
# ECS 289: Theory of Molecular Computing

Winter 2016, University of California, Davis

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## Description

The computing revolution of the 20th century focused on the systematic manipulation of information. In this century a new revolution is underway, and its goal is the systematic manipulation of *matter* at the molecular level. DNA nanotechnology especially has established several basic low-level tools, such as tile assembly, DNA origami, and strand displacement, out of which more sophisticated molecular systems can be composed.

A traditional programming language is a simplified abstraction of the possible behaviors of the several billion low-level wires and transistors in a modern electronic computer. By analogy this course introduces theoretical abstractions of molecular systems suitable for programming them to have desired behaviors. Emphasis is placed on formal reasoning and proofs as a way to discover fundamental limits to our ability to engineer artificial molecular systems.

The course will cover the theory of chemical reaction networks, molecular circuits, DNA self-assembly, thermodynamics of computation, and connections to the field of distributed computing.

**Course registration number**: 44328

## Prerequisites

ECS 120 or equivalent (Chapters 1,3,4,7 of *Introduction to the Theory of Computation* by Michael Sipser)

Familiarity with basic probability is helpful.

No knowledge of chemistry, physics, or biology is assumed.

## Grading

Homework/Project/Participation (no exams)

## Syllabus

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| Week 1 | algorithmic self-assembly I |
| Week 2 | algorithmic self-assembly II |
| Week 3 | algorithmic self-assembly III |
| Week 4 | chemical reaction networks I |
| Week 5 | chemical reaction networks II |
| Week 6 | chemical reaction networks III |
| Week 7 | population protocols |
| Week 8 | DNA strand displacement |
| Week 9 | thermodynamics of computing |
| Week 10 | project presentations |

## Textbook

No textbook. Some papers will be assigned reading.

Image: *Crystals that count! Physical principles and experimental investigations of DNA tile self-assembly,* Constantine Evans, Ph.D. thesis, California Institute of Technology, 2014. The atomic force microscope image is of a ribbon made from DNA strands that count in binary; each bump is a streptavidin molecule, which are designed to attach to the DNA strands that represent the bit 1, to help read out the bits.