**Exercise A.5.2**

Conventional cell cultures often take place within a Petri dish and consist of a large population of cells within a homogenous culture medium. Conventional systems often require large volumes of fluids, expensive equipment, and large numbers of cells especially if multiple culture conditions are being tested. Microfluidic cell cultures utilize small quantities of reagents and culture medium, which reduces costs for materials and operations (as opposed to manually replacing fresh media, long incubation times, etc). Some microfluidic systems are also modular, so they can easily be integrated with other devices for more complex and completely automated systems. Microfluidic devices can be consistently mass produced at very low costs, and microchannels can get down to single cell resolution for specific applications. Since delivery of reagents and medium involves laminar flow through channels, mass transport of biomolecules to cells can be easily predicted. Some limitations of microfluidic culture systems include the possibility of cellular debris occluding small channels, so additional washing steps may be needed. Some devices also require training to operate them, whereas conventional Petri dishes are simple and widely available for use. PDMS, a material commonly used for microfluidic cultures, often needs to be pre-treated to prevent unwanted adsorption of small molecules or to promote cellular adhesion within channels.

**Exercise A.5.2 (different student)**

Microfluidic cell cultures provide many advantages over conventional cell cultures:

* Use smaller quantities of precious/hazardous reagents, lowering costs and waste
* Can be mass produced in low-cost, portable units
* The microchannels are on a similar scale to single cells (micron resolution)
* Has the possibility of integrating with other microfluidic devices to create a holistic system. Cell cultures could be incorporated with microfluidic biosensors.
* Laminar flow in the microchannels due to the larger surface area to volume ratio. This allows for simpler, more accurate modeling and predictions.
* PDMS can be used to create the devices. It is inexpensive, requires little expertise, transparent, and biocompatible.
* Shows potential for higher throughput devices that will allow researchers to conduct more in-depth studies and more quantitative analysis of single cell behavior.
* Can be automated to with microvalves and micropumps to circumvent the fluid handling limiting step.
* Can yield greater cell collection concentrations to reduce noise.

However, there are still obstacles that need to be overcome for microfluidic cultures to reach the current standard.

* Seeding cells in microchannels requires period where flow is stopped. Loosely attached or delicate cells can be sheared off due to the pulse need to restart the flow.
* Stopping flow can also negatively impact the microenvironment by depleting nutrition with the accumulation of metabolites.
* High throughput microfluidic devices can be difficult to meter without specialized flow visualization techniques.
* Creating a microfluidic substitute for incubators that do not modify the cell culture medium is difficult and has not been achieved.
* Cell collection volumes are much smaller and assays may not be sensitive enough. Microengineered assays may need to be created to accommodate this challenge. In addition, they are low throughput hindering the benefits of the high throughput culture.

**Exercise A.5.6**

Dean Number (De) = (ρVDh/μ) (Dh/2R) 1/2

ρ- The density of the fluid medium

V - Average fluid velocity

Dh – Microchannel’s hydraulic diameter (Dh ≡ 2HW/(H+W))

μ - Fluid viscosity

R - Radius of curvature of the path of the channel

The dean number is proportional to Dh in the first term and proportional to the square root of Dh in the second term (total 3/2 proportionality) and inversely proportional to the square root of R.

Thus, if we increase Dh by 2, and halved R, the new Dean Number would be 23/2/(0.5)1/2 = 4 times the original Dean number.

0.47 \* 4 = **1.88**