Making the micRO*BiO*T
(micro biotic robots)

(Module 2 of What is Engineering?)

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micRO*BiO*T

- Robots don't necessarily have to be inorganic
- micRO*BiO*Ts are purely organic
  - Programming is encoded in organic (carbon-based) molecules, not in silicon like PCs
  - Think X-Men, not Terminators

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NOT

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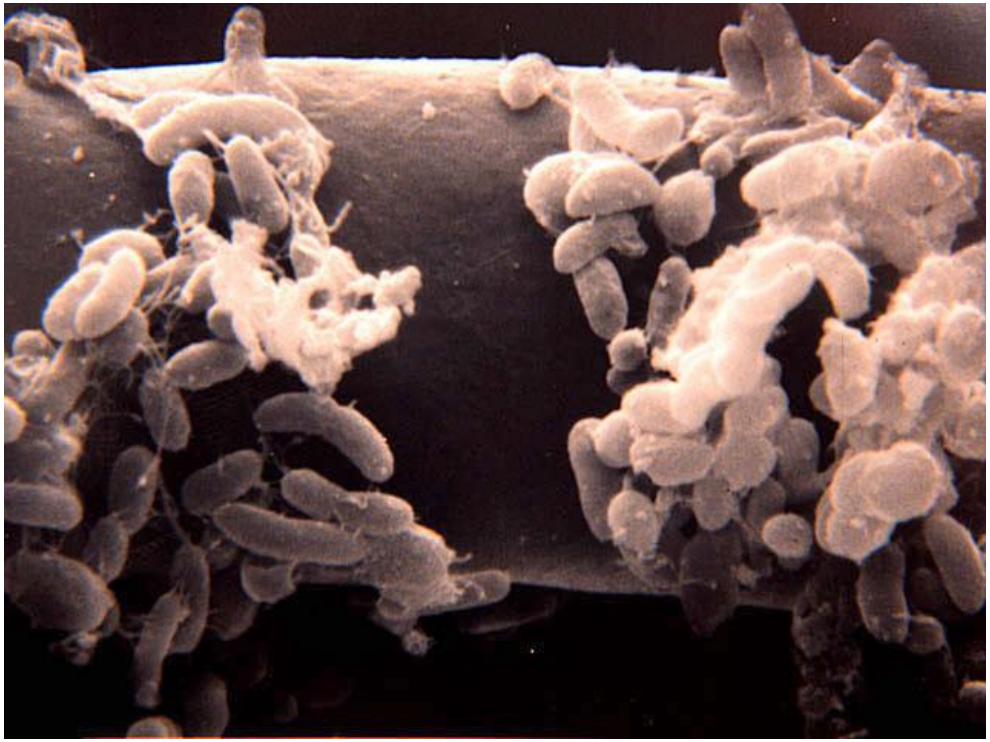
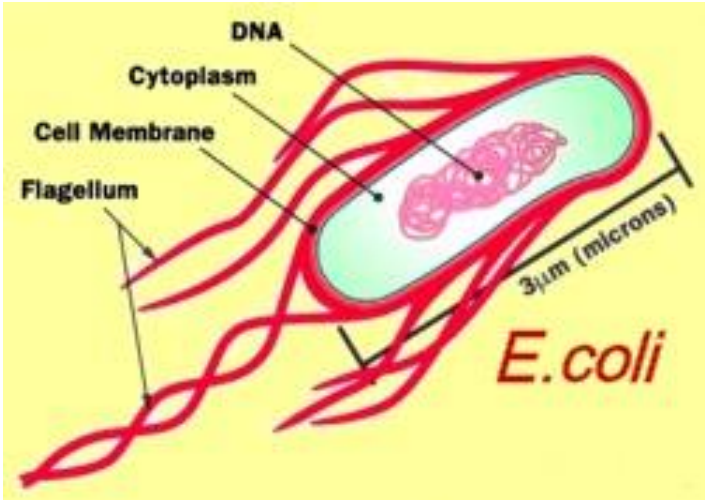
- Engineered *E. coli*
  - Where is *E. coli* naturally found?
  - How big is it?

