Supramolecular Chemistry

Kay Severin

Course Structure

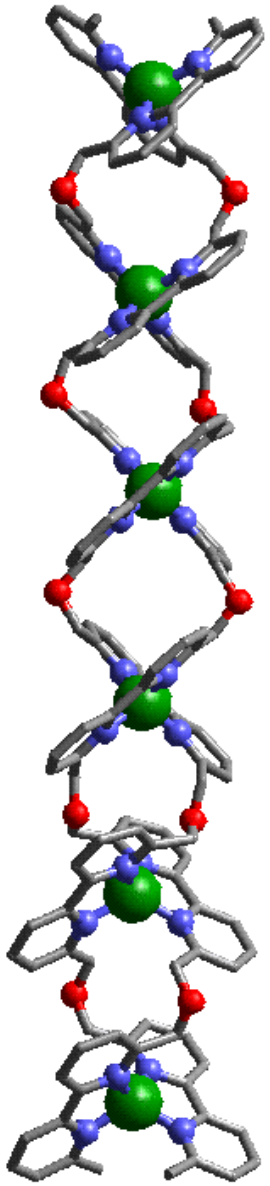
First Part: Introduction to Supramolecular Chemistry

Written Exam

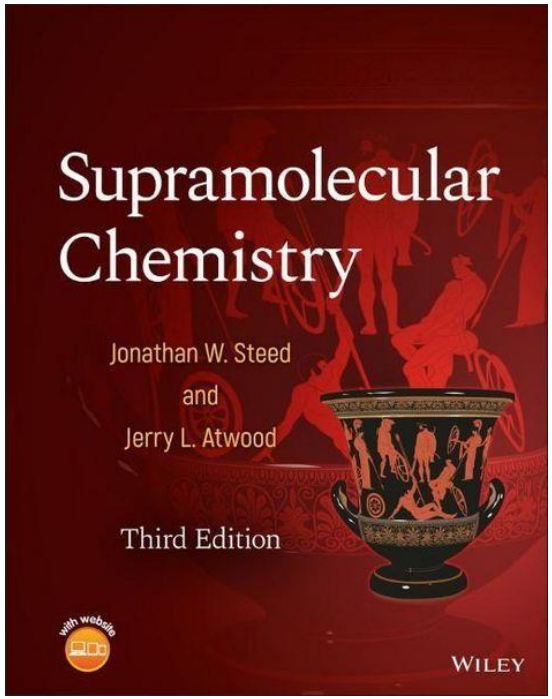
Last part: Presentation and Discussion of Recent Publications

Content

- Introduction
- Basics
- Cation Receptors
- Anion Receptors
- Neutral Molecule Receptors
- Supramolecular Coordination Chemistry
- Rotaxanes and Catenanes
- Devices, Machines, and Motors
- Supramolecular Catalysis
- Misc Topics



Literature

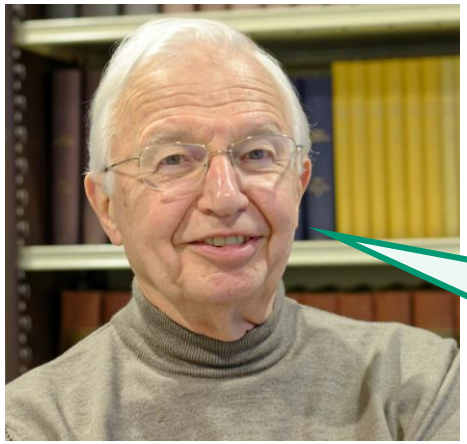


« Supramolecular Chemistry, 3rd Edition »
Jonathan W. Steed, Jerry L. Atwood
Published: 2022
Comment: Nice overview.
2nd Edition online: → link

Definitions

"The chemistry of molecular assemblies and of the intermolecular bond"

