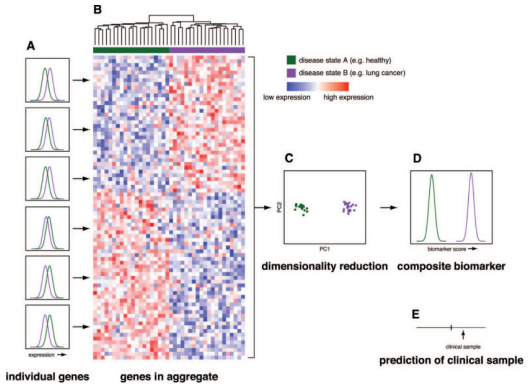
BIOE 210 is a core course, not a computational track elective.

Can we classify breast cancer subtype by gene expression?



Beane et al. J Thor Onc (2009)

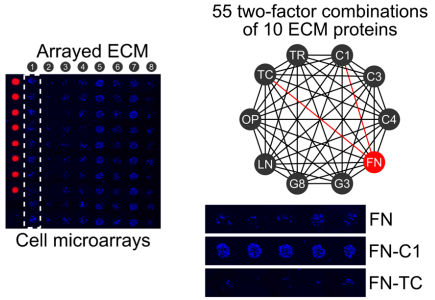
Can we identify predictors of heart attacks from medical records?

```
load hospital

hospital(1:10,:)
ans =
    LastName      Sex      Age    Weight    Smoker    BloodPressure      Trials
    YPL-320    'SMITH'     Male      38       176      true             124          93    [        18]
    GLI-532    'JOHNSON'   Male      43       163      false            109          77    [1×3 double]
    PNI-258    'WILLIAMS'  Female    38       131      false            125          83    [1×0 double]
    MIJ-579    'JONES'     Female    40       133      false            117          75    [1×2 double]
    XLK-030    'BROWN'     Female    49       119      false            122          80    [1×2 double]
    TFP-518    'DAVIS'     Female    46       142      false            121          70    [        19]
    LPD-746    'MILLER'    Female    33       142      true             130          88    [        13]
    ATA-945    'WILSON'    Male      40       180      false            115          82    [1×0 double]
    VNL-702    'MOORE'     Male      28       183      false            115          78    [         2]
    LQW-768    'TAYLOR'    Female    31       132      false            118          86    [        11]

hospital.meanBP = mean(hospital.BloodPressure, 2);
hospital(1:10,:)
ans =
    LastName      Sex      Age    Weight    Smoker    BloodPressure      Trials             meanBP
    YPL-320    'SMITH'     Male      38       176      true             124          93    [        18]    108.5
    GLI-532    'JOHNSON'   Male      43       163      false            109          77    [1×3 double]       93
    PNI-258    'WILLIAMS'  Female    38       131      false            125          83    [1×0 double]      104
    MIJ-579    'JONES'     Female    40       133      false            117          75    [1×2 double]       96
    XLK-030    'BROWN'     Female    49       119      false            122          80    [1×2 double]      101
    TFP-518    'DAVIS'     Female    46       142      false            121          70    [        19]     95.5
    LPD-746    'MILLER'    Female    33       142      true             130          88    [        13]      109
    ATA-945    'WILSON'    Male      40       180      false            115          82    [1×0 double]     98.5
    VNL-702    'MOORE'     Male      28       183      false            115          78    [         2]     96.5
    LQW-768    'TAYLOR'    Female    31       132      false            118          86    [        11]      102
```

What matrix materials interact when culturing human cells?



Kaylan KB, et al. (2016). Integr Biol 8,1221.

Can we quantify the odds of developing Huntington's?

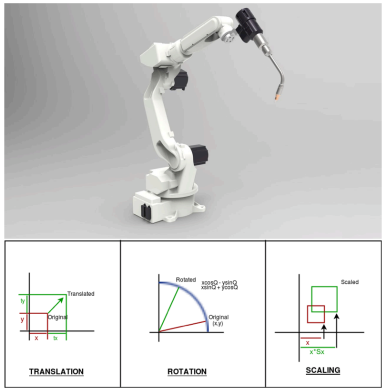
Leu Lys Ser Phe Gln Gln ... Gln Gln Gln Gln Pro

ctc aag tcc ttc cag cag ... cag cag caa cag ccg

Classification of the trinucleotide repeat, and resulting disease status, depends on the number of CAG repeats[27]

Repeat count	Classification	Disease status
<26	Normal	Unaffected
27–35	Intermediate	Unaffected
36–40	Reduced penetrance	+/- Affected
>40	Full penetrance	Affected

How do we calculate the position of a robotic arm?



