



# COS 116: The Computational Universe

Sanjeev Arora  
Spring 2011

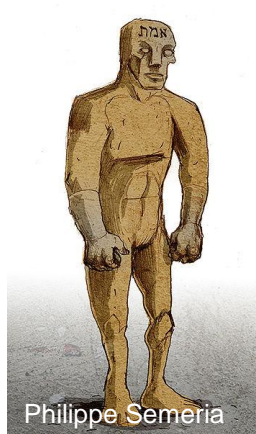


# COS 116:

## The Computational Universe

- Instructor: Sanjeev Arora
- TA: Dominic Kao
- Lab
  - Wed 7:30-10:20pm, Friend 007
  - This week only: take-home lab
- Course homepage:  
<http://www.cs.princeton.edu/courses/archive/spring11/cos116/>  
(copyrighted material on blackboard site)

# Ancient dream: “Breathe life into matter”



Golem (Jewish mythology)



Automaton (Europe)



Frankenstein (Shelley 1818)



Robot (Capek 1920)

# Breathing life into matter...



NB: Military was a major sponsor of computational research in 20<sup>th</sup> century

# Computation strikes back....

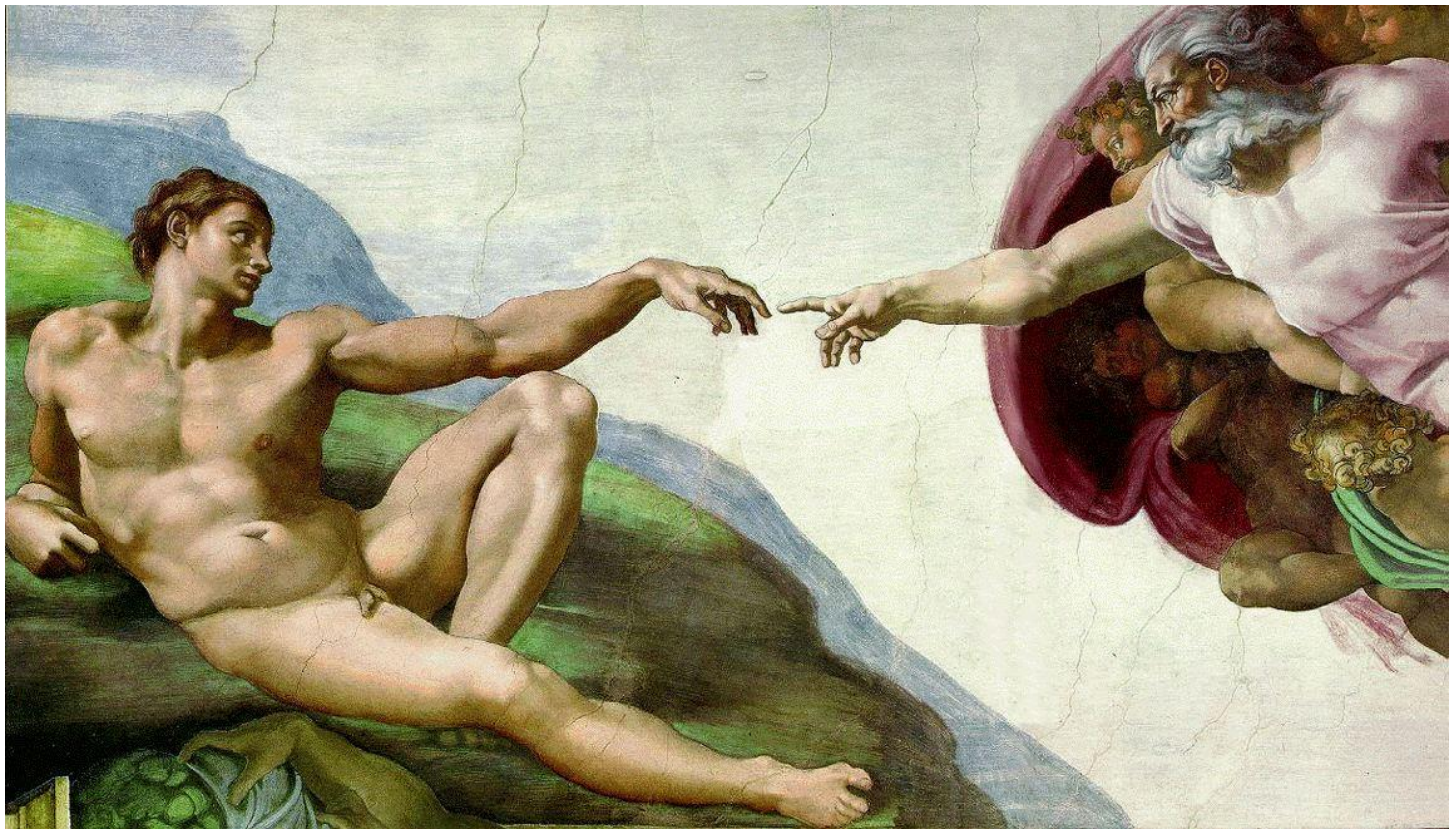


## Egypt Revolution 2011

Egypt Revolution 2011 Videos (LIVE UPDATES) [Page 1](#), [Page 2](#),  
[Page 3](#), [Page 4](#), [Page 5](#), [Page 6](#), [Page 7](#), [Page 8](#), [Page 9](#)