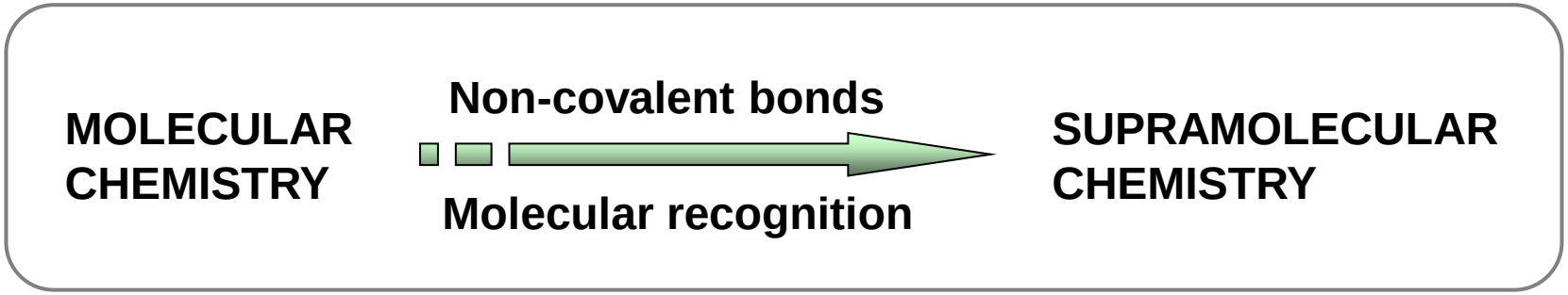
"Supermolecules are to molecules and the intermolecular bond what molecules are to atoms and the covalent bond"



Chemistry beyond the molecule

J.-M. Lehn, in Supramolecular Chemistry, VCH, Weinheim, 1995

Key Aspects of Supramolecular Chemistry

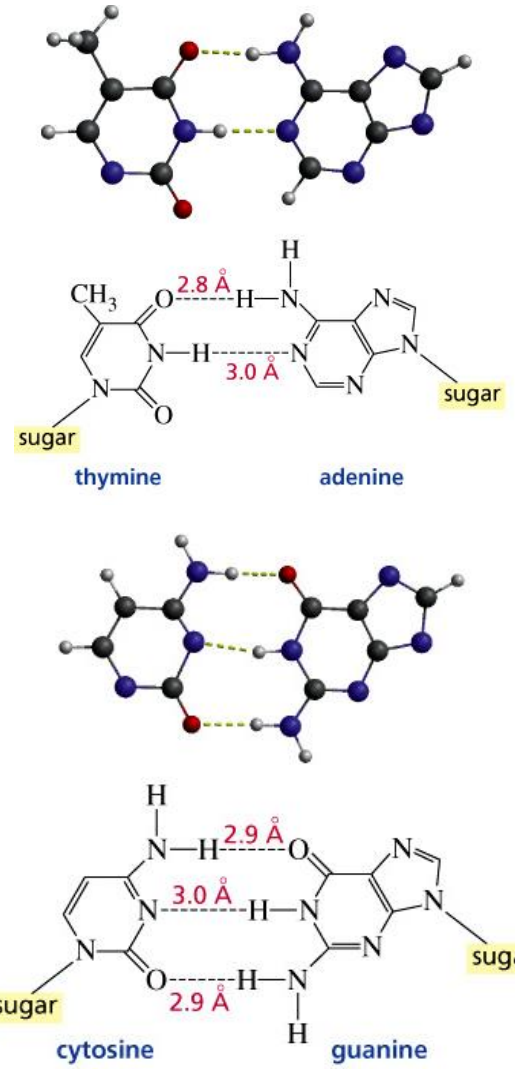


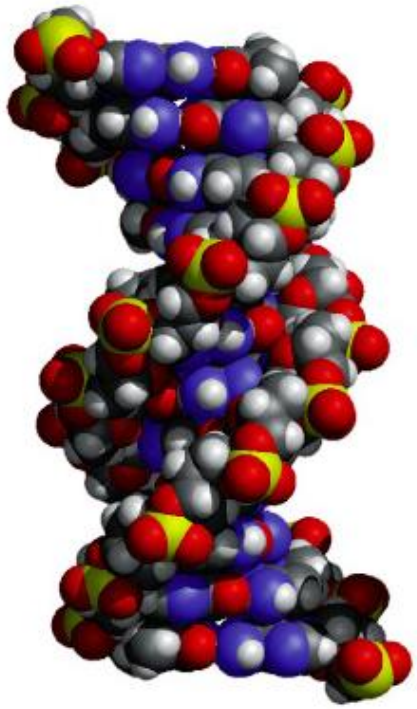
- **Preprogrammed** synthesis or construction
- **Self-assembly** of discrete chemical structures
- **Self-organization** of higher-order structures
- **Weak chemical forces**
- **Molecular** rather than atomic building blocks
- **Nanoscale** rather than angstrom scale

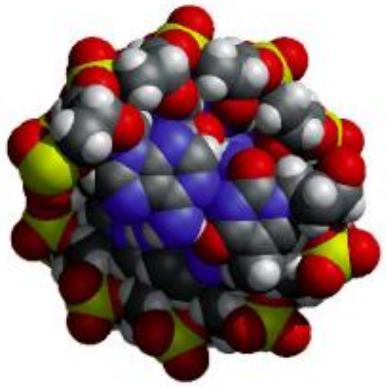
Self-Assembly

“During a self-assembling process, components will autonomously assemble into the final desired structure through an exploration of alternative configurations. Neither central control mechanism nor external assistance is needed during this process.”

