Biology, Computers & Python

Michael Schatz

Sept 3, 2013

QB Bootcamp Lecture 1

Outline

Part 1: Overview & Fundamentals

- Overview of Computer Systems
- Python Primer

Part 2: Sequence Analysis Theory

Part 3: Genomics Resources

Part 4: Unix Primer

Part 5: Example Analysis

Modern Biology Challenges

The foundations of biology will continue to be *observation*, *experimentation*, and *interpretation*

- Technology will continue to push the frontier
- Measurements will be made *digitally* over large populations, at extremely high resolution, and for diverse applications

Rise in Quantitative and Computational Demands

1. *Experimental design*: selection, collection & metadata
2. *Observation*: measurement, storage, transfer, computation
3. *Integration*: multiple samples, assays, analyses
4. *Discovery*: visualizing, interpreting, modeling

Ultimately limited by the human capacity to execute extremely complex experiments and interpret results

How do we draw conclusions?

- Comparison & Correlations: How does X compare to Y?

X	Y
Exomes of kids with autism	Exomes of kids that do not
Genomes of Europeans	Genomes of non-Europeans, mammals, …
Gene expression in mutants	Gene expression in wild type
Firing patterns of mutant fly neurons	Firing patterns of wild type

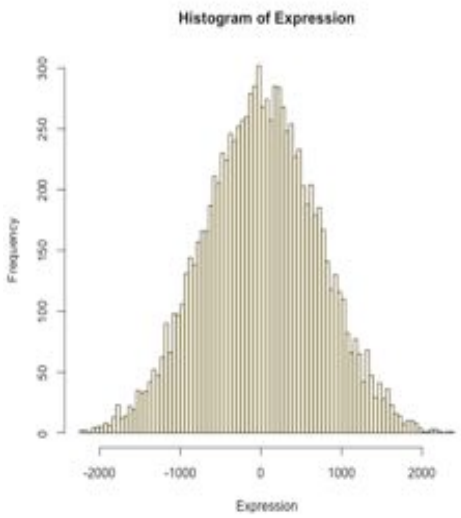
- Modeling & Predictions: How will X respond to Y?

X	Y
Mutant tomatoes	Increased temperatures
Human Microbiome	Probiotic treatments
Gene expression in mice	Knockout of transcription factor
Firing rate in flies	Decreased sodium levels

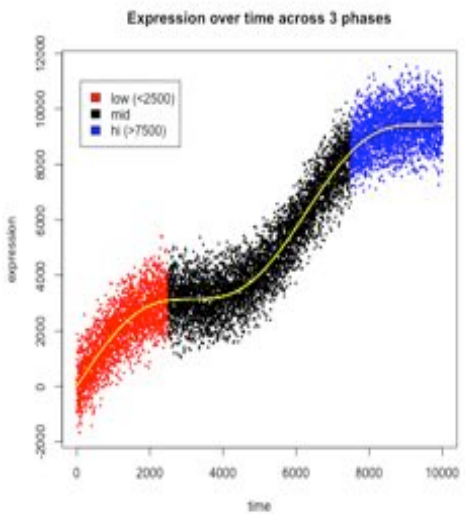
How do we DRAW conclusions?

```
-902.473
 242.817
-872.453
 73.9297
 236.169
 46.7525
 975.014
 716.563
-533.971
-120.282
  725.12
 -736.76
 176.156
 189.224
 1847.46
-159.099
-56.4754
-973.626
  1181.9
-315.455
-1480.43
 215.293
-747.505
 682.577
    …
```

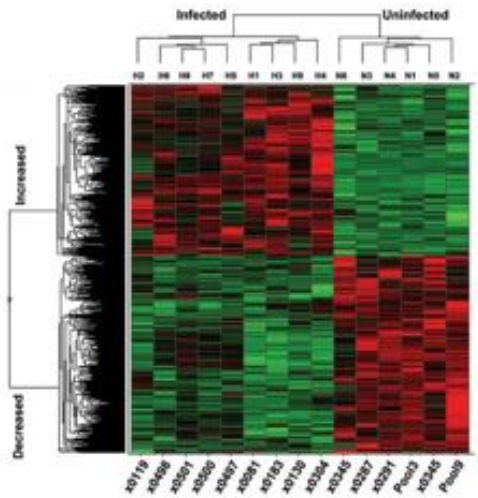
Histogram



Scatterplot



Heatmap



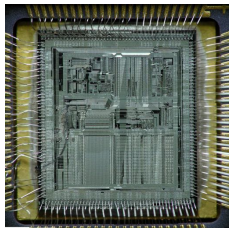
Data and data transformations are ubiquitous in science
Data are too numerous and transformations are too complex to do by hand
==> Mendel: 100k observations, 10 years
==> HiSeq 2000: 600B observations, 10 days
==> Make friends with your computational tools

What is a computer?

