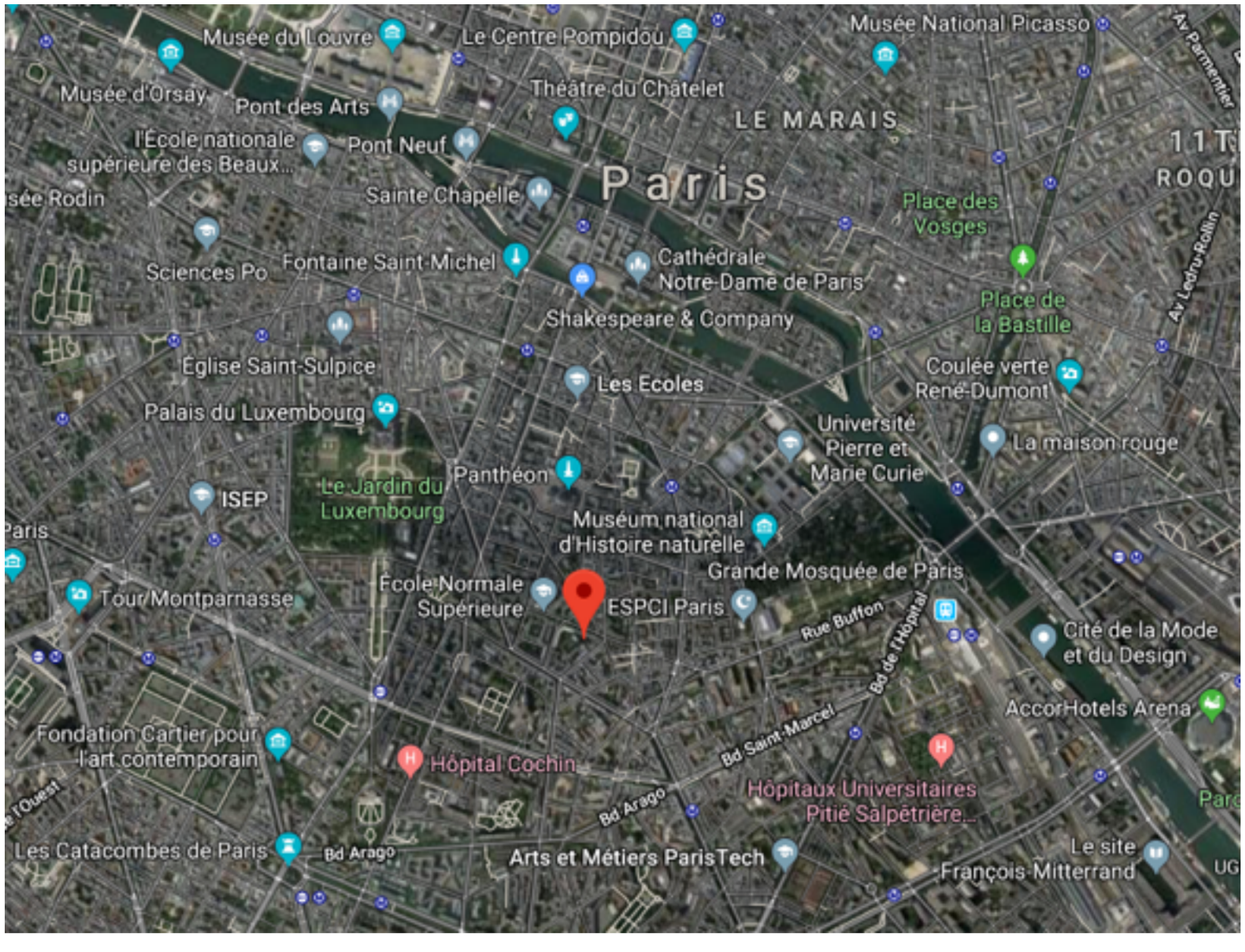
Memories in a Jar

Zorana Zeravcic
Gulliver lab, PCT equipe
ESPCI PSL Research University, Paris

ÉCOLE SUPÉRIEURE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLES DE LA VILLE DE PARIS



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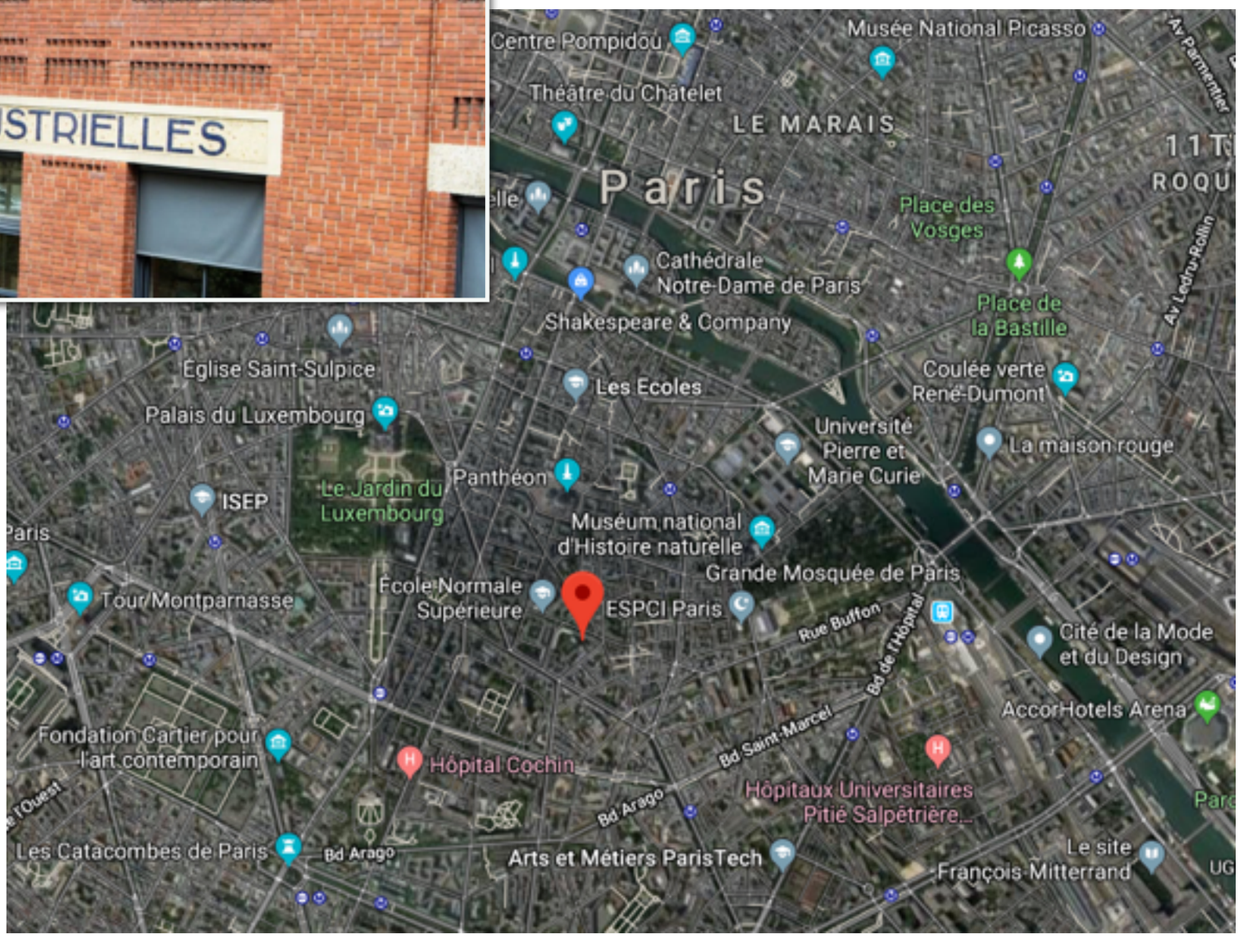

ÉCOLE SUPÉRIEURE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLES DE LA VILLE DE PARIS

- founded in 1882 by the city of Paris
- education is free
- interdisciplinary education - all students take classes in Physics, Chemistry and Biology

ÉCOLE SUPÉRIEURE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLES DE LA VILLE DE PARIS


Marie Curie


Frédéric Joliot-Curie


Pierre-Gilles de Gennes


Georges Charpak

5 researchers and alumni from ESPCI Paris have been awarded the Nobel Prize:

- Pierre and Marie Curie (Physics, 1903),
- Marie Curie - second Nobel Prize (Chemistry, 1911),
- Frédéric Joliot-Curie (Chemistry, 1935),
- Pierre-Gilles de Gennes (Physics, 1991),
- Georges Charpak (Physics, 1992).

- founded in 1882 by the city of Paris
- education is free
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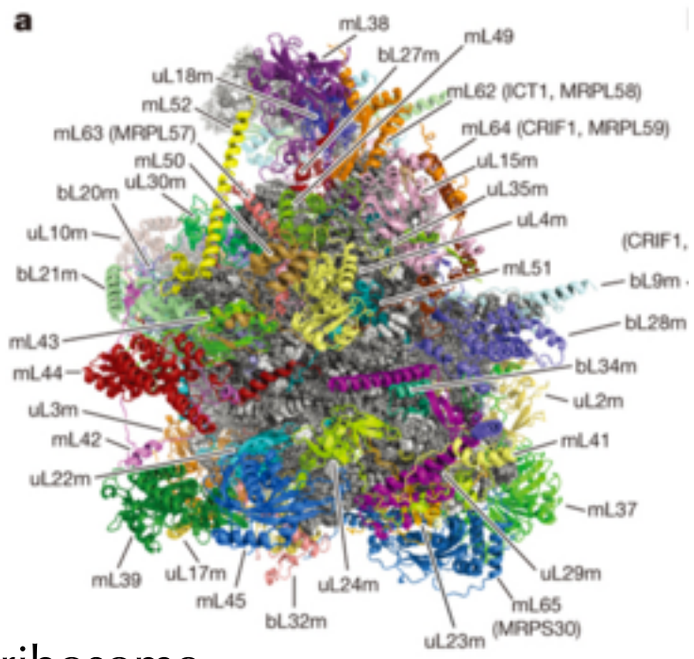
Man-made Stuff

dreamstime.com

Nature-made Stuff



ribosome -
small subunit Greber *et al*. Nature 2014

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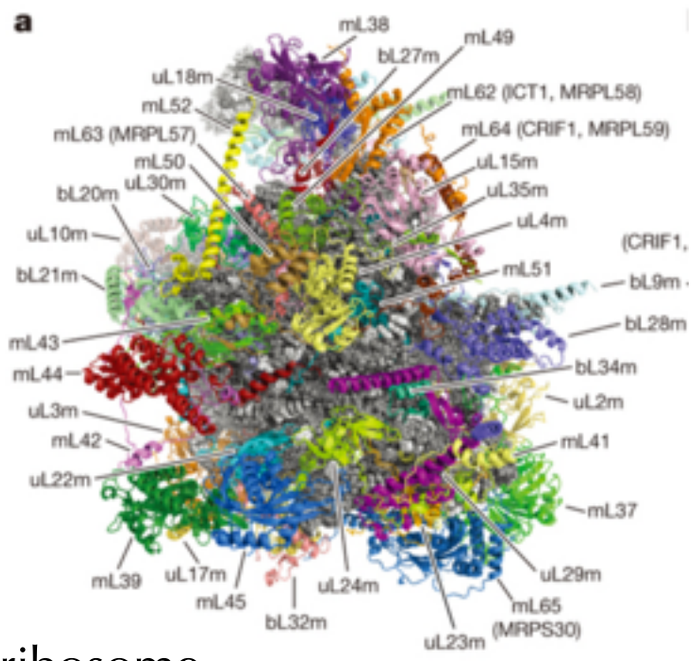
dreamstime.com

dutchforce.com

Nature-made Stuff



ribosome -
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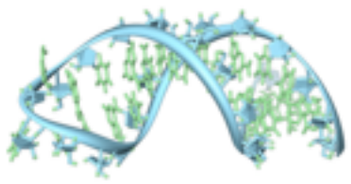
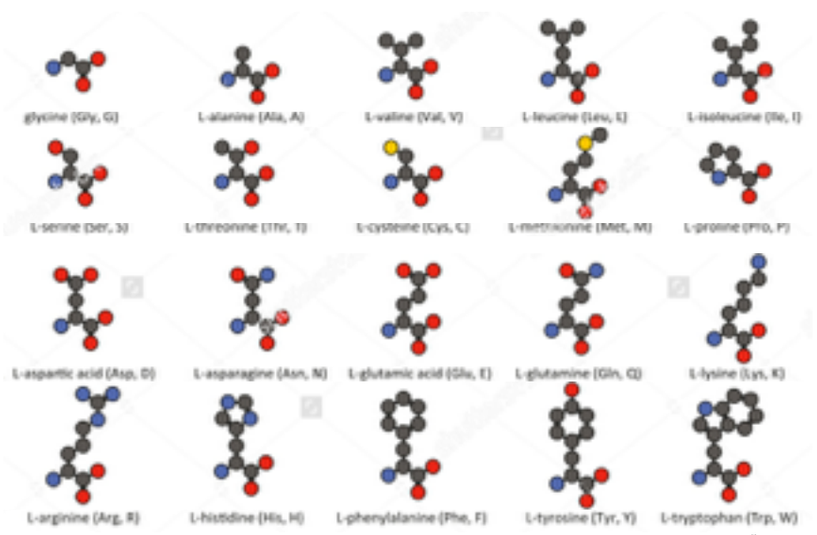
BUILDING BLOCKS

RNA





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amino acids

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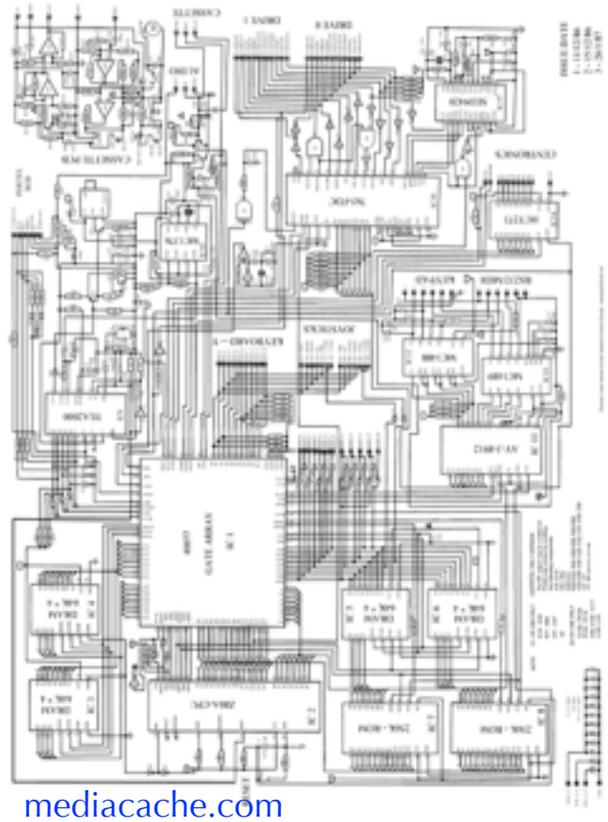
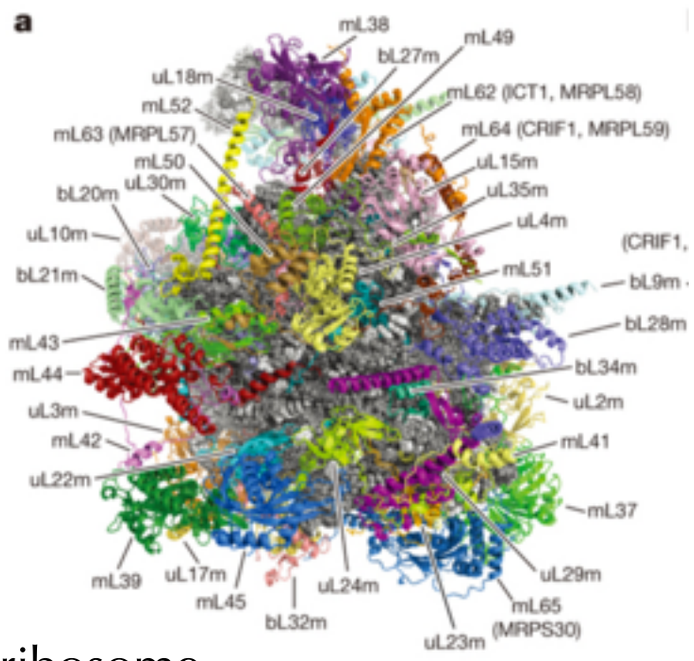
dreamstime.com

dutchforce.com



mediacache.com

Nature-made Stuff



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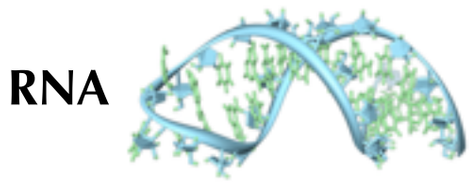


