Laminar flow and diffusion based mixing in a ‘Christmas tree structure’ are shown in an oversized microfluidic device. Two different coloured juices or food dyes can demonstrate the concept. Concentration gradients generated by such a device can be used to test the toxicity of chemicals on cells, which can be visualised with pH paper in the outlet chambers and basic and acidic solutions acting as the ‘toxic’ chemicals.

AIM
To make laminar flow and diffusion based mixing in microchannels accessible to school children and the general public by:
• producing a safe, interactive experiment to help explain and visualise fluid handling;
• highlighting the applications of the technology.

THE ACTIVITY

THE DEVICE

How it works

(a) Extra-large chip with six outlets for coloured dye demonstration. (b) Device with four outlets used in outreach experiments.

Additional resources for activity to increase understanding and engagement:

Fig. 1: Design images of the PMMA chips showing the Christmas tree mixing structure. (a) Extra-large chip with six outlets for coloured dye demonstration. (b) Device with four outlets used in outreach experiments.

Fig. 2: (a) Red and yellow coloured fruit juices are pushed through the channel network with four outlet chambers. Even pressure at both syringes generates the best gradient. (b) Applications of concentration gradients for cell toxicity studies are explained through a simple setup with acid and base solutions. A strip of pH paper is placed below the outlet; lemon juice and baking soda solution are pushed through the network and drip on the pH paper. The range concentrations in the different outlets is visible as a pH gradient on the paper strip.

RESEARCH BASIS

Gradients have been used at the University of Hull to test toxicity of chemicals on cells. This has been achieved by trapping cells within microfluidic chambers and then exposing the cells to a gradient of toxic chemicals generated in a Christmas tree mixing structure. This microfluidic toxicity screening system holds many benefits over static plate-based bioassays. Simple testing of different formulations and concentrations can be achieved alongside regulated fresh nutrient and analyte inputs. Further the device is adaptable to a diverse set of conditions and can facilitate the optimum conditions for different cell types. Its size and simplicity also affords potential portability.

KEY REFERENCES