MATLAB project No. 1: Fick's II Law

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Q1:

The Graphs for different k values:

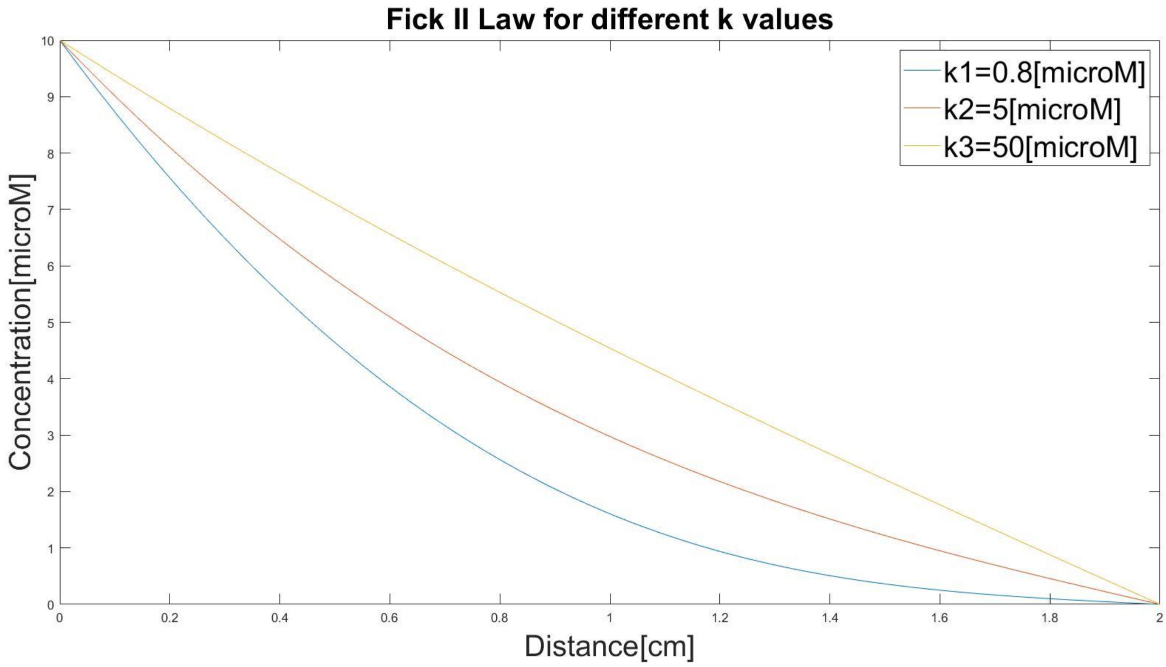

Figure 1: Fick II Law for different k values

Q2:

$K_{1,2,3}$ in the formula is Michaelis constant, which is defined as the concentration of the substrate in which the reaction is equal to half of V_{max} – the maximum consumption rate. Vmax is given as a constant. As can be seen from the graph, different K values result in different solution convex, therefore affect the reaction rate, but not the total reaction time, as all solutions decay in 2 seconds.

As K increases, reaction rate will increase as well, as can be seen in figure 1, which means that for a fixed time, the consumption is lower.

Q4:

The model where consumption rate (Vmax) is gaussian recognizes that the more cells with higher consumption rate are at a certain location, the overall consumption rate is greater as we go closer to that specific location. In our case, according to the given data, as we go closer to 0.5 cm, more cells with higher consumption rate are apparent, therefore the overall consumption rate is higher, and the concentration is lower.

Q5:

Changing the gaussian parameters so: $Vmax = Vmax(1 + \frac{1}{\sigma * \sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}})$

- For the morphogen to affect only the closest cells we want that the gaussian will be centered in 0.5 cm. To achieve such feature, σ should be reduced. The more the std is reduced, the gaussian is more centered, as can be seen in the Figure 2:

