The mechanisms by which selective biofilters function were investigated using both theory and experiment, using selective transport through the cell’s nuclear pore as inspiration. The nuclear pore, a nanoscale channel lined with intrinsically disordered FG nucleoporin proteins, permits a high flux of transport factor proteins and their cargos while suppressing transport of proteins which cannot bind to the FG nucleoporins. A minimal model of nuclear transport was developed which relies on mobility of the FG nucleoporin-transport factor complex; this bound diffusion arises from transient, multivalent binding to flexible, dynamic tethers. Tunable hydrogel nuclear pore mimics were designed which display non-zero bound diffusion. Both the model and experimental system can be applied to high-throughput, highly-selective biofilters more generally.