DNA Bricks

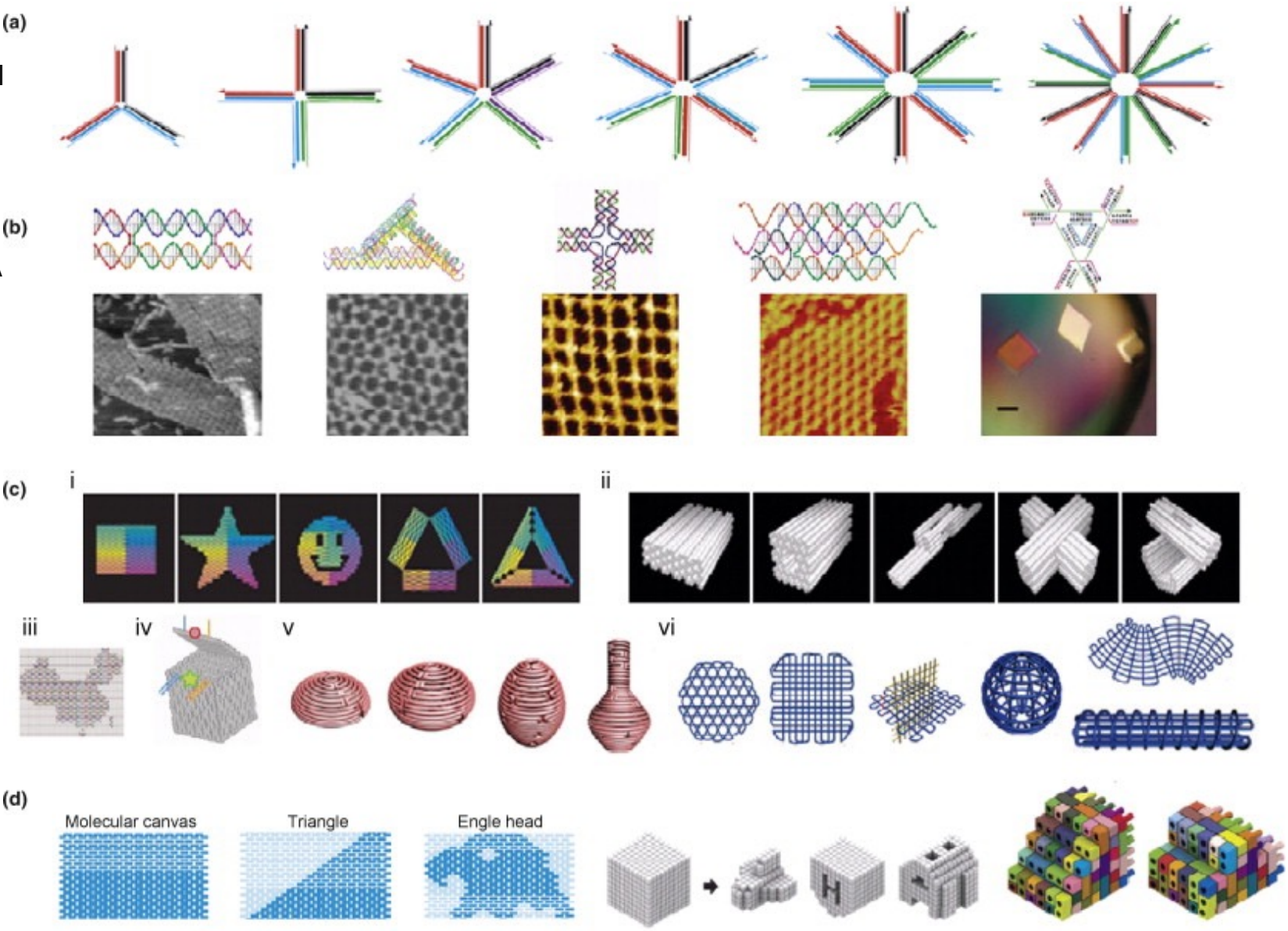
Ke, Y., Ong, L. L., Shih, W. M. & Yin, P. Three-dimensional structures self-assembled from DNA bricks. *Science* **338**, 1177–1183 (2012).

Examples of prior DNA nanostructures:

(a) Immobile nucleic acid junctions: three-arm, four-arm , five-arm, six-arm, eight-arm and even twelve-arm junctions.

(b) Different shaped DNA tiles and their 2D arrays or 3D crystals: DX, DX-triangle, DX-cross, TX, tensegrity triangle;

(c) DNA origami: (i) 2D shapes (ii) complex 3D shapes in a honeycomb-lattice strategy (iii) China map (iv) 3D box (v) 3D structure with complex curvatures;(vi) DNA gridiron nanostructures; (d) 2D and 3D] DNA canvas.

