Systems Thinking in Living Machines - Application3: Design a microfluidic device for a drug delivery experiment

This is a team assignment. Every team member should contribute to this assignment, and only the team members should work on this assignment. Once you submit this form, you will receive a copy of your responses to your email address.

You may use the following resources for this assignment:

- NEET Living Machines presentation, slides/pages 18-24

You are allowed to use additional resources, as long as you report on your use below.
You are allowed to use generative AI, as long as you report on your use below.

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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 function, you will need to design a microfluidic device (system of interest) containing the pathogenic (disease-causing) bacteria, with the following inputs and outputs:

Input: two concentrations: 0% (buffer) and 100% (all chemical), from one or more input entity/system. In this particular case, the input is from a syringe. You may use unlimited amounts of either concentration.

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

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

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

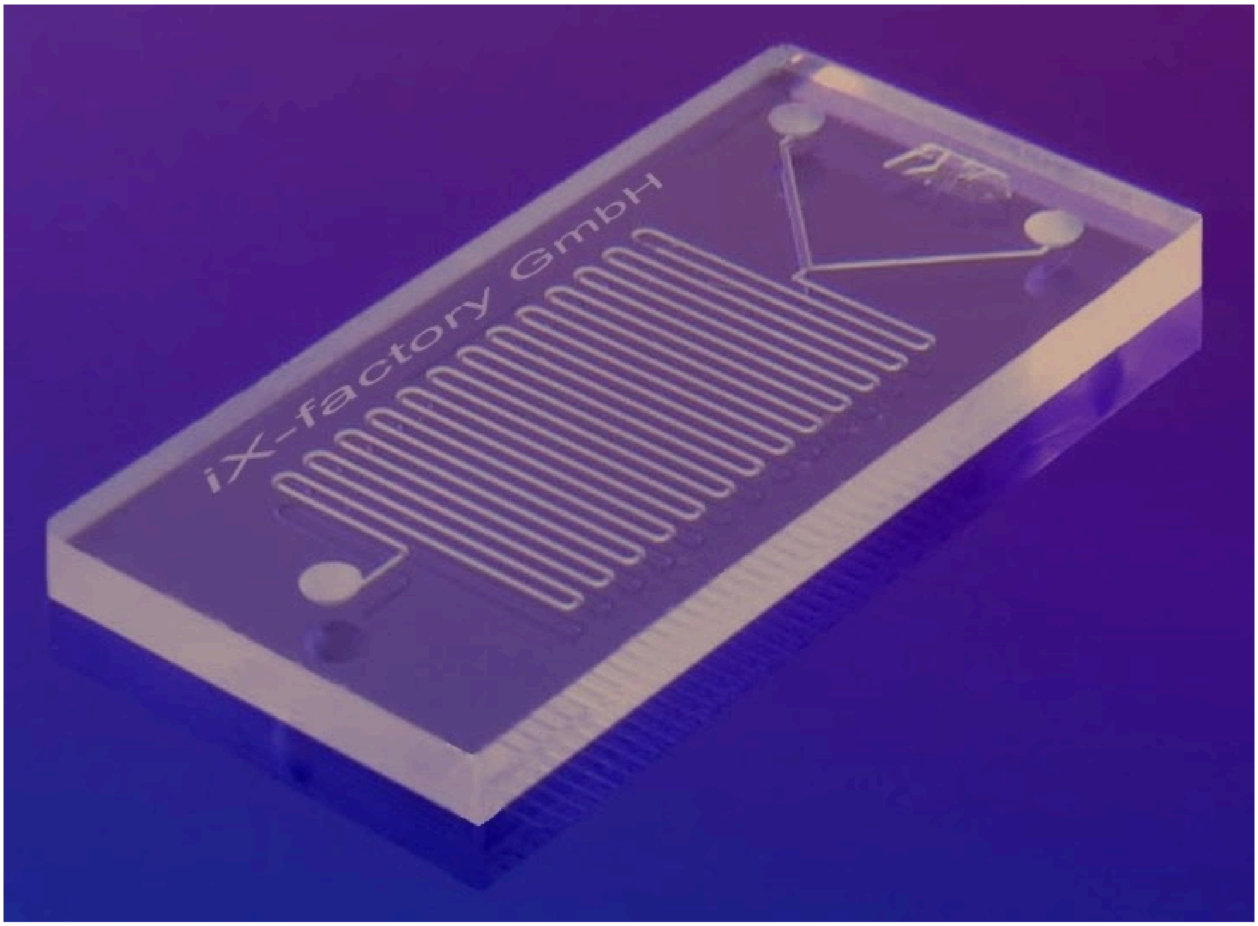
1. Email *

2. First name and last name of every team member *

Microfluidic chip fabricated in glass.
This chip contains two inlets, multiple channels (or one long, winding channel), and one outlet. Each channel is 50μm deep and 150μm wide.

