liquid phase separation of proteins and/or nucleic acids in eukaryotes. These organelles play crucial roles in cell physiology and pathology, and thus give rise to a fundamental mechanism for organizing the intracellular milieu. However, such cellular compartments have yet to be discovered or created synthetically in prokaryotes. In this talk, I will introduce the formation of liquid protein condensates within the living cells of prokaryotic Escherichia coli upon heterologous overexpression of intrinsically disordered proteins such as spider silk and resilin. In vitro reconstitution under conditions that mimic intracellular physiologically crowding environments of E. coli revealed that the condensates are formed via liquid-liquid phase separation. Functionalization of these condensates was further achieved via fusion and targeted colocalization of fluorescent or catalytic cargo proteins to the compartments. The ability to form and functionalize membraneless compartments may serve as a versatile tool to develop artificial organelles with on-demand functions in prokaryotes for applications in synthetic biology. The research work delivered may also inspire the exploration of natural membraneless compartments in E coli and other prokaryotes.

Dr. Xiaoxia Xia is currently a professor in Department of Bioengineering at Shanghai Jiao Tong University (SJTU). She earned her Ph.D. in Chemical and Biomolecular Engineering at

at KAIST and Tufts University, she joined SJTU in 2012. Her current research focuses on artificial biomacromolecules and functional materials created with synthetic biology. She has coauthored more than 50 peer-reviewed papers in the international journals including Nature Chemical Biology and PNAS. She was awarded Eastern Scholar Professorship in 2012 and 2017, and



Pujiang Talent Award in 2013. She is also serving as an editorial board member for ACS Biomaterials Science & Engineering, Biotechnology Journal, and Metabolic Engineering Communications.

Computational design of transmembrane proteins

Peilong Lu School of Life Sciences, Westlake University

Abstract

The computational design of transmembrane proteins with more than one membranespanning region remained a major challenge. Here, we present the design of transmembrane homodimers and tetramers that adopt the target oligomerization state in detergent solution. Crystal structures of the designed dimer and tetramer a rocket-shaped structure with a wide cytoplasmic base that funnels into eight transmembrane helices are very close to the design models. More interestingly, we have successfully designed two hexameric and octameric transmembrane protein pores formed by two concentric rings of

-helices. Patch clamp electrophysiology experiments show that a hexameric 12-helix transmembrane pore expressed in insect cells allows passage of ions across the membrane with selectivity for potassium over sodium. An octameric 16-helix transmembrane pore, but not the hexameric pore, allows passage of biotinylated Alexa Fluor 488 when incorporated into liposomes using in vitro protein synthesis. A cryo-EM structure of the octameric transmembrane pore fused to helical repeat domains closely matches the design model. The ability to produce structurally well-defined transmembrane channels opens the door to the creation of designer pores and other functional transmembrane proteins for a wide variety of applications.

Dr. Peilong Lu

Science in 2009, from University of Science and Technology of China (USTC). He got his doctoral degree at Tsinghua University

training. In 2019, he joined School of Life Sciences at Westlake University as a principal investigator. His lab mainly focuses on computationally design of new generations of functional multipass transmembrane proteins, and design of protein therapeutics.



Direct Visualization of Chain Folding and Growth of Lamellae of a Dynamic Helical Poly(phenylacetylene)

Er-Qiang Chen

Center for Soft Matter Science and Engineering, College of Chemistry and Molecular Engineering, Peking University, Beijing 100871, China

Abstract

Chain folding is a fundamental mechanism in self-assembly of bio- and non-biological polymers. In crystalline polymers, chain folding leads to lamellar crystals that are extremely important to the ultimate properties. Understanding chain folding at the molecular level

Yi Cao Department of Physics, Nanjing University, Nanjing, China

Abstract

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Prof. Yi Cao

degree (Supervisor: Prof. Xiqun Jiang) in 2004 from Nanjing University. He then obtained his Ph.D. in 2009 from the University of British Columbia (Supervisor: Prof. Hongbin Li). After a one-year postdoc at the same place, he started his independent career at the Department of Physics, Nanjing University as a full professor. His work was recognized by several awards including the 2014 IUPAP Young Scientist Prize in vator Award in

Biomedical Polymer Materials Division of the Chinese Society for Biomaterials.



