

This practice 'short mock final' is open book, notes and articles. It is to be completed solo, without consulting others. Time limit is 45 min.

**Total Points: 100**

**Problem 1 (50 pts).** You're a first year graduate student collaborating with the Jet Propulsion Lab to analyze live cells that astrophysicists discovered on the surface of Mars in 2019. One day in the lab, you make an amazing discovery: when the humidity changes in San Antonio, most of the cells overexpress a light-sensitive compound that glows bright red. You name this compound SOLIEL. You observe that SOLIEL also changes how fast the cells grow. After a series of follow-up protein array studies, many known proteins from Earth eukaryotes show up, and you make the following conclusions:

SOLEIL is upstream of the cell cycle protein complex Cyclin B / Cyclin-Dependent Kinase 1 (Cyclin B-CDK1). This complex can coregulate cell mitosis. You also find that SOLIEL regulates a hypoxic response transcription factor (HIF1). HIF1 also regulates cell mitosis.

Excited by your discovery, you quickly sketch out a diagram of the relationships between the environmental stimuli, the three compounds (SOLEIL, Cyclin B-CDK1, HIF1), and mitosis.

a) Draw that diagram here, and state any assumptions:

- b) Aiming for the Nobel Prize rather than the Ig Nobel, you decide you'll need to perform a series of rigorous tests to prove these relationships. To estimate the number of experiments and controls you'll need, you represent your diagram in (a) by Bayesian relationships.
- (i) For simplicity, you also assume Boolean values for all your variables. If you assume conditional independence of variables in your diagram, how many probabilities/parameters do you need to calculate the joint probability of everything being on or present?
  
  - (ii) If you made no assumptions about conditional dependence or Bayesian assumptions, how many parameters would you need? Write out the full joint probability calculation.
- c) You did it! Your paper is coming out in the famous new journal Alien Biotech in 2021. Reviewers were very enthusiastic and suggested new experiments. They want to see time course analysis. (10 pts)
- (i) You decide to use modeling to help you plan the time course experiments. How would you define relationships in your system (diagram from part a) in a time-dependent manner? Write out the equations and assumptions.

**Problem 2 (50 pts).** Ten years later, you're head of the Mars National Research Center, which occupies the only major building on the planet. Recent news of a bacteria-born deadly epidemic on Earth is threatening to shut down any transport between Mars and Earth for the foreseeable future. You are asked to assess the risk and minimize the spread of the organism should a visitor from Earth bring the bacteria to your center. Your Center houses every human on the planet. It has a medical clinic and restaurant.

a) You gather your close senior team, and inform them that they are essential to preserving human life on Mars. You need to determine who is most at risk and find ways to minimize their potential exposure to the bacteria. They concur and quickly provide details on their potential high contact risk activities. List all assumptions in your analysis / calculations.

Mars Senior Scientist	Works in Medical Clinic	Ave. Times / Day eats at Restaurant	Ave. Days Travels to Earth / Month	Ave. Days Contact with Other Scientists / Month
Andy	Yes	1	4.20	28.00
Bagrat	Yes	2	7.58	17.00
Caitlin	Yes	3	5.37	14.00
Calvin	No	3	1.00	26.00
Chelsey	No	2	0.27	25.00
Christopher	Yes	3	5.00	17.00
Emily T	No	3	1.20	22.00
Jacob	Yes	2	0.00	30.00
John	No	4	0.74	25.00
Maria	No	4	2.01	12.00
Nicholaus	Yes	3	0.68	11.00
Reid	No	1	8.00	18.00
Emily R	Yes	2	2.12	29.00
Ruojia	Yes	1	8.40	26.00
Samantha	No	2	0.79	19.00
Sydney	No	4	3.87	20.00
Tien	Yes	1	8.55	16.00
Yi	No	3	7.00	24.00

Describe how you would categorize your team:

(i) Name two techniques that would allow you to quickly determine two major categories of scientists in the team: a higher and lower risk category.