Image by Dr. Sven Tombrink, Process Engineer iX-factory GmbH.

Source: https://commons.wikimedia.org/wiki/File:Microfluidic_Chip_iX-factory.jpg



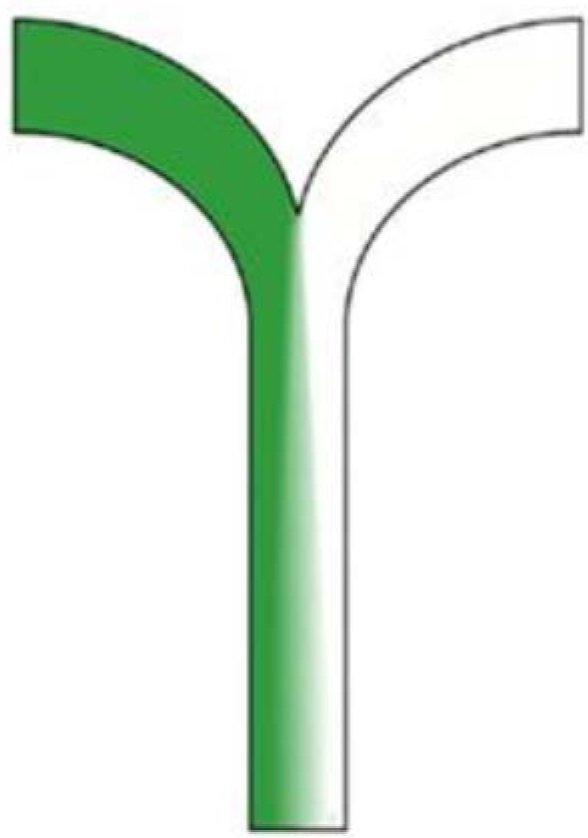
A diagram of a T-junction in a microfluidic chip. The junction is made-up of two inlets and one channel.
Green: 100% chemical
White: buffer (100% water, no chemical)

The image shows one inlet with 100% chemical and another inlet with buffer, together creating a chemical concentration gradient inside a channel.

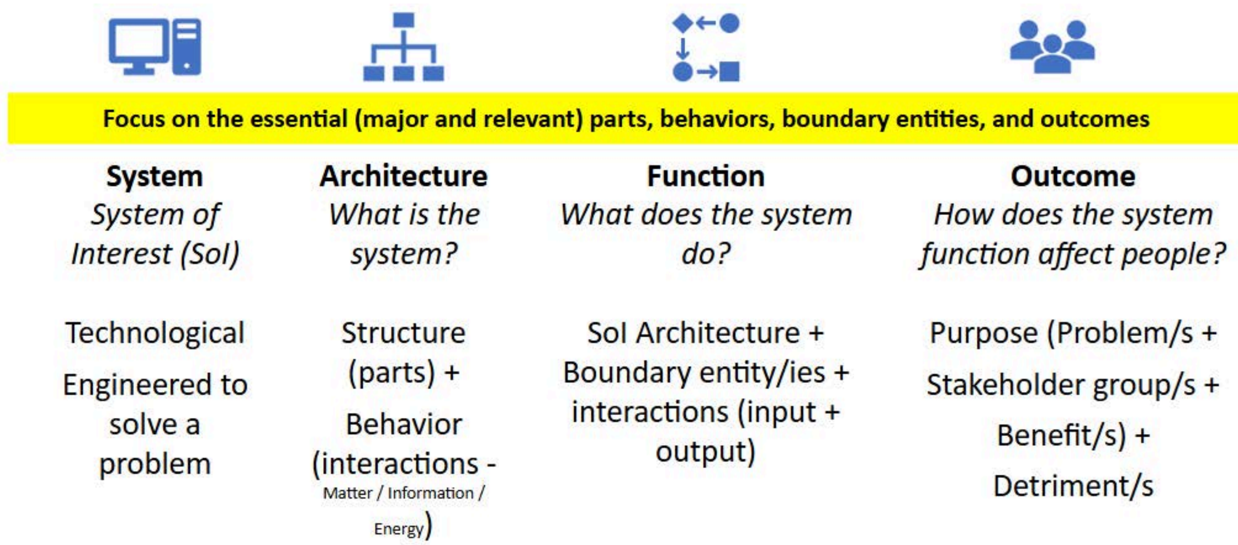
As shown in the image, the gradient becomes more pronounced (i.e., having a larger number of distinct chemical concentrations) as the fluid flows farther inside the channel and the two inputs mix together more.