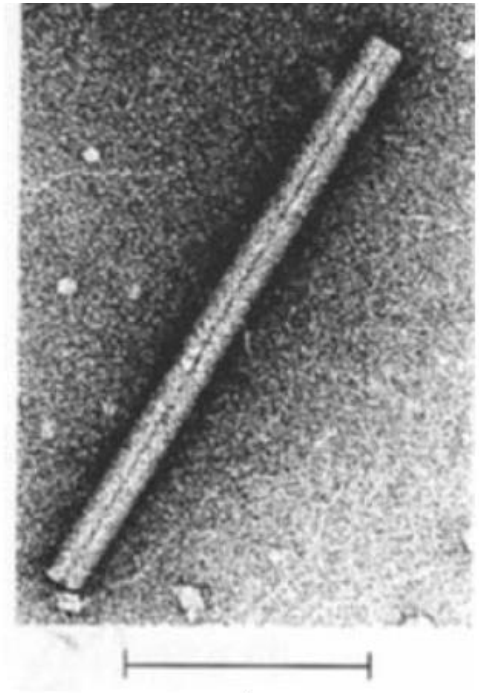
Self-Assembly in Biological Systems: DNA

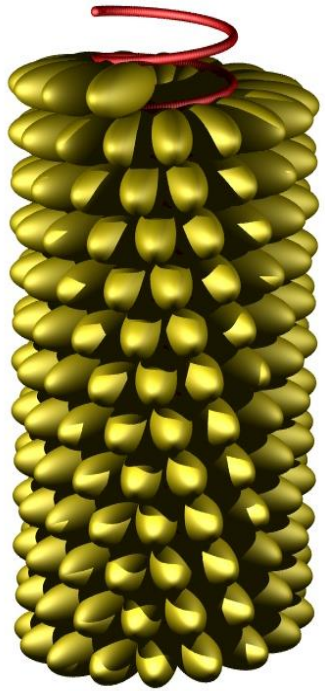






Self-Assembly in Biological Systems: Viruses



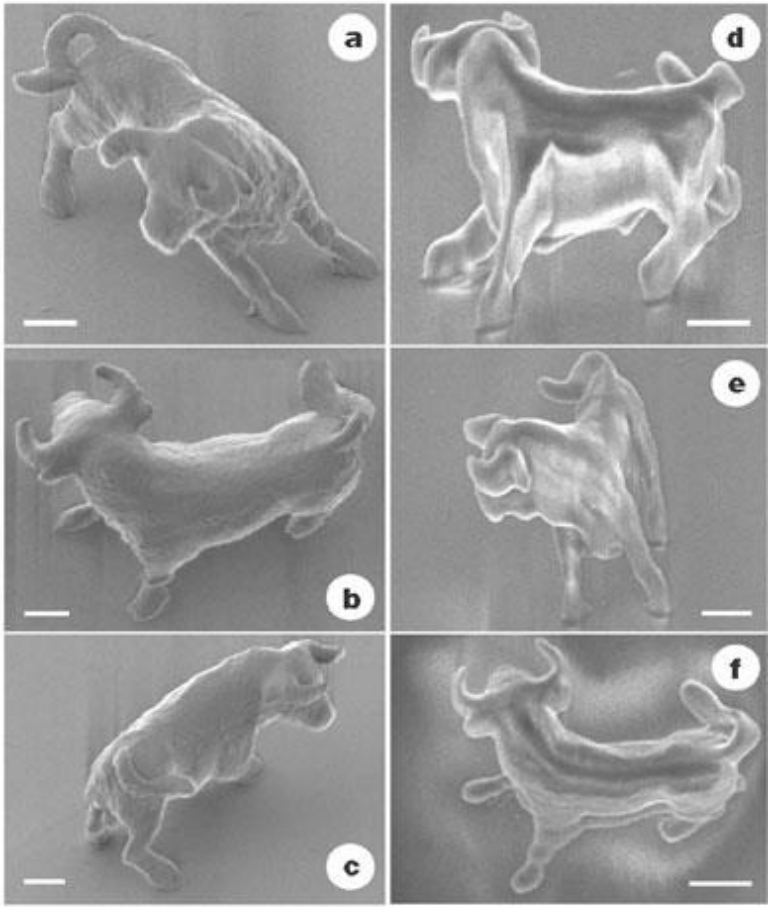


Tabak mosaic virus: 2130 protein units self-assemble around RNA strand via non-covalent interactions.