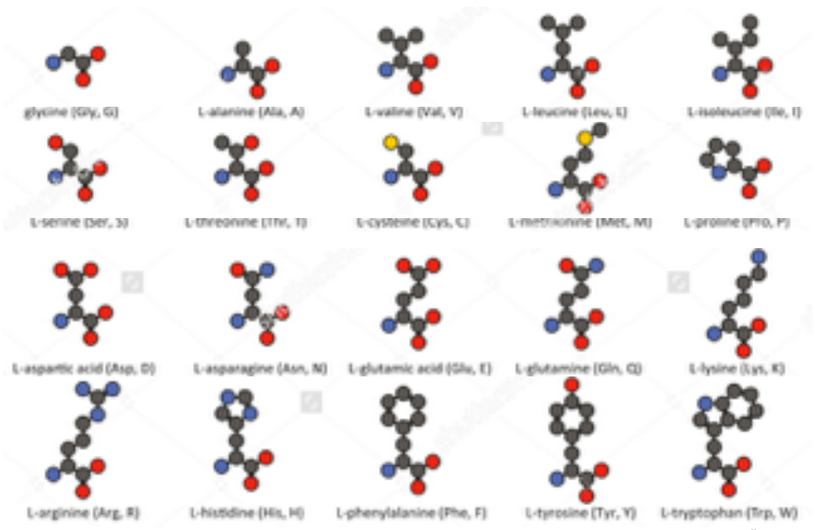
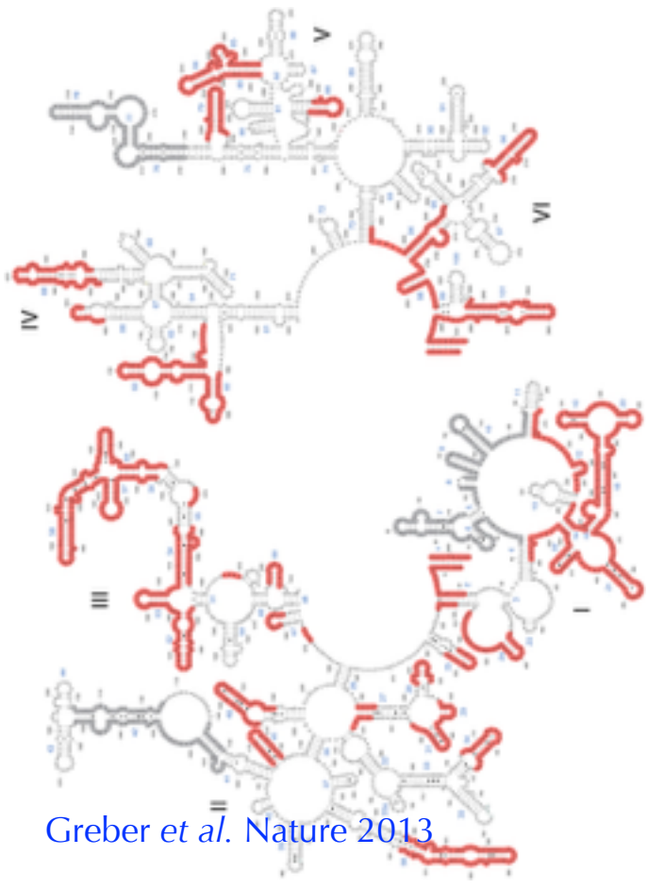


image.shutterstock.com amino acids

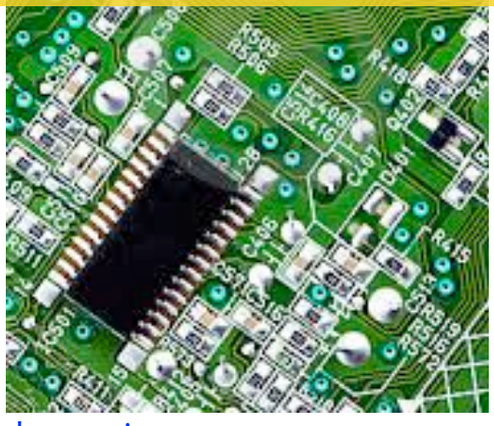
BLUEPRINT



Greber *et al.* Nature 2013

Man-made Stuff

TOP-DOWN (assembly line)



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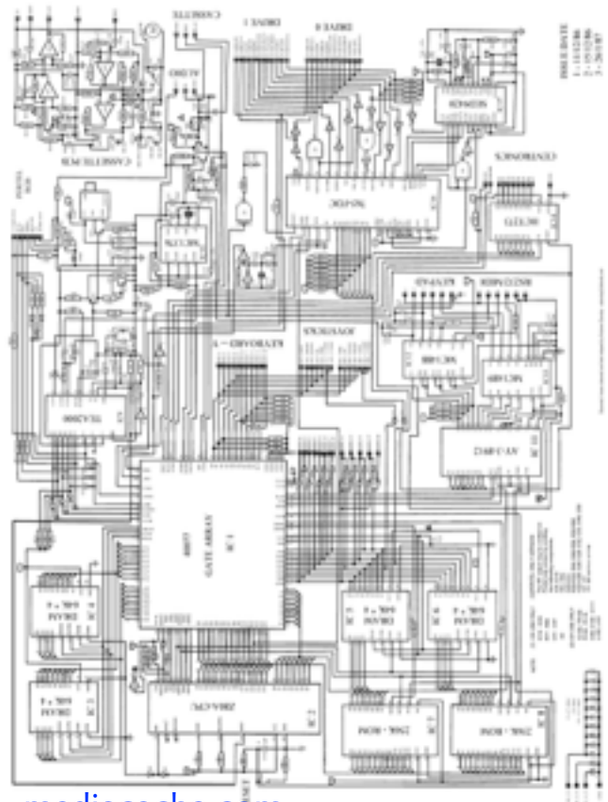
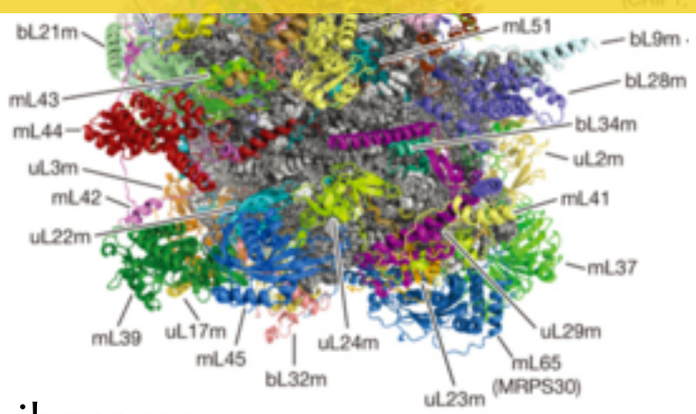


mediacache.com

Nature-made Stuff

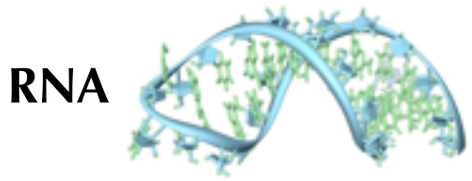
BOTTOM-UP (self-assembly)

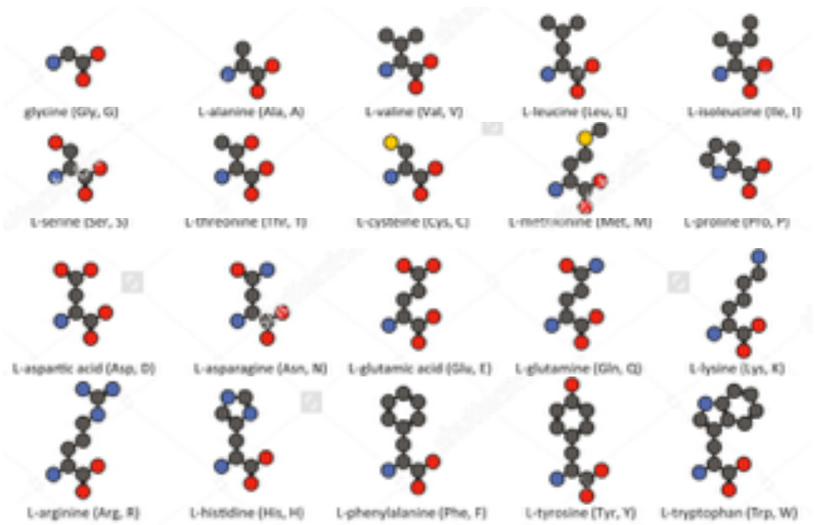


ribosome - small subunit Greber *et al.* Nature 2014

BUILDING BLOCKS

RNA





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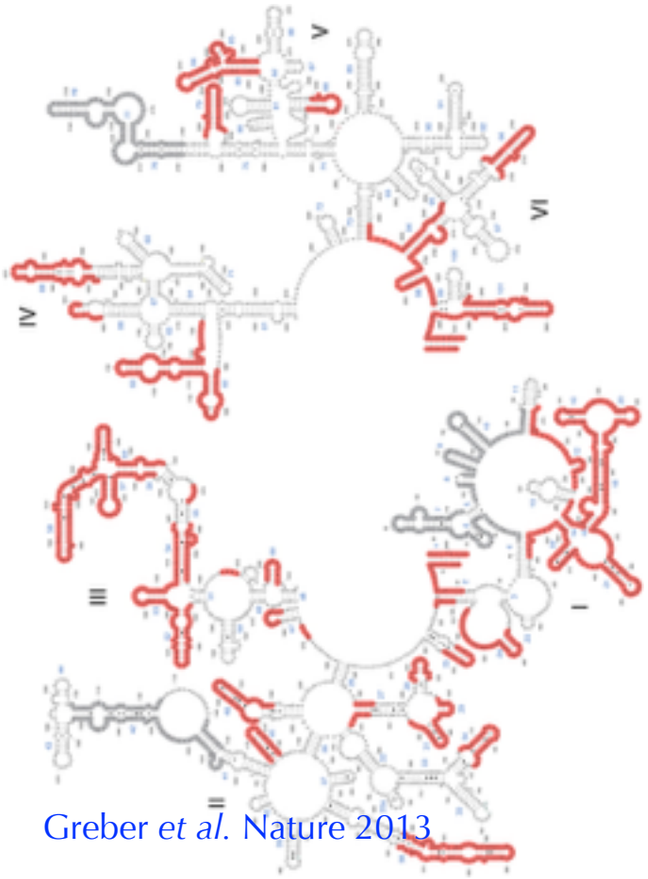

Greber *et al.* Nature 2013

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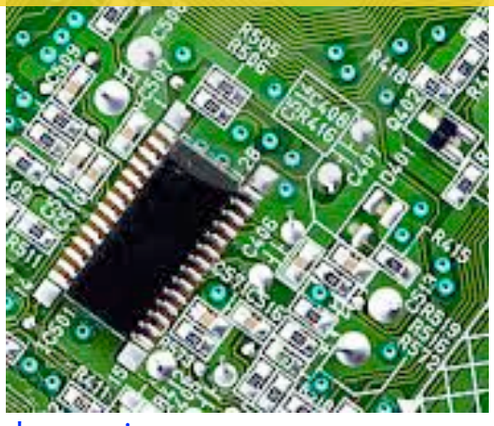

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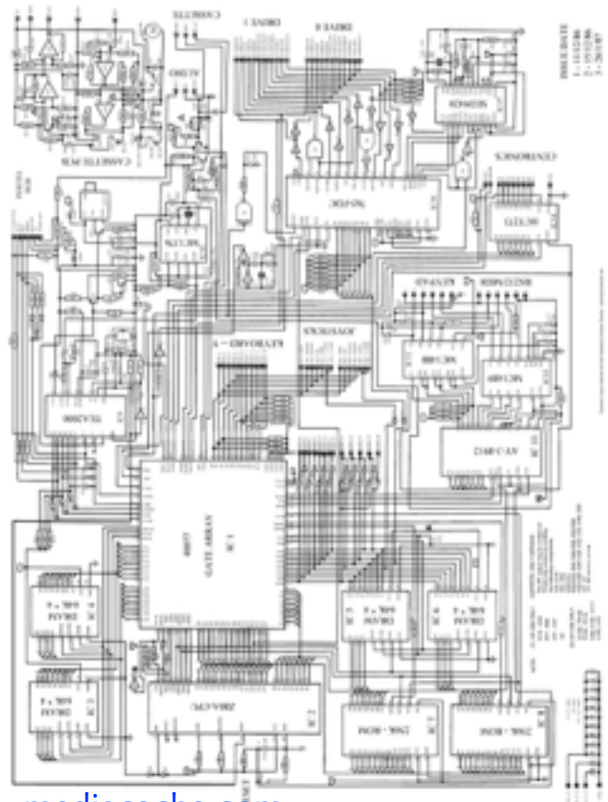

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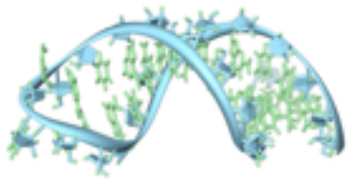
Nature-made Stuff

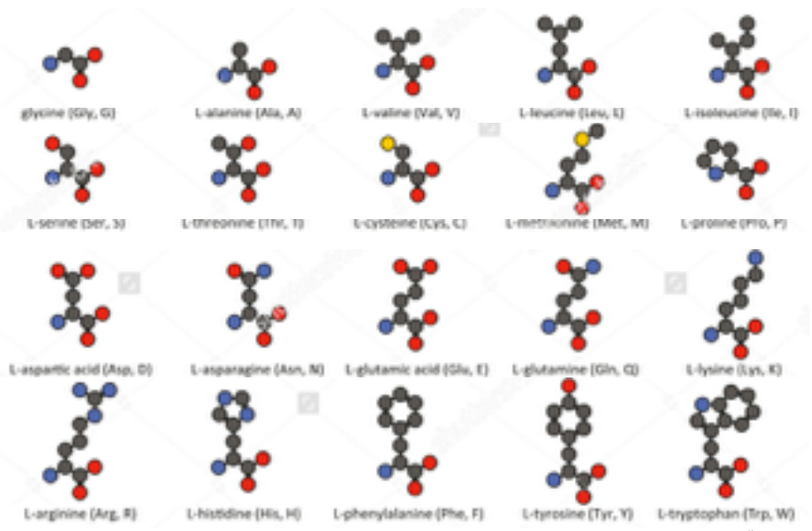
BOTTOM-UP (self-assembly) can: REPAIR ITSELF **REPLICATE** **ADAPT** **EVOLVE**

ribosome - small subunit Greber *et al.* Nature 2014

BUILDING BLOCKS

RNA





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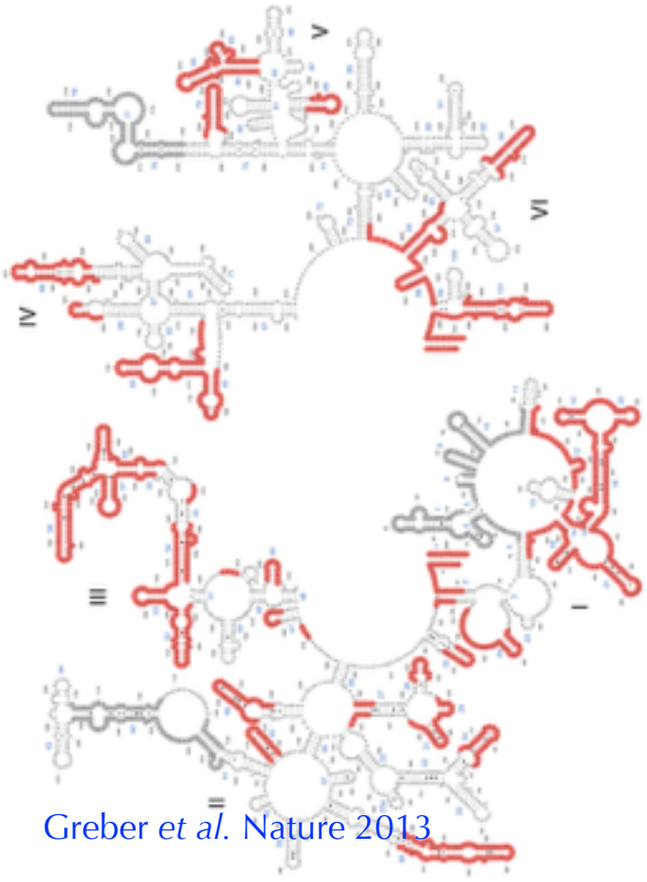