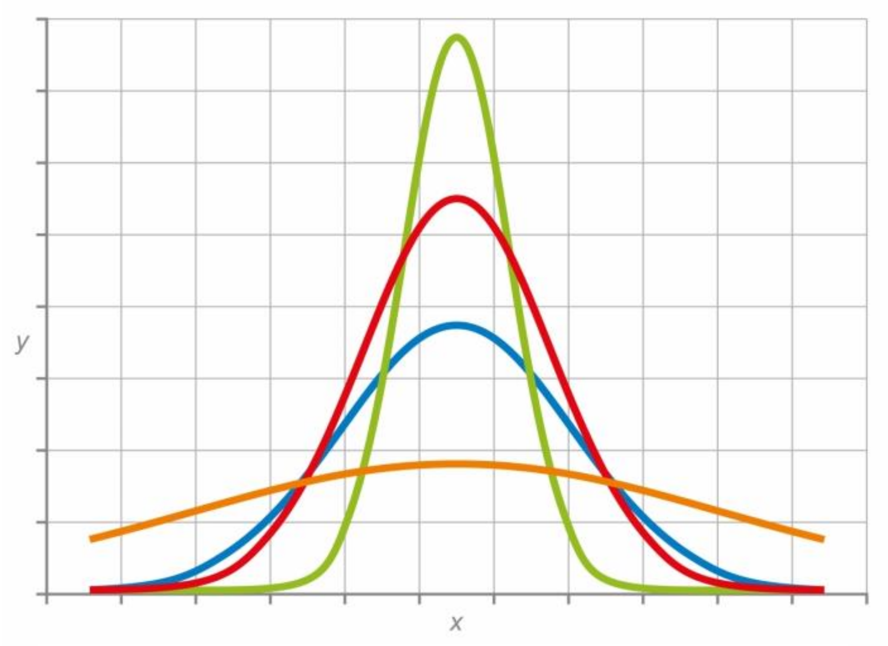

Figure 2: Illustration of gaussian with gradually raising σ values, from green to orange accordingly

- $Vmax$ will not be dependent on location- μ should be enlarged, so the gaussian doesn't affect Vmax, as can be seen by the limit:

$$\lim_{\mu \to \infty} Vmax(1 + \frac{1}{\sigma * \sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}) = Vmax(1 + 0) = Vmax$$

- The high consumption will be in a different place in the tissue- μ should be changed to a different value in the tissue's distance range(0-2cm), as can be calculated using the given Vmax formula.

Q6:

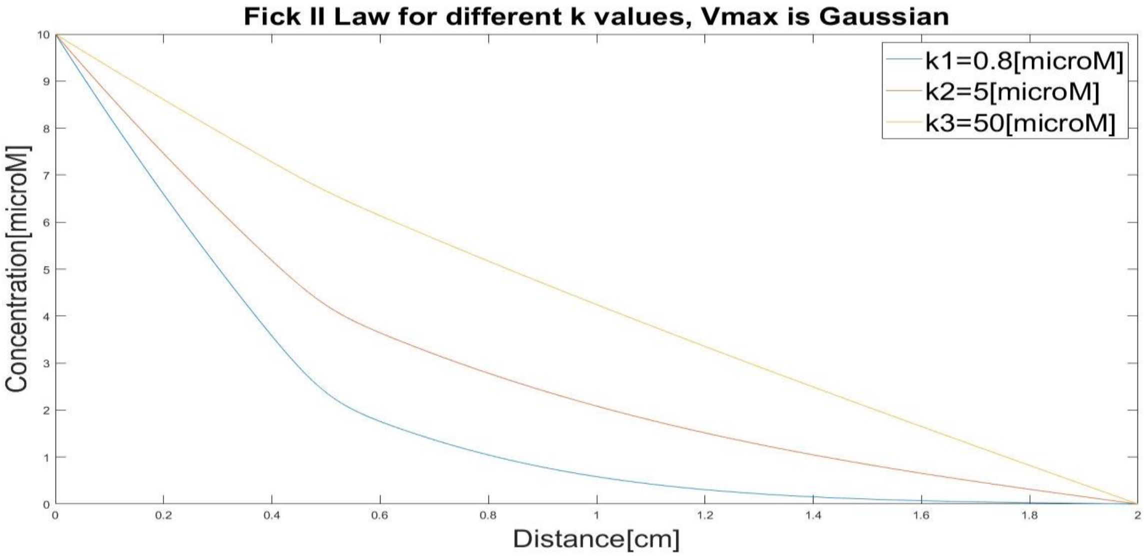

Figure 3: Fick II Law for different k values when Vmax is Gaussian

As we can see in the graph, and as expected and explained in Q4, there is a decrease in concentration around 0.5 cm. As we go closer to 0.5 cm, more cells with higher consumption rate are apparent, therefore the overall consumption rate is higher, and the concentration is lower. Compared to figure 1("old morphogen"), we can see that the morphology for each graph for each k value accordingly, persists, and the only change between the new and old morphogen are the behaviors around 0.5 cm.

Q7:

Distance AP range[cm] / Concentration vector[µM]	0.015-0. 2	0. 3-0.4	0. 4-0.5
1	9.73	5.03	3.58
2	9.38	4.95	3.44
3	9.03	4.87	3.31
4	8.68	4.79	3.18
5	8.33	4.70	3.04
6	7.99	4.62	2.91
7	7.64	4.54	2.78
8	7.29	4.46	2.64
9	6.94	4.37	2.51
10	6.59	4.29	2.37