Functional Polymer Nanoarrays

Huibin Qiu Shanghai Jiao Tong University, Shanghai, 200240

Abstract

The fabrication of tailored micro/nanostructures on surfaces can introduce unique physical and chemical properties into various material systems. It is highly important to develop

Zhengjie Zhang Nankai University, Tianjin, China

Abstract

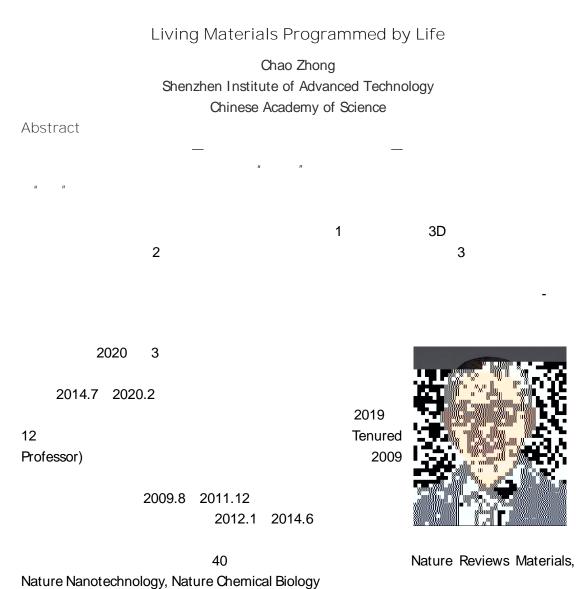
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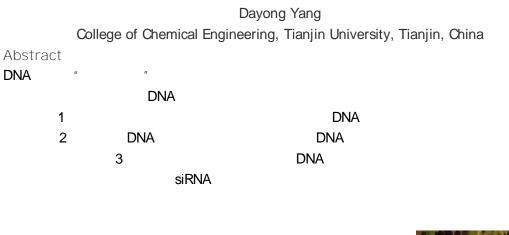
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Coated bacteria and their applications in enhanced therapy

Jinyao Liu Biomaterials and Translational Medicine Lab

Institute of Molecular Medicine, Shanghai Jiao Tong University, Shanghai 200127, China Abstract

The gut microbiota has been demonstrated to be an important regulator in human health. Disorders in the gut ecosystem have been implicated in various diseases, such as

fecal microbiota transplantation has demonstrated effective to positively modulate the gut microbiome, the implementation has been largely restricted by invasive operation and indeterminate composition, which inevitably result in low patient compliance and safety issues. Oral delivery of probiotic species to the gut microflora is an alternative to address these limitations, unfortunately, environmental complexity and a continuous flow within the gastrointestinal tract result in low oral bioavailability and limited intestinal colonization. Surface modification of bacteria, which includes chemical conjugation and physical encapsulation, has been utilized to introduce exogenous functions that are naturally unachievable. Recently, my group has wrapped bacteria with various entire coatings to increase bacterial survival and colonization in vivo following administration. In this

functional coatings and also discuss the applications of these coated bacteria for enhanced treatment.

Prof. Jinyao Liu is Professor and Assistant to the Dean of Institute of Molecular Medicine, Shanghai Jiao Tong University, China. After received his PhD at Shanghai Jiao Tong University in Materials Science and Engineering under the supervision of Prof. De

in the Department of Biomedical Engineering at Duke University (04. 2013-

Koch Institute for Integrative Cancer Research at MIT (09. 2015-03. 2018) as a postdoc associate. His current research interests include oral delivery, bacterial-based bioagents, hydrogels and nanomedicine. He has published more than 50 peer-reviewed



publications and is named inventor on 5 international patents, and was awarded numerous prestigious grants and prizes, including the Young Thousand Talents Program of China, cations have been

featured by MIT News, Boston Herald, Noteworthy Chemistry, Nature Communications Editors' Highlights, etc.

Versatile biomanufacturing through cell-material feedback

Zhuojun Dai

Institute of Synthetic Biology, SIAT, Chinese Academy of Sciences

Abstract

A key focus of synthetic biology is to utilize modular biological building blocks to assemble the cell-based circuits. Scientists have programmed the living organisms using these circuits to attain multiple delicate and well-defined functions. With the integration of tools or technologies from other disciplines, these rewired cells can achieve even more complex tasks. In this talk, we will present our recent work in versatile biomanufacturing of biologics and functional material fabrication by integrating the engineered cells and polymer physics and chemistry. By exploiting cell-material feedback, we are able to design a concise platform to achieve versatile production, analysis, and purification of diverse proteins and protein complexes, and also assembly of functional living materials. Our work demonstrates the use of the feedback between living cells and materials to engineer a modular and flexible platform with sophisticated yet well-defined programmed functions.

Dr. Zhuojun Dai is currently an Associate Professor at the Institute of Synthetic Biology, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences. She received her Bachelor degree from Zhejiang University. She obtained PhD degree from The Chinese University of Hong Kong under the supervision of Prof Chi Wu, where she investigated the polymer chain dynamics, interactions between the polycations and polyanions and cell-material interactions from the view of polymer physics and chemistry. Then, she undertook



postdoctoral training at Duke University in Prof Lingchong You's lab, where she integrated the stimulus-sensitive materials with synthetic gene circuit to build a versatile manufacturing platform. Since Sep, 2018, she started her lab in iSynBio, focusing on developing method in engineered microbial consortia assembly and living functional material fabrication.