Greber *et al.* Nature 2013

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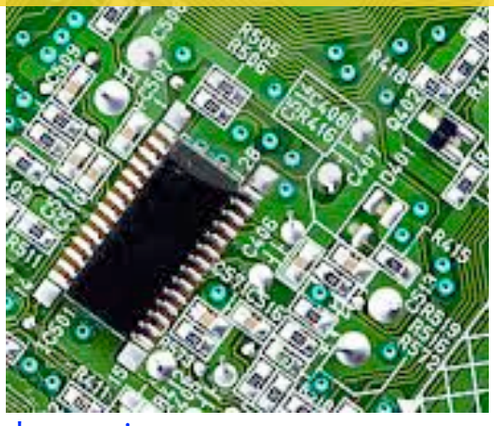

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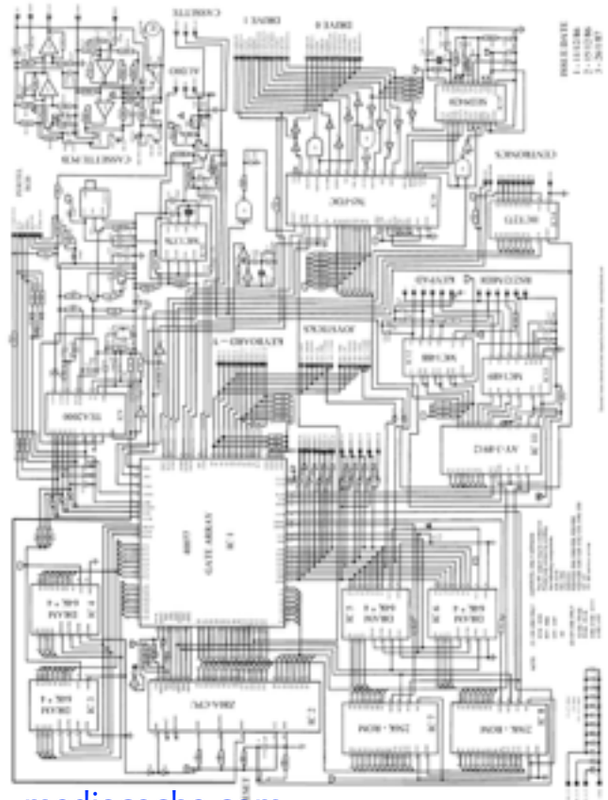

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Nature-made Stuff

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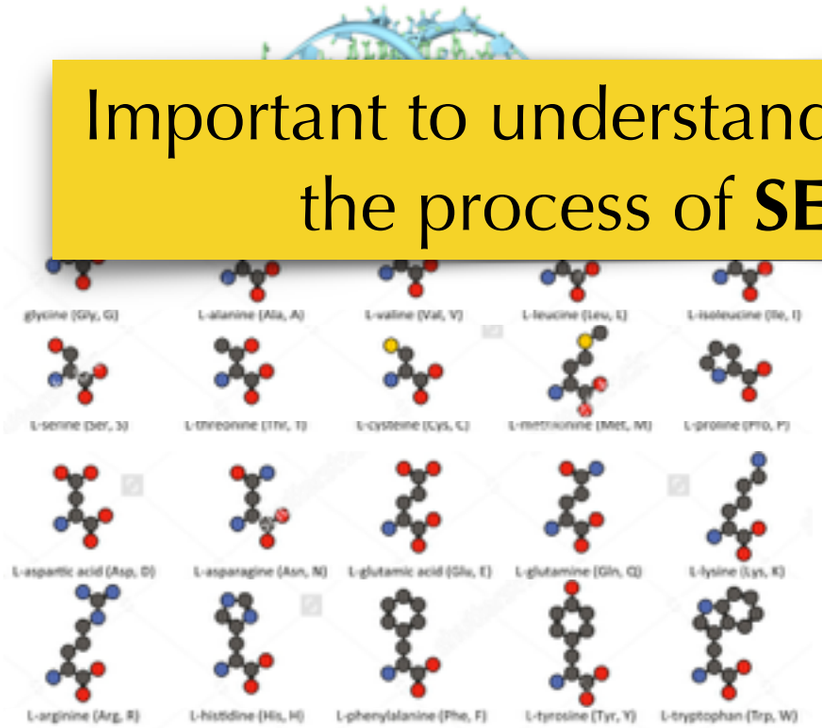
ribosome - small subunit Greber *et al.* Nature 2014

BUILDING BLOCKS



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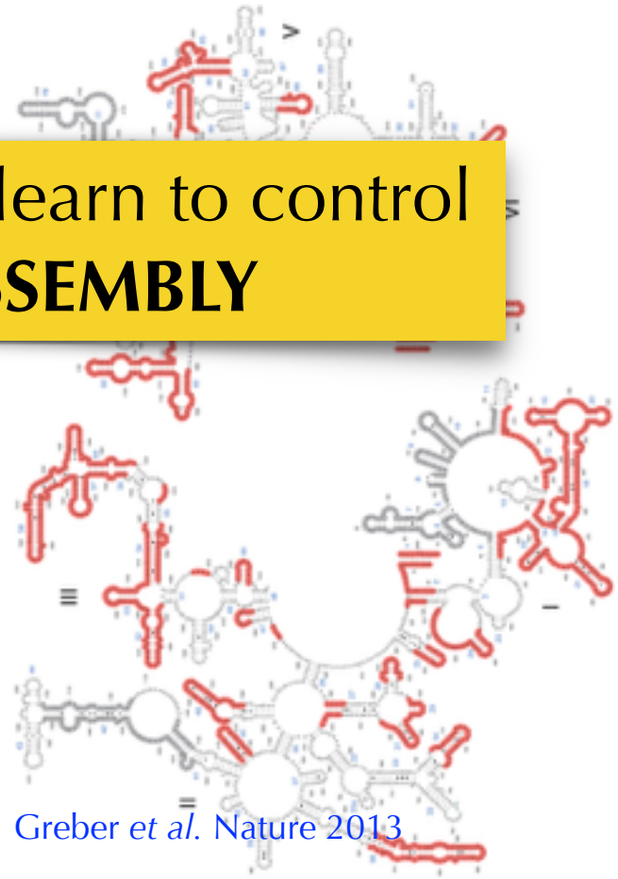
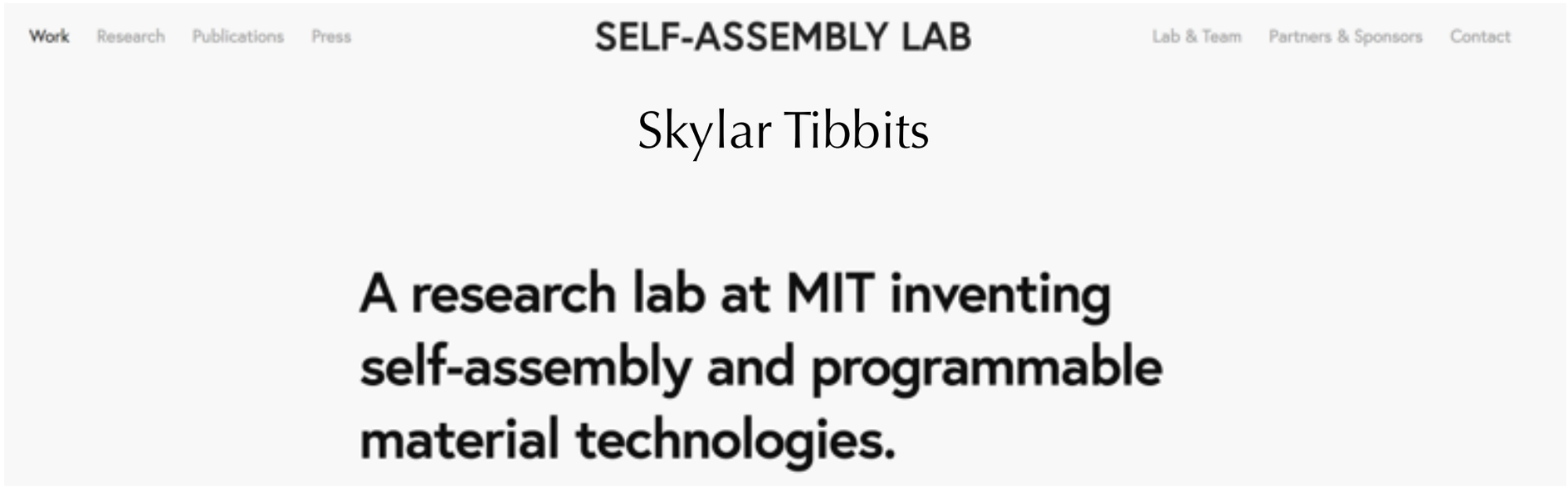


Greber *et al.* Nature 2013

Important to understand and learn to control the process of **SELF-ASSEMBLY**

Self-Assembly on Macro scale



Memories in a Jar

What are memories for me?

small rigid structures

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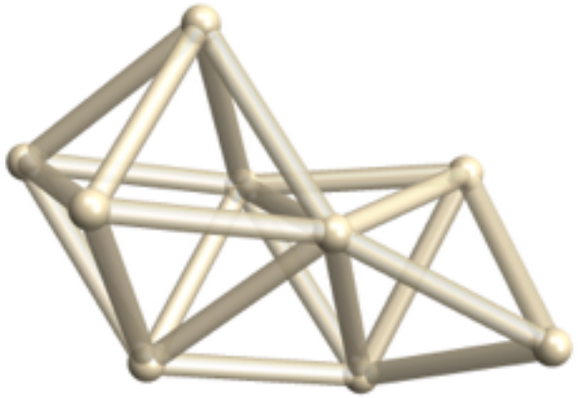
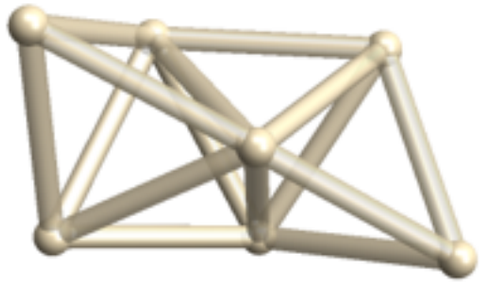
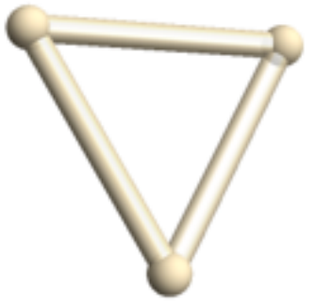
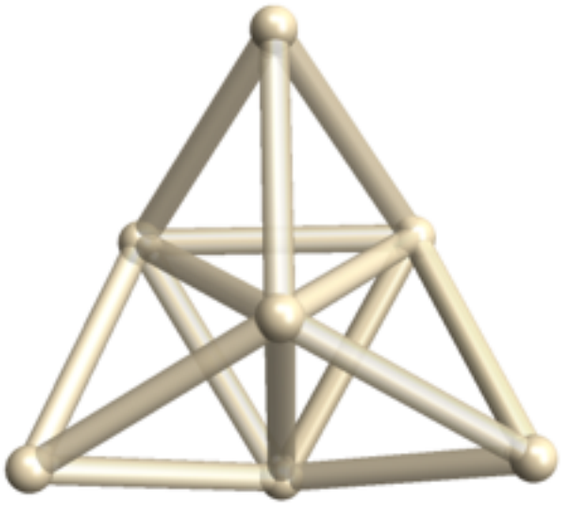
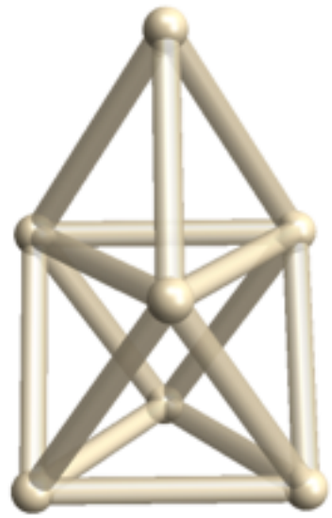
small rigid structures





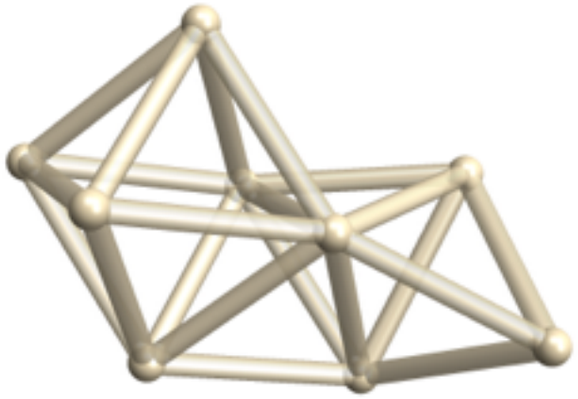


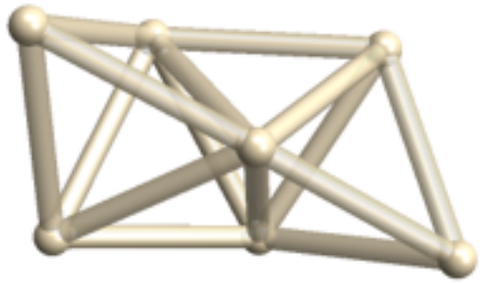


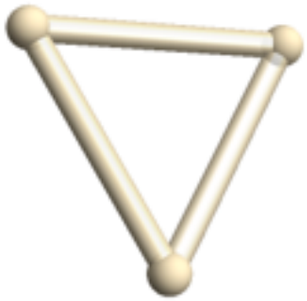


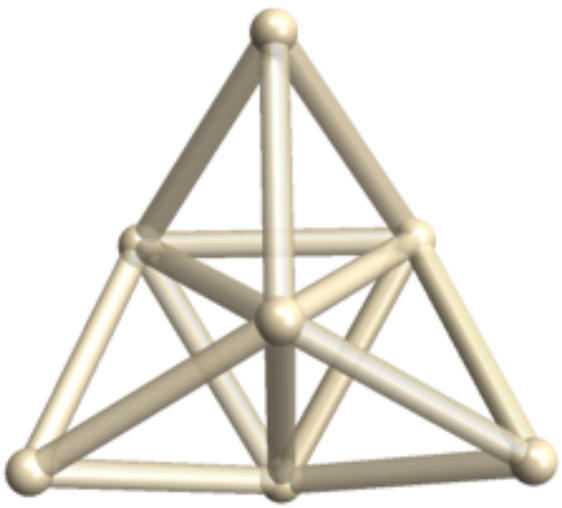
What are memories for me?

