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CTE Science Laboratory Investigation

MICROFLUIDIC DEVICES

**Background Information**

From the time of the Romans, humans have been building pipes, tubes and channels to carry water around. While the technology has surely become more advanced, the same laws of physics have always governed how water moves through any device. There are several factors that affect the flow of a fluid.

First, there is the fluid itself. One property of all fluids is called viscosity, which is simply a measure of how much the fluid resists flowing. So a fluid with a high viscosity like honey will not flow very easily, while something with a low viscosity like water will flow quite nicely. The density of the fluid will affect how it flows, as well. A very dense fluid will have more mass for any given volume, and so it will take more energy to get it moving (or to keep it moving).

Something that not many people consider when examining fluid flow is friction, both within the fluid and with the walls of the tube or device. As a fluid moves through a tube, there is friction with the walls of the tube, albeit a very small amount. This causes the fluid near the wall to flow slightly slower than the fluid in the middle of the tube. This difference in velocity can cause turbulent flow if it is big enough. If the difference is very small, then the two sections of fluid will flow very evenly in what is called laminar flow.

Other factors, such as the pressure of the fluid and the overall size of the pipe can come into play as well. In the case of blood, we also need to consider the fact that human blood is really a different type of fluid than, say, water. Blood is made up of some liquids, but much of the volume of a sample of blood is made of tiny suspended particles like cells or platelets. So the way that blood behaves is different than a standard fluid.

**Purpose**

The purpose of this investigation is to allow you to understand some of the principles that determine how a fluid flows through a microfluidic device. You’ll be able to use simple calculations that will allow you to determine certain properties of the liquid in question as well as the device.

**Materials**

Ruler

Timer

Foam plate

Jell-O ®

PENCIL

Coffee stirs

Double-sided tape

Syringes

Various fluids

Food coloring

**Procedure**

DAY 1

1. Design the path of your microfluidic chip using coffee stirs. Stick them to the foam plate with double-sided tape.

2. Make sure that any juncture is smooth and that each stir directly contacts the one next to it.

3. Mix together the Jell-O powder and the gelatin and add boiling water as directed.

4. Carefully spread a small amount of non-stick cooking spray around the edges of your plate to make it easier to remove.

5. When the solution is prepared, carefully pour it into your prepared mold. Be sure that there are no air bubbles and that the coffee stirs remain stuck to the foam plate.

6. Incubate the mold overnight at 4 degrees Celsius

DAY 2

1. When the mold has cured completely, carefully remove it from the plate. Do this by gently working your fingers or a coffee stir under the edge of the mold and peeling it off.

2. Place the mold, channel side down, on a smooth surface, pressing down gently to ensure a good seal.

3. Carefully punch an inlet and outlet hole at either end of your channel using a straw.

4. Fill a syringe or syringes (depending on your design) with colored water and record how much fluid you place into your syringe in table 1.

5. Place the syringe so that it is perpendicular to the flow of the chip (that is, standing straight up and down).

6. Begin to push the fluid into your chip at a constant rate, and start the timer as soon as you start pushing. Time how long it takes to completely empty your syringe. Record this time in table 1.

7. Calculate the Reynolds Number of your chip by using formula 1. Record this data in table 1.

**Re = udρ/v**

Formula 1. The equation for the Reynolds Number, where u is the velocity of the fluid in mL/s, d is the diameter of your tube, ρ is the density of the fluid and v is the viscosity of your fluid.

|  |  |
| --- | --- |
| **Condition** | **Reynolds Number** |
| Laminar | 100 or less |
| Transitional | 101-2000 |
| Turbulent | 2001 or more |

Table A. Reynolds Numbers that indicate various conditions within a fluid.

**Analysis**

QUESTION 1: Compare your Reynolds Number with that of a few other students. Were they the same or different? Can you find a pattern?

QUESTION 2: Describe a use for a microfluidic device where it might be beneficial to have laminar flow.

QUESTION 3: Describe a use for a microfluidic device where it might be beneficial to have turbulent flow.

QUESTION 4: There are several uses for microfluidic devices. One such use is a “lab on a chip.” What this means is that instead of using a large volume of a sample (such as blood), doctors might be able to use just a few drops and perform their tests on a very small scale. Explain at least two benefits and two detriments of such a system in the space below.

QUESTION 5: Microfluidic devices might also be used for personalizing medicines. For example, cells could be collected from various organs in a patient’s body, placed in a microfluidic device, and then blood with a particular medicine could be profused through the device. What benefits might this have for the patient?