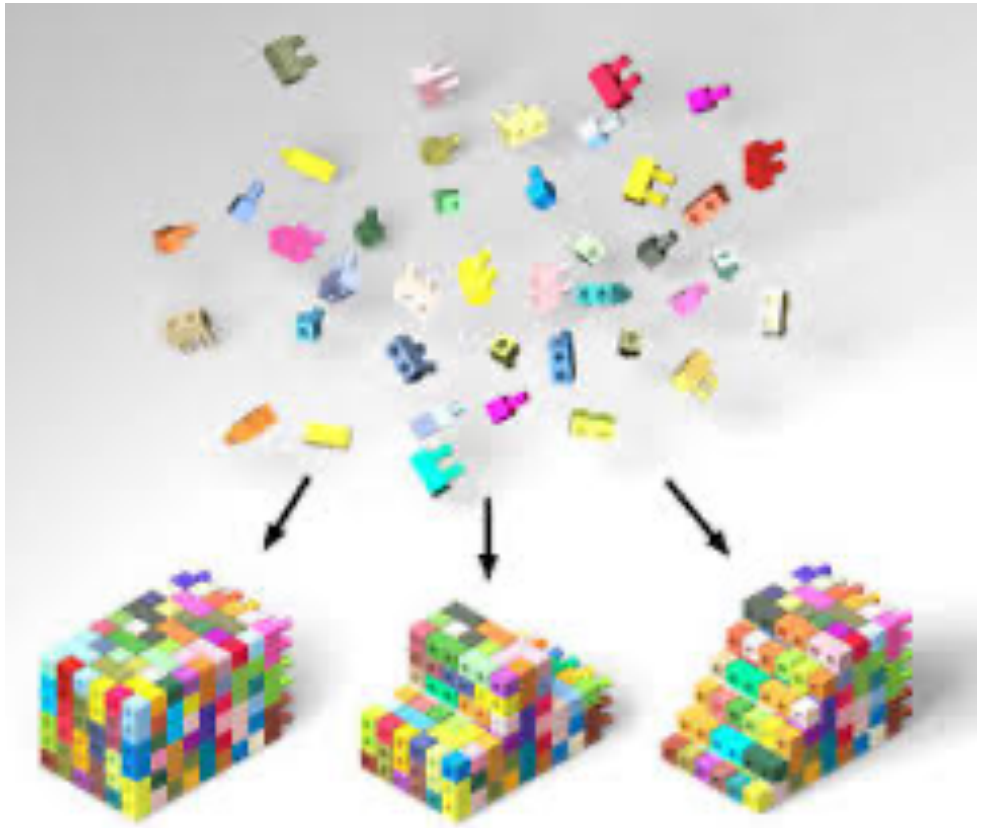


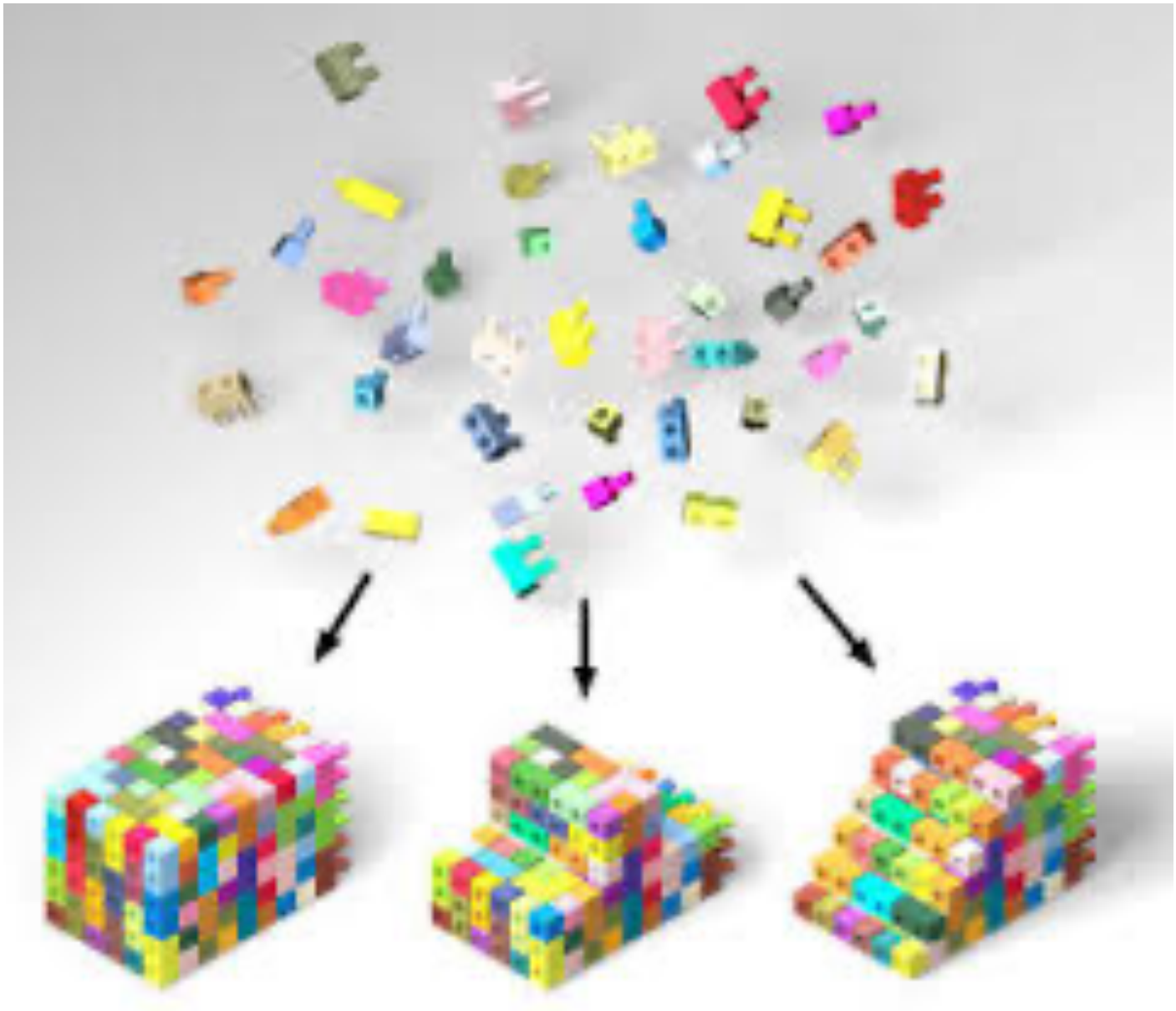
Prior DNA Nanostructures

Legos

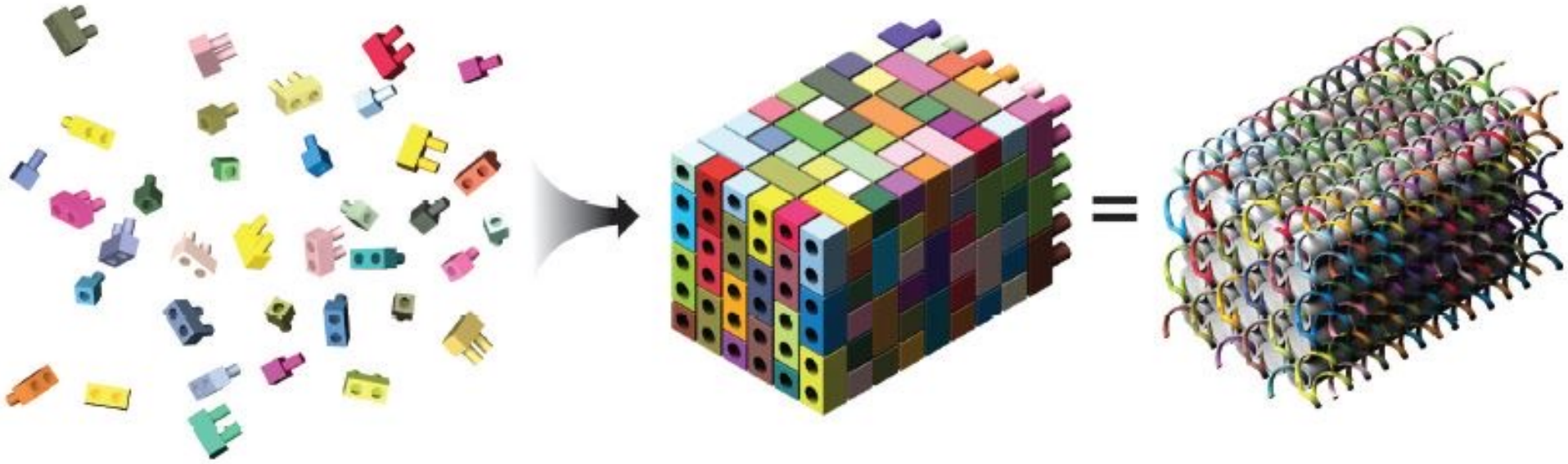
Modular Assembly

Fixed number of part types that interconnect

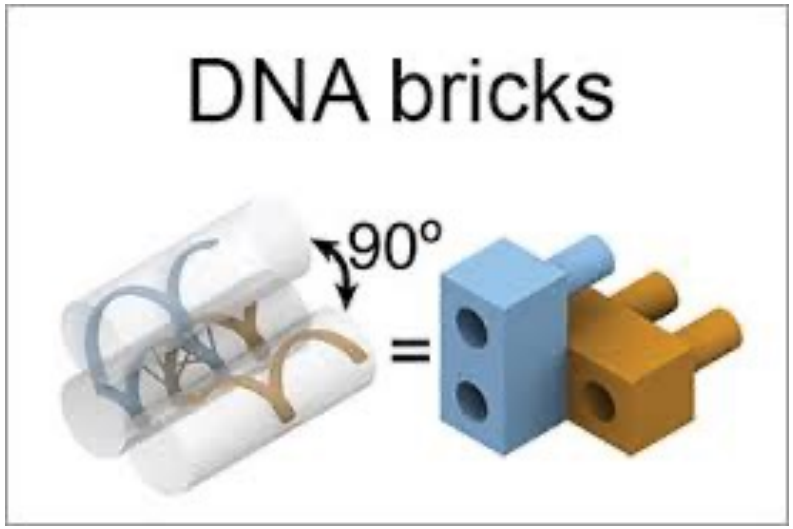




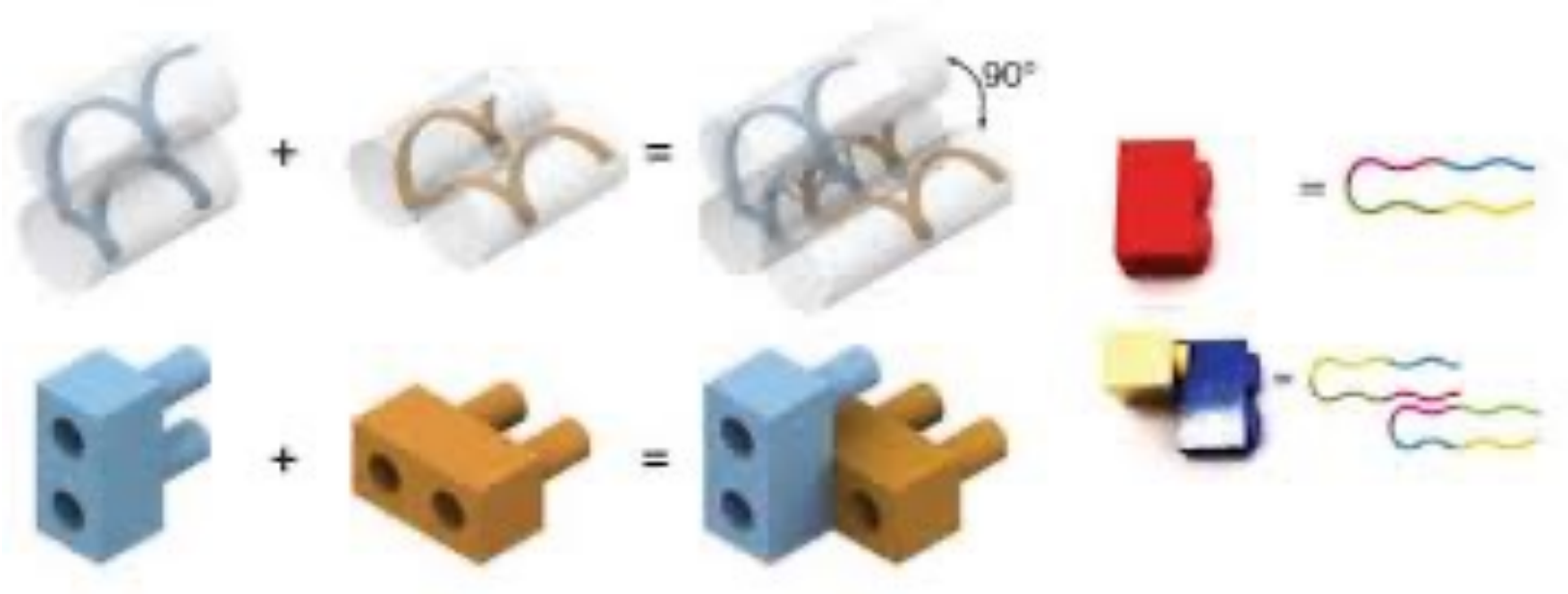
How to use DNA Bricks to Assemble 3D Nanostructures?



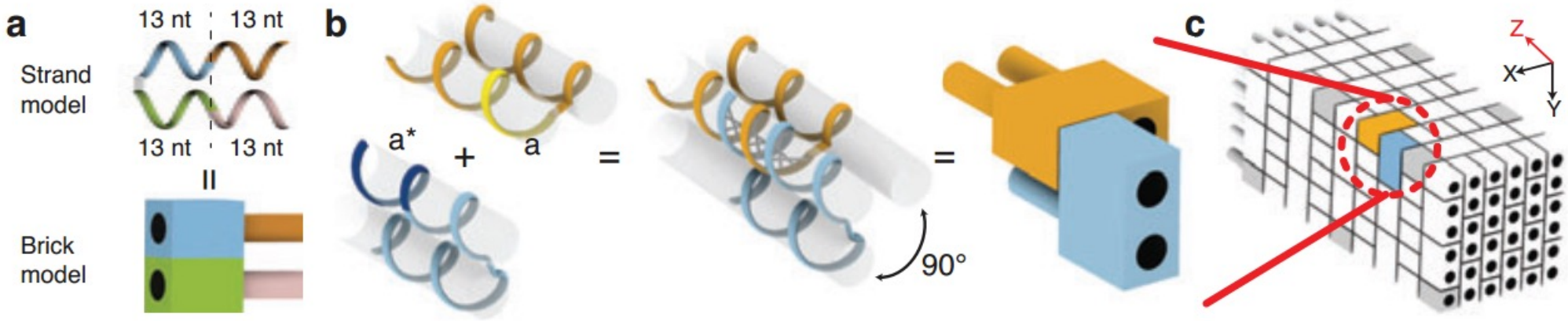
Idea of DNA Brick Self-Assembly



Individual DNA Bricks



