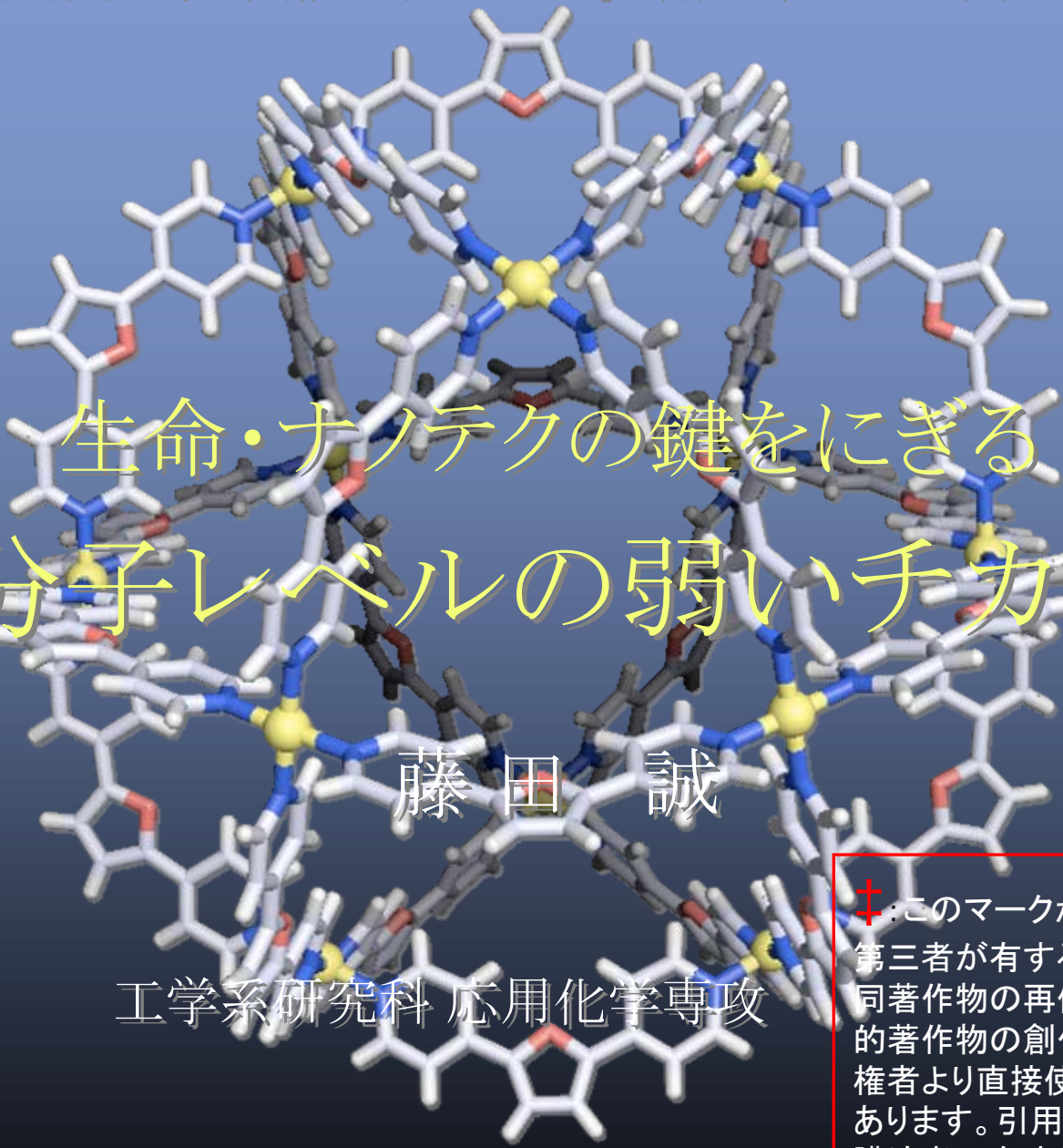
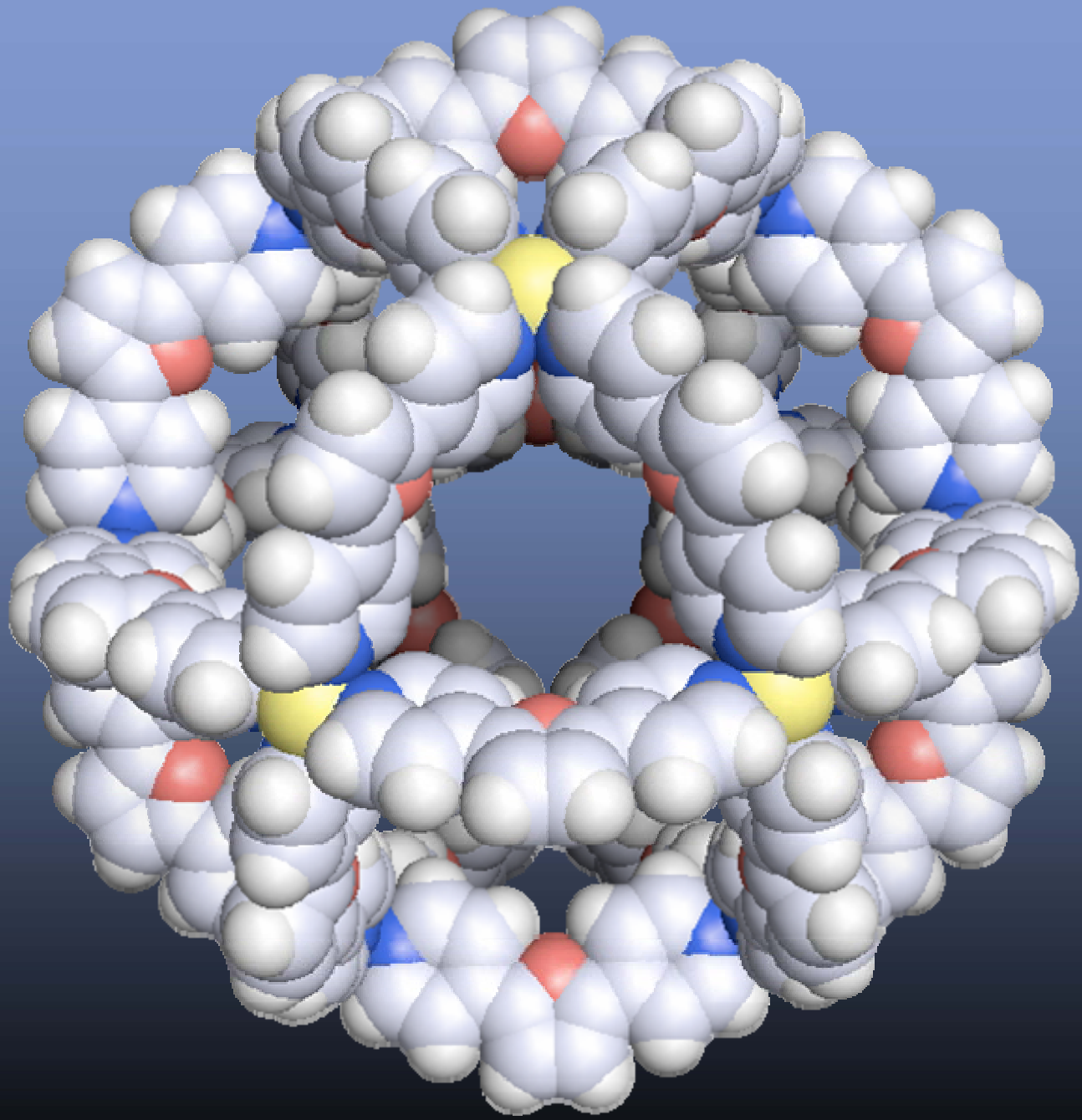
第107回 東京大学公開講座「力＜チカラ＞」 平成19年9月22日東京大学安田講堂

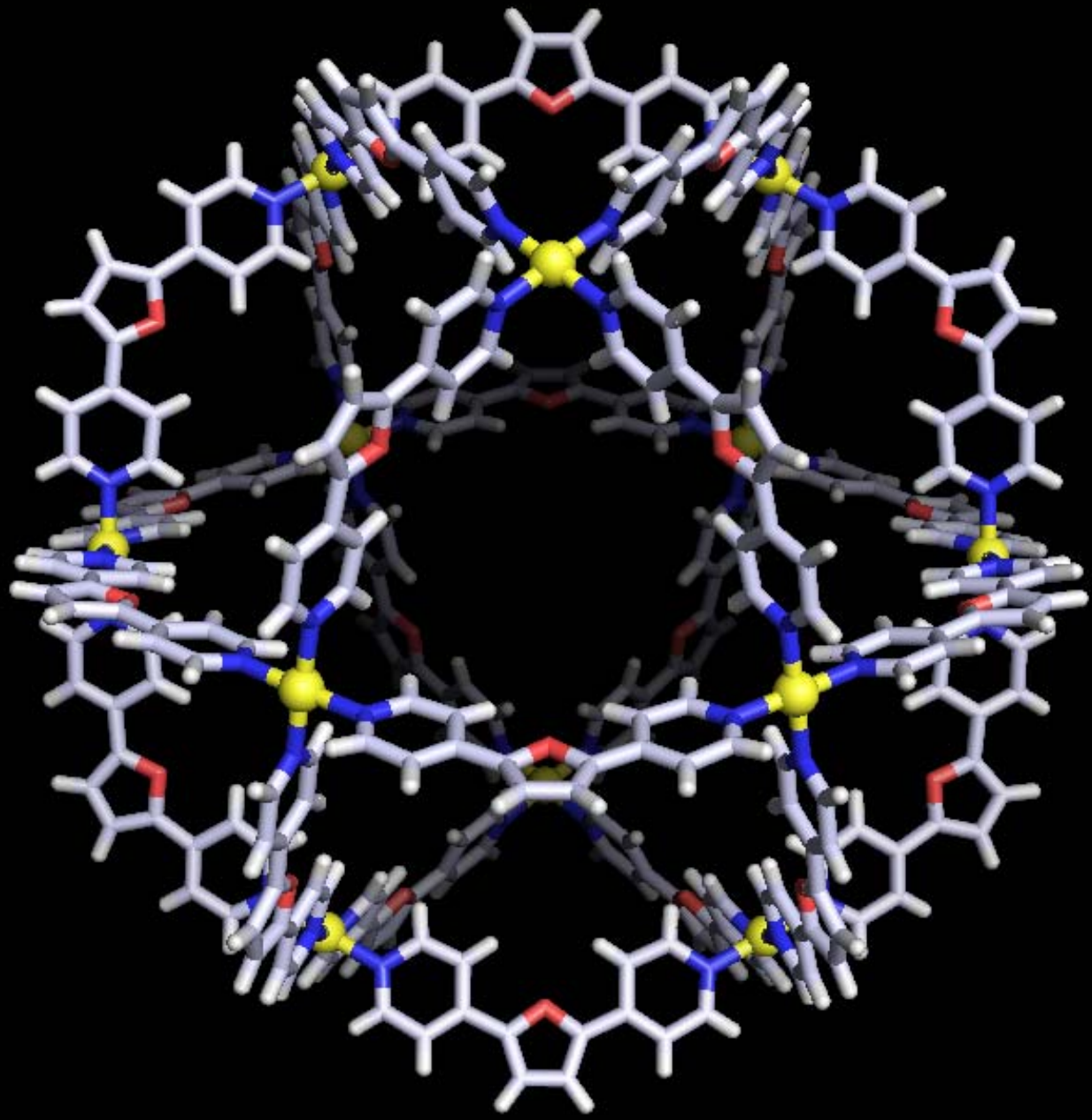


生命・ナノテクの鍵をにぎる
分子レベルの弱いチカラ

藤田　誠

工学系研究科 応用化学専攻



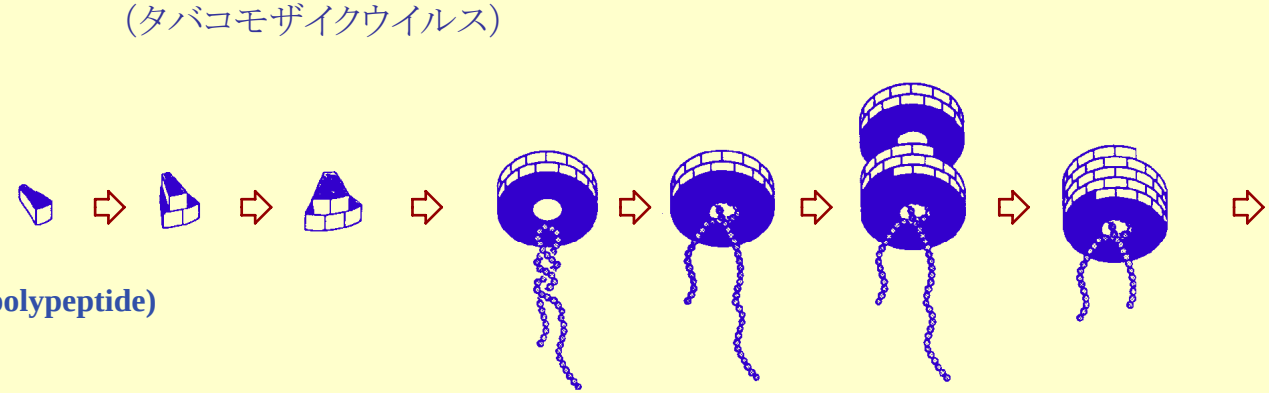


おのおののピースが居心地の良さを求めたら…

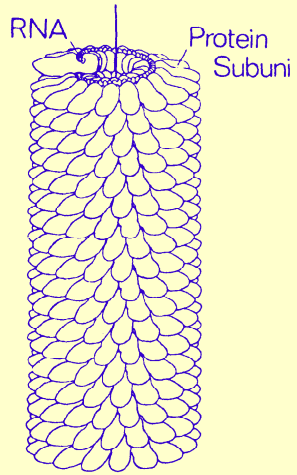
Self-Organization in Nature

自己組織化

Generation of ***Tobacco Mosaic Virus***
(タバコモザイクウイルス)



(a polypeptide)