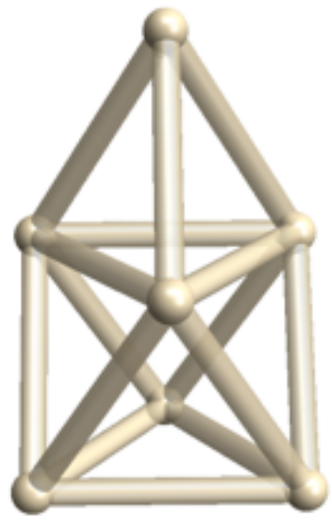
small rigid structures











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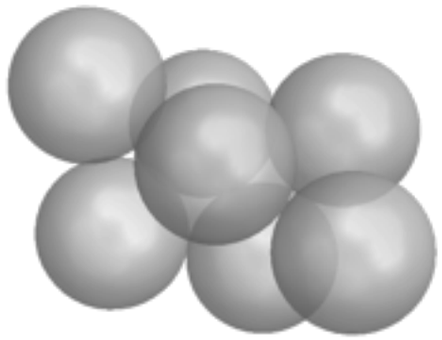
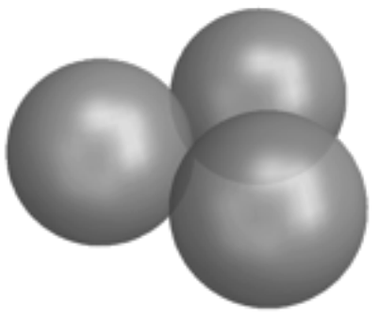
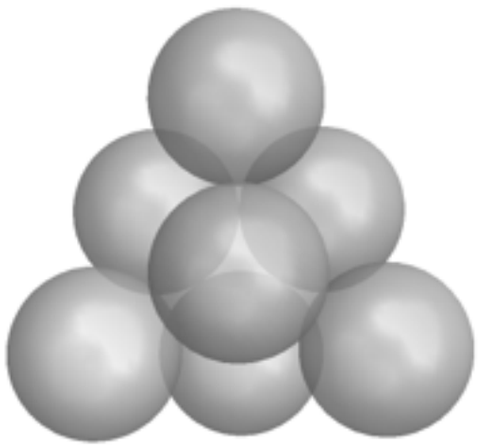
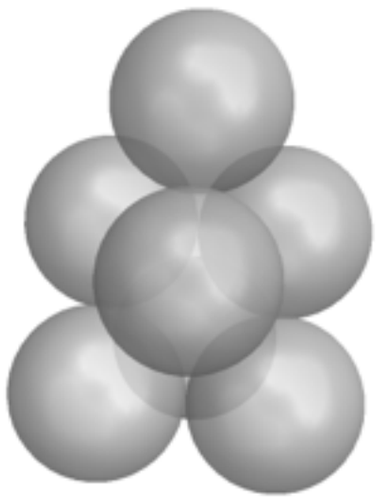


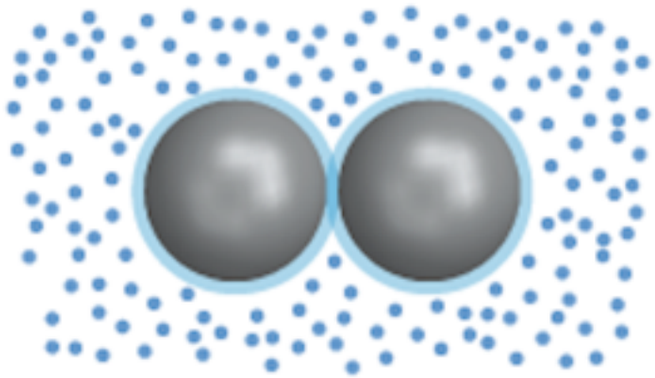


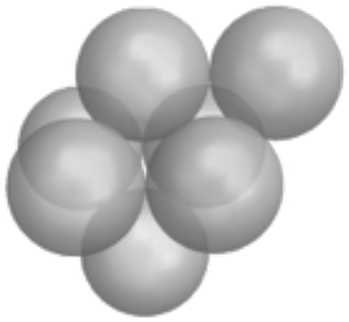


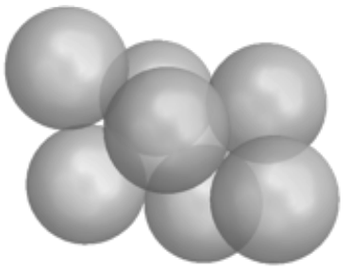


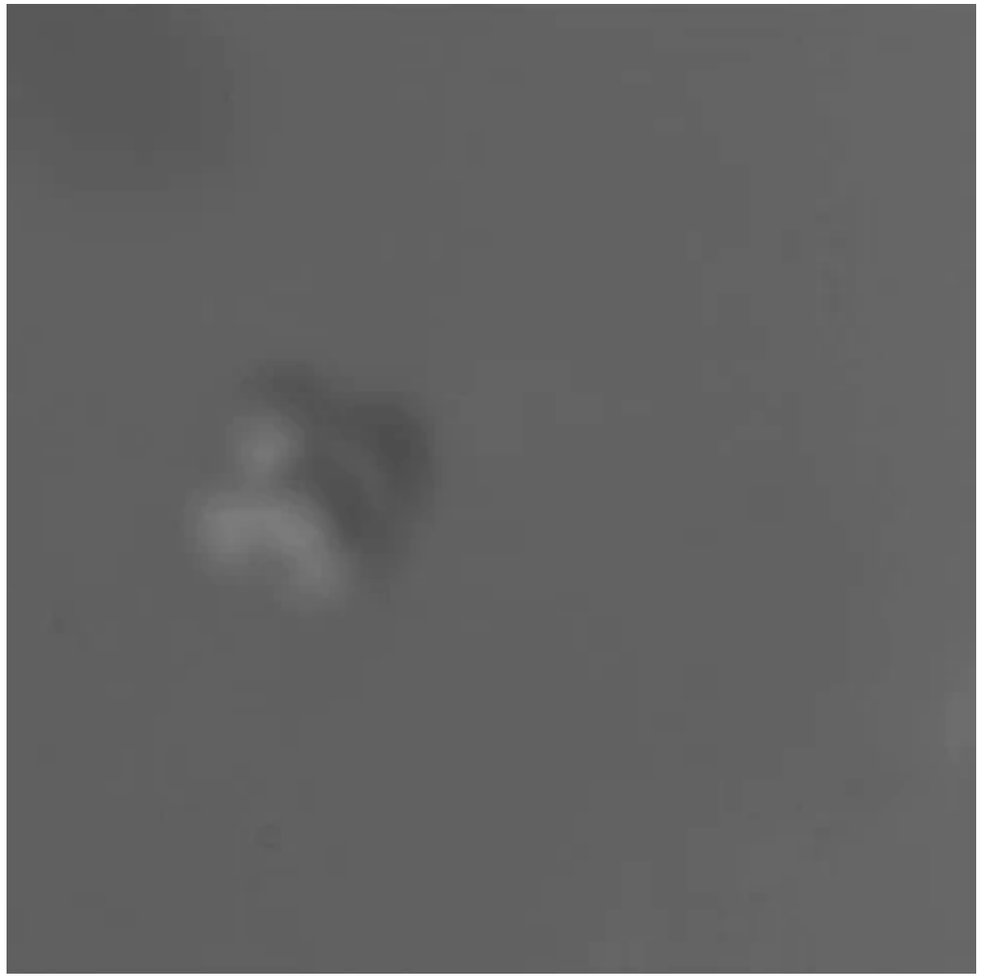
Small sphere clusters

depletion interactions

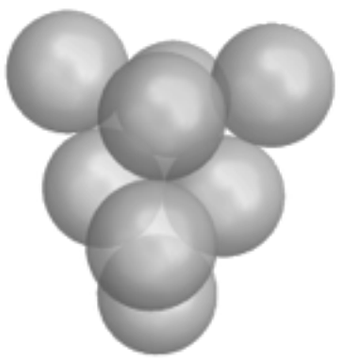








Meng, Arkus, Brenner, Manoharan, (2010) Science



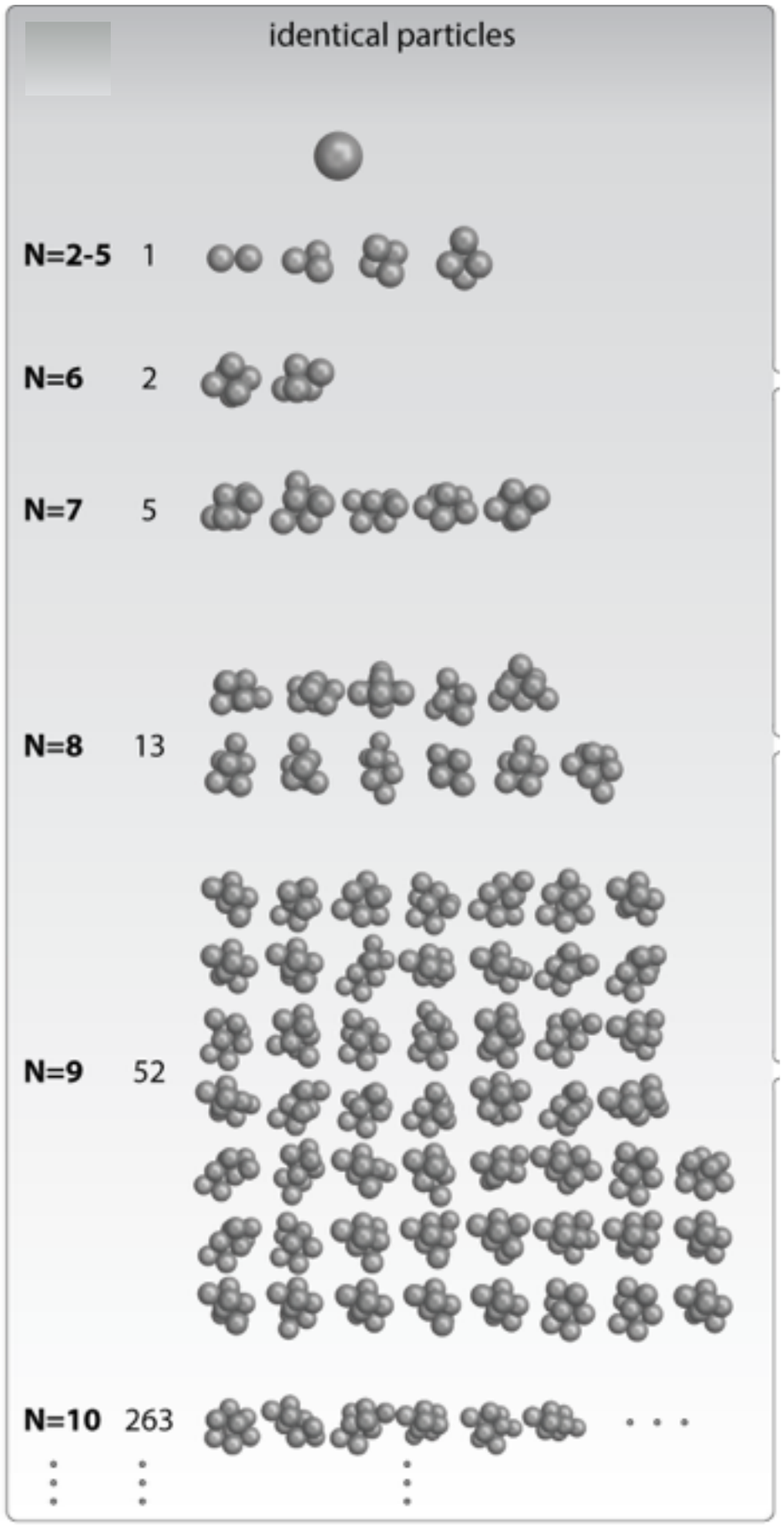
Theory: Arkus, Brenner, Manoharan, Holmes-Cerfon, Hoy, Connelly, Wales…
Experiments: Meng, Manoharan, Pine…

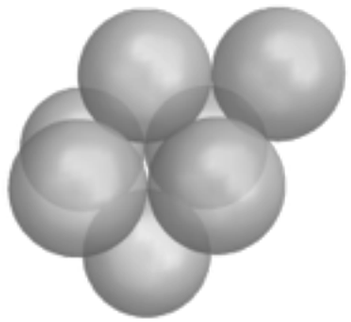
Self-assembly

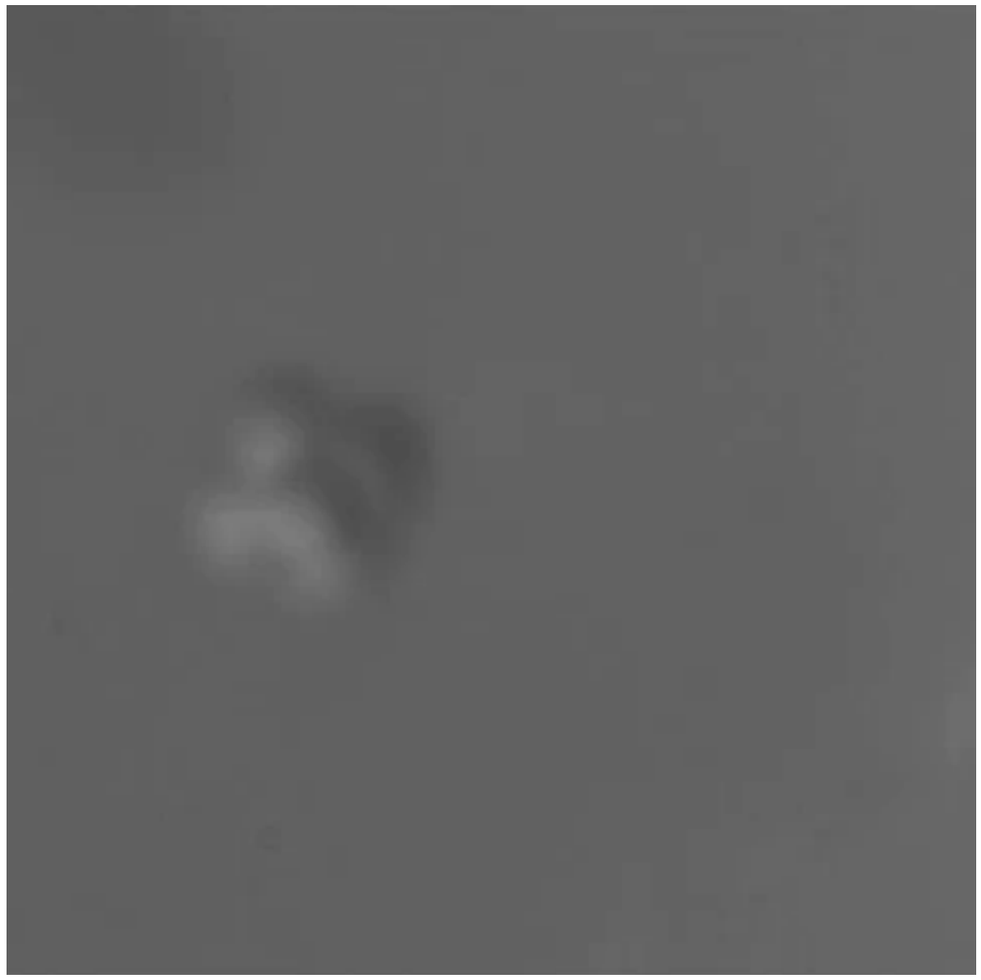
LIVE demo :)

need volunteers!

Small sphere clusters







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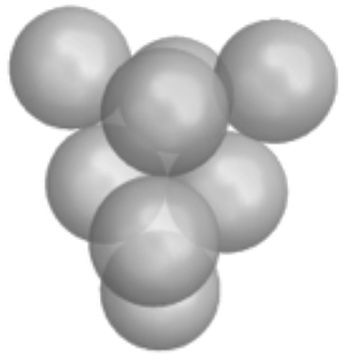

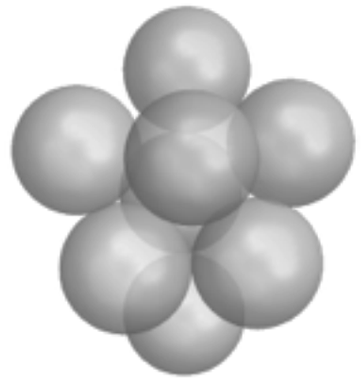

more than 10^6 for N=14

Theory: Arkus, Brenner, Manoharan, Holmes-Cerfon, Hoy, Connelly, Wales…
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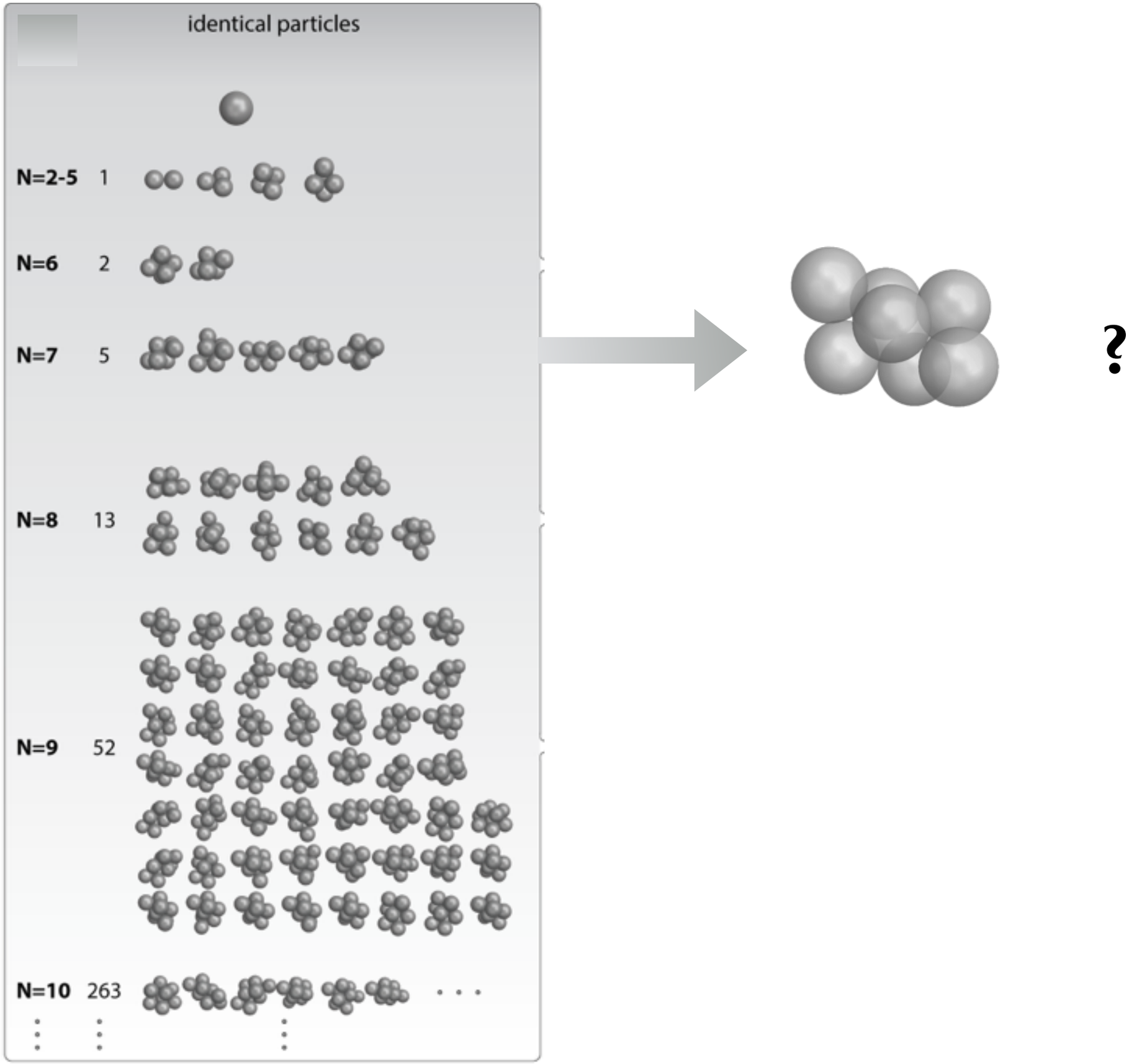
Small sphere clusters - how do we make only one memory assemble?