Domain length controls size and folding conditions of DNA bricks

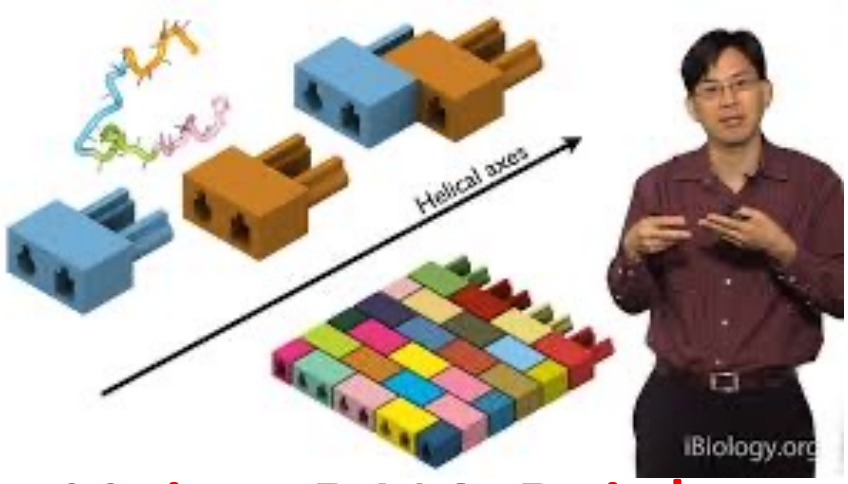


Hybridization Length	$MgCl_2$ (mM)	ΔH (kcal/mol)	ΔS (e.u.)	T_m(°C) @5 nM	T_m (°C) @100 nM
8	40	-62.5	-175.8	16.9	25.1
16	40	-128.1	-352.0	53.0	58.1
13	20	-103.5	-287.0	42.6	48.4
26	20	-210.1	- 576.7	67.1	70.4
13	40	-103.5	- 285.5	44.1	50
26	40	-210.1	- 573.5	68.9	72.2
18.5	40	-148.6	-407.4	58.5	62.9
37	40	-300.3	-817.2	76.9	76.9