The Top-Down Approach

«There's plenty of room at the bottom»

R. P. Feynman
Eng. Sci., 1960, *23*, 22

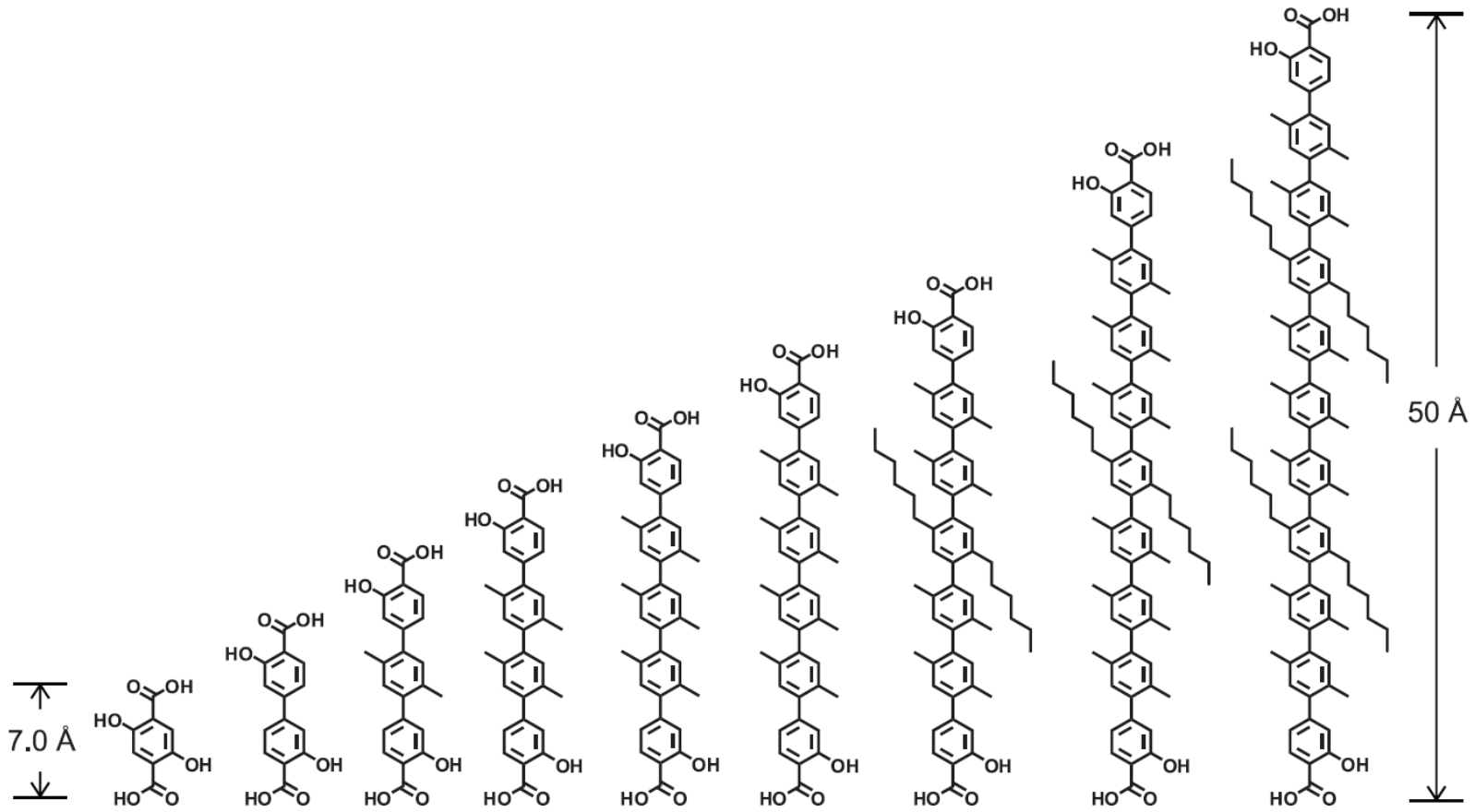


Scanning electron micrographs of 'micro-bull' sculptures crafted on a resin by two-photon photo-polymerization.

