Teacher's Preparatory Guide

Modeling Self-Assembly, Part II: *The Water Maze*

Purpose
The *Water Maze* is a reinforcement challenge activity to *The Fly Prison*, and relates to on-the-spot lab testers that use nanotechnology, but are the physical size of a credit card. For example, a person in a remote place could quickly test a drop of blood or urine by placing the drop on one part of the card. The liquid would then be drawn through a series of channels that provide information.

Level Middle school

Time required
Two 50-minute class periods or one 90-minute block day

Safety Information None.

Advance preparation Laminate the page of description cards and cut along the dotted lines. Punch a hole along the left side and attach to a keyring.

Assemble the following materials for each group of students:

- a one piece of butcher paper
- markers
- a keyring of laminated description cards from *The Fly Prison* activity
- a keyring of laminated description cards from *The Water Maze* activity

Print copies of the rubric (next page) for each group in your classes

Developed by xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Development and distribution partially funded by the National Science Foundation

NNIN Document: NNIN-1104
Rev: 11/07

Group Assessment

Names of Group members	Basic Understanding of Self-Assembly	Creativity in Design	Basic Understanding of the attraction of molecules
Score:			

Final Score:__________

Comments:____

____

____

Group Assessment

Names of Group members	Basic Understanding of Self-Assembly	Creativity in Design	Basic Understanding of the attraction of molecules
Score:			

Final Score:__________

Comments:____

____

____

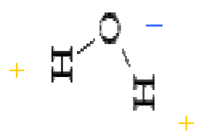
Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

NNIN Document: NNIN-1104

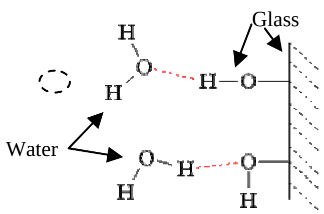
Rev: 11/07

Description cards

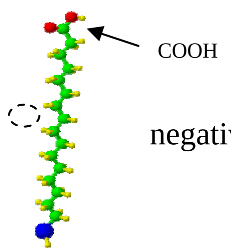
Laminate this page of description cards and cut along the dotted lines. Punch a hole along the left side and attach to a keyring.



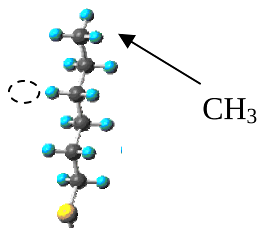
Water (H_2O) is a bent molecule made of 2 hydrogens and 1 oxygen. The oxygen end is negatively charged. The hydrogen ends are positively charged.



Capillary Action pulls water up the walls of a tiny thin tube—even against gravity—because the charged water molecule is strongly attracted to the charged surface of glass (SiO_2).



Mercaptohexadecanoic Acid (MA) molecules have a sulfur-hydrogen (SH) group on one end that can bond to gold, and a (COOH) group on the top that is negatively charged (*hydrophilic* and mixes with water). UV light at 254nm can break the bond between the sulfur and the gold.



Hexadecane Thiol (HT) HT molecules have a sulfur-hydrogen (SH) group on one end that can bond to gold, and a (CH_3) on the other end that does not mix with water (*hydrophobic*) and bonds with other molecules that do not mix with water. UV light at 254nm can break the covalent bond between the sulfur and the gold.

Developed by Roquel Stanley and Angela Berenstein

Development and distribution partially funded by the National Science Foundation

NNIN Document: NNIN-1104

Rev: 11/07

Teaching Strategies This advanced activity should only be used on students who have a good grasp of the information in *The Fly Prison* activity. Divide students in the same groups as with *The Fly Prison*. Students may need to refer to their work on *The Fly Prison* as they do *The Water Maze Challenge*.

Begin the lesson by reviewing how students developed a fly prison by asking students to explain why they did each step in the procedure. Ask students: Which parts of *The Fly Prison* activity used self-assembly? *the steps in the procedure chart* Which steps did not use self-assembly? *the stencil portion*

This activity is assessed as each group presents. Directions for the presentation are as follows:

Presentation Rules:

1. Everyone must have a speaking part.
2. Each presentation must explain:
    - The steps of assembly
    - The reasons for the steps
    - The final maze design
    - How the maze moves the water molecules
    - Some concerns as to how well this will work
3. Have the butcher paper with the design clearly drawn and labeled. Make your words and drawings big, colorful, and easy to read from the back of the room.