Answer - make puzzle pieces!

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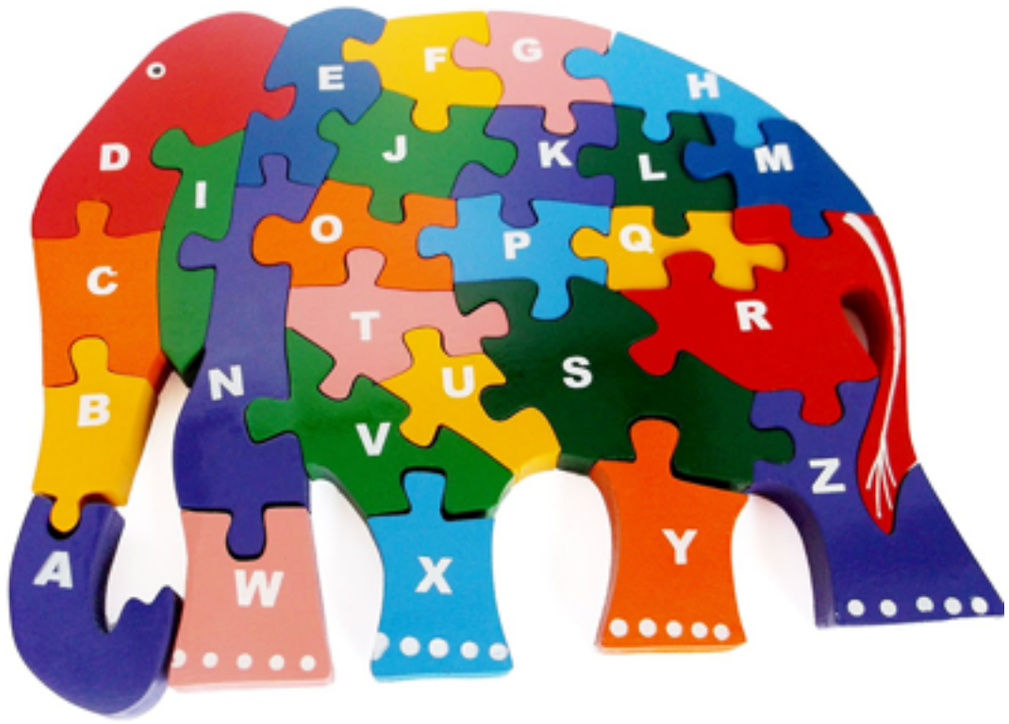
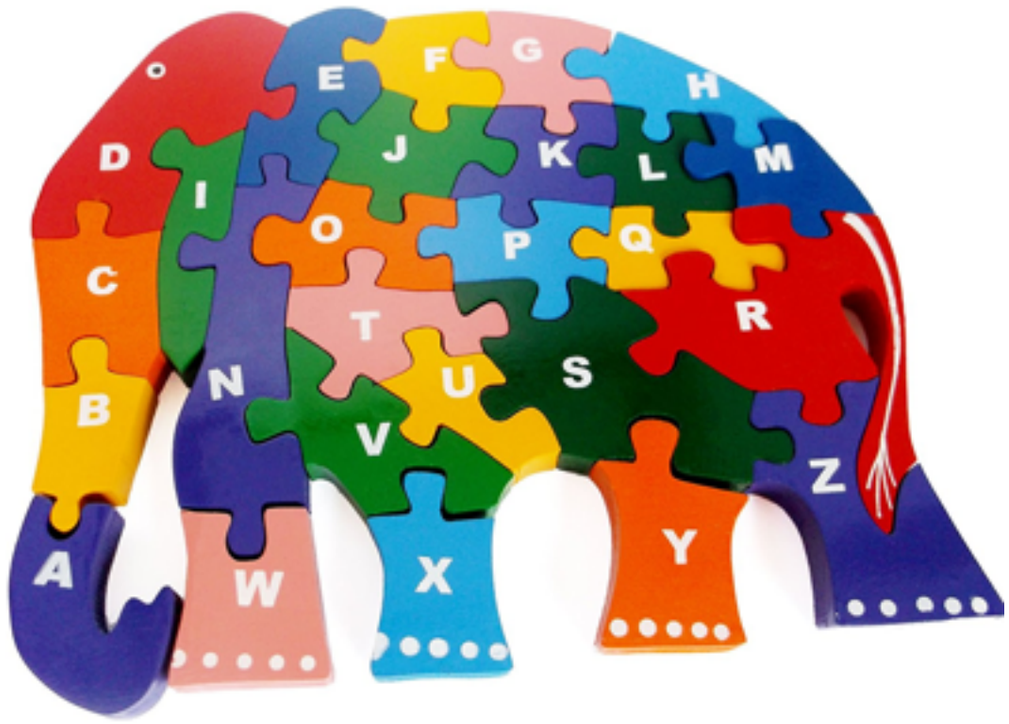
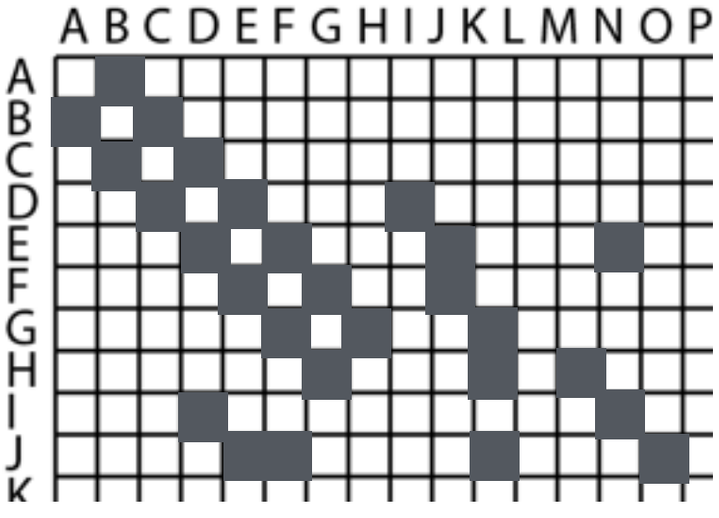


Answer - make puzzle pieces!



blueprint

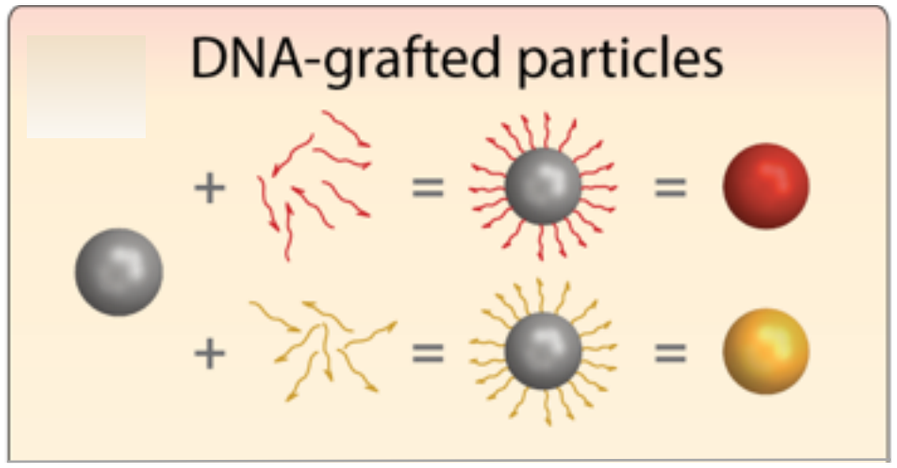


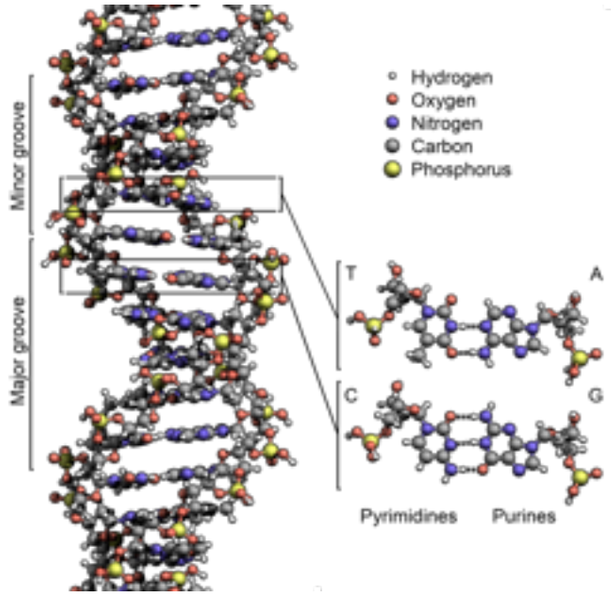
How to make puzzle pieces with spheres?

?

Use DNA!

Designing our parts

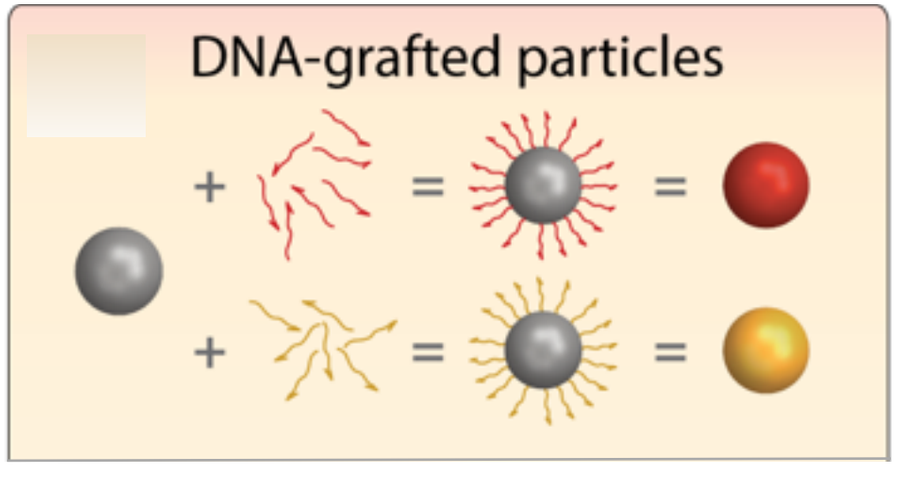


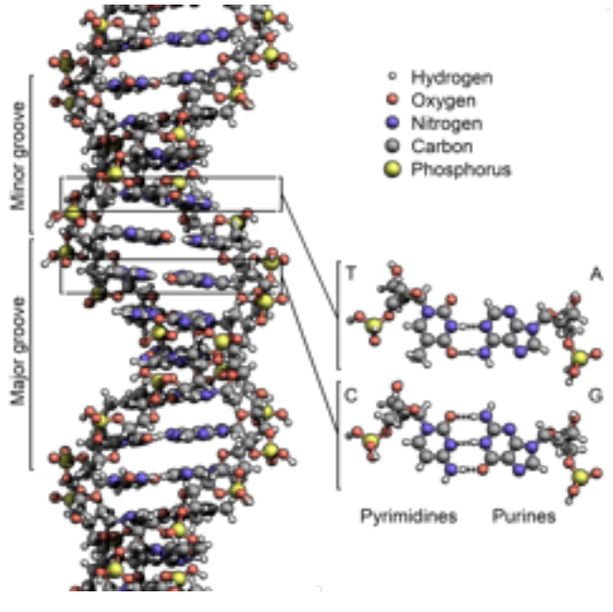


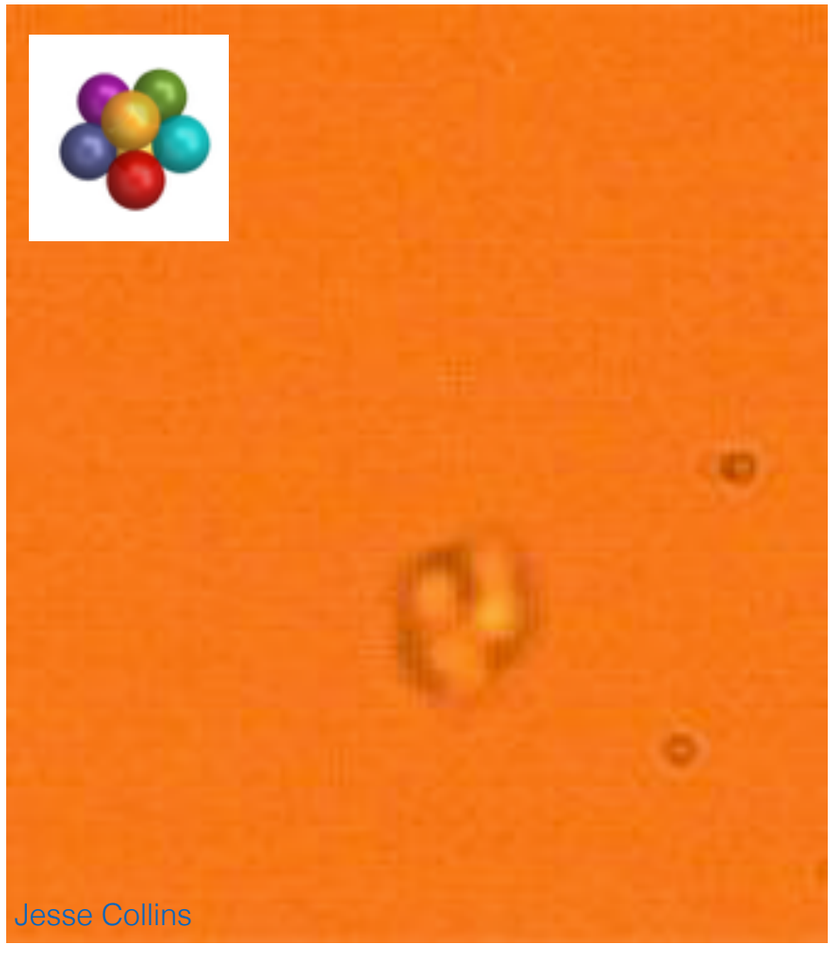
Use DNA!

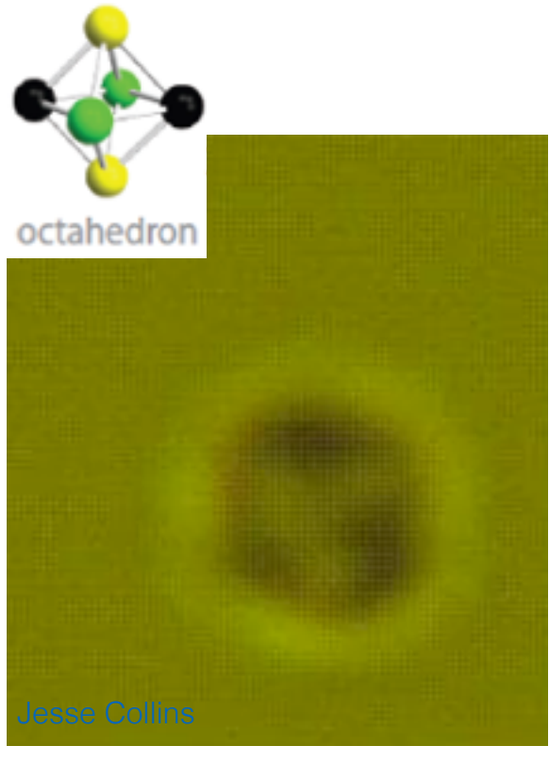
?