These questions (and more) are homework problems from Spring 2021.

What's in BIOE 210?

- **Part I: Linear Systems**

Field axioms	Norms & dot products
Multiplication	Translation matrices
Gaussian Elimination	Inverses, solvability, & rank
Finite differences	Linear regression

- **Part II: Nonlinear Systems**

Root finding	Optimization & convexity
Gradient descent	Regularization
Geometry	Support Vector Machines

- **Part III: High-Dimensional Systems**

Basis vectors	Orthogonality
Eigenvectors/values	SVD / PCA / Low-rank approximations
Image compression	***Recommender systems***

What's *not* in BIOE 210?

- Several classes use linear algebra or related topics.
  These topics are referenced, but not covered in BIOE 210:
  - Linear systems (state space), Laplace & Fourier transforms [BIOE 205]
  - Probability & statistics, clustering [BIOE 310]
  - Design of experiments, reinforcement learning [BIOE 498 PJ]

- Topics in other linear algebra courses (MATH 257, 415/416)
  - Subspaces, quadratic forms, heavy use of the determinant, operator and spectral theory.
  - These are replaced with more applied topics: **statistical models**, **machine learning**, and **numerical methods**.

Class Structure

- 3 exams (60%)
  - February 15, March 29, May 3 (last day of class)
  - There is no final exam

- 14 homework sets (40%)
  - Due every **Monday by 5pm.**
  - Includes analytical and machine problems.
  - All work submitted on Gradescope.
  - Your 10 best scores will be used for your final grade -- **no exceptions**.

- Late policy:
  - < 24 hours = 10% off
  - < 48 hours = 50% off
  - 48+ hours = ungraded

Assessment

- Homeworks are *formative* assessments to help you learn.
- Full credit does **not** mean you did everything perfectly.
- Your job is to compare your answers with the solutions.
- Exams are *summative* assessments to measure your proficiency.
- Exam problems will look like homework problems.
- I will not ask you to “code” on exams, but I will ask you to interpret computational results.

Communication

- Stay tuned to the class website: http://bioe210.github.io

- The instructor responds to e-mails during business hours (8am-4pm, Monday-Friday)

- Office hours will be on Zoom:
  - Instructor: Friday, 3-4pm
  - TA (Kurt): Thursday, 1-2pm
  - Matlab Help Session: TBA

- All online sessions use the same Zoom link (sent by e-mail)

Pandemic-related Schedule Changes

- Lectures may need to go online **with short notice**.
  - I will send an e-mail if class will be
    (a) moved online using the class Zoom link
    (b) canceled

- If you need to miss class or are feeling unwell
  - Just stay home
  - You do not need to contact me or ask “what did I miss?”
  - Read the assigned chapter in the textbook and try the homework
  - Ask questions at office hours or by e-mail

- I became ill near a homework deadline. Should I ask for an extension?
  - No. Focus on recovering and staying current with the reading.
  - Only 10 of 14 assignments are scored.

Class Rules

1. You do **not** need to come to class.

2. If you come to class, you will be respectful of your colleagues.

3. If you have any questions on Rule #2, see Rule #1.

Lectures **supplement** the material in the book. Lectures are your chance to ask questions and participate.

The lectures are not recorded, and you are **not** allowed to record your classmates (or the instructor).

You do not need to take notes. **Try just listening and participating!**

Succeeding in BIOE 210

1. Linear algebra is powerful, elegant, and beautiful. Trust me.

2. **Everything you need to know is in the book**. I'm not trying to keep this stuff a secret.
   - If you can't find something, look deeper before you look wider.

3. There will be no surprises:
   - Textbook
   - Lecture
   - Homework problems
   - Office hours
   - Practice exams
   - Exams

Be careful on the internet

Pythagorean theorem:

$$c = \sqrt{a^2 + b^2} \qquad \neq \frac{a + b}{2}$$

"The standard deviation is the average distance between the mean and each point in the sample." *– popular online math video*

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \qquad \neq \frac{\sum |x_i - \bar{x}|}{n}$$

"It might not be exactly correct, but it's much easier for students to understand." *– creator of the popular online math video*

The BIOE 210 Philosophy

“Everything should be made as simple as possible,
but no simpler.”

1. The course is designed around tools that are useful to bioengineers.

2. The course omits topics that are not essential *for these tools*.

3. We favor *understanding* fewer topics over surveying many topics.

Topics for today

1. Algebra

2. Linearity

Muhammad ibn Musa al-Khwarizmi
c. 780 - 850