Supplementary Information 1 - Flow rate and shear tress simulation

As for comsol simulation, CFD module was used to model fluid flow through porous membrane and culture chamber (free and porous media flow). This module combines the laminar flow interface and the brinkman equation (extended Darcy's Law) interface to model fluid flow in systems with both free and porous media flow and solve the velocity field and pressure. In the porous matrix properties, permeability (*k*) was calculated using the following equation and set to be 5×10^{-16} m². Water was used as a fluid material and dynamic viscosity was set to be 0.7 mPa. Flow rate was 0.5 µl/min.

$$k = \frac{\varphi r^2}{8}$$

where φ is the porosity of the membrane (0.1), and r is the pore diameter (0.2 µm). In this model, we assumed a no-slip condition and rigid wall. A physics-controlled normal size mesh was automatically constructed and stationary study was performed to obtain the velocity profile and pressure contour. Shear stress was obtained and visualized by setting a 3D plot group for the bottom surface with an expression using the following equation,

$$\tau = \mu \frac{dU}{dz}$$

where $\frac{dU}{dz}$ is velocity gradient and μ is the dynamic viscosity.

Supplementary Information 2 – Device fabrication



Figure S1. Step-by-step device fabrication based on rapid prototyping using digital cutter. (a) Digital-cut PSA used to: pattern the surface of medium reservoirs and cell seeding port, connect the wells and define the shape and dimension of culture chamber, and adhere and seal the PCTE membrane and PETE membrane. (b) Glass bottom with channel PSA layer and membrane sealing PSA layer adhered. PETE membrane (transparent) and PCTE membrane are adhered on top. (c) Punched PDMS with patterned PSA adhered. (d) Top view of assembled device. (e) Bottom view of assembled device.

Supplementary Information 3 – HCS imaging



Figure S2. Fluorescence images captured by HCS showing the effect of bortezomib to MM.1S. For each chamber, 9 images were scanned and combine, further cell viability analysis was based on those 9 fields in each chamber. (a) MM.1S response to bortezomib in MM.1S alone control group, (b) MM.1S response to bortezomib in co-culture group. Scale bar = 500 µm.