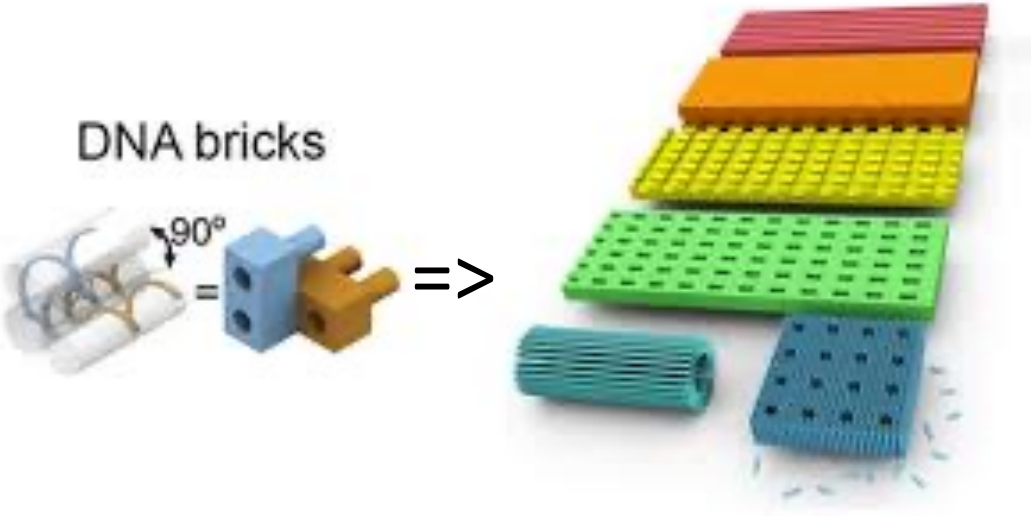
Supplementary Table 2. Average melting temperatures at 5 nM strand concentration and energies. Values are derived from the SantaLucia and calculations are performed following equations 2 to 4.

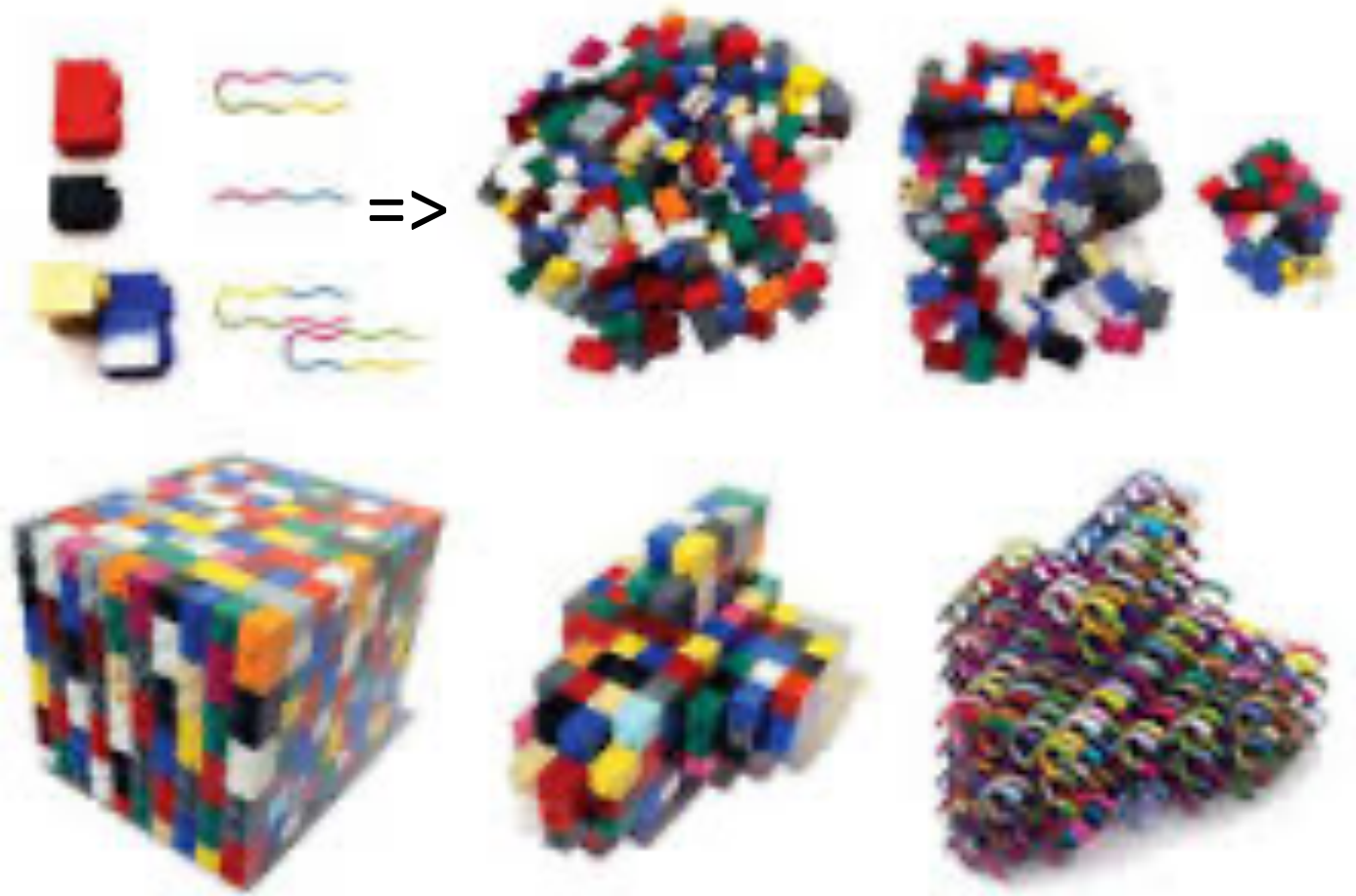
Domain length controls size and folding conditions of DNA bricks.

