Generation of Chemical Gradient of Varying Shapes Using Microfluidic Devices

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Chemotaxis

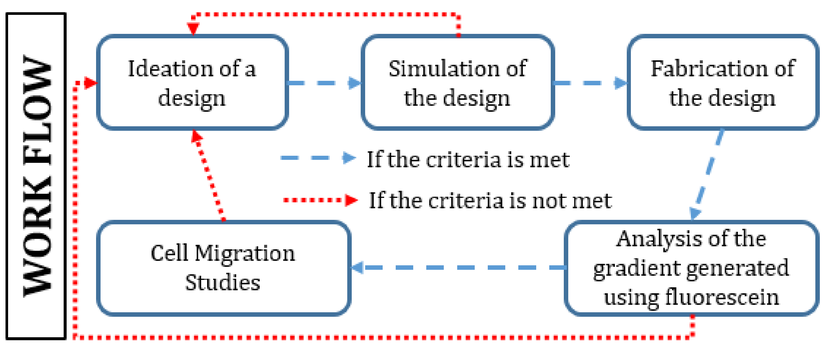
Migration of cells induced by a chemical gradient of one or more chemicals is called chemotaxis. Like other types of cell migration chemotaxis is a pivotal process involved in normal and abnormal aspects of life. For example, a stage of sperms' movement towards the ova is through chemotaxis, whereas metastasis of cancer also involves chemotaxis.

Microfluidics

This technology employs devices that have channels with widths of micron size. Increased hydraulic resistance, laminar flow and diffusion dominated system enable better temporal and spatial control over the concentration gradient and cells. Using this, it possible to generate chemical gradients of desired profile for prolonged duration and to mimic the *in vivo* chemical and physical constraints.

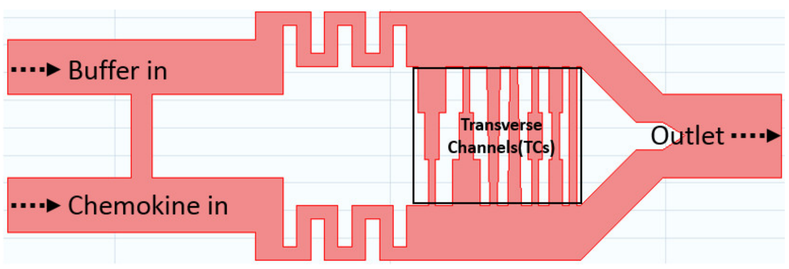
Objectives

- To develop different concentration profiles.
- To develop microfluidic devices for chemotactic studies.
- To develop on-chip clinical tools.



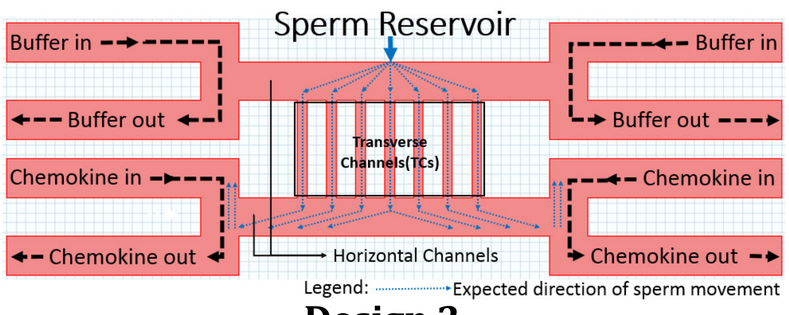
Geometry

Effective shape of the channels do change when the cell enters them. Geometry of **Design 1** was designed to develop different concentration profiles and to study how the profile would change with change in the shape of the TC geometry.



Design 1

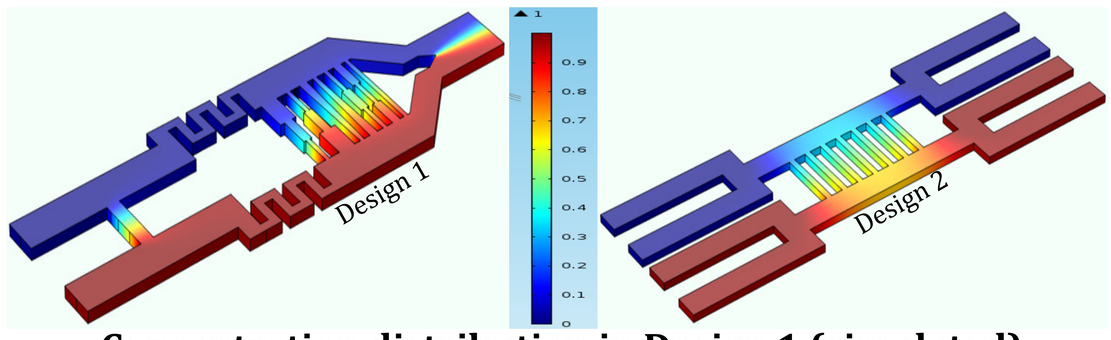
Design 2 was developed to create a non-flow region that lie outside of TC so as to avoid cells from experiencing shear.



