

The mathematics of cell division - Activity sheet

1. In the program, set the death rate to 0.3, the survival rate to 0.2, and the division rate to 0.5.

(a) Write down the probabilities that there are 0, 1 or 2 cells after 1 hour:

$$p_0 = \dots\dots$$

$$p_1 = \dots\dots$$

$$p_2 = \dots\dots$$

(b) Starting with 1 cell, run the simulation 10 times for 1 hour and record the population sizes at hour 1. Use these numbers to calculate the mean population size after 1 hour.

Simulation number	1	2	3	4	5	6	7	8	9	10
Population size										

From simulations, the mean population size after 1 hour is cells.

(c) Using the probabilities p_0 , p_1 and p_2 , calculate the mean population size exactly. Does this agree with the mean you calculated in part (b)?

(d) What happens to the mean if there are initially 3 cells? Can you write an equation for the mean population size after 2 hours? Use the simulations and the tables below to check your answers.

Simulation number	1	2	3	4	5	6	7	8	9	10
Population size										

Starting with 3 cells, the mean population size after 1 hour is cells.

Simulation number	1	2	3	4	5	6	7	8	9	10
Population size										

The mean population size after 2 hours is cells.

2. In the program, set the death rate to 0.5, the survival rate to 0.2, and the division rate to 0.3.
- (a) Calculate the mean population size after 1 hour using the same method as in question 1(c). Is the mean higher or lower? Can you explain why?

- (b) Starting with 1 cell, simulate the model 10 times for 2 hours. In the table below, record whether or not the population went extinct. Use this to estimate the probability of extinction.

Simulation number	1	2	3	4	5	6	7	8	9	10
Extinct?										

The probability of extinction after 2 hours is

- (c) Use the probabilities p_0 , p_1 and p_2 to find the missing extinction probabilities

- The probability of extinction by hour 1 is
- The probability of extinction by hour 2 is How does this compare to your answer from part (b)?

- (d) How do you think the probability of extinction will change if we start with 2 cells instead of 1?

3. Run the program for different numbers of cells, hours, and probabilities and investigate the behaviour of the stochastic process for different rates. See if you can predict the outcome of a given simulation before you run it.