The next page has a basic grading rubric that may be modified to fit your style. The rubric can be much more specific, but these are three basic objectives of the question. This inquiry-based activity can have several correct answers—it was designed to encourage students to think creatively.

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

Student Worksheet with Answer Key

Modeling Self-Assembly, Part II: *The Water Maze*

Lab-on-a Chip, Inc. may hire your team to design a device that will allow people in remote areas to do medical blood tests. Blood is mostly made of water, and our company has had difficulty in controlling how the blood moves through the chip.

Your task is to design a maze that allows water molecules to move from one end of a maze to the other end, down a desired path using some of the tools provided and using self assembly. Use only the tools that you need. Please remember that, when working with things this small, gravity has no effect.

Finally, you will present your plan to the CEO of the company, who will hire the team with the best plan and presentation. Our company is looking for scientific accuracy, and creativity in the design.

Problem: How can our group create a water maze using self assembly?

Procedure: Review the cards of the tools and molecules at your disposal. Answer the questions below:

1. What does each end of water attract to?_____*The oxygen end of a water molecule is negative, so it will attract to positively-charged ends of molecules. The hydrogen end of a water molecule is positive, so it will attract to negatively--charged ends of molecules*____

2. How will you move the water molecules?___*Answers may vary. Example answer: I will use hydrophobic molecules (molecules that repel/don't mix with water) on the outside of the maze.*___

3. How will you keep the water molecules going down one path?_*Answers may vary. Example answer: I will use hydrophilicic molecules (molecules that attract/ mix with water) on the inside of the maze.*___

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation
NNIN Document: NNIN-1104
Rev: 11/07

4. How are you going to manipulate the self assembly of this design that will put all the molecules in the places that you want them? *Answers may vary. An example answer is provided in the diagram below.*

5. What mask(s) will you use? You can design a mask and make as many masks as necessary to complete the challenge. *Answers may vary. An example answer is provided in the diagram below.*

6. What order will you apply the molecules to the wafer? *Answers may vary. An example answer is provided in the diagram below.*

7. Draw, color, and label a wafer on the large sheet of paper provided.

8. What will you do with the wafer next? Beside the wafer drawing, explain the next step and why you are taking this step.

9. Draw, color, and label what the wafer will look like after taking this step.

10. Repeat steps 8–9 until your water maze is complete.

11. Are there parts of your plan that you are uncertain whether it will work? What are they?

Answers may vary.

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

12. As a group, present your water maze design following these presentation rules:

Presentation Rules:

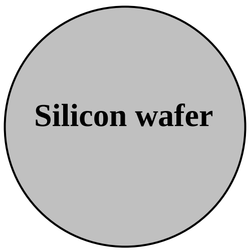
1. Everyone must have a speaking part.
2. Each presentation must explain:
    - The steps of assembly
    - The reasons for the steps
    - The final maze design
    - How the maze moves the water molecules
    - Some concerns as to how well this will work
3. The design must be clearly drawn and labeled. Words and drawings should be big, colorful, and easy to read from the back of the room.

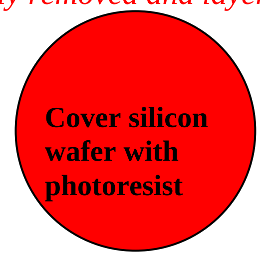
Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

To have a dynamic system like this would be far more complicated. So students can be insightful in that this problem has many challenges and would need more techniques and tools than given to accomplish this goal.