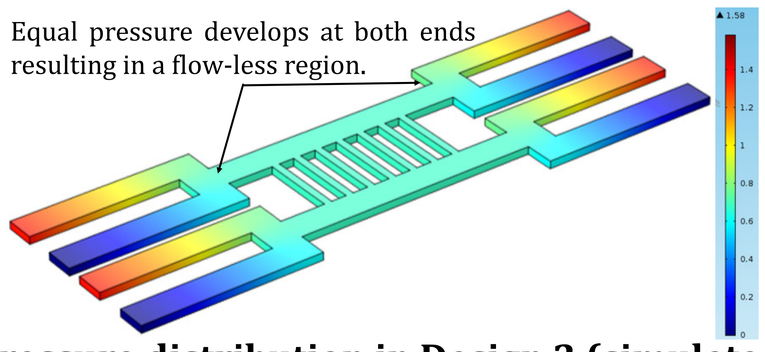
Design 2

Results

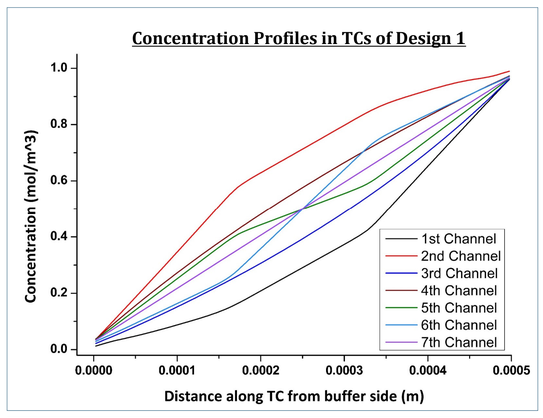
Designs were simulated using inlet velocities of 100 μm/s and outlet pressure of 0 Pa. Following results are obtained using 'spf' and 'tds' physics in COMSOL.

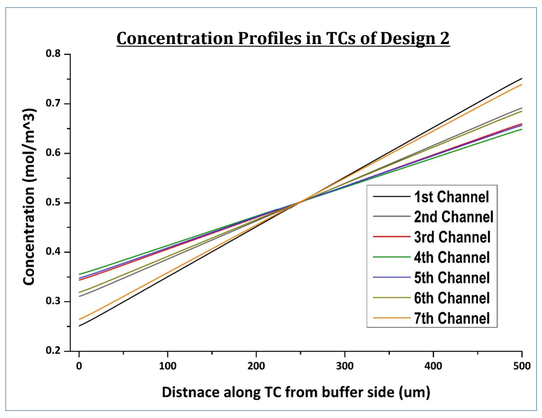


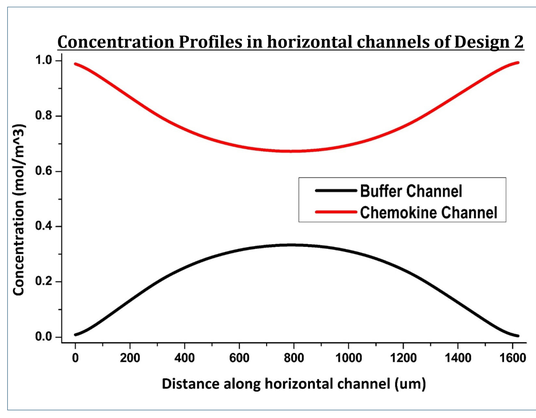
Concentration distribution in Design 1 (simulated)

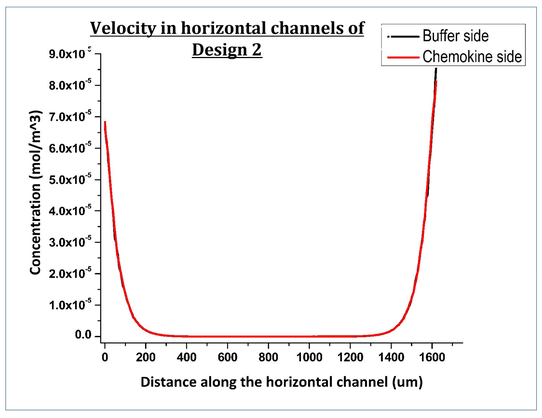


Pressure distribution in Design 2 (simulated)









Conclusion

Design 1 developed different concentration profiles in different TCs and **Design 2** developed expected concentration and velocity profiles.

References

D.A. Lauffenburger* and A.F. Horwitz, Cell Migration: A Physically Integrated Molecular Process, Cell, Vol. 84, 359-369, 1996.

P. Friedl and K. Wolf, Tumour-Cell Invasion and Migration: Diversity and Escape Mechanisms, Vol. 3, 362-374, 2003.

S.H. Zigmond and J.G. Hirsch, Leukocyte Locomotion and Chemotaxis: New Methods for Evaluation and Demonstration of a Cell-Derived Chemotactic Factor, J Exp Med., 387-410, Vol. 137, 1973.

D. Irimia et. al., Polar Stimulation and Constrained Cell Migration in Microfluidic Channels, Lab Chip, Vol. 7, 1783-1790, 2007.

D. Fuller et. al., External and Internal Constraints on Eukaryotic Chemotaxis, PNAS, Volume 107, 9656-9659, 2010.