De novo Design and optimization orthogonal and modular cell-cell communication systems

Chunbo Lou Shenzhen Institute of Advanced Technology Chinese Academy of Science

Abstract

Cell-cell communications are essential for individual cells to acquire multicellular behaviors such as division of labor, coordination to adapt environment and development into tissues or organs. They are widespread in both prokaryotic and eukaryotic systems and encompass quite diverse molecules to implement the signaling functions. One well known example is bacterial quorum sensing system which can coordinate the whole population to control the formation of biofilm, as well as the expression of bioluminescence and virulence factors. Meanwhile, more other types of intercellular communication systems exist in multi-cellular organism to differentiate various cell fate during embryo development or to coordinate different immune responses. The huge repertoire of diverse signals thus offers great potential to be engineered as intercellular regulation toolbox. Here, we present the design of ten modular and orthogonal cell-cell communication systems, six of which are first designed with diverse signaling-molecule structure. All of their signals are synthesized from cellular central carbon metabolic pathways, and are freely diffusible cross the cell membrane. Their signal and promoter orthogonality were thoroughly characterized in Escherichia coli (E. coli). Several intercellular signals were transferred from E. coli to other prokaryotic and eukaryotic cells to estimate their modularity and the capability of the crossspecies and cross-kingdom functions. To demonstrate the advantage of the orthogonal signaling toolbox, simple genetic circuits were constructed with two-, three- and fourchannel intercellular signals to form some interesting patterns or to mimic the preypredator ecosystem. We believe such expanded intercellular signaling toolbox could facilitate the design of multicellular genetic circuits to achieve more advanced spatially and temporally regulatory functions

Dr. Chunbo Lou is an Investigator of Shenzhen Institute of Advanced Technology, CAS. He obtained his Ph.D. in biophysics from Peking University in 2009 supervised by Prof Qi Ouyang, and started his postdoctoral research with Prof. Chris Voigt at UCSF and MIT. He joined Institute of Microbiology, CAS from 2013, and moved to Shenzhen from 2019. He has developed insulator and other fundamental design principles for genetic programming, and



designed a binary-counter and complex logic-gate circuit. His lab is currently developing high-quality regulatory parts for mammalian genetic circuit, and predictably design complex spatial-temporal control circuits for vaccine engineering, tissue engineering and precise expression in engineering stem cell and cancer cells. He have published more than 30 peer-reviewed papers on scientific journals, including Nature, Nature Biotechnology, Nature Communications, Nucleic Acids Research, PNAS, Molecular Systems Biology and ACS Synthetic Biology.

Next generation industrial biotechnology (NGIB) for PHA production

George Guo-Qiang Chen Center of Synthetic and Systems Biology, School of Life Sciences, Department of Chemical Engineering, Tsinghua University, Beijing 100084

Abstract

Polyhydroxyalkanotes (PHA) are a family of environmentally friendly biomaterials synthesized by various bacteria. The diversity of PHA reflected by structures and properties has resulted in various applications, making them a promising alternative of petroleum-based plastics, yet their industrialization is challenged owning to the high production cost

(NGIB) has been developed, namely, a long-lasting, open and continuous, energy-saving fermentation process under artificial intelligent control using extremophilic bacteria grown on low-cost mixed substrates and less freshwater, as demonstrated successfully by halophilic Halomonas spp. NGIB overcomes the disadvantages of the current industrial biotechnology (CIB) to reduce the bioproduction cost and process complexity, leading to successful industrial production of PHA.

Prof. George Guo-Qiang Chen received his BSc and PhD from South China University of Technology in 1985 and Graz University of Technology (Austria) in 1989, respectively. He also conducted research in 1990-1994 as a postdoc at University of Nottingham in UK and University of Alberta in Canada, respectively. He has been focusing his research on microbial materials polyhydroxyalkanoates (PHA) metabolic engineering, synthetic biology and PHA biomaterial application since 1986. After joining Tsinghua University in 1994, he has been actively promoting the microbial Bio- and Material Industries in China. Professor Chen



has more than 35 years of R&D experiences on microbial physiology, microbial PHA production and applications, has published over 370 international peer reviewed papers with over 20,500 citations (H-Index 69) as reported in Web of Science. With over 40 issued

companies that succeeded in mass production of microbial polyhydroxyalkanoates (PHA). He has received many awards for his contributions to the microbial manufacturing fields. Beginning from 2015, he becomes the Funding Director of the Center for Synthetic and Systems Biology in Tsinghua University. From 2015-2024, he serves as chair Professor of Synthetic Biology, The University of Manchester/UK.