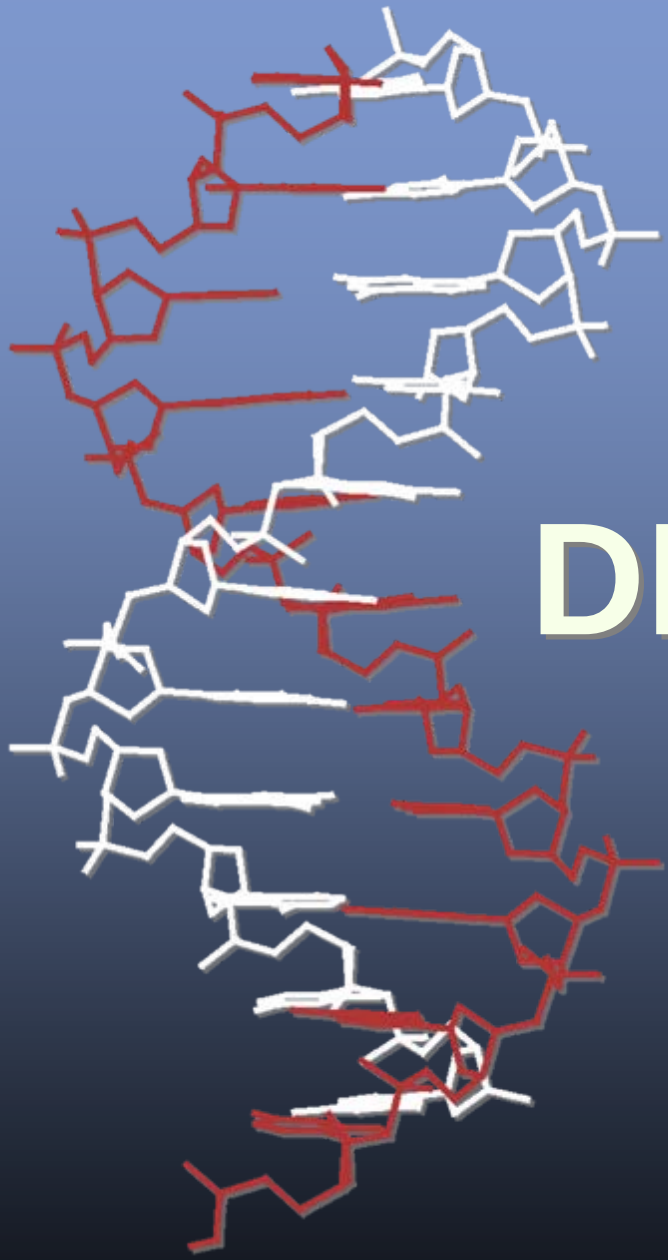


behaves as
a chemical substance

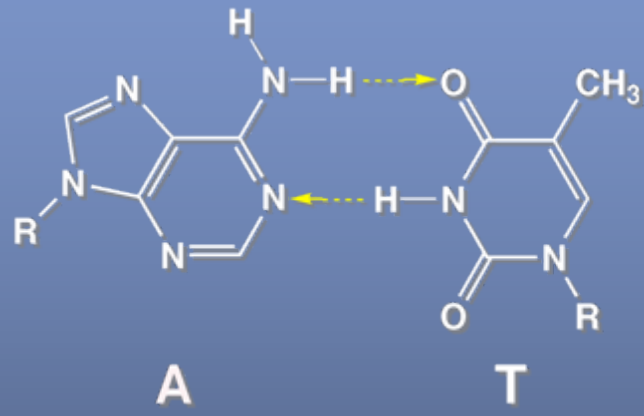
化学物質

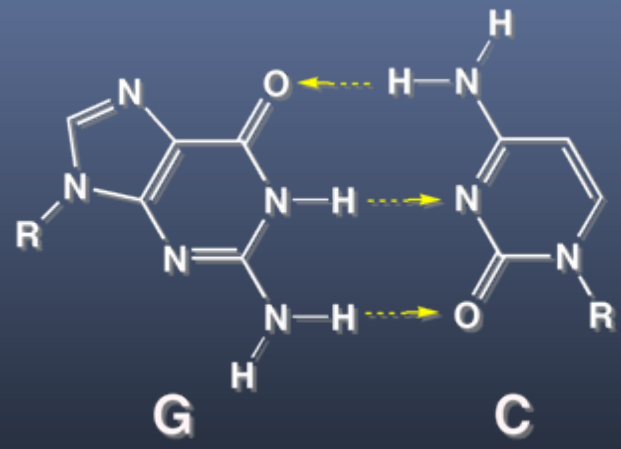
behaves as
an organism

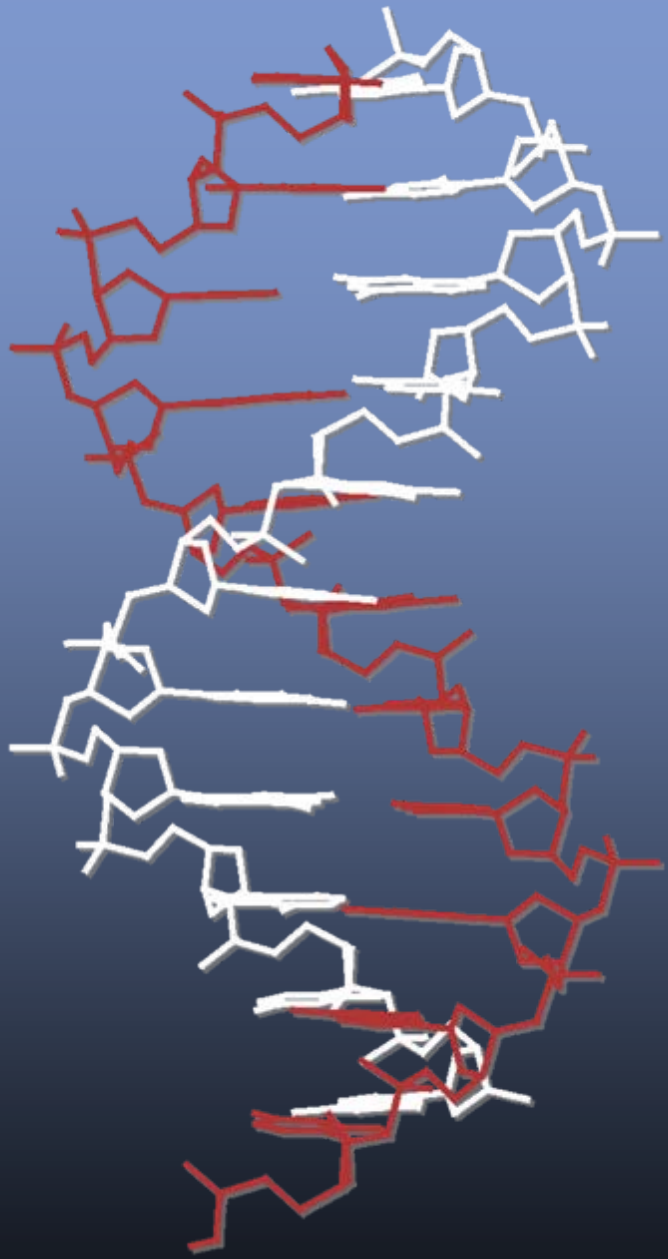
生物

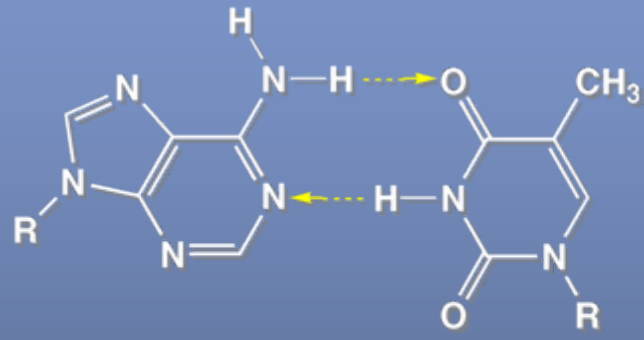


DNA

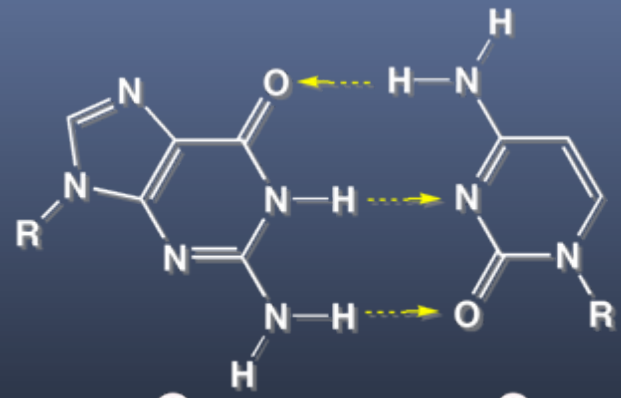






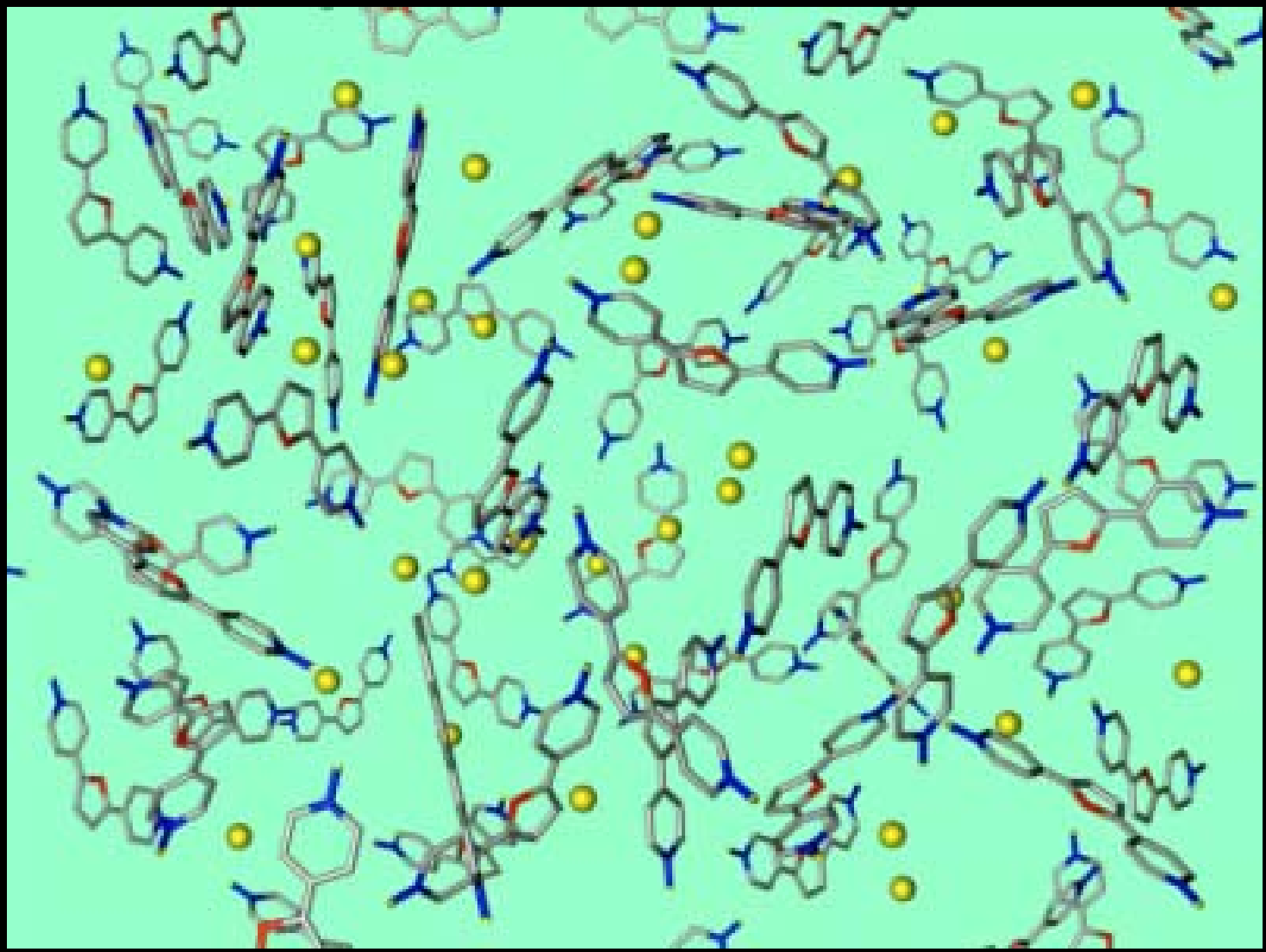


A T



G C

おのおのの分子が汚染土地の良さを求めたら…



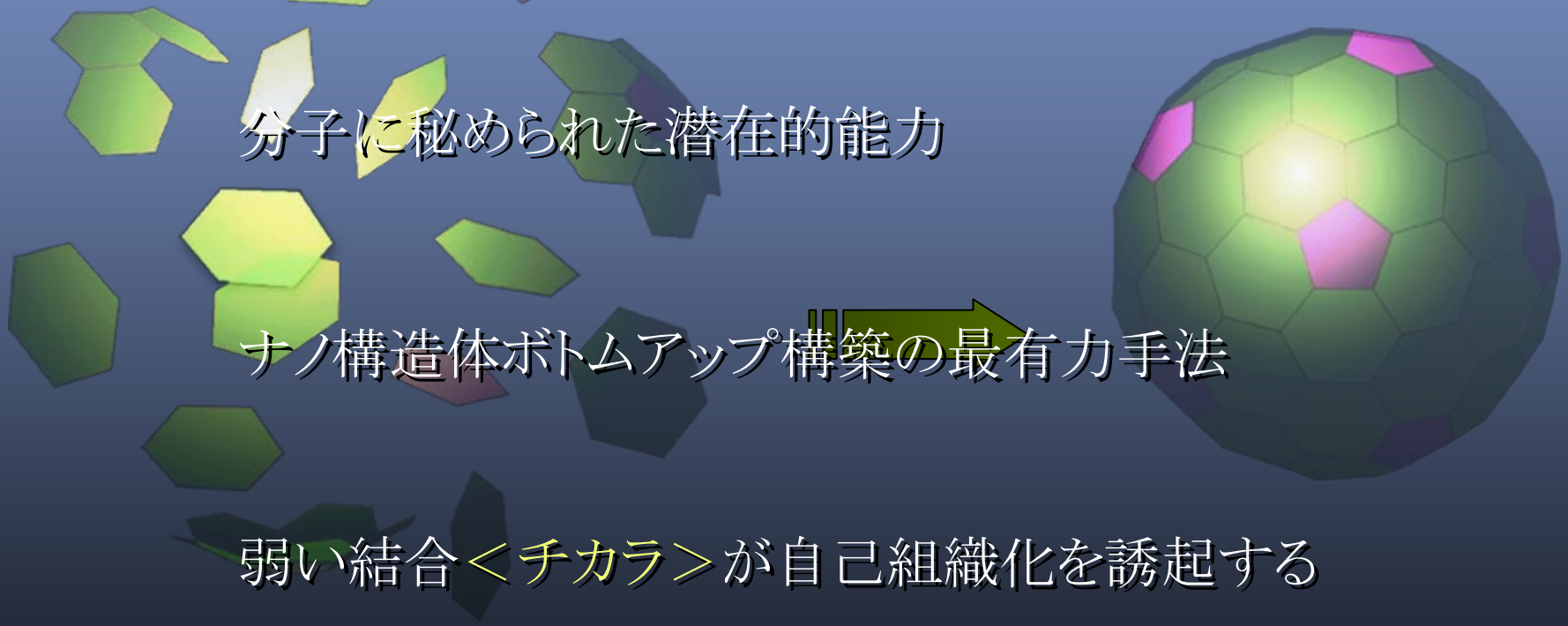
自己組織化

分子がひとりでに秩序だって機能化するしくみ

分子に秘められた潜在的能力

ナノ構造体ボトムアップ構築の最有力手法

弱い結合＜チカラ＞が自己組織化を誘起する



弱い結合＜チカラ＞

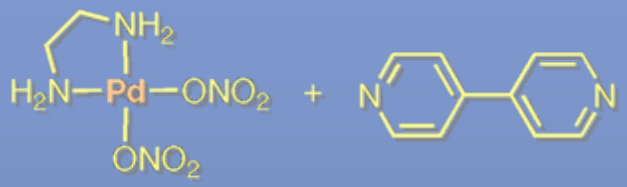
ファンデルワールス力

イオン結合

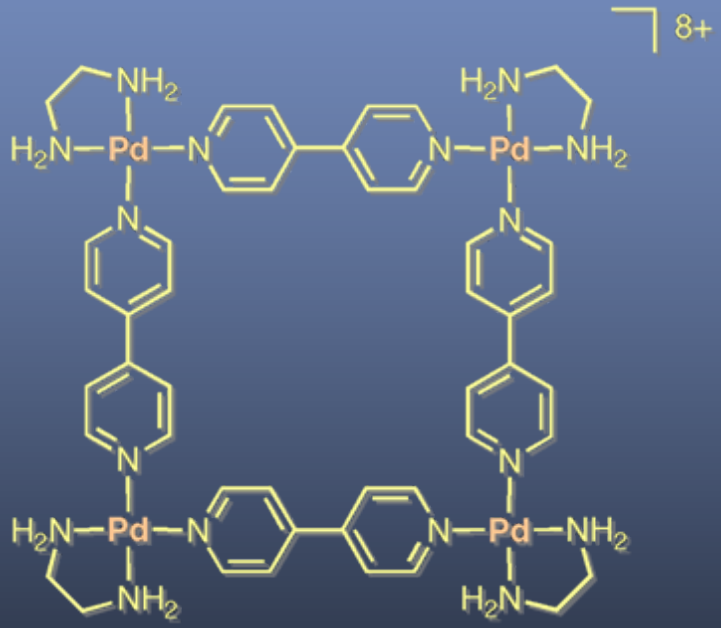
水素結合　（自然界が巧みに活用）

配位結合　（自然界ではあまり利用されない）

共有結合　（強すぎる）

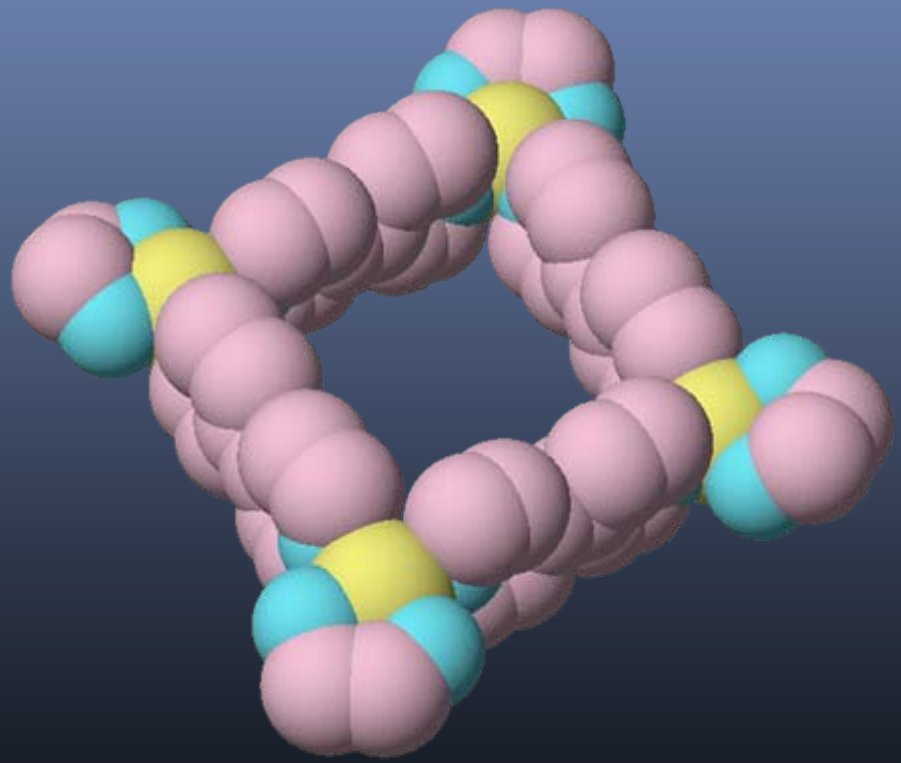


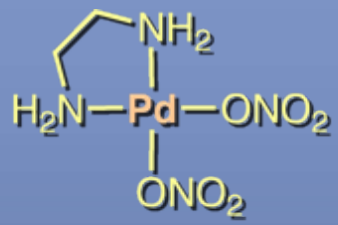
90° 180°



(1990)

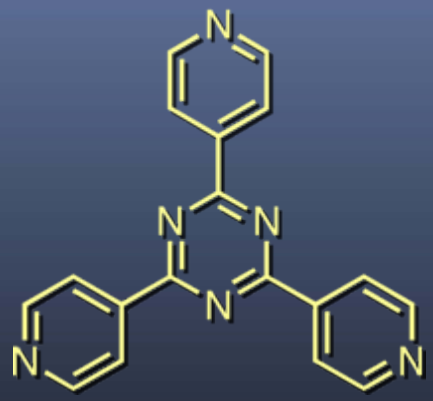
正方形分子



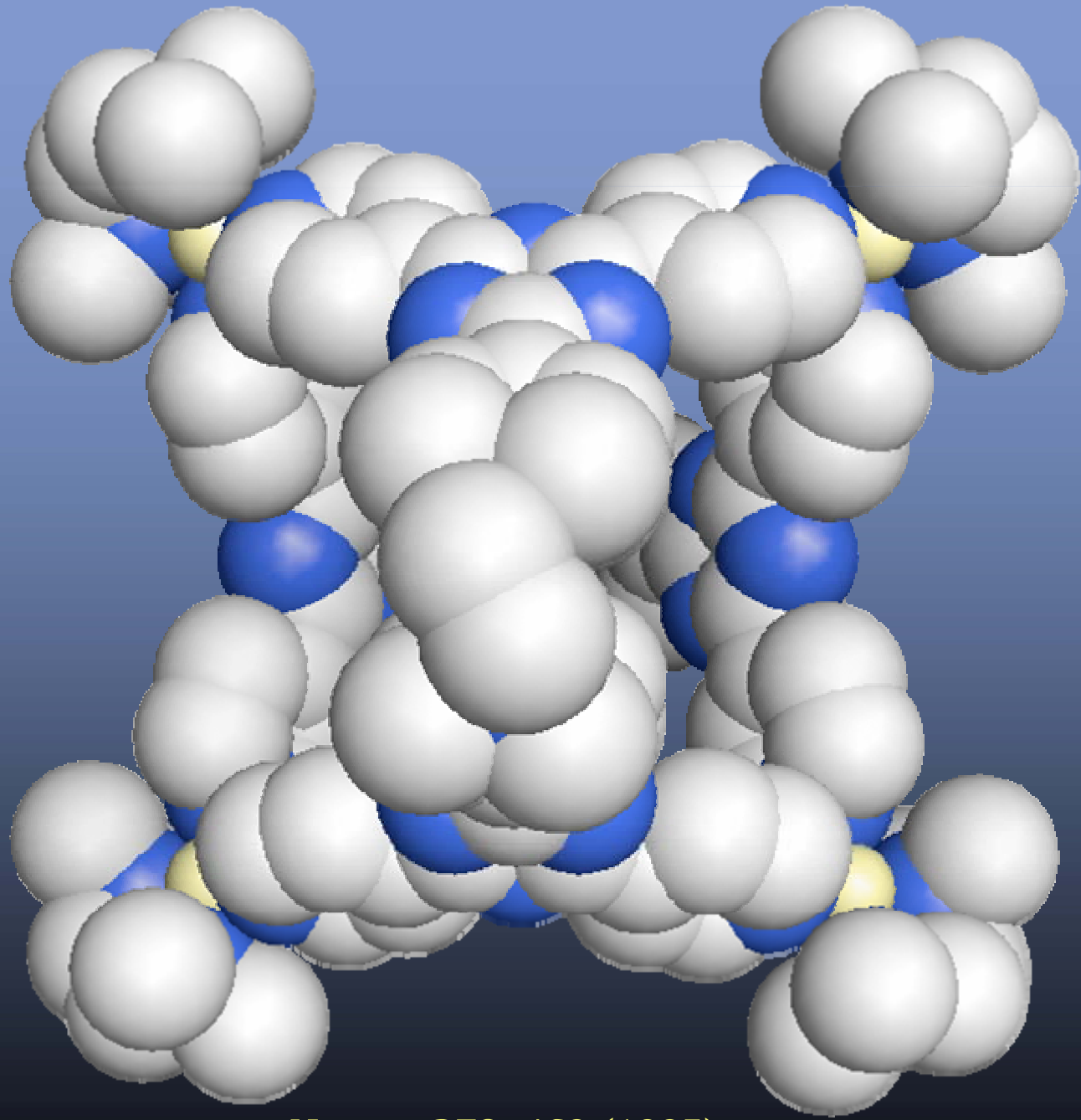


90°

+



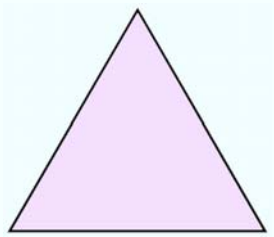
120°

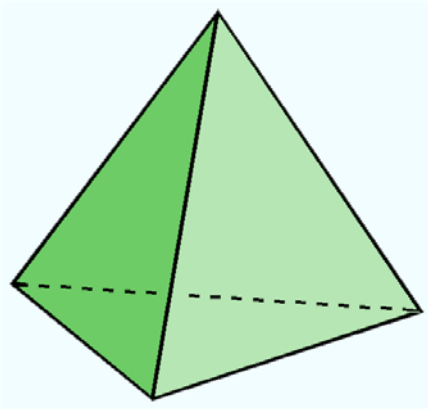


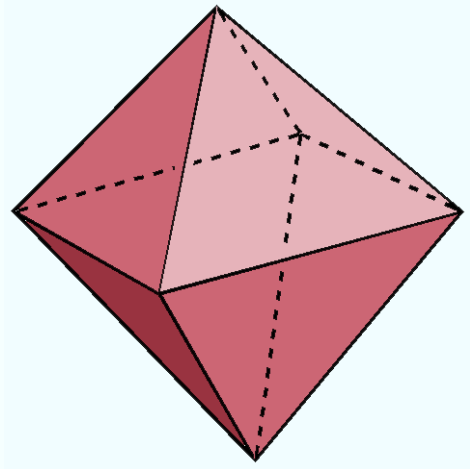
Nature, **378**, 469 (1995)

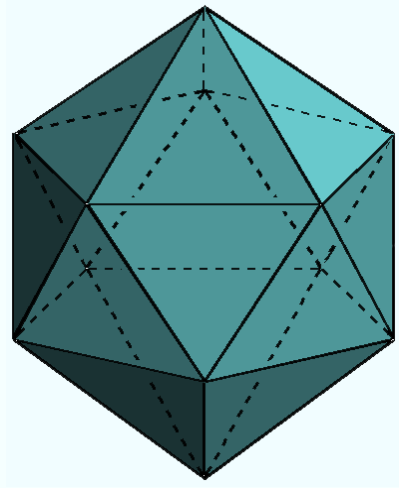
"Paneling"

n

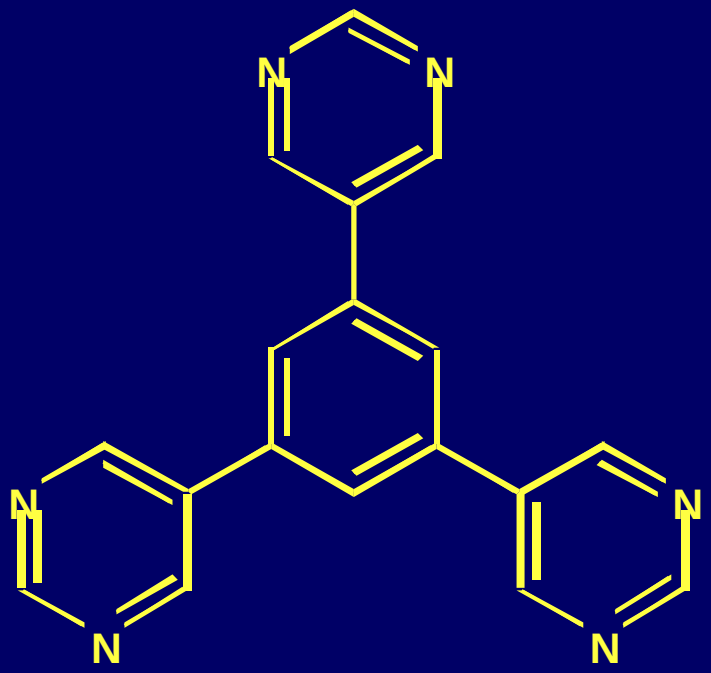


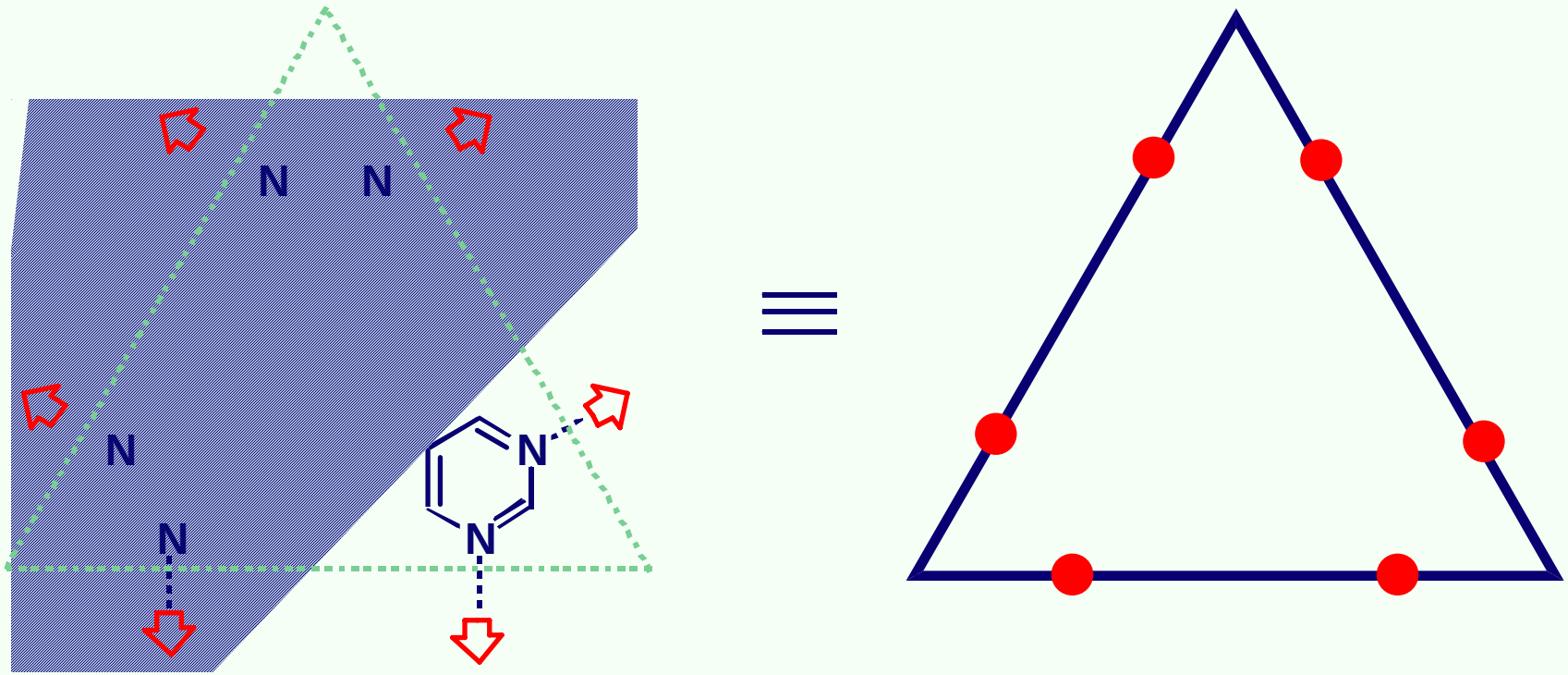






How can you enjoy?