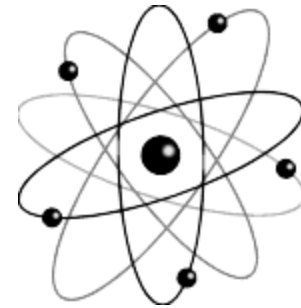


# “Breathe life into matter” – Another perspective

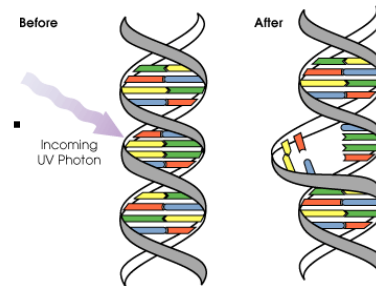


# “Breathe life into matter” – A 20<sup>th</sup> century perspective

- “Matter”: Atoms, molecules, quantum mechanics, relativity ...



- “Life”: Cells, nucleus, DNA, RNA, ...



- “Breathe life into matter”: Computation



**One interpretation: Make matter do useful,  
interesting things on its own**

May 11th, 1997  
**Computer won world champion of chess**  
(Deep Blue) (Garry Kasparov)



(Reuters = Kyodo News)



# Computational Universe



Google™







## Some important distinctions

|                  |   |
|------------------|---|
| Computer Science | vs. Computer Programming<br>(Java, C++, etc.) |
|------------------|---|

|                       |  |
|-----------------------|--|
| Notion of computation | vs. Specific implementation<br>(Silicon, robots, Xbox, etc.) |
|-----------------------|--|



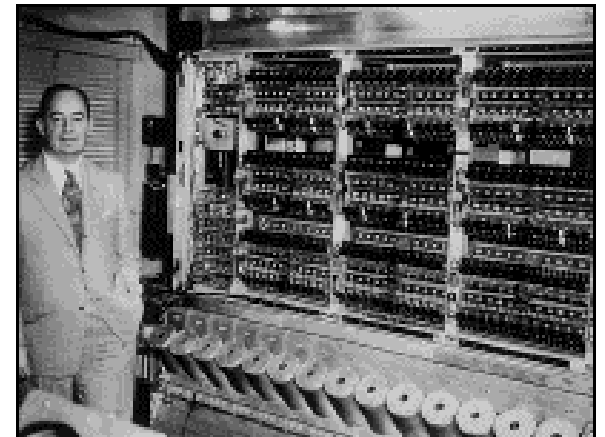
# No programming in this course!

- Not necessary for understanding
- More time for us to cover computer science (COS 116 broader than COS126!)
- No advantage to those who have prior programming experience

# Brief history of computation

## ■ Technological:

- Mechanical Clocks (13<sup>th</sup> century)
- Clockwork “Automata”
- Mechanized looms, steam engines
- Vacuum tubes, electronic calculators (1910-1930's)
- ENIAC (1945)
- von Neumann Computer (1949, Princeton)
- First PCs, 1970s



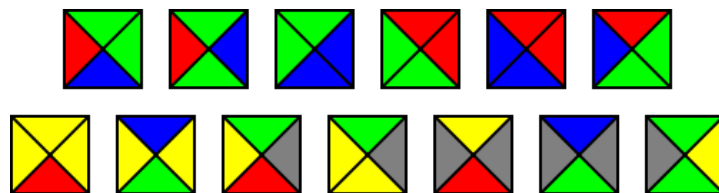
# Brief history of computation

## ■ Intellectual

- Ancient Greeks, philosophers
  - (How to “formalize thought”)
- Boolean logic (G. Boole, 1815-1864)
- Crisis in math
  - Hilbert: Call to systematize math
  - Gödel: Incompleteness theorem
- Lambda calculus (A. Church, 1936)
- Turing machines (A. Turing, 1937)

Both at Princeton;

First clear notion of  
“What is computation?”



Wang tiles 1961





# Computer Science:

## A new way of looking at the world

Example 1:



