**Membrane Diffusion Tutorial**

*Learning Goals*

1. Understand the role of membrane channels
2. Gain insight in to the role of stochastic (random) effects in transmembrane diffusion
3. Understand concentration gradients
4. Appreciate how bidirectional diffusion leads to equilibrium

*In the class*

1. Load the membrane channel simulation

How to use the simulator:

There are 2 compartments separated by an impermeable membrane.

Clicking on a red button releases a single particle in to the appropriate compartment.

The colour of the particle can be changed by clicking on the check box.

Drag and drop to add membrane channels.

Gated channels can be opened and closed using the buttons to the right of the simulation.

Use the play/pause button to start and stop the simulation

Activities:

 A. Add 10 blue particles to bottom compartment. Place 2 blue channels in the membrane. Time 30 seconds. Stop the simulation using the play/pause button. Write down the number of blue particles in each compartment. Press reset all. Repeat 3 times. Is the number in each compartment the same each time? Why?

 B. Press reset all. Place 1 blue gated channel in the membrane. Ensure that it is closed. Add 20 blue particles to bottom compartment. Open the channel and immediately start a timer. After 5 s pause simulation and timer. Count blue particles in top compartment. Enter the time and number of particles in a spreadsheet in Excel. Restart simulation and timer. Repeat counts at 10 s (10 s in total not another 20 s), 20 s, 30 s , 40 s, 60 s, 90 s and 120 s. Enter these values in the spreadsheet. Enter time in one column and number of particles in the next column. Press reset all. Repeat all of the measurements with 2 and 4 gated channels (enter the number of particles in the spreadsheet). Plot graphs for each number of channels.

How does the number of channel affect the increase in number of particles in the top compartment? Does the number of particles in the top compartment always increase? Which direction do particles move after 120 s with 4 channels?

C. Press reset all. Add 20 blue particles the bottom compartment. Place 2 gated blue channels in the membrane. When you open the gate time how long it takes for there to be 10 blue particles in the top compartment. During this time (before there are 10 particles in the top compartment) count how many particles moved back from top to bottom. Press “clear particles”. Repeat, starting with 30, 40 and 60 blue particles in the bottom compartment. For each number of number of particles also count the number of particles moving from top to bottom and time how long it takes to reach 10 particles in the top compartment. How does the starting number of particles affect both of these values? Why?

D. Repeat A. but with an additional 2 green channels in the membrane and 10 green particles in the bottom compartment. Does this change the result in A? Would this change if blue and green particles went through the same channel? (unfortunately the simulation does not do this).

2.Ten minutes before the end of the session, or after all students have completed the activities, discuss the answers to the questions as a group.