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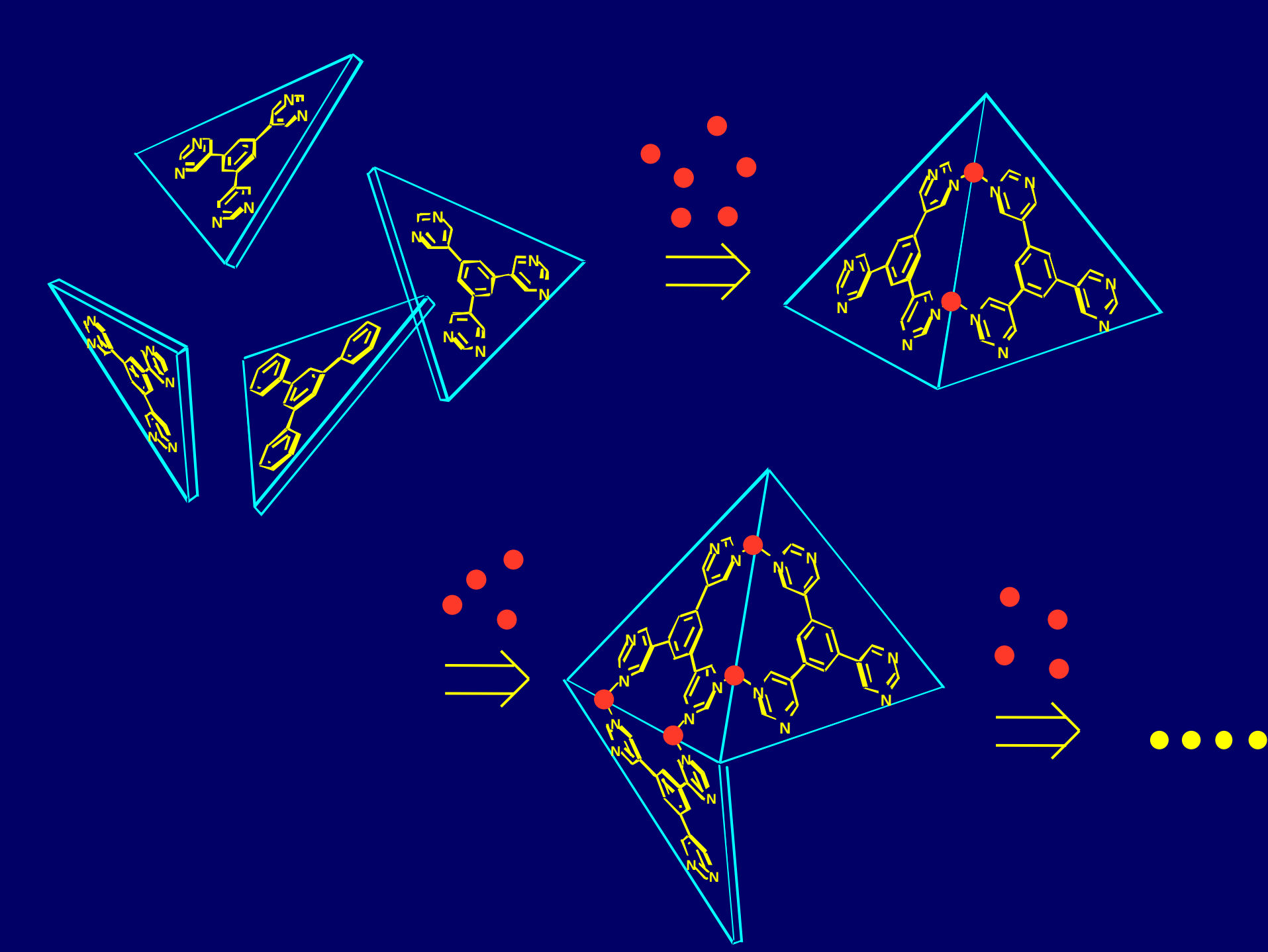
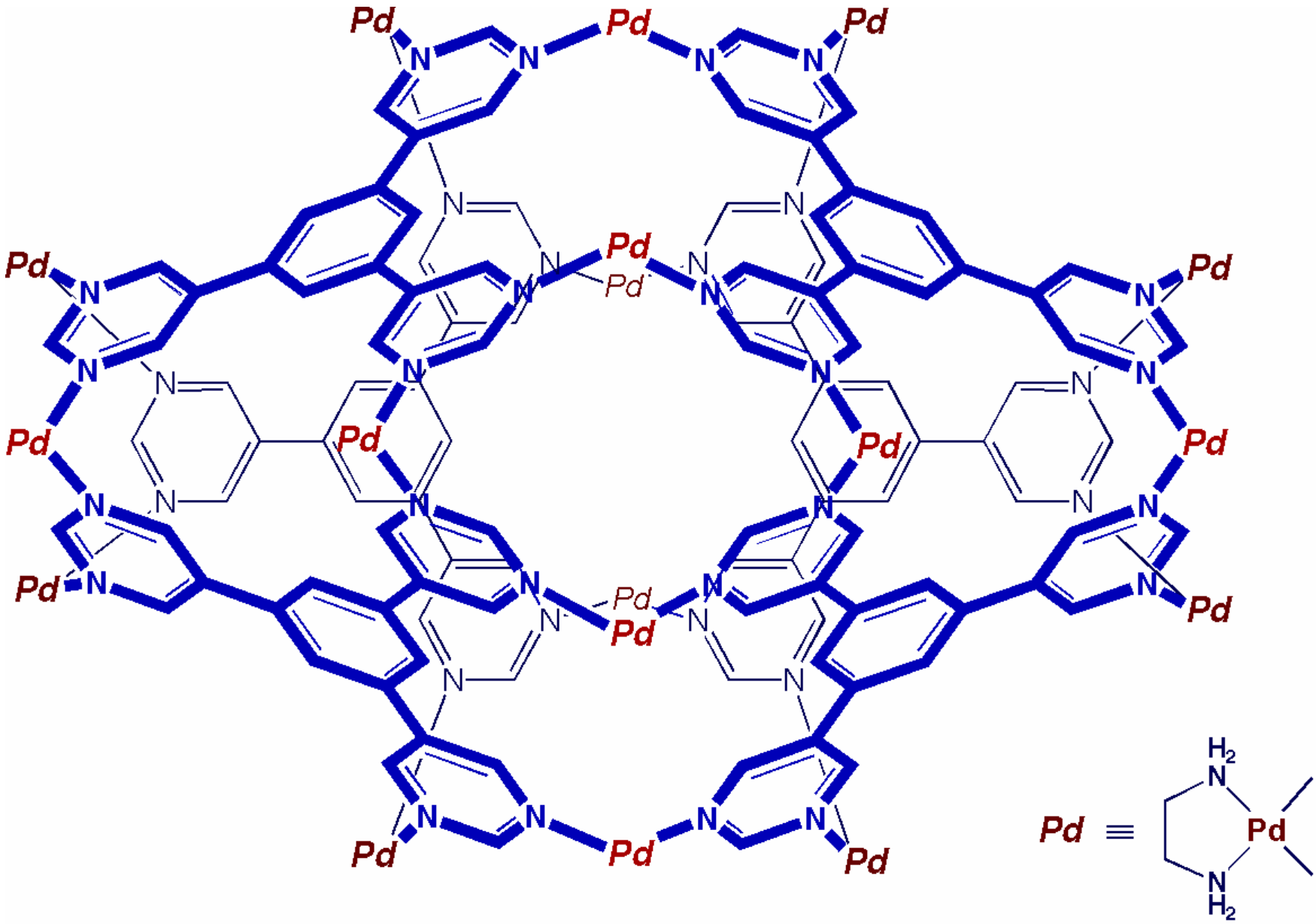
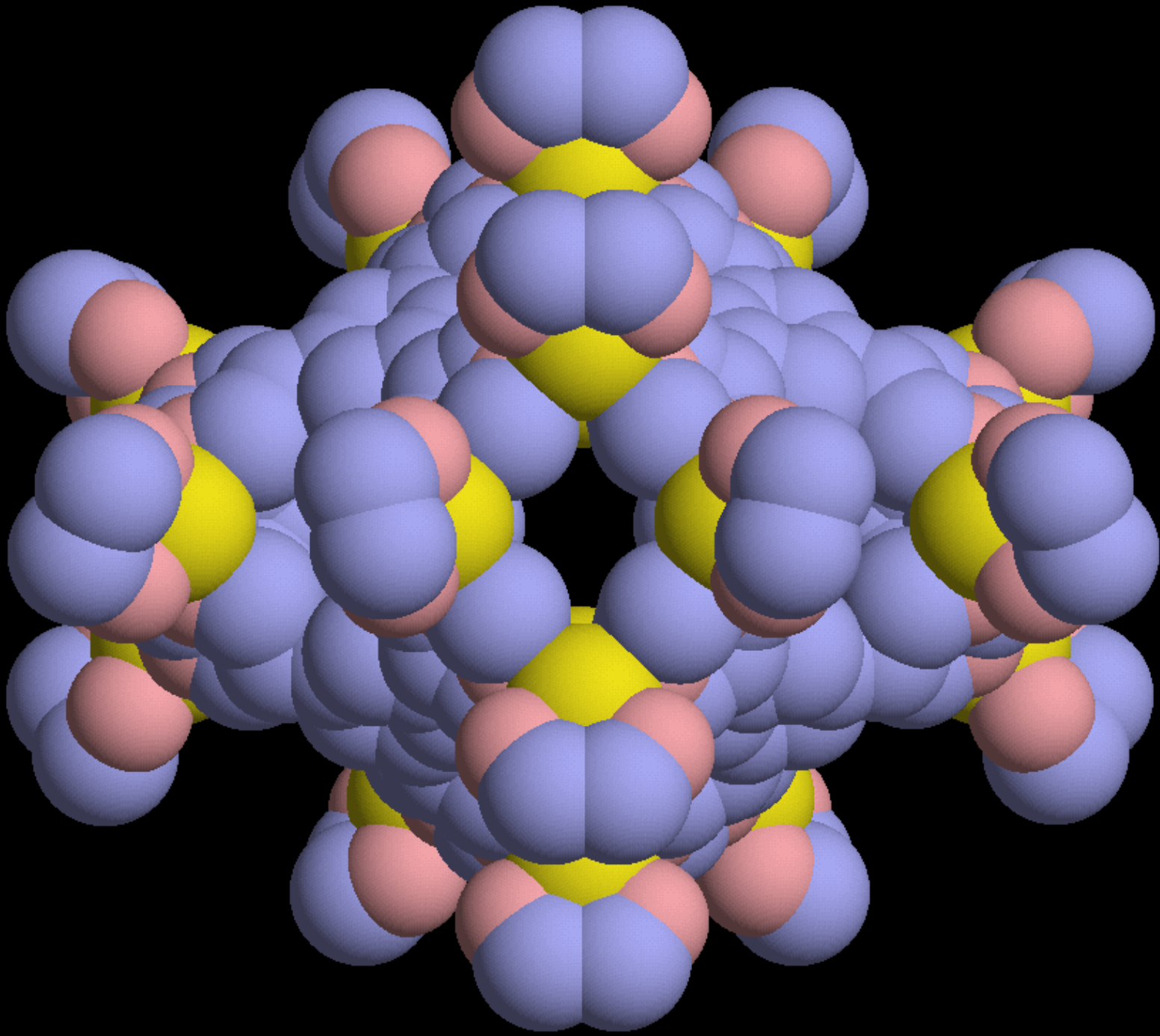
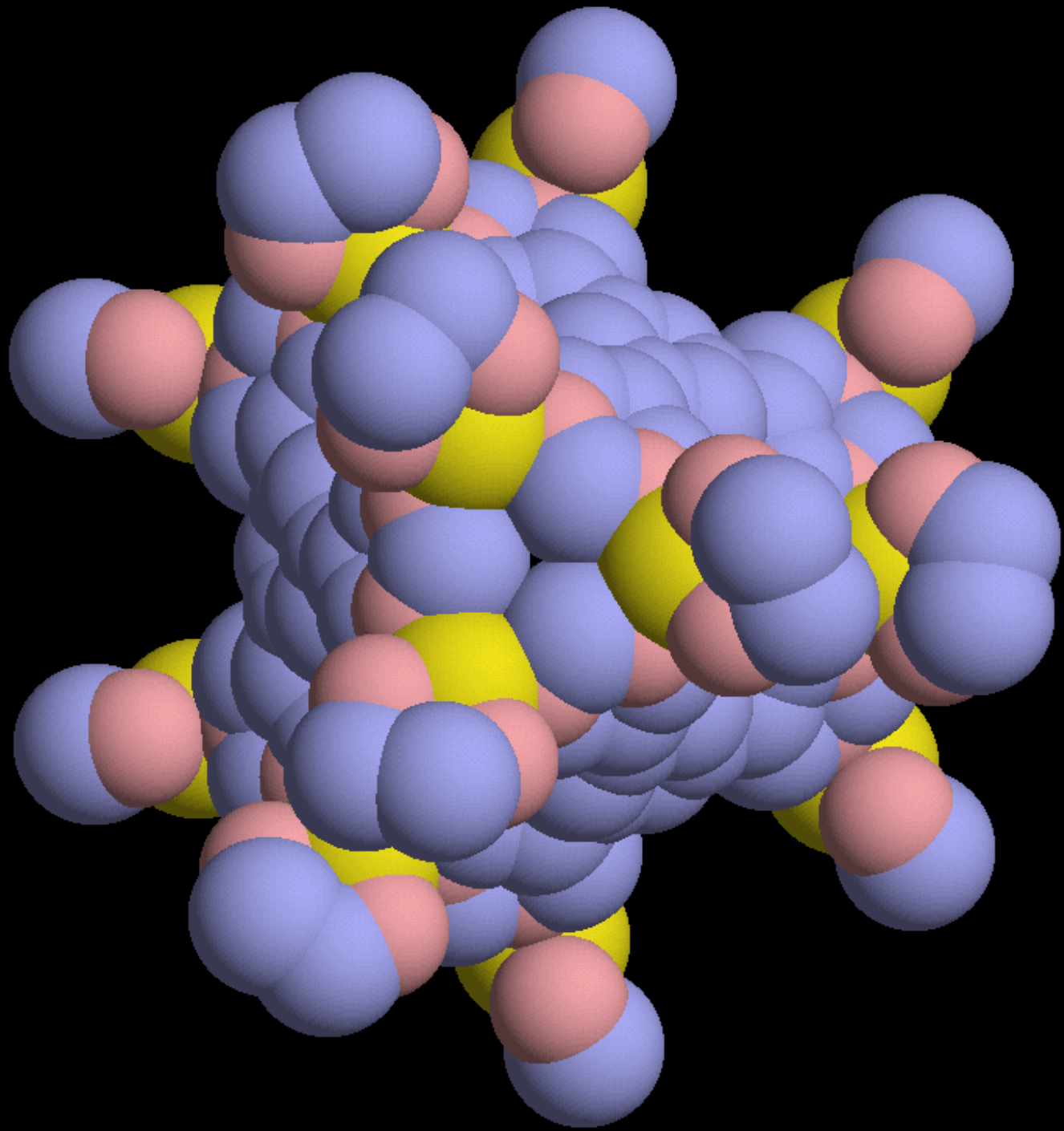
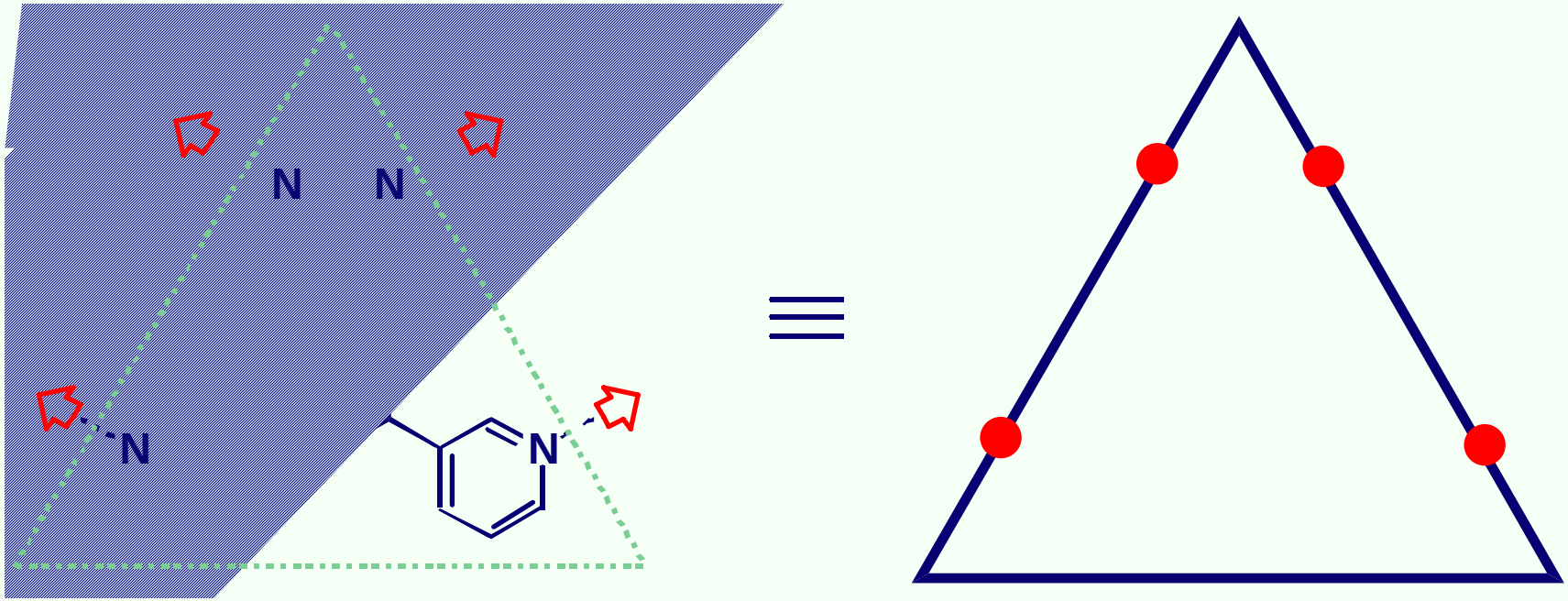