Scale: perspective

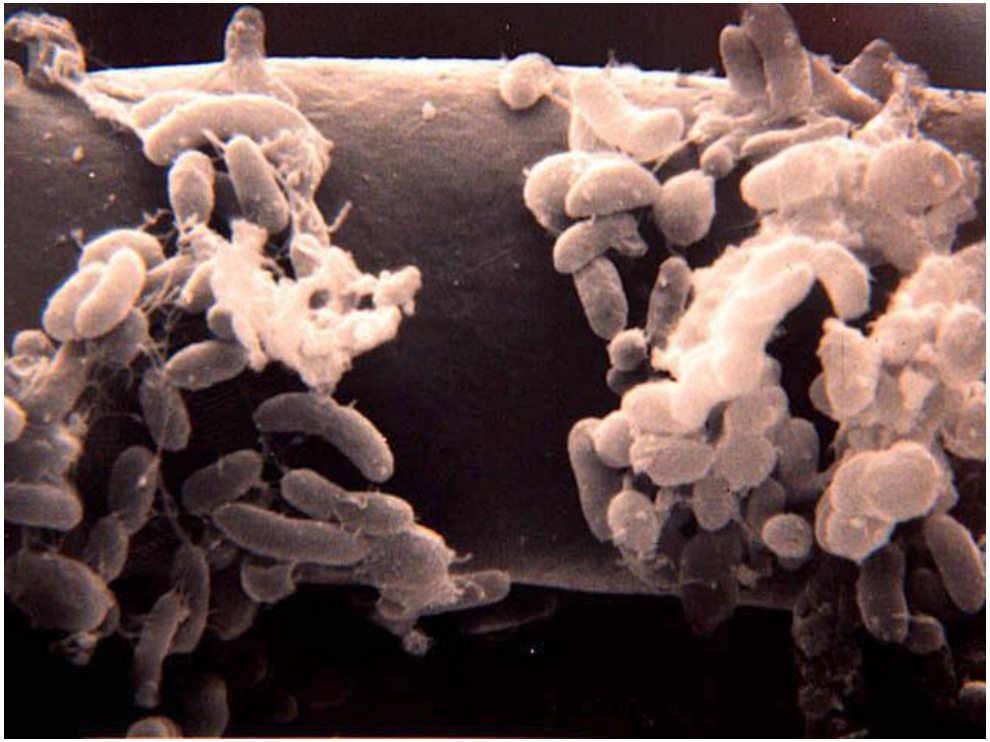


Bacteria on human hair



http://www.gardenscience.co.nz/graphics/Bugs/rhizobact.jpg
http://www.nature-education.org/cart/ecoli-cell.jpg

Scale: perspective



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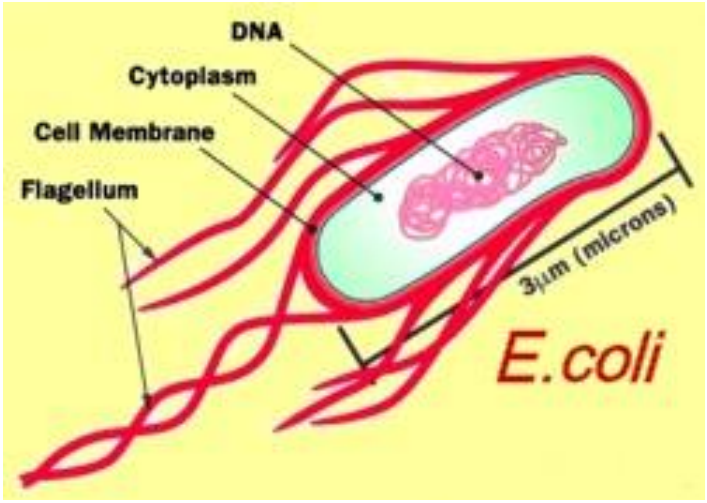

