

# Application: Design a microfluidic device for a drug delivery experiment

This is a team assignment; every member of your team must take part in doing this assignment. Only one member of your team needs to submit this form.

Once you submit this form, please email a schematic diagram of your designed microfluidic device to [realavi@mit.edu](mailto:realavi@mit.edu). The diagram can be hand-drawn or digital.

## The challenge

Imagine you are an applied researcher at a pharmaceutical company, working on the development of a new antibiotic drug (chemical) for treating an infectious disease caused by bacteria.

Initial testing of the chemical seems promising, and you are now at the stage of drug development where you need to determine the optimal amount of the chemical in terms of effectiveness and toxicity for the most common patient profile, in preparation for clinical trials. To do this, you will need to run a drug delivery experiment by monitoring cultured (living and growing) cells as they are exposed to varying concentrations of the chemical.

To achieve this benefit, you will need to design a microfluidic device (system of interest) containing the pathogenic (disease-causing) bacteria, with the following function:

Input: a concentration of chemical (0 [buffer] and 100% [chemical]) from one or more input systems, in unlimited amounts. In this particular case, an input system is a syringe.

Output: ten concentrations of the chemical, ranging from \*medium\* (50% chemical, 50% water) to \*high\* (almost 100% chemical) delivered to an output system. In this particular case, an output system is a reservoir.

Select the simplest and most efficient design required to achieve the intended function of the system. You can use any part, any number of parts, and any amount of the chemical in any concentration. The parts you can use are inlets, outlets, channels, mixers, valves, and membranes.

You can use the [Preparation article on systems thinking](#) as a source for the systems thinking framework (SAFO).

## Parts and their behaviors

Inlet: transports the solution toward a channel or a mixer.



Outlet: transports the solution toward the waste/reservoirs or for recollection of fluid for chemical analysis.

Channel: transports the solution inside the device. For purposes of this assignment, we assume that the input concentrations reach a linear gradient in the channel and do not mix completely.

Mixer: generates a new concentration of chemical in the solution from multiple inputs of different concentrations. A mixer can be connected to inlet/s and/or channel/s. The concentration at the exit point of the mixer is an average of the input concentrations. For example, two inputs with low and high concentration, respectively, will result in a medium concentration at the exit point of the mixer.

Valve: blocks or releases the flow of the solution through different parts of a microfluidic device, usually inlet/s or outlet/s. For purposes of this assignment, assume you can control the valves as you like.

Membrane: Used to filter molecules within the solution by size.