Nature 1999



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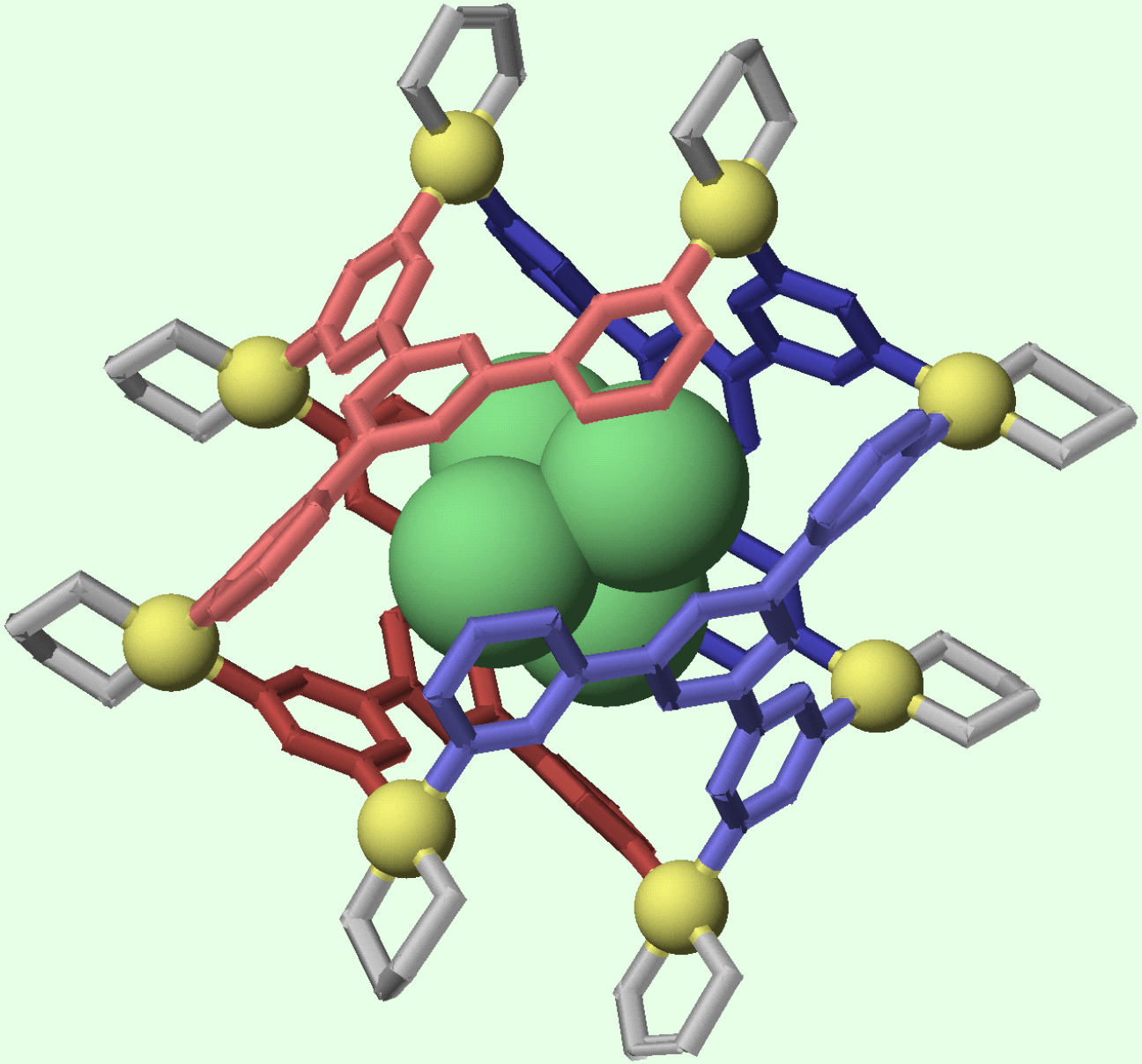
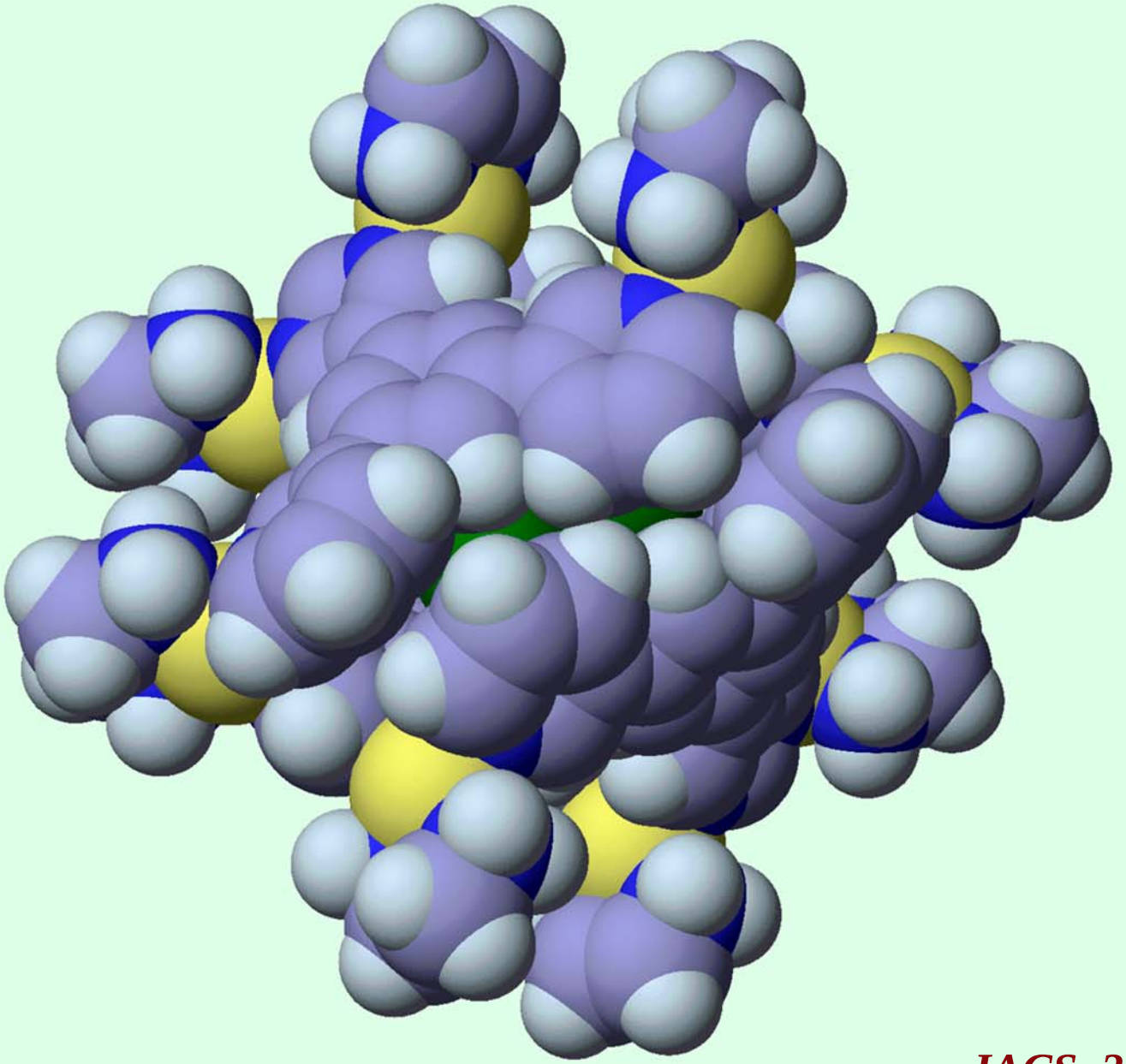
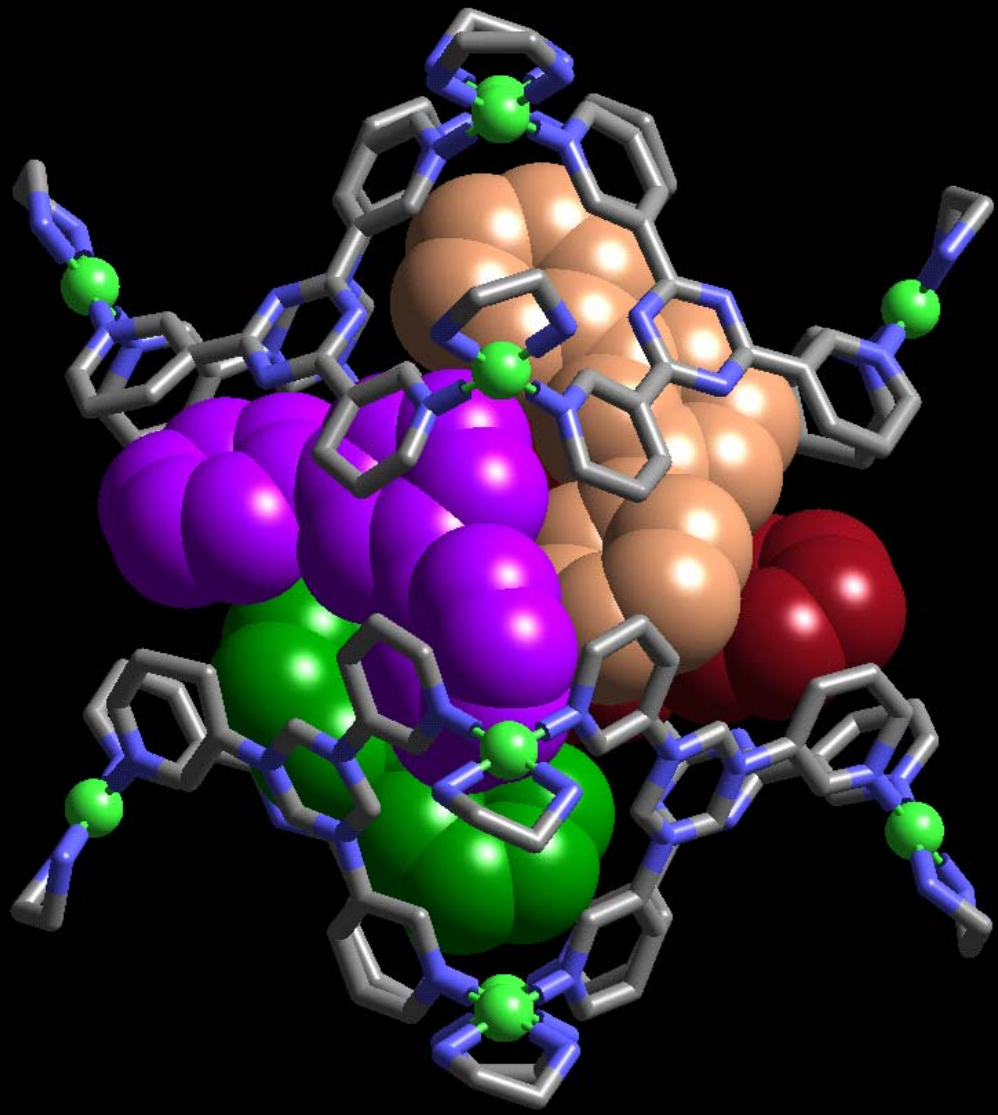




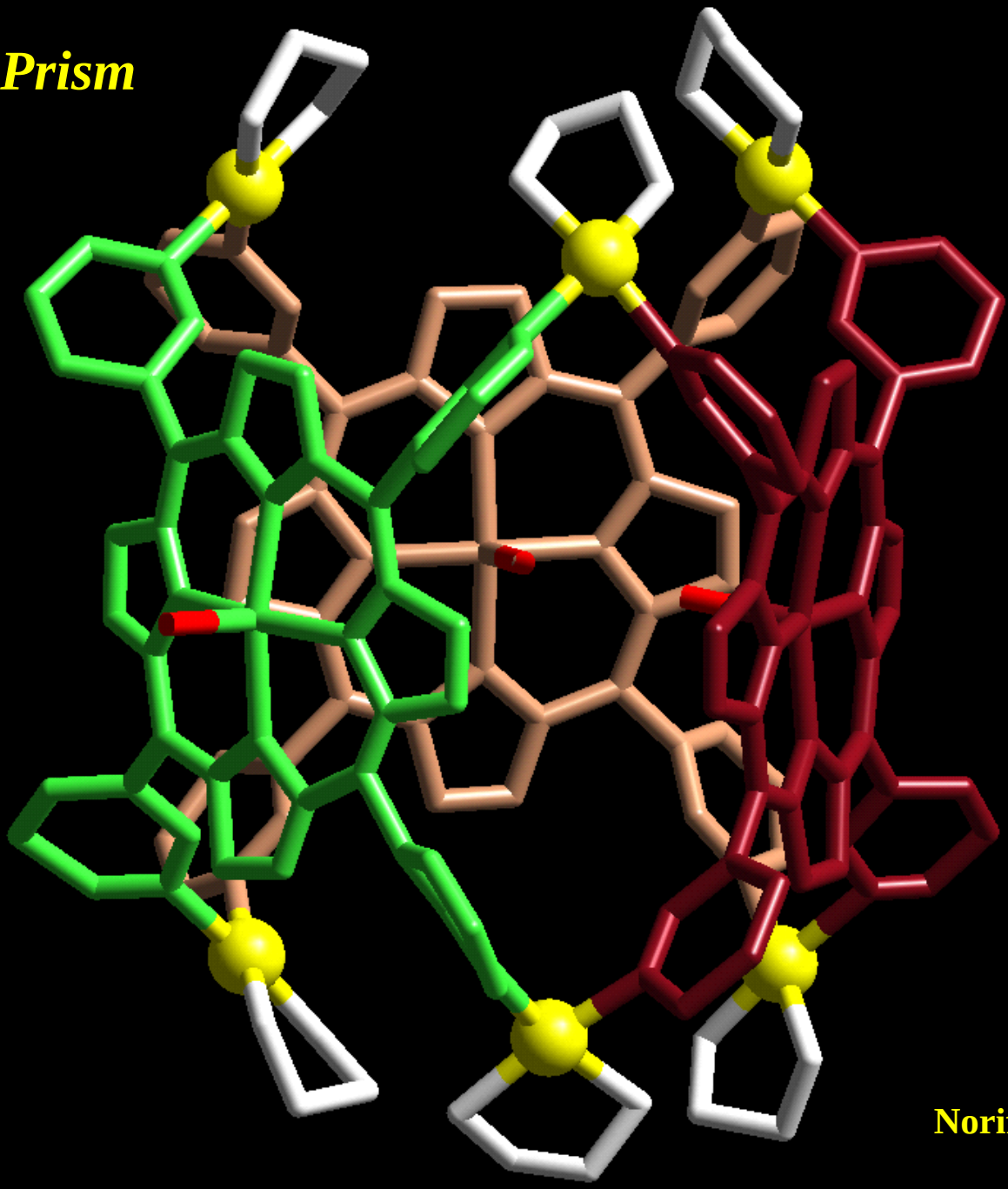
JACS, 2000

A Dimeric Coordination Nanobowl



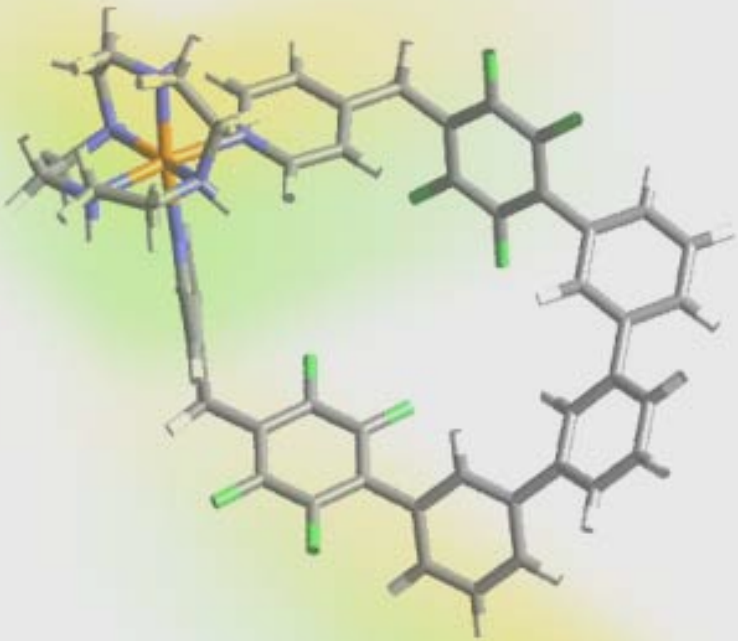
Dr. Shu-yan YU

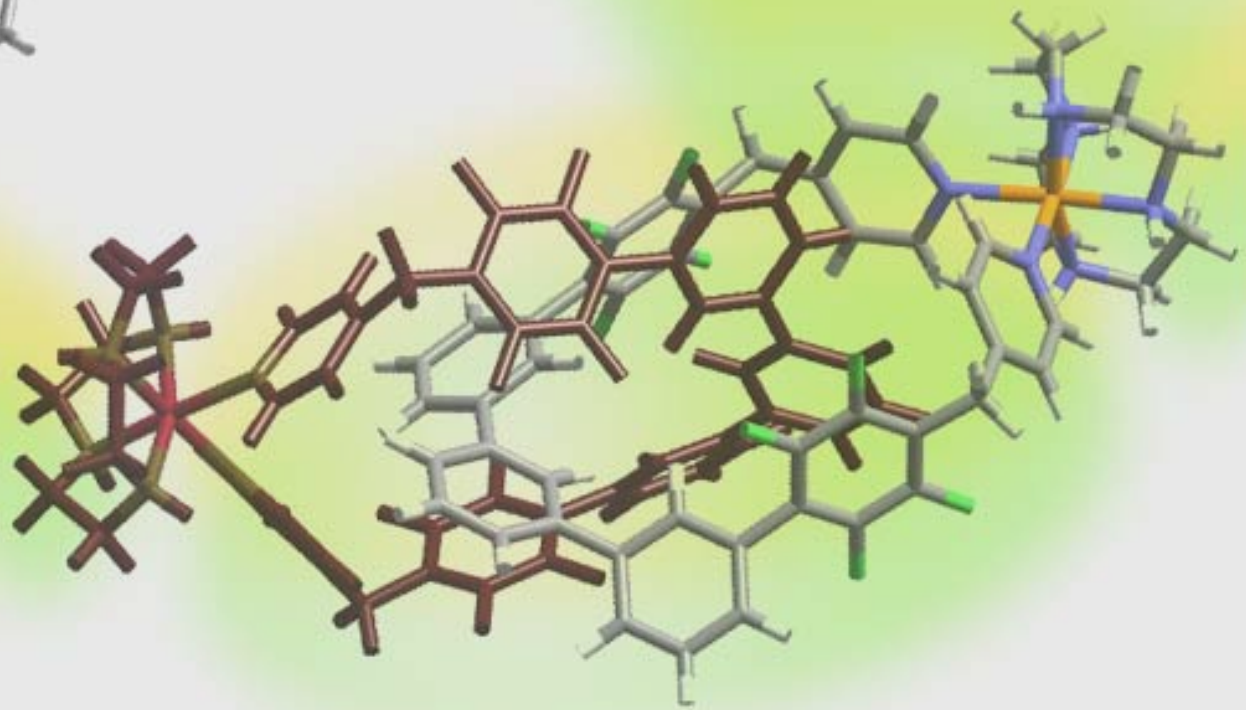
A Porphirin Prism

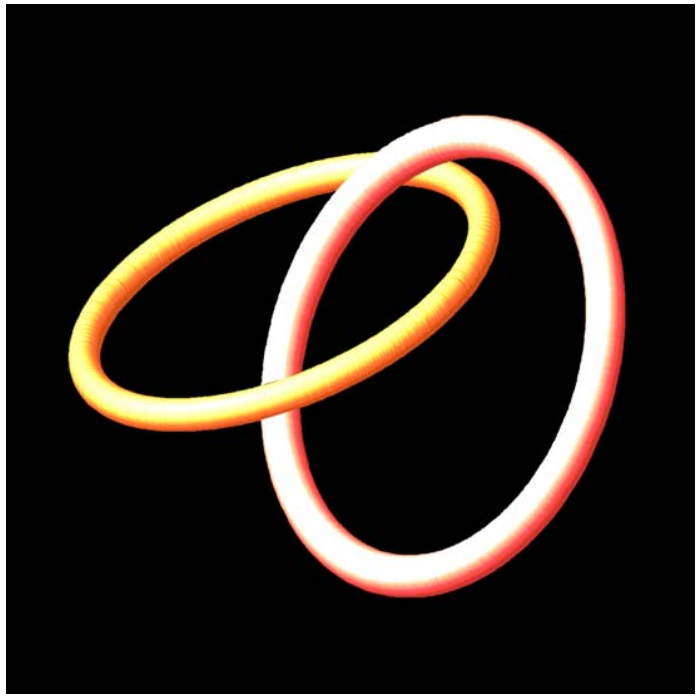


Norifumi FUJITA

Molecular Magic Rings

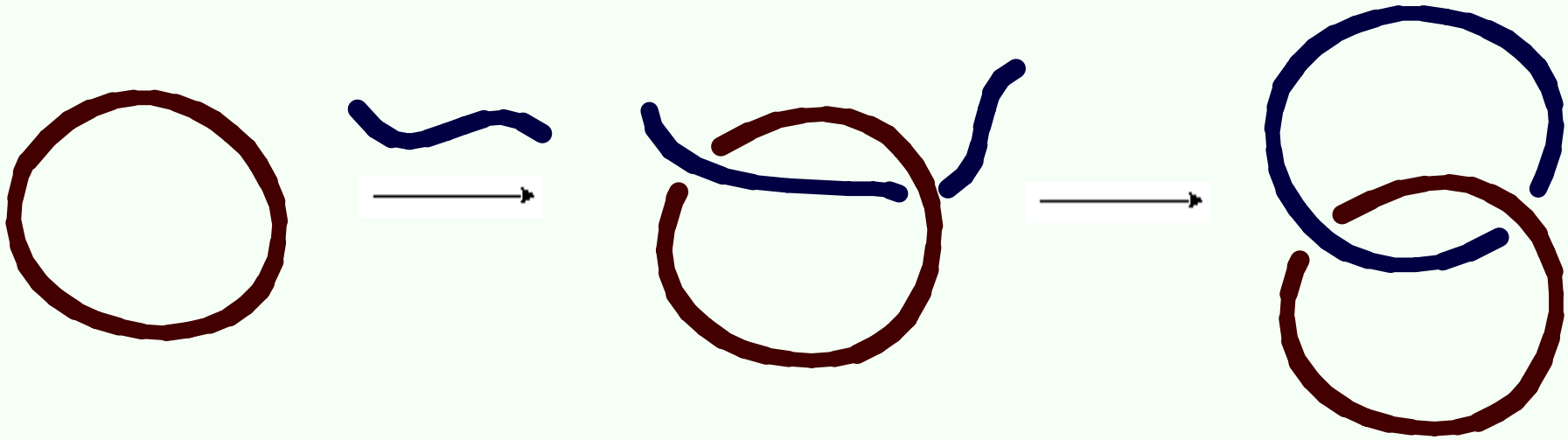




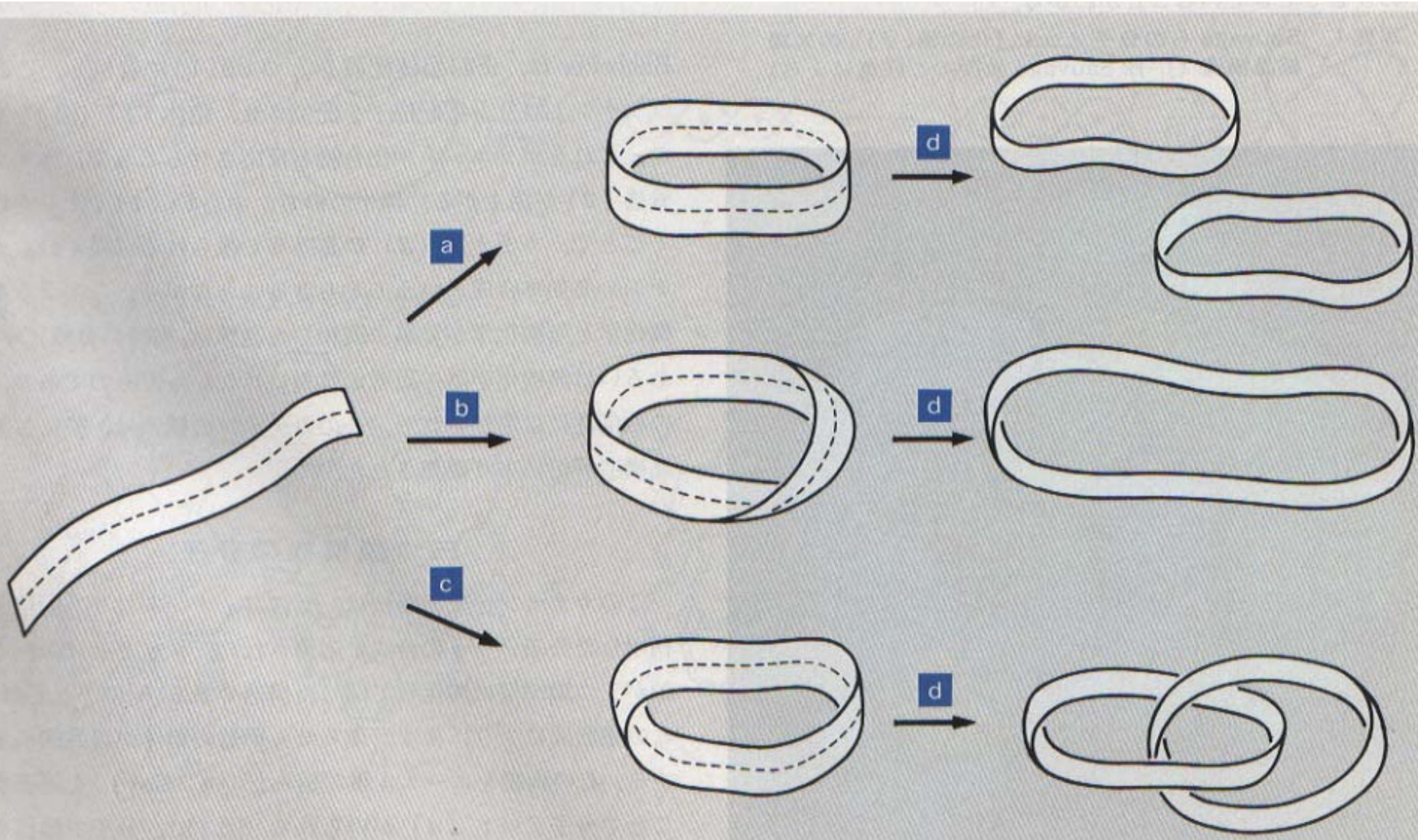


"Catenation"

