Calculating Transformation Efficiency

The basic unit of all living organisms, from bacteria to humans, is the cell. Most cells contain DNA, which is the genetic blueprint used to build an organism. In nature, bacteria pass small pieces of DNA back and forth through transformation. In the laboratory, we can force cells to take up DNA using the "heat shock" technique, where the combination of charged ions and a rapid change in temperature force bacteria to take up DNA from the surrounding environment.

In practice, transformation is highly inefficient—only one in every 10,000 cells successfully incorporates the plasmid DNA. However, since many cells are used in a transformation experiment (about a billion cells), only a few cells must be transformed to achieve a positive outcome.

We can use the data from our experiment to determine how well our transformation worked by calculating the transformation efficiency. This is a quantitative determination of the number of cells transformed per 1 µg of plasmid DNA. In essence, it is an indicator of the success of the transformation experiment.

To calculate the transformation efficiency:

Count the number of colonies on the transformation plate. A convenient method to keep track of counted colonies is to mark each colony with a lab marking pen on the outside of the plate.

Determine the transformation efficiency using the following formula:

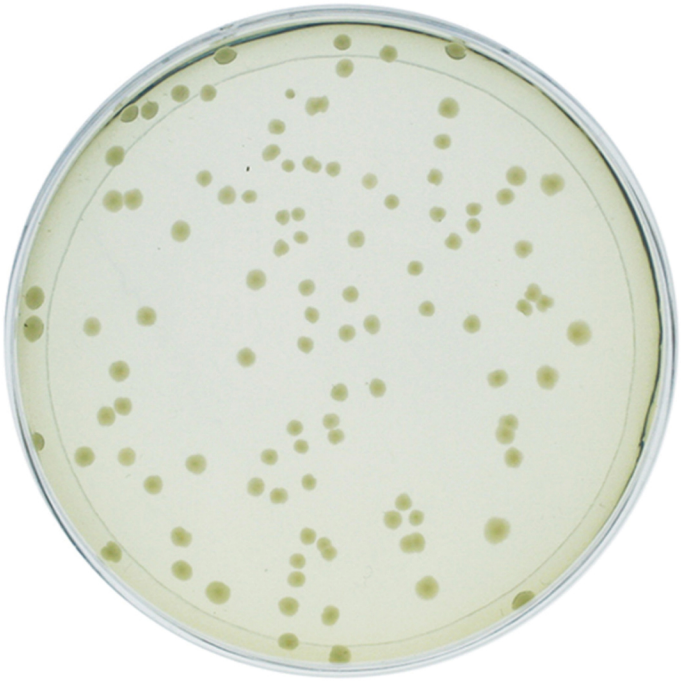
$$\frac{\text{Number of transformants}}{\text{µg of DNA}} \times \frac{\text{final vol at recovery (mL)}}{\text{vol plated (mL)}} = \text{Number of transformants per µg}$$

Example: Assume you observed 40 colonies:

$$\frac{40 \text{ transformants}}{0.05 \text{ µg}} \times \frac{0.5 \text{ mL}}{0.25 \text{ mL}} = 1600 \ (1.6 \times 10^3) \text{ transformants per µg}$$

Transformation efficiency generally ranges from 1×10^4 to 1×10^8 cells transformed per µg plasmid. A fun way to explore this concept in class would be to change the heat shock conditions and to analyze the results. Can you make your transformation more efficient by adding more DNA or changing the duration or temperature of the heat shock?
Try it and find out!

Calculating Transformation Efficiency



Practice problem for calculating transformation efficiency:

The bacterial plate, above, represents the results from your most recent transformation experiment. In this experiment, you added 15 ng of DNA to 125 µL of competent cells for transformation. After heat shock, 300 µL of nutrient broth was added to the cells for recovery. 100 µl of the cell suspension was plated on the selective agar plates before they were incubated overnight. Using the data from your transformation experiment, calculate the efficiency.

Answer Key:
There are 101 colonies on the plate.
The transformation efficiency is 2.86×10^4