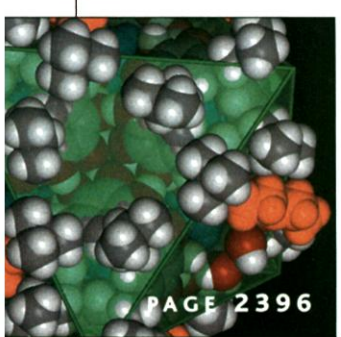
INTRODUCTION

# Strength in Numbers

Chemical reactions are usually thought of in terms of the breaking and forming of strong covalent bonds. However, weaker interactions, such as hydrogen bonds, salt bridges, and solvation forces, can add up and play just as strong a role, determining, for example, the properties of liquids, the solubility of solids, and the organization of molecules in membranes. Nature has exploited these interactions in biorecognition and biomolecular organization for billions of years. Learning from biology, chemists are now developing highly complex chemical systems from components that interact via noncovalent intermolecular forces. Such forces were exploited long before the terms "supramolecular chemistry" and "self-assembly" were introduced. The difference is that in supramolecular chemistry, molecules are designed and synthesized to interact specifically with other molecules or to form larger aggregates.

With just a few building blocks, strands of nucleic acids allow huge amounts of information to be sorted, retrieved, and processed via weak hydrogen bonds. Lehn (p. 2400) discusses how supramolecular chemistry has implemented these principles of molecular information in chemistry. Increasingly, the ability of supramolecular assemblies to adapt and evolve is exploited. Reinhoudt and Crego-Calama (p. 2403) define a supramolecule as "a collection of atoms held together by covalent and noncovalent bonds." Noncovalent and covalent synthesis both aim to introduce specific connectivities between atoms, but supramolecules may be highly dynamic, allowing for error correction and chemical evolution. A News story (p. 2396) discusses how chemists are using noncovalent bonds to revolutionize everything from polymers to materials implanted in the body.




Whitesides and Grzybowski (p. 2418) define self-assembly as a process that involves preexisting components, is reversible, and can be controlled by proper design of the components. They consider the possible applications of self-assembly from crystallization to robotics to nanotechnology. Knowledge of what drives and controls self-assembly is necessary for understanding life itself, as illustrated by the report by Sumper (p. 2430) on the role of self-assembly in the formation of diatom shells.

Organic crystals and liquid crystals represent two areas in which weak interactions have long been exploited. Hollingsworth (p. 2410) discusses the progress made in using crystal packing to create porous networks, which can be exploited in gas separation and storage, and the use of host-guest chemistry to change the ordering and symmetry of a crystal, which can lead to materials with nonlinear optical properties. Kato (p. 2414) reviews how self-assembly and phase segregation in liquid crystalline systems can be used in drug delivery, batteries, and electro-optical devices.

Ikkala and ten Brinke (p. 2407) discuss how the self-assembly of polymeric supramolecules can be used to produce hierarchically structured functional materials. By controlling the structure and properties of the material at different length scales, different functionalities may be combined in a single material and may be tuned separately.

Two News stories (pp. 2398 and 2399) highlight potential applications of self-assembly. Researchers have become adept at making electronic devices and circuits from small collections of molecules. But to create more powerful molecular electronic chips, they need to find ways to self-assemble large numbers of devices on surfaces. Self-assembly also promises to revolutionize optics by creating photonic crystals, which are ideal for integrating high-speed electronics with optical communications.

Supramolecular chemistry and self-assembly are highly interdisciplinary subjects that bring together scientists from chemistry, biology, physics, and engineering. This issue gives a flavor of the fascinating insights and applications that are emerging from these collaborations.

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*See also Reports on pp. 2425 and 2430.*

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