These **10 μm long, 7 μm high** bulls are about the size of a red blood cell.

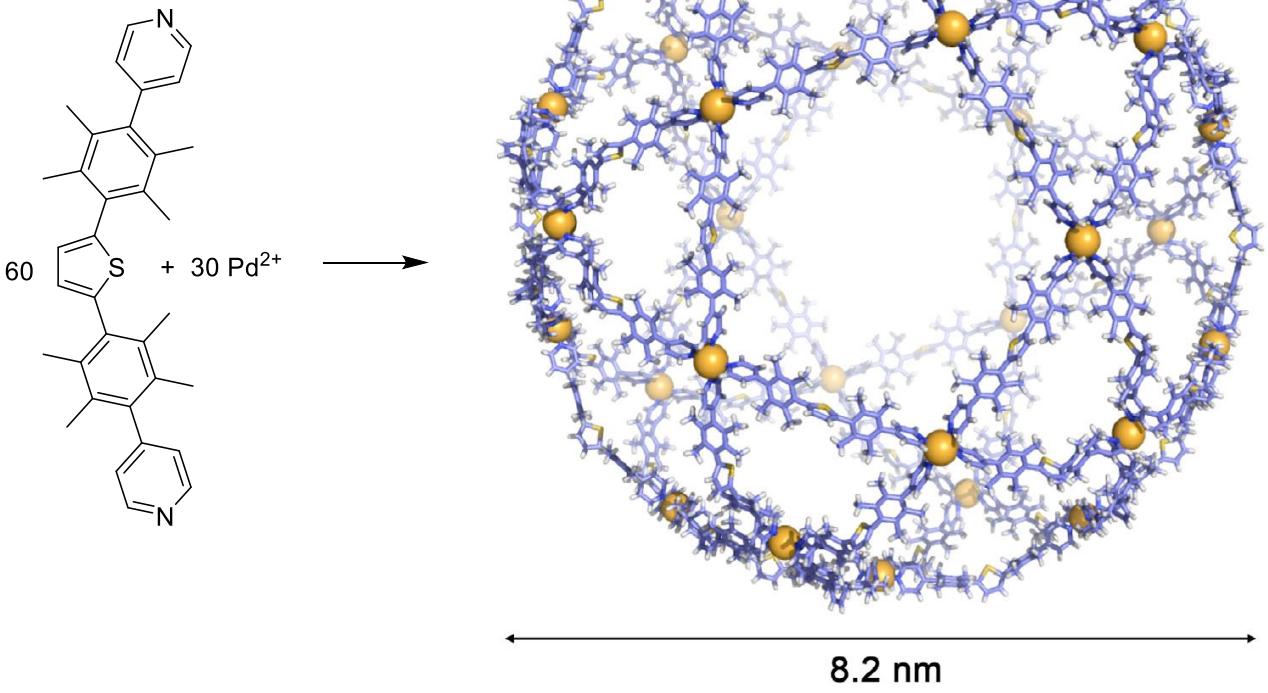
Kawata et al., *Nature* **2001**, *412*, 697.