(*Catena* = Chain in *Latin*)



A Catenane



テープの端と端を a)そのままつなげる．b)1 回ひねってつなげる．c)2 回ひねってつなげる．d)点線に沿って切断する．

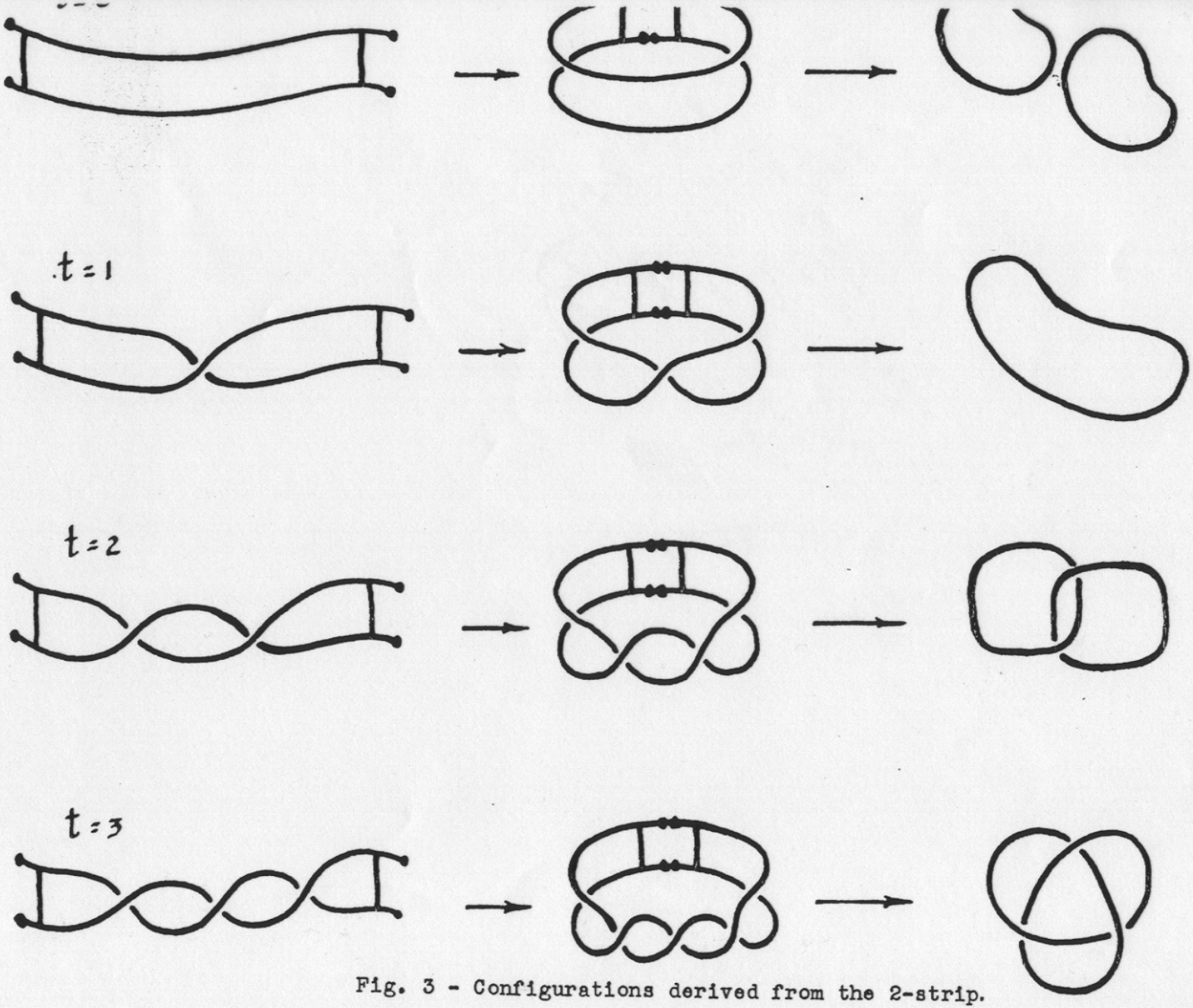


Fig. 3 - Configurations derived from the 2-strip.

Total Synthesis of the First Molecular Möbius Strip

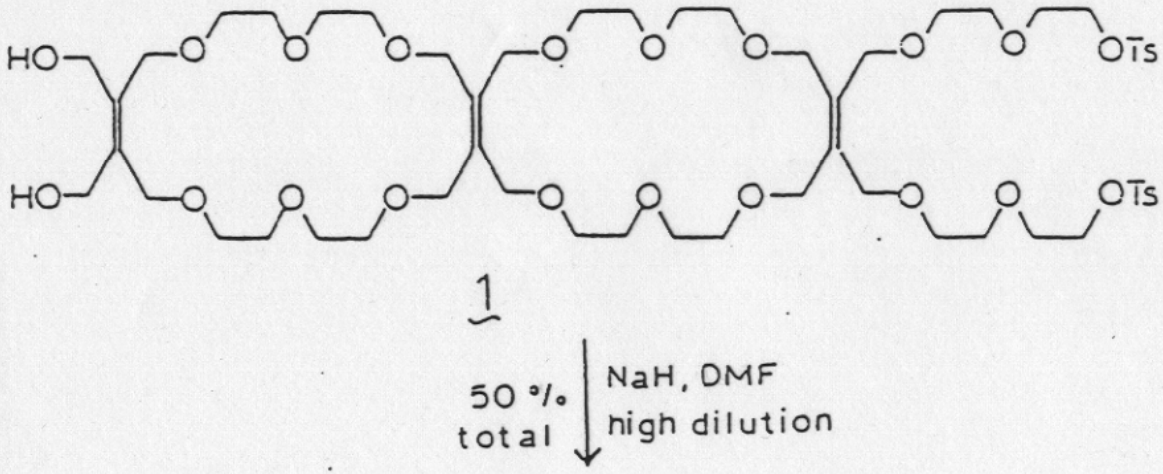
David M. Walba,* Rodney M. Richards, and
R. Curtis Haltiwanger

Department of Chemistry, University of Colorado
Boulder, Colorado 80309

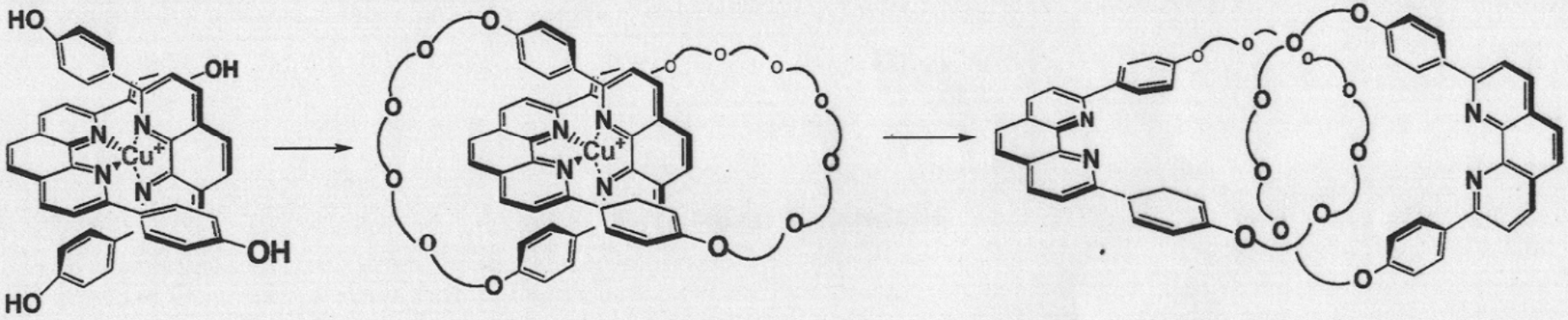
Received February 19, 1982

J. Am. Chem. Soc. ~~82~~ 104, 3219 (1982)

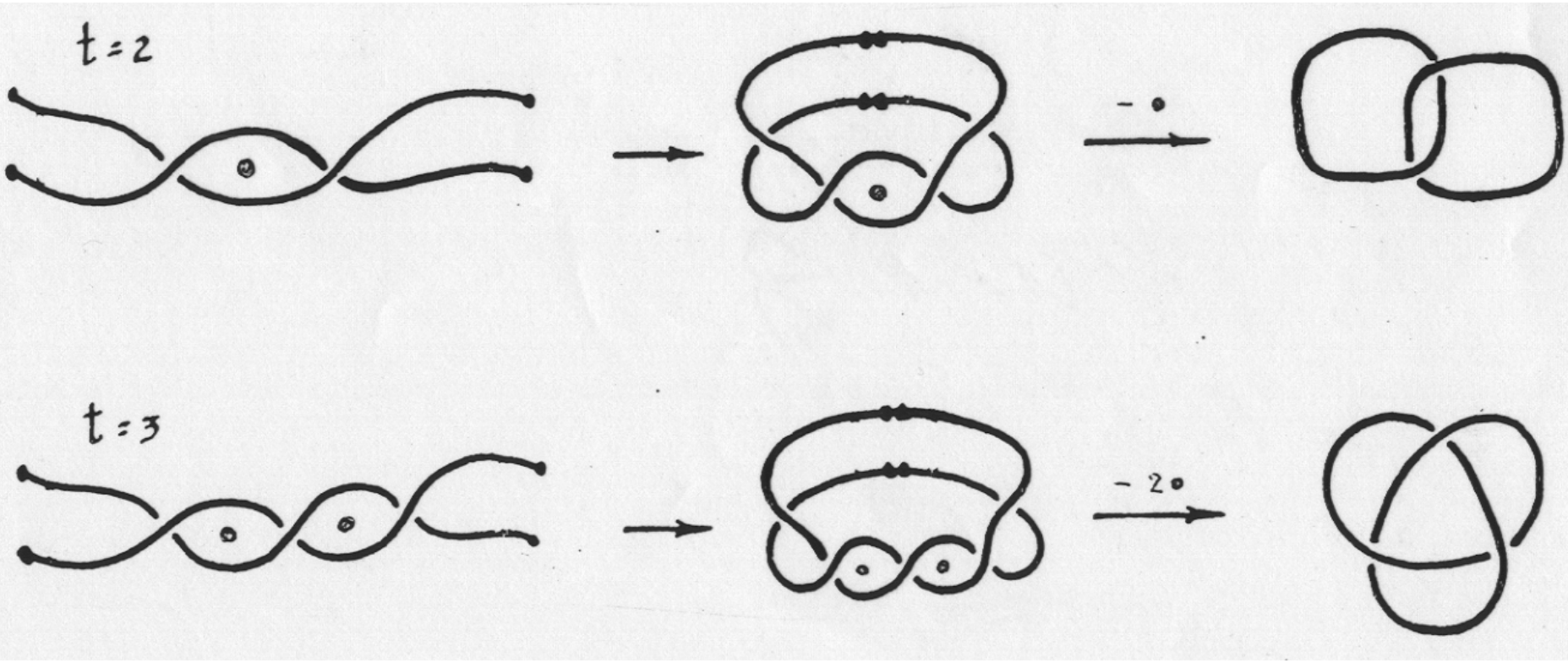
Scheme I



A Sauvage's Catenane (1983)



Dietrich-Buchecker, C. O.; Sauvage, J.-P.; Kintzinger, J. P. *Tetrahedron Lett.* **1983**, *24*, 5095.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t=3
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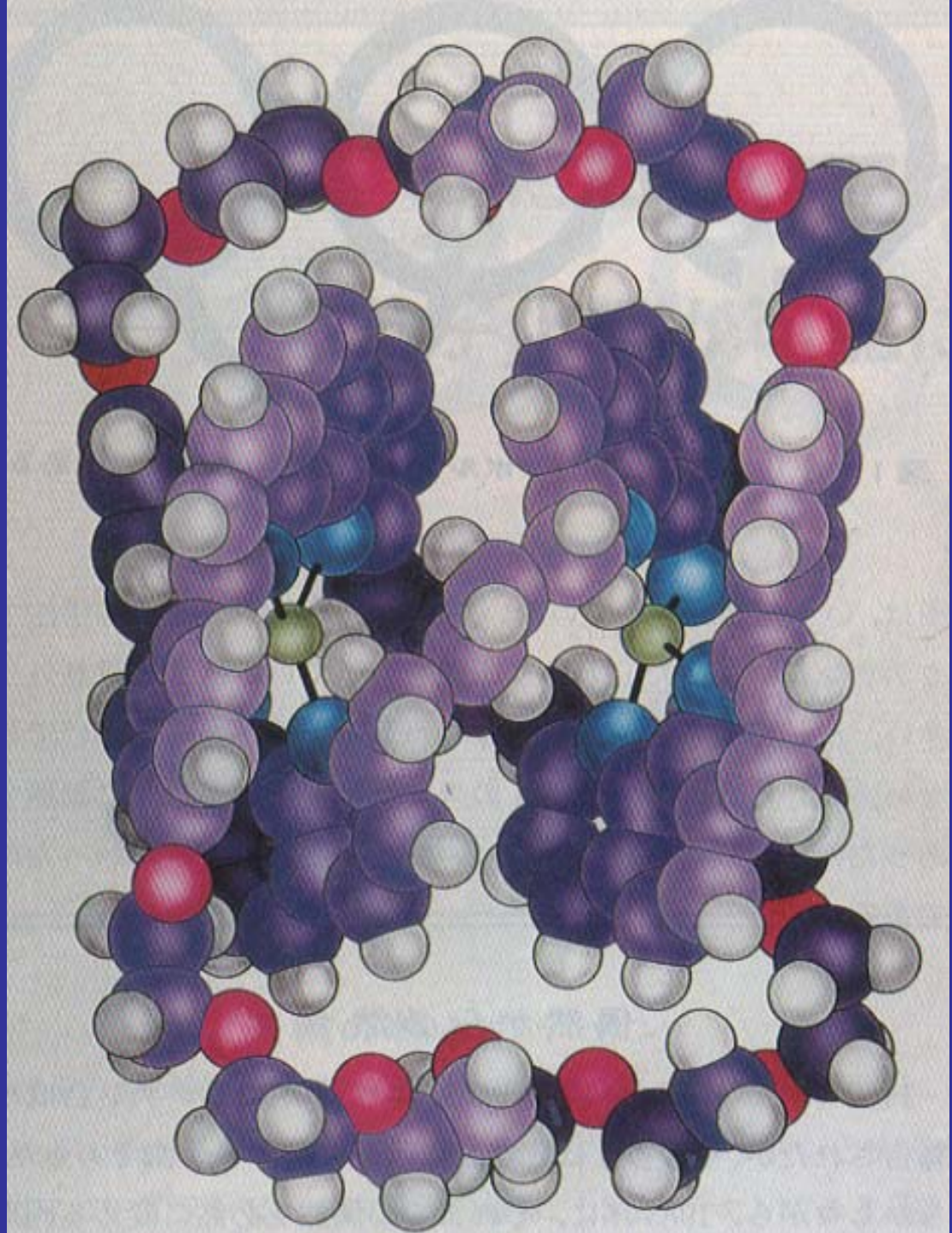
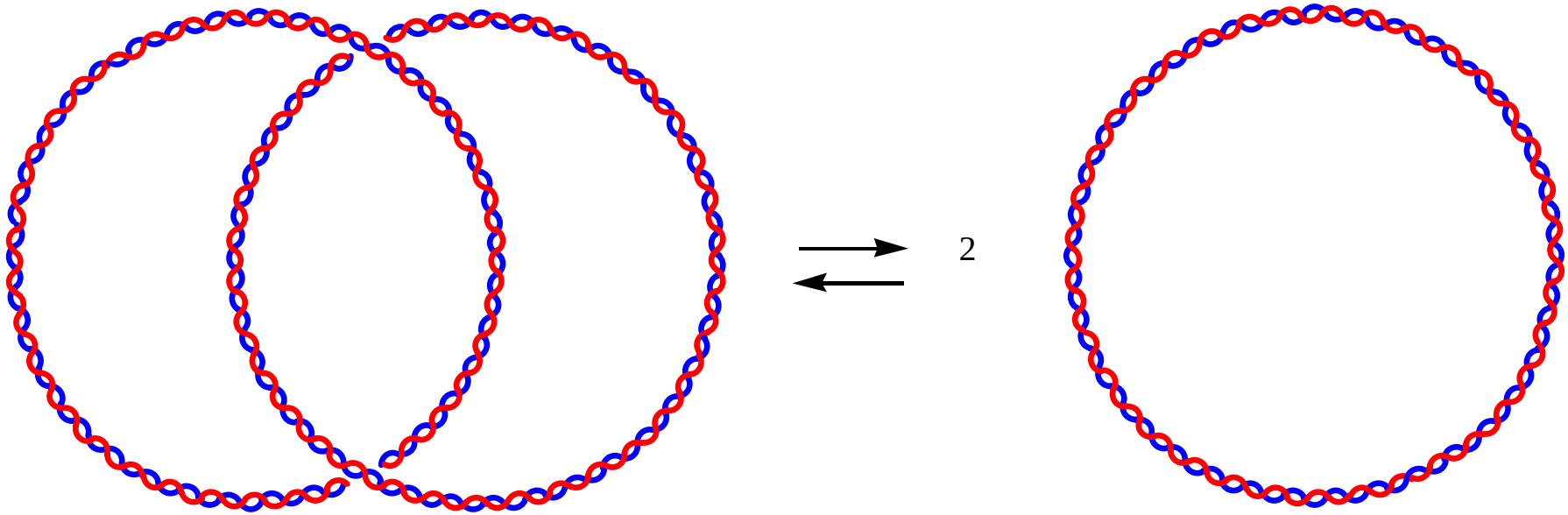
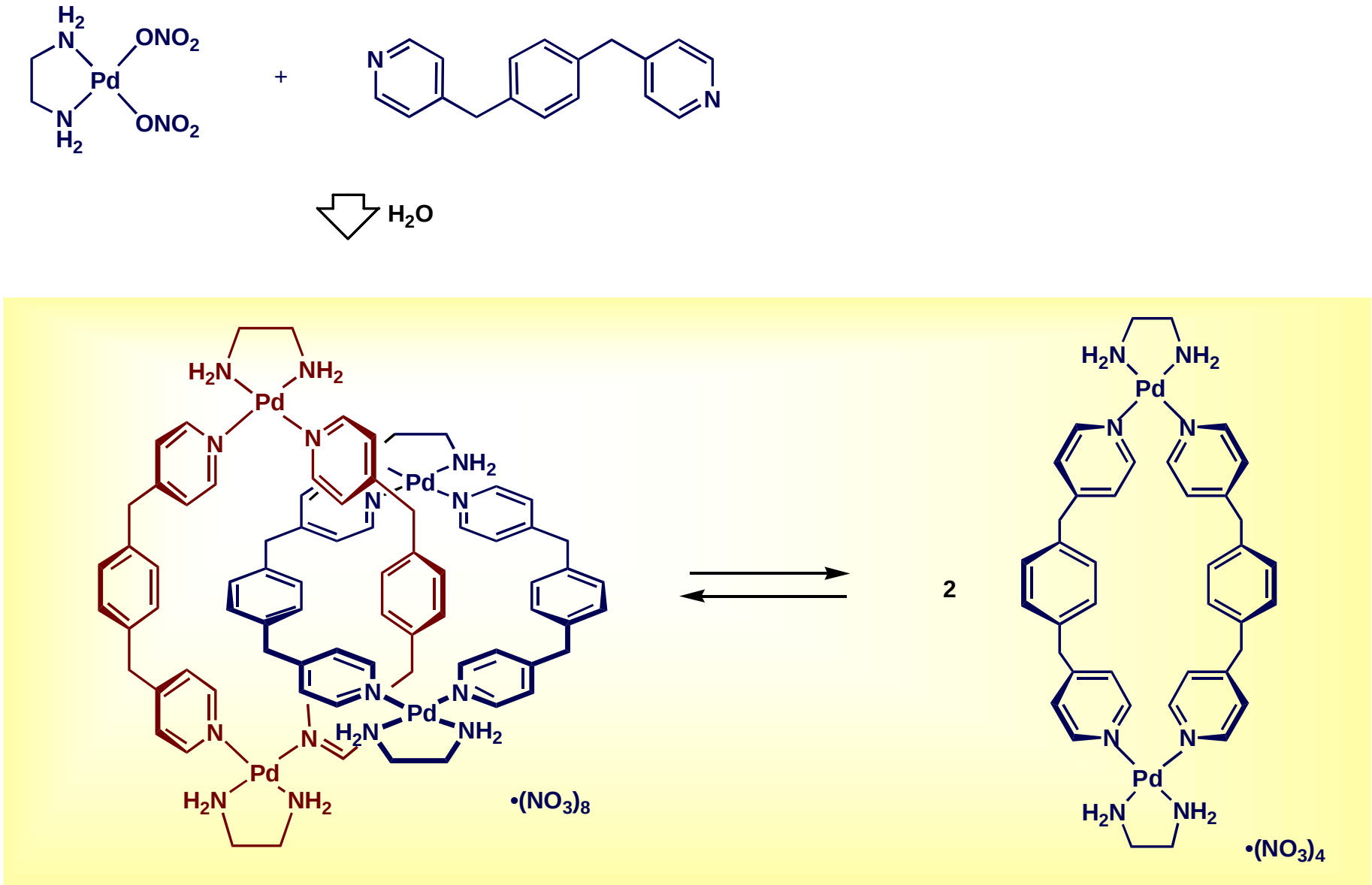