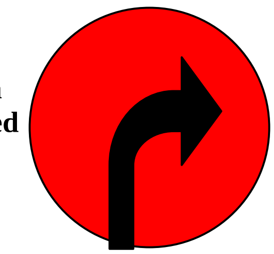
Example Scenario #1:

Stencil Procedure: *If the procedure uses a stencil/mask, all stencils should follow a similar procedure (masks will vary, but students should get the correct steps and correctly identify which areas are selectively removed and layered.)*



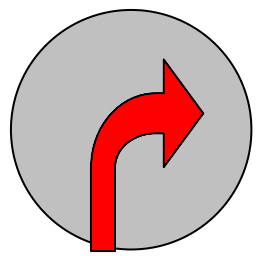


Put mask on top of silicon wafer covered with photoresist

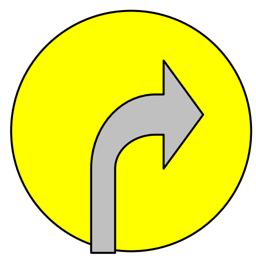


Illuminate mask with UV light to weaken the photoresist in places where the light touches. UV light passes through the clear parts of the mask and does not pass through the black parts of the mask.

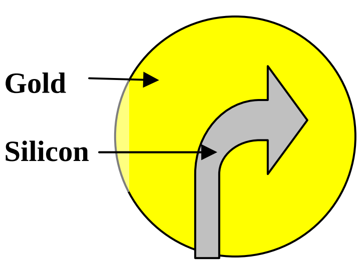
Remove the mask and put the wafer in developer to wash away the weakened photoresist. The gray area is silicon.



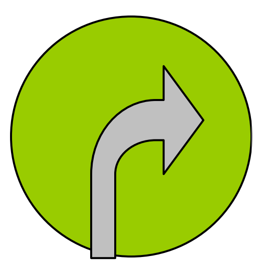
Put the wafer in a solvent to wash away all of the photoresist and the gold on top of it. The yellow area is gold and the gray area is silicon.



Self-Assembly Portion of the Procedure: *This part of the procedure will vary, depending on what molecules were chosen. Students should correctly identify which molecules will bond with other molecules. An example procedure is provided below that uses the stencil procedure on the previous page:*



Dip the wafer in a beaker with HT molecules (shown in green). HT molecules will bond only with gold.



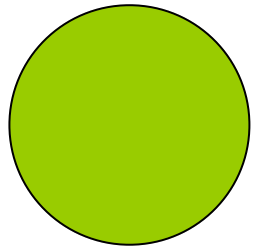
Dip the wafer in a beaker with water. The water will be repelled by the HT molecules and stay in the gray area.

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

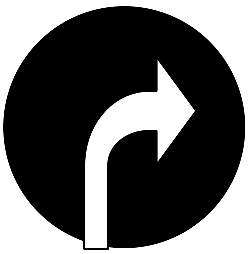
NNIN Document: NNIN-1104
Rev: 11/07

Example Scenario #2: *This example is another possibility that does not use the stencil procedure on the previous page.*

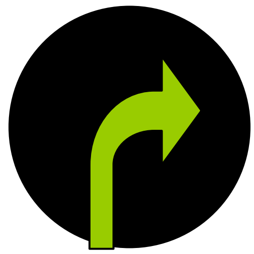
Dip the wafer in a beaker with HT molecules (shown in green). HT molecules will bond only with gold.



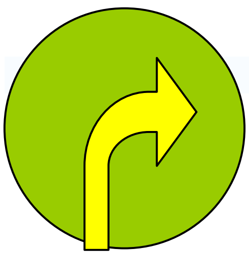
Get Mask



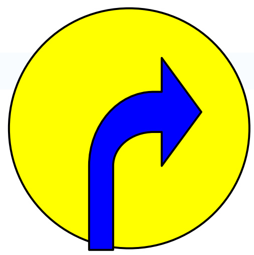
Put mask on top of silicon wafer covered with HT molecules.



Illuminate mask with UV light to break the bonds between the HT molecules and the gold.



Remove the mask. Dip the wafer in developer to remove the weakened HT molecules from the gold.



Dip the wafer in MA molecules, which will bod only with the gold.

Dip the wafer in a beaker with water. The water will attract to the HT molecules and stay in the blue area.

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation

Developed by Roquel Stanley and Angela Berenstein
Development and distribution partially funded by the National Science Foundation