\* Indicates required question

Email \*

Your email

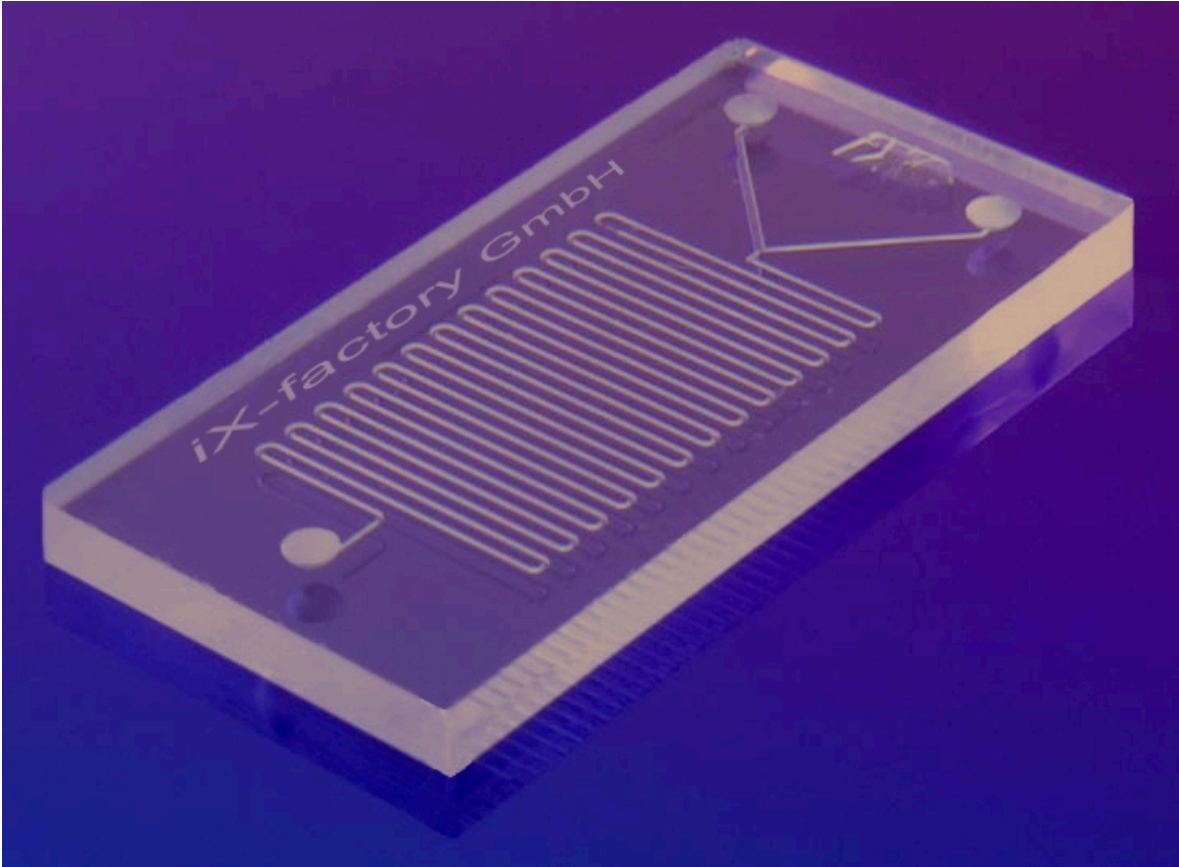
Select your team's letter. \*

- D
- A
- B
- C



Microfluidic chip fabricated in glass.

This chip contains two inlets, multiple channels (or one long, winding channel), and one outlet. Each channel is 50 $\mu$ m deep and 150 $\mu$ m wide.



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## System Architecture-Function-Outcome (SAFO) framework



**System\***  
Technological  
Engineered



**Architecture**  
Structure +  
Behavior



**Function**  
The system of interest's  
interactions with boundary  
systems\*\*:  
Input systems and inputs  
Output systems and outputs

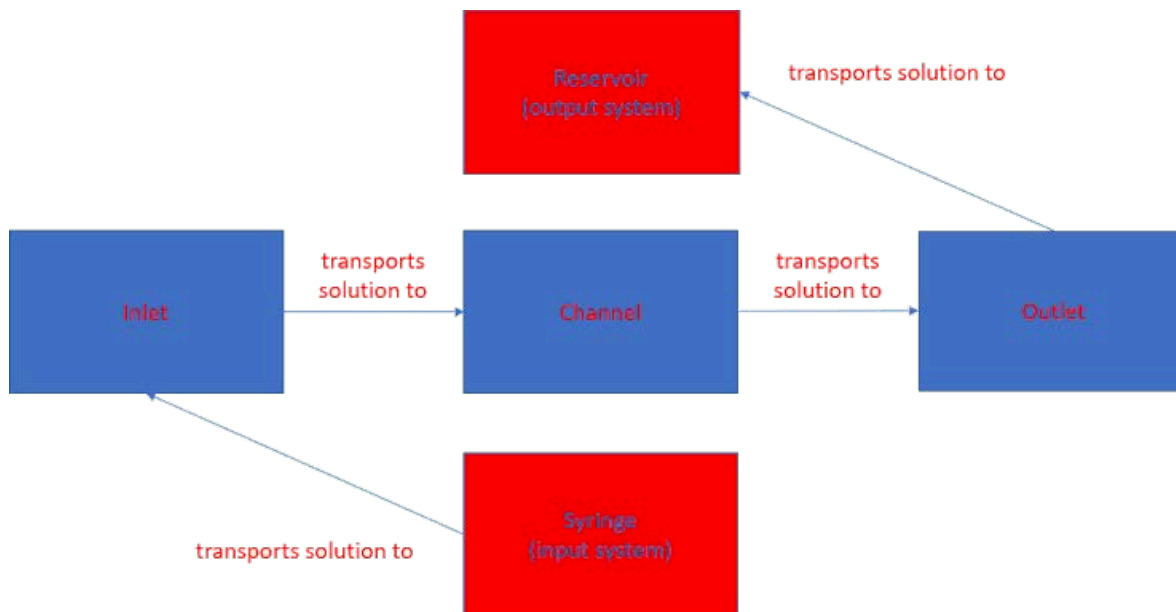


**Outcome:**  
Problem  
Stakeholders  
Benefits  
Detriments

\* System of interest

\*\* Boundary systems do not have to be technological.

Schematic of the system architecture and function of a basic microfluidic device for this particular case, containing one inlet, one channel, and one outlet.



Select parts (system structure) for achieving the intended function of the system \*  
of interest (the microfluidic device).

- Membrane/s
- Inlet/s
- Mixer/s
- Outlet/s
- Valve/s
- Channel/s

For each part you selected, explain your choice. In your explanation, refer to the \*  
intended behavior of each part and to the intended function of the system of  
interest (the microfluidic device).

Your answer

A copy of your responses will be emailed to the address you provided.

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