Catenanes in Biology

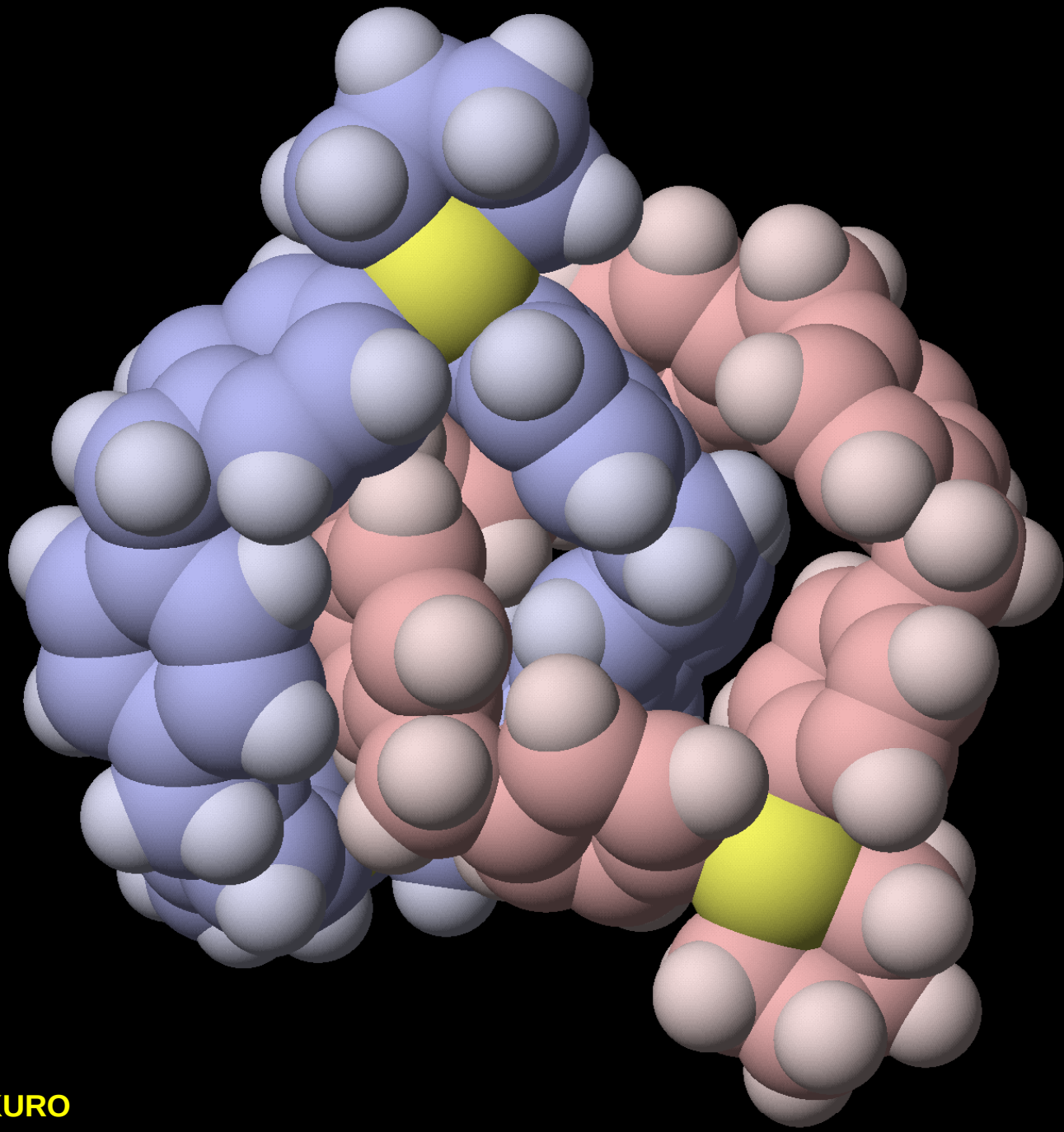


(Catenated DNA Rings)

Catalyzed by *Topoisomerase II*

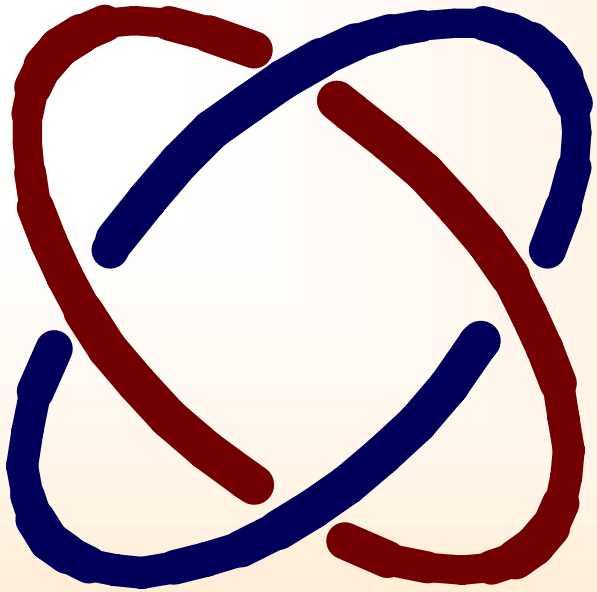


Fujita, M.; Ibukuro, F.; Hagihara, H.; Ogura, K. *Nature* **1994**, *367*, 720.

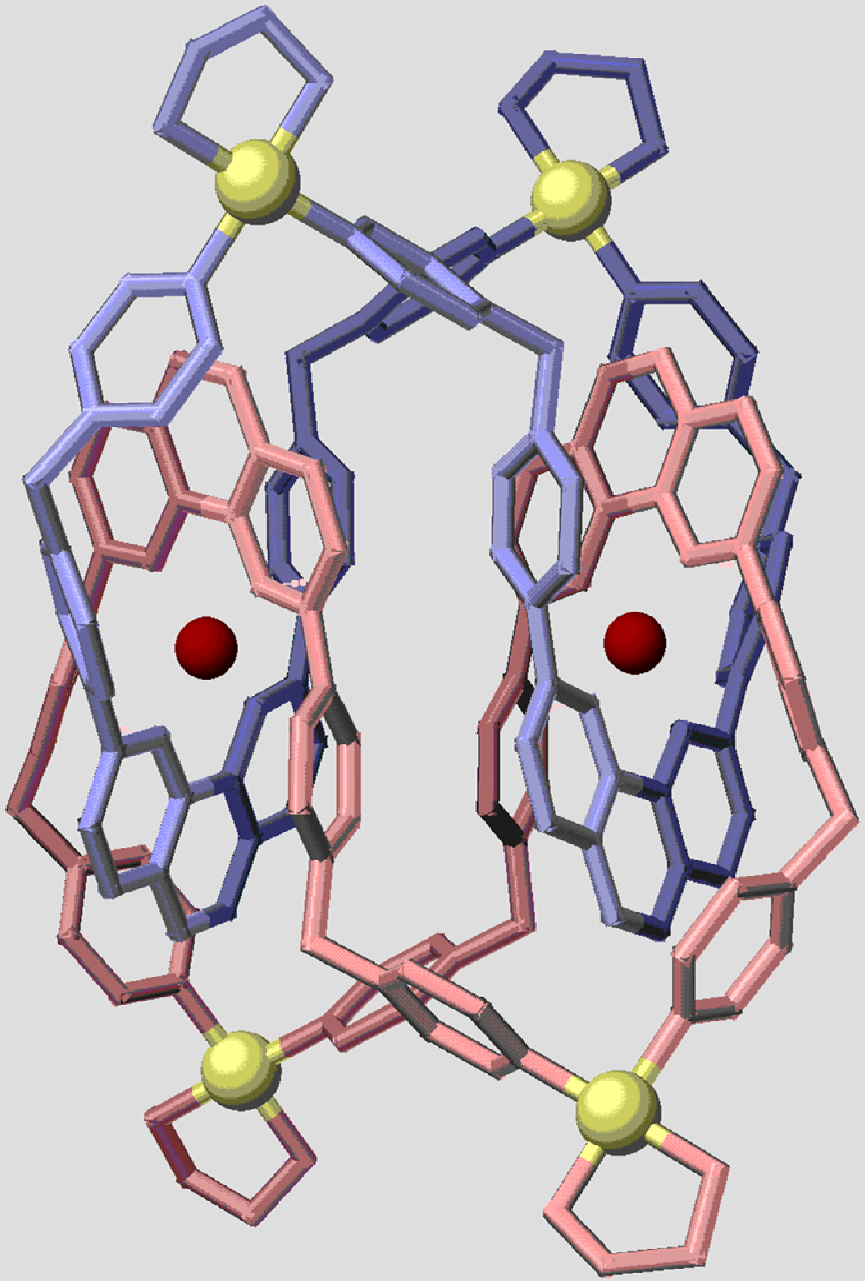


Dr. Fumiaki IBUKURO

Doubly Interlocking [2]Catenane

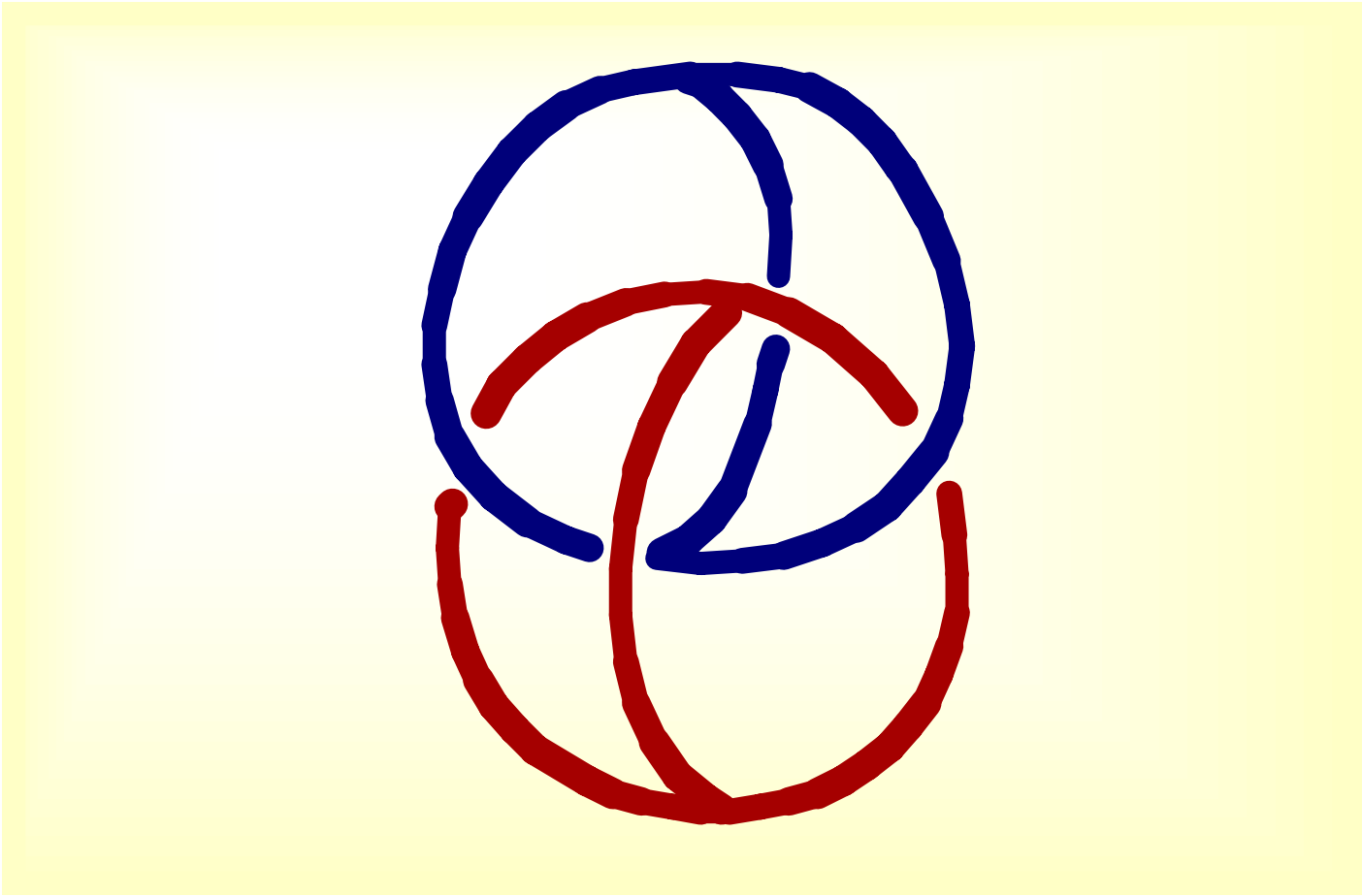


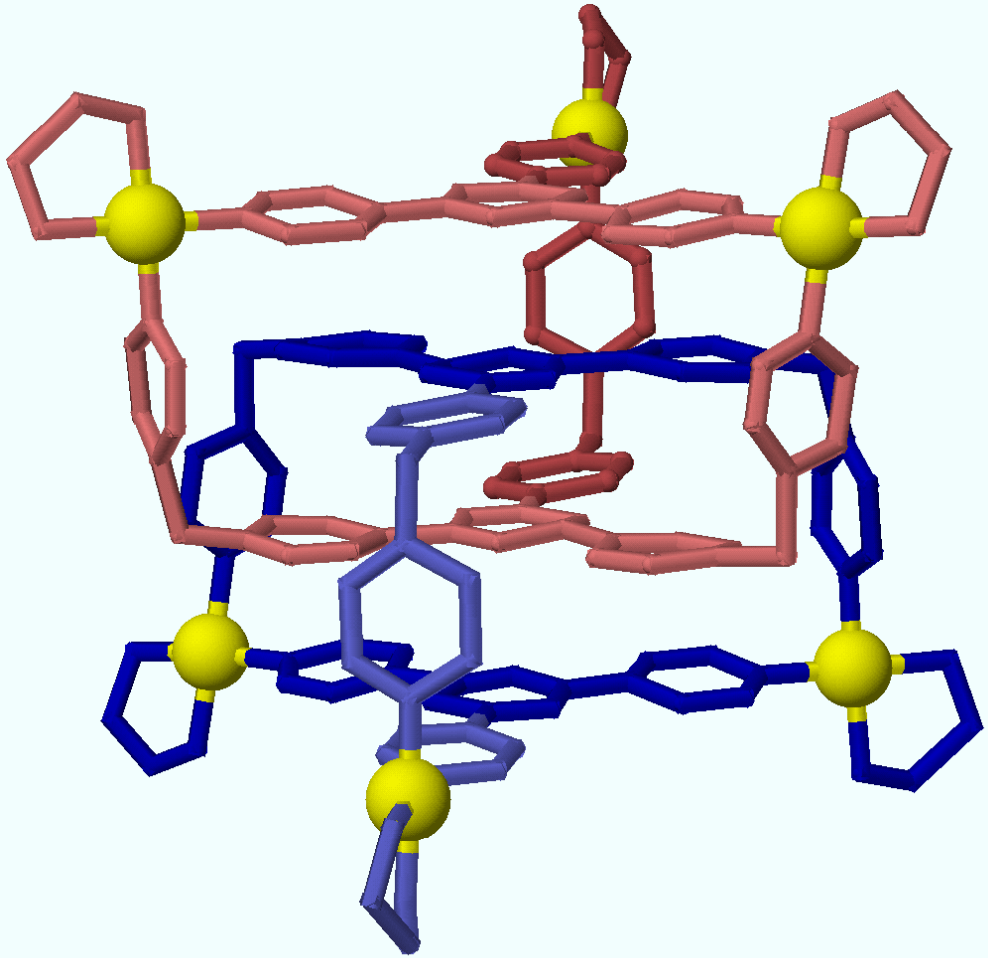
Sauvage & Fujita 1999



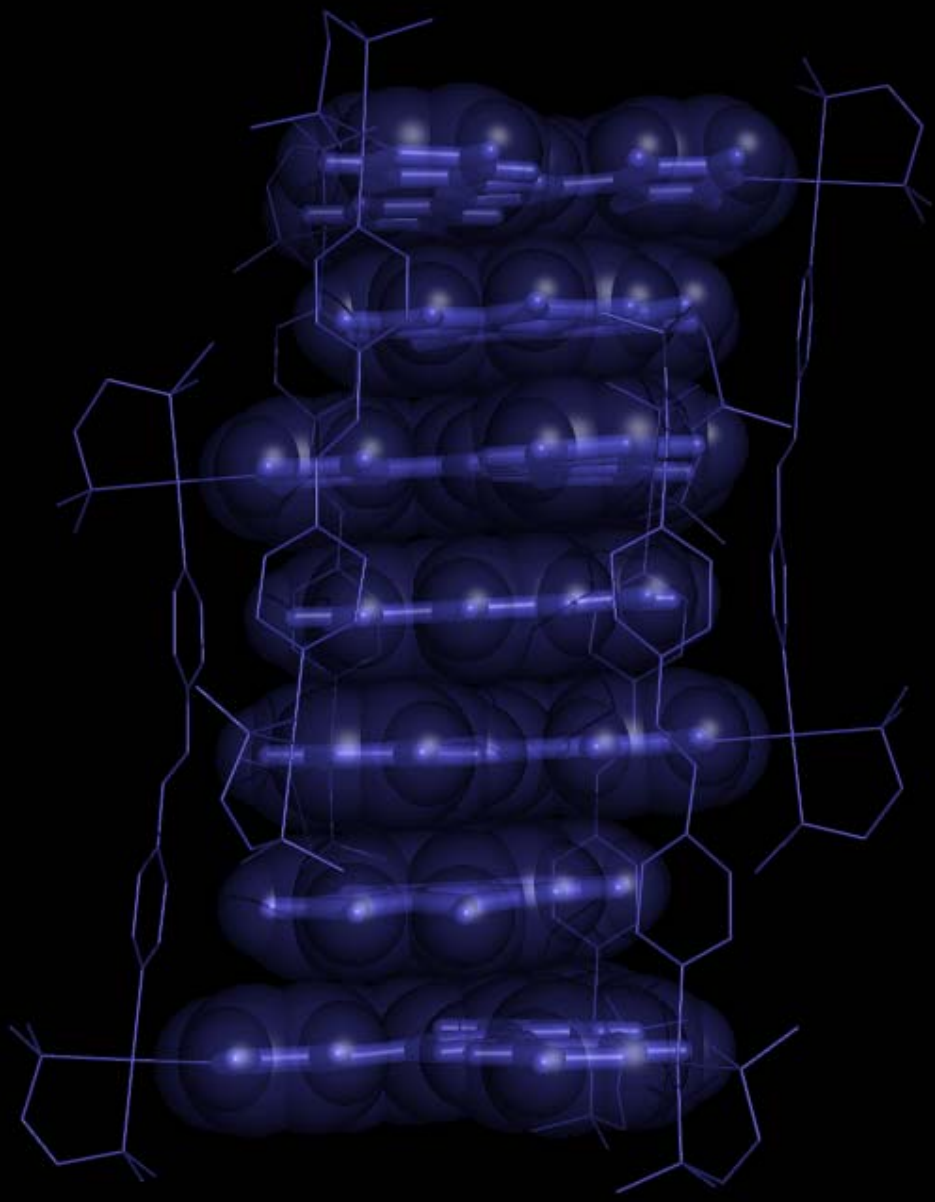
Refined by MD/MM2

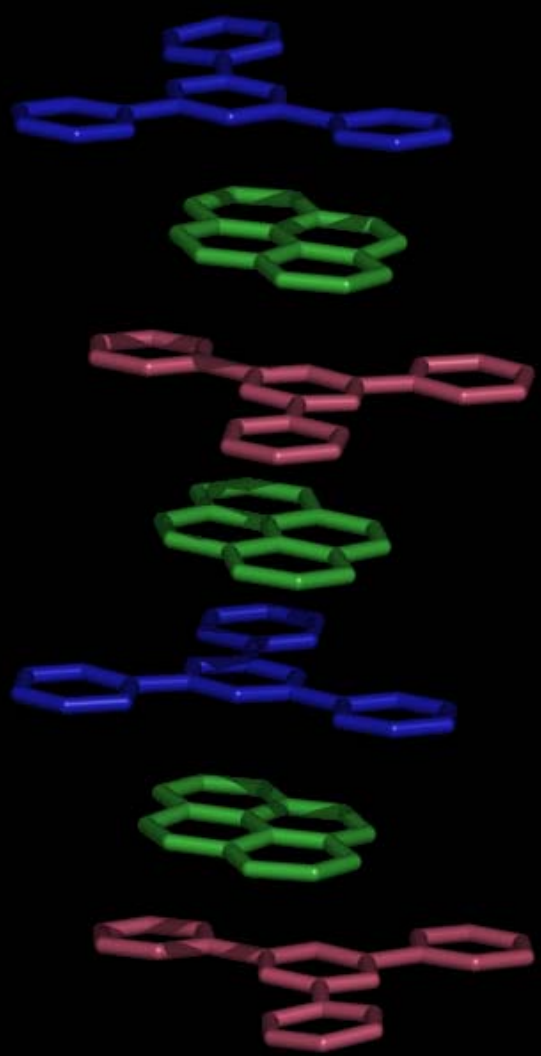
A Three-dimensionally Interlocked Molecule

