**“Underlying Science and Technology of Synthetic Membrane Processes: Leads from Nature”**

**Georges Belfort**

**Howard P. Isermann Department of Chemical and Biological Engineering, and**

**Center for Biotechnology and Interdisciplinary Studies**

**Rensselaer Polytechnic Institute**

**Troy NY 12180-3590, USA**

What do fundamental water structure and hydrogen bonding1-3, fluid mechanics, interfacial science, and optical interference patterns5 have in common? They are topics investigated by the Belfort Group that are either intimately connected with ionic selectivity and water transport in hydrophobic pores4, or offer opportunities to reduce membrane fouling and understand membrane transport. Examples demonstrating novel approaches to the separation of biological molecules, such as using secondary flow for a self-cleaning module design6 and high throughput synthesis and screening of new surfaces for anti-protein fouling membranes7,8, will be presented. Direct measurement of concentration polarization5 and modeling of reverse osmosis transport confirmed that the solution diffusion model holds. Copying nature is the quintessential complement to evolution.

**References**

**Water structure**

1. Imbrogno, J. and Belfort, G. (2016) (Invited Review) Membrane desalination: Where are we and what can we learn from fundamentals? Annual Review of Chemical and Biomolecular Engineering *, in press*.
2. Patel, A. J., et al. (2011). "Quantifying Density Fluctuations in Volumes of All Shapes and Sizes Using Indirect Umbrella Sampling." Journal of Statistical Physics **145**(2): 265-275.Acharya et al. (2010) Farad. Disc.
3. Peter, C. and G. Hummer (2005). "Ion transport through membrane-spanning nanopores studied by molecular dynamics simulations and continuum electrostatics calculations." Biophysical Journal **89**(4): 2222-2234.

**Water transport**

1. Nair, R., et al. (2012). "Unimpeded permeation of water through helium-leak–tight graphene-based membranes." Science **335**(6067): 442-444.

**Diffusion**

1. Mahlab, D., Ben Joseph, N., and Belfort, G. (1980), Interferometric measurement of concentration polarization profile for dissolved species in unstirred batch hyperfiltration (reverse osmosis), *Chem. Eng. Commun*. 6, 225-243.

**Fluid mechanics**

1. Chung, K.-Y., Bates, R., and Belfort, G. (1993), Dean vortices with wall flux in a curved channel membrane system: 4. Effect of vortices on permeation fluxes of suspensions in microporous membrane, *J. Membrane Sci*., 81, 139-150.

**Surface modification**

1. Zhou, M., Liu, H., Venkiteshwaran, A., Kilduff, J. C., Anderson, D. G., Langer, R. and Belfort G. (2011) High throughput discovery of new fouling-resistant surfaces, *J. Mater. Chem.*, 21, 693-704.
2. Grimaldi,J. Imbrogno, J. and Belfort G. (2015) A new class of synthetic membranes: Oganophilic pervaporation brushes for organic recovery, *ACS Chemistry of Materials 27, (11)* 4142-4148.