- **8 nt: 30 repeated domains per 1440 sequences**
- **13 nt: 1 repeated domain per 8000 sequences**
  - **Improved stability due to higher binding energy per component from longer complementary sequences**
  - **Fewer spurious interactions forming incomplete structures**

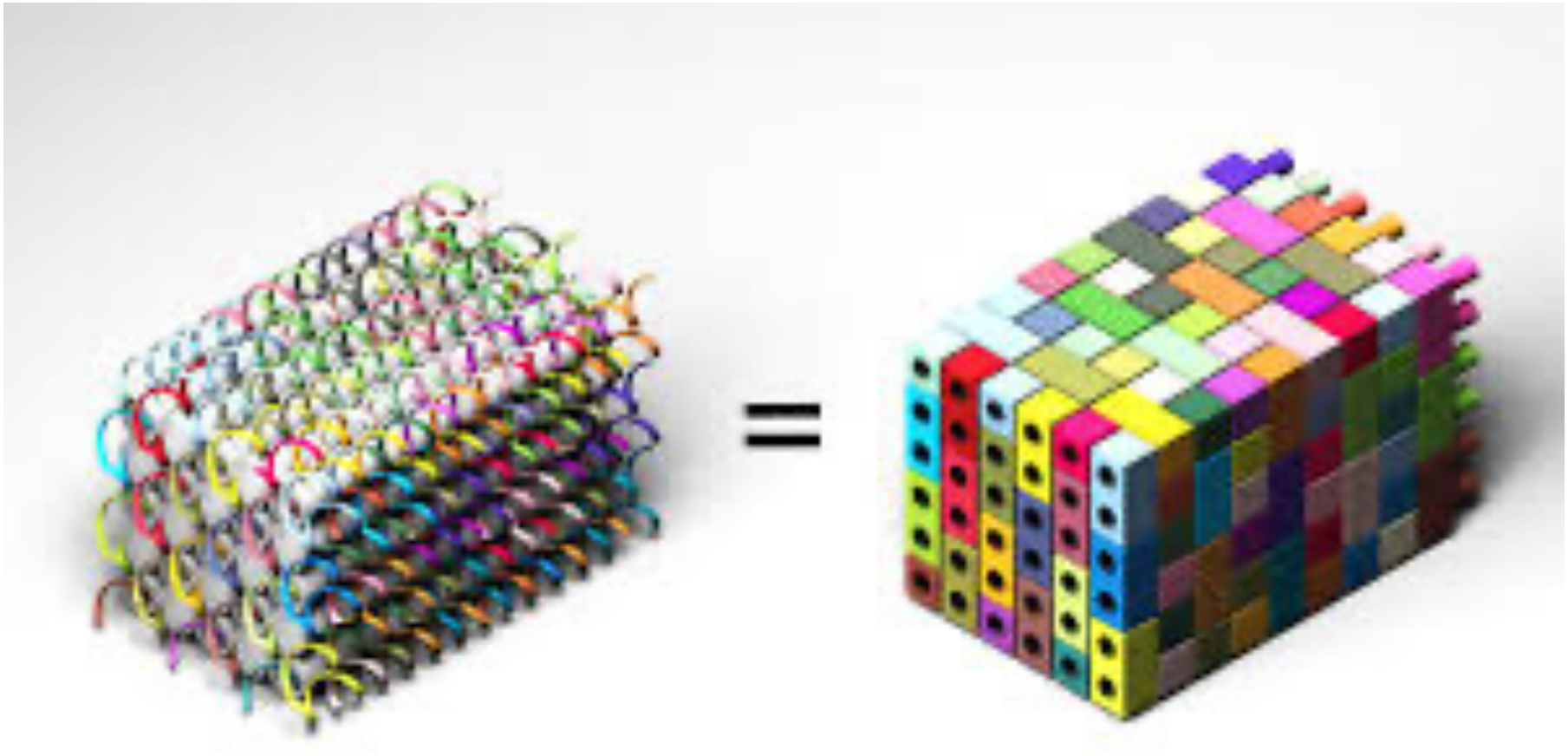


Using DNA Bricks to Assemble 2D Nanostructures

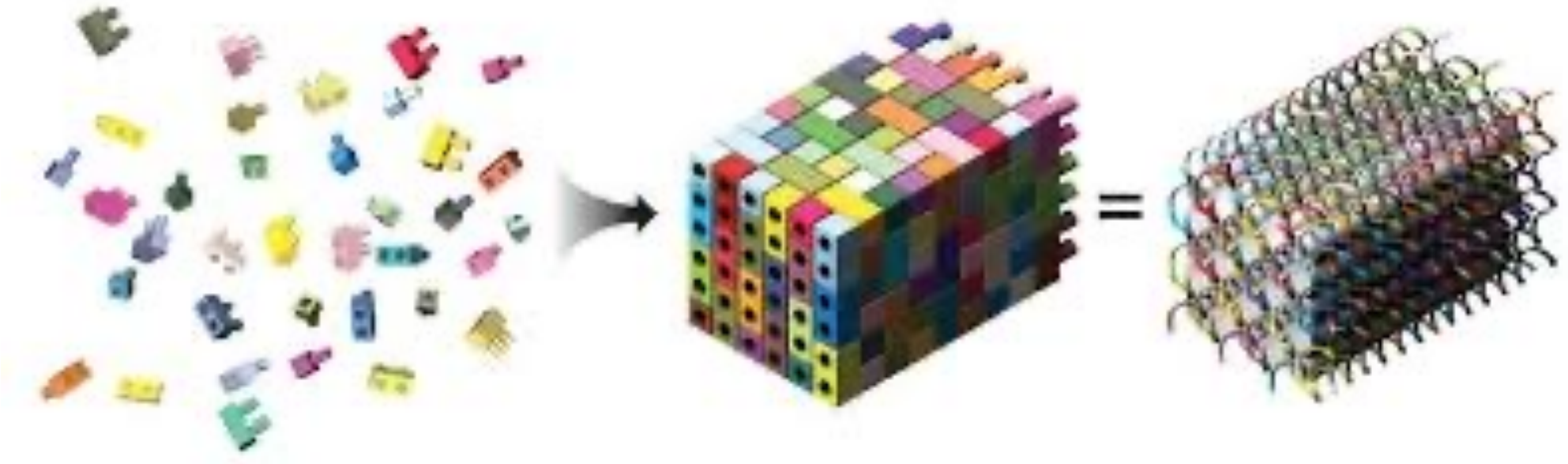




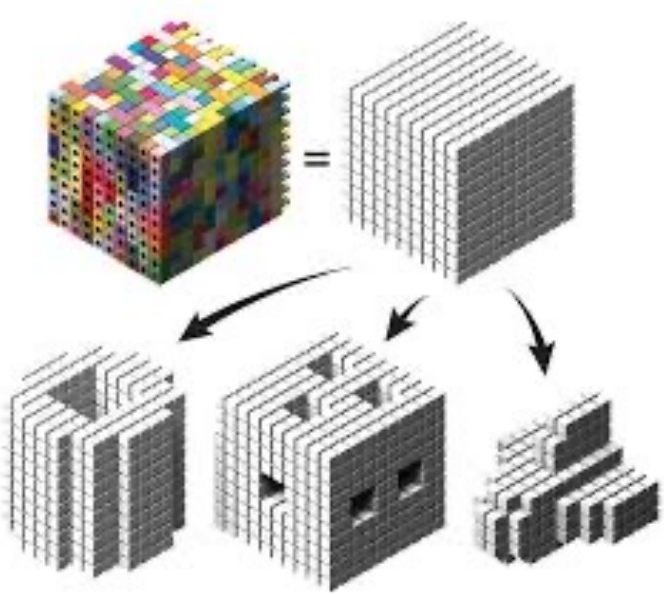
How to use DNA Bricks to Assemble 3D Nanostructures?