The tube in front of you contains ~same # of cells as there are human on earth

http://www.gardenscience.co.nz/graphics/Bugs/rhizobact.jpg
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Biological sensor

Input
(external stimulus)
(eg: movement)

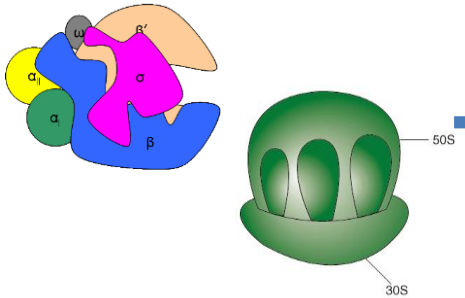
Detector
(recognizes input, creates signal)
(eg: motion detector)

Actuator
(takes input signal and converts it to output)
(eg: switch)

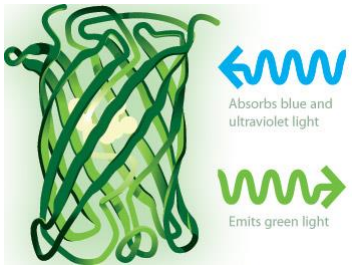
Output
(detectable signal)
(eg: light)

Pathogen metabolite

Binding protein



Cellular protein production machinery



Fluorescent protein

Experimental protocol

- Step-by-step instructions on putting plasmid inside *E. coli* cells (transformation)

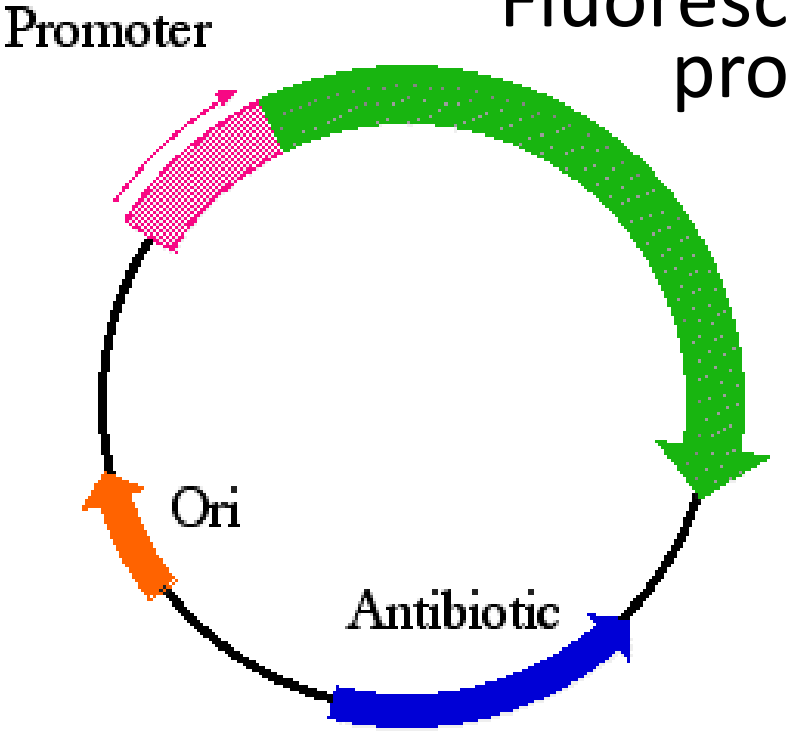
- Inoculating media with transformed cells (Plating)

Plasmid
(genetic program carrier)