The Classical Organic Synthesis Approach



J. F. Stoddart, O. M. Yaghi et al., *Science* **2012**, *336*, 1018.

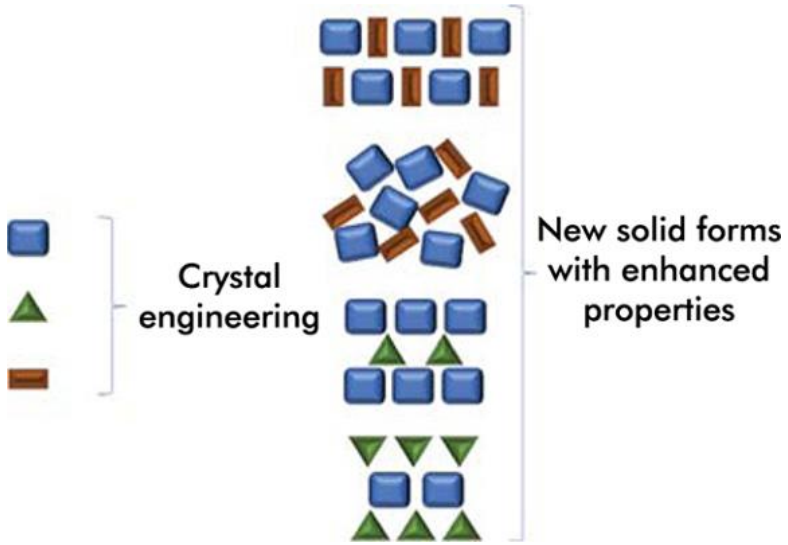
The Bottom-Up Approach



(see Part 6)