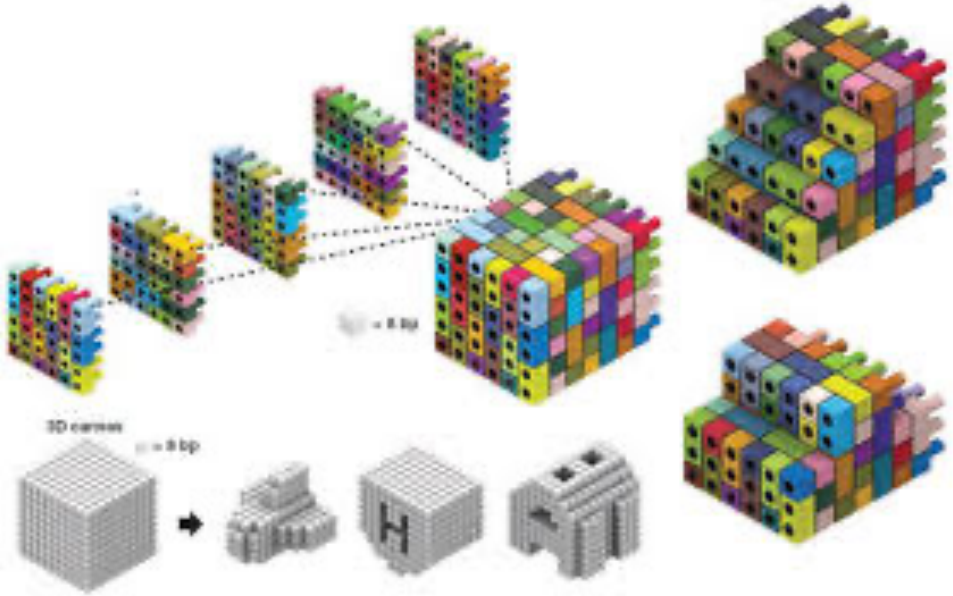


DNA Helices composing 3D Cube



Assembly of 3D Cube from DNA Bricks





Assembly General 3D Shapes from DNA Bricks

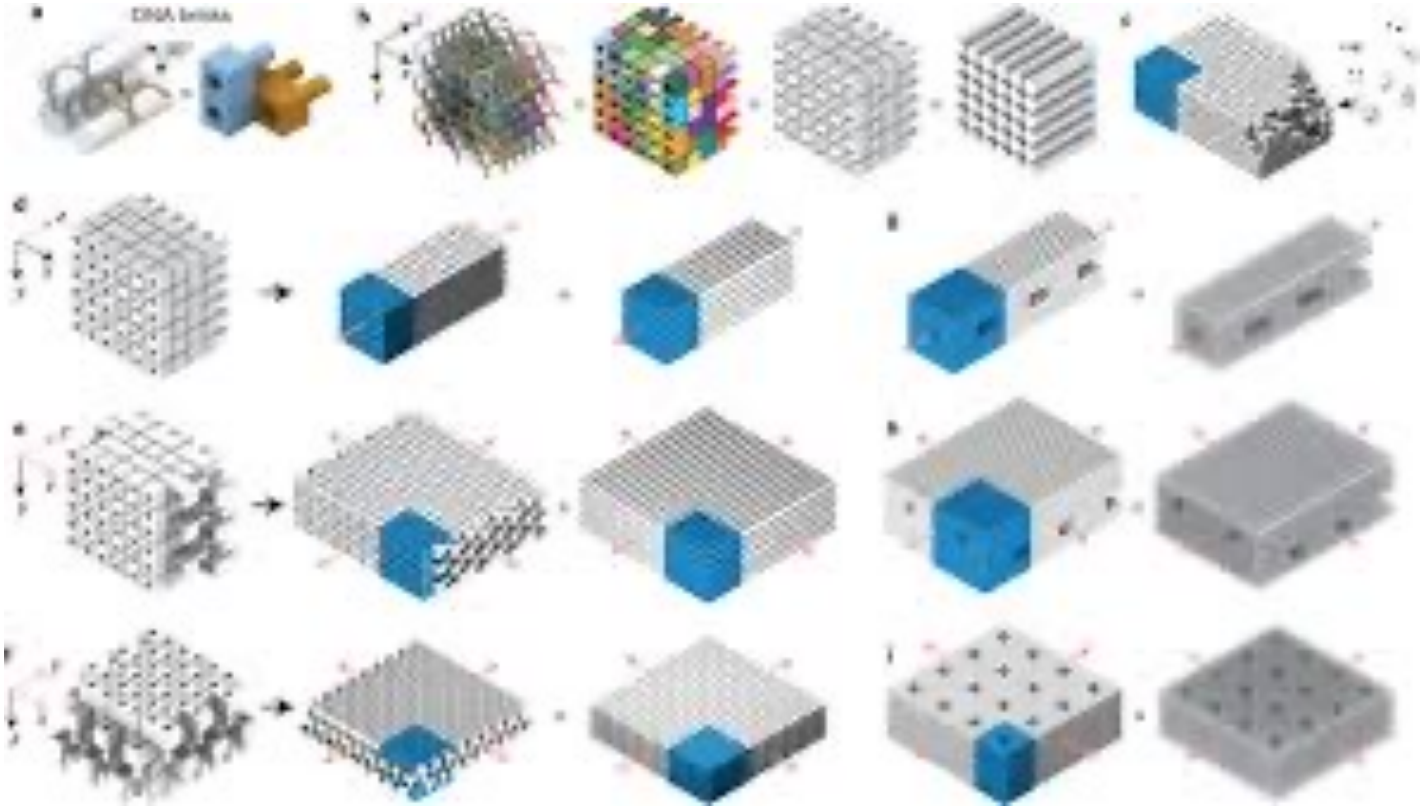


Fig. 1 Design of DNA brick structures analogous to structures built of LEGO® bricks:

(A) A 32-nt four-domain single-stranded DNA brick. Each domain is 8 nt in length. The connected domains 2 and 3 are "head" domains; domains 1 and 4 are "tail" domains.