Designing our parts





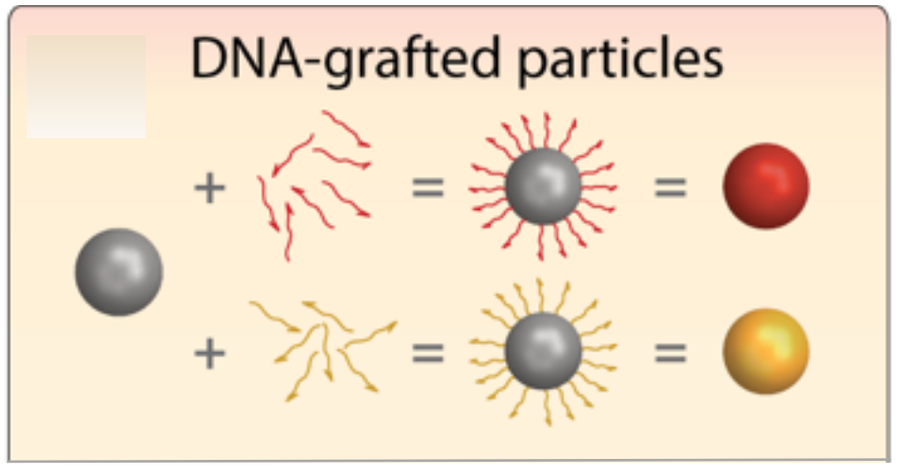


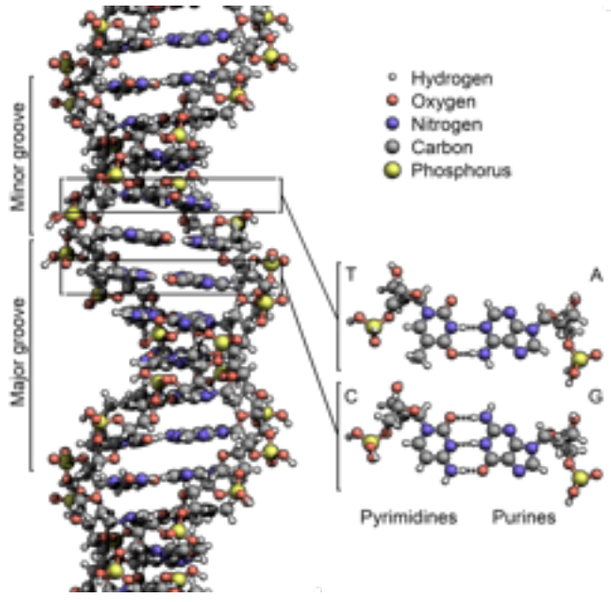


The power of DNA - huge number of possible puzzle pieces

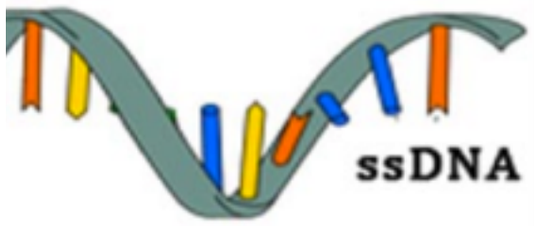
?

DESIGNING OUR PARTS





AATTCCGGAA



TTAAGGCCTT

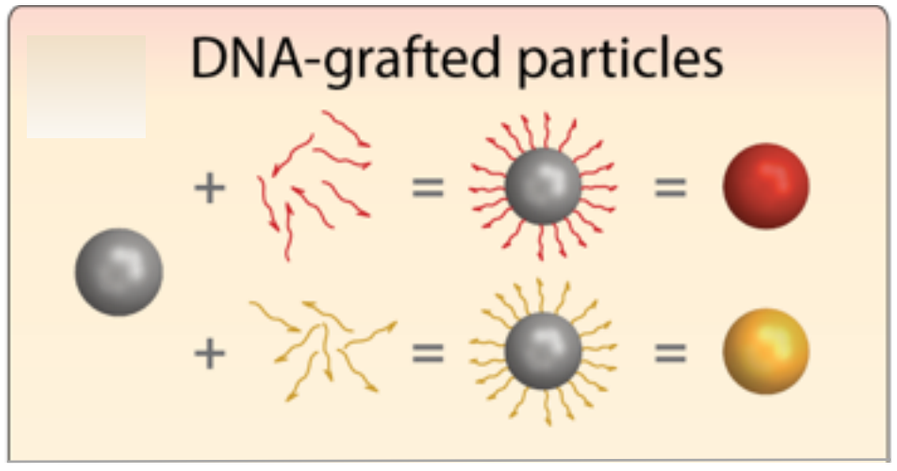
length of DNA strand = **11**bases
each base can be one of **four** types A,T,C or G

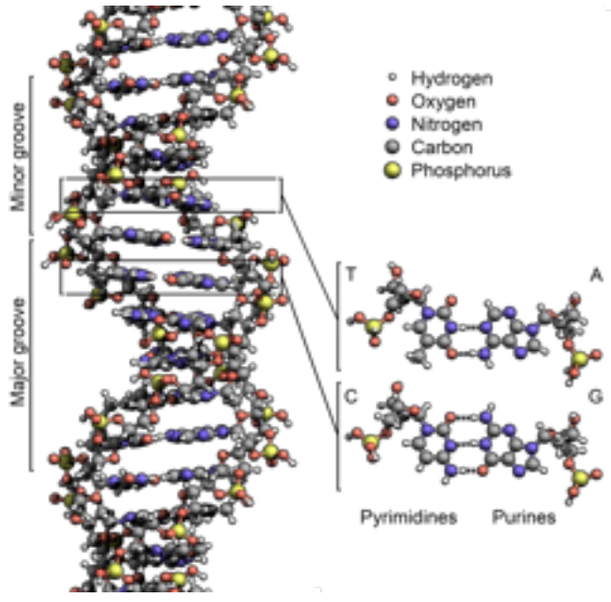
—-> **2,097,152** different types of puzzle pieces!
much much more than what regular chemistry can give us!

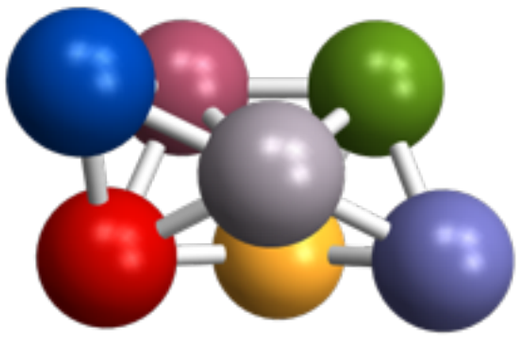
Blueprint for our cluster

?

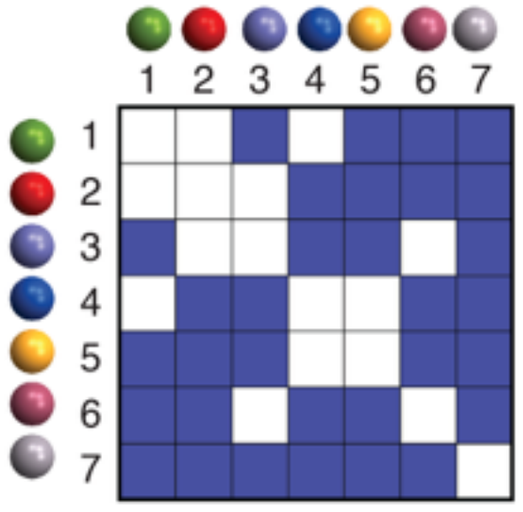
DESIGNING OUR PARTS





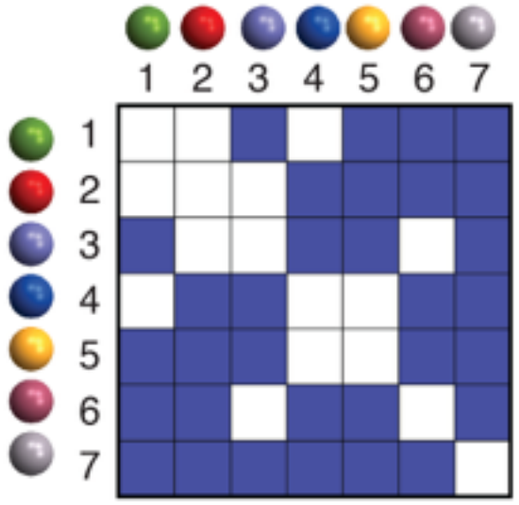


blueprint



Memory in a Jar

+



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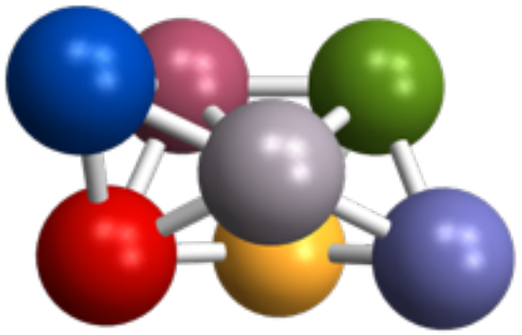
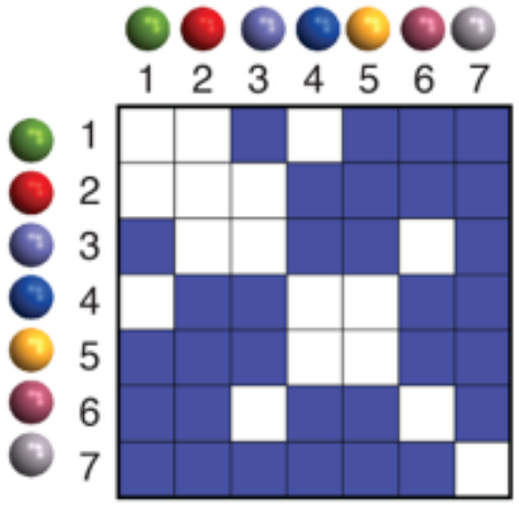


Memory in a Jar

+



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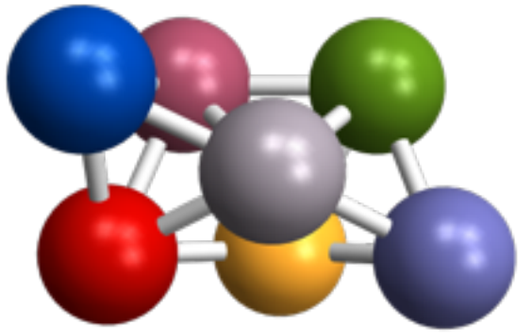
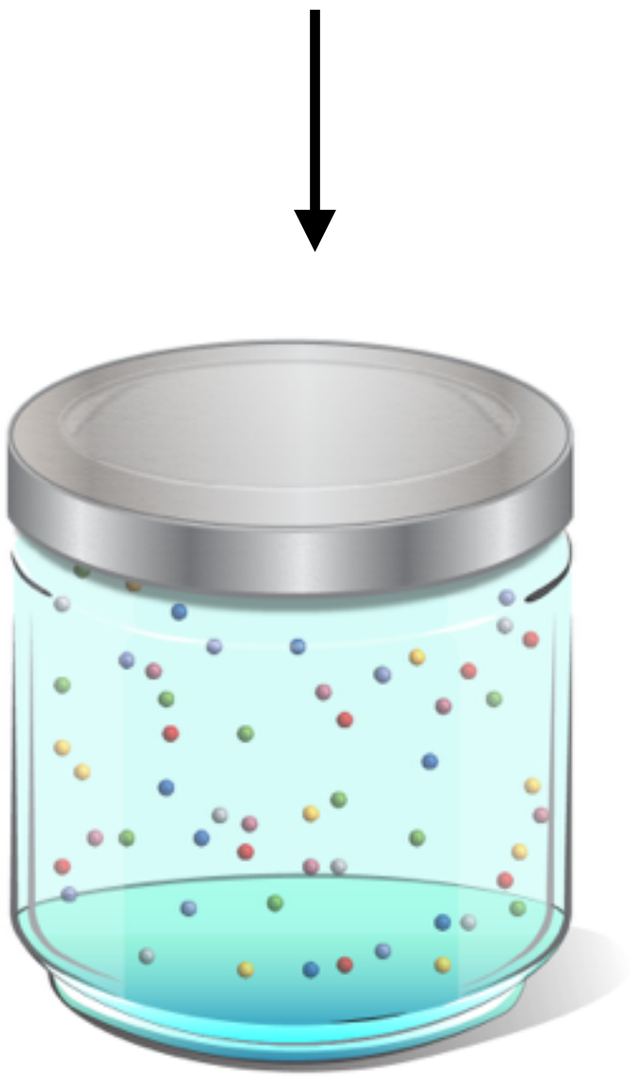


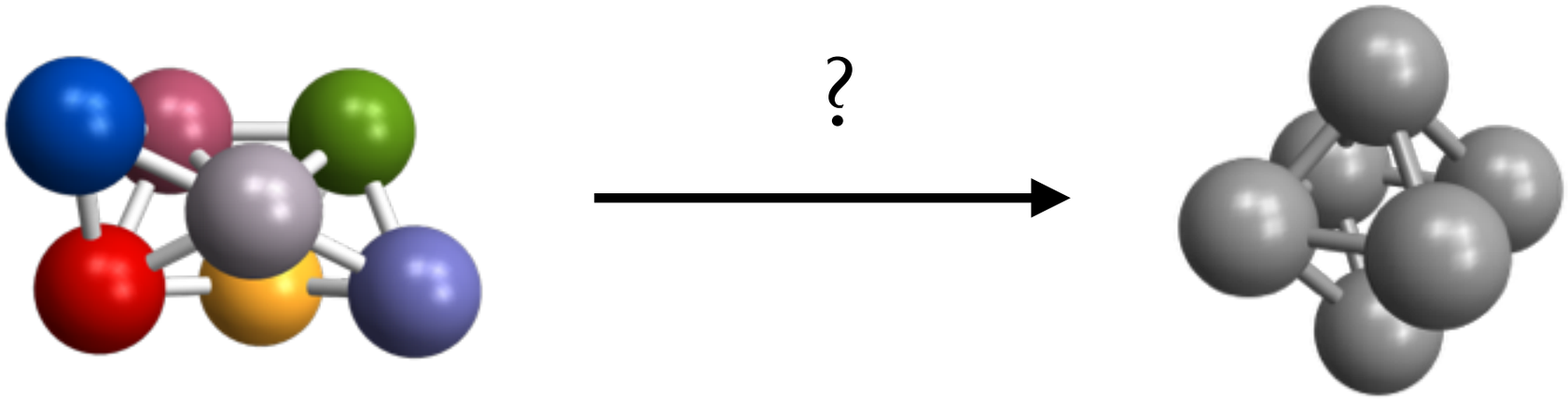


Memory in a Jar - what can go wrong?

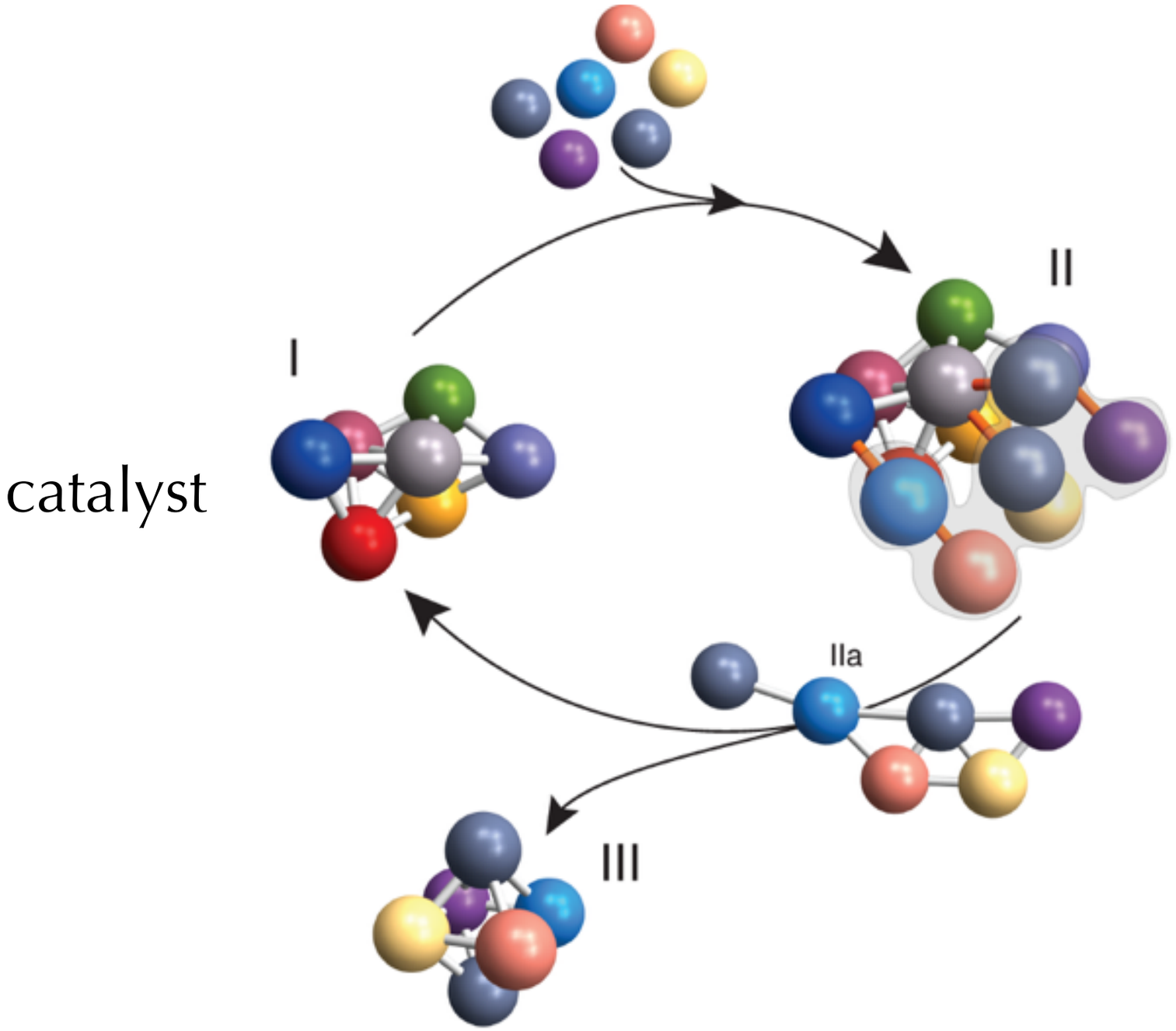
LIVE demo :)

need volunteers!