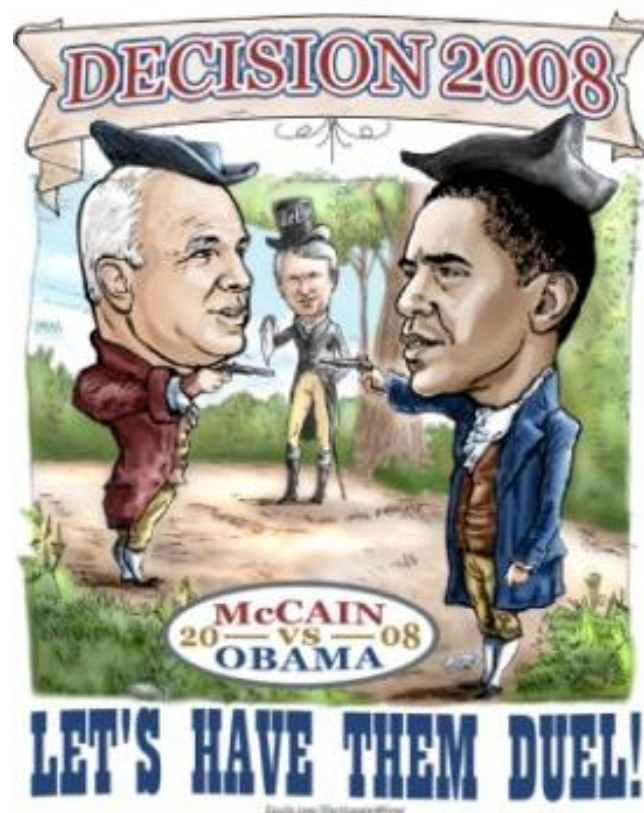
## Example 2: Public closed-ballot elections

- Hold an election in this room

- ☐ Everyone speaks publicly (no computers, email, etc.)
- ☐ End: everyone agrees on who won and margin
- ☐ No one knows how anyone else voted

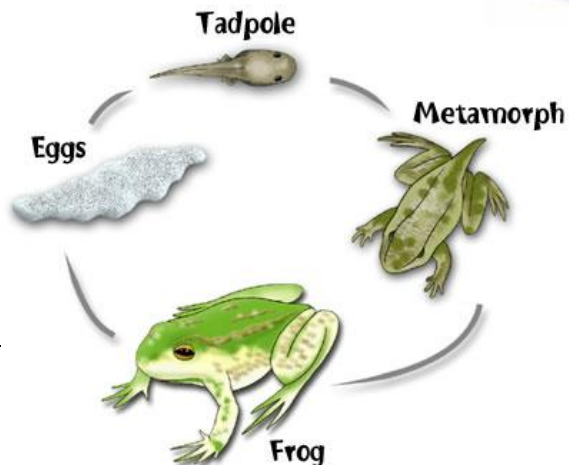
- Is this possible?

- ☐ Yes! (A. Yao, Princeton)

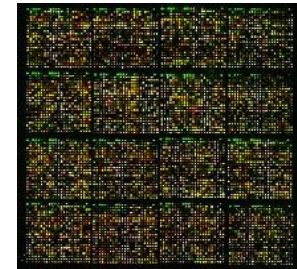
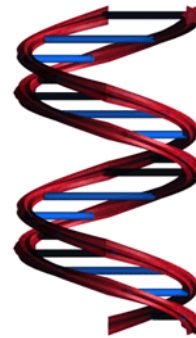


## Example 3: Computational Biology

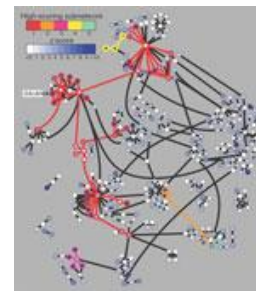
Old Biology



New Biology



Microarrays



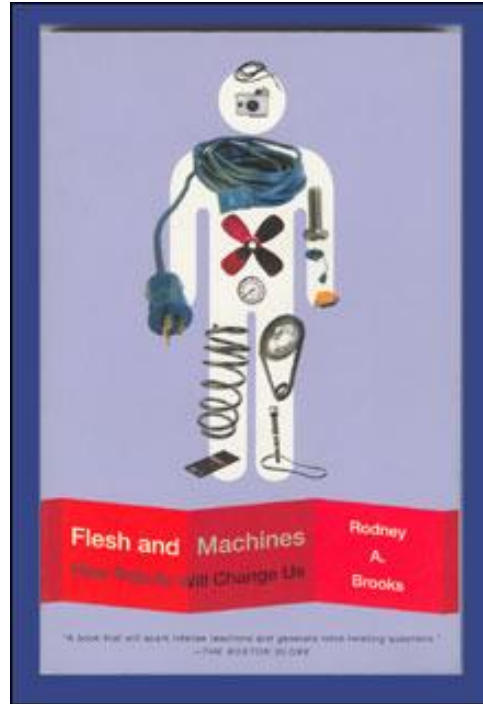
Pathways





# COS 116

- First 10 lectures:
  - Cool things computers do and how
- Next 8 lectures:
  - What's inside computers, silicon chips, internet.
- Last 6 lectures:
  - Complexity, cryptography, viruses, search engines, artificial intelligence



This week's reading:  
Brooks  
pp 12-21, pp 32-51.  
(on blackboard)

This week's lab: Web 2.0

(Take-home lab – will be posted by Tues night)



# Grading

- Midterm: 15%
- Final: 35%
- Lab reports: 35%
- Participation (class, blog): 15%
  
- Attendance expected at lectures and labs

Next couple labs: Scribbler.  
What determines its behavior?