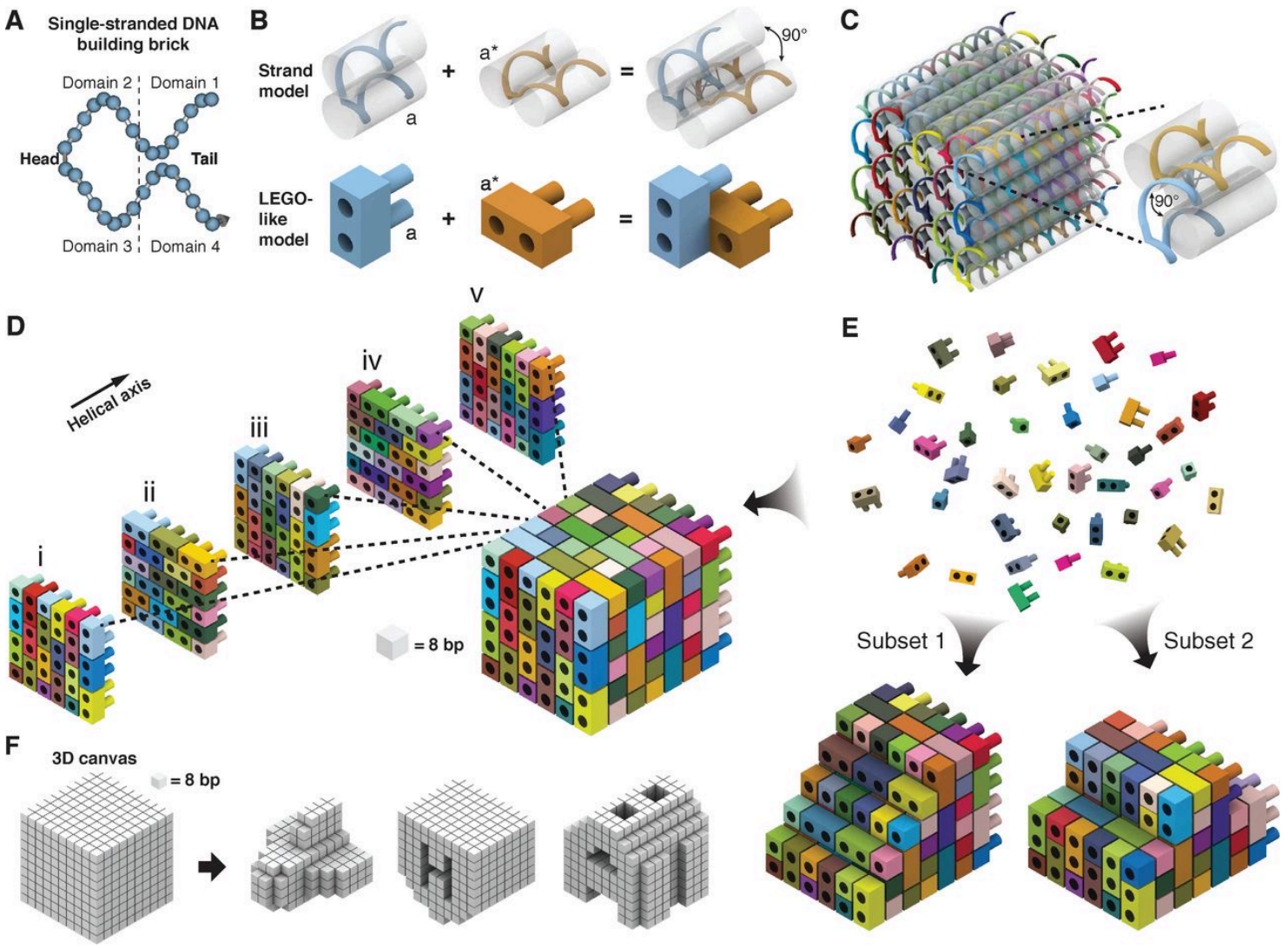
(B) Each two-brick assembly forms a 90° dihedral angle via hybridization of two complementary 8-nt domains "a" and "a*".

(C) A molecular model that shows the helical structure of a 6H by 6H by 48B cuboid 3D DNA structure. Each strand has a particular sequence, as indicated by a distinct color. The inset shows a pair of bricks.

(D) A LEGO-like model of the 6H by 6H by 48B cuboid. Each brick has a particular sequence. The color use is consistent with (B). Half bricks are present on the boundary of each layer.

(E) The 6H by 6H by 48B cuboid is self-assembled from DNA bricks. The bricks are not interchangeable during self-assembly because of the distinct sequence of each brick. Using the 6H by 6H by 48B as a 3D molecular canvas, a smaller shape can be designed by using a subset of the bricks.

(F) 3D shapes designed from a 10 by 10 by 10–voxel 3D canvas; each voxel fits 8 bp (2.5 nm by 2.5 nm by 2.7 nm).



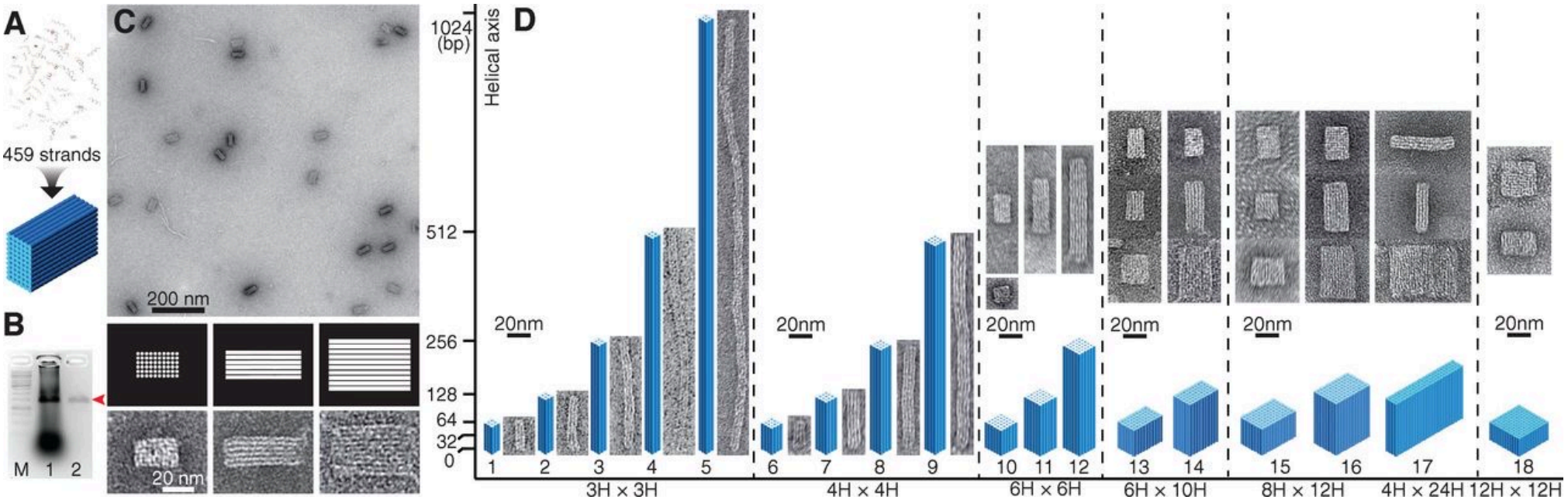
Details of Assembly of 3D Cube from DNA Bricks

Experimental Results

Design:

AFM Imaging:

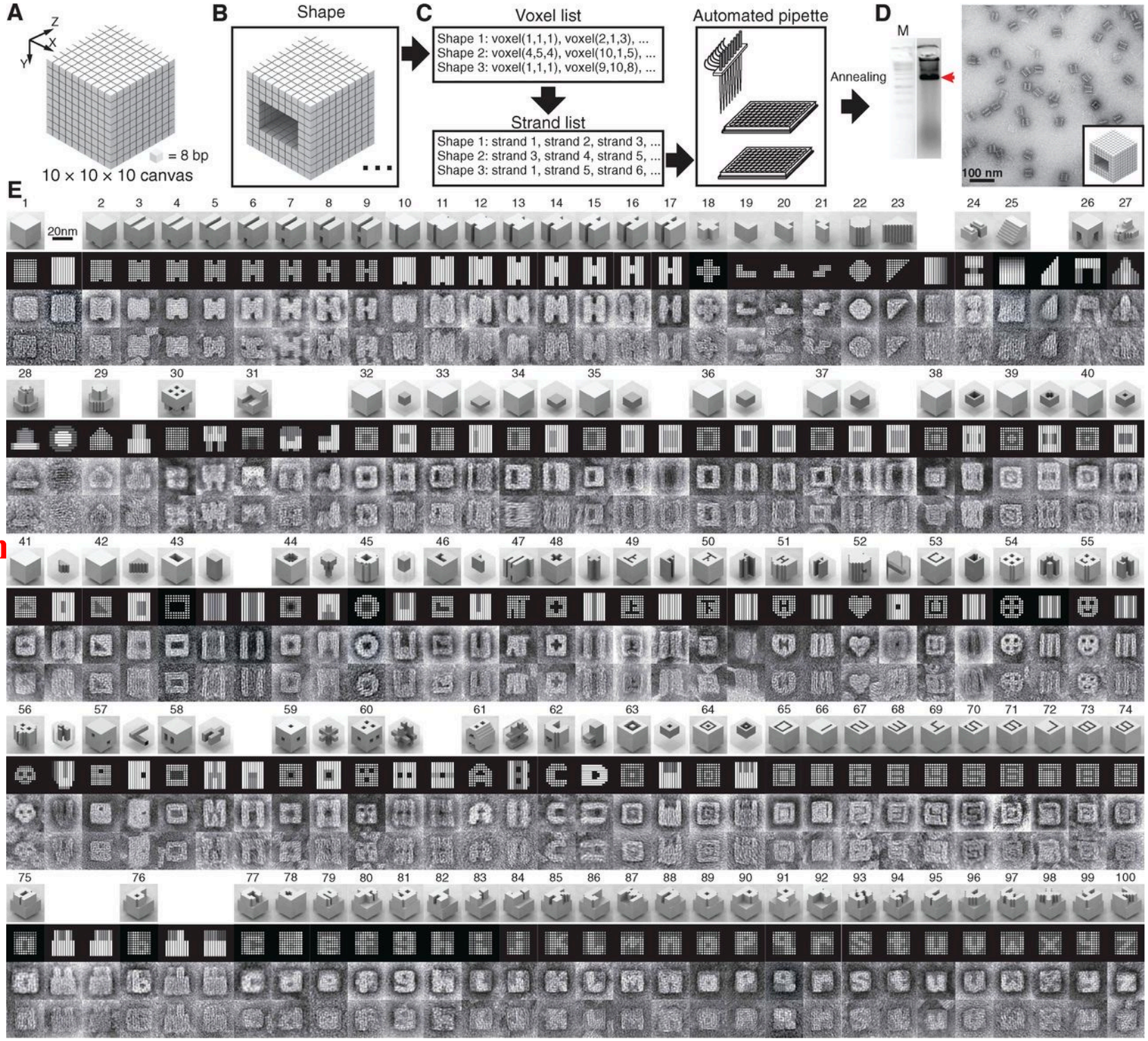
Experimental Results



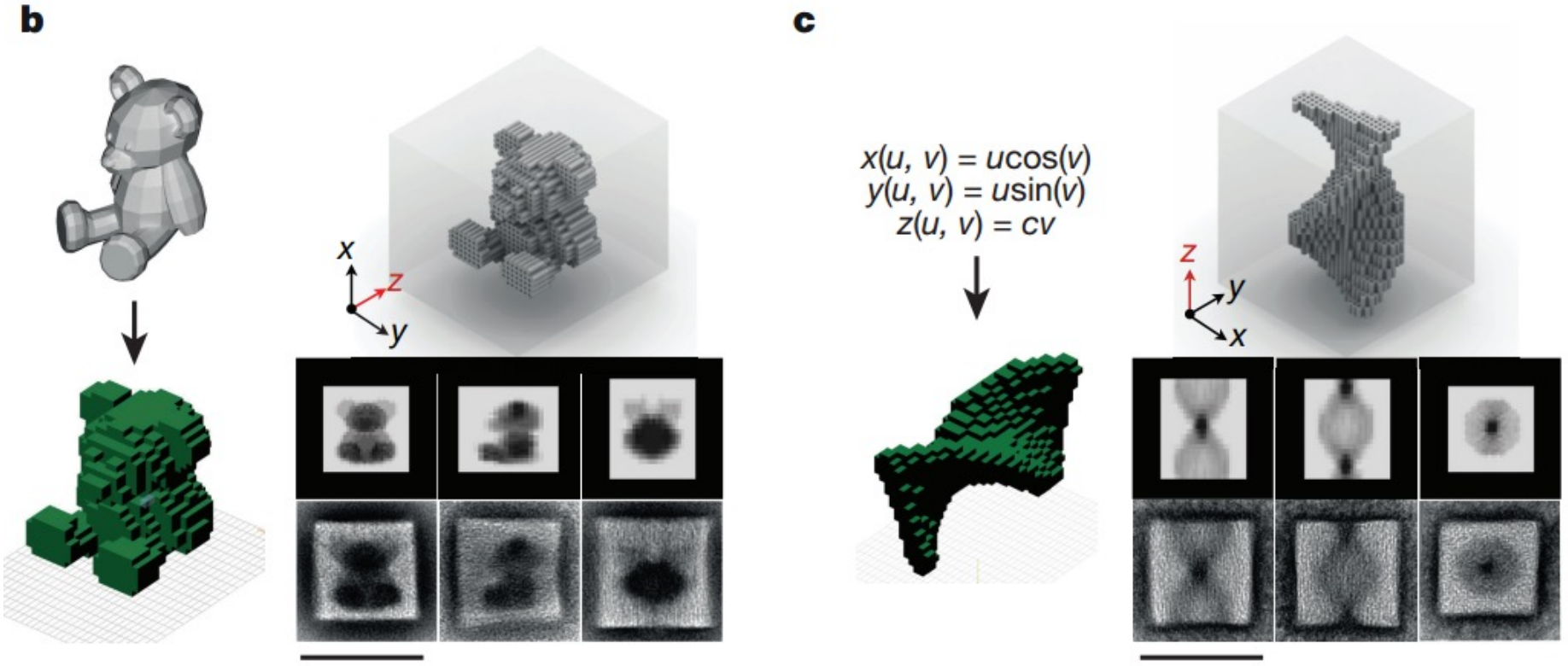
Cuboid structures self-assembled from DNA bricks.

Experimental Results

3D Shapes from self-assembled from DNA bricks.



Complex 3D Shapes using DNA Bricks
Ong et al, Nature 2017



Bricks can be consolidated as voxels and elaborate designs can be implemented within by excluding specific bricks.