Template-based colloidal catalysis

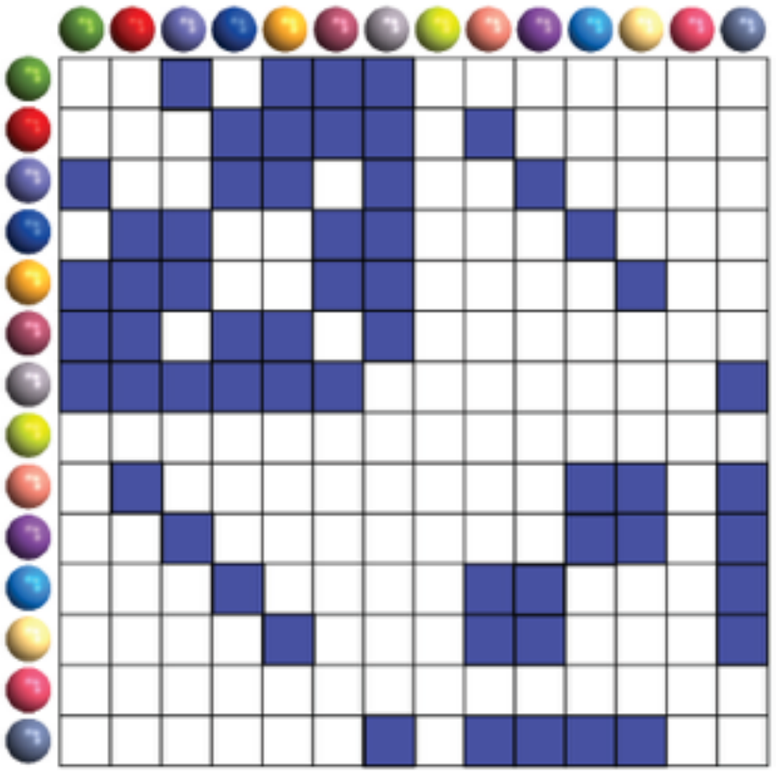


Template-based colloidal catalysis

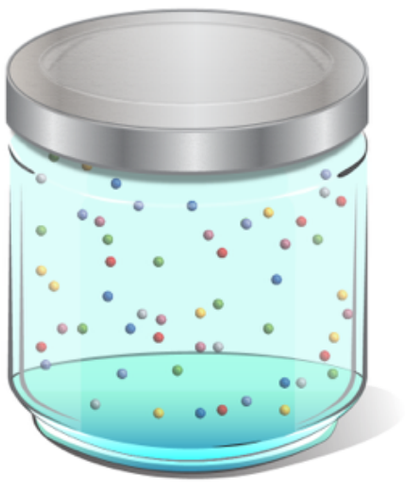


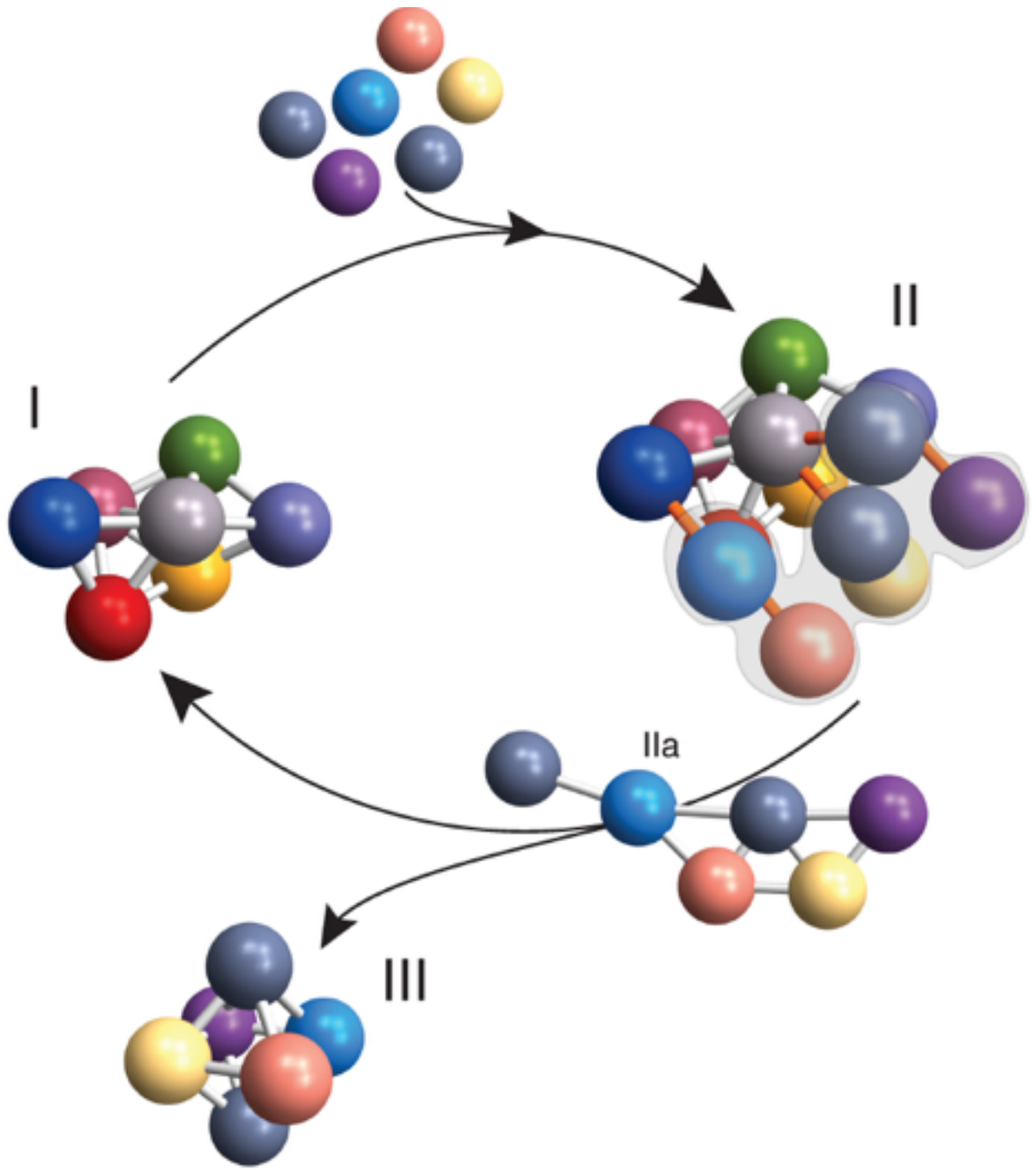
Design of the blueprint

blueprint



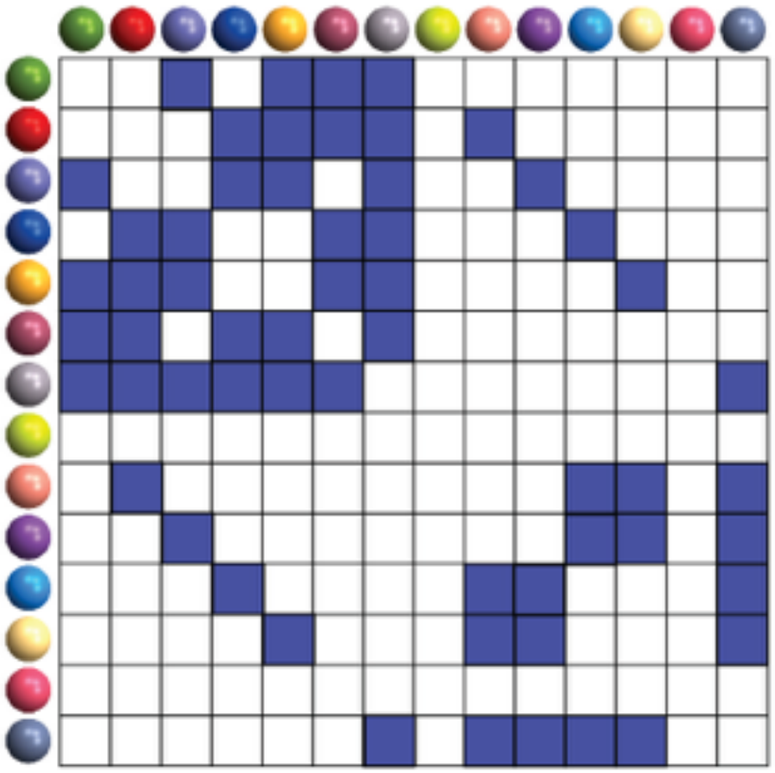
very diluted system
filled with
complementary species



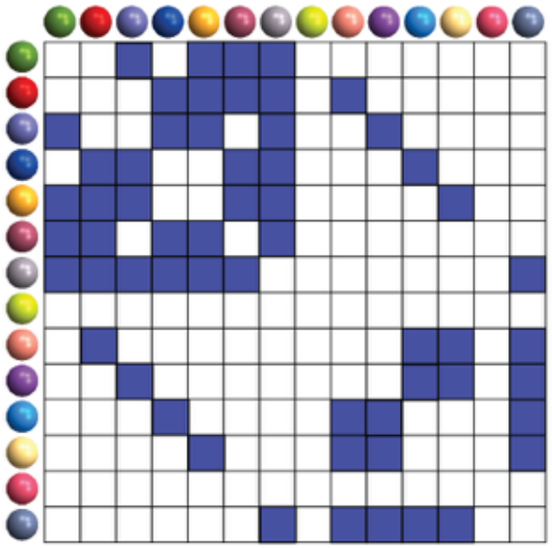


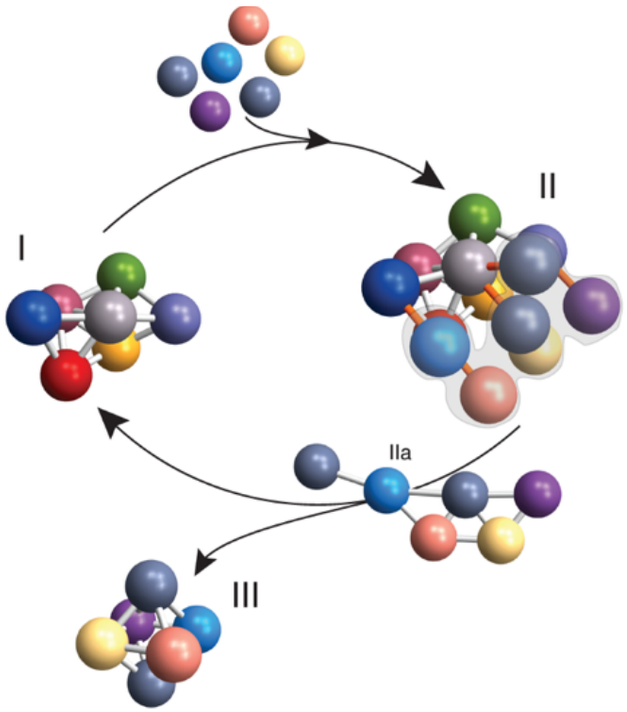
Simulations: can we remember our structure?

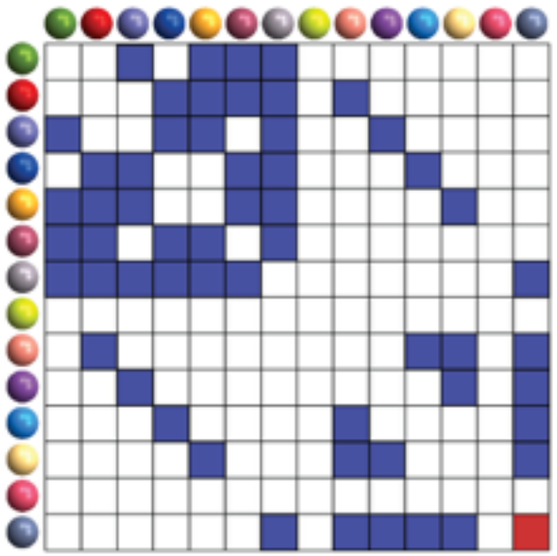
blueprint

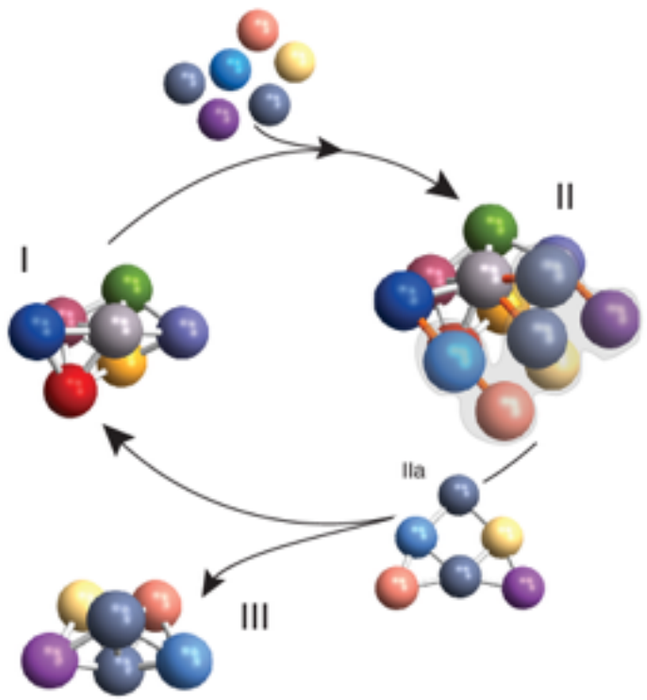


Can we remember two structures?