Arabinose-responsive

Fluorescent protein

+

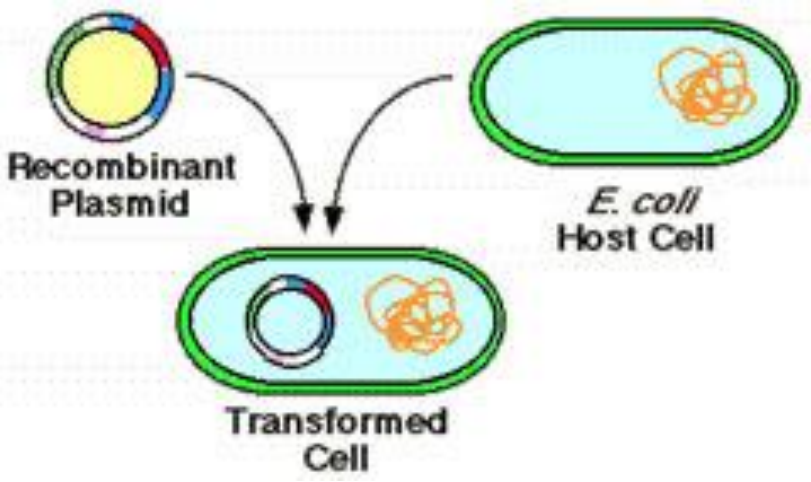


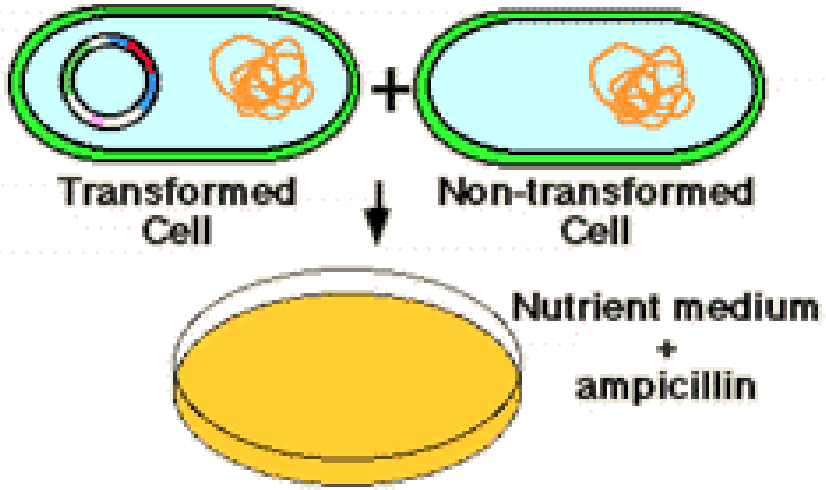
=

```
for i in people.data.users:
    response = client.api.statuses.user_timeline.get(screen_nam
    print 'Got', len(response.data), 'tweets from', i.screen_na
    if len(response.data) != 0:
        ltdate = response.data[0]['created_at']
        ltdate2 = datetime.strptime(ltdate,'%a %b %d %H:%M:%S +
        today = datetime.now()
        howlong = (today-ltdate2).days
        if howlong < daywindow:
            print i.screen_name, 'has tweeted in the past' , da
            totaltweets += len(response.data)
            for j in response.data:
                if j.entities.urls:
                    for k in j.entities.urls:
                        newurl = k['expanded_url']
                        urlset.add((newurl, j.user.screen_name)
        else:
            print i.screen_name, 'has not tweeted in the past',
```


https://qph.is.quoracdn.net/main-qimg-cec043ac61e46bdb6377cb62090354c0?convert_to_webp=true

Transformation
(moving programing into cells)