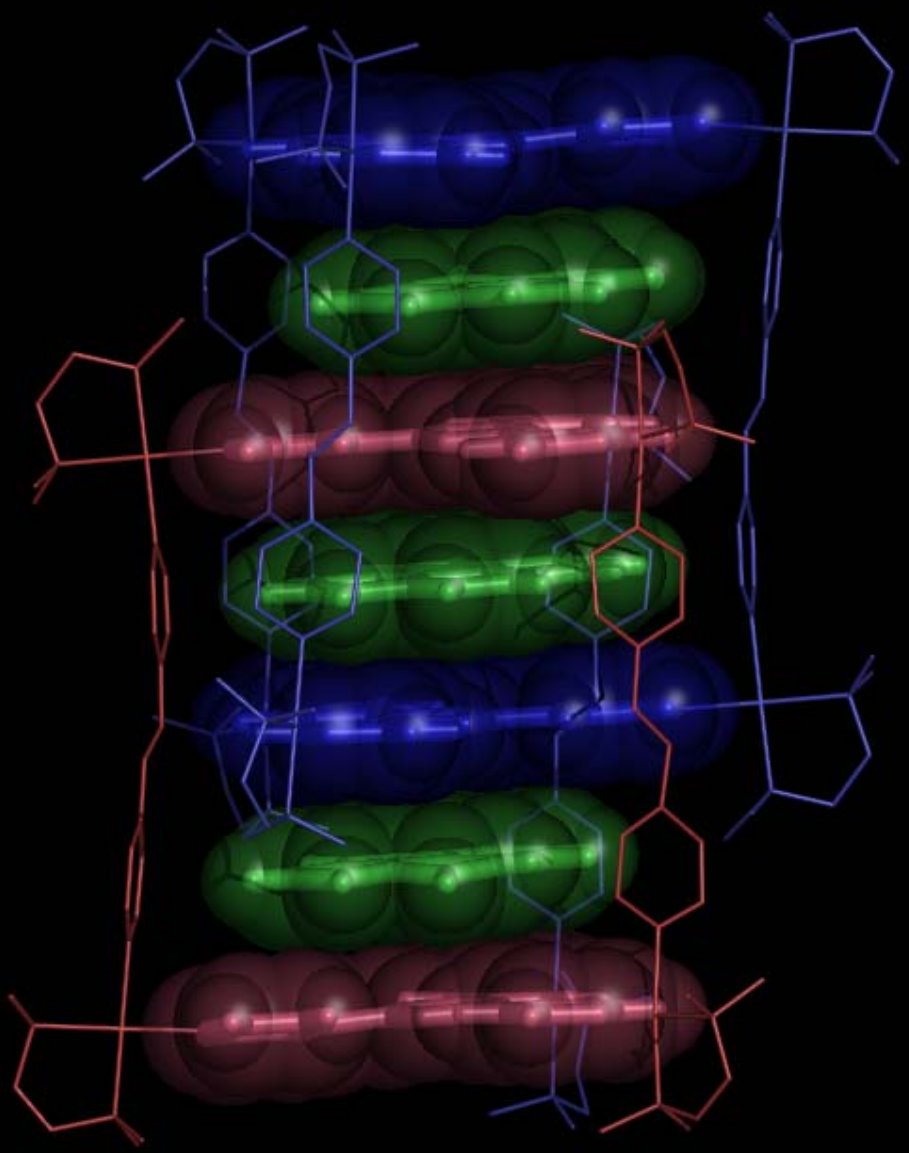


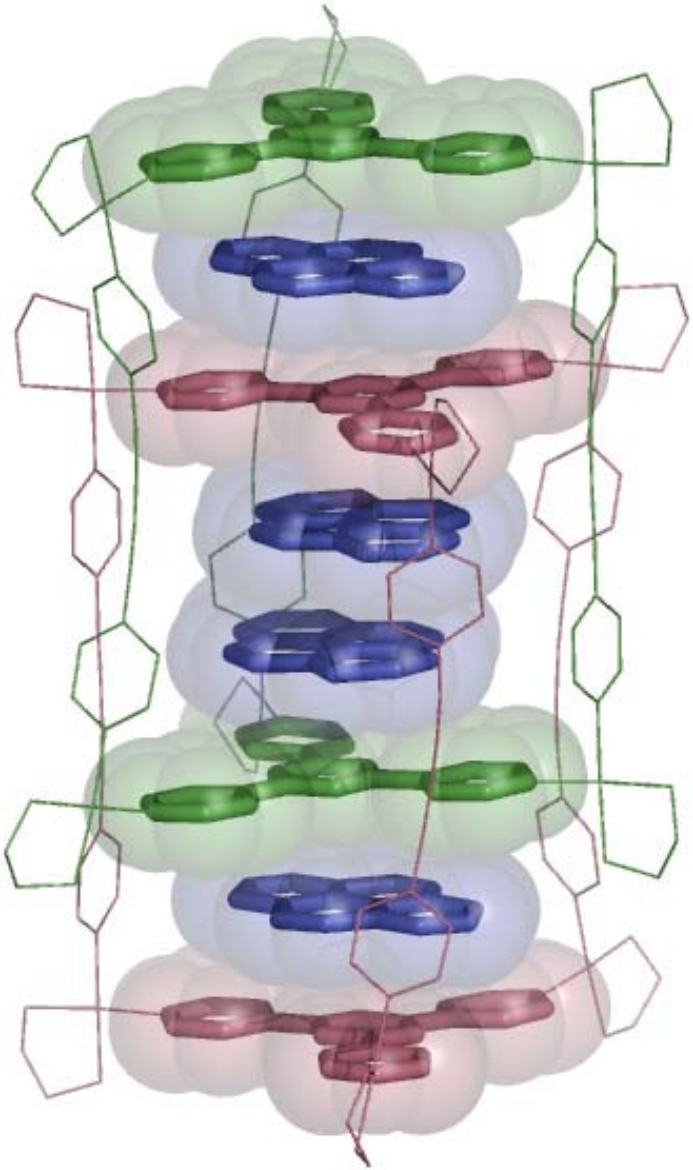


***Nature* 1999**

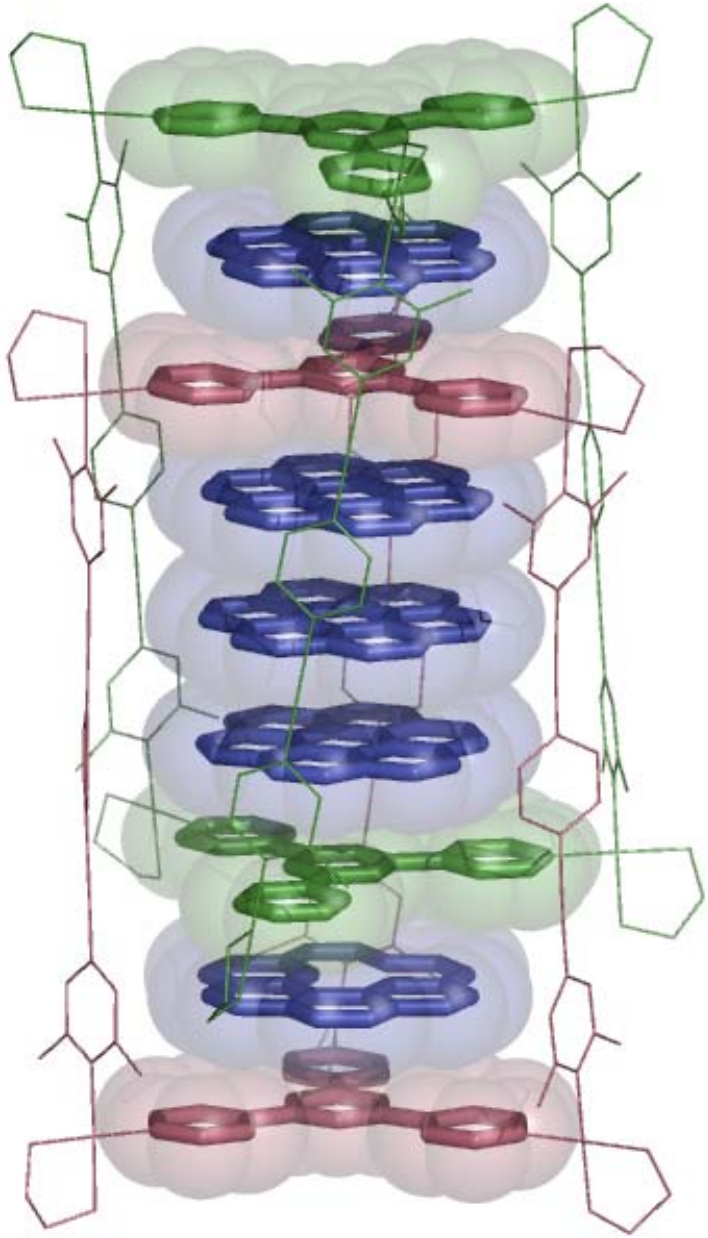




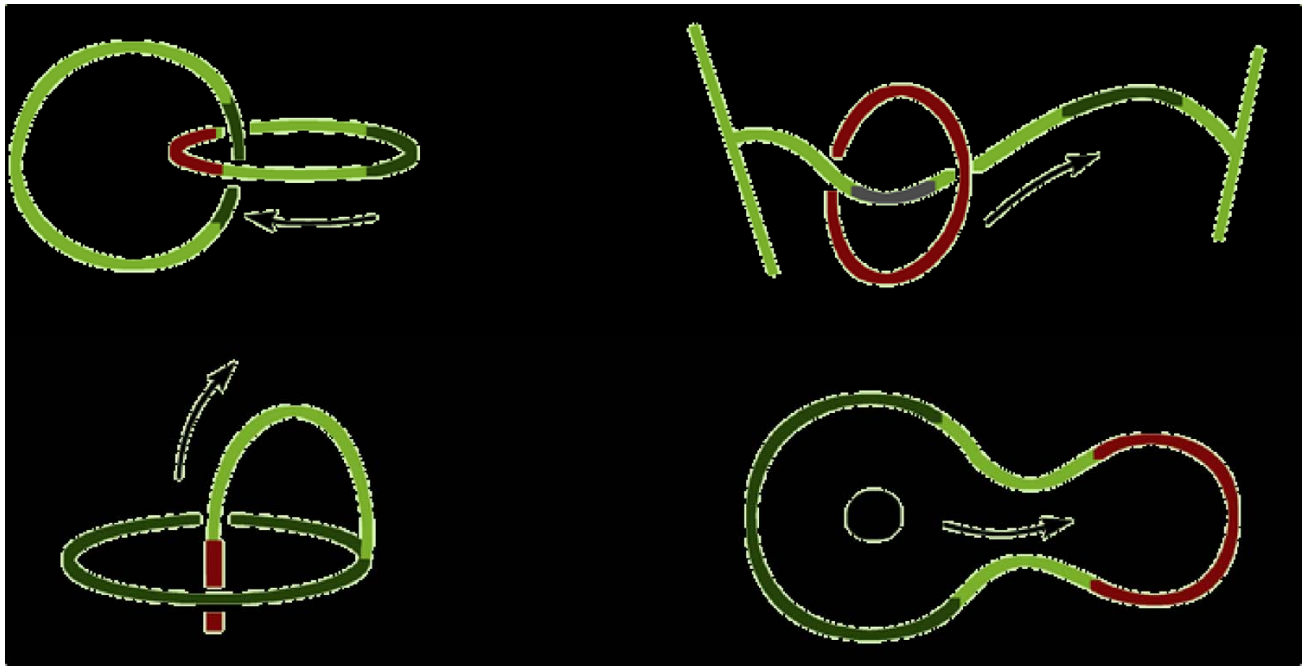




(X-ray)



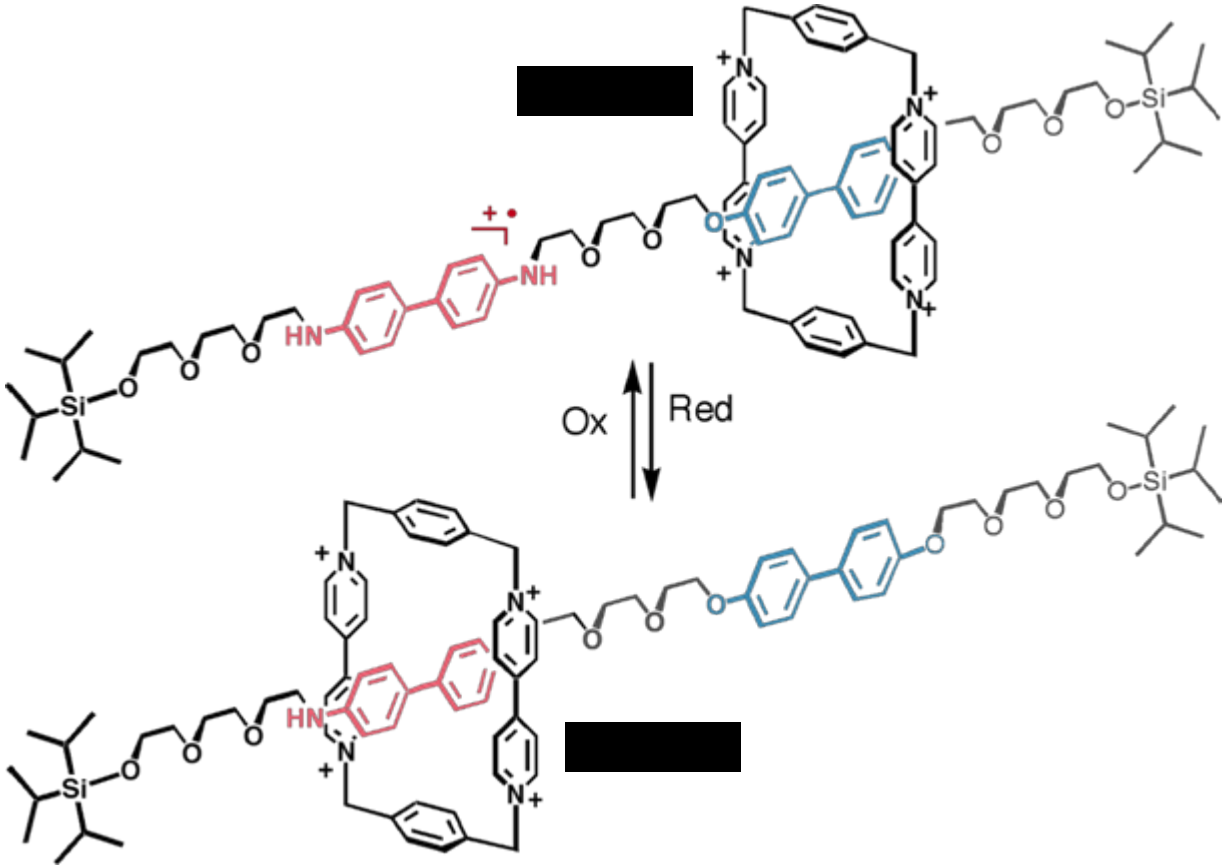
(modeling)

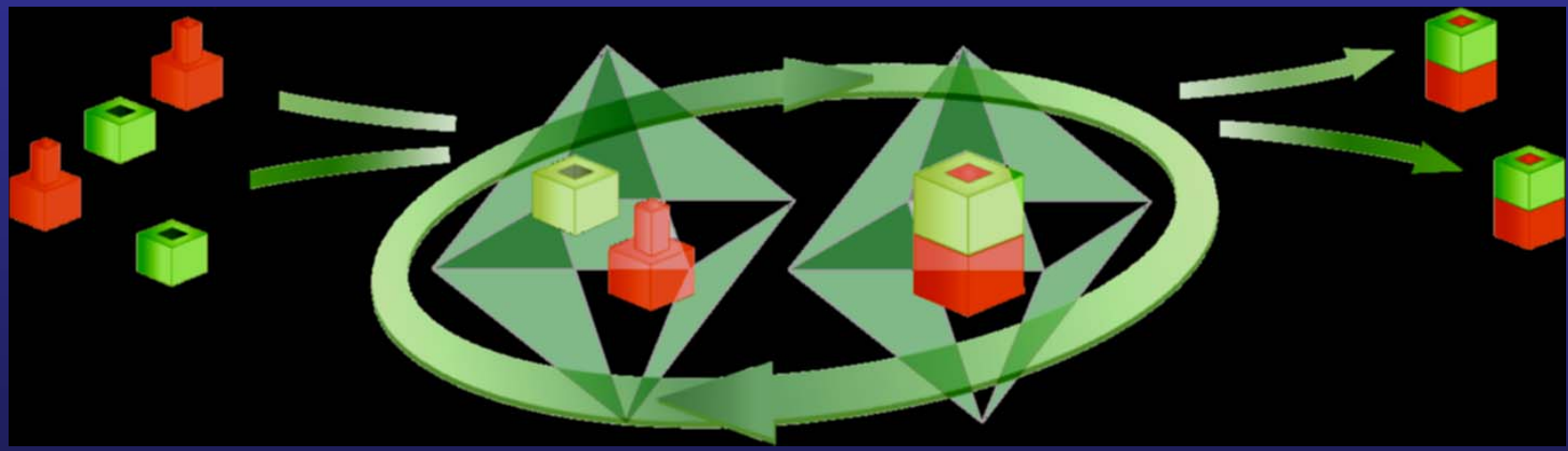


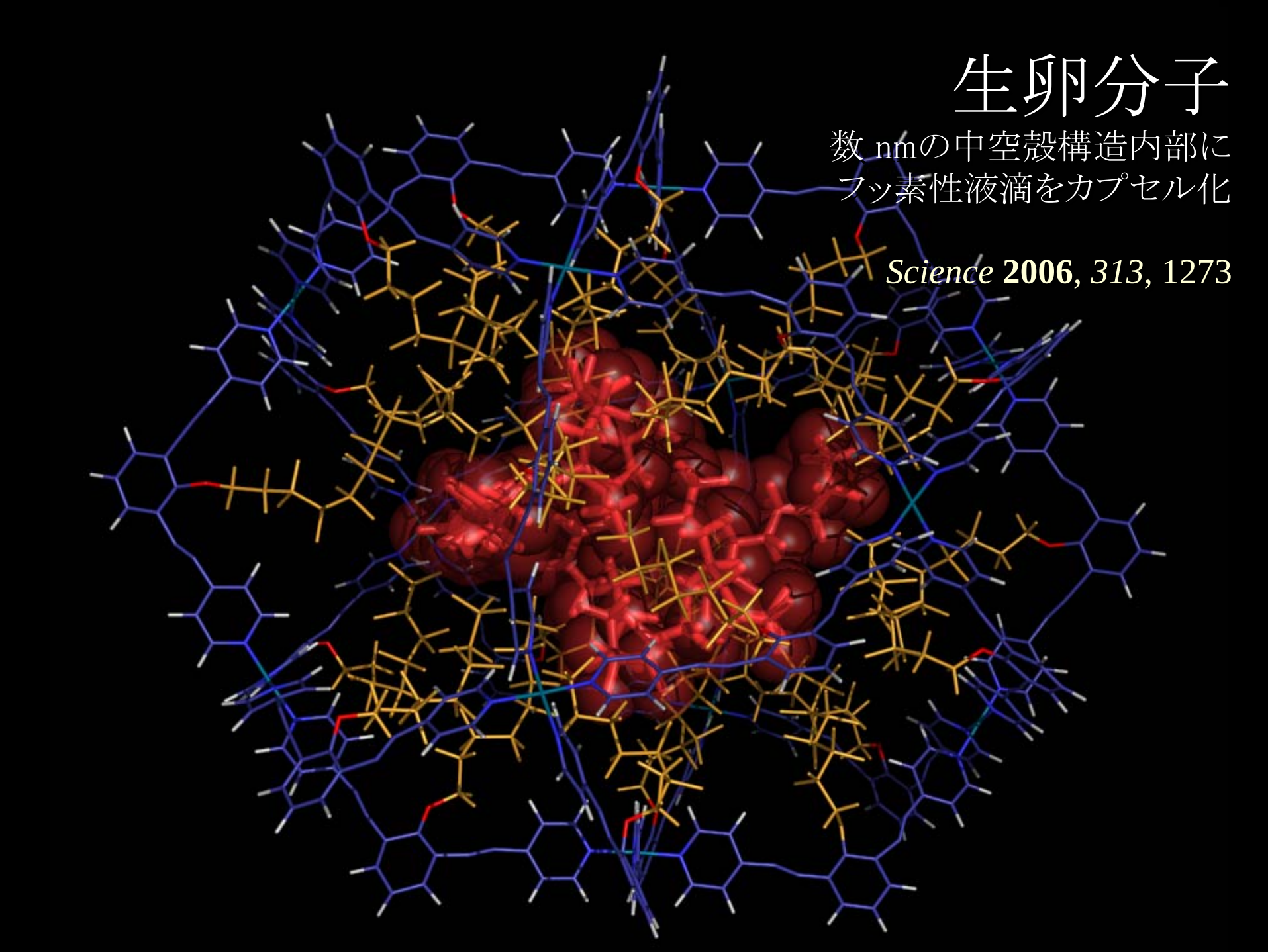
(B)