M. Fujita *et al. Chem* **2016**, *1*, 91.

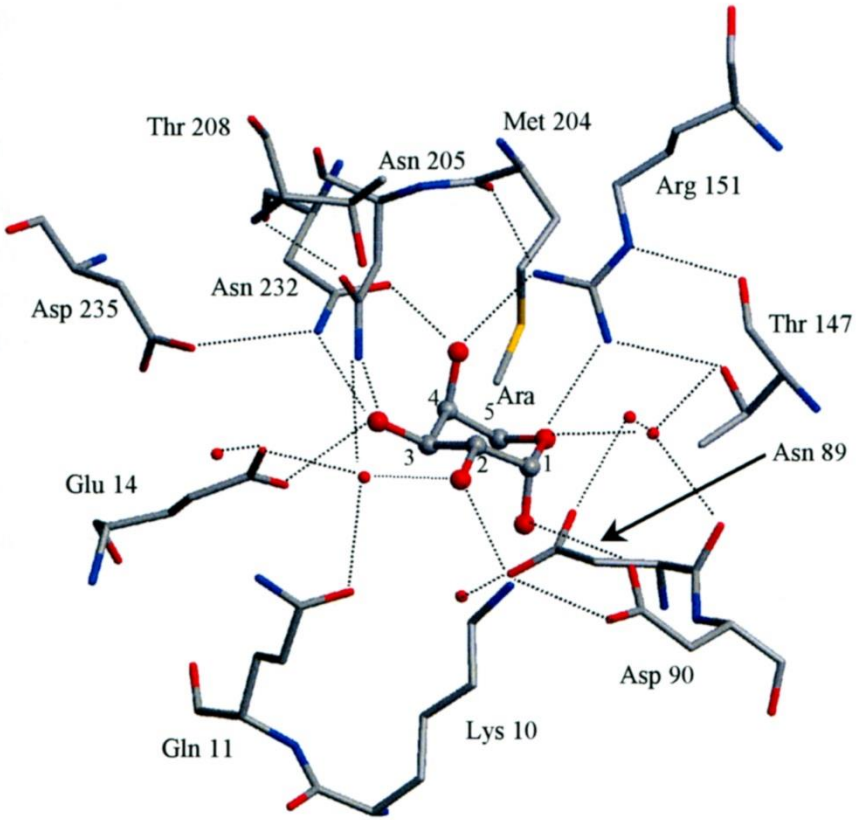
Crystal Engineering

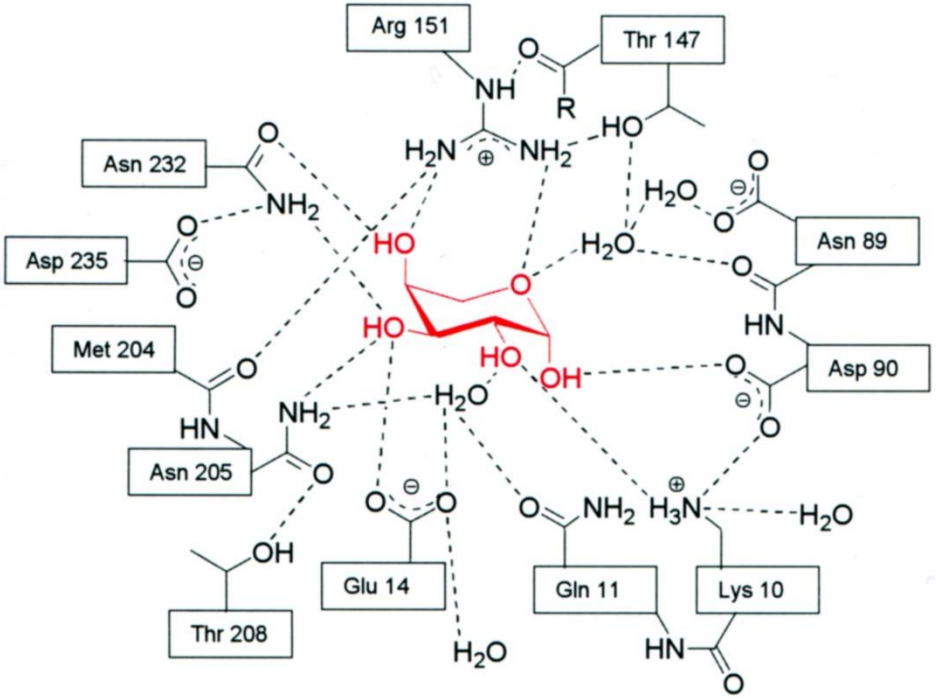


"Crystal engineering is the understanding of intermolecular interactions in the context of crystal packing and the utilization of such understanding in design of new solids with desired physical and chemical properties

'Crystal Engineering: From Molecule to Crystal'
G. R. Desiraju *J. Am. Chem. Soc.* **2013**, *135*, 9952.

Molecular Recognition in Biological Systems: An L-Arabinose Binding Protein





F. A. Quiocho et al. *Nature*, **1984**, *310*, 381.

History

1893 Alfred Werner: coordination chemistry

1894 Emil Fischer: ‘lock and key’ concept

1906 Paul Ehrlich: introduction of the concept of a receptor “*Molecule do not act if they do not bind*”

1937 K. L. Wolf: the term ‘Übermolekül’ is coined to describe organized entities arising from self-assembly (e.g. acetic acid dimer)

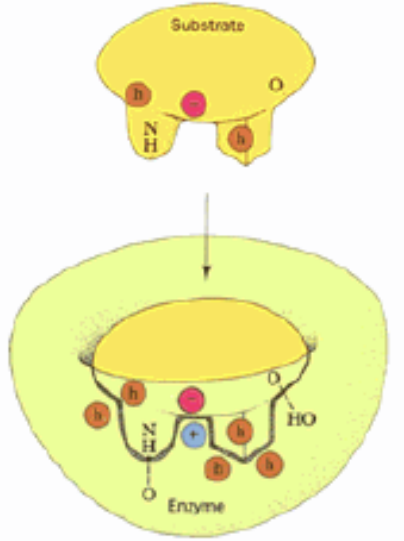
1953 Watson and Crick: structure of DNA

1967 Charles Pederson: crown ethers

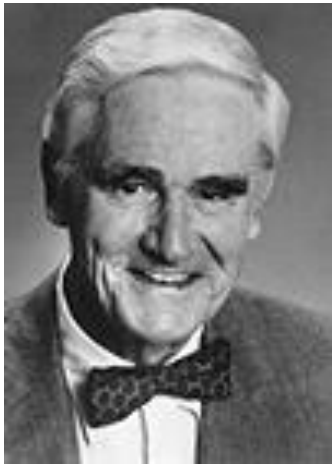
1969 Jean-Marie Lehn: synthesis of the first cryptands

1973 Donald Cram: spherical hosts to test the importance of preorganisation

1978 Jean-Marie Lehn: introduction of the term ‘Supramolecular Chemistry’



History



Donald Cram

Jean-Marie Lehn

Charles Pedersen

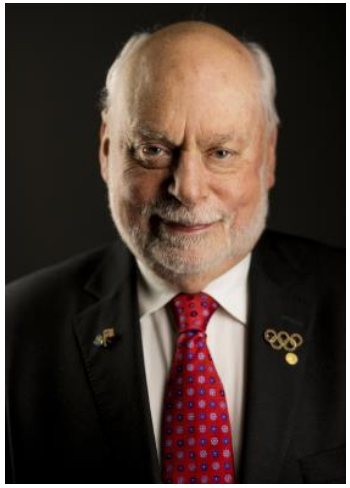
Chemistry Noble Prize 1987

"for their development and use of molecules with structure-specific interactions of high selectivity"

History

Jean-Pierre Sauvage

nobel lecture



Sir J. Fraser Stoddart

nobel lecture

Bernard L Feringa

nobel lecture

Chemistry Noble Prize 2016

"for the design and synthesis of molecular machines"