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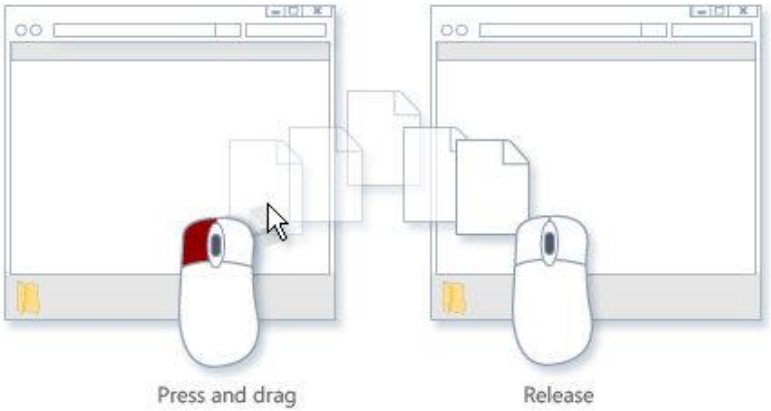
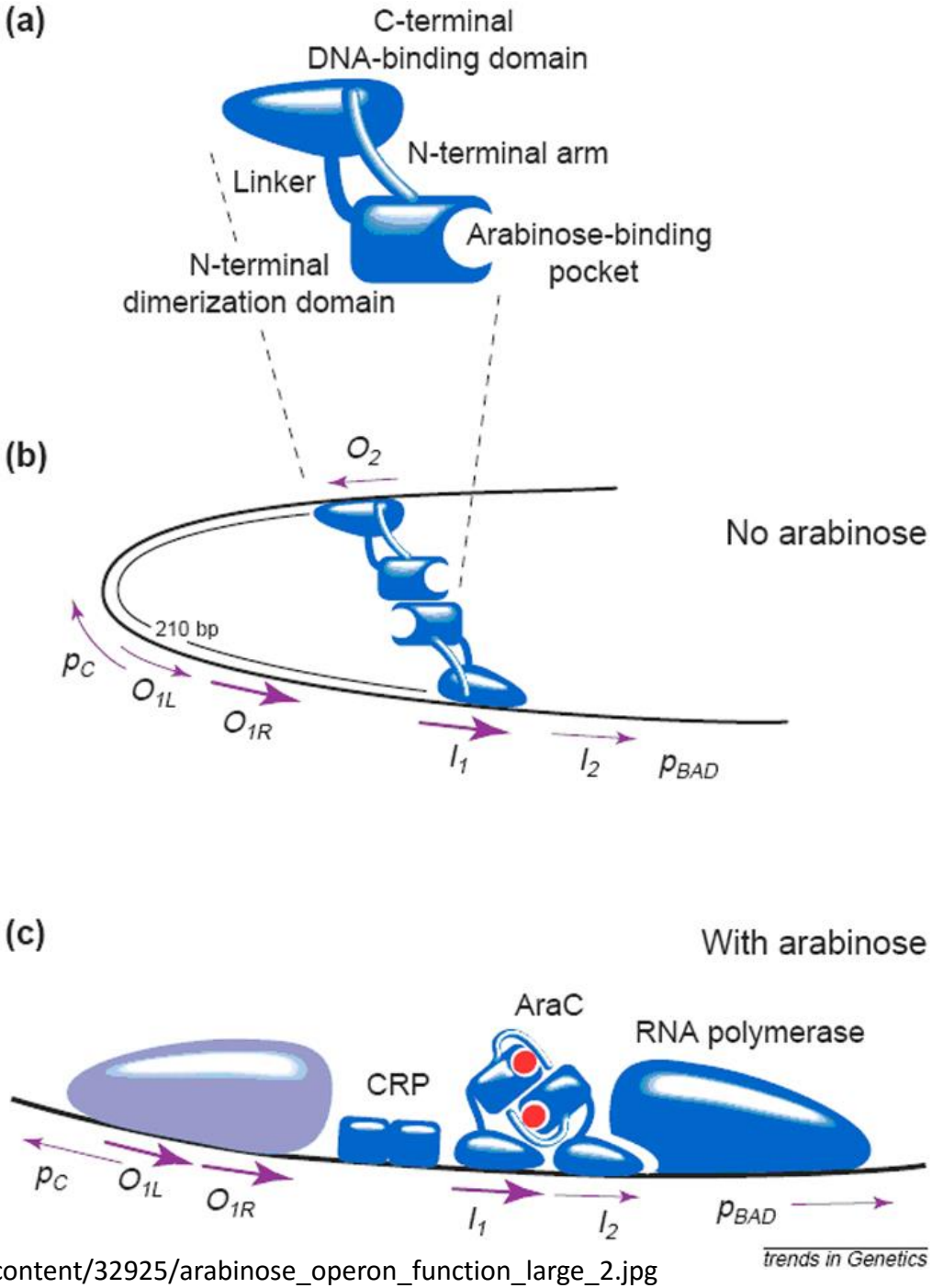


https://www.learner.org/interactives/dna/images/engineering6.jpg
http://www.biology.arizona.edu/molecular_bio/problem_sets/recombinant_dna_technology/graphics/05ta.gif

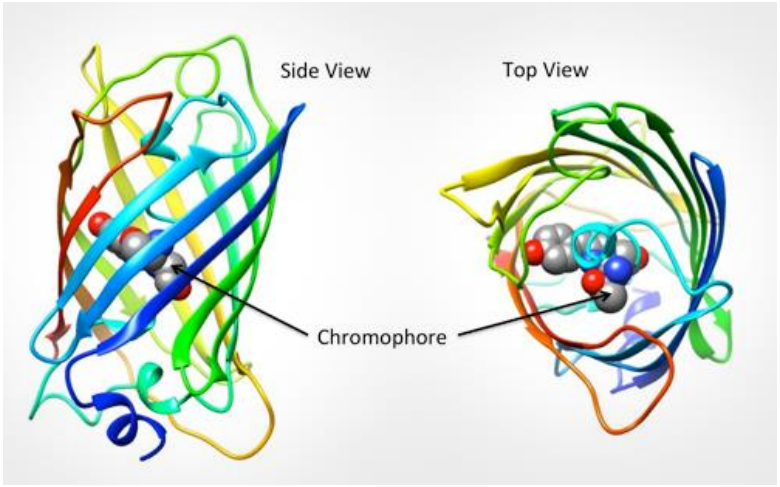
While we wait…

Arabinose sensor



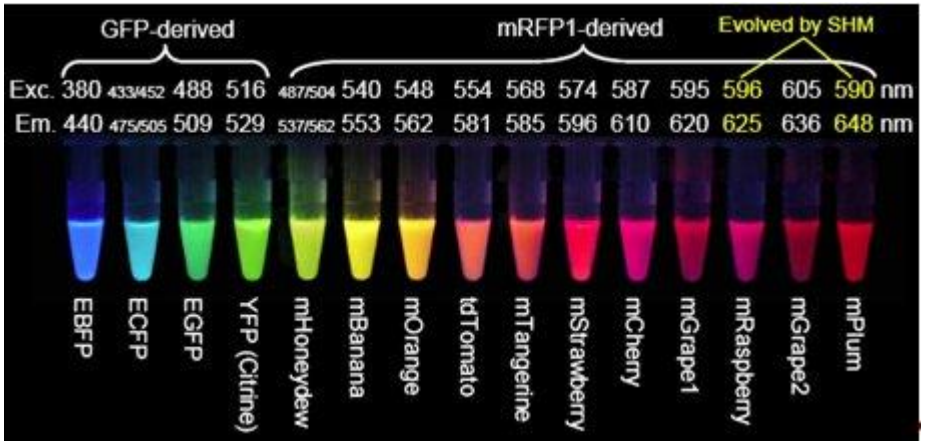
http://www.nature.com/scitable/content/32925/arabinose_operon_function_large_2.jpg

GFP and FPs



Engineered variants

(scientists want to know how GFP fluoresces; engineers want to know how to change its color)



http://cdn.zmescience.com/wp-content/uploads/2016/02/ZSVIqEL.jpg
http://cdn.rcsb.org/pdb101/learn/resources/gfp-activity-assets/gfp-image1.jpg
http://www.chm.bris.ac.uk/motm/GFP/GFPh.htm

Where is “patient zero” from?

- Patients with symptoms of Candidiasis test for the diagnosed with the biosensor
- # of cases vary with town
- Seem to be clustered in certain towns around Boston

- Hypothesis: infection travels downriver

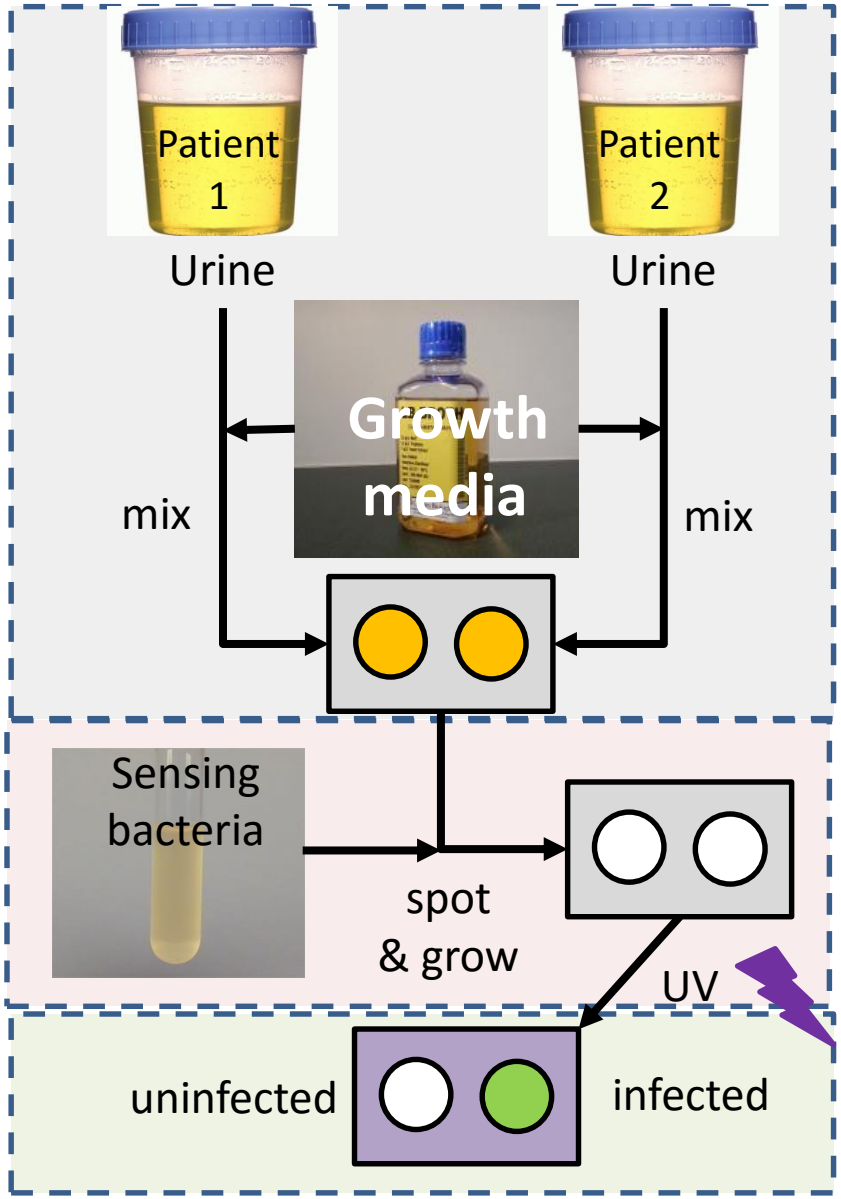
Forensic investigation of infection

- Arabinose: metabolite (biological chemical) produced by *Candida albicans* excreted in urine (not in uninfected people)
- Biosensor is responsive to arabinose

done

Your goal to do this today

Your goal to do this tomorrow



Find “ground zero”

Summary

- What is a plasmid?
- What is transformation?
- Why do we select on antibiotics?
- Workings of the micRO*BiO*T
  - Sense arabinose
  - Make a decision
  - Create an output
  - Fluorescence vs. luminescence

More questions about engineering?

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