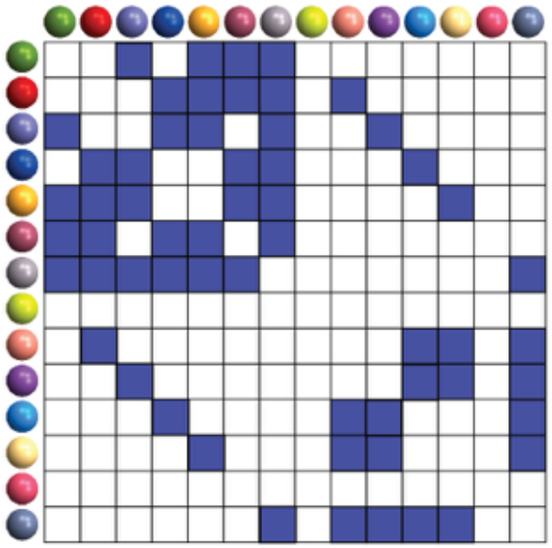


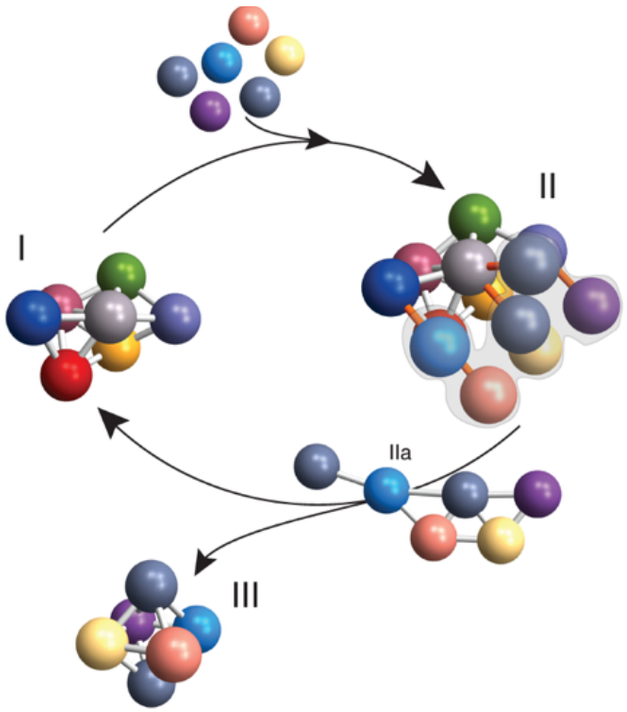


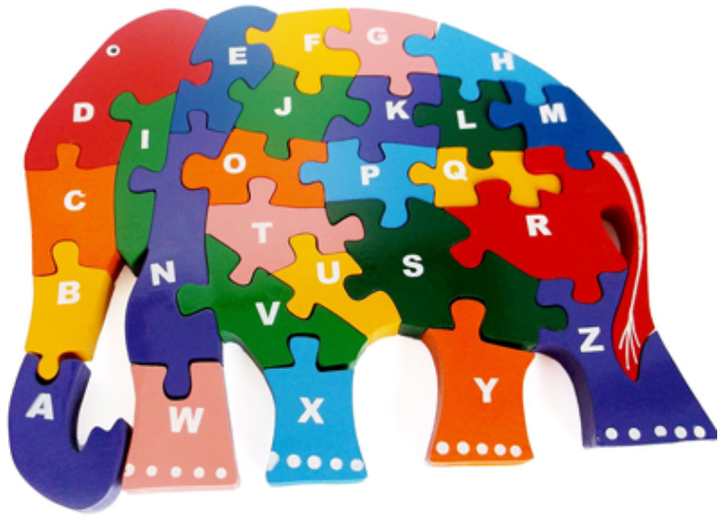


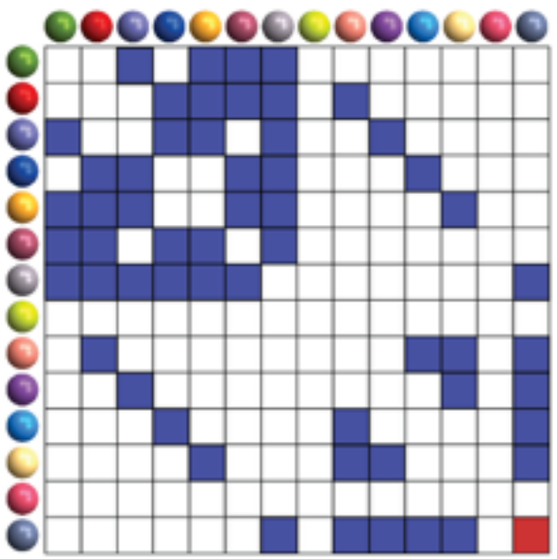


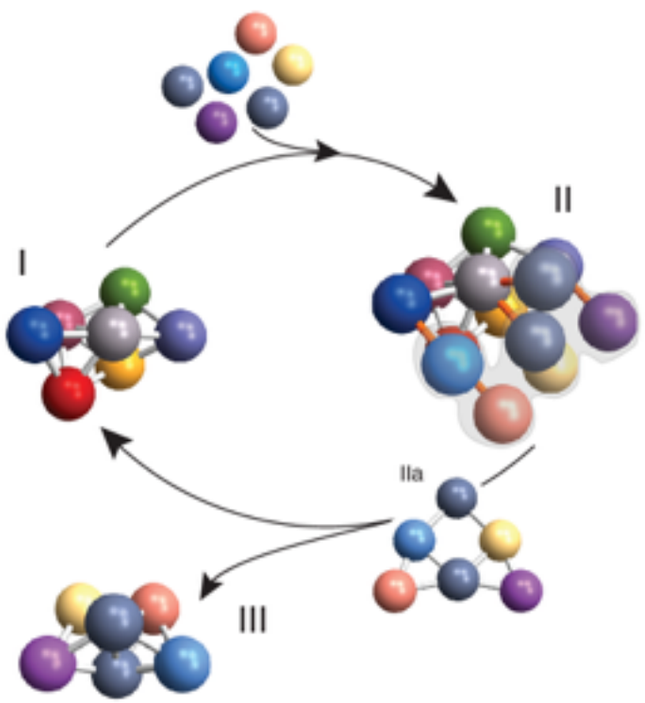
Can we remember two structures?



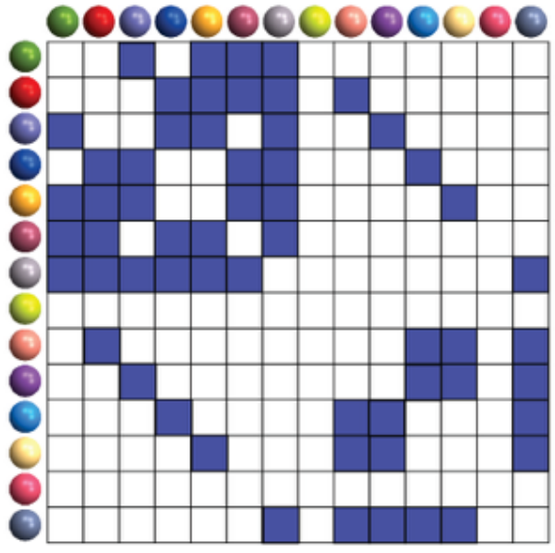


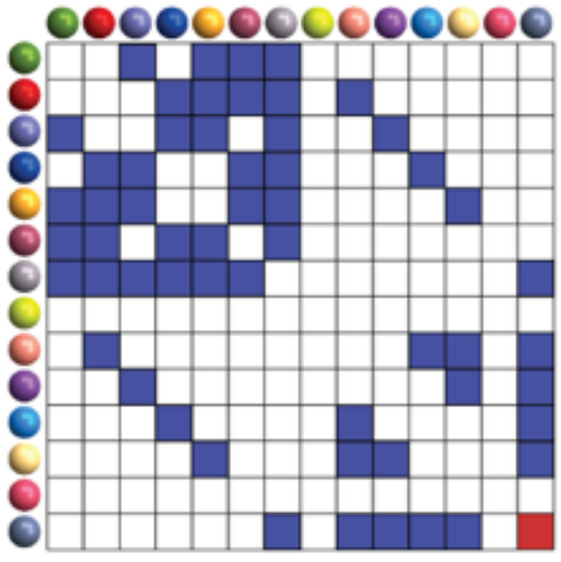


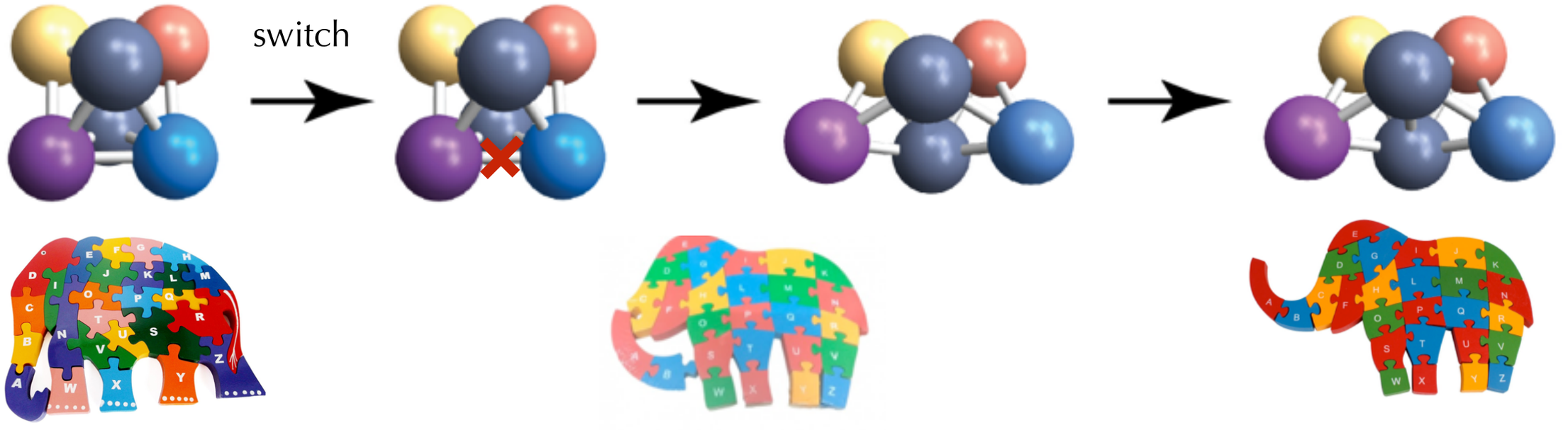




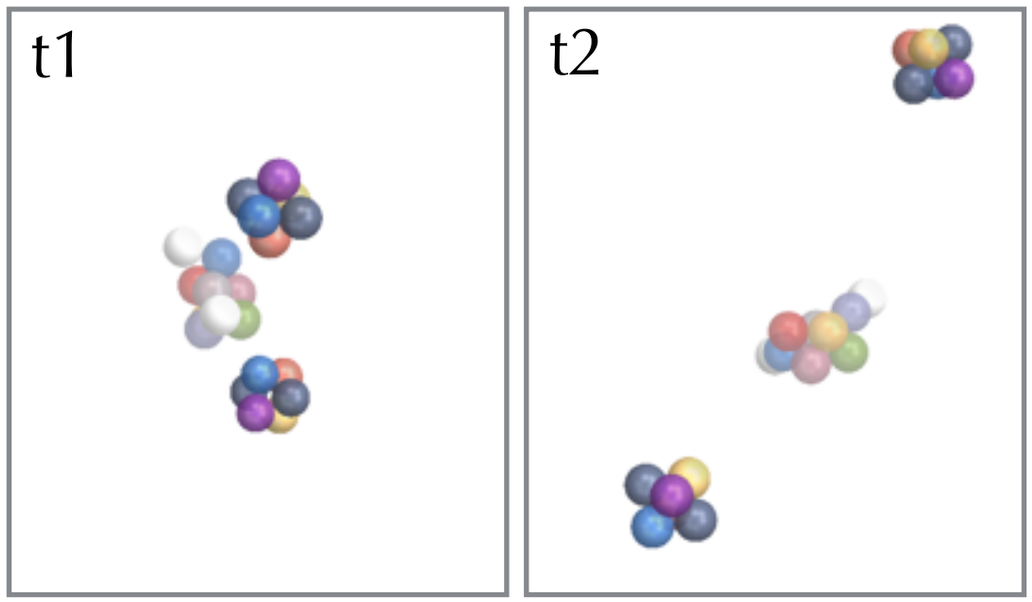
Can we switch between two memories?

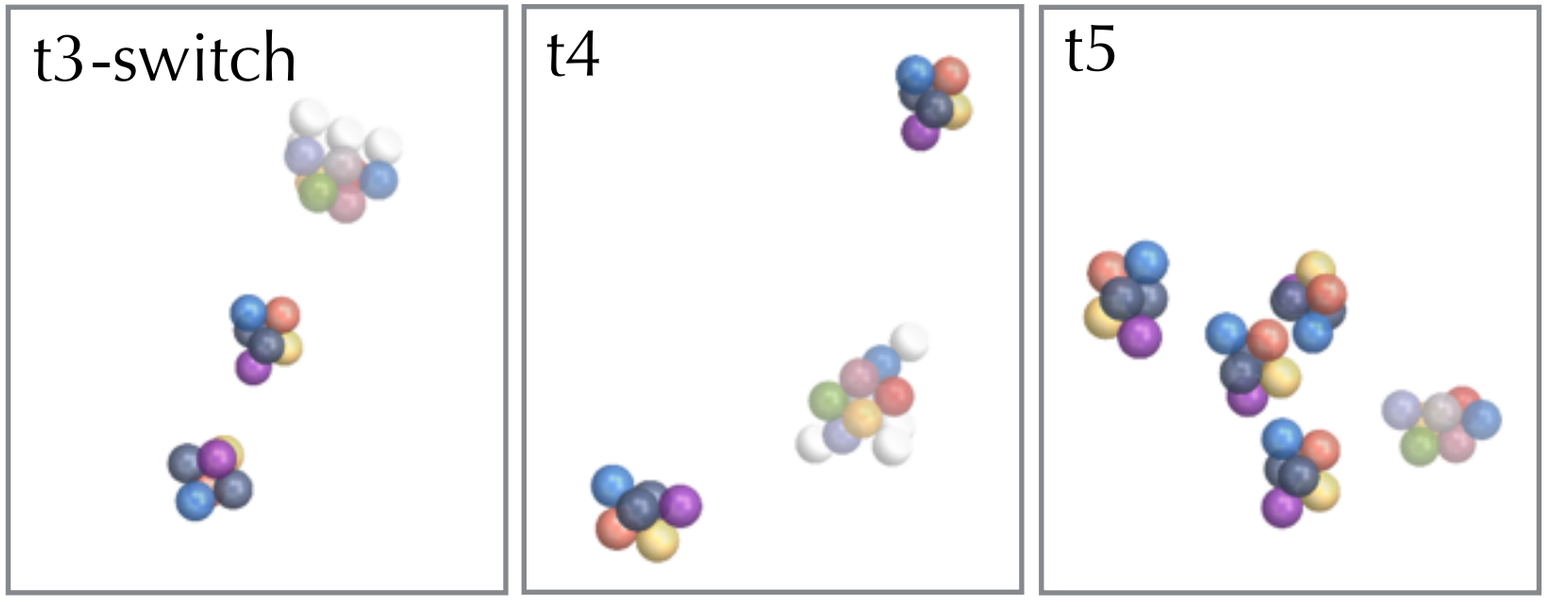






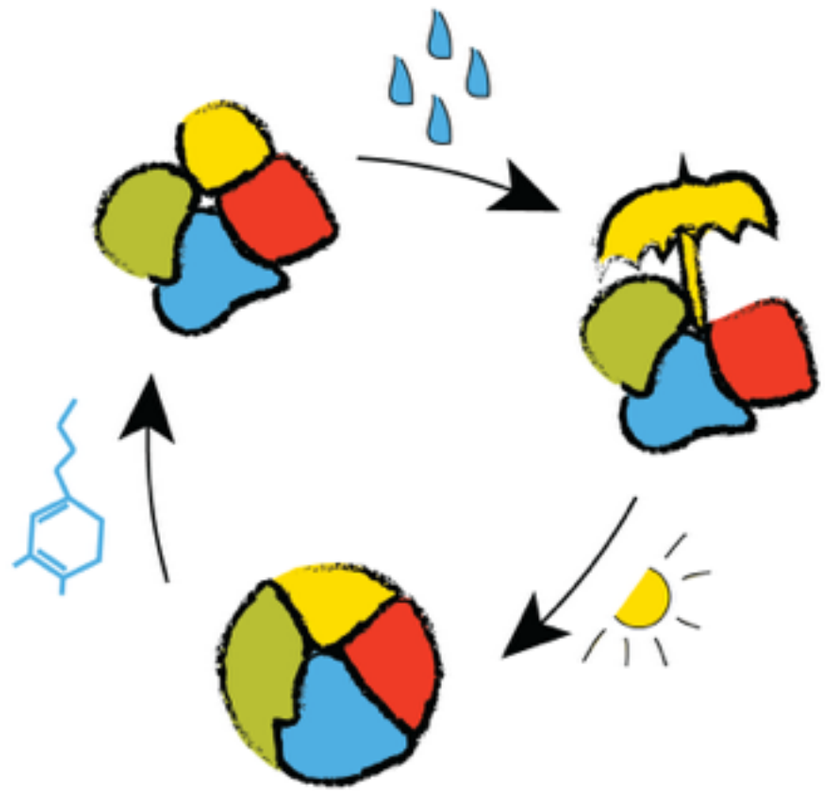
Simulations: from one memory to another





Use spontaneous assembly to make complex materials

Nature inspired design crucial



Realizable in experiment (almost)

Michael Brenner Vinothan Manoharan
Harvard

Resources that might be of interest to you:

Topics will include:

- How molecules influence flavor
- The role of heat in cooking
- Diffusion, revealed by the phenomenon of spherification, the culinary technique pioneered by Ferran Adrià.

You will also have the opportunity to become an experimental scientist in your very own laboratory — your kitchen. By following along with the engaging recipe of the week, taking precise measurements, and making skillful observations, you will learn to think like both a cook and a scientist. The lab is certainly one of the most unique components of this course — After all, in what other science course can you eat your experiments?

What you'll learn:

- The scientific concepts that underlie everyday cooking and haute cuisine techniques;
- How to apply principles of physics, engineering, and chemistry to cooking;
- How to become an experimental scientist in your own kitchen;
- How to think like a chef AND a scientist.

edX platform