[hardware]

Hard Drive
Permanent Storage – 1TB
(big, slow, cheap)

RAM
Working Storage – 8 GB
(small, fast, expensive)



Processor
Arithmetic, logic
cores, clock speed

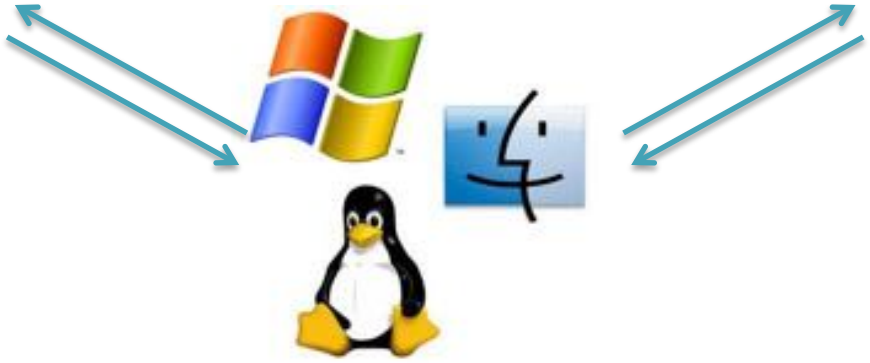
Display
Human Interface

Network
Computer Interface
Home: 10Mb/s, CSHL: 1Gb/s

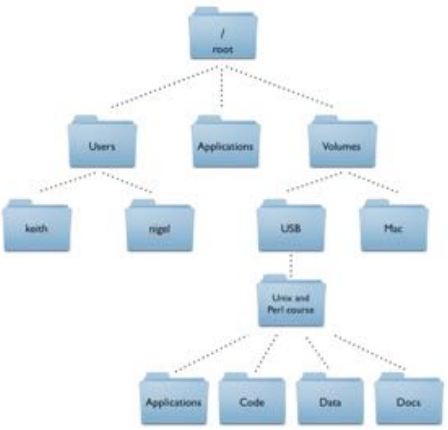
What is a computer?

[software]

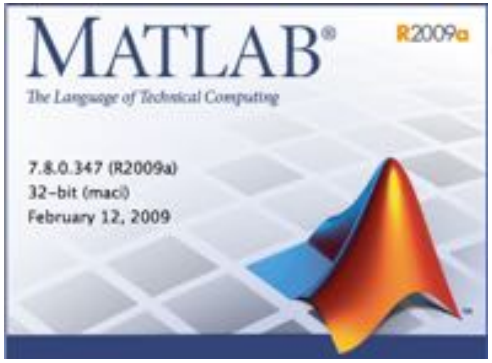
Office Applications
Presentations, Documents
Simple statistics and plots



Operating System
Mission Control
Windows, Mac, Unix, iOS



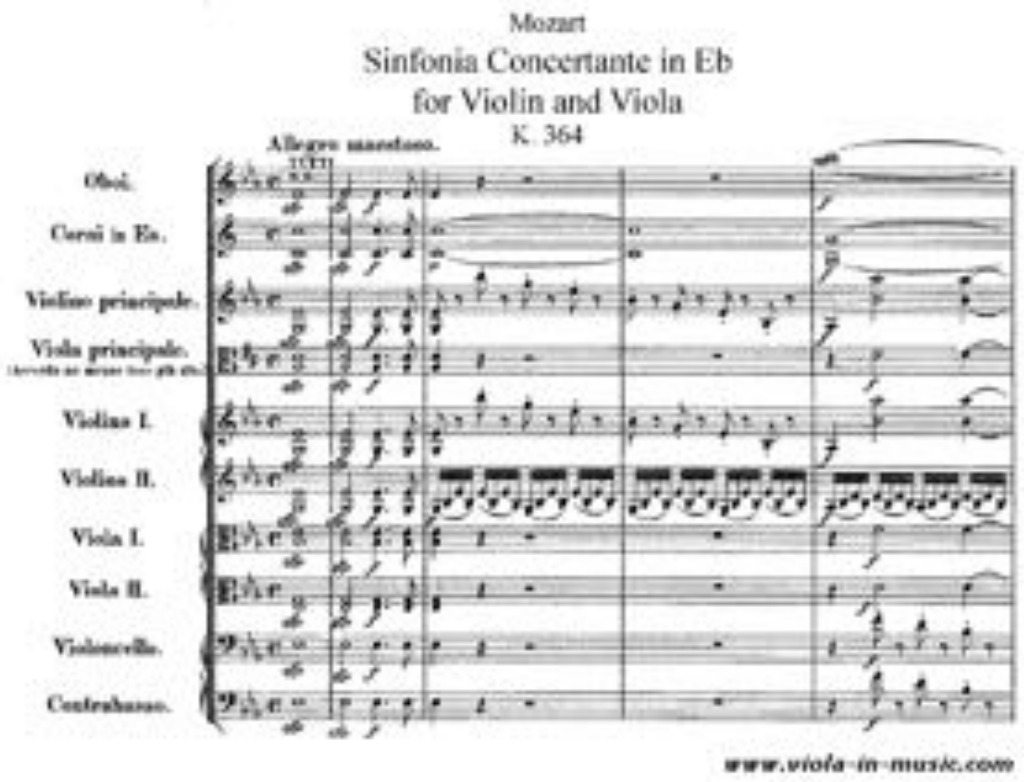
Files / Data
Papers, sequences,
measurements