For purposes of this assignment, we assume that mixing fluids from multiple inlets in a single channel will always result in a concentration gradient, as long as the different inlets contain different concentrations of a chemical.

Source: Andrew J. deMello, Nature, 2006

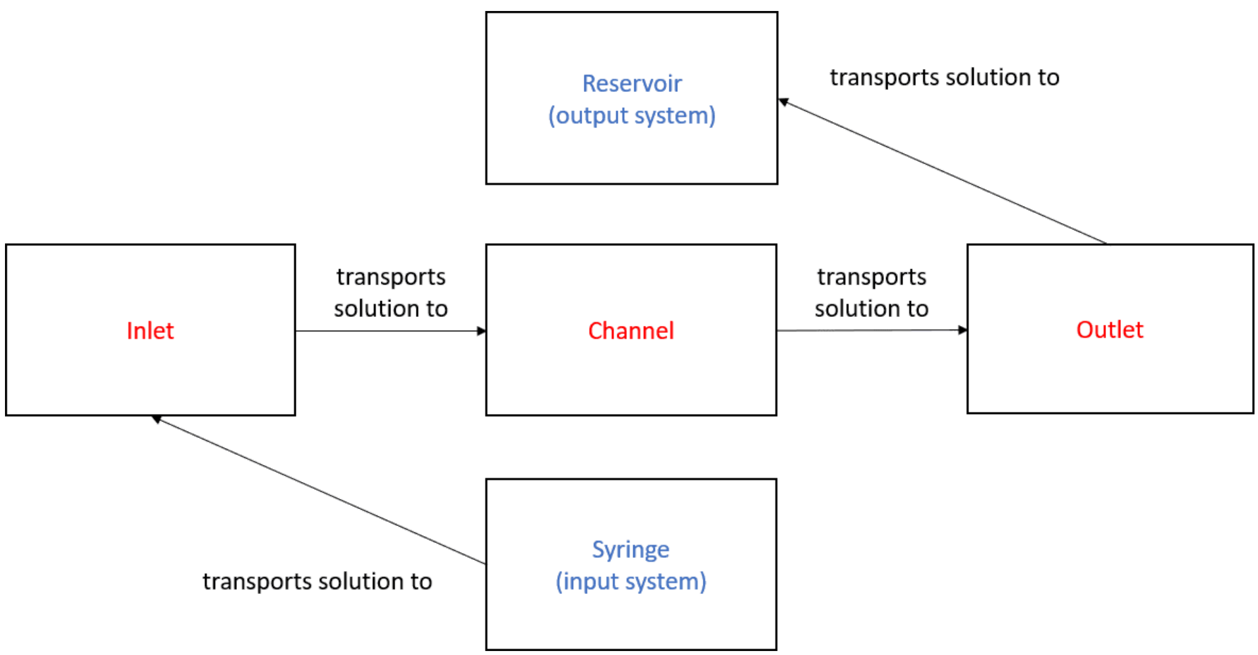


System Architecture-Function-Outcome construct



Red text: system of interest, SoI (a microfluidic device).

Blue text: boundary systems (directly interacting with the SoI's architecture).



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

Check all that apply.

- [ ] Additional inlet/s
- [ ] Additional outlet/s
- [ ] Additional channel/s
- [ ] Mixer/s
- [ ] Valve/s
- [ ] Membrane/s

4. For each part you selected, mention the number of parts and describe their behavior (interactions with the other parts). *

5. Explain how your designed architecture will help achieve the system's intended function. *

6. Upload a diagram of your system architecture design **HERE**. The file name should contain the first name of every team member. *

   Your diagram can be a physical or digital drawing.

   Mark only one oval.

   ⬭ Done

7. If you used any additional resources for this assignment, please provide their URLs/references here and describe what item/s you used them for.

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8. If you made use of generative AI (like chatGPT) while working on this assignment, please provide details here about what tool/s you used, how you used them, how you found it useful, and what potential shortcomings you found. Add any other information you deem relevant.

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9. If there was anything that was not clear in this assignment, please add your comments here.