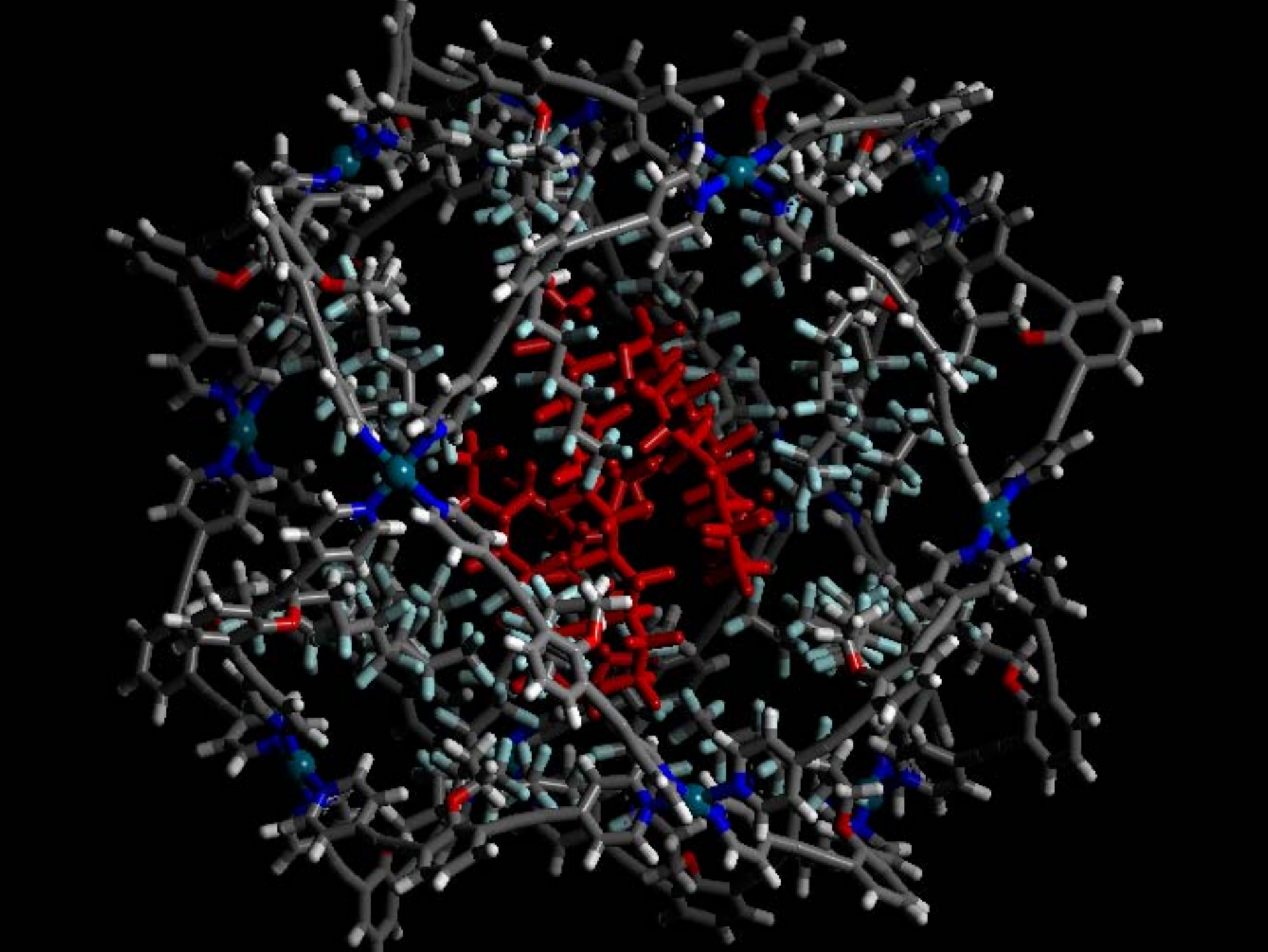
(D)

Background: Sauvage Strategy


Ox
Red

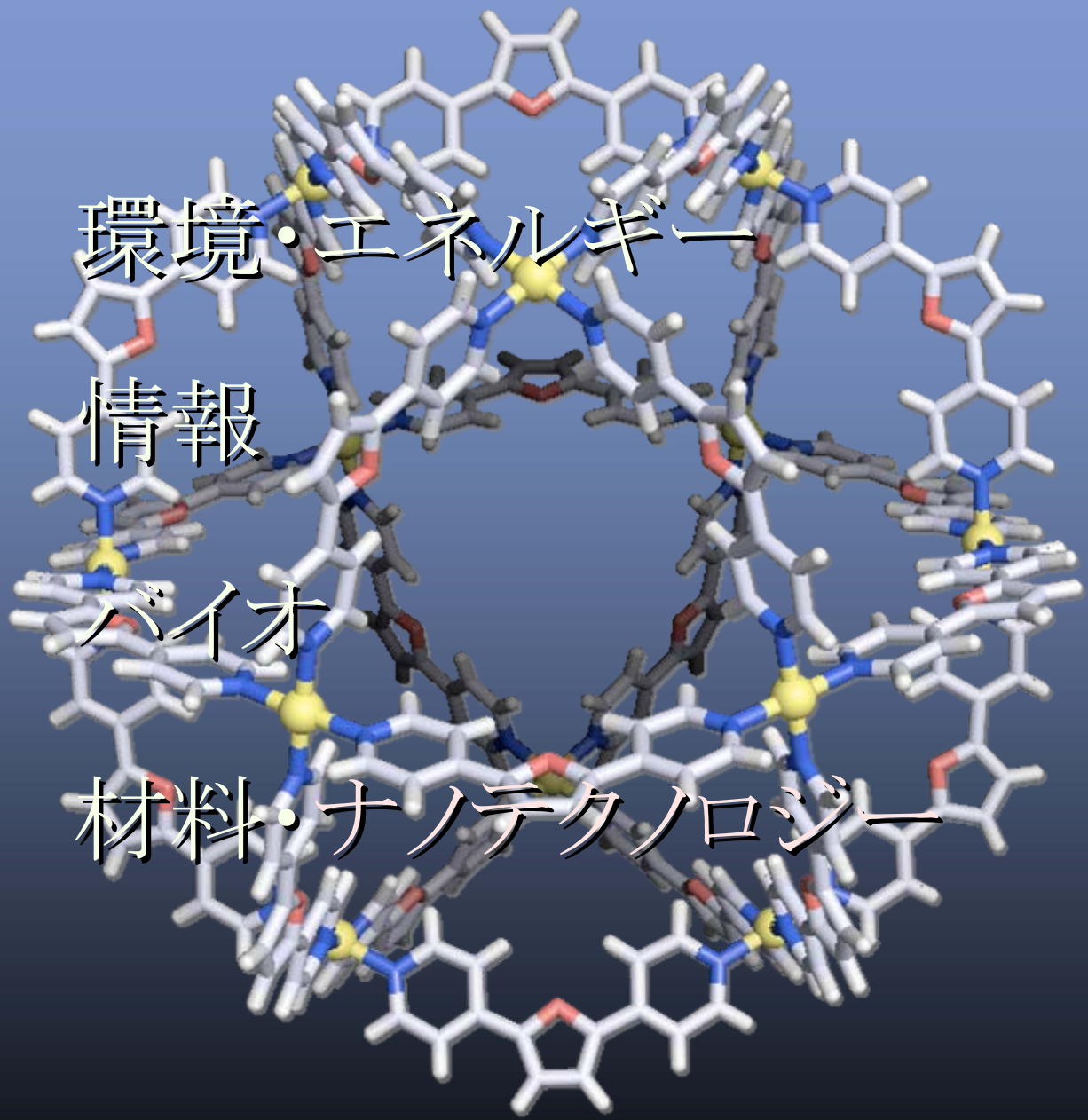



生卵分子
数 nmの中空殻構造内部に
フッ素性液滴をカプセル化
Science **2006**, *313*, 1273

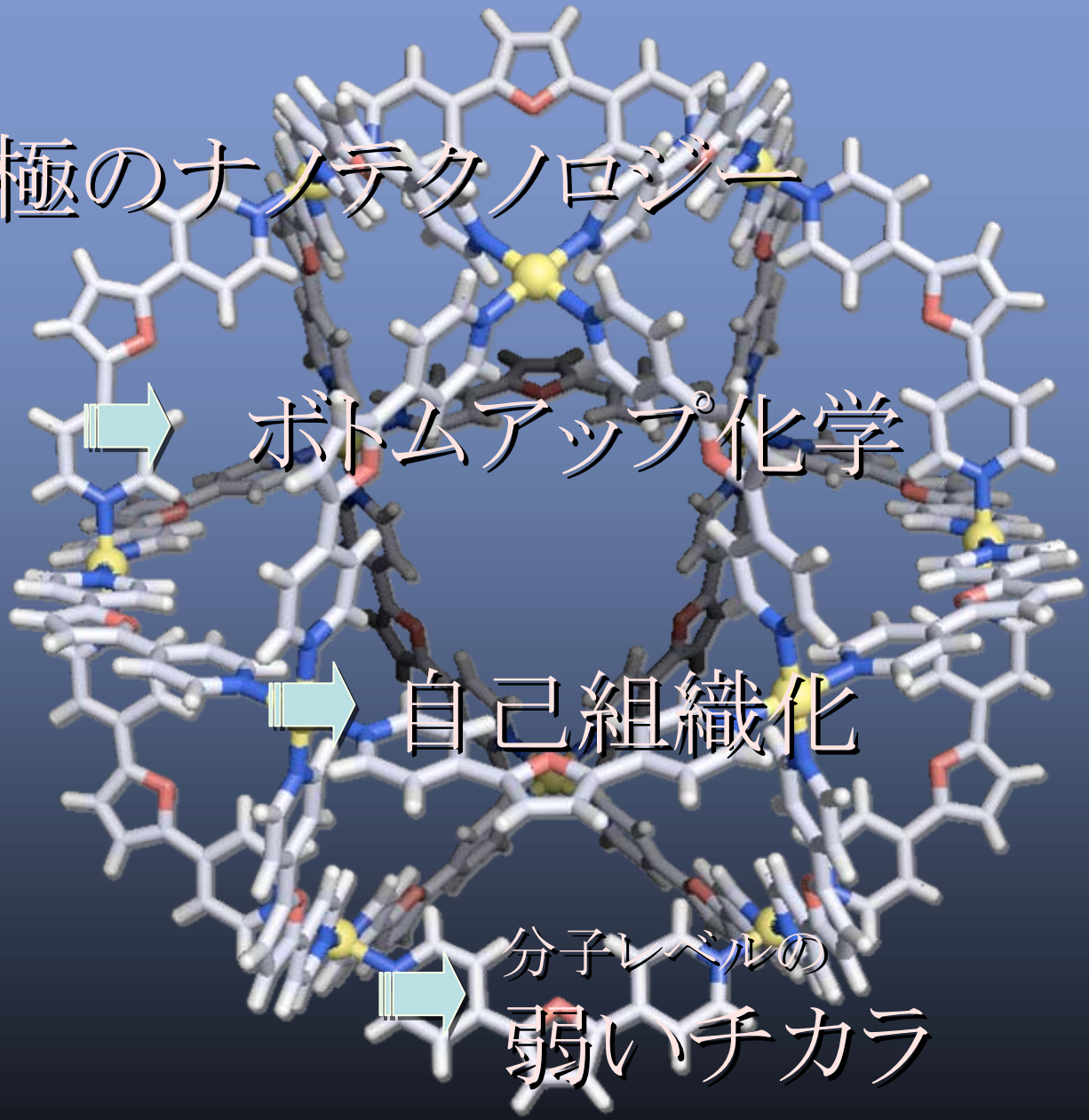


集合分子系の構築　＝　21世紀の分子・物質科学

	原子と原子をつなぐ	分子と分子をつなぐ
生物的手法 （自然界での物質構築）	**酵素反応**	**自己組織化** DNA二重らせん、自己複製 たんぱく質高次構造, etc.
化学的手法 （人工系での物質構築）	**合成化学** 有機金属化学 有機元素化学 が主役	人工系での **自己組織化** 21世紀の分子・物質科学


環境・エネルギー
情報
バイオ
材料・ナノテクノロジー

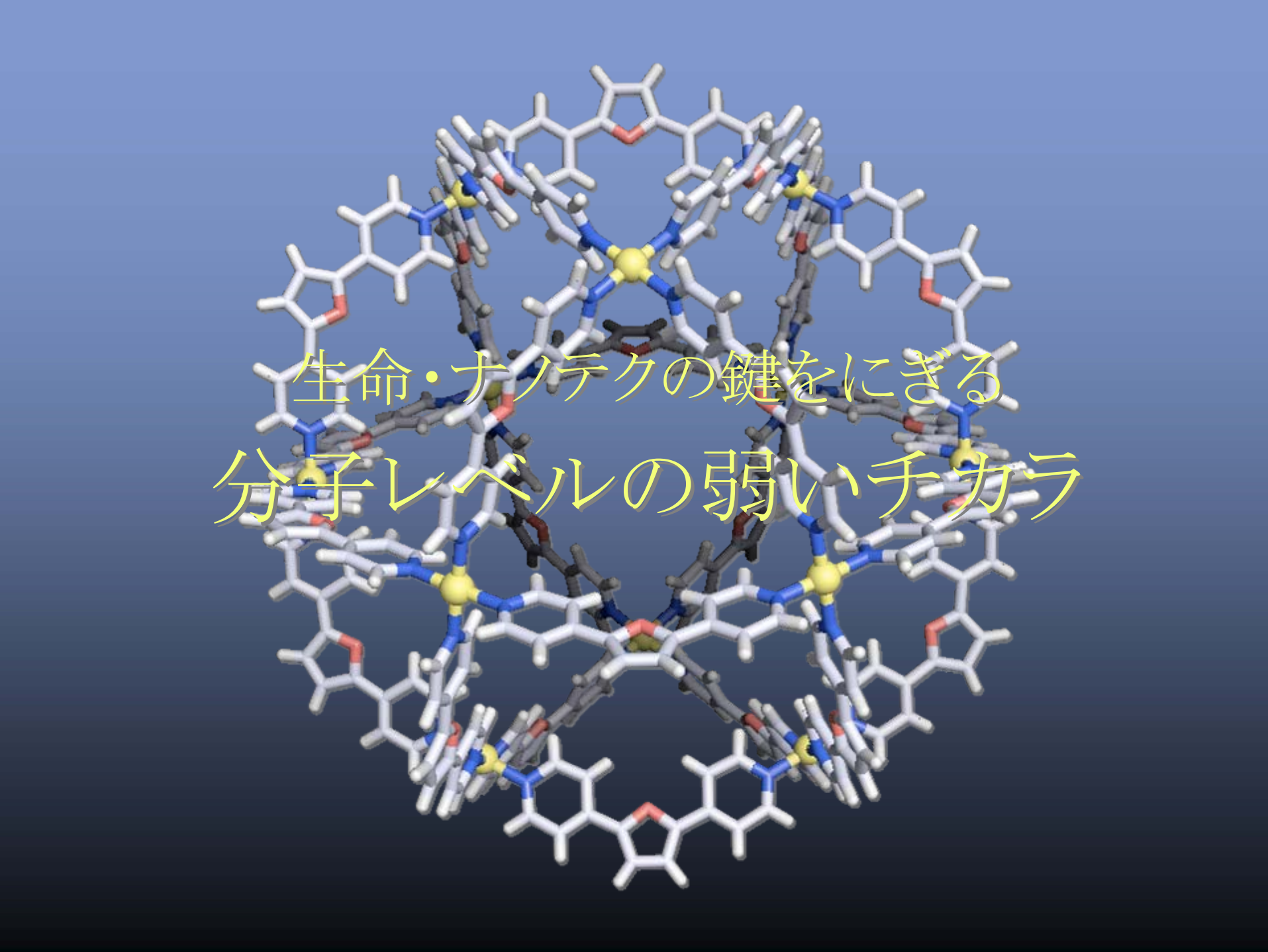
究極のナノテクノロジー

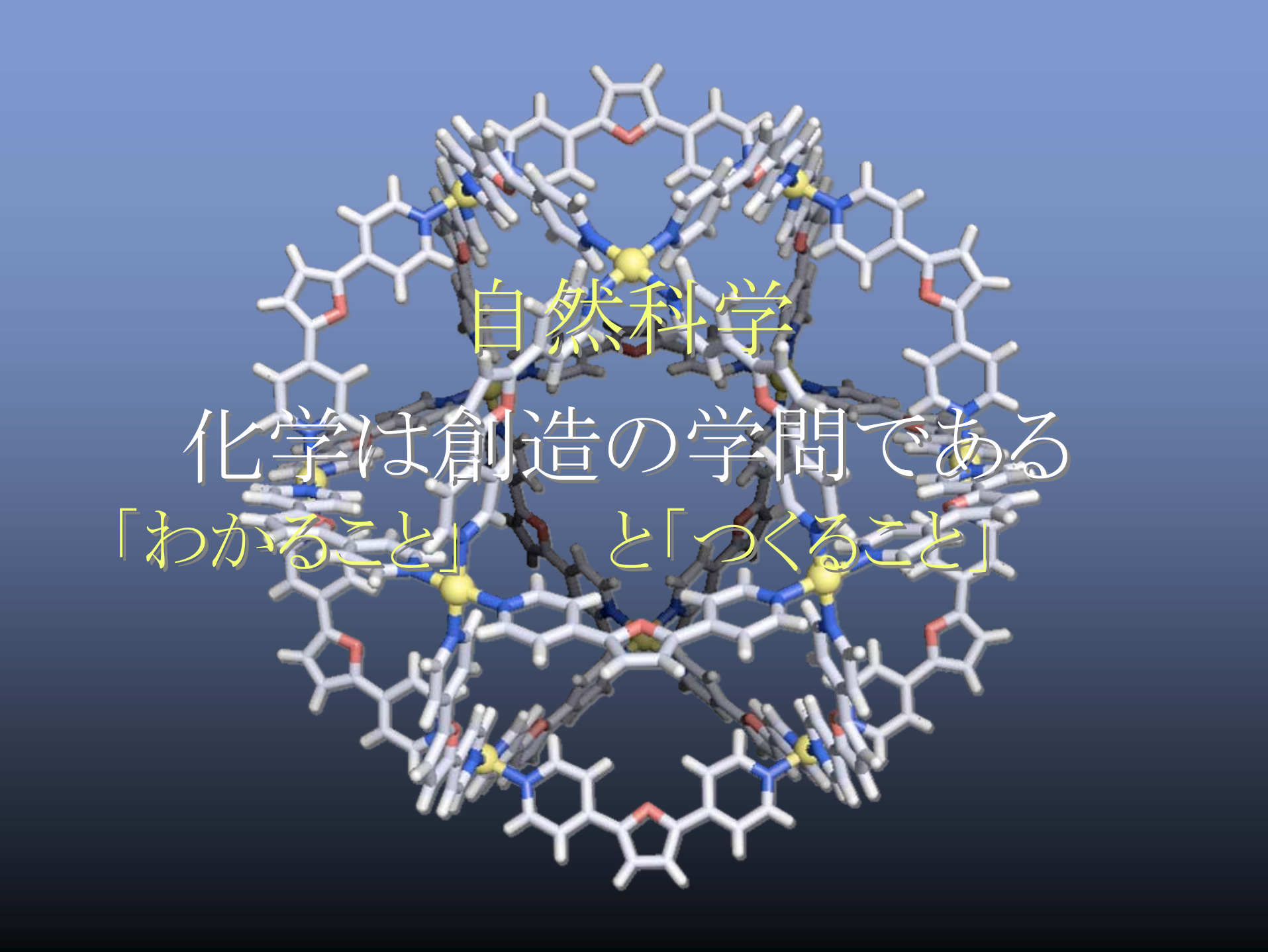


⇒ ボトムアップ化学

⇒ 自己組織化

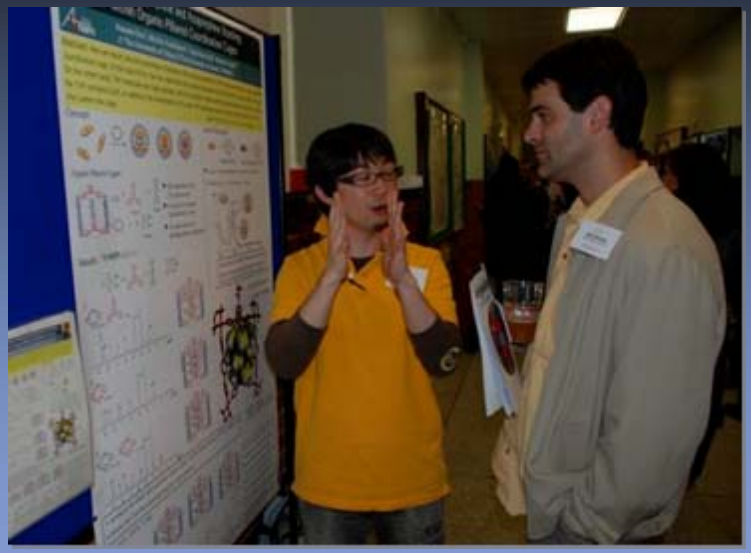
⇒ 分子レベルの
弱いチカラ


生命・ナノテクの鍵をにぎる
分子レベルの弱いチカラ


自然科学
化学は創造の学問である
「わかること」　と「つくること」

研究室風景


ULTRASHIELD
500 PLUS



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http://www.appchem.t.u-tokyo.ac.jp/appchem/labs/fujita/