Scientific Applications
Specialized Analysis
Commercial

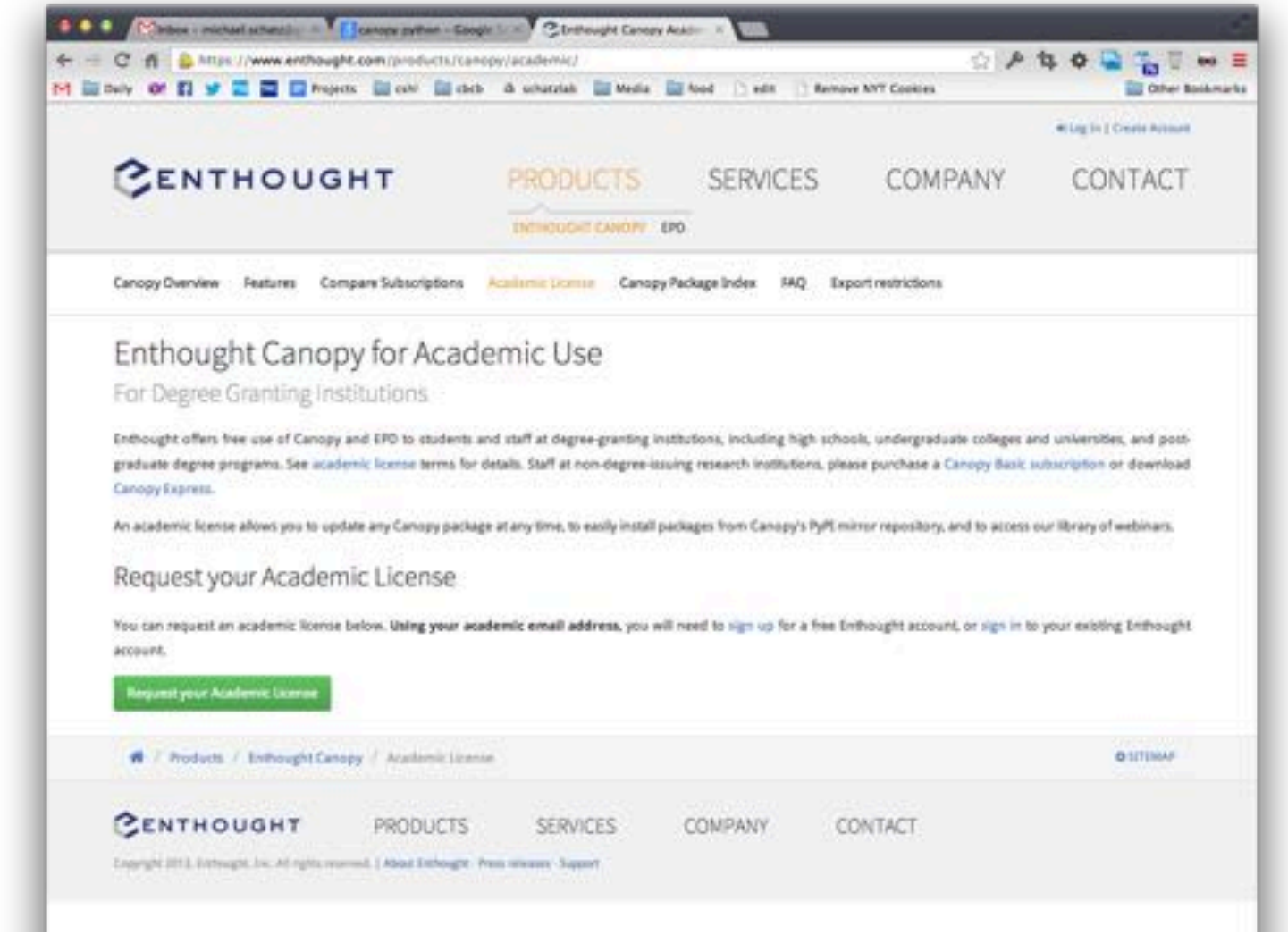
Code / Scripts
Research Applications
Academic

Programming 101



A software program is like sheet music for the orchestra inside your computer
Static, written representations of an active process

Programming with Python



https://www.enthought.com/products/canopy/academic/
http://www.codecademy.com/tracks/python

Questions?

http://schatzlab.cshl.edu