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Transport of Macromolecules through Glomerular Basement Membrane

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The main function of human kidneys is to filter blood and remove metabolic waste while retaining the normal blood composition and volume. The first step of this process is blood filtration through the glomerular capillary wall, which consists of multiple layers: endothelium cell layer, the glomerular basement membrane (GBM) and the epithelial foot processes with their interconnecting slit diaphragm. A hydrodynamic model is introduced to describe hindered transport of electrically neutral macromolecules through the slit diaphragm and the glomerular basement membrane (GBM). The glomerular basement membrane is modeled as an isotropic fibrous medium, where as the epithelial slit is modeled as a row of parallel cylindrical fibers, and the dimensionless flow resistance is calculated using finite element method. The non-uniform cylinder spacing is assumed to follow the gamma distribution. The mean value of the spacing and its standard deviation are calculated from the experimentally obtained hydraulic permeability using the Newton-Raphson's method. The averaged sieving coefficient is calculated by using those distribution functions and is compared with the total sieving coefficient of Ficoll from experiments.

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