Lab-on-a-Chip examination, July 4th 2012

You may answer the questions in English or Dutch

Every question is worth 10 points out of a total of 80.

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1. Micro-/nanofluidics:

a. Explain the working mechanism of electroosmotic flow. What can electroosmotic flow be used for? Describe the flow profile of electroosmotic flow in a microfluidic channel and in a nanofluidic channel with double layer overlap. Compare it to the flow profile of pressure-driven flow. What can be advantages of electroosmotic flow with respect to pressure-driven flow?

b. What is electrophoresis? Describe the working principle of electrophoresis. What is electrophoresis used for? What role does electroosmotic flow play in electrophoresis?

2. Micro-/nanofluidics:

a. Describe the main characteristic of laminar flow and turbulent flow. Which factors (related to both the fluid and the channel) can you mention that determine whether we have laminar or turbulent flow?

b. What is the main mechanism that we can use for mixing in microchannels in case of laminar flow? How does this mechanism depend on the device dimensions?

3. Surface treatment:

a. How does the surface of glass looks like at the atomic scale? You can use a drawing to represent it.

b. Is the glass surface hydrophilic or hydrophobic?

c. Which approach(es) is (are) available to tune the affinity of the surface for water?

d. For some particular applications, a patterned surface with hydrophilic and hydrophobic areas is highly interesting. Mention 3 examples where such a mixed surface is needed. How can such a patterned surface be prepared (different answers are possible)?

e. Is such a hydrophilic/hydrophobic surface interesting and sufficient to immobilize cells on a substrate? If not, which approach(es) would you recommend to immobilize cells on a glass substrate according to the pattern represented in figure 1?

Figure 1: Cell patterning on a glass substrate on well-defined geometrical shapes. Cells are to be grown on the white areas, and no cell should be present on the grey area.

4. Microfluidics and cells:
a. Which parameters (physical, biochemical, chemical…) that are essential to keep cells alive in *in vitro* culture are controlled in a conventional approach (culture flasks in an incubator)?
b. Which other parameters of the *in vivo* cell microenvironment – which are essential for the proper functional of cells - can be reproduced in a microfluidic format, and not in a conventional format (culture flasks, well plates..)?
c. Mention 4 unique features of miniaturized/microfluidic devices for single cell experimentation.
d. What are the different steps to be implemented on a LOC device for mRNA analysis at the single cell level?

5. Optical Detection Methods:
a. Describe two differences between fluorescence and phosphorescence.
b. Write the Beer-Lambert equation relating absorbance A to transmittance T. What does the length L represent ?
c. Why are semiconductor quantum dots interesting alternatives to fluorophores or chemophores for fluorescence spectroscopy?

6. Label-free Biosensing:
a. Describe how a cantilever resonator sensor detects a small mass attached to the sensor surface.
b. Describe how the quartz crystal microbalance sensor detects a small mass attached to the sensor.What does a surface plasmon resonance (SPR) biosensor detect when molecules adsorb on the gold sensing surface ?
c. Which sensor (from a. and b.) has the larger sensitivity when immersed in a water solution? Why?

7. Electrochemistry:
a. Make a sketch of a typical amperometric setup, including all the required basic elements and annotate them.
b. Name 1 benefit and 1 drawback of using amperometry in a Lab-on-Chip compared to the other known electrochemical detection methods.
c. How does mass transport of ions by convection affect the amperometric detection?

8. Microfluidic platforms:
a. What is the commonly used fabrication material used in the LSI platform? What is the basic unit mostly used in the large scale integration (LSI) platform? How does that basic unit work?
b. Name 3 other platforms besides the LSI platform. List one strong point and one weak point of each platform you give.