Models in science

MCSB Bootcamp — Mathematical and Computational Track

Jun Allard

What a model is

Coffee bean titration



Coffee bean dynamical system



Coffee bean strategy

Coffee beans, measuring each aliquot and titrating it in carefully. Mixing the two gradually. So I guess at day 10 it should be at 50%.

```
N = 10  # number of scoops in each jar
n_max = 2 * N  # max number of days to simulate

x = np.zeros(n_max)  # fraction caffeinated
x[0] = 1.0  # initial fraction caffeinated

for n in range(1, n_max):

    x[n] = (1 - 1 / N) * x[n - 1]

# finished loop through days

days = np.arange(1, n_max + 1)

fig, ax = plt.subplots()
ax.plot(days, x, "-ok")
ax.set_ylabel("Fraction caffeinated")
ax.set_xlabel("Days")
plt.show()
```

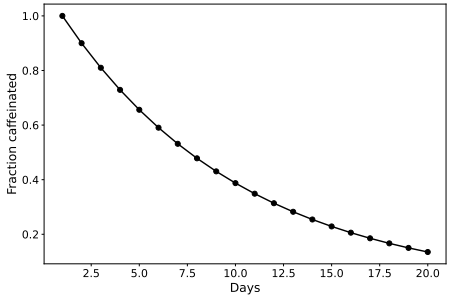


Figure 1: Fraction of the jar still caffeinated, day by day, for a ten-scoop jar.

What a model is



- A model takes model parameters and assumptions and leads to an inevitable predicted behavior.
- ("Inevitable" does not mean deterministic. Can be stochastic.)
- The input assumptions can be imperfect.
- The output can be counter-intuitive and surprising.
- It's not always time that separates inputs from outputs.

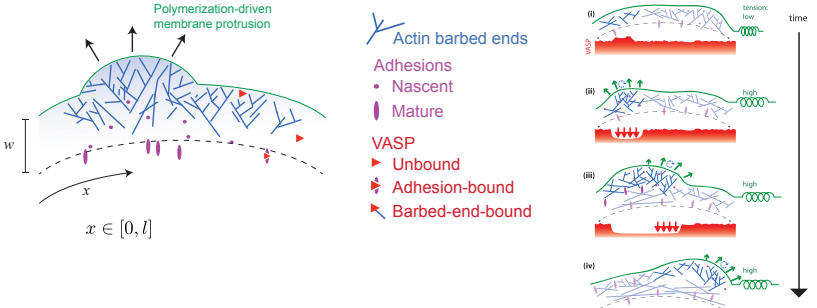
Barnhart et al., 2016

Current Biology
Article

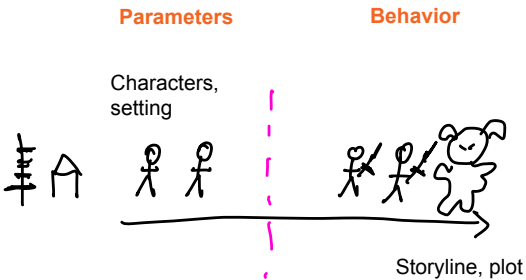
CellPress

Adhesion-Dependent Wave Generation in Crawling Cells

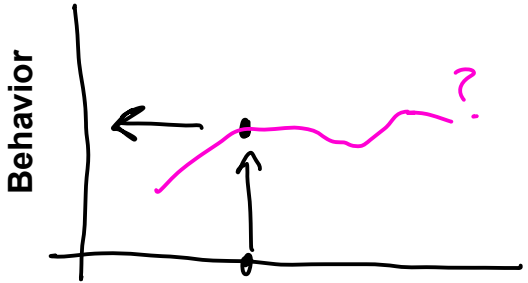
Erin L. Barnhart,[1,6] Jun Allard,[2,6] Sunny S. Lou,[1,3] Julie A. Theriot,[1,4,*] and Alex Mogilner[5,7,*]



Story, setting, characters traits, and plotline



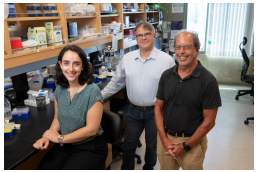
Inevitability is what makes it useful as a hypothesis-rejection tool.
Why might you do this?

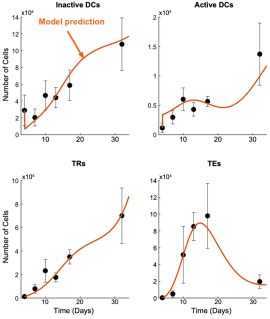


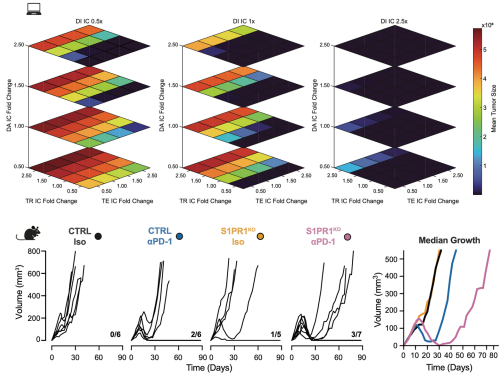
Reason 1: *Perturbable predictive understanding of the world*
"If someone changes *this*, then the biological system will do *this*."
This is what is needed for modern engineering practices to be brought to biomedical and biotech.

Models in MCSB

Sousa (MCSB 2026) et al. *Cancer Research*, 2026



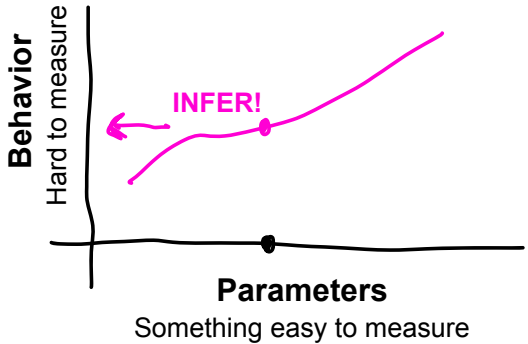




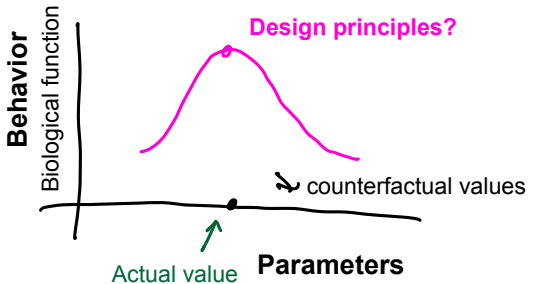
We are in the infancy of a field.

Why might you do this?

Reason 2: Reverse-engineer something that is hard to observe



Reason 3: Learning about evolution's design principles - some functional output, and some parameter. Why did evolution choose this value? "